CWEMF
IWFM v4.0 Workshop

January 7-8, 2014
West Yost Associates, Davis, CA

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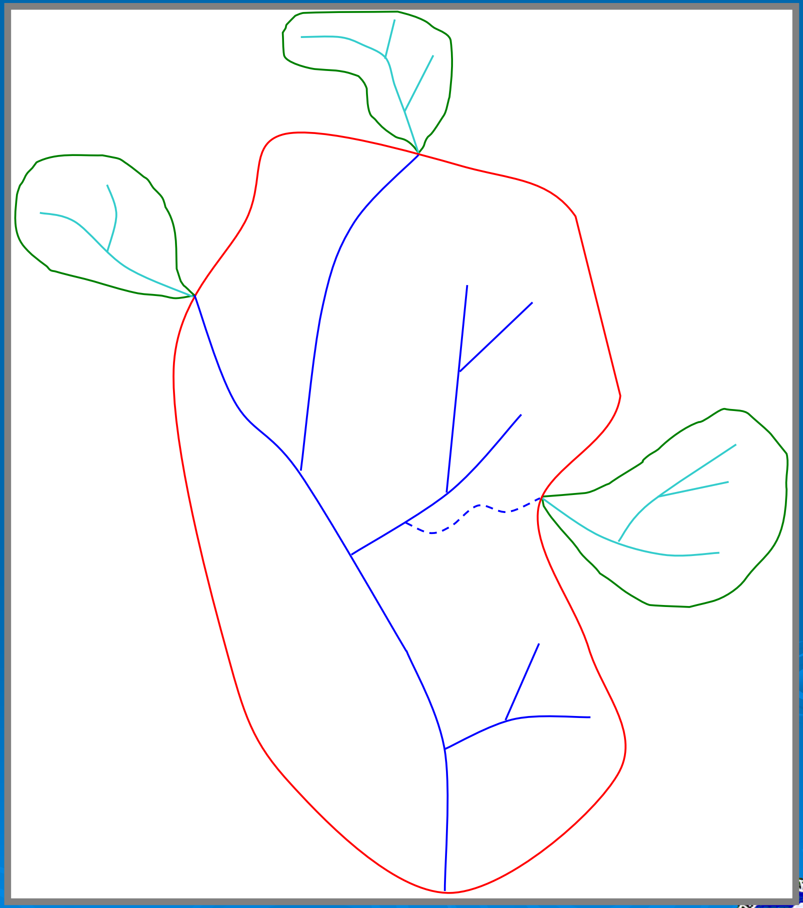
Session 8:

Small Watershed Boundary Condition and Simulation of Multiple Aquifer Layers

Small Watershed Boundary Condition

- Subsurface and surface flows into modeled area from adjacent small watersheds are simulated approximately
- Surface flows from small watersheds can contribute to groundwater as well as stream flows



Small Watershed Boundary Condition

- Subsurface flow from small watersheds contribute to groundwater at nodes specified by the user:

$$Q_{wg} = C_{wg} S_{wg}$$

Q_{wg} = subsurface outflow component, (L^3/T);
C_{wg} = subsurface flow recession coefficient, ($1/T$);
S_{wg} = groundwater storage within the small watershed boundary, (L^3).

Small Watershed Boundary Condition

- Surface flow from small watersheds contribute to stream flow at nodes specified by the user:

$$Q_{ws} = C_{ws}\left(S_{wg} - S_{wgt}\right) \quad \text{if} \quad S_{wg} > S_{wgt}$$

Q_{ws} = surface outflow component, (L^3/T);
C_{ws} = surface runoff recession coefficient, ($1/T$);
S_{wg} = groundwater storage within small watershed boundary, (L^3);
S_{wgt} = threshold value for groundwater storage within the small watershed , (L^3).

