

Estimation of Daily Flows in CalSim 3 for Sites Project

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DISCLAIMER

This is a work in progress. All slides, figures, tables, and information is draft and pre-decisional but is presented with permission from the Sites Project Authority.

Outline

- Background
 - Why produce daily flow estimates
- Methodology
 - Data gathered
 - Daily Pattern Development
 - Calculations implemented in CalSim wresl file
- Sites Diversion Criteria
 - Criteria implemented on a daily basis
 - Daily Diversion Control Figures

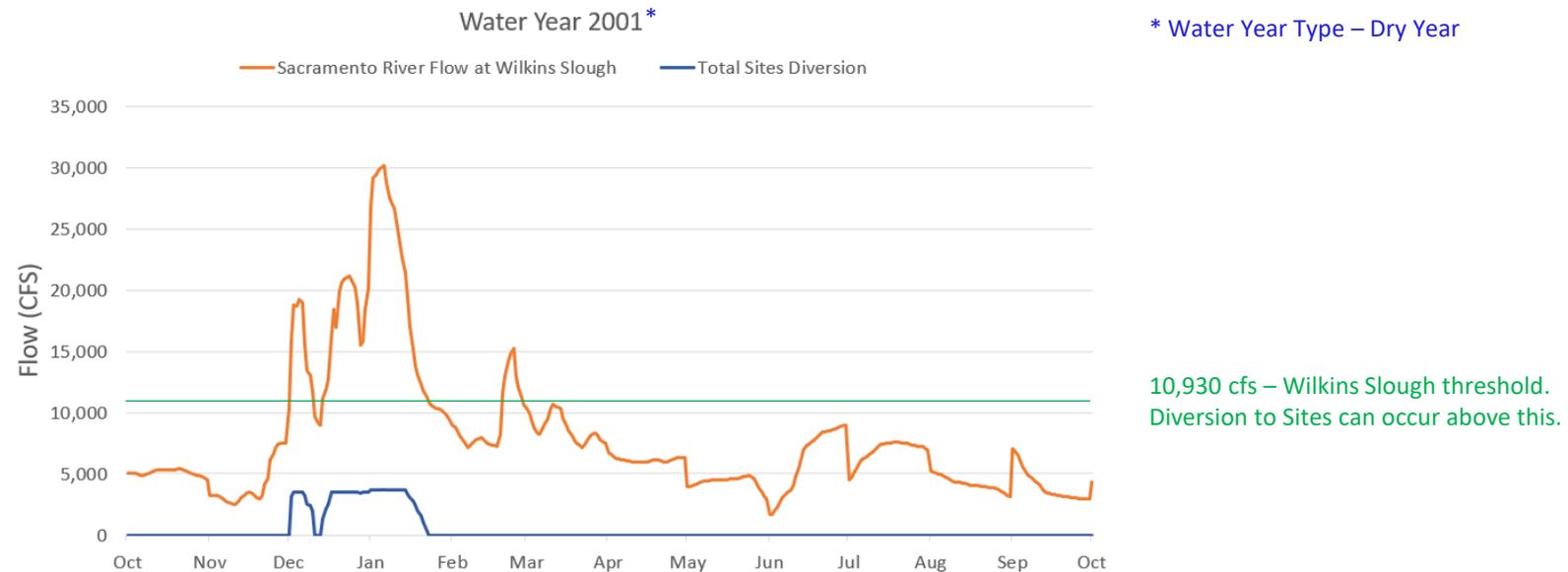
```
weir_steps_dailyops.wresl
```

```
146
147 ! Sacramento River flow at Bend Bridge
148 define qsac257_1 {value QsacREG_1+QsacUNREG_1}
149 define qsac257_2 {value QsacREG_2+QsacUNREG_2}
150 define qsac257_3 {value QsacREG_3+QsacUNREG_3}
151 define qsac257_4 {value QsacREG_4+QsacUNREG_4}
152 define qsac257_5 {value QsacREG_5+QsacUNREG_5}
153 define qsac257_6 {value QsacREG_6+QsacUNREG_6}
154 define qsac257_7 {value QsacREG_7+QsacUNREG_7}
155 define qsac257_8 {value QsacREG_8+QsacUNREG_8}
156 define qsac257_9 {value QsacREG_9+QsacUNREG_9}
157 define qsac257_10 {value QsacREG_10+QsacUNREG_10}
158 define qsac257_11 {value QsacREG_11+QsacUNREG_11}
159 define qsac257_12 {value QsacREG_12+QsacUNREG_12}
160 define qsac257_13 {value QsacREG_13+QsacUNREG_13}
161 define qsac257_14 {value QsacREG_14+QsacUNREG_14}
162 define qsac257_15 {value QsacREG_15+QsacUNREG_15}
163 define qsac257_16 {value QsacREG_16+QsacUNREG_16}
164 define qsac257_17 {value QsacREG_17+QsacUNREG_17}
165 define qsac257_18 {value QsacREG_18+QsacUNREG_18}
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167 define qsac257_20 {value QsacREG_20+QsacUNREG_20}
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169 define qsac257_22 {value QsacREG_22+QsacUNREG_22}
170 define qsac257_23 {value QsacREG_23+QsacUNREG_23}
171 define qsac257_24 {value QsacREG_24+QsacUNREG_24}
172 define qsac257_25 {value QsacREG_25+QsacUNREG_25}
173 define qsac257_26 {value QsacREG_26+QsacUNREG_26}
174 define qsac257_27 {value QsacREG_27+QsacUNREG_27}
175 define qsac257_28 {value QsacREG_28+QsacUNREG_28}
176 define qsac257_29 {value QsacREG_29+QsacUNREG_29}
177 define qsac257_30 {value QsacREG_30+QsacUNREG_30}
178 define qsac257_31 {value QsacREG_31+QsacUNREG_31}
```

Background

Background

- CalSim – runs on monthly timestep – not a daily representation of flows
 - Process was to include daily flow inputs for Sacramento, American, and Feather Rivers
- Purpose
 - Allow for more accurate representation of Sites diversion criteria
 - More accurate representation of daily variability in river flows and weir spills



