

RECLAMATION

Managing Water in the West

Reclamation Perspective on Operational Snow Data and Needs

Snowpack Monitoring for Streamflow
Forecasting and Drought Planning
August 11, 2015



U.S. Department of the Interior
Bureau of Reclamation

Reclamation Operational Modeling

3 Colorado Basin-wide Models

Operations of the major reservoirs at a monthly timestep

24-Month Study

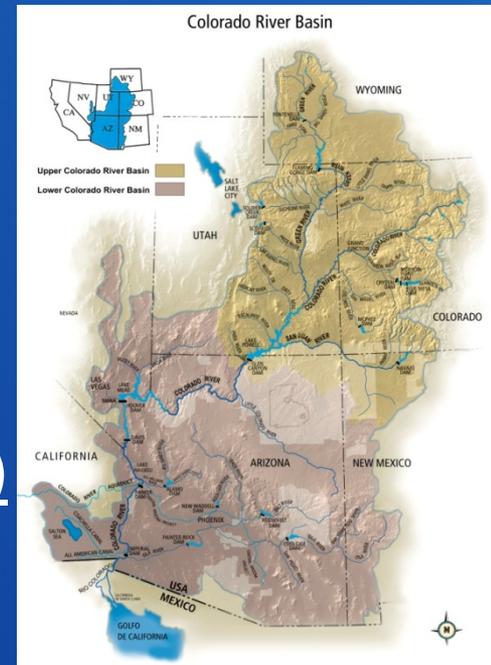
Official operations model, used in Annual Operating Plan (AOP)

Mid-Term Operations Model (MTOM)

Probabilistic version of 24-Month Study, used for risk and uncertainty analysis (recently developed)

Colorado River Simulation System (CRSS)

Long-term planning model, used in EISs, planning studies, etc.

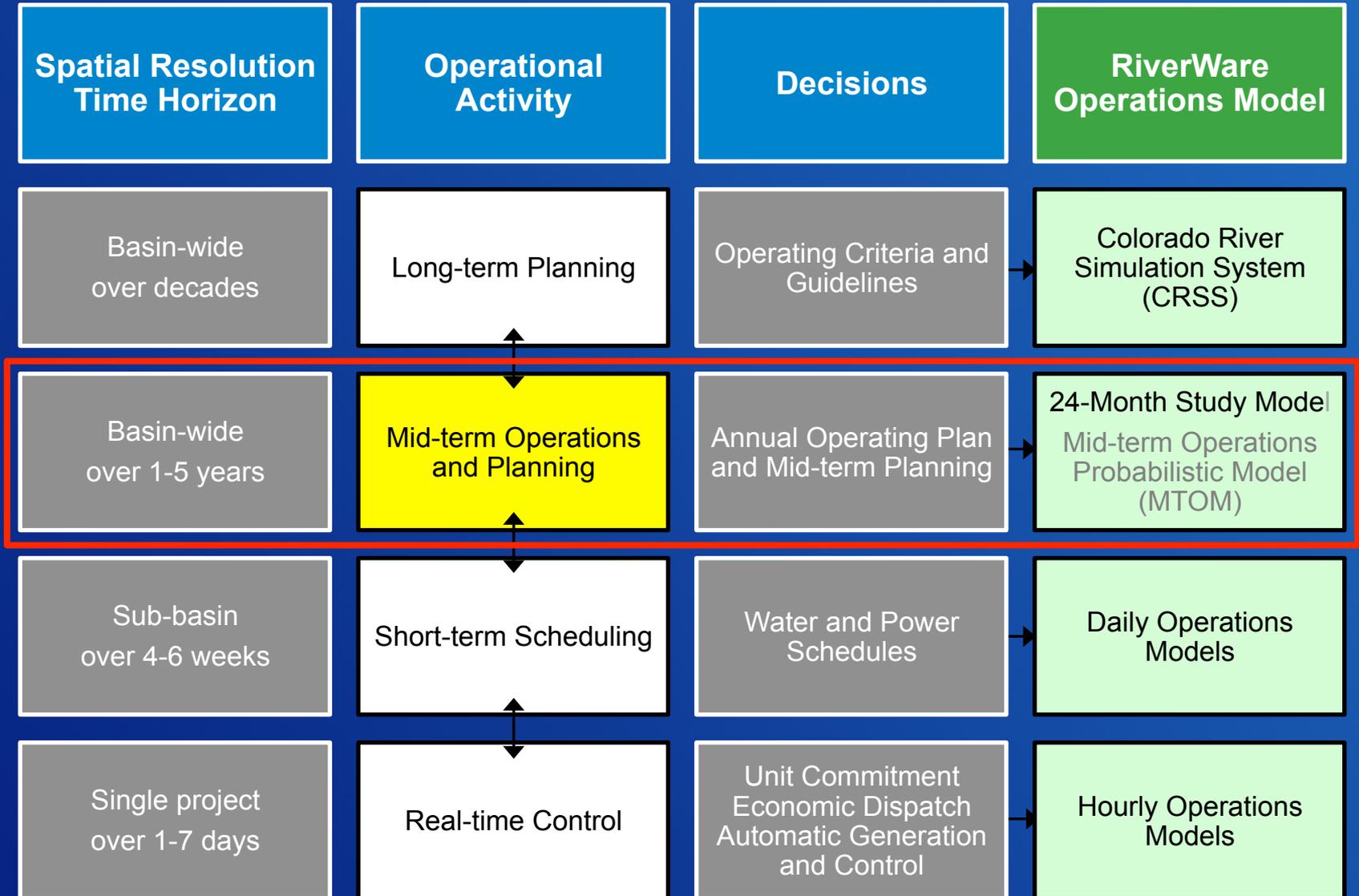


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Reclamation Operational Modeling Model Comparison