Small Watershed Boundary Condition

- Groundwater storage in small watershed:

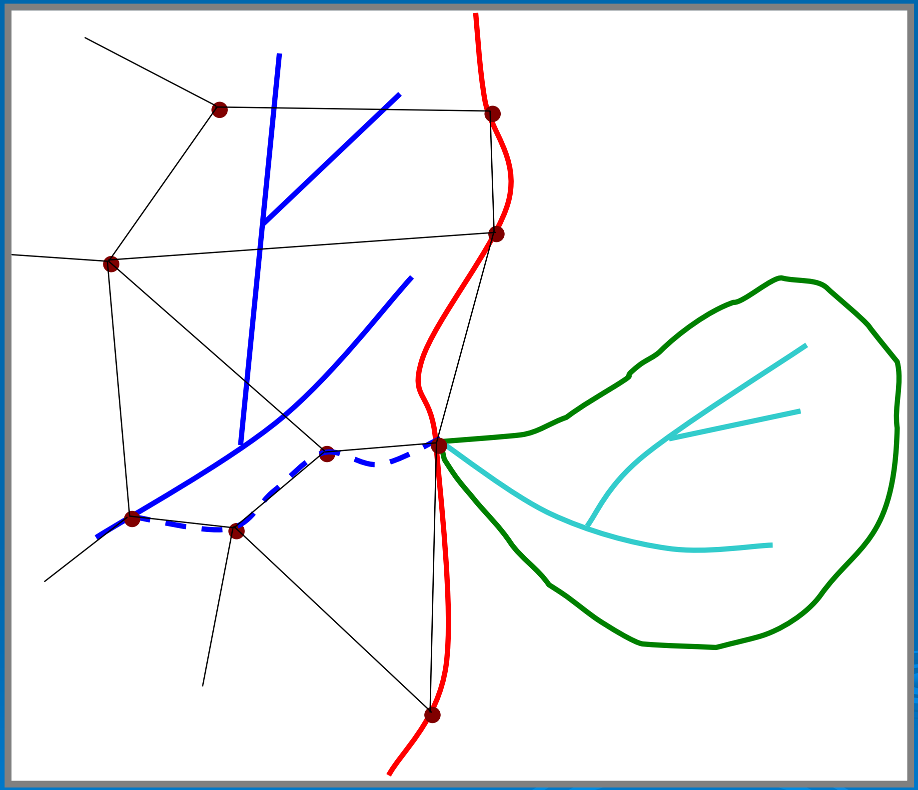
$$S_{wg}^{t+1} = S_{wg}^{t} + D_{sw} - \left(Q_{ws} + Q_{wg}\right)\Delta t$$

- Deep percolation in small watersheds, D_{sw}, is simulated the same way as in the root zone component using either Campbell's or van Genuchten-Mualem equation
- Routing of soil moisture in small watersheds is the same as in the root zone component:

$$Z_{sw}\theta_{sw}^{t+1} = Z_{sw}\theta_{sw}^{t} + \Delta t\left(P_{sw} - R_{P_{sw}} - D_{sw} - ET_{sw}\right)$$

Small Watershed Boundary Condition

- Surface flows from small watersheds may contribute to groundwater as percolation from creeks that are not modeled
- User defined percolation rates at specified groundwater nodes



Groundwater Flow in Multiple Aquifer Layers

$$\frac{\partial S_s h}{\partial t} - \vec{\nabla}\left(T\ \vec{\nabla} h\right) - I_u q_u - I_d q_d - Q = 0$$

S_s = Storativity, (dimensionless);
h = Groundwater head, (L);
T = Transmissivity = Kh_s, (L^2/T);
K = Hydraulic conductivity; (L/T);
h_s = Saturated thickness of aquifer, (L);
t = Time (T);
q_u, q_d = Flow from adjacent upper and lower aquifer layers, (L/T);
I_u, I_d = Indicator functions for top and bottom aquifer, (dimensionless);
Q = Source/sink term, (L/T).

