

EPA Tools and Resources Training Webinar: EPA's Hydrologic Evaluation of Landfill Performance (HELP) Model v4.0

Max Krause

Thabet Tolaymat

US EPA Office of Research and Development

April 7, 2022

Hydrologic Evaluation of Landfill Performance (HELP) Model

- The HELP model is used by landfill designers/owners to demonstrate that the leachate depth over a landfill liner does not exceed the 30 cm (one foot) limit required by the Resource Conservation and Recovery Act 40 CFR 264.301 “Design and Operating Requirements” for landfills.
- The HELP model is a quasi-two-dimensional hydrologic model of water movement through landfills. The program can also evaluate:
 - Runoff
 - Evapotranspiration
 - Infiltration of precipitation into the landfill
 - Vertical percolation of leachate
 - Leachate collection rate

HELP Model - Background

The model uses the following key inputs to model the water balance and percolation through waste and leachate collection system:

1. Vegetation cover quality
2. Soil types
3. Geosynthetic materials
4. Initial moisture conditions
5. Layer thicknesses
6. Slope of the bottom liner
7. Leachate collection pipe spacing and liner placement quality

HELP Model - Background

HELP v3.07

1. The HELP model was developed for the EPA by the US Army Corps of Engineers Waterways Experiment Station in the early 1980s. Version 3.0 was published in 1994.
2. It has a Disk Operating System (DOS)-based user interface.
3. The output is provided in a text file. The output file data export into Microsoft (MS) Excel for data analysis is a time and labor-intensive process.

HELP v4.0 Upgrades

1. HELP v4.0 is the latest version of the HELP model available for public use.
2. It uses an Excel workbook with embedded macros to support the user interface. It is platform-independent.
3. Outputs are in spreadsheet format.
4. The number of locations that can be modeled is significantly expanded in this version.

Downloading and Installing HELP v4.0

Link: <https://www.epa.gov/land-research/hydrologic-evaluation-landfill-performance-help-model>


or

Search for “EPA HELP v4.0” on Google

Click on
to download
the HELP v4.0



Downloads

 [HELP Model 4.0.1 \(zip\)](#)

[HELP 4.0 User Manual](#)

Documentation to Learn More About HELP

US EPA. (2017) [Walkthrough to Install and Operate the Hydrologic Evaluation of Landfill Performance \(HELP\) Model, Version 3.07](#).

US EPA. (1984) [Hydrologic Evaluation Of Landfill Performance \(HELP\) Model, Volume 1 \(PDF\)](#). Publication No. EPA/530/SW-84/009.

US EPA. (1984) [Hydrologic Evaluation Of Landfill Performance \(HELP\) Model Volume 2 \(PDF\)](#). Publication No. EPA/530/SW-84/010.

US EPA. (1994) [Hydrologic Evaluation of Landfill Performance \(HELP\) Model: A \(Set Includes, A- User's Guide for Version 3 w/disks, B- Engineering Documentation for Version 3\) \(PDF\)](#). Publication No. EPA/600/R-94/168A, 1994

US EPA. (1994) [Hydrologic Evaluation of Landfill Performance \(HELP\) Model B \(Set Includes, A- User's Guide for Version 3 w/disks, B- Engineering Documentation for Version 3\) \(PDF\)](#). Publication No. EPA/600/R-94/168b, 1994

US EPA. (1988) [Verification Of The Hydrologic Evaluation Of Landfill Performance \(HELP\) Model Using Field Data](#). Project Summary. Publication No. EPA/600/S2-87/050

US EPA. (1987) Verification of the Hydrologic Evaluation of Landfill Performance (HELP) Model Using Field Data. Report. NTIS PB87-227518

This page also contains a **User Manual** for HELP v4.0 and **documentation about the fundamentals of the model.**

Downloading and Installing HELP v4.0

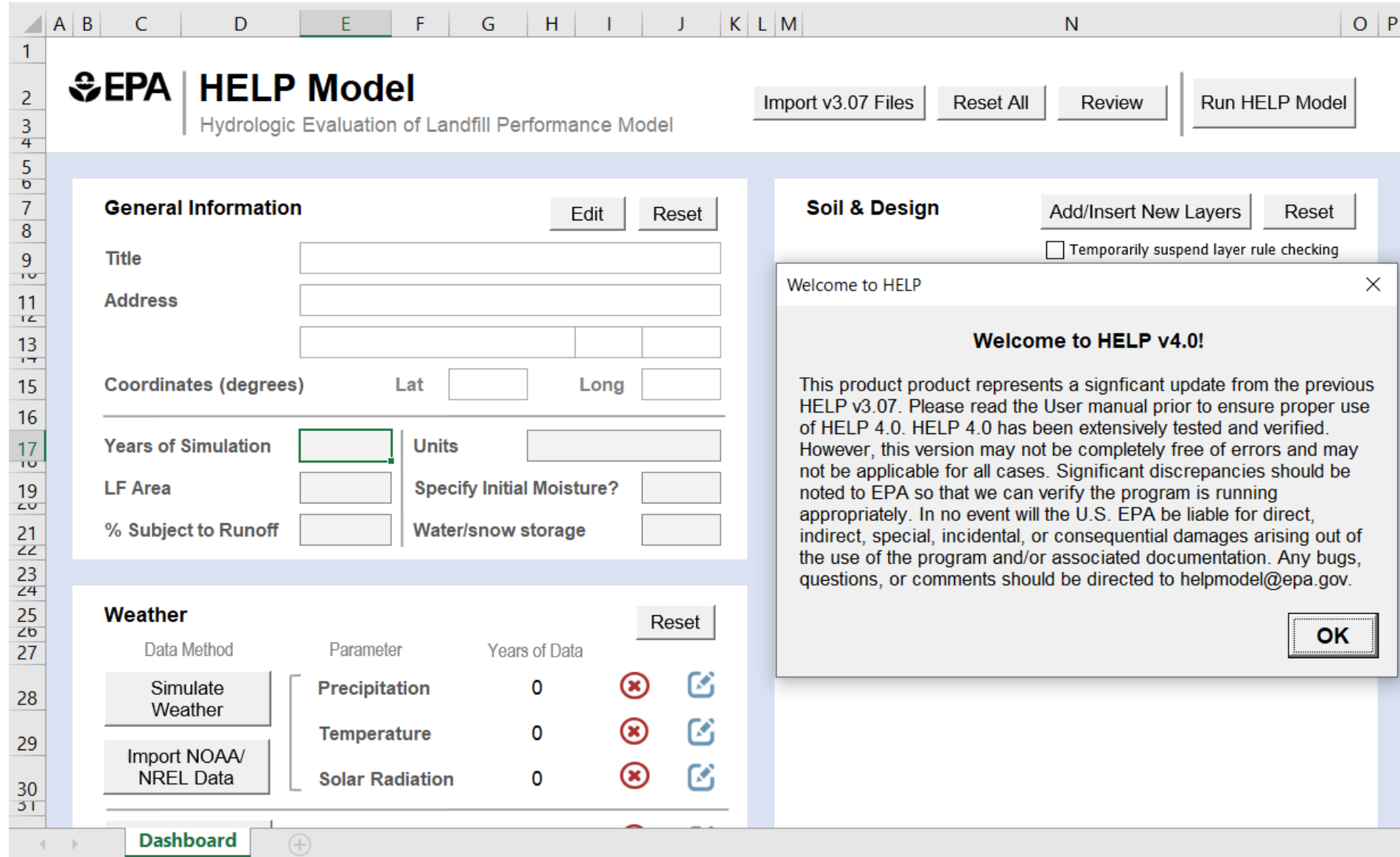
1. Unzip and extract the files from the downloaded zip file.
2. The extracted folder will contain two files, HELP v4.0 and WGEN

