SIMULATION OF TRICKLE IRRIGATION, AN EXTENSION TO THE U.S. GEOLOGICAL SURVEY'S COMPUTER PROGRAM VS2D

By R. W. Healy

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METRIC CONVERSION FACTORS

The International System of Units (SI) used in this report may be converted to inch-pound units by the following conversion factors:

Multiply	By	To obtain
millimeter (mm)	.03937	inch
meter (m)	3.281	foot
meter per hour (m/h)	3.281	foot per hour
cubic meter per hour (m^3/h)	35.32	cubic foot per hour
centimeter per cubic centimeter (cm/cm^3)	6.542	inch per cubic inch
liter per hour (L/h)	0.2642	gallon per hour

SIMULATION OF TRICKLE IRRIGATION, AN EXTENSION
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ABSTRACT

A method is presented for simulating water movement through unsaturated porous media in response to a constant rate of application from a surface source. Because the rate at which water can be absorbed by soil is limited, the water will pond; therefore, the actual surface area over which the water is applied may change with time and in general will not be known beforehand. An iterative method is used to determine the size of this ponded area at any time. This method will be most useful for simulating trickle irrigation, but also may be of value for simulating movement of water in soils as the result of an accidental spill.

The method is an extension to the finite-difference computer program VS2D developed by the U.S. Geological Survey, which simulates water movement through variably saturated porous media. The simulated region can be a vertical, 2-dimensional cross section for treatment of a surface line source or an axially symmetric, 3-dimensional cylinder for a point source. Five test problems, obtained from the literature, are used to demonstrate the ability of the method to accurately match analytical and experimental results.

INTRODUCTION

Trickle irrigation is a method of applying water to fields at slow rates at selected points or lines. Mechanical emitters can be set to discharge at any desired rate. The primary advantage of trickle irrigation compared to flood or sprinkle irrigation is a greatly improved water-use efficiency, consequently, the method is used mainly in areas where water is scarce or expensive. The popularity of trickle irrigation has increased continuously, since its modern-day inception in Israel in the early 1960's (Bucks and others, 1982). The United States has more land under trickle irrigation than any other country. McNeill (1980) estimated that there were 175,000 hectares in the United States under trickle irrigation during 1980. Frazier (1977) predicted that the acreage could be 1 million hectares by 1990.

Trickle Irrigation System

Schematic plan and section diagrams of a point trickle-irrigation system are shown in figure 1. Water flows from the point emitter at a constant rate. Because that rate generally is faster than the rate at which the soil immediately beneath the emitter can absorb water, there is some surface ponding. This results in a circular area of the land surface becoming saturated. The wetted radius of that area, $\rho(t)$, is a function of time. Under a constant application rate, $\rho(t)$ increases with time until a maximum, steady-state value is attained. At that constant value, the irrigation rate is equal to the flow from the circular area. For a line trickle-irrigation system, the wetted surface has a length of 2 $\rho(t)$ when viewed from a 2-dimensional vertical cross section perpendicular to the irrigation line. The rate of expansion of $\rho(t)$ generally decreases with time (Bresler, 1978, p. 7). In general, it is not possible to exactly determine the value of $\rho(t)$ beforehand, although Warrick (1985) has derived an equation to define $\rho(t)$ at steady state under special conditions.

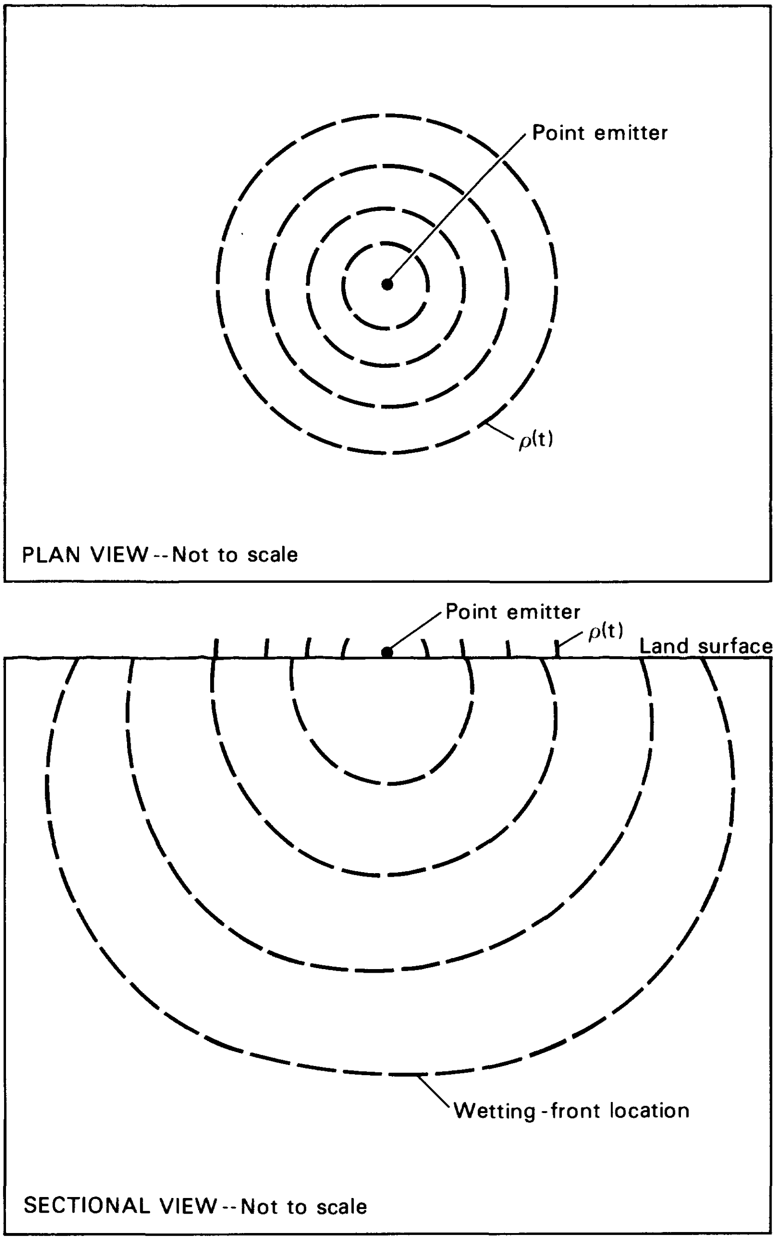

Figure 1.-- Schematic plan and sectional diagrams of a point trickle-irrigition system.

An understanding of the soil-water regime in the vicinity of an emitter could be used to improve the performance of a trickle irrigation system. Knowledge of the rate at which wetting fronts move, both horizontally and vertically, can aid in determining optimal application rates, frequency of application, and spacing between emitters. Although there has been much work done in studying water movement through partially saturated soils, relatively little has been done in the area of trickle irrigation. This is probably true because the flow field is 3-dimensional for a point source and 2-dimensional for a line source, and the surface boundary condition is quite complex. Both numerical and analytical solutions have been proposed for the solution of the water-flow equation in the vicinity of an emitter. Brandt and others (1971) presented a finite-difference technique for a single emitter both for a point-source (3-dimensional with axial symmetry) and a line-source (vertical 2-dimensional cross section). Taghavi and others (1984) developed a finite element program to accomplish the same goals as Brandt and others (1971). However, that code is somewhat limited in that the wetted radius must be known beforehand. Wooding (1968) presented an analytical solution to the linearized steady-state flow of water from a circular disk of fixed radius. Bresler (1978) used Wooding's (1968) solution to determine the required spacing between emitters to insure a specified pressure head at the soil surface midway between the emitters. Warrick (1974) developed a time-dependent linearized solution to the water-flow equation, which could be used to estimate wetting-front location for single or multiple emitters. However, this method could not account for saturation at the soil surface.

Purpose and Scope

The purpose of this report is to describe a model for simulating the movement of soil-water under trickle irrigation. The technique actually is an extension to U.S. Geological Survey's computer program VS2D (Lappala and others, 1987), which simulates water movement through variably saturated porous media. The extension consists of a new subroutine (TRICKLE) and slight modifications to existing routines. Five test problems are presented to check the ability of this code to match experimental data, theory, and a previously published simulation. Subroutine TRICKLE and the required modifications to program VS2D are listed in Attachment I. A flow chart of the revised computer program is shown in Attachment II. Explanations of data-entry requirements are listed in Attachment III. An example of data entry and program results is listed in Attachment IV. Attachments I-IV are listed at the back of the report.

Computer program VS2D uses a finite-difference approximation to the nonlinear water-flow equation (based on total hydraulic head). It can simulate problems in 1, 2 (vertical cross section), or 3-dimensions (axially symmetric). The porous media may be heterogeneous and anisotropic, but principal directions must coincide with vertical and horizontal axes. Boundary conditions can take the form of fixed pressure heads, infiltration with ponding, evaporation from the soil surface or plant transpiration. Seepage faces also may be simulated by program VS2D; however, because of program structure, seepage faces and trickle-irrigation boundaries are not allowed in the same simulation. The program also allows for some flexibility in selecting the pressure-head moisture-content and pressure-head relative hydraulic-conductivity relations. These data can be entered in tabular form or by functional relations, such as given by Brooks and Corey (1964) or van Genuchten (1980). Potential users need to obtain a copy of Lappala and others (1987) for more detail on the use of computer program VS2D.

THEORY

The partial differential equation that governs the flow of water through variably saturated porous medium can be written as:

$$C(h)\partial h/\partial t = \nabla \cdot (K(h)\nabla H) + q \qquad (1)$$

where $C(h)$ = specific water capacity, (L^{-1});
h = pressure head, (L);
H = $h - z$ or hydraulic head, (L);
z = depth (reference at land surface), (L);
t = time, (T);
$K(h)$ = hydraulic conductivity, (LT^{-1});
q = source (or sink) term, (T^{-1}); and
∇ = vector gradient operator, (L^{-1}).

Computer program VS2D solves the finite-difference equations equivalent to equation 1. The domain to be simulated is divided into a grid of cells (fig. 2). Nodes are located at the center of each cell. At each node, equation 1 is approximated by a finite-difference equation. The finite-difference equations for all nodes are then solved simultaneously. The reader is referred to Lappala and others (1987) for details on the derivation of the finite-difference approximations as well as assumptions inherent in this approach. The only item to be discussed here is the manner in which the trickle-irrigation boundary condition is implemented.

Formally, the trickle-irrigation boundary at the land surface may be defined by:

$$h(x,z) = 0,\ 0 \le x \le \rho(t),\ 0 < t \le T,\ z = 0 \qquad (2)$$

$$\partial H(x,z)/\partial z = 0,\ \rho(t) < x \le X,\ 0 \le t \le T,\ z = 0 \qquad (3)$$

$$2\pi\int_0^{\rho(t)} [K(h)\nabla H(x,z)]x\,dx = Q.\quad 0 < t \le T,\ z = 0 \text{ (point source)} \qquad (4a)$$

$$\int_0^{\rho(t)} K(h)\nabla H(x,z)dx = Q/2\quad 0 < t \le T,\ z = 0 \text{ (line source)} \qquad (4b)$$

where Q = emitter flow rate, (L^3T^{-1} or L^2T^{-1});
T = maximum simulation time, (T); and
X = radial extent of domain, (L).

Equations 2 to 4 state that at time greater than 0 the land surface is saturated at distances equal to or less than $\rho(t)$ from the origin and that there is no vertical flow across land surface at distances greater than $\rho(t)$. This second condition is not required, as evaporation or plant transpiration could be allowed to occur from that area. Also these equations are based on the assumption that the emitter is located at the origin; that is, the leftmost node that represents land surface. Because of radial symmetry this must be true when a point source is simulated; hence, only a single point source can be included in any simulation. Symmetry also is assumed when a line source is simulated. That is the reason that the emitter flow rate (Q) in equation 4b has been divided by 2. Either 1 or 2 line sources can be represented in a simulation, but because of symmetry they must be located at either the leftmost or the rightmost node that represents land surface. Although equations 2 to 4, and some following equations are written for the emitter located at the origin, the same form of equations can be used to describe an emitter located at the rightmost node representing the land surface.

The value of $\rho(t)$ needs to be determined at every time step. Because of the discrete nature of the finite-difference grid, it is not possible to represent equations 2-4 exactly. This is true because $\rho(t)$ is a continuous variable and, therefore, can have values that are different than the spacing between adjacent nodes. In practice, equations 2-4 need to be modified to account for this discretization. The finite difference grid in the vicinity of the trickle-irrigation boundary that is shown in figure 2 helps to illustrate the algorithm. For convenience, nodal locations are indexed by j and k, so that H(j,k) refers to total hydraulic head at the node located at radial or horizontal distance x_j and vertical distance z_k from the origin. Similarly, the boundary between two adjacent finite-difference nodes, say (j,k) and (j,k+1), is indicated by (j,k+1/2). The actual boundary conditions used are as follows.

$$h(j,1) = 0, \quad 0 < j \le i, \qquad 0 < t \le T \tag{5}$$

$$\partial H(j,1/2)/\partial z = 0 \quad i < j < NCOL, \quad 0 \le t \le T \tag{6}$$

$$Q_i = \pi \sum_{\ell=1}^{i} K(h)\nabla H(\ell,1\tfrac{1}{2})(x^2_{\ell+\frac{1}{2}} - x^2_{\ell-\frac{1}{2}}), \quad 0 < t \le T \text{ (point source)} \tag{7a}$$

$$= \sum_{\ell=1}^{i} K(h)\nabla H(\ell,1\tfrac{1}{2})(x_{\ell+\frac{1}{2}} - x_{\ell-\frac{1}{2}}), \quad 0 < t \le T \text{ (line source)} \tag{7b}$$

$$q(i+1,1) = Q - Q_i \tag{8}$$

where i = column index such that $x_i \le \rho(t) < x_i+1$, and $Q_i < Q < Q_{i+1}$;
NCOL = total number of columns within the grid; and
q(j,k) = a specified flux at node j,k (L^3T^{-1} or L^2T^{-1}).

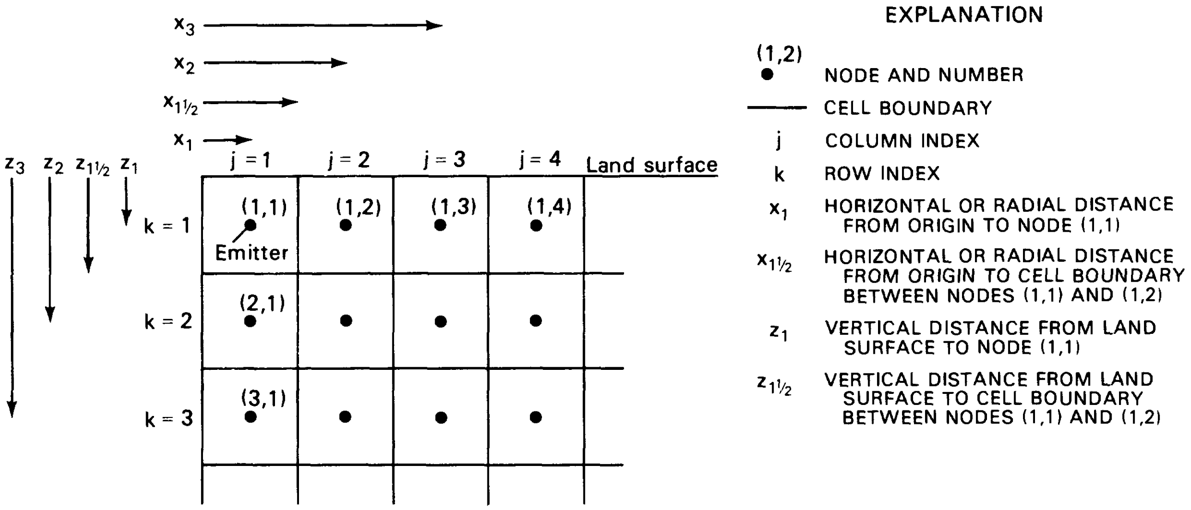

Figure 2.--Sketch showing finite-difference grid at trickle-irrigation boundary.

