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Wageningen

INTRODUCTION OF SUCTION AS A LOWER BOUNDARY CONDITION IN PROGRAM SWATR (FOR DEEP WATER TABLES)

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Hun inhoud varieert sterk en kan zowel betrekking hebben op een eenvoudige weergave van cijferreeksen, als op een concluderende discussie van onderzoeksresultaten. In de meeste gevallen zullen de conclusies echter van voorlopige aard zijn omdat het onderzoek nog niet is afgesloten.
Bepaalde nota's komen niet voor verspreiding buiten het Instituut in aanmerking

C O N T E N T S

I. INTRODUCTION

This paper describes an extension of the SWATR program as developed by FEDDES, KOWALIK and ZARADNY (1978). The program can be applied to problems dealing with the transient water flow in a heterogeneous soil root system. Input data in the model are: soil moisture retention and hydraulic conductivity relationships for upper and lower soil layer; depth of the root zone; critical values of the root extraction term; initial soil moisture profile; boundary conditions at the soil surface of both potential transpiration and potential soil evaporation rate; as lower boundary condition the depth of the groundwater table is specified, i.e. the depth where the soil moisture pressure head is zero. Output data of the model include cumulative values of transpiration, of integrated water content over the soil profile, of upward/downward flows, of runoff, of moisture content and root extraction both as functions of depth and time.

The program is able to handle maximally 25 nodal points, thus the soil profile is discretized in 25 constant depth increments. With shallow water tables, 1-2 m say, these depth increments are rather small.

With deep water tables, however, increments become too large to allow accurate computation. In these situations variations in the hydrological conditions of the deep subsoils close to the watertable are generally small. Most of the moisture variations occur in the top soil i.e. in the root zone and in a restricted zone below it. Therefore for most applications it will be sufficient to consider in the computations only the 2 to 3 meter top soil, say. This allows a densily spaced nodal network, which will increase the accuracy of computation. Moreover for those flow situations where it is not necessavarious moments of time

KOD(6) = 2: prescribed values of soil surface flux, maximum suction value at the surface and potential transpiration rate are calculated by SWATR from meteorological and external conditions as functions of time

7. Water table as bottom boundary

At the lower boundary of the considered soil profile the program expects the water table (i.e. the phreatic surface, where $h = 0$). The depth of the water table must be given for each day of computation.

The distance between the nodal points is kept constant throughout the whole run of the program. The depth of the water table may vary with time. Because the time step is variable and the depth of the water table is given only at each day, the depth of the water table at times in between the days must be computed by interpolation. The nodal point just above the water table is computed (N1). From the place of this point and the depth of the water table, the distance between nodal point N1 and the water table (SN1N) is computed (fig. 1). This distance is used in computing the suction in point N1 and the flux from the phreatic surface.

b. Estimation of the time step

The flux q_L in the lowest part of the unsaturated zone (between nodal point N1 and the water table) is used for the calculation of the time step. According to Darcy's equation this flux is computed in two different ways (fig. 2):

1. if SN1N < DXH: $q_L = \left| K \cdot \left\{ - \frac{0.5 * (S(N1) + S1(N1))}{SN1N} + Z \right\} \right|$

2. if SN1N $\geqslant$ DXH: $q_L = \left| K \cdot \left\{ \frac{SN1N - DXH - .5 * (S(N1) + S1(N1))}{DXH} + Z \right\} \right|$

where			
	N1	= number of nodal point just above the water table	
	SN1N	= distance between nodal point N1 and water table	(cm)
	K	= conductivity	($cm.day^{-1}$)
	DXH	= half of the distance between the nodal points	(cm)
	S(N1)	= suction in nodal point N1 computed in last iteration	(cm)

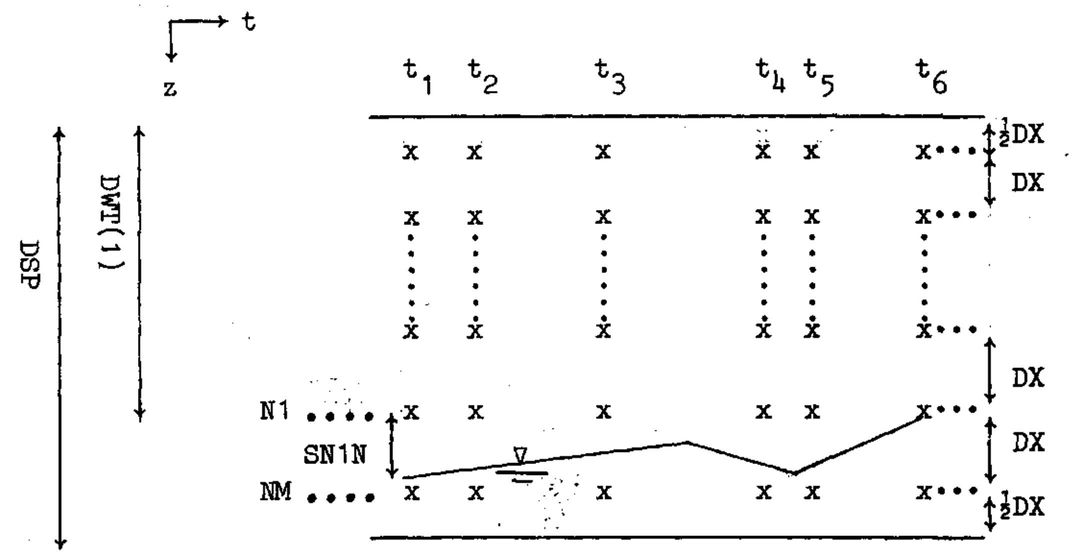

Fig. 1. Illustration of the distribution of nodal points along the soil profile and the fluctuation of the water table depth

S1(N1) = suction in nodal point N1 computed in before-last iteration

Z = constant which can have two values:

Z = 1 if the origin of the z-axis is at the soil surface

Z = -1 if the origin of the z-axis is at the bottom of the system

The program then checks which of the fluxes is the largest: the one just above the water table (q_L) or the one in the top of the profile (q_U). The time step is then calculated according to:

$$\Delta t^{i+1} = f \cdot \frac{DX}{q^i}$$

where Δt^{i+1} = time step i+1

q^i = max $\{q_L, q_U\}$ at time i

f = constant between 0.015 and 0.035

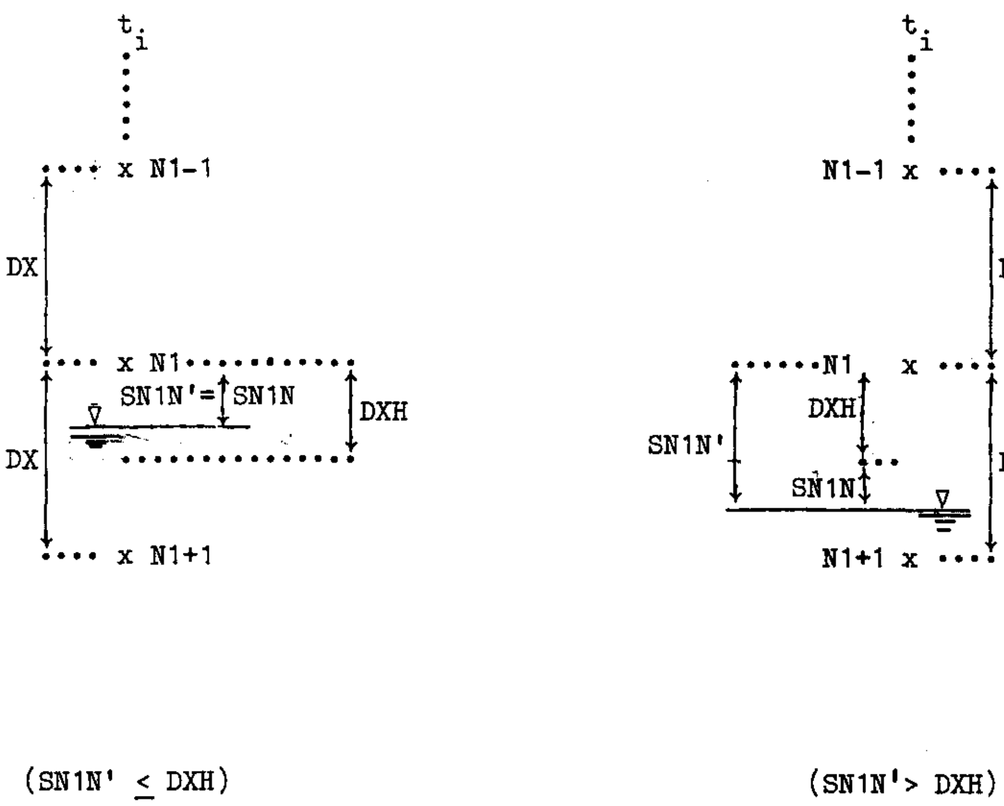

Fig. 2. Definition of SN1N above the water table in order to calculate the q_L for two cases. SN1N' is the height of point N1 above the water table

III. MODIFIED PROGRAM SWATR

a. Specified suction as bottom boundary condition

When the water table is deep it is desirable to have a possibility of using only a small part of the soil profile. The lower boundary then must be given as a specified suction. In this chapter the changes introduced in the original program to achieve this, are discussed.

To tell the computer whether it has to deal with a specified suction or the water table as the lower boundary, the variable KOD(7) has been introduced with the following meaning:

KOD(7) = 0: depth of water table is given (original problem), i.e. the depth where the suction is zero

KOD(7) = 1: time varying suction is specified at a given depth (DIST)

KOD(7) = 2: constant suction is specified at a given depth (DIST)

In order to get the same nodal point distribution as in the original program, the computation of the distance between the nodal points (DX) is performed in a slightly different way. The reason for this change is to be able to compare in the nodal points results obtained with KOD(7) = 0, with those obtained using KOD(7) ≠ 0.

KOD(7) = 0: DX = DSP/NM

KOD(7) ≠ 0: DX = DIST/(NM-.5)

where:	DX	= constant distance between nodal points	(cm)
	DSP	= depth of soil profile	(cm)
	NM	= number of nodal points	
	DIST	= depth at which suction is specified	(cm)

A disadvantage of this method for KOD(7) ≠ 0 is that the lowest nodal point represents only half a length DX (fig. 3). This has to be taken into account when computing the moisture content of the soil profile.

Instead of the depth of the water table (DWT), the specified suction (GSUC) is read as an input. The values of GSUC are placed in an EQUIVALENCE-statement with the DWT-values, so the increase in memory use is minimal.

In the case of KOD(7) ≠ 0, the value of N1 is set equal to the value of NM. Just as for the depth of root zone [DRZ, KOD(3) = 0] and for the depth of the water table [DWT, KOD(7) = 0], the suction must be specified for each day GSUC, [KOD(7) = 1]. In the same way as the variables DRZ and DWT the suction at a time T1 will be interpolated from the given values. The interpolated suction will be denoted GIVSUC.

The variables SNIN and CFWT, which are not used when KOD(7) ≠ 0, are set equal to .0001 and 10 * DX.

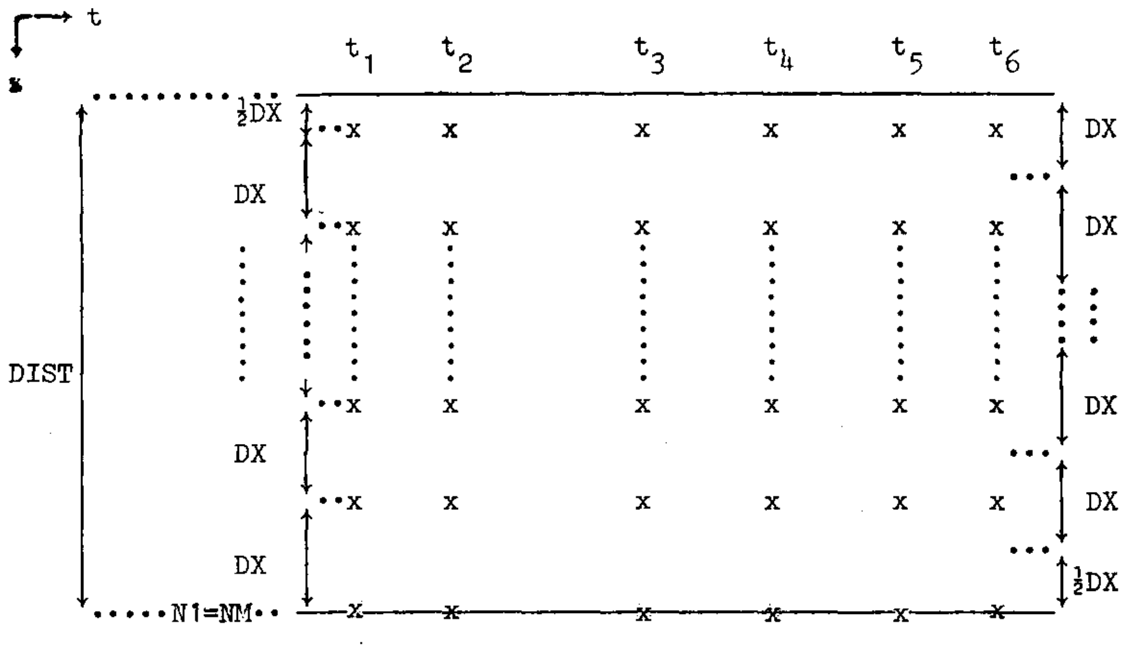

Fig. 3. Distribution of nodal points when KOD(7) ≠ 0. At the left hand side the distances are given, at the right hand side the length of the profile that each point represents

The iteration procedure has not been changed except for one thing (see fig. 4). The original procedure is:

$$\bar{h}_1 = \frac{1}{4} \cdot (h^{i}_{NM-1} + h^{i}_{NM} + h^{i-1}_{NM-1} + h^{i-1}_{NM})$$

where h^{i}_{NM} is the suction in nodal point NM at time i.

But h^{i}_{NM} and h^{i-1}_{NM} are prescribed now, and denoted GIVSUC and OLDSUC respectively, so the equation becomes

$$\bar{h}_1 = \frac{1}{4} \cdot (h^{i}_{NM-1} + h^{i-1}_{NM-1} + \text{GIVSUC} + \text{OLDSUC})$$

When computing the new suction after an iteration, the suction in point NM is not computed, but set equal to the prescribed suction GIVSUC.