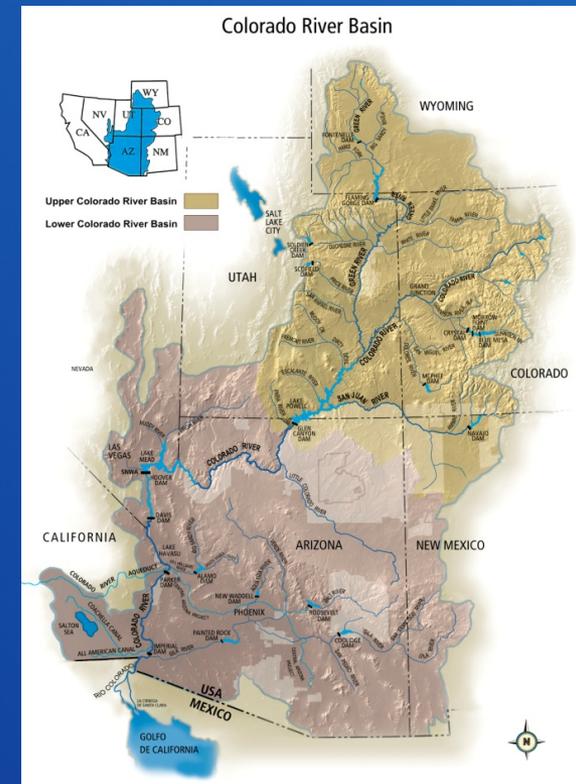
	CRSS	MTOM	24MS
Primary Use	Long-term planning, comparison of alternatives (NEPA)	Risk-based operational planning	AOP Tier determination
Probabilistic/ Deterministic	Probabilistic – 107 (or more) traces	Probabilistic – 30 (or more) traces	Deterministic
Rule-driven/ Manual Operations	Rule-driven	Rule-driven	Manual Operator Input
Time Horizon	~50 years	5 years	24-32 months
Upper Basin Inflow	Natural: historic hydrology, paleo-hydrology, climate change	Unregulated ESP forecast, 30 traces	Unregulated forecast, 1 trace
Upper Basin Demands	Explicit, 2007 UCRC assumptions	Implicit, in unregulated inflow forecast	Implicit, in unregulated inflow forecast
Lower Basin Demands	General assumptions	Official approved or operational	Official approved or operational

Operational Decision-making Hierarchy



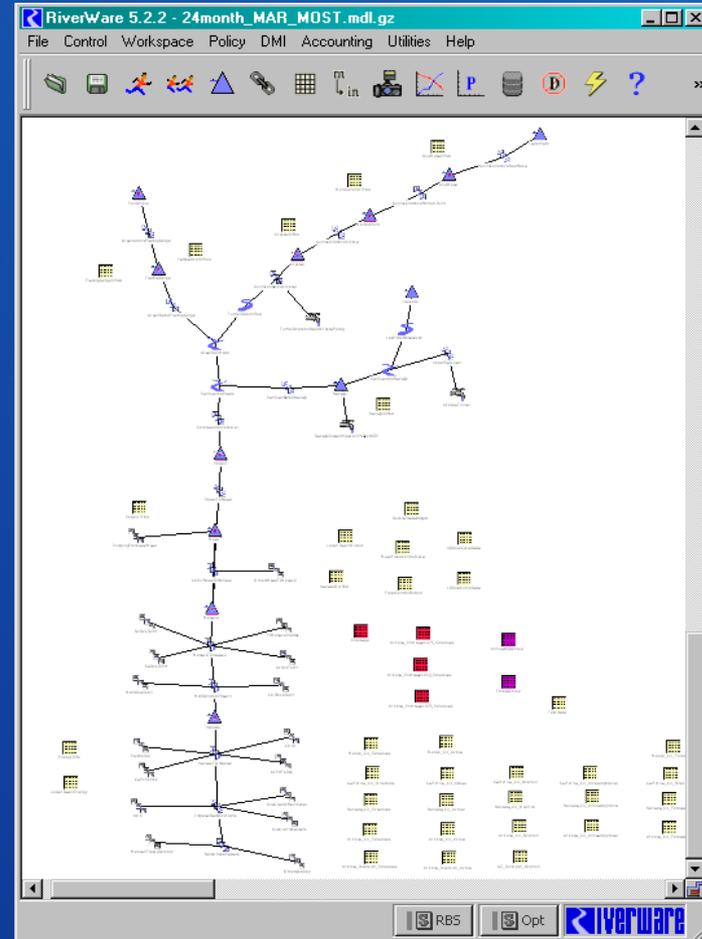
24-Month Study Model

- Basin-wide reservoir operations tool
- Deterministic: “best guess” projection for upcoming 24 months of operations
- Projects monthly reservoir releases, elevations, storages, hydropower, etc.
- Updated monthly



Model Configuration

- Reservoir Operation
 - 12 major reservoirs
- Monthly time step
- 24-month projection
- Updated monthly



Output

- Annual Operating Plan (written document)
- 24-Month Study Report (mostly tabular data), monthly update to the AOP

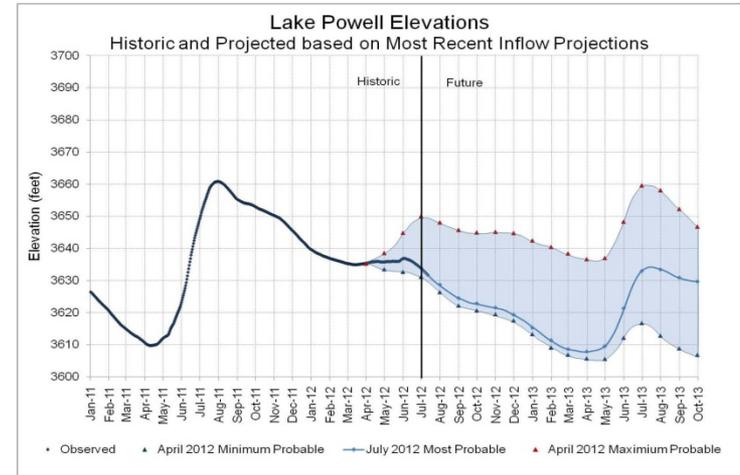
OPERATION PLAN FOR COLORADO RIVER SYSTEM RESERVOIRS
October 2012 24-Month Study
 Most Probable Inflow*
Lake Powell



