Team 06 Presentation 3

HYDROEUROPE

Presentation 3: Results of 2nd Week

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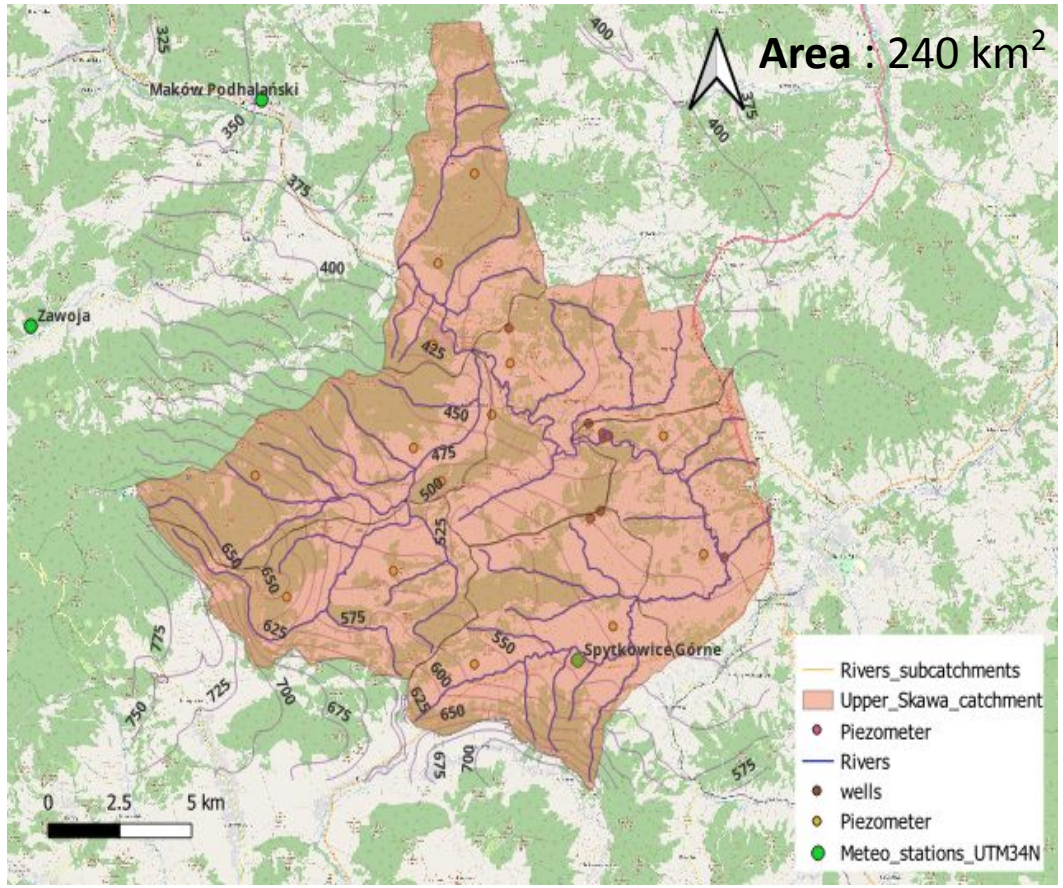
Upper Skawa Catchment : Model assumptions and input data



- **Input Data** :
  DEM, Rainfall, rivers, meteo stations, wells, piezometers (Observations), CORINE land cover database, groundwater table contour map

- **Assumptions**
  Two dimensional flow representation, uniform geological layer, unconfined aquifer, steady-state and saturated flow conditions, surface and groundwater catchment no overlap, no-flow boundaries and first type boundary conditions, recharge and discharge (rivers and drains).

- **Recharge rate = $P \cdot \alpha \cdot \beta \cdot \gamma \cdot \delta$**
- **Hydraulic conductivity**
- **Conductance of the rivers**

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Objectives of the study

1. Prepare a well calibrated model that best represents the actual aquifer in Upper Skawa Catchment
2. Estimate contamination travel time to the Skawa River under 2 scenarios:
   - **Scenario 1:** Contamination source stays forever
   - **Scenario 2:** Excavation after 180 days
3. Remediation plan proposal: Pump and Treat
4. Additional Studies:
   - Finer Grid Discretization
   - Sensitivity analysis on Porosity, Longitudinal Dispersivity and Transverse Dispersivity

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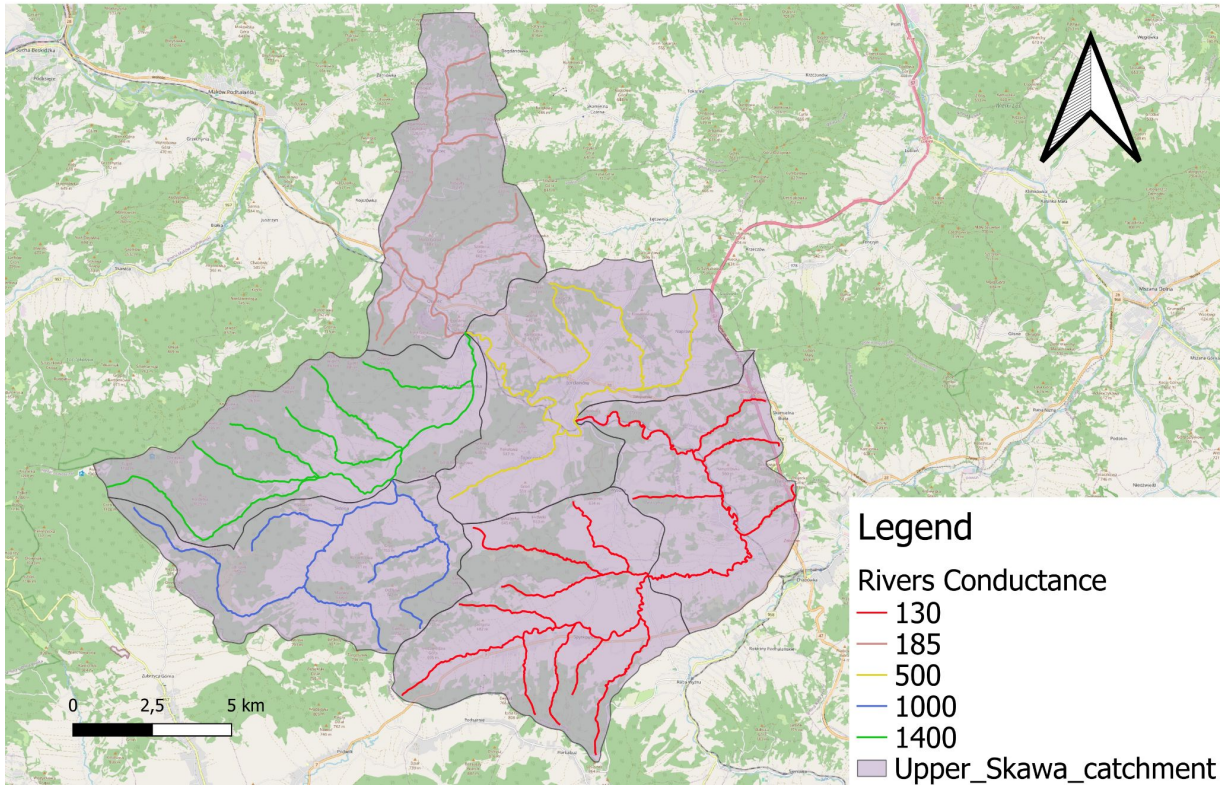
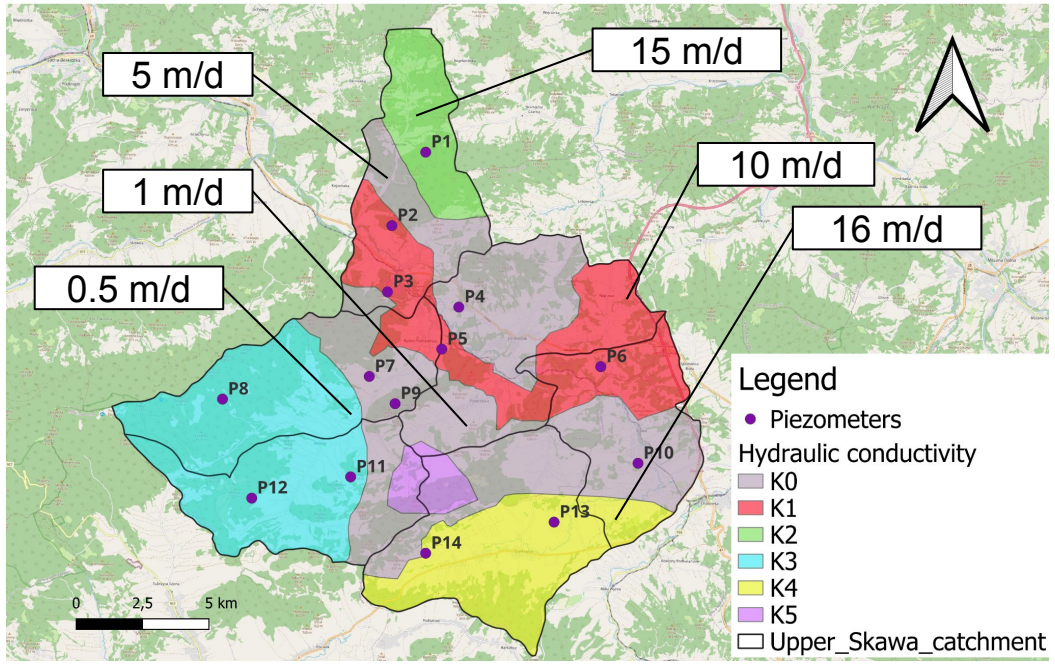
Model calibration : Conductance and Hydraulic Conductivity

