Chapter 1

Introduction to Green Roofs

Our roofs, which keep us safe and dry, are subject to a range of environmental stresses. They are exposed to substantial rains and damaging hail, destructive heat and UV radiation, strong winds, and heavy snow. Our changing seasons and associated temperatures can wreak havoc on the waterproof membrane material used on many roofs, causing it to expand, contract, dry, crack, and then leak or break down.

Investing in a quality roofing membrane gives homeowners peace of mind in keeping their house protected. But why not go further? Why not utilize the roof space as a means to contribute to the biodiversity in your neighborhood and offer a protective place for pollinators or birds to feed? Why not reduce the impact of this space by reducing the heat it would normally reflect or capturing the rain that would run off of it? Why not do *all* these things? Why not make your roof do *more*?

You can. You can build a green roof.

Green roofs, eco-roofs, vegetative roofs, vegetated roof assemblies, or living roofs—regardless of the name, they are all roof systems designed to support plant life. Green roofs provide a range of benefits for your site and your community, and they are an opportunity to turn a static surface into a buzzing tapestry of color.

Fig. 1.1: *A roof structure gets battered from many exterior forces while protecting precious interiors.* Photo Credit: Restoration Gardens, Inc.

Fig. 1.2: *Green roofs serve many purposes and bring life to an otherwise inanimate roofscape.* Photo Credit: Restoration Gardens, Inc.

Green Roof Systems

While some green roofs can be complex, others can be quite simple in design. Regardless of your design, for a green roof

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Fig. 1.3: *A built-in-place system is installed in layers on the roof.* Photo Credit: Restoration Gardens, Inc.

Fig. 1.4: *An example of a hybrid system: layers are installed individually and finished with pre-grown vegetation mats.* Photo Credit: Restoration Gardens, Inc.

to succeed it must include the following five main elements:

- a strong roof structure
- a waterproof membrane
- suitable growing media
- good drainage
- appropriate plants

Understanding how these elements come together will allow you to design and build the green roof you need. Throughout this book, I will provide you with visual examples to guide you.

You can build a green roof layer by layer (a built-in-place [BIP] system), or you can install manufactured products, such as trays that come pre-fitted with all the needed layers, often including pre-grown vegetation. You can also create hybrid systems. For example, layers can be installed on the roof with a pre-grown vegetation mat unrolled overtop, or you can install modules pre-filled with media and complete the planting on the roof.

Green Roof Categories

Green roofs fall into three categories: *Extensive, Intensive,* or *Semi-Intensive.*

Extensive systems have shallow planting, making them inhospitable to many species. This means they support less plant diversity; however, they require less maintenance and upfront cost. These are the types of roofs most people think of when they think "green roof." *Intensive systems* have few restrictions and can be designed as accessible public parks with soil depths deep enough to support trees. The middle ground of a *semi-intensive* roof typically allows for greater plant diversity than an extensive roof and therefore requires a little more maintenance, but they are not as resource heavy as

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intensive roofs. See Photos 1–3 in the Color Section for images of each kind.

This book is focused on extensive roofs and semi-intensive roofs, but it also introduces food production roofs. Food roofs, rooftop farms, and edible roofs are all terms referring to green roofs that are built or modified for the production of food. These are often considered semi-intensive or intensive roofs due to the depth of the growing media and the frequency of maintenance that is required. Photo 4 in the Color Section shows a food roof in an urban setting.

Extensive, semi-intensive, and small food roofs can easily be built and managed by an enthusiastic and competent DIYer on simple residential or outbuilding rooftops. Intensive roofs should be left to professional contractors, as they require an integrated approach with input from architects, engineers, landscape architects, and material suppliers. The table in Figure 1.5 highlights comparisons between the three types of green roofs this book will cover.

