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SIMULATION MODEL OF THE WATER BALANCE OF A CROPPED SOIL PROVIDING DIFFERENT TYPES OF BOUNDARY CONDITIONS (SWATRE)

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C O N T E N T S

I. INTRODUCTION

FEDDES, KOWALIK and ZARADNY (1978) developed the program SWATR that calculates the actual use of water by a field crop. In SWATR as bottom boundary conditions the groundwater level is specified, i.e. the level where the soil water pressure head is zero. WESSELING and FEDDES (1979) introduced at the bottom of the system a second boundary condition, i.e. a soil water pressure head that may be constant or vary with time. In the present program, SWATRE(-xtended) the following types of conditions at the bottom of the system can be used (Fig. 1):

- groundwater level;
- flux from the saturated zone (prescribed); the groundwater level is computed;
- flux from the saturated zone (calculated as the sum of the flux towards ditches and the flux of deep percolation); the groundwater level is computed;
- flux from the saturated zone (calculated with a flux - groundwater level relationship); the groundwater level is computed;
- pressure head of bottom compartment;
- zero flux at the bottom (of an unsaturated soil profile); i.e. when an impermeable layer is present;
- free drainage at the bottom (unit hydraulic gradient; unsaturated soil profile).

As compared with the previous programs, the following modifications have been made:

- application of a different numerical scheme;
- extension to five soil layers that may have different properties;
- addition of another root water extraction pattern (that accounts for preferential extraction from the upper to lower layers of the root zone).

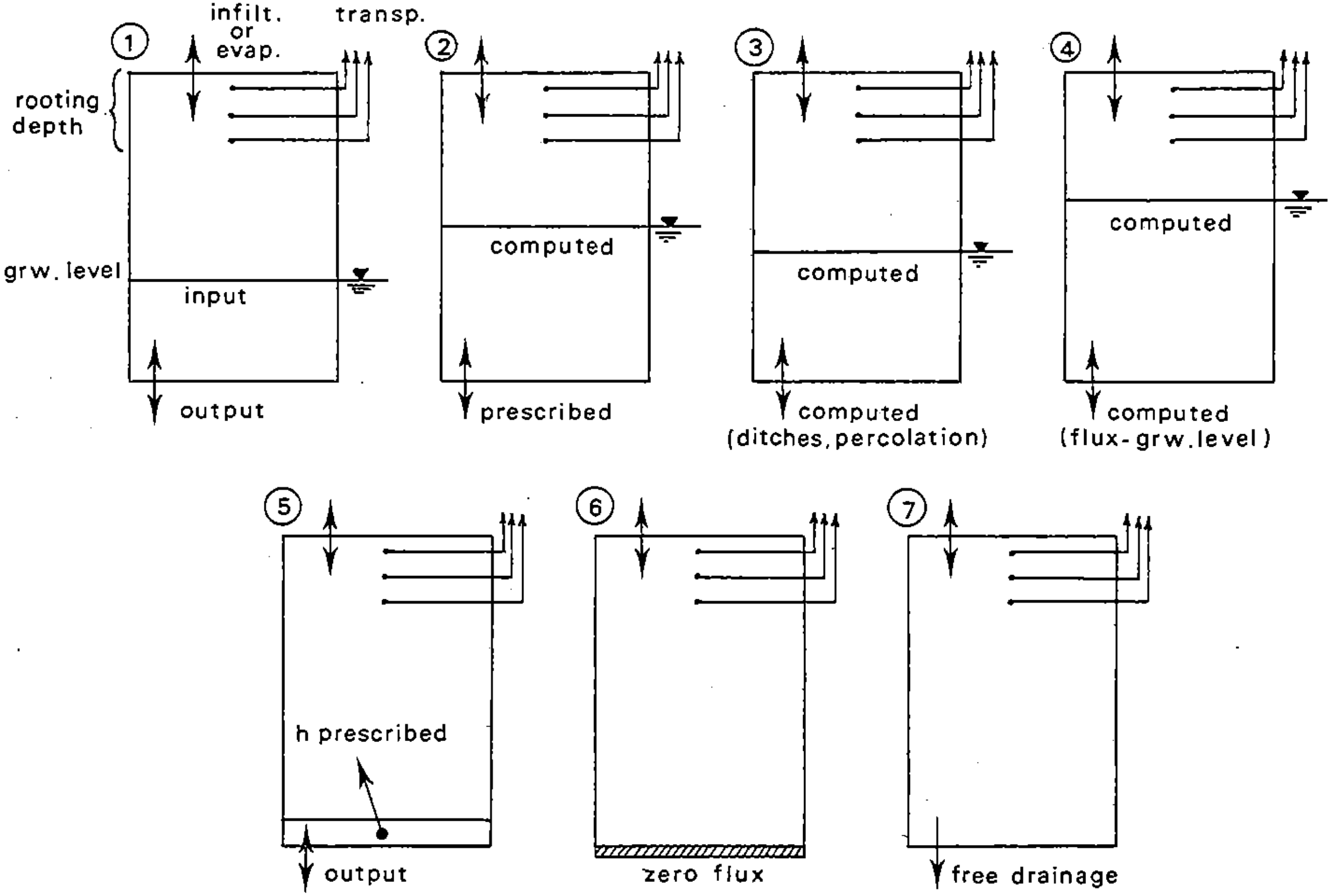


Fig. 1. Schematic representation of the 7 boundary conditions at the bottom of the unsaturated soil profile

II. THEORY

II.1. Basics of water flow in soil-root system

One-dimensional water flow in soil can be described by Darcy's law as:

$$q = -K \frac{\partial H}{\partial z} \tag{1}$$

where q = soil water flux ($cm^3.cm^{-2}.d^{-1}$)
K = hydraulic conductivity ($cm.d^{-1}$)
H = hydraulic head (cm)
z = vertical coordinate (cm), with origin at the soil surface and directed positive upwards

The hydraulic head, H, is the sum of soil water pressure head, h, and gravitational head, z, thus:

$$H = h + z \tag{2}$$

The continuity equation reads as:

$$\frac{\partial \theta}{\partial t} = - \frac{\partial q}{\partial z} - S \tag{3}$$

where θ = volumetric water content ($cm^3.cm^{-3}$)
t = time (d)
S = volume of water taken up by the roots per unit bulk volume of soil in unit time ($cm^3.cm^{-3}.d^{-1}$)

Combination of (1), (2) and (3) and introduction of the differential moisture capacity C = dθ/dh, one arrives at the basic flow equation:

$$\frac{\partial h}{\partial t} = \frac{1}{C(h)} \frac{\partial}{\partial z} \left[K(h)\left(\frac{\partial h}{\partial z} + 1\right)\right] - \frac{S(h)}{C(h)} \tag{4}$$

For more details, see FEDDES et al. (1978), who defined z positive downwards.

II.2. Sink term

FEDDES et al. (1978) defined the sink term S

$$S(h) = \alpha(h)\ S_{max} \qquad (5)$$

with

$$S_{max} = \frac{T^*}{L_r} \qquad (6)$$

and where $\alpha(h)$ = prescribed function of soil water pressure head (Fig. 2)
T^* = potential transpiration rate ($cm.d^{-1}$)
L_r = rooting depth (cm)

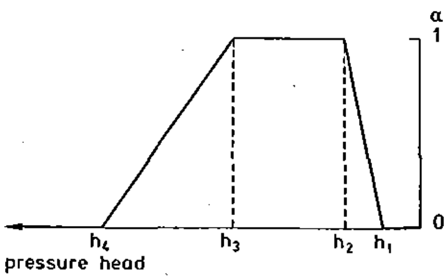


Fig. 2. General shape of the dimensionless sink term variable, α, as a function of the soil water pressure head, h (after FEDDES et al., 1978)

The value of h_3 in Fig. 2 varies with the evaporative demand of the atmosphere. Under conditions of high evaporative demand, a drop in root water uptake generally occurs at higher h-values than under conditions of low demand.

Eqs (5) and (6) can be combined to:

$$S(h) = \alpha(h)\ \frac{T^*}{L_r} \qquad (7)$$

Eq. (7) implies that the prescribed potential transpiration demand over the various layers of the root zone is equally distributed, and that the reduction in extraction occurs through the soil water pressure head, h.

In the present program an option is included that describes the sink according to HOOGLAND, BELMANS and FEDDES (1980) as:

$$S(h,z) = \alpha(h)\ S_{max}(z) \tag{8}$$

In eq. (8), the h_3-value of the $\alpha(h)$ function is taken to be constant (i.e. not varying with potential transpiration rate).

For eq. (8) the condition holds that

$$\int_z^0 S\ dz \leqslant T^* \tag{9}$$

Eq. (9) implies that water extraction may occur to a certain depth $|z| \leqslant |L_r|$. This formulation offers the advantage that the water extraction pattern is from top to bottom. Also it allows that water is extracted preferentially from wet layers. One may expect that the maximum sink, S_{max}, decreases with soil depth z (Fig. 3). Here we assume a linear decrease according to

$$S_{max} = a - b|z| \tag{10}$$

where a and b are constants in principle to be determined from measured root water uptake data. As a first guess we assume $0.01 \leqslant a \leqslant 0.03\ d^{-1}$, with a mean value of $a \approx 0.02$ often found in literature. For the moment we are compelled to take b = 0, until more information becomes available.

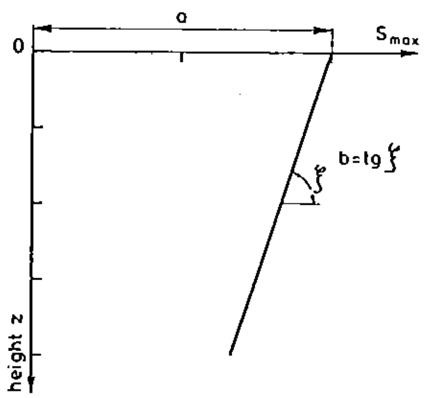


Fig. 3. Assumed variation of the maximum root extraction rate, S_{max}, with depth

The formulation of eq. (10) implies that S_{max} is decreasing with soil depth because of effects of aeration, soil temperature, rooting intensity and xylem resistances. In fact eq. (10) is a crude approximation to account for these effects.

II.3. Boundary conditions at the soil surface

A number of ways in which the maximum possible transpiration rate T*, and soil evaporation flux, E_s*, can be determined from the maximum possible evapotranspiration flux ET* are described in detail by FEDDES et al. (1978). In the program SWATRE three alternatives to calculate potential evapotranspiration, ET*, are given.

The first is according to the PRIESTLEY and TAYLOR (1972) equation:

$$ET^* = \alpha \frac{\delta}{(\delta+\gamma)L} R_n \qquad (kg.m^{-2}.s^{-1}) \qquad (12a)$$

where α = empirical factor (α = 1.35 $\pm$ 0.10)
δ = slope of the saturation pressure curve (mbar.K^{-1})
γ = psychrometric constant (mbar.K^{-1})
R_n = net radiation (W.m^{-2})
L = latent heat of vaporization of water (J.kg^{-1})

The second approach is based on the Penman open water evaporation, E_o, (see DE BRUIN and LABLANS, 1980) and a crop coefficient, f, as:

$$ET^* = f.E_o \qquad (12b)$$

where

$$E_o = \frac{\delta\ R_n/L + \gamma\ E_a}{\delta+\gamma} \qquad (mm.d^{-1}) \qquad (12c)$$

with

$$E_a = 0.26(0.54u + 0.5)(e_a - e_d) \qquad (mm.d^{-1}) \qquad (12d)$$

where u = wind velocity at 2 m height (m.s^{-1})
e_a = saturated vapour pressure (mbar)
e_d = prevailing vapour pressure (mbar)

and with R_n being calculated as:

$$R_n = (1-0.06)R_s - \sigma T_a^4(0.47-0.067\sqrt{e_d})(1-0.8\ m)$$

where R_s = shortwave radiation flux ($W.m^{-2}$)
σ = Stefan-Boltzmann constant ($\sigma = 5.67.10^{-8}\ W.m^{-2}.K^{-4}$)
T_a = air temperature at 2 m height (K)
m = degree of cloudiness (fraction)

For f-factors for a number of various crops in different stages of growth, one is referred for example to Table 18 of DOORENBOS et al. (1979).

The third approach is according to Monteith-Rijtema (see FEDDES et al., 1978):

$$ET^* = \frac{\delta+\gamma}{\delta+\gamma(1+\frac{r_s}{r_a})}(E^* - E_i) \qquad (12e)$$

where r_s = crop resistance ($s.m^{-1}$), taken to be constant
E^* = evapotranspiration of a wet crop surface (eq. 3.29 of FEDDES et al., 1978) ($kg.m^{-2}.s^{-1}$)
E_i = evaporation flux of intercepted water ($kg.m^{-2}.s^{-1}$)

Note that in eq. (3.33) of FEDDES et al. (1978) a term '$+E_i$' is included, because there total evapotranspiration E^{**} is including the evaporation of intercepted water. In the present program we start with the calculation of E^*. In the presence of water upon the leaves, this water evaporates with the same intensity as E^*. Then (E^*-E_i) is reduced to a potential evapotranspiration flux, ET^*.

For all the 3 described ET^* calculations, we apply RITCHIE (1972) equation to estimate potential soil evaporation E_s^*:

$$E_s^* = \frac{\delta}{(\delta+\gamma)L} R_n\ e^{-0.39I} \qquad (kg.m^{-2}.s^{-1}) \qquad (12f)$$

where I = leaf area index, derived from fraction of soil cover (see FEDDES et al., 1978; page 73, Fig. 31)

III. NUMERICAL SOLUTION

III.1. Solution for the intermediate nodal points

In order to be able to solve eq. (4) by finite difference techniques a grid is laid over the 'time - depth' region of the unsaturated zone as occupied by the independent variables t (index i) and z (index j) (Fig. 4). The unsaturated zone contains a number of n nodal points. In these cases where a fluctuating groundwater table is present n is not constant.

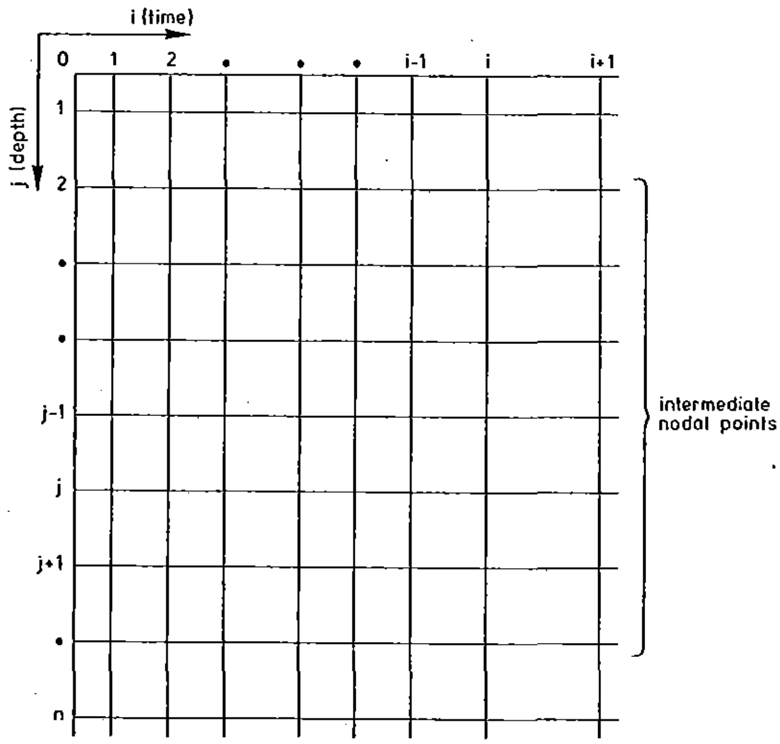


Fig. 4. Finite difference mesh superimposed on the depth-time region of the unsaturated zone. The soil profile is divided in compartments of equal thickness with the nodal points at the center of the compartments

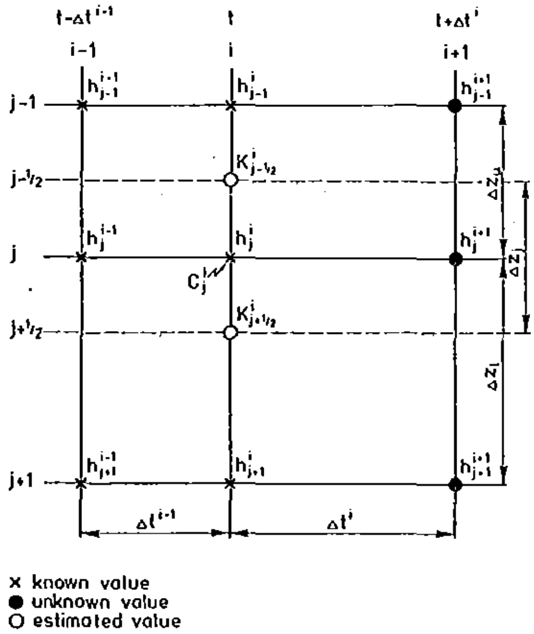


Fig. 5. Depth-time region under consideration, with location of the pressure heads, h, of the hydraulic conductivities, K, and of the differential moisture capacities, C, as used in the numerical scheme

According to HAVERKAMP et al. (1977) and VAUCLIN et al. (1979) a finite difference scheme has been chosen which results in lower computing times than the scheme used in SWATR and which yields an acceptable accuracy of the water balance. Eq. (4) can for compartments of different size for each nodal point (i,j) be approximated by the following implicit scheme with explicit linearization (see also Fig. 5):

$$\frac{\Delta h}{\Delta t^i} = \frac{1}{C_j^i} \cdot \frac{1}{\Delta z_j} \left\{ K^i_{j-\frac{1}{2}} \left[\left(\frac{\Delta h}{\Delta z_u} \right)^{i+1}_{j-\frac{1}{2}} + 1 \right] - K^i_{j+\frac{1}{2}} \left[\left(\frac{\Delta h}{\Delta z_l} \right)^{i+1}_{j+\frac{1}{2}} + 1 \right] \right\} - \frac{S_j^i}{C_j^i} \qquad (13)$$

$$\frac{\Delta h}{\Delta t^i} = \frac{h_j^{i+1} - h_j^i}{\Delta t^i} \qquad (14)$$

$$\left(\frac{\Delta h}{\Delta z_u}\right)^{i+1}_{j-\frac{1}{2}} = \frac{h^{i+1}_{j-1} - h^{i+1}_{j}}{\Delta z_u} \tag{15}$$

$$\left(\frac{\Delta h}{\Delta z_1}\right)^{i+1}_{j+\frac{1}{2}} = \frac{h^{i+1}_{j} - h^{i+1}_{j+1}}{\Delta z_1} \tag{16}$$

$$\frac{h^{i+1}_j - h^i_j}{\Delta t^i} = \frac{1}{C^i_j} \cdot \frac{1}{\Delta z_j}\left[K^i_{j-\frac{1}{2}}\left(\frac{h^{i+1}_{j-1} - h^{i+1}_j}{\Delta z_u}\right) + K^i_{j-\frac{1}{2}}\right] - \frac{1}{C^i_j} \cdot \frac{1}{\Delta z_j}\left[K^i_{j+\frac{1}{2}}\left(\frac{h^{i+1}_{j} - h^{i+1}_{j+1}}{\Delta z_1}\right) + K^i_{j+\frac{1}{2}}\right] - \frac{S^i_j}{C^i_j} \tag{17}$$

$$h^{i+1}_j - h^i_j = \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_u} K^i_{j-\frac{1}{2}}\left(h^{i+1}_{j-1} - h^{i+1}_j\right) + \frac{\Delta t^i}{C^i_j\,\Delta z_j} K^i_{j-\frac{1}{2}} - \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_1} K^i_{j+\frac{1}{2}}\left(h^{i+1}_j - h^{i+1}_{j+1}\right) - \frac{\Delta t^i}{C^i_j\,\Delta z_j} K^i_{j+\frac{1}{2}} - \frac{\Delta t^i}{C^i_j} S^i_j +$$

$$- \left(\frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_1} K^i_{j+\frac{1}{2}}\right) h^{i+1}_{j+1} + \left(1 + \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_u} K^i_{j-\frac{1}{2}} + \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_1} K^i_{j+\frac{1}{2}}\right) h^{i+1}_j - \left(\frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_u} K^i_{j-\frac{1}{2}}\right) h^{i+1}_{j-1} =$$

$$= h^i_j - \frac{\Delta t^i}{C^i_j\,\Delta z_j} K^i_{j+\frac{1}{2}} + \frac{\Delta t^i}{C^i_j\,\Delta z_j} K^i_{j-\frac{1}{2}} - \frac{\Delta t^i}{C^i_j} S^i_j \tag{18}$$

Eq. (18) is a linear algebraic equation valid for each intermediate nodal point, according to:

$$-A_j\, h^{i+1}_{j+1} + B_j\, h^{i+1}_j - D_j\, h^{i+1}_{j-1} = E_j \tag{19}$$

where $A_j = \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_1} K^i_{j+\frac{1}{2}}$ (20)

$$B_j = 1 + \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_u} K^i_{j-\frac{1}{2}} + \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_1} K^i_{j+\frac{1}{2}} \tag{21}$$

$$D_j = \frac{\Delta t^i}{C^i_j\,\Delta z_j\,\Delta z_u} K^i_{j-\frac{1}{2}} \tag{22}$$

$$E_j = h^i_j - \frac{\Delta t^i}{C^i_j\,\Delta z_j} K^i_{j+\frac{1}{2}} + \frac{\Delta t^i}{C^i_j\,\Delta z_j} K^i_{j-\frac{1}{2}} - \frac{\Delta t^i}{C^i_j} S^i_j \tag{23}$$

For the intermediate nodal points we now have (n-2) linear equations with n unknowns (the pressure heads at the n nodal points of the unsaturated zone h_j^{i+1}, j = 1, ... n). The solution for the top nodal point (see 2) gives one equation more, this leads to (n-1) equations. For the bottom compartment of the unsaturated zone one can distinguish between two cases:

- the pressure head is known (Dirichlet condition), e.g. case 1, 2, 3, 4 and 5 of Fig. 1, and one has left a system of (n-1) equations with (n-1) unknowns, which can be solved;
- the flux through the bottom of the unsaturated zone is known (Neumann condition), e.g. case 6 and 7, which gives us an additional equation leading to n equations with n unknowns, which can also be solved.

