

MASTER THESIS PRESENTATION

Proposing and demonstrating a toolbox for designing Bioswales and evaluating their impact on Sustainability using Building Information Modeling (BIM): a Case study of Breitscheidstrasse, Stuttgart

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Bioswales are shallow, plant-filled channels that help absorb and clean rainwater before it reaches drains.

- Reduce flooding
- Protect city infrastructure from water accumulation
- Filter pollution
- Support greenery in cities
- Reduce the Urban Heat Island effect

Source: Holmes, D., available online at <https://worldlandscapearchitect.com/rainproof-ringsted-solving-the-stormwater-problem-creates-opportunities/?v=5f02f0889301>

Cause:

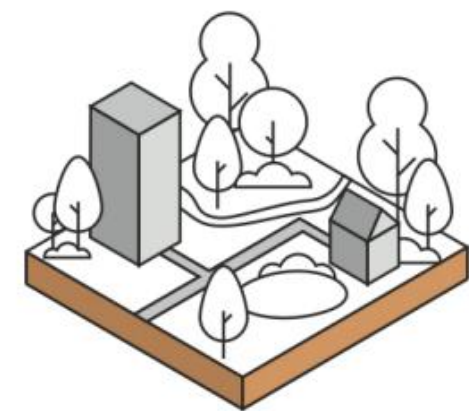
Existing drainage systems failed, leading to catastrophic consequences.

These floods highlight the need for improved stormwater management solutions, such as bioswales, to enhance urban resilience and prevent future disasters.



over 220 deaths
€30 billion in damages

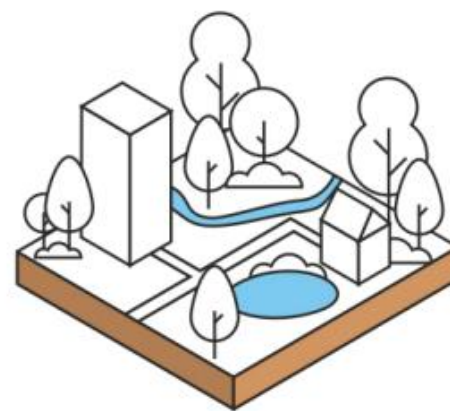
View of Iversheim showing the aftermath of the 2021 floods (Stache and Fassbender, 2022). Available at:
<https://www.theguardian.com/world/2022/jul/13/floods-then-and-now-photographs-germany-ahr-valley-flooding-disaster-july-2021>



GREY INFRASTRUCTURE



GREEN INFRASTRUCTURE



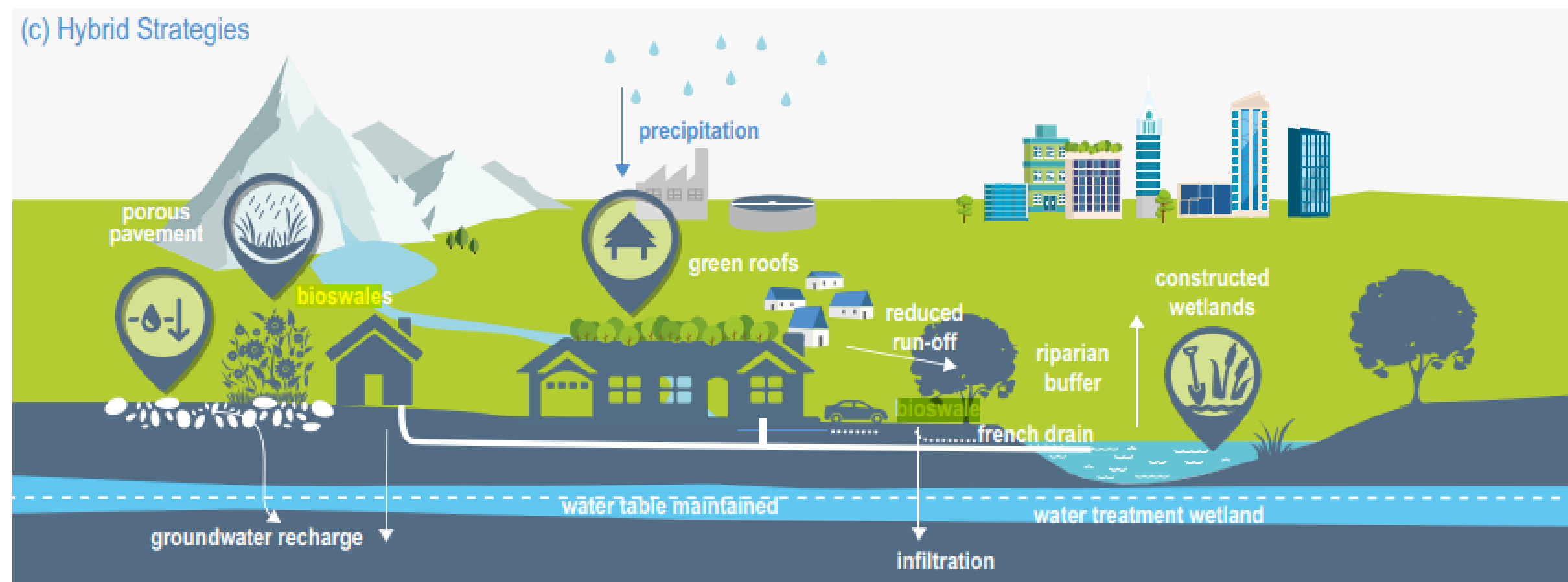
BLUE INFRASTRUCTURE



BLUE-GREEN INFRASTRUCTURE

Source: Concept of blue-green infrastructure (Pochodyła et al., 2021, p. 3).

Blue-Green infrastructure integrates vegetation and water elements in urban environments.



