The California Central Valley Groundwater-Surface Water Simulation Model

C2VSim Overview

CWEMF C2VSim Workshop

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Outline

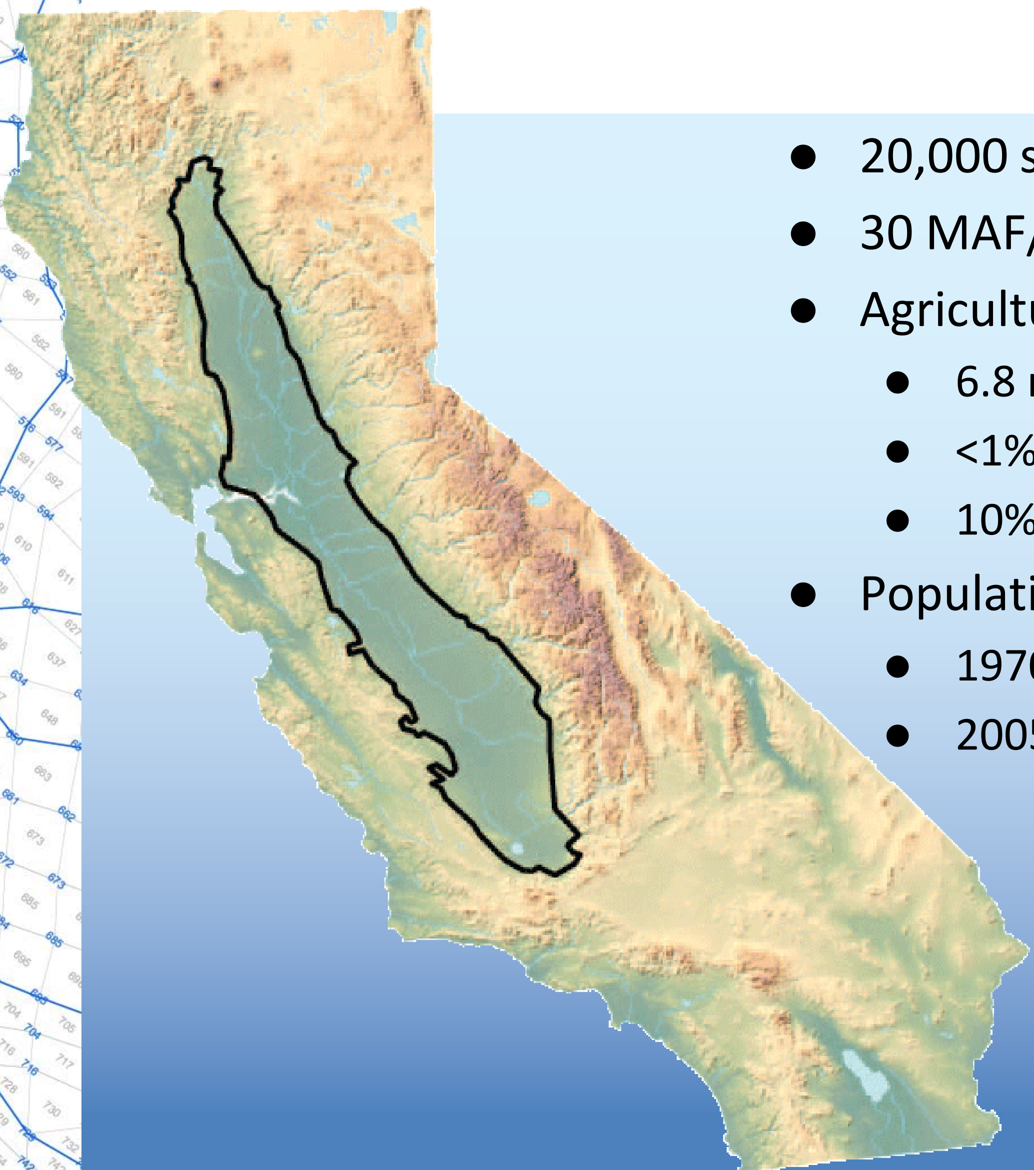
Background and Development History

C2VSim Framework

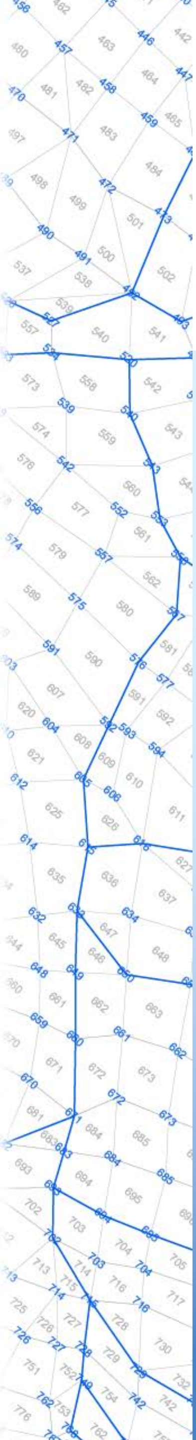
Coarse-Grid and Fine-Grid Versions

Future Directions

California's Central Valley



- 20,000 sq. mi. (55,000 sq. km.)
- 30 MAF/yr Surface Water Inflow
- Agricultural Production
  - 6.8 million acres (27,500 sq. km)
  - <1% of US farm land
  - 10% of US crops value in 2002
- Population Growth
  - 1970: 2.9 million
  - 2005: 6.4 million
- Groundwater Pumping
  - ~9 MAF in 2002
  - 10-18% if US pumping
  - Not measured or regulated



C2VSim Development

Derived from the CVGSM model

- WY 1922-1980 Boyle & JM Montgomery (1990)
- WY 1981-1998 CH_2M Hill for CVPIA PEIS

Steady modification

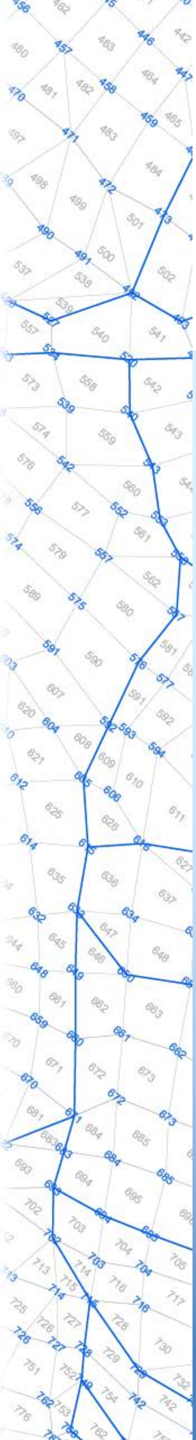
- DWR IWFM/C2VSim development began in 2000
- IWFM process and solver improvements
- C2VSim data sets reviewed and refined
- C2VSim input data extended through WY 2009

Calibration

- PEST parameter estimation program
- Three phases: Regional, Local, Nodal
- Calibration Period: WY 1973-2003 in phases 1 & 2, 1922-2004 in phase 3

Release

- C2VSim 3.02-CG released December 2012, updated June 2013
- C2VSim 3.02-FG expected in 2014



C2VSim Applications

- CalSim 3 groundwater component
- Integrated Regional Water Management Plans
- Stream-groundwater flows
- Climate change assessments
- Groundwater storage investigations
- Planning studies
- Ecosystem enhancement scenarios
- Infrastructure improvements
- Impacts of operations on Delta flows

C2VSim Versions

C2VSim CG 3.02 (R374): Release Version

- Current version, released June 2013
- Water Years 1922-2009, monthly time step
- IWFM version 3.02

C2VSim FG 3.02 (R374): Draft Version

- Based on C2VSim 3.02 CG
- Refine rivers, inflows, land use
- Upgrade to match CG version before release
- Expected release in 2014

Planned Improvements

- C2VSim 3.02 CG/FG: Extend to WY 2011 or 2012
- C2VSim 4 FG: Element-level land use, crop and diversion data

Steady Improvement of C2VSim

R375: September 2013

- Make the supply adjustment flags easier to use

R376: November 2013

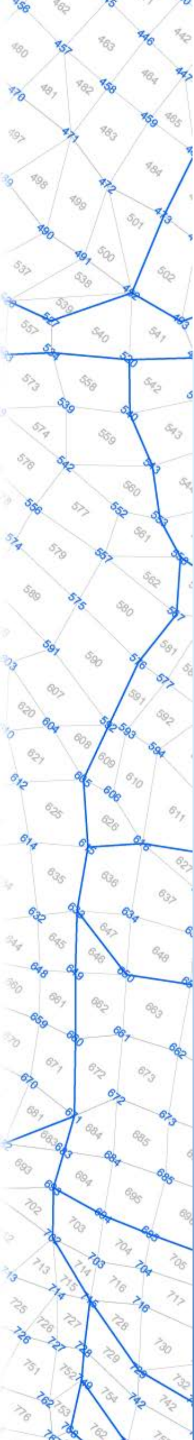
- Modify irrigation schedules in subregions 15-17
- Modify curve numbers in small watersheds 103-114
- Add M&I imports from Placer Co Water Agency
- Make irrigation fraction flags easier to use

R377: April 2014

- Remove ASR at end of the Tule & Kaweah Rivers
- Limit ASR on the Kern River Flood Channel to 1,000 cfs

R378: April 2014

- Modify basement altitude between Merced and Los Banos to match base of fresh water



C2VSim Coarse Grid

"C2VSim CG-3.02"

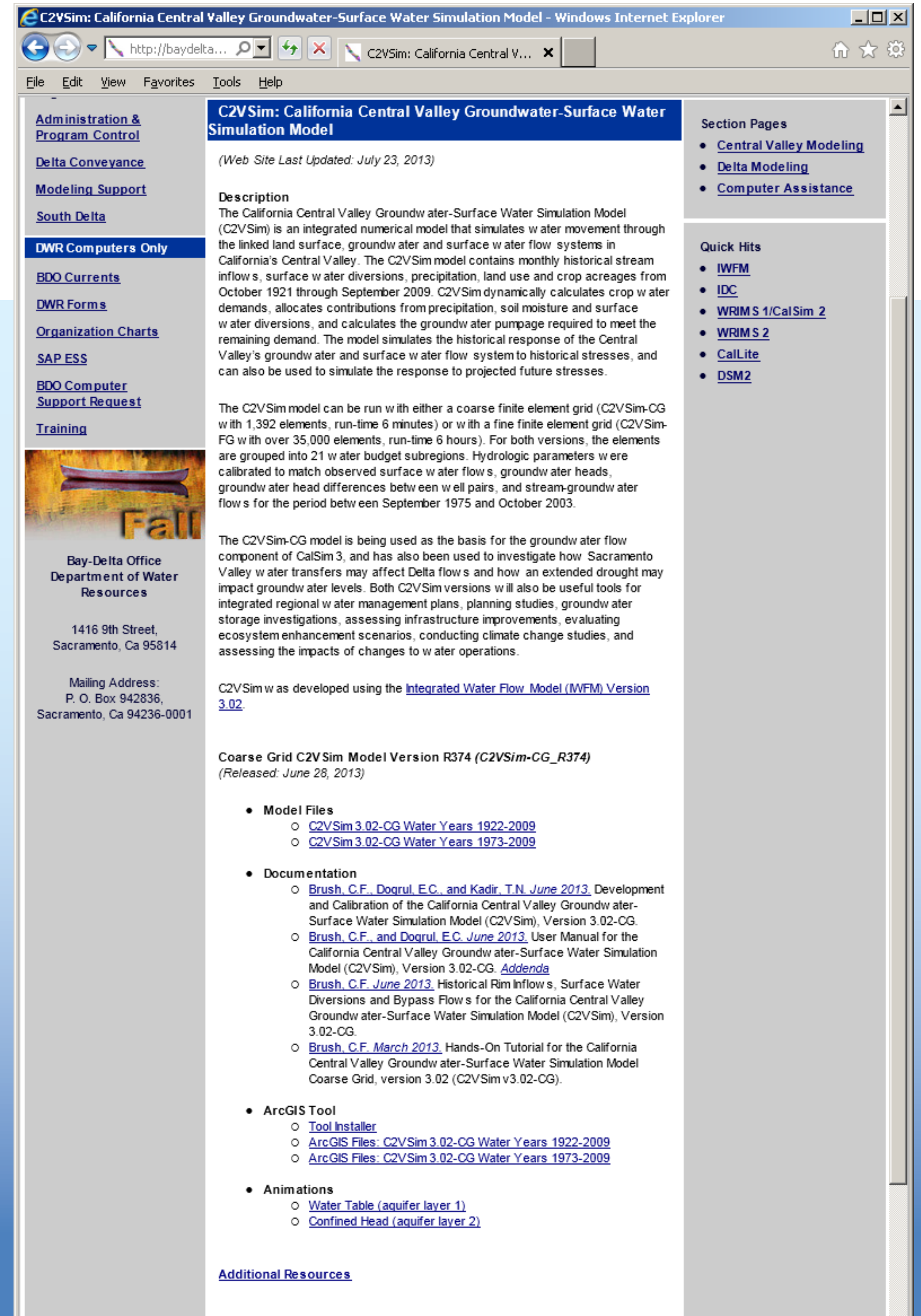
DWR Web Site

- Model files
- Documetation
- C2VSim ArcGIS GUI
- IWFM Application
- IWFM Tools

Support

- **Training**: IWFM and C2VSim workshops will be offered through CWEMF
- **Technical support**: Email and telephone

A Google search for "C2VSim" brings up this page

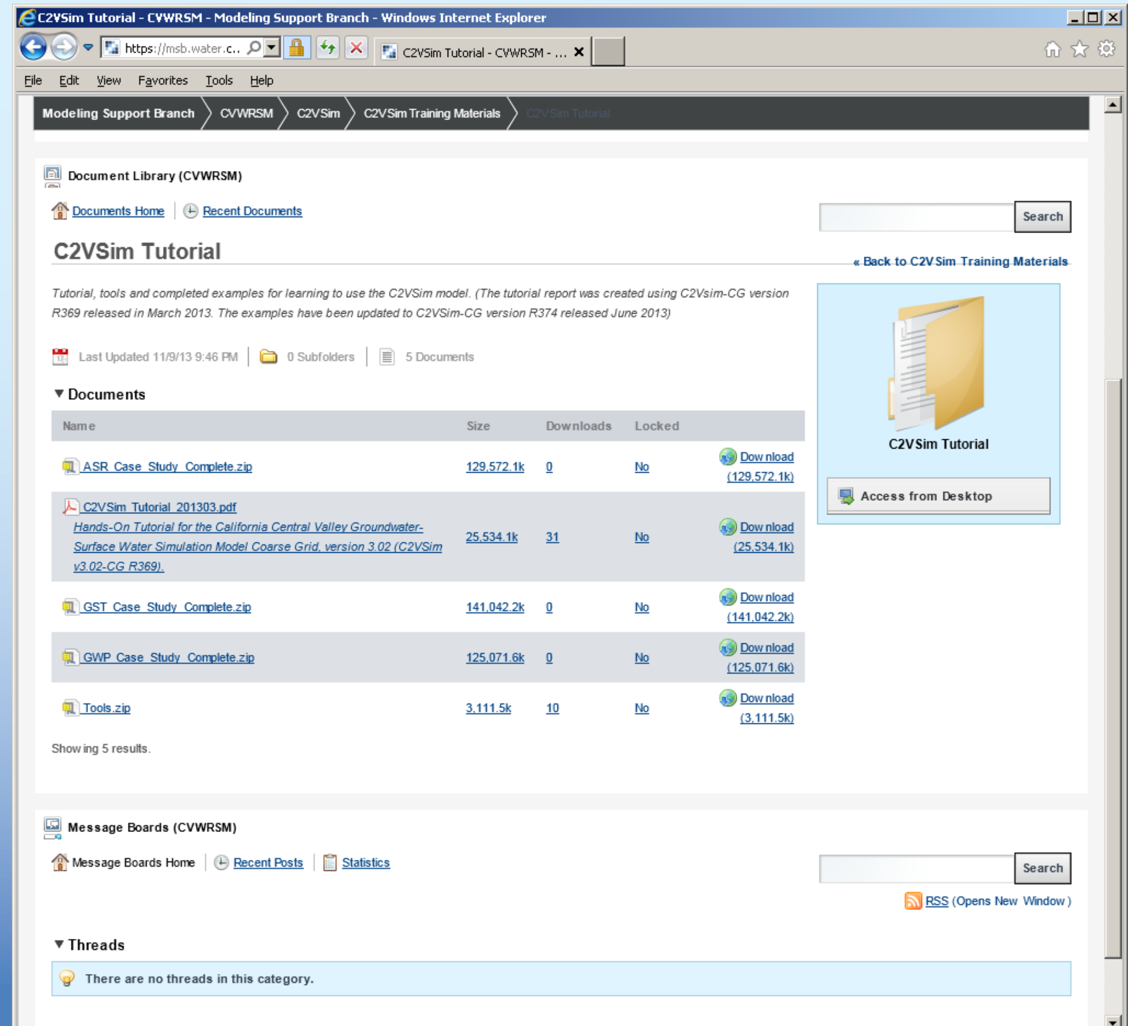


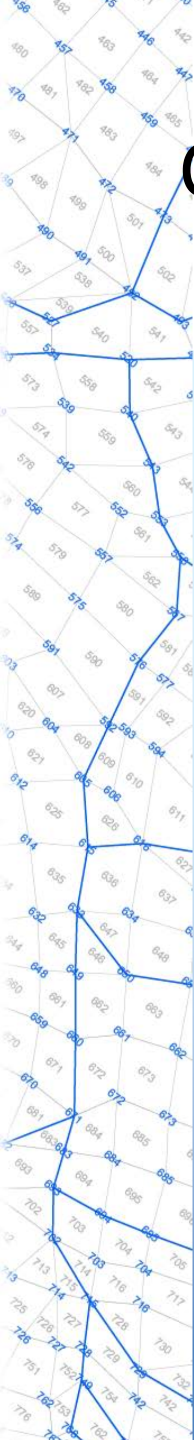
C2VSim Portal

Additional Tools tab on C2VSim page

Interactive Web Site

- Tutorial Files
- Project Files
- Collaboration
- Message Board
- User/Password for additional access





C2VSim Coarse-Grid

"C2VSim CG-3.02"

