Estimating regional impacts of conjunctive use with an integrated hydrologic model of California's Central Valley

CWEMF Conference
Asilomar, CA
February 26, 2008

Charles Brush

Hydrology & Operations, Bay-Delta Office

California Department of Water Resources

Sacramento, CA

Collaborators

Tariq Kadir & Can Dogrul

Modeling Support Branch, DWR

Bob Niblack

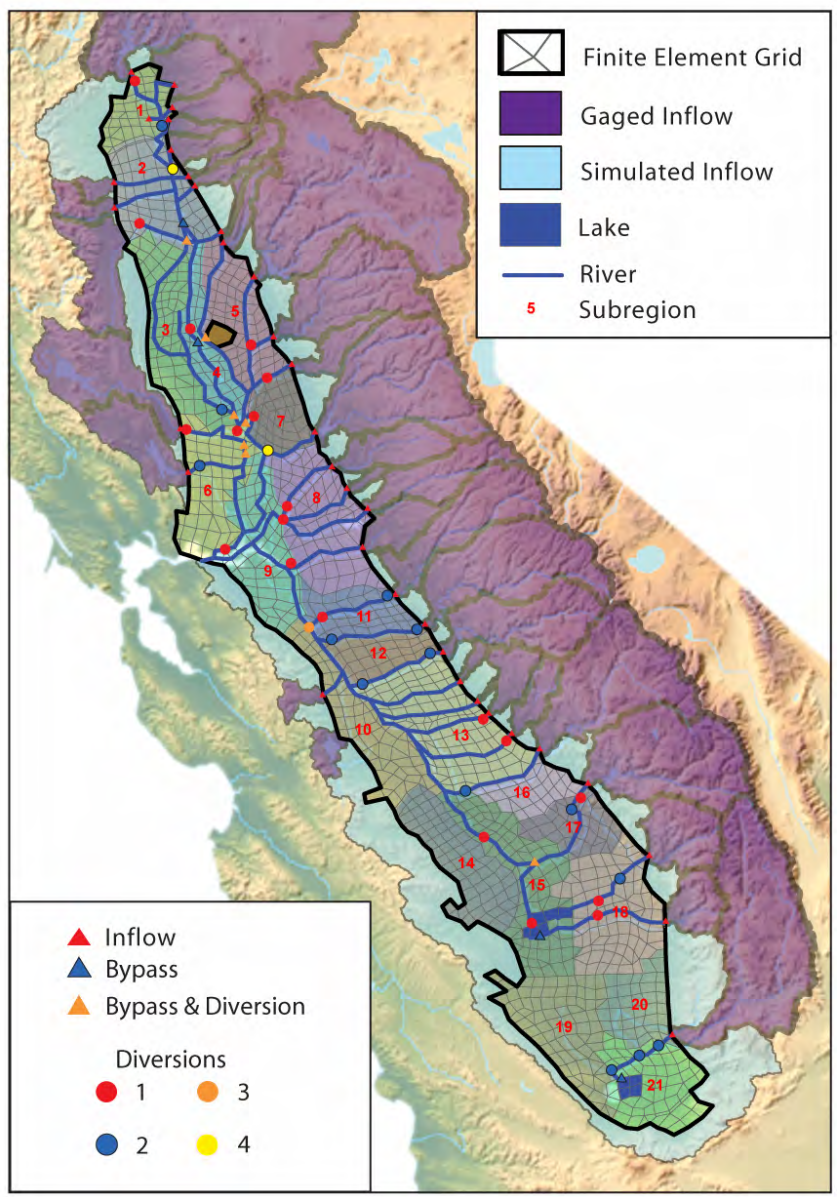
Division of Planning and Local Assistance, DWR

C2VSIM Model Grid

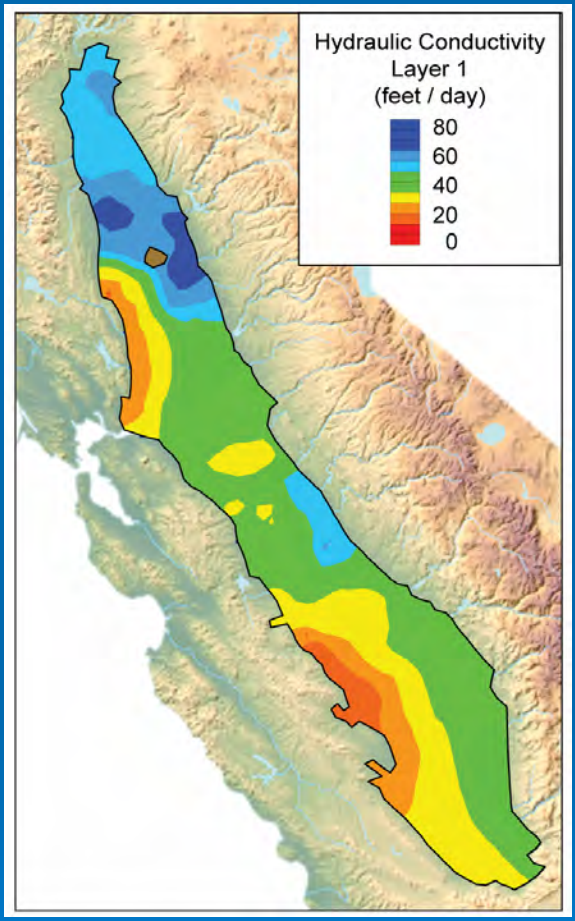
Finite Element Grid
- 3 layers
- 1393 nodes
- 1392 elements

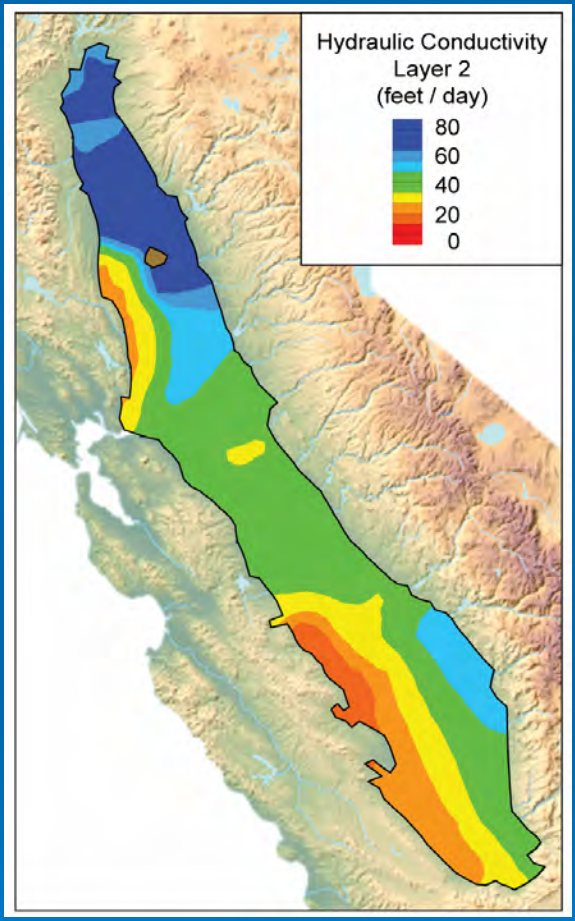
Surface Water System
- 72 stream reaches
- 97 surface water diversion points
- 2 lakes
- 8 bypass canals

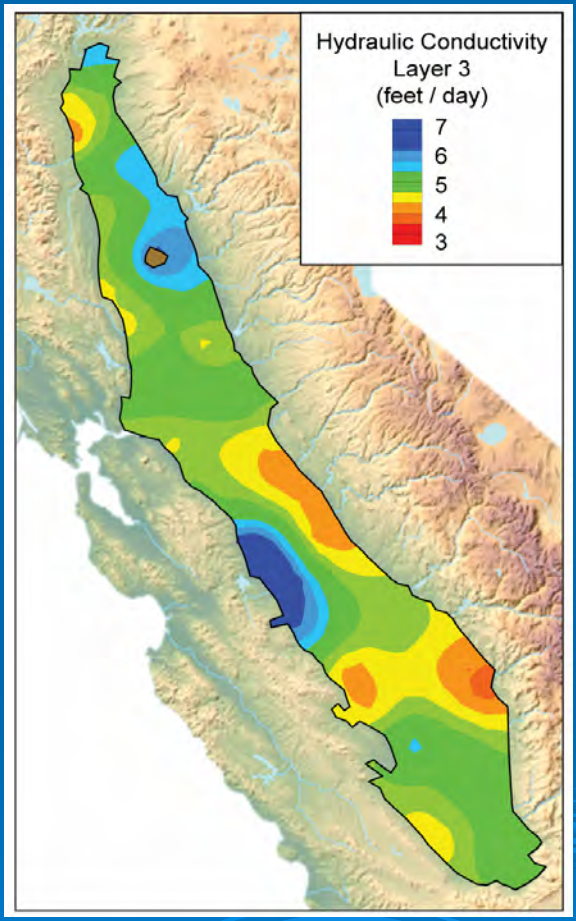
Land Use Process
- 21 subregions
- 4 Land Use Types
  - Agriculture
  - Urban
  - Native
  - Riparian