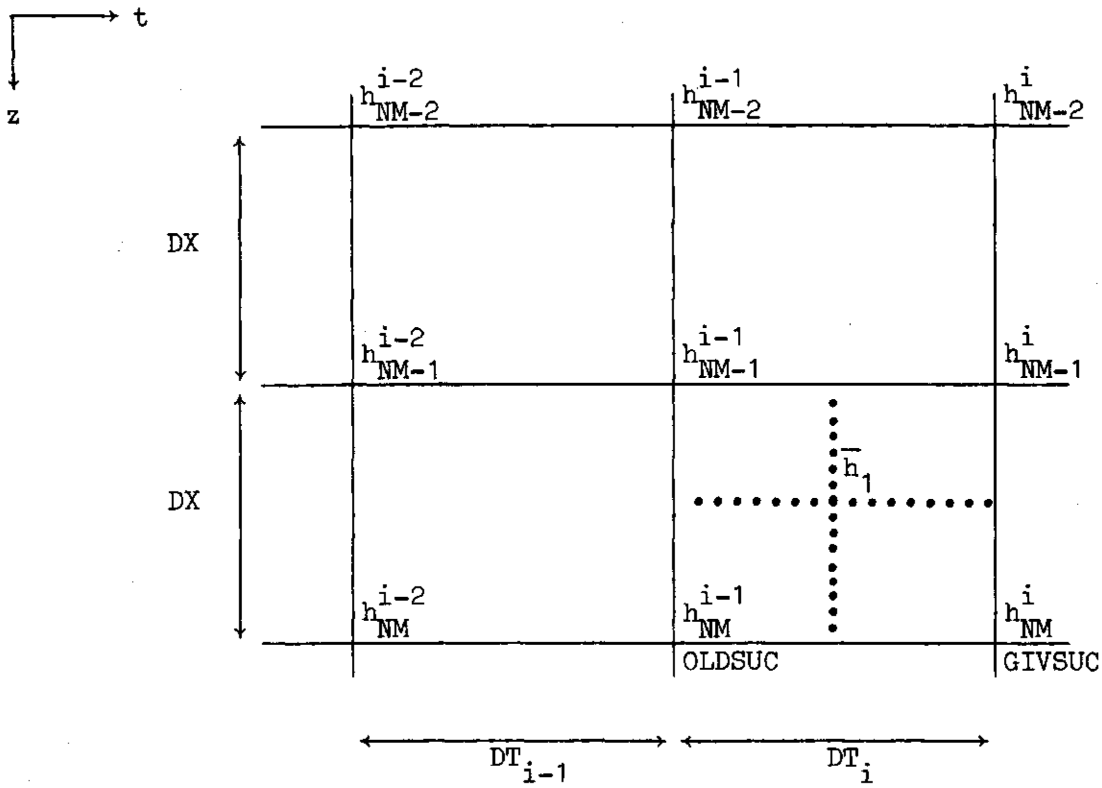

Fig. 4. Iteration procedure when KOD(7) ≠ 0. Suction is prescribed in nodal point NM

Because of the constant depth of point N1 and not using SN1N, the flux in the lowest part of the profile is computed as:

$$q_L = \left| k \cdot \left\{ \frac{S(NM) - S(NM-1)}{DX} + Z \right\} \right|$$

with Z = 1 (origin of the z-axis at the soil surface).
If there is only a small difference in suction between two neighbouring nodal points, it is possible that the flux, computed by SWATR, will be very small and the sign of it may become just opposite of the sign one may expect from the suction profile. This is due to the Z-term in the equation of Darcy:

$$q = k \cdot \left\{ \frac{S(I) - S(I-1)}{DX} + 1 \right\}$$

If $-1 \leqslant \frac{S(I) - S(I-1)}{DX} < 0$ then the flux will be positive, although it might be expected from the suctions that the flux would be negative. So, with very small suction gradients in the lower part of the profile, the computer output may sometimes list under the heading 'FLUX' very small numbers, which are practically of no importance.

b. Computation of soil evaporation

Cumulative soil evaporation may be derived from the water balance (fig. 5).

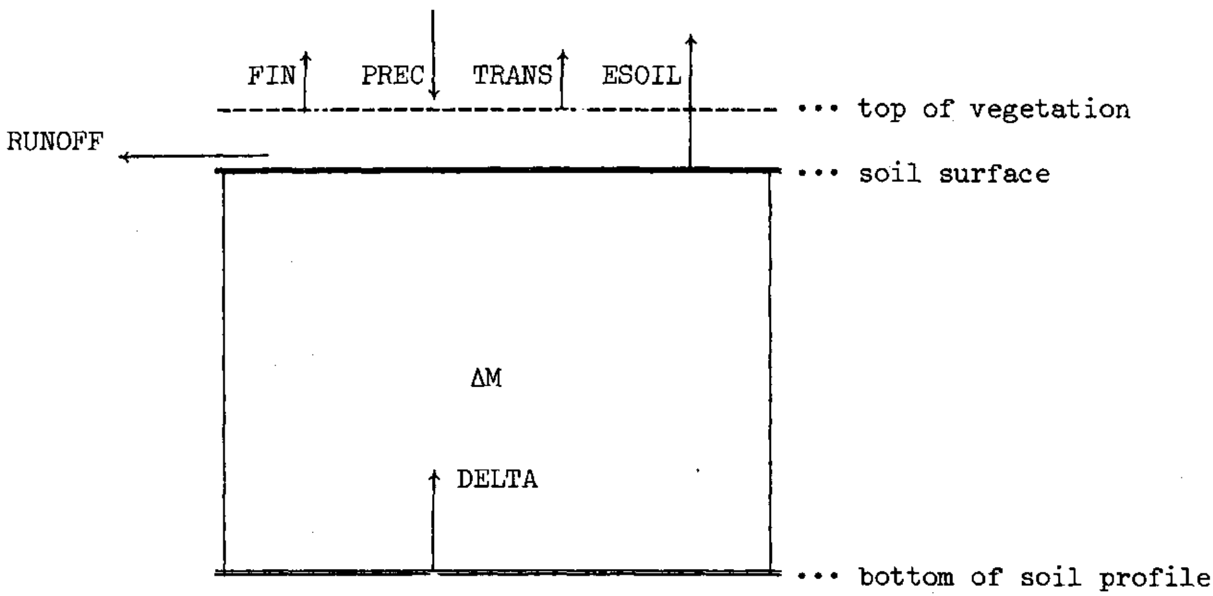

Fig. 5. Water balance of a soil profile

In the following water balance equation the terms from SWATR are used. These have the following meaning:

PREC = precipitation (mm)
FIN = interception (mm)
RUNOFF = runoff (mm)
ESOIL = soil evaporation (cm)

TRANS = transpiration (cm)

DELTA = amount of water coming from the zone below the computing zone (cm)

ΔM = change in moisture content of the soil (cm)

From the water balance (in = out + change in moisture content) we now get

$$.1 \times (PREC - FIN - RUNOFF) + DELTA = ESOIL + TRANS + \Delta M$$

Now suppose the effective precipitation is INFIL = PREC - FIN then the water balance can be written as

$$.1 \times (INFIL - RUNOFF) + DELTA = ESOIL + TRANS + \Delta M$$

or

$$ESOIL = .1 \times (INFIL - RUNOFF) + DELTA - TRANS - \Delta M$$

Accumulated from time t_0 to time t_1 the equation becomes

$$CUMESOIL = .1 \times (CUMINFIL - RUNOFFC) + SDELTA - CUMTRANS + VOL(t_0) - VOL(t_1)$$

where CUMESOIL = cumulative soil evaporation (cm)

CUMINFIL = cumulative effective precipitation (mm)

RUNOFFC = cumulative runoff (mm)

SDELTA = amount of water coming from the zone below the bottom of the soil profile considered during the time interval $t_0 - t_1$ (cm)

CUMTRANS = cumulative transpiration (cm)

$VOL(t_0)$ = moisture content of profile at time t_0 (cm)

$VOL(t_1)$ = moisture content of profile at time t_1 (cm)

According to the last equation ESOIL is computed, and the result is given for every time a printout is requested.

IV. MODIFICATIONS IN INPUT DECK

With regard to the original input of SWATR, (see FEDDES et al., 1978), a few changes have to be introduced. The changes are in the groups B, E and L. These groups are described in detail below.

Group	Columns	Format	Symbol	Description
B	1- 5	I5	KOD(1)	
	6-10	I5	KOD(2)	
	11-15	I5	KOD(3)	the meaning of KOD is described in sections
	16-20	I5	KOD(4)	II.a. and III.a.
	21-25	I5	KOD(5)	
	26-30	I5	KOD(6)	
	31-35	I5	KOD(7)	
	1- 5	I5	LU	minimum value (LU = $100.\theta_{min}$) of water content of upper soil layer
	6-10	I5	MU	maximum value (MU = $100.\theta_{sat}$) of water content of upper soil layer)
	11-15	I5	LL	as LU, but for lower soil layer
	16-20	I5	ML	as MU, but for lower soil layer
	21-25	I5	NM	maximum number of nodal points under consideration
	26-30	I5	NL	number of nodal point where the physical properties of the soil change (boundary between upper and lower layer)
	31-35	I5	LMAX	desired maximum number of iterations
	36-40	I5	L2	maximum number of daily outputs to be printed (see also group Z)
	1- 5	I5	L(1)	
	6-10	I5	L(2)	
	11-15	I5	L(3)	
	16-20	I5	L(4)	see for description of the L's the cited
	21-25	I5	L(5)	reference
	26-30	I5	L(6)	
	31-35	I5	L(7)	
	36-40	I5	L(8)	
	41-45	I5	L(9)	
	46-50	I5	L(10)	
				Group B consists of 3 cards
E	1- 9	F9.4	DT	see cited reference
	10-18	F9.4	STM	" " "
	19-27	F9.4	TM	" " "
	28-36	F9.4	WSP	" " "
	37-45	F9.4	DS	" " "

Group	Columns	Format	Symbol	Description
E(cont.)	46-54	F9.4	DSP	see cited reference
	55-63	F9.4	EPS	" " "
	64-72	F9.4	FAC	" " "
	73-79	F7.2	DIST	Depth at which suction is given when KOD(7) ≠ 0. If KOD(7) = 0 then DIST must be set equal to 0.00
L	If KOD(7) = 0: see cited reference			
	If KOD(7) = 1: then			
	1-10	E10.4	GSUC(1)	prescribed suction at depth DIST on day 1
	11-20	E10.4	GSUC(2)	
	21-30	E10.4	GSUC(3)	
	31-40	E10.4	GSUC(4)	as above, but for 2^{nd}, 3^{rd}, ..., 8^{th} day of calculation, etc.
	41-50	E10.4	GSUC(5)	
	51-60	E10.4	GSUC(6)	
	61-70	E10.4	GSUC(7)	
	71-80	E10.4	GSUC(8)	
	If KOD(7) = 2: then			
	1-10	E10.4	GSUC(1)	constant prescribed suction at depth DIST

LITERATURE

FEDDES, R.A., P.J. KOWALIK and H. ZARADNY, 1978. Simulation of field water use and crop yield. Simulation monograph ISBN 90-220--0676-X, PUDOC, Wageningen, the Netherlands.
For U.S.A., Canada and Latin America: ISBN 0-470-26463-2, Halsted Press, John Wiley & Sons, New York - Toronto.

```
1=SIMULATION MODEL SWATR, VERSION MAY 1979.
2=    2    1    0    0    1    2    1
3=    0   60    0   50   23   11   10    7
4=  172  179   28   21    6   10    1    1    1    1
5=     1.000      .600       .500    10.000   172.000   179.000
6=      .100    32.500      4.700  1000.000 20000.000     1.000
7=     .0500     .5000    7.0000     .0150     .0350  100.0000     .0100  24.0000  180.00
8=      13.0      0.77      4.77      395.       11.      .010        .0
9=      14.8      0.93      5.58      307.       12.      .010        .0
10=     13.6      0.89      4.09      240.       12.      .010        .0
11=     13.6      0.95      2.46      176.       13.      .010       2.0
12=     16.7      0.86      5.49      301.       13.      .010       7.7
13=     13.3      0.89      3.92      428.       13.      .020        .0
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15=     14.2      0.90      5.40      404.       14.      .030        .0
16= .4120E+03 .4400E+03 .4600E+03 .4800E+03 .4400E+03 .3900E+03 .3850E+03 .4120E+03
17=      76.0      77.0      78.0      79.0      80.0      81.0      82.0      83.0
18= .4800E+04 .3700E+04 .2800E+04 .2000E+04 .1470E+04 .1300E+04 .1140E+04 .1040E+04
19= .9500E+03 .8600E+03 .7900E+03 .7200E+03 .6500E+03 .6000E+03 .5600E+03 .5200E+03
20= .5000E+03 .4850E+03 .4700E+03 .4550E+03 .4400E+03 .4300E+03 .4200E+03
21= .1000E+08 .5248E+07 .3162E+07 .2042E+07 .1445E+07 .1072E+07 .8511E+06 .6607E+06
22= .5433E+06 .4365E+06 .3548E+06 .2951E+06 .2399E+06 .1905E+06 .1622E+06 .1288E+06
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37= 0.330E-08 0.440E-08 0.580E-08 0.740E-08 0.980E-08 0.134E-07 0.166E-07 0.227E-07
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39= 0.252E-06 0.334E-06 0.448E-06 0.575E-06 0.785E-06 0.104E-05 0.137E-05 0.176E-05
40= 0.233E-05 0.318E-05 0.420E-05 0.548E-05 0.713E-05 0.988E-05 0.133E-04 0.170E-04
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43= 0.120E-02 0.220E-02 0.500E-02 0.170E-01 0.230E-01
44= 0.100E-09 0.200E-09 0.300E-09 0.500E-09 0.900E-09 0.130E-08 0.180E-08 0.250E-08
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46= 0.282E-07 0.385E-07 0.509E-07 0.684E-07 0.891E-07 0.122E-06 0.151E-06 0.194E-06
47= 0.252E-06 0.334E-06 0.448E-06 0.575E-06 0.785E-06 0.104E-05 0.137E-05 0.176E-05
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49= 0.233E-04 0.298E-04 0.407E-04 0.603E-04 0.982E-04 0.158E-03 0.249E-03 0.457E-03
50= 0.500E-02 0.176E-01 0.230E-01
51=      172.        0.        1.        1.        1.        1.        1.        1.
52=        1.
```

DAY=179.00   CUMULATIVE TRANS.= .942 CM   AVERAGE TRANS.= 1.08 MM/DAY   NUMBER OF TIME STEP= 46   NUMBER OF ITER.=   0

RUNOFF= 0.00 MM   DELTA=   .05 SDELTA=   .08 CM   THETA OF LOWER LAYER AT THE CONTACT WITH UPPER=.3956 CM**3/CM**3

CUMULATIVE SOIL EVAPORATION =   1.56 CM

Z CM	THETA VOL.	CUM. WATER CM	SUCTION CM	FLUX CM/DAY	ROOT EXTR. 1/DAY
4.0	.2902	2.324	.7562E+04	-.121E+00	0.
12.0	.3118	4.815	.4960E+04	-.109E-01	.145E-02
20.0	.3263	7.426	.3627E+04	-.973E-02	.209E-02
28.0	.3403	10.148	.2680E+04	-.953E-02	.221E-02
36.0	.3526	12.969	.2111E+04	-.789E-02	.229E-02
44.0	.3612	15.858	.1774E+04	-.608E-02	.234E-02
52.0	.3669	18.793	.1551E+04	-.499E-02	.237E-02
60.0	.3716	21.766	.1389E+04	-.458E-02	.239E-02
68.0	.3776	24.787	.1243E+04	-.539E-02	.241E-02
76.0	.3843	27.862	.1085E+04	-.866E-02	.334E-02
84.0	.3956	31.027	.8396E+03	-.105E-01	0.
92.0	.4018	34.241	.7288E+03	-.602E-02	0.
100.0	.4076	37.502	.6595E+03	-.450E-02	0.
108.0	.4119	40.798	.6067E+03	-.373E-02	0.
116.0	.4151	44.118	.5654E+03	-.307E-02	0.
124.0	.4176	47.459	.5327E+03	-.240E-02	0.
132.0	.4195	50.815	.5075E+03	-.175E-02	0.
140.0	.4211	54.183	.4877E+03	-.126E-02	0.
148.0	.4223	57.562	.4718E+03	-.886E-03	0.
156.0	.4234	60.949	.4587E+03	-.671E-03	0.
164.0	.4243	64.343	.4464E+03	-.109E-02	0.
172.0	.4258	67.750	.4279E+03	-.143E-02	0.
180.0	.4270	71.166	.4120E+03	-.127E-02	0.