Groundwater Flow in Multiple Aquifer Layers

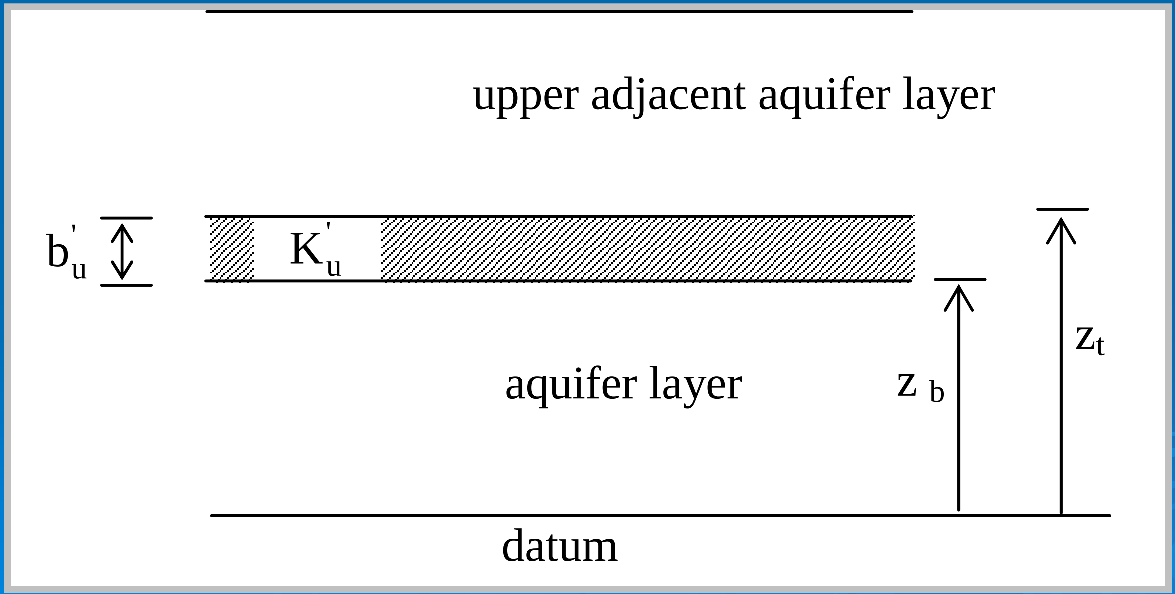
$$\frac{\partial S_s h}{\partial t} - \vec{\nabla}\left(T\,\vec{\nabla} h\right) - I_u q_u - I_d q_d - Q = 0$$

S_s	=	Storativity, (dimensionless);
h	=	Groundwater head, (L);
T	=	Transmissivity = Kh_s, (L^2/T);
K	=	Hydraulic conductivity; (L/T);
h_s	=	Saturated thickness of aquifer, (L);
t	=	Time (T);
q_u, q_d	=	Flow from adjacent upper and lower aquifer layers, (L/T);
I_u, I_d	=	Indicator functions for top and bottom aquifer, (dimensionless);
Q	=	Source/sink term, (L/T).

Vertical Flow

(Aquifer Layers Separated by an Aquitard)

