LECTURE #12

INSTREAM WATER QUALITY – TEMPERATURE, SEDIMENT, & GENERAL CONSTITUENT

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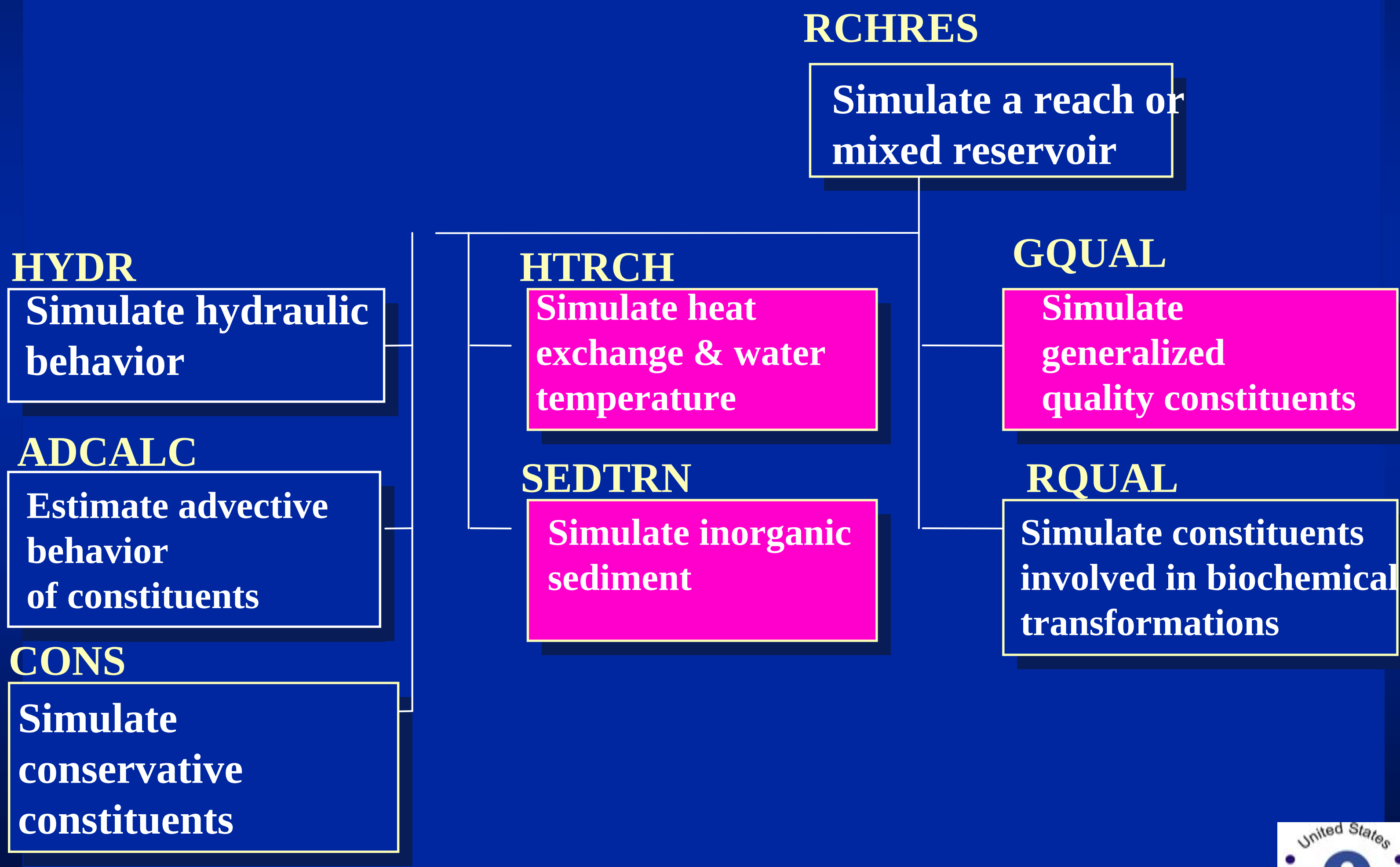
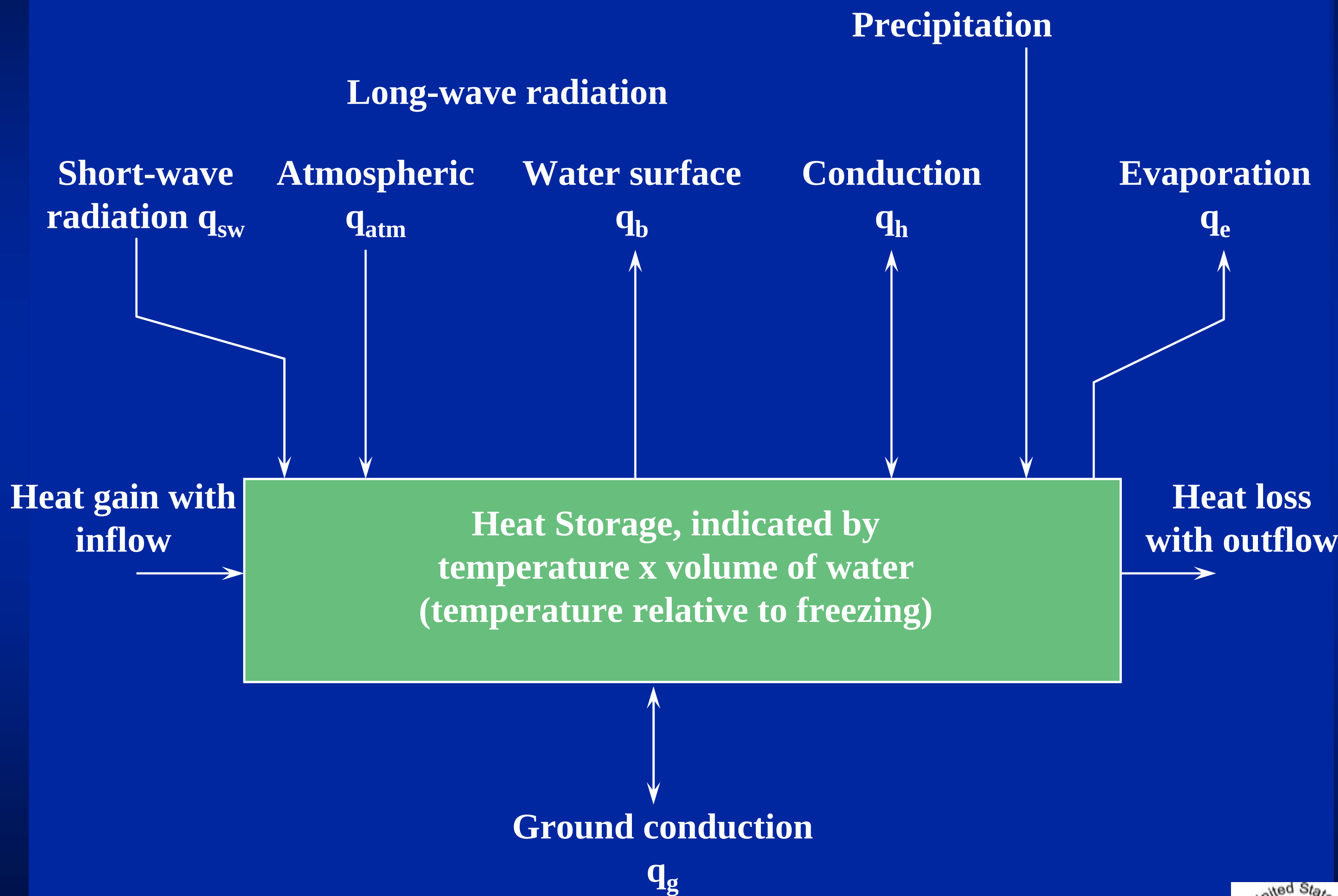
RCHRES STRUCTURE CHART



