Rockwool (Lapinus)

Reference manual – how to model Rockflow in MIKE+

19. January. 2023
(Revision 3)

Made for:
Rockwool (Lapinus)

Prepared by:
EnviDan A/S
Thomas Aagaard Jensen & Louise Toft Anker
E-mail: lsj@envidan.dk
Directed tel.: +45 86 80 63 44
Project name: Reference manual – how to model Rockflow in MIKE+
Project nr.: 1212529
Quality assurance: Magnus Emil Holmgaard

EnviDan

Vejlsøvej 23 • DK-8600 Silkeborg • Tlf.: +45 86 80 63 44 • www.envidan.dk • CVR 18 33 43 05

Table of contents

Vejlsøvej 23 • DK-8600 Silkeborg • Tlf.: +45 86 80 63 44 • www.envidan.dk • CVR 18 33 43 05

1. Introduction

This document describes how to setup a Rockflow Magazine (RM) and its hydraulics parameters in MIKE+. The manual is targeting experienced users of MIKE+. Therefore, the basics of MIKE+ are not described in this document.

This document refers only to the hydraulic aspects of the RM. For other information on Rockflow including dimensioning of inlet channels and volume size of the RM, please see references in Appendix C.

1.1 How to use the manual

The manual consists of two parts:

- This document
- An Excel spreadsheet for calculation of the parameters used for describing the RM in MIKE+: *Tool for input parameters for Rockflow in Mike+.xlsx*

To model a RM:

1. firstly, use WSPs dimensioning directions (see Appendix C), thus the physical parameters of the RM are given.
2. The physical parameters of the RM are necessary before being able to use the spreadsheet (*Tool for input parameters for Rockflow in Mike+.xlsx*) included in this manual.
3. When given the dimensions of the RM, channels, and magazine elevation, it is possible to model the RM.

1.2 Abbreviations

RM : Rockflow magazine

1.3 WSP directions

To ensure that the inlet channels are not limiting the flow of water, the dimensioning and maintenance of the RM should follow the recommendations stated in “ANVENDELSE AF ROCKFLOW TIL NEDSIVNING, MAGASINERING OG RENSNING AF REGNVAND” by WSP, please see references in Appendix C.

2. User guide – Rockflow setup in MIKE+

The MIKE+ setup mimics the hydraulics of the RM: *the magazine is filled quickly and emptied slowly*.

2.1 Getting started (Simplification of the Rockflow solution)

The following physical dimensions and parameters related to the RM must be known before setting up the RM in MIKE+:

1) If the inlet is placed in the top of the RM:
    a. RM, length [m]
    b. RM, width [m]
    c. Bottom elevation of the magazine [m]
    d. Top elevation of the magazine [m]
    e. Downstream level in inlet pipe (elevation of inlet pipes) [m]
    f. Total length of the inlet channels [m]
    g. Inlet channel diameter [m]
2) If the inlet is placed in the bottom of the RM:
    a. RM, length [m]
    b. RM, width [m]
    c. Bottom elevation of the magazine [m]
    d. Top elevation of the magazine [m]
    e. Downstream level in inlet pipe (elevation of inlet pipes) [m]
    f. Length of one inlet channel [m]
    g. Number of open channels in the bottom
    h. Number of closed channels in the bottom
    i. Inlet channel diameter [m]

The above parameters are used as input for the excel spreadsheet, thus the correct MIKE+ parameters are calculated for the Rockflow volume and outlet flow.

The relation between the RM and up- and downstream stormwater systems are not described in this document as the stormwater system varies depending on the specific location, however a project example is described in chapter 3.

The MIKE+ setups for three possible Rockflow solutions are described in this manual:

- Discharge to sewer, inlet in top of the RM (no infiltration)
- Discharge to sewer, inlet in the bottom of the RM (no infiltration)
- Infiltration

2.2 Discharge to sewer (no infiltration)

The first two solutions, where the RM discharges to a downstream sewer system, no infiltration occurs from the RM into the soil. There will only be an outlet into the downstream sewer or recipient. This MIKE+ setup consists of:

a) A Soakaway with a "Basin Geometry"
   i. Cover type: sealed
   ii. No infiltration
   iii. Porosity of fill material: 0,95
b) Inlet in the top (solution 1)
   i. Inlet pipe with a flow regulation Qmax (H)
   ii. Outlet pipe 1 with a flow regulation Qmax (H)
   iii. Outlet pipe 2 with a flow regulation Qmax (dH)
c) Inlet in the bottom (solution 2)
   i. Inlet pipe 1 with a flow regulation Qmax (dH)
   ii. Inlet pipe 2 with a flow regulation Qmax (dH)
   iii. Outlet pipe 1 with a flow regulation Qmax (H)
   iv. Outlet pipe 2 with a flow regulation Qmax (dH)