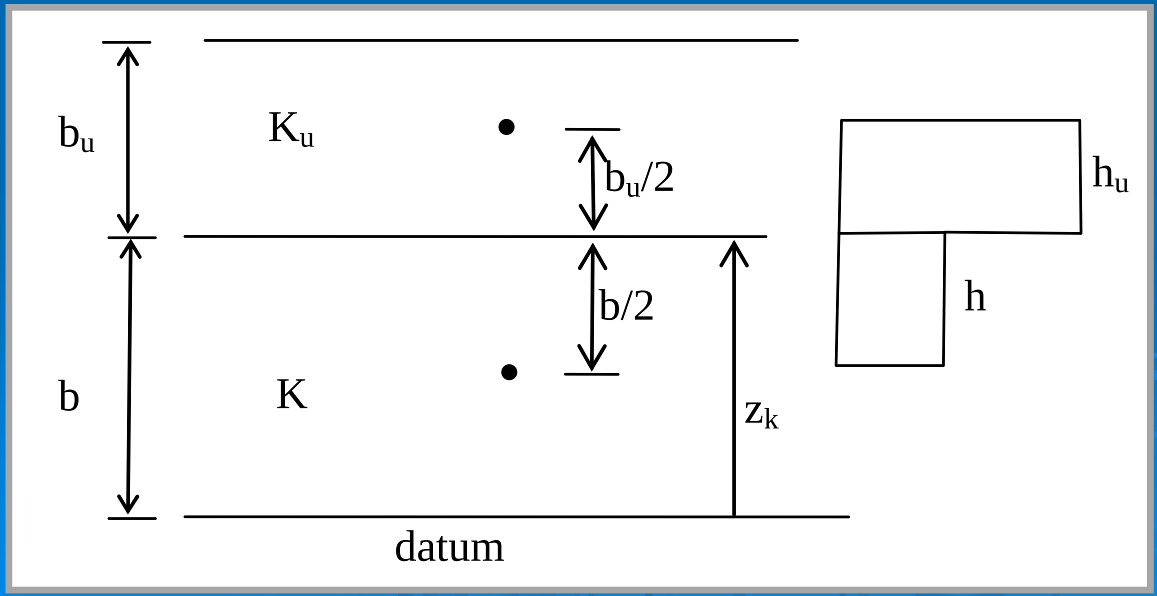
$$q_u = -L_u\left(h - h_u\right) = -\frac{K_u'}{b_u'}\left(h - h_u\right)$$



Vertical Flow

(Aquifer Layers not Separated by an Aquitard)

$$q_u = -L_u\left(h - h_u\right) = -\left[\frac{1}{0.5\left(\frac{b_u}{K_u} + \frac{b}{K}\right)}\right]\left(h - h_u\right)$$