WATER TEMPERATURE (HTRCH)

- Temperature is a critical habitat characteristic for fish and other organisms
- Temperature affects rates of other water quality processes
- Dissolved oxygen concentrations are dependent on temperature

HEAT EXCHANGE PROCESSES



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WATER TEMPERATURE - ENERGY BALANCE

$$q_{total} = q_{sw} + q_{atm} + q_b + q_h + q_e + q_g$$

	Component	Key parameters and inputs
q_{sw}	Short-wave radiation	Solar radiation*, shading factor
q_{atm}	Long-wave radiation (atmospheric)	Cloud cover*, air temperature,* LW radiation coefficient
q_b	Long-wave radiation (back)	
q_h	Conduction/convection	Air temperature*, wind speed*, Heat transport coefficient
q_e	Evaporation	Dewpoint*, air temperature*, wind speed*, evaporation coefficient
q_g	Ground conduction (optional)	Ground temperature, conduction coefficients

Note: Air temperature is corrected for elevation

***Time series input**

DATA REQUIRED FOR WATER TEMPERATURE

- Meteorologic data
  - solar radiation
  - air temperature
  - wind speed
  - cloud cover
  - dewpoint temperature
- Surface area of water exposed to radiation (shade)
- Boundary conditions – inflow/outflow rates and temperatures
- Hydrodynamic data – flows, water body geometry
- Measured water temperatures for model calibration

WATER TEMPERATURE CALIBRATION

- Inspect hourly simulation results to verify that diurnal variation is reasonable and stable; adjust FTABLE for low flow to improve stability

- Calibration parameters:

  CFSAEX - fraction of water surface exposed to solar radiation

  KATRAD - atmospheric long-wave radiation coefficient (~ 9)

  KCOND - conduction coefficient (1 – 20)

  KEVAP - evaporation coefficient (1 – 5)

  KMUD - water-bed sediment heat conduction coefficient

  KGRND - ground-bed sediment heat conduction coefficient in two-interface method

  MUDDEP – depth of mud or bed sediment layer in two-interface method

  TGRND – ground temperature

  - inflow temperature (heat loading from land)

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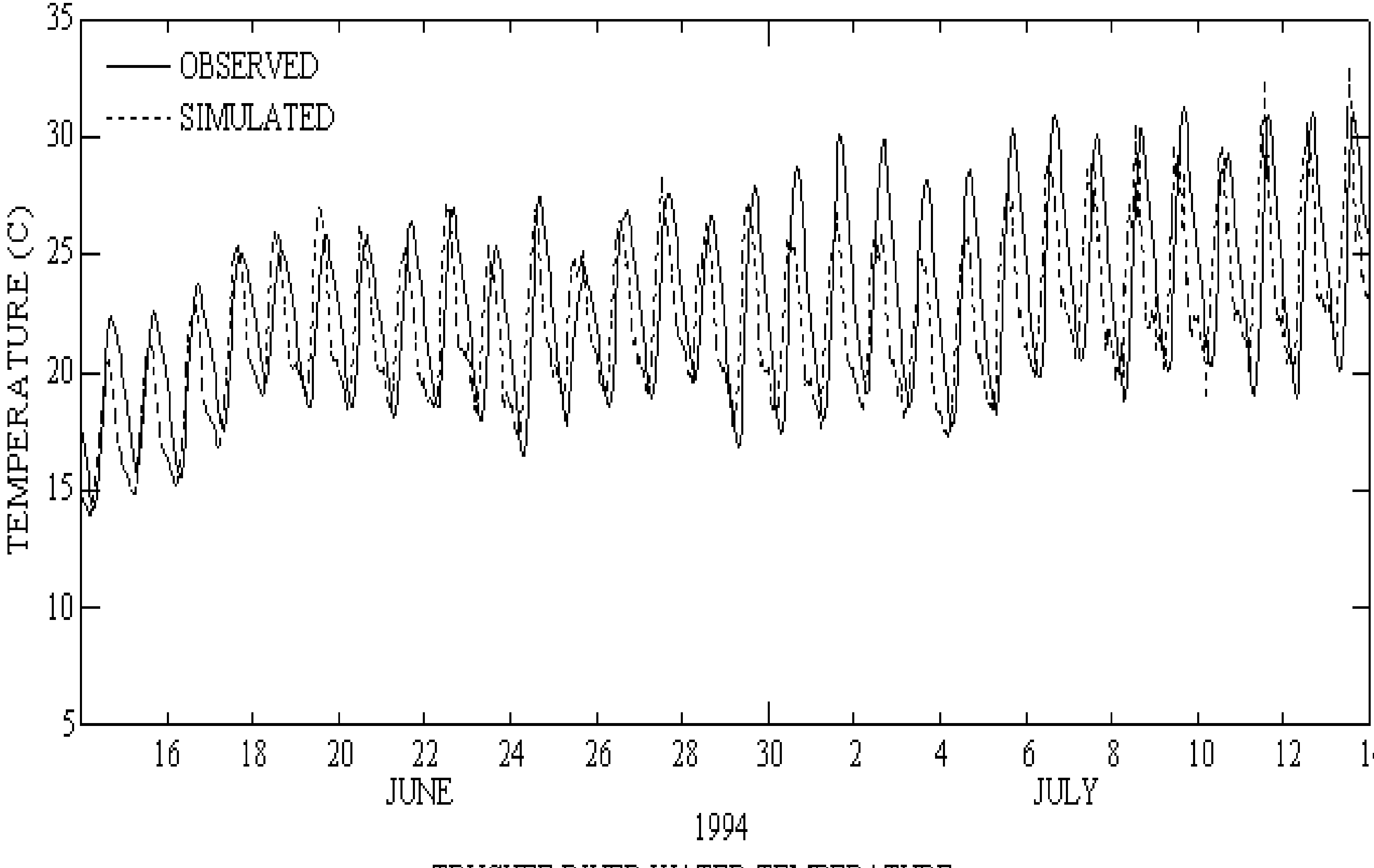
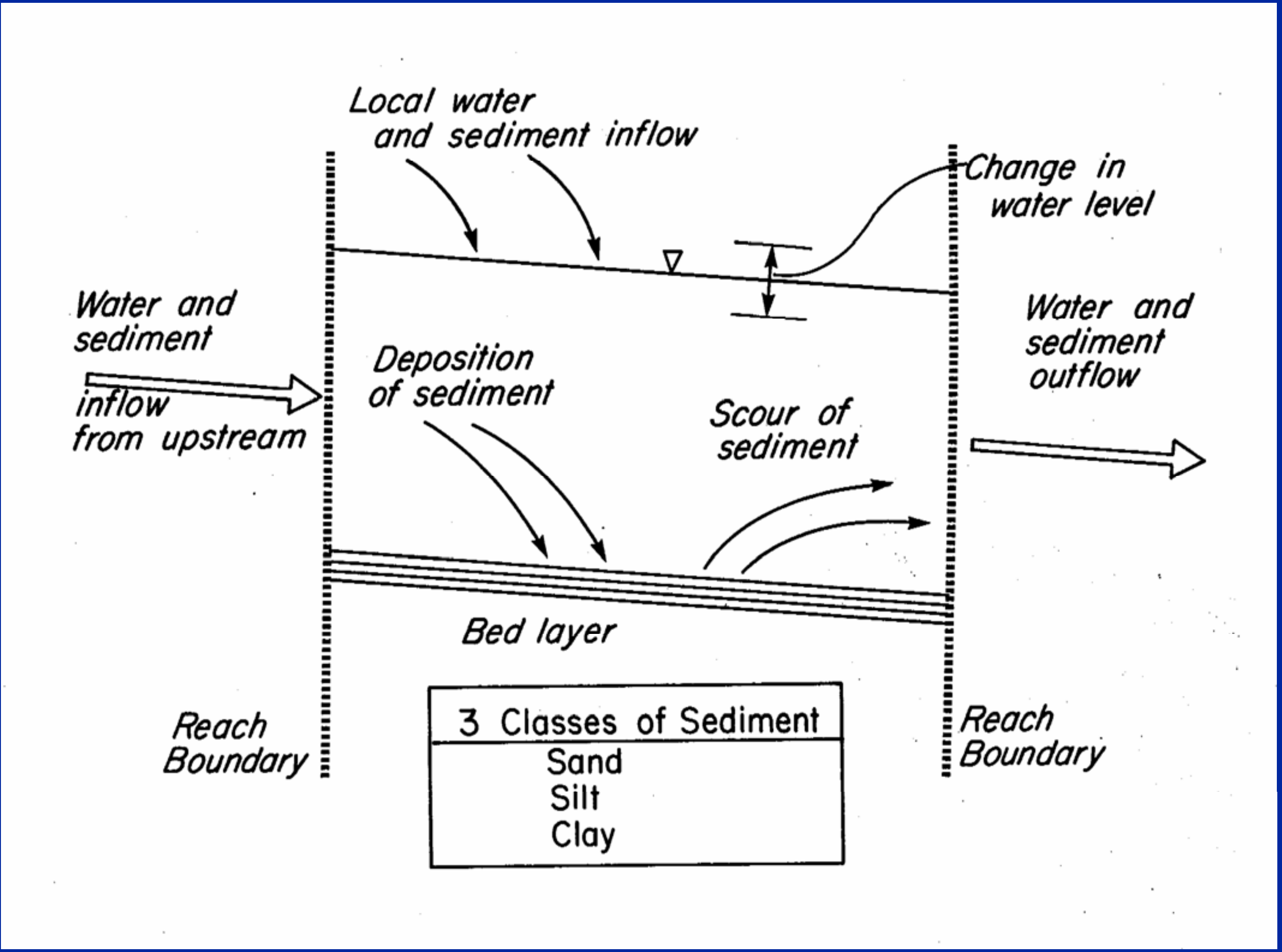
TRUCKEE RIVER – WATER TEMPERATURE



