hölscher wasserbau

AERFIT – infiltration of rain water by hw-dsi-infiltration

pilot test field in Werder/Germany
monitoring results 01-06/2023
-Final Report-

ADAPTATION EXTREME RAINFALL

execution:
Hölscher Wasserbau GmbH
Hinterm Busch 23 | 49733 Haren (Ems)

contact:
Helena Demel
Mobil +49 (0) 170 376 92 75
demel@hoelscher-wasserbau.de

Glindow, 04/08/2023

Table of Contents

1. Background

The project partners of the AERFIT project, which is funded by the EU LIFE program, are working in several subprojects on the practical implementation of rainwater infiltration under real conditions. In addition to several test sites in the Netherlands, a test site was installed in northeastern Germany. As the biggest licensee for Düsensauginfiltration (hw-dsi) on the German market, Hölscher Wasserbau GmbH is carrying out a pilot test on the site of the East branch in Glindow/ Werder.

In a first report results of the hydrogeological site exploration and the setup of the test site was described ("Project description and first results" from 26/07/2022). Another report was issued as a review of the first 6 months of operation ("Monitoring results" from 27/01/2022). The subject of this final report is the operation of the plant and its monitoring results.

2. Test Site

2.1. Location

The site is located in the northeastern part of Germany, about 50 km south-west of Berlin in a commune called Glindow, a small municipality belonging to the town Werder(Havel).
The test field itself was setup on the company site of Hölscher Wasserbau's branch in Berlin (Figure 1).

The test arrangement consists of 8 hw-dsi-infiltration units with total depth between up to 25.0 m below ground level.

Figure 1 left: location of Hölscher Wasserbau, branch Berlin; right: test field (yel-low), roof for rain water collection (red rectangle) and infiltration units (blue)

2.2. Setup of the infiltration system

On the test site, rain water is collceted on a flat root next to the test site and directly led to the infiltration field. The area of the roof is around 130 m^2, providing up to 6 m^3/h of rainwater at an extreme rain event (statistical value based on KOSTRA-DWD with a probability of once in a 100 years period and a duration on 60 min).

A treatment unit and the discharge of the rainwater into the infiltration units are meant to have small dimensions and enable water flow without pumps, only by gravitiy. The scheme of the setup is shown in Figure 2.

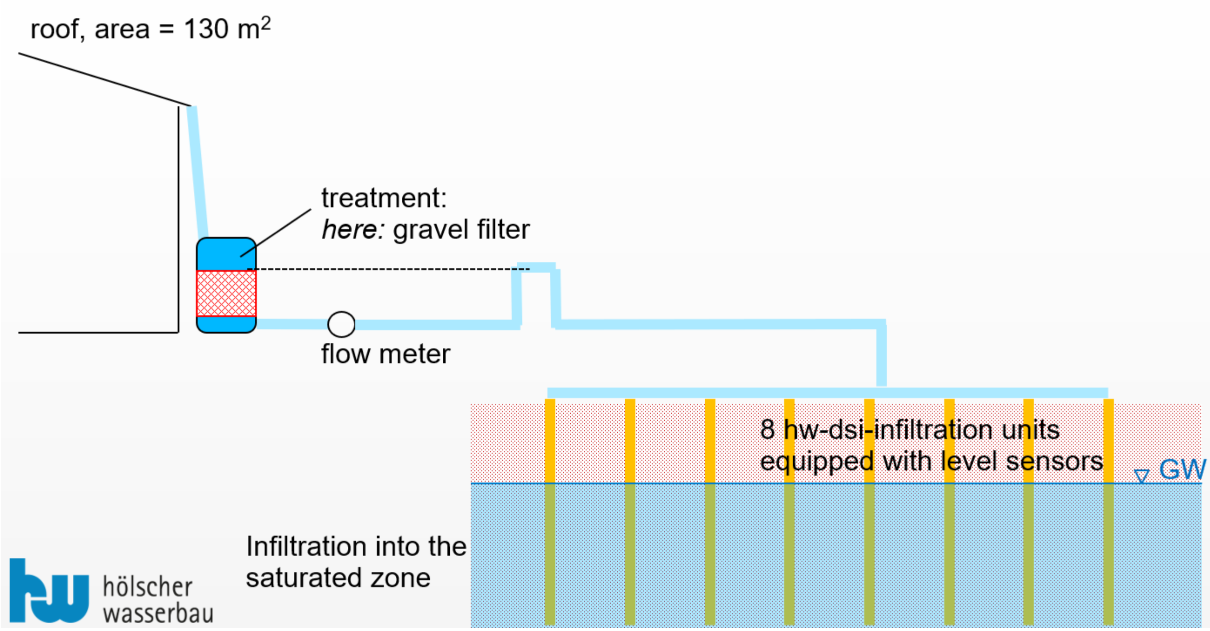


Figure 2 scheme of the system

3. Monitoring Data

3.1. Data Record

The long-term data record of the plant includes the flow rate respectively the total amounts of infiltrated rain water as well as groundwater levels within each infiltration unit. Data is generally saved as mean values of 15-minute-intervalls. In case values vary more than a defined range, data is automatically saved in a higher time resolution of up to 5 seconds.

