Examples of modelling assessment of point and non-point measures impact to water balance and water quality

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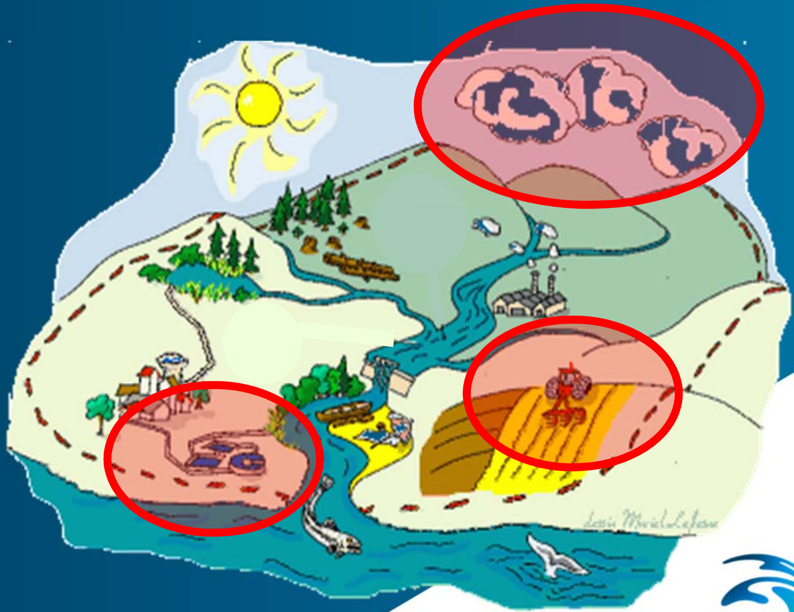
WFD implementation process assumes effective measures…

challenges:

- What are most effective measures?
- What is an optimal combination?
- Will be set of measures sufficient?

impact calculations needed



Methodology for measures impact calculations

steps

1. analysis of **current pollution sources**
2. calculation of input **flow and concentrations** in **river network** and water reservoirs
3. quantification of expected impact of individual measures to runoff, discharge and concentrations.

advantage: use of mathematical modelling techniques

Two DHI approaches for water balance and water quality modelling

- Simplified models for river basin scale (MIKE BASIN)
- Complex integrated hydrological simulation system, suitable for detailed simulations (MIKE SHE)

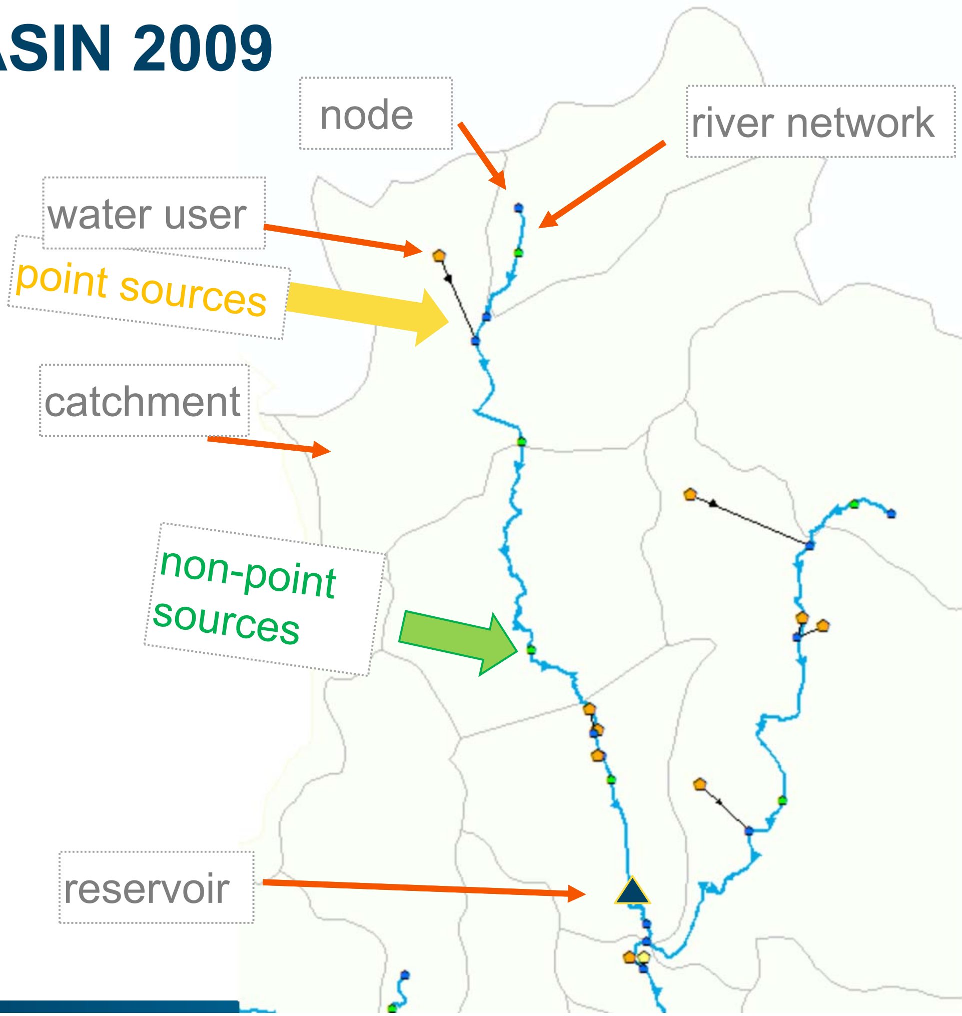
Modelling software: MIKE BASIN 2009

simple water balance and WQ model

- vector elements linked to time series
- extension of ESRI ArcGIS
- MS Access database
- dynamic simulation of changes in time