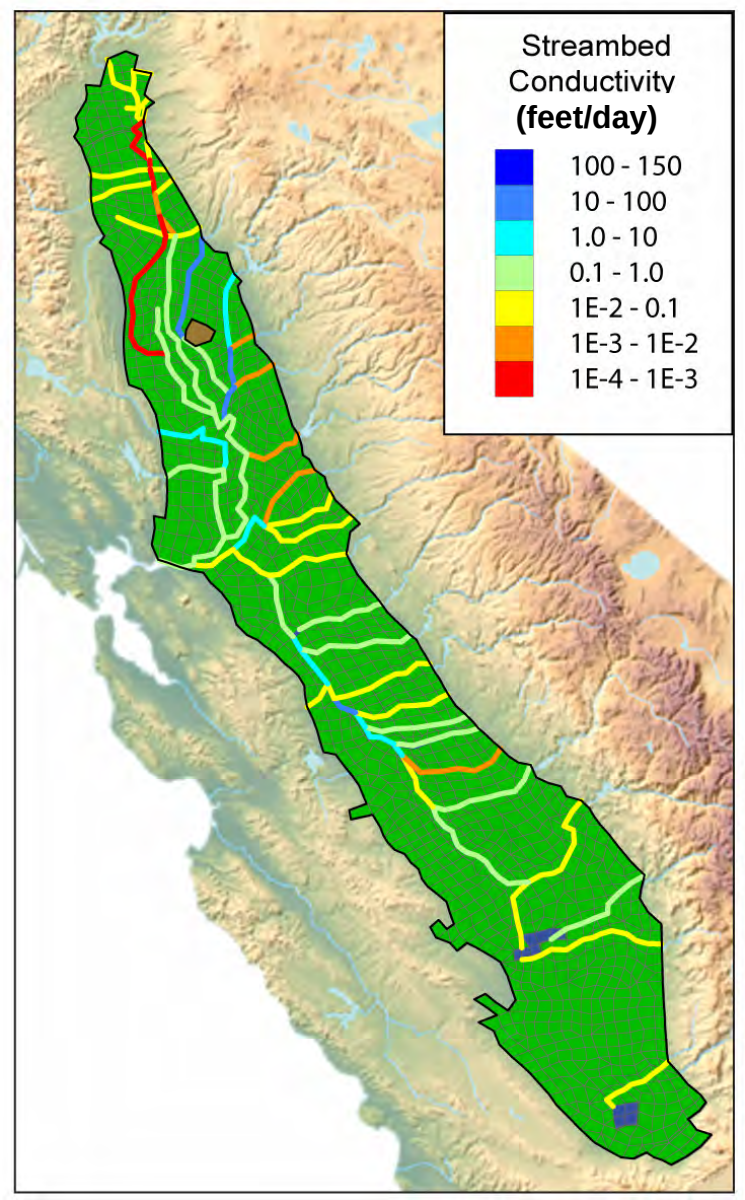
Hydraulic Conductivity



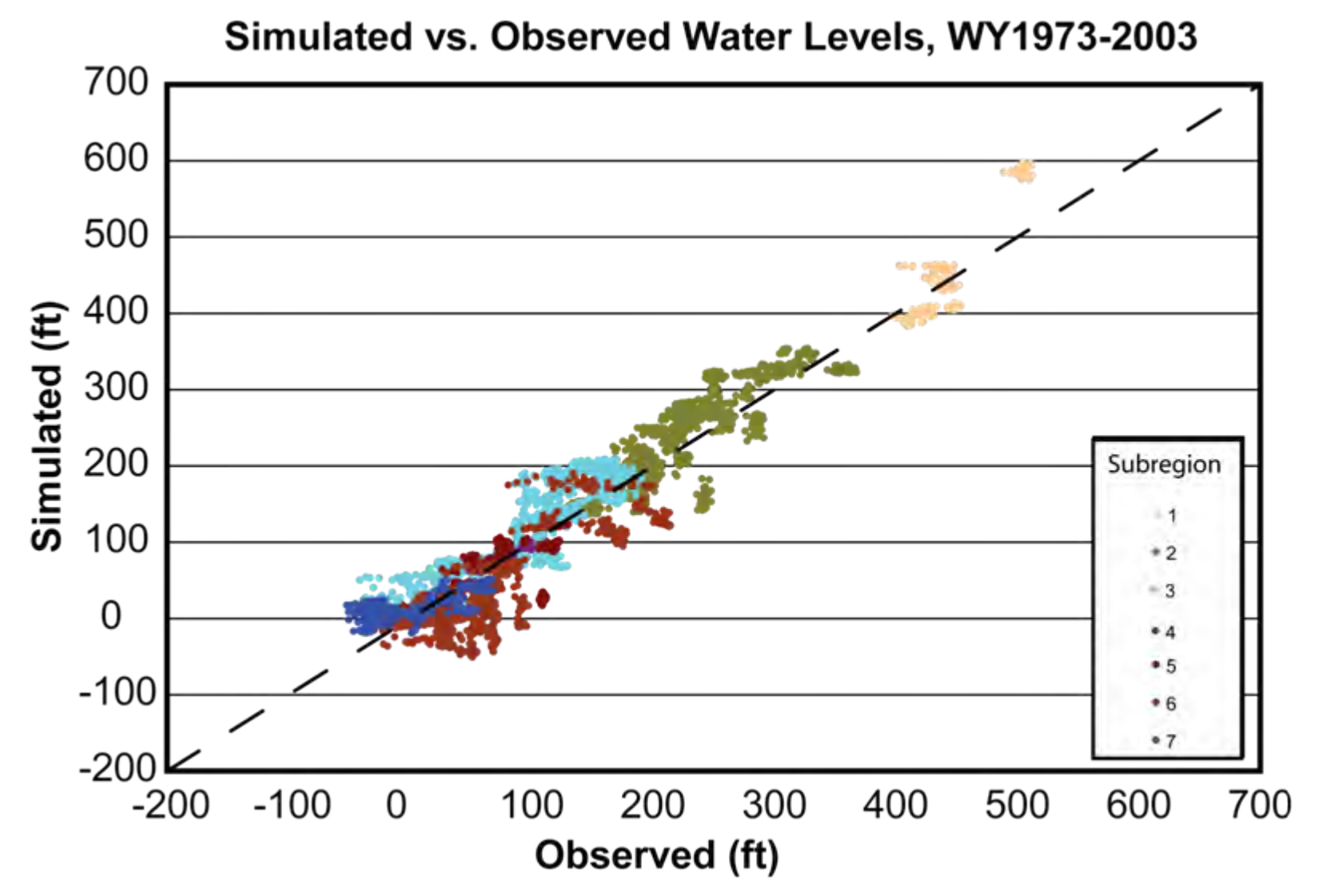




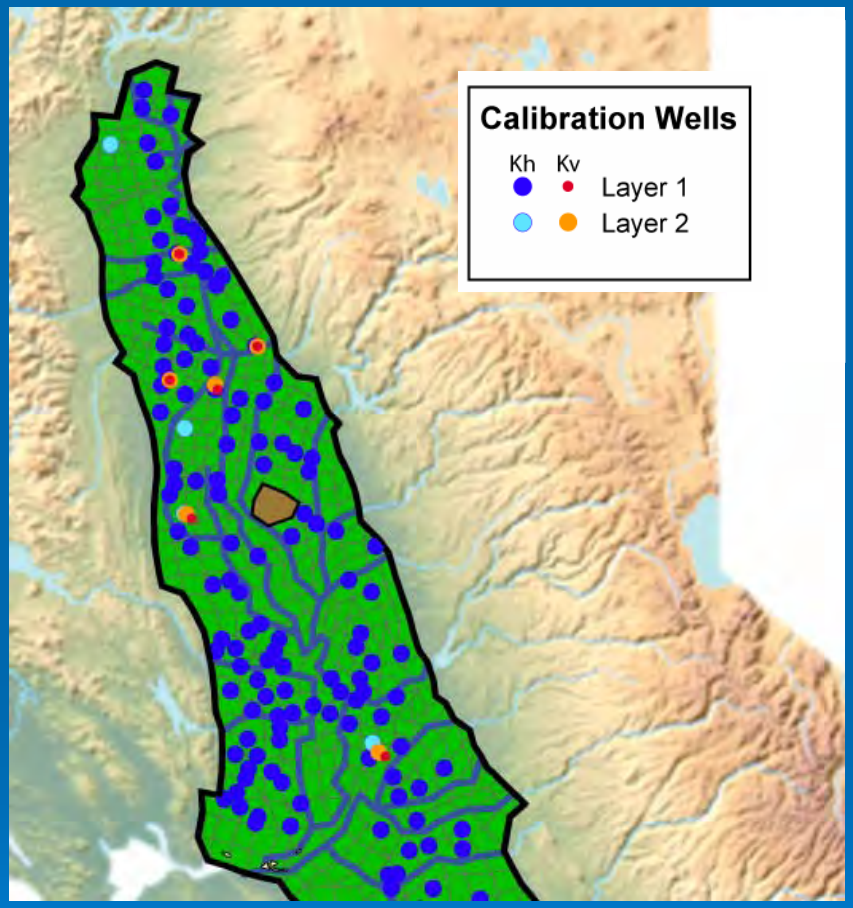
Streambed Conductance

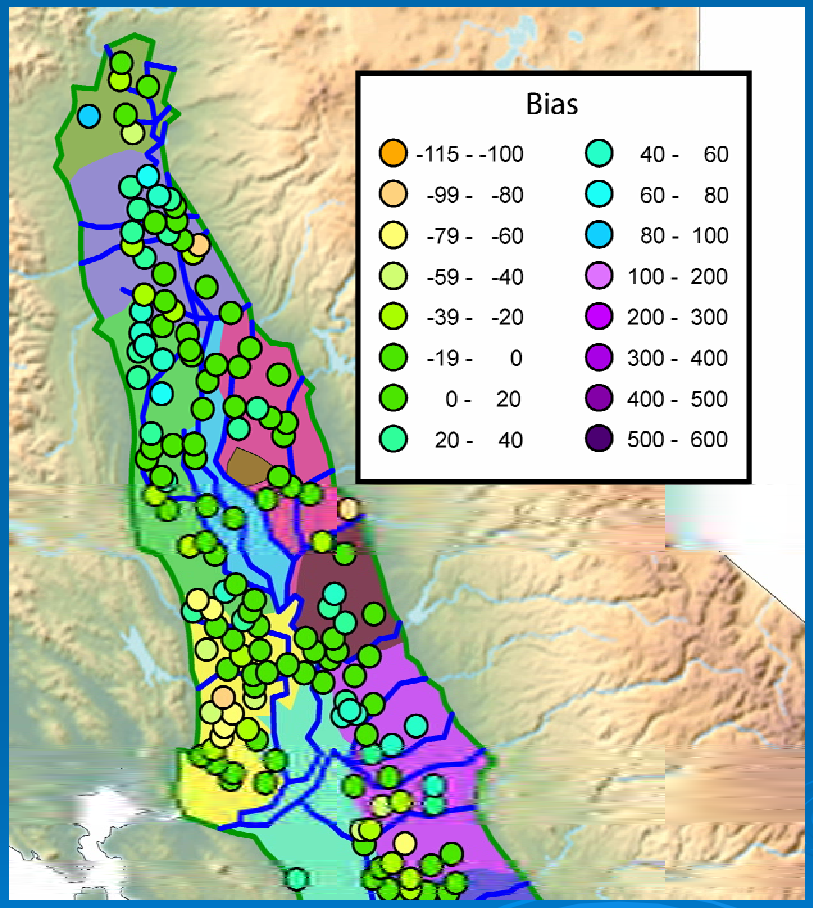


Calibration Results - Heads

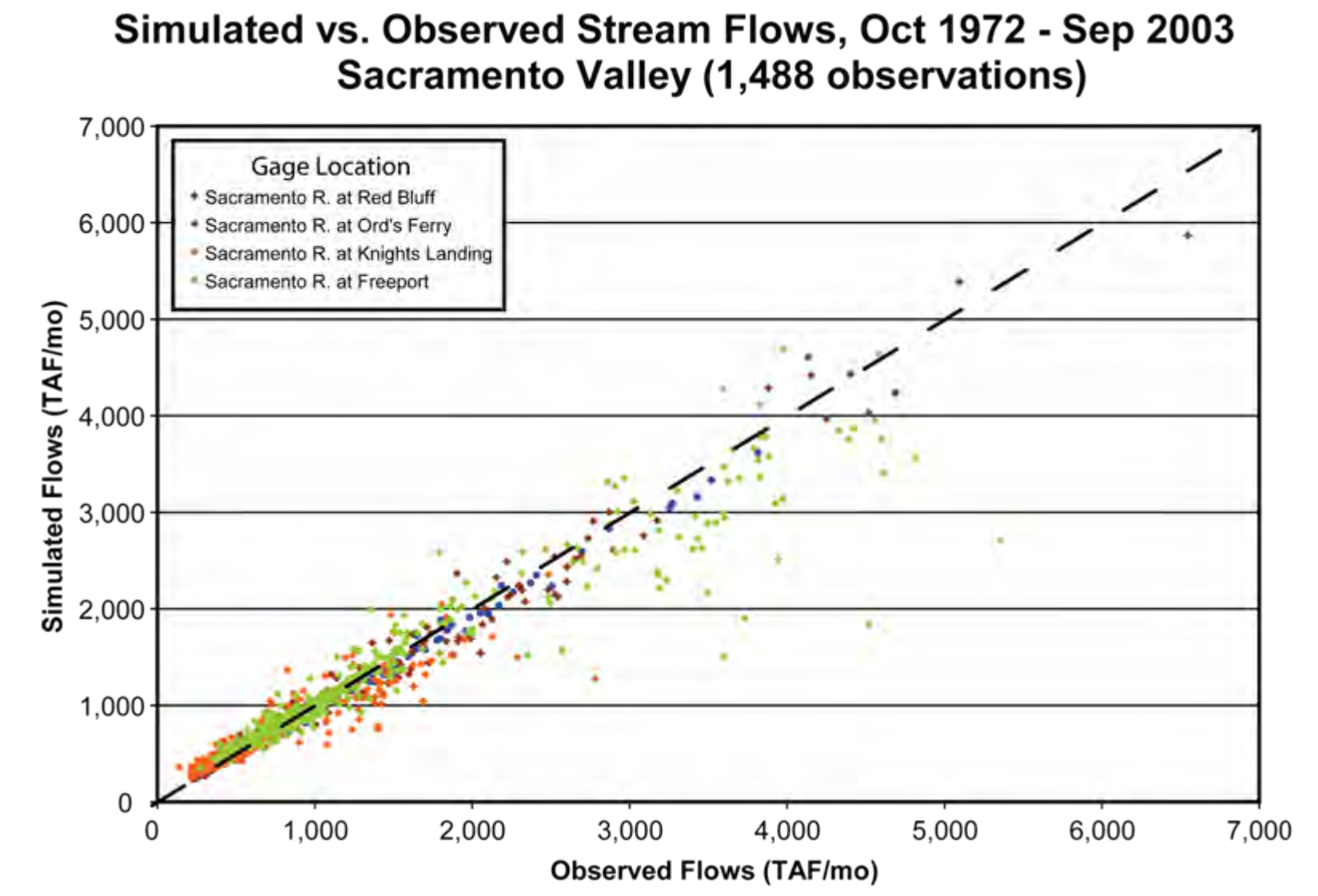


C2VSIM Calibration

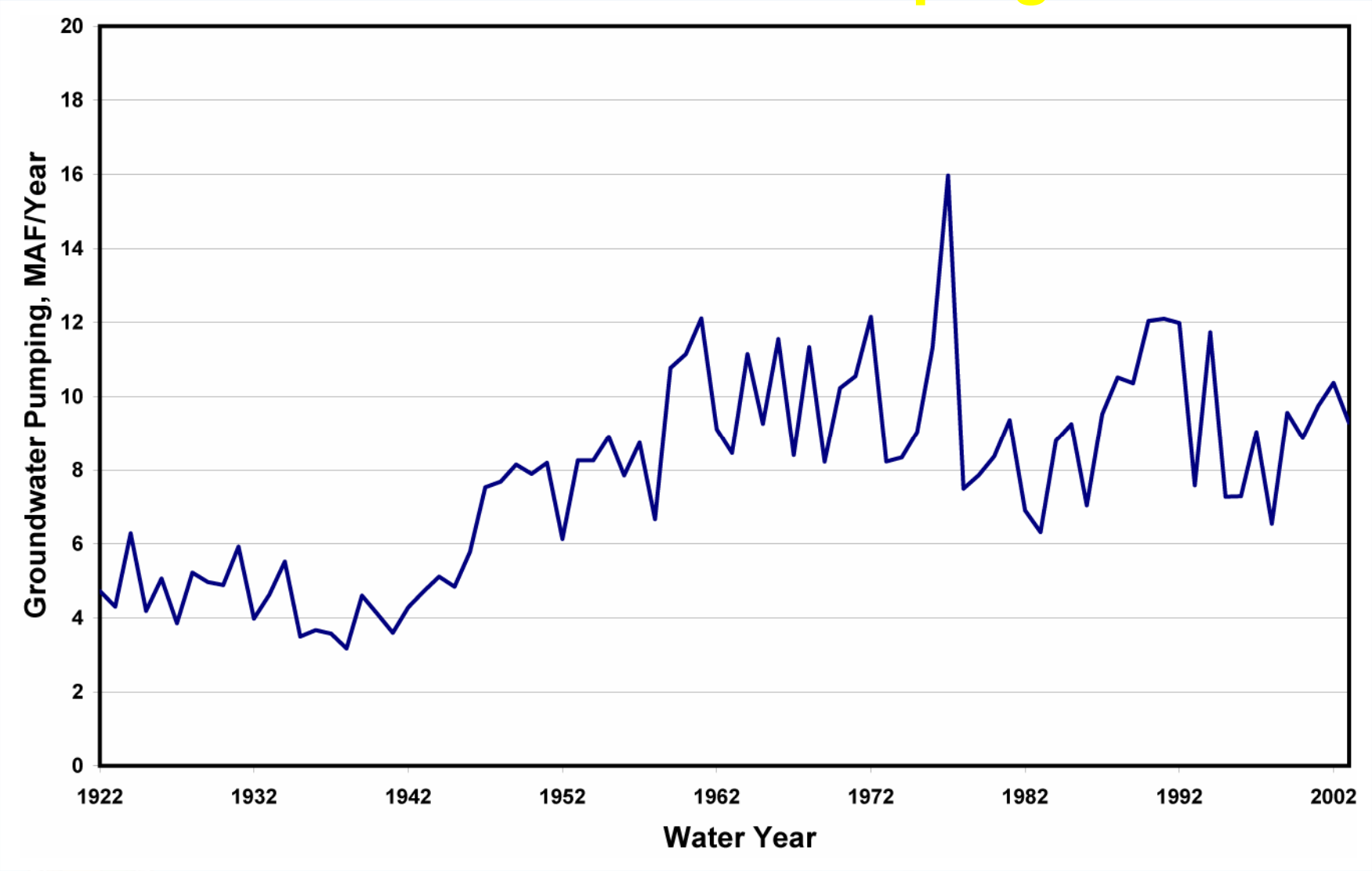




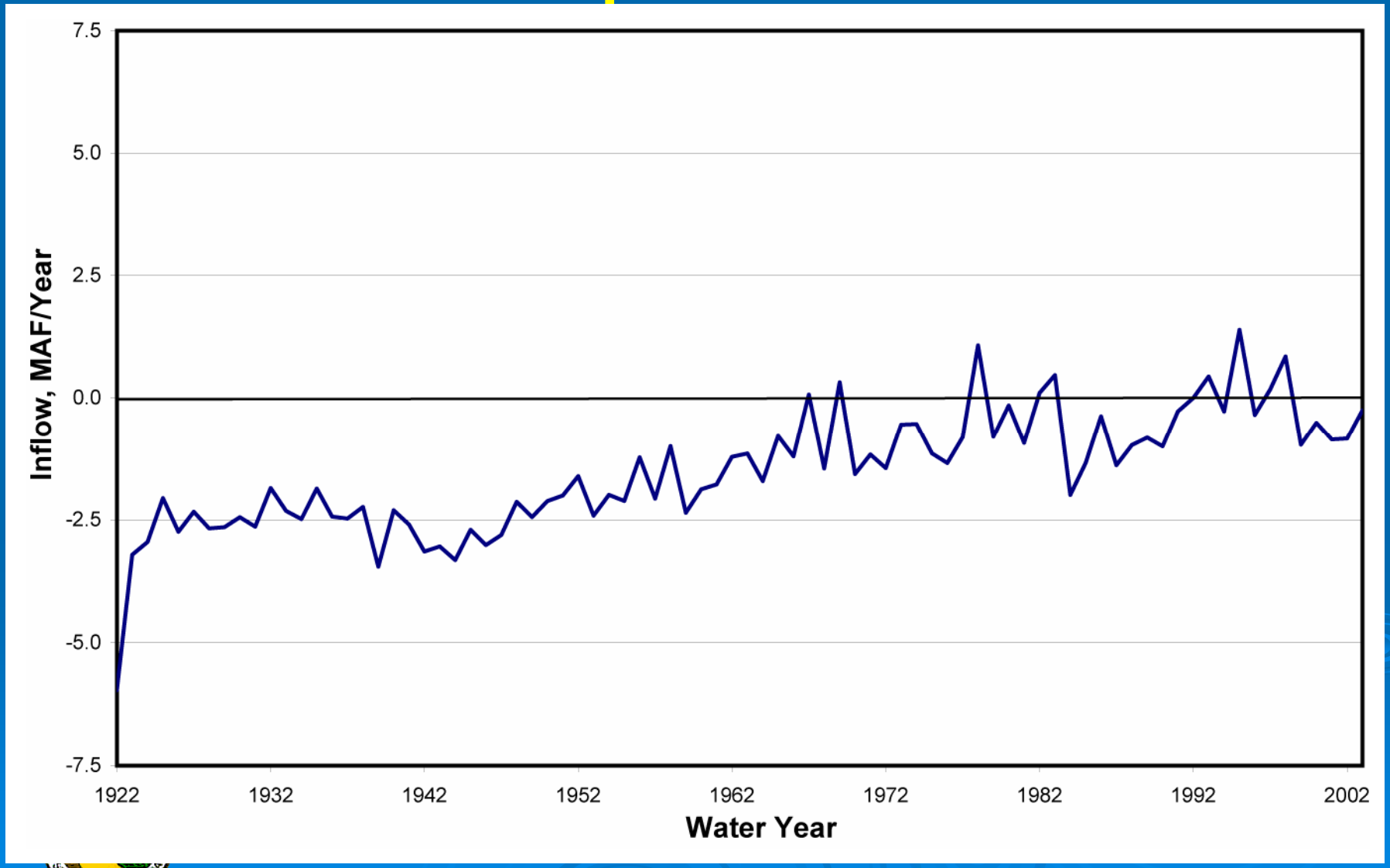
Calibration Results - Flows



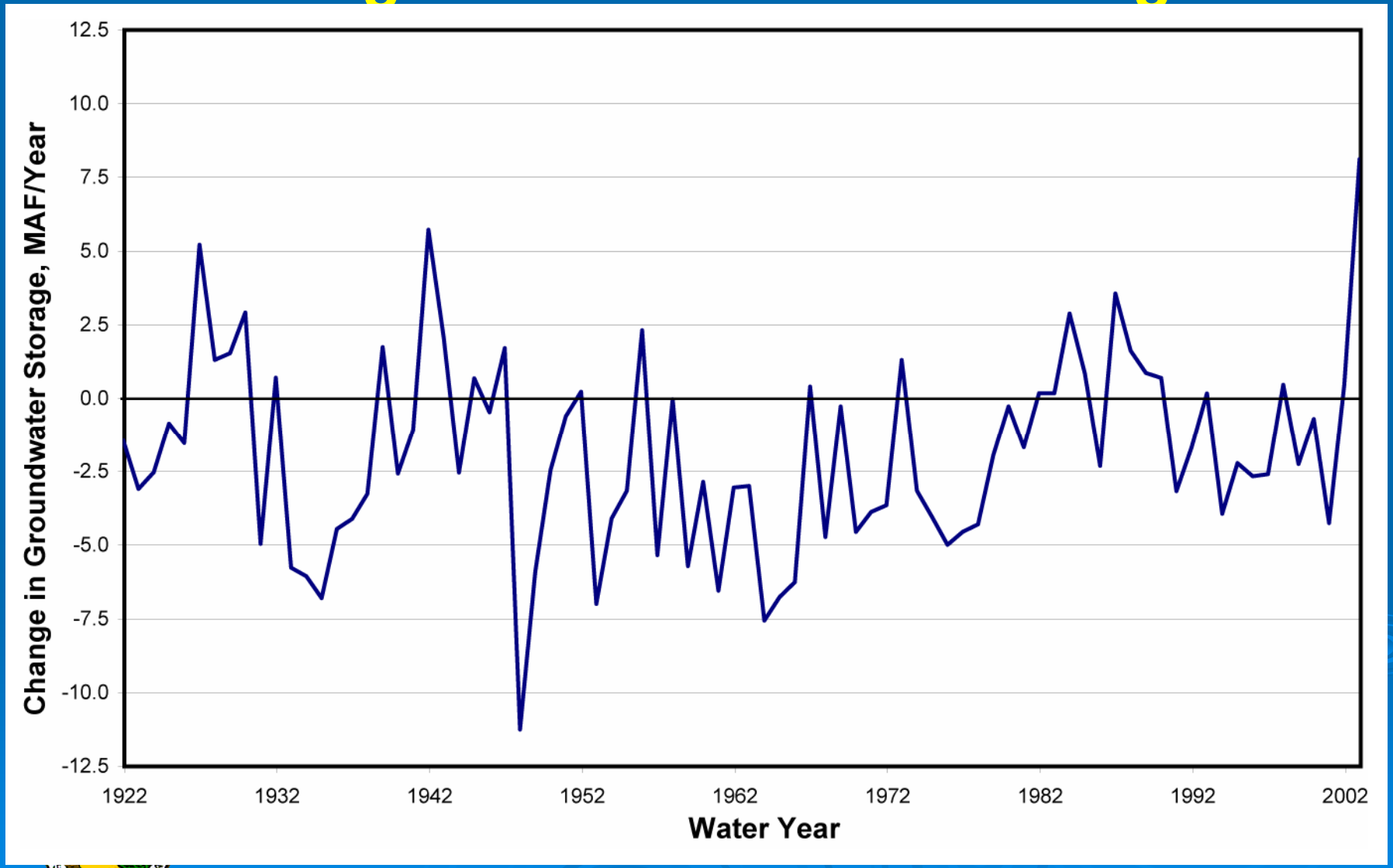
Groundwater Pumping



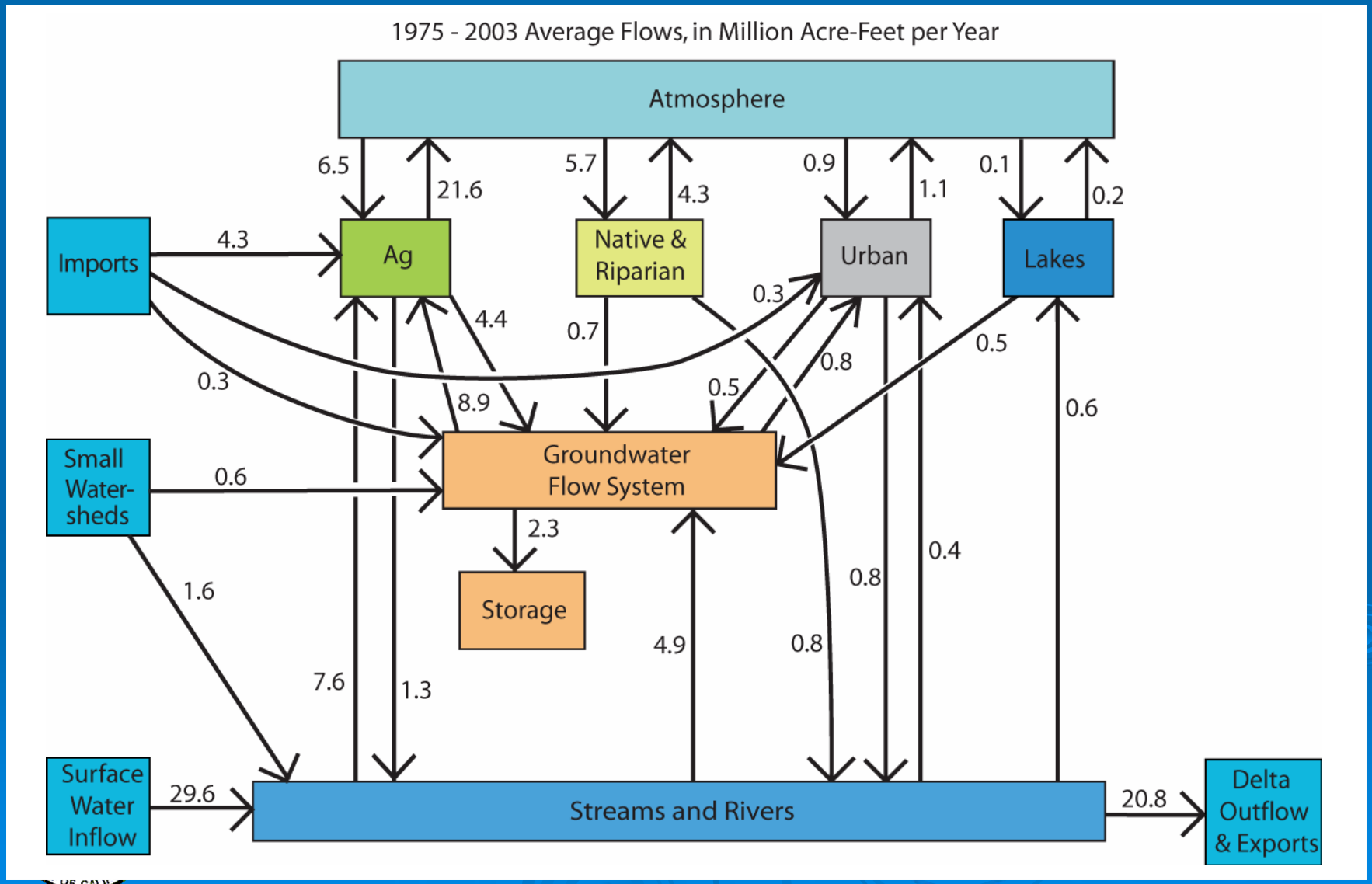
Stream-Aquifer Interaction



