Attachment A2
Supplemental Modeling and Sensitivity Analysis

Contents

Tables

Figures

Abbreviations and Acronyms

μmhos/cm	micromhos per centimeter
AF	acre-foot (feet)
Banks	Harvey O. Banks Pumping Plant
CalSim II	California Simulation Model II
cfs	cubic feet per second
CVP	Central Valley Project
Delta	Sacramento-San Joaquin River Delta
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DWR	California Department of Water Resources
EC	electrical conductivity
Jones	C.W. “Bill” Jones Pumping Plant
mmhos/cm	millimhos per centimeter
Project	Delta-Mendota Canal Recirculation Project
Reclamation	Bureau of Reclamation
SJR	San Joaquin River
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
WQO	Water Quality Objective

Attachment A2
Supplemental Modeling and Sensitivity Analysis

A2.1 Introduction and Background

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) is evaluating the feasibility of using recirculation strategies to improve water quality and flows in the lower San Joaquin River (SJR). The Delta-Mendota Canal (DMC) Recirculation Project (Project) involves the recirculation of water from the Sacramento-San Joaquin River Delta (Delta) through export pumping and conveyance facilities to the SJR upstream of Vernalis (the point at which the SJR enters the Delta).

The primary objective of the Project is to respond to flow and water quality requirements. Other opportunities for the Project may include improvements in water supply reliability, prevention of further groundwater overdraft, fishery improvements, and supplemental flows to improve water levels in the South Delta.

The purposes of the Feasibility Study are to identify and evaluate the feasibility of alternatives for the Project and to determine whether the Project will provide greater flexibility in meeting existing water quality standards and flow objectives while reducing the reliance on New Melones water releases to meet applicable objectives. The alternative plans are described in **Chapter 4** of the Plan Formulation Report.

At the March 10, 2008, stakeholder meeting, several suggestions were provided about how to refine the alternative plans that were developed for the Feasibility Study. Several stakeholders recommended expanding the analyses by conducting supplemental modeling of additional alternative plans and sensitivity analysis. The additional modeling is referred to as "sensitivity analysis,", even though, strictly speaking, some of the model runs are focused on new objectives not considered in the original analysis, and are not sensitivity runs of existing alternative plans.

This attachment addresses the following issues:

- Sensitivity of the modeling assumptions that were used to determine when water is available for recirculation—specifically, assumptions that relate to the minimum water quality in the DMC required to allow recirculation

- Potential reduction in New Melones releases that could result if the Stanislaus River dissolved oxygen (DO) standard at Ripon were modified
- Use of recirculation to improve compliance with Southern Delta Interior electrical conductivity (EC) objectives
- Use of recirculation to maintain minimum flow in the SJR at Vernalis during the irrigation season

A2.1.1 Flow and Water Quality Standards

The State Water Resources Control Board (SWRCB) established flow and water quality standards for the SJR at Vernalis and the Delta in the *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (referred to as the Bay/Delta Plan) (SWRCB 2006) and the SWRCB Decision 1641 (D-1641, issued on December 29, 1999, and revised on March 15, 2000) (SWRCB 2000).

The SWRCB has also established water quality standards for the Delta in the Bay/Delta Plan and D-1641 (SWRCB 2000) for the operation of the Central Valley Project (CVP) and State Water Project (SWP) facilities. Salinity objectives published in D-1641 are shown in **Table A2-1**.

A2.1.2 California Simulation Model II

California Simulation Model II (CalSim II) is a planning model designed to simulate the operations of CVP's and SWP's reservoir and water delivery systems for current and future facilities, flood-control operating criteria, water delivery policies, in-stream flow and Delta outflow requirements, and hydroelectric power-generation operations. CalSim II is the standard systemwide hydrologic model that Reclamation and the California Department of Water Resources (DWR) use to conduct planning and impact analyses of potential projects.

CalSim II is the primary tool for evaluating water operations for recirculation (**Appendix A**). CalSim II is used to establish systemwide conditions, including flow and quality in the SJR, Stanislaus River conditions, and Delta conditions; recirculation demand; available water supply for recirculation; releases from New Melones Reservoir explicitly made to meet water quality and flow objectives; and the effects of recirculation on SJR Basin operations. Water operations have been analyzed for Alternatives A1 through D for the existing and projected levels of development.

Table A2-1. Water Quality Objectives for Salinity from D-1641[1]

Location	Period	Water Year Type	Electrical Conductivity
EC objective for agricultural beneficial uses SJR at Airport Way Bridge, Vernalis	April–August	All	0.7 mmhos/cm (700 µmhos/cm)
	September–March	All	1.0 mmhos/cm (1,000 µmhos/cm)
EC objective for agricultural beneficial uses South Delta Stations, SJR at Brandt Bridge, Old River near Middle River, Old River at Tracy Road Bridge	April–August	All	0.7 mmhos/cm (700 µmhos/cm)
	September–March	All	1.0 mmhos/cm (1,000 µmhos/cm)

Notes:

1 In D-1641, Footnote 5 of Table 2 indicated the interim objective of 1.0 mmhos/cm (1,000 µmhos/cm) expired April 1, 2005, due to the lack of construction of permanent barriers or equivalent measures. The EC objective is currently undergoing review through a State Water Resources Control Board process.

WQOs are evaluated as the 30-day running average of the mean daily EC.

