Klamath Basin RiverWare Model

Summary Reports

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Phase 3 Task 1 of the Klamath RiverWare model project, says:

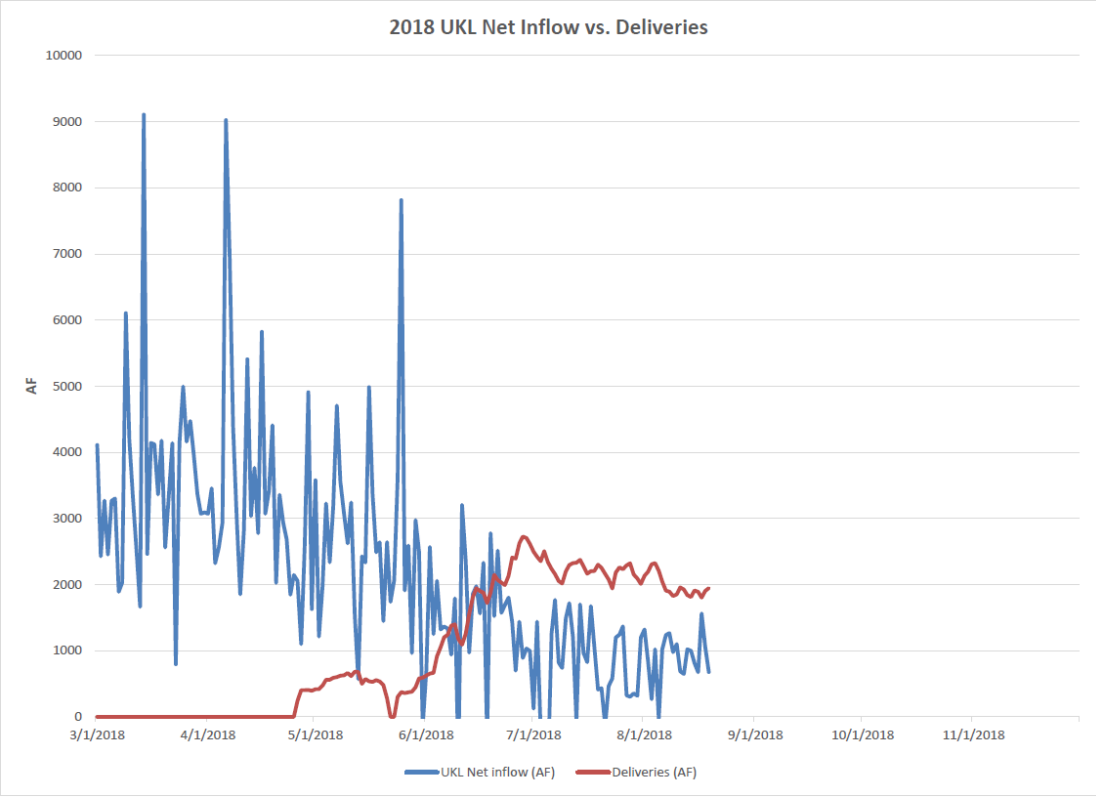
CU-CADSWES will support Reclamation's TSC in developing an automatic model summary report for the Klamath Basin RiverWare model. The elements of the report will be defined in consultation with KBAO. The report will be constructed to satisfy KBAO's regular reporting requirements. This work will commence while Klamath Basin RiverWare operations model is in the testing phase (Phase 3 Task 4).

This document describes KBAO's reporting requirements, RiverWare's output options, and a discussion on the reporting options available to meet KBAO's needs.

Requirements

KBAO provided an output report called the Deliveries and Demands (D and D) report. Following is a screenshot of the two page report. Page one is a plot of the UKL Net Inflow vs total Deliveries:

Figure 1. Deliveries and Demands Report, page 1: UKL Net Inflow vs Deliveries



Page two is a table showing the monthly and total statistics for deliveries over the period of record (2001 to 2010) and the year to date information for the current year, 2018. Also shown is project supply used and available:

Figure 2. Deliveries and Demands Report, page 2: Agricultural Deliveries table

Agricultural Deliveries in TAF (1980-2016, excluding 2001 and 2010)
through 8/19/2018

BiOp Calculated Project Supply (TAF) 310.881
Available Project Supply (TAF) 234.000

