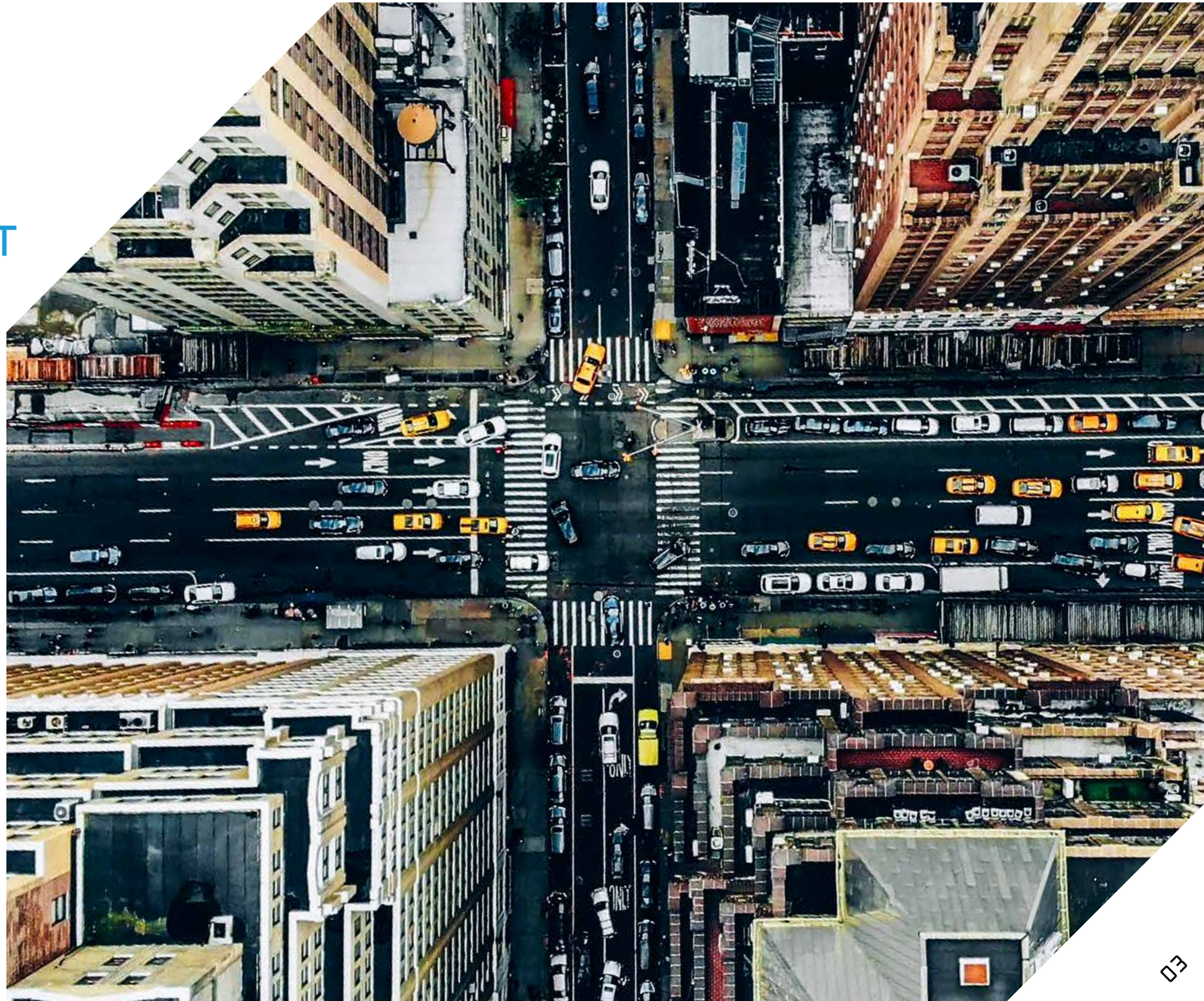


permavoid
the Foundation for our Future

PERMAVOID SOLUTIONS FOR SUBBASE REPLACEMENT

In today's world where cities become denser every day to accommodate the increasing number of inhabitants, the necessity to assign multiple functions to any single urban area increases continuously. Where, for example, in the past a car park could just be a car park, nowadays its design has to incorporate storm water management, protect water quality, and facilitate urban cooling by supporting surrounding green infrastructure.

This growing demand for the multifunctional-layered city in urban planning creates new levels of complexity in civil engineering. Permavoid has been at the forefront of innovating, developing, testing and building future proof solutions in civil engineering for over twenty years. By incorporating multiple functions in reliable subbase solutions, any paved area can be 'put to work' for the city to create a climate resilient, safe and liveable city for future generations.





IN NATURE ALL MATTER IS RECYCLED AND NOTHING IS WASTE

NATURE AS SOURCE OF INSPIRATION

Incredible levels of diversity characterize our natural world. No two ecosystems are the same. Yet all ecosystems share one core component: water. In nature water is managed as a valuable resource by means of catchment, attenuation, absorption and evaporation and is intrinsically incorporated in all life forms and ecosystems. This enables ecosystems to cope with shortages and plentitudes without being seriously affected in their survival or functioning. Being able to thrive with uncertainties in water availability and being able to recover from sudden changes is called resilience and protects the ecosystem on species level and as a whole.

Integrate resiliency in civil engineering

Where water management is at the core of every natural system, in urban planning we have tried to separate functional (paved) urban spaces and water management for decades. Stormwater is fed into pipes and transported over long distances to be treated off-site. The lack of resiliency in this design paradigm now becomes visible in the light of climate change: during rain events cities flood, during prolonged dry spells our green infrastructure experiences water shortages and open water quality is under threat of pollution from surface run-off.

By reintegrating on-site water management in urban planning, just like in nature, cities become more resilient and are able to absorb the effects of changing weather patterns, preventing economic- and ecological damage while protecting human health and well-being.

FROM LINEAR TO CIRCULAR APPROACH

In our cities we create large impervious surfaces, both above and below ground, forcing us to drain water in ever-bigger pipes, with increasingly faster, polluted and more voluminous flows, creating an end-of-pipe problem. This linear water management requires large amounts of energy for transport and purification before stormwater can be fed back into nature. In addition, the man-made peak in rainwater discharge creates increased urban floods with economic, ecological and human health risks as result.

