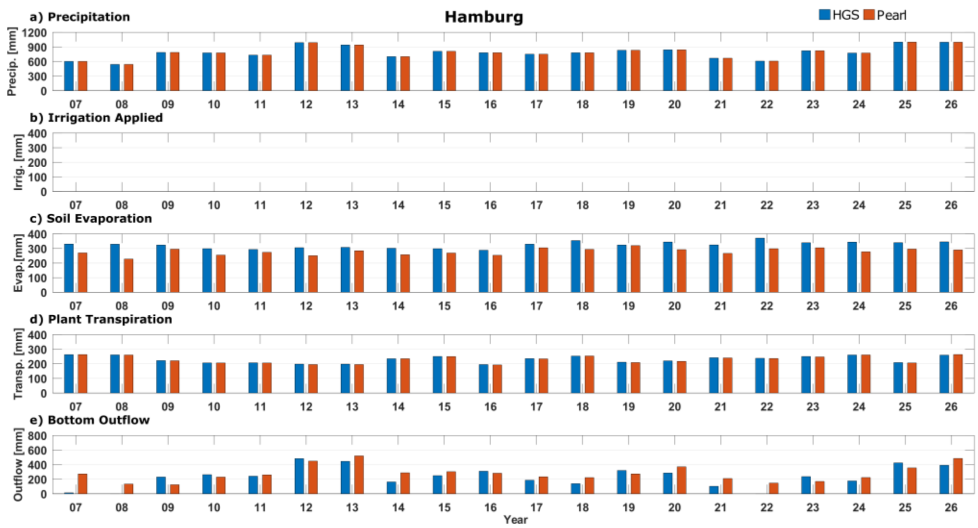

Figure S1. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Hamburg groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

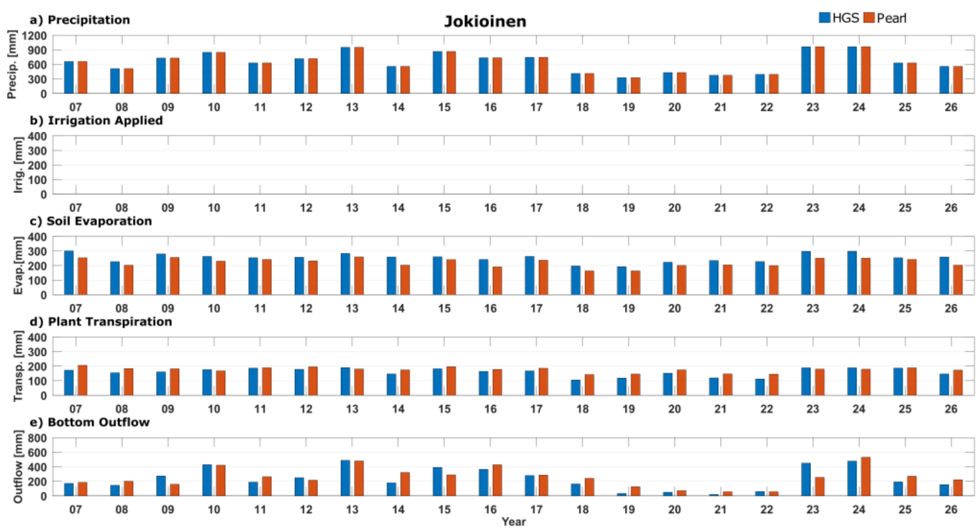

Figure S2. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Jokioinen groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