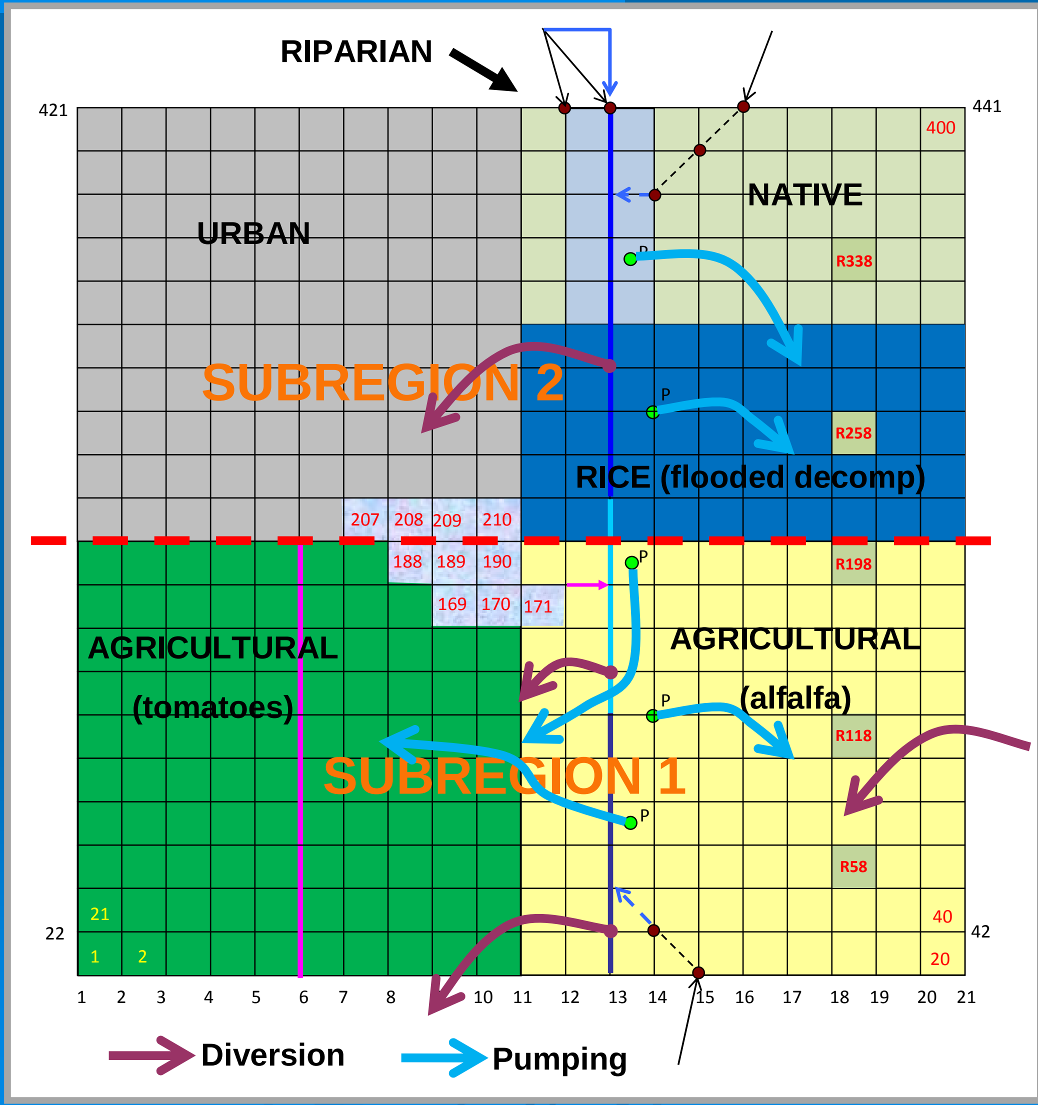


Groundwater Flow in Multiple Aquifer Layers *(after substitution)*

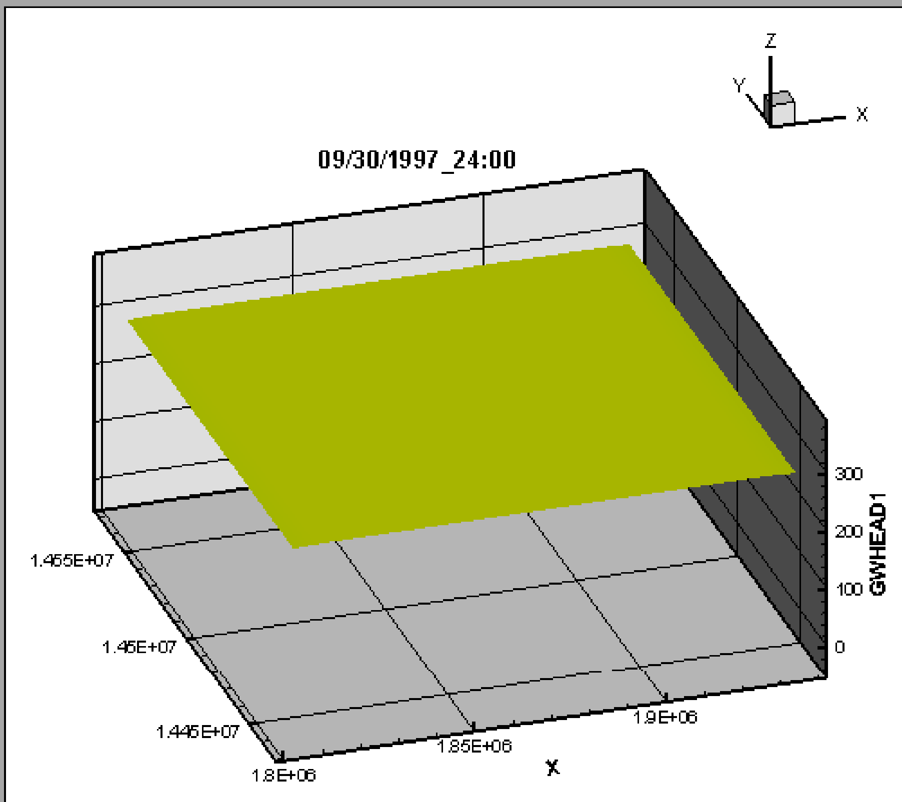
$$\frac{\partial S_s h}{\partial t} - \vec{\nabla}\left(T\,\vec{\nabla} h\right) + I_u L_u \left(h - h_u\right) + I_d L_d \left(h - h_d\right) - Q = 0$$