Four key elements from natural ecosystem functioning have been the inspiration for Permavoid designs in civil engineering.

Match load with load bearing capacity

In nature footprints are designed in such a fashion that they do not exert loads larger than the load bearing capacity of the soil. This is what prevents camels from sinking into desert sands and swamp trees from disappearing into the peat subgrade.





Fast discharge of stormwater from paved areas into sewers can only lead to overloaded systems, failing at their lowest or most vulnerable point, with an obvious negative effect on local economies and a potential threat to human health.



El Rio Sur in Costa Rica carries a predictable amount of water year-round thanks to the sponge function of the soil and tropical forests on the surrounding hillsides, despite the significant differences in seasonal precipitation.

Manage water where it falls

An important characteristic of water management in nature is on-site retention and detention, right there where it rains. Only when soil and vegetation cannot hold any more water, the system starts to slowly release clean water for infiltration to groundwater.

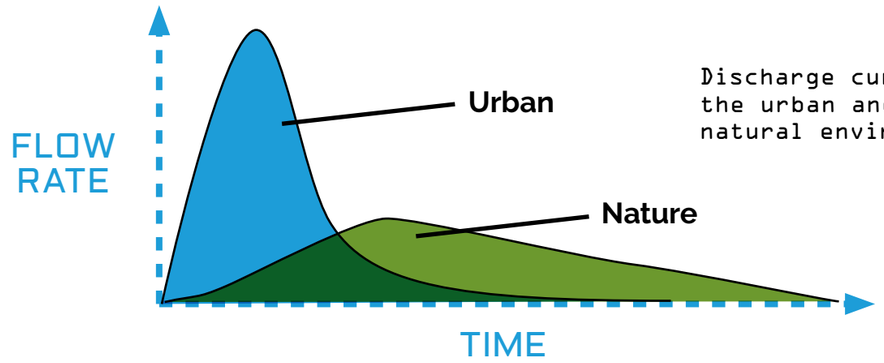
Reduce flow rates

With large areas of pervious (open) surfaces, storm-water can infiltrate into the soil. There it is stored and transported via groundwater flows, slowly; creating a natural filtering effect.

These reduced flow rates result in a 'flat' discharge curve. This means water is available longer for the ecosystem, and fast run-off taking soil and nutrients away from the system is prevented. This is referred to as the 'sponge' function and serves to retain water and protect surface water quality. In rivers and streams the reduction of flow speeds pays off too: it allows for the sedimentation of suspended solids before water enters the oceans.

Energy for water management

Keeping water on site as much as possible greatly reduces the amount of energy required for water management in nature. While energy for the worldwide water cycle is generated by the sun, transport of water on land is powered by gravity. Retaining water high in the profile maintains its potential energy for transport downstream later on.



Discharge curves for the urban and the natural environment.

PERMAVOID ENGINEERING

Even though engineered infrastructure remains hidden in trafficked and paved designs to most users, structural integrity and reliability are essential for all Permavoid solutions. In the design and manufacturing of the Permavoid subbase replacement systems the following design elements are key.

Product characteristics

Permavoid is designed as a lightweight, hollow subbase replacement unit. It is an integral part of any paved or landscaped surface and thus has to guarantee structural stability and provide reliability for the many years it has to perform its function in the subbase. Permavoid's patented systems are unique in the sense that:

- The combination of arches, surface webbing and the vertical cylindrical columns in the design create high vertical compression strength
- The units are connected over the full height with conically shaped ties, pulling the units tightly together to create a stable raft in the subbase, allowing for tensile stress created by traffic loading to be transferred over a large area, promoting load distribution
- The subbase can be created of any size with the modular Permavoid units. Common designs are only one unit deep, but with the Permavoid Sheer Connector even deeper systems can be created when required
- The recycled Polypropene units maintain their structural integrity in a wide temperature range
- The PermaTies can be removed so the units can be dismantled as easily as they are installed and are reusable multiple times; also allowing the system to be used for temporary installations in fast changing cities

Permavoid's reliable high strength subbase replacement systems can be integrated with Sustainable Urban Drainage Designs (SuDS):

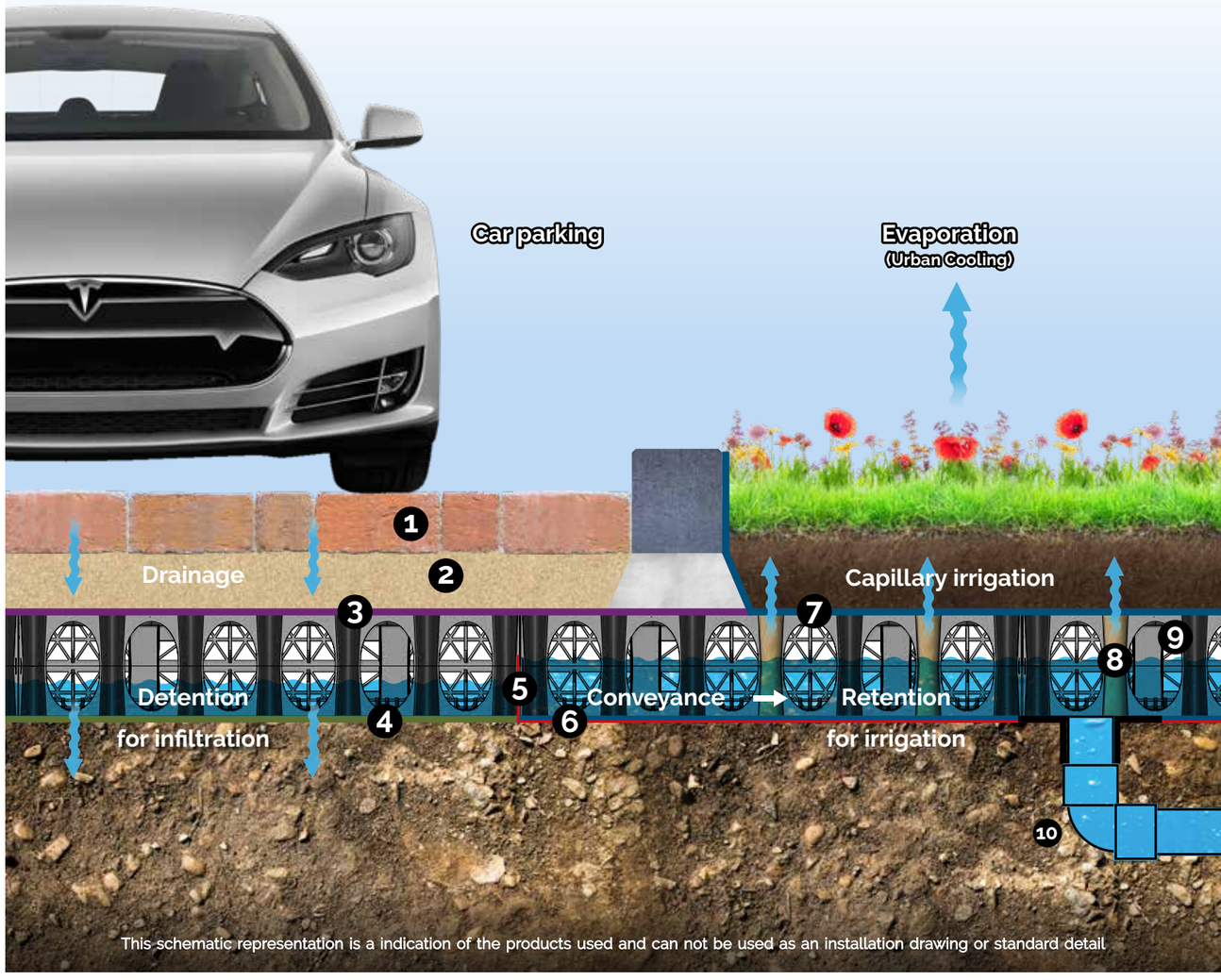
- With a water permeable geotextile, on-site water attenuation for infiltration is created under the hardscape, mimicking pre-construction hydrology
- With a waterproof membrane a combined water retention and conveyance system is created
- With Permavoid treatment-textiles incorporated in the design, oils and other hydrocarbons can be separated from water and kept out of the downstream catchment, protecting drainage and open water quality
- Capillary fibre columns can be inserted in the units to create natural passive irrigation with water in the units for vegetation growing on top