3.2. Operational Notes

During the frost period a winter protection was installed. An insulation respectively a heating system was necessary for all parts of the plant that were permanently filled with water. Thus, the treatment unit, the magnetic and the mechanical flow meters were enclosed by an insulated walk-in container, equipped with a portable electric heating (Figure 3).

Figure 3 winter protection of the plant

In June 2022 pollen had clogged the treatment unit, so that rain water needed to be diverted temporarily. After the installation of coconut fiber in the gutter of the roof area and adjustments of the water level within the treatment unit, we were curious whether these settings could prevent this problem in the following season. In 2023 however, there was hardly any precipitation during the pollen period of mid-May until mid-June. So results on this issue are still pending.

Figure 4 clogged treatment unit in June 2022 (left), coconut fiber in the gutter (right)

3.3. Precipitation Amounts and Events

Figure 5 shows the accumulated monthly sums of the data record of the flow meter. The data record of June 2022 is not shown as it represents mainly data of the infiltration test and does not represent actual precipitation data.

In the attachment of this report you find monthly monitoring sheets for the time period from January until June 2023 where the recorded data is summarized and presented in diagrams.

In total 73.2 m^3 were infiltrated into the groundwater during the observation period of 1 year. About 20% of the total precipitation fell in June 2023, 11.5 m^3 during one rain event within 24 h hours.

