Continuous Simulation Modeling of Stormwater Ponds, Lakes, & Wetlands:
A BUILT-IN APPLICATION OF PONDS 3.2

PRESENTED AT THE SFWMD WORKSHOP
PRE-DEVELOPMENT VERSUS POST DEVELOPMENT
RUNOFF VOLUME ANALYSIS
WPB HEADQUARTERS/B-1 AUDITORIUM
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SOME OF THE NEW COOL STUFF IN PONDS 3.2 (Sept 1999)

- Ability to model submerged discharge structures (i.e., time-variant tailwater effects).
- Can now specify rating curves for complicated discharge structures
- Generate hydrographs without routing (predevelopment)
- User option to route hydrograph with or without infiltration credits. User option to modify initial water level for routed hydrograph.
- TODAY'S HIGHLIGHTED FEATURE - Generate only (i.e., no pond) or generate/route (with pond) continuous simulation hydrographs for single or interconnected systems

CONTINUOUS SIMULATION MODELING: WHAT IS IT?

- A model which analyzes the day to day hydrology of the system over a long period of time (say 3 to 100 years), taking into account all components of the system's water budget (ground water as well as surface water).
- Such a model can predict, on a daily basis, stages, inflows, and discharge rates and volumes (both ground water & surface water components).

CONTINUOUS SIMULATION MODELING: WHY IS IT NEEDED?

- Because of potential water quantity & water quality impacts in volume-sensitive basins, there is a growing concern for regulating cumulative discharge volume from stormwater management systems. This is apart from regulating peak discharge rates.

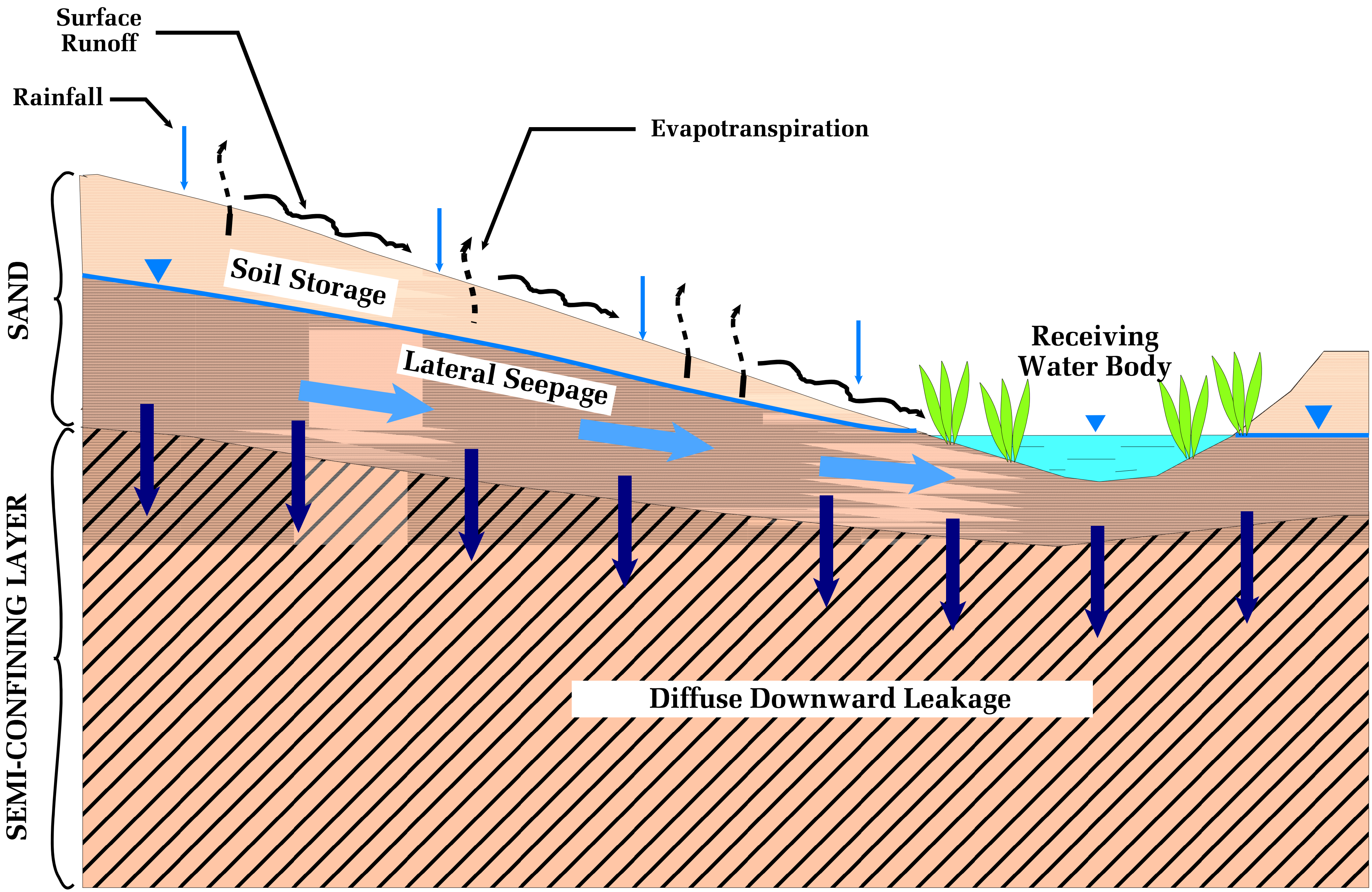
- Useful for predicting predevelopment and postdevelopment wetland hydroperiods.

