

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

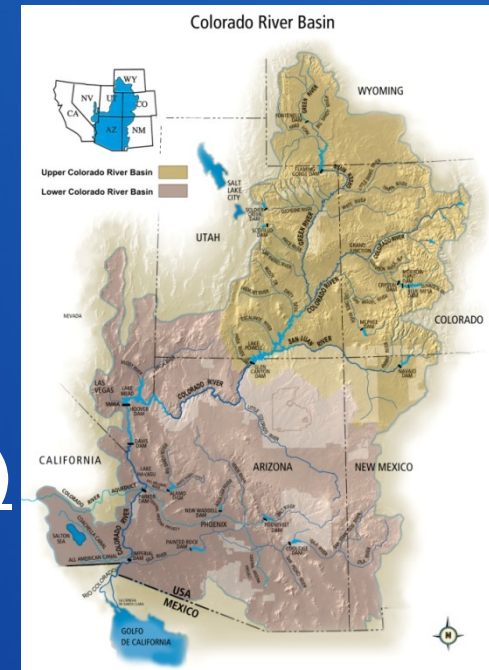
Official operations model, used in Annual Operating Plan (AOP)

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.



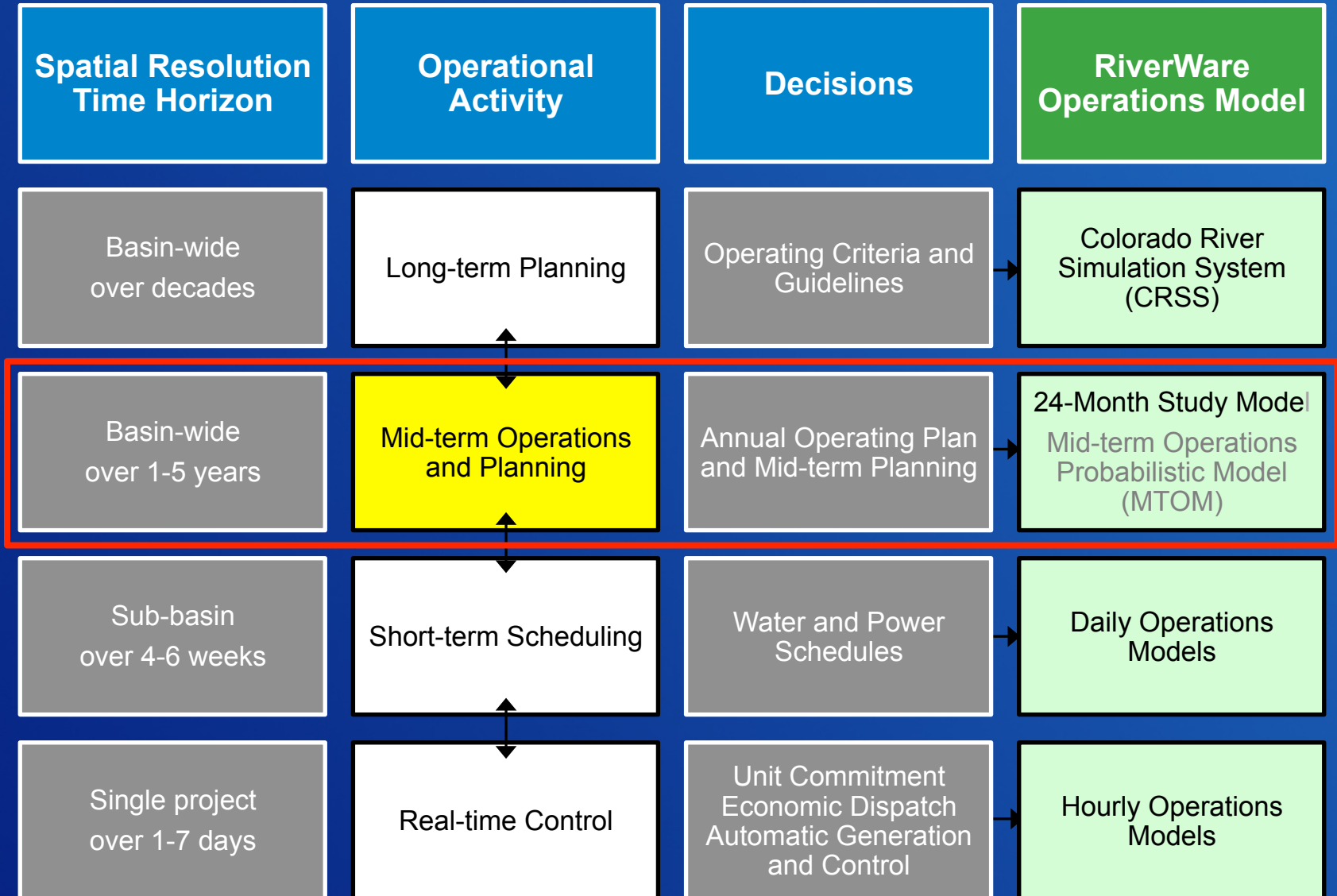
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Reclamation Operational Modeling