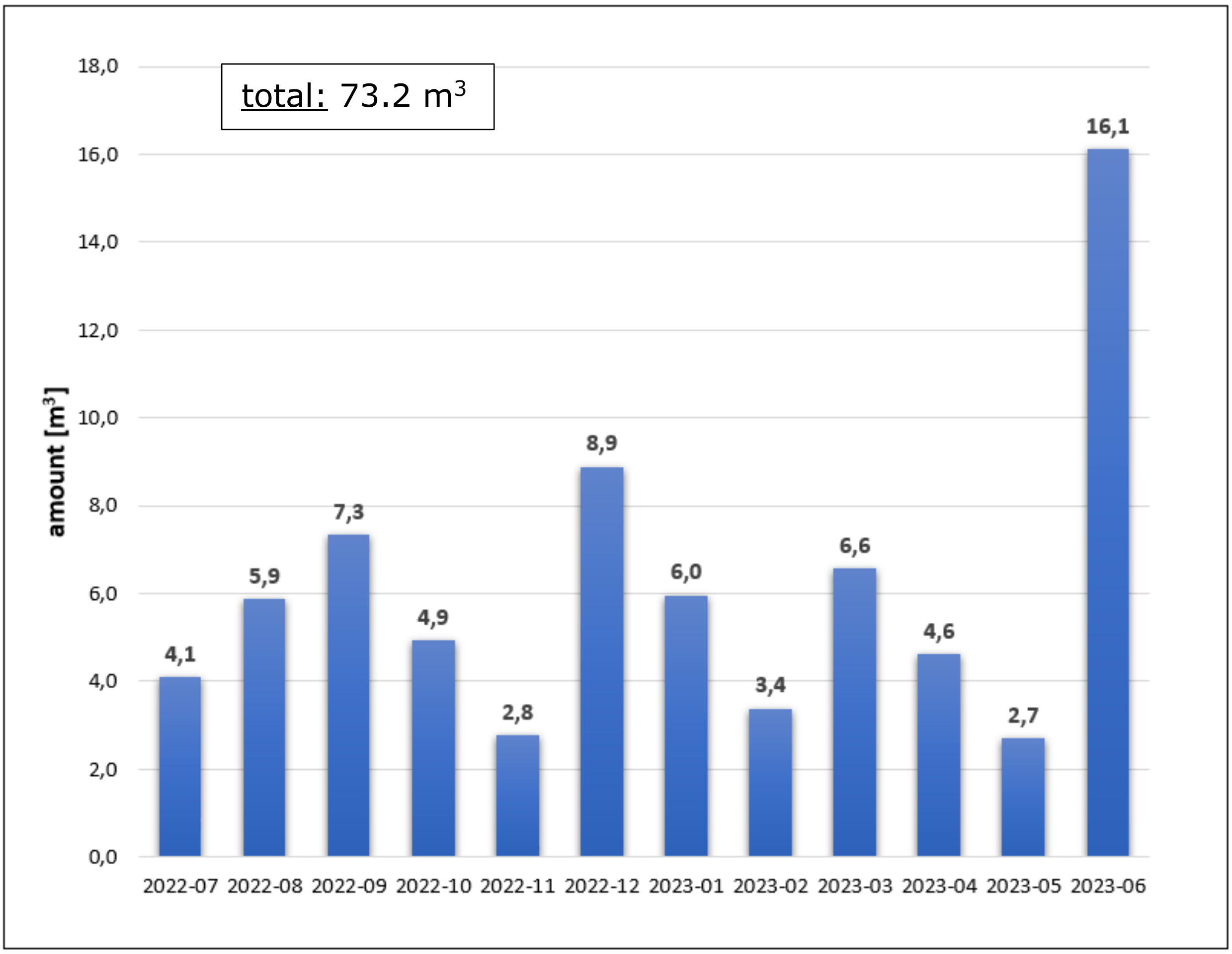


Figure 5 accumulated monthly amounts of infiltrated rainwater

A detailed data record of the intense rain event of 22nd/23rd of June is shown in Figure 6. In total 11.5 m³ of water was infiltrated during this event.
As previous records have shown already, water levels within the infiltration units respond with different intensity. On the one hand this is caused by the inhomogeneity of the aquifer and the variation of hydraulic conductivity and on the other hand a consequence of the unequal distribution of the rain water caused by the plant's setup.

Water levels of the units dsi8, dsi6 and dsi5 show the biggest increases. However, dsi5 (green line) shows a fast increase at the beginning of a rain period followed by an immediate decrease.

In summary, water levels within the infiltration units do not rise more than 1,5 m above resting water level. All infiltration units show water levels that go back to resting water level right after the rain event stops. This is an indication that after one year of operation, all infiltration units still have a good hydraulic connection to the aquifer and divert the rain water instantly to the groundwater.
The intense precipitation event can be considered as an intense system test under real conditions. In average 0.5 m³/h were infiltrated during 24 hours. The maximum flow rate reached 2.75 m³/h.

During the event no water was diverted to the emergency outlet at the treatment unit. This shows, that the infiltration units were able to cope with the water amounts as well as the treatment unit – the bottleneck of the plant - was able to handle the water flow.
This points out that the flow capacity of the treatment unit, consisting of a coarse sieve and a gravel filter, has not decreased within the past year.