concentrations: 1st order decay

used in frame of planning in river basins (WFD implementation) in CZ



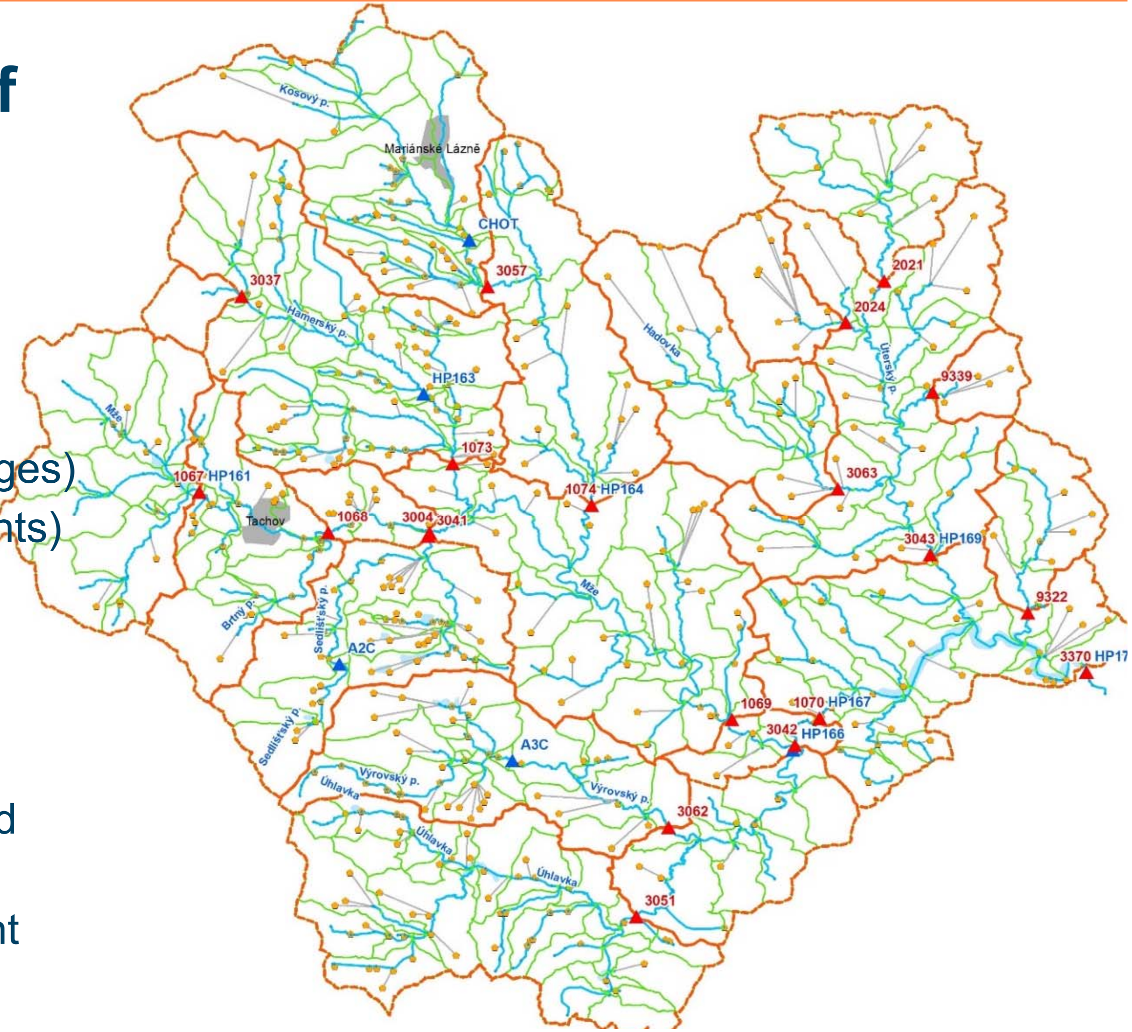
River basin model: data

River basin upstream of Hracholusky reservoir

aim: measures to decrease
P input to the reservoir

area 1609 km^2, southwest Bohemia

- observed river discharge (10 gauges)
- measured concentrations (20 points)
- 451 water users
- 300 catchments
- 1400 river reaches
- calculation of variables for each
  - catchment specific runoff and matter flux
  - river reach - decay coefficient



