# DryRivers

## Groundwater modelling for low flow risk-management

SPONSORED BY THE

Federal Ministry of Education and Research

**Bastian Winkels, M.Sc. RWTH**
Dr.-Ing. Jan Oetjen
Dr.-Ing. Catrina Brüll
Univ.-Prof. Dr.-Ing. Holger Schüttrumpf
Prof. Dr.-Ing. Daniel Bachmann

Institute of Hydraulic Engineering and Water Resources management, RWTH Aachen University

# Contents

- **Introduction and context**
  - The need for low flow management
  - DryRivers Project

- **LoFloDeS – Low Flow Decision Support**
  - Objective
  - Challenges
  - Concept

- **Outlook**

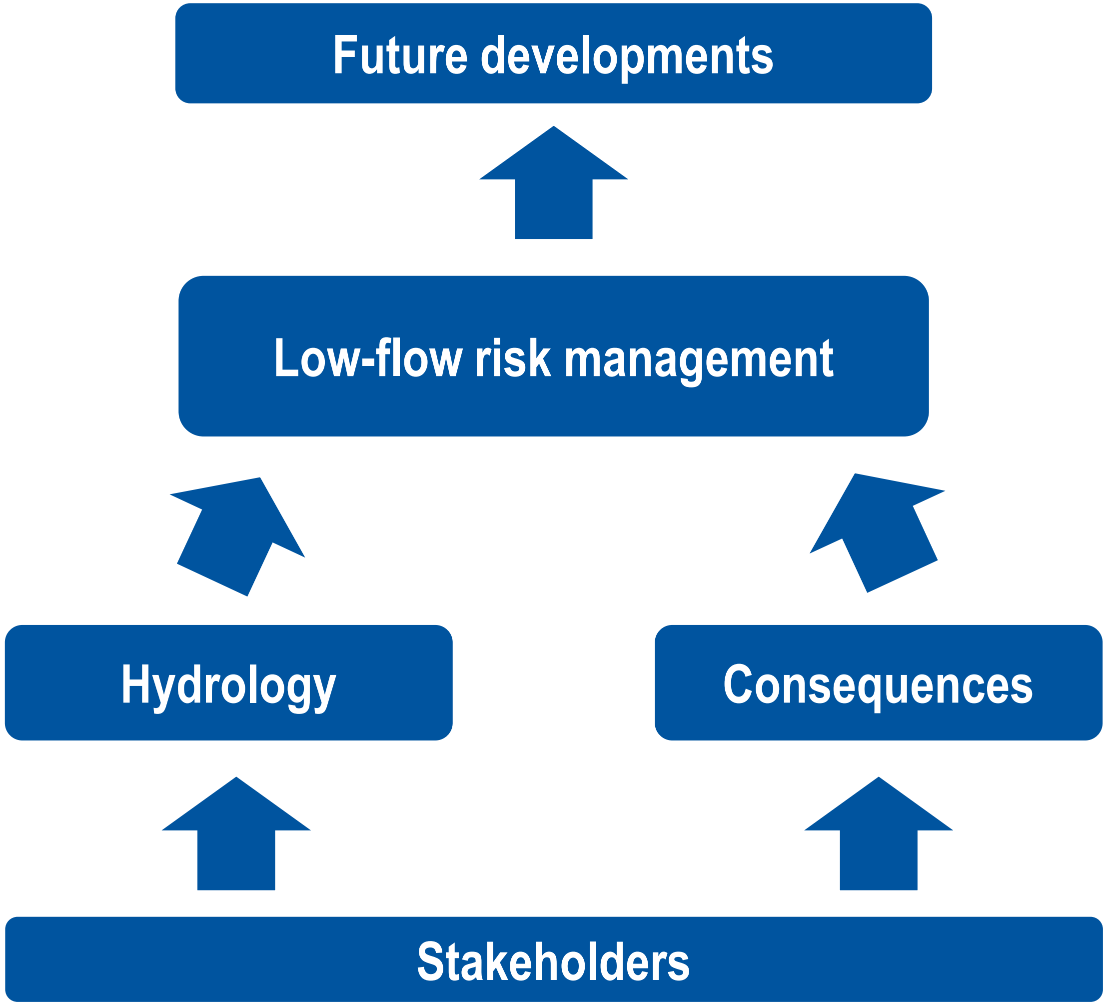
# Introduction and Context

- **Droughts become an increasingly regular „event“**
  - Far-reaching consequences
- **The topic has been widely neglected in Germany**
  - Crisis response instead of management
- **Lack of management tools**