Equations 5 to 8 simply state that surface nodes between the origin and $\rho(t)$ are treated as contant head or Dirichlet nodes with pressure head equal to 0. The node at (i,1) represents the furthest node from the origin that still remains within the wetted radius. The flow from all of nodes between the origin and (i,1) is summed. This sum is then subtracted from the specified application rate and the resulting excess is treated as a specified flux to node (i+1,1). Although the exact value of $\rho(t)$ is not required, the value of i needs to be determined at each time step. Because this value can change between time steps, an iterative method is used to determine it at each time step.

The entire algorithm can be given as:

```
1.  Begin simulation by setting
        i = 0 and
        q(1,1) = Q.
2.  Advance to next time step.
3.  Solve finite-difference equations for all nodes.
4   If h(i+1,1) > 0 then
        Increase wetted radius
        q(i+1,1) = 0
```

```
        $h(i+1,1) = 0$ becomes a fixed head
        $i = i+1$
        $q(i+1,1) = \sigma Q$
        Go to step 6.
  5.  Calculate $Q_i$ from equation 7
        $\hat{Q} = Q - Q_i$
        $\bar{Q} = 1 - [\hat{Q} + q(i+1,1)]/Q$
        If $|\bar{Q}| \leq \epsilon$ then
          Solution has been reached for current time step
          Go to step 2.
        If $\hat{Q} < 0$ then
          Decrease wetted radius
          $q(i+1,1) = 0$
          $i = i-1$
          $h(i+1,1)$ is no longer a fixed head
          $q(i+1,1) = (Q - Q_i)(1-\sigma)$
          Go to step 6.
        If $\hat{Q} > 0$ then
          Reset specified flux
          $q(i+1,1) = (1+\sigma)\hat{Q}$.
  6.  Reset all heads (except fixed heads) to values at end of previous
      time step
        Go to step 3.
        End algorithm.
```

In the algorithm:

ϵ = user-defined closure criterion for inner iteration loop (generally set at 0.03 to 0.05). Small values improve the agreement between the specified application rate and the rate actually used in the simulator but may require excessive computer time; and

σ = user-defined relaxation parameter, may be taken to be 0, but experience has indicated that small numbers improve convergence rate (must be less in magnitude than ϵ).

Steps 4 and 5 are repeated if a second trickle-irrigation source is being simulated. In order to avoid excessive computer time, the program permits steps 4 and 5 of the algorithm to be performed a maximum of user-defined MITR times per time step, after which the simulation advances to the next time step. Values of MITR OF 4 or 5 have been determined to be sufficient for most applications.

Although the computer program does not calculate values of $\rho(t)$, an estimate of $\rho(t)$ at any time can be obtained as follows:

$$\rho(t) = x_{i+1/2} + (x_{i+1/2} - x_{i+1/2})\left[\frac{q(i+1,1)}{q_s}\right] \tag{9}$$

where q_s is the flux that would be expected from node (i+1,1) if that node was fully saturated. A value of q_s can be determined from Darcy's Law by assuming that $h(i+1,1) = 0$.

VERIFICATION PROBLEMS

Five test problems are presented in order to check the accuracy of the new simulator. Two of the problems have analytical solutions, two problems contain experimental data, and one problem contains results of a published simulation. All of the problems involve infiltration from a point source, and so an axially symmetric, 3-dimensional grid was used for each. No line-source problems were found in the literature.

Steady infiltration from a circular pond

The analytical solution for this problem was developed by Wooding (1968), using the linearized diffusion equation of Philip (1968). This requires that the hydraulic conductivity be of the form:

$$K(h) = K_{sat}\exp(\alpha h) \tag{10}$$

where K_{sat} = the saturated hydraulic conductivity (LT^{-1}); and
α = a scaling coefficient (L^{-1}).

The media was assumed to have uniform properties and initial conditions. The region was semi-infinite and the radius of the pond was constant. Radial symmetry was assumed.

Although Wooding's (1968) solution is strictly for steady state, the problem is simulated here for times prior to steady state. The simulation region was 3.60 m in depth, with a radius of 1.94 m. The grid spacing was variable ranging from 0.03 m near the trickle source to 0.40 m at the distal boundaries. The moisture-retention curve of the Nahal Sinai sandy soil, given by Bresler and others (1971, p. 685), was fit to the equation of van Genuchten (1980):

$$\theta = \theta_r + (\theta_s - \theta_r)/[1 + (\alpha'|h|)^n]^m \qquad (11)$$

where

θ = volumetric moisture content, dimensionless;
θ_r = residual moisture content, dimensionless,
= 0.02;
θ_s = porosity, dimensionless,
= 0.26;
α' = shape parameter, in inverse meters,
= 2.10 m^{-1};
h = pressure head, in meters;
n = curve fitting parameter, dimensionless; and
m = 1 - 1/n,
= 0.73.

Values of $\alpha = 3.33\ m^{-1}$ and $K_{sat} = 0.120$ m/h were used. Wooding's (1968) calculated irrigation rate for a radius of 0.06 m for these values is: 0.01037 m^3/h. Therefore, this irrigation rate was used in the simulation and the wetted radius was allowed to vary. Initial pressure heads were everywhere assumed to be equal to -3.00 m [corresponding to $\theta(h) = 0.022$ and $K(h) = 7 \times 10^{-7}$ m/h]. For convenience, the data used for this and all other verification problems are listed in table 1.

Results in terms of relative hydraulic conductivity (Wooding, 1968) are shown for 4 times in figure 3. The lengths in that figure are scaled by $1/\rho*$, where $\rho* = 0.06$ m is the steady-state wetted radius for this problem. Also shown is the steady-state solution of Wooding (1968). Steady-state was reached within the plotted region at about 45 hours. The simulated results show excellent agreement with those of Wooding (1968). The wetted radius calculated in this simulation was 0.04 m, which is noticably different from Wooding's (1968) value. Brandt and others (1971) noted that this value is difficult to accurately determine, and is highly dependent on the grid spacing that is used.

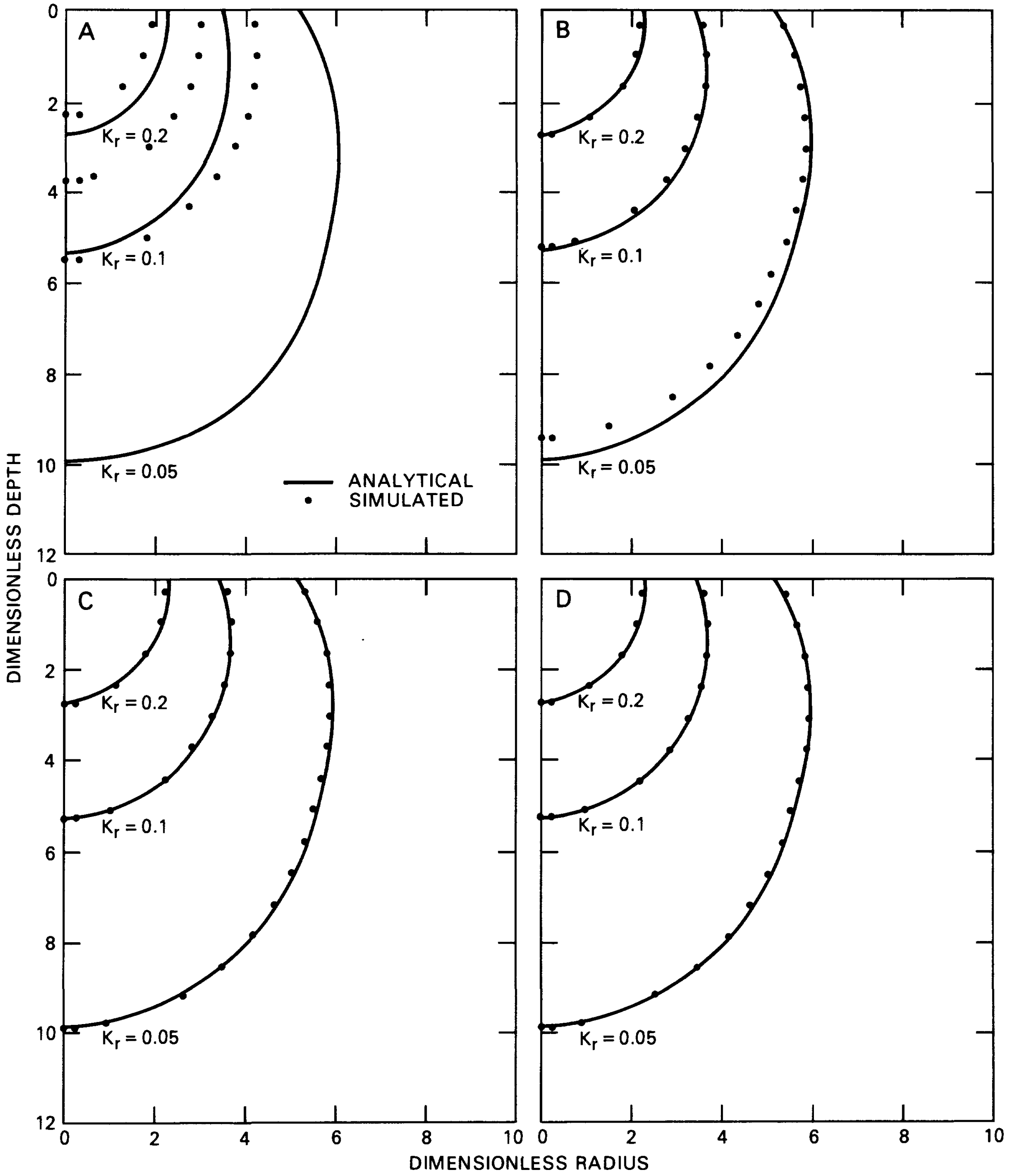

Figure 3.--Points of equal relative hydraulic conductivity, K_r, for infiltration from a circular pond--Verification problem 1. Theoretical steady state and simulated at A) 1 hour; B) 10 hours; C) 45 hours; and D) 55 hours.

Non-steady Linearized Infiltration from a Buried Point Source

Warrick (1974) extended previous analytical solutions of linearized steady-state infiltration (Philip, 1968, 1969; Wooding, 1968; and Raats, 1971) to the non-steady case. His solution required the hydraulic conductivity to be of the form given in equation 10. It also required that the slope of hydraulic-conductivity moisture-content curve be constant;

$$dK(h)/d\theta = k \tag{12}$$

where k = constant.

This is equivalent to specifying a constant diffusivity.

For this simulation, the vertical and horizontal grid spacings were constant ($\Delta x = 30$ mm, $\Delta z = 60$ mm). Radial symmetry was assumed. The point source was located at a depth of 30 mm below land surface (that is, it was located in the uppermost row of cells). The irrigation rate was 0.000546 m^3/h which was not large enough to cause ponding, so the trickle boundary condition was actually not required. However, this example is included because Warrick's (1974) solution has been applied in the past to trickle-irrigation problems (Bucks and others, 1982). The hypothetical soil column was 1,920 mm deep (32 rows) with a radius of 900 mm (30 columns). It was assumed that $k = K_{sat}/\theta_{sat} = 0.39$ m/h. The other pertinent variables are listed in table 1.

Analytical and simulated results after 5 hours of infiltration are shown in figure 4. The results are again in terms of relative hydraulic conductivity and lengths are scaled by $\alpha = 10.0\ m^{-1}$ for easy comparison with Warrick's (1974) solution. The results are almost identical at all points.

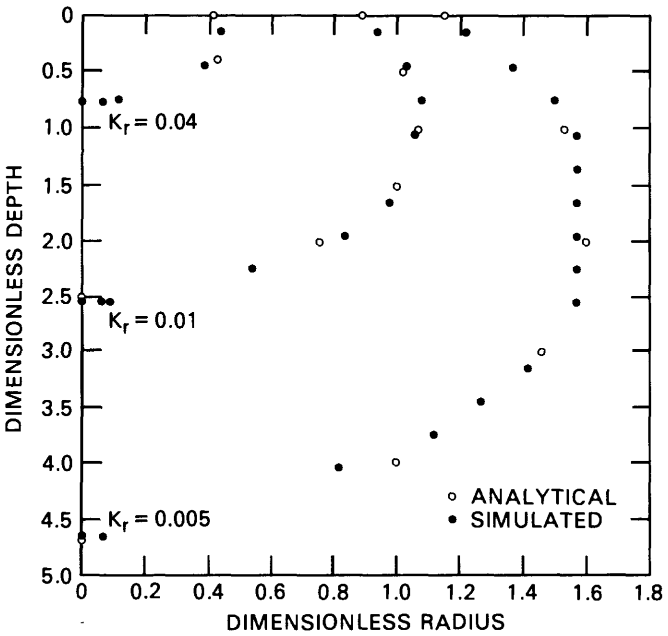

Figure 4.--Analytical and simulated points of equal relative hydraulic conductivity, K_r, after 5 hours of infiltration from a buried point source --Verification problem 2.

Trickle-irrigation experiment

This problem involves simulation of experiments conducted by Angelakis (1977) and simulated by Taghavi and others (1984). A clay-loam soil was packed into a square tank 0.50 m on each side and 1.00 m deep. The point source was located over one of the corners to take account of radial symmetry. The initial moisture content of the soil was 0.044; the hydraulic conductivity was represented by equation 10 ($\alpha = 2.80\ m^{-1}$, $K_{sat} = 0.0085$ m/h); and moisture content was assumed to be linearly related to pressure head by Taghavi and others (1984):

$$\theta(h) = \theta_s + 0.0013\ h \qquad (13)$$

where $\theta_s = 0.53$; and
h = pressure head in centimeters.

Two infiltration experiments were simulated, one for 77.78 hours at the rate of 0.0021 m^3/h and the other for 58.17 hours at the rate of 0.0033

m^3/h. The simulated region was 1.00 m deep, with a radius of 0.52 m. Grid spacing was uniform ($\Delta x = \Delta z = 0.04$ m). Experimental and simulated results for several different times are depicted in figure 5. The wetting front is defined as the set of points where $\theta = 0.144$. In general, experimental and simulated results were similar at early times. However, as time increased, the difference between the experimental and simulated the wetting fronts also increased. The reason for this is not apparent, although the simulation by Taghavi and others (1984) had similar discrepancies. At the higher rate, the simulated wetting front was much wider and deeper than the data indicated at 31.03 hours. It is obvious that by this time the no-flow radial boundary had a substantial effect on the simulated results, yet it seems to have had no effect on the experimental results. At the end of the simulation for the slower irrigation rate, the wetted radius was determined to be 0.09 m, which is similar to the fixed value of 0.08 m that was used by Taghavi and others (1984) in their simulation. The final value of the wetted radius at the higher irrigation rate was 0.14 m. Taghavi and others (1984) used a wetted radius of 0.10 m for their simulation.