SEDIMENT PROCESSES IN WATERBODIES



SEDIMENT TRANSPORT SIMULATION

- Sand, silt and clay fractions
- Advection, deposition and scour
- Completely-mixed (CSTR) water column and bed compartments
- Sand transport - three options
  - Toffaleti method (SANDFG = 1)
  - Colby method (SANDFG = 2)
  - Power function (SANDFG = 3)
- Cohesive (silt, clay) deposition and scour based on shear stress calculations (Krone and Partheniades)
- Scour and deposition does not affect hydraulic properties
- Reach-dependent parameters
- No lateral movement of bed materials between reaches
- Local sediment inflow (from land surface) divided into constant sand, silt and clay fractions

SAND TRANSPORT SIMULATION: TOFFALETI METHOD

Toffalleti method (SANDFG = 1)

- **Stream divided into four depth zones**
- **Velocity and relative concentration profiles assumed**
- **Temperature correction included**
- **Sand transport capacity calculated for each zone**
- **Input: water temperature, particle diameter, settling velocity, slope**

SAND TRANSPORT SIMULATION: COLBY METHOD

Colby method (SANDFG = 2)

- Empirical relationships based on data
- Sand transport estimated from nomograph as a function of hydraulic radius, flow velocity, and sediment diameter
- Transport corrected for water temperature and fine sediment concentration
- Acceptable parameter ranges:

Median bed sediment diameter	0.1 - 0.8 mm.
Hydraulic radius	0.1 - 100 ft.
Mean stream velocity	1.0 - 10.0 ft/sec

SAND TRANSPORT SIMULATION: POWER FUNCTION METHOD

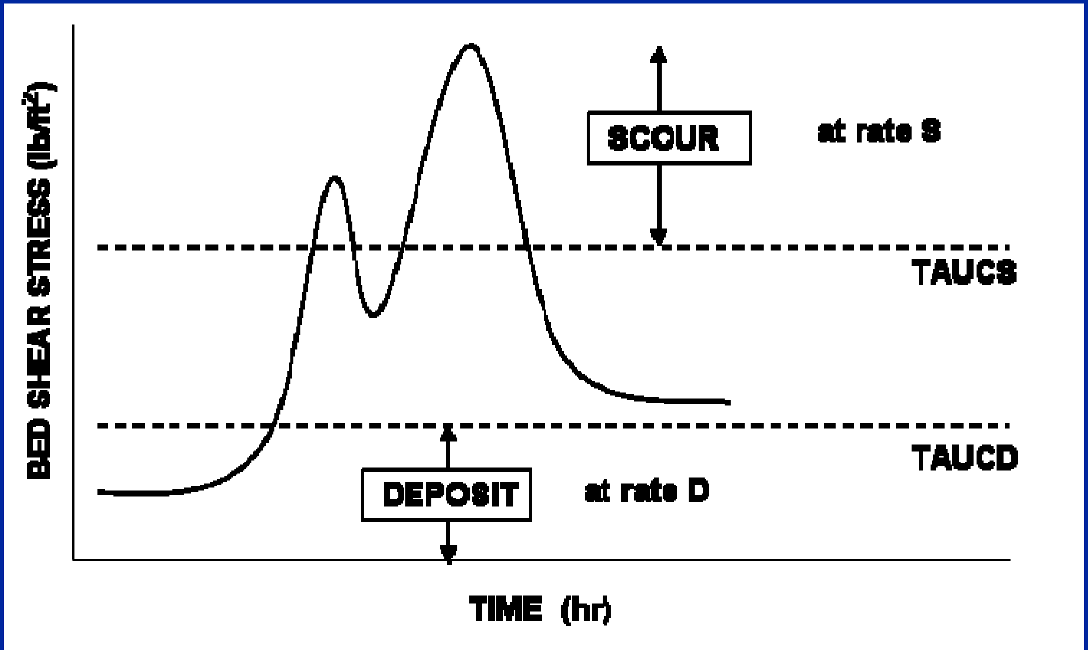
Power function equation (SANDFG = 3)

$$PSAND = (KSAND)*(AVVELE)^{EXPSND}$$

Where:

PSAND = Potential sand concentration
KSAND = Coefficient (input parameter)
AVVELE = Average stream velocity
EXPSND = Exponent (input parameter)

SCOUR/DEPOSITION FOR COHESIVE SEDIMENTS (SILT & CLAY)



Scour rate: S = M * (TAU/TAUCS – 1.0)

Deposition rate: D = W * CONC * (1.0 – TAU/TAUCD)

Shear stress: TAU = SLOPE * GAM * HRAD

Where

- M = erodibility coefficient (lb/ft^2/hr)
- W = particle fall velocity in still water (ft/hr)
- TAUCS = critical shear stress for scour (lb/ft^2)
- TAUCD = critical shear stress for deposition (lb/ft^2)
- CONC = concentration of sediment (lb/ft^3)
- GAM = density of water (lb/ft^3)
- HRAD = hydraulic radius (ft)