- In land-locked basins, excess cumulative rainfall over a 2 to 3 year period can result in stages which approach or exceed the 100 year flood elevations. *Is 210 inches of rain in 3 years more critical than 10.6 inches of rain in 24 hours? How about 23 inches in 3 dry season months such as El Nino gave us during Dec 1997 to Feb 1998?* Conventional modeling and current regulatory requirements do not address this type of occurrence which many of us saw first hand in 1994-1996 and late 1997, early 1998.

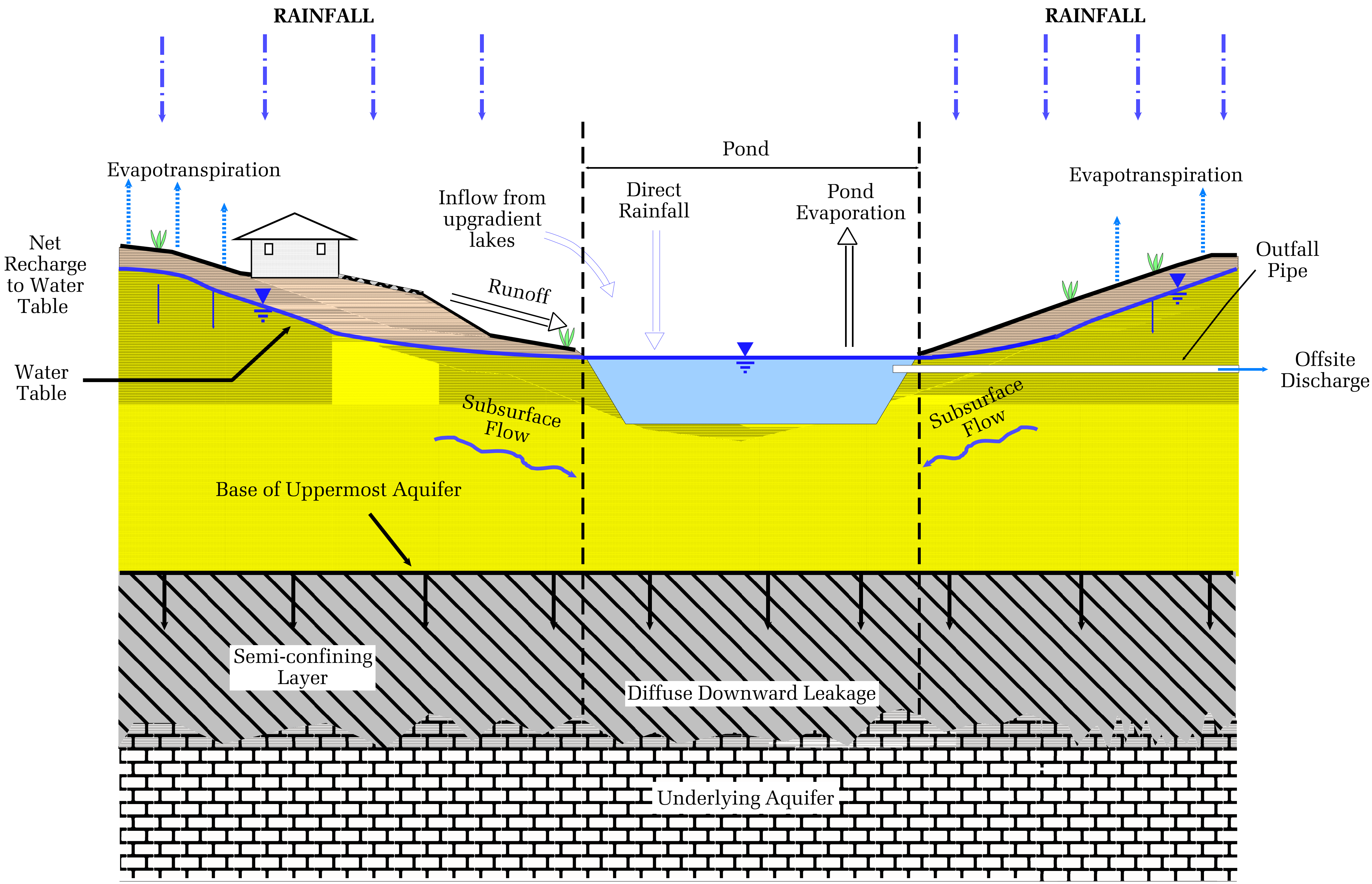
CONTINUOUS SIMULATION MODELING: CONCEPTUAL MODELS SIMPLE vs. LESS SIMPLE

- PONDS 3.2 can tackle simple as well as complicated continuous simulation models.
- What determines if a model is "simple" or "complicated"? To help understand this differentiation, let us first visualize the hydrologic components involved in such modeling.
- Focus on the parameter "diffuse downward leakage".

