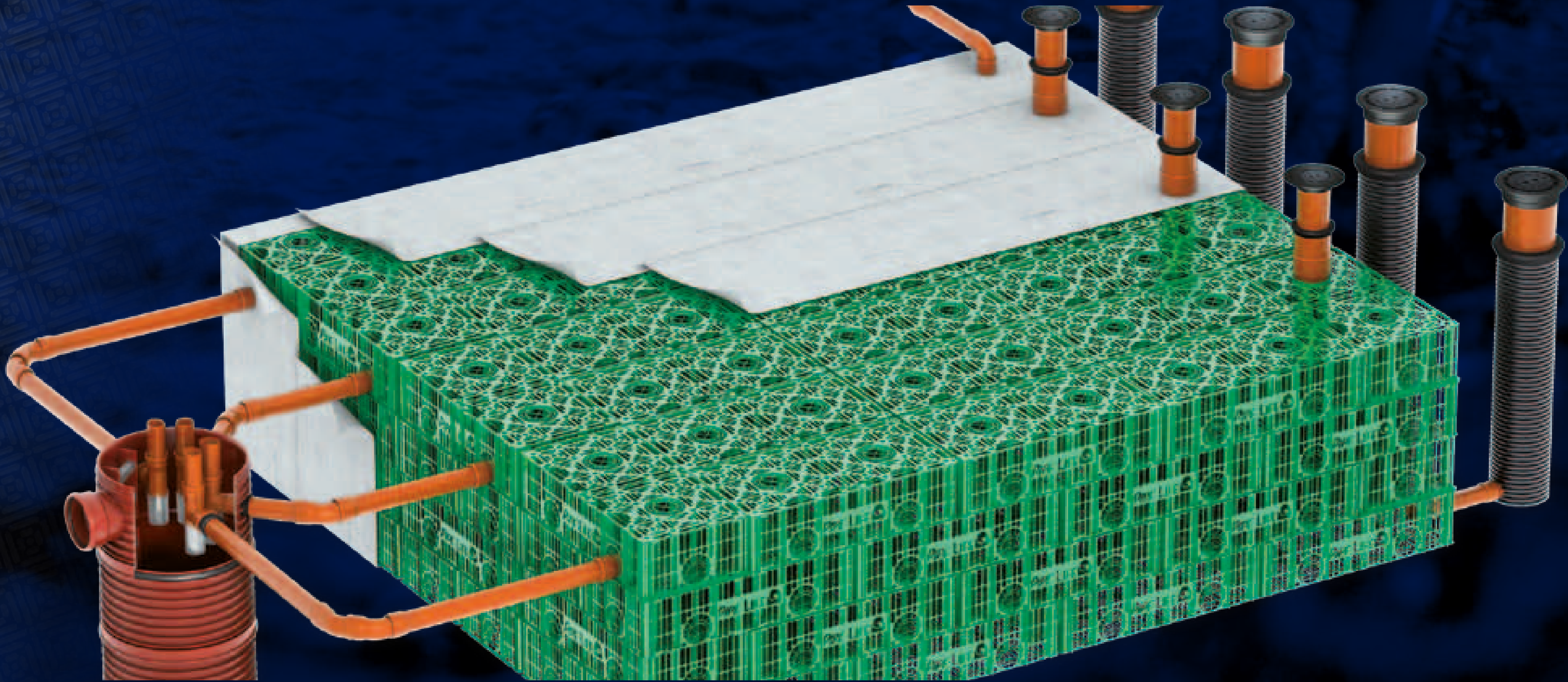
® Raineo
Flood becomes fiction

Raineo®: the Stormbox system



Contents

1. Technical description

1.1. General information

The Stormbox system is designed to manage rainwater by retention and non-pressure distribution and infiltration into the ground.

Rainwater collected from building roofs and industrial facilities is directed through gutters, discharge pipes and sewage pipes into a chamber with a settling tank, and then to infiltration boxes.
Rainwater collected from other hard surfaces, such as roads, car parks, streets, yards and green areas, run through linear drainage systems, storm inlets and pre-treatment devices (e.g. settling tanks and hydrocarbon separators) into the Stormbox system.

The progress of civilisation has meant that, particularly in urban agglomerations, rainwater from hard, impervious surfaces (roofs, streets, car parks) flows directly to rainwater drainage systems or combined sewage systems. Where runoff is directed to water treatment plants, it causes additional load (decreased efficiency) and increased treatment costs.
Directing runoff to sewage systems leads to an increase in pipe dimensions (unnecessary overdimensioning), and consequently to significantly higher pipeline installation costs.
It is estimated that approx. 80% of runoff ends up in rainwater drainage systems and water courses.

The situation could be improved by the construction of retention and retention-infiltration tanks. Appropriate management of rainwater in its catchment area may also alleviate the consequences of potential flooding.

Why is rainwater infiltration such a good idea?
Water is one of those natural resources that have no substitute. In some countries conditions with regard to access to water, annual amount of precipitation, very large fluctuations in temperature and amount of rainfall are significantly worse than in other countries. Inland fresh surface waters (rivers, lakes, estuaries, ponds and artificial water reservoirs) constitute approx. 2.5% of the country's area.

Fluctuating climate conditions and weather anomalies cause an excess of water during heavy storms or snow meltdowns, and water deficits during periods of drought.

Modern runoff drainage planning
Involves decreasing and slowing down the outflow from impervious surfaces. The progress of urbanisation leads to the destruction of natural water flow paths. Hence the increased significance of the designer, who can plan alternative runoff paths by building underground retention and infiltration systems. It is recommended that rainwater should be collected in the area where it falls, and then allowed to infiltrate into the ground or stored, as required. Percolating to the greater depths of subsurface layers, rainwater rejuvenates the groundwater resources.

Directing rainwater into the ground does not incur any additional fees (as opposed to discharging it into the sewage system).

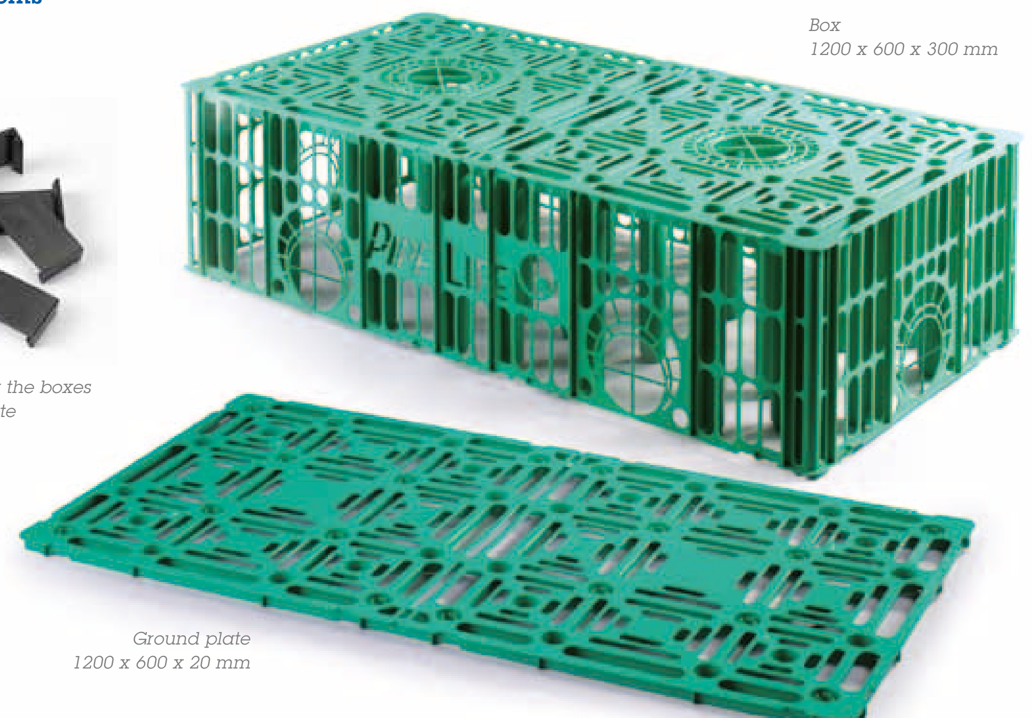
It is also possible to increase small retention by infiltrating groundwater, and then using it e.g. to water green areas, for cleaning and rinsing purposes, or as process water in service and industrial facilities.

Rainwater retention and infiltration
- lowers outflow rate, flattens flow peaks,
- regulates groundwater levels,
- compensates for the adverse impact on groundwater of using water for industrial and residential purposes (changes in the load-bearing capacity of the ground, cracks in buildings),
- increases the efficiency of water treatment plants,
- helps to avoid overdimensioning of rainwater drainage systems,
- improves the condition of urban open waters,
- lowers the impact of the flow from a distribution or combined sewage system on the sewage receiver.

The construction of modern underground drainage systems may contribute to the protection of ground and surface waters.

Component elements

Clips to connect the boxes and ground plate



Box 1200 x 600 x 300 mm

Ground plate 1200 x 600 x 20 mm

1.2. Basic technical information

The basic Stormbox system kit includes:
- Stormbox infiltration boxes,
- ground plates,
- clips to connect the boxes,
- geotextile to protect the boxes,
- PVC, PP or PE foil (when installing an underground water storage tank),
- settling chambers for rainwater drainage system (DN/OD 400, DN/OD 630, DN/ID 800, DN/ID 1000),
- sewage pipes and connectors,
- 200÷500 mm adaptors.

The infiltration boxes and ground plates of the Stormbox system are made from a primary raw material, polypropylene (PP-B), using the injection method. The boxes are connected using PP-B clips. The primary raw material has the original manufacturer's certificate.
The boxes have three internal channels for CCTV inspection and introducing cleaning equipment. The boxes have the IBAK certificate and the OFI Technologie & Innovation GmbH certificate which confirm that they can be inspected using CCTV and that they can be hydrodynamically cleaned with a pressure of up to 180 bar.

Basic technical information	
Material	PP-B polypropylene
Dimensions (L x W x H)	1200 x 600 x 300 mm
Number of openings	8
Opening diameters d_n: **- top** **- side walls**	110, 125, 160, 200 mm 110, 125, 160 200, 250, 315, 400, 500 mm (through an adaptor)
Gross capacity	216 dm³
Storage factor	95.5%
Net water capacity	206 dm³
Colour	green (RAL 6024)

1.3. Description

Element name		Description and functions	Basic dimensions, material
Stormbox		boxes with open-work walls, to be connected into modules (vertically and horizontally) and secured with clips, wrapped in geotextile, placed in a trench on gravel bedding, and in case of poor permeability of the soil, surrounded by gravel pack; used for rainwater retention and infiltration	material: *green polypropylene (PP-B)* dimensions: *1200x600x300 mm,* gross capacity: *216 l,* net water capacity: *206 l,* weight: *8.8 kg,* connections: *d_n 110, 125,160, 200 mm* *d_n 200, 250, 315, 400, 500 mm (through an adaptor)* number of openings: *8*
Box accessories	**a) ground plate**	ground plate to be connected to a box, used only for the first layer of boxes	material: *green polypropylene (PP-B)* dimensions: *1200x600x20 mm,* weight: *2.07 kg,*
	b) clips	elements used to join boxes into modules vertically and horizontally	material: *black polypropylene (PP-B)* dimensions: *36.5x21.5 mm,* Weight: *2.3 g*

2. The advantages of Stormbox

- High resistance,
- Good weight to resistance ratio,
- High net water capacity – 206 dm³,
- High storage factor – 95.5%,
- Large average useful surface of openings (over 50%)
- Boxes can be inspected horizontally and vertically (through 3 horizontal and 2 vertical channels),
- d_n 110, 125, 160 and 200 mm pipes can be connected directly, and 200, 250, 315, 400, 500 mm pipes through an adaptor,
- 8 inspection openings in side walls and at the top (6 openings Ø110-160 mm in side walls and 2 openings at the top Ø110-200 mm),
- Boxes can be split in half and connected into modules,
- Boxes can be stacked alternately (like brickwork),
- Small weight,
- Easy assembly,
- Ground plates are used only for the first layer,
- Tank cost is reduced by about 20% compared to boxes with bottom plates,
- IBAK certificates confirm that the boxes can be inspected,
- OFI certificate confirms that the boxes are resistant to hydrodynamic pressure of 180 bar,
- Pipelife offers technical support during installation.

3. Standards, approvals, certificates

AT-15-7731/2008 ITB
"Stormbox system kit for rainwater infiltration"

AT/2008-03-2402 IBDiM
"Stormbox system elements for rainwater infiltration"

Standards: BRL 52250
„Kunststof infiltratiesystemen voor hemelwater"

Certificates:
KOMO KIWA N.V.K54088/01 *(the Netherlands)*
IBAK KOKS RIDDERKERK *(the Netherlands)*
IBAK Retel IPEK
403388-4 OFI Technologie & Innovation GmbH *(Austria)*

4. Intended use

- rainwater infiltration,
- water storage (retention tanks) using geomembrane,
- infiltration of wastewater subject to national regulations.

The Stormbox kit is designed for the retention and infiltration of rainwater in the ground. Rainwater is collected from hard surfaces of building roofs using gutters and discharge pipes, and then distributed to the infiltration boxes through an inspection chamber with a settling tank.
Elements of the Stormbox system may be used to distribute and infiltrate rainwater collected from hardscape areas (streets, car parks, yards, patios etc.).
The Stormbox system may also be used to retain rainwater (construction of underground tanks).

5. Scope and conditions of use

- traffic routes such as car parks and yards with car and HGV traffic (LUW 12, SLW 30, SLW 60),
- green areas.

5.1. Installation parameters for areas subject to traffic loads

- minimum depth of the cover layer over infiltration boxes: 0.8 m,
- ground compaction around the boxes: min. 97% Standard Proctor Density,
- standard number of box layers: 6 for HGV traffic load (box height max. 1.82 m), 10 for car traffic load (box height max. 3 m),
- depth of the bottom layer: up to 4.5 m. If boxes are to be placed at a lower level, please contact Pipelife for an analysis of the ground conditions and expected loads.

5.2. Installation parameters for green areas

- minimum depth of the cover layer over infiltration boxes: 0.4 m
- ground compaction around the boxes: min. 95% Standard Proctor Density
- maximum number of box layers: 10 (box height max. 3 m).

Elements of the rainwater distribution and infiltration system, i.e. the settling chamber, the sewage pipes and the infiltration boxes, are connected using standard socket and spigot joints.

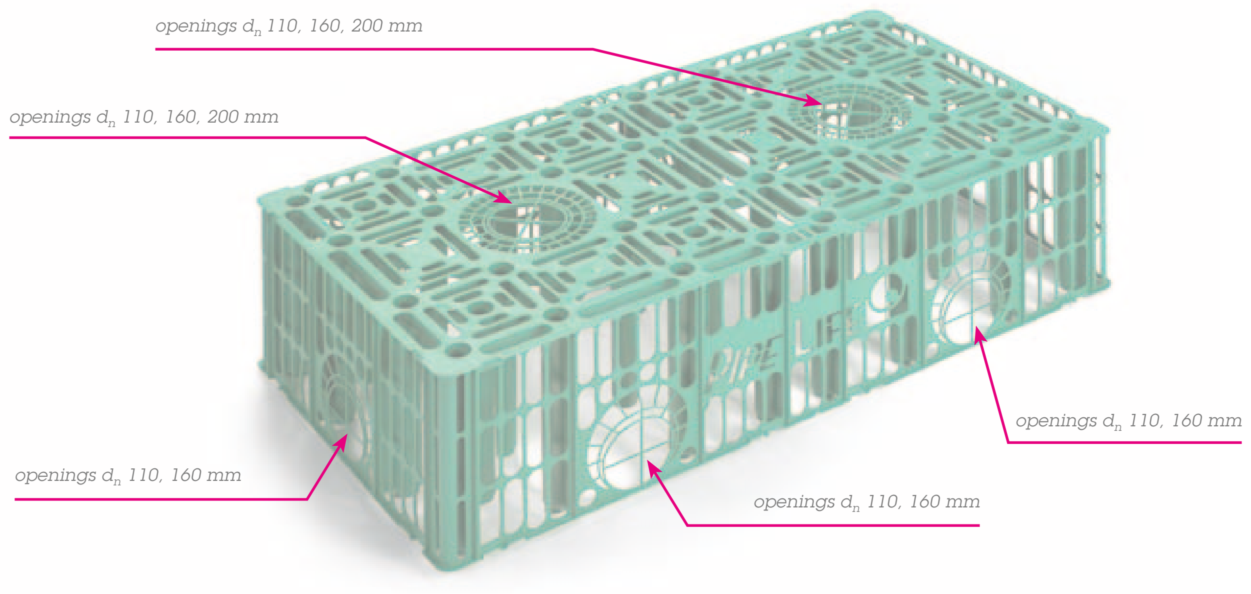
The Stormbox kit is useful in areas with low groundwater levels, in light and permeable soils and in cohesive soils (low permeability) combined with a gravel pack to increase the rate of infiltration.