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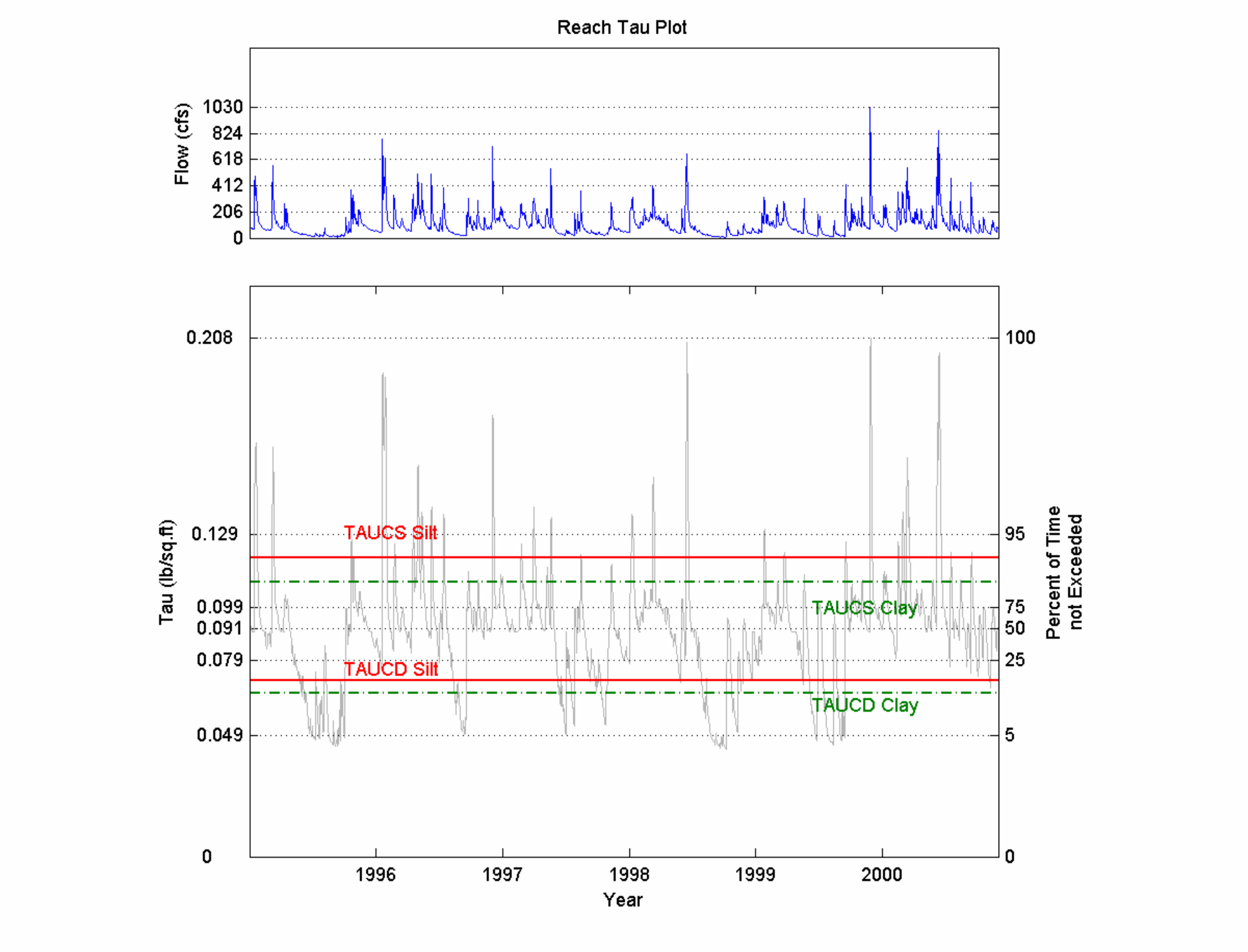
TAU PLOT



Reach Tau Plot
Flow (cfs)
1030
824
618
412
206
0
0.208
0.129
0.099
0.091
0.079
0.049
0
Tau (lb/sq.ft)
TAUCS Silt
TAUCS Clay
TAUCD Silt
TAUCD Clay
100
95
75
50
25
5
0
Percent of Time not Exceeded
1996
1997
1998
1999
2000
Year

SEDIMENT TRANSPORT PARAMETERS

SED - GEN PARM

BEDWID - Width of stream cross-section where deposition occurs
BEDWRN - When bed depth exceeds this value, a warning message is printed
POR - Bed porosity – used for calculating bed depth

HYDR - PARM 2

LEN - Length of RCHRES
DELTH - Drop in water surface elevation over RCHRES length
DB50 - Median diameter of bed sediment

SAND - PM

D - Effective diameter of transported sand particles
W - Sand particle fall velocity
RHO - Sand particle density
KSAND - Coefficient in sand transport power function equation
EXPSND - Exponent in sand transport power function equation

SILT - CLAY - PM (table is entered twice, first for silt and second for clay)

D - Effective particle diameter
W - Particle fall velocity
RHO - Particle density
TAUCD - Critical bed shear stress for deposition
TAUCS - Critical bed shear stress for scour
M - Erodibility coefficient

SEDIMENT TRANSPORT CALIBRATION

- **Estimate initial parameter values for both cohesive (silt, clay) and non-cohesive (sand) sediment fractions**
- **Make calibration run and output shear stress (TAU) values (max and min daily) calculated for each reach**
- **Perform sediment mass balance to determine land surface versus stream channel contributions**
- **Examine/evaluate sediment load simulation for both mass outflow and composition compared to available data**
- **Adjust TAUCS and TAUCD to affect scour and deposition of cohesive sediments at appropriate times**
- **Adjust erodibility (M) to improve calibration of cohesive sediments for storms with good flow simulation**
- **Adjust non-cohesive (sand) parameters based on bed and load composition compared to available data**
- **Re-do calibration run and output analyses**

TABULATION OF STREAM SEDIMENT FLUXES AND BEHAVIOR FOR REVIEW

Reach Segment	Nonpoint	Point Source	Upstream In	Total Inflow	Outflow	Deposit (+) Scour (-)	Cumulative Point/NonPt	Cumulative Trapping Efficiency	Reach Trapping Efficiency
	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)	(%)	(%)
Mainstem 1	212.5	107.4	6,453.7	6,785.3	6,186.3	599.7	10,566.9	41.5	8.8
Mainstem 2	68.8	0.0	6,186.3	6,255.0	5,384.8	870.6	10,635.7	49.4	13.9
Tributary 1	102.4	0.0	0.0	102.2	125.0	-22.7	102.2	-22.0	-22.0
Mainstem 3	5.8	0.0	5,509.8	5,515.6	4,916.3	599.9	10,744.0	54.2	10.9
Tributary 2	281.1	0.0	0.0	280.5	352.6	-72.1	280.5	-25.5	-25.5
Mainstem 4	215.4	0.0	5,268.9	5,483.9	4,269.8	1,215.1	11,240.4	62.0	22.1
Mainstem 5	54.1	0.0	4,269.8	4,323.8	3,507.1	826.2	11,294.5	68.9	18.9
Mainstem 6	93.9	0.0	3,507.1	3,600.8	2,190.8	1,421.3	11,388.4	80.8	39.2

