



# BIOSWALE



ADDRESSED HAZARDS



PROTECTED CRITICAL INFRASTRUCTURE


[WWW.NATURE-DEMO.EU/](http://WWW.NATURE-DEMO.EU/)


**Constructed Swale in USM Engineering Campus**

Image Credit: [Ngai Weng Chan/Universiti Sains Malaysia], [2020]. Used with permission

## Primary functions and key services

(Anbumozhi et al., 2005; Castelle et al., 1994; Cole et al., 2020)

- **Soil moisture retention:** bioswales capture runoff and allow it to percolate into the soil, this allows to prevent minor flooding affecting critical infrastructure such as local roads and neighbourhoods (Woods-Ballard et al., 2007).
- **Water infiltration:** bioswales slow down water flow, allowing it to gradually soak into the soil while preventing that conventional drainage system over-exceeds its capacity.
- **Erosion control:** bioswales reduce surface erosion by slowing water movement and stabilising soil, preventing erosion processes in the receiving bodies, such as grey water infrastructure.
- **Groundwater recharge:** bioswales increase water infiltration, which helps replenish groundwater levels.

## Environmental impacts (EU taxonomy)

- Climate change mitigation
- Climate change adaptation
- Sustainable use and protection of water and marine resources
- Transition to a circular economy
- Pollution prevention and control
- Protection and restoration of biodiversity and ecosystems.

## Main components

- **Shallow ditches or trenches:** a linear trench or ditch, designed with a gentle slope (longitudinal cross-section) for water release. Side slopes in the transversal section allow for water capture. Bioswales are dug on contour (perpendicular to the slope) so that water can flow across the land instead of downhill.
- **Vegetation cover:** planted with grasses, shrubs, or other species that are tolerant to both drought and water-logged conditions. Species support soil stabilisation, erosion control, and pollutants filtering.
- **Infiltration basin (optional) and Mounds or berms:** a small basin in the end of the swale, and soil from the trench is sometimes piled on the downhill side.

## What is it?

**Bioswales** are a linear rainwater run-off retention system designed as a shallow, gently sloping non-concrete channel (allowing for water infiltration). This system basically captures, retains and slowly releases the water run-off and direct rainwater into a conventional piping drainage system and/or the air (evapotranspiration) and soil (infiltration) media. Bioswales are often planted with grasses or other vegetation to further aid in water retention, evapotranspiration, soil stabilisation and phyto-remediation (enhancing the removal of common pollutants carried by stormwater runoff). Bioswales are often conceived as a linear element integrated to one or both sides of a roadway, in an urban and rural environment, ear performing as a sustainable urban drainage system for conveying and treating the sub-catchment and roadway runoff (Chan et al., 2019, Ekka et al., 2021; Lu et al. 2024; Woods-Ballard et al., 2007).

## Challenges this NbS addresses

- **Drought** – prevention and mitigation
- **Flood** – reduction
- **Stormwater runoff** – treatment
- **Heatwaves** – reduction

## Site suitability, scale and coverage

Rural, peri-urban or urban regions characterised by minor flooding challenges and suitable for implementation of decentralised NbS systems for water runoff retention/ storage and potential reuse. Its suitability is clearly enhanced by the below reasons (Lu et al. 2024):

- **Flexible system:** adaptable design allows customisation to fit various site conditions, sizes, and purposes, including shape, depth, and planting schemes to accommodate different landscapes and needs.
- **Tailored to local characteristics:** the system can be designed and implemented based on local environmental conditions, such as soil type, climate, and hydrology, ensuring effective stormwater management while supporting local biodiversity and meeting community needs (Lu et al. 2024).
- **Minimal land take:** requires relatively small areas, allowing them to be integrated into existing landscapes without significant land use changes, especially for urban settings where space is limited.

## Ecosystem services

- ▶ **Increased soil moisture:** enhance soil moisture, especially useful in agricultural areas and landscapes prone to drought. (Lu et al. 2024).
- ▶ **Biodiversity:** provide habitat for small wildlife and beneficial insects in vegetated areas.
- ▶ **Improved water quality:** filter pollutants from surface runoff, improving the quality of water that enters groundwater sources.
- ▶ **Soil health maintenance:** enhances soil fertility and structure, supporting long-term agricultural productivity.
- ▶ **Carbon sequestration:** small vegetation of swales contribute to capturing and sequestering moderate amounts of CO<sub>2</sub>.



## ▼ Cost-benefit profile

The cost of implementing a Sustainable urban Drainage Solution (SuDS) scheme is typically similar to the equivalent conventional drainage system, but SuDS costs can be weighed against the various benefits that they provide – although many of these benefits are likely to accrue to society. In addition to capital costs, SuDS require routine monitoring, maintenance and long-term operating finance streams. It is recommended that a whole life cost approach is taken to scheme costing, which involves estimating present day value of total costs of the structure throughout its likely operating life. The inclusion of monitoring and management plans is crucial to reduce uncertainties. Benefits should accrue throughout the lifetime of a SuDS scheme and may not be realised immediately following construction, so any economic appraisal that quantifies both costs and benefits needs to adopt a long-term approach. Construction costs should include:

- 1 The cost of erosion and sediment control during construction.
- 2 Material costs.
- 3 Construction (labour and equipment costs).
- 3 Planting and landscaping costs.

The cost of constructing a SuDS scheme is inherently variable and will depend heavily on the size of the contributing catchment area (as well as other factors such as soil type and the needs for excavation, groundwater vulnerability, the need for installing an impermeable geomembrane, and the inlet/outlet hydraulic controls among other design features) (Woods-Ballard et al., 2007).

Bioswales require regular maintenance, including vegetation management and sediment removal. Annual maintenance costs have been estimated at €0.37 per connected square meter (including taxes, based on 2005 prices), compared to €0.26 per square meter for conventional systems. It's noteworthy that some maintenance activities overlap with general green space upkeep, potentially offsetting additional expenses (Urban Green Blue Grids, n.d.).

A bioswale implemented at the SPICE Home shopping centre parking lot in Riga, Latvia, had a total construction cost of approximately €50,000. Additionally, per connected square meter, bioswales have been reported to cost around €5.17 (including taxes, based on 2005 prices), compared to conventional sewer systems at €8.97 per square meter (AQUARES, Interreg Europe, 2020). Panduro et al., (2024) studied the cost-effectiveness of urban NbS in a stepwise ranking approach.

Bioswales costs:

CAPEX: average construction cost for swales was EUR 70/m<sup>2</sup>

OPEX: average maintenance cost in EU was EUR 0.52/m<sup>2</sup> (Panduro et al., 2024)



Left - **Bioswale**

Image Credit: [IRIDRA], [2022],  
Used with permission

Right - **Geographic location and Setup overview of site Bioswale example 2**

Image Credit: [Xiao, MDPI], [2017].  
Open Access Creative Commons CC 4.0 License;

## Examples of installation

- ▶ **1. Integrated Urban Plan Metropolitan Sponge City** (IRIDRA, 2024)
  - ▶ **Location:** Metropolitan City of Milan, Lombardy Region, Italy
  - ▶ **Implemented by:** Client was Gruppo CAP
  - ▶ **Description and results:** The project 'Integrated Urban CMM Sponge Plans' of the Metropolitan City of Milan, aims at relieving the sewerage network of several municipalities, in order to ensure the proper drainage of rainwater; in particular, IRIDRA designed 26 of the 90 planned interventions in 32 municipalities of the Metropolitan City of Milan. The project chose to propose unconventional solutions belonging to the 'Sustainable Urban Drainage Systems' (SuDS) or 'Nature-Based Solutions' (NbS) families. The solutions identified for the objectives set are solutions that allow easy insertion into the area of interest and the ability to offer multiple ecosystem services; among the proposed solutions are rain gardens, detention basins, drainage trenches, permeable pavements, vegetated ditches and infiltrating geocellular modules. The sum of the surface areas of the SuDS elements of all 26 interventions is 31,019 m<sup>2</sup>, for a total of 6314 m<sup>3</sup> of lamination volume.
- ▶ **2. Bioswale near the Visitor Center of University of California, Davis (CA)** (Lu et al., 2024; Xiao, 2017)
  - ▶ **Location:** Davis, CA, USA
  - ▶ **Implemented by:** Research Institution at University of California, Davis (CA)
  - ▶ **Description and results:** The experimental site for the implementation of bioswale near the Buehler Alumni/Visitor Center, on the University of California Davis CA (United States). The map on the left shows relative geographic location within the state of California. The map on the right shows the experimental setup. 341.1 m<sup>2</sup> experimental site, first used for turfgrass research. Site slightly elevated and gently sloped (~3%) to the northeast for drainage. Surface runoff from the turf grass area passed through the bare soil strip before discharging to an adjacent storm drainage ditch. The study demonstrated the effectiveness of using bioswales to reduce surface runoff, remove pollutants from surface runoff, and support tree growth in an urban landscape. After eight years, the bioswale using engineered soil mixes (ESM) was functioning at the designed capacity and it reduced much more runoff and pollutants when compared with a traditional control plot bioswale using native soil. The study confirms that bioswales with ESM can be a highly effective stormwater management practice in the suite of green infrastructure strategies.



## References

AQUARES, Interreg Europe (2020) Bioswale at the SPICE Home shopping centre parking lot. Retrieved from: <https://www.interregeurope.eu/good-practices/bioswale-at-the-spice-home-shopping-centre-parking-lot> (accessed 10.03.2025)

Chan, N. W., Tan, M. L., Ghani, A. A., & Zakaria, N. A. (2019). Sustainable urban drainage as a viable measure of coping with heat and floods due to climate change. In IOP Conference Series: Earth and Environmental Science (Vol. 257, No. 1, p. 012013). IOP Publishing.

Ekka, S. A., Rujner, H., Leonhardt, G., Blecken, G. T., Viklander, M., & Hunt, W. F. (2021). Next generation swale design for stormwater runoff treatment: A comprehensive approach. Journal of Environmental Management, 279, 111756.

IRIDRA (2024). Portfolio of the most significant projects on NbS for SuDS, climate change adaptation, green infrastructures. Retrieved from: <https://u.pcloud.link/publink/show?code=XZXdtQ5ZncAB4p0pBIFBPSwfmL-6jyatAYG7> (accessed 03.04.2025)

Lu, L., Johnson, M., Zhu, F., Xu, Y., Ruan, T., & Chan, F. K. S. (2024). Harnessing the runoff reduction potential of urban bioswales as an adaptation response to climate change. Scientific Reports, 14(1), 12207. <https://doi.org/10.1038/s41598-024-61878-7>

Panduro, T. E., Nainggolan, D., & Zandersen, M. (2024). Cost-effectiveness analysis of urban nature-based solutions: A stepwise ranking approach. Nature-Based Solutions, 100186.

Urban Green Blue Grids (n.d.). Bioswales. Retrieved from: <https://urbangreenbluegrids.com/measures/bioswales/> (accessed 10.03.2025)

Woods-Ballard, B., Kellagher, R., Martin, P., Jefferies, C., Bray, R., & Shaffer, P. (2007). The SUDS manual (C697). doi: London C697. ISBN: 9780860176978.

Xiao, Q., Mcpherson, E., Zhang, Q., Xinle, Dahlgren, R. (2017). Performance of Two Bioswales on Urban Runoff Management. Infrastructures. 2. 12. 10.3390/infrastructures2040012.