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

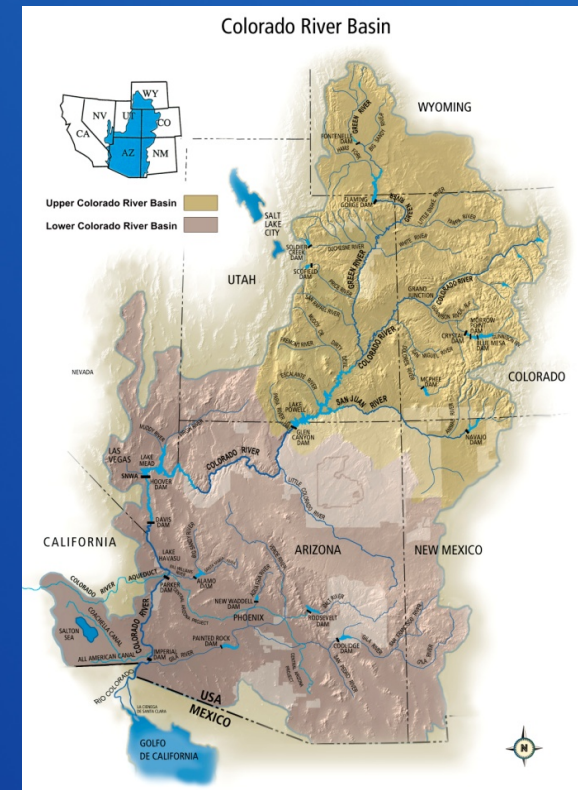
Operational Decision-making Hierarchy



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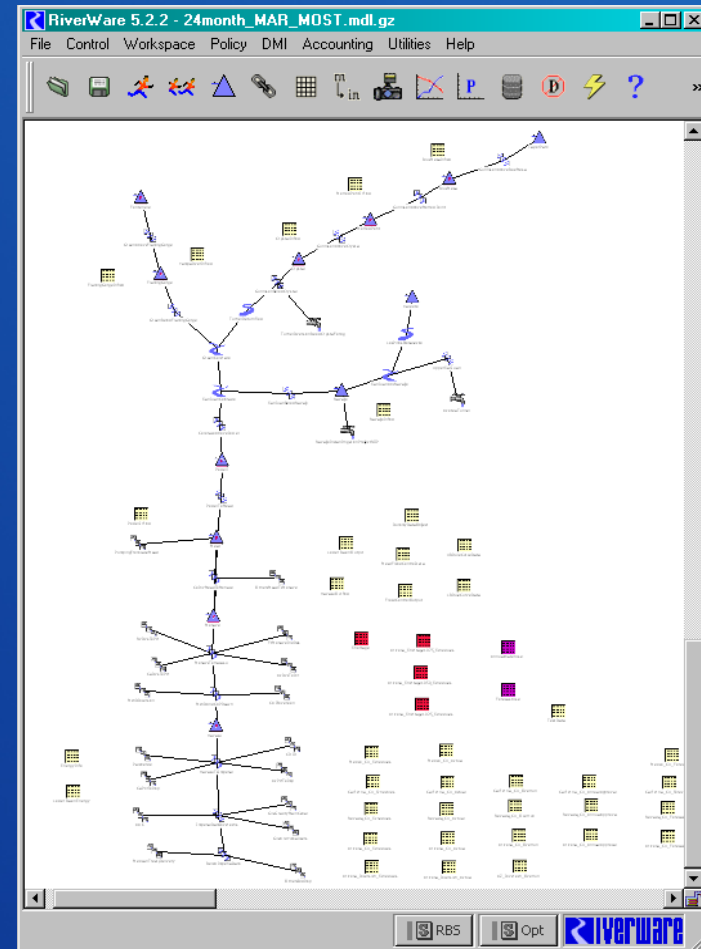
24-Month Study Model