Key:

mmhos/cm = millimhos per centimeter
µmhos/cm = micromhos per centimeter
D-1641 = State Water Resources Control Board Decision 1641
EC = electrical conductivity
SJR = San Joaquin River

For the modeling presented in **Appendix A,** recirculation is used for two purposes: (1) to assist in meeting flow objectives at Vernalis, and (2) to assist in meeting EC objectives at Vernalis. The amount of recirculation possible for Vernalis flow purposes is calculated by comparing the need for flow at Vernalis and the availability of recirculation flow. DMC's water quality is also a consideration during periods of recirculation for flow purposes. The use of recirculation for the purpose of improving water quality at Vernalis is a function of blending SJR water with better quality DMC water. As the levels of EC in the DMC increase in relation to SJR's quality, more recirculation flow is required to improve the water quality at Vernalis.

Sensitivity analyses were performed to expand on the CalSim II modeling presented in **Appendix A**. The supplemental modeling scenarios were selected based on stakeholder comments.

A2.2 Delta-Mendota Canal Water Quality

In the original modeling, recirculation was not allowed to satisfy requirements at Vernalis under the following conditions:

- When DMC EC is higher than the water quality standard at Vernalis

- When DMC EC is within 200 micromhos per centimeter (µmhos/cm) of the Vernalis EC objective , (referred to as the 200 µmhos/cm buffer)
- When DMC EC is predicted to be higher than the EC at Vernalis, recirculation is conducted to help achieve flow objectives (referred to as the Condition 1 filter in Appendix A)

These conditions are shown in **Appendix A, Figures A-6** and **A-7**.

The sensitivity of the modeling assumptions that were used to determine water supply for recirculation—specifically, assumptions used to screen DMC water quality to prevent degradation of the SJR—were investigated in Sensitivity Analysis 1; the results of the analysis are summarized in this section.

In Sensitivity Analysis 1, the 200 µmhos/cm buffer and the Condition 1 filter were removed to determine how these assumptions influenced the frequency and quantity of recirculation and compliance with water quality and flow objectives. Although the water quality modeled at Vernalis was allowed to be degraded for the purpose of flow compliance, it was not allowed to be degraded to a degree that the Vernalis Water Quality Objective (WQO) was not achieved.

A2.2.1 Modeling Description

The modeling assumptions used in Sensitivity Analysis 1 were:

- A 0 µmhos/cm buffer (the difference between DMC EC and Vernalis EC) rather than the 200 µmhos/cm buffer used in previous modeling.
- Recirculation was used to meet flow objectives in the SJR at Vernalis even if the DMC EC was higher than the SJR EC at Vernalis.
- SJR water quality at Vernalis was not allowed to be degraded to the degree that the Vernalis WQO was not achieved as a result of recirculation.
- The maximum amount of recirculation within a month was limited to 1300 cubic feet per second (cfs), the maximum amount of recirculation from the previous analysis with the buffer. When the buffer was removed, limiting the maximum amount of recirculation was necessary to prevent large amounts of DMC water that was of only slightly better quality than the standard from being used to meet the WQO.

Alternatives B2 and D were analyzed using these criteria, and the results were compared to the results from the analysis for Alternatives B2 and D using the previous criteria.

A2.2.2 Results and Findings

A comparison of the results from the original analysis and Sensitivity Analysis 1 for Alternatives B2 and D indicate that in the Sensitivity Analysis 1, there is more frequent recirculation and increased quantity of recirculation, particularly recirculation for the purpose of improving water quality (**Table A2-2**); increased pumping, primarily at C.W. “Bill” Jones Pumping Plant (Jones) (**Table A2-3**); further decreases in CVP deliveries; further reductions in New Melones releases; increases in New Melones end-of-September storage; no increase in compliance with the flow objective (**Table A2-4**); minor increase in compliance with the EC objective for Alternative B2; and a minor decrease in compliance with the EC objective for Alternative D.

The primary advantage of the additional recirculation in the Sensitivity Analysis 1 is to further reduce reliance on New Melones releases. However, the increased recirculation has little effect on additional flow or water quality compliance at Vernalis.

Table A2-2. Sensitivity Analysis 1: Modeled Recirculation

Component	No-Action Alternative	Alternative B2		Alternative D	
		Original Analysis	**Sensitivity Analysis 1**	**Original** Analysis	**Sensitivity Analysis 1**
Average Annual Total Recirculation (TAF per year)	0	16	24	32	44
Average Annual Recirculation for Flow (TAF per year)	0	13	14	25	27
Average Annual Recirculation for Water Quality (TAF per year)	0	3	10	7	17
Years with Recirculation (out of the 82 years)	0	44	51	56	61
Periods with Recirculation (out of 1,148 periods)	0	77	105	147	184

Notes:

CalSim II, 82-year simulation. There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods.