Map of the conductance



Map of the piezometers and the hydraulic conductivity



	Rivers Conductance BC (m^2/s)	Rivers Conductance AC (m^2/s)
Rivers 1	1000	185
Rivers 2	1000	1400
Rivers 3	1000	1000
Rivers 4	1000	500
Rivers 5	1000	130

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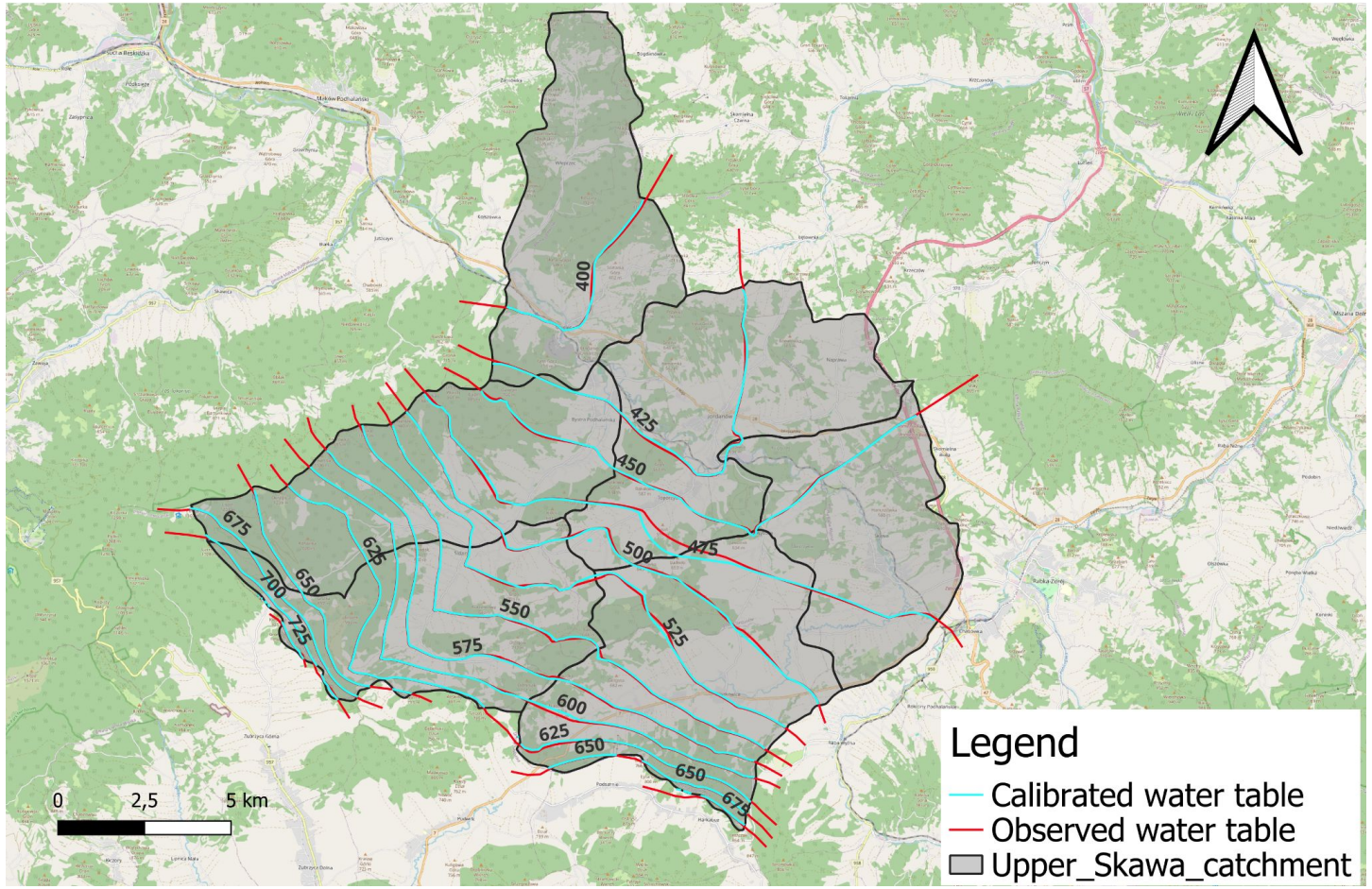
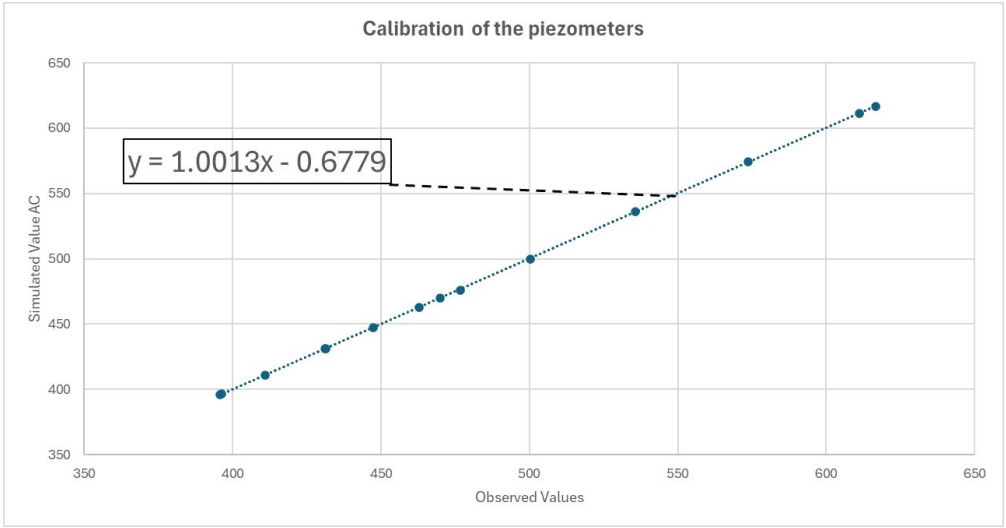
Calibration Results





Observation Name	Observed Value	Simulated Value AC	Residual (Observation/simulation)
P1	395.79	396.09	-0.30
P2	396.39	396.35	0.04
P3	411.07	410.90	0.17
P4	431.35	431.08	0.27
P5	431.29	431.08	0.21
P6	447.32	447.28	0.04
P7	462.96	462.82	0.14
P8	611.06	611.05	0.01
P9	476.64	475.97	0.67
P10	469.93	469.99	-0.06
P11	535.72	536.19	-0.47
P12	616.55	616.54	0.01
P13	500.23	499.52	0.71
P14	573.80	574.48	-0.68

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Processes Description : Diffusion, advection, dispersion

- **Advection**: Transport of contaminants with groundwater flow, at a velocity equal to that of the fluid in the pores. (Ex: A pollutant moves with the water flow without spreading.)

