



Supplement of

Mapping water content dynamics in SAT systems using 3D electrical tomography

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S1. About the WWTP and SATs

The WWTP was designed for 165,000 equivalent-inhabitants, accommodating the sharp increase in population during the summer tourist season, when it reaches full capacity. Outside the tourist season, the local population drops to approximately 90,000 inhabitants. The region has a typical Mediterranean climate, with annual precipitation averaging 450 mm, mainly during spring and autumn. Minimum temperatures reach 3 °C in February and maximums rise to 36 °C in July-August.

The coastline is exposed to strong winds from various directions, occasionally from the sea (typically in January and October), which can increase electrical conductivity due to the inflow of seawater into the sewer collectors. A full meteorological station (METER) was installed alongside the SAT systems, recording rainfall, temperature, air water content, solar radiation, and wind velocity and every 15 min (Figure S1).

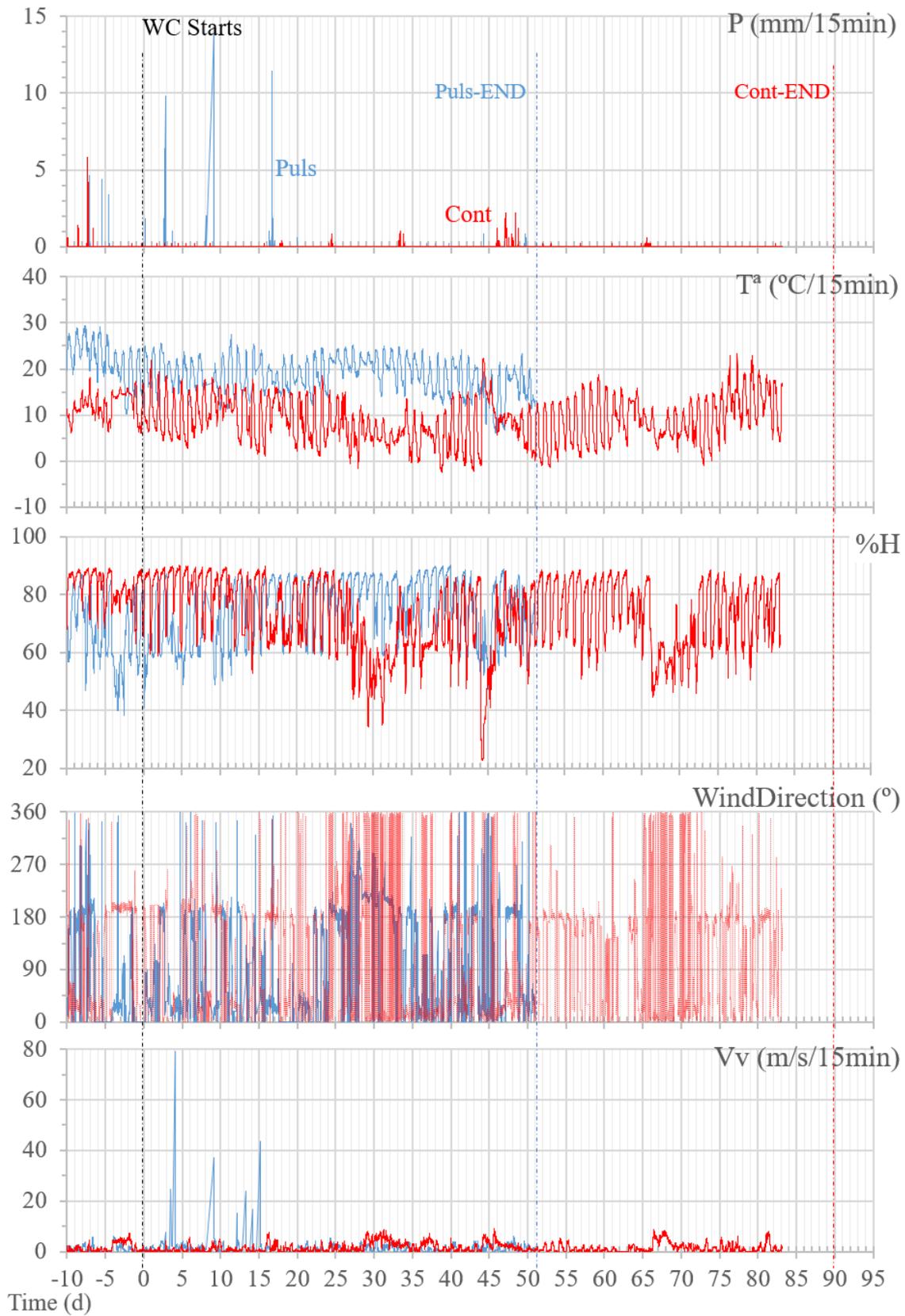
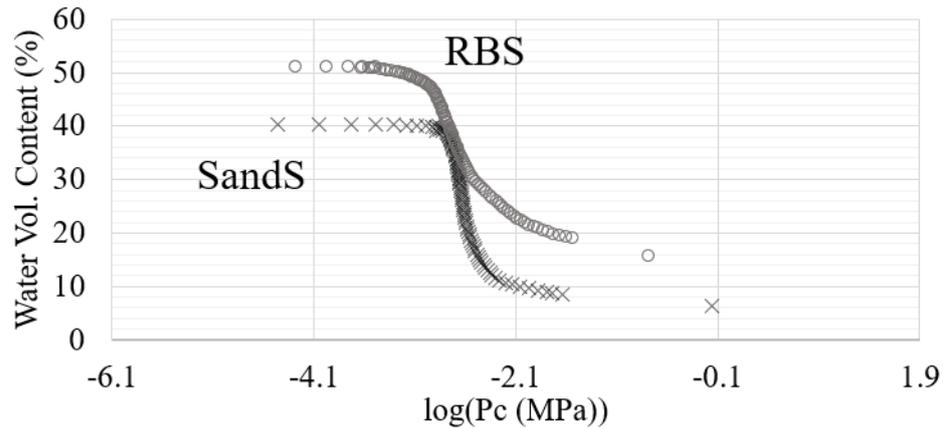


Figure S1: Rainfall, temperature, air water content, wind direction and velocity every 15 min at the weather station in the WWTP during the testing period. Time 0 represents the WC starts for both Puls (blue) and Cont (red) recharge episodes. Vertical slashed lines indicated the start and end for Puls (blue) and Cont (red) recharge episodes.

