The California Central Valley Groundwater-Surface Water Simulation Model

Surface Water Processes

CWEMF C2VSim Workshop

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Outline

IWFM Surface Water Process

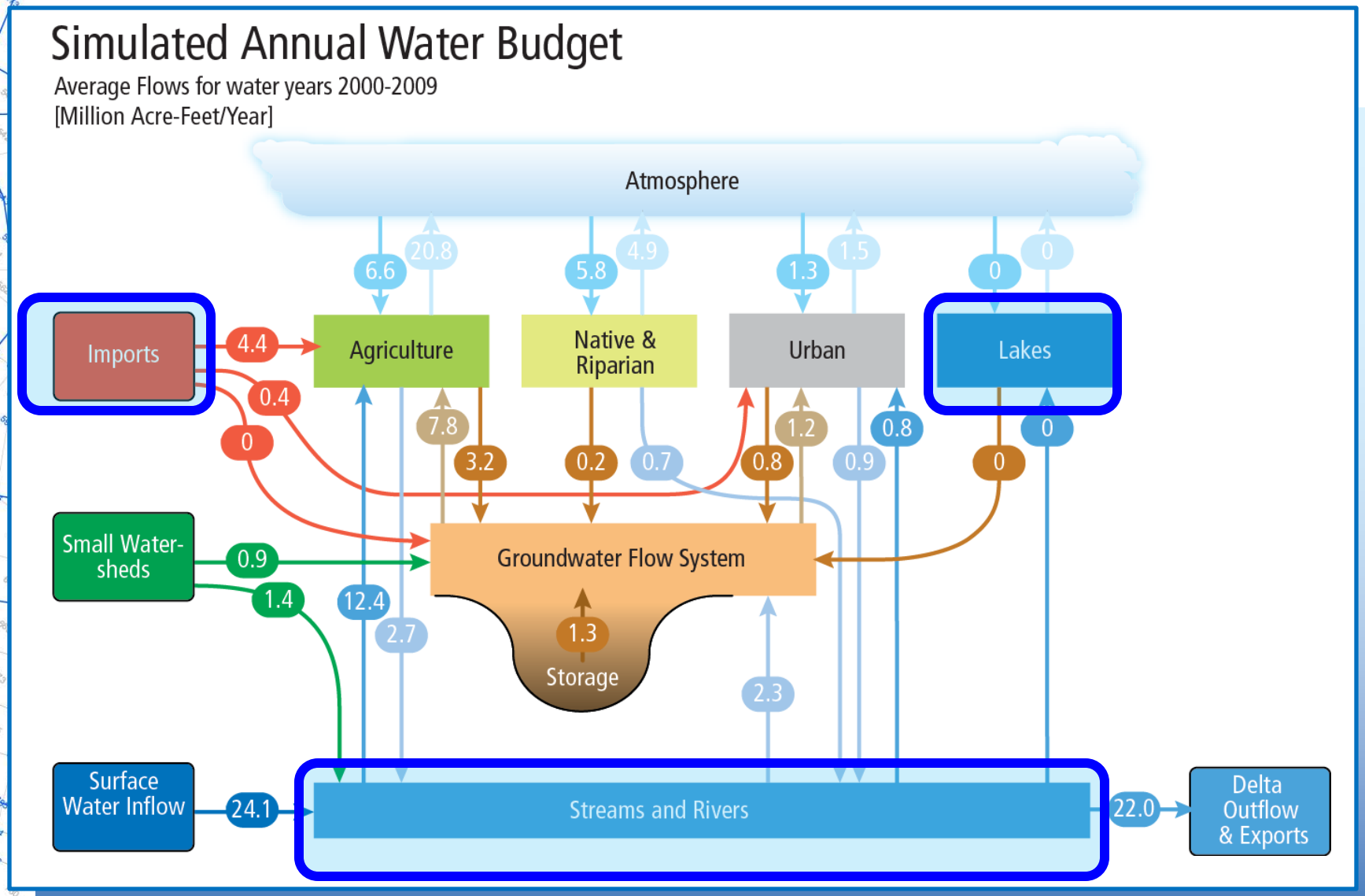
- Stream Reach Budget

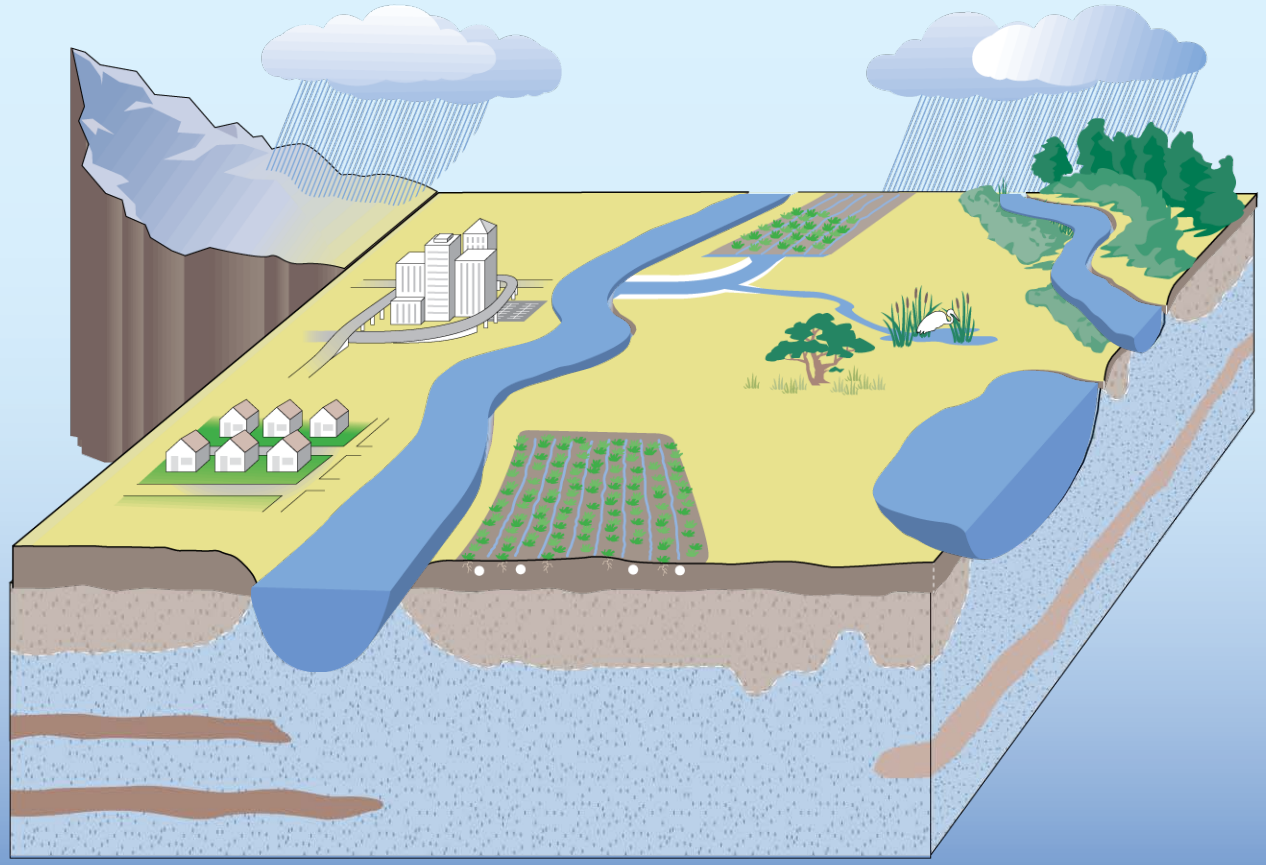
IWFM Small-Stream Watersheds Process

- Small Watersheds Budget

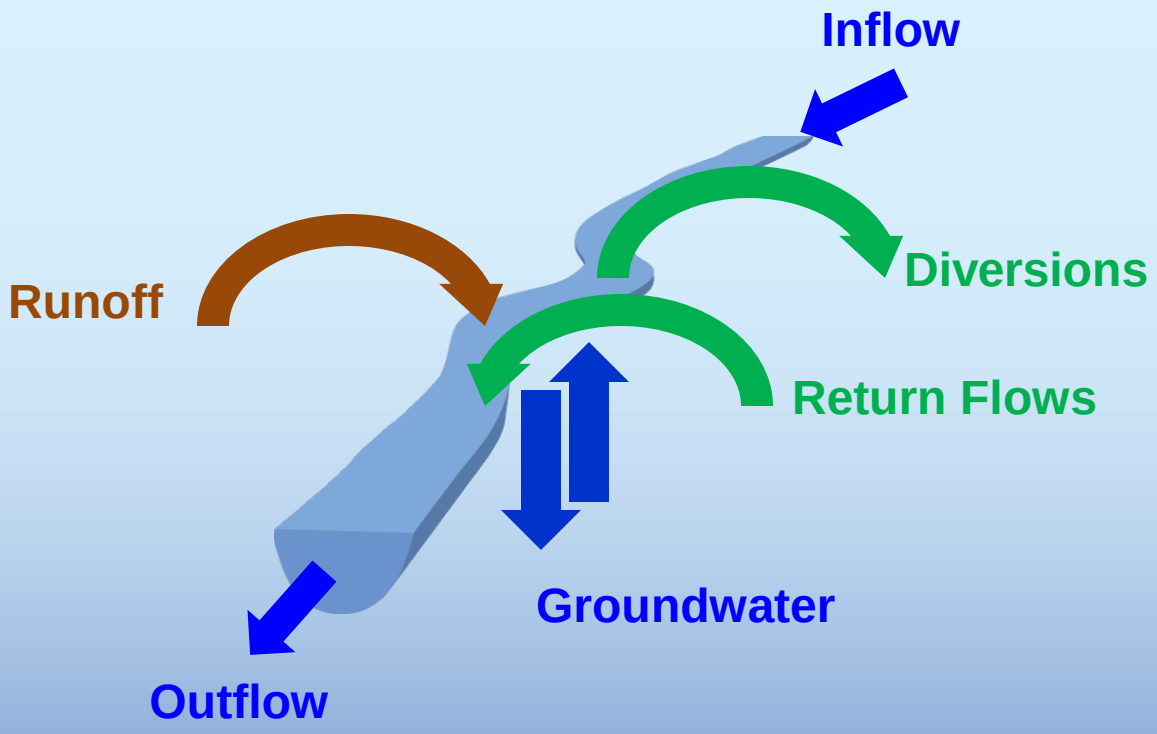
C2VSim Results

IWFM Surface Water Process

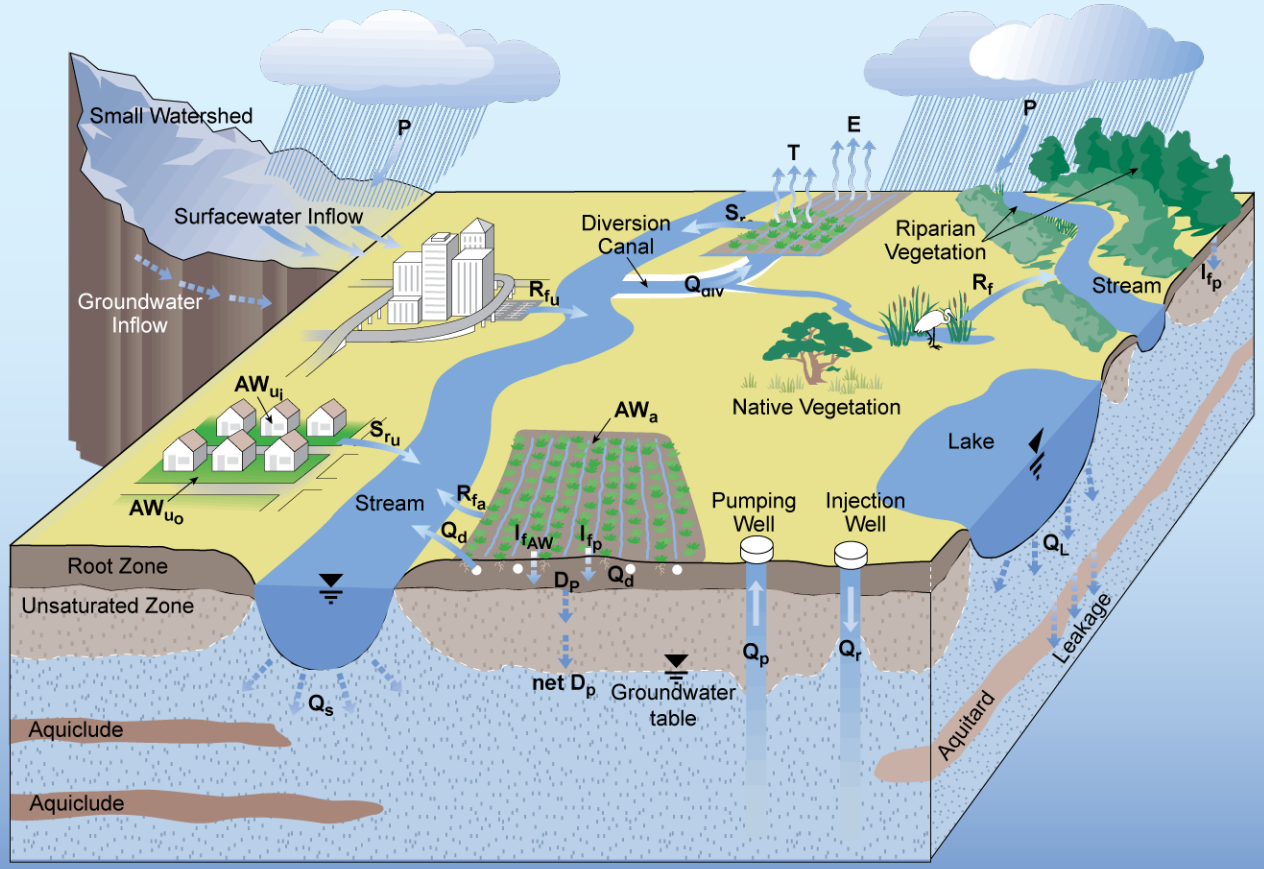




Surface Water Process

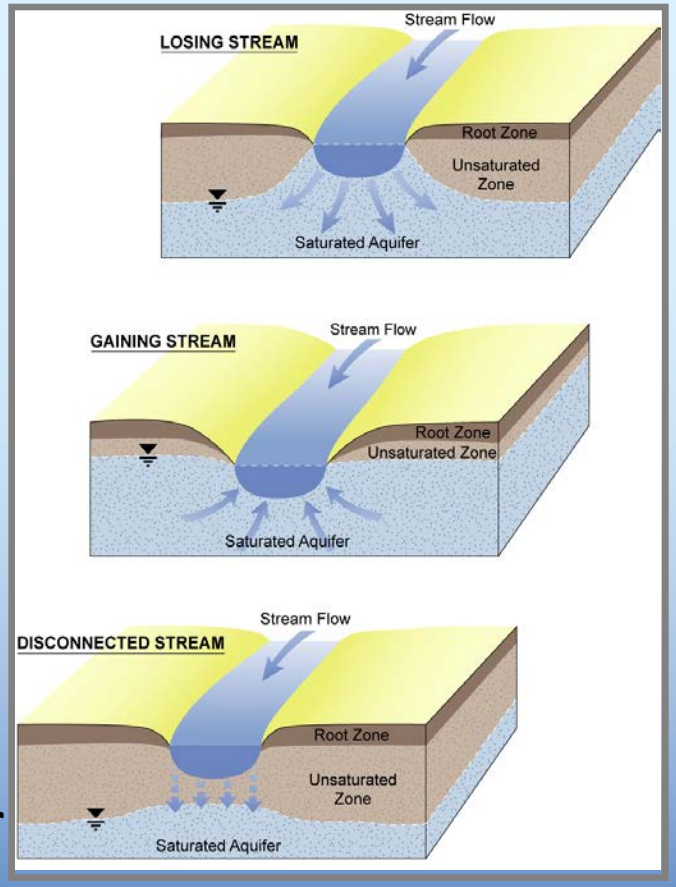


IWFM


Small Watershed
P
Surfacewater Inflow
Groundwater Inflow
T
E
P
Diversion Canal
Riparian Vegetation
Stream
Native Vegetation
Lake
Stream
Pumping Well
Injection Well
Root Zone
Unsaturated Zone
Aquiclude
Aquiclude
Aquitard
Leakage
net Dp
Groundwater table

Stream Flow and Stream-Aquifer Interaction

- Assumption of zero storage at a stream node in computing stream flows; i.e. total inflow equals total outflow
- Fully coupled stream and groundwater conservation equations
- Simultaneous solution of stream and groundwater equations results in the computation of stream-aquifer interaction



Stream Flow

- Assumption of zero storage at a stream node

$$Q_{s\ in} - Q_{s\ out} = 0$$

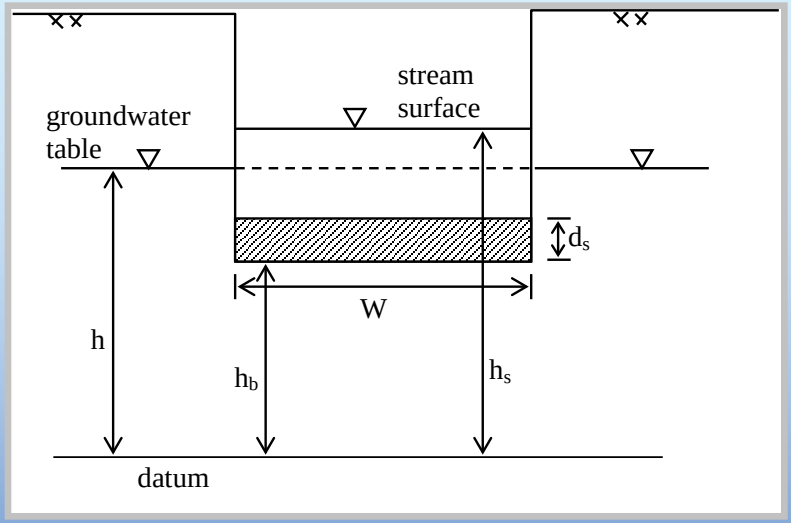
Q_{sin} = inflows into stream (flow from upstream nodes, return flow, rainfall runoff, tributary inflows, tile drain, lake outflow, bypass, user specified flows), (L^3/T)

Q_{sout} = outflows from stream (diversions, bypass flows, stream-aquifer interaction), (L^3/T)

- Assumption requires simulation time step to be large enough for stream flow to travel from upstream to downstream in a single time step

Stream-Groundwater Interaction

$$Q_{sint} = C_s\left[\max\left(h_s, h_b\right) - \max\left(h, h_b\right)\right] \quad ; \quad C_s = \frac{K_s}{d_s} LW$$



Q_{sint} = stream-aquifer interaction, (L^3/T)

h = groundwater head, (L)

h_s = stream surface elevation, (L)

h_b = stream bottom elevation, (L)

K_s = stream bed hydraulic conductivity, (L/T)

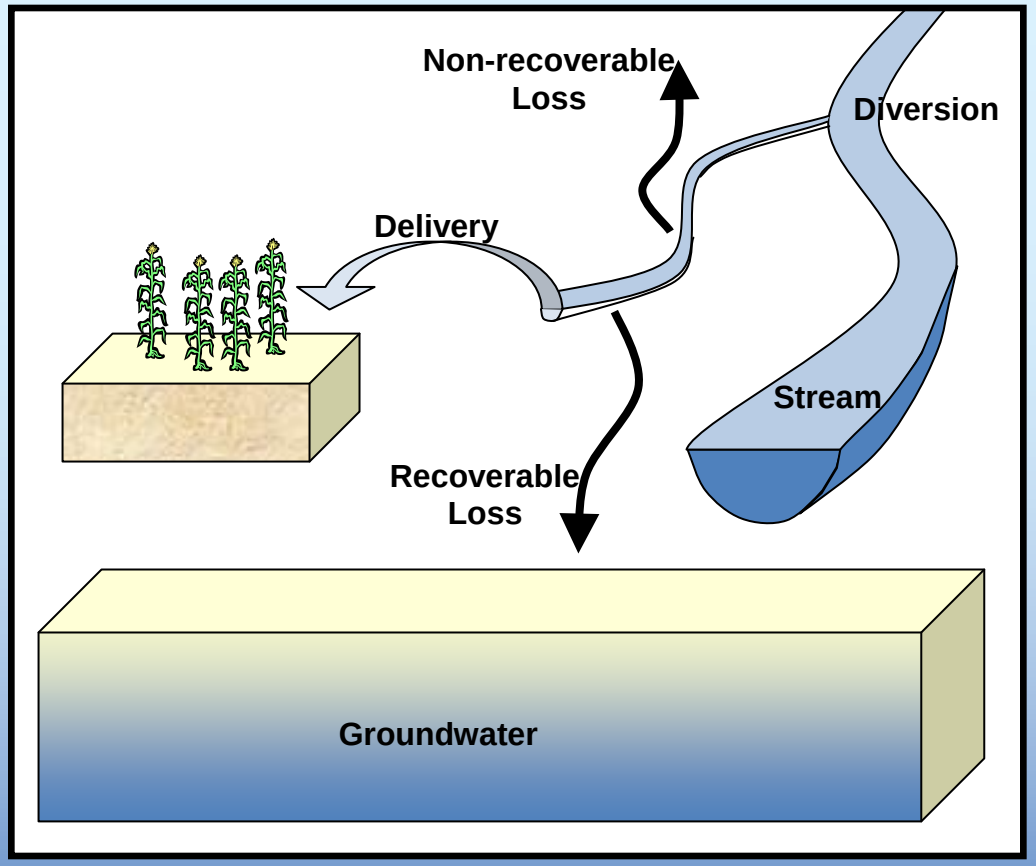
d_s = stream bed thickness, (L)

L = length of stream segment, (L)

W = channel width, (L)

Stream Diversions

- Used to meet agricultural and urban water demands
- User-specified fractions of diversion become recoverable (recharge to groundwater) and non-recoverable (evaporation) losses
- May be used to simulate spreading basins (100% recoverable and non-recoverable losses)



Lake-Groundwater Interaction

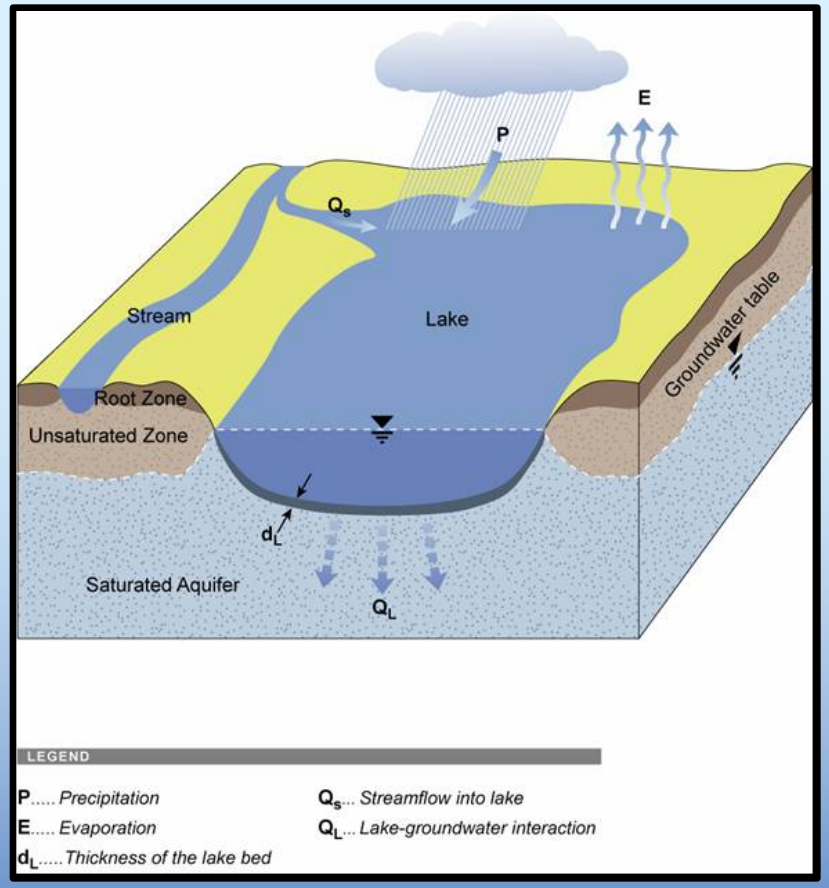
- One or more elements can be specified as lake elements
- Lakes are fully coupled with groundwater
- Lake storage is a function of precipitation, evaporation, inflows, lake-aquifer interaction and lake outflow

$$\frac{\Delta S_{lk}}{\Delta t} - Q_{lkin} + Q_{lkout} = 0$$

ΔS_{lk} = change in lake storage, (L^3)

Q_{lkin} = lake inflow (precipitation, inflows from streams and upstream lakes), (L^3/T)

Q_{lkout} =lake outflow (evaporation, lake spill, lake-aquifer interaction), (L^3/T)



Lake-Groundwater Interaction

$$Q_{lkint} = C_{lk}\left[\max\left(h_{lk}, h_{blk}\right) - \max\left(h, h_{blk}\right)\right] \; ; \quad C_{lk} = \frac{K_{lk}}{d_{lk}} A_{lk}$$

Q_{lkint} = lake-aquifer interaction, (L^3/T)

h = groundwater head, (L)