Change in Groundwater Storage



Water Budget



C2VSIM Simulation of the Sacramento Valley Water Management Program

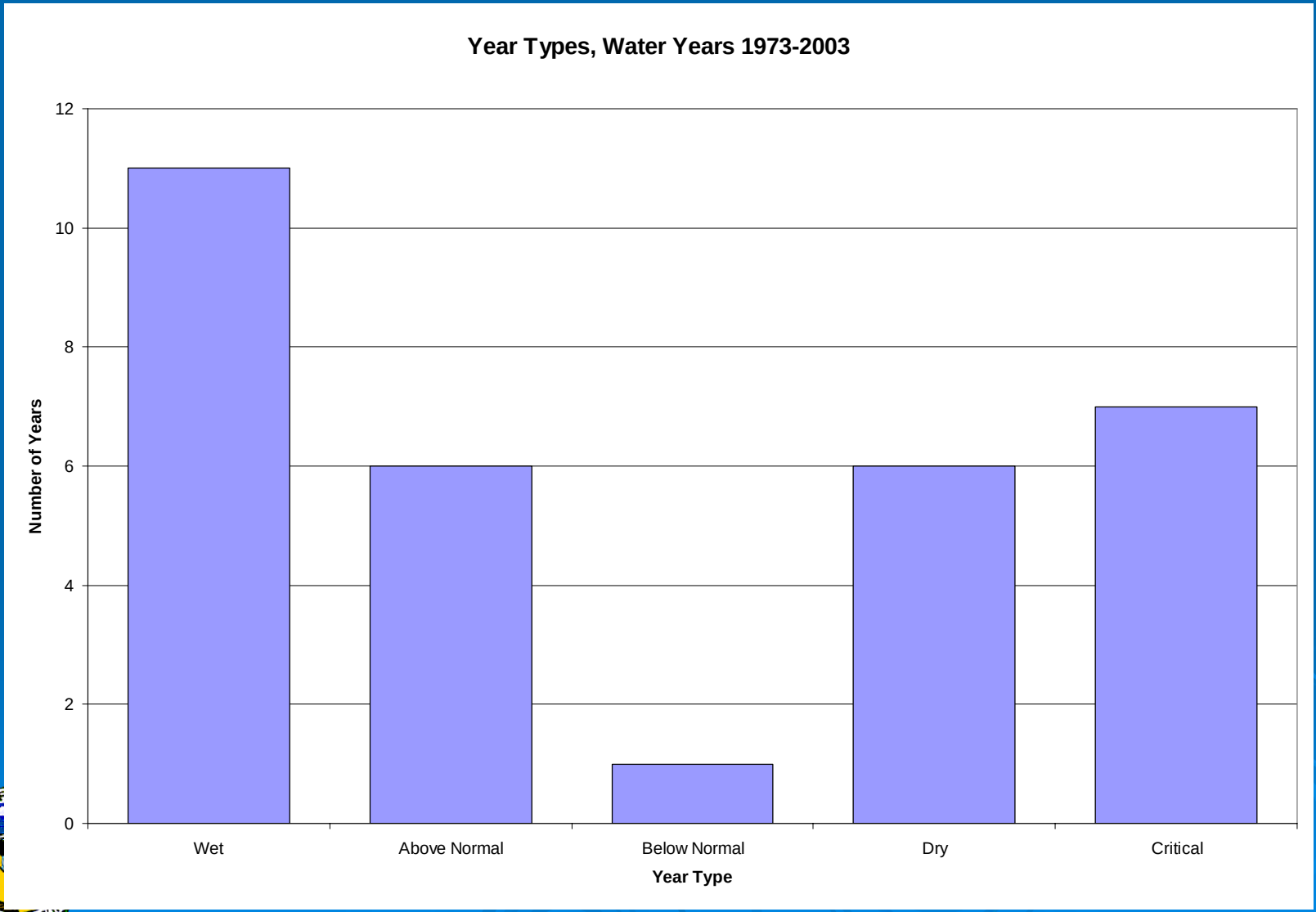
- Identify individual wells and pumping rates
- Prepare IWFM input files
  - October 1972 through September 2003
  - Pumps on in non-wet years
- C2VSIM runs
  1. Turn on groundwater adjustment
  2. Turn on surface water adjustment
  3. Turn on SVWMP wells & reduce diversions in non-wet years (Sacramento River Index)

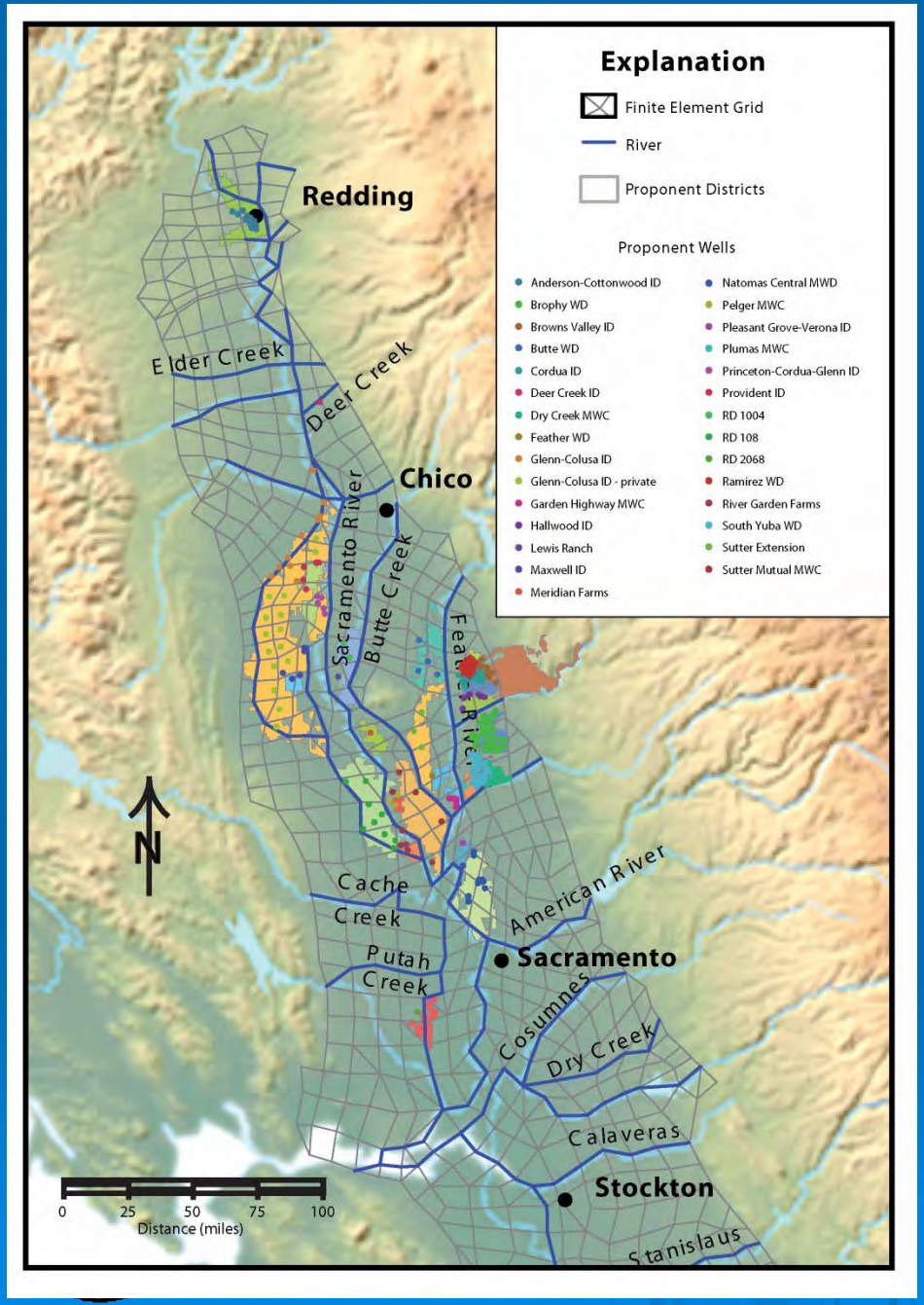
Sacramento River Index

Water Year	WY Index Index	WY Index Yr-type	SVWMP Operation
1972	7.29	BN	-
1973	8.58	AN	ON
1974	12.99	W	OFF
1975	9.35	W	OFF
1976	5.29	C	ON
1977	3.11	C	ON
1978	8.65	AN	ON
1979	6.67	BN	ON
1980	9.04	AN	ON
1981	6.21	D	ON
1982	12.76	W	OFF
1983	15.29	W	OFF
1984	10	W	OFF
1985	6.47	D	ON
1986	9.96	W	OFF
1987	5.86	D	ON

Water Year	WY Index Index	WY Index Yr-type	SVWMP Operation
1988	4.65	C	ON
1989	6.13	D	ON
1990	4.81	C	ON
1991	4.21	C	ON
1992	4.06	C	ON
1993	8.54	AN	ON
1994	5.02	C	ON
1995	12.89	W	OFF
1996	10.26	W	OFF
1997	10.82	W	OFF
1998	13.31	W	OFF
1999	9.8	W	OFF
2000	8.94	AN	ON
2001	5.76	D	ON
2002	6.35	D	ON
2003	8.21	AN	ON

