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THE HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL

Volume III. User's Guide for Version 2

by

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SECTION 1

INTRODUCTION

The Hydrologic Evaluation of Landfill Performance (HELP) computer program is a quasi-two-dimensional hydrologic model of water movement across, into, through and out of landfills. The model accepts climatologic, soil and design data and utilizes a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage and lateral drainage. Landfill systems including various combinations of vegetation, cover soils, waste cells, special drainage layers and relatively impermeable barrier soils, as well as synthetic membrane covers and liners, may be modelled. The program was developed to facilitate rapid estimation of the amounts of runoff, drainage and leachate that may be expected to result from the operation of a wide variety of landfill designs. The model, applicable to open, partially closed and fully closed sites, is a tool for both designers and permit writers.

BACKGROUND

The HELP program, Versions 1 and 2, was developed by the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, for the U.S. Environmental Protection Agency (EPA) Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, in response to needs identified by the EPA Office of Solid Waste, Washington, D.C.

HELP Version 1 (Schroeder et al., 1984) represented a major advance beyond the Hydrologic Simulation on Solid Waste Disposal Sites (HSSWDS) program (Perrier and Gibson, 1980; Schroeder and Gibson, 1982) which was also developed at WES. For example, the HSSWDS model did not allow for lateral flow through drainage layers, handled saturated vertical flow only in a very rudimentary manner, and included infiltration, percolation and evapotranspiration routines almost identical to those used in the Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS) model which was developed by Knisel (1980) for the U.S. Department of Agriculture (USDA). The HELP model is much improved (in terms of applicability to landfills) with respect to these components; however, the infiltration routine still relies heavily on the Hydrology Section of the National Engineering Handbook (USDA, Soil Conservation Service, 1972) as do both HSSWDS and CREAMS.

In Version 2, the capabilities of the HELP model have been greatly enhanced. The WGEN synthetic weather generator developed by the USDA Agricultural Research Service (Richardson and Wright, 1984) has been added to the model which produces daily values of precipitation, temperature and solar radiation for determining snowmelt and evapotranspiration. Also, a vegetative growth model from the SWRRB model developed by the USDA Agricultural Research Service (Arnold et al., 1986) has been merged into the

HELP model to calculate daily leaf area indices. Modelling of unsaturated hydraulic conductivity and flow has been improved along with lateral drainage computations. Accuracy has been increased due to the use of double precision. Default soil data has been improved, and the model permits use of more layers and initialization of soil moisture content. Input and editing have been simplified. Output has been clarified, and standard deviations are reported.

The HELP model is applicable to most landfill applications, but was developed specifically to perform hazardous waste disposal landfill evaluations as required by the Resource Conservation and Recovery Act. Hazardous waste disposal landfills generally should have a liner to prevent migration of waste out of the landfill, a final cover to minimize the production of leachate following closure, careful controls of runon and runoff, and limits on the buildup of leachate head over the liner to no more than one foot. The HELP model is useful for predicting the amounts of runoff, drainage and leachate expected for reasonable designs as well as the build up of leachate above the liner. However, the model should not be expected to produce credible results from input unrepresentative of landfills.

OVERVIEW

The principal purpose of this user's guide is to provide the basic information needed to use the computer program. Thus, while some attention must be given to definitions, descriptions of variables and interpretation of results, only a minimal amount of such information is provided. However, detailed documentation providing in-depth coverage of the theory and assumptions on which the model is based, as well as the internal logic of the program, is also available in an accompanying volume (Schroeder et al., 1989a). Potential HELP users are strongly encouraged to read through the documentation and this user's guide before attempting to use the program to evaluate a landfill design.

The outline of the remainder of this manual is presented below.

Section 2 - Basic landfill design concepts

Section 3 - Program definitions, options and restrictions

Section 4 - Program input

Section 5 - Program output

Appendix A - Detailed explanation of how to execute the program on an IBM-compatible personal computer

Appendix B - Input data worksheets

SECTION 2

BASIC LANDFILL DESIGN CONCEPTS

BACKGROUND

Over the past 30 to 40 years the sanitary landfill has come to be widely recognized as an economical and effective means for disposal of municipal and industrial solid wastes. Today, modern methods of landfill construction and management are sufficiently developed to ensure that even large volumes of such materials can be handled and disposed of in such a way as to protect public health, minimize adverse effects on the environment and, in many cases, ultimately enhance land values.

More recently, public attention has been focused on a special class of materials commonly referred to as hazardous wastes. The chemical and physical diversity, environmental persistence, and acute and long-term detrimental effects on human, plant and animal health of many of these substances are such that great care must be exercised in disposing of them. Hazardous wastes are produced in such large quantities and are so diverse that universally acceptable disposal methods have yet to be devised. However, it appears that, for the present, disposal (or, often more precisely, storage) in secure landfills is the prudent approach in many instances. The current state-of-the-art is an extension of sanitary landfill technology utilizing very conservative design criteria. Some important basic principles and concepts of landfill design are summarized below. Specific emphasis is given to disposal of hazardous materials, but the discussion is applicable to ordinary sanitary landfills as well.

LEACHATE PRODUCTION

Storage of any waste material in a landfill poses several potential problems. Among these is the possible contamination of soil and ground and surface waters that may occur as leachate produced by water or liquid wastes moving into, through and out of the landfill migrates into adjacent areas. This problem is especially important when hazardous wastes are involved since many of these substances are quite resistant to biological or chemical degradation and, thus, may be expected to persist in their original form for many years, perhaps even for centuries. Given this possibility it is desirable for hazardous waste landfills to be designed to prevent any waste or leachate from ever moving into adjacent areas. This objective is beyond the capability of current technology, but does represent a goal in the design and operation of today's landfills. The Hydrologic Evaluation of Landfill Performance (HELP) model has been developed specifically as a tool that may be used by designers and regulatory reviewers to choose designs that minimize potential contamination problems, yet are practical given the state-of-the-art.

In the context of a landfill, leachate may be described as liquid that has percolated through the layers of waste material. Thus, leachate may be composed of liquids that originate from a number of sources including reactions associated with decomposition of waste materials, precipitation, surface drainage and groundwater. The chemical quality of leachate varies widely depending upon a number of factors including the quantity produced, the original nature of the buried waste materials and the various chemical and biochemical reactions that may occur as the waste materials decompose. In the absence of evidence to the contrary, most regulatory agencies prefer to assume that any leachate produced will be contaminated to such an extent that entry into either ground or surface waters is undesirable. Considered in the light of the potential water quality impact of leachate contamination, this approach appears reasonable.

The quantity of leachate produced is affected to some extent by decomposition reactions, but is largely governed by the amount of external water entering the landfill. Thus, a key first step in controlling leachate contamination is to limit production by preventing, to the extent feasible, the entry of external water into the waste layers. A second step is to collect any leachate that is produced for subsequent treatment and disposal. Techniques are currently available to limit the amount of leachate that migrates into adjoining areas to a virtually immeasurable volume so long as the integrity of the landfill structure and leachate control system is maintained.

DESIGN FOR LEACHATE CONTROL

A schematic profile view of a typical hazardous waste landfill is shown in Figure 1. The bottom layer of soil may be hauled in, placed and compacted to specifications following excavation to a suitable subgrade, or may be naturally existing material. In either case, the base of the landfill should act as a barrier layer having some minimum thickness and a very low hydraulic conductivity (or permeability). Chemical treatment may be used either with or without compaction to reduce permeability to an acceptable level. As an added factor of safety, an impermeable synthetic membrane may be carefully bedded in granular material and placed at the top of the barrier soil layer. The combination of low permeability barrier soil and optional membrane is often referred to as the landfill liner.

Immediately above the barrier soil liner is a leakage detection drainage layer and a leakage collection drainage layer separated by a flexible membrane liner. Both drainage layers consist of sand with suitably spaced perforated or open joint drain pipe embedded at the base. The drainage layers are typically at least one-foot thick. The leakage detection drainage layer serves to detect any leakage that may percolate through the flexible membrane liner above. The leakage collection drainage layer serves to collect any leachate that may percolate through the waste layers. The drainage layers are sloped to prevent ponding by encouraging leachate to flow toward the drains. The net effect is that very little leachate should percolate through the barrier soil liner to the natural formations below.

Taken as a whole the drainage layers, flexible membrane liners and barrier soil may be referred to as the drainage/liner system.

After the landfill is closed, the drainage/liner system serves basically in a back-up capacity. However, while the landfill is open and waste is being added, these components are the principal defense against contamination of adjacent areas. Thus, care must be given to their design and construction.

Day-to-day operation of a modern sanitary landfill calls for wastes to be placed in relatively thin lifts, compacted and covered with compacted soil each day. Thus, wastes should not be left exposed more than a few hours. While the daily soil cover serves effectively to hide the wastes and limit the access of nuisance insects and potential disease vectors, it is of limited value for preventing the formation of leachate. Thus, even though a similar procedure may be utilized for hazardous wastes, it is imperative that the drainage/liner system function well throughout the active life of the landfill and beyond.

When the capacity of the landfill is reached, the waste cells may be covered with a cap, or final cover, typically composed of three distinct layers as shown in Figure 1. At the base of the cap, or cover, is a drainage layer and barrier soil layer similar to that used at the base of the landfill. Again, a flexible membrane liner may be used if needed. The top of the barrier soil layer is graded so that water percolating into the drainage layer will tend to move horizontally toward some removal system located at the edge of the landfill or subunit thereof.

A layer of soil suitable for the support of vegetative growth is placed on top of the upper drainage layer to complete the landfill. A two-foot-thick layer of soil having a high loam content serves this purpose well. The upper surface is graded so that runon is minimized and as much precipitation as possible is converted to runoff without causing excessive erosion of the cap. The vegetation used should be selected to grow readily, provide a good cover even during the winter when it is dormant and have a root system that will not penetrate into the upper barrier layer. Grasses are usually best for this purpose.

The combination of site selection, surface grading, transpiration from vegetation, soil evaporation, drainage through the sand and the low hydraulic conductivity of the barrier soil serves effectively to minimize leachate production from external water. Added effectiveness is gained by the use of flexible membrane liners in the cap and barrier soil liner. However, it is important that the cap be no more permeable than the liner; otherwise, the landfill could gradually fill with liquid and ultimately overflow into adjacent areas. This phenomenon is sometimes referred to as the "bathtub" effect.

The HELP model is designed to perform water budget calculations for landfills having as many as 12 layers by modeling each of the hydrologic processes that occur. Thus, it is possible to design a landfill to achieve specific goals, or evaluate the performance of a given landfill design, with the aid of the model. A description of the program is presented in the following section.

SECTION 3

PROGRAM DEFINITIONS, OPTIONS AND LIMITATIONS

INTRODUCTION

The HELP program was developed to provide landfill designers and regulators with a tool for rapid, economical screening of alternative designs. The program may be used to estimate the magnitudes of various components of the water budget, including the volume of leachate produced and the thickness of water-saturated soil (head) above barrier layers. The results may be used to compare the leachate production potential of alternative designs, to select and size appropriate drainage and collection systems and to size leachate treatment facilities.

The program uses climatologic, soil and design data to produce daily estimates of water movement across, into, through and out of landfills. To accomplish this, daily precipitation is partitioned into surface storage (snow), snowmelt, runoff, infiltration, surface evaporation, subsurface evapotranspiration, stored soil moisture, barrier-layer percolation and subsurface lateral drainage to maintain a water budget.

This chapter discusses data requirements, nomenclature, important assumptions and limitations, and other fundamental information needed to run the program. The program documentation manual (Schroeder et al., 1989) contains detailed explanations of the solution techniques employed, along with a complete listing of the program.

DATA REQUIREMENTS

The HELP program requires three general types of input data: climatological data, soil data and design data. A summary of input options and data requirements is presented below. Section 4 provides step-by-step input instructions. Section 5 presents the output options. Example input and output along with example data files are presented on diskette with the HELP model executable codes.

Climatologic Data

The HELP user may enter climatologic data using one of three options: a default precipitation option, a manual precipitation option and a synthetic precipitation option. The data requirements for the three options are listed below.

Default Precipitation Option
- Location (select from list of 102 U.S. cities in Table 1)
- Maximum leaf area index
- Evaporative zone depth, in inches
- Normal mean monthly temperatures, in degrees F. (optional)

Manual Precipitation Option
- One or more years of daily precipitation data, in inches
- Location (select from list of 184 U.S. cities in Table 3)
- Maximum leaf area index
- Evaporative zone depth, in inches
- Normal mean monthly temperatures, in degrees F. (optional)

Synthetic Precipitation Option
- Location (select from list of 139 U.S. cities in Table 2)
- Number of years of data to be generated
- Maximum leaf area index
- Evaporative zone depth, in inches
- Normal mean monthly precipitation in inches (optional)
- Normal mean monthly temperatures, in degrees F. (optional)

Under the default option, the user may select five years of historical precipitation data for any of the 102 U.S. cities listed in Table 1. Under the manual option, the user may enter from 1 to 20 years of daily precipitation data manually. The years of precipitation data, which need not be consecutive, can be entered in any order. The program arranges the data by year in chronological order. The manual option also allows the user to check, modify or add to previously entered data. Under the synthetic option, the program will generate from 1 to 20 years of daily precipitation data stochastically.

The user should be aware of the limitations of using the default precipitation data. None of the 102 locations for which data is available may be representative of the study site. Also, the five years for which default data are available (1974-1978 in most cases) may have been unusually wet or dry. It is therefore highly recommended that the user run the simulation for more than five years, using either historical or synthetic data, to examine the design under the range of possible climatologic conditions.

The program can generate a synthetic daily precipitation record 1 to 20 years in length for any of the 139 cities shown in Table 2. The synthetic precipitation data will have approximately the same statistical characteristics as the historical data at the selected location. The user has the option of entering normal mean monthly precipitation values for the project location. These values are used to adjust the synthetic precipitation record. The user is advised to enter normal mean monthly precipitation values if the project site is located some distance from the city selected from Table 2.

Daily temperature and solar radiation data are generated stochastically under all three precipitation options. Under the default option, the program generates these data for the location selected from Table 1. Under the synthetic option, the program uses the location selected from Table 2. Under the manual option, daily temperature and solar radiation data can be generated for any of the 184 cities shown in Table 3. The user must select from this list the city with climatologic conditions most like those at the project site. The user can improve the record of synthetic daily temperatures by entering optional normal mean monthly temperatures for the project location.

Daily precipitation data and monthly means of temperature and precipitation for most locations are readily available in publications of the National Oceanic and Atmospheric Administration. Information on climatological data sources can be obtained from the National Climatic Data Center, NOAA, Federal Building, Asheville, NC 28801.

The user must enter a maximum value of leaf area index for the vegetative cover. Leaf area index is defined as the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. The program provides the user with typical values for the location selected previously. If the value entered by the user cannot be supported without irrigation because of low rainfall or a short growing season, the program prints a warning.

The user must also specify an evaporative zone depth. This is the maximum depth from which water may be removed by evapotranspiration. Where surface vegetation is present, the evaporative depth should at least equal the expected average depth of root penetration. The influence of plant roots usually extends somewhat below the depth of root penetration because of capillary suction. Setting the evaporative depth equal to the expected average root depth is therefore conservative. Some evaporative depth should be specified for bare ground to account for direct evaporation from the soil. Suggested conservative values of evaporative depth are 18 inches for bare ground, 36 inches for a fair stand of grass and 60 inches for an excellent stand of grass. The program does not permit the evaporative depth to exceed the depth to the top of the topmost barrier soil layer.

Soil Data

The user may enter soil data using either a default option or a manual option. The data requirements for the two options are listed below. An explanation of these requirements follows.

Default Option

- Number of layers
- Layer types
- Thicknesses, in inches
- Soil texture classes or soil characteristics
- Compaction
- Initial soil water contents, in vol/vol (optional)
- Leakage fractions for synthetic membrane liners
- Vegetative cover type
- Runoff curve number (optional)

Manual Option

- Number of layers
- Layer types
- Thicknesses, in inches
- Wilting points, in vol/vol
- Field capacities, in vol/vol
- Porosities, in vol/vol
- Saturated hydraulic conductivities, in cm/sec
- Initial soil water contents, in vol/vol (optional)
- Leakage fractions for synthetic membrane liners
- Runoff curve number

Landfill Profile--

The HELP program may be used to model landfills with up to twelve distinct layers of soil or waste. Figure 1 shows a typical landfill profile with eight layers. The program recognizes three general types of layers: vertical percolation layers, lateral drainage layers and barrier soil layers. Correct classification of layers is very important because the program models the flow of water through the three types of layers in different ways.

Flow in a vertical percolation layer (e.g., layers 1 and 4 in Figure 1) is either downward due to gravity drainage or upward due to evapotranspiration. The rate of gravity drainage (percolation) in a vertical percolation layer is assumed to be independent of conditions in adjacent layers. Waste layers and layers designed to support vegetation are normally designated as vertical percolation layers.

Lateral drainage layers (e.g., layers 2, 5 and 7 in Figure 1) are generally placed above barrier soil layers. Vertical flow in a lateral drainage layer is modeled in the same manner as for a vertical percolation layer, but lateral drainage is allowed. The hydraulic conductivity of a lateral drainage layer should be greater than or equal to the hydraulic conductivity of the overlying layer. A lateral drainage layer may be underlain by only another lateral drainage layer or a barrier soil layer. The slope of the bottom of the layer may vary from 0 to 30 percent.

Barrier soil layers are intended to restrict vertical flow. These layers should have hydraulic conductivities substantially lower than those of the other types of layers. The program allows only downward flow in barrier soil layers. Thus, any water moving into a barrier layer will eventually percolate through. Percolation rate depends upon the depth of water-saturated soil (head) above the base of the layer. The program recognizes two types of barrier layers: those composed of soil alone and those composed of soil overlain by an impermeable synthetic membrane. For the latter type, the user must specify some membrane leakage fraction. This factor may be considered the ratio of the daily percolation that occurs with the membrane in place to the daily percolation that would occur without the membrane. The net effect of specifying a membrane leakage fraction is to reduce the effective hydraulic conductivity of the layer. The program does not model aging of the membrane. Layers 3, 6 and 8 shown on Figure 1 are barrier layers.

While the HELP program is quite flexible, there are some basic rules that must be followed regarding the arrangement of layers in the profile. First, a vertical percolation layer or a waste layer may not be placed directly below a lateral drainage layer. Second, a barrier soil layer may not be placed directly below another barrier soil layer. Third, when a barrier soil layer is not placed directly below the lowest drainage layer, all drainage layers in the lowest subprofile are treated as vertical percolation layers. Thus, no lateral drainage is allowed in this subprofile. Fourth, the top layer may not be a barrier soil layer. Fifth, the profile can contain no more than four barrier soil layers.

For computational purposes, the soil profile is partitioned into subprofiles. Subprofiles are defined in relation to the location of the barrier soil layers. The upper subprofile shown on Figure 1 extends from the landfill surface to the bottom of the upper barrier soil layer (layer 3), the middle subprofile extends from the top of the waste layer to the base of the middle barrier soil layer and the bottom subprofile extends from the top of the leakage detection drainage layer to the base of the lowest barrier soil layer. Since there can be no more than four barrier soil layers, there can be no more than four subprofiles. The program models the flow of water through one subprofile at a time from top to bottom, with the percolation from one subprofile serving as the inflow to the underlying subprofile.

Soil Characteristics--

The user can assign soil characteristics to a layer using either the default option or the manual option. Table 4 shows the default characteristics for 18 soil texture classes. These soil textures are classified according to two standard systems--the U.S. Department of Agriculture system and the Unified Soil Classification System. The default characteristics are typical of agricultural soils, which may be less dense and more aerated than soils typically placed in landfills (Breazeale and McGeorge, 1949; England, 1970; Lutton et al., 1979). Clays and silts in landfills would generally be compacted except within the vegetative layer, which might be tilled to promote vegetative growth. Untilled vegetative layers would generally be more compacted than the loams listed in Table 4. Soil texture type 18 is representative of typical municipal solid waste that has been compacted. Soil texture types 16 and 17 denote very well compacted clay soils that might be used for barrier layers. The user assigns default soil characteristics to a layer simply by specifying the appropriate soil texture number. The default input option accepts non-default soil characteristics for layers assigned soil textures 19 and 20. This is especially convenient for specifying characteristics of waste layers.

The manual input option requires values for porosity, field capacity, wilting point, and saturated hydraulic conductivity. These and other related soil properties are defined briefly below.

Soil Water Content--the ratio of the volume of water in a soil to the total volume occupied by the soil.

Porosity--the soil water content at saturation.

Field capacity--the soil water content after a prolonged period of gravity drainage.

Wilting point--the lowest soil water content that can be achieved by plant transpiration.

Available (or plant available) water capacity--the difference between the soil water contents at field capacity and wilting point.

Hydraulic conductivity--the rate at which water drains vertically through a saturated soil with no vertical pressure gradient.

Porosity, field capacity and wilting point are all dimensionless numbers between 0 and 1. Porosity must be greater than field capacity, which in turn must be greater than wilting point.

The program does not use all these data for every layer. Porosity, field capacity and wilting point are not used for barrier soil layers.

If a value of 1 through 15 is specified for soil texture class, the program asks the user whether the layer is to be compacted. If compaction is specified, the soil characteristics are adjusted as follows: (1) the saturated hydraulic conductivity is reduced by a factor of 20, (2) the porosity is reduced by 25 percent of the difference between the uncompacted porosity and wilting point and (3) the field capacity is reduced by 25 percent of the difference between the uncompacted field capacity and wilting point.