The system may also be used to store water when isolated from the surrounding soil, for example by using a geomembrane.

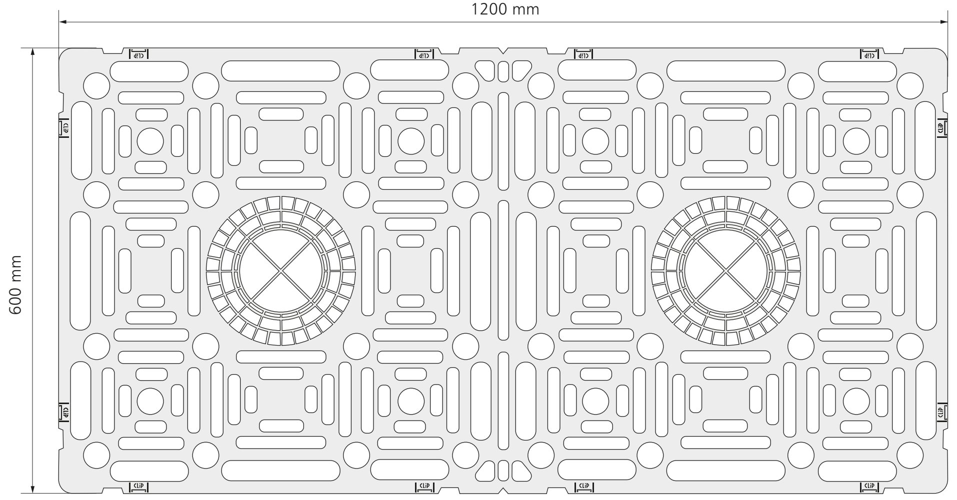
The following conditions should be met when using the Stormbox kit:

- the gutter system should be connected to the settling chamber and the infiltration box module using external sewage PVC-U or PP pipes and fittings compliant with PN-EN 1401-1, PN-EN 13476-2 or PN-EN 1852-1, and structural Pragma PP-B pipes compliant with PN-EN 13476-3. Water is conducted to boxes wrapped with polypropylene filter fabric;
- the Stormbox kit should be used in accordance with the Manufacturer's design and installation guidelines, as well as with applicable standards;
- the drain gully gratings should comply with PN-EN 124;
- the infiltration boxes should be located at least 1.0 m above groundwater level;
- rainwater drainage pipes should be placed at a slight downgrade angle;
- the distance between the infiltration boxes and the building should be at least 1.5 of the building's foundation's depth.

Construction of the Stormbox infiltration and retention box



Dimensions of the Stormbox infiltration and retention box



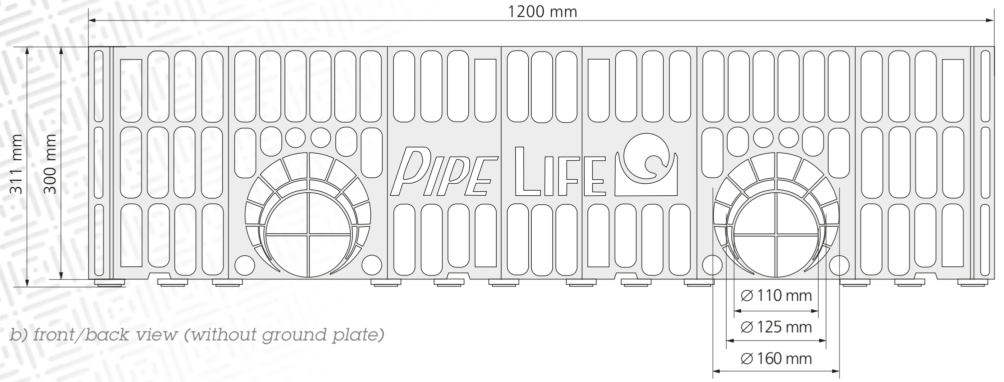
a) top view

6. The structure of the Stormbox

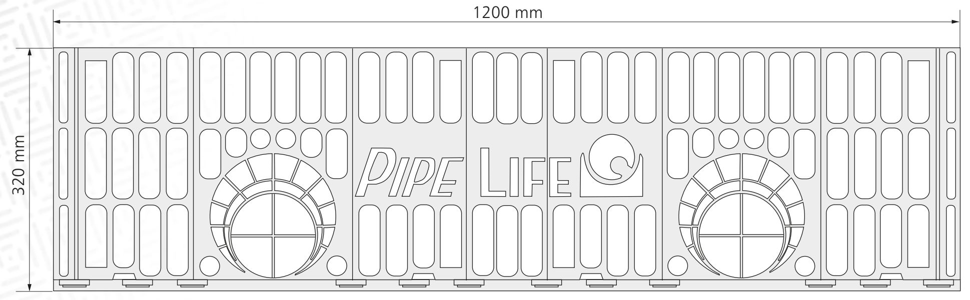
6.1. Infiltration box

Stormbox infiltration boxes are cuboid, with 5 faces (no bottom). Inside the box are vertical supports, clipped to appropriate holes in the ground plate or in the box underneath.
In the top part of the box are 2 inspection openings, for constant access to the inside of the box and bleeding the air out. There are 2 inspection openings in the front and back walls and 1 inspection opening in each of the side walls.
All the side walls of the box have openings to connect the rainwater drainage system, ventilation pipes, and wash and inspection pipes, diameters d_n 110, 125 and 160 mm, and in the top wall d_n 110, 125, 160 and 200 mm. An adaptor can be used to connect pipes 200 – 500 mm in diameter.

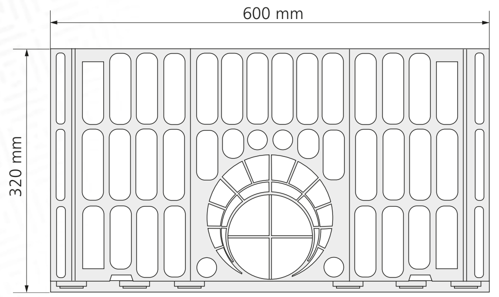
Dimensions of the Stormbox infiltration and retention box



b) front/back view (without ground plate)



c) front/back view of a box (with ground plate)



d) left/right view of a box (with ground plate)

Special vertical and lateral reinforcements of the Stormbox ensure very high durability, but take up very little space – the box's storage capacity is as high as 95.5%.

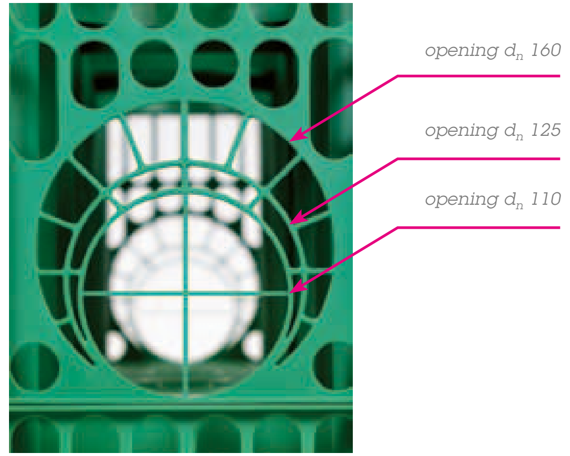
Openings in the sides of the box are 110 mm, 125 mm and 160 mm in diameter. The diameters are suitable to connect the plain end of a PVC-U sewage pipe, manufactured in accordance with PN-EN 1401-1, PN-EN 13476-2, or a structural Pragma PP-B pipe, manufactured in accordance with PN-EN 13476-3, or other similar pipes

The box and the ground plate are designed in such a way that they may be cut in half widthwise. Net water capacity of a half-box is 103 dm³.

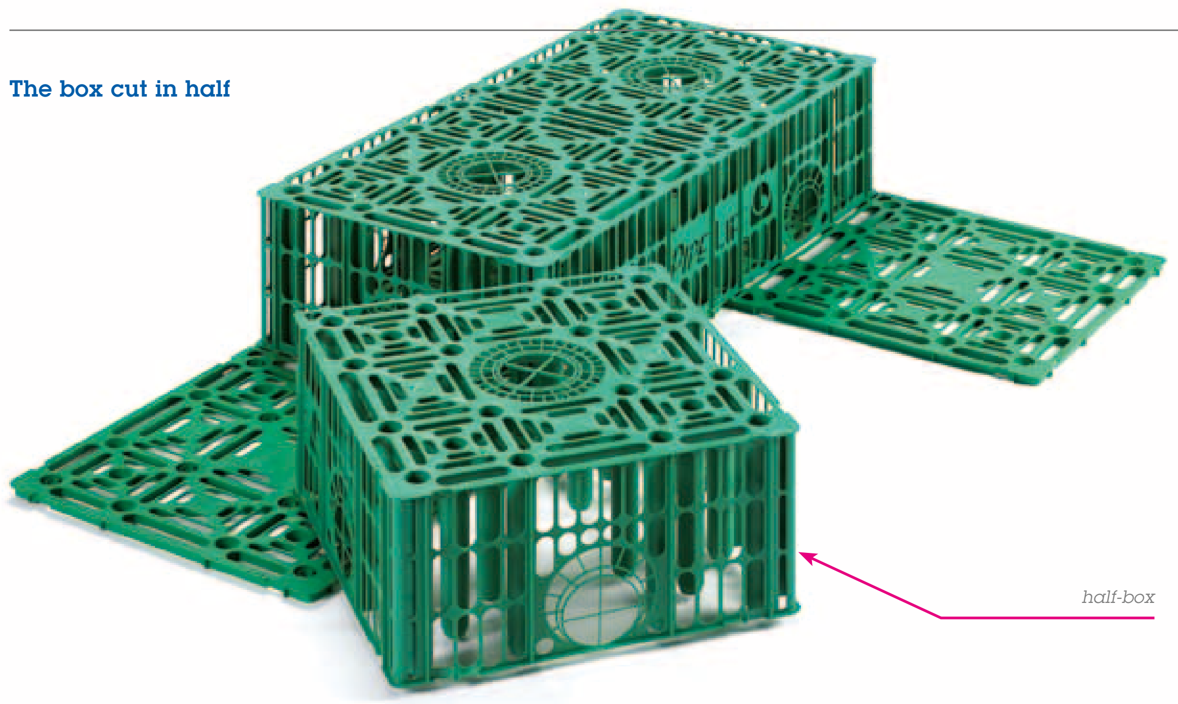
Note

The openings are secured with open-work covers. Before connecting the pipes the covers must be cut, adjusting the size of the opening to the connected pipe.

Diameters of the Stormbox side openings



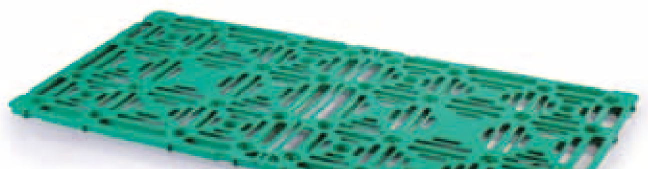
The box cut in half



6.2. Ground plate

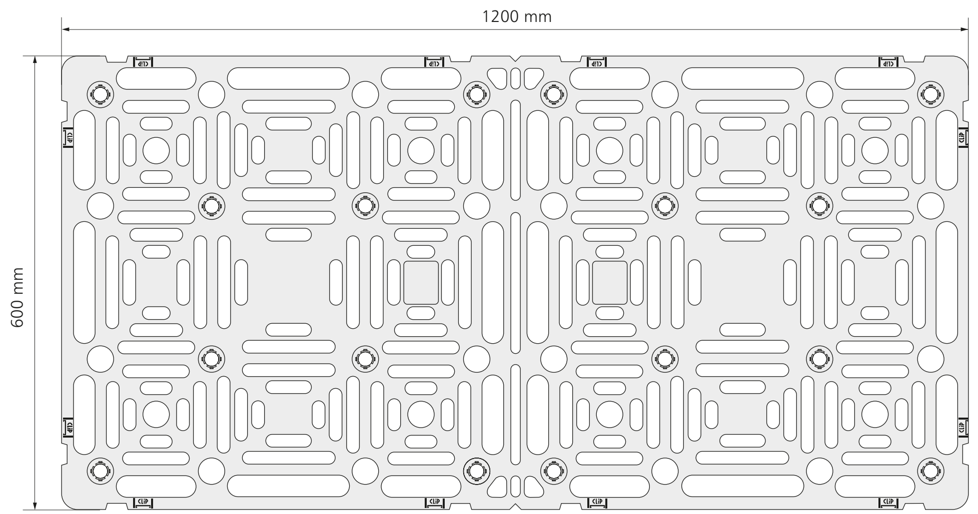
The ground plate is connected to the box. It is only used in the first layer of boxes.

The dimensions of the ground plate (L x W x H) are 1200 x 600 x 20 mm. The ground plate has catches which clip onto the vertical tubes of the box.



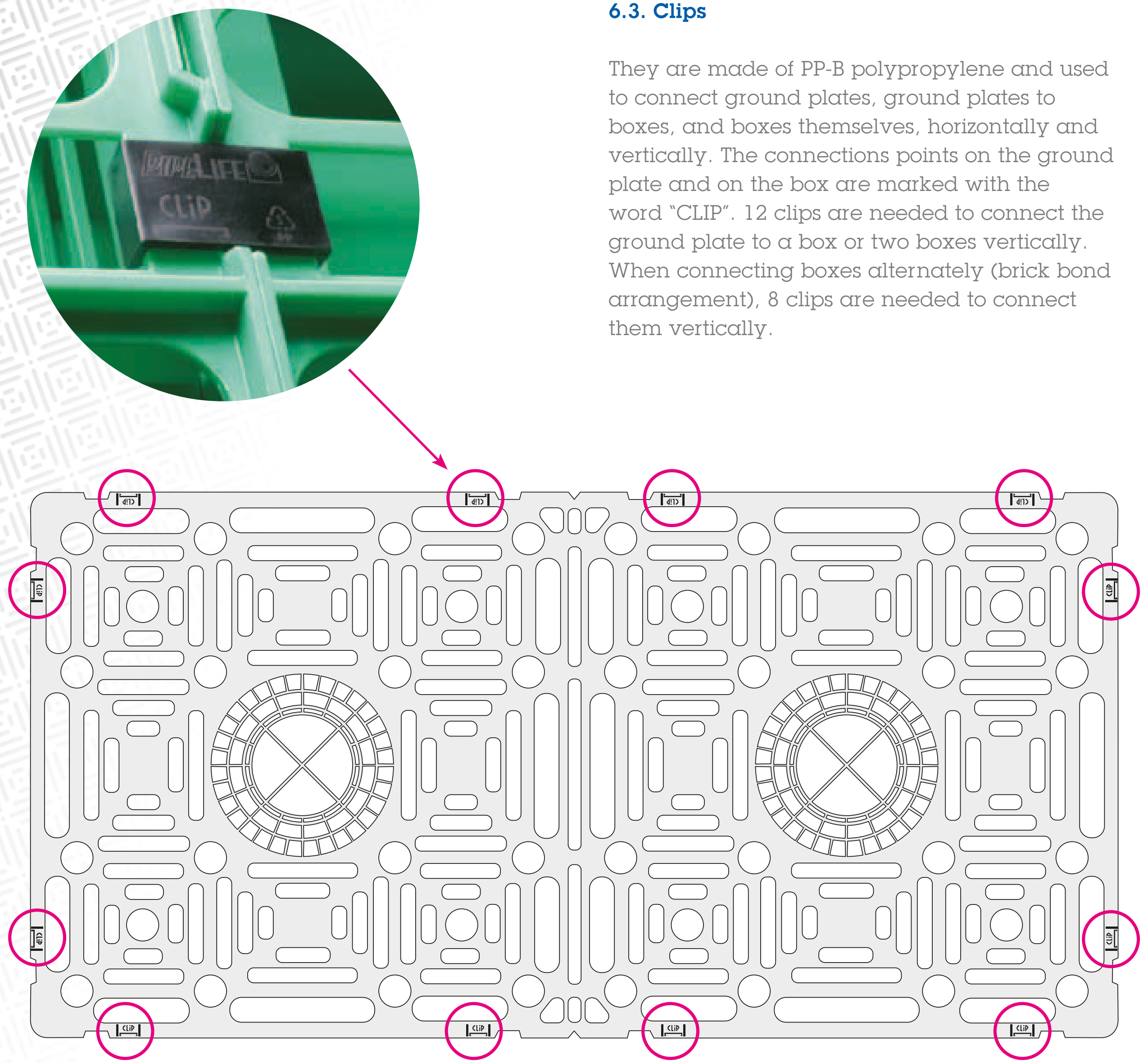
Ground plate

Dimensions of the Stormbox ground plate



Boxes are connected to each other and to the ground plates using clips. Ground plates may also be used to connect boxes together. Since they are rectangles made up of two symmetrical squares, they may be used to connect boxes arranged side by side as well as a row of boxes.