CONCEPTUAL MODEL FOR PREDEVELOPMENT



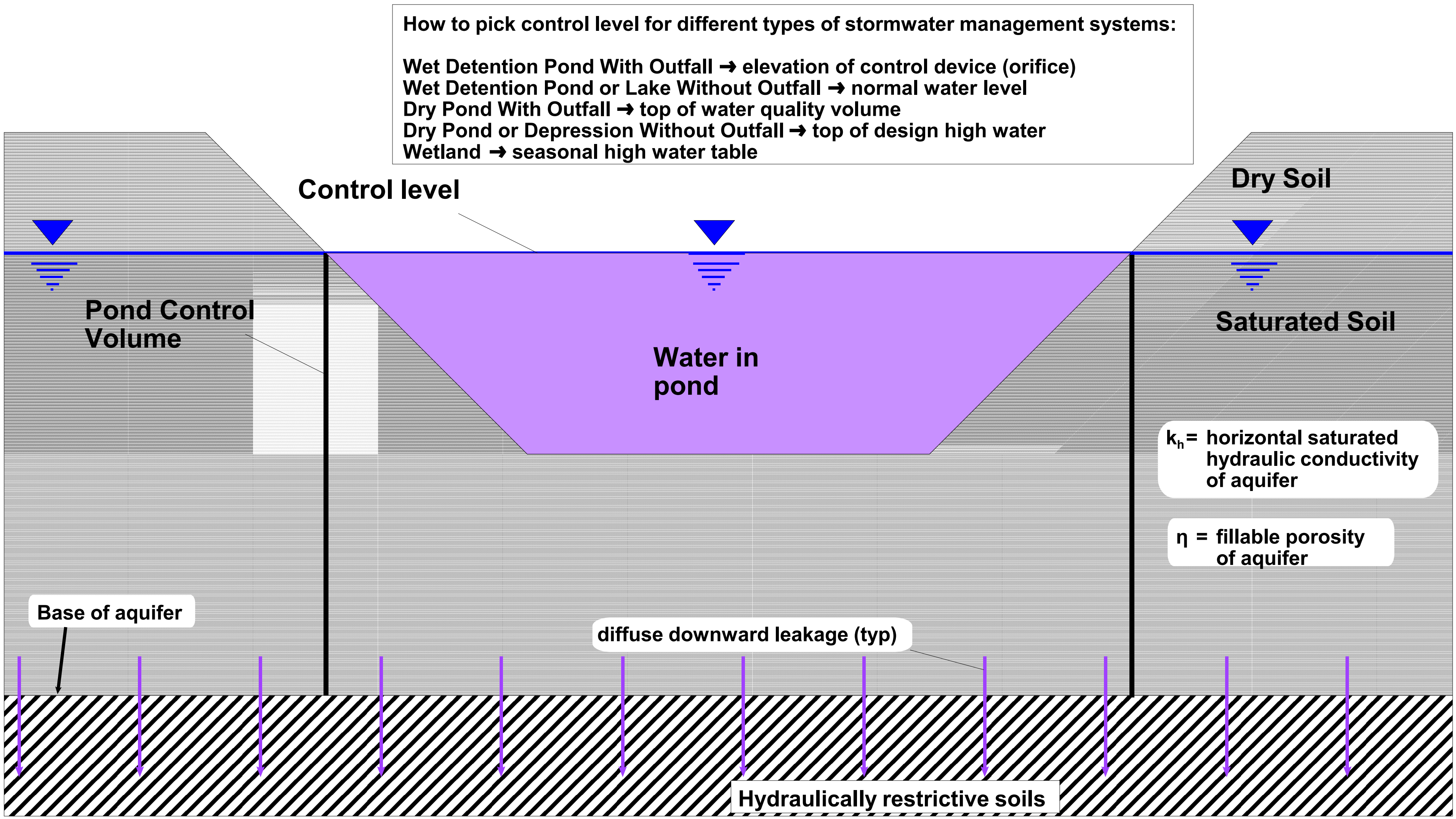