Date	Unreg Inflow (1000 Aa-Ft)	Regulated Inflow (1000 Aa-Ft)	Evap Losses (1000 Aa-Ft)	PowerPlant Release (1000 Aa-Ft)	Bypass Release (1000 Aa-Ft)	Total Release (1000 Aa-Ft)	Reservoir Elev End of Month (ft)	Bank Storage (1000 Aa-Ft)	EQM Storage (1000 Aa-Ft)	Lees Ferry (1000 Aa-Ft)
* Oct 2011	513	630	45	956	0	956	3650.27	5434	17249	979
H Nov 2011	506	590	30	1059	0	1059	3645.97	5388	16983	1104
I Dec 2011	393	490	33	1223	0	1223	3639.75	5302	15974	1226
B Jan 2012	358	503	10	852	0	852	3636.91	5305	15841	846
T Feb 2012	342	490	11	653	0	653	3635.28	5290	15453	954
O Mar 2012	560	605	19	600	0	600	3635.33	5299	15458	927
R Apr 2012	764	689	29	606	0	606	3635.78	5294	15208	612
I May 2012	792	770	35	601	0	601	3636.93	5304	15032	926
C Jun 2012	353	398	54	729	0	729	3633.90	5277	15204	712
A Jul 2012	154	285	62	886	0	886	3628.45	5228	14880	892
L Aug 2012	101	289	60	800	0	800	3623.92	5186	14151	810
* Sep 2012	154	296	54	481	0	481	3621.66	5168	13929	478
WY 2012	4968	5964	455	9466	0	9466				9527
Oct 2012	200	276	37	494	0	494	3619.34	5149	13993	494
Nov 2012	300	327	35	600	0	600	3616.62	5126	13426	600
Dec 2012	250	310	27	800	0	800	3611.96	5089	12929	800
Jan 2013	250	307	8	800	0	800	3607.84	5051	12465	800
Feb 2013	250	286	9	675	0	675	3603.59	5021	12066	675
Mar 2013	425	298	15	600	0	600	3601.14	5002	11859	600
Apr 2013	675	633	23	600	0	600	3600.27	4996	11776	600
May 2013	1500	1214	28	600	0	600	3605.86	5039	12318	600
Jun 2013	2150	1919	45	800	0	800	3614.91	5111	13221	800
Jul 2013	875	616	55	811	0	811	3614.34	5107	13173	811
Aug 2013	400	502	55	850	0	850	3610.89	5078	12800	850
Sep 2013	335	414	50	600	0	600	3608.92	5060	12562	600
WY 2013	7600	7161	396	6230	0	6230				6230
Oct 2013	443	470	34	600	0	600	3606.99	5048	12429	600
Nov 2013	441	434	33	600	0	600	3606.13	5033	12246	600
Dec 2013	363	383	28	800	0	800	3600.90	5001	11836	800
Jan 2014	361	396	8	800	0	800	3596.69	4970	11455	800
Feb 2014	353	405	8	600	0	600	3594.87	4955	11287	600
Mar 2014	665	562	14	600	0	600	3594.36	4951	11220	600
Apr 2014	1006	644	22	600	0	600	3596.95	4968	11425	600
May 2014	2343	1929	28	600	0	600	3609.00	5084	12630	600
Jun 2014	2668	2267	47	850	0	850	3623.00	5160	14084	850
Jul 2014	1091	696	59	850	0	850	3623.14	5167	14164	850
Aug 2014	500	601	58	900	0	900	3620.88	5190	13833	900
Sep 2014	426	531	53	600	0	600	3619.33	5149	13692	600
WY 2014	16729	8918	388	6230	0	6230				6230

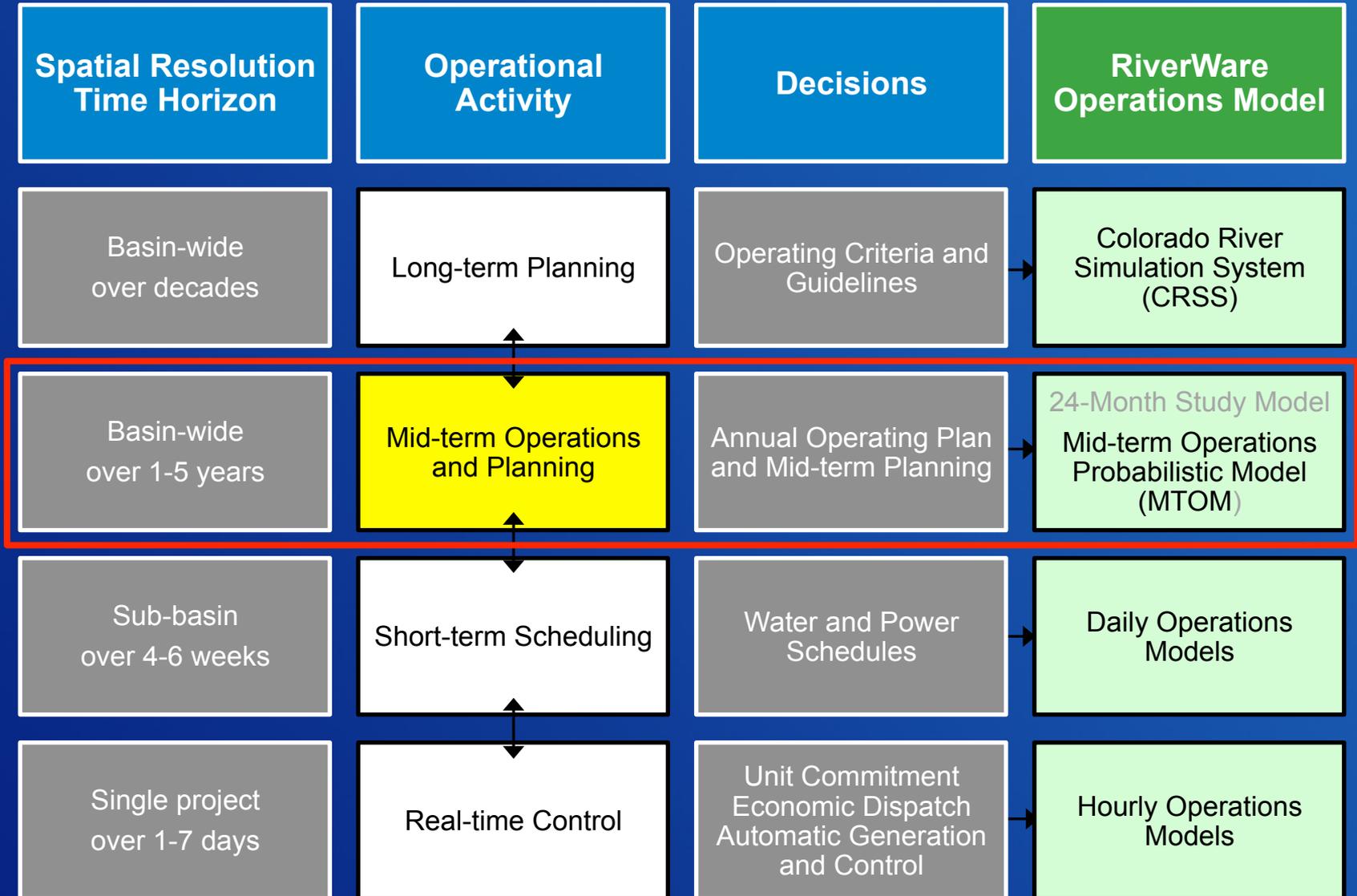
* Based on the Colorado River Basin Forecast Center's Most Probable Water Supply Forecast