The HELP user has the option of specifying the initial water contents of all non-barrier layers. Barrier soil layers are assumed to remain saturated at all times. If the user chooses not to specify initial water contents, the program assumes values and then runs the first year of the simulation. The soil water contents at the end of this first year are taken as the initial values for the simulation period. The program then runs the complete simulation, starting again from the beginning of the first year of data. The results for the initialization period are not reported.

The soil data input routines also request some information on landfill surface conditions. In the default input routine, the user must specify one of five vegetative cover types: bare ground, poor grass, fair grass, good grass or excellent grass. The default hydraulic conductivities of the soils in the top half of the evaporative zone are multiplied by an empirical factor that accounts for the effects of vegetation. The values of this factor are 1.0 for bare ground, 1.8 for poor grass, 3.0 for fair grass, 4.2 for good grass and 5.0 for excellent grass. In the manual input routine, the user must supply a value of the SCS runoff curve number for Antecedent

Moisture Condition II. The default input routine also allows the user to specify a runoff curve number if desired. Some general guidance for selection of runoff curve numbers is provided in Figure 2 (USDA, Soil Conservation Service, 1972; Li, 1975). Typical values of minimum infiltration rate are shown in Table 4. The National Engineering Handbook, Section 4, Hydrology (USDA, Soil Conservation Service, 1972) contains detailed information on selection of runoff curve numbers.

Site Data

The user must provide the program with the following site data:

Landfill surface area, in square feet
For each barrier soil liner underlying a lateral drainage layer:
- Slope of top of layer, in percent
- Maximum lateral drainage distance along slope, in feet

Fraction of daily potential runoff that actually runs off (open landfills only)

The lateral drainage submodel is applicable for barrier-layer slopes from 0 to 30 percent. Maximum lateral drainage distance is measured along the slope rather than horizontally; however, for slopes of less than ten percent, the difference is negligible. The maximum horizontal drainage distance is one-half the maximum spacing between parallel drains with sawtooth bottom slopes. For parallel drains on a constant slope the maximum horizontal drainage length is the spacing between parallel drains. Where drains are not used, the appropriate distance is the maximum distance that water must travel to reach a free discharge.

The user must specify whether the landfill is active (uncovered) or inactive (covered). If uncovered, the user must specify the fraction of the potential surface runoff that actually runs off.

OVERVIEW OF MODELING PROCEDURE

The hydrologic processes modeled by the program can be divided into two categories: surface processes and subsurface processes. The surface processes modeled are snowmelt, interception of rainfall by vegetation, surface runoff and surface evaporation. The subsurface processes modeled are soil evaporation, plant transpiration, vertical unsaturated drainage, barrier-layer percolation and lateral saturated drainage.

Daily infiltration into the landfill is determined indirectly from a surface-water balance. Each day, infiltration is assumed to equal the sum of rainfall and snowmelt, minus the sum of runoff and surface evaporation. No liquid water is held in surface storage from one day to the next. The daily surface-water accounting proceeds as follows. Snowfall is added to the surface snow storage, and then snowmelt is computed and added to rainfall. The SCS rainfall-runoff relationship is used to determine the runoff resulting from the combined snowmelt and rainfall. Surface evaporation is then computed. Surface evaporation is not allowed to exceed the sum of surface snow storage and intercepted rainfall. The snowmelt and rainfall that does not run off or evaporate is assumed to infiltrate into the landfill.

The first subsurface processes considered are soil evaporation and plant transpiration from the evaporative zone of the upper subprofile. A vegetative growth model accounts for the daily growth and decay of the surface vegetation. The other subsurface processes are modeled one subprofile at a time, from top to bottom, using a six-hour time step. A storage-routing procedure is used to redistribute the soil water among the modelling segments that comprise the subprofile. This procedure accounts for infiltration or percolation into the subprofile and evapotranspiration from the evaporative zone. Then, if the subprofile contains a barrier layer, the program computes the head on the barrier layer, the percolation rate through it and the lateral drainage rate.

ASSUMPTIONS AND LIMITATIONS

Methods of Solution

The modeling procedures documented in the previous section are necessarily based on many simplifying assumptions. Generally, these assumptions are reasonable and consistent with the objectives of the program when applied to standard landfill designs. However, some of these assumptions may not be reasonable for unusual designs. The major assumptions and limitations of the program are summarized below.

Runoff is computed using the SCS method based on daily amounts of rainfall and snowmelt. The program assumes that areas adjacent to the landfill do not drain onto the landfill. The time distribution of rainfall intensity is not considered. The program cannot be expected to give accurate estimates of runoff volumes for individual storm events on the basis of daily rainfall data. However, because the SCS rainfall-runoff relationship is based on considerable daily field data, long-term estimates of runoff should be reasonable. The SCS method does not explicitly consider the length and slope of the surface over which overland flow occurs. This is not a concern provided that these characteristics do not differ dramatically from those of the test plots upon which the SCS method is based. One would expect the SCS method to underestimate runoff somewhat where the overland-flow distance is very short or the slope is very steep.

The HELP program assumes Darcy flow through the soil and waste layers. It does not consider flow through channels such as cracks, root holes, or animal burrows. The drainage rate out of a segment is assumed to equal the unsaturated hydraulic conductivity of the segment corresponding to its moisture content, provided that the segment directly below is not a barrier layer and is not saturated. Except in these special cases, the drainage rate out of a segment cannot be limited by the hydraulic conductivity of the segment below it. This is reasonable provided that each segment in a subprofile (excluding the barrier layer) has a hydraulic conductivity greater than or equal to the segment directly above it. Where adjacent segments have identical saturated hydraulic conductivities, this limitation is satisfied only if the lower segment has the higher water content. Because the assumption could be violated in the vicinity of a wetting front, the program might tend to overestimate the rate at which a wetting front moves downward through a subprofile.

Where an impervious synthetic membrane is placed over a barrier soil layer, percolation occurs only if the membrane fails. The HELP program is useful for modelling the build-up of head on an impervious liner. The user can investigate the consequences of failure of a synthetic membrane by specifying a leakage fraction. This can be considered the fraction of the horizontal area of soil through which percolation is occurring under the leaking synthetic liner. The HELP program assumes any leakage to be distributed uniformly over the area of the liner.

The lateral drainage model is based on the assumption that the relationship between lateral drainage rate and average saturated depth that exists for steady drainage also holds for unsteady drainage. This implies that saturated conditions exist, and therefore percolation occurs over the entire barrier layer at all times. This assumption is reasonable for the liner drainage system where drainage conditions should be fairly steady. Where drainage conditions are more variable, such as in the cap drainage system, the assumption is conservative.

Limits of Application

The model can handle water routing through or storage in up to twelve soil or waste layers; as many as four of the layers may be barrier soil or restrictive layers. The simulation period can range from 1 to 20 years. The model has limits on the order that layers can be arranged in the landfill profile. Each layer must be described as being one of three types: vertical percolation, lateral drainage or barrier soil. The model does not permit a vertical percolation layer to be placed below a lateral drainage layer. A barrier soil layer may not be placed directly below another barrier soil layer. The top layer may not be a barrier soil layer. If a barrier soil layer is not placed directly below the lowest lateral drainage layer, the lateral drainage layers in the lowest subprofile are treated by the model as vertical percolation layers. No other restrictions are placed on the order of the layers.

The lateral drainage equation was developed for the expected range of hazardous waste landfill design specifications. Permissible ranges for slope and maximum drainage length of the drainage layer are 0 to 30 percent and 25 to 2000 feet. The liner leakage fraction and the fraction of potential runoff for open sites can range between 0 and 1.

Several relationships must exist between the soil characteristics of a layer and of the soil subprofile. The porosity, field capacity and wilting point can theoretically range from 0 to 1 in units of volume per volume, but the porosity must be greater than the field capacity, and the field capacity must be greater than the wilting point.

Several of the soil characteristics for some layers are not used by the model; these include the porosity, field capacity and wilting point of barrier soil liners.

Values for the leaf area index may range from 0 for bare ground to 5 for an excellent stand of grass. Detailed recommendations for leaf area indices and evaporative depths are given in the program.

The default values for the evaporation coefficient are based on experimental results. The basis for the calculation of these default values is described in the documentation for Version 2 (Schroeder et al., 1989). The model imposes upper and lower limits of 5.1 and 3.3 so as not to exceed the range of experimental data.

Other important assumptions should be noted. First, the program assumes that the entire landfill lies above the water table and that no flow occurs through the sides of the landfill. Second, it is assumed that surface runoff from adjacent areas does not run onto the landfill. Third, the program assumes that the physical characteristics of the landfill specified by the user remain constant over the modeling period. The program does not account for the changes that occur in these characteristics as the landfill ages. In addition, the program cannot model the filling process within a single simulation.

Default Soil Characteristics

The HELP model contains default values of soil characteristics based on soil texture class. The documentation for Version 2 describes the origin of these default values (Schroeder et al., 1989). Recommended default values for leaf area index and evaporative depth are given in the program.

Manual Soil Characteristics

The HELP model contains default values for the three Brooks-Corey parameters described in the documentation for Version 2 (Schroeder et al., 1989) based on soil texture class. However, if the user manually inputs values for porosity, field capacity and wilting point, the model must compute corresponding values of the three Brooks-Corey parameters. The documentation for Version 2 describes this calculation.

Soil Moisture Initialization

The soil moisture of the layers may be initialized by the user or the program. If initialized by the program, the soil moisture is initialized in three steps. The first step sets the soil moisture of all layers except barrier soil liners equal to field capacity and all barrier soil liners to porosity or saturation.

In the second step the program computes a soil moisture for each layer below the top barrier soil liner. These soil moistures are computed to yield an unsaturated hydraulic conductivity equal to 85 percent of the effective saturated hydraulic conductivity of the barrier soil liner directly above the layer, including consideration for the possible presence of a synthetic flexible membrane liner. If the unsaturated hydraulic conductivity is greater than 1 x 10-6 cm/sec or if the computed soil moisture is greater than field capacity, the soil moisture is set to equal the field capacity. If the computed soil moisture is less than wilting point, the soil moisture is set to equal wilting point. In all other cases, the computed soil moistures are used.

The third step in the initialization consists of running the model for one year of simulation using the first year of climatological data and the initial soil moistures selected in step 2. At the end of the year of initialization, the soil moistures existing at that point are reported as the initial soil moistures. The simulation is then started using the first year of climatological data again.

Synthetic Temperature and Solar Radiation Values

The synthetically-generated temperature and solar radiation values are assumed to be representative of the climate at the site. Synthetic daily temperature is a function of mean monthly temperature and daily rainfall. Synthetic daily solar radiation is a function of latitude, daily rainfall, average daily dry-day solar radiation and average daily wet-day solar radiation.

SECTION 4

PROGRAM INPUT

INTRODUCTION

Once the input program is started, it automatically solicits input from the user. This chapter describes the input commands given by the program, the questions the program asks, possible responses the user can provide and the implications of these responses. For convenience, both input commands and questions are referred to as "questions" in this chapter. Obviously, the commands are really statements and not questions. For reference, each question has been assigned an identification number which will enable the user to find a description of the question in this chapter. A brief description of how to obtain and run the program on an IBM-compatible personal computer is given in Appendix A.

The twelve types of data that the user can enter are listed below:

1. Overall Program Control (MAIN),
2. Default Climatological Data (DCDATA),
3. Manual Rainfall Data (MCDATA),
4. Synthetic Rainfall Data (SCDATA),
5. Default Soil Data (DSDATA),
6. Manual Soil Data (MSDATA),
7. Temperature and Solar Radiation Data and Coefficients (TRRCF),
8. Modify Yearly Rainfall Dàta (PREMOD),
9. Edit Daily Rainfall Data (PRECHK),
10. Site Description (SITE),
11. Characteristics of Open Sites (OPEN),
12. Edit Soil Data (SDCHK),

The names in parentheses are the subroutines in which the data are entered. The relationship between subroutines is shown schematically in Figure 3. MAIN is the main program.

RULES

There are a few fundamental rules that a user must keep in mind when using the program. These are summarized below.

When the program requests a word response, the response must be left justified and the first four characters must be spelled correctly. For example, _YES and NO_Sir are not acceptable responses to a YES/NO question. However, since many questions in the program request a YES or NO, a response of yes, no, Y, y, N or n is also acceptable for these questions. When entering numerical data, there must be no stray signs or decimals. If fewer values are entered on a line than are called for, the program assigns zeros to the remaining locations. For example, if 10 daily rainfall values are required on a line and the values are

```
0.   0.9   0.   0.4 0.  0.   0.25   0.   0.   0.
```

the user can enter

```
0   .9   0   .4   0   0   .25
```

But if the user entered

```
0.  .   .   .9   -   0   .4   0.   0.   .25
```

the program would store

```
0.   0.   0.   .9   -0.   0.   0.4   0.   0.   0.25
```

The user should always enter at least one character on any line. Otherwise, because most computers regard a blank line as an end-of-file, the run may be prematurely terminated. For example, if the user is entering rainfall data for a 10-day period with no rain, it is permissible to enter

0

but not to leave the entire line blank.

Trailing decimal points are not required on input as the program automatically knows whether to treat a value as an integer or floating point variable. For example, if a user wishes to enter the number nine, either 9, 9. or 9.00 is acceptable. The program decides whether to store the value as 9 or 9.000000.

If the program is expecting one of several responses to a question (e.g. 1, 2, 3 or 4) and the user does not enter such a response, the program warns the user and provides another opportunity to respond correctly. In most cases the entire question is not repeated.

The user is discouraged from terminating a run during input because some of the data may be lost. If necessary, though, the user can terminate input by hitting the "BREAK" key or Ctrl-Alt-Del keys on personal computers.

Each question (and input command) has been assigned an identifying code composed of two arabic numerals separated by a decimal point. The first number always refers to the appropriate subroutine, while the second indicates the order of the questions (and input commands) within the subroutine. These identifying codes assist the user in locating the portion of this chapter that may be of interest in interpreting the questions (and input commands).

OVERALL PROGRAM CONTROL (1. MAIN)

When the program starts, it first prints a heading introducing the HELP program and then asks the following:

1.1 SELECT INPUT OPERATION:

```
ENTER 1 TO ENTER, EDIT OR REVIEW CLIMATOLOGICAL DATA,
      2 TO ENTER, EDIT OR REVIEW SOIL AND DESIGN DATA, OR
      5 TO STOP THE PROGRAM.
```

If the user answers 1 to question 1.1, the program asks the user what type of rainfall data is to be used in the run:

1.2 SELECT TYPE OF RAINFALL DATA INPUT:

```
ENTER 1 TO USE DEFAULT RAINFALL DATA,
      2 TO SPECIFY YOUR OWN RAINFALL DATA OR TO EDIT
        EXISTING CLIMATOLOGICAL DATA, OR
      3 TO SYNTHETICALLY GENERATE RAINFALL DATA.
```

The user answers 1 to build new files (DATA4, DATA7, DATA11 and DATA13) of climatological data from the default data files (TAPE2 and TAPE3), 2 to enter climatological data manually or edit existing climatological data and 3 to generate files of synthetic rainfall and other climatological data. Entering 1 transfers control to subroutine 2. DCDATA (question 2.1), entering 2 transfers control to subroutine 3. MCDATA (question 3.1) and entering 3 transfers control to subroutine 4. SCDATA (question 4.1).

If the user answers 2 to question 1.1, the program asks the following question:

1.3 SELECT TYPE OF SOIL AND DESIGN DATA INPUT:

```
ENTER 1 TO USE DEFAULT SOIL CHARACTERISTICS,
      2 TO SPECIFY YOUR OWN SOIL CHARACTERISTICS, OR
      3 TO EDIT YOUR EXISTING SOIL AND DESIGN DATA.
```

The user should enter 1 to build a new data file for soil data from the default soil texture data, 2 to enter soil data manually during the run or 3 to edit previously entered soil and design data.

If the user answers 5 to question 1.1, the run is halted and the following message is printed:

1.4 ENTER RUNHELPI TO RERUN INPUT PROGRAM.
ENTER RUNHELPO TO RUN OUTPUT PROGRAM.

DEFAULT CLIMATOLOGICAL DATA (2. DCDATA)

If the user specified that default rainfall data would be used (an entry of 1 in response to question 1.2), the program first asks whether the user wants a list of cities for which default climatological data are stored:

2.1 DO YOU WANT A LIST OF DEFAULT CITIES?
ENTER YES OR NO.

A YES response will result in the program printing a list (Table 1) of the 102 cities for which 5-year precipitation data sets are stored:

DEFAULT DATA ARE PROVIDED ONLY FOR THE FOLLOWING CITIES AND STATES:

DISK 1	DISK 2	DISK 3	DISK 4
ALASKA	IDAHO	NEBRASKA	PENNSYLVANIA
ANNETTE	BOISE	GRAND ISLAND	PHILADELPHIA
BETHEL	POCATELLO	NORTH OMAHA	PITTSBURGH
FAIRBANKS	ILLINOIS	NEVADA	RHODE ISLAND
ARIZONA	CHICAGO	ELY	PROVIDENCE
FLAGSTAFF	E. ST. LOUIS	LAS VEGAS	SOUTH CAROLINA
PHOENIX	INDIANA	NEW HAMPSHIRE	CHARLESTON
TUCSON	INDIANAPOLIS	CONCORD	SOUTH DAKOTA
ARKANSAS	IOWA	NASHUA	RAPID CITY
LITTLE ROCK	DES MOINES	NEW JERSEY	TENNESSEE
CALIFORNIA	KANSAS	EDISON	KNOXVILLE
FRESNO	DODGE CITY	SEABROOK	NASHVILLE
LOS ANGELES	TOPEKA	NEW MEXICO	TEXAS
SACRAMENTO	KENTUCKY	ALBUQUERQUE	BROWNSVILLE
SAN DIEGO	LEXINGTON	NEW YORK	DALLAS
SANTA MARIA	LOUISIANA	CENTRAL PARK	EL PASO

ENTER RETURN TO VIEW MORE DEFAULT CITIES.

DISK 1	DISK 2	DISK 3	DISK 4
COLORADO	LAKE CHARLES	ITHACA	MIDLAND
DENVER	NEW ORLEANS	NEW YORK CITY	SAN ANTONIO
GRAND JUNCTION	SHREVEPORT	SCHENECTADY	UTAH
CONNECTICUT	MAINE	SYRACUSE	CEDAR CITY
BRIDGEPORT	AUGUSTA	NORTH CAROLINA	SALT LAKE CITY
HARTFORD	BANGOR	GREENSBORO	VERMONT
NEW HAVEN	CARIBOU	NORTH DAKOTA	BURLINGTON
FLORIDA	PORTLAND	BISMARCK	MONTPELIER
JACKSONVILLE	MASSACUSETTS	OHIO	RUTLAND
MIAMI	BOSTON	CINCINNATI	VIRGINIA
ORLANDO	PLAINFIELD	CLEVELAND	LYNCHBURG
TALLAHASSEE	WORCESTER	COLUMBUS	NORFOLK
TAMPA	MICHIGAN	PUT-IN-BAY	WASHINGTON
W. PALM BEACH	E. LANSING	OKLAHOMA	PULLMAN
GEORGIA	SAULT STE. MARIE	OKLAHOMA CITY	SEATTLE
ATLANTA	MINNESOTA	TULSA	YAKIMA
WATKINSVILLE	ST. CLOUD	OREGON	WISCONSIN
HAWAII	MISSOURI	ASTORIA	MADISON

ENTER RETURN TO VIEW MORE DEFAULT CITIES.

DISK 1	DISK 2	DISK 3	DISK 4
HONOLULU	COLUMBIA	MEDFORD	WYOMING
	MONTANA	PORTLAND	CHEYENNE
	GLASGOW		LANDER
	GREAT FALLS		PUERTO RICO
			SAN JUAN

Regardless of the answer to 2.1, this question is printed:

2.2 ENTER NAME OF STATE OF INTEREST IN UPPER CASE LETTERS.

The user need only enter the first four characters of the state name. Some states have no cities for which climatological data are stored. For these, the program responds

THERE ARE NO DEFAULT VALUES FOR ________________.

and control is returned to question 2.1. In that case, the user must enter climatological data manually, use the synthetic weather generator option or use the default data for a nearby city from a neighboring state.

Once the state name is entered, the user must enter the name of the city for which climatological data are to be used in response to

2.3 ENTER NAME OF CITY OF INTEREST IN UPPER CASE LETTERS.

The user can only select names from the 102 cities given in response to question 2.1. If the name of the city is not found in the list of default cities, the program responds

THERE ARE NO DEFAULT VALUES FOR ____________________.

and control is returned to question 2.1. If the user wants a listing of the cities, the program produces a listing of the cities and returns to question 2.2; otherwise, the program returns to question 2.3.

If the name of the city is found in the list of default cities, program control is transferred to subroutine 7. TRRCF (question 7.1) where coefficients necessary to generate daily temperatures and solar radiation values are read from data file TAPE2. After returning from TRRCF, when running on the IBM PC, the program responds

2.4 ENTER THE LETTER OF THE DRIVE WHERE THE DEFAULT PRECIPITATION DATA SHOULD BE READ (A, B, C OR D).

The user should respond with one of the appropriate letters. If an incorrect choice is made, the program prints

E IS AN INCORRECT CHOICE.

and returns to question 2.4.

Once question 2.4 is answered, the program requests

2.5 LOAD THE CORRECT DEFAULT PRECIPITATION DATA
ON THE APPROPRIATE DRIVE AND THEN ENTER YES.
IF YOU MUST STOP EXECUTION TO LOAD THE DATA, ENTER NO.