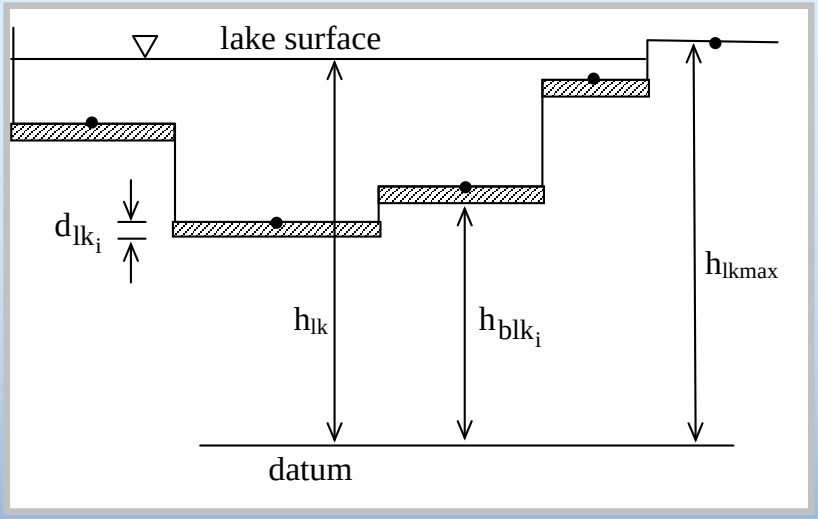
h_{lk} = lake surface elevation, (L)

h_{blk} = lake bottom elevation, (L)

K_{lk} = lake bed hydraulic conductivity, (L/T)

d_{lk} = lake bed thickness, (L)

A_{lk} = area of lake, (L)



- Lake outflow is computed when lake surface elevation exceeds maximum lake elevation
- Lake outflow can be directed to a stream node or a downstream lake

Documentation

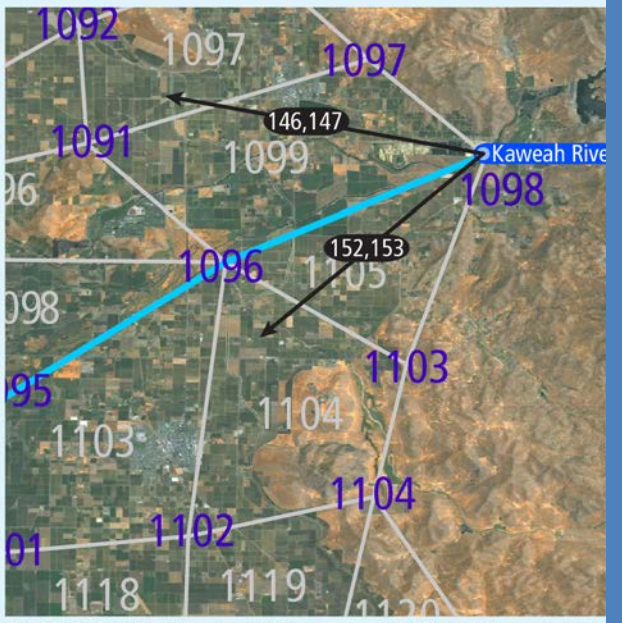
DWR Technical Memorandum

Historical Rim Inflows, Surface Water Diversions and Bypass Flows

for the

California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG

Charles F. Brush



Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 958

C2VSim-CG Version R374, released June 2013

165. Kern River at Calloway Weir for Ag

Water is diverted from the Kern River at the Calloway Weir for agricultural use in C2VSim subregion 21. For water years 1922 to 1969, 6% of the Kern River diversions to subregion 21 from the CVGSM model (James M. Montgomery Consulting Engineers 1990) are assumed to have occurred at the Calloway Weir. For water years 1970 to 2009, water diverted to the Farmers, Stine and Anderson canals and 13% of the water diverted to the Calloway Canal is assumed to have been diverted at the Calloway Weir and used in C2VSim subregion 21. In addition, 95% of the water diverted from March through September is assumed to have been delivered to agricultural users. Recoverable losses are assumed to be 8%, and non-recoverable losses are assumed to be 2%.

Start Date	End Date	Source
10/01/1921	09/30/1969	CVGSM Model (James M. Montgomery Consulting Engineers, 1990)
10/01/1969	09/30/2009	City of Bakersfield

166. Kern River at Calloway Weir for M&I

Water is diverted from the Kern River at the Calloway Weir for municipal and industrial use in C2VSim subregion 21. For water years 1922 to 1969, 6% of the Kern River diversions to subregion 21 from the CVGSM model (James M. Montgomery Consulting Engineers 1990) are assumed to have occurred at the Calloway Weir. For water years 1970 to 2009, water diverted to the Farmers, Stine and Anderson canals and 13% of the water diverted to the Calloway Canal is assumed to have been diverted at the Calloway Weir and used in C2VSim subregion 21. In addition, 5% of this water is assumed to have been delivered to municipal and industrial users. Recoverable losses are assumed to be 8%, and non-recoverable losses are assumed to be 2%.

Start Date	End Date	Source
10/01/1921	09/30/1969	CVGSM Model (James M. Montgomery Consulting Engineers, 1990)
10/01/1969	09/30/2009	City of Bakersfield

Inflows

Monthly at 38 locations

Inflows File

```
C-----------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-----------------------------------------------------------------------------
          41                                          / NCOLSTRM
          43560000.0                                  / FACTSTRM  (TAF/mon --> ft^3/mon)
          1                                           / NSPSTRM
          0                                           / NFQSTRM
                                                      / DSSFL
C-----------------------------------------------------------------------------
```

```
C-----------------------------------------------------------------------------
C   IRST
C-----------------------------------------------------------------------------
    205                         / 1:     205   Sacramento River
    211                         / 2:     211   Cow Creek
    220                         / 3:     220   Battle Creek
    218                         / 4:     218   Cottonwood Creek
    225                         / 5:     225   Paynes and Sevenmile Creek
    233                         / 6:     233   Antelope Creek Group
    243                         / 7:     243   Mill Creek
    237                         / 8:     237   Elder Creek
    248                         / 9:     248   Thomes Creek
    256                         /10:     256   Deer Creek Group
    263                         /11:     263   Stony Creek
    269                         /12:     269   Big Chico Creek
    283                         /13:     283   Butte and Chico Creek
    341                         /14:     341   Feather River
    349                         /15:     349   Yuba River
    357                         /16:     357   Bear River
    390                         /17:     390   Cache Creek
    374                         /18:     374   American River
    400                         /19:     400   Putah Creek
    188                         /20:     188   Consumnes River
    182                         /21:     182   Dry Creek
    173                         /22:     173   Mokelumne River
    161                         /23:     161   Calaveras River
    146                         /24:     146   Stanislaus River
```

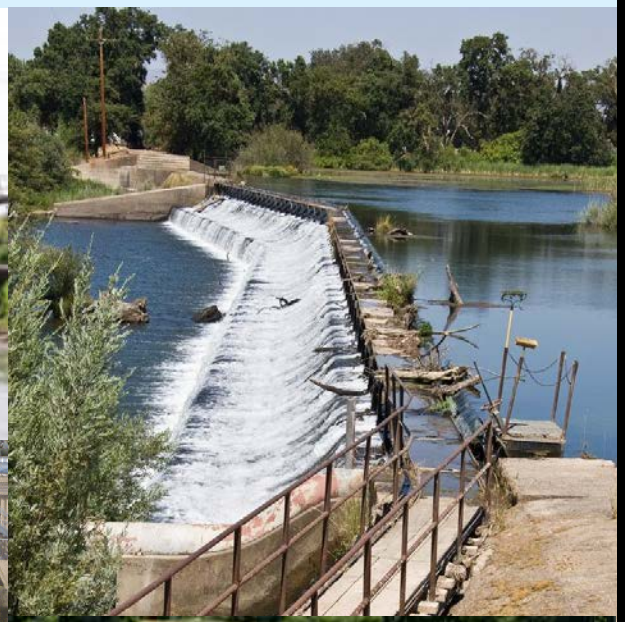
Inflows File

Sacramento River

```
C-----------------------------------------------------------------------------
C   ITST     ASTRM(1)  ASTRM(2)  ASTRM(3) ...
C                  1        2        3        4        5        6        7        8        9       10       11       12       13       14       15
C-----------------------------------------------------------------------------
10/31/1921_24:00     232.000 7.500    15.700   9.000    0.560    6.592    6.900    0.500    0.197   10.534   1.700    1.890    11.904   99.241   20.
11/30/1921_24:00     237.000 22.500   19.500   17.900   1.030    6.180    6.400    1.000    1.077   11.626   1.000    2.640    11.904   97.051   27.
12/31/1921_24:00     335.000 49.600   29.100   52.600   6.320    18.128   18.700   4.000    18.539  34.061   9.000    9.760    30.876   190.489  119
01/31/1922_24:00     302.000 78.000   36.500   89.500   6.040    13.802   14.200   3.000    24.810  25.997   8.000    8.250    25.420   184.647  121
02/28/1922_24:00     547.000 71.200   33.400   96.700   20.690   37.904   39.100   8.000    24.025  71.651   52.000   25.780   62.124   390.538  338
03/31/1922_24:00     610.000 56.800   33.700   84.800   13.190   27.810   28.600   7.000    19.774  52.453   27.050   18.980   47.988   447.937  274
04/30/1922_24:00     780.000 40.300   33.000   56.800   8.340    31.312   32.400   8.000    58.475  59.296   37.250   19.820   52.452   827.107  414
05/31/1922_24:00     629.000 26.700   33.000   33.900   3.970    43.054   44.500   4.000    40.348  81.553   25.950   18.130   71.796   1469.554
06/30/1922_24:00     338.000 9.000    24.100   15.900   0.460    24.720   25.600   1.000    4.760   46.939   6.900    6.190    43.772   659.901  662
07/31/1922_24:00     240.000 2.400    16.300   6.200    0.050    8.446    8.800    0.500    1.119   15.923   6.200    2.210    17.980   165.586  94.
08/31/1922_24:00     214.000 1.600    13.000   4.700    0.040    5.974    6.100    0.500    0.118   11.411   5.200    1.670    11.532   106.558  31.
09/30/1922_24:00     202.000 2.700    12.600   5.200    0.080    5.356    5.400    0.500    0.009   9.947    4.500    1.510    9.548    92.886   17.
10/31/1922_24:00     232.000 6.100    12.700   7.300    0.410    7.210    6.200    0.500    1.119   10.370   2.050    1.790    10.912   101.455  22.
11/30/1922_24:00     255.000 18.200   15.800   14.500   2.640    13.802   11.800   1.000    5.111   18.353   10.700   4.420    19.096   141.858  55.
12/31/1922_24:00     336.000 40.100   23.500   42.600   15.350   44.702   38.300   4.000    28.856  63.273   36.000   19.500   56.792   383.129  308
01/31/1923_24:00     399.000 63.100   29.500   72.400   7.940    24.308   20.700   4.000    28.383  34.265   32.000   11.070   33.976   310.205  172
02/28/1923_24:00     312.000 57.600   27.000   78.200   3.170    13.802   11.800   3.000    15.395  19.379   15.000   5.780    21.452   201.433  113
03/31/1923_24:00     333.000 46.000   27.300   68.600   1.810    13.802   11.800   3.000    10.207  19.546   9.050    5.840    21.452   303.257  144
04/30/1923_24:00     590.000 32.600   26.700   45.900   1.970    29.664   25.300   5.000    35.369  41.644   27.750   8.420    39.308   563.802  407
05/31/1923_24:00     357.000 21.600   26.700   27.400   0.310    14.832   12.600   2.000    11.228  20.700   6.550    2.510    23.932   385.773  411
06/30/1923_24:00     267.000 7.300    19.500   12.800   0.110    9.064    7.800    1.000    5.724   11.023   5.500    1.260    16.492   181.547  200
07/31/1923_24:00     214.000 1.900    13.100   5.100    0.030    6.180    5.200    0.500    0.563   8.594    5.850    1.030    10.416   115.966  72.
08/31/1923_24:00     194.000 1.300    10.500   3.800    0.020    5.768    4.900    0.500    0.384   8.155    4.850    1.050    7.812    104.959  27.
09/30/1923_24:00     196.000 2.200    10.200   4.200    0.060    6.592    5.700    0.500    0.248   8.524    3.800    1.140    8.556    94.433   23.
10/31/1923_24:00     222.000 2.400    5.000    2.900    0.470    4.120    7.500    0.500    0.726   8.870    1.000    1.110    10.540   105.144  30.
11/30/1923_24:00     206.000 7.200    6.200    5.700    1.030    3.502    6.400    0.500    0.976   8.218    1.000    1.450    9.052    96.516   21.
12/31/1923_24:00     218.000 15.800   9.300    16.800   1.360    4.120    7.200    1.000    2.349   9.299    3.000    1.790    10.540   92.723   34.
01/31/1924_24:00     226.000 24.900   11.700   28.600   1.800    4.326    7.900    2.000    3.671   10.084   3.000    2.110    12.028   100.655  40.
02/29/1924_24:00     334.000 22.700   10.700   30.900   3.960    11.124   20.000   2.000    17.969  25.494   10.000   5.330    28.396   257.347  110
03/31/1924_24:00     230.000 18.100   10.800   27.100   1.240    6.798    12.300   2.000    3.007   15.729   1.350    3.070    18.476   96.167   51.
04/30/1924_24:00     210.000 12.900   10.500   18.100   0.460    5.562    9.900    1.000    2.696   12.535   2.400    1.740    16.988   127.696  95.
05/31/1924_24:00     184.000 8.500    10.500   10.800   0.140    3.296    6.200    1.000    1.119   7.880    3.700    0.910    10.292   76.614   49.
06/30/1924_24:00     169.000 2.900    7.700    5.100    0.060    2.884    5.100    0.500    0.084   6.529    2.000    0.520    6.448    55.000   11.
07/31/1924_24:00     171.000 0.800    5.200    2.000    0.040    2.884    5.100    0.500    0.000   6.461    0.000    0.490    6.200    52.381   9.6
```