- 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

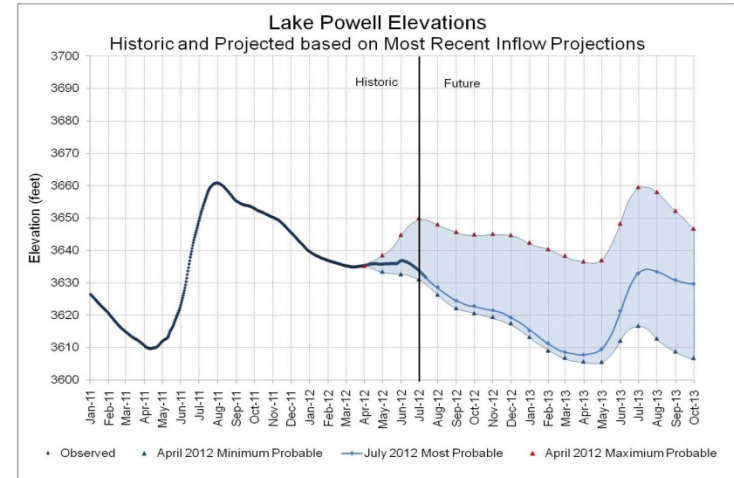


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Output

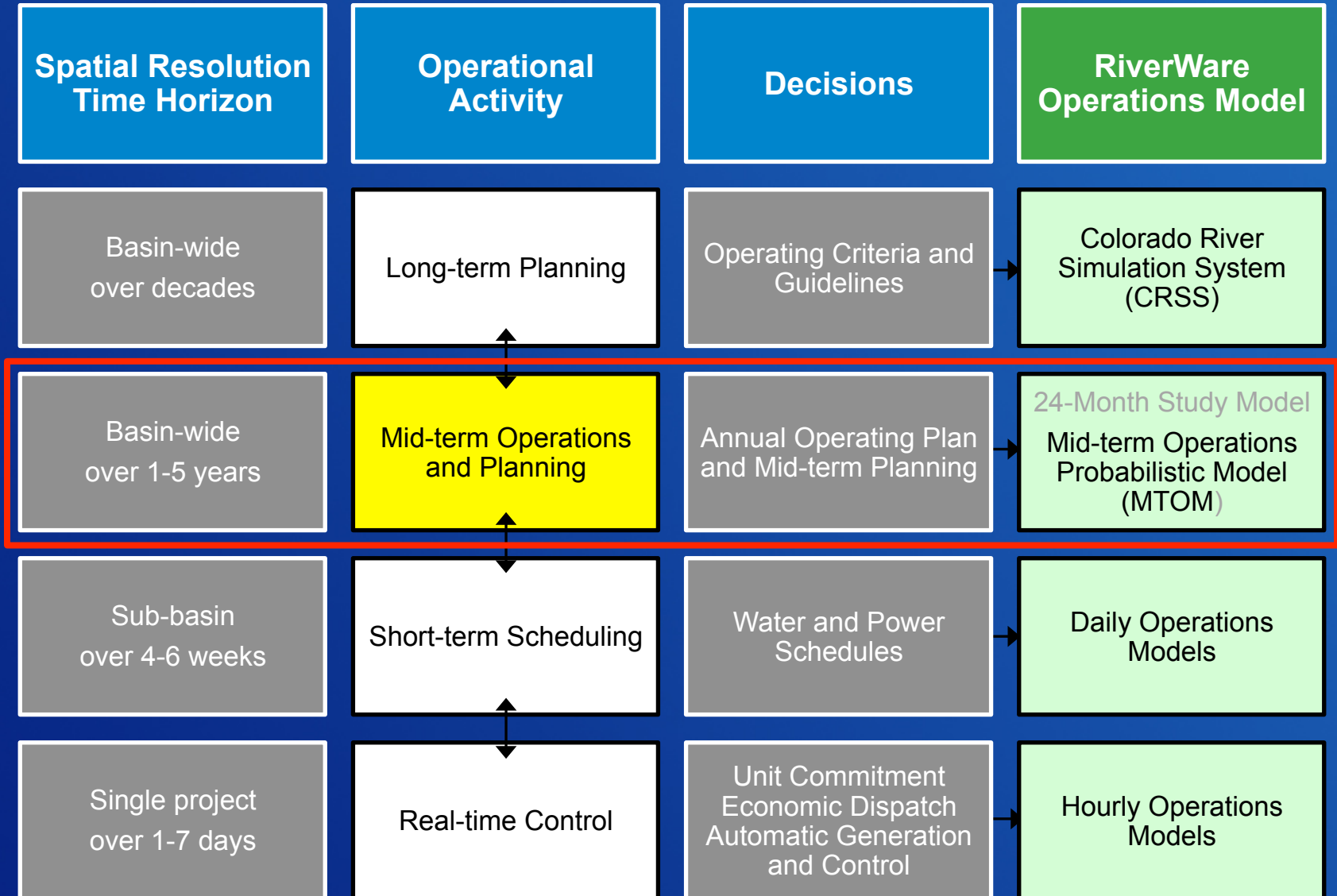
- Annual Operating Plan (written document)
- 24-Month Study Report (mostly tabular data), monthly update to the AOP