If the data is not already loaded, the user places the diskette containing climatic data for the city entered in question 2.3 in the appropriate drive and then types YES. If execution must be terminated, the user types NO. At this point, if the program cannot find the data file on the drive specified in question 2.4, it prints this message:

PROGRAM CANNOT ACCESS DATA FILE ON DRIVE B.

If the program finds the data file, and the name of the city is in the list of cities but does not correspond with the user specified state, the program responds

PITTSBURGH LOUISIANA CANNOT BE FOUND ON
DEFAULT PRECIPITATION DATA FILE, TAPE3.

and the program returns to question 2.1.

Once the program has read the default precipitation data from storage, it asks the user to specify the maximum leaf area index.

```
2.6  ENTER THE MAXIMUM LEAF AREA INDEX.

TYPICAL VALUES ARE:
                  0 FOR BARE GROUND,
                1.0 FOR POOR GRASS,
                2.0 FOR FAIR GRASS,
                3.3 FOR GOOD GRASS, AND
                5.0 FOR EXCELLENT GRASS.
```

The user enters a value for the maximum leaf area index based on the vegetative cover type. If the entered value is greater than the maximum value stored for the city in the default database, the program warns

```
LOCATION CANNOT SUPPORT THIS LEAF AREA INDEX UNLESS IRRIGATED
DUE TO LOW RAINFALL AND SHORT GROWING SEASON.

TYPICAL MAXIMUM FOR TULSA                OKLAHOMA            IS 3.50.
                    ----------------------------------------    ----
2.7  DO YOU WANT TO SELECT A DIFFERENT LEAF AREA INDEX?
ENTER YES OR NO.
```

If the user answers YES to question 2.7 the program gives the user another opportunity to enter the maximum leaf area index by asking question 2.6 again.

The program then asks for the thickness of the evaporative zone as follows:

```
2.8  ENTER THE EVAPORATIVE ZONE DEPTH IN INCHES.

TYPICAL VALUES FOR TULSA                OKLAHOMA            ARE:
         10 IN. FOR BARE GROUND,
         22 IN. FOR FAIR GRASS, AND
         40 IN. FOR EXCELLENT GRASS.
```

and the user must respond with an appropriate value.

MANUAL RAINFALL DATA (3. MCDATA)

If the user specified 2, in response to question 1.2, the program displays this menu:

```
                              ANSWER ALL QUESTIONS
***************************************************************************
                  A VALUE **MUST** BE ENTERED FOR EACH COMMAND
                          EVEN WHEN THE VALUE IS ZERO.
***************************************************************************
```

```
3.1  ENTER 1 TO ENTER A NEW SET OF PRECIPITATION DATA,
           2 TO ADD, DELETE OR REPLACE YEAR(S) OF EXISTING
             PRECIPITATION DATA,
           3 TO CHECK OR EDIT DAILY VALUES FROM EXISTING
             PRECIPITATION DATA,
           4 TO ENTER/CORRECT OTHER CLIMATOLOGICAL DATA, OR
           5 TO EXIT.
```

If the user wishes to enter a completely new set of precipitation data, he chooses option 1. The user chooses option 2 if he wishes to add, replace or delete years of precipitation data in the existing data file. Selecting either option 1 or 2 transfers control to subroutine 8. PREMOD (question 8.1). To check or edit daily values of precipitation, option 3 is chosen and control passes to subroutine 9. PRECHK (question 9.1). To enter or correct maximum leaf area index or evaporative zone depth, or to compute daily temperatures and solar radiation values, the user selects option 4. To exit the manual climatological input routine, the user selects option 5. If the user enters a value other than 1 through 5, the program responds

```
6    IS AN INCORRECT CHOICE.
```

and returns to question 3.1.

Control stays within subroutine 3. MCDATA when the user selects option 4. If the existing precipitation set has not been modified through options 1, 2 or 3, the program asks the user if he wishes to compute daily temperatures:

```
3.2  DO YOU WANT NEW DAILY TEMPERATURES AND
SOLAR RADIATION VALUES COMPUTED?
ENTER YES OR NO.
```

If the user answers YES to question 3.2, daily temperatures and solar radiation values will be computed based on the existing precipitation set. If the precipitation set has been modified, daily temperatures will be computed anyway, since they depend on rainfall. In this case, the message is

```
DAILY TEMPERATURES WILL BE COMPUTED SINCE RAINFALL HAS BEEN CHANGED.
```

If the user has not yet selected a city nearby the location of interest, the program prints

```
YOU MUST SELECT A NEARBY CITY BEFORE PROCEEDING.
```

If a city has been chosen previously, the program gives the user the opportunity to change the city by prompting, for example,

```
3.3  CURRENT LOCATION IS TULSA               OKLAHOMA
                         -----------------------------------------.
DO YOU WANT TO SELECT A NEW LOCATION?
ENTER YES OR NO.
```

If the user decides to select a new location by answering YES to question 3.3, the program asks

```
3.4  DO YOU WANT A LIST OF 184 CITIES TO CHOOSE A NEARBY CITY
TO YOUR LOCATION?
ENTER YES OR NO.
```

If the answer is YES, the program will print a list of the 184 cities for which temperature, radiation and rainfall coefficients necessary to generate daily temperatures and solar radiation values are stored.

```
     TEMPERATURE, SOLAR RADIATION AND RAINFALL PARAMETERS
     ARE PROVIDED ONLY FOR THESE CITIES AND STATES:
                  ----
ALABAMA             INDIANA             NEBRASKA             RHODE ISLAND
   BIRMINGHAM          EVANSVILLE          GRAND ISLAND         PROVIDENCE
   MOBILE              FORT WAYNE          NORTH PLATTE      SOUTH CAROLINA
   MONTGOMERY          INDIANAPOLIS        OMAHA                CHARLESTON
ALASKA              IOWA                   SCOTTSBLUFF          COLUMBIA
   ANNETTE             DES MOINES       NEVADA               SOUTH DAKOTA
   BETHEL              DUBUQUE             ELKO                 HURON
   FAIRBANKS        KANSAS                 ELY                  RAPID CITY
ARIZONA                DODGE CITY          LAS VEGAS         TENNESSEE
   FLAGSTAFF           TOPEKA              RENO                 CHATTANOOGA
   PHOENIX             WICHITA             WINNEMUCCA           KNOXVILLE
   TUCSON           KENTUCKY            NEW HAMPSHIRE           MEMPHIS
   YUMA                COVINGTON           CONCORD              NASHVILLE
ARKANSAS               LEXINGTON           MT. WASHINGTON    TEXAS
   FORT SMITH          LOUISVILLE          NASHUA               ABILENE
ENTER RETURN TO VIEW MORE AVAILABLE CITIES.

   LITTLE ROCK      LOUISIANA           NEW JERSEY              AMARILLO
CALIFORNIA             BATON ROUGE         EDISON               AUSTIN
   BAKERSFIELD         LAKE CHARLES        NEWARK               BROWNSVILLE
   BLUE CANYON         NEW ORLEANS         SEABROOK             CORPUS CHRISTI
   EUREKA              SHREVEPORT       NEW MEXICO              DALLAS
   LOS ANGELES      MAINE                  ALBUQUERQUE          EL PASO
   FRESNO              AUGUSTA             ROSWELL              GALVESTON
   MT. SHASTA          BANGOR           NEW YORK                HOUSTON
   SACRAMENTO          CARIBOU             ALBANY               MIDLAND
   SAN DIEGO           PORTLAND            BUFFALO              SAN ANTONIO
   SAN FRANCISCO    MARYLAND               CENTRAL PARK         TEMPLE
   SANTA MARIA         BALTIMORE           ITHACA               WACO
COLORADO            MASSACHUSETTS          NEW YORK CITY     UTAH
   COLORADO SPGS       BOSTON              SCHENECTADY          CEDAR CITY
   DENVER              NANTUCKET           SYRACUSE             MILFORD
   GRAND JUNCTION      PLAINFIELD       NORTH CAROLINA          SALT LAKE CITY
   PUEBLO              WORCHESTER          ASHEVILLE         VERMONT
CONNECTICUT         MICHIGAN               CHARLOTTE            BURLINGTON
   BRIDGEPORT          DETROIT             GREENSBORO           MONTPELIER
   HARTFORD            E. LANSING          RALEIGH              RUTLAND
ENTER RETURN TO VIEW MORE AVAILABLE CITIES.
```

```
  NEW HAVEN
  WINDSOR LOCKS
DELAWARE
  WILMINGTON
DIST. OF COL.
  WASHINGTON
FLORIDA
  JACKSONVILLE
  MIAMI
  ORLANDO
  TALLAHASSEE
  TAMPA
  W. PALM BEACH
  GRAND RAPIDS
  SAUL STE. MARIE
MINNESOTA
  DULUTH
  MINNEAPOLIS
  ST. CLOUD
MISSISSIPPI
  JACKSON
  MERIDIAN
MISSOURI
  COLUMBIA
  KANSAS CITY
  ST. LOUIS
NORTH DAKOTA
  BISMARCK
  WILLISTON
OHIO
  CINCINNATI
  CLEVELAND
  COLUMBUS
  PUT-IN-BAY
  TOLEDO
OKLAHOMA
  OKLAHOMA CITY
  TULSA
OREGON
VIRGINIA
  LYNCHBURG
  NORFOLK
  RICHMOND
WASHINGTON
  OLYMPIA
  PULLMAN
  SEATTLE
  SPOKANE
  STAMPEDE PASS
  WALLA WALLA
  YAKIMA
WEST VIRGINIA
ENTER RETURN TO VIEW MORE AVAILABLE CITIES.

GEORGIA
  ATLANTA
  AUGUSTA
  MACON
  SAVANNAH
  WATKINSVILLE
HAWAII
  HONOLULU
IDAHO
  BOISE
  POCATELLO
ILLINOIS
  CHICAGO
  E. ST. LOUIS
MONTANA
  BILLINGS
  GLASGOW
  GREAT FALLS
  HAVRE
  HELENA
  KALISPELL
  MILES CITY
  ASTORIA
  BURNS
  MEACHEM
  MEDFORD
  PENDLETON
  PORTLAND
  SALEM
  SEXT. SUMMIT
PENNSYLVANIA
  PHILADELPHIA
  PITTSBURGH
  CHARLESTON
WISCONSIN
  GREEN BAY
  LACROSSE
  MADISON
  MILWAUKEE
WYOMING
  CHEYENNE
  LANDER
PUERTO RICO
  SAN JUAN
```

Regardless of the answer to question 3.4, the program prints

> 3.5 ENTER NAME OF STATE CORRESPONDING TO YOUR LOCATION IN UPPER CASE LETTERS.

The user need only enter the first four characters of the state name. If the user misspells the first four letters or enters a state which has no cities for which data are stored, the program responds

> THERE ARE NO DEFAULT VALUES FOR ____________________.

and control returns to question 3.4. If no default values are stored for the user's location, the user must choose a nearby city from a neighboring state.

Once the state name is entered, the user is asked to enter the name of the city for which climatologic data are to be used:

> 3.6 ENTER NAME OF CITY NEAREST TO YOUR LOCATION IN UPPER CASE LETTERS.

The user can only select names from the 184 cities given in response to question 3.4. If the name of the city is not found in the list of cities, the program responds with

THERE ARE NO DEFAULT VALUES FOR ____________________.

and asks question 3.4. In most cases, only the first four letters of the city are needed; however, for San Diego and San Francisco, the entire city name is needed. If the entire city name is needed but not supplied, the program responds

PLEASE TYPE ENTIRE NAME OF CITY.

and returns to question 3.6.

Once the city name has been entered correctly, control passes to subroutine 7. TRRCF (question 7.1), where temperature, radiation and rainfall coefficients are read from a data file.

After reading the coefficients, the program computes daily temperatures and solar radiation values and stores them on a data file. If the location was not changed (a NO response to question 3.3), the program prints, for example,

3.7 CURRENT MAXIMUM LEAF AREA INDEX IS 4.20.

DO YOU WANT TO SELECT A NEW MAXIMUM LEAF AREA INDEX?
ENTER YES OR NO.

The program skips this question if a new location has been chosen. The user answers YES to question 3.7 if it is desired to change the vegetative cover, and the program responds

3.8 ENTER THE MAXIMUM LEAF AREA INDEX.

TYPICAL VALUES ARE:
0 FOR BARE GROUND,
1.0 FOR POOR GRASS,
2.0 FOR FAIR GRASS,
3.3 FOR GOOD GRASS, AND
5.0 FOR EXCELLENT GRASS.

The value entered in question 3.8 is used in computing the daily leaf area indices. If the user enters a value greater than the maximum LAI value stored on the default data base, the program responds

LOCATION CANNOT SUPPORT THIS LEAF AREA INDEX UNLESS IRRIGATED
DUE TO LOW RAINFALL AND SHORT GROWING SEASON.

TYPICAL MAXIMUM FOR TULSA OKLAHOMA IS 2.50.

3.9 DO YOU WANT TO SELECT A DIFFERENT LEAF AREA INDEX?
ENTER YES OR NO.

If the user answers YES to question 3.9 the program gives the user another opportunity to enter the maximum leaf area index by asking question 3.8 again.

Next, the program allows the user to enter or correct the thickness of the evaporative zone depth. If the location was not changed by responding with NO to question 3.3, the program prints

```
3.10  CURRENT EVAPORATIVE DEPTH IS 15.0 IN.

DO YOU WANT TO ENTER A NEW EVAPORATIVE DEPTH?
ENTER YES OR NO.
```

If the location was changed, this question is skipped and the program asks question 3.11. The user should answer YES to question 3.10 if he wishes to change the evaporative zone depth. In this case, the program responds

```
3.11  ENTER THE EVAPORATIVE ZONE DEPTH IN INCHES
TO BE USED FOR ALL YEARS OF SIMULATION.

TYPICAL VALUES FOR OKLAHOMA CITY        OKLAHOMA        ARE:
        10 IN. FOR BARE GROUND,
        22 IN. FOR FAIR GRASS, AND
        40 IN. FOR EXCELLENT GRASS.
```

and the user must respond with an appropriate value. The single evaporative zone depth entered in response to question 3.11 is used for each year of simulation. After the user answers this question, the program stores the input data on a file and returns to question 3.1.

If the user chooses option 5 from the menu in question 3.1 and the precipitation data set has been modified through options 1, 2 or 3, the program displays

```
DAILY TEMPERATURES WILL BE COMPUTED SINCE RAINFALL HAS CHANGED.
```

and proceeds as previously described following question 3.2. If precipitation has not been modified, the program exits this subroutine and returns to question 1.1.

SYNTHETIC CLIMATOLOGIC INPUT (4. SCDATA)

If the user specified 3 in response to question 1.2, the program asks

```
4.1  DO YOU WANT A LIST OF DEFAULT CITIES FOR
SYNTHETIC CLIMATIC DATA GENERATION?
ENTER YES OR NO.
```

A YES response results in the program printing a list of 139 cities for which rainfall generation parameters are stored:

SYNTHETIC DATA ARE PROVIDED <u>ONLY</u> FOR THESE CITIES AND STATES:

- ALABAMA
  - BIRMINGHAM
  - MOBILE
  - MONTGOMERY
- ARIZONA
  - FLAGSTAFF
  - PHOENIX
  - YUMA
- ARKANSAS
  - FORT SMITH
  - LITTLE ROCK
- CALIFORNIA
  - BAKERSFIELD
  - BLUE CANYON
  - EUREKA
- IOWA
  - DES MOINES
  - DUBUQUE
- KANSAS
  - DODGE CITY
  - TOPEKA
  - WICHITA
- KENTUCKY
  - COVINGTON
  - LEXINGTON
  - LOUISVILLE
- LOUISIANA
  - BATON ROUGE
  - NEW ORLEANS
  - SHREVEPORT
- NEVADA
  - ELKO
  - LAS VEGAS
  - RENO
  - WINNEMUCCA
- NEW HAMPSHIRE
  - CONCORD
  - MT. WASHINGTON
- NEW JERSEY
  - NEWARK
- NEW MEXICO
  - ALBUQUERQUE
  - ROSWELL
- NEW YORK
  - ALBANY
- SOUTH DAKOTA
  - HURON
  - RAPID CITY
- TENNESSEE
  - CHATTANOOGA
  - KNOXVILLE
  - NASHVILLE
  - MEMPHIS
- TEXAS
  - ABILENE
  - AMARILLO
  - AUSTIN
  - BROWNSVILLE
  - CORPUS CHRISTI
  - DALLAS

ENTER RETURN TO VIEW MORE AVAILABLE CITIES.

  - FRESNO
  - MT. SHASTA
  - SAN DIEGO
  - SAN FRANCISCO
- COLORADO
  - COLORADO SPRINGS
  - DENVER
  - GRAND JUNCTION
  - PUEBLO
- CONNECTICUT
  - WINDSOR LOCKS
- DELAWARE
  - WILMINGTON
- DIST. OF COLUMBIA
  - WASHINGTON
- FLORIDA
  - JACKSONVILLE
  - MIAMI
  - TALLAHASSEE
  - TAMPA
- MAINE
  - CARIBOU
  - PORTLAND
- MARYLAND
  - BALTIMORE
- MASSACHUSETTS
  - BOSTON
  - NANTUCKET
- MICHIGAN
  - DETROIT
  - GRAND RAPIDS
- MINNESOTA
  - DULUTH
  - MINNEAPOLIS
- MISSISSIPPI
  - JACKSON
  - MERIDIAN
- MISSOURI
  - COLUMBIA
  - KANSAS CITY
  - BUFFALO
  - NEW YORK
  - SYRACUSE
- NORTH CAROLINA
  - ASHEVILLE
  - CHARLOTTE
  - GREENSBORO
  - RALEIGH
- NORTH DAKOTA
  - BISMARCK
  - WILLISTON
- OHIO
  - CLEVELAND
  - COLUMBUS
  - TOLEDO
- OKLAHOMA
  - OKLAHOMA CITY
  - TULSA
- OREGON
  - BURNS
  - EL PASO
  - GALVESTON
  - HOUSTON
  - SAN ANTONIO
  - TEMPLE
  - WACO
- UTAH
  - MILFORD
  - SALT LAKE CITY
- VIRGINIA
  - NORFOLK
  - RICHMOND
- WASHINGTON
  - OLYMPIA
  - SPOKANE
  - STAMPEDE PASS
  - WALLA WALLA
  - YAKIMA
- WEST VIRGINIA
  - CHARLESTON

ENTER RETURN TO VIEW MORE AVAILABLE CITIES.

GEORGIA
ATLANTA
AUGUSTA
MACON
SAVANNAH
HAWAII
HONOLULU
IDAHO
BOISE
POCATELLO
ILLINOIS
CHICAGO
INDIANA
EVANSVILLE
FORT WAYNE
INDIANAPOLIS
ST. LOUIS
MONTANA
BILLINGS
GREAT FALLS
HAVRE
HELENA
KALISPELL
MILES CITY
NEBRASKA
GRAND ISLAND
NORTH PLATTE
SCOTTSBLUFF
MEACHEM
MEDFORD
PENDLETON
PORTLAND
SALEM
SEXT. SUMMIT
PENNSYLVANIA
PHILADELPHIA
PITTSBURGH
RHODE ISLAND
PROVIDENCE
SOUTH CAROLINA
CHARLESTON
COLUMBIA
WISCONSIN
GREEN BAY
LACROSSE
MADISON
MILWAUKEE
WYOMING
CHEYENNE
PUERTO RICO
SAN JUAN

Regardless of the answer to question 4.1, the program prompts

4.2 ENTER NAME OF STATE OF INTEREST IN UPPER CASE LETTERS.

The user need only to enter the first four characters of the state name. Some states have no cities for which rainfall parameters are stored. If the user enters one of these states or incorrectly enters one of the states in the above table the program responds

THERE ARE NO SYNTHETIC VALUES FOR ____________________.

and control returns to question 4.1. In that case, the user must enter rainfall manually or by selecting default values for a nearby city from a neighboring state. Once the state name is entered and accepted by the program, the user must enter the name of the city for which synthetic rainfall will be generated in response to

4.3 ENTER NAME OF CITY OF INTEREST IN UPPER CASE LETTERS.

In most cases, the user need only enter the first four letters of the city name; however, for San Diego and San Francisco, the entire name is needed. If the entire name is needed but not supplied, the program prints

PLEASE TYPE ENTIRE NAME OF CITY.

Once the city name is entered, the program asks

4.4 ENTER NUMBER OF YEARS OF DATA TO BE GENERATED.

The user enters the number of years for which the program will generate rainfall, temperature and solar radiation values.

Next, the program passes control to subroutine 7. TRRCF (question 7.1) where temperature, radiation, and rainfall parameters are read from a data file. After returning from TRRCF, the program asks

4.5 DO YOU WISH TO IMPROVE THE GENERATED RAINFALL DATA BY ENTERING THE NORMAL MEAN MONTHLY RAINFALL FOR YOUR EXACT LOCATION? ENTER YES OR NO.

If the user answers YES, a correction factor based on the typical mean monthly rainfall values will be applied when generating daily rainfall. The program instructs the user,

4.6 ENTER THE NORMAL MEAN MONTHLY RAINFALL IN INCHES FOR THE SIMULATION PERIOD.

ENTER THE VALUES FOR JANUARY THROUGH JUNE.
ENTER ALL 6 VALUES ON THE SAME LINE.

If fewer than 6 values are entered, the remaining values are assumed to be zeroes. After the user responds to question 4.6, the program asks

4.7 ENTER NORMAL MEAN MONTHLY RAINFALL VALUES IN INCHES.
ENTER THE 6 VALUES FOR JULY THROUGH DECEMBER ON THE SAME LINE.

After the user responds, the program lists the 12 values and then asks if the values need to be corrected. For example:

THESE ARE THE INPUT RAINFALL VALUES.