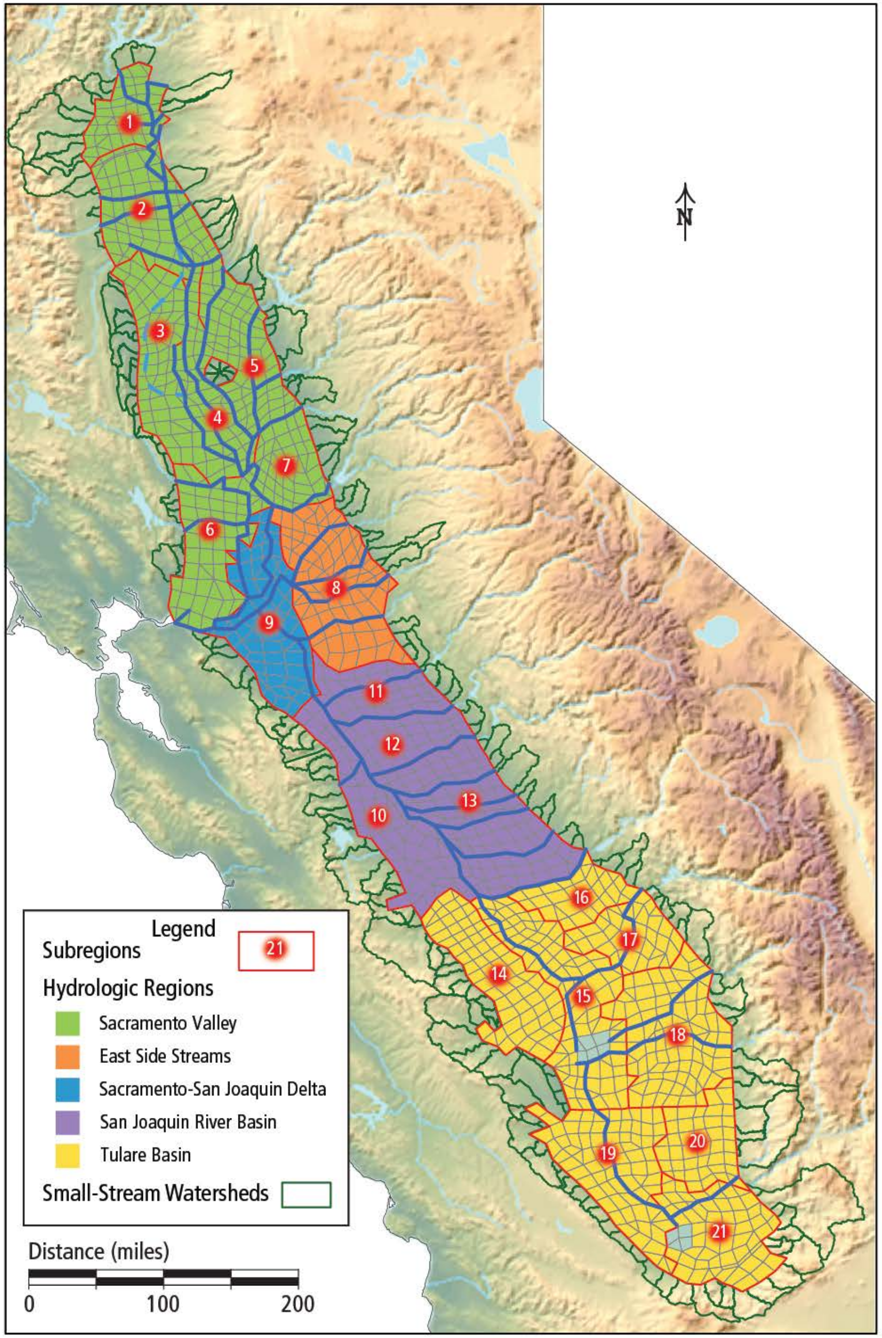
Finite Element Grid
- 3 Layers or 9 Layers
- 1393 Nodes & 1392 Elements

Surface Water System
- 75 River Reaches, 2 Lakes
- 243 Surface Water Diversions
- 38 Inflows, 11 Bypasses
- 210 Small-Stream Watersheds

Land Use Process
- 21 Subregions (DSAs)
- 4 Land Use Types

Simulation periods
- 10/1921-9/2009 (88 yrs)
- runs in 3-6 min

IWFM version 3.02

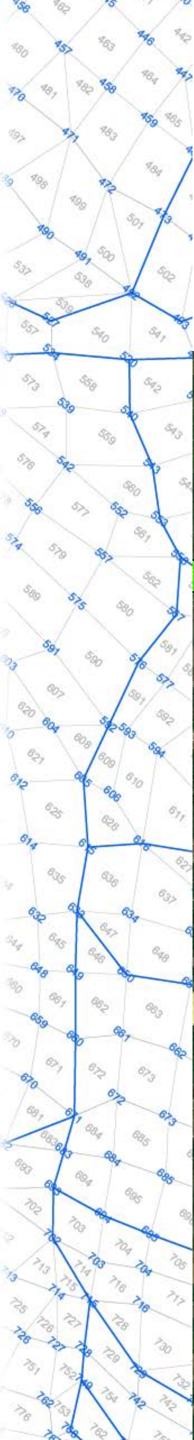


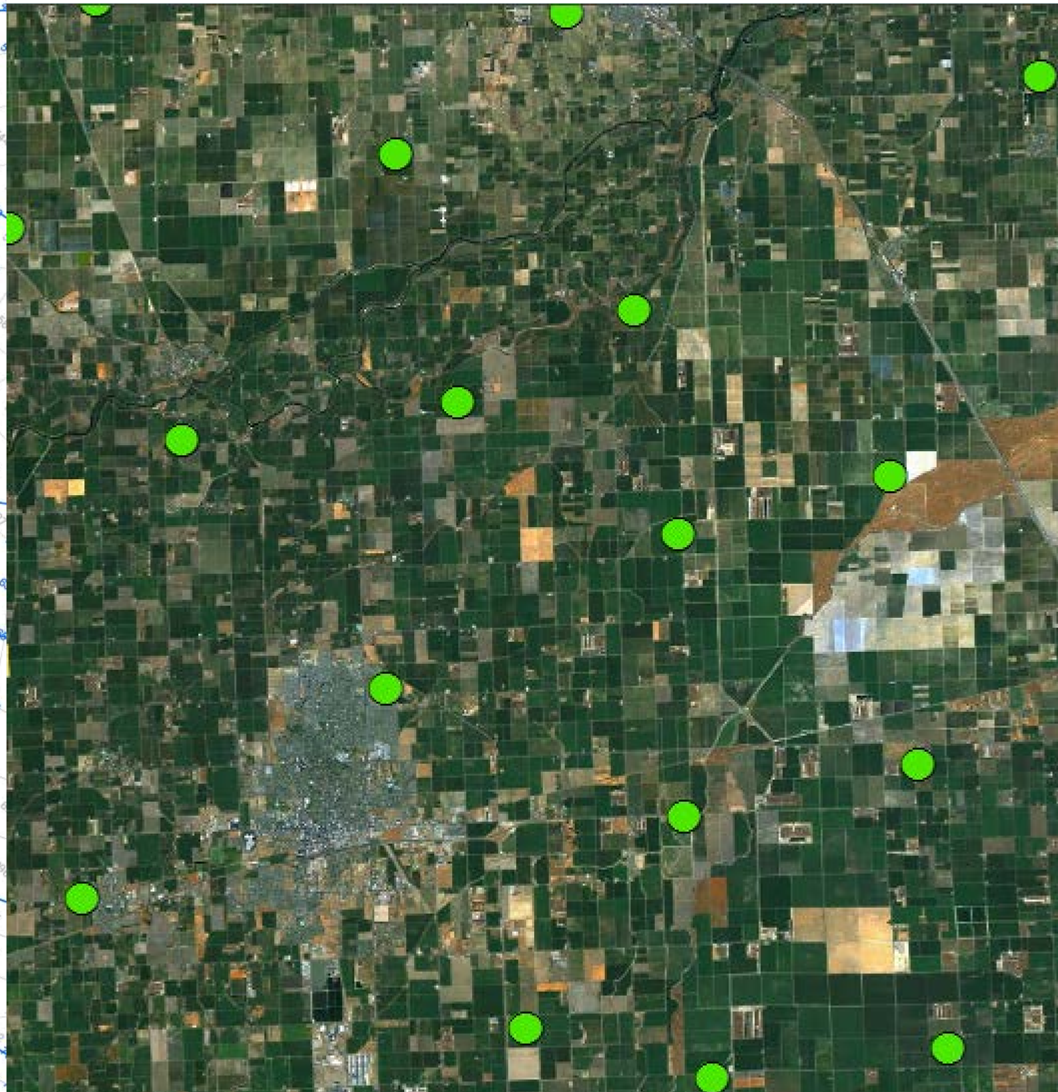
C2VSim Framework

Pre-processor

- Nodal coordinates
- Nodes form elements
- Vertical aquifer stratigraphy
- Lakes
- River nodes
- River reaches & flow network
- Element properties
- Pumping wells
- Assign elements to subregions

Nodes





X-Y Grid

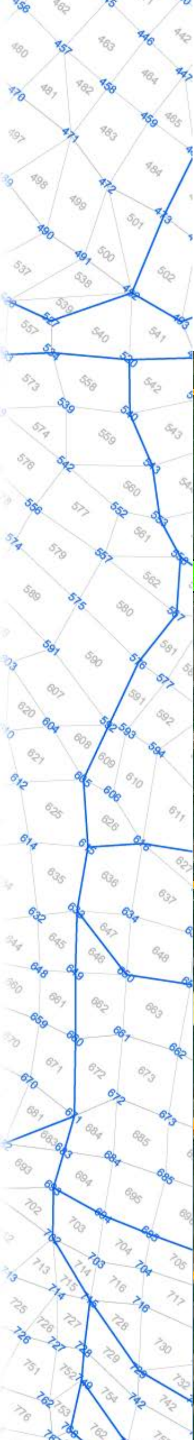
- UTM 10N
- X = Easting
- Y = Northing

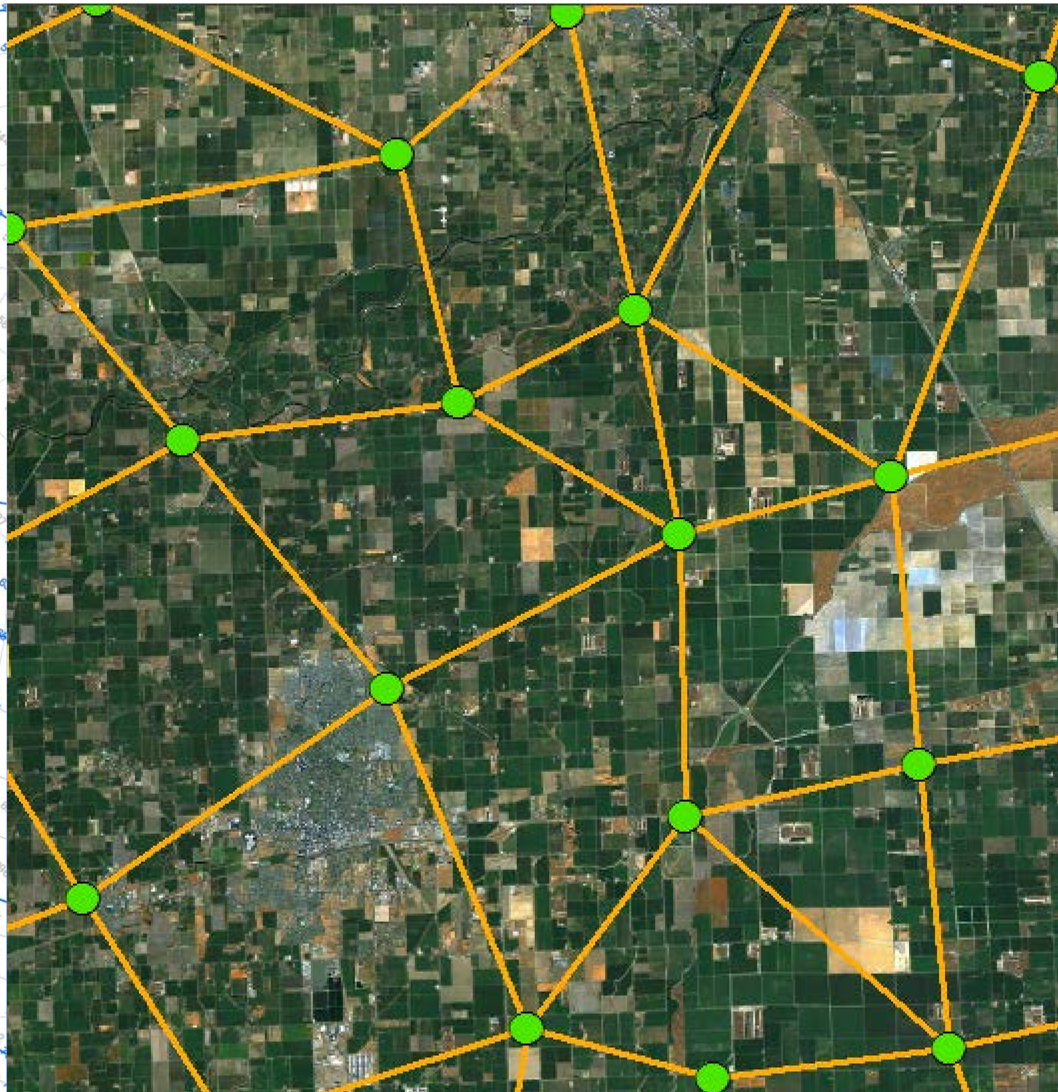
Convert to FT

- FACT = 3.2808

```
C*******************************************************************
C                    Groundwater Node Specifications
C
C    ND;     Number of groundwater nodes
C    FACT;   Conversion factor for nodal coordinates
C-------------------------------------------------------------------
C    VALUE                            DESCRIPTION
C-------------------------------------------------------------------
   1393                                  /ND
   3.2808                                /FACT
C-------------------------------------------------------------------
C*******************************************************************
C                      Groundwater Node Locations
C    The following lists the node number and x & y coordinate of
C
C    ID;    Groundwater node number
C    X,Y;   Coordinates of groundwater node location; [L]
C
C-------------------------------------------------------------------
C    Node     ----------Coordinates----------
C     ID             X                 Y
C-------------------------------------------------------------------
      1          551396.4          4496226
      2          555618.8          4497861
      3          561555.5          4500441
      4          568374.3          4498058
      5          553186.9          4492706
      6          558611.6          4492797
      7          566864.0          4493337
      8          548989.2          4487360
      9          553710.4          4488293
     10          559339.9          4488690
     11          566095.7          4489966
     12          576267.3          4488069
     13          539084.8          4481476
```

Elements





Finite Element Mesh

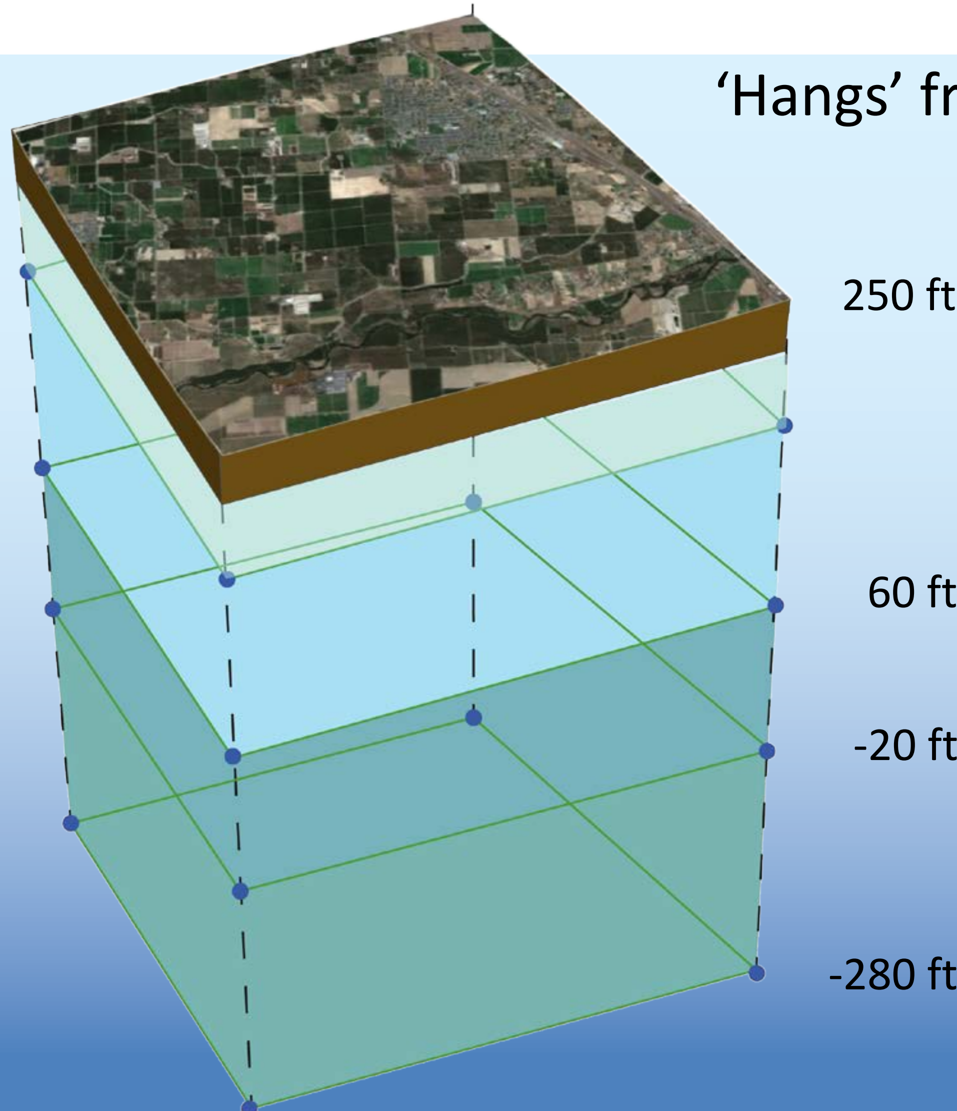
- 4 nodes = quadrilateral
- 3 nodes = triangle