Model Run ID: 2130 Processed On: 10/10/2012 2:34:27PM

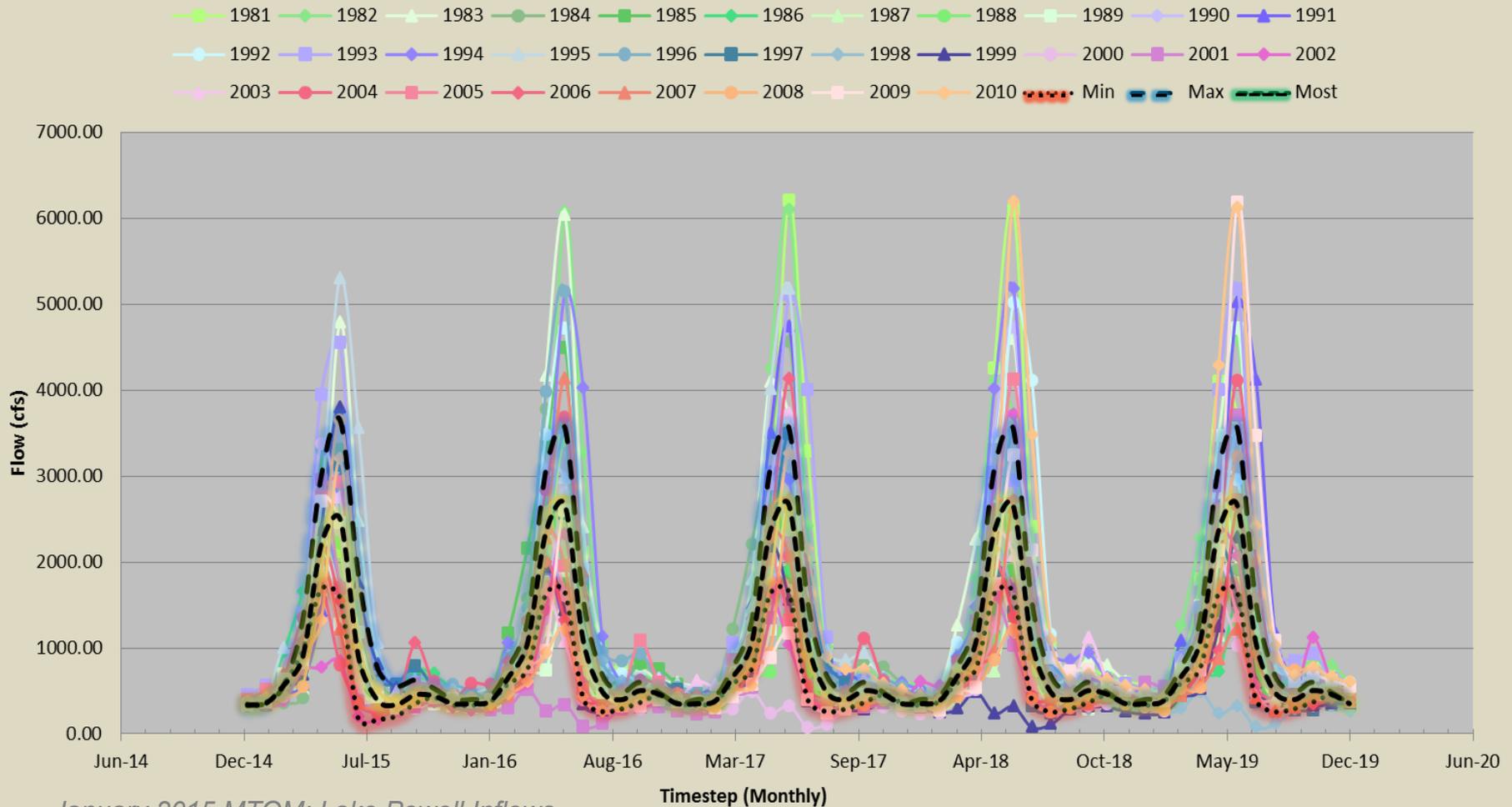


---Chart Explanation below---

Operational Decision-making Hierarchy



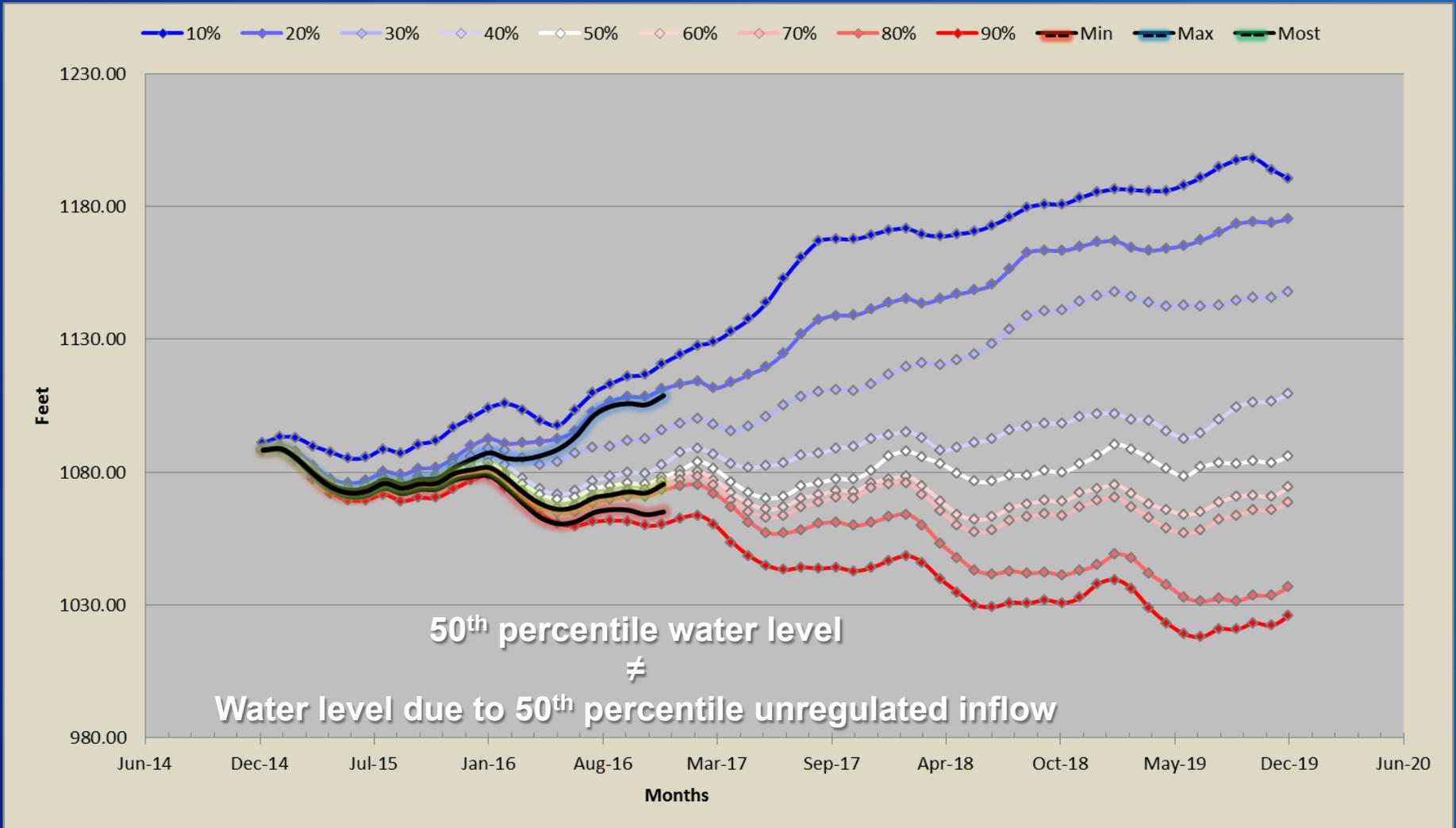
MTOM Inputs: Ensemble vs Discrete