		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Mar-Sep Total	Oct-Nov Total	Estimated Remaining Demand (A1,A2 Mar-Sep)	Estimated Remaining Demand (Oct-Nov)	Estimated Remaining Spring/Summer Demand (A1 Mar-Nov, A2 Mar-Sept)	Remaining Water Supply from UKL
A Canal	min	0.00	3.30	17.52	27.68	33.23	28.45	16.16	1.16	0.00	126.34	1.16				
	median	0.00	14.66	40.59	45.79	53.49	50.47	36.18	11.01	0.00	241.18	11.01				
	average	0.03	16.38	39.65	45.31	52.96	49.11	35.13	10.87	0.00	238.57	10.87	55.19	4.46	59.65	
	max	0.38	28.42	53.50	56.06	62.16	58.41	45.04	16.79	0.03	303.97	16.82				
	2018 YTD	0.00	1.29	11.96	32.37	43.04	25.22	0.00	0.00	0.00	113.87	0.00				
Miller Hill	min	0.00	-0.45	-0.22	0.10	0.38	0.20	-0.23	-0.30	-0.13	-0.22	-0.43				
	median	0.00	-0.04	2.49	3.60	4.86	3.92	1.14	-0.08	0.00	15.97	-0.08				
	average	0.00	0.22	2.31	3.31	4.39	3.63	1.33	0.02	0.00	15.20	0.02	2.54	-0.08	2.46	
	max	0.04	2.76	5.95	6.06	6.45	5.91	3.78	0.80	0.00	30.96	0.80				
	2018 YTD	0.00	0.00	1.63	1.74	2.88	1.42	0.00	0.00	0.00	7.67	0.00				
Station 48	min	0.00	0.00	0.43	4.03	9.39	2.64	0.31	0.00	0.00	16.80	0.00				
	median	1.15	4.91	6.62	17.71	17.10	9.87	2.69	0.79	0.09	60.06	0.87				
	average	1.94	6.82	7.82	17.06	16.87	10.59	2.89	1.24	0.70	63.99	1.95	6.79	0.87	7.66	
	max	8.09	24.96	18.99	25.34	25.17	20.52	10.24	5.20	2.90	133.30	8.10				
	2018 YTD	0.00	0.56	6.53	16.61	19.54	8.38	0.00	0.00	0.00	51.62	0.00				
North Canal	min	0.00	0.00	1.03	2.28	2.12	1.26	0.84			7.53					
	median	0.77	1.33	2.26	4.26	5.38	3.95	2.92			20.87					
	average	1.16	1.57	2.62	4.16	5.22	3.64	2.94			21.32		4.33		4.33	
	max	6.08	3.92	5.42	6.22	7.55	5.91	5.17			40.28					
	2018 YTD	0.10	0.00	0.72	2.29	3.75	2.15	0.00	0.00	0.00	9.01	0.00				
Ady Canal to Ag	min	0.00	0.00	0.00	0.00	0.89	0.27	0.06			1.23					
	median	4.51	2.59	3.56	6.38	5.84	5.58	3.71			32.16					
	average	4.11	2.83	3.72	6.00	5.33	5.02	4.21			31.22		5.65		5.65	
	max	9.92	9.14	8.63	9.61	11.99	8.34	10.29			67.92					
	2018 YTD	0.00	0.00	0.00	3.66	4.42	3.64	0.00	0.00	0.00	11.72	0.00				
GW to LRDC	2018 YTD	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00				
Total Ag	min	0.30	5.46	19.90	42.20	50.13	36.14	26.61	1.98	0.49	180.74	2.47				
	median	7.26	24.41	55.31	76.49	90.43	74.92	47.40	17.79	7.46	376.23	25.24				
	average	7.24	28.00	56.18	75.84	84.77	71.99	46.50	17.44	8.11	370.52	25.55	269.16	25.24	294.41	
	max	16.40	62.10	87.92	97.39	101.58	87.82	60.80	28.33	16.51	514.01	44.85				
	2018 YTD	0.10	1.85	20.84	56.67	73.63	40.80	0.00	0.00	0.00	0.00	0.00				
Ag From UKL	min	0.00	3.27	17.17	33.74	46.68	34.06	24.82	0.93	0.00	159.74	0.93				
	median	0.50	20.42	49.14	70.25	84.80	65.32	40.27	8.27	0.00	330.70	8.27				
	average	2.13	23.46	50.32	69.37	79.70	65.33	40.01	8.98	0.35	330.32	9.33	65.56	7.11	72.67	
	max	10.87	61.17	87.09	88.53	97.30	81.39	59.51	15.53	5.76	485.85	21.30				
	est 2018 distribution	0.00	1.85	14.48	51.18	69.22	54.15	34.63	7.11	0.00	225.52	7.11				
	2018 YTD	0.00	1.85	14.48	51.18	69.22	37.68	0.00	0.00	0.00	174.41	0.00				
Ady to Refuge	2018 YTD	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.57	0.00	27.37	18.15	45.52	
														Project Supply - Used YTD =		59.023

In addition to this PDF report, KBAO says they would like to report values about the Environment Water Account (EWA) including the total used and the total remaining.