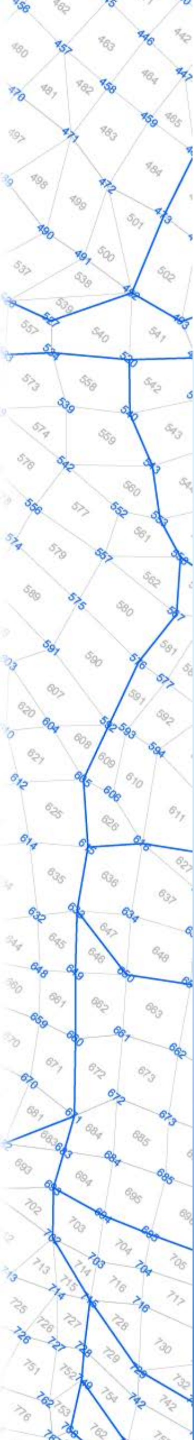
1392 elements

```
C*****************************************************************
C                 Element Configuration Data
C
C    NE;     Number of elements within the model domain
C-----------------------------------------------------------------
C   VALUE                          DESCRIPTION
C-----------------------------------------------------------------
     1392                           /NE
C-----------------------------------------------------------------
C*****************************************************************
C
C   The data listed below represents all elements and correspo
C   within the model domain.
C
C   IE;       Element number
C   IDE;      Nodes corresponding to each element
C             *Note* IDE(4) is zero for all triangular elements
C
C-----------------------------------------------------------------
C   Element      ------------Corresponding Nodes---------------
C   IE           IDE(1)        IDE(2)        IDE(3)        IDE(4)
C-----------------------------------------------------------------
       1            1             8             9             5
       2            1             5             6             2
       3            2             6             7             3
       4            3             7             4             0
       5            5             9            10             6
       6            6            10            11             7
       7            8            14            15             9
       8            9            15            16            10
       9           10            16            17            11
      10           11            17            18            12
      11           13            19            20            14
      12           14            20            21            15
      13           15            21            22             0
```

Stratigraphy

‘Hangs’ from Ground Surface





Stratigraphy

At each node:

Land Surface Elevation

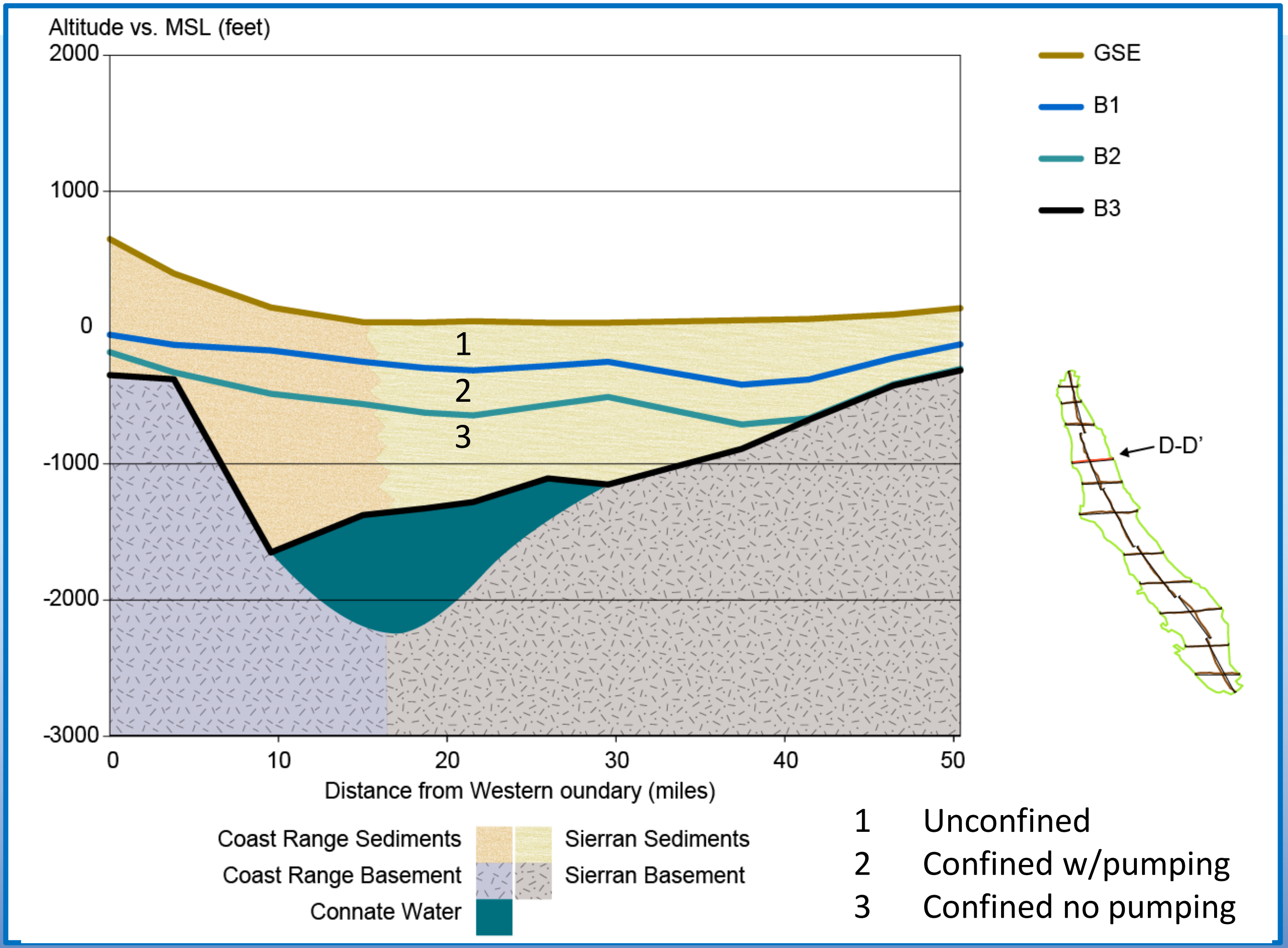
For each layer

- Aquiclude thickness
- Aquifer thickness

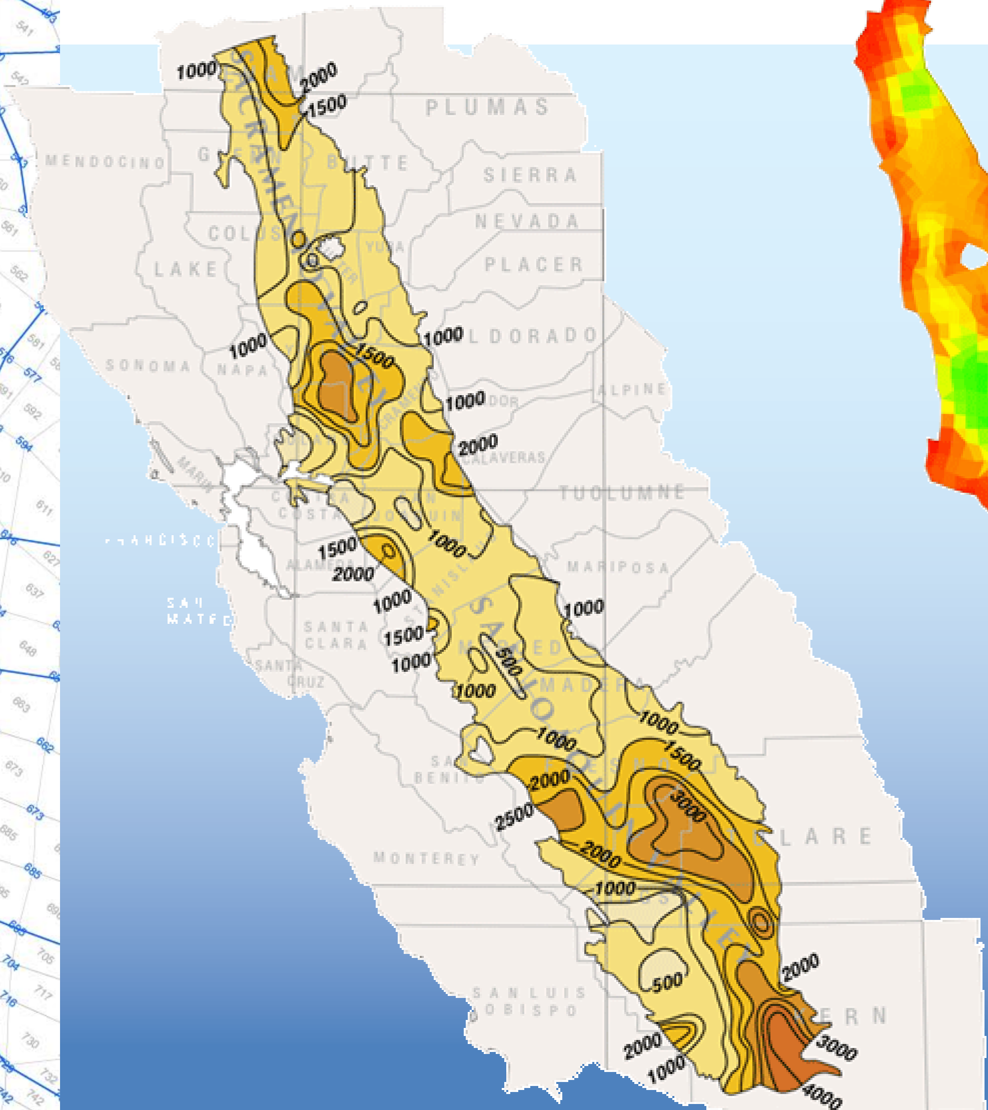
```
C*****************************************************************************
C                   Stratigraphy Specification Data
C
C   NL;     Number of layers to be modeled
C   FACT;   Conversion factor for stratigraphic data
C-----------------------------------------------------------------------------
C   VALUE                            DESCRIPTION
C-----------------------------------------------------------------------------
     3                                /NL
     1                                /FACT
C-----------------------------------------------------------------------------
```

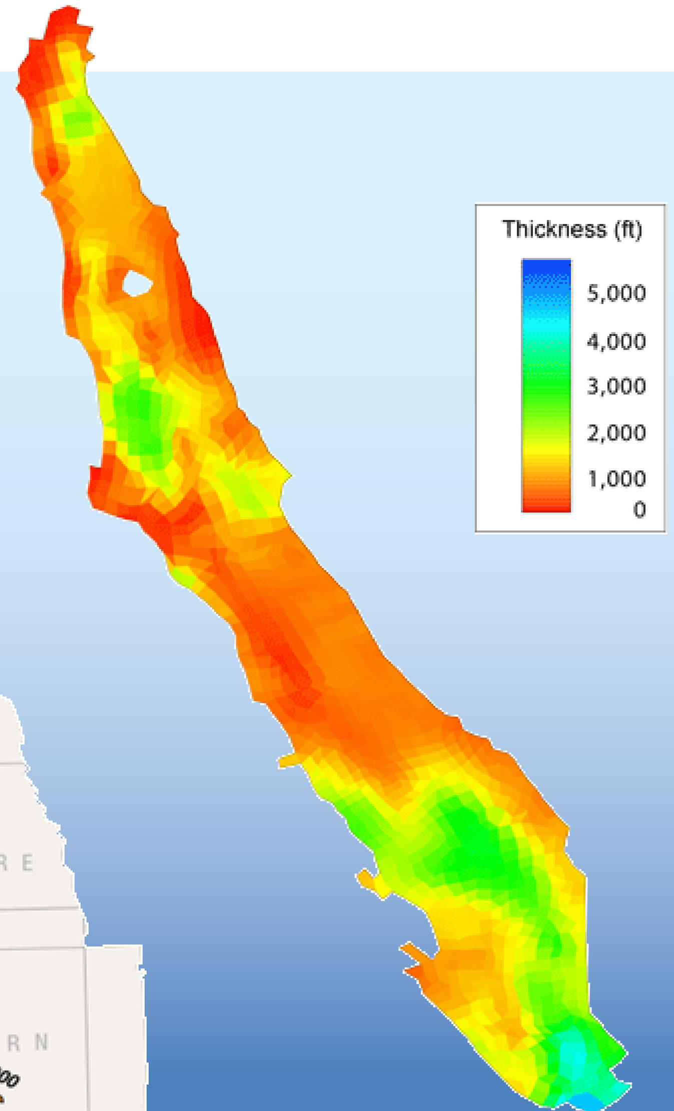
```
C---------------------------------------------------------------------
C     Node  Elevation     --Layer #1--     --Layer #2--     --Layer #3--
C      ID      ELV        W(1)     W(2)    W(3)    W(4)     W(5)     W(6)
C---------------------------------------------------------------------
         1      733          0      243       0     100        0      100
         2      695          0      245       0     100        0      100
         3      705          0      235       0     100        0      100
         4      732          0      282       0     100        0      100
         5      463          0       89       0     133        0      134
         6      590          0      186       0     134        0      133
         7      705          0      334       0     133        0      134
         8      613          0      213       0     100        0      100
         9      455          0      133       0     133        0      133
        10      554          0      296       0     178        0      179
        11      460          0      168       0     143        0      144
        12      800          0      326       0     134        0      134
        13     1056          0      606       0     100        0      100
        14      795          0      345       0     100        0      100
        15      418          0      144       0     163        0      164
        16      496          0      317       0     235        0      236
        17      499          0      340       0     248        0      249
        18      777          0      474       0     167        0      166
        19      885          0      305       0     100        0      130
        20      818          0      314       0     133        0      134
        21      599          0      326       0     198        0      198
        22      403          0      420       0     413        0      413
        23      457          0      401       0     319        0      318
        24      635          0      411       0     186        0      185
        25      631          0      122       0     133        0      133
        26      622          0      257       0     164        0      165
        27      669          0      536       0     317        0      318
        28      580          0      808       0     654        0      653
        29      372          0      341       0     333        0      334
        30      594          0      424       0     213        0      213
        31      613          0       20       0     120        0      133
        32      735          0      226       0     133        0      133
        33      726          0      313       0     140        0      139
        34      521          0      246       0     215        0      216
        35      436          0      346       0     351        0      351
        36      408          0      706       0     697        0      698
```