Diversions

Monthly at 246 locations



Surface Water Diversions

- Diversions and imports
  - “Diversions” means water taken from a simulated river node, subject to availability
  - “Imports” generally means water taken from a source that is not modeled
    - Reservoirs outside the model area serving canals
    - Reservoirs inside the model area that are not modeled (for example Black Butte and Camanche)
    - Complex delivery systems (California Aqueduct)

Surface Water Imports

- Friant-Kern Canal
  - Release water from Millerton Lake to canal
  - Deliveries to contractors along canal
  - Wasteway flows to river beds for delivery to down-stream customers
  - Flows to Kern River

Surface Water Imports

- Friant-Kern Canal deliveries simulated as:
  - Imports to individual subregions
  - Separate diversions for
    - Agricultural
    - Urban
    - Refuges
    - Spreading (Aquifer Storage)
  - Diversions to some districts via river channels
    - Inflow “FKC Wasteway Deliveries to Tule River”
    - Diversion from river

Surface Water Exports & Imports

- California Aqueduct
  - Pump water from Delta to San Luis Reservoir (outside model area)
  - Release water from San Luis Reservoir for use inside model area
  - Release water from San Luis Reservoir for use outside model area
- Simulated as exports and imports
  - Too complex to incorporate in a regional model

Diversion Specification

Diversion source and destination

```
C   NRDV;    Number of surface water diversions included in the model.
C-----------------------------------------------------------------------------
C   VALUE                        DESCRIPTION
C-----------------------------------------------------------------------------
    246                          / NRDV
C-----------------------------------------------------------------------------
C
C   The following lists the specifications for each surface water diversion
C   (skip if no diversions are modeled, i.e. NRDV = 0)
C
C   ID      ; Surface water diversion identification number
C   IRDV    ; Stream node from where the diversion takes place. Enter '0' if the stream node is outside the model area.
C   ICDVMAX ; Maximum diversion amount - this number corresponds to the  appropriate data column in the diversion data file Unit 26
C   FDVMAX  ; Fraction of data value specified in column ICDVMAX to be used as maximum diversion amount
C   ICOLRL  ; Recoverable loss -  this number corresponds to the appropriate data column in the diversion data file Unit 26
C   FRACRL  ; Relative proportion of the data value that is specified by ICOLRL to be used as recoverable loss
C   ICOLNL  ; Non-recoverable loss - this number corresponds to the appropriate data column in the diversion data file Unit 26
C   FRACNL  ; Relative proportion of the data value that is specified by ICOLNL to be used as non-recoverable loss
C   NDLDV   ; Number  of sub-regions to which diverted surface water is delivered
C   IRGDL   ; Sub-region number to which the delivery is made (1...NDLDV)
C   ICOLDL  ; Delivery to sub-region IRGDL - this number corresponds to the appropriate data column in the diversion data file Unit 26
C   FRACDL  ; Relative proportion of the data value that is specified by ICOLDL to be used as delivery to subregion IRGDL
C   ICFSIRIG; Fraction of the delivery that is used for irrigation purposes - this number corresponds to the appropriate data column in the
C              irrigation fraction data file Unit 27 (remaining amount will be used to supply the user specified urban demand)
C   ICADJ   ; Supply adjustment specification - this number corresponds to the appropriate data column in the supply adjustment
C              specifications data file Unit 12
C
C-------------------------------------------------------------------------------------------------------------------------------
C Description
C ID    IRDV    ICDVMAX FDVMAX  ICOLRL  FRACRL  ICOLNL  FRACNL  NDLDV   IRGDL   ICOLDL  FRACDL  ICFSIRIG        ICADJ
C-------------------------------------------------------------------------------------------------------------------------------
C
C  Whiskeytown and Shasta imports for SR1 Ag
C
1     0       265     1       1       0.03    1       0.01    1       1       1       0.96    23      1
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Whiskeytown and Shasta imports for SR1 M&I
C
2     0       265     1       2       0.03    2       0.01    1       1       2       0.96    22      2
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 Ag
C
3     206     265     1       3       0.03    3       0.02    1       1       3       0.95    23      3
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 M&I
C
4     206     265     1       4       0.03    4       0.01    1       1       4       0.96    22      4
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for Export
```

Source River Node (0 = import)

Allocation to losses and delivery

Destination subregion

Land use (23 = Ag, 22 = urban)

Diversion Specification

Recharge area for recoverable losses

```
C=====================================================================================================
C
C                  Recharge zone for each diversion point
C       (Skip if no diversions are being modeled, i.e. NRDV = 0)
C
C   ID    ;  Recharge zone identification number (*Note* Recharge zone ID's should match river diversion ID numbers)
C   NERELS;  Total number of elements through which recharge occurs
C   IERELS;  Element number through which recharge occurs
C   FERELS;  Relative proportion of the recoverable loss to be applied to
C               element IERELS as recharge
C
C-----------------------------------------------------------------------------
C    ID         NERELS      IERELS     FERELS
C-----------------------------------------------------------------------------
C
C  Whiskeytown and Shasta imports for SR1 Ag
C
     1            1           12       1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Whiskeytown and Shasta imports for SR1 M&I
C
     2            1           12       1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 Ag
C
     3            2           2        1
                              3        1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 M&I
C
     4            2           2        1
                              3        1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for Export
C
     5            2           5        1
                              8        1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River Keswick to Red Bluff for SR1 Ag
C
     6            9           5        1
                              8        1
                              13       1
                              14       1
                              15       1
                              19       1
                              20       1
                              26       1
                              27       1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River Keswick to Red Bluff for SR1 M&I
C
     7            9           5        1
```

Bypasses

- Flood control
- Kings River bifurcation
- ASR programs

Bypass Specification

Source and destination river nodes

```
C*****************************************************************************
C
C                 Bypass Configuration Specifications
C
C   NDIVS;  Number of bypasses
C   FACTX;  Conversion factor for DIVX - It is used to convert only the spatial component of the unit;
C   TUNITX; Time unit of stream flow.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C   FACTY;  Conversion factor for DIVY - It is used to convert only the spatial component of the unit;
C   TUNITX; Time unit of diversion.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C
C-----------------------------------------------------------------------------
C   VALUE                       DESCRIPTION
C-----------------------------------------------------------------------------
      12                        / NDIVS
      60                        / FACTX       values in CFS * 60 -> CFM
      1min                      / TUNITX
      60                        / FACTY       values in CFS * 60 -> CFM
      1min                      / TUNITY
C-----------------------------------------------------------------------------------------------------------
C
C   ID   ;  Bypass identification number
C   IA   ;  Stream node number where bypass is exported
C   IDIVT;  Stream node number where bypass is imported
C   IDIVC;  If positive, IDIVC is the column number in the diversion data file Unit 26 for bypass flow
C           If negative, IDIVC is the number of points in the diversion rating table
C   DIVRL;  Fraction of the diversion assigned as recoverable loss
C   DIVNL;  Fraction of the diversion assigned as non-recoverable loss
C   DIVX ;  Stream flow available at stream node IA; [L^3/T]
C   DIVY ;  Diversion amount corresponding to DIVX; [L^3/T]
C
C  ID   IA  IDIVT   IDIVC   DIVRL  DIVNL
C                           DIVX   DIVY ( this rating table should follow if IDIVC < 0 )
C-----------------------------------------------------------------------------------------------------------
C Bypass 1 - Moulton Weir spill to Butte Basin
C
   1   280    290   251      0.       0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 2 - Colusa Weir spill to Butte Basin
C
   2   282    291   252      0.       0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 3 - Tisdale Weir near Grimes
C
   3   297    337   253      0.       0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 4 - Freemont Weir spill to Yolo Bypass
C
   4   367    396   254      0.       0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 5 - Sacramento Weir spill to Yolo Bypass
C
   5   372    397   255      0.       0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Bypass Specification

Source and destination river nodes

```
C
C - - -
```

Bypass Specification

Recharge area for recoverable losses

```
C=====================================================================================================
C
C               Seepage locations for bypass canals
C
C      The following information specifies the recharge zone for each bypass.
C      (Skip if no bypass is being modeled, i.e. NDIVS = 0)
C
C   ID    ;  Recharge zone identification number (*Note* Recharge zone ID's should match bypass ID numbers)
C   NERELS;  Total number of elements through which recharge occurs
C   IERELS;  Element number through which recharge occurs
C             (If bypass to lake elements, provide negative sequential lake number, as in the LAKE input data file)
C   FERELS;  Relative proportion of the recoverable loss to be applied to element IERELS as recharge.
C
C-------------------------------------------------------------------------------
C    ID         NERELS      IERELS     FERELS
C-------------------------------------------------------------------------------
C Bypass 1 - Moulton Weir spill to Butte Basin
C             All losses go outside the model (losses = 0)
C
   1              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 2 - Colusa Weir spill to Butte Basin
C             All losses go outside the model (losses = 0)
C
   2              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 3 - Tisdale Weir to Yolo Bypass
C             All losses go outside the model (losses = 0)
C
   3              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 4 - Freemont Weir to Yolo Bypass
C             All losses go outside the model (losses = 0)
C
   4              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 5 - Sacramento Weir to Yolo Bypass
C             All losses go outside the model (losses = 0)
C
   5              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 6 - Knights Landing Ridge Cut flood flow to Yolo Bypass
C             All losses go outside the model (losses = 0)
C
   6              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 7 - Kings River to Fresno Slough
C             All losses go outside the model (losses = 0)
C
   7              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 8 - End of Kaweah River to be spread in Kaweah River Fan as recharge
C -- Aquifer Storage Program - no observed flow past this stream node
```

River Parameters

```
C*****************************************************************************************************
C                        STREAM BED PARAMETERS
C
C     The following lists the parameters to model streams.
C     *Note* Skip data input if no streams are modeled
C
C   FACTK ;   Conversion factor for stream bed conductivity - It is used to convert only the spatial component of the unit;
C   TUNITK;   Time unit of conductivity.  This should be one of the units
C              recognized by HEC-DSS that are listed in the Main Control File.
C   FACTL ;   Conversion factor for stream bed thickness and wetted perimeter
C   IR    ;   Stream node number
C   CSTRM ;   Hydraulic conductivity of stream bed; [L/T]
C   DSTRM ;   Thickness of stream bed; [L]
C   WETPR ;   Wetted perimeter; [L]
C
C-------------------------------------------------------------------------
C   VALUE                 DESCRIPTION
C-------------------------------------------------------------------------
     1.0                  / FACTK
     1mon                 / TUNITK
     1.0                  / FACTL
C-------------------------------------------------------------------------
C    IR       CSTRM       DSTRM      WETPR        River Name (Optional)
C-------------------------------------------------------------------------
      1     3.91109000   1.         300.0      REACH  1   -   KERN RIVER
      2     7.64316000   1.         300.0
      3     4.27314000   1.         300.0
      4     14.6494000   1.         300.0
      5     3.44887000   1.         300.0
      6     2.01865000   1.         300.0
      7     1.63871000   1.         300.0
      8     2.23515000   1.         300.0
      9     .920359000   1.         300.0
     10     1.84849000   1.         420.0      REACH  6   -   TULE RIVER
     11     14.1967000   1.         420.0
     12     2.54948000   1.         420.0
     13     1.44002000   1.         420.0
     14     .928433000   1.         420.0
     15     1.47745000   1.         420.0
     16     1.23984000   1.         420.0
     17     1.04805000   1.         420.0
     18     6.85300E-4   1.         420.0      REACH  6a   -   TULE RIVER(ZERO)
     19     8.68300E-4   1.         420.0
     20     8.39200E-4   1.         420.0
     21     8.15800E-4   1.         420.0
     22     8.14200E-4   1.         420.0
     23     .673012000   1.         475.0      REACH  2   -   KINGS RIVER
     24     .542923000   1.         475.0
     25     .478602000   1.         475.0
     26     .376210000   1.         475.0
     27     .337160000   1.         475.0
     28     .473797000   1.         475.0
     29     .644172000   1.         475.0
```

Lake Parameters