Sustainable Urban Drainage Systems (SuDS) use nature-based methods to manage stormwater, including bioswales, green roofs, permeable pavements, rain gardens, and retention ponds.

Source: Strategies for urban water adaptation. (a) Blue-green Strategies (b) Grey infrastructure Strategies (c) Hybrid Strategies (IPCC, 2022, p.630)

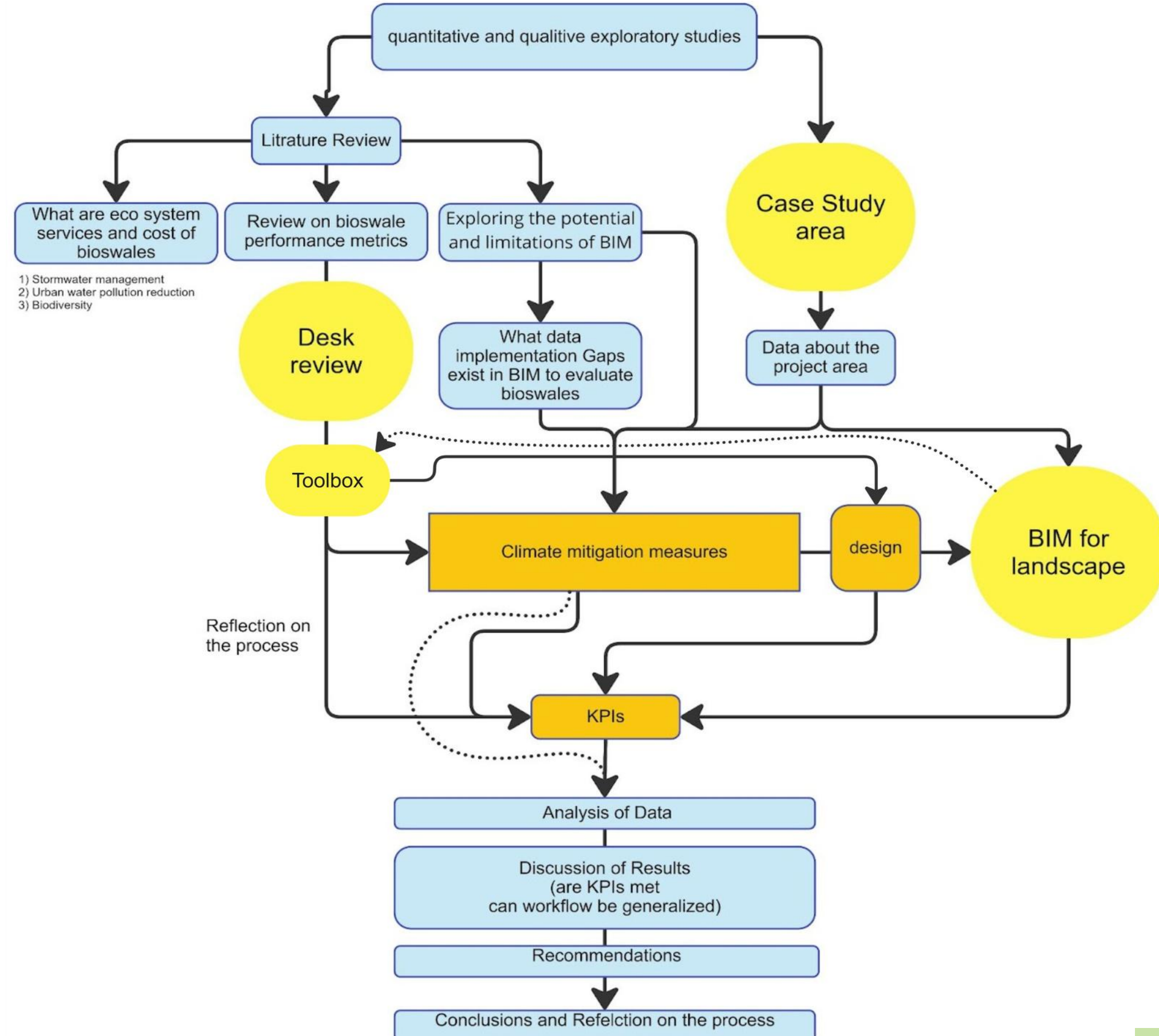
The primary goal of research is to develop a practical toolbox for designing bioswales and evaluating their effectiveness.

