RECOMMEDATIONS
HYDROLOGIC DESIGN CRITERIA
LAKE TAHOE BASIN

US Army Corps of Engineers

Sacramento District

in cooperation with

Lake Tahoe SWQIC

Hydrologic Design Problem

- Convey or Control Runoff for a Particular Exceedance Frequency/Return Interval (e.g. 100 year peak annual flow)
- Most Often Drainage Area of Interest is Ungaged
- Approaches to Estimating Design Flow
  - Statistical – Regional Regression Equations
  - Watershed Models - Simulation of Precipitation

Lake Tahoe Design Problem

- Precipitation Gage Information Limited
- Gaged Watersheds
  - Relatively Large > 0.5 sq mi
  - Natural
- Many Design Problems for Smaller Urbanized Watersheds
- Parameters and Equations Developed for Gaged Watersheds need to be Extrapolated to Smaller Watersheds

AN INCONVENIENT TRUTH

- No Precipitation Runoff Data
- General problem is ungaged analysis
- Water Resources Council Nationwide Test Comparing Watershed Model and Regression Equations (1981)
  - Regression Equations more Accurate than Event Watershed Models on the Average
  - Regression equation predictions at 100yr worth < 10 years of data
  - Bulletin 17B analysis >10yrs for gaged analysis

Watershed Model Investigation

- Review
  - State-of-the-Art
  - Current County Practice

- Recommend modeling approach

State of the Art

- Event Oriented – conceptual [HEC-1, HMS, TR-55]

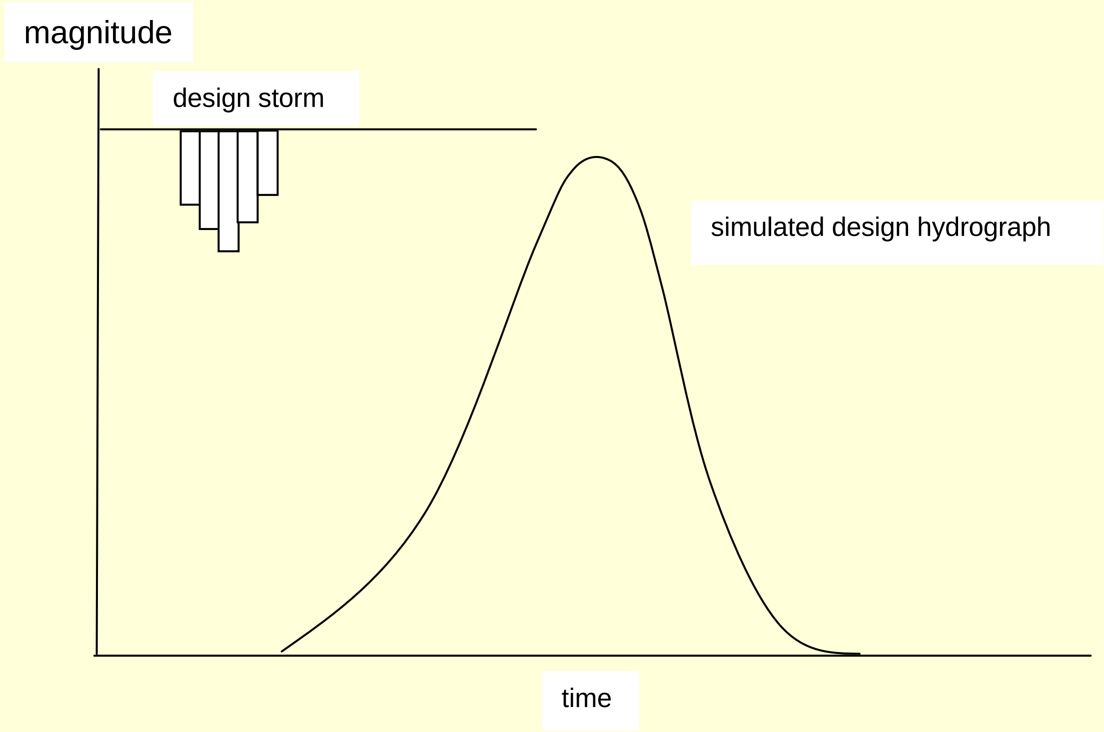
- Continuous (SMA) Simulation conceptual [PRMS {USGS, Jeton}, LSPC – HSPF {LRWQCB}]