## Partners

- Department of Water, Environment, Construction and Safety / Department of Economics (University Magdeburg-Stendal)
- Institute of Hydraulic Engineering and Water Resources Management (RWTH Aachen University)
- Institute of Sociology (RWTH Aachen University)
- Environmental Office essen Bolle and Partner GbR
- LimnoPlan - Fish- and Water Body Ecology

- **Overall Goal:**
  - Creation of a praxis-ready tool to support Low-flow risk-management
- **Holistic approach**
  - Stakeholder involvement
  - Modelling
  - Risk management
  - Risk communication

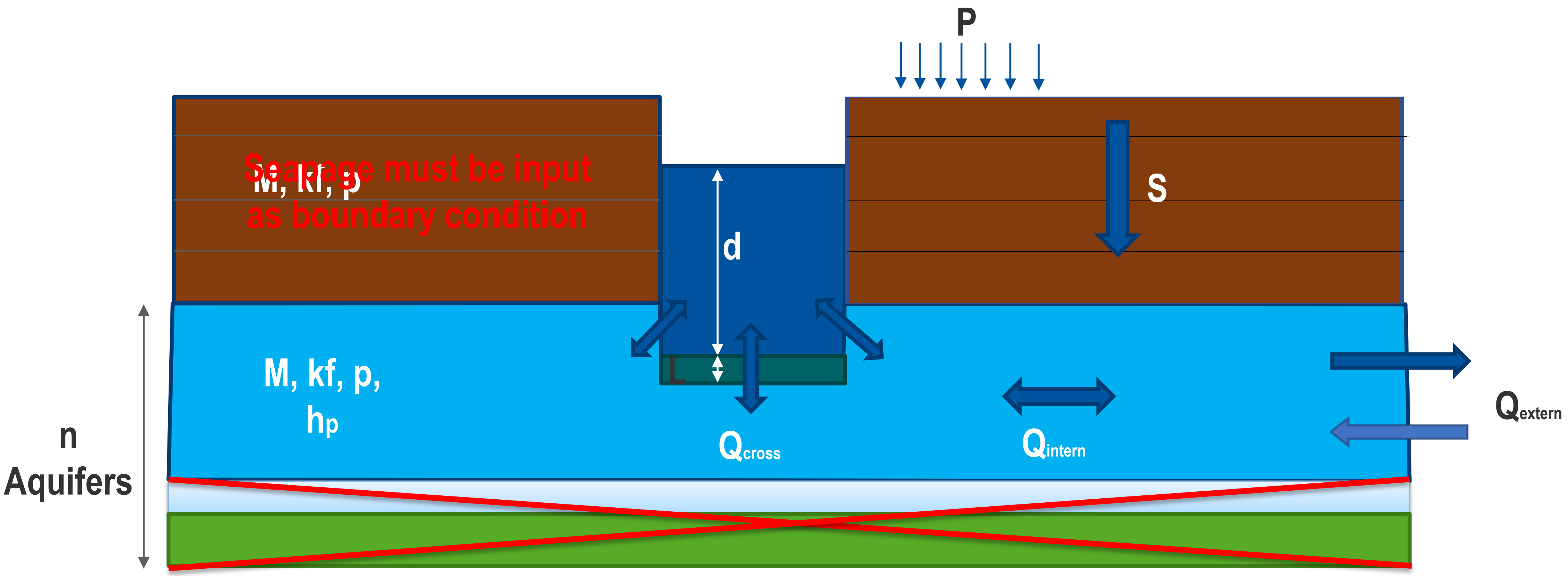



- **Task of IWW:**
  - LoFloDeS development

# LoFloDeS (Low Flow Decision Support)

- **Objective:**
  - Numerical modelling of groundwater and rivers in low-flow situations
- **Based on ProMaIDeS**
  - https://promaides.myjetbrains.com/youtrack/articles/PMID-A-7/General
- **Challenges:**
  - Not location-specific
    - High flexibility
    - Sufficient quality
  - Droughts have memory
    - Long time frames
    - Efficient calculation