```
C*****************************************************************************
C                          LAKE PARAMETERS
C
C     The parameters required to model lakes are listed below.
C     *Note* Skip data input if no lakes are modeled
C
C   FACTK  :   Conversion factor for lake bed hydraulic conductivity
C   TUNITK :   Time unit of hydraulic conductivity.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C   FACTL  :   Conversion factor for thickness of lake bed
C   IL     :   Lake number
C   CLAKE  :   Hydraulic conductivity of the lake bed; [L/T]
C   DLAKE  :   Thickness of the lake bed; [L]
C   ICHLMAX:   Column of max-lake file that gives maximum lake elevation
C
C-----------------------------------------------------------------------------
C   VALUE                 DESCRIPTION
C-----------------------------------------------------------------------------
     1.0                  / FACTK
     1mon                 / TUNITK
     1.0                  / FACTL
C-----------------------------------------------------------------------------
C   IL       CLAKE      DLAKE    ICHLMAX    Lake Name (Optional)
C-----------------------------------------------------------------------------
     1       20.0       1.00000    1        Buena Vista Lake Bed
     2       20.0       1.00000    2        Tulare Lake Bed
C*****************************************************************************
```

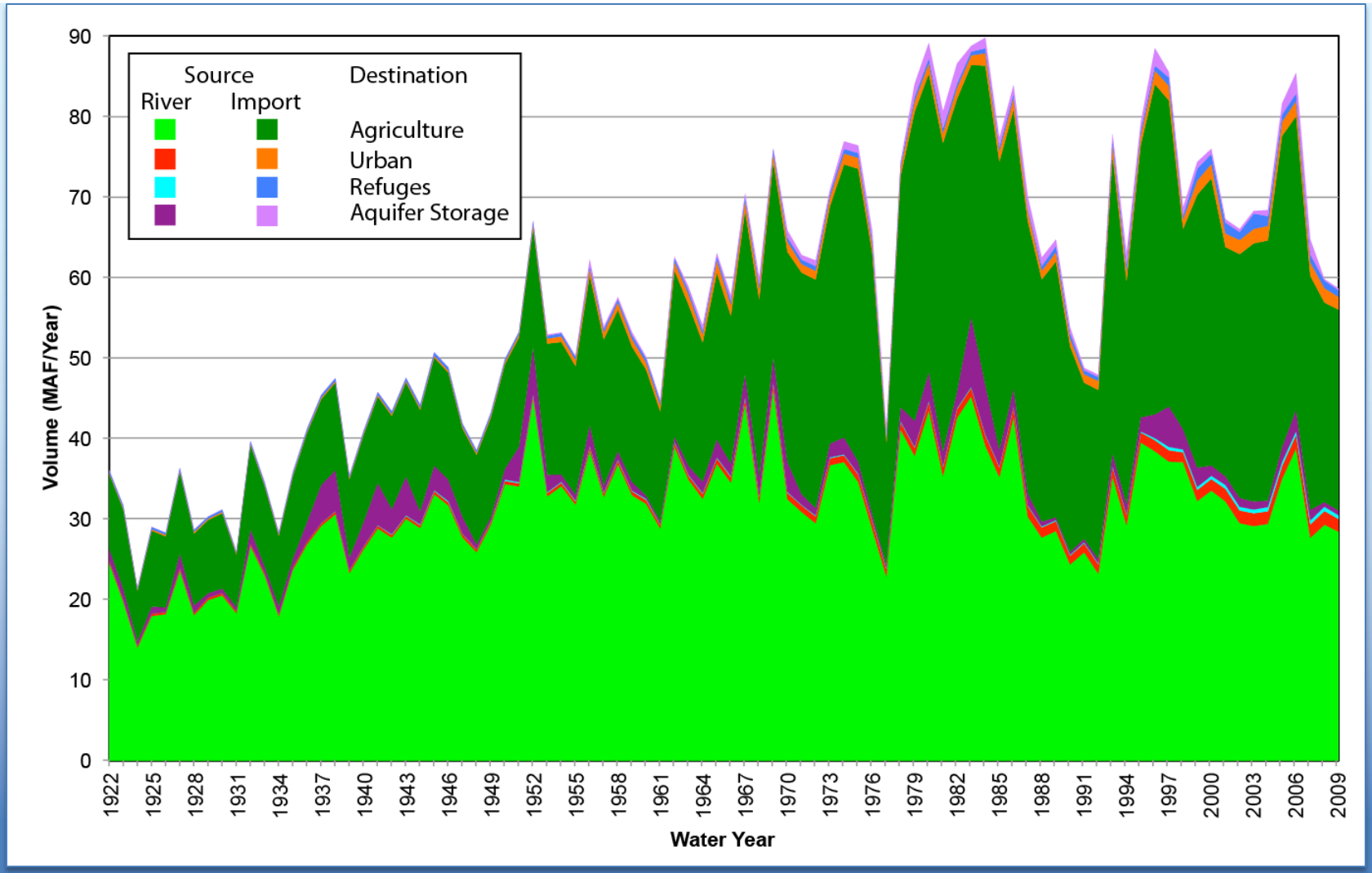
Stream Reach Budget

Column	Flow	08/31/2004	Process
Upstream Inflow (+)	IN	2,944	
Downstream Outflow (-)	OUT	781	
Tributary Inflow (+)	IN	0	SWS
Tile Drain (+)	IN	0	GW
Runoff (+)	IN	0	LS
Return Flow (+)	IN	2	LS
Gain from Groundwater (+)	+/-	-1,593	GW
Gain from Lake (+)	+/-	0	
Diversion (-)	OUT	0	LS
By-pass Flow (-)	OUT	573	
Discrepancy (=)		0.00	
Diversion Shortage		0	

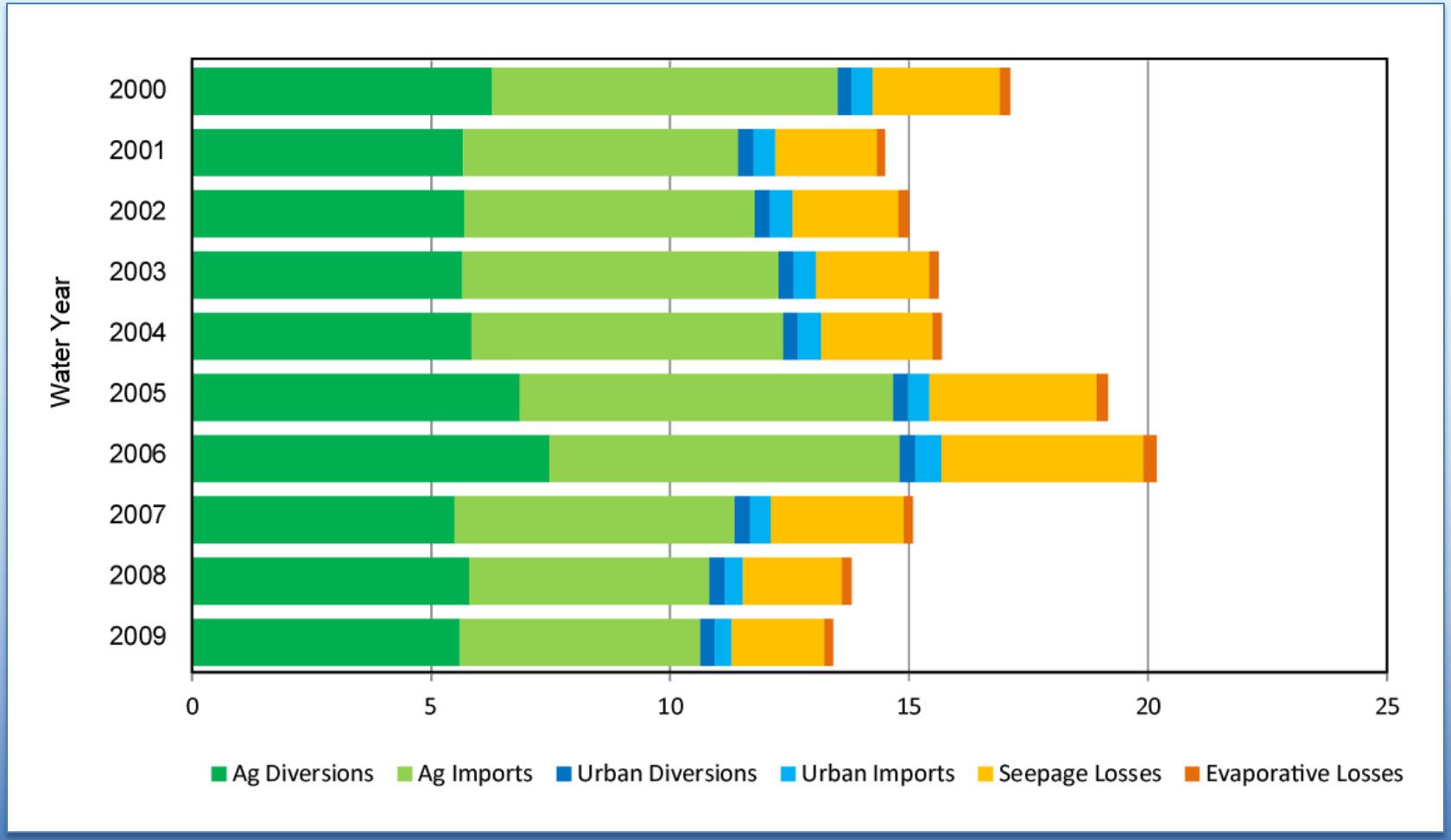
Lake Budget

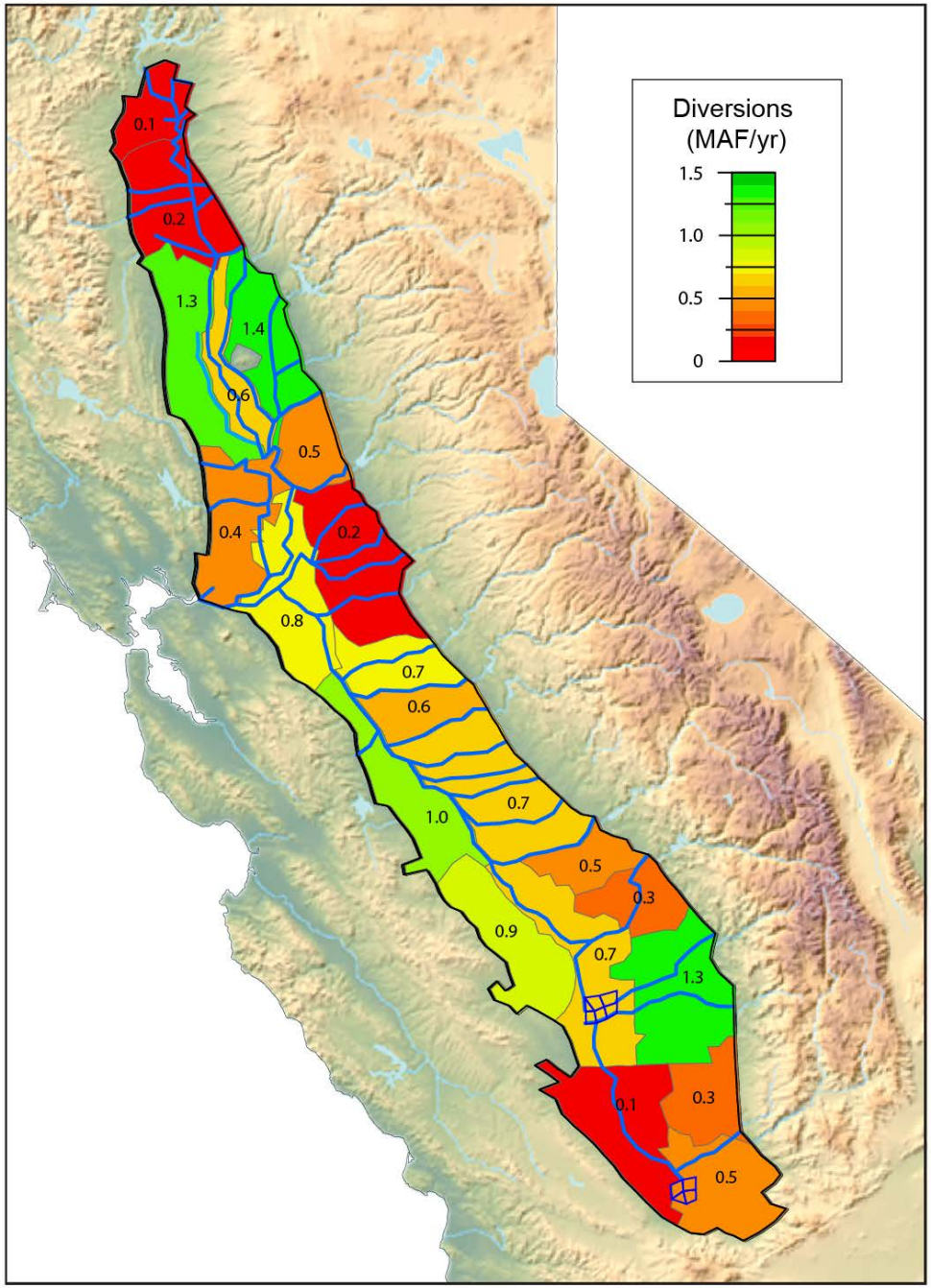
Column	Flow	08/31/2004	Process
Beginning Storage (+)		63,418	
Ending Storage (-)		51,052	
Flow from Upstream Lake (+)	IN	0	
Flow from By-passes (+)	IN	799	
Precipitation (+)	IN	0	
Gain from Groundwater (+)	+/-	1,939	GW
Lake Evaporation (-)	OUT	15,104	
Lake Outflow (-)	OUT	0	
Discrepancy (=)		0.30	
Lake Surface Elevation (FEET)		185	

Diversions & Imports



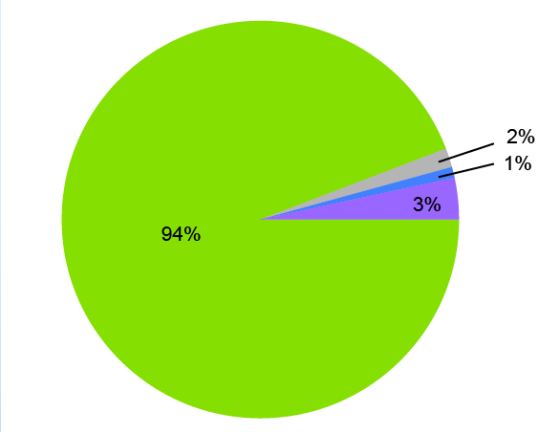