 HELP4.0.1 WGEN ParVals for OPP Grid

3. The 'HELP4.0.1' file is the HELP model.
4. The 'WGEN ParVals for OPP Grid' (developed by the US Department of Agriculture (USDA) Agricultural Research Service) file is a synthetic weather generator.
5. HELP 4.0 can stochastically generate up to 100 years of daily precipitation, temperature, and solar radiation data for over 13,000 locations in the US.

Running the HELP model

1. Open the file 'HELP4.0.1'
2. The interface of the model is a worksheet titled **Dashboard**.



EPA HELP Model
Hydrologic Evaluation of Landfill Performance Model

Buttons: Import v3.07 Files, Reset All, Review, Run HELP Model

General Information (Edit, Reset)

Title:
 Address:
 Coordinates (degrees): Lat Long
 Years of Simulation: Units:
 LF Area: Specify Initial Moisture?:
 % Subject to Runoff: Water/snow storage:

Soil & Design (Add/Insert New Layers, Reset)

Temporarily suspend layer rule checking

Welcome to HELP v4.0!

This product represents a significant update from the previous HELP v3.07. Please read the User manual prior to ensure proper use of HELP 4.0. HELP 4.0 has been extensively tested and verified. However, this version may not be completely free of errors and may not be applicable for all cases. Significant discrepancies should be noted to EPA so that we can verify the program is running appropriately. In no event will the U.S. EPA be liable for direct, indirect, special, incidental, or consequential damages arising out of the use of the program and/or associated documentation. Any bugs, questions, or comments should be directed to helpmodel@epa.gov.

OK

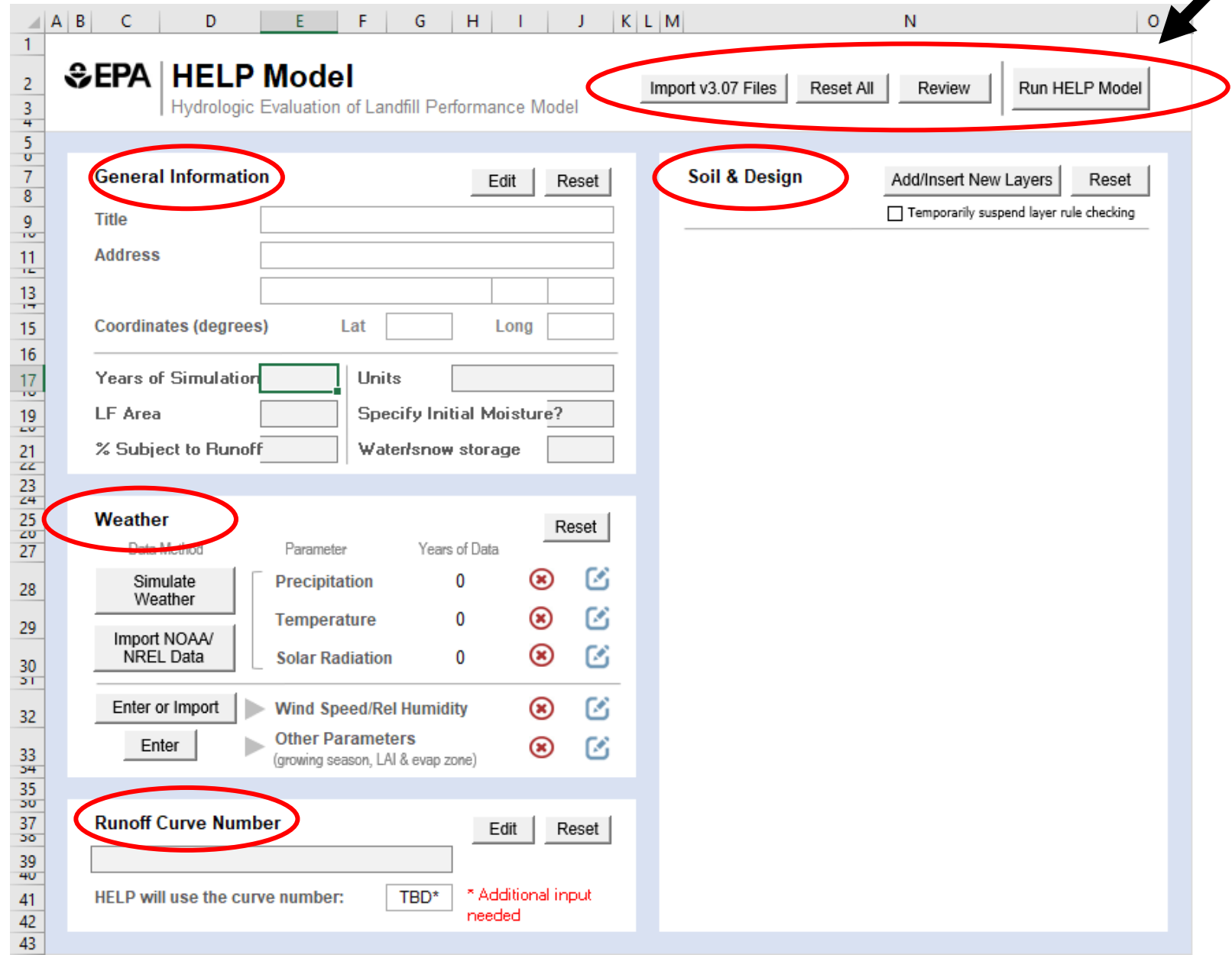
Weather (Reset)