- Physically Based [WEHY – Kavvas]

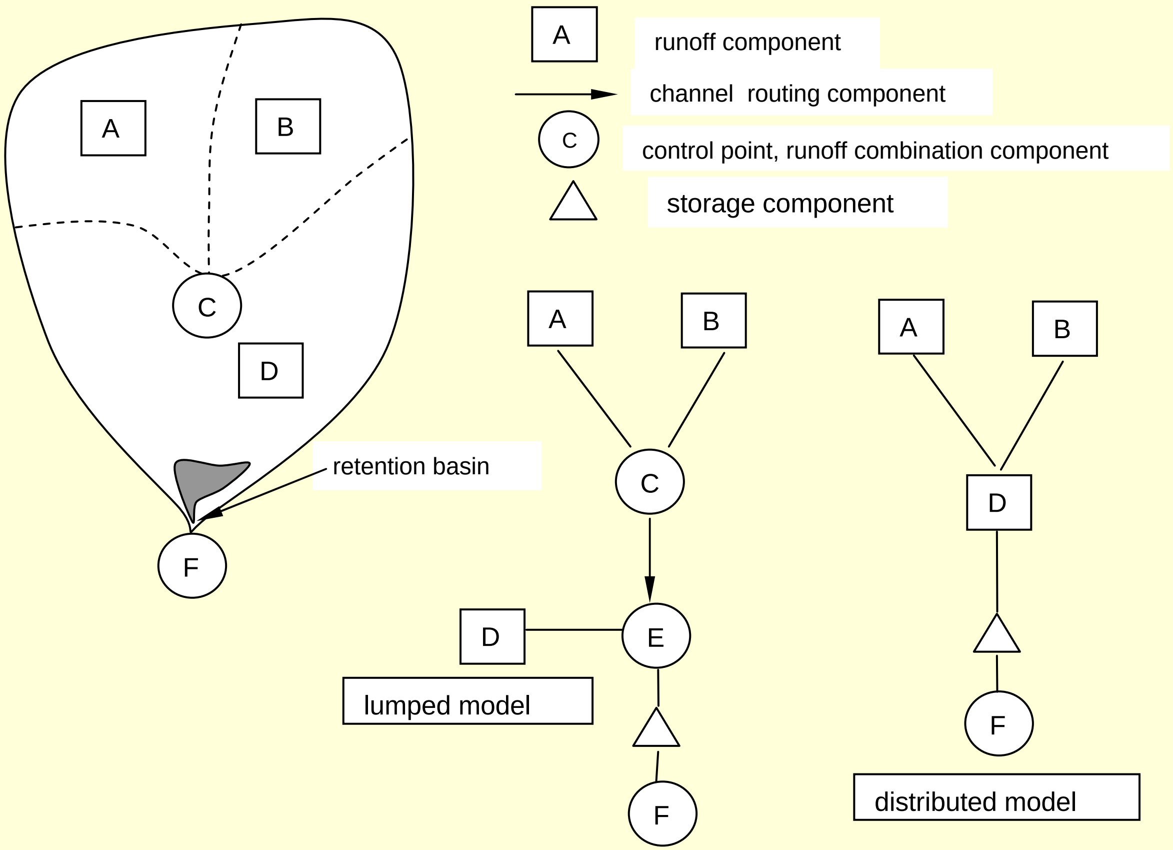
Approach Selection

- No Comprehensive Comparative Testing of Modeling Approaches since Late 1970's (ASCE – Singh & Woolhiser)
- Focus on Event Oriented Watershed Modeling Approach
  - Commensurate with Precipitation – Discharge Data Available
  - Counties Familiar with Approach
  - Relative Accuracy of Technique has been Explored

