

## **Artificial rainfall experiments for green roofs depending on the flow length at 0 degrees and 2 % slope and different rain intensities**

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### **Notes on the 2015, 2019 and 2020 test series**

The experiments in 2015 were based on the previous research project "Investigations of runoff in extensive green roofs with a zero degree slope" by the Fachvereinigung Bauwerksbegrünung (FBB, today Bundesverband Gebäudegrün BUGG; source:

<https://www.gebaeudegruen.info/service/downloads/bugg-untersuchungen>).

The experimental setup was adopted and re-examined in regards to the question of the influence of flow length on the runoff coefficient.

The methodology and technique for the determination of the water level in the substrate were developed and further tested during the previous research project. The measurement of the water level in the substrate was used to computationally determine the slope of the water level in the substrate between two points. The goal of simulating these water levels did not emerge until the 2020 series of experiments.

The experiments in 2019 and 2020 served the purpose of comparability with the experiments conducted in 2015. In 2019 and 2020, a different substrate was used, which is sold by the same manufacturer under the same product name. Substrates are always subject to some fluctuations with regard to the measured and tested product properties. Both substrates have been tested according to the FLL green roof guidelines for extensive substrates in single layer construction.

### **Notes on the observed water levels**

General:

- Water levels (hydraulic head) were read from camera footage when possible. When water levels exceeded the maximum possible water level from the cameras, measurements were taken by hand (millimeter stick was used at measurement site).

Notes on the database:

- Water levels in the database are based on the start of irrigation; 0 minutes is the start of irrigation. Since runoff takes a long time, especially in single-layer structures, a water level is present at the start of irrigation for the measurements with a 0° slope.
- The levels in the database are the water levels of the first 30 minutes after the start of irrigation.
- For some measurements, no water levels were recorded (e.g., Me2015-11a).
- Camera images that could not be read were stored in the database as 999.
- Water levels read from camera images were stored in the database at 0 seconds.
- Water levels read from camera images have a delay of approximately 5 seconds from the first image (camera 1) to the last image (camera 9) at 20m flow length, due to automatic image acquisition. This delay time is neglected and noted as 0 seconds, due to the slow flow process.

- When measuring water level by hand, the reading time is noted in the database. The time between the first water level read (camera 1) to the last water level read applies.
- Water levels read by hand have an accuracy of +/- 1 mm during irrigation due to poorer visibility (water on the millimeter stick; rain mist in the system), and +/- 0.5 mm after irrigation.
- In the 2015 test phase of the camera measurements, the measuring points were first covered with lids. However, it happened that an air bubble formed underneath and therefore the water level did not rise during sprinkling, at some measuring points. Corresponding values were removed from the database and stored as 999.
- Larger deviations occurred and could mainly be attributed to the test methodology. For example, slight changes in direction occurred due to nozzle clogging and/or displacement of the nozzles in the irrigation hose. In some cases, direct irrigation of the measuring point occurred, causing the water level to rise disproportionately fast (especially at the beginning of the measurements). These misalignments were corrected as quickly as possible. The measured values that were too high were taken out and stored at the appropriate location, as 999, in the database.
- Smaller deviations of the water level between the measuring points occur more often and show a kind of "wave" during the flow process.
- An example of this are measurements Me 2020-47 to Me 2020-49 (camera 4 at minute 480).
- In the protective fleece, further flow processes probably take place at a water level of 0 mm. The protective fleece itself stores water. Measurements Me 2020-47 to Me 2020-49 at camera 4 and minute 480 can serve as an example: Although the water level is 0 mm at almost all measurement points, a water level is detected at camera 4. At the later measurement time, all measurement points show no water level. The water has evaporated in the meantime or has been absorbed by the protective fleece.

## Notes on the water measurements

### General:

- The runoff quantities for the first 30 minutes after the start of irrigation are stored in the database as a total.
- Irrigation (artificial rainfall) volume was checked at 30 second intervals.
- 2015 Measurements:
- For some irrigations, the real irrigation volume was not accurately noted (e.g., measurements 2015-04 through 2015-12, measurements 2015-14 through 2015-18, and measurements 2015-20 through 2015-24).
- At measurement 2015-19, sprinkling lasted 15:30 minutes.
- At measurement 2015-22, 235 liters were irrigated in 15 minutes.

### Measurements 2019 and 2020:

- Measurement 2019-21: For this measurement, a second catch basin was opened and noted separately due to heavy runoff at minute 11. Since there is a significant jump in the noted discharge curve, it is assumed that there was a reading error. The discharge at minute 12 was corrected from 275 liters to 290 liters.