Design base

The core behind Permavoid as subbase replacement is to create a shallow-but-wide usable void high in the profile, as close to the surface as structurally possible. The first design characteristics focus on structural stability and reliability under paved and trafficked constructions.

Permavoid's high compressive strength allows for placement close to the surface, creating the advantage of shallow excavation and minimal subgrade disruptions (rocky subgrades, groundwater, utilities, tree roots) and minimal material transport during construction. A typical detail for car parking starts with a 130 mm buildup of pavement and bedding on top of Permavoid, up to a total buildup of 400 mm for HGV accessible roads.

Secondly, creating a void over the entire surface enables the system to act as a catchment for the entire paved surface with ample attenuation volume. Retaining water high in the profile also maintains the gravity fed water conveyance potential.



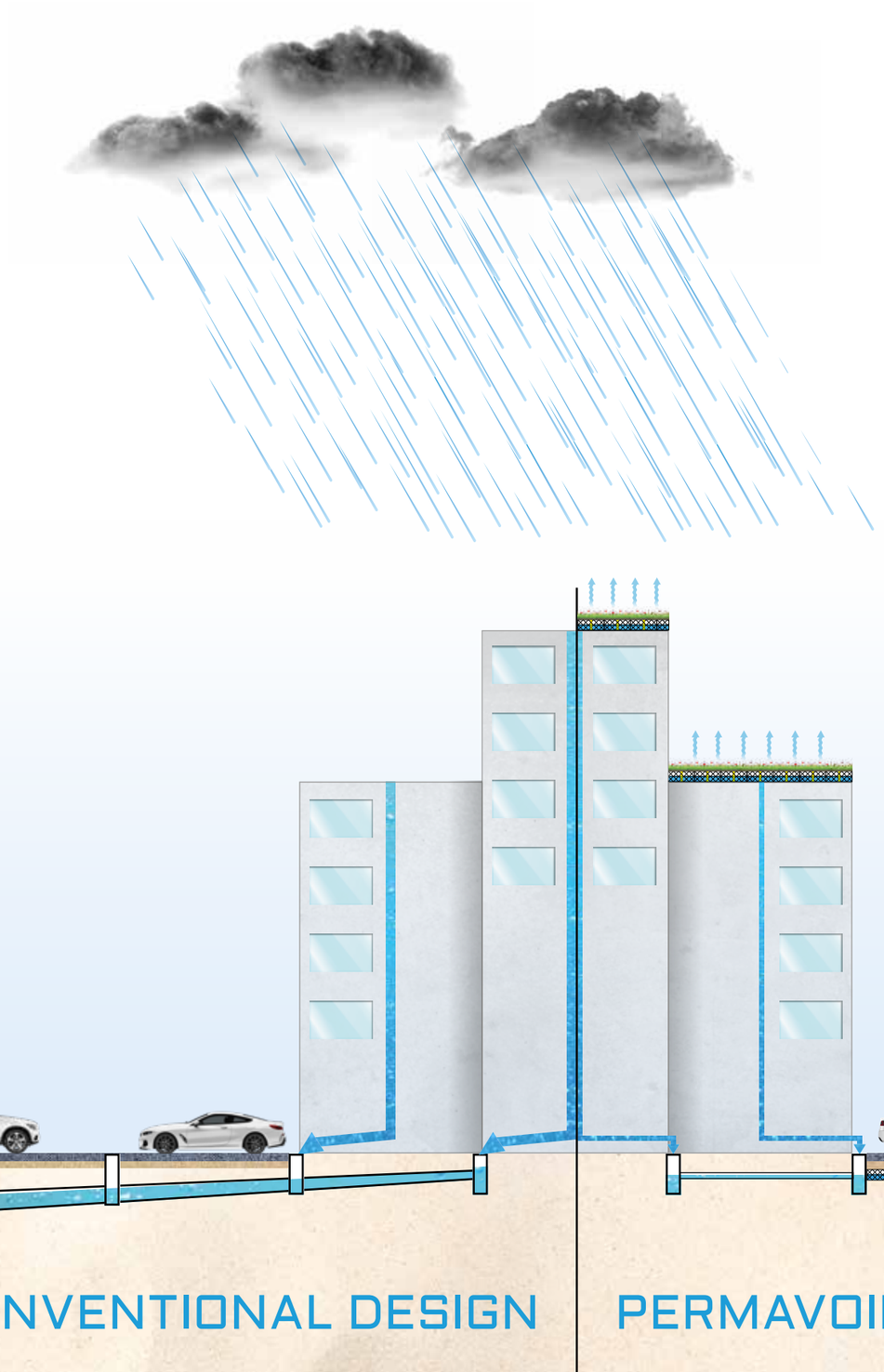
1. **Pavement**
   Permeable, or impermeable in combination with PermaChannel
2. **Bedding layer**
   50-80 mm
3. **PermaFilter**
   Hydrocarbon separation geotextile
4. **PermaTex 300HD**
   Separation and infiltration Geotextile
5. **Permavoid Flex 700**
   Waterproof liner
6. **PermaTex 300 HD**
   Protective Geotextile
7. **PermaTex CAP**
   Water conducive geotextile
8. **Capillary irrigation column**
9. **Permavoid 150**
   Structural subbase replacement
10. **Full water management**
    Managing incoming and outgoing flows with connection to water management chamber