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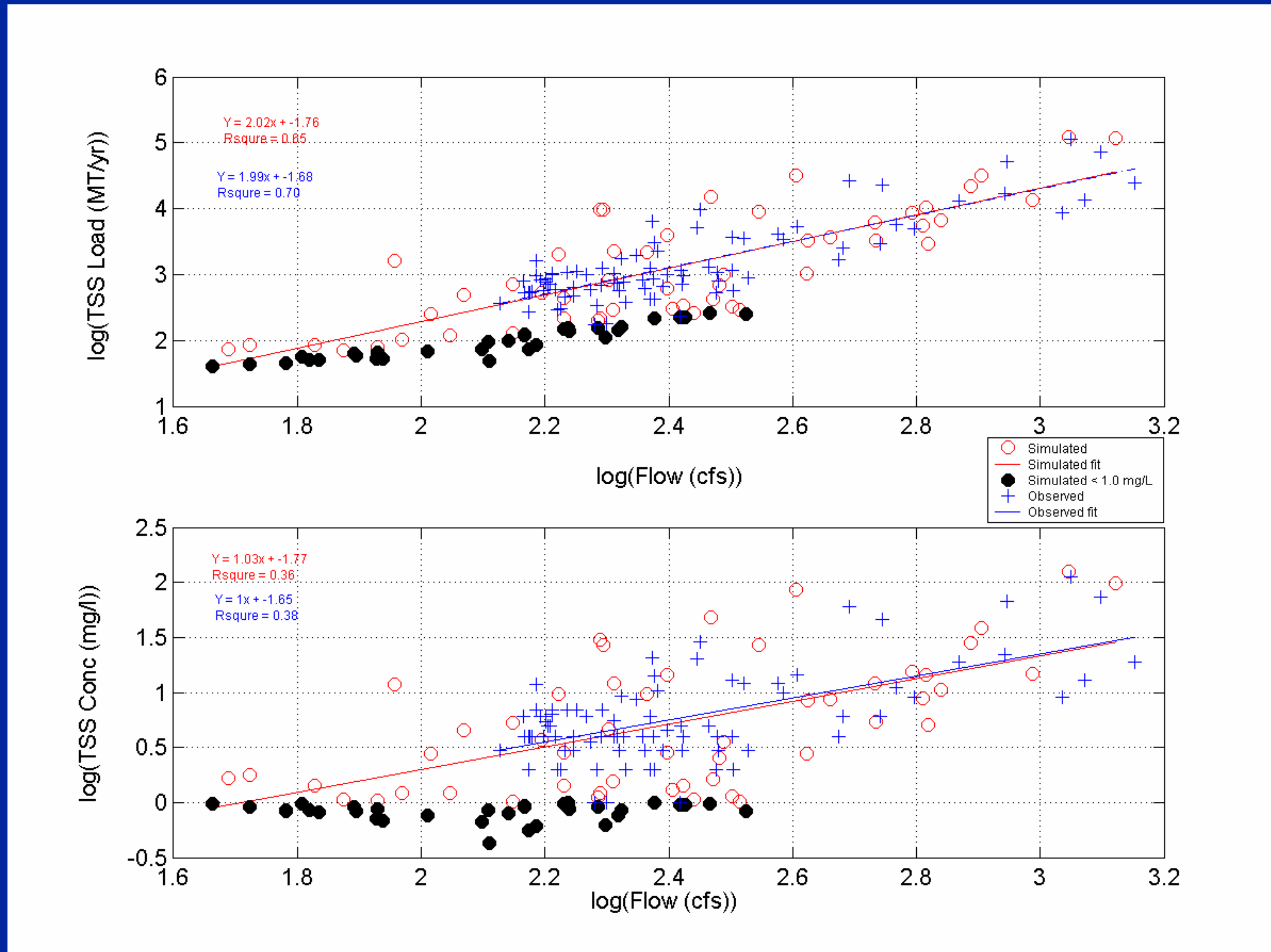
OBSERVED AND SIMULATED RATING CURVES



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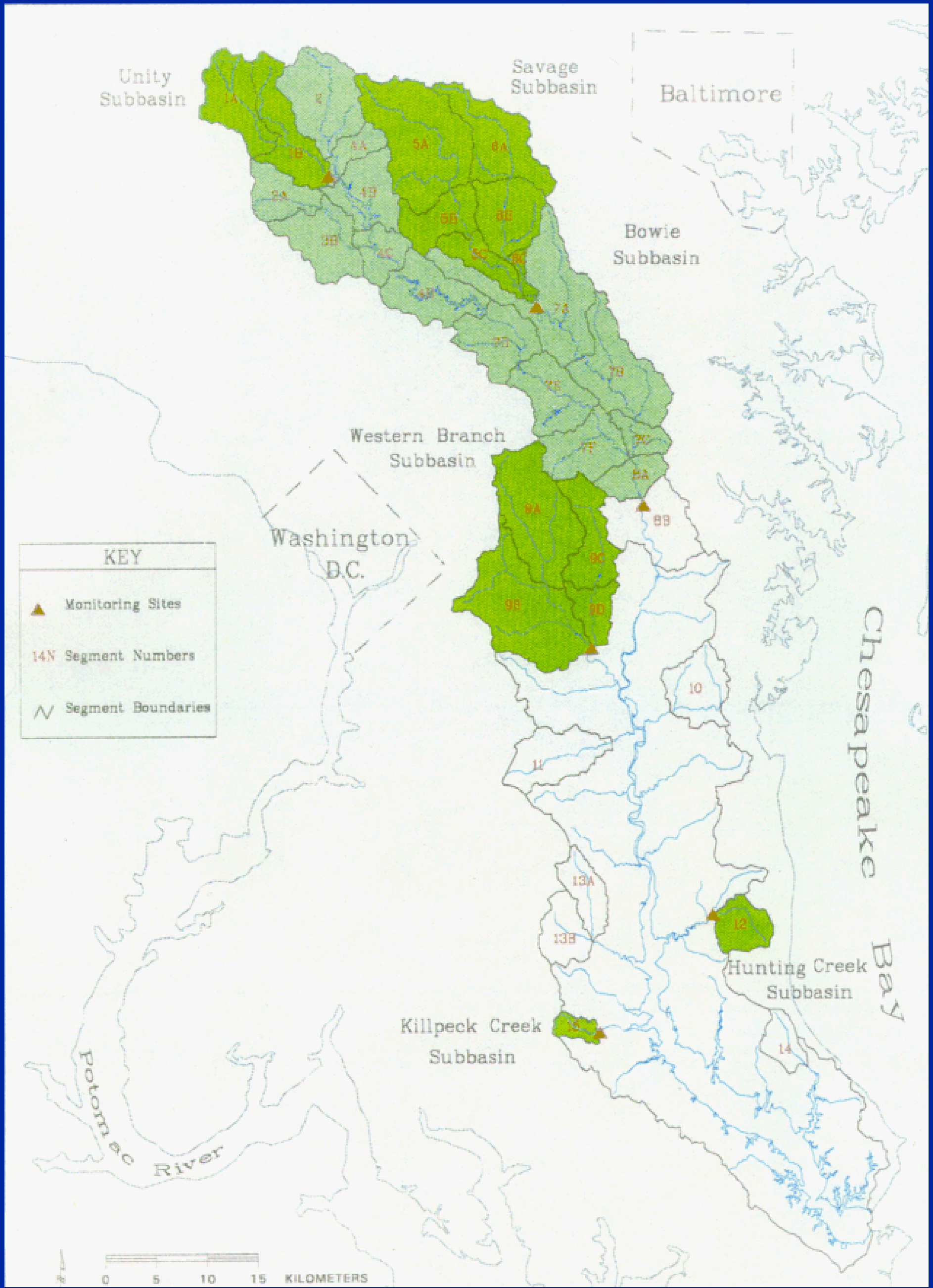
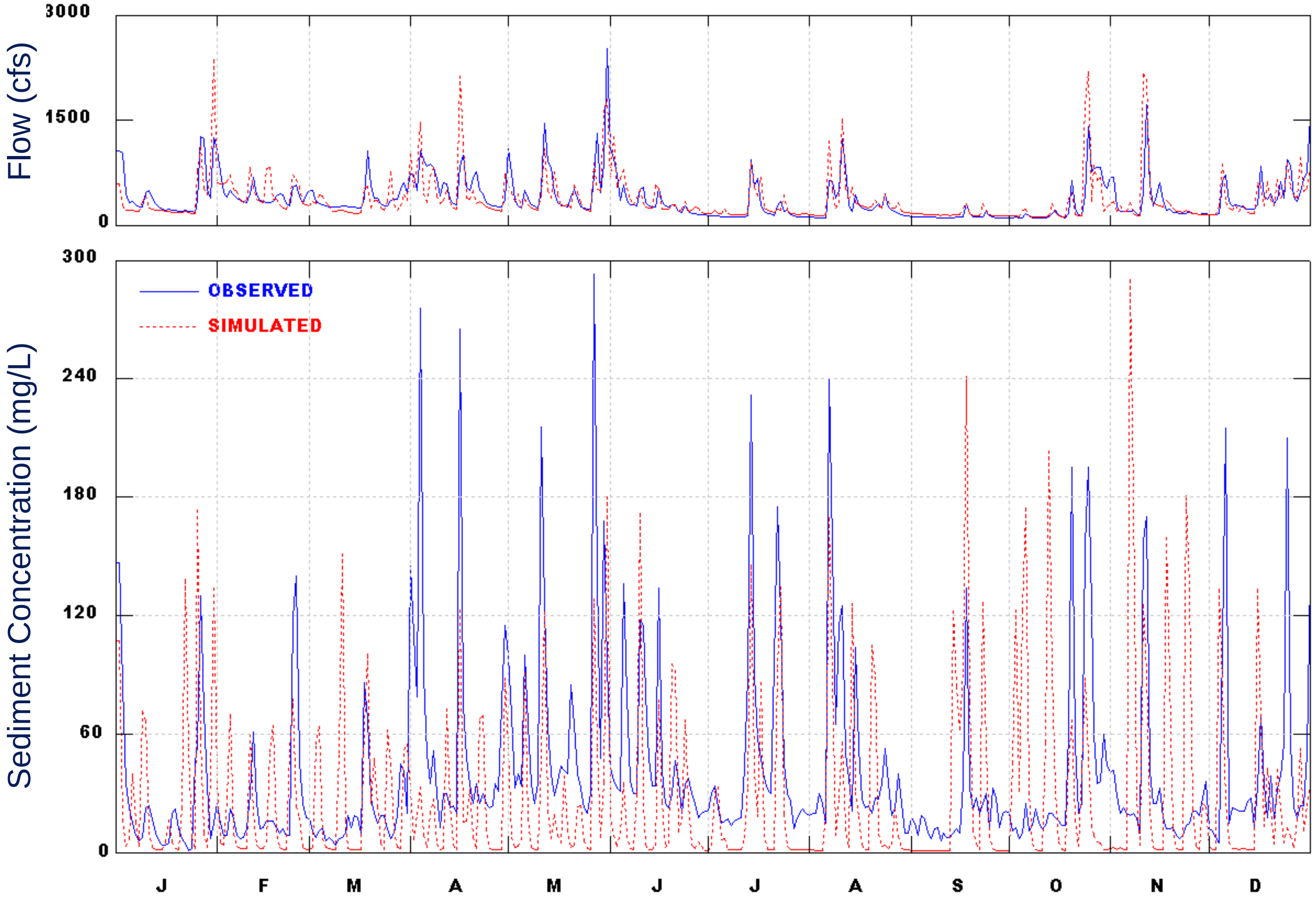
PATUXENT RIVER BASIN (MD)