Thus, the requirements for this reporting task are to produce a report that shows this same summary information as the D and D report and information about the EWA account. In addition, the report should show other information that is available and could be useful to KBAO or stakeholders.

RiverWare's Output Devices

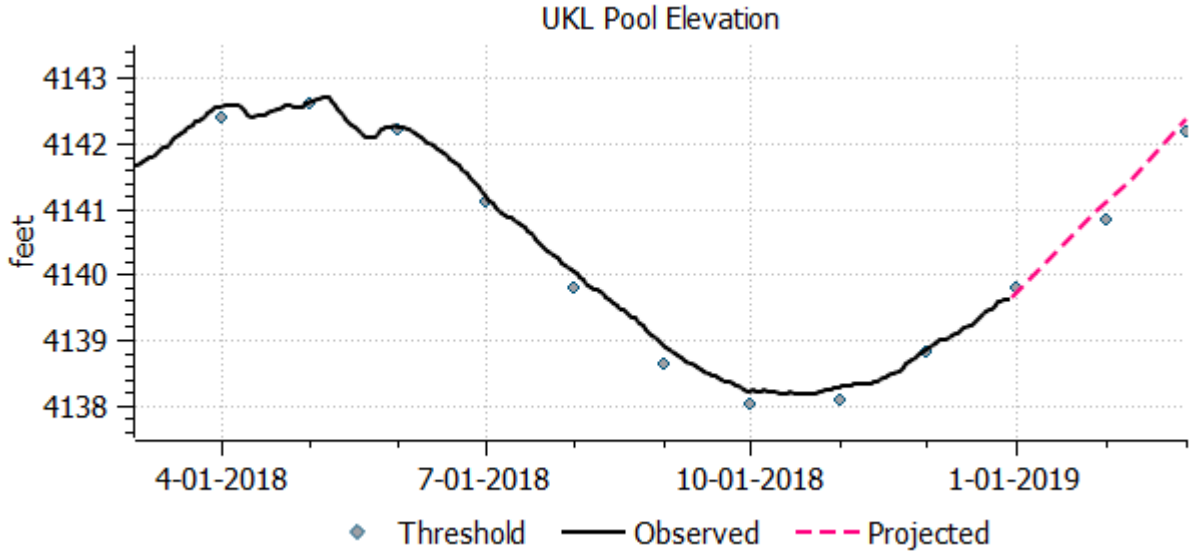
The following section describes RiverWare's output options with examples from the Klamath RiverWare model.

Plots

RiverWare has a feature rich plotting package. Although the plots won't look exactly the same as those produced in the IGD Calculator, the plots will be close. Figure 3. shows a sample plot from the model.

The black line is the observed elevation while the pink dotted line is the projected elevation. The diamonds represent the thresholds for which UKL's Pool Elevation should remain above.

Figure 3. Sample UKL Pool Elevation with thresholds



Tabular Series Slot Reports

RiverWare can produce two HTML output formats, Tabular Series Slot Reports and Model Reports. Often Tabular Series Slot Reports are included in Model Reports.

Tabular Series Slot Reports show time series data in a tabular format in either text or HTML output. The user selects the slots to show, the timesteps at which to show and then whether to show summary information such as min, max, or average. The user can choose some formatting options for the HTML.

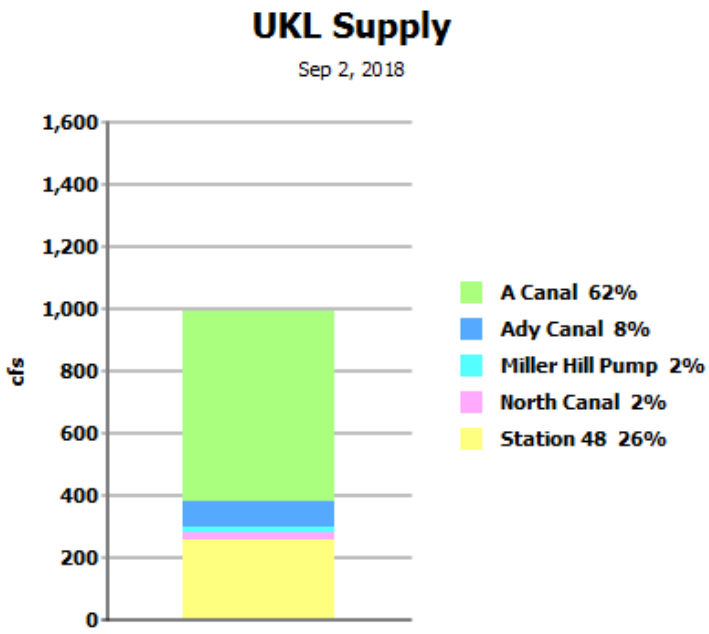
Model Reports

RiverWare can output information to a HTML report using the "Model Report" output device. The content, organization, and formatting is highly configurable. Reports are commonly used for two purposes: documenting the model and ruleset and providing output results for distribution to stakeholders, other agencies, or others. Results can be output in both tabular and graphical format including plots, charts and the output canvas.

Charts

RiverWare can produce pie and bar charts. These are useful to show the relative amount compared to the total amount in the basin. Figure 4. shows a bar chart of the water supplied by UKL (i.e. deliveries) for a particular date.

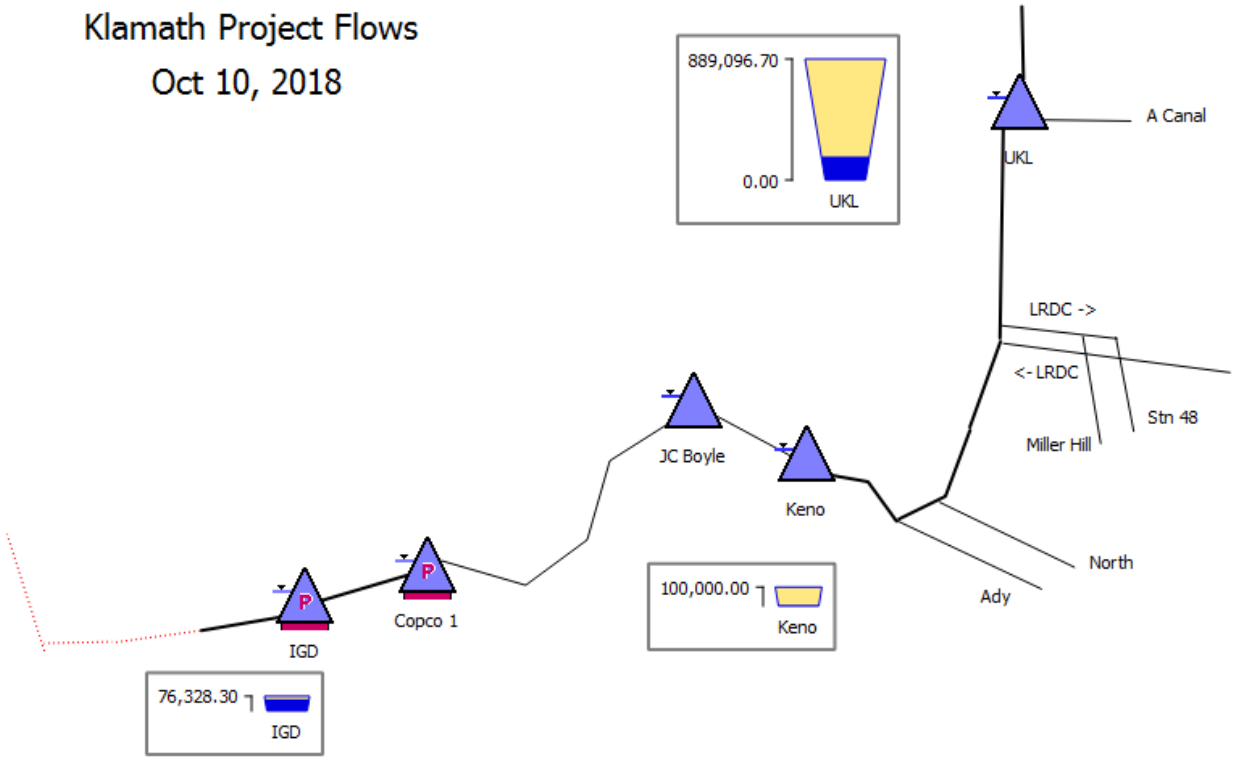
Figure 4. Sample Bar Chart showing UKL supply



Output Canvas

The Output Canvas provides spatially distributed output and can include teacups, flow lines, and other items. Figure 5. Shows a sample screenshot of an output canvas on a particular date. The canvas can be animated to show how the volume (teacups) and flows (flow lines) change over time. As flows increase, the lines get thicker; as they cross defined thresholds the colors and line types change. The animation can be exported as an image or a movie file.

Figure 5. Screenshot of sample Output Canvas showing teacups and flow lines



Additional Utilities

This section describes additional utilities that can be used to compute summary information.

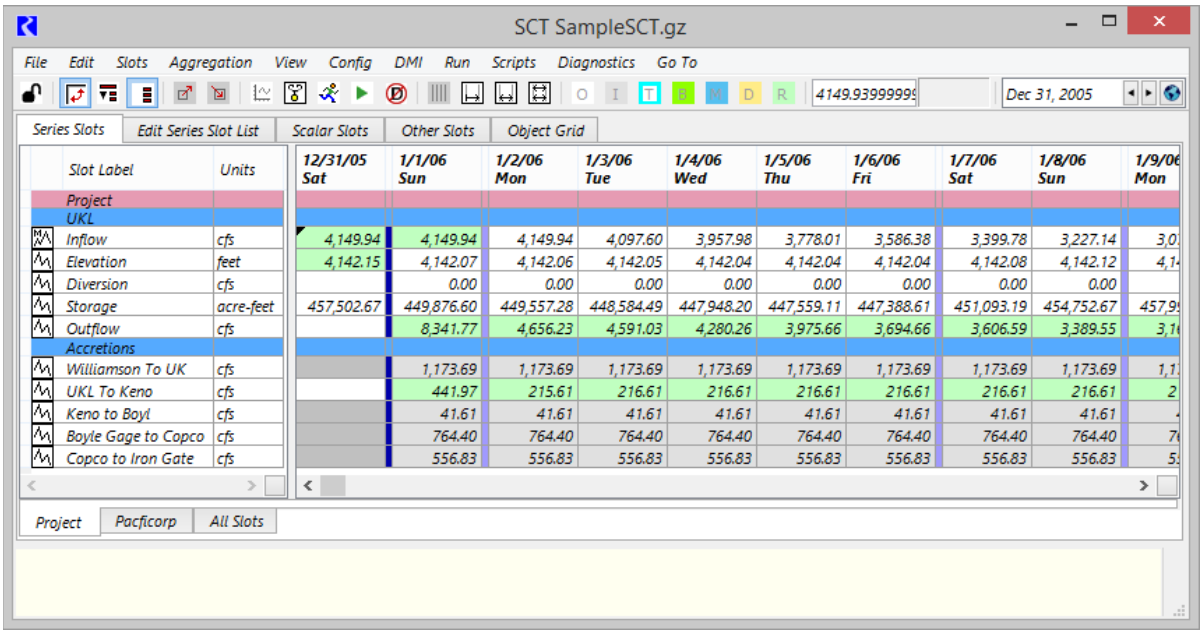
System Control Tables (SCTs)

System Control Tables (SCTs) are a highly customizable, editable spreadsheet-like view into the data stored in slots. The model developer or operator can create one or more SCTs that show the data how they like to see it. If desired, different operators can have different SCTs allowing each operator a customized view. SCT don't just show the data, but the data can be edited directly on the SCT, runs can be made, and DMIs and scripts can be executed.

SCTs are included in this document because they provide summary information within RiverWare for the operators and those running the model.

Figure 6. is a screenshot of a possible SCT showing data from the basin study.

Figure 6. Sample SCT with time as columns and data variables as rows



SCTs can be printed to a piece of paper or a PDF file (using a PDF print driver). In addition, data on the SCT can be copy/pasted to an external application. Any data in RiverWare can be exported to text/excel/DSS files via a DMI.

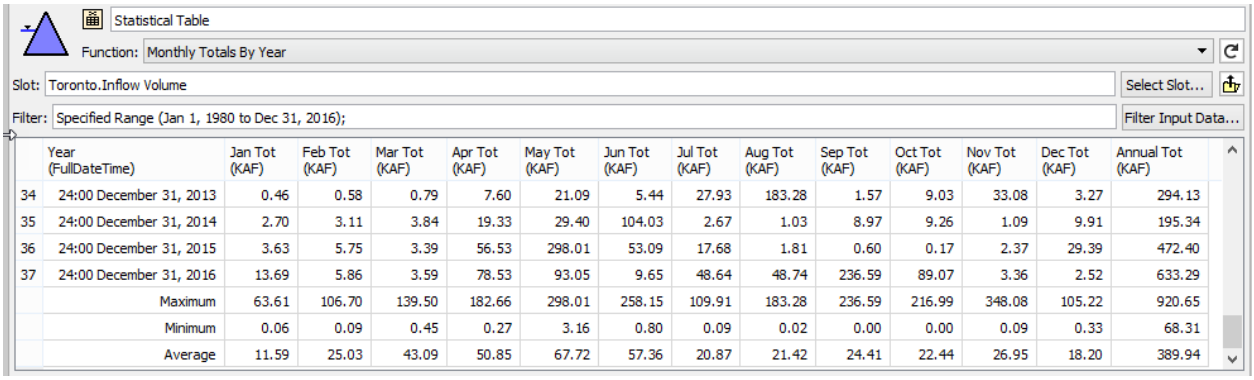
Statistical Table Slots

Statistical table slots compute statistics using the data contained on the specified series slot. The user specifies:

- An input series slot
- A statistical function, such as a flow duration curve, or monthly averages
- Any filters to apply to the input data

The statistical data table can then be plotting or exported to another application. The following figure shows the Monthly Total by Year. It shows the total volume for each month of each year and then the Max, Min, and Average value. The total annual volumes are also shown. The summary statistics (Max, Min and average) are similar to those shown on the D and D report, although the median is not shown.

Figure 7. Sample Statistical Table Slot showing Monthly Totals



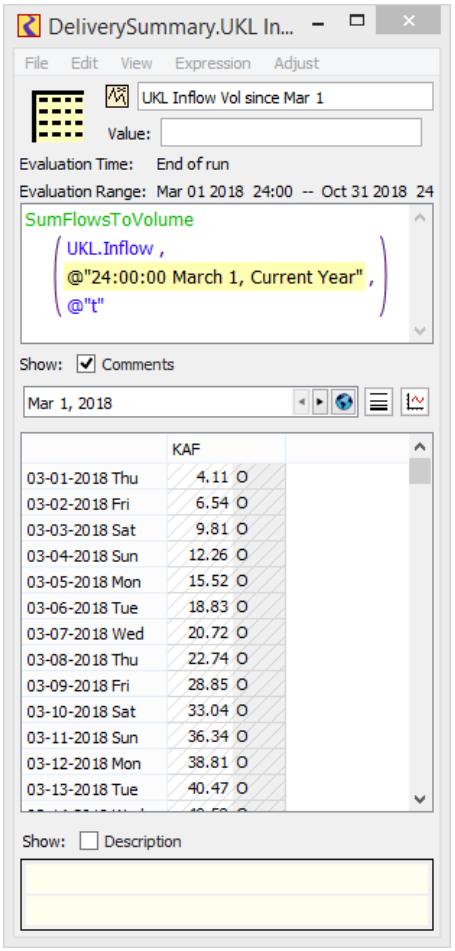
	Year (FullDateTime)	Jan Tot (KAF)	Feb Tot (KAF)	Mar Tot (KAF)	Apr Tot (KAF)	May Tot (KAF)	Jun Tot (KAF)	Jul Tot (KAF)	Aug Tot (KAF)	Sep Tot (KAF)	Oct Tot (KAF)	Nov Tot (KAF)	Dec Tot (KAF)	Annual Tot (KAF)
34	24:00 December 31, 2013	0.46	0.58	0.79	7.60	21.09	5.44	27.93	183.28	1.57	9.03	33.08	3.27	294.13
35	24:00 December 31, 2014	2.70	3.11	3.84	19.33	29.40	104.03	2.67	1.03	8.97	9.26	1.09	9.91	195.34
36	24:00 December 31, 2015	3.63	5.75	3.39	56.53	298.01	53.09	17.68	1.81	0.60	0.17	2.37	29.39	472.40
37	24:00 December 31, 2016	13.69	5.86	3.59	78.53	93.05	9.65	48.64	48.74	236.59	89.07	3.36	2.52	633.29
	Maximum	63.61	106.70	139.50	182.66	298.01	258.15	109.91	183.28	236.59	216.99	348.08	105.22	920.65
	Minimum	0.06	0.09	0.45	0.27	3.16	0.80	0.09	0.02	0.00	0.00	0.09	0.33	68.31
	Average	11.59	25.03	43.09	50.85	67.72	57.36	20.87	21.42	24.41	22.44	26.95	18.20	389.94

Expression Slots

Expression slots contain user defined computations. There are both series slots (at a user specified timestep size) and scalar slots representing a single value computation. Expression slots can be computed at the beginning of the run, beginning of the timestep, end of timestep, end of run or interactively.

Expression slots (and rule computations) provide the ultimate flexibility to perform statistical calculations as the user can define any computation desired.

An example expression series slot is shown. It sums the UKL Inflow volume since March 1 and converts it to a volume. This is a similar computation that would occur with demands on the D and D report.



Reporting Proposal

To meet KBAO's needs a combination of RPL logic and expression slots, plots and other functionality will be used to compute the desired summary information. Model reports will be used to output the information to an HTML file outside of RiverWare. The format of the data will not match the existing D and D Report exactly, but the same information can be included.

