The California Central Valley Groundwater-Surface Water Simulation Model

Land Surface Process

CWEMF C2VSim Workshop
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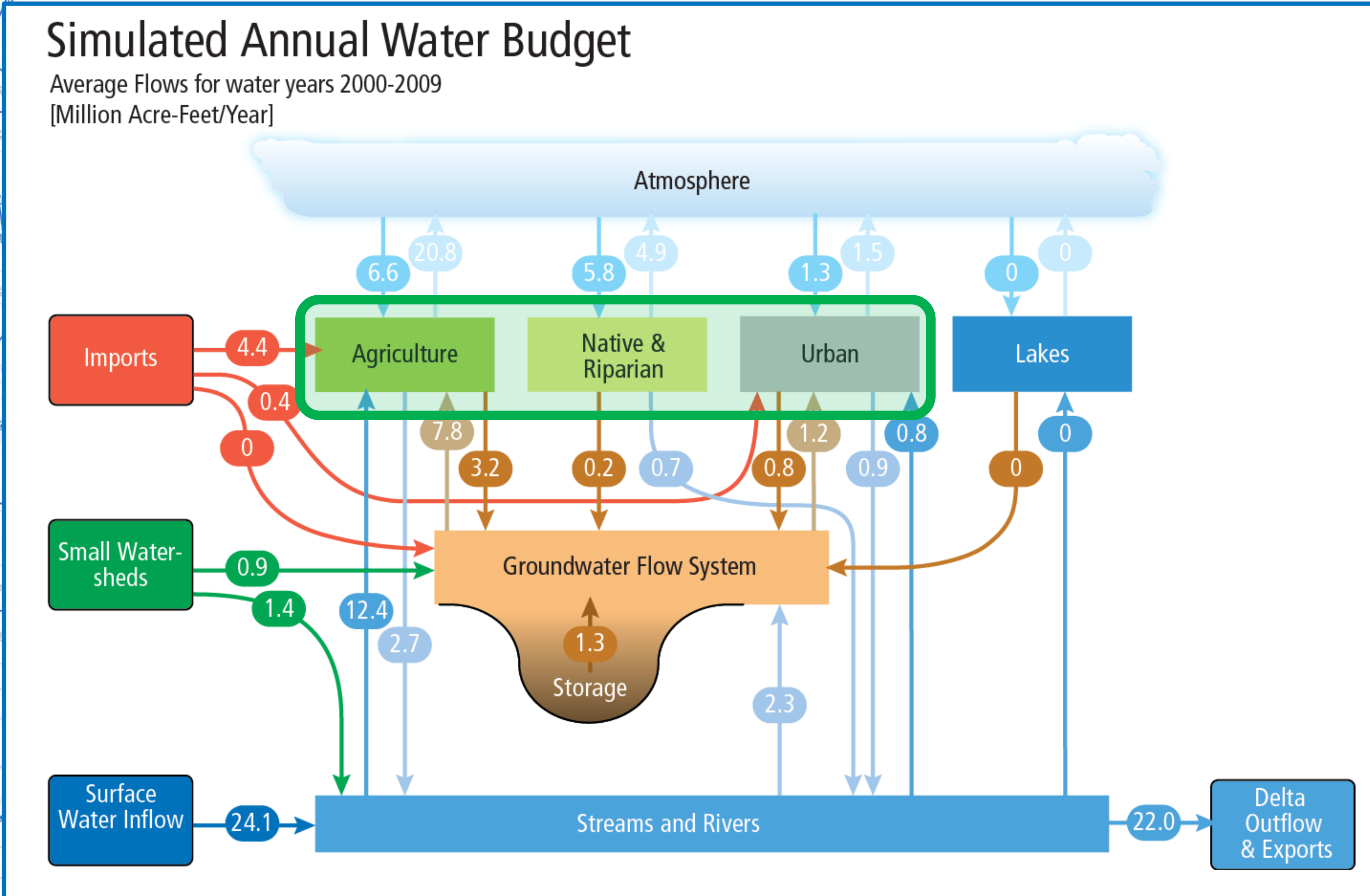
Outline

IWFM Land Surface Process

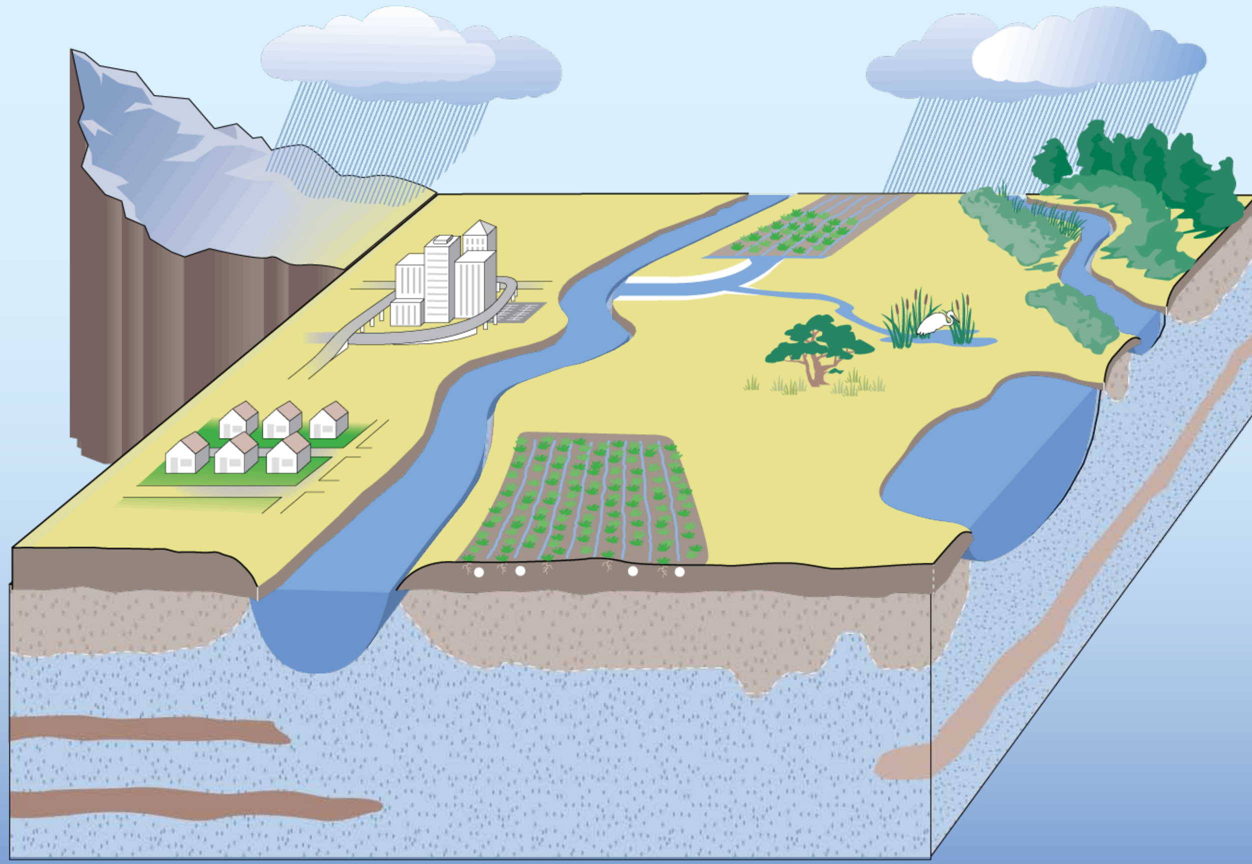
- Land and Water Use Budget
- Root Zone Budget

C2VSim Results

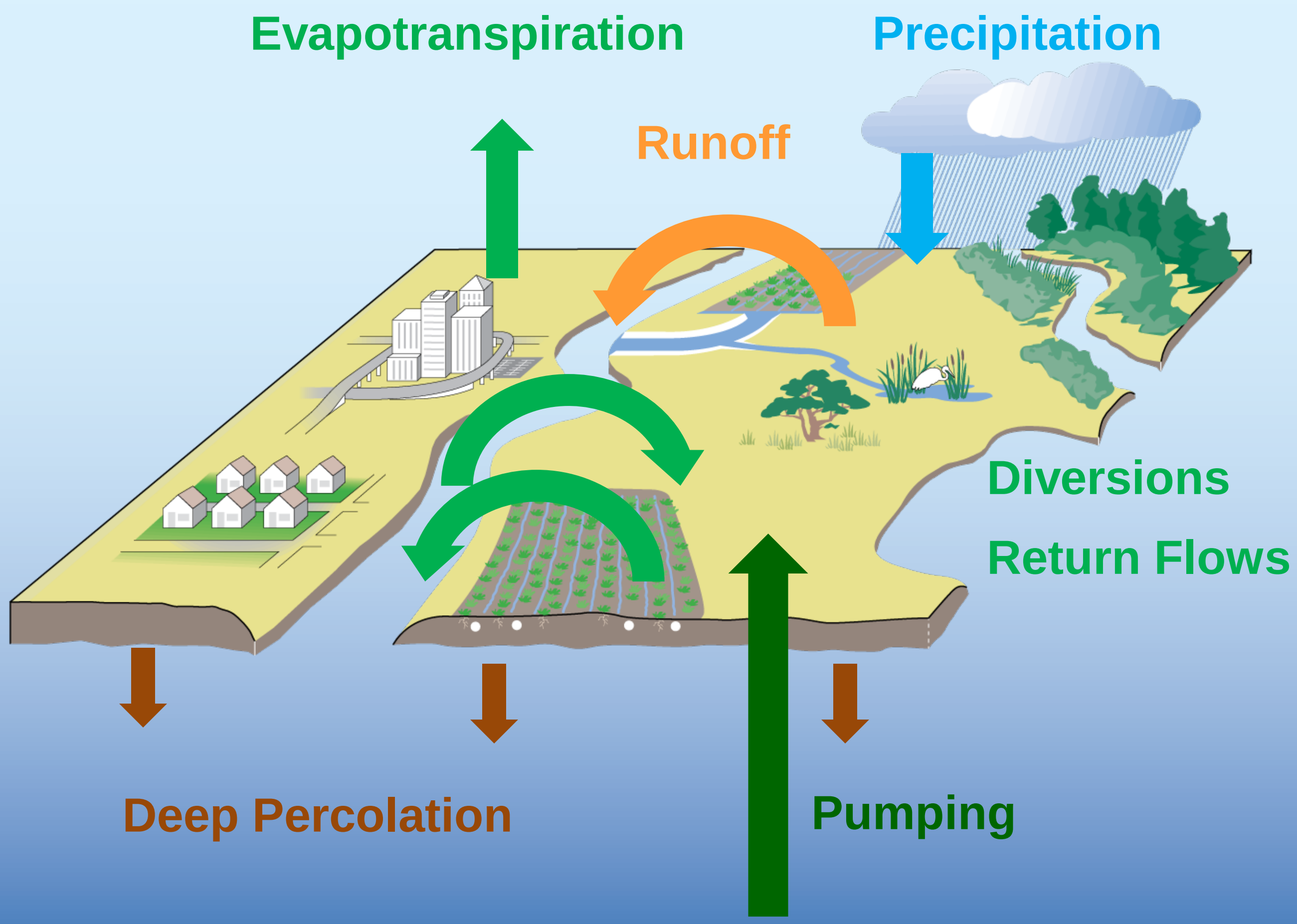
IWFM Water Balance Diagram



Land Surface Process

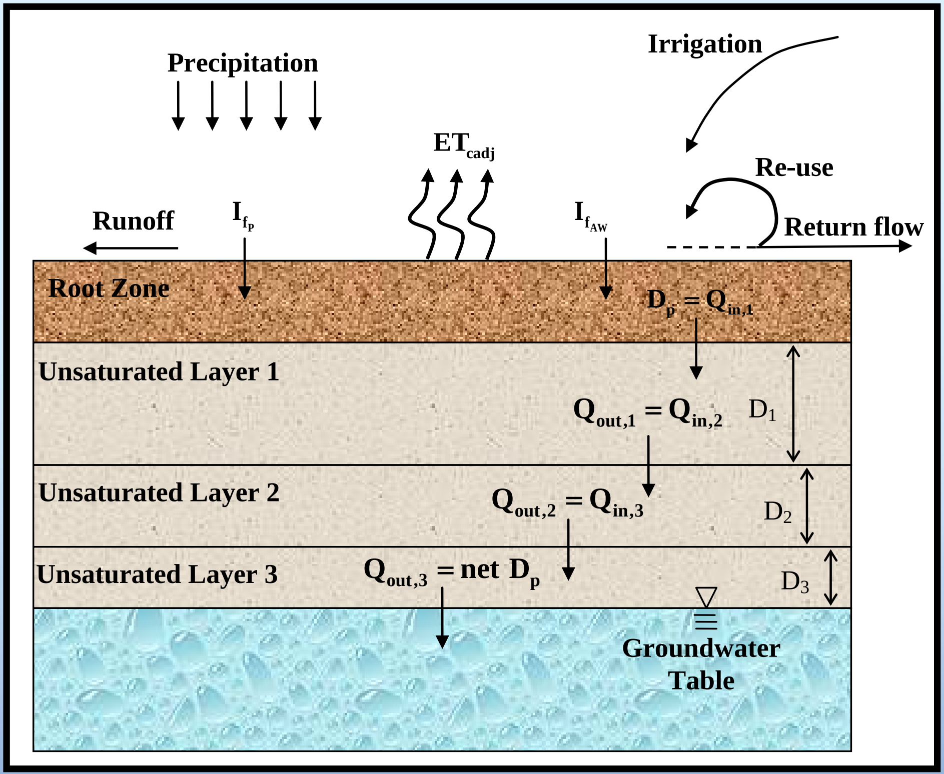


Land Surface Process



Land Surface & Root Zone Processes

- Precipitation and irrigation less direct runoff and return flow is the inflow into root zone
- Deep percolation from root zone is the inflow into unsaturated zone
- Net deep percolation from unsaturated zone is the recharge to groundwater
- 4 land-use types considered:
  - agricultural, urban, native
  - vegetation, riparian vegetation



- Unsaturated zone layer thicknesses are time-dependent; conservation equations in unsaturated zone layers are solved iteratively

Land Surface & Root Zone Processes

- Governing conservation equation for the root zone:

$$\theta_r^{t+1} = \theta_r^t + \left[\left(P - S_r \right) + \left(A_W - R_f \right) - ET_{cadj} - D_p \right] \Delta t$$

where θ_r **= soil moisture, (L);**

P	=	**precipitation, (L/T);**
S_r	=	**surface runoff from precipitation, (L/T);**
A_W	=	**applied water, (L/T);**
R_f	=	**return flow of applied water, (L/T);**
ET_{cadj}	=	**adjusted evapotranspiration, (L/T);**
D_p	=	**deep percolation, (L/T);**
Δt	=	**time step length, (T);**
t	=	**time step counter (dimensionless).**

C2VSim Land Surface Process

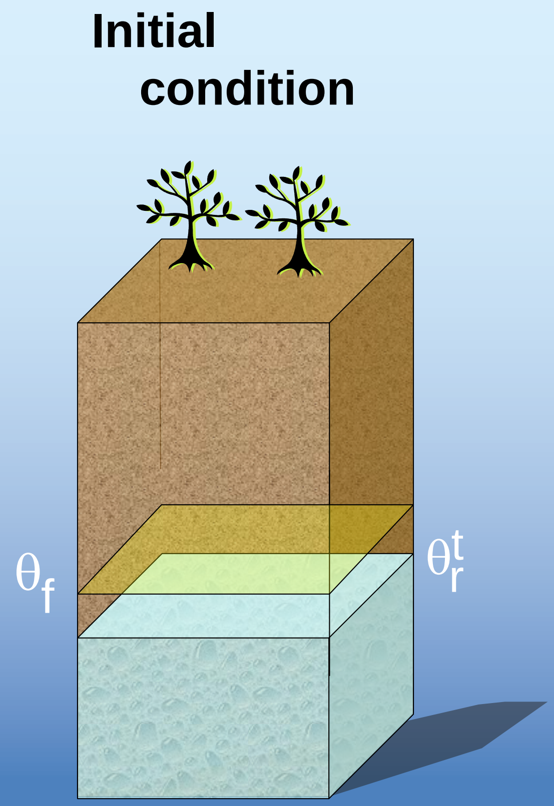
- 21 Subregions
  – Annual crop acreages
  – Monthly evapotranspiration rates
  – Monthly urban demand
  – Monthly surface water diversions (Ag & Urban)
  – Monthly groundwater pumping (Ag & Urban)
  – Regional water re-use factors
- 1392 Elements
  – Annual land use distribution
  – Monthly precipitation

C2VSim Land Surface Process

Input Files:

- Precipitation
- Land Use
- Evapotranspiration Rates
- Crop Acreage
- Crop Demands
- Urban Demands
- Urban Specification
- Re-Use Factor

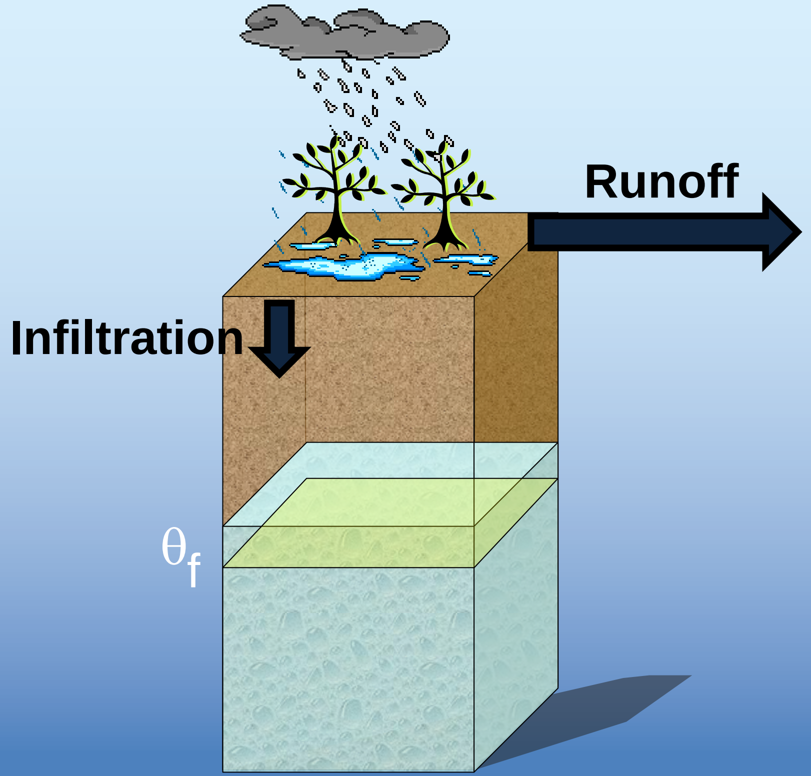
Land Surface & Root Zone Processes



Land Surface & Root Zone Processes

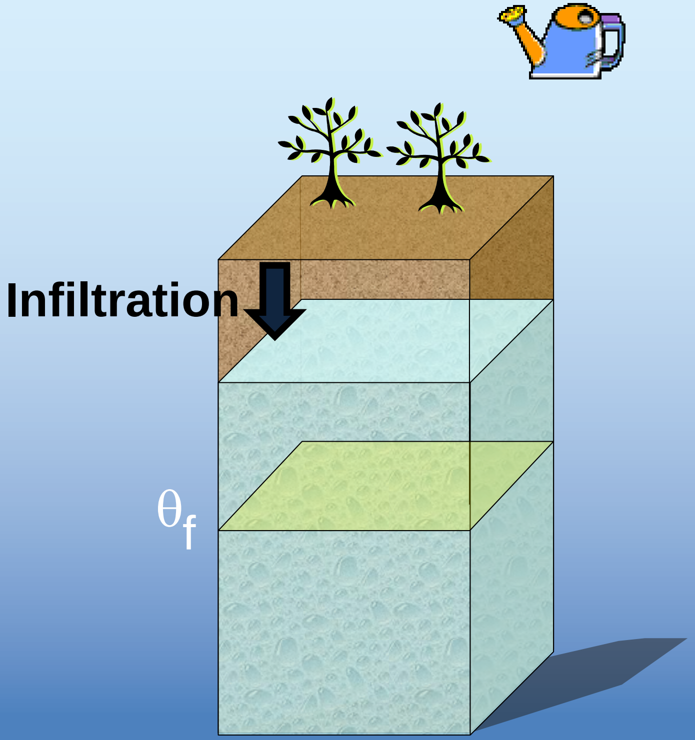
Step 1: Compute rainfall runoff and infiltration of precipitation