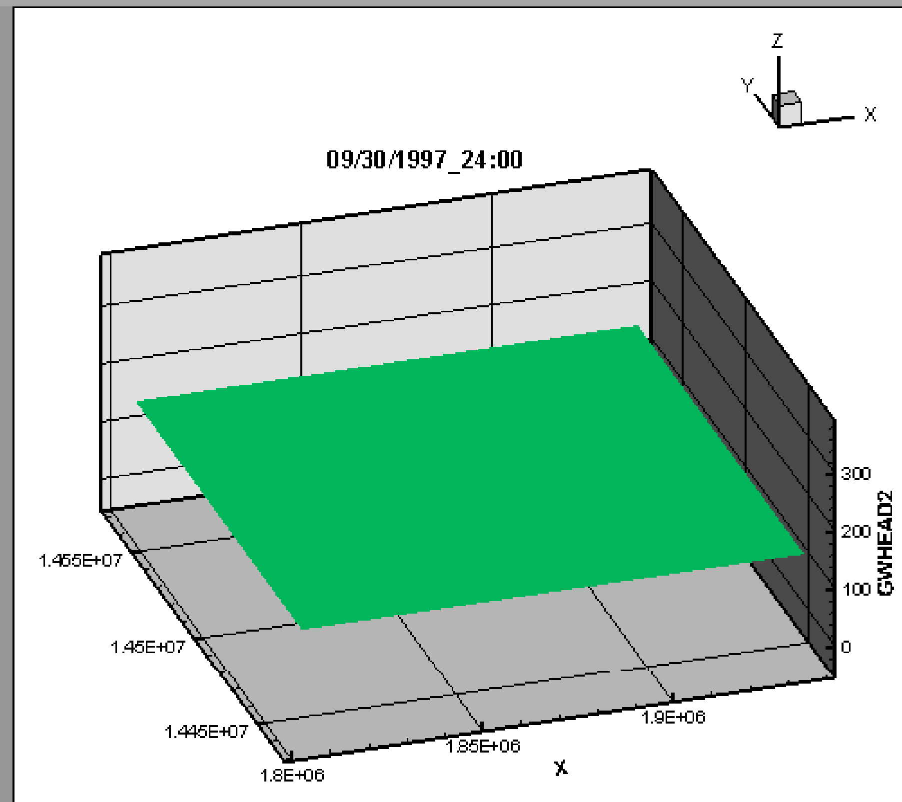
- S_s = Storativity, (dimensionless);
- h = Groundwater head, (L);
- T = Transmissivity = Kh_s, (L^2/T);
- K = Hydraulic conductivity; (L/T);
- h_s = Saturated thickness of aquifer, (L);
- t = Time (T);
- I_u, I_d = Indicator functions for top and bottom aquifer, (dimensionless);
- h_u, h_d = Groundwater head at adjacent upper and lower aquifer layers, (L/T);
- L_u,L_d = Leakage coefficients of adjacent upper and lower aquifer layers, (1/T);
- Q = Source/sink term, (L/T).