Methodology

Data for Analysis

- Gathered historic hydrologic data from
 - USGS – United States Geological Survey
 - CDEC – California Data Exchange Center

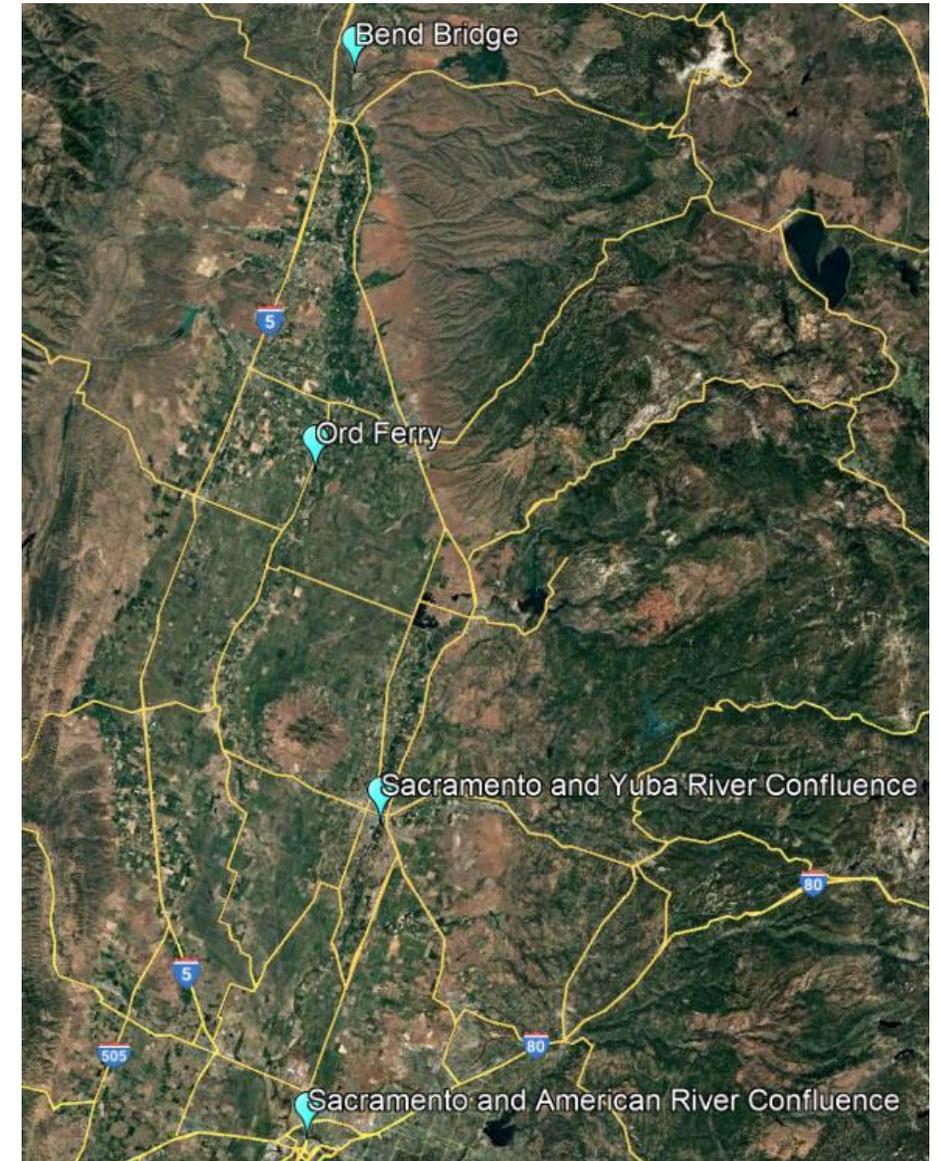


CALIFORNIA DATA EXCHANGE CENTER
CALIFORNIA DEPARTMENT OF
WATER RESOURCES

- The historic hydrologic data was used for USRDOM (Upper Sacramento Daily Operations Model) to simulate daily flows for Sacramento river tributaries

Daily Patterns

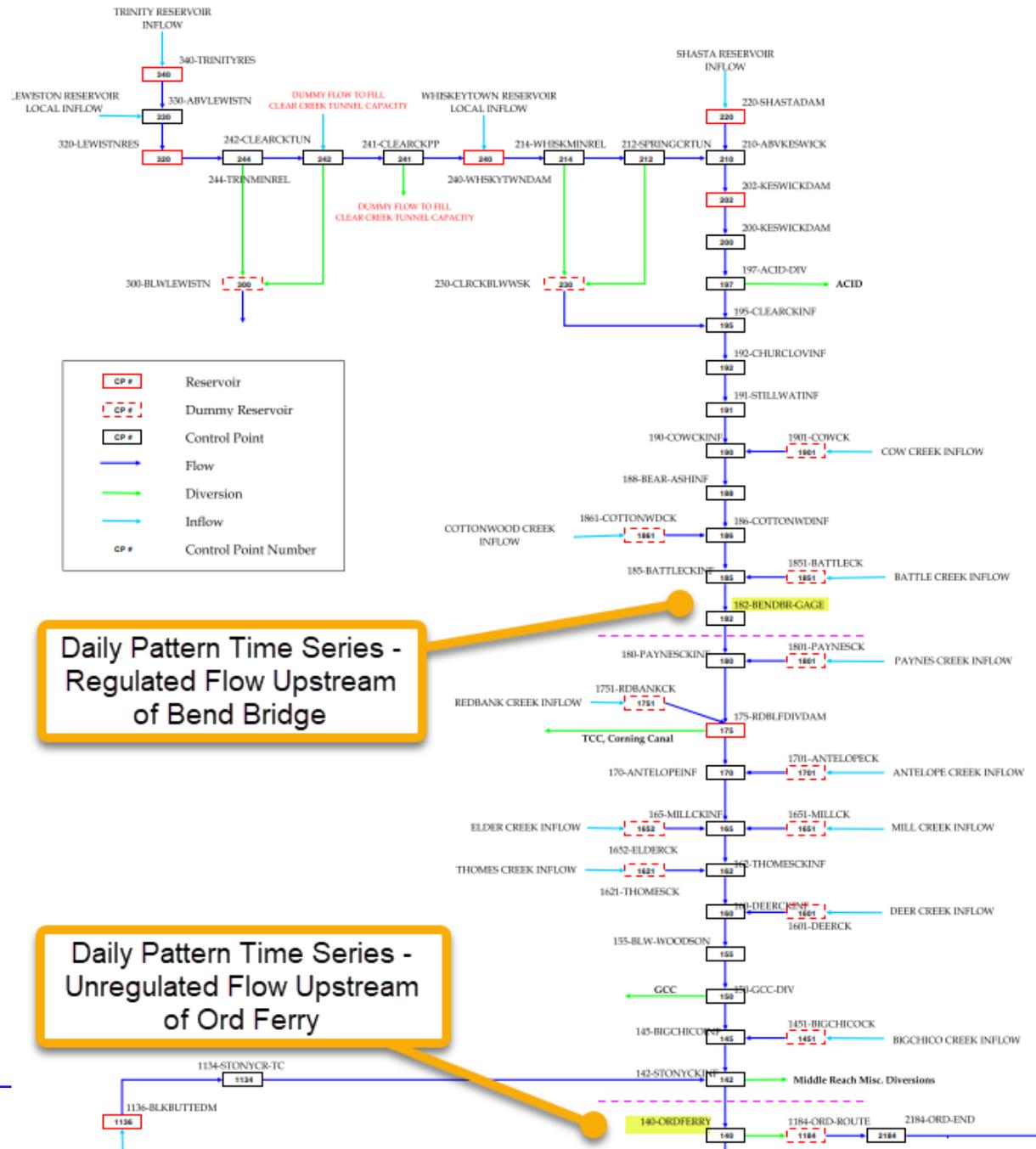
- Developed daily patterns by taking daily observed flow divided by the monthly average observed flow
- In CalSim, the daily flows are estimated by multiplying the monthly flow simulated by CalSim with the corresponding daily pattern ratios
- Four daily pattern time series were developed
 - Regulated flow upstream of Bend Bridge
 - Unregulated flow upstream of Ord Ferry
 - Feather River flow at the confluence of the Sacramento River
 - American River flow at the confluence of the Sacramento River