The setup in MIKE+ is shown below:

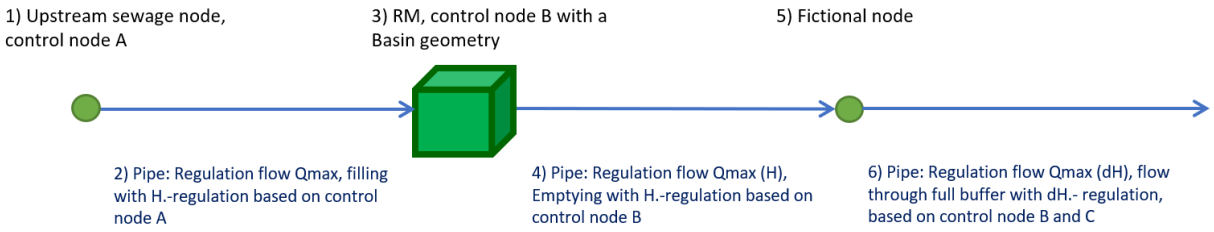


Figure 2-1. MIKE+ setup for RM, with inlet in top (no infiltration).

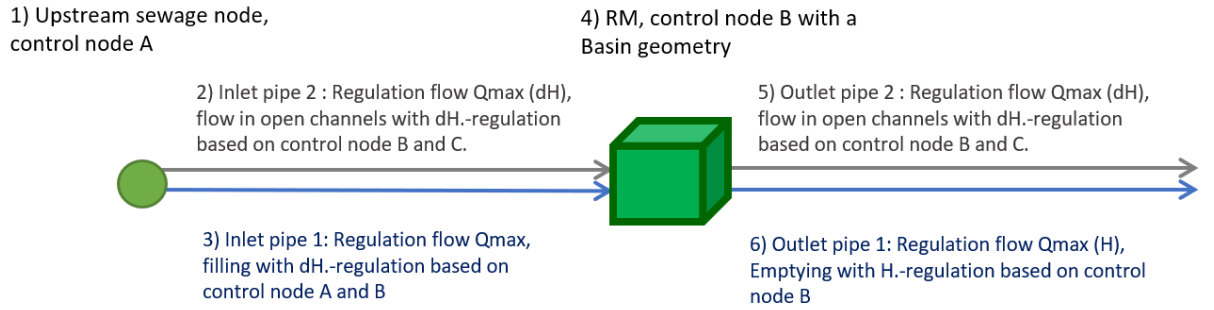


Figure 2-2. MIKE+ setup for RM, with inlet in top (no infiltration).

The basin describes the volume of the RM. While the regulation of the inlet- and the outlet pipes describes the filling and drainage flow within the RM.

The excel spreadsheets graphs is copied directly into "Curves & relations" for basin geometry and flow regulation. The MIKE+ setup is shown in appendix A.1.

2.3 Infiltration

In this third solution, there is infiltration from the RM into the soil. This MIKE+ setup consists of:

1) A Soakaway with a “Basin Geometry”
    a. Cover type: sealed
    b. Infiltration method: infiltration
    c. Porosity of fill material: 0,95
2) Hydraulic condutivity of the soil
    a. Kfs, side
    b. Kf, bottom

The excel spreadsheets graphs is copied directly into “Curves & relations” for basin geometry and the soakaway parameters. The MIKE+ setup is shown in appendix A.2.

Some calculation errors have been observed when using Mike Urban for modelling infiltration from soakaway nodes. Therefore, it is recommended to only use this setup in MIKE+.

3. Project example (Risvang Alle)

The simple MIKE+ setup of the RM has been used to simulate a real-life Rockflow solution, located in Risvang Alle, Aarhus Denmark. The inlet- and outlet flow of the magazine have been measured over time. With this setup it has been possible to model the filling and drainage of the RM and compare the measured outlet flow with the model results. An example is given in the following chapters. The calibration of the MIKE+ parameters and setup are described in Appendix B. There is no infiltration from the RM.

3.1 RM and the construction conditions

The construction drawings of the RM at Risvang Alle are illustrated below.