Surface Water Destinations



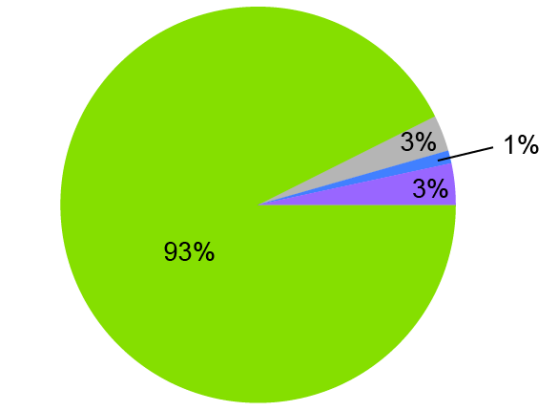

Diversions
(MAF/yr)
1.5
1.0
0.5
0
0.1
0.2
1.3
1.4
0.6
0.5
0.4
0.2
0.8
0.7
0.6
1.0
0.7
0.5
0.3
0.9
0.7
1.3
0.1
0.3
0.5

Surface Water Destinations

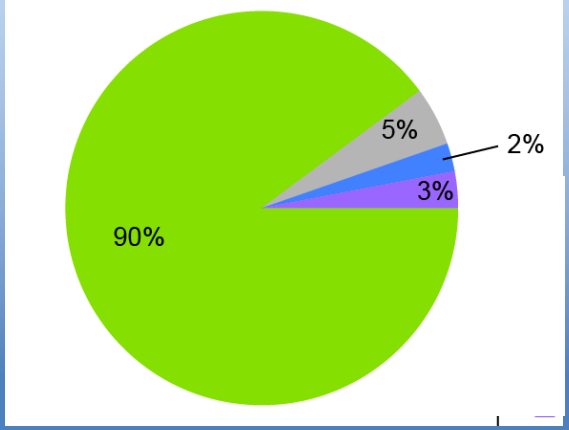
1922-1929

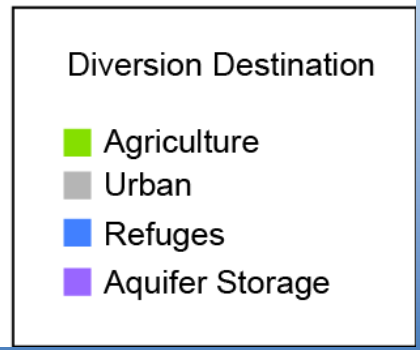


1960-1969

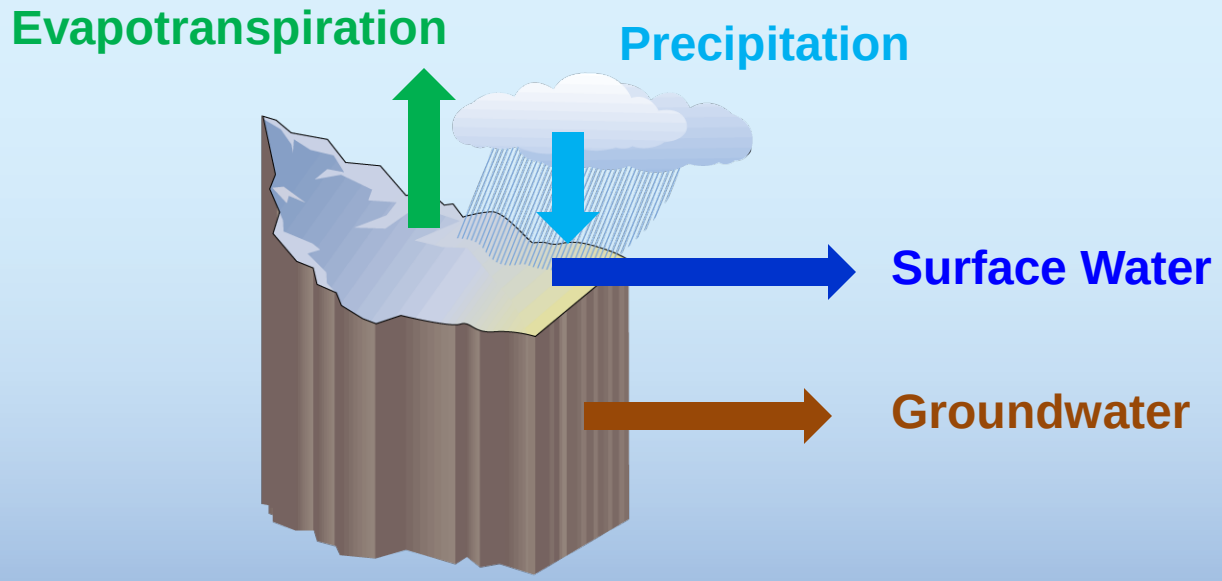


2000-2009





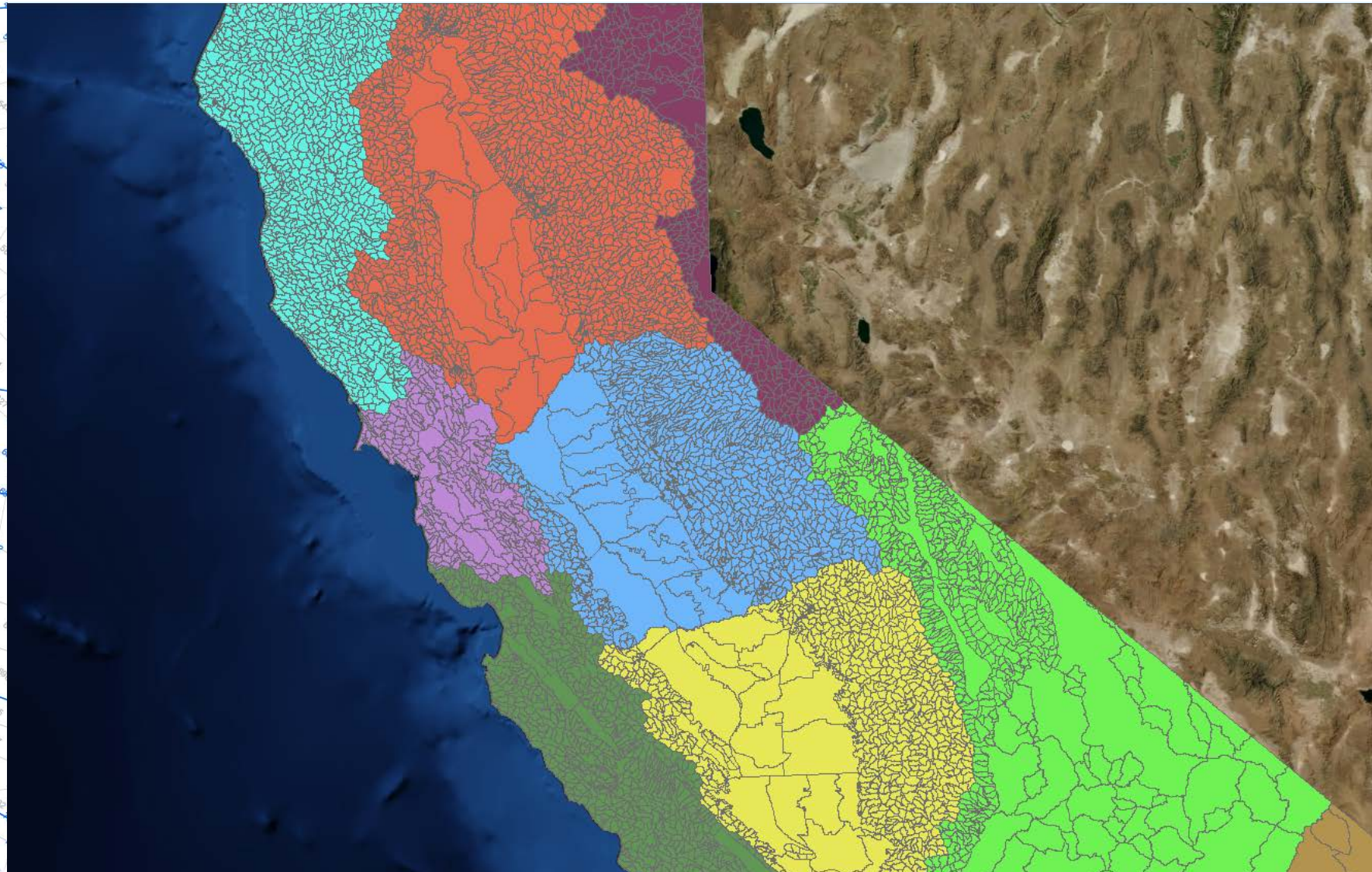
IWFM Small Watersheds



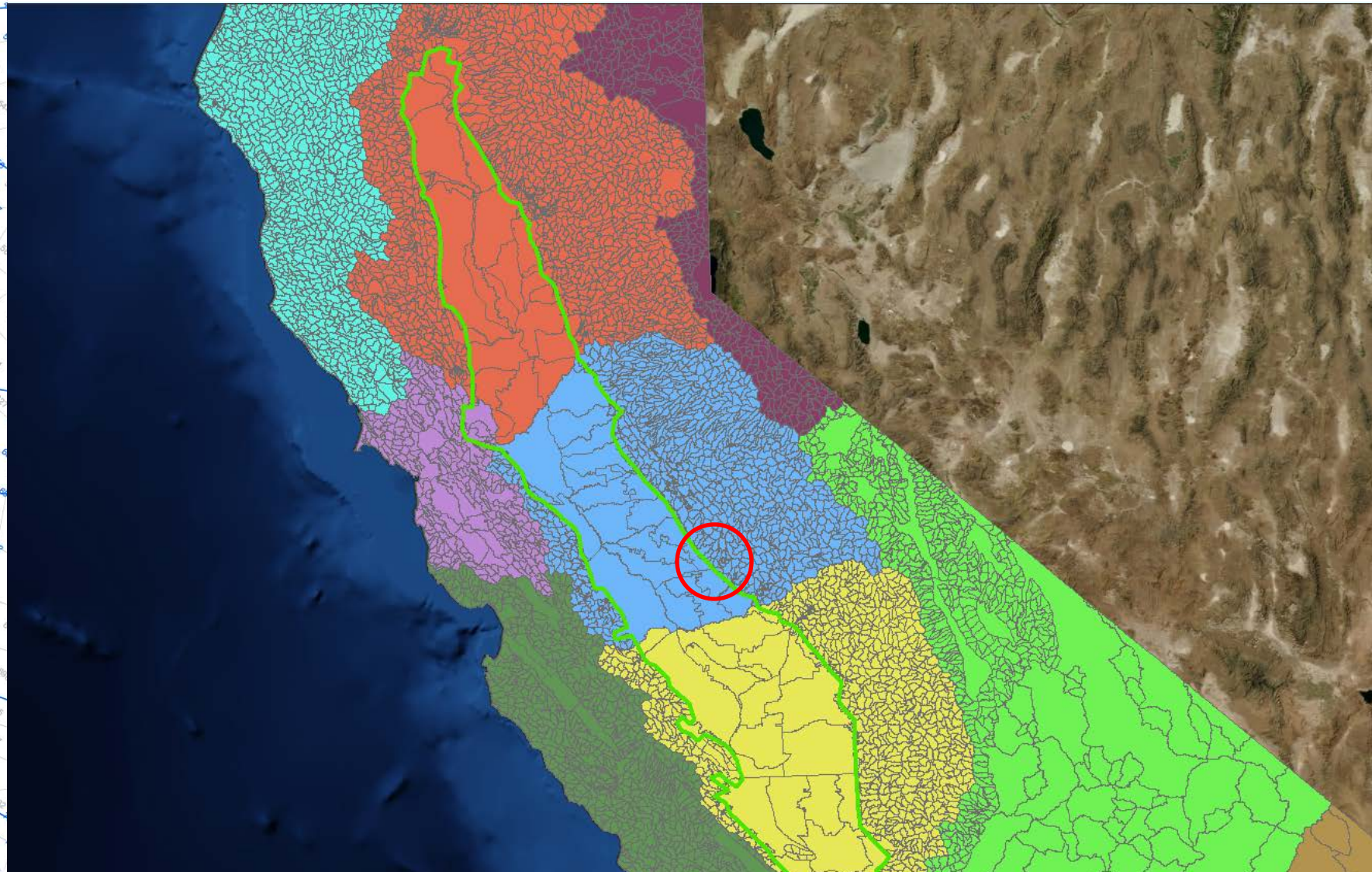
Small-Stream Watersheds

- Calculate monthly ungaged surface water inflows and groundwater inflows
- Areas and flow channels from CalWater watershed coverage
- Grouped with nearest boundary node
- Resulted in 210 small-stream watersheds
- Approximately 5% of surface water inflow

Small-Stream Watersheds

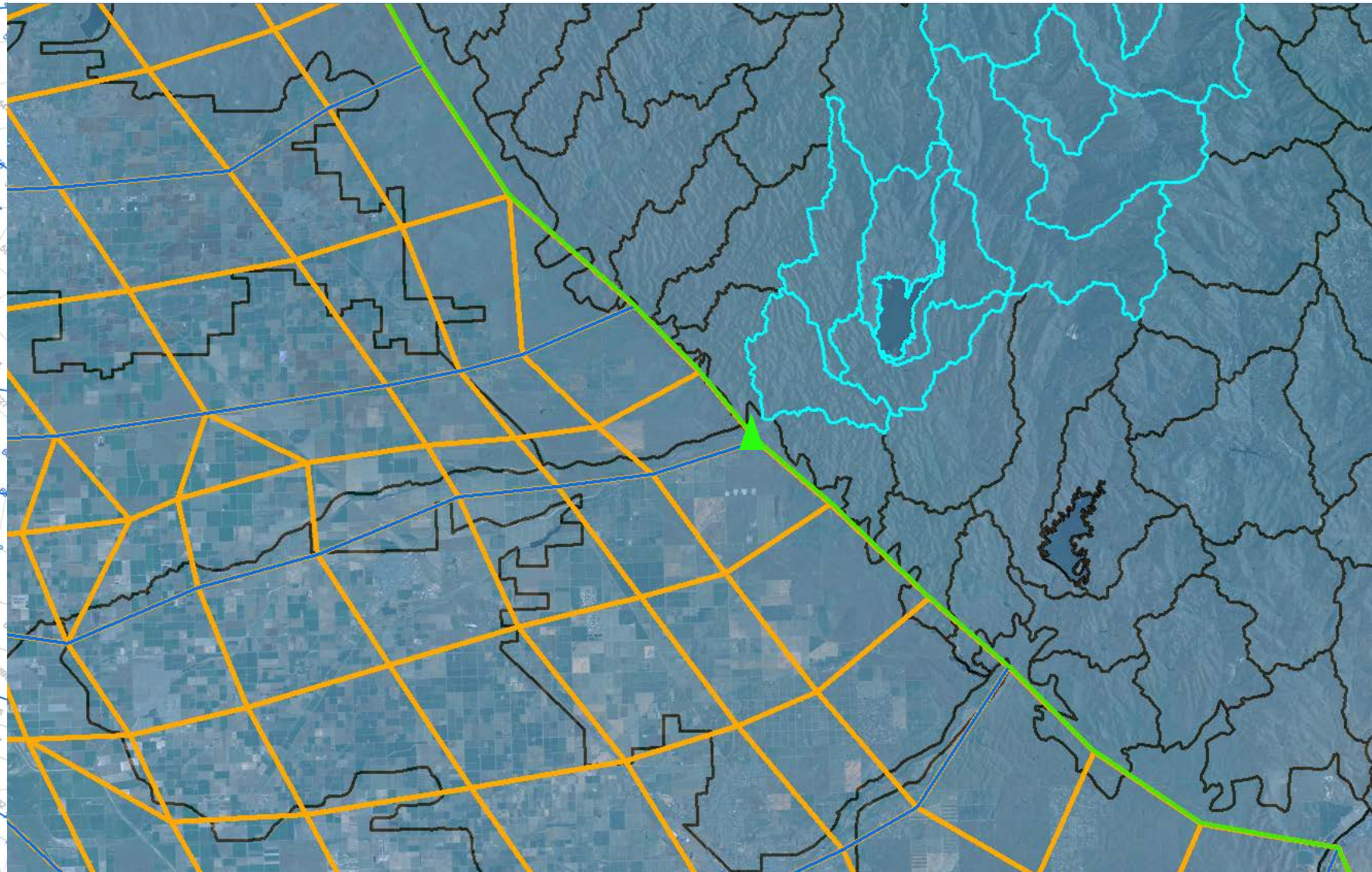


Small-Stream Watersheds



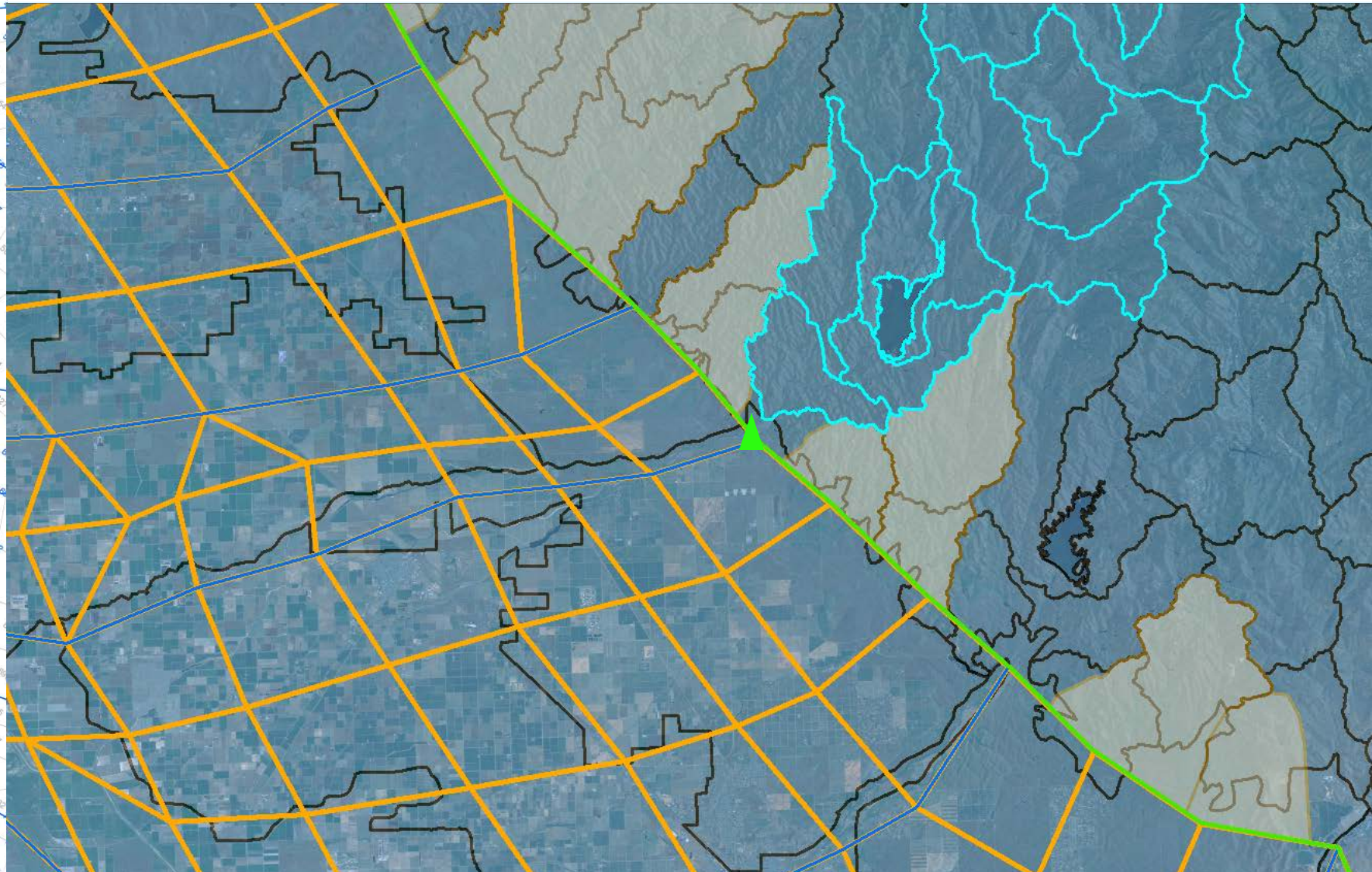
Small-Stream Watersheds

Eliminate the gaged watershed



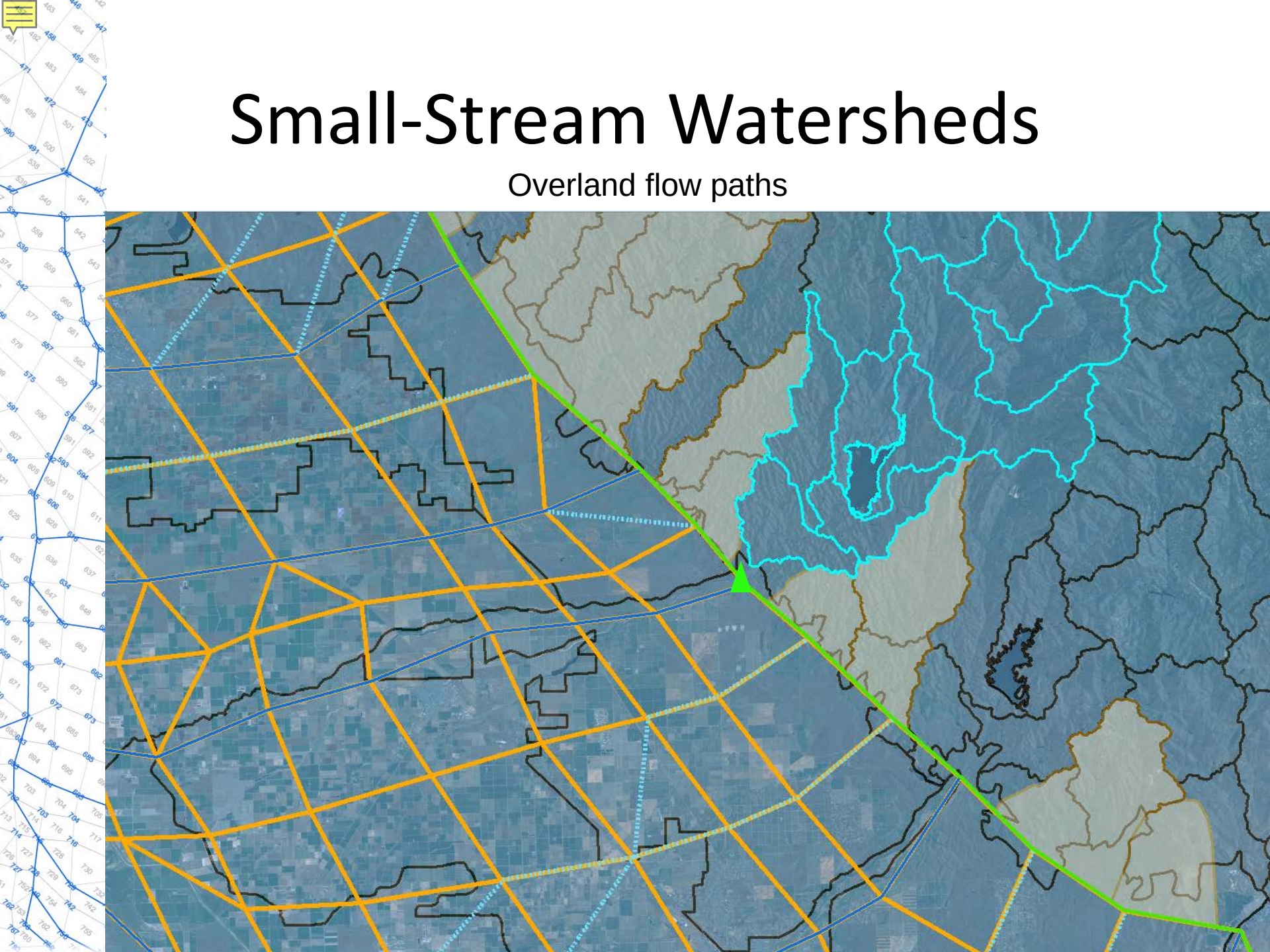
Small-Stream Watersheds

These are the ungaged watersheds



Small-Stream Watersheds

Overland flow paths



Small Watersheds