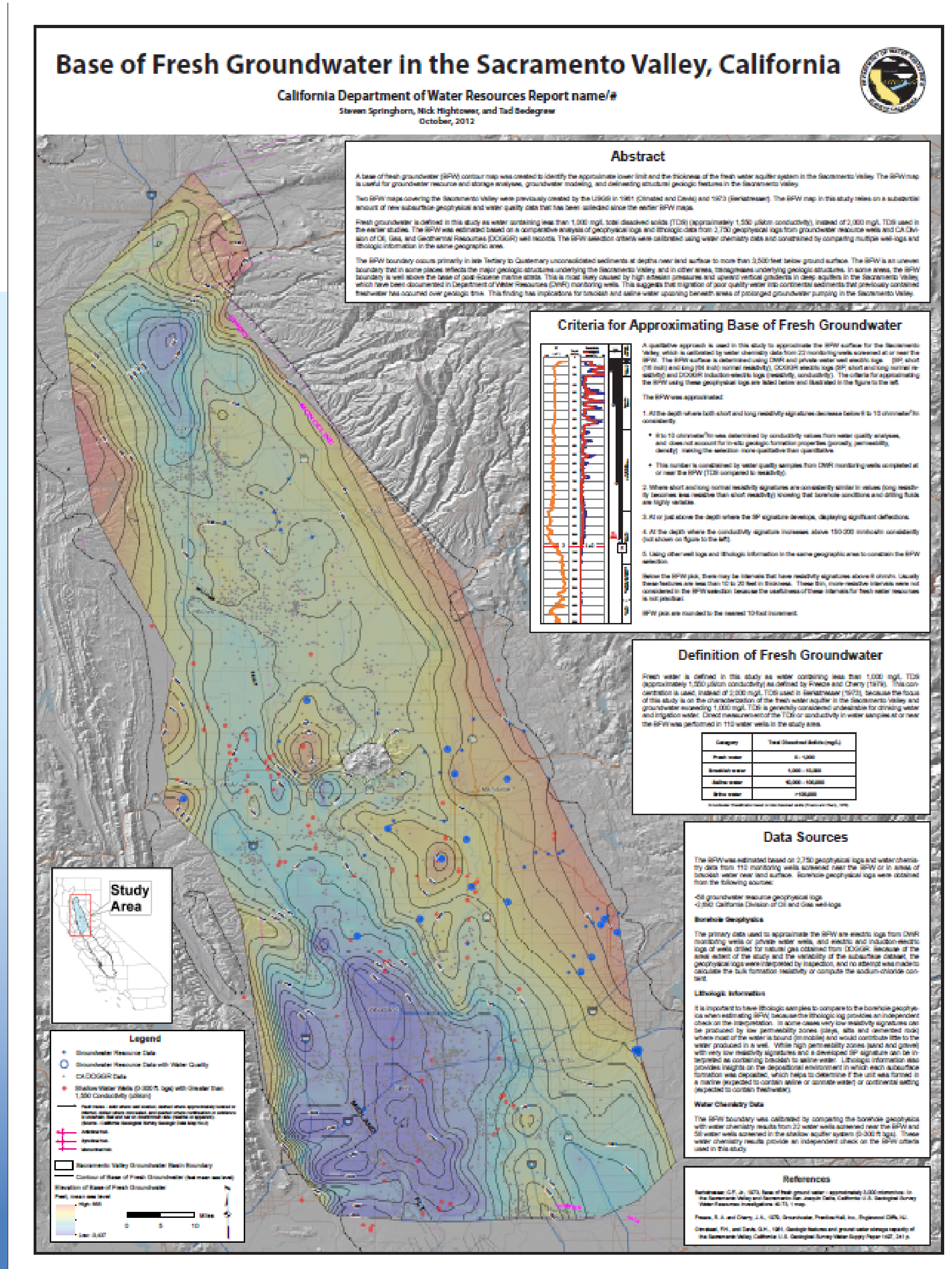
C2VSim Aquifer Cross Section



C2VSim Aquifer Thicknesses



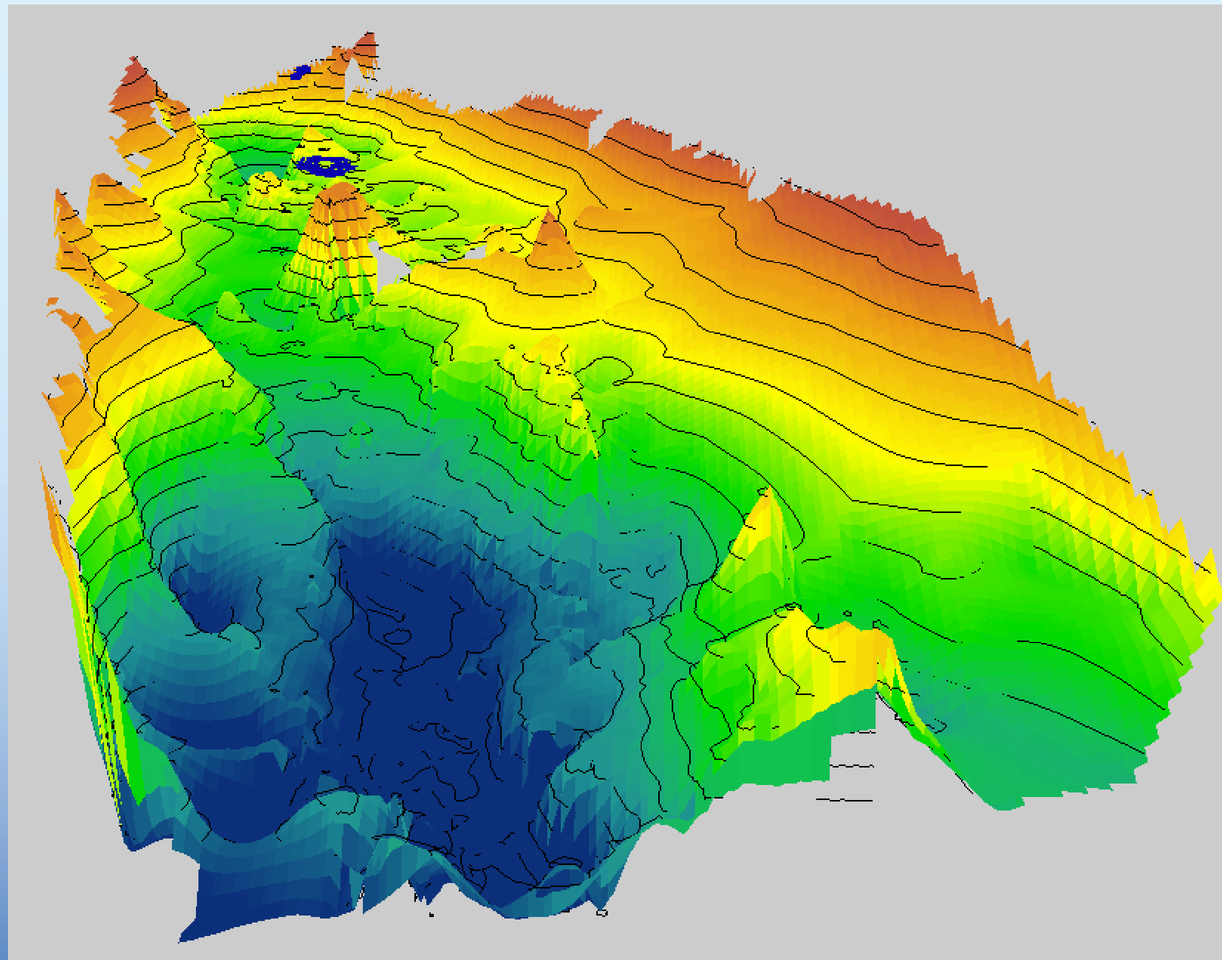




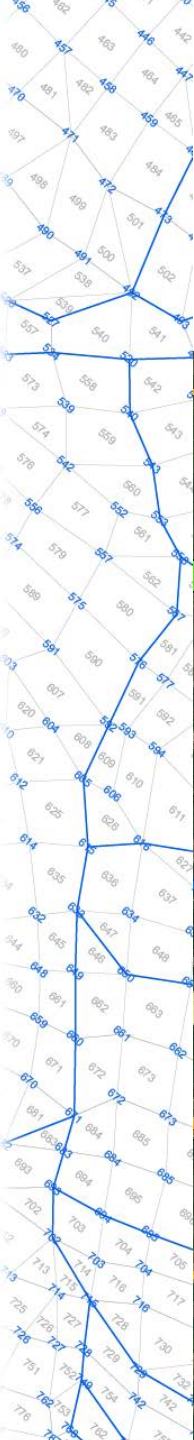
Base of Fresh Groundwater in the Sacramento Valley, California
California Department of Water Resources Report name/#
Steven Springhorn, Nick Hightower, and Tad Bedegrew
October, 2012
Abstract
Criteria for Approximating Base of Fresh Groundwater
Definition of Fresh Groundwater
Data Sources
References
Study Area
Legend

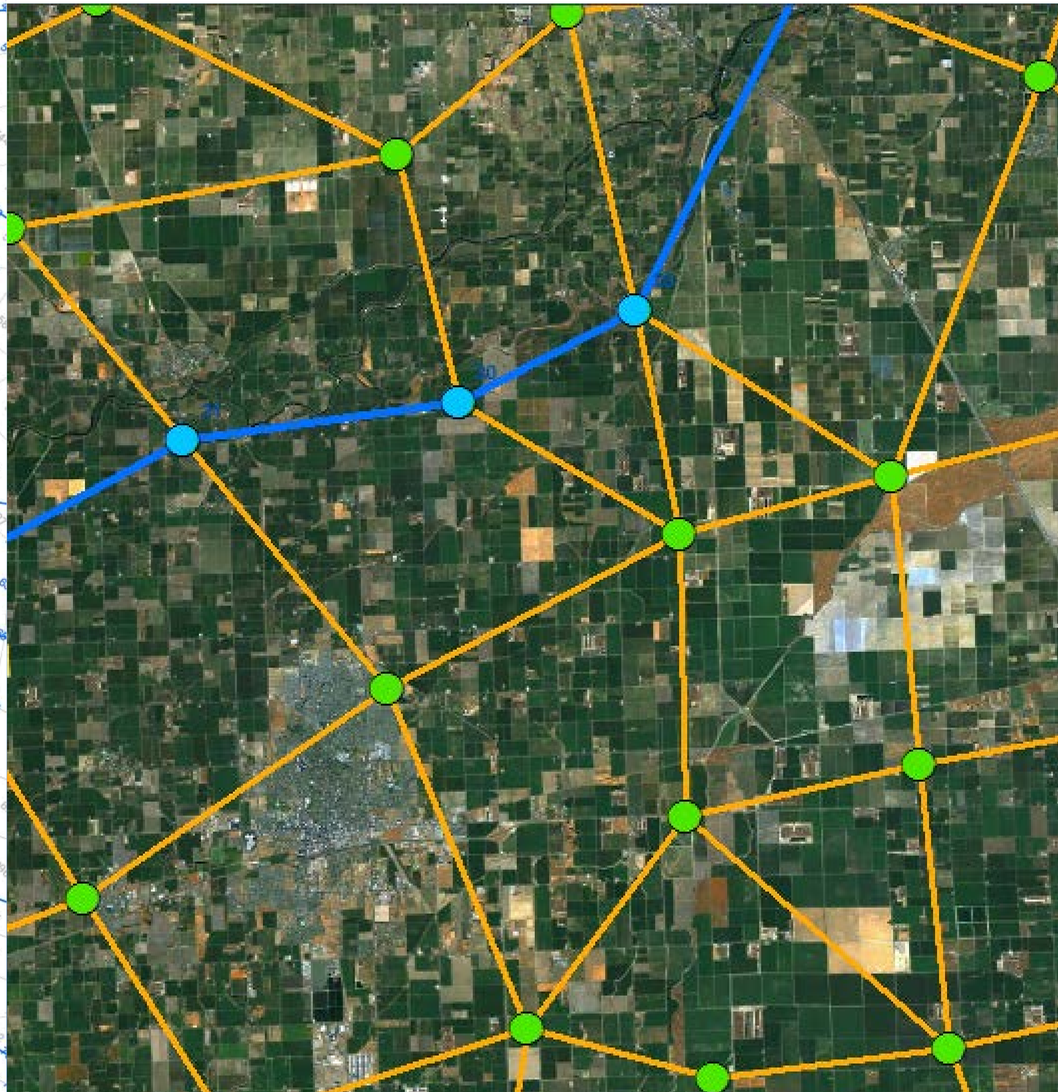
Base of Fresh Water

Three dimensional view (looking north) of the base of fresh water surface



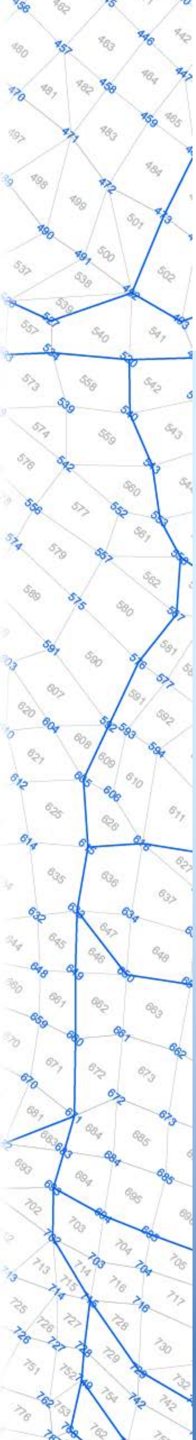
River Nodes and Reaches





Listed by Reach
Nodes linked to mesh

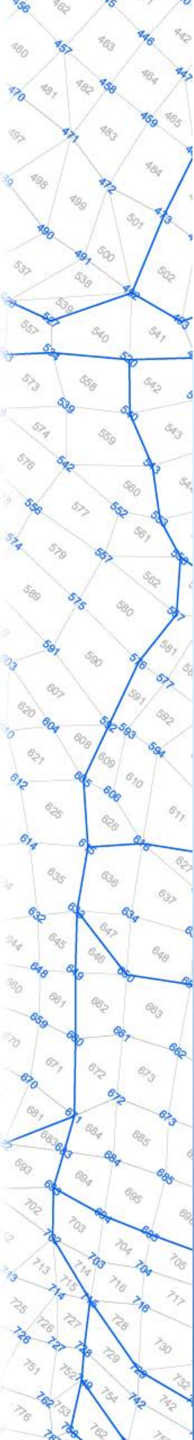
```
C*********************************************************
C
C                       Stream Reach Specifications
C
C    NRH;   Number of stream reaches modeled
C    NR;    Number of stream nodes modeled
C    NRTB;  Number of data points in stream rating tables
C
C---------------------------------------------------------
C    VALUE                           DESCRIPTION
C---------------------------------------------------------
     75                               / NRH
     449                              / NR
     5                                / NRTB
C---------------------------------------------------------

C---------------------------------------------
C     REACH  1  -  KERN RIVER
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C---------------------------------------------
     1        1          9          434
C---------------------------------------------
C    Stream  Groundwater  Subregion
C    node       node      number
C    IRV        IGW        IRGST
C---------------------------------------------
     1         1304        21
     2         1315        21
     3         1317        21
     4         1326        21
     5         1325        21
     6         1333        21
     7         1332        21
     8         1331        21
     9         1342        21
C---------------------------------------------
C     REACH 2  -  KINGS RIVER
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C---------------------------------------------
     2        23         32         33
C---------------------------------------------
C    Stream  Groundwater  Subregion
```



River Nodes and Reaches

Rating table for each node
at the end of the file

```
C-------------------------------------------------------------------------------
C   VALUE                           DESCRIPTION
C-------------------------------------------------------------------------------
     1.0                            / FACTLT
     60.0                           / FACTQ    (cfs --> cu.ft./min; since "second" is not recognized
     1min                           / TUNIT
C-------------------------------------------------------------------------------
C   The following lists a stream rating table for each of the stream nodes
C   *Note* In order to define a specified stream depth, enter all HRTB values
C            as equal to the specified depth value
C
C   ID;    Stream node number
C   BOTR;  Stream bottom elevation relative to a common datum [L]
C   HRTB;  Stream depth [L]
C   QRTB;  Flow rate at stream depth HRTB [L^3/T]
C
C-------------------------------------------------------------
C   Stream    Bottom   Stream      Flow
C   node     elevation  depth      rate
C   ID         BOTR     HRTB       QRTB
C-------------------------------------------------------------
     1         420.0      0.0        0.00
                          2.7      100.00
                          5.7     1000.75
                         14.4     6000.00
                         21.6    20000.00
     2         400.0      0.0        0.00
                          2.7      100.00
                          5.7     1000.75
                         14.4     6000.00
                         21.6    20000.00
     3         378.3      0.0        0.00
                          2.7      100.00
                          5.7     1000.75
                         14.4     6000.00
                         21.6    20000.00
     4         354.0      0.0        0.00
                          2.7      100.00
                          5.7     1000.75
                         14.4     6000.00
                         21.6    20000.00
     5         328.7      0.0        0.00
                          2.7      100.00
                          5.7     1000.75
                         14.4     6000.00
```



River Nodes and Reaches

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```
C-------------------------------------------------------------------------------
C   VALUE                            DESCRIPTION
C-------------------------------------------------------------------------------
     1.0                            / FACTLT
     60.0                           / FACTQ    (cfs --> cu.ft./min; since "second" is not recognized
     1min                           / TUNIT
C-------------------------------------------------------------------------------
C   The following lists a stream rating table for each of the stream nodes
C   *Note* In order to define a specified stream depth, enter all HRTB values
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C
C   ID;    Stream node number
C   BOTR;  Stream bottom elevation relative to a com
C   HRTB;  Stream depth [L]
C   QRTB;  Flow rate at stream depth HRTB [L^3/T]
C
C-----------------------------------------------------
C   Stream    Bottom   Stream       Flow
C   node     elevation  depth        rate
C   ID         BOTR      HRTB        QRTB
C-----------------------------------------------------
     1         420.0      0.0         0.00
                          2.7       100.00
                          5.7      1000.75
                         14.4      6000.00
                         21.6     20000.00
     2         400.0      0.0         0.00
                          2.7       100.00
                          5.7      1000.75
                         14.4      6000.00
                         21.6     20000.00
     3         378.3      0.0         0.00
                          2.7       100.00
                          5.7      1000.75
                         14.4      6000.00
                         21.6     20000.00
     4         354.0      0.0         0.00
                          2.7       100.00
                          5.7      1000.75
                         14.4      6000.00
                         21.6     20000.00
     5         328.7      0.0         0.00
                          2.7       100.00
                          5.7      1000.75
                         14.4      6000.00
```
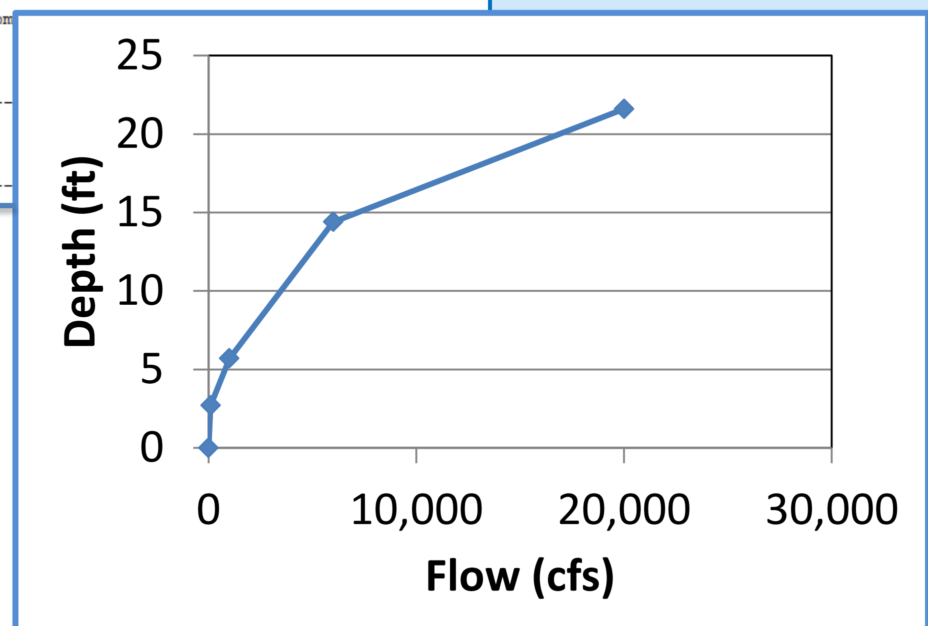
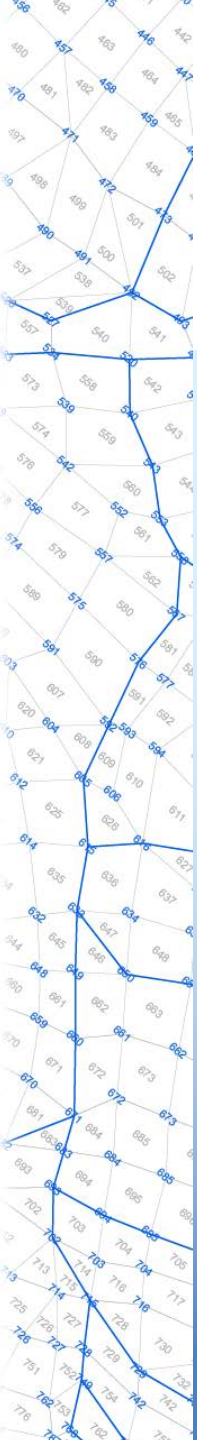



Lakes

Groups of Elements

Outflow = River Node #

```
C*******************************************************************************
C                    Lake Configuration Data
C
C   NLAKE  ; Number of lakes that are being modeled
C   NTELAKE; Total number of lake elements
C
C-------------------------------------------------------------------------------
C   VALUE                            DESCRIPTION
C-------------------------------------------------------------------------------
      2                              / NLAKE
      10                             / NTELAKE
C-------------------------------------------------------------------------------
C