Retention curves (Figure S2) were measured from undisturbed samples collected from the central part of the USZ for each system (SandS and RBS). The retention curves were obtained using HYPROP 2 (UMS), which also provided density and total porosity data for the tested materials. The results indicate that the RB has a lower density and higher total porosity compared to Sand, attributed to the presence of organic matter in its composition.



	SandS	RBS
Density (gr/cm ³)	1.65	1.08
Porosity (total)	0.38	0.59

Figure S2: Retention curves and density and total porosity values obtained for SandS and RBS.

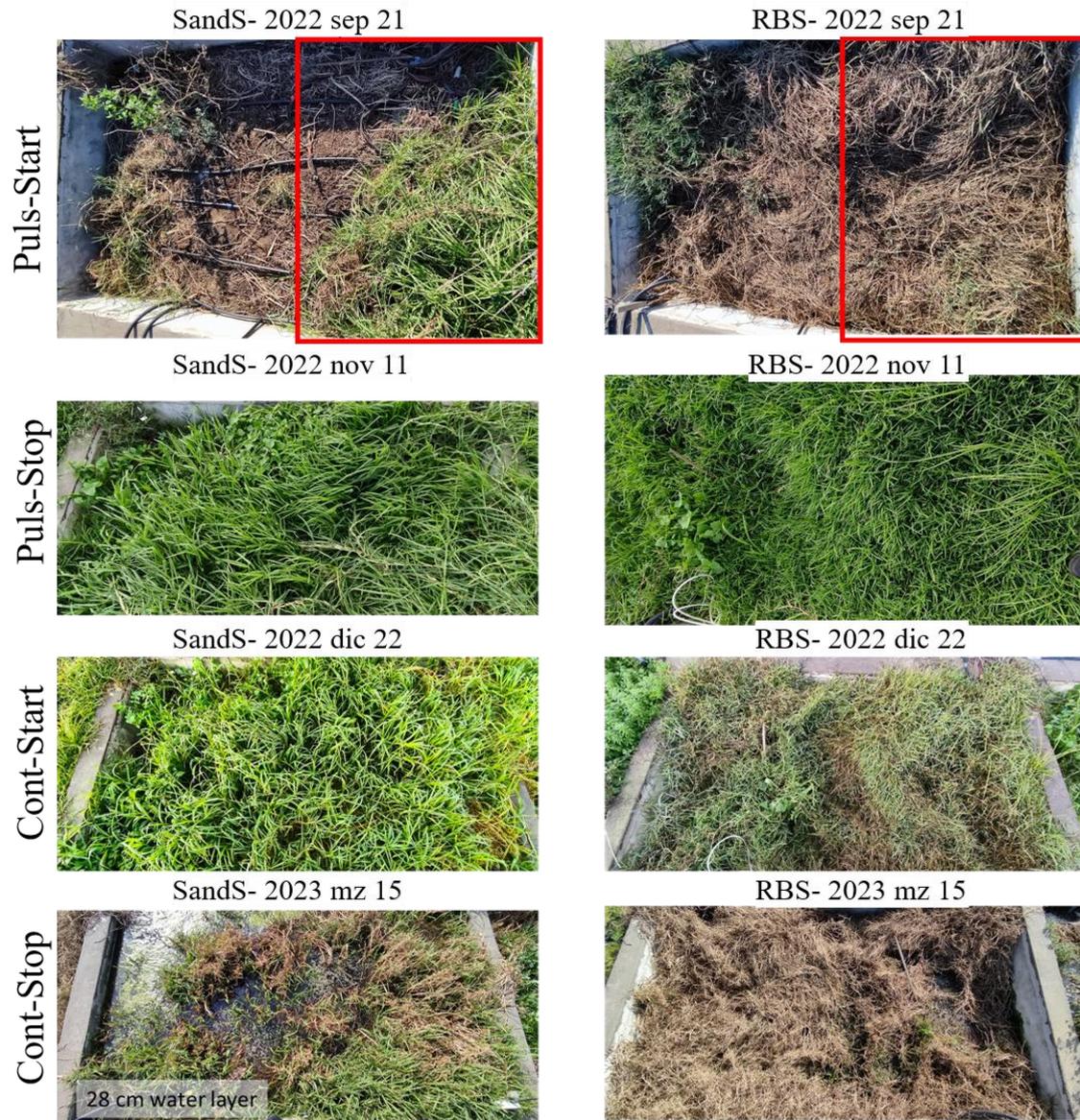


Figure S3: Plants growth over the recharge surface at the times the ERT acquisitions were made Red square in the upper pictures indicates the surface of the tomography measured.