New Builds versus Retrofits

Green roofs can be built on both new and existing roofs. On new roofs, you have the freedom to build the roof structure based on your green roof design intent, whereas on an existing roof, your green roof may not exceed the existing structural capacity. If your

Figure 1.5: Comparisons of Green Roof Categories and System Types

	Extensive	Semi-Intensive	Food Production Roof
Depth of Growing Media	<6"; the ideal minimum is 4"*	Approximately 4–8"	Varying depths of 6–12" or higher
Type of Growing Media	Traditionally aggregate-based with low percentage of organics	Typically involves a higher organic content	Can be as much as 100% organic
Typical Plants	Moss Sedums Some grasses Some flowering perennials	Grasses Flowering perennials Some bulbs Some shrubs	Fruits, vegetables, and herbs
Irrigation Needs After Establishment	Low	Moderate; depends on soil composition and climate	High
Modular Systems Available	Yes	Yes	Can use some modular components but do planting yourself
Saturated Weight**	4" systems are approximately 20–30 psf	30–60 psf	50–100 psf, depending on the depth of soil over 6"
Cost***	Low	Moderate	Most expensive (in terms of ongoing resource and maintenance needs)
Maintenance	Lowest	Moderate	High

* Systems with less than 4 inches of growing media tend to require permanent irrigation systems and provide fewer ecosystem services. Systems with shallow growing media are most appropriate for existing roofs with restricted weight loads.

**Ranges are based on commercially available blends. Custom soil blends could be higher.

***Total costs typically escalate as the growing media deepens. On a sq. ft basis, the cost per sq. ft will go down the larger the roof gets. For a DIY install (where labor is typically free), you will have to do your own cost comparisons for materials to compare modular and BIP systems.

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existing roof does not allow for the added weight of a green roof, you can retrofit your roof to accommodate your loading needs; however, this can be a costly venture.

This book will give you everything you need to know about building a green roof but it does not directly show you how to design or build the roof structure underneath it. The typical green roof assembly does not include the roof structure itself. However, these two building components are highly interdependent. Reviews of local codes and/or a call to a structural engineer are necessary to ensure your structure is adequate for the amount of additional loading you intend to add.

How This Book Can Help You

The green roof industry is still relatively young and, therefore, still evolving. In North America, awareness and interest in green roofs has exponentially increased in the past decade and a half, and there is a growing body of research and publications. Whereas the early research was concerned with how the newly developed systems from Germany could be of use to our cities, research is now more focused on region-specific systems and designs for specific ecosystem services. Twenty years ago, the only books published on green roofs were intended to educate contractors on this new type of construction. Now, many books are published filled with award-winning designs of green roofs around the world. In addition, the industry is still learning many valuable lessons and developing products specifically for green roofs. As awareness and interest increase, many individuals are left wondering how they might build their own simple system.

Referencing lessons from these valuable resources as well as my experience in building green roofs for the past ten years, this book aims to provide the necessary information and planning steps for the Do-It-Yourself builder. The lessons in this book are for homeowners building simple green roof projects; they are not intended to be applied to complex installations or used by commercial installers (who must strictly adhere to municipal building and safety codes and may have to follow manufacturer recommendations for warranty purposes).

My goal for this book was to use common language that would not require a horticulture or construction background; however, I want you to be familiar with the key terms so you feel competent when ordering supplies or talking to professionals.

In addition to terminology, you will find planning steps, installation and design considerations, plant and material choices, two installation examples, maintenance considerations, and an introduction to food production roofs. Consideration is given to the diversity of North American climates. Many details are provided so that regardless of the size of your build, you will have all the necessary planning preparation in front of you. However, if you are merely building a small green roof over a tool shed or a dog shed (in no way am I diminishing Spot's need for well-being), you may not need to consider all the steps found in Chapters 3 and 4. They are still worth a read, however, so you can make informed decisions down the road.

Attention to Details

Racing through details can cause big problems, especially when you are dealing with water overtop of your home. Do not underestimate the ability of water to find small imperfections. In this book, you will find very detailed drawings illustrating the

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concepts; please review these carefully and apply the same level of detailed attention to any new ideas or variations you may wish to perform.

Fig. 1.6: *Water is starting to find a way through this green roof after 10 years.* Photo Credit: Restoration Gardens, Inc.

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Chapter 2

Green Roof Layers and Roofing Terminology

Green Roof Layers

A GREEN ROOF INCORPORATES a series of layers that work together to protect the building underneath it from water while supporting plant life. These layers are divided into two categories: (1) those that are required to ensure the green roof will function properly, and (2) those that are optional based on the design specifics. Descriptions of these layers are found in this chapter, and in Chapter 7 you will find material specifications.