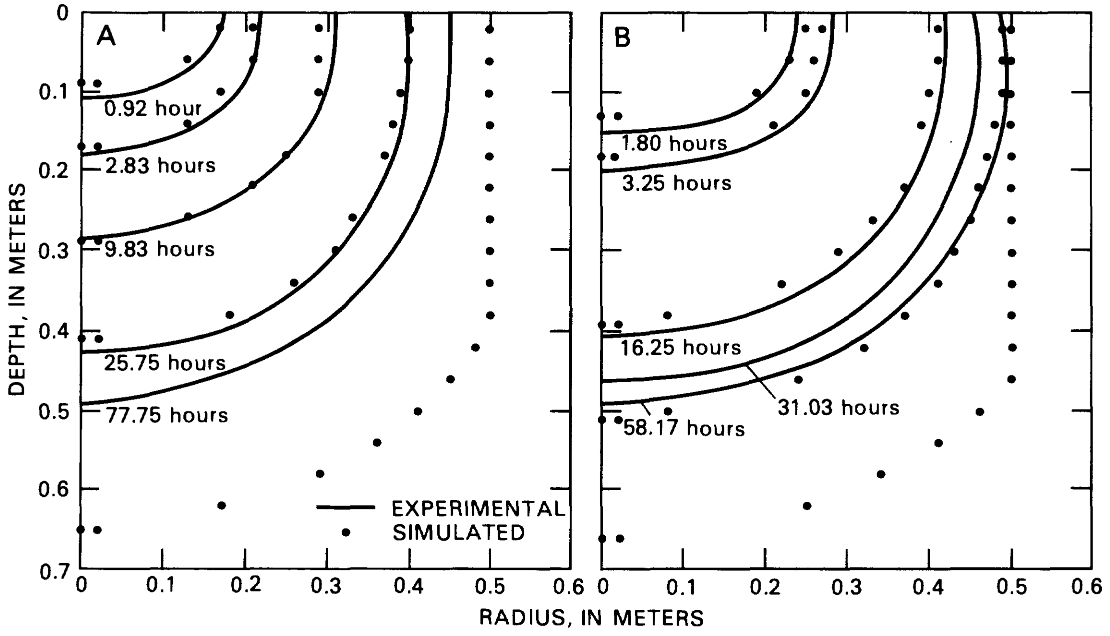

Figure 5.--Experimental and simulated wetting fronts ($\theta = 0.144$) for tank experiments--Verification problem 3. A) irrigation rate of 2.1×10^{-3} cubic meters per hour; and B) irrigation rate of 3.3×10^{-3} cubic meters per hour.

Comparison with a previous simulation

In this example, an attempt was made to reproduce results of a simulation made by Bresler (1978) using the computer program described by Brandt and others (1971). The problem involved infiltration to the Nahal Sinai sandy soil at the rate of 0.004 m^3/h for 4 hours. Values of the pertinent data are included in table 1. Actually, several different simulations of this problem were performed due to some ambiguity in the data values presented by Bresler (1978). The moisture-retention curve was represented exactly as described in Verification problem 1 (eq. 11). Bresler (1978, p. 8) gave values for K_{sat} of 0.0828 m/h and for α of 6.50 m^{-1}. However, use of these values produced results markedly different from those of Bresler (1978). This simulation indicated the wetted volume to be much wider and shallower than that shown in figure 4 of Bresler (1978, p. 9). Two possible explanations for this are that the parameters of the moisture-content function or the initial moisture content of the sand were incorrectly estimated. In an attempt to better match Bresler's (1978) results, the α' variable of the moisture-content function (eq. 11) was varied. Results when a value of $\alpha' = 4.10$ m was used are shown in figure 6. The simulated results are fairly similar to those of Bresler (1978). However, the resulting moisture-retention curve is somewhat different than that in Bresler and others (1971).

Constant-flux infiltration from a hemispherical cavity

Infiltration experiments, described by Clothier and Scotter (1982), were conducted in a cube 200 mm by 200 mm in cross section and 300 mm in depth. The box was packed with Manawatu fine sandy loam at a uniform initial moisture content of 0.055. Hydraulic conductivity was defined by equation 10 with $K_{sat} = 0.004$ m/h and $\alpha = 2.80\ m^{-1}$. The moisture-retention curve (given by Clothier and Scotter, 1982, fig. 1) was approximated by equation 11. A relatively small flux of 0.00036 m^3/h was applied over one of the corners of the box, thus taking advantage of radial symmetry. This created a cavity of about 4 mm radius that remained filled with water throughout the experiment. The experiment was simulated for 9.67 hours. Uniform grid spacing was used ($\Delta z = \Delta x = 20$mm).

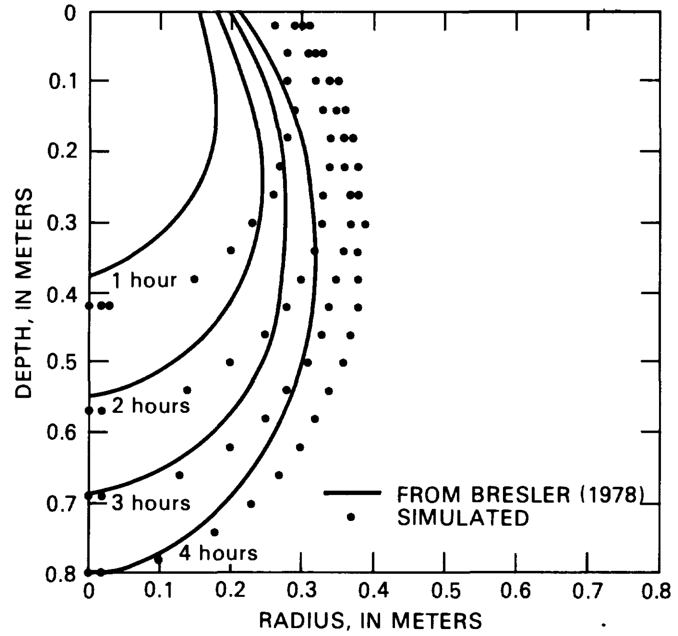

Figure 6.--Wetting fronts during infiltration to Nahal Sinai sandy soil--Verification problem 4.

The location of experimental and simulated wetting fronts at different times is shown in figure 7. For this simulation, the wetting front was defined as the points where $\theta = 0.118$. There is good agreement between results at early time steps. However, as time increased, the differences between experimental and simulated results also increased. Experimental results were of less radial extent than simulated results. The reasons for this are not apparent. At larger times the simulated values obviously were affected by the no-flow radial boundary, as indicated by the shape of the wetting front near that boundary at 6 hours. Clothier and Scotter (1982) presented results at 9.67 hours, however, the simulated results at that time indicated that the moisture content was greater than 0.118 at all points within the domain and, therefore, a wetting front could not be delineated.

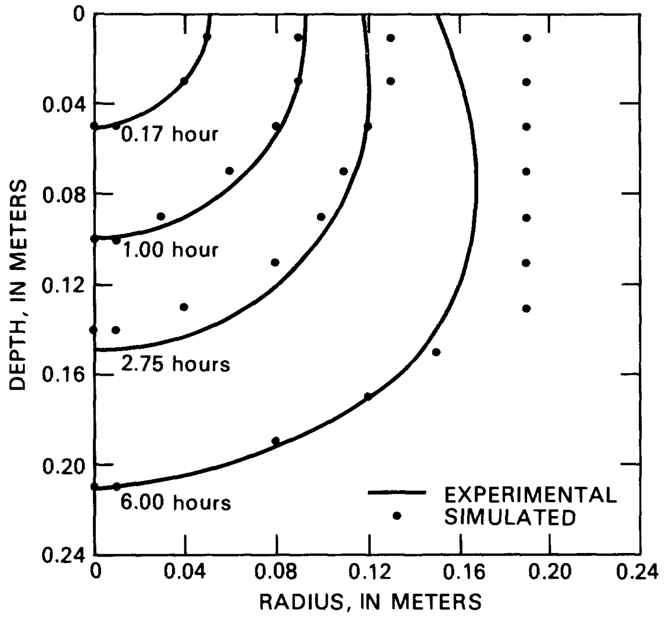

Figure 7.--Experimental and simulated ($\theta = 0.118$) wetting fronts during infiltration to Manawatu fine sandy loam--Verification problem 5.

SUMMARY

A method has been developed and tested for the simulation of water movement through variably saturated porous media in response to the application of water at land surface at a constant rate. This method should be useful for simulating the effects of trickle irrigation. Estimates of rates of wetting-front movement obtained with this method could possibly be used to optimize application rates and spacing between emitters. The method also may be of use in simulating the movement of water in soils as the result of an accidental spill on land surface. Point sources (3-dimensional axially-symmetric grid) or line sources (2-dimensional vertical cross section) can be simulated. The method involves use of the finite-difference computer program VS2D developed by the U.S. Geological Survey along with the subroutine TRICKLE presented in this report.

Five problems, obtained from the literature, were used to verify the method. Excellent results were obtained for the two problems for which analytical solutions exist. Results for the problems that involved experimental data were not as good. This should be expected because of two reasons. First, experiments of this kind are extremely difficult to conduct because of the need to accurately measure moisture content or pressure head at precise locations and times within small tanks. Second, assumptions made in modeling the infiltration, such as uniform material properties and initial moisture contents, were doubtlessly over-simplifications of the real systems. Nevertheless, the method can be a valuable tool to the study of water movement through soils in response to surface application. Included in attachments are a listing of subroutine TRICKLE and required modifications to program VS2D, a flow chart of the revised computer program, a description of data-entry requirements, and a listing of data used and results for an example problem.

Table 1.--Summary of data used for verification problems

Problem number and reference	Saturated hydrauic conductivity, Ksat, in meters per hour	scaling coeffi-cent, α, in inverse meters	Porosity, θs, dimen-sionless	Residual moisture constant, θr dimen-sionless	Equation used determining for $\theta(h)$	Shape parameter, α', in inverse m	Curve-fitting parameter, n, dimen-sionless	Irrigation rate in cubic meters per hour	Initial moisture content, dimen-sionless
1. Wooding (1968)	0.120	3.33	0.26	0.02	11	2.10	3.75	0.01037	0.022
2. Warrick (1974)	0.101	10.0	0.26	-	12	-	-	0.000546	0.0000118
3. Angelakis (1977)	0.0085	2.80	0.53	-	13	-	-	0.0021 and 0.0033	0.044
4. Bresler (1978)	0.0828	6.50	0.26	0.02	11	4.10	3.75	0.004	0.037
5. Clothier and Scotter (1982)	0.004	2.80	0.45	0.05	11	2.80	3.55	0.00036	0.055

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ATTACHMENT I

Listing of subroutine TRICKLE and required changes to program VS2D.

```
      SUBROUTINE TRICKLE(IFET)                                          350000
C*                                                                      350100
C*  ROUTINE TO SET BOUNDARY CONDITIONS FOR SIMULATION                   350200
C*  OF A TRICKLE IRRIGATION SYSTEM.                                     350300
C*                                                                      350400
      IMPLICIT DOUBLE PRECISION (A-H,P-Z)                               350500
      COMMON/RSPAC/DELZ(100),DZZ(100),DXR(100),RX(100),DELY,PI2         350600
      COMMON/ISPAC/NLY,NLYY,NXR,NXRR,NNODES                             350700
      COMMON/KCON/HX(0900),NTYP(0900)                                   350800
      COMMON/PRESS/P(0900),PXXX(0900)                                   350900
      COMMON/DISCH/Q(0900),QQ(0900),ETOUT,ETOUT1,RHOZ                   351000
      COMMON/HCON/HCND(0900),HKLL(0900),HKTT(0900)                      351100
      COMMON/SPFC/JSPX(3,25,4),NFC(4),JLAST(4),NFCS                     351200
      COMMON/PND/POND                                                   351300
      COMMON/WGT/WUS,WDS                                                351400
      COMMON/TCON/STIM,DSMAX,KTIM,NIT,KP                                351500
      COMMON/QTR/ITR,MITR,QTRICK(2),ERQ,SIG,QSA(2),INA(2)               351600
      DIMENSION II(2)                                                   351700
      SAVE II                                                           351800
      QSA(1)=0.                                                         351900
      QSA(2)=0.                                                         352000
      IF(IFET.NE.0) GO TO 10                                            352100
      II(1)=0                                                           352200
      II(2)=0                                                           352300
   10 IFET=0                                                            352400
      DO 180 K=1,NFCS                                                   352500
C                                                                       352600
C  CALCULATE TOTAL FLOW THROUGH FIXED HEAD NODES.                       352700
C                                                                       352800
      SUM1=0                                                            352900
      DO 100 J=1,NFC(K)                                                 353000
      IN=JSPX(1,J,K)                                                    353100
      IF(NTYP(IN).NE.1) GO TO 110                                       353200
      JP1=IN+1                                                          353300
      IF(WUS.NE.0)GO TO 20                                              353400
      DD=HKTT(JP1)*DSQRT(HCND(JP1)*HCND(IN))                            353500
      GO TO 30                                                          353600
   20 DD=(HCND(IN)*WUS+HCND(JP1)*WDS)*HKTT(JP1)                         353700
   30 D1=DD*(P(IN)-P(JP1))                                              353800
      IM1=IN+NLY                                                        353900
      IF(HX(IM1).EQ.0.OR.NTYP(IM1).EQ.1) GO TO 60                       354000
      IF (WUS.NE.0) GO TO 40                                            354100
      CC=HKLL(IM1)*DSQRT(HCND(IM1)*HCND(IN))                            354200
      GO TO 50                                                          354300
   40 CC=(HCND(IN)*WUS+HCND(IM1)*WDS)*HKLL(IM1)                         354400
   50 IF(P(IN).GT.P(IM1))D1=D1+CC*(P(IN)-P(IM1))                        354500
   60 IM1=IN-NLY                                                        354600
      IF(HX(IM1).EQ.0.OR.NTYP(IM1).EQ.1) GO TO 90                       354700
      IF(WUS.NE.0) GO TO 70                                             354800
      CC=HKLL(IN)*DSQRT(HCND(IM1)*HCND(IN))                             354900
      GO TO 80                                                          355000
   70 CC=HKLL(IN)*(HCND(IN)*WUS+HCND(IM1)*WDS)                          355100
```

```
   80 IF(P(IN).GT.P(IM1))D1=D1+CC*(P(IN)-P(IM1))
   90 SUM1=SUM1+D1
      QS1=(SUM1-QTRICK(K))/QTRICK(K)
      IF (QS1.GT.ERQ) GO TO 120
  100  CONTINUE
C*
C*  ALL NODES ON TRICKLE BOUNDARY ARE PONDED.  SIMULATION TERMINATED.
C*
      WRITE(6,1000)
      JSTOP=1
      RETURN
  110 JJ=JSPX(2,J,K)
C*
C*  CHECK FOR PONDING AT FLUX NODE.
C*
      P1=POND-DZZ(JJ)
      QS=SUM1+QQ(IN)
      QE=(1+ERQ)*QTRICK(K)
      IF(P(IN).LE.P1.OR.(QS.GT.QE.AND.ITR.LT.MITR)) GO TO 150
C*
C*  PONDING OCCURRED.  CHANGE NODE TO FIXED HEAD.
C*  ESTIMATE FLUX FOR NEXT NODE ON TRICKLE FACE.
C*
      IF(II(K).EQ.10) GO TO 160
      II(K)=5
      IFET=1
      P(IN)=P1
      NTYP(IN)=1
      QQ(IN)=0
      IN=JSPX(1,J+1,K)
      QQ(IN)=QTRICK(K)*SIG
      NTYP(IN)=2
      WRITE(6,1200) J
      GO TO 160
  120 SUM2=SUM1-D1
C*
C*  TOO MUCH FLUX THRU FIXED HEADS.  REMOVE FIXED
C*  HEAD FROM CURRENT NODE AND ESTIMATE FLUX.
C*
      IF(II(K).EQ.5) GO TO 130
      NTYP(IN)=2
      WRITE(6,1100) J
      QQ(IN)=(QTRICK(K)-SUM2)*(1-SIG)
      II(K)=10
      IFET=1
  130 DO 140 J2=J+1,NFC(K)
      IN=JSPX(1,J2,K)
      QQ(IN)=0.
  140 NTYP(IN)=3
      GO TO 160
  150 CONTINUE
C*
C*  CHECK TO SEE IF ACTUAL FLUX IS CLOSE ENOUGH
C*  TO PRESCRIBED TRICKLE FLUX.
```

ATTACHMENT I

Listing of subroutine TRICKLE and required changes to program VS2D--Continued.

```
C*
      QSA(K)=QTRICK(K)-QS
      QS1=DABS(QSA(K))
      INA(K)=IN
      IF(QS1.LE.ERQ*QTRICK(K))GO TO 160
      IFET=1
      QQ(IN)=(QTRICK(K)-SUM1)*(1+SIG)
  160 CONTINUE
      IF(IFET.EQ.0) GO TO 180
C*
C*  RESET HEADS TO VALUES AT END OF PREVIOUS TIME STEP
C*
      NIT=0
      DO 170 KK=NLY,NNODES
      IF(NTYP(KK).EQ.1.OR.HX(KK).EQ.0.) GO TO 170
      P(KK)=PXXX(KK)
  170 CONTINUE
  180 CONTINUE
      RETURN
 1000 FORMAT('  ALL NODES ON TRICKLE BOUNDARY ARE PONDED.',
     1'  SIMULATION TERMINATED.  IRRIGATION RATE MUST BE REDUCED'
     2'  OR NUMBER OF NODES ON TRICKLE BOUNDARY INCREASED.')
 1100 FORMAT('  UNPONDING AT NODE  ',I8)
 1200 FORMAT('  PONDING AT NODE  ',I8)
      END
```

ATTACHMENT I

Listing of subroutine TRICKLE and required changes to program VS2D--Continued.