# Overview

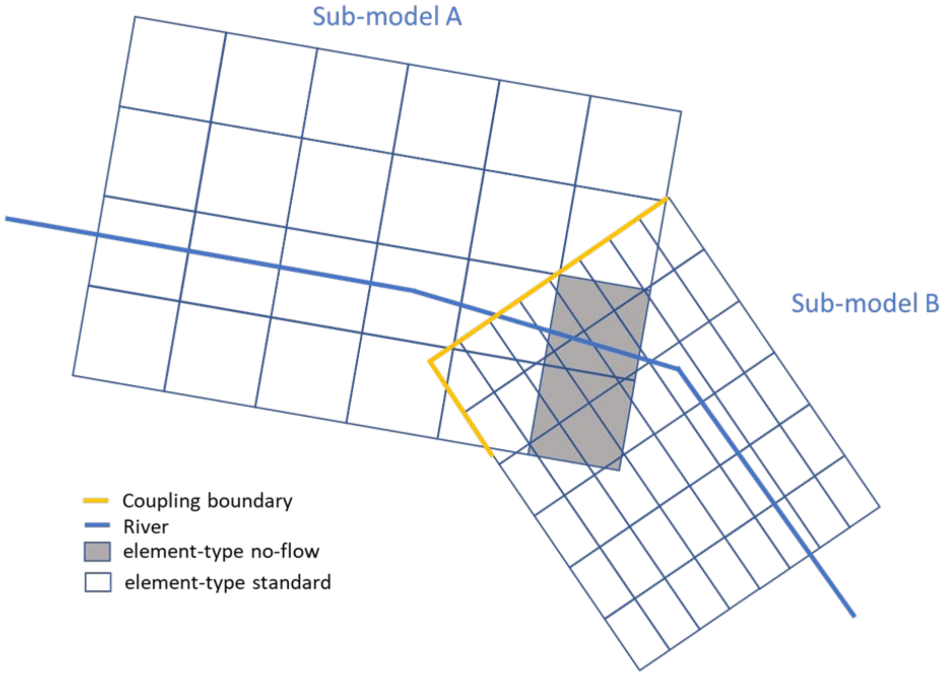



Only 1st aquifer is modelled

# Spatial discretization

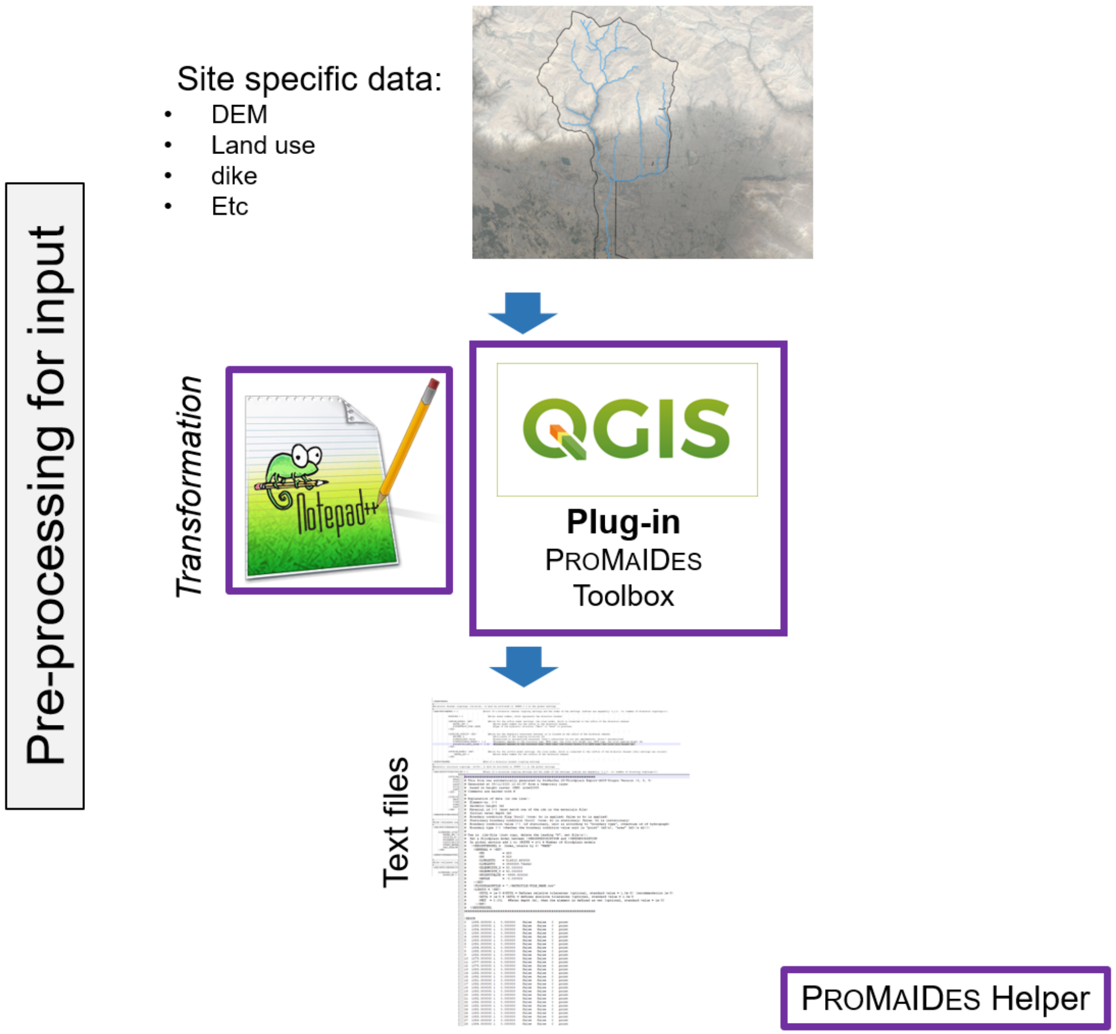
- **Regular grids**
  - Efficient storage
  - Efficient computational handling
  - Compatability with ProMaIDeS