Key

TAF = thousand acre-feet

Table A2-3. Sensitivity Analysis 1: Modeled Change in Pumping, CVP Deliveries, New Melones Releases, and End-of-September Storage

Component (Average Annual TAF per year)	No-Action Alternative	Change Relative to No-Action Alternative			
		Alternative B2		Alternative D	
		Original Analysis	Sensitivity Analysis 1	Original Analysis	Sensitivity Analysis 1
Pumping at Jones	2,423	7.9	14	8.0	15
Pumping at Banks	3,528	6.4	7.6	6.4	7.6
CVP South of Delta Deliveries	2,423	–1.5	–2.5	–18.0	–22
New Melones Releases for Vernalis Water Quality and Flow	15	–3.8	–5.9	–8.1	–11
New Melones Releases for Vernalis Flow	4.4	–1.8	–1.9	–3.3	–3.4
New Melones Releases for Vernalis Water Quality	10	–2.0	–4.0	–4.8	–8.1
End of September Storage at New Melones	1,505	5.0	9.4	9.1	21

Note:

CalSim II, 82-year simulation

Key

CVP = Central Valley Project

TAF = thousand acre-feet

Table A2-4. Sensitivity Analysis 1: Modeled Compliance with EC and Flow Objectives at Vernalis

Component	No-Action Alternative	Alternative B2		Alternative D	
		Original Analysis	Sensitivity Analysis 1	Original Analysis	Sensitivity Analysis 1
Number of periods where flow objective is not met	166	128	128	88	88
Number of periods that met the flow objective because of recirculation	—	38	38	78	78
Number of periods where the WQO for EC is not met	22	17	16	14	14
Number of periods that met the WQO for EC because of recirculation	—	5	6	8	8

Note:

CalSim II, 82-year simulation. There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods.

Key:

EC = electrical conductivity

WQO = water quality objective

A2.3 Stanislaus River Dissolved Oxygen Standard at Ripon

The original modeling for the Stanislaus River assumed a flow release from Goodwin Dam that was sufficient to satisfy the DO requirement at Ripon, as well as additional flow releases for in-stream fishery, water quality at Vernalis, flow for Vernalis, and flood control. The release at Goodwin Dam was assumed to be at least 222 cfs in June, 263 cfs in July, 267 cfs in August, and 240 cfs in September because of the DO requirement at Ripon. When recirculation is used to achieve standards at Vernalis, the water demand at New Melones for Vernalis standards decreases. However, sometimes the water supply savings in New Melones from recirculation are not realized because water must still be released to satisfy the DO requirement at Ripon.

Stakeholders requested an analysis in which the DO objective in the Stanislaus River at Ripon was removed to allow examination of potential reductions in New Melones releases and the potential for increased delivery to water contractors who receive water from New Melones. Sensitivity Analysis 2 was conducted to investigate the potential benefit of such a change, and the results are summarized in this section.

Modeling assumptions regarding New Melones releases were modified to remove the release requirement for DO at Ripon on the Stanislaus River. A minimum flow was maintained in the Stanislaus River for fish, and the minimum flow was assumed to be 175 cfs in June and September and 200 cfs in July and August. For Sensitivity Analysis 2, a new No-Action Alternative condition using the revised flow requirements was developed first, and then the recirculation condition was added to determine the effect of the alternative plans.

A2.3.1 Modeling Description

The modeling assumptions that were used in Sensitivity Analysis 2 were:

- The flow surrogate for the DO objective in the Stanislaus River is replaced with a lower flow surrogate.
- The lower flow surrogate was adjusted so that adequate flow remains in the Stanislaus River.
- The DMC water quality buffer from the original analysis is used.
- The analysis was restricted to the SJR basin upstream from Vernalis (i.e., Delta pumping was not adjusted when recirculation resulted in lower New Melones releases during balanced Delta Inflow and Outflow conditions).

Alternatives B2 and D were analyzed using the new No-Action Alternative condition.

A2.3.2 Results and Findings

A comparison of the results from the original analysis and Sensitivity Analysis 2 for the No-Action Alternative and Alternatives B2 and D indicates that in Sensitivity Analysis 2, there is more frequent recirculation, with a similar quantity of total recirculation (**Table A2-5**); similar reductions in New Melones releases but with a decreased baseline condition (**Table A2-6**); higher New Melones end-of-September storage, primarily because of a higher baseline condition; and similar compliance with EC and flow objectives (**Table A2-7**) for the sensitivity results relative to the original results.

Changes in Stanislaus River allocations are seen primarily in the new No-Action Alternative condition; releases for DO were decreased and allocation for in-stream fisheries and Stanislaus River deliveries was increased (**Table A2-8**).

Stanislaus River allocations and additional water at New Melones (as seen by the change in September storage) are the result primarily of assumptions used for the No-Action Alternative condition rather than changes in recirculation.

Table A2-5. Sensitivity Analysis 2: Modeled Recirculation

Component	Original Analysis			Sensitivity Analysis 2		
	No-Action Alternative	Alt B2	Alt D	No-Action Alterna-tive	Alt B2	Alt D
Average Annual Total Recirculation (TAF per year)	0	16	32	0	16	32
Average Annual Recirculation for Flow (TAF per year)	0	13	25	0	13	25
Average Annual Recirculation for Water Quality (TAF per year)	0	2.6	6.6	0	3.0	7.0
Years with Recirculation (out of the 82 years)	0	44	56	0	45	56
Periods with Recirculation (out of 1,148 periods)	0	77	147	0	85	156

Note:

CalSim II, 82-year simulation. There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods.