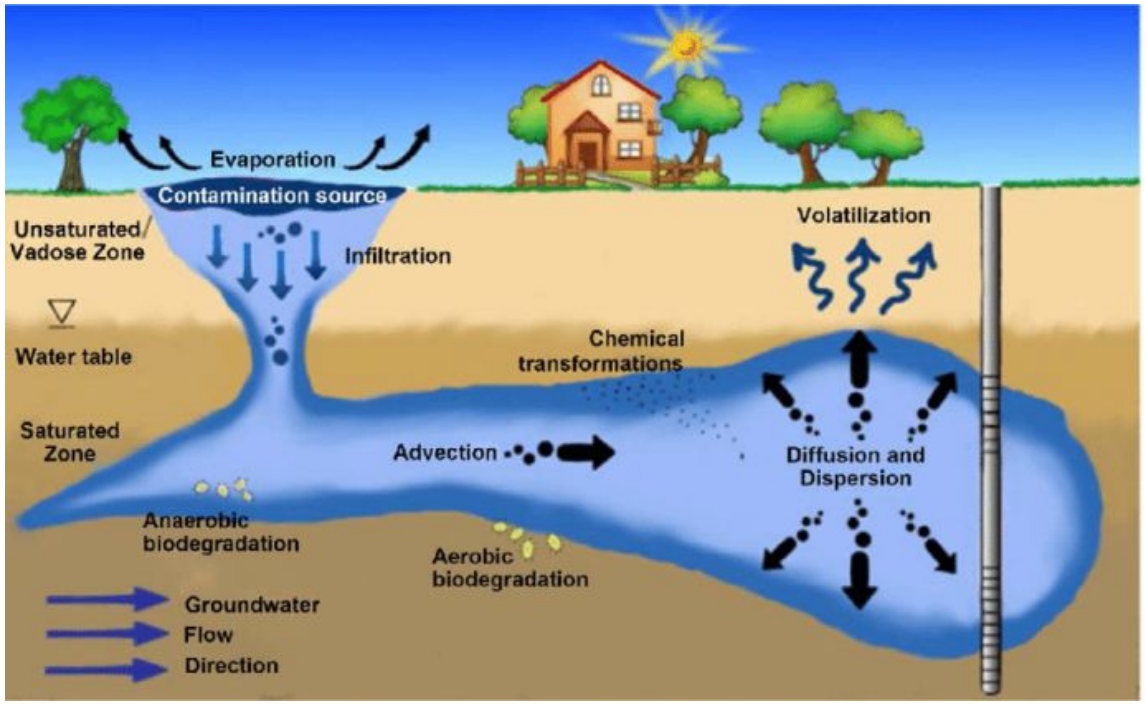
$$J^*_{adw} = C \cdot \mathbf{v}_p$$

- **Diffusion**: Molecular movement of contaminants driven by concentration gradients, even in stagnant water. (Ex: A contaminant slowly spreads in a stagnant zone.)

$$J^*_{dyf} = -D^*_d grad(C)$$

- **Dispersion**: Spreading of contaminants due to local velocity variations, combining mechanical dispersion and diffusion. (Ex: A pollution plume widens as it moves through an aquifer.)

$$J^*_{dysp} = -D^*_{dysp} grad(C)$$



Total flux of mass in groundwater

$$J^* = J^*_{adw} + J^*_{dyf} + J^*_{dysp}$$

$$J = nC\mathbf{v}_p - nD^*_h grad(C)$$

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Introduction of Contaminant to the Catchment

Situation: Chemical barrels buried 10 m underground may leak into groundwater.

Objective: Estimate contamination travel time to the Skawa River.

Assumptions:

- **Tracer:** Sulfate ions (SO_4).
- **SO_4 Concentrations:** Background: 10 mg/L, Source: 12,000 mg/L.
- **Dispersion Coefficients:** Longitudinal: 25 m, Transverse: 10% of longitudinal.

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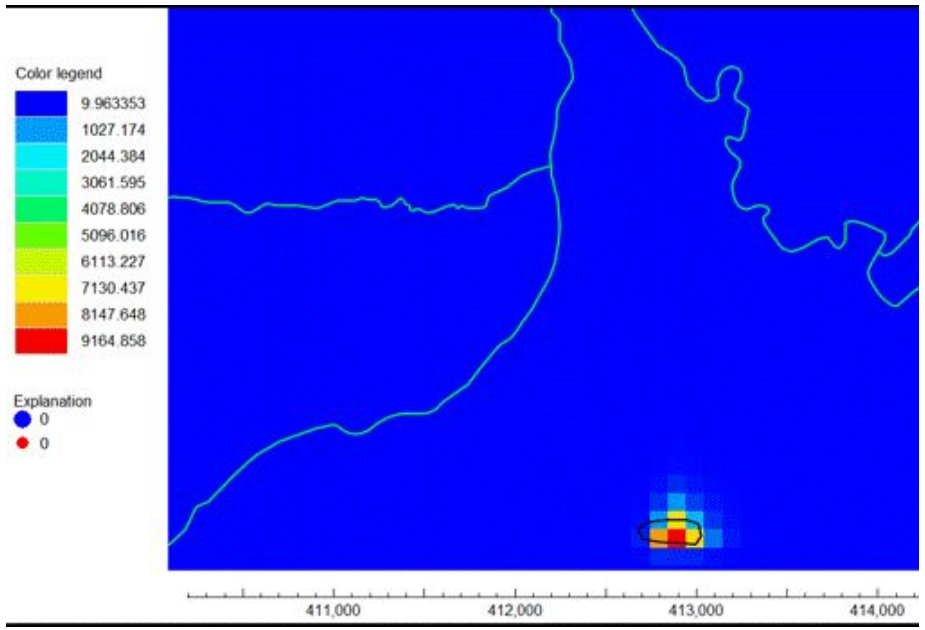
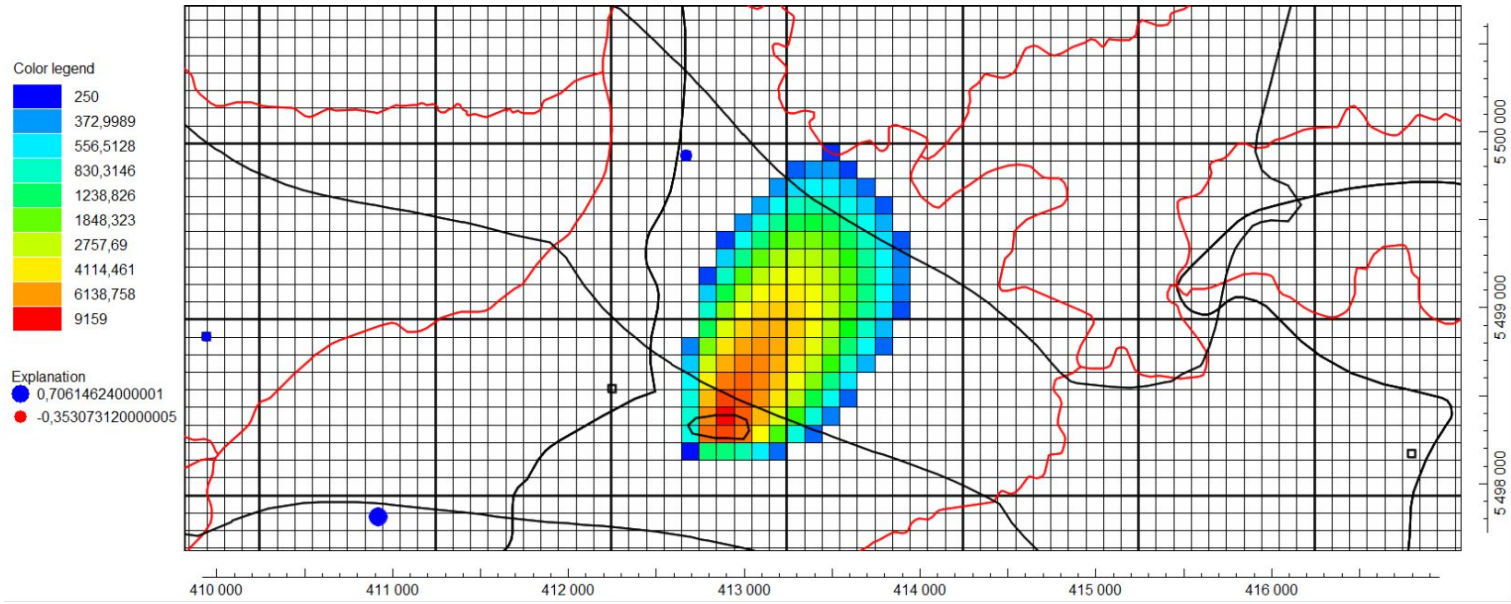
Scenario 1: No Excavation of Pollutant Source