- **Couplings**
  - 2D-2D Coupling
  - Spatial optimization
  - Option to embed more detailed local grids



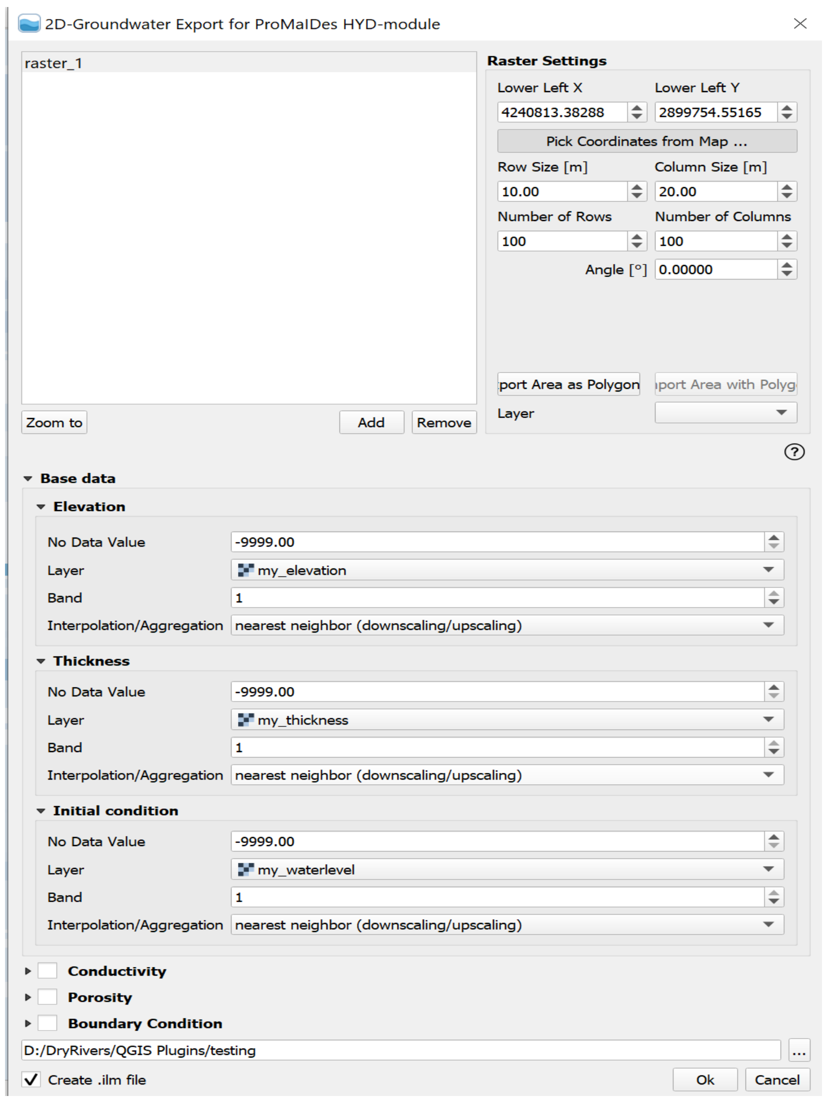
# Data input

- **Data input through QGIS plugins**
- **Plugins generate ProMaIDeS compatible text-files**
- **Open-source**
  - Usable anywhere by anyone