Key:

TAF = thousand acre-feet

Table A2-6. Sensitivity Analysis 2: Modeled Change in New Melones Releases and End-of-September Storage

Component (Average Annual TAF per year)	Original Analysis			Sensitivity Analysis 2		
	No-Action Alternative	Change from No-Action Alternative		No-Action Alternative	Change from No-Action Alternative	
		Alt B2	Alt D		Alt B2	Alt D
New Melones Releases for Water Quality and Flow	15	–3.8	–8.1	14	–3.8	–8.0
New Melones Releases for Vernalis Flow	4.4	–1.8	–3.3	4.2	–1.7	–3.2
New Melones Releases for Vernalis Water Quality	10	–2.0	–4.8	10	–2.1	–4.8
End of September Storage at New Melones	1,505	5.0	9.1	1,527	4.9	14

Note:

CalSim II, 82-year simulation

Key:

TAF = thousand acre-feet

Table A2-7. Sensitivity Analysis 2: Modeled Compliance with EC and Flow Objectives at Vernalis

Component	Original Analysis			Sensitivity Analysis 2		
	No-Action Alternative	Alt B2	Alt D	No-Action Alternative	Alt B2	Alt D
Number of periods where flow objective is not met	166	128	88	164	126	85
Number of periods that met the flow objective because of recirculation	—	38	78	—	38	79
Number of periods where the WQO for EC is not met	22	17	14	25	17	15
Number of periods that met the WQO for EC because of recirculation	—	5	8	—	8	10

Note:

CalSim II, 82-year simulation. There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods.

Key:

EC = electrical conductivity

WQO = water quality objective

Table A2-8. Sensitivity Analysis 2: Average Annual Allocation for the Stanislaus River (1,000 AF)

Component (Average Annual TAF per year)	Original Analysis			Sensitivity Analysis 2		
	No-Action Alternative	Change from No-Action Alternative		No-Action Alternative	Change from No-Action Alternative	
		Alt B2	Alt D		Alt B2	Alt D
Stanislaus River Deliveries	47.3	0.1	0.4	48.0	0.1	0.4
Allocation to In-stream Fishery	282	0.6	2.4	286	0.6	2.3
Releases for Vernalis Water Quality	10.2	–2.0	–4.8	10.2	–2.1	–4.8
Release for DO	14.5	1.2	1.9	7.2	1.2	2.0

Note: CalSim II, 82-year simulation

Key:

AF = acre-foot(feet)
DO = dissolved oxygen
TAF = thousand acre-feet

A2.4 South Delta Water Quality Target

Stakeholders requested an analysis in which recirculation was operated to meet EC water quality standards in the interior south Delta as well as at Vernalis. This analysis would add a new use of recirculation and could be thought of as a new alternative plan. To evaluate this alternative, a correlation analysis was conducted to compare Vernalis EC to the EC at the interior south Delta compliance sites (the sites are listed in **Table A2-1**). Water quality targets were then developed for Vernalis EC that reflect the improved quality needed to increase compliance at three south Delta locations. These water quality targets were used as a basis for an additional modeling scenario. The water quality targets and results of Sensitivity Analysis 3 are summarized below.

A2.4.1 Development of Water Quality Targets

Existing data were used to compare the 30-day running average of the mean daily EC measured at Vernalis to the 30-day running average of the mean daily EC measured at the three south Delta compliance sites. When a linear correlation was determined to exist, the target EC for Vernalis was determined, which correlated with the EC that consistently met the WQO at the south Delta compliance station.

The DWR provided mean daily data for Water Years 2000 to 2004 for the SJR at Vernalis, the SJR at Brandt Bridge, the Old River near Middle River, and the Old River at Tracy Road Bridge (Amerti 2008). Each data set was divided into periods when the Vernalis standard was 1,000 µmhos/cm or 700 µmhos/cm.

Figures A2-1a and **A2-1b** show the 30-day running average EC for a south Delta compliance site relative to Vernalis for each period, the water quality objective that applies during that period, and the 1:1 correlation line.

Old River at Tracy Road Bridge A poor correlation was found for EC measured at Old River at Tracy Road Bridge relative to EC measured at Vernalis from April through August and from September through March. (**Figures A2-1a** and **A2-1b**, respectively). Water quality is highly influenced by pumping, fish barriers, and agriculture barriers at this site.

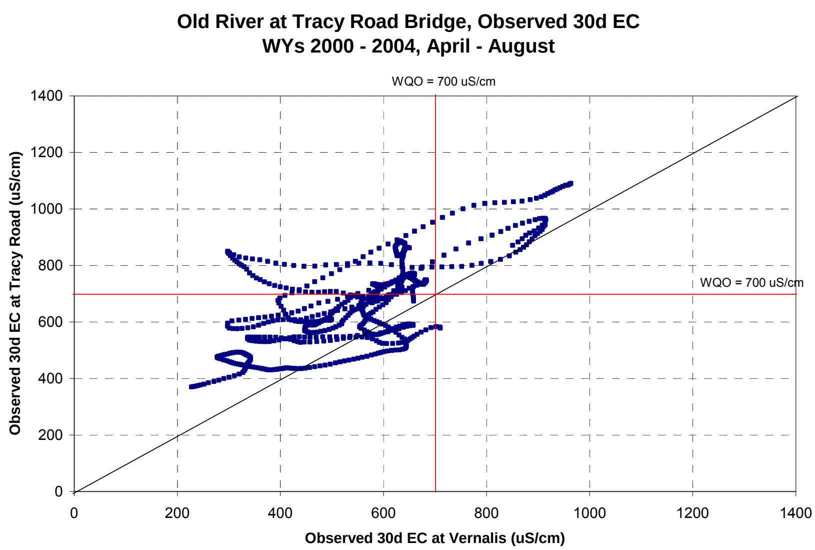

Figure A2-1a. Thirty-day Running Average EC Measured at Old River at Tracy Road Bridge and Vernalis; April through August, Water Years 2000–2004.