- **Modified SCS Curve Number method (retention parameter, S, decreases as moisture goes above half of field capacity)**



Land Surface & Root Zone Processes

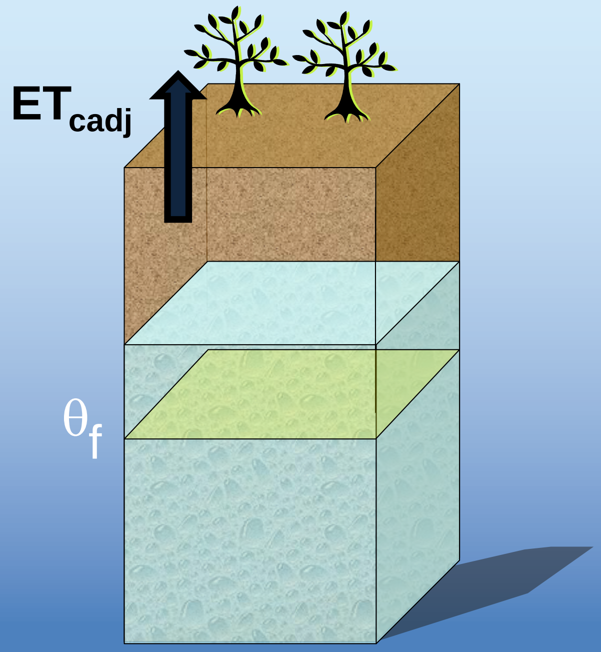
Step 2: Apply irrigation and initially assume all infiltrates



Land Surface & Root Zone Processes

Step 3: Compute evapotranspiration (FAO Paper 56, 1998)

- **Same as potential ET when moisture is at or above half of field capacity**
- **Decreases linearly when moisture is below half of field capacity**

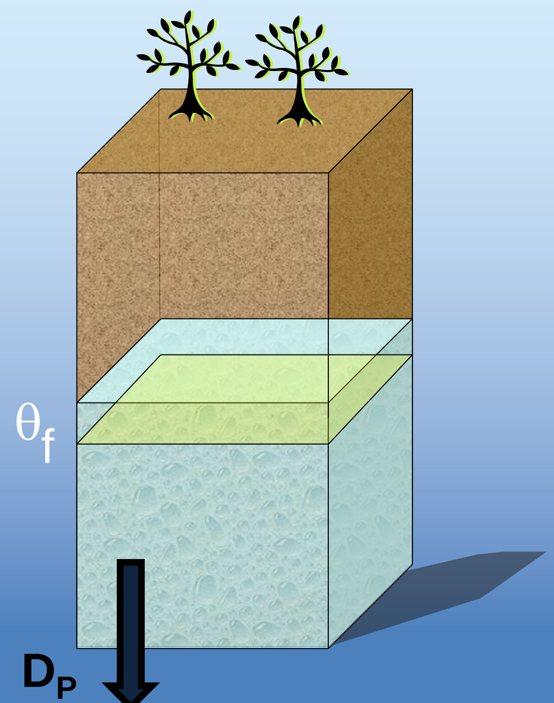


Land Surface & Root Zone Processes

Step 4: Compute deep percolation if moisture is above field capacity

Expressed using one of the methods below specified by user

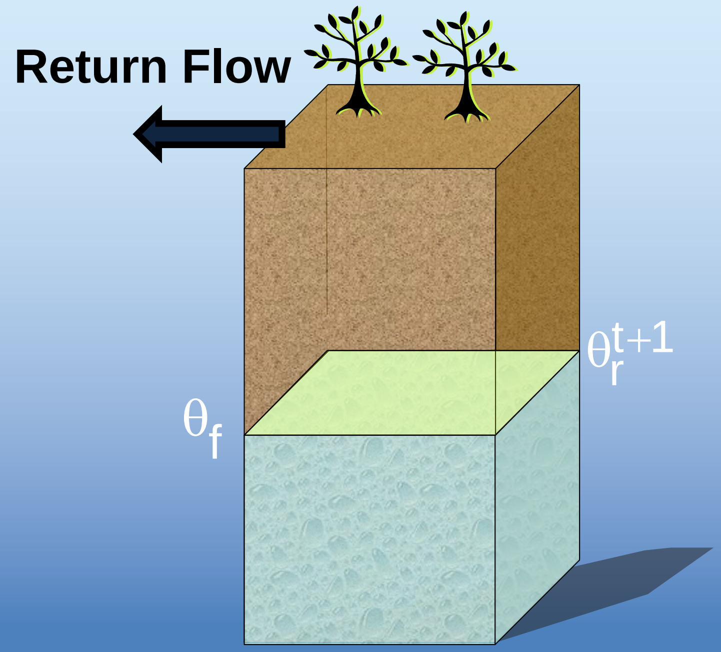
- **A fraction of moisture that is above field capacity**
- **Physically-based method using hydraulic conductivity;**



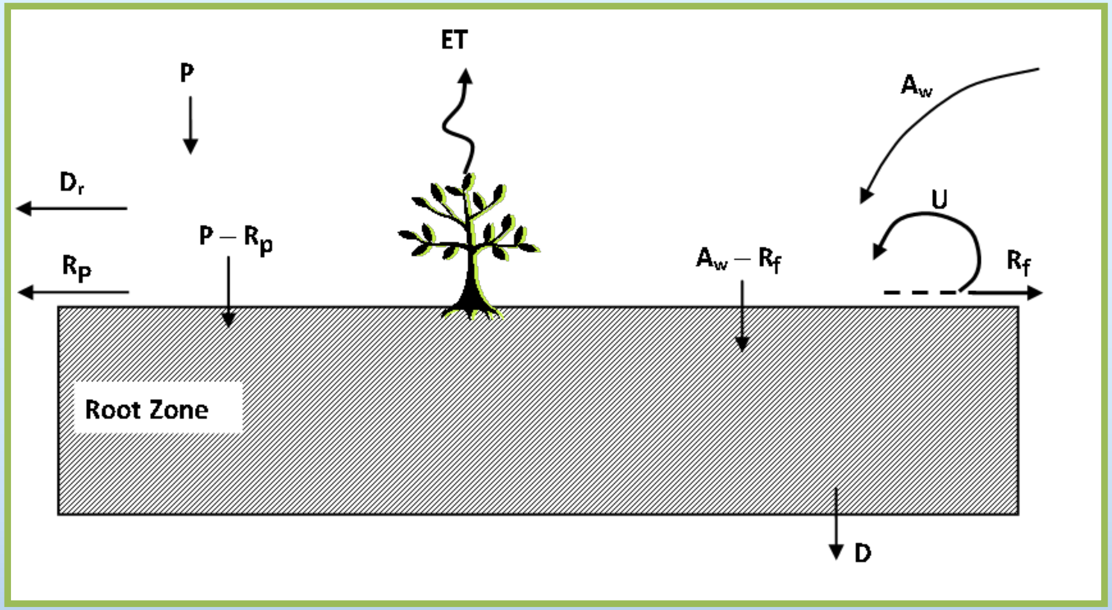
$$D_P = K_S\left(\frac{\theta_r}{\eta_T}\right)^4$$

Land Surface & Root Zone Processes

Step 5: Compute return flow and update infiltration of applied water



Schematic Representation of Flow Components



P = precipitation

A_w = applied water

R_P = direct runoff

U = re-use

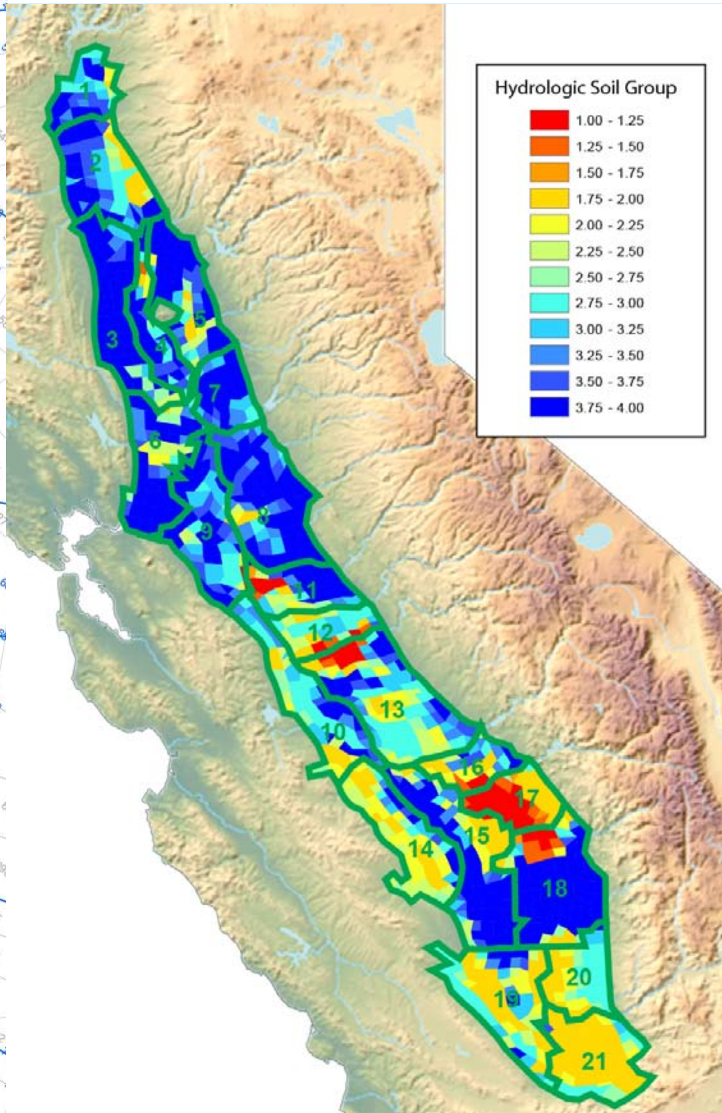
ET = evapotranspiration

D_r = drain from ponds

D = deep percolation

R_f = net return flow

Soil Moisture Parameters




```
C*******************************************************************************
C                    PARAMETERS FOR SOIL MOISTURE ROUTING
C
C   The following lists the soil moisture and hydrologic properties for each hydrologic soil group
C
C-------------------------------------------------------------------------------
C
C   KUSAGE; Flag that specifies how the value entered for variable K will be interpreted.  Enter
C             0 : Values listed for K are the fraction of excess soil moisture that will become d
C             1 : Values listed for K are saturated hydraulic conductivity of soil
C   FACT;   Conversion factor for root zone hydraulic conductivity - It is used to convert only th
C   TUNIT;  Time unit of hydraulic conductivity.  This should be one of the units recognized by HEC
C             * Note: If KUSAGE = 0, enter anything
C
C-------------------------------------------------------------------------------
C   VALUE                        DESCRIPTION
C-------------------------------------------------------------------------------
    0                            / KUSAGE
    1.0                          / FACT
    1mon                         / TUNIT
C-------------------------------------------------------------------------------
C
C   IREGN;      Subregion number
C   FC    ;     Field capacity; [L/L]
C   EF    ;     Total porosity; [L/L]
C   K     ;     Hydraulic conductivity of the root zone; [L/T]
C   CN    ;     Curve number depending on the land use type:
C                1-Agricultural ; 2-Urban ; 3-Native veg. ; 4-Riparian veg.
C               (Reference: USDA, 1985)
C
C-------------------------------------------------------------------------------
```

IREGN	SOIL GROUP A FC	EF	K	CN BY LAND 1	2	3	4	SOIL GROUP B FC	EF	K	CN BY LAND 1	2	3	4
1	0.067	0.477	1.000	79.0	83.0	81.0	81.0	0.473	0.483	0.014	84.0	86.0	84.0	84.0
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.110	0.481	1.000	86.0	87.0	86.0	86.0
3	0.119	0.438	0.620	83.0	86.0	84.0	84.0	0.033	0.471	0.632	86.0	87.0	86.0	86.0
4	0.121	0.428	1.000	83.0	86.0	84.0	84.0	0.286	0.473	0.857	86.0	87.0	86.0	86.0
5	0.194	0.440	0.764	83.0	85.0	84.0	84.0	0.380	0.390	0.050	86.0	87.0	86.0	86.0
6	0.164	0.429	1.000	83.0	86.0	84.0	84.0	0.040	0.400	0.654	86.0	87.0	86.0	86.0
7	0.045	0.440	0.938	83.0	85.0	84.0	84.0	0.178	0.480	0.980	86.0	87.0	86.0	86.0
8	0.048	0.438	0.969	83.0	86.0	84.0	84.0	0.010	0.456	0.817	86.0	87.0	86.0	86.0
9	0.010	0.444	0.992	86.0	87.0	86.0	84.0	0.010	0.462	0.931	87.0	90.0	89.0	84.0
10	0.037	0.438	0.947	87.0	90.0	89.0	89.0	0.018	0.481	0.689	90.0	92.0	90.0	90.0
11	0.080	0.439	0.984	86.0	87.0	86.0	86.0	0.180	0.459	0.234	87.0	90.0	89.0	89.0
12	0.352	0.422	1.000	86.0	89.0	86.0	86.0	0.457	0.500	0.336	89.0	91.0	90.0	90.0
13	0.124	0.451	1.000	86.0	89.0	86.0	86.0	0.200	0.257	0.031	89.0	91.0	90.0	90.0
14	0.081	0.440	1.000	89.0	91.0	90.0	90.0	0.088	0.481	0.252	91.0	93.0	92.0	92.0
15	0.108	0.440	0.976	89.0	91.0	90.0	90.0	0.177	0.480	0.125	91.0	93.0	92.0	92.0
16	0.095	0.435	1.000	86.0	89.0	86.0	86.0	0.241	0.450	0.123	89.0	91.0	90.0	90.0

C2VSim Crop Acreage File

ID	CODE	Description
1	PA	PASTURE
2	AL	ALFALFA
3	SB	SUGAR BEET
4	FI	FIELD CROPS
5	RI	RICE
6	TR	TRUCK CROPS
7	TO	TOMATO
8	TH	TOMATO (HAND PICKED)
9	TM	TOMATO (MACHINE PICKED)
10	OR	ORCHARD
11	GR	GRAINS
12	VI	VINEYARD
13	CO	COTTON
14	SO	CITRUS & OLIVES
15	UR	URBAN
16	NV	NATIVE VEGETATION
17	RV	RIPARIAN VEGETATION

```
C-----------------------------------------------------------------------------
C
C ITCR                IR   ACROP(1)  ACROP(2)  ACROP(3) .... ACROP(15)  ACROP(16)  ACROP(17)
C-----------------------------------------------------------------------------
09/30/1922_24:00      1      12692       765         0       393          0        135         0
                      2      22800     11100         0      2700          0        500         0
                      3      22400      8600         0      6200      40000       3400         0
                      4       5100      2600         0     31900      22000       3600         0
                      5      27200     15800       600     11400      31800       4400         0
                      6       6200      5300       600      3400       6000       3900         0
                      7      19800      5200      1200      8600       1200       2700         0
                      8      40000      7800       500     10300       3100       9500         0
                      9      23200     40100     19500     79900       2900     121500         0
                     10       8937     44348      1012     51482       5844      15605         0
                     11      25709     11311       163     27674       3708       4400         0
                     12      12672     16298        33     39301         22       3217         0
                     13      31982     61743       794     35543       5826       6980         0
                     14        741     27419      3281     56059        637      11196         0
                     15      13456     94550      2300     77785       1890       1056         0
                     16      16986      9140        96     11873          0       1564         0
                     17       9604      7972       285     12821          0       2208         0
                     18      21473     54838       990     84272       1869       2256         0
                     19       2621     43917      1634     30845        223       3960         0
                     20        643     11943       180      8537          1       2272         0
                     21       4376     42223      1233     23837        381      15484         0
09/30/1923_24:00      1      12692       765         0       393          0        135         0
                      2      22300     10900         0      2700          0        500         0
                      3      22400      8600         0      6200      40000       3400         0
                      4       5200      2600         0     32600      22000       3700         0
                      5      27600     15900       700     11600      31800       4400         0
                      6       6600      5700       600      3600       7000       4300         0
                      7      20500      5300      1200      8800       1200       2800         0
                      8      41800      8100       600     10800       3200       9700         0
                      9      24000     40100     20900     80700       2900     109100         0
                     10       9016     44780      1012     50646       5427      16278         0
                     11      25936     11421       163     27225       3443       4590         0
                     12      12784     16457        33     38663         20       3355         0
                     13      32264     62343       794     34966       5410       7281         0
                     14        744     27550      3281     56279        637      11224         0
                     15      13514     95003      2300     78090       1890       1059         0
                     16      17059      9183        96     11919          0       1568         0
                     17       9645      8010       285     12872          0       2214         0
                     18      21565     55101       990     84603       1869       2262         0
                     19       2633     44127      1634     30966        223       3970         0
                     20        646     12000       180      8571          1       2278         0
                     21       4395     42426      1233     23931        381      15523         0
09/30/1924_24:00      1      12692       765         0       393          0        135         0
                      2      21900     10700         0      2600          0        500         0
                      3      25900      9900         0      7100      31000       3900         0
                      4       4700      2400         0     29400      29000       3300         0
                      5      29300     16900       700     12300      25200       4800         0
                      6       7100      6100       700      3900       7000       4500         0
                      7      21500      5700      1300      9300        800       2900         0
```

C2VSim Land Use File

```
C    ITLN ;    Time
C    IE    ;    Element number
C    ALAND;    Area (or fraction of area) corresponding to each land use type
C               over an element; [L^2] or [L/L]
C
C-----------------------------------------------------------------------------------------
C                                      ALAND
C                             ----------------------------------------------------------------------
C    ITLN               IE        Agricultural          Urban          Native veg.         Riparian veg.
C-----------------------------------------------------------------------------------------
09/30/1922_24:00         1            812.39          956.00          3874.25               0.00
                         2              0.00            0.00          5625.63               0.00
                         3              0.00            0.00         12265.58               0.00
                         4              0.00            0.00          4421.92               0.00
                         5              0.00            0.00          5855.80               0.00
                         6              0.00            0.00          6928.58               0.00
                         7           1397.53            0.00          7923.39               0.00
                         8           1647.31            0.00          5281.87               0.00
                         9              0.00            0.00          8373.83               0.00
                        10              0.00            0.00         11541.16               0.00
                        11              0.00            0.00          8469.64               0.00
                        12            264.51            0.00          7137.77               0.00
                        13           1044.74            0.00          2102.55               0.00
                        14            594.70            0.00          1863.60               0.00
                        15              0.00            0.00          6973.75               0.00
                        16              0.00            0.00          8585.76               0.00
                        17              0.00            0.00          9435.92               0.00
                        18              0.00            0.00          9088.77               0.00
                        19            992.13            0.00          8331.88               0.00
                        20           2829.00            0.00          5748.34               0.00
                        21            130.90            0.00          4985.11               0.00
                        22              0.00            0.00          2461.97               0.00
                        23              0.00            0.00          7223.77               0.00
                        24              0.00            0.00          2689.48               0.00
                        25             93.29            0.00          6549.50               0.00
                        26           1985.93            0.00          4354.26               0.00
                        27           2717.61            0.00          7035.07               0.00
```