Sacramento River Index



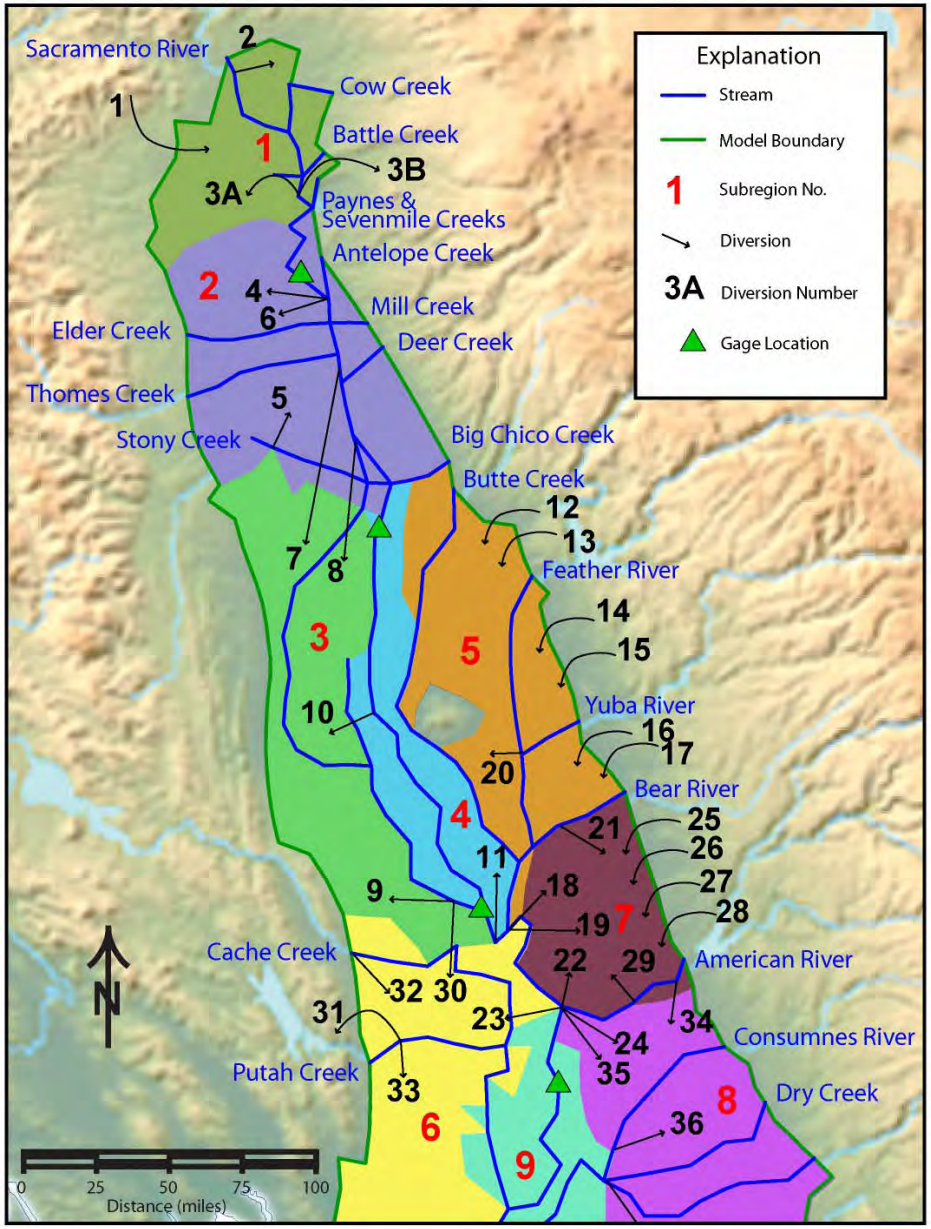


SVWMP Wells

- 29 Districts
- 293 wells
- 187,633 AF/year

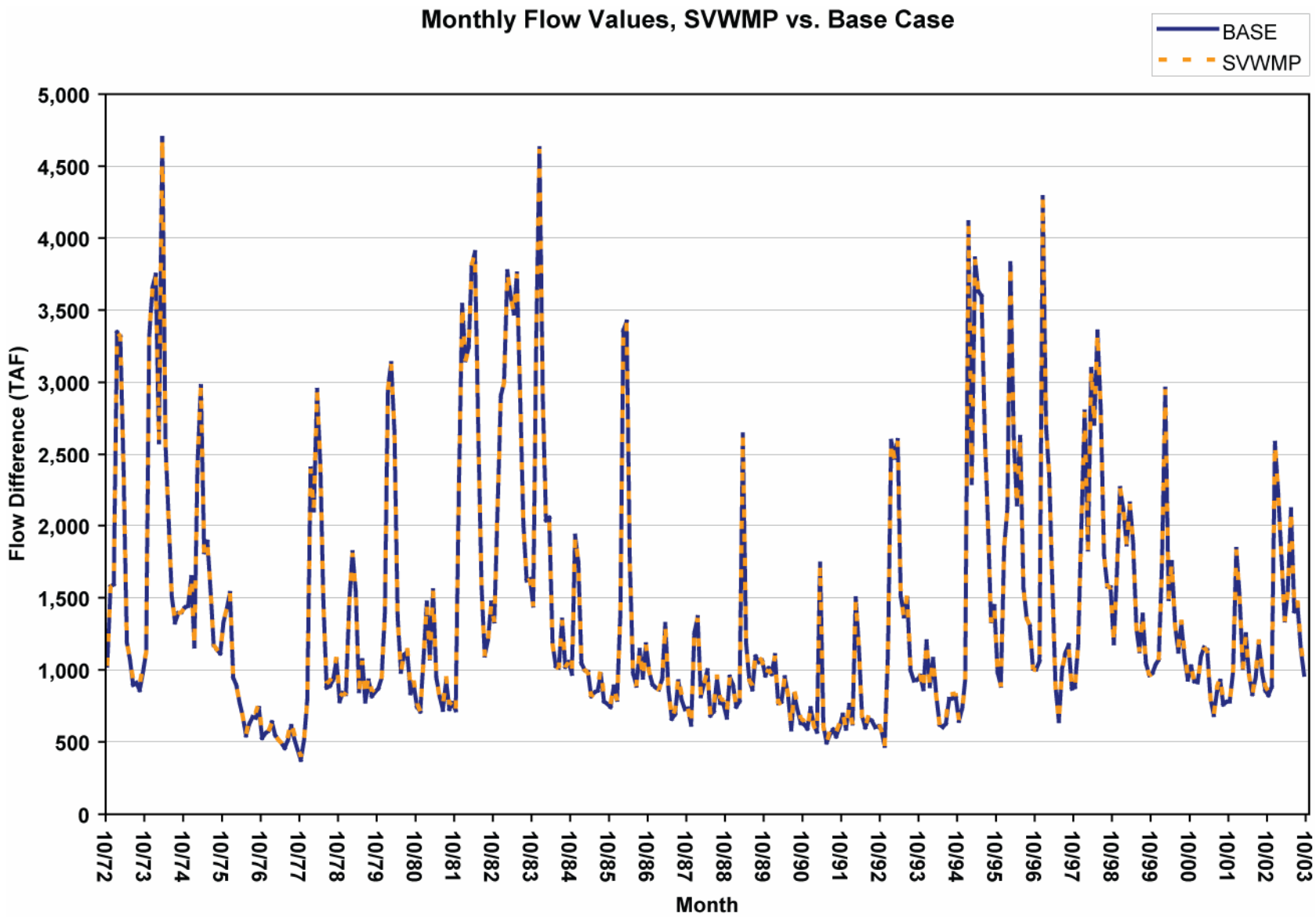
Operate non-wet years

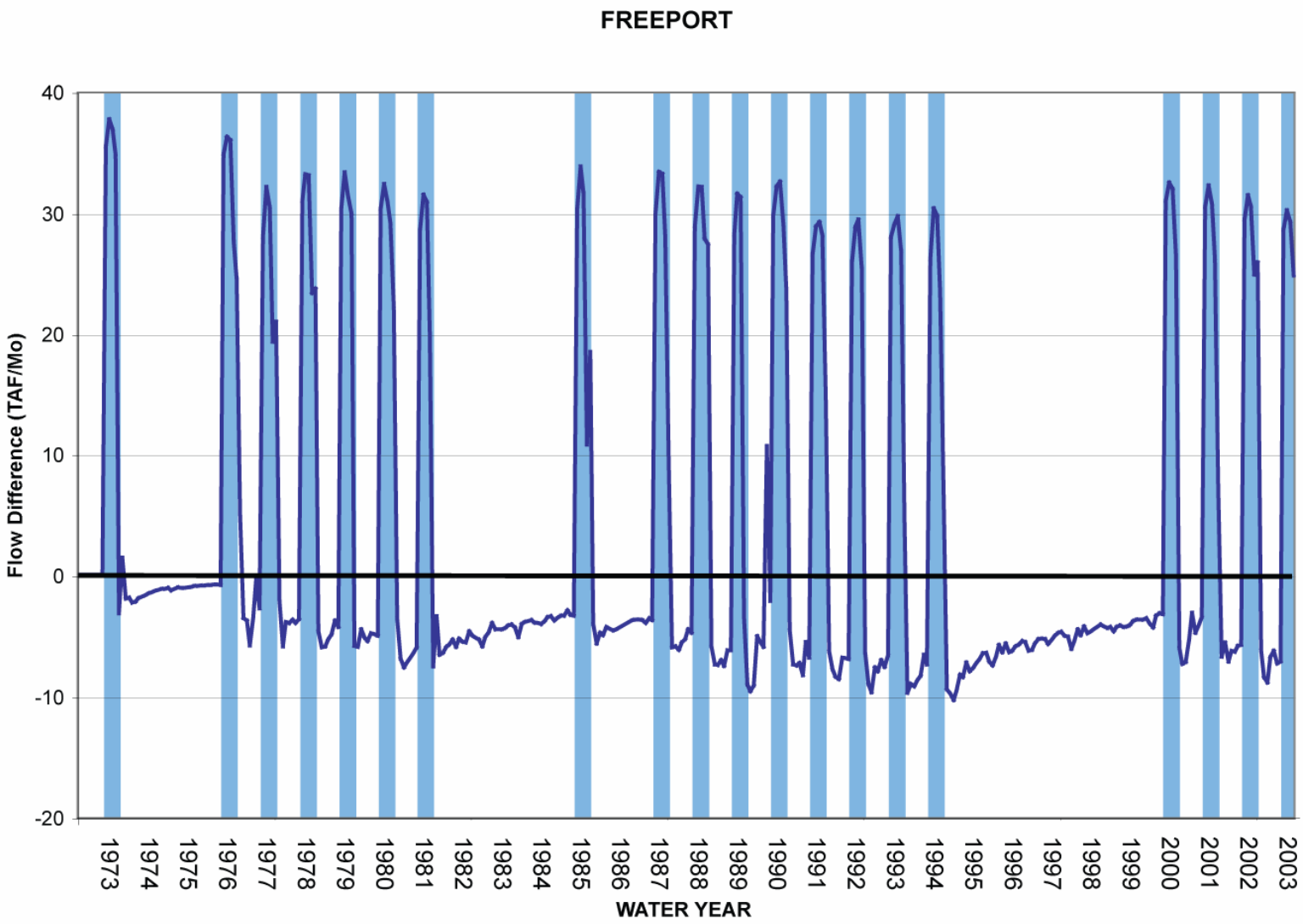
- 1973 1 yr
- 1976-81 6 yrs
- 1985 1 yr
- 1987-94 8 yrs
- 2000-03 4 yrs