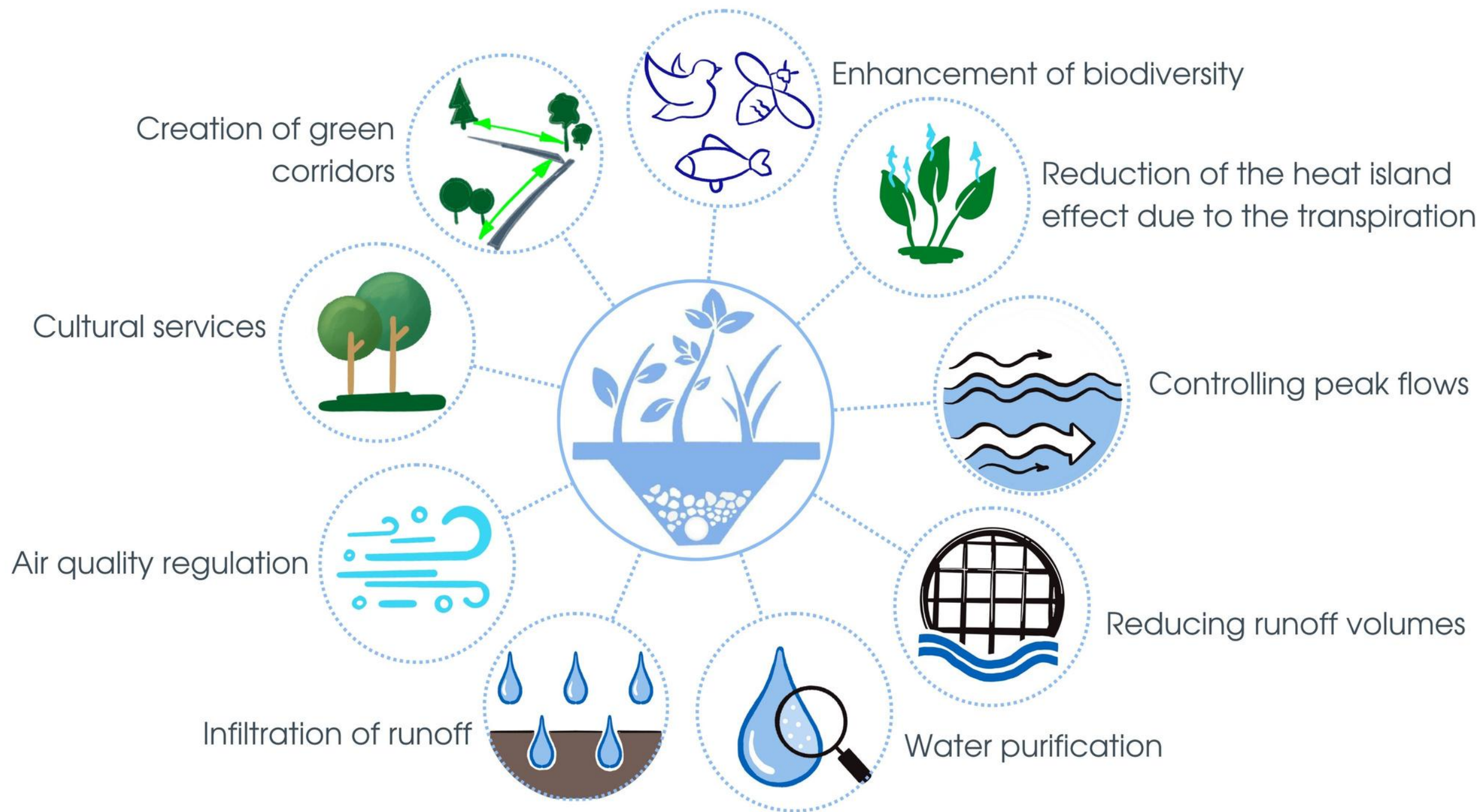
Understanding the benefits and challenges of bioswale integration in urban settings.

Utilizing BIM tools like Civil 3D and InfoDrainage to model and analyze bioswale performance.

Applying this methodology to a real-world case study – Breitscheidstraße, Stuttgart.

Providing recommendations for urban planners, landscape architects.





Key performance metrics
for bioswales

reduction in runoff
infiltration rate
peak flow reduction

Source: Created by Author Mariya Bodylevskaya, 2024

The decision to implement bioswales was based on site-specific characteristics and SuDS ecosystem services data. Bioswales are the most effective solution for local challenges, as they significantly reduce runoff and perform better than other SuDS elements along roads and parking areas.



Source: <https://maps.stuttgart.de>

SuDS ecosystem services data

ECOSYSTEM SERVICE	Green roofs	Retention ponds	Permeable pavements	Bioswales	Rain gardens	Natural Ecosystems	Parks, Urban landscape	Green facades
Cultural and Recreational services								
Erosion control								
Support of the hydrological cycle (regulating service)								
Reduction of the Heat Island Effect due to the transpiration								
Air quality regulation								
Biodiversity								
Insolation								
Water Retention								
Groundwater replenishment/ Infiltration								
Flows reducing runoff volumes								
Water purification								
Creating green corridors								
Water treatment								
Controlling peak flows								

Key ecosystem services provided by various elements of blue-green infrastructure (Created by author Mariya Bodylevskaya, 2025).

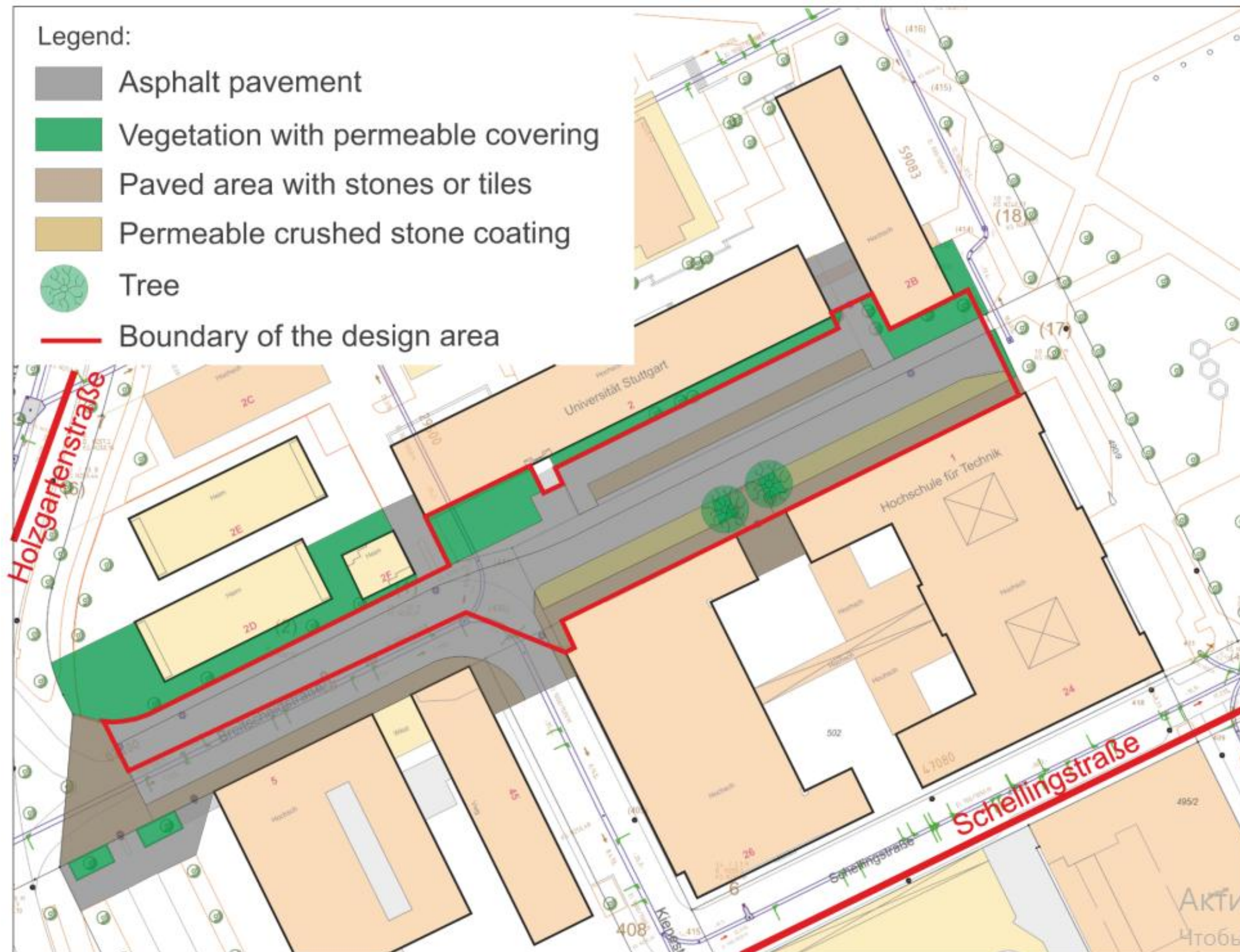
According to the German Weather Service (DWD), heavy rainfall is categorized into three intensity levels:

Rainfall of 15–25 mm in 1 hour or 20–35 mm in 6 hours (Severe weather warning)

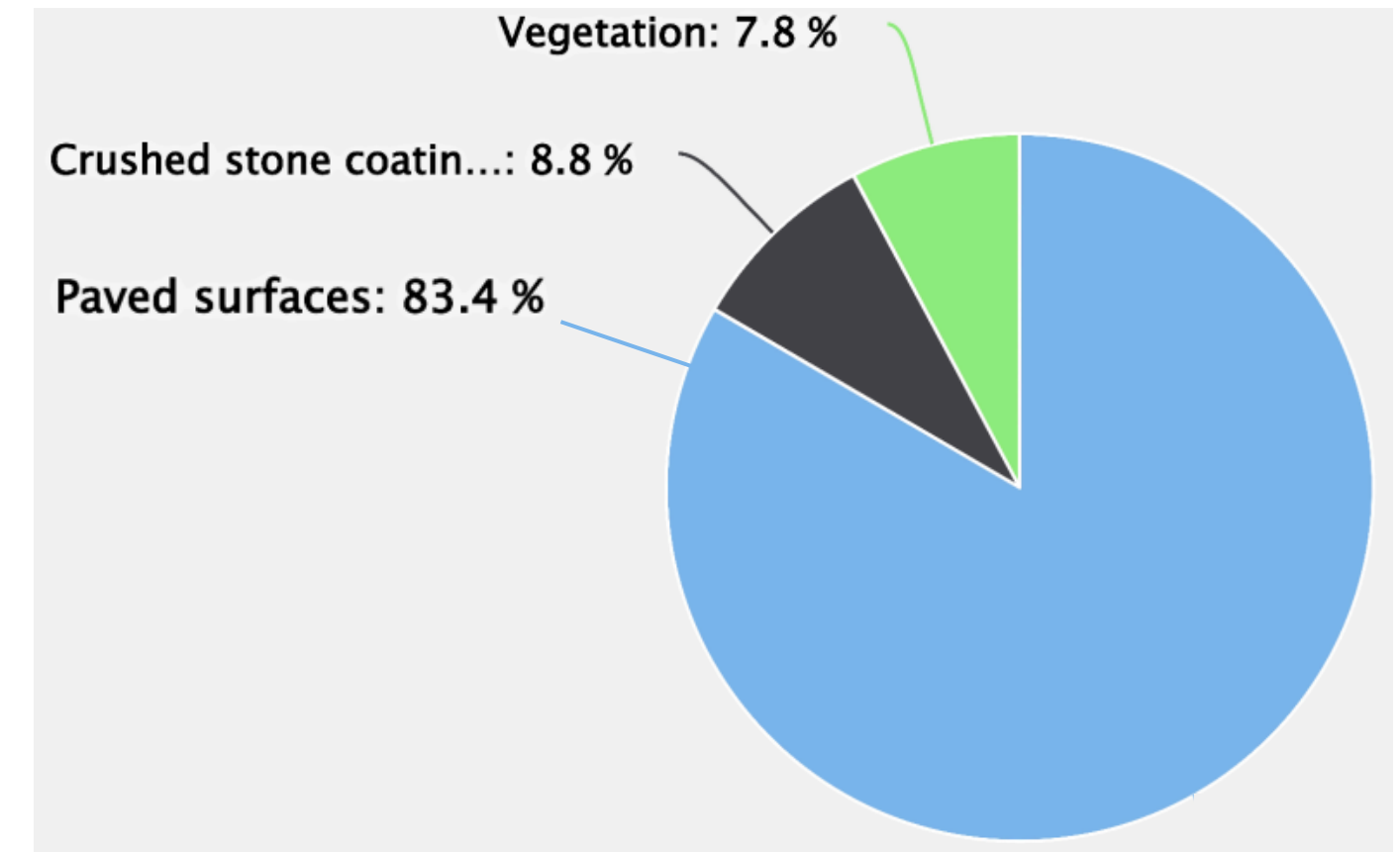
Rainfall of >25–40 mm in 1 hour or 30–60 mm in 6 hours (Storm warning)