SOIL MOISTURE CONTENT PROFILE

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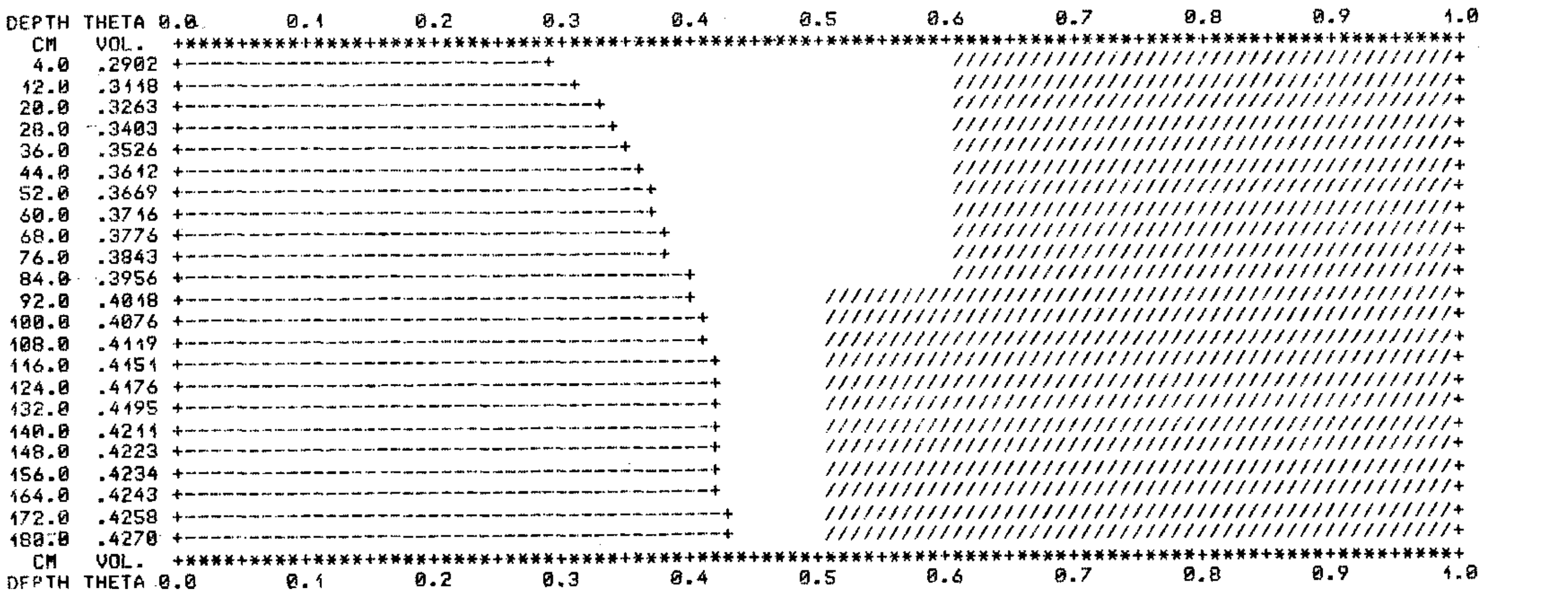

```
      PROGRAM SWATR(DATA,OUTPUT,TAPE8=DATA)
C*****SIMULATION MODEL OF SOIL WATER DYNAMICS FOR LAYERED SOIL PROFILE
C*****WITH FLUCTUATING WATER TABLE AND WATER UPTAKE BY ROOTS
C*****THIS PROGRAM IS DEVELOPED BY R.A.FEDDES,INSTITUTE FOR LAND AND
C*****WATER MANAGEMENT RESEARCH,P.O.BOX 35,6700 AA  WAGENINGEN,
C*****THE NETHERLANDS; P.J.KOWALIK,INSTITUTE OF HYDROTECNICS,TECHNICAL
C*****UNIVERSITY,P.O.BOX 612,80-952 GDANSK,POLAND; H.ZARADNY,INSTITUTE
C*****OF HYDRO- ENGINEERING,POLISH ACADEMY OF SCIENCES,UL.CYSTERSOW 11,
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C.....*************************************************************
C.....*****************VERSION MAY 1979****************************
C.....*************************************************************
C     -------------------------------------------------------------
C"""""THE NAME OF THIS PROGRAM CONSISTS OF THE FIRST LETTERS OF 5 WORDS:
C"""""*SOIL*,*WATER*,*ACTUAL*,*TRANSPIRATION*,*RATE*-I.E.-S-W-A-T-R-
C     -------------------------------------------------------------
C=====THE FOLLOWING VALUES MUST BE PRESCRIBED:
C-----THE INITIAL CONDITION-VALUE OF THETA(THEN KOD(5)=0)
C                            -KOD(5)=1 MUST BE SET
C                            -SUCTION(NEGATIVE VALUE OF PRESSURE HEAD),
C-----THE BOUNDARY CONDITIONS (DAILY VALUES):
C.....AT THE BOTTOM-DEPTH OF WATER TABLE
C.....AT THE SURFACE-A) TEM-TEMPERATURE OF AIR(DEGREES CELCIUS)
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 IF L(7)=0,OTHER-
C                            WISE IN CAL/CM**2/DAY IF L(7))0)
C                       CH-CROP HEIGHT(CM)
C                       SC-SOIL COVER(FRACTION)
C                       FLUX-PRECIPITATION(MM/DAY)
C                       FOR CASE A KOD(6)=2
C                 OR  B)-EP-POTENTIAL PLANT TRANSPIRATION(MM/DAY)
C                       FLUX-SURFACE FLUX-(UP:SIGN-,DOWN:SIGN+)(MM/DAY)
C                       SGL-CRITICAL VALUE OF SUCTION AT THE SURFACE(CM)
C                       FOR CASE B KOD(6)=1
C                 OR  C)-THETA(CM**3/CM**3) IF KOD(6)=0
C-----THE DEPTH OF ROOT ZONE(CM)
C
C=====MAXIMALLY CAN BE USED:
C     365-VALUES OF THE BOUNDARY CONDITION(1 YEAR)
C     80-VALUES OF PRESSURE HEAD AND CONDUCTIVITY(FOR EVERY LAYER)
C     25-NODAL POINTS OF THE SOIL PROFILE
C     52-OUTPUTS
C==================================================================
      INTEGER PRZ,PT
      REAL INFILT,INFILTA
      DIMENSION KOD(7),IA(99),TEM(365),CH(365),RH(365),U(365),HNT(365),
     1SC(365),FLUX(365),DWT(365),DRZ(365),CU(80),CL(80),SU(80),WCS(365),
     2SL(80),CHU(80),CHL(80),R1(25),R2(25),QK(25),W(25),W2(25),S(25),
     3S1(25),S2(25),SN1(25),SN2(25),X(25),EP(365),SGL(365),IB(69),KA(5),
     4HED(20),TR(52),L(10),IX(52,25,5),TRA(364),KM(12),GSUC(365),
     5INFILT(365)
      EQUIVALENCE (CH,EP),(RH,SGL,WCS),(HNT,DRZ,TRA),(TEM(1),CHL(1)),
     1(TEM(81),CHU(1)),(TEM(161),SU(1)),(TEM(241),R1(1)),(TEM(266),
     2R2(1)),(TEM(291),QK(1)),(TEM(316),W(1)),(TEM(341),W2(1)),(U(1),
     3CL(1)),(U(81),SL(1)),(U(161),CU(1)),(U(241),S1(1)),(U(266),S2(1)),
     4(U(291),S(1)),(U(316),SN1(1)),(U(341),SN2(1)),(IA(1),IB(1)),(IA(70
     5),KM(1)),(SC,DWT,GSUC)
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
      COMMON/BONC/ DWT,SGL,EP,DRZ,FLUX,INFILT
      COMMON/SINK/ SM8,SMU1,SML1,SM2,SM3,QM,SMM,PRZ,AQ,BQ
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      COMMON/FACT/ TEM,U
      COMMON/DECL/ HED,L
      DATA KA/10H1000*W(J) ,10H   10*V   ,10H  100*PF  ,10H  1000*Q  ,10
     1H10000*QR  /,L3,L4,L5,L6,L7,L8,ITER,ITERM,ITIME/9*0/,GG,GG1,Z,ZZ,
     2TINIT,RUNOFF,VOL1,SDELTA/8*0.0/,END/4HEND /,RESTAR/4HREST/,L1/1*1/
      NER=0
10    READ(8,20) HED
20    FORMAT(20A4)
      IF(HED(1).EQ.END ) STOP
C=====GENERAL INFORMATION:
C     LU,MU,LL,ML-NUMBERS DESCRIBING LIMIT OF ARRAY(PRESSURE HEAD,
C     CONDUCTIVITY)
C     NM-MAXIMUM NUMBER OF NODAL POINTS
C     NNL-NODAL POINT WHERE THE SOIL PROFILE IS LAYERED
C     L2-MAXIMUM NUMBER OF OUTPUT
C     IMAX-MAXIMUM NUMBER OF ITERATIONS
C     FAC,FAC1-TIME CONSTANTS DEPENDING ON UNITS USED IN PROBLEM
C     SWCU,SWCL-SATURATED WATER CONTENT  OF UPPER AND LOWER LAYER
C     AA-FACTOR(0.7<AA>1.0)
C     RNAM,TB,TE-MAX. VALUE OF ROOTING DEPTH NON-ACTIVE AND:
C     BEGINNING AND END RNA OCCURS
C     SMB,SML1,SMU1,SM2,SM3,AQ,BQ-VALUES DESCRIBING SINK TERM
C     DT,STM,TM,WSP,DS-STARTING TIME STEP AND VALUES DESCRIBING
C     VARIATION OF TIME STEP FOR NEXT STAGES OF COMPUTATION
C     STM-IT IS RECOMMENDED TO SET STM EQUAL TO 10*DT
C     TM-OUTPUTS TIME STEP
C     WSP-IT IS RECOMMENDED TO SET WSP BETWEEN 0.015 AND 0.035
C     DS-ESTIMATED MAX. TIME STEP OF COMPUTATION(DTMAX=TM*DS)
C     DSP-DEPTH OF SOIL PROFILE(DSP=DX*NM)
C     EPS-MAXIMUM RELATIVE CHANGE IN THE VALUES OF SUCTION BETWEEN
C         ANY TWO SUCCESSIVE ITERATIONS(FRACTION)
C-----L-10 VALUES: L(1)-FIRST DAY OF CALCULATION(FROM BEGINNING OF YEAR)
C                  L(2)-LAST DAY OF CALCULATION
C                  L(3)-NUMBER OF DAYS IN FEBRUARY(28 OR 29)
C                  L(4)-DATE OF THE BEGINNING OF CALCULATION
C                  L(5)-FIRST MONTH OF CALCULATION
C                  L(6)-LAST MONTH OF CALCULATION
C                  L(7)-IF EQUALS 0-NET RADIATION IN W/M**2;
C                       IF EQUALS 1-NET RADIATION IN CAL/CM**2/DAY
C                  L(8),L(9),L(10)-VALUES OF 0 OR 1 MUST BE SET
C
C --- THE MEANING OF THE ELEMENTS OF THE ARRAY KOD IS THE FOLLOWING:
C ---    KOD(1) : 0 = SUCTION MUST BE GIVEN AS A TABLE OF S(SUCTION)
C ---                 VERSUS MOISTURE CONTENT W,THE HYDRAULIC CONDUCTIVI-
C ---                 TY AN AN ANALYTICAL FUNCTION OF S.
C ---             1 = SUCTION AS A FUNCTION OF MOISTURE CONTENT,
C ---                 HYDRAULIC CONDUCTIVITY AS A FUNCTION OF SUCTION.
C ---             2 = SUCTION AS A TABLE OF MOISTURE CONTENT,
C ---                 HYDRAULIC CONDUCTIVITY AS A TABLE OF MOISTURE
C ---                 CONTENT
C ---    KOD(2) : 0 = CALCULATION STARTS FROM T = 0,
C ---             1 = CALCULATION STARTS FROM T > 0.
C ---    KOD(3) : 0 = DEPTH OF ROOTZONE IS VARYING WITH TIME,
C ---             1 = DEPTH OF ROOTZONE IS CONSTANT WITH TIME.
C ---    KOD(4) : 0 = Z = 0 AT THE SOIL SURFACE, SO VERTICAL FLOW IS
C ---                 POSITIVE DOWNWARD,
C ---             1 = HORIZONTAL FLOW(NOT YET INCLUDED IN PROGRAM)
C ---             2 = Z = 0 AT THE BOTTOM OF THE SYSTEM, SO VERTICAL FLOW
C ---                 IS POSITIVE UPWARD (NOT YET INCLUDED IN PROGRAM)
C ---    KOD(5) : 0 = INITIAL VALUE IS GIVEN AS A VALUE OF MOISTURE
C ---                 CONTENT
C ---             1 = INITIAL VALUE IS GIVEN AS A VALUE OF SUCTION.
C ---    KOD(6) : 0 = PRESCRIBED VALUE OF POTENTIAL TRANSPIRATION RATE
C ---                 AND WATER CONTENT AT THE SURFACE AT VARIOUS MOMENTS
C ---                 OF TIME
C ---             1 = PRESCRIBED SOIL-SURFACE FLUX, MAXIMUM SUCTION VALUE
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C ---                 AT THE SURFACE AND POTENTIAL TRANSPIRATION RATE ALL
C ---                 AT VARIOUS MOMENTS OF TIME.
C ---             2 = PRESCRIBED VALUES OF SOIL-SURFACE FLUX, MAXIMUM SUC
C ---                 TION VALUE AT THE SURFACE AND POTENTIAL TRANSPIRAT
C ---                 ION ARE CALCULATED BY SWATR FROM METEOROLOGICAL AND
C ---                 EXTERNAL CONDITIONS AS FUNCTIONS OF TIME.
C ---   KOD(7) : 0 = DEPTH OF WATER TABLE AS LOWER BOUNDARY CONDITION
C ---             1 = VARYING SUCTION AS LOWER BOUNDARY CONDITION
C ---             2 = CONSTANT SUCTION AS LOWER BOUNDARY CONDITION
C
      READ(8,30)(KOD(I),I=1,7)
      READ(8,30) LU,MU,LL,ML,NM,NNL,IMAX,L2
      READ(8,30)(L(I),I=1,10)
30    FORMAT(10I5)
      READ(8,41) AA,SWCU,SWCL,RNAM,TB,TE
      READ(8,41)SMB,SMU1,SML1,SM2,SM3,BQ
      READ(8,40)DT,STM,TM,WSP,DS,DSP,EPS,FAC,DIST
40    FORMAT(8F9.4,F7.2)
41    FORMAT(8F10.3)
      IW1=MU-LU+1
      IW2=ML-LL+1
      ID=L(2)-L(1)+1
      AQ=1.0-BQ
      CALL PARAM(ID,NM,DIST)
      CHL(1)=TEM(1)
      CHU(1)=TEM(81)
      SU(1)=TEM(161)
      W(1)=TEM(316)
      CL(1)=U(1)
      SL(1)=U(81)
      CU(1)=U(161)
      S1(1)=U(241)
      IF(KOD(5).EQ.0) CALL HEPR(W,S1,SU,SL,NM)
      IF(KOD(5).EQ.1) CALL WACO(SU,SL,W,WCL,NM,S1)
      AM=1.0
      BM=1.5
      STN=DT
      DT1=DT
      IF(KOD(7) .EQ. 0) DX=DSP/NM
      IF(KOD(7) .NE. 0) DX = DIST/(NM - .5)
C --- COMPUTING MOISTURE CONTENT OF SOIL AND COORDINATES OF NODAL POINTS
      DO 50 J=1,NM
         VOL1=VOL1+W(J)*DX
         S2(J)=S1(J)
         X(J)=DX*(J-0.5)
50    CONTINUE
C --- IF KOD(7) =1 THEN NODAL POINT NM REPRESENTS ONLY HALF A LENGTH
C --- DX.
      IF(KOD(7) .NE. 0) VOL1 = VOL1 - .5 * DX * W(NM)
      VOLINIT = VOL1
      N=NM
      N1=NM
      H1=DT/DX
      H2=H1/DX
      IF(KOD(4).EQ.0) Z=1.0
      IF(KOD(4).EQ.2) Z=-1.0
      IF(KOD(2).EQ.1) READ(8,41) TINIT,GG,(TR(J),J=1,L2)
      IF(KOD(2).NE.1) TR(1)=TM
      T=TINIT
      ZZ = GG
C --- COMPUTE INITIAL SUCTION.
      IF(KOD(7) .EQ. 0)GO TO 55
      IF(KOD(7) .EQ. 2)GO TO 53
      PT = T - L(1) + 1
      GIVSUC = GSUC(PT)
      GO TO 55
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53    GIVSUC = GSUC(1)
55    TMA=T+TR(1)
      IF(KOD(6).EQ.0)  CALL HEPAS(WCS,SU,ID)
      DXH=0.5*DX
      SSS=T+STM
      TER1=GG
      KN=1
      YY1=GG
      TEE2=T
      LPA=L1
      FWT=FAC*CSAT2
      CUMINF=0.0
C --- START OF TIME STEP.
60    T=T+DT
      GG1=GG
      RUNOFF1=RUNOFF
      KY=L(1)+KN
      IF(T.LE.KY) GO TO 640
      IF(ABS(TM-1.0).LT.1.E-6 .AND. KN.EQ.1) ABC=AVTR
      IF(ABS(TM-1.0).LT.1.E-6 .AND. KN.GT.1) TRA(KN-1)=AVTR