C2VSim Precipitation File

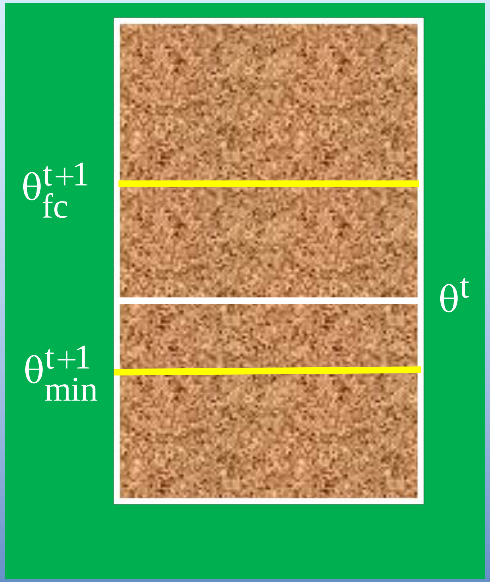
C---

C Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10/31/1921_24:00	1.34	1.34	1.32	1.27	1.34	1.31	1.30	1.34	1.29	1.07	1.27	1.27	1.33	1.34	1.27	1.03
11/30/1921_24:00	3.64	3.62	3.59	3.49	3.62	3.51	3.56	3.62	3.41	3.07	3.42	3.46	3.57	3.59	3.33	3.06
12/31/1921_24:00	8.15	8.14	7.86	7.49	8.08	7.43	8.01	7.97	7.14	6.40	7.21	7.77	7.95	7.72	6.96	6.28
01/31/1922_24:00	1.32	1.46	1.62	1.80	1.22	1.40	1.27	1.11	1.34	1.61	1.73	1.29	1.11	1.05	1.27	1.54
02/28/1922_24:00	7.61	7.95	7.98	8.02	7.25	7.23	7.09	6.63	6.66	6.56	7.30	6.81	6.43	6.26	6.16	5.95
03/31/1922_24:00	4.33	4.39	4.31	4.28	4.22	4.03	4.09	4.06	3.73	3.48	3.85	3.86	3.92	3.84	3.45	3.15
04/30/1922_24:00	0.94	0.91	0.92	0.91	0.94	0.93	0.93	0.94	0.92	0.79	0.83	0.89	0.94	0.94	0.89	0.73
05/31/1922_24:00	2.20	2.18	2.18	2.09	2.22	2.19	2.18	2.26	2.19	1.80	1.96	2.12	2.24	2.28	2.12	1.77
06/30/1922_24:00	0.71	0.72	0.67	0.62	0.76	0.58	0.74	0.82	0.65	0.36	0.54	0.70	0.84	0.86	0.62	0.34
07/31/1922_24:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
08/31/1922_24:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
09/30/1922_24:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10/31/1922_24:00	3.44	3.45	3.39	3.23	3.42	3.28	3.39	3.40	3.15	2.85	3.16	3.27	3.37	3.32	3.01	2.74
11/30/1922_24:00	3.54	3.64	3.74	3.79	3.47	3.51	3.41	3.22	3.22	3.40	3.66	3.39	3.13	3.00	2.95	3.16
12/31/1922_24:00	8.44	8.84	8.63	8.94	8.22	8.27	8.01	7.75	7.82	7.80	8.65	7.88	7.64	7.55	7.37	7.16
01/31/1923_24:00	4.06	4.09	4.02	3.90	4.05	3.95	3.99	4.01	3.83	3.53	3.79	3.85	3.93	3.94	3.61	3.37
02/28/1923_24:00	1.14	1.14	1.14	1.22	1.11	1.11	1.12	1.08	1.08	1.11	1.14	1.11	1.07	1.04	1.03	1.06
03/31/1923_24:00	0.57	0.58	0.61	0.61	0.64	0.66	0.64	0.73	0.69	0.53	0.44	0.67	0.75	0.76	0.69	0.52
04/30/1923_24:00	6.06	6.19	6.12	6.05	5.88	5.64	5.82	5.50	5.30	5.02	6.12	5.66	5.41	5.24	4.89	4.70
05/31/1923_24:00	0.73	0.74	0.71	0.72	0.70	0.68	0.70	0.65	0.65	0.66	0.68	0.67	0.64	0.63	0.61	0.62
06/30/1923_24:00	2.03	2.01	1.94	1.74	1.96	1.82	1.96	1.91	1.71	1.35	1.97	1.92	1.88	1.86	1.68	1.31
07/31/1923_24:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
08/31/1923_24:00	0.12	0.12	0.13	0.13	0.13	0.16	0.14	0.16	0.14	0.12	0.15	0.16	0.16	0.16	0.14	0.12
09/30/1923_24:00	2.99	2.95	2.93	2.84	3.04	2.98	2.84	3.04	2.92	2.59	2.41	2.56	2.80	3.02	2.87	2.58
10/31/1923_24:00	1.59	1.61	1.59	1.54	1.62	1.60	1.58	1.64	1.59	1.36	1.48	1.54	1.62	1.65	1.56	1.27
11/30/1923_24:00	0.79	0.79	0.82	0.86	0.76	0.78	0.75	0.72	0.73	0.75	0.85	0.75	0.69	0.67	0.66	0.71
12/31/1923_24:00	2.08	2.15	2.23	2.30	1.99	2.07	2.03	1.86	1.86	1.89	2.14	1.94	1.79	1.74	1.72	1.75
01/31/1924_24:00	3.01	3.10	3.10	3.22	3.00	3.03	3.02	2.97	2.99	3.10	3.34	3.08	2.99	2.93	2.92	2.99
02/29/1924_24:00	4.09	4.06	3.94	3.80	3.95	3.74	3.89	3.77	3.55	3.31	3.80	3.72	3.67	3.61	3.44	3.16
03/31/1924_24:00	1.44	1.48	1.56	1.68	1.33	1.39	1.34	1.19	1.28	1.52	1.60	1.30	1.16	1.11	1.21	1.43
04/30/1924_24:00	0.28	0.29	0.32	0.34	0.28	0.30	0.28	0.25	0.28	0.37	0.36	0.30	0.25	0.24	0.28	0.36
05/31/1924_24:00	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.01	0.04	0.04	0.04	0.04	0.03	0.00
06/30/1924_24:00	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.00	0.02	0.04	0.04	0.02	0.00	0.00	0.01	0.04
07/31/1924_24:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
08/31/1924_24:00	0.28	0.28	0.27	0.25	0.25	0.25	0.27	0.24	0.24	0.20	0.31	0.27	0.24	0.24	0.22	0.20
09/30/1924_24:00	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.00	0.02	0.04	0.04	0.01	0.00	0.00	0.01	0.04

Agricultural Demand Computation

During an irrigation or pre-irrigation period, if the moisture content is below a user-specified threshold, the governing conservation equation is used to compute the value of A_w that will raise the moisture to field capacity:

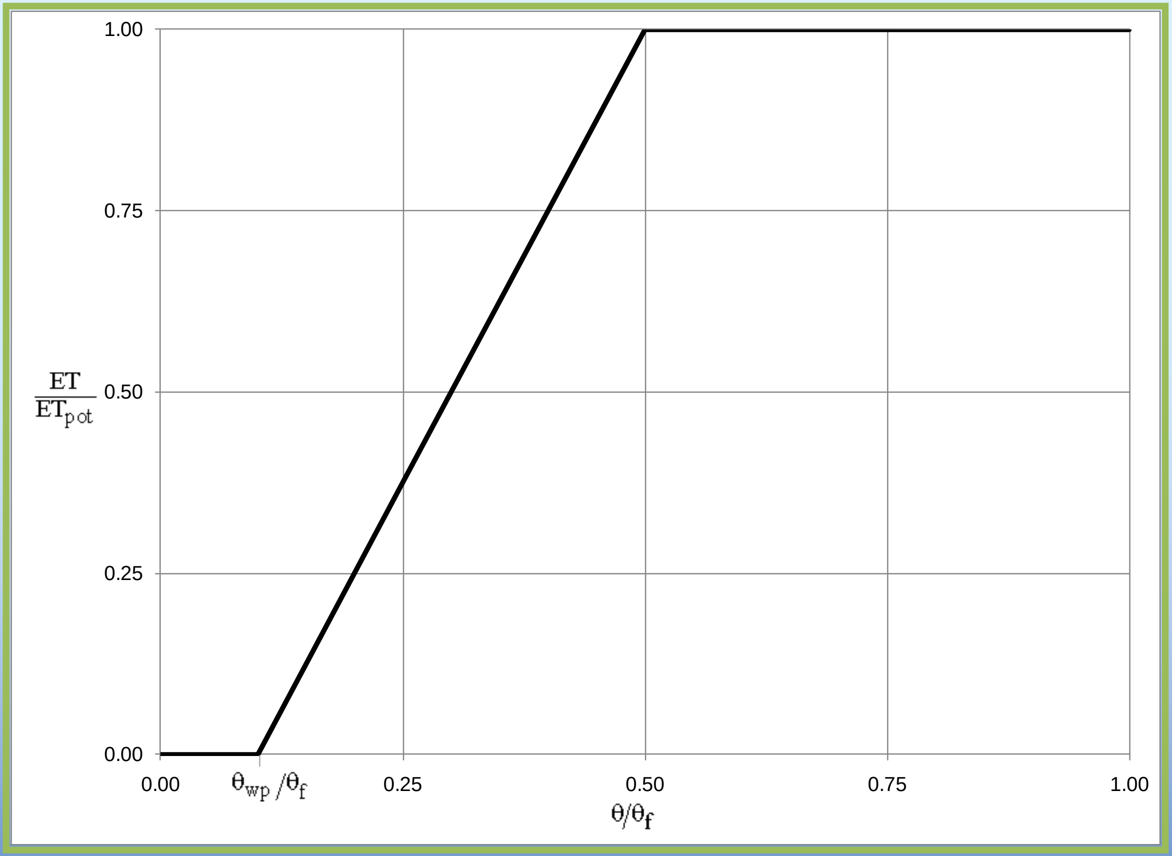
$$A_W = \begin{cases} \dfrac{\dfrac{\theta_{fc}^{t+1} - \theta^t - \Delta\theta_a}{\Delta t} - P + R_p + D_{fc} + ET_{pot}}{1 - \left(f_{R_{f,ini}} - f_U\right)} & \text{if} \quad \theta^t < \theta_{min}^{t+1} \\ 0 & \text{if} \quad \theta^t \geq \theta_{min}^{t+1} \end{cases}$$



Evapotranspiration

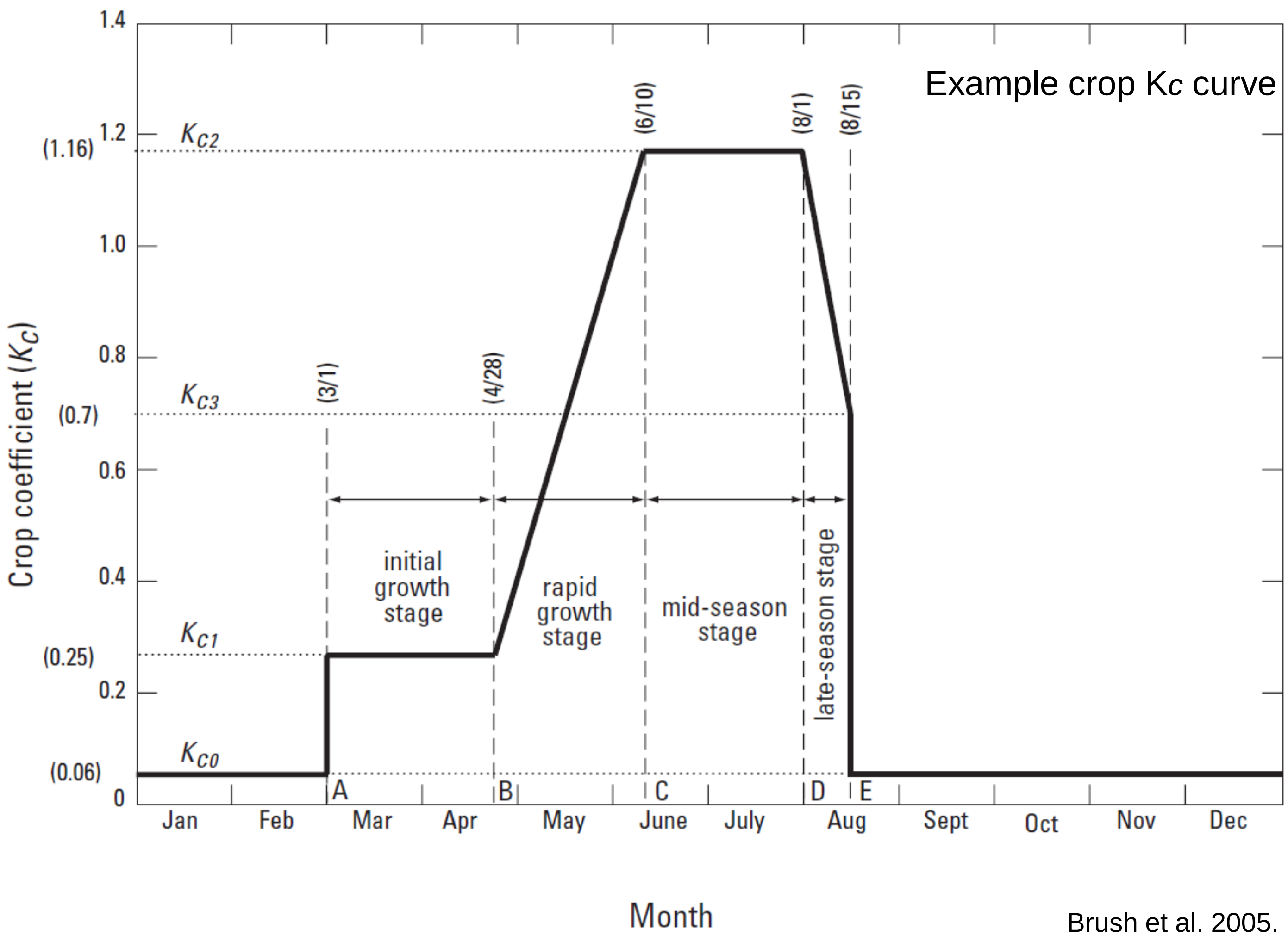
Assumptions:

- **p is taken as 0.5**
- **ET_{pot} can be taken as ET_c, ET_{cadj} or whatever is specified by the user**



Crop Demand Varies Monthly

Crop ET = K*c* * ET*o*

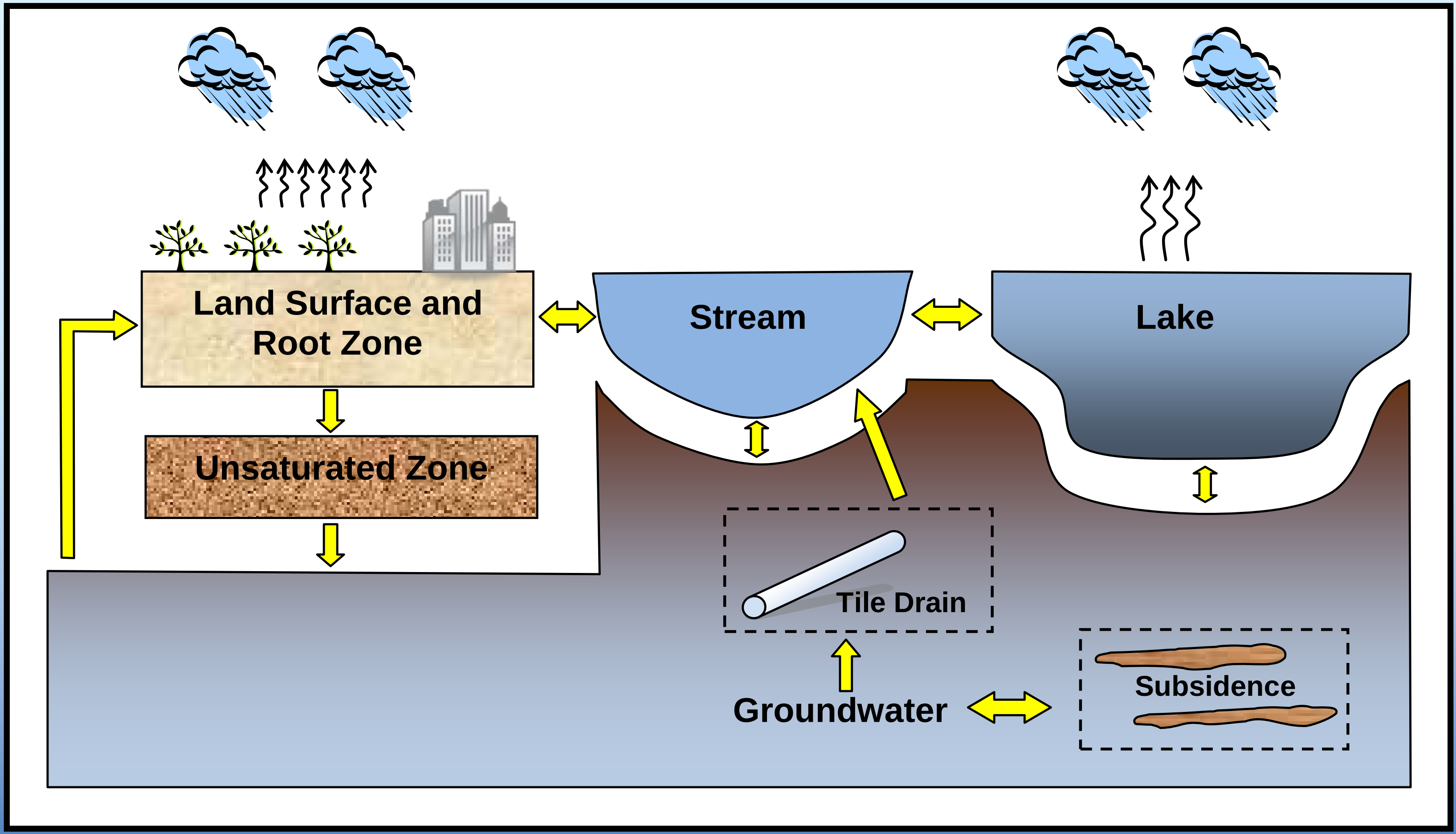


Brush et al. 2005.