Data Method	Parameter	Years of Data		
Simulate Weather	Precipitation	0	✘	🔗
	Temperature	0	✘	🔗
	Solar Radiation	0	✘	🔗
Import NOAA/NREL Data	Precipitation			
	Temperature			
	Solar Radiation			

Dashboard

Running the HELP model

Control Panel



The screenshot shows the EPA HELP Model interface. The title bar includes the EPA logo and the text "HELP Model Hydrologic Evaluation of Landfill Performance Model". The interface is divided into several panels, each circled in red:

- Control Panel:** Located at the top right, containing buttons for "Import v3.07 Files", "Reset All", "Review", and "Run HELP Model".
- General Information:** Located on the left side, containing fields for "Title", "Address", "Coordinates (degrees) Lat", "Long", "Years of Simulation", "Units", "LF Area", "% Subject to Runoff", and "Water/snow storage".
- Soil & Design:** Located on the right side, containing buttons for "Add/Insert New Layers" and "Reset", and a checkbox for "Temporarily suspend layer rule checking".
- Weather:** Located in the middle, containing a table of weather parameters and a "Reset" button.

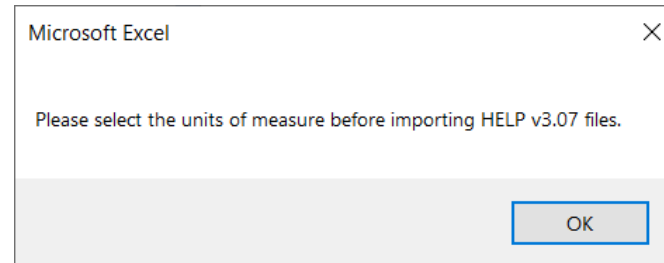
Data Method	Parameter	Years of Data		
Simulate Weather	Precipitation	0	✘	🔗
Import NOAA/NREL Data	Temperature	0	✘	🔗
Enter or Import	Solar Radiation	0	✘	🔗
Enter	Wind Speed/Rel Humidity		✘	🔗
	Other Parameters (growing season, LAI & evap zone)		✘	🔗
- Runoff Curve Number:** Located at the bottom, containing a field for the curve number and buttons for "Edit" and "Reset".

The Dashboard consists of five main panels:

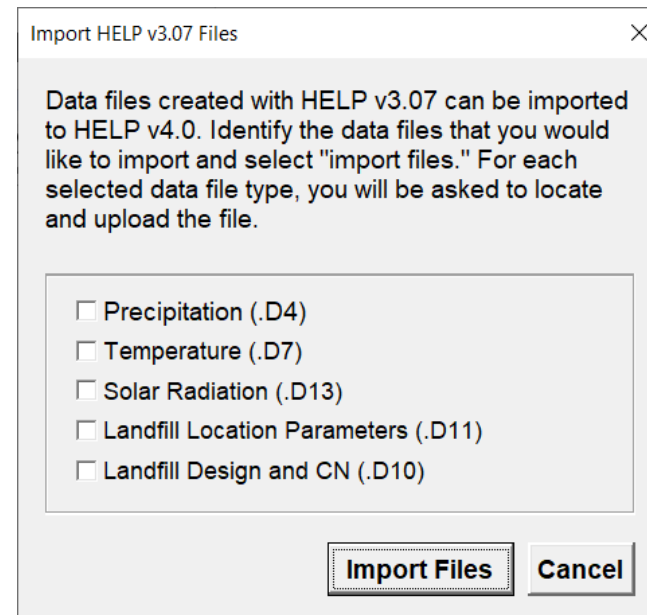
1. General Information
2. Weather
3. Runoff Curve Number
4. Soil & Design
5. Control Panel

Running the HELP model

- Before the user can input or import any data, the HELP model requires the user to select the unit system.