ANNUAL TIMESERIES PLOT



Patuxent River at Bowie, MD

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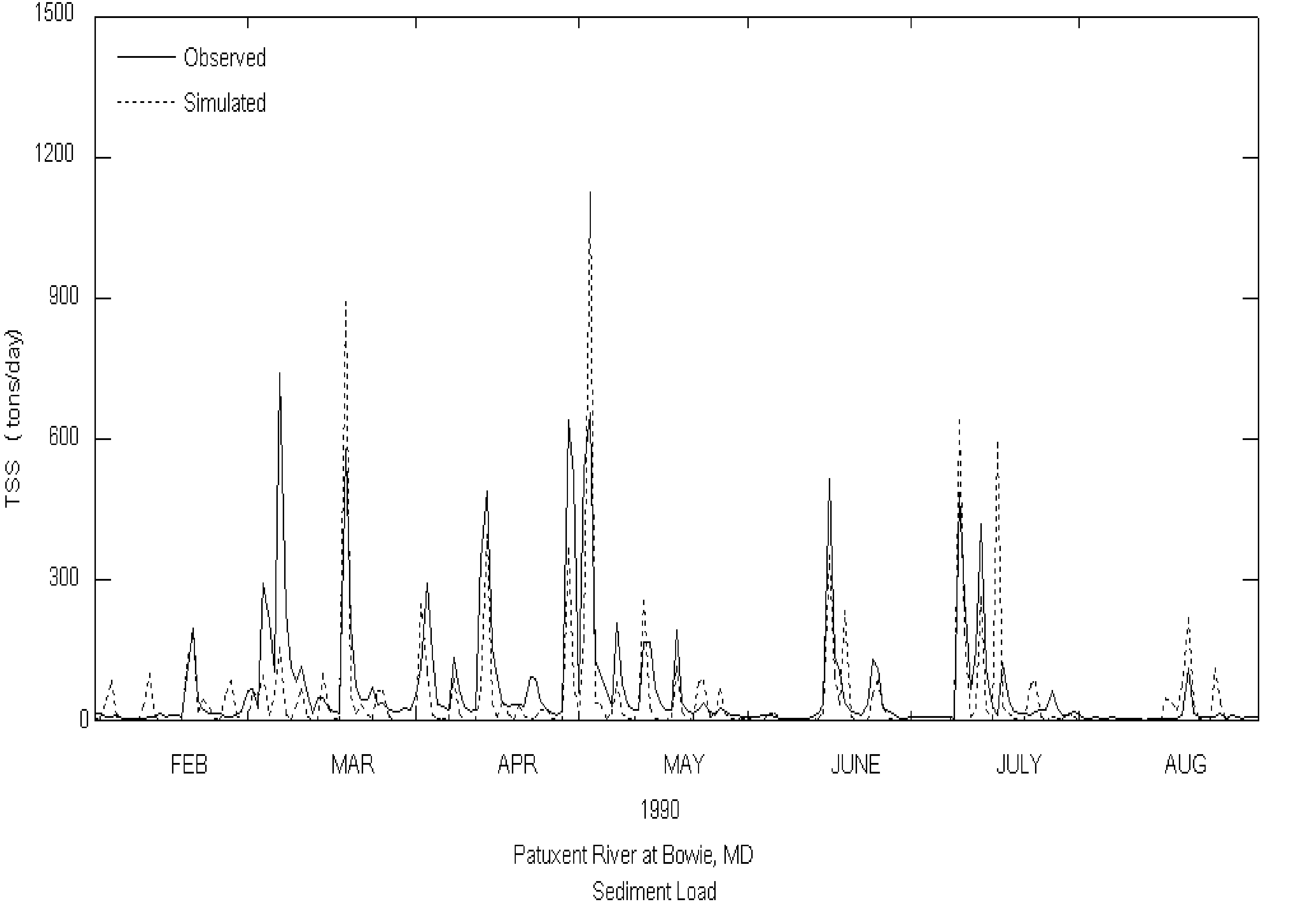
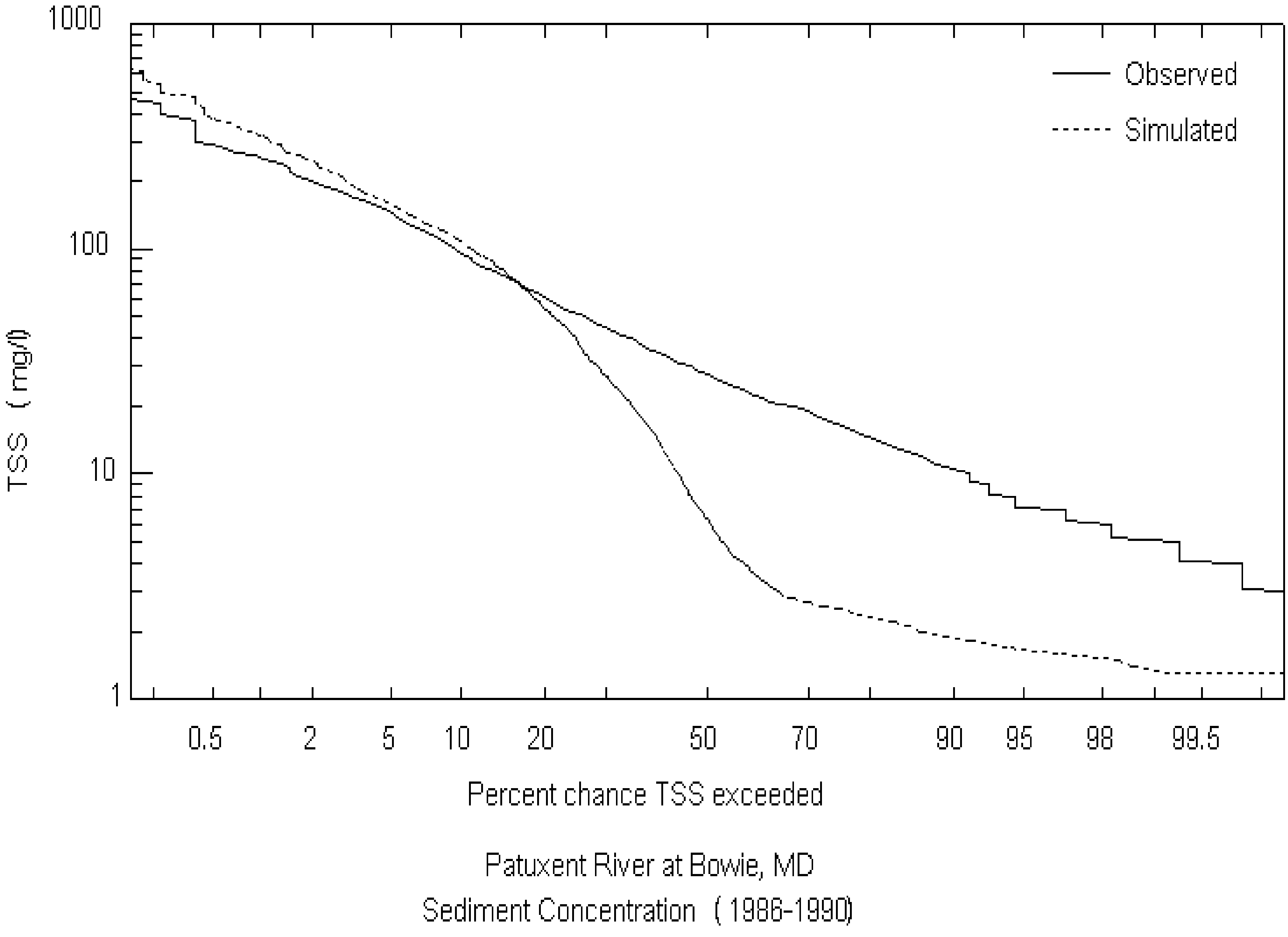
PATUXENT RIVER - SEDIMENT LOADS



