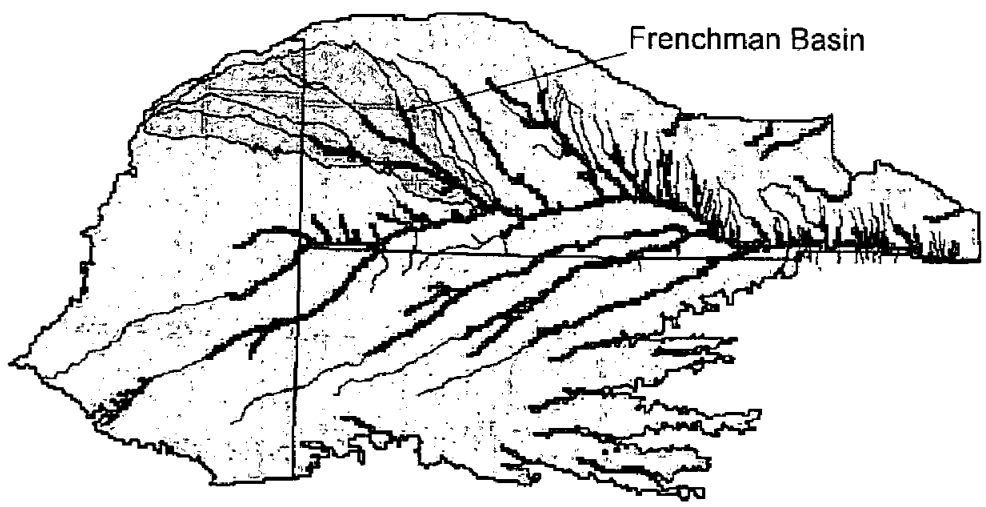
Jim Blaneider
Handout
8-24-2007

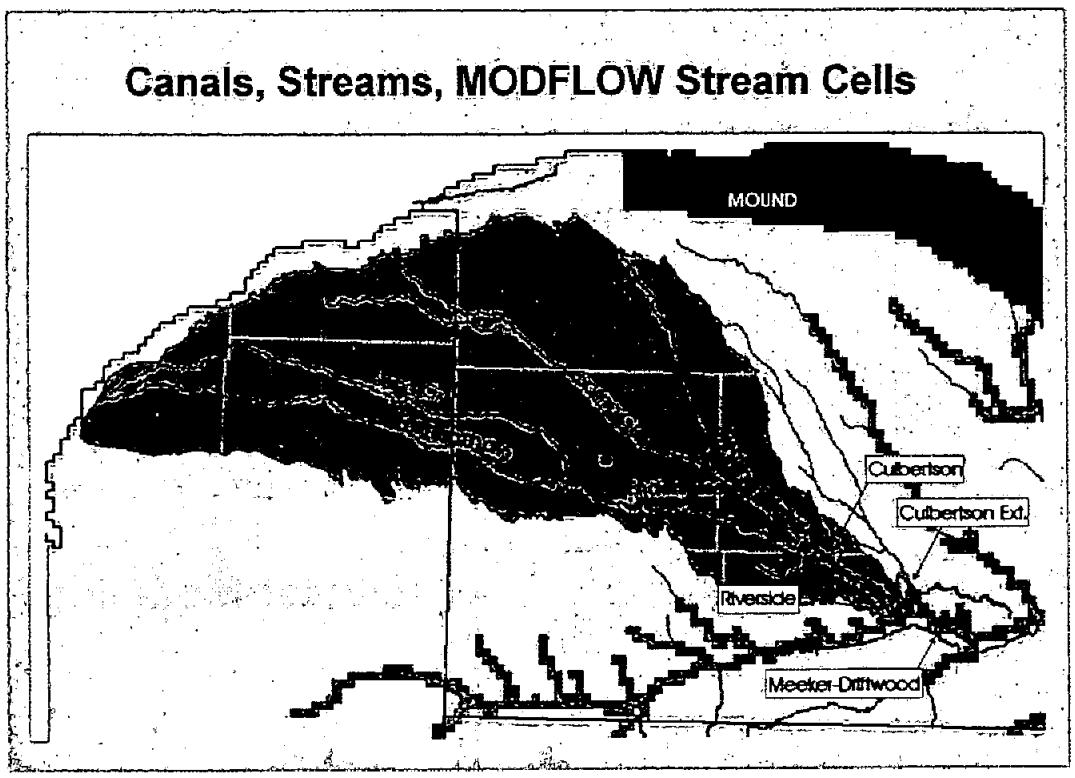
Frenchman Valley Appraisal Study

Nebraska Department of Natural Resources

Phase I – Preliminary Groundwater Modeling Phase

RRCA Model Region

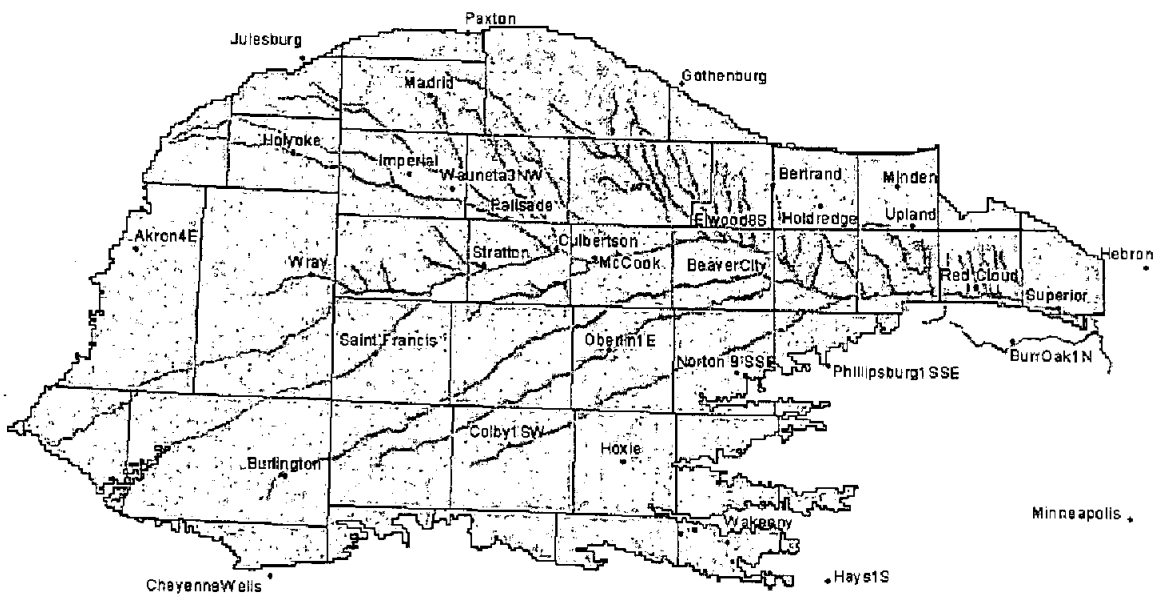




Overview – Phase One

- Simulate the baseflows in Frenchman Creek under a dry, average, and wet climate scenario.
- Pumping based on historical use during a dry, average, or wet year on a per acre basis.
- 2005 level of irrigated acres are used
- Pumping levels are capped where needed based on current allocations.
- Reduce pumping within climate scenarios to meet target river flows

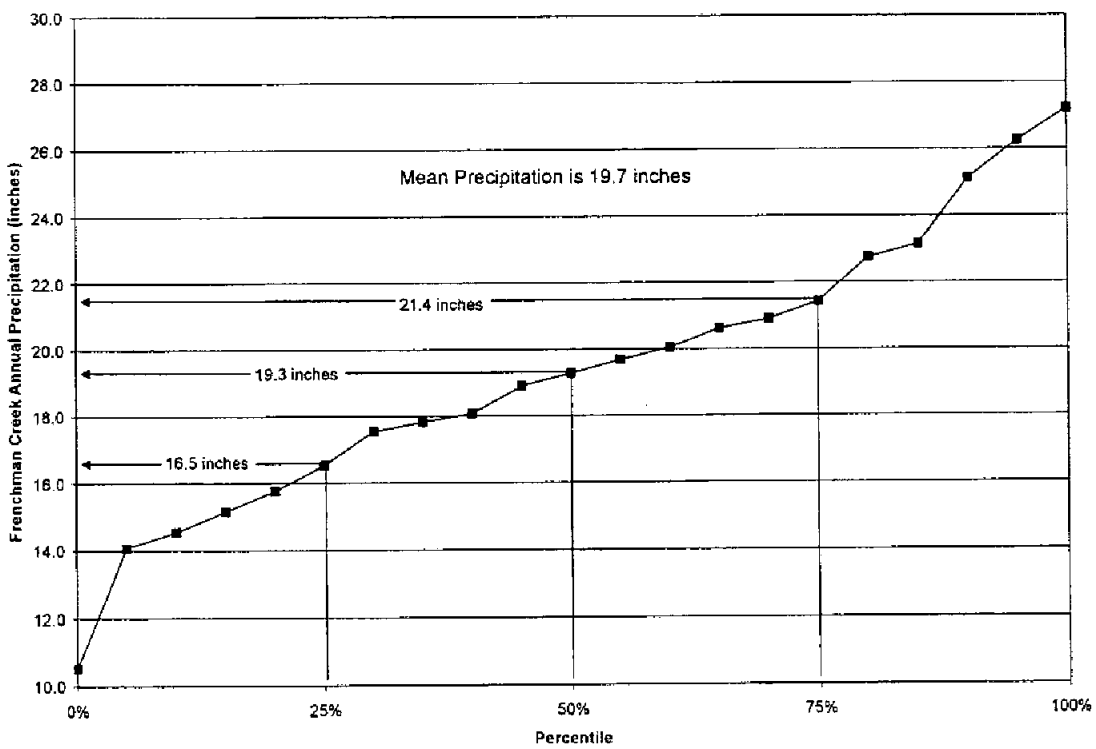
RRCA Precipitation Stations



Precipitation Scenarios

- Based on the period of record for the six Compact rain gauges within the Frenchman Basin – Holyoke, Madrid, Imperial, Wauneta, Palisade, Culbertson
- "Dry" – 25th percentile rainfall
- "Average" – 50th percentile rainfall
- "Wet" – 75th percentile rainfall

Basin Precipitation Statistics



Selection of Years to Model

- Choose a year to repeat in order to capture irrigation behavior under each climate condition.
- Average conditions – DNR previously had completed a scenario that repeats 1988-1991, for Frenchman Basin these years had average precip. of 19.7 inches.
- Dry Scenario – Basin had average precip. of 16.2 inches in 2000.
- Wet Scenario – Basin had average precip. of 21.7 inches in 1987.

More Details for Model Scenarios

- Groundwater exclusive, groundwater commingled, and surface water commingled inputs were based on the year chosen to represent climate condition (both for NE and the other states)
- Surface water exclusive inputs and recharge from canal seepage were also based on chosen year except for dry condition (uses 2005 – low surface water year)
- Evapotranspiration and reservoir levels were based on 1988-1991 conditions
- NE municipal pumping from 2004 was used

Groundwater Model Inputs	DRY Scenario	AV. Scenario	WET Scenario
Groundwater Irrigated Acres Base Year....	2005	2005	2005
Pumping Base Years.....	2000	1988-1991	1987
Surface Water Inputs Base Years.....	2005	1988-1991	1987
Commingled Inputs Base Years.....	2000	1988-1991	1987
Evapotranspiration Base Years.....	1988-1991	1988-1991	1988-1991
Precipitation Base Years.....	2000	1988-1991	1987
6-Station Av. Precipitation Depth.....	16.5	19.3	21.4
Precipitation Base Year Av. Precip Depth	16.2	19.5	21.7

Frenchman Modeling Study Pumping Depths

COUNTY	% Depth Alloc Cut DRY Scenario	Depth Alloc Cut DRY Scenario	GWEX Depth DRY Scenario	% Depth Alloc Cut AV Scenario	Depth Alloc Cut AV Scenario	GWEX Depth AV Scenario	% Depth Alloc Cut WET Scenario	Depth Alloc Cut WET Scenario	GWEX Depth WET Scenario
Perkins	15	2.5	13	1	0.12	13	0	0	10.5
Chase	38	8.2	13	21	3.6	13	14	2.2	13
Dundy	50	13.5	13	18	3.3	13	12	2	13
Hayes	37	7.5	13.5	18	2.8	13.5	0.4	0.4	13.5
Hitchcock	58	18.2	13.5	46	11.2	13.5	10	10.4	13.5

FLIPPED

PUMPING DEPTHS USED IN MODEL

EGS. IN HITCHCOCK CO. IN DRY YEAR THE PUMPED 5.2 + 13.5 = 51.7 IS APPLIED A 58% REDUCTION TO GET CURRENT ALLOCATION (AF)

PERKINS WAS THE ONLY COUNTY WHERE PUMPING WAS UNDER CURRENT ALLOCATIONS DURING WET YEAR.

Phase I Results

- Imperial Gage – Inflows to Enders
- Palisade Gages (Frenchman and Stinking Water Creek) – Total natural flows available at Culbertson Diversion Dam
  - Below Enders Only
  - Total including above Enders (i.e. assume Enders is bypassed year round)
- Culbertson Gage – Riverside ID and discharge to mainstem

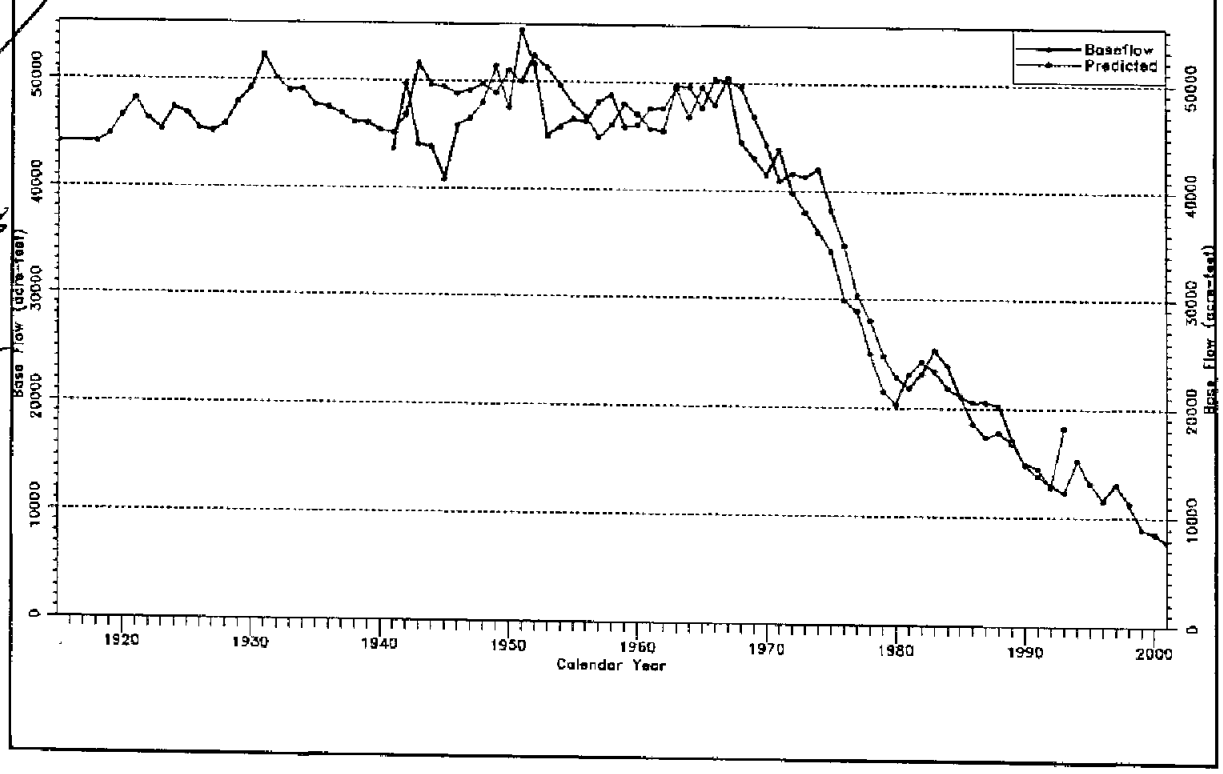
Imperial Gage Analysis

- Two Target Levels – based on recreation and wildlife
  - 3089.4 ft
  - 3099 ft
- Target inflows based on these levels and the following deliveries
  - None
  - 3" FVID
  - 3" FVID and H&RW
  - 6" FVID
  - 6" FVID and H&RW

NOTE THAT QUALITY OF CALIBRATION IN A LARGE REGIONAL MODEL VARIES FROM FT. TO FT.

CALIBRATION HERE IS PRETTY GOOD

Model Calibration at Imperial



USBR Enders Supply Model

-Used to determine the necessary inflows for each combination of target water levels and deliveries
-The table below is for both irrigation districts
-USBR supplied separate model for FVID only

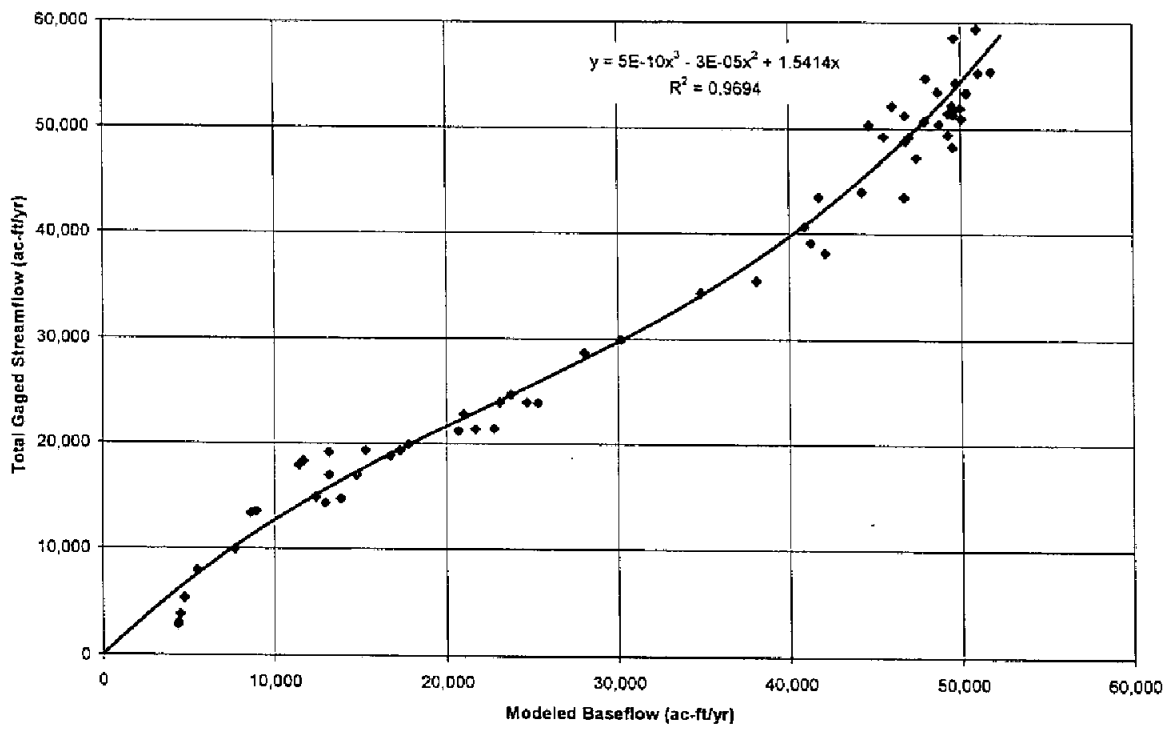
Enders Shutoff Content	Inches from Enders	Estimated Delivery Efficiency	Inches From Pickup	Loss to Headgate Pickup	Storage for 1" Delivery	Enders Storage Needed	Enders Estimated Seepage	Enders Estimated Evap
3089.40	0.00	50.0%	0.00	65.0%	5438	0	2534	2904
14,009	3.00	50.0%	0.24	65.0%	5438	15031	2534	3758
	6.00	50.0%	0.47	65.0%	5438	30063	2534	4442
	9.00	50.0%	0.71	65.0%	5438	45094	2534	4783
	12.00	50.0%	0.94	65.0%	5438	60126	2534	5125
3099.00	0.00	50%	0.00	65.0%	5438	0	2896	4100
23,789	3.00	50%	0.24	65.0%	5438	15031	2896	5125
	6.00	50%	0.47	65.0%	5438	30063	2896	5808
	9.00	50%	0.71	65.0%	5438	45094	2896	6492
	12.00	50%	0.94	65.0%	5438	60126	2896	7175

Enders Seepage and Evaporation at Different Elevations

Elevation (ft)	Seepage (AF)	Evaporation (AF)	Total (AF)
3082.4	2171	2221	4392
3089.4	2534	2904	5438
3099	2896	4100	6996

* With no deliveries

Regression to relate modeled baseflow at Imperial to total streamflow at Imperial

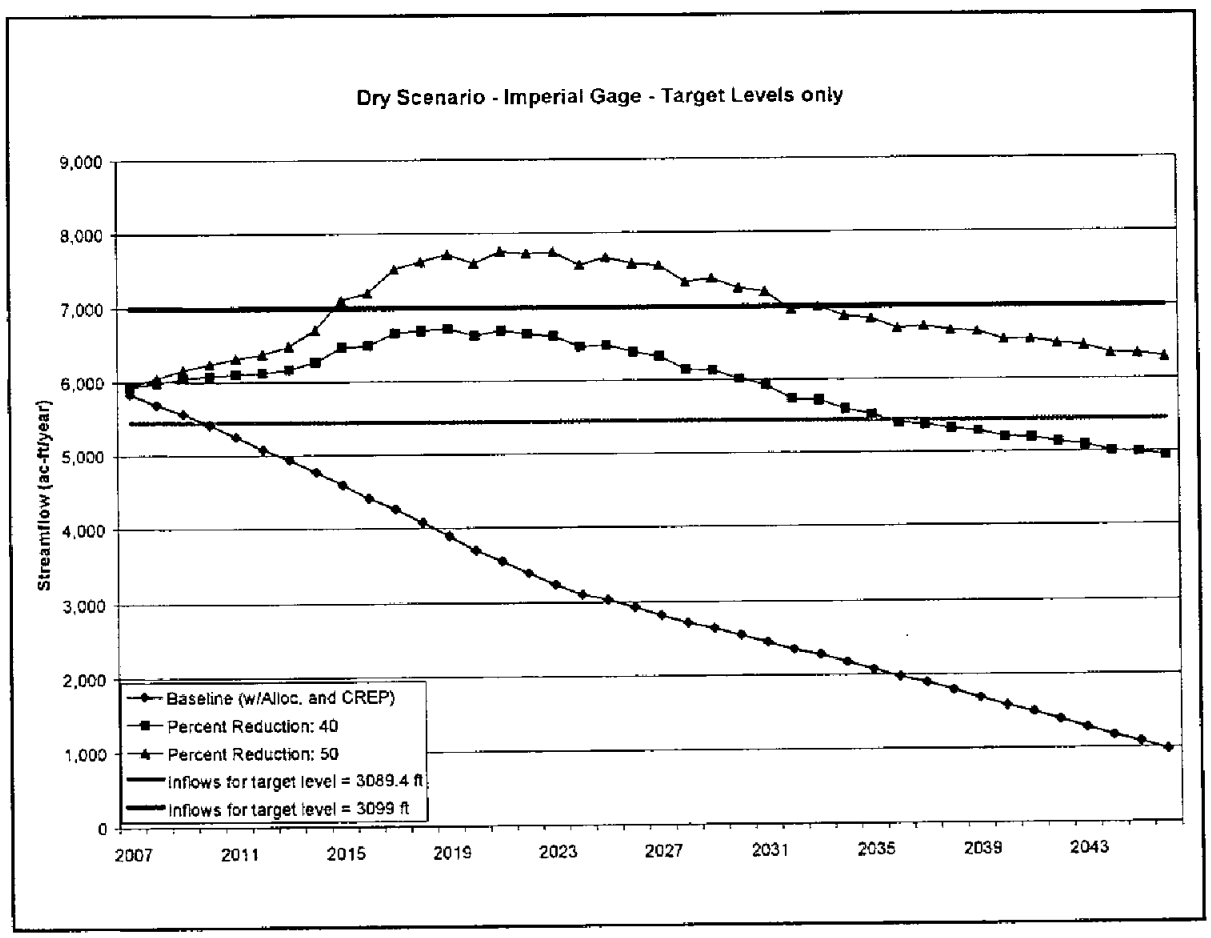


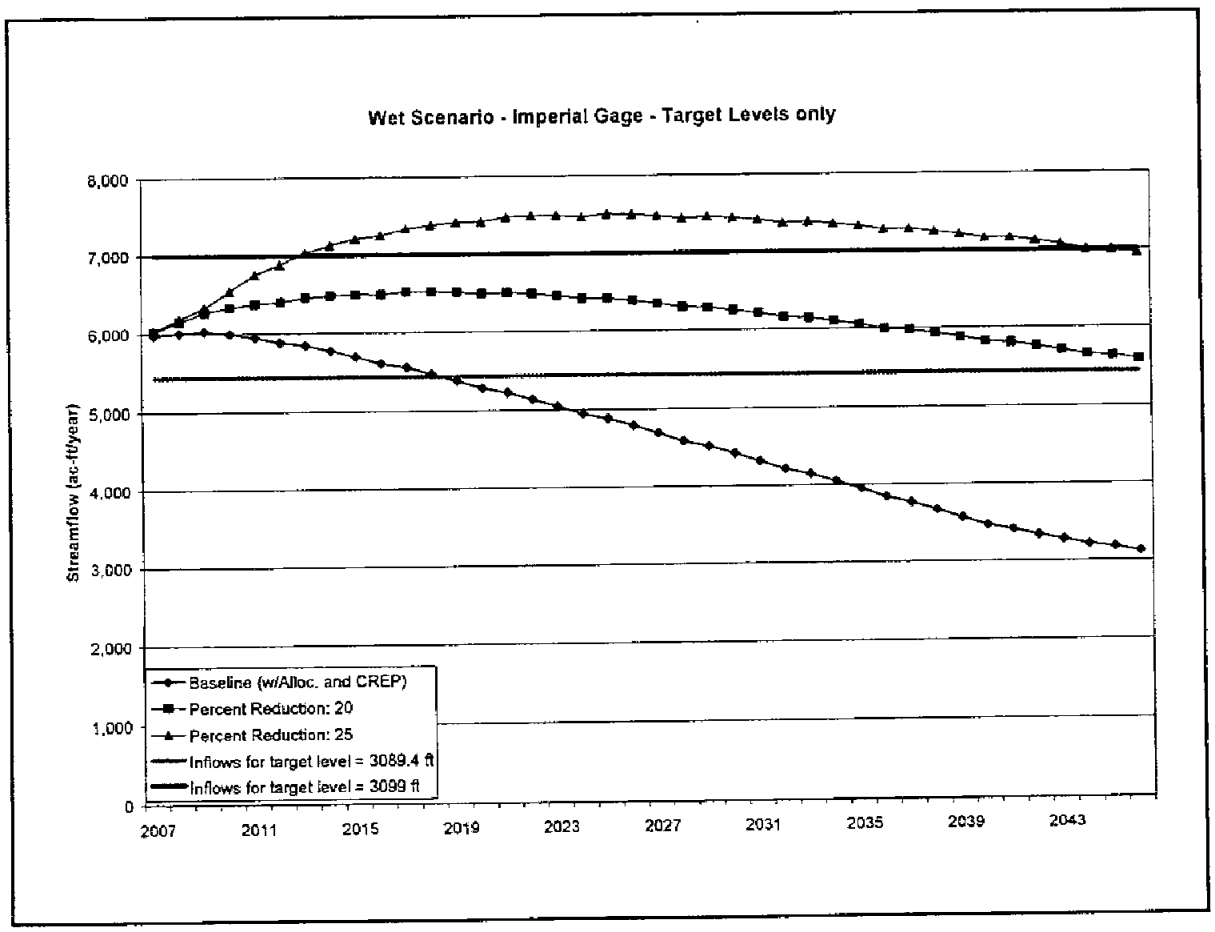
DATA BACK TO 1950 OR SO

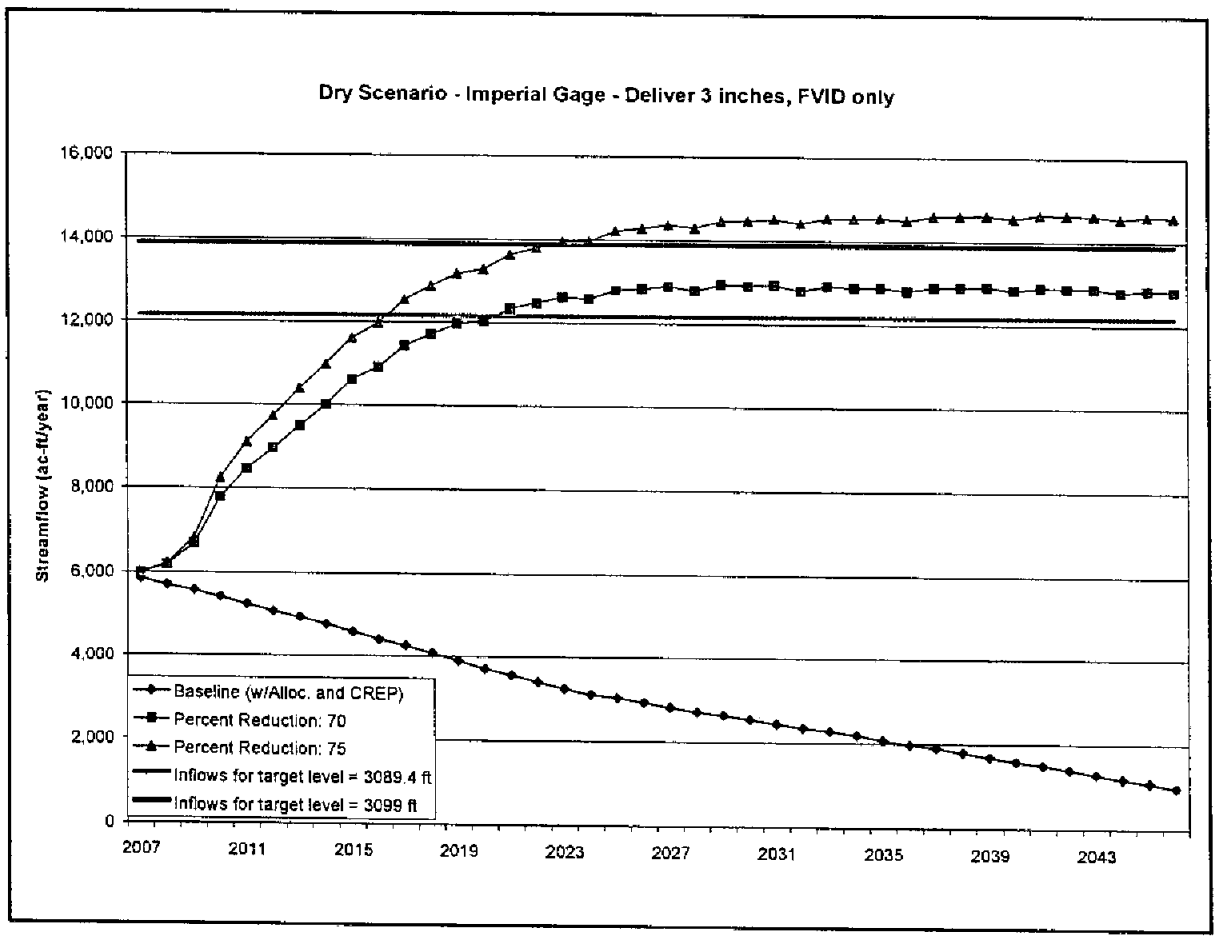
3RD ORDER POLYNOMIAL FIT BEST

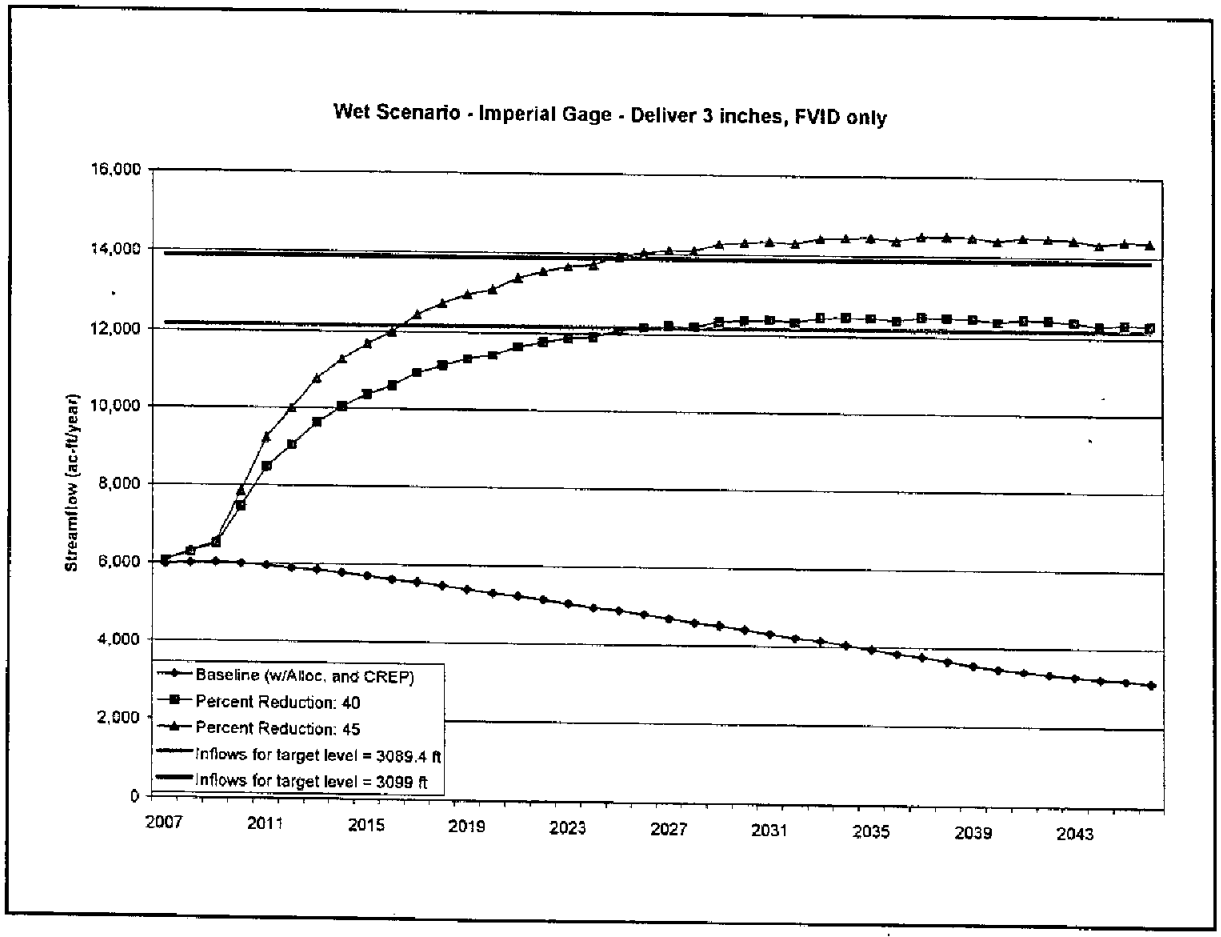
Imperial Gage Results

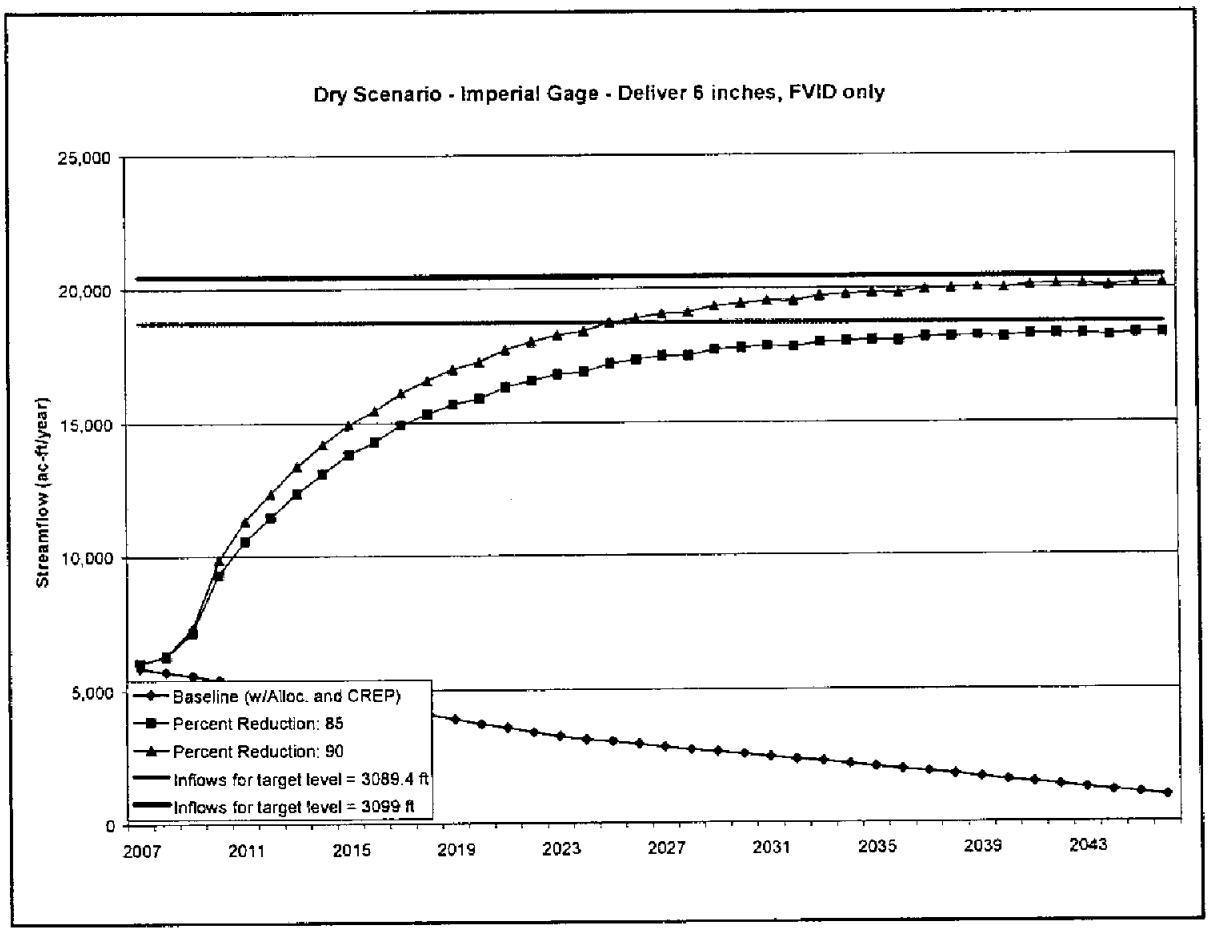
- For each climate scenario, the impact reduction achieved with a 20%, 50%, and 100% reduction in pumping was modeled.
- The results were interpolated to 5% increments.
- Then the percent reduction that best balanced the inflows to the target level over the long term was determined
- The following five slides graphically demonstrate the results for the Dry scenario.
- The remaining graphed results for the other climate scenarios and gage analyses are presented in the attached Appendix.

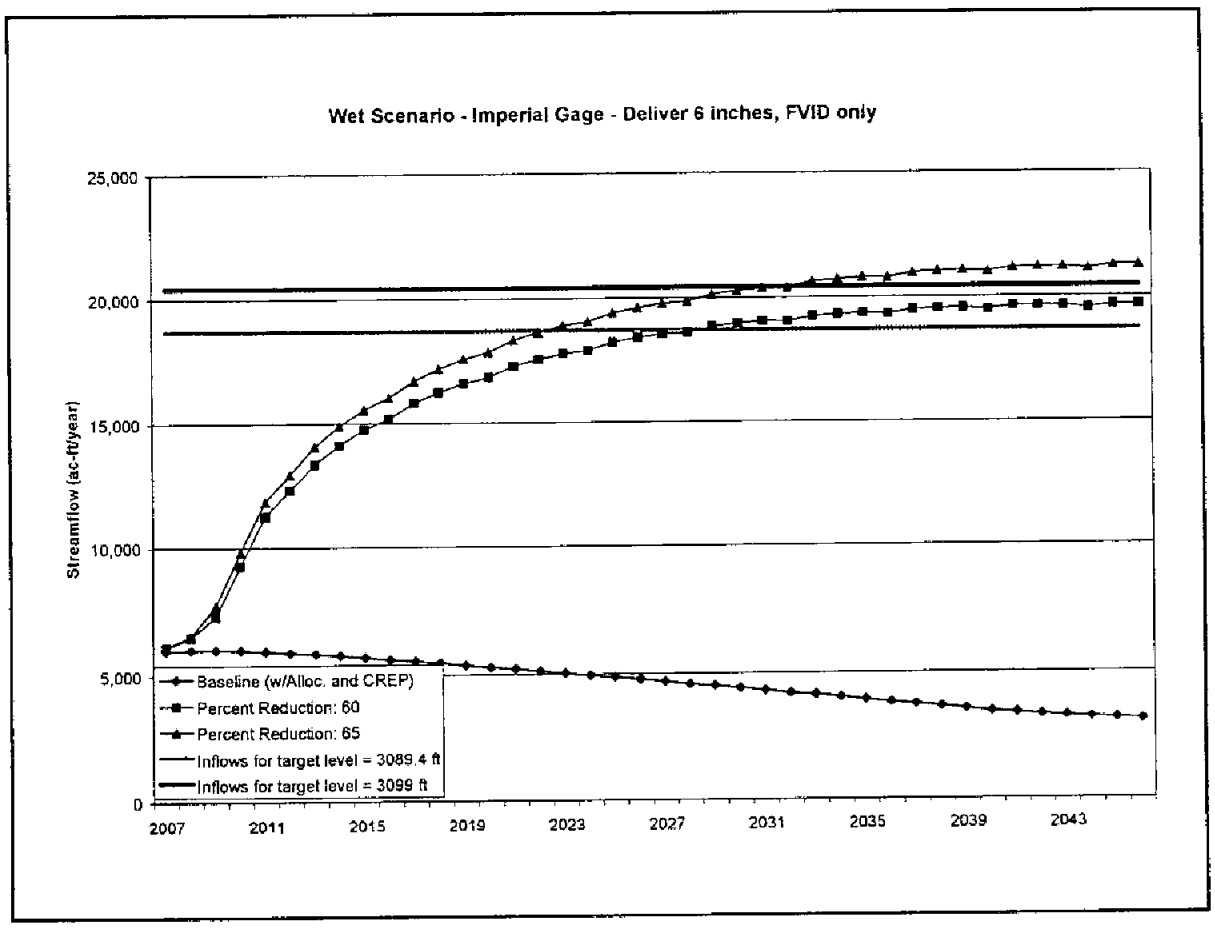

Dry Scenario - Imperial Gage - Target Levels only
Streamflow (ac-ft/year)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 40
Percent Reduction: 50
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft

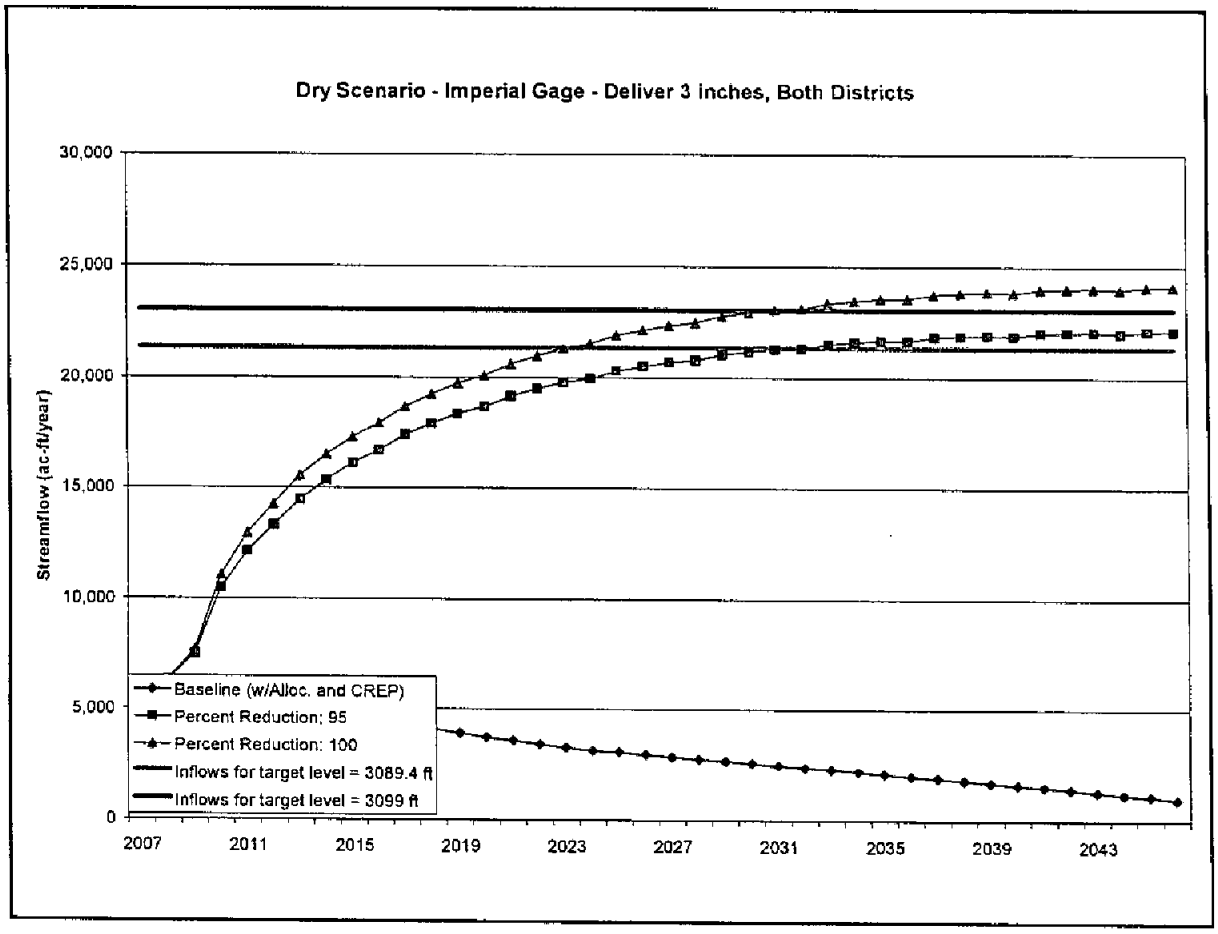

Wet Scenario - Imperial Gage - Target Levels only
Streamflow (ac-ft/year)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 20
Percent Reduction: 25
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft

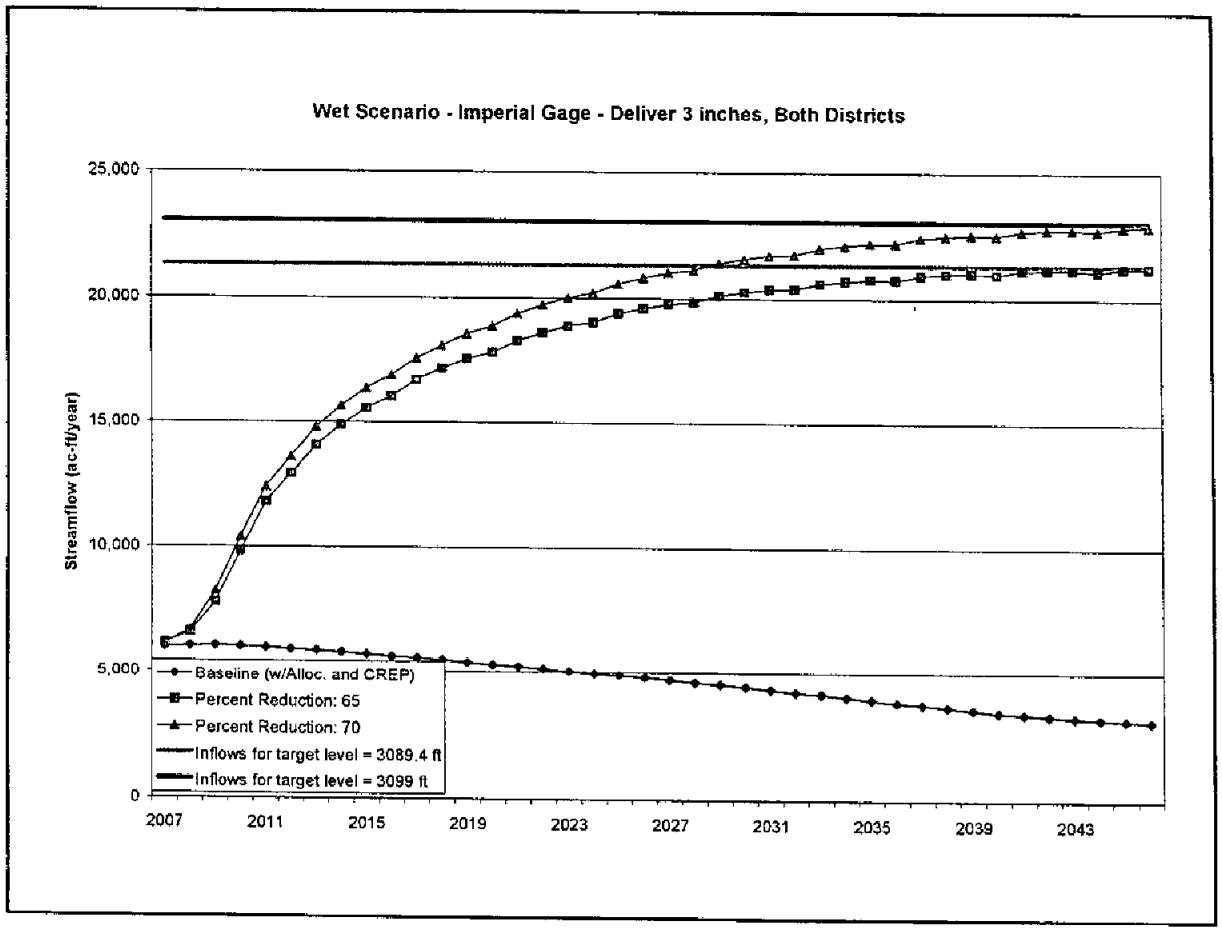

Dry Scenario - Imperial Gage - Deliver 3 inches, FVID only
Streamflow (ac-ft/year)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 70
Percent Reduction: 75
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft

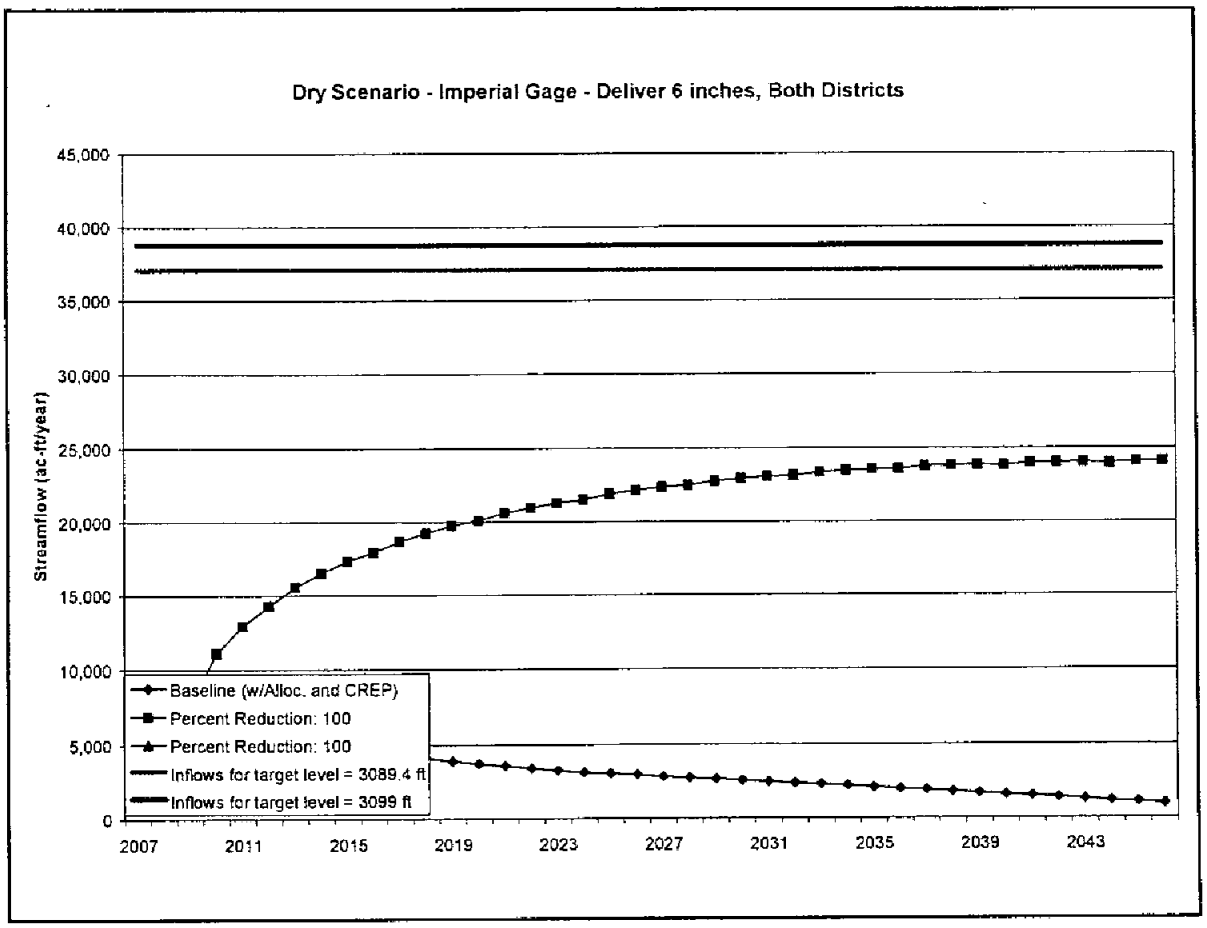

Wet Scenario - Imperial Gage - Deliver 3 inches, FVID only
Streamflow (ac-ft/year)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 40
Percent Reduction: 45
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft

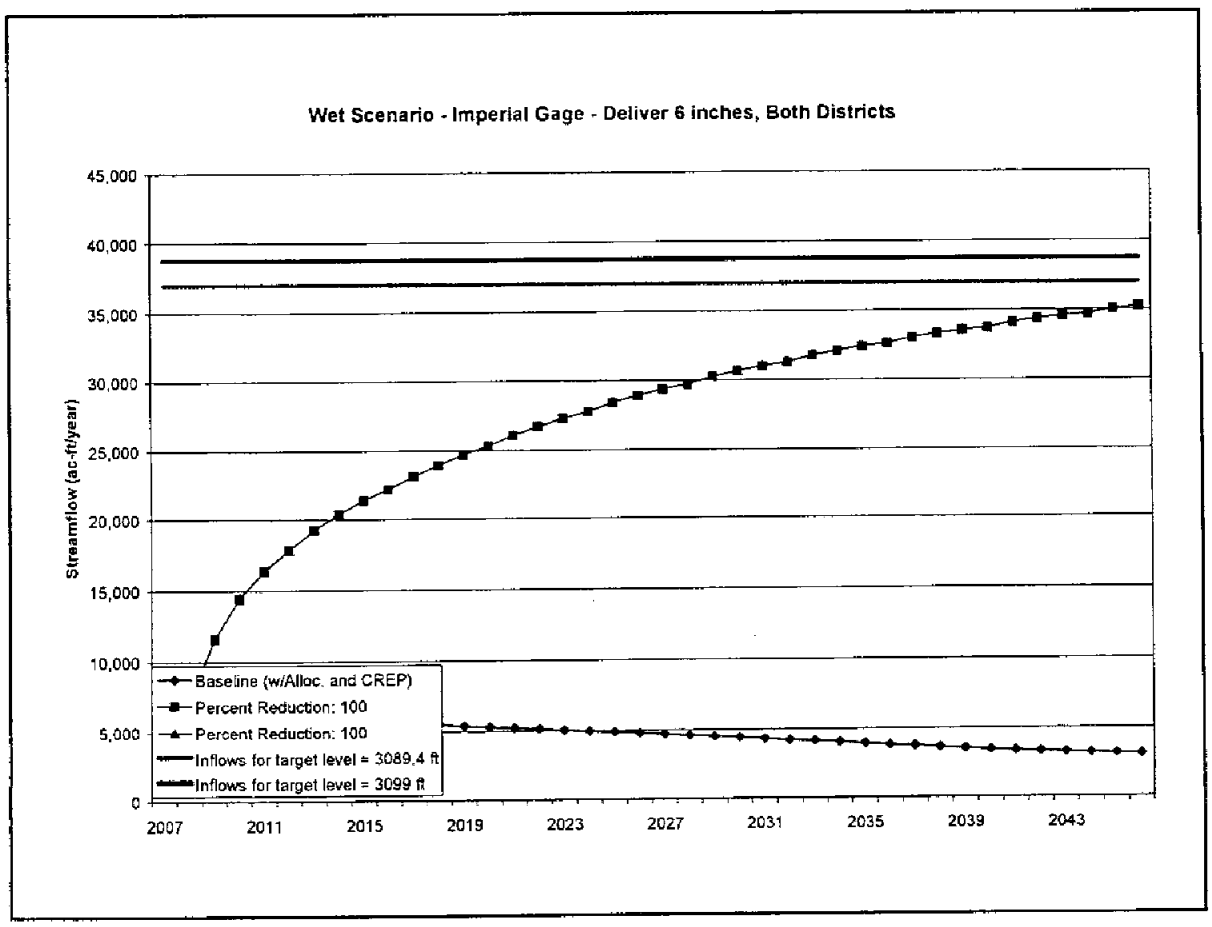

Dry Scenario - Imperial Gage - Deliver 6 inches, FVID only
Streamflow (ac-ft/year)
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 85
Percent Reduction: 90
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft

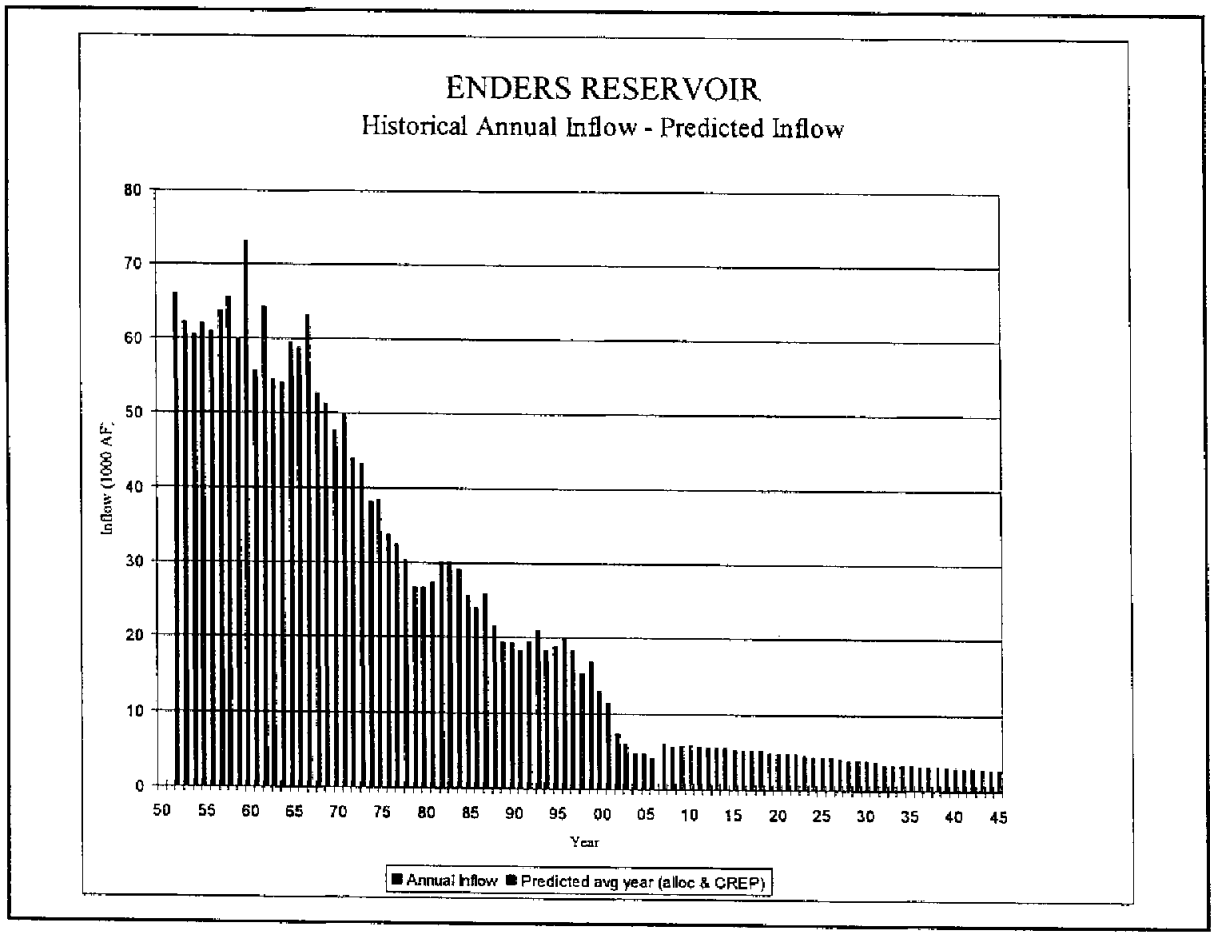

Wet Scenario - Imperial Gage - Deliver 6 inches, FVID only
Streamflow (ac-ft/year)
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 60
Percent Reduction: 65
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft


Dry Scenario - Imperial Gage - Deliver 3 inches, Both Districts
Streamflow (ac-ft/year)
30,000
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 95
Percent Reduction: 100
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft


Wet Scenario - Imperial Gage - Deliver 3 inches, Both Districts
Streamflow (ac-ft/year)
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 65
Percent Reduction: 70
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft

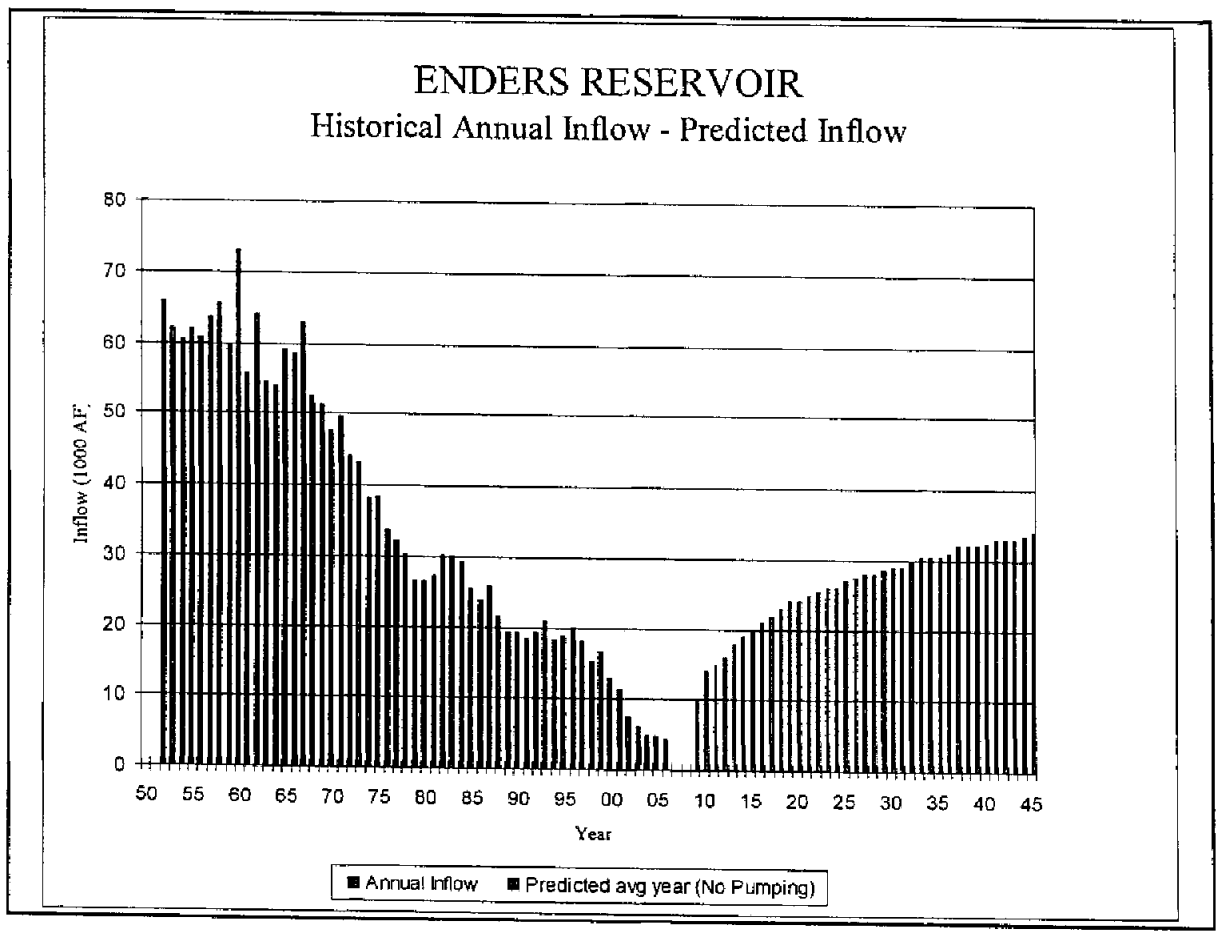

Dry Scenario - Imperial Gage - Deliver 6 inches, Both Districts
Streamflow (ac-ft/year)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 100
Percent Reduction: 100
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft


Wet Scenario - Imperial Gage - Deliver 6 inches, Both Districts
Streamflow (ac-ft/year)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 100
Percent Reduction: 100
Inflows for target level = 3089.4 ft
Inflows for target level = 3099 ft



precip

Average - no reductions in pumping



Average precip
No pumping

Pumping Reductions Needed to Meet Target Flows at Imperial

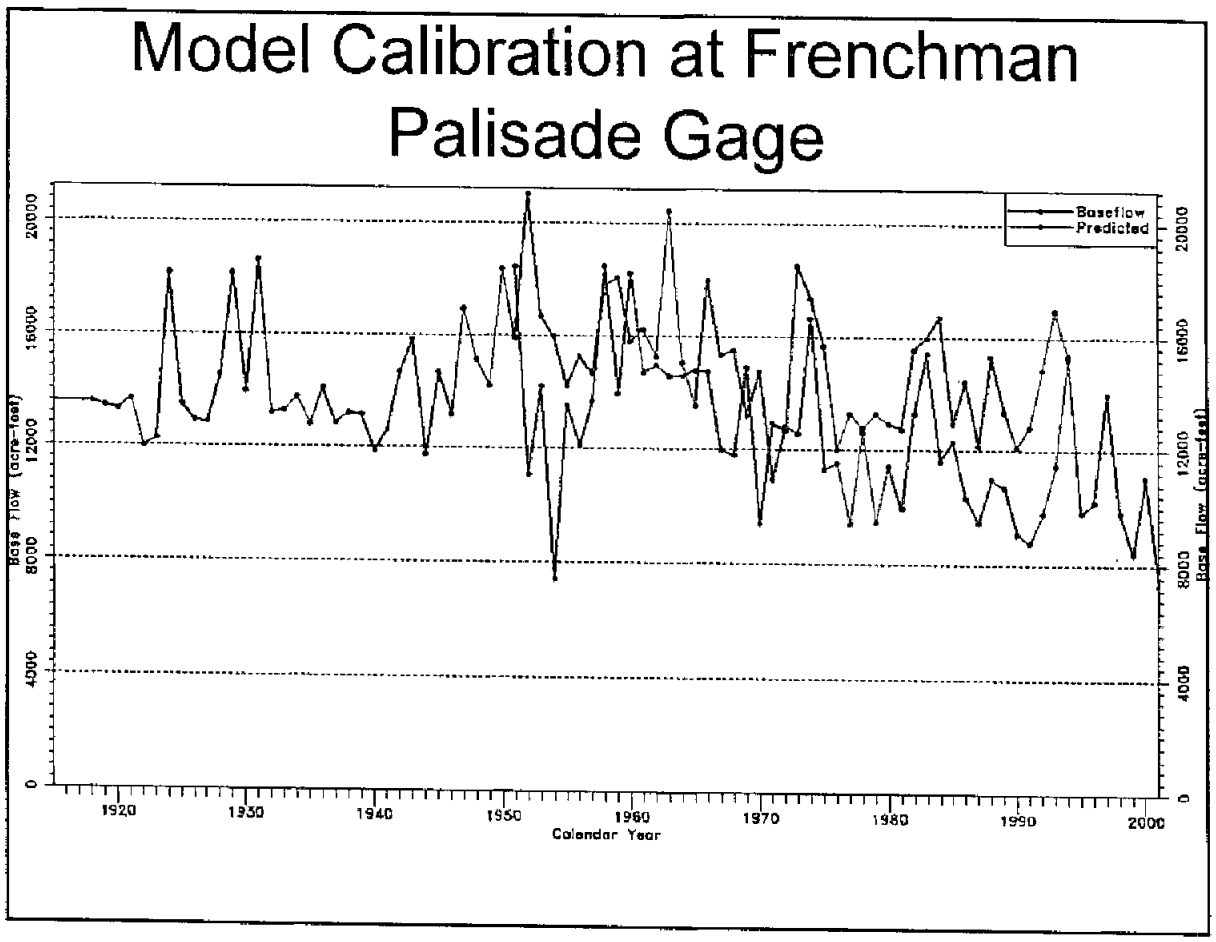
	Dry	Average	Wet
3089.4 – No Deliveries	40%	20%	20%
3099 – No Deliveries	50%	25%	25%
3089.4 – 3" FVID	70%	45%	40%
3099 – 3" FVID	75%	50%	45%
3089.4 - 6" FVID	85%	65%	60%
3099 – 6" FVID	90%	70%	65%
3089.4 – 3" Both Districts	95%	75%	65%
3099 – 3" Both Districts	100%	80%	70%
3089.4 – 6" Both Districts	**	**	**
3099 – 6" Both Districts	**	**	**

** Target not met with 100% reduction

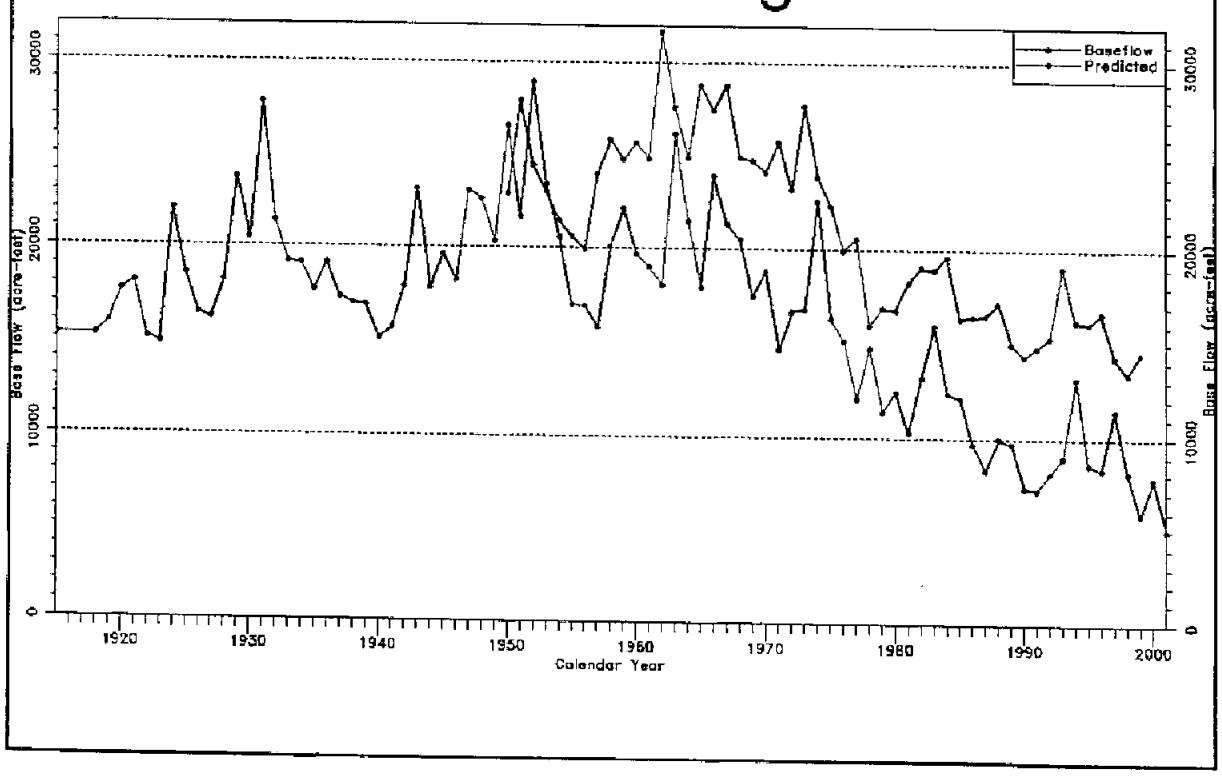
Palisade Gage Analysis

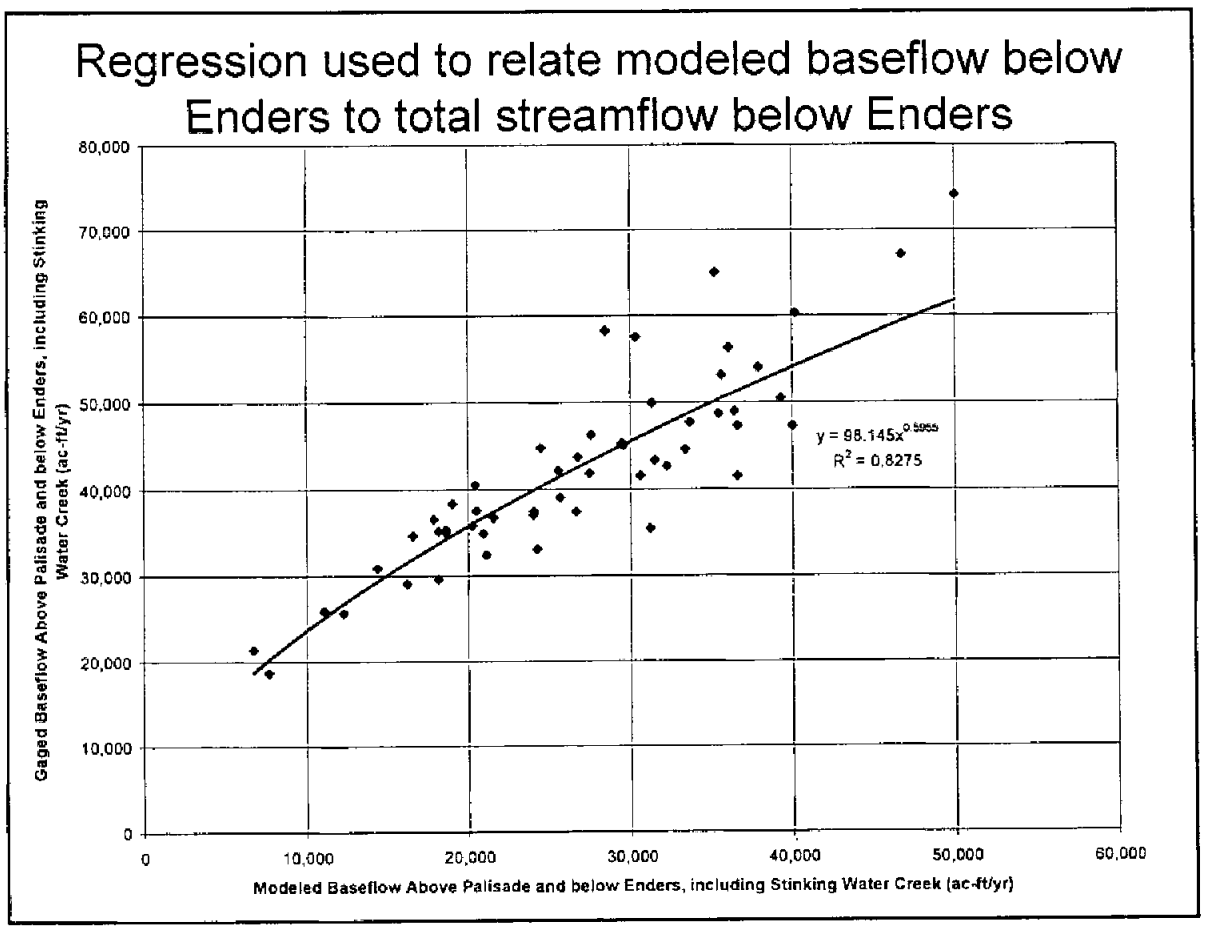
- Looking at reductions needed to supply natural flows to FVID under two scenarios
  - Natural flows below Enders only – Natural flows below Enders and from Stinking Water Creek
  - Natural flows with Enders bypassed – Total Natural Flows above Culbertson Diversion Dam
- The "Enders Bypassed" scenario accounts for needed Enders inflows to maintain level at top of inactive
- Assumes a 50% canal efficiency
- Assumes 50% of streamflow occurs during the irrigation season (6 months)

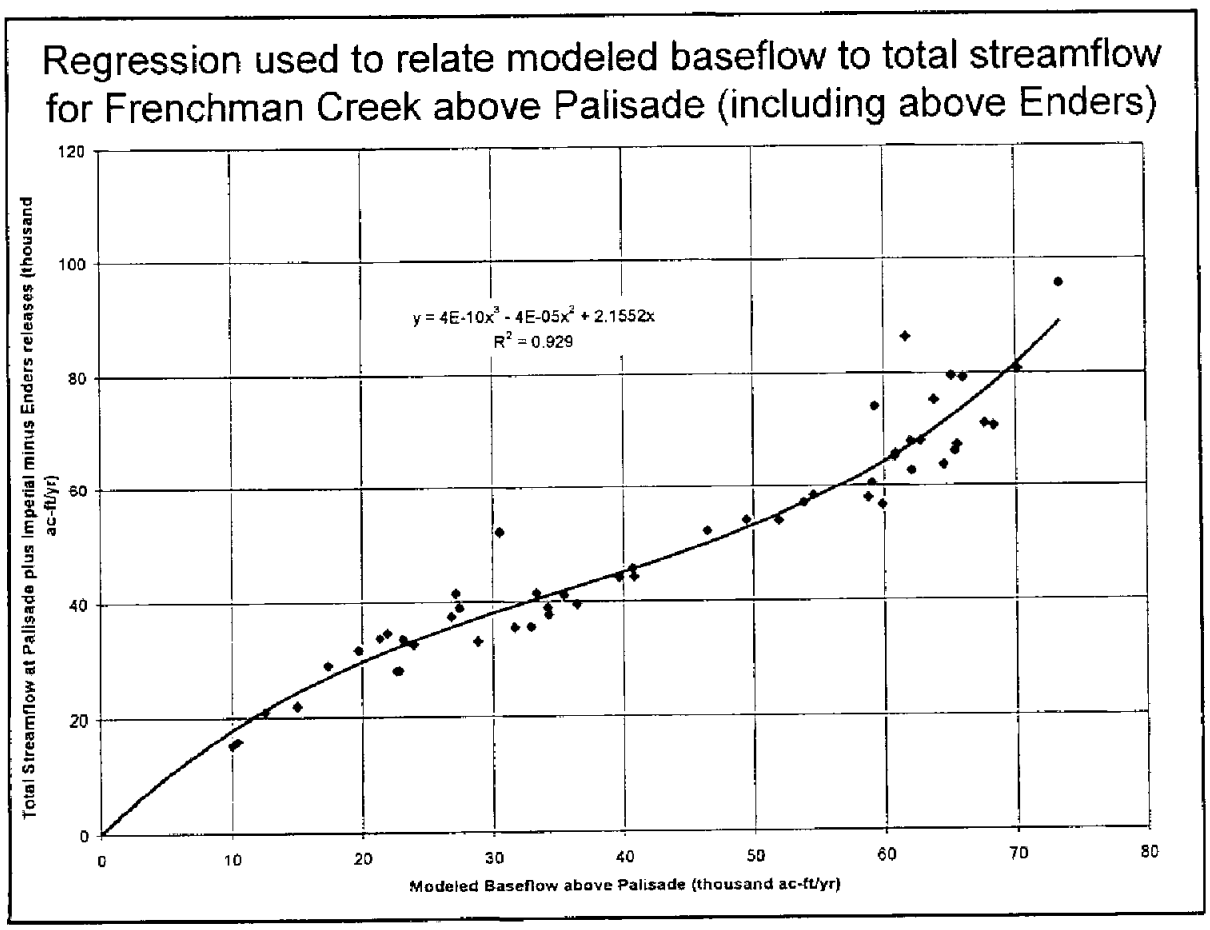
Model Calibration at Frenchman Palisade Gage

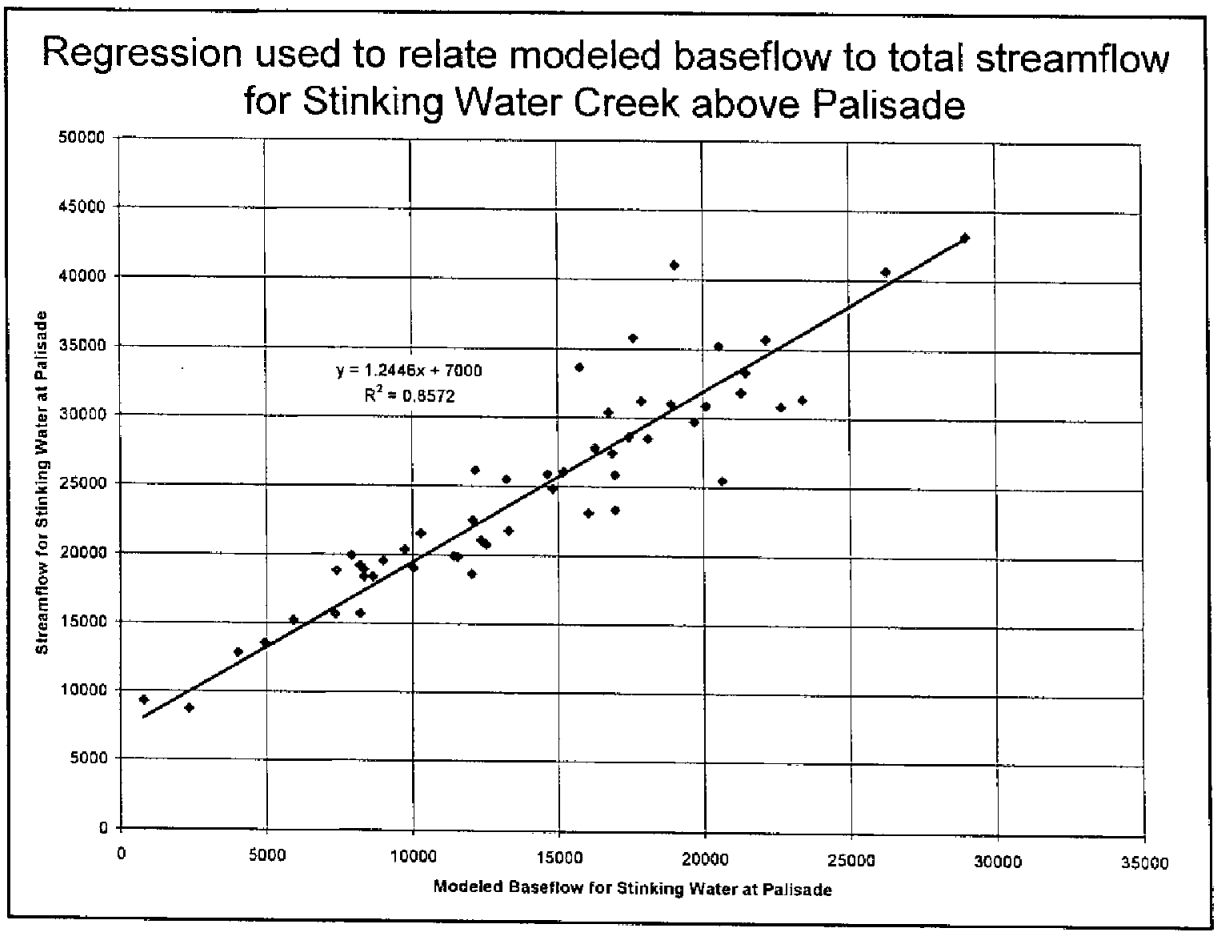


Model Calibration at Stinking Water Palisade Gage




Regression used to relate modeled baseflow below Enders to total streamflow below Enders
Gaged Baseflow Above Palisade and below Enders, including Stinking Water Creek (ac-ft/yr)
Modeled Baseflow Above Palisade and below Enders, including Stinking Water Creek (ac-ft/yr)
y = 98.145x^0.5955
R² = 0.8275
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000


Regression used to relate modeled baseflow to total streamflow for Frenchman Creek above Palisade (including above Enders)
Total Streamflow at Palisade plus imperial minus Enders releases (thousand ac-ft/yr)
Modeled Baseflow above Palisade (thousand ac-ft/yr)
y = 4E-10x³ - 4E-05x² + 2.1552x
R² = 0.929
0
20
40
60
80
100
120
0
10
20
30
40
50
60
70
80



Summary – Palisade Gage

Pumping reductions needed to make target deliveries to FVID from natural flows occurring below Enders only (i.e. Enders storing all inflows for deliveries not included in the inch totals below)

	Dry	Average	Wet
3" – FVID w/ storage	5%	0%	0%
6" – FVID w/ storage	45%	0%	0%
9" – FVID w/ storage	65%	45%	30%
12" – FVID w/ storage	85%	65%	60%

* With no supply from above Enders

Summary – Palisade Gage

Pumping reductions needed to make target deliveries to FVID from natural flows occurring above and below Enders (i.e. Enders bypassing all inflows)

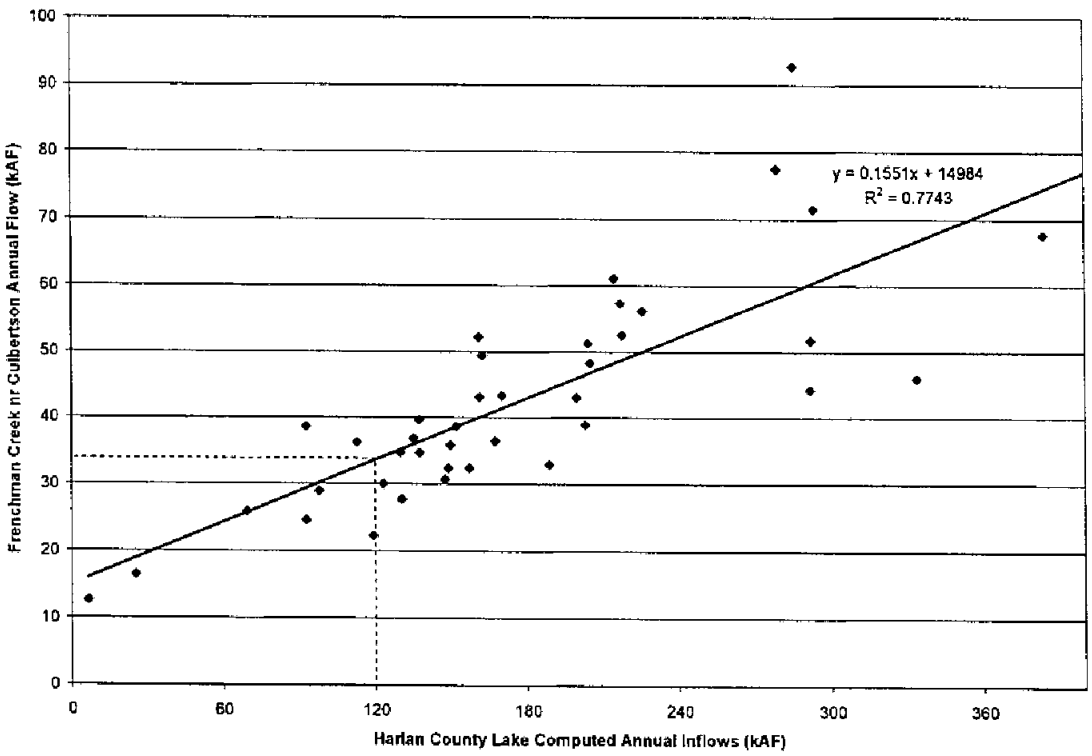
	Dry	Average	Wet
3" – FVID w/o storage	10%	0%	0%
6" – FVID w/o storage	50%	0%	0%
9" – FVID w/o storage	70%	30%	15%
12" – FVID w/o storage	90%	45%	35%

* Bypassing Enders inflows year round

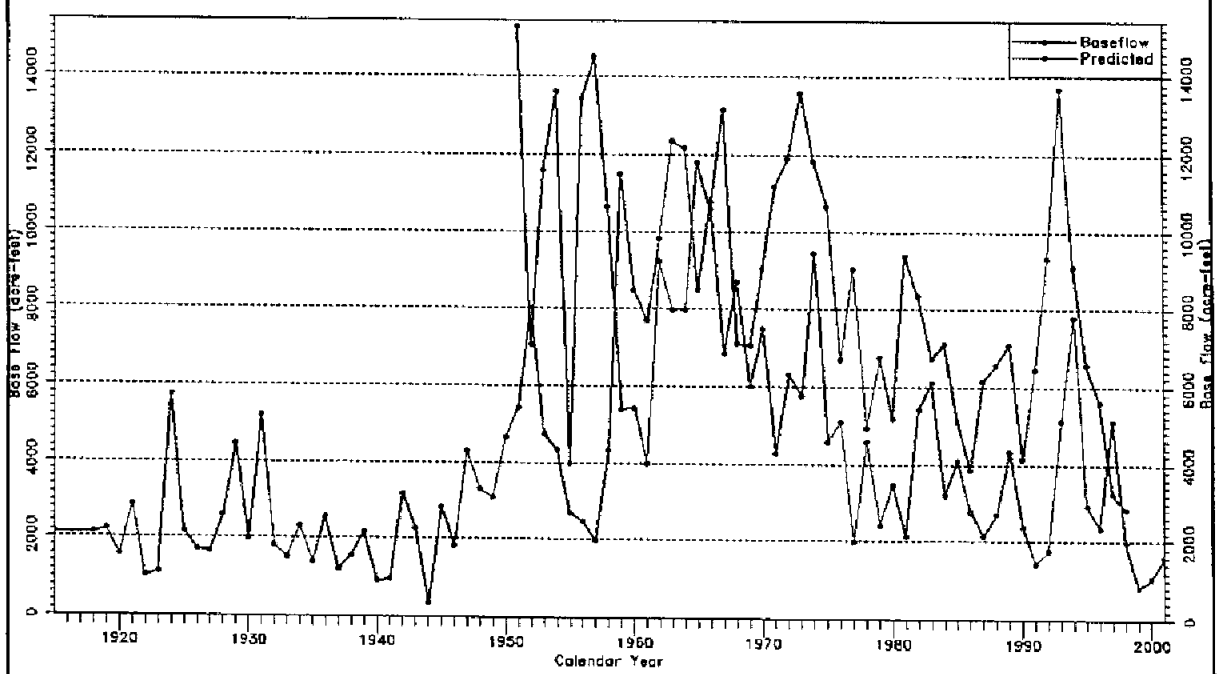
Culbertson Gage Analysis

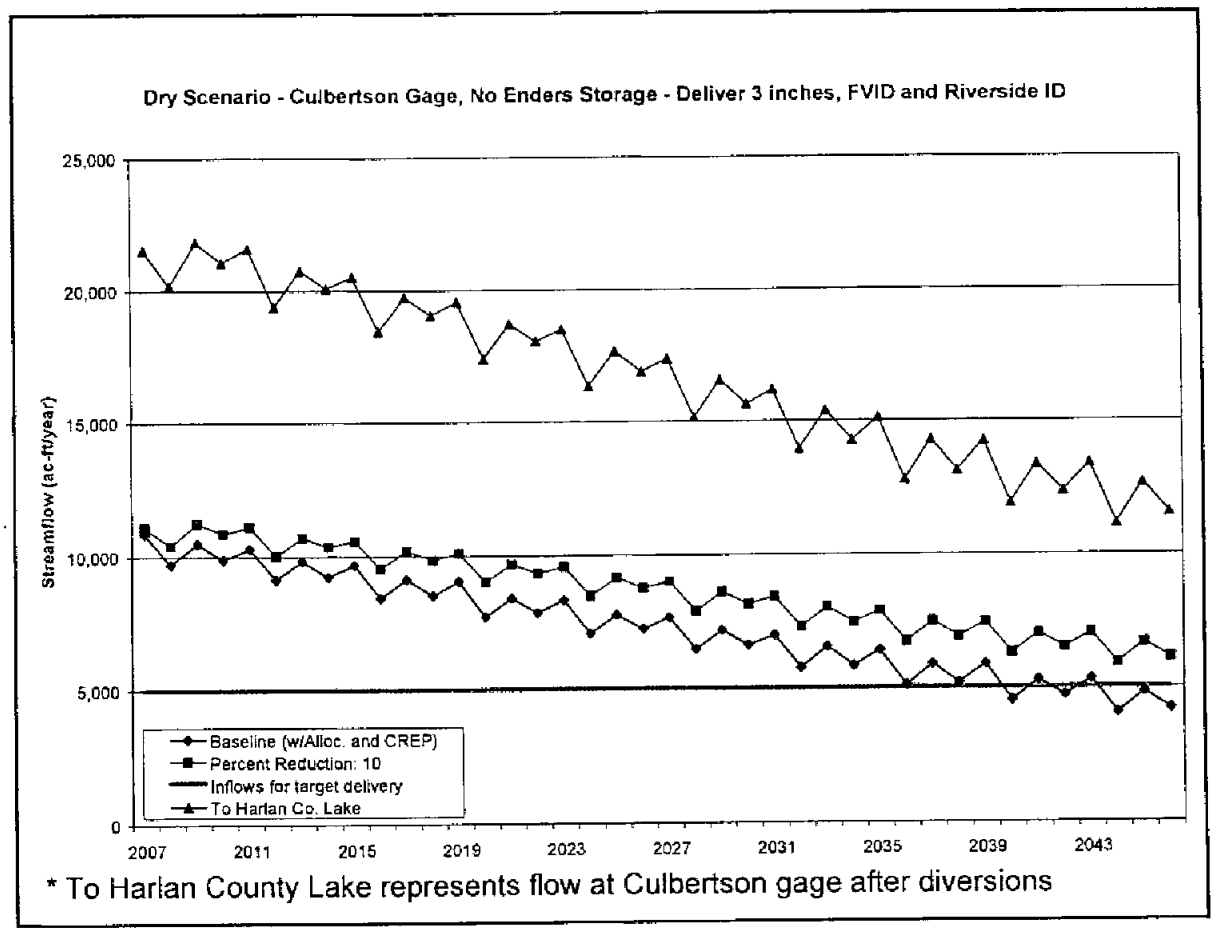
- Applies The same reductions needed to meet target natural flows at Palisade without Enders storage.
- Adds Riverside Irrigation District with same deliveries as FVID for the target streamflows
- Meant to show the streamflows that would reach the mainstem (and potentially Harlan County Lake) under these reduction and delivery scenarios
- Historically, Frenchman Creek has accounted for about one third of the inflows to Harlan County Lake
- Example graphs for Dry Scenario shown below, all graphs included in Appendix

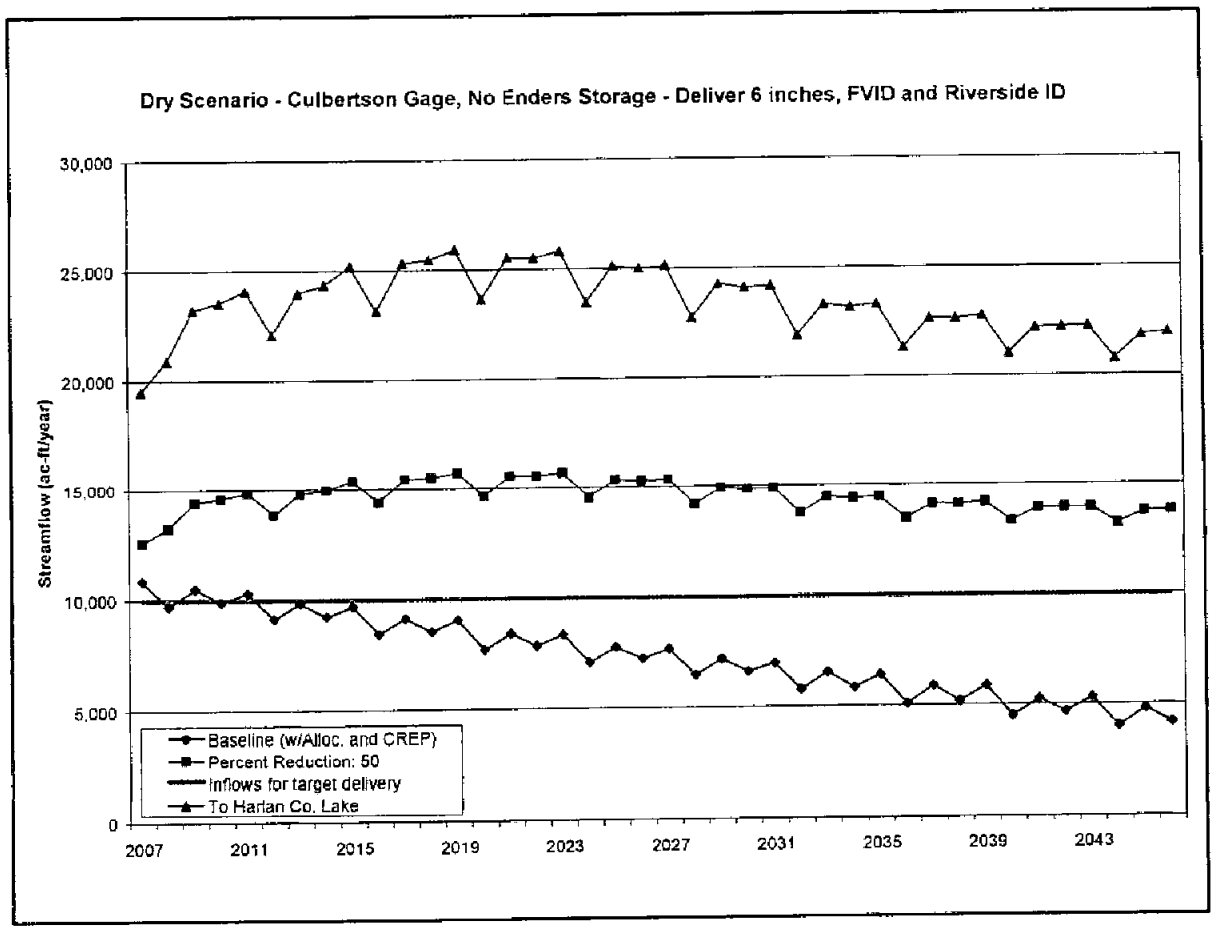
Frenchman Contribution to Harlan County Lake

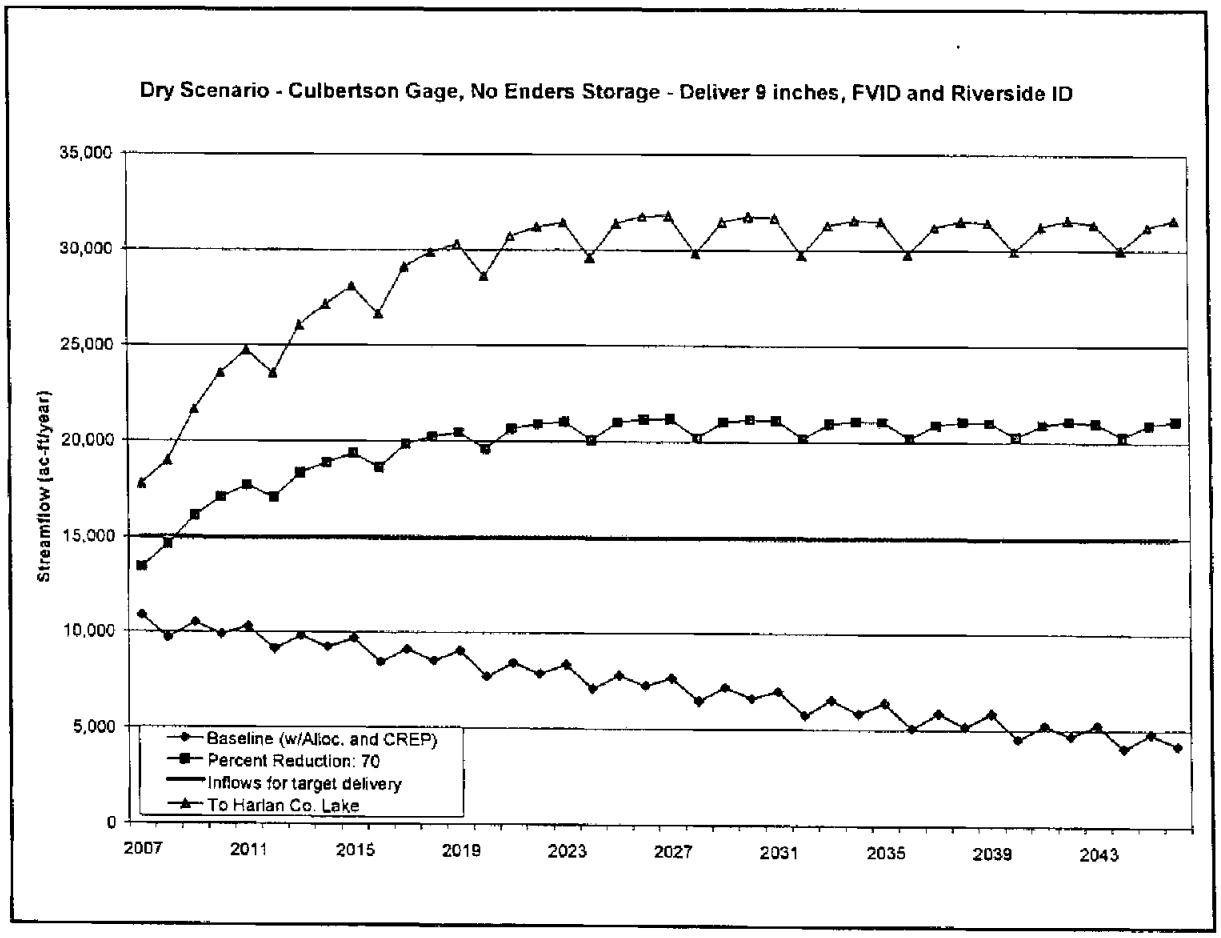


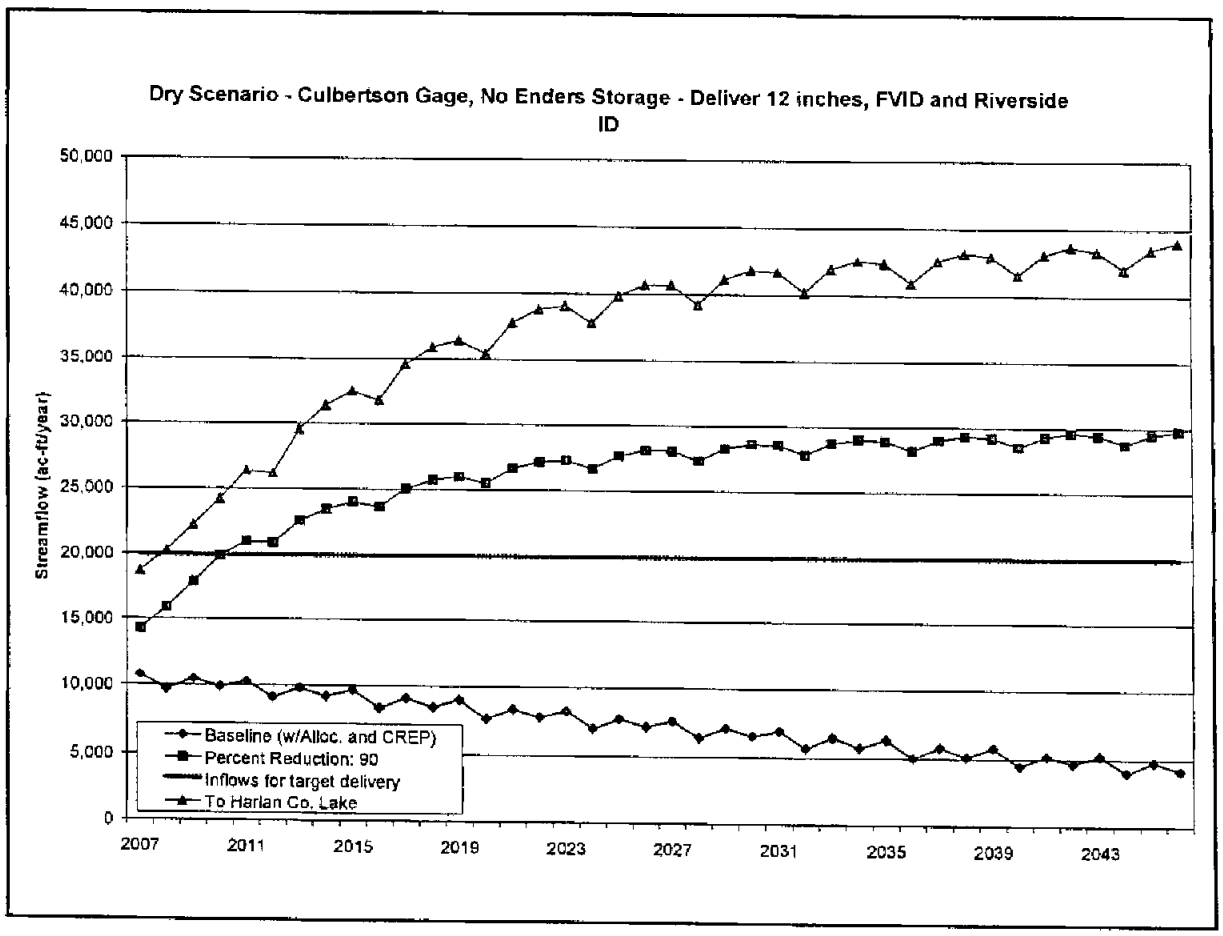
Model Calibration for Culbertson Gage




Dry Scenario - Culbertson Gage, No Enders Storage - Deliver 3 inches, FVID and Riverside ID
Streamflow (ac-ft/year)
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 10
Inflows for target delivery
To Harlan Co. Lake
* To Harlan County Lake represents flow at Culbertson gage after diversions


Dry Scenario - Culbertson Gage, No Enders Storage - Deliver 6 inches, FVID and Riverside ID
Streamflow (ac-ft/year)
30,000
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 50
Inflows for target delivery
To Harlan Co. Lake


Dry Scenario - Culbertson Gage, No Enders Storage - Deliver 9 inches, FVID and Riverside ID
Streamflow (ac-ft/year)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 70
Inflows for target delivery
To Harlan Co. Lake


Dry Scenario - Culbertson Gage, No Enders Storage - Deliver 12 inches, FVID and Riverside ID
Streamflow (ac-ft/year)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Baseline (w/Alloc. and CREP)
Percent Reduction: 90
Inflows for target delivery
To Harlan Co. Lake

Summary and Conclusions

- The potential for increased streamflow in Frenchman Creek was simulated under three climate scenarios – dry, average, and wet.
- The reductions in pumping required to meet target inflows to Enders and target flows at the Culbertson Diversion Dam were determined
- Under most scenarios, significant reductions in pumping were required to meet streamflow targets.
- Some target streamflows were not attainable even with 100% reductions in groundwater pumping.

Conclusions Cont.

- Very drastic pumping reductions were required to achieve reasonable levels of deliveries to H&RW ID
- Under average conditions, a 45% reduction in pumping should allow FVID and Riverside ID to deliver ~12 inches (whether or not Enders is storing or passing inflows)
- This pumping reduction would result in about 30kAF discharging to the mainstem

3" WOULD BE STORED; DELIVERY OUT OF ENDERS → IT'S A WASH