

TECHNICAL NOTE ON USING HELP MODEL (VER. 3.07)

I: INPUT STEPS GUIDE

The purpose of this document is to help the users of HELP Model through the input procedures, and interpretation of the output results . All information contained herein are from HELP “User’s Guide” and “Engineering Documentation” for version 3. Included is a step-by-step example, which is a part of the GRI report # 19, page 34- 37 (leachate collection system).

INSTALLATION NOTE

You can download the latest version of HELP Model 3.07 from the following web-site address: <http://www.wes.army.mil/el/elmodels/index.html>. You will save the downloaded file (zhelp3w.exe or zhelp3p.exe) onto a temporary subdirectory, after you execute the file it will be self extracted into some files needed for the setup. From the files that have been self extracted, you run the setup file follow the steps that will show on the screen.

Whether you download HELP Model program from the internet or install it from a floppy, the files should be installed (or copied) in a subdirectory directly under the root, i.e. C:\ or D:\. The executable file is called “Help3.bat”.

INPUT STEPS

1. Weather Data

From the main menu you choose option 1 “**Enter/ Edit Weather Data**”, this will prompt you to another screen with the following four options:

Evapotranspiration; Precipitation; Temperature; and Solar radiation

For each you hit “PgDn” to start new file, or “F4” to choose from a list of saved files. Below is a description of the input data required for each of the four weather selections.

1.1 Evapotranspiration

Evapotranspiration is the first weather option the program is going to prompt you for if you are starting a new project. However, if you’re editing an existing project you’ll be prompted to the screen corresponding to your selection of either of the four weather data.

- a) Units: with up or down arrows you select either 1 Customary (English), or 2 Metric. In the current example we selected **Metric**.
- b) City: If you’re going to select **default** option, you hit ”F5” to select a “State” first and then a “City” that is closest to the landfill location, then all the corresponding required data will be filled except for the following two data:

“**Evaporative Zone Depth**” in centimeters which is at least equal to the expected average depth of root penetration. To the right of the screen a table with three columns will appear that indicates the input value, you choose a value depending on the condition of vegetation expected.

Bare	Fair	Excellent
25	55	101

In our example we’ll select **Texas, Austin, 25 cm** (for no vegetation)

“**Leaf Area Index**” (LAI), LAI is a dimensionless ratio of the leaf area that is actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. Below is a table that lists the LAI values for different conditions of vegetation.

Bare	Poor Stand of Grass	Fair Stand of Grass	Good Stand of Grass	Excellent Stand of Grass
0.0	1.0	2.0	3.5	5.0

In our example we’ll choose **0.0** for no vegetation condition.

If you’re going to select the **manual** option, in addition to the above two parameters you’ll be asked to input the following parameters: location (city and state), dates of starting and ending the growing season, normal average annual wind speed, and Normal average quarterly relative humidity. The last three data are available from “Climatic Atlas of the United States” (NOAA, 1974)

1.2 Precipitation, Temperature, Solar Radiation

The input options for the above three weather data are: **Synthetic, Create/Edit, NOAA tape, Climatedata, ASCII file, HELP Version 2, and Canadian Climatological**. Only Precipitation has an extra option which is **Default**. Below is a description of the input options:

Default (Precipitation only): The user may select any of the stored 102 cities for which the historical precipitation data are recorded during 5 years from 1974 to 1978. In the current example this option is chosen and the city of **San Antonio, Texas** is selected.

Synthetic: the program will generate from 1 to 100 years of daily Precipitation, Temperature, or Solar Radiation data stochastically for the selected location using a synthetic weather generator. The user may enter normal mean monthly precipitation values for the location to improve the statistical characteristics of the resulted daily values. For that option user needs to specify a location from 139 stored cities, number of years of data to be generated, and normal mean monthly value (optional).

For the current example the synthetic option is chosen for both temperature and solar radiation data where the city of **Austin, Texas**, and **5** years are selected.

Create/Edit, NOAA tape, Climatedata, ASCII file, HELP Version 2, and Canadian Climatological: all of these 6 options require the user to input the location (city and state), and the corresponding daily precipitation, temperature, or solar radiation data stored in a saved file(s) name, the format of the file(s) differs from option to the other. All options accept customary or metric units.

After completing entering the weather data input, you hit “F10” to end and save by typing the path and the name of each of the four saved files. The files will take automatically a default extensions as: D4; D7; D13; and D11 for Precipitation; Temperature; Solar radiation; and Evapotranspiration respectively (do not attempt to change the default extensions). After saving the files, you’ll be prompted to the main menu screen. The program will prompt you to a warning screen if one or more of the data is missed or incorrect.

2. Soil Data

From the main menu you choose option 2 “**Enter/ Edit Soil Data**”, this will prompt you to another screen where you either hit “PgDn” to start new file, or “F4” to choose from a list of saved files. Below is a description of the input soil data:

2.1 Initial Information

The first screen of soil data input contains the following required information:

Unit System: on the same screen you are prompted to select a unit system, in the current example we selected **Metric**, Then you’re prompted to another screen where you input;

Project Title: in the current example: “**Example in GRI Report # 19**”

Landfill Area: in the current example: **4 hectares**

Percent of landfill where runoff is possible: in the current example **100%**

Method of initialization of moisture storage: you have two options: 1) to choose to enter the initial moisture content for the soil layers in the analyzed profile as per the available soil information, and then at the following screen you’ll input the corresponding values. 2) to let the program initialize the moisture content to the near steady-state condition, **option (2)** is selected in the current example.

Initial Snow/Water Storage: this piece of information is optional and needed when moisture storage is user-defined.

2.2 Layers Information

The second, third, and fourth screens contain the layers information as follows:

2.2.1 General Soil Information

Layer Type: four types of layers are supported by HELP model; 1) vertical percolation, 2) lateral drainage, 3) barrier soil liner, and 4) geomembrane liner

Layer thickness: in customary or Metric systems

Soil Texture: the soil texture information contains four properties;

- Porosity (vol/vol)
- Field Capacity (vol/vol)
- Wilting point (vol/vol), and
- Saturated hydraulic conductivity (cm/sec)

The user has the option to select from a 42 default soil/ material textures, select from user-built soil texture library where the properties will be automatically assigned, or to enter the above information manually. To learn more about the above properties refer to section “3.5 Soil Characteristics” of HELP Model User’s Guide.

Initial moisture storage: vol/vol, optional if you choose option (1) of “Method of initialization of moisture storage” in section 2.1.

Rate of subsurface inflow to layer: optional, customary or Metric unit systems (mm or inch/year).

2.2.2 Layer Specific Information

The four types of layers that are supported by HELP model are explained below:

Vertical Percolation Layer: waste and vegetation support layers are examples of vertical percolation layer. The downward flow in the vertical percolation layer is modeled by the unsaturated vertical gravity drainage. The upward flux due to evapotranspiration is modeled as an extraction.

Lateral Drainage Layer: the lateral drainage layer is designed to promote drainage laterally to a collection and removal system. The vertical flow in this layer is modeled as in the vertical percolation layer, however, a saturated lateral drainage is also allowed. In addition to the soil data in section 2.2.1, the following information are also required to model the lateral drainage layer:

- Max drainage length: customary or Metric. The horizontal projection of the slope, rather than the distance along the slope.
- Drain slope: percent. From 0 to 50 percent

- Percentage of recirculated to collected leachate. From 0 to 100%
- Layer No. to receive the recirculated leachate. Vertical percolation or lateral drainage. Layer number.

Barrier soil liners: are intended to restrict vertical drainage/ leakage/ percolation. These layers should have significantly lower hydraulic conductivity than the other layers. The barrier soil layer is assumed to be saturated all time but leak only when there is a positive head on the top surface of the liner. HELP model allows only downward saturated flow through the barrier soil layer, thus any water moving into the liner will eventually percolate through it. Evapotranspiration and lateral drainage are not permitted.

Geomembrane liners: are virtually impermeable synthetic membranes that reduce the area of vertical drainage/ leakage/ percolation to a very small fraction of the area located near manufacturing flaws and installation defects. Also a small quantity of vapor transport is modeled by specifying the vapor diffusivity of the geomembrane liner. In addition to data listed in section 2.2.1, the following information is required:

- Pinhole density: (#/acre or hectare). Defects of a diameter equal or smaller than the membrane thickness (estimated as 1 mm in diameter). Typical geomembranes may have from 0.5 to 1 pinhole per acre (1 to 2 per hectare).
- Installation defects density: (#/acre or hectare). Defects of a diameter greater than the membrane thickness (estimated as 1 cm² in area).

