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Rattlesnake Creek Basin Modeling Scenarios

Division of Water Resources

November 4, 2014

Overview

- Purpose of modeling evaluation
- Method of evaluation
- Model versions
- Overview of scenarios evaluated
- Model results
  - Basin-wide curtailment/reductions
  - Targeted curtailments
- Observations and discussion

Purpose of modeling evaluation

- To calculate the benefits of pumping reductions to streamflow [i.e. baseflow] and impacts on evapotranspiration and groundwater storage

- To help inform management decisions

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To evaluate pumping impacts:

- Calculate water budget differences between two model runs:
  - baseline (historical pumping)
  - alternative pumping scenario

- Baseline: historical conditions for 1940-2007.

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Model versions

- 7-layer model developed by Balleau:
  - Ran for baseline and scenario 11 to compare with 1-layer model (runtime: 5-12 hours)
- 1-layer model developed by SSPA from 7-layer model:
  - Functionally equivalent for calculating pumping impacts
  - Shorter runtimes allow exploring more alternatives (runtime: 30-60 minutes)
  - More detailed output allows calculating basin water budget
  - Used for initial evaluations presented here
- 1-layer model with alternative calibration with low evapotranspiration and recharge (SSPA)

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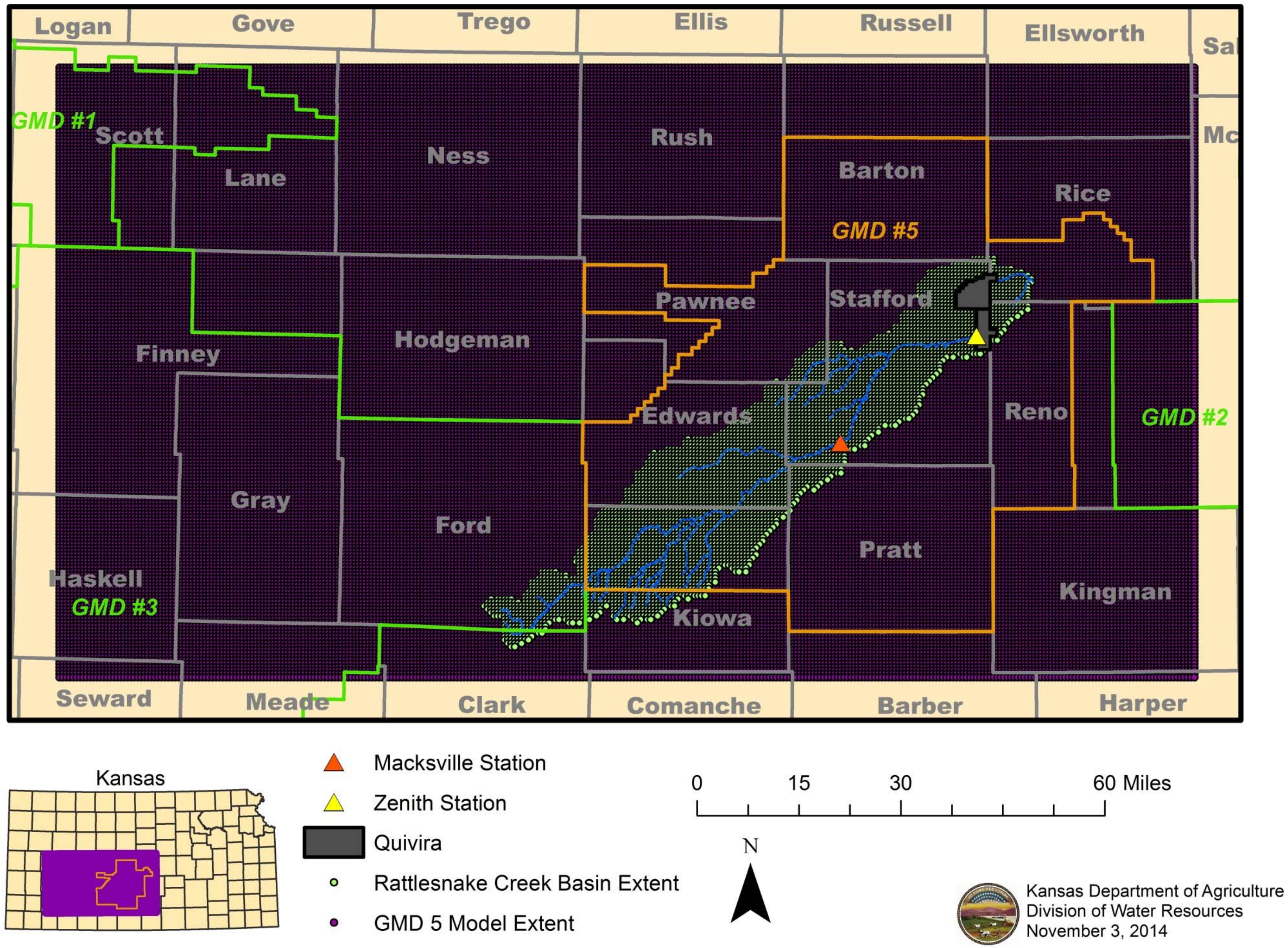
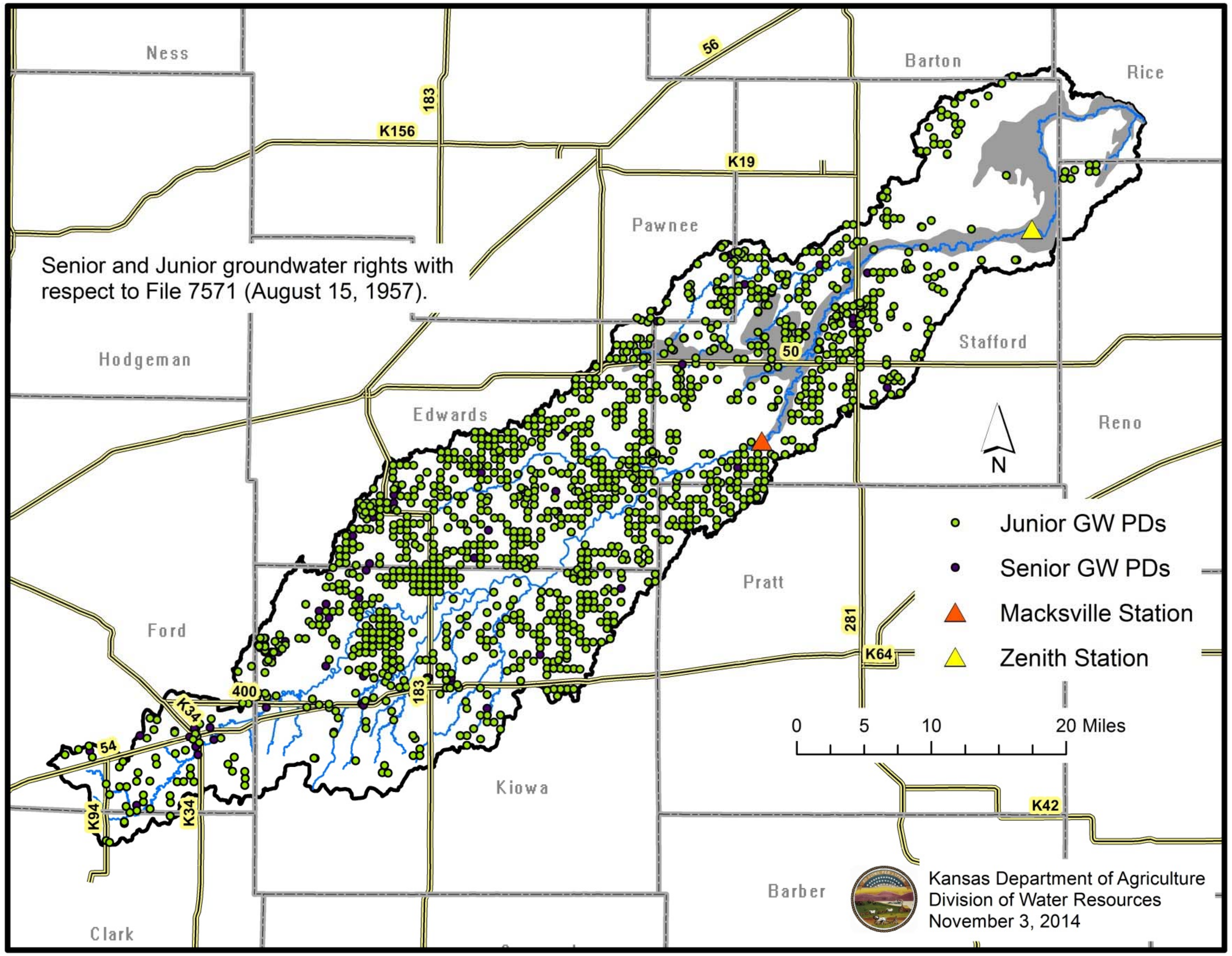
GMD #5 Model Area



Rattlesnake Creek Basin
Groundwater Points of Diversion



Scenario development

- DWR evaluated a wide range of pumping reduction scenarios including:
  - Basin-wide curtailments beginning in 1958 and 1990 [1-2]
  - Basin-wide water use reductions [2.5 and 2.75]
  - Targeted curtailments near the stream [3-11]
    - Balleau response zones [7-9]
    - 1 and 2 mile corridors [10,11]
- All scenarios restrict only junior rights above Quivira intake
- All start restrictions in 1990 (except scenario 1)

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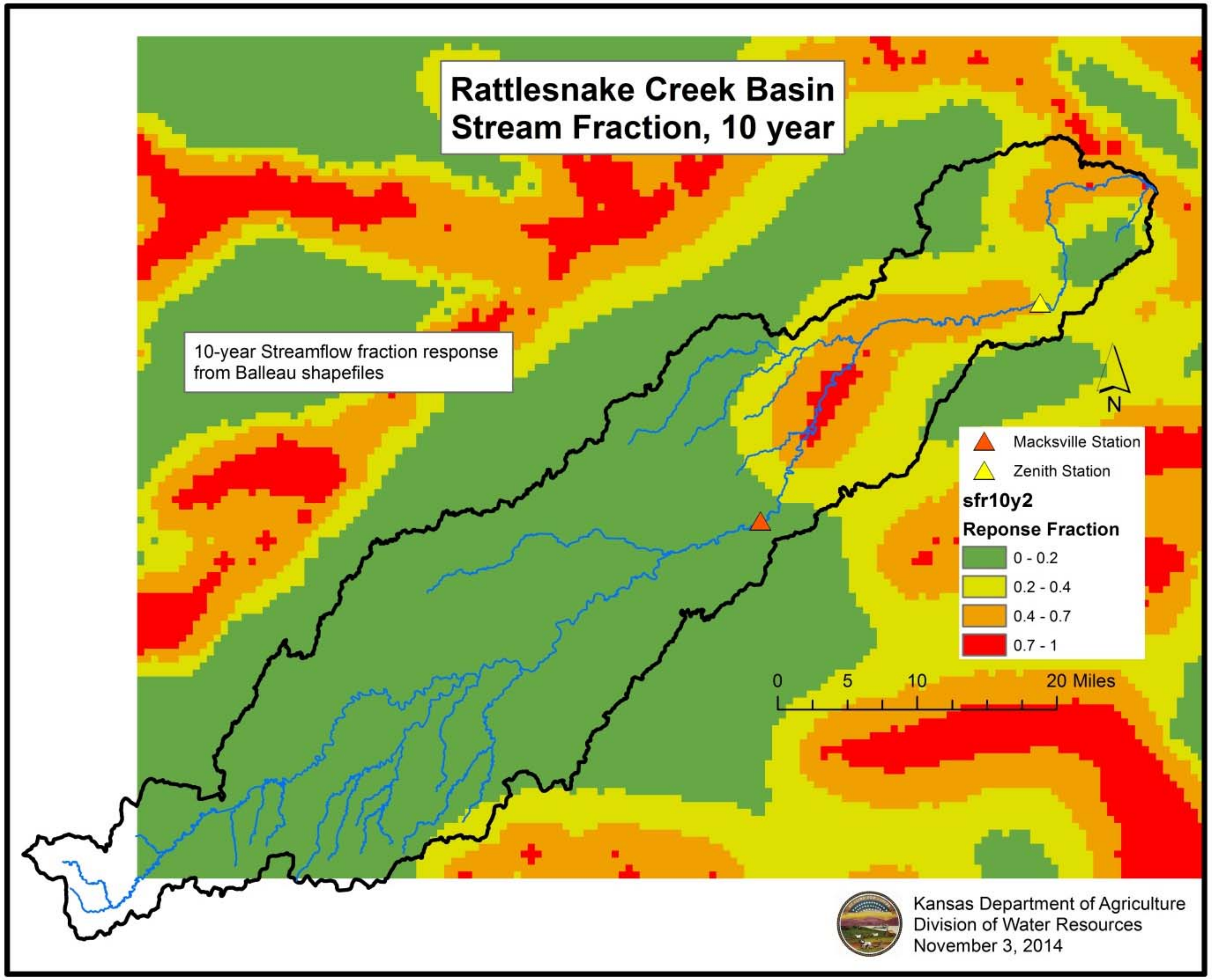
Rattlesnake Creek Basin
Stream Fraction, 10 year
10-year Streamflow fraction response from Balleau shapefiles
N
Macksville Station
Zenith Station
sfr10y2
Reponse Fraction
0 - 0.2
0.2 - 0.4
0.4 - 0.7
0.7 - 1
0 5 10 20 Miles
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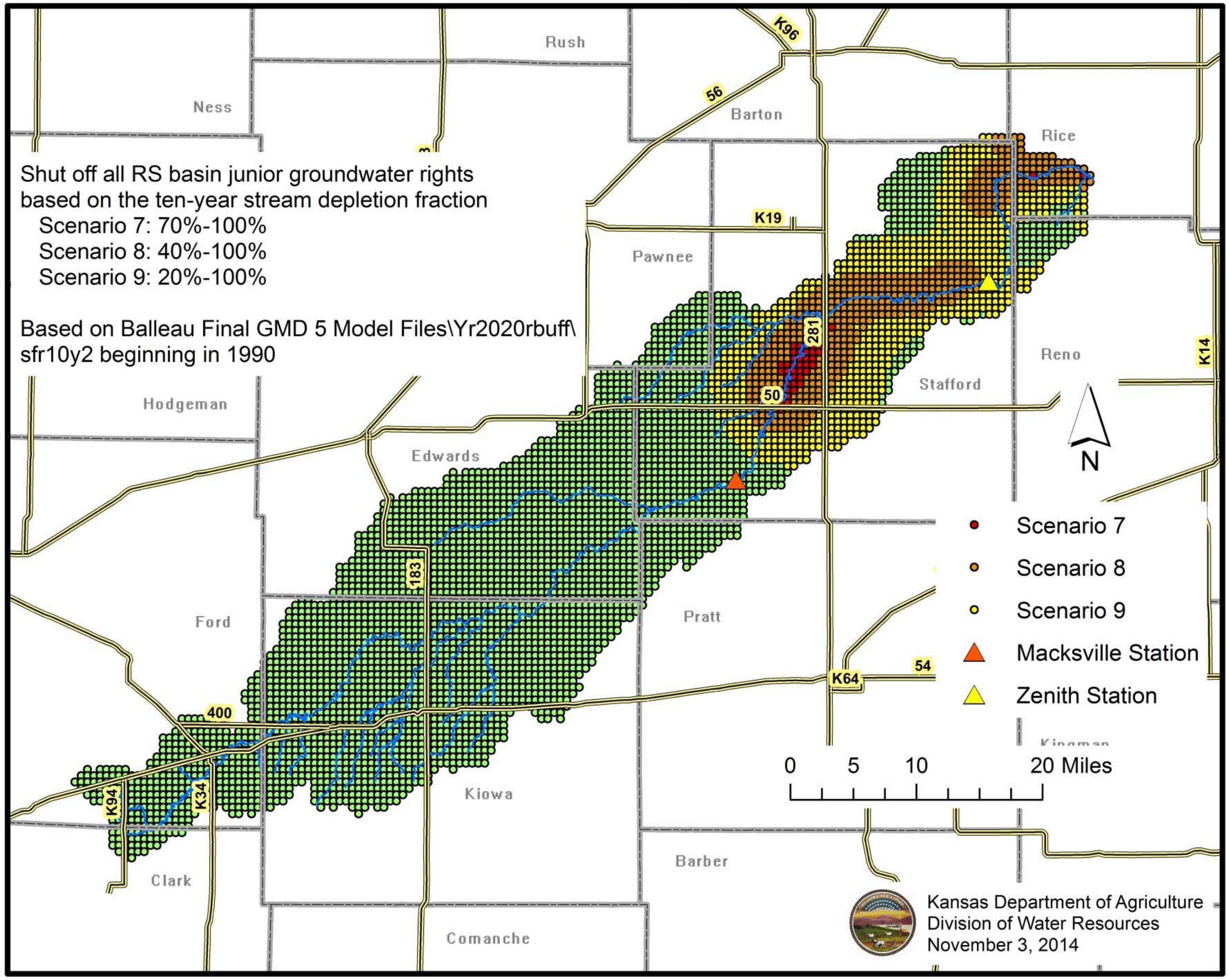
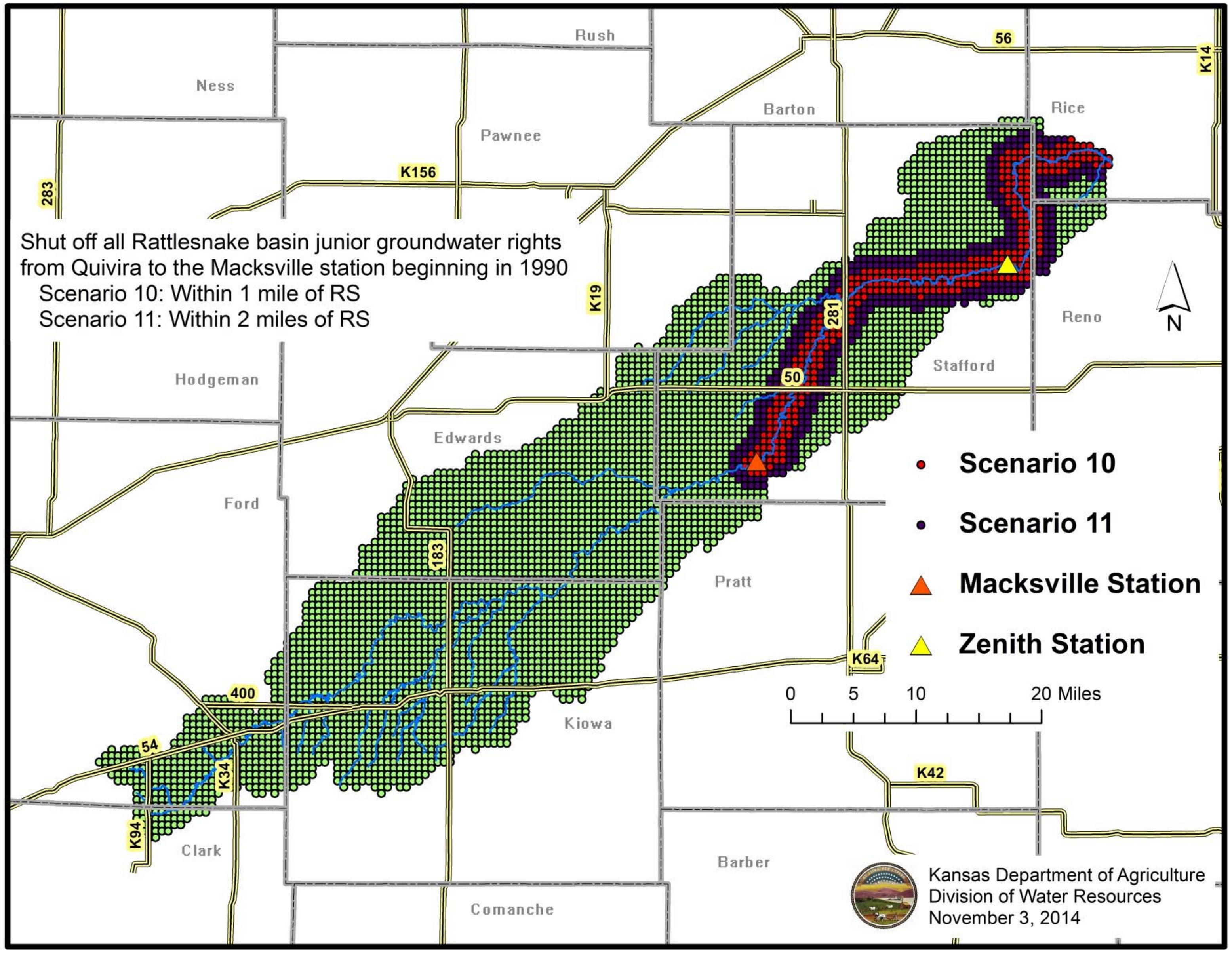
Division of Water Resources
November 3, 2014

Rattlesnake Creek Basin
Scenarios 7, 8 and 9



Rattlesnake Creek Basin
Scenarios 10 and 11



Additional scenarios examined

- 11-ML: 2-mi corridor with multi-layer model
- Delay pumping reductions to 2000
- Alternative 1-layer model calibration with lower ET and recharge

- 3: 1 mile corridor entire length
- 4: alluvial extent
- 5-6: Balleau response zones (from map; not coverage); replaced by 7-9

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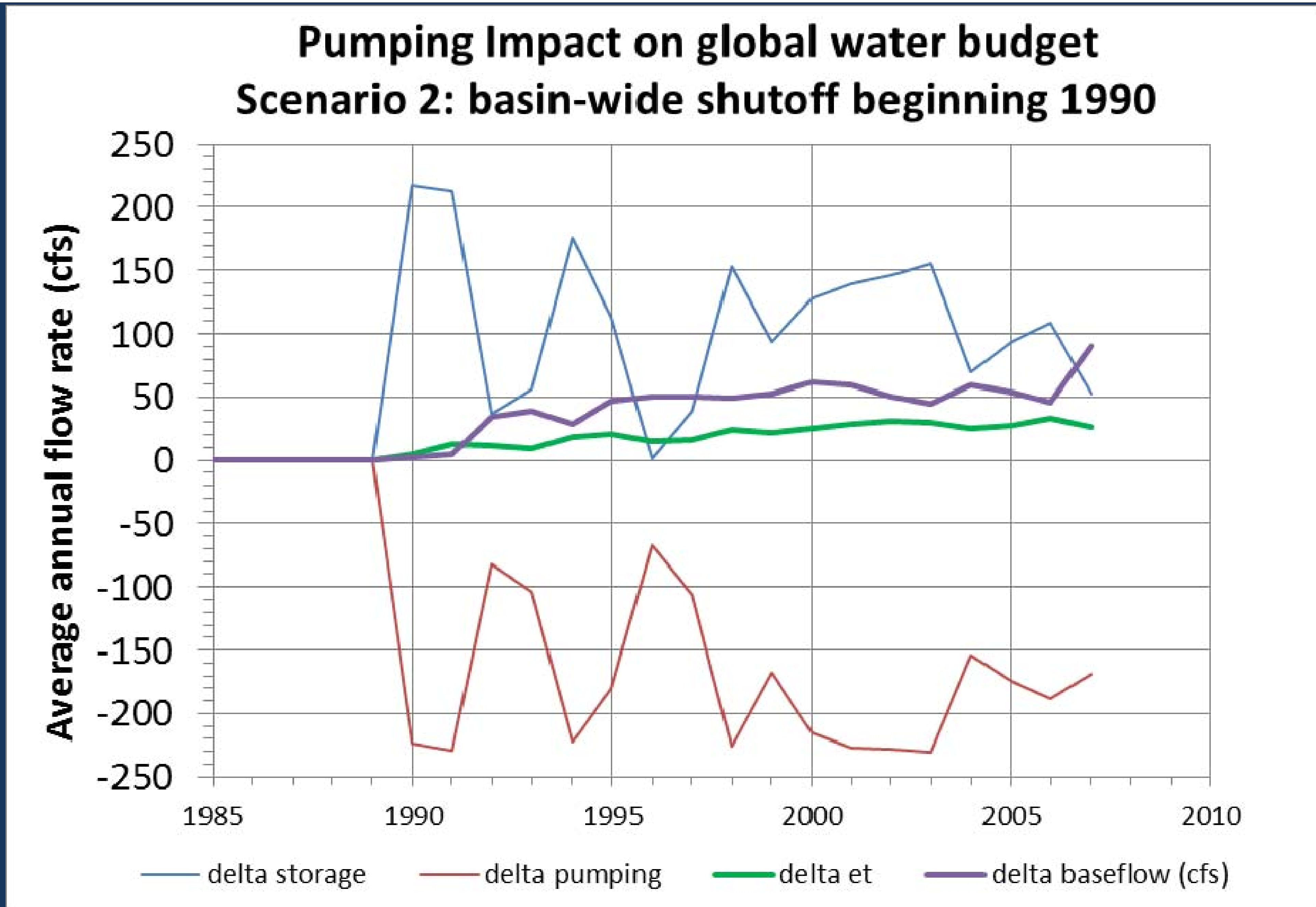
Streamflow response statistics evaluated

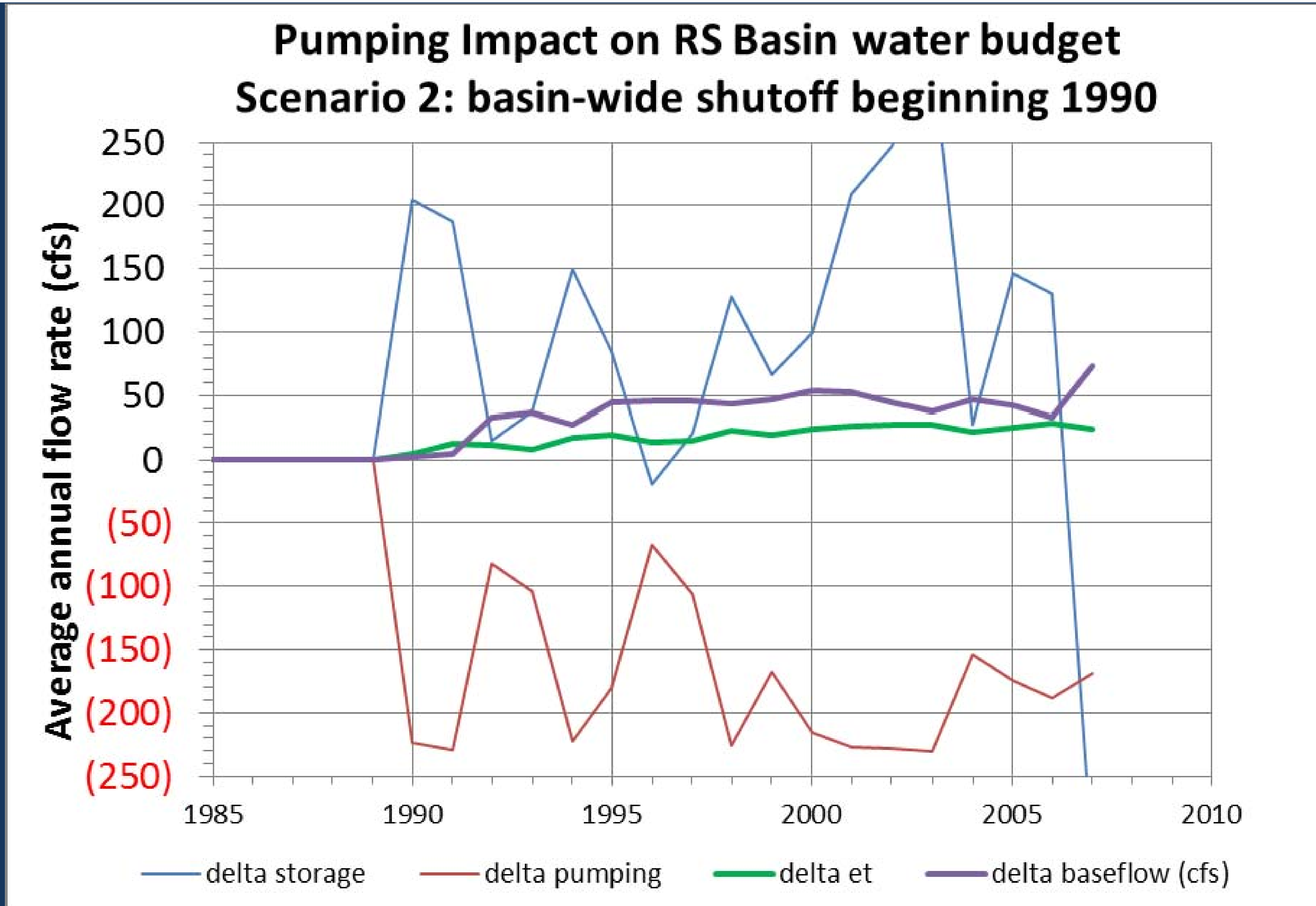
- Average baseflow increase for years 1998-2007
- Ratio of baseflow increase to pumping reduction
- Response time: lag between pumping reduction and baseflow increase

Presented scenarios
Rattlesnake C Basin impacts 1998-2007
acre-feet/yr

scenario	Scenario definition	Δpumping	Δbaseflow	ΔB cfs	ΔB/ΔP	Δstorage	Δ et
1	basinwide shutoff from 1958 on	(143,529)	42,053	58.0	29.3%	70,505	22,387
2	basinwide shutoff from 1990 on	(143,529)	34,420	47.5	24.0%	76,837	18,007
2.5	basinwide 50% pumping	(71,765)	13,366	18.4	18.6%	34,019	8,662
2.75	basinwide 75% pumping	(35,882)	5,475	7.6	15.3%	18,200	4,265
7	response zone >70%	(1,059)	661	0.9	62.4%	77	253
8	response zone >40%	(9,701)	4,646	6.4	47.9%	1,442	2,597
9	response zone >20%	(19,604)	8,326	11.5	42.5%	3,350	4,975
10	RSC 1-mi corridor to Macksville	(3,932)	2,115	2.9	53.8%	410	1,094
11	RSC 2-mi corridor to Macksville	(11,230)	5,560	7.7	49.5%	1,396	3,086
Notes:	[1] Restrict selections to Rattlesnake C basin wells junior to Aug 15 1957 (USF&W File 7571).						
	[2] Scenario 1 selection begins Jan 1958 (str per 218); others begin Jan 1990 (str per 602).						
	[3] Scenarios are specified as input to preprocessor by scenario id and pump scaling factor.						



Pumping Impact on global water budget
Scenario 2: basin-wide shutoff beginning 1990
Average annual flow rate (cfs)
250
200
150
100
50
0
-50
-100
-150
-200
-250
1985
1990
1995
2000
2005
2010
delta storage
delta pumping
delta et
delta baseflow (cfs)


Pumping Impact on RS Basin water budget
Scenario 2: basin-wide shutoff beginning 1990
Average annual flow rate (cfs)
250
200
150
100
50
0
(50)
(100)
(150)
(200)
(250)
1985
1990
1995
2000
2005
2010
delta storage
delta pumping
delta et
delta baseflow (cfs)

Scenario 2 variations: scale pumping basin-wide by 50% and 75%

- Rattlesnake Creek Basin impacts:

scenario	Scenario definition	Δpumping	Δbaseflow	ΔB cfs	ΔB/ΔP	Δstorage	Δ et
2	basinwide shutoff from 1990 on	(143,529)	34,420	47.5	24.0%	76,837	18,007
2.5	basinwide 50% pumping	(71,765)	13,366	18.4	18.6%	34,019	8,662
2.75	basinwide 75% pumping	(35,882)	5,475	7.6	15.3%	18,200	4,265

Average impacts 1998-2007 acre-feet/yr unless otherwise noted

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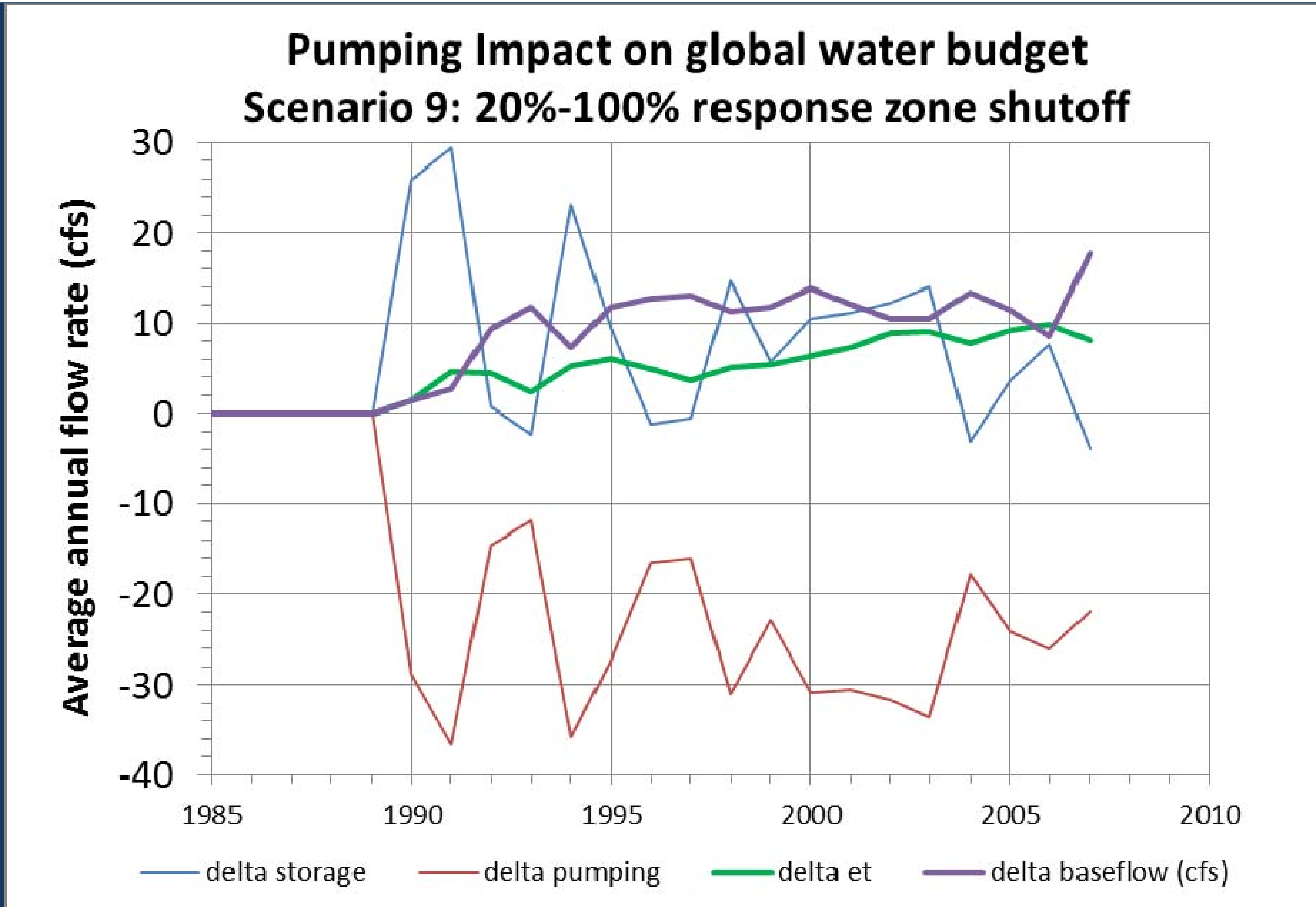
Scenarios 7, 8 and 9:
Streamflow response zones

- Rattlesnake Creek Basin impacts

scenario	Scenario definition	Δpumping	Δbaseflow	ΔB cfs	ΔB/ΔP	Δstorage	Δ et
7	response zone >70%	(1,059)	661	0.9	62.4%	77	253
8	response zone >40%	(9,701)	4,646	6.4	47.9%	1,442	2,597
9	response zone >20%	(19,604)	8,326	11.5	42.5%	3,350	4,975

Average impacts 1998-2007 acre-feet/yr unless otherwise noted



Pumping Impact on global water budget
Scenario 9: 20%-100% response zone shutoff
Average annual flow rate (cfs)
30
20
10
0
-10
-20
-30
-40
1985
1990
1995
2000
2005
2010
delta storage
delta pumping
delta et
delta baseflow (cfs)

Scenarios 10 and 11: 1- and 2-mi corridors

- Rattlesnake Creek Basin impacts:

scenario	Scenario definition	Δpumping	Δbaseflow	ΔB cfs	ΔB/ΔP	Δstorage	Δ et
10	RSC 1-mi corridor to Macksville	(3,932)	2,115	2.9	53.8%	410	1,094
11	RSC 2-mi corridor to Macksville	(11,230)	5,560	7.7	49.5%	1,396	3,086

Average impacts 1998-2007 acre-feet/yr unless otherwise noted

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Comparison of results of single and multi-layer models

- Scenario 11
  - Global budget impacts:

scenario id	Scenario definition [1,2,3]	Δpumping ac-ft/y	Δbaseflow ac-ft/yr	Δbaseflow cfs	ΔB/ΔP pct	Δstorage ac-ft/y	Δ ET ac-ft/yr
11	RSC 2-mi corridor to Macksville	(11,230)	5,729	7.9	51.0%	2,253	3,275
11 ML [4]	RSC 2-mi corridor to Macksville	(11,230)	5,464	8	48.7%	2,404	3,379
difference	[multi - single] layer versions	0	(265)	(0)	-2.4%	150	104

Average impacts 1998-2007 acre-feet/yr unless otherwise noted

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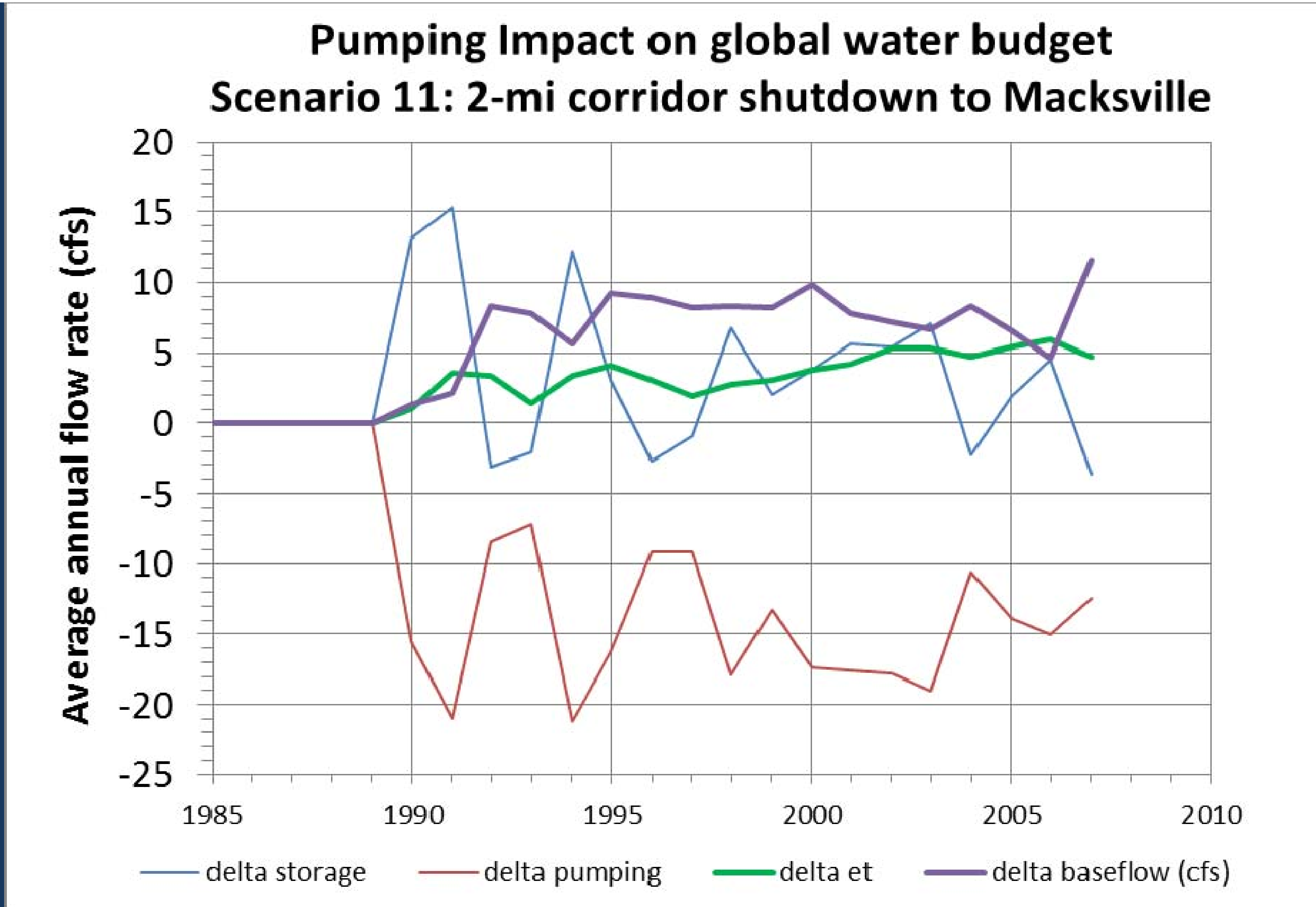
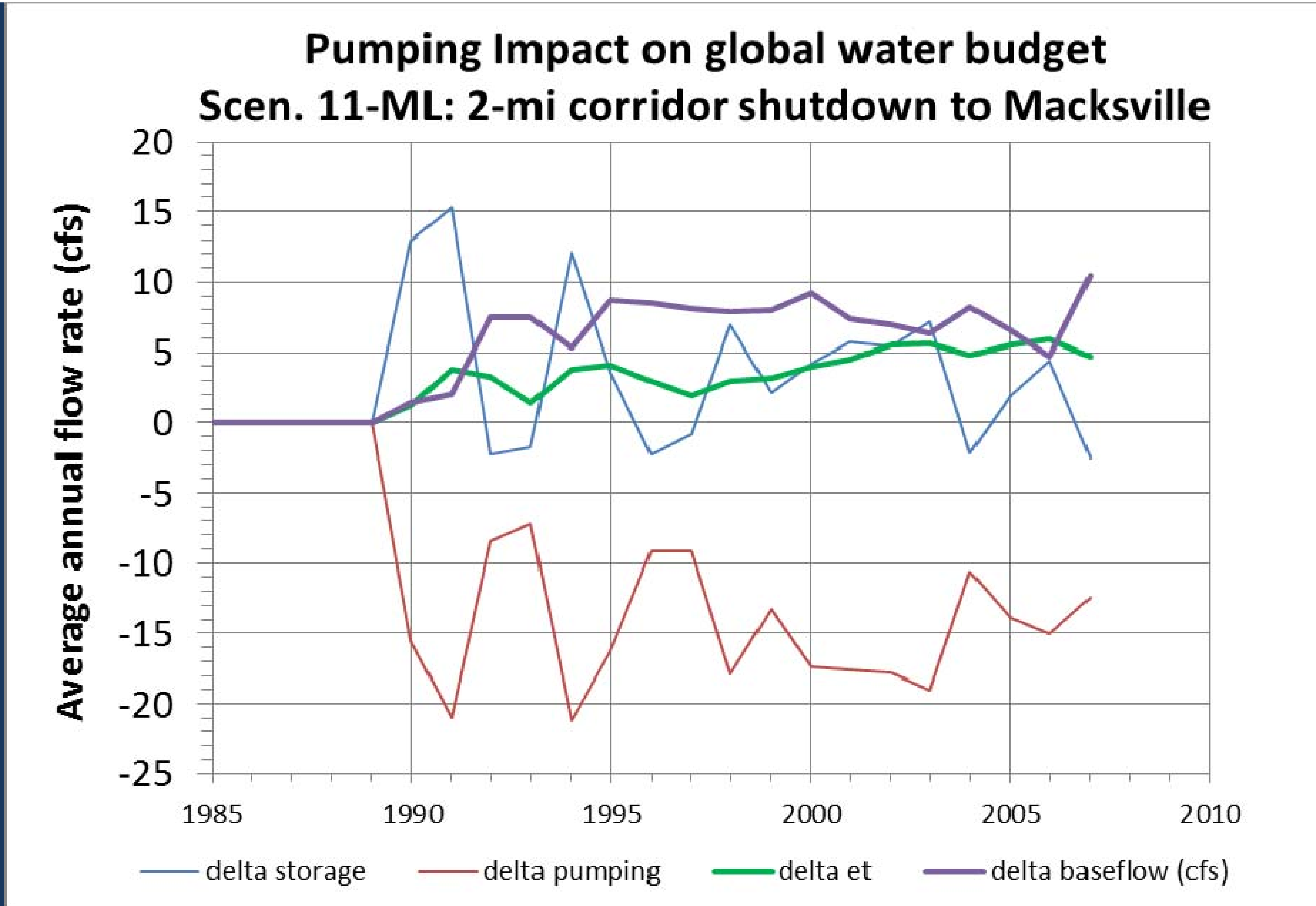


Pumping Impact on global water budget
Scenario 11: 2-mi corridor shutdown to Macksville
Average annual flow rate (cfs)
20
15
10
5
0
-5
-10
-15
-20
-25
1985
1990
1995
2000
2005
2010
delta storage
delta pumping
delta et
delta baseflow (cfs)


Pumping Impact on global water budget
Scen. 11-ML: 2-mi corridor shutdown to Macksville
Average annual flow rate (cfs)
20
15
10
5
0
-5
-10
-15
-20
-25
1985
1990
1995
2000
2005
2010
delta storage
delta pumping
delta et
delta baseflow (cfs)

Observations

- The single and multi-layer models are functionally equivalent for determining pumping impacts on streamflow.
- The GMD5 model shows that baseflow reductions due to junior pumping are significant
- Pumping reductions near the stream provides more effective streamflows benefits.
- Pumping shutoff scenarios take two to three years to produce a significant baseflow response.

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Augmentation Scenarios
January 29, 2015

- DWR evaluated two augmentation scenarios:
  - Four augmentation wells were placed northeast of St. John; pipe outflow was placed below Wildhorse Creek on Rattlesnake Creek.

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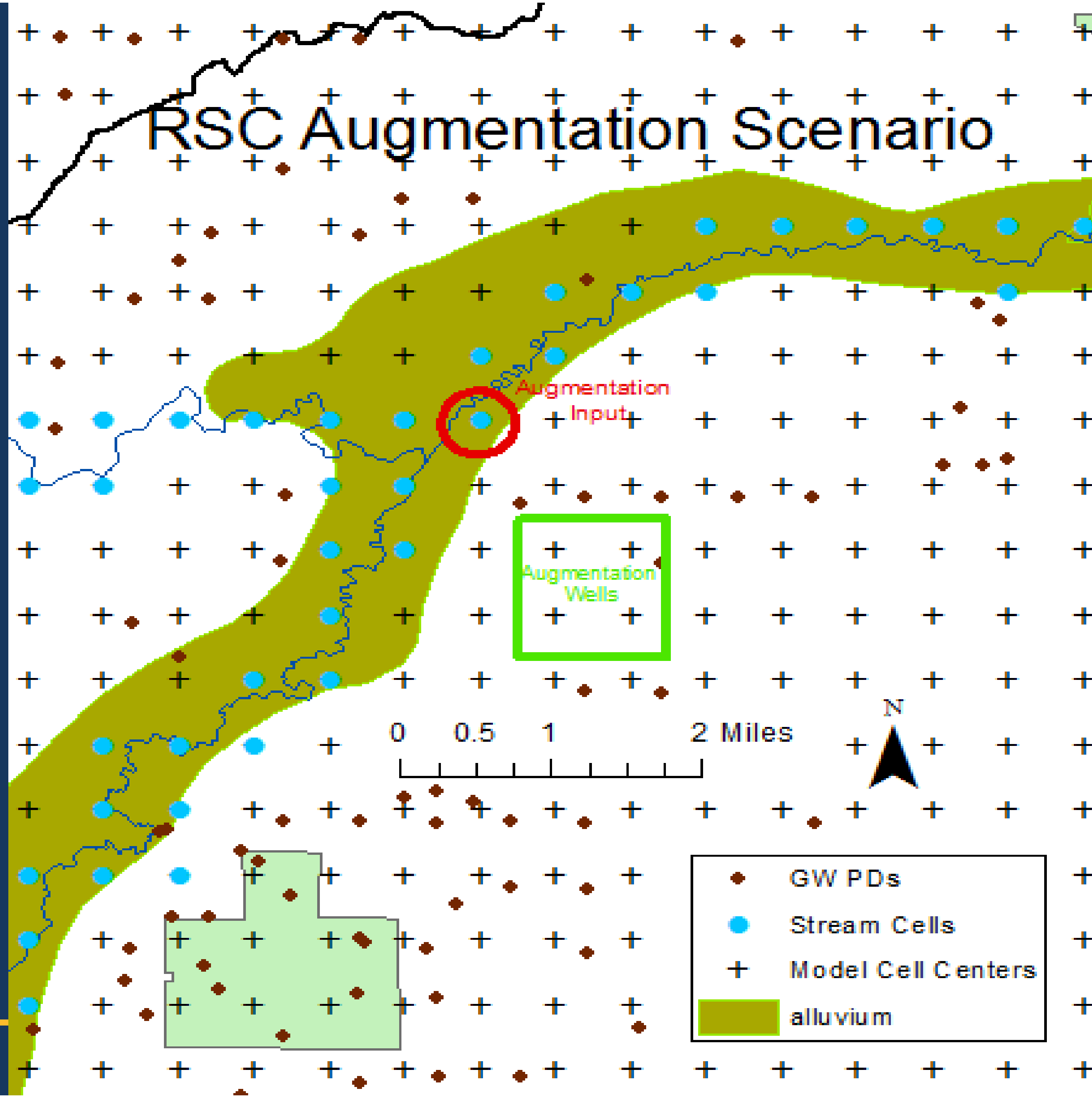
RSC Augmentation Scenario



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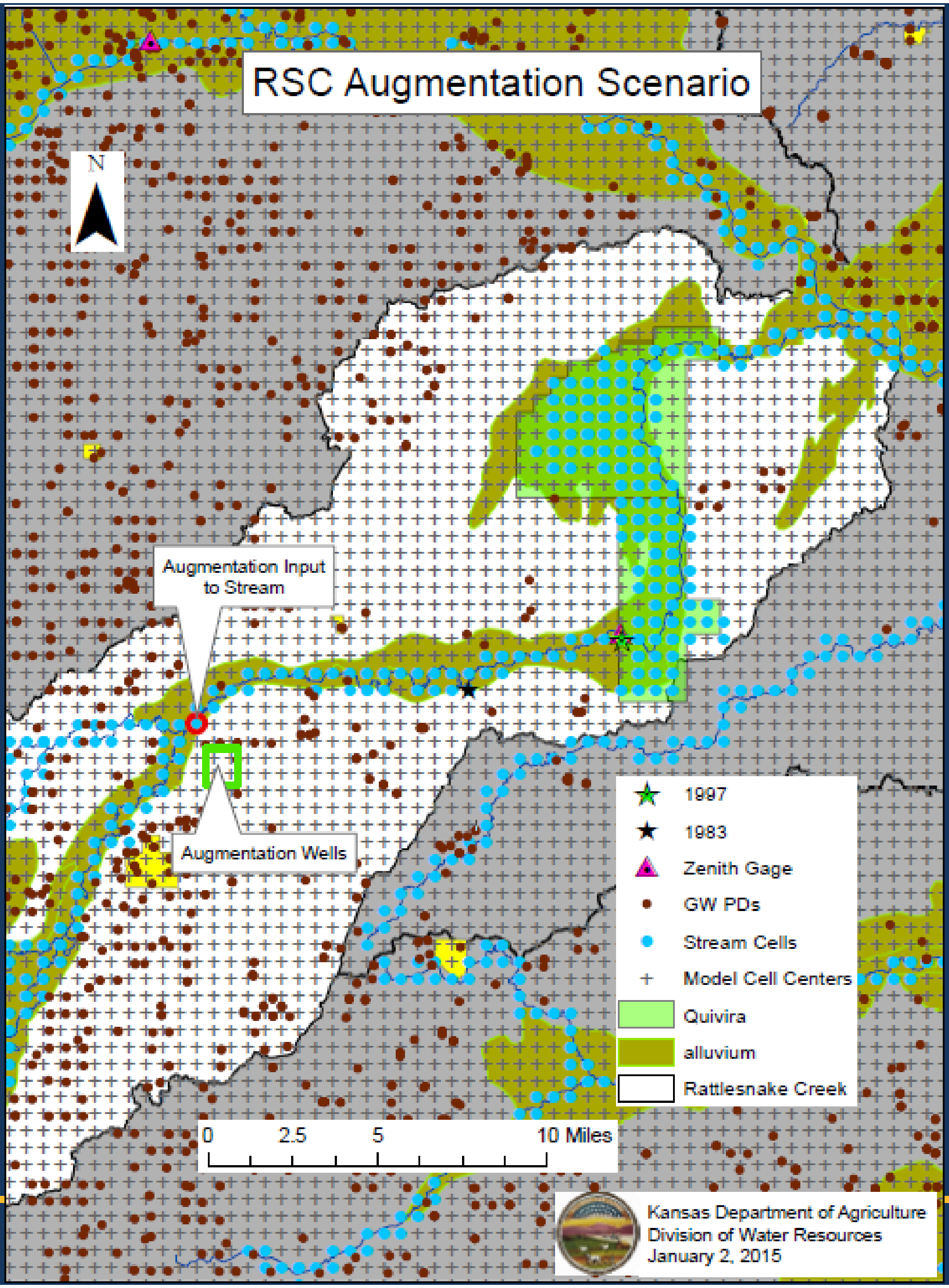

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Locations of streamflow and groundwater level response hydrographs

- Streamflow at 5 locations along Rattlesnake creek
  - Macksville gage, augmentation outflow, sw of Quivira and Zenith gage
- Groundwater level at 14 locations along stream
  - At stream hydrograph locations and 1-2 mi either side
  - All four augmentation wells

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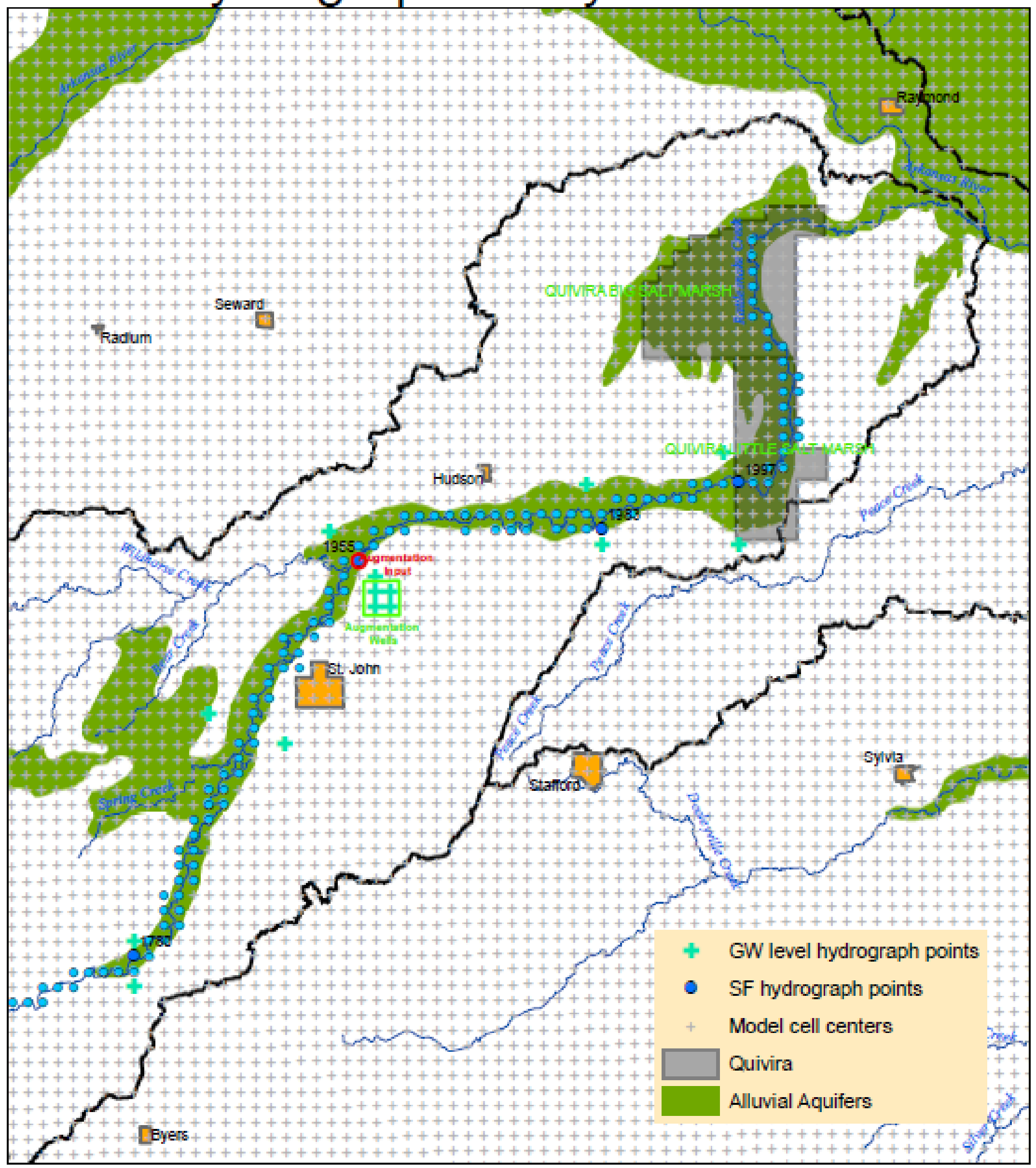
RSC Augmentation
Hydrograph Analysis Points



0 2.5 5 10 Miles

N

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Division of Water Resources
January 21, 2015

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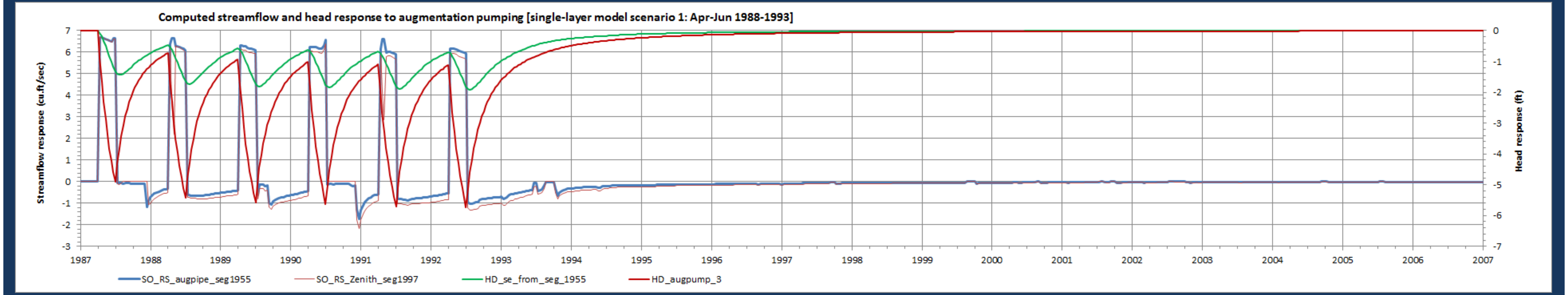
Scenario 1

- 1,200 AF April-June, years 1988-1993, flow at 6.7 cfs
- Conditions suggested by Dave Romero, Balleau and Associates

Scenario 1 response plots

- Plots are differences in streamflow or groundwater level between augmentation scenario and baseline model runs. Figures:

- 1. Both streamflow and water level response.
- 2. Augmentation pumping and streamflow
- 3. Cumulative streamflow
- Single- and multilayer versions are compared.



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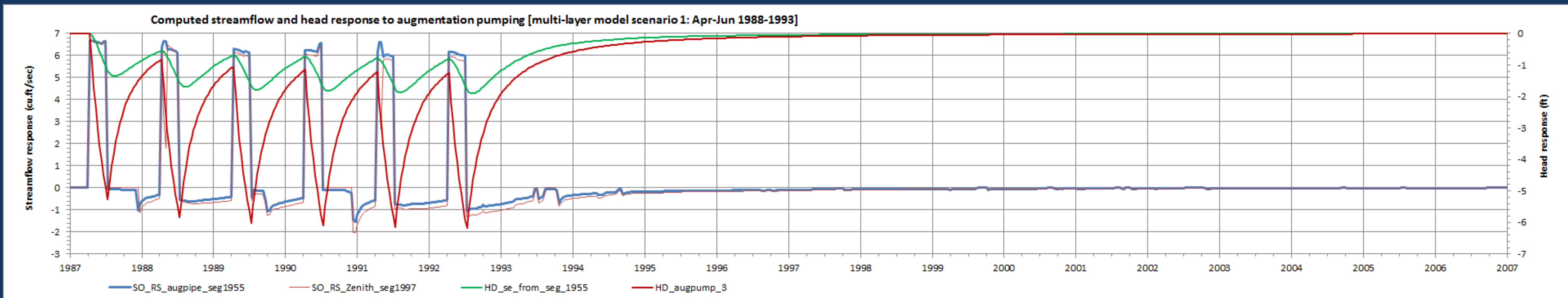

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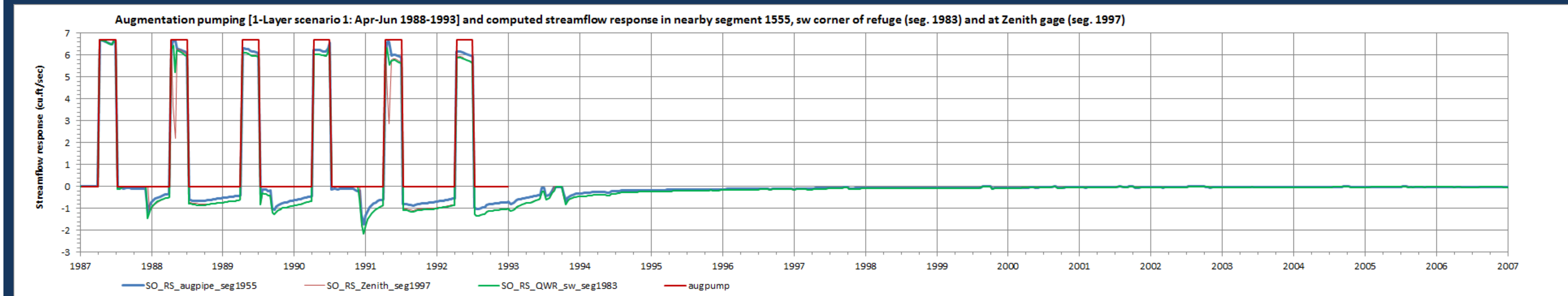

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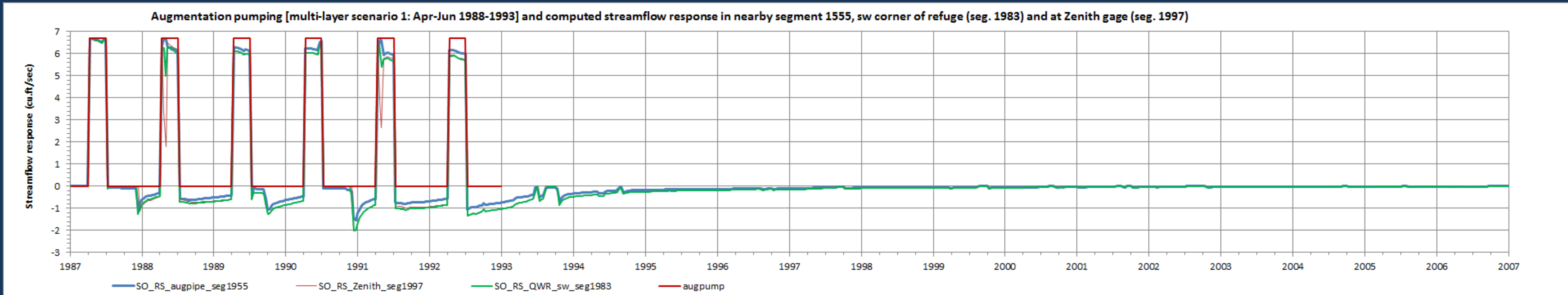

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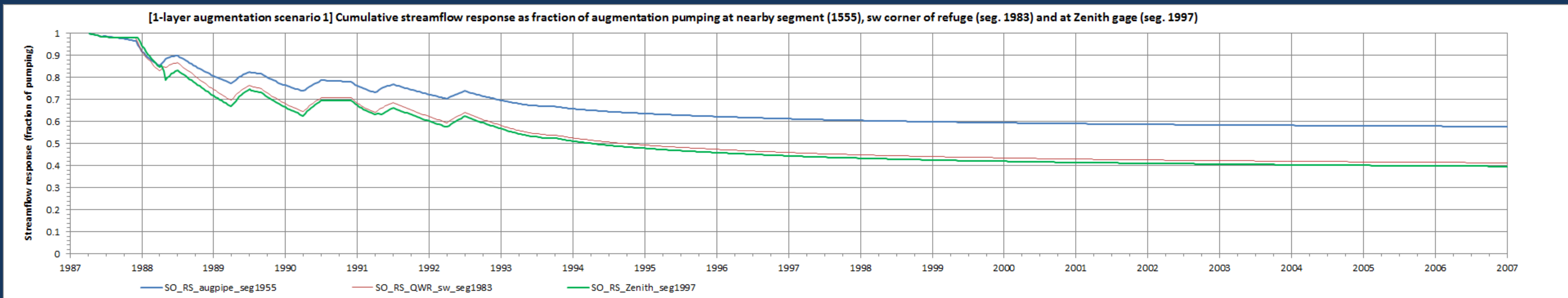

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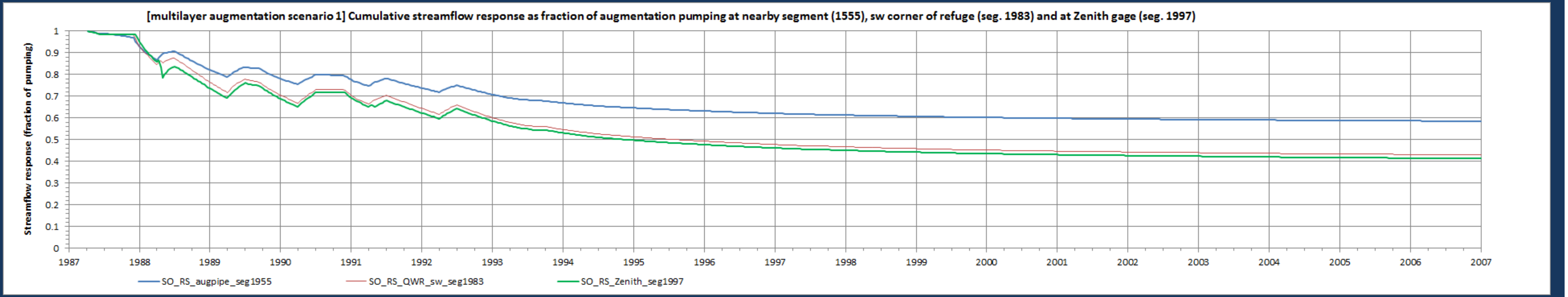

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Scenario 2

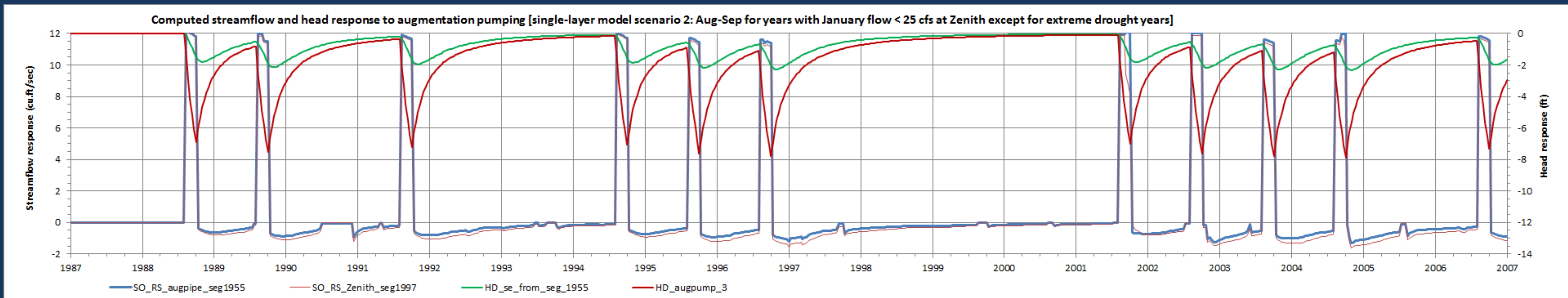
- 1,460 AF August-September, years of January flow less than 25 cfs and without severe drought as determined in July, flow at 12.1 cfs

- Conditions are based on Kansas Water Office report.

Scenario 2 response plots

- Plots are same format as Scenario 1. Figures:

- 4. Both streamflow and water level response.
- 5. Augmentation pumping and streamflow
- 6. Cumulative streamflow
- Only single-layer model versions are shown (multilayer versions are similar and available).



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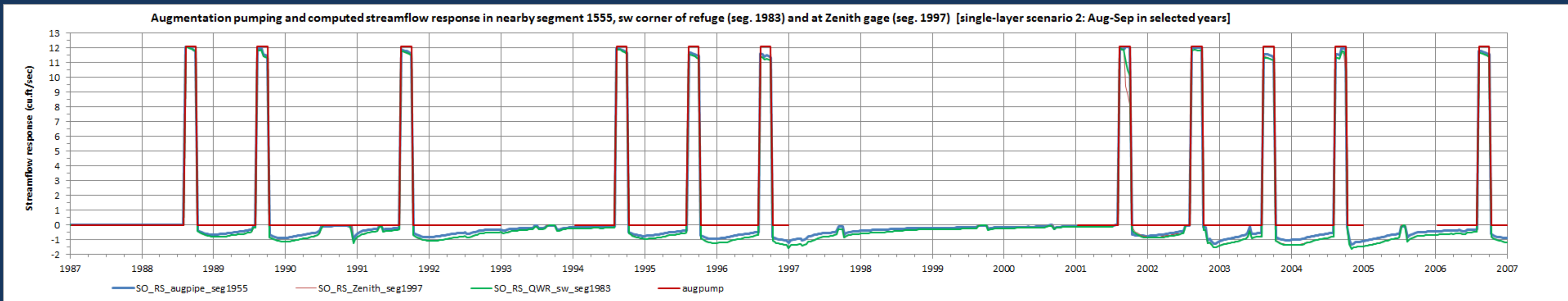

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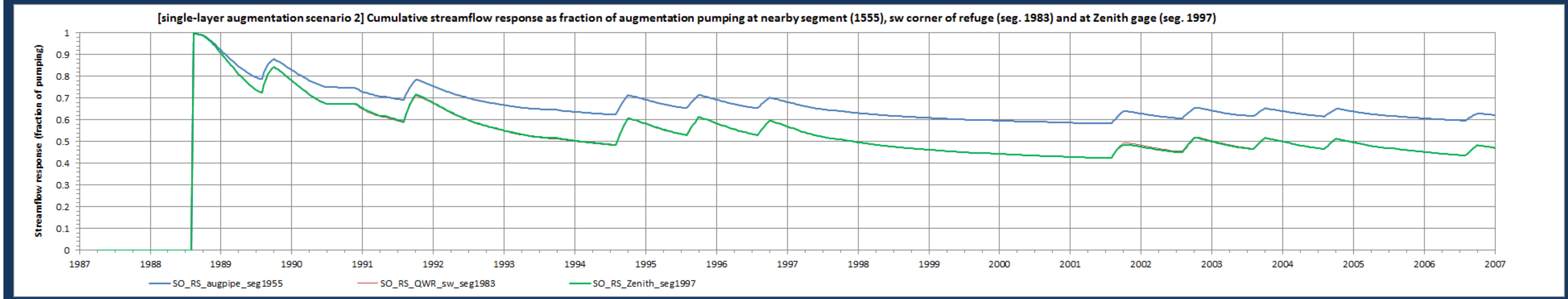

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Augmentation impact hydrographs show:

- Differences in impacts between 1- and 7-layer versions are negligible.
- Scenarios 1 and 2 show similar effects.
- Cumulative impact on streamflow over time is reduced significantly by depletion effect of pumping.
- Streamflow losses due to augmentation pumping occur both during and following pumping cycles.

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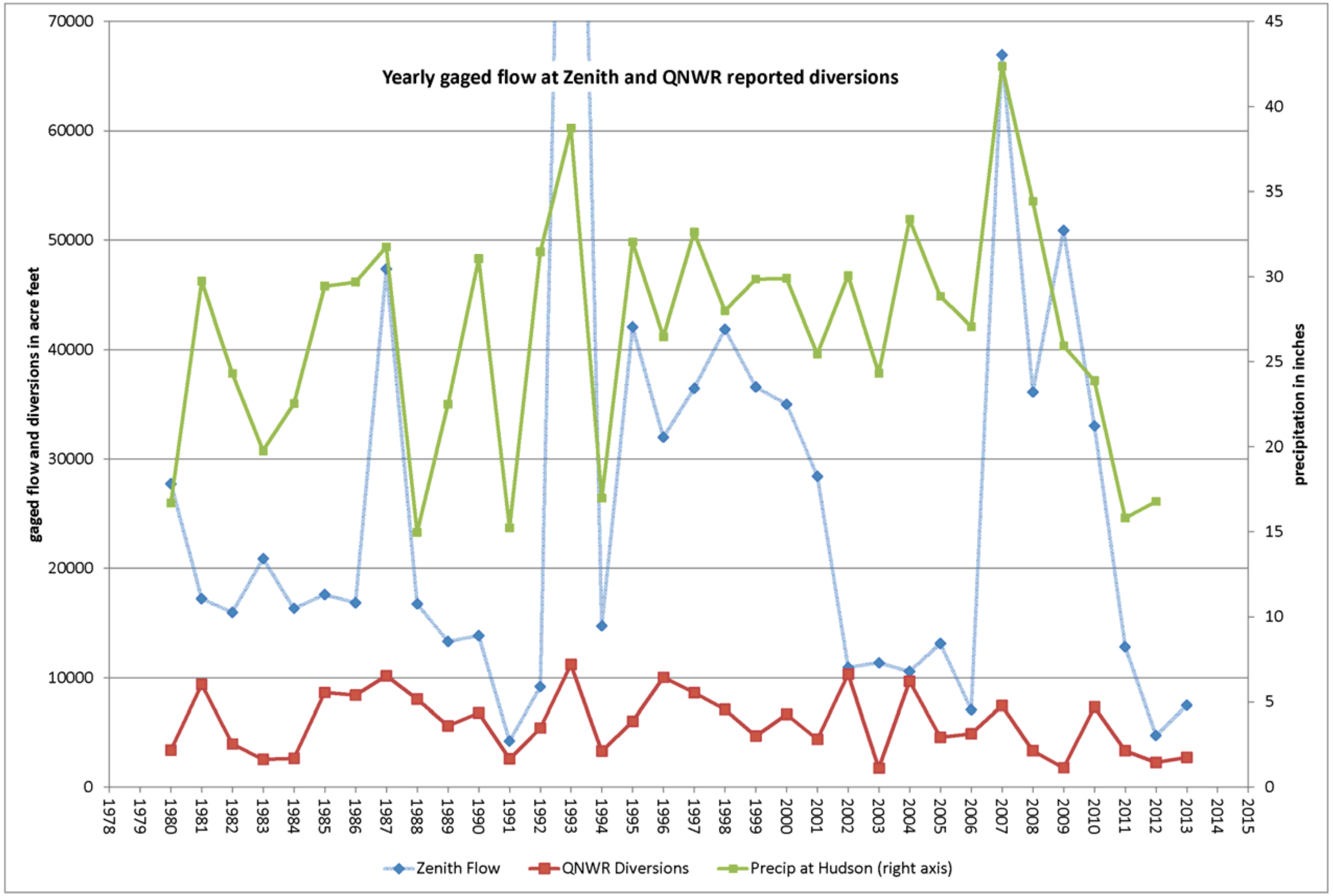

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Augmentation Scenario 2 variation May 20, 2015

- DWR evaluated a variation on augmentation scenario 2:
  - Pump augmentation wells from layer 2 instead of layer 1 as suggested by Dave Romero.

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Scenario 2 variation

- Compare multilayer version of original Scenario 2 with this variation:
- A) Scenario 2, multilayer version, but pumping from layer 1 (Figs. 4-ML, 5-ML and 6-ML)
- B) same as (A) but pumping from layer 2 (Figs. 4-ML-L2, 5-ML-L2 and 6-ML-L2)

Scenario 2-ML response plots (multilayer model, pump from layer 1)

- Figures:
- 4-ML. Both streamflow and water level response.
- 5-ML. Augmentation pumping and streamflow
- 6-ML. Cumulative streamflow

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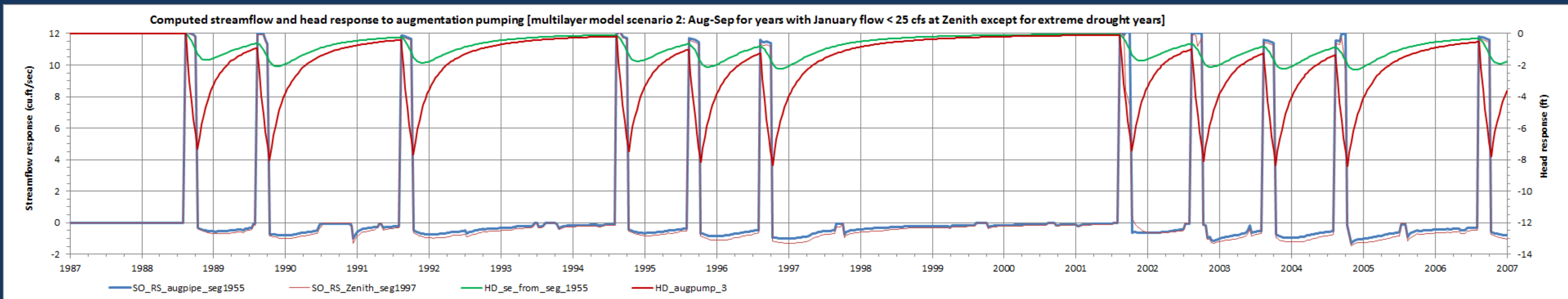

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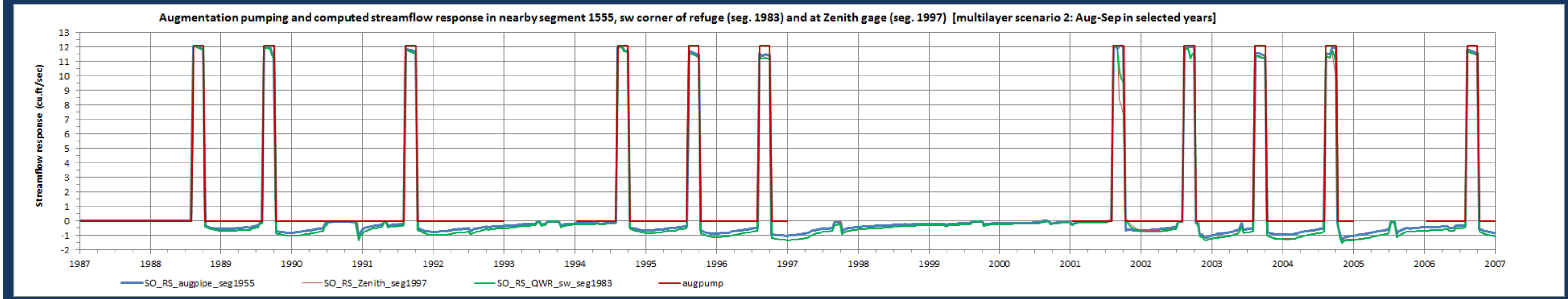

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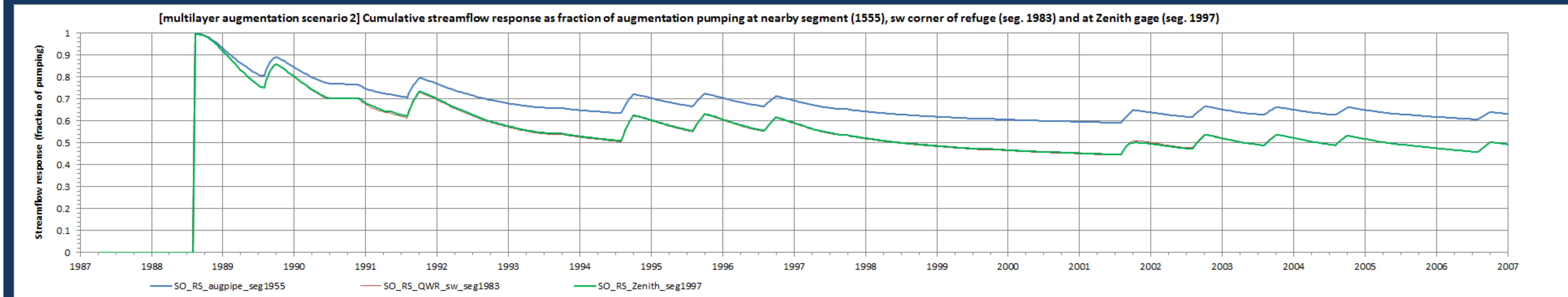

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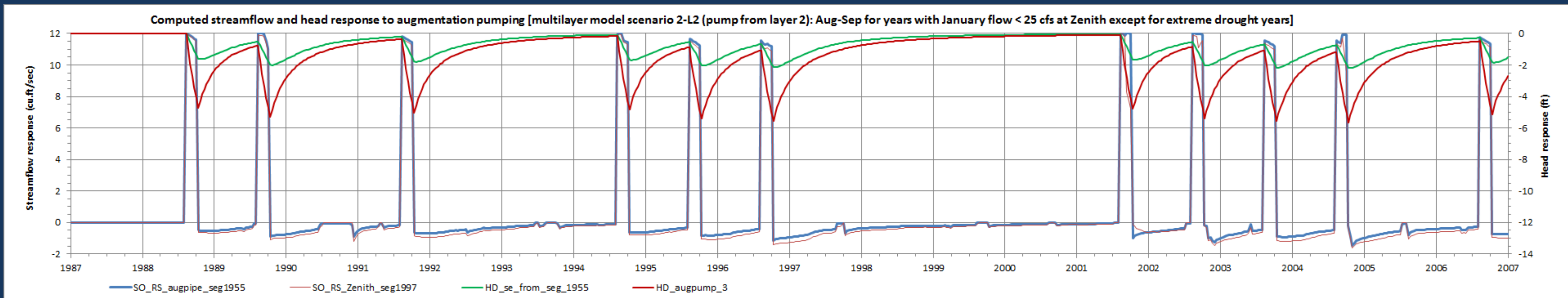
Scenario 2-ML-L2 response plots (multilayer model, pump from layer 2)

- Figures:
- 4-ML-L2. Streamflow and water level response.
- 5-ML-L2. Augmentation pumping and streamflow
- 6-ML-L2. Cumulative streamflow



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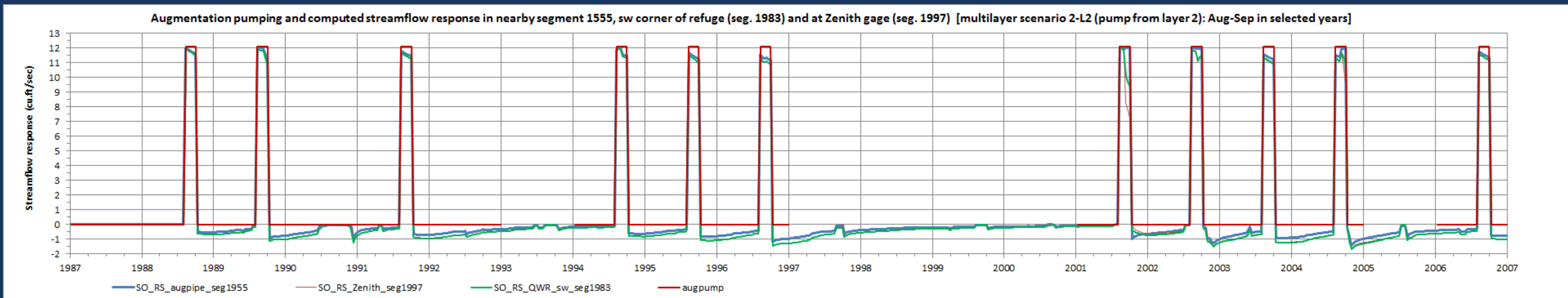

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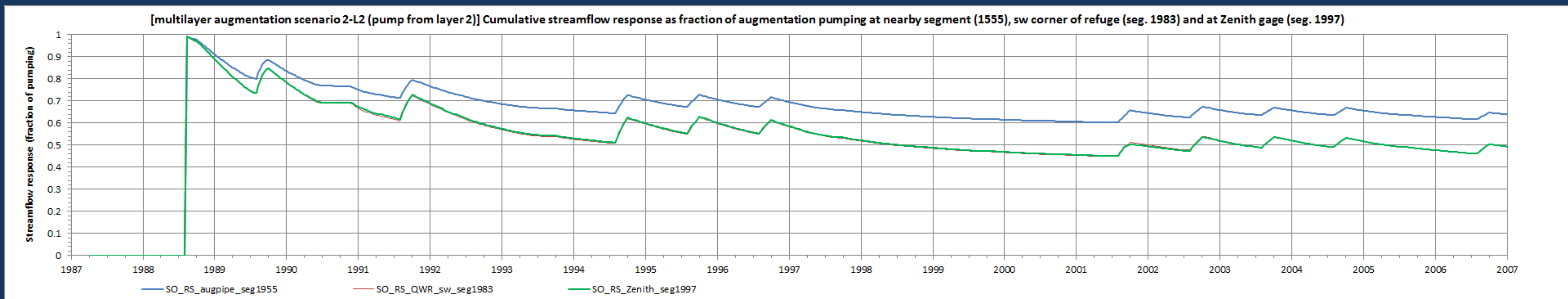

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Effect of pumping from Layer 2 instead of layer 1

- Streamflow response shows neglibible difference (Figs. 4-ML-L2 and 6-ML-L2);

- Maximum drawdown in layer 1 is approx. 5 ft for pumping from layer 2 (Fig. 4-ML-L2, right axis), and approx. 8 ft for pumping from layer 1 (Fig. 4-ML, right axis).

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Thanks!