Example 8

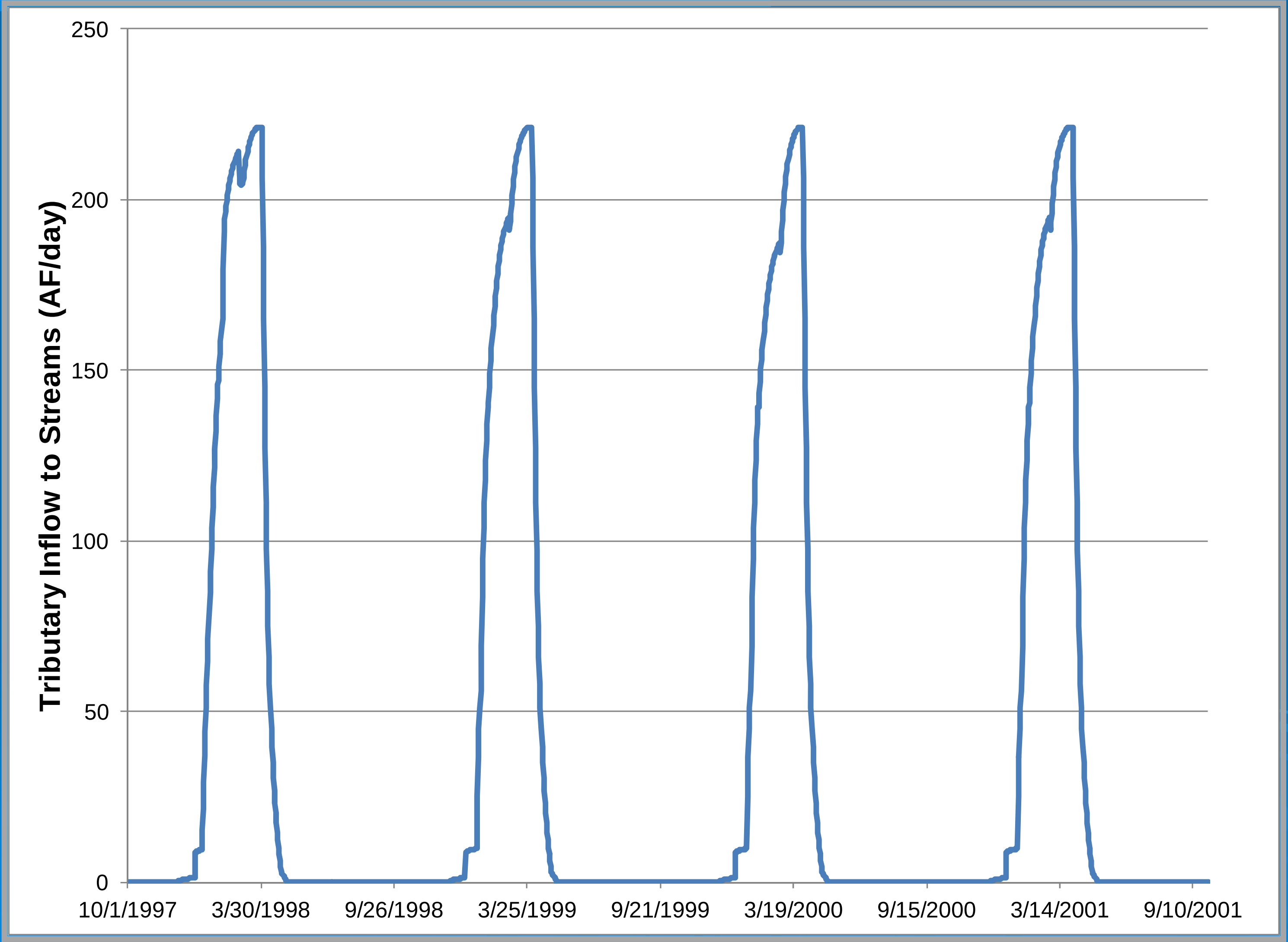

RIPARIAN
421
441
400
NATIVE
URBAN
R338
SUBREGION 2
R258
RICE (flooded decomp)
207
208
209
210
188
189
190
R198
169
170
171
AGRICULTURAL
AGRICULTURAL
(tomatoes)
(alfalfa)
R118
SUBREGION 1
R58
21
40
22
42
1
2
20
1 2 3 4 5 6 7 8 10 11 12 13 14 15 16 17 18 19 20 21
Diversion
Pumping