In solving the system of equations, a direct method was used by applying the so-called Thomas (tridiagonal) algorithm (see e.g. REMSON et al., 1971).

As indicated before the values of hydraulic conductivity K and differential moisture capacity C are obtained by explicit linearization. This implies that K and C are taken at time t.
For C at the nodal points: C_j^i
For K in between the nodal points we take the geometrical mean:

$$K_{j-\frac{1}{2}}^i = \sqrt{K_{j-1}^i \, K_j^i} \tag{24}$$

$$K_{j+\frac{1}{2}}^i = \sqrt{K_j^i \, K_{j+1}^i} \tag{25}$$

III.2. Solution for the top nodal point

Except for the last two unsaturated nodal points just above the water table (i.e. for the cases 1 to 4 of Fig. 1) we take for all nodal points that

$$\Delta z = \Delta z_j = \Delta z_u = \Delta z_1 \tag{26}$$

The solution for the top nodal point j = 1 is obtained by introducing as boundary condition a flux in eq. (13), i.e.:

$$K^{i}_{j-\frac{1}{2}} \left[\left(\frac{\Delta h}{\Delta z}\right)_{u}{}^{i+1}_{j-\frac{1}{2}} + 1 \right] \rightarrow q_{top} \tag{27}$$

The coefficients of eq. (19) then become:

$$A_1 = \frac{\Delta t^i}{C_1^i\ (\Delta z)^2} K^i_{1+\frac{1}{2}} \tag{28}$$

$$B_1 = 1 + A_1 \tag{29}$$

$$D_1 = 0 \tag{30}$$

$$E_1 = h_1^i - \frac{\Delta t^i}{C_1^i\ \Delta z} K^i_{1+\frac{1}{2}} - \frac{\Delta t^i}{C_1^i\ \Delta z} q_{top} - \frac{\Delta t^i}{C_1^i} S_1^i \tag{31}$$

III.3. Solution for the boundary condition at the bottom of the unsaturated zone

Case 1: The solution for the bottom boundary condition of the unsaturated zone of case 1 (groundwater level prescribed) is as follows (see Fig. 6).

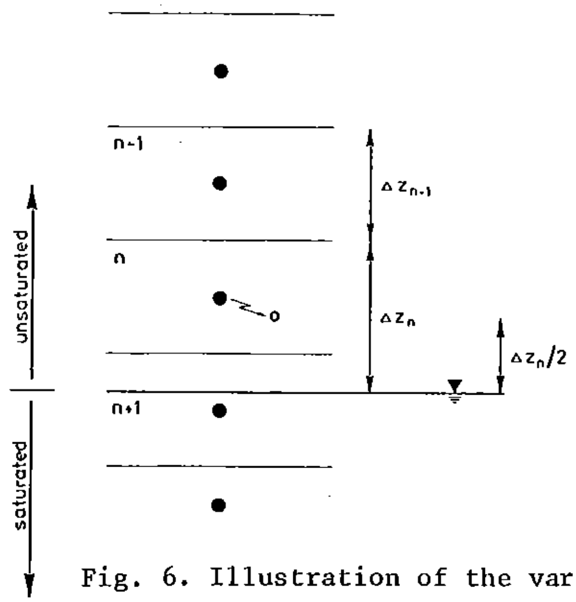


Fig. 6. Illustration of the varying size (Δz_n) of the first unsaturated soil compartment that is situated just above the groundwater level

The thickness of the bottom compartment (Δz_n) of the unsaturated zone is taken variable. Thus the nodal point of this compartment (always taken in the center of the compartment) has no fixed position. The pressure head at this nodal point is always taken to be equal to the negative value of the height above the prescribed groundwater level (equilibrium condition) at the beginning of the time step, i.e. $h_n^i = -\Delta z_n^i/2$. Now the groundwater level is hold constant during the time step Δt^i. At the end of the time step $t+\Delta t^i$, the new groundwater level is read as an input. Then Δz_n^{i+1} and h_n^{i+1} are determined, giving the new pressure head profile.

Case 2: The approach to be followed will be explained with the aid of two simplified flow cases (Fig. 7):

Fig. 7A - Water is evapotranspiring, there is no flux downwards through the bottom of the system, the moisture profile is initially in equilibrium situation.

Fig. 7B - There is no flux through the top of the system, water is only flowing through the bottom of the system and the moisture profile is initially in equilibrium situation.

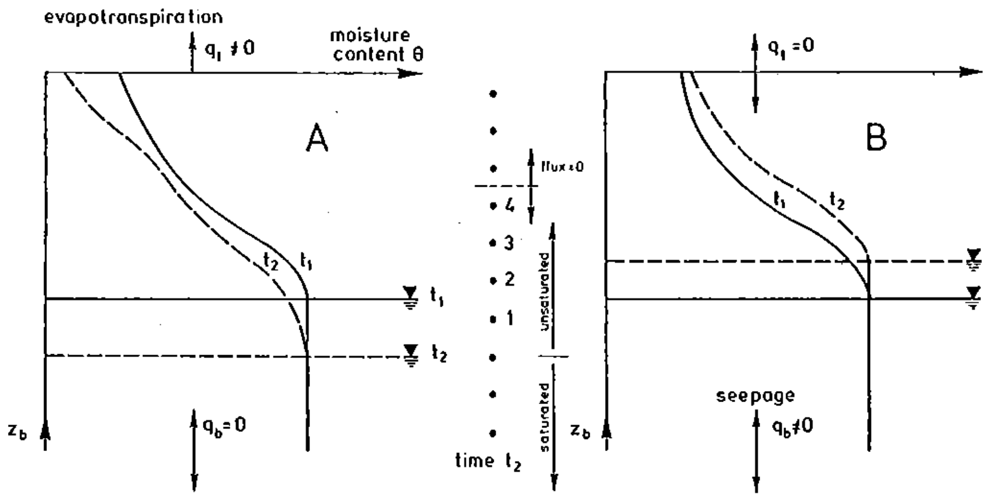


Fig. 7. Two simplified flow cases (A and B) to illustrate the general solution procedure followed for the calculation of the groundwater level

In the situation depicted in Fig. 7A water is flowing from the saturated to the unsaturated zone and the groundwater level is lowered. During each time step the amount of water flowing from the saturated to the unsaturated zone (U_1) is calculated according to:

$$U_1 = \int_{t_1}^{t_2} \int_{z_b}^{0} \frac{d\theta}{dt} dz.dt + \int_{t_1}^{t_2} T.dt + \int_{t_1}^{t_2} E.dt \quad \text{(cm)} \qquad (32)$$

where for the time period t_1 to t_2 the first integral of eq. (32) yields the change of water storage (cm) of the entire profile, the second integral the transpiration (cm) and the third integral the soil evaporation (cm). During each time step the groundwater level is kept constant. Then for each time step the calculated value of U_1 is added to a summation variable W, according to

$$W^{i+1} = W^i + U_1^i \qquad (33)$$

where i is time index.
If $|W| \geqslant 0.1$ cm (arbitrarily taken), then the resulting lowering of the groundwater level is computed in sequential steps (size of step read as an input). After each step the pressure head profile of the first four nodal points above the freatic surface is adjusted by an iteration procedure taking the flux at the top of the soil layer that is represented by the four nodal points, equal to zero (Fig. 7A). At the end of each of such a time step the water storage is computed, and then W is lowered with the difference in water storage between the end (V^{i+1}) and the beginning (V^i) of the iteration step:

$$W^{i+1} - (V^{i+1} - V^i) \rightarrow W^{i+1} \quad \text{(cm)} \qquad (34)$$

This procedure of lowering the water table step by step is continued until $|W| \leqslant 0.05$ cm (arbitrarily taken).

In the situation of Fig. 7B water flows through the bottom of the system into the profile (flux q_b). As a result the groundwater level rises and water flows towards the unsaturated zone. In this case the total amount of water in the entire soil profile increases and for each time step the equation holds:

$$W^{i+1} = W^i + U_2^i \qquad \text{(cm)} \qquad (35)$$

where $U_2 = -\int_{t_1}^{t_2} q_b \, dt$

represents the amount of water coming in through the bottom of the system. Then the same procedure as described in the situation of Fig. 7A is followed to calculate the new groundwater level.

The general situation, i.e. with evapotranspiration/infiltration and seepage is solved by the equation:

$$W^{i+1} = W^i + U_1^i + U_2^i \qquad \text{(cm)} \qquad (36)$$

Otherwise the same procedure is followed as described for the situation of Fig. 7A,B.

Case 3: This situation is in principle the same as case 2, with the exception that q_b is calculated in the program as a result of in/out flow from/to ditches and down/upward flow to/from deep aquifers (Fig. 8).

Flow from the ditches is calculated as:

$$q_1 = - \frac{\phi_1 - \phi_2}{T} \qquad (\text{cm.d}^{-1}) \qquad (37)$$

where ϕ_1 = level of open water in ditch (cm)
ϕ_2 = groundwater level midway between the ditches (cm)
T = drainage resistance (d)

According to ERNST (1962) the drainage resistance can be calculated as:

$$T = Lw + \frac{L^2}{8kD} \qquad \text{(d)} \qquad (38)$$

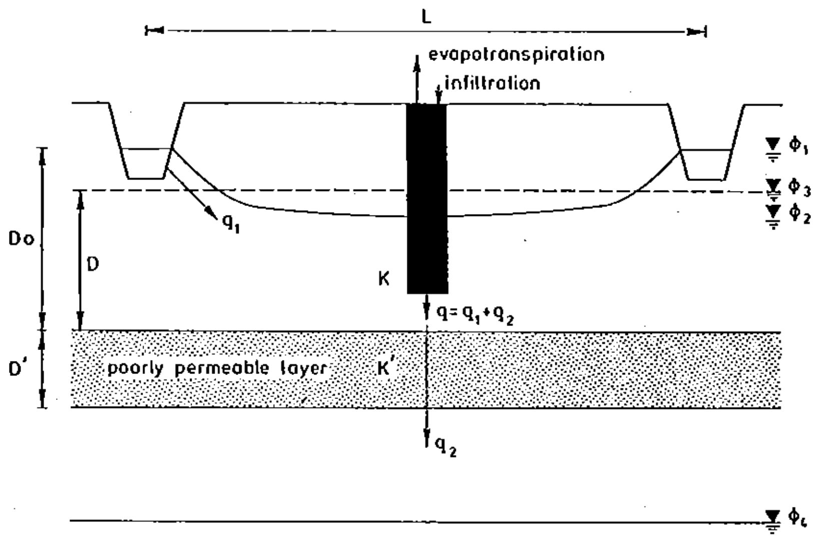


Fig. 8. Schematic representation of the flow situation in between two ditches with sub-irrigation and downward flow to deep aquifers

where L = spacing between ditches (m)

w = radial resistance ($d.m^{-1}$)

k = hydraulic conductivity for horizontal flow in the saturated zone ($m.d^{-1}$)

D = average thickness of the aquifer (m)

For homogeneous soils and small variations in height of freatic surface, the radial resistance w can be found from (ERNST, 1962):

$$w = \frac{1}{\pi k} \ln \frac{D_o}{B_w} \qquad (d.m^{-1}) \qquad (39)$$

where D_o = thickness of the aquifer below the water level in the ditch

B_w = wet perimeter

Note: The ditches are considered to be parallel. The formula also apply to parallel tube drain systems.

The flow to the deep aquifer (seepage) is computed from:

$$q_2 = - \frac{\phi_3 - \phi_4}{c} \qquad (cm.d^{-1}) \qquad (40)$$

where ϕ_3 = level of the freatic surface averaged over the area (cm)

ϕ_4 = piezometric level of the deep groundwater (cm)

c = vertical resistance of the poorly permeable layer (d), being the ratio of layer thickness D' over vertical saturated permeability factor k' (c = D'/k')

The value of ϕ_3 can be obtained from:

$$\phi_3 = \phi_1 + \alpha_{fr}(\phi_2 - \phi_1) \tag{41}$$

where α_{fr} is a reduction coefficient depending on the shape of the freatic surface. If this shape is parabolic then $\alpha_{fr} = 2/3$, sinusoidal then $\alpha_{fr} = 2/\pi = 0.64$ and an elliptic then $\alpha_{fr} = \pi/4 = 0.79$.

The vertical flux per unit area midway between the ditches, q_b, is now taken to pass the bottom of our soil profile system and calculated as:

$$q_b = q_1 + q_2 \tag{42}$$

Case 4: For the high sandy soils in the eastern half of the Netherlands there exists a relationship between groundwater level, ϕ_3, and discharge, q_b. In Fig. 9 (after ERNST and FEDDES, 1979) this relationship is shown for a number of sandy areas in the Netherlands. The general relationship, $q_b(\phi_3)$, can be expressed as:

$$q_b = a\ e^{b|\phi_3|} \tag{43}$$

where a and b are parameters to be determined from Fig. 9, or to be derived from measurements.
The solution for this bottom boundary condition is the same as for case 2 and 3.

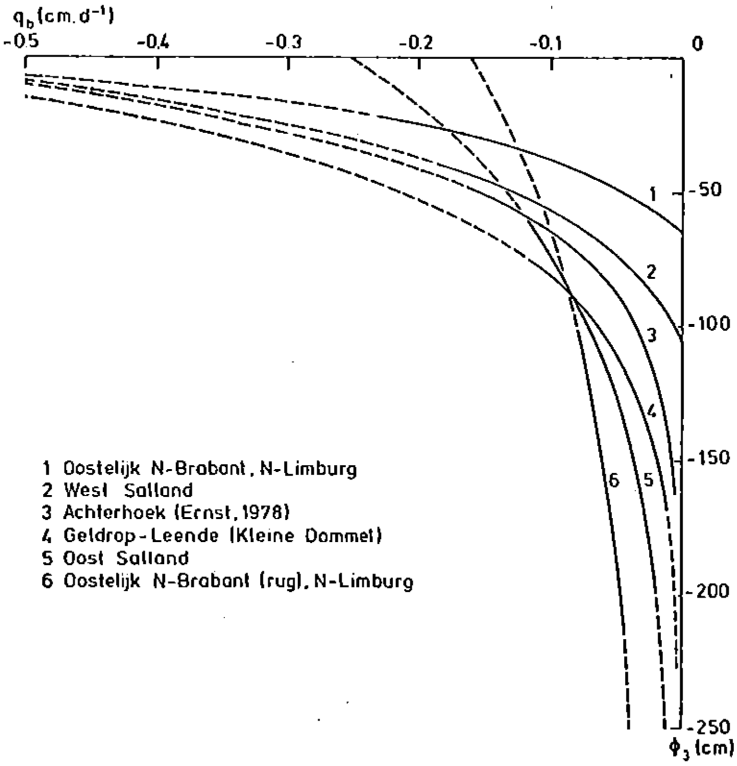


Fig. 9. Discharge rate, q_b, as a function of groundwater level, ϕ_3, for some sandy areas in the Netherlands (adapted from ERNST and FEDDES, 1979)

Case 5: Here the pressure head of the nodal point in the center of the bottom compartment, h_N, is given as a function of time. As the pressure head of nodal point n is known, one has to solve (n-1) equations with (n-1) unknowns.

Case 6: In this case the flux through the bottom of the soil system is taken to be zero. The system has to remain always unsaturated, i.e. no groundwater table can be built up. For the numerical solution, see Case 7.

Case 7: In this case the bottom of the system is allowed to drain fully. The flux is always directed in downward direction. The gradient $\partial H/\partial z = 1$, so the Darcian flux

$$q = -K \qquad (44)$$

where $K = K^i_{j=n}$, i.e. the hydraulic conductivity in the nodal point of the bottom compartment.
The solution for the bottom nodal point j = n is obtained by introducing as boundary condition a flux in eq. (13), i.e.:

$$K^i_{n+\frac{1}{2}} \left[\left(\frac{\Delta h}{\Delta z}\right)^{i+1}_{1\ n+\frac{1}{2}} + 1 \right] \rightarrow q_{bot} \tag{45}$$

For the cases 6 and 7 the coefficients of eq. (19) then become:

$$A_n = 0 \tag{46}$$

$$B_n = 1 + D_n \tag{47}$$

$$D_n = \frac{\Delta t^i}{C^i_n.(\Delta z)^2} K^i_{j-\frac{1}{2}} \tag{48}$$

$$E_n = h^i_n + \frac{\Delta t^i}{C^i_n.\Delta z} K^i_{j-\frac{1}{2}} + \frac{\Delta t^i}{C^i_n.\Delta z} q_{bot} - \frac{\Delta t^i}{C^i_n} S^i_n \tag{49}$$

III.4. Calculation of time step

The time step is taken variable and is explicitly estimated in the following way:

$$\Delta t^i = \frac{\Delta\theta_{max}}{(\Delta\theta/\Delta t)^i_{max}} \tag{50}$$

where $\Delta\theta_{max}$ is to be assigned a specific value, i.e. $\Delta\theta_{max} = 0.001$ $cm^3.cm^{-3}$. This empirically obtained value is based on a number of computed flow cases which were rather different in type of soil and magnitude of fluxes. It is recommended that $0.001 \leqslant \Delta\theta_{max} \leqslant 0.002$. Values below this region result in increasing computing times with a slight improvement of the water balance only. Values above the region result in poor water balances.

The denominator of eq. (50) is obtained from the equation:

$$\left(\frac{\Delta\theta}{\Delta t}\right)^{i}_{max} = \text{Max}_{j=1}^{j=n} \quad S^{i}_{j} + \left|\left(\frac{\Delta q}{\Delta z}\right)^{i}_{j}\right| \qquad (51)$$

where q^{i}_{j} are the fluxes through the boundaries of the various compartments.

The time step Δt^{i} as calculated from eqs (50, 51) is restricted by two additional conditions. First a maximum is prescribed, i.e. Δt_{max} = 0.1d, secondly Δt is taken that small that at least in between two printing plots 5 iterations are performed.

III.5. Calculation of soil physical parameters

The input of the soil physical parameters pressure head, h(θ), and hydraulic conductivity, K(θ), are in the form of tables. The θ-increment in the table is 0.01 $cm^3.cm^{-3}$. In between the tabulated values, both h and K are linearly interpolated.

The differential moisture capacity C(θ) = dθ/dh, is taken as the slope of the h(θ) curve. It is taken to be constant in between the tabulated h(θ) values.

VI. EXECUTION OF SWATRE

VI.1. Summary of main sequential input data

All input data apply to subsequent periods of 24-hour days

- The input data for the geometry of the soil system are the following (see Fig. 10):
  - . depth of soil profile (DSP, cm);
  - . number of compartments of equal size in which the entire soil profile is divided (NCS), maximally 40;
  - . number of different soil layers in which the profile has to be divided (NPL, maximally 5). It is recommended to take compartments of 10 cm depth, say. The choice of the number of compartments has to be such that the boundary between different soil layers corres-

ponds as much as possible with a boundary plane between two compartments. This is because of the concept of compartments of equal size;

. numbers of compartments corresponding to bottom compartment of each separate soil layer (NC(I), I = 1 ... NPL). One has to provide as many NC-values as indicated by NPL. Then if NPL = 2, then NC(1) and NC(2) have to be assigned.

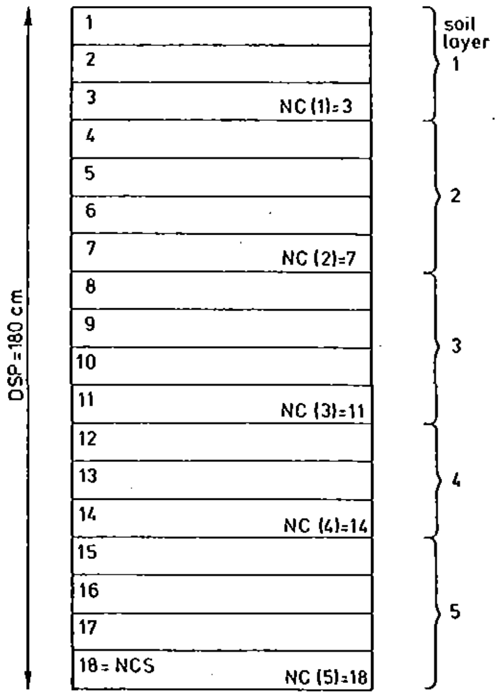


Fig. 10. Example of the way of schematizing the soil into the different soil layers

- The input data for the soil physical characteristics for each separate soil layer are:

  . lowest, LV(I), and highest fraction, MV(I), of soil water content of the h(θ) and K(θ) relationship (to be read later in the program), where I is the index of soil layer;
  . saturated water content (expressed as fraction) of each layer;
  . saturated hydraulic conductivity of upper layer, CS1;
  . factor, FAC, with which conductivities have to be multiplied to arrive for hydraulic conductivity, K, values in units of $cm.d^{-1}$, e.g. if K in $cm.hr^{-1}$, then FAC = 24.

- The input data for the sink term are:
  . choice between two water extraction patterns:
    1) Feddes et al. (1978)
    2) Hoogland et al. (1981)
  . the pressure heads describing the shape of the sink term.

- Time increment for output at selected days (TPR-array).

- Input for the upper boundary condition

  A choice between four approaches can be made:

  . precipitation ($cm.d^{-1}$), potential soil evaporation ($cm.d^{-1}$), potential transpiration ($cm.d^{-1}$), and minimum allowed pressure head (cm) at the soil surface are prescribed;
  . precipitation ($cm.d^{-1}$) is given, potential evapotranspiration ($cm.d^{-1}$) is calculated with eq. (12a); potential soil evaporation (cm) is calculated with eq. (12f);
  . precipitation is given, potential evapotranspiration ($cm.d^{-1}$) is calculated as $f.E_o$ (eq. 12b), potential soil evaporation is calculated with eq. (12f);
  . precipitation ($cm.d^{-1}$) is given, potential evapotranspiration ($cm.d^{-1}$) is calculated with eq. (12e), potential soil evaporation ($cm.d^{-1}$) is calculated with eq. (12f).