C   ID    ;  Sequential number for the lakes
C   INLAKE;  Next downstream lake number
C              0 : if flow from lake leaves the modeled area
C            -nd : if flow from lake goes to stream node nd
C             nd : if flow from lake goes to the downstream lake, nd
C   NELAKE;  Number of lake elements where lake lies
C   IELAKE;  Element in which the lake is located
C--------------------------------------------------------------------------
C   Lake No.    Next Lake  Elem per Lake   Element
C     ID         INLAKE       NELAKE        IELAKE
C--------------------------------------------------------------------------
C    Buena Vista Lake
      1          -434          4             1352
                                             1353
                                             1363
                                             1364
C    Tulare Lake
      2           -42          6             1109
                                             1110
                                             1111
                                             1136
                                             1137
                                             1138
```



Element Characteristics

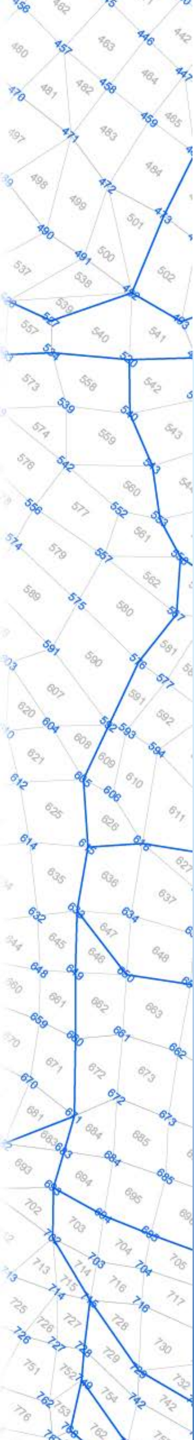
- Precipitation data column
- River node receiving drainage
- Subregion
- Soil type

A = 1 B = 2

C = 3 D = 4

```
C
C  The following lists the hydrologic characteristics of each element:
C
C  IE;     Element number
C  IRNE;    Rainfall station assigned to the element IE
C          (enter zero for all elementsif no land processes other than
C           streams and lakes are modeled)
C  FRNE;    Factor to convert rainfall at the assigned rainfall station to
C          rainfall at the element IE
C  ISTE;    Stream node to which surface water from element IE drains to
C          (enter zero if the surface flow from element IE leaves the model area)
C  IRGE;    Subregion number to which element IE belongs to
C  ISGE;    Element sub-group number to which element IE belongs to
C  ISOILE;  Hydrologic soil property of the element (ie. A=1, B=2, C=3, D=4)
C          (Reference for A-D soil types: USDA, 1985)
C
C-----------------------------------------------------------------------------------
C  Element  Rain     Rain     Drain   Sub-    Sub-    Soil
C  number   station  factor   node    region  group   type
C  IE       IRNE     FRNE     ISTE    IRGE    ISGE    ISOILE
C-----------------------------------------------------------------------------------
```

IE	IRNE	FRNE	ISTE	IRGE	ISGE	ISOILE
1	1	1	207	1	1	3.100
2	2	1	206	1	1	3.000
3	3	1	206	1	1	3.000
4	4	1	206	1	1	3.000
5	5	1	207	1	1	3.850
6	6	1	207	1	1	3.150
7	7	1	208	1	1	3.150
8	8	1	208	1	1	4.000
9	9	1	208	1	1	4.000
10	10	1	213	1	1	2.200
11	11	1	209	1	1	3.000
12	12	1	209	1	1	3.100
13	13	1	209	1	1	3.000
14	14	1	209	1	1	3.900
15	15	1	210	1	1	3.850
16	16	1	214	1	1	2.200
17	17	1	216	1	1	3.000
18	18	1	216	1	1	3.000
19	19	1	216	1	1	3.200
20	20	1	216	1	1	2.900



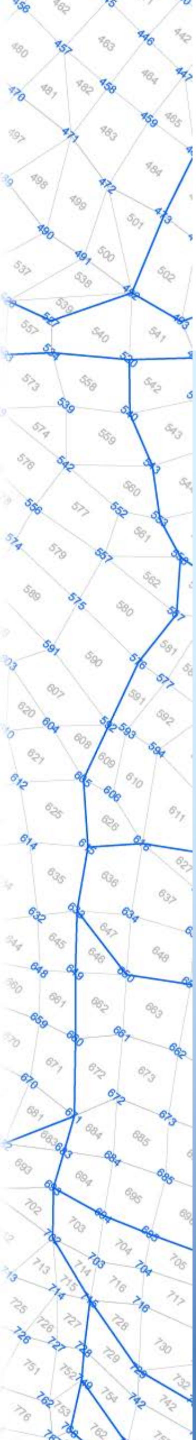
Pumping Wells

X-Y Location
- UTM 10N
- X = Easting
- Y = Northing

Convert to FT
- FACT = 3.2808

Well Properties
- RWELL = 1
- Screen Top
- Screen Bottom

```
*******************************************************************************
           List of modeled wells and their corresponding parameters

   NWELL ; Number of wells modeled
   FACTCX; Conversion factor for well coordinates
   FACTRW; Conversion factor for well diameter
   FACTLT; Conversion factor for perforation depths

------------------------------------------------------------------------------
          VALUE                                        DESCRIPTION
------------------------------------------------------------------------------
    133                    / NWELL
    3.2808                 / FACTCX
    1.0                    / FACTRW
    1.0                    / FACTLT
-------------------------------------------------------------------------------
*******************************************************************************

   ID;          Well identification number
   XWELL,YWELL; X-Y coordinates for each well; (L)
   RWELL;       Well diameter; (L)
   PERFT,PERFB; Elevations of the top and bottom perforations; (L)