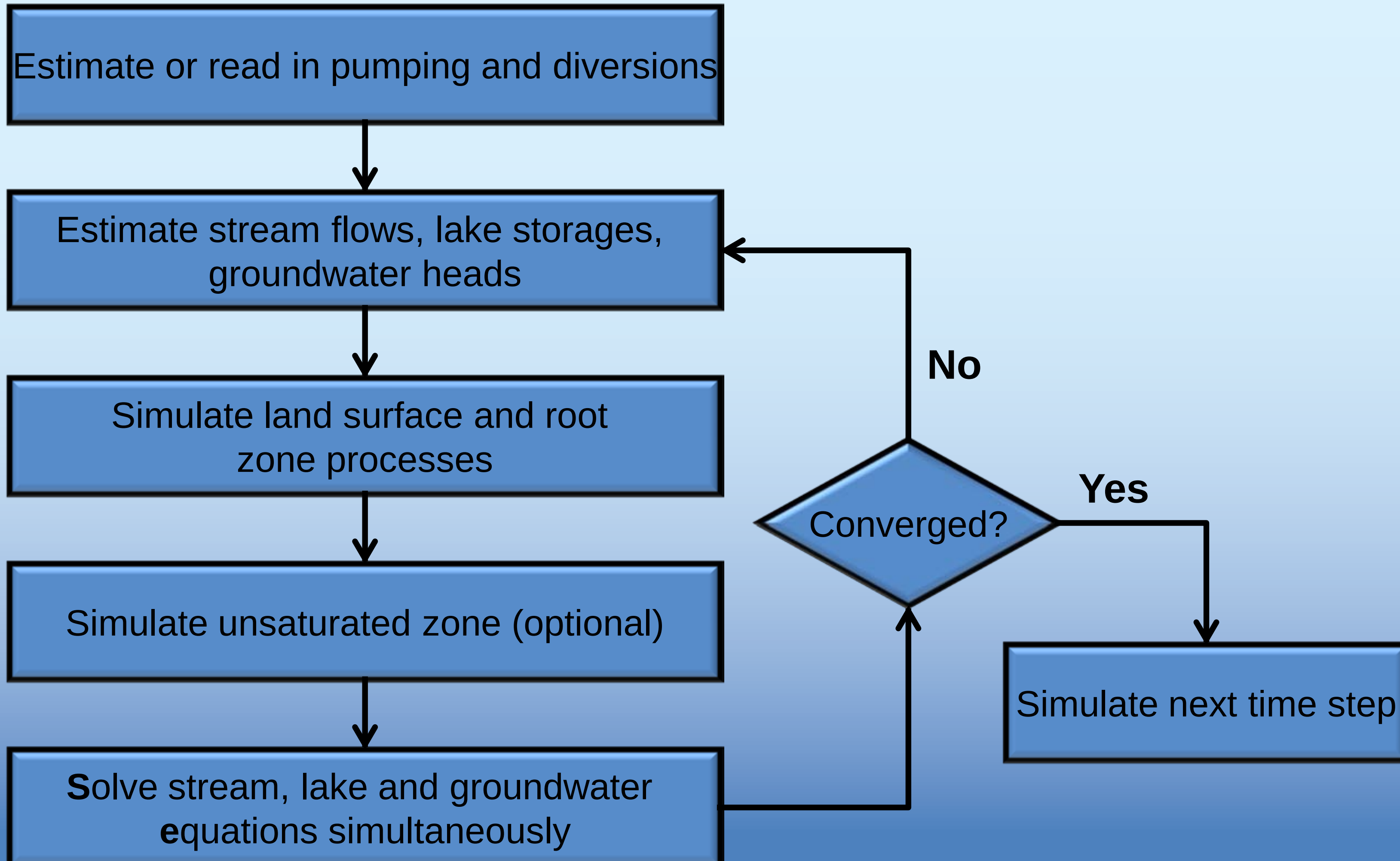
C2VSim ETc File

C ITEV	IREGN	AEVAP(1) PA	AEVAP(2) AL	AEVAP(3) ... SB	FI	RI	TR	TO	TH	TM	OR	GR	VI	CO	SO	UR	N
10/31/4000_24:00	1	3.42	3.52	2.01	1.61	2.21	1.61	1.41	1.41	1.01	2.81	1.61	1.61	2.31	2.11	3.42	3.4
	2	3.42	3.52	2.01	1.11	2.21	1.01	1.41	1.41	1.01	2.61	1.01	1.41	2.31	2.11	3.42	3.4
	3	3.40	3.50	2.00	1.10	2.20	1.00	1.40	1.40	1.00	2.50	1.00	1.60	2.30	2.10	3.40	3.4
	4	3.40	3.50	2.00	1.10	2.20	1.00	1.40	1.40	1.00	2.40	1.00	1.60	2.30	2.10	3.40	3.4
	5	3.41	3.51	2.01	1.10	2.21	1.10	1.40	1.40	1.10	2.71	1.10	1.80	2.31	2.11	3.41	3.4
	6	3.40	3.50	2.60	1.10	2.20	1.00	1.40	1.40	1.00	2.60	1.00	2.00	2.30	2.10	3.40	3.4
	7	3.75	3.86	2.43	1.32	2.43	1.32	1.54	1.54	1.32	2.98	1.32	1.54	2.54	2.32	3.75	3.7
	8	2.94	3.04	2.58	0.92	2.02	0.92	0.92	1.29	0.92	2.39	0.92	1.20	2.12	1.93	2.94	2.9
	9	2.75	2.75	2.14	1.12	1.94	1.53	1.02	1.43	1.02	2.44	1.02	1.12	2.34	2.14	2.85	2.8
	10	3.36	3.46	1.83	1.02	2.24	1.22	1.02	1.43	1.02	2.34	1.02	1.32	2.34	2.04	3.06	3.3
	11	3.31	3.41	1.81	1.00	2.21	1.20	1.00	1.40	1.00	2.31	1.00	1.30	2.31	2.01	3.01	3.3
	12	3.31	3.41	1.81	1.00	2.21	1.20	1.00	1.40	1.00	2.31	1.00	1.30	2.31	2.01	3.01	3.3
	13	3.15	3.23	1.72	0.95	2.10	1.15	0.95	1.33	0.95	2.20	0.95	1.23	2.20	1.90	2.86	3.1
	14	3.14	3.23	1.71	0.95	2.09	1.14	0.95	1.81	0.95	2.00	0.95	1.24	2.28	1.90	2.85	3.1
	15	3.48	3.58	1.89	1.05	2.31	1.26	1.05	2.00	1.05	2.21	1.05	1.37	2.53	2.10	3.16	3.4
	16	2.93	3.02	1.60	0.89	1.95	1.07	0.89	1.69	0.89	1.87	0.89	1.16	2.13	1.78	2.67	2.9
	17	3.19	3.29	1.74	0.97	2.13	1.17	0.97	1.84	0.97	2.04	0.97	1.26	2.32	1.94	2.91	3.1
	18	2.93	3.02	1.60	0.89	1.95	1.06	0.89	1.69	0.89	1.86	0.89	1.15	2.13	1.77	2.66	2.9
	19	3.94	4.06	2.15	1.20	2.62	1.44	1.20	2.26	1.20	2.50	1.20	1.56	2.86	2.38	3.58	3.9
	20	4.08	4.20	2.22	1.24	2.72	1.49	1.24	2.34	1.24	2.59	1.24	1.61	2.97	2.47	3.70	4.0
	21	4.64	4.79	2.54	1.42	3.10	1.69	1.42	2.67	1.42	2.95	1.42	1.82	3.38	2.81	4.23	4.6
	1	3.4	3.7														
	2	3.4	3.7														
	3	3.4	3.7														
	4	3.4	3.7														
	5	3.4	3.7														
	6	3.4	3.7														
	7	3.4	3.7														
	8	3.4	3.7														
	9	3.4	3.7														
	10	3.4	3.7														
	11	3.4	3.7														
	12	3.4	3.7														
	13	3.4	3.7														
	14	3.4	3.7														

IWFM Component Interactions



Simulation Scheme



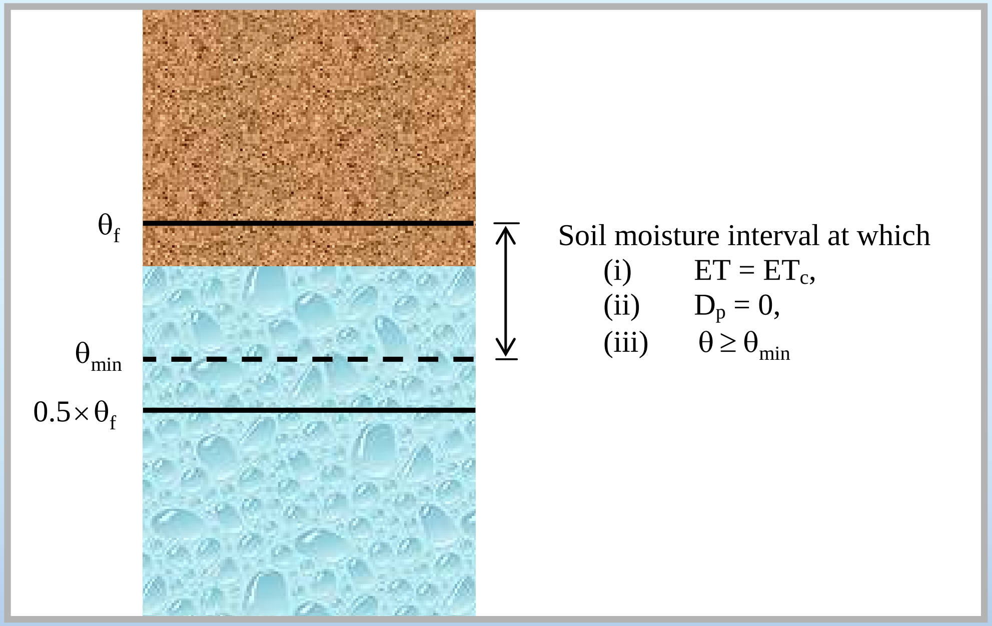
A Need for Demand Computation

$$\theta_r^{t+1} = \theta_r^t + \left[\left(P - S_r \right) + \left(A_W - R_f \right) - ET_{cadj} - D_p \right] \Delta t$$

- Routing of water through a developed basin requires the knowledge of applied water
- In California, groundwater pumping is generally neither measured nor regulated; i.e. total historical applied water is unknown
- Most major surface diversions are measured in California's Central Valley but their spatial allocation may be unknown
- For planning studies applied water is an unknown and has to be computed dynamically
- To address the uncertainties in historical and future water supplies and where these supplies were/will be used, a demand-supply balance is needed

Agricultural Demand Computation

- Agricultural demand is the required amount of applied water in order to maintain optimum agricultural conditions



- At optimum agricultural conditions
  1) ET rates are at their potential levels for proper crop growth
  2) soil moisture loss as deep percolation and return flow is minimized
  3) minimum soil moisture requirement for each crop is met at all times

Agricultural Demand Computation

- Use governing conservation equation to express the applied water that will satisfy the optimum agricultural conditions:

$$\theta_{min} = \theta_r^t + \left[\left(P - S_r \right) + CU_{AW} - ET_c \right] \Delta t$$

$$\Rightarrow \quad CU_{AW} = \frac{\theta_{min} - \theta_r^t}{\Delta t} - \left(P - S_r \right) + ET_c \quad \geq \quad 0$$

$$D_{ag} = \frac{CU_{AW}}{I_E}$$

where

CU_{AW} = potential consumptive use of applied water assuming 100% irrigation efficiency, (L/T)

I_E = irrigation efficiency, (dimensionless)

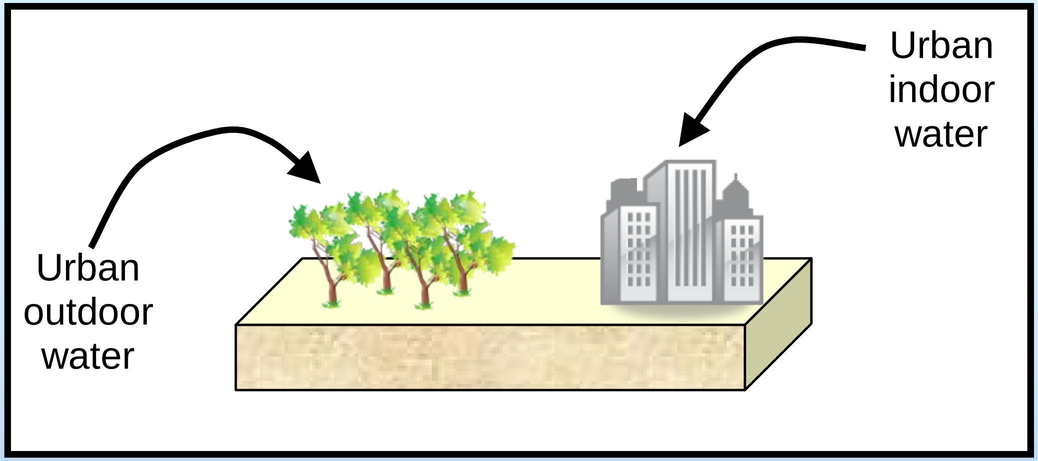
D_{ag} = agricultural water demand, (L/T)

C2VSim Crop Demands File

```
C
C                       SMMIN(1)  SMMIN(2)  SMMIN(3) ...
C  TIME           IR    CREFF(1)  CREFF(2)  CREFF(3) ...
C-----------------------------------------------------------------------------------------------------------------
C                         PA        AL        SB        FI        RI        TR        TO        TH        TM        OR        GR        VI        CO
10/31/4000_24:00  1      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.69      0.73      0.73      0.00      0.00      0.00      0.00      0.00      0.00      0.75      0.00      0.76      0.0
                  2      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.70      0.72      0.73      0.00      0.00      0.00      0.00      0.00      0.00      0.78      0.00      0.76      0.0
                  3      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.69      0.71      0.71      0.00      0.00      0.00      0.00      0.00      0.00      0.80      0.00      0.76      0.0
                  4      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.70      0.69      0.70      0.00      0.00      0.00      0.00      0.00      0.00      0.75      0.00      0.76      0.0
                  5      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.66      0.69      0.68      0.00      0.00      0.00      0.00      0.00      0.00      0.72      0.00      0.76      0.0
                  6      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.64      0.68      0.68      0.00      0.00      0.00      0.00      0.00      0.00      0.70      0.00      0.68      0.0
                  7      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.64      0.68      0.68      0.00      0.00      0.00      0.00      0.00      0.00      0.70      0.00      0.68      0.0
                  8      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.65      0.68      0.68      0.00      0.00      0.00      0.00      0.00      0.00      0.70      0.00      0.70      0.0
                  9      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.64      0.68      0.68      0.00      0.00      0.00      0.00      0.00      0.00      0.70      0.00      0.69      0.0
                 10      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.67      0.64      0.75      0.00      0.00      0.00      0.00      0.00      0.00      0.76      0.00      0.75      0.0
                 11      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.67      0.68      0.74      0.00      0.00      0.00      0.00      0.00      0.00      0.72      0.00      0.71      0.0
                 12      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.68      0.65      0.74      0.00      0.00      0.00      0.00      0.00      0.00      0.78      0.00      0.77      0.0
                 13      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.69      0.68      0.76      0.00      0.00      0.00      0.00      0.00      0.00      0.76      0.00      0.71      0.0
                 14      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.85      0.87      0.75      0.00      0.00      0.00      0.00      0.00      0.00      0.75      0.00      0.85      0.0
                 15      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.72      0.68      0.72      0.00      0.00      0.00      0.00      0.00      0.00      0.75      0.00      0.74      0.0
                 16      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
                         0.67      0.63      0.72      0.00      0.00      0.00      0.00      0.00      0.00      0.79      0.00      0.72      0.0
                 17      0.50      0.44      0.40      0.17      0.08      0.22      0.13      0.13      0.13      0.44      0.17      0.40      0.1
```

Urban Demand & Moisture Routing

- Urban water demands are user-specified time-series input data
- Outdoor urban applied water and precipitation are routed through the root zone using the governing conservation equation



- Urban indoor applied water and precipitation over non-pervious urban areas become entirely return flow and surface runoff

Urban Water Use Parameters

```
C*******************************************************************************
C                        WATER USE PARAMETERS
C
C   The following lists the water use parameters for each subregion and the
C   crop root zone depth for each crop type including urban (lawn) and
C   native vegetation (skip if soil moisture is not routed,
C   i.e. if there are no rain gages)
C
C   IR      :  Subregion number
C   PERV    :  Fraction of pervious area to total urban areas
C   ICRUFAG :  Fraction of the surface runoff from agricultural applied water
C               that is re-used - this number corresponds to the appropriate data
C               column in irrigation water re-use factor data file (Unit 29)
C   ICRUFURB:  Fraction of the surface runoff and return flow from urban areas
C               that is re-used - this number corresponds to the appropriate data
C               column in irrigation water re-use factor data file (Unit 29)
C   IURIND  :  Urban return flow specification
C                 -2;   Urban return flow goes out of model boundary
C                 -1;   Urban return flow goes into groundwater recharge
C                  0;   Urban return flow enters streams
C                 nd;   Urban return flow enters streams at stream node, nd
C
C-------------------------------------------------------------------------------
C   IR    PERV    ICRUFAG   ICRUFURB    IURIND
C-------------------------------------------------------------------------------
     1    .62         1         22          0
     2    .62         2         22          0
     3    .62         3         22          0
     4    .62         4         22          0
     5    .62         5         22          0
     6    .62         6         22          0
     7    .62         7         22          0
     8    .62         8         22          0
     9    .62         9         22          0
    10    .62        10         22         -1
    11    .62        11         22         -1
    12    .62        12         22         -1
    13    .62        13         22         -1
    14    .62        14         22         -1
    15    .62        15         22         -1
    16    .62        16         22         -1
    17    .62        17         22         -1
    18    .62        18         22         -1
    19    .62        19         22         -1
    20    .62        20         22         -1
    21    .62        21         22         -1
C-------------------------------------------------------------------------------
```

C2VSim Urban Specifications File

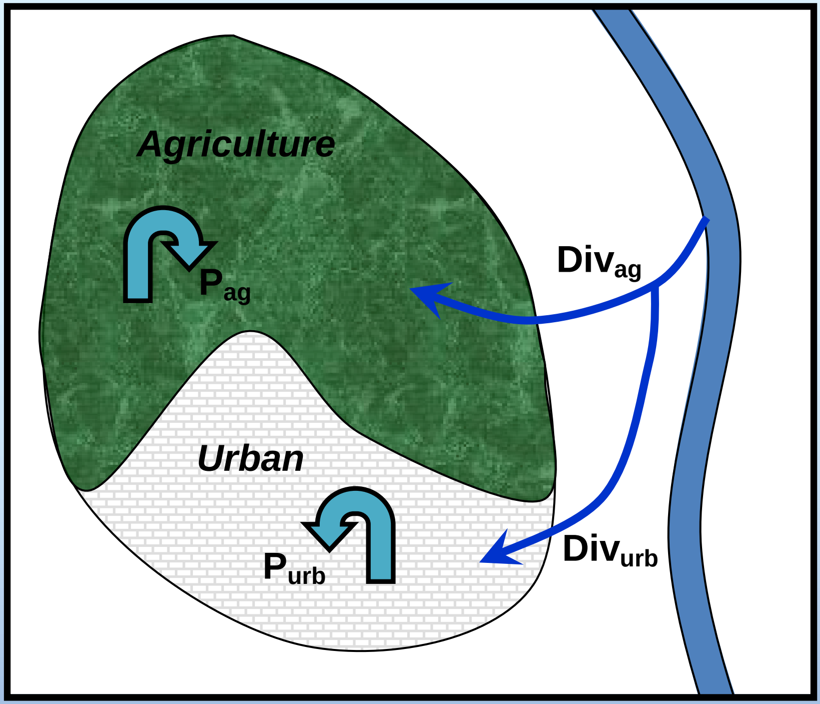
```
C   ITUSP ;  Time
C   IR    ;  Subregion number
C   URINDR;  Fraction of total urban water that is used indoors
C
C--------------------------------------------------------------------
C   ITUSP              IR    URINDR
C--------------------------------------------------------------------
10/31/4000_24:00        1     0.5
                        2     0.5
                        3     0.5
                        4     0.5
                        5     0.5
                        6     0.5
                        7     0.5
                        8     0.5
                        9     0.5
                       10     0.5
                       11     0.5
                       12     0.5
                       13     0.5
                       14     0.5
                       15     0.5
                       16     0.5
                       17     0.5
                       18     0.5
                       19     0.5
                       20     0.5
                       21     0.5
11/30/4000_24:00        1     0.7
                        2     0.7
                        3     0.7
                        4     0.7
                        5     0.7
                        6     0.7
```