Rainfall of >40 mm in 1 hour or more than 60 mm in 6 hours (Warning of extreme weather conditions)

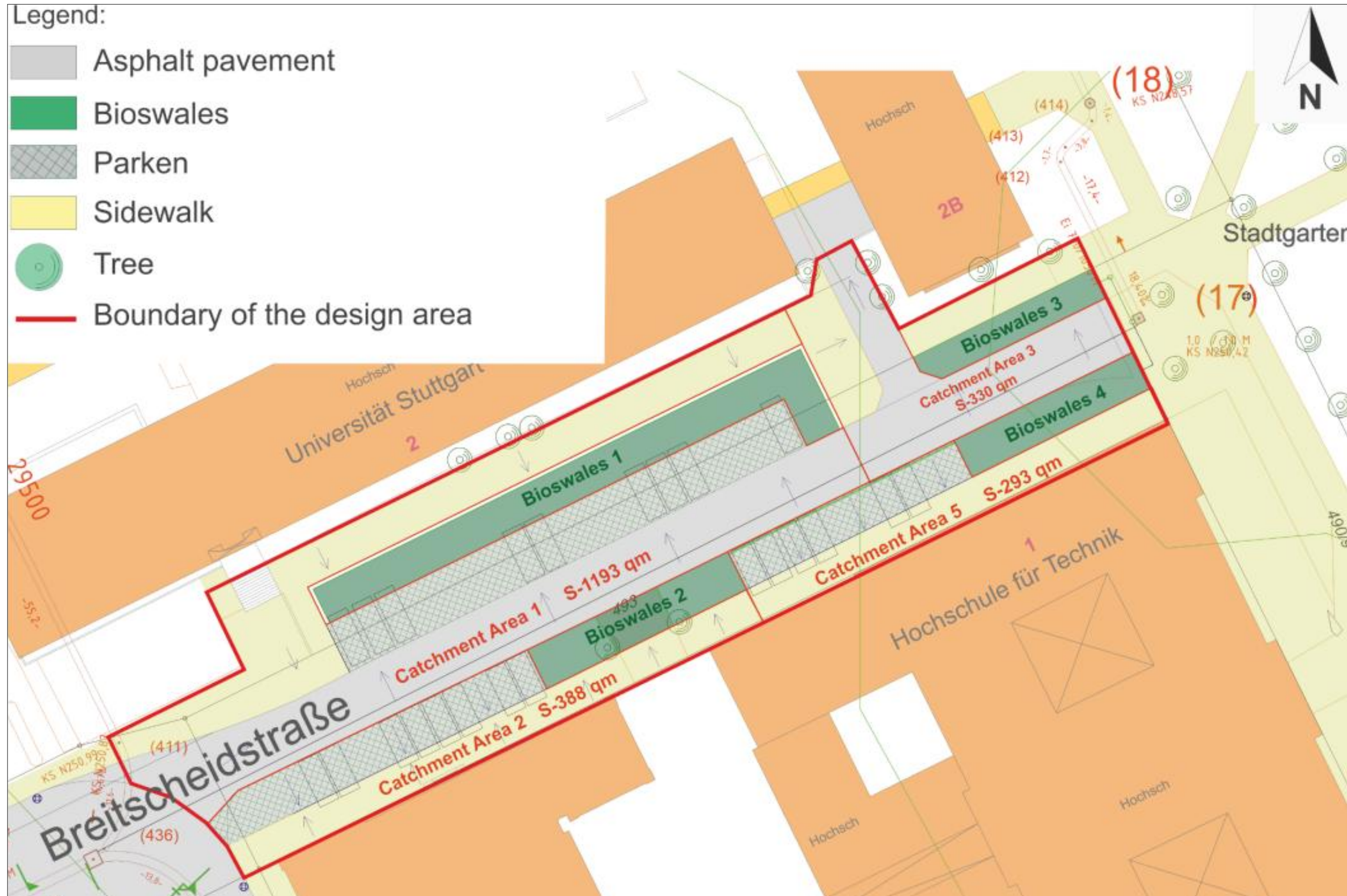
Source: Deutscher Wetterdienst, 2025



Drawing of the Breitscheidstraße street with bioswales (Created by Mariya Bodylevskaya, 2024).



Most of the site is covered with asphalt, showing a high percentage of impermeable surfaces. The lack of greenery and permeable surfaces increases flood risks, urban heat island effects, and reduces comfort.