Required Layers

Waterproof Membrane

The most essential part of any green roof, a waterproof membrane keeps water out of the structure, protecting the integrity of the building. This layer usually lies directly on top of the building's roof deck.

Root Barrier

A root barrier protects the membrane from root penetration. Some roots are quite aggressive and can cause damage if allowed

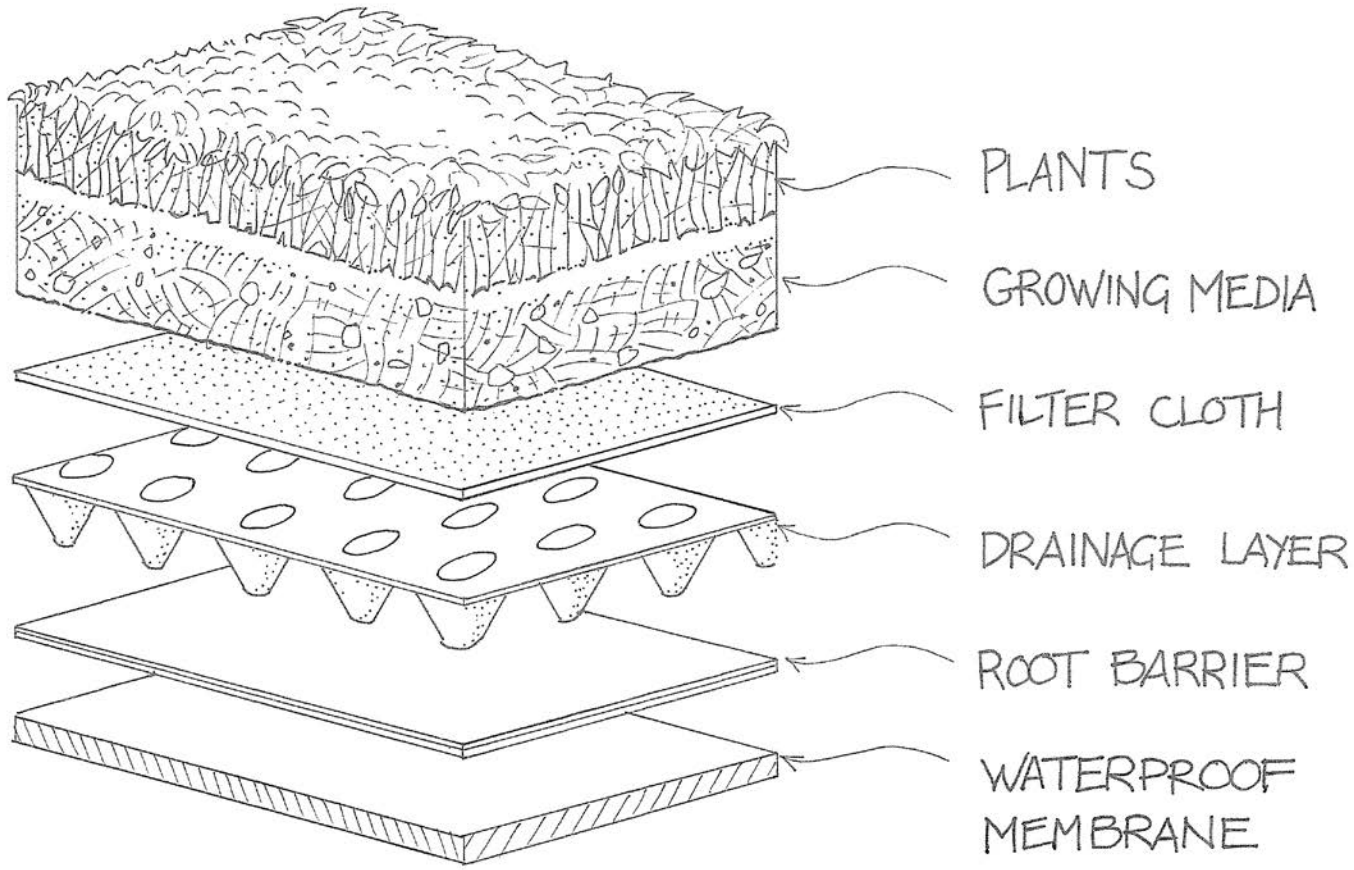

Fig. 2.1: *Required layers of a green roof.*

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Fig. 2.2: *Roots growing within the granules of a typical modified bitumen roof.* Photo Credit: Restoration Gardens, Inc.

to grow without restrictions. This layer is an absolute requirement if the membrane does not contain root-resistant properties.

