Delta Wetlands Project
In-Delta Storage Model

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Contents

Page

List of Tables and Figures

Acronyms and Abbreviations

Banks	SWP Harvey O. Banks Pumping Plant
BO	Biological Opinion
CA	California Aqueduct
CACMP	Common Assumptions Common Model Package
CALFED	CALFED Bay-Delta Program
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
D-1485	State Water Resources Control Board water right Decision 1485
D-1641	State Water Resources Control Board water right Decision 1641
Delta	Sacramento–San Joaquin River Delta
Delta Wetlands	Delta Wetlands Properties
DWR	California Department of Water Resources
E/I	export/inflow
EIR	Environmental Impact Report
FMWT	Fall Midwater Fish Trawl
FNA	Future No Action
IDSM	In-Delta Storage Model
Joint-Point	Joint Point of Diversion operations for the CVP and SWP
Jones	CVP Tracy C.W. “Bill” Jones Pumping Plant
LOD	Level of Development
MBK	MBK Engineers, Inc.
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Units
OCAP	Operation Criteria and Plan
OMR	Old and Middle River
Project	Delta Wetlands Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Semitropic	Semitropic Water Storage District
State Water Board	State Water Resources Control Board
SWP	State Water Project
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan
WQCP	Water Quality Control Plan

Delta Wetlands Project
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Introduction

Delta Wetlands Properties (Delta Wetlands) proposes to develop two island reservoirs in the Sacramento–San Joaquin River Delta (Delta) as part of the Delta Wetlands Project (Project). Bacon Island and Webb Tract are the designated sites for water storage. The intended operation is to divert water onto the islands during periods of Delta surplus (i.e., State Water Project [SWP] and Central Valley Project [CVP] pumping at permitted capacity with more than required Delta outflow) and release water for south-of-Delta export or increased Delta outflow for improved water quality or habitat conditions.

Delta Wetlands has identified specific places of use for the project and has submitted petitions with the State Water Resources Control Board (State Water Board) to add these proposed places of use to the project's applications. Delta Wetlands needed to explore the benefits of integrating the in-Delta water storage facilities with groundwater banks located in the San Joaquin Valley and southern California and with designated places of use for the delivered water. In previous studies, there was no modeled linkage between the project's water supply delivery at south Delta CVP or SWP pumping plants and south-of-Delta demands. The Reservoir Islands were intended to hold water for less than a year, and some of the water the project diverted to storage was during wet and above normal runoff years. South-of-Delta groundwater banks would provide the means to store project water for dry year supply.

To address designated place of use deliveries, the recent OMR flow criteria, groundwater bank integration, and the many issues of water operations in the Delta, MBK Engineers, Inc. (MBK) developed the In-Delta Storage Model (IDSM) to evaluate monthly project operations under various regulatory requirements and rules of operation. The model provides the output necessary to perform environmental assessments for the SEIS and provides flexibility to compare multiple alternatives for project operating rules. This document provides a description of the IDSM logic and the necessary CalSim II results that are used as the baseline conditions for exploring project operations. The document also discusses the IDSM calculations and user input and output interface (i.e., tables and graphs).

General Description

The IDSM was developed to simulate In-Delta Storage operations at a monthly time-step based on water years 1922–2003 hydrologic conditions as simulated by CALSIM II. The IDSM model is a Microsoft Excel spreadsheet. Each month of a simulation, IDSM simulates the diversion of water to storage or the discharge of water from the island reservoirs to export or increase Delta outflow, based on several Delta flow conditions including available Delta surplus (within the export/inflow [E/I] ratio), available island storage capacity, Delta water quality, available export capacity, available south-of-Delta conveyance capacity, and south-of-Delta water demand. IDSM tracks Webb and Bacon Island storages, island diversions and discharges, Delta outflow, X2, Rock Slough salinity, QWEST, flow in Old and Middle Rivers, Delta exports, groundwater bank recharge and pumping, groundwater bank storage, and south-of-Delta delivery of project water. IDSM output is provided in monthly and annual plots and tables.

The control worksheet provides the ability to easily modify project design, regulations, and operations to evaluate different project alternatives. For instance, the user can choose different CalSim baselines to reflect changed Delta regulations; specify island diversion and discharge constraints; specify the island reservoirs and groundwater banks storage and flow capacities; identify the place of use demand parameters; and specify discharge operations for water quality improvement (increased outflow).

The project is simulated without interference to the baseline CVP and SWP Delta operations. IDSM calculations change Delta outflow, Delta exports, and south-of-Delta conveyance and deliveries from the selected CalSim baseline without changing the baseline CVP and SWP operations. Upstream reservoir operations and Delta inflow are left unchanged, and CVP and SWP Delta exports, as simulated in the CalSim baseline, are not changed. The IDSM-calculated diversions to the project are solely from Delta surplus—water that is unneeded for in-basin use and that no other diverters in the Sacramento-San Joaquin basins have the capacity or right to take. South-of-Delta exports of Project water are made using CVP Tracy C.W. “Bill” Jones Pumping Plant (Jones) and SWP Harvey O. Banks Pumping Plant (Banks) capacity that was unused by the SWP, CVP, and third party transfers to CVP and SWP contractors as represented in the CalSim baseline.

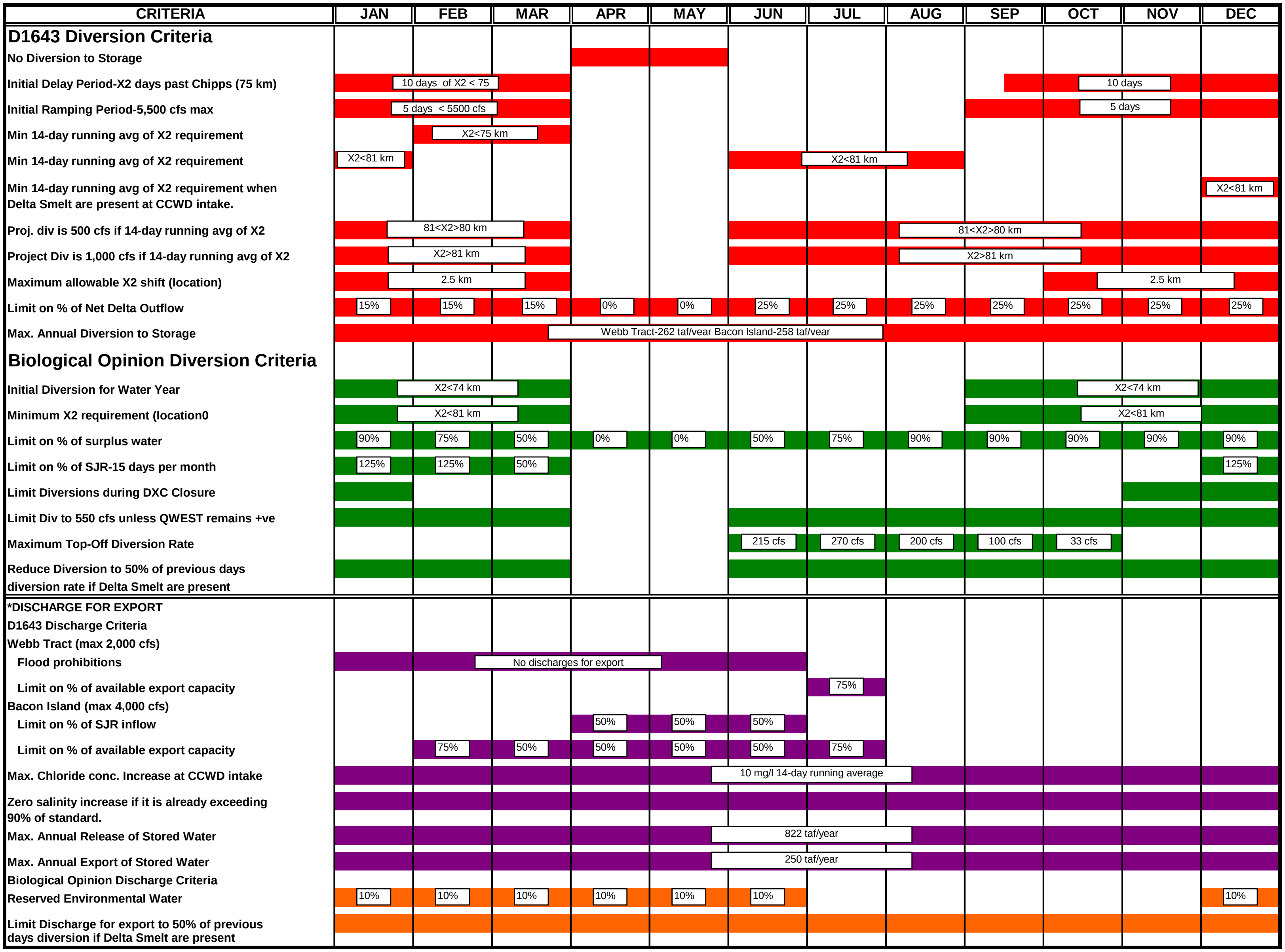


Figure D-1. D-1643 and Biological Opinion Constraints on Project Operations

CalSim Baselines

A standardized package of models have been developed for the California Department of Water Resources (DWR) and the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) for use in feasibility analyses and CEQA and National Environmental Policy Act (NEPA) analyses of the CALFED Bay-Delta Program (CALFED) surface storage projects. These projects include expanded Lake Shasta, expanded Los Vaqueros Reservoir, Sites Reservoir, Upper San Joaquin River storage, and In-Delta Storage (DWR's proposed variation of the project). The suite of tools include CalSim II (water supply planning), DSM2 (Delta hydrodynamics and water quality), LCPSIM and CVPM (water supply economics), LTGEN/SWP Power (power generation/consumption), and others.

Reclamation and DWR are currently using Common Assumptions Common Model Package (CACMP) Version 9B for the CEQA/NEPA analysis of several water resource projects currently in the planning stages.

Description of CalSim II Assumption

CalSim II is a planning model designed to simulate the operations of the CVP and SWP reservoirs and water delivery system for current and future facilities, flood control operating criteria, water delivery policies, instream flow and Delta outflow requirements. CalSim II is a widely accepted tool for modeling the CVP and SWP and is the primary system-wide hydrologic model being used by DWR and Reclamation to conduct planning and water supply analyses of potential projects using a monthly time-step.

CalSim II is a monthly simulation with optimization model. The model simulates operations by solving a mixed-integer linear program to maximize an objective function (i.e., meet constraints and flow objectives) for each month of the simulation. CalSim II was developed to simulate the operation of the CVP and SWP for defined facilities, hydrological conditions and a set of regulatory requirements. The model simulates the operations of the CVP and SWP using 82 years of historical hydrology from water year 1922–2003.