Modifications to routine VSEXEC

Add statements

```
      COMMON/QTR/ITR,MITR,QTRICK(2),ERQ,SIG,QSA(2),INA(2)                6710
      ITR=0                                                             22410
      IF(KTIM.GT.1) THEN                                                22420
      DO 225 M=1,NFCS                                                   22430
      IM=INA(M)                                                         22440
      QQ(IM)=QQ(IM)+QSA(M)                                              22450
      IF (QQ(IM).LT.0)QQ(IM)=0                                          22460
  225 CONTINUE                                                          22470
      END IF                                                            22480
      ITR=ITR+1                                                         22510
      CALL VSCOEF                                                       22910
      IF(ITR.LE.MITR) CALL TRICKLE(IFET)                                22920
      IF(IFET.NE.0.AND.ITR.LE.MITR)GO TO 230                            23310
      WRITE(6,4180) ITR                                                 23320
 4180 FORMAT('  NUMBER OF PASSES THROUGH TRICKLE LOOP = ',I4)           30110
```

Delete statements

```
      CALL VSPOND(IFET,IFET1,IFET2)                                     22900
      IF(IFET.NE.0) GO TO 230                                           23300
      CALL VSCOEF                                                       23800
```

Modifications to routine VSTMER

Add statements

```
      COMMON/QTR/ITR,MITR,QTRICK(2),ERQ,SIG,QQA(2),INA(2)               64110
      READ(5,*) JJ,MITR,QTRICK(K),ERQ,SIG                               68810
      IF(MITR.LE.0) MITR=8                                              68820
      IF(J.NE.1) GO TO 40                                               70010
      QQ(N2)=QTRICK(K)                                                  70020
      NTYP(N2)=2                                                        70030
```

ATTACHMENT I

Listing of subroutine TRICKLE and required changes to program VS2D--Continued.

```
----------------------------------
Delete statements
----------------------------------

     READ(5,*) JJ,JLAST(K)                                        68800
     IF(J.LE.JLAST(K)) GO TO 30                                   69800
     GO TO 40                                                     70000
30   NTYP(N2)=1                                                   70100
     P(N2)=-DZZ(J1)                                               70200
```

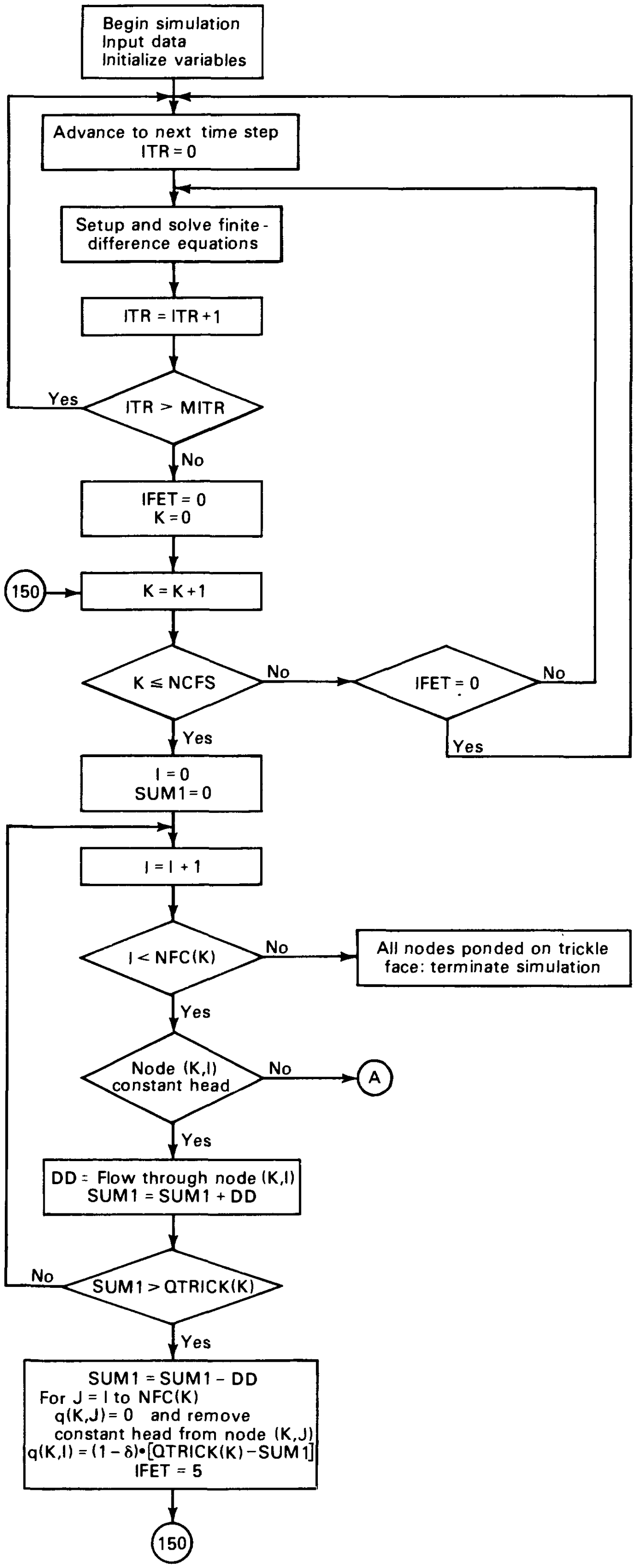
Modifications to routine VSMGEN

```
----------------------------------
Delete statement
---------------------

     IF (SEEP) CALL VSSFAC                                        93800
```

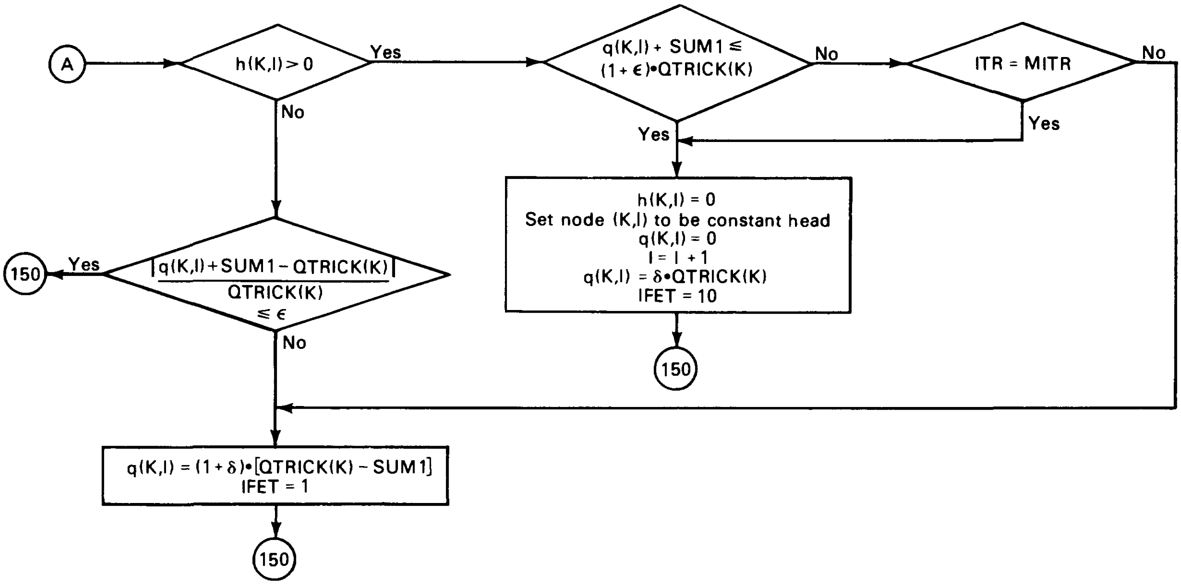
Attachment II

Flow chart of revised computer program



Attachment II

Flow chart of revised computer program--Continued



ATTACHMENT III

Description of input instructions

The trickle-boundary condition replaces the seepage-face boundary in program VS2D. Therefore, without program modification these two boundaries cannot be used in the same simulation. In addition, infiltration can not be simulated at nodes that are not located on a trickle boundary. A complete list of data-entry instructions follows, for more details on any particular variable, the reader is referred to Lappala and others (1987). The variables that apply for the trickle-boundary option are marked with an asterisk.

ATTACHMENT III
Description of input instructions

Card	Variable	Description
[Line group A read by VSEXEC]		
A-1	TITL	80-character problem description (formatted read, 20A4).
A-2	TMAX	Maximum simulation time, T.
	STIM	Initial time (usually set to 0), T.
A-3	ZUNIT	Units used for length (A4).
	TUNIT	Units used for time (A4).
	CUNX	Units used for mass (A4).
Note: Line A-3 is read in 3A4 format, so the unit designations must occur in columns 1-4, 5-8, 9-12, respectively.		
A-4	NXR	Number of cells in horizontal or radial direction.
	NLY	Number of cells in vertical direction.
A-5	NRECH	Number of recharge periods.
	NUMT	Maximum number of time steps.
A-6	RAD	Logical variable = T if radial coordinates are used; otherwise = F.
	ITSTOP	Logical variable = T if simulation is to terminate after ITMAX iterations in one time step; otherwise = F.
A-7	F11P	Logical variable = T if head, moisture content, and saturation at selected observation points are to be written to file 11 at end of each time step; otherwise = F.
	F7P	Logical variable = T if head changes for each iteration in every time step are to be written in file 7; otherwise = F.
	F8P	Logical variable = T if output of pressure heads to file 8 is desired at selected observation times; otherwise = F.
	F9P	Logical variable = T if one-line mass balance summary for each time steps to be written to file 9; otherwise = F.
	F6P	Logical variable = T if mass balance is to be written to file 6 for each time step; = F if mass balance is to be written to file 6 only at observation times and ends of recharge periods.

Card	Variable	Description
A-8	THPT	Logical variable = T if volumetric moisture contents are to be written to file 6; otherwise = F.
	SPNT	Logical variable = T if saturations are to be written to file 6; otherwise = F.
	PPNT	Logical variable = T if pressure heads are to be written to file 6; otherwise = F.
	HPNT	Logical variable = T if total heads are to be written to file 6; otherwise = F.
A-9	IFAC	= 0 if grid spacing in horizontal (or radial) direction is to be read in for each column and multiplied by FACX. = 1 if all horizontal grid spacing is to be constant and equal to FACX. = 2 if horizontal grid spacing is variable, with spacing for the first two columns equal to FACX and the spacing for each subsequent column equal to XMULT times the spacing of the previous column, until the spacing equals XMAX, whereupon spacing becomes constant at XMAX.
	FACX	Constant grid spacing in horizontal (or radial) direction (if IFAC=1); constant multiplier for all spacing (if IFAC=0); or initial spacing (if IFAC=2), L.
Line set A-10 is present if IFAC = 0 or 2.		
If IFAC = 0,		
A-10	DXR	Grid spacing in horizontal or radial direction. Number of entries must equal NXR, L.
If IFAC = 2,		
A-10	XMULT	Multiplier by which the width of each node is increased from that of the previous node.
	XMAX	Maximum allowed horizontal or radial spacing, L.
A-11	JFAC	= 0 if grid spacing in vertical direction is to be read in for each row and multiplied by FACZ. = 1 if all vertical grid spacing is to be constant and equal to FACZ.

ATTACHMENT III

Description of input instructions--Continued

Card	Variable	Description
A-11--JFAC--Continued		
		= 2 if vertical grid spacing is variable, with spacing for the first two rows equal to FACZ and the spacing for each subsequent row equal to ZMULT times the spacing at the previous row, until spacing equals ZMAX, whereupon spacing becomes constant at ZMAX.
	FACZ	Constant grid spacing in vertical direction (if JFAC=1); constant multiplier for all spacing (if JFAC =0); or initial vertical spacing (if JFAC=2), L.
Line set A-12 is present only if JFAC = 0 or 2.		
If JFAC = 0,		
A-12	DELZ	Grid spacing in vertical direction; number of entries must equal NLY, L.
If JFAC = 2,		
A-12	ZMULT	Multiplier by which each node is increased from that of previous node.
	ZMAX	Maximum allowed vertical spacing, L.
Line sets A-13 to A-14 are present only if F8P = T,		
A-13	NPLT	Number of time steps to write heads to file 8 and heads, saturations and/or moisture contents to file 6.
A-14	PLTIM	Elapsed times at which pressure heads are to be written to file 8, and heads, saturations and/or moisture contents to file 6, T.
Line sets A-15 to A-16 are present only if F11P = T,		
A-15	NOBS	Number of observation points for which heads, moisture contents, and saturations are to be written to file 11.
A-16	J,N	Row and column of observation points. A double entry is required for each observation point, resulting in 2xNOBS values.
	[Line group B read by subroutine VSREAD]	
B-1	EPS	Closure criteria for iterative solution, units used for head, L.
	HMAX	Relaxation parameter for iterative solution. See discussion in text for more detail. Value is generally in the range of 0.4 to 1.2.

ATTACHMENT III

Description of input instructions--Continued

Card	Variable	Description
B-1--Continued		
	WUS	Weighting option for intercell relative hydraulic conductivity: WUS = 1 for full upstream weighting. WUS = 0.5 for arithmetic mean. WUS = 0.0 for geometric mean.
B-2	RHOZ	Fluid density (M/L^3 in units designated in line A-3).
B-3	MINIT	Minimum number of iterations per time step.
	ITMAX	Maximum number of iterations per time step. Must be less than 201.
B-4	PHRD	Logical variable = T if initial conditions are read in as pressure heads; = F if initial conditions are read in as moisture contents.
B-5	NTEX	Number of textural classes or lithologies having different values of hydraulic conductivity, specific storage, and/or constants in the functional relations among pressure head, relative conductivity, and moisture content.
	NPROP	Number of material properties to be read in for each textural class. When using Brooks and Corey or van Genuchten functions, set NPROP = 6, and when using Haverkamp functions, set NPROP = 8. When using tabulated data, set NPROP = 6 plus number of data points in table. [For example, if the number of pressure heads in the table is equal to N1, then set NPROP =3*(N1+1)+3]
Line sets B-6 and B-7 must be repeated NTEX times		
B-6	ITEX	Index to textural class.
B-7	ANIZ(ITEX)	Ratio of vertical-to-horizontal or radial conductivity for textural class ITEX.
	HK(ITEX,1)	Horizontal saturated hydraulic conductivity (K) for class ITEX, LT^{-1}.
	HK(ITEX,2)	Specific storage (Ss) for class ITEX, L^{-1}.
	HK(ITEX,3)	Porosity for class ITEX.

Card	Variable	Description
B-7--Continued		

Definitions for the remaining sequential values on this line are dependent upon which functional relation is selected to represent the nonlinear coefficients. Four different functional relations are allowed: (1) Brooks and Corey, (2) van Genuchten, (3) Haverkamp, and (4) tabular data. The choice of which of these to use is made when the computer program is compiled, by including only the function subroutine which pertains to the desired relation (see discussion in text for more detail).

In the following descriptions, definitions for the different functional relations are indexed by the above numbers. For tabular data, all pressure heads are input first (in decreasing order from the largest to the smallest), all relative hydraulic conductivities are then input in the same order, followed by all moisture contents.

