MGS Flood
Continuous Flow Model for Stormwater Facility Analysis

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Problem

- Streams in western Washington Support Salmonids,
- Several Species Recently listed as Endangered,
- Design Stormwater Control Facilities that Maintain Channel Stability of Receiving Stream (Maintain Habitat),
- Minimize Pond Size to Reduce Cost Impacts

Overview

MGSFlood: A PC Based Software Package for Designing Stormwater Treatment for Urbanizing Watersheds

Features…

- ✓ Applicable for use in western Washington
- ✓ Continuous Rainfall–Runoff model (HSPF algorithm)
- ✓ Optimization Routine for Automatically Designing Ponds to Maintain Stream Channel Stability
- ✓ Includes "Extended" Precipitation Timeseries 120 to 158 years in Length for western Washington

Past Practice

Single Event Methods (SCS, SBUH, HEC-1)

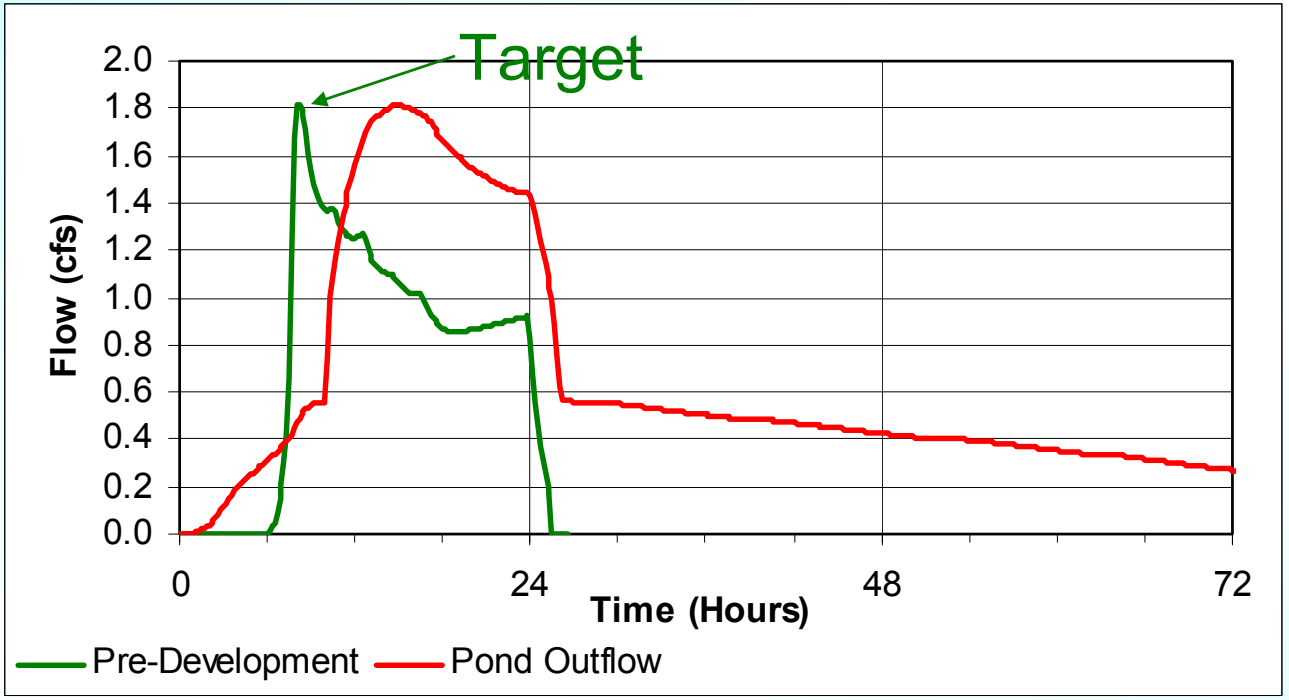
- Precip Distribution (SCS Type 1A) is Unrepresentative of Rainfall Patterns in western Washington
- Method doesn't Account for Sub-Surface Flow, which Dominates Runoff from Undeveloped Sites
- 24-Hour Design Event is Typically too short
- Results in Ponds that are too Small
- Results in Degraded Stream Channels, Poor Quality Habitat

Comparison of Past Practice with New Approach Required by Washington State

	Past Practice	New Approach
Design Goal	Flood Control	Stream Channel Stability
Design Standard	Peak Flow 2-year & 10-year	Match Flow Duration
Hydrologic Model Type	Single Event (SCS, SBUH)	Continuous (MGSFlood, HSPF)

Single Event Pond Design

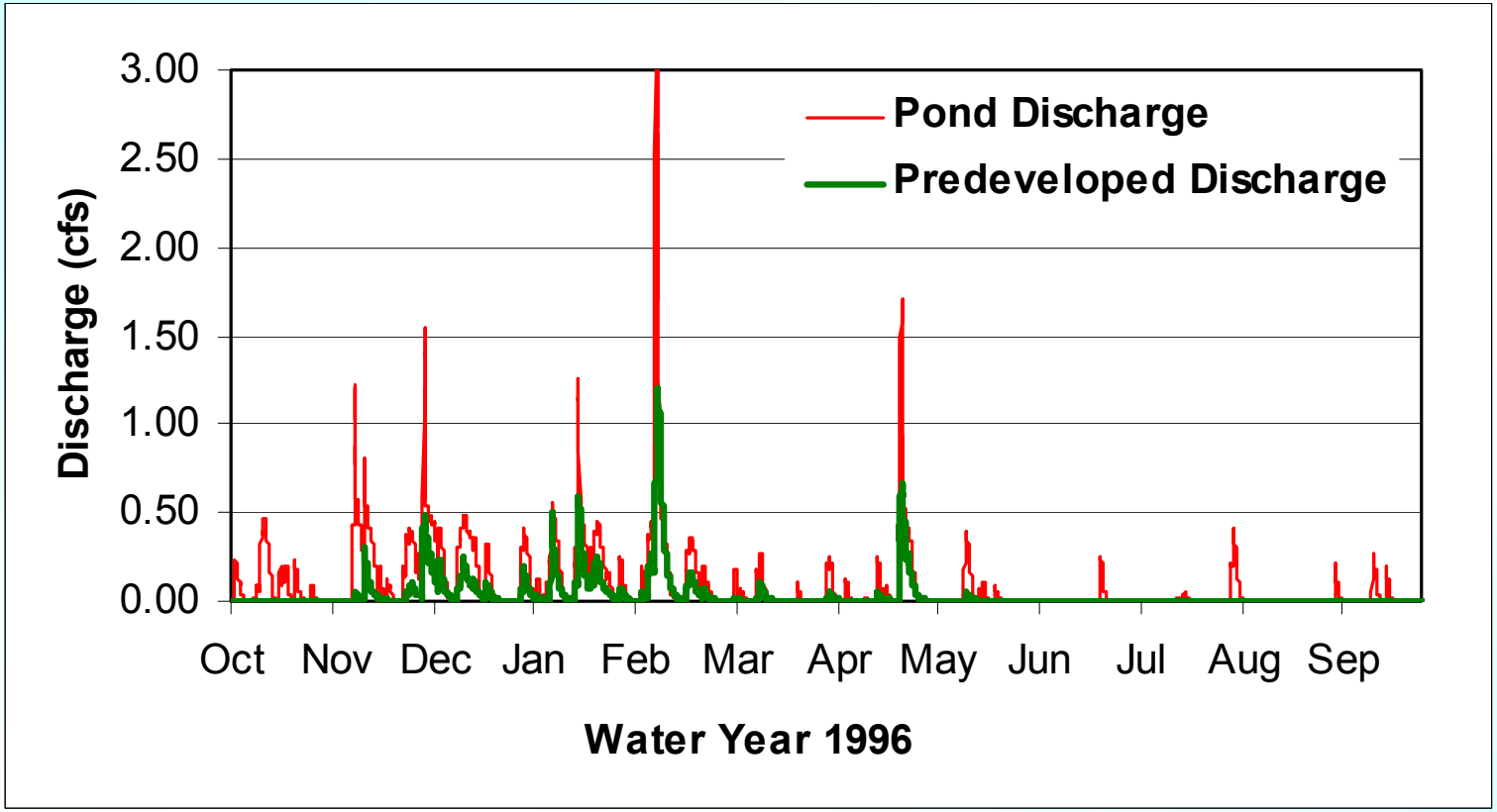
(Goal is Flood Peak Mitigation)