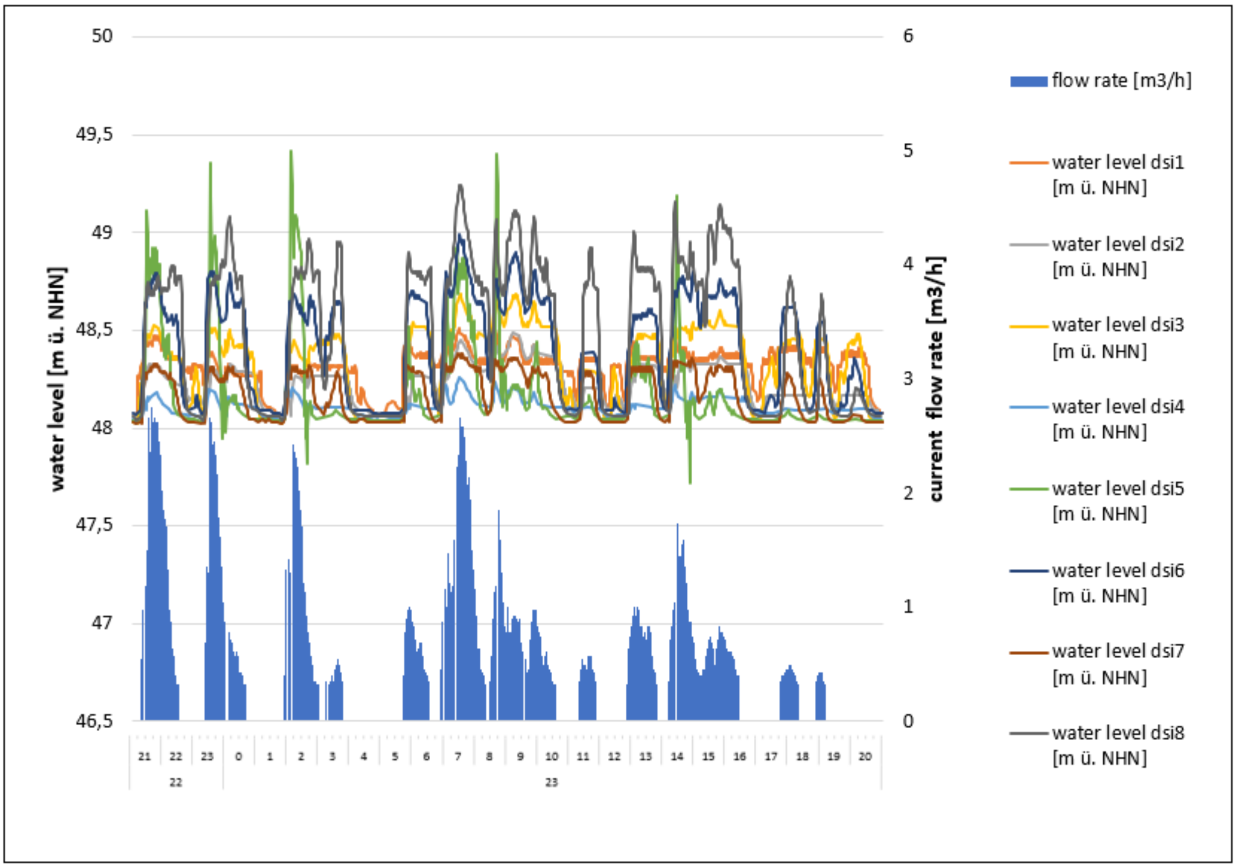


Figure 6 intense rain event on June 22/23

3.4. Long-term impact on the Infiltration Capacities

Table 1 shows the counter readings of the mechanical flow meters installed on each dsi unit. All counters were set to 0 at the beginning of the monitoring period, the last reading was performed on July 11 in 2023.

Table 1 counter numbers and readings of the mechanical water meters on July 11 2023

well name	counter number	counter reading [m³]
dsi 1	2240003852	7,6257
dsi 2	2240003851	9,4812
dsi 3	2240003849	10,0099
dsi 4	2240003853	7,0093
dsi 5	2240003846	14,3416