Event Watershed Model



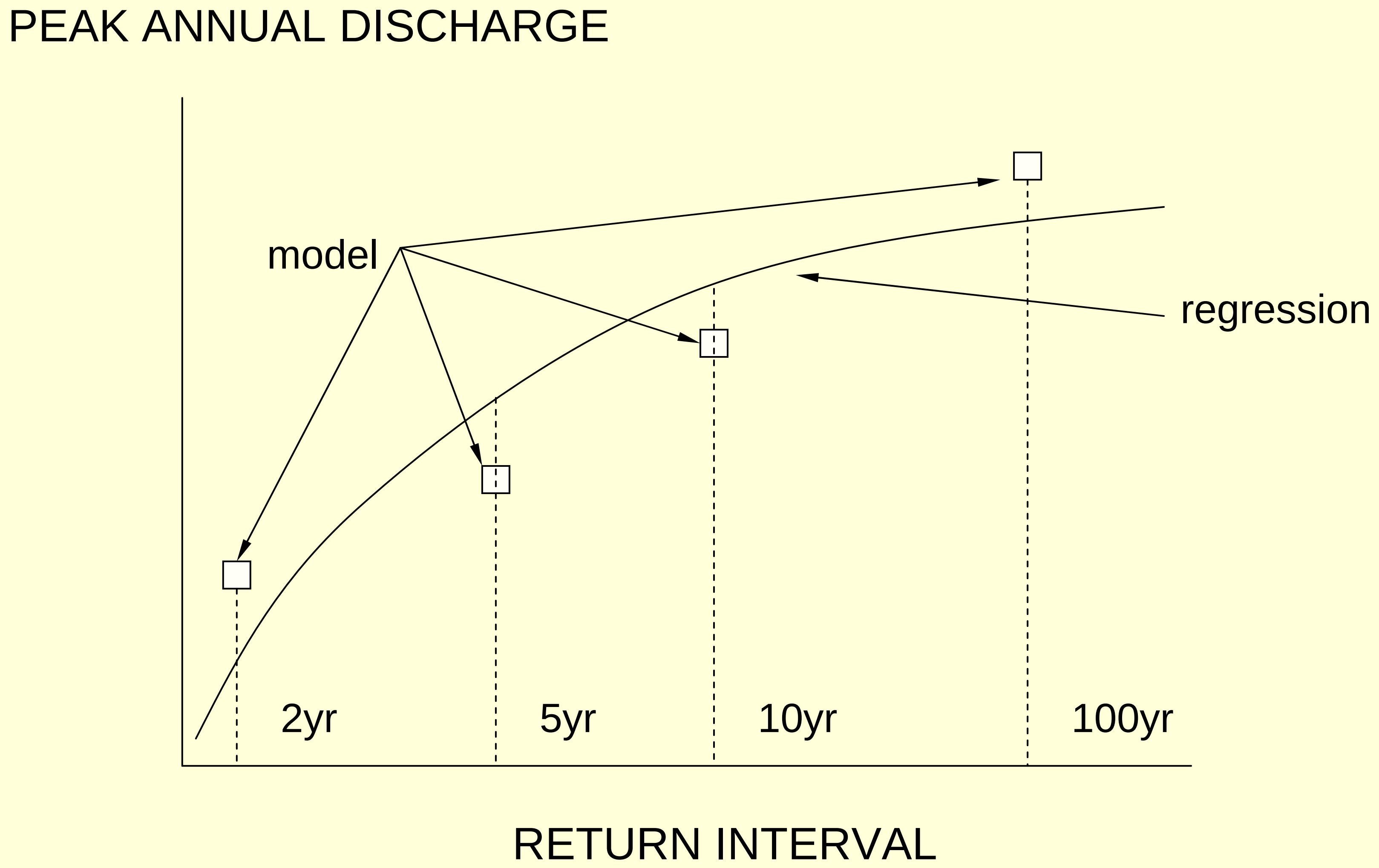
Watershed Model Structure



Watershed Model Parameter Estimates

- Sources
  - Regression relationships
    - Calibration to Observed Events for Gage Watersheds
    - Relate Calibration Parameters to Watershed Characteristics
  - Watershed Characteristics

Application with Regional Regression Estimates



Application with Regression Estimates

- Problem
  - To What Extent should Watershed Model Parameters be Adjusted to Agree with Regression Estimates (future studies)
- Water Resources Council Nationwide Test Comparing Watershed Model and Regression Equations (1981)
  - Regression Equations more Accurate than Event Watershed Models on the Average

Watershed Model Application Challenges

- *Design Storm Shape and Duration*
- *Antecedent Snow Pack*
- *Loss Rates/Runoff Coefficient*
- Runoff Routing Method
- Channel Routing Method
- Correspondence with Statistical Estimates of Flow Frequency Curves

Current Practice

- Guidelines in County Drainage Design Manuals Rely on Event Oriented Modeling (El Dorado, Placer, Washoe and Douglas Counties)
- Small Drainage Area < 200 acres
  - Rational Method or Similar Runoff Coefficient Method
- Large Drainage Area
  - HEC-1, HMS, TR-55