      IF(ABS(TM-1.0).LT.1.E-6) GO TO 650
      TE2=T-DT
      IF(TE2.LT.KY) YY1=GG
      IF(TE2.LT.KY) TEE2=TE2
      IF(TE2.LT.KY) GO TO 640
      AT=YY1+(GG-YY1)*(KY-TEE2)/(TE2-TEE2)
      IF(KN.EQ.1) ABC=10.0*(AT-TER1)
      IF(KN.GT.1) TRA(KN-1)=10.0*(AT-TER1)
      TEE2=KY
      YY1=AT
      TER1=AT
650   KN=KN+1
640   L6=L6+1
      T1=T-0.5*DT
300   IF(T1.LE.TB) RNA=0.0
      IF(T1.GT.TB.AND.T1.LT.TE) RNA=RNAM*(T1-TB)/(TE-TB)
      IF(T1.GE.TE) RNA=RNAM
      OLDSUC = GIVSUC
      CALL BOCO(EPA,SGLA,FLUXA,DRZA,SN1N,CFWT,DX,N1,ID,L,KOD,T1,
     1GIVSUC,GSUC,N,INFILTA)
      IF(DRZA-RNA.LE.0.0) QM=0.0
      IF(DRZA-RNA.GT.0.0) QM=.1*EPA/(DRZA-RNA)
      SMM=BQ*QM/(SM3-SM2)
      PRZ=DRZA/DX+.501
70    IF(KOD(7).EQ.0)GO TO 75
      DX1=DXH
      RR=2.
      AGPF=0.0
      GO TO 100
75    IF(SN1N.GE.DXH) GO TO 80
      DX1=SN1N
      SN1N=0.0
      GO TO 90
80    SN1N=SN1N-DXH
      DX1=DXH
90    RR=DX/DX1
      IF(N.GE.N1) GO TO 100
      AGPF=(S(N)-SN1N)/(DX*(N1-N)+DX1)
      IF(AGPF.LT.0.0) AGPF=0.0
      J=N1+1
110   J=J-1
      SN1(J-1)=SN1N+(N1-J+1.0/RR+0.5)*DX*AGPF*AA
      IF(J.LE.N+1) GO TO 100
      SN2(J)=SN1(J-1)
      GO TO 110
C
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C --- ITERATION.
100   N2=N-1
      IF(KOD(7).NE.0)GO TO 131
C --- KOD(7)=0
      DO 130 J=1,N2
         IF(L8.EQ.1) GO TO 140
         SN1(J)=0.5*BM*(S1(J+1)+S1(J))-0.25*AM*(S2(J+1)+S2(J))
         GO TO 150
140      SN1(J)=.25*(S1(J+1)+S1(J)+S(J)+S(J+1))
150      SN2(J+1)=SN1(J)
130   CONTINUE
      GO TO 139
C --- KOD(7) = 1
131   DO 138 I=1,N2
         J =  I + 1
         IF(L8 .EQ. 1) GO TO 135
         A = S2(I)
         B = S2(J)
         C = S1(I)
         D = S1(J)
         IF(J .EQ. N) B = OLDSUC
         IF(J .EQ. N) D = GIVSUC
         SN1(I) = .5 * BM * (C + D) - .25 * AM * (A+B)
         GO TO 137
135      A = S1(I)
         B = S1(J)
         C = S(J)
         D = S(I)
         IF(J .EQ. N) C = GIVSUC
         SN1(I) = .25 * (A + B + C + D)
137      SN2(J) = SN1(I)
138   CONTINUE
C
C --- CALCULATION OF COEFFICIENTS FOR J=1.
139   N=N1
      J=1
      IF(L8.EQ.1) SG1=0.5*(S(1)+S1(1))
      IF(L8.NE.1) SG1=BM*S1(1)-.5*AM*S2(1)
720   SG=.5*(SG1+SGLA)
      CALL CON(J,C1,C2,SG1,SGLA,CU,CL,SU,SL)
      C2U=SQRT(C1*C2)
      CALL CON(J,C1,C2,SN1(J),SG,CU,CL,SU,SL)
      C2=C2U
      CALL DMC(J,CH1,SG1,CHU,CHL,SU,SL)
      C=0.0
      IF(KOD(6).EQ.0) C=-H2*C2/CH1
      A=-H2*C1/CH1
      B=2.0+A+2.0*C
      QK(J)=0.0
      IF(J.GT.PRZ) GO TO 160
C --- ROOT EXTRACTION.
      CALL RER(J,Q2,Q1,SG,SN1(J),NNL)
      IF(RNA.LE.DXH) QK(J)=0.5*(Q1+Q2*(DXH-RNA)/DXH)
      IF(RNA.GT.DXH.AND.RNA.LE.DX) QK(J)=Q1*(DX-RNA)/DX
      IF(L8.EQ.0) GG=GG+QK(J)*DX*DT
160   IF(KOD(6).EQ.0) GO TO 170
C --- FLUX.
      FLUXM=C2*(SG1-SGLA+Z*DXH)/DXH
      IF(FLUXM.LE.0.0.AND.FLUXA.LE.0.0) GO TO 180
      IF(FLUXM.GT.0.0.AND.FLUXA.GT.0.0) GO TO 190
      IF(FLUXM.GT.0.0.AND.FLUXA.LE.0.0) FLUXM=0.0
      IF(FLUXM.LE.0.0.AND.FLUXA.GT.0.0) FLUXM=0.0
      IF(FLUXA.GT.0.0) GO TO 740
      IF(FLUXA.LE.0.0) GO TO 200
180   IF(FLUXM.LT.0.1*FLUXA) FLUXM=0.1*FLUXA
      GO TO 200
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190    IF(FLUXM.GT.0.1*FLUXA) FLUXM=0.1*FLUXA
740    RUNOFF=RUNOFF+(FLUXA-10.0*FLUXM)*DT
200    E=A*S1(2)+(2.0-A)*S1(1)-2.0*Z*H1/CH1*C1+2.0*H1*FLUXM/CH1-2.0*DT*
      1QK(1)/CH1
       GO TO 210
170    E=A*S1(2)+(4.0-B)*S1(1)+4.0*C*SGLA-2.0*Z*H1*(C1-C2)/CH1-2.*DT*QK(1
      1)/CH1
210    R1(1)=A/B
       R2(1)=-E/A
C
C ---  CALCULATION OF COEFFICIENTS FOR 1 < J < N.
       III=N-1
       DO 220 J=2,III
          CALL CON(J,C1,C2,SN1(J),SN2(J),CU,CL,SU,SL)
          SN12=0.5*(SN1(J)+SN2(J))
          CALL DMC(J,CH1,SN12,CHU,CHL,SU,SL)
          C=-H2*C2/CH1
          A=-H2*C1/CH1
          B=2.0+A+C
          QK(J)=0.0
          DXL=J*DX
          IF(J.GE.PRZ+1.OR.RNA.GT.DXL) GO TO 230
C ---     ROOT EXTRACTION.
          DXU=(J-1)*DX
          DXM=(J-0.5)*DX
          CALL RER(J,Q1,Q2,SN1(J),SN2(J),NNL)
          IF(J.EQ.PRZ) Q1=Q1*(DRZA-DX*(J-0.5))/DXH
          IF(RNA.LE.DXU) QK(J)=0.5*(Q1+Q2)
          IF(RNA.LE.DXM.AND.RNA.GT.DXU) QK(J)=0.5*(Q1+Q2*(DXM-RNA)/DXH)
          IF(RNA.GT.DXM.AND.RNA.LE.DXL) QK(J)=Q1*(DXL-RNA)/DX
230       E=A*S1(J+1)+(4.0-B)*S1(J)+C*S1(J-1)-2.0*Z*H1*(C1-C2)/CH1-2.0
     1    *DT*QK(J)/CH1
          R1(J)=A/(B-C*R1(J-1))
          R2(J)=(C*R1(J-1)*R2(J-1)-E)/A
          IF(L8.EQ.0) GG=GG+QK(J)*DT*DX
220    CONTINUE
C
C ---  CALCULATION OF COEFFICIENTS FOR J=N.
       J=N
       IF(KOD(7).EQ.0)CALL CON(J,C1,C2,SN1N,SN2(N),CU,CL,SU,SL)
       IF(KOD(7).NE.0)CALL CON(J,C1,C2,GIVSUC,SN2(N),CU,CL,SU,SL)
       IF(KOD(7).EQ.0)GO TO 235
       SN12=.5 * (SN2(N) + GIVSUC)
       GO TO 236
235    IF(ABS(DX1-DXH).LT.1.E-6) SN12=0.5*(SN2(N)+SN1N)
       IF(ABS(DX1-DXH).GE.1.E-6) SN12=SN2(N)*(1.0-DX/(DX+2.0*DX1))
236    CALL DMC(J,CH1,SN12,CHU,CHL,SU,SL)
       A=-H2*C1/CH1
       C=-H2*C2/CH1
       B=2.0+A*RR+C
       QK(J)=0.0
       DXM=(N-0.5)*DX
       IF(KOD(7) .EQ. 0) DXL=DXM+DX1+SN1N
       IF(KOD(7) .NE. 0) DXL = DXM
       IF(RNA.GT.DXL.OR.J.GE.PRZ+1) GO TO 240
C ---  ROOT EXTRACTION.
       IF(KOD(7).EQ.0)CALL RER(J,Q1,Q2,SN1N,SN2(J),NNL)
       IF(KOD(7).NE.0)CALL RER(J,Q1,Q2,GIVSUC,SN2(J),NNL)
       DXU=(N-1)*DX
       IF(J.EQ.PRZ) Q1=Q1*(DRZA-DX*(PRZ-0.5))/DXH
       IF(RNA.LE.DXU) QK(J)=0.5*(Q1+Q2)
       IF(RNA.LE.DXM.AND.RNA.GT.DXU) QK(J)=0.5*(Q1+Q2*(DXM-RNA)/DXH)
       IF(RNA.GT.DXM.AND.RNA.LE.DXL) QK(J)=Q1*(DXL-RNA)/DX
       IF(L8.EQ.0.AND.KOD(7).EQ.0) GG=GG+QK(J)*DT*DX
       IF(L8.EQ.0.AND.KOD(7).NE.0) GG=GG+QK(J)*DT*DXH
240    IF(KOD(7) .NE. 0) GO TO 243
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      E=(4.0-B)*S1(N)+C*S1(N-1)+2.0*A*RR*SN1N-2.0*Z*H1*(C1-C2)/CH1-2.0*
     1DT*QK(N)/CH1
C
C --- CALCULATION OF S(J).
      S(N)=(E-C*R1(N-1)*R2(N-1))/(B-C*R1(N-1))
      GO TO 245
243   S(N)=GIVSUC
245   J=N+1
710   J=J-1
      IF(J.LT.2) GO TO 250
      S(J-1)=R1(J-1)*(S(J)-R2(J-1))
      IF(S(J-1).LT.0.001) S(J-1)=0.001
      GO TO 710
C
C --- DEVIATION.
250   N2=N-1
      DO 260 J=1,N2
         DEV=ABS(S(J)+S(J+1)+S1(J)+S1(J+1)-4.0*SN1(J))*0.25
         IF(DEV.GT.1.0.AND.DEV.GT.EPS*SN1(J)) GO TO 270
260   CONTINUE
      ITER=0
      GO TO 280
270   ITER=ITER+1
      IF(ITER.LT.IMAX) GO TO 290
C
C --- COMPUTE RELATIVE DEVIATION AFTER LAST ITERATION ALLOWED.
      ITERM=ITERM+1
      ITIME=ITIME+1
      IF(ABS(SN1(J)) .GE. 1.E-12) EPSM=DEV/SN1(J)
      IF(ABS(SN1(J)).LT.1.E-12) EPSM=EPS
      GO TO 310
C
C --- COMPUTE NEW SN1(J).
290   DO 320 J=1,N2
         SN1(J)=0.25*(S(J)+S(J+1)+S1(J)+S1(J+1))
         IF(J.GT.1) SN2(J)=SN1(J-1)
320   CONTINUE
      J=1
      GG=GG1
      RUNOFF=RUNOFF1
      SG1=0.5*(S1(1)+S(1))
      GO TO 720
310   IF(LPA.EQ.L1) PRINT 330, EPS,ITIME,ITERM,J,EPSM,DEV,T
      IF(LPA.NE.L1) PRINT 730, EPS,ITIME,ITERM,J,EPSM,DEV,T
330   FORMAT(1H1,49H NUMBER OF IMAX NOT ENOUGH TO REACH ACCURACY EPS=,F5
     1.4,/,
     217H  VALUE OF ITIME=,I5,8H  ITERM=,I5,15H  NODE POINT J=,I2,"
     3EPSM=",F6.4,18H  VALUE OF DEV(J)=,E10.3,7H  TIME=,F7.3/)
730   FORMAT(49H NUMBER OF IMAX NOT ENOUGH TO REACH ACCURACY EPS=F5.4/
     117H  VALUE OF ITIME=I5,8H  ITERM=I5,15H  NODE POINT J=I2,7H  EPSM=
     2F6.4,18H  VALUE OF DEV(J)=E9.3,7H  TIME=F7.3/)
      LPA=LPA+1
280   NS=N+1
      IF(NS.GT.NM .OR. KOD(7).NE.0) GO TO 400
      DO 620 I=NS,NM
         IF(KOD(1).EQ.1) S(I)=1.0
         IF(KOD(1).NE.1) S(I)=0.001
         QK(I)=0.0
620   CONTINUE
C
C --- COMPUTE MOISTURE CONTENT OF PROFILE.
400   CALL WACO(SU,SL,W,WCL,NM,S)
      VOL2=0.0
      DO 630 I=1,NM
         VOL2=VOL2+W(I)*DX
630   CONTINUE
```

```
C --- IF KOD(7) = 1 THEN NODAL POINT NM REPRESENTS ONLY HALF A LENGTH
C --- DX.
      IF(KOD(7) .NE. 0) VOL2 = VOL2 - .5 * DX * W(NM)
C --- CHANGE IN MOISTURE CONTENT.
      DELTA=VOL2-VOL1+GG-GG1-FLUXM*DT
      VOL1=VOL2
      SDELTA=SDELTA+DELTA
      CUMINF=CUMINF + INFILTA * DT
      IF(T.LE.SSS) GO TO 340
      IF(L8.NE.0) GO TO 350
C --- FLUX.
      IF(KOD(7).EQ.0) FLOW=ABS(0.5*C1/DX1*(2.0*SN1N-S(N)-S1(N)+2.0*Z*
     1DX1))
      IF(KOD(7).NE.0)FLOW=ABS(C2*((S(N)-S(N-1))/DX + Z))
      IF(KOD(6).EQ.0) FLUXM=C2U/DXH*(SG1-SGLA+Z*DXH)
      IF(FLOW.LE.ABS(FLUXM)) FLOW=ABS(FLUXM)
      IF(L5.NE.0) GO TO 340
      ST=WSP*DX/FLOW
      L3=L3+1
      CFWT=CFWT*FWT
      IF(CFWT.GT.1.0) CFWT=1.0
      IF(ST.GT.(CFWT*DS*TM)) ST=CFWT*DS*TM
      IF(L3.EQ.1) SS=ST
      IF((L3-L4).NE.1) GO TO 360
      DT1=DT1+STN
      STN=DT1
      L4=L4+1
360   IF(L4.EQ.0.AND.DT1.LT.SS) GO TO 340
      DT1=SS
      L4=0
340   IF(ABS(T-TMA).GT..001*DT) GO TO 370
      IF(L8.EQ.1) GO TO 350
C --- T1 = T1 + .5 * DT.
      T1=T
      L8=1
      RUNOFF=RUNOFF1
      GO TO 300
C
C --- OUTPUT.
350   DO 390 I=1,N
         K=I/2
         IF(I.GT.2.AND.I.NE.2*K) CALL CON(I,W2(I),W2(I-1),S(I),S(I-1),
     1   CU,CL,SU,SL)
         IF(I.EQ.1) CALL CON(I,W2(I),C2,S(I),SG,CU,CL,SU,SL)
         IF(I.EQ.N.AND.KOD(7).EQ.0) CALL CON(I,C1,W2(I),SN1N,S(I),CU,
     1   CL,SU,SL)
         IF(I.EQ.N.AND.KOD(7).NE.0) CALL CON(I,C1,W2(I-1),S(N),S(N-1),
     1   CU,CL,SU,SL)
390   CONTINUE
      C1=SQRT(C1*W2(N))
      AVTR=10.0*(GG-ZZ)/TR(L1)
      CUMEPSO = VOLINIT-VOL2-GG+.1*(CUMINF-RUNOFF) + SDELTA
      PRINT 410, T,GG,AVTR,L6,ITERM,RUNOFF,DELTA,SDELTA,WCL,CUMEPSO
410   FORMAT(1H1,4HDAY=,F6.2,22H     CUMULATIVE TRANS.=,F6.3,21H CM   AVE
     1RAGE TRANS.=,F5.2,29H MM/DAY  NUMBER OF TIME STEP=,I4,19H   NUMBER
     2 OF ITER.=,I4//
     38H RUNOFF=,F6.2,12H MM   DELTA=,F6.2,8H SDELTA=,F6.2," CM   THETA
     4 OF LOWER LAYER AT THE CONTACT WITH UPPER=",F5.4,12H CM**3/CM**3,
     5//," CUMULATIVE SOIL EVAPORATION =",F7.2," CM")
      PRINT 420
420   FORMAT(//81H     Z          THETA         CUM. WATER          SUCTION
     1        FLUX          ROOT EXTR./