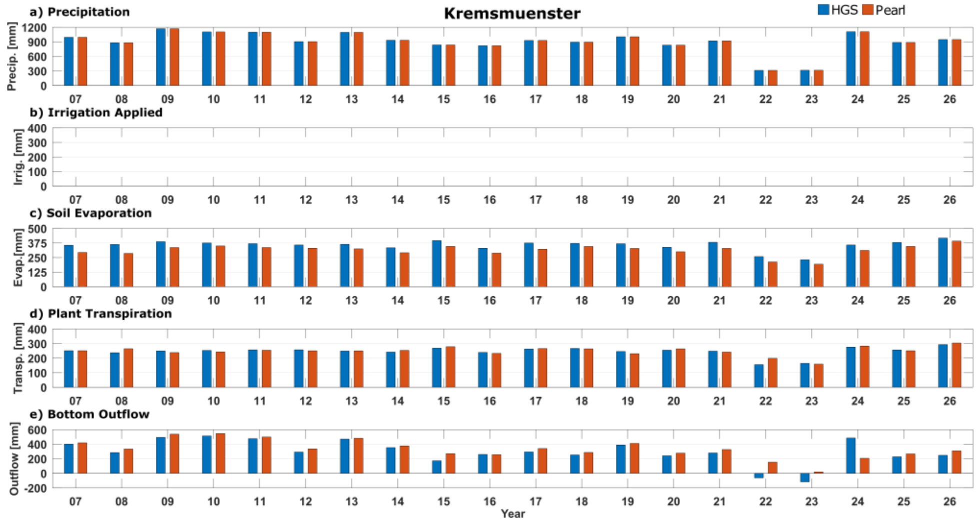

Figure S3. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Kremsmuenster groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

Figure S4. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Okehampton groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

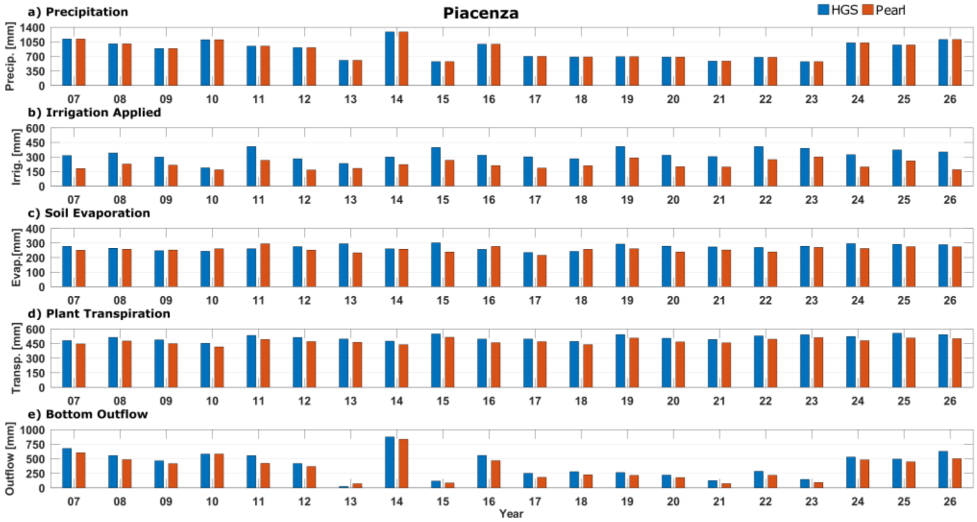

Figure S5. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Piacenza groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

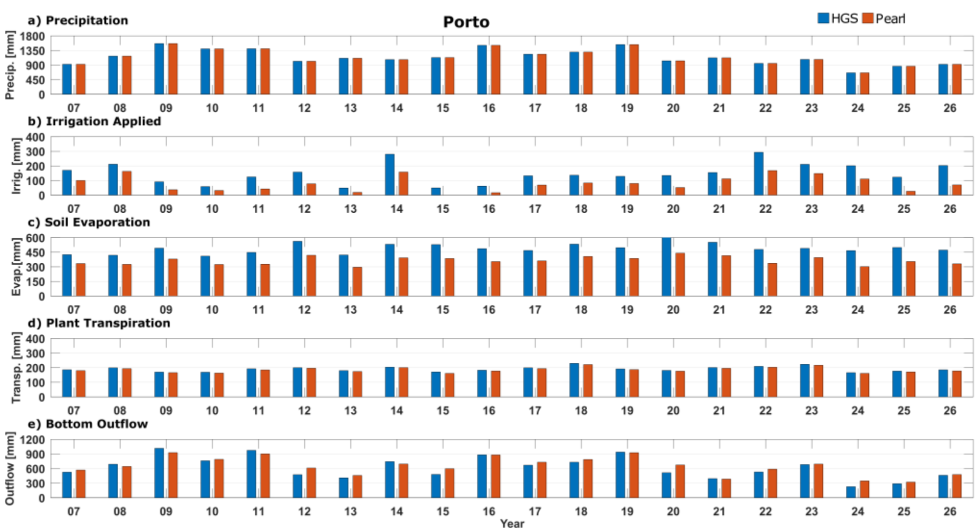

Figure S6. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Porto groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