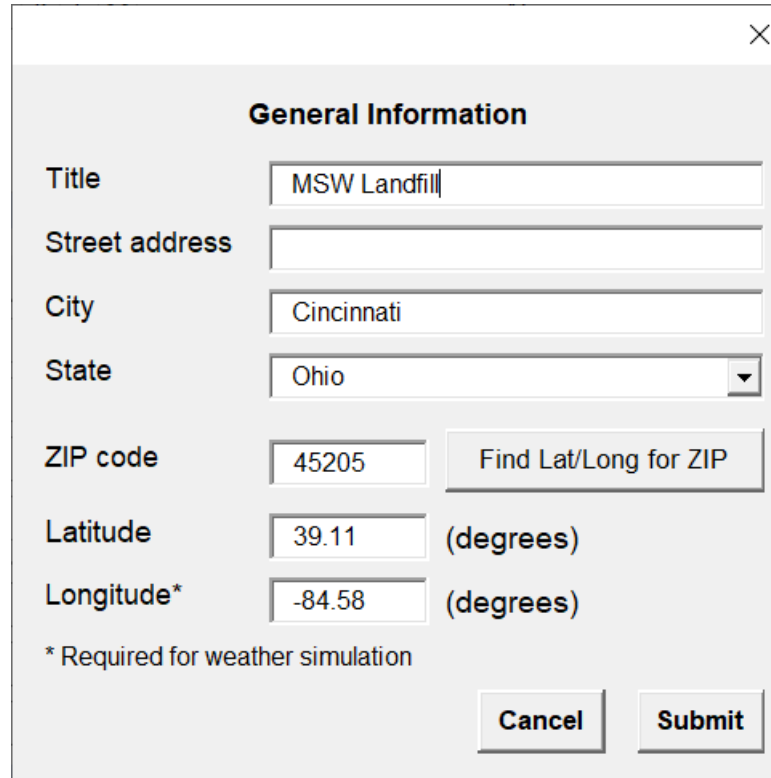
- The Control Panel allows the user to make global changes, including importing data files from HELP v3.07, resetting all fields, reviewing model input, and running the HELP model.
- The new version allows importing one or more v3.0.7 input files. Clicking on the 'Import v3.0.7 files' opens a pop-up window for the user to import.



Running the HELP model

General Information

- The HELP model can identify the latitude and longitude of the landfill based on the zip code input.
- The coordinates can be used to generate location-specific weather data.



The screenshot shows a dialog box titled "General Information" with a close button (X) in the top right corner. The form contains the following fields and controls:

- Title:** Text input field containing "MSW Landfill".
- Street address:** Empty text input field.
- City:** Text input field containing "Cincinnati".
- State:** Dropdown menu showing "Ohio".
- ZIP code:** Text input field containing "45205".
- Find Lat/Long for ZIP:** Button next to the ZIP code field.
- Latitude:** Text input field containing "39.11" followed by "(degrees)".
- Longitude*:** Text input field containing "-84.58" followed by "(degrees)".
- * Required for weather simulation:** A note below the longitude field.
- Cancel:** Button at the bottom right.
- Submit:** Button at the bottom right.

Running the HELP model

General Information

- 1. Years of Simulation (simulation duration):** Should be between 1 and 100.
- 2. Landfill Area:** It is the landfill footprint.
 1. The user can run multiple sections individually (e.g., top deck, side slopes) in separate model runs.
- 3. % Subject to Runoff:** The portion of the sloped area to promote run off the surface.

General Information		Edit	Reset
Title	<input type="text" value="MSW Landfill"/>		
Address	<input type="text"/>		
	<input type="text" value="Cincinnati"/>	<input type="text" value="OH"/>	<input type="text" value="45205"/>
Coordinates (degrees)	Lat	<input type="text" value="39.11"/>	Long <input type="text" value="-84.58"/>
Years of Simulation	<input type="text" value="10"/>	Units	<input type="text" value="U.S. Standard"/>
LF Area (acres)	<input type="text" value="1.00"/>	Specify Initial Moisture?	<input type="text" value="No"/>
% Subject to Runoff	<input type="text" value="75"/>	Water/snow storage (in)	<input type="text"/>

Running the HELP model

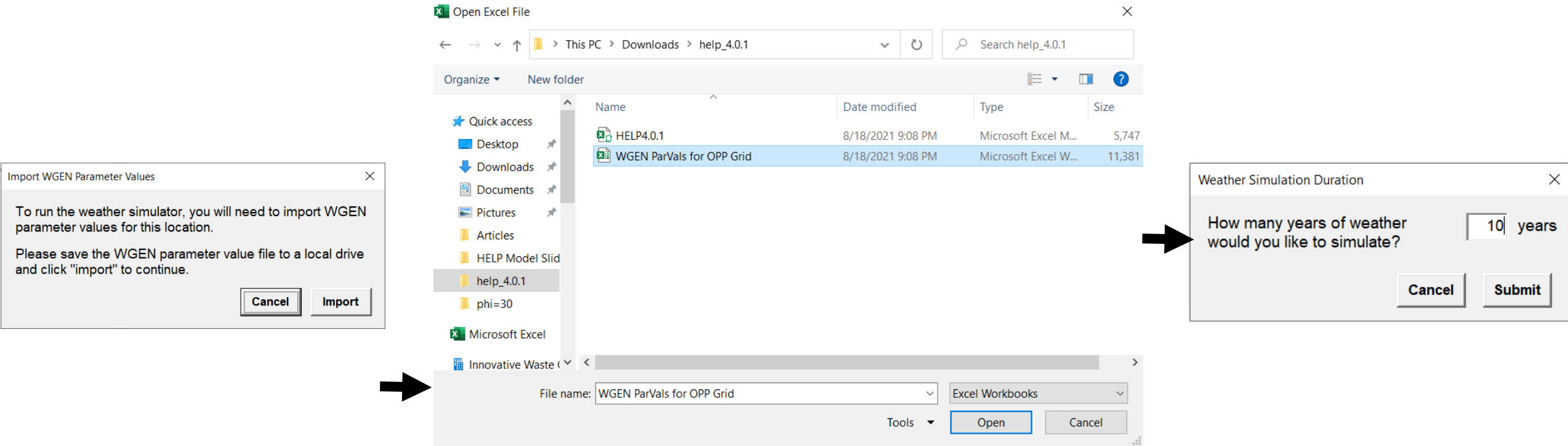
General Information

- 3. Specify Initial Moisture?:** Initial moisture content for the landfill layers can be specified if data are available by clicking 'Yes.' If 'No' is selected, the model assumes near steady-state values and runs the first year of the simulation to improve the initialization to steady-state. Soil water contents at the end of this year of initialization are used as the initial values for the simulation period.
- 4. Initial water/snow water storage on landfill:** If the user decides to specify initial moisture, the amount of water or snow water on the landfill surface can be entered.