     278H    CM          VOL.             CM                 CM            CM/
     3DAY          1/DAY/)
      V=0.0
      DO 430 I=1,NM
```

```
          V=V+W(I)*DX
          IF(I.EQ.1) QQ=FLUXM
          IF(I.GE.N.AND.KOD(7).EQ.0) QQ=C1*((SN1N-SN2(N1))/(DX1+DXH)+Z)
          IF(I.GE.N.AND.KOD(7).NE.0) QQ=C1*((S(N)-S(N-1))/DX + Z)
          IF(I.NE.1.AND.I.LT.N) QQ=0.5*W2(I)/DX*(S(I+1)-S(I-1)+2.0*Z*DX)
          IF(S(I).LT.1.0) S2(I)=1.0
          IF(S(I).GE.1.0) S2(I)=S(I)
          PRINT 440, X(I),W(I),V,S(I),QQ,QK(I)
          IT=L1
          RETC=ALOG10(S2(I))
          IX(IT,I,1)=W(I)*1000.+0.5
          IX(IT,I,2)=V*10.+0.5
          IX(IT,I,3)=RETC*100.+0.5
          IX(IT,I,4)=QQ*1000.+0.5
          IX(IT,I,5)=QK(I)*10000.+0.5
430    CONTINUE
440    FORMAT(2X,F5.1,6X,F5.4,8X,F7.3,9X,E10.4,4X,E10.3,4X,E10.3)
       PRINT 450, T,WCL,GG,RUNOFF,SWCU,SWCL
450    FORMAT(//81H                                                SOIL
      1 MOISTURE  CONTENT  PROFILE,/
      28H    DAY=,F6.2,24H    THETA AT THE CONTACT=,F5.4,"    CUM. TRANS.="
      3,F5.2,10H    RUNOFF=,F6.2,24H   POROSITIES ARE UPPER=,F4.3,
      4"  AND LOWER=",F4.3/)
       PRINT 460
460    FORMAT(1H,11HDEPTH THETA,1X,3H0.0,7X,3H0.1,7X,3H0.2,7X,3H0.3,7X,3H
      10.4,7X,3H0.5,7X,3H0.6,7X,3H0.7,7X,3H0.8,7X,3H0.9,7X,3H1.0)
       PRINT 470
470    FORMAT(1H,114H  CM   VOL.  +*********+*********+*********+*********
      1*+*********+*********+*********+*********+*********+*********+)
       I1=SWCU*100.0+0.5
       I2=SWCL*100.0+0.5
       DO 480 J=1,NM
          IY=W(J)*100.0+0.5
          IF(J.GT.NNL) I1=I2
          DO 490 I=1,I1
             IF(IY.GT.I) IA(I)=1H-
             IF(IY.EQ.I) IA(I)=1H+
             IF(IY.LT.I) IA(I)=1H
490       CONTINUE
          NY=I1+1
          DO 500 I=NY,99
             IA(I)=1H/
500       CONTINUE
          PRINT 510, X(J),W(J),IA
480    CONTINUE
510    FORMAT(1H,F5.1,1X,F6.4,2H +,99A1,1H+)
       PRINT 470
       PRINT 460
       ZZ=GG
C
C ---- READY?
       IF(L1.GE.L2) GO TO 520
       L1=L1+1
       LPA=L1
       LB=0
       IF(KOD(2).NE.1) TR(L1)=TM
       TMA=T+TR(L1)
370    IF(L3-L4.EQ.0) GO TO 380
       TC=TMA-T
       IF(TC.LE.5.01*ST) GO TO 530
       IF(ST.GT.1.1*DT) ST=1.1*DT
       IF(ST.LT.0.9*DT) ST=0.9*DT
       DT1=ST
       GO TO 380
530    IF(LS.EQ.0) GO TO 540
       DT1=SKS
```

```
      LS=LS-1
      GO TO 380
540   DT1=0.2*TC
      SKS=DT1
      LS=4
380   DO 550 I=1,N
         S2(I)=S1(I)
         S1(I)=S(I)
550   CONTINUE
C
C --- NEXT TIME STEP.
      IF(T+DT1.GT.TMA) DT1=TMA-T
      IF(ABS(DT1-DT).LE. 1.E-6) GO TO 560
      H1=DT1/DX
      H2=H1/DX
      AM=DT1/DT
      BM=1.0+0.5*AM
      DT=DT1
      GO TO 60
560   AM=1.0
      BM=1.5
      GO TO 60
C
520   TRA(ID-2)=10.*(SG-TER1)
      DO 570 KKK=1,5
         PRINT 580, KA(KKK)
         PRINT 590, (X(J),J=1,NM)
         T=TINIT
         DO 600 J=1,L2
            T=T+TR(J)
            LJ=T
            PRINT 610, LJ,(IX(J,I,KKK),I=1,NM)
600      CONTINUE
570   CONTINUE
580   FORMAT(1H1,10X,A10/5X,20(1H-)/)
590   FORMAT(7X,25F5.0)
610   FORMAT(1X,I4,2X,25I5)
660   FORMAT(1H1,39H            ACTUAL TRANSPIRATION (MM/DAY)///)
      PRINT 660
      PRINT 670, 0,(I,I=1,10)
670   FORMAT(11I10)
      KX=ID/10+1
      LY=0
      LB=0
      LC=0
680   LY=LY+1
      LA=LB+1
      LB=10*LY-1
      IF(LY.GT.KX) GO TO 690
      IF(LY.EQ.KX) LB=ID-2
      IF(LY.EQ.1) PRINT 700, LC,ABC,(TRA(KN),KN=LA,LB)
      IF(LY.GT.1) PRINT 700, LC,(TRA(KN),KN=LA,LB)
      LC=LB+1
      GO TO 680
700   FORMAT(I10,10F10.2)
690   STOP
      END
C
C
C
C
      SUBROUTINE PARAM(ID,NM,DIST)
      REAL LAI,INFILT,INFILTA
      DIMENSION TEM(365),RH(365),U(365),HNT(365),CH(365),SC(365),FLUX(36
     15),DWT(365),DRZ(365),CU(80),SU(80),CHU(80),CL(80),SL(80),CHL(80),
     2S1(25),W(25),SGL(365),IB(69),KM(12),THETA(2),WCS(365),EP(365),HED(
```

```
     320),L(10),KOD(7),LC1(5),GSUC(365),INFILT(365)
      EQUIVALENCE (CH,EP),(RH,SGL,WCS),(SC,DWT,GSUC),(HNT,DRZ),(TEM(1),
     2CHL(1)),(TEM(81),CHU(1)),(TEM(161),SU(1)),(TEM(316),W(1)),(U(1),
     3CL(1)),(U(81),SL(1)),(U(161),CU(1)),(U(241),S1(1))
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
      COMMON/BONC/ DWT,SGL,EP,DRZ,FLUX,INFILT
      COMMON/FACT/ TEM,U
      COMMON/DECL/ HED,L
      DATA KM(1),KM(3),KM(5),KM(7),KM(8),KM(10),KM(12)/7*31/,KM(4),KM(6)
     1,KM(9),KM(11)/4*30/,GAMMA/1*0.66713/,SEP/1*0.0/
      KM(2)=L(3)
C=====BOUNDARY CONDITIONS
C     IF KOD(6)=0-PRESCRIBED THETA AT THE SURFACE
C     IF KOD(6)=1-PRESCRIBED FLUX,SGL AND EP AT THE SURFACE
C     IF KOD(6)=2-BOUNDARY CONDITION AT THE SURFACE IS ESTIMATED FROM
C                    METEOROLOGICAL DATA: TEM,RH,U,HNT,CH AND FLUX
C     IF L(7)=0-HNT IS GIVEN IN W/M**2,OTHERWISE IN CAL/CM**2/DAY
C-----------------------------------------------------------------------
      PRINT 10, HED
10    FORMAT(1H1,20A4///)
      PRINT 30
30    FORMAT(1H,31H BOUNDARY CONDITIONS AT THE TOP/)
      IF(KOD(6).EQ.1) READ(8,640) (FLUX(I),EP(I),SGL(I),I=1,ID)
      IF(KOD(6).EQ.2) READ(8,650) (TEM(I),RH(I),U(I),HNT(I),CH(I),SC(I),
     1FLUX(I),I=1,ID)
      IF(KOD(6).EQ.0) READ(8,20) (EP(I),WCS(I),I=1,ID)
20    FORMAT(8F10.4)
640   FORMAT(2(F10.3,F10.3,E10.4))
650   FORMAT(7F10.3)
      IF(KOD(6).NE.2) GO TO 300
      PRINT 40
40    FORMAT(//7X,3HDAY,5X,5HTEMP.,4X,8HREL HUM.,4X,9HWIND VEL.,4X,9HNET
     1 RAD.,5X,11HCROP HEIGHT,4X,10HSOIL COVER,4X,9HPRECIPIT./)
      DO 50 I=1,ID
      LC=L(1)+I-1
      IF(L(7).NE.0) HNT(I)=0.48426*HNT(I)
      TEM(I)=TEM(I)+273.15
      PRINT 60, LC,TEM(I),RH(I),U(I),HNT(I),CH(I),SC(I),FLUX(I)
50    CONTINUE
60    FORMAT(I10,3X,F6.2,7X,F5.3,6X,F6.2,6X,F7.2,7X,F7.2,9X,F5.2,9X,F5.2
     1)
C
C     FGA,FGB,FGC,FGD,FGM,FMCH-COEFFICIENTS OF G(CH)-FUNCTION
C
      FGA=.370E-07
      FGB=.283
      FGC=.164E-07
      FGD=.59
      FGM=1.3E-07
      FMCH=20.0
      IF(L(8).EQ.0) READ(8,430) FGA,FGB,FGC,FGD,FGM,FMCH
C
C     FLA,FLB,FLC-COEFFICIENTS OF LAI-FUNCTION
C
      FLA=1.179
      FLB=.25
      FLC=1.171
      IF(L(9).EQ.0) READ(8,20) FLA,FLB,FLC
C
C     FIA,FIB,FIC,FID,FMP,FMI-COEFFICIENTS OF INTERCEPTION (FIN(PREC))-
C                              FUNCTION
C
      FIA=.55
```

```
      FIB=.53
      FIC=.0085
      FID=5.0
      FMP=20.0
      FMI=1.85
      IF(L(10).EQ.0) READ(8,20) FIA,FIB,FIC,FID,FMP,FMI
      PRINT 70
70    FORMAT(//50H            THE FUNCTIONS OF G(CH),LAI AND FIN(PREC)/)
C-----PRINTING OF THE G(CH)-FUNCTION
      PRINT 80, FGA,FGB,FMCH,FGC,FGD,FMCH,FGM
80    FORMAT(16H            G(CH)=E10.3,5H*CH**F6.3,29H
     1FOR CH.GE.F7.2,3H CM/
     216H            G(CH)=E10.3,5H*CH**F6.3,29H                    FOR CH.
     3LT.F7.2,3H CM/
     433H            MAXIMUM VALUE OF G(CH)=E10.3/)
C-----PRINTING OF THE LAI-FUNCTION
      PRINT 100,FLA,FLB,FLC
100   FORMAT(14H            LAI=F6.3,4H*SC+F6.3,7H*SC**2+F6.3,6H*SC**3/)
C-----PRINTING OF THE FIN(PREC)-FUNCTION
      PRINT 110, FIA,FIB,FIC,FID,FMP,FMI,FMP
110   FORMAT(23H            FIN(PREC)=SC*F6.3,8H*PREC**(F5.2,1H-F6.4,7H*(P
     1REC-F5.2,24H))            FOR.PREC.LT.F5.2,7H MM/DAY/
     223H            FIN(PREC)=SC*F5.2,57H
     3            FOR.PREC.GE.F5.2,7H MM/DAY/)
C
C=====CALCULATION AND PRINTING OF THE VALUES--EWET-,-ES-,-EP-,-SEPLANT-,
C                                                     FLUX-,-SGL
C     ESOIL=ES,-EPLANT=EP,-SEPLANT IS THE SUM OF THE EP-VALUES
C     FLUX=PREC-ES-FIN
C     FIN IS INTERCEPTION,SGL IS THE MINIMUM ALLOWED SUCTION AT
C     THE SOIL SURFACE,EV IS THE SATURATED WATER VAPOUR PRESSURE,DL IS
C     THE SLOPE OF SATURATION VAPOUR PRESSURE CURVE
C     VPD IS THE VAPOUR PRESSURE DEFICIT OF AIR
C
      PRINT 120
120   FORMAT(1H1//30X,50HCALCULATION OF MAXIMUM POSSIBLE EVAPOTRANSPIRAT
     1ION///)
      PRINT 130
130   FORMAT(//55X,38HPOTENTIAL TRANSPIRATION RATE  (MM/DAY)//)
      PRINT 140
140   FORMAT(1H,32HDATE  DAY  EWET ESOIL EPLANT 0.0,7X,3H2.0,7X,3H4.0,7X
     1,3H6.0,7X,3H8.0,6X,4H10.0,6X,4H12.0,6X,4H14.0,1X,7HSEPLANT,1X,5HFL
     2UX,5X,3HSGL,4X,3HVPD)
      PRINT 150
150   FORMAT(1H,30X,71H+*****+*****+*****+*****+*****+*****+*****+*****
     1*+*****+*****+*****+)
      NE=L(1)-1
      LF=L(5)
      LE=L(6)
      L1=L(1)
      L4=L(4)
C
      DO 160 M=LF,LE
         I2=KM(M)
         DO 170 J=L4,I2
            NE=NE+1
            I=NE-L1+1
            WED=.058302635*TEM(I)-2.19386068
            EV=1.3332*EXP((1.08871906 1*TEM(I)-276.4883955)/WED)
            DEL=13.73150407*EV/(WED**2)
            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
            LAI=FLA*SC(I)+FLB*SC(I)**2+FLC*SC(I)**3
            VPD=(1.0-RH(I))*EV
            EWET=.0352*(DEL*HNT(I)+1.8804E+08*GCH*(U(I)**.75)*VPD)/
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```
     1        (DEL+GAMMA)
              ES=0.0352*DEL*HNT(I)*EXP(-0.39*LAI)/(DEL+GAMMA)
              IF(ES.GT.EWET) ES=EWET
              CH(I)=EWET-ES
              IF(FLUX(I).LE.FMP) FIN=SC(I)*FIA*FLUX(I)**(FIB-FIC*(
     1        FLUX(I)-FID))
              IF(FLUX(I).GT.FMP) FIN=SC(I)*FMI
              INFILT(I)=FLUX(I)-FIN
              FLUX(I)=INFILT(I)-ES
              SEP=SEP+CH(I)
              IF(FLUX(I).GT.0.0) SGL(I)=0.001
              IF(FLUX(I).LE.0.0) SGL(I)=-4708.0*TEM(I)*ALOG(RH(I))
              II=(CH(I)*5.0+0.5)
              DO 180 I3=1,69
                 IF(II.GT.I3) IB(I3)=1H-
                 IF(II.EQ.I3) IB(I3)=1H+
                 IF(II.LT.I3) IB(I3)=1H
180           CONTINUE
              PRINT 190, J,M,NE,EWET,ES,CH(I),IB,SEP,FLUX(I),SGL(I),VPD
190           FORMAT(1H,I2,1X,I2,1X,I3,1X,F5.2,1X,F5.2,1X,F5.2,3X,1H+,
     1        69A1,1H+,1X,F6.2,1X,F6.2,1X,E9.3,1X,F5.1)
              IF(NE.GE.L(2)) GO TO 200
170         CONTINUE
            L4=1
160       CONTINUE