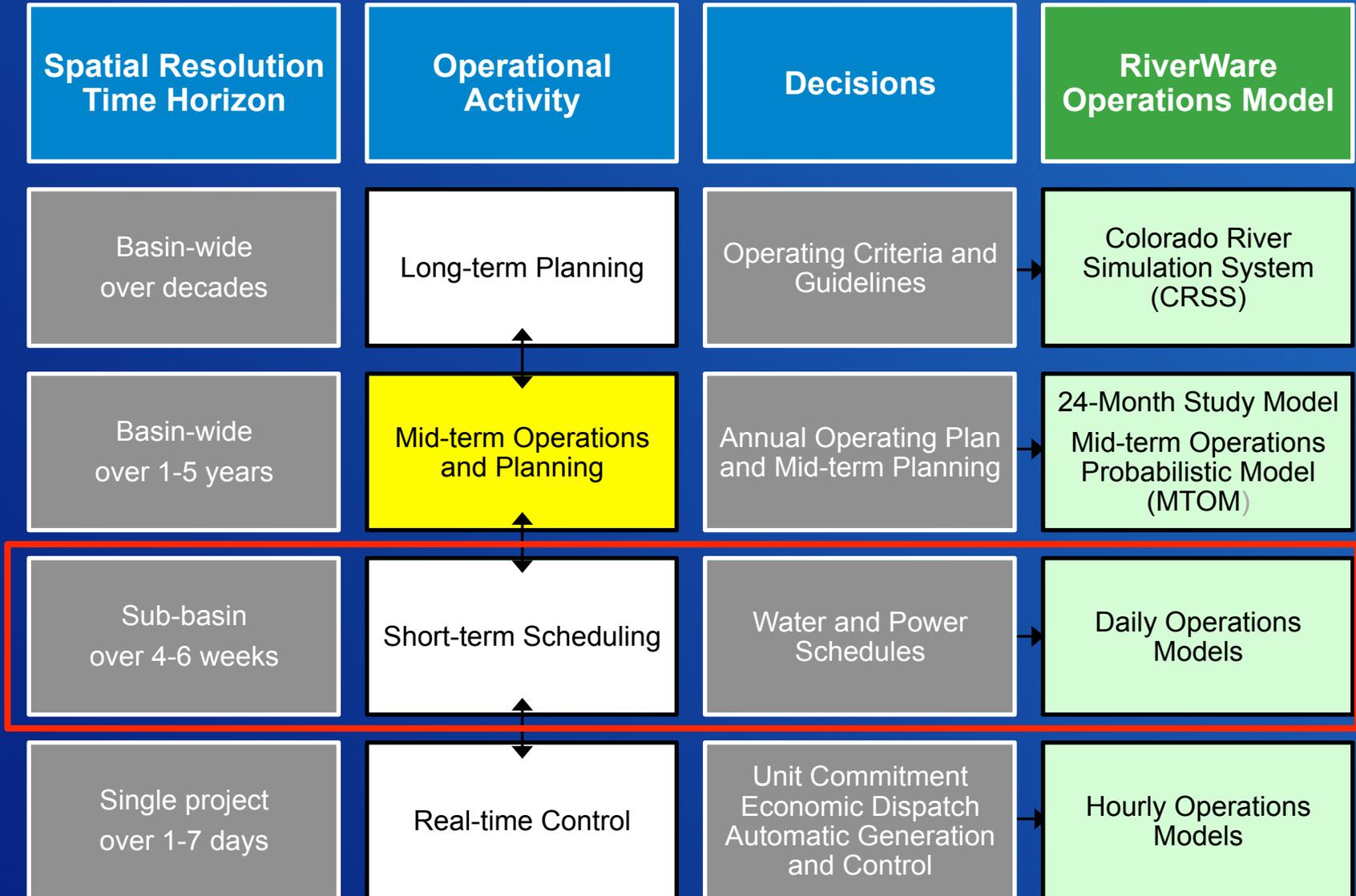
Note: Official Min, Most, and Max Probable forecasts
"extended" to 5 years by repeating the last year

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MTOM Output: Ensemble vs Discrete