C2VSim Urban Demands File

```
C-----------------------------------------------------------------------------
C ITDU     RDMUR(1)  RDMUR(2)  RDMUR(3) ...
C                 1    2    3    4    5    6    7    8    9    10   11   12   13   14   15   16   17   18   19   20   21
C-----------------------------------------------------------------------------
10/31/1921_24:00  0.2  0.4  0.2  0.1  0.7  0.4  1.0  2.1  1.4  0.2  0.7  0.3  0.6  0.3  0.5  1.6  0.5  1.1  0.2  0.3  1.1
11/30/1921_24:00  0.2  0.3  0.1  0.1  0.5  0.3  0.4  1.6  0.7  0.1  0.4  0.2  0.4  0.1  0.3  1.2  0.3  0.8  0.1  0.2  0.7
12/31/1921_24:00  0.2  0.3  0.2  0.1  0.5  0.3  0.4  1.6  0.7  0.1  0.5  0.2  0.4  0.2  0.3  1.0  0.3  0.7  0.1  0.2  0.7
01/31/1922_24:00  0.2  0.3  0.2  0.1  0.5  0.3  0.4  1.6  0.7  0.1  0.5  0.2  0.4  0.2  0.3  1.0  0.3  0.7  0.1  0.2  0.7
02/28/1922_24:00  0.1  0.3  0.1  0.1  0.5  0.3  0.4  1.5  0.7  0.1  0.4  0.2  0.4  0.1  0.3  0.9  0.3  0.6  0.1  0.2  0.6
03/31/1922_24:00  0.2  0.4  0.2  0.1  0.5  0.3  0.4  1.7  1.0  0.1  0.5  0.2  0.4  0.2  0.3  1.1  0.3  0.8  0.1  0.2  0.8
04/30/1922_24:00  0.3  0.6  0.2  0.1  1.1  0.4  1.3  2.5  1.9  0.2  0.7  0.4  0.7  0.3  0.6  2.3  0.7  1.5  0.3  0.5  1.4
05/31/1922_24:00  0.3  0.6  0.3  0.1  1.1  0.4  1.6  2.6  2.0  0.2  0.9  0.4  0.8  0.4  0.7  2.5  0.7  1.6  0.3  0.5  1.6
06/30/1922_24:00  0.3  0.7  0.2  0.1  1.3  0.4  2.0  3.0  2.4  0.3  0.9  0.4  0.9  0.3  0.7  2.6  0.8  1.8  0.3  0.6  1.6
07/31/1922_24:00  0.4  0.8  0.4  0.1  1.3  0.5  2.2  3.1  2.7  0.3  1.0  0.4  0.9  0.5  0.8  2.7  0.8  1.8  0.3  0.6  1.8
08/31/1922_24:00  0.3  0.7  0.3  0.1  1.2  0.4  2.0  2.9  2.6  0.2  1.0  0.4  0.8  0.4  0.7  2.6  0.8  1.7  0.3  0.6  1.7
09/30/1922_24:00  0.3  0.6  0.2  0.1  1.1  0.4  1.7  2.6  2.0  0.2  0.7  0.4  0.7  0.3  0.6  2.2  0.6  1.5  0.2  0.5  1.3
10/31/1922_24:00  0.2  0.3  0.2  0.1  0.6  0.3  0.7  1.7  1.4  0.3  0.7  0.3  0.7  0.3  0.5  1.7  0.5  1.1  0.2  0.4  1.1
11/30/1922_24:00  0.2  0.3  0.1  0.1  0.5  0.3  0.4  1.6  0.7  0.1  0.5  0.2  0.4  0.2  0.3  1.2  0.3  0.8  0.1  0.2  0.8
12/31/1922_24:00  0.2  0.3  0.2  0.1  0.5  0.3  0.4  1.7  0.8  0.2  0.5  0.2  0.5  0.2  0.3  1.1  0.3  0.7  0.1  0.3  0.7
01/31/1923_24:00  0.2  0.3  0.2  0.1  0.5  0.3  0.4  1.7  0.8  0.2  0.5  0.2  0.5  0.2  0.3  1.1  0.3  0.7  0.1  0.3  0.7
02/28/1923_24:00  0.1  0.3  0.1  0.1  0.5  0.3  0.4  1.5  0.7  0.1  0.4  0.2  0.4  0.1  0.3  1.0  0.3  0.6  0.1  0.2  0.6
03/31/1923_24:00  0.2  0.5  0.3  0.2  0.8  0.4  1.0  1.8  1.7  0.3  0.8  0.3  0.7  0.3  0.6  2.0  0.6  1.3  0.2  0.5  1.3
04/30/1923_24:00  0.2  0.5  0.2  0.1  0.7  0.4  0.6  1.6  1.2  0.2  0.7  0.3  0.6  0.3  0.5  1.8  0.5  1.2  0.2  0.4  1.2
05/31/1923_24:00  0.3  0.7  0.3  0.1  1.1  0.4  1.8  1.8  2.2  0.4  1.0  0.4  1.0  0.4  0.7  2.7  0.8  1.7  0.3  0.7  1.7
06/30/1923_24:00  0.3  0.6  0.2  0.1  1.2  0.4  2.0  1.7  2.4  0.3  1.0  0.4  0.9  0.4  0.8  2.8  0.8  1.8  0.3  0.6  1.8
07/31/1923_24:00  0.4  0.8  0.4  0.1  1.3  0.5  2.2  1.9  2.9  0.4  1.1  0.5  1.0  0.5  0.8  2.9  0.8  1.9  0.3  0.7  1.8
08/31/1923_24:00  0.3  0.7  0.3  0.1  1.2  0.4  2.0  1.8  2.7  0.4  1.0  0.4  1.0  0.4  0.7  2.7  0.8  1.7  0.3  0.7  1.7
09/30/1923_24:00  0.2  0.5  0.2  0.1  0.9  0.4  1.4  1.7  1.8  0.2  0.8  0.3  0.7  0.4  0.6  2.2  0.6  1.4  0.2  0.5  1.4
10/31/1923_24:00  0.2  0.4  0.3  0.1  0.8  0.4  0.9  1.7  1.6  0.3  0.7  0.3  0.7  0.3  0.5  1.7  0.5  1.1  0.2  0.4  1.1
11/30/1923_24:00  0.2  0.3  0.1  0.1  0.5  0.3  0.5  1.7  0.8  0.2  0.6  0.2  0.6  0.2  0.4  1.3  0.4  0.9  0.1  0.3  0.9
12/31/1923_24:00  0.2  0.3  0.2  0.1  0.5  0.3  0.4  1.7  0.8  0.2  0.5  0.2  0.5  0.2  0.3  1.1  0.3  0.7  0.1  0.3  0.7
01/31/1924_24:00  0.2  0.3  0.2  0.1  0.5  0.3  0.4  1.7  0.8  0.2  0.5  0.2  0.5  0.2  0.3  1.1  0.3  0.7  0.1  0.3  0.7
02/29/1924_24:00  0.1  0.3  0.1  0.1  0.5  0.3  0.4  1.6  0.7  0.1  0.4  0.2  0.4  0.1  0.3  1.0  0.3  0.6  0.1  0.2  0.6
03/31/1924_24:00  0.2  0.3  0.2  0.1  0.5  0.3  0.6  1.7  1.4  0.3  0.7  0.3  0.7  0.3  0.4  1.7  0.5  1.1  0.2  0.4  1.1
04/30/1924_24:00  0.3  0.6  0.2  0.1  1.2  0.4  1.7  1.8  2.1  0.3  0.9  0.4  0.9  0.4  0.6  2.4  0.7  1.5  0.3  0.5  1.5
05/31/1924_24:00  0.3  0.7  0.3  0.1  1.3  0.4  1.9  1.8  2.2  0.4  1.0  0.4  1.0  0.4  0.7  2.7  0.8  1.8  0.3  0.7  1.7
```

Automated Supply Adjustment

- Automatic adjustment of diversions and pumping to meet agricultural and urban water demands
- Diversion or pumping adjustment can be turned on or off during simulation period (represents evolution of water supply facilities over time)
- All supplies have equal priorities; handling of complex water rights is deferred to systems models like CalSim



- Useful in estimating historical pumping in Central Valley, and future diversions and pumping
- No supply adjustment for native and riparian vegetation

Balance between Supply and Demand

- IWFM can route water supplies (diversions and pumping) as specified or automatically adjust supplies to meet demands (increase/decrease in diversions and/or pumping)
- When supplies are adjusted, they may still be less than demand if there is not enough water in the system
- When supply is less than demand deep percolation, return flows, moisture content and ET diminish; when larger than demand deep percolation, return flow and moisture content increase

IWFM Output

- Land and Water Use Budget
  - Agricultural supply and demand
  - Urban supply and demand
  - Surface water imports and exports
- Root Zone Moisture Budget
  - Agricultural, Urban, Native/Riparian sections
  - Land surface water balance for each
  - Root zone moisture balance for each

Land and Water Use Budget

- Balance Water Supply and Demand
- Agricultural and Urban Sections
- Calculated for each Subregion
- Agricultural Supply Requirement = Potential CUAW/Irrigation Efficiency
- Urban Supply Requirement is input time series
- Supply Requirement = Pumping + Diversions + Shortage

Land and Water Use Budget

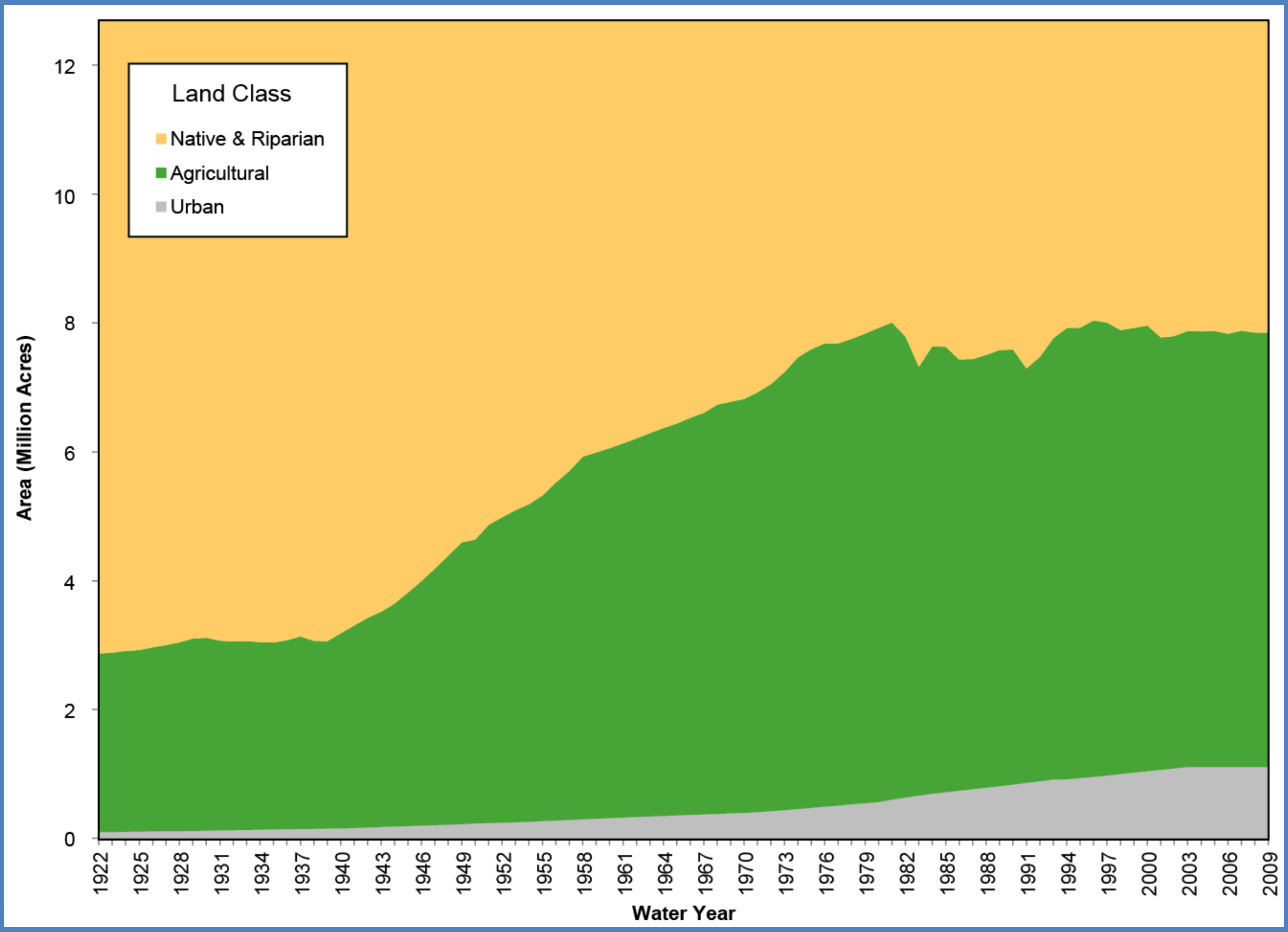
IWFM (v3.02.0064)
LAND AND WATER USE BUDGET IN AC.FT. FOR SUBREGION 1 (DSA 58)
AREA: 328277.68 AC

	Agricultural Area							Urb		
Time	Area (AC)	Potential CUAW	Agricultural Supply Requirement	Pumping (-)	Diversion (-)	Shortage (=)	Re-use	Area (AC)	Urban Supply Requirement	Pumpi (-)
10/31/1921_24:00	14659.1	4268.4	6147.5	0.0	7622.6	-1475.1	0.0	956.0	200.0	152.
11/30/1921_24:00	14659.1	0.0	0.0	0.0	590.5	-590.5	0.0	956.0	200.0	157.
12/31/1921_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	151.
01/31/1922_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	156.
02/28/1922_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	100.0	61.
03/31/1922_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	155.
04/30/1922_24:00	14659.1	5583.9	8047.8	691.0	7356.9	0.0	0.0	956.0	300.0	243.
05/31/1922_24:00	14659.1	5393.8	7771.4	0.0	14457.6	-6686.2	0.0	956.0	300.0	205.
06/30/1922_24:00	14659.1	6335.9	9127.2	0.0	18571.6	-9444.4	0.0	956.0	300.0	211.
07/31/1922_24:00	14659.1	7867.6	11330.6	0.0	22662.8	-11332.2	0.0	956.0	400.0	257.
08/31/1922_24:00	14659.1	7860.5	11315.3	0.0	22512.3	-11197.0	0.0	956.0	300.0	148.
09/30/1922_24:00	14659.1	6062.5	8727.2	0.0	15636.8	-6909.7	0.0	956.0	300.0	300.
10/31/1922_24:00	14659.1	0.0	0.0	0.0	7282.9	-7282.9	0.0	956.0	200.0	152.
11/30/1922_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	157.
12/31/1922_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	151.
01/31/1923_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	155.
02/28/1923_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	100.0	61.
03/31/1923_24:00	14659.1	390.4	562.3	180.4	381.9	0.0	0.0	956.0	200.0	154.
04/30/1923_24:00	14659.1	4187.8	6035.6	0.0	6145.1	-109.5	0.0	956.0	200.0	143.
05/31/1923_24:00	14659.1	6426.7	9259.5	0.0	14960.1	-5700.6	0.0	956.0	300.0	205.
06/30/1923_24:00	14659.1	5501.4	7925.1	0.0	18196.8	-10271.7	0.0	956.0	300.0	210.
07/31/1923_24:00	14659.1	7867.5	11330.5	0.0	22659.3	-11328.8	0.0	956.0	400.0	257.
08/31/1923_24:00	14659.1	7684.7	11062.2	0.0	22485.0	-11422.9	0.0	956.0	300.0	147.
09/30/1923_24:00	14659.1	3012.2	4336.2	0.0	14665.3	-10329.1	0.0	956.0	200.0	200.
10/31/1923_24:00	14659.1	526.6	758.5	205.0	553.5	0.0	0.0	956.0	200.0	152.
11/30/1923_24:00	14659.1	857.5	1242.8	779.9	462.9	0.0	0.0	956.0	200.0	157.
12/31/1923_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	151.
01/31/1924_24:00	14659.1	0.0	0.0	0.0	0.0	0.0	0.0	956.0	200.0	155.

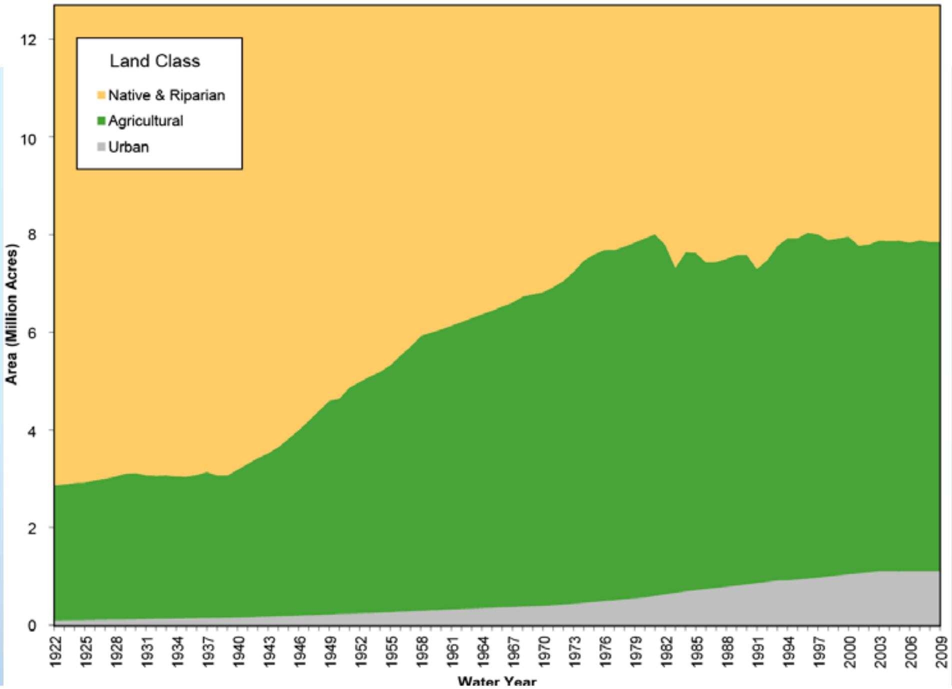
Land and Water Use Budget

	Column	Flow	08/31/2004	Source
Agricultural	Area (AC)		6,604,404	
	Potential CUAW		2,586,635	
	Supply Requirement	OUT	3,294,699	
	Pumping	IN	1,601,200	GW
	Diversion	IN	1,693,677	SW
	Shortage	(IN)	-177	
	Re-use		67,228	
Urban	Area (AC)		1,147,412	
	Supply Requirement	OUT	249,902	
	Pumping	IN	162,716	GW
	Diversion	IN	91,371	SW
	Shortage	(IN)	-4,185	
	Re-use		0	
	Import		949,507	
	Export		369,919	