CONCEPTUAL MODEL FOR POSTDEVELOPMENT



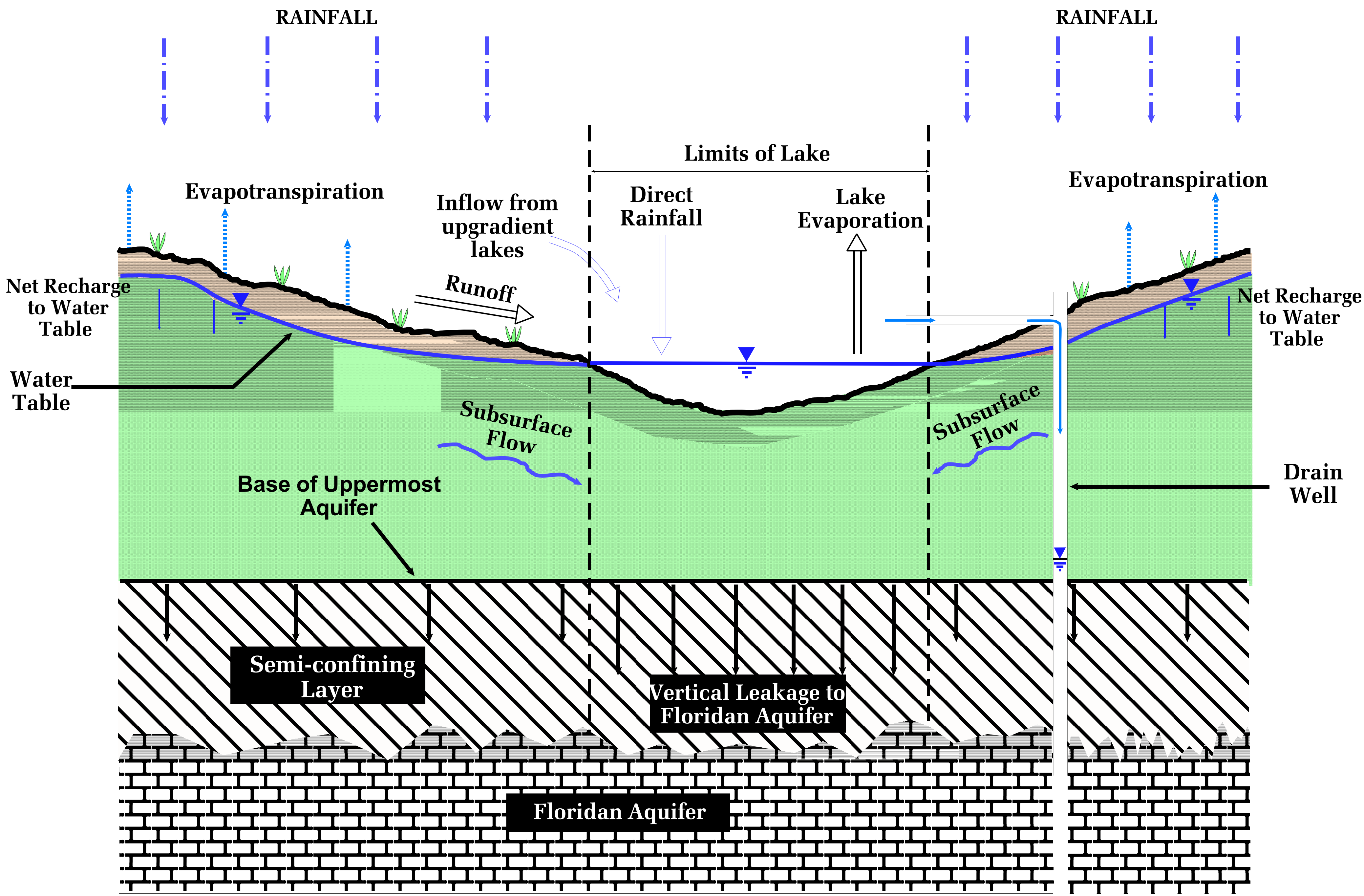
DEFINITIONS:

A_{open} = Area of water surface in pond, varies with stage
A_c = Area of water surface in pond at control level
η = Soil porosity or soil storage
S_b = Stage at physical bottom of pond
S_c = Stage at pond control level

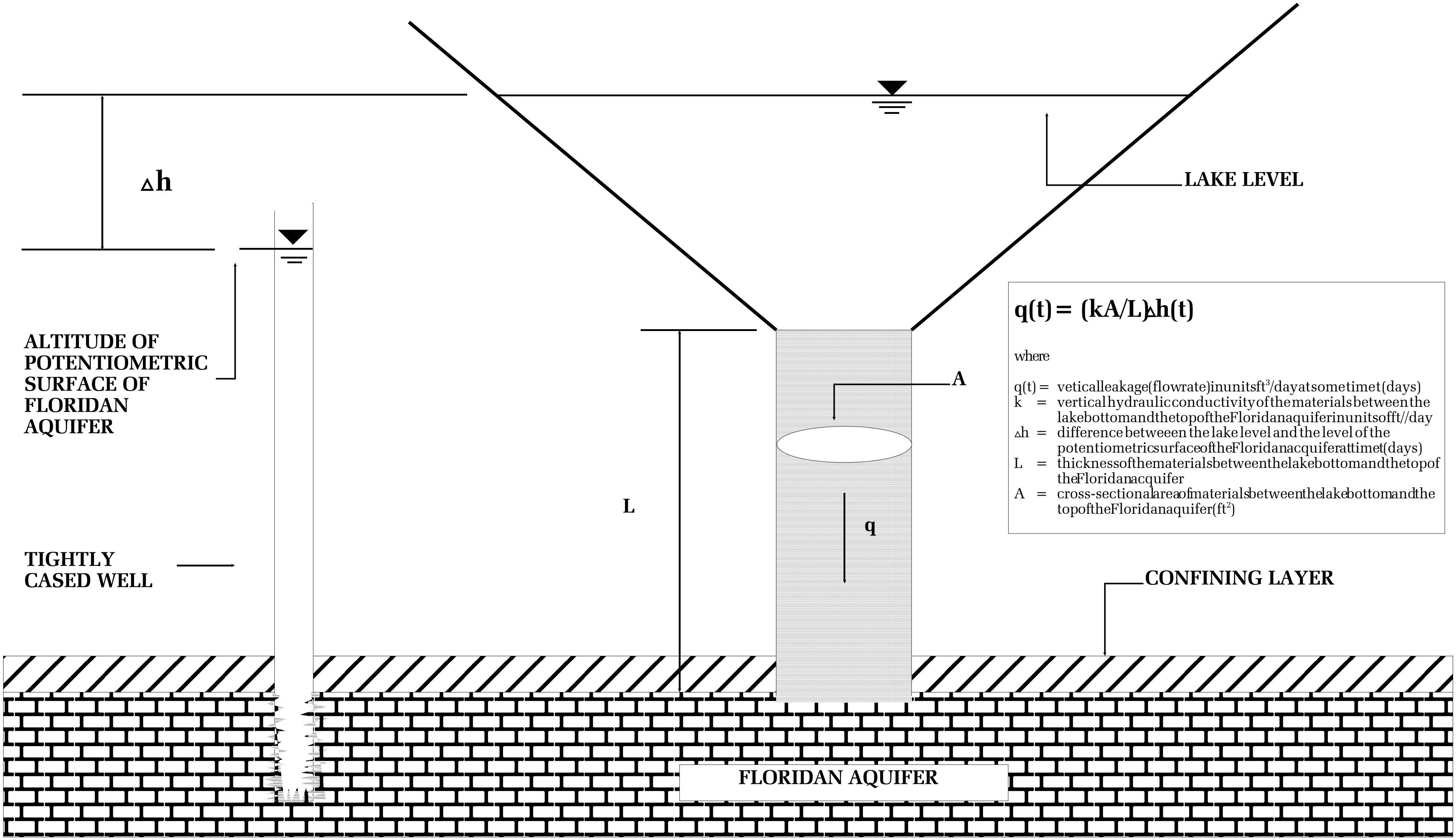
STAGE	AREA FOR MODEL
$> S_c$	A_{open}
S_c	$A_c = A_{open}$
$S_b \rightarrow S_c$	$[A_c - A_{open}]\ \eta + A_{open}$
$< S_b$	$A_c \times \eta$