- Input data for lower boundary condition

  A choice between 7 conditions can be made:

  . groundwater level (cm) is given;
  . flux ($cm.d^{-1}$) from/to saturated zone is given, the groundwater level (cm) is calculated;
  . flux ($cm.d^{-1}$) from/to saturated zone is calculated as a flux from/to ditches and deep percolation;
  . flux - groundwater level relationship;
  . pressure head of bottom compartment;
  . zero flux;
  . free drainage (unit hydraulic gradient).

- Depth of the root zone (cm)

- Input of soil physical parameters

  For each soil layer:

  . pressure head h (cm) as a table of moisture content θ ($cm^3.cm^{-3}$);
  . hydraulic conductivity K (arbitrary unit) as a table of θ. For both tables the θ-increment is 0.01 $cm^3.cm^{-3}$. Maximally 79 θ-increments can be used.

VI.2. Summary of main sequential output data

In the first part of the output some of the input data are printed:

- boundary condition at the top;
  if evapotranspiration is calculated, daily values of potential soil evaporation and potential transpiration are printed
- boundary condition at the bottom;
- rooting depth;
- initial condition;
- soil physical parameters of each layer.

In the second part variables are printed for initial time (t = TINIT), for selected times [t = TPR(I)] and for the end of the last day (t = TEND). In the list given below all cumulative values are initiated at t = TINIT.

CPREC	: cumulative precipitation
CINTCEP	: cumulative interception
CPINFILT	: cumulative potential infiltration (CPINFILT = CPREC - CINTCEP)
CINFILT	: actual cumulative infiltration
CRUNOFF	: cumulative runoff (CRUNOFF = CPINFILT - CINFILT)
CPETR	: cumulative potential evapotranspiration
CPTRANSP	: cumulative potential transpiration
CPSEVAP	: cumulative potential soil evaporation

CETR : cumulative actual evapotranspiration

CTRANSP : cumulative actual transpiration

CSEVAP : cumulative actual soil evaporation

FLUX1 : water flux through soil surface

CFLXSD : integrated Darcian flux at bottom of compartment ISD; when the groundwater level arises above the bottom of that compartment this flux has no meaning and then in the output 'stars' will appear

CFLXSDP : integrated positive (= upward) Darcian flux at bottom of compartment ISD

CFLXSDN : integrated negative (= downward) Darcian flux at bottom of compartment ISD

FLXSD : actual Darcian flux at bottom of compartment ISD

ISD : number of compartment at which the Darcian flux is integrated

CFLXBU : integrated Darcian flux at the bottom of the unsaturated profile (only in the case of free drainage, otherwise 'stars' will appear)

FLXBU : actual flux of free drainage

CQDEEP : integrated flux through the bottom of the soil profile for those cases where the groundwater level is calculated. For all other boundary conditions at the bottom 'stars' appear

CQDEEPP : positive part of CQDEEP

CQDEEPN : negative part of CQDEEP

QDEEPA : actual flux through the bottom of the soil profile for those cases where the groundwater level is calculated

CDELTA : cumulative net amount of water that passed through the bottom of the soil profile; calculated as the rest term of the soil water balance. If the groundwater level is calculated, 'stars' will appear

CDELTAP : positive part of CDELTA

CDELTAN : negative part of CDELTA

DELTA : actual amount of water that passed during the last time step through the bottom of the soil profile; calculated as the rest term of the soil water balance (see eq. 32; in program this is implemented as: DEL = VOL - VOL1 + CTRA - CTRA1 + FLXS(1) * DT)

VOLINIT : water storage in the entire soil profile at initial time, t = TINIT

VOL : actual water storage in the entire soil profile

GWLA : actual groundwater level

DRZA : actual rooting depth

N : number of first unsaturated nodal point above the groundwater level

Below the values mentioned, a table is printed containing:

COMP.NR. : number of soil compartment with numbering starting from top to bottom

LEVEL : position of nodal point with respect to the soil surface

THETA : volumetric moisture content ($cm^3.cm^{-3}$)

PR.HEAD : soil water pressure head

CONDUC : hydraulic conductivity

ROOT EXT : root extraction rate ($cm^3.cm^{-3}.d^{-1}$), i.e. the actual sink

C.ROOT EXT : cumulative amount of water extracted by the roots

CUM.WATER : water storage in the soil profile summed up from soil surface to bottom of compartment

FLUXES : Darcian flux through the bottom of each compartment

Below the table a print plot is made of soil moisture content (dotted lines), fraction of air (blank) and fraction of solid material (slashes), all as a function of depth.

The third part of the output concerns various terms of the water balance expressed at the end of each day in the period considered.

TIME : end of day

C.INFILT : actual cumulative infiltration

TRANSP : actual transpiration rate

CTRANSP : cumulative actual transpiration

SEVAP	:	actual soil evaporation rate
CSEVAP	:	cumulative soil evaporation
CFLXBOTP	:	cumulative amount of water that flowed through the bottom of the soil profile that flows i n t o the system. If no groundwater level is calculated the value CDELTAP will be printed. If the groundwater level is calculated then the value CQDEEPP will be printed
CFLXBOTN	:	as above but for flows o u t of the system and with CDELTAN or CQDEEPN being printed
VOL-VOLI	:	change in water storage over the entire soil profile with respect to VOL at t = TINIT
GROUNDW.LEV	:	groundwater level with respect to the soil surface

IV.3. Instructions for input

The daily input has been arranged in groups A, B, ..., Z and should be punched on cards in FORTRAN-code according to the instructions. It should be kept in mind that F-formats can also be read as E-formats. All integers are ending in columns which are multiples of 5, and all reals in columns which are multiples of 10. References to equations are to the book of FEDDES et al. (1978).

Columns	Format	Symbol	Description
			GROUP A
1-80	20A4	HED	desired heading to be printed
			group A consists of 1 card
			GROUP B
			Choice of type of initial and boundary conditions, of constant/variable rooting depth and of constant/variable output increments
1- 5	I5	KOD(1)	= 0 : groundwater level is input (cm) = 1 : flux from the saturated zone is input (positive upwards; $cm.d^{-1}$) = 2 : flux towards ditches and deep percolation is calculated (positive upwards; $cm.d^{-1}$) = 3 : flux from the saturated zone is calculated as a function of groundwater level (positive upwards; $cm.d^{-1}$) = 4 : pressure head of bottom compartment is input (cm) = 5 : zero flux at the bottom of an unsaturated profile = 6 : free drainage at the bottom of an unsaturated profile (negative downwards; $cm.d^{-1}$), flux is equal to hydraulic conductivity of bottom compartment
6-10	I5	KOD(2)	= 0 : bottom boundary condition is varying with time = 1 : bottom boundary condition is constant with time If KOD(1) = 3, 5 or 6, KOD(2) may be set to 0
			KOD(3) describes the upper boundary condition
11-15	I5	KOD(3)	= 0 : absolute values of precipitation ($cm.d^{-1}$), soil evaporation ($cm.d^{-1}$), transpiration ($cm.d^{-1}$) and minimum allowed pressure head at the soil surface (cm) is input = 1 : potential evapotranspiration ($cm.d^{-1}$) is calculated with the Priestley and Taylor equation = 2 : potential evapotranspiration ($cm.d^{-1}$) is calculated as E_0 (Penman) x crop coefficient (for Penman eq. see 3.26) = 3 : potential evapotranspiration ($cm.d^{-1}$) is calculated with Monteith-Rijtema equation (eq. 3.33, without the '$+E_i$'-term, because we are considering soil evaporation and transpiration only; for r_s a constant value has to be taken) If KOD(1) = 1, 2 or 3 potential soil evaporation is calculated with eq. 3.31 and minimum allowed pressure head at the soil surface with eq. 4.11
16-20	I5	KOD(4)	= 0 : upper boundary condition is varying with time = 1 : upper boundary condition is constant with time
21-25	I5	KOD(5)	= 0 : moisture content at each nodal point is input ($cm^3.cm^{-3}$) = 1 : pressure head at each nodal point is input (cm) = 2 : pressure head at each nodal point is calculated as being in equilibrium with the initial groundwater table (cm)
26-30	I5	KOD(6)	= 0 : rooting depth is varying with time (cm) = 1 : rooting depth is constant with time (cm)
31-35	I5	KOD(7)	= 0 : time increment between outputs (water balance terms, moisture content profile, etc.) is variable (days) = 1 : time increment between outputs is constant (days)
			group B consists of 1 card
			GROUP C
			Geometry of soil profile
1-10	F10.1	DSP	depth of soil profile (cm)
11-15	I5	NCS	number of soil compartments of equal size (maximally 40)
16-20	I5	NPL	number of different types of soil layers (maximally 5)
21-25	I5	NC(1)	number of bottom compartment of 1st soil layer
26-30	I5	NC(2)	
31-35	I5	NC(3)	
36-40	I5	NC(4)	as above, but for 2nd, 3rd, ..., 5th soil layer
41-45	I5	NC(5)	
46-50	I5	ISD	number of soil compartment at which bottom the Darcian-flux will be integrated over the time. This integral is an approximation only
			group C consists of 1 card

Columns	Format	Symbol	Description
			G R O U P D
			Way of input of soil physical characteristics of each separate soil layer
1-10	F10.2	LV(1)	lowest input value of moisture content ($cm^3.cm^{-3}$) of K(θ) and h(θ) table of 1st soil layer
11-20	F10.2	LV(2)	as above, but for 2nd, 3rd, ..., 5th soil layer
21-30	F10.2	LV(3)	
31-40	F10.2	LV(4)	
41-50	F10.2	LV(5)	
1-10	F10.2	MV(1)	highest input value of moisture content ($cm^3.cm^{-3}$) of K(θ) and h(θ) table of 1st soil layer
11-20	F10.2	MV(2)	as above, but for 2nd, 3rd, ..., 5th soil layer
21-30	F10.2	MV(3)	
31-40	F10.2	MV(4)	
41-50	F10.2	MV(5)	
1-10	F10.2	SWC(1)	saturated moisture content ($cm^3.cm^{-3}$) of 1st soil layer
11-20	F10.2	SWC(2)	as above, but for 2nd, 3rd, ..., 5th soil layer
21-30	F10.2	SWC(3)	
31-40	F10.2	SWC(4)	
41-50	F10.2	SWC(5)	
1-10	E10.3	CS1	saturated hydraulic conductivity of 1st soil layer (must be given in the same units as chosen for the hydraulic conductivities of the groups V-Z)
11-20	E10.3	FAC	factor to convert units of input hydraulic conductivity to units of $cm.d^{-1}$
			group D consists of 4 cards
			G R O U P E
			Description of sink term and root extraction pattern
1- 5	I5	IRER	= 0 : sink term according to eq. (5) and eq. (6) of this paper = 1 : sink term according to eq. (8) and eq. (10) of this paper
11-20	E10.4	ARER	intercept a of eq. (10) of this paper, see Fig. 3
21-30	E10.4	BRER	slope b of eq. (10) of this paper, see Fig. 3
1-10	F10.3	RNAM	maximum depth (cm, absolute value) at top of profile where roots are non-active during the period t > TE
11-20	F10.3	TB	point of time at which roots become non-active (drought damage or morphological reasons)
21-30	F10.3	TE	point of time at which roots reach their maximum depth of non-activity for t ≤ TB : RNA = 0 for TB < t < TE: $RNA = RNAM \frac{t-TB}{t-TE}$ for t ≥ TE : RNA = RNAM where t is time (days) and RNA, the actual depth where roots are non-active
1-10	F10.0	P0	value of pressure head below which roots start to extract water from the soil (starting point)
11-20	F10.0	PU1	value of pressure head below which roots start to extract water optimally from the upper soil layer
21-30	F10.0	PL1	as above, but for the lower soil layers
31-40	F10.0	P2H	value of pressure head below which the roots cannot extract water optimally any-more, for potential transpiration rate equal to 5 $cm.d^{-1}$ (limiting point)
41-50	F10.0	P2L	as above, but for potential transpiration rate equal to 0.1 $cm.d^{-1}$ - the values P2H and P2L are used only if IRER = 0 (see Fig. 11) P2 is calculated from linear interpolation in between P2H and P2L, according to $P2 = P2H + (\frac{0.5-EPA}{0.5-0.1}) \cdot (P2L - P2H)$ for $0.1 \leq EPA \leq 0.5$ P2 = P2L if EPA < 0.1 $cm.d^{-1}$ P2 = P2H if EPA > 0.5 $cm.d^{-1}$ where EPA is potential transpiration rate ($cm.d^{-1}$)

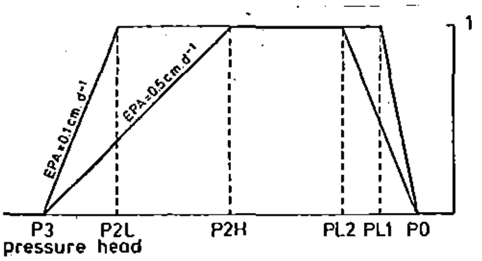


Fig. 11. Shape of sink term used in connection with the water extraction pattern of FEDDES et al. (1977)

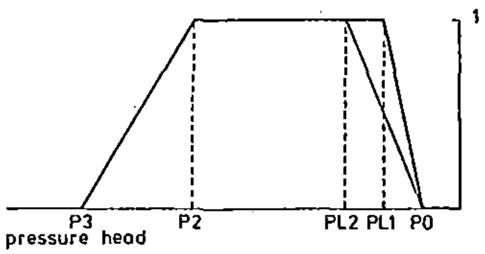


Fig. 12. Shape of sink term used in connection with the water extraction pattern of HOOGLAND et al. (1981)

Columns	Format	Symbol	Description
51-60	F10.0	P2	value of pressure head below which the roots cannot extract water optimally anymore (limiting point); this value is used only if IRER = 1 (see Fig. 12)
61-70	F10.0	P3	value of pressure head below which no water uptake by roots is possible (wilting point)
			group E consists of 3 cards
			G R O U P F
			Describes times of input and coefficients of wind function, leaf area index and interception
1- 5	I5	L(1)	first day of input (reckoned from the beginning of the year)
6-10	I5	L(2)	last day of input (the same)
11-15	I5	L(3)	number of days in February (28 or 29)
16-20	I5	L(4)	first day of input in the first month under consideration (e.g. L(4) = 21)
21-25	I5	L(5)	first month of input (e.g. June - L(5) = 6)
26-30	I5	L(6)	last month of input (e.g. October - L(6) = 10)
31-35	I5	L(7)	= 0 : 6 coefficients of the G(CH)-function must be prescribed in group M = 1 : 6 coefficients of the G(CH)-function are as Fig. 30 (book FEDDES et al., 1978) for the G(CH)-function see eq. (8.3) to (8.5); only used if KOD(3) = 3
36-40	I5	L(8)	= 0 : 6 coefficients of the FIN-function must be prescribed in group M = 1 : 6 coefficients of the FIN-function are as in Fig. 32 (book FEDDES et al., 1978), but transformed to units of $cm.d^{-1}$ for the FIN-function see eq. (8.7) to (8.9); only used if KOD(3) = 3
			group F consists of 1 card
			G R O U P G
			Describes the calculation period and length of time step
1-10	F10.0	TINIT	starting time of calculations (TINIT $\geq$ L(1) - 1); for L-values see group F
11-20	F10.0	TEND	finishing time of calculations (TEND $\leq$ L(2)); for L-values see group F
21-30	F10.3	DTMI	maximum value of time step allowed (d); we advise 0.1 $\leq$ DTMI $\leq$ 0.2
31-40	E10.3	DTHM	maximum change of moisture content allowed within one time step; we advise 0.001 $\leq$ DTHM $\leq$ 0.002
41-50	F10.3	CGWLAM	maximum change of groundwater level (cm) within one time step; we advise 0.1 $\leq$ CGWLAM $\leq$ 0.25 this applies only for cases for which the groundwater level is calculated
			group G consists of 1 card
			G R O U P H
			Describes the number and the increments of output
1-10	I5	NPR	number of outputs (water balance terms, moisture content profile, etc.); standard output at t = TINIT is not included in NPR
1-10	F10.0	TPRINT	only if KOD(7) = 1; TPRINT is a constant time increment (d) for which the output must be printed; output is listed at t = TINIT + i x TPRINT where i = 1 to NPR
1-10	F10.0	TPR(1)	only if KOD(7) = 0; TPR(1) is time increment for 1st output
11-20	F10.0	TPR(2)	
21-30	F10.0	TPR(3)	as above, but for 2nd, 3rd, ..., NPRth output
etc.	F10.0	TPR(NPR)	
			output is listed at time t = TINIT + TPR(1), t = TINIT + TPR(1) + TPR(2), etc.
			group H consists of maximally 7 cards
			G R O U P I
			Group I is used only if KOD(3) = 0. Describes upper boundary condition
1-10	F10.2	PREC(L(1))	precipitation ($cm.d^{-1}$) } for first day of input, L(1)
11-20	F10.3	ES(L(1))	potential soil evaporation rate ($cm.d^{-1}$) } for first day of input, L(1)
21-30	F10.3	EP(L(1))	potential transpiration ($cm.d^{-1}$) } for first day of input, L(1)
31-40	E10.4	PHS(L(1))	minimum allowed pressure head (cm) at the soil surface } for first day of input, L(1) if KOD(4) = 0 : 1 card is required for each day of input L(1) to L(2), or [L(2) - L(1) + 1] cards if KOD(4) = 1 : only one card is required
			group I consists of maximally 366 cards

Columns	Format	Symbol	Description
			G R O U P J
			Group J is used only if KOD(3) = 1. Describes the upper boundary condition. Potential evapotranspiration rate ($cm.d^{-1}$) is calculated with the Priestley and Taylor equation
1-10	F10.3	ALPHA	empirical constant in the Priestley and Taylor equation (ALPHA = 1.35 ± 0.10)
1-10	F10.2	PREC(L(1))	precipitation ($cm.d^{-1}$) } for first day of input, L(1)
11-20	F10.1	HNT(L(1))	flux of net radiation ($W.m^{-2}$) } for first day of input, L(1)
21-30	F10.1	TEM(L(1))	mean daily air temperature (°C) } for first day of input, L(1)
31-40	F10.3	RH(L(1))	mean daily air humidity (fraction) } for first day of input, L(1)
41-50	F10.3	SC(L(1))	soil cover (fraction) } for first day of input, L(1)
			if KOD(4) = 0 : 1 card is required for each day of input, L(1) to L(2), or [L(2) - L(1) + 1] cards if KOD(4) = 1 : only 1 card is required
			group J consists of maximally 367 cards (1 card for the ALPHA value and 366 cards for daily inputs)
			G R O U P K
			Group K is used only if KOD(3) = 2. Describes the upper boundary condition. Potential evapotranspiration rate ($cm.d^{-1}$) is calculated as E_o (Penman, open water) x crop coefficient
1-10	F10.2	PREC(L(1))	precipitation ($cm.d^{-1}$) } for first day of input, L(1)
11-20	F10.1	HSH(L(1))	short-wave radiation flux ($W.m^{-2}$) } for first day of input, L(1)
21-30	F10.3	DCL(L(1))	degree of cloudiness (fraction) } for first day of input, L(1)
31-40	F10.1	TEM(L(1))	mean daily air temperature (°C) } for first day of input, L(1)
41-50	F10.3	RH(L(1))	mean daily air humidity (fraction) } for first day of input, L(1)
51-60	F10.2	U(L(1))	mean daily wind velocity at 2 m height ($m.s^{-1}$) } for first day of input, L(1)
61-70	F10.3	SC(L(1))	soil cover (fraction) } for first day of input, L(1)
71-80	F10.3	CH(L(1))	crop coefficient (fraction) } for first day of input, L(1)
			if KOD(4) = 0 : 1 card is required for each day of input, L(1) to L(2), or [L(2) - L(1) + 1] cards if KOD(4) = 1 : only 1 card is required
			group K consists of maximally 366 cards
			G R O U P L
			Group L is used only if KOD(3) = 3. Describes the upper boundary condition. Potential evapotranspiration rate ($cm.d^{-1}$) is calculated with the Montheith - Rijtema equation
1-10	F10.1	RS	stomatal resistance ($s.m^{-1}$)
1-10	F10.2	PREC(L(1))	precipitation ($cm.d^{-1}$) } for first day of input, L(1)
11-20	F10.1	HNT(L(1))	net radiation flux ($W.m^{-2}$) } for first day of input, L(1)
21-30	F10.1	TEM(L(1))	mean daily air temperature (°C) } for first day of input, L(1)
31-40	F10.3	RH(L(1))	mean daily air humidity (fraction) } for first day of input, L(1)
41-50	F10.2	U(L(1))	mean daily wind velocity at 2 m height ($m.s^{-1}$) } for first day of input, L(1)
51-60	F10.3	SC(L(1))	soil cover (fraction) } for first day of input, L(1)
61-70	F10.0	CH(L(1))	crop height (cm) } for first day of input, L(1)
			if KOD(4) = 0 : 1 card is required for each day of input L(1) to L(2), or [L(2) - L(1) + 1] cards if KOD(4) = 1 : only 1 card is required
			group L consists of maximally 367 cards (1 card for RS-value and 366 cards for daily inputs)
			G R O U P M
			Describes the crop height - wind function, the leaf area index relationship with soil cover and the interception function depending on precipitation. For details see pages 73-75 of FEDDES et al. (1978)
1-10	E10.4	FGA	
11-20	E10.4	FGB	coefficients of G(CH)-function, which is used to estimate potential evapotranspiration flux (see eq. 8.3 to 8.5)
21-30	E10.4	FGC	
31-40	E10.4	FGD	
41-50	E10.4	FGM	use this card only if KOD(3) = 3 and if L(7) = 0
51-60	E10.4	FMCH	(if L(7) = 1, standard values of the coefficients are used, see Fig. 30 of FEDDES et al, 1978)