County Design Storm Recommendations

County	temporal pattern	depth area reduction	spatial pattern	duration
Placer	[1]balanced	none	[4]uniform	[5]4*(response time)
El Dorado	[2,7]SCS type I, Ia	[3]Weather Bureau, 1958	uniform	[5](response time)
Washoe	[1]balanced	[3,6]NOAA, 1973	uniform	-------
Douglas	[7]SCS type II	“NOAA methods”	--------	[8]6,24 hour

Snowmelt and Loss Rates

County	snow cover	frozen ground	[1]ARC	loss rate	melt rate	base flow
Placer	[2]yes	[3]zero loss rate	saturated soil	[4]constant	[5]constant	[6]1.0 cfs/sq-mi
El Dorado	[7]yes	no	ARCII	[9]CN	[7]yes	[8]constant/HEC-1
Washoe	no	no	ARCII	CN	no	no
Douglas	no	no	no	no	no	no

Runoff Routing

County	model	method
Placer	distributed preferred, lumped possible	kinematic wave, NRCS UH
El Dorado	lumped	NRCS UH
Washoe	lumped	NRCS UH
Douglas	distributed or lumped	kinematic wave or UH

Time of Concentration County Estimates

Overland flow travel time (minutes)
example (length = 100 ft, Slope=0.15 ft/ft)

cover	Placer	[1]El Dorado	Washoe
forest	7	17	8
open	6	15	8
lawn	3	7	8
impervious	3	1	2

Overland flow roughness coefficients

flow	forest	open	lawn	impervious
[1]overland	0.6	0.4	0.15	[4]0.011
[2]C_5	0.05	0.05	0.05	0.82

Overland flow travel time (minutes)
example (length = 100 ft, Slope=0.02 ft/ft)

cover	Placer	[1]El Dorado	Washoe
forest	13	57	15
open	10	41	15
lawn	6	19	15
impervious	5	15	4

[1]2-year 24hour precipitation 1.98 (in)

Watershed Modeling Recommendations

- Design Storm/Effective Loss Rate Combination (Elevations < 6700 ft)
  - NOAA14 Balanced Storm (5 minute minimum IDF)
  - Loss rates intended a surrogate for a runoff coefficient
  - Surrogate runoff coefficient includes snow affects (precipitation phase, snow condition, melt)

Calibration Loss Rates for HEC-1, NOAA14 balanced storm (5 minute interval)
Drainage Area below 6700 ft

Watershed	100 year	2 year
Upper Truckee	0.2	0.1
General	0.2	0.1
Ward	0.05	0.1
Incline	0.3	0.1
Third	0.3	0.1
Glenbrook	0.3	0.1
Trout	0.3	0.1

Recommendations

- Drainage area elevations > 6700 ft
  - Use regression equation predictions as loss rate/runoff coefficient estimation guide

Recommendations

- Runoff Routing
  - Open/natural areas NRCS Unit Hydrograph
  - Urban Areas Distributed Modeling with KW Overland and Muskingum-Cunge Channel Routing
- Time of Concentration Calculations
  - NRCS TR-55 methodology

Channel Routing

- Muskingum-Cunge
- Muskingum (with Calibration)

Small Drainage Areas

- Rational method
  - Rule of thumb 200 acres or less
  - No complicated drainage systems (detention basins)
  - Despite limitations likely to be as accurate as any distributed modeling approach (see Urbonis and Roesner, Handbook of Hydrology, ed Maidment
  - Easily applied

Small drainage areas

- Rational method (continued)
  - Q = CiA
  - C runoff coefficient – 0.9 to 1.0 – conservative because of potential snow effects
  - i rainfall intensity for duration equal to time of concentration – see recommendation on time of concentration

Limitations

- Snow Affected Runoff
  - Time of concentration studies do not include snow
  - U.H. studies do not include snow
  - Urban snowmelt not well studied
- Scale problem
  - Calibration results are for large areas compared to those important for urban distributed modeling

Future Work

- NRCS SNOTEL Data
  - Insulate gages to prevent temperature affects on readings. Summer rainfall cannot be accurately recorded currently.
  - Smaller time intervals in data base
    - Recently precipitation and temperature is stored hourly
    - SWE should be stored hourly