Date	Unreg. Inflow (1000 Acre-Ft)	Regulated Inflow (1000 Acre-Ft)	Evap. Losses (1000 Acre-Ft)	Power/Plant Release (1000 Acre-Ft)	Bypass Release (1000 Acre-Ft)	Total Release (1000 Acre-Ft)	Reservoir Elev. End of Month (ft)	Bank Storage (1000 Acre-Ft)	EOB Storage (1000 Acre-Ft)	Lees Ferry Storage (1000 Acre-Ft)
* Oct 2011	513	630	45	958	0	958	3650.27	5434	17249	979
H Nov 2011	506	530	43	1059	0	1059	3645.97	5388	16983	1104
I Dec 2011	363	460	33	1223	0	1223	3639.75	5332	15974	1226
B Jan 2012	358	503	10	852	0	852	3636.91	5305	15841	846
T Feb 2012	342	460	11	653	0	653	3630.28	5290	15453	954
O Mar 2012	560	625	19	600	0	600	3635.33	5290	15458	927
R Apr 2012	764	689	29	606	0	606	3635.78	5294	15508	912
I May 2012	792	770	35	601	0	601	3636.93	5304	15932	926
C Jun 2012	353	368	54	739	0	739	3633.90	5277	15394	712
A Jul 2012	154	285	62	886	0	886	3628.45	5228	14880	892
L Aug 2012	101	289	60	800	0	800	3623.62	5186	14151	810
* Sep 2012	154	286	54	481	0	481	3621.56	5168	13920	478
WTY 2012	4908	5964	455	5466	0	5466				9527
Oct 2012	200	276	37	454	0	454	3619.34	5149	13693	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	3607.34	5051	12465	800
Feb 2013	250	286	9	675	0	675	3603.59	5021	12096	675
Mar 2013	425	358	15	600	0	600	3601.14	5002	11859	600
Apr 2013	675	633	23	600	0	600	3600.27	4966	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	816	55	811	0	811	3614.34	5107	13173	811
Aug 2013	400	502	55	850	0	850	3610.89	5078	12800	850
Sep 2013	325	514	50	850	0	850	3608.52	5060	12562	850
WTY 2013	7690	7161	386	6236	0	6236				6236
Oct 2013	443	470	34	600	0	600	3606.99	5048	12429	600
Nov 2013	441	434	33	600	0	600	3605.13	5033	12246	600
Dec 2013	363	383	28	800	0	800	3600.90	5001	11836	800
Jan 2014	361	399	8	800	0	800	3596.88	4970	11495	800
Feb 2014	363	405	8	600	0	600	3594.87	4955	11267	600
Mar 2014	665	562	14	600	0	600	3594.36	4951	11220	600
Apr 2014	1006	844	22	600	0	600	3596.55	4968	11425	600
May 2014	2343	1929	28	600	0	600	3609.00	5084	12630	600
Jun 2014	2689	2267	47	850	0	850	3623.00	5180	14084	850
Jul 2014	1091	999	59	850	0	850	3623.14	5187	14164	850
Aug 2014	500	601	58	800	0	800	3620.86	5190	13833	800
Sep 2014	425	531	53	850	0	850	3619.33	5149	13692	850
WTY 2014	16728	9918	386	6236	0	6236				6236