Permavoid source control in Sustainable Urban Drainage Designs

With the design basics of shallow-but-large subsurface tanks instead of compact, deep tanks, nature is mimicked in the sense of reducing flow speeds in the subbase and having water available under the entire landscape with optional zero-energy capillary irrigation, while creating sufficient retention volume.

Permavoid as a subbase layer enables capture, conveyance and storage of stormwater at source, while removing pollution and silts. The method where water is held back and stored as close to the point of origin as possible is known as Source Control.

Permavoid provides a volumetric water storage capacity of 92% by replacing the traditional subbase layer with a structural void. This equates to a standard Permavoid module of 150 mm deep, holding 138 mm of water over the entire area: equivalent to a massive 1.38 million litres per hectare. The cleansed water can be retained and made available as a useful resource to recharge groundwater, maintain moisture content of soils (irrigate), used for flushing toilets, washdowns, cool the environment through evaporation or generate potable water. Water retention for reuse does not only save drinking water, it doubles in functionality by keeping rainwater out of the often overloaded sewer systems.



Sloping areas can be split up into small flat areas, each passively cascading into the next lower level in a controlled manner. These individual small water-managed areas are known as micro-catchments. The Permavoid System can attenuate water on almost any given gradient by implementing this cascading philosophy.

Full water management

Creating an actual water level in de Permavoid units in the subbase allows for full water management. The actual amount of water in storage can be measured, incoming and outgoing flows can be controlled, water can be redirected to other systems for reuse and water can be added from other sources for example to keep the capillary irrigation system operational.

This can be done low-tech by means of passive overflows, or high-tech with pro-active digital and online sensors and controls. Even the inclusion of artificial intelligence, processing rain-radar data of oncoming rainstorms, helping the system evaluate whether or not to change the current water level accordingly, is an option.



The 18.100 m² hardscaped Longstanton Park and Ride in Cambridge was allowed to discharge only 10l/s accounting for a 100 year storm return period, with 20% added for climate change. In light of the high ground water table Permavoid was used in conjunction with permeable block paving and the PermaChannel drainage system to create a multi level drainage system. The combination of the PermaChannel and the PermaFilter oil separation geotextile protects water quality in the catchment.



PERMAVOID CIVIL SYSTEMS

Building resilient cities encompasses the incorporation of multifunctionality in as many urban surfaces as possible. Where nature creates resilience with an abundance of species, a city does so with a multitude of sustainable engineering solutions for hardscapes and green infrastructure.

Parking

The concept of sustainable water management is a major driver in nowadays urban development. Peak rain events, driven by climate change, are becoming ever more frequent. In response, Governments are increasingly introducing legislation (such as the UK Floods and Water Management Act 2010) setting out ways to manage surface water via Sustainable Urban Drainage Systems (SuDS).

Conventional car parking designs do the exact opposite. Large areas of former naturally water-infiltrating green space is transformed into a waterproof hardscape, leading to large volumes of stormwater, released in a short time frame, which need to be taken off-site in a conventional end-of-pipe design. With Permavoid beneath the car park water can be managed on-site, without the use of complex piping systems. With pervious pavement stormwater can be captured and attenuated underneath the paved surface and with impervious pavement types water can be fed into the geocellular units using the PermaChannel system or specially designed gullies. This creates effective on-site source control water management.

The PermaFilter treatment geotextile surrounding the Permavoid units can be added as an extra treatment step and acts as a hydrocarbon barrier, keeping pollution where it occurred and out of the water management system.

If the goal is not to infiltrate directly, but convey water to a central collection point for attenuation or retention and use, the large surface area of the Permavoid slows the flow of stormwater to the desired collection point, reducing flow speeds of water in the system. The system can be designed to regulate outflow speeds and specific retention and detention volumes, so the attenuation and detention infrastructure size (pond or tank) can be reduced significantly.

With Permavoid it doesn't stop with releasing or infiltrating water. Having water available allows for re-use for plant irrigation or even toilet flushing too, with no changes to the Permavoid subbase assembly.

Managing water quality and water quantity with fundamentals of Sustainable Urban Drainage: Capture. Treat. Store. Release.

PERMAVOID CIVIL SYSTEMS

Lightweight road construction

The necessity to construct roads in unfavorable locations is not uncommon. Many types of soil are unsuitable for road construction when the load bearing capacity is taken into account. For these ultimate challenging conditions Permavoid can offer the following lightweight solutions.

Low load bearing soils

Peat soils are an example of a low load bearing soil unsuited for conventional road construction. Construction with heavy conventional stone-based materials adds too much weight to the profile with road subsidence as a possible consequence. The Permavoid 150 creates a stable and lightweight raft (12 kg/m²) at the appropriate depth underneath the roadway, which creates the necessary load distribution capacity thanks to the tensile strength of the entire sub-surface raft.

Contaminated locations

Removing and treating soil from contaminated sites is costly. With the shallow Permavoid subbase, deep excavation and transport of contaminated soil is prevented, saving time, money and preventing health hazards. By placing an impermeable liner underneath the Permavoid subbase, infiltrating rainwater can be captured and conveyed to a central collection point, preventing it from infiltrating into the subgrade and potentially further contaminating ground water. The contaminated soil underneath is isolated from the new soil and landscape on top by Permavoid.

