PREDEVELOPMENT VERSUS POSTDEVELOPMENT VOLUME ANALYSIS:
An Application of Continuous Simulation Modeling using PONDS Version 3 Software

PRESENTATION TO:
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
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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.

- Such a model can predict, on a daily basis, stages, inflows, and discharge rates and volumes (both ground water & surface water).

CONTINUOUS SIMULATION MODELING: WHY IS IT NEEDED?

- **For reasons of water quantity & water quality, there is a growing concern for regulating cumulative discharge volume from stormwater management systems in volume-sensitive basins.**

- **Such a model is also useful for predicting wetland hydroperiods and impacts due to alteration of drainage patterns, etc.**

- **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. After all, *is 210 inches of rain in 3 years more critical than 10.6 inches of rain in 24 hours?* Conventional modeling and current regulatory requirements do not address this type of occurrence which many of us saw first hand in 1994-1996.**

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.
- Important to point out that this methodology has been used successfully on numerous projects in the Central Florida area.

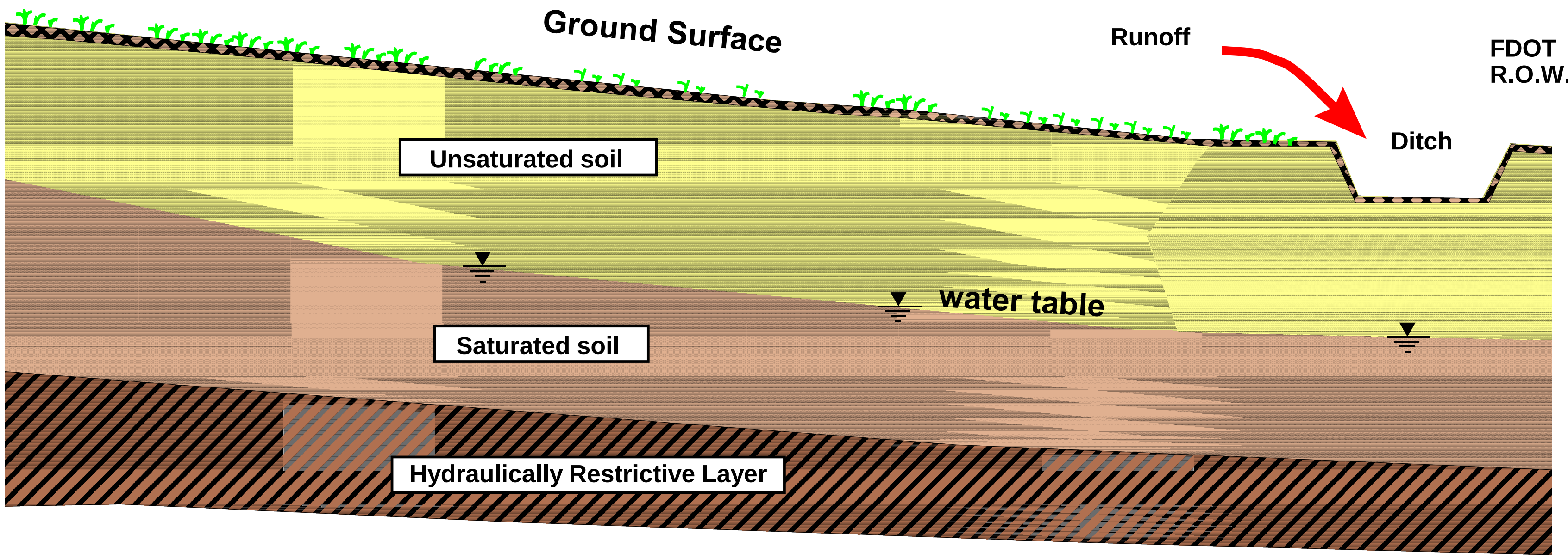
CONTINUOUS SIMULATION MODELING: INPUTS TO GENERATE HYDROGRAPH

- **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.**
- **Evaporation loss & rainfall (daily)**
- **E.T. within non-DCIA area of watershed (daily)**
- **Artificial recharge within non-DCIA area of watershed**

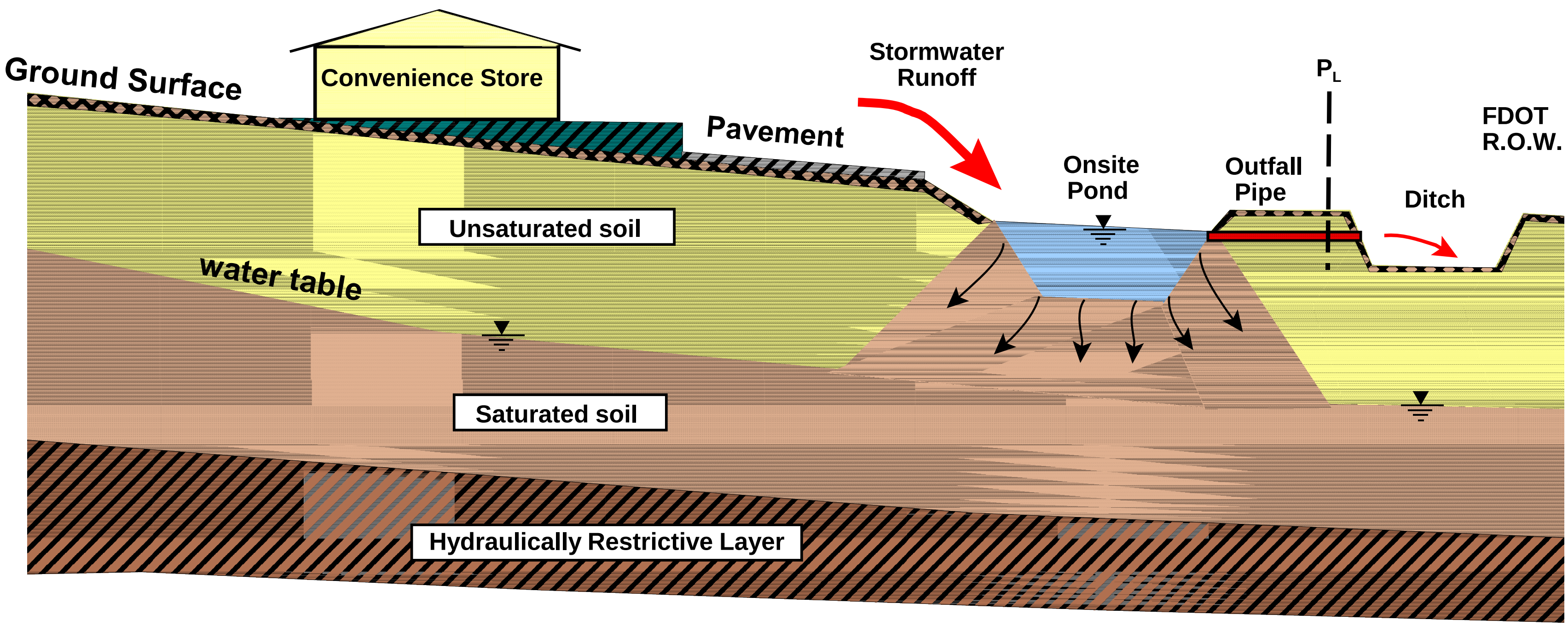
CONTINUOUS SIMULATION MODELING: POND DEFINITION

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

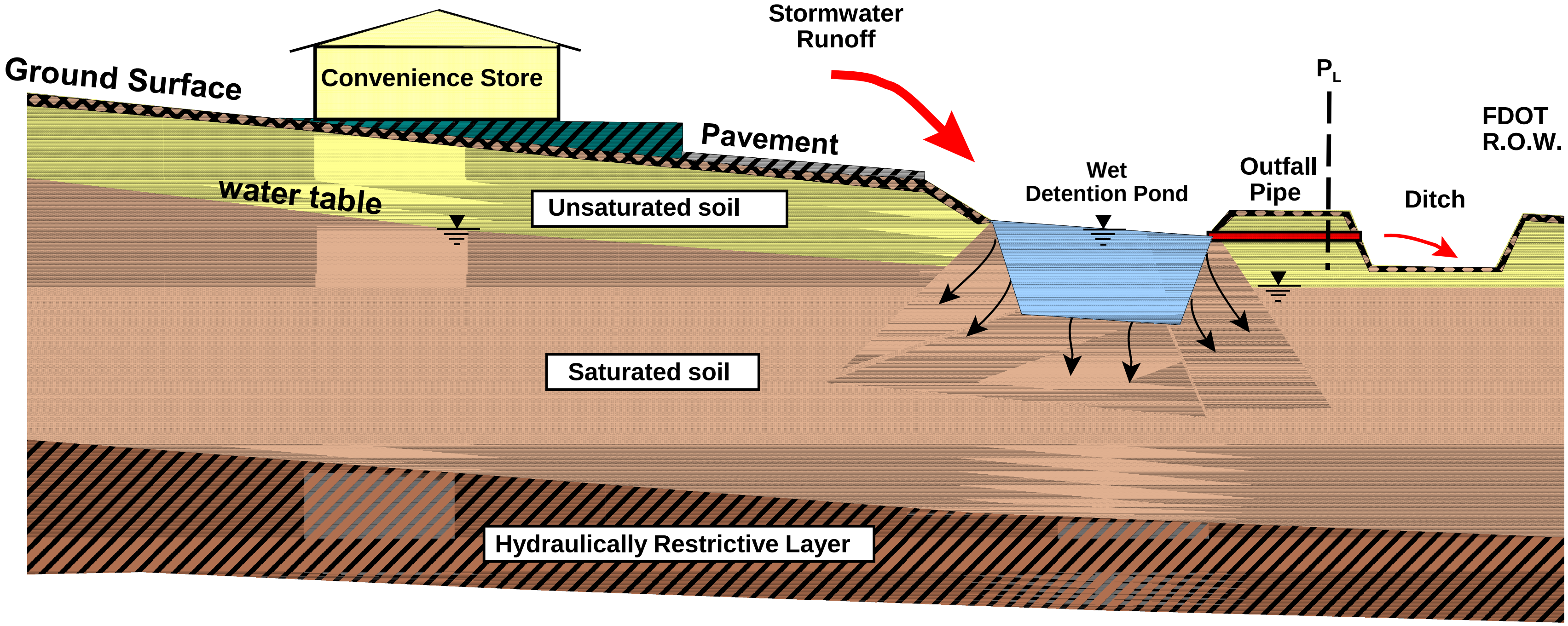
PREDEVELOPMENT



POSTDEVELOPMENT - DRY BOTTOM POND



POSTDEVELOPMENT - WET BOTTOM POND



EXAMPLE PROBLEM
MODEL INPUT: DRAINAGE BASIN PARAMETERS

PARAMETER	UNIT	MAGNITUDE	
		PRE	POST
Area of contributing drainage basin	ft^2	35,031	35,031
Area of contributing drainage basin	acre	0.804	0.804
Non-impervious (non-DCIA) area	ft^2	35,031	12,296
Curve Number (CN) for non-DCIA area (AMC I)	-	30	30
Curve Number (CN) for non-DCIA area (AMC II)		49	49
Curve Number (CN) for non-DCIA area (AMC III)		69	69
Impervious area (DCIA)	ft^2	0	22,735
Directly connected impervious area	%	0.00%	64.90%

EXAMPLE PROBLEM
MODEL INPUT: RAINFALL DATA

Month	Average for Orlando Intl Airport [1964-93] (inch)	Normal Year [1982] (inch)
January	2.23	1.72
February	2.70	1.34
March	3.53	4.85
April	2.62	6.27
May	3.40	5.29
June	6.98	6.06
July	7.83	11.81
August	6.68	5.03
September	6.74	6.96
October	3.36	0.74
November	1.88	0.53
December	1.99	1.01
TOTALS	49.94	51.61

Each simulation was run for a 365-day (1 year) period starting January 1, 1982 and ending December 31, 1982. The simulation time step was 24 hours (i.e., 1 day). The total rainfall over each 24-hr period was treated as a single rainfall event for computing stormwater runoff.

EXAMPLE PROBLEM
MODEL INPUT: STAGE-AREA DATA OF POND

Geometric Parameters for Pond

Parameter	Unit	Magnitude
Equivalent pond length	ft	120
Equivalent pond width	ft	25

Stage (ft NGVD)	Area Excluding Soil Voids in Side Slope (ft^2)	Area Including Soil Voids in Side Slope (ft^2)
101.0	0	548
104.0	756	1,152
105.0	1,484	1,735
106.0	2,738	2,738
107.0	3,876	3,876

EXAMPLE PROBLEM
MODEL INPUT: POND DISCHARGE STURCTURES

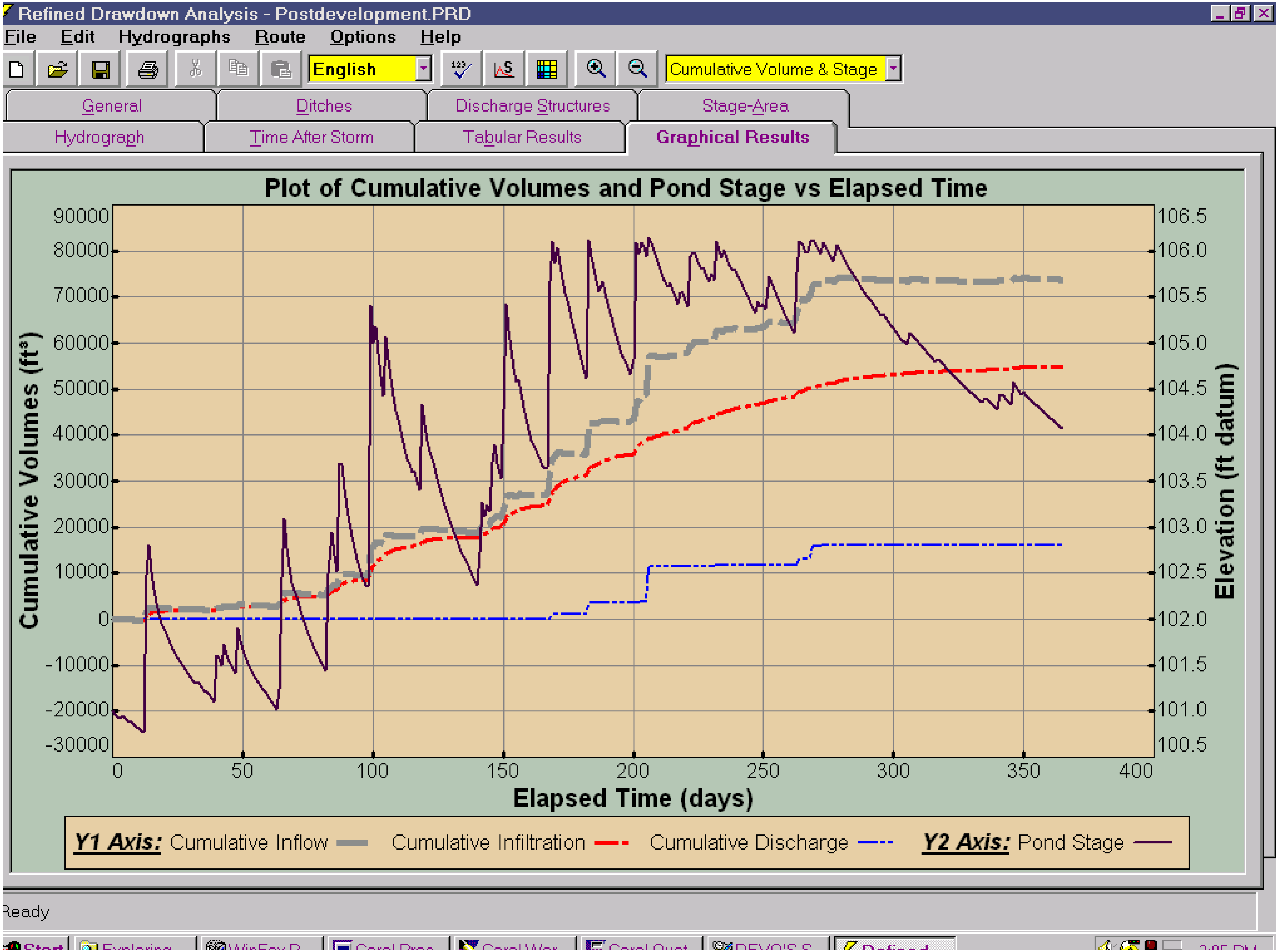
Description	Parameter	Unit	Magnitude
SIDE CONTROL WEIR	Discharge elevation	ft NGVD	106.09
	Weir length	ft	1.83
	Weir coefficient	-	3.13
	Weir exponent	-	1.5
TOP CONTROL WEIR	Discharge elevation	ft NGVD	106.22
	Weir length	ft	7.83
	Weir coefficient	-	3.13
	Weir exponent	-	1.5
DROP CURB TO ENTRY POINT BLVD	Discharge elevation	ft NGVD	106.90
	Weir length	ft	30
	Weir coefficient	-	2.861
	Weir exponent	-	1.5

EXAMPLE PROBLEM
MODEL INPUT: AQUIFER PARAMETERS

Parameter	Unit	Magnitude
Base of mobilized aquifer	ft NGVD	+99
Seasonal high water table	ft NGVD	+101
Horizontal hydraulic conductivity	ft/day	5
Fillable porosity	%	20
Vertical recharge to Floridan aquifer within pond	in/yr	6
Vertical recharge to Floridan aquifer outside pond	in/yr	6

EXAMPLE PROBLEM
MODEL INPUT: EVAPORATION & EVAPOTRANSPIRATION

Month	No. of days in month	Monthly rates (inch)			Daily rates (inch)	
		Normal Rainfall	Lake Evaporation	Evapo-transpiration	Lake Evaporation	Evapo-transpiration
January	31	2.10	2.2	1.969	0.07097	0.06350
February	28	2.83	2.5	1.850	0.08929	0.06609
March	31	3.20	3.9	2.677	0.12581	0.08636
April	30	2.19	5.5	3.307	0.18333	0.11024
May	31	3.96	6.7	3.071	0.21613	0.09906
June	30	7.39	5.8	4.882	0.19333	0.16273
July	31	7.78	6.2	4.764	0.20000	0.15367
August	31	6.32	5.5	4.449	0.17742	0.14351
September	30	5.62	4.4	4.094	0.14667	0.13648
October	31	2.82	3.6	4.055	0.11613	0.13081
November	30	1.78	2.4	2.323	0.08000	0.07743
December	31	1.83	2.2	1.969	0.07097	0.06350
TOTALS	365	47.82	50.9	39.409		



Refined Drawdown Analysis - Postdevelopment.PRD
File Edit Hydrographs Route Options Help
English
Cumulative Volume & Stage
General
Ditches
Discharge Structures
Stage-Area
Hydrograph
Time After Storm
Tabular Results
Graphical Results
Plot of Cumulative Volumes and Pond Stage vs Elapsed Time
Cumulative Volumes (ft³)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
-20000
-30000
106.5
106.0
105.5
105.0
104.5
104.0
103.5
103.0
102.5
102.0
101.5
101.0
100.5
Elevation (ft datum)
0
50
100
150
200
250
300
350
400
Elapsed Time (days)
Y1 Axis: Cumulative Inflow
Cumulative Infiltration
Cumulative Discharge
Y2 Axis: Pond Stage
Ready

RESULTS FOR THIS EXAMPLE

AVERAGE RAINFALL YEAR IS 1982

- **Predevelopment runoff volume for calendar year 1982 is 4,012 cubic feet**
- **Postdevelopment runoff volume for calendar year 1982 is 16,171 cubic feet**
- **If soil permeability is doubled from 5 ft/day to 10 ft/day, the postdevelopment runoff volume for calendar year 1982 is 5,676 cubic feet**
- **If soil permeability is quadrupled from 5 ft/day to 20 ft/day, the postdevelopment runoff volume for calendar year 1982 is 1,563 cubic feet (16,171 ➜ 5,676 ➜ 1,563)**

WHAT ARE THE OPTIONS FOR REGULATING VOLUMETRIC DISCHARGE

- For the areas within SFWMD where pre-post volume regulations are needed & physically feasible, there are two (2) approaches the district may consider in quantitative criteria for regional or local facilities:

  - Option #1: The most assured method will be to require continuous simulation modeling for an average rainfall year, as demonstrated in this presentation. However, such comprehensive calculations may prove too onerous (& expensive) for the majority of consultants.

  - Option #2: Define an approriate retention volume & a corresponding recovery time which will ensure sufficient onsite recharge. Examples of similar existing criteria include:
    - Wekiva River Basin in SJRWMD: retention of 3 inches of runoff from DCIA with a maximum 14 day recovery period.
    - Cypress Creek and Reedy Creek Basins in Orange County (see chart in next slide).

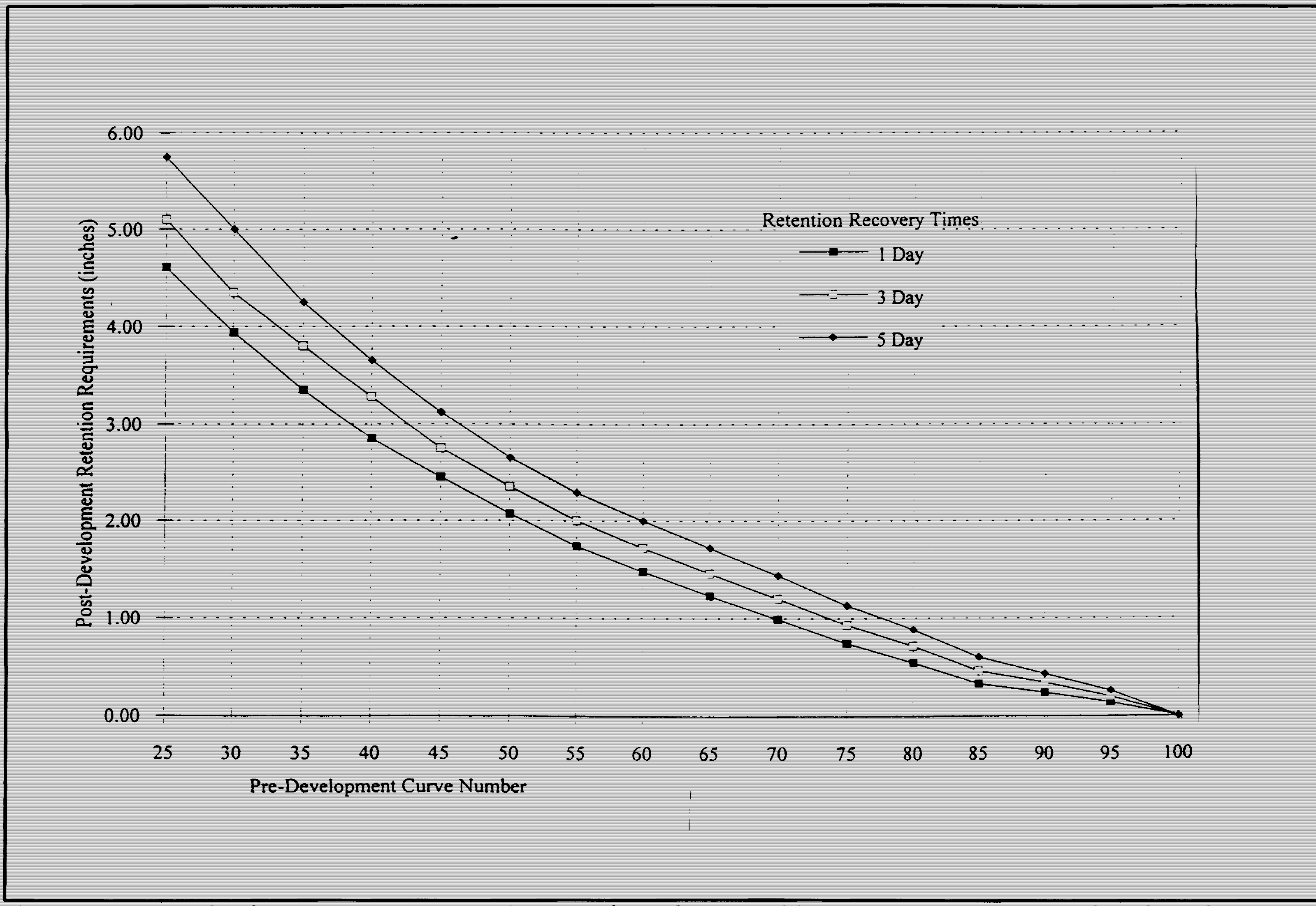


Figure 12. **Post development Retention Requirements for Volume Sensitive Systems in Cypress Creek and Reedy Creek Basins (Singhofen & Associates, 1996)**