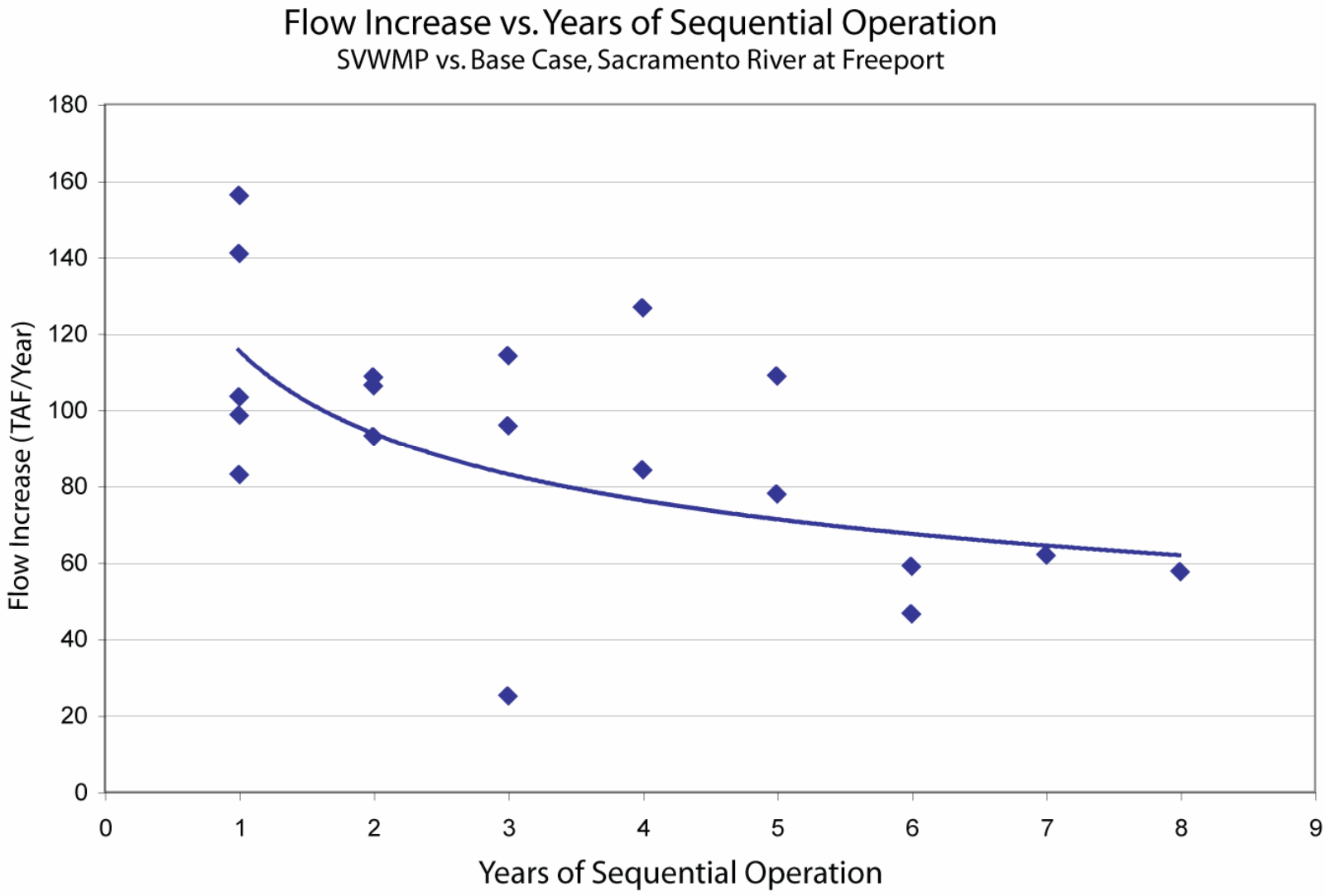


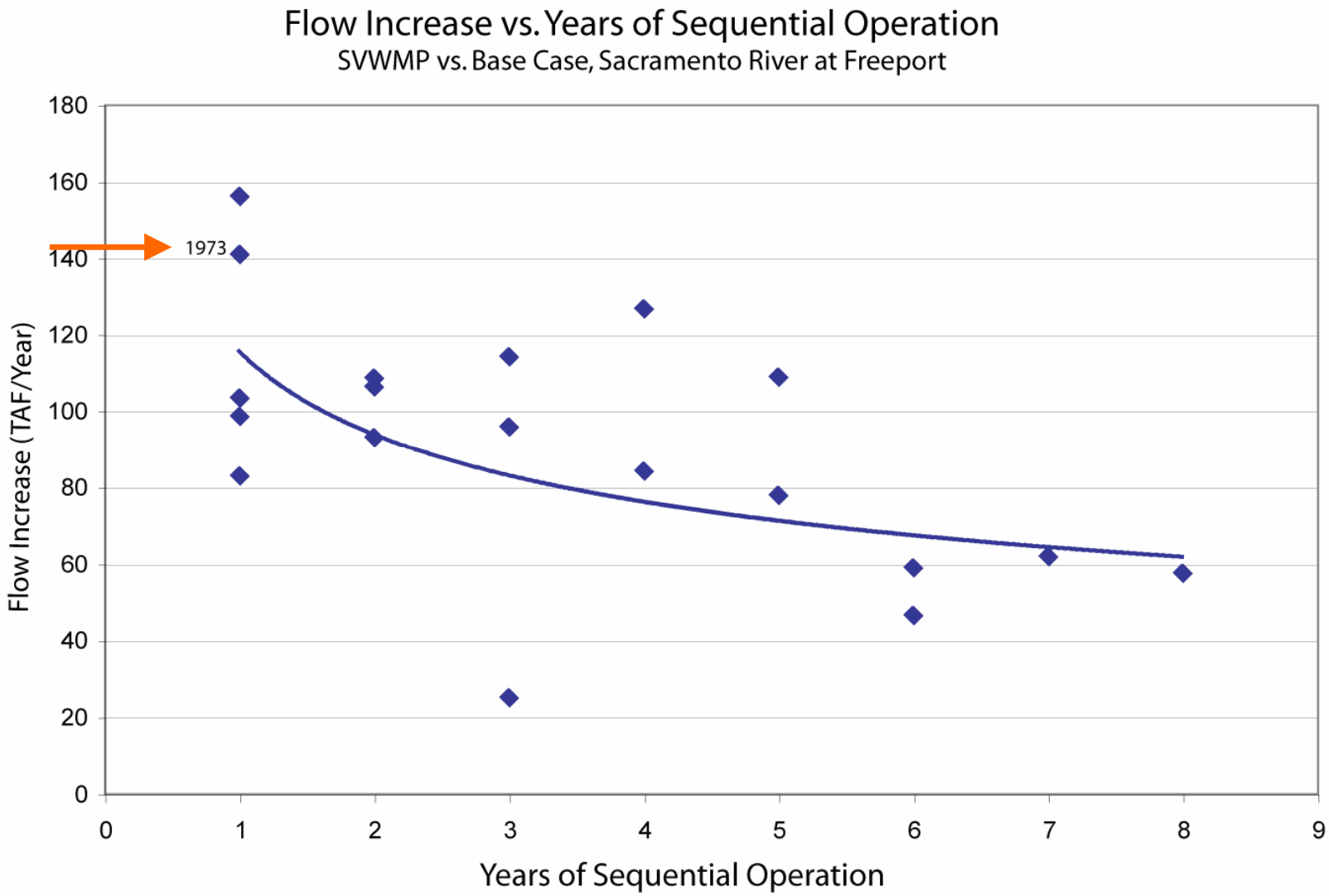
C2VSIM Diversions

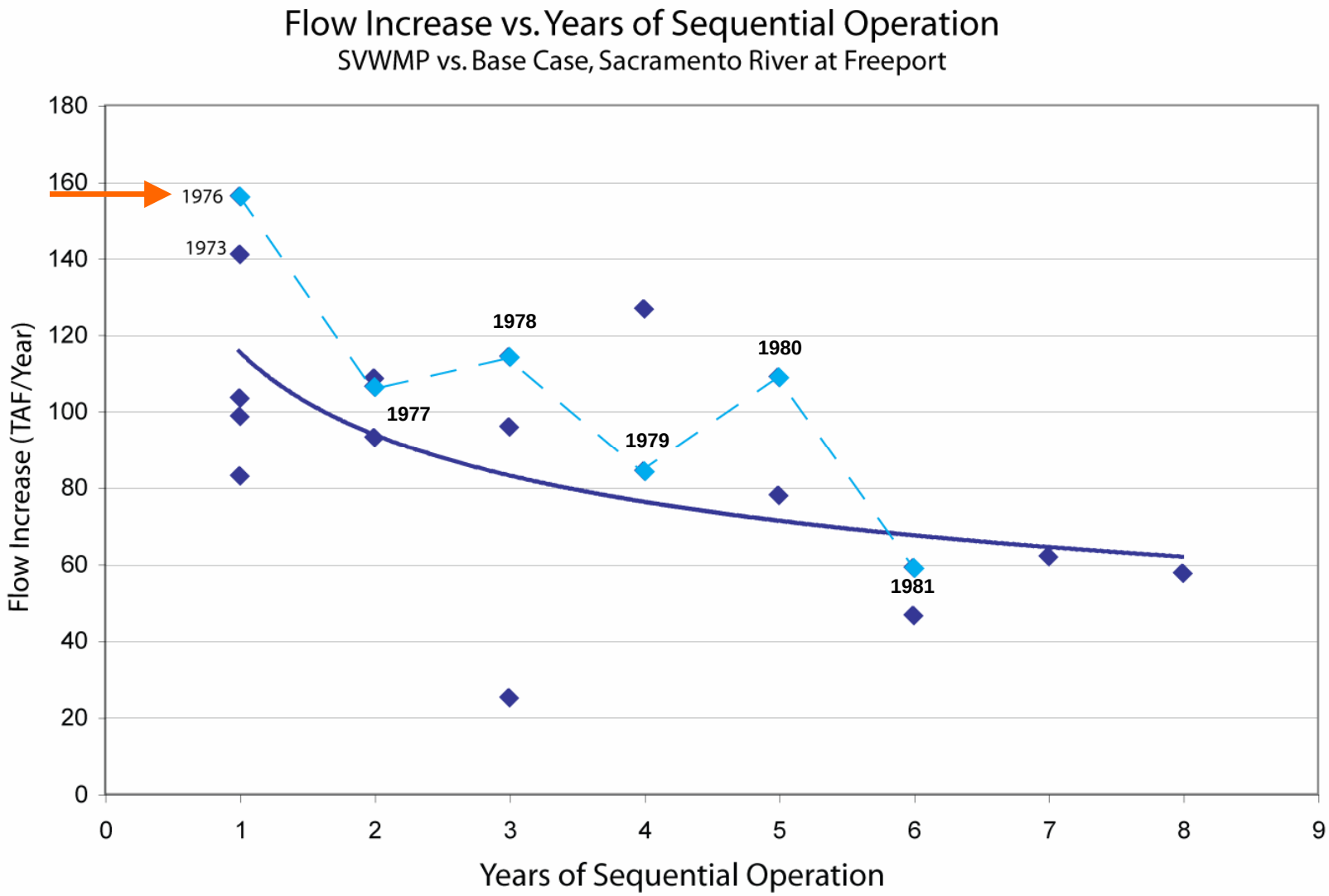
- Adjusted:
  - 19 diversions above Freeport
- Unadjusted:
  - 11 imports
  - 2 exports

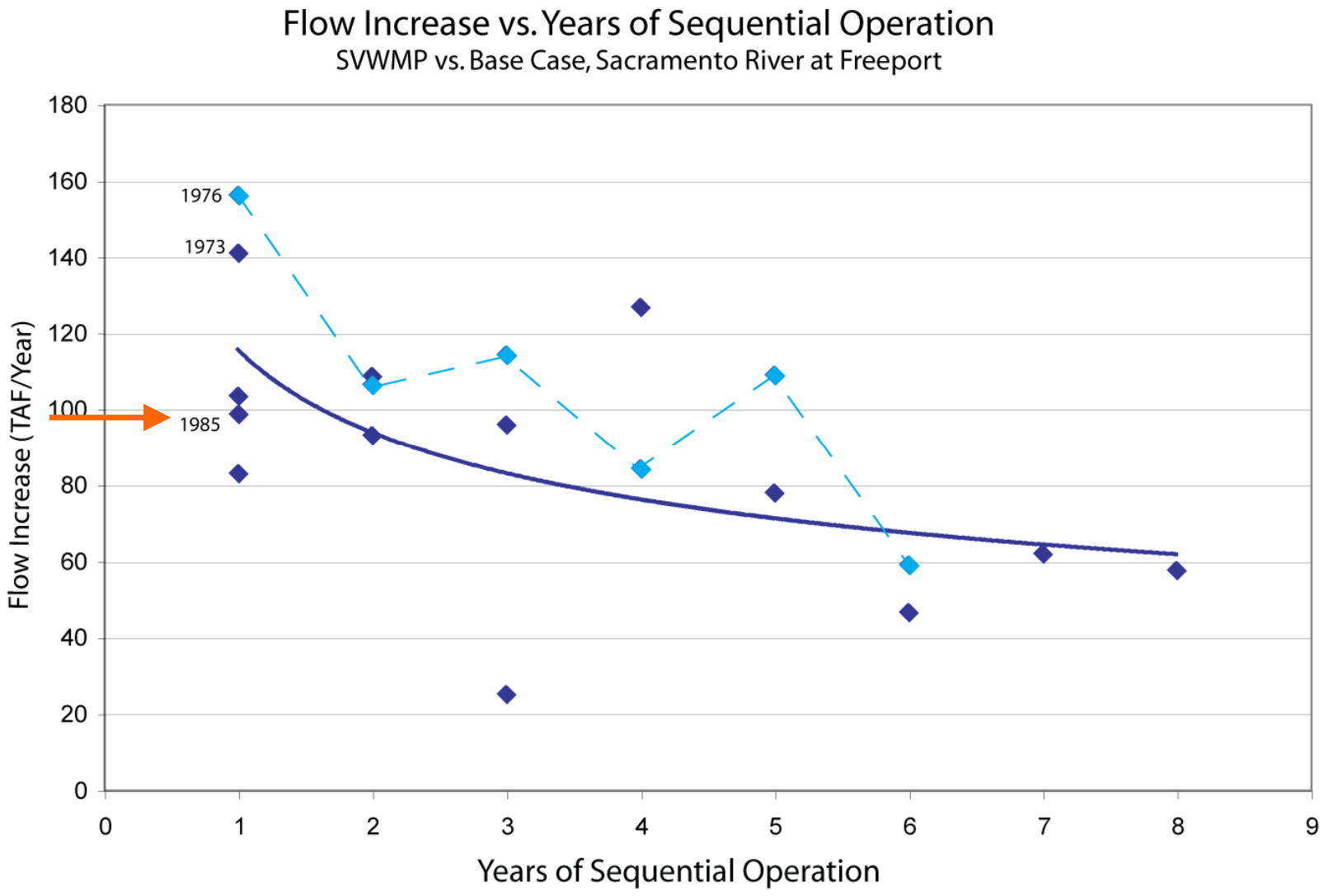

Monthly Flow Values, SVWMP vs. Base Case
BASE
SVWMP
Flow Difference (TAF)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
10/72
10/73
10/74
10/75
10/76
10/77
10/78
10/79
10/80
10/81
10/82
10/83
10/84
10/85
10/86
10/87
10/88
10/89
10/90
10/91
10/92
10/93
10/94
10/95
10/96
10/97
10/98
10/99
10/00
10/01
10/02
10/03
Month

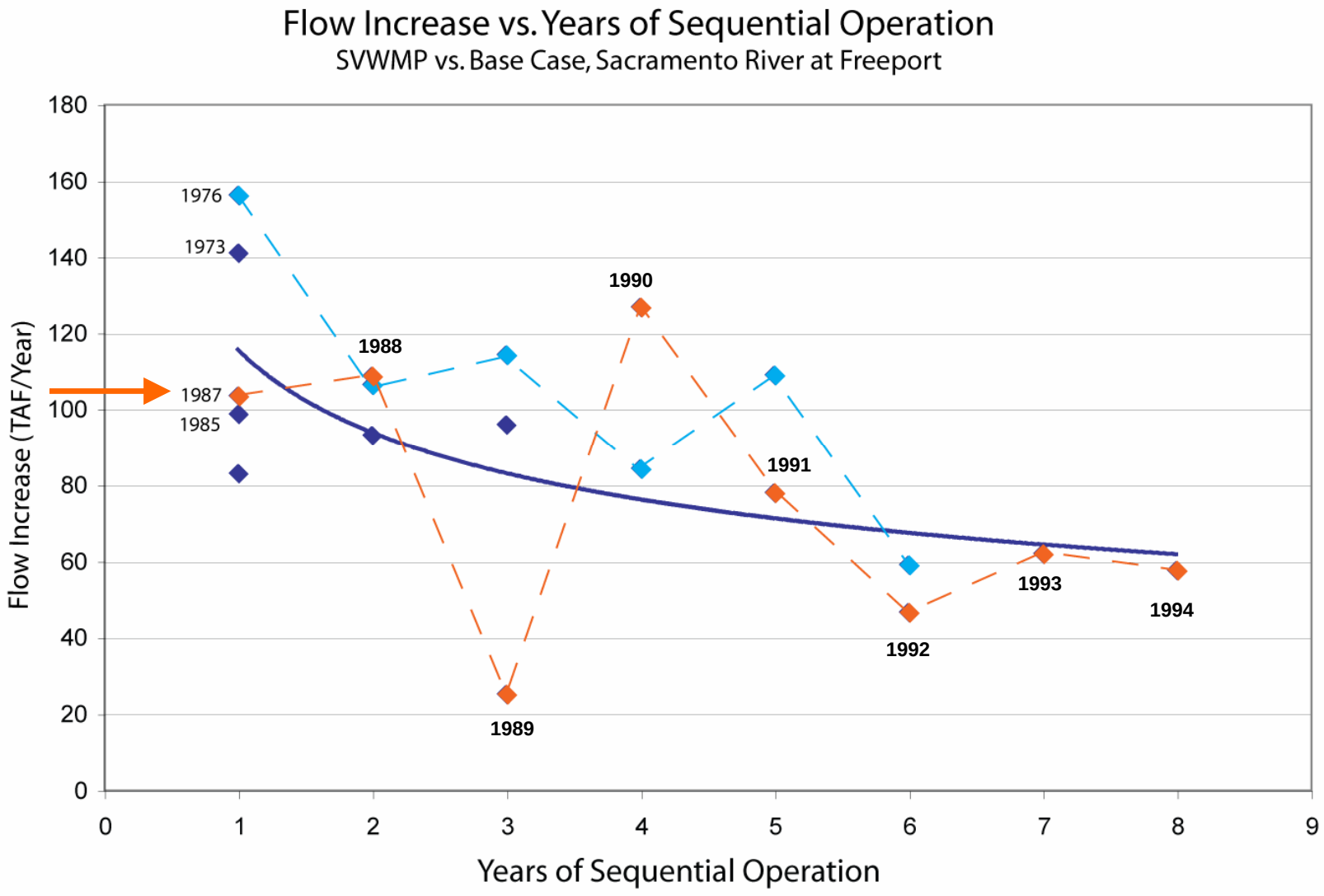

FREEPORT
Flow Difference (TAF/Mo)
40
30
20
10
0
-10
-20
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
WATER YEAR

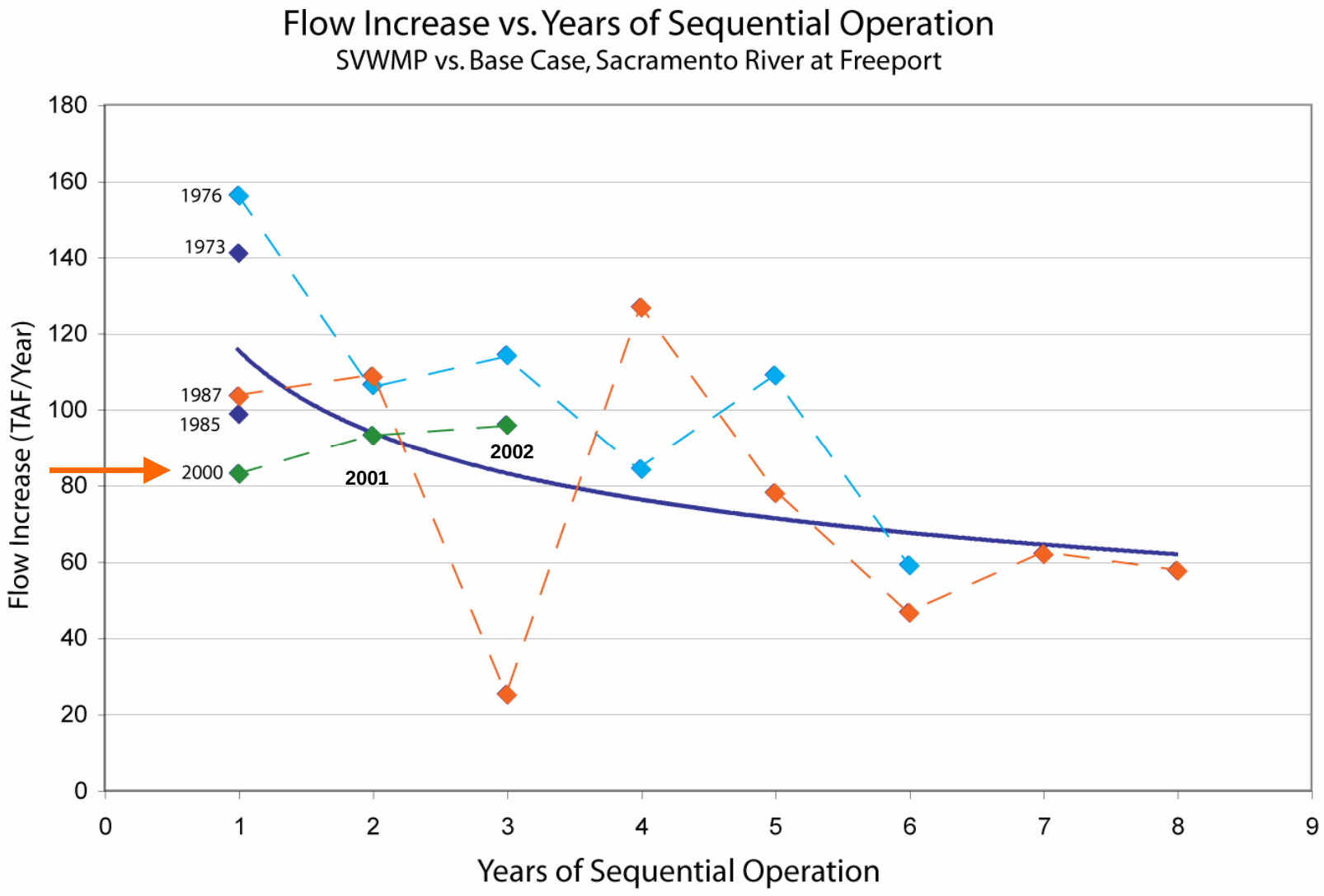

Flow Increase vs. Years of Sequential Operation
SVWMP vs. Base Case, Sacramento River at Freeport
Flow Increase (TAF/Year)
180
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
Years of Sequential Operation