Variable		Description
HK(ITEX,4)	(1)	h_b, L. (must be less than 0.0).
	(2)	α', L. (must be less than 0.0).
	(3)	A', L. (must be less than 0.0).
	(4)	Largest pressure head in table.
HK(ITEX,5)	(1)	Residual moisture content (θ_r).
	(2)	Residual moisture content (θ_r).
	(3)	Residual moisture content (θ_r).
	(4)	Second largest pressure head in table.
HK(ITEX,6)	(1)	λ.
	(2)	β'.
	(3)	B'.
	(4)	Third largest pressure head in table.
HK(ITEX,7)	(1)	Not used.
	(2)	Not used.
	(3)	α, L. (must be less than 0.0).
	(4)	Fourth largest pressure head in table.
HK(ITEX,8)	(1)	Not used.
	(2)	Not used.
	(3)	β.
	(4)	Fifth largest pressure head in table.

For functional relations (1), (2), and (3) no further values are required on this line for this textural class. For tabular data (4), data input continues as follows:

Card	Variable	Description
B-7--Continued		
HK(ITEX,9)	Next largest pressure head in table.	
K(ITEX,N1+3)	Minimum pressure head in table. (Here N1 = Number of pressure heads in table; NPROP = 3*(N1+1)+3).	
HK(ITEX,N1+4)	Always input a value of 99.	
HK(ITEX,N1+5)	Relative hydraulic conductivity corresponding to first pressure head.	
HK(ITEX,N1+6)	Relative hydraulic conductivity corresponding to second pressure head.	
•		
•		
•		
HK(ITEX,2*N1+4)	Relative hydraulic conductivity corresponding to smallest pressure head.	
HK(ITEX,2*N1+5)	Always input a value of 99.	
HK(ITEX,2*N1+6)	Moisture content corresponding to first pressure head.	
HK(ITEX,2*N1+7)	Moisture content corresponding to second pressure head.	
•		
•		
•		
HK(ITEX,3*N1+5)	Moisture content corresponding to smallest pressure head.	
HK(ITEX,3*N1+6)	Always input a value of 99.	
Regardless of which functional relation is selected there must be NPROP+1 values on line B-7.		
B-8	IROW	If IROW = 0, textural classes are read for each row. This option is preferable if many rows differ from the others. IF IROW = 1, textural classes are read in by blocks of rows, each block consisting of all the rows in sequence consisting of uniform properties or uniform properties separated by a vertical interface.
Line set B-9 is present only if IROW = 0.		
B-9	JTEX	Indices (ITEX) for textural class for each node, read in row by row. There must be NLY*NXR entries.
Line set B-10 is present only if IROW = 1.		
As many groups of B-10 variables as are needed to completely cover the grid are required. The final group of variables for this set must have IR = NXR and JBT = NLY.		
B-10	IL	Left hand column for which texture class applies. Must equal 1 or [IR(from previous card)+1].

Card	Variable	Description
B-10--Continued		
	IR	Right hand column for which texture class applies. Final IR for sequence of rows must equal NXR.
	JBT	Bottom row of all rows for which the column designations apply. JBT must not be increased from its initial or previous value until IR = NXR.
	JRD	Texture class within block.
Note: As an example, for a column of uniform material; IL = 1, IR = NXR, JBT = NLY, and JRD = texture class designation for the column material. One line will represent the set for this example.		
B-11	IREAD	If IREAD = 0, all initial conditions in terms of pressure head or moisture content as determined by the value of PHRD are set equal to FACTOR. If IREAD = 1, all initial conditions are read from file IU in user-designated format and multiplied by FACTOR. If IREAD = 2 initial conditions are defined in terms of pressure head, and an equilibrium profile is specified above a free-water surface at a depth of DWTX until a pressure head of HMIN is reached. All pressure heads above this are set to HMIN.
	FACTOR	Multiplier or constant value, depending on value of IREAD, for initial conditions, L.
Line B-12 is present only if IREAD = 2,		
B-12	DWTX	Depth to free-water surface above which an equilibrium profile is computed, L.
	HMIN	Minimum pressure head to limit height of equilibrium profile; must be less than zero, L.
Line B-13 is read only if IREAD = 1,		
B-13	IU	Unit number from which initial head values are to be read.
	IFMT	Format to be used in reading initial head values from unit IU. Must be enclosed in quotation marks, for example '(10X,E10.3)'.
B-14	BCIT	Logical variable = T if evaporation is to be simulated at any time during the simulation; otherwise = F.

Card	Variable	Description
B-14--Continued		
	ETSIM	Logical variable = T if evapotranspiration (plant-root extraction) is to be simulated at any time during the simulation; otherwise = F.
Line B-15 is present only if BCIT = T or ETSIM = T.		
B-15	NPV	Number of ET periods to be simulated. NPV values for each variable required for the evaporation and/or evapotranspiration options must be entered on the following lines. If ET variables are to be held constant throughout the simulation code, NPV = 1.
	ETCYC	Length of each ET period, T.
Note: For example, if a yearly cycle of ET is desired and monthly values of PEV, PET, and the other required ET variables are available, then code NPV = 12 and ETCYC = 30 days. Then 12 values must be entered for PEV, SRES, HA, PET, RTDPTH, RTBOT, RTTOP, and HROOT. Actual values, used in the program, for each variable are determined by linear interpolation based on time.		
Line B-16 to B-18 are present only if BCIT = T.		
B-16	PEVAL	Potential evaporation rate (PEV) at beginning of each ET period. Number of entries must equal NPV, LT^{-1}.
To conform with the sign convention used in most existing equations for potential evaporation, all entries must be greater than or equal to 0. The program multiplies all nonzero entries by -1 so that the evaporative flux is treated as a sink rather than a source.		
B-17	RDC(1,J)	Surface resistance to evaporation (SRES) at beginning of ET period, L^{-1}. For a uniform soil, SRES is equal to the reciprocal of the distance from the top active node to land surface, or 2./DELZ(2). If a surface crust is present, SRES may be decreased to account for the added resistance to water movement through the crust. Number of entries must equal NPV.
B-18	RDC(2,J)	Pressure potential of the atmosphere (HA) at beginning of ET period; may be estimated using equation 6, L. Number of entries must equal NPV.

Card	Variable	Description
Lines B-19 to B-23 are present only if ETSIM = T.		
B-19	PTVAL	Potential evapotranspiration rate (PET) at beginning of each ET period, LT^{-1}. Number of entries must equal NPV. As with PEV, all values must be greater than or equal to 0.
B-20	RDC(3,J)	Rooting depth at beginning of each ET period, L. Number of entries must equal NPV.
B-21	RDC(4,J)	Root activity at base of root zone at beginning of each ET period, L^{-2}. Number of entries must equal NPV.
B-22	RDC(5,J)	Root activity at top of root zone at beginning of each ET period, L^{-2}. Number of entries must equal NPV.
Note: Values for root activity generally are determined empirically, but typically range from 0 to 3.0 cm/cm^3. As programmed, root activity varies linearly from land surface to the base of the root zone, and its distribution with depth at any time is represented by a trapezoid. In general, root activities will be greater at land surface than at the base of the root zone.		
B-23	RDC(6,J)	Pressure head in roots (HROOT) at beginning of each ET period, L. Number of entries must equal NPV.
[Line group C read by subroutine VSTMER, NRECH sets of C lines are required]		
C-1	TPER	Length of this recharge period, T.
	DELT	Length of initial time step for this period, T.
C-2	TMLT	Multiplier for time step length.
	DLTMX	Maximum allowed length of time step, T.
	DLTMIN	Minimum allowed length of time step, T.
	TRED	Factor by which time-step length is reduced if convergence is not obtained in ITMAX iterations. Values usually should be in the range 0.1 to 0.5. If no reduction of time-step length is desired, input a value of 0.0.
C-3	DSMAX	Maximum allowed change in head per time step for this period, L.
	STERR	Steady-state head criterion; when the maximum change in head between successive time steps is less than STERR, the program assumes that steady state has been reached for this period and advances to next recharge period, L.

Card	Variable	Description
C4	POND	Maximum allowed height of ponded water for constant flux nodes. See text for detailed discussion of POND, L. Note: Ponding is not allowed when simulating trickle irrigation.
C5	PRNT	Logical variable = T if heads, moisture contents, and/or saturations are to be printed to file 6 after each time step; = F if they are to be written to file 6 only at observation times and ends of recharge periods.
C6	BCIT	Logical variable = T if evaporation is to be simulated for this recharge period; otherwise = F.
	ETSIM	Logical variable = T if evapotranspiration (plant-root extraction) is to be simulated for this recharge period; otherwise = F.
*	SEEP	Logical variable = T if trickle irrigation is to be simulated for this recharge period; otherwise = F

C-7 to C-9 cards are present only if SEEP = T,

Card	Variable	Description
C-7 *	NFCS	Number of trickle-irrigation emitters to be simulated. If radial coordinates are used, only one emitter may be simulated, if rectangular coordinates are used either 1 or 2 emitters may be simulated.

Cards C-8 and C-9 are required for each trickle-irrigation emitter to be simulated.

Card	Variable	Description
C-8 *	JJ	Number of nodes on trickle face.
*	MITR	Maximum number of passes through trickle-irrigation subroutine per time step. If convergence has not occurred after MITR passes, the simulation advances to the next time step. Values in the range of 5 to 8 generally are sufficient.
*	QTRICK(K)	Trickle-irrigation rate; for radial coordinates units are L^3/T; for rectangular coordinate units are L^2/T and one-half of the flux that actually is applied should be specified because symmetry is assumed.
*	ERQ	Closure criteria for trickle loop (ϵ on p. 9). When 1 minus the absolute value of the ratio of actual flux from the trickle emitter to specified flux is less than ERQ, the simulation advances to the next time step.

ATTACHMENT III

Description of input instructions--continued

Card	Variable	Description
*	SIG	Relaxation parameter for estimating flux for constant-flux node (σ on p. 9). SIG should be less in magnitude than ERQ.
C-9 *	J, N	Row and column of each cell on a trickle face. Because this simulator assumes symmetry in land-surface elevation and material properties in the vicinity of an emitter, the following rules must be adhered to in specifying cells that comprise a trickle face. All cells must represent the land surface, that is, the overlying cell must be inactive. For radial coordinates, the first node listed must be the left-most node in the grid that represents the land surface; the remaining nodes must be listed from left to right. For rectangular coordinates, nodes may either be listed as above or the first node listed must be the right-most node in the grid that represents the land surface. In the latter case, remaining nodes are listed from right to left.
C10	IBC	Code for reading in boundary conditions by individual node (IBC=0) or by row or column (IBC=1). Only one code may be used for each recharge period, and all boundary conditions for period must be input in the sequence for that code.

Line set C-11 is read only if IBC = 0. One line should be present for each node for which new boundary conditions are specified.

Card	Variable	Description
C-11	JJ	Row number of node.
	NN	Column number of node.

ATTACHMENT III

Description of input instructions--continued

Card	Variable	Description
C-11--Continued		
	NTX	Node type identifier for boundary conditions. = 0 for no specified boundary (needed for resetting some nodes after intial recharge period); = 1 for specified pressure head; = 2 for specified flux per unit horizontal surface area in units of LT^{-1}; = 3 for possible seepage face; = 4 for specified total head; = 5 for evaporation; = 6 for specified volumetric flow in units of L^3T^{-1}.
	PFDUM	Specified head for NTX = 1 or 4 or specified flux for NTX = 2 or 6. If codes 0, 3, or 5 are specified, the line should contain a dummy value for PFDUM or should be terminated after NTX by a blank and a slash.

C-12 is present only if IBC = 1. One card should be present for each row or column for which new boundary conditions are specified,

Card	Variable	Description
C-12	JJT	Top node of row or column of nodes sharing same boundary condition.
	JJB	Bottom node of row or column of nodes having same boundary condition. Will equal JJT if a boundary row is being read.
	NNL	Left column in row or column of nodes having same boundary condition.
	NNR	Right column of row or column of nodes having same boundary condition. Will equal NNL if a boundary column is being read in.
	NTX	Same as line C-11.
	PFDUM	Same as line C-11.
C-13		Designated end of recharge period. Must be included after line C-12 data for each recharge period. Two C-13 lines must be included after final recharge period. Line must always be entered as 999999 /.

ATTACHMENT IV

Example Problem

The purpose of this example is to demonstrate the data requirements and results listing for the simulator. This example also can be used as a test of the code after it has been installed in a computer. Actually output is exactly the same as that described for VS2D in Lappala and others (1987). The problem is concerned with infiltration from a point source, so radial coordinates were used. The simulated region was 0.9 m deep and 0.9 m in radial extent. Vertical and radial grid spacing was uniform at 0.05 m. The medium is a sandy loam with moisture and hydraulic-conductivity curves defined by the van Genutchen (1980) equations using the following values:

$\theta_s = 0.45$
$\theta_r = 0.10$
$n = 1.90$
$\alpha' = 1.0\ \mathrm{m}^{-1}$
$K_s = 0.04$ m/hr
initial pressure head = - 2.20 m everywhere

An irrigation rate of 10 L/h is to be applied for 5 hours. We wish to determine the pressure-head distribution within the vicinity of the trickle source at 1, 3, and 5 hours. A full listing of the input data the results follows.

Attachment IV
Example problem--continued

Data entered for example problem

```
EXAMPLE PROBLEM  -- POINT SOURCE, RADIAL COORDINATES
      5.00     0.00                     A2--MAX SIMULATION TIME, INITIAL TIME
   M  HR  KG                            A3--UNITS
 20 20                                  A4--NO. OF COLUMNS, NO. OF ROWS
1  100                                  A5--NO. OF RECHARGE PERIODS, NO. OF TIME STEPS
T T                                     A6--RADIAL? ITSTOP?
F T T T F                               A7--OUTPUT TO FILE 11? 7? 8? 9? MASS BAL TO 6?
T F T F                                 A8--PRINT THETA? SATURATION? PRSS. HEAD? TOTAL HEAD?
         1      0.05                    A9--IFAC,FACX
         1      0.05                    A11--JFAC,FACZ
         3                              A13--NO. OF TIMES TO PRINT PROFILES
1.0  3.0  5.0                           A14--TIMES TO PRINT PROFILES
.0001  .75  0.0                         B1--CLOSURE CRITERION, HMAX, WEIGHTING FOR KR
    1000.0                              B2--FLUID DENSITY
         2       050                    B3--MIN ITS, MAX ITS
T                                       B4--HEADS READ AS INITIAL CONDITIONS?
1  6                                    B5--NO. OF TEXTURES, NO. OF PROPERTIES FOR EACH TEXTURE
         1                              B6--TEXTURE CLASS
1.0  0.040  0.0  0.45  -1.0  .10  1.90  B7--ANIZ, KSAT,SS,POR,ALPHA,RSAT,N
         1                              B8--TEXTURE CLASS READ BY BLOCK
1  20 20  1                             B10--FIRST COL, LAST COL, LAST ROW, CLASS CODE
0  -2.20                                B11--HEAD CODE, INITIAL HEAD OR FACTOR
F,F                                     B14--EVAPORATION ? PLANT TRANSPIRATION ?
      5.00     .0001                    C1--TPER,DELT
      1.50      0.50      .0001    0.00 C2--TMULT,TMAX,TMIN,TRED
      100.         0                    C3--DSMAX,STERR
         0                              C4--POND
F                                       C5--RESULTS TO FILE 6 EVERY TIME STEP?
F F T                                   C6--EVAP?  TRANSPIRATION? SEEPAGE FACES?
1                                       C7--NUMBER OF TRICKLE SOURCES
 9  8  0.01  .03  .02                   C8--JJ,MITR,QTRICK,ERQ,SIG
 2 2 2 3 2 4 2 5 2 6 2 7 2 8 2 9 2 10   C9--ROW AND COL OF TRICKLE CELLS
0                                       C10--BOUNDARY CONDITION BY POINT
999999 /                                C13 END OF BOUNDARY CONDITIONS FOR TPER
999999 /                                C13 END OF FILE
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem

```
                                   ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
                                   +                         VS2D                             +
                                   +    SIMULATION OF 2-DIMENSIONAL VARIABLY                  +
                                   +    SATURATED HEAD AND FLUID SATURATION                   +
                                   +    DISTRIBUTIONS. IMPLICIT FINITE DIFFERENCE             +
                                   +    BODY-CENTERED CELLS USED                              +
                                    ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++



****************************************************************************************************
    EXAMPLE PROBLEM  -- POINT SOURCE, RADIAL COORDINATES
****************************************************************************************************

         SPACE AND TIME CONSTANTS
         ----------------------
    MAXIMUM SIMULATION TIME =     5.0000   HR
    STARTING TIME =     0.0000
    NUMBER OF RECHARGE PERIODS =         1
    MAXIMUM NUMBER OF TIME STEPS =        100
    NUMBER OF ROWS =    20
    NUMBER OF COLUMNS =    20
         SOLUTION OPTIONS
         ----------------
    WRITE ALL PRESSURE HEADS TO FILE 8 AT OBSERVATION TIMES? T
    STOP SOLUTION IF MAXIMUM NO. OF ITERATIONS EXCEEDED IN ANY TIME STEP?,T
    WRITE MAXIMUM CHANGE IN HEAD FOR EACH ITERATION TO FILE 7? T
    WRITE RESULTS AT SELECTED OBSERVATION POINTS TO FILE 11? F
    WRITE MASS BALANCE RATES TO FILE 9? T
    WRITE MASS BALANCE RATES TO FILE 6? F
    WRITE MOISTURE CONTENTS TO FILE 6? T
    WRITE SATURATIONS TO FILE 6? F
    WRITE PRESSURE HEADS TO FILE 6? T
    WRITE TOTAL HEADS TO FILE 6? F
                                             GRID SPACING IN VERTICAL DIRECTION, IN    M
    0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050
    0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050
                                             GRID SPACING IN HORIZONTAL OR RADIAL DIRECTION, IN    M
    0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050
    0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050
    TIMES AT WHICH H WILL BE WRITTEN TO FILE 08
        1.0000    3.0000    5.0000
```

Attachment IV
Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
    COORDINATE SYSTEM IS RADIAL
    MATRIX EQUATIONS TO BE SOLVED BY SIP
         INITIAL MOISTURE PARAMETERS
         ___________________________

    CONVERGENCE CRITERIA FOR SIP  =   1.000E-04    M
    DAMPING FACTOR, HMAX =    7.500E-01
    FLUID DENSITY AT ZERO PRESSURE =   1.000E+03   KG/   M**3
    GEOMETRIC MEAN USED FOR INTERCELL CONDUCTIVITY
    NUMBER OF SOIL TEXTURAL CLASSES =          1
    NUMBER OF SOIL PARAMETERS FOR EACH CLASS =         6
    MINIMUM PERMITTED NO. OF ITERATIONS/TIME STEP =        2
    MAXIMUM PERMITTED NO. OF ITERATIONS/TIME STEP =       50
                                        CONSTANTS FOR SOIL TEXTURAL CLASSES

         ANISOTROPY       KSAT     SPECIFIC    POROSITY
                                   STORAGE
CLASS # 1
              1.000D+00   4.000D-02   0.000D-01   4.500D-01  -1.000D+00   1.000D-01   1.900D+00
         TEXTURAL CLASS INDEX MAP


    TEXTURAL CLASSES READ IN BY BLOCK
       1  11111111111111111111
       2  11111111111111111111
       3  11111111111111111111
       4  11111111111111111111
       5  11111111111111111111
       6  11111111111111111111
       7  11111111111111111111
       8  11111111111111111111
       9  11111111111111111111
      10  11111111111111111111
      11  11111111111111111111
      12  11111111111111111111
      13  11111111111111111111
      14  11111111111111111111
      15  11111111111111111111
      16  11111111111111111111
      17  11111111111111111111
      18  11111111111111111111
      19  11111111111111111111
      20  11111111111111111111
```

Attachment IV
Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
                                          DEPTH FROM SURFACE
 Z, IN
   M                    X OR R DISTANCE, IN    M
          0.02      0.07      0.12      0.17      0.22      0.27      0.32      0.37      0.42      0.47      0.52      0.57      0.62
          0.67      0.72      0.77      0.82      0.87
   0.02   0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
 .000   0.000    0.000
   0.07   0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050     0.050
          0.050     0.050     0.050     0.050     0.050
   0.12   0.100     0.100     0.100     0.100     0.100     0.100     0.100     0.100     0.100     0.100     0.100     0.100     0.100
          0.100     0.100     0.100     0.100     0.100
   0.17   0.150     0.150     0.150     0.150     0.150     0.150     0.150     0.150     0.150     0.150     0.150     0.150     0.150
          0.150     0.150     0.150     0.150     0.150
   0.22   0.200     0.200     0.200     0.200     0.200     0.200     0.200     0.200     0.200     0.200     0.200     0.200     0.200
          0.200     0.200     0.200     0.200     0.200
   0.27   0.250     0.250     0.250     0.250     0.250     0.250     0.250     0.250     0.250     0.250     0.250     0.250     0.250
          0.250     0.250     0.250     0.250     0.250
   0.32   0.300     0.300     0.300     0.300     0.300     0.300     0.300     0.300     0.300     0.300     0.300     0.300     0.300
          0.300     0.300     0.300     0.300     0.300
   0.37   0.350     0.350     0.350     0.350     0.350     0.350     0.350     0.350     0.350     0.350     0.350     0.350     0.350
          0.350     0.350     0.350     0.350     0.350
   0.42   0.400     0.400     0.400     0.400     0.400     0.400     0.400     0.400     0.400     0.400     0.400     0.400     0.400
          0.400     0.400     0.400     0.400     0.400
   0.47   0.450     0.450     0.450     0.450     0.450     0.450     0.450     0.450     0.450     0.450     0.450     0.450     0.450
          0.450     0.450     0.450     0.450     0.450
   0.52   0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500
          0.500     0.500     0.500     0.500     0.500
   0.57   0.550     0.550     0.550     0.550     0.550     0.550     0.550    0.550     0.550     0.550     0.550
          0.550     0.550     0.550     0.550     0.550
   0.62   0.600     0.600     0.600     0.600     0.600     0.600     0.600     0.600     0.600     0.600     0.600     0.600     0.600
          0.600     0.600     0.600     0.600     0.600
   0.67   0.650     0.650     0.650     0.650     0.650     0.650     0.650     0.650     0.650     0.650     0.650     0.650     0.650
          0.650     0.650     0.650     0.650     0.650
   0.72   0.700     0.700     0.700     0.700     0.700     0.700     0.700     0.700     0.700     0.700     0.700     0.700     0.700
          0.700     0.700     0.700     0.700     0.700
   0.77   0.750     0.750     0.750     0.750     0.750     0.750     0.750     0.750     0.750     0.750     0.750     0.750     0.750
          0.750     0.750     0.750     0.750     0.750
   0.82   0.800     0.800     0.800     0.800     0.800     0.800     0.800     0.800     0.800     0.800     0.800     0.800     0.800
          0.800     0.800     0.800     0.800     0.800
   0.87   0.850     0.850     0.850     0.850     0.850     0.850     0.850     0.850     0.850     0.850     0.850     0.850     0.850
          0.850     0.850     0.850     0.850     0.850
 INITIAL PRESSURE HEAD OR MOISTURE CONTENT WAS SET TO A CONSTANT VALUE OF  -2.200E+00
 5SIP ITERATION PARAMETERS:  0.1421085D-13  0.7675047D+00  0.9459459D+00  0.9874327D+00  0.9970782D+00
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
EXAMPLE PROBLEM  -- POINT SOURCE, RADIAL COORDINATES
TOTAL ELAPSED TIME =   0.000E-01   HR
TIME STEP     0

                                  PRESSURE HEAD
Z, IN
M                    X OR R DISTANCE, IN     M
          0.02      0.07      0.12      0.17      0.22      0.27      0.32      0.37      0.42      0.47      0.52      0.57      0.62
          0.67      0.72      0.77      0.82      0.87
0.02-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.07-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.12-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.17-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.22-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.27-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.32-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.37-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.42-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.47-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.52-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.57-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.62-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.67-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.72-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.77-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
0.82-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
```

Attachment IV
Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

---

```
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.87-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
                                                 MOISTURE CONTENT
Z, IN
   M                    X OR R DISTANCE, IN    M
            0.02     0.07     0.12     0.17     0.22     0.27     0.32     0.37     0.42     0.47     0.52     0.57     0.62
            0.67     0.72     0.77     0.82     0.87
   0.02    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.07    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.12    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.17    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.22    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.27    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.32    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.37    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.42    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.47    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.52    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.57    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.62    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.67    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.72    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.77    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.82    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.87    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256    0.256
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

---

```
      0.256    0.256    0.256    0.256    0.256
 DATA FOR RECHARGE PERIOD     1

     LENGTH OF THIS PERIOD =   5.000E+00   HR
     LENGTH OF INITIAL TIME STEP FOR THIS PERIOD = 1.000E-04   HR
     MULTIPLIER FOR TIME STEP =  1.500E+00
     MAXIMUM TIME STEP SIZE =  5.000E-01   HR
     MINIMUM TIME STEP SIZE =  1.000E-04   HR
     TIME STEP REDUCTION FACTOR =  0.000E-01
          MAXIMUM PRESSURE HEAD CHANGE ALLOWED IN ONE TIME STEP = 100.000
          STEADY-STATE CLOSURE CRITERION =  0.000E-01
          MAXIMUM DEPTH OF PONDING =     0.000
          PRINT SOLUTION AFTER EVERY TIME STEP? F
          SIMULATE EVAPORATION? F
          SIMULATE EVAPOTRANSPIRATION? F
          SIMULATE SEEPAGE FACES? T

 NODE TYPE AND INITIAL BOUNDARY CONDITIONS FOR PERIOD    1
 LEGEND:
          0 = INTERIOR CELL
          1 = SPECIFIED PRESSURE HEAD CELL
          2 = SPECIFIED FLUX CELL
          3 = POTENTIAL SEEPAGE FACE NODE
          5 = NODE FOR WHICH EVAPORATION IS PERMITTED


   1    00000000000000000000
   2    02333333330000000000
   3    00000000000000000000
   4    00000000000000000000
   5    00000000000000000000
   6    00000000000000000000
   7    00000000000000000000
   8    00000000000000000000
   9    00000000000000000000
  10    00000000000000000000
  11    00000000000000000000
  12    00000000000000000000
  13    00000000000000000000
  14    00000000000000000000
  15    00000000000000000000
  16    00000000000000000000
  17    00000000000000000000
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
  18      00000000000000000000
  19      00000000000000000000
  20      00000000000000000000
NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    1  RECHARGE PERIOD =    1 ELAPSED TIME =    1.500E-04   HR REQUIRED ITERATIONS =    7

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    2  RECHARGE PERIOD =    1 ELAPSED TIME =    3.750E-04   HR REQUIRED ITERATIONS =    7

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    3  RECHARGE PERIOD =    1 ELAPSED TIME =    7.125E-04   HR REQUIRED ITERATIONS =    8

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    4  RECHARGE PERIOD =    1 ELAPSED TIME =    1.219E-03   HR REQUIRED ITERATIONS =    8

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    5  RECHARGE PERIOD =    1 ELAPSED TIME =    1.978E-03   HR REQUIRED ITERATIONS =    8

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    6  RECHARGE PERIOD =    1 ELAPSED TIME =    3.117E-03   HR REQUIRED ITERATIONS =    8

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    7  RECHARGE PERIOD =    1 ELAPSED TIME =    4.826E-03   HR REQUIRED ITERATIONS =    8

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =    8  RECHARGE PERIOD =    1 ELAPSED TIME =    7.389E-03   HR REQUIRED ITERATIONS =   10

PONDING AT NODE        1
NUMBER OF PASSES THROUGH TRICKLE LOOP =    4
    TIME STEP NUMBER =    9  RECHARGE PERIOD =    1 ELAPSED TIME =    1.123E-02   HR REQUIRED ITERATIONS =   12

NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
    TIME STEP NUMBER =   10  RECHARGE PERIOD =    1 ELAPSED TIME =    1.700E-02   HR REQUIRED ITERATIONS =   12

NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
    TIME STEP NUMBER =   11  RECHARGE PERIOD =    1 ELAPSED TIME =    2.565E-02   HR REQUIRED ITERATIONS =   14

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =   12  RECHARGE PERIOD =    1 ELAPSED TIME =    3.862E-02   HR REQUIRED ITERATIONS =   13

NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
    TIME STEP NUMBER =   13  RECHARGE PERIOD =    1 ELAPSED TIME =    5.809E-02   HR REQUIRED ITERATIONS =   14
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
   TIME STEP NUMBER =   14  RECHARGE PERIOD =    1 ELAPSED TIME =   8.728E-02   HR REQUIRED ITERATIONS =   15

NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
   TIME STEP NUMBER =   15  RECHARGE PERIOD =    1 ELAPSED TIME =   1.311E-01   HR REQUIRED ITERATIONS =   15

NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
   TIME STEP NUMBER =   16  RECHARGE PERIOD =    1 ELAPSED TIME =   1.968E-01   HR REQUIRED ITERATIONS =   17

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
   TIME STEP NUMBER =   17  RECHARGE PERIOD =    1 ELAPSED TIME =   2.953E-01   HR REQUIRED ITERATIONS =   14

NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
   TIME STEP NUMBER =   18  RECHARGE PERIOD =    1 ELAPSED TIME =   4.431E-01   HR REQUIRED ITERATIONS =   14

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
   TIME STEP NUMBER =   19  RECHARGE PERIOD =    1 ELAPSED TIME =   6.648E-01   HR REQUIRED ITERATIONS =   14

PONDING AT NODE         2
NUMBER OF PASSES THROUGH TRICKLE LOOP =    2
   TIME STEP NUMBER =   20  RECHARGE PERIOD =    1 ELAPSED TIME =   9.973E-01   HR REQUIRED ITERATIONS =   14

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
   TIME STEP NUMBER =   21  RECHARGE PERIOD =    1 ELAPSED TIME =   1.000E+00   HR REQUIRED ITERATIONS =    4

   EXAMPLE PROBLEM  -- POINT SOURCE, RADIAL COORDINATES
  TOTAL ELAPSED TIME =   1.000E+00   HR
  TIME STEP    21


                                PRESSURE HEAD
Z, IN
  M                 X OR R DISTANCE, IN    M
         0.02     0.07     0.12     0.17     0.22     0.27     0.32     0.37     0.42     0.47     0.52     0.57     0.62
         0.67     0.72     0.77     0.82     0.87
  0.02 0.00E-01 0.00E-01-2.84E-01-5.45E-01-8.24E-01-1.17E+00-1.58E+00-1.95E+00-2.15E+00-2.22E+00-2.24E+00-2.25E+00-2.25E+00
    -2.25E+00-2.25E+00-2.25E+00-2.25E+00-2.25E+00
  0.07-1.61E-01-2.05E-01-3.83E-01-5.99E-01-8.62E-01-1.20E+00-1.61E+00-1.95E+00-2.13E+00-2.19E+00-2.21E+00-2.22E+00-2.22E+00
    -2.22E+00-2.22E+00-2.22E+00-2.22E+00-2.22E+00
  0.12-3.34E-01-3.87E-01-5.22E-01-7.14E-01-9.71E-01-1.31E+00-1.70E+00-1.99E+00-2.14E+00-2.19E+00-2.20E+00-2.21E+00-2.21E+00
    -2.21E+00-2.21E+00-2.21E+00-2.21E+00-2.21E+00
  0.17-5.22E-01-5.76E-01-6.97E-01-8.84E-01-1.15E+00-1.49E+00-1.83E+00-2.05E+00-2.15E+00-2.19E+00-2.20E+00-2.20E+00-2.20E+00
    -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
```