General Information				Edit	Reset
Title	MSW Landfill				
Address					
	Cincinnati	OH	45205		
Coordinates (degrees)	Lat	39.11	Long	-84.58	
Years of Simulation	10	Units	U.S. Standard		
LF Area (acres)	1.00	Specify Initial Moisture?	No		
% Subject to Runoff	75	Water/snow storage (in)			

Running the HELP model

Synthetically Generated Weather Data



The screenshot illustrates the process of running the HELP model. It features three main components:

- Open Excel File Dialog:** A file explorer window showing the path `This PC > Downloads > help_4.0.1`. It contains a table of files:

Name	Date modified	Type	Size
HELP4.0.1	8/18/2021 9:08 PM	Microsoft Excel M...	5,747
WGEN ParVals for OPP Grid	8/18/2021 9:08 PM	Microsoft Excel W...	11,381

The file `WGEN ParVals for OPP Grid` is selected. Below the table, the `File name` field contains `WGEN ParVals for OPP Grid` and the file type is set to `Excel Workbooks`. The `Open` button is highlighted.

- Import WGEN Parameter Values Dialog:** A dialog box with the text: "To run the weather simulator, you will need to import WGEN parameter values for this location. Please save the WGEN parameter value file to a local drive and click 'import' to continue." It includes `Cancel` and `Import` buttons.
- Weather Simulation Duration Dialog:** A dialog box asking "How many years of weather would you like to simulate?" with a text input field containing `10` and `years`. It includes `Cancel` and `Submit` buttons.

Arrows indicate the flow of the process: from the `Open` button in the file dialog to the `Import` button, and from the `Submit` button to the next step.

Running the HELP model

Importing Weather Data from NOAA¹/NREL²

Choose Weather Data to Import

Please choose the type of data that you wish to import:

- Precipitation and Temperature Data from NOAA
- Solar Radiation Data from NREL (NSRDB)

Import Data **Cancel**

Import Precipitation and Temperature Data

Step 1. Download NOAA precipitation and temperature data for three stations near the landfill. Please refer to Appendix B of the User Manual for detailed instructions.

Step 2. When you've downloaded and saved the data, select "import" to continue.

Cancel **Import**

Import Solar Radiation Data

Step 1. Download solar radiation data from the National Solar Radiation Data Base (NSRDB). Please refer to Appendix C of the User Manual for detailed instructions.

Step 2. When you've downloaded and saved the data, enter the NSRDB site name below and select "import" to continue.

Site Name:

Cancel **Import**

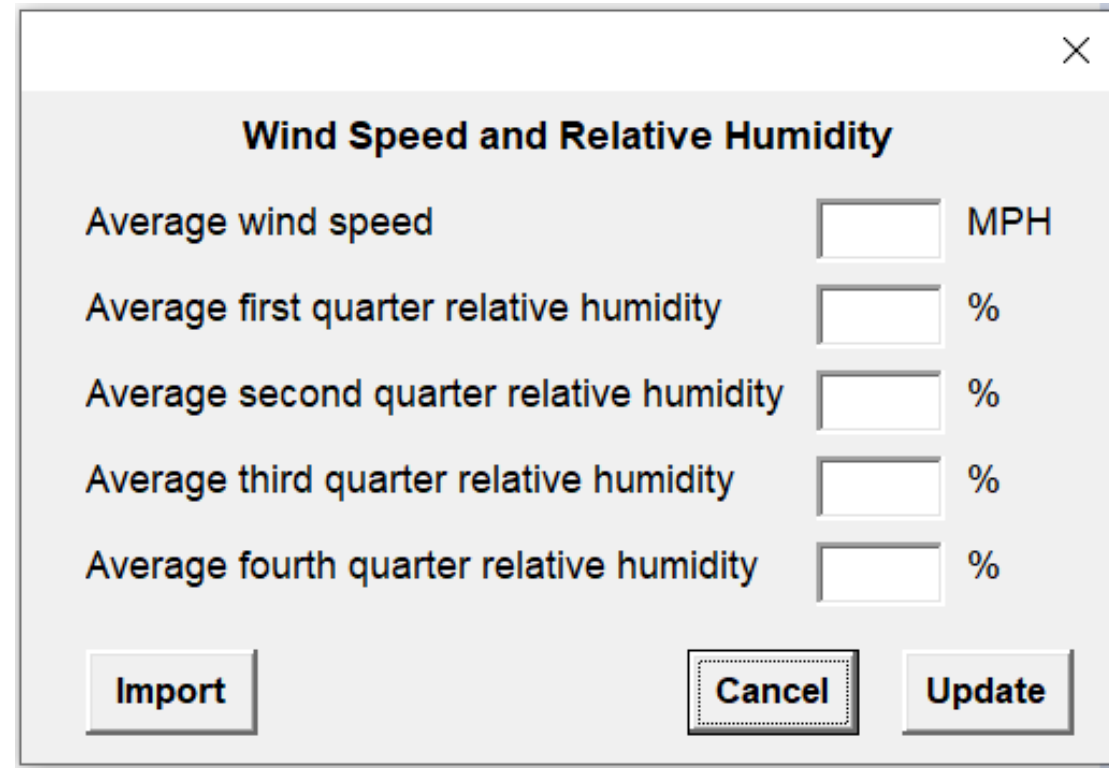
¹National Oceanic and Atmospheric Administration

²National Renewable Energy Laboratory

Running the HELP model

Wind Speed and Relative Humidity

- User may input the average wind speed and relative humidity manually or import wind speed and relative humidity data from the NSRDB¹ website.