Flow Increase vs. Years of Sequential Operation
SVWMP vs. Base Case, Sacramento River at Freeport
1973
Flow Increase (TAF/Year)
Years of Sequential Operation
0
20
40
60
80
100
120
140
160
180
0
1
2
3
4
5
6
7
8
9

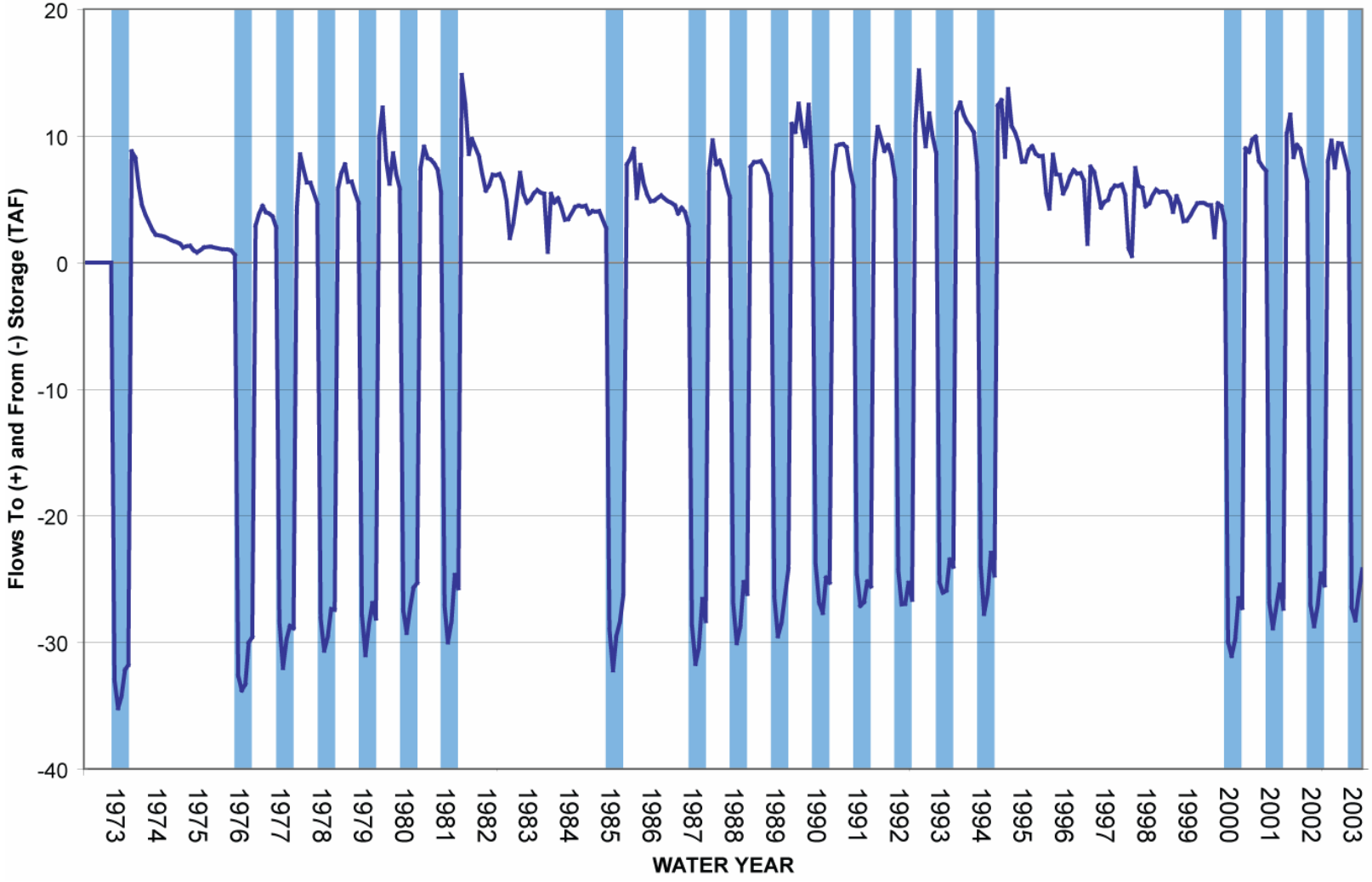

Flow Increase vs. Years of Sequential Operation
SVWMP vs. Base Case, Sacramento River at Freeport
Flow Increase (TAF/Year)
Years of Sequential Operation
180
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
1976
1973
1977
1978
1979
1980
1981


Flow Increase vs. Years of Sequential Operation
SVWMP vs. Base Case, Sacramento River at Freeport
Flow Increase (TAF/Year)
Years of Sequential Operation
1976
1973
1985
0
20
40
60
80
100
120
140
160
180
0
1
2
3
4
5
6
7
8
9

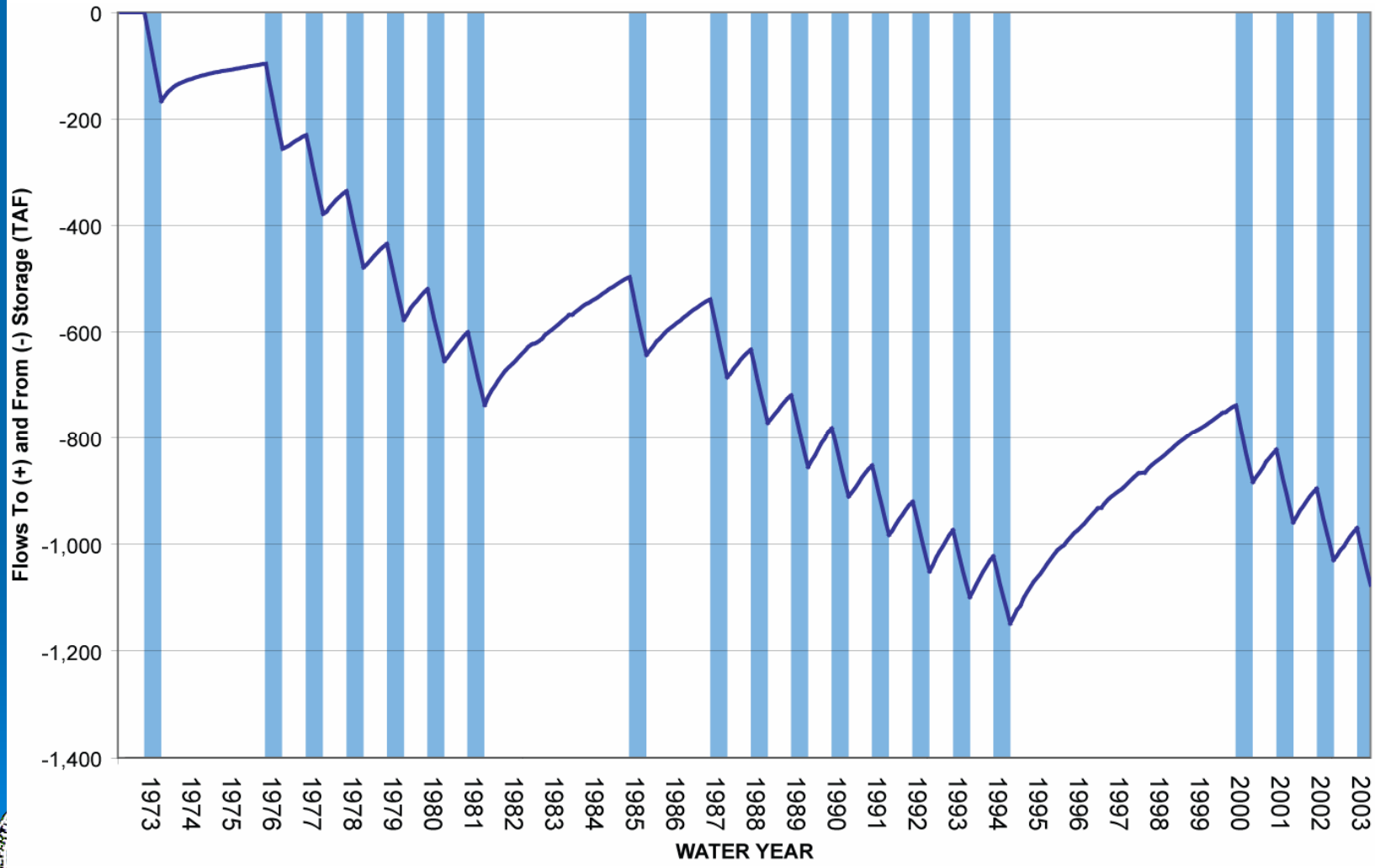

Flow Increase vs. Years of Sequential Operation
SVWMP vs. Base Case, Sacramento River at Freeport
Flow Increase (TAF/Year)
Years of Sequential Operation
180
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
1976
1973
1987
1985
1988
1989
1990
1991
1992
1993
1994


Flow Increase vs. Years of Sequential Operation
SVWMP vs. Base Case, Sacramento River at Freeport
Flow Increase (TAF/Year)
Years of Sequential Operation
180
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
1976
1973
1987
1985
2000
2001
2002

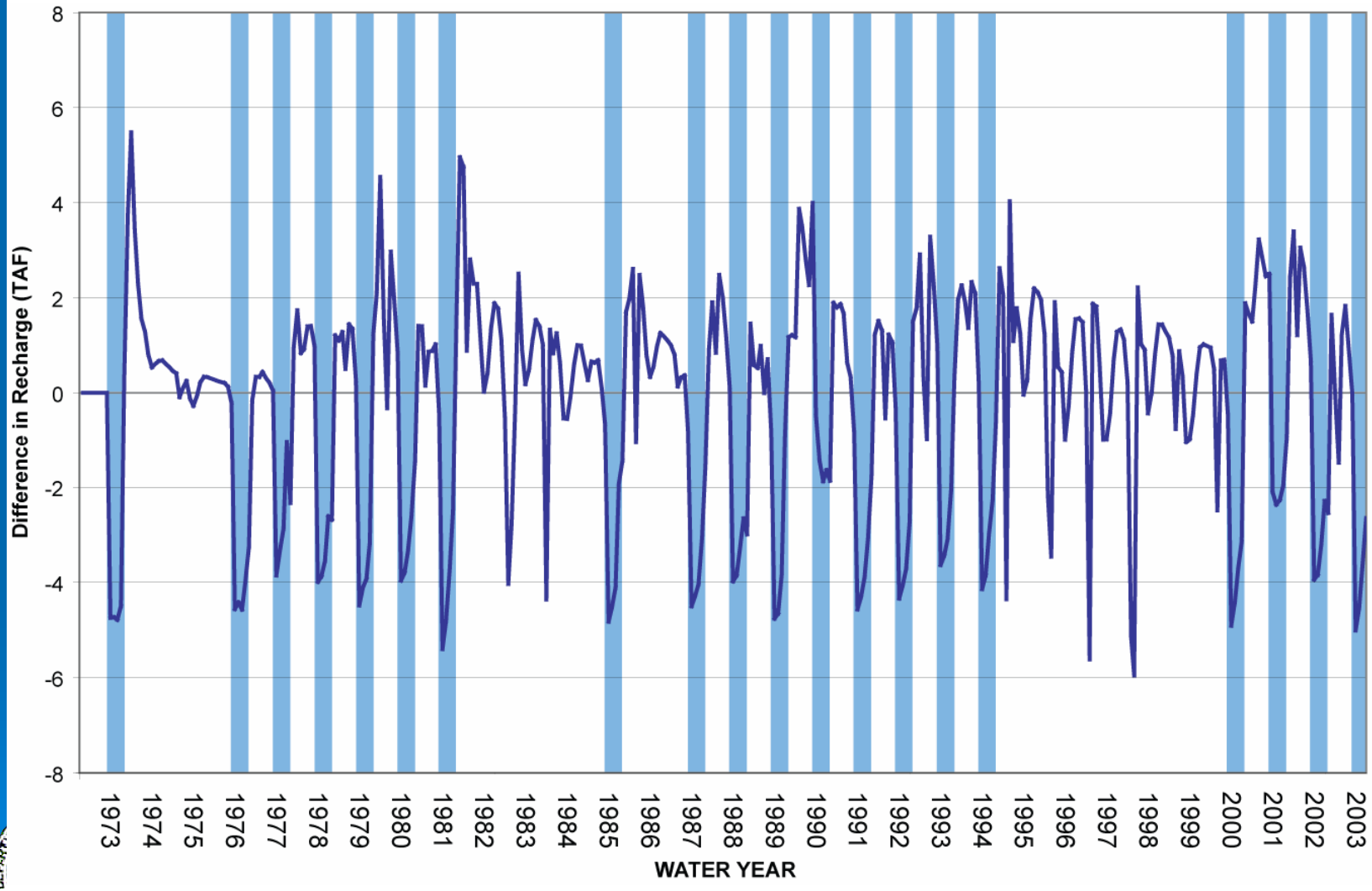
Difference in Groundwater Storage, SVWMP vs. Base Case