USRDOM Schematic

– Source:

- USRDOM Development, Calibration, and Application
- Prepared for USBR Mid Pacific Region
- August 2011
- Jacobs (Legacy CH2MHill)



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Daily Pattern Mapping

- Daily flow variability was created for two periods: pre-development and post-development of major dams or reservoirs in the river basins.
- Post-Development Period
 - Used the historic data and USRDOM data (when historic data had gaps) to generate daily patterns that are applied directly to the post development period, which is water years 1965-2021.
- Pre-Development Period
 - Before water year 1965 - Not all the dams and reservoirs were developed. USGS and CDEC has minimal historic records.
 - For the pre-development period or when observation data was unavailable, each month was assigned the daily pattern of the month from the post-development period with the most similar average monthly flow

/CALSIM/AMERDAY14/VOL-FRACTION/01JA...		
File Edit View Help		
Ordinate	Date / Time	AMERDAY14 VOL-FRACTION L2020A
Units		NONE
Type		PER-AVER
1	31 Oct 1921, 24:00	0.0347
2	30 Nov 1921, 24:00	0.0329
3	31 Dec 1921, 24:00	0.0324
4	31 Jan 1922, 24:00	0.0179
5	28 Feb 1922, 24:00	0.0290
6	31 Mar 1922, 24:00	0.0334
7	30 Apr 1922, 24:00	0.0322
8	31 May 1922, 24:00	0.0329
9	30 Jun 1922, 24:00	0.0327
10	31 Jul 1922, 24:00	0.0293
11	31 Aug 1922, 24:00	0.0291
12	30 Sep 1922, 24:00	0.0312
13	31 Oct 1922, 24:00	0.0317
14	30 Nov 1922, 24:00	0.0343
15	31 Dec 1922, 24:00	0.0072
16	31 Jan 1923, 24:00	0.0077
17	28 Feb 1923, 24:00	0.0212
18	31 Mar 1923, 24:00	0.0307
19	30 Apr 1923, 24:00	0.0321
20	31 May 1923, 24:00	0.0502
21	30 Jun 1923, 24:00	0.0215
22	31 Jul 1923, 24:00	0.0334
23	31 Aug 1923, 24:00	0.0459
24	30 Sep 1923, 24:00	0.0324
25	31 Oct 1923, 24:00	0.0321
26	30 Nov 1923, 24:00	0.0329
27	31 Dec 1923, 24:00	0.0324
28	31 Jan 1924, 24:00	0.0323
29	29 Feb 1924, 24:00	0.0371
30	31 Mar 1924, 24:00	0.0312
31	30 Apr 1924, 24:00	0.0324
32	31 May 1924, 24:00	0.0323
33	30 Jun 1924, 24:00	0.0335
34	31 Jul 1924, 24:00	0.0303
35	31 Aug 1924, 24:00	0.0404
36	30 Sep 1924, 24:00	0.0330
37	31 Oct 1924, 24:00	0.0330
38	30 Nov 1924, 24:00	0.0324
39	31 Dec 1924, 24:00	0.0327
40	31 Jan 1925, 24:00	0.0321
41	28 Feb 1925, 24:00	0.0669
42	31 Mar 1925, 24:00	0.0432
43	30 Apr 1925, 24:00	0.0339
44	31 May 1925, 24:00	0.0502
45	30 Jun 1925, 24:00	0.0314
46	31 Jul 1925, 24:00	0.0341
47	31 Aug 1925, 24:00	0.0421
48	30 Sep 1925, 24:00	0.0324
..