Drainage (Layers and Outlets)

The drainage layer allows water to flow freely through the built assembly and toward the drain outlets. Drainage outlets allow water to run off the roof. Both drainage elements (down and out) are required to eliminate standing water (especially on flat roofs).

Filter Cloth

Also known as geotextile, filter cloth is required to keep the fine particles of the growing media out of the drainage layer, ensuring that the drainage layer does not become clogged, which would restrict the movement of water.

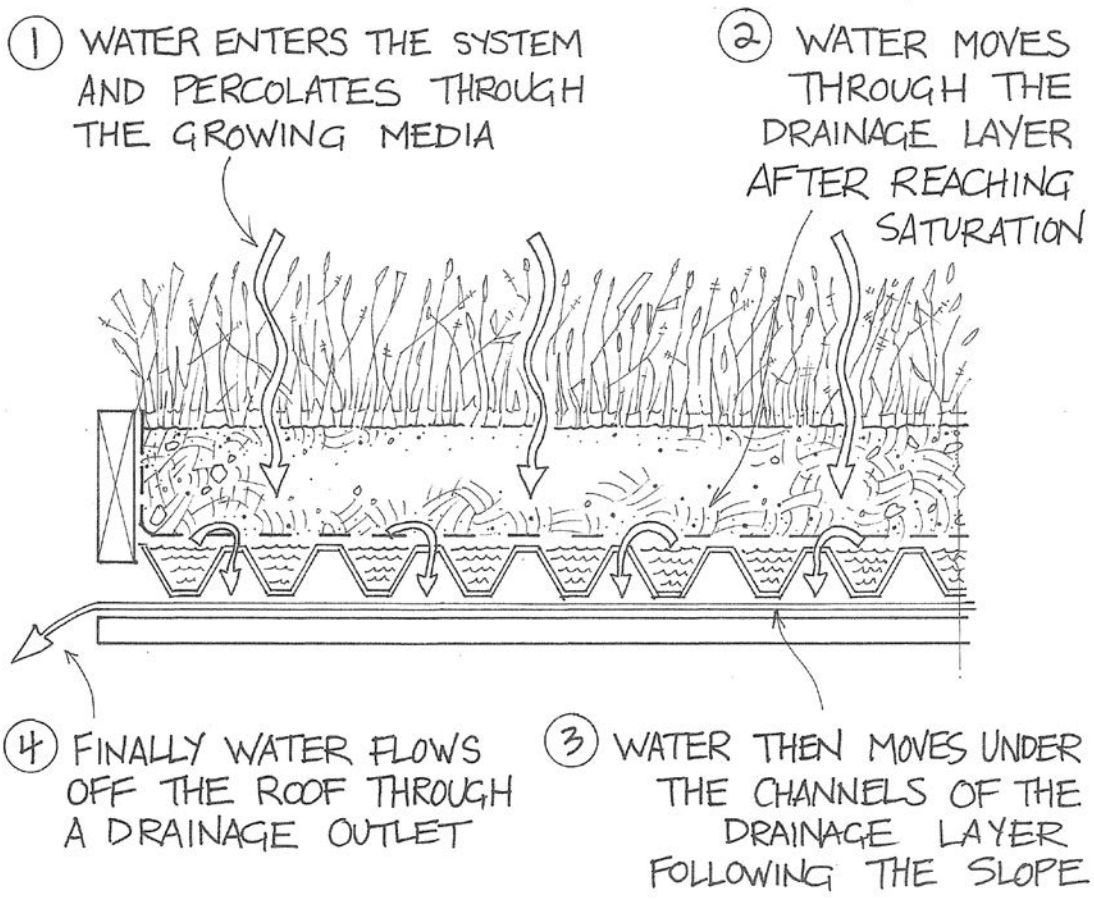

Fig. 2.3: *Drainage systems allow the passage of water through the growing media to mitigate oversaturation; they also give water an exit from the roof to reduce ponding and excessive weight. Some drainage layers are designed to retain small amounts of water for plants to use, but allow most of the water to move through.*