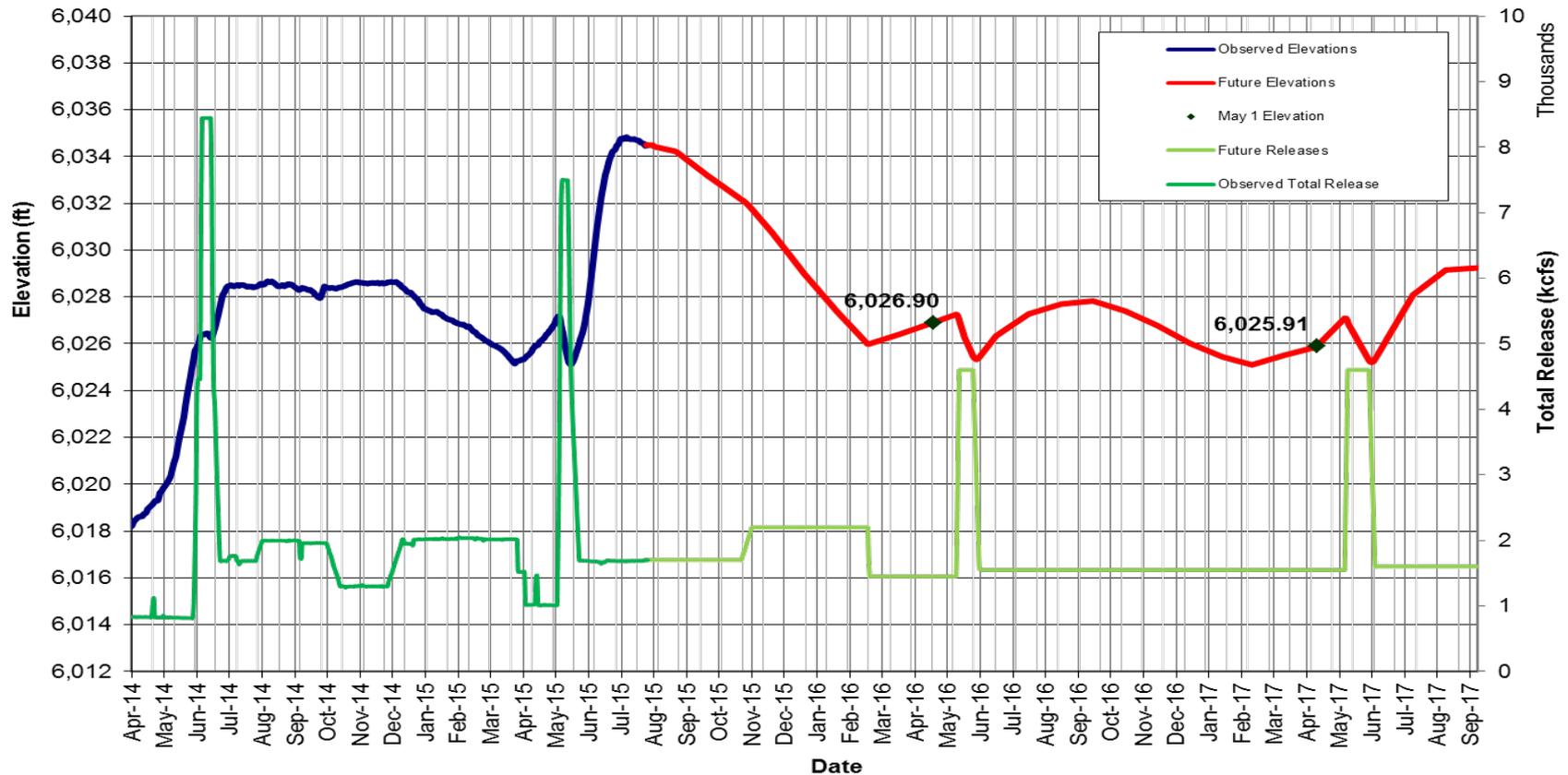


Operational Decision-making Hierarchy

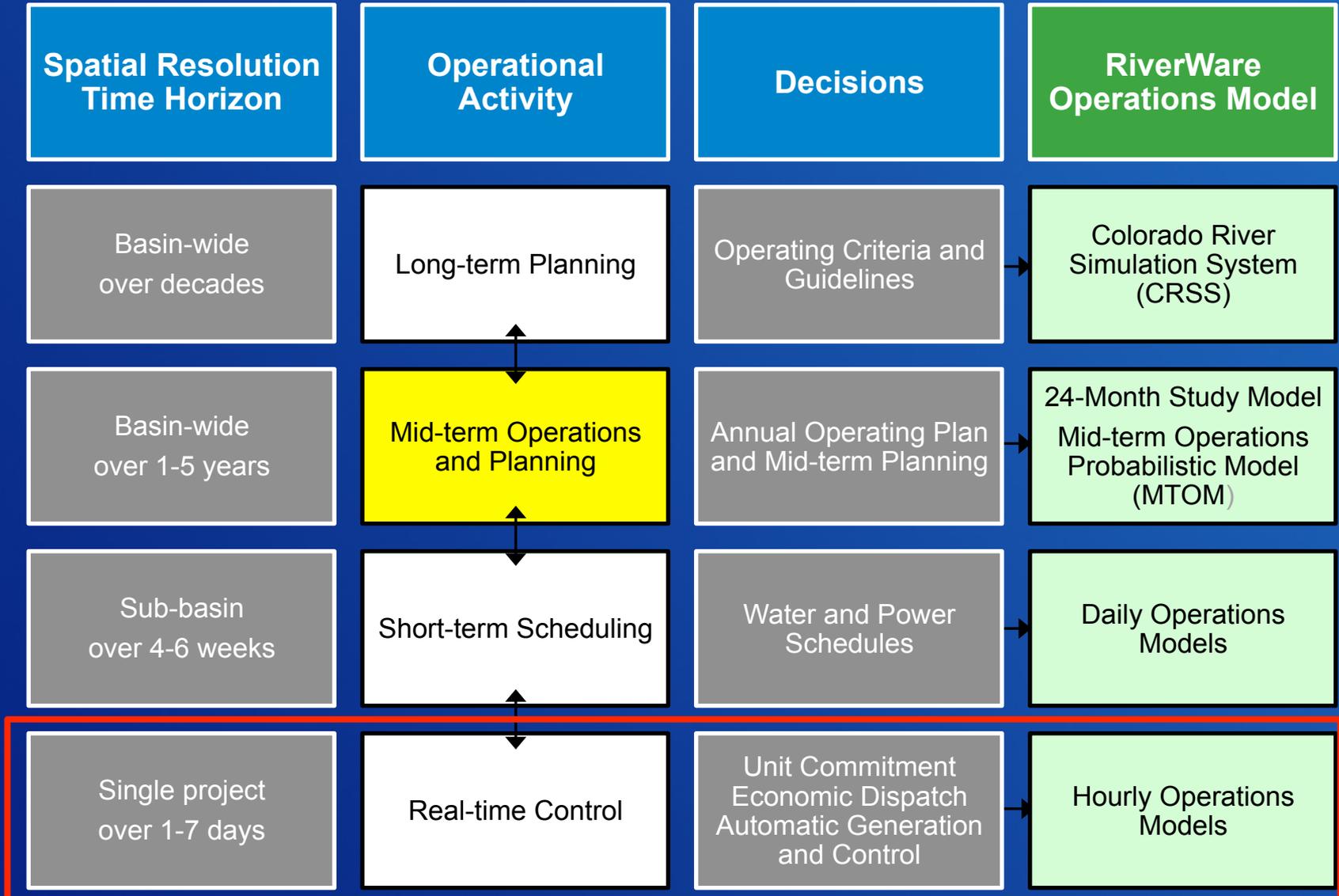


Daily Operation Model Output