-------------------------------------------------------------------------------
     ID     XWELL     YWELL   RWELL PERFTOP PERFBOT
-------------------------------------------------------------------------------
      1  559446 4477519   1         200       0       / Anderson
      2  560944 4470571   1         200       0       / Cottonwood
      3  551369 4492833   1         450     400       / Redding A (Downtown)
      4  555410 4490970   1         450     400       / Redding B (Enterprise)
      5  570071 4419834   1         200       0       / Corning
      6  584397 4399421   1          50    -100       / Hamilton City
      7  576717 4430310   1          50    -100       / Los Molinos
      8  568798 4399798   1         150       0       / Orland
      9  564962 4447605   1         200       0       / Red Bluff
     10  574748 4430889   1          50    -100       / Tehama
     11  581466 4318921   1          50    -100       / Arbuckle
     12  573445 4334080   1           0    -200       / Williams
     13  569277 4375051   1          50    -150       / Willows
     14  585470 4340806   1           0    -200       / Colusa
     15  610713 4363090   1         -50    -150       / Biggs
     16  599583 4398071   1          50    -150       / Chico
     17  612513 4357721   1           0    -100       / Gridley
     18  615500 4348007   1           0    -100       / Live Oak
     19  621676 4333692   1         -50    -200       / Marysville
     20  625136 4328130   1         -50    -200       / Olivehurst
     21  607655 4335030   1         -50    -200       / Sutter
     22  636457 4318838   1         -50    -150       / Wheatland
     23  619438 4333059   1         -50    -200       / Yuba City
     24  609719 4266809   1        -100    -300       / Davis
     25  602713 4255729   1        -100    -300       / Dixon
     26  585403 4282871   1          50     -50       / Esparto
```



Calibrated Parameters

Aquifer nodes
- Conductivity
- Storage
- Subsidence

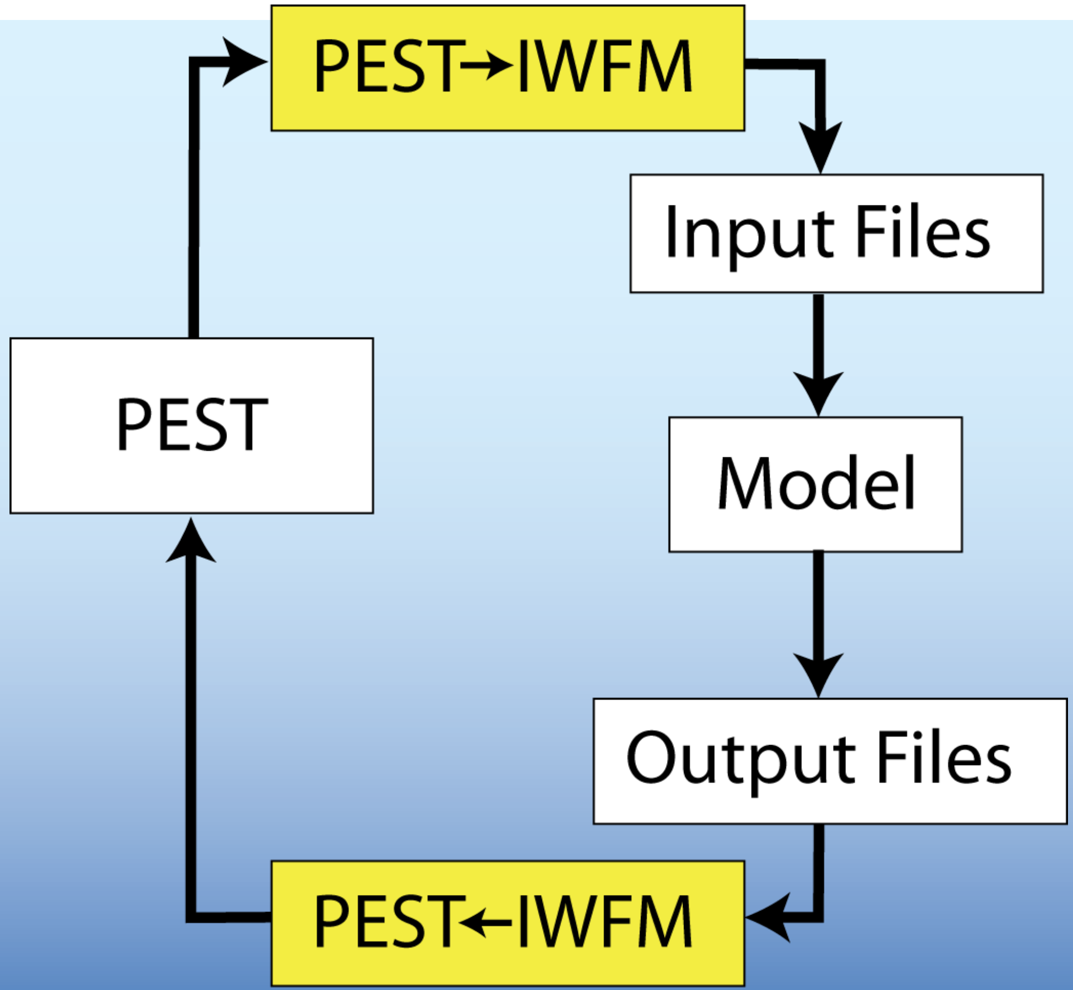
River nodes
- Conductance

Unsaturated Zone
- Porosity
- Conductivity