(Hydrographs Computed Using SBUH)

- Flood Peak is Reduced to Predeveloped Level, but higher Runoff Volume Extends Length of Flood
- Results in More Erosive Work done on Stream Channel than in Predeveloped Condition

Performance of Single Event Pond Design



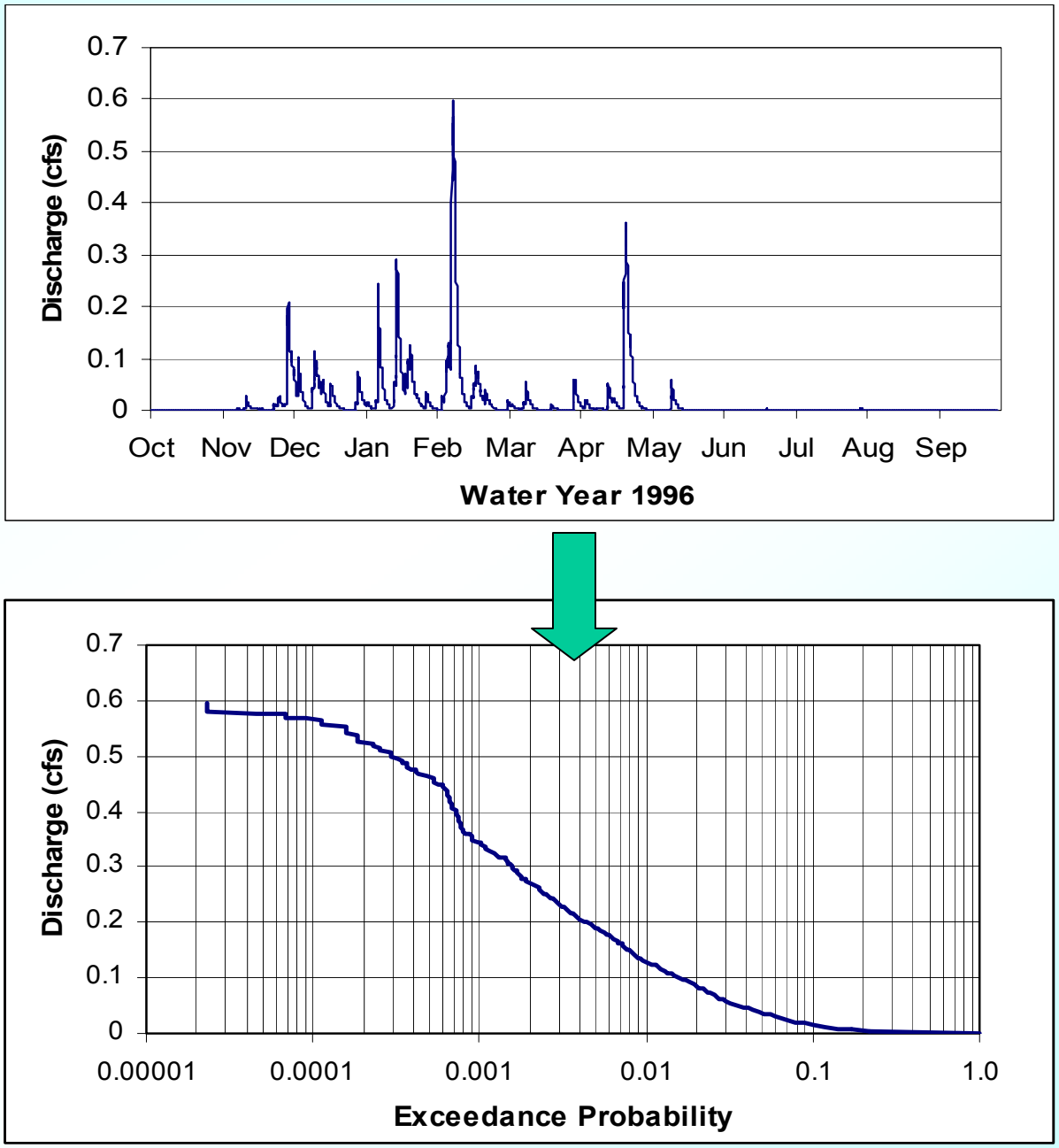
- Flood Peaks not Reduced to Predeveloped Levels
- Many More Runoff Events in Postdeveloped Condition…
  Results in Greater Erosive Work on Receiving Channels