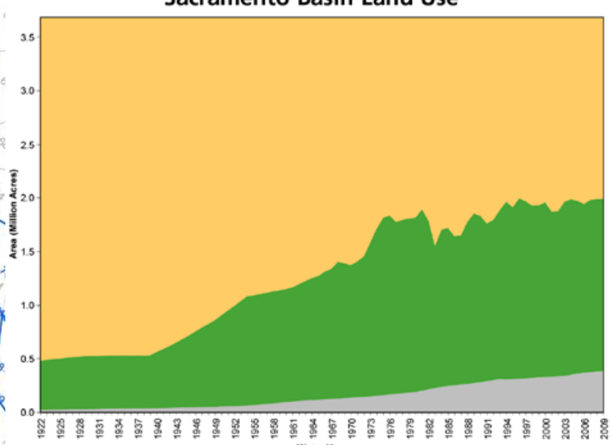
Land Use Change



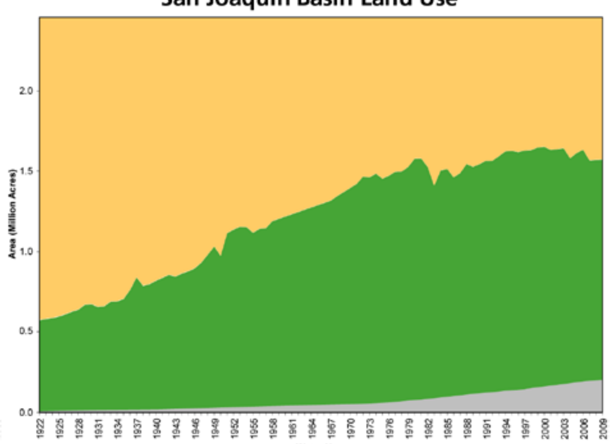
Land Use Change



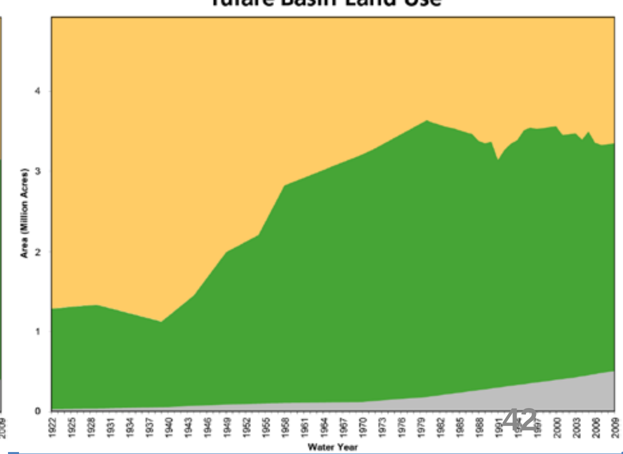
Sacramento Basin Land Use



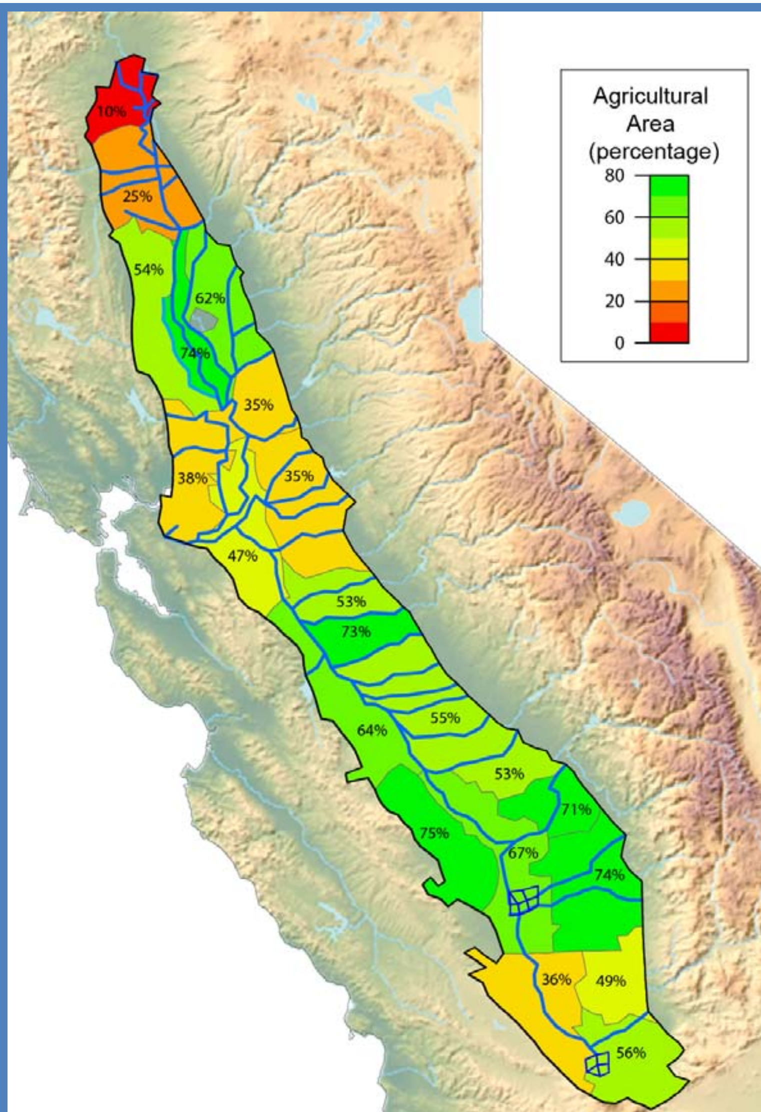
San Joaquin Basin Land Use

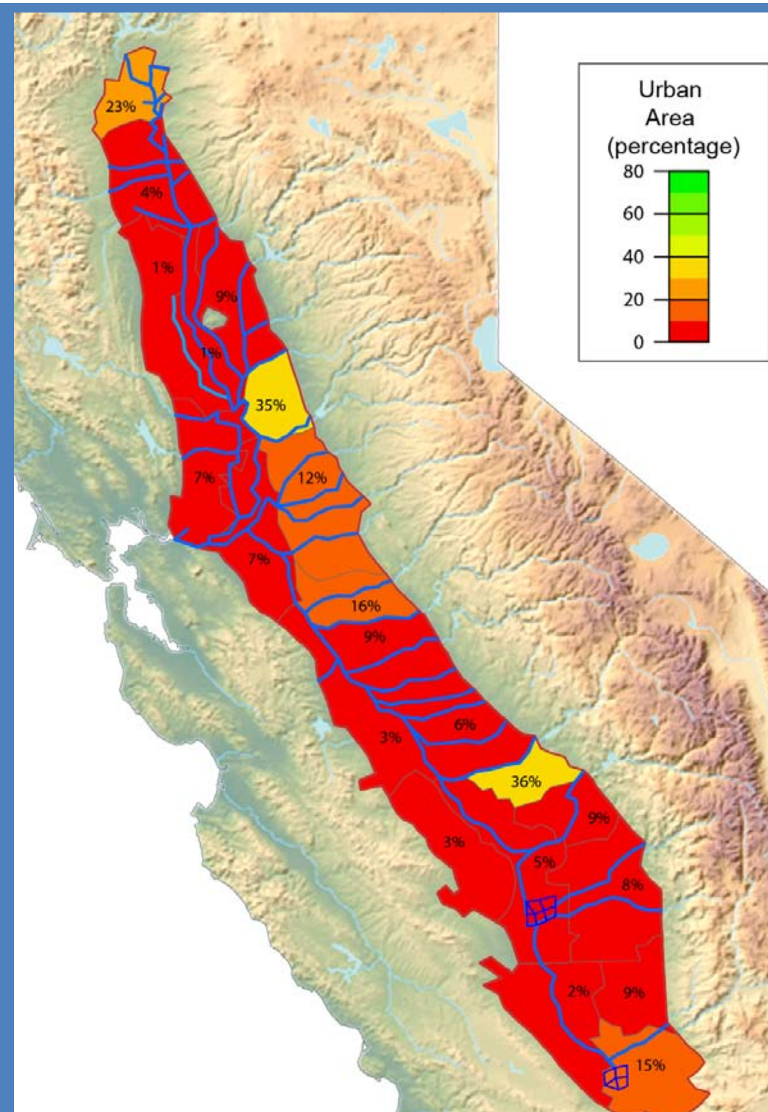


Tulare Basin Land Use

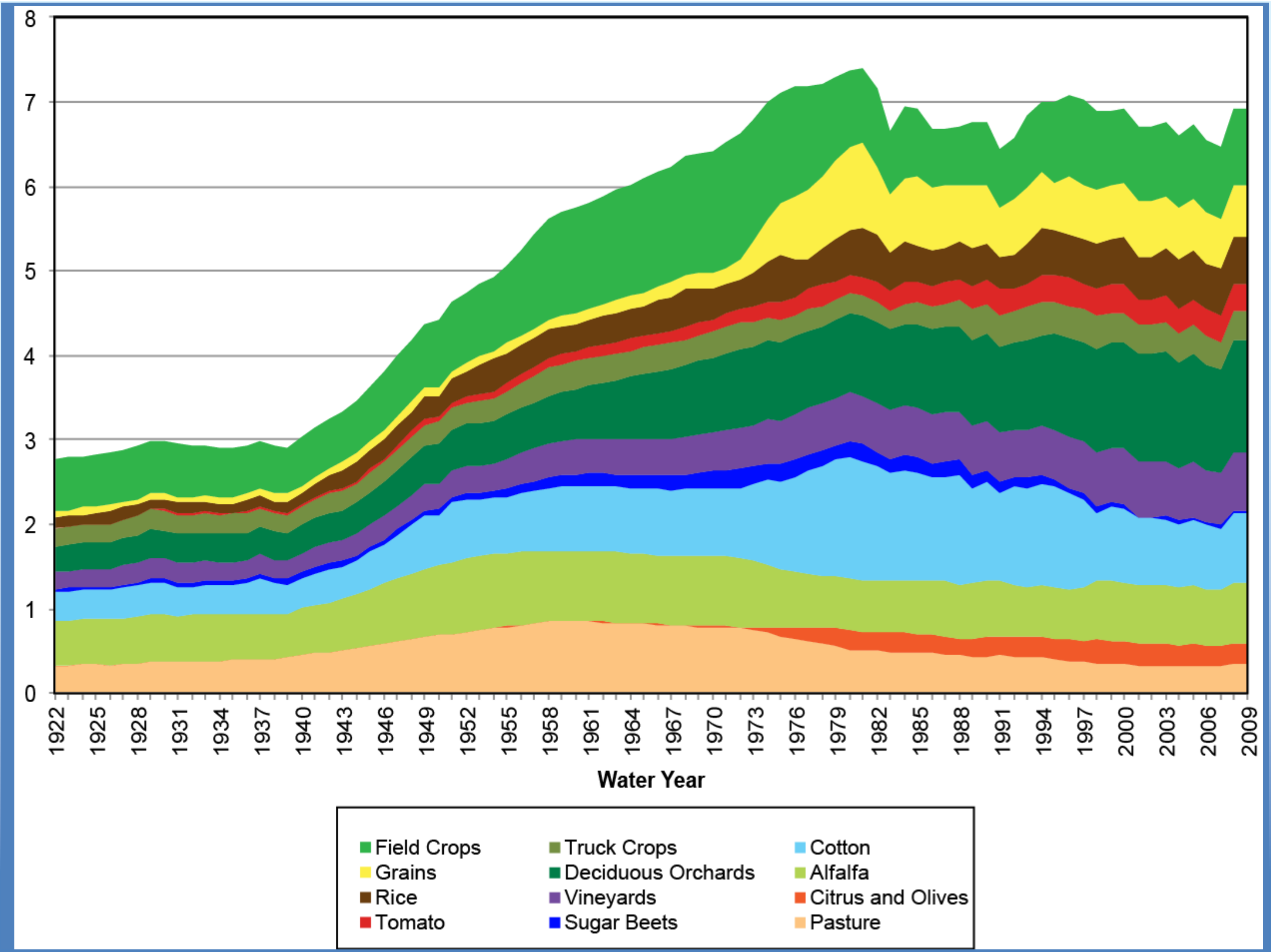


Subregion Land Use

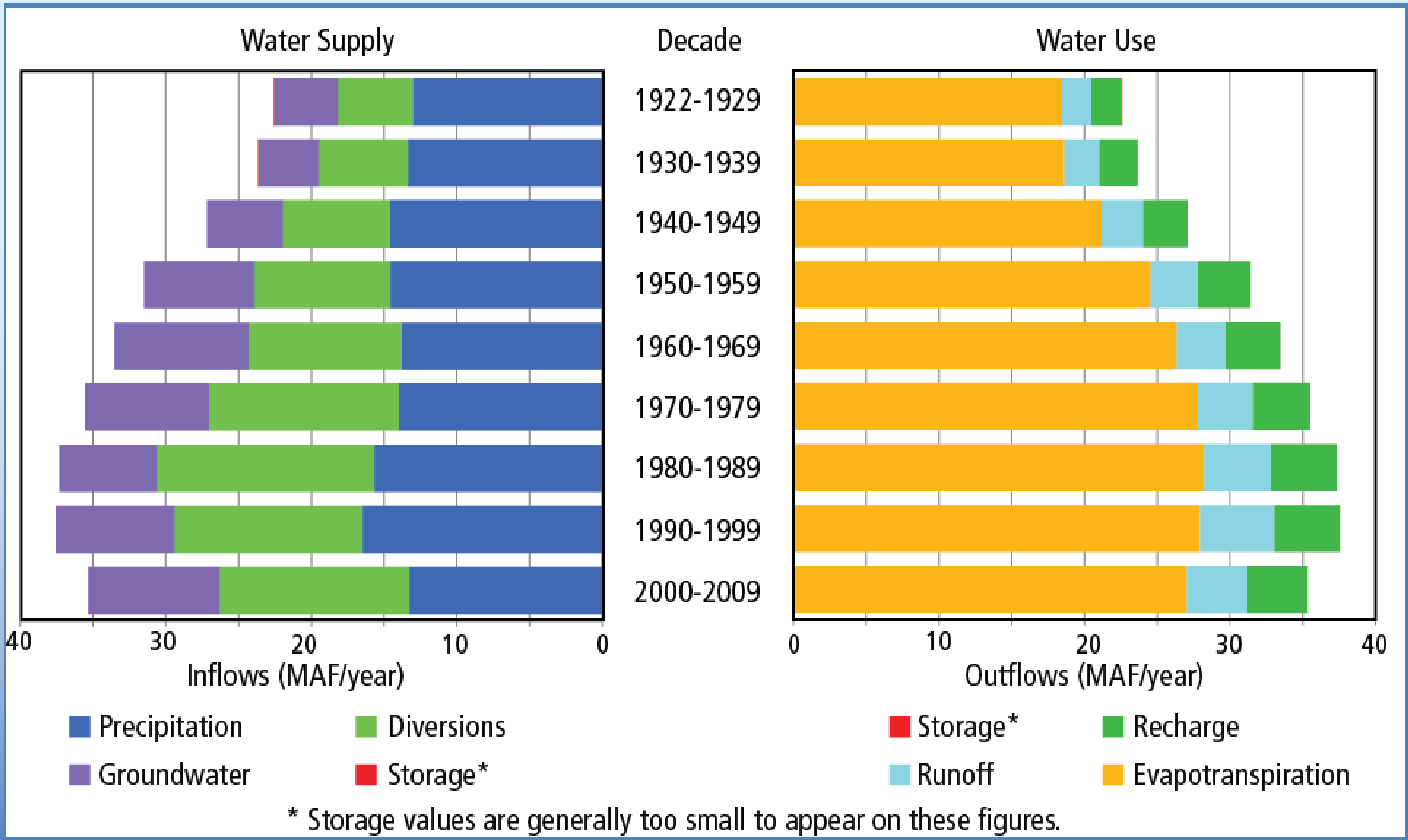




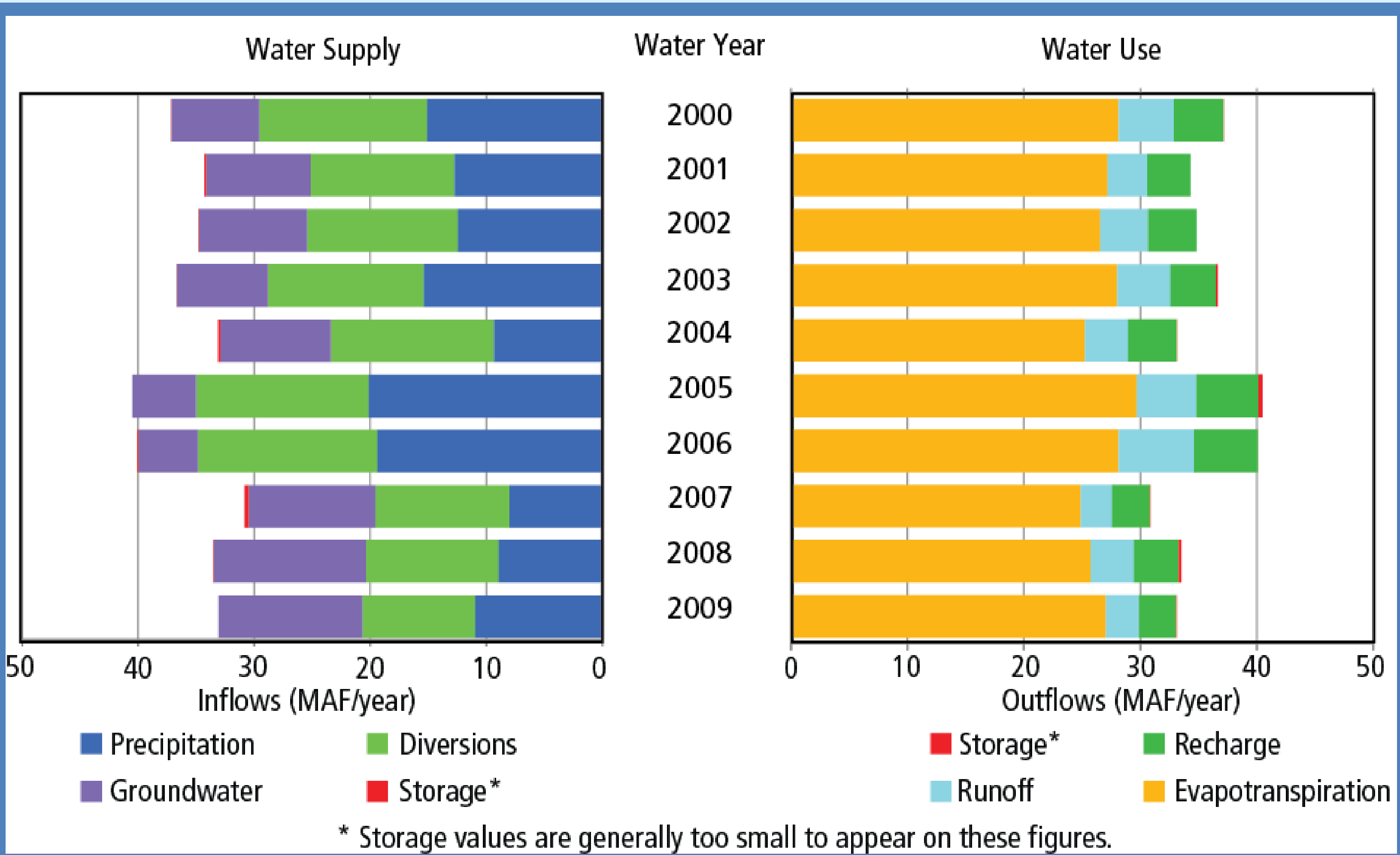
Crop Acreage



Sources and Sinks

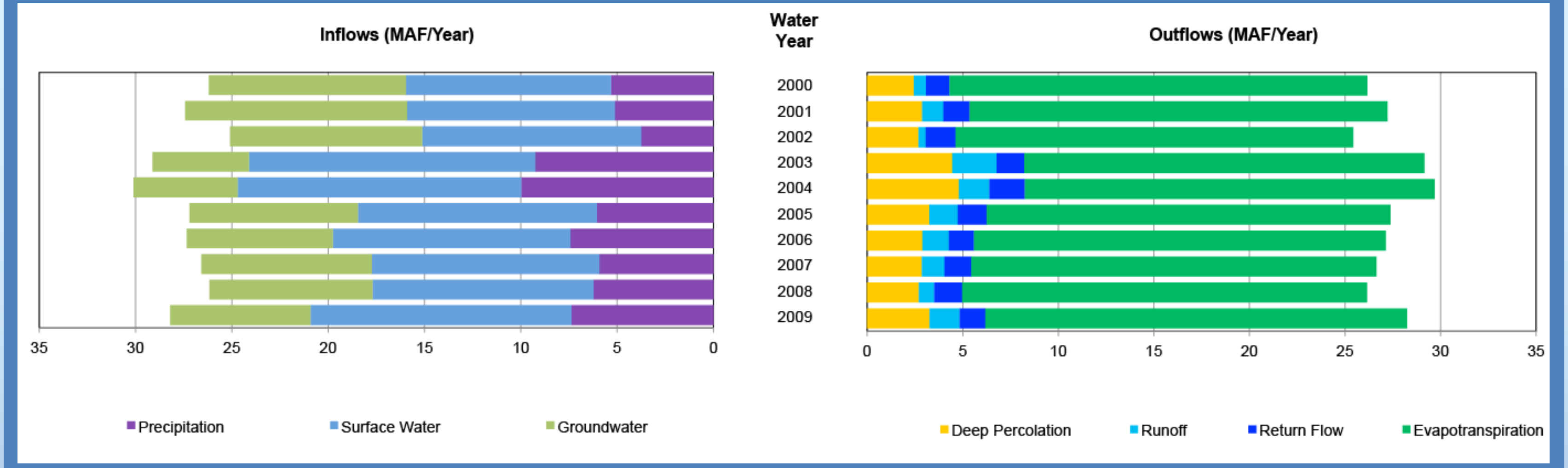


Sources and Sinks



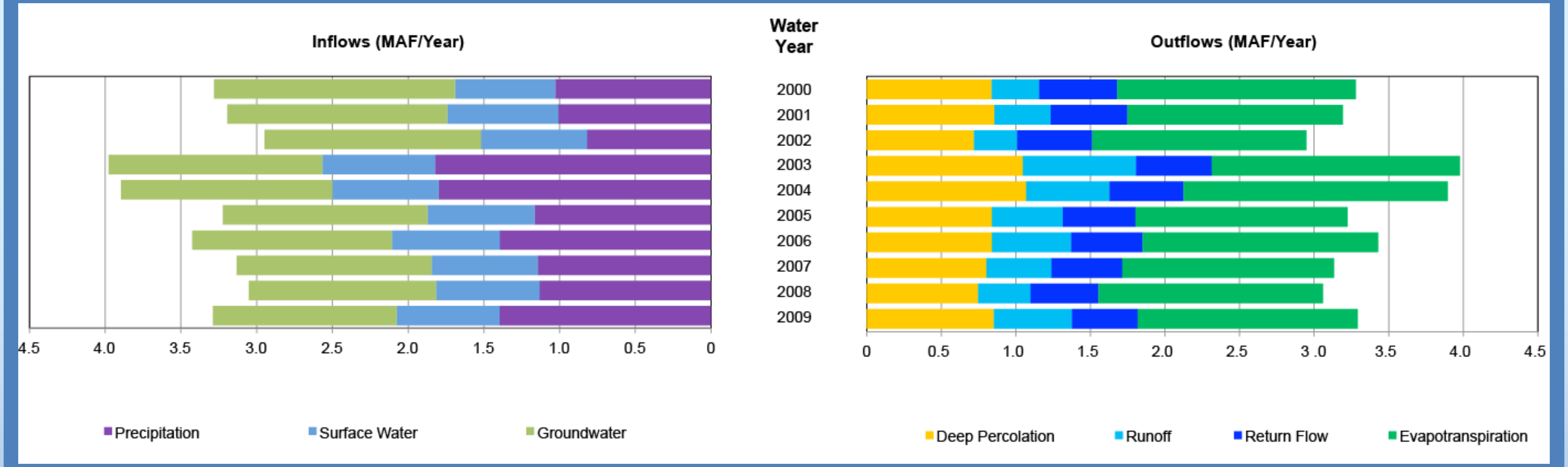
Agricultural Budget

2000-2009



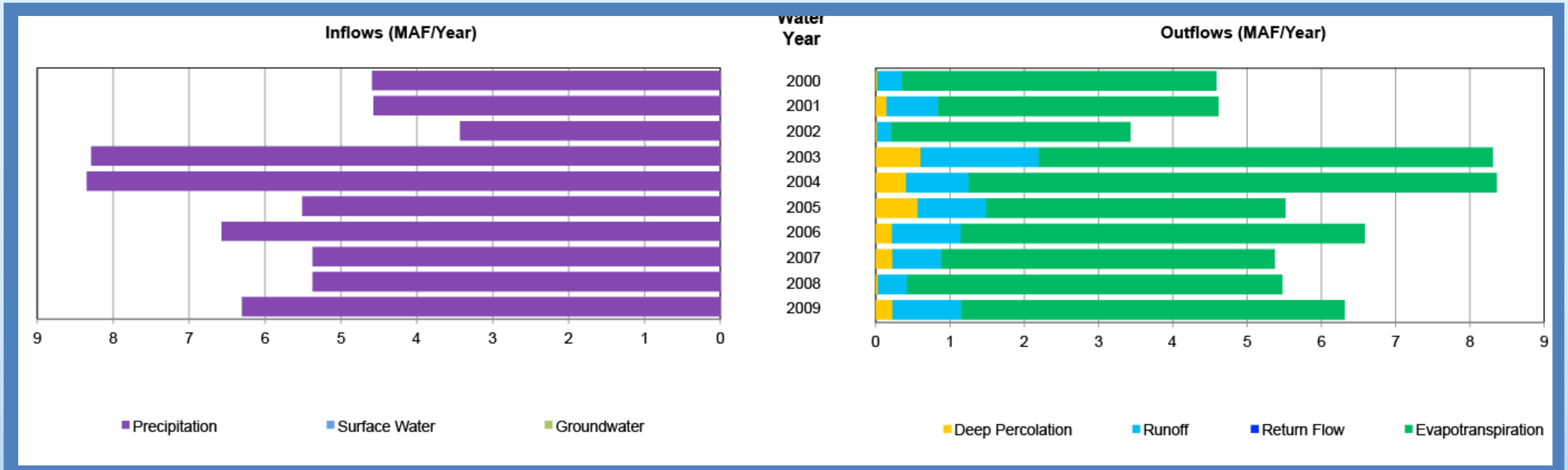
Urban Budget

2000-2009

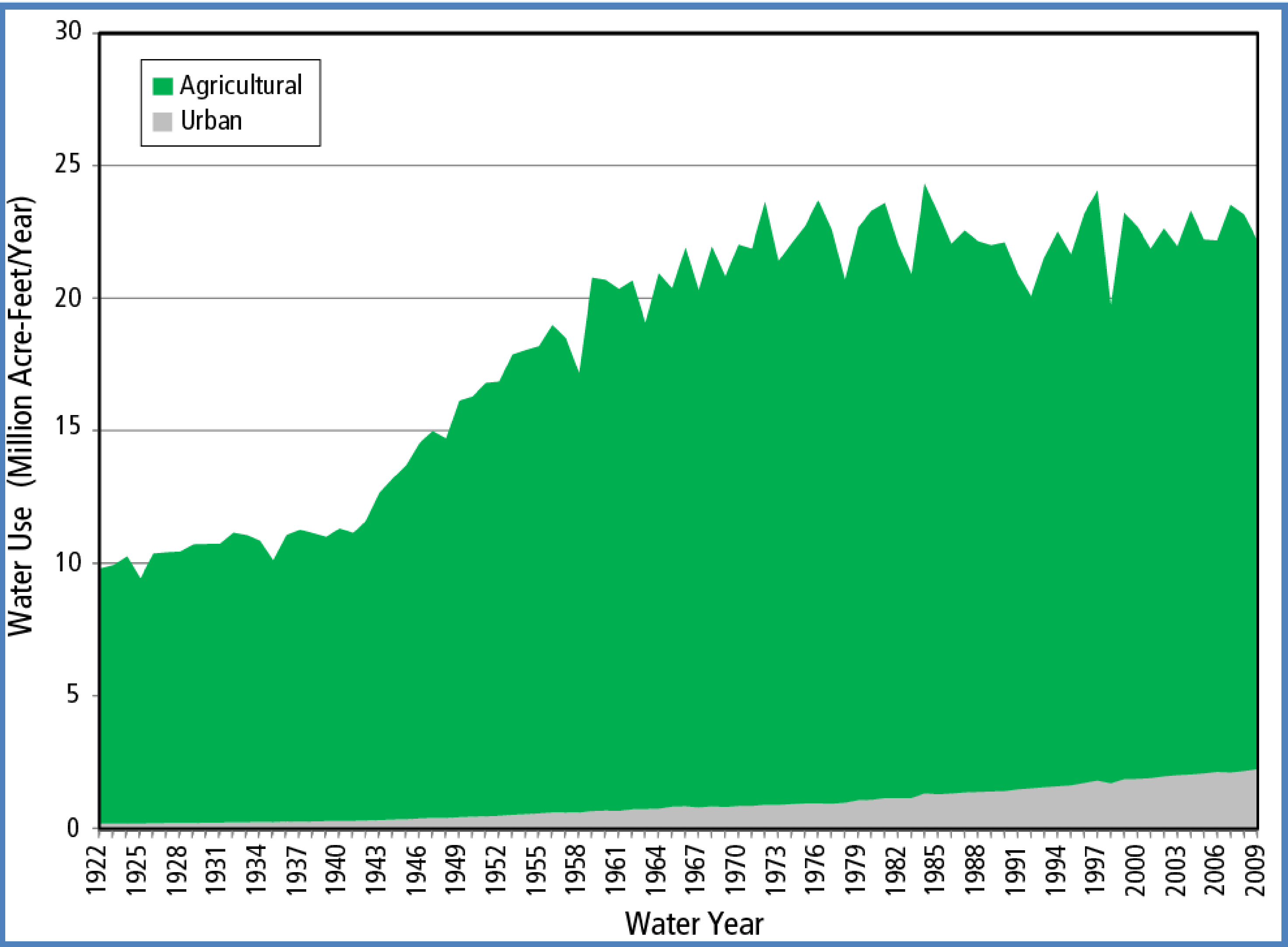


Native & Riparian Budget

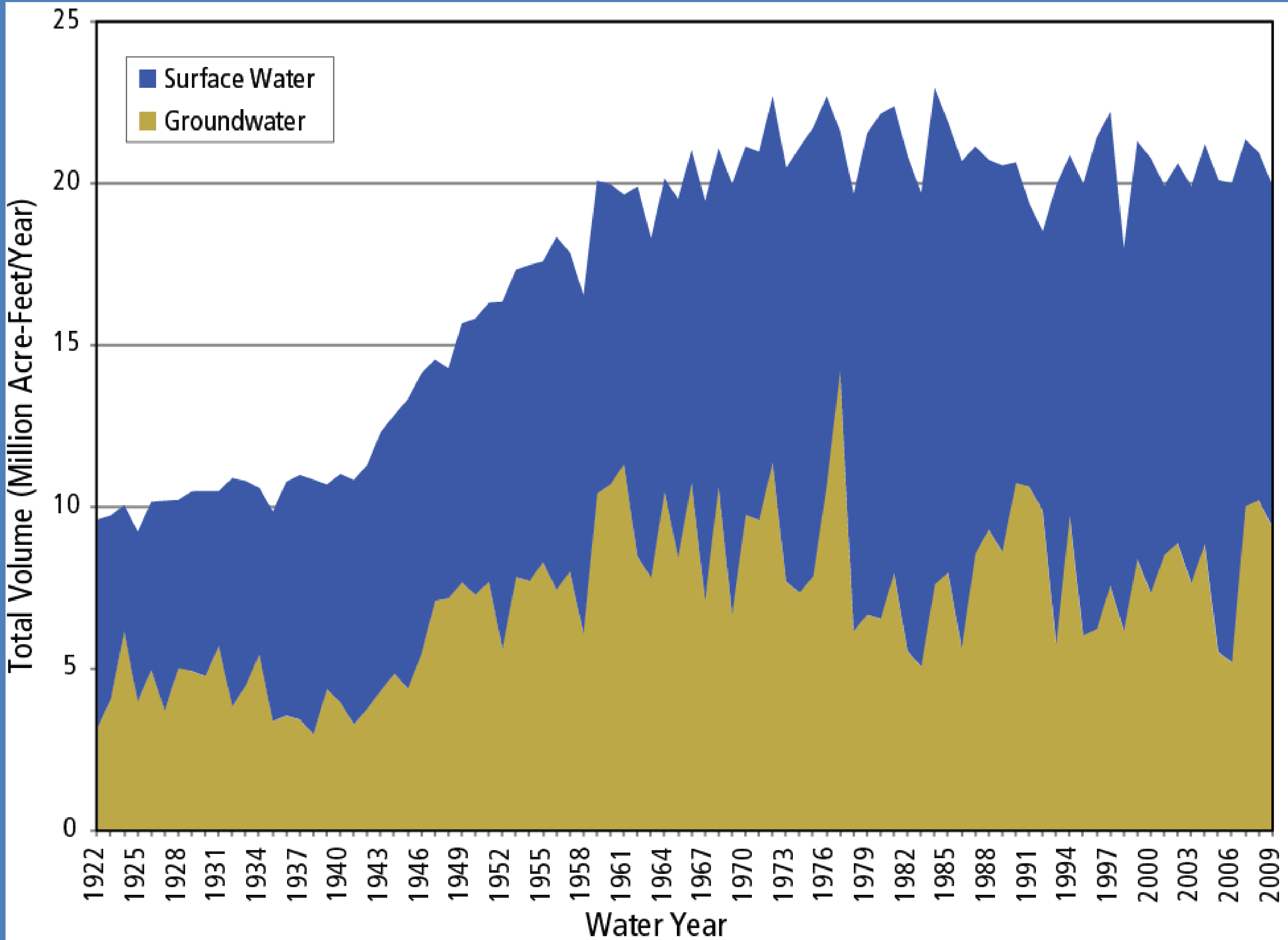
2000-2009



Ag and Urban Water Use



Agricultural Water Sources



Root Zone Moisture Budget

- Agricultural, Urban and Native/Riparian
- Water Sources and Root Zone sections
- Printed for each Subregion
- Water sources:
  - All have precipitation
  - Agricultural and Urban have applied water
- Root zone
  - Soil moisture storage +/- land expansion
  - Beginning storage + infiltration – ET – deep percolation = ending storage

Root Zone Moisture Budget

	Agricultural Area								
Time	Area (AC)	Precipitation	Runoff	Prime Applied Water	Reused Water	Total Applied Water	Return Flow	Beginning Storage	Net Gain fr Land Expans (+)
10/31/1921_24:00	14659.1	1501.4	0.0	7622.6	0.0	7622.6	0.0	3874.9	0
11/30/1921_24:00	14659.1	4047.2	812.8	590.5	0.0	590.5	0.0	8928.7	0
12/31/1921_24:00	14659.1	8849.5	5418.6	0.0	0.0	0.0	0.0	10786.7	0
01/31/1922_24:00	14659.1	1559.6	344.6	0.0	0.0	0.0	0.0	11243.6	0
02/28/1922_24:00	14659.1	7649.5	4662.9	0.0	0.0	0.0	0.0	11060.1	0
03/31/1922_24:00	14659.1	4339.9	1768.4	0.0	0.0	0.0	0.0	10891.2	0
04/30/1922_24:00	14659.1	1048.7	0.2	8047.8	0.0	8047.8	13.6	9773.5	0