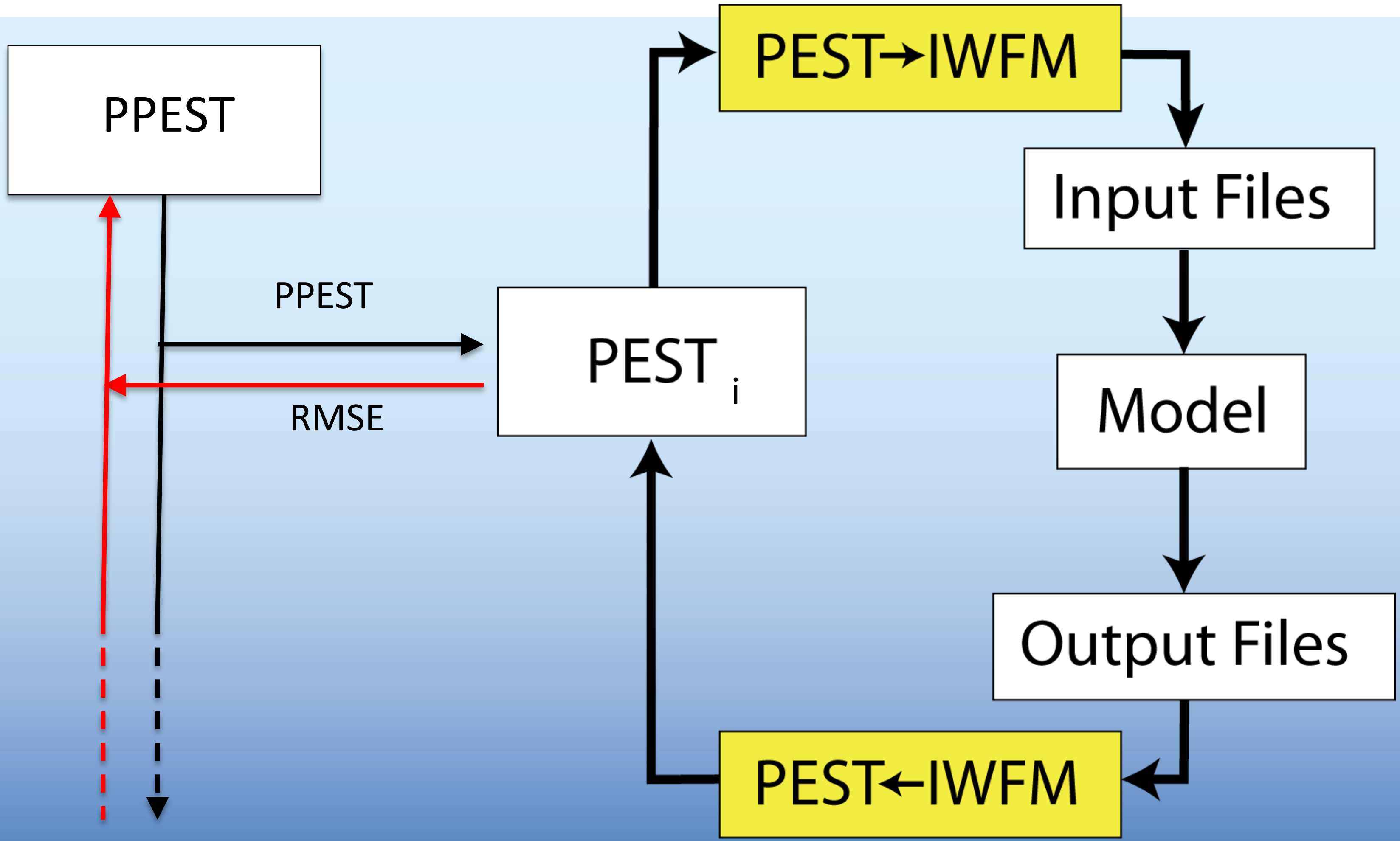
Soil properties
- Field capacity
- Porosity
- Recharge factor
- Curve Numbers

Small Watersheds
- Field capacity
- Porosity
- Conductivity
- Discharge threshold
- Recession coefficients

Calibration with PEST



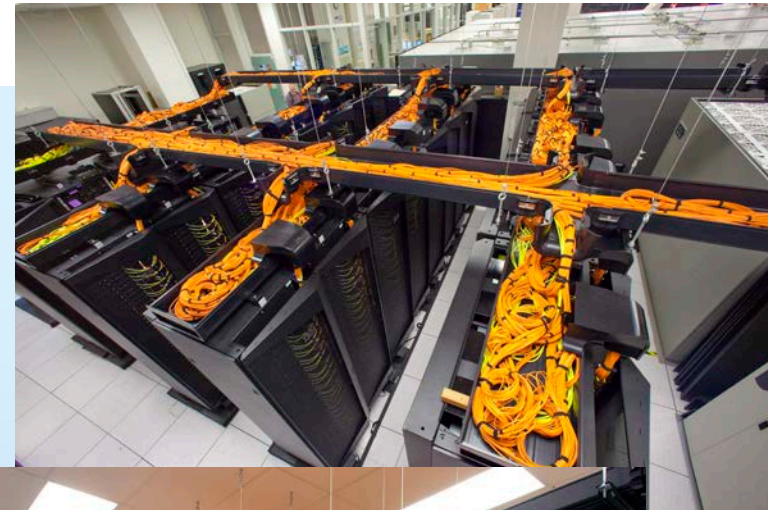
Calibration with PPEST



C2VSim Calibration

- Calibrate parameter values at each model node and layer
- Using computers at the USDOE National Energy Research Scientific Computing Center (NERSC)
  - Carver
    - IBM iDataPlex
    - 3,200 CPU cores, 34 Tflop/s
- Comparison:

	PPs	Compter	Run Time
R300	137	15 PCs	1 week
R326	394	15 PCs	3 weeks
R346	1393	15 PCs	16 weeks
R346	1393	NERSC	2 weeks



Calibration Observations

Groundwater Heads
- 56,947 observations at 1,145 wells

Vertical Head Difference
- 3,017 observations at 121 well pairs

Surface Water Flow
- 5,636 observations at 21 locations

Stream-Groundwater Flows
- Average annual rates on 24 reaches

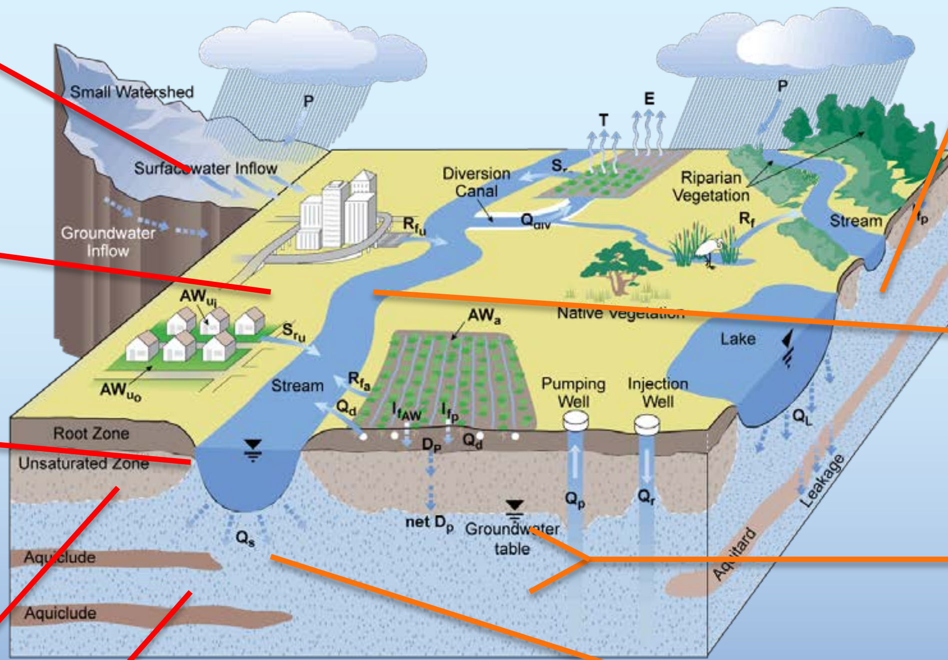
Parameter Sensitivity

Parameters

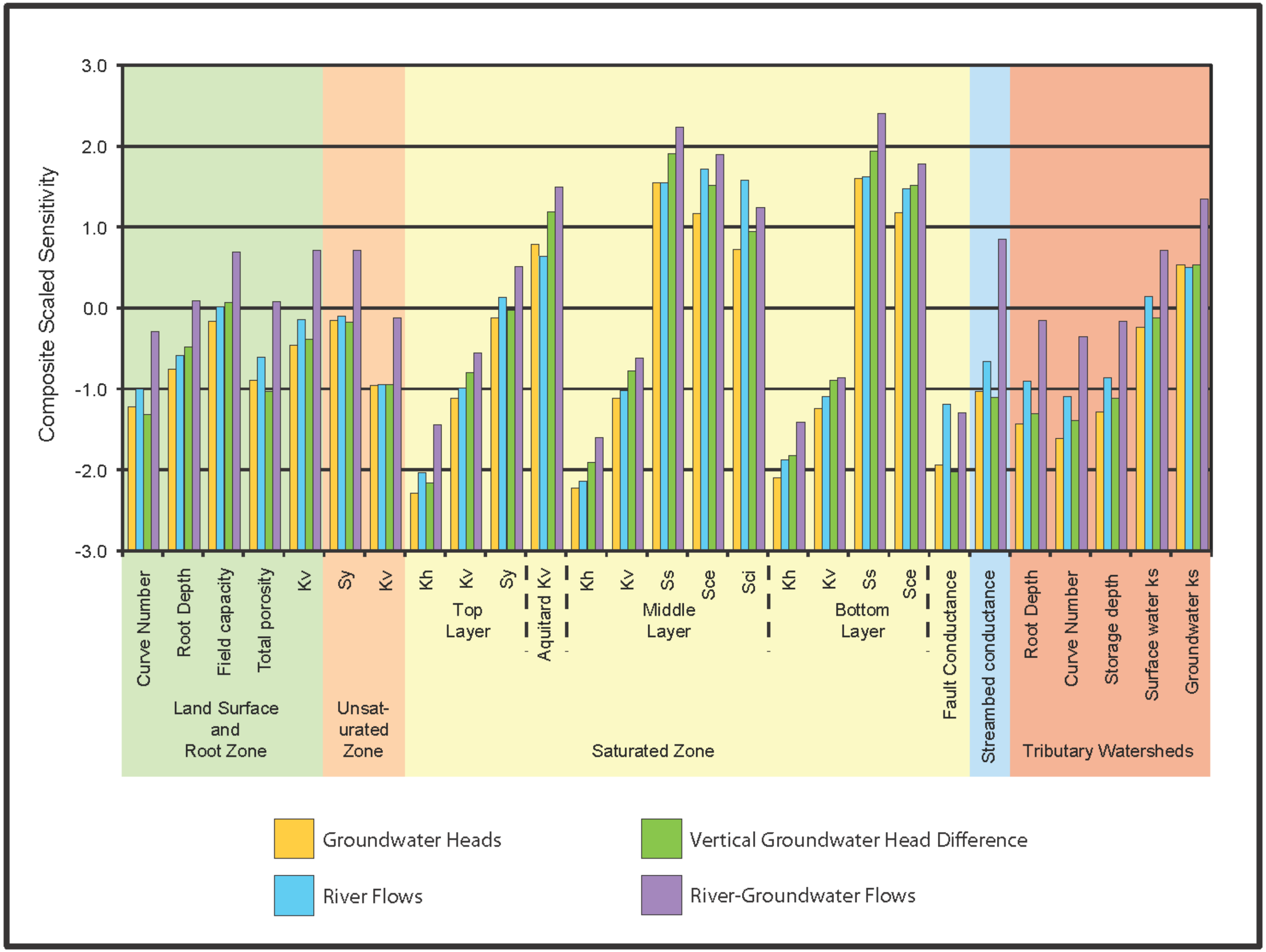
- Ungaged Watersheds
- Land Surface
- Streambed
- Unsaturated Zone
- Saturated Zone

Observations

- Groundwater Head
- River Flow
- Groundwater Gradient
- Stream-Groundwater Flow

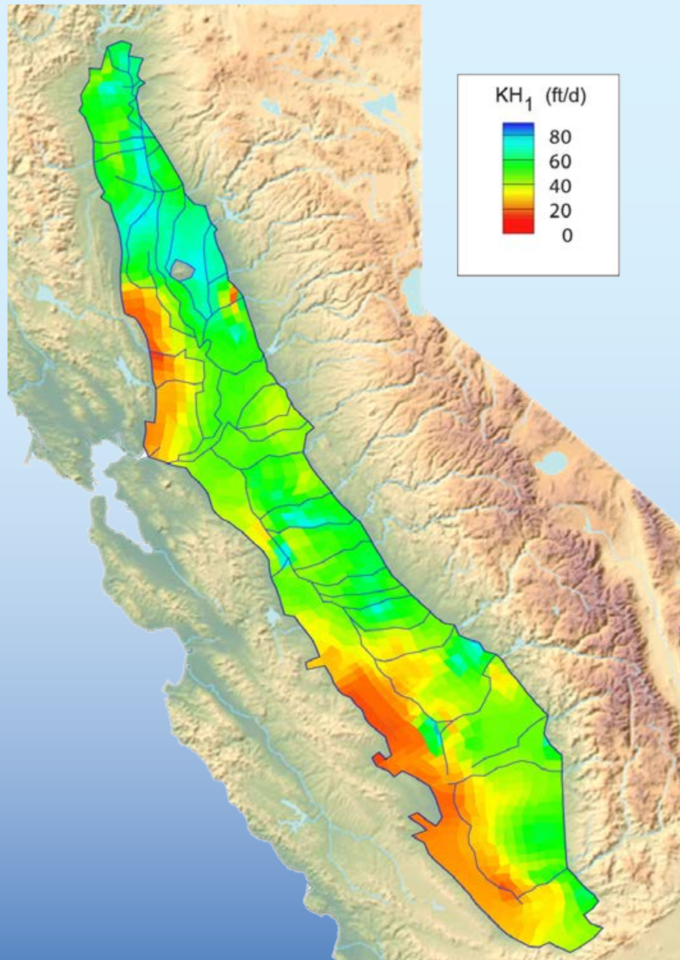


Parameter Sensitivity

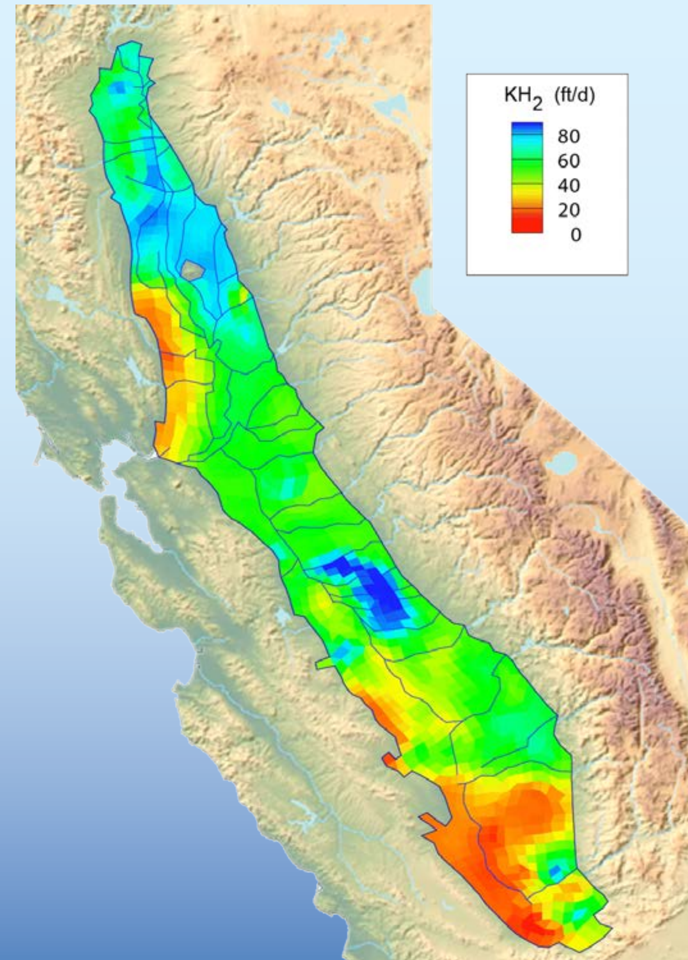


Hydraulic Conductivity

Layer 1

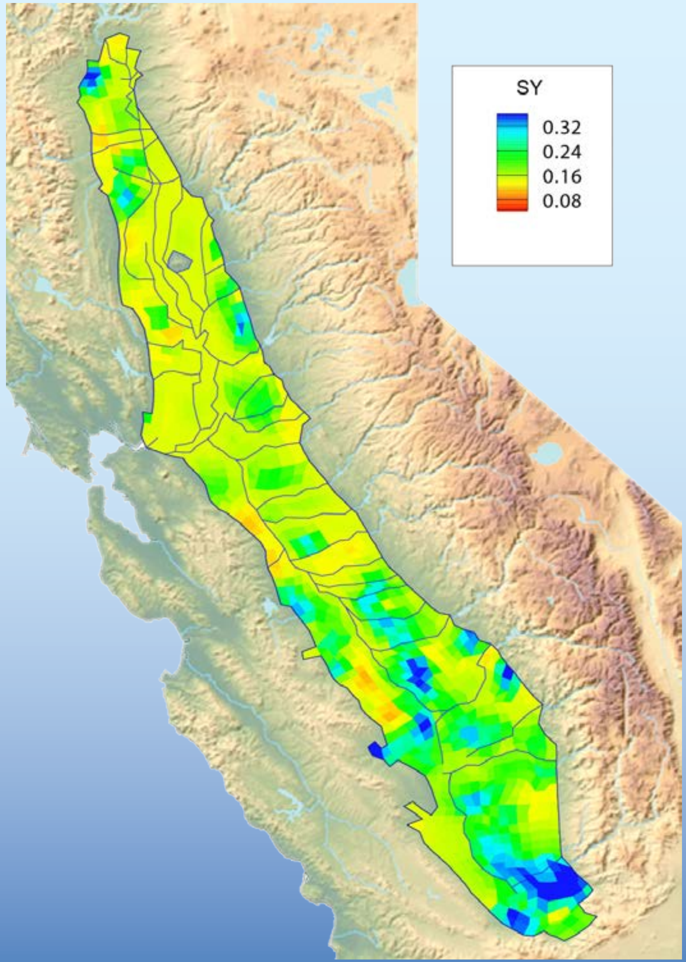


Layer 2

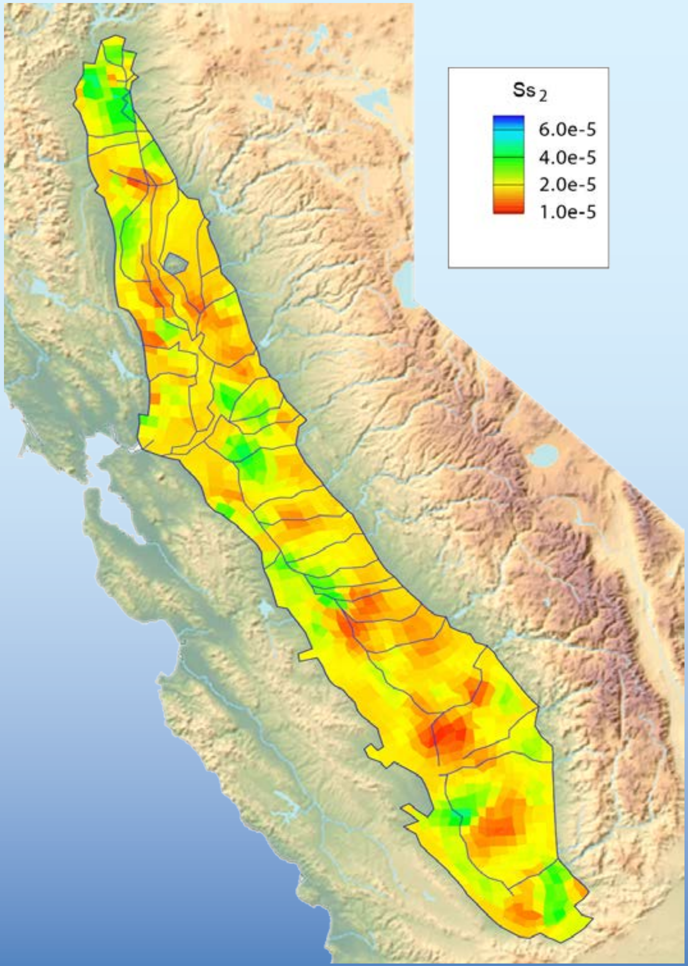


Storage Parameters

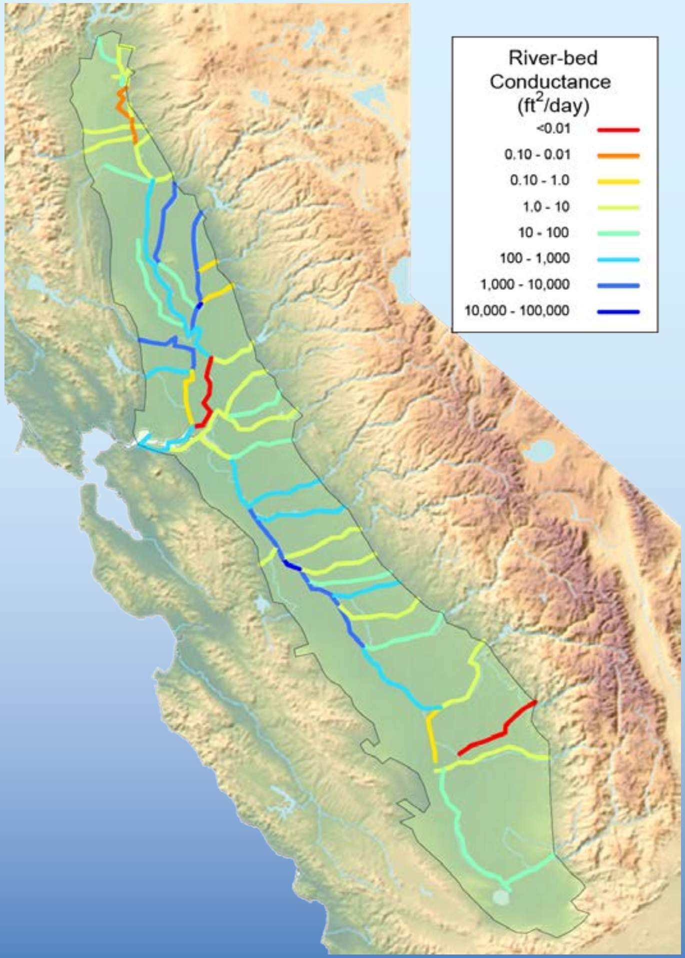
Layer 1



Layer 2



River-Bed Conductance



Model Performance

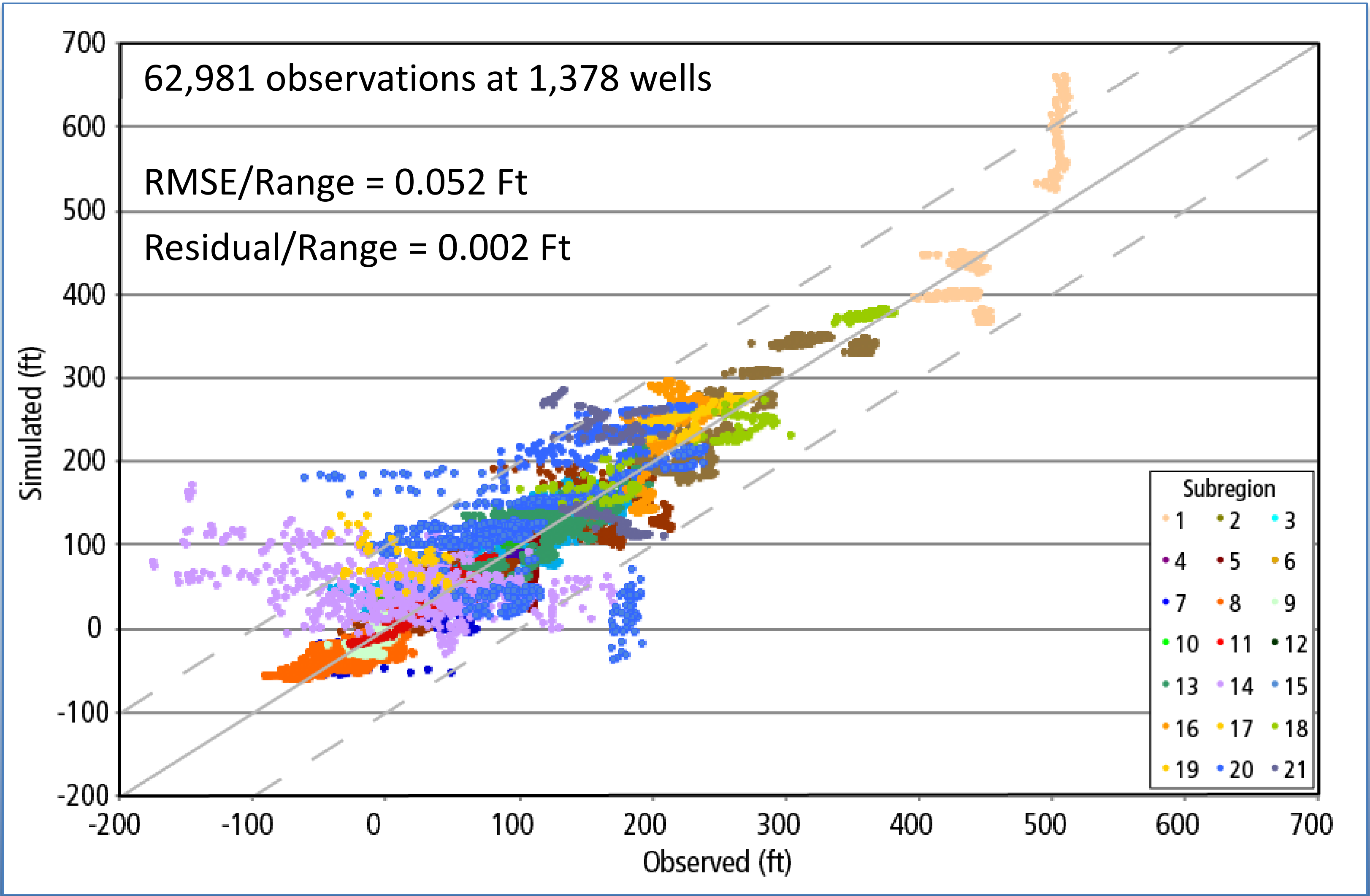
Observation Type	No. Observation Sites	No. Observations	Range
Groundwater heads	1,378	62,981	1,252
Vert. Groundwater Head Difference	163	3,017	698
River Flows	22	5,636	6,561,453
River-Groundwater Flows	33	33	38,117
Subsidence	24	3,700	6.2
TOTAL	1,620	75,367	

Observation Type	Root Mean Squared Error	Residual	RMSE Range	Residual Range
Groundwater heads	65.4	2.14	0.052	0.002
Vert. Groundwater Head Difference	96.2	-13.3	0.138	-0.019