Columns	Format	Symbol	Description
1-10	E10.4	FLA	coefficients of the leaf area index - soil cover function
11-20	E10.4	FLB	
21-30	E10.4	FLC	use this card only if KOD(3) ≥ 1
1-10	E10.4	FIA	
11-20	E10.4	FIB	coefficients of the FIN-function describing reduction in precipitation rate as
21-30	E10.4	FIC	caused by interception (eq. 8.7 - 8.9)
31-40	E10.4	FID	
41-50	E10.4	FMP	use this card only if KOD(3) = 3
51-60	E10.4	FMI	(if L(8) = 1, standard values of the coefficients are used: FIA = 0.169; FIB = 0.516; FIC = 0.1787; FID = 0.0593; FMP = 2.0; FMI = .19; see also Fig. 42 of book FEDDES et al, 1978)
			group M consists of maximally 3 cards
			G R O U P N
			Group N is used only if KOD(1) = 0. Describes the daily groundwater level. Absolute values may be given as input (soil surface is used as reference level)
1-10	F10.1	GWL(L(1))	groundwater level (cm) for the first day of input, L(1)
11-20	F10.1	GWL(L(1)+1)	as above, but for the 2nd, 3rd, ..., L(2)th day of input
etc.	F10.1	GWL(L(2))	if KOD(2) = 0 : L(2) - L(1) + 1 values must be entered if KOD(2) = 1 : only 1 value, GWL(L(1)), must be entered
			group N consists of maximally 46 cards
			G R O U P O
			Group O is used only if KOD(1) = 1. Describes the initial groundwater level and the daily values of the flux from the saturated zone (positive upwards, $cm.d^{-1}$)
1-10	F10.1	GWLA	initial groundwater level (cm), for t = TINIT
1-10	F10.3	QDEEP(L(1))	flux from the saturated zone for the first day of input, L(1)
11-20	F10.3	QDEEP(L(1)+1)	as above, but for the 2nd, 3rd, ..., L(2)th day of input
etc.	F10.3	QDEEP(L(2))	if KOD(2) = 0 : [L(2)-L(1) + 1] values must be given if KOD(2) = 1 : only 1 value, QDEEP(L(1)), must be given
			group O consists of maximally 47 cards
			G R O U P P
			Group P is used only if KOD(1) = 2. Describes saturated flow to ditches and deep percolation (soil surface is used as the reference level for water tables/levels)
1-10	F10.1	GWLA	initial groundwater level (cm), for t = TINIT
1-10	F10.1	CHND	spacing between channels (m)
11-20	F10.3	CHNR	radial resistance of channel ($d.m^{-1}$)
21-30	F10.3	DKD	transmissivity for horizontal flow ($m^2.d^{-1}$); k x D value of eq. (38) of this paper
31-40	F10.3	ALPHAR	shape factor of groundwater level
41-50	F10.1	DGRWL	deep groundwater level (cm)
51-60	F10.1	SIMPR	vertical resistance of poorly permeable layer (d)
1-10	F10.1	CHNL(L(1))	open water level in the ditch (cm); may be given as absolute value
11-20	F10.1	CHNL(L(1)+1)	as above, but for 2nd, 3rd, ..., L(a)th day of input
etc.	F10.1	CHNL(L(2))	if KOD(2) = 0 : [L(2)-L(1)+1] values must be given if KOD(2) = 1 : only 1 value, CHNL(L(1)), must be given
			group P consists of maximally 48 cards
			G R O U P Q
			Group Q is used only if KOD(1) = 3. Describes the flux - groundwater level relationship
1-10	F10.1	GWLA	initial groundwater level (cm), for t = TINIT
1-10	F10.	AREL	value of a in eq. 43 of this paper; see also Fig. 3
11-20	F10.	BREL	value of b in eq. 43 of this paper; see also Fig. 3
			group Q consists of 2 cards

Columns	Format	Symbol	Description
			G R O U P R
			Group R is used only if KOD(1) = 0. Describes daily values of pressure head of bottom compartment
1-10	E10.4	GPRH(L(1))	pressure head of bottom compartment for 1st day of input, L(1); absolute value may be given
11-20 etc.	E10.4 E10.4	GPRH(L(1)+1) GPRH(L(2))	as above, but for 2nd, 3rd, ..., L(2)th day of input
			if KOD(2) = 0 : [L(2)-L(1)+1] values must be given if KOD(2) = 1 : only 1 value, GPRH(L(1)), must be given
			group R consists of maximally 46 cards
			G R O U P S
			Describes the rooting depth
1-10	F10.1	DRZ(L(1))	rooting depth (cm) for the first day of input, L(1)
11-20 etc.	F10.1 F10.1	DRZ(L(1)+1) DRZ(L(2))	as above, but for 2nd, 3rd, ..., L(2)th day of input
			if KOD(6) = 0 : [L(2)-L(1)+1] values must be given if KOD(6) = 1 : only 1 value, DRZ(L(1)), must be given
			group S consists of maximally 46 cards
			G R O U P T
			Group T is used only if KOD(5) = 0. Describes the initial moisture content profile (t = TINIT)
1-10	F10.3	WC(1)	initial water content ($cm^3.cm^{-3}$) of 1st nodal point (surface compartment)
10-20 etc.	F10.3 F10.3	WC(2) WC(NCS)	as above, but for 2nd, 3rd, ..., NCSth nodal point; numbering is from top to bottom of soil profile
			group T consists of maximally 5 cards
			G R O U P U
			Group U is used only if KOD(5) = 1. Describes the initial pressure head profile (t = TINIT)
1-10	E10.4	PH(1)	initial pressure head (cm) of 1st nodal point (surface compartment); absolute value may be given
10-20 etc.	E10.4 E10.4	PH(2) PH(3)	as above, but for 2nd, 3rd, ..., NCSth nodal point; numbering is from top to bottom of soil profile
			group U consists of maximally 5 cards
			G R O U P V
			Describes the physical characteristics of soil layer 1 (numbering of layers is from top to bottom). Units of hydraulic conductivity can be chosen arbitrarily; see also factor FAC, group D
1-10	E10.4	PRH(1,x)	pressure head (cm) for 1st soil layer at water content θ = LV(1) ($cm^3.cm^{-3}$); absolute values may be given
11-20 etc.	E10.4 E10.4	PRH(1,x) PRH(1,x)	as above, but for pressure heads at θ = LV(1)+0.01, θ = LV(1)+0.02, ..., θ = MV(1)
1-10	E10.4	CON(1,x)	hydraulic conductivity for 1st soil layer at water content θ = LV(1) ($cm^3.cm^{-3}$)
11-20 etc.	E10.4 E10.4	CON(1,x) CON(1,x)	as above, but for hydraulic conductivities at θ = LV(1)+0.01, θ = LV(1)+0.02, ..., θ = MV(1) the x-values have not to be defined
			group V consists of maximally 20 cards (10 for h-values, 10 for K-values)
			G R O U P W
			Group W may be omitted if NPL = 1. Describes the physical characteristics of soil layer 2. Units of hydraulic conductivity as in group V
			as group V, but LV(1), MV(1), PRH(1,x), CON(1,x) become LV(2), MV(2), PRH(2,x), CON(2,x) respectively
			group W consists of maximally 20 cards

Columns	Format	Symbol	Description
			G R O U P X
			Group X may be omitted if NPL ≤ 2. Describes the physical characteristics of soil layer 3. Units of hydraulic conductivity as in group V as group U, but LV(1), MV(1), PRH(1,x), CON(1,x) become LV(3), MV(3), PRH(3,x), CON(3,x) respectively *group X consists of maximally 20 cards*
			G R O U P Y
			Group Y may be omitted if NPL ≤ 3. Describes the physical characteristics of soil layer 4. Units of hydraulic conductivity as in group V as group V, but LV(1), MV(1), PRH(1,x), CON(1,x) become LV(4), MV(4), PRH(4,x), CON(4,x) respectively *group Y consists of maximally 20 cards*
			G R O U P Z
			Group Z may be omitted if NPL ≤ 4. Describes the physical characteristics of soil layer 5. Units of hydraulic conductivity as in group V as group V, but LV(1), MV(1), PRH(1,x), CON(1,x) become LV(5), MV(5), PRH(5,x), CON(5,x) respectively *group Z consists of maximally 20 cards*

IV.4. Example of partial input

As an example of input we selected a loamy sand with an arable top layer of 20 cm that overlies a loamy fine sand down to 200 cm. Calculations were performed over the period of 15 April to 11 September of the relatively dry year 1976.

As boundary conditions for the top of the system actual rainfall intensities, potential soil evaporation and transpiration rates were introduced. The latter values were calculated as 0.8 x E_o (Penman).

As bottom boundary condition a q_b (ϕ_3) relationship of the type shown in eq. (43) was used. In the beginning the groundwater table was set at 35 cm below soil surface. The initial moisture profile above the groundwater table was taken to be in equilibrium with it.

As an example we present below a partial list of the input data, i.e. for the period 15 to 25 April 1976. Note that in this period precipitation rate, potential soil evaporation rate and minimum allowed pressure head at the soil surface are all set equal to zero. The rooting depth is taken to be constant during this time, i.e. 35 cm.

For the same restricted period of input, also as an example a listing of output data of the program is given. For this output see under Section IV.5.

The program was run for the entire period of 15 April to 11 September. The main results are presented in the Figs. 13A and 13B. In Fig. 13A cumulative values of calculated actual transpiration and measured precipitation are shown. In Fig. 13B the cumulative discharge pattern is shown together with the variation of the groundwater table with time. Note that during the first 25 days, say, the groundwater table decreases fast, with a less pronounced drawdown during the remainder of the period.

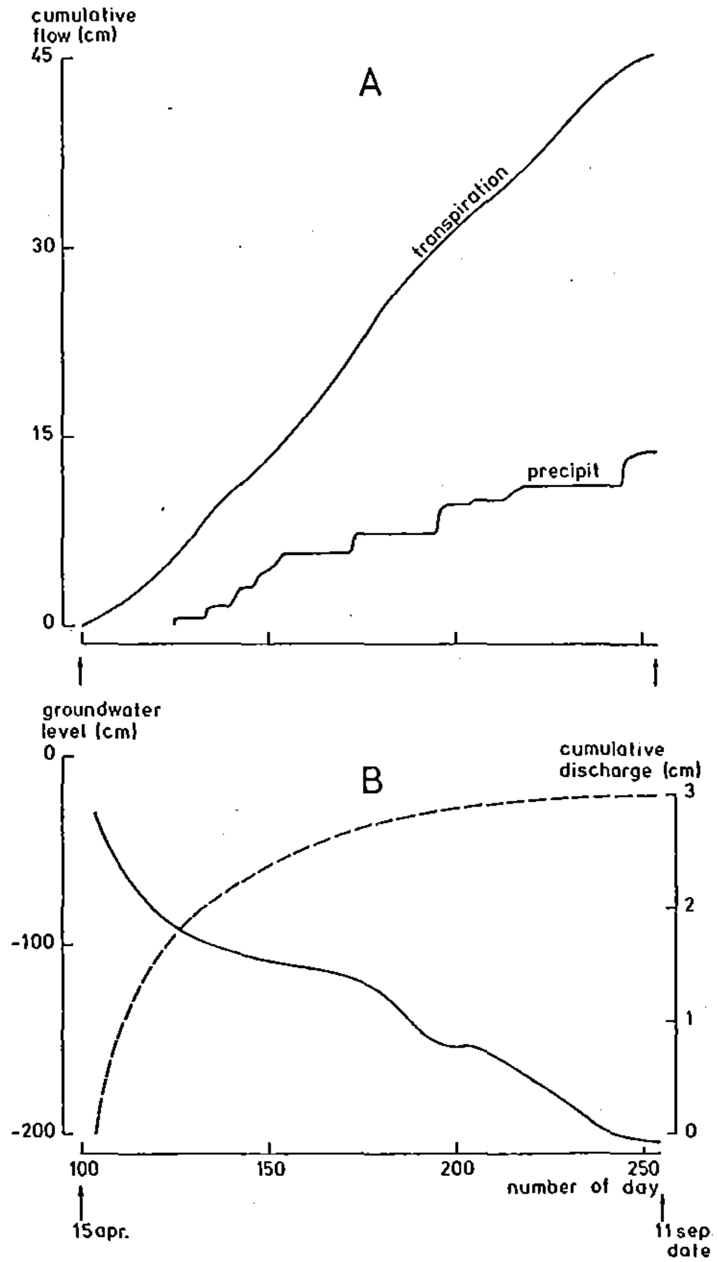


Fig. 13A. Cumulative values of calculated actual transpiration and measured precipitation during the period 15/4-11/9, 1976 for a loamy sand soil overlying a loamy fine sand

13B. Cumulative values of discharge and groundwater table depth, as calculated with SWATRE for the period indicated above

Example of partial input

```
* L O A M Y   S A N D * P E R I O D : 15 TO 25 APRIL 1976 *
     3     0      0     0     2     1     1
       200.     20      2     2    20    20    20    20     2
       0.05        0.05
       0.45        0.36
       0.45        0.36
       50.0          1.
     1             0.02          0.0
        0.0        365.         366.
       -10.        -25.         -25.      -300.0      -600.0      -500.0  -16000.0
   105  114     29   15     4     4     1     1
       104.        114.          .20       0.002         .20
     1
        10.
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     0.000       0.000          .248       0.000
     -35.0
      -0.8      -0.035
      35.0
    1.00E5      5.00E4      2.50E4      1.60E4      1.00E4      7.40E3      5.00E3      4.20E3
    3.20E3      2.50E3      2.00E3      1.60E3      1.30E3      1.00E3      7.90E2      6.30E2
    5.00E2      4.00E2      3.20E2      2.50E2      2.00E2      1.80E2      1.60E2      1.50E2
    1.30E2      1.25E2      1.20E2      1.15E2      1.10E2      1.00E2      9.80E1      8.90E1
    7.90E1      6.60E1      6.00E1      5.00E1      4.20E1      3.10E1      2.00E1      1.00E1
    0.00E0
    7.0E-6      1.2E-5      2.0E-5      3.0E-5      4.0E-5      6.0E-5      1.0E-4      1.5E-4
    2.1E-4      3.6E-4      6.0E-4      9.5E-4      1.6E-3      2.7E-3      4.6E-3      8.0E-3
    1.5E-2      2.8E-2      5.0E-2      8.2E-2      1.4E-1      2.3E-1      3.8E-1      5.55-1
    9.0E-1      1.2E00      1.9E00      2.5E00      3.5E00      5.0E00      6.5E00      8.0E00
    1.0E01      1.2E01      1.7E01      2.0E01      2.5E01      3.0E01      3.7E01      4.4E01
    5.2E01
    1.66E3      1.32E3      9.77E2      7.41E2      5.75E2      5.01E2      3.63E2      3.09E2
    2.29E2      1.95E2      1.62E2      1.41E2      1.32E2      1.05E2      9.33E1      8.13E1
    7.08E1      6.17E1      5.25E1      4.79E1      4.17E1      3.80E1      3.55E1      3.16E1
    2.82E1      2.51E1      2.00E1      1.41E1      1.00E1      5.01E0      2.19E0      0.00E0
    7.2E-5      9.9E-5      1.5E-4      2.2E-4      3.2E-4      3.9E-4      6.1E-4      7.7E-4
    1.1E-3      1.4E-3      1.9E-3      2.3E-3      5.1E-3      9.3E-3      2.5E-2      6.9E-2
    1.7E-1      3.6E-1      8.1E-1      1.1E00      2.0E00      2.7E00      3.4E00      4.7E00
    6.3E00      8.2E00      1.2E01      2.1E01      2.9E01      4.5E01      5.8E01      7.0E01
```

IV.5. Example of partial output

```
* L O A M Y  S A N D * P E R I O D : 15 TO 25 APRIL 1976 *


I N P U T    V A R I A B L E S :
- - - - -    - - - - - - - - -


KOD(1)=3  KOD(2)=0  KOD(3)=0   KOD(4)=0  KOD(5)=2  KOD(6)=1  KOD(7)=1

DEPTH OF SOIL PROFILE  :   200.0 CM
NUMBER OF COMPARTMENTS : 20
NUMBER OF SOIL LAYERS  :  2
NC - ARRAY :     2   20   20   20   20
DARCIAN FLUX INTEGRATED AT BOTTOM OF COMPARTMENT NR :  2

LV - ARRAY  :  .050  .050 0.000 0.000 0.000
MV - ARRAY  :  .450  .360 0.000 0.000 0.000
SWC - ARRAY :  .450  .360 0.000 0.000 0.000

SATURATED HYDRAULIC CONDUCTIVITY OF FIRST SOIL LAYER :  .500E+02
FAC :  .100E+01



S I N K  T E R M  V A R I A B L E S

    IRER      ARER      BRER
     1      .200E-01 0.

    RNAM       TB        TE
     0.0      365.      366.

     PO        PU1       PL1       P2H       P2L       P2        P3
    -10.      -25.      -25.      -300.     -600.     -500.    -16000.



L - ARRAY :  105  114   29   15    4    4    1    1


START OF CALCULATIONS : 104. DAYS
END OF CALCULATIONS   : 114. DAYS
MAXIMUM TIME STEP     :  .200E+00 DAYS
MAXIMUM CHANGE OF MOISTURE CONTENT   :  .200E-02 CM**3/CM**3
MAXIMUM CHANGE OF GROUNDWATER LEVEL  :  .200E+00 CM

NUMBER OF PRINTPLOTS :     1
PRINTING INTERVAL    :  10. DAYS


BOUNDARY CONDITIONS AT THE TOP :
-------- ---------- -- --- ---
```

DAY	PREC	ESOIL	EPLANT	PHS
105	0.00	0.00	.25	0.0
106	0.00	0.00	.25	0.0
107	0.00	0.00	.25	0.0
108	0.00	0.00	.25	0.0
109	0.00	0.00	.25	0.0
110	0.00	0.00	.25	0.0
111	0.00	0.00	.25	0.0
112	0.00	0.00	.25	0.0
113	0.00	0.00	.25	0.0
114	0.00	0.00	.25	0.0

```
BOUNDARY CONDITION AT BOTTOM OF SOIL PROFILE :
-------- --------- -- ------ -- ---- -------


FLUX-GROUNDWATER LEVEL RELATIONSHIP

FLUX = -.800E+00 * EXP( -.350E-01 * ABS(GROUNDWATER LEVEL))   (CM/DAY)
IN PROGRAM : QDEEPA = AREL * EXP(BREL * ABS(GWLA))



THE ROOTING DEPTH IS CONSTANT = -35.0 CM
--- ------- ----- -- --------



INITIAL CONDITION :
------- ---------

+++++ PRESSURE HEAD PROFILE IS CALCULATED(EQUILIBRIUM WITH GROUNDWATER LEVEL) +++++

   -.3000E+02     -.2000E+02     -.7500E+01     0.             0.
   0.             0.             0.             0.             0.
   0.             0.             0.             0.             0.
   0.             0.             0.             0.             0.



SOIL PHYSICAL PARAMETERS OF PROFILE LAYER NUMBER :    1
```

THETA	PR.HEAD	CONDUCTIV.	THETA	PR.HEAD	CONDUCTIV.
0.000	-.1000E+06	.7000E-05	.010	-.5000E+05	.1200E-04
.020	-.2500E+05	.2000E-04	.030	-.1600E+05	.3000E-04
.040	-.1000E+05	.4000E-04	.050	-.7400E+04	.6000E-04
.060	-.5000E+04	.1000E-03	.070	-.4200E+04	.1500E-03
.080	-.3200E+04	.2100E-03	.090	-.2500E+04	.3600E-03
.100	-.2000E+04	.6000E-03	.110	-.1600E+04	.9500E-03
.120	-.1300E+04	.1600E-02	.130	-.1000E+04	.2700E-02
.140	-.7900E+03	.4600E-02	.150	-.6300E+03	.8000E-02
.160	-.5000E+03	.1500E-01	.170	-.4000E+03	.2800E-01
.180	-.3200E+03	.5000E-01	.190	-.2500E+03	.8200E-01
.200	-.2000E+03	.1400E+00	.210	-.1800E+03	.2300E+00
.220	-.1600E+03	.3800E+00	.230	-.1500E+03	.5550E+00
.240	-.1300E+03	.9000E+00	.250	-.1250E+03	.1200E+01
.260	-.1200E+03	.1900E+01	.270	-.1150E+03	.2500E+01
.280	-.1100E+03	.3500E+01	.290	-.1000E+03	.5000E+01
.300	-.9800E+02	.6500E+01	.310	-.8900E+02	.8000E+01
.320	-.7900E+02	.1000E+02	.330	-.6600E+02	.1200E+02
.340	-.6000E+02	.1700E+02	.350	-.5000E+02	.2000E+02
.360	-.4200E+02	.2500E+02	.370	-.3100E+02	.3000E+02
.380	-.2000E+02	.3700E+02	.390	-.1000E+02	.4400E+02
.400	0.	.5200E+02	.410	0.	0.