Data processing

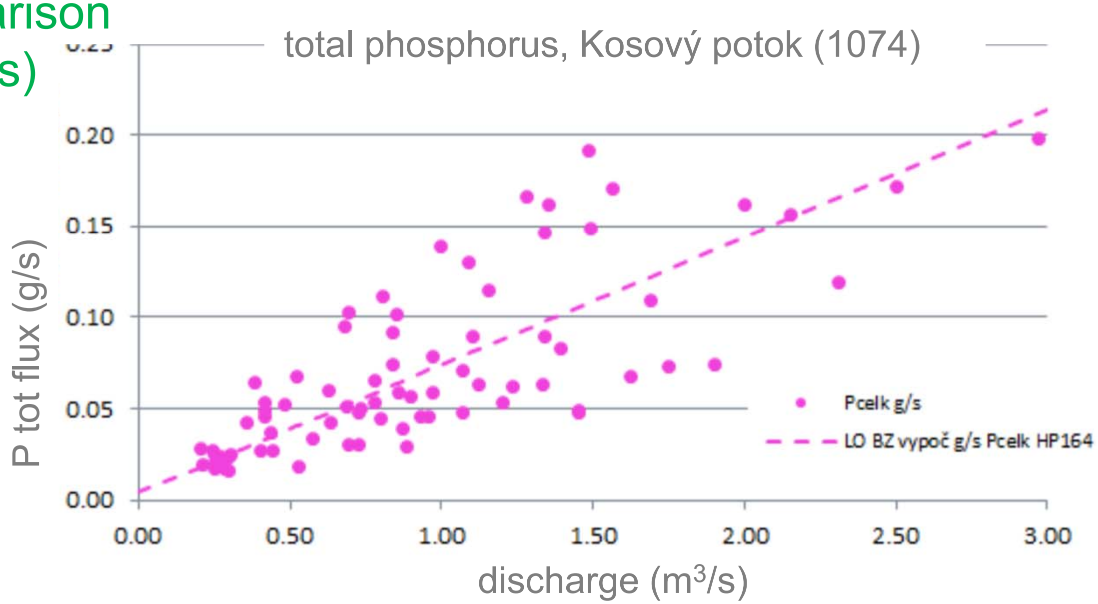
- assessment of 4 matters: P total, N total, P-PO_4, N-NO_3
- daily discharge data and instant concentration for 2012-2017 period
- 12 monthly values of river discharge and concentrations in sampling points are used for calculation of runoff and flux catchments and river reaches

- pollution sources
  a) point (connected to river node, discharge and concentration in data)
  b) other (incl. all non-point and also unidentified point sources)

- results: average annual discharge, average annual matter fluxes (concentrations) for current status (2012-2017) in whole river network

DHI Methodology

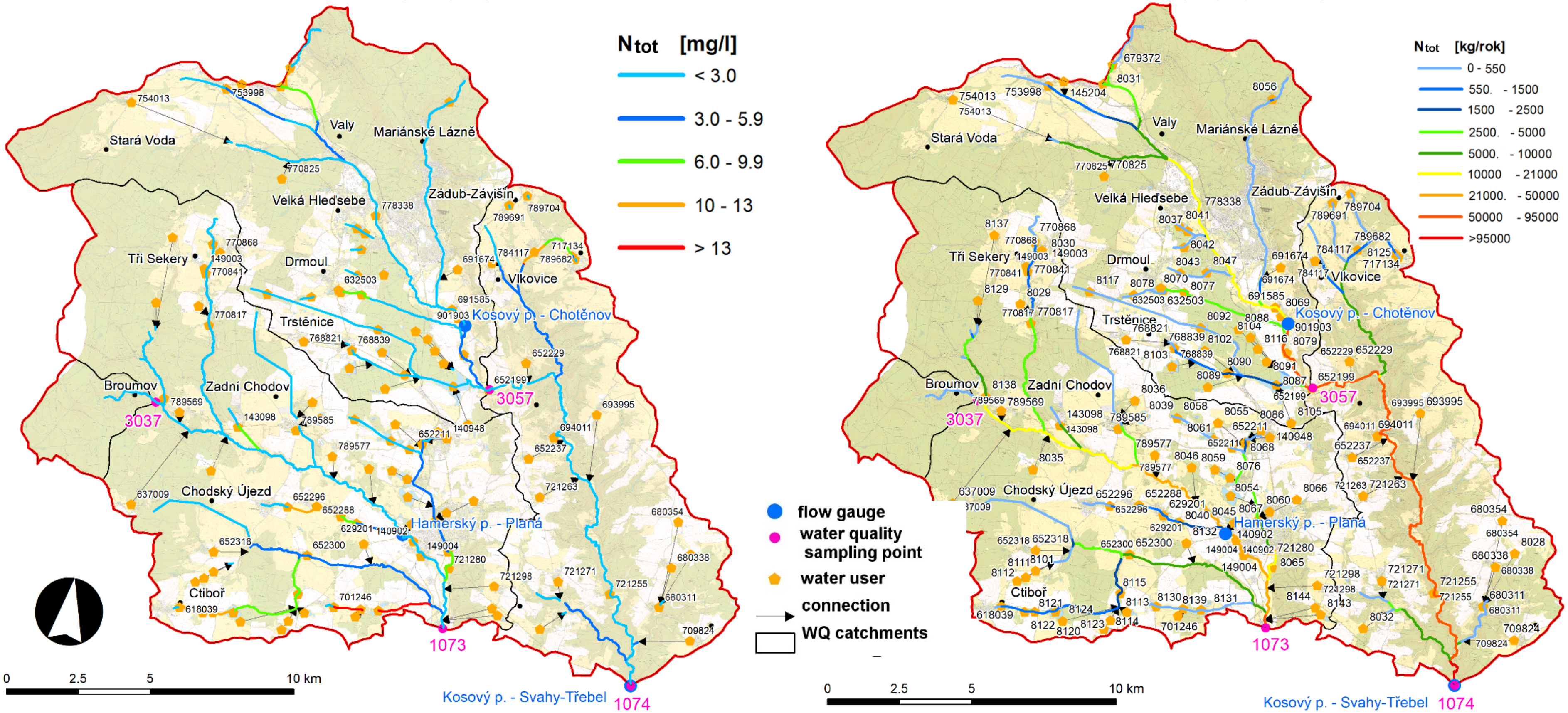
1. data processing (monthly discharges and matter fluxes, linear regression relationship analysis)
2. GIS model structure building
3. water balance simulation
4. simulation of concentrations
5. variant simulations and comparison (impact of individual measures)