JAN.-JUNE	JULY-DEC.
2.01	3.46
1.81	3.15
2.32	2.03
3.03	3.02
2.84	4.01
4.04	2.51

4.8 DO YOU WANT TO CHANGE THEM?
ENTER YES OR NO.

If the user answers YES, the program asks question 4.6 again. If the user answers NO to question 4.8 or does not enter mean monthly rainfall, the program asks

4.9 ENTER THE MAXIMUM LEAF AREA INDEX.

TYPICAL VALUES ARE:
0.0 FOR BARE GROUND
1.0 FOR POOR GRASS
2.0 FOR FAIR GRASS
3.3 FOR GOOD GRASS, AND
5.0 FOR EXCELLENT GRASS.

The value entered in question 4.9 is used in computing the daily leaf area indices. If the user enters a value greater than the maximum LAI value stored on the default data base, the program responds

LOCATION CANNOT SUPPORT THIS LEAF AREA INDEX UNLESS IRRIGATED
DUE TO LOW RAINFALL AND SHORT GROWING SEASON.

TYPICAL MAXIMUM FOR OKLAHOMA CITY   OKLAHOMA   IS 1.50.
--   ----

4.10 DO YOU WANT TO SELECT A DIFFERENT LEAF AREA INDEX?
ENTER YES OR NO.

If the user answers YES to question 4.10 the program gives the user another opportunity to enter the maximum leaf area index by asking question 4.9 again.

The program then asks for the thickness of the evaporative zone depth:

4.11 ENTER THE EVAPORATIVE ZONE DEPTH IN INCHES.

TYPICAL VALUES FOR OKLAHOMA CITY   OKLAHOMA   ARE:
10 IN. FOR BARE GROUND,
22 IN. FOR FAIR GRASS, AND
40 IN. FOR EXCELLENT GRASS.

and the user must respond with an appropriate value.

The single evaporative zone depth entered in response to question 4.11 is used for each year of simulation.

DEFAULT SOIL DATA (5. DSDATA)

If the user responds with 1 to question 1.3, the program prints

ANSWER ALL QUESTIONS
****
****
A VALUE **MUST** BE ENTERED FOR EACH COMMAND
EVEN WHEN THE VALUE IS ZERO.
****

5.1 ENTER A 3-LINE TITLE. FOR EXAMPLE:
ENTER PROJECT TITLE ON LINE 1,
ENTER LOCATION OF DISPOSAL SITE ON LINE 2,
AND ENTER TODAY'S DATE ON LINE 3.

The user can enter this information on the following lines in any format desired since this information is only used for a heading. The program then responds.

5.2 DO YOU WANT THE PROGRAM TO INITIALIZE THE SOIL
WATER CONTENT FOR EACH LAYER? IF YOU ANSWER NO, YOU WILL
BE ASKED TO ENTER THE SOIL WATER CONTENT FOR EACH LAYER.
ENTER YES OR NO.

If the user answers YES, the program assumes values and then runs the first year of the simulation. The soil water contents at the end of this first year are taken as the initial values for the simulation period. The program then runs the complete simulation, starting again from the beginning of the first year of data. The results for the initialization period are not reported. Then the program prints

THREE TYPES OF LAYERS MAY BE USED IN THE DESIGN:
VERTICAL PERCOLATION, LATERAL DRAINAGE, AND BARRIER SOIL LINER.

A LAYER OF MODERATE TO HIGH PERMEABILITY MATERIAL WITHOUT DRAINAGE COLLECTION SYSTEMS IS CLASSIFIED AS A VERTICAL PERCOLATION LAYER.

A LAYER PERMITTING LATERAL DRAINAGE TO COLLECTION SYSTEMS OR PERIMETER DRAINS IS CLASSIFIED AS A LATERAL DRAINAGE LAYER. VERTICAL DRAINAGE AND LATERAL DRAINAGE BOTH OCCUR IN A LATERAL DRAINAGE LAYER.

A LAYER OF MATERIAL DESIGNED TO INHIBIT PERCOLATION IS CLASSIFIED AS A BARRIER SOIL LINER. IN ADDITION, A LAYER OR A PART OF A LAYER OF MATERIAL COVERED BY A FLEXIBLE MEMBRANE LINER IS CLASSIFIED AS A BARRIER SOIL LINER WITH A FLEXIBLE MEMBRANE LINER.

**** RULES ****

1. THE TOP LAYER CANNOT BE A BARRIER SOIL LINER.
2. A BARRIER SOIL LINER MAY NOT BE ADJACENT TO ANOTHER SOIL LINER.
3. A VERTICAL PERCOLATION LAYER MAY NOT BE PLACED DIRECTLY BELOW A LATERAL DRAINAGE LAYER.

5.3 ENTER THE NUMBER OF LAYERS IN YOUR DESIGN.
YOU MAY USE UP TO 12 LAYERS AND UP TO 4 BARRIER SOIL LINERS.

If the user enters a value between 2 and 12 for the number of layers (e.g., 5), the program responds

THE LAYERS ARE NUMBERED SUCH THAT
SOIL LAYER 1 IS THE TOP LAYER AND
SOIL LAYER 5 IS THE BOTTOM LAYER.

If the user enters 1, the program responds

SOIL LAYER 1 IS THE ONLY SOIL LAYER.

If the user enters a value which is less than 1 or greater than 12, the program responds

5.4 YOU MAY HAVE 1 TO 12 LAYERS.
ENTER THE NUMBER OF LAYERS IN YOUR DESIGN.

and the user must enter the number of layers again.

After the user has entered an acceptable number of layers, the program instructs the user to enter information describing the soil layers by repeating a loop of questions for each layer. The loop contains questions 5.5, 5.6, 5.9, 5.14 and also 5.8 for layer 1. The first instruction, given here for layer 1, is

5.5 ENTER THICKNESS OF SOIL LAYER 1 IN INCHES.

If the user enters a value that is less than or equal to zero, the program warns

THICKNESS MUST BE GREATER THAN ZERO.

and returns control to question 5.5.

After question 5.5 has been answered satisfactorily, the program instructs the user to

5.6 ENTER THE LAYER TYPE FOR LAYER 1.

When data are being entered for the first layer, the program prints the following list of possible layer types. This list is not repeated for the other layers.

```
ENTER 1 FOR A VERTICAL PERCOLATION LAYER,
      2 FOR A LATERAL DRAINAGE LAYER,
      3 FOR A BARRIER SOIL LINER, AND
      4 FOR A BARRIER SOIL LINER WITH A FLEXIBLE MEMBRANE LINER.
```

If the user enters a number other than 1 through 4 (e.g., 6), the program responds

6 INAPPROPRIATE VALUE--TRY AGAIN.

and returns control to question 5.6.

Several rules governing the order of layers in the landfill design were given immediately preceding question 5.3. If these rules are not followed, the program prints an appropriate warning and returns control to question 5.6 to obtain an acceptable layer type. The warnings are

THE TOP LAYER MAY NOT BE A BARRIER SOIL LINER.

EITHER A LATERAL DRAINAGE LAYER OR A BARRIER SOIL LINER MUST FOLLOW A LATERAL DRAINAGE LAYER--TRY AGAIN.

A BARRIER SOIL LINER MAY NOT BE PLACED DIRECTLY BELOW ANOTHER BARRIER SOIL LINER.

If a layer below the top layer is identified as type 4, the program asks for the flexible membrane liner leakage fraction:

> 5.7 WHAT FRACTION OF THE AREA OF THE SOIL LINER DRAINS FROM LEAKS IN THE FLEXIBLE MEMBRANE OR WHAT FRACTION OF THE DAILY POTENTIAL PERCOLATION THROUGH THE BARRIER SOIL LINER IS ABLE TO OCCUR ON ANY DAY? TYPICAL VALUES MAY RANGE FROM 0.01 TO 0.00001 DEPENDING ON LINER MATERIAL, BEDDING MATERIAL, CONSTRUCTION PRACTICE AND QA/QC PLAN. ENTER BETWEEN 0 AND 1.

If the value entered for question 5.7 is less than 0 or greater than 1, the program responds

> INAPPROPRIATE VALUE--TRY AGAIN.

and question 5.7 is repeated.

After an acceptable layer type is entered for layer 1, the program asks:

> 5.8 DO YOU WANT A LIST OF DEFAULT SOIL TYPES AND CHARACTERISTICS? ENTER YES OR NO.

If the answer is YES, the following table is printed:

DEFAULT, UNVEGETATED, UNCOMPACTED SOIL CHARACTERISTICS

SOIL TEXTURE			DIMENSIONLESS			SAT. HYD
HELP	USDA	USCS	POROSITY	FIELD CAPACITY	WILTING POINT	CONDUCTIVITY (CM/SEC)
1	CoS	GS	0.417	0.045	0.018	1.0E-02
2	S	SW	0.437	0.062	0.024	5.8E-03
3	FS	SM	0.457	0.083	0.033	3.1E-03
4	LS	SM	0.437	0.105	0.047	1.7E-03
5	LFS	SM	0.457	0.131	0.058	1.0E-03
6	SL	SM	0.453	0.190	0.085	7.2E-04
7	FSL	SM	0.473	0.222	0.104	5.2E-04
8	L	ML	0.463	0.232	0.116	3.7E-04
9	SiL	ML	0.501	0.284	0.135	1.9E-04
10	SCL	SC	0.398	0.244	0.136	1.2E-04
11	CL	CL	0.464	0.310	0.187	6.4E-05
12	SiCL	CL	0.471	0.342	0.210	4.2E-05
13	SC	CH	0.430	0.321	0.221	3.3E-05

ENTER RETURN TO VIEW THE REST OF THE SOIL TYPES.

SOIL TEXTURE			DIMENSIONLESS			SAT. HYD. CONDUCTIVITY (CM/SEC)
HELP	USDA	USCS	POROSITY	FIELD CAPACITY	WILTING POINT	
14	SiC	CH	0.479	0.371	0.251	2.5E-05
15	C	CH	0.475	0.378	0.265	1.7E-05
16	Liner	Soil	0.430	0.366	0.280	1.0E-07
17	Liner	Soil	0.400	0.356	0.290	1.0E-08
18	Mun. Waste		0.520	0.294	0.140	2.0E-04
19		USER SPECIFIED SOIL CHARACTERISTICS				
20		USER SPECIFIED SOIL CHARACTERISTICS				

Question 5.8 is not repeated for layers below layer 1. The program follows with

5.9 ENTER SOIL TEXTURE OF SOIL LAYER 1.

If the user enters a number other than 1 through 20 (e.g., 26), the program responds

26 INAPPROPRIATE SOIL TEXTURE NUMBER--TRY AGAIN.

and returns control to question 5.9.

Default soil data exist only for soil textures 1 through 18 as given in the above table. Soil textures 19 and 20 are available to provide the user an opportunity to describe the soil characteristics of some layers manually while using default soil data for other layers. Therefore, if soil texture 19 or 20 is specified, the program asks questions 5.10 through 5.13 to obtain the soil characteristics. An appropriate value must be entered in response to each of the following commands. The program will check the appropriateness of the input values. If a value is outside the acceptable range, the program will display an error message and repeat the question.

5.10 ENTER THE WILTING POINT OF THE LAYER IN VOL/VOL.

If the user enters a value less than 0.02 for the wilting point, the program warns

WILTING POINT VALUE MUST BE 0.02 OR GREATER.

and asks question 5.10 again. Otherwise the program continues with this command.

5.11 ENTER THE FIELD CAPACITY OF THE LAYER IN VOL/VOL.

If the user enters a value less than the wilting point entered in response to question 5.11, the program prints

FIELD CAPACITY MUST BE GREATER THAN WILTING POINT.

and repeats question 5.11. Otherwise, the program asks

5.12 ENTER THE POROSITY OF THE LAYER IN VOL/VOL.

If the porosity entered is less than the field capacity the program responds

POROSITY MUST BE GREATER THAN FIELD CAPACITY.

and asks question 5.12 again. After answering question 5.12, the program displays the following question:

5.13 ENTER THE HYDRAULIC CONDUCTIVITY OF THE LAYER IN CM/SEC.

The default soil data for soil texture types 1 through 15 are typical values for uncompacted soils while default soil data for soil texture types 16, 17, and 18 are typical values for compacted municipal solid waste and compacted clay barrier soils. Therefore, if a value of 1 through 15 is specified, the program provides the user with an opportunity to correct the default soil data for compaction by asking (in this case for soil layer 2)

5.14 IS SOIL LAYER 2 COMPACTED?
ENTER YES OR NO.

If the layer under consideration is the top layer, the program also prints

THE VEGETATIVE SOIL LAYER IS GENERALLY NOT COMPACTED.

If the layer under consideration had been designated to be a barrier soil layer (layer type 3 or 4), the program also prints

THE BARRIER SOIL LAYER IS GENERALLY COMPACTED.

If question 5.14 is answered YES, the saturated hydraulic conductivity is reduced by a factor of 20, the drainable porosity and plant available water capacity are reduced by 25 percent. If this question is answered NO, the data used are from the list printed in response to question 5.8.

If the user answered NO to question 5.2, the program asks for the initial water content of the layer. For example,

5.15 ENTER THE INITIAL SOIL WATER CONTENT FOR SOIL LAYER 2 IN VOL/VOL.

When the layer is a barrier soil liner, the program automatically sets the initial water content equal to the porosity of the layer and skips question 5.15. If a value smaller than the wilting point or greater than the porosity is entered, the program warns

INITIAL SOIL WATER CONTENT CANNOT BE LESS
THAN THE WILTING POINT NOR GREATER THAN THE POROSITY.

and gives the user another opportunity to enter the initial water content of the layer.

After the first layer has been described, the loop of questions 5.5 through 5.15 is repeated for the remaining layers. After data for all layers have been specified, the program checks the layer type of the bottom layer. If the bottom layer is a lateral drainage layer and less than 12 layers have been used in the design, the program provides the user with an opportunity to enter data for a barrier layer to be placed under the bottom lateral drainage layer by asking

5.16 A BARRIER LAYER SHOULD BE USED BELOW THE BOTTOM LATERAL DRAINAGE LAYER.
DO YOU WANT TO ENTER DATA FOR A BARRIER SOIL LINER?
ENTER YES OR NO.

IF NO IS ENTERED, THE MODEL ASSUMES THAT LATERAL DRAINAGE DOES NOT OCCUR FROM THE BOTTOM LAYER.

If the bottom layer is a lateral drainage layer and 12 layers have already been used in the design, the program responds

A BARRIER LAYER SHOULD HAVE BEEN SPECIFIED.
THE MODEL ASSUMES THAT LATERAL DRAINAGE DOES NOT OCCUR FROM THE BOTTOM LAYER.

A barrier soil layer must be placed below the bottom lateral drainage layers if the program is to estimate lateral drainage from the bottom subprofile. If a barrier soil layer is not used, the program models the lateral drainage layers in the bottom subprofile as if they were vertical percolation layers.

If the user answers YES to questions 5.16, control is transferred to question 5.5 where the loop for entering data for a layer starts.

After the bottom layer has been checked, control is passed to question 5.17 where the user is requested to describe the vegetative cover. Specifying the top layer to be a waste layer indicates to the program that the landfill is open and unvegetated.

The program requests a description of the vegetative cover as follows:

5.17 SELECT THE TYPE OF VEGETATIVE COVER.

ENTER NUMBER 1 FOR BARE GROUND
2 FOR POOR GRASS
3 FOR FAIR GRASS
4 FOR GOOD GRASS
5 FOR EXCELLENT GRASS

If the user enters a value that is less than 1 or greater than 5 (e.g., 9), the program responds

9 INAPPROPRIATE VALUE--TRY AGAIN.

and repeats question 5.17.

The program calculates the SCS runoff curve number based on the vegetation type and the soil texture of the top layer if one of the default soil textures was specified for this layer (soil texture types 1 through 18). The equation used to calculate the curve numbers was developed for landfills with mild surface slopes (2 to 5 percent). However, the effect of surface slope on runoff is largely insignificant for slopes ranging from 2 to 20 percent. At slopes of less than 2 percent less runoff should be expected and a lower curve number should normally be used. For surface slopes between 20 and 40 percent runoff increases slightly with increasing slope and therefore slightly larger runoff curve numbers should be used. Runoff increases significantly with increasing surface slope above 40 percent and significantly higher curve numbers should be used. The program provides the user with an opportunity to enter a curve number and override the default value as follows:

> 5.18 DO YOU WANT TO ENTER A RUNOFF CURVE
> NUMBER TO OVERRIDE THE DEFAULT VALUE?
> ENTER YES OR NO.

If YES is answered or if the top layer has a soil texture number of 19 or 20, the program asks the user to

> 5.19 ENTER SCS RUNOFF CURVE NUMBER (BETWEEN 0 AND 100).

The program then asks

> 5.20 IS THE LANDFILL OPEN OR ACTIVE (UNCOVERED)?
> ENTER YES OR NO.

If the user answers YES, control is transferred to subroutine 11. OPEN (question 11.1). After returning from subroutine OPEN or if the user answers NO to question 5.20, the program calls subroutine 10. SITE (question 10.1) where the program requests additional information describing the landfill site and design. Finally the program asks

> 5.21 DO YOU WANT TO CORRECT OR CHECK
> THE EXISTING DESIGN AND SOIL DATA?
> ENTER YES OR NO.

If the user answers YES, control is transferred to 12. SDCHK where existing design and soil data can be changed. If the user answers NO, control is transferred to question 1.1.

MANUAL SOIL DATA (6. MSDATA)

If the user specified 2 in response to question 1.3, the program enters the manual soil data input subroutine (MSDATA). Many of the questions are the same in the default and manual soil data subroutines. The primary difference is that in entering manual soil data, the user must specify numerical values for soil porosity, field capacity, wilting point and hydraulic conductivity, whereas in the default soil data subroutine the user merely needs to specify a code number for the soil type. The program asks the user to begin building a data file:

```
YOU ARE ENTERING A COMPLETE NEW DATA SET.

                         ANSWER ALL QUESTIONS
*****************************************************************************
              A VALUE **MUST** BE ENTERED FOR EACH COMMAND
                    EVEN WHEN THE VALUE IS ZERO.
*****************************************************************************
```

```
6.1  ENTER A 3-LINE TITLE.  FOR EXAMPLE:
ENTER PROJECT TITLE ON LINE 1,
ENTER LOCATION OF DISPOSAL SITE ON LINE 2,
AND ENTER TODAY'S DATE ON LINE 3.
```

After the user enters the title, the program asks

```
6.2  DO YOU WANT THE PROGRAM TO INITIALIZE THE SOIL
WATER CONTENT FOR EACH LAYER?  IF YOU ANSWER NO, YOU WILL
BE ASKED TO ENTER THE SOIL WATER CONTENT FOR EACH LAYER.
ENTER YES OR NO.
```

If the user answers YES, the program assumes values and then runs the first year of the simulation. The soil water contents at the end of this first year are taken as the initial values for the simulation period. The program then runs the complete simulation, starting again from the beginning of the first year of data. The results for the initialization period are not reported.

Then the program prints out the same description of layer types and rules as printed immediately before question 5.3. The program then prints

```
6.3  ENTER THE NUMBER OF LAYERS IN YOUR DESIGN.
YOU MAY USE UP TO 12 LAYERS AND UP TO 4 BARRIER SOIL LINERS.
```

If the user enters a value between 2 and 12 (e.g., 3), the program responds

```
THE LAYERS ARE NUMBERED SUCH THAT SOIL LAYER 1 IS THE TOP LAYER
AND SOIL LAYER 3 IS THE BOTTOM LAYER.
```

If the user entered 1, the program responds

```
SOIL LAYER 1 IS THE ONLY LAYER.
```

If the user entered a value that is less than 1 or greater than 12, the program responds

```
6.4  YOU MAY HAVE 1 TO 12 LAYERS.
ENTER THE NUMBER OF LAYERS IN YOUR DESIGN.
```

and the user must enter the number of layers again.

After the user answers question 6.3, the program instructs the user to enter information describing the soil layers by repeating a loop of questions for each layer. The loop contains questions 6.5 through 6.11. The loop also contains question 6.11 if layer type 4 is used and question 6.12 if initial soil water contents are entered. The first instruction, shown here for layer 1, is

6.5 ENTER THICKNESS OF SOIL LAYER 1 IN INCHES.

If the user enters a value that is less than or equal to zero, the program warns

THICKNESS MUST BE GREATER THAN ZERO.

and returns control to question 6.5.

After question 6.5 is answered satisfactorily, the program asks the following questions. The program will check the appropriateness of the specified numerical values. If the value is unreasonable, the program will display an error message and repeat the question.

6.6 ENTER THE WILTING POINT OF SOIL LAYER 1 IN VOL/VOL.

If the user enters a value less than 0.02 for the wilting point, the program warns

WILTING POINT VALUE MUST BE 0.02 OR GREATER.

and asks question 6.6 again. Otherwise the program continues with this command:

6.7 ENTER THE FIELD CAPACITY OF SOIL LAYER IN 1 IN VOL/VOL.

If the user enters a value less than the wilting point entered in response to question 6.6 the program prints

FIELD CAPACITY MUST BE GREATER THAN WILTING POINT.

and repeats question 6.7. Otherwise, the program asks

6.8 ENTER THE POROSITY OF SOIL LAYER 1 IN VOL/VOL.

If the porosity entered is less than the field capacity the program responds

POROSITY MUST BE GREATER THAN WILTING POINT.

and asks question 6.8 again. After question 6.8 is answered, the program displays the following question:

6.9 ENTER THE HYDRAULIC CONDUCTIVITY OF SOIL LAYER 1 IN CM/SEC.

After questions 6.6 through 6.9 have been answered, the program instructs the user to

6.10 ENTER THE LAYER TYPE FOR LAYER 1.

When data are being entered for the first layer, the program prints the following list of possible layer types. This list is not repeated for the other layers.

ENTER 1 FOR A VERTICAL PERCOLATION LAYER,
2 FOR A LATERAL DRAINAGE LAYER,
3 FOR A BARRIER SOIL LINER, AND
4 FOR A BARRIER SOIL LINER WITH A FLEXIBLE MEMBRANE LINER.

If the user enters a value other than 1 through 4 (e.g., 7), the program responds

7 INAPPROPRIATE VALUE--TRY AGAIN.

and repeats question 6.10 until an acceptable response is given.

Several rules governing the order of layers in the landfill design were given immediately following question 5.3. If these rules are not followed, the program prints an appropriate warning and returns control to question 6.10 to obtain an acceptable layer type. The warnings are

THE TOP LAYER MAY NOT BE A BARRIER SOIL LAYER.

EITHER A LATERAL DRAINAGE LAYER OR A BARRIER SOIL LINER MUST FOLLOW A LATERAL DRAINAGE LAYER--TRY AGAIN.

A BARRIER SOIL LINER MAY NOT BE PLACED DIRECTLY BELOW ANOTHER BARRIER SOIL LINER.

If a layer below the top layer is identified as type 4, the program asks for the flexible membrane liner leakage fraction:

6.11 WHAT FRACTION OF THE AREA OF THE SOIL LINER DRAINS FROM LEAKS IN THE FLEXIBLE MEMBRANE OR WHAT FRACTION OF THE DAILY POTENTIAL PERCOLATION THROUGH THE BARRIER SOIL LINER IS ABLE TO OCCUR ON ANY DAY? TYPICAL VALUES MAY RANGE FROM 0.01 TO 0.00001 DEPENDING ON LINER MATERIAL, BEDDING MATERIAL, CONSTRUCTION PRACTICE AND QA/QC PLAN. ENTER BETWEEN 0 AND 1.

If the value entered for question 6.11 is less than 0 or greater than 1, the program responds

INAPPROPRIATE VALUE--TRY AGAIN.

and question 6.11 is repeated.

If the user has requested to enter initial soil water contents for the layers by answering NO to question 6.2, the program asks for the initial water content of the layer. For example,

6.12 ENTER THE INITIAL SOIL WATER CONTENT FOR
SOIL LAYER 1 IN VOL/VOL.

When the layer is a barrier soil liner, the program automatically sets the initial water content equal to the porosity of the layer and skips question 6.12. If a value smaller than the wilting point or greater than the porosity is entered, the program warns

INITIAL SOIL WATER CONTENT CANNOT BE LESS
THAN THE WILTING POINT NOR GREATER THAN THE POROSITY.

and gives the user another opportunity to enter the initial water content of the layer.

After the first layer has been described, the loop of questions 6.5 through 6.12 is repeated for the remaining layers. After data for all layers have been specified, the program checks the layer type of the bottom layer. If the bottom layer is a lateral drainage layer and less than 12 layers have been used in the design, the program provides the user with an opportunity to enter data for a barrier layer to be placed under the bottom lateral drainage layer by asking

6.13 A BARRIER SOIL LINER SHOULD BE USED BELOW THE BOTTOM LATERAL DRAINAGE LAYER.

DO YOU WANT TO ENTER DATA FOR A BARRIER SOIL LINER?
ENTER YES OR NO.

IF NO IS ENTERED, THE MODEL ASSUMES THAT LATERAL
DRAINAGE DOES NOT OCCUR FROM THE BOTTOM LAYER.

If the bottom layer is a lateral drainage layer and 12 layers have already been used in the design, the program responds

A BARRIER SOIL LINER SHOULD HAVE BEEN SPECIFIED.
THE MODEL ASSUMES THAT LATERAL DRAINAGE DOES NOT OCCUR
FROM THE BOTTOM LAYER.

A barrier soil liner must be used below the bottom lateral drainage layers if the program is to estimate lateral drainage from the bottom subprofile. If a barrier soil layer was not used, the program models the lateral drainage layers in the bottom subprofile as if they were vertical percolation layers.

If the user answers YES to question 6.13, control is transferred to question 6.5, where the loop for entering data for a layer starts.

After the bottom layer has been checked, control is passed to question 6.14 where the user is requested to enter the SCS runoff curve number:

6.14 ENTER THE SCS RUNOFF CURVE NUMBER FOR THE DESIGN VEGETATIVE SOIL AND VEGETATIVE COVER UNDER ANTECEDENT MOISTURE CONDITION II. (BETWEEN 0 AND 100)

The user must enter an appropriate runoff curve number since the program does not check the numerical value.

The program then asks

6.15 IS THE LANDFILL OPEN OR ACTIVE (UNCOVERED)?
ENTER YES OR NO.

If the user answers YES, control is passed to subroutine 11. OPEN (question 11.1). Control is passed to subroutine 10. SITE (question 10.1) after asking question 6.15 or the questions in subroutine OPEN. In subroutine SITE the program requests additional information describing the landfill design. Finally the program asks

6.16 DO YOU WANT TO CORRECT OR CHECK
THE EXISTING DESIGN AND SOIL DATA?
ENTER YES OR NO.

If the user answers YES, control is transferred to 12. SDCHK where existing design and soil data can be changed. If the user answers NO, control is transferred to question 1.1.

TEMPERATURE, RADIATION AND RAINFALL COEFFICIENTS (7. TRRCF)

After entering state and city names in subroutines DCDATA, MCDATA or SCDATA, the program passes control to this subroutine. The program asks

7.1 ENTER THE LETTER OF THE DRIVE WHERE TEMPERATURE,
SOLAR RADIATION, AND RAINFALL PARAMETERS FOR THE SYNTHETIC
WEATHER GENERATOR SHOULD BE READ. (A, B, C OR D)

The user should respond with the letter of the drive where the temperature, radiation and rainfall parameters are stored (the diskette containing this data is included in the set of diskettes sent to the user). If the user enters anything but A, B, C or D, the program prints

E IS AN INCORRECT CHOICE.

and the program repeats question 7.1.

Once a correct response is made, the program prompts

7.2 LOAD THE TEMPERATURE, SOLAR RADIATION, AND RAINFALL PARAMETERS
ON THE APPROPRIATE DRIVE AND THEN ENTER YES.
IF YOU MUST STOP EXECUTION TO LOAD THE DATA, ENTER NO.

If the data is not already loaded, the user places the diskette containing the data in the drive corresponding to the letter entered in question 7.1

and enters YES. If execution must be terminated to load the data, the user enters NO.

If the program cannot access the data file (i.e., it is not loaded or not in the drive specified in question 7.1), the program prints

PROGRAM CANNOT ACCESS DATA FILE ON DRIVE B.

and control returns to question 7.1 where the correct drive specification may be entered.

If the program cannot find the user-specified city corresponding to the user-specified state, the program prints for example

FRESNO   ARIZONA   CANNOT BE FOUND ON FILE
CONTAINING TEMPERATURE, RADIATION, AND RAINFALL PARAMETERS.

and the program again asks the user for the state and city names.

Next the user is given the opportunity to enter mean monthly temperatures for the location of interest. When generating daily temperatures, a correction factor will be applied based on these mean monthly temperatures if entered. The program asks

7.3 DO YOU WANT TO ENTER THE NORMAL MEAN MONTHLY
TEMPERATURE DATA FOR YOUR LOCATION?
ENTER YES OR NO.

If NO, the program exits this routine and control returns to the calling subroutine. If YES, the program asks

7.4 ENTER NORMAL MEAN MONTHLY TEMPERATURES IN DEGREES FAHRENHEIT.
ENTER VALUES FOR JANUARY THROUGH JUNE.
ENTER ALL SIX VALUES ON THE SAME LINE.

If fewer than 6 values are entered, the remaining values are assumed zeros. After the user responds, the program prompts the user to

7.5 ENTER NORMAL MEAN MONTHLY TEMPERATURES IN DEGREES FAHRENHEIT.
ENTER THE SIX VALUES FOR JULY THROUGH DECEMBER ON THE SAME LINE.

The program then prints a list of the 12 values and asks if they need to be corrected. For example,

THESE ARE THE INPUT TEMPERATURE VALUES.

JAN.-JUNE	JULY-DEC.
24.5	68.2
26.7	66.1
31.2	53.9
45.3	49.9
54.2	41.8
67.2	35.0

7.6 DO YOU WANT TO CHANGE THEM?
ENTER YES OR NO.

If the user answers YES, control returns to question 7.4. If the user answers NO, control leaves this subroutine and returns to the calling subroutine.

ENTERING AND MODIFYING YEARS OF RAINFALL DATA (8. PREMOD)

Selecting option 1 or option 2 from the manual climatologic input menu displayed in question 3.1 transfers control to this subroutine. If the user chooses option 1, indicating that he wishes to enter a completely new set of precipitation data, the program states

PRECIPITATION INPUT WILL ACCEPT **20** YEARS MAXIMUM

****

WHEN ENTERING PRECIPITATION DATA, TEN DAILY VALUES ARE TO BE ENTERED PER LINE AND 37 LINES OF VALUES PER YEAR.

IF ALL TEN VALUES ARE ZEROES (0), ONLY ONE ZERO (0) NEEDS TO BE ENTERED BEFORE ENTERING A CARRIAGE RETURN.

IF A LINE CONTAINS BOTH ZERO AND NON-ZERO VALUES, A CARRIAGE RETURN MAY BE ENTERED AFTER THE LAST NON-ZERO VALUE INSTEAD OF ENTERING THE ZERO VALUES AT THE END OF THE LINE.

****

YOU ARE ENTERING A COMPLETE NEW SET OF PRECIPITATION DATA.

8.1 ENTER THE YEAR OF PRECIPITATION DATA TO BE ADDED OR REPLACED.
ENTER 0 (ZERO) TO END RAINFALL INPUT.

If the user enters 0 in response to instruction 8.1, precipitation input is stopped and the program returns control to subroutine 3. MCDATA (question 3.1). Otherwise, the user enters the year for which precipitation data is to be supplied, and the program prompts

ENTER TEN DAILY PRECIPITATION VALUES PER LINE
AND 37 LINES PER YEAR FOR 1985.

8.3 ENTER LINE 1.

The user should enter 10 values for daily rainfall in inches in accordance with the guidance presented previously in this section under the heading "RULES". After each line is entered, the program repeats instruction 8.3 until all 37 lines of data are entered for the year. The program then returns control to question 8.1 until the user enters 0 (zero) to end rainfall input or until 20 years of data (the maximum allowed) have been entered. Once either of these conditions are met, control returns to the manual climatologic input menu (question 3.1).

If the user enters a year for which precipitation data have been previously entered, the program responds

```
8.2  1985 ALREADY EXISTS IN THE DATA.
DO YOU WANT TO REPLACE THE EXISTING DATA?
ENTER YES OR NO.
```

If the user answers NO to question 8.2, control is returned to question 8.1 and a new year must be specified. If the user answers YES, the program asks question 8.3 and replaces the data for the specified year.

If option 2 is chosen from the menu in question 3.1, the program allows the user to add, replace or delete years of precipitation data from the existing data file. The program reads the data file and prints, for example,

```
DATA EXIST FOR 5 YEARS:   1974  1975  1976  1977  1978
```

and asks

```
8.4  DO YOU WANT TO ADD OR REPLACE ANY YEAR OF PRECIPITATION
VALUES IN THE EXISTING DATA?
ENTER YES OR NO.
```

If the user answers NO to question 8.4, control passes to question 8.7. If the user answers YES, control transfers to question 8.1. If the data set already contains twenty years of precipitation data, the program responds

```
8.5  TWENTY YEARS OF PRECIPITATION DATA HAVE ALREADY BEEN ENTERED.
DO YOU WISH TO REPLACE ANY YEARS OF DATA?
ENTER YES OR NO.
```

A NO answer to question 8.5 transfers control to question 8.7, where the user is allowed to delete years of data from the data set. A YES answer produces the following instruction:

```
8.6  ENTER THE YEAR TO BE REPLACED.
```

If the user responds with one of the years in the data file, control is passed to question 8.3. If data for the year specified by the user are not already stored, the program responds

```
1985 IS NOT IN THE EXISTING DATA.
```

and returns control to question 8.5.

If the user answers NO in response to question 8.4 or question 8.5 or enters 0 (zero) in response to question 8.1 when option 2 from the menu in question 3.1 has been chosen, the program prints

8.7 DO YOU WANT TO DELETE ANY YEAR OF PRECIPITATION VALUES
FROM THE EXISTING DATA?
ENTER YES OR NO.

If the user answers NO to question 8.7, control is returned to subroutine 3. MCDATA (question 3.1). Otherwise, the program asks

8.8 ENTER THE YEAR OF PRECIPITATION DATA TO BE DELETED.
ENTER 0 (ZERO) IF YOU DO NOT WANT TO DELETE ANY YEAR.

If the user enters 0 (zero) in response to this question, control is returned to subroutine 3. MCDATA (question 3.1). Otherwise, the program deletes precipitation values from the data set for the year entered and then asks the same question again. If all years of precipitation values in a data set are deleted, the program prints

8.9 DATA SET IS NOW EMPTY. SELECT OPTION 1 FROM
MENU TO ENTER A NEW DATA SET.

and returns control to the menu in question 3.1.

EDITING DAILY PRECIPITATION DATA (9. PRECHK)

This subroutine allows the user to edit lines of the precipitation data. The user cannot enter new years of data in this subroutine. This subroutine is called when the user has chosen option 3 from the menu displayed in question 3.1. The program starts by printing a list of years for which precipitation data are stored. For example,

DATA EXIST FOR 5 YEARS: 74 75 76 77 78.

The program then instructs the user to

9.1 ENTER YEAR TO BE CHECKED.

If the user enters a year other than those listed above (e.g., 82), the program responds

DATA FOR YEAR 82 ARE NOT IN THE DATA FILE.

and question 9.1 is repeated.

If the user enters a year that is in the precipitation data set, the program responds

THE DATA FOR 78 ARE:

```
78 0.01 0.0  0.11 0.0  0.0  0.0  0.05 0.40 1.85 0.0     1
78 0.0  0.0  0.77 0.0  0.0  0.0  0.25 0.01 1.44 0.01    2
78 0.0  0.0  0.01 0.46 4.60 2.13 0.0  0.01 0.06 0.0     3
78 0.70 0.27 0.53 0.30 0.0  0.0  0.0  0.0  0.0  0.02    4
```

and so on until the 37 lines of precipitation values are printed. The program then asks

9.2 DO YOU WANT TO CHANGE OR CORRECT ANY OF THESE VALUES?
ENTER YES OR NO.

If the user enters NO, the program passes control to question 9.6. If the user answers YES, the program instructs the user to

9.3 ENTER NUMBER OF LINE TO BE CHANGED.

If the user enters a number that is less than 1 or greater than 37, the program responds

LINE NUMBERS MUST RANGE FROM 1 to 37.
TRY AGAIN.

and repeats question 9.3.

After receiving a valid line number, the program responds

9.4 ENTER THE TEN DAILY PRECIPITATION VALUES.

The user must enter all values on the same line. The rules for entering precipitation data were described previously in this section under the heading "RULES". After the user enters the new precipitation values, the program asks

9.5 DO YOU WANT TO CHANGE ANOTHER LINE OF THIS YEAR?
ENTER YES OR NO.

If the user answer YES, the program returns to question 9.3.

If the user enters NO in response to question 9.5, the program asks

9.6 DO YOU WANT TO CHECK OR CORRECT ANOTHER
YEAR OF PRECIPITATION VALUES?
ENTER YES OR NO.

If the user answers YES, control is passed to question 9.1. Otherwise, the program passes control to the manual climatologic input menu in subroutine 3. MCDATA (question 3.1).

If precipitation data have not been entered, the program responds

THE DATA FILE CONTAINS NO PRECIPITATION VALUES.

Before the data can be edited, the user must enter precipitation data either by using the manual or default climatologic data input options or by generating rainfall through the synthetic climatologic input routine. After the above message is printed, control is returned to subroutine 3. MCDATA (question 3.1).

SITE DESCRIPTION (10. SITE)

After the user has completed soil data input using either the default or manual options, the program asks the user for additional information on the design. In order to compute estimates of the water budget components in volume units, the program needs the surface area of the landfill. This is requested as follows:

10.1 ENTER THE TOTAL AREA OF THE SURFACE, IN SQUARE FEET.

Lateral drainage rate depends upon the slope of the surface of the barrier soil layer and the maximum drainage distance to the collector along the surface of the barrier soil layer. The program requests this information as follows:

10.2 ENTER THE SLOPE AT THE BASE OF SOIL LAYER 1, IN PERCENT.

10.3 ENTER THE MAXIMUM DRAINAGE DISTANCE HORIZONTALLY TO THE COLLECTOR, IN FEET.

These two questions are repeated for each lateral drainage subprofile.

If the user has specified the initial soil water contents, the program will then ask

10.4 ENTER THE INITIAL QUANTITY OF WATER ON THE SURFACE IN THE FORM OF ICE OR SNOW.

If the default soil data input option was used, the program then passes control to question 1.1. Otherwise, the program proceeds to subroutine 12. SDCHK (question 12.1) to check the soil and design data.

CHARACTERISTICS OF OPEN SITES (11. OPEN)

For an open landfill (i.e., where the top layer is a waste layer), the user can specify the fraction of the total potential runoff that actually drains from the surface of the waste layer. This is especially useful when the top of the waste cell is in a pit without provisions for drainage. The question is

11.1 WHAT FRACTION OF THE DAILY POTENTIAL RUNOFF IS ABLE TO DRAIN FROM THE SURFACE OF THE OPEN LANDFILL?
ENTER BETWEEN 0 AND 1.

The user input is not checked. After this question is answered, control passes to subroutine 10. SITE (question 10.1), where additional design information is requested.

EDITING SOIL AND DESIGN DATA (12. SDCHK)

This subroutine allows the user to edit manually entered soil and design data. The program calls this subroutine when the user answers YES to question 6.1, and also after all design data has been entered (i.e., after question 10.3) if the manual soil-data input routine was used. The program first lists the design and soil data as follows:

```
THE DESIGN AND SOIL DATA ARE:
(THE LAST NUMBER OF EACH LINE OF DATA IS THE LINE NUMBER.)

TITLE:
CHECK PROGRAM
TULSA OKLAHOMA
27 JUNE 1988

# OF LAYERS, RUNOFF FRACTION FOR OPEN SITES, AND AMC-II RUNOFF CURVE
NUMBER:
  6   1.000000         80.000000     4

THICKNESSES:
  24.00     24.00     36.00     36.00     36.00     60.00     5
   0.00      0.00      0.00      0.00      0.00      0.00     6

POROSITIES;
  0.3573    0.4790    0.4300    0.5200    0.3762    0.5200     7
  0.0000    0.0000    0.0000    0.0000    0.0000    0.0000     8
ENTER RETURN TO VIEW MORE SOIL AND DESIGN DATA.

FIELD CAPACITIES:
  0.1131    0.3720    0.3667    0.2950    0.2034    0.2950     9
  0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    10

WILTING POINTS:
  0.0581    0.2508    0.2804    0.1404    0.1160    0.1404    11
  0.0200    0.0200    0.0200    0.0200    0.0200    0.0200    12

HYDRAULIC CONDUCTIVITIES:
  0.0001500000071 0.0000249999994 0.0000001000000 0.0001999999949 13
  0.0000184999990 0.0001999999949 0.0000000000000 0.0000000000000 14
  0.0000000000000 0.0000000000000 0.0000000000000 0.0000000000000 15

INITIAL SOIL WATER CONTENTS:
  0.1000    0.3000    0.4000    0.5200    0.3000    0.5200    16
  0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    17

SURFACE AREA:
  10000.     18
ENTER RETURN TO VIEW MORE SOIL AND DESIGN DATA.

LAYER TYPES:
  1   2   2   3   2   4   0   0   0   0   0   0   19

LAYER SLOPES:
  0.00     0.00     2.00     0.00     3.00     0.00     20
  0.00     0.00     0.00     0.00     0.00     0.00     21
```

```
LAYER DRAINAGE LENGTHS:
  0.0      0.0      50.0     0.0      200.0    0.0      22
  0.0      0.0       0.0     0.0        0.0    0.0      23

FLEXIBLE MEMBRANE LINER LEAKAGE FRACTIONS:
  1.00000000 1.00000000 1.00000000 1.00000000 1.00000000 0.00010000  24
  1.00000000 1.00000000 1.00000000 1.00000000 1.00000000 1.00000000  25

INITIAL INCHES OF WATER ON SURFACE AS SNOW:
  5.0000      26
```

The program then asks

```
12.1 DO YOU WANT TO CHANGE ANY LINES?
ENTER YES OR NO.
```

If this is the first time this question has been asked and the user answers NO (i.e., the user does not want to change any of the original data), the program returns control to question 1.1 If the user answers NO after changing some lines, the program asks question 12.6.

The first time the user answers YES in response to question 12.1, the program asks

```
12.2  DO YOU WANT TO CHANGE THE TITLE?
ENTER YES OR NO.
```

If the user answers NO, the program asks question 12.4. If the user answers YES, the program instructs the user to

```
12.3  ENTER A 3-LINE TITLE.  FOR EXAMPLE:
ENTER PROJECT TITLE ON LINE 1,
ENTER LOCATION OF DISPOSAL SITE ON LINE 2,
AND ENTER TODAY'S DATE ON LINE 3.
```

and then repeats question 12.1.