PATUXENT RIVER - SEDIMENT FREQUENCY CURVE



PATUXENT RIVER - SOIL EROSION TARGETS & ANNUAL SEDIMENT LOADS

Soil Erosion Targets For Patuxent Model (tons/acre/year)

Low Density Residential	0.09
Med Density Residential	0.27
Commercial	0.67
Forest	0.009 – 0.017
Pasture	0.05 – 0.09
Hay	0.11 – 0.21
High-till crops	0.38 – 1.93
Low-till crops	0.27 – 0.91

Simulated and Observed Annual Sediment Loads at Bowie (tons)

YEAR	SIMULATED	OBSERVED
1986	20,000	20,200
1987	21,000	18,900
1988	13,100	18,700
1989	46,400	36,000
1990	18,200	23,500
MEAN	23,700	23,500

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PATUXENT RIVER – SEDIMENT PARAMETERS

	SAND	SILT	CLAY
D (in)	0.005	0.0004	0.0001
W (in/sec)	0.10	0.0003	0.00001
RHO (g/cm^3)	2.50	2.20	2.00
KSAND	0.05 – 0.10		
EXPSND	1.7 – 5.5		
TAUCD (lbs/ft^2)		0.08 – 0.12	0.10 – 0.14
TAUCS (lbs/ft^2)		0.10 – 0.32	0.10 – 0.40
M ($lbs/ft^2/day$)		0.01 – 0.90	0.01 – 0.90

GENERAL QUALITY CONSTITUENTS – GQUAL

ORGANICS/PESTICIDES
BACTERIA
METALS

1. **Can simulate up to five independent constituents**

2. **Constituent can be a “daughter” product of another constituent**

3. **Optional decay mechanisms**

4. **Sediment association (adsorption/desorption)**

GENERAL QUALITY CONSTITUENTS – GQUAL

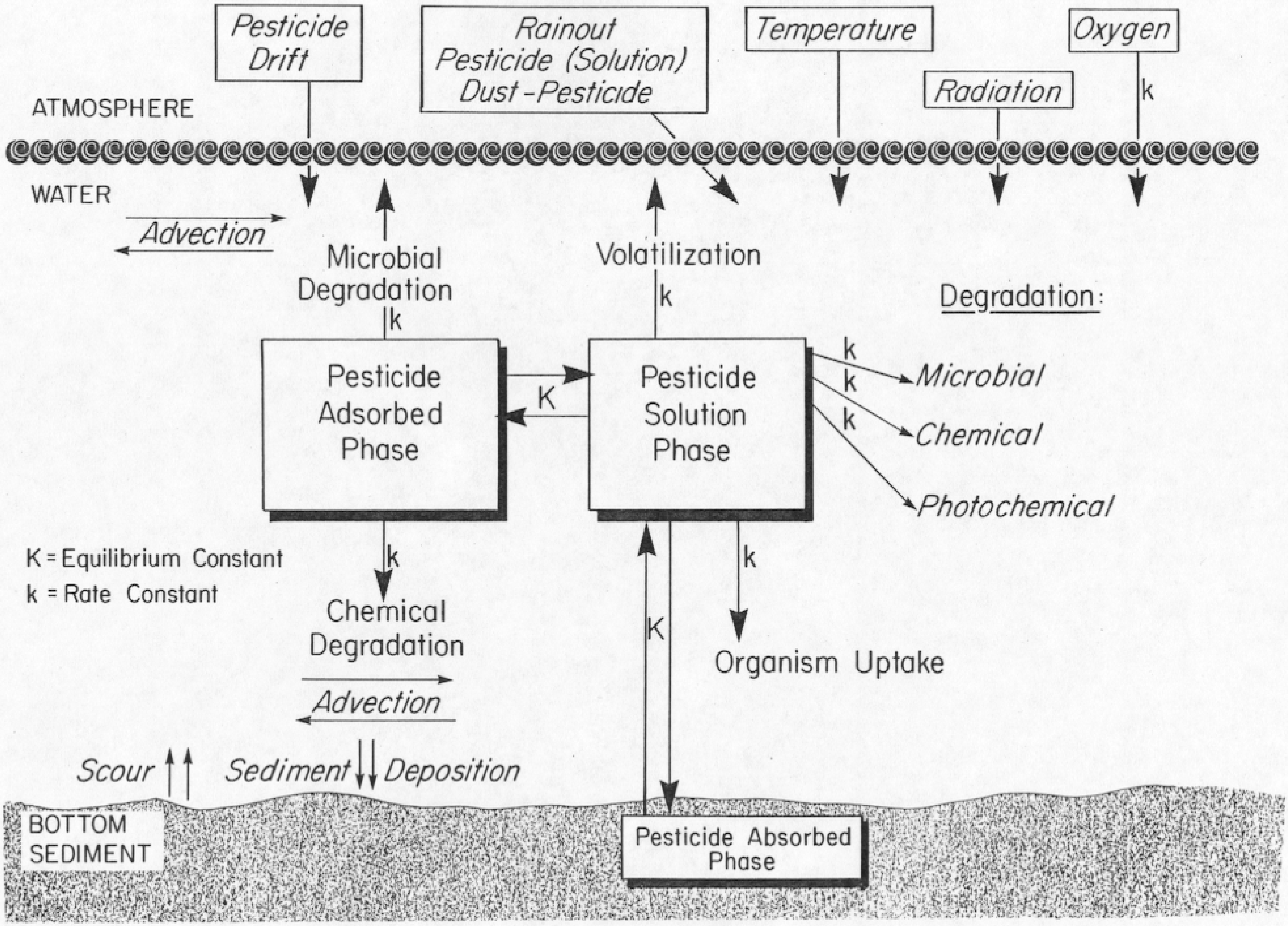
Instream Transport & Fate Processes

- **Advection**
- **Decay/Die-Off**
- **Adsorption/Desorption**
- **Sedimentation & Scour**