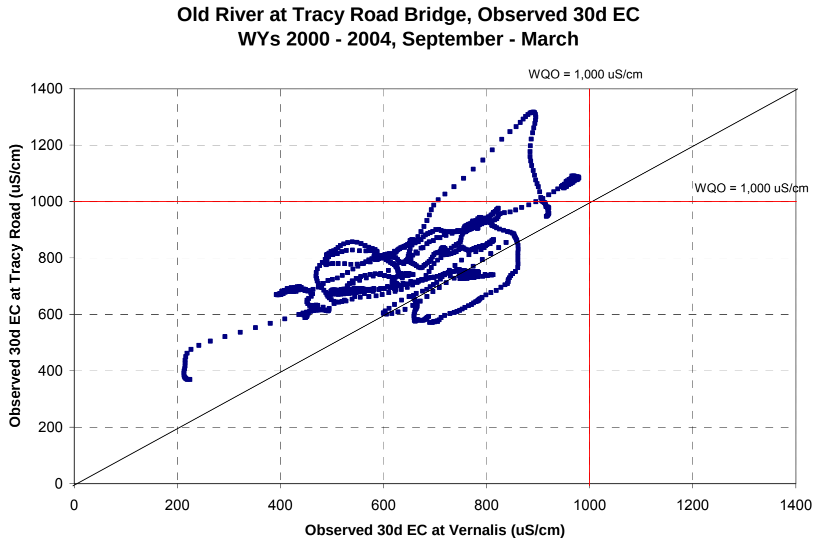

Figure A2-1b. Thirty-day Running Average EC Measured at Old River at Tracy Road Bridge and Vernalis; September through March, Water Years 2000–2004.

San Joaquin River at Brandt Bridge A linear correlation was found between EC measured at SJR at Brandt Bridge and EC measured at Vernalis for both periods (**Figures A2-2a** and **A2-2b**). When the 30-day average EC at Vernalis was below 550 µmhos/cm, the EC at SJR at Brandt Bridge consistently met the 700 µmhos/cm WQO from April through August (**Figure A2-2a**). Similarly, when the 30-day average EC at Vernalis was below 900 µmhos/cm, the EC at SJR at Brandt Bridge was consistently below the 1,000 µmhos/cm WQO from September through March **Figure A2-2b**).

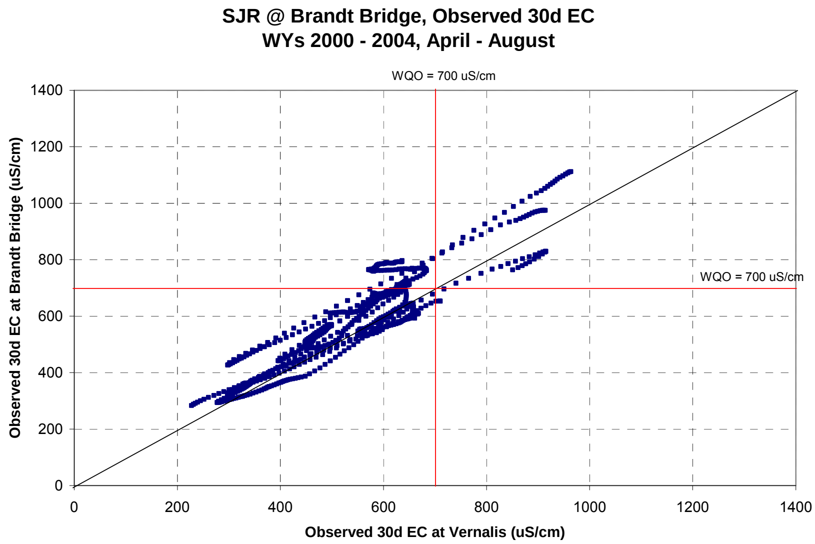

Figure A2-2a. Thirty-day Running Average EC Measured at San Joaquin River at Brandt Bridge and Vernalis; April through August, Water Years 2000–2004.

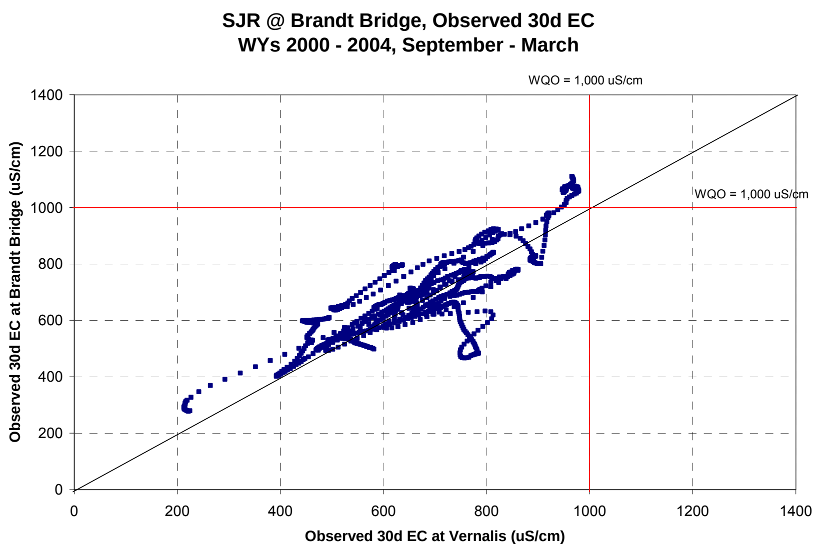

Figure A2-2b. Thirty-day Running Average EC Measured at San Joaquin River at Brandt Bridge and Vernalis; September through March, Water Years 2000–2004.