High ground water

When phreatic levels are close to the surface the Permavoid high strength subbase can be used in the design to limit the foundation depth and keep it above the local groundwater levels. When necessary, the hollow Permavoid units can act as local drainage layer, allowing incoming groundwater to be taken off site and kept away from the road foundation.

Water sensitive sub soils

In locations where rainwater infiltration capacity cannot be diminished by construction of an impermeable road surface, the Permavoid subbase can act as on-site attenuation structure. Rainwater from the paved surface can be fed into the hollow foundation for on-site infiltration to maintain soil moisture as before in for example peat or clay soils.

Construction of a lightweight floating road in the Emmastraat in Gouda in an area with peat soils and high groundwater tables.

Bike paths

Cities worldwide are in the process of developing bike path networks to facilitate carbon neutral commuting to and from the city and increase exercise amongst inhabitants.

Bike paths are usually constructed on the outsides of the road profile, closest to roadside trees, or even constructed in green spaces alongside roads, over existing tree roots or low loadbearing soils.

Trees and bike paths are not always considered best friends: Compaction of soil leads to root development high in the profile, causing damage to the hardscape. Much needed rainwater for irrigation is drained off-site and impervious pavement hampers gas exchange between the soil and atmosphere.

The Permavoid Sandwich Construction negates costly pavement damages and growth-limitating factors by creating a high strength, stable and open raft underneath the pavement to:

- Prevent roots growing directly underneath the pavement, thus preventing pavement damage.
- Ensure optimum load distribution preventing compaction of the rootable volume underneath.
- Optimise gas exchange for the soil.
- With an option to manage surface water on-site.

The shallow application of the system makes it possible to retain the existing soil profile and the root system of the trees and reduces the amount of material that must be supplied and removed for construction. The system can be finished with a choice of pavement systems like block pavers, concrete or asphalt.

The Permavoid subbase can be used as detention system for attenuation of rainwater, harvested from the paved surface as a source of irrigation water. This way the construction of a bicycle path through an existing landscape does not change the natural functionality of the soil, enabling the continuation of healthy tree growth. The Permavoid system protects both the pavement on top and the tree roots below in bicycle paths through cities and natural areas like forests and parks. Thanks to Permavoid trees and bike paths are no longer adversaries.

Creation of a new bike path with a Permavoid foundation along a major access road in Hengelo, the Netherlands. Despite their close proximity both the trees and the hardscape can co-exist effortlessly.











By creating stormwater attenuation volumes on this podiumdeck in London, in-building tanks were negated, creating high value car parking spaces in the garage below.

PERMAVOID CIVIL SYSTEMS

Trafficked podium decks

In dense urban developments on-site rainwater infiltration is often limited with the majority of surfaces being build or paved. Yet more cities impose requirements on real estate developers restricting the amount, and speed of stormwater discharge. The necessity of on-site stormwater management can lead to costly, space consuming, in-building attenuation tanks and treatment systems, and in the end usable water slowly 'draining to waste'.

In these dense urban situations, many podium decks are paved and used as car park, entrance way or for sports or recreation. It is unacceptable to have standing water on the pavement during rain and at the same time water attenuation in the building is not favored. For these situations the Permavoid subbase on the podiumdeck fulfills both functions of drainage and attenuation between the building and the hardscape, replacing the need of in-building attenuation tanks. The high-volume shallow attenuation subbase structure captures, cleans, stores and releases water in accordance with any prescribed site discharge rate.

Secondly, storing water in the subbase on roofs or podium decks can feed the Permavoid capillary irrigation system with rainwater, and allows harvesting of stored water for other uses such as toilet flushing without the use of pumps. With Permavoid, managing rainwater is shifted from just discharge to harvest and re-use, aiding in further reducing sewer loading and mains water consumption.

The open shape of the units acts as a conduit, with flows driven by hydraulic head. The sheer surface area of the raft creates the required flow speed reduction, allowing water to be taken to the edge of the deck or roof for drainage. It prevents the need for underslung pipework and greatly limits the number of deck penetrations. Creating the required attenuation volume on roofs also maintains the option to use gravity to bring retained water further into the city for other uses such as plant or tree irrigation or surface water recharge.

Greenwich Warf.
A trafficked podium deck
in London, UK.



PERMAVOID CIVIL SYSTEMS

Hardscapes and trees

Civil engineers face the task of creating safe and reliable streetscapes, while Arborists aim at optimising soil conditions in the urban environment so trees can grow and fulfill their important role in creating a climate resilient and future proof city. For existing trees, the challenge is to protect them in the changing city during (re-)construction and for new trees, creating sufficient rootable soil volume in the already busy landscape below ground is an increasing challenge.

The goal of every Permavoid subbase is to create a multifunctional growing site, in a fully paved urban situation such as walkways, squares and car parking spaces. To protect the paved surface from root damage, and maximise usable above ground space, the Permavoid construction creates sufficient load distribution to prevent soil compaction and maintains gas exchange between soil and atmosphere. The shallow depth of the Permavoid System allows ample rootable soil for the tree, so it can grow as if it was in the forest, without using valuable space or hampering urban functionality.

The Permavoid Sandwich Construction can be used with new and existing trees. For existing trees where a previously open growing site is converted into a (partial) hardscape, Permavoid's superficial placement is very favorable: the underlying root system in the existing soil profile is not affected.

For new trees a complete growing site can be constructed with Permavoid units under the pavement and the Permavoid Capillary Irrigation System beneath the rootzone, mimicking an artificial groundwater level, enabling the growing site to capture, store and reuse stormwater for later irrigation. Trees now better help to keep stormwater out of the sewer and have a capillary available water buffer to sustain growth during prolonged dry spells.





Combination of a growing site for trees and car parking in the Amstelvlietstraat in Amsterdam.



PERMAVOID CIVIL SYSTEMS

Geocellular stormwater management systems

It is not always possible to create the required shallow attenuation volume due to limited space. The extra volume needs to be found elsewhere in the project. With the Permavoid MD this extra volume can be created by forming big attenuation tanks deeper in the ground (with an approximate 800 mm cover). With a void ratio of 95% and high structural strength, these subsurface attenuation tanks can be created underneath landscapes and paved areas ranging from pedestrian to HGV trafficked areas.