If the user answers YES to question 12.1 after it has been asked more than once, or if the user answers NO to question 12.2, the program responds

```
12.4  ENTER THE NUMBER OF THE LINE.
```

Upon receiving a line number, the program responds

```
12.5  ENTER THE DATA VALUES FOR LINE 11.
CURRENT VALUES ARE:
WILTING POINTS:
0.1500     0.2000     0.2000     0.0200     0.0200     0.0200
.15     .25     .30     .02     .02     .02
```

After the user enters these values, the program returns control to question

12.1, but the program first prints a message if the user changed line 4. The program warns

```
IT IS RECOMMENDED THAT YOU REENTER ALL SOIL DATA
IF YOU WANT TO CHANGE THE NUMBER OF LAYERS.  OTHERWISE;
YOU MUST CHANGE LINES 5 THROUGH 17 AND 19 THROUGH 25.
```

If, after making some changes, the user answers NO to question 12.1, the program asks

```
12.6  DO YOU WANT TO CHECK THE DATA SET AGAIN?
ENTER YES OR NO.
```

If the user answers YES, control is returned to message 12.1 after listing the current design and soil data. If the user answers NO, the program returns control to question 1.1.

SECTION 5

PROGRAM OUTPUT

The HELP program provides the user with several output options. Six general types of output are available: (1) daily values, (2) monthly totals, (3) annual totals, (4) averages of monthly and annual totals for the simulation period, (5) peak daily values for the simulation period and (6) end-of-simulation values. The user may request either detailed output or only summary output. Summary output consists of items 4, 5 and 6 above. Detailed output consists of these data plus annual totals for each year of simulation. Under the detailed output option, the user may also obtain either monthly totals or daily values or both for the entire simulation period. The program always prints all input data except daily precipitation values. The latter are printed only if the user requests daily output. This section describes the output options. A brief description of how to run the simulation and obtain output is given in Appendix A.

SIMULATION OUTPUT CONTROL (13. SIMULA)

This subroutine allows the user to run the simulation and to specify output options. When the output program starts, it first prints a heading introducing the HELP program and then asks the following:

1.5 SELECT OUTPUT OPERATION:

ENTER 3 TO RUN THE SIMULATION AND OBTAIN DETAILED OUTPUT,
4 TO RUN THE SIMULATION AND OBTAIN ONLY SUMMARY OUTPUT, OR
5 TO STOP THE PROGRAM.

If the response to question 1.5 is 5, the program will end. If the response to question 1.5 is either 3 or 4, control passes to question 13.1:

13.1 LOAD YOUR CLIMATOLOGICAL, SOIL AND DESIGN DATA
ON THE DEFAULT DRIVE AND THEN ENTER YES.
IF YOU MUST STOP THE EXECUTION TO LOAD THE DATA, ENTER NO.

The program will end if the user answers no. The following question appears if the user answers yes:

13.2 HOW MANY YEARS OF OUTPUT DO YOU WANT?
(UP TO 20 YEARS MAY BE USED.)

Up to twenty years of data can be simulated if rainfall data were synthetically generated (3 entered in response to question 1.2). Up to five years of data can be simulated if default rainfall data were used (1 entered in response to question 1.2).

If the user specified 4 in response to question 1.5, control is passed to question 13.5. If the user specified 3 in response to question 1.5, the program asks

```
13.3  DO YOU WANT DAILY OUTPUT?
ENTER YES OR NO.
```

A listing of output for each day of the year is provided if the user answers yes to question 13.3. The program next asks

```
13.4  DO YOU WANT MONTHLY TOTALS?
ENTER YES OR NO.
```

A listing of output for each month of the year is provided if the user answers yes to question 13.4.

The user must specify the file name for output in response to the following question:

```
13.5  ENTER DATA FILE NAME FOR OUTPUT.
FOR EXAMPLE:  A:CASE1.OUT
```

Then, the program allows the user to place an output diskette in the appropriate drive,

```
13.6  PLACE THE OUTPUT DATA DISKETTE (IF REQUIRED)
IN THE APPROPRIATE DRIVE AND THEN ENTER YES.
```

If the user requested daily output and there are more than six possible daily output variables (heads above barrier soil layers, percolation through barrier soil layers and drainage from lateral drainage layers), the program responds as shown in the following example:

```
THE AVAILABLE DAILY OUTPUT VARIABLES ARE:

     VARIABLE 1:  HEAD ON TOP OF LAYER 2
     VARIABLE 2:  PERCOLATION THROUGH LAYER 2
     VARIABLE 4:  HEAD ON TOP OF LAYER 5
     VARIABLE 5:  PERCOLATION THROUGH LAYER 5
     VARIABLE 6:  LATERAL DRAINAGE FROM LAYER 4
     VARIABLE 7:  HEAD ON TOP OF LAYER 7
     VARIABLE 8:  PERCOLATION THROUGH LAYER 7
     VARIABLE 9:  LATERAL DRAINAGE FROM LAYER 6

14.1  SELECT UP TO SIX CHOICES BY ENTERING THEIR VARIABLE NUMBERS
FROM THE ABOVE LIST.  SEPARATE THE CHOICES BY A BLANK SPACE.
```

Following question 13.6 or 14.1, the program begins the simulation.

OUTPUT DATA

The types of output data printed by the HELP model are listed below for the six output options. Each list is followed by an example printout.

Input and output data for a complete example simulation are presented on the floppy diskettes provided with the HELP program. A listing of all questions and answers required by the input program to create the example input data files is contained in the file EXAMPLE.IN. The example input data files themselves are also contained on the floppy diskettes so that the complete example simulation can be run by the user. The example output for this simulation is contained in the file EXAMPLE.OUT.

Daily Values

The following types of output data are included when the user specifies daily output values:

- Julian date
- Flag indicating whether mean temperature is above or below 32 degrees F.
- Precipitation, in inches
- Runoff, in inches
- Evapotranspiration, in inches
- Head on top of any barrier soil liner, in inches
- Percolation through any barrier soil liner, in inches
- Lateral drainage from surface of any barrier soil liner, in inches
- Soil water content in evaporative zone, in vol/vol

An example of the first 6 days of output for a year of simulation is shown below:

VARIABLE 1: HEAD ON TOP OF LAYER 3
VARIABLE 2: PERCOLATION THROUGH LAYER 3
VARIABLE 3: LATERAL DRAINAGE FROM LAYER 2
VARIABLE 4: UNUSED VARIABLE
VARIABLE 5: UNUSED VARIABLE
VARIABLE 6: UNUSED VARIABLE

****

DAILY OUTPUT FOR YEAR 74

DAY	RAIN IN.	RUNOFF IN.	ET IN.	VAR. 1 IN.	VAR. 2 IN.	VAR. 3 IN.	VAR. 4 IN.	VAR. 5 IN.	VAR. 6 IN.	SOIL WATER IN/IN
1	0.06	0.000	0.027	3.1	0.0000	0.177	0.000	0.000	0.000	0.2931
2	0.05	0.000	0.027	3.2	0.0000	0.180	0.000	0.000	0.000	0.2870
3	0.70	0.000	0.046	3.1	0.0000	0.176	0.000	0.000	0.000	0.3077
4	0.20	0.000	0.018	2.9	0.0000	0.167	0.000	0.000	0.000	0.3141
5	0.01	0.000	0.020	2.8	0.0000	0.159	0.000	0.000	0.000	0.3089
6	0.01	0.000	0.025	2.8	0.0000	0.156	0.000	0.000	0.000	0.2997

Monthly Totals

The following types of output data are included when the user specifies monthly totals:

Precipitation, in inches
Runoff, in inches
Evapotranspiration, in inches
For each subprofile:
- Percolation, in inches
- Lateral drainage, in inches
- Monthly average daily head, in inches
- Monthly standard deviation of daily heads, in inches

An example of monthly totals for a year of simulation is shown below:

****

MONTHLY TOTALS FOR YEAR 74

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	5.36	6.37	2.44	3.72	3.83	3.20
	4.64	6.26	1.06	1.22	3.89	5.31
RUNOFF (INCHES)	0.011	0.063	0.000	0.082	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.006
EVAPOTRANSPIRATION (INCHES)	1.472	2.326	2.072	2.740	4.605	4.257
	4.640	5.164	2.156	0.424	1.569	1.811
LATERAL DRAINAGE FROM LAYER 2 (INCHES)	4.2044	4.7898	1.4885	1.5456	0.2501	0.0801
	0.0627	0.0548	0.0458	0.0405	0.0335	1.2999
PERCOLATION FROM LAYER 3 (INCHES)	0.0006	0.0005	0.0006	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

MONTHLY SUMMARIES FOR DAILY HEADS

AVG. DAILY HEAD ON LAYER 3 (INCHES)	2.39	3.01	1.27	1.25	0.96	0.96
	0.89	0.78	0.67	0.57	0.49	1.03
STD. DEV. OF DAILY HEAD ON LAYER 3 (INCHES)	0.63	0.53	0.52	0.37	0.00	0.01
	0.03	0.03	0.03	0.03	0.02	0.93

Annual Totals

Annual totals for the following data are presented in three types of units: (1) inches, (2) cubic feet and (3) percentage of annual precipitation.

- Precipitation
- Runoff
- Evapotranspiration
- For each subprofile:
  - Percolation
  - Lateral drainage
- Soil water in storage at beginning of year
- Soil water in storage at end of year
- Snow water in storage at beginning of year
- Snow water in storage at end of year
- Annual change in total storage

An example of annual totals is shown below:

****

ANNUAL TOTALS FOR YEAR 74

	(INCHES)	(CU.FT.)	PERCENT
PRECIPITATION	47.30	39417.	100.00
RUNOFF	0.161	134.	0.34
EVAPOTRANSPIRATION	33.235	27696.	70.27
LATERAL DRAINAGE FROM LAYER 2	13.8956	11580.	29.38
PERCOLATION FROM LAYER 3	0.0065	5.	0.01
CHANGE IN WATER STORAGE	0.001	1.	0.00
SOIL WATER AT START OF YEAR	19.28	16070.	
SOIL WATER AT END OF YEAR	19.29	16071.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

****

Averages and Standard Deviations of Monthly and Annual Totals

Averages and standard deviations of monthly totals (in inches) are printed for the following variables:

Precipitation
Runoff
Evapotranspiration
For each subprofile:
    Percolation
    Lateral drainage

Averages and standard deviations of annual totals are printed in three types of units: (1) inches, (2) cubic feet and (3) percentage of average annual precipitation. The following variables are included:

Precipitation
Runoff
Evapotranspiration
For each subprofile:
    Percolation
    Lateral drainage

An example of these averages and standard deviations of monthly and annual totals is shown below:

```
*****************************************************************************

          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78
-----------------------------------------------------------------------------

                          JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
                          ------- ------- ------- ------- ------- -------

PRECIPITATION
-------------

  TOTALS                   5.48    3.94    6.21    2.94    4.96    3.39
                           4.79    4.05    2.08    3.34    4.50    3.76

  STD. DEVIATIONS          1.26    3.60    3.57    1.25    2.19    1.23
                           2.28    2.33    1.81    1.90    1.47    0.98

RUNOFF
------

  TOTALS                  0.237   0.066   0.394   0.056   0.093   0.006
                          0.048   0.066   0.001   0.072   0.203   0.027

  STD. DEVIATIONS         0.250   0.116   0.686   0.087   0.168   0.012
                          0.068   0.091   0.002   0.112   0.381   0.056
```

EVAPOTRANSPIRATION

TOTALS	1.804	1.683	2.621	2.597	4.258	4.941
	4.165	4.269	2.318	1.885	1.654	1.769
STD. DEVIATIONS	0.294	0.661	0.531	0.627	0.807	1.217
	2.073	1.863	1.633	0.945	0.262	0.136

LATERAL DRAINAGE FROM LAYER 2

TOTALS	3.7213	3.0561	2.6528	1.7347	0.5747	0.3745
	0.0645	0.0569	0.0497	0.1480	1.3285	0.8574
STD. DEVIATIONS	1.2365	2.2734	1.9793	0.8972	0.6352	0.4615
	0.0040	0.0035	0.0061	0.1583	2.0760	0.4383

PERCOLATION FROM LAYER 3

TOTALS	0.0006	0.0005	0.0006	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	49.46	(9.546)	41213.	100.00
RUNOFF	1.269	(0.873)	1058.	2.57
EVAPOTRANSPIRATION	33.964	(4.830)	28303.	68.68
LATERAL DRAINAGE FROM LAYER 2	14.6191	(4.9379)	12183.	29.56
PERCOLATION FROM LAYER 3	0.0065	(0.0001)	5.	0.01
CHANGE IN WATER STORAGE	-0.403	(0.288)	-336.	-0.81

****

Peak Daily Values

Peak daily values are printed for the following variables:

Precipitation, in inches and cubic feet
Runoff, in inches and cubic feet
For each subprofile:
   Percolation, in inches and cubic feet
   Lateral drainage, in inches and cubic feet
   Head, in inches
Snow water in storage, in inches and cubic feet
Maximum soil water content in evaporative zone, in vol/vol
Minimum soil water content in evaporative zone, in vol/vol

An example output depicting these peak values is shown below:

****

PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	3.43	2858.3
RUNOFF	0.955	795.8
LATERAL DRAINAGE FROM LAYER 2	0.4091	340.9
PERCOLATION FROM LAYER 3	0.0000	0.0
HEAD ON LAYER 3	7.2	
SNOW WATER	1.26	1050.0
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3830	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1152	

****

End-of-Simulation Values

The soil water content in each layer in printed at the end of each simulation. An example output is shown below:

FINAL WATER STORAGE AT END OF YEAR 78

	LAYER	(INCHES)	(VOL/VOL)
	1	6.05	0.2519
	2	0.90	0.0753
	3	10.32	0.4300
SNOW WATER		0.00	

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APPENDIX A

DETAILED EXPLANATION OF HOW TO EXECUTE THE PROGRAM ON AN IBM-COMPATIBLE PERSONAL COMPUTER

The PC version of the HELP model consists of 8 double-sided, double-density (DS/DD) or 3 double-sided, high-density (DS/HD) 5.25-inch floppy diskettes. The contents of each are shown here.

DS/DD Diskette	Contents	File Name	Size (Kb)
1.	HELP input program	RUNHELPI.EXE	292,842
2.	HELP execution and output program	RUNHELPO.EXE	189,977
	Example daily rainfall data	DATA4	13,320
	Example daily temperature data	DATA7	13,320
	Example soil and design data	DATA10	1,606
	Example miscellaneous climatological data	DATA11	416
	Example daily insolation data	DATA13	13,320
	Example input	EXAMPLE.IN	46,000
	Example output	EXAMPLE.OUT	28,233
3.	Synthetic rainfall generation coefficients for 139 cities	TAPE1	22,102
	Synthetic temperature and solar radiation coefficients for 184 cities	TAPE2	65,873
4.	Default 5-yr rainfall data sets for states AL-HI	TAPE3.A	348,192
5.	Default 5-yr rainfall data sets for states ID-MT	TAPE3.I	334,800
6.	Default 5-yr rainfall data sets for states NE-OR	TAPE3.N	334,800
7.	Default 5-yr rainfall data sets for states PA-WY and Puerto Rico	TAPE3.P	348,192
8.	HELP input source code listing	HELPI.FOR	147,079
	HELP execution and output source code listing	HELPO.FOR	144,696

DS/HD Diskette	Contents	File Name	Size (Kb)
1.	HELP input program	RUNHELPI.EXE	292,842
	HELP execution and output program	RUNHELPO.EXE	189,977
	Example daily rainfall data	DATA4	13,320
	Example daily temperature data	DATA7	13,320
	Example soil and design data	DATA10	1,606
	Example miscellaneous climatological data	DATA11	416
	Example daily isolation data	DATA13	13,320
	Example input	EXAMPLE.IN	46,000
	Example output	EXAMPLE.OUT	28,233
	Synthetic rainfall generation coefficients for 139 cities	TAPE1	22,102
	Synthetic temperature and solar radiation coefficients for 184 cities	TAPE2	65,873
2.	Default 5-yr rainfall data sets for states AL-HI	TAPE3.A	348,192
	Default 5-yr rainfall data sets for states ID-MT	TAPE3.I	334,800
	Default 5-yr rainfall data sets for states NE-OR	TAPE3.N	334,800
3.	Default 5-yr rainfall data sets for states PA-WY and Puerto Rico	TAPE3.P	348,192
	HELP input source code listing	HELPI.FOR	147,079
	HELP execution and output source code listing	HELPO.FOR	144,696

The user should make a backup copy of each of these diskettes prior to running the HELP model. Each of the default 5-yr precipitation data floppy diskettes has a list of states on its label. The user should search the precipitation data diskettes, select the diskette which has the state of interest and wait until the model requests the user to insert the diskette into the drive of the user's choice. Alternatively, the user can load the default precipitation data onto a hard disk. The user may also copy the synthetic weather generation coefficients onto a hard disk.

REQUIRED HARDWARE

The following IBM-compatible CPU (8088, 80286 or 80386) hardware is required:

a. Monitor
b. Floppy Disk Drive (5.25-inch double-sided, double- or high-density)
c. Hard Disk Drive or a Second Floppy Disk Drive
d. 384k bytes or more of RAM memory
e. 8087, 80287 or 80387 Math Co-processor
f. Printer if a hard copy is desired

SOFTWARE REQUIREMENT

The user must use Micro Soft Disk Operating System (MS-DOS) Version 2.10 or a higher version. The user must create or add to an existing CONFIG.SYS file the following commands:

```
FILES=20
BUFFERS=20
```

The purpose of the CONFIG.SYS File is to increase the number of data files which the PC can access. Additional FILES and BUFFERS will be required if DOS is overlain by other software. Increase the number from 20 if Error Number 3012 is encountered while running the HELP model. The CONFIG.SYS file must be in the root or boot-up directory. The RUNHELPI.EXE and RUNHELPO.EXE executable modules were compiled and linked with IBM Personal Computer Professional FORTRAN developed by Ryan-McFarland Corporation. This Professional FORTRAN is not needed to run the HELP Model.

SOURCE PROGRAM

The source program is listed in the ASCII files named HELPI.FOR and HELPO.FOR on the floppy diskette.

HARD DISK INSTALLATION

Typically the user would install the program in its own subdirectory. The user can build a HELP subdirectory on its root directory by the following set of commands.

```
C> CD\
C> MD HELP
```

The user should copy the diskette labeled RUNHELPI.EXE and the diskette labeled RUNHELPO.EXE from the A drive (floppy disk drive) to the hard disk drive in the HELP subdirectory by these commands:

```
C> CD\HELP
C> COPY A:*.*
```

The user normally would also copy TAPE1 and TAPE2 to the hard drive in an analogous manner.

RUNNING HELP VERSION 2 WITH A HARD DISK

A user may run HELP in two ways with a hard disk. The default drive (the drive displayed in the prompt) may either be the hard disk drive or the floppy disk drive. To run the program with the hard disk drive as the default drive, the user must change the default drive to C and enter into the appropriate subdirectory where the program is located if the computer is not currently in the correct drive and subdirectory. To start the HELP model for entering data, the user should type this command:

C> RUNHELPI

Once the model starts, it will function according to the instructions in this volume. During the climatological input, the program will need to read the diskette containing the coefficients for the user specified city to generate daily temperatures, solar radiation and rainfall (synthetic method only). The user need only enter the letter of the drive which contains the synthetic weather generation coefficients in response to

ENTER THE LETTER OF THE DRIVE WHERE TEMPERATURE, RADIATION, AND RAINFALL PARAMETERS SHOULD BE READ. (A, B, C OR D)

If the user selects the default method of entering precipitation data, the program will need to read the five-year precipitation data set from the diskette containing the user specified state. The user enters the letter of the drive which contains the precipitation data diskette in response to

ENTER THE LETTER OF THE DRIVE WHERE THE DEFAULT RAINFALL DATA SHOULD BE READ. (A, B, C OR D)

The default precipitation data are arranged on the disks by the alphabetical order of the states. After loading the data, the model will function according to instructions in this volume.

After the user has entered the climatological, soil and design data, the execution and output program can be run by typing

C> RUNHELPO

The program will function according to instructions in this volume.

To run the HELP model using the floppy diskette drive for storing data for the run, the user should first insert a formatted diskette into the floppy diskette drive and change the default drive to the floppy drive (in most cases drive A). The program will store all data files (those named with a "DATA" prefix) created while running the RUNHELPI program onto the floppy diskette and read these data files when running the RUNHELPO program. Therefore, it is very important that a user does not remove the diskette in the floppy drive while running the HELP model. If the letter of the floppy drive is A, the user should type these commands to begin running the program for entering input:

```
C> CD\HELP
C> A:
A> C:RUNHELPI
```

The user must have previously copied the RUNHELPI program onto the hard disk and under the HELP subdirectory where the computer can find the program. When the program asks the user to enter a letter of the drive where data should be read, the user should specify C if the data is on the hard disk, or B if the user has another floppy drive and has not copied the synthetic weather coefficient data or default precipitation data onto the hard disk. When the user is finished entering climatological and soil data, the user may run the executable and output program by typing

A> C:RUNHELPO

while keeping the data diskette in drive A. The model will function according to the instructions in this volume.