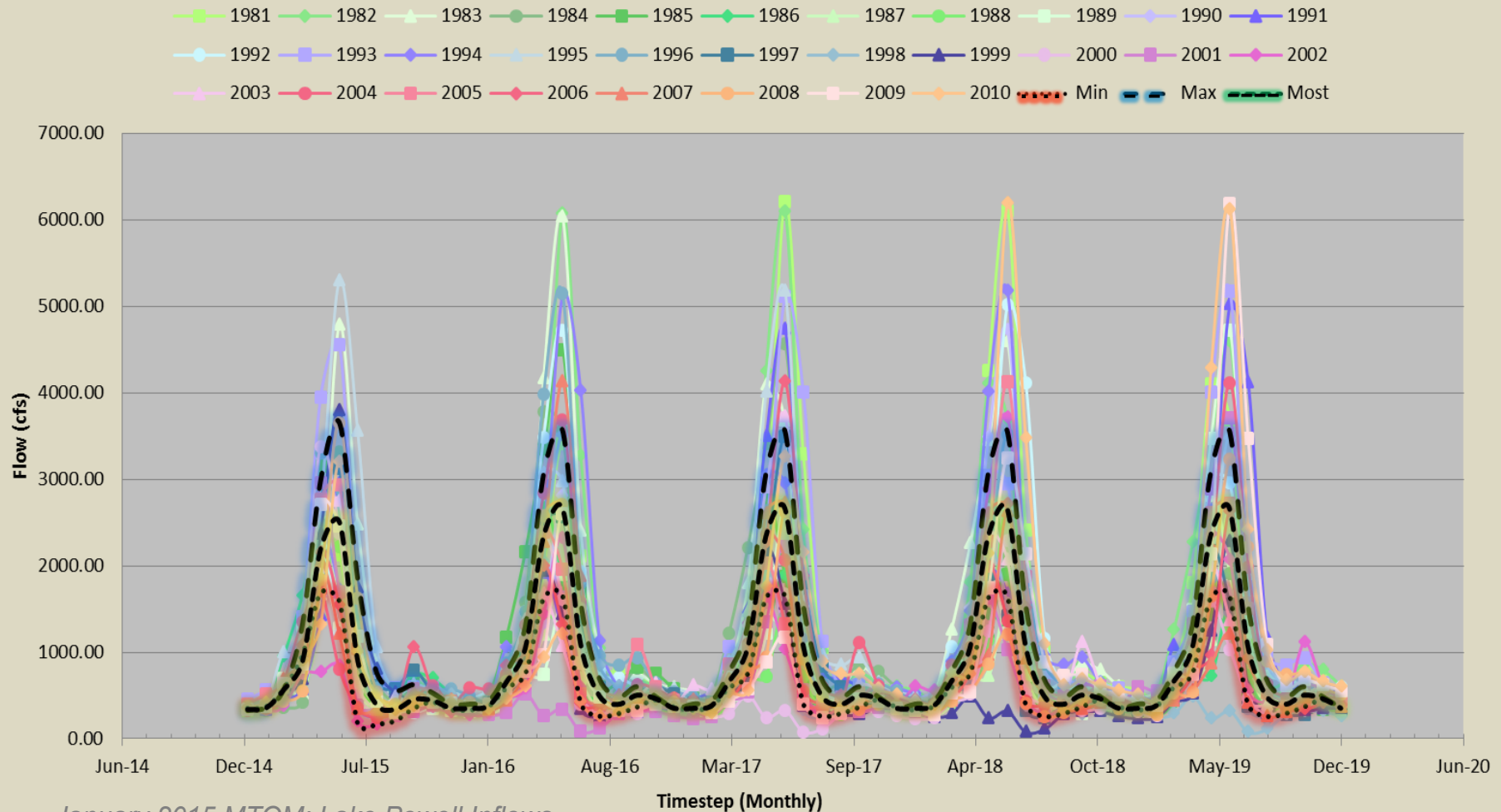
—Chart Explanation below—

Operational Decision-making Hierarchy



