DEPARTMENT OF THE ARMY
ENGINEER RESEARCH AND DEVELOPMENT CENTER, CORPS OF ENGINEERS
ENVIRONMENTAL LABORATORY
WATERWAYS EXPERIMENT STATION, 3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199

REPLY TO
ATTENTION OF

24 February 2006

CEERD-EP-E

MEMORANDUM FOR: U.S. Army Engineer District, Detroit, ATTN: CELRE-PL-E (L. Weigum)

SUBJECT: Leachate Seepage and Surface Runoff from the Grassy Island, Wayne County, MI

1. This memorandum was prepared for CELRE in response to a request for assistance under the Dredging Operations Technical Support (DOTS) program, DOTS request 2006-001. The objectives were to estimate annual average drainage to the overflow weir due to runoff and annual average seepage through the dike walls. A water balance model, the U.S. Environmental Protection Agency's (USEPA) Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder *et al*. 1994a, Schroeder *et al*. 1994b), was used. Studies cited by Millsap (2004) were reviewed for water table elevations and other hydrologic data for input to the model.

2. The water balance of a place, whether it be an agricultural field, watershed, or continent, can be determined by calculating the input, output, and storage changes of water at the ground surface. Figure 1 below is a definition sketch for the water balance at Grassy Island.

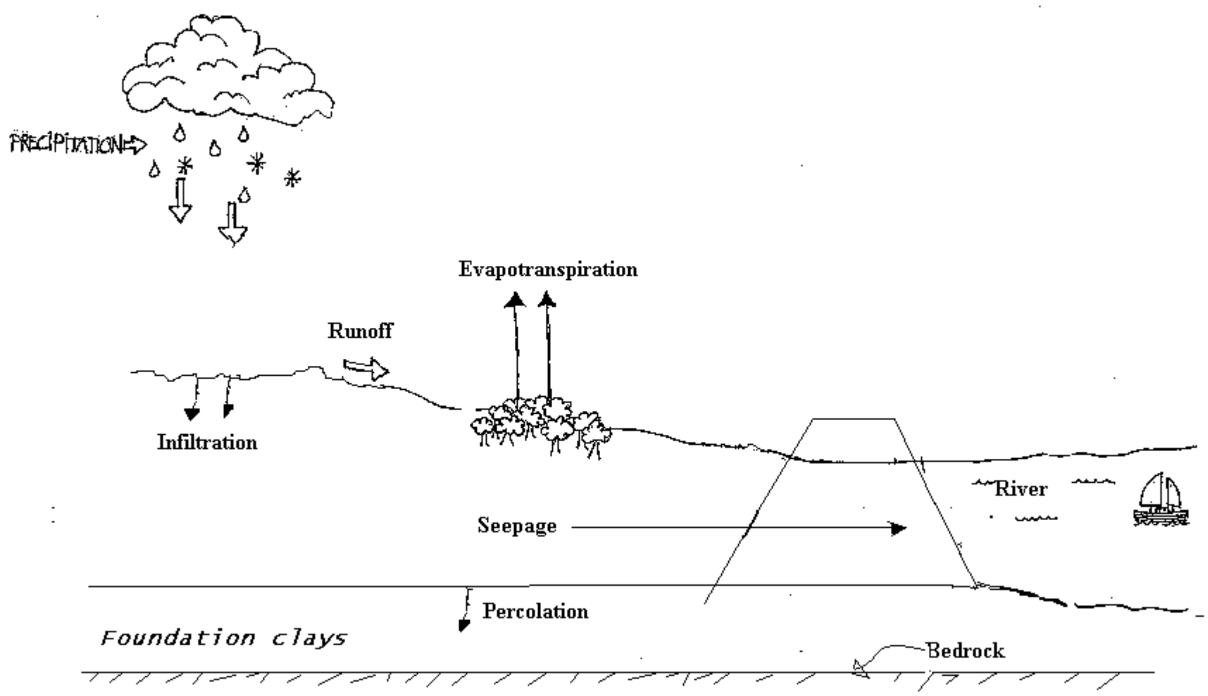

Figure 1. Water Balance Sketch for Grassy Island, MI.

An accounting of the inputs and outputs of water depicted in Figure 1 yields

$$\begin{bmatrix} \textit{Change in Soil} \\ \textit{Storage of Water} \end{bmatrix} = \textit{Precipitation} - \textit{Evapotranspiration} - \textit{Runoff} - \textit{Seepage} - \textit{Percolation} .$$

The HELP model balances the water budget at the ground surface, then routes the infiltrated water throughout the soil profile. A particularly important feature of the HELP model is the coupling of weather and subsurface hydraulics. This is important because seepage generation in a dredged material disposal facility is driven by the interaction of local climate with soil conditions at the surface of the facility. HELP either simulates (as was the case in this application) or uses historical daily climatological data to develop the water balance at the surface and then computes runoff, evapotranspiration, and infiltration on a daily basis. Snowmelt is included and performed automatically as well as is a simulation for frozen soil conditions and vegetative growth and decay. HELP is a quasi-two-dimensional model that divides the vertical soil profile into sub-profiles and computes the drainage values for each sub-profile. HELP models seepage through dikes by employing a lateral drainage layer in which flow is both vertical (unsaturated and saturated) and horizontal (saturated portion of the lateral drainage layer).