Installation Quality	Defect Density (#/acre)	Frequency (%)
Excellent	Up to 1	10
Good	1 to 4	40
Fair	4 to 10	40
Poor	10 to 20 (old landfills)	10

- Placement quality: addresses the quality of contact between geomembrane and the underneath soil that limits the drainage rate. The table below explains the 6 cases supported by HELP model:

- | | |
|---------------|--|
| 1. Perfect | Assumes perfect, (no gap, “sprayed-on” seal) |
| 2. Excellent | Assumes exceptional contact (typically achievable only in the lab) |
| 3. Good | Assumes good field installation with well-prepared, smooth soil surface and geomembrane wrinkle control |
| 4. Poor | Assumes poor field installation with a less well-prepared soil surface and/ or geomembrane wrinkling control |
| 5. Worst Case | Assumes that contact between geomembrane and the underneath does not limit drainage rate |

6. Separating Geotextile Assumes leakage spreading and rate is controlled by the in-plane transmissivity of the geotextile separating the geomembrane and the adjacent soil layer. This quality does not apply to GCL where bentonite swells upon wetting and extrudes into the geotextile significantly reducing its ability to spread the leakage.

- Saturated hydraulic conductivity: (vapor diffusivity), cm/sec
- Geotextile in-plane transmissivity, cm^2/sec (optional when placed with geomembrane)

In the current example two layers are simulated, the following is the information required from the user as input. Other information is set up as default values corresponding to the layer's texture number:

1) Lateral drainage layer

- Type 2
- thickness 45 cm
- texture number 21
- slope length 10 m
- slope: 33%
- percent of recirculated leachate; zero%

2) Geomembrane liner

- Type 4
- thickness 0.15 cm
- texture number 35
- zero pinholes and zero installation defects
- placement quality: 1 (perfect)

2.3 Site Characteristics

The third screen contains the runoff curve number information, the user has three options to input the SCS runoff curve number: 1) defined by the user, 2) defined by the user and modified

by HELP model for slope surface and length, and 3) computed by HELP model based on top layer texture, slope length and slope.

In the current example **option 3** is selected and the corresponding slope %, slope length, soil texture and vegetation conditions (1: bare, 2:poor, 3: fair, 4:good, 5: excellent stand of grass) are input as in the previous step for the top layer (drainage layer). The SCS runoff curve number calculated by HELP model is **75.9**.

After completing entering the soil data input, you hit “F10” to end and save by typing the path and name of the file, the file will take automatically a default extension as: D10 (do not attempt to change the default extensions). After saving the file, you’ll be prompted to the main menu screen. The program will prompt you to a warning screen if one or more of the data is missed or incorrect.

3. Execution, Viewing and Printing Results

From the main menu you choose option 3 “**Execute Simulation**” which will prompt you to a screen where you type the five files’ names which contain weather and soil data information. Then to another screen where the program asks for the unit system wanted for the output (regardless of the system used in the input data), number of years during which the output is generated, and the intervals of the generated output; annual, monthly, or daily. The program will take few minuets (variable depending on your computer speed) to execute the project information, then it’ll prompt to the main menu. To view or to print* the out put you choose either option 4 “**View Results**”, or option 5 “**Print Results**”.

A printout of the example discussed above is included.

*Since HELP model is DOS operated program, a conflict in the printing command may occur. It’s recommended to open and print the output file “**filename.out**” through the program “**Notepad**” found in your Windows 95 system under: “start/programs/accessories/notepad”.

4. Flux Calculations

Referring to the output table: “Peak Daily Values for Years 1974 Through 1978”, drainage collected from layer 1= 61.12513 mm (0.061 m/day)

$$\begin{aligned} \text{Hourly Flux (m}^3\text{/hr)/ width (m)} &= \text{Depth of Liquid Collected Daily (m/day) x Slope length (m)} \\ &/ 24 \text{ (hr/day)} \\ &=(0.061)*(10)/24 = 0.025 \text{ m}^3\text{/hr-m width} \end{aligned}$$

II: DRAINAGE GEOCOMPOSITE INPUT DATA

As discussed in section I, the input data for the lateral drainage Layer (Layer Type 2) could be divided into two categories; 1) project specific , and 2) product specific. The properties under the project specific category are listed on page 4 of section I. This section discusses the product specific properties for the lateral drainage layer with an emphasis on geosynthetic drainage geocomposites. In general, it should be noted that unlike the conventional soil drainage layer (sand or aggregate), the physical and hydraulic properties of geosynthetic materials are highly dependent on project's design criteria, such as anticipated normal load, hydraulic gradient, and boundary conditions. The five required properties for the drainage layer are as follows:

1. Thickness (mm, inch)

The layer thickness determined at the anticipated normal load.

2. Porosity (vol/vol)

The volume of space/total volume.

3. Field Capacity (vol/vol)

Field capacity as defined in HELP Model is the amount of water that the product will accept before gravity flow could commence in the layer.