Use of Continuous Flow Model for Pond Design

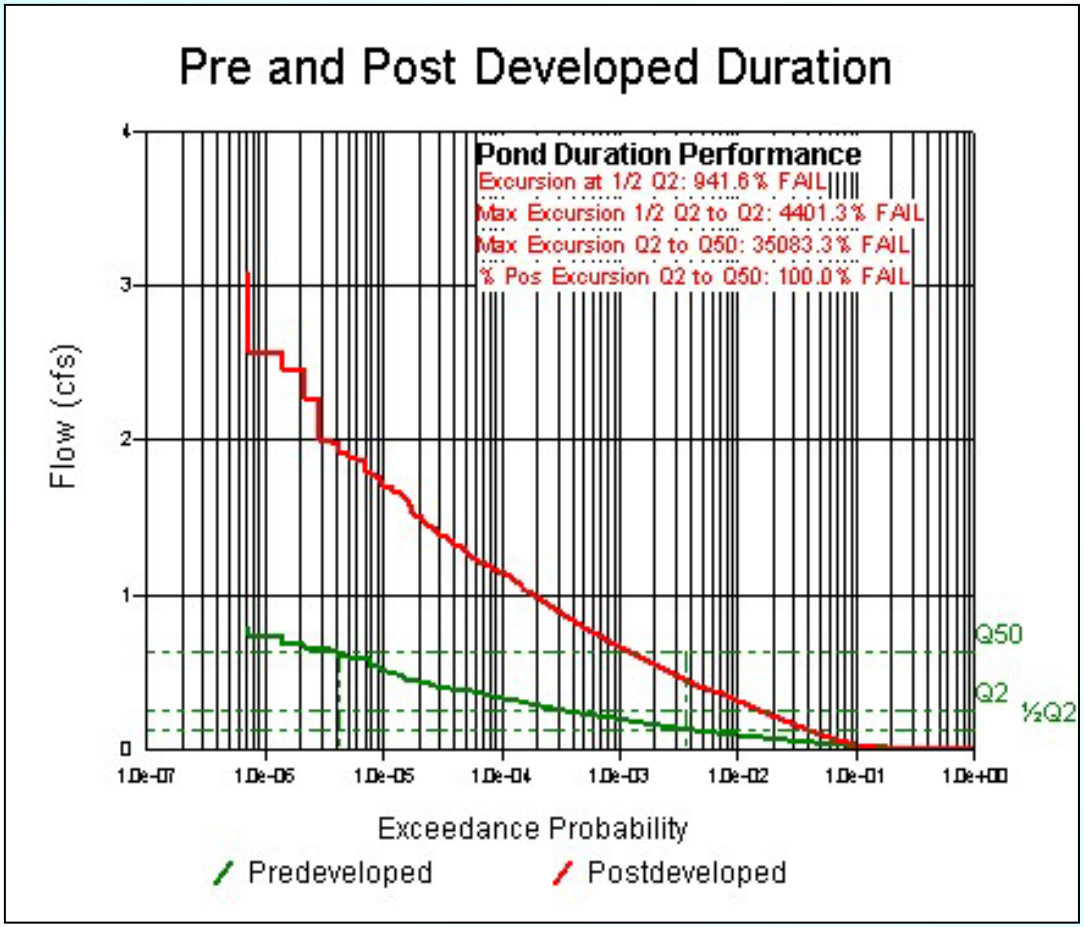
- Hydrological Simulation Program FORTRAN (HSPF) is the basis for MGS Flood
- Simulates hourly runoff for 50 to 150 years (depending on precipitation/ evaporation input)
- Allows for pond performance to be evaluated using a wide range of storms and antecedent conditions,
- Allows for Calculation of *Flow Duration Statistics*, which are used to design ponds for Channel Stability,
- Rainfall-Runoff algorithms in HSPF are more detailed than SCS, produces much better estimates of runoff.

Flow Duration Definition:

Track the Fraction of Time that a Given Flow is Equaled or Exceeded



Pre and Post Development Flow Duration Curves



Developed Condition:

- Higher Flows Occurring for Longer Duration
- Results in More Erosive Work Performed on Channel

Pond Design for Channel Stability

Control the Duration of Flow to Predeveloped Levels Above the Bedload Movement Threshold

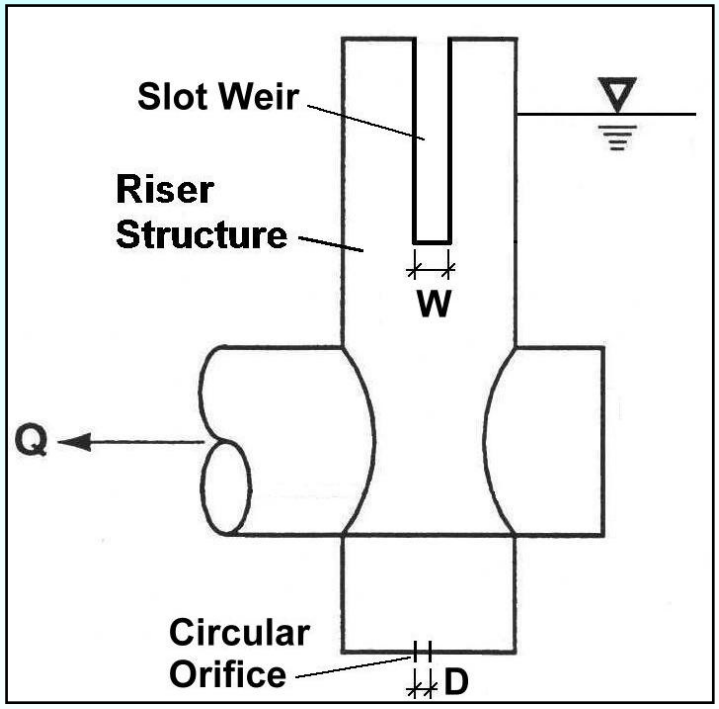
Bedload Movement Threshold:

"A rate of about 50-percent of the predevelopment 2-year discharge is a credible generic value for the initiation of sediment transport in gravel-bedded streams …"

(Derek Booth, 2000)

Match developed flow Duration Curve to predeveloped Curve from 50-percent of the 2-year to the full 50-year peak flow.