When the reactive barriers with grass cover were installed to control the growth of vegetation on the basin surfaces, the vegetative cover was left without maintenance. Consequently, plants grew and died depending on the season and recharge evolution, contributing organic carbon to the system upon decomposition. Figure S3 shows photographs illustrating the state of the vegetative cover at the beginning and end of each WC for both Puls and Cont recharge episodes. The images for SandS are displayed in the left column, while those for RBS are on the right. At the start of the Puls episode, the surface appears dry, following a summer without managed recharge. By the end of the Cont episode, a water layer can be observed on the basin surface in the SandS, whereas no such water layer is present on the RBS.

S2. Measurements

S2.1. Water balance measurements

Figure S4 and Figure S5 present measurements related to the water balance of the USZ. Both figures illustrate the recharge scheme, the water volume content at a depth of 40 cm, and the aquifer's response, represented by depth to water table measurements at the O piezometer (Figure 1). The Puls episode (in blue) consists of 12/12 h cycles with a recharge rate of 0.8 m/d, while the Cont episode involves a constant recharge rate of 0.4 m/d. Although the temporal distribution of recharge differed between the two schemes, the total volume of water recharged was identical.

Water is pumped from the WWTP effluent tank (INF) to the basin surface using dosing pumps (PRIUS), with the volume recorded every half hour using an ISOIL MS600 flowmeter. The INF water is distributed over the basin surface via a perforated irrigation pipe. Soil moisture content is measured at six points from the surface at 10 cm depth intervals using an Aquacheck probe. The Aquacheck probe is a capacitance-based moisture sensor that emits an electromagnetic signal to measure the humidity content of the surrounding soil volume.

The head evolution in the aquifer is measured using a CTD Dive sensor, which also allows for the measurement of electrical conductivity (EC) and temperature. The aquifer's response to the SATs, in terms of depth to water table evolution, is illustrated in Figure S4 and Figure S5 (c plots), where it is presented as "Depth to water" in meters. This sensor only functions when saturated; it does not take measurements when dry. Refer to the sensor's position in the c plot.

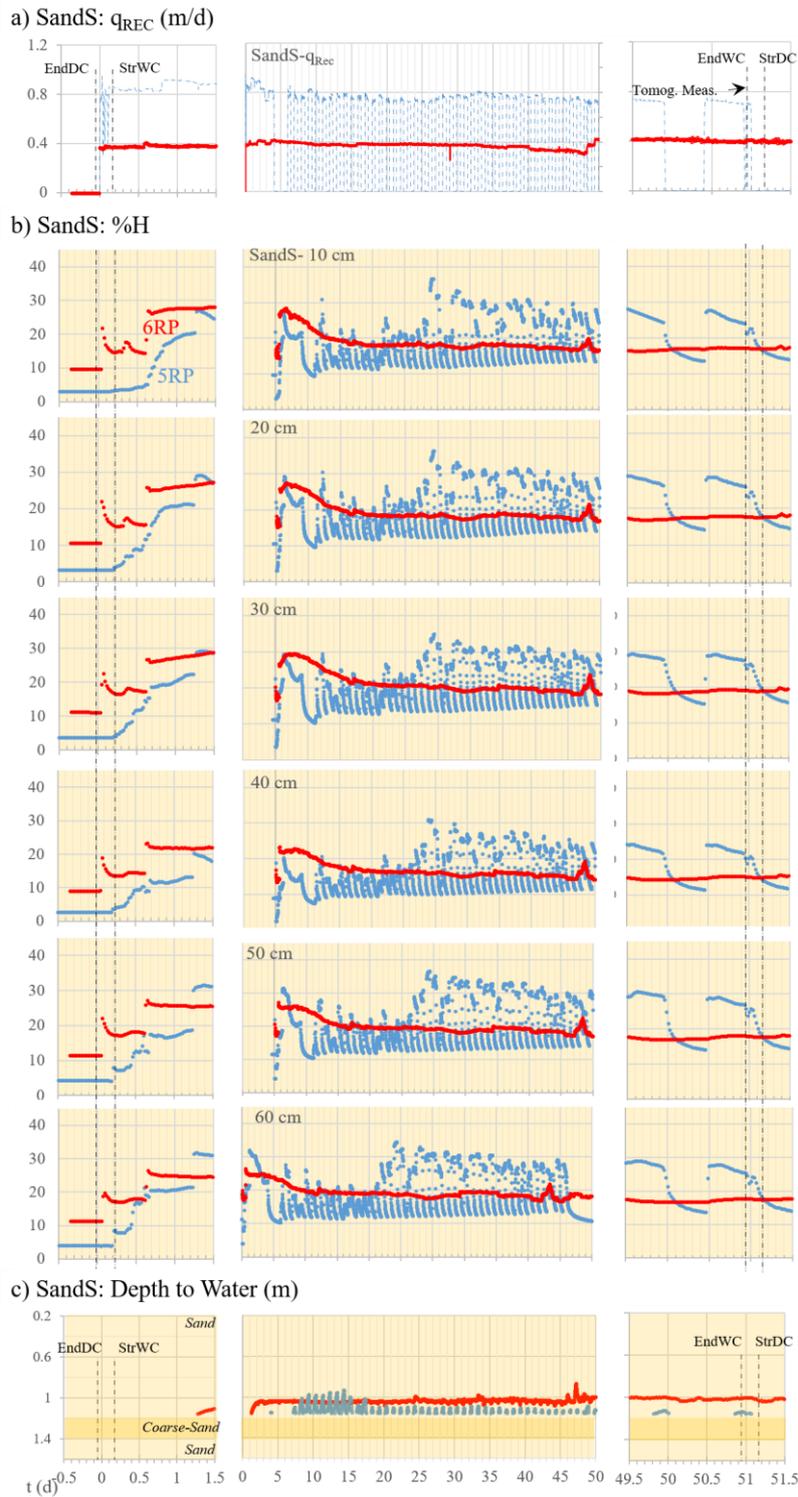


Figure S4: Measurements in the SandS. The plots are arranged in three columns to allow zooming into the initial and final times, facilitating visualization of the moments when tomography data were acquired. Start data for both Puls. and Cont. recharge episodes are shown at time 0, while only the stop of the Puls. (at 51 d) is included to simplify visualization, as only the Puls. data (blue dots) respond to the recharge stop. The times when tomography data were registered are indicated by dotted vertical lines, labelled as EndDC (End Dry Cycle), StrWC (Start Wet Cycle), EndWC (End Wet Cycle) and StrDC (Start Dry Cycle). a) Recharge flow rates during the Puls (in blue) and Cont (in red) operational schemes. Note that the flow exhibits a double maximum during Puls to deliver the same daily volume as Cont. b) Effect of the recharge pattern on %H distribution in the USZ at six depths c) Effect of the recharge pattern on depth to the water table, expressed as pressure over the initially dry sensor located at 1.2 m depth. The graphic also shows the position of the different materials composing the USZ.

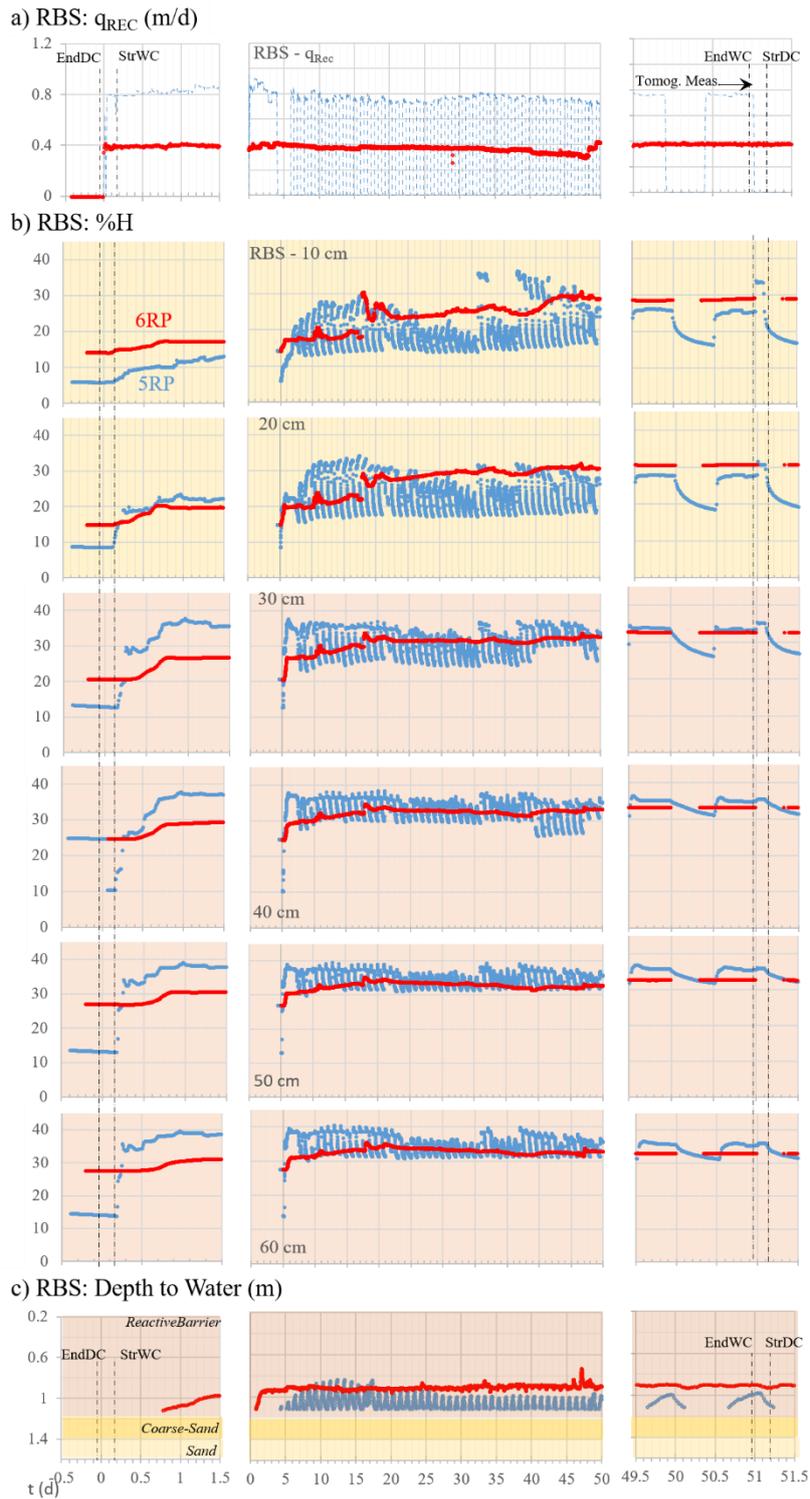


Figure S5: Measurements in the RBS. The plots are arranged in three columns to allowing zooming into the initial and final times, facilitating visualization of the moments when tomography data were acquired. Start data for both Puls. and Cont. recharge episodes are shown at time 0, while only the stop of the Puls. (at 51 d) is included to simplify visualization, as only the Puls. data (blue dots) respond to the recharge stop. The times when tomography data were registered are indicated by dotted vertical lines, labelled as EndDC (End Dry Cycle), StrWC (Start Wet Cycle), EndWC (End Wet Cycle) and StrDC (Start Dry Cycle). a) Recharge flow rates during the Puls (in blue) and Cont (in red) operational schemes. Note that the flow exhibits a double maximum during Puls to deliver the same daily volume as Cont. b) Effect of the recharge pattern on %H distribution in the USZ at six depths c) Effect of the recharge pattern on the depth to the water table, expressed as pressure over the initially dry sensor located at 1.2 m depth. The graphic also shows the position of the different materials composing the USZ.

S2.2. Electrical Conductivity

Electrical Conductivity was recorded every 30 min using a CTD-Diver. Figure S6 illustrates EC variations during Puls (blue) and Cont (red) recharge episodes in the INF (solid line) and O piezometers (in dots), for SandS (a) and RBS (b). The baseline EC in the INF was around 2 mS/cm, with localized drops caused by rainfall (dilution) and peaks caused by seawater entrance into the sewerage system driven by winds.

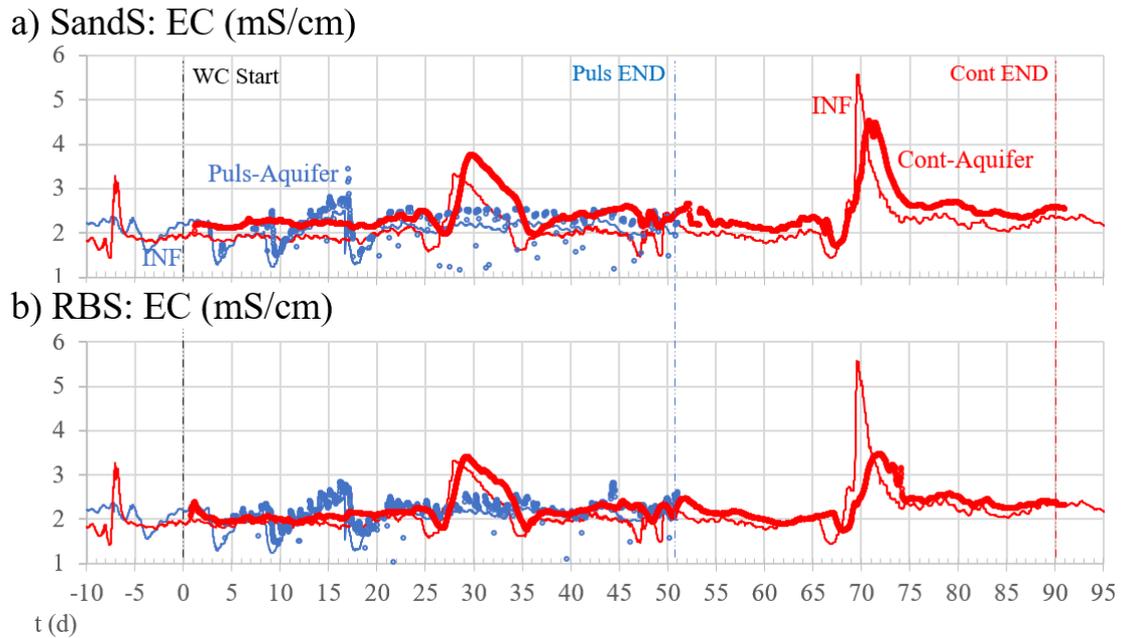


Figure S6: Electrical Conductivity measured in water using a CTD-Diver. Solid lines represent measurements in the WWTP Effluent (INF), and dotted lines correspond to the aquifer in O piezometer. Blue indicates data during Puls recharge and red correspond to Cont recharge. a) Data for the SandS ;b) Data for the RBS.

S2.3. Temperature

The Aquachek probe measures water content and temperature at the same locations, from 10 cm to 60 cm depth in 10 cm intervals. Figure S7 shows temperature measurements at 40 cm depth for SandS (a) and RBS (b), for comparison which those presented in the main text of this paper.