Old River at Middle River. The EC measured at Old River at Middle River and the EC measured at Vernalis also followed a linear correlation for both periods (**Figure A2-3a** and **A2-3b**). Similar to the SJR at Brandt Bridge, when the 30-day average EC was below 550 µmhos/cm at Vernalis, the EC at Old River at Middle River consistently met the 700 µmhos/cm WQO from April through August (**Figure A2-3a**). In slight contrast to the SJR at Brandt Bridge, when the 30-day average EC at Vernalis was below 800 μmhos/cm, the EC at Old River at Middle River was consistently below the 1,000 μmhos/cm WQO from September through March (**Figure A2-3b**).

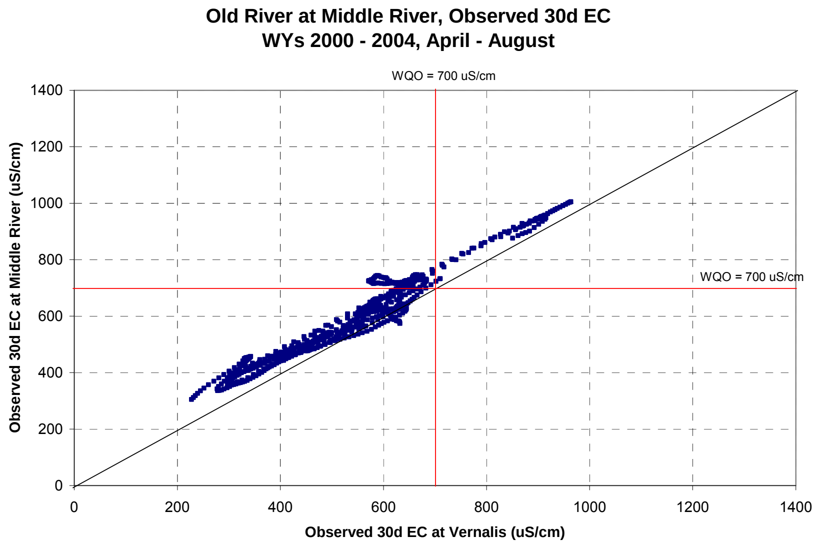

Figure A2-3a. Thirty-day Running Average EC Measured at Old River at Middle River and Vernalis; April through August, Water Years 2000–2004.

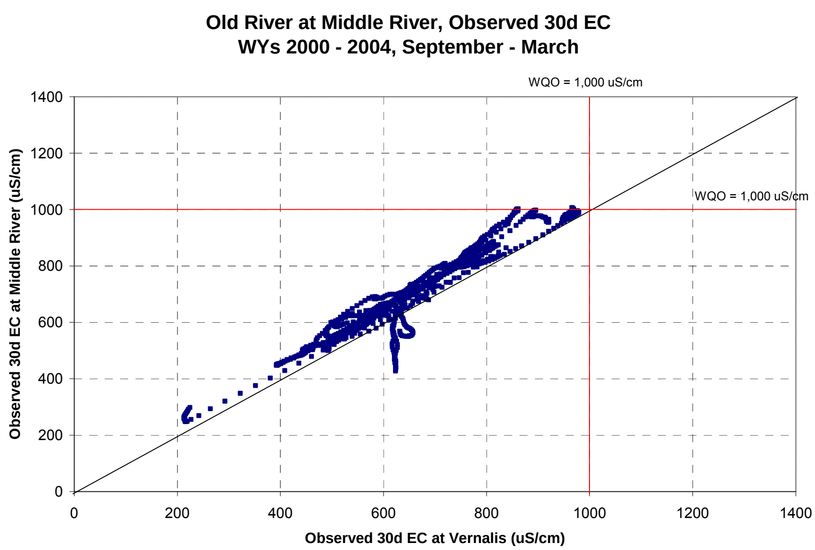

Figure A2-3b. Thirty-day Running Average EC Measured at Old River at Middle River and Vernalis; September through March, Water Years 2000–2004.

The results of the correlation analysis have shown that there is a relationship between EC measured at both SJR at Brandt Bridge and Old River at Middle River and the EC measured at Vernalis. The relationship between the EC at Old River at Tracy Road Bridge and EC at Vernalis is less clear. However, using the relationship at the other two sites, when water recirculation demands are modeled to meet the EC values at Vernalis of 550 µmhos/cm from April through August, and 850 µmhos/cm from September through March, the data suggest that WQO would consistently be met at SJR at Brandt Bridge and Old River at Middle River.

A2.4.2 Modeling Description

The modeling assumptions used in Sensitivity Analysis 3 were:

- Vernalis water quality targets of 550 and 850 µmhos/cm, which reflect increased compliance at the SJR at Brandt Bridge and the Old River at Middle River.
- The DMC water quality buffer used in the original analysis was also used in the sensitivity analysis.
- New Melones operations are affected when recirculation is used to meet Vernalis requirements.
- New Melones was not reoperated to meet the water quality surrogates.

Alternatives B2 and D were analyzed, and the results were compared to the results from the original analysis from Alternatives B2 and D.