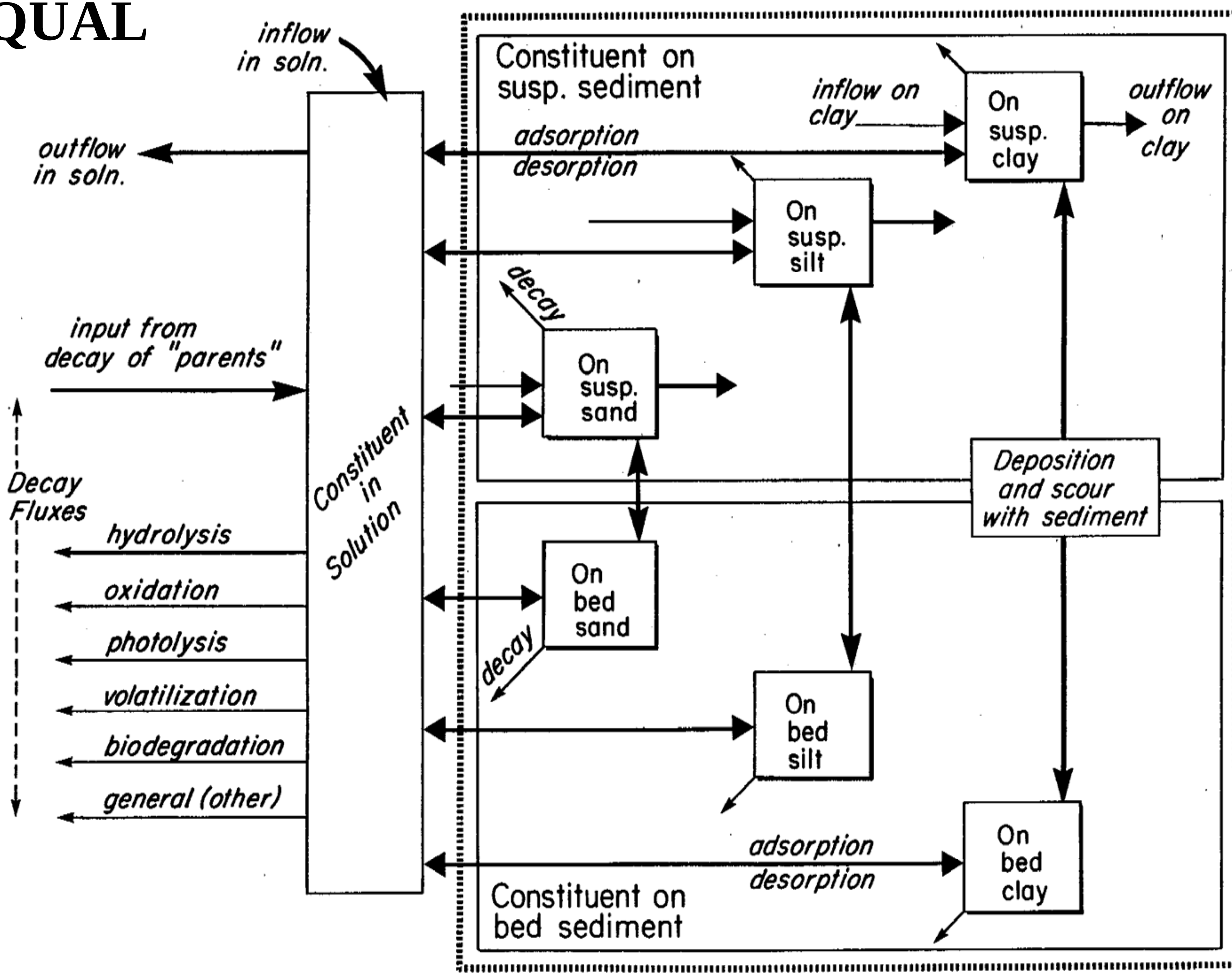
Pollutant Sources

- **Nonpoint Source**
  - **PQUAL/IQUAL or PEST**
  - **potency factor or accumulation/washoff method**
- **Point Source**
  - **characterize flow and pollutant load**

PESTICIDE PROCESSES IN STREAMS



GQUAL



inflow in soln.
outflow in soln.
Constituent on susp. sediment
inflow on clay
On susp. clay
outflow on clay
adsorption desorption
On susp. silt
decay
input from decay of "parents"
On susp. sand
Constituent in Solution
Decay Fluxes
hydrolysis
oxidation
photolysis
volatilization
biodegradation
general (other)
Deposition and scour with sediment
On bed sand
decay
On bed silt
adsorption desorption
On bed clay
Constituent on bed sediment

GQUAL PARAMETERS – DISSOLVED PHASE

Process	Input Parameters	Environmental Variables
Hydrolysis		
- Rates	**KA**, **KB**, **KN**	PHVAL
- Temperature correction coefficient	**THHYD**	TW
Oxidation by Free Radical Oxygen		
- Rate	**KOX**	ROC
- Temperature correction coefficient	**THOX**	TW
Photolysis		
- Chemical absorption coefficients	**PHOTPM** (1-18)	
- Quantum Yield	**PHOTPM** (19)	
- Temperature correction coefficient	**PHOTPM** (20)	TW
- Base (water) absorption coefficients	**ALPH** (1-18)	
- Sediment absorption coefficients	**GAMM** (1-18)	SDCNC
- Plankton absorption coefficients	**DEL** (1-18)	PHY
- Extinction efficiency of cloud	**KCLD** (1-18)	CLD
- Fraction of surface exposed to radiation	**CFSAEX**	
Volatilization - ratio of rate to reaeration	**CFGAS**	
- reaeration rate (from OXRX)	**KOREA**	
Biodegradation - rate	**BIOCON**	BIO
- temperature correction coefficient	**THBIO**	TW
Generalized 1st Order Decay - rate	**FSTDEC**	
- temperature correction coefficient	**THFST**	TW

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GQUAL PARAMETERS – ADSORBED PHASE

Process	Input Parameters	Environmental Variables
Decay Rate		
- Suspended	**ADDCPM (1)**	
- Bed	**ADDCPM (3)**	
Temperature Correction Coefficient		
- Suspended	**ADDCPM (2)**	TW
- Bed	**ADDCPM (4)**	TW
Adorption/Desorption		
- Partition Coefficient	**ADPM (1-6*, 1)**	
- Transfer Rate	**ADPM (1-6*, 2)**	
- Temperature Correction Coefficient	**ADPM (1-6*, 3)**	TW

* Six (6) Values Are Input for Suspended Sand, Silt, Clay; and Bed Sand, Silt, Clay.

GQUAL PARAMETERS – CONV CONVERSION FACTOR

CONCentration = **CONV** * (**QTYID**/VOLume)

where

- **CONC**entration = dissolved concentration units (e.g., µg/L, mg/L, #organisms/L)
- **CONV** = conversion factor
- **QTYID** = mass units (e.g., lbs, kg, or #organisms)
- VOLume = volume of water (ft^3 if **EMFG**=1; m^3 if **EMFG**=2)

Examples:

	CONC units	QTYID	EMFG	CONV
Metal/Pest/Organic	µg/L	lbs	1	1.602E+07
Metal/Pest/Organic	µg/L	kg	1	3.532E+07
Bacteria	#organisms/L	#organisms	1	0.03532
Bacteria	#organisms/L	#organisms	2	0.001

GQUAL CALIBRATION

Key Parameters:

- **Partition Coefficients**
- **Decay/Transformation Rates**
- **Adsorption/Desorption Transfer Rates**

CALABAZAS CREEK (CA) - COPPER