Wetlands Dynamic Water Budget Model

PURPOSE: The hydraulic and hydrologic characteristics of a wetland influence all wetland functions, and consequently are of primary importance in evaluating these functions. The processes by which water is introduced to, temporarily stored in, and removed from a wetland are commonly known as the water budget. A Wetlands Dynamic Water Budget Model (WDWBM) has been developed through the Wetlands Research Program (WRP) at the U.S. Army Engineer Waterways Experiment Station to predict the interaction of surface water, groundwater, and vertical transport processes within wetlands (Walton and others 1995).

The model has been designed to simulate the major components of the hydrologic cycle, which include meteorological input, canopy interception, overland flow, channel routing, infiltration, saturated groundwater flow, evapotranspiration, and upstream watershed inflows (Figure 1). This technical note describes the features of the WDWBM.

MODEL STRUCTURE: The WDWBM is a coupled surface/aquifer simulation program that computes the dynamic movement of water through various types of watersheds, such as wetlands. The model has three modules (Figure 2), which predict surface water flow, vertical processes, and horizontal groundwater flow. Emphasizing efficiency and ease of use, the model uses an explicit quasi-three-dimensional link-node structure.

Input is organized into files containing information required by each of the modules. Output consists of files containing water surface elevations, flows, velocities, groundwater heads, and volume balances. An interactive PC tutorial is available to help the user identify data sources, prepare input data files, execute and calibrate the model, and select output options. A postprocessing program is available to model the output for graphical display.

SURFACE WATER MODULE: The surface water module was designed to simulate channel and overbank flows, tidal forcing, river inflows, upstream basin flows, wind shear, flooding and drying, various bottom friction formulations, and hydraulic structures such as culverts, weirs, and gates.

The module is based on a quasi-two-dimensional, link-node model structure (Figure 3), which has been successfully applied to the Bolsa Chica wetlands in California (Hales and others 1990), and the Black Swamp of the Cache River (Walton and others 1995). A momentum equation (the dynamic wave equation, the diffusion wave equation, or an equation for a hydraulic structure) is solved along each link, and volume conservation is enforced at each node to compute stage.

A variety of boundary conditions can be applied, including a prescribed stage hydrograph, prescribed flow hydrograph, loop rating curve, specified rating curve, and inflows from upstream basins.

VERTICAL PROCESSES MODULE: The processes simulated in the vertical module are canopy interception, canopy evaporation, surface water evaporation, soil water evaporation, transpiration, and infiltration. The vertical module is based on the HELP model (Schroeder and others 1988) and the SPUR model (Wright and Skiles 1987) and solves a series of one-dimensional, vertical flow equations.