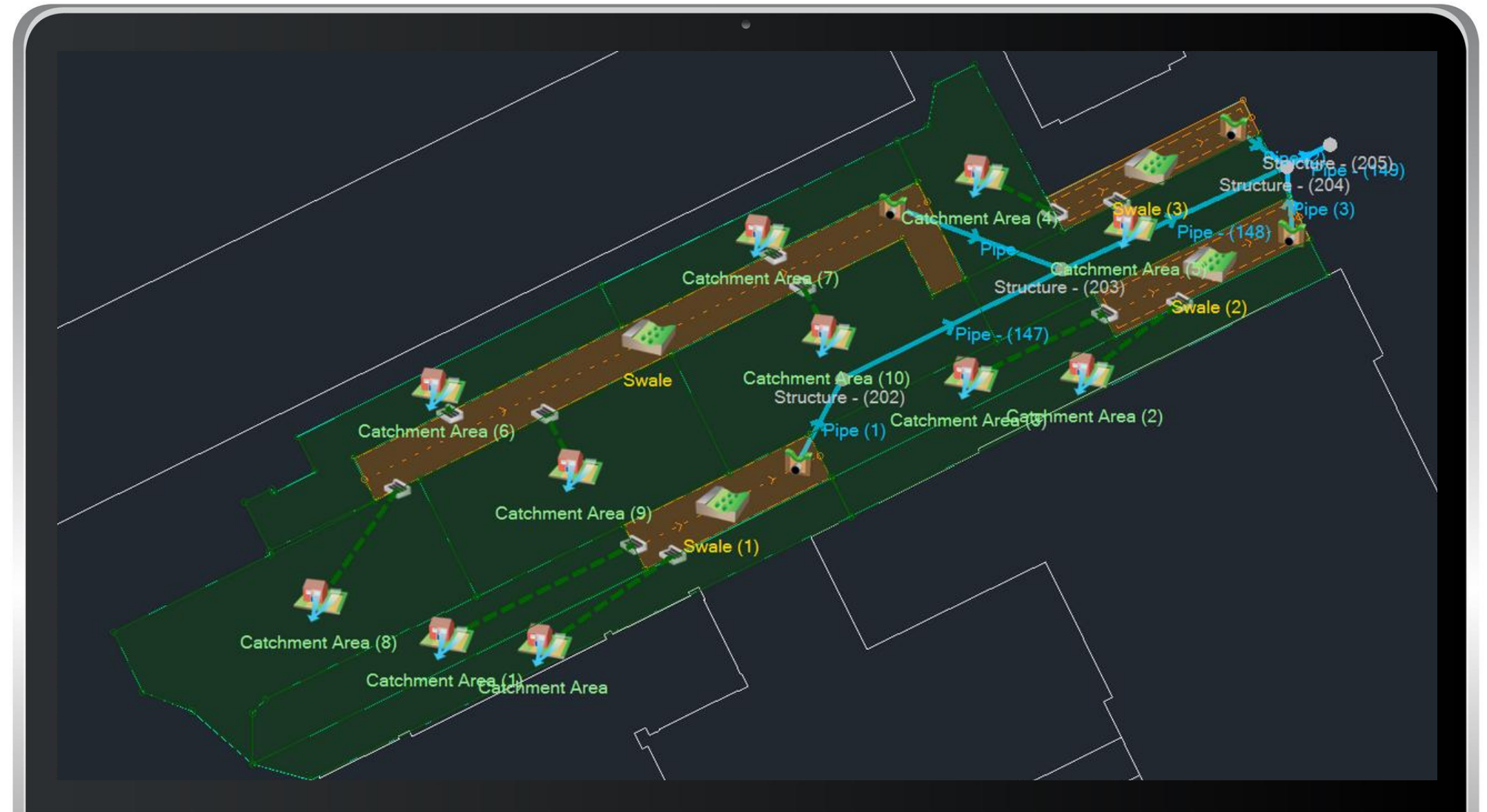
Roads and parking areas were combined into a single zone, separated by bioswales from the pedestrian and recreational areas. This clear separation helps improve stormwater management and enhances pedestrian comfort.

Drawing of the Breitscheidstraße street with bioswales (Created by Mariya Bodylevskaya, 2024).

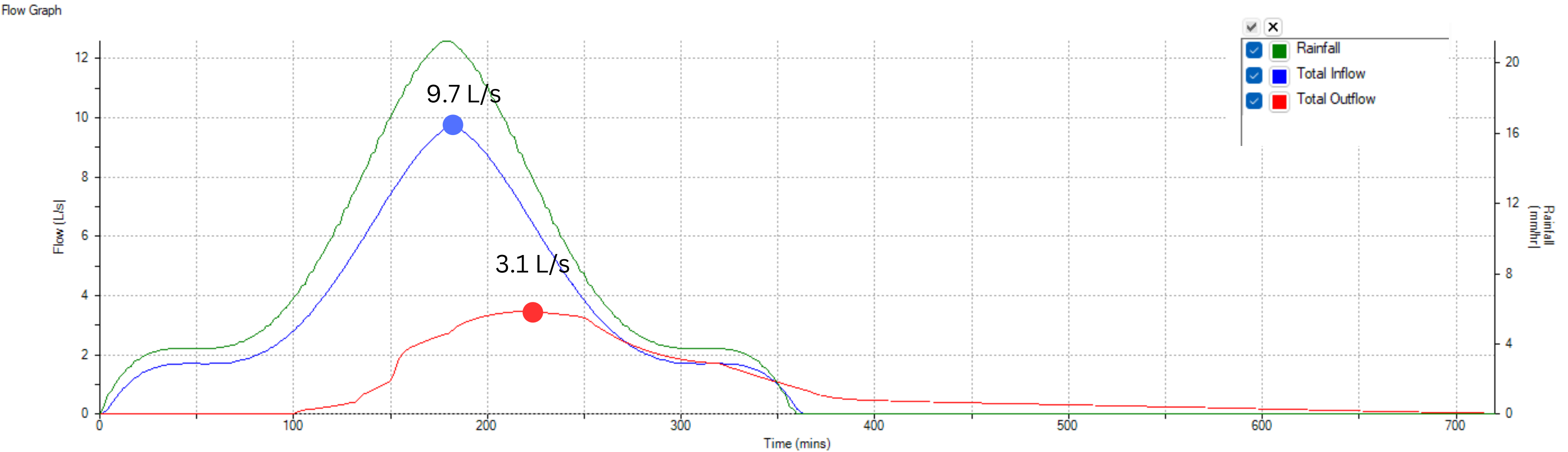


The view from the exit of Building 5 towards Bioswale 1 (Created by Mariya Bodylevskaya, 2024).

- Import the Civil 3D model into the InfoDrainage plugin
- Bioswale components are defined.
- Catchment areas are configured
- The imported sewer system directs water to the discharge point.
- Weather parameters are set
- Each system component is assigned properties.
- Analysis.