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Growing Media

Growing media is the substrate in which the plants grow. As opposed to most gardening soils, media on a green roof is typically a mix of organic material and lightweight aggregate.

Plants

Plants are the last thing to go on the green roof. They serve as visual indications of how well you have built the assembly and the health of your system.

Optional Layers

In addition to the required layers of a green roof, there are optional layers. The necessity of these items will be based on your green roof design.

Membrane Protection

This layer protects the membrane from continuous friction or pressure points coming from the overlying layers. Membrane protection is normally required for intensive systems because they are heavier and are more prone to foot traffic; the need for membrane protection in extensive systems depends on your membrane type and the overlying drainage layer.

Insulation

Insulation in a green roof is typically in the form of rigid boards. In flat roofs, insulation can be part of the underlying roof structure as the primary thermal barrier, or it can be added on top of the roof structure, where it can act either as the primary thermal barrier or as an enhancement to the thermal performance of insulation that already exists in the ceiling.

Water Retention

A water-retention layer temporarily holds water in between rain events. A water retention layer may be required for green roofs with steep slopes, in areas with high winds, or for roofs with very shallow depths (i.e., 2 inches or less).

Slope Restraints

On steep green roofs, a manufactured or built-on-site restraint system must be incorporated to prevent growing media from sliding.

Wind Erosion Protection

This type of protection is a temporary or permanent mechanism or design feature intended to prevent wind from blowing the growing media off the roof.

Irrigation

It may be necessary to provide a temporary or permanent source of supplementary water to plants in between rain events.

Roof Terminology

Gable Roof

A roof with two sides that meet at a ridge.

Shed Roof

A simple roof with one slope. This is probably the best type for a DIYer to work with the first time.

Roof Deck

The roof deck is the construction material that sits between the structural supports (joists or trusses) and the waterproofing material (membrane). In residential applications, it usually consists of plywood or tongue-and-groove lumber.

Parapet

A parapet is a small wall that runs along the perimeter of the roof deck. In a green roof application, the parapet works to keep the green roof material contained on the roof as

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well as aid in wind erosion protection. It can be made of stacked or formed lumber sitting on top of the roof deck, or it can be made of stacked stone; it can also be a continuation of the exterior wall.

Cant Strip

A triangular strip placed in the angle between a roof and a parapet or any other vertical surface to which the roof abuts (including building walls). This strip provides support behind membranes in areas where sharp corners may be hard to achieve. Cant strips can be made of concrete, wood, steel, insulation, or insulation composites.

Scupper

A scupper is an opening in the parapet where water exits. It is usually at the lowest point of the slope, and more than one may be necessary based on the slope, design, or size of the roof.

Emergency Overflow

An emergency overflow is a fail-safe way to ensure that water can escape from the roof in the event of a clogged scupper. In a situation where the parapets are high, a clogged scupper would result in excess water pooling—potentially exceeding the weight allowance for the structure.

Cricket

A cricket is a high point designed into the roof deck to divert water. They are often used around building structures, such as chimneys, and at transitions from one roof section to another; they are also used on roofs where one slope may not clear all the water off the roof.