dsi 6	2240003847	9,3451
dsi 7	2240003848	7,5062
dsi 8	2240003843	7,981
Sum		**73,3**

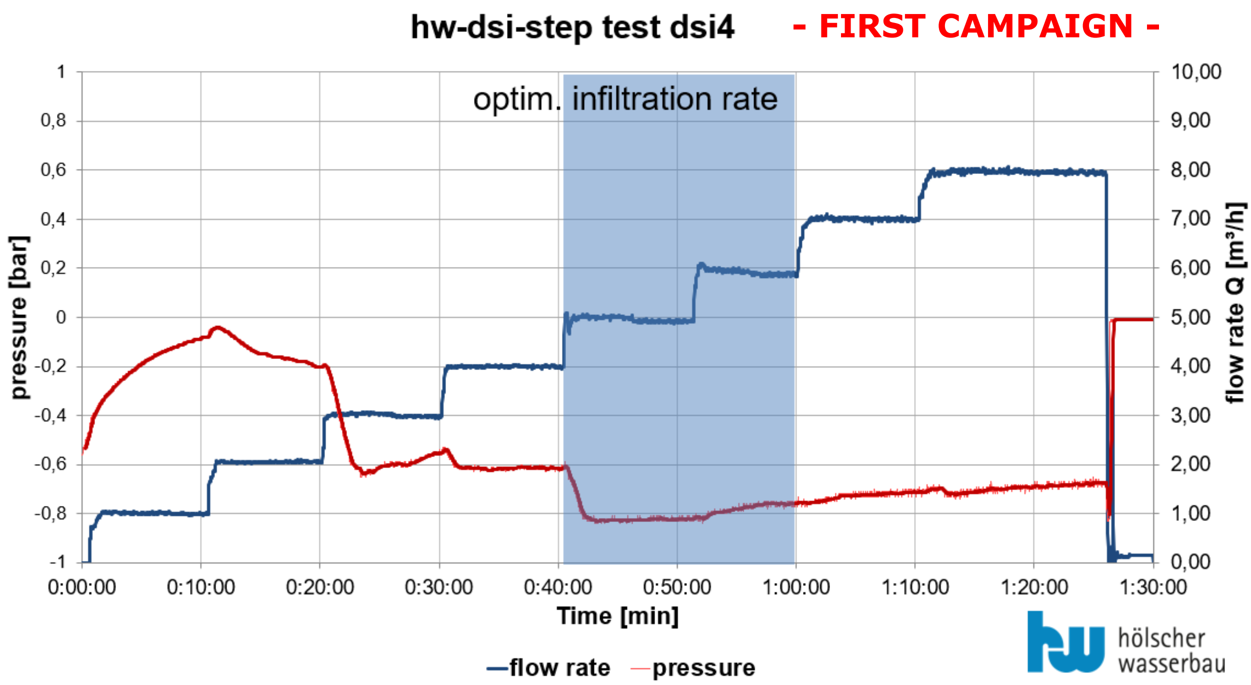
The counter readings show, that the water was not distributed evenly. More than 14 m³ were infiltrated by dsi5. While infiltration units dsi 1, dsi7, dsi4 and dsi8 each infiltrated 7 m³ - half of the amount of dsi5. All others range between 7 and 14 m³.
During the intense rain event of 22nd/23rd of June (see Figure 6 above), water levels of dsi5 show the highest increase. Considering the total infiltration amount, the observed increase of water levels in dsi5 is not a surprise.