CalSim II is set up to simulate and account for the effects of various regulatory requirements through a multi-step algorithm. CalSim II model "steps" simulate operations of the system under select regulatory requirements and agreements. The model is run for one year for each step and end of year conditions from the final step become input to start the next year for the first step. The Version 9B model contains five steps. The only purpose for the steps is to calculate incremental effects of several sets of constraints and objectives. Only the results from the final step are used for the next year's simulation.

1. **State Water Board water right Decision 1641 (D-1641)**—D-1641 was issued in 1999, revised in 2000, and specifies how the 1995 Water Quality

Control Plan (WQCP) is to be implemented. D-1641 provides both flow and water quality requirements at key locations in the Delta. D-1641 is the current basis for most regulatory requirements governing the Delta which in turn affects how the SWP and CVP operate upstream reservoirs and Delta export pumps. The Vernalis Adaptive Management Plan (VAMP) flows and export reductions are simulated in this step.

2. **State Water Board water right Decision 1485 (D-1485)**—Section b(2) of the Central Valley Project Improvement Act (CVPIA) dedicated 800,000 acre-feet of water to be made available for environmental purposes. Non-discretionary b(2) water, is the difference in water costs (either additional releases from upstream reservoirs or water available but not exported from the Delta) to meet the more stringent requirements of D-1641 instead of the previous requirements of D-1485.
3. **CVPIA b(2)**—Discretionary b(2) water may include additional winter releases from upstream reservoirs or export reductions in the weeks before and after the reductions that occur in the spring as part of the VAMP.
4. **Conveyance**—The conveyance and transfer steps of CalSim II are primarily used to simulate specific secondary aspects of project operations. The conveyance step simulates Stage 1 water transfers associated with the Phase 8 Settlement and the Lower Yuba River Accord, which are included in the allocations for the CVP and SWP and include transfers.
5. **Transfer**—The CalSim II transfer step layers Stage 2 water transfers onto the operations and simulates Joint Point of Diversion operations for the CVP and SWP (Joint-Point). Stage 2 transfers are private party transfers moved through the Delta as a last priority for export capacity. Joint-Point operations increase the flexibility of CVP and SWP exports by allowing both projects to utilize available export capacity at the other project’s pumps. The transfer step also includes the wheeling of CVP water for Cross Valley Canal contractors at the Banks pumping plant. The project could be considered as a third-party transfer in this step of the CALSIM model, but is not included in the common assumptions simulations (V9B).

Level of Development

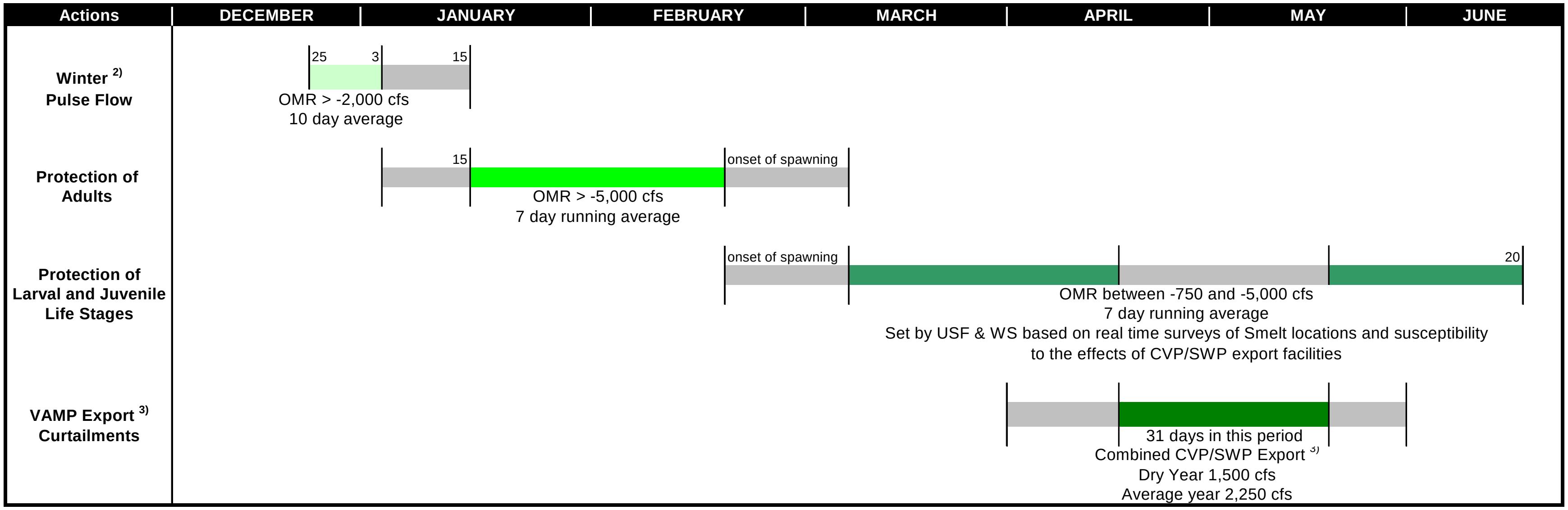
An existing Level of Development (LOD) study assumes that current land use, facilities and operational objectives are in place for each year of simulation (water year 1922–2003). The results are a depiction of the current water system operations which provides a basis for comparison of project effects for existing conditions (NEPA analysis). A Future LOD study is used to explore how the water system may perform under an assumed future set of physical and institutional circumstances. This future setting is developed by assuming year 2030 land use, facilities and operational objectives and is used for the Future No-Action (FNA) conditions (NEPA analysis). The Project was simulated with IDSM using the CALSIM existing level of development (2005) results.

Old and Middle River Flow Criteria

Regulations and criteria governing operation of the Delta and upstream facilities sometimes change to reflect new concerns or protections. In December 2007, there was an interim court order (Wanger Decision-remedy actions) that established a set of Old and Middle River flow criteria to protect Delta smelt. The remedy actions are outlined in Table D-1. These remedy actions could significantly reduce SWP and CVP Delta exports from January to June since pumping at that time would be restricted to satisfy the maximum allowed reverse flow criteria. As a consequence, the OMR criteria could boost SWP and CVP reliance on summer exports to make up for lost winter and spring exports. Interim OMR flow criteria were simulated as an optional regulatory condition in CACMP V9B CalSim II.

Reclamation is currently developing its revised Operation Criteria and Plan (OCAP) that will include operating rules protecting Delta smelt, salmon, and other fish, as specified by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The December 2008 USFWS Biological Opinion (BO) on OCAP for Delta smelt and the June 2009 NMFS BO on OCAP for Chinook salmon, steelhead, and green sturgeon supplanted Wanger's interim order. While there are similarities between the interim decision and the BO requirements, there are also some significant differences including a Fall Delta outflow requirement. To date, there is no CalSim simulation of the recent OCAP BOs in the Common Assumptions package.

Table D-1. 2007 Delta Smelt Interim Remedy Order1



1) This table only shows the parts of the December 14, 2007 Order that affect water supplies.

2) Triggered only if turbidity exceeds 12 NTU at any of 3 specific Delta Stations. Action lasts for 10 days once triggered.

3) The Vernalis Adaptive Management Plan (VAMP) includes San Joaquin River flow enhancements and curtailed CVP/SWP pumping.

As shown in Table D-1, application of the interim OMR criteria is dependent on turbidity in December and January, and the onset of smelt spawning along with the opinion of USFWS smelt working group from February to June. None of these adaptive management conditions can be simulated in CalSim II. Therefore, to formulate a CalSim baseline with OMR flow criteria, it was assumed that turbidity exceeds 12 Nephelometric Turbidity Units (NTU) at the sampling stations on December 25th of every year. Also, it was assumed that smelt spawning commences on February 19th, and that the USFWS imposes the strictest OMR criteria allowed from this day to the 20th of June. From a water supply perspective, both are conservative (i.e., minimum exports) assumptions. Table D-2 provides the resulting OMR criteria applied in the CalSim modeling. The CVP and SWP south-of-Delta delivery allocation procedures were modified to account for resulting reductions in available Delta export capacity.

Table D-2. Assumed Old and Middle River Flow Criteria in CalSim

Date	CalSim OMR Criteria (cfs)
December 25–January 3	-2,000
January 4–February 18	-5,000
February 19–April 14	-750
April 15–May 15	Exports controlled by VAMP criteria
May 16–June 20th	-750

Notes: cfs = cubic feet per second; OMR = Old and Middle River; VAMP = Vernalis Adaptive Management Plan

Two CalSim baselines have been included in IDSM. The first is a CACMP Version 9B CalSim II simulation at an existing level of development with no OMR flow criteria. In IDSM, this baseline is referred to as V9B. The second baseline is a CACMP Version 9B CalSim II simulation at existing level of development with interim OMR flow criteria as specified in Table D-2. This baseline is referred to as V9BOMR in IDSM.

IDSM Simulation Calculations

In IDSM, all monthly calculations are made in the worksheet titled Model. A full listing of the columns and equations contained in the Model worksheet is provided in the Attachment. The purpose of this section is to provide a qualitative discussion of the IDSM logic and assumptions for operating the island reservoirs.

Each month there are three possible modes of operation for Bacon Island and Webb Tract: (1) divert to storage, (2) discharge for export, or increased Delta outflow (improved water quality), and (3) do nothing. Operations are simulated based on hydrologic conditions from the CalSim baseline, and project constraints and operations rules specified by the IDSM user. IDSM first looks for an opportunity to divert water onto Bacon Island or Webb Tract. Available surplus Delta outflow is calculated from the CalSim baseline hydrology and consideration of the export to inflow limits found in D-1641. The project diversions are assumed to satisfy the D-1641 E/I limits. All user specified constraints on island diversions are calculated, and the individual island maximum allowed diversions are taken as the controlling bounds (i.e., minimum of the individual constraints) for each Reservoir Island.

IDSM next calculates the project discharges from both Reservoir Islands for export. Project discharges for export can go directly to designated places of use or be used to recharge groundwater banks; direct delivery takes priority over recharge. IDSM quantifies contractor unmet demands from the CalSim baseline and recharge capacity from user input. Contractor unmet demands may be further limited by place of use restrictions (i.e., percent of CVP and SWP unmet demands). The model calculates available permitted export capacity and California Aqueduct (CA) physical conveyance capacity from the CalSim baseline. IDSM calculates a maximum potential south-of-Delta export of project water for the given month. Next, IDSM quantifies user defined bounds on island discharge, including whether project exports are limited by the D-1641 E/I ratio.

Once export opportunities are taken, prospects for increasing Delta outflow to improve water quality or estuarine habitat benefits are calculated. Project discharges for Delta outflow are specified by the IDSM user and are based on the Delta outflow and salinity conditions in the CalSim baseline. Discharge for outflow is limited to the remaining specified discharge capacity or water on the island. Available capacity and storage may already be reduced due to project discharges for export.

IDSM operates on a month-by-month basis with no attempt to optimize operations for a particular objective. For example, if the model can provide a Delta benefit in a given month, the model will discharge to provide this benefit without consideration of potential discharge for export opportunities in future months. The IDSM user must specify Delta outflow rules carefully to achieve a mix of water supply, water quality, and habitat benefits.