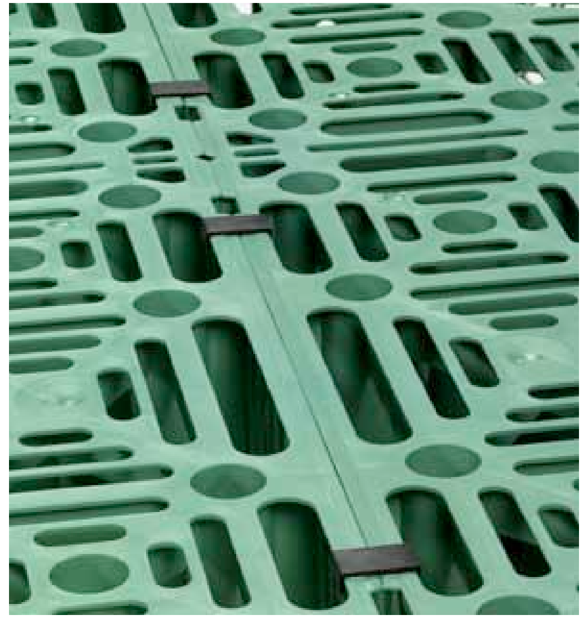
Connection using ground plates is, however, only auxiliary and does not eliminate the need to use clips.



6.3. Clips

They are made of PP-B polypropylene and used to connect ground plates, ground plates to boxes, and boxes themselves, horizontally and vertically. The connections points on the ground plate and on the box are marked with the word "CLIP". 12 clips are needed to connect the ground plate to a box or two boxes vertically. When connecting boxes alternately (brick bond arrangement), 8 clips are needed to connect them vertically.

Boxes are also clipped together horizontally. On top of every box there are 12 places marked with the word "CLIP". Pipelife prepares calculations regarding the number of clips necessary to assemble the boxes. A clip mounting device is available from Pipelife.



7. Surface area of openings

7.1. Total surface area of openings

The average area of Stormbox openings is very substantial and amounts to approx. 50% of the box surface.

7.2. Surface area of side wall openings

The area of the openings in the side walls is very large and amounts to approx. 50% of the box surface, creating very favourable conditions for the infiltration of rainwater.
The generous surface area of openings, particularly in the side walls of the boxes, is significant, since with time the rate of infiltration naturally decreases, approaching a limit value which depends on soil properties.

7.3. Surface area of ground plate openings

The decrease in the rate of water infiltration through the ground plate depends mainly on the type of soil underneath and on the amount of sediment collecting at the bottom of the infiltration boxes.

The openings in the ground plate have a large surface area (approx. 43%), ensuring very favourable conditions for the infiltration of rainwater.

8. Box marking

The construction of the Stormbox with the large surface area of openings at the bottom and in the side walls ensures the most favourable conditions for the infiltration of rainwater.

The raised Stormbox markings are created in the process of high pressure injection molding. The markings should comprise at least:

- manufacturer's logo: *PIPELIFE*
- product name: *Stormbox*
- material symbol: *PP*
- manufacturing date, year and month, e.g.: *2008.07*
- box capacity: *Volume 216 Liter*

MARKING EXAMPLE:

Stormbox=PIPELIFE=PP=
Volume 216 Liter=2008.07

9. Load resistance

Pipelife Stormbox infiltration boxes have undergone load resistance analysis using the Finite Elements Method (FEM) and laboratory tests using a load resistance testing machine at Pipelife Nederland B.V., the Netherlands.

The tests have determined that the Stormbox is resistant to a short-term vertical load of 579 kN/m² and a lateral lengthwise load of 134 kN/m². The test results confirm the high load resistance of the boxes.

The boxes comply with load resistance requirements of standard BRL 52250 (the Netherlands), which specifies a 3 days vertical load of 200 kN/m² and a lateral load of 85 kN/m². The high load resistance and quality of the boxes has been confirmed by the Kiwa N.V. KOMO Certificate.

Load testing of the Stormbox

10. Transport and storage

Boxes are stored and delivered on wooden pallets 1.2 m x 1.2 m, in 8 layers (height 2.4 m). Boxes should be loaded and unloaded using forklift trucks. Boxes may be stored outdoors, on a flat and even area. In case of outdoor storage for a period longer than 12 months they should be stored in shade or, if necessary, covered with light-coloured, opaque tarpaulin.

Name	Units/pallet
Stormbox	16
Ground plate	100
Clip	1800/carton - 4 cartons/pallet

Due care should be taken when loading and unloading, especially at temperatures below 5°C. The Stormbox system elements should be protected against damage and deformation at each stage, from storage, through transport, to the place of installation.

11. Installation guidelines

Rainwater from a building roof or another drained surface (e.g. a yard) is directed through gutters and discharge pipes to a settling chamber where mechanical impurities are separated, and then through sewage pipes to infiltration boxes wrapped in filtration mats, so that water may infiltrate into the ground.
The infiltration boxes are combined horizontally and vertically into modules, whose size depends on the requirements (the module size mainly depends on the size of the drained area and the degree of soil permeability). In order to accelerate the filling of the system, the other end of the box set should be ventilated by means of a PVC-U sewage pipe d_n 110 mm (160 or 200 mm), which should be connected to the hole in the top plate of the box. A ventilation pipe with an air valve cover should extend above ground to the height of approx. 50 cm.

PVC-U or PP pipes and fittings (for external sewage systems) compliant with PN-EN 1401-1, PN-EN 13473-2 or PN-EN 1852-1 are used to connect the gutter system to the supply/settling chamber, the infiltration boxes and the ventilation chamber. When using structural PP-B Pragma pipes (compliant with AT/99-02-0752-03 and PN-EN 13476-3), adapters for PVC-U sewage pipes should be used.

DN/OD 400 and DN/OD 630 settling chambers are made of polypropylene (technical parameters compliant with the AT/2007-03-0096 approval). PRO 800 and PRO 1000 settling chambers are made of polypropylene (technical parameters compliant with the AT/2005-02-1538-02 and AT/2004-04-1717 approvals).

The outlets of the settling chambers might be fitted with a device blocking impurities from entering the box set, e.g. self-cleaning steel filters.

Before the boxes are laid down, it is necessary to decide the points where inspection equipment will be inserted through manholes PRO 800, PRO 1000 and vertical inspection pipes, depending on the size of the system. The hole diameters make it possible to introduce cleaning equipment or CCTV into the box module through 6 openings (110, 160 mm) located on the side walls of the boxes and through the 2 openings on the top (110, 160, 200 mm).

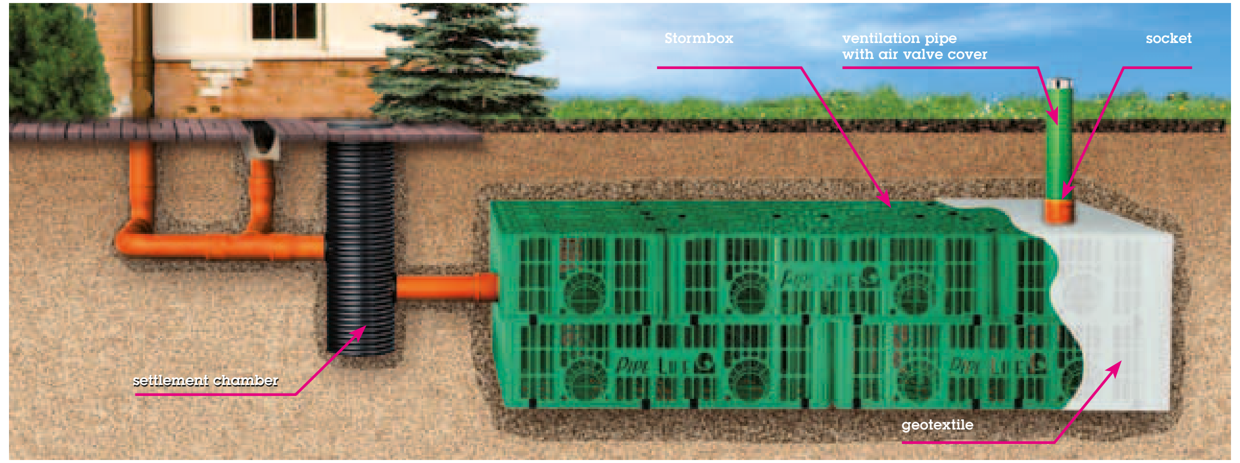
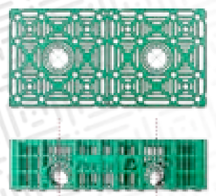


Diagram showing the Stormbox rainwater infiltration system

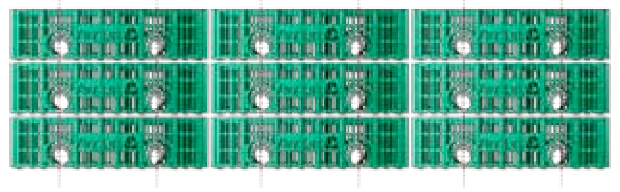
11.1. Diagrams of various Stormbox arrangements

Stormbox infiltration boxes may be arranged in the following configurations:

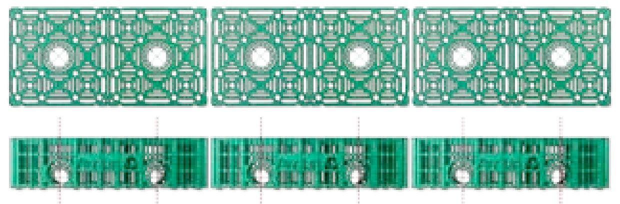
1 Single box



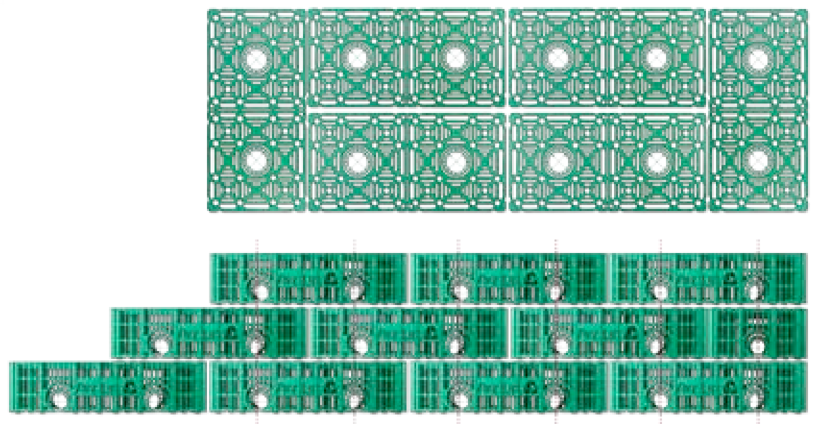
2 Row of boxes



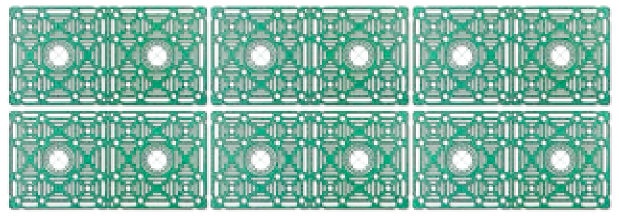
2 Double row (top view)



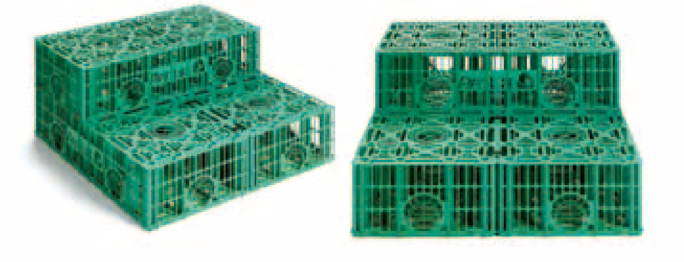
3 Double row, several layers, brick bond arrangement (lateral and top view)



2 Double row, several layers (lateral view)

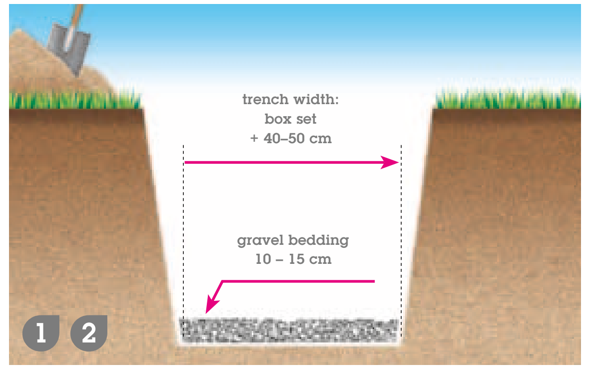


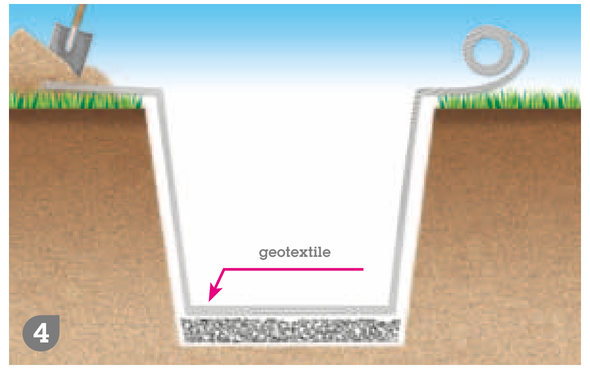
2 Stormbox units arranged in an alternating pattern

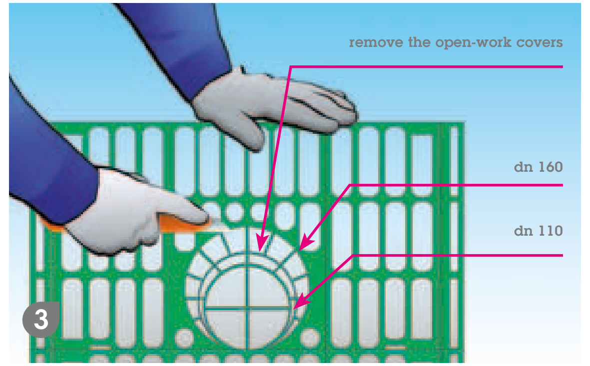


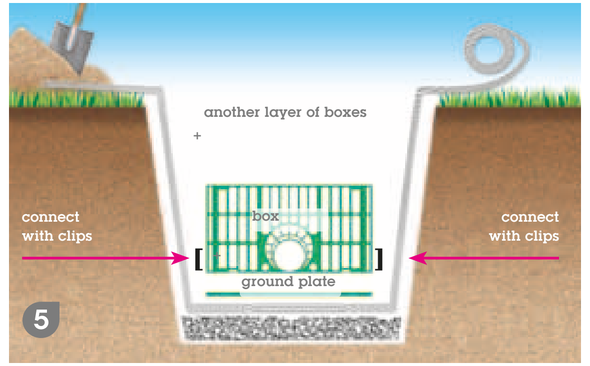
The Stormbox system stands out due to its unique way of creating diverse and very durable arrangements. The best stability is achieved when boxes are arranged in alternating layers (similar to a brick bond formation). The ends of the vertical reinforcements clip onto holes in the bottom layer, securing the whole structure from sliding. The design of the boxes makes it possible to move away from building tall parallel stacks, more vulnerable to vertical tilting.