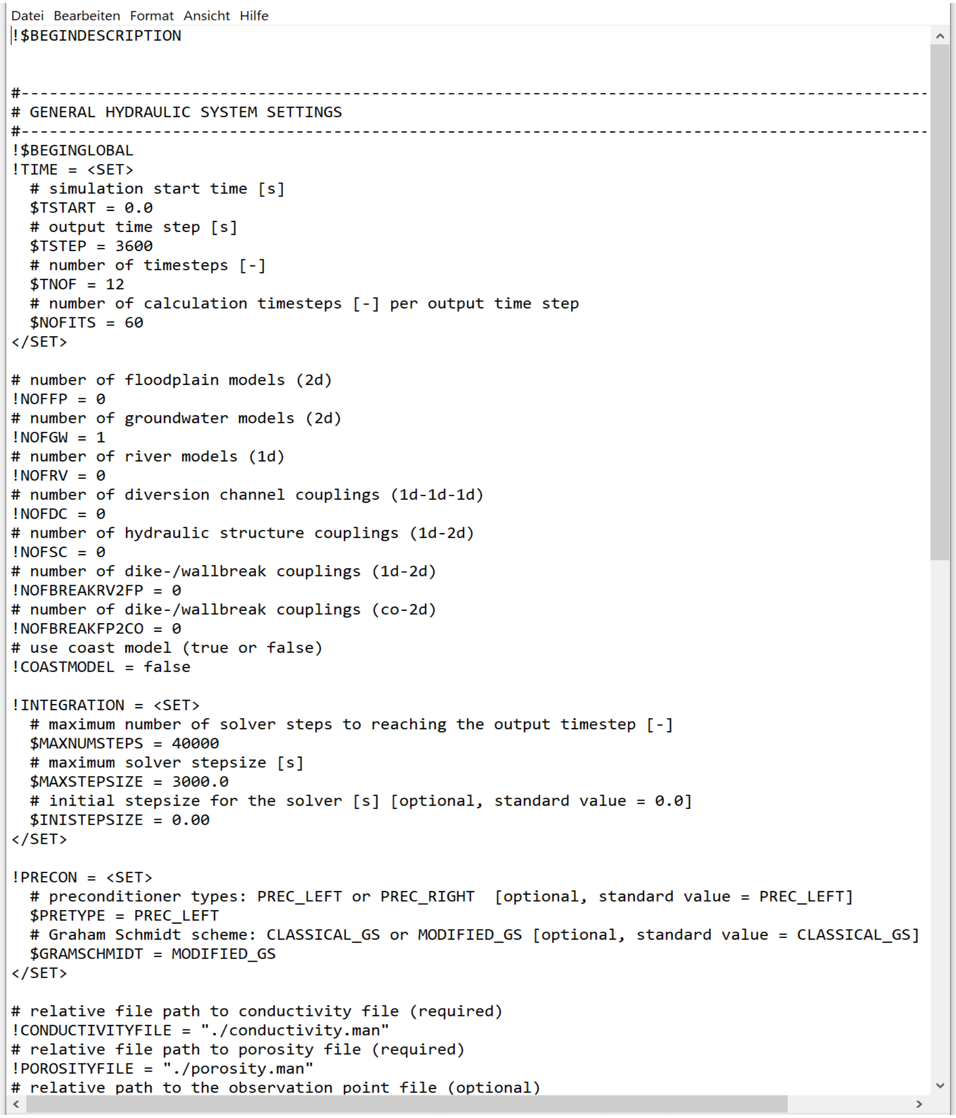



**Source: Magdeburg-Stendal University**

# Data input



2D-Groundwater Export for ProMaIDes HYD-module
raster_1
Raster Settings
Lower Left X
Lower Left Y
4240813.38288
2899754.55165
Pick Coordinates from Map ...
Row Size [m]
Column Size [m]
10.00
20.00
Number of Rows
Number of Columns
100
100
Angle [°]
0.00000
port Area as Polygon
port Area with Polyg
Layer
Zoom to
Add
Remove
Base data
Elevation
No Data Value
-9999.00
Layer
my_elevation
Band
1
Interpolation/Aggregation
nearest neighbor (downscaling/upscaling)
Thickness
No Data Value
-9999.00
Layer
my_thickness
Band
1
Interpolation/Aggregation
nearest neighbor (downscaling/upscaling)
Initial condition
No Data Value
-9999.00
Layer
my_waterlevel
Band
1
Interpolation/Aggregation
nearest neighbor (downscaling/upscaling)
Conductivity
Porosity
Boundary Condition
D:/DryRivers/QGIS Plugins/testing
Create .ilm file
Ok
Cancel