4. Wilting Point (vol/vol)

Wilting point by definition is the maximum amount of moisture in the material that can not be drawn by plants

5. Saturated Hydraulic Conductivity (cm/sec)

The saturated hydraulic conductivity of the geonets are determined by dividing the transmissivity measured under the required design and field conditions by the corresponding thickness of the geonet.

The table below presents the above discussed properties for two of Tenax's geocomposites; Tenflow and Tendrain used typically for landfill capping and lining applications respectively.

Tenax's Lateral Drainage Layer Input Data for HELP Model

Geonet Type	Thickness* (mm/mils)	Porosity (vol/vol)	Field Capacity+ (vol/vol)	Wilting Point+ (vol/vol)	Saturated Hydraulic Conductivity++ (cm/sec)
Tenflow	7.30/ 287	0.86	0.01	0.005	15.8
Tendrain	5.14/ 202	0.70	0.01	0.005	12.4

*Measured at anticipated stress level of 1,000 psf for Tenflow, and 15,000 for Tendrain (geonet only)

+ Per HELP Model default value for drainage geonets

++Determining the Design Hydraulic Conductivity for Drainage Geocomposites.

Equations:

$$T_{all} = \frac{T_{ult}}{RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}} \quad (1)$$

Where,

T_{all} = allowable Transmissivity [cm^2/s]

T_{ult} = ultimate Transmissivity measured in the lab [cm^2/s]

RF_{in} = reduction factor for intrusion of adjacent geotextile

RF_{cr} = reduction factor for creep deformation

RF_{cc} = reduction factor for chemical clogging

RF_{bc} = reduction factor for biological clogging

$$T_{dsg} = \frac{T_{all}}{FS} \quad (2)$$

Where,

T_{dsg} = design Transmissivity used in calculations [cm^2/s]

FS = overall factor of safety

$$T_{dsg} = k_{dsg} * t_{dsg} \quad (3)$$

Where,

k_{dsg} = design hydraulic conductivity used in calculations [cm^2/s]

t_{dsg} = design thickness used in calculations [cm]

Solution:

Landfill Final Closure:

- 1) Estimated design load on landfill foundation = 1,000 psf
- 2) Ultimate Transmissivity = $T_{ult} = 4.0 * 10E-3 \text{ m}^2/\text{sec} = 40 \text{ cm}^2/\text{s}$
(geocomposite tested in soil boundary condition under 1,000 psf, a hydraulic gradient of 0.33, and a seating period of 100 hours)
- 3) Using Table 1 for typical values of reduction factors, *Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International*: $R_{Fin} = 1.1$, $R_{Fcc} = 1.1$, $R_{Fbc} = 1.4$
- 4) Using $R_{Fcr} = 1.02$ (determined value for Tenflow)
- 5) $FS = 2.0$ (state of practice typical value)
- 6) **$t_{dsg} = 0.730 \text{ cm (0.287 inches)}$**

Substituting in Equation (1): $T_{all} = 23.1 \text{ cm}^2/\text{sec}$

Substituting in Equation (2): $T_{dsg} = 11.6 \text{ cm}^2/\text{sec}$

Substituting in Equation (3): **$k_{dsg} = 15.8 \text{ cm/sec}$**

Landfill Liner Prior to Final Closure:

- 1) Estimated design load on landfill foundation = 15,000 psf
- 2) Ultimate Transmissivity = $T_{ult} = 5.0 * 10E-3 \text{ m}^2/\text{sec} = 50 \text{ cm}^2/\text{s}$
(geocomposite tested in soil boundary condition under 15,000 psf, a hydraulic gradient of 0.02, and a seating period of 100 hours)
- 3) Using Table 1 for typical values of reduction factors, *Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International*: $R_{Fin} = 1.2$, $R_{Fcc} = 1.75$, $R_{Fbc} = 1.75$
- 4) Using $R_{Fcr} = 1.07$ (determined value for Tendrain)

5) FS = 2.0 (state of practice typical value)

6) $t_{dsg} = 0.514 \text{ cm (0.202 inches)}$

Substituting in Equation (1): $T_{all} = 12.7 \text{ cm}^2/\text{sec}$

Substituting in Equation (2): $T_{dsg} = 6.4 \text{ cm}^2/\text{sec}$

Substituting in Equation (3): $k_{dsg} = 12.4 \text{ cm}/\text{sec}$

Please note that the above calculations were done assuming typical information for the design requirements of a landfill liner and a landfill cap systems, as well as product design data for specific drainage geocomposites. The design engineer should implement the design data that are representative to the project in design and the considered products.