RUNNING HELP VERSION 2 WITH TWO FLOPPY DISK DRIVES AND NO HARD DISK

If the user has a two floppy diskettes system, place the diskette labeled RUNHELPI.EXE into drive A, and enter the command:

A> RUNHELPI

After the computer has finished loading the module into memory and displayed the input program menu, remove the input diskette from drive A and insert a blank formatted data diskette into drive A. The HELP Model will then function according to the instructions in this volume. When the program requests the letter of the drive where data should be read, specify the letter of the empty floppy disk drive (in most cases B) and insert the appropriate data diskette. This diskette will either be the synthetic weather coefficient diskette or a diskette containing default five-year precipitation data.

When the user has finished entering climatological, soil and design data, insert the diskette labeled RUNHELPO.EXE in drive B and type

A> B:RUNHELPO

The HELP model will function according to the instructions in this volume.

The RUNHELPI program stores the data files for your run (data files: DATA4, DATA7, DATA10, DATA11, and DATA13) on the default drive and the RUNHELPO program reads these data files from the default drive during execution. Therefore, it is very important that your data files be located on the default drive (the drive displayed in the prompt).

OBTAINING OUTPUT

Output may be obtained by two methods. First, the user may obtain printed output during execution by turning on the power to his printer and then pressing simultaneously Ctrl PrtSc (control print screen). The second method of obtaining output is by capturing the output in a data file. The program will write the output in a data file of the user's choice. The user must specify a data file name in response to the following instruction:

```
ENTER DATA FILE NAME FOR OUTPUT.
FOR EXAMPLE:  A:CASE1.OUT
```

The program will either create a new data file of the specified name or overwrite the output in the file if it already exists.

TABLE 1. CITIES FOR WHICH DEFAULT HISTORICAL PRECIPITATION DATA ARE AVAILABLE

- ALASKA
  - ANNETTE
  - BETHEL
  - FAIRBANKS
- ARIZONA
  - FLAGSTAFF
  - PHOENIX
  - TUCSON
- ARKANSAS
  - LITTLE ROCK
- CALIFORNIA
  - FRESNO
  - LOS ANGELES
  - SACRAMENTO
  - SAN DIEGO
  - SANTA MARIA
- COLORADO
  - DENVER
  - GRAND JUNCTION
- CONNECTICUT
  - BRIDGEPORT
  - HARTFORD
  - NEW HAVEN
- FLORIDA
  - JACKSONVILLE
  - MIAMI
  - ORLANDO
  - TALLAHASSEE
  - TAMPA
  - W. PALM BEACH
- GEORGIA
  - ATLANTA
  - WATKINSVILLE
- HAWAII
  - HONOLULU
- IDAHO
  - BOISE
  - POCATELLO
- ILLINOIS
  - CHICAGO
  - E. ST. LOUIS
- INDIANA
  - INDIANAPOLIS
- IOWA
  - DES MOINES
- KANSAS
  - DODGE CITY
  - TOPEKA
- KENTUCKY
  - LEXINGTON
- LOUISIANA
  - LAKE CHARLES
  - NEW ORLEANS
  - SHREVEPORT
- MAINE
  - AUGUSTA
  - BANGOR
  - CARIBOU
  - PORTLAND
- MASSACHUSETTS
  - BOSTON
  - PLAINFIELD
  - WORCESTER
- MICHIGAN
  - E. LANSING
  - SAULT STE. MARIE
- MINNESOTA
  - ST. CLOUD
- MISSOURI
  - COLUMBIA
- MONTANA
  - GLASGOW
  - GREAT FALLS
- NEBRASKA
  - GRAND ISLAND
  - NORTH OMAHA
- NEVADA
  - ELY
  - LAS VEGAS
- NEW HAMPSHIRE
  - CONCORD
  - NASHUA
- NEW JERSEY
  - EDISON
  - SEABROOK
- NEW MEXICO
  - ALBUQUERQUE
- NEW YORK
  - ALBANY
  - CENTRAL PARK
  - ITHACA
  - NEW YORK CITY
  - SYRACUSE
- NORTH CAROLINA
  - GREENSBORO
- NORTH DAKOTA
  - BISMARCK
- OHIO
  - CINCINNATI
  - CLEVELAND
  - COLUMBUS
  - PUT-IN-BAY
- OKLAHOMA
  - OKLAHOMA CITY
  - TULSA
- OREGON
  - ASTORIA
  - MEDFORD
  - PORTLAND
- PENNSYLVANIA
  - PHILADELPHIA
  - PITTSBURGH
- RHODE ISLAND
  - PROVIDENCE
- SOUTH CAROLINA
  - CHARLESTON
- SOUTH DAKOTA
  - RAPID CITY
- TENNESSEE
  - KNOXVILLE
  - NASHVILLE
- TEXAS
  - BROWNSVILLE
  - DALLAS
  - EL PASO
  - MIDLAND
  - SAN ANTONIO
- UTAH
  - CEDAR CITY
  - SALT LAKE CITY
- VERMONT
  - BURLINGTON
  - MONTPELIER
  - RUTLAND
- VIRGINIA
  - LYNCHBURG
  - NORFOLK
- WASHINGTON
  - PULLMAN
  - SEATTLE
  - YAKIMA
- WISCONSIN
  - MADISON
- WYOMING
  - CHEYENNE
  - LANDER
- PUERTO RICO
  - SAN JUAN

TABLE 2. CITIES FOR WHICH SYNTHETIC PRECIPITATION DATA CAN BE GENERATED

- ALABAMA
  - BIRMINGHAM
  - MOBILE
  - MONTGOMERY
- ARIZONA
  - FLAGSTAFF
  - PHOENIX
  - YUMA
- ARKANSAS
  - FORT SMITH
  - LITTLE ROCK
- CALIFORNIA
  - BAKERSFIELD
  - BLUE CANYON
  - EUREKA
  - FRESNO
  - MT. SHASTA
  - SAN DIEGO
  - SAN FRANCISCO
- COLORADO
  - COLORADO SPGS
  - DENVER
  - GRAND JUNCTION
  - PUEBLO
- CONNECTICUT
  - WINDSOR LOCKS
- DELAWARE
  - WILMINGTON
- DIST. OF COLUMBIA
  - WASHINGTON
- FLORIDA
  - JACKSONVILLE
  - MIAMI
  - TALLAHASSEE
  - TAMPA
- GEORGIA
  - ATLANTA
  - AUGUSTA
  - MACON
  - SAVANNAH
- HAWAII
  - HONOLULU
- IDAHO
  - BOISE
  - POCATELLO
- ILLINOIS
  - CHICAGO
- INDIANA
  - EVANSVILLE
  - FORT WAYNE
  - INDIANAPOLIS
- IOWA
  - DES MOINES
  - DUBUQUE
- KANSAS
  - DODGE CITY
  - TOPEKA
  - WICHITA
- KENTUCKY
  - COVINGTON
  - LEXINGTON
  - LOUISVILLE
- LOUISIANA
  - BATON ROUGE
  - NEW ORLEANS
  - SHREVEPORT
- MAINE
  - CARIBOU
  - PORTLAND
- MARYLAND
  - BALTIMORE
- MASSACHUSETTS
  - BOSTON
  - NANTUCKET
- MICHIGAN
  - DETROIT
  - GRAND RAPIDS
- MINNESOTA
  - DULUTH
  - MINNEAPOLIS
- MISSISSIPPI
  - JACKSON
  - MERIDIAN
- MISSOURI
  - COLUMBIA
  - KANSAS CITY
  - ST. LOUIS
- MONTANA
  - BILLINGS
  - GREAT FALLS
  - HAVRE
  - HELENA
  - KALISPELL
  - MILES CITY
- NEBRASKA
  - GRAND ISLAND
  - NORTH PLATTE
  - SCOTTSBLUFF
- NEVADA
  - ELKO
  - LAS VEGAS
  - RENO
  - WINNEMUCCA
- NEW HAMPSHIRE
  - CONCORD
  - MT. WASHINGTON
- NEW JERSEY
  - NEWARK
- NEW MEXICO
  - ALBUQUERQUE
  - ROSWELL
- NEW YORK
  - ALBANY
  - BUFFALO
  - NEW YORK
  - SYRACUSE
- NORTH CAROLINA
  - ASHEVILLE
  - CHARLOTTE
  - GREENSBORO
  - RALEIGH
- NORTH DAKOTA
  - BISMARCK
  - WILLISTON
- OHIO
  - CLEVELAND
  - COLUMBUS
  - TOLEDO
- OKLAHOMA
  - OKLAHOMA CITY
  - TULSA
- OREGON
  - BURNS
  - MEACHEM
  - MEDFORD
  - PENDLETON
  - PORTLAND
  - SALEM
  - SEXT. SUMMIT
- PENNSYLVANIA
  - PHILADELPHIA
  - PITTSBURGH
- RHODE ISLAND
  - PROVIDENCE
- SOUTH CAROLINA
  - CHARLESTON
  - COLUMBIA
- SOUTH DAKOTA
  - HURON
  - RAPID CITY
- TENNESSEE
  - CHATTANOOGA
  - KNOXVILLE
  - MEMPHIS
  - NASHVILLE
- TEXAS
  - ABILENE
  - AMARILLO
  - AUSTIN
  - BROWNSVILLE
  - CORPUS CHRISTI
  - DALLAS
  - EL PASO
  - GALVESTON
  - HOUSTON
  - SAN ANTONIO
  - TEMPLE
  - WACO
- UTAH
  - MILFORD
  - SALT LAKE
- VIRGINIA
  - NORFOLK
  - RICHMOND
- WASHINGTON
  - OLYMPIA
  - SPOKANE
  - STAMPEDE PASS
  - WALLA WALLA
  - YAKIMA
- WEST VIRGINIA
  - CHARLESTON
- WISCONSIN
  - GREEN BAY
  - LACROSSE
  - MADISON
  - MILWAUKEE
- WYOMING
  - CHEYENNE
- PUERTO RICO
  - SAN JUAN

TABLE 3. CITIES FOR WHICH SYNTHETIC TEMPERATURE AND SOLAR RADIATION DATA CAN BE GENERATED

- ALABAMA
  - BIRMINGHAM
  - MOBILE
  - MONTGOMERY
- ALASKA
  - ANNETTE
  - BETHEL
  - FAIRBANKS
- ARIZONA
  - FLAGSTAFF
  - PHOENIX
  - TUCSON
  - YUMA
- ARKANSAS
  - FORT SMITH
  - LITTLE ROCK
- CALIFORNIA
  - BAKERSFIELD
  - BLUE CANYON
  - EUREKA
  - LOS ANGELES
  - FRESNO
  - MT. SHASTA
  - SACRAMENTO
  - SAN DIEGO
  - SAN FRANCISCO
  - SANTA MARIA
- COLORADO
  - COLORADO SPGS
  - DENVER
  - GRAND JUNCTION
  - PUEBLO
- CONNECTICUT
  - BRIDGEPORT
  - HARTFORD
  - NEW HAVEN
  - WINDSOR LOCKS
- DELAWARE
  - WILMINGTON
- DIST. OF COLUMBIA
  - WASHINGTON
- FLORIDA
  - JACKSONVILLE
  - MIAMI
  - ORLANDO
  - TALLAHASSEE
  - TAMPA
  - W. PALM BEACH
- ILLINOIS
  - CHICAGO
  - E. ST. LOUIS
- INDIANA
  - EVANSVILLE
  - FORT WAYNE
  - INDIANAPOLIS
- IOWA
  - DES MOINES
  - DUBUQUE
- KANSAS
  - DODGE CITY
  - TOPEKA
  - WICHITA
- KENTUCKY
  - COVINGTON
  - LEXINGTON
  - LOUISVILLE
- LOUISIANA
  - BATON ROUGE
  - LAKE CHARLES
  - NEW ORLEANS
  - SHREVEPORT
- MAINE
  - AUGUSTA
  - BANGOR
  - CARIBOU
  - PORTLAND
- MARYLAND
  - BALTIMORE
- MASSACHUSETTS
  - BOSTON
  - NANTUCKET
  - PLAINFIELD
  - WORCHESTER
- MICHIGAN
  - DETROIT
  - E. LANSING
  - GRAND RAPIDS
  - SAUL STE. MARIE
- MINNESOTA
  - DULUTH
  - MINNEAPOLIS
  - ST. CLOUD
- MISSISSIPPI
  - JACKSON
  - MERIDIAN
- NEBRASKA
  - GRAND ISLAND
  - NORTH PLATTE
  - OMAHA
  - SCOTTSBLUFF
- NEVADA
  - ELKO
  - ELY
  - LAS VEGAS
  - RENO
  - WINNEMUCCA
- NEW HAMPSHIRE
  - CONCORD
  - MT. WASHINGTON
  - NASHUA
- NEW JERSEY
  - EDISON
  - NEWARK
  - SEABROOK
- NEW MEXICO
  - ALBUQUERQUE
  - ROSWELL
- NEW YORK
  - ALBANY
  - BUFFALO
  - CENTRAL PARK
  - ITHACA
  - NEW YORK CITY
  - SCHENECTADY
  - SYRACUSE
- NORTH CAROLINA
  - ASHEVILLE
  - CHARLOTTE
  - GREENSBORO
  - RALEIGH
- NORTH DAKOTA
  - BISMARCK
  - WILLISTON
- OHIO
  - CINCINNATI
  - CLEVELAND
  - COLUMBUS
  - PUT-IN-BAY
  - TOLEDO
- OKLAHOMA
  - OKLAHOMA CITY
  - TULSA
- RHODE ISLAND
  - PROVIDENCE
- SOUTH CAROLINA
  - CHARLESTON
  - COLUMBIA
- SOUTH DAKOTA
  - HURON
  - RAPID CITY
- TENNESSEE
  - CHATTANOOGA
  - KNOXVILLE
  - MEMPHIS
  - NASHVILLE
- TEXAS
  - ABILENE
  - AMARILLO
  - AUSTIN
  - BROWNSVILLE
  - CORPUS CHRISTI
  - DALLAS
  - EL PASO
  - GALVESTON
  - HOUSTON
  - MIDLAND
  - SAN ANTONIO
  - TEMPLE
  - WACO
- UTAH
  - CEDAR CITY
  - MILFORD
  - SALT LAKE CITY
- VERMONT
  - BURLINGTON
  - MONTPELIER
  - RUTLAND
- VIRGINIA
  - LYNCHBURG
  - NORFOLK
  - RICHMOND
- WASHINGTON
  - OLYMPIA
  - PULLMAN
  - SEATTLE
  - SPOKANE
  - STAMPEDE PASS
  - WALLA WALLA
  - YAKIMA

(Continued)

TABLE 3. (Concluded)

GEORGIA	MISSOURI	OREGON	WEST VIRGINIA
ATLANTA	COLUMBIA	ASTORIA	CHARLESTON
AUGUSTA	KANSAS CITY	BURNS	WISCONSIN
MACON	ST. LOUIS	MEACHAM	GREEN BAY
SAVANNAH	MONTANA	MEDFORD	LACROSSE
WATKINSVILLE	BILLINGS	PENDLETON	MADISON
HAWAII	GLASGOW	PORTLAND	MILWAUKEE
HONOLULU	GREAT FALLS	SALEM	WYOMING
IDAHO	HAVRE	SEXT. SUMMIT	CHEYENNE
BOISE	HELENA	PENNSYLVANIA	LANDER
POCATELLO	KALISPELL	PHILADELPHIA	PUERTO RICO
	MILES CITY	PITTSBURGH	SAN JUAN

TABLE 4. DEFAULT SOIL CHARACTERISTICS

Soil Texture Class HELP	USDA	USCS	Total Poros.	Resid. Sat.	Bubbl. Press. (cm)	Pore-Size Dist. Index	Field Cap.	Wilt. Pt.	Sat. Hyd. Cond. cm/s	Sat. Hyd. Cond. in/hr	Min. Inf. Rate in/hr	Evap. Coef. $mm/day^{0.5}$
1	CoS	GS	0.417	0.015	6.53	0.651	0.045	0.018	1.0E-02	14.173	0.500	3.3
2	S	SW	0.437	0.020	7.26	0.592	0.062	0.024	5.8E-03	8.220	0.400	3.3
3	FS	SM	0.457	0.025	7.99	0.533	0.083	0.033	3.1E-03	4.394	0.390	3.3
4	LS	SM	0.437	0.035	8.69	0.474	0.105	0.047	1.7E-03	2.409	0.380	3.3
5	LFS	SM	0.457	0.040	9.56	0.425	0.131	0.058	1.0E-03	1.417	0.340	3.3
6	SL	SM	0.453	0.041	14.66	0.322	0.190	0.085	7.2E-04	1.020	0.300	3.3
7	FSL	SM	0.473	0.046	16.13	0.290	0.222	0.104	5.2E-04	0.737	0.250	5.1
8	L	ML	0.463	0.027	11.15	0.220	0.232	0.116	3.7E-04	0.524	0.200	5.1
9	SiL	ML	0.501	0.015	20.76	0.211	0.284	0.135	1.9E-04	0.269	0.170	3.9
10	SCL	SC	0.398	0.068	28.08	0.250	0.244	0.136	1.2E-04	0.170	0.110	5.1
11	CL	CL	0.464	0.075	25.89	0.194	0.310	0.187	6.4E-05	0.091	0.090	5.1
12	SiCL	CL	0.471	0.040	32.56	0.151	0.342	0.210	4.2E-05	0.060	0.070	5.1
13	SC	CH	0.430	0.109	29.17	0.168	0.321	0.221	3.3E-05	0.047	0.060	4.5
14	SiC	CH	0.479	0.056	34.19	0.127	0.371	0.251	2.5E-05	0.035	0.020	5.1
15	C	CH	0.475	0.090	37.30	0.131	0.378	0.265	1.7E-05	0.024	0.010	4.6
16	Barrier		0.430	0.120	45.00	0.113	0.366	0.280	1.0E-07	0.000	0.002	3.3
17	Barrier		0.400	0.140	50.00	0.096	0.356	0.290	1.0E-08	0.000	0.001	3.3
18	Mun. Waste		0.520	0.015	20.76	0.211	0.294	0.140	2.0E-04	0.283	0.230	5.1

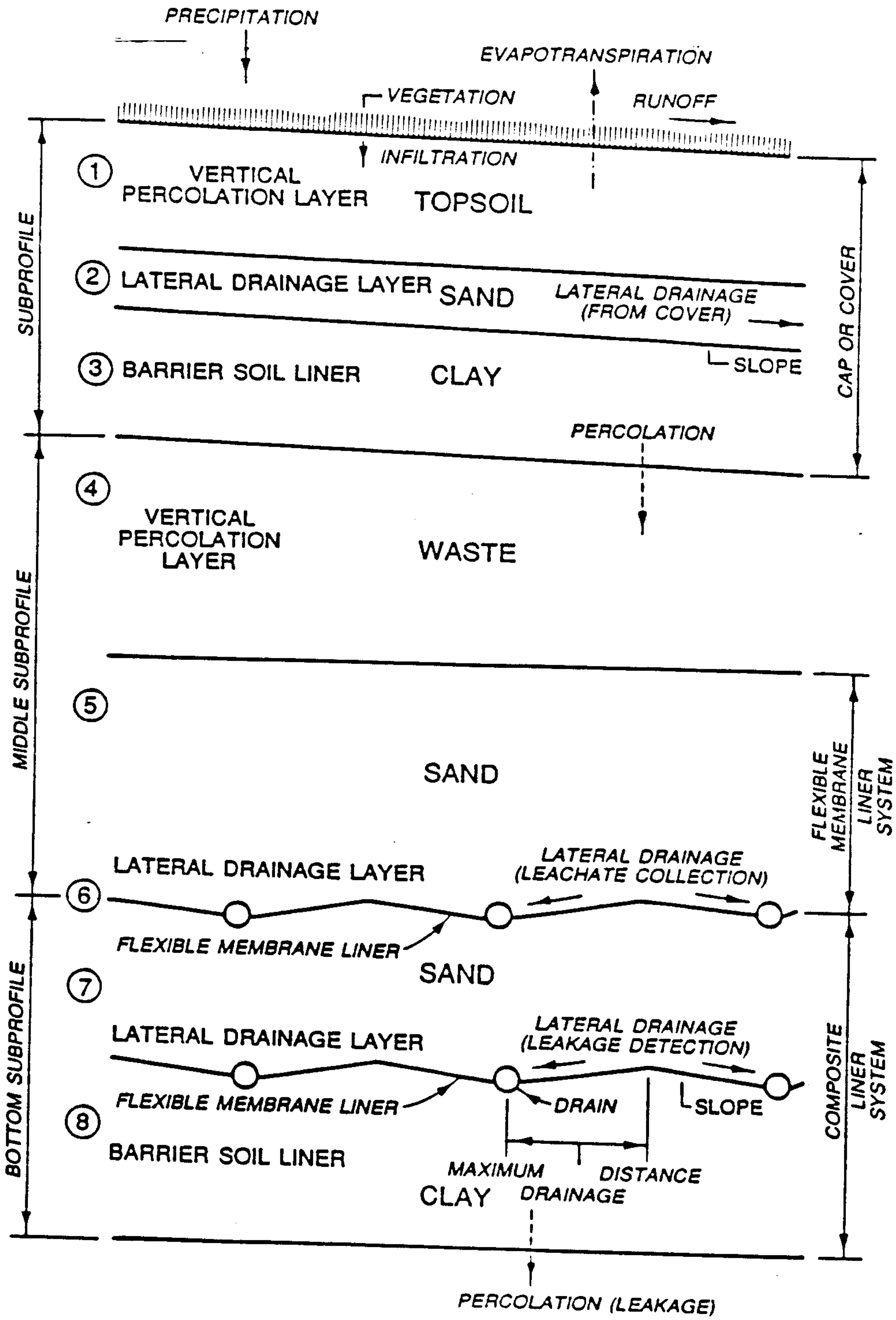

Figure 1. Typical hazardous waste landfill profile.