The combination of low-velocity shallow storage with Permavoid 85 or 150 mm with Permavoid MD deep attenuation creates a truly space saving hybrid system with attention for water quantity and water quality.

To be sure the water quality in the deep attenuation tank is clean enough to be safely infiltrated or reused, Permavoid developed an extra cleansing step in the MD unit, the Biomat. This floating Biomat traps any residual hydrocarbons and oils in the water. The floating mat is always at the water surface and allows bacteria to naturally deteriorate the hydrocarbons down to less harmful elements with the available oxygen. This integrated treatment feature helps protect groundwater and the downstream catchment from potential contamination.

With the appropriate liner the Permavoid MD attenuation tank can perform the desired functions:

- Waterproof liner for water retention and attenuation
- PermaFilter for treatment and infiltration
- PermaTex 300 for infiltration and protection

The Permavoid MD units have integrated connection points for pipe and inspection points and can be incorporated in an integral water management system with sand and silt treatment chambers on the inflow side and flow regulating chambers on the outflow side. Successful designs so far have demonstrated that in combination with water management on all levels of the development (roofs, podium decks and at ground level) the size of the Permavoid MD tank can be kept smaller when compared to conventional end-of-pipe designs.

The long and narrow design of the Permavoid MD tank for detention at Kattenburgerstraat in Amsterdam aims at maximum surface area for rapid infiltration to groundwater.



Building a relatively compact and deep stormwater infiltration system for maximum water attenuation capacity with Permavoid MD units in Dubai.





A CLOSER LOOK: PROJECT KATTENBURGERSTRAAT

Client	: City of Amsterdam
Total project size	: 1.680 m²
Vegetation	: Mix of flowering grasses, herbs and bulbs (750 m²)
Stormwater harvested from	: Walkway and bike path (720 m²)
Extra stormwater harvesting	: Adjacent rooftop (210 m²)
Retention for irrigation capacity	: 140.000 litres (Soil + Permavoid 85S)
Detention for infiltration capacity	: 108.000 litres (Permavoid MD)
Water management	: Passive 3-Stage Design with retention, capillary irrigation, and infiltration
Applied substrate	: 300 mm deep sand-based soil with 4% organic matter
Waterproof membrane	: Permavoid Flex 700, prefabricated to size.
Capillary Geotextile	: PermaTex CAP
Construction	: 2020

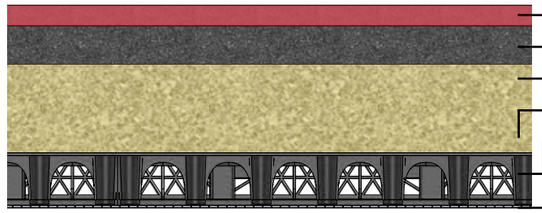
The city of Amsterdam is developing a new main-bicycle-network to accommodate the high volume of commuting cyclists in the city. In the reconstruction of the Kattenburgerstraat the goal was to:

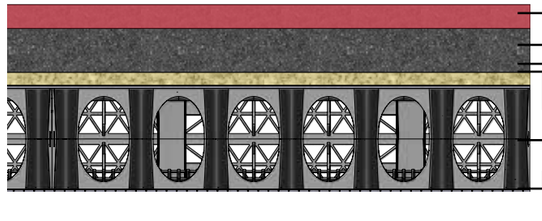
- create a high-quality bike path;
- protect the existing London Plane trees;
- prevent root-damage to the bike path;
- include rainwater harvesting for capillary plant irrigation and;
- infiltrate excess rainwater to groundwater.

The combination of these elements creates a climate resilient design in which water is used for plant growth, groundwater is being recharged, peak rain events are kept out of the sewers and trees and vegetation continue to provide shade and cool the urban environment.

Multifunctional hardscape

Permavoid 85 and 150 mm were used in two different configurations (depths) in the foundation of the bike path to improve aeration of the rootzone of the trees and prevent future tree-root damage to the asphalt paving.





Permavoid subbase configurations used in project Kattenburgerstraat for soil gas exchange to support healthy tree root growth away from the surface and improved load-bearing capacity to prevent soil compaction in the root zone. Shallow application of the Permavoid 150 separated from the asphalt base layer with just 20 mm of crushed rock and the standard application of the Permavoid 85 with 150 mm of mixed structural subbase.

Water management

A 3-step water management system has been designed in the streetscape. Stormwater from the walkway, the bikepath and a large adjacent roof is (A) collected in chambers with a novel first-flush system to remove the bulk of suspended solids and road salts in winter, before it is (B) fed into the Permavoid 85S capillary irrigation subbase. As soon as the retention and capillary irrigation system is at level (60 mm), the system (C) overflows into the deep drainage Permavoid MD units, from where the water can infiltrate and recharge groundwater for the London Plane trees to absorb and grow with. The Permavoid MD units are equipped with the PermaFilter bio mats to skim and trap any remaining hydrocarbons for further bacterial degradation to prevent unwanted groundwater pollution.

The result is a high-quality bike path while not a drop of water is being wasted. The paved surface is protected from root damage, while the tree root system itself is protected from soil compaction and supported with better soil gas exchange. Rain is no longer a nuisance, but a resource for plants and trees to grow with to help cool the city on hot summer days, while supporting urban biodiversity. Linear stormwater management leading to overloaded sewer systems has been transformed into local on-site circular water management. Just like in nature.

permavoid

PROJECT KATTENBURGERSTRAAT AMSTERDAM



Construction of the Permavoid 85S Retention and capillary irrigation system. Note that on the right-hand side the Permavoid 85 units have been used, without capillary irrigation columns, which indicates the position of the paved walkway over the system.





Construction of the deep infiltration system build with the Permavoid MD elements. In order to maximise infiltration-surface a long (60 m) detention tank was designed 1.2 m (3 layers) deep, and one unit (0.5 m) wide.

The Permavoid 150 subbase during construction and the result after the top layer of asphalt has been laid.



1. **Surface runoff**
2. **Sand/silt trap**
3. **Water level management chamber and first flush separator**
4. **Permavoid 85S Retention and Capillary irrigation system**
5. **Overflow**
6. **Permavoid MD Detention and infiltration system**
7. **Extra rainwater harvesting for irrigation**
8. **Groundwater**
9. **Emergency backup overflow**
10. **Permavoid 150 subbase structural raft for gas exchange and compaction prevention**

Schematic cross-section of Project Kattenburgerstraat. Not true to scale.



A CLOSER LOOK: PROJECT LONDON GREENSTREETS

Client	: London, UK
Total project size	: 1.000 m²
Surface	: Water permeable asphalt
Detention capacity	: 150.000 litres
Water management	: Passive overflow
Waterproof membrane	: Permavoid Flex 700, welded on-site
Capillary Geotextile	: PermaFilter for oil separation
Construction	: 2016

Counters Creek Flood Alleviation SuDS Scheme

Between 1971 and 2007, the Counters Creek area in London lost around 20 percent of its permeable green space. This, along with the loss of all open watercourses in the locality, has led to a rise in surface water run-off, which increases the risk of local flooding. As part of the London Greenstreets program a sustainable urban drainage installation was constructed at Arundel Gardens in the Royal Borough of Kensington and Chelsea to reduce sewer overflow into open water and minimise the risk of urban flooding.

The goal is to slow the flow of water into the sewer during periods of rainfall by detaining stormwater on-site. Creating substantial stormwater detention volume in a densely build area is not easy, but with backing of Thames Water, the Borough and Transport for London a design was created with the detention volume in Permavoid units directly below the road surface. Rainwater enters the Permavoid detention system through a permeable asphalt road surface layer and prior to entering the storage tank, water passes through the PermaFilter geomembrane to remove any oils and other vehicle pollutants.

This buildup created 140 mm of stormwater retention capacity, enough to handle a 1 in 30-year storm with an extra +20% accounting for climate change. As a result, the former flowrates of 200 l/s at Arundel gardens were reduced with 97% to 6 l/s during peak rain events. And as a bonus, part of the detained rainwater was used to irrigate the Magnolia trees in the street using the Permavoid Capillary Irrigation System.



OUR SUSTAINABLE JOURNEY

Circular thinking forms the basis of all our products and designs. This concerns both the materials used and functionality of our systems. For urban water management we collect, store and reuse rainwater on location as much as possible and minimise use of drinking water.

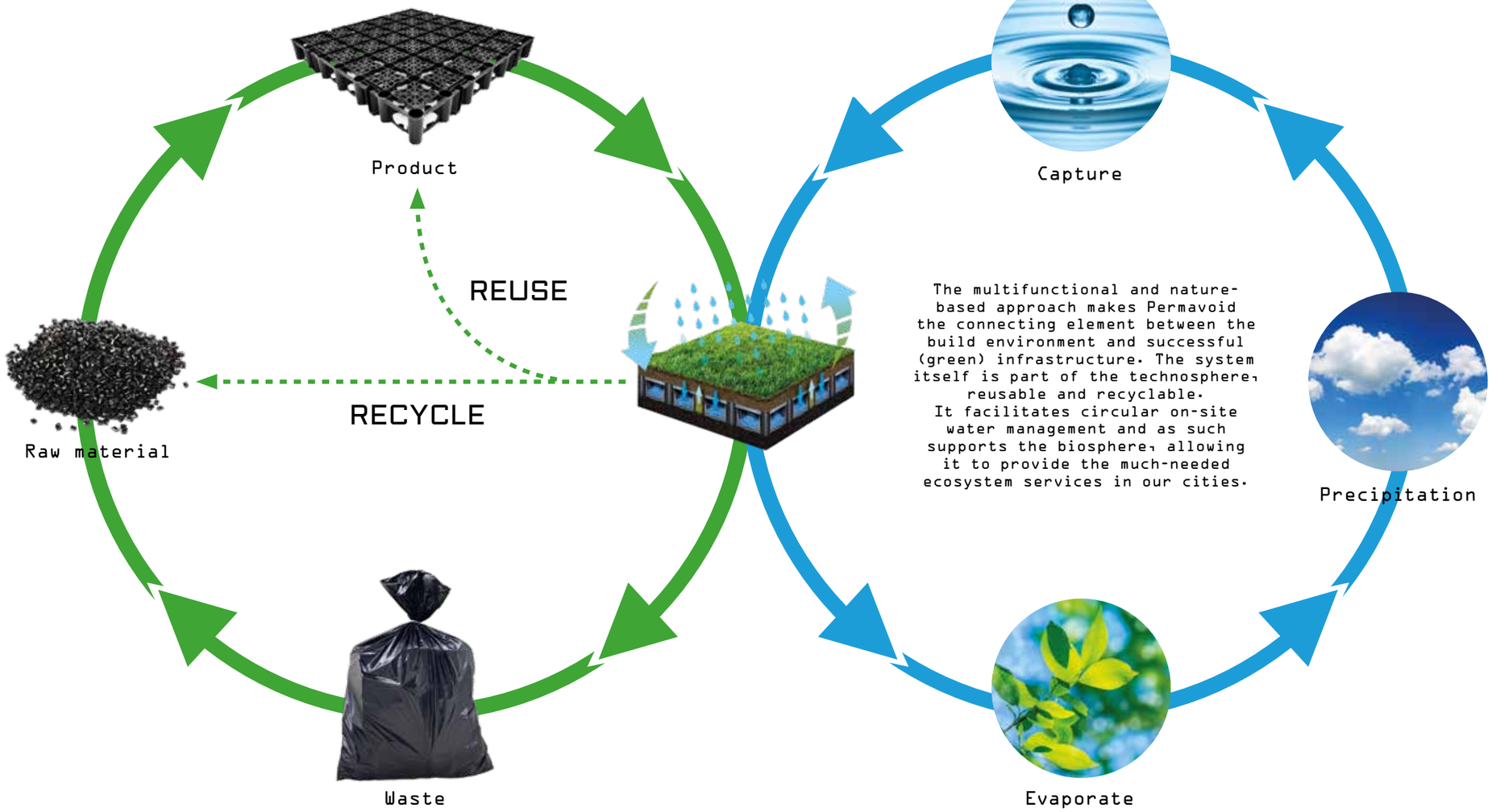
The units are made from high quality recycled materials and therefore fit 100% in the cradle-to-cradle philosophy. The plastics used can be fully recycled, but in practice they rarely are since the units can easily be disconnected and reused elsewhere thanks to their construction and the removable PermaTies. We aim at local manufacturing, preventing unnecessary worldwide shipping, shortening transport distances, further reducing our carbon footprint.