Flow Duration Standard Pond Design …



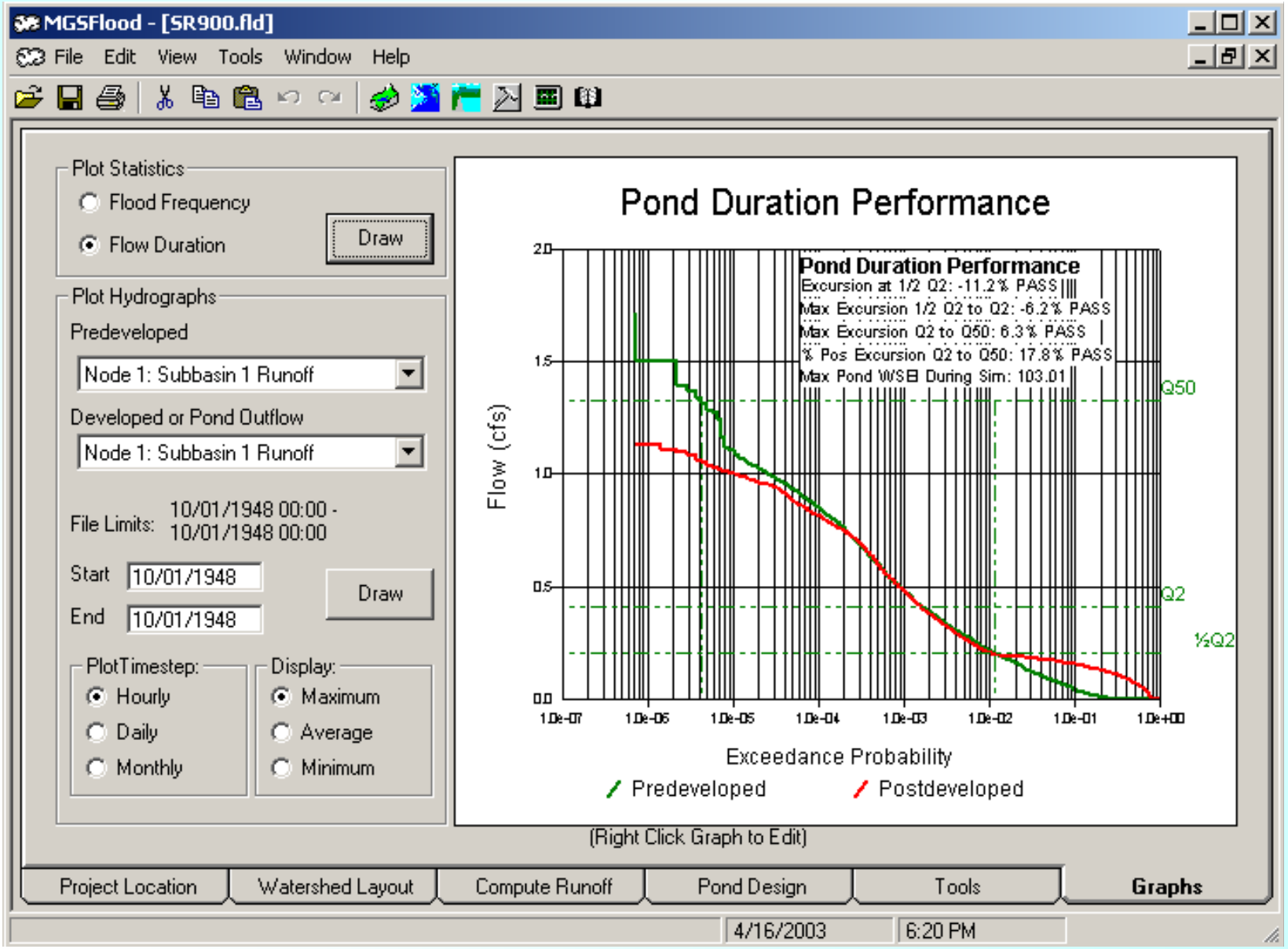
Unknowns:

- Pond Volume
- Bottom Orifice Size (D)
- Slot Weir Invert Elev.
- Slot Weir Width (W) …

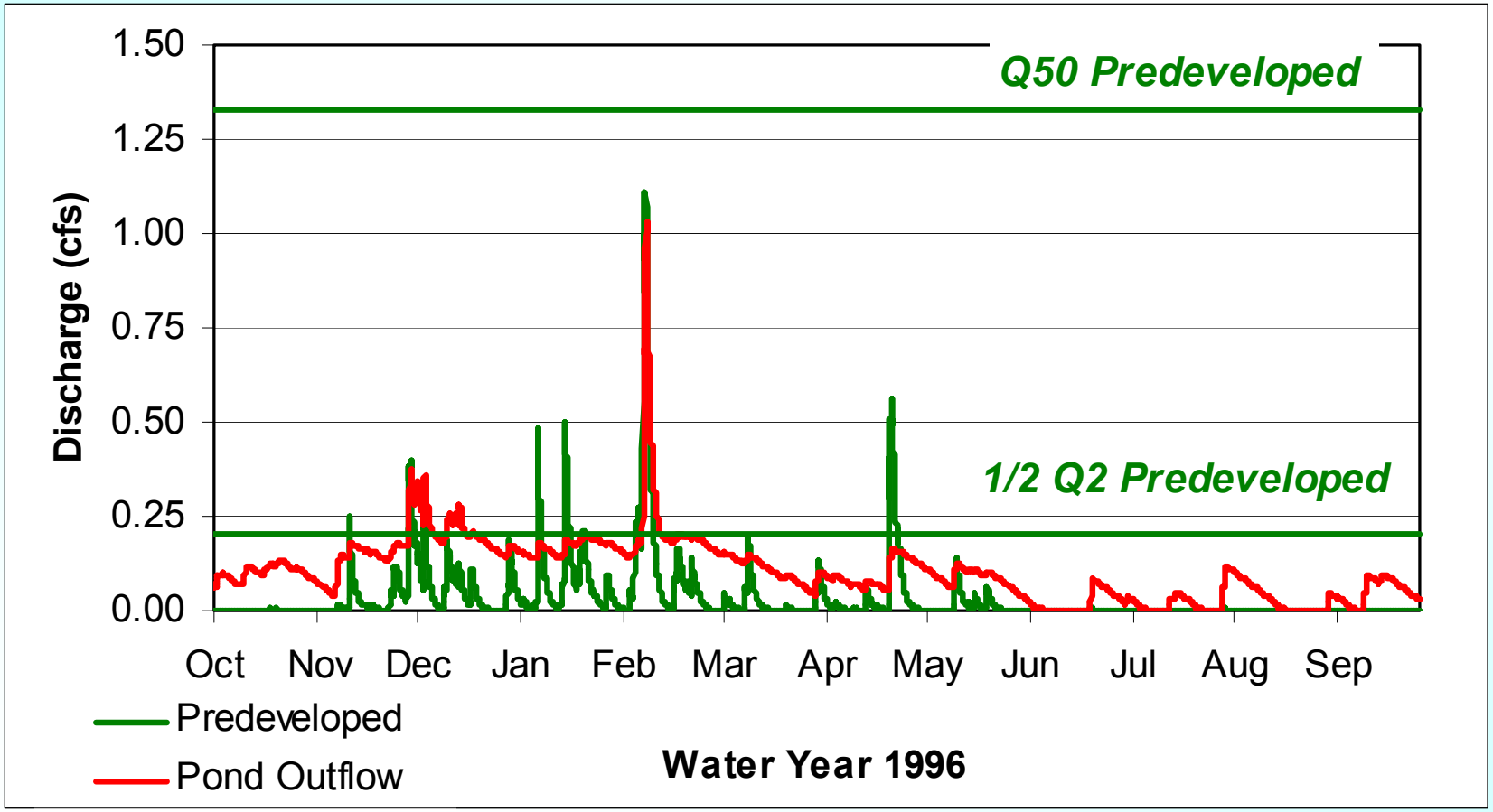
Difficult to find a pond configuration that <u>minimizes</u> the pond volume and meets the duration standard using a manual trial and error approach