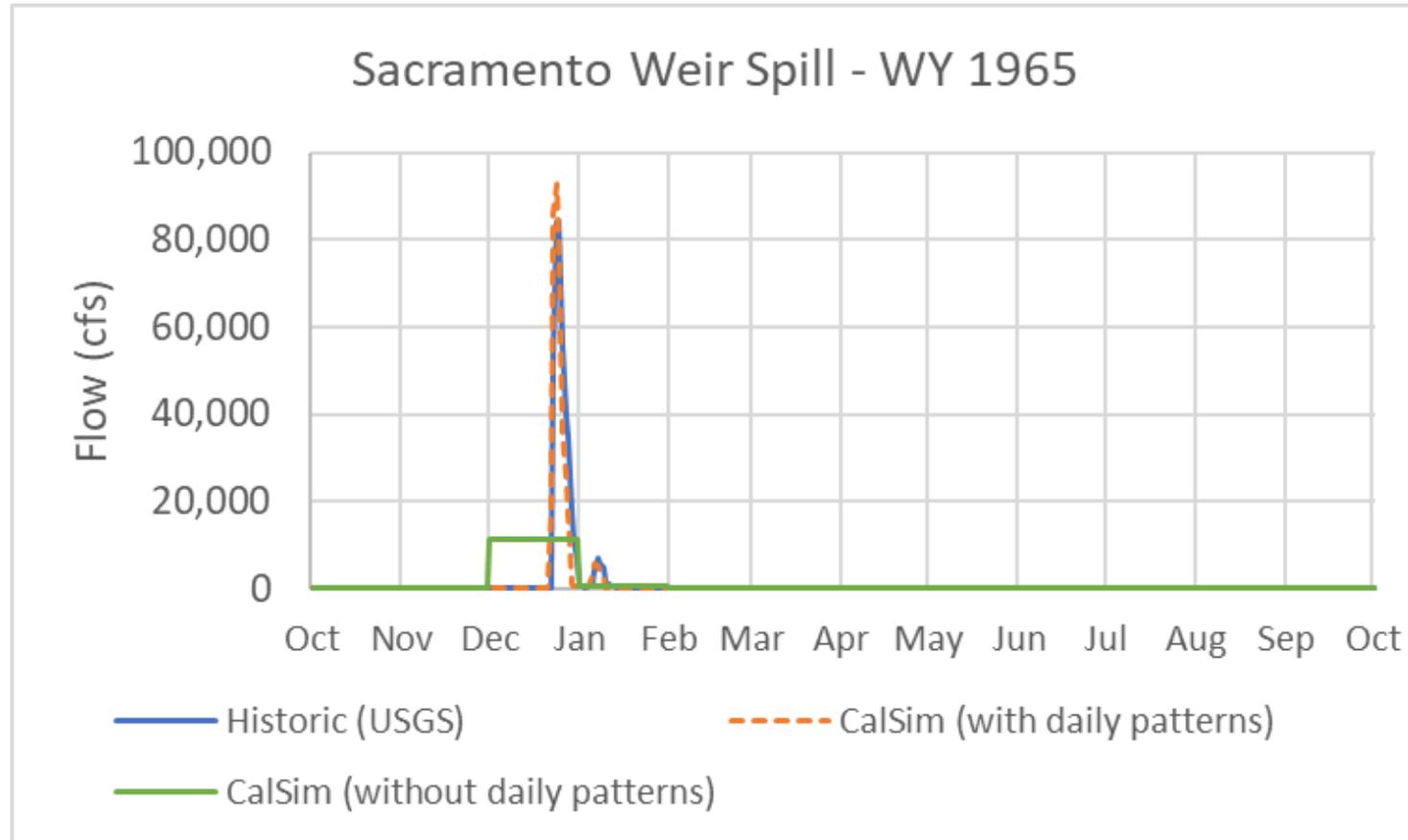
Implementation in CalSim

- Daily flow calculations are implemented in the monthly weighted cycle in a wresl file called WeirStepsDailyOps and daily flow estimates are calculated for each node along the Sacramento river from Bend Bridge to the Sacramento Weir, carried downstream through mass balance
- These are used to estimate weir spills into the Sutter Bypass and Yolo Bypass
- These are also used for daily calculations in the Sites_diversion.wresl file

```
weir_steps_dailyops.wresl
1802
1803 !Sacramento River flow upstream of Fremont Weir (without Sutter Bypass inflow)
1804 !Add daily flow downstream of Tisdale to the change in Sac R flow between Tisc
1805 define qsac085_1 {value Qsac122_1+qsac085_prv-qsac122_prv - C_SSL001_prv}
1806 define qsac085_2 {value Qsac122_2+qsac085_prv-qsac122_prv - C_SSL001_prv}
1807 define qsac085_3 {value Qsac122_3+qsac085_prv-qsac122_prv - C_SSL001_prv}
1808 define qsac085_4 {value Qsac122_4+qsac085_prv-qsac122_prv - C_SSL001_prv}
1809 define qsac085_5 {value Qsac122_5+qsac085_prv-qsac122_prv - C_SSL001_prv}
1810 define qsac085_6 {value Qsac122_6+qsac085_prv-qsac122_prv - C_SSL001_prv}
1811 define qsac085_7 {value Qsac122_7+qsac085_prv-qsac122_prv - C_SSL001_prv}
1812 define qsac085_8 {value Qsac122_8+qsac085_prv-qsac122_prv - C_SSL001_prv}
1813 define qsac085_9 {value Qsac122_9+qsac085_prv-qsac122_prv - C_SSL001_prv}
1814 define qsac085_10 {value Qsac122_10+qsac085_prv-qsac122_prv - C_SSL001_prv}
1815 define qsac085_11 {value Qsac122_11+qsac085_prv-qsac122_prv - C_SSL001_prv}
1816 define qsac085_12 {value Qsac122_12+qsac085_prv-qsac122_prv - C_SSL001_prv}
1817 define qsac085_13 {value Qsac122_13+qsac085_prv-qsac122_prv - C_SSL001_prv}
1818 define qsac085_14 {value Qsac122_14+qsac085_prv-qsac122_prv - C_SSL001_prv}
1819 define qsac085_15 {value Qsac122_15+qsac085_prv-qsac122_prv - C_SSL001_prv}
1820 define qsac085_16 {value Qsac122_16+qsac085_prv-qsac122_prv - C_SSL001_prv}
1821 define qsac085_17 {value Qsac122_17+qsac085_prv-qsac122_prv - C_SSL001_prv}
1822 define qsac085_18 {value Qsac122_18+qsac085_prv-qsac122_prv - C_SSL001_prv}
1823 define qsac085_19 {value Qsac122_19+qsac085_prv-qsac122_prv - C_SSL001_prv}
1824 define qsac085_20 {value Qsac122_20+qsac085_prv-qsac122_prv - C_SSL001_prv}
1825 define qsac085_21 {value Qsac122_21+qsac085_prv-qsac122_prv - C_SSL001_prv}
1826 define qsac085_22 {value Qsac122_22+qsac085_prv-qsac122_prv - C_SSL001_prv}
1827 define qsac085_23 {value Qsac122_23+qsac085_prv-qsac122_prv - C_SSL001_prv}
1828 define qsac085_24 {value Qsac122_24+qsac085_prv-qsac122_prv - C_SSL001_prv}
1829 define qsac085_25 {value Qsac122_25+qsac085_prv-qsac122_prv - C_SSL001_prv}
1830 define qsac085_26 {value Qsac122_26+qsac085_prv-qsac122_prv - C_SSL001_prv}
1831 define qsac085_27 {value Qsac122_27+qsac085_prv-qsac122_prv - C_SSL001_prv}
1832 define qsac085_28 {value Qsac122_28+qsac085_prv-qsac122_prv - C_SSL001_prv}
```