The sulfate (SO_4) pollution limit in Poland's aquifer is **250 mg/L**.

SO_4 reached the river's aquifer in **540 days (1.5 years).**
SO_4 concentration of 250 mg/L reached in approximately **1,260 days (3.5 years)**

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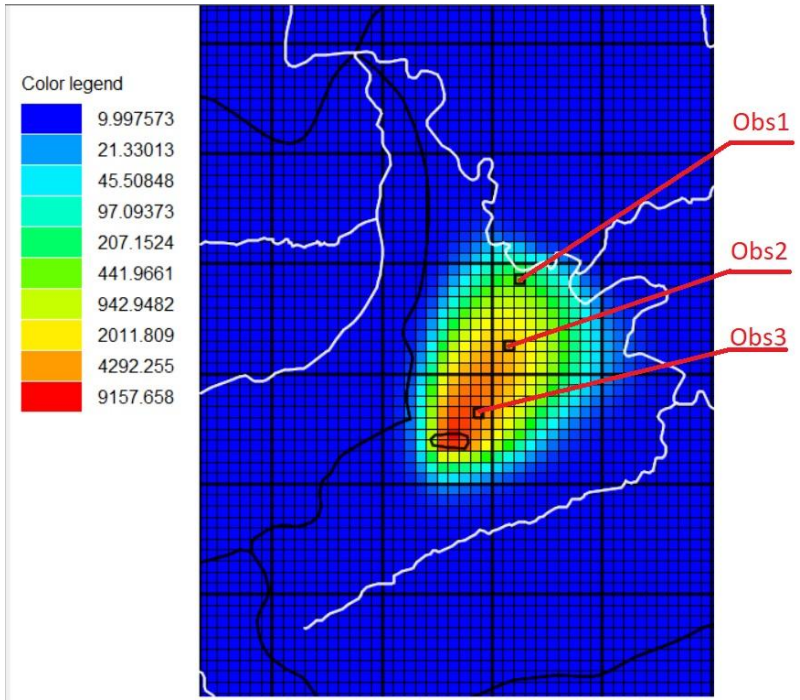
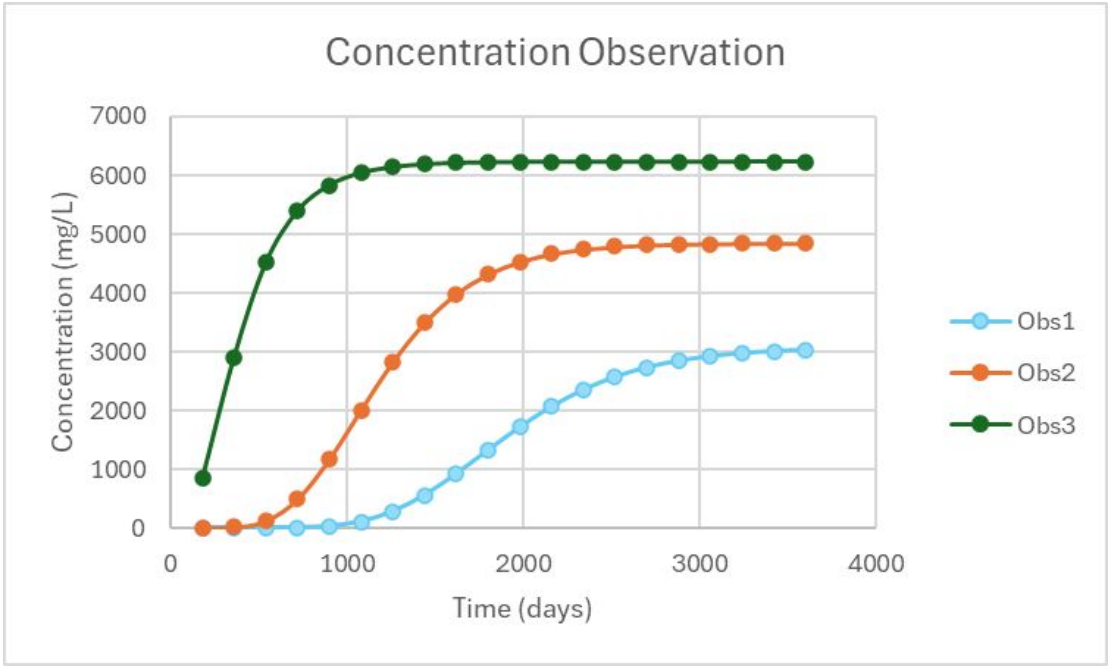


Time	Concentration Measurement		
	Obs1	Obs2	Obs2
180	10.00	10.07	844.08
360	10.00	19.71	2913.93
540	10.27	126.14	4515.16
720	14.27	496.64	5397.78
900	38.26	1174.09	5834.23
1080	117.18	2013.98	6042.86
1260	**288.90**	2827.04	6141.87
1440	567.08	3495.09	6188.98
1620	929.76	3985.71	6211.55
1800	1331.29	4318.74	6222.46
1980	1723.48	4532.37	6227.77
2160	2070.91	4663.86	6230.39
2340	2355.87	4742.37	6231.68
2520	2575.65	4788.18	6232.33
2700	2736.97	4814.46	6232.66
2880	2850.73	4829.34	6232.82
3060	2928.37	4837.68	6232.91
3240	2979.94	4842.32	6232.95
3420	3013.46	4844.89	6232.97
3600	3034.85	4846.31	6232.98



Condition at 1260 days (3.5 years)