Some simplifications of project operations were necessary due to the monthly time-step of CalSim and IDSM. For example, a single island can’t divert and discharge in the same month. If IDSM determines a given month is a diversion opportunity for Webb Tract, the discharge for Webb Tract will be set to zero. In real-time operations, this may not always be the case. It is reasonable to expect that the project could divert during high Delta inflows in the first half of the month and discharge for export or Delta outflow benefits during the second half of the month.

IDSM may determine that one island has a diversion opportunity and the other has a discharge for export opportunity if the islands have different specified monthly operating criteria. For instance, consider the following rules for project operations when OMR flow criteria controls south-of-Delta exports:

1. Webb Tract is allowed to divert Delta surplus
2. Webb Tract is not allowed to discharge for export

3. Bacon Island is not allowed to divert Delta surplus
4. Bacon Island is allowed to discharge for export

The reasoning behind these rules might be that Webb Tract diversions won't negatively impact (i.e., increase) reverse OMR flow whereas Webb Tract discharge for export would increase the measured reverse OMR flow. Bacon Island diversions would draw water (and fish) up the Old and Middle River channels, but Bacon Island discharge for export would not change the transport of fish towards the export pumps. Under these rules, when OMR criteria limit exports, and there is surplus Delta outflow, there are occasional diversion opportunities on Webb Tract in the same month that IDSM simulates a discharge for export opportunity for Bacon Island. Without the OMR criteria, the IDSM model does not simulate discharge for export when surplus Delta outflow is available, because project diversions are generally more limiting, and CVP and SWP exports would already be at the maximum permitted level.

Filling of Bacon Island is given priority over filling Webb Tract. This priority is based on the discharge constraints placed on Webb Tract by D-1643. As specified in D-1643 Webb Tract can't discharge for export from February to June. No such restrictions are placed on Bacon Island by D-1643. So the idea is to fill Bacon Island first because there is greater opportunity for early discharge for export.

IDSM also has operating rules for the groundwater banks. As stated previously, exported project water will first go to SWP/CVP contractor unmet demands within the identified place of use. Once that monthly demand is satisfied, the remainder of project exports can go to recharge groundwater banks. The user specifies total bank capacity and maximum recharge rates. IDSM tracks storage in the groundwater banks. If SWP Table A allocations fall below a certain user specified threshold, water is pumped from the groundwater banks to identified SWP contractor unmet demand. In months where there is both island storage and groundwater available, island discharge for export takes priority over groundwater pumping for meeting demand within the identified place of use.

IDSM Spreadsheet Layout

IDSM is organized in worksheets. The worksheets are grouped by function such as user input, simulation calculations, simulation results, and input/output processing. The first worksheet of the model, Documentation, lists each worksheet and its purpose as shown in Figure D-2. Most IDSM users will focus only on worksheets containing user input, model calculations, and analysis of results.

Control

IDSM user input is organized in the Control worksheet. At the top of the Control worksheet, as shown in Figure D-3, a color coded user input key is provided along with a summary results table. Values that can be changed by the user are color coded yellow, pink and green. Yellow cells are parameters of particular interest to these studies such as the Old and Middle River Flow Criteria, place of use, and groundwater banks among others. Pink cells are used to implement rules associated with D-1643 and associated biological opinions and protest dismissal agreements. Green cells cover some of the physical constraints such as island reservoir capacity, storage area-curves, and monthly evaporation rates. After making changes, the user runs the model by pressing F9 (calculation).

Group	Worksheet	Description
User Input	Control	From this page, the user can change change IDS operational parameters and turn on or off various operational constraints
Model Calcs	Model	The simulation of IDS is performed in this worksheet. Decisions are made concerning island diversion, discharge, and destination of discharge according to baseline conditions and user specified operational controls.
View Results	TS_plot	Time series plot for entire simulation
	Ann_plot	Annual summary graphics and tables
	MonthlyStudyComparison	Monthly time series plots comparing current and saved studies
	AnnualStudyComparison	Annual summary graphics and tables comparing current and saved studies
	System schematic	Results viewer on system schematic
	Table	User defined output table
	TS_plot 10yr	Time series plots focusing on the last 10 years of the simulation (1994-2003)
Intermediate Calcs	SavedAnnualResults	Annual results saved by pushing the SAVE button on the CONTROL worksheet
	SavedPOEResults	Probability of exceedance results saved by pushing the SAVE button on the CONTROL worksheet
	SavedMonthlyResults	Monthly time series results saved by pushing the SAVE button on the CONTROL worksheet
	Saved Graph Calcs	Output to support plots of saved study
	Graph Calcs	Calculation to support output graphics of current simulation
	Schematic Data	Data used for system schematic
	Conversions	CFS-TAF conversion
CalSim Input and Output Processing	CalSimIn	Selected CalSim model inputs
	CalSimOut	CalSim model output used in IDSM
	Control Calc	Calculation of Delta outflow controls
	Export Control	Calculation of available export capacity
	CalSimOut_CA	CalSim output for California Aqueduct (CA) flows
	CA Avail	Available CA capacity at key locations
	Qwest	Calculation of Qwest that can vary by selected CalSim baseline
	OMR	Calculation of Old and Middle River flow which can vary by selected CalSim baseline
	River Indicies	Sacramento and San Joaquin River indicies
DSS Data Retrieval	DSSPathnames	Pathnames for CalSim DV DSS output and SV DSS input. Works for all applicable CalSim studies.
	DSSPathnames_CA	Pathnames for CalSim DV DSS output concerning California Aqueduct. Works for all applicable CalSim studies.
	DSSPathnames_B2	Pathnames for CalSim DV DSS output from b2 step
	DSSPathnames_RA	Pathnames for CalSim DV DSS output from Remedy Action study.

Figure D-2. Documentation—IDSM Worksheet Descriptions

The summary results table at the top of the control sheet (shown in Figure D-3) allows the user to modify operations rules or infrastructure and immediately see the effects on island operations on the same page. Summary results include average annual island discharge by destination and the overall deliveries to SWP and CVP contractors. Results are also averaged over different water year types so the user can see how project benefits are distributed over dry and wet years. If the user likes a particular simulation, the monthly results can be saved for comparison to subsequent simulations by using the SAVE button (shown to the left of the summary table in Figure D-3). Tabular and graphical comparisons of results from the saved and current simulations are found in worksheets MonthlyComparison and AnnualComparison.

In-Delta Storage Model (IDSM)

Model Operations Control Worksheet

(yellow)	Yellow cells are the parameters of interest for this study and can be changed by the user.
(pink)	Pink cells are parameters set in the original permit application, D1643, or associated documents. They can also be varied by the user.
(green)	Green cells are parameters pulled from the DWR IDS Feasibility Studies. These can be varied by the user.

Summary Results:

SAVE

	Island Discharge (TAF/year)								SOD Deliveries (TAF/year)		
Sac Index WY Type	Direct SWP Delivery	Direct CVP Delivery	AVWB Put	SWRU Put	OSWSD Put	SWSD Put	Delta Outflow Release	**Total**	SWP Delivery	CVP Delivery	**Total**
W	19	34	17	12	8	1	77	**167**	50	34	**84**
AN	27	63	29	24	9	1	33	**187**	55	63	**118**
BN	58	56	23	21	13	1	63	**236**	98	56	**154**
D	65	7	23	24	13	1	20	**152**	151	7	**158**
C	2	2	13	12	9	1	26	**64**	57	2	**59**
ALL	34	31	20	18	10	1	48	**163**	82	31	**113**

Figure D-3. IDSM Control Worksheet Provides a Summary Results Table at the Top

The first cell (yellow) for user input is to select the CalSim baseline as shown in Figure D-4. Currently, there are two baselines provided: (1) V9B and (2) V9BOMR. The user simply types “1” or “2” in the yellow cell to make the selection. The key difference between the two baselines is that V9B does not include Old and Middle River flow criteria, whereas V9BOMR does. This affects the availability of Delta surplus for island diversion and export pumping capacity for island discharge. It also affects unmet south-of-Delta water demand and available conveyance capacity in the California Aqueduct. By selecting the CalSim baseline, the IDSM user defines the Delta conditions for evaluation of the project. IDSM can incorporate new CalSim baselines as necessary.

CalSim II baseline and fish action selection

This section allows the user to select a fish action regulatory baseline. The two baselines provided are (1) V9B with no OMR criteria and (2) V9BOMR which includes the most stingent OMR criteria in the Wanger Decision.

Select Baseline Fish Action 1

1	V9B	CalSimO	CalSimO	RemedyA	QwestV9	OMR_Hu	CalSimInputV9B	CalSimOutV9B
2	V9BOMR	CalSimO	CalSimO	RemedyA	QwestV9	OMR_Hu	CalSimInputV9B	CalSimOut_CAV9B

RemedyActionV9B
QwestV9B
OMR_Hutton
CalSimInputV9B

Figure D-4. User Selection of the CalSim Baseline in the Control Worksheet

The next section of user input is to define diversion and discharge for export rules for the island reservoirs when OMR flow criteria are controlling Delta exports (Figure D-5). Rules can vary by island and month. For diversion or discharge, the first option the user has is to turn the rules off or on: “0” or “1”, respectively. In the monthly tables, the user can specify a flow diversion or discharge restriction to apply (0 cfs or greater) when OMR flow criteria restrict Delta exports. (Note that these restrictions will only be applied when the CalSim baseline with OMR flow criteria is selected-V9BOMR.) IDSM also reevaluates OMR flow under project operations to determine if island diversion or discharge for export creates an OMR flow criteria control. Diversions to Bacon or Webb will not change OMR flow, but discharges for export from Bacon or Webb will reduce OMR flow (i.e., greater reverse OMR).

IDS Allowed Diversions/Discharges Under Remedy Actions (Only applies for OMR flow criteria baselines)

Webb Tract allowed diversion when a Remedy Action is controlling exports.

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Off(0)/On(1)	1	2	3	4	5	6	7	8	9	10	11	12	
Webb maximum diversion	0	0	0	0	0	0	0	0	0	0	0	0	0	cfs
		0	0	0	0	0	0	0	0	0	0	0	0	off(0)/on(1)

Webb Tract allowed discharge for export when a Remedy Action is controlling. Allowance of diversions preempts allowance of discharge.

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Off(0)/On(1)	1	2	3	4	5	6	7	8	9	10	11	12	
Webb max. exp. dis.	1	0	0	0	0	0	0	0	0	0	0	0	0	cfs
		0	0	0	0	0	0	0	0	0	0	0	0	cfs
		1	1	1	1	1	1	1	1	1	1	1	1	off(0)/on(1)

Bacon Island allowed diversion when a Remedy Action is controlling exports.

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Off(0)/On(1)	1	2	3	4	5	6	7	8	9	10	11	12	
Bacon maximum diversion	1	0	0	0	0	0	0	0	0	0	0	0	0	cfs
		1	1	1	1	1	1	1	1	1	1	1	1	off(0)/on(1)

Bacon Island allowed discharge for export when a Remedy Action is controlling. Allowance of diversions preempts allowance of discharge.

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Off(0)/On(1)	1	2	3	4	5	6	7	8	9	10	11	12	
Bacon max. exp. Dis.	0	0	0	0	0	0	0	0	0	0	0	0	0	cfs
		0	0	0	0	0	0	0	0	0	0	0	0	cfs
		0	0	0	0	0	0	0	0	0	0	0	0	off(0)/on(1)

Figure D-5. User-Defined Project Diversion and Discharge Operations under OMR Flow Criteria

IDSM allows user-specified diversions under the OMR criteria. It also allows user- specified discharge for export under the criteria. However, for a given island in a given month, IDSM does not allow the user to specify both allowed diversions and discharges. If the user specifies both, IDSM ignores the discharge for export allowance. Enabling both diversion and discharge in a given month would defeat the purpose of the fish protection measures

The user-specified controls for project diversions, as shown in Figure D-6, take the form of the major D-1643 constraints (shown in Figure D-1). The purpose was to allow the user to apply the original D-1643 constraints, or to test changes in those constraints to match changes in Delta regulations. In the Diversion Criteria section of the Control worksheet, there is a cell for specifying an initial X2 trigger location, a monthly table for limiting diversions by percentage of Delta surplus and maintaining a minimum QWEST. Monthly allowances for topping off—diversions to replenish storage lost to evaporation—are also included. Similar constraints on project operations were part of D-1643. In some cases, the original D-1643 daily constraints were simplified to fit the monthly time-step of IDSM.

Diversion Criteria

Total diversion capacity to the islands was specified as 9000 cfs in the original permit application. At a monthly timestep, this will never bound diversions due to storage capacity limits.

Total Diversion

Max. Total Diversion Rate	4000	cfs	
Initial X2 trigger	81		D1643 specifies that X2 must be downstream of Chipps Island (75 km) for 10 days prior to initial water year diversions

The following table sets montly diversion constraints and triggers as expressed in D1643 and associated documents.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1	2	3	4	5	6	7	8	9	10	11	12	month number
Diversion Allowed (1=yes, 0=no)	1	1	1	1	1	1	0	0	1	1	1	1	trigger
no div is X2 east of	81	81	81	81	74	74	74	74	81	81	81	81	km
% of Delta Surplus	100	100	100	100	100	100	100	100	100	100	100	100	%
% of previous outflow	25	25	25	25	25	25	0	0	25	25	25	25	%
% of SJR	999	999	999	999	999	999	999	999	999	999	999	999	%
Qwest Minimum (cfs)	-20000	-20000	-20000	-20000	-20000	-20000	-20000	-20000	-20000	-20000	-20000	-20000	cfs
Qwest Diversion Limit (cfs)	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	cfs
DXC closed													
Delta inflow <30,000 cfs	9999	3000	3000	3000	9999	9999	9999	9999	9999	9999	9999	9999	cfs
Delta inflow >30,000 cfs	9999	4000	4000	4000	9999	9999	9999	9999	9999	9999	9999	9999	cfs

Lookup table to constrain diversions according to X2 location as specified in D1643.

	X2	div rate
X2<80km	0	9999
X2>80km	80	2000
X2>81km	81	1000

Habitat Island Diversion	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1	2	3	4	5	6	7	8	9	10	11	12	
Diversion (cfs)	30.9	28.6	30.9	3.3	19.8	0.0	0.0	6.5	50.4	58.5	42.3	45.4	cfs

Allowed Topping Off (must subtract Habitat Isl. Div)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1	2	3	4	5	6	7	8	9	10	11	12	
Diversion (cfs)	33	0	0	0	0	0	0	0	215	270	200	100	cfs

Webb Tract

Max. Webb Diversion Rate	2000	cfs
Maximum annual diversion	155	taf
Maximum diversion Dec 15 -Mar 31	106.900	taf

Bacon Island

Max. Bacon Diversion Rate	2000	cfs
Maximum annual diversion	147.000	taf
Maximum diversion Dec 15 - Mar31	110.570	taf

Figure D-6. User-Defined Project Diversion Criteria with Flexibility to Implement D-1643 Specifications

Figure D-7 shows project discharge criteria input in the Control worksheet. Again, input flexibility to apply D-1643 discharge criteria or test changes in these criteria was provided. This included limits on the percentage of available export capacity available for project transfers, limits on Webb Tract discharge for export from February to June, and percentage of San Joaquin River flow limits placed on Bacon Island. The project discharges can be constrained by the D-1641 E/I ratio or allowed to exceed the E/I ratio. The user can modify these constraints as necessary.

Discharge Criteria													
Combined Discharge													
Maximum discharge rate	4000	cfs											
Maximum export of stored water	250	taf											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1	2	3	4	5	6	7	8	9	10	11	12	month number
% of available export capacity	100	100	100	100	75	50	50	50	50	75	100	100	%
Webb Island													
Maximum discharge rate	2000	cfs											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1	2	3	4	5	6	7	8	9	10	11	12	month number
Discharge (1=yes, 0=no)	1	1	1	0	0	0	0	0	0	1	1	1	trigger
% of available export capacity	100	100	100	100	0	0	0	0	0	75	100	100	%
Bacon Island													
Maximum discharge rate	2000	cfs											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1	2	3	4	5	6	7	8	9	10	11	12	month number
Discharge (% of SJR)	999	999	999	999	999	999	50	50	50	999	999	999	%
% of available export capacity	100	100	100	100	75	50	50	50	50	75	100	100	%

Figure D-7. User-Defined Project Discharge for Export Criteria with Flexibility to Implement D-1643 Specifications

Some D-1643 constraints, such as those tied to the Fall Midwater Fish Trawl (FMWT) delta smelt index, cannot be modeled in a simulation model like IDSM. Accordingly, there is no alteration of diversion or discharge constraints based on the FMWT index value. The diversion and discharge constraints are consistently applied as specified in the Control worksheet for each year of the simulation. Furthermore, IDSM does not constrain island diversions or discharge based on water quality operating criteria which are specified in various Protest Dismissal Agreements. Analyses related to FMWT criteria and water quality operating criteria must be conducted outside the context of the IDSM.

In the section shown in Figure D-8, the IDSM user can specify a month at which the contents of the reservoir will be released for Delta outflow when storage exceeds a user specified level. Unique rules can be applied to each island. The current model implementation gives priority to discharge for export, if the opportunity arises, over discharge for outflow. The purpose of this control is to allow the user to empty the island reservoirs by a given month each year to reduce the accumulation of salinity and TOC in the stored water.

End of Year Storage Release		
Select the wateryear month to release all remaining Delta Wetlands storage (Oct = 1). To turn off select 0 for month.		
	WY Month	Storage Trigger Level (TAF)
Select month to release remaining water from Webb	2	0
Select month to release remaining water from Bacon	2	0

Figure D-8. User-Defined Month to Release Reservoir Contents when Storage Exceeds a Specified Level

Figure D-9 shows the Control worksheet section where the user specifies the project allocation under which SWP and CVP contractors would request project water from the islands or stored in groundwater banks. The allocation trigger for both the SWP and CVP is set at 90% in Figure D-9. In this case, if SWP allocations were higher than 90% in a given year, SWP contractors would not request project water in that year. Project water could still be stored in groundwater banks when not needed for direct delivery. Place of use can be limited by specifying the percent of unmet SWP and CVP demand that can be delivered from the project islands or groundwater bank. For instance, assume the project identifies a number of SWP contractors that represent 50% of Table A water demands. The IDSM user would enter 50% next to SWP for "percent of demand to meet." This would limit delivery of project water to SWP contractors with 50% of unmet Table A demands.

SWP and CVP Demand Triggers, Place of Use Limitations, and Direct Transfer Restrictions

Enter percent allocation below which Delta Wetlands water will be purchased for direct delivery or groundwater extraction. Presently, groundwater reserved for SWP use.

	Allocation Trigger	Percent Demand to meet
SWP	90%	50%
CVP	90%	50%

The following triggers are for direct delivery from IDS to SWP and CVP contractors.

Use Banks and Jones to meet unmet CVP demands, JPOD (1=yes,0=no)	1
Use Banks to meet unmet SWP demands (1=yes,0=no)	1

Figure D-9. Direct Transfer and Place of Use Limits

The project has identified four groundwater banks to store its water during wet years when unmet demand in the designated places of use are low. They are Antelope Valley Water Bank, Stored Water Recovery Unit, Original Semitropic Water Storage District, and Semitropic Water Storage District. In the Control worksheet, as shown in Figure D-10, the user can define, for each bank, maximum storage capacity, maximum monthly and annual put rates, and maximum monthly and annual take rates. Also, a loss factor can be set for each water bank. The loss is set as a percentage of groundwater bank puts.

Ground Water Banks

Antelope Valley Water Bank (AVWB)

Maximum storage (1000 AF)	500	*Set to 0 to turn off AVWB.*
Initial Storage	0	
Losses (% of put)	0%	
Maximum Put (cfs)	350	
Maximum Put (TAF / Year)	100	
Maximum Take (cfs)	250	
Maximum Take (TAF / Year)	100	

Stored Water Recovery Unit (SWRU)

Maximum storage (1000 AF)	450	*Set to 0 to turn off SWRU.*
Initial Storage	0	
Losses (% of put)	0%	
Maximum Put (cfs)	420	270-420
Maximum Put (TAF / Year)	50	
Maximum Take (cfs)	420	
Maximum Take (TAF / Year)	150	150-283

Original Semitropic Water Storage District (OSWSD)

Maximum storage (1000 AF)	1000	*Set to 0 to turn off OSWSD.*
Initial Storage	0	
Losses (% of put)	0%	
Maximum Put (cfs)	530	
Maximum Put (TAF / Year)	100	90.5-350
Maximum Take (cfs)	300	
Maximum Take (TAF / Year)	100	90-223

Semitropic Water Storage District (SWSD)

Maximum storage (1000 AF)	66.7	*Set to 0 to turn off SWSD.*
Initial Storage	0	
Losses (% of put)	0%	
Maximum Put (cfs)	100	
Maximum Put (TAF / Year)	30.015	
Maximum Take (cfs)	100	
Maximum Take (TAF / Year)	19.143	

Figure D-10. Groundwater Bank Specifications

IDSM tracks salinity impacts at various Delta locations using the G-Model[1]. (The G-Model is a salinity-outflow relationship based on a set of empirical equations.) The islands divert water during high flow periods when Delta salinity is low, and the islands release water during low flow periods when Delta salinity is high. Project releases for Delta outflow can help push seawater downstream. The Control worksheet section shown in Figure D-11 provides the user some options for project water quality releases along with some discharge for export flexibility under D-1641 regulations. The first yellow cell in Figure D-11 allows the user to decide whether the project can discharge for export when the export to inflow ratio specified in D-1641 is controlling exports. If yes (1), project discharge can be exported without regard to the E/I ratio. The next user settings are for “carriage water” (fraction of discharge reserved for outflow) to be paid for export of project water. The constraints can be turned on (1) or off (0), and the carriage is set as a percentage of discharge for export by month. The next user control in Figure D-11 allows discharge for export when D-1641 Delta salinity standards are otherwise controlling Delta inflow or exports. The user enters “1” to allow it, or “0” to not. The last user control in Figure D-11 allows for project water quality releases at specified Rock Slough chloride concentrations. The constraint can be turned on or off and the maximum water quality release and the water quality trigger are specified by month.

[1] Denton, R.A. (1993). *Accounting for Antecedent Conditions in Seawater Intrusion Modeling – Applications for the San Francisco Bay-Delta.* Hydraulic Engineering 93, Vol1 pp. 448-453. Proceedings of the ASCE National Conference on Hydraulic Engineering, San Francisco.

Delta Salinity and Export to Inflow Ratio

G model parameters for water quality

	Rock Slough	Rock Slough	Jersey Point	Emmaton	Collinsville	Mallard
	Chloride	EC	EC	EC	EC	EC
A	16.5	150	150	150	150	150
B	2200	5000	8000	10000	25000	30000
C	0.0006	0.0005	0.0004	0.0004	0.0003	0.00025

Quality = A + B * EXP(-C * Delta Outflow)

Export to Inflow Ratio

Allow discharge export when EI Ratio controls (1=yes, 0=no): **1** — 1 indicates that E/I does not limit discharge for export, suggest setting to 0

Carriage Water

Manual Carriage Setting: **0** Turns on/off discharge for export carriage costs in table below.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	1	2	3	4	5	6	7	8	9	10	11	12
CW all months	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%

ANN Control of Discharge for Export

Allow export when ANN controls WQ (1=yes, 0=no): **1**

The water quality release will occur when concentrations exceed the specified trigger level.

Release for Delta water quality (1=yes, 0=no): **0**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	1	2	3	4	5	6	7	8	9	10	11	12
Max release for WQ (cfs)	1000	1000	1000	0	0	0	0	0	0	0	0	1000
Rock Slough CL trigger (mg/L)	150	150	150	150	150	150	150	150	150	150	150	150

Figure D-11. Discharge for Export Constraints Pertaining to Water Quality Standards and the Delta Export to Inflow Ratio

Figure D-12 shows a section in the Control worksheet where the user can expand Banks permitted capacity by month. The user specified flow is added to the monthly permitted capacity as determined from the CalSim baseline. The user can turn off any specified additional monthly permitted capacity by using the switch at the top of the table.

Expanded Banks Permitted Pumping Capacity

Expand Permitted Capacity (0 = no, 1 = yes): 0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	1	2	3	4	5	6	7	8	9	10	11	12
Expanded Capacity (cfs)	0	0	0	0	0	0	0	0	0	1820	1820	1820

Figure D-12. User Defined Additional Permitted Banks Pumping Capacity

Figure D-13 allows the user to open the Delta Cross Channel gates in months that the CalSim baseline closes the gates for a portion or the entire month. The purpose is to boost QWEST when project diversion operations are constrained by QWEST minimum flows. A switch is provided for the user to turn the monthly Delta Cross Channel settings off.

Delta Cross Channel Operation

Reoperate Gate (0 = no, 1 = yes): 0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	1	2	3	4	5	6	7	8	9	10	11	12
Month to open (1 = open all month, 0 = base operation)	0	0	0	1	1	1	1	1	1	0	0	0

Figure D-13. User Control of the Delta Cross Channel Operation

A section in the Control worksheet also allows the user to size the island reservoirs and set monthly evaporation rates. This section is shown in Figure D-14.

Webb and Bacon Storage Capacity, Storage-Area Curves and Evaporation Rates

Webb Tract Max Storage	100.664	TAF											
Webb Tract Storage-Area Curve													
Storage (acre-ft)	0	37442	100664										
Area (acres)	0	5097	5374										
Bacon Island Max Storage	114.965	TAF											
Bacon Island Storage Area Curve													
Storage (acre-ft)	0	18707	114965										
Area (acres)	0	5301	5450										
Evaporation Rates were obtained from the DWR CalSim studies. As I recall, they were based on historical pan evaporation rates as measure on some Delta island.													
	Off(0)/On(1)												
IDS Evap Rate	1												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1	2	3	4	5	6	7	8	9	10	11	12	
Evap (inches)	1.4	1.1	0.6	0.7	1.5	2.1	2.7	3.8	4.9	5.8	4.3	2.3	inches

Figure D-14. Webb and Bacon Storage Capacity, Storage-Area Curve, and Evaporation Rate Settings

IDSM Output Tables and Graphs

There are several IDSM worksheets provided to help the user review simulation results. In worksheet TS_plot, monthly project operations with resulting changes in Delta outflow, exports, groundwater bank storage, and south-of-Delta operations are plotted over the water year 1922–2003 period of simulation. An example plot, containing 10 years of the 82 year simulation, of Webb Tract and Bacon Island storage is provided in Figure D-15. The timeseries plots are organized so that the model user can trace operations from month to month and determine the reasons for diversion and discharge decisions and the destination of island discharge.

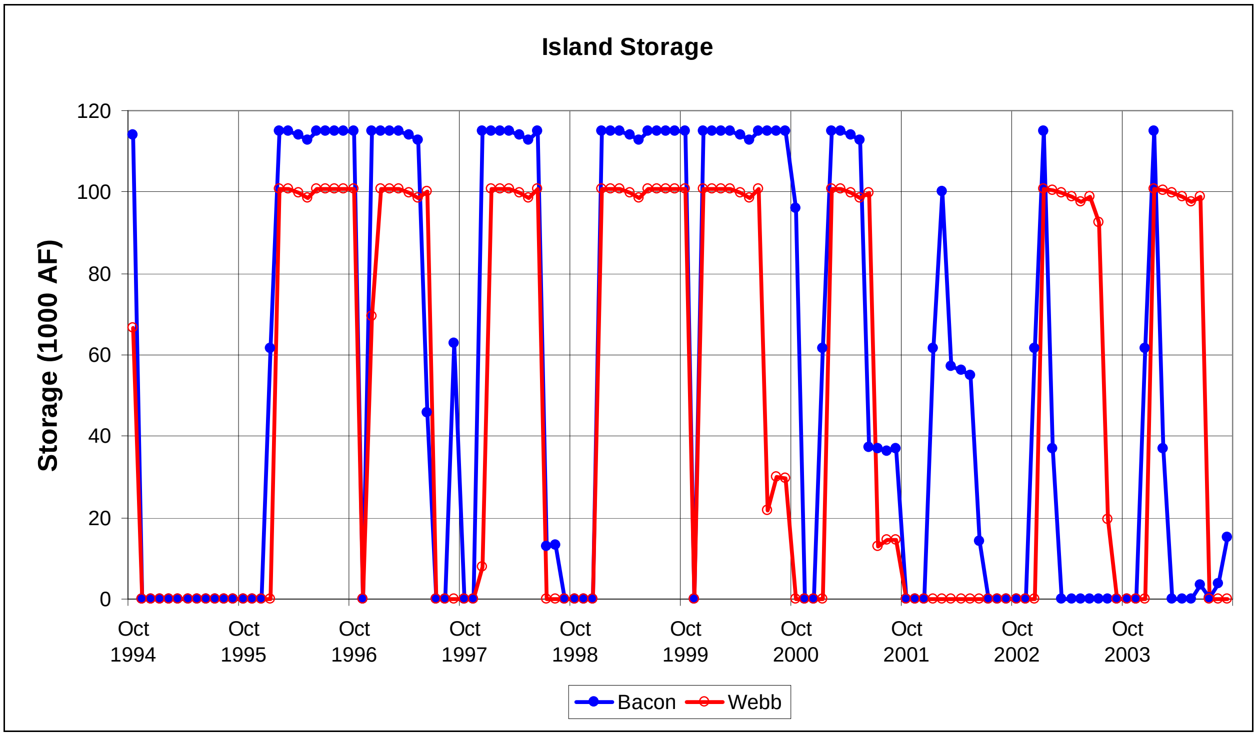


Figure D-15. Example Plot of Monthly Island Storage from the TS_plot Worksheet

IDSM results are also summarized in annual plots and tables. Figure D-16 contains a plot of annual discharge for export and specifies whether the water is delivered to SWP contractors, CVP contractors, or groundwater banks. Figure D-17 is an example table of annual average analysis of Project operations provided in Ann_plot. The Ann_plot worksheet also includes information on available Delta surplus, island diversions, discharge for Delta outflow, SWP and CVP contractor deliveries, and other key operational variables.

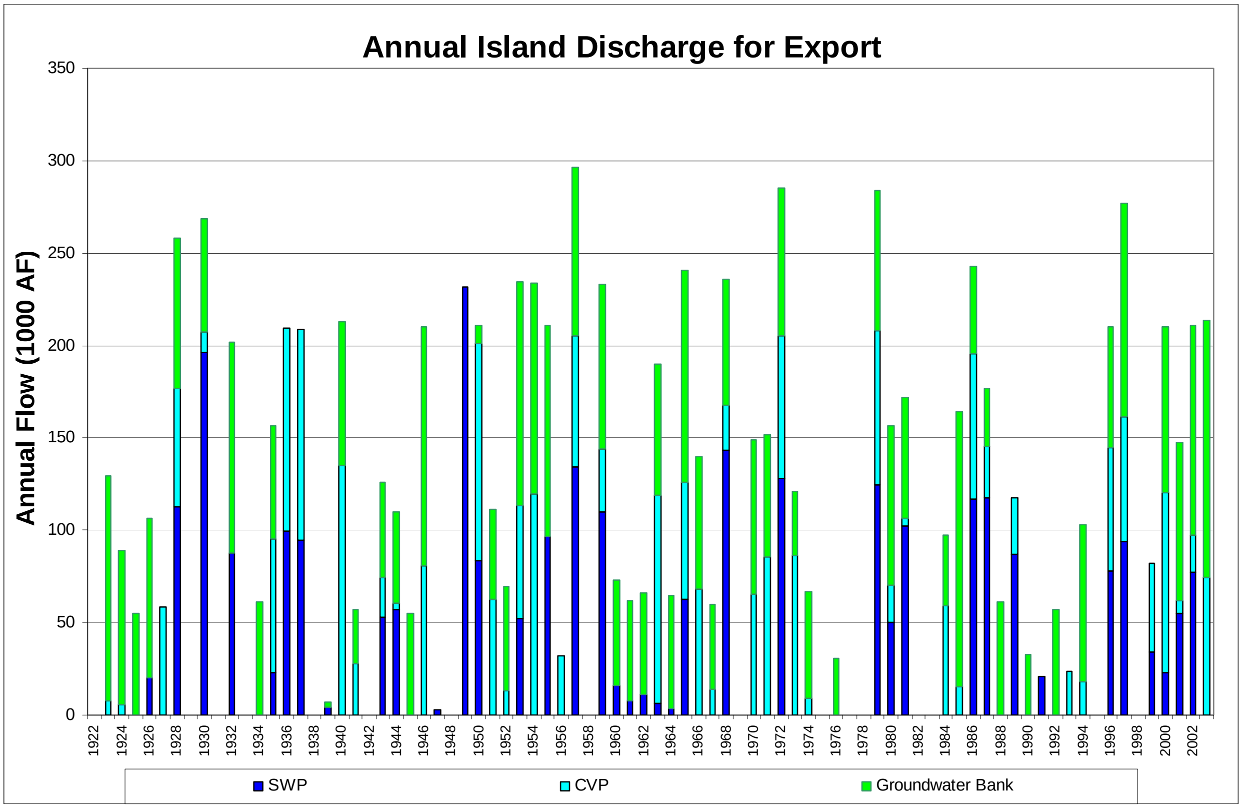


Figure D-16. Example Annual Plot of Island Discharge for Export from the Ann_plot Worksheet

Island Discharge (TAF/year)								
Sac Index WY Type	Direct SWP Delivery	Direct CVP Delivery	AVWB Put	SWRU Put	OSWSD Put	SWSD Put	Delta Outflow Release	Total
W	19	34	17	12	8	1	77	167
AN	27	63	29	24	9	1	33	187
BN	58	56	23	21	13	1	63	236
D	65	7	23	24	13	1	20	152
C	2	2	13	12	9	1	26	64
ALL	34	31	20	18	10	1	48	163

Figure D-17. Example Table of Annual Average Island Discharge by Purpose and Water Year Type as Found in the Ann_plot Worksheet

Another helpful tool for reviewing IDSM output is the IDSM schematic (worksheet System Schematic) as shown in Figure D-18. Using the buttons seen at the top left corner, the user can step through the current IDSM simulation month by month and view the CalSim baseline boundary conditions and associated project operations. Enough detail is provided to allow the user to diagnose the controlling constraints in each time-step whether its available Delta surplus, available export capacity, or south-of-Delta demand. The schematic also compares baseline X2, Delta outflow, Qwest, OMR flow, and exports to the updated values that incorporate the effects of island diversion and discharge.

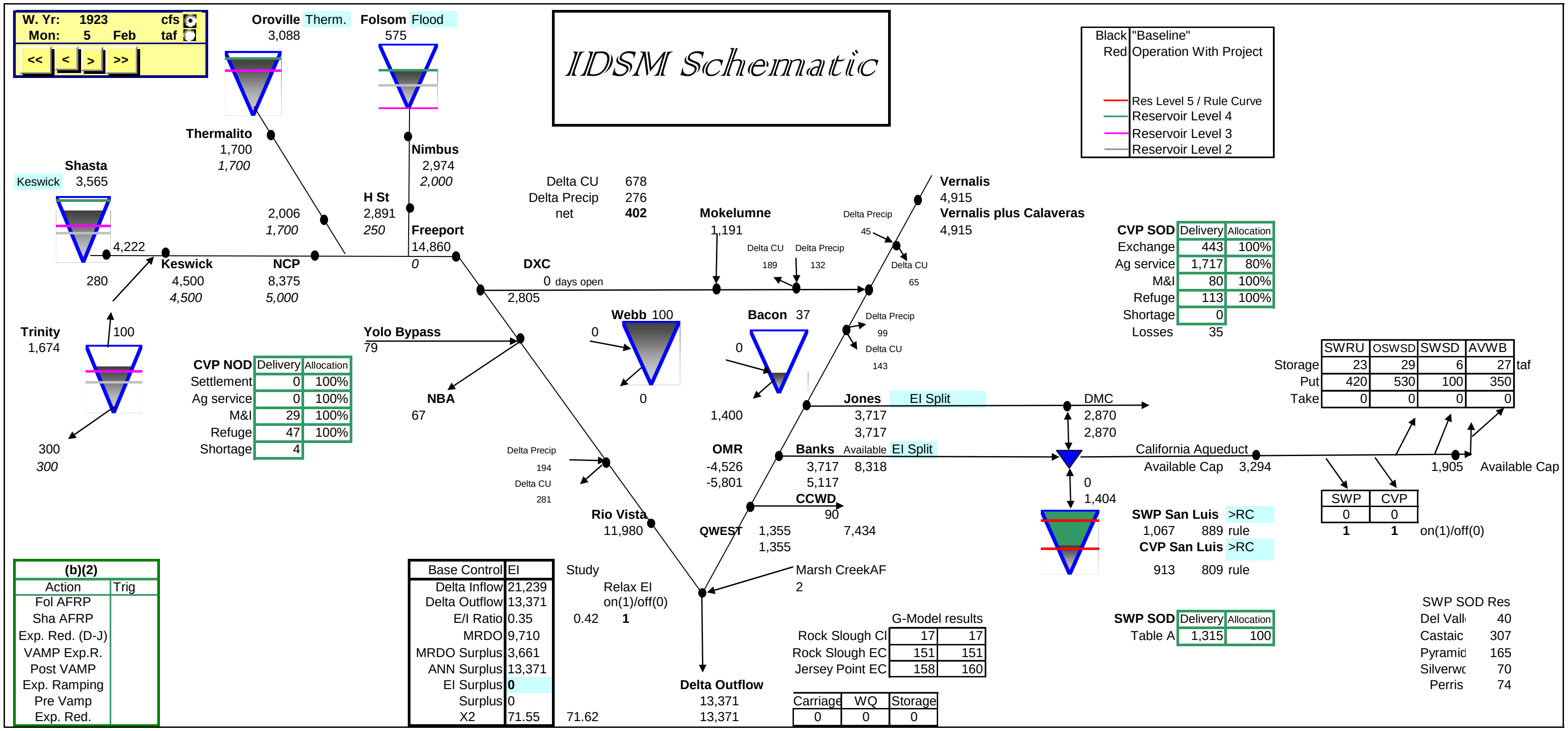


Figure D-18. IDSM Schematic Allows Model Users to Step Through Simulations Month-by-Month to View Results and Analyze Constraints

Attachment 1

Columns and Simulation Equations in the IDSM Worksheet Model

Heading	Sub-Heading / variable description	Column Title	Units:	Column	Formula / data
		Wateryear.mon		A	1922.01
		Water year		B	=INT(A13)
		Mon Num		C	1
		Month		D	Oct
		Sac River Index SRI		E	=VLOOKUP($B13,'River Indices'!$A$3:$C$84,3)
		San Joaquin River Index SJRI		F	=VLOOKUP($B13,'River Indices'!$A$3:$F$84,6)
		Days in month	Units:	G	=Conversions!D13
From CalSim "Baseline"	INFLOW	Delta inflow	cfs	H	=HLOOKUP(H$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	X2_PRV	"Baseline" Previous month X2 position	km	I	=HLOOKUP(I$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	D419	Banks Pumping	cfs	J	=HLOOKUP(J$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		Available Banks capacity	cfs	K	=MAX('Export Control'!M13-'Export Control'!E13,0)
	S12	SWP San Luis	TAF	L	=HLOOKUP(L$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	swp_in_total	Total Article 21	cfs	M	=HLOOKUP(M$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	D418	Jones Pumping	cfs	N	=HLOOKUP(N$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		Available Jones capacity	cfs	O	=MAX('Export Control'!AB13-'Export Control'!D13,0)
	S11	CVP San Luis	TAF	P	=HLOOKUP(P$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		EI Surplus	cfs	Q	='Control Calc'!CN13
		WQ (ANN) Surplus	cfs	R	='Control Calc'!CM13
		Exportable Delta Surplus	cfs	S	='Control Calc'!CQ13
		"Baseline" Total Delta Outflow	cfs	T	='Control Calc'!CL13
	D407	Required Delta Outflow	cfs	U	=HLOOKUP(U$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	C639	San Joaquin River at Vernalis	cfs	V	=HLOOKUP(V$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	C400	Sac River at Freeport	cfs	W	=HLOOKUP(W$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	DXC	Number of Days Cross Channel Gate Open	days/month	X	=HLOOKUP(X$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	Qwest	Qwest	cfs	Y	=HLOOKUP(Y$9,Qwest!$C$2:$E$996,'Control Calc'!$A13,FALSE)
	C401B	DXC + Geo. Slough	cfs	Z	=HLOOKUP(Z$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	EXPRATIO_	E/I Ratio		AA	=HLOOKUP(AA$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		AprMay Exp Ctrl		AB	='Export Control'!AC13
		AprMay Tracy Ctrl		AC	='Export Control'!AD13
		AprMay Banks Ctrl		AD	='Export Control'!AE13
	SWP_PERDELDV	SWP Allocation (%)		AE	=HLOOKUP(AE$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		SWP Demand Trigger		AF	=IF(AE13<$AF$1,IF(OR(C13<3,C13>7,),1,0),0)
	SWP_TA_TOTAL	SWP Table A Delivery		AG	=HLOOKUP(AG$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	SHORT_SWP_TOT_	SWP SOD Shortage		AH	=HLOOKUP(AH$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		SWP Table A Request		AI	=MIN((AG13+AH13)/AE13,500/Conversions!C13)
		Unmet SWP demand		AJ	=MAX(0,MIN(AI13-AG13,'Graph Calcs'!AS13/Conversions!C13-Model!AG13))
		SWP Demand for Additional Supply		AK	=AJ13*AF13*AK$1
	SWP_CO_TOTAL	SWP Article 56 Delivery		AL	=HLOOKUP(AL$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	PERDV_CVPAG_S	CVP Allocation (%)		AM	=HLOOKUP(AM$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		CVP Demand Trigger		AN	=IF(AM13<$AN$1,IF(OR(C13<3,C13>8,),1,0),0)
	DEL_CVP_PAG_S	CVP SOD AG Delivery		AO	=HLOOKUP(AO$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		CVP SOD AG Request		AP	=IF(AM13=0,0,AO13/AM13)
		Unmet CVP demand		AQ	=AP13-AO13
		CVP Demand for Additional Supply		AR	=AQ13*AN13*AR$1
	I410	Delte Precipitation	cfs	AS	=HLOOKUP(AS$9,CalSimIn!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	I412	Delte Precipitation	cfs	AT	=HLOOKUP(AT$9,CalSimIn!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	DEMAND_D410	Delta CU	cfs	AU	=HLOOKUP(AU$9,CalSimIn!$C$2:$IV$996,'Control Calc'!$A13,FALSE)/Conversions!C13
	DEMAND_D412	Delta CU	cfs	AV	=HLOOKUP(AV$9,CalSimIn!$C$2:$IV$996,'Control Calc'!$A13,FALSE)/Conversions!C13
		NDCU for South Delta	cfs	AW	=AU13-AS13+AV13-AT13
	D418	Jones Delta Export	cfs	AX	=HLOOKUP(AX$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	D419	Banks Delta Export	cfs	AY	=HLOOKUP(AY$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
	D408	CCWD Export	cfs	AZ	=HLOOKUP(AZ$9,CalSimOut!$C$2:$IV$996,'Control Calc'!$A13,FALSE)
		South Delta Diversions	cfs	BA	=SUM(AW13:AZ13)
		Trigger for Water Quality Demand		BB	='Control Calc'!DM13
		B2 Delta Action (0=yes, 1=no)		BC	='Control Calc'!DN13

Base Delta Conditions		"Baseline" Previous month X2 position	km	BD	=122.2+0.3278*BD13-17.65*LOG(BE13,10)
		Delta Outflow	cfs	BE	=T13
		Gmodel Ending Antecedent		BF	=BE13/(1+(BE13/BF12-1)*EXP(-BE13/6000))
		Gmodel Effective Outflow		BG	=BE13+6000*LN(BF12/BF13)
	OMR	OMR Flow	cfs	BH	=HLOOKUP(BH$9,OMR!$C$2:$D$996,'Control Calc'!$A13,FALSE)
		QWEST	cfs	BI	=Y13
		QWEST with DXC gate reop	cfs	BJ	=BI13+Control!$B$250*HLOOKUP($C13,Control!$B$252:$M$253,2,FALSE)*(0.133*W13+829+0.16*W13+1261-Z13)
	Water Quality from G Model	Rock Slough	Chloride	BK	=Control!C$200+Control!C$201*EXP(-Control!C$202*$BG13)
		Rock Slough	EC	BL	=Control!D$200+Control!D$201*EXP(-Control!D$202*$BG13)
		Jersey Point	EC	BM	=Control!E$200+Control!E$201*EXP(-Control!E$202*$BG13)
		Emmaton	EC	BN	=Control!F$200+Control!F$201*EXP(-Control!F$202*$BG13)
		Collinsville	EC	BO	=Control!G$200+Control!G$201*EXP(-Control!G$202*$BG13)
		Mallard	EC	BP	=Control!H$200+Control!H$201*EXP(-Control!H$202*$BG13)
Study Delta Conditions		Previous month X2 position	km	BQ	=122.2+0.3278*BQ13-17.65*LOG(BS13,10)
		Delta Water Quality Demand	cfs	BR	=IF(BK13>HLOOKUP(C13,Control!$B$221:$M$223,3,FALSE),HLOOKUP(C13,Control!$B$221:$M$222,2,FALSE),0)*$BR$1
		Delta Outflow	cfs	BS	=BE13-DO13-EB13+ET13
		Gmodel Ending Antecedent		BT	=BS13/(1+(BS13/BT12-1)*EXP(-BS13/6000))
		Gmodel Effective Outflow		BU	=BS13+6000*LN(BT12/BT13)
		Change in Banks Export	cfs	BV	=MIN(DI13,EP13)
		Change in Jones Export	cfs	BW	=EP13-BV13
		Banks Export	cfs	BX	=BV13+AY13
		Jones Export	cfs	BY	=BW13+AX13
		OMR Flow	cfs	BZ	=BH13+EP13*OMR!D13
		Qwest with DXC gate reop	cfs	CA	=BJ13+DP13+EC13-DO13-EB13-BV13-BW13
	Water Quality from G Model	Rock Slough	Chloride	CB	=Control!C$200+Control!C$201*EXP(-Control!C$202*$BU13)
		Rock Slough	EC	CC	=Control!D$200+Control!D$201*EXP(-Control!D$202*$BU13)
		Jersey Point	EC	CD	=Control!E$200+Control!E$201*EXP(-Control!E$202*$BU13)
		Emmaton	EC	CE	=Control!F$200+Control!F$201*EXP(-Control!F$202*$BU13)
		Collinsville	EC	CF	=Control!G$200+Control!G$201*EXP(-Control!G$202*$BU13)
		Mallard	EC	CG	=Control!H$200+Control!H$201*EXP(-Control!H$202*$BU13)

Diversion to Storage Constraints	Initial X2 delay and ramping	Days in month X2 west of Chipps	days/month	CH	=INT(IF(AND(BD13<Control!$B$56,BD14<Control!$B$56),G13,IF(AND(BD14<Control!$B$56,BD13>=Control!$B$56),G13/(BD14-BD13)*(BD14-Control!$B$56),0)))
		10 day X2 west of Chipps trigger	days	CI	=IF(C13=1,MIN(CH13,10),IF(CI12+CH13>=10,10,CH13))
		Diversion days	days/month	CJ	=IF(AND(C13=1,CI13>=10),CH13-CI13,IF(AND(CI13>=10,CI12>=10),G13,IF(AND(CH12>0,CI13>=10),G13-CI13+CI12,IF(CI13>=10,CH13-CI13,0))))
		Diversion Ramping days	days/month	CK	=IF(C13=1,MIN(CJ13,5),IF(CJ12>=5,0,IF(CJ13<5,CJ13,5-CK12)))
		Percent of month full diversion allowed	%	CL	=MIN(1,(CJ13-CK13)/G13)*100
		Percent of month diversion up to 5,500cfs allowed	%	CM	=CK13/G13*100
		X2 delay and ramping diversion constraint	cfs	CN	=CL13/100*9000+CM13/100*5500
		X2 constraint X2>81=500 cfs X2>80=1000cfs	cfs	CO	=VLOOKUP(BQ13,Control!$B$74:$C$76,2)
		No diversion if X2>value	cfs	CP	=IF(AND(BQ13>HLOOKUP(C13,Control!$B$60:$M$62,3),I14>HLOOKUP(C13,Control!$B$60:$M$62,3)),0,9000)
		Diversion Allowed	cfs	CQ	=IF(HLOOKUP($C13,Control!$B$60:$M$61,2)=0,0,9000)
		X2 Shift diversion constraint	cfs	CR	=MAX(0,IF(AND(C13>=1,C13<=6),T13-10^((122.2 + 0.3278*I13-I14-2.5)/17.65),9000))
	Total	Maximum Diversion Rate	cfs	CS	=CS$1
	Webb	Maximum Diversion Rate to Webb	cfs	CT	=CT$1
	Bacon	Maximum Diversion Rate to Bacon	cfs	CU	=CU$1
		Percent of Delta Surplus	cfs	CV	=HLOOKUP($C13,Control!$B$60:$M$63,4)/100*S13
		Percent of Delta Outflow	cfs	CW	=HLOOKUP($C13,Control!$B$60:$M$64,5)/100*T13
		Max Diversions from Dec to Mar	cfs	CX	=IF(OR(C13<4,C13>6),0,MAX(CX12,EO12))
		Percent of SJR from Dec to Mar	cfs	CY	=IF(OR(C13<3,C13>6,AND(C13>3,OR(CX12>1000,CX12>CY12-100))),9000,HLOOKUP($C13,Control!$B$60:$M$65,6)/100*V13)
		Qwest Constraint	cfs	CZ	=MAX(0,BJ13-HLOOKUP(C13,Control!$B$60:$M$70,7,FALSE),HLOOKUP(C13,Control!$B$60:$M$70,8,FALSE))
		DXC Constraint	cfs	DA	=IF(H13>30000,HLOOKUP(C13,Control!$B$60:$M$70,11,FALSE)*(G13-X13)/G13,HLOOKUP(C13,Control!$B$60:$M$70,10,FALSE)*(G13-X13)/G13)+MIN(CN13,CO13,CP13,CQ13,CR13,CS13,CV13,CW13,CY13,CT13+CU13,CZ13)*X13/G13
		Maximum diversion to IDS	cfs	DB	=MIN(CN13,CO13,CP13,CQ13,CR13,CS13,CV13,CW13,CY13,CT13+CU13,CZ13,DA13)
Discharge Constraints		Carriage Water %		DC	=HLOOKUP($C13,Control!$B$212:$M$213,2,FALSE)*DC$1
		Maximum Discharge Rate	cfs	DD	=DD$1
		Max Export under VAMP	cfs	DE	=IF(OR(C13<7,C13>8,DE$1=0),15000,MIN(AB13-AX13-AY13,AC13+AD13-AX13-AY13))
		Max Export under EI	cfs	DF	=MAX(99999*DF$1,'Export Control'!T13-'Export Control'!C13)
		Max Export under ANN	cfs	DG	=MAX(99999*DG$1,'Export Control'!AF13-'Export Control'!C13)
		Available Banks Capacity plus specified increase		DH	=MAX(K13+HLOOKUP($C13,Control!$B$246:$M$247,2,FALSE)*Control!$B$244,0)
		Max Use of Available SWP Exports	cfs	DI	=HLOOKUP(C13,Control!$B$120:$M$121,2,FALSE)/100*DH13
	Combined	Max Use of Available CVP Exports (w/ B2)	cfs	DJ	=HLOOKUP(C13,Control!$B$120:$M$121,2,FALSE)/100*O13*BC13
	Webb	Release for Export max 3000 no dis from Jan to Jun	cfs	DK	=HLOOKUP(C13,Control!$B$128:$M$129,2)*DK$1
		Balanced Condition or RA controlling	cfs	DL	=IF(OR(S13<0.1,RemedyAction!C13-AX13-AY13<0.1),9999,0)
	Bacon	SJR constraint	cfs	DM	=IF(HLOOKUP(C13,Control!$B$136:$M$137,2)=999,DM$1,MIN(DM$1,HLOOKUP(C13,Control!$B$136:$M$137,2)/100*V13/(1-DC13)))
		Balanced Condition or RA controlling	cfs	DN	=IF(OR(S13<0.1,RemedyAction!C13-AX13-AY13<0.1),9999,0)