Automatic Pond Design Optimization Routine

Determines Pond and Outlet Works Configuration Automatically



Duration Pond Discharge Performance



Predeveloped: 20 Acres Forest
Developed: 20 Acres Impervious

Use of Precipitation Time-Series in Continuous Hydrological Modeling …

Quality of Rainfall-Runoff Modeling

only as good as the model inputs

Precipitation Time-Series

→ one of the key inputs

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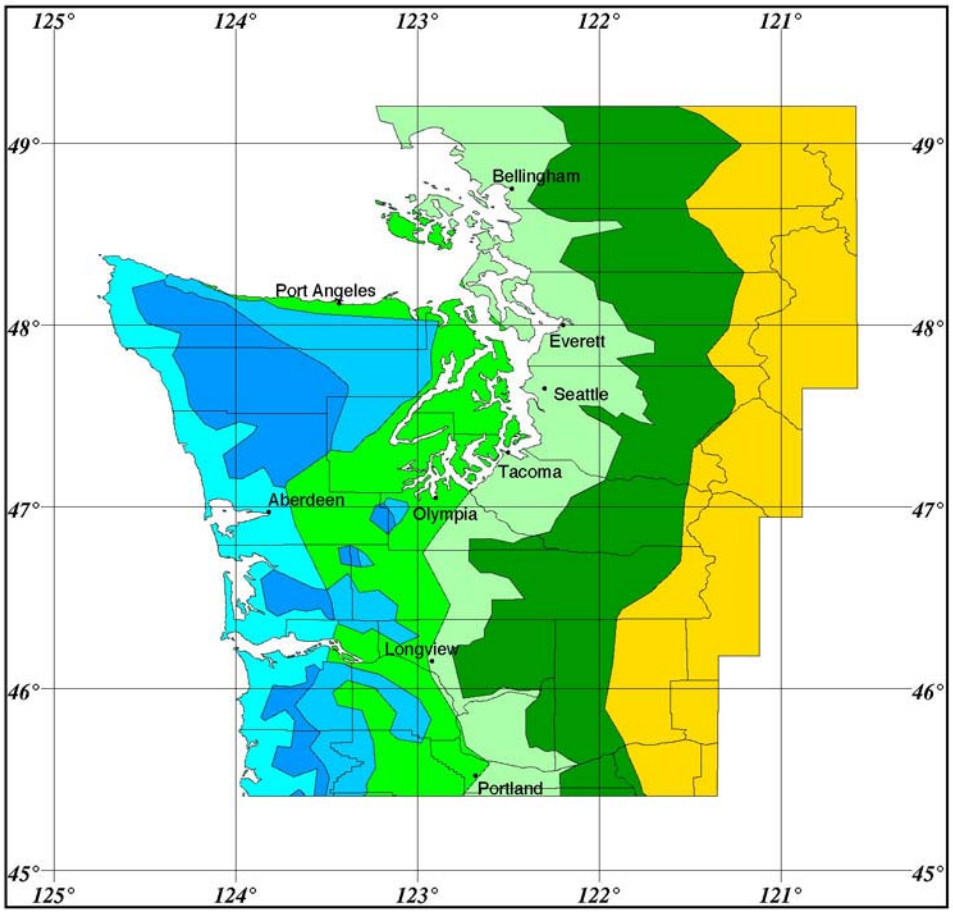
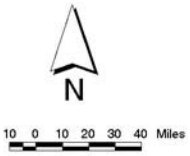
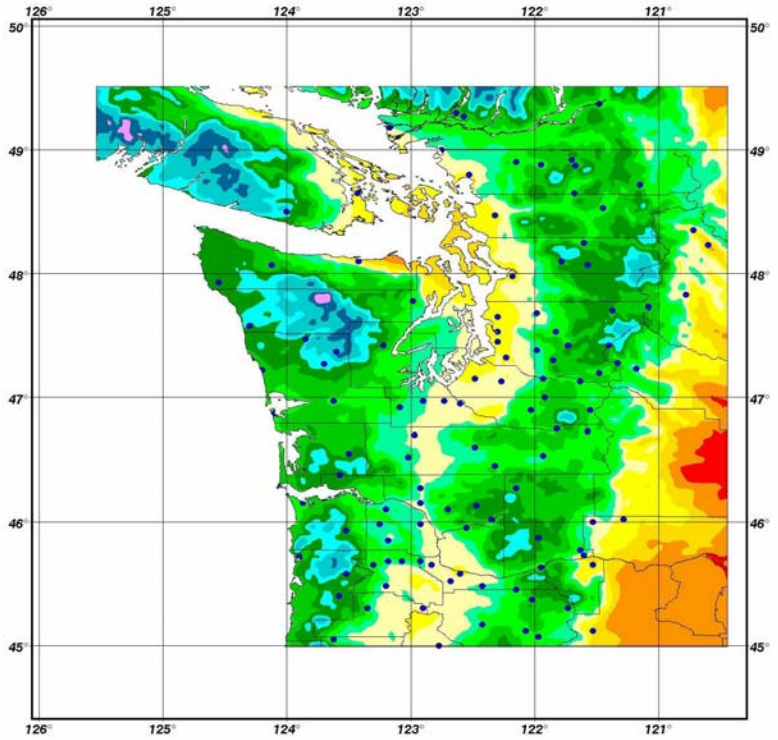
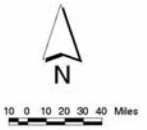
Climatic Zones for Precipitation Characteristics





Variability of Precipitation in Western Washington





Use of Precipitation Time-Series in Continuous Hydrological Modeling …

- *Past Practice*
  use nearest hourly precipitation gage
  and simple scaling procedure
  (Can Introduce Significant Errors into Simulation)

- *New Technology used in MGSFlood*
  create Extended Precipitation Time-Series
  using L-Moment statistics
  derived from regional precipitation analysis

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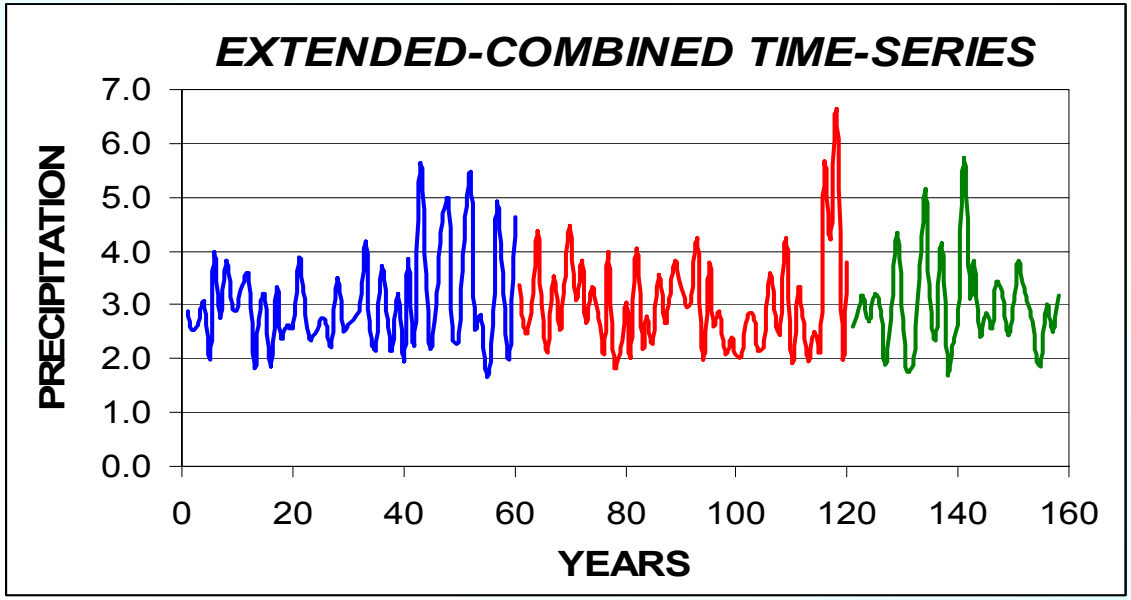
What is an Extended Precipitation Time-Series …