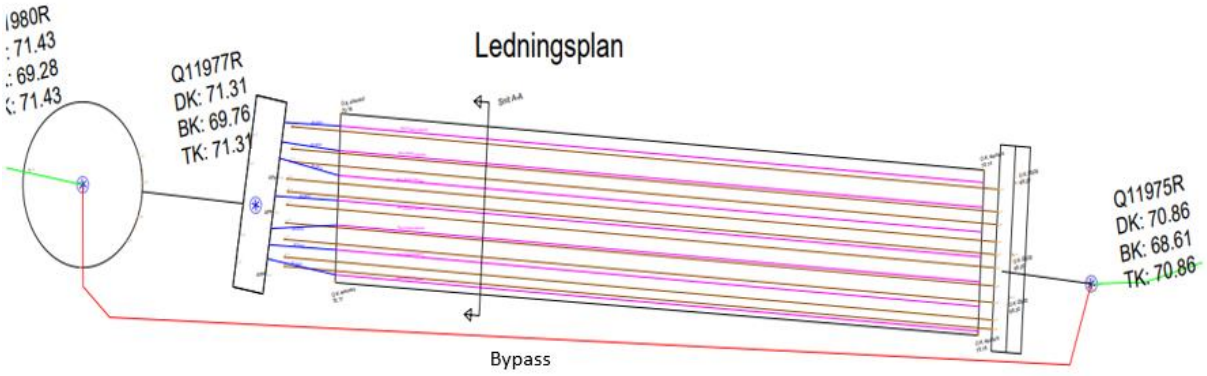


Figure 3-1. Surface plan.

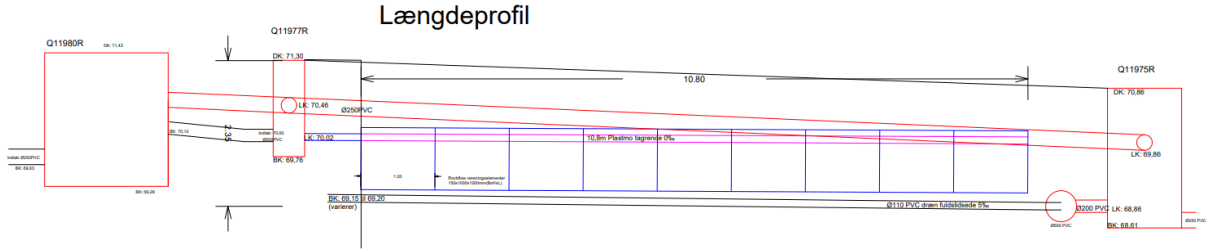


Figure 3-2. Length profile.

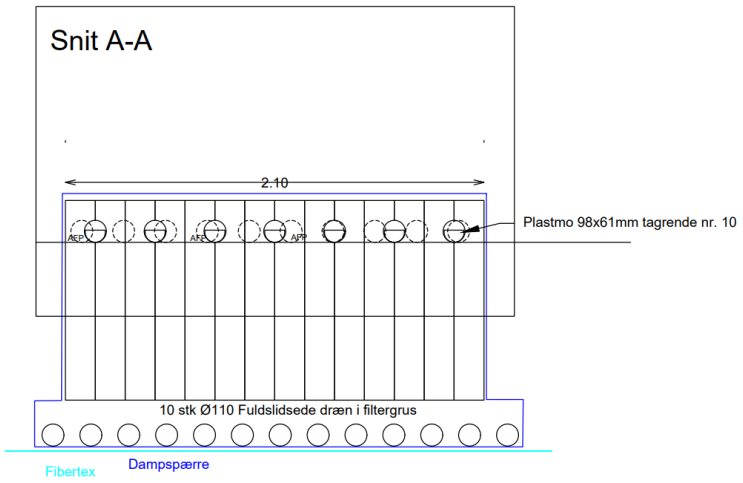


Figure 3-3. Cross section.

Important parameters for the MIKE+-setup are seen below:

Construction condition	Input
- Rockflow magazine, length [m]	10,8
- Rockflow magazine, width [m]	2,1
- Bottom elevation of the magazine [m]	69,16
- Top elevation of the magazine [m]	70,16
- Downstream level in inlet pipe (elevation of inletpipes)	70,02
- Total lenght of inlet channels [m]	75,6
- Inlet channel, diameter [m]	0,098

With the above physical magazine parameters, the volume and regulation curves are given by the Excel spreadsheet:

MIKE+ setup

Input for the Rockflow magazine		
Type: bassin geometry		
.H [m]	**.Ac [m^2]**	**.As [m^2]**
69,16	**0**	**22,68**
70,16	**2,10**	**22,68**

Input for Soakaway	
Infiltration method	**No infiltration**
Inftiltration rate	
Porosity of fill material	**0,95**
Initial water level	**69,16**
Kfs, side	
☑ Use kfs, bottom	

Filling with H.-regulation based on control node A	
Type: regulation Qmax (H)	
.H [m]	**.Qmax [m^3/s]**
70,02	**0,002**
75,16	**0,427**

Emptying with H.-regulation based on control node B	
Type: regulation Qmax (H)	
.H [m]	**.Qmax [m^3/s]**
69,16	**0,0000**
69,26	**0,0001**
69,36	**0,0005**
69,46	**0,0013**
69,56	**0,0025**
69,66	**0,0043**
69,76	**0,0066**
69,86	**0,0096**
69,96	**0,0132**
70,06	**0,0175**
70,16	**0,0226**
75,16	**0,1200**

Flow through full buffer with dH.-regulation based on control node B and C	
Type: Regulation Qmax(dH)	
dH [m]	**Qmax [m^3/s]**
0	**0**
6	**0,1**

The above basin geometry and regulation flows were copied and pasted directly into MIKE+, under “Curves and relation”.