05/31/1922_24:00	14659.1	2479.8	889.4	14457.6	0.0	14457.6	74.5	11290.5	0
06/30/1922_24:00	14659.1	750.3	109.2	18571.6	0.0	18571.6	91.9	11290.5	0
07/31/1922_24:00	14659.1	0.0	0.0	22662.8	0.0	22662.8	115.1	11290.5	0
08/31/1922_24:00	14659.1	0.0	0.0	22512.3	0.0	22512.3	127.3	11290.5	0
09/30/1922_24:00	14659.1	0.0	0.0	15636.8	0.0	15636.8	82.4	11290.5	0
10/31/1922_24:00	14659.1	3767.4	1743.9	7282.9	0.0	7282.9	43.3	11290.5	-33
11/30/1922_24:00	14659.1	3833.4	1816.4	0.0	0.0	0.0	0.0	11291.2	0
12/31/1922_24:00	14659.1	9085.7	5689.6	0.0	0.0	0.0	0.0	10858.8	0
01/31/1923_24:00	14659.1	4479.6	2256.6	0.0	0.0	0.0	0.0	11252.9	0
02/28/1923_24:00	14659.1	1279.6	149.4	0.0	0.0	0.0	0.0	11107.1	0
03/31/1923_24:00	14659.1	759.2	0.6	562.3	0.0	562.3	0.0	10026.3	0
04/30/1923_24:00	14659.1	6309.5	1589.5	6145.1	0.0	6145.1	22.5	7658.1	0
05/31/1923_24:00	14659.1	762.7	111.9	14960.1	0.0	14960.1	78.2	11291.2	0
06/30/1923_24:00	14659.1	2113.6	672.4	18196.8	0.0	18196.8	94.9	11291.2	0
07/31/1923_24:00	14659.1	0.0	0.0	22659.3	0.0	22659.3	119.2	11291.2	0
08/31/1923_24:00	14659.1	175.8	2.5	22485.0	0.0	22485.0	133.1	11291.2	0
09/30/1923_24:00	14659.1	3301.5	1431.3	14665.3	0.0	14665.3	86.0	11291.2	0
10/31/1923_24:00	14659.1	1834.9	511.0	758.5	0.0	758.5	0.0	11291.2	-30
11/30/1923_24:00	14659.1	845.3	0.0	1242.8	0.0	1242.8	0.0	9272.6	0
12/31/1923_24:00	14659.1	2172.6	144.9	0.0	0.0	0.0	0.0	9393.9	0
01/31/1924_24:00	14659.1	3571.3	920.6	0.0	0.0	0.0	0.0	10187.8	0

Root Zone Moisture Budget

	Column	Flow	08/31/2004	Process
Agricultural	Area (AC)		6,604,404	
	Precipitation	IN	92	
	Runoff	OUT	0	SW
	Prime Applied Water		3,294,876	
	Reused Water		67,228	
	Total Applied Water	IN	3,362,104	GW/SW
	Return Flow	OUT	99,094	SW
	Beginning Storage		4,100,673	
	Net Gain from Land Expansion (+)	+/-	0	
	Infiltration (+)	IN	3,195,874	
	Actual ET (-)	OUT	3,051,486	
	Deep Percolation (-)	OUT	166,381	GW
	Ending Storage (=)		4,078,680	