River basin model: examples of results

Kosový and Hamerský brook catchments, average annual

total N concentration (mg/l) | total N flux (kg/year)



River basin model: examples of results

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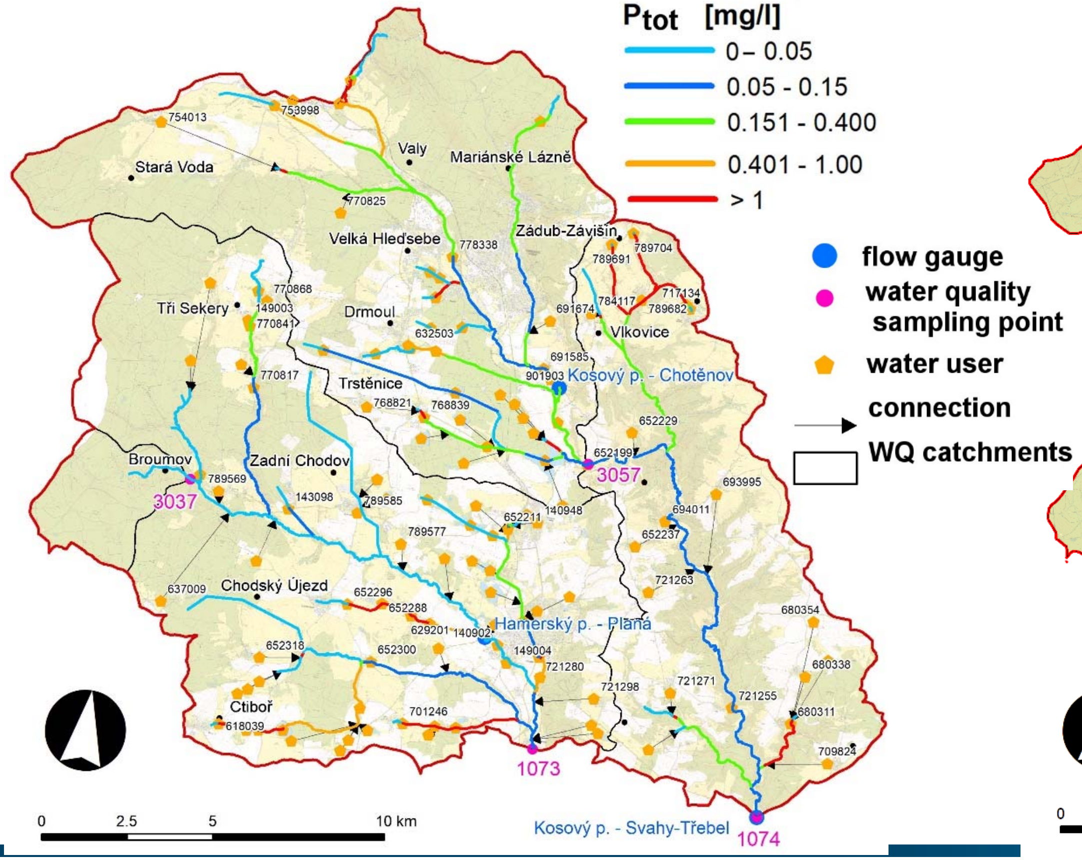
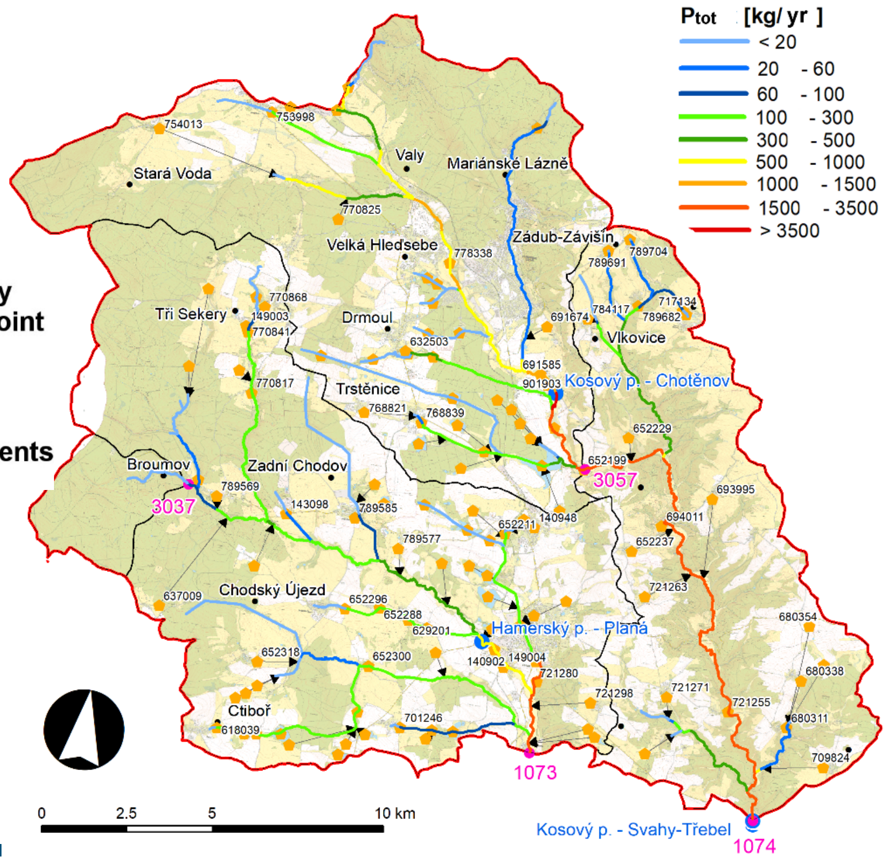