3.1.1 MIKE+ setup

The Risvang Alle sewer solution has been set up in MIKE+. The MIKE+ setup is illustrated in the figure below.

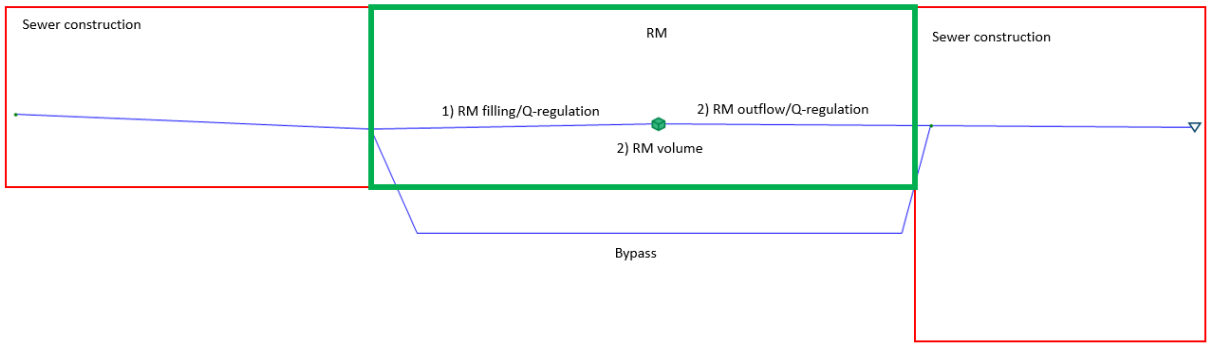


Figure 3-4. MIKE+ setup of the Risvang Alle solution (inlet pipes, RM, outlet pipes, bypass etc.). The green box marks the MIKE+ setup for the RM.

On the upstream and downstream sides of the RM, the sewer construction is modelled. The RM set-up (hydraulics of the RM) is in between, see the figure above.

Inlet flow

The inlet flow was measured at the location in Risvang Alle. The inlet flow was adjusted as a boundary condition in network loads:

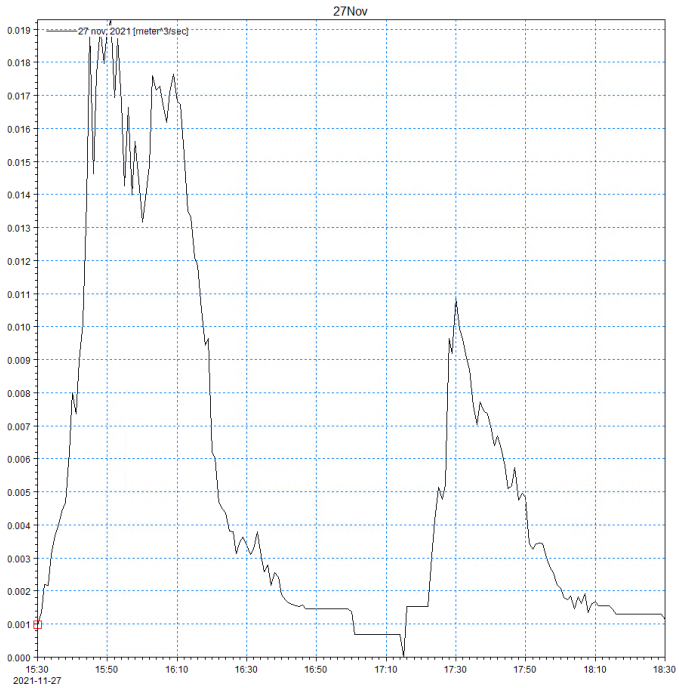
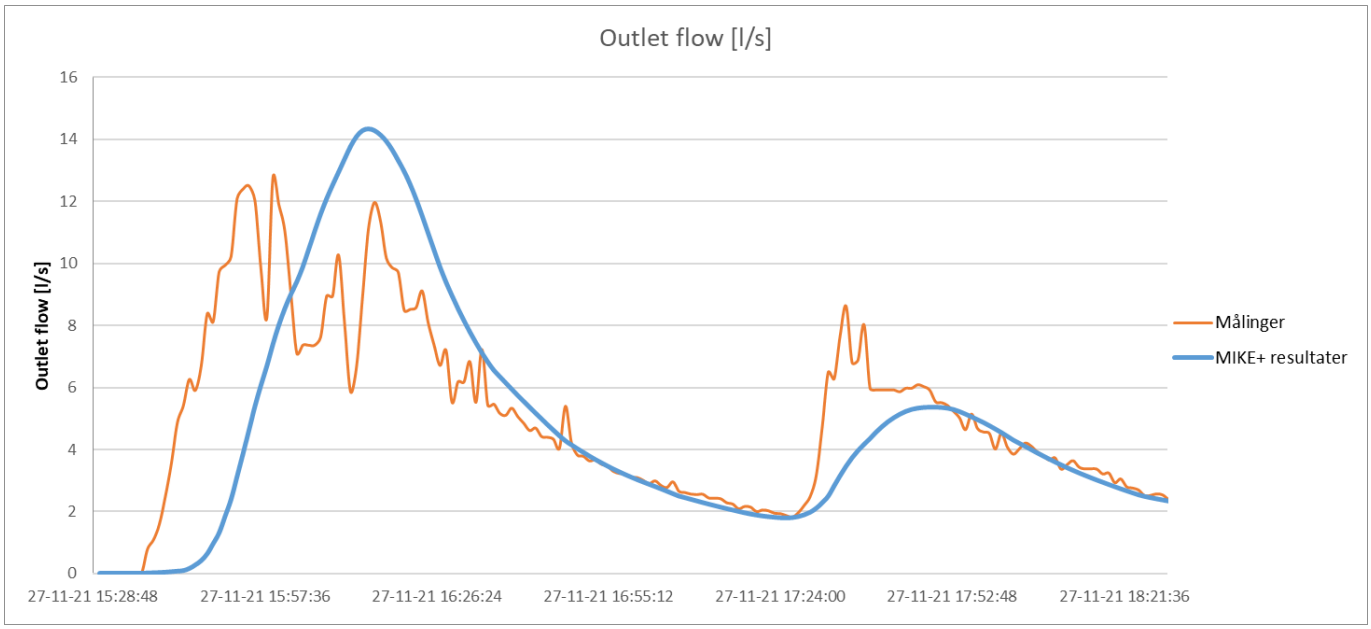


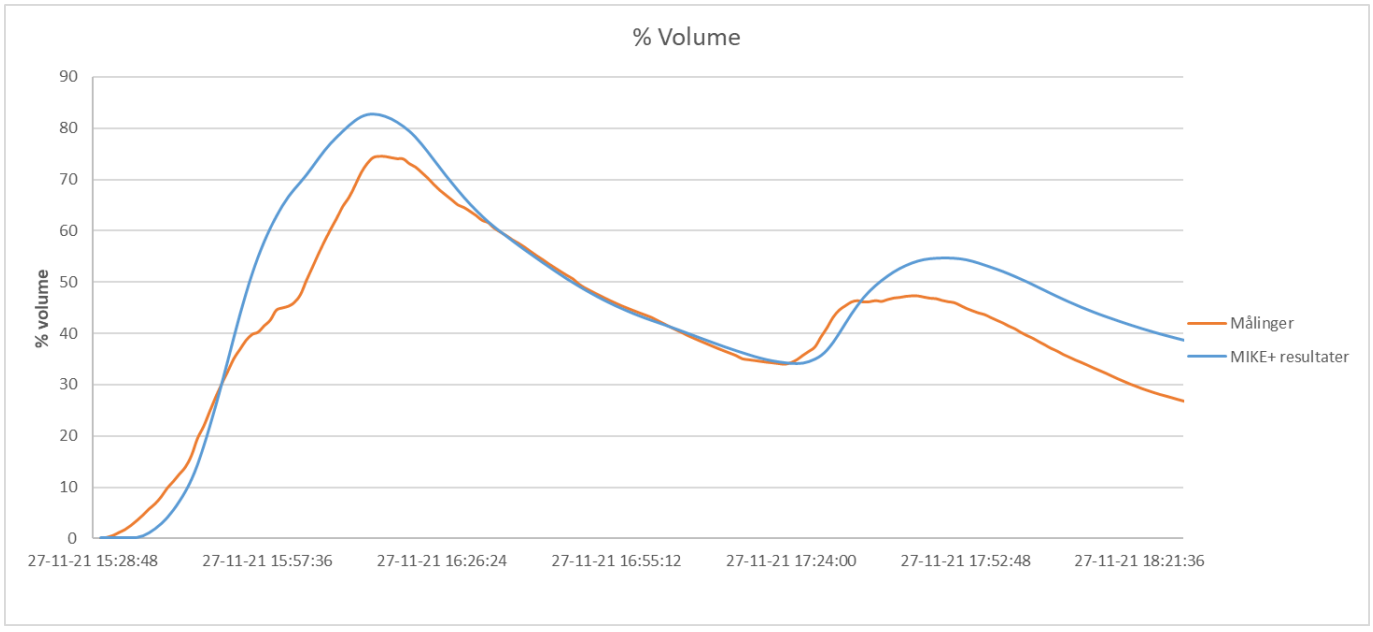
Figure 3-5. Measured inlet flow, November 27, 2021.