C
200       PRINT 150
          PRINT 140
          GO TO 210
300       IF(KOD(6).EQ.0) GO TO 220
          PRINT 230
230       FORMAT(//2(7X,3HDAY,4X,6HEPLANT,6X,4HFLUX,7X,3HSGL)/)
C
          DO 240 I=1,ID,2
            DO 680 J=1,2
              LC1(J)=L(1)+I-2+J
              IF(LC1(J).EQ.L(2)) GO TO 690
680         CONTINUE
            J=J-1
690         PRINT 250, (LC1(IL),EP(I+IL-1),FLUX(I+IL-1),SGL(I+IL-1),IL=1,J)
240       CONTINUE
C
250       FORMAT(2(I10,3X,F7.3,3X,F7.2,1X,E9.3))
          GO TO 210
C
220       PRINT 270
270       FORMAT(//4(7X,3HDAY,4X,6HEPLANT,5X,5HTHETA))
C
          DO 280 I=1,ID,4
            DO 290 J=1,4
              LC1(J)=L(1)+I-2+J
              IF(LC1(J).EQ.L(2)) GO TO 310
290         CONTINUE
            J=J-1
310         PRINT 660, (LC1(IL),EP(I+IL-1),WCS(I+IL-1),IL=1,J)
280       CONTINUE
90        FORMAT(5(I10,F10.1))
660       FORMAT(4(I10,2(F10.3)))
C
C=====READING AND PRINTING THE BOUNDARY CONDITION AT THE BOTTOM
C
210       GO TO(315,800,900),KOD(7)+1
C --- DEPTH OF WATERTABLE IS GIVEN.
315       PRINT 320
320       FORMAT(1H1,33H BOUNDARY CONDITION AT THE BOTTOM///5(7X,3HDAY,5X,5H
         1DEPTH))
```

```
      READ(8,20) (DWT(I),I=1,ID)
C
      DO 330 I=1,ID,5
         DO 340 J=1,5
            LC1(J)=L(1)+I-2+J
            IF(LC1(J).EQ.L(2)) GO TO 350
340      CONTINUE
         J=J-1
350      PRINT 90, (LC1(IL),DWT(I+IL-1),IL=1,J)
330   CONTINUE
      GO TO 990
C
C --- SUCTION GIVEN AT DEPTH DIST.
800   PRINT 810,DIST
810   FORMAT(1H1,"BOUNDARY CONDITION AT BOTTOM, SUCTION IS GIVEN
     1AT DEPTH",F7.2,///,5(7X,3HDAY,5X,7HSUCTION))
      READ(8,430)(GSUC(I),I=1,ID)
      DO 860 I=1,ID,5
         DO 840 J=1,5
            LC1(J) = L(1) + I - 2 + J
            IF(LC1(J) .EQ. L(2)) GO TO 850
840      CONTINUE
         J = J - 1
850      PRINT 870,(LC1(IL),GSUC(I+IL-1),IL=1,J)
860   CONTINUE
870   FORMAT(5(I10,F12.5))
      GO TO 990
C
C --- SUCTION CONSTANT AND GIVEN AT DEPTH DIST.
900   READ(8,430)GSUC(1)
      PRINT 910,DIST,GSUC(1)
910   FORMAT(1H1,"BOUNDARY CONDITION AT BOTTOM.",//," SUCTION IS
     1CONSTANT AT DEPTH",F10.4," WITH VALUE",F10.4," CM.")
C
C=====READING AND PRINTING THE DEPTH OF ROOTS
C
990   IF(KOD(3).NE.0) GO TO 360
      READ(8,20) (DRZ(I),I=1,ID)
      PRINT 380
380   FORMAT(/24H TABLE OF DEPTH OF ROOTS///5(7X,3HDAY,5X,5HDEPTH))
C
      DO 390 I=1,ID,5
         DO 400 J=1,5
            LC1(J)=L(1)+I-2+J
            IF(LC1(J).EQ.L(2)) GO TO 410
400      CONTINUE
         J=J-1
410      PRINT 90, (LC1(IL),DRZ(I+IL-1),IL=1,J)
390   CONTINUE
C
360   IF(KOD(3).EQ.1) READ(8,20) DRZ(1)
      IF(KOD(3).EQ.1) PRINT 670, DRZ(1)
670   FORMAT(//36H THE DEPTH OF ROOTS IS CONSTANT-DRZ=F5.1,3H CM//)
      IF(KOD(3).NE.1) GO TO 710
      DO 720 I=1,ID
         DRZ(I)=DRZ(1)
720   CONTINUE
C
C=====READING AND PRINTING THE INITIAL CONDITION
C
710   PRINT 370
370   FORMAT(/87H INITIAL CONDITION(IF KOD(5)=1-SUCTION (CM) ;IF KOD(5)=
     10-WATER CONTENT IS PRESCRIBED     /)
      PRINT 420, KOD(5)
420   FORMAT(//13H       KOD(5)=I1/)
      IF(KOD(5).EQ.1) READ(8,430) (S1(I),I=1,NM)
```

```
      IF(KOD(5).EQ.0) READ(8,20) (W(I),I=1,NM)
430   FORMAT(8E10.4)
      IF(KOD(5).EQ.1) PRINT 430, (S1(I),I=1,NM)
      IF(KOD(5).EQ.0) PRINT 20, (W(I),I=1,NM)
C
C=====READING AND PRINTING THE HYDRAULIC PARAMETERS OF SOILS
C
      PRINT 440
440   FORMAT(/26H PARAMETERS OF UPPER LAYER/)
450   FORMAT(/26H PARAMETERS OF LOWER LAYER/)
460   FORMAT(2(43H  THETA    SUCTION    CONDUCTIV.  DIF.W.CAP.)/)
470   FORMAT(2(34H  THETA    SUCTION    DIF.W.CAP.)/)
480   FORMAT(2(2X,F5.3,2(2X,E10.4)))
490   FORMAT(2(2X,F5.3,3(2X,E10.4)))
      IF(KOD(1).EQ.1) GO TO 500
      READ(8,430) (SU(I),I=1,IW1)
      READ(8,430) (SL(I),I=1,IW2)
      DO 510 I=1,IW1
         IF(I.EQ.1) CHU(I)=0.01/(SU(I+1)-SU(I))
         IF(I.GT.1.AND.I.LT.IW1) CHU(I)=0.005/(SU(I+1)-SU(I))+0.5*
     1   CHU(I-1)
         IF(I.EQ.IW1.AND..01*(I+LU-1).GE.SWCU) CHU(I)=0.01/(SU(I)-
     1   SU(I-1))
         IF(I.EQ.IW1.AND..01*(I+LU-1).LT.SWCU) CHU(I)=0.5*((.01*
     1   (I+LU-1)-SWCU)/SU(I)+CHU(I-1))
510   CONTINUE
C
      DO 520 I=1,IW2
         IF(I.EQ.1) CHL(I)=0.01/(SL(I+1)-SL(I))
         IF(I.GT.1.AND.I.LT.IW2) CHL(I)=0.005/(SL(I+1)-SL(I))+0.5*
     1   CHL(I-1)
         IF(I.EQ.IW2.AND..01*(I+LL-1).GE.SWCL) CHL(I)=0.01/(SL(I)-
     1   SL(I-1))
         IF(I.EQ.IW2.AND..01*(I+LL-1).LT.SWCL) CHL(I)=0.5*((.01*
     1   (I+LL-1)-SWCL)/SL(I)+CHL(I-1))
520   CONTINUE
C
      IF(KOD(1).EQ.2) READ(8,430) (CU(I),I=1,IW1)
      IF(KOD(1).EQ.2) READ(8,430) (CL(I),I=1,IW2)
      THETA(1)=(LU-2)*0.01
      THETA(2)=THETA(1)+0.01
      IF(KOD(1).EQ.2) PRINT 460
      IF(KOD(1).EQ.0) PRINT 470
C
      DO 530 I=1,IW1,2
         DO 540 J=1,2
            THETA(J)=THETA(J)+0.02
            IF(THETA(J).GE.(MU*0.01)) GO TO 550
540      CONTINUE
         IF(KOD(1).EQ.2) CSAT2=CL(IW2)
         J=J-1
550      IF(KOD(1).EQ.2) PRINT 490, (THETA(IL),SU(I+IL-1),CU(I+IL-1),
     1   CHU(I+IL-1),IL=1,J)
         IF(KOD(1).EQ.0) PRINT 480, (THETA(IL),SU(I+IL-1),CHU(I+IL-1),
     1   IL=1,J)
530   CONTINUE
C
      IF(KOD(1).EQ.2) GO TO 560
      READ(8,20) CSAT1,CUA1,CUA2,CUB1,CUB2
      READ(8,20) CSAT2,CLA1,CLA2,CLB1,CLB2
      PRINT 570, 1,CSAT1,CUA1,CSAT1,CUA2,CUA1,CUA1,CUB1,CUB2,CUB1
570   FORMAT(//32H            CONDUCTIVITY FOR SOIL=I1,1H:/
     117H         K(PSI)=F8.3,52H
     2  FOR!PSI!.LE.F5.1,3H CM/
     317H         K(PSI)=F8.3,6H*EXP(-F6.4,8H*(!PSI!-F5.1,27H))
     4      FOR!PSI!.GT.F5.1,14H.AND.!PSI!.LT.F5.1,3H CM/
```

```
     517H          K(PSI)=F5.2,55H*(!PSI!)**(-1.4)
     6     FOR!PSI!.GE.F5.1,3H CM//)
      GO TO 560
500   READ(8,20)CSAT1,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,CUA1,CUA2,
     1CUA3,CUB1,CUB2,CUB3,CUC,CUD
      READ(8,20)CSAT2,SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CLA1,CLA2,
     1CLA3,CLB1,CLB2,CLB3,CLC,CLD
      PRINT 580, 1,SUA1,SUB1,SUB1,SUC,SUA2,SUB2,SUC,SUD,SUA3,SUB3,SUD
      PRINT 700, CSAT1,CUA1,CUB1,CUC,CSAT1,CUA2,CUB2,CUC,CUD,CUA3,CUB3,
     1CUD
580   FORMAT(//39H           HYDRAULIC PARAMETERS OF SOIL=I1,5H ARE:/
     126H           1) SUCTION (CM):/
     218H           PSI=EXP(F8.4,2H*(F7.4,38H-THETA))                 FOR
     3 THETA.LE.F5.4,14H.AND.THETA.GE.F5.4/
     418H           PSI=EXP(F8.4,2H*(F7.4,38H-THETA))                 FOR
     5 THETA.LT.F5.4,14H.AND.THETA.GE.F5.4/
     618H           PSI=EXP(F8.4,2H*(F7.4,38H-THETA))                 FOR
     7 THETA.LT.F5.4//)
700   FORMAT(35H            2) CONDUCTIVITY:/
     112H           K=F8.4,6H*EXP(-F8.6,8H*(!PSI!-F6.3,25H))          FOR
     2 !PSI!.LE.F6.1,3H CM/
     312H           K=F8.4,6H*EXP(-F8.6,8H*(!PSI!-F6.3,25H))          FOR
     4 !PSI!.GT.F6.1,14H.AND.!PSI!.LT.F6.1,3H CM/
     513H           K=(F5.2,1H+F5.3,48H*LOG10(!PSI!)*(!PSI!)**(-1.4)
     6 FOR.!PSI!.GE.F6.1,3H CM//)
560   PRINT 450
      IF(KOD(1).EQ.1) GO TO 590
      THETA(1)=(LL-2)*0.01
      THETA(2)=THETA(1)+0.01
      IF(KOD(1).EQ.2) PRINT 460
      IF(KOD(1).EQ.0) PRINT 470
C
      DO 600 I=1,IW2,2
         DO 610 J=1,2
            THETA(J)=THETA(J)+0.02
            IF(THETA(J).GE.(ML*0.01)) GO TO 620
610      CONTINUE
         J=J-1
620      IF(KOD(1).EQ.2) PRINT 490, (THETA(IL),SL(I+IL-1),CL(I+IL-1),
     1   CHL(I+IL-1),IL=1,J)
         IF(KOD(1).EQ.0) PRINT 480, (THETA(IL),SL(I+IL-1),CHL(I+IL-1),
     1   IL=1,J)
600   CONTINUE
C
      IF(KOD(1).EQ.2) GO TO 630
      PRINT 570, 2,CSAT2,CLA1,CSAT2,CLA2,CLA1,CLA1,CLB1,CLB2,CLB1
      GO TO 630
590   PRINT 580, 2, SLA1,SLB1,SLB1,SLC,SLA2,SLB2,SLC,SLD,SLA3,SLB3,SLD
      PRINT 700, CSAT2,CLA1,CLB1,CLC,CSAT2,CLA2,CLB2,CLC,CLD,CLA3,CLB3,
     1CLD
630   RETURN
      END
C
C
C
      SUBROUTINE WACO(SU,SL,W,WCL,NM,S)
C --- SUBROUTINE WACO TO CALCULATE THE WATER CONTENTS AT NODAL
C --- POINTS FROM SUCTION DATA.
      INTEGER P
      DIMENSION KOD(7),SU(80),SL(80),W(25),S(25)
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
      IF(KOD(1).EQ.1) GO TO 10
C
```

```
C --- KOD(1)#1
      I=0
C
20    I=I+1
      IF(I.GT.NNL) GO TO 30
      DO 40 J=2,IW1
         X=S(I)
         Y=1.0
         IF(X.LT.SU(1).AND.X.GE.SU(J)) Y=(J+LU-1+(SU(J)-X)/(SU(J-1)-
     1   SU(J)))/100.0
         IF(X.GE.SU(1)) Y=0.01*LU
         IF(X.LT.SU(IW1).AND.SU(IW1).GT.0.001) Y=SWCU-(SWCU-0.01*
     1   (IW1+LU-1))/SU(IW1)*X
         IF(X.LT.SU(IW1).AND.SU(IW1).LE.0.001) Y=SWCU
         IF(ABS(Y-1.0).GE.1.E-6) W(I)=Y
         IF(ABS(Y-1.0).GE.1.E-6) GO TO 20
40    CONTINUE
C
C --- LOWER LAYER
30    P=NNL-1
50    P=P+1
      IF(P.GT.NM) GO TO 60
      X=S(P)
      Y=1.0
      DO 70 J=2,IW2
      IF(X.LT.SL(1).AND.X.GE.SL(J)) Y=(J+LL-1+(SL(J)-X)/(SL(J-1)-SL(J)))
     1/100.0
      IF(X.GE.SL(1)) Y=0.01*LL
      IF(X.LT.SL(IW2).AND.SL(IW2).GT.0.001) Y=SWCL-(SWCL-0.01*(IW2+LL-1)
     1)/SL(IW2)*X
      IF(X.LT.SL(IW2).AND.SL(IW2).LE.0.001) Y=SWCL
      IF(ABS(Y-1.0).GE.1.E-6 .AND. P.EQ.NNL) WCL=Y
      IF(ABS(Y-1.0).GE.1.E-6 .AND. P.GT.NNL) W(P)=Y
      IF(ABS(Y-1.0).GE.1.E-6) GO TO 50
70    CONTINUE
C
C --- KOD(1)=1
10    IF(L6.GT.1) GO TO 80
      SUM1=EXP(SUA1*(SUB1-SUC))
      SUM2=EXP(SUA2*(SUB2-SUD))
      SLM1=EXP(SLA1*(SLB1-SLC))
      SLM2=EXP(SLA2*(SLB2-SLD))
80    J=0
90    J=J+1
      IF(J.GT.NNL) GO TO 100
      X=S(J)
      IF(X.LT.1.0) X=1.0
      IF(X.LE.SUM1) W(J)=SUB1-ALOG(X)/SUA1
      IF(X.GT.SUM1.AND.X.LE.SUM2) W(J)=SUB2-ALOG(X)/SUA2
      IF(X.GT.SUM2) W(J)=SUB3-ALOG(X)/SUA3
      GO TO 90
100   P=NNL-1
110   P=P+1
      IF(P.GT.NM) GO TO 60
      X=S(P)
      IF(X.LT.1.0) X=1.0
      IF(X.LE.SLM1) Y=SLB1-ALOG(X)/SLA1
      IF(X.GT.SLM1.AND.X.LE.SLM2) Y=SLB2-ALOG(X)/SLA2
      IF(X.GT.SLM2) Y=SLB3-ALOG(X)/SLA3
      IF(P.EQ.NNL) WCL=Y
      IF(P.GT.NNL) W(P)=Y
      GO TO 110
60    RETURN
      END
C
C
```