```
C*****************************************************************************
C
C          Boundary Conditions for Small Watershed Inflow Computation
C
C   NTWB  ; Number of small watersheds where inflows will be computed and specified as boundary flux
C   FACTA ; Conversion factor for small watershed drainage area
C   FACTQ ; Conversion factor for maximum recharge rate - It is used to convert only the spatial component of the unit;
C   TUNIT ; Time unit of max. recharge rate.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C
C-----------------------------------------------------------------------------
C       VALUE                   DESCRIPTION
C-----------------------------------------------------------------------------
        210                     / NTWB
        43560.0                 / FACTA  (ac --> ft^2)
        43560.0                 / FACTQ  (ac.ft/mon --> cu.ft./mon)
        1mon                    / TUNIT
C-----------------------------------------------------------------------------
C   ID    ; Small watershed identification number
C   IWBS  ; Watershed group number corresponding to the watershed parameter groups specified in the parameter data file Unit 7
C   AREAS ; Drainage area of the small watershed; [L^2]
C   IWBTS ; Stream node that receives the surface runoff from the small watershed
C   NWB   ; Number of groundwater nodes that receive the base flow and the percolation of surface flow from the small watershed
C   IWB   ; Groundwater node number small watershed baseflow is routed through
C   QMAXWB; Maximum recharge rate for each node; [L^3/T]
C           (Enter -1 to specify which groundwater node(s) receive baseflow from the small watersheds)
C
C     ID    IWBS     AREAS   IWBTS     NWB     IWB       QMAXWB
C-----------------------------------------------------------------------------
      1       1     48887     434       3    1371           -1
                                             1369     200.0000
                                             1370     200.0000
      2       2     38177     434       3    1368           -1
                                             1369     200.0000
                                             1370     200.0000
      3       3     22140     434       3    1360           -1
                                             1361     200.0000
                                             1362     200.0000
      4       4     20783     434       3    1349           -1
                                             1350     200.0000
                                             1351     200.0000
      5       5      9992     434       3    1339           -1
                                             1340     200.0000
                                             1341     200.0000
      6       6     14459     434       4    1329           -1
                                             1330     200.0000
                                             1340     200.0000
                                             1341     200.0000
      7       7     11979     434       5    1318           -1
                                             1319     200.0000
                                             1320     200.0000
                                             1321     200.0000
                                             1341     200.0000
      8       8     13309     440       3    1305           -1
```

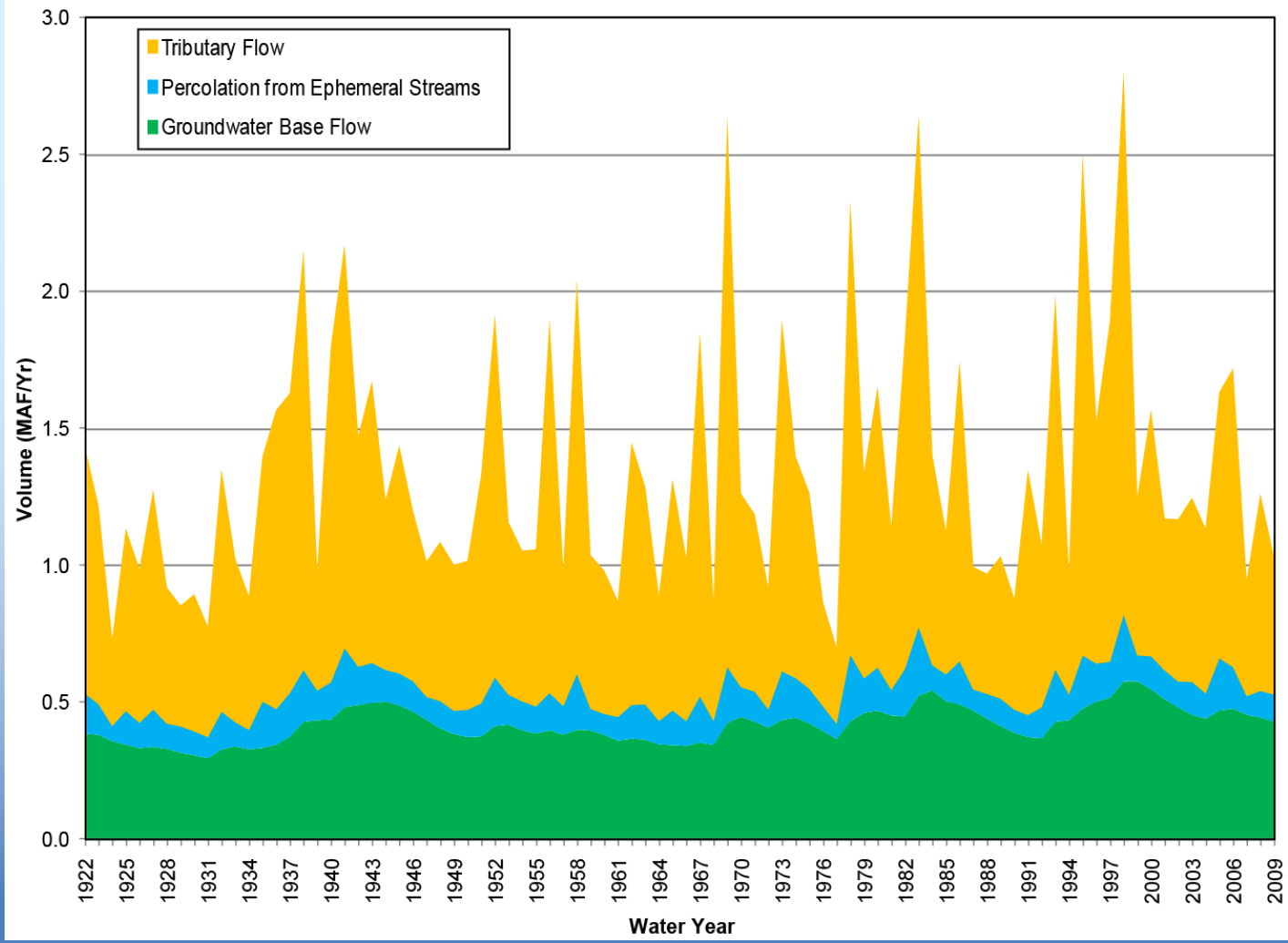
Small Watershed Parameters