Wind Speed and Relative Humidity

Average wind speed MPH

Average first quarter relative humidity %

Average second quarter relative humidity %

Average third quarter relative humidity %

Average fourth quarter relative humidity %

Running the HELP model

Other Parameters

- User must input the start of the growing year, end of the growing year, maximum leaf area index, and the evaporative zone depth.
- The start and end of the growing season are dependent on the normal mean daily temperature.

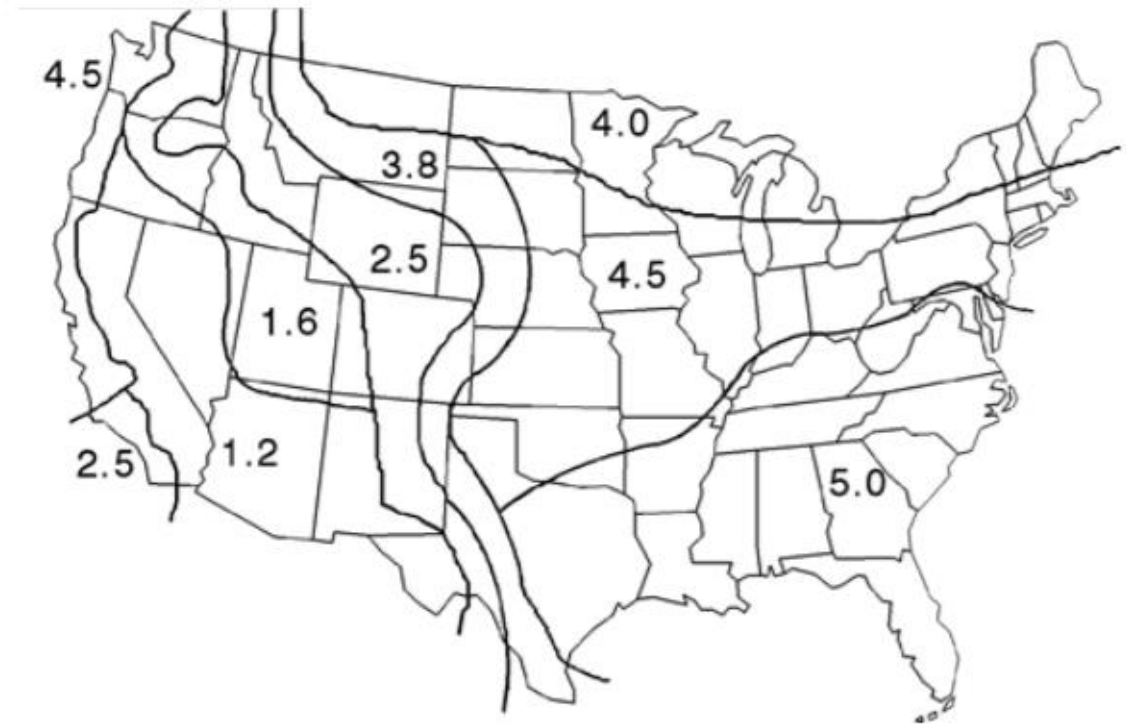
Other Weather-Related Parameters

Start of growing season day of year

End of growing season day of year

Maximum leaf area index

Evaporative zone depth inches

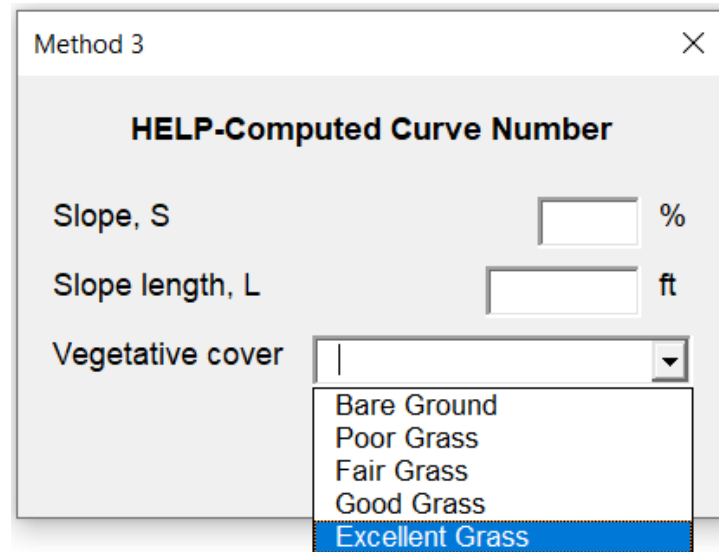


Geographic Distribution of Maximum Leaf Area Index

Running the HELP model

Runoff Curve Number

- The model uses Soil Conservation Society (SCS) runoff curve number (CN) for Antecedent Moisture Condition II (AMC-II).
- The SCS curve runoff number can be input by three methods:
 - Method 1, User-specified CN:** The user enters an SCS AMC-II CN directly.
 - Method 2, Modified User's CN:** The user enters an SCS AMC-II CN, landfill surface slope, and slope length, and the model computes a modified SCS AMC-II CN, accounting for slope and slope length.
 - Method 3, HELP-computed CN:** The user enters the landfill surface slope, slope length, and vegetative cover, and the model computes an SCS AMC-II CN based on these inputs and the soil texture of the topmost layer.