Before the commissioning of the plant in June 2022, infiltration step tests were performed on each infiltration unit (See also report "AERFIT pilot test field in Werder/Germany – exploration - project description and results" form 26/07/22). The aim of the test was to determine the optimum infiltration rate for each dsi unit.

Two of the tests were repeated at the end of the monitoring period, means: after one year of rain water infiltration. The test results should give an indication to what extend a degeneration of the well-specific infiltration capacity has taken place. The decrease of the well capacity is an unavoidable process for infiltration wells as well as pumping wells. Its intensity depends on the water quality and the operating regime.

The second campaign of the tests was performed on dsi 4 and dsi5. Dsi4 previously showed the highest infiltration capacity of all units: about 4 to 5 m³/h. Dsi5 showed a relatively low infiltration capacity of around 0,75 m³/h.
For an easier comparison, tests were performed with the same infiltration steps than previously.

The results are shown in Figure 7 and Figure 8.



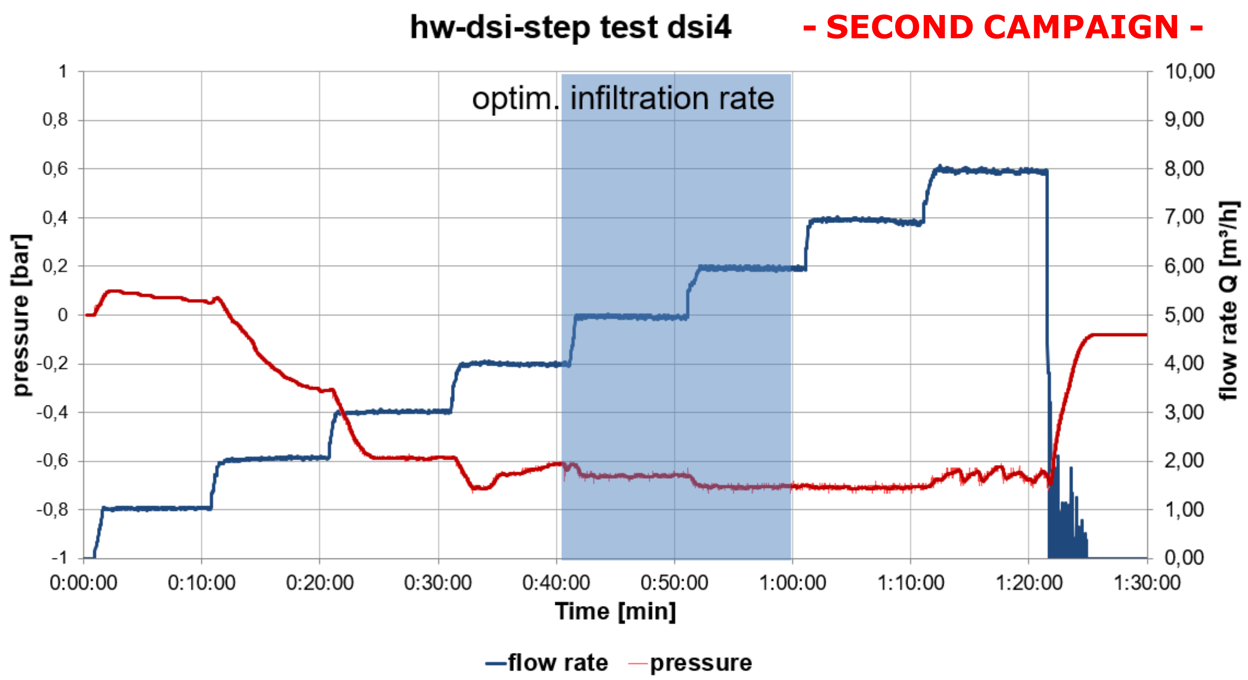
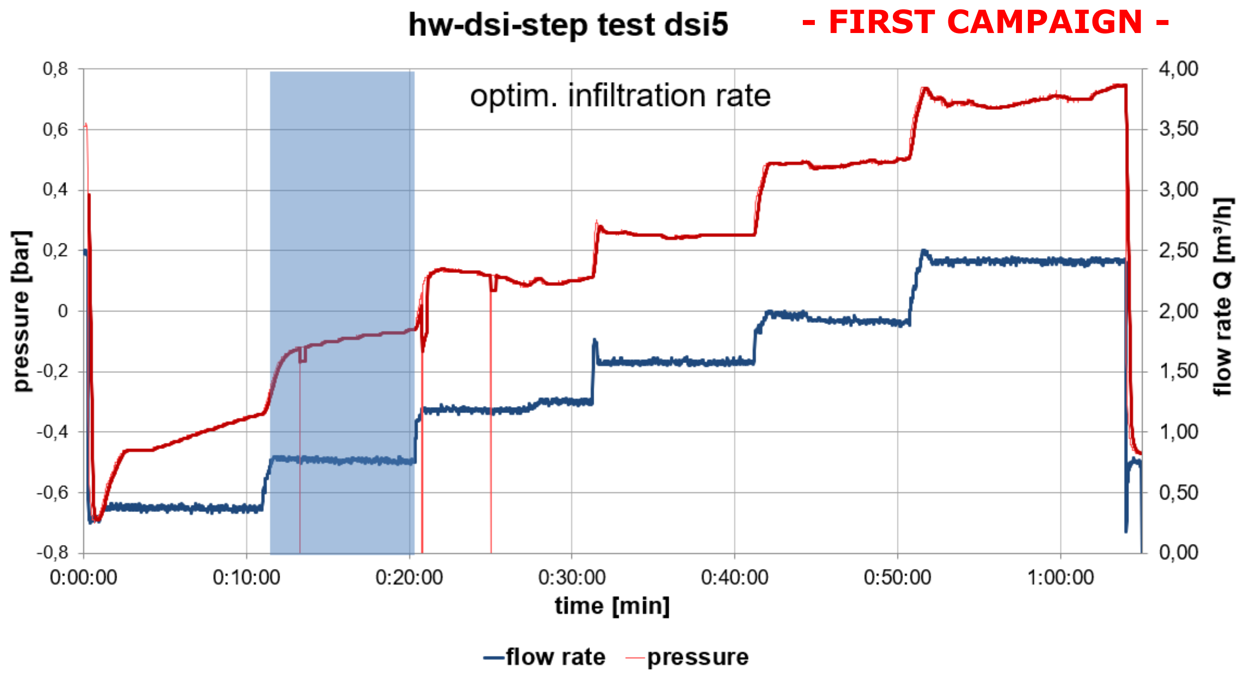