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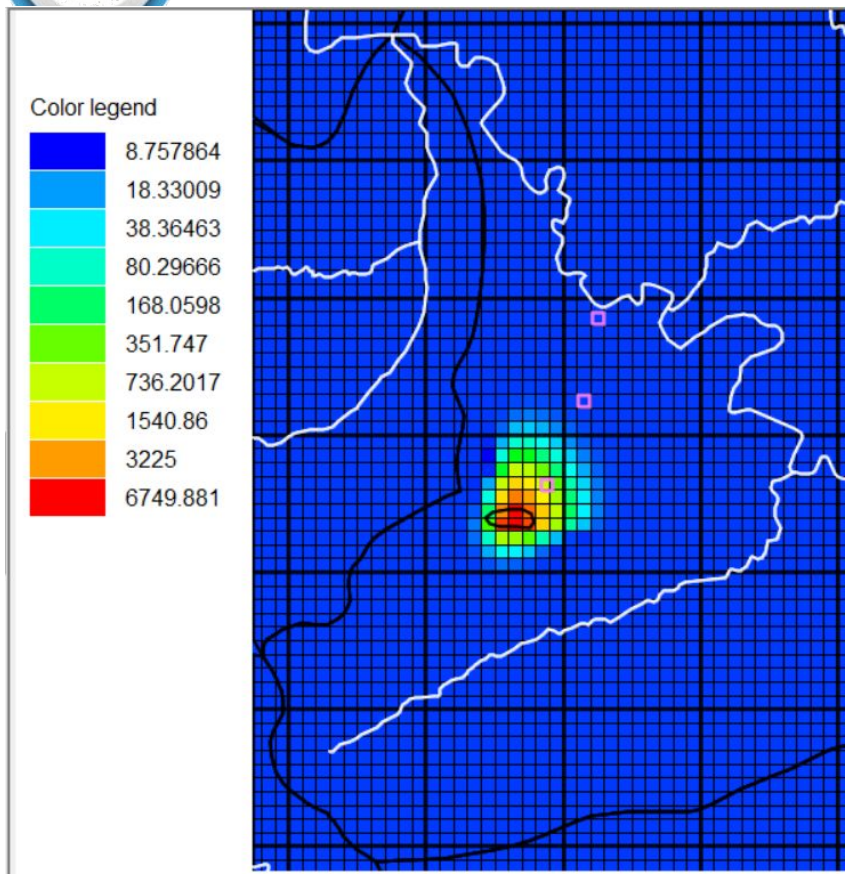
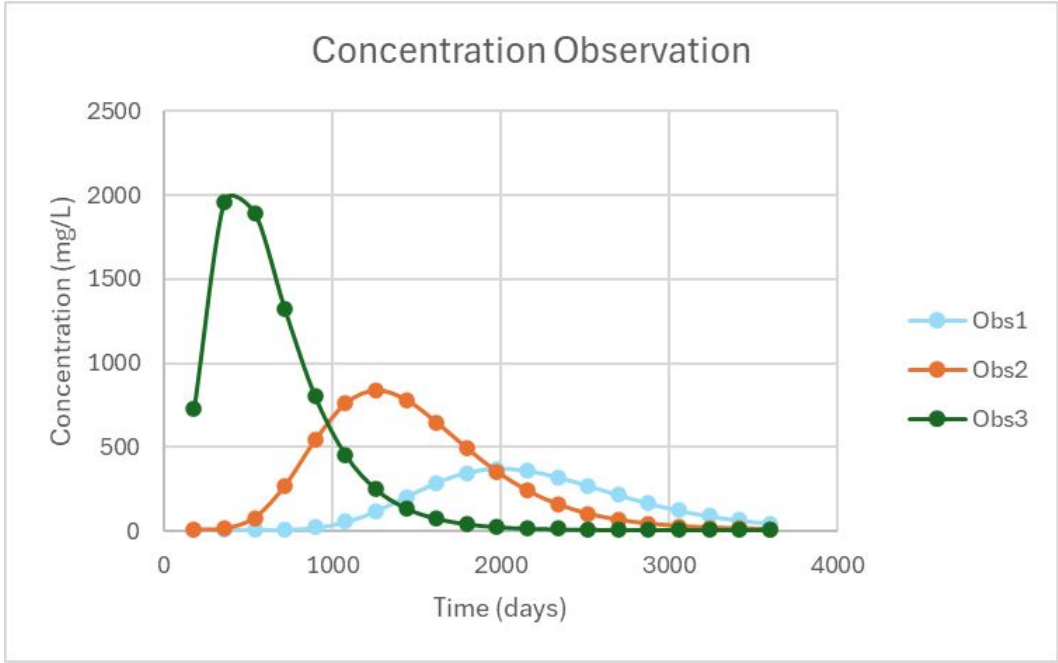
Scenario 2: Excavation of Pollutant Source After 180 Days



Time	Concentration Measurement		
	Obs 1	Obs 2	Obs 3
180	10.00	10.04	728.17
360	10.00	16.92	1958.82
540	10.15	81.37	1891.32
720	12.19	271.58	1319.23
900	23.41	542.31	801.41
1080	56.71	759.63	456.87
1260	119.88	837.20	253.44
1440	204.40	781.47	140.02
1620	**287.87**	648.36	78.67
1800	**347.39**	494.09	46.03
1980	**370.76**	354.00	28.84
2160	**358.85**	242.70	19.84
2340	**321.23**	161.55	15.13
2520	**270.13**	105.82	12.68
2700	216.12	69.18	11.40
2880	166.30	45.87	10.73
3060	124.27	31.42	10.38
3240	91.03	22.63	10.20
3420	66.00	17.38	10.11
3600	47.88	14.27	10.06



Condition at 180 days (0.5 year), when the pollutant source is excavated

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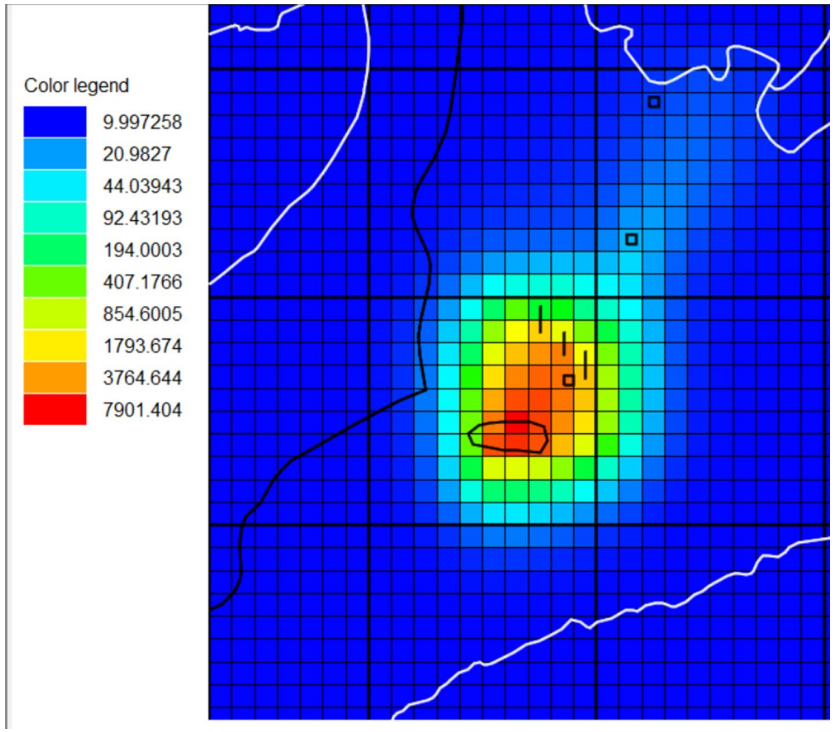
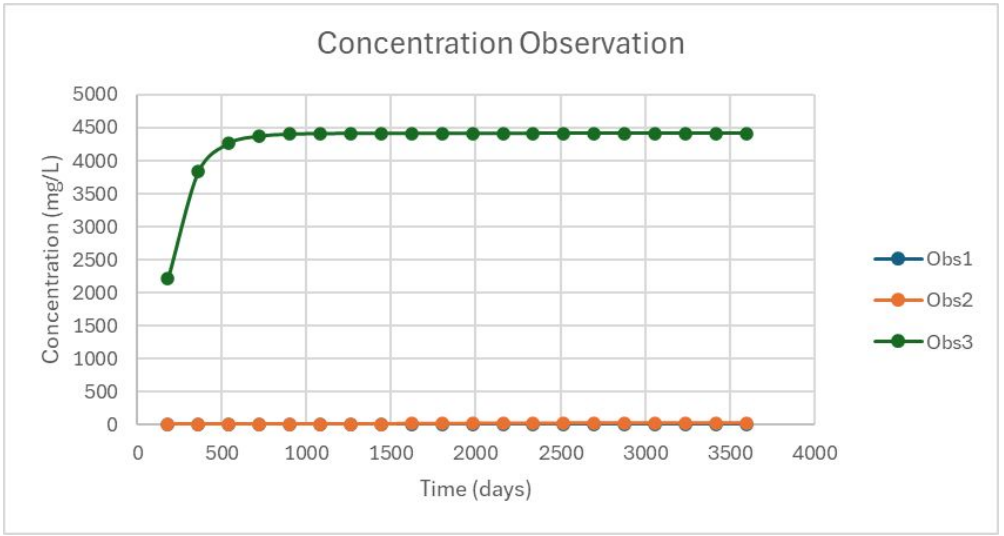
Remediation: Pump and Treat in Scenario 1