MIKE+ results

The graph below shows the modelled and measured outlet flow of the RM:



The graph below shows the percentage filling of the Rockflow volume:

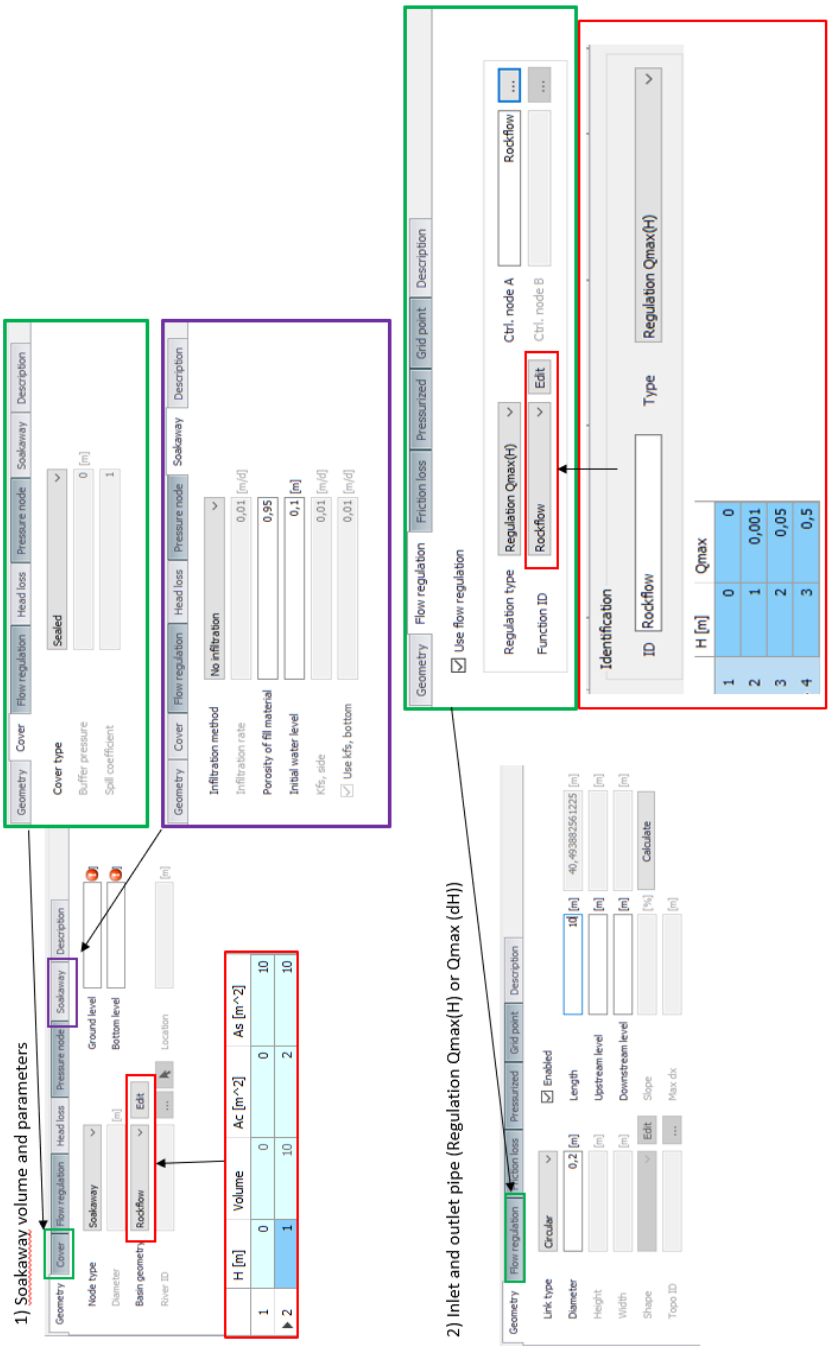


As the figures above show the MIKE+ results are comparable with the measurements.