Example 8:
Groundwater Heads

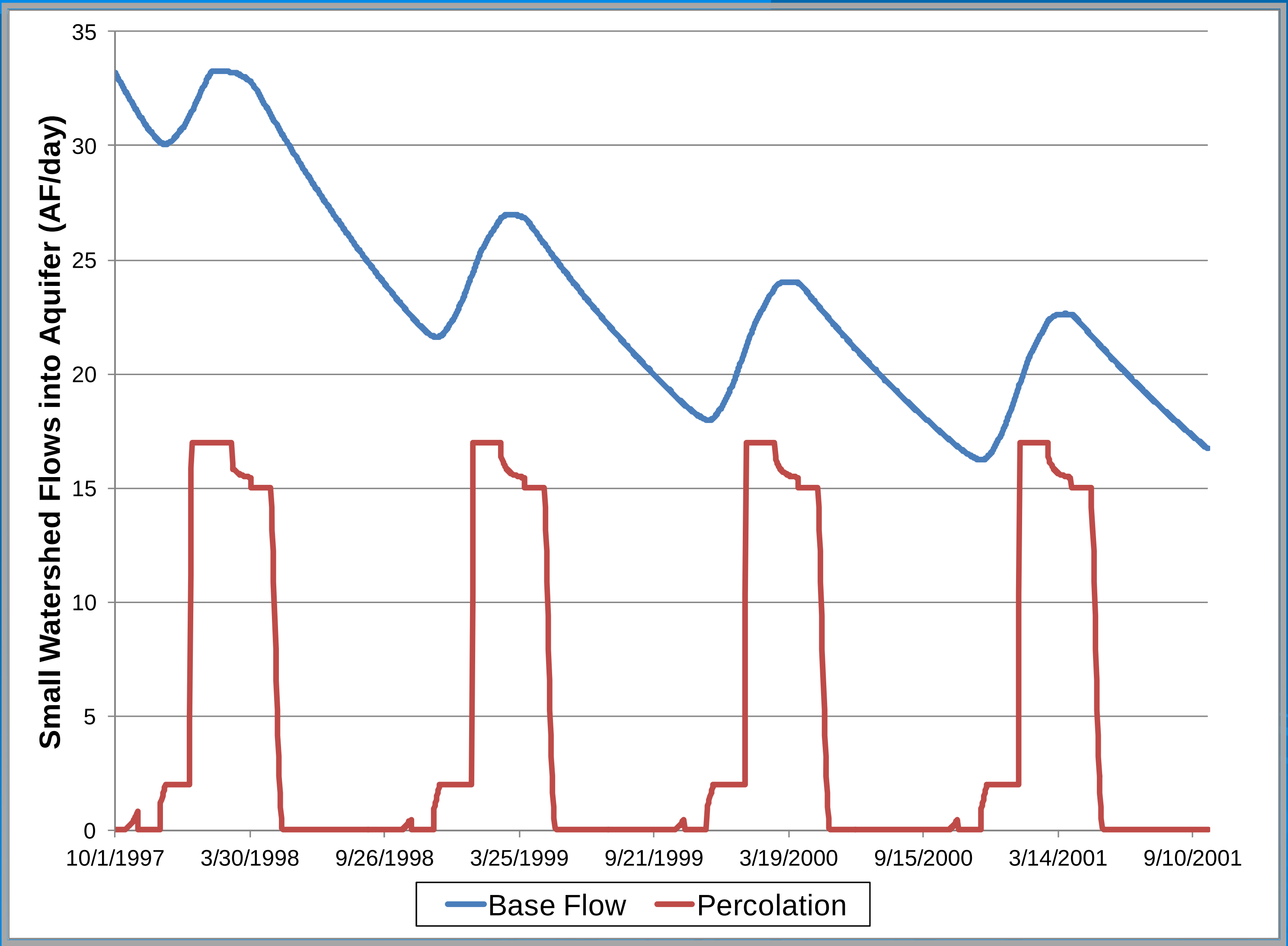




Example 8:
Contribution of Small Watersheds to Streams



Example 8:
Contribution of Small Watersheds to Groundwater



Example 8:
Vertical Flow