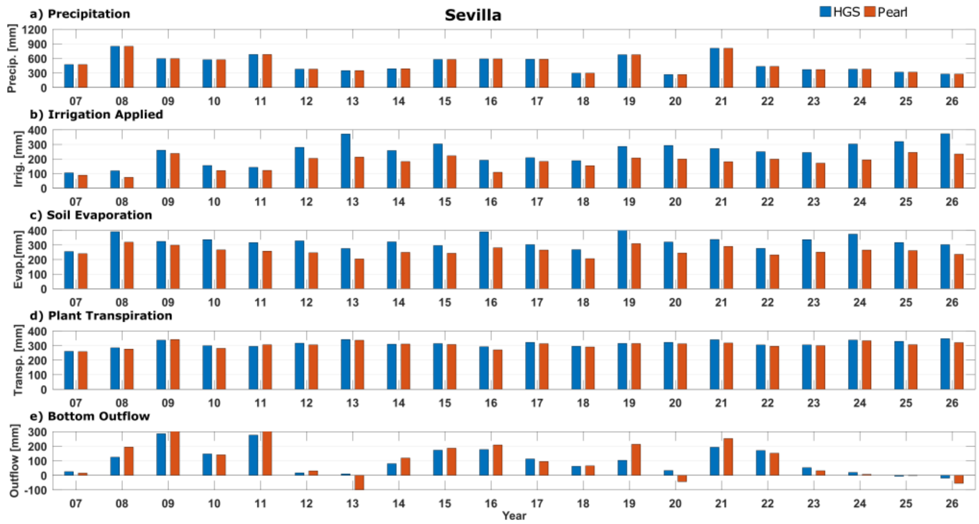

Figure S7. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Sevilla groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

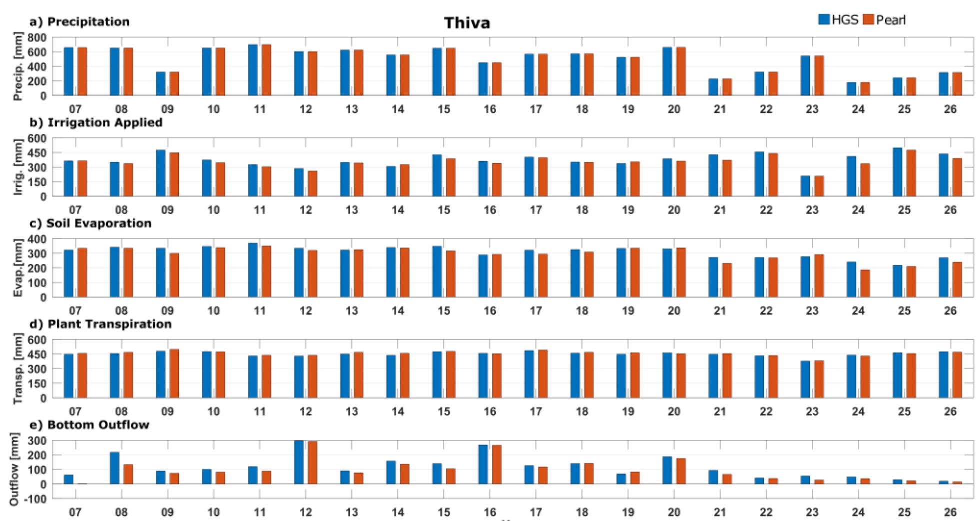

Figure S8. Comparison of annual water balance components between the HGS and PEARL models for a twenty-year period for the FOCUS Thiva groundwater scenario: precipitation (a), irrigation applied (b), soil evaporation (c), plant transpiration (d) and bottom outflow (e). PEARL model results after Diamantopoulos et al. (2017).

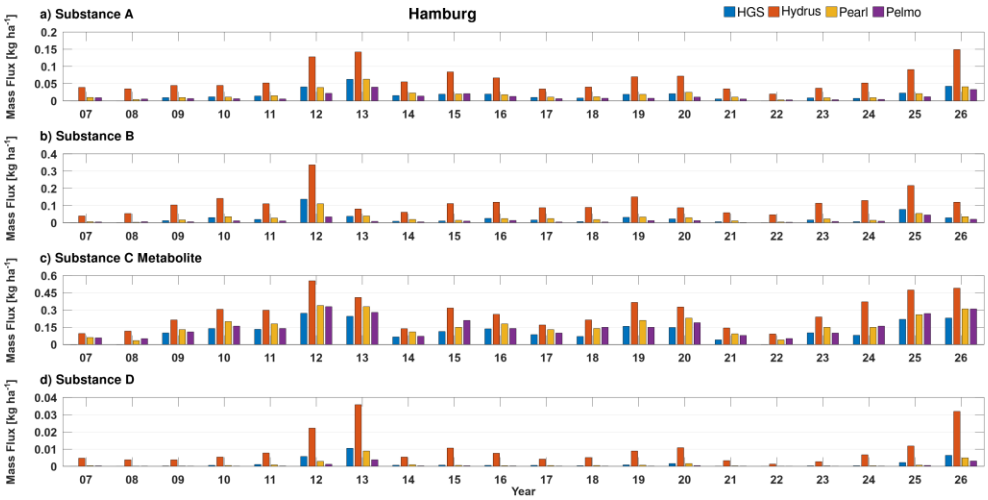

Figure S9. Comparison of annual PPP mass flux to groundwater for the Hamburg potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

Figure S10. Comparison of annual PPP mass flux to groundwater for the Jokioinen potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

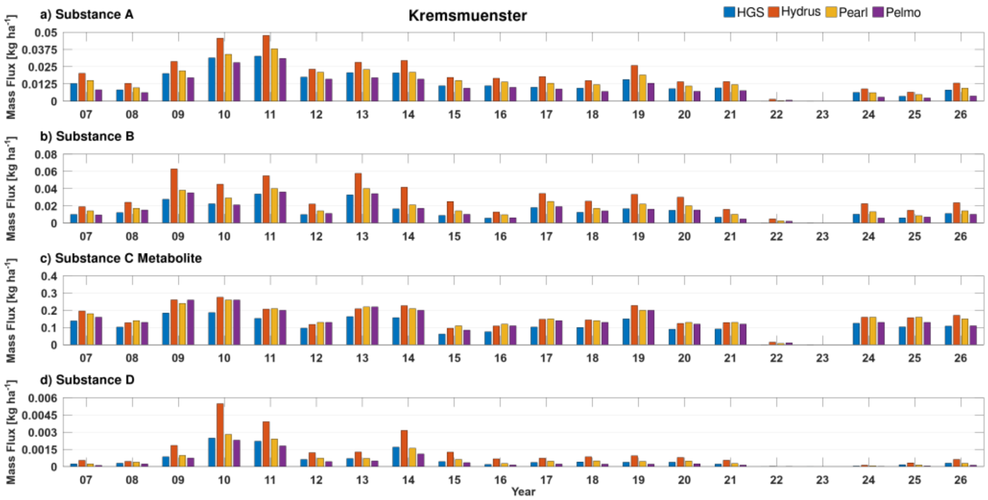

Figure S11. Comparison of annual PPP mass flux to groundwater for the Kremsmuenster potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

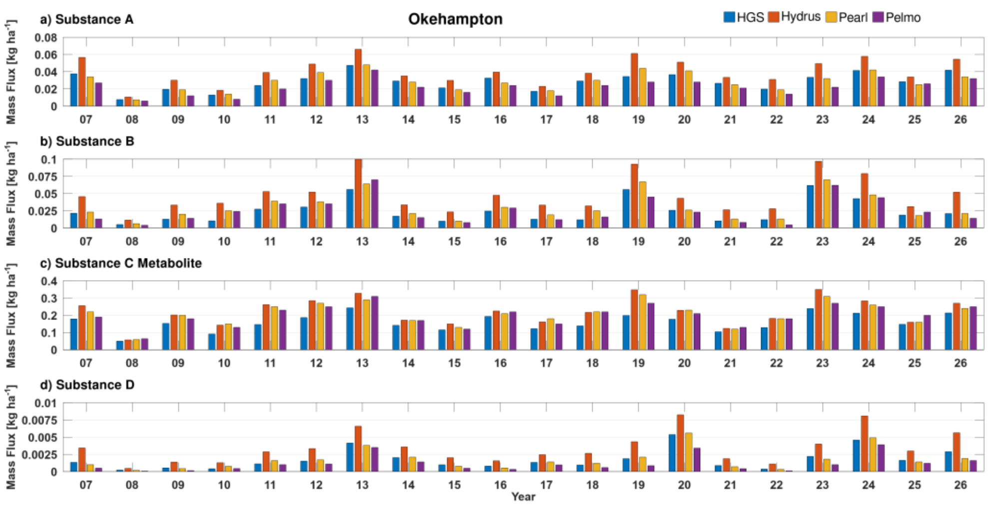

Figure S12. Comparison of annual PPP mass flux to groundwater for the Okehampton potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