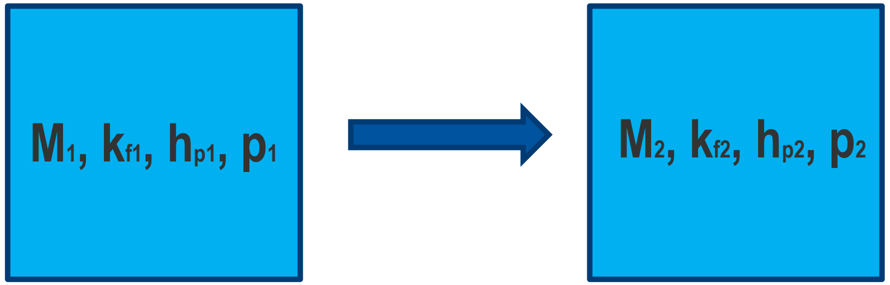
Datei Bearbeiten Format Ansicht Hilfe
!$BEGINDESCRIPTION
#------------------------------------------------------------------------------------------
# GENERAL HYDRAULIC SYSTEM SETTINGS
#------------------------------------------------------------------------------------------
!$BEGINGLOBAL
!TIME = <SET>
# simulation start time [s]
$TSTART = 0.0
# output time step [s]
$TSTEP = 3600
# number of timesteps [-]
$TNOF = 12
# number of calculation timesteps [-] per output time step
$NOFITS = 60
</SET>
# number of floodplain models (2d)
!NOFFP = 0
# number of groundwater models (2d)
!NOFGW = 1
# number of river models (1d)
!NOFRV = 0
# number of diversion channel couplings (1d-1d-1d)
!NOFDC = 0
# number of hydraulic structure couplings (1d-2d)
!NOFSC = 0
# number of dike-/wallbreak couplings (1d-2d)
!NOFBREAKRV2FP = 0
# number of dike-/wallbreak couplings (co-2d)
!NOFBREAKFP2CO = 0
# use coast model (true or false)
!COASTMODEL = false
!INTEGRATION = <SET>
# maximum number of solver steps to reaching the output timestep [-]
$MAXNUMSTEPS = 40000
# maximum solver stepsize [s]
$MAXSTEPSIZE = 3000.0
# initial stepsize for the solver [s] [optional, standard value = 0.0]
$INISTEPSIZE = 0.00
</SET>
!PRECON = <SET>
# preconditioner types: PREC_LEFT or PREC_RIGHT [optional, standard value = PREC_LEFT]
$PRETYPE = PREC_LEFT
# Graham Schmidt scheme: CLASSICAL_GS or MODIFIED_GS [optional, standard value = CLASSICAL_GS]
$GRAMSCHMIDT = MODIFIED_GS
</SET>
# relative file path to conductivity file (required)
!CONDUCTIVITYFILE = "./conductivity.man"
# relative file path to porosity file (required)
!POROSITYFILE = "./porosity.man"
# relative path to the observation point file (optional)

# Groundwater grid

- User input
  - Thickness
  - Initial water level
  - Conductivity-Index
  - Porosity-Index

# Conductivity and porosity input through IDs

- Link to external files
- Simplified calibration




**Exchange after Darcy:**

$$Q_{internal} = \frac{2\,T_1 T_2}{T_1 + T_2} * \Delta y * \frac{h_{p1} - h_{p2}}{\Delta x}$$

**with:**

$$T_i = k_{fi} * M_i$$

$Q_{internal}$ = Discharge; $T_i$ = Transmissivity;
$h_i$ = Potential; $M_i$ = Thickness

```
!BEGIN
0	45.000000	20.000000	1	1	10.000000	true	true	true	x_dir	57	area
1	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
2	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
3	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
4	45.000000	20.000000	1	1	10.000000	true	true	true	x_dir	53	area
5	45.000000	20.000000	1	1	10.000000	true	true	true	x_dir	57	area
6	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
7	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
8	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
9	45.000000	20.000000	1	1	10.000000	true	true	true	x_dir	53	area
10	45.000000	20.000000	1	1	10.000000	true	true	true	x_dir	57	area
11	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
12	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
13	45.000000	20.000000	1	1	10.000000	false	false	false	x_dir	0	point
14	45.000000	20.000000	1	1	10.000000	true	true	true	x_dir	53	area
!END
```