11.2. Sequence of tasks to be performed when installing a rainwater infiltration system









1. Dig a trench at least 40 – 50 cm wider than the width of the box module.

2. Remove any protruding stones from the bottom and lay down min. 10 – 15 cm of gravel bedding, grain size e.g. 8 – 16, 12 – 24 (30) mm, or a layer of coarse sand. Even out and compact the ground.

3. Reove the open-work covers from the connection points of the 160 mm supply pipes, 110 – 220 mm ventilation pipes and 200 mm inspection pipes.

4. Lay the geotextile at the bottom, leaving an overlap of 15 cm – 50 cm and an appropriate amount at the sides to be able to wrap the boxes on all sides. The geotextile protects the boxes from contamination by the surrounding soil.

5. Lay out the ground plates on the geotextile and connect them together, using clips. The points where clips should be placed are marked with the word "CLIP". Next, place the boxes on the ground plates, pushing them down. The vertical tubes in the boxes should clip onto the ground plates. Connect the boxes and the ground plates using clips. If applicable, lay subsequent layers of boxes, connecting them with clips vertically and horizontally.

6. Carefully wrap the geotextile around the boxes, leaving an overlap of 15 cm – 50 cm. At the inlets prepare star-shaped openings by making 8 cuts in the geotextile. Then insert approx. 20 of the supply pipe, so that the socket extends from the opening.

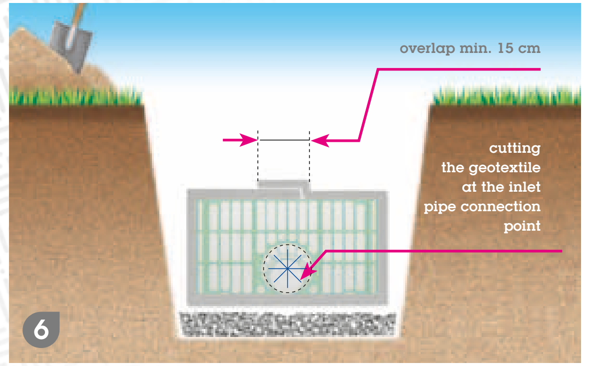
7. Connect the boxes to 160

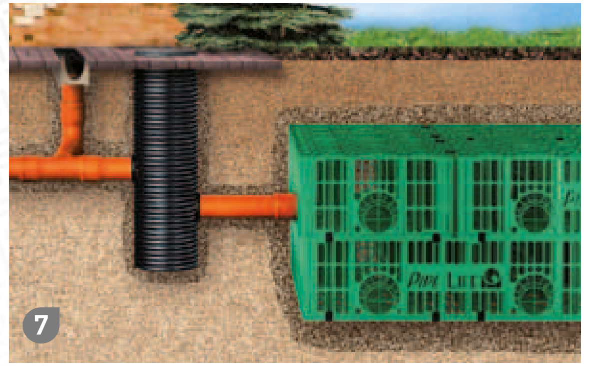
> **Note**
> All the open-work covers should be removed at the expected locations of inspection manholes or vertical riser pipes.

mm supply pipes from the inspection settling chamber PRO 400, PRO 630 or manhole PRO 800, PRO 1000. The required stiffness of the pipes is SN 4 kN/m² (for green areas) or SN 8 kN/m². The number of chamber outlet pipes should be chosen based on the water flow. 200÷500 mm pipes require the use of an adaptor. A 600 × 550 mm adaptor is connected to the box with catches at the height of 0.6 m (2 layers).

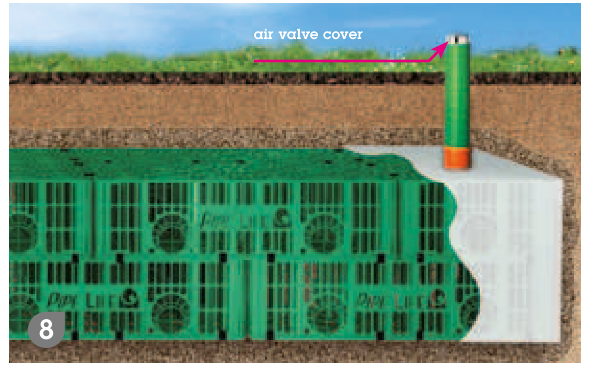
Note

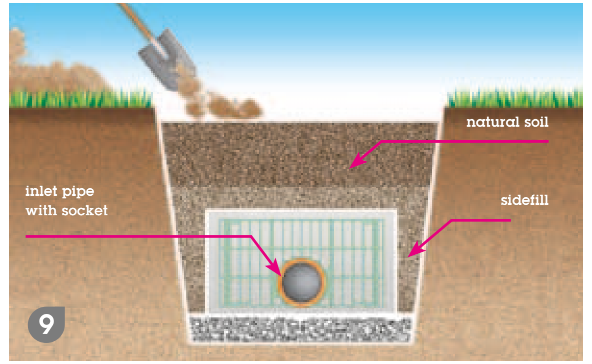
Make sure that the geotextile adheres tightly (without gaps) to the pipe socket.





8. Install a ventilation pipe at the other end of the box set by connecting a PVC-U sewage pipe d_n 110 mm (160 or 200 mm) to the socket of the pipe mounted in the top opening of the box. The ventilation pipe with an air valve cover should extend approx. 50 cm above ground. The pipe may also be used for inspections. For purposes of inspection and cleaning install 200 mm chambers above the boxes or 400, 630 mm inspection chambers at the end of the tank.





9. Fill the sides with 15 – 30 cm layers of gravel pack, grain size e.g. 8 – 16, 12 – 24 (30) mm, or with coarse sand. Even out and compact the ground. Adjust the ground compaction level to the expected loads.
Cover the boxes with a 10 – 15 cm layer of sand (without stones or other sharp-edged elements which might damage the geotextile or the boxes) and compact it.

To make an initial calculation of the necessary number of clips, regardless of the number of layers, use the following formula: number of boxes x ≈ 14 pcs. Pipelife can calculate the exact number of clips for a given solution.

When conducting groundwork, laying out and assembling the boxes and the plastic pipes, observe standards PN-EN 1610, PN-ENV 1046.

To ensure adequate support for the boxes it is necessary to determine the technical properties of the materials used to fill in the trench, in particular the sidefill and its compaction. Geotextile parameters should be chosen based on the box arrangement and the expected loads. It is recommended that geotextile which comes in contact with gravel should have the tensile strength of over 8 kN/m and static puncture resistance (CBR) of over 1.2 kN.

Technical parameters of selected polypropylene geotextiles

No	Properties	Unit	Test method	Type						
				SF 37	TCM 250	TCM 300	T 225	T 275	150 HTS	200 HTS
1.	Tensile strength	kN/m	EN ISO 10319	$8.5^{-0.9}$	7.6	9.6	9	11	8.5	14.5
2.	Static puncture resistance (CBR)	kN	EN ISO 12236	$1.275^{-0,16}$	1.61	2.47	1.6	2.1	1.6	2.4
3.	Dynamic puncture resistance (cone drop test)	mm	EN918	33	22	21	26	24	20	15
4.	Water permeability perpendicular to the surface	m/s	EN ISO 11058	$55 \cdot 10^{-3}$	$5 \cdot 10^{-2}$	$4.6 \cdot 10^{-2}$	$2.5 \cdot 10^{-2}$	$2.3 \cdot 10^{-2}$	$9 \cdot 10^{-2}$	$7.8 \cdot 10^{-2}$
5.	Thickness under load 2 kN/m² 200 kN/m²	 mm mm	EN ISO 9863-1	0.45 0.35	2.7 2.1	3.4 2.5	1.5 1.1	1.8 1.2	- -	- -
6.	Surface density	g/m²	ISO 9864	125	$250^{\pm 25}$	$300^{\pm 30}$	$190^{\pm 19}$	$220^{\pm 22}$	150	150
7.	Colour	-	-	grey	white	white	grey, white	grey, white	white	white
8.	Geotextile type	-	-	H	N	N	H	H	N	N

T – heat-bonded geotextile, I – needle-punched geotextile
Geotextiles of other technical parameters may be ordered according to the Customer's requirements.

Basic functional diagram showing the Stormbox rainwater infiltration and retention system (additionally with excess water drainage)

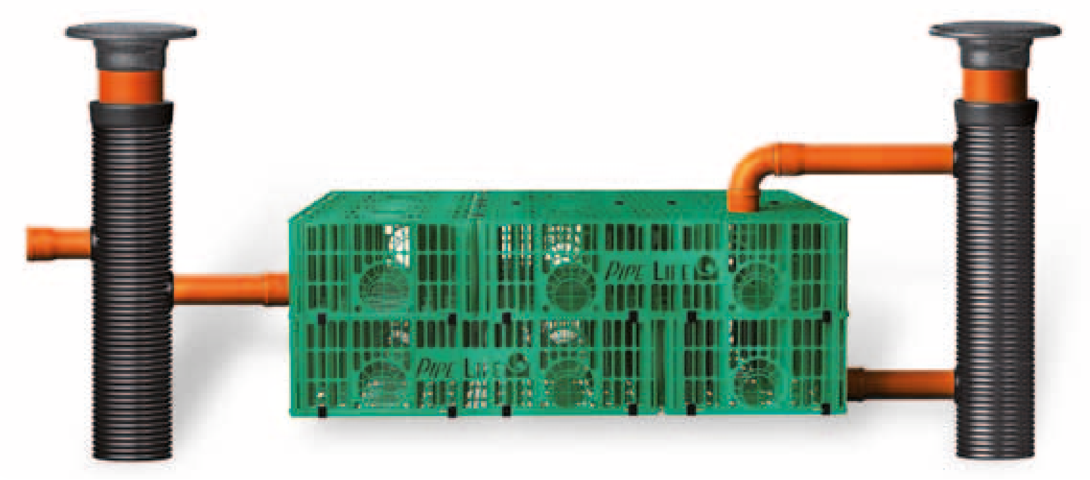
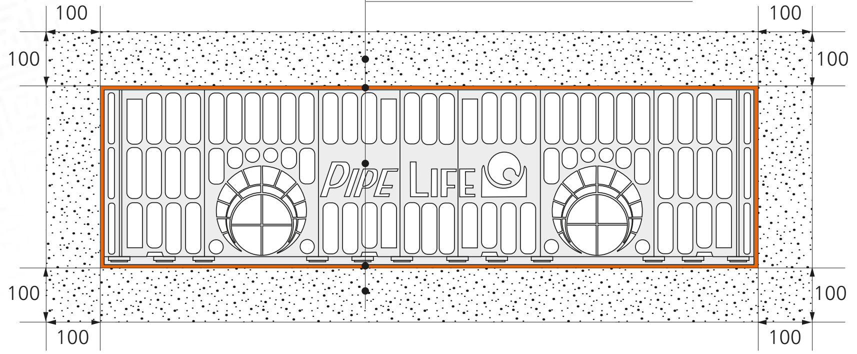
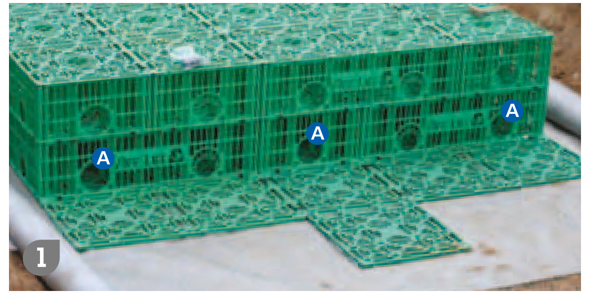
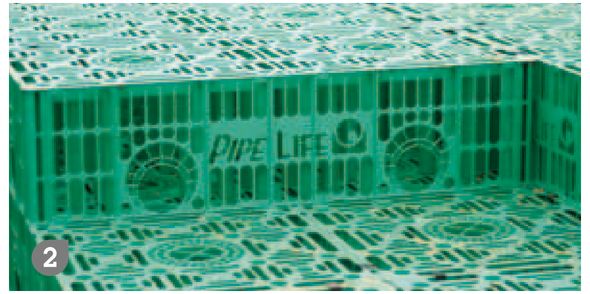


Diagram showing the typical installation of a rainwater infiltration box.



1. Laying down of the geotextile, ground plates and first layer of boxes. A It is important to remove the internal grids to create inspection channels.
2. Laying down subsequent layers of boxes in an alternating pattern (the middle boxes are turned by a 90SDgr angle), building a stable module.
3. Wrapping the geotextile around the boxes
4. Wrapping geotextile around the boxes and filling the sides of the trench
5. Example layout of dn 200 mm inspection pipes





11.3. Sequence of tasks to be performed when installing a rainwater storage system

1. Dig a trench at least 40 – 50 cm wider than the width of the box module.

2. Remove any protruding stones from the trench bed and lay down min. 10 – 15 cm of sand bedding (no stones). Even out and compact the ground.

3. Remove the open-work covers from the connection points of the 160 mm supply pipes, 110 – 220 mm ventilation pipes and 200 mm inspection pipes.

Note

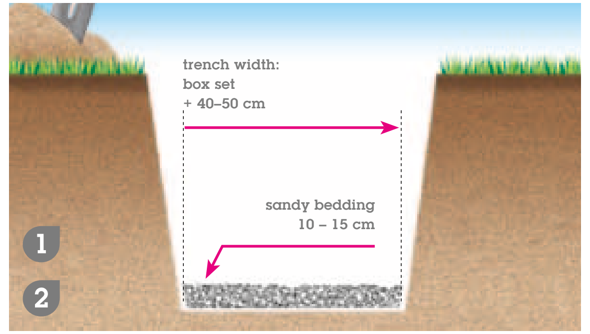
All the open-work covers should be removed at the expected locations of inspection manholes or vertical riser pipes (both along the horizontal and the vertical channels).

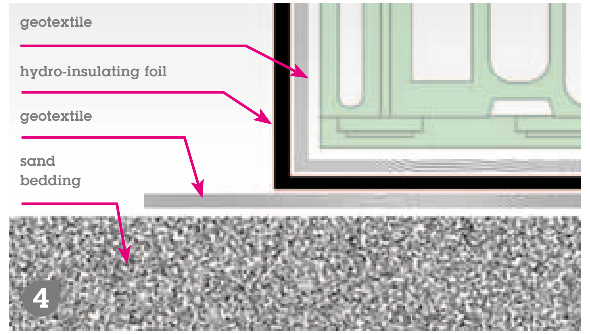
4. At the bottom lay out the geotextile (grammage at least 300 g/m²), leaving an overlap of at least 15 cm – 30 cm, then lay out the geomembrane (hydro-insulating foil), at least 1.5 mm thick.
   The foil (dimensions 2 m x 20 m) is laid out with an overlap of approx. 10 cm and welded.

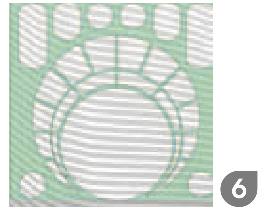
Next lay out the second layer of geotextile at the bottom, leaving an overlap of 15 cm – 50 cm and an appropriate amount at the sides to be able to wrap the boxes on all sides. The geotextile protects the foil from damage.

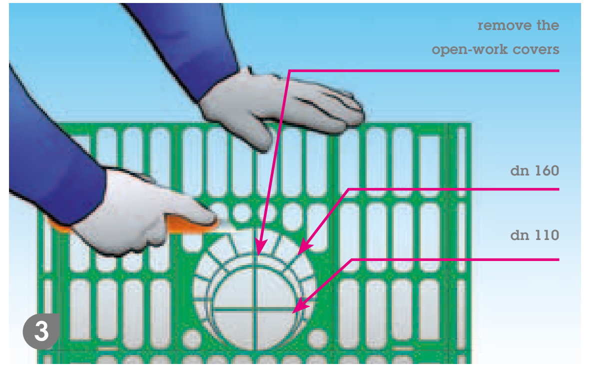
5. Lay out the ground plates and boxes on the geotextile and connect them together, using clips. The points where clips should be placed are marked with the word "CLIP".

6. Carefully wrap the geotextile around the boxes, leaving an overlap of 15 cm – 50 cm. At the inlets prepare openings by making cuts in the geotextile.