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C
      SUBROUTINE BOCO(EPA,SGLA,FLUXA,DRZA,SN1N,CFWT,DX,N1,ID,L,KOD,T1,
     1GIVSUC,GSUC,N,INFILTA)
C --- SUBROUTINE BOCO TO COMPUTE THE INTERMEDIATE VALUES OF THE BOUNDARY
C --- CONDITIONS AT ANY STAGE OF COMPUTATION.
      REAL INFILT,INFILTA
      INTEGER P
      DIMENSION EP(365),DWT(365),DRZ(365),SGL(365),FLUX(365),L(10),KOD(7
     1),GSUC(365),INFILT(365)
      COMMON/BONC/ DWT,SGL,EP,DRZ,FLUX,INFILT
      P=T1-L(1)+1
      IF(P.GE.ID) GO TO 10
      TA=T1-L(1)-P+1
      EPA=EP(P)+(EP(P+1)-EP(P))*TA
      INFILTA=INFILT(P)+(INFILT(P+1)-INFILT(P))*TA
      IF(KOD(3).NE.1) DRZA=DRZ(P)+(DRZ(P+1)-DRZ(P))*TA
      IF(KOD(3).EQ.1) DRZA=DRZ(1)
      SGLA=SGL(P)
      IF(KOD(7) .NE. 0)GO TO 5
C --- DEPTH OF WATERTABLE AT TIME=T1.
      CFWT=DWT(P)+(DWT(P+1)-DWT(P))*TA
C --- NUMBER OF FIRST NODAL POINT ABOVE WATERTABLE.
      N1=CFWT/DX+0.49
C --- DISTANCE BETWEEN NODAL POINT N1 AND WATERTABLE.
      SN1N=CFWT-DX*(N1-0.5)+0.001
      IF(ABS(DWT(P)-DWT(P+1)).LT.1.E-6) CFWT=10.*DX
      IF(ABS(DWT(P)-DWT(P+1)).GE.1.E-6) CFWT=DX/ABS(DWT(P+1)-DWT(P))
5     IF(KOD(6).EQ.0) GO TO 20
      FLUXA=FLUX(P)
      GO TO 20
10    EPA=EP(ID)
      DRZA=DRZ(ID)
      SGLA=SGL(ID)
      INFILTA = INFILT(ID)
      IF(KOD(7) .NE. 0) GO TO 15
      N1=DWT(ID)/DX+0.49
      SN1N=DWT(ID)-DX*(N1-0.5)+0.001
15    CFWT=1.0
      IF(KOD(6).EQ.0) GO TO 20
      FLUXA=FLUX(ID)
20    GO TO(30,22,21),KOD(7)+1
21    GIVSUC = GSUC(1)
      GO TO 26
22    IF(P .LT. ID) GO TO 25
      GIVSUC = GSUC(ID)
      GO TO 26
25    GIVSUC=GSUC(P) + (GSUC(P+1)-GSUC(P)) * TA
26    N1=N
      SN1N=.0001
      CFWT = 10. * DX
      IF(P .GE. ID) CFWT = 1.
30    RETURN
      END
C
C
C
      SUBROUTINE HEPR(W,S,SU,SL,NM)
C --- SUBROUTINE HEPR TO CALCULATE THE SUCTIONS FOR EACH NODAL POINT
C --- WHEN INITIAL CONDITION IS GIVEN AS A VALUE OF WATER CONTENT.
C --- (KOD(5)=0)
      INTEGER P
      DIMENSION W(25),S(25),SU(80),SL(80),KOD(7)
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
```

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C
      SUBROUTINE BOCO(EPA,SGLA,FLUXA,DRZA,SN1N,CFWT,DX,N1,ID,L,KOD,T1,
     1GIVSUC,GSUC,N,INFILTA)
C --- SUBROUTINE BOCO TO COMPUTE THE INTERMEDIATE VALUES OF THE BOUNDARY
C --- CONDITIONS AT ANY STAGE OF COMPUTATION.
      REAL INFILT,INFILTA
      INTEGER P
      DIMENSION EP(365),DWT(365),DRZ(365),SGL(365),FLUX(365),L(10),KOD(7
     1),GSUC(365),INFILT(365)
      COMMON/BONC/ DWT,SGL,EP,DRZ,FLUX,INFILT
      P=T1-L(1)+1
      IF(P.GE.ID) GO TO 10
      TA=T1-L(1)-P+1
      EPA=EP(P)+(EP(P+1)-EP(P))*TA
      INFILTA=INFILT(P)+(INFILT(P+1)-INFILT(P))*TA
      IF(KOD(3).NE.1) DRZA=DRZ(P)+(DRZ(P+1)-DRZ(P))*TA
      IF(KOD(3).EQ.1) DRZA=DRZ(1)
      SGLA=SGL(P)
      IF(KOD(7) .NE. 0)GO TO 5
C --- DEPTH OF WATERTABLE AT TIME=T1.
      CFWT=DWT(P)+(DWT(P+1)-DWT(P))*TA
C --- NUMBER OF FIRST NODAL POINT ABOVE WATERTABLE.
      N1=CFWT/DX+0.49
C --- DISTANCE BETWEEN NODAL POINT N1 AND WATERTABLE.
      SN1N=CFWT-DX*(N1-0.5)+0.001
      IF(ABS(DWT(P)-DWT(P+1)).LT.1.E-6) CFWT=10.*DX
      IF(ABS(DWT(P)-DWT(P+1)).GE.1.E-6) CFWT=DX/ABS(DWT(P+1)-DWT(P))
5     IF(KOD(6).EQ.0) GO TO 20
      FLUXA=FLUX(P)
      GO TO 20
10    EPA=EP(ID)
      DRZA=DRZ(ID)
      SGLA=SGL(ID)
      INFILTA = INFILT(ID)
      IF(KOD(7) .NE. 0) GO TO 15
      N1=DWT(ID)/DX+0.49
      SN1N=DWT(ID)-DX*(N1-0.5)+0.001
15    CFWT=1.0
      IF(KOD(6).EQ.0) GO TO 20
      FLUXA=FLUX(ID)
20    GO TO(30,22,21),KOD(7)+1
21    GIVSUC = GSUC(1)
      GO TO 26
22    IF(P .LT. ID) GO TO 25
      GIVSUC = GSUC(ID)
      GO TO 26
25    GIVSUC=GSUC(P) + (GSUC(P+1)-GSUC(P)) * TA
26    N1=N
      SN1N=.0001
      CFWT = 10. * DX
      IF(P .GE. ID) CFWT = 1.
30    RETURN
      END
C
C
C
      SUBROUTINE HEPR(W,S,SU,SL,NM)
C --- SUBROUTINE HEPR TO CALCULATE THE SUCTIONS FOR EACH NODAL POINT
C --- WHEN INITIAL CONDITION IS GIVEN AS A VALUE OF WATER CONTENT.
C --- (KOD(5)=0)
      INTEGER P
      DIMENSION W(25),S(25),SU(80),SL(80),KOD(7)
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
```

```
C --- KOD(1)#1
      I=0
C
20    I=I+1
      IF(I.GT.NNL) GO TO 30
      DO 40 J=2,IW1
         X=S(I)
         Y=1.0
         IF(X.LT.SU(1).AND.X.GE.SU(J)) Y=(J+LU-1+(SU(J)-X)/(SU(J-1)-
     1   SU(J))))/100.0
         IF(X.GE.SU(1)) Y=0.01*LU
         IF(X.LT.SU(IW1).AND.SU(IW1).GT.0.001) Y=SWCU-(SWCU-0.01*
     1   (IW1+LU-1))/SU(IW1)*X
         IF(X.LT.SU(IW1).AND.SU(IW1).LE.0.001) Y=SWCU
         IF(ABS(Y-1.0).GE.1.E-6) W(I)=Y
         IF(ABS(Y-1.0).GE.1.E-6) GO TO 20
40    CONTINUE
C
C --- LOWER LAYER
30    P=NNL-1
50    P=P+1
      IF(P.GT.NM) GO TO 60
      X=S(P)
      Y=1.0
      DO 70 J=2,IW2
      IF(X.LT.SL(1).AND.X.GE.SL(J)) Y=(J+LL-1+(SL(J)-X)/(SL(J-1)-SL(J))))
     1/100.0
      IF(X.GE.SL(1)) Y=0.01*LL
      IF(X.LT.SL(IW2).AND.SL(IW2).GT.0.001) Y=SWCL-(SWCL-0.01*(IW2+LL-1)
     1)/SL(IW2)*X
      IF(X.LT.SL(IW2).AND.SL(IW2).LE.0.001) Y=SWCL
      IF(ABS(Y-1.0).GE.1.E-6 .AND. P.EQ.NNL) WCL=Y
      IF(ABS(Y-1.0).GE.1.E-6 .AND. P.GT.NNL) W(P)=Y
      IF(ABS(Y-1.0).GE.1.E-6) GO TO 50
70    CONTINUE
C
C --- KOD(1)=1
10    IF(L6.GT.1) GO TO 80
      SUM1=EXP(SUA1*(SUB1-SUC))
      SUM2=EXP(SUA2*(SUB2-SUD))
      SLM1=EXP(SLA1*(SLB1-SLC))
      SLM2=EXP(SLA2*(SLB2-SLD))
80    J=0
90    J=J+1
      IF(J.GT.NNL) GO TO 100
      X=S(J)
      IF(X.LT.1.0) X=1.0
      IF(X.LE.SUM1) W(J)=SUB1-ALOG(X)/SUA1
      IF(X.GT.SUM1.AND.X.LE.SUM2) W(J)=SUB2-ALOG(X)/SUA2
      IF(X.GT.SUM2) W(J)=SUB3-ALOG(X)/SUA3
      GO TO 90
100   P=NNL-1
110   P=P+1
      IF(P.GT.NM) GO TO 60
      X=S(P)
      IF(X.LT.1.0) X=1.0
      IF(X.LE.SLM1) Y=SLB1-ALOG(X)/SLA1
      IF(X.GT.SLM1.AND.X.LE.SLM2) Y=SLB2-ALOG(X)/SLA2
      IF(X.GT.SLM2) Y=SLB3-ALOG(X)/SLA3
      IF(P.EQ.NNL) WCL=Y
      IF(P.GT.NNL) W(P)=Y
      GO TO 110
60    RETURN
      END
C
C
```

```
      I=0
      IF(KOD(1).EQ.1) GO TO 10
C
C --- KOD(1) # 1
20    I=I+1
      IF(I.GT.NNL) GO TO 30
C --- UPPER LAYER
      X=-1.0
      DO 40 P=2,IW1
         IF(W(I).LE.0.01*(LU+P-1)) X=SU(P-1)+(SU(P)-SU(P-1))*(100.0*W(I)
     1   -P-LU+2)
         IF(W(I).LE.(0.01*LU)) X=SU(1)
         IF(W(I).GE.SWCU) X=0.001
         IF(ABS(X + 1.0) .GE. 1.E-6) S(I)=X
         IF(ABS(X + 1.0) .GE. 1.E-6) GO TO 20
40    CONTINUE
C --- LOWER LAYER
30    I=NNL
50    I=I+1
      IF(I.GT.NM) GO TO 60
      X=-1.0
      DO 70 P=2,IW2
         IF(W(I).LE.0.01*(LL+P-1)) X=SL(P-1)+(SL(P)-SL(P-1))*(100.0*W(I)
     1   -P-LL+2)
         IF(W(I).LE.(0.01*LL)) X=SL(1)
         IF(W(I).GE.SWCL) X=0.001
         IF(ABS(X + 1.0) .GE. 1.E-6) S(I)=X
         IF(ABS(X + 1.0) .GE. 1.E-6) GO TO 50
70    CONTINUE
C
C --- KOD(1)=1
10    DO 80 I=1,NNL
         IF(W(I).GE.SUC) S(I)=EXP(SUA1*(SUB1-W(I)))
         IF(W(I).LT.SUC.AND.W(I).GE.SUD) S(I)=EXP(SUA2*(SUB2-W(I)))
         IF(W(I).LT.SUD) S(I)=EXP(SUA3*(SUB3-W(I)))
80    CONTINUE
      P=NNL+1
      DO 90 I=P,NM
         IF(W(I).GE.SLC) S(I)=EXP(SLA1*(SLB1-W(I)))