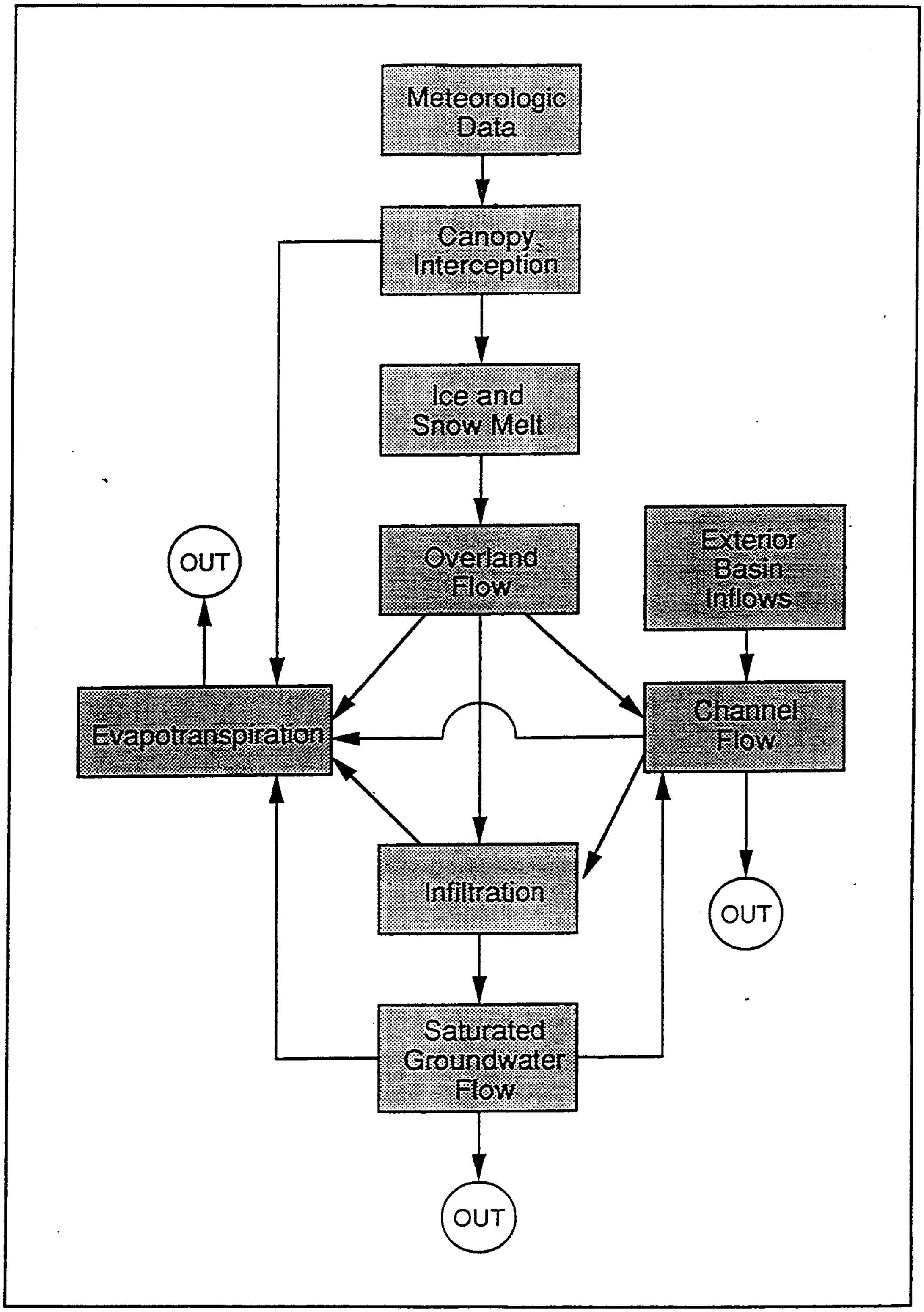

Figure 1. Schematic processes

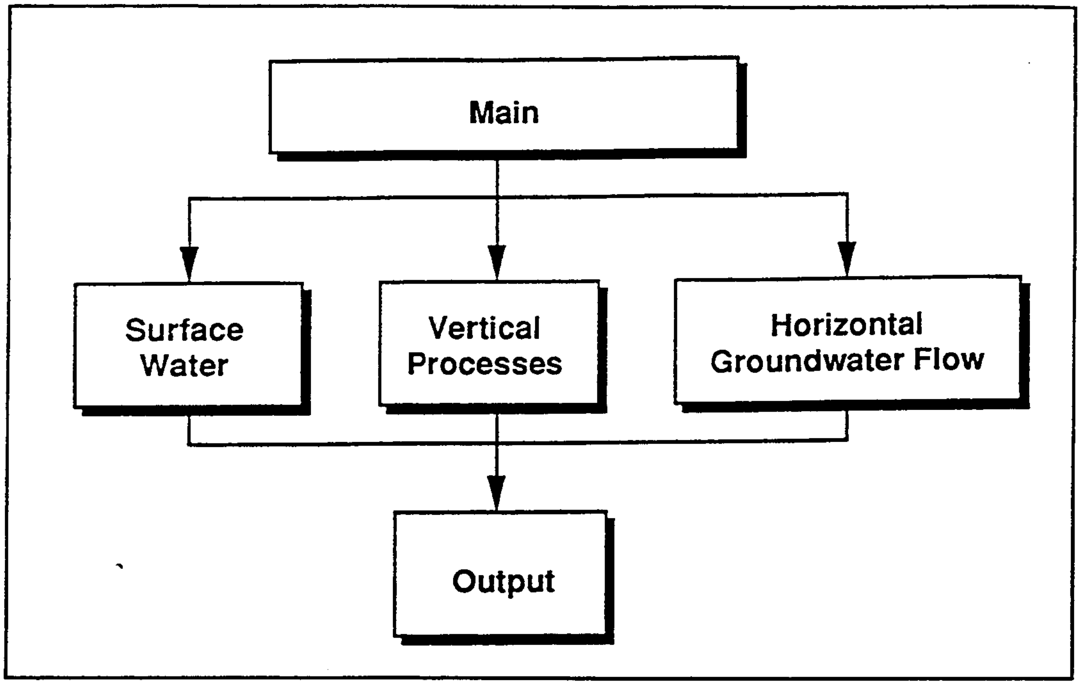

Figure 2. Three modules of Wetlands Dynamic Water Budget Model

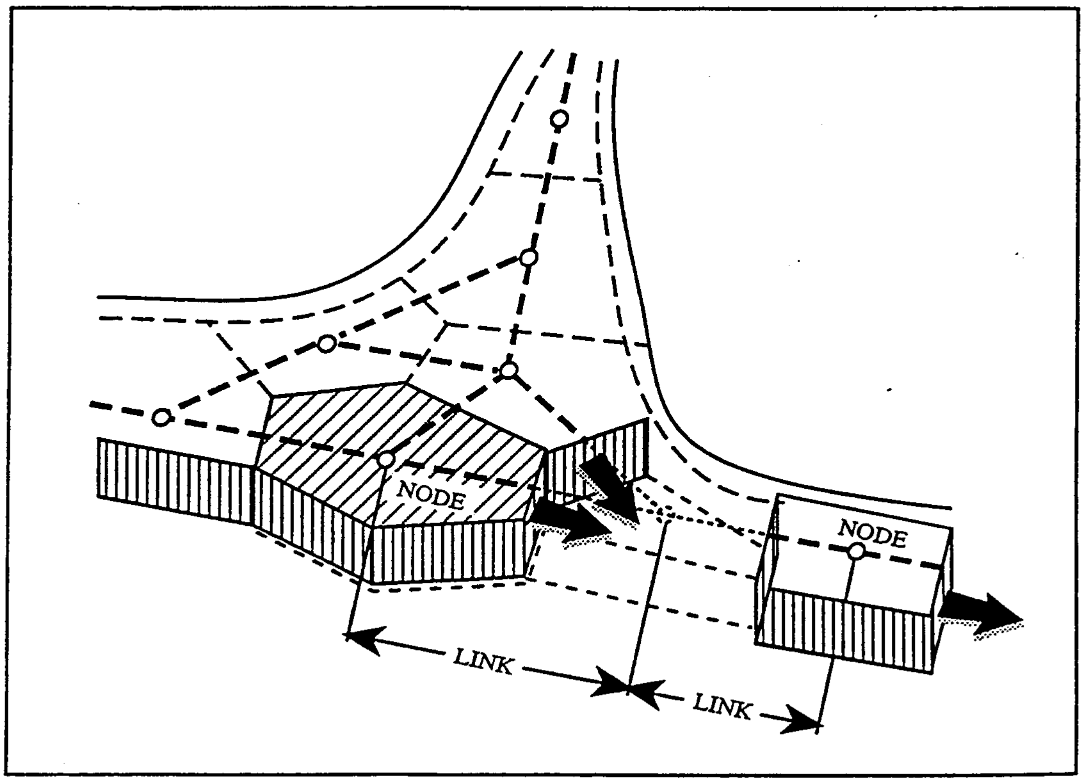

Figure 3. Link-node schematic

The vertical direction is divided into soil layers, which correspond to the layers in the groundwater model. Coupled above the soil layers are the surface water module and the canopy module (Figure 4).

HORIZONTAL GROUNDWATER FLOW MODULE: The groundwater flow module simulates variably saturated horizontal flow in the same soil layers as defined for the vertical processes module. Processes include variably saturated horizontal groundwater flow, fixed-head boundary conditions, and wells.

The subsurface region is divided into a number of layers sufficient to describe vertical variations in soil properties, or to provide suitable resolution of vertical processes. In each vertical layer, the horizontal discretization of the soil is the same as used in the surface water module (Figure 5). Horizontal groundwater flow, both in the unsaturated and saturated zones, is based on Darcy's Law along links, and conservation of volume is enforced for groundwater heads and soil moisture at nodes.

MODEL LINKAGE AND STABILITY CONDITIONS: The surface water module is linked to the vertical processes module through the surface water volume at each node. The vertical processes module is linked to the horizontal groundwater flow module through soil moisture content at each node in each soil layer. The surface water module has no direct linkage to the horizontal groundwater flow module.

The model is governed by two main stability conditions. The channel flow routine of the surface water module uses an explicit link-node scheme that is governed by a one-dimensional Courant condition. Flows in the vertical processes module and the horizontal groundwater flow modules are also treated explicitly. The flows are governed by one-dimensional diffusion conditions in each link, where the diffusion term is the hydraulic conductivity divided by the specific storativity.