7. Wrap the boxes with foil and weld it. Make openings at the inlets of supply, ventilation and inspection pipes into the boxes. Next, prepare pipes of a total length of 50 cm (excluding the socket). Onto each of the prepared pipe ends place a butyl gasket and then a foil sleeve, which should be welded to the pipe.
   Insert approx. 20 cm of the pipe into the box opening, and then weld the foil sleeves around the pipes. Place a metal rim around the foil sleeve and tighten the pipe joint. The rim may be additionally secured by wrapping with foil and welding.

8. Install a ventilation pipe at the other end of the box set by connecting a sewage pipe d_n 110 mm (160 or 200 mm) to the socket of the pipe mounted in the top opening of the box. The ventilation pipe with an air valve cover should extend approx. 50 cm above ground. For purposes of inspection and cleaning install a grating made of a 200 mm pipe covered with a T20 (40 t), T05M (5 t) telescope or a class A15 cone with a concrete chamber cover.

9. Fill the sides with 15 – 30 cm layers of graded sand without stones or other sharp-edged elements. Even out and compact the ground. Adjust the ground compaction level to the expected loads.

10. Cover the boxes with a 10 – 15 cm layer of graded sand without stones or other sharp-edged elements. Even out and compact the ground. Pay particular attention to securing the trench sides so as to prevent stones and other sharp elements from mixing with the sidefill surrounding the foil. It is recommended to additionally protect the foil by covering it with geotextile.

Geotextile and geomembrane parameters should be chosen based on the box arrangement and the expected loads.
Before the construction of the tank, bearing capacity of the soil should be tested. In case of low bearing capacity, soil settlement should be prevented by complete removal of the bed and replacement with concrete footing or compacted gravel and sand footing (1:0.3) at least 15 cm deep. Construction stability in areas of low bearing capacity may also be increased by using e.g. Certus G polyester geogrids.

Particular care should be taken when groundwater is present. It requires a perimeter drain constructed around the tank using 100 mm pipe to lower the water lever to beneath the bottom of the tank. You should also ask Pipelife to perform load resistence calculations.

Rainwater retention tank

Buffer tank in the rainwater drainage system

Note

Guidelines for sealing the foil by glueing
Position the edges of the foil on an even, hard surface, overlapping them by at least 5 cm. The sealed edges must be dry, clean and degreased. Using a flat brush apply glue to both edges and immediately press them together.

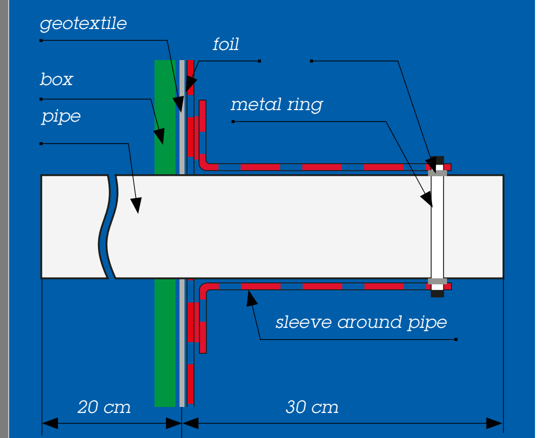
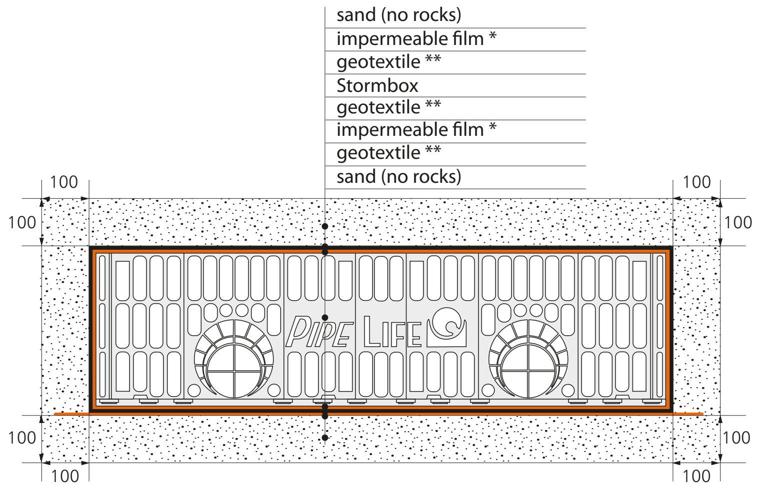


Diagram showing the method of sealing a pipe opening in the wall of the box.

Diagram showing the typical installation of a rainwater storage box



* water-proof PVC foil, e.g. 1.5 mm thick FolGAM H type
** PP geotextile, grammage min. 300 g/m². If ungraded sand (with stones) is used as packing material, additional protective geotextile should be used around the foil.

Parameters of PVC foil used in the construction of underground retention tanks

No	Properties	Unit	Test method	Parameters
1.	Thickness	mm	PN-EN 1849-2	1.5 ± 10%
2.	Dimensions (L x W)	m	PN-EN 1848-2	2 x 20 ± 5%
3.	Tensile strength – longitudinal – transverse	MPa	PN-EN 527-1/3	14 12
4.	Static puncture	kN	PN-EN ISO 12236	2.5
5.	Compatibility with asphalt	-	PN-EN 1548 PN-EN 1928	compatible with bitumen
6.	Resistance to root penetration	-	PR-CEN/TS 14416	no perforation
7.	Reaction to fire	-	PN-EN 13501-1	Class E

The softened PVC foil complies with standard PN-EN 13967. "Flexible sheets for waterproofing. Plastic and rubber damp-proof sheets including plastic and rubber basement tanking sheet. Definitions and characteristics".

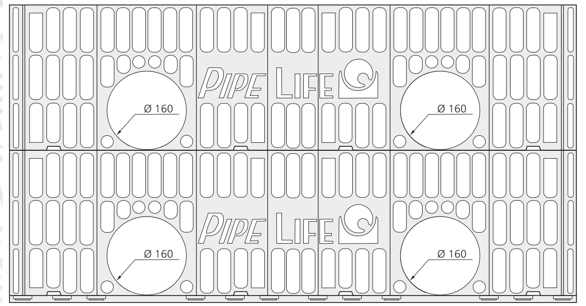
Technical parameters of geotextiles used in the construction of underground retention tanks

No	Properties	Unit	Test method	Type					
				TCM 300	TCM 350	TCM 400	250 HTS	300 HTS	350 HTS
1.	Surface density	g/m²	ISO 9864	300	350	400	250	300	350
2.	Tensile strength – longitudinal – transverse	kN/m	ISO 10319	14 12	11.6 11.6	13.2 13.2	18 22	20 28	22 40
3.	Thickness under load 2 kPa 20 kPa 200 kPa	ISO 9863-1	mm	3.4 2.5 1.3	3.9 2.9 1.5	4.4 3.3 1.8			
4.	Static puncture resistance (CBR)	kN	ISO 12236	2.47	2.48	2.72	3.0	3.8	4.3
5.	Dynamic puncture resistance (cone drop test)	mm	EN 918 ISO 13433	21	20	19	15	12	12
6.	Water flow rate (in the transverse direction, without load)	m/s ▪10^{-2}	ISO 11058	4.6	4.2	3.8	7.1	5.2	4.6
7.	Colour	-	-	white					
8.	Geotextile type	-	-	needle-punched geotextile					

Surface density tolerance is ±10%.

11.4. Connecting pipes to boxes

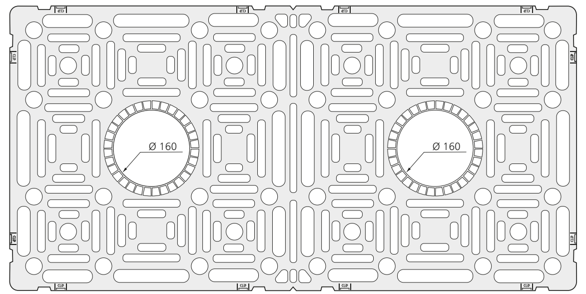
160 mm inspection openings in Stormbox side walls



In order to connect the plain ends of PVC-U, PP-B d_n 110, 160 mm pipes to the side walls, cut out the polypropylene reinforcements from the inlet openings. After wrapping geotextile around

Diagram showing the connection of a d_n 160 mm PVC-U inlet pipe to the side of the box

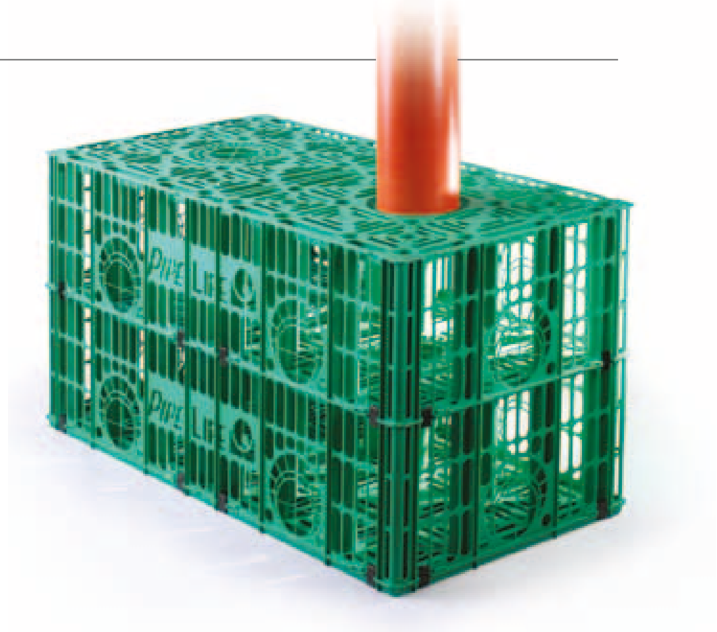
Diagram showing the connection of a 160 mm PVC-U inlet pipe to the top of the box



the boxes and cutting out a hole matching the diameter of the pipe, insert a PVC-U, PP-B pipe approx. 20 cm long. Carefully secure the connection so as to prevent the soil from entering the box module.

The illustration above shows a box with prepared 160 mm holes.
When building wide tanks with a large, flat surface, plan water supply connections in several places, to distribute water evenly. You can make holes in the other side walls and in the top boxes in a similar manner.

At the top of every box there are 2 openings d_n 110, 160 or 200 mm, which can be used to insert cleaning equipment or CCTV all the way to the bottom of the box module (provided that the open-work covers have been removed from the holes of every layer of boxes).



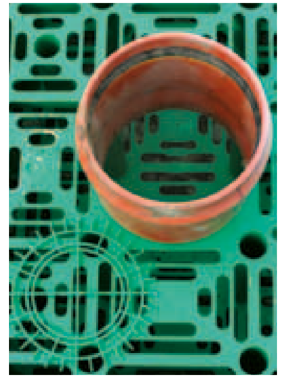
160 mm inspection openings at the top of Stormbox

Every Stormbox has holes located along the same horizontal and vertical axis. It allows access into the boxes as far as the other end of the box module, both through the side walls and through the top.

The top inspection opening may be used for the duct connector of a d_n 160, 200 mm PVC-U sewage pipe with a socket. Vertical sewage pipes running to the level of the ground should be installed at the points at the top at which inspections will be carried out.

The pipes should be covered to protect them from inadvertent water entry. The polypropylene reinforcements should be cut out from all the holes located on the sides and at the top, through which inspections are to be carried out.

Cutting out the open-work cover of a d_n 200 mm hole located at the top of the box



Placing a 200 mm PVC-U pipe in the opening

Above-ground section of a vertical inspection pipe, d_n 200 mm

11.5. Connecting boxes to settling chambers

The boxes may be connected to inspection chambers PRO 400, PRO 630 and manholes PRO 800 and PRO 1000 with a settling tank and a filter at the outlet. Depending on the flow rate, the flow should be distributed between an appropriate number of 160 mm supply

Approximate number of outlet pipes based on the inlet diameter:

Inlet diameter [mm]	Outlet diameter [mm]	Min. number of pipes at the outlet [pcs.]	Chamber type
200	160 mm	2	PRO 630 PRO 800
250	160 mm	3	PRO 1000
315	160 mm	4	PRO 1000
400	160 mm	6	PRO 1000

The final number of pipes at the outlet can be calculated based on the flow rate (dm3/s) and pipe gradient (%).

pipes connected to the side, or 200 mm pipes connected to the top of the boxes.
200÷500 mm diameter pipes can be connected to the boxes using a Stormbox adaptor.

When connecting a large diameter (e.g. 315 mm) pipe to a PRO 800 or PRO 1000 manhole, make 4 holes at the outlet in the body of the chamber for in-situ 186/160 mm gaskets and 160 mm filters, or 1 hole for a 341/315 mm gasket and a 315 mm filter.

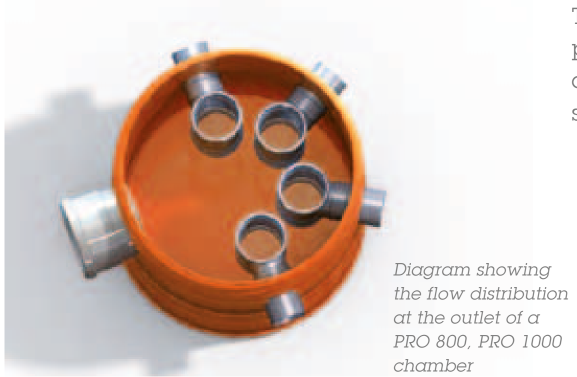
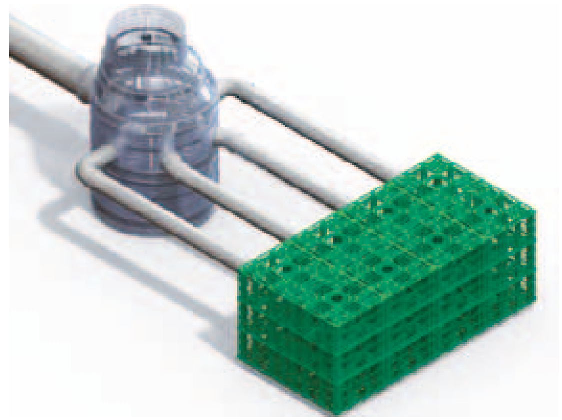


Diagram showing the flow distribution at the outlet of a PRO 800, PRO 1000 chamber

Diagram showing the connection of a box module to a PRO 800, PRO 1000 chamber

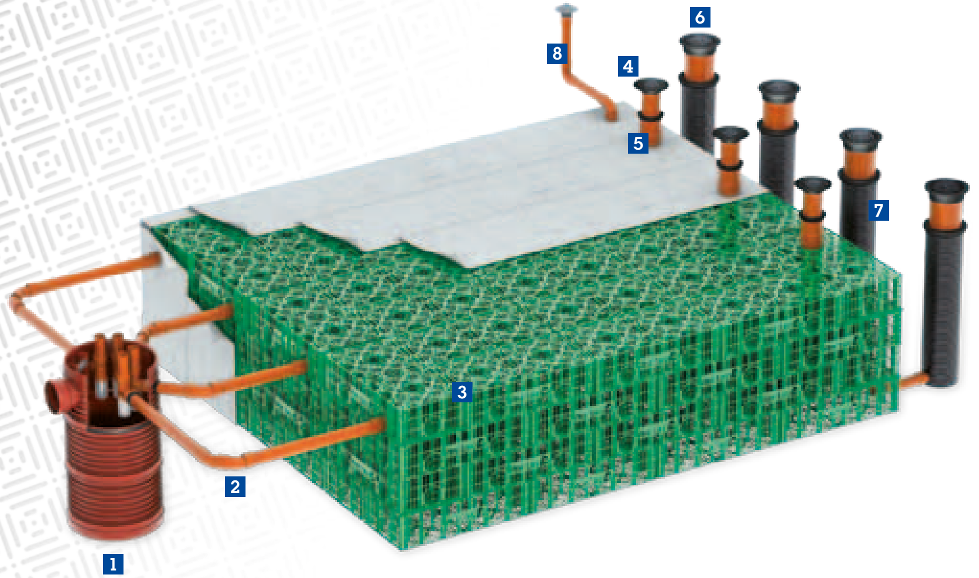


Settling chambers PRO 400 and PRO 630 may be fitted with a settling bucket, located underneath the inlet to the chamber, where leaves and other debris will collect. This solution is particularly useful if there are trees near the building.

For draining yards or car parks there are inspection chambers with a telescope and frame, T30K (12.5 t) or T50K (25 t), and a settling bucket, made of PE or galvanised steel.

