Hydrologic Design for Wetlands

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Hydrologic Issues

1. Time step (monthly or daily)
2. Water budget interpretation (frequency and duration)
3. Runoff methodology (design storm v continuous)

Hydrologic Design Goals

- Inundation/saturation (hydroperiod)
  - Depth Requirements
  - Duration
  - Frequency
- Coordination with wetland scientist

Duration and Frequency

- Duration
  - Number of days?
  - Consecutive or not?
- Frequency
  - Exceedence probability, e.g. meet requirements 8 of 10 years?
  - Can we be too wet as well as too dry?

Example

- Proposed wetland mitigation site: upstream of a secondary road on Clear Creek. (South Carolina)
- Site features:
  - Drainage area – 695 ha
  - Wetland site – 4.5 ha
  - Latitude – 34 degrees
  - Baseflow – 0.0005 m^3/s (spring fed)
  - Soil Permeability, K = 8 x 10^{-5} mm/s

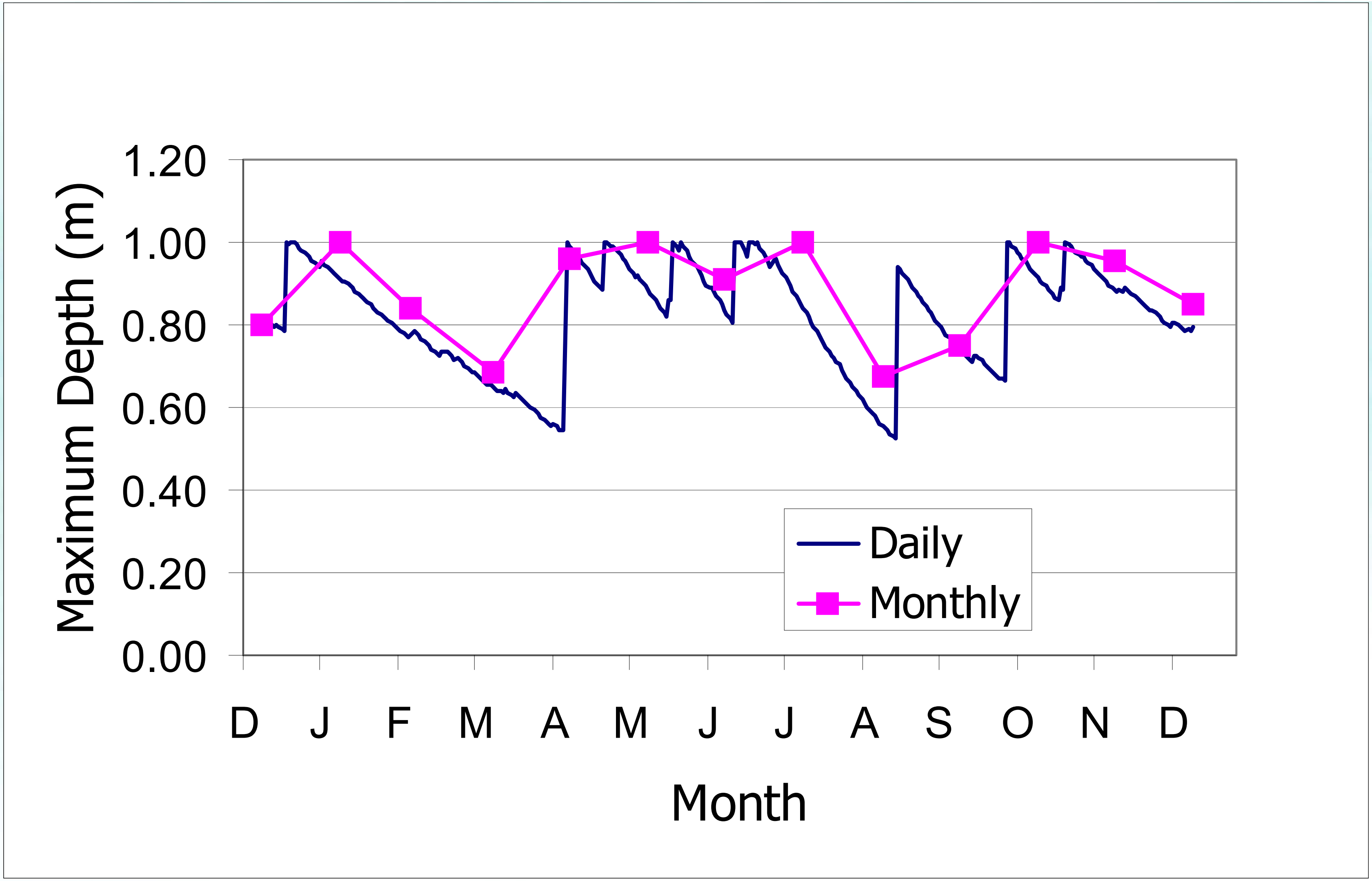
Rainfall (52-yr record)

- Typical Year
  - 1968
  - Precipitation =1236 mm
- Dry Year
  - 1954
  - Precipitation =696 mm
- Wet Year
  - 1964
  - Precipitation = 2043 mm

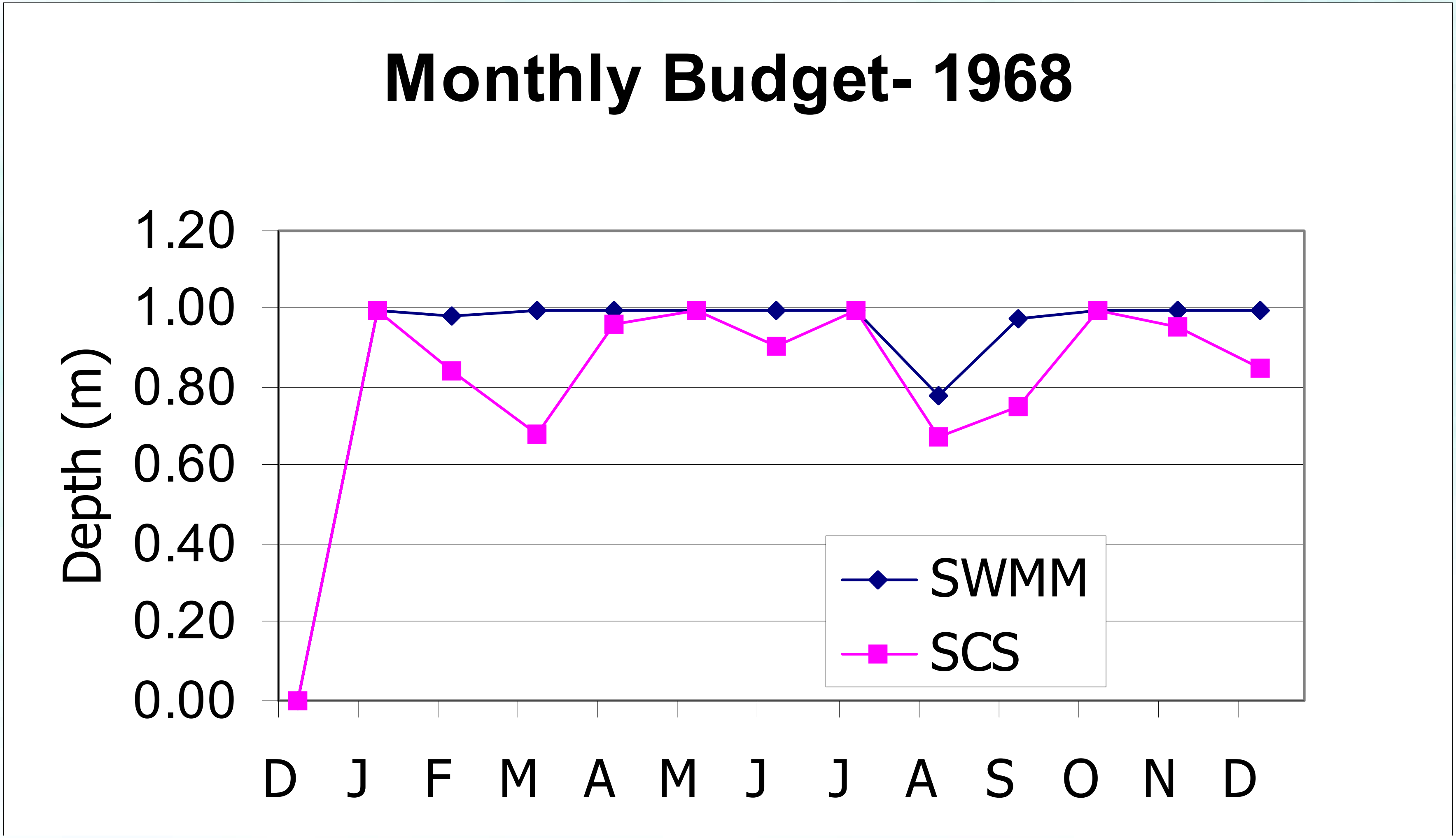
Design Requirements

- 90 days of inundation > 500 mm for submergents over 0.5 ha in 8 of 10 years.
- 90 days of inundation < 500 mm for emergents over 2.0 ha in 8 of 10 years.

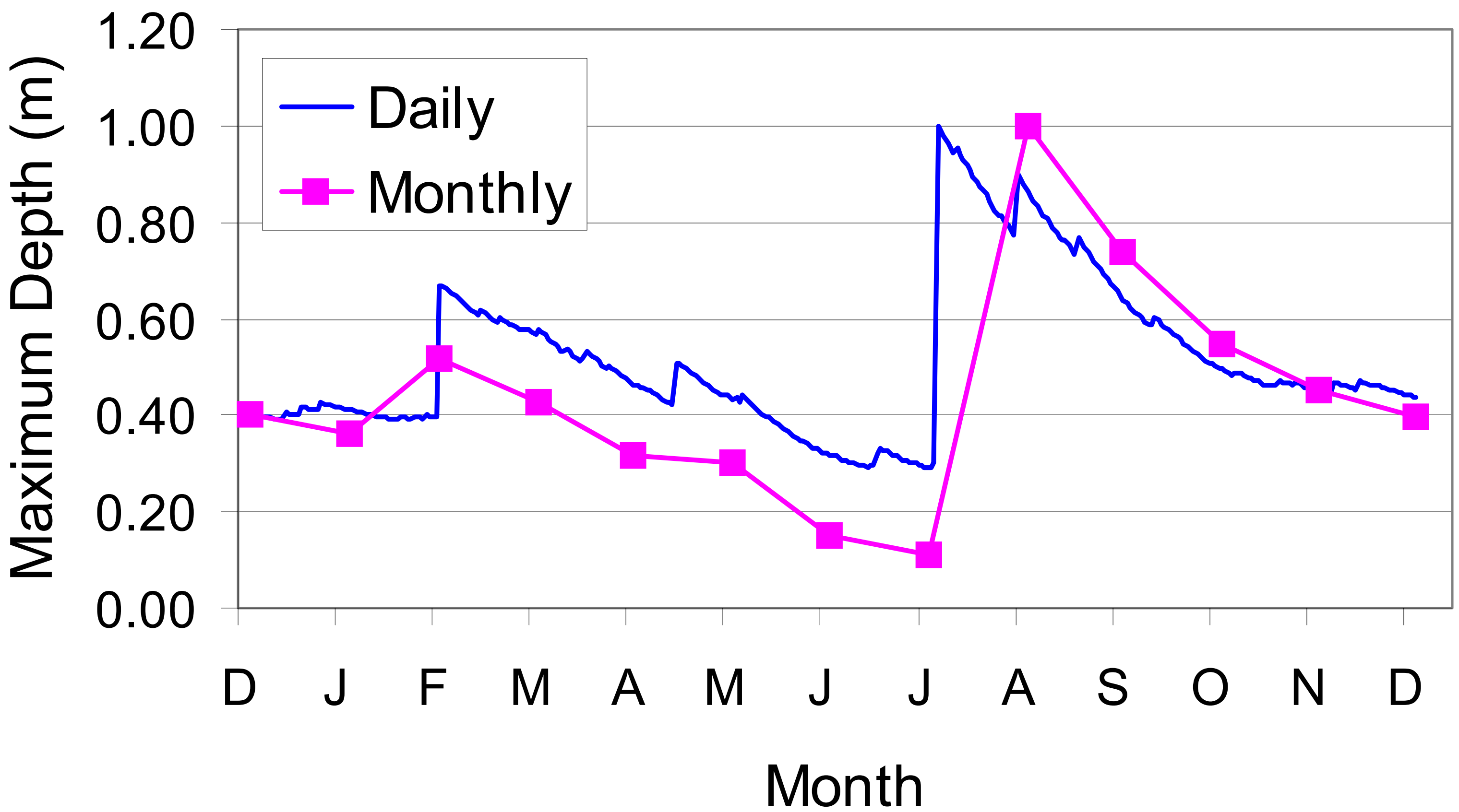
1968 Water Budget – Design Storm (SCS)



Budget Comparison



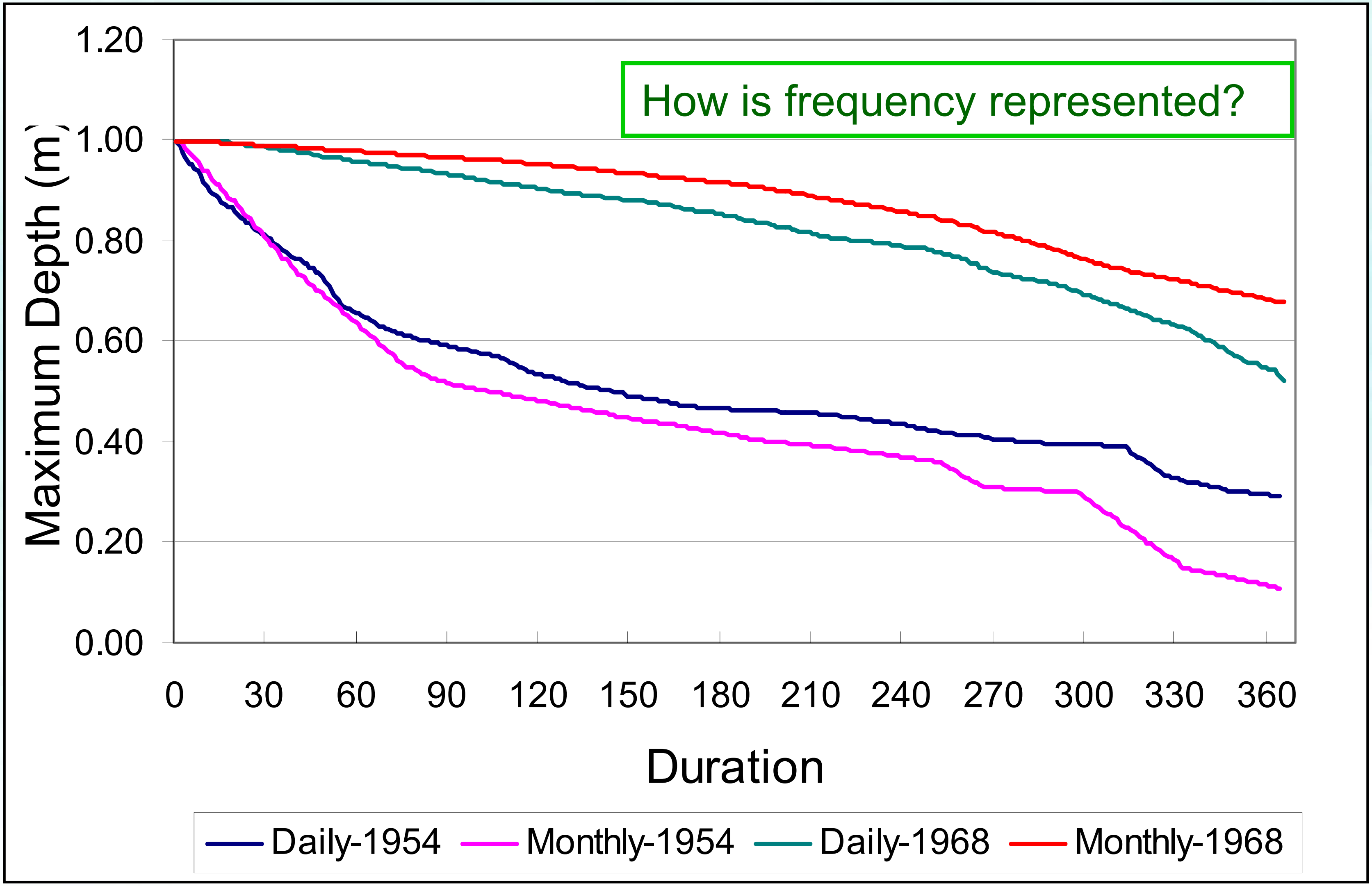
1954 Water Budget



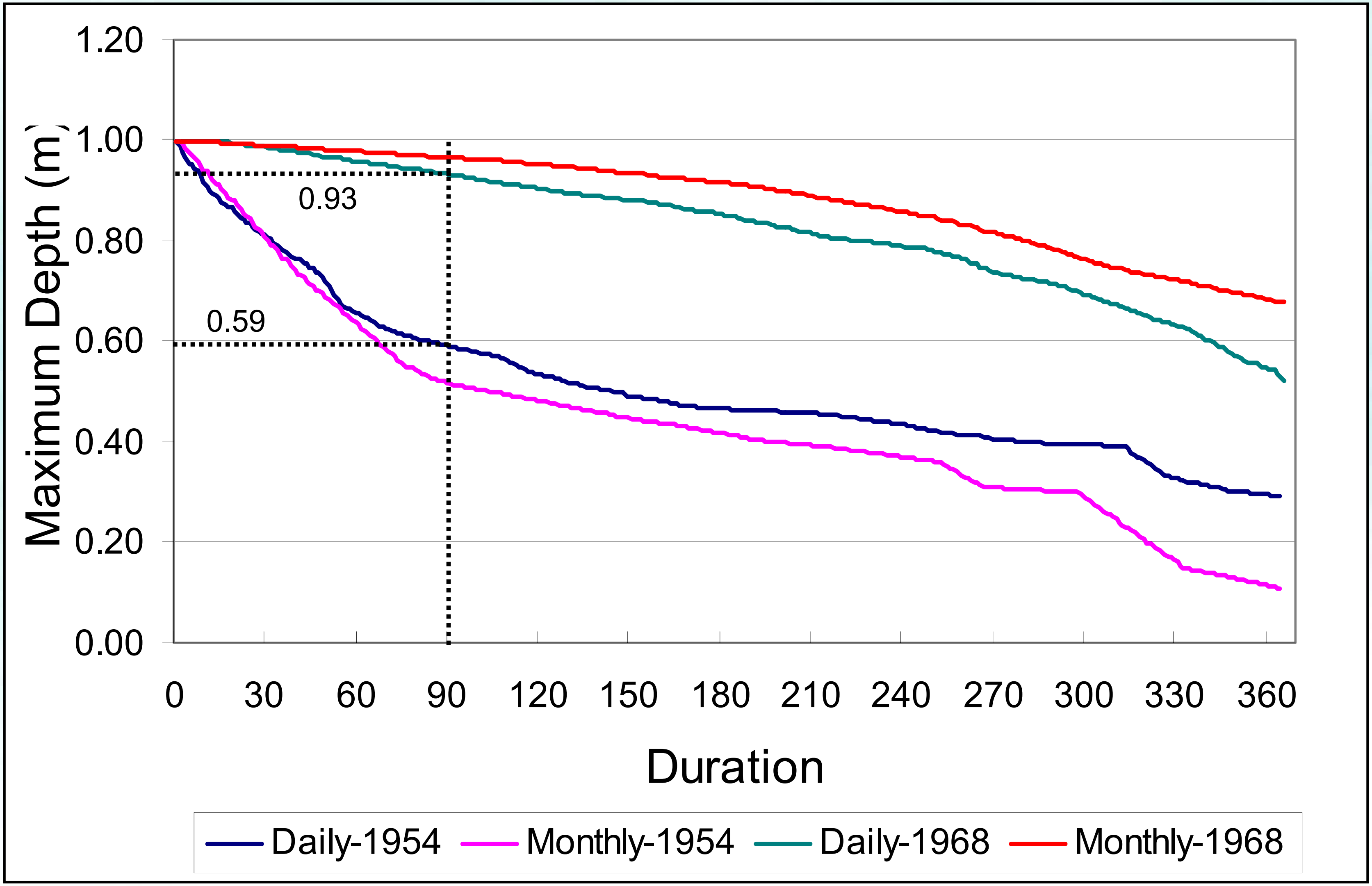
Recall the Design Requirements

- 90 days of inundation > 500 mm for submergents over 0.5 ha in 8 of 10 years.
- 90 days of inundation < 500 mm for emergents over 2.0 ha in 8 of 10 years.

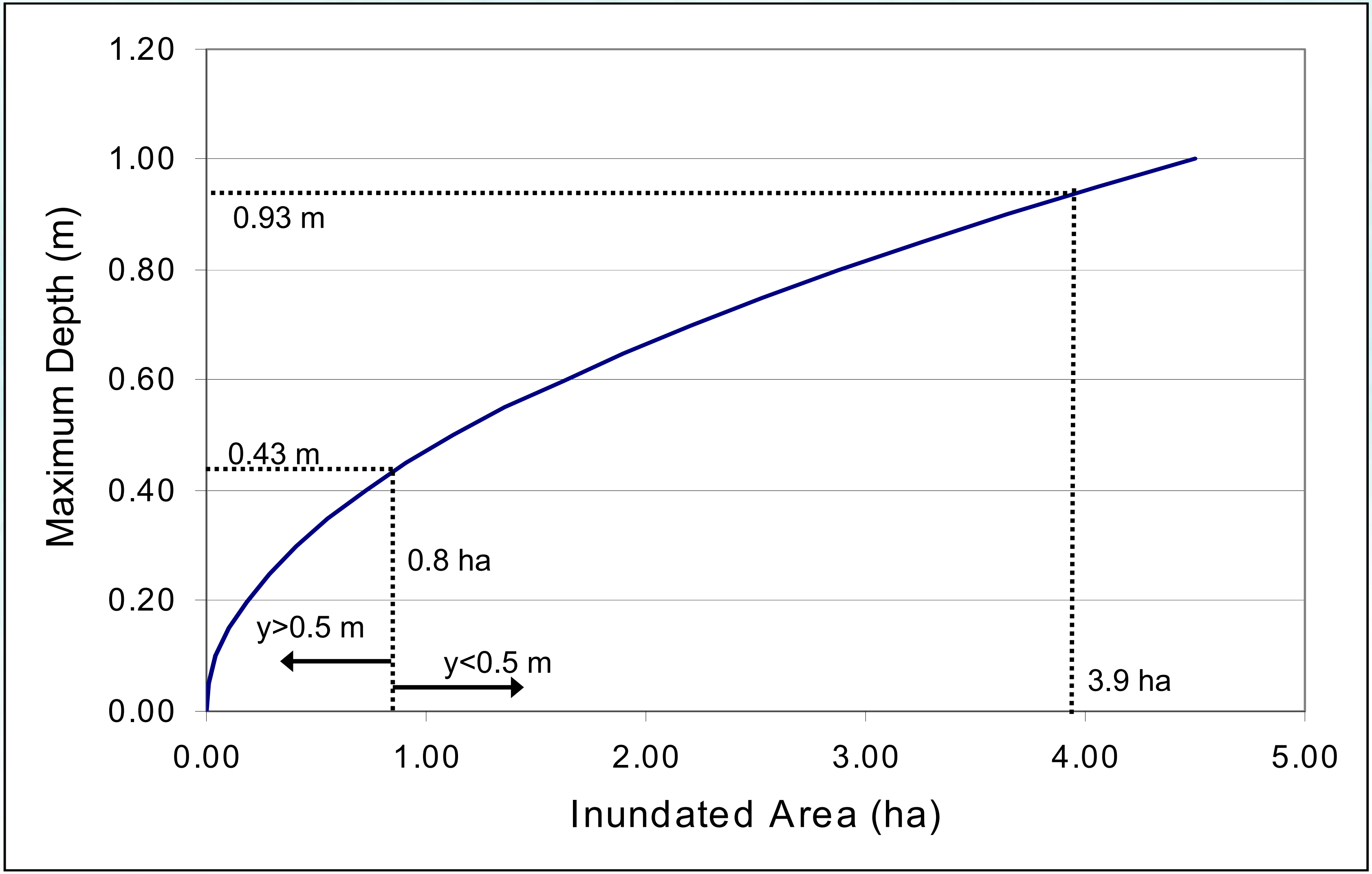
Depth-Duration-Frequency



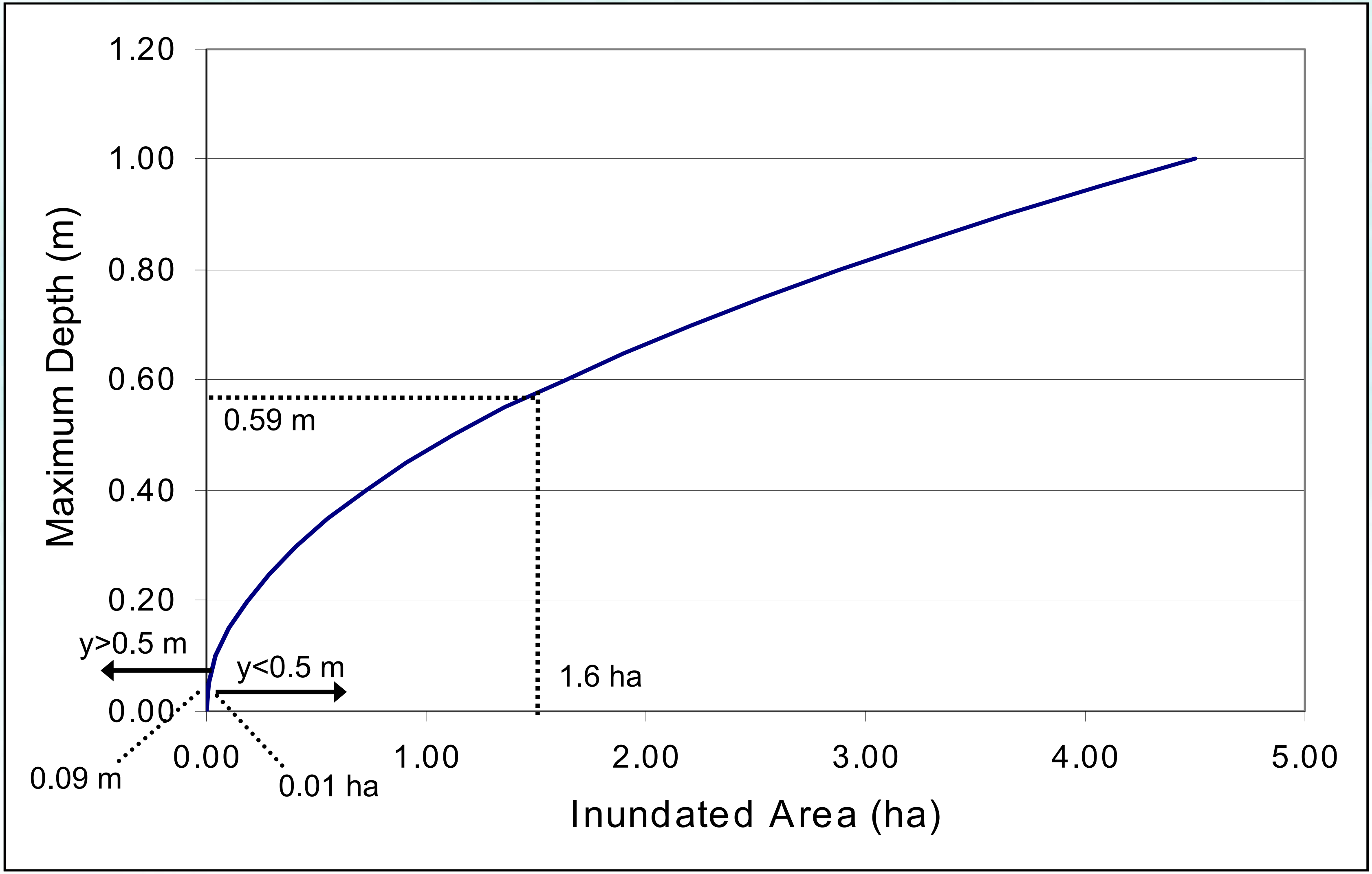
Depth-Duration-Frequency



1968 90-day Inundation



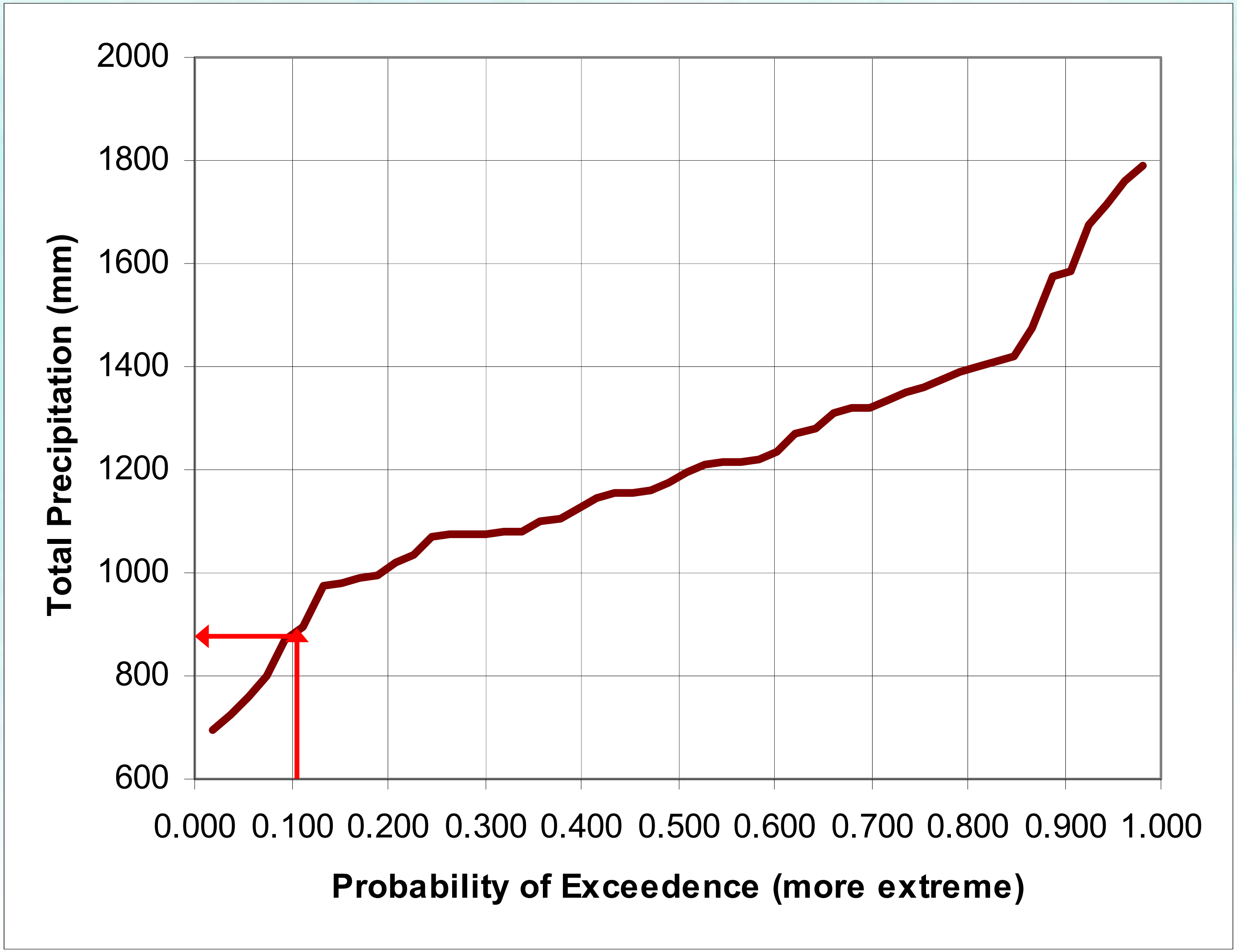
1954 90-day Inundation



Comparison

	Submergents (ha)	Emergents (ha)
Requirement	*0.5*	*2.0*
1968 (average)	0.8	3.1
20% exceedence	?	?
1954 (driest)	0.01	1.59

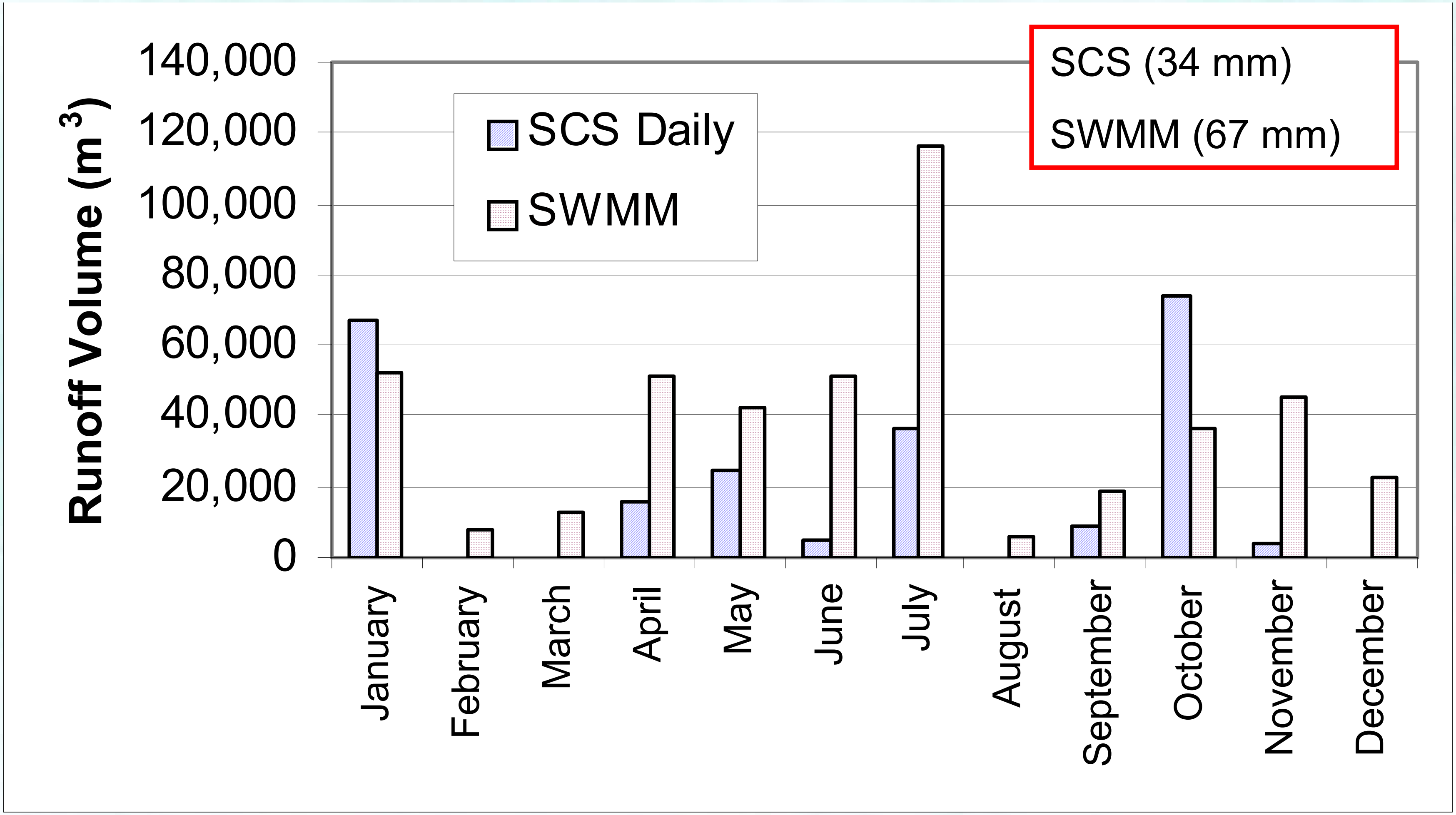
Precip in 9 of 10 years



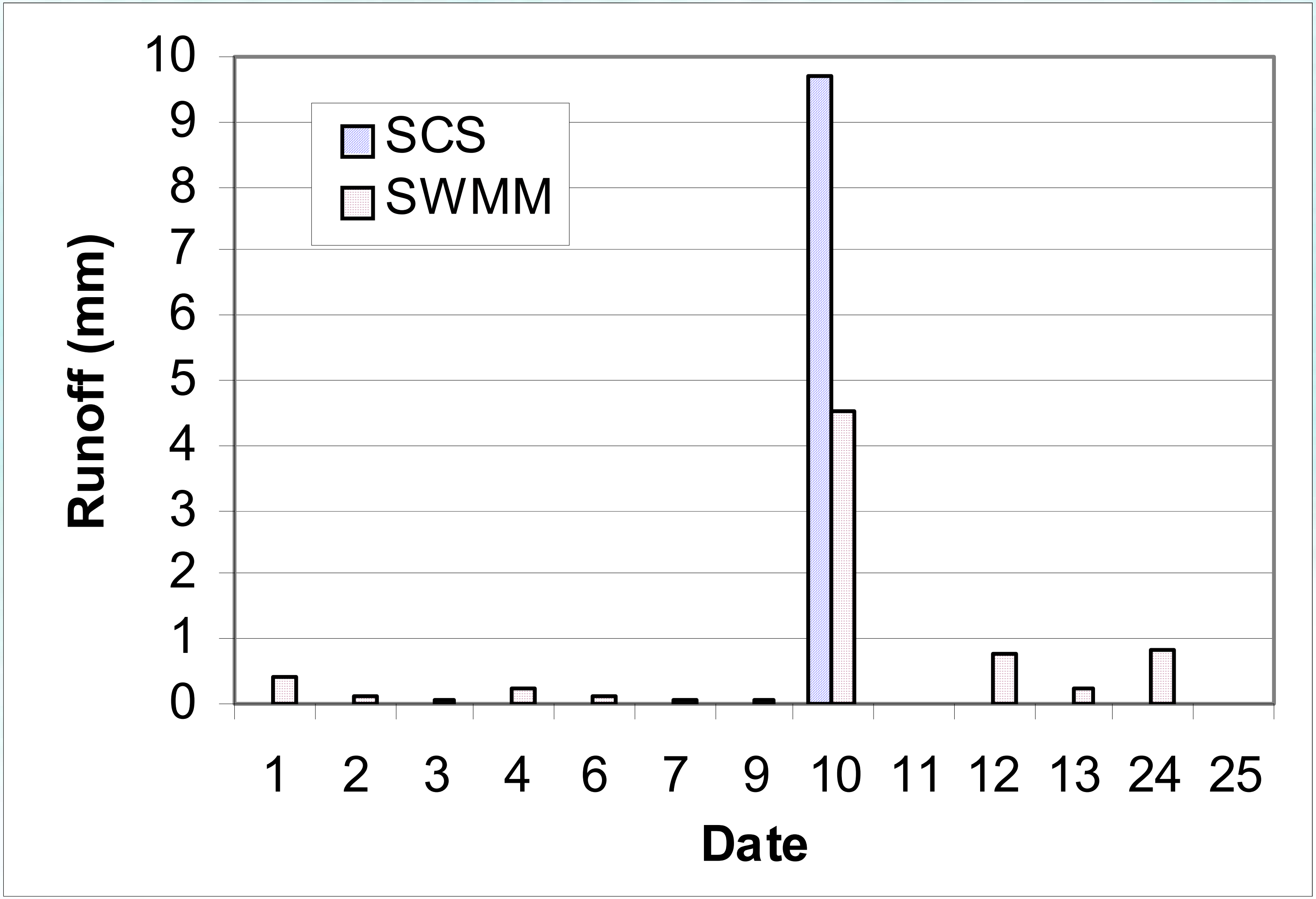
Runoff Method?

- Design Storm (e.g. SCS)
- Continuous Simulation (e.g. SWMM)

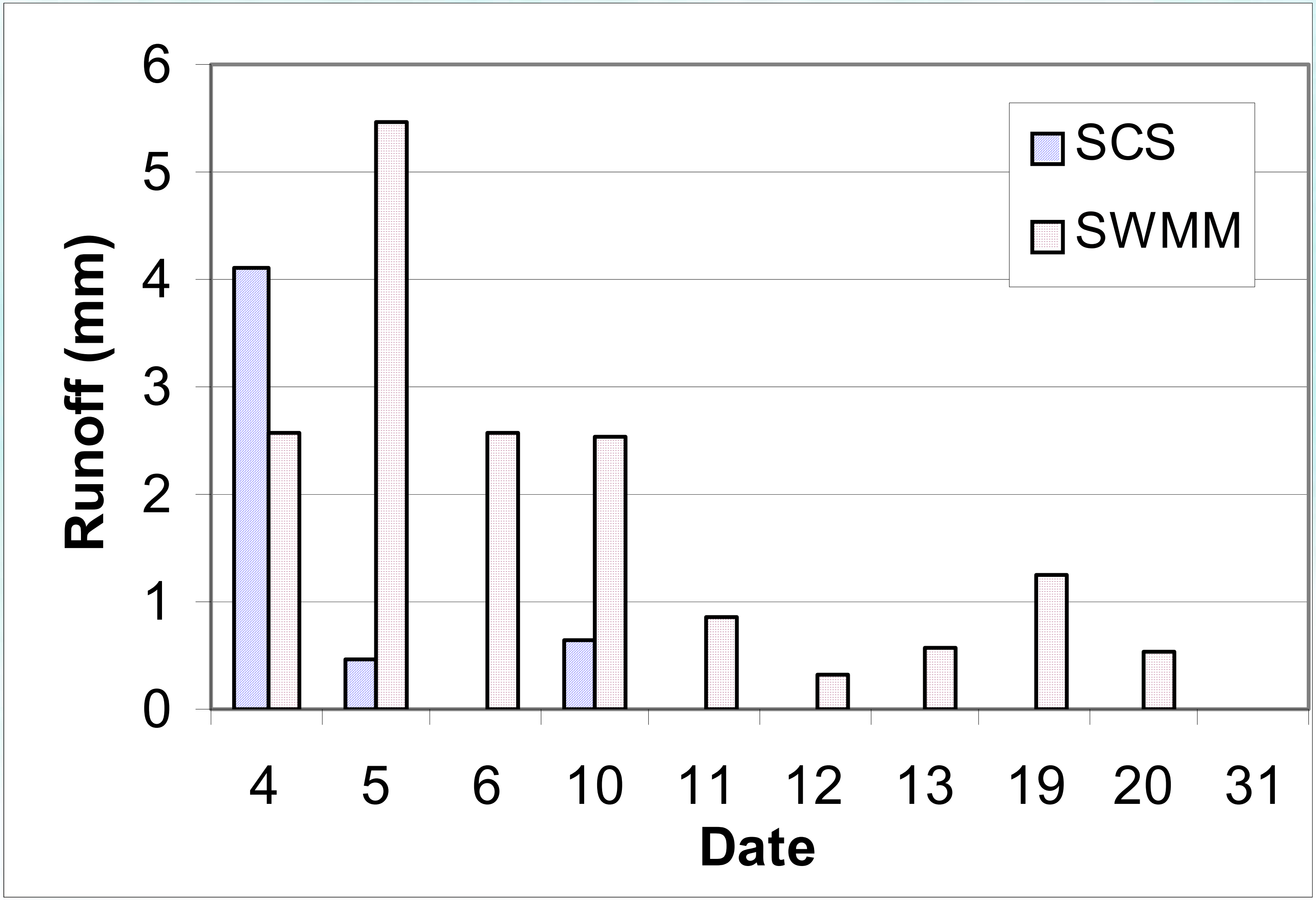
Runoff Volume-1968



January 1968



July 1968



Runoff Volume

- Runoff volume, Q, computed by:

$$Q = \frac{\left(P - I_a\right)^2}{\left(P + S - I_a\right)}$$

Where,

Q = Runoff depth

P = Rainfall depth

I_a = Initial abstraction (depth)

S = Maximum potential retention (depth)

SCS Runoff Considerations

- With SCS methodology:
  - No runoff up to a threshold, I_a
  - 1968: Precip.=1236 mm; Runoff=34 mm (14 days)
  - 1954: Precip.=696 mm; Runoff=7.7 mm (5 days)
- Other assumptions:
  - Each day is independent of previous and subsequent days (conservative).
  - No cumulative rainfall effects (conservative).
  - Watershed size such that runoff response within 24-hours (implicit).

Continuous Simulation - SWMM

- Hourly precipitation data
- Daily carry-over
- Watershed accounting of infiltration, evaporation, & runoff
- Watershed size not specifically limited as $T_c < 10$ h for SCS approach
- SWMM more complex and data intensive

Runoff Data Requirements

- SCS
  - Area
  - Curve Number
  - Initial Abstraction
  - Daily rainfall
  - Daily accounting

- SWMM
  - Area
  - Watershed shape, slope, & roughness
  - % impervious
  - Infiltration Parameters
  - Depression storage
  - Evaporation
  - Hourly rainfall
  - Continuous accounting

Advantages of Continuous Simulation

- Better use of precipitation data
- Better description of watershed (At least SCS v. SWMM)
- More appropriate for smaller storms? (Not a design storm methodology.)
- Note: may or may not be conservative.

Recommendations

1. Use daily water budget wherever possible.
2. Develop depth-duration-frequency curves to interpret budget results and design req.
3. Use continuous simulation with hourly precipitation to generate runoff.
4. Use exceedence probability to define extreme events (In coordination with wetland scientist).