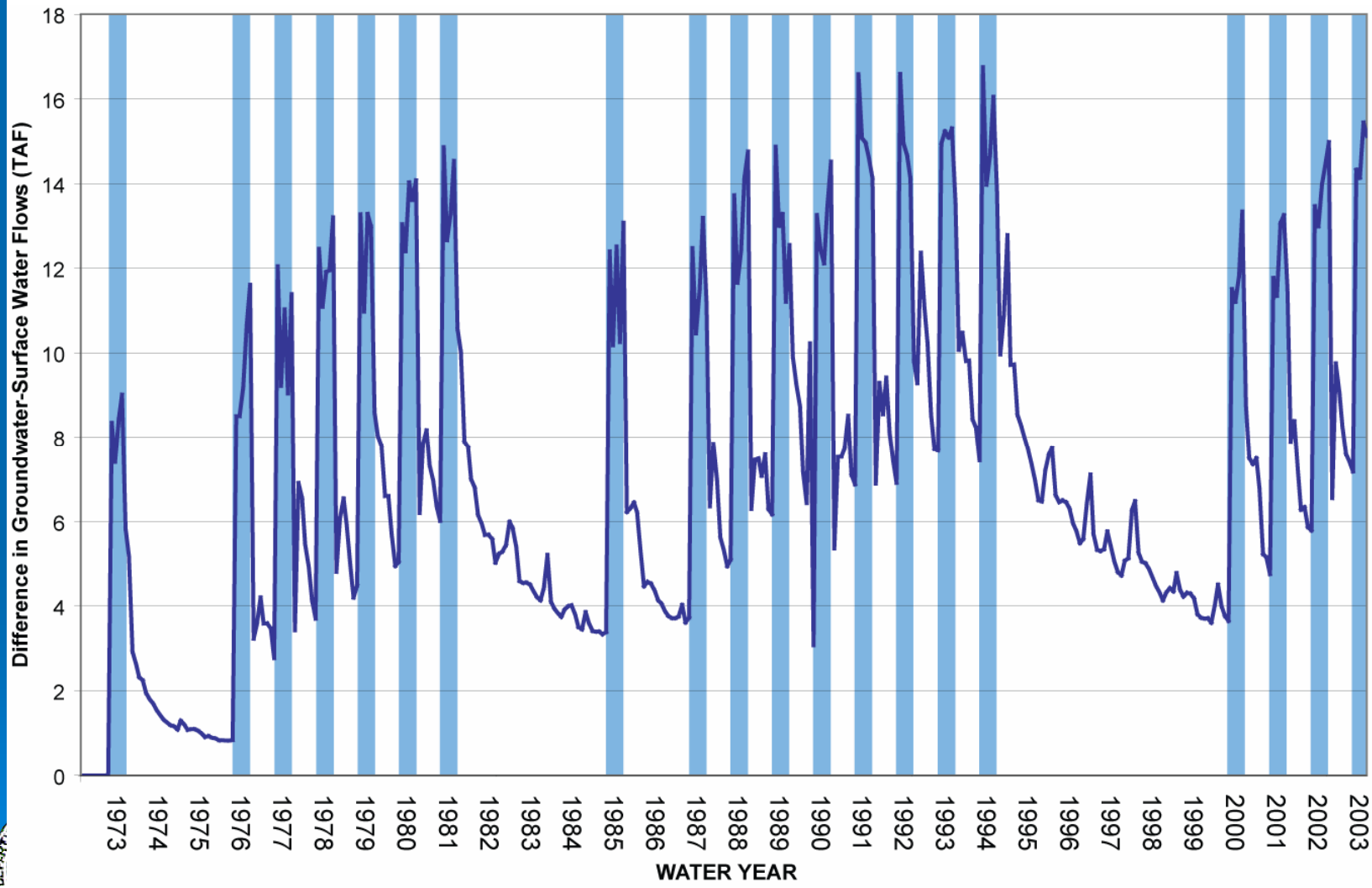
Cumulative Difference in Groundwater Storage, SVWMP vs. Base Case



Difference in Recharge, SVWMP vs. Base Case

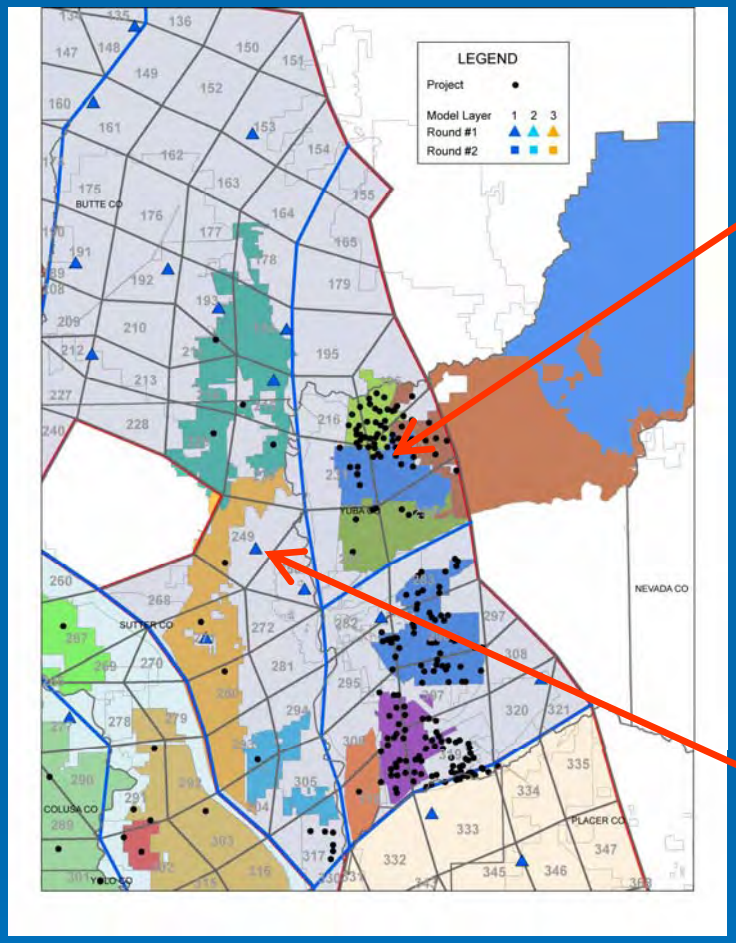


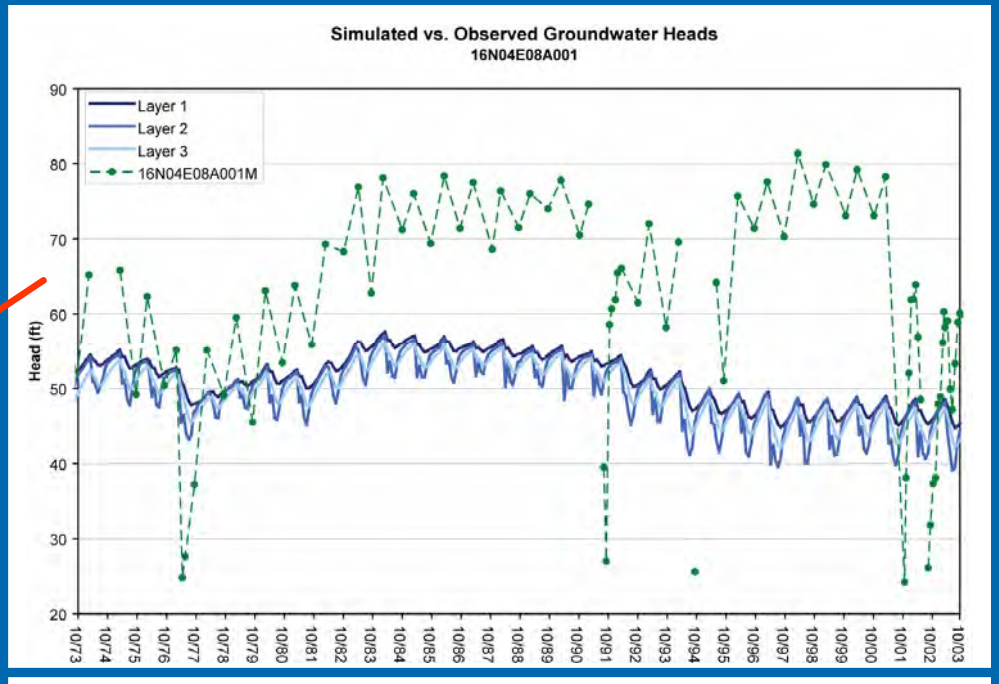
Difference in Groundwater-Aquifer Flows, SVWMP vs. Base Case

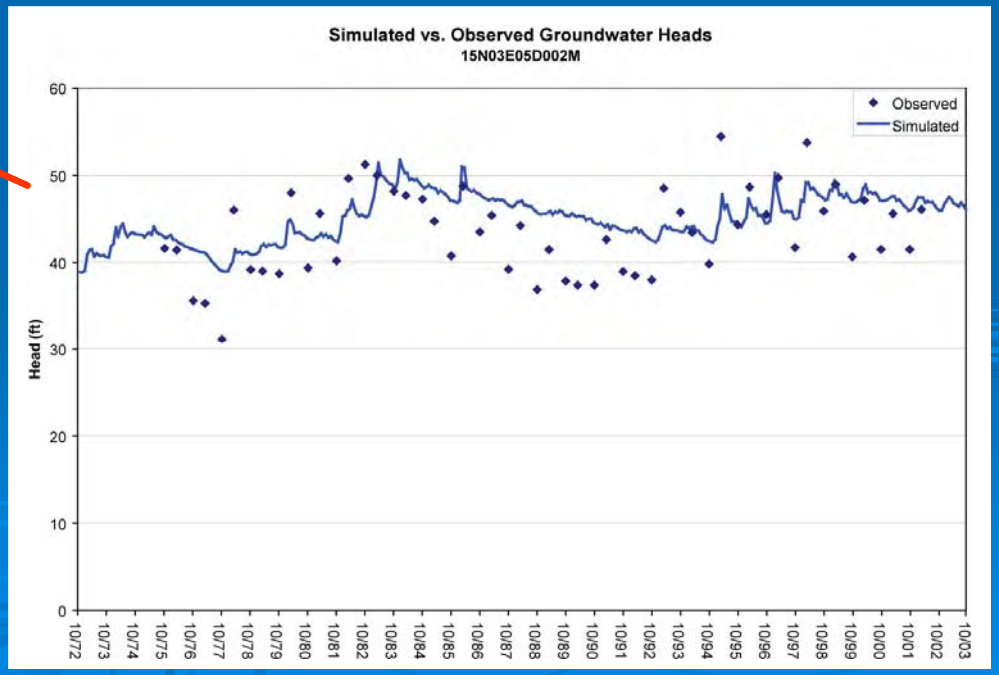


Simulation vs. Reality

- Observations vs. Reality
  - Groundwater heads
  - River flows
- Input data vs. reality
  - Land use
  - Crop water use
  - Precipitation & ET
  - Surface water diversions
  - Groundwater pumping


LEGEND
Project
Model Layer 1 2 3
Round #1
Round #2
BUTTE CO
YUBA CO
NEVADA CO
SUTTER CO
COLUSA CO
PLACER CO
YOLO CO


Simulated vs. Observed Groundwater Heads
16N04E08A001
Layer 1
Layer 2
Layer 3
16N04E08A001M
Head (ft)
90
80
70
60
50
40
30
20
10/73
10/74
10/75
10/76
10/77
10/78
10/79
10/80
10/81
10/82
10/83
10/84
10/85
10/86
10/87
10/88
10/89
10/90
10/91
10/92
10/93
10/94
10/95
10/96
10/97
10/98
10/99
10/00
10/01
10/02
10/03


Simulated vs. Observed Groundwater Heads
15N03E05D002M
Observed
Simulated
Head (ft)
60
50
40
30
20
10
0
10/72
10/73
10/74
10/75
10/76
10/77
10/78
10/79
10/80
10/81
10/82
10/83
10/84
10/85
10/86
10/87
10/88
10/89
10/90
10/91
10/92
10/93
10/94
10/95
10/96
10/97
10/98
10/99
10/00
10/01
10/02
10/03

Preliminary Findings

- C2VSIM simulation of SVWMP operations
  - SVWMP simulation is easy to implement in C2VSIM
  - Average flow increase at Freeport is 130 MAF (70%)
  - Lots of information – areal recharge, storage, GW-SW

- Issues regarding C2VSIM and SVWMP
  - Scale: C2VSIM is a ‘regional’ model
  - Water budget: Subregional ‘virtual farms’
  - Calibration data set: few deep wells
  - Groundwater pumping: largely unknown (estimated)
  - All currently being addressed in continued development of C2VSIM and IWFM

Future Work

- Refine C2VSIM calibration & water budgets
  - Increase accretions-depletions data set
  - Calibrate small watershed parameters
  - Modify pumping distribution (spatial and vertical)
  - High wet-season diversions (refuges?)
  - Crop ET looks high in some areas
- Refine SVWMP simulation
  - Identify individual pumping wells
  - Directly reduce diversions (vs. automated)