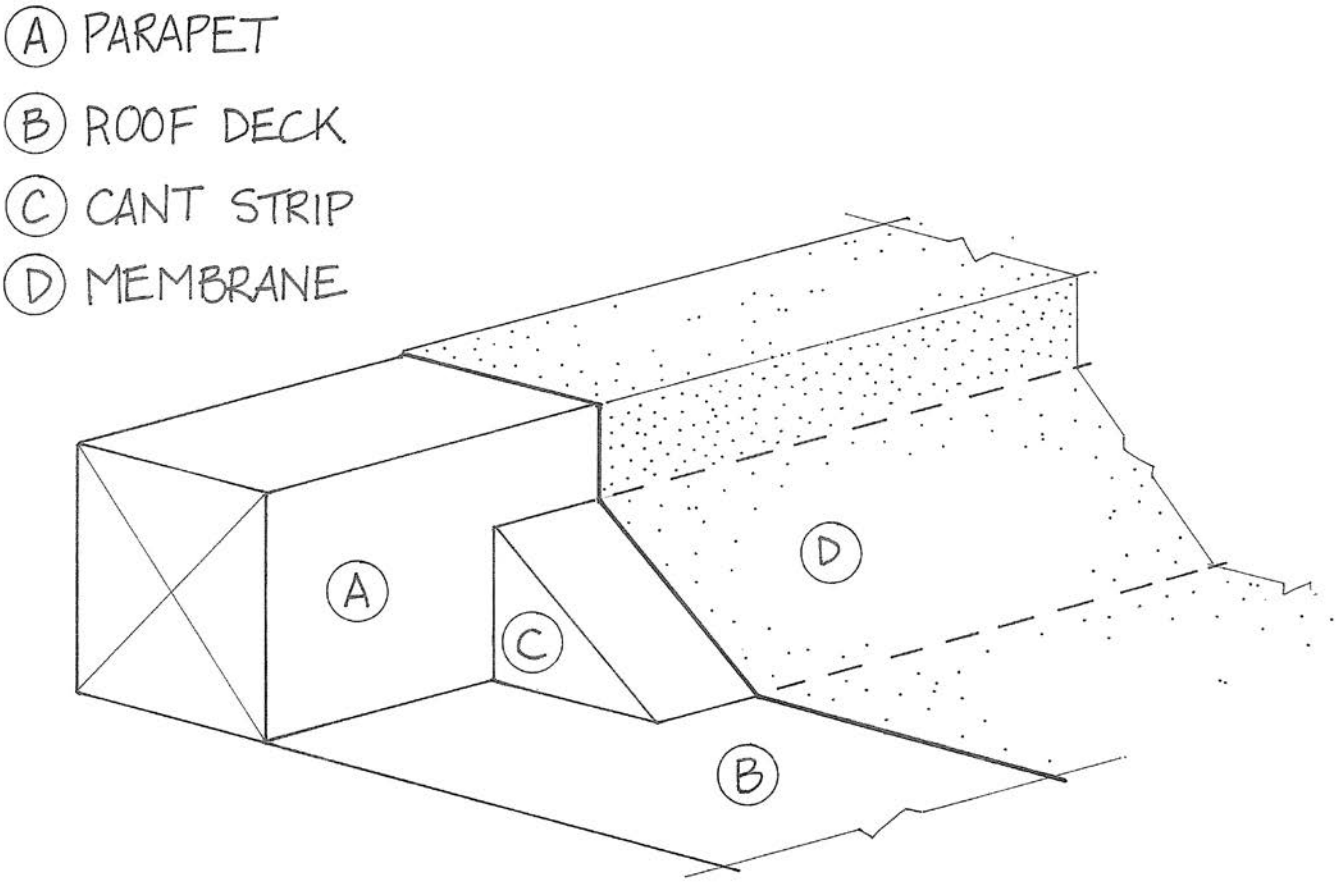

Fig. 2.4: *The placement of a cant strip can make angles easier to work with.*

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Drip Edge

A drip edge is a metal flashing used to force the water off the lower edge of the roof instead of allowing it to trail back toward the house. It is also the term used for the lower edge of the roof where water drains off.

Rake Edge

The rake edge runs along the roof from the lowest point to the highest point. Water typically does not flow off these edges.

Fig. 2.5: *A flat roof with a typical scupper. Scupper openings allow for water to exit the roof and into a downspout.*
Photo Credit: Restoration Gardens Inc.