Implementation in CalSim

- The following figure demonstrates how the daily pattern logic allows for more accurate representation of weir spills on a sub-monthly basis.



Sites Diversion Criteria

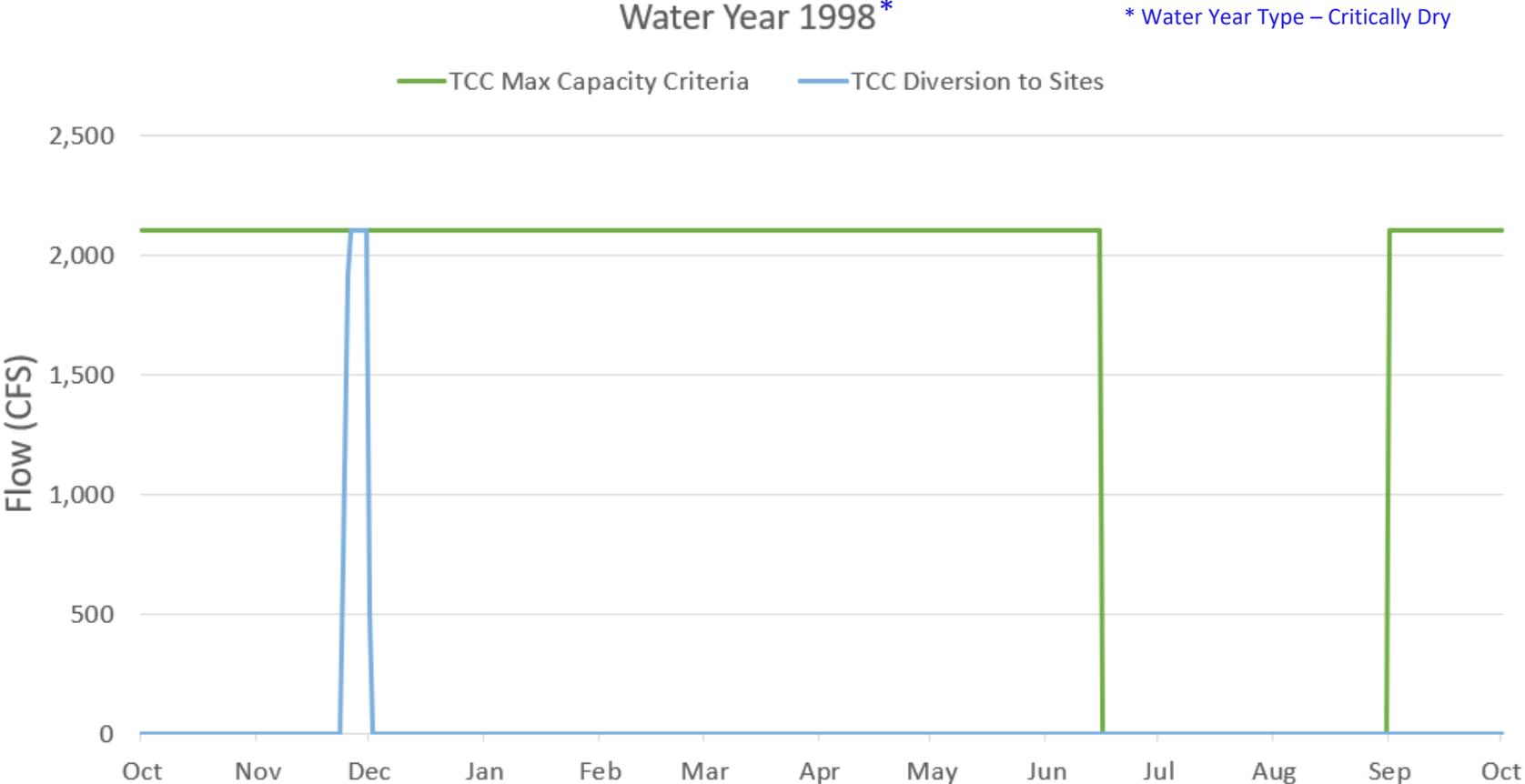
Sites Diversion Criteria

- In CalSim 3, diversions to fill Sites are subject to criteria in the CDFW Sites Operations ITP (2024)
 - A summary table of operations criteria is on the next slide
- Criteria implemented on a daily basis:
 - Physical Conveyance Capacity and Storage Capacity
 - Bypass flow criteria at Red Bluff, Hamilton City, and Wilkins Slough
 - Flow Dependent Diversions
 - Minimum pumping levels – if diversion flow available is below threshold, pumps will not be turned on for diversion to fill Sites
 - TCC (Tehama-Colusa Canal) = 125 cfs
 - GCC (Glen-Colusa Canal) = 100 cfs
 - GCID maintenance (last week of January; first week of February)
 - Fully appropriated streamflow (diversions allowed only between September 1 – June 14)