Long Precipitation Record

Obtaining by Combining Records from Distant Stations



Record from Each Station Rescaled

to have Storm Statistics Representative of Site of Interest

What is an Extended Precipitation Time-Series

Long Time-Series Created by Combining Precipitation Records

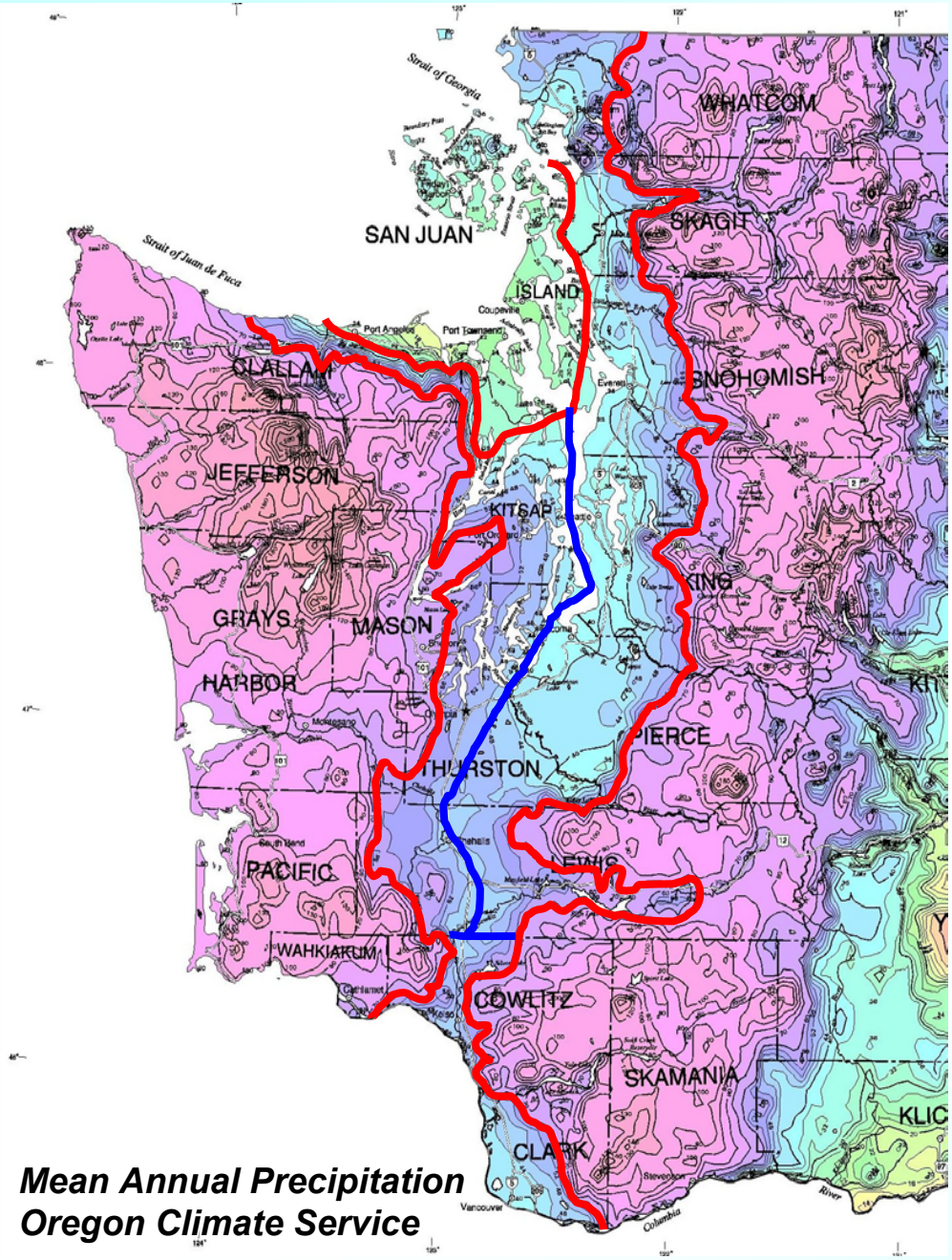
Vancouver, BC	*38-years*
Seattle, WA	*60-years*
Salem, OR	*60-years*

Why use Extended Precipitation Time-Series …

- *Allows use of high-quality stations with long records*
- *Avoids pot-luck of using nearby stations*

Many hourly stations have short records of poor-quality

- *Provides greater diversity and variability of storm temporal patterns*
- *Provides for increased number of large storms*
- *Allows interpolation of 50-year and 100-year floods rather than extrapolation*