CONCLUSION: WDWBM has been designed to simulate long-term wetland processes, but it has all the elements necessary for a comprehensive dynamic watershed simulation model, as well. It was designed to simulate processes in various types of wetlands including riverine, tidal, and depressional. WDWBM, the PC tutorial, and the postprocessing program are available through the WES Engineering Computer Programs Library (ATTN: CEWES-ID-E), phone (601) 634-2581. The reference number for WDWBM is 722-PD-R0008.

REFERENCES:

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Schroeder, P. R., McEnroe, B. M., Peyton, R. L., and Sjostron, J. W. (1988). "The Hydrologic Evaluation of Landfill Performance (HELP) model." Prepared for Office of Solid Waste and Emergency Response, Environmental Protection Agency, Washington, DC, by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Walton, R., Martin, T. H., Chapman, R. S., and Davis, J. E. (1995). "Investigation of wetlands hydraulic and hydrologic processes, model development and application," Technical Report WRP-CP-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

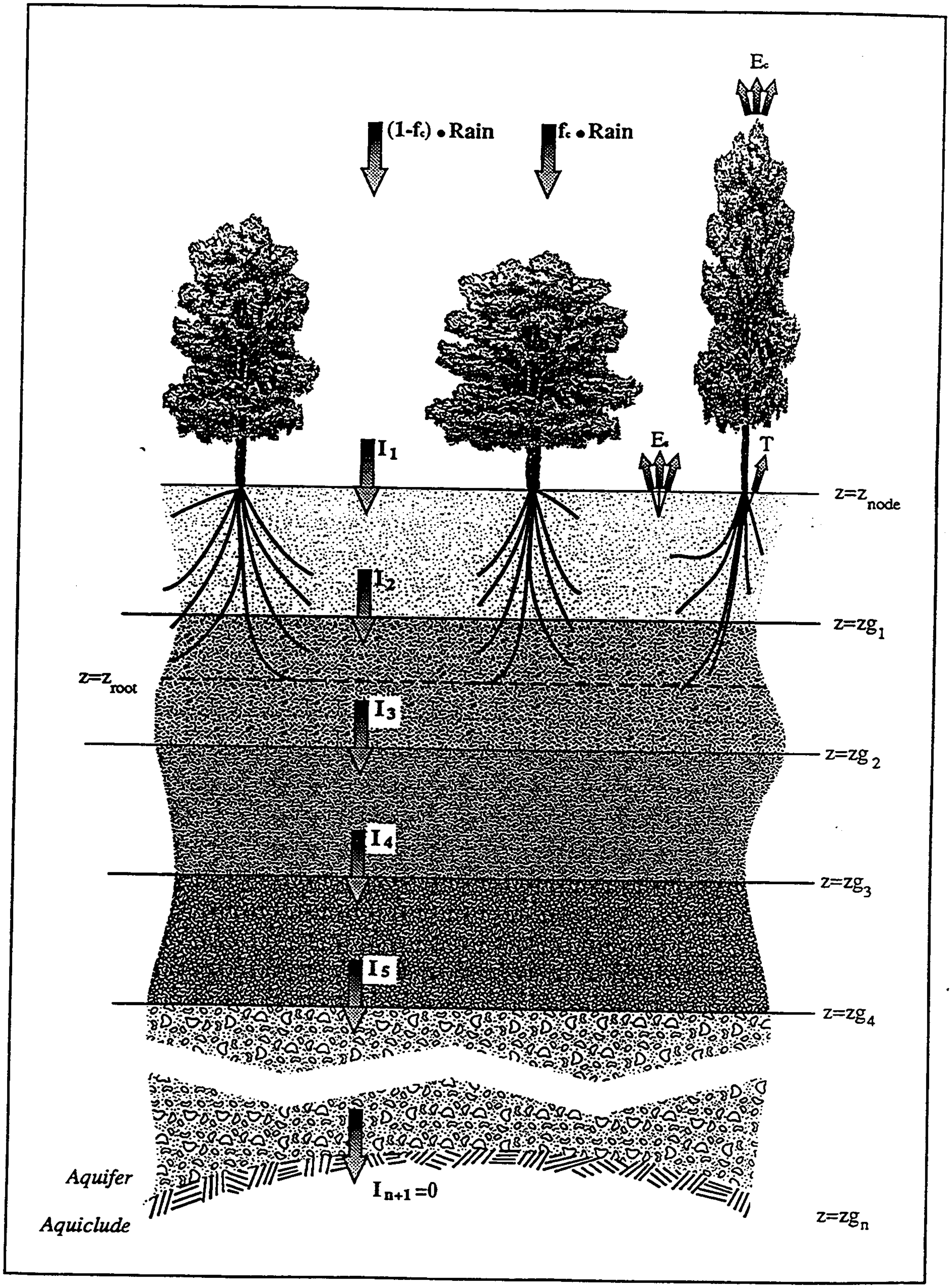

Figure 4. Vertical flow processes

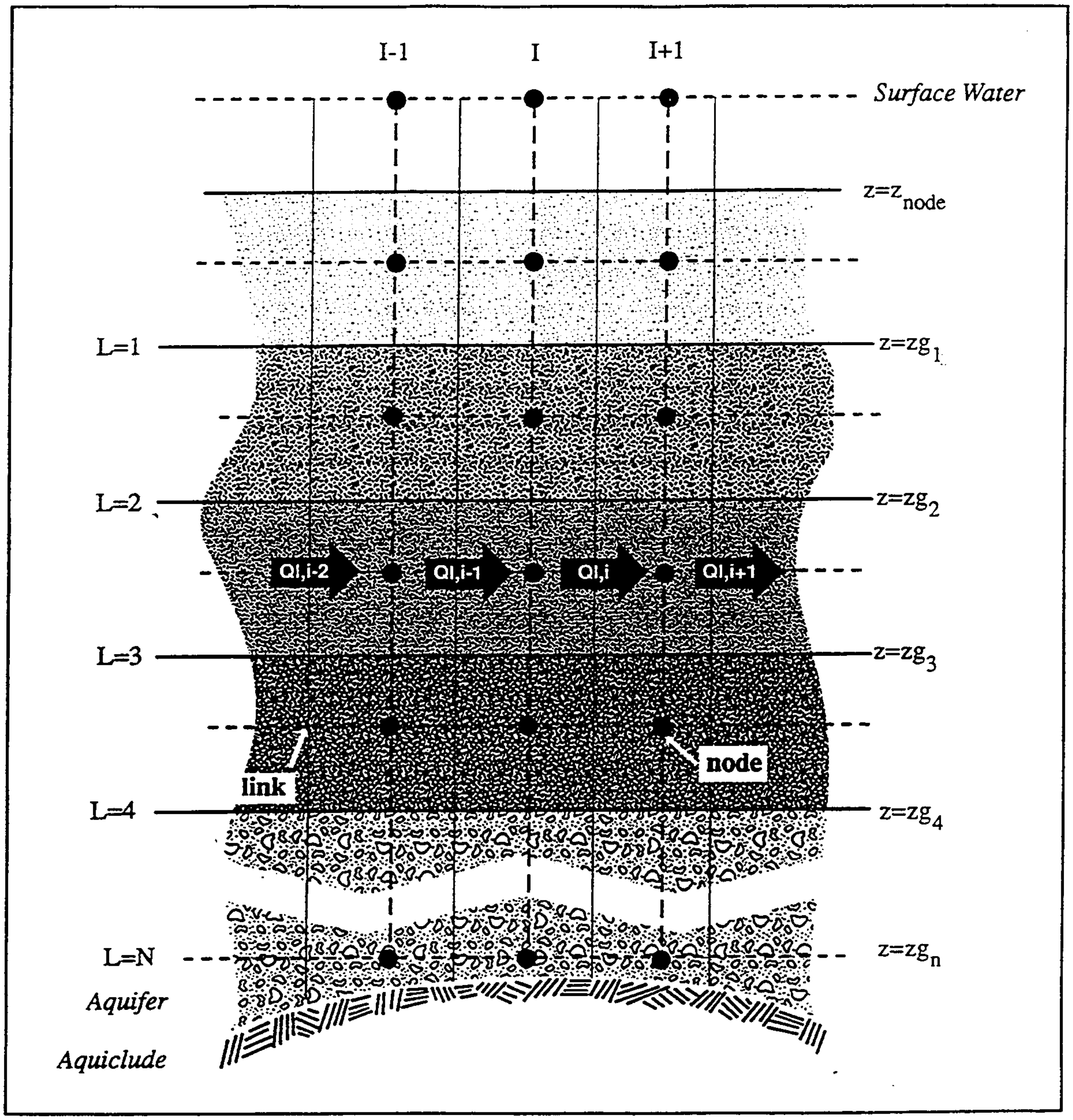

Figure 5. Horizontal groundwater flow

Wright, J. R., and Skiles, J. W. (1987). "SPUR, simulation of production and utilization of rangelands; Documentation and users guide," U.S. Department of Agriculture, Agricultural Research Service, Beltsville, MD.

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