SOIL PHYSICAL PARAMETERS OF PROFILE LAYER NUMBER : 2

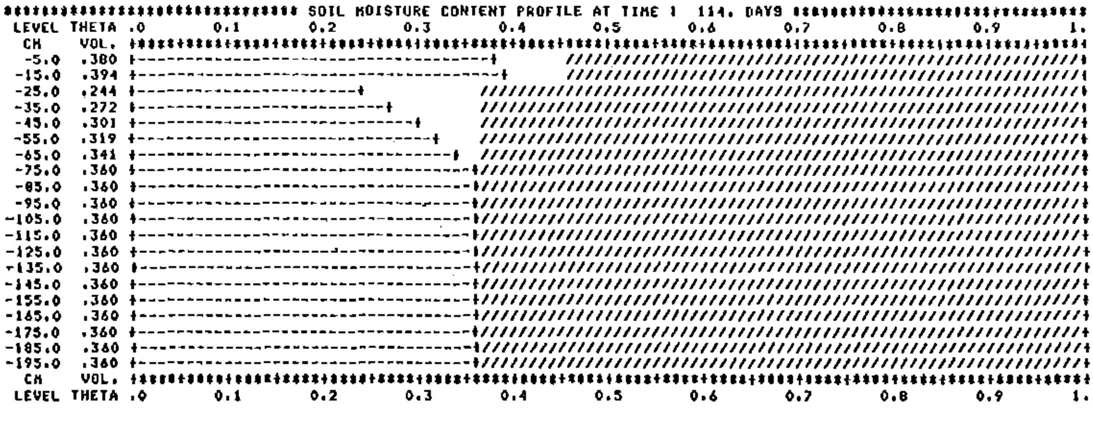
THETA	PR.HEAD	CONDUCTIV.	THETA	PR.HEAD	CONDUCTIV.
0.000	-.1660E+04	.7200E-04	.010	-.1320E+04	.9900E-04
.020	-.9770E+03	.1500E-03	.030	-.7410E+03	.2200E-03
.040	-.5750E+03	.3200E-03	.050	-.5010E+03	.3900E-03
.060	-.3630E+03	.6100E-03	.070	-.3090E+03	.7700E-03
.080	-.2290E+03	.1100E-02	.090	-.1950E+03	.1400E-02
.100	-.1620E+03	.1900E-02	.110	-.1410E+03	.2300E-02
.120	-.1320E+03	.5100E-02	.130	-.1050E+03	.9300E-02
.140	-.9330E+02	.2500E-01	.150	-.8130E+02	.6900E-01
.160	-.7080E+02	.1700E+00	.170	-.6170E+02	.3600E+00
.180	-.5250E+02	.8100E+00	.190	-.4790E+02	.1100E+01
.200	-.4170E+02	.2000E+01	.210	-.3800E+02	.2700E+01
.220	-.3550E+02	.3400E+01	.230	-.3160E+02	.4700E+01
.240	-.2820E+02	.6300E+01	.250	-.2510E+02	.8200E+01
.260	-.2000E+02	.1200E+02	.270	-.1410E+02	.2100E+02
.280	-.1000E+02	.2900E+02	.290	-.5010E+01	.4500E+02
.300	-.2190E+01	.5800E+02	.310	0.	.7000E+02

TIME : 114. DAYS   TIME STEP= .556E-01 DAY   NUMBER OF TIME STEP= 199

```
CPREC   =  0.000 CM    CINTCEP =  0.000 CM    CPINFILT=  0.000 CM    CINFILT =     0.000 CM
CPETR   =  2.480 CM    CPTRANSP=  2.480 CM    CPSEVAP =  0.000 CM    CRUNOFF =     0.000 CM
CETR    =  2.480 CM   *CTRANSP =  2.480 CM*  *CSEVAP  =  0.000 CM*   FLUX1   =  0.000000 CM/DAY
CFLXSD  =  1.400 CM    CFLXSDP =  1.463 CM    CFLXSDN =  -.063 CM    FLXSD   =   .190845 CM/DAY    ISD=  2
CFLXBU  =******* CM                                                  FLXBU   =********** CM/DAY
CQDEEP  = -1.206 CM    CQDEEPP =  0.000 CM    CQDEEPN = -1.206 CM    QDEEPA  =  -.076678 CM/DAY
CDELTA  =******* CM    CDELTAP =******* CM    CDELTAN =******* CM    DELTA   =   .668E-02 CM
VOLINIT = 72.934 CM    VOL     = 69.326 CM    GWLA    =  -69.4 CM    DRZA    =     -35.0 CM        N  =  7
```

COMP. NR	LEVEL (CM)	THETA (VOL)	PR.HEAD (CM)	CONDUC (CM/DAY)	ROOT EXT (1/DAY)	C.ROOT EXT (CM)	CUM.WATER (CM)	FLUXES (CM/DAY)	COMP. NR
1	-5.0	.380	-.640E+02	.120E+02	.200E-01	.200E+01	3.800	.164E+00	1
2	-15.0	.394	-.559E+02	.182E+02	.480E-02	.480E+00	7.741	.191E+00	2
3	-25.0	.244	-.455E+02	.145E+01	.222E-16	.216E-14	10.180	.162E+00	3
4	-35.0	.272	-.348E+02	.363E+01	0.	0.	12.898	.142E+00	4
5	-45.0	.301	-.245E+02	.861E+01	0.	0.	15.909	.135E+00	5
6	-55.0	.319	-.144E+02	.205E+02	0.	0.	19.103	.134E+00	6
7	-65.0	.341	-.470E+01	.464E+02	0.	0.	22.514	.134E+00	7
8	-75.0	.360	0.	.700E+02	0.	0.	26.114	-.767E-01	8
9	-85.0	.360	0.	.700E+02	0.	0.	29.714	-.767E-01	9
10	-95.0	.360	0.	.700E+02	0.	0.	33.314	-.767E-01	10
11	-105.0	.360	0.	.700E+02	0.	0.	36.914	-.767E-01	11
12	-115.0	.360	0.	.700E+02	0.	0.	40.514	-.767E-01	12
13	-125.0	.360	0.	.700E+02	0.	0.	44.114	-.767E-01	13
14	-135.0	.360	0.	.700E+02	0.	0.	47.714	-.767E-01	14
15	-145.0	.360	0.	.700E+02	0.	0.	51.314	-.767E-01	15
16	-155.0	.360	0.	.700E+02	0.	0.	54.914	-.767E-01	16
17	-165.0	.360	0.	.700E+02	0.	0.	58.514	-.767E-01	17
18	-175.0	.360	0.	.700E+02	0.	0.	62.114	-.767E-01	18
19	-185.0	.360	0.	.700E+02	0.	0.	65.714	-.767E-01	19
20	-195.0	.360	0.	.700E+02	0.	0.	69.314	-.767E-01	20

SOIL MOISTURE CONTENT PROFILE AT TIME : 114. DAYS



```
TIME I  104. DAYS                                          TIME STEP=  .100E-09 DAY     NUMBER OF TIME STEP=   1

CPREC   =  0.000 CM       CINTCEP =  0.000 CM       CPINFILT=  0.000 CM       CINFILT =      0.000 CM
CPETR   =   .000 CM       CPTRANSP=   .000 CM       CPSEVAP =  0.000 CM       CRUNOFF =      0.000 CM
CETR    =   .000 CM      *CTRANSP =   .000 CM*     *CSEVAP  =  0.000 CM*      FLUX1   =  0.000000 CM/DAY
CFLXSD  =   .000 CM       CFLXSDP =   .000 CM       CFLXSDN =  0.000 CM       FLXSD   =   .000000 CM/DAY       TSD=  2
CFLXBU  =******* CM                                                           FLXBU   =********** CM/DAY
CQDEEP  =  -.000 CM       CQDEEPP =  0.000 CM       CQDEEPN =  -.000 CM       QDEEPA  =  -.235006 CM/DAY
CDELTA  =******* CM       CDELTAP =******* CM       CDELTAN =******* CM       DELTA   =  .244E-12 CM
VOLINIT = 72.934 CM       VOL     = 72.934 CM       GWLA    =  -35.0 CM       DRZA    =     -35.0 CM            N  =  3

COMP. NR   LEVEL   THETA    PR.HEAD     CONDUC     ROOT EXT  C.ROOT EXT  CUM.WATER         FLUXES          COMP. NR
           (CM)    (VOL)     (CM)      (CM/DAY)    (1/DAY)     (CM)       (CM)           (CM/DAY)

     1     -5.0    .421   -.300E+02   .306E+02   .200E-01   .200E-10     4.209          .563E-08            1
     2    -15.0    .430   -.200E+02   .370E+02   .480E-02   .400E-11     8.509          .156E-08            2
     3    -25.0    .335   -.750E+01   .370E+02  0.          0.           11.859          .156E-08            3
     4    -35.0    .360   0.          .700E+02  0.          0.           15.459         -.235E+00            4
     5    -45.0    .360   0.          .700E+02  0.          0.           19.059         -.235E+00            5
     6    -55.0    .360   0.          .700E+02  0.          0.           22.659         -.235E+00            6
     7    -65.0    .360   0.          .700E+02  0.          0.           26.259         -.235E+00            7
     8    -75.0    .360   0.          .700E+02  0.          0.           29.859         -.235E+00            8
     9    -85.0    .360   0.          .700E+02  0.          0.           33.459         -.235E+00            9
    10    -95.0    .360   0.          .700E+02  0.          0.           37.059         -.235E+00           10
    11   -105.0    .360   0.          .700E+02  0.          0.           40.659         -.235E+00           11
    12   -115.0    .360   0.          .700E+02  0.          0.           44.259         -.235E+00           12
    13   -125.0    .360   0.          .700E+02  0.          0.           47.859         -.235E+00           13
    14   -135.0    .360   0.          .700E+02  0.          0.           51.459         -.235E+00           14
    15   -145.0    .360   0.          .700E+02  0.          0.           55.059         -.235E+00           15
    16   -155.0    .360   0.          .700E+02  0.          0.           58.659         -.235E+00           16
    17   -165.0    .360   0.          .700E+02  0.          0.           62.259         -.235E+00           17
    18   -175.0    .360   0.          .700E+02  0.          0.           65.859         -.235E+00           18
    19   -185.0    .360   0.          .700E+02  0.          0.           69.459         -.235E+00           19
    20   -195.0    .360   0.          .700E+02  0.          0.           73.059         -.235E+00           20

******************************** SOIL MOISTURE CONTENT PROFILE AT TIME I  104. DAYS ********************************
 LEVEL THETA .0        0.1       0.2       0.3       0.4       0.5       0.6       0.7       0.8       0.9       1.
   CM   VOL. +****************************************************************************************************+
  -5.0  .421 +-----------------------------------------+ /////////////////////////////////////////////////////////+
 -15.0  .430 +------------------------------------------+ ////////////////////////////////////////////////////////+
 -25.0  .335 +--------------------------------+ /////////////////////////////////////////////////////////////////+
 -35.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
 -45.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
 -55.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
 -65.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
 -75.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
 -85.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
 -95.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-105.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-115.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-125.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-135.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-145.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-155.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-165.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-175.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-185.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
-195.0  .360 +-----------------------------------+////////////////////////////////////////////////////////////////+
   CM   VOL. +****************************************************************************************************+
 LEVEL THETA .0        0.1       0.2       0.3       0.4       0.5       0.6       0.7       0.8       0.9       1.
```