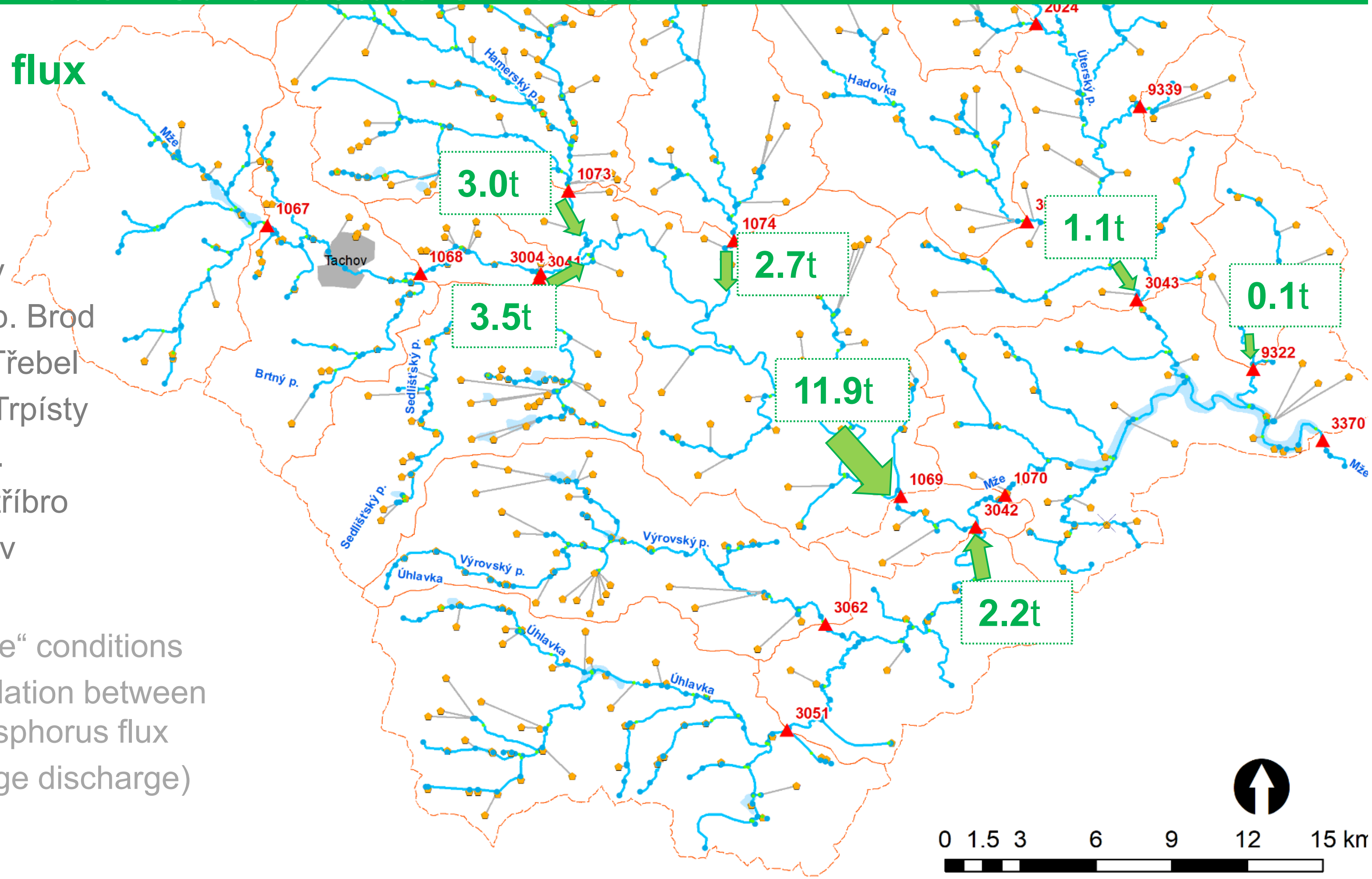
total P flux (kg/year)



River basin model: Curent state simulation

annual total P flux (tons / year)

sampling points
3004 = Mže, Kočov
1073 = Hamerský p. Brod
1074 = Kosový p. Třebel
3043 = Úterský p. Trpísty
9322 = Žebrácký p.
3042 = Úhlavka, Stříbro
1069 = Mže, Milíkov



derived for „average“ conditions (according to correlation between discharge and phosphorus flux and monthly average discharge)

River basin model: variant simulation - decrease of Ptot

set measures at WWTP Planá, Hamerský p.