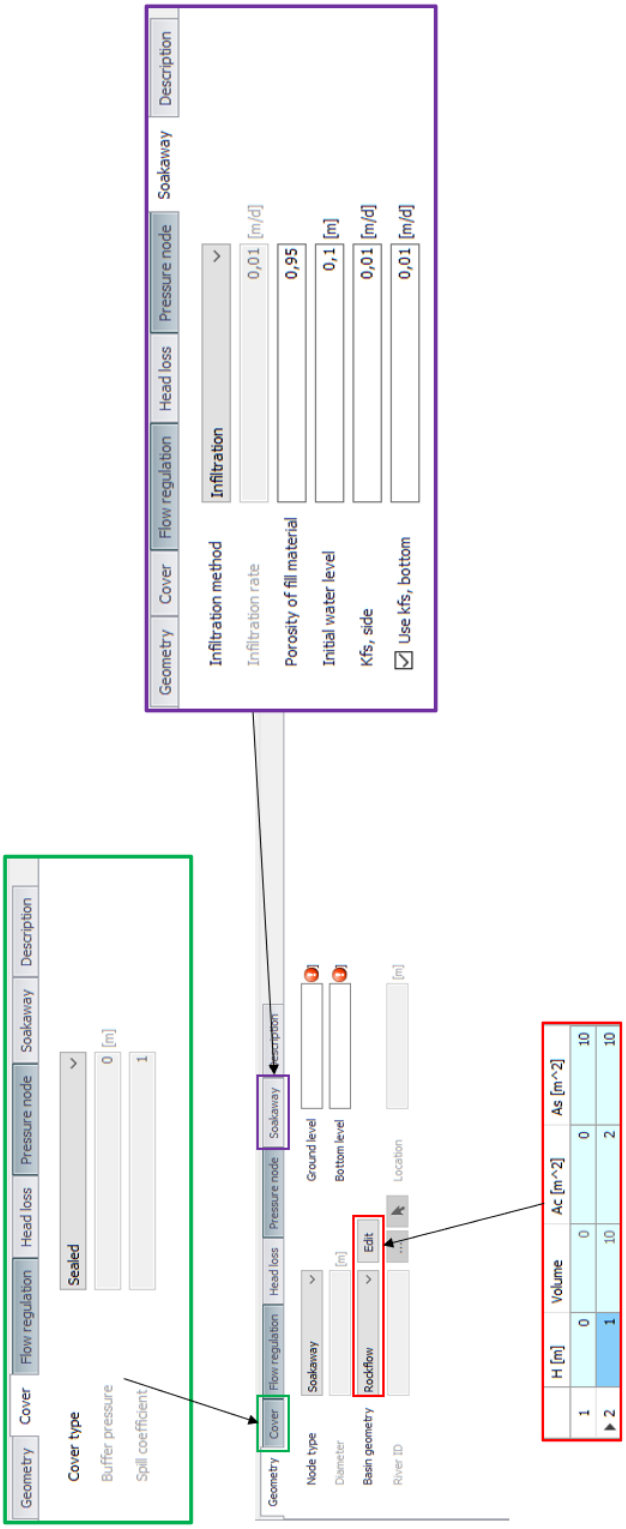
Appendix

Appendix A. MIKE+ setup

A. 1. No infiltration (closed RM, with H.-regulation example)



A.2. Infiltration



Appendix B. Calibrations of an outlet flow from a RM

The MIKE+ setup for Rockflow with no infiltration (discharge to sewer) was tested/calibrated with two controlled laboratory experiments. In the experiments, the drainage of two 5 m^3 containers with Rockflow were measured.

The calibration has been validated with a real-life RM, located at Risvang Alle in Aarhus, Denmark. The inlet and outlet flow have been measured over time at Risvang Alle. The validation of the MIKE+ setup is mainly focused on the outlet and filling of the magazine.

Modelling of the saturated and unsaturated flow

The outlet flow of a RM is determined by whether the magazine is fully saturated or partly filled.

When the magazine is 100 % filled and all pores within the magazine are saturated, the determining physical principle is Darcy's law of hydraulics. The outlet flow is therefore controlled by the hydraulic conductivity, area of the magazine, and the pressure gradient.

However, in many cases the RM is not fully saturated and therefore Darcy's law is no longer applicable. In unsaturated conditions, the flow through a porous medium is much smaller when compared to flow under saturated conditions. The unsaturated flow is here described with a simple equation, and thus, it can be implemented in MIKE+:

- Factor (m) for the unsaturated flow
- The surface area (As)
- Filling degree of the magazine (V/V_{full})
- Hydraulic conductivity of the buffer (K_2)

$$Q = K_2 * As * \left(\frac{V}{V_{full}}\right)^m$$

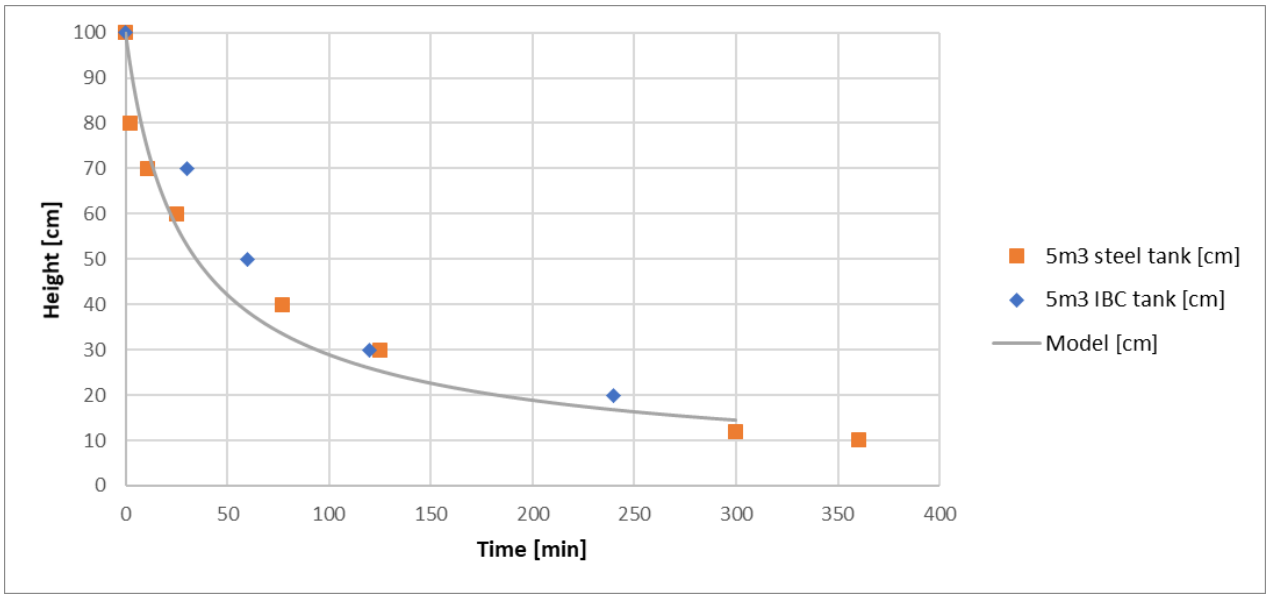
The factor m is a calibration factor based on a relation between the saturation of the magazine and the drainage time. The calibration factor m was found to be approx. 2,4. The calibration factor is used in the Excel spreadsheet for calculation of the parameters used in MIKE+.

The hydraulic conductivity differed in the laboratory setup and the Risvang Alle RM. The test result from the laboratory setup is shown in chapter B.1. and Risvang Alle in chapter 3.1.1.

B. 1. Calibration (laboratory experiments)

In the controlled laboratory experiments RMs with 5 m^3 volume were used. The RMs were filled 100 % (100 cm) and the drainage time was measured.

The measurements and the modelled water height are shown in the graph below:



The experiments showed that around 80 % of the magazines were emptied within 4 hours. With this drainage time, the hydraulic conductivity was estimated to be 45 m/d.

B. 2. Validation (Risvang Alle)

For validation of the calibration factor, a model was set up to simulate a real-life Rockflow solution located at Risvang Alle in Aarhus, Denmark. The inlet and outlet flow were measured and were used in this validation. The Risvang Alle location had problems with coating of the filter within the inlet channels over time. All the data was therefore not suitable in this validation. The graphs in chapter 3.1.1 show a period where the coating of the inlet channels was non existing and therefore useful for the validation.

The measurements indicated a faster outlet flow than measured in the controlled laboratory experiments and a more suitable hydraulic conductivity of 86 m/d were determined for this Rockflow solution, and is for now used in the excel spreadsheet for calculation of the parameters used in MIKE+.

Appendix C. References

"ANVENDELSE AF ROCKFLOW TIL NEDSIVNING, MAGASINERING OG RENSNING AF REGNVAND" by WSP and other information for designing a Rockflow system can be found here: https://www.rockwool.com/dk/produkter-og-konstruktioner/rockflow/installering-af-rockflow/design-af-et-rockflow-anlaeg/

A direct link to **"ANVENDELSE AF ROCKFLOW TIL NEDSIVNING, MAGASINERING OG RENSNING AF REGNVAND"**: https://www.rockwool.com/syssiteassets/applications-and-products/rockflow/downloads/guides/wsp_anvisning-for-rockflow-dk.pdf

A lot of relevant information on Rockflow is gathered here:

In English: https://www.rockwool.com/group/products-and-applications/rockflow/

In Danish: https://www.rockwool.com/dk/produkter-og-konstruktioner/rockflow/

Vejlsøvej 23 • DK-8600 Silkeborg • Tlf.: +45 86 80 63 44 • www.envidan.dk • CVR 18 33 43 05