******** TERMS OF THE WATER BALANCE ********

TIME	CINFILT CM	TRANSP CM/DAY	CTRANSP CM	SEVAP CM/DAY	CSEVAP CM	CFLXBOTP CM	CFLXBOTN CM	VOL-VOLI CM	GROUNDW.LEV CM	TIME
105	0.00	.25	.25	0.00	0.00	0.00	-.21	-.39	-40.8	105
106	0.00	.25	.50	0.00	0.00	0.00	-.39	-.83	-46.8	106
107	0.00	.25	.74	0.00	0.00	0.00	-.53	-1.20	-50.6	107
108	0.00	.25	.99	0.00	0.00	0.00	-.66	-1.61	-54.6	108
109	0.00	.25	1.24	0.00	0.00	0.00	-.77	-1.93	-57.4	109
110	0.00	.25	1.49	0.00	0.00	0.00	-.87	-2.32	-61.2	110
111	0.00	.25	1.74	0.00	0.00	0.00	-.97	-2.61	-62.4	111
112	0.00	.25	1.98	0.00	0.00	0.00	-1.05	-3.01	-65.6	112
113	0.00	.25	2.23	0.00	0.00	0.00	-1.13	-3.26	-67.0	113
114	0.00	.25	2.48	0.00	0.00	0.00	-1.21	-3.61	-69.4	114

```
      PROGRAM SWATRE(DATA,OUTPUT,Z,TAPE5=DATA,TAPE6=OUTPUT,TAPE7=Z)
C
C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       *                                                           *
C       *  SIMULATION MODEL OF THE WATER BALANCE OF A CROPPED SOIL  *
C       *     PROVIDING DIFFERENT TYPES OF BOUNDARY CONDITIONS      *
C       *               ( S   W   A   T   R   E )                   *
C       *                                                           *
C       *                 ...................                       *
C       *                 . ICW NOTA NR 1257 .                      *
C       *                 ...................                       *
C       *                                                           *
C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     *                                                               *
C     *  T H I S   P R O G R A M   I S   D E V E L O P E D   A T   T H E !*
C     *                                                               *
C     *     ..................................................        *
C     *     . INSTITUTE FOR LAND AND WATER MANAGEMENT RESEARCH .      *
C     *     ..................................................        *
C     *                                                               *
C     *  BY !  C. BELMANS(1), J.G. WESSELING(2) AND R.A. FEDDES(2)    *
C     *                                                               *
C     *    (1) SOIL SURVEY INSTITUTE; P.O.BOX 98; 6700 AA WAGENINGEN; *
C     *    (2) INSTITUTE FOR LAND AND WATER MANAGEMENT RESEARCH;      *
C     *             P.O. BOX 35; 6700 AA WAGENINGEN; THE NETHERLANDS  *
C     *                                                               *
C     * S W A T R E IS A MODIFIED AND EXTENDED VERSION OF  S W A T R  *
C     * AS DEVELOPED BY ! R.A. FEDDES, P.J. KOWALIK AND H. ZARADNY !  *
C     *     'SIMULATION OF FIELD WATER USE AND CROP YIELD'            *
C     * SIMULATION MONOGRAPH 1978 PUDOC WAGENINGEN,ISBN 90-220-0676-X *
C     *                                                               *
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C
C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       *         V E R S I O N   M A R C H   1 9 8 1               *
C       * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C
C
C*********************************************************************
C
C
C              *** THE FOLLOWING VALUES MUST BE PRESCRIBED ! ***
C
C    -INITIAL CONDITIONS !
C     ------- ----------
C                      -A) VALUES OF MOISTURE CONTENT          [KOD(5)=0]
C                   OR -B) VALUES OF PRESSURE HEAD             [KOD(5)=1]
C
C
C    -BOUNDARY CONDITIONS (DAILY VALUES)!
C     -------- ---------- --------------
C  -AT THE BOTTOM    -A) GROUNDWATER LEVEL                     [KOD(1)=0]
C                    -B) FLUX FROM  SATURATED ZONE             [KOD(1)=1]
C                    -C) FLUX TOWARDS DITCHES AND DEEP PERCOLATION
C                                                              [KOD(1)=2]
C                    -D) FLUX-GROUNDWATER LEVEL RELATIONSHIP   [KOD(1)=3]
C                    -E) PRESSURE HEAD OF BOTTOM COMPARTMENT   [KOD(1)=4]
C                    -F) ZERO FLUX (UNSATURATED SOIL PROFILE)  [KOD(1)=5]
C                    -G) FREE DRAINAGE                         [KOD(1)=6]
C
C  -AT THE SURFACE   -A) KOD(3)=0 ! PRESCRIBED VALUES OF !
C                        PREC ! PRECIPITATION (CM/DAY)
C                        ES   ! POTENTIAL SOIL EVAPORATION (CM/DAY)
C                        EP   ! POTENTIAL TRANSPIRATION (CM/DAY)
C                        PHS  ! MINIMUM ALLOWED  PRESSURE HEAD AT
C                               THE SOIL SURFACE (CM)
C
C                    -B) KOD(3)=1 !  PRIESTLEY AND TAYLOR FORMULA
C                        INPUT ! PREC,HNT,TEM,RH,SC (SEE UNDER -D)
C
```

```
C                    -C) KOD(3)=2 ! PENMAN(OPEN WATER)*CROP COEFFICIENT
C                        INPUT ! HSH ! SHORT WAVE RADIATION (W/M**2)
C                                DCL ! DEGREE OF CLOUDINESS (FRACTION)
C                                PREC,TEM,RH,SC ( SEE UNDER -D) )
C
C                    -D) KOD(3)=3 ! MONTEITH-RYTEMA FORMULA
C                        PREC   ! PRECIPITATION(CM/DAY)
C                        RH     ! RELATIVE HUMIDITY OF AIR(FRACTION)
C                        U      ! WIND VELOCITY AT 2 M HEIGHT(M/S)
C                        HNT    ! NET RADIATION FLUX (W/M**2)
C                        CH     ! CROP HEIGHT(CM)
C                        SC     ! SOIL COVER(FRACTION)
C                        TEM    ! TEMPERATURE OF AIR(DEGREES CELSIUS)
C
C    -DEPTH OF ROOT ZONE(CM)
C     ----- -- ---- -------
C
C********************************************************************
C      MAXIMALLY CAN BE USED!
C      366 VALUES OF THE BOUNDARY CONDITION
C      80  VALUES OF PRESSURE HEAD AND CONDUCTIVITY(FOR EVERY LAYER)
C      40  NODAL POINTS OF THE SOIL PROFILE
C      52  OUTPUTS
C********************************************************************
C
      DIMENSION PH(40),WC(40),R1(40),R2(40),TEM(366),RH(366),U(366),
     $GWL(366),DCL(366),FIN(366),SC(366),QDEEP(366),GPRH(366),HSH(366)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
      EQUIVALENCE (TEM,EP),(RH,ES),(U,DRZ),(HNT,HSH,GWL,QDEEP,GPRH),
     $(CH,FIN),(SC,PHS),(DCL,ESR)
      DATA IWT,ITS,NTS,NPRA/4*0/,PH/40*0./,WC/40*0./
C
C
C
C
C
C********************************************************************
C**********    M  A  I  N     P  R  O  G  R  A  M    ******************
C********************************************************************
C
C
C
C
C
C*READING OF INPUT AND INITIAL CALCULATIONS*
      CALL RDATA(PH,WC)
      IF(KOD(1).GT.0.AND.KOD(1).LT.4) IWT=1
      IPRT=1
      T=TINIT
C
C
C
C******************************** 'S T A R T   O F   T I M E   S T E P' ***
C
9999  T=T+DT
      NTS=NTS+1
C
C*UPDATING OF PRESSURE HEADS*
      CALL PRHEAD(PH)
C
C*CALCULATION OF CUMULATIVE VALUES*
      CALL INTGRL(PH)
C
C*READING OF BOUNDARY CONDITIONS*
      CALL BOCO(T,PH)
```

```
C
C*CALCULATION OF WATER CONTENT AND WATER STORAGE*
      CALL WACO(WC,PH)
      DEL=VOL-VOL1+CTRA-CTRA1+FLXS(1)*DT
      IF(DEL.GT.0.) CDELP=CDELP+DEL
      CDEL=CDEL+DEL
C
C*CALCULATION OF GROUNDWATER LEVEL*
C    *ONLY IF KOD(1)=1,KOD(1)=2 OR KOD(1)=3*
      IF(IWT.EQ.1) CALL CALGWL(PH,WC)
C
C*CALCULATION OF DIF. MOIST. CAPACITIES AND HYDR. CONDUCTIVITIES*
      CALL DMCCON(WC)
C
C*CALCULATION OF FLUXES IN BETWEEN THE NODAL POINTS*
      CALL FLUXES(PH)
C
C*CALCULATION OF ROOT EXTRACTION RATES*
      CALL RER(T,PH)
C
C*OUTPUT*
      IF(IPRT.EQ.1.OR.ITS.EQ.1) CALL PRTPLT(T,WC,PH,ITS,NTS,NPRA)
C
C*CALCULATION OF NEXT TIME STEP (DT)*
      CALL CALCDT(T,ITS)
C
C******************  GO TO    'S T A R T   O F   T I M E   S T E P' ***
      GO TO 9999
C
C
      END
C
C
C
C
C
C
C*********************************************************************
C*************   S   U   B   R   O   U   T   I   N   E   S   *****************
C*********************************************************************
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE RDATA(PH,WC)
C     SUBROUTINE RDATA : READING AND PRINTING OF INITIAL CONDITIONS,BOUN
C                        DARY CONDITIONS, DEPTH OF ROOT ZONE AND  HYDRAU
C                        LIC PARAMETERS OF THE DIFFERENT SOIL LAYERS
      REAL LAI
      DIMENSION KM(12),TEM(366),RH(366),U(366),GWL(366),FIN(366),
     $DCL(366),HSH(366),SC(366),QDEEP(366),GPRH(366),PH(40),WC(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,EGA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
      EQUIVALENCE (TEM,EP),(RH,ES),(U,DRZ),(HNT,HSH,GWL,QDEEP,GPRH),
     $(CH,FIN),(SC,PHS),(DCL,ESR)
      DATA KM(1),KM(3),KM(5),KM(7),KM(8),KM(10),KM(12)/7*31/,KM(4),KM(6)
     $,KM(9),KM(11)/4*30/,GAMMA/1*0.66713/,SEP,SES/2*0.0/,IPL/1H+/,
     $IMN/1H-/,IBL/1H /,ISL/1H//,FGA,FGB,FGC,FGD,FGM,FMCH,FIA,FIB,FIC,
     $FID,FMP,FMI/.37E-7,.283,.164E-7,.59,1.3E-7,20.,0.169,0.516,0.1787,
     $0.0593,2.0,.19/
      DO 5000 I=1,366
         TEM(I)=0.0
         RH(I)=0.0
         U(I)=0.0
         HNT(I)=0.0
         CH(I)=0.0
         SC(I)=0.0
         DCL(I)=0.0
```

```
5000  CONTINUE
C
C
C** READING AND PRINTING OF INPUT DATA  AND  INITIAL CALCULATIONS ******
C   ------- --- -------- -- ----- ----  ---  ------- ------------
      READ(5,1000) HED
      WRITE(6,1001) HED
1000  FORMAT(20A4)
1001  FORMAT(1H1,20A4,/////)
      WRITE(6,1002)
1002  FORMAT(1H ,'I  N  P  U  T      V  A  R  I  A  B  L  E  S !',/,
     $          ' -  -  -  -  -      -  -  -  -  -  -  -  -  -',///)
      READ(5,1020) (KOD(I),I=1,7)
      WRITE(6,1021) (KOD(I),I=1,7)
1021  FORMAT(1H ,'KOD(1)=',I1,'  KOD(2)=',I1,'  KOD(3)=',I1,
     $'   KOD(4)=',I1,'  KOD(5)=',I1,'  KOD(6)=',I1,'  KOD(7)=',I1,//)
      READ(5,1030)  DSP,NCS,NPL,(NC(I),I=1,5),ISD
      WRITE(6,1031) DSP,NCS,NPL,(NC(I),I=1,5),ISD
1031  FORMAT(1H ,'DEPTH OF SOIL PROFILE  !',F8.1,' CM',/,' NUMBER OF COM
     $PARTMENTS !',I3,/,' NUMBER OF SOIL LAYERS  !',I3,/,' NC - ARRAY !'
     $,5I5,/,' DARCIAN FLUX INTEGRATED AT BOTTOM OF COMPARTMENT NR !',
     $I3,//)
      READ(5,1040) (SWC(I),I=1,5)
      WRITE(6,1041) (SWC(I),I=1,5)
1041  FORMAT(1H ,'LV - ARRAY  !',5F6.3)
      DO 1060 I=1,5
1060  LV(I)=SWC(I)*100.+.5
      READ(5,1040) (SWC(I),I=1,5)
      WRITE(6,1042) (SWC(I),I=1,5)
1042  FORMAT(1H ,'MV - ARRAY  !',5F6.3)
      DO 1070 I=1,5
1070  MV(I)=SWC(I)*100.+.5
      READ(5,1040) (SWC(I),I=1,5)
      WRITE(6,1043) (SWC(I),I=1,5)
1043  FORMAT(1H ,'SWC - ARRAY !',5F6.3,//)
      READ(5,1040)  CS1,FAC
      WRITE(6,1044) CS1,FAC
1044  FORMAT(1H ,'SATURATED HYDRAULIC CONDUCTIVITY OF FIRST SOIL LAYER !
     $',E10.3,/,' FAC !',E10.3,/////)
      READ(5,1050)  IRER,INL,ARER,BRER
      WRITE(6,1051) IRER,INL,ARER,BRER
1051  FORMAT(1H ,'S I N K  T E R M  V A R I A B L E S',//,'     IRER',
     $2X,'INL',6X,'ARER',6X,'BRER',/,7X,I1,4X,I1,3X,2(1X,E9.3),/)
      READ(5,1040)  RNAM,TB,TE
      WRITE(6,1052) RNAM,TB,TE
1052  FORMAT(1H ,'     RNAM',7X,'TB',8X,'TE',/,F9.1,(2(6X,F4.0)),/)
      READ(5,1040) P0,PU1,PL1,P2H,P2L,P2,P3
      READ(5,1020) (L(I),I=1,8)
      READ(5,1040) TINIT,TEND,DTMI,DTHM,CGWLAM
      READ(5,1020) NPR
      IF(KOD(7).EQ.0) READ(5,1040) (TPR(I),I=1,NPR)
      IF(KOD(7).NE.0) READ(5,1040) TPRINT
1020  FORMAT(10I5)
1030  FORMAT(F10.1,8I5)
1040  FORMAT(8E10.3)
1050  FORMAT(2I5,2E10.4)
C
      DX=ABS(DSP/NCS)
      DXH=0.5*DX
      IF(ISD.GT.NCS) ISD=NCS/2
C
      NNL=NC(1)
      NLA=1
      DO 1080 I=1,NCS
         IF(I.LE.NNL) GO TO 1090
         NLA=NLA+1
         NNL=NC(NLA)
1090     SWCA(I)=SWC(NLA)
1080  CONTINUE
C
      CS1=CS1*FAC
      P0=-ABS(P0)
      PU1=-ABS(PU1)
      PL1=-ABS(PL1)
      P2H=-ABS(P2H)
      P2L=-ABS(P2L)
```

```
      P2=-ABS(P2)
      P3=-ABS(P3)
      WRITE(6,1053) P0,PU1,PL1,P2H,P2L,P2,P3
 1053 FORMAT(1H ,'        P0        PU1         PL1         P2H         P2L
     $  P2        P3',/,10(1X,F9.0))
      WRITE(6,1061) (L(I),I=1,8)
 1061 FORMAT(1H ,/////,' L - ARRAY :',8I5,//)
      WRITE(6,1071) TINIT,TEND,DTMI,DTHM,CGWLAM
 1071 FORMAT(1H ,'START OF CALCULATIONS :',F5.0,' DAYS',/,' END OF CALCU
     $LATIONS   :',F5.0,' DAYS',/,' MAXIMUM TIME STEP      :',E10.3,
     $' DAYS',/,' MAXIMUM CHANGE OF MOISTURE CONTENT   :',E10.3,' CM**3/
     $CM**3',/,' MAXIMUM CHANGE OF GROUNDWATER LEVEL  :',E10.3,' CM',//)
      RNAM=-ABS(RNAM)
      WRITE(6,1081) NPR
 1081 FORMAT(1H ,'NUMBER OF PRINTPLOTS :',I5)
      IF (KOD(7).NE.0) GO TO 1083
      WRITE(6,1082) (TPR(I),I=1,NPR)
 1082 FORMAT(1H ,'PRINTING INTERVALS (DAYS) :',10F5.0)
      GO TO 1085
 1083 WRITE(6,1084) TPRINT
 1084 FORMAT(1H ,'PRINTING INTERVAL     :',F5.0,' DAYS')
 1085 RNAM=-ABS(RNAM)
      IF(CGWLAM.LE.0.0) CGWLAM=0.25
      KM(2)=L(3)
      L1=L(1)
      L2=L(2)
      DT=1.E-10
      DT1=DT
      T2=L(2)-1.
      TOUTP=TINIT+DT
      TMD=TINIT+1.
      IAD=TINIT+1
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C********* BOUNDARY CONDITIONS AT THE TOP OF THE SYSTEM ***************
C          -------- ---------- -- --- --- -- --- ------
      WRITE(6,10)
10    FORMAT(1H1,'BOUNDARY CONDITIONS AT THE TOP :',/,
     $          ' -------- ---------- -- --- ---',/)
C
C * KOD(3)=0 *
      IF(KOD(3).NE.0) GO TO 100
      IF(KOD(4).EQ.0) GO TO 20
      READ(5,2) PREC(L1),ES(L1),EP(L1),PHS(L1)
      DO 30 I=L1,L2
         PREC(I)=ABS(PREC(L1))
         ES(I)=ABS(ES(L1))
         EP(I)=ABS(EP(L1))
         PHS(I)=-ABS(PHS(L1))
30    CONTINUE
      GO TO 40
C
20    READ(5,2) (PREC(I),ES(I),EP(I),PHS(I),I=L1,L2)
      DO 50 I=L1,L2
         PREC(I)=ABS(PREC(I))
         ES(I)=ABS(ES(I))
         EP(I)=ABS(EP(I))
50       PHS(I)=-ABS(PHS(I))
40    WRITE(6,60)
60    FORMAT(3(1X,' DAY',4X,'PREC',3X,'ESOIL',2X,'EPLANT',5X,'PHS',4X))
      LL=L2
      IF(KOD(4).EQ.1) LL=L1
      DO 70 I=L1,LL,3
       WRITE(6,80) ((I+J-1),PREC(I+J-1),ES(I+J-1),EP(I+J-1),PHS(I+J-1),
     $ J=1,3)
70    CONTINUE
80    FORMAT(3(1X,I4,4F8.3,4X))
      GO TO 400
C
C * KOD(3)=1,2, OR 3 *
100   LL=L2
      IF(KOD(4).EQ.1) LL=L1
      IF(KOD(3).EQ.2) GO TO 102
      IF(KOD(3).EQ.3) GO TO 103
      READ(5,1) ALPHA
      READ(5,3) (PREC(I),HNT(I),TEM(I),RH(I),SC(I),I=L1,LL)
```

```
      WRITE(6,110)
110   FORMAT(//,2X,'DAY',2X,' PRECIPITATION',2X,' NET RADIATION',2X,
     $'    TEMPERATURE',2X,' REL. HUMIDITY',2X,'    SOIL COVER',/)
      GO TO 140
102   READ(5,1) (PREC(I),HSH(I),DCL(I),TEM(I),RH(I),U(I),SC(I),CH(I),
     $I=L1,LL)
      WRITE(6,120)
120   FORMAT(//,2X,'DAY',2X,' PRECIPITATION',2X,'     RADIATION',2X,
     $'     CLOUDINESS',2X,'   TEMPERATURE',2X,' REL. HUMIDITY',2X,
     $' WIND VELOCITY',2X,'    SOIL COVER',2X,'   CROP COEFF.',/)
      GO TO 140
103   READ(5,1) RS
      READ(5,4) (PREC(I),HNT(I),TEM(I),RH(I),U(I),SC(I),CH(I),I=L1,LL)
      WRITE(6,130)
130   FORMAT(//,2X,'DAY',2X,' PRECIPITATION',2X,' NET RADIATION',2X,
     $'   TEMPERATURE',2X,' REL. HUMIDITY',2X,' WIND VELOCITY',2X,
     $'    SOIL COVER',2X,'  CROP. HEIGHT',/)
      ISTP=0
140   DO 150 I=L1,L2
         TEM(I)=TEM(I)+273.15
         IF(KOD(4).EQ.0) GO TO 151
         PREC(I)=PREC(L1)
         HNT(I)=HNT(L1)
         TEM(I)=TEM(L1)
         RH(I)=RH(L1)
         U(I)=U(L1)
         SC(I)=SC(L1)
         CH(I)=CH(L1)
         DCL(I)=DCL(L1)
151   IF(ISTP.EQ.1) GO TO 150
         IF(KOD(3).EQ.1) WRITE(6,7) I,PREC(I),HNT(I),TEM(I),RH(I),SC(I)
         IF(KOD(3).EQ.2) WRITE(6,8) I,PREC(I),HSH(I),DCL(I),TEM(I),RH(I)
     $   ,U(I),SC(I),CH(I)
         IF(KOD(3).EQ.3) WRITE(6,9) I,PREC(I),HNT(I),TEM(I),RH(I),U(I),
     $   SC(I),CH(I)
      IF(KOD(4).EQ.1) ISTP=1
150   CONTINUE
C
      WRITE(6,170)
170   FORMAT(//////,' THE FUNCTIONS OF G(CH), LAI(SC) AND  FIN(PREC)',/,
     $              ' --- --------- -- -----  ------- ---  ---------',/)
C
C********* READING AND PRINTING OF THE G(CH)-FUNCTION *****************
C          ------- --- -------- -- --- ----- --------
      IF(KOD(3).NE.3) GO TO 185
C     FGA,FGB,FGC,FGD,FGM,FMCH :            COEFFICIENTS OF G(CH)-FUNCTION
      IF(L(7).EQ.0) READ(5,1) FGA,FGB,FGC,FGD,FGM,FMCH
      WRITE(6,180) FGA,FGB,FMCH,FGC,FGD,FMCH,FGM
180   FORMAT(1X,'G(CH)=',E10.3,' * (CH**',F6.3,24X,'FOR CH.GE.',F7.2,
     $' CM',/,' G(CH)=',E10.3,' * (CH**',F6.3,24X,'FOR CH.LT.',F7.2,
     $' CM',/,' MAXIMUM VALUE OF G(CH)=',E10.3,' CM',/)
C
C********* READING AND PRINTING OF THE LAI(SC)-FUNCTION ****************
C          ------- --- -------- -- --- ------- --------
C     FLA,FLB,FLC : COEFFICIENTS OF LAI-FUNCTION
185   READ(5,1) FLA,FLB,FLC
      WRITE(6,190) FLA,FLB,FLC
190   FORMAT(1X,'LAI=',F6.3,' * SC + ',F6.3,' * SC**2 + ',F6.3,
     $' * SC**3',/)
C
C******** READING AND PRINTING OF THE FIN(PREC)-FUNCTION ***************
C         ------- --- -------- -- --- ----------------
C     FIA,FIB,FIC,FID,FMP,FMI : COEFFICIENTS OF INTERCEPTION FUNCTION
      IF(KOD(3).EQ.0) GO TO 195
      IF(L(8).EQ.0) READ(5,1) FIA,FIB,FIC,FID,FMP,FMI
      WRITE(6,200) FIA,FIB,FIC,FID,FMP,FMI,FMP
200   FORMAT(1X,'FIN(PREC)= SC *',F6.3,' * PREC**(',F5.2,'-',F6.4,
     $' * (PREC-',F5.2,'))     FOR.PREC.LT.',F5.2,' CM/DAY',/,
     $' FIN(PREC)= SC *',F5.2,43X,' FOR.PREC.GE.',F5.2,' CM/DAY',/)
C
C********************** CALCULATION  OF : ******************************
C                       -----------  --
C      - EPOT = POTENTIAL EVAPOTRANSPIRATION(CM)
C      - ES   = SOIL EVAPORATION(CM/DAY)
C      - EP   = TRANSPIRATION(CM/DAY)
C      - SEP  = CUMULATIVE TRANSPIRATION(CM)
```