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

---

```
   0.22-7.43E-01-8.00E-01-9.25E-01-1.12E+00-1.40E+00-1.71E+00-1.97E+00-2.11E+00-2.17E+00-2.19E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.27-1.03E+00-1.09E+00-1.23E+00-1.43E+00-1.69E+00-1.92E+00-2.08E+00-2.15E+00-2.18E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.32-1.40E+00-1.46E+00-1.59E+00-1.76E+00-1.94E+00-2.07E+00-2.14E+00-2.18E+00-2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.37-1.78E+00-1.82E+00-1.91E+00-2.01E+00-2.09E+00-2.15E+00-2.18E+00-2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.42-2.03E+00-2.05E+00-2.09E+00-2.13E+00-2.16E+00-2.18E+00-2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.47-2.14E+00-2.15E+00-2.16E+00-2.18E+00-2.19E+00-2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.52-2.18E+00-2.19E+00-2.19E+00-2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.57-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.62-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.67-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.72-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
       -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
   0.77-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00
       -2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00
   0.82-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00
       -2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00
   0.87-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00
       -2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00
                                                 MOISTURE CONTENT
Z, IN
   M                    X OR R DISTANCE, IN    M
            0.02     0.07     0.12     0.17     0.22     0.27     0.32     0.37     0.42     0.47     0.52     0.57     0.62
            0.67     0.72     0.77     0.82     0.87
   0.02    0.450    0.450    0.436    0.407    0.373    0.334    0.296    0.271    0.259    0.255    0.254    0.254    0.254
           0.254    0.254    0.254    0.254    0.254
   0.07    0.445    0.442    0.426    0.401    0.368    0.330    0.294    0.271    0.260    0.257    0.256    0.255    0.255
           0.255    0.255    0.255    0.255    0.255
   0.12    0.431    0.426    0.410    0.386    0.355    0.320    0.288    0.268    0.260    0.257    0.256    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.17    0.410    0.404    0.388    0.366    0.336    0.304    0.278    0.264    0.259    0.257    0.257    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
   0.22    0.383    0.376    0.361    0.339    0.312    0.287    0.269    0.261    0.258    0.257    0.257    0.256    0.256
           0.256    0.256    0.256    0.256    0.256
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
  0.27   0.349   0.342   0.328   0.309   0.288   0.272   0.263   0.259   0.257   0.257   0.257   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.32   0.312   0.306   0.295   0.283   0.271   0.264   0.259   0.258   0.257   0.257   0.256   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.37   0.282   0.279   0.273   0.267   0.262   0.259   0.258   0.257   0.257   0.257   0.256   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.42   0.266   0.264   0.262   0.260   0.259   0.257   0.257   0.257   0.257   0.256   0.256   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.47   0.259   0.259   0.258   0.258   0.257   0.257   0.257   0.257   0.256   0.256   0.256   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.52   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.256   0.256   0.256   0.256   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.57   0.257   0.257   0.257   0.257   0.257   0.256   0.256   0.256   0.256   0.256   0.256   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.62   0.257   0.257   0.257   0.257   0.256   0.256   0.256   0.256   0.256   0.256   0.256   0.256   0.256
         0.256   0.256   0.256   0.256   0.256
  0.67   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257
         0.257   0.257   0.257   0.257   0.257
  0.72   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257
         0.257   0.257   0.257   0.257   0.257
  0.77   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257   0.257
         0.257   0.257   0.257   0.257   0.257
  0.82   0.258   0.258   0.258   0.258   0.258   0.258   0.258   0.258   0.258   0.258   0.258   0.258   0.258
         0.258   0.258   0.258   0.258   0.258
  0.87   0.259   0.259   0.259   0.259   0.259   0.259   0.259   0.259   0.259   0.259   0.259   0.259   0.259
         0.259   0.259   0.259   0.259   0.259
                ---------- MASS BALANCE SUMMARY FOR TIME STEP  21 ----------
                  PUMPING PERIOD NUMBER    1
                  TOTAL ELAPSED SIMULATION TIME =  1.000E+00   HR

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                                                                              +
+                                                                              MASS  THIS          RATE FOR THIS               +
+                                                               TOTAL  MASS     TIME STEP           TIME STEP                  +
+                                                                   KG             KG                KG/  HR                   +
+   FLUX INTO DOMAIN ACROSS SPECIFIED PRESSURE HEAD BOUNDARIES --   4.47811E+00    2.61532E-02        9.60463E+00              +
+ FLUX OUT OF DOMAIN ACROSS SPECIFIED PRESSURE HEAD BOUNDARIES --   0.00000E-01    0.00000E-01        0.00000E-01              +
+            FLUX INTO DOMAIN ACROSS SPECIFIED FLUX BOUNDARIES --   5.39087E+00    1.01501E-03        3.72757E-01              +
+          FLUX OUT OF DOMAIN ACROSS SPECIFIED FLUX BOUNDARIES --   0.00000E-01    0.00000E-01        0.00000E-01              +
+                                      TOTAL FLUX INTO DOMAIN --   9.86897E+00    2.71682E-02        9.97739E+00              +
+                                    TOTAL FLUX OUT OF DOMAIN --   0.00000E-01    0.00000E-01        0.00000E-01              +
+                                                 EVAPORATION --   0.00000E-01    0.00000E-01        0.00000E-01              +
+                                               TRANSPIRATION --   0.00000E-01    0.00000E-01        0.00000E-01              +
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
+                                       TOTAL EVAPOTRANSPIRATION --      0.00000E-01         0.00000E-01         0.00000E-01     +
+                               CHANGE IN FLUID STORED IN DOMAIN --      9.87687E+00         2.69846E-02         9.90993E+00     +
+                                             FLUID MASS BALANCE --     -7.89262E-03         1.83690E-04         6.74590E-02     +
+                                                                                                                                +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   22  RECHARGE PERIOD =     1 ELAPSED TIME =   1.004E+00   HR REQUIRED ITERATIONS =     4

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   23  RECHARGE PERIOD =     1 ELAPSED TIME =   1.010E+00   HR REQUIRED ITERATIONS =     5

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   24  RECHARGE PERIOD =     1 ELAPSED TIME =   1.019E+00   HR REQUIRED ITERATIONS =     5

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   25  RECHARGE PERIOD =     1 ELAPSED TIME =   1.033E+00   HR REQUIRED ITERATIONS =     6

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   26  RECHARGE PERIOD =     1 ELAPSED TIME =   1.054E+00   HR REQUIRED ITERATIONS =     6

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   27  RECHARGE PERIOD =     1 ELAPSED TIME =   1.085E+00   HR REQUIRED ITERATIONS =     6

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   28  RECHARGE PERIOD =     1 ELAPSED TIME =   1.131E+00   HR REQUIRED ITERATIONS =     7

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   29  RECHARGE PERIOD =     1 ELAPSED TIME =   1.201E+00   HR REQUIRED ITERATIONS =     8

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   30  RECHARGE PERIOD =     1 ELAPSED TIME =   1.306E+00   HR REQUIRED ITERATIONS =     9

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   31  RECHARGE PERIOD =     1 ELAPSED TIME =   1.463E+00   HR REQUIRED ITERATIONS =     9

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   32  RECHARGE PERIOD =     1 ELAPSED TIME =   1.698E+00   HR REQUIRED ITERATIONS =    10

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   33  RECHARGE PERIOD =     1 ELAPSED TIME =   2.052E+00   HR REQUIRED ITERATIONS =    11

NUMBER OF PASSES THROUGH TRICKLE LOOP =     1
    TIME STEP NUMBER =   34  RECHARGE PERIOD =     1 ELAPSED TIME =   2.552E+00   HR REQUIRED ITERATIONS =    12
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

---

```
NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
   TIME STEP NUMBER =   35  RECHARGE PERIOD =    1 ELAPSED TIME =   3.000E+00   HR REQUIRED ITERATIONS =  11

   EXAMPLE PROBLEM  -- POINT SOURCE, RADIAL COORDINATES
  TOTAL ELAPSED TIME =   3.000E+00   HR
  TIME STEP    35


                                                     PRESSURE HEAD
Z, IN
  M                     X OR R DISTANCE, IN    M
             0.02      0.07      0.12      0.17      0.22      0.27      0.32      0.37      0.42      0.47      0.52      0.57      0.62
             0.67      0.72      0.77      0.82      0.87
  0.02 0.00E-01 0.00E-01-2.15E-01-4.27E-01-6.14E-01-7.94E-01-9.83E-01-1.19E+00-1.43E+00-1.68E+00-1.92E+00-2.10E+00-2.21E+00
      -2.26E+00-2.29E+00-2.30E+00-2.30E+00-2.30E+00
  0.07-1.36E-01-1.72E-01-3.04E-01-4.60E-01-6.21E-01-7.89E-01-9.71E-01-1.18E+00-1.41E+00-1.66E+00-1.90E+00-2.07E+00-2.18E+00
      -2.23E+00-2.25E+00-2.26E+00-2.26E+00-2.26E+00
  0.12-2.72E-01-3.11E-01-4.04E-01-5.26E-01-6.64E-01-8.19E-01-9.92E-01-1.19E+00-1.42E+00-1.67E+00-1.89E+00-2.06E+00-2.16E+00
      -2.21E+00-2.23E+00-2.23E+00-2.24E+00-2.24E+00
  0.17-4.01E-01-4.36E-01-5.08E-01-6.08E-01-7.31E-01-8.75E-01-1.04E+00-1.24E+00-1.46E+00-1.70E+00-1.92E+00-2.07E+00-2.15E+00
      -2.19E+00-2.21E+00-2.22E+00-2.22E+00-2.22E+00
  0.22-5.25E-01-5.56E-01-6.17E-01-7.05E-01-8.17E-01-9.54E-01-1.12E+00-1.31E+00-1.54E+00-1.76E+00-1.95E+00-2.08E+00-2.15E+00
      -2.19E+00-2.20E+00-2.21E+00-2.21E+00-2.21E+00
  0.27-6.51E-01-6.79E-01-7.34E-01-8.15E-01-9.23E-01-1.06E+00-1.22E+00-1.42E+00-1.63E+00-1.84E+00-2.00E+00-2.11E+00-2.16E+00
      -2.19E+00-2.20E+00-2.20E+00-2.21E+00-2.21E+00
  0.32-7.86E-01-8.12E-01-8.65E-01-9.44E-01-1.05E+00-1.19E+00-1.35E+00-1.55E+00-1.75E+00-1.92E+00-2.05E+00-2.13E+00-2.17E+00
      -2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
  0.37-9.37E-01-9.64E-01-1.02E+00-1.10E+00-1.21E+00-1.35E+00-1.51E+00-1.69E+00-1.87E+00-2.01E+00-2.10E+00-2.15E+00-2.18E+00
      -2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
  0.42-1.11E+00-1.14E+00-1.20E+00-1.28E+00-1.39E+00-1.53E+00-1.68E+00-1.84E+00-1.97E+00-2.07E+00-2.13E+00-2.17E+00-2.19E+00
      -2.19E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
  0.47-1.32E+00-1.35E+00-1.41E+00-1.49E+00-1.60E+00-1.72E+00-1.85E+00-1.97E+00-2.06E+00-2.12E+00-2.16E+00-2.18E+00-2.19E+00
      -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
  0.52-1.56E+00-1.58E+00-1.64E+00-1.71E+00-1.80E+00-1.90E+00-1.99E+00-2.07E+00-2.12E+00-2.16E+00-2.18E+00-2.19E+00-2.19E+00
      -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
  0.57-1.79E+00-1.81E+00-1.85E+00-1.91E+00-1.97E+00-2.03E+00-2.09E+00-2.13E+00-2.16E+00-2.17E+00-2.19E+00-2.19E+00-2.19E+00
      -2.20E+00-2.20E+00-2.20E+00-2.20E+00-2.20E+00
  0.62-1.97E+00-1.98E+00-2.01E+00-2.04E+00-2.08E+00-2.11E+00-2.14E+00-2.16E+00-2.17E+00-2.18E+00-2.19E+00-2.19E+00-2.19E+00
      -2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00
  0.67-2.08E+00-2.09E+00-2.10E+00-2.12E+00-2.13E+00-2.15E+00-2.16E+00-2.17E+00-2.18E+00-2.18E+00-2.19E+00-2.19E+00-2.19E+00
      -2.19E+00-2.19E+00-2.19E+00-2.19E+00-2.19E+00
  0.72-2.13E+00-2.13E+00-2.14E+00-2.15E+00-2.15E+00-2.16E+00-2.17E+00-2.17E+00-2.17E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
        -2.18E+00-2.18E+00-2.18E+00-2.18E+00-2.18E+00
    0.77-2.14E+00-2.14E+00-2.15E+00-2.15E+00-2.15E+00-2.15E+00-2.16E+00-2.16E+00-2.16E+00-2.16E+00-2.16E+00-2.16E+00-2.16E+00
        -2.16E+00-2.16E+00-2.16E+00-2.16E+00-2.16E+00
    0.82-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00
        -2.14E+00-2.14E+00-2.14E+00-2.14E+00-2.14E+00
    0.87-2.09E+00-2.09E+00-2.09E+00-2.09E+00-2.09E+00-2.10E+00-2.10E+00-2.10E+00-2.10E+00-2.10E+00-2.10E+00-2.10E+00-2.10E+00
        -2.10E+00-2.10E+00-2.10E+00-2.10E+00-2.10E+00
                                                          MOISTURE CONTENT
 Z, IN
    M                     X OR R DISTANCE, IN    M
            0.02      0.07      0.12      0.17      0.22      0.27      0.32      0.37      0.42      0.47      0.52      0.57      0.62
            0.67      0.72      0.77      0.82      0.87
    0.02   0.450     0.450     0.441     0.421     0.399     0.376     0.354     0.332     0.309     0.289     0.272     0.262     0.256
           0.253     0.252     0.252     0.251     0.251
    0.07   0.446     0.444     0.434     0.417     0.398     0.377     0.355     0.333     0.311     0.290     0.274     0.263     0.258
           0.255     0.254     0.253     0.253     0.253
    0.12   0.437     0.433     0.424     0.410     0.393     0.373     0.353     0.331     0.310     0.290     0.274     0.264     0.259
           0.256     0.255     0.255     0.254     0.254
    0.17   0.424     0.420     0.412     0.400     0.384     0.367     0.347     0.327     0.306     0.287     0.273     0.264     0.259
           0.257     0.256     0.255     0.255     0.255
    0.22   0.410     0.406     0.399     0.388     0.374     0.357     0.339     0.319     0.300     0.283     0.270     0.263     0.259
           0.257     0.256     0.256     0.256     0.256
    0.27   0.394     0.391     0.384     0.374     0.361     0.346     0.328     0.310     0.292     0.278     0.267     0.262     0.259
           0.257     0.257     0.256     0.256     0.256
    0.32   0.377     0.374     0.368     0.358     0.346     0.332     0.316     0.299     0.284     0.272     0.265     0.260     0.258
           0.257     0.257     0.256     0.256     0.256
    0.37   0.359     0.356     0.350     0.341     0.330     0.317     0.302     0.288     0.276     0.267     0.262     0.259     0.258
           0.257     0.257     0.256     0.256     0.256
    0.42   0.339     0.337     0.331     0.323     0.312     0.301     0.289     0.278     0.269     0.263     0.260     0.258     0.257
           0.257     0.257     0.256     0.256     0.256
    0.47   0.319     0.316     0.311     0.304     0.295     0.286     0.277     0.269     0.264     0.261     0.259     0.257     0.257
           0.257     0.257     0.256     0.256     0.256
    0.52   0.298     0.296     0.292     0.287     0.280     0.274     0.268     0.264     0.261     0.259     0.258     0.257     0.257
           0.257     0.257     0.257     0.257     0.257
    0.57   0.281     0.280     0.277     0.273     0.270     0.266     0.263     0.260     0.259     0.258     0.257     0.257     0.257
           0.257     0.257     0.257     0.257     0.257
    0.62   0.269     0.269     0.267     0.265     0.263     0.261     0.260     0.259     0.258     0.257     0.257     0.257     0.257
           0.257     0.257     0.257     0.257     0.257
    0.67   0.263     0.263     0.262     0.261     0.260     0.259     0.258     0.258     0.258     0.257     0.257     0.257     0.257
           0.257     0.257     0.257     0.257     0.257
    0.72   0.260     0.260     0.260     0.259     0.259     0.259     0.258     0.258     0.258     0.258     0.258     0.258     0.258
           0.258     0.258     0.258     0.258     0.258
    0.77   0.260     0.260     0.259     0.259     0.259     0.259     0.259     0.259     0.259     0.259     0.259     0.259     0.258
```

Attachment IV

<u>Example problem--continued</u>

Listing of results transferred to file 6 for example problem--Continued