River Flows	145,591	-13,720	0.022	-0.002
River-Groundwater Flows	8,875	3,620	0.233	0.095
Subsidence	17.4	-11.5	2.81	-1.86

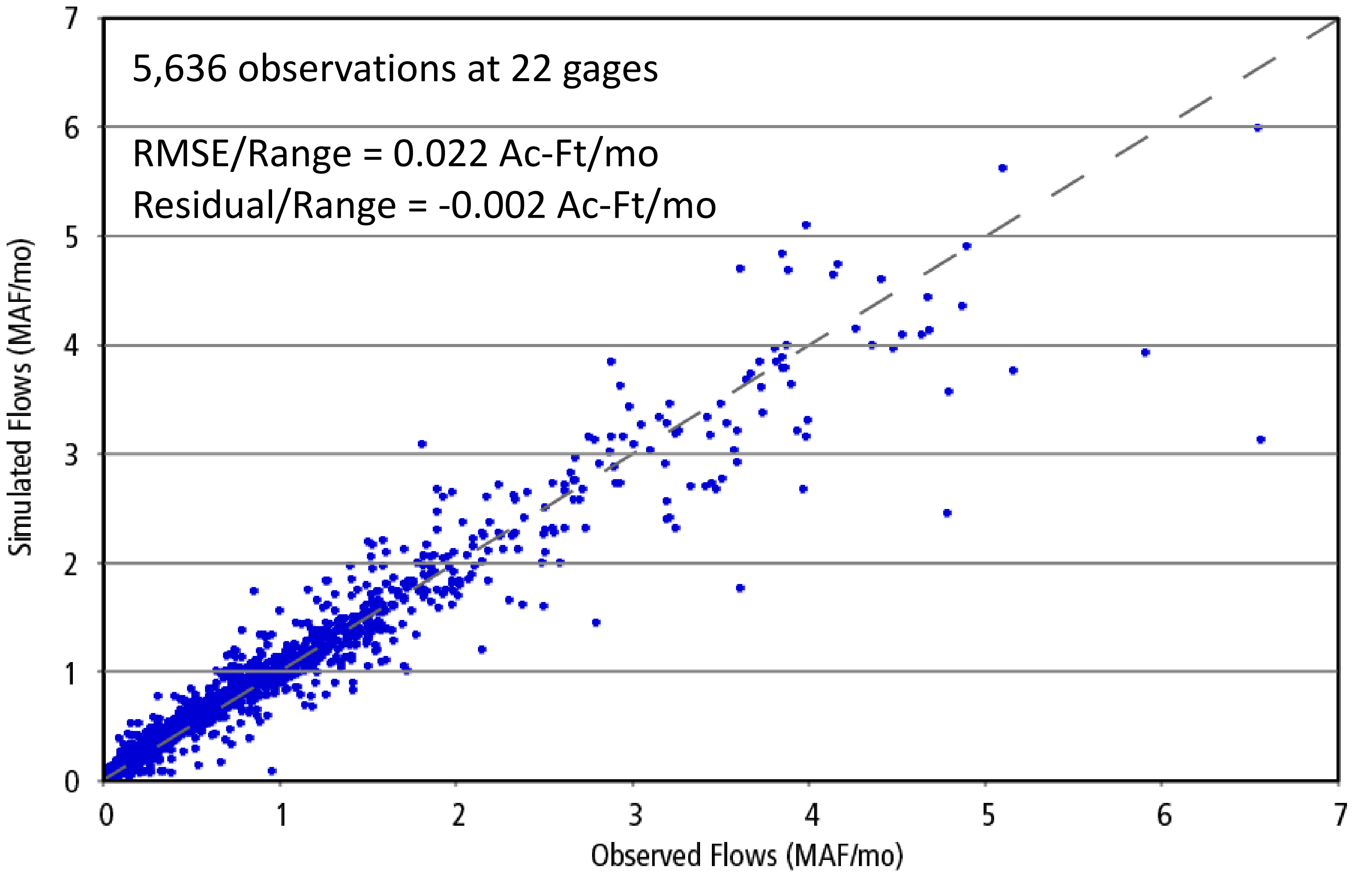
Units: Heads and subsidence in feet, flows in acre-feet

Head and flow observations from October 1975 to September 2003, Subsidence observations from September 1957 to May 2004

Groundwater Heads

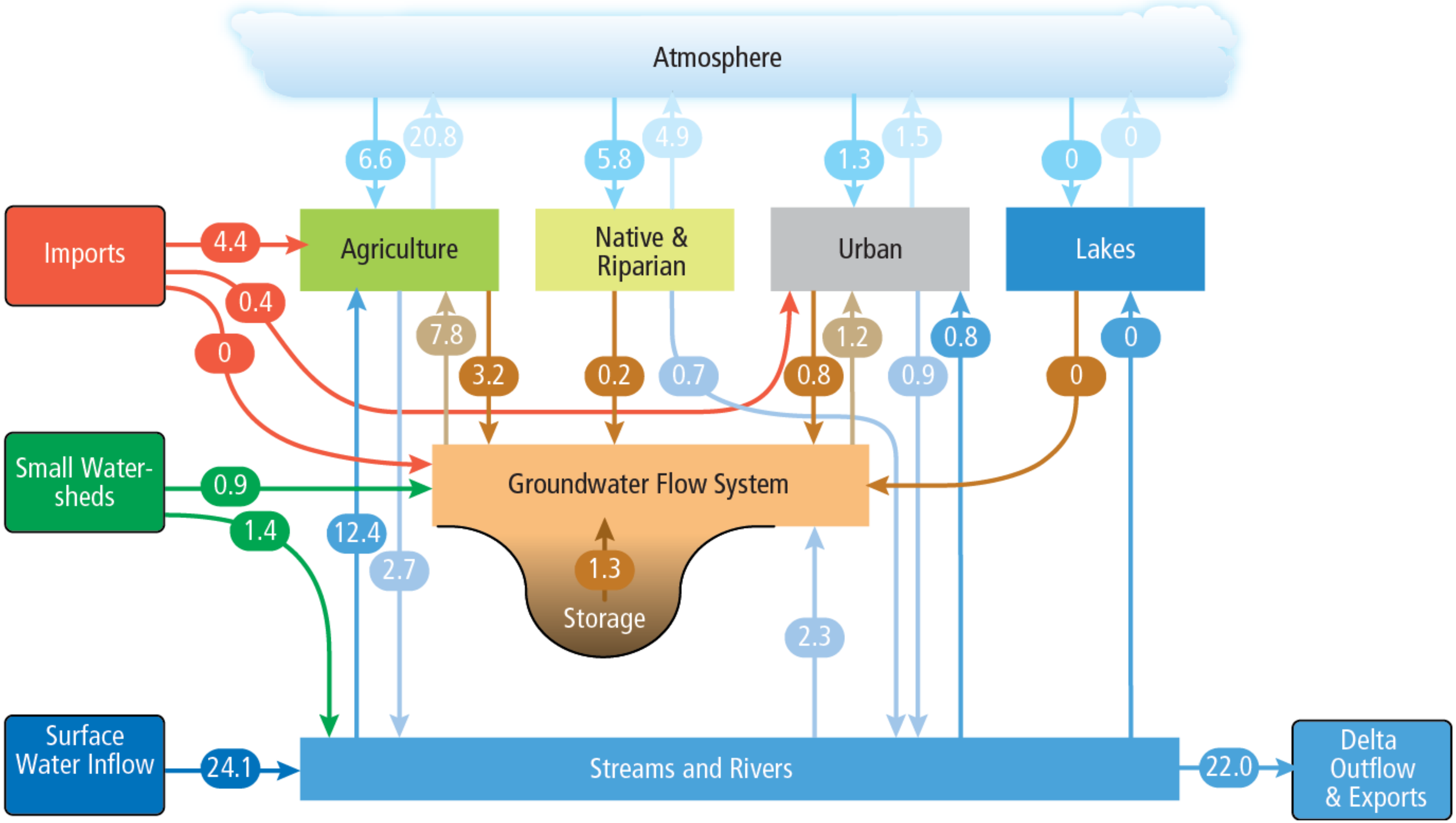


Surface Water Flows



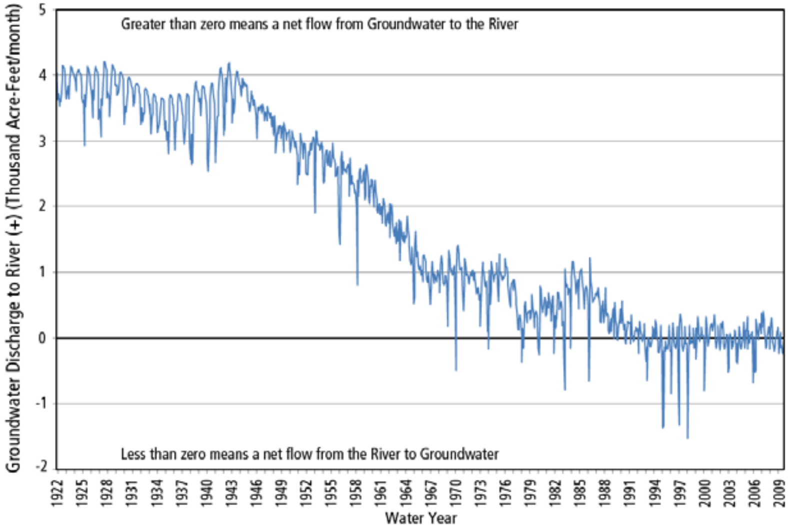
Simulated Annual Water Budget

Average Flows for water years 2000-2009
[Million Acre-Feet/Year]

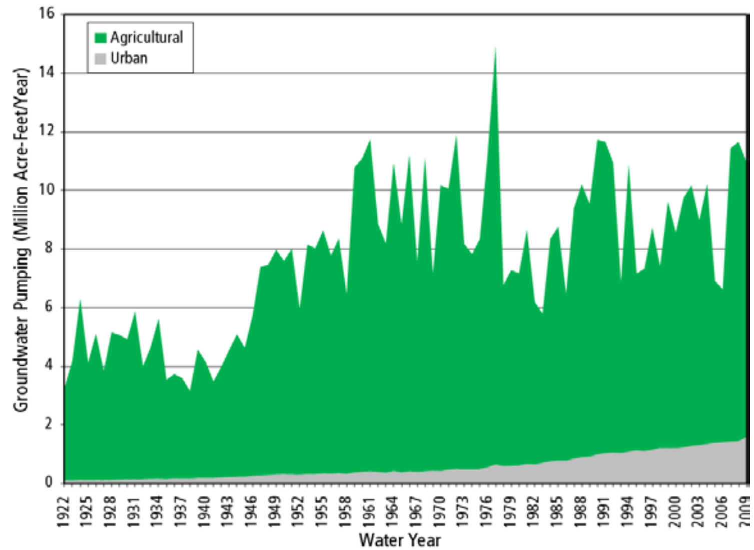


River-Groundwater Flows

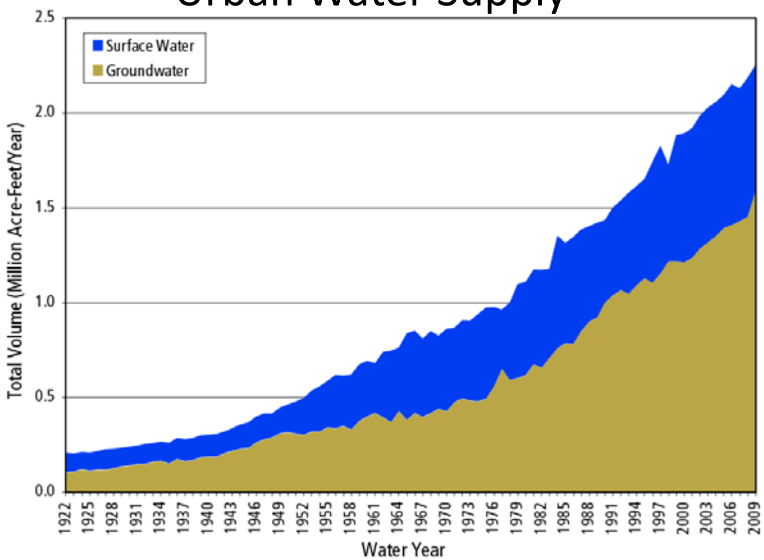
Sacramento River reach near Chico



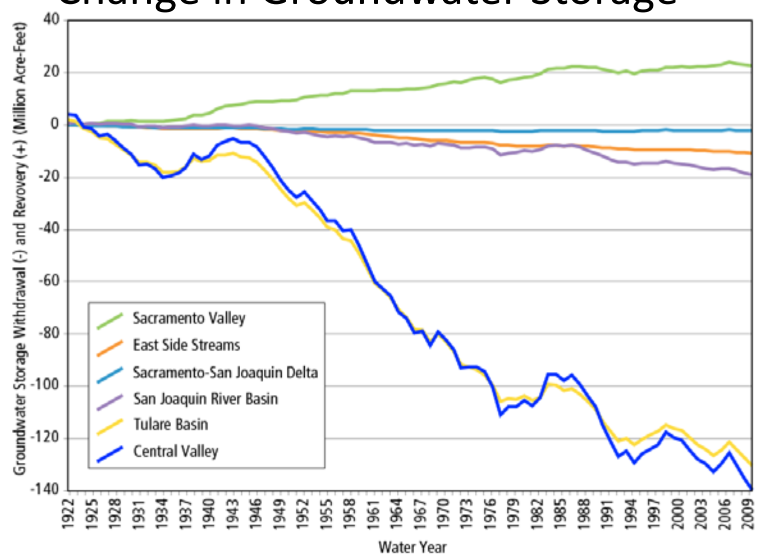
Groundwater Pumping

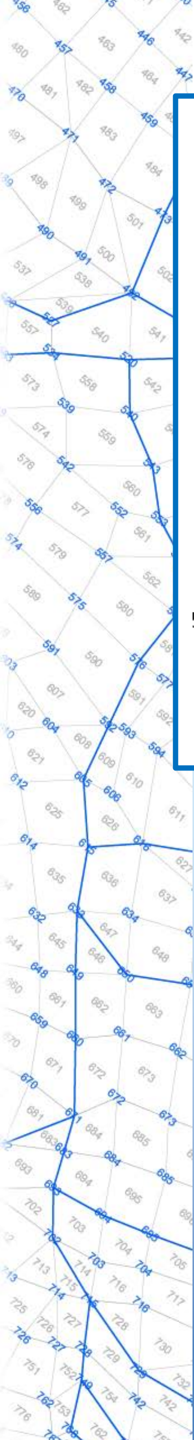


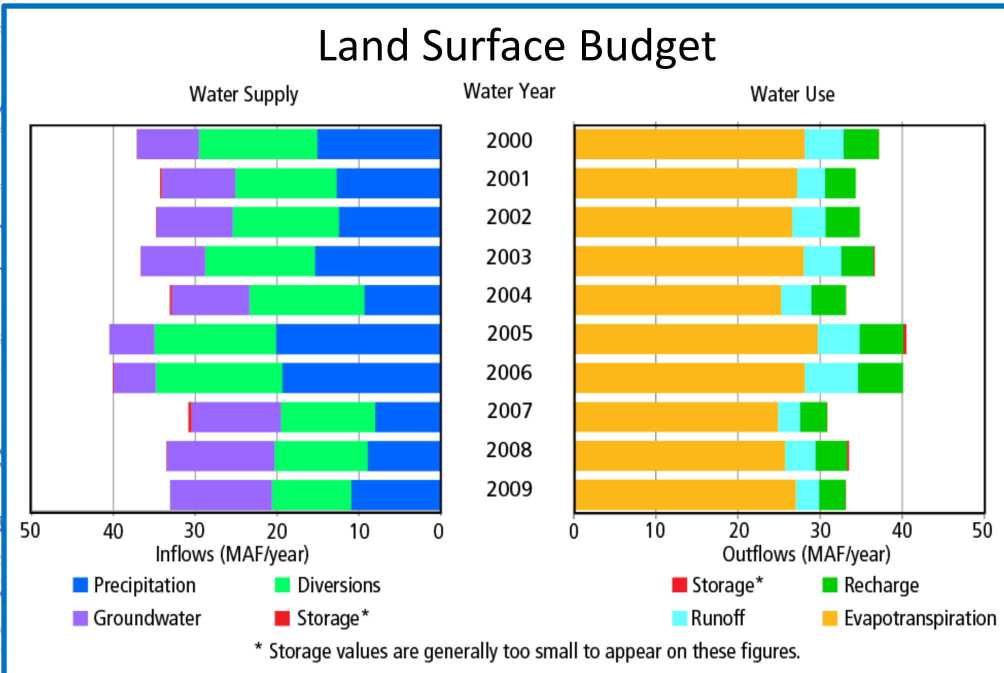
Urban Water Supply



Change in Groundwater Storage

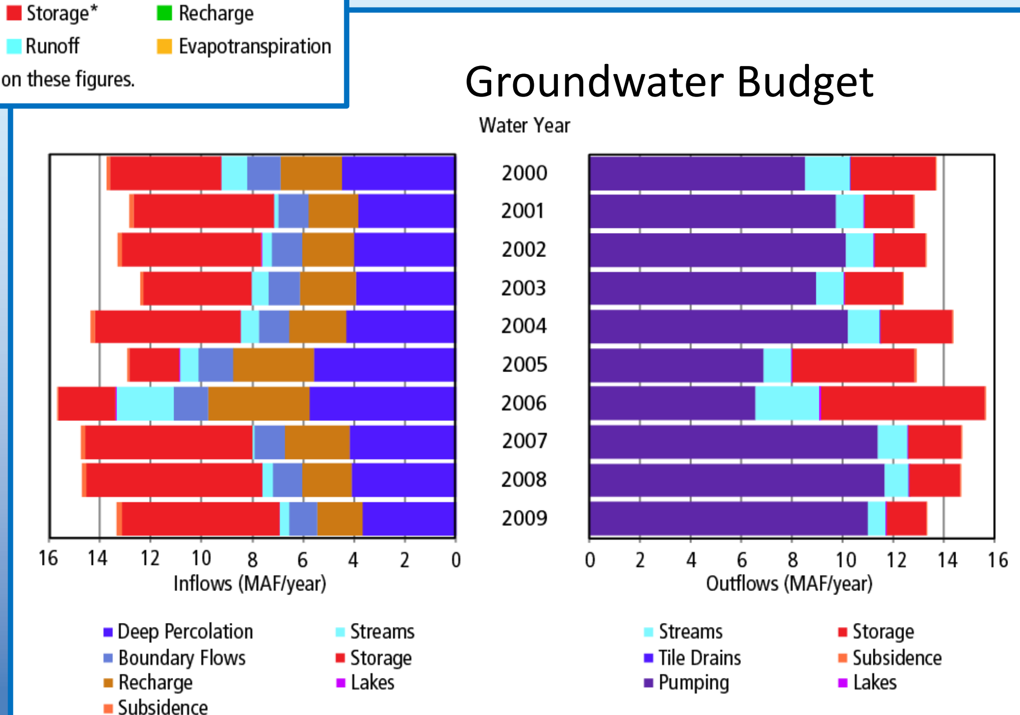






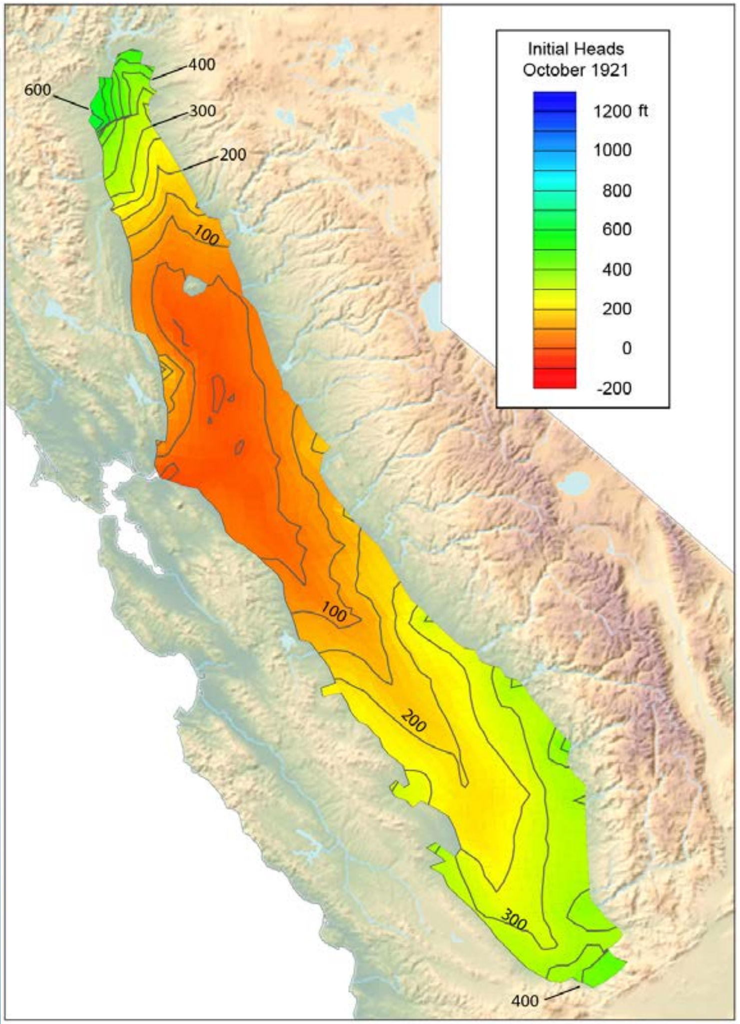
Process-level output tables have a complete water balance, and can be used to produce budget figures

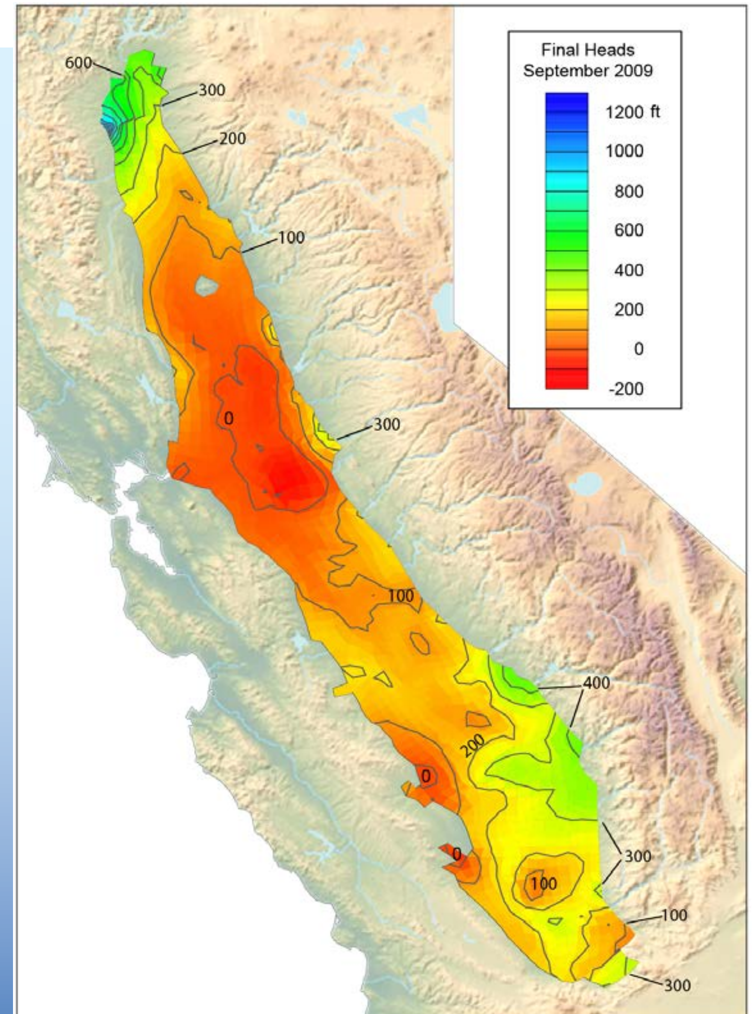
Groundwater budgets can also be produced for 'zones' of one to many elements



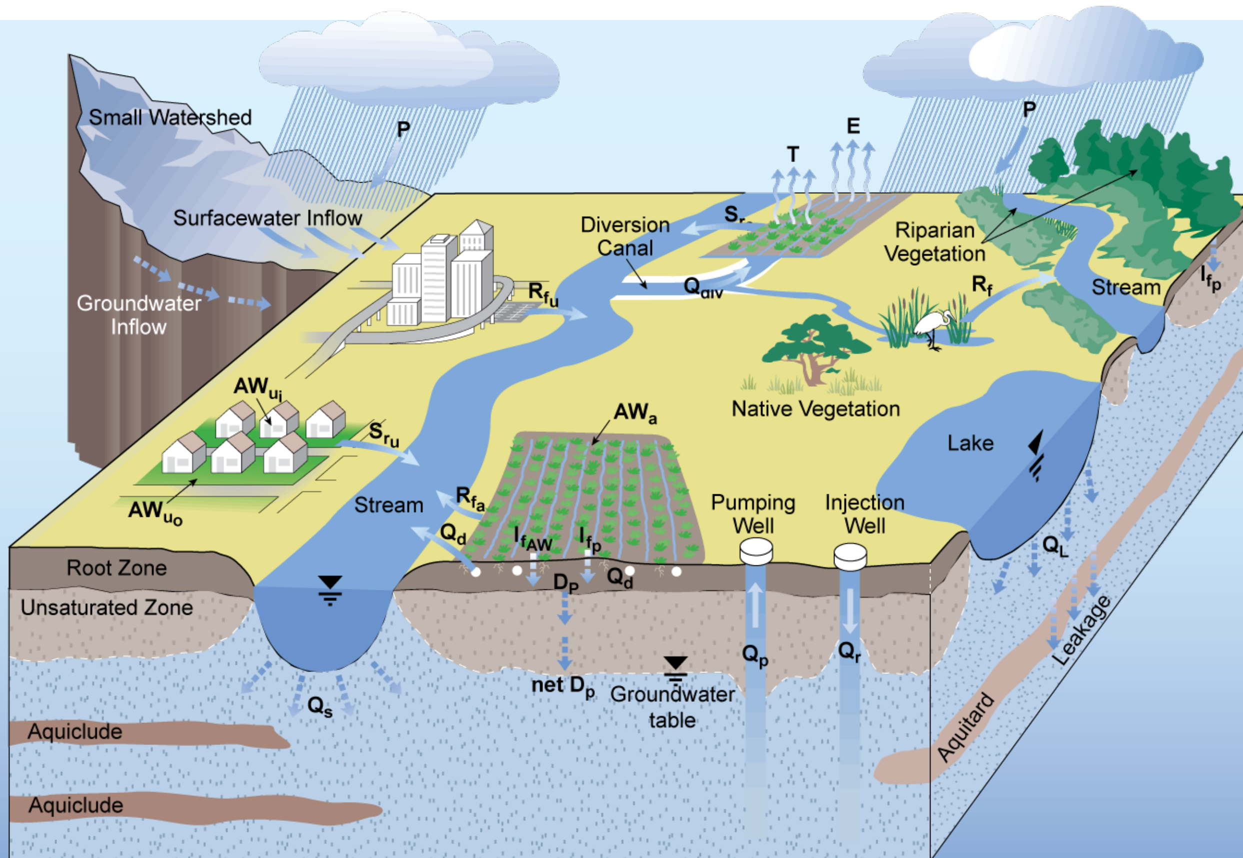
Water Table Altitude

Produced from IWFM's TecPlot® output files

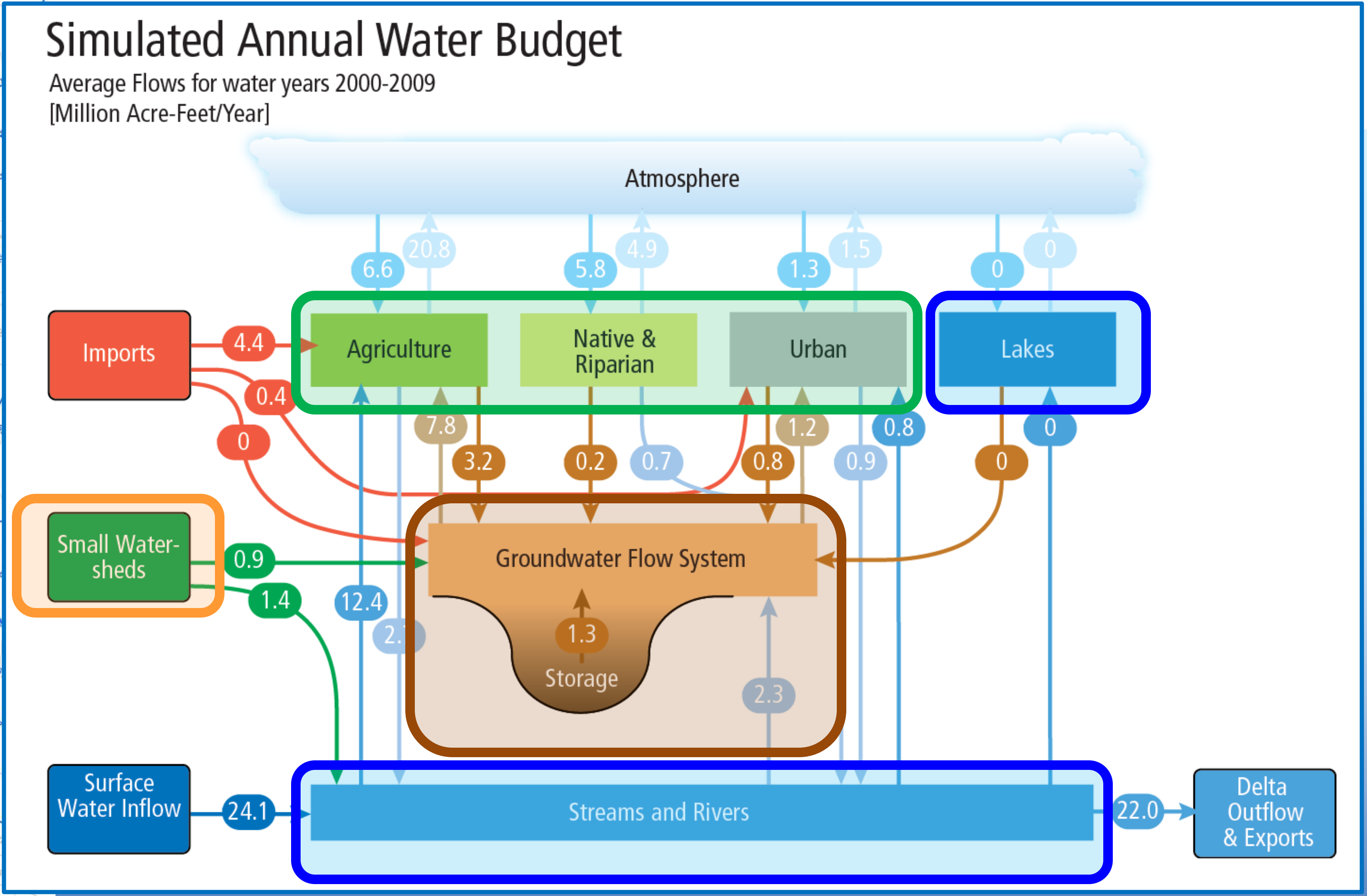




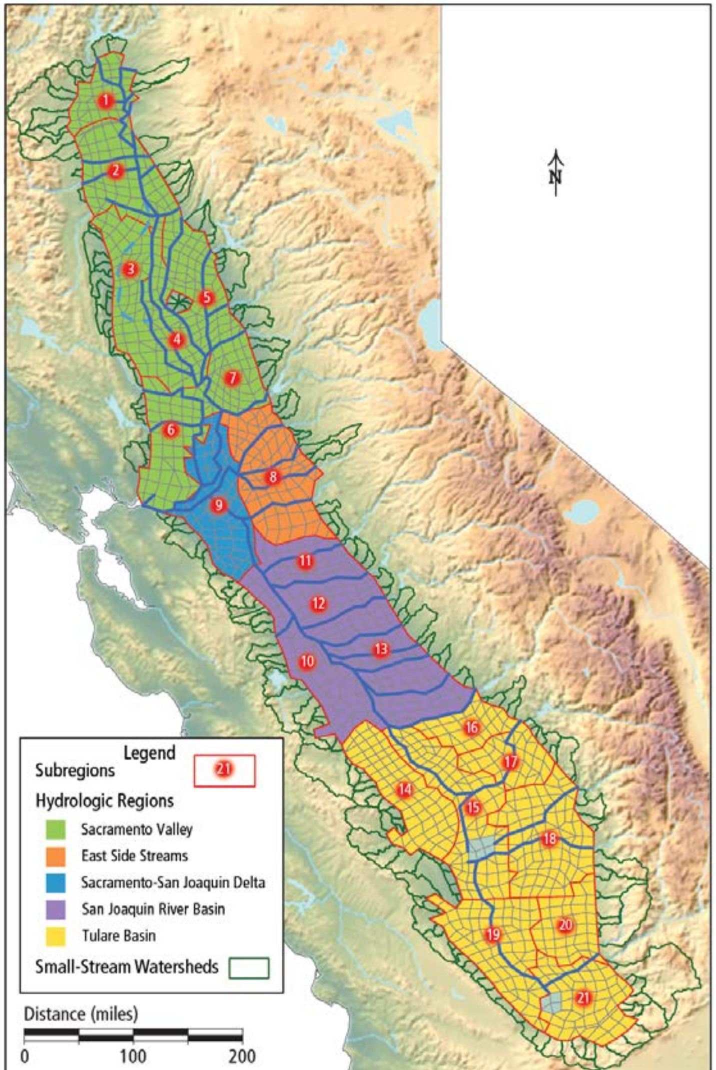
IWFM


Small Watershed
P
Surfacewater Inflow
Groundwater Inflow
Diversion Canal
S_r
T
E
P
Riparian Vegetation
R_{f_u}
Q_{div}
R_f
Stream
I_{f_p}
AW_{u_i}
AW_a
Native Vegetation
S_{r_u}
Lake
AW_{u_o}
Stream
R_{f_a}
Q_d
$I_{f_{AW}}$
I_{f_p}
Pumping Well
Injection Well
Q_L
Root Zone
D_p
Q_d
Unsaturated Zone
Q_p
Q_r
Leakage
net D_p
Groundwater table
Q_s
Aquiclude
Aquitard
Aquiclude

IWFM Water Balance Diagram



C2VSim Model



- Land Surface Processes
  - Land and Water Use Budget
  - Root Zone Budget

- Groundwater Process
  - Groundwater Budget
  - Z-Budget Budget

- Surface Water Processes
  - Stream Reach Budget
  - Lake Budget

- Small-Streams Watershed Process
  - Small Watershed Budget

END