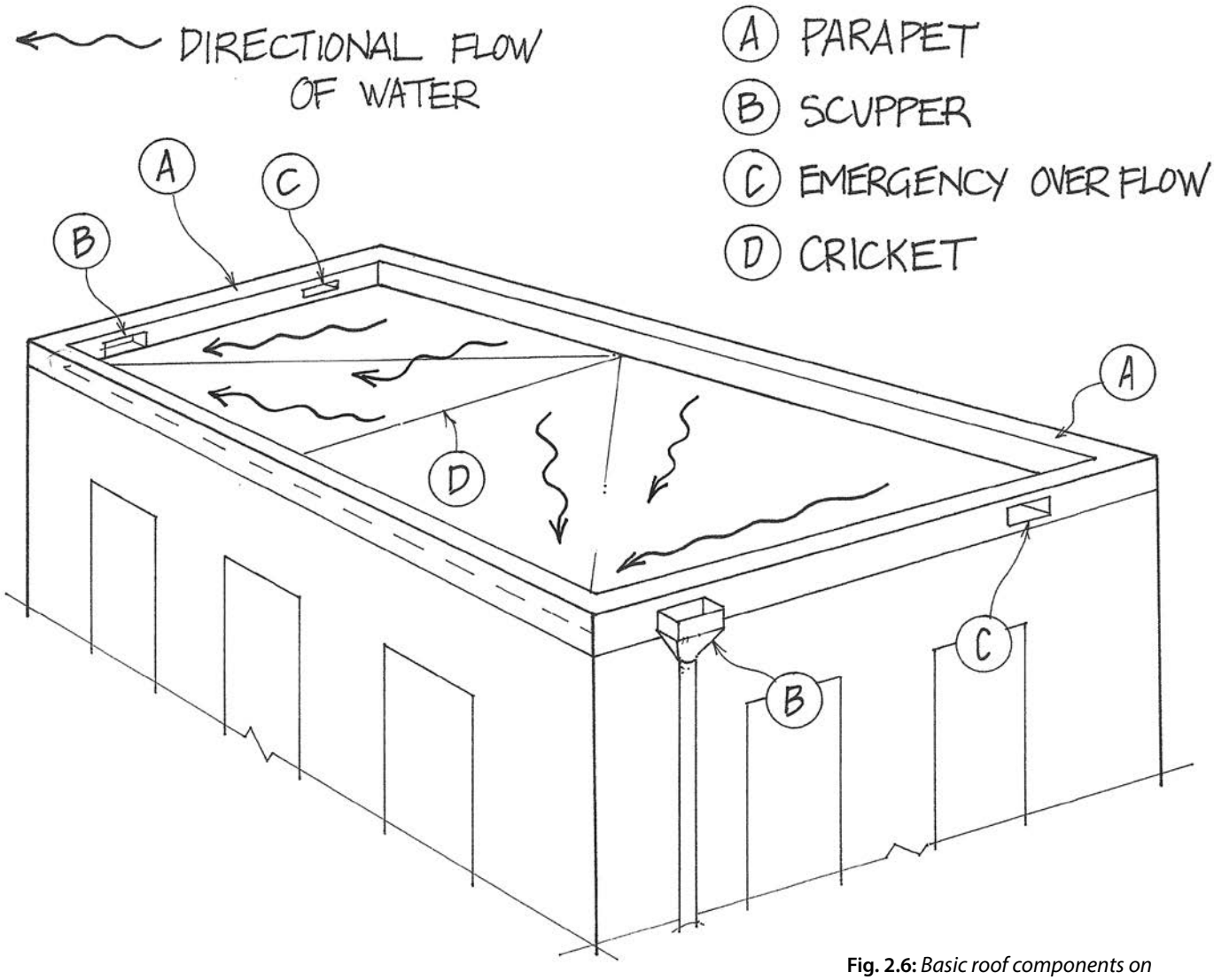

Fig. 2.6: *Basic roof components on a typical flat roof with parapets.*

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Eaves

Eaves are the section of the roof that overhangs from the wall out to the end of the joist. The job of the eaves is to protect the walls from water coming off the roof and/or from rain.

Gutter/Eavestrough

Gutters, as they are known in the US, or *eavestrough,* as they are known in Canada, are channels that are fastened to the fascia board at the drip edge. Gutters collect water and direct it down a downpipe (or rain chain) away from the foundation of the house.