Sites Modeling Diversion Criteria		Daily vs Monthly Implementation
Sites Storage Capacity	1.5 MAF	Daily
Red Bluff diversion capacity	2,100 cfs	Daily
Red Bluff Bypass	3,250 cfs	Daily
Hamilton City diversion capacity	1,800 cfs & variable winter capacities	Daily
Hamilton City Bypass	4,000 cfs	Daily
GCID Main Canal maintenance	Last week in Jan, first week in Feb	Daily
Wilkins Slough Bypass	10,930 cfs	Daily
Balanced Conditions	No diversions when Delta is in Balanced conditions	Monthly
Fully Appropriated Streamflow	No diversion from Jun 15 to Aug 31	Daily
Flow Dependent Diversions	Diversions limited by flow at Bend Bridge and Hamilton City (per Section 9.14 of the Sites Ops ITP)	Daily
Near Excess conditions	Limit diversions to not use first 3,000 cfs of Surplus Delta Outflow	Monthly
Shasta Spring Pulse	Limit diversions in months with Shasta releases for Spring Pulse objectives	Monthly

TCC Max Capacity vs TCC Diversion to Sites

- TCC Diversion to Sites cannot exceed the maximum capacity of the canal at 2,100 cfs
- Meets max capacity in cfs for:
 - 5 days in November



TCC Flow Available for Diversion vs TCC Diversion to Sites

Water Year 1965*

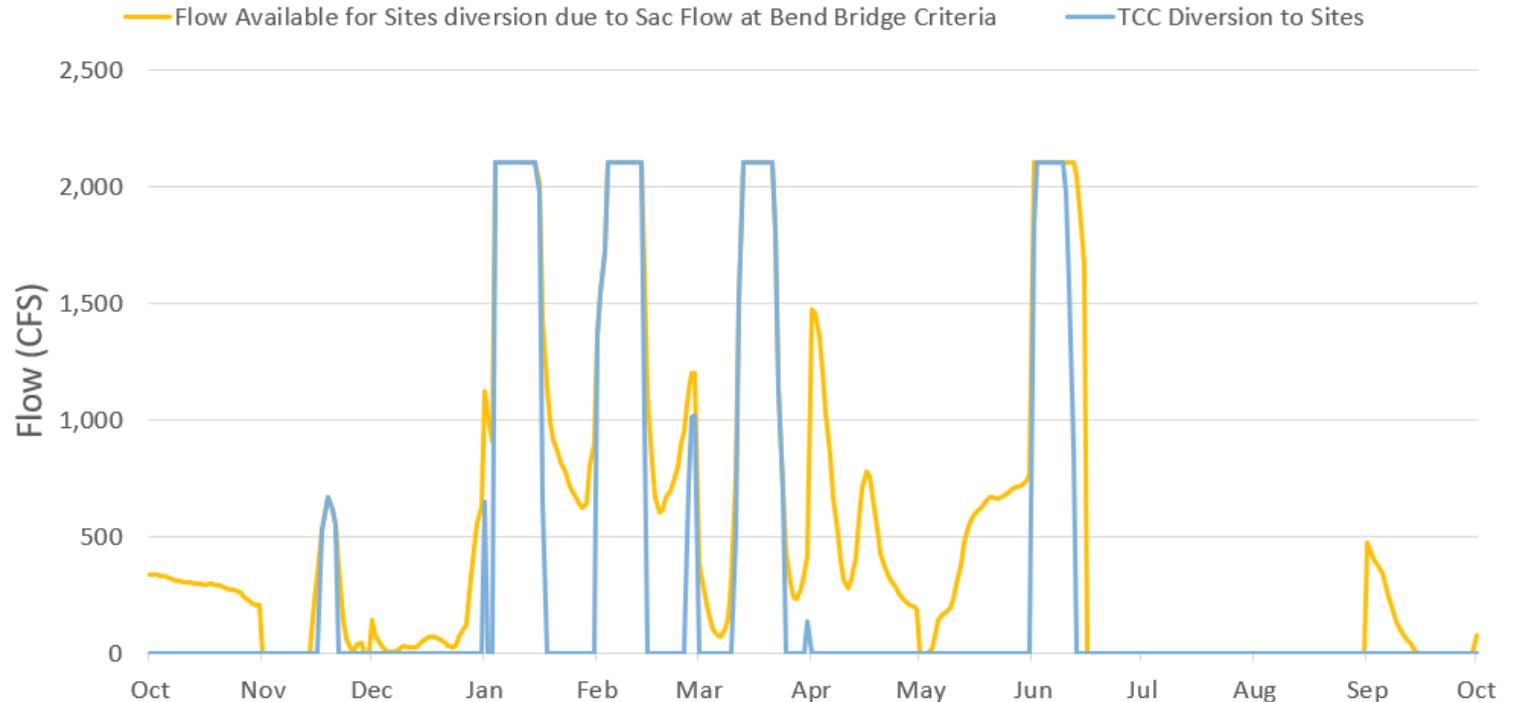
* Water Year Type – Below Normal

ITP Requirements

Jan 1 to Feb 28/29		March 1 to June 14 Sept. 1 to Dec. 31	
Real-Time Flow at Bend Bridge (BND) in (cfs)	Maximum Diversion (cfs)	Real-Time Flow at Bend Bridge (BND) in (cfs)	Maximum Diversion (cfs)
4,800	0	6,300	0
5,000	130	7,000	120
6,000	230	8,000	220
7,000	360	9,000	340
8,000	520	10,000	480
9,000	710	11,000	640
10,000	930	12,000	810
11,000	1,180	13,000	1,010
12,000	1,450	14,000	1,220
13,000	1,760	15,000	1,460
14,000	2,100	16,000	1,710
14,100	2,120	17,000	1,980
>14,000	2,120	17,500	2,120

- TCC Diversion to Sites meets flow available from ITP requirements for:

- 4 days in November
- 2 weeks in January
- 2 weeks in February
- 2 weeks in March
- 1 week in June



GCC Flow Available for Diversion vs GCC Diversion to Sites

ITP Requirements

Sept. 1 to June 14

Real-Time Flow at Hamilton City (HMC) in (cfs) ³⁸	Maximum Diversion (cfs)
10,500	0
11,500	280
12,500	370
13,500	480
14,500	590
15,500	720
16,500	850
17,500	980
18,500	1,130
19,500	1,290
20,500	1,450
21,500	1,620
22,500	1,800
23,500	1,990
24,500	2,200
>24,500	2,200