Figure 7 results of the infiltration step test of dsi4 before commissioning of the plant (first diagram) and after one year of infiltration (second diagram)



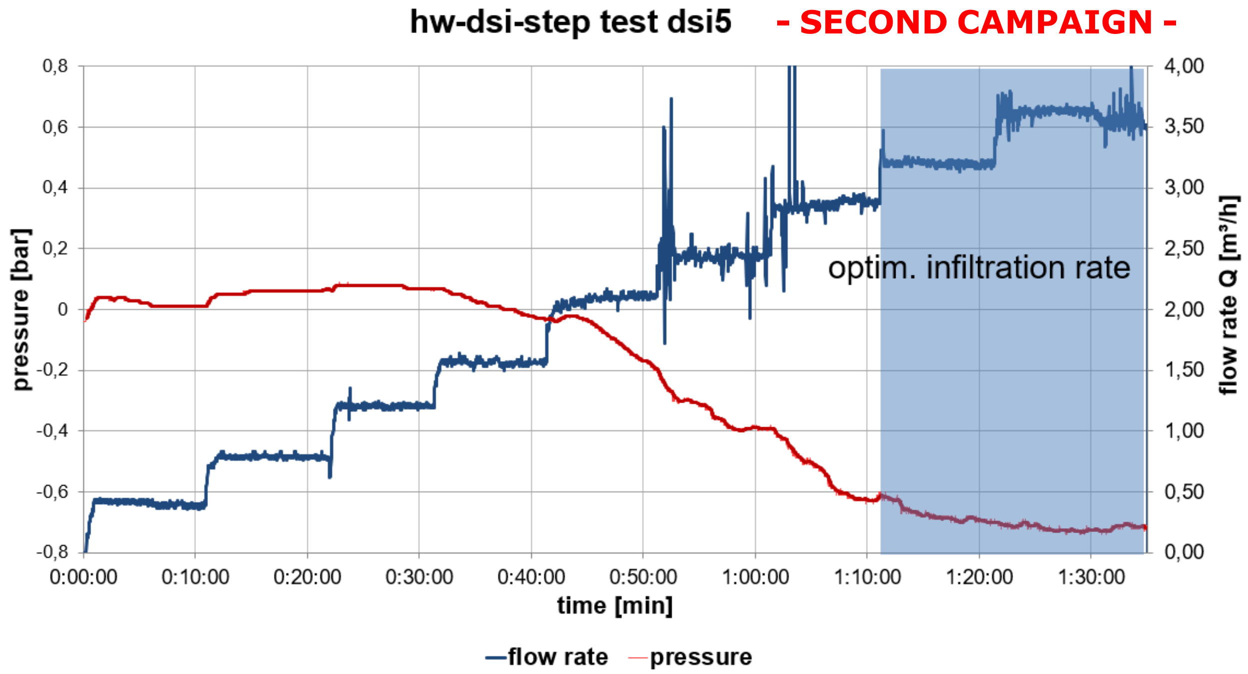


Figure 8 results of the infiltration step test of dsi5 before commissioning of the plant (first diagram) and after one year of infiltration (second diagram)

Comparing the test results of dsi4 (Figure 7), the graphs show nearly the same courses. For each step of the flow rate (blue line), the infiltration pressures (red line) of both campaigns is on nearly the same level. It can be concluded, that rain infiltration as well as longer periods without infiltration have not led to an alteration of the well's infiltration capacity.

For dsi5 the results are unexpected at first. Given that fine particles or the growth of algae might clog the infiltration unit, it was expected that infiltration capacities would be reduced after a certain period of operation. However, the test results show, a completely different reaction to infiltration (Figure 8). In the first campaign, pressure (red line) increases with each increase of the flow rate (blue line). Whereas in the second campaign, the course of the pressure appears in a way that is typical for dsi-infiltration in a closed, airless system: with the increase of the infiltration rate the infiltration pressure decreases and reaches a minimum. In this case the minimum pressure was reached at the highest infiltration rate: -0.7 bar at around 3.4 m^3/h. Taking a closer look at Figure 6 this behavior can be observed during rain water infiltration, too: at the start of the rain period, the water level of dsi5 increases (Figure 6, green line). After some time of constant inflow, the water level jumps down and reaches a level even below resting water level, which can be equaled to a negative pressure within the infiltration unit.

This leads to the question, why this behavior did not occur during the first campaign. Two explanations seem plausible. First, the setup of the test during the first campaign was not ideal. It is possible, that the system (water source, hose connection, standpipe on top of the well and the infiltration unit itself) did not form a closed system, so that water and/or air could enter or run out during the test. Second, it could be possible, that the well itself did not have a good hydraulic connection to the aquifer at the beginning, so that infiltrated water could not be discharged immediately into the groundwater. Long term infiltration “flushed” the filter of the infiltration unit bit by bit.

3.5. Regional Precipitation- and Groundwater-monitoring

Figure 9 shows the course of groundwater levels and rain events between June 2022 and June 2023 for the site. The table summarizes the measured amounts of rain, that were collected on the 130 m² roof area. These amounts were converted to the global unit of precipitation in mm per square meter (middle column). Accordingly, 563 mm/m² of precipitation fell during the observation period of 1 year. In comparison, official data from Deutscher Wetterdienst (dwd.de) mentions average precipitation of about 574 mm/m² for the region. Thus, the recorded precipitation data ranges within the regional average.

	amount [m3] per 130 m2	amount [mm/m²]	average precipitation (dwd.de) [mm]
2022-07	4,1	31,5	25,0
2022-08	5,9	45,2	65,0
2022-09	7,3	56,4	45,0
2022-10	4,9	37,9	35,0
2022-11	2,8	21,3	45,0
2022-12	8,9	68,3	45,0
2023-01	6,0	45,9	45,0
2023-02	3,4	26,0	35,0
2023-03	6,6	50,5	62,0
2023-04	4,6	35,5	45,0
2023-05	2,7	20,8	15,0
2023-06	16,1	124,0	112,0
Sum	**73,2**	**563,3**	**574,0**