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C      - SES   = CUMULATIVE SOIL EVAPORATION(CM)
C      - FIN   = FLUX OF INTERCEPTED WATER(CM/DAY)
C      - EV    = SATURATED WATER VAPOUR PRESSURE(MBAR)
C      - DEL   = SLOPE OF THE SATURATED VAPOUR PRESSURE CURVE(MBAR/K)
C      - VPD   = THE VAPOUR PRESSURE DEFICIT OF THE AIR(MBAR)
C      - PHS   = MINIMUM ALLOWED PRESSURE HEAD AT THE SOIL SURFACE(CM)
C
C
 195   WRITE(6,210)
 210   FORMAT(1H1,//,48X,'CALCULATION OF POTENTIAL EVAPOTRANSPIRATION',/)
C
       WRITE(6,220)
 220   FORMAT(1X,//,50X,'POTENTIAL TRANSPIRATION RATE  (CM/DAY)',/)
       WRITE(6,230)
 230   FORMAT(1H ,'DATE  DAY  EPOT ESOIL EPLANT 0.0',7X,'0.2',7X,'0.4',7X
      $,'0.6',7X,'0.8',7X,'1.0',7X,'1.2',7X,'1.4',3X,'SEP',4X,'SES',5X
      2,'PHS',5X,'VPD')
       WRITE(6,240)
 240   FORMAT(1X,30X,'+****+****+****+****+****+****+****+****+****+****+
      $****+****+****+****+')
       I=L(1)
       LF=L(5)
       LE=L(6)
       L4=L(4)
C
       DO 250 M=LF,LE
        I2=KM(M)
        DO 260 J=L4,I2
         WED=.0583*TEM(I)-2.1938
         EV=1.3332*EXP((1.08872*TEM(I)-276.4884)/WED)
         DEL=13.7315*EV/(WED**2)
         VPD=(1.0-RH(I))*EV
         IF(KOD(3).NE.1) GO TO 261
         EPOT=.00352*HNT(I)*ALPHA*DEL/(DEL+GAMMA)
         IF(PREC(I).LE.FMP) FINI=SC(I)*FIA*PREC(I)**(FIB-FIC*
      $  (PREC(I)-FID))
         IF(PREC(I).GT.FMP) FINI=SC(I)*FMI
         GO TO 265
 261     IF(KOD(3).NE.2) GO TO 262
         HNT(I)=(1-.06)*HSH(I)-5.67E-8*TEM(I)**4*
      $  (.47-.067*SQRT(EV))*(1-.8*DCL(I))
         EPOT=.00352*CH(I)*(DEL*HNT(I)+GAMMA*28.368*
      $  .26*(.54*U(I)+.5)*VPD)/(DEL+GAMMA)
         GO TO 265
 262     IF(CH(I).GE.FMCH) GCH=FGA*CH(I)**FGB
         IF(CH(I).LT.FMCH) GCH=FGC*CH(I)**FGD
         IF(GCH.GT.FGM)    GCH=FGM
         RA=6.43E-6/(GCH*U(I)**.75)
         EWET=.00352*(DEL*HNT(I)+1210./RA*VPD)/(DEL+GAMMA)
         EPOT=((DEL+GAMMA)/(DEL+GAMMA*(1.+RS/RA)))*(EWET-FINI)
 265     FIN(I)=FINI
         LAI=FLA*SC(I)+FLB*SC(I)**2+FLC*SC(I)**3
         PHS(I)=4708.0*TEM(I)*ALOG(RH(I))
         ES(I)=0.9*EXP(-0.6*LAI)*EPOT
         IF(ES(I).GT.EPOT) ES(I)=EPOT
         EP(I)=EPOT-ES(I)
         SEP=SEP+EP(I)
         SES=SES+ES(I)
         II=(EP(I)*50.+.5)
          DO 270 I3=1,69
           IF(II.GT.I3) IB(I3)=IMN
           IF(II.EQ.I3) IB(I3)=IPL
           IF(II.LT.I3) IB(I3)=IBL
 270      CONTINUE
         WRITE(6,280) J,M,I,EPOT,ES(I),EP(I),IB,SEP,SES,PHS(I),VPD
 280     FORMAT(1X,I2,1X,I2,1X,I3,1X,F5.2,1X,F5.2,1X,F5.2,3X,1H+,
      $  69A1,1H+,1X,F6.2,1X,F6.2,1X,E9.3,1X,F5.1)
         IF(I.GE.L(2)) GO TO 300
         I=I+1
 260    CONTINUE
        L4=1
 250   CONTINUE
C
 300   WRITE(6,240)
       WRITE(6,230)
       GO TO 400
```

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
C**** READING AND PRINTING THE BOUNDARY CONDITION AT THE BOTTOM ********
C     ------- --- -------- --- -------- --------- -- --- ------
C
400   WRITE(6,401)
401   FORMAT(/////,' BOUNDARY CONDITION AT BOTTOM OF SOIL PROFILE :',/,
     $             ' -------- --------- -- ------ -- ---- -------',//)
C***************** THE GROUNDWATER LEVEL IS GIVEN *******************
C                  --- ----------- ----- -- -----
      IF(KOD(1).NE.0) GO TO 410
      IF(KOD(2).EQ.0) GO TO 430
      READ(5,1) GWLA
      GWLA=-ABS(GWLA)
      WRITE(6,440) GWLA
440   FORMAT(1H ,' THE GROUNDWATER LEVEL IS CONSTANT AT',F7.1,' CM')
      GO TO 700
430   READ(5,1) (GWL(I),I=L1,L2)
      DO 435 I=1,366
435   GWL(I)=-ABS(GWL(I))
      IT=TINIT+1
      GWLA=GWL(IT)
      WRITE(6,450)
450   FORMAT(1X,' THE GROUNDWATER LEVEL IS GIVEN',///,
     $5(11X,'DAY',5X,'LEVEL'),/)
      GO TO 500
C
C
C**** THE FLUX OF WATER THROUGH THE BOTTOM OF THE SOIL PROFILE IS GIVEN
C     --- ---- -- ----- ------- --- ------ -- --- ---- ------- -- -----
410   IF(KOD(1).NE.1) GO TO 460
      READ(5,1) GWLA
      GWLA=-ABS(GWLA)
      IF(KOD(2).EQ.0) GO TO 470
      READ(5,1) QDEEPA
      WRITE(6,480) QDEEPA
480   FORMAT(1X,' THE FLUX OF WATER THROUGH THE BOTTOM IS CONSTANT :',
     $F8.1,' CM/DAY',//)
      GO TO 700
470   READ(5,1) (QDEEP(I),I=L1,L2)
      QDEEPA=QDEEP(L1)
      WRITE(6,490)
490   FORMAT(1X,' THE FLUX OF WATER THROUGH THE BOTTOM IS GIVEN :',
     $///,5(11X,3HDAY,5X,5HDEPTH),/)
500   DO 510 I=L1,L2,5
         DO 520 J=1,5
            LC1(J)=I-1+J
            IF(LC1(J).EQ.L(2)) GO TO 530
520      CONTINUE
530   WRITE(6,5) (LC1(IL),GWL(I+IL-1),IL=1,5)
510   CONTINUE
      GO TO 700
C
C************ FLUX TOWARDS DITCHES AND DEEP PERCOLATION ***************
C             ---- ------- ------- --- ---- -----------
460   IF(KOD(1).NE.2) GO TO 540
      WRITE(6,550)
550   FORMAT(1X,'FLUX TOWARDS DITCHES AND DEEP PERCOLATION',///)
      READ(5,1) GWLA
      GWLA=-ABS(GWLA)
      READ(5,1) CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR
C
      DGRWL=-ABS(DGRWL)
      WRITE(6,560) CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR
560   FORMAT(1X,
     $'DISTANCE BETWEEN THE CHANNELS            :',F12.0,'  M',/
     $,' RADIAL RESISTANCE OF THE CHANNEL       :',E12.3,'  DAY/M',/
     $,' TRANSMISSIVITY (SATURATED FLOW)        :',E12.4,'  M**2/DAY',/
     $,' REDUCTION COEFFICIENT (ALPHAR)         :',F12.3,/
     $,' DEEP GROUNDWATER LEVEL                 :',F12.0,'  CM',/
     $,' RESISTANCE OF SEMI-IMPERMEABLE LAYER   :',F12.0,'  DAY',///)
      IF(KOD(2).EQ.0) GO TO 561
      READ(5,1) CHNL
      CHNL=-ABS(CHNL)
      WRITE(6,565) CHNL
565   FORMAT(1H ,'THE WATER LEVEL IN  THE CHANNELS IS CONSTANT :',
```

```
     $F10.1,'CM',/)
      GO TO 700
561   READ(5,1) (GWL(I),I=L1,L2)
      DO 566 I=L1,L2
566   GWL(I)=-ABS(GWL(I))
      WRITE(6,567)
567   FORMAT(1X,//,'THE WATER LEVEL IN THE CHANNELS IS GIVEN !',///,
     $5(11X,'DAY',4X,' LEVEL'))
      GO TO 500
C
C************ FLUX-GROUNDWATER LEVEL RELATIONSHIP ********************
C             ---- ----------- ----- ------------
540   IF(KOD(1).NE.3) GO TO 545
      WRITE(6,541)
541   FORMAT(1H ,'FLUX-GROUNDWATER LEVEL RELATIONSHIP',/)
      READ(5,1) GWLA
      GWLA=-ABS(GWLA)
      READ(5,1) AREL,BREL
      WRITE(6,542) AREL,BREL
542   FORMAT(1H ,'FLUX =',E10.3,' * EXP(',E10.3,' * ABS(GROUNDWATER LEVE
     $L))    (CM/DAY)',/,
     $' IN PROGRAM ! QDEEPA = AREL * EXP(BREL * ABS(GWLA))')
      GO TO 700
C
C********** PRESSURE HEAD OF LOWEST COMPARTMENT IS GIVEN ***************
C           -------- ---- -- ------ ----------- -- -----
545   IF(KOD(1).NE.4) GO TO 570
      IF(KOD(2).EQ.0) GO TO 580
      READ(5,1) GPRHA
      GPRHA=-ABS(GPRHA)
      WRITE(6,590) GPRHA
590   FORMAT(1X,'THE PRESSURE HEAD OF THE BOTTOM COMPARTMENT IS CONSTANT
     $!',E10.3,' CM',/)
      GO TO 700
580   READ(5,1) (GPRH(I),I=L1,L2)
      DO 585 I=1,366
585   GPRH(I)=-ABS(GPRH(I))
      GPRHA=GPRH(L1)
      WRITE(6,600)
600   FORMAT(1X,' THE PRESSURE HEAD OF THE BOTTOM COMPARTMENT IS GIVEN',
     $///,5(11X,'DAY',5X,'DEPTH'),/)
      GO TO 500
C
C******* ZERO FLUX AT THE BOTTOM OF AN UNSATURATED SOIL PROFILE ********
C        ---- ---- -- --- ------ -- -- ----------- ---- -------
570   IF (KOD(1).NE.5) GO TO 610
      WRITE(6,620)
620   FORMAT(1X,'ZERO FLUX AT THE BOTTOM OF THE SOIL PROFILE')
      GO TO 700
C
C********************** FREE DRAINAGE **********************************
C                       ---- --------
C
610   WRITE(6,630)
630   FORMAT(1X,' FREE DRAINAGE AT THE BOTTOM OF THE SOIL PROFILE')
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C************ READING AND PRINTING THE ROOTING DEPTH ******************
C             ------- --- -------- --- ------- -----
700   IF(KOD(6).NE.0) GO TO 710
      READ(5,1) (DRZ(I),I=L1,L2)
      DO 705 I=1,366
705   DRZ(I)=-ABS(DRZ(I))
      WRITE(6,720)
720   FORMAT(1H1,'TABLE OF ROOTING DEPTH !',/,
     $           ' ----- -- ------- -----',//,5(11X,'DAY',5X,'DEPTH'),/)
C
      DO 730 I=L1,L2,5
         DO 740 J=1,5
            LC1(J)=I-1+J
            IF(LC1(J).EQ.L(2)) GO TO 750
740      CONTINUE
750      WRITE(6,5) (LC1(IL),DRZ(I+IL-1),IL=1,5)
730   CONTINUE
      GO TO 800
C
```

```
710   READ(5,1) DRZA
      DRZA=-ABS(DRZA)
      WRITE(6,760) DRZA
760   FORMAT(////////,' THE ROOTING DEPTH IS CONSTANT =',F6.1,' CM',/,
     $                 ' --- ------- ----- -- --------')
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C************ READING AND PRINTING THE INITIAL CONDITION **************
C             ------- --- -------- --- ------- ---------
800   WRITE(6,810)
810   FORMAT(1H ,//////////,' INITIAL CONDITION :',/,
     $                       ' ------- ---------',///)
C
820   FORMAT(1H ,'+++++ WATER CONTENT PROFILE IS GIVEN +++++',/)
830   FORMAT(1H ,'+++++ PRESSURE HEAD PROFILE IS GIVEN +++++',/)
840   FORMAT(1H ,'+++++ PRESSURE HEAD PROFILE IS CALCULATED(EQUILIBRIUM
     $WITH GROUNDWATER LEVEL) +++++',/)
C
      IF(KOD(5).EQ.2) GO TO 860
      IF(KOD(5).EQ.1) GO TO 850
C
C* WATER CONTENT PROFILE IS GIVEN *
      READ(5,1) (WC(I),I=1,NCS)
      IF(KOD(1).GT.3) GO TO 845
      N1=-GWLA/DX+1.499999
      DO 846 I=N1,NCS
846   WC(I)=SWCA(I)
845   WRITE(6,820)
      WRITE(6,6) (WC(I),I=1,NCS)
      GO TO 880
C
C* PRESSURE HEAD PROFILE IS GIVEN *
850   READ(5,1) (PH(I),I=1,NCS)
      IF(KOD(1).GT.3) GO TO 855
      N1=-GWLA/DX+1.499999
      DO 856 I=N1,NCS
856   PH(I)=0.0
855   DO 857 I=1,NCS
857   PH(I)=-ABS(PH(I))
      WRITE(6,830)
      WRITE(6,6) (PH(I),I=1,NCS)
      GO TO 880
C
C* PRESSURE HEAD PROFILE IS CALCULATED *
860   N=-GWLA/DX+.499999
      PH(N)=-0.5*(-GWLA-(N-1)*DX)
      JJ=N-1
      DO 865 J=1,JJ
865   PH(J)=GWLA+(J-0.5)*DX
      JJ=N+1
      DO 870 J=JJ,NCS
870   PH(J)=0.0
      WRITE(6,840)
      WRITE(6,6) (PH(I),I=1,NCS)
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C********* READING AND PRINTING THE SOIL HYDRAULIC PARAMETERS **********
C          ------- --- -------- --- ---- --------- ----------
C
880   WRITE(6,890)
890   FORMAT(1H1)
900   FORMAT(///,' SOIL PHYSICAL PARAMETERS OF SOIL LAYER NR :',I4,
     $//,(4(1X,'THETA',3X,'PR.HEAD',4X,'CONDUC',4X)),/,
     $(4(11X,'CM',7X,'CM/DAY',4X)),/)
910   FORMAT(4(1X,F5.3,(2E10.3),4X))
C
      DO 920 I=1,NPL
         K1=LV(I)+1
         K2=MV(I)-LV(I)+K1
         READ(5,1) (PRH(I,J),J=K1,K2)
         DO 925 J=1,80
925      PRH(I,J)=-ABS(PRH(I,J))
         READ(5,1) (CON(I,J),J=K1,K2)
         WRITE(6,900) I
C
            DO 930 M=K1,K2
```

```
              CON(I,M)=CON(I,M)*FAC
930         CONTINUE
C
         THETA(1)=LV(I)*0.01 - 0.04
C
           DO 940 IPR=K1,K2,4
            THETA(1)=THETA(1)+0.04
            THETA(2)=THETA(1)+0.01
            THETA(3)=THETA(2)+0.01
            THETA(4)=THETA(3)+0.01
         WRITE(6,910) (THETA(IL),PRH(I,IPR+IL-1),CON(I,IPR+IL-1),IL=1,4)
940        CONTINUE
C
         PRH(I,K2+1)=-PRH(I,K2-1)
         PRH(I,K2+2)=-PRH(I,K2-2)
         CON(I,K2+1)=CON(I,K2)
         CON(I,K2+2)=CON(I,K2)
C
920   CONTINUE
C
C
C* CHECK INPUT DATA OF PRESSURE HEAD AND HYDRAULIC CONDUCTIVITY *
C
      WRITE(6,1500)
1500  FORMAT(1H1)
         ISTOP=0
      DO 2000 I=1,NPL
         K1=LV(I)+1
         K2=MV(I)-LV(I)+K1-1
       DO 2000 J=K1,K2
          JJ=J+1
          IF(PRH(I,J).LT.PRH(I,JJ)) GO TO 2020
          RJ=(J-1)/100.
          RJJ=J/100.
          WRITE(6,2030) I,RJ,RJJ
          ISTOP=ISTOP+1
2020      IF(CON(I,J).LT.CON(I,JJ)) GO TO 2000
          RJ=(J-1)/100.
          RJJ=J/100.
          WRITE(6,2040) I,RJ,RJJ
          ISTOP=ISTOP+1
2000  CONTINUE
C
      IF(ISTOP.EQ.0) GO TO 2070
      WRITE(6,2050)
2050  FORMAT(1X,///,' P R O G R A M    S T O P P E D ',/,
     $' C H E C K   I N P U T   T A B L E S   O F   PRESSURE HEAD   A N
     $ D   HYDRAULIC CONDUCTIVITY   !!!!!!!!!!')
C
2030  FORMAT(1X,'ERROR IN PRESSURE HEAD TABLE OF PROFILE LAYER NR :',I2,
     $5X,'PRH(',F4.2,')  >  PRH(',F4.2,')')
2040  FORMAT(1X,'ERROR IN HYDRAULIC CONDUCTIVITY TABLE OF PROFILE LAYER
     $ NR :',I2,5X,'CON(',F4.2,')  >  CON(',F4.2,')')
C
C* CHECK IF   PRH(1,LOWEST VALUE)  <  PHS(*)  <  PRH(1,HIGHEST VALUE) *
2070  K1=LV(1)+1
      K2=MV(1)-LV(1)+K1
      ISTOP1=0
      DO 2100 I=LF,LE
         IF(PHS(I).LT.PRH(1,K1)) GO TO 2110
         IF(PHS(I).GT.PRH(1,K2)) GO TO 2120
         GO TO 2100
2110     WRITE(6,2200)
         GO TO 2100
2120     WRITE(6,2300)
         ISTOP1=1
2100  CONTINUE
      IF(ISTOP1.EQ.0) GO TO 2500
      WRITE(6,2400)
2400  FORMAT(1X,'P R O G R A M   S T O P P E D ',/,
     $' EXTEND PRESSURE HEAD  AND  HYDRAULIC CONDUCTIVITY TABLES OF PROF
     $ILE LAYER NR 1  !!!!!!!!!!!!!!')
2500  IF(ISTOP.NE.0.OR.ISTOP1.NE.0) STOP
C
2200  FORMAT(1X,'PHS(',I3,')  <  PRH(1,LOWEST VALUE)')
2300  FORMAT(1X,'PHS(',I3,')  >  PRH(1,HIGHEST VALUE)')
```

```
C
C*CONTINUATION OF INITIAL CALCULATIONS*
      N=-GWLA/DX+.499999
      IF(KOD(1).GT.3) GWLA=1.E10
      IF(KOD(1).GT.3) N=NCS
      IF(KOD(5).EQ.0) CALL HEPR(PH,WC)
      VOL=0.0
      CALL WACO(WC,PH)
      VOLI=VOL
C
C
C*REDUCTION OF POTENTIAL SOIL EVAPORATION*
      TBV=1.
      IF(PH(1).LT.-100.) TBV=5.
      ESR(L1)=AMIN1(ES(L1),.35*(SQRT(TBV)-SQRT(TBV-1.)))
      L11=L1+1
C
      DO 3010 I=L11,L2
      TBV=TBV+1.
      IF(PREC(I).GT.1.0) GO TO 3000
      ESR(I)=AMIN1(ES(I),(0.35*(SQRT(TBV)-SQRT(TBV-1.))))
      GO TO 3010
3000  TBV=1.
      ESR(I)=AMIN1(ES(I),0.35)
3010  CONTINUE
C
C*COMPUTING THE COORDINATES OF NODAL POINTS*
      DO 1100 J=1,NCS
         X(J)=-DX*(J-0.5)
1100  CONTINUE
C
C*CALCULATION OF BOUNDARY CONDITIONS (T=TINIT)*
      DXN=DX
      DXG=0.5*(DX+DXN)
      CALL BOCO(TINIT,PH)
C*CALCULATION OF DIF. MOIST. CAPACITIES AND HYDR. CONDUCTIVITIES
      CALL DMCCON(WC)
C*CALCULATION OF ROOT EXTRACTION RATES*
      CALL RER(T,PH)
C*CALCULATION OF FLUXES IN BETWEEN THE NODAL POINTS*
      CALL FLUXES(PH)
      FLX1=FLXS(ISD+1)
C
      IF(KOD(1).LT.5) CFLBU=1.E10
      IF(KOD(1).LT.5) CFLBUP=5.E10
      IF(KOD(1).EQ.0.OR.KOD(1).GT.3) CQDP=1.E10
      IF(KOD(1).EQ.0.OR.KOD(1).GT.3) CQD=5.E10
      IF(KOD(1).GT.0.AND.KOD(1).LT.4) CDEL=1.E10
      IF(KOD(1).GT.0.AND.KOD(1).LT.4) CDELP=5.E10
C
1     FORMAT(8E10.4)
2     FORMAT(4E10.4)
3     FORMAT(5E10.4)
4     FORMAT(7E10.4)
5     FORMAT(5(I14,F10.1))
6     FORMAT(5(2X,E12.4))
7     FORMAT(I5,F13.2,F16.1,F16.1,F16.3,F16.3)
8     FORMAT(I5,F13.2,F16.1,F16.3,F16.1,F16.3,F16.3,F16.3,F16.2)
9     FORMAT(I5,F13.2,(2(F16.1)),F16.3,F16.1,F16.3,F16.1)
C
      RETURN
      END
C
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE WACO(WC,PH)
C     SUBROUTINE WACO :  CALCULATES THE WATER CONTENTS AT THE NODAL
C                        POINTS FROM PRESSURE HEAD DATA AND WATER
C                        STORAGE IN THE SOIL PROFILE
      DIMENSION PH(40),WC(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $P0,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
```

```
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
C
      NLA=1
      NNL=NC(1)
      DO 10 I=1,NCS
       IF(I.LE.NNL) GO TO 20
       NLA=NLA+1
       NNL=NC(NLA)
20     K=LV(NLA)+1
30     K=K+1
       IF(PH(I).GT.PRH(NLA,K)) GO TO 30
       WC(I)=.01*((K-2)+(PH(I)-PRH(NLA,K-1))/(PRH(NLA,K)-PRH(NLA,K-1)))
10    CONTINUE
C
      VOLI=VOL
      VOL=0.0
      DO 360 I=1,NCS
         VOL=VOL+WC(I)*DX
360   CONTINUE
      N1=-GWLA/DX+1
      IF(KOD(1).LT.4) VOL=VOL+(N*DX+GWLA)*(SWCA(N1)-WC(N))
C
      RETURN
      END
C
C
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE BOCO(T,PH)
C     SUBROUTINE BOCO : DETERMINES THE VALUES OF THE BOUNDARY CONDITIONS
C                       AT ANY STAGE OF COMPUTATION
      DIMENSION HSH(366),GWL(366),QDEEP(366),GPRH(366),DCL(366),FIN(366)
     $,PH(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
      EQUIVALENCE (TEM,EP),(RH,ES),(U,DRZ),(HNT,HSH,GWL,QDEEP,GPRH),
     $(CH,FIN),(SC,PHS),(DCL,ESR)
C
      IF(T.GT.T2) GO TO 100
C
      M=T+1
      TA=T+1-M
      EPA=EP(M)
      ESA=ES(M)
      ESRA=ESR(M)
      PRECA=PREC(M)
      FINA=FIN(M)
      PHSA=PHS(M)
      FLXA=ESRA-(PRECA-FINA)
      IF(FLXA.LT.0.0) PHSA=0.0
      IF(KOD(6).EQ.0) DRZA=DRZ(M)+TA*(DRZ(M+1)-DRZ(M))
C
      IF(KOD(1).NE.0) GO TO 10
      IF(KOD(2).EQ.0) GWLA=GWL(M)+TA*(GWL(M+1)-GWL(M))
      N=-GWLA/DX+0.499999
      GO TO 50
C
10    IF(KOD(1).NE.1) GO TO 20
      IF(KOD(1).EQ.0) QDEEPA=QDEEP(M)
      GO TO 50
C
20    IF(KOD(1).NE.2) GO TO 30
      IF(KOD(2).EQ.0) CHNL=GWL(M)+TA*(GWL(M+1)-GWL(M))
      QDEEP1=(CHNL-GWLA)/(CHND*CHNR+(CHND**2)/(8.0*DKD))
      QDEEP2=-(CHNL+ALPHAR*(GWLA-CHNL)-DGRWL)/SIMPR
      QDEEPA=QDEEP1+QDEEP2
```

```
      GO TO 50
C
30    IF(KOD(1).NE.3) GO TO 40
      QDEEPA=AREL*EXP(BREL*ABS(GWLA))
      GO TO 50
C
40    IF(KOD(1).NE.4) GO TO 100
      IF(KOD(2).EQ.0) GPRHA=GPRH(M)+TA*(GPRH(M+1)-GPRH(M))
      GO TO 100
C
50    DXN=-GWLA-(N-1)*DX
      DXG=0.5*(DX+DXN)
      PH(N)=-DXN/2.
      J=N+1
      DO 60 I=J,NCS
60       PH(I)=0.
C
100   RETURN
      END
C
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE HEPR(PH,WC)
C     SUBROUTINE HEPR :  CALCULATES THE PRESSURE HEADS FOR EACH NODAL
C                        POINT WHEN THE INITIAL CONDITION IS GIVEN AS
C                        VALUES OF MOISTURE CONTENT            [KOD(5)=0]
      DIMENSION WC(40),PH(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
C
      NLA=1
      NNL=NC(1)
C
      DO 10 I=1,NCS
         M=WC(I)/0.01+1
         H=(M-1)*0.01
         IF(I.LE.NNL) GO TO 20
         NLA=NLA+1
         NNL=NC(NLA)