Datei Bearbeiten Format Ansicht Hilfe

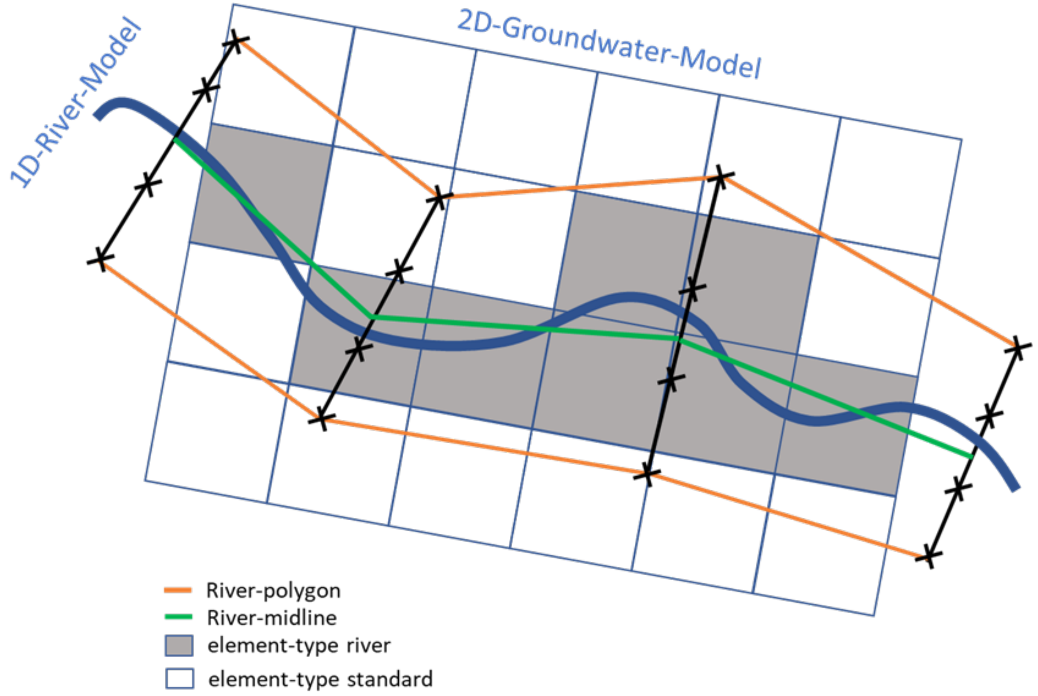
```
##########################################################################
# This file for LoFloDeS conductivity file
# Generated Manually
# Comments are marked with #
#
# Explanation of data:
#  Start with number of rows
#  id  value type (KF)
#  The conductivity-ids are connected to the 2d-raster files;
#  adjust it to your purpose
# Use in .ilm-file (just copy, delete the leading "#", set file(s)):
# Set in global section between !$BEGINGLOBAL and !$ENDGLOBAL
#  !CONDUCTIVITYFILE = "./PATH2FILE/FILE_NAME.txt"
##########################################################################
3 #number of rows
1	0.003000000	KF
2	0.000333333	KF
3	0.000033333	KF
```

Datei Bearbeiten Format Ansicht Hilfe

```
##########################################################################
# This file for LoFloDeS porosity file
# Generated manually
# Comments are marked with #
#
# Explanation of data:
#  Start with number of rows
#  id  value type (EP)
#  The porosity-ids are connected to the 2d-raster files;
#  adjust it to your purpose
# Use in .ilm-file (just copy, delete the leading "#", set file(s)):
# Set in global section between !$BEGINGLOBAL and !$ENDGLOBAL
#  !POROSITYFILE = "./EPATH2FILE/FILE_NAME.txt"
##########################################################################
4 #number of rows
0	0.3	EP
1	0.4	EP
2	0.5	EP
3	0.6	EP
```

# Groundwater-River-Coupling (1D-2D)

- **Boundary Polygon creation from river profiles**
  - automatic
- **Currently coupling of the cells that are located completely inside the polygon**
- **Coupling discharge calculation with leakage approach**