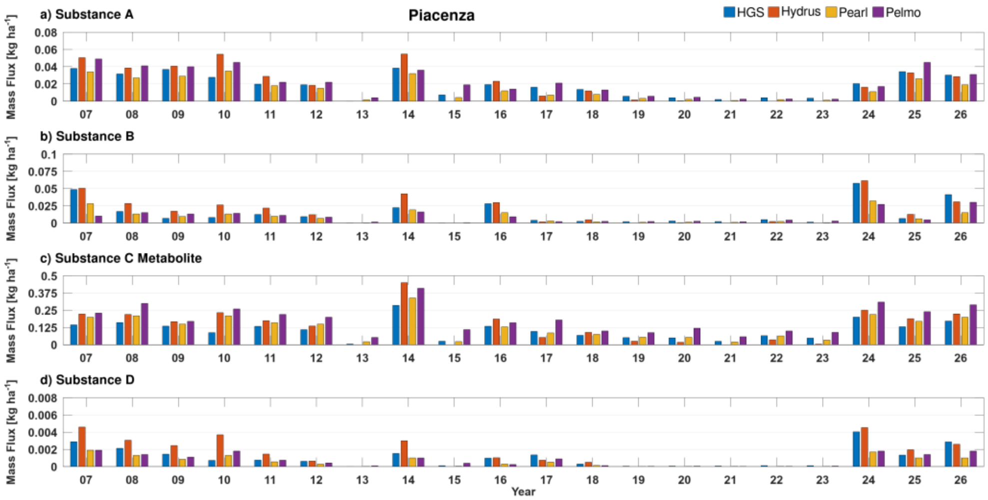

Figure S13. Comparison of annual PPP mass flux to groundwater for the Piacenza potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

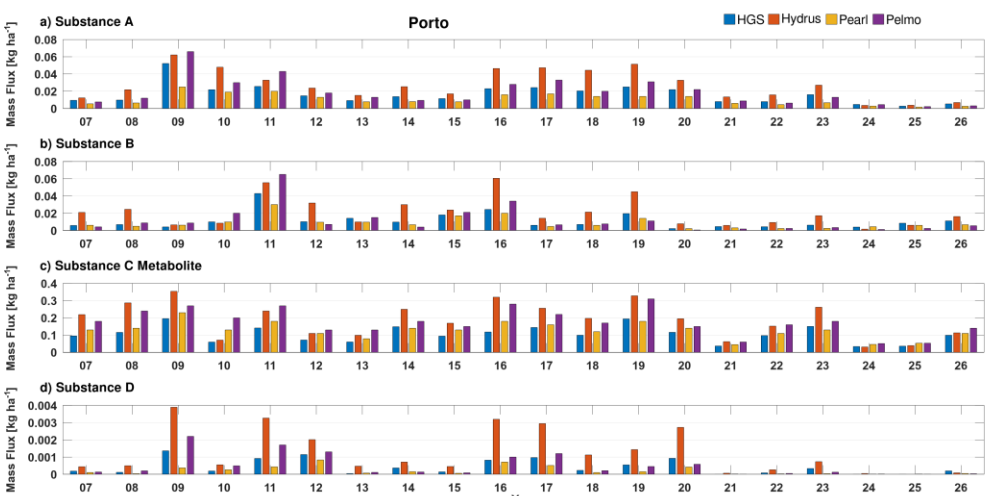

Figure S14. Comparison of annual PPP mass flux to groundwater for the Porto potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

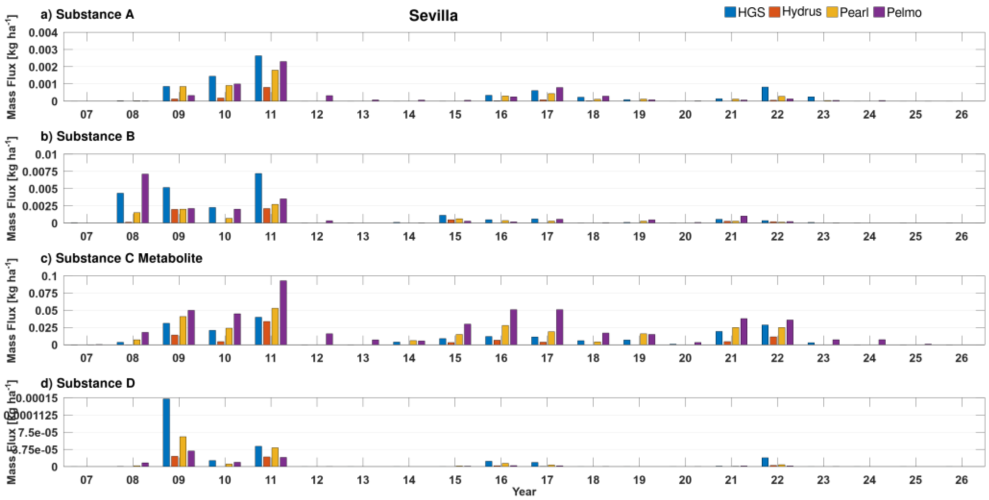

Figure S15. Comparison of annual PPP mass flux to groundwater for the Sevilla potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