Now that you have a basic understanding of a green roof system and the parts of a roof, we can go through how to build one.

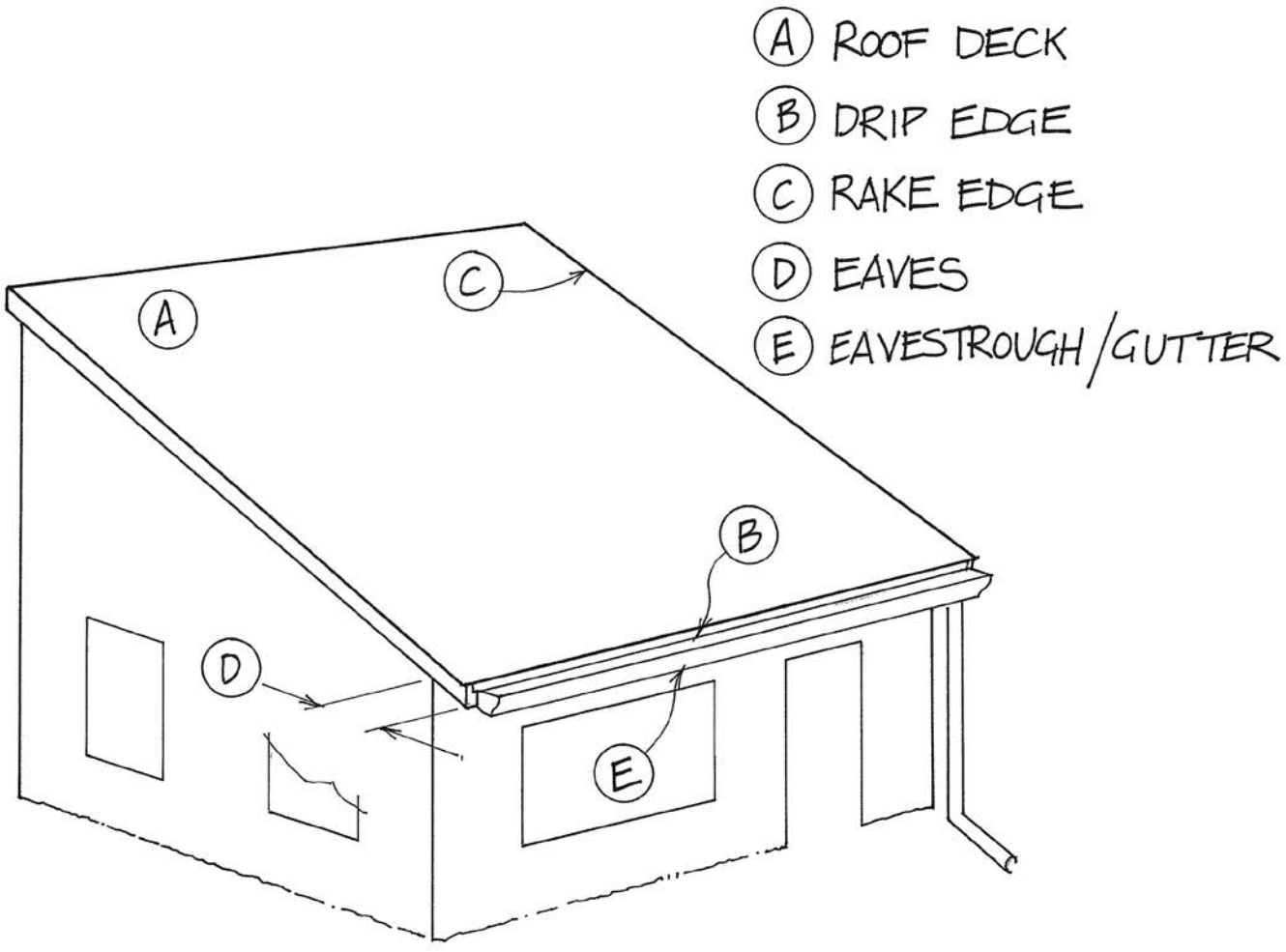

Fig. 2.7: *Basic roof components on a typical shed roof with no parapets.*

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