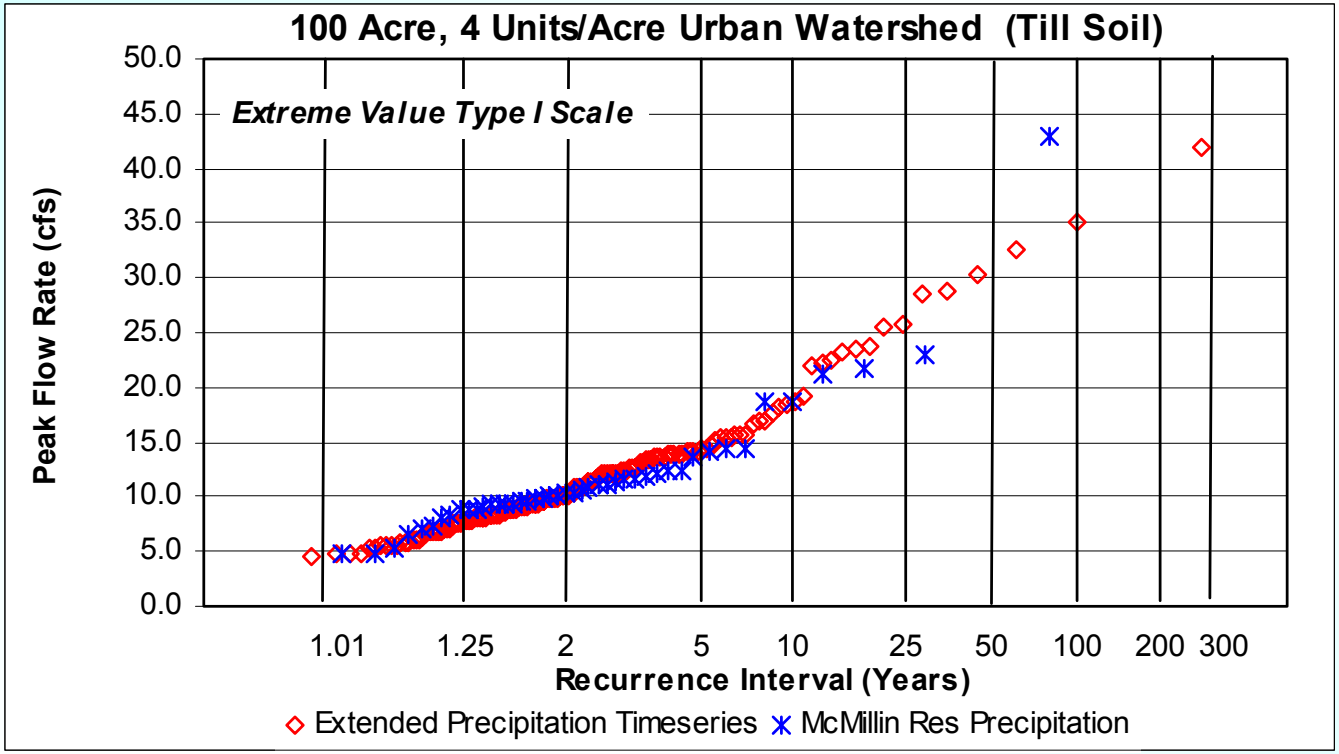


Mean Annual Precipitation
Oregon Climate Service

Areas Covered by Extended Time-Series …

subdivided into zones of mean annual precipitation

Flood Peak Comparison – Extended Timeseries and Station Data



Extended Timeseries Allows for Interpolation Rather than Extrapolation of Rare Floods

Summary

MGSFlood: A PC Based Software Package for Designing Stormwater Treatment for Urbanizing Watersheds

- ✓ Applicable for use in western Washington
- ✓ Continuous Rainfall–Runoff model (HSPF algorithm)
- ✓ Pre-Loaded with "Extended" Precipitation Timeseries 120 to 158 years in Length
- ✓ Can Simulate a Variety of Hydraulic Structures
- ✓ Optimization Routine for Automatically Designing Ponds to maintain Stream Channel Stability
- ✓ Minimizes Pond Volume: Reduces Project $$
- ✓ Eliminates Laborious Trial and Error Approach

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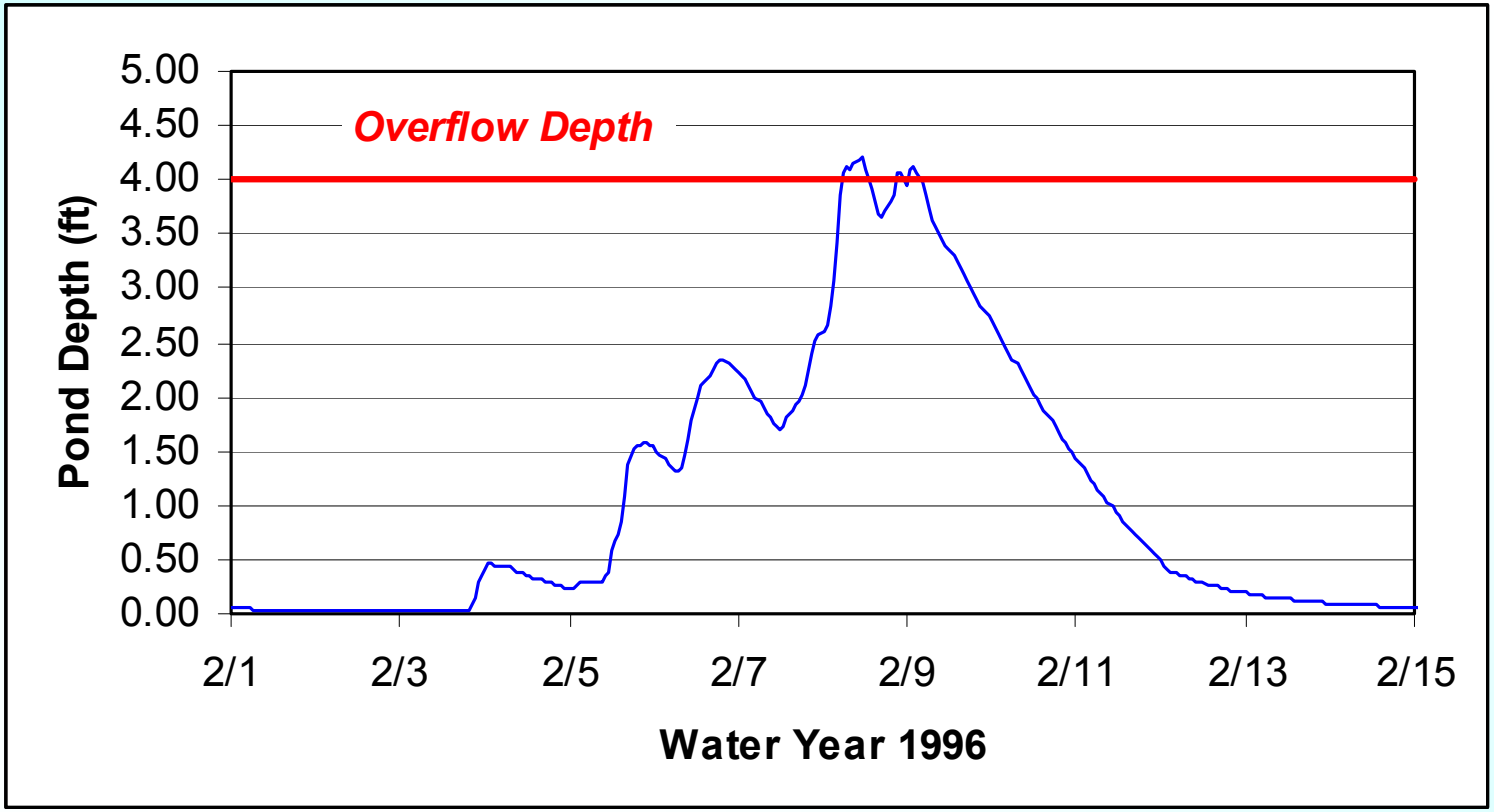
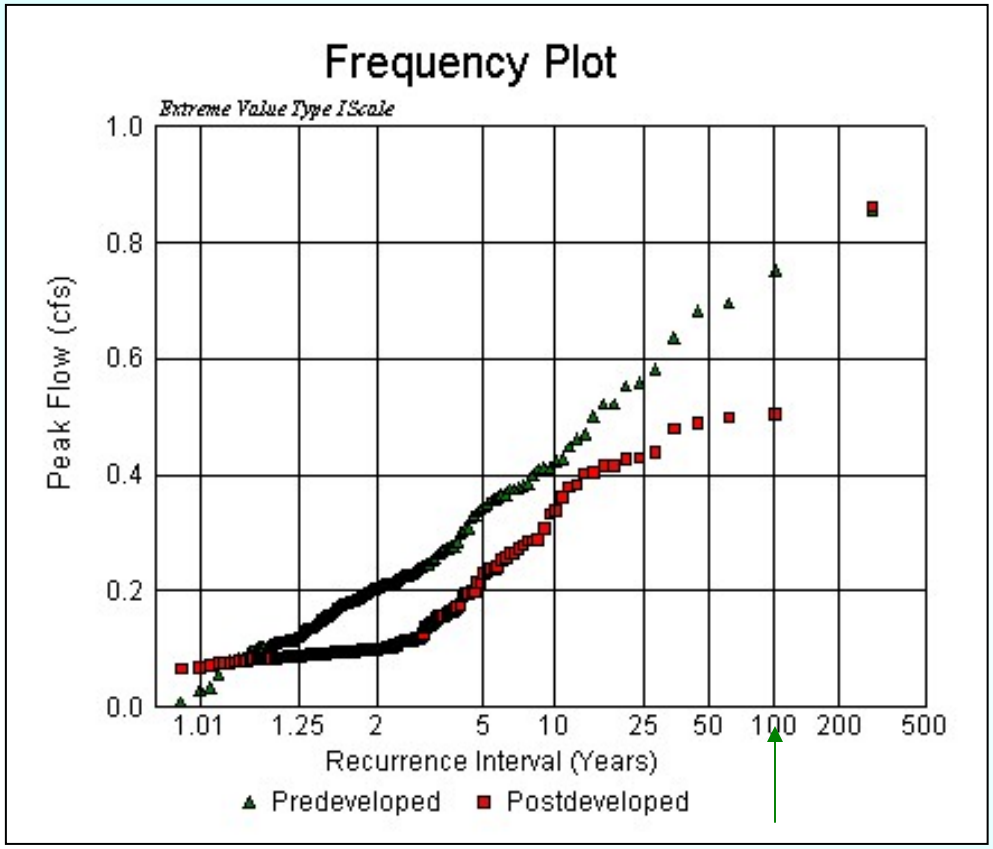
Performance of Single Event Pond Design