20       PH(I)=PRH(NLA,M)+(PRH(NLA,M+1)-PRH(NLA,M))*((WC(I)-H)/0.01)
10    CONTINUE
C
      RETURN
      END
C
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE DMCCON(WC)
C     SUBROUTINE DMC :  CALCULATES THE DIFFERENTIAL MOISTURE CAPACITIES
C                       AND HYDRAULIC CONDUCTIVITIES (AS A FUNCTION OF
C                       WATER CONTENT) FOR EACH NODAL POINT
      DIMENSION WC(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
C
      CSURF=CS1
      IF(PHSA.GE.0.0) GO TO 20
      M=LV(1)+1
10    M=M+1
      IF(PHSA.GT.PRH(1,M)) GO TO 10
      CSURF=CON(1,M-1)+(CON(1,M)-CON(1,M-1))*((PHSA-PRH(1,M-1))/
     $(PRH(1,M)-PRH(1,M-1)))
C
20    NLA=1
```

```
      NNL=NC(1)
C
      DO 30 I=1,NCS
         M=WC(I)/0.01+1
         H=(M-1)*0.01
         IF(I.LE.NNL) GO TO 40
         NLA=NLA+1
         NNL=NC(NLA)
40       DMCAP(I)=0.01/(PRH(NLA,M+1)-PRH(NLA,M))
         CONDUC(I)=CON(NLA,M)+(CON(NLA,M+1)-CON(NLA,M))*((WC(I)-H)/0.01)
30    CONTINUE
C
      CONIN(1)=SQRT(CSURF*CONDUC(1))
C
      DO 50 I=2,NCS
         CONIN(I)=SQRT(CONDUC(I)*CONDUC(I-1))
50    CONTINUE
C
      CONIN(N+1)=SQRT(CONDUC(N+1)*CONDUC(N))
C
      RETURN
      END
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE RER(T,PH)
C     SUBROUTINE RER : CALCULATES THE ROOT EXTRACTION RATES (AS A
C                      FUNCTION OF PRESSURE HEAD) FOR EACH NODAL
C                      POINT (IF ROOTS ARE PRESENT)
      DIMENSION PH(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
C
      RNA=0.0
      IF(T.GE.TE) GO TO 10
      IF(T.GT.TB) RNA=RNAM*(T-TB)/(TE-TB)
      GO TO 20
10    RNA=RNAM
20    QM=0.0
      IF(RNA-DRZA.GT.0.0) QM=EPA/(RNA-DRZA)
      IF(IRER.NE.0) QM=1.
      IRZ=-DRZA/DX+.99999
      IP=IRZ-1
      P1=PU1
      IF(IRER.EQ.1) GO TO 25
      P2=P2H
      IF(EPA.LT.0.1) GO TO 21
      IF(EPA.GT.0.5) GO TO 25
      P2=P2H+((0.5-EPA)/0.4)*(P2L-P2H)
      GO TO 25
21    P2=P2L
25    DO 30 I=1,IRZ
         RTEX(I)=0.0
         IF(PH(I).LE.P3.OR.PH(I).GE.PO) GO TO 30
         IF(PH(I).LE.P2) GO TO 40
         RTEX(I)=QM
         IF(I.GT.NC(1)) P1=PL1
         IF(PH(I).GT.P1) RTEX(I)=QM*(PO-PH(I))/(PO-P1)
         GO TO 30
40       IF(INL.EQ.0) RTEX(I)=QM*(P3-PH(I))/(P3-P2)
      IF(INL.NE.0) RTEX(I)=QM*(P2/PH(I))
30    CONTINUE
C
C****************** EXTRACTION PATTERN FEDDES,KOWALIK,ZARADNY ***********
      IF(IRER.NE.0) GO TO 100
      IF(RNA.EQ.0.0) GO TO 50
      IF(-RNA.GT.DX) RTEX(1)=0.0
```

```
      IF(-RNA.LT.DX) RTEX(1)=RTEX(1)*(DX+RNA)/DX
C
C
      DO 60 J=2,IP
         IF(-RNA.LT.(J-1)*DX) GO TO 50
         IF(-RNA.GT.J*DX) RTEX(J)=0.0
         IF(-RNA-(J-1)*DX.LT.DX) RTEX(J)=RTEX(J)*(J*DX+RNA)/DX
60    CONTINUE
C
50    RTEX(IRZ)=RTEX(IRZ)*(-DRZA-(IP*DX))/DX
      GO TO 200
C
C**************** EXTRACTION PATTERN HOOGLAND,BELMANS,FEDDES **********
100   CRDEM=EPA
      J1=1
110   IF(J1*DX.GT.-RNA) GO TO 120
      RTEX(J1)=0.
      J1=J1+1
      GO TO 110
120   RTEX(J1)=AMIN1(RTEX(J1)*(ARER-BRER*ABS(X(J1)))
     $*(J1*DX+RNA)/DX,CRDEM/DX)
      CRDEM=CRDEM-RTEX(J1)*DX
      J2=J1
      IF(CRDEM.LT.1.E-10) GO TO 160
      J1=J1+1
      DO 130 I=J1,IP
         RTEX(I)=AMIN1(RTEX(I)*(ARER+BRER*X(I)),CRDEM/DX)
         CRDEM=CRDEM-RTEX(I)*DX
         J2=I
         IF(CRDEM.LT.1.E-10) GO TO 160
130   CONTINUE
135   J2=IRZ
      RTEX(J2)=RTEX(J2)*(ARER+BRER*X(J2))*(-DRZA-IP*DX)/DX
      RTEX(J2)=AMIN1(RTEX(J2),CRDEM/DX)
160   J2=J2+1
      DO 140 I=J2,NCS
         RTEX(I)=0.0
140   CONTINUE
C
200   RETURN
      END
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE FLUXES(PH)
C     SUBROUTINE FLUXES ! CALCULATES THE DARCIAN FLUXES IN BETWEEN THE
C                         NODAL POINTS
      DIMENSION PH(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOLI,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
C
      FLX1=FLXS(ISD+1)
      FLXS(1)=-CONIN(1)*(PHSA-PH(1)+DXH)/DXH
      IF(FLXS(1).GT.0.0.AND.FLXA.GT.0.0) GO TO 10
      IF(FLXS(1).LT.0.0.AND.FLXA.LT.0.0) GO TO 20
      FLXS(1)=0.0
      GO TO 30
10    IF(FLXS(1).GT.FLXA) FLXS(1)=FLXA
      GO TO 30
20    IF(FLXS(1).LT.FLXA) FLXS(1)=FLXA
C
30    DO 40 I=2,NCS
         FLXS(I)=-CONIN(I)*((PH(I-1)-PH(I))/DX+1.)
40    CONTINUE
C
      IF(N.GT.1) FLXS(N)=-CONIN(N)*((PH(N-1)-PH(N))/DXG+1.)
      FLXS(NCS+1)=-CONDUC(NCS)
```

```
      IF(KOD(1).LE.4) FLXS(N+1)=FLXS(N)
      IF(KOD(1).EQ.5) FLXS(NCS+1)=0.0
C
      IF(FLXS(ISD+1).GT.0.0) CFLSDP=CFLSDP+0.5*(FLX1+FLXS(ISD+1))*DT
      CFLSD=CFLSD+0.5*(FLX1+FLXS(ISD+1))*DT
C
      RETURN
      END
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE PRHEAD(PH)
      DIMENSION R1(40),R2(40),PH(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
C
      H1=DT/DX
      H2=H1/DX
C****** CALCULATION OF COEFFICIENTS OF TRIDIAGONAL MATRIX ************
C
C#CALCULATION OF COEFFICIENTS FOR I=1#
      A=H2*CONIN(2)/DMCAP(1)
      B=1.0+A
      E=PH(1)-H1*(CONIN(2)+FLXS(1))/DMCAP(1)-DT*RTEX(1)/DMCAP(1)
      R1(1)=A/B
      R2(1)=-E/A
C
C#CALCULATION OF COEFFICIENTS FOR 1<I<N#
      J=N-1
      DO 10 I=2,J
         C=H2*CONIN(I)/DMCAP(I)
         IF(I.EQ.N-1) H2=DT/(DX*DXG)
         A=H2*CONIN(I+1)/DMCAP(I)
         B=1.0+A+C
         E=PH(I)-H1*(CONIN(I+1)-CONIN(I))/DMCAP(I)-DT*RTEX(I)/DMCAP(I)
         R1(I)=A/(B-C*R1(I-1))
         R2(I)=(C*R1(I-1)*R2(I-1)-E)/A
10    CONTINUE
C
      IF(KOD(1).LT.5) GO TO 20
C
C#CALCULATION OF COEFFICIENTS FOR I=N#
      C=H2*CONIN(N)/DMCAP(N)
      B=1.0+C
      E=PH(N)+H1*(FLXS(N+1)+CONIN(N))/DMCAP(N)-DT*RTEX(N)/DMCAP(N)
      GO TO 30
C
C********** CALCULATION OF PRESSURE HEAD VALUES AT TIME (T) ***********
20    IF(KOD(1).EQ.4) PH(N)=GPRHA
      GO TO 40
30    PH(N)=(E-C*R1(N-1)*R2(N-1))/(B-C*R1(N-1))
40    J=N+1
50    J=J-1
      IF(J.LT.2) GO TO 60
      PH(J-1)=AMIN1(0.0,R1(J-1)*(PH(J)-R2(J-1)))
      GO TO 50
C
60    RETURN
      END
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE INTGRL(PH)
C     SUBROUTINE INTGRL : CALCULATION OF CUMULATIVE VALUES
      DIMENSION PH(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
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     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
C
      CPREC=CPREC+PRECA*DT
      CINTC=CINTC+FINA*DT
      CPSEV=CPSEV+ESA*DT
      CPTRA=CPTRA+EPA*DT
C
      IF(FLXS(1).GT.0.0) GO TO 10
      CINF=CINF-FLXS(1)*DT+ESRA*DT
      CSEV=CSEV+ESRA*DT
      GO TO 20
10    CSEV=CSEV+FLXS(1)*DT
      IF(PRECA.LE.0.0) GO TO 20
      CSEV=CSEV+(PRECA-FINA)*DT
      CINF=CINF+(PRECA-FINA)*DT
C
20    IF(QDEEPA.GT.0.) CQDP=CQDP+QDEEPA*DT
      CQD=CQD+QDEEPA*DT
C
      CTRA1=CTRA
      DO 30 I=1,IRZ
         CTRA=CTRA+RTEX(I)*DX*DT
         CRTEX(I)=CRTEX(I)+RTEX(I)*DX*DT
30    CONTINUE
C
      IF(KOD(1).LT.6) GO TO 40
      IF(FLXS(N+1).GT.0.0) CFLBUP=CFLBUP+FLXS(N+1)*DT
      CFLBU=CFLBU+FLXS(N+1)*DT
C
40    RETURN
      END
C
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE CALGWL(PH,WC)
      DIMENSION PH(40),WC(40),R1(40),R2(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $PO,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
C
      DVOL=DVOL+DEL-QDEEPA*DT
      IF(ABS(DVOL).LT.0.10) GO TO 200
      VOL2=VOL
      CGWLA=CGWLAM
      IF(DVOL.LT.0.0) CGWLA=-CGWLA
C
10    GWLA=GWLA-CGWLA
      IF(-GWLA.GE.DSP) STOP
      N=-GWLA/DX+.499999
      IF(N.LE.2)       STOP
      PH(N+1)=0.0
      DXN=-GWLA-(N-1)*DX
      DXG=0.5*(DX+DXN)
      PH(N)=-DXN/2.0
      VOL3=VOL
      CALL WACO(WC,PH)
      VOL=VOL3
      CALL DMCCON(WC)
      DT2=DT/10.
      H1=DT2/DX
      H2=H1/DX
      JJ=AMAX0(N-3,2)
      JJJ=N-1
```

```
      CONJJ=CONIN(JJ)
      CONIN(JJ)=0.0
C
      DO 20 I=JJ,JJJ
         C=H2*CONIN(I)/DMCAP(I)
         IF(I.EQ.N-1) H2=DT2/(DX*DXG)
         A=H2*CONIN(I+1)/DMCAP(I)
         B=1.0+A+C
         E=PH(I)-H1*(CONIN(I+1)-CONIN(I))/DMCAP(I)
         R1(I)=A/(B-C*R1(I-1))
         R2(I)=(C*R1(I-1)*R2(I-1)-E)/A
20    CONTINUE
C
      CONIN(JJ)=CONJJ
      J=N+1
30    J=J-1
      IF(J.LT.JJ+1) GO TO 40
      PH(J-1)=R1(J-1)*(PH(J)-R2(J-1))
      GO TO 30
C
40    CALL WACO(WC,PH)
C
      DVOL1=DVOL
      DVOL=DVOL-(VOL1-VOL)
      IF(ABS(VOL1-VOL).GT.ABS(DVOL1)) GO TO 200
      IF(ABS(DVOL).GT.0.05) GO TO 10
C
200   RETURN
      END
C
C
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE CALCDT(T,ITS)
C     SUBROUTINE CALCDT ! CALCULATION OF THE TIME STEP (DT)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $P0,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
C
      DTDT=RTEX(1)+ABS((FLXS(1)-FLXS(2))/DX)
      J=N-1
      DO 10  I=2,J
         DTDT=AMAX1(DTDT,RTEX(I)+ABS((FLXS(I)-FLXS(I+1))/DX))
10    CONTINUE
      DTDT=AMAX1(DTDT,RTEX(N)+ABS((FLXS(N)-FLXS(N+1))/DXN))
      IF(DTDT.GT.0.0) DT=DTHM/DTDT
      DT=AMIN1(DT,DTM,1.2*DT1)
      DT1=DT
      IF(T+DT.LT.TMD) GO TO 20
      DT=TMD-T
      ITS=1
      TMD=TMD+1.
      IF(T+DT.GE.TOUTP) IPRT=1
      IF(T+DT.GE.TEND)  IPRT=1
20    IF(T+DT.GT.TEND) STOP
C
      RETURN
      END
C
C
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE PRTPLT(T,WC,PH,ITS,NTS,NPRA)
C     SUBROUTINE PRTPLT ! PRINTING AND PLOTTING
      DIMENSION WC(40),PH(40)
      COMMON IAD,N,NPL,NCS,IRZ,IRER,INL,IPRT,ISD,NPR,
     $LV(5),MV(5),NC(5),KOD(7),L(8),IA(99),IB(69),LC1(5),HED(20),
     $P0,PU1,PL1,P2H,P2L,P2,P3,RNAM,CGWLAM,DSP,DX,DXG,DXH,DXN,CS1,ESRA,
     $FAC,DT,DT1,DTI,DTM,DTMI,DTHM,TINIT,TEND,TPRINT,TOUTP,TMD,T2,TB,TE,
     $VOL1,VOLI,VOL,FINA,GWLA,DRZA,GPRHA,QDEEPA,ESA,EPA,PHSA,PRECA,FLXA,
     $ARER,BRER,AREL,BREL,FLX1,CHNL,CHND,CHNR,DKD,ALPHAR,DGRWL,SIMPR,
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     $TPR(52),PREC(366),CH(366),PHS(366),EP(366),ES(366),DRZ(366),
     $HNT(366),X(40),PRH(5,81),CON(5,81),CONDUC(41),CONIN(41),DMCAP(40),
     $RTEX(40),FLXS(41),THETA(4),SWC(5),SWCA(40),DOUTP(366,9),ESR(366)
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
      DATA IPL/1H+/,IMN/1H-/,IBL/1H /,ISL/1H//
C
C********************* PRINTING AND PLOTTING ***************************
      CPETR=CPTRA+CPSEV
      CETR=CTRA+CSEV
      CPINF=CPREC-CINTC
      CRUNO=CPINF-CINF
      IF(N.LE.ISD) CFLSD=1.E10
      IF(N.LE.ISD) CFLSDP=5.E10
      CFLSDN=CFLSD-CFLSDP
      FLXBUA=FLXS(N+1)
      IF(KOD(1).LT.6) FLXBUA=1.E10
      IF(KOD(1).EQ.0.OR.KOD(1).GT.3) QDEEPA=1.E10
      CQDN=CQD-CQDP
      CDELN=CDEL-CDELP
      IF(IPRT.EQ.0) GO TO 150
      WRITE(6,10) T,DT1,NTS,CPREC,CINTC,CPINF,CINF,CPETR,
     $CPTRA,CPSEV,CRUNO,CETR,CTRA,CSEV,FLXS(1),CFLSD,CFLSDP,CFLSDN,
     2FLXS(ISD+1),ISD,CFLBU,FLXBUA,CQD,CQDP,CQDN,QDEEPA,CDEL,CDELP,
     3CDELN,DEL,VOLI,VOL,GWLA,DRZA,N
10    FORMAT(1H1,'TIME :',F6.0,' DAYS',45X,'TIME STEP=',E10.3,' DAY',5X,
     $'NUMBER OF TIME STEP=',I4,//,
     $' CPREC    =',F7.3,' CM',6X,'CINTCEP =',F7.3,' CM',6X,'CPINFILT=',
     $F7.3,' CM',6X,'CINFILT =',F10.3,' CM',/,
     $' CPETR    =',F7.3,' CM',6X,'CPTRANSP=',F7.3,' CM',6X,'CPSEVAP =',
     $F7.3,' CM',6X,'CRUNOFF =',F10.3,' CM',/,
     $' CETR     =',F7.3,' CM',5X,'*CTRANSP =',F7.3,' CM*',4X,'*CSEVAP  =
     $',F7.3,' CM*',5X,'FLUX1   =',F10.6,' CM/DAY',/,
     $' CFLXSD   =',F7.3,' CM',6X,'CFLXSDP =',F7.3,' CM',6X,'CFLXSDN =',
     $F7.3,' CM',6X,'FLXSD   =',F10.6,' CM/DAY',7X,'ISD=',I3,/,
     $' CFLXBU   =',F7.3,' CM',56X,'FLXBU   =',F10.6,' CM/DAY',/
     $' CQDEEP   =',F7.3,' CM',6X,'CQDEEPP =',F7.3,' CM',6X,'CQDEEPN =',
     $F7.3,' CM',6X,'QDEEPA  =',F10.6,' CM/DAY',/,
     $' CDELTA   =',F7.3,' CM',6X,'CDELTAP =',F7.3,' CM',6X,'CDELTAN =',
     $F7.3,' CM',6X,'DELTA   =',E10.3,' CM',/,
     $' VOLINIT =',F7.3,' CM',6X,'VOL      =',F7.3,' CM',6X,'GWLA    =',
     $F7.1,' CM',6X,'DRZA    =',F10.1,' CM',11X,'N  =',I3)
      WRITE(6,20)
20    FORMAT(1X,/,' COMP. NR',2X,' LEVEL',3X,'THETA',4X,'PR.HEAD',3X,
     $' CONDUC',4X,'ROOT EXT',2X,'C.ROOT EXT',2X,'CUM.WATER',10X,
     $' FLUXES',10X,'COMP. NR',/,
     $13X,'(CM)',3X,'(VOL)',5X,'(CM)',5X,'(CM/DAY)',4X,'(1/DAY)',5X,
     $' (CM)',6X,'(CM)',13X,'(CM/DAY)',/)
C
      IF(N.EQ.NCS) GO TO 26
      N1=N+1
      DO 25 I=N1,NCS
         IF(KOD(1).EQ.0) FLXS(I+1)=DEL/DT
         IF(KOD(1).GT.0.AND.KOD(1).LT.4) FLXS(I+1)=QDEEPA
25    CONTINUE
26    V=0.0
      DO 30 I=1,NCS
         V=V+WC(I)*DX
         PHI=AMIN1(PH(I),0.0)
         WRITE(6,40) I,X(I),WC(I),PHI,CONDUC(I),RTEX(I),CRTEX(I),V,
     $   FLXS(I+1),I
30    CONTINUE
C
40    FORMAT(I8,F9.1,F8.3,(4(E11.3)),F11.3,E19.3,I10)
      IF(NCS.GT.20) WRITE(6,45)
45     FORMAT(1H1,//)
      WRITE(6,50) T
50    FORMAT(/,1H ,'****************************** SOIL MOISTURE CONTEN
     $T PROFILE AT TIME :',F6.0,' DAYS ********************************')
      WRITE(6,60)
60    FORMAT(1X,' LEVEL THETA',1X,'.0',7X,'0.1',7X,'0.2',7X,'0.3',7X,
     $'0.4',7X,'0.5',7X,'0.6',7X,'0.7',7X,'0.8',7X,'0.9',7X,'1.')
      WRITE(6,70)
70    FORMAT(1X,'  CM    VOL. +****+****+****+****+****+****+****+****+*
```

```
     ******************************************************************')
C
C
      DO 80 J=1,NCS
         IY=WC(J)*100.0+0.5
         I1=SWCA(J)*100.+.5
C
         DO 90 I=1,I1
            IF(IY.GT.I) IA(I)=IMN
            IF(IY.EQ.I) IA(I)=IPL
            IF(IY.LT.I) IA(I)=IBL
90       CONTINUE
C
         NY=I1+1
         DO 100 I=NY,99
            IA(I)=ISL
100      CONTINUE
         WRITE(6,110) X(J),WC(J),(IA(I),I=1,99)
80    CONTINUE
110    FORMAT(1X,F6.1,1X,F5.3,2H +,99A1,1H+)
      WRITE(6,70)
      WRITE(6,60)
C
      NPRA=NPRA+1
      IPRT=0
      DTM=DTMI
      TOUTP=TEND
      IF(NPRA.GT.NPR) GO TO 150
      IF(KOD(7).EQ.0) TPRINT=TPR(NPRA)
      DTM=AMIN1(DTMI,0.2*TPRINT)
      TOUTP=T+TPRINT
      IF(NTS.EQ.1) TOUTP=TINIT+TPRINT
      IF(NPRA.EQ.1) DT1=0.05
C
C********* STORAGE OF THE OUTPUT DATA AT THE END OF THE DAY ************
150   IF(ITS.EQ.0) GO TO 300
      ITS=0
      DOUTP(IAD,1)=CINF
      DOUTP(IAD,2)=(CTRA-CTRA2)
      DOUTP(IAD,3)=CTRA
      DOUTP(IAD,4)=(CSEV-CSEV2)
      DOUTP(IAD,5)=CSEV
      DOUTP(IAD,6)=CDELP
      DOUTP(IAD,7)=CDELN
      IF(KOD(1).GT.0.AND.KOD(1).LE.3) DOUTP(IAD,6)=CQDP
      IF(KOD(1).GT.0.AND.KOD(1).LE.3) DOUTP(IAD,7)=CQDN
      IF(KOD(1).EQ.5) DOUTP(IAD,6)=0.
      IF(KOD(1).EQ.5) DOUTP(IAD,7)=0.
      DOUTP(IAD,8)=VOL-VOLI
      DOUTP(IAD,9)=GWLA
      IF(KOD(1).GT.3) DOUTP(IAD,9)=1.E10
      CTRA2=CTRA
      CSEV2=CSEV
      IAD=IAD+1
C
C************** PRINTING OF THE OUTPUT DATA  ****************************
      IF(T.LT.TEND) GO TO 300
      WRITE(6,200)
200   FORMAT(1H1,35X,'******** TERMS OF THE WATER BALANCE ********',//,
     $1X,'TIME',5X,'CINFILT',5X,'TRANSP ',5X,'CTRANSP',5X,'SEVAP',4X,
     $'   CSEVAP   ',2X,' CFLXBOTP',3X,' CFLXBOTN ',4X,'VOL-VOLI',
     $4X,'GROUNDW,LEV',5X,'TIME',/,13X,'CM',7X,'CM/DAY',8X,'CM',8X,
     $'CM/DAY',8X,'CM',10X,'CM',10X,'CM',10X,'CM',12X,'CM',/)
      IFD=TINIT+1
      ILD=T
C
      DO 210 I=IFD,ILD
         WRITE(6,220) I,(DOUTP(I,J),J=1,9),I
210   CONTINUE
220   FORMAT(I4,8(2X,F10.2),6X,F10.1,7X,I3)
      STOP
C
300   RETURN
      END
C
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      BLOCK DATA
      COMMON/CUM/ CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CQDN,CDEL,CDELP,DEL,DVOL,
     $CRTEX(40)
      DATA CPREC,CINTC,CINF,CPTRA,CPSEV,CTRA,CTRA1,CTRA2,CSEV,
     $CSEV2,CFLSD,CFLSDP,CFLBU,CQD,CQDP,CDEL,CDELP,DEL,DVOL
     $/19*0.0/,CRTEX/40*0.0/
      END
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LITERATURE

BRUIN, H.A.R. DE en W.N. LABLANS, 1980. Een test van een nieuwe berekeningswijze van de open-water verdamping volgens Penman ten behoeve van snelle voorlichting omtrent de verdamping. KNMI, Verslagen V-357, De Bilt.

ERNST, L.F., 1962. Grondwaterstromingen in de verzadigde zone en hun berekening bij aanwezigheid van horizontale open leidingen. Versl. Landbouwk. Onderz. 67.15. Pudoc, Wageningen. 189 p.

ERNST, L.F. en R.A. FEDDES, 1979. Invloed van grondwateronttrekking voor beregening en drinkwater op de grondwaterstand. Nota ICW 1116. 10 p.

FEDDES, R.A., P.J. KOWALIK and H ZARADNY, 1978. Simulation of field water use and crop yield. Simulation Monographs. Pudoc, Wageningen. 189 p.

HAVERKAMP, R., M. VAUCLIN, J. TOUMA, P.J. WIERENGA and G. VACHAUD, 1977. A comparison of numerical simulation models for one-dimensional infiltration. Soil Sci. Soc. Am. Proc. 41: 285-294.

LAAT, P.J.M. DE, 1980. Model for unsaturated flow above a shallow water table, applied to a regional sub-surface flow problem. Doc. thesis, Pudoc, Wageningen. 126 p.

MONTEITH, J.L., 1965. Evaporation and environment. Proc. Symp. Soc. Exp. Biol. 19: 205-234.

PRIESTLEY, C.H.B. and R.J. TAYLOR, 1972. On the assessment of surface flux and evaporation using large-scale parameters. Month. Weather Rev. 100: 81-92.

REMSON, I., G.M. HORNBERGER and F.J. MOLZ, 1971. Numerical methods in subsurface hydrology. Wiley Intersci., New York. 389 p.

RITCHIE, J.T., 1972. A model for predicting evaporation from a row crop with incomplete cover. Water Resour. Res. 8(5): 1204-1213.

RIJTEMA, P.E., 1965. An analysis of actual evapotranspiration. Agric. Res. Rep. 859. Pudoc, Wageningen. 107 p.

VAUCLIN, M., R. HAVERKAMP et G. VACHAUD, 1979. Résolution numérique d'une équation de diffusion non linéaire. Application à l'infiltration de l'eau dans les sols non-saturés. Presses Universitaires de Grenoble.

WESSELING, J.G. and R.A. FEDDES, 1979. Introduction of suction as a lower boundary condition in program SWATR (for deep water tables). Nota ICW 1127. 38 p.