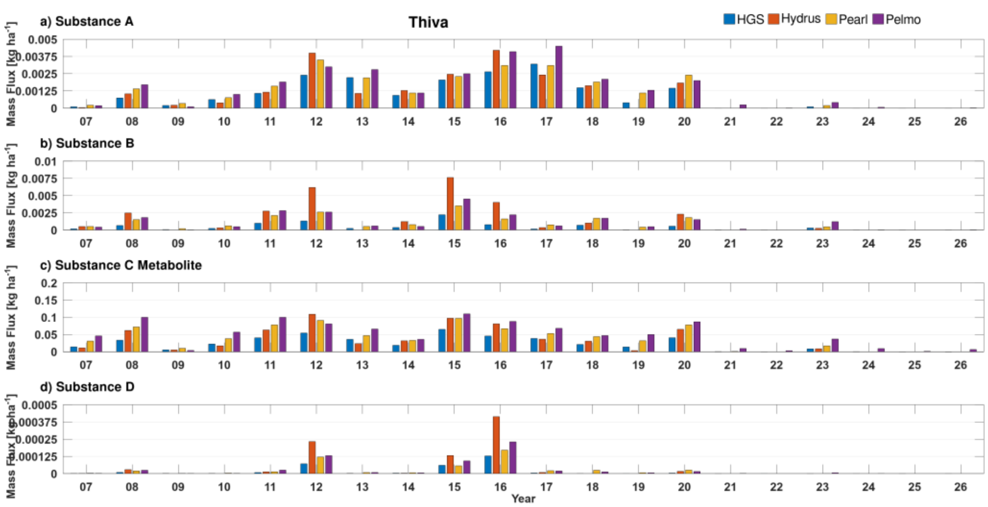

Figure S16. Comparison of annual PPP mass flux to groundwater for the Thiva potato crop scenario simulated using HGS, HYDRUS, PEARL and PELMO models for Test Substances: A (a), B (b), C-Metabolite (c) and D (d). HYDRUS, PEARL and PELMO model results after Diamantopoulos et al. (2017).