-986 kg P/year

Brod n.T.
-854 kg P/year

Mže confl. H. p.
-662 kg P/year

Mže confl. Kos.p
-414 kg P/year

Milíkov
-213 kg P/year

Detailed hydrologic model

Kopaninský potok, microcatchment P6

(experimental catchment operated by VUMOP Praha)

Bohemo-moravian Highland, Želivka river basin

- area 15.7 ha
- 467 až 578 m a. s. l.,
- Pa: 665 mm/year
- Ta: 7°C

- dystric cambisol
- paragneiss
- tile drainage (61%)

MIKE SHE model

(MIKE by DHI software)

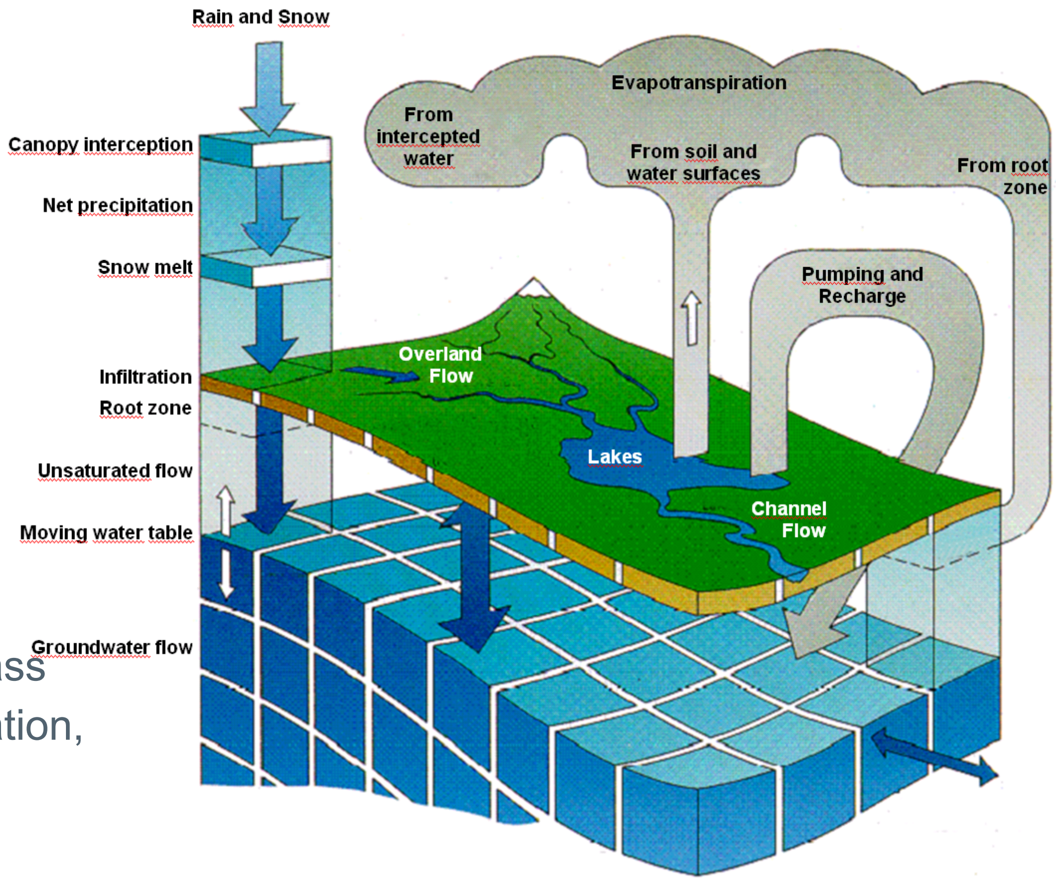
integrated deterministic mathematical modelling system for water movement and water quality simulations. Finite differences.

approximations used:

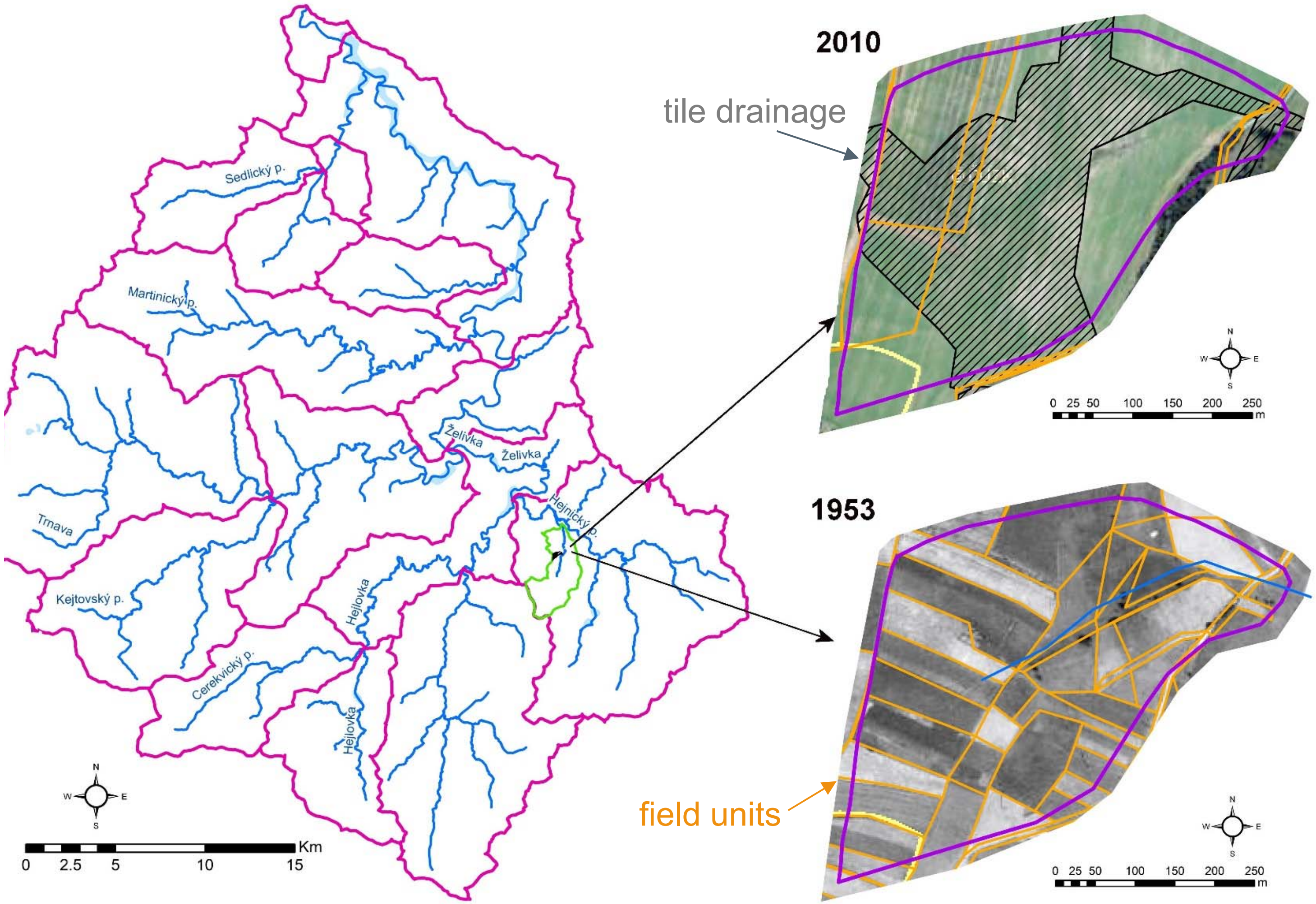
- overland flow: 2D diffusive wave
- channel flow: 1D HD
- unsaturated zone: 1D (vertical) approx. of Richards equation + bypass
- saturated zone: 3D Boussinesq equation, finite difference.

computational mesh: 12 x 12 m

time step: 10 min



Detailed hydrologic model: land-use change



model **calibrated** for current conditions (2004-12)

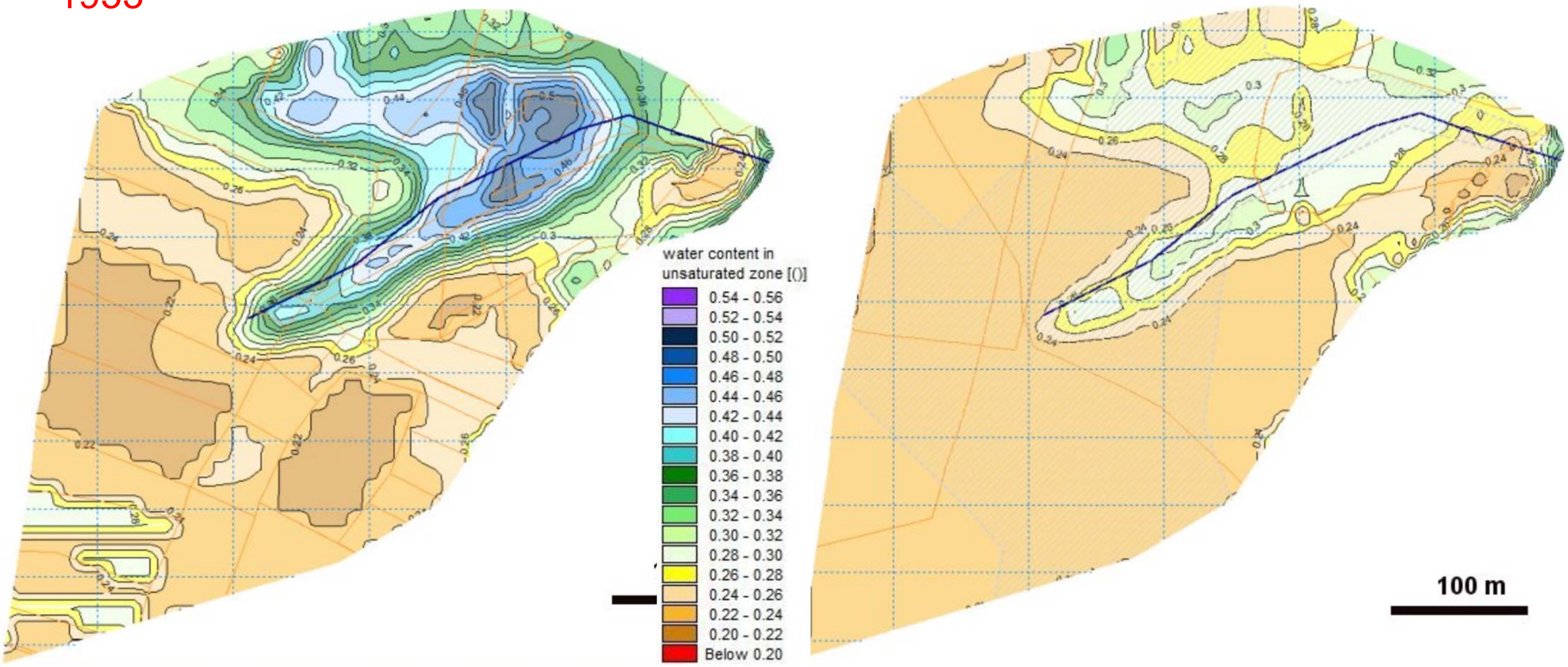
then **changed** model settings to 1953 conditions
(drainage removed
land use map and crop rotation altered)