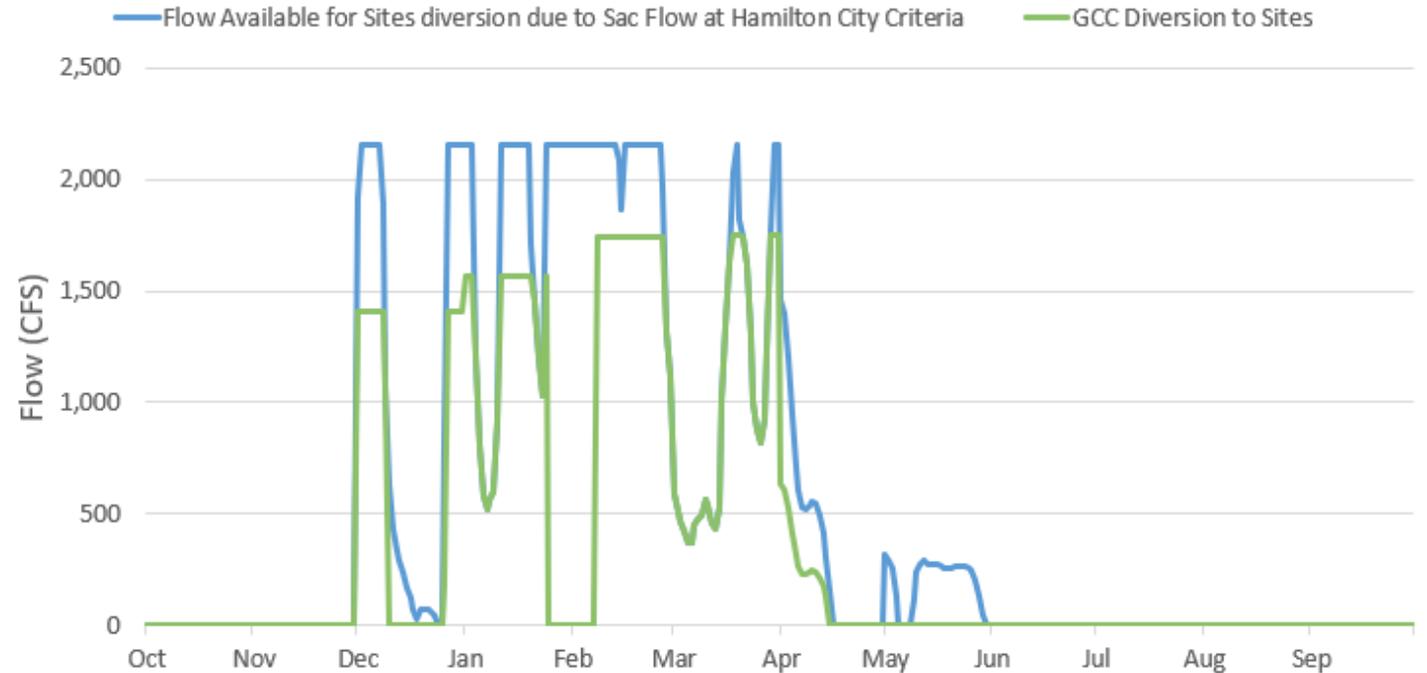
GCID Requirements in code

```

1  ! Table file Sites_GCCFill
2  ! Specifies variable constraints associated with
3  !
4  ! month 1 is October
5  ! period of condition is October through March
6  ! days_avail are the days that pumping can occur
7  ! cap_winter is the daily capacity available when
8  !
9  Sites_GCCFill
10 month    days_avail    cap_winter
11 1         99           1287
12 2         99           1266
13 3         99           1411
14 4         24           1565
15 5         21           1744
16 6         99           1752
    
```