A2.4.3 Results and Findings

A comparison of the results from the original analysis and Sensitivity Analysis 3 for the No-Action Alternative condition and for Alternatives B2 and D indicates that in Sensitivity Analysis 3, there is more frequent recirculation and an increase in the quantity of total recirculation (**Table A2-9**); a decrease in the quantity of recirculation for flow but an increase in the quantity of recirculation for water quality; increased pumping at Jones and Harvey O. Banks Pumping Plant (Banks) (**Table A2-10**); a further decrease in CVP deliveries for Alternative D (but not for Alternative B2); not as many reductions in New Melones releases; not as many increases in New Melones end-of-September storage for Alternative B2 (but not for Alternative D); and similar compliance with EC and flow objectives (not shown).

The EC target values for Vernalis were not met in the No-Action Alternative condition approximately 25% of the time (**Table A2-11**). Target values were met as a result of recirculation relatively infrequently. Only 1 to 9% of the periods during which the EC target was not met in the No-Action Alternative condition were able to be met by the alternative plans.

EC target values for Vernalis might have been met more frequently if restraints on recirculation demand, specifically, the 200 µmhos/cm buffer, were removed in a manner similar to Sensitivity Analysis 1.

Table A2-9. Sensitivity Analysis 3: Modeled Recirculation

Component	No-Action Alternative	Alternative B2		Alternative D	
		Original Analysis	Sensitivity Analysis 3	Original Analysis	Sensitivity Analysis 3
Average Annual Total Recirculation (TAF per year)	0	16	19	32	53
Average Annual Recirculation for Flow (TAF per year)	0	13	11	25	20
Average Annual Recirculation for Water Quality (TAF per year)	0	2.6	8.0	6.6	32
Years with Recirculation (out of the 82 years)	0	44	46	56	58
Periods with Recirculation (out of 1,148 periods)	0	77	78	147	168

Note:

CalSim II, 82-year simulation. There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods.

Key:

TAF = thousand acre-feet

Table A2-10. Sensitivity Analysis 3: Modeled Change in Pumping, CVP Deliveries, New Melones Releases, and End-of-September Storage

Component (Average Annual TAF per year)	No-Action Alternative	Change Relative to No-Action Alternative			
		Alternative B2		Alternative D	
		Original Analysis	Sensitivity Analysis 3	Original Analysis	Sensitivity Analysis 3
Pumping at Jones	2,423	7.9	9.9	8.0	10
Pumping at Banks	3,528	6.4	7.8	6.4	7.8
CVP South of Delta Deliveries	2,423	–1.5	–0.9	–18	–35
New Melones Releases for Vernalis Water Quality and Flow	15	–3.8	–2.1	–8.1	–4.5
New Melones for Vernalis Flow	4.4	–1.8	–1.8	–3.3	–3.2
New Melones Releases for Vernalis Water Quality	10	–2.0	–0.3	–4.8	–1.2
End of September Storage at New Melones	1,505	5.0	2.6	9.1	10

Note:

CalSim II, 82-year simulation.

Key:

CVP = Central Valley Project;
TAF = thousand acre-feet

Table A2-11. Sensitivity Analysis 3: Ability to Meet Modeled Target Values for EC

Component	No-Action Alternative	Alternative B2	Alternative D
Number of periods when sensitivity target is not met	290	286	265
Number of periods when sensitivity target is met by recirculation	—	4	25

Note:

CalSim II, 82-year simulation. There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods.

The target value for EC is 550 µmhos/cm during April to August, and 850 µmhos/cm during September to March

Key:

µmhos/cm = micromhos per centimeter
EC = electrical conductivity

A2.5 Minimum Flow during the Irrigation Season

Stakeholders were interested in how recirculation could be used during the irrigation season to maintain a minimum water level at agricultural intakes just downstream of Vernalis. This analysis, Sensitivity Analysis 4, introduces a new use for recirculation and can be thought of as a new alternative plan.

Sensitivity Analysis 4 models recirculation so that a minimum flow of 1,500 cfs is maintained in the SJR at Vernalis from April through August. The maximum recirculation during these months is assumed to be 300 cfs, which is similar to pilot project recirculation flows. Results of Sensitivity Analysis 4 are summarized in this section.

A2.5.1 Modeling Description

The modeling assumptions used in Sensitivity Analysis 4 were as follows:

- If SJR at Vernalis is modeled to be below 1,500 cfs, then recirculation is used to maintain the flow at 1,500 cfs.
- Recirculation is limited to 300 cfs.
- Recirculation is allowed from April through August.
- Recirculation occurs supplemental to New Melones releases.
- No recirculation was performed for the purpose of Vernalis EC or flow standards.

As in Sensitivity Analysis 1, Sensitivity Analysis 4 assumed a 0 µmhos/cm buffer (the difference between DMC EC and Vernalis EC) rather than the 200 µmhos/cm buffer used in the original modeling. Also, in similar fashion to Sensitivity Analysis 1, recirculation was used to meet the 1,500 cfs flow target in the SJR at Vernalis even if DMC EC was higher than Vernalis EC. The Vernalis EC objectives were not violated as a result of recirculation for the flow target.

A2.5.2 Results and Findings

In the original analysis, recirculation was for compliance purposes, whereas recirculation Sensitivity Analysis 4 was to maintain a minimum flow in the SJR at Vernalis from April though August. The results of Sensitivity Analysis 4 are presented along with the results of original analysis for Alternatives B2 and D for perspective. It should be noted that the two sensitivity analyses are not comparable inasmuch as the goals for use of recirculation are different.