Detail hydrologic model: results

simulated soil water content (-) in depth 15 cm for dry conditions (23rd may)

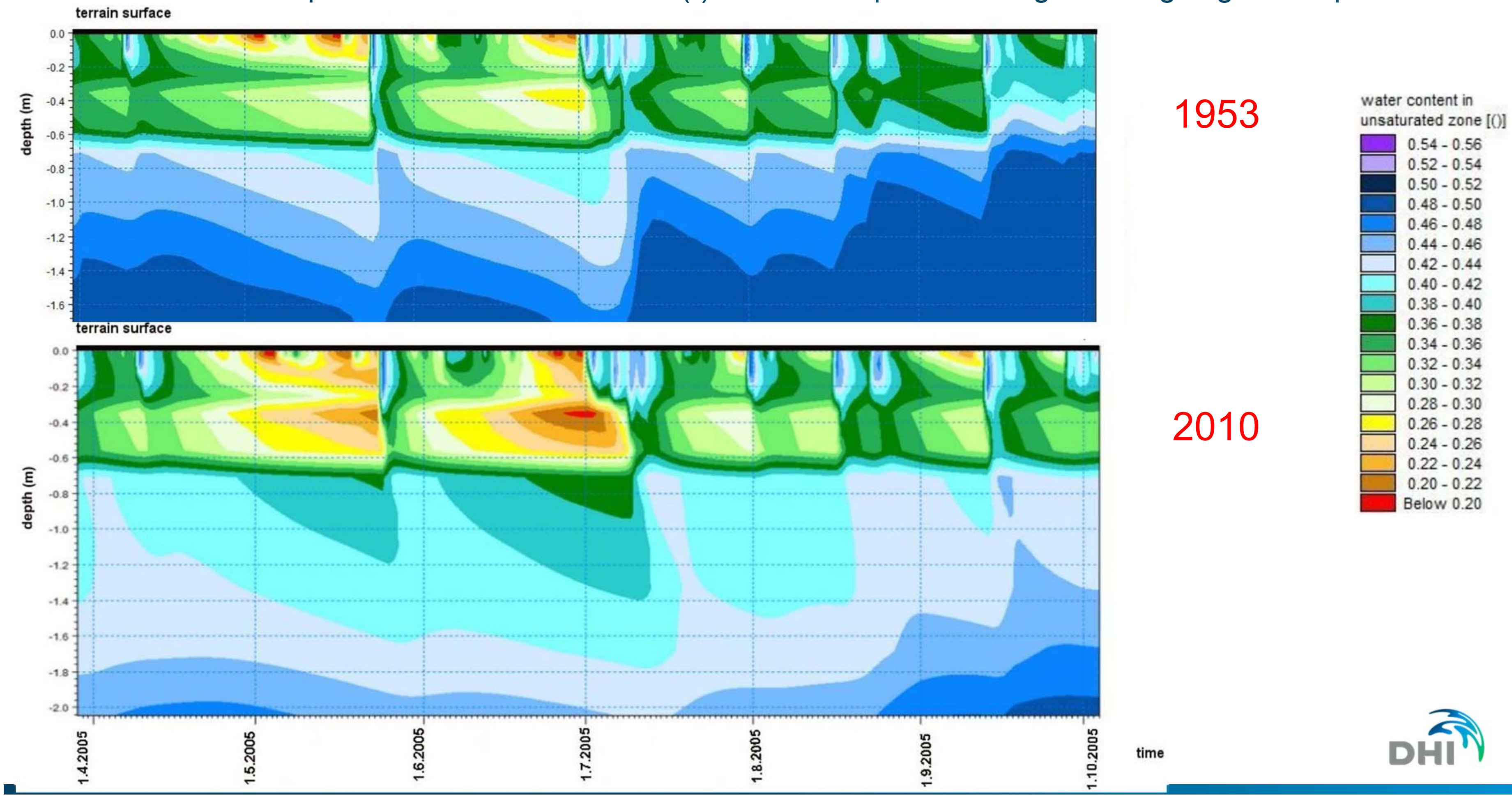
1953

2010



Detail hydrologic model: results

simulated vertical profile of soil water content (-) in selected point - changes during vegetation period



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Modelling approaches
for water balance and water quality modelling

- **small-scale** detailed studies are important **source of knowledge** about local impact of measures on runoff and nutrients flux
- **basin-wide** scale models give impression in **easy-to-understand, effective and fast** way over large areas and complex river networks
- **combination** of both allows selection of the most appropriate approach for optimal **proposal** of different types of **measures** and its spatial distribution
- further on
- more observed **event-based water quality** time series are needed
- more **complex local research studies** are needed for knowledge generalization

Thank you for attention

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Parts of following project results were used: MZe NAZV QH 82095; MZe NAZV QC 0242 (both coordinated by VUMOP v.v.i.); TAČR TA 01021844 (coordinated by CTU FCE) and “Studie na zlepšení jakosti vod na vodním díle Hracholusky” (client: Plzeňský kraj, conducted by VRV a.s. and DHI a.s.).