3. A 30-yr simulation was run beginning in 1975 using 4 layers to a) simulate the surface crust with vegetation, b) a vertical percolation layer to simulate a transition layer below the surface crust, c) a lateral drainage layer to simulate most of the dredged material profile (86.5 inches thick) above the external water table; and d) a barrier soil layer that simulates the foundation clays beneath Grassy Island. The respective hydraulic conductivities of each layer were 1.9 E-4, 1.9 E-4, 0.9 E-5, and 1 E-10 cm/sec. Precipitation, temperature, and solar radiation data were synthetically generated by the HELP model using default coefficients for Detroit, MI. The initial condition for water content was set at saturation, characteristic of hydraulically placed dredged material.

4. The HELP model predicted an average annual precipitation of 30.12 inches. The predicted distribution as a percent of this input is shown in Figure 2. Evapotranspiration accounted for 92.2 percent of the water budget, runoff accounted for 8.6 percent, and seepage through the dikes accounted for 0.6 percent. There is an excess of 1.4 percent (greater than 100% of the precipitation) in the simulated water budget that was excess water in the saturated dredged material at the beginning of the simulation – water input from the dredge. This water either evaporated or drained out, yielding slightly more output than input for the long-term water balance. Annual average seepage through dikes was predicted to be 0.0016 cubic feet per second (cfs), and annual average runoff flow was 0.02 cfs. (For reference, the average home refrigerator has 15 to 24 cubic feet of space.) Daily peak flows for runoff and dike seepage were 6.3 cfs and 0.02 cfs, respectively. These peak flows would be expected to occur once every 30 years and to last for one day. Thus, the peak daily runoff was 315 times the peak daily seepage flow. If all this runoff flowed to the weir and was discharged over the weir, there would be a point discharge of 6.3 cfs for one day into the Detroit River. The Detroit River has an average flow of 187,143 cfs (Millsap 2004), and the flow past the weir is approximately

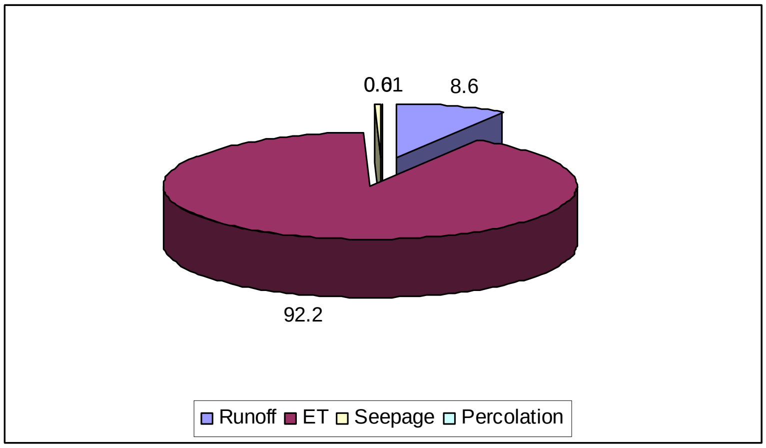

Figure 2. Average Annual Distribution of Water Input to Grassy Island, MI.

30 percent of the average flow (Federal Water Pollution Control Administration (1967). At the point of discharge there would an available dilution of at least 8,912 for this event that happens about once every 30 years. The available dilution of seepage would be nearly ten million-fold. On the basis of this analysis, sustained water quality violations in the Detroit River due to runoff or seepage are not to be expected. Water quality monitoring by the U.S. Army Engineer District, Detroit during active disposal operations in the 1970s and 1980s generally showed upstream and downstream water quality to be similar (Millsap 2004).

5. Conclusions. This analysis does not indicate a potential for water quality impacts by either discharge of runoff or dike seepage and suggests that further analysis of runoff and dike seepage is unwarranted. Attention should be directed to the other concerns raised by Millsap (2004).

6. References.

Federal Water Pollution Control Administration. (1967). "Pilot study of Rouge river dredging August – December 1967," Federal Water Pollution Control Administration, Grosse Ile, MI.

Millsap, S. (2004). "Preliminary assessment and site Inspection Grassy Island disposal facility Wayne County, Michigan," U.S. Fish and Wildlife Service, East Lansing, MI.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M., and Zappi, P. A. (1994a). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's guide for Version 3," EPA/600/R-94/168a, U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.

Schroeder, P. R, Dozier, T. S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L., (1994b). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering documentation for Version 3," EPA/600/R-94/168b, U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.

TOMMY E. MYERS, Ph.D.
Research Environmental Engineer