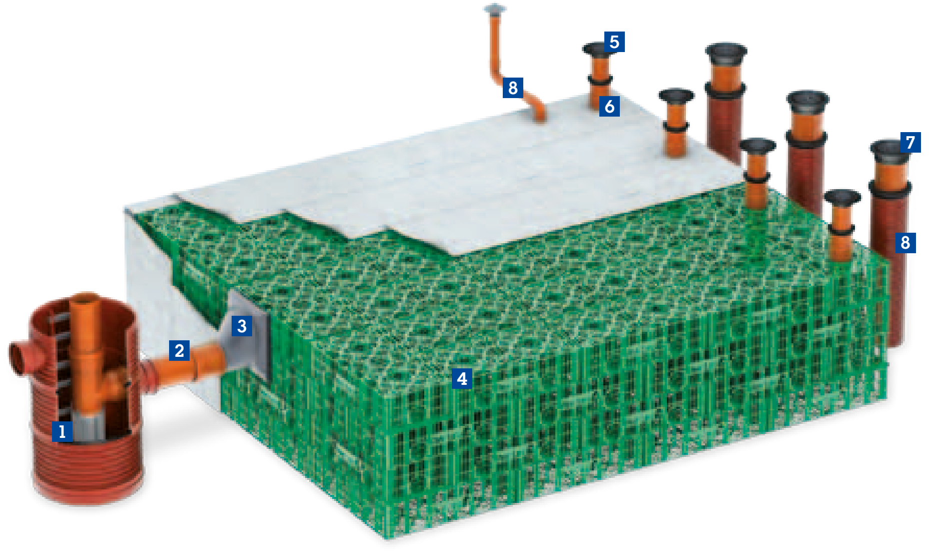
The settling bucket with a steel frame should be placed inside the telescope. The settling buckets are supported by special grips which fit both the short (h=25 cm) and the long (h=40 cm) model.

Diagram showing an example of a PRO 1000, PRO 800 settling chamber connected with a 160 mm pipe



1. PRO 800, PRO 1000 chamber with settling tank and filter,
2. 160 mm PVC-U sewage pipe,
3. Stormbox,
4. telescope T20 (40 t) or T05M (5 t),
5. 160 mm PVC-U riser pipe,
6. telescope class A15 ÷ D400,
7. PRO 400 chamber,
8. ventilation pipe with air valve cover 110 or 160 mm

Diagram showing an example of a PRO 1000, PRO 800 settling chamber connected with a Stormbox adaptor



1. Sedimentation trap with filter
2. Sewage pipe 200 to 500 mm
3. Stormbox adapter 200 to 500 mm
4. Stormbox
5. Telescope
6. Core pipe 200 mm
7. Telescope class A15 till D 400
8. Inspection chamber
9. Ventilation pipe 110 or 160 mm.

PRO 1000 or PRO 800 settling chamber with a steel filter

Filter properties:

- Made from stainless steel,
- Large filtration surface,
- Conical shape for easier self-cleaning,
- Filter diameters 160 ÷ 400 mm for larger flows (larger drainage areas),
- Filter diameter 110 mm for small flows (small drainage areas),
- Can be used with 90° triple connectors to external sewage systems,
- Can be used in plastic and concrete chambers,
- The number of filters at the outlet (up to 4) can be adjusted to the diameter of the chamber inlet (up to 400 mm),
- Quick installation of the chamber and filter at the site.

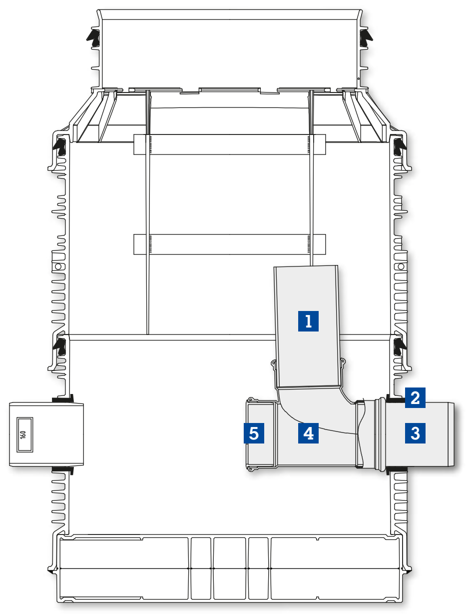
The top part of the filter should be inserted into the socket of the triple connector, and the steel catches should be fixed with a clamping ring. To preserve the minimum safe distance of 50 mm from the concrete ring, trim the top part of the 630 mm reducer outlet by 26 mm (to 35 mm).

Selecting the hole diameter in the outflow regulator

Flow Q [dm³/s]*	Hole diameter D [mm]
1	25
2	36
3	44
4	51
5	57
6	62
7	67
8	72
9	76
10	80

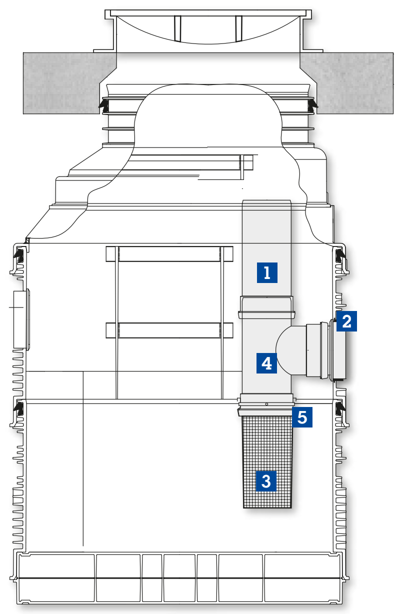
** Water outflow from the regulator depends on the height of the water level*

PRO 800, PRO 1000 settling chamber with outflow regulator

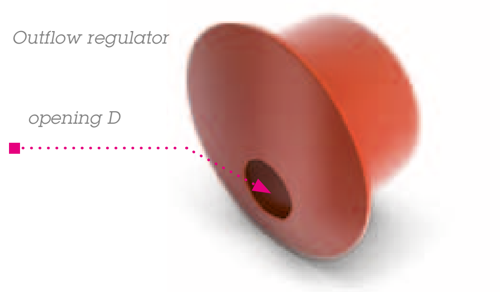


1. pipe 160 mm * L – the length of the pipe depends on the height of the box module,
2. gasket 160 mm,
3. pipe 160 mm,
4. triple connector 160×160 87,5SDgr,
5. outflow regulator.

Diagram showing a PRO 1000 or PRO 800 settling chamber with a steel filter at the outlet



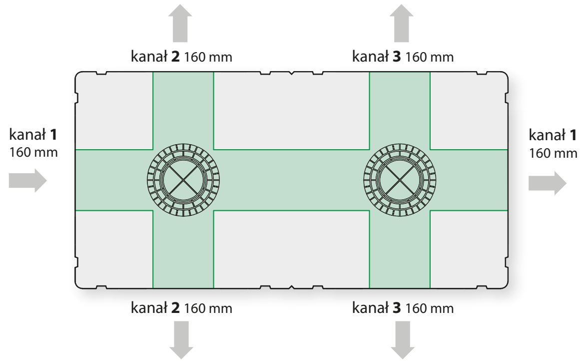
1. pipe d_n,
2. 4-lip seal ring
3. Stormbox conical filter,
4. triple connector $d_n \times d_n$ 90SDgr,
5. clamping ring



11.6. Inspections and cleaning of the boxes

Stormbox units have three internal horizontal inspection channels to introduce CCTV and cleaning equipment. The boxes have certificates issued by IBAK KOKS RIDDERKERK (the Netherlands), IBAK Retel IPEK (Poland), 403388-4 OFI Technologie & Innovation GmbH (Austria), confirming that it is possible to perform CCTV inspection and hydrodynamic cleaning up to 180 bar. The boxes were subjected to water pressure of 180 bar through standard nozzles 50 times (25 cycles). The test results showed no damage to the box structure that could adversely affect their functioning. The OFI certificate confirms the high quality of the boxes and their high resistance to hydrodynamic pressure.

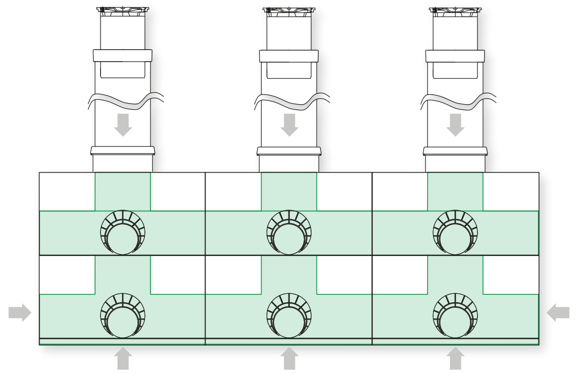
Stormbox may be inspected vertically and horizontally.
Boxes with a vertical channel enable maintenance and the introduction of cleaning equipment from the ground all the way to the bottom through 200 mm chambers installed above the boxes or 400, 630, 800 and 1000 mm chambers installed next to the tank. Two vertical



openings 200 mm in diameter provide access from the ground all the way to the bottom of the tank for purposes of inspection and cleaning. There are 6 openings 160 mm in diameter in the side walls and 2 openings 200 mm in diameter at the top of the box. Supply pipes 200÷500 mm in diameter can be connected to the side of Stormbox using an adaptor.

Stormbox has three horizontal inspection channels 160 mm in diameter and two vertical channels 200 mm in diameter. Please note, however, that according to standards PN-EN 13476-1, EN 14654-1 maximum nozzle pressure should not exceed 120 bar.

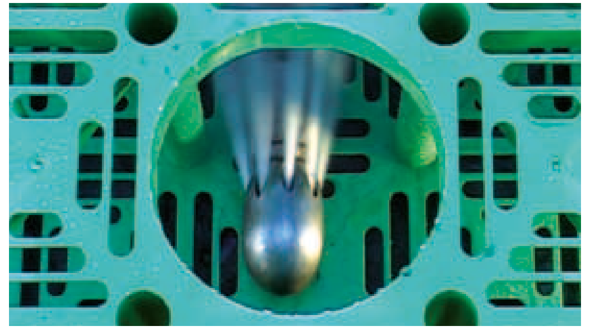
Diagram showing an example method of inspecting the Stormbox module



Research and general practices in Europe have shown that a 120 bar pressure is sufficient for all plastics. It removes any blockages which may occur during normal operation, and impurities are directed to chambers with large amounts of water. The results of independent rinsing studies have shown that a large amount of water at a low pressure is more effective as a means of removing obstacles and completely cleaning out sediment buildup from pipes, as well as for routine maintenance. Such methods use large diameter nozzles (typically 2.8 mm).

Inspecting the boxes

Hydrodynamic cleaning



Hydrodynamic cleaning

Recommended practical parameters for high pressure cleaning:
For soft debris and impurities, 60 bar is sufficient.

Rinsing pressure/flow speed:
1. Recommended nozzle pressure: up to 60 bar.
2. Recommended debris rinsing speed: 6 m/min – 12 m/min.

Rinsing equipment:
1. Choose rinsing equipment using low pressure and large amounts of water.
2. Avoid methods requiring high pressure and small amounts of water.
3. Choose nozzle size based on the equipment used and the size of the pipe to be cleaned.

Diagram showing an example of a Stormbox system with a settling chamber PRO 400 mm or PRO 630 mm with a cascade at the inlet and a 200 mm or 400 mm inspection chamber

1. settling chamber 400 mm or 630 mm with cascade
2. PVC-U sewage pipe 160 mm,
3. Stormbox
4. 200 mm inspection chamber with telescope T05M (5 t) or T20 (40 t)
5. ventilation pipe with air valve cover 110 mm or 160 mm

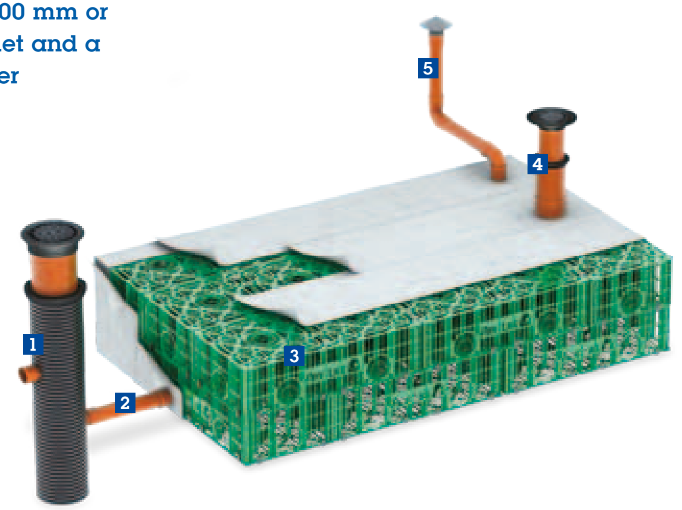
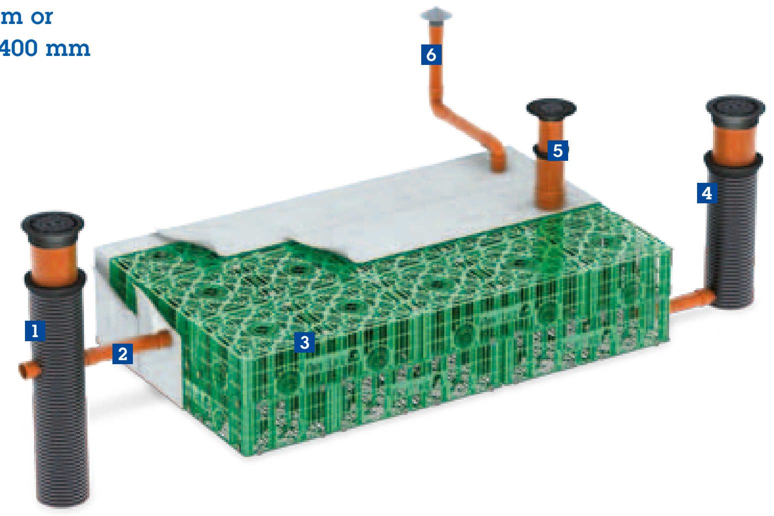


Diagram showing an example of a Stormbox system with a settling chamber 400 mm or 630 mm at the inlet and a 200 mm or 400 mm inspection chamber

1. settling chamber 400 mm or 630 mm
2. PVC-U sewage pipe 160 mm,
3. Stormbox
4. 400 mm chamber with a 160 mm socket
5. 200 mm inspection chamber with telescope T05M (5 t) or T20 (40 t)
6. ventilation pipe with air valve cover 110 mm or 160 mm



11.7. Minimum distances from the building or other objects

Minimum distances between the infiltration boxes and the building or other objects:

- 2.0 m from a building with insulation,
- 5.0 m from a building without insulation,
- the distance between the infiltration boxes and the building should be at least 1.5 of the building's foundation's depth,
- 3.0 m from trees,
- 2.0 m from the plot boundary,
- 1.5 m from water or gas supply pipelines,
- 0.8 m from power cables,
- 0.5 m from telecommunication cables,
- 1.0 m from groundwater level.

11.8. Digging trenches

- earthwork may be done manually or mechanically,
- the trench bed should be even, without sharp-edged elements, uniformly supporting the boxes along the whole length of the tank,
- the recommended method is to dig the trench to 5 – 10 cm above the planned level of the trench bed when working manually or 10 cm above the planned level when working mechanically, and then manually deepen it to the planned level, forming the appropriate profile,
- the trench should be secured against landslides to prevent the soil or sand from entering the boxes,
- the trench should be filled with permeable materials, such as gravel, working in layers and compacting the ground to the required level, as per documentation.

11.9. Preparing the trench bed

The trench bed must be even, without large stones, large lumps of soil or frozen material. It may be more cost effective to mechanically dig trenches to a greater depth, and then even out the bottom by spreading out appropriate graded material. Coarse sand or rockfill is the most cost efficient solution since it requires the least compaction to achieve the correct density.

Permeable graded material (sand, rockfill) is placed in the trench using appropriate equipment, and then manually evened out and formed to ensure that the ground is suitable, well compacted and ready to provide good support for the box modules.
A suitable bed may also achieved using soil dug out from the trench and appropriately prepared, provided the soil does not contain large stones (more than 40 mm in diameter), hard lumps or debris, and can be compacted to the right density.

Materials used for the sidefill and backfill must not have sharp edges or frozen lumps of soil. Soils containing large rock fragments and soils with high organic content, caked silt and aggradate mud should not be used for bedding, either on their own or mixed with other materials.

10.10. Soil classification

Category I
Category I includes gravel and coarse rockfill with grain size 4-8, 4-16, 8-12, 8-22 mm. A maximum of 5-20% of 2 mm grains is allowed. This is the best bedding material.

Category II
Coarse sand and gravel with maximum grain size approx. 40 mm and other graded sands and gravels of various grain size, with a small percentage of small particles. Generally these are granular materials, non-cohesive both when dry and wet. This category also includes various uniform and non-uniform gravels and sands, or mixtures of sand and gravel with varying small particle content.

A maximum of 5-20% of 0.2 mm grains is allowed. It is good bedding material.

Category III
Fine grade sands, clayey gravels, mixtures of fine sand, clayey sand or gravel and clay. This category also includes silty gravels and mixtures of: gravel – sand – particulates, gravel – sand – silt, silty sand – sandy particulates. A maximum of 5% of 0.02 mm grains is allowed. It is moderately good bedding material.

Infiltration systems should not be installed in soils belonging to category IV and V. Such soils should also not be used for sidefill.

11.11. Sidefill compaction

Ground compaction in the tank area and the selection of soils suitable for compaction should comply with PN-ENV 1046.

The degree of compaction, with relation to the stability of the structure, depends on the load conditions:

- under yards, car parks (road traffic):
- the required degree of sidefill compaction is min. 97% SPD*, recommended: 98 – 100%
- without road traffic:
- the required degree of sidefill compaction is 95% SPD
- for elements with a cover layer of up to 3 m the sidefill should be compacted to min. 97% SPD*
- higher degrees of compaction may be used e.g. due to requirements regarding the surface structure.

) Standard Proctor Density

In the absence of detailed information regarding natural soil, it is usually assumed that its consolidation coefficient is between 91% and 97% of Standard Proctor Density (SPD).
In areas with road traffic a high (H) degree of compaction should be used. It is not recommended to use a low (L) degree of compaction for group 4 or 3 soils without road traffic.
Table 3 shows the maximum layer thickness and the number of passes required to reach a specified degree of compaction for various type of compacting equipment and backfill material. It also shows the minimum thickness of the cover layer above the pipe before using appropriate compacting equipment above the boxes.

Degree of soil compaction for various compaction classes

Compaction degree	Description			Backfill material group			
	English	French	German	4 SPD %	3 SPD %	2 SPD %	1 SPD %
Low (L) Medium (M) High (H)	Not Moderate Well	Non Modéré Soigné	Nicht Mäßig Gut	75 to 80 81 to 89 90 to 95	79 to 85 86 to 92 93 to 96	84 to 89 90 to 95 96 to 100	90 to 94 95 to 97 98 to 100

Compaction index

Description	Compaction index			
Standard Proctor Density [%]	≤ 80	81 - 90	91 - 94	95 - 100
Blow sieve number	0 - 10	11 - 30	31 - 50	> 50
Expected degree of consolidation in compaction classes	Low (L)			
		Medium (M)		
			High (H)	
Granular soil	loose	moderately compacted	compacted	heavily compacted
Cohesive and organic soil	soft	compact	stiff	hard

Recommended layer thickness and number of compaction passes

Equipment	Number of passes for compaction classes		Maximum layer thickness, after compaction for soil group				Minimum thickness above top of box before compaction
	Good	Moderate	1	2	3	4	m
Foot or hand operated rammer min. 15 kg	3	1	0.15	0.10	0.10	0.10	0.20
Vibratory rammer min. 70 kg	3	1	0.30	0.25	0.20	0.15	0.30
Vibratory Plate min. 50 kg min. 100 kg min. 200 kg min. 400 kg min. 600 kg	 4 4 4 4 4	 1 1 1 1 1	 0.10 0.15 0.20 0.30 0.40	 -- 0.10 0.15 0.25 0.30	 -- -- 0.10 0.15 0.20	 -- -- -- 0.10 0.15	 0.15 0.15 0.20 0.30 0.50

11.12. Example resistance calculations

Pipelife can also perform resistance calculations for boxes stacked under various load conditions according to the methodology of ATV-DVWK-A-127.

Such load calculations assume a long time period of 50 years and take into account the safety factor, everyday load frequency and average stiffness modules of the materials used. For other values please contact Pipelife for resistance calculations.

Maximum short-term resistance is:
- 579 kN/m² to vertical loads
- 134 kN/m² to lateral loads

Maximum long-term resistance is:
- 100 kN/m² to vertical loads
- 23 kN/m² to lateral loads

Conclusions:
Stormbox units may be installed under a cover layer of at least 0.8 m for HGV traffic load of SLW 40, SLW 60 assuming ground compaction of at least 95% and appropriate surface structure (at least 40 cm).

Example calculations for various box arrangement conditions

Height			Soil parameters		Traffic load	Surface structure	Vertical load [kN/m²]	Horizontal load [kN/m²]
h_p [m]	h_s [m]	h_d [m]	Sidefill type	Standard Proctor Density [%]				
1.0	1.82	2.8	G1	95	SLW 60 (60 t)	Asphalt h_1 = 0.2 m, E_p = 13,000 MPa, rockfill with cement h_2 = 0.2 m, E_p = 12,500	54	10
1.8	1.82	3.62	G1	95	SLW 60 (60 t)	Asphalt h_1 = 0.1 m, E_p = 13,000 MPa, rockfill with cement h_2 = 0.3 m, E_p = 12500 MPa	67	13
0.8	1.82	2.62	G1	95	SLW 40 (40 t)	Asphalt h_1 = 0.2 m, E_p = 13,000 MPa, rockfill with cement h_2 = 0.2 m, E_p = 10000 MPa	45	9
2.18	1.82	4.0	G1	97	SLW 40 (40 t)	Asphalt h_1 = 0.2 m, E_p 13,000 MPa, rockfill with cement h_2 = 0.2 m, E_p = 10,000 MPa	66	13
0.8	1.82	2.62	G1	95	SLW 30 (30 t)	Asphalt h_1 = 0.1 m, E_p = 10,000 MPa, rockfill with cement h_2 = 0.2 m, E_p = 8,000 MPa	46	9
0.5	1.82	2.32	G1	95	LKW 12 (12 t)	Concrete h_1 = 0.1 m, E_p = 15,000 MPa	64	9
2.48	1.82	4.3	G1	95	none	Green area	60	13

h_p – depth of cover layer above boxes [m]
h_s – height of boxes [m]
h_d – depth of the bottom of the box modules [m]
G1 – non-cohesive (sandy) soils

12. Design guidelines

12.1. Hydraulic conductivity

It is a property of rock and soil that describes the ease with which water in laminar flow can move through porous substances. The percolation occurs through a network of channels made up of soil pores.

The soil resists the percolating water; the degree of resistance and the hydraulic conductivity depend on the soil properties:
- type of soil medium
- porosity
- granulation
- soil structure
- properties of the percolating liquid – viscosity.

Determining hydraulic conductivity

1. Empirical formula method
Requires data on the granulometric composition of the soil, the granulation chart and the porosity value. This method gives approximate results.

2. Constant hydraulic gradient measurement
The test involves percolating water through a sample of known geometric dimensions and measuring the flow rate and the hydraulic gradient. Hydraulic conductivity is determined using Darcy's equation:

$$k = \frac{Q}{F * I}$$

where:
Q – flow rate
F – cross-sectional area
I – hydraulic gradient

3. Field method (percolation test)
The test involves measuring the amount of time needed for the water level to drop in a presoaked hole 15 cm in diameter and 30 cm in height.

12.2. Determining the infiltration suitability of soil

The infiltration suitability of soil should be determined based on geotechnical tests of the soil, establishing the hydraulic conductivity of the soil and the groundwater level. Soil permeability may be initially assessed by means of a percolation test according to local or American methodology (EPA).

1. Percolation test – Polish method
At the appropriate depth, at the level of the ground plates, make a hole 30 cm x 30 cm in cross-section and 15 cm deep. Presoak the soil with water.

In case of sandy soils several buckets will suffice. On soils with low permeability, the presoaking may take several hours. Pour 12.5 dm³ of water into the hole and measure the percolation rate, expressed in minutes. Based on the percolation time it is possible to assess the soil category and its suitability for infiltration.

1

Soil classification and properties			
percolation rate of 12,5 dm³ of water [min.]	permeability [min./cm]	soil category	soil category
< 20	< 1.4	sandy gravel, gravel, coarse sand	A – very good permeability
20 - 30	1.4 - 2.1	medium and fine sand, clayey sand	B – good permeability
30 - 180	2.1 – 12.8	sandy clays	C – moderate permeability
> 180	> 12.8	clay or silt with a small amount of sand	D – low permeability

2. Percolation test – EPA (American) method
A hole 15 cm in diameter is filled with water to the height of 30 cm. After presoaking (similar to the Polish method) the drop in water level from 30 cm to 27.5 cm is timed. The percolation rate, measured in min./25 mm, is the basis for determining permeability and filtration rate.

12.3. Hydraulic conductivity for various types of soil

3. Hydraulic conductivity
In order to be suitable for rainwater infiltration, hydraulic conductivity of the soil must be 10^{-3} m/s – 10 m/s.

12.4. Guidelines on rainwater infiltration into the ground

Infiltration systems are usually designed without drainage. It is possible, however, for the infiltration system to be equipped with an emergency overflow, through a settling chamber to another receptacle of rainwater, such as a rainwater drainage system. Soil permeability, tank depth, number and thickness of drainage layers underneath and around the box system and groundwater level are particularly important when designing a solution of this type.

The useful volume of the box system should be chosen based on the least favourable conditions, in practice for precipitation lasting from 15 min to 360 min. The amount of precipitation should be based on actual precipitation in the given region (data from the Institute of Meteorology and Water Management).
Infiltration systems should be able to contain rainwater from the planned catchment area. The first wave of water from the drainage area contains the most impurities. For that reason a chamber with a settling tank should be installed upstream of the infiltration system in order to capture mineral impurities.
When draining car parks and roads, the infiltration system should be protected from an influx of excessive amounts of petroleum derivatives by the use of a hydrocarbon separator.

2

Water percolation rate [min./25 mm]	Soil type	Permeability [min./cm]	Filtration rate [cm/h]
< 1	Gravel	< 0.4	< 150
5	Sand	2	30
10	Fine sand	4	15
15	Clayey sand	6	10
20	Sandy clay	8	7.5
30	Clay	12	5
40	Clay	16	3.75
80	Heavy silty clay	32	1.875
120	Very heavy clay	48	1.25
> 120	Silt	> 48	> 1.25

3

Permeability type	Hydraulic conductivity			Permeability coefficient
	[m/s]	[m/h]	[m/d]	[Darcy]
Very good: rockfill, gravel, coarse and uniform sand	> 10^{-3}	> 3.6	> 86.4	> 100
Good: non-uniform and medium sand	10^{-4} - 10^{-3}	0.36 - 3.6	8.64 - 86.4	10 - 100
Medium: fine sand, loess	10^{-5} - 10-4	0.036 - 0.36	0.864 - 8.64	1 - 10
Poor: silty and clayey sand, loam, sandstone	10^{-6} - 10^{-5}	0.0036 - 0.036	0.0864 - 0.864	0.1 - 1
Semipermeable rock: clay, aggregate mud, mudstone, sandy silt	10^{-8} - 10^{-6}	0.000036 - 0.0036	0.000864 - 0.0864	0.001 - 0.1
Impermeable rock: silt, claystone, compact silty clay, silty marl	<10^{-8}	< 0.000036	< 0.000864	< 0.001

Pazdro Z., Kozerski B., Hydrogeologia ogólna, Warszawa, Wydawnictwa Geologiczne, 1990

12.5. Dimensioning guidelines

For hydraulic calculations, Pipelife used precipitation data from local weather institutes and weather stations. The absorption system should be chosen based on the accepted rainfall intensity for a given region. The retention and infiltration system must have appropriate storage capacity to hold the water until it infiltrates into the ground.

Note

When dimensioning the system, make calculations for the given exceedance probability from p=2÷10 years for all rainfall durations from 15 minutes to 360 minutes. Then find the critical rainfall intensity and duration for which the retention capacity will be largest. You should limit your calculations, e.g. to just one rainfall duration of 15 minutes and one rainfal intensity of 131 dm_3/s.ha only when local authorities require this.

According to ATV-A 117 and ATV-A 138, the maximum capacity of a retention tank must be chosen based on rainfall intensity and duration, so as to ensure reliability of the system in case of an overload.

The following data is needed to calculate tank dimensions:
- type and area of the drained surface [m^2]
- type of soil and its hydraulic conductivity [m/s]
- initial size of the trench, installation depth etc.

12.6. Precipitation regions

Before beginning the design of an infiltration system it is necessary to determine the purpose of the system:

- infiltration of water into the ground
- retention of water
- holding the first wave of runoff

The retention and infiltration system must have appropriate storage capacity to hold the water until it infiltrates into the ground. Recommendations for road drainage are usually based on a 15-minute design rainfall. It is a reliable criterion e.g. for bypass separators, but not for retention and infiltration systems.

When calculating tank dimensions, it is necessary to take into account precipitation lasting from 15 to 360 minutes, for which the required size of the box module is largest (for the critical time and intensity of rainfall).

12.7. Probability of precipitation

According to ATV A-118 the following rainfall values are accepted:

- p = 100% for rural settlements – 1 in 1 year event
- p = 50% for urban settlements – 1 in 2 year event (taking into account flooding)
- p = 20% for objects in town centres and manufacturing and service centres – 1 in 5 year event (not taking into account flooding)
- p = 10% for particularly important objects, e.g. underground facilities, low-level parts of commercial centres – 1 in 10 year event

The system must not be overloaded by the chosen design rainfall. In urban settlements the flooding frequency is once every 20 years (1 in 20 year event), in town centres once every 30 years (1 in 30 year event), and for underground facilities it is once every 50 years (1 in 50 year event).

Methods of preventing the overload of retention tanks (in case of selection for short rainfall duration):

- water flowing out to the surface, with appropriate modulation,
- water elevation in the system over a short period of time,
- water flowing out into a ditch or basin and directed to a receptacle,
- connection to a receptacle through an overflow chamber with backwater protection.

When designing underground rainwater infiltration and storage systems, emergency overflow should be planned. The overflow protects the system from an overload caused by rainfall heavier than the value assumed for calculation purposes, with an appropriate exceedance probability.
The level of reliability should be increased in underground infiltration systems located in industrial areas which are subject to additional contamination hazards. Such is the case where there is a risk of malfunction related to the leaking of petroleum derivatives or chemicals. Such surfaces should be isolated using special treatment devices, e.g. control chambers, hydrocarbon separators and light fluid separators. Valves may be installed between devices to cut off the flow if necessary. Tanks to collect the excess of contaminated water should be planned as needed.

12.9. Calculating the amount of runoff from a given catchment area

$$Q = F \cdot \psi \cdot q \ [dm^3/s]$$

where:
Q – amount of rainfall [dm^3/s]
F – size of catchment area [ha]
ψ – surface runoff coefficient
q – intensity of design rainfall [dm^3/s • ha]

The surface runoff coefficient ψ indicates the ratio of runoff from a given area to rainfall onto the same area ($\psi < 1$).