         IF(W(I).LT.SLC.AND.W(I).GE.SLD) S(I)=EXP(SLA2*(SLB2-W(I)))
         IF(W(I).LT.SLD) S(I)=EXP(SLA3*(SLB3-W(I)))
90    CONTINUE
60    RETURN
      END
C
C
C
      SUBROUTINE HEPAS(WCS,SU,ID)
C --- SUBROUTINE HEPAS TO CALCULATE THE SUCTIONS AT SOIL SURFACE WHEN
C --- THE BOUNDARY CONDITION IS GIVEN AS A VALUE OF WATER CONTENT
C --- (KOD(6)=0)
      INTEGER P
      DIMENSION WCS(365),SU(80),KOD(7)
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
      IF(KOD(1).EQ.1) GO TO 10
C --- KOD(1) # 1
      I=0
20    I=I+1
      IF(I.GT.ID) GO TO 30
      X=-1.0
      DO 40 P=2,IW1
         IF(WCS(I).LE.0.01*(LU+P-1)) X=SU(P-1)+(SU(P)-SU(P-1))*(100.0*
     1   WCS(I)-P-LU+2)
```

```
          IF(WCS(I).LE.(0.01*LU)) X=SU(1)
          IF(WCS(I).GE.SWCU) X=0.001
          IF(ABS(X+1.0).GE.1.E-6) WCS(I)=X
          IF(ABS(X+1.0).GE.1.E-6) GO TO 20
40    CONTINUE
C --- KOD(1) = 1
10    DO 50 I=1,ID
          IF(WCS(I).GE.SUC) X=EXP(SUA1*(SUB1-WCS(I)))
          IF(WCS(I).LT.SUC.AND.WCS(I).GE.SUD) X=EXP(SUA2*(SUB2-WCS(I)))
          IF(WCS(I).LT.SUD) X=EXP(SUA3*(SUB3-WCS(I)))
          WCS(I)=X
50    CONTINUE
30    RETURN
      END
C
C
C
      SUBROUTINE DMC(J,CH1,X,CHU,CHL,SU,SL)
C --- SUBROUTINE DMC TO CALCULATE THE DIFFERENTIAL MOISTURE CAPACITIES
C --- AT SUCTIONS PREVAILING IN THE NODAL POINTS.
      INTEGER P
      DIMENSION CHU(80),CHL(80),SU(80),SL(80),KOD(7)
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
      IF(KOD(1).EQ.1) GO TO 10
C
C --- KOD(1) # 1
      IF(J.GT.NNL) GO TO 20
C --- UPPER LAYER
      CH1=0.0
      DO 30 P=1,IW1
          IF(X.GE.SU(1)) CH1=CHU(1)
          IF(X.LE.SU(IW1)) CH1=CHU(IW1)
          IF(X.LT.SU(1).AND.X.GT.SU(P)) CH1=CHU(P)-(CHU(P)-CHU(P-1))*(
     1    SU(P)-X)/(SU(P)-SU(P-1))
          IF(ABS(CH1).GE.1.E-12) GO TO 40
30    CONTINUE
40    IF(J-NNL) 50,60,20
60    SI=1.0
      GO TO 70
20    SI=0.0
C --- LOWER LAYER
70    CH2=0.0
      DO 80 P=1,IW2
          IF(X.GE.SL(1)) CH2=CHL(1)
          IF(X.LE.SL(IW2)) CH2=CHL(IW2)
          IF(X.LT.SL(1).AND.X.GT.SL(P)) CH2=CHL(P)-(CHL(P)-CHL(P-1))*(
     1    SL(P)-X)/(SL(P)-SL(P-1))
          IF(ABS(CH2).GE.1.E-12) GO TO 90
80    CONTINUE
90    CH1=0.5*((2.0-SI)*CH2+SI*CH1)
      GO TO 50
C
C --- KOD(1) = 0
10    IF(L6.NE.1) GO TO 100
      SUM1=EXP(SUA1*(SUB1-SUC))
      SUM2=EXP(SUA2*(SUB2-SUD))
      SLM1=EXP(SLA1*(SLB1-SLC))
      SLM2=EXP(SLA2*(SLB2-SLD))
100   IF(J.GT.NNL) GO TO 110
      IF(X.LT.1.0) X=1.0
      IF(X.LE.SUM1) CH1=-1.0/(SUA1*X)
      IF(X.GT.SUM1.AND.X.LE.SUM2) CH1=-1.0/(SUA2*X)
      IF(X.GT.SUM2) CH1=-1.0/(SUA3*X)
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```
      IF(J-NNL) 50,120,110
120   SI=1.0
      GO TO 130
110   SI=0.0
      IF(X.LT.1.0) X=1.0
130   IF(X.LE.SLM1) CH2=-1.0/(SLA1*X)
      IF(X.GT.SLM1.AND.X.LE.SLM2) CH2=-1.0/(SLA2*X)
      IF(X.GT.SLM2) CH2=-1.0/(SLA3*X)
      CH1=0.5*((2.0-SI)*CH2+SI*CH1)
50    RETURN
      END
C
C
C
      SUBROUTINE CON(J,A,B,SA,SB,CU,CL,SU,SL)
C --- SUBROUTINE CON TO CALCULATE THE HYDRAULIC CONDUCTIVITIES FROM
C --- SUCTION VALUES. THE CONDUCTIVITIES ARE COMPUTED FOR SUCTIONS
C --- SA(COND.A) AND SB(COND.B). THE VARIABLE J IS ONLY USED TO
C --- CHECK IF THE POINTS ARE IN THE UPPER OR IN THE LOWER LAYER.
      INTEGER P
      DIMENSION CL(80),SL(80),CU(80),SU(80),KOD(7)
      COMMON/CONDU/ CSAT1,CSAT2,SUA1,SUA2,SUA3,SUB1,SUB2,SUB3,SUC,SUD,
     1SLA1,SLA2,SLA3,SLB1,SLB2,SLB3,SLC,SLD,CUA1,CUA2,CUA3,CUB1,CUB2,
     2CUB3,CUC,CUD,CLA1,CLA2,CLA3,CLB1,CLB2,CLB3,CLC,CLD,KOD,NNL,IW1,
     3IW2,L6,SWCU,SWCL,LU,LL,MU,ML,FAC
      LK=1
      IF(J.GT.NNL) GO TO 10
      SS=SB
      IF(KOD(1).NE.0) GO TO 20
30    IF(SS.LE.CUA1) A1=FAC*CSAT1
      IF(SS.GT.CUA1.AND.SS.LT.CUB1) A1=FAC*CSAT1*EXP(-CUA2*(SS-CUA1))
      IF(SS.GE.CUB1) A1=FAC*CUB2*(SS**(-1.4))
      IF(LK.EQ.1) B=A1
      IF(LK.EQ.0) A=A1
      IF(LK.EQ.0) GO TO 40
      LK=0
      IF(J.GE.NNL) GO TO 10
      SS=SA
      GO TO 30
10    IF(KOD(1).NE.0) GO TO 20
      SS=SA
50    IF(SS.LE.CLA1) B1=FAC*CSAT2
      IF(SS.GT.CLA1.AND.SS.LT.CLB1) B1=FAC*CSAT2*EXP(-CLA2*(SS-CLA1))
      IF(SS.GE.CLB1) B1=FAC*CLB2*(SS**(-1.4))
      IF(LK.NE.2) A=B1
      IF(LK.EQ.0) GO TO 40
      IF(LK.EQ.1) SS=SB
      IF(LK.EQ.2) B=B1
      IF(LK.EQ.2) GO TO 40
      LK=2
      GO TO 50
20    IF(KOD(1).NE.2) GO TO 60
      IF(J.GT.NNL) GO TO 70
      SS=SB
90    A1=0.0
      DO 80 P=1,IW1
         IF(SS.GE.SU(P).AND.SS.LT.SU(1)) A1=FAC*(CU(P-1)+(CU(P)-CU(P-1
     1   ))*(SU(P-1)-SS)/(SU(P-1)-SU(P)))
         IF(SU(1).LE.SS) A1=FAC*CU(1)
         IF(SU(IW1).GE.SS) A1=FAC*CU(IW1)
         IF(ABS(A1).GE.1.E-12) GO TO 140
80    CONTINUE
140   IF(LK.EQ.1) B=A1
      IF(LK.EQ.0) A=A1
      IF(LK.EQ.0) GO TO 40
      LK=0
```

```
      IF(J.GE.NNL) GO TO 70
      SS=SA
      GO TO 90
70    SS=SA
      B1=0.0
110   DO 100 P=1,IW2
         IF(SS.GE.SL(P).AND.SS.LT.SL(1)) B1=FAC*(CL(P-1)+(CL(P)-CL(P-1
     1   ))*(SL(P-1)-SS)/(SL(P-1)-SL(P)))
         IF(SS.GE.SL(1)) B1=FAC*CL(1)
         IF(SS.LE.SL(IW2)) B1=FAC*CL(IW2)
         IF(ABS(B1).GE.1.E-12) GO TO 150
100   CONTINUE
150   IF(LK.NE.2) A=B1
      IF(LK.EQ.0) GO TO 40
      IF(LK.EQ.1) SS=SB
      IF(LK.EQ.2) B=B1
      IF(LK.EQ.2) GO TO 40
      LK=2
      B1=0.0
      GO TO 110
60    IF(J.GT.NNL) GO TO 120
      SS=SB
130   IF(SS.LE.CUC) A1=FAC*CSAT1*EXP(-CUA1*(SS-CUB1))
      IF(SS.GT.CUC.AND.SS.LT.CUD) A1=FAC*CSAT1*EXP(-CUA2*(SS-CUB2))
      IF(SS.LT.1.0) SS=1.0
      IF(SS.GE.CUD) A1=FAC*(CUA3+CUB3*ALOG10(SS))*(SS**(-1.4))
      IF(LK.EQ.1) B=A1
      IF(LK.EQ.0) A=A1
      IF(LK.EQ.0) GO TO 40
      LK=0
      IF(J.GE.NNL) GO TO 120
      SS=SA
      GO TO 130
120   SS=SA
160   IF(SS.LE.CLC) B1=FAC*CSAT2*EXP(-CLA1*(SS-CLB1))
      IF(SS.GT.CLC.AND.SS.LT.CLD) B1=FAC*CSAT2*EXP(-CLA2*(SS-CLB2))
      IF(SS.LT.1.0) SS=1.0
      IF(SS.GE.CLD) B1=FAC*(CLA3+CLB3*ALOG10(SS))*(SS**(-1.4))
      IF(LK.NE.2) A=B1
      IF(LK.EQ.0) GO TO 40
      IF(LK.EQ.1) SS=SB
      IF(LK.EQ.2) B=B1
      IF(LK.EQ.2) GO TO 40
      LK=2
      GO TO 160
40    RETURN
      END
C
C
C
      SUBROUTINE RER(J,A,B,SA,SB,NNL)
C --- SUBROUTINE RER TO CALCULATE THE ROOT EXTRACTION RATES AT EACH
C --- NODAL POINT.
      INTEGER PRZ
      COMMON/SINK/ SMB,SMU1,SML1,SM2,SM3,QM,SMM,PRZ,AQ,BQ
      LK=1
      IF(J.GT.PRZ) GO TO 10
      IF(J.GT.NNL) GO TO 20
      SS=SA
30    A1=0.0
      IF(SS.GT.SMB.AND.SS.LT.SMU1) A1=QM*(SS-SMB)/(SMU1-SMB)
      IF(SS.GE.SMU1.AND.SS.LE.SM2) A1=QM
      IF(SS.GT.SM2.AND.SS.LE.SM3) A1=SMM*(SM3-SS)+AQ*QM
      IF(LK.EQ.1) A=A1
      IF(LK.EQ.0) B=A1
      IF(LK.EQ.0) GO TO 40
      LK=0
      IF(J.GE.NNL) GO TO 20
      SS=SB
      GO TO 30
20    SS=SB
50    B1=0.0
      IF(SS.GT.SMB.AND.SS.LT.SML1) B1=QM*(SS-SMB)/(SML1-SMB)
      IF(SS.GE.SML1.AND.SS.LE.SM2) B1=QM
      IF(SS.GT.SM2.AND.SS.LE.SM3) B1=SMM*(SM3-SS)+AQ*QM
      IF(LK.NE.2) B=B1
      IF(LK.EQ.0) GO TO 40
      IF(LK.EQ.1) SS=SA
      IF(LK.EQ.2) A=B1
      IF(LK.EQ.2) GO TO 40
      LK=2
      GO TO 50
10    A=0.0
      B=0.0
40    RETURN
      END
```