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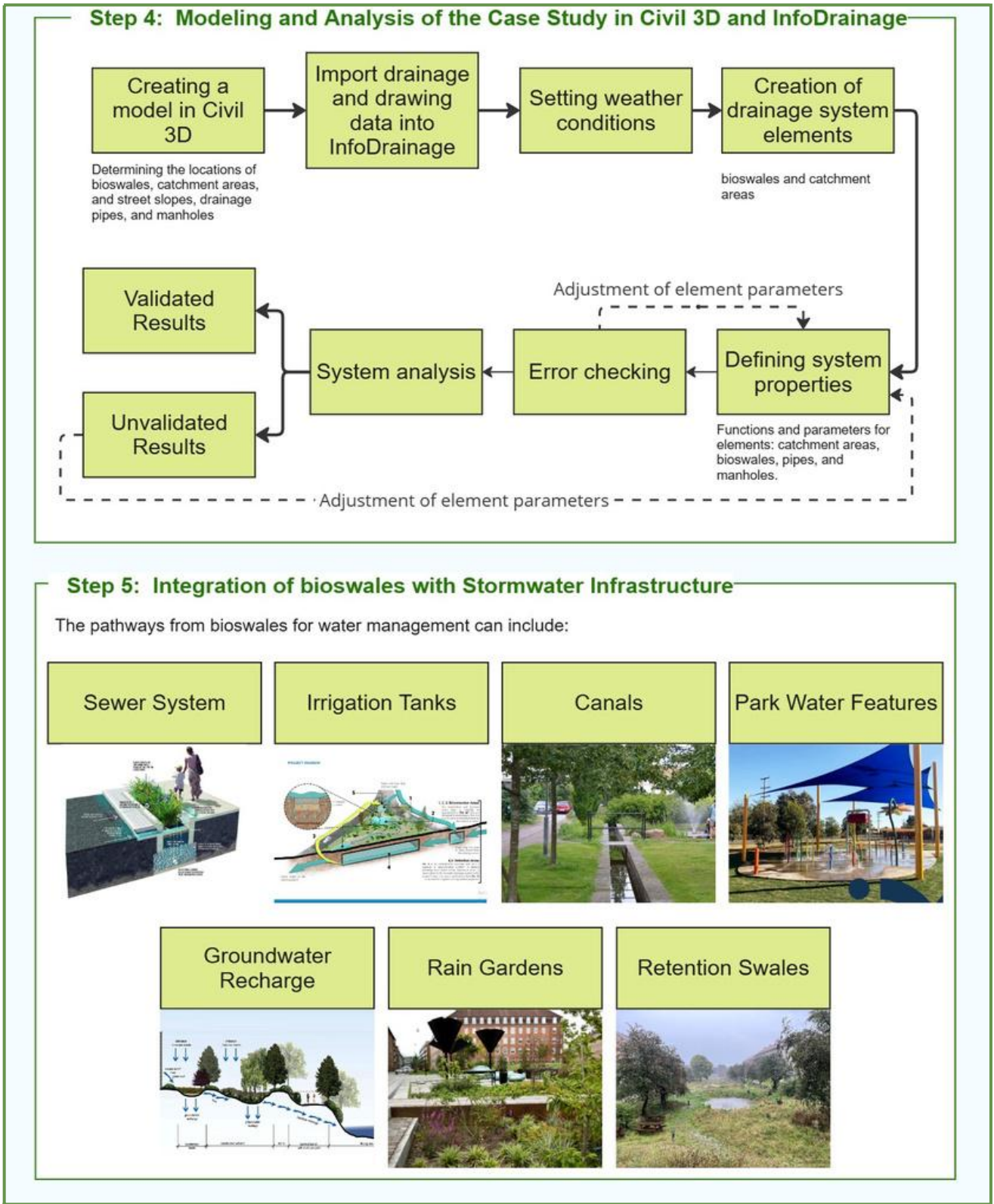
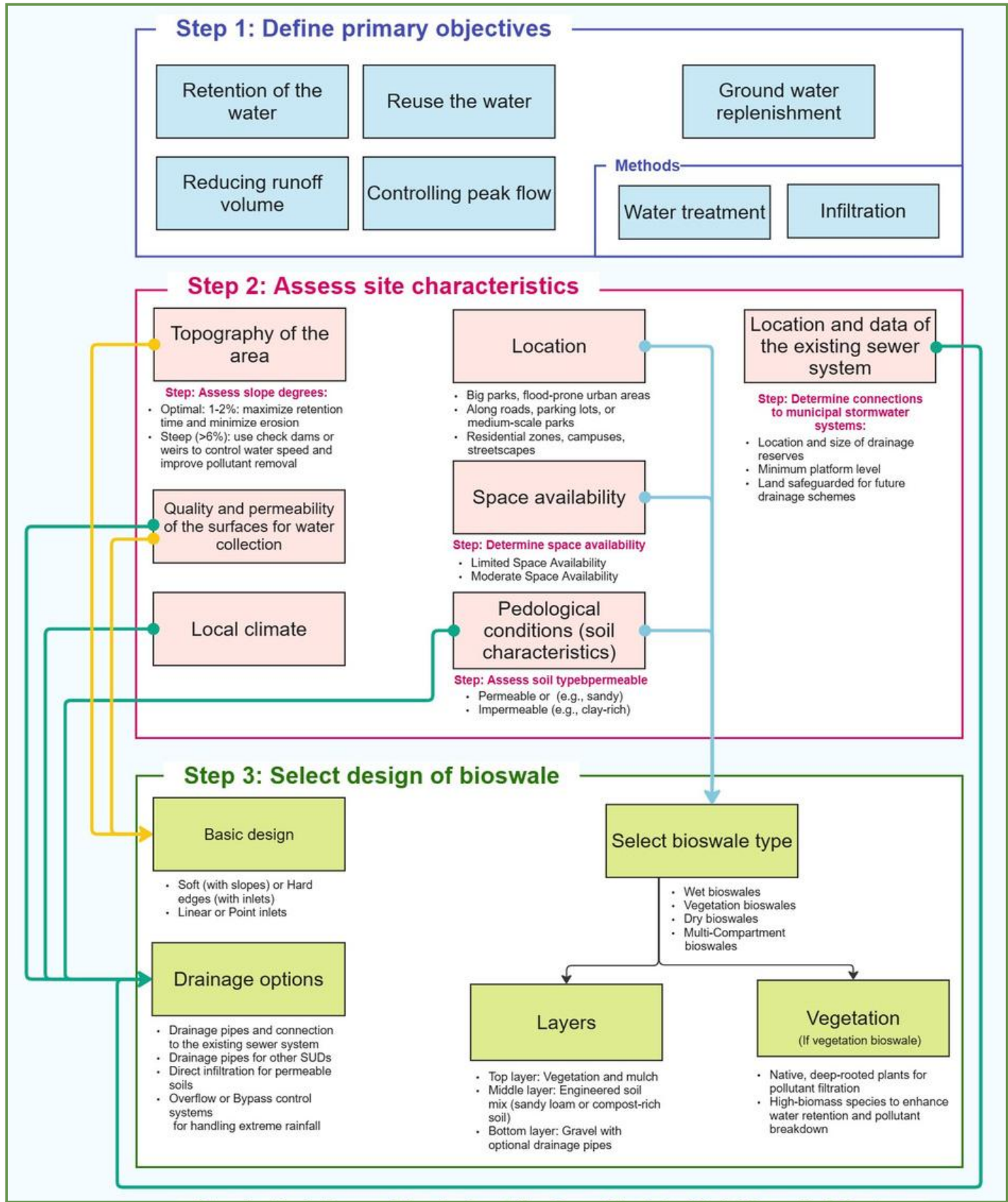
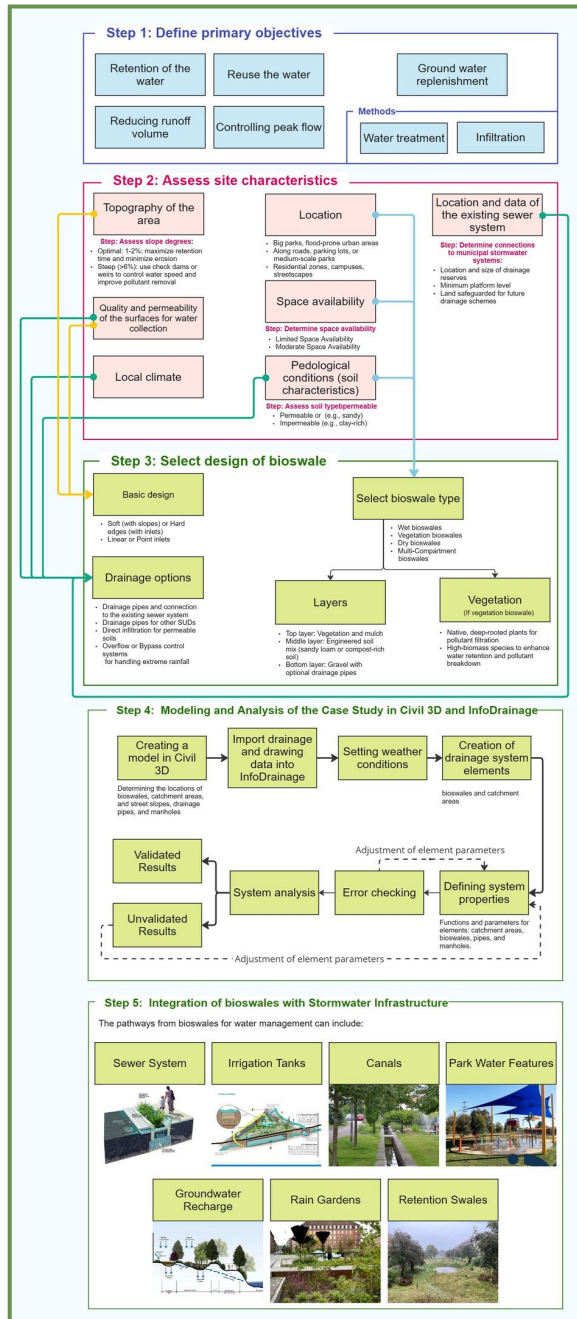