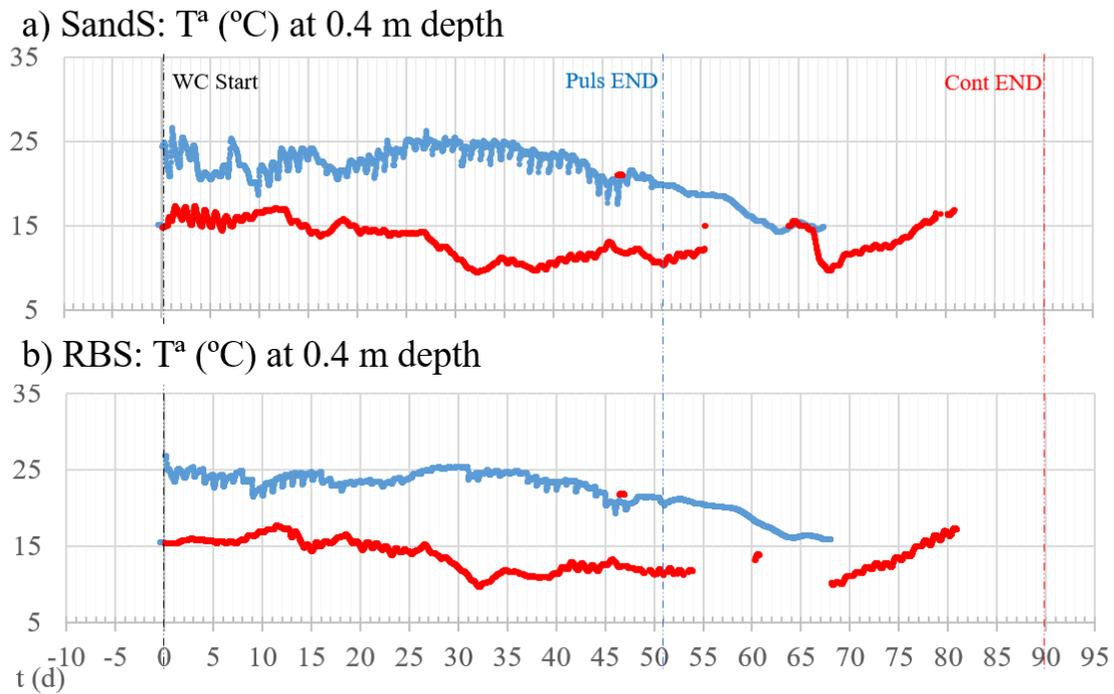


Figure S7: Temperature measured every 30 min at 0.4 m depth in SandS and RBS during recharge under Cont (red) and Puls (blue) strategies Cont took place from December to March (winter) and Puls from May to July (summer).

S2.4. Superficial water layer

During recharge episodes, a thin water layer may accumulate on the basin surface, mainly due to the deposition of fine organic material carried by WWTP effluent (INF). With proper system management, this layer may remain only a few centimetres thick or not form at all. However, a sudden increase in thickness indicates the need to initiate the dry cycle (DC) to allow degradation of the fine particles. A normal wet cycle (WC) can start after a few days.

Figure S8 (SandS) and Figure S9 (RBS) illustrate the evolution of parameters measured in this layer over the course of the recharge episodes. In the SandS, under continuous recharge, the layer began to form after 70 days, reaching 5 cm and remaining stable for 5 days. Afterward, accumulation continued, eventually reaching 25 cm, at which point recharge was stopped. The RBS, in contrast, recharged normally without any s

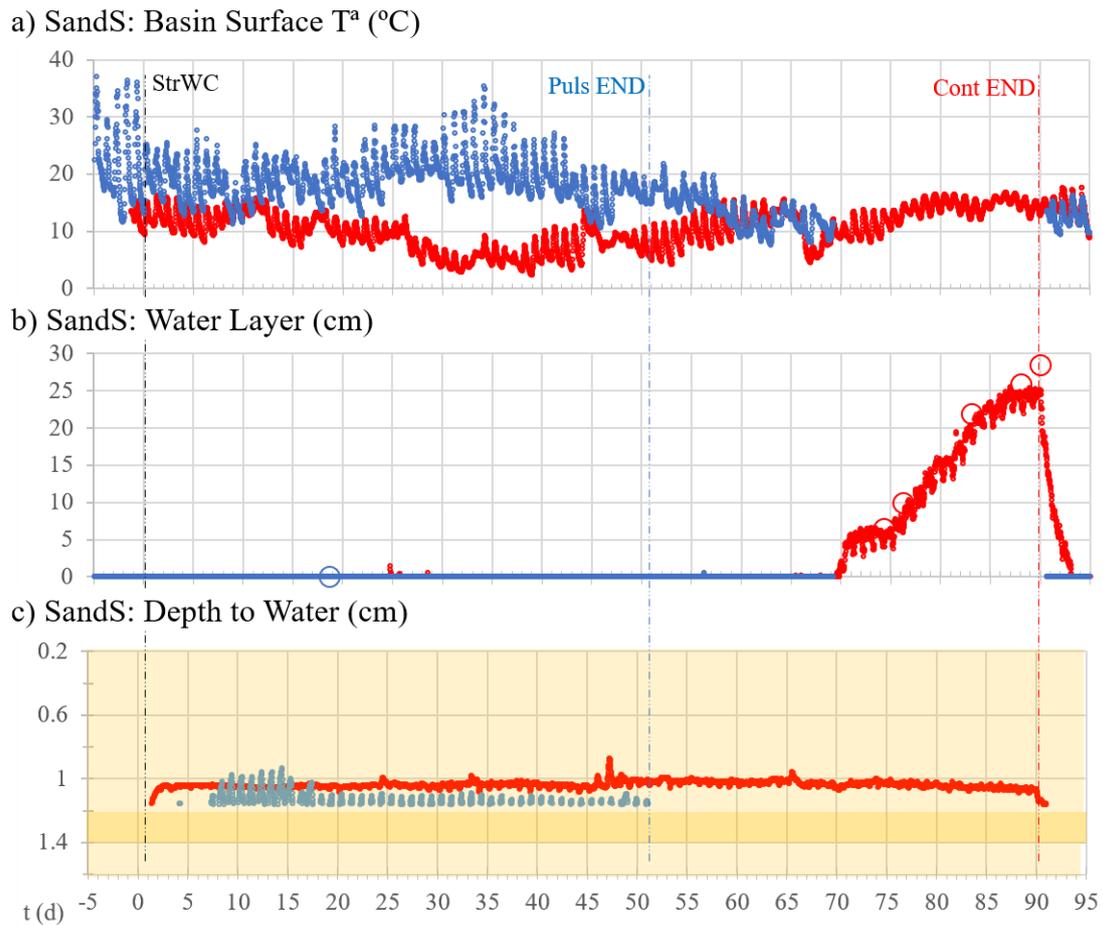
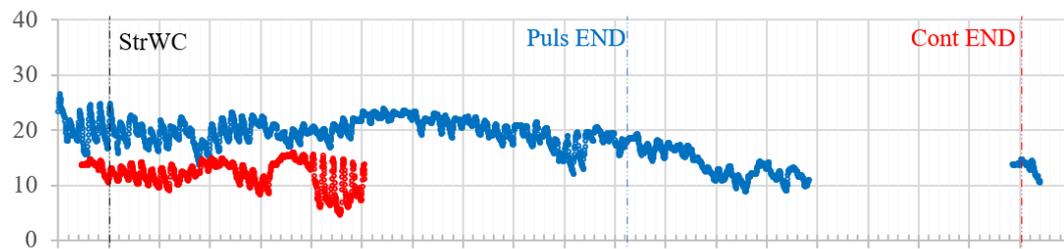
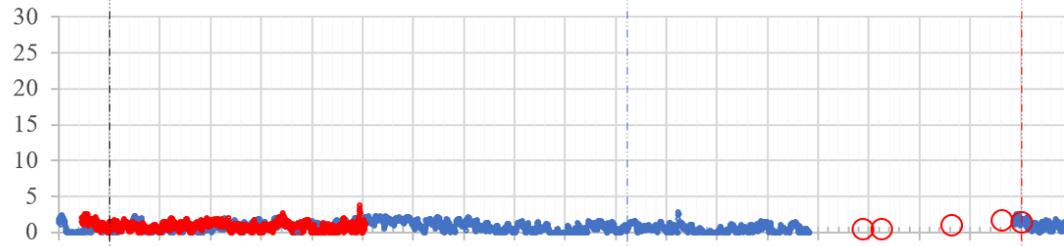