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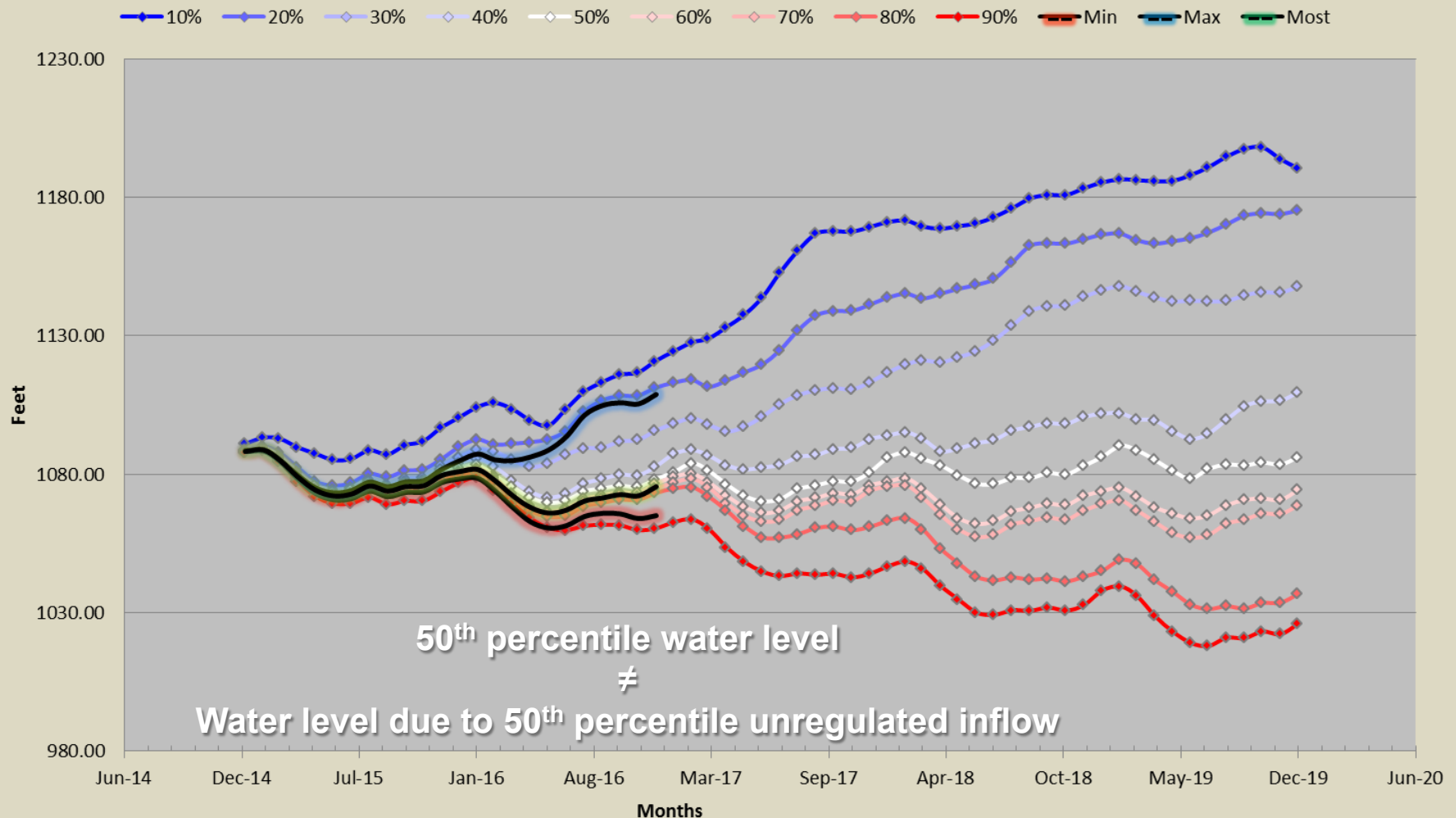
MTOM Inputs: Ensemble vs Discrete