Method 3

HELP-Computed Curve Number

Slope, S %

Slope length, L ft

Vegetative cover

- Bare Ground
- Poor Grass
- Fair Grass
- Good Grass
- Excellent Grass

Running the HELP model

Soil and Design

Soil & Design
✕

Layer No. 1

Layer category Waste

- Final cover soil (topmost layer)
- Vertical percolation layer (soil)
- Lateral drainage layer (soil)
- Barrier soil liner
- Waste
- Geomembrane liner
- Geosynthetic drainage net

Layer description Waste

Layer thickness texture no.

Standard HELP layer

Saved custom layer

New custom layer

Total porosity (vol/vol)

Field capacity (vol/vol)

Wilting point (vol/vol)

Saturated hydraulic conductivity (cm/s)

Subsurface inflow* (in/y)

* Optional (blank value assumed to be "0" or N/A)

Cancel
Reset
Submit

Soil & Design
✕

Layer No. 1

Layer category Vertical percolation layer (soil)

Layer description

Layer thickness

Total porosity (vol/vol)

Field capacity (vol/vol)

Standard HELP layer

Saved custom layer

New custom layer

G - Gravel

CoS - Coarse Sand

S - Sand

FS - Fine Sand

LS - Loamy Sand

LFS Loamy Fine Sand

SL - Sandy Loam

- FSL - Fine Sandy Loam

Subsurface inflow* (in/y)

* Optional (blank value assumed to be "0" or N/A)

Cancel
Reset
Submit

Running the HELP model

Soil and Design

The model also requires that the arrangement of layers in the landfill profile conform to the following basic rules:

1. A vertical percolation layer cannot be underlying a lateral drainage layer
2. A barrier soil liner cannot be underlying another barrier soil liner
3. A geomembrane liner cannot be placed between two barrier soil liners
4. A geomembrane liner cannot be underlying another geomembrane liner
5. A barrier soil liner cannot be placed directly between two geomembrane liners
6. The top layer cannot be a barrier soil liner
7. The top layer cannot be a geomembrane liner
8. The profile can contain no more than five barrier soil liners and geomembrane liners

Output

The HELP4.0 output file consists of the following tabs:

1. Model Data
2. A tab for each year with daily output data
3. Averages and Totals
4. Peak Daily
5. Final Water Storage

Model Data

Year1

Year2

Year3

Year4

Year5

Averages and Totals

Peak Daily

Final Water Storage

Results

Model Data

The model data tab contains:

1. General information and hydraulic properties of every layer
2. General design and evaporative zone data
3. Evapotranspiration and weather data
4. Normal mean monthly precipitation
5. Normal mean monthly temperature

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE					
HELP MODEL VERSION 4.0 BETA (2018)					
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY					
Title:	MSW Landfill			Simulated On:	9/10/2021 0:38
Layer 1					
Type 1 - Vertical Percolation Layer (Cover Soil)					
CL - Clay Loam					
Material Texture Number 11					
Thickness			=	6	inches
Porosity			=	0.464	vol/vol
Field Capacity			=	0.31	vol/vol
Wilting Point			=	0.187	vol/vol
Initial Soil Water Content			=	0.2544	vol/vol
Effective Sat. Hyd. Conductivity			=	6.40E-05	cm/sec
Layer 2					
Type 1 - Vertical Percolation Layer (Waste)					
Municipal Solid Waste (MSW) (900 pcy)					
Material Texture Number 18					
Thickness			=	120	inches
Porosity			=	0.671	vol/vol
Field Capacity			=	0.292	vol/vol
Wilting Point			=	0.077	vol/vol
Initial Soil Water Content			=	0.4143	vol/vol
▶ Model Data Year1 Year2 Year3 Year4 Year5 Averages and Totals Pe					

Results

Daily Output Data

The daily output tab contains:

1. Precipitation
2. Runoff
3. Evapotranspiration
4. Evaporation zone water
5. Head on liner
6. Drainage generated
7. Leakage through barrier layer

Daily Output for Year 1									
						Column key: Head #1: drainage from Layer 3			
Title:		MSW Landfill							
Simulated On:		9/10/2021 0:38							
						Leak #1: leakage thru Layer 4			
Day	Freezing Status*		Rain	Runoff	ET	Evap. Zone Water	Head #1	Drain #1	Leak #1
	Air	Soil	(inches)	(inches)	(inches)	(in/in)	(inches)	(inches)	(inches)
1			0.00	0.000	0.047	0.2465	38.7112	0.0000	1.32E-04
2			0.00	0.000	0.081	0.2330	38.7108	0.0000	1.32E-04
3			0.59	0.000	0.074	0.3186	38.7105	0.0000	1.32E-04
4			0.00	0.000	0.036	0.3126	38.7101	0.0000	1.32E-04
5			0.00	0.000	0.025	0.3085	38.7098	0.0000	1.32E-04
6			0.00	0.000	0.037	0.3023	38.7094	0.0000	1.32E-04
7	*		0.00	0.000	0.021	0.2985	38.7091	0.0000	1.32E-04
8			0.00	0.000	0.058	0.2874	38.7196	0.0000	1.32E-04
9			0.00	0.000	0.091	0.2702	38.7501	0.0000	1.32E-04
10			0.00	0.000	0.126	0.2488	38.7730	0.0000	1.32E-04
11			0.00	0.000	0.107	0.2309	38.7742	0.0000	1.32E-04
12			0.71	0.000	0.120	0.3297	38.7738	0.0000	1.32E-04
13			0.00	0.000	0.063	0.3099	38.7833	0.0000	1.32E-04
14			0.00	0.000	0.054	0.2981	38.9172	0.0000	1.33E-04
15			0.00	0.000	0.057	0.2860	38.9789	0.0000	1.33E-04
16			0.00	0.000	0.085	0.2689	39.0237	0.0000	1.33E-04
17			0.00	0.000	0.061	0.2571	39.0639	0.0000	1.33E-04
18			0.30	0.000	0.076	0.2944	39.0846	0.0000	1.34E-04
19			0.00	0.000	0.069	0.2828	39.0870	0.0000	1.34E-04
20			0.00	0.000	0.082	0.2692	39.0866	0.0000	1.34E-04

