ATTACHMENT III-D.8-2

REFERENCES

Technically Complete, March 11, 2016

THE HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL

USER'S GUIDE FOR VERSION 3

by

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1. ***Default Evapotranspiration Option with Location Specific Guidance*** *(Customary and Metric Units)*. This option uses the data provided by the HELP model for selected U.S. cities. The cities are listed in Table 1. The data needed for this option are:

   - **Location**

   - **Evaporative zone depth** (Guidance is available for the selected location based on a thick layer of loamy soil with a grassy form of vegetation. Clayey soils would generally have larger evaporative zone depths since it exerts greater capillary suction; analogously, sandy soils would have smaller evaporative depths. Shrubs and trees with tap roots would have larger evaporative zone depths than the values given in the guidance.) The user must specify an evaporative zone depth and can use the guidance along with specific design information to select a value. The program does not permit the evaporative depth to exceed the depth to the top of the topmost liner. Similarly, the evaporative zone depth would not be expected to extend very far into a sand drainage layer. The evaporative zone depth must be greater than zero. The evaporative zone depth is the maximum depth from which water may be removed by evapotranspiration. The value specified influences the storage of water near the surface and therefore directly affects the computations for evapotranspiration and runoff. 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 to the roots. The depth specified should be characteristic of the maximum depth to which the moisture changes near the surface due to drying over the course of a year, typically occurring during peak evaporative demand or when peak quantity of vegetation is present. Setting the evaporative depth equal to the expected average root depth would tend to yield a low estimate of evapotranspiration and a high estimate of drainage through the evaporative zone. An evaporative depth should be specified for bare ground to account for direct evaporation from the soil; this depth would be a function of the soil type and vapor and heat flux at the surface. The depth of capillary draw to the surface without vegetation or to the root zone may be only several inches in gravels; in sands the depth may be about 4 to 8 inches, in silts about 8 to 18 inches, and in clays about 12 to 60 inches.

   - **Maximum leaf area index** (Guidance is available for the selected location). The user must enter a maximum value of leaf area index for the vegetative cover. Leaf area index (LAI) 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 a maximum LAI value typical of the location selected if the value entered by the user cannot be supported without irrigation because of low rainfall or a short growing season. This statement should be considered only as a warning. The maximum LAI for bare ground is zero. For a poor stand of grass the LAI could approach 1.0; for a fair stand of grass, 2.0; for a good stand of grass, 3.5; and for an excellent

TABLE 1. CITIES FOR EVAPOTRANSPIRATION DATA AND SYNTHETIC TEMPERATURE AND SOLAR RADIATION DATA

ALABAMA
- Birmingham
- Mobile
- Montgomery

ALASKA
- Annette
- Bethel
- Fairbanks

ARIZONA
- Flagstaff
- Phoenix
- Tucson
- Yuma

ARKANSAS
- Fort Smith
- Little Rock

CALIFORNIA
- Bakersfield
- Blue Canyon
- Eureka
- Fresno
- Los Angeles
- Mt. Shasta
- Sacramento
- San Diego
- San Francisco
- Santa Maria

COLORADO
- Colorado Springs
- Denver
- Grand Junction
- Pueblo

CONNECTICUT
- Bridgeport
- Hartford
- New Haven
- Windsor Locks

DELAWARE
- Wilmington

DISTRICT OF COLUMBIA
- Washington

FLORIDA
- Jacksonville
- Miami
- Orlando
- Tallahassee
- Tampa
- West Palm Beach

GEORGIA
- Atlanta
- Augusta
- Macon
- Savannah
- Watkinsville

HAWAII
- Honolulu

IDAHO
- Boise
- Pocatello

ILLINOIS
- Chicago
- East 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
- East Lansing
- Grand Rapids
- Sault Sainte Marie

MINNESOTA
- Duluth
- Minneapolis
- St. Cloud

MISSISSIPPI
- Jackson
- Meridian

MISSOURI
- Columbia
- Kansas City
- St. Louis

MONTANA
- Billings
- Glasgow
- Great Falls
- Havre
- Helena
- Kalispell
- Miles City

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
- Syracuse

NORTH CAROLINA
- Asheville
- Charlotte
- Greensboro
- Raleigh

NORTH DAKOTA
- Bismarck
- Williston

OHIO
- Cincinnati
- Cleveland
- Columbus
- Put-in-Bay
- Toledo

OKLAHOMA
- Olkahoma City
- Tulsa

OREGON
- Astoria
- Burns
- Meacham
- Medford
- Pendleton
- Portland
- Salem
- Sexton Summit

PENNSYLVANIA
- Philadelphia
- Pittsburgh

RHODE ISLAND
- Providence

SOUTH CAROLINA
- Charleston
- Columbia

SOUTH DAKOTA
- Huron
- Rapid City

TENNESSEE
- Chattanooga
- Knoxville
- Memphis
- Nashville

(Continued)

TABLE 1 (continued). CITIES FOR EVAPOTRANSPIRATION DATA AND SYNTHETIC TEMPERATURE AND SOLAR RADIATION DATA

TEXAS	UTAH	WASHINGTON	WISCONSIN
Abilene	Cedar City	Olympia	Green Bay
Amarillo	Milford	Pullman	Lacrosse
Austin	Salt Lake City	Seattle	Madison
Brownsville	VERMONT	Spokane	Milwaukee
Corpus Christi	Burlington	Stampede Pass	WYOMING
Dallas	Montpelier	Walla Walla	Cheyenne
El Paso	Rutland	Yakima	Lander
Galveston	VIRGINIA	WEST VIRGINIA	PUERTO RICO
Houston	Lynchburg	Charleston	San Juan
Midland	Norfolk		
San Antonio	Richmond		
Temple			
Waco			

(Concluded)

stand of grass, 5.0. The LAI for dense stands of trees and shrubbery would also approach 5. The program is largely insensitive to values above 5. If the vegetative species limit plant transpiration (such as succulent plants), the maximum LAI value should be reduced to a value equivalent of the LAI for a stand of grass that would yield a similar quantity of plant transpiration. Most landfills would tend to have at best a fair stand of grass and often only a poor stand of grass because landfills are not designed as ideal support systems for vegetative growth. Surface soils are commonly shallow and provide little moisture storage for dry periods. Many covers may have drains to remove infiltrated water quickly, reducing moisture storage. Some covers have liners near the surface restricting root penetration and causing frequent saturation of the surface soil which limits oxygen availability to the roots. Some landfills produce large quantities of gas which, if uncontrolled, reduces the oxygen availability in the rooting zone and therefore limits plant growth.

The program produces values for the Julian dates starting and ending the growing season, the annual average wind speed, and the quarterly average relative humidity for the location. The values for the growing season should be checked carefully to agree with the germination and harvesting (end of seasonal growth) dates for your type of vegetation. For example, grasses in southern California would germinate in the fall when the rains occur and die off in late spring when the soil moisture is depleted. This contrasts with a typical growing season, which would start in the spring and end in the fall.

*2. **Manual Option*** *(Customary and Metric Units).* The data needed for this option are: