Salinity Projection Model for USBR, Yuma Area Office

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August 27, 2013

Acknowledgments

- Yuma Area Office (YAO) – Water Operations Group
  - Hong Nguyen-DeCorse, Ed Virden, Aaron Marshall, Iris Lopez, Jacob Davis, Sal Teposte
- Carol Marra Consulting, Inc.
  - Hydrologic Database (HDB)

Overview

- Minute No. 242 of the 1944 Treaty with the Republic of Mexico
- Salinity and groundwater management
- RiverWare Salinity Projection Model

YAO Area of Responsibility

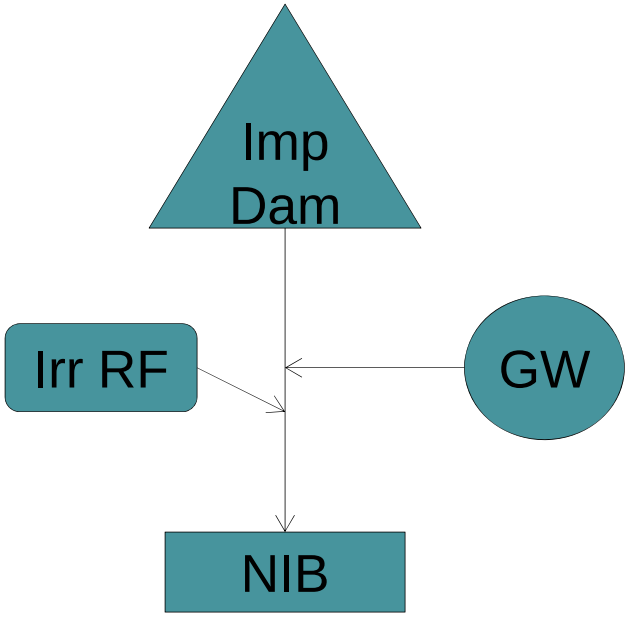

Miles
0 1 2 3
N
Imperial Dam
Laguna Dam
All American Canal
Yuma Main Canal
Gila Gravity Main Canal
COLORADO RIVER
GILA RIVER
UNITED STATES
California
Northerly International Boundary
Yuma Gage
Yuma
MEXICO
Baja California
Morelos Dam
95
8
UNITED STATES
Arizona
T.Staggs - YAOGIS2011-0120

Minute No. 242

- International Boundary and Water Commission (IBWC) Minute No. 242 – Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River
- Referring to annual volume of 1.5 MAF of Colorado River water guaranteed to Mexico under the 1944 Treaty:
  - Delivery of 1.36 MAF at the Northerly International Boundary with Mexico (NIB) shall have annual average salinity of no more than 115 PPM +/- 30 PPM over the annual average salinity of Colorado River water arriving at Imperial Dam (aka Salinity Differential)
  - Delivery at the Southerly International Border (SIB) of 140,000 AF will continue to have annual salinity substantially the same as customarily delivered there

Minute No. 242

- Salinity differential of less than 145 ppm at end of calendar year
  - Difference between annual, flow-weighted average salinity of water arriving at NIB and water arriving at Imperial Dam



Groundwater Pumping and Salinity Management

- Saline groundwater 1,000 – 2,500 PPM (1,600 – 1,800 ppm typical average)
- 22 wells in South Gila well field (modeled)
- 38 wells in Yuma Valley/Mesa area (modeled)
- Groundwater must be pumped to keep water table below the root zone (plus buffer zone)
- Ideally, would like to deliver pumped groundwater to NIB to count towards 1.36 MAF requirement
- This increases salinity differential

Groundwater Pumping and Salinity Management

- Ideally, run all groundwater pumping wells and send to river for delivery at NIB
- Last resort but best avoided: Order fresh water from Parker Dam to send to NIB to decrease differential. Not ideal because these deliveries would be in excess of order at NIB
- If projected salinity differential is too high, turn off wells or re-route drainage channels and/or conduit to SIB
- Salinity Projection Model Objective: Plan operation of well fields to stay below 145 ppm end-of-year salinity differential and avoid excess flows at NIB

Run-Off & Pumped Groundwater

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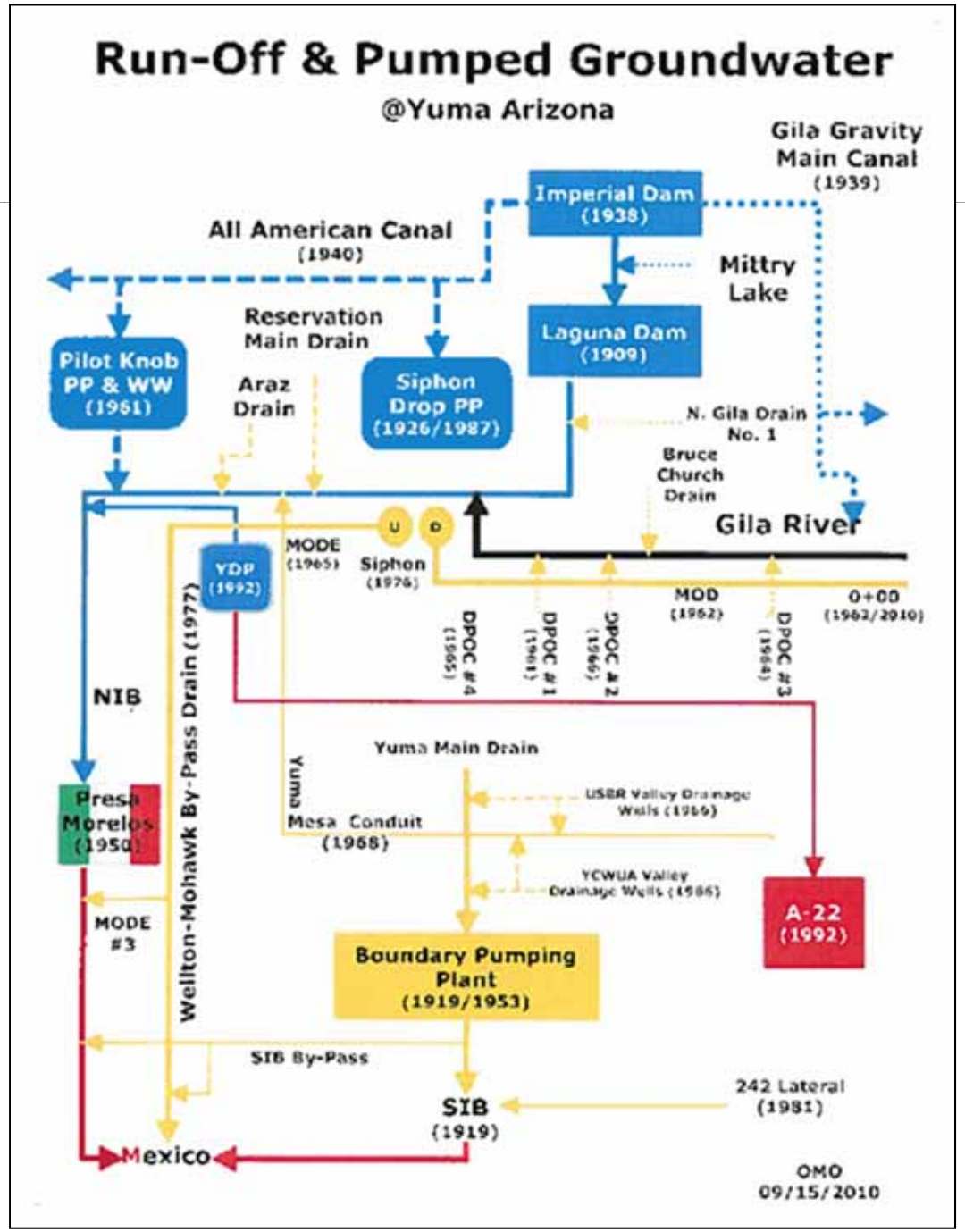
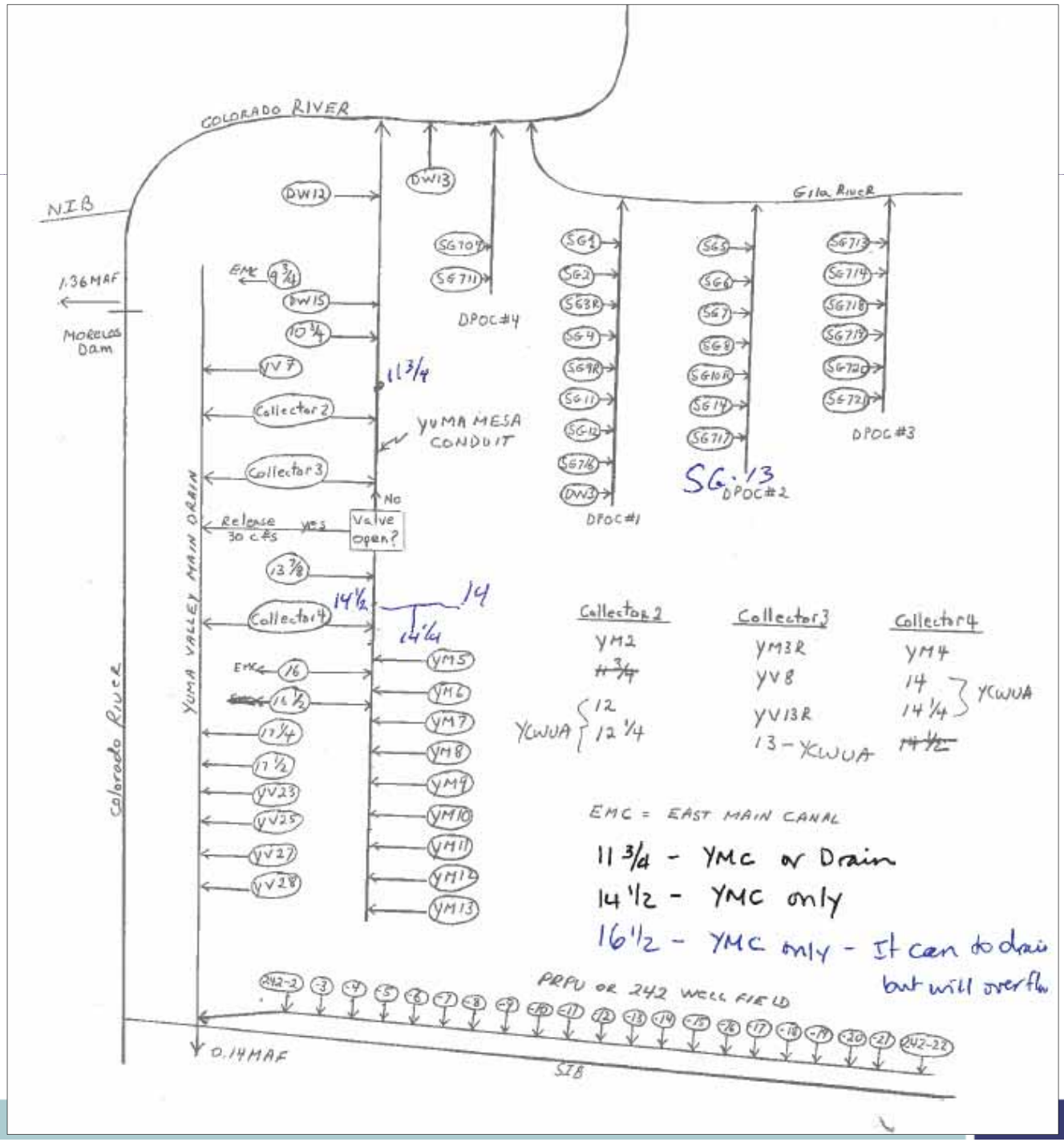



COLORADO RIVER
NIB
1.36 MAF
MORELOS Dam
Colorado River
YUMA VALLEY MAIN DRAIN
0.14 MAF
SIB
Gila River
DPOC #4
DPOC #3
DPOC #2
DPOC #1
DW12
DW13
DW15
SG10?
SG11
SG1
SG2
SG3R
SG4
SG9R
SG11
SG12
SG7/8
DW3
SG5
SG6
SG7
SG8
SG10R
SG14
SG7/7
SG13
SG7/4
SG7/8
SG7/9
SG7/2C
SG7/2
EMC
9 3/4
10 3/4
11 3/4
YV7
Collector 2
YUMA MESA CONDUIT
Collector 3
Release 30 cfs
yes
No
Valve open?
13 7/8
14 1/2
14
14 1/4
Collector 4
16
16 1/2
12 3/4
17 1/2
YV23
YV25
YV27
YV28
YM5
YM6
YM7
YM8
YM9
YM10
YM11
YM12
YM13
Collector 2
YM2
~~11 3/4~~
YCWUA 12
12 1/4
Collector 3
YM3R
YV8
YV13R
13 - YCWUA
Collector 4
YM4
14
14 1/4
YCWUA
~~14 1/2~~
EMC = EAST MAIN CANAL
11 3/4 - YMC or Drain
14 1/2 - YMC only
16 1/2 - YMC only - It can do drain but will overflow
PRPU OR 242 WELL FIELD
242-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
242-22

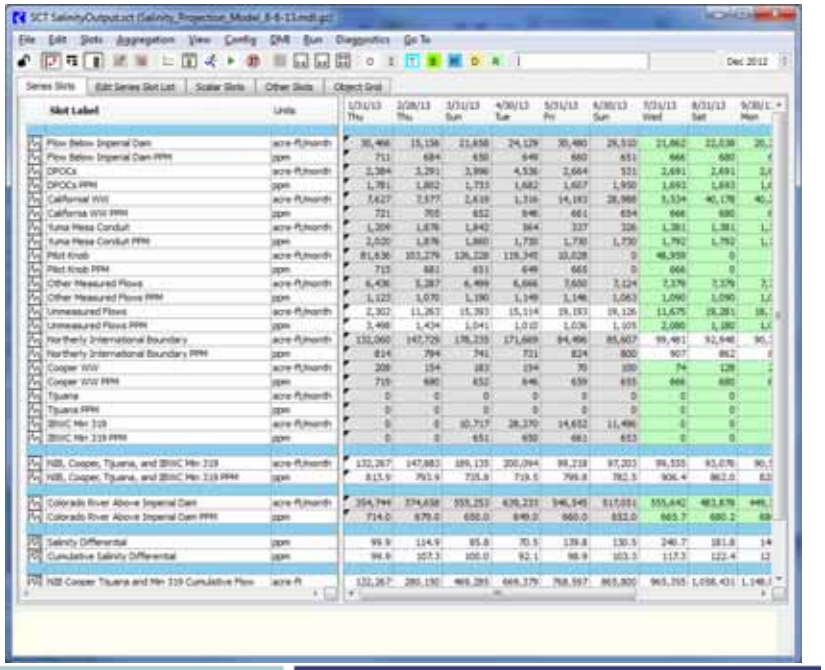
Model Requirements

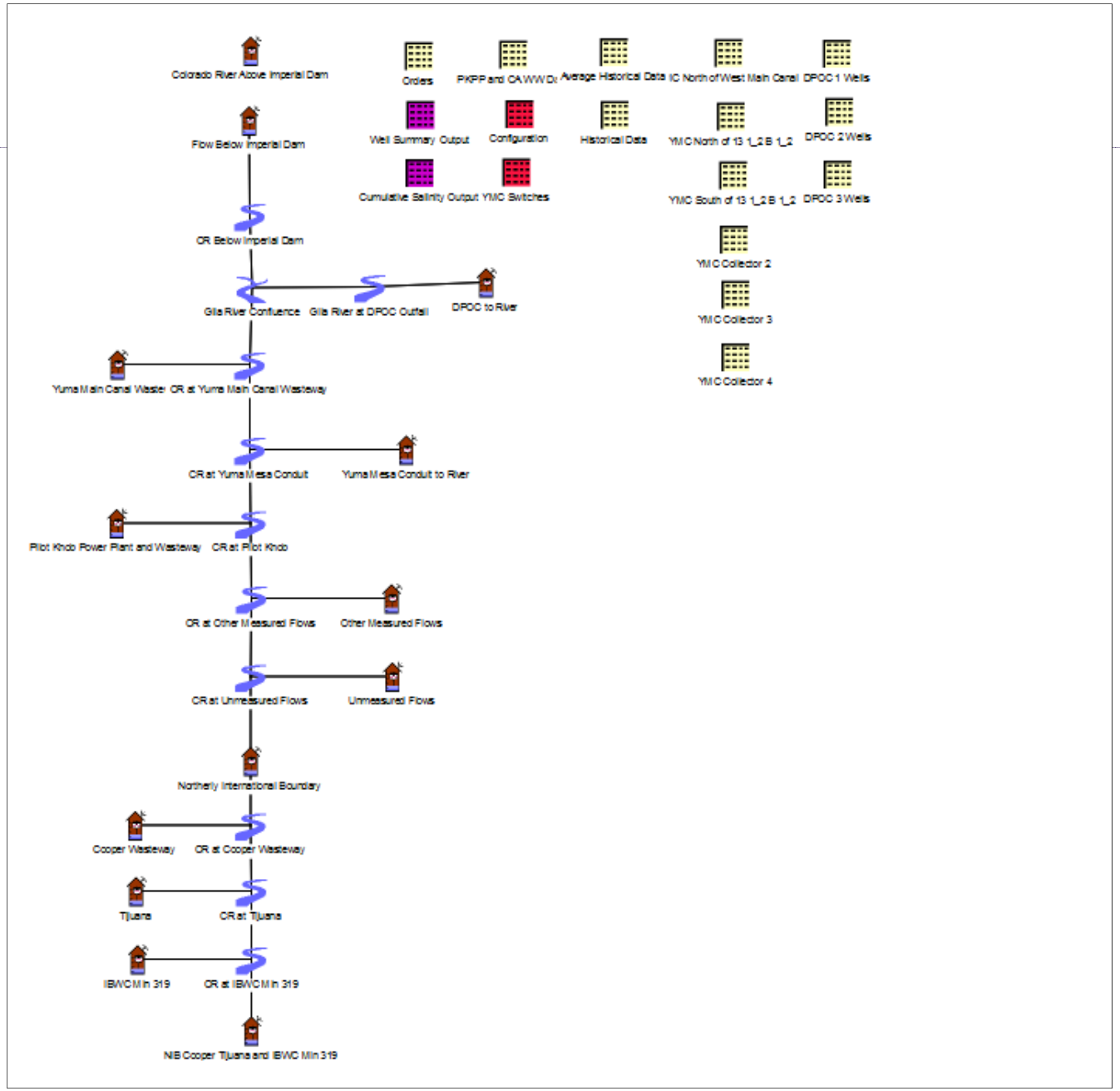
- Current projection process requires at least three different spreadsheets and manual data entry
  - Spreadsheet for well field calculations, spreadsheet to manage orders and projected flow arriving at Imperial Dam, projection spreadsheet (salinity differential calculations)

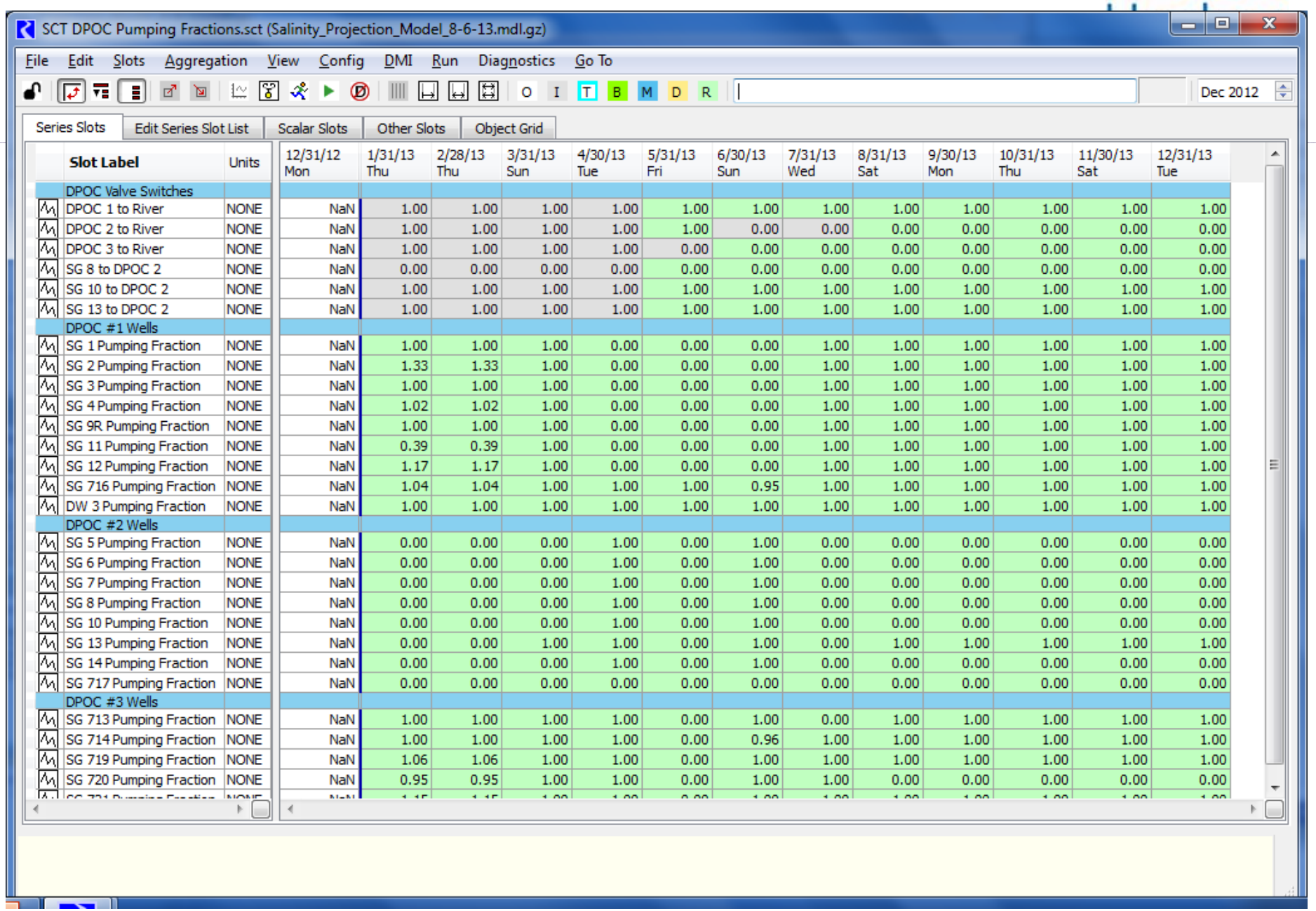
- Objectives:
  - All calculations in one place
  - Automated data entry
  - Automatic projection calculations
  - Easy to vary projections and run “What if?” scenarios to determine model sensitivity and reliability of projected salinity differential

RiverWare Model

- Monthly timestep
- January 1 – December 31
  - January – current month: observed data
  - Current month – December 31: projected data
- Automated connection with HDB




Colorado River Above Imperial Dam
Orders
PKPP and CA WW Dt
Average Historical Data
IC North of West Main Canal
DPOC 1 Wells
Flow Below Imperial Dam
Well Summary Output
Configuration
Historical Data
YMC North of 13 1_2 B 1_2
DPOC 2 Wells
Cumulative Salinity Output
YMC Switches
YMC South of 13 1_2 B 1_2
DPOC 3 Wells
YMC Collector 2
YMC Collector 3
YMC Collector 4
CR Below Imperial Dam
Gila River Confluence
Gila River at DPOC Outfall
DPOC to River
Yuma Main Canal Waste
CR at Yuma Main Canal Wasteway
CR at Yuma Mesa Conduit
Yuma Mesa Conduit to River
Pilot Knob Power Plant and Wasteway
CR at Pilot Knob
CR at Other Measured Flows
Other Measured Flows
CR at Unmeasured Flows
Unmeasured Flows
Northerly International Boundary
Cooper Wasteway
CR at Cooper Wasteway
Tijuana
CR at Tijuana
IBWC Mn 319
CR at IBWC Mn 319
NB Cooper Tijuana and IBWC Mn 319



Slot Label	Units	12/31/12 Mon	1/31/13 Thu	2/28/13 Thu	3/31/13 Sun	4/30/13 Tue	5/31/13 Fri	6/30/13 Sun	7/31/13 Wed	8/31/13 Sat	9/30/13 Mon	10/31/13 Thu	11/30/13 Sat	12/31/13 Tue
DPOC Valve Switches														
DPOC 1 to River	NONE	NaN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DPOC 2 to River	NONE	NaN	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DPOC 3 to River	NONE	NaN	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 8 to DPOC 2	NONE	NaN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 10 to DPOC 2	NONE	NaN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 13 to DPOC 2	NONE	NaN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DPOC #1 Wells														
SG 1 Pumping Fraction	NONE	NaN	1.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 2 Pumping Fraction	NONE	NaN	1.33	1.33	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 3 Pumping Fraction	NONE	NaN	1.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 4 Pumping Fraction	NONE	NaN	1.02	1.02	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 9R Pumping Fraction	NONE	NaN	1.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 11 Pumping Fraction	NONE	NaN	0.39	0.39	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 12 Pumping Fraction	NONE	NaN	1.17	1.17	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 716 Pumping Fraction	NONE	NaN	1.04	1.04	1.00	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00
DW 3 Pumping Fraction	NONE	NaN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DPOC #2 Wells														
SG 5 Pumping Fraction	NONE	NaN	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 6 Pumping Fraction	NONE	NaN	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 7 Pumping Fraction	NONE	NaN	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 8 Pumping Fraction	NONE	NaN	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 10 Pumping Fraction	NONE	NaN	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 13 Pumping Fraction	NONE	NaN	0.00	0.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00
SG 14 Pumping Fraction	NONE	NaN	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
SG 717 Pumping Fraction	NONE	NaN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DPOC #3 Wells														
SG 713 Pumping Fraction	NONE	NaN	1.00	1.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00
SG 714 Pumping Fraction	NONE	NaN	1.00	1.00	1.00	1.00	0.00	0.96	1.00	1.00	1.00	1.00	1.00	1.00
SG 719 Pumping Fraction	NONE	NaN	1.06	1.06	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SG 720 Pumping Fraction	NONE	NaN	0.95	0.95	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00

Model SCT

SCT SalinityOutput.sct (Salinity_Projection_Model_8-6-13.mdl.gz)

File Edit Slots Aggregation View Config DMI Run Diagnostics Go To

Dec 2012

Series Slots | Edit Series Slot List | Scalar Slots | Other Slots | Object Grid

Slot Label	Units	1/31/13 Thu	2/28/13 Thu	3/31/13 Sun	4/30/13 Tue	5/31/13 Fri	6/30/13 Sun	7/31/13 Wed	8/31/13 Sat	9/30/13 Mon	10/31/13 Thu	11/30/13 Sat	12/31/13 Tue
Flow Below Imperial Dam	acre-ft/month	30,466	15,156	21,658	24,129	30,480	29,510	21,862	22,038	20,234	19,173	18,942	19,847
Flow Below Imperial Dam PPM	ppm	711	684	650	649	660	651	666	681	688	703	720	744
DPOCs	acre-ft/month	2,384	3,291	3,996	4,536	747	4,437	3,924	4,207	4,071	4,207	4,071	4,207
DPOCs PPM	ppm	1,781	1,802	1,733	1,682	2,011	1,735	1,789	1,740	1,740	1,740	1,740	1,740
California WW	acre-ft/month	7,627	7,577	2,619	1,316	14,193	28,988	5,534	38,662	38,771	3,689	38,909	50,193
California WW PPM	ppm	721	705	652	646	661	654	666	681	688	703	720	744
Yuma Mesa Conduit	acre-ft/month	1,209	1,876	1,842	564	337	326	1,381	1,381	1,337	1,381	1,337	1,381
Yuma Mesa Conduit PPM	ppm	2,020	1,876	1,860	1,730	1,730	1,730	1,792	1,792	1,792	1,792	1,792	1,792
Pilot Knob	acre-ft/month	81,636	103,279	126,228	119,345	10,028	0	47,726	0	0	0	0	0
Pilot Knob PPM	ppm	715	681	651	649	665	0	666	0	0	0	0	0
Other Measured Flows	acre-ft/month	6,436	5,287	6,499	6,666	7,600	7,124	7,379	7,379	7,736	8,608	8,331	8,608
Other Measured Flows PPM	ppm	1,123	1,070	1,190	1,149	1,146	1,063	1,090	1,090	1,070	1,120	1,170	1,220
Unmeasured Flows	acre-ft/month	2,302	11,263	15,393	15,114	21,111	15,220	11,675	19,281	18,189	17,926	15,595	8,580
Unmeasured Flows PPM	ppm	3,498	1,434	1,041	1,010	1,074	951	2,080	1,180	1,000	1,180	1,460	1,430
Northerly International Boundary	acre-ft/month	132,060	147,729	178,235	171,669	84,496	85,607	99,481	92,948	90,337	54,984	87,184	92,816
Northerly International Boundary PPM	ppm	814	794	741	731	824	800	923	881	848	1,031	959	912
Cooper WW	acre-ft/month	208	154	183	154	70	85	74	128	222	591	389	259
Cooper WW PPM	ppm	719	680	652	646	659	652	666	681	688	703	720	744
Tijuana	acre-ft/month	0	0	0	0	0	0	0	0	0	377	0	0
Tijuana PPM	ppm	0	0	0	0	0	0	0	0	0	703	0	0
IBWC Min 319	acre-ft/month	0	0	10,717	28,270	14,652	11,496	0	0	0	0	0	0
IBWC Min 319 PPM	ppm	0	0	651	650	661	653	0	0	0	0	0	0
NIB, Cooper, Tijuana, and IBWC Min 319	acre-ft/month	132,267	147,883	189,135	200,094	99,218	97,188	99,555	93,076	90,559	55,952	87,573	93,075
NIB, Cooper, Tijuana, and IBWC Min 319 PPM	ppm	813.9	793.9	735.8	719.5	799.8	782.5	923.1	880.9	847.2	1,024.8	958.4	911.5
Colorado River Above Imperial Dam	acre-ft/month	354,744	374,658	555,253	639,233	546,545	517,051	554,409	482,362	447,907	392,053	336,121	273,557
Colorado River Above Imperial Dam PPM	ppm	714.0	679.0	650.0	649.0	660.0	652.0	666.0	680.6	688.5	702.9	720.0	743.5
Salinity Differential	ppm	99.9	114.9	85.8	70.5	139.8	130.5	257.2	200.3	158.7	321.9	238.4	168.0
Cumulative Salinity Differential	ppm	99.9	107.3	100.0	92.1	98.9	103.3	119.0	125.6	127.7	135.5	142.7	145.6

Future Work

- WQ Modeling from Lake Mead to Imperial Dam to improve salinity projections
- Extend model to Southerly International Boundary
- Enhanced projection features (multiple traces)
- Automated connection to groundwater model