Water Year 1951*

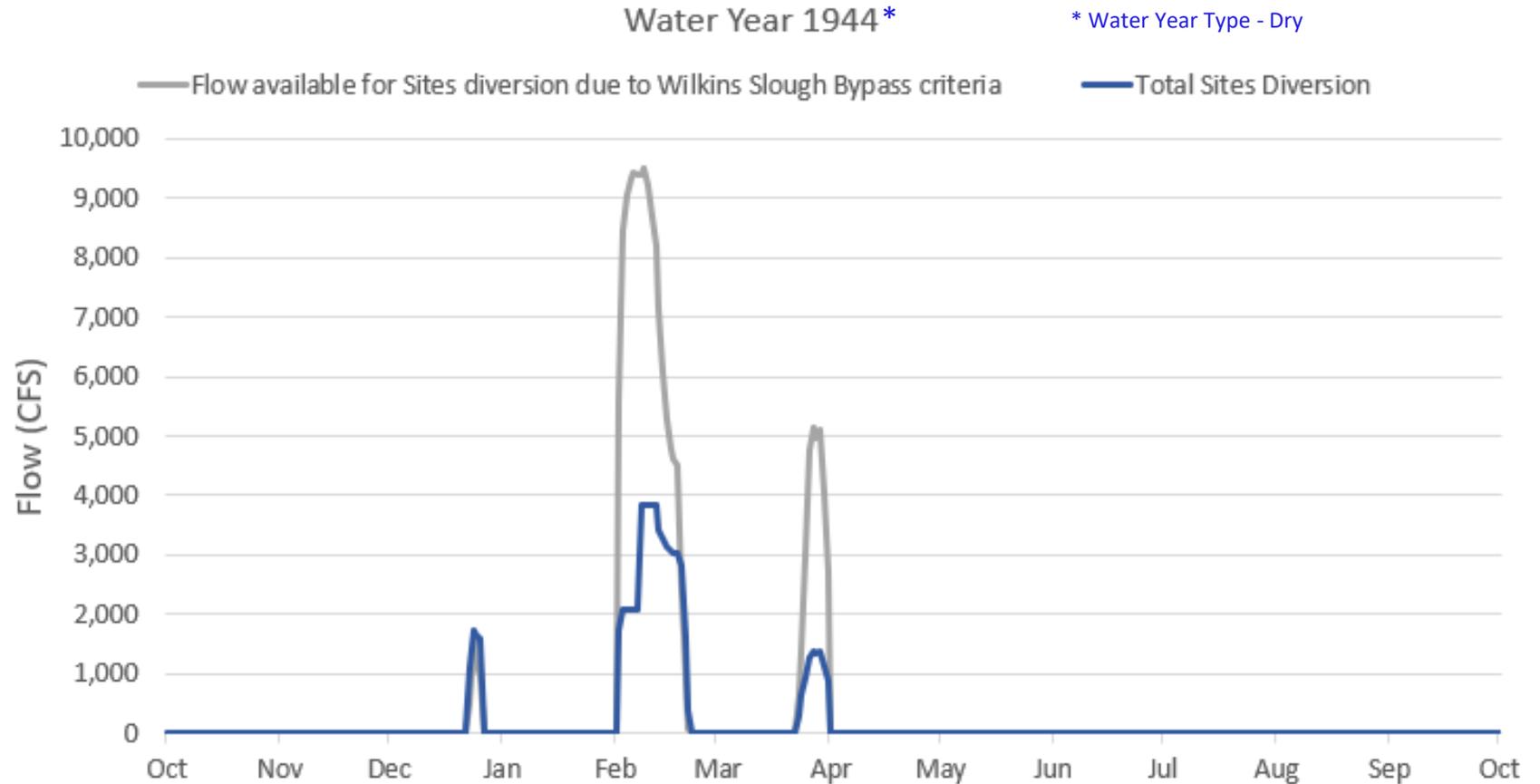
* Water Year Type - Wet



- GCC Diversion to Sites meets flow available from ITP requirements for:
 - 1 day in December
 - 1 week in January
 - 3 weeks in March

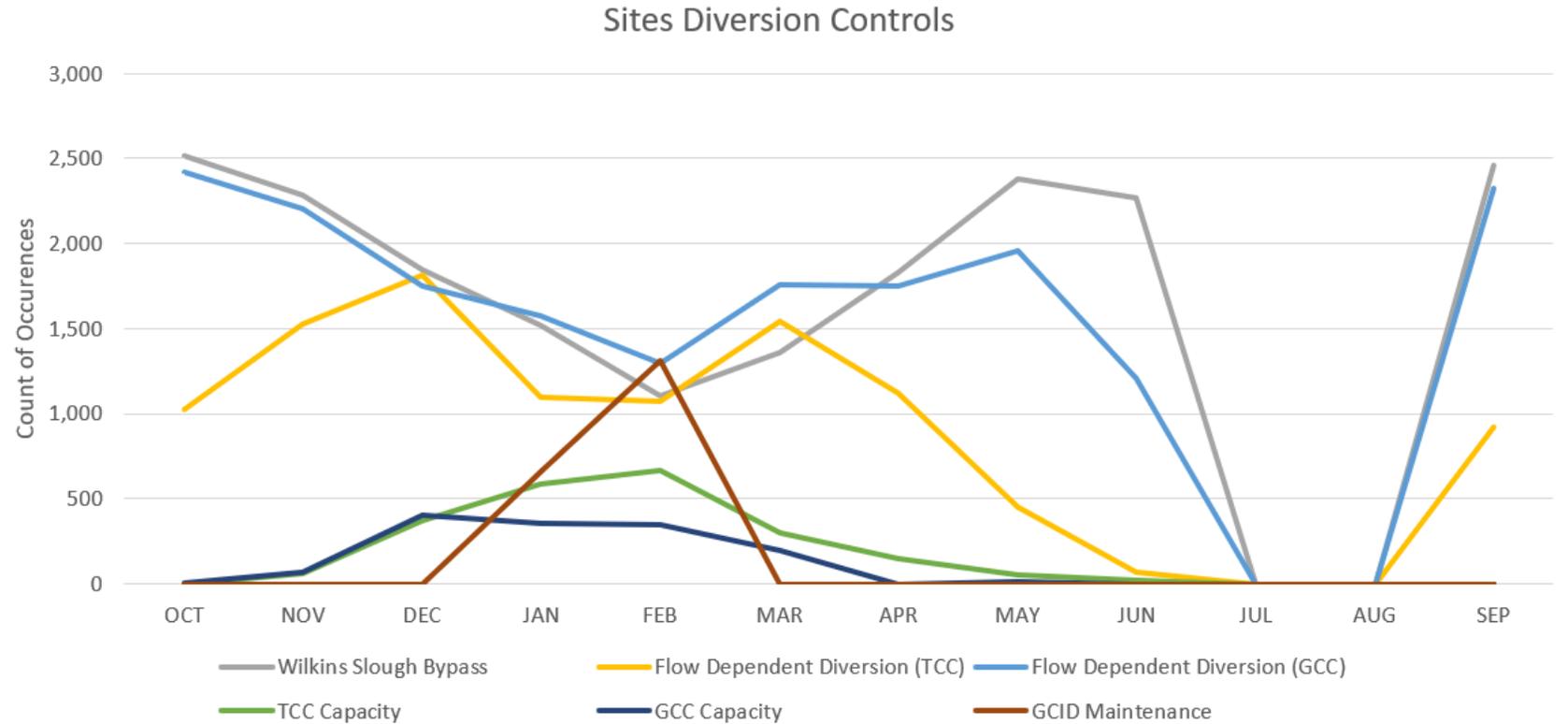
Wilkins Slough Bypass Criteria vs Total Sites Diversions

- Sites can only divert when Wilkins Slough bypass is greater than 10,930 cfs (graph shows available flow – 10,930 cfs)
- Total Sites Diversion meets available flow from Wilkins Slough bypass criteria for:
 - 4 days in December
 - 3 weeks in February
 - 1 week in March



Wilkins Slough Bypass Criteria vs Total Sites Diversions

- By identifying the primary constraint for any given day in the model, we can sum the occurrences to show what is preventing Sites diversions the most throughout the year.



Special Thanks

USBR – USRDOM and Daily Pattern Review

Stantec – Daily Pattern Review, Sites Specific

MBK - Daily Pattern Review, Sites Specific

Questions?

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Reinventing tomorrow.