Time	Concentration Measurement		
	Obs 1	Obs 2	Obs 3
180	10.00	10.00	2214.53
360	10.00	10.00	3834.77
540	10.00	10.03	4263.67
720	10.00	10.19	4371.84
900	10.00	10.62	4402.31
1080	10.00	11.42	4411.98
1260	10.01	12.57	4415.38
1440	10.02	13.98	4416.66
1620	10.04	15.55	4417.17
1800	10.09	17.14	4417.39
1980	10.16	18.68	4417.48
2160	10.26	20.10	4417.53
2340	10.39	21.36	4417.55
2520	10.55	22.45	4417.56
2700	10.72	23.38	4417.56
2880	10.89	24.16	4417.57
3060	11.07	24.81	4417.57
3240	11.25	25.33	4417.57
3420	11.41	25.76	4417.57
3600	11.56	26.11	4417.57



Condition at day 1260 (3.5 years)
Pumping rate: 12,552.76 m^3/day

Without Pump and Treat, pollutant is expected to reach the river's aquifer at day 540 (1.5 years), and exceed the standard at day 1260 (3.5 years).

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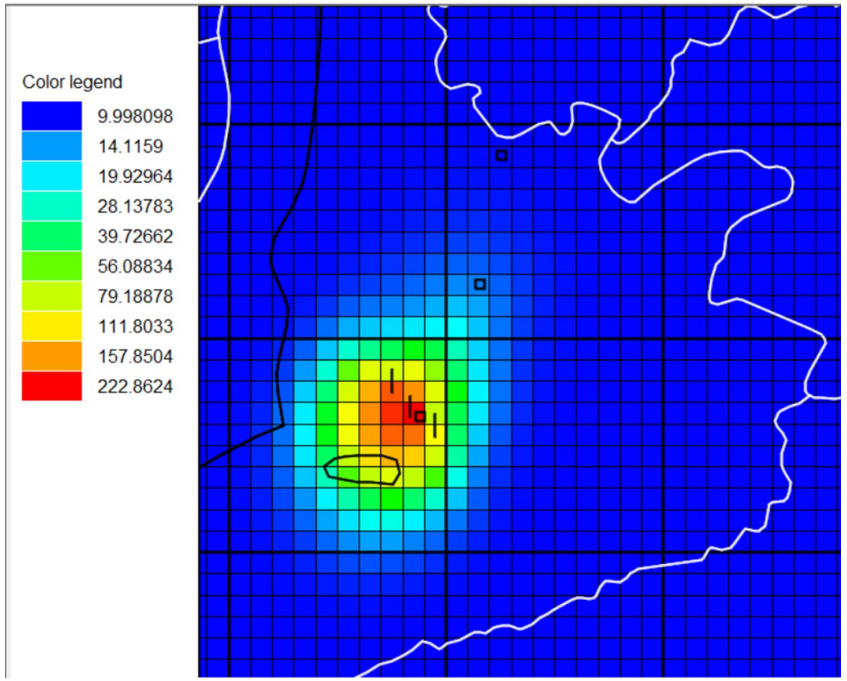
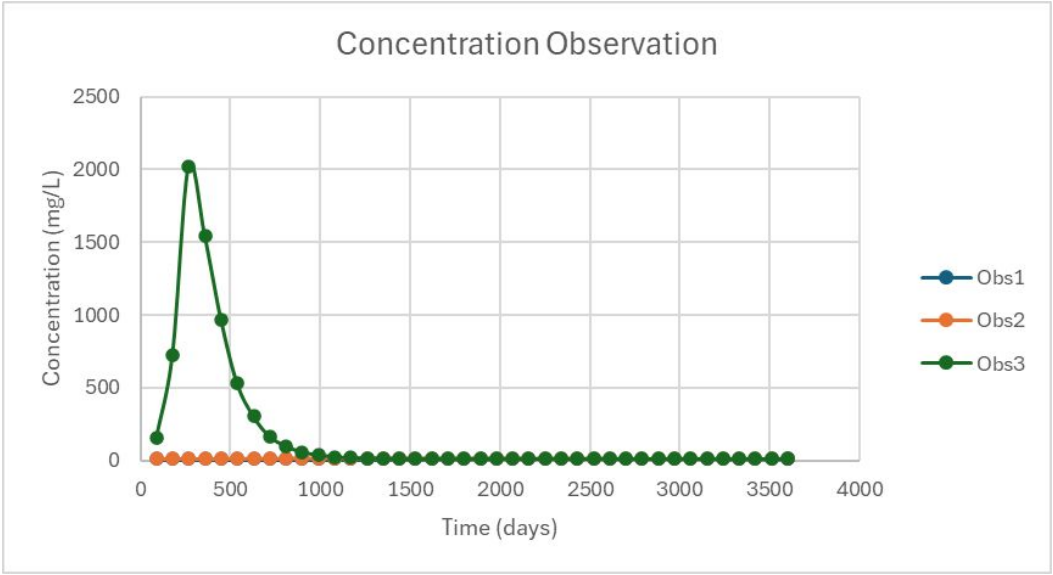
Remediation: Pump and Treat in Scenario 2



Time	Concentration Measurement		
	Obs 1	Obs 2	Obs 3
180	10.00	10.04	728.17
360	10.00	10.52	1540.72
540	10.00	11.52	528.40
720	10.02	12.84	165.73
900	10.07	14.16	58.56
1080	10.17	15.28	26.17
1260	10.30	16.06	15.80
1440	10.48	16.44	12.25
1620	10.66	16.45	10.96
1800	10.85	16.14	10.45
1980	11.02	15.61	10.23
2160	11.14	14.95	10.13
2340	11.22	14.25	10.08
2520	11.25	13.55	10.05
2700	11.24	12.92	10.04
2880	11.18	12.36	10.03
3060	11.09	11.88	10.02
3240	10.98	11.48	10.01
3420	10.86	11.16	10.01
3600	10.74	10.90	10.01



Condition at day 720 (2 year)
Pumping rate: 10,096.79 m^3/day

Pumping started on day 180 (0.5 year) and stopped around day 720 (2 years), as the concentration has dropped below the standard threshold of 250 mg/L.

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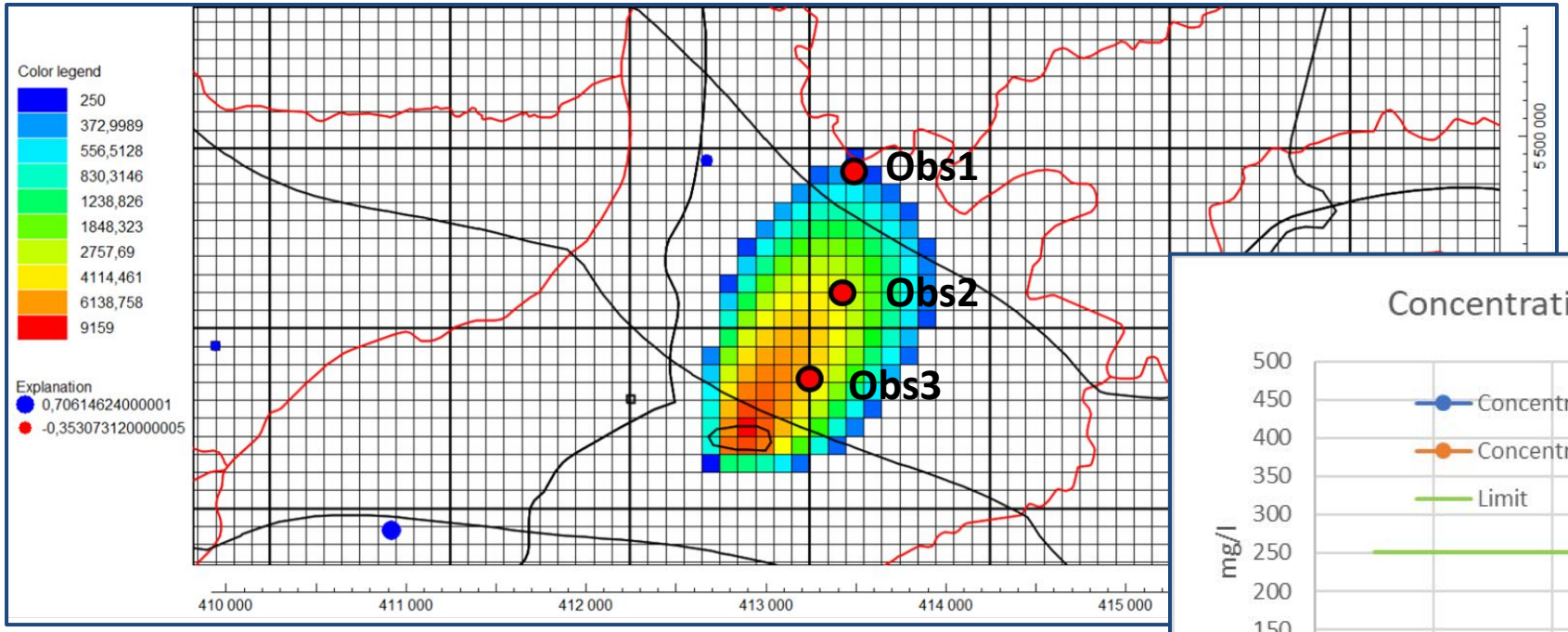
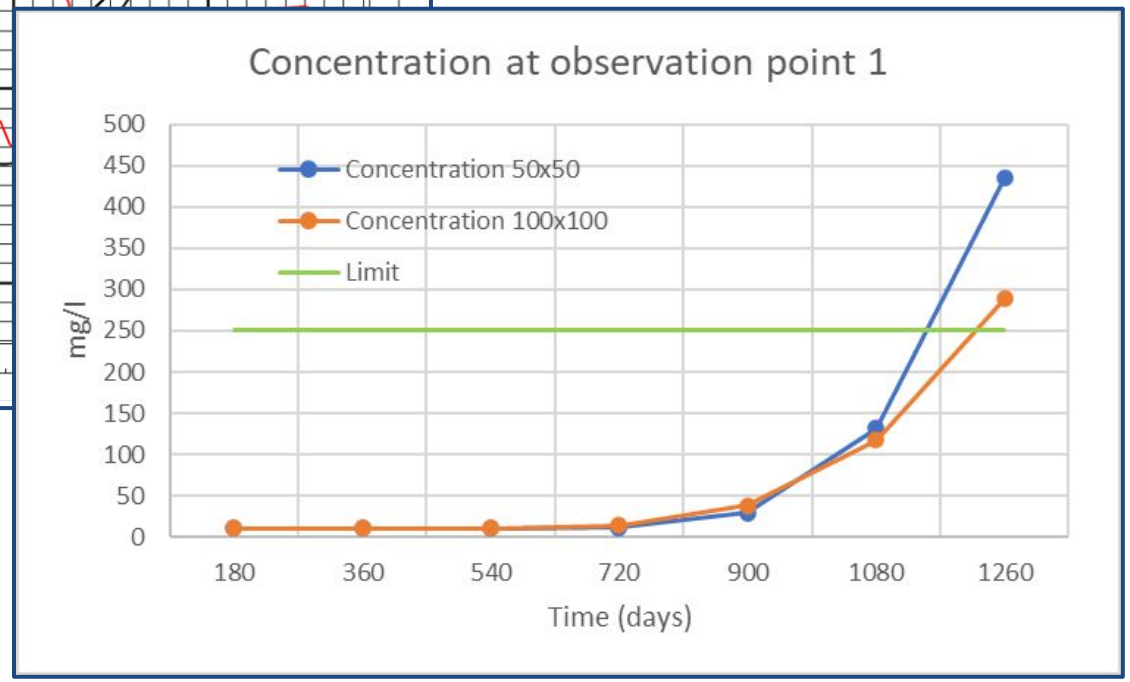
Travel time discretization : 50x50 and 100x100



Numerical dispersion in a coarse grid artificially delays the arrival of peak concentration. The smearing effect due to large grid cells makes the contaminant spread out, giving an impression of slower transport.



Time to reach the river in 100x100 : 1322 days

Time to reach the river in 50x50 : 1180 days

Accuracy? Underestimating?

Which one is the best?

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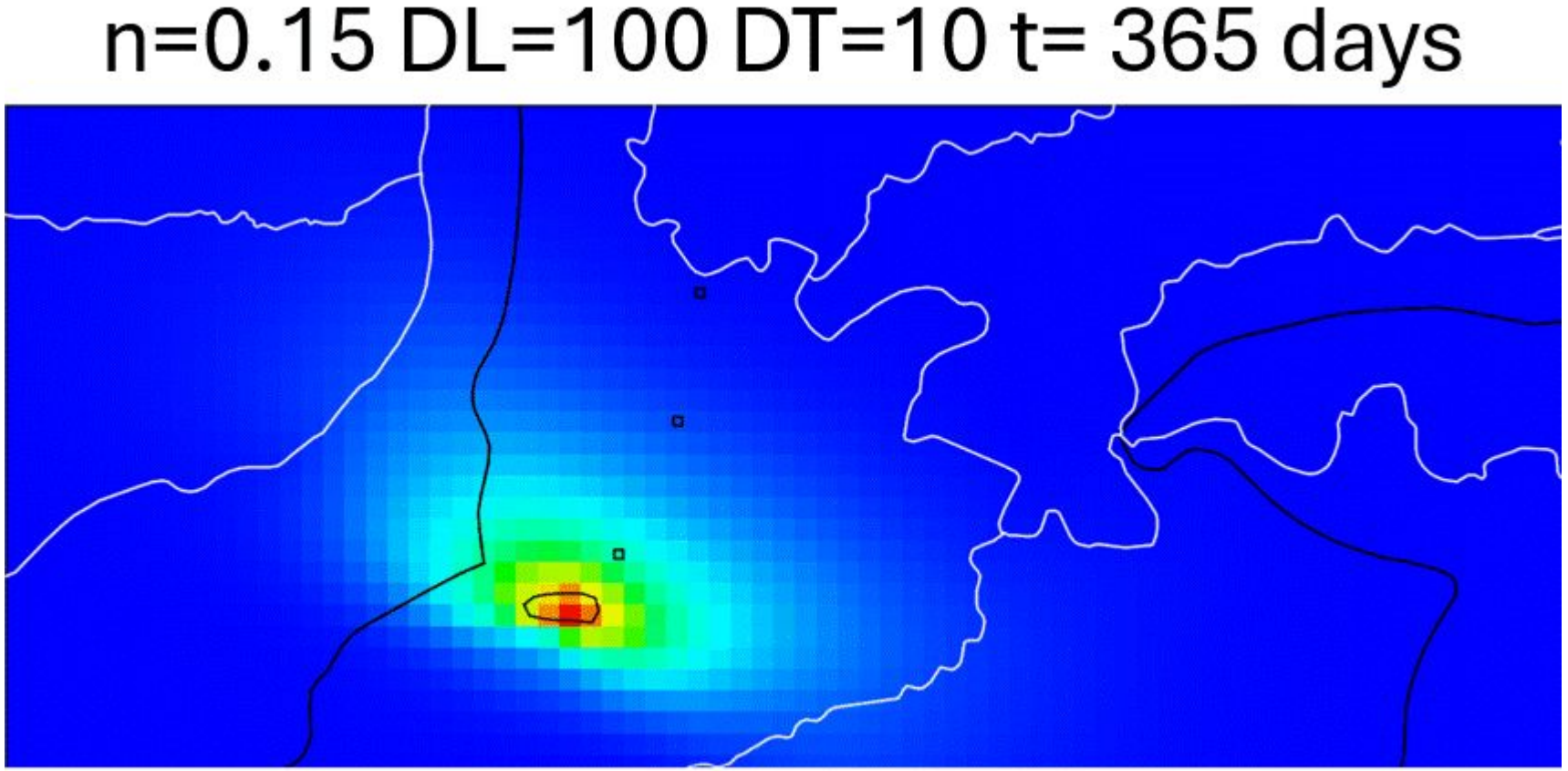
Continuous leaks : 365 days



Parameters

T : 365 days

n : Porosity (0.15; 0.20; 0.25; 0.30)

DL : Longitudinal dispersivity (1; 10; 100)

DT : Transverse dispersivity (0.1; 10)

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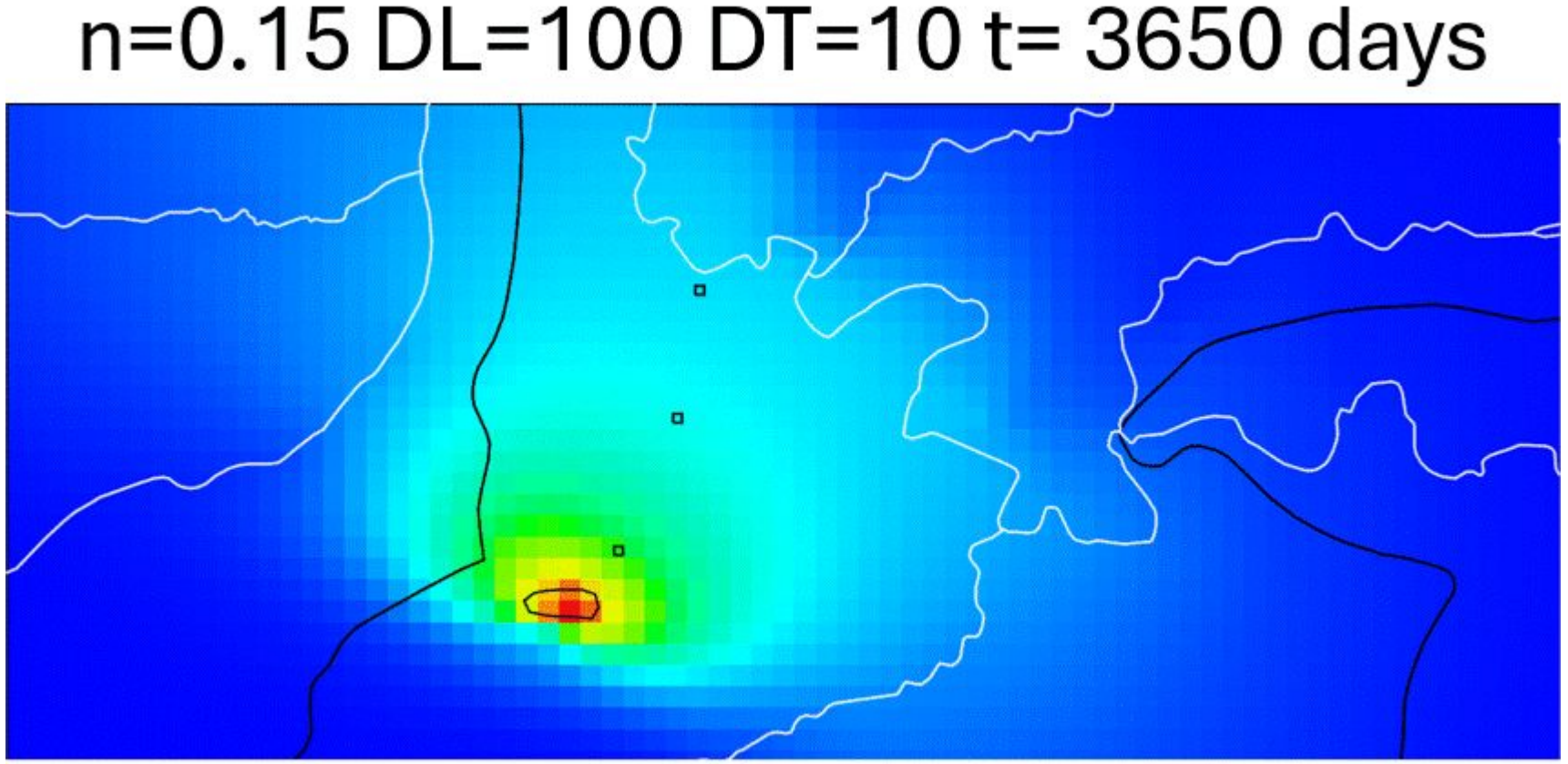
Continuous leaks : 3650 days



Parameters

T : 3650 days

n : Porosity (0.15; 0.20; 0.25; 0.30)

DL : Longitudinal dispersivity (1; 10; 100)

DT : Transverse dispersivity (0.1; 10)

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Conclusions

- **Scenario 1:** SO_4 → 540 days (1.5 years), 1260 days (3.5 years)
- **Scenario 1 + PnT (pumping rate: 12,552.76 m^3/day)** → SUCCESS!
- **Scenario 2:** SO_4 lower than 250 mg/L after 2520 days (7 years)
- **Scenario 2 + PnT (pumping rate: 10,096.79 m^3/day)** → SO_4 lower than 250 mg/L after 720 days (2 years)
- Finer grids are crucial for local-scale studies to capture detailed transport dynamics accurately, while coarser grids work for regional studies but may introduce artificial dispersion and longer apparent travel times.
- Porosity must be determined as it directly influences pollutant transport velocity. Dispersivity can cause pollution to reach unexpected locations.

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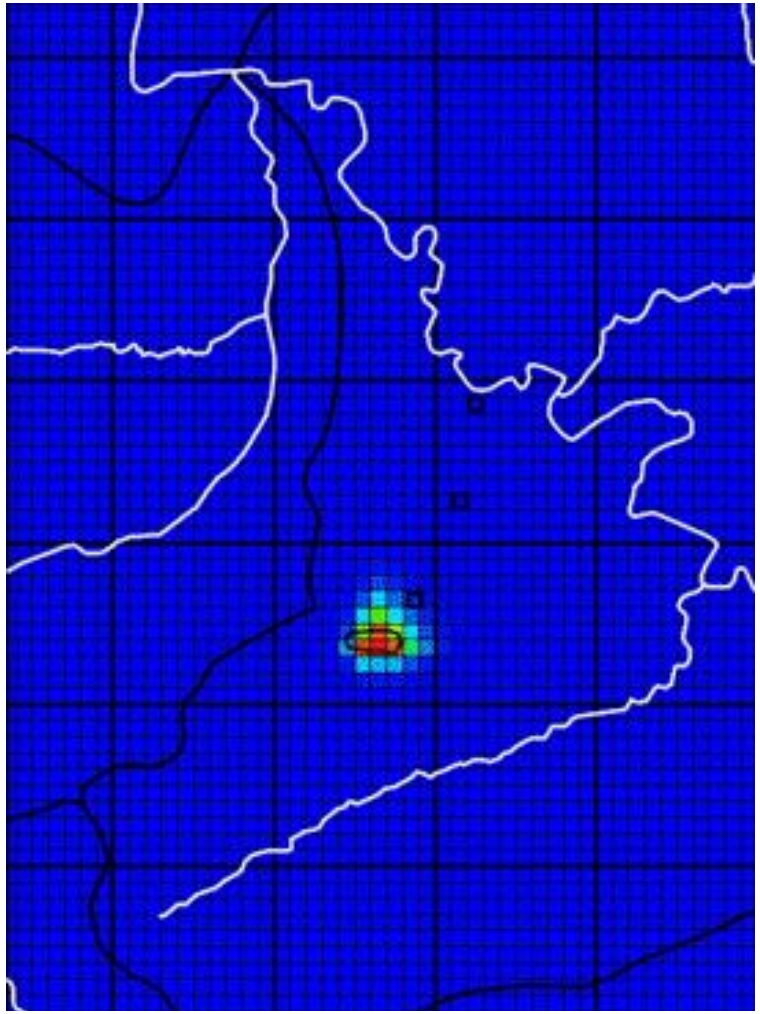
Accidental Groundwater Pollution - Case Study Skawa Catchment



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