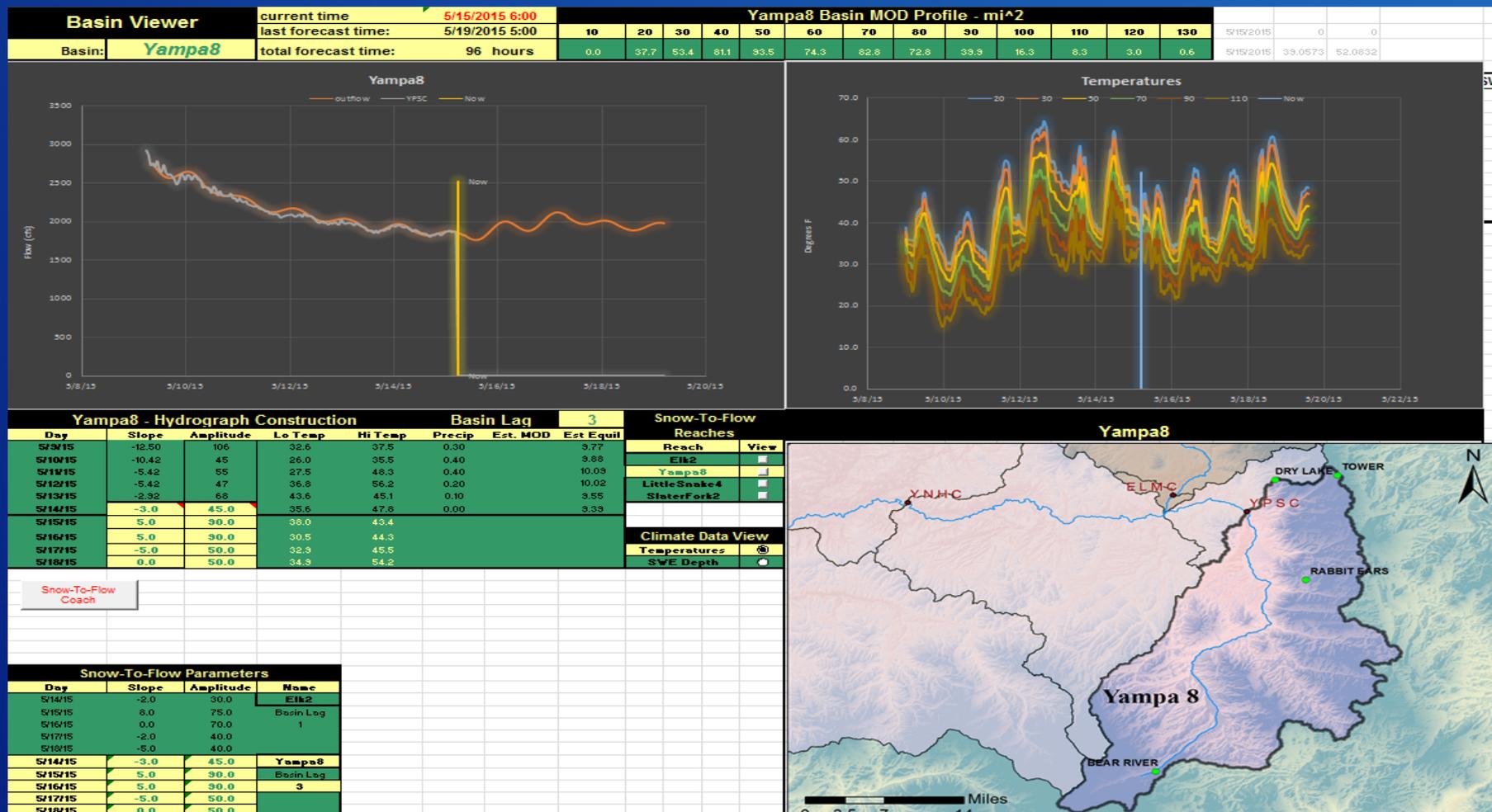
Flaming Gorge Operations WY2015-2017
Most Probable Operations August Most Final Forecast