```
C*************************************************************************
C                        SMALL STREAM WATERSHED DATA
C
C   The following  lists the small watershed parameters that are used in the computation of runoff from the tributary watersheds outside the model boundary.
C
C   NSW    ;   Number of small watershed groups
C   FACTL  ;   Conversion factor for root zone depth and groundwater threshold value
C   FACTK  ;   Conversion factor for hydraulic conductivity
C   TUNITK;    Time unit of hydraulic conductivity.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C   FACTT  ;   Conversion factor for recession coefficients
C   TUNITT;    Time unit of recession coefficients.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C
C-------------------------------------------------------------------------
C   VALUE                 DESCRIPTION
C-------------------------------------------------------------------------
    210                   / NSW
    1.00000               / FACTL
    1.00000               / FACTK
    1day                  / TUNITK
    1.00000               / FACTT
    1mon                  / TUNITT
C-----------------------------------------------------------------------------------------------------------
C   IS     ;   Small watershed group identification number
C   IRNS   ;   Rainfall station number associated with the small watershed
C   FRNS   ;   Rainfall weighting factor for the small watershed
C   FLDCAS;    Field capacity; [L/L]
C   TPOROS;    Total porosity; [L/L]
C   CROOT  ;   Root zone depth of native vegetation in the small watershed; [L]
C   SOILKS;    Hydraulic conductivity of the root zone; [L/T]
C   CN     ;   Curve number for small watershed area
C              (Reference: USDA, 1985)
C   GWSOS  ;   Threshold value of groundwater depth above which groundwater
C                 storage of small watershed contributes to surface runoff; [L]
C   SWKS   ;   Recession coefficient for surface outflow; [1/T]
C   GWKS   ;   Recession coefficient for base flow; [1/T]
C
C IS    IRNS    FRNS    FLDCAS  TPOROS  CROOT   SOILKS  CN      GWSOS   SWKS    GWKS
C-----------------------------------------------------------------------------------------------------------
1       1393    1       0.109   0.235   6.2     6.43    65.0    9.99    0.1000  0.01044
2       1394    1       0.073   0.236   6.2     2.75    72.0    9.99    0.1000  0.01044
3       1395    1       0.006   0.139   4.0     7.51    97.7    10.00   0.1000  0.01000
4       1396    1       0.022   0.150   4.0     7.85    97.7    10.00   0.1000  0.01000
5       1397    1       0.043   0.173   4.0     7.82    98.9    10.00   0.1000  0.01000
6       1398    1       0.102   0.231   4.0     7.29    97.7    10.00   0.1000  0.01000
7       1399    1       0.153   0.273   4.0     4.20    94.0    10.00   0.1000  0.01000
8       1400    1       0.202   0.309   4.0     2.47    84.1    10.00   0.1000  0.01000
9       1401    1       0.214   0.333   4.0     2.83    86.6    10.00   0.1000  0.01000
10      1402    1       0.250   0.383   4.0     3.03    94.0    10.00   0.1000  0.01000
11      1403    1       0.217   0.351   4.0     4.45    94.0    10.00   0.1000  0.01000
12      1404    1       0.283   0.427   4.0     2.72    92.8    10.00   0.1000  0.01000
13      1405    1       0.291   0.440   4.0     2.66    79.2    10.00   0.1000  0.01000
```

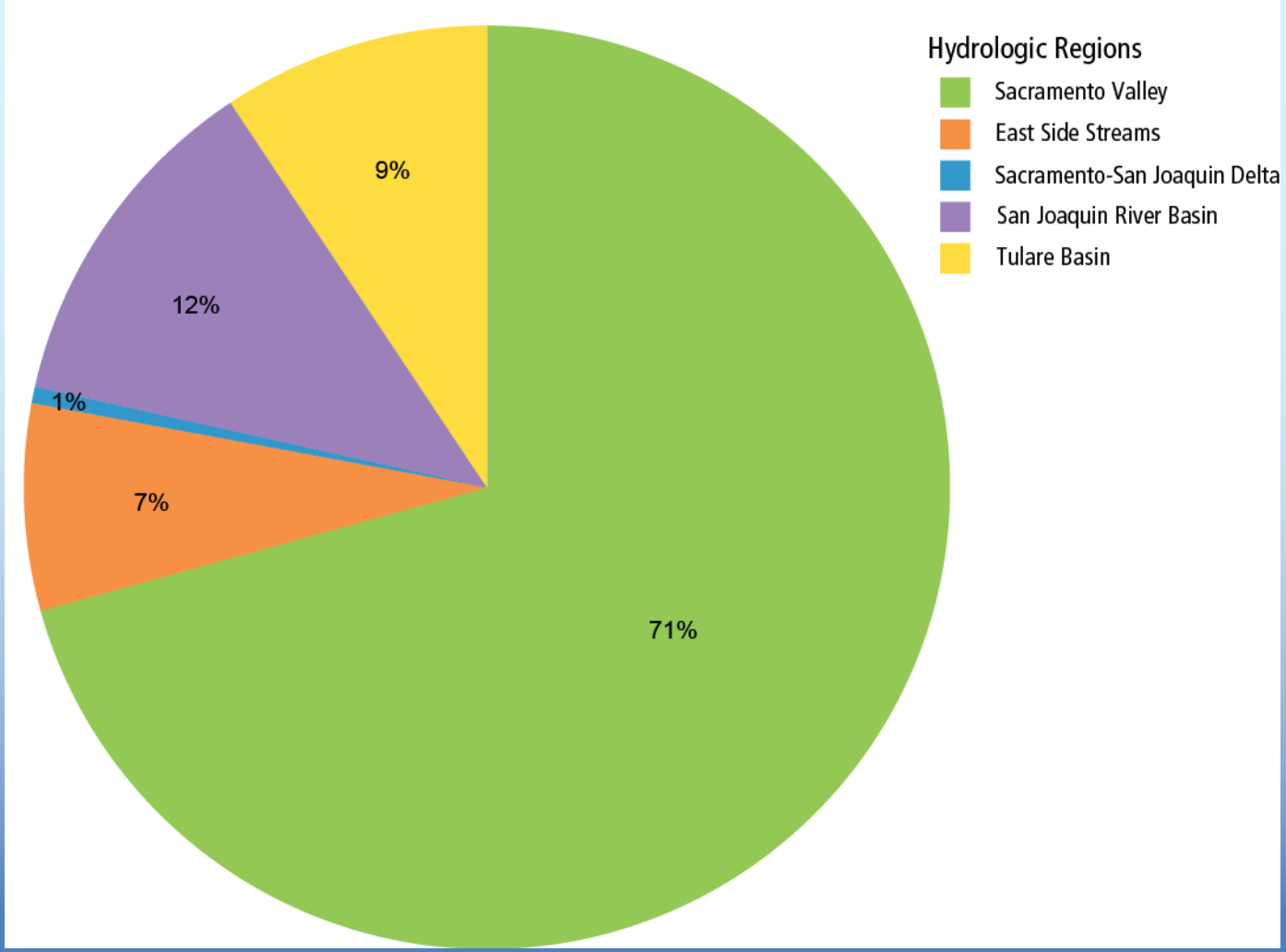
Small Watershed Budget

Column	Flow	08/31/2004	Process
Total SW Outflow	OUT	6,049	
GW Base Outflow	OUT	90,386	
Base Flow + Surface Percolation	OUT	90,456	
Net Surface Outflow to Streams	OUT	5,979	

Small-Watershed Inflows



Small Watershed Inflows



END