CONCEPTUAL MODEL FOR NATURAL DEPRESSIONS



MODEL FOR COMPUTING DISCHARGE FROM LAKE OR POND TO FLORIDAN AQUIFER - WELL CONNECTED SCENARIO



CONTINUOUS SIMULATION MODELING: CONCEPTUAL MODELS
DIFFUSE DOWNWARD LEAKAGE - THINK ABOUT THIS FIRST

- Simple models are those where the vertical recharge rate (aka ”diffuse downward leakage”) is uniform with time. There are actual sites like this in the areas of very low recharge (for example, East Orange County).
- Less simple models are those where the diffuse downward leakage changes markedly with time based on rainfall and the water level (pot surface) in the underlying Floridan aquifer. These models require some calibration to back-compute the daily or monthly recharge rate. All other parameters are known.

CONTINUOUS SIMULATION MODELING: THE METHODOLOGY

- The long-term, continuous simulation model is performed using the PONDS Version 3 computer program (Win95/NT version). This is a MODFLOW-based ground water/surface water interaction model which computes ground water and surface water discharges during and following transient hydraulic loading of a water management pond or lake.

- The first step is to create a long-term, continuous simulation hydrograph and the second step is to route it through the stormwater management pond.

- This methodology has been used successfully on numerous projects in the Central Florida area.

CONTINUOUS SIMULATION MODELING: THE ROUTING MODULE

- Saturated ground water flow is simulated using a modified (recompiled) version of the USGS MODFLOW computer code. The three relevant modifications to MODFLOW are as follows:
  - A new subprogram (written by the author) has been included to model non-linear discharge structures such as unsubmerged weirs, orifices, notches, rating curves, etc., and
  - Irregular surface area vs. stage relationships are modeled by changing the storage coefficient as a function of the water elevation within the "limits" of the water body.
  - The computer code has been compressed and optimized such that 40,000+ MODFLOW stress periods can be executed in a reasonable computational time.

- Code has been formally approved by the St. Johns River Water Management District (Florida) for routing analyses and it is also used by the Southwest Florida Water Management District (Florida) for permit review purposes.

CONTINUOUS SIMULATION MODELING: THE HYDROGRAPH

- **Unlike conventional surface water routing models, the continuous simulation inflow hydrograph includes 3 columns of data:**
  - the elapsed time (in hr),
  - the flow rate (in cfs) into the water body (which may be positive or negative), and
  - the recharge rate (in ft/day) to the water table aquifer adjacent to the water body (which may also be positive or negative).
- **The first two columns of data in the hydrograph are the same as the conventional surface water routing models but the third column is added to model fluctuation of the water table adjacent to the water body.**

CONTINUOUS SIMULATION MODELING: INPUTS TO GENERATE HYDROGRAPH

- Surface water inflow: Directly Connected Impervious Area (DCIA) (acres), non-DCIA area (acres), CN for non-DCIA area. Note CN is automatically adjusted daily based on antecedent rainfall. Also note that precise definition of DCIA is extremely important when modeling small rainfall events.
- Evaporation loss & rainfall (daily)
- E.T. within non-DCIA area of watershed (daily)
- Artificial recharge within non-DCIA area of watershed

CONTINUOUS SIMULATION MODELING: POND DEFINITION

- Stage-area relationship & perimeter of water body
- Typical parameters for surficial aquifer system: permeability, porosity, and depth of aquifer (from site-specific geotechnical report)
- Overflow discharge structures (up to 3)
- Vertical exchange of water between water body & Floridan aquifer (linear or non-linear relationship established by geotech).