A comparison of the results from the original analysis and Sensitivity Analysis 4 for Alternatives B2 and D indicates that in Sensitivity Analysis 4, there are a similar number of periods with recirculation but fewer years with recirculation (**Table A2-12**); a decrease in total recirculation, potentially because of the 300 cfs restriction on recirculation; an increase in pumping at Jones and a decrease in pumping at Banks (**Table A2-13**); and fewer reductions in CVP deliveries for the sensitivity results relative to the original results.

The Sensitivity Analysis 4 results had little change in New Melones releases relative to the No-Action Alternative condition (not shown) because recirculation was modeled to occur supplemental to New Melones releases. The

Sensitivity Analysis 4 results also showed less frequent compliance with the Vernalis EC and flow objectives (not shown) relative to the original analysis results because recirculation was not modeled for compliance purposes in the Sensitivity Analysis 4.

Flow at Vernalis was below the 1,500 cfs flow target during 26% of the April through August model periods in the No-Action Alternative condition (**Table A2-14**). As a result of recirculation, this flow was reduced to approximately 22% and 12% of the April through August model periods for Alternatives B2 and D, respectively.

The South Delta Water Authority has proposed a flow target of 1,000 cfs at Vernalis as sufficient to overcome low water level. The results of Sensitivity Analysis 4 were examined to determine how often recirculation is able to meet this flow rate. Flow at Vernalis was below 1,000 cfs during 6% of the April through August periods in the No-Action Alternative condition (**Table A2-14**). Due to recirculation, this flow was reduced to approximately 3% and 1% of the April through August periods for Alternatives B2 and D, respectively.

Thus, Sensitivity Analysis 4 has shown that recirculation can be a relatively successful tool at increasing flow to maintain the flow target and presumably the water levels at agricultural intakes just downstream of Vernalis during the irrigation season.

Table A2-12. Sensitivity Analysis 4: Modeled Recirculation

Component	No-Action Alternative	Alternative B2		Alternative D	
		Original Analysis	Sensitivity Analysis 4	Original Analysis	Sensitivity Analysis 4
Average Annual Total Recirculation (TAF per year)	0	16	10	32	21
Average Annual Recirculation for Flow[1] (TAF per year)	0	13	10	25	21
Average Annual Recirculation for Water Quality (TAF per year)	0	2.6	0	6.6	0
Years with Recirculation (out of the 82 years)	0	44	29	56	43
Periods with Recirculation (out of 1,148 periods)	0	77	73	147	150

Notes:

[1] Recirculation for flow in the original CalSim II analysis is for compliance with the Vernalis flow objective. Recirculation for flow in the sensitivity analysis is to maintain a minimum flow in the SJR at Vernalis during April though August.

CalSim II, 82-year simulation. There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods.

Key:

SJR – San Joaquin River

TAF = thousand acre-feet

Table A2-13. Sensitivity Analysis 4: Modeled Change in Pumping and CVP Deliveries

Component (Average Annual TAF per year)	No-Action Alternative	Change Relative to No-Action Alternative			
		Alternative B2		Alternative D	
		Original Analysis	Sensitivity Analysis 4	Original Analysis	Sensitivity Analysis 4
Pumping at Jones	2,423	7.9	8.9	8.0	8.9
Pumping at Banks	3,528	6.4	0.9	6.4	0.9
CVP South of Delta Deliveries	2,423	–1.5	0	–18	–11

Note:

CalSim II, 82-year simulation.

Key:

CVP = Central Valley Project

TAF = thousand acre-feet

Table A2-14. Sensitivity Analysis 4: Ability to Meet Flow Target

Component	No-Action Alternative	Alternative B2	Alternative D
Number of periods during the entire year flow is less than 1,500 cfs	189	162	108
Number of periods flow is less than 1,500 cfs during April through August	151	124	70
Number of periods during the year when 1,500 cfs is met due to recirculation	—	27	81
Number of periods flow is less than 1,000 cfs during April through August	32	18	7
Number of periods during the year when 1,000 cfs is met due to recirculation	—	14	25

Notes:

CalSim II, 82-year simulation.

The flow target for the sensitivity analysis is 1,500 cfs.

Recirculation is modeled to occur during April through August periods only.

There are 14 modeling periods per year, which include June through March and the April and May pulse and non-pulse periods. The total number of modeling periods is 1,148. The total number of April through August periods is 574.

Key:

cfs = cubic foot(feet) per second

A2.6 Recommendations

The following recommendations were developed, based on the supplemental modeling and the results of four sensitivity analyses, for incorporation into the Feasibility Study, and will be evaluated in the Environmental Impact Study/Environmental Impact Review and Feasibility Report.

- Revise the assumptions used in the modeling for the alternative plans that are carried forward to eliminate use of the water quality buffer, consistent with the analysis presented in Sensitivity Analysis 1.

- Add an alternative plan that uses recirculation as a tool to meet south Delta water quality objectives into the Feasibility Study. This alternative plan would be similar to Sensitivity Analysis 3. To be consistent with the other alternative plans, the CalSim II modeling should be adjusted so that the water quality buffer is not used.
- Add an alternative plan that contains a minimum flow objective at Vernalis during irrigation season.

A2.7 References

Ameri, Khalid. 2008. South Delta Water Quality Data. Written communication from Khalid Ameri, DWR to URS with attached file, 10-09-07 South Delta EC.xls. April 10.

SWRCB (State Water Resources Control Board). 2000. Water Rights Decision 1641 (Revised). March 15.

———. 2006. Water Quality Control Plan for the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary. December 13.