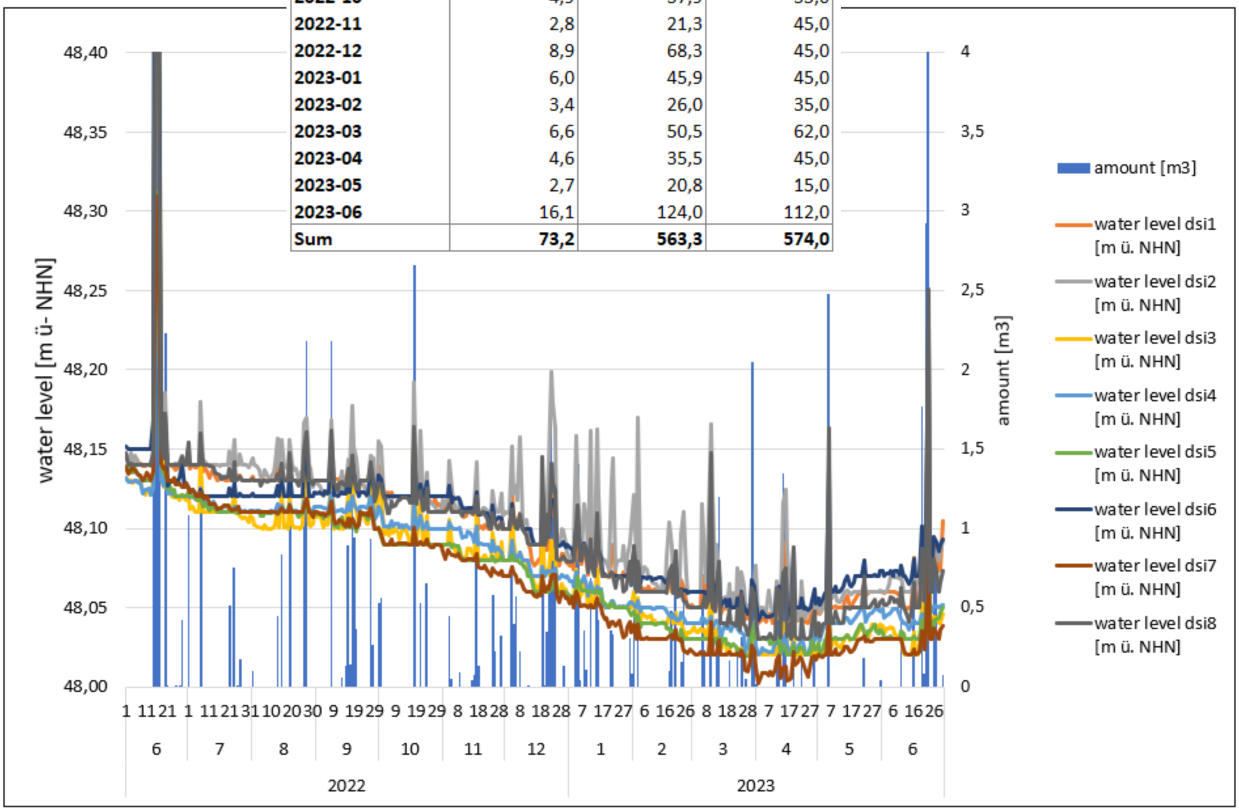


Figure 9 groundwater levels and rain events between June 2022 and June 2023

After a decreasing long-term trend, hydrographs show a slight recovery since April 2023. However, comparing June 2022 and June 2023, ground water levels still range about 10 cm below initial water level.
Unfortunately, official monitoring data for the region from a monitoring well about 3 km northwest of the test site was not updated since January 2023

(https://apw.brandenburg.de). Other monitoring wells of the region are located next to lakes and are strongly influenced by surface water levels and represent different hydrogeological settings. Hence, for the six months of monitoring in 2023 there is no available official data record to verify the plant's water level data.

4. Summary and Conclusion

During the monitoring period of one year, 73.2 m³ of rain water was treated (gravel filter) and infiltrated into the ground water. The recorded measurements of precipitation amount and water levels correspond to official data for the region.

One intense rain event took place on June 22 and 23 (2023). 11.5 m³ of rain water was infiltrated within 24 hours. The plant was able to treat and divert all water to the groundwater.

In summary, the monitoring data showed that rain water infiltration can succeed even in location with not ideal conditions such as inhomogeneous extension of hydraulic conductivity and low ground water levels (here: about 12 m below ground level). However, the plant was designed with an overcapacity of infiltration units. The bottle neck of the plant, the treatment unit, did not limit the plant’s operation, even under extreme rain conditions.
The long-term infiltration of rain water did not lead to a decrease of infiltration capacity.

With the experience of one year’s operation and in consideration of the design of a future plant, it is recommended to reevaluate the following issues:

- An overcapacity of infiltration units can be advantageous for locations with unfavorable hydrogeologic conditions such as low permeabilities or an inhomogeneous character of the aquifer or for adapting to extreme rain events
- Clogging of the filter screen of the infiltration units leading to a significant decrease of the infiltration capacity was not detected during a one year’s period. However, bigger precipitation amounts or more polluted rain water can have a stronger influence on the capacity.
- The design of the treatment plant should have cleaning capabilities for both, suspended matter with a relatively high density as well as light, hydrophobic particles such as pollen
- For permanent plants a permanent frost insulation is necessary
- The present design of the plant was not able to distribute the water evenly

5. Attachment