Results

Averages and Totals

The averages and totals tab contains:

1. Average annual precipitation
2. Average annual runoff
3. Average annual evapotranspiration
4. Average annual leakage through barrier layer
5. Average annual head on liner
6. Average annual change in water storage

Average Annual Totals Summary				
Title:	MSW Landfill			
Simulated on:	9/10/2021 0:39			
	Average Annual Totals for Years 1 - 10*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	49.60	[7]	180,036.0	100.00
Runoff	6.215	[4.408]	22,558.7	12.53
Evapotranspiration	40.179	[6.559]	145,849.1	81.01
Subprofile1				
Percolation/leakage through Layer 4	0.165454	[0.039013]	600.6	0.33
Average Head on Top of Layer 3	110.2387	[22.5718]	---	---
Water storage				
Change in water storage	3.0379	[5.6053]	11,027.5	6.13
* Note: Average inches are converted to volume based on the user-specified area.				

Results

Peak Daily

The peak daily tab presents peak daily:

1. Precipitation
2. Runoff
3. Evapotranspiration
4. Leakage through barrier layer
5. Head on the liner
6. Change in water storage

Peak Values Summary			
Title:	MSW Landfill		
Simulated on:	9/10/2021 0:39		
	Peak Values for Years 1 - 10*		
	(inches)		(cubic feet)
Precipitation	3.56		12,906.8
Runoff	1.826		6,629.6
Subprofile1			
Percolation/leakage through Layer 4	0.000531		1.9293
Average head on Layer 3	125.9998		
Other Parameters			
Snow water	0.5203		1,888.9
Maximum vegetation soil water	0.4640	(vol/vol)	
Minimum vegetation soil water	0.1870	(vol/vol)	

Results

Final Water Storage

The final water storage tab provides each layer's water storage and volumetric moisture content at the year of the simulation period.

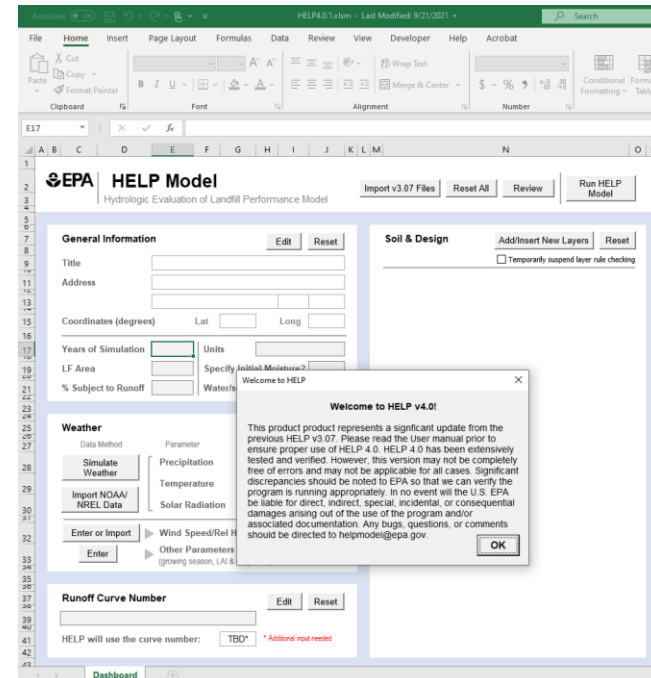
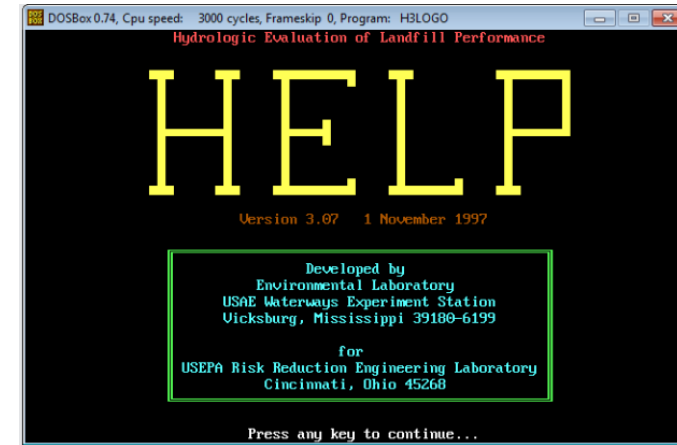
Final Water Storage in Landfill Profile at End of Simulation Period		
Title:	MSW Landfill	
Simulated on:	9/10/2021 0:39	
Simulation period:	10 years	
	Final Water Storage	
Layer	(inches)	(vol/vol)
1	1.1221	0.1870
2	80.4947	0.6708
3	0.0000	0.0000
4	5.4120	0.4510
Snow water	0.0000	---

Future Improvements

- Extreme weather events
- More dynamic modeling
- Exposed geomembrane covers
- Liquid introduction

Key Takeaways

- HELP 4.0 for Microsoft Excel
 - Can run on Windows or Mac
 - New visual interface
 - Outputs are in spreadsheet format for easy analysis/review
- Updated weather data for contiguous US
- New updates are in development
 - Exposed geomembrane
 - Extreme weather



Contacts

Thabet Tolaymat

Environmental Engineer

Center for Environmental Solutions and Emergency Response

US EPA Office of Research and Development

tolaymat.thabet@epa.gov

513-429-9941

Max Krause

Engineer

Center for Environmental Solutions and Emergency Response

US EPA Office of Research and Development

krause.max@epa.gov

<https://www.epa.gov/land-research/hydrologic-evaluation-landfill-performance-help-model>