> **Note:** With development, RiverWare could be enhanced to produce reports more similar to the D and D report. We will not explore this further in this document, but that is always an option. A funding source would be needed to do further design and implementation. We do list some ideas for possible enhancement at the end of this report.

In this section we will show a prototype HTML report that displays the general structure. We call this a prototype as feedback from KBAO will inform how the final report should be structured and any additional information to show. The proposal has 3 components as follows:

1. Use of RPL Logic

Although statistical slots provide much of the desired information, they do not provide all of the data. As a result, we propose to use expression slots or rules to compute summary information on custom slots. These will include all of the information shown on the D and D reports.

2. Plots

Plots have been created to show the Net UKL Inflow vs Deliveries as shown in Figure 1. Plots showing the Pool Elevations and Thresholds as shown in Figure 3. are also available.

3. Model Reports will bring it all together

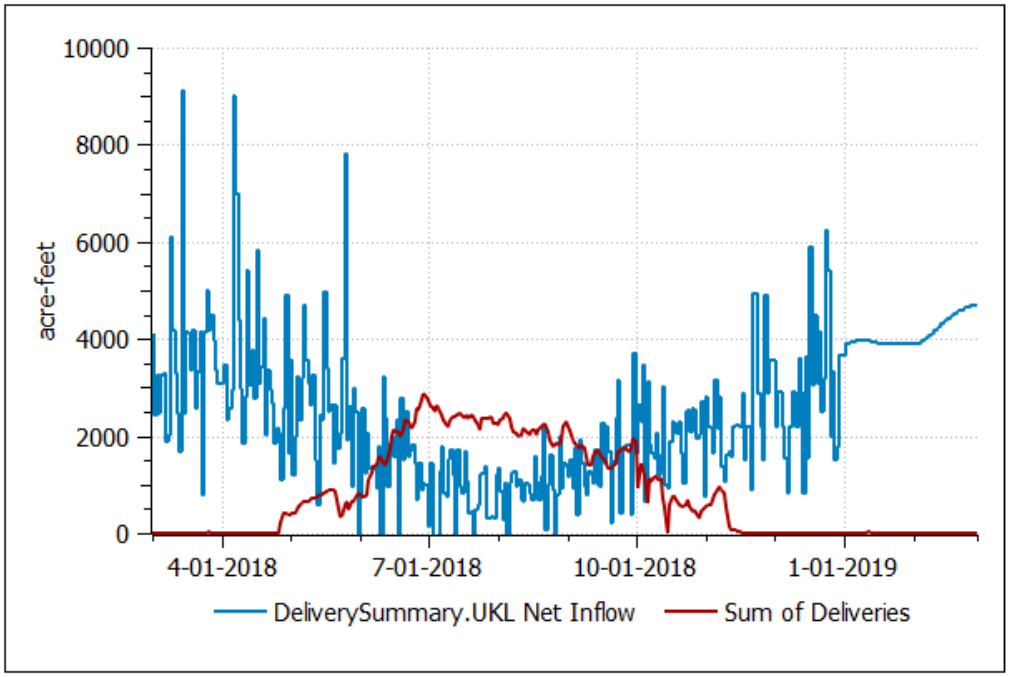
A model report will be created to bring all of this together.

The prototype report was created in the model using mostly real data but some dummy data was used for historical values that were not in the development model. The report only includes the A Canal but has a place holder for other delivery locations. In addition, supplement information like the threshold plot and output canvas were included as well, but are not shown here as the same information is shown above.

Klamath RiverWare Model Deliveries and Demands

1 Plots

UKL Net Inflows vs. Deliveries



2 A Canal

	min KAF	median KAF	average KAF	max KAF	2018 YTD KAF
03-2018	0.00	0.00	0.03	0.38	0.00
04-2018	3.30	14.66	16.38	28.42	1.29
05-2018	17.52	40.59	39.65	53.50	11.96
06-2018	27.68	45.79	45.31	56.06	32.37
07-2018	33.23	53.49	52.96	62.16	43.04
08-2018	28.45	50.47	49.11	58.41	40.19
09-2018	16.16	36.18	35.13	45.04	30.44
10-2018	1.16	11.01	10.87	16.79	6.98
11-2018	0.00	0.00	0.00	0.03	0.00
12-2018	0.00	0.00	0.00	0.00	0.00
Mean:					16.63

Slot	Value	Units
Mar to Sep Total	159.28	KAF
Oct to Nov Total	6.98	KAF

POR summary statistics

	min KAF	median KAF	average KAF	max KAF
Mar to Sep	126.34	241.18	238.57	303.97
Oct to Nov	1.16	11.01	10.87	16.82

A Canal Remaining

Slot	Value	Units
Estimated Remaining Demand A1 A2 Mar to Sep	55.19	KAF
Estimated Remaining Demand Oct to Nov	4.46	KAF
Estimated Remaining Spring Summer Demand	59.65	KAF
Remaining Water Supply from UKL	0.00	KAF

3 Miller Hill Pump

TODO: Create slots for this and other delivery points.