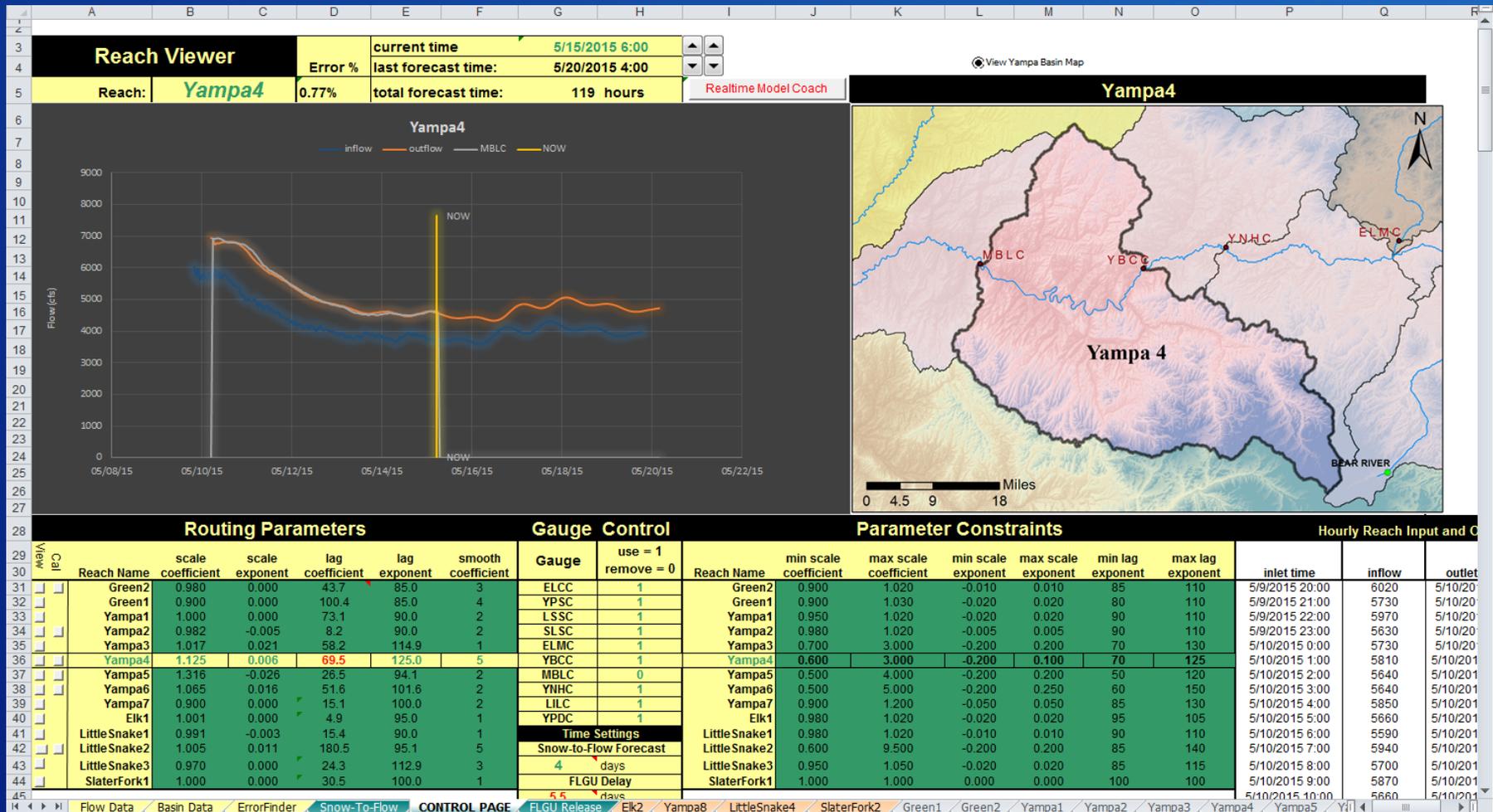
Operational Decision-making Hierarchy



Hourly Yampa and Green River Model



Hourly Yampa and Green River Model



Hourly Yampa and Green River Model

FLGU Release Control Release Construction Coach

Release Change Scheduler Matrix

Hour	14-May	15-May	16-May	17-May	18-May	19-May	20-May
0	6,480	7,960					
1	6,510	8,010					
2	6,460	8,020					
3	6,460	8,020					
4	6,590	8,030					
5	6,460	8,060					
6	6,510						
7	6,510						
8	6,770		8,000	8,600	8,600	8,000	8,000
9	7,890						
10	8,020						
11	7,990						
12	8,020						
13	7,960						
14	7,960		8,000			8,000	
15	8,090						
16	8,090						
17	7,950						
18	7,980		8,600				
19	8,080						
20	7,980						
21	7,990						
22	8,030						
23	7,980						

Jensen Goal Matrix

Hour	15-May	16-May	17-May	18-May	19-May	20-May
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						

FLGU Release Viewer

Forecasted Jensen Flow Matrix

Hour	14-May	15-May	16-May	17-May	18-May	19-May	20-May
0	#####	#####	#####	#####	#####	#####	#####
1	#####	#####	#####	#####	#####	#####	#####
2	#####	#####	#####	#####	#####	#####	#####
3	#####	#####	#####	#####	#####	#####	#####
4	#####	#####	#####	#####	#####	#####	#####
5	#####	#####	#####	#####	#####	#####	#####
6	#####	#####	#####	#####	#####	#####	#####
7	#####	#####	#####	#####	#####	#####	#####
8	#####	#####	#####	#####	#####	#####	#####
9	#####	#####	#####	#####	#####	#####	#####
10	#####	#####	#####	#####	#####	#####	#####
11	#####	#####	#####	#####	#####	#####	#####
12	#####	#####	#####	#####	#####	#####	#####
13	#####	#####	#####	#####	#####	#####	#####
14	#####	#####	#####	#####	#####	#####	#####
15	#####	#####	#####	#####	#####	#####	#####
16	#####	#####	#####	#####	#####	#####	#####
17	#####	#####	#####	#####	#####	#####	#####
18	#####	#####	#####	#####	#####	#####	#####
19	#####	#####	#####	#####	#####	#####	#####
20	#####	#####	#####	#####	#####	#####	#####

Absolute Residual Matrix

Hour	15-May	16-May	17-May	18-May	19-May	20-May
0		564	346	1,470	1,915	1,580
1		567	341	1,506	1,919	1,522
2		562	333	1,530	1,914	1,452
3		550	320	1,544	1,901	1,372
4		532	304	1,549	1,881	1,291
5		509	286	1,547	1,857	1,209
6	104	483	271	1,540	1,829	1,134
7	190	456	265	1,531	1,800	1,067
8	260	428	271	1,521	1,772	1,009
9	310	401	290	1,512	1,745	959
10	342	376	325	1,507	1,721	921
11	356	353	376	1,507	1,702	894
12	360	334	445	1,514	1,687	878
13	364	319	530	1,529	1,677	865
14	372	309	626	1,552	1,672	858
15	383	303	729	1,585	1,672	854
16	397	301	834	1,624	1,674	854
17	415	304	938	1,670	1,679	857
18	436	309	1,039	1,717	1,685	861
19	461	318	1,136	1,765	1,691	866
20	488	327	1,224	1,810	1,692	871

Residual Summary

	15-May	16-May	17-May	18-May	19-May	20-May	Total
Average Hourly Residual	380	401	638	1,611	1,752	1,033	995
Max Hourly Residual	553	567	1,423	1,903	1,919	1,580	1,919
Min Hourly Residual	104	301	265	1,470	1,626	854	104

Solver Constraints

Max Release	8,600	cfs
Min Release	800	cfs
Outside of Range	-	cfs
Solver Goal	995	cfs

Data Needs

- Wind Rivers SNOTEL network
- Should we continue putting in more SNOTEL?
 - Gamma
 - Model NOHRSC
 - Aerial JPL

Questions and Discussion



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