- Pond Contains Water for Multiple Days
- 24-Hour Design Storm Too Short

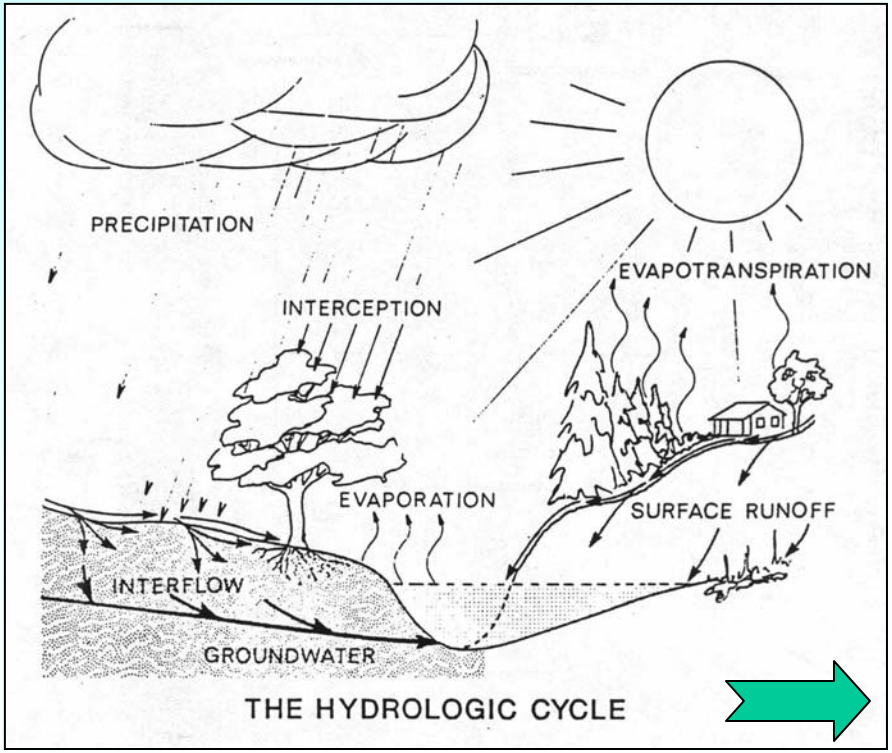
Flow Duration Pond, Peak Flow Performance

MGSFlood Flood Peak Performance Plot

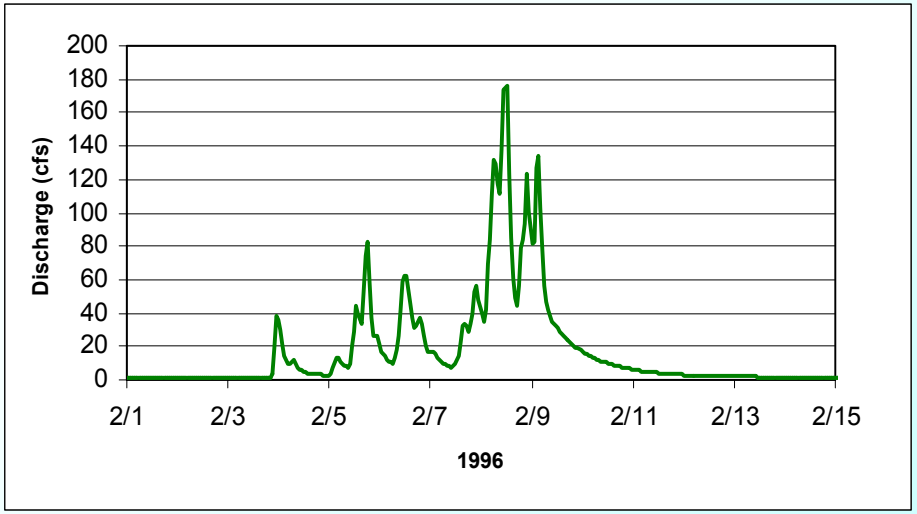


Generally, Ponds Designed to the Ecology
Flow Duration Standard Control Flood Peaks to Predeveloped
Levels out to or beyond the 100-Year Recurrence Interval

Hydrologic Processes Simulated by MGSFlood



Processes Simulated by MGS Flood
(HSPF Runoff Algorithms)



Example Model Output