```
           0.258    0.258    0.258    0.258    0.258
   0.82    0.260    0.260    0.260    0.260    0.260    0.260    0.260    0.260    0.260    0.260    0.260    0.260    0.260
           0.260    0.260    0.260    0.260    0.260
   0.87    0.262    0.262    0.262    0.262    0.262    0.262    0.262    0.262    0.262    0.262    0.262    0.262    0.262
           0.262    0.262    0.262    0.262    0.262
                   ---------- MASS BALANCE SUMMARY FOR TIME STEP  35 ----------
                       PUMPING PERIOD NUMBER    1
                       TOTAL ELAPSED SIMULATION TIME =  3.000E+00   HR

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                                                                               +
+                                                                                          MASS  THIS        RATE FOR THIS      +
+                                                                    TOTAL  MASS          TIME STEP           TIME STEP         +
+                                                                         KG                KG                 KG/  HR          +
+    FLUX INTO DOMAIN ACROSS SPECIFIED PRESSURE HEAD BOUNDARIES --     2.18795E+01         3.74631E+00         8.35710E+00     +
+  FLUX OUT OF DOMAIN ACROSS SPECIFIED PRESSURE HEAD BOUNDARIES --     0.00000E-01         0.00000E-01         0.00000E-01     +
+              FLUX INTO DOMAIN ACROSS SPECIFIED FLUX BOUNDARIES --     7.69578E+00         6.69225E-01         1.49288E+00     +
+            FLUX OUT OF DOMAIN ACROSS SPECIFIED FLUX BOUNDARIES --     0.00000E-01         0.00000E-01         0.00000E-01     +
+                                         TOTAL FLUX INTO DOMAIN --     2.95753E+01         4.41553E+00         9.84998E+00     +
+                                       TOTAL FLUX OUT OF DOMAIN --     0.00000E-01         0.00000E-01         0.00000E-01     +
+                                                    EVAPORATION --     0.00000E-01         0.00000E-01         0.00000E-01     +
+                                                  TRANSPIRATION --     0.00000E-01         0.00000E-01         0.00000E-01     +
+                                       TOTAL EVAPOTRANSPIRATION --     0.00000E-01         0.00000E-01         0.00000E-01     +
+                               CHANGE IN FLUID STORED IN DOMAIN --     2.95806E+01         4.41497E+00         9.84873E+00     +
+                                             FLUID MASS BALANCE --    -5.30437E-03         5.57904E-04         1.24455E-03     +
+                                                                                                                               +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =   36  RECHARGE PERIOD =    1 ELAPSED TIME =   3.500E+00   HR REQUIRED ITERATIONS =   11

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =   37  RECHARGE PERIOD =    1 ELAPSED TIME =   4.000E+00   HR REQUIRED ITERATIONS =   10

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =   38  RECHARGE PERIOD =    1 ELAPSED TIME =   4.500E+00   HR REQUIRED ITERATIONS =   10

NUMBER OF PASSES THROUGH TRICKLE LOOP =    1
    TIME STEP NUMBER =   39  RECHARGE PERIOD =    1 ELAPSED TIME =   5.000E+00   HR REQUIRED ITERATIONS =   10

    EXAMPLE PROBLEM  -- POINT SOURCE, RADIAL COORDINATES
   TOTAL ELAPSED TIME =   5.000E+00   HR
   TIME STEP    39
```

Attachment IV
Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
                                      PRESSURE HEAD
 Z, IN
   M                 X OR R DISTANCE, IN    M
          0.02      0.07      0.12      0.17      0.22      0.27      0.32      0.37      0.42      0.47      0.52      0.57      0.62
          0.67      0.72      0.77      0.82      0.87
   0.02 0.00E-01 0.00E-01-1.95E-01-3.98E-01-5.70E-01-7.27E-01-8.80E-01-1.04E+00-1.20E+00-1.38E+00-1.58E+00-1.77E+00-1.96E+00
       -2.11E+00-2.21E+00-2.27E+00-2.30E+00-2.32E+00
   0.07-1.29E-01-1.63E-01-2.83E-01-4.28E-01-5.73E-01-7.17E-01-8.62E-01-1.01E+00-1.18E+00-1.35E+00-1.55E+00-1.74E+00-1.93E+00
       -2.07E+00-2.17E+00-2.23E+00-2.26E+00-2.28E+00
   0.12-2.56E-01-2.92E-01-3.76E-01-4.85E-01-6.06E-01-7.35E-01-8.70E-01-1.02E+00-1.17E+00-1.35E+00-1.54E+00-1.73E+00-1.91E+00
       -2.05E+00-2.15E+00-2.21E+00-2.24E+00-2.25E+00
   0.17-3.73E-01-4.04E-01-4.68E-01-5.55E-01-6.58E-01-7.73E-01-8.99E-01-1.04E+00-1.19E+00-1.36E+00-1.55E+00-1.74E+00-1.91E+00
       -2.04E+00-2.14E+00-2.19E+00-2.22E+00-2.23E+00
   0.22-4.81E-01-5.07E-01-5.59E-01-6.32E-01-7.22E-01-8.26E-01-9.45E-01-1.08E+00-1.23E+00-1.40E+00-1.58E+00-1.76E+00-1.92E+00
       -2.05E+00-2.13E+00-2.18E+00-2.20E+00-2.21E+00
   0.27-5.84E-01-6.06E-01-6.51E-01-7.15E-01-7.96E-01-8.93E-01-1.01E+00-1.14E+00-1.29E+00-1.45E+00-1.63E+00-1.80E+00-1.95E+00
       -2.06E+00-2.13E+00-2.17E+00-2.20E+00-2.20E+00
   0.32-6.86E-01-7.06E-01-7.46E-01-8.04E-01-8.80E-01-9.73E-01-1.08E+00-1.21E+00-1.36E+00-1.52E+00-1.69E+00-1.85E+00-1.98E+00
       -2.08E+00-2.14E+00-2.17E+00-2.19E+00-2.20E+00
   0.37-7.92E-01-8.11E-01-8.48E-01-9.03E-01-9.75E-01-1.07E+00-1.17E+00-1.30E+00-1.45E+00-1.60E+00-1.76E+00-1.91E+00-2.02E+00
       -2.10E+00-2.15E+00-2.18E+00-2.19E+00-2.20E+00
   0.42-9.05E-01-9.23E-01-9.59E-01-1.01E+00-1.08E+00-1.17E+00-1.28E+00-1.41E+00-1.55E+00-1.70E+00-1.84E+00-1.97E+00-2.06E+00
       -2.12E+00-2.16E+00-2.18E+00-2.19E+00-2.19E+00
   0.47-1.03E+00-1.05E+00-1.08E+00-1.14E+00-1.21E+00-1.30E+00-1.41E+00-1.53E+00-1.67E+00-1.80E+00-1.93E+00-2.02E+00-2.10E+00
       -2.14E+00-2.17E+00-2.18E+00-2.19E+00-2.19E+00
   0.52-1.17E+00-1.19E+00-1.22E+00-1.28E+00-1.35E+00-1.44E+00-1.55E+00-1.66E+00-1.79E+00-1.90E+00-2.00E+00-2.07E+00-2.12E+00
       -2.16E+00-2.17E+00-2.18E+00-2.19E+00-2.19E+00
   0.57-1.33E+00-1.35E+00-1.38E+00-1.44E+00-1.51E+00-1.59E+00-1.69E+00-1.80E+00-1.90E+00-1.99E+00-2.06E+00-2.11E+00-2.14E+00
       -2.16E+00-2.18E+00-2.18E+00-2.19E+00-2.19E+00
   0.62-1.50E+00-1.52E+00-1.55E+00-1.60E+00-1.67E+00-1.75E+00-1.83E+00-1.91E+00-1.99E+00-2.05E+00-2.10E+00-2.13E+00-2.15E+00
       -2.17E+00-2.17E+00-2.18E+00-2.18E+00-2.18E+00
   0.67-1.67E+00-1.69E+00-1.72E+00-1.76E+00-1.82E+00-1.88E+00-1.94E+00-2.00E+00-2.05E+00-2.09E+00-2.12E+00-2.14E+00-2.15E+00
       -2.16E+00-2.17E+00-2.17E+00-2.17E+00-2.17E+00
   0.72-1.83E+00-1.84E+00-1.86E+00-1.89E+00-1.93E+00-1.98E+00-2.02E+00-2.05E+00-2.08E+00-2.11E+00-2.13E+00-2.14E+00-2.15E+00
       -2.15E+00-2.15E+00-2.15E+00-2.16E+00-2.16E+00
   0.77-1.93E+00-1.94E+00-1.96E+00-1.98E+00-2.00E+00-2.03E+00-2.05E+00-2.07E+00-2.09E+00-2.11E+00-2.12E+00-2.12E+00-2.13E+00
       -2.13E+00-2.13E+00-2.13E+00-2.13E+00-2.13E+00
   0.82-1.98E+00-1.99E+00-2.00E+00-2.01E+00-2.02E+00-2.04E+00-2.05E+00-2.07E+00-2.08E+00-2.08E+00-2.09E+00-2.09E+00-2.10E+00
       -2.10E+00-2.10E+00-2.10E+00-2.10E+00-2.10E+00
   0.87-1.98E+00-1.98E+00-1.99E+00-2.00E+00-2.01E+00-2.02E+00-2.03E+00-2.04E+00-2.04E+00-2.05E+00-2.05E+00-2.06E+00-2.06E+00
       -2.06E+00-2.06E+00-2.06E+00-2.06E+00-2.06E+00
                                      MOISTURE CONTENT
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

```
 Z, IN
  M                 X OR R DISTANCE, IN     M
         0.02     0.07     0.12     0.17     0.22     0.27     0.32     0.37     0.42     0.47     0.52     0.57     0.62
         0.67     0.72     0.77     0.82     0.87
  0.02  0.450    0.450    0.443    0.424    0.404    0.385    0.366    0.348    0.330    0.313    0.297    0.282    0.270
        0.261    0.256    0.253    0.251    0.251
  0.07  0.447    0.445    0.436    0.421    0.404    0.386    0.368    0.350    0.333    0.316    0.299    0.284    0.272
        0.263    0.258    0.255    0.253    0.253
  0.12  0.438    0.435    0.427    0.415    0.400    0.384    0.367    0.350    0.333    0.316    0.300    0.285    0.273
        0.265    0.259    0.256    0.255    0.254
  0.17  0.427    0.424    0.417    0.406    0.393    0.379    0.364    0.348    0.331    0.315    0.299    0.285    0.273
        0.265    0.260    0.257    0.256    0.255
  0.22  0.415    0.412    0.406    0.397    0.385    0.373    0.358    0.343    0.328    0.312    0.296    0.283    0.272
        0.265    0.260    0.258    0.256    0.256
  0.27  0.403    0.400    0.394    0.386    0.376    0.364    0.351    0.337    0.322    0.307    0.293    0.280    0.271
        0.264    0.260    0.258    0.257    0.256
  0.32  0.390    0.387    0.382    0.375    0.366    0.355    0.343    0.329    0.315    0.301    0.288    0.277    0.269
        0.263    0.260    0.258    0.257    0.257
  0.37  0.377    0.374    0.370    0.363    0.355    0.345    0.333    0.321    0.307    0.295    0.283    0.273    0.266
        0.262    0.259    0.258    0.257    0.257
  0.42  0.363    0.361    0.357    0.351    0.343    0.333    0.322    0.311    0.299    0.287    0.277    0.270    0.264
        0.261    0.259    0.258    0.257    0.257
  0.47  0.349    0.347    0.343    0.337    0.330    0.321    0.311    0.300    0.290    0.280    0.272    0.266    0.262
        0.260    0.258    0.257    0.257    0.257
  0.52  0.334    0.332    0.328    0.323    0.316    0.308    0.299    0.290    0.281    0.274    0.268    0.263    0.261
        0.259    0.258    0.257    0.257    0.257
  0.57  0.318    0.316    0.313    0.308    0.302    0.295    0.288    0.281    0.274    0.268    0.264    0.261    0.259
        0.258    0.258    0.257    0.257    0.257
  0.62  0.303    0.301    0.299    0.295    0.290    0.284    0.278    0.273    0.268    0.265    0.262    0.260    0.259
        0.258    0.258    0.258    0.257    0.257
  0.67  0.289    0.288    0.286    0.283    0.279    0.275    0.271    0.268    0.265    0.262    0.261    0.260    0.259
        0.258    0.258    0.258    0.258    0.258
  0.72  0.279    0.278    0.276    0.274    0.272    0.269    0.267    0.264    0.263    0.261    0.260    0.260    0.259
        0.259    0.259    0.259    0.259    0.259
  0.77  0.272    0.271    0.270    0.269    0.267    0.266    0.265    0.263    0.262    0.262    0.261    0.261    0.260
        0.260    0.260    0.260    0.260    0.260
  0.82  0.269    0.268    0.268    0.267    0.266    0.265    0.264    0.264    0.263    0.263    0.262    0.262    0.262
        0.262    0.262    0.262    0.262    0.262
  0.87  0.269    0.269    0.268    0.268    0.267    0.267    0.266    0.266    0.265    0.265    0.265    0.264    0.264
        0.264    0.264    0.264    0.264    0.264
                ---------- MASS BALANCE SUMMARY FOR TIME STEP  39 ----------
                    PUMPING PERIOD NUMBER     1
                    TOTAL ELAPSED SIMULATION TIME =   5.000E+00    HR
```

Attachment IV

Example problem--continued

Listing of results transferred to file 6 for example problem--Continued

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```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                                                                                 +
+                                                                                            MASS  THIS        RATE FOR THIS      +
+                                                                     TOTAL  MASS           TIME STEP           TIME STEP         +
+                                                                          KG                  KG                 KG/  HR         +
+    FLUX INTO DOMAIN ACROSS SPECIFIED PRESSURE HEAD BOUNDARIES --       3.80365E+01          3.97365E+00         7.94730E+00     +
+  FLUX OUT OF DOMAIN ACROSS SPECIFIED PRESSURE HEAD BOUNDARIES --       0.00000E-01          0.00000E-01         0.00000E-01     +
+            FLUX INTO DOMAIN ACROSS SPECIFIED FLUX BOUNDARIES --       1.13339E+01          9.87849E-01         1.97570E+00     +
+          FLUX OUT OF DOMAIN ACROSS SPECIFIED FLUX BOUNDARIES --       0.00000E-01          0.00000E-01         0.00000E-01     +
+                                        TOTAL FLUX INTO DOMAIN --       4.93704E+01          4.96150E+00         9.92300E+00     +
+                                      TOTAL FLUX OUT OF DOMAIN --       0.00000E-01          0.00000E-01         0.00000E-01     +
+                                                   EVAPORATION --       0.00000E-01          0.00000E-01         0.00000E-01     +
+                                                 TRANSPIRATION --       0.00000E-01          0.00000E-01         0.00000E-01     +
+                                      TOTAL EVAPOTRANSPIRATION --       0.00000E-01          0.00000E-01         0.00000E-01     +
+                              CHANGE IN FLUID STORED IN DOMAIN --       4.93713E+01          4.96038E+00         9.92076E+00     +
+                                            FLUID MASS BALANCE --      -8.86617E-04          1.12188E-03         2.24376E-03     +
+                                                                                                                                 +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
   *******************************************************************************************************
   END OF SIMULATION
   *******************************************************************************************************
TOTAL NUMBER OF ITERATIONS =    386
```

*U.S. GOVERNMENT PRINTING OFFICE: 1987-0-573-635/85018