Runoff coefficient values for various surfaces

Surface type	Runoff coefficient ψ
Roofs:	
– sloping: ceramic, metal, glass, concrete	0.95
– sloping: roofing felt, brick	0.9
– flat (up to 3° or approx. 5%): metal, glass, concrete	0.95
– flat (up to 3° or approx. 5%): roofing felt	0.9
– green (sloping up to 15°): humus depth < 10 cm	0.5
– green (sloping up to 15°): humus depth > 10 cm	0.3
Asphalt roads	0.9
Block paving, narrow joints	0.8
Openwork paving, wide joints	0.5
Flat surfaces without gravel	0.75
Flat surfaces with gravel	0.55
Loose gravel	0.3
Green surfaces	0.2
Unpaved surfaces	0.15
Parks and gardens	0.1

In case of surfaces with different runoff coefficients, it is possible to determine the so-called substitution coefficient for the whole catchment area.

$$\psi_z = \frac{\psi_1 \cdot F_1 + \psi_2 \cdot F_2 + \ldots + \psi_i \cdot F_i}{F_1 + F_2 + \ldots + F_i}$$

where:
ψ_z – substitution surface runoff coefficient
ψ_i – runoff coefficient for the ith component surface
F_i – size of the ith component surface

12.12. Calculating the amount of outflow in a system for holding the first wave of runoff

The necessary tank capacity can be calculated using the following equation:

Calculations should assume precipitation amounts of at least 25 mm. The correct amount can be found in the tables in point 12.10, taking into account long-term rainfall (central region) and the correct return period in years.

$$V_{st} = P \cdot F \cdot \psi \ [m^3]$$

where:
V_{st} – retention volume of the first wave of runoff [m^3]
P – amount of precipitation [m]
F – size of catchment area [m^2]
ψ – surface runoff coefficient

For the given retention capacity for the first wave of runoff, you can calculate the necessary number of Stormbox units using the following equation:

$$n = \frac{V_{st}}{V_{s\ net}} \ [pcs]$$

where:
n – number of boxes
V_{st} – retention volume of the first wave of runoff [m^3]
$V_{S\ netto}$ – net Stormbox capacity [m^3] equal to 0.206

EXAMPLE:

Given:
F = 500 m^2
P = 0.029 m (for the central region and duration of 360 min. with the probability p = 2 years)

$$V_{st} = 0.029 \cdot 500 = 14.5 \ m^3$$

$$n = \frac{14,5}{0,206} = 70,4 \approx 71 \ pcs.$$

To hold the first wave of runoff, you need 71 Stormbox units.

Tank capacities calculated using the first wave of runoff holding method – P = 50% (2 years)

Duration of rainfall t [min]	Amount of pre-cipitation [mm]	Tank capacity and number of boxes	Drainage area [m²], ψ = 1									
	P = 20% (5 years)		100	200	300	400	500	600	700	800	900	1000
15	13.0	Volume [m³]	1.3	2.6	3.9	5.2	6.5	7.8	9.1	10.4	11.7	13.0
		Number of boxes [pcs]	7.0	13.0	19.0	26.0	32.0	38.0	45.0	51.0	57.0	64.0
30	16.4	Volume [m³]	1.6	3.3	4.9	6.6	8.2	9.8	11.5	13.1	14.8	16.4
		Number of boxes [pcs]	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0
60	20.0	Volume [m³]	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
		Number of boxes [pcs]	10.0	20.0	30.0	39.0	49.0	59.0	68.0	78.0	88.0	98.0
120	24.1	Volume [m³]	2.4	4.8	7.2	9.6	12.1	14.5	16.9	19.3	21.7	24.1
		Number of boxes [pcs]	12.0	24.0	36.0	47.0	59.0	71.0	82.0	94.0	106.0	117.0
300	28.1	Volume [m³]	2.8	5.6	8.4	11.2	14.1	16.9	19.7	22.5	25.3	28.1
		Number of boxes [pcs]	14.0	28.0	41.0	55.0	69.0	82.0	96.0	110.0	123.0	137.0
360	29.0	Volume [m³]	2.9	5.8	8.7	11.6	14.5	17.4	20.3	23.2	26.1	29.0
		Number of boxes [pcs]	15.0	29.0	43.0	57.0	71.0	85.0	99.0	113.0	127.0	141.0

Duration of rainfall t [min]	Amount of precipitation [mm]	Tank capacity and number of boxes	Drainage area [m²], ψ = 1									
	P = 20% (5 years)		100	200	300	400	500	600	700	800	900	1000
15	19.1	Volume [m³]	1.9	3.8	5.7	7.6	9.6	11.5	13.4	15.3	17.2	19.1
		Number of boxes [pcs]	10.0	19.0	28.0	38.0	47.0	56.0	65.0	75.0	84.0	93.0
30	24.1	Volume [m³]	2.4	4.8	7.2	9.6	12.1	14.5	16.9	19.3	21.7	24.1
		Number of boxes [pcs]	12.0	24.0	36.0	47.0	59.0	71.0	82.0	94.0	106.0	117.0
60	29.3	Volume [m³]	2.9	5.9	8.8	11.7	14.7	17.6	20.5	23.4	26.4	29.3
		Number of boxes [pcs]	15.0	29.0	43.0	57.0	72.0	86.0	100.0	114.0	129.0	143.0
120	35.0	Volume [m³]	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0
		Number of boxes [pcs]	17.0	34.0	51.0	68.0	85.0	102.0	119.0	136.0	153.0	170.0
300	40.1	Volume [m³]	4.0	8.0	12.0	16.0	20.1	24.1	28.1	32.1	36.1	40.1
		Number of boxes [pcs]	20.0	39.0	59.0	78.0	98.0	117.0	137.0	156.0	176.0	195.0
360	41.2	Volume [m³]	4.1	8.2	12.4	16.5	20.6	24.7	28.8	33.0	37.1	41.2
		Number of boxes [pcs]	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0

The calculations have been performed for a runoff coefficient of ψ = 1. For runoff from roofs, roads etc. the volume given in the table should be multiplied for the given surface area and amount of precipitation by the appropriate runoff coefficient value.

Pipelife calculates the tank retention capacity according with ISSO 70-1 and DWA A-117.

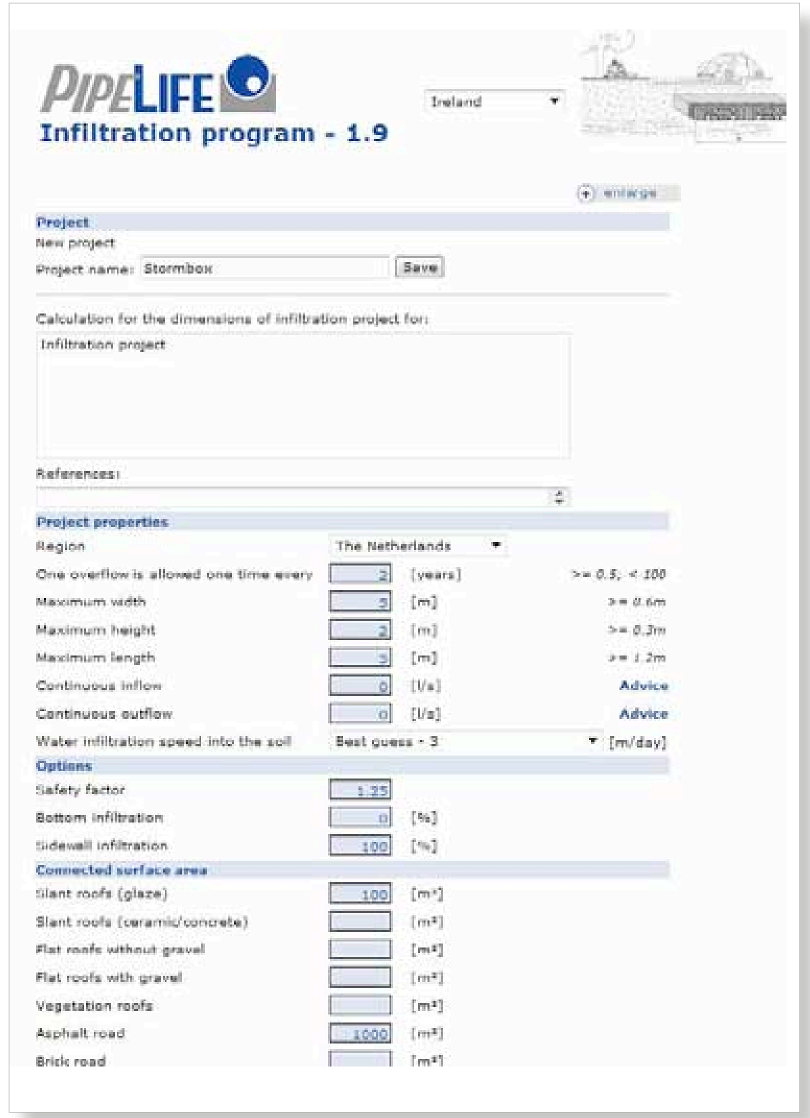
12.13. Calculating the required size of a rainwater infiltration system

Tank dimensions may be calculated e.g. using the following formula according to DWA-A 138:

$$L = \frac{\Sigma(A \cdot \psi) \cdot 10^{-7} \cdot r_{D(n)} \cdot D \cdot 60 \cdot f_z}{(b \cdot h \cdot s_r + (b + (\frac{h}{2})) \cdot D \cdot 60 \cdot f_z \cdot (\frac{k_f}{2}))} \text{ [m]}$$

where:
- L – *length of infiltration boxes [m]*
- A – *surface area [m²]*
- ψ – *runoff coefficient*
- $r_{D(n)}$ – *rainfall intensity [dm³/s · ha]*
- D – *rainfall duration [min.]*
- f_z – *safety factor, f_z = 1,2*
- b – *width of infiltration boxes [m]*
- h – *height of infiltration boxes [m]*
- s_r – *net water capacity factor (for Stormbox s_r = 0,955)*
- k_f – *hydraulic conductivity of the soil [m/s]*

Tank dimensions can also be calculated using the formula given in ISSO 70-1.
Pipelife calculates the required number of boxes assuming infiltration through the bottom and side walls or through side walls only.
The large surface area of side wall openings (approx. 59% of the total surface) ensures very favourable conditions for the infiltration of rainwater. It is possible to check the operation of the system with reduced infiltration through the bottom (in case of poor maintenance of the bottom of the system).



Stormbox system selection program

The program assists in choosing the optimum number of boxes for the planned maximum tank dimensions (L x W x H).

Pipelife can also perform calculations related to the selection of retention tanks or retention and infiltration tanks with a constant outflow through a flow regulator.

Stormbox volume depending on tank size

Number of boxes / length	Length	Net volume of Stormbox infiltration boxes in a single layer [m³]. Number of boxes [pcs] / width [m]									
		1	2	3	4	5	6	7	8	9	10
[pcs]	[m]	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0
1	1.2	0.206	0.412	0.618	0.824	1.030	1.236	1.442	1.648	1.854	2.060
2	2.4	0.412	0.824	1.236	1.648	2.060	2.472	2.884	3.296	3.708	4.120
3	3.6	0.618	1.236	1.854	2.472	3.090	3.708	4.326	4.944	5.562	6.180
4	4.8	0.824	1.648	2.472	3.296	4.120	4.944	5.768	6.592	7.416	8.240
5	6.0	1.030	2.060	3.090	4.120	5.150	6.180	7.210	8.240	9.270	10.300
6	7.2	1.236	2.472	3.708	4.944	6.180	7.416	8.652	9.888	11.124	12.360
7	8.4	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442
8	9.6	1.648	3.296	4.944	6.592	8.240	9.888	11.536	13.184	14.832	16.480
9	10.8	1.854	3.708	5.562	7.416	9.270	11.124	12.978	14.832	16.686	18.540
10	12.0	2.060	4.120	6.180	8.240	10.300	12.360	14.420	16.480	18.540	20.600
11	13.2	2.266	4.532	6.798	9.064	11.330	13.596	15.862	18.128	20.394	22.660
12	14.4	2.472	4.944	7.416	9.888	12.360	14.832	17.304	19.776	22.248	24.720
13	15.6	2.678	5.356	8.034	10.712	13.390	16.068	18.746	21.424	24.102	26.780
14	16.8	2.884	5.768	8.652	11.536	14.420	17.304	20.188	23.072	25.956	28.840
15	18.0	3.090	6.180	9.270	12.360	15.450	18.540	21.630	24.720	27.810	30.900
16	19.2	3.296	6.592	9.888	13.184	16.480	19.776	23.072	26.368	29.664	32.960
17	20.4	3.502	7.004	10.506	14.008	17.510	21.012	24.514	28.016	31.518	35.020
18	21.6	3.708	7.416	11.124	14.832	18.540	22.248	25.956	29.664	33.372	37.080
19	22.8	3.914	7.828	11.742	15.656	19.570	23.484	27.398	31.312	35.226	39.140
20	24.0	4.120	8.240	12.360	16.480	20.600	24.720	28.840	32.960	37.080	41.200

Note

Boxes are a more modern and more efficient water infiltration solution than e.g. concrete soakways or collector pipes. The net capacity of an infiltration box is 206 dm³; that is 3 times more than a drainage ditch filled with rockfill. One box can replace approx. 1200 kg of rockfill (approx. 0.69 m³) with the storage factor of 30%. To achieve the same capacity as a box, a rockfill trench would have to be 3 times longer, with the dimensions 0.6 m x 0.3 m x 3.8 m. An infiltration box can replace approx. 32 m of a 100 mm PVC-U collector pipe.

12.14. Example calculations of the required number and volume of boxes

The following calculations assume rainfall duration of 15 min to several hours, with rainfall probability of 1 in 2 years.

North-west region of Poland

Soil type	Average soil permeability coefficient k		Volume and number of boxes	Roof drainage area [m2], □ = 0.95				
	[m/s]	[m/d]		100	150	200	250	300
Coarse sand	10-3	86.4	Net volume [m3]	0.41	0.62	0.82	1.03	1.24
			Number of boxes [pcs]	2	3	4	5	6
Medium sand	5▪10-4	43.2	Net volume [m3]	0.62	1.03	1.24	1.65	2.06
			Number of boxes [pcs]	3	5	6	8	10
Fine sand	5▪10-5	4.32	Net volume [m3]	1.65	2.47	3.09	4.12	4.94
			Number of boxes [pcs]	8	12	15	20	24
Silty or clayey sand	5▪10-6	0.432	Net volume [m3]	2.88	4.12	5.77	7.21	8.65
			Number of boxes [pcs]	14	20	28	35	42
Clay. silt	< 10-8	< 8.6▪10-4	Net volume [m3]	Infiltration not possible				
			Number of boxes [pcs]					

The calculation of number of boxes is approximate. To obtain accurate calculations, please contact Pipelife Customer Service Department.

13. Operation of the infiltration system

An infiltration system should undergo periodic inspections. Settling chambers must be checked for the amount of debris collected. It is recommended that the chambers should be inspected every six months and the collected debris periodically removed.
Stormbox infiltration boxes have 6 inspection openings 110, 160 mm in diameter and 2 openings 110, 160 and 200 mm in diameter to enable the insertion of cleaning equipment and CCTV.

Underground infiltration systems require periodic inspections – at least once a year.
Such inspections should be carried out before periods of frost.

Underground systems should be for example:

- Protected from leaves and other debris,
- Kept at a suitable distance from trees (to protect the boxes from damage by developing root systems),
- Infiltration boxes should be rinsed,
- Mechanical pre-treatment devices should undergo maintenance. Approx. every 6 months check the amount of debris in the setting tank and remove as necessary.

13.2. Operation in winter

Underground rainwater infiltration systems are generally resistant to reduced infiltration in winter. Minimum cover layer above the boxes should be preserved, according to the ground freezing depth in the area. Additionally boxes are covered with a layer of LECA at least 20 cm in depth.
The risk of flooding in freezing temperatures is slight, as torrential rains very rarely fall on frozen ground. The maximum rate of snow melting is 2 mm/h, much less than the runoff of a standard design rainfall.

14. Standard requirements

The following requirements should be met when installing Stormbox infiltration systems:

- **PN-EN 1610:2002** Construction and inspection of sewage systems;
- **PN-ENV 1046:2007** Plastic pipeline systems – Outdoor water and sewage systems – Overground and underground installation practices;
- **PN-EN 1295-1:2002** Static calculations for ground-buried pipelines at various load conditions. Part 1: General requirements;
- **PN-B-10736:1999** Ground work. Open excavations for water and sewage systems. Technical conditions of work;
- **"Technical conditions of the construction and commissioning of sewage systems"**. Technical requirements of COBRTI INSTAL. Booklet 9. Editor: COBRTI INSTAL/Information Centre. Installation Technology in Construction, June 2003
- **ATV-A 118E** "Hydraulic Dimensioning and Verification of Drainage Systems".
- **DWA-A 138** "Planung, Bau und Betrieb von Anlagen zur Versickerung von Niederschlangswasser".
- **DIN 1989-1** "Rainwater harvesting systems – Part 1: Planning, installation, operation and maintenance".
- **DIN 1989-3** "Rainwater harvesting systems – Part 3: Collecting tanks for rainwater".
- **ISSO 70-1** "Omgaan met hemelwater binnen de perceelgrens".
- **BRL 52250** "Kunststof infiltratiesysttemen voor hemelwater".
- **DWA A-117** Bemessung von Regenrückhalterăumen.
- Regulation of the Minister of Transport and Marine Economy of 2 March 1999 on the technical conditions to be fulfilled by public roads and their location (Poland)

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