Figure S8: a) Evolution of Temperature (°C), b) surface water column accumulation (large circles indicate manual measurements), and c) depth to the water table in the aquifer on the SandS surface during the Puls (blue) and Cont (red) recharge episodes.

a) RBS: Basin Surface T^a (°C)



b) RBS: Water Layer (cm)



c) RBS: Depth to Water (cm)

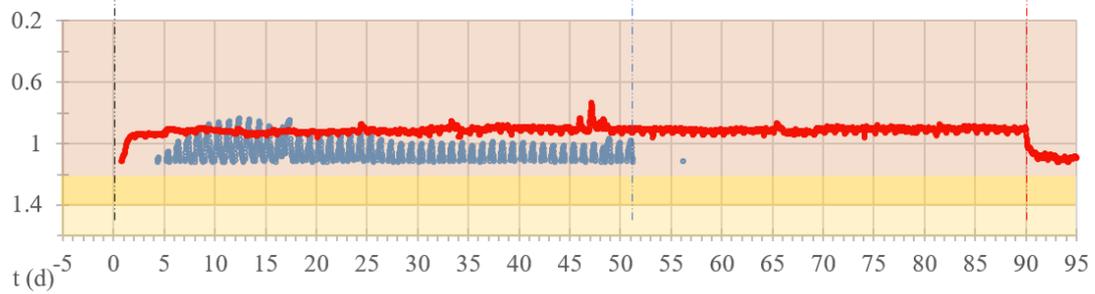


Figure S9: a) Evolution of Temperature (°C), b) surface water column accumulation (large circles indicate manual measurements), and c) depth to the water table in the aquifer at the RBS surface during the Puls (blue) and Cont (red) recharge episodes.

S2.5. Dissolved Oxygen Measurements

Oxygen dipping probes measure the partial pressure of both gaseous and dissolved oxygen. They consist of a polymer optical fiber (POF) with a polished distal tip which is coated with a planar oxygen-sensitive foil. The end of the POF is enclosed in a high-grade steel tube to protect the sensor. The detection range 0 – 100% oxygen, with a detection limit of 15 ppb, (Oxygen Dipping Probe PSt3, PreSens Precision Sensing). Figure S10 and Figure S11 present measurements from sensors located at depths of 35 and 90 cm in SandS and RBS respectively. Values recorded during the Puls (blue) and Cont (red) recharge episodes are shown. The dotted line indicates the end of each recharge episode.

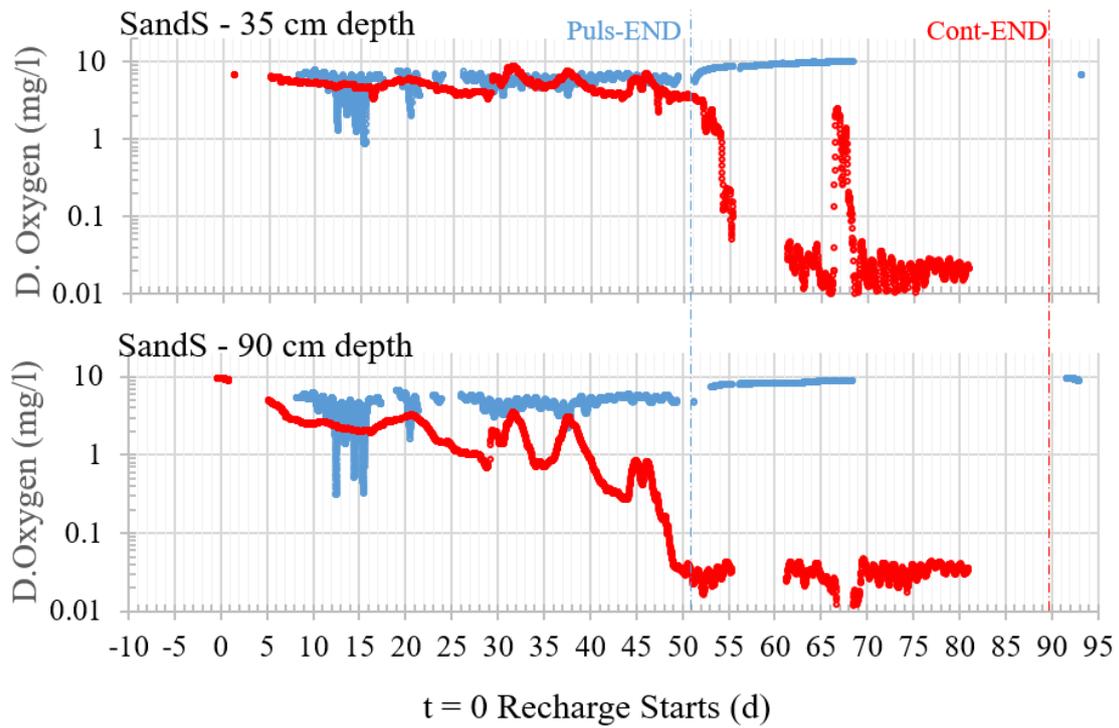


Figure S10: Dissolved Oxygen recorded in the USZ at two depths during Cont (red) and Puls (blue) recharge episodes for SandS. Vertical dotted lines indicate the end of the WC for each recharge episode.