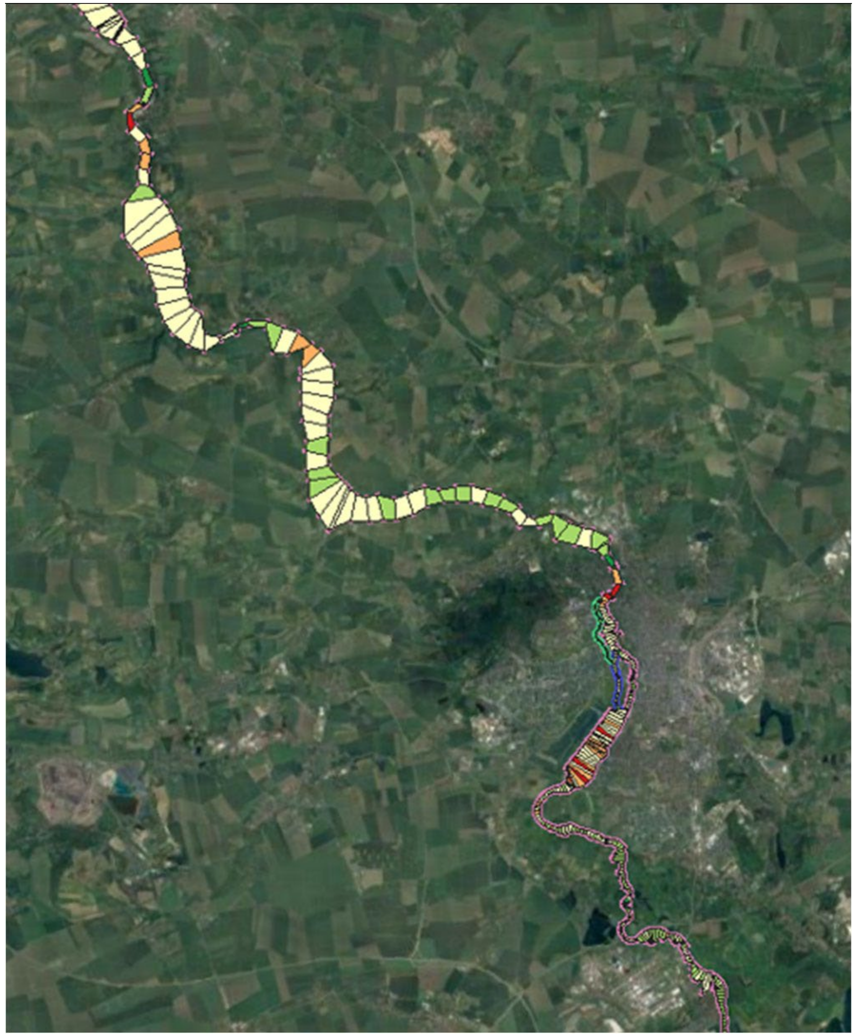

$$Q_{cross} = C_{RIV} * \Delta h$$

$$C_{RIV} = K_{fRIV} * L * \frac{W_{RIV}}{M_{RIV}}$$

$Q_{cross}$ = Exchange-discharge; $C_{RIV}$ = Leakage-Factor; $\Delta h$= Potential-diff.; $L$ = Flowlength; $M_{RIV}$ = thickness; $W_{RIV}$ = wetted perimeter

# Outlook

- Finalization of Groundwater-River-Coupling
- Enable storage in database
  - Visualization in QGIS
- Adapt user-interface
- Test-runs/debugging
- Optimization



Source: Magdeburg-Stendal University

# Thank you for your attention!

# Questions or suggestions?

**Bastian Winkels, M.Sc. RWTH**
**Univ.-Prof. Dr.-Ing. Holger Schüttrumpf**
**Prof. Dr.-Ing. Daniel Bachmann**
**Dr.-Ing. Catrina Brüll**
**Dr.-Ing. Jan Oetjen**
winkels@iww.rwth-aachen.de
schuettrumpf@iww.rwth-aachen.de
bruell@iww.rwth-aachen.de
oetjen@iww.rwth-aachen.de

**Institute of Hydraulic Engineering and Water Resources Management**
Univ.-Prof. Dr.-Ing. Holger Schüttrumpf
Mies-van-der-Rohe-Str. 17
52074 Aachen
http://www.iww.rwth-aachen.de