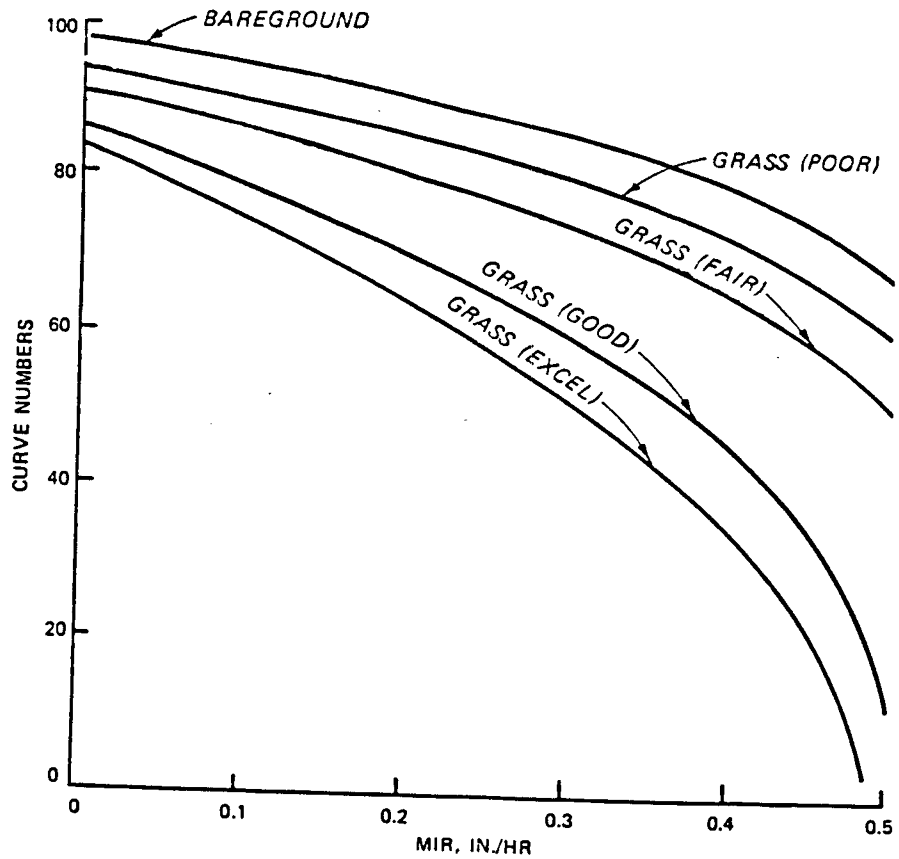

Figure 2. Relationship between SCS curve numbers for runoff and minimum infiltration rate (MIR) for default soils with various levels of vegetation.

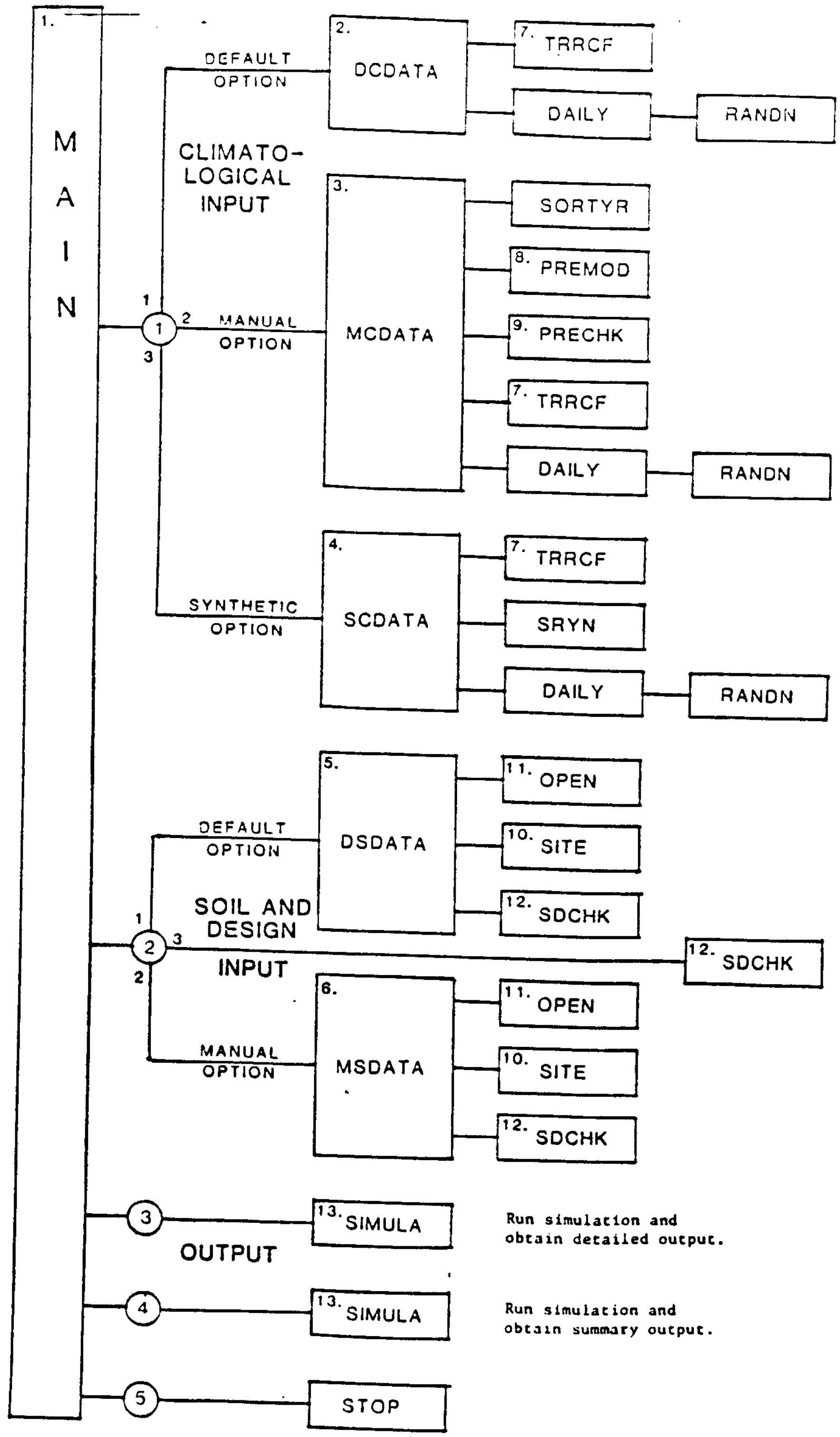

Figure 3. Overall program control.

DEFAULT SOIL AND DESIGN DATA INPUT

Title: ______________________________

____

____

Do you want the program to initialize the soil water? ____________

Number of layers: ____________

Layer data:

Layer 1
(a) thickness ____________ inches
(b) layer type ____________ (1 or 2)
(c) liner leakage fraction (only for layer type 4) ____________ (0 to 1)
(d) soil texture number ____________ (1 to 20)*
(e) compacted? (only for soil textures 1 to 15) ____________ (Yes or No)
(f) initial soil water content (not asked if program is to initialize the soil water or if layer type is 3 or 4) ____________ vol/vol
(must be between wilting point and porosity)

Layer 2
(a) thickness ____________ inches
(b) layer type ____________ (1 to 4)
(c) liner leakage fraction (only for layer type 4) ____________ (0 to 1)
(d) soil texture number ____________ (1 to 20)*
(e) compacted? (only for soil textures 1 to 15) ____________ (Yes or No)
(f) initial soil water content (not asked if program is to initialize the soil water or if layer type is 3 or 4) ____________ vol/vol
(must be between wilting point and porosity)

Layer 3
(a) thickness ____________ inches
(b) layer type ____________
(c) liner leakage fraction (only for layer type 4) ____________ (0 to 1)
(d) soil texture number ____________ (1 to 20)*
(e) compacted? (only for soil textures 1 to 15) ____________ (Yes or No)
(f) initial soil water content (not asked if program is to initialize the soil water or if layer type is 3 or 4) ____________ vol/vol
(must be between wilting point and porosity)

	Layer 4		Layer 5		Layer 6
(a)	____________	(a)	____________	(a)	____________
(b)	____________	(b)	____________	(b)	____________
(c)	____________	(c)	____________	(c)	____________
(d)	____________	(d)	____________	(d)	____________
(e)	____________	(e)	____________	(e)	____________
(f)	____________	(f)	____________	(f)	____________

Layer 7	Layer 8	Layer 9
(a) ______	(a) ______	(a) ______
(b) ______	(b) ______	(b) ______
(c) ______	(c) ______	(c) ______
(d) ______	(d) ______	(d) ______
(e) ______	(e) ______	(e) ______
(f) ______	(f) ______	(f) ______

Layer 10	Layer 11	Layer 12
(a) ______	(a) ______	(a) ______
(b) ______	(b) ______	(b) ______
(c) ______	(c) ______	(c) ______
(d) ______	(d) ______	(d) ______
(e) ______	(e) ______	(e) ______
(f) ______	(f) ______	(f) ______

If soil texture number of layer 1 is between 1 and 15, enter:
Type of vegetation: ______ (1 to 5)
SCS runoff curve number (optional): ______ (0 to 100)

If the soil texture number of layer 1 is between 16 and 20, enter:
SCS runoff curve number: ______ (0 to 100)

If landfill is open, enter potential runoff fraction: ______ (0 to 1)

Surface area: ______ square feet

Slope of top liner/drain system: ______ percent
Distance from crest to drain in top liner/drain system: ______ feet

Slope of second liner/drain system: ______ percent
Distance from crest to drain in second liner/drain system: ______ feet

Slope of third liner/drain system: ______ percent
Distance from crest to drain in third liner/drain system: ______ feet

Slope of fourth liner/drain system: ______ percent
Distance from crest to drain in fourth liner/drain system: ______ feet

Initial quantity of snow or ice water on surface (not asked if program is to initialize the soil water): ______ inches

* If soil texture number is 19:

(a) wilting point ______ vol/vol
(b) field capacity ______ vol/vol
(c) porosity ______ vol/vol
(d) saturated hydraulic conductivity ______ cm/sec

If soil texture number is 20:

(a) wilting point ______ vol/vol
(b) field capacity ______ vol/vol
(c) porosity ______ vol/vol
(d) saturated hydraulic conductivity ______ cm/sec

USER-SPECIFIED SOIL AND DESIGN DATA INPUT

Title: ______________________________

____

____

Do you want the program to initialize the soil water? ____________

Number of layers: ____________

Layer data:

Layer 1
(a) thickness ____________ inches
(b) wilting point ____________ vol/vol
(c) field capacity ____________ vol/vol
(d) porosity ____________ vol/vol
(e) saturated hydraulic conductivity ____________ cm/sec
(f) layer type ____________ (1 or 2)
(g) liner leakage fraction (only for layer type 4) ____________ (0 to 1)
(h) initial soil water content (not asked if program is to initialize the soil water or if layer type is 3 or 4) ____________ vol/vol
(must be between wilting point and porosity)

Laver 2
(a) thickness ____________ inches
(b) wilting point ____________ vol/vol
(c) field capacity ____________ vol/vol
(d) porosity ____________ vol/vol
(e) saturated hydraulic conductivity ____________ cm/sec
(f) layer type ____________ (1 to 4)
(g) liner leakage fraction (only for layer type 4) ____________ (0 to 1)
(h) initial soil water content (not asked if program is to initialize the soil water or if layer type is 3 or 4) ____________ vol/vol
(must be between wilting point and porosity)

Laver 3
(a) thickness ____________ inches
(b) wilting point ____________ vol/vol
(c) field capacity ____________ vol/vol
(d) porosity ____________ vol/vol
(e) saturated hydraulic conductivity ____________ cm/sec
(f) layer type ____________
(g) liner leakage fraction (only for layer type 4) ____________ (0 to 1)
(h) initial soil water content (not asked if program is to initialize the soil water or if layer type is 3 or 4) ____________ vol/vol
(must be between wilting point and porosity)

Layer 4	Layer 5	Layer 6
(a) ______	(a) ______	(a) ______
(b) ______	(b) ______	(b) ______
(c) ______	(c) ______	(c) ______
(d) ______	(d) ______	(d) ______
(e) ______	(e) ______	(e) ______
(f) ______	(f) ______	(f) ______
(g) ______	(g) ______	(g) ______
(h) ______	(h) ______	(h) ______

Layer 7	Layer 8	Layer 9
(a) ______	(a) ______	(a) ______
(b) ______	(b) ______	(b) ______
(c) ______	(c) ______	(c) ______
(d) ______	(d) ______	(d) ______
(e) ______	(e) ______	(e) ______
(f) ______	(f) ______	(f) ______
(g) ______	(g) ______	(g) ______
(h) ______	(h) ______	(h) ______

Layer 10	Layer 11	Layer 12
(a) ______	(a) ______	(a) ______
(b) ______	(b) ______	(b) ______
(c) ______	(c) ______	(c) ______
(d) ______	(d) ______	(d) ______
(e) ______	(e) ______	(e) ______
(f) ______	(f) ______	(f) ______
(g) ______	(g) ______	(g) ______
(h) ______	(h) ______	(h) ______

SCS runoff curve number: ______ (0 to 100)

If landfill is open, enter potential runoff fraction: ______ (0 to 1)

Surface area: ______ square feet

Slope of top liner/drain system: ______ percent
Distance from crest to drain in top liner/drain system: ______ feet

Slope of second liner/drain system: ______ percent
Distance from crest to drain in second liner/drain system: ______ feet

Slope of third liner/drain system: ______ percent
Distance from crest to drain in third liner/drain system: ______ feet

Slope of fourth liner/drain system: ______ percent
Distance from crest to drain in fourth liner/drain system: ______ feet

Initial quantity of snow or ice water on surface (not asked if program is to initialize the soil water): ______ inches

CLIMATOLOGICAL DATA INPUT

Synthetic Precipitation Option

Location: ______________________________

Number of Years to Be Generated: ____________

Normal Mean Monthly Temperatures in Degrees Fahrenheit (Optional)		Normal Mean Monthly Precipitation in Inches (Optional)	
Jan.	________	Jan.	________
Feb.	________	Feb.	________
Mar.	________	Mar.	________
Apr.	________	Apr.	________
May	________	May	________
Jun.	________	Jun.	________
Jul.	________	Jul.	________
Aug.	________	Aug.	________
Sep.	________	Sep.	________
Oct.	________	Oct.	________
Nov.	________	Nov.	________
Dec.	________	Dec.	________

Maximum Leaf Area Index: ____________

Evaporative Zone Depth in Inches: ____________

CLIMATOLOGICAL DATA INPUT

Default Precipitation Option

Location: ____

Normal Mean Monthly Temperatures in Degrees Fahrenheit (Optional)

Jan.	________	Jul.	________
Feb.	________	Aug.	________
Mar.	________	Sep.	________
Apr.	________	Oct.	________
May	________	Nov.	________
Jun.	________	Dec.	________

Maximum Leaf Area Index: ________

Evaporative Zone Depth in Inches: ________

CLIMATOLOGICAL DATA INPUT

User-Specified Precipitation Option

Location: ______________________________

Normal Mean Monthly Temperatures in Degrees Fahrenheit (Optional)

Jan.	________	Jul.	________
Feb.	________	Aug.	________
Mar.	________	Sep.	________
Apr.	________	Oct.	________
May	________	Nov.	________
Jun.	________	Dec.	________

Maximum Leaf Area Index: ________

Evaporative Zone Depth in Inches: ________

Daily Precipitation Values in Inches Leap Year: ____________

Line	1	2	3	4	5	6	7	8	9	10
1	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/10
2	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	1/20
3	1/21	1/22	1/23	1/24	1/25	1/26	1/27	1/28	1/29	1/30
4	1/31	2/1	2/2	2/3	2/4	2/5	2/6	2/7	2/8	2/9
5	2/10	2/11	2/12	2/13	2/14	2/15	2/16	2/17	2/18	2/19
6	2/20	2/21	2/22	2/23	2/24	2/25	2/26	2/27	2/28	2/29
7	3/1	3/2	3/3	3/4	3/5	3/6	3/7	3/8	3/9	3/10
8	3/11	3/12	3/13	3/14	3/15	3/16	3/17	3/18	3/19	3/20
9	3/21	3/22	3/23	3/24	3/25	3/26	3/27	3/28	3/29	3/30
10	3/31	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	4/9
11	4/10	4/11	4/12	4/13	4/14	4/15	4/16	4/17	4/18	4/19
12	4/20	4/21	4/22	4/23	4/24	4/25	4/26	4/27	4/28	4/29
13	4/30	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9
14	5/10	5/11	5/12	5/13	5/14	5/15	5/16	5/17	5/18	5/19
15	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29
16	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8
17	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/16	6/17	6/18
18	6/19	6/20	6/21	6/22	6/23	6/24	6/25	6/26	6/27	6/28
19	6/29	6/30	7/1	7/2	7/3	7/4	7/5	7/6	7/7	7/8
20	7/9	7/10	7/11	7/12	7/13	7/14	7/15	7/16	7/17	7/18
21	7/19	7/20	7/21	7/22	7/23	7/24	7/25	7/26	7/27	7/28
22	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5	8/6	8/7
23	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17
24	8/18	8/19	8/20	8/21	8/22	8/23	8/24	8/25	8/26	8/27
25	8/28	8/29	8/30	8/31	9/1	9/2	9/3	9/4	9/5	9/6
26	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16
27	9/17	9/18	9/19	9/20	9/21	9/22	9/23	9/24	9/25	9/26
28	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6
29	10/7	10/8	10/9	10/10	10/11	10/12	10/13	10/14	10/15	10/16
30	10/17	10/18	10/19	10/20	10/21	10/22	10/23	10/24	10/25	10/26
31	10/27	10/28	10/29	10/30	10/31	11/1	11/2	11/3	11/4	11/5
32	11/6	11/7	11/8	11/9	11/10	11/11	11/12	11/13	11/14	11/15
33	11/16	11/17	11/18	11/19	11/20	11/21	11/22	11/23	11/24	11/25
34	11/26	11/27	11/28	11/29	11/30	12/1	12/2	12/3	12/4	12/5
35	12/6	12/7	12/8	12/9	12/10	12/11	12/12	12/13	12/14	12/15
36	12/16	12/17	12/18	12/19	12/20	12/21	12/22	12/23	12/24	12/25
37	12/26	12/27	12/28	12/29	12/30	12/31				

Daily Precipitation Values in Inches

Year: ______

Line	1	2	3	4	5	6	7	8	9	10
1	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/10
2	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	1/20
3	1/21	1/22	1/23	1/24	1/25	1/26	1/27	1/28	1/29	1/30
4	1/31	2/1	2/2	2/3	2/4	2/5	2/6	2/7	2/8	2/9
5	2/10	2/11	2/12	2/13	2/14	2/15	2/16	2/17	2/18	2/19
6	2/20	2/21	2/22	2/23	2/24	2/25	2/26	2/27	2/28	3/1
7	3/2	3/3	3/4	3/5	3/6	3/7	3/8	3/9	3/10	3/11
8	3/12	3/13	3/14	3/15	3/16	3/17	3/18	3/19	3/20	3/21
9	3/22	3/23	3/24	3/25	3/26	3/27	3/28	3/29	3/30	3/31
10	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	4/9	4/10
11	4/11	4/12	4/13	4/14	4/15	4/16	4/17	4/18	4/19	4/20
12	4/21	4/22	4/23	4/24	4/25	4/26	4/27	4/28	4/29	4/30
13	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10
14	5/11	5/12	5/13	5/14	5/15	5/16	5/17	5/18	5/19	5/20
15	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30
16	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	6/9
17	6/10	6/11	6/12	6/13	6/14	6/15	6/16	6/17	6/18	6/19
18	6/20	6/21	6/22	6/23	6/24	6/25	6/26	6/27	6/28	6/29
19	6/30	7/1	7/2	7/3	7/4	7/5	7/6	7/7	7/8	7/9
20	7/10	7/11	7/12	7/13	7/14	7/15	7/16	7/17	7/18	7/19
21	7/20	7/21	7/22	7/23	7/24	7/25	7/26	7/27	7/28	7/29
22	7/30	7/31	8/1	8/2	8/3	8/4	8/5	8/6	8/7	8/8
23	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18
24	8/19	8/20	8/21	8/22	8/23	8/24	8/25	8/26	8/27	8/28
25	8/29	8/30	8/31	9/1	9/2	9/3	9/4	9/5	9/6	9/7
26	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16	9/17
27	9/18	9/19	9/20	9/21	9/22	9/23	9/24	9/25	9/26	9/27
28	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7
29	10/8	10/9	10/10	10/11	10/12	10/13	10/14	10/15	10/16	10/17
30	10/18	10/19	10/20	10/21	10/22	10/23	10/24	10/25	10/26	10/27
31	10/28	10/29	10/30	10/31	11/1	11/2	11/3	11/4	11/5	11/6
32	11/7	11/8	11/9	11/10	11/11	11/12	11/13	11/14	11/15	11/16
33	11/17	11/18	11/19	11/20	11/21	11/22	11/23	11/24	11/25	11/26
34	11/27	11/28	11/29	11/30	12/1	12/2	12/3	12/4	12/5	12/6
35	12/7	12/8	12/9	12/10	12/11	12/12	12/13	12/14	12/15	12/16
36	12/17	12/18	12/19	12/20	12/21	12/22	12/23	12/24	12/25	12/26
37	12/27	12/28	12/29	12/30	12/31					