Island operation	Bacon	Diversion to Bacon Island	cfs	DO	=IF(AND(C13=Control!$B$144,EA12>Control!$C$144),0,MAX(0,MIN(DR13,DS13,DB13,CU13)))
		Discharge from Bacon Island	cfs	DP	=MAX(IF(AND(C13'=Control!$B$144,EA12>Control!$C$144),DU13,0),MIN(3000,DD13-EC13,MIN(DE13,DF13,DG13)/(1-DC13)-EC13+BR13,DN13-EC13+BR13,DI13/(1-DC13)+MIN(DJ13,AR13)/(1-DC13)*Control!$B$155+BR13-EC13,DM13+MAX(0,BR13-EC13),DT13,DU13,(AK13*Control!$B$156+FD13+FN13+FX13+GH13+AR13*Control!$B$155)/(1-DC13)+BR13-EC13))
		Bacon Island Change in Storage	taf	DQ	=(DO13-DP13)*Conversions!C13
		Remedy Action bound on diversion	cfs	DR	=MIN(9999, MAX(RemedyAction!C13-AX13-AY13+HLOOKUP(C13,Control!$C$39:$N$41,2,FALSE),9999-9999*DR$1))
		Max rate to island	cfs	DS	=(DS$1-EA12+DW13)/Conversions!C13
		Remedy Action bound on discharge	cfs	DT	=MIN(9999,MAX((RemedyAction!C13-AX13-AY13+HLOOKUP(C13,Control!$C$45:$N$48,3,FALSE))/(1-DC13)+BR13,9999-9999*HLOOKUP(C13,Control!$C$45:$N$48,4,FALSE)))
		Max discharge rate	cfs	DU	=EA12/Conversions!C13-DW13/Conversions!C13
		Bacon Initial Surface Area	acres	DV	=IF(EA12*1000>Control!$C$265,Control!$C$266+(EA12*1000-Control!$C$265)/(Control!$D$265-Control!$C$265)*(Control!$D$266-Control!$C$266),EA12*1000/Control!$C$265*Control!$C$266)
		Bacon Prev. Month Evap Estimate	taf	DW	=MIN(EA12,HLOOKUP($C12,Control!$B$82:$M$83,2,FALSE)/12*DV13/1000)*DW$1
		Bacon Top Off	taf	DX	=MIN(DZ13,(Control!$B$106-DZ13),DY12,Conversions!$C13*MAX(0,HLOOKUP($C13,Control!$B$91:$M$92,2,FALSE)-HLOOKUP($C13,Control!$B$86:$M$87,2,FALSE)))
		Bacon Top Off Account	taf	DY	=IF($C13=2,0,DY12+DW13-DX13)
		Bacon Island Storage before topoff	taf	DZ	=EA12+DQ13-DW13
		Bacon Island Storage after topoff	taf	EA	=DZ13+DX13
	Webb	Diversion to Webb Tract	cfs	EB	=IF(AND(C13=Control!$B$143,EN12>Control!$C$143),0,MAX(0,MIN(EE13,EF13,DB13-DO13,CT13)))
		Discharge from Webb Tract	cfs	EC	=MAX(IF(AND(C13=Control!$B$143,EN12>Control!$C$143),EH13,0),MIN(3000,DD13,MIN(DE13,DF13,DG13)/(1-DC13)+BR13,DL13+BR13,DI13/(1-DC13)+MIN(DJ13,AR13)/(1-DC13)*Control!$B$155+BR13,DK13+BR13,EG13,EH13,(AK13*Control!$B$156+FD13+FN13+FX13+GH13+AR13*Control!$B$155)/(1-DC13)+BR13))
		Webb Tract Change in Storage	taf	ED	=(EB13-EC13)*Conversions!C13
		Remedy Action bound on diversion	cfs	EE	=MIN(9999, MAX(RemedyAction!C13-AX13-AY13+HLOOKUP(C13,Control!$C$26:$N$28,2,FALSE),9999-9999*EE$1))
		Max Diversion Rate to Webb Tract	cfs	EF	=(EF$1-EN12+EJ13)/Conversions!C13
		Remedy Action bound on discharge	cfs	EG	=MIN(9999,MAX((RemedyAction!C13-AX13-AY13+HLOOKUP(C13,Control!$C$32:$N$35,3,FALSE))/(1-DC13)+BR13,9999-9999*HLOOKUP(C13,Control!$C$32:$N$35,4,FALSE)))
		Max DischargeRate from Webb Tract	cfs	EH	=EN12/Conversions!C13-EJ13/Conversions!C13
		Webb Initial Surface Area	acres	EI	=IF(EN12*1000>Control!$C$260,Control!$C$261+(EN12*1000-Control!$C$260)/(Control!$D$260-Control!$C$260)*(Control!$D$261-Control!$C$261),EN12*1000/Control!$C$260*Control!$C$261)
		Webb Prev. Month Evap Estimate	taf	EJ	=MIN(EN12,HLOOKUP($C12,Control!$B$82:$M$83,2,FALSE)/12*EI13/1000)*EJ$1
		Webb Top Off	taf	EK	=MIN(EM13,(Control!$B$98-EM13),EL12,Conversions!$C13*MAX(0,HLOOKUP($C13,Control!$B$91:$M$92,2,FALSE)-HLOOKUP($C13,Control!$B$86:$M$87,2,FALSE)-DX13))
		Webb Top Off Account	taf	EL	=IF($C13=2,0,EL12+EJ13-EK13)
		Webb Tract Storage before topoff	taf	EM	=EN12+ED13-EJ13
		Webb Tract Storage after topoff	taf	EN	=EM13+EK13
	Total IDS	Diversion to Islands	cfs	EO	=EB13+DO13
		Discharge for Export	cfs	EP	=MIN(MIN(EC13*(1-DC13),DK13,EG13)+MIN(DP13*(1-DC13),DM13,DT13),DI13+DJ13*Control!$B$155,DE13,DF13,DG13,(AK13*Control!$B$156+FD13+FN13+FX13+GH13+AR13*Control!$B$155))
		Carriage Water	cfs	EQ	=EP13/(1-DC13)-EP13
		WQ Release	cfs	ER	=MIN(EC13+DP13-EP13-EQ13,BR13)
		Storage Release	cfs	ES	=EC13+DP13-EP13-EQ13-ER13
		Discharge for Delta	cfs	ET	=EC13+DP13-EP13
		Evaporation	taf	EU	=DW13+EJ13
		Topoff	taf	EV	=DX13+EK13
		Storage	taf	EW	=EN13+EA13

South of Delta Operation	Aqueduct Capacity	Available CA Capacity O'Neill to Semitropic	cfs	EX	='CA Avail'!CM13
		Available CA Capacity Semitropic to Edmonston	cfs	EY	='CA Avail'!CN13
		Available CA Capacity Edmonston to Antelope Valley	cfs	EZ	='CA Avail'!CO13
		SWP Direct Delivery	cfs	FA	=MIN(AK13*Control!$B$156,EP13)
		CVP Direct Delivery	cfs	FB	=MIN(EP13-FA13,AR13*Control!$B$155)
	Antelope Valley Water Bank (AVWB)	AVWB Maximum Put	cfs	FC	=MIN((FL$1-FL12)/Conversions!$C13,(FH$1-FH12)/Conversions!$C13,$FC$1)
		Maximum Put Constrained by Conveyance	cfs	FD	=MIN(FC13,EX13:EZ13)
		Remaining Available CA Capacity O'Neill to Semitropic		FE	=MAX(0,EX13-MIN(FC13,EY13,EZ13))
		Maximum Take	cfs	FF	=MIN($AK13-FA13,FL12/Conversions!$C13,FF$1,(FJ$1-FJ12)/Conversions!$C13)
		AVWB Put	cfs	FG	=MIN(EP13-FA13-FB13,FD13)
		Cumulative Annual Put	taf	FH	=IF($C13=1,0,FH12+FG13*Conversions!C13)
		AVWB Take	cfs	FI	=FF13
		Cumulative Annual Take	taf	FJ	=IF($C13=1,0,FJ12+FI13*Conversions!C13)
		AVWB Losses	cfs	FK	=FK$1*FG13
		AVWB Storage	taf	FL	=FL12+(FG13-FI13-FK13)*Conversions!$C13
	Stored Water Recovery Unit (SWRU)	SWRU Maximum Put	cfs	FM	=MIN((FV$1-FV12)/Conversions!$C13,(FR$1-FR12)/Conversions!$C13,FM$1)
		Maximum Put Constrained by Conveyance	cfs	FN	=MIN(FM13,$FE13)
		Remaining Available CA Capacity O'Neill to Semitropic		FO	=MAX(0,FE13-FM13)
		Maximum Take	cfs	FP	=MIN($AK13-FA13-FI13,FV12/Conversions!$C13,FP$1,(FT$1-FT12)/Conversions!$C13)
		SWRU Put	cfs	FQ	=MIN($EP13-$FA13-$FB13-$FG13,FN13)
		Cumulative Annual Put	taf	FR	=IF($C13=1,0,FR12+FQ13*Conversions!$C13)
		SWRU Take	cfs	FS	=FP13
		Cumulative Annual Take	taf	FT	=IF($C13=1,0,FT12+FS13*Conversions!$C13)
		SWRU Losses	cfs	FU	=FU$1*FQ13
		SWRU Storage	taf	FV	=FV12+(FQ13-FS13-FU13)*Conversions!$C13
	Original Semitropic Water Storage District (OSWSD)	OSWSD Maximum Put	cfs	FW	=MIN((GF$1-GF12)/Conversions!$C13,(GB$1-GB12)/Conversions!$C13,FW$1)
		Maximum Put Constrained by Conveyance	cfs	FX	=MIN(FW13,$FO13)
		Remaining Available CA Capacity O'Neill to Semitropic		FY	=MAX(0,FO13-FW13)
		Maximum Take	cfs	FZ	=MIN($AK13-FA13-FI13-FS13,GF12/Conversions!$C13,FZ$1,(GD$1-GD12)/Conversions!$C13)
		OSWSD Put	cfs	GA	=MIN($EP13-$FA13-$FB13-$FG13-$FQ13,FX13)
		Cumulative Annual Put	taf	GB	=IF($C13=1,0,GB12+GA13*Conversions!$C13)
		OSWSD Take	cfs	GC	=FZ13
		Cumulative Annual Take	taf	GD	=IF($C13=1,0,GD12+GC13*Conversions!$C13)
		OSWSD Losses	cfs	GE	=GE$1*GA13
		OSWSD Storage	taf	GF	=GF12+(GA13-GC13-GE13)*Conversions!$C13
	Semitropic Water Storage District (SWSD)	SWSD Maximum Put	cfs	GG	=MIN((GO$1-GO12)/Conversions!$C13,(GK$1-GK12)/Conversions!$C13,GG$1)
		Maximum Put Constrained by Conveyance	cfs	GH	=MIN(GG13,$FY13)
		Maximum Take	cfs	GI	=MIN($AK13-FA13-FI13-FS13-GC13,GO12/Conversions!$C13,GI$1,(GM$1-GM12)/Conversions!$C13)
		SWSD Put	cfs	GJ	=MIN($EP13-$FA13-$FB13-$FG13-$FQ13-$GA13,GH13)
		Cumulative Annual Put	taf	GK	=IF($C13'=1,0,GK12+GJ13*Conversions!$C13)
		SWSD Take	cfs	GL	=GI13
		Cumulative Annual Take	taf	GM	=IF($C13=1,0,GM12+GL13*Conversions!$C13)
		SWSD Losses	cfs	GN	=GN$1*GJ13
		SWSD Storage	taf	GO	=GO12+(GJ13-GL13-GN13)*Conversions!$C13
	Total SOD Deliveries	SWP Direct Delivery	cfs	GP	=FA13
		SWP GWB Delivery	cfs	GQ	=FI13+FS13+GC13+GL13
		Total SWP Delivery	cfs	GR	=GP13+GQ13
		CVP Direct Delivery	cfs	GS	=FB13