Developing multifunctional systems can only be accomplished in close corporation with valued partners. Based on equality and willingness to share, we work with market leaders in R&D like KWR-Water, STRI, University of Coventry and Wageningen University and Research, manufactures like Veolia, Ten Cate, Sioen and Lapinus and distributors like Polypipe, Optigruen, Perflow, ABT and many others. Together with local stakeholders, governments, cities and institutes we invest in pilot projects to ascertain the local challenges and create perfectly adapted multifunctional solutions.

The solutions designed with Permavoid can function for decades and will continue to fulfil their function for generations. The materials and designs used by Permavoid have been thoroughly tested by independent institutes for strength, reliability, pollution and temperature resistance and have been approved and used for subbase replacement in structural engineering for more than twenty years.

In our vision waste is upcycled to integrated solutions for future-proof cities.
C.H. van Raam, 2020.

MATERIALS (TECHNOSPHERE)



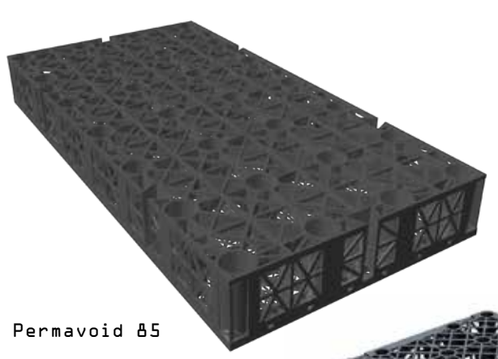
The multifunctional and nature-based approach makes Permavoid the connecting element between the build environment and successful (green) infrastructure. The system itself is part of the technosphere, reusable and recyclable.
It facilitates circular on-site water management and as such supports the biosphere, allowing it to provide the much-needed ecosystem services in our cities.

WATER (BIOSPHERE)

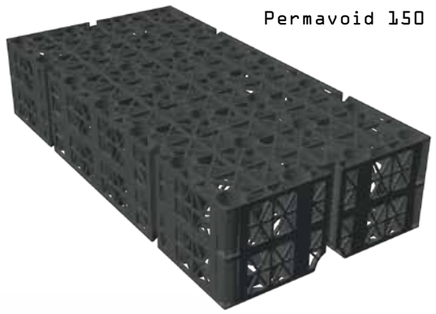
PRODUCTS

Permavoid units

Permavoid units are high strength, lightweight hollow subbase units able to support sports, landscaped and paved surfaces on rooftops, podium decks and at ground level. In combination with the Permavoid capillary columns the system can be used in water sensitive urban designs, enabling stormwater attenuation, conveyance, infiltration and natural capillary (passive) irrigation.



Permavoid 85



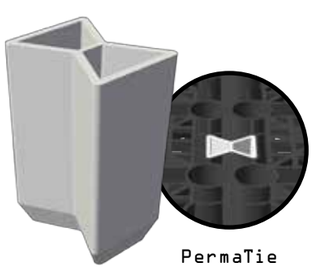
Permavoid 150



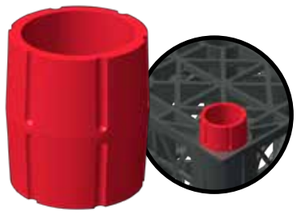
Permavoid MD

Ancillaries

Various Permavoid ancillaries are used to tie units/panels together into stable rafts, create stable stacks, enable capillary irrigation and allow the attachment of components and products directly to the Permavoid units.



PermaTie



Shear Connector

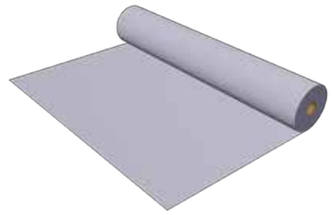


Capillary Column

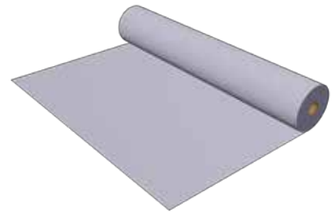
The products displayed are a selection of the full range of Permavoid products most relevant to the applications discussed in this brochure.

Geotextiles and membranes

Geotextiles are an integral part of every Permavoid design, protecting the waterproof membrane from punctures, determining the water infiltration rates and quality and facilitating successful capillary irrigation. The waterproof membrane is used to determine the attenuation, retention or detention functionality of the designed system.



PermaTex 300HD



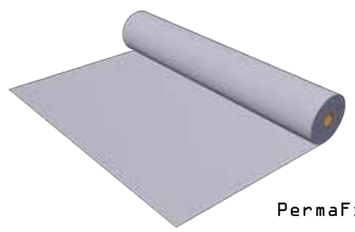
PermaTex CAP



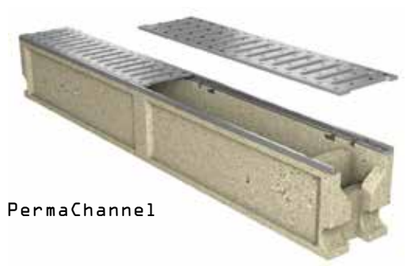
Permavoid Flex 700

Water Treatment

In addition to water quantity management systems, Permavoid also supplies products to help protect downstream water quality through pollutant removal and treatment at the source.



PermaFilter



PermaChannel

PVOD components

Permavoid "PVOD" components are designed to provide easy to install connections and access points into the Permavoid system, essential for reliable integration in SuDS schemes and access for maintenance.



Saddle Connection



Overflow Chamber

Full product range information and detailed datasheets are available upon request.

permavoid

THE FOUNDATION FOR OUR FUTURE

The Permavoid range of products and systems are capable of creating circular, nature-based solutions for sustainable water management in metropolitan areas. Solutions encompass urban trees, Blue-Green roofs, podium decks, gardens, sports pitches and SuDS aiming at water-sensitive design.

Permavoid source control ensures that no precious water goes to waste by catching, storing and reusing stormwater for irrigation, evaporation or infiltration. For more information about Permavoid solutions please contact us or visit permavoid.com to find your local Permavoid distributor.

Other solutions by Permavoid



Permavoid trees

Blue-Green roofs



Permavoid sports

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