Key Data from InfoDrainage Modeling

- Total Inflow:** 9.7 L/s → **Total Outflow:** 3.1 L/s.
- Peak Flow Reduction:** 600% compared to the traditional drainage system.
- Surface Runoff Volume Reduction:** 42%, aligning with literature values (~49.75%).
- Bioswales retained water for 680 minutes**, compared to 360 minutes of rainfall.
- No flooding was recorded** in the bioswale system, unlike traditional drainage, which showed overload risks.

NAMES / SPECS	USING BIOSWALES	EXISTING SEWER
Total inflow	9.7 L/s	19.9 L/s
Total outflow	3.1 L/s	19.2 L/s
Reduction in surface runoff volume	42 %	0 %
Total system drainage time	680 min	405 min
Flooding risk	No flooding was recorded	The risk of flooding in the area was recorded

Demonstration of a Toolbox for bioswale design



Source: Created by Author Mariya Bodylevskaya, 2024).



Bioswales effectively manage stormwater and reduce sewer system overload.

The case study showed bioswales handled 35 mm/h rainfall for 11 hours, while the sewer overflowed in 1 hour.

Key factors for performance include soil type, infiltration rate, slope, and configuration.

Beyond runoff control, bioswales improve aesthetics, recreation, and public awareness.

Civil 3D and InfoDrainage help optimize bioswale design through modeling and analysis.