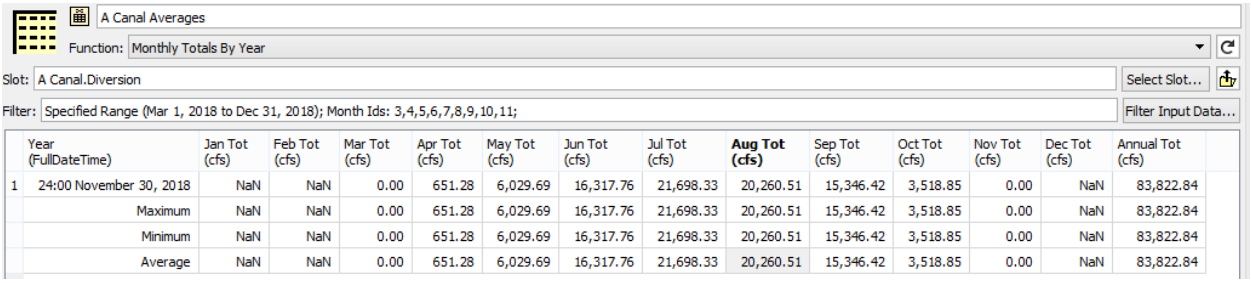
4 System Information

Slot	Value	Units
1 BiOp Project Supply	310.88	KAF
2 Available Project Supply	234.00	KAF
3 Project Supply minus Used YTD	59.02	KAF

Enhancements ideas

While working on this process, we noted a number of enhancements that could be made to improve reporting in RiverWare. These are noted below:

- Include an HTML representation of SCT data in a model report.
- Add a script action to print an SCT to a PDF file.
- The D and D report uses TAF; RiverWare has either 1000 acre-feet or KAF. It would be trivial to add TAF as a valid unit.
- Improve Statistical Table slot Monthly Totals by Year function:
  - Add an option to “Show only yearly data” or “Show only summary data” as configuration option. Yearly data is needed for current year. Summary data is needed for historical period
  - Don’t show columns for months when that month is filtered out. In the screenshot below, it is filtered to show Mar-Nov, but Jan, Feb and Dec are still shown.
  - In the model report slot item for the same statistical slot, show max, min, average as labels. For example, in the second screenshot below, the Year column shows Dec 31, 1799 instead of Maximum, Minimum, and Average shown on the slot dialog.


A Canal Averages

Function: Monthly Totals By Year

Slot: A Canal.Diversion — Select Slot...

Filter: Specified Range (Mar 1, 2018 to Dec 31, 2018); Month Ids: 3,4,5,6,7,8,9,10,11; — Filter Input Data...

	Year (FullDateTime)	Jan Tot (cfs)	Feb Tot (cfs)	Mar Tot (cfs)	Apr Tot (cfs)	May Tot (cfs)	Jun Tot (cfs)	Jul Tot (cfs)	**Aug Tot (cfs)**	Sep Tot (cfs)	Oct Tot (cfs)	Nov Tot (cfs)	Dec Tot (cfs)	Annual Tot (cfs)
1	24:00 November 30, 2018	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	NaN	83,822.84
	Maximum	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	NaN	83,822.84
	Minimum	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	NaN	83,822.84
	Average	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	NaN	83,822.84

	Year FullDateTime	Jan Tot cfs	Feb Tot cfs	Mar Tot cfs	Apr Tot cfs	May Tot cfs	Jun Tot cfs	Jul Tot cfs	Aug Tot cfs	Sep Tot cfs	Oct Tot cfs	Nov Tot cfs	Dec Tot cfs	Annual Tot cfs
1	24:00 Dec 31, 2018	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	0.00	83,822.84
2	24:00 Dec 31, 1799	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	0.00	83,822.84
3	24:00 Dec 31, 1799	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	0.00	83,822.84
4	24:00 Dec 31, 1799	NaN	NaN	0.00	651.28	6,029.69	16,317.76	21,698.33	20,260.51	15,346.42	3,518.85	0.00	0.00	83,822.84