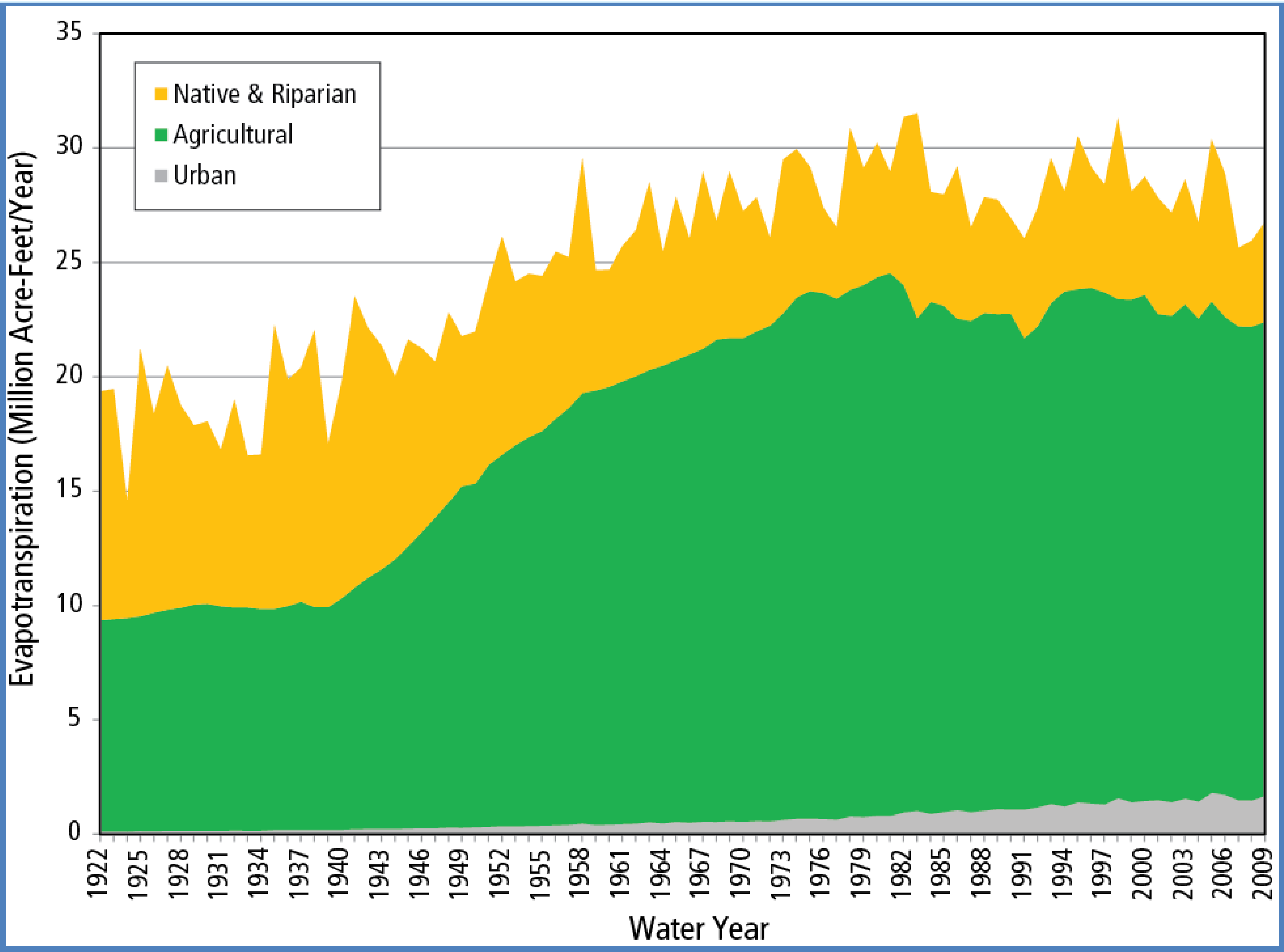
Root Zone Moisture Budget

	Column	Flow	08/31/2004	Process
Urban	Area (AC)		1,147,412	
	Precipitation	IN	208	
	Runoff	OUT	79	SW
	Prime Applied Water		254,086	
	Reused Water		0	
	Total Applied Water	IN	254,086	GW/SW
	Return Flow	OUT	46,801	SW
	Beginning Storage		0	
	Net Gain from Land Expansion (+)	+/-	0	
	Infiltration (+)		207,414	
	Actual ET (-)		152,581	
	Deep Percolation (-)		54,833	GW
	Ending Storage (=)		0	

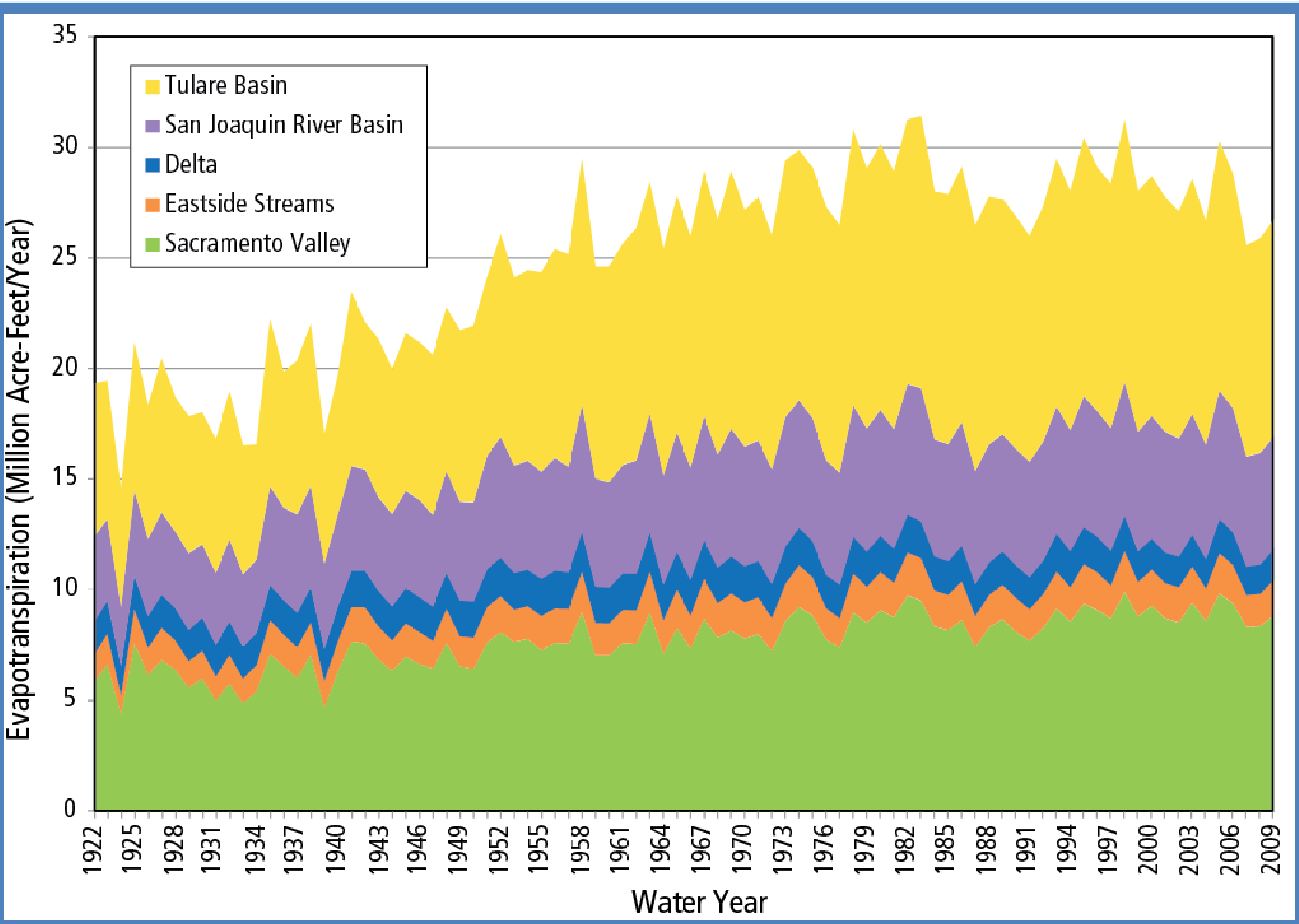
Root Zone Moisture Budget

	Column	Flow	08/31/2004	Process
Native & Riparian Veg	Area (AC)		4,947,899	
	Precipitation	IN	1,249	
	Runoff	OUT	0	SW
	Beginning Storage		0	
	Net Gain from Land Expansion (+)	+/-	0	
	Infiltration (+)		1,249	
	Actual ET (-)		1,249	
	Deep Percolation (-)		0	GW
	Ending Storage (=)		0	

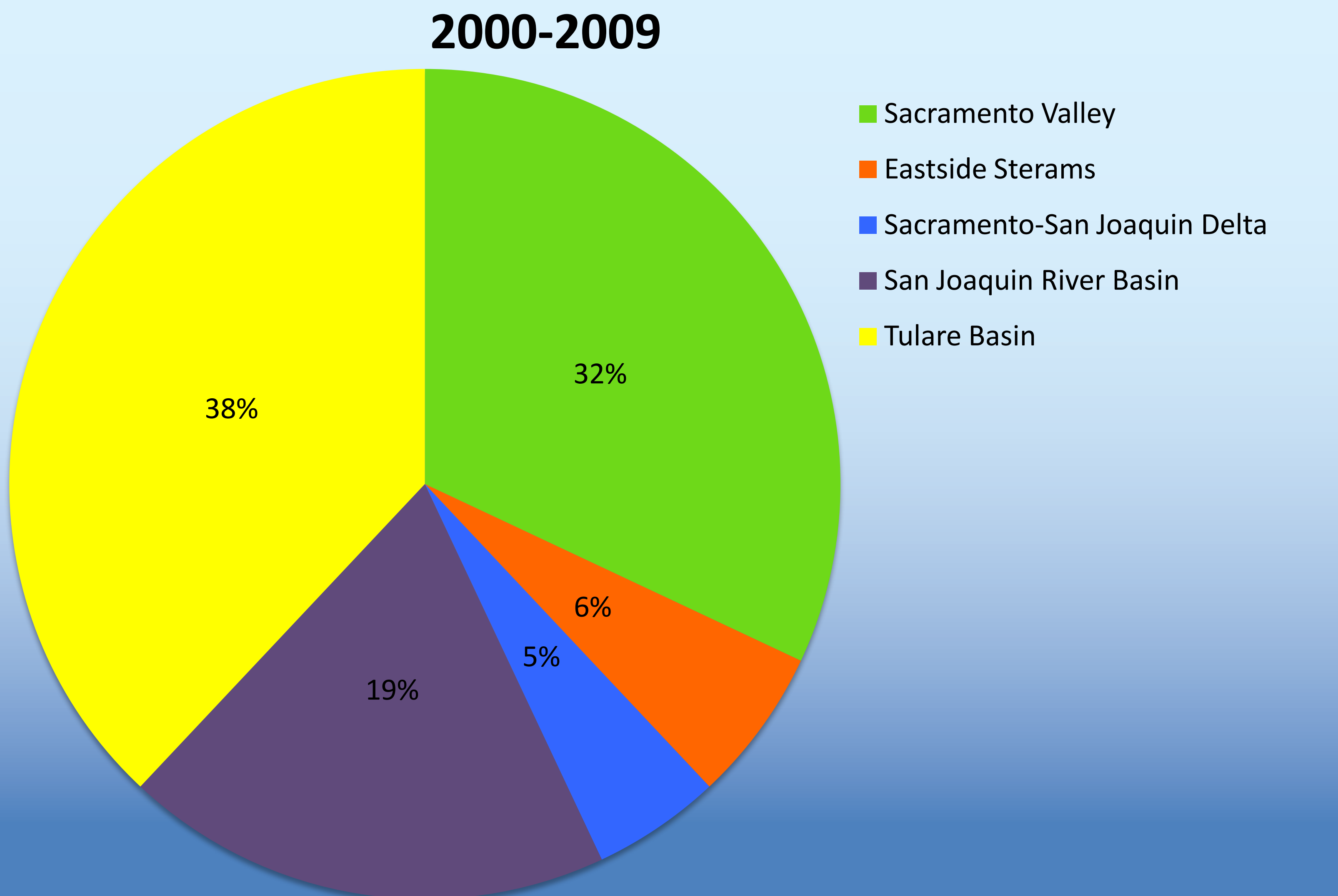
Annual Evapotranspiration



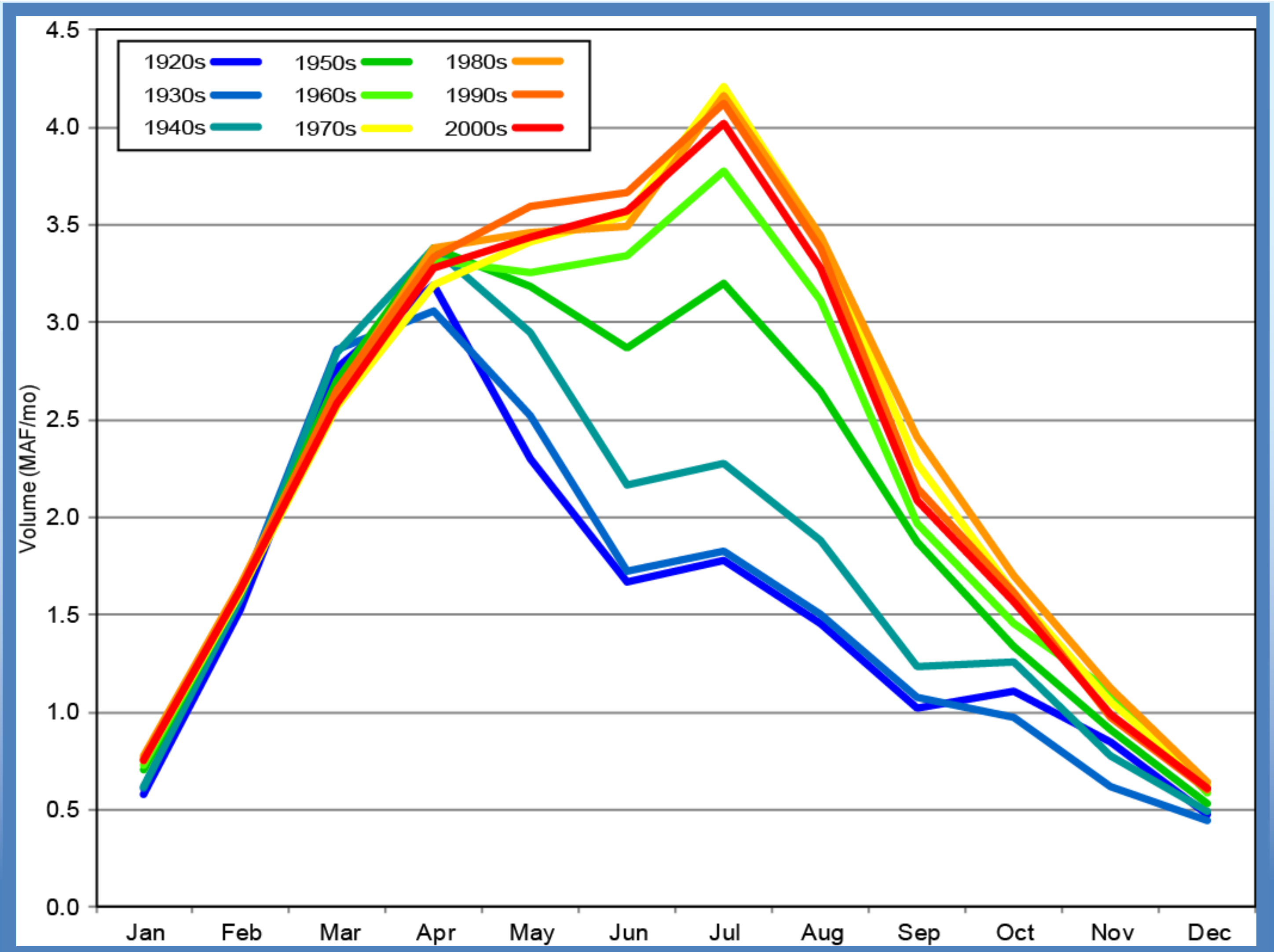
Regional ET Distribution



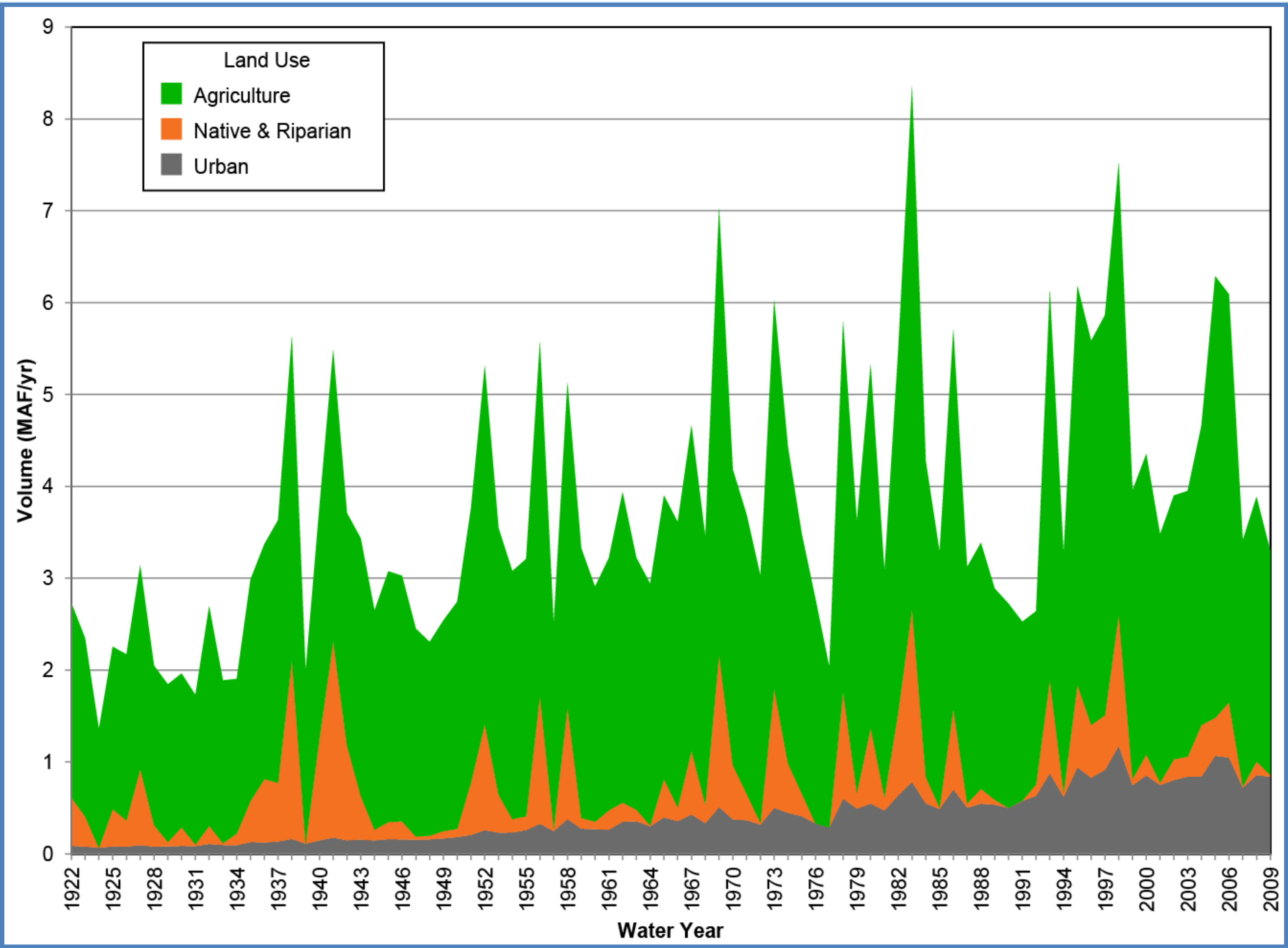
Regional ET Distribution



Monthly Evapotranspiration



Deep Percolation by Land Use



Summary

- IWFM Land and Water Use Process
  - Known inflows: Surface Water Diversions
  - Estimated outflows: Evapotranspiration
  - Calculated inflows: Groundwater Pumping
- Constrained by water balance between inter-process flows

End