1.34 WASTE CONTAINMENT AND SITE REMEDIATION TECHNOLOGY
HOMEWORK 7 – DUE APRIL 26, 2004

You may work together to formulate and discuss approaches to homework problems. However, the work that you submit must be your own.

1.   (6 points)
Complete a Thornthwaite water balance for a location of your choosing. You will need to use the following reference materials:

C.W. Thornthwaite and J.R. Mather, 1957. Instructions and tables for computing potential evapotranspiration and the water balance. Publications in Climatology, Vol. 10, No. 3, pp.185-311. Laboratory of Climatology, Drexel Institute of Technology, Centerton, New Jersey. – available in pdf format from the course web site. Referred to as T&M henceforth.

Climatological data (mean monthly precipitation and air temperature) – generally available on the internet (try this site as a starting point for locations in the US: http://www.nrcc.cornell.edu/other_rcc.html), but if not, data are available from Weather of U.S. Cities, Climates of the States, or Climates of the World (all in Lindgren library).

There are some deviations in the water-balance procedure for landfills, therefore you should follow the procedure below (adapted with corrections from: McBean, E.A., F.A. Rovers and G.J. Farquhar, 1995. *Solid Waste Landfill Engineering and Design*. Prentice Hall PTR, Englewood Cliffs, New Jersey.)

Construct a spreadsheet or table with the following rows (a spreadsheet is much easier!):
  T – Air temperature – enter mean monthly air temperature for your location
  i – heat index – look up in T&M Table 1 or 2 as function of air temperature
  UPET – Unadjusted potential evapotranspiration – look up in T&M Table 3 or 4 as function of temperature
  r – PE adjustment factor for duration of sunlight – look up in T&M Table 6 or 7 as function of latitude and month
  PET – potential evapotranspiration = r × UPET – amount of ET that could occur if there was sufficient soil moisture

  P – precipitation – enter mean monthly precipitation for your location
  Cro – runoff coefficient – empirical coefficient representing fraction of rainfall that runs off (not included in Thornthwaite's original method) – values of Cro are given by McBean *et al.* as follows:

Surface conditions	Runoff coefficient
Sandy soil, flat (<2% slope)	0.05 – 0.10
Sandy soil, average (2-7% slope)	0.10 – 0.15
Sandy soil, steep (>7% slope)	0.15 – 0.20
Heavy soil, flat (<2% slope)	0.13 – 0.17
Heavy soil, average (5-7% slope)	0.18 – 0.22
Heavy soil, steep (>7% slope)	0.25 – 0.35

RO – monthly runoff = P × Cro

I – infiltration = P - RO

I-PET – Infiltration less potential evapotranspiration = water available for storage

ACC WL – accumulated water loss = running total of negative I–PET values

ST – soil moisture storage

Initial soil moisture storage is the field capacity of the root zone—you can assume 4 inches or 100 mm for this problem

Assign a value of ST = field capacity in the last month having I-PET>0 (i.e., at the start of the dry season)

For the subsequent months with negative I-PET, determine ST as a function of the accumulated water loss using C&M Table 15 or 26

Once the months again have positive I-PET, add I-PET to the preceding month's ST value, but do not exceed the field capacity

This last procedure "wraps around from the end of the table (December) to the start of the table (January)

Special procedures are required for very dry climates: see Thornthwaite and Mather for details

ΔST – change in soil moisture from last month

Compute as the current month's value of ST less the previous month's value

AET – actual ET

= PET for wet months when I $\geq$ PET

= I – ΔST for dry months when I < PET)

PERC – percolation

= (I – PET – ΔST) for wet months, I $\geq$ PET

= 0 for dry months, I < PET

As a check, compute P = PERC + AET + ΔST + RO and compare with P entered above. If the numbers differ, there is an error in the calculation.

2.   (4 points)
Use the HELP model with the example problem provided with the model (a RCRA landfill in Nashville, Tennessee). Assume you have a cheapskate client who has decided to save some money by eliminating the lowermost drainage layer, geomembrane liner, and clay liner.

How much will the leachate escaping from the bottom of the landfill change by eliminating these three layers from the design?

You can run the model on CEE net computers. A Windows version of the model is available on computers.

Alternatively, you can download the DOS model for free from the Corps of Engineers web site and install it on your own PC. A link is available on the course 1.34 web site or use the following:

http://www.wes.army.mil/el/elmodels/index.html#landfill