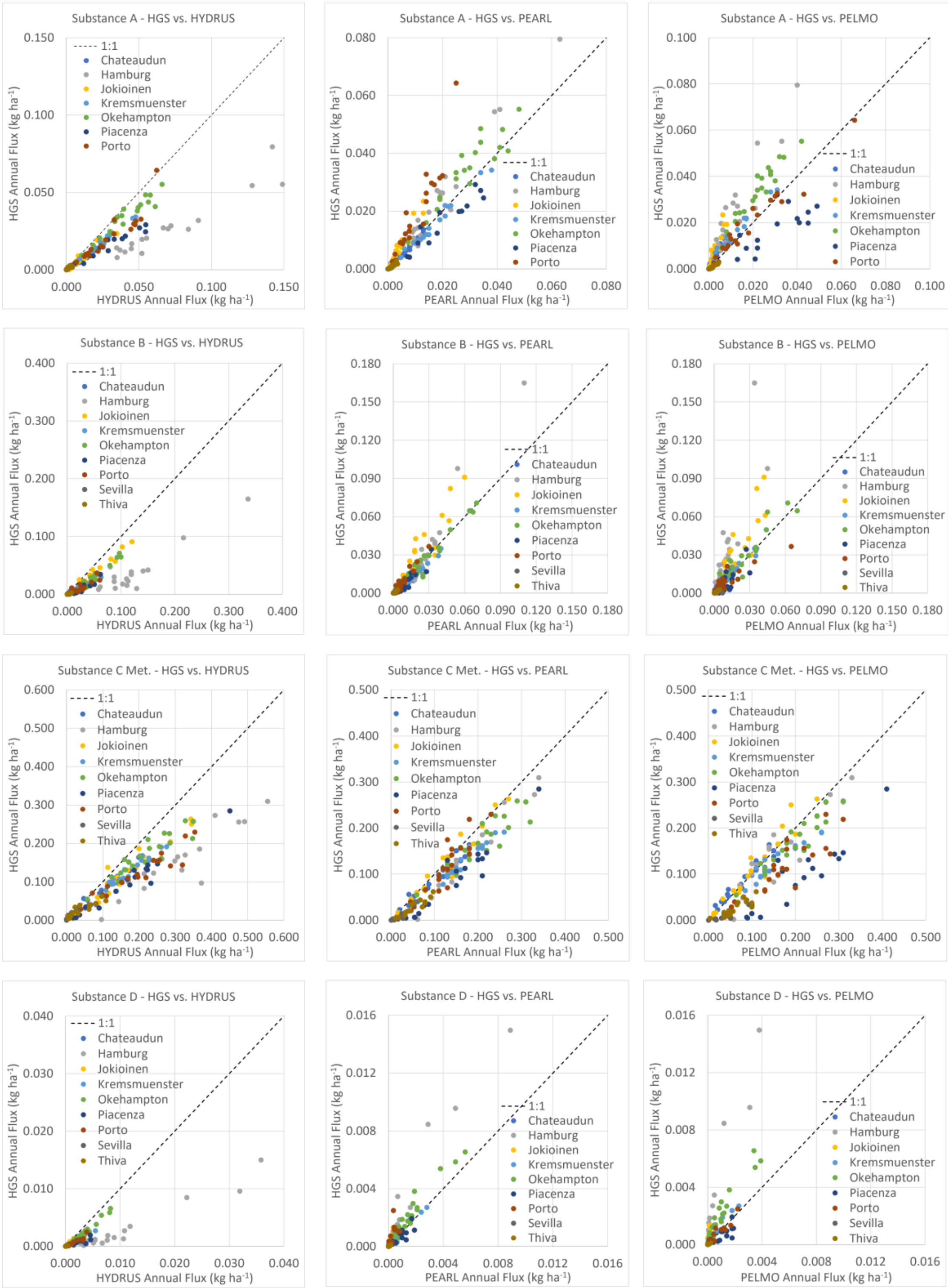

Figure S-17. Crossplots of simulated annual mass of PPP leached to groundwater for a 20-year period: HGS vs. HYDRUS, HGS vs. PEARL, and HGS vs. PELMO in columns for

test substances A, B, C-Metabolite, and D in rows. HYDRUS, PEARL, and PELMO results after Diamantopoulos et al. (2017).

Table S1. Summary of the nine FOCUS groundwater model inputs: water input, soil layers, and bottom boundary conditions (after, 1. EC, 2014; 2. USDA [1975] classification; and 3. Diamantopoulos et al., 2017).

Scenario	Water Input[1]	PPP Application Date	Soil Layers[2]	Bottom Boundary Conditions[3]
Châteaudun, FR	R + I	29 April	seven (SiCL, SiCL, SiL, limestone[four])	free drainage
Hamburg, DE	R	9 May	six (SL, SL, S, S, S, S)	deep drainage
Jokioinen, DK	R	4 June	six (LS, LS, LS, LS, LS, S)	deep drainage
Kremsmünster, AT	R	4 June	five (L/SiL, L/SiL, L/CL, L/CL, L/CL)	deep drainage
Okehampton, UK	R	29 April	five (L, L, SL, SL, SL)	deep drainage
Piacenza, IT	R + I	19 April	six (L, L, SiL, SiL, S, S)	time varying pressure head
Porto, PT	R + I	14 March	four (L, SL, SL, SL)	deep drainage
Sevilla, ES	R + I	30 January	six (SiL, SiL, SiL, CL, CL, CL)	time varying pressure head
Thiva, GR	R + I	28 February	six (L, L, CL, CL, CL, CL)	free drainage

R, rainfall; I, Irrigation; CL, clay loam; L, loam; SiCL, silty clay loam; SiL, silt loam; SL, sandy loam; S, sand

Table S2. Summary of the surface water loading scenarios for HGS demonstration, after FOCUS (2001).

Scenario	Mean spring and autumn temp. (°C)	Mean annual rainfall (mm)	Mean annual recharge (mm)	Slope (%)	Soil Description
D4	6.6 – 10	600 – 800	100 – 200	0.5 – 2	Light loam over slowly permeable substrate
R3	10 – 12.5	800 – 1000	>300	4 – 10	Heavy loam with small organic matter

Table S3. Soil matrix hydraulic parameters for the HGS tile drain model for the FOCUS D4 scenario.

Soil Layer	θ_r* ($m^3\ m^{-3}$)	θ_s ($m^3\ m^{-3}$)	α_{vg} (m^{-1})	n_{vg} (-)	K_m ($m\ s^{-1}$)
Ap	0.068	0.42	1.03	1.44	1.39×10^{-6}
Eb	0.067	0.36	1.85	1.44	2.78×10^{-6}
Ebg	0.071	0.36	1.71	1.39	1.94×10^{-6}
Btg	0.097	0.33	0.81	1.27	2.78×10^{-7}
BCg	0.060	0.30	2.16	1.41	2.78×10^{-7}
Ap-Trench	0.068	0.42	1.03	1.44	1.39×10^{-6}
Eb -Trench	0.067	0.36	1.85	1.44	2.78×10^{-6}
Ebg -Trench	0.071	0.36	1.71	1.39	1.94×10^{-6}
Btg -Trench	0.097	0.33	0.81	1.27	2.78×10^{-7}

*First four columns are terms in the van Genuchten (1980) unsaturated soil hydraulic property model; K_m, matrix saturated hydraulic conductivity.

Table S4. Soil macropore hydraulic parameters and macropore – matrix water exchange parameters for the HGS tile drain model for the FOCUS D4 scenario.

Soil Layer	θ_r ($m^3\ m^{-3}$)	θ_s ($m^3\ m^{-3}$)	α_{vg} (m^{-1})	n_{vg}	K_f ($m\ s^{-1}$)	K_a ($m\ s^{-1}$)	w_f (%)
Ap	0.05	0.90	25	3.5	3.49×10^{-4}	1.39×10^{-7}	2.0
Eb	0.05	0.90	25	3.5	7.22×10^{-5}	2.78×10^{-7}	2.0
Ebg	0.05	0.90	25	3.5	1.58×10^{-5}	1.94×10^{-7}	2.0
Btg	0.05	0.90	25	3.5	2.78×10^{-7}	2.78×10^{-8}	2.0
BCg	0.05	0.90	25	3.5	2.78×10^{-7}	2.78×10^{-8}	0.1
Ap-Trench	0.05	0.90	25	3.5	3.49×10^{-3}	1.39×10^{-7}	2.0
Eb -Trench	0.05	0.90	25	3.5	7.22×10^{-4}	2.78×10^{-7}	2.0
Ebg -Trench	0.05	0.90	25	3.5	1.58×10^{-4}	1.94×10^{-7}	2.0
Btg -Trench	0.05	0.90	25	3.5	1.10×10^{-3}	2.78×10^{-8}	2.0

*First four columns are terms in the van Genuchten (1980) unsaturated soil hydraulic property model; K_f, macropore saturated hydraulic conductivity; K_a, matrix-macropore interface saturated hydraulic conductivity; w_f**,** macropore volumetric fraction.

Interface K_a was set to 0.1 of matrix K_m, which nominally agrees with the factor 0.08 reported by Frey et al. (2016). The matrix-macropore water transfer coefficient, α_w = 397 m^{-2} was calculated using the formulation of Gerke and van Genuchten (1993) using a geometric factor, β = 3, γ = 0.4, and an effective diffusion path length of 0.055 m. Interface hydraulic properties were set equal to the matrix properties. For the trench materials Ap, Eb and Ebg, K_f was set to a factor of 10 greater than that of the corresponding undisturbed soils. The first order solute mass transfer term, $\alpha_s = 2.47 \times 10^{-7}$ s^{-1}, was calculated using the formulation of Gerke and van Genuchten (1993) using $\beta = 3$, a matrix tortuosity of 0.5 and an effective diffusion pathlength of 0.055 m.

During the construction of the HGS model and parameterization of the Btg trench material, it was found that 10x the macropore hydraulic conductivity did not allow sufficient drainage for the Btg trench material to occur, relative to the MACRO model results. Therefore, the bulk hydraulic conductivity of the Btg trench material was set to be equal to the overlying Ebg trench material. A bulk hydraulic conductivity of 2.23×10^{-5} m s^{-1} for the Btg trench material resulted in a calculated macropore hydraulic conductivity of 1.10×10^{-3} m s^{-1}. The relatively high magnitude of the Btg trench macropore hydraulic conductivity illustrates constraints that can occur when constructing a physics-based 2D tile drain model using HGS from a 1D tile drainage model, such as the MACRO example used here.