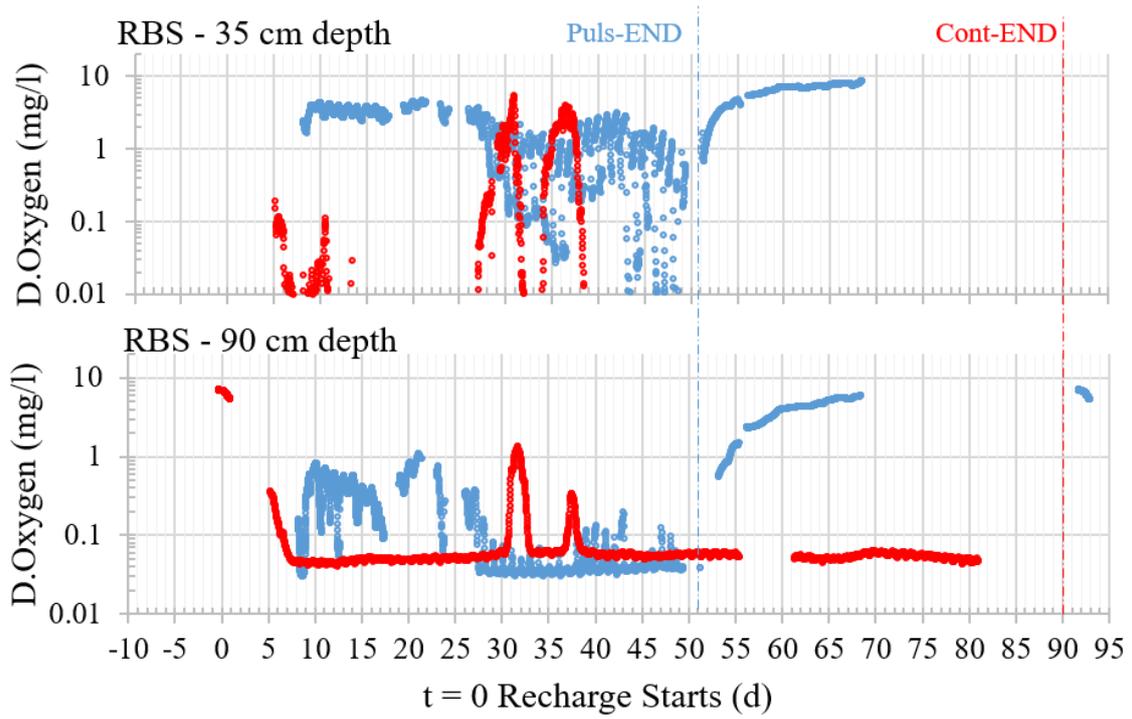


Figure S11: Dissolved Oxygen recorded in the USZ at two depths during Cont (red) and Puls (blue) recharge episodes for RBS. Vertical dotted lines indicate the end of the WC for each recharge episode.

S2.6. Extracellular polymeric substances (EPS) soil content.

Samples for EPS quantification were collected at three depths (28, 41, and 54 cm) in each system during the wet cycles. EPS are considered a key indicator of biofilm development. Table S1 presents the total EPS concentrations measured at these depths in both SandS and RBS during the Puls and Cont recharge episodes.

Table S1: Total EPS concentration ($\mu\text{g/g}$) measured at depths of 28, 41, and 51 cm on each sampling day ($t = 0$ indicates the start of the recharge episode). An asterisk (*) denotes that no sample was recovered due to dry material conditions.

Recharge strategy		Puls WC				
System Days/Depth (cm)	SandS			RBS		
	28	41	54	28	41	54
1	126.94	*	*	779.64	340.43	417.69
2	*	*	*	532.40	555.63	579.50
5	118.91	60.64	31.25	293.86	350.20	434.20
12	41.79	44.49	39.50	315.21	430.46	258.88
20	57.42	56.98	46.29	272.70	293.83	349.81
26	101.11	100.13	74.02	301.95	226.78	287.34
34	98.93	88.35	100.51	397.01	363.67	413.31
Recharge strategy		Cont WC				
System Days/Depth (cm)	SandS			RBS		
	28	41	54	28	41	54
1	52.66	50.74	53.70	110.86	144.51	195.99
2	*	*	*	*	*	*
5	31.08	45.07	41.83	201.99	222.16	183.02
12	55.37	37.96	28.46	176.92	137.08	198.31
20	39.05	22.44	25.69	169.52	164.36	148.10
26	213.19	52.00	85.87	295.68	208.08	275.58
34	92.47	70.21	103.51	319.31	300.20	165.41
39	41.28	111.07	53.86	221.04	236.16	510.82
53	95.78	107.03	78.71	338.89	219.48	220.06
74	101.31	99.80	73.60	296.61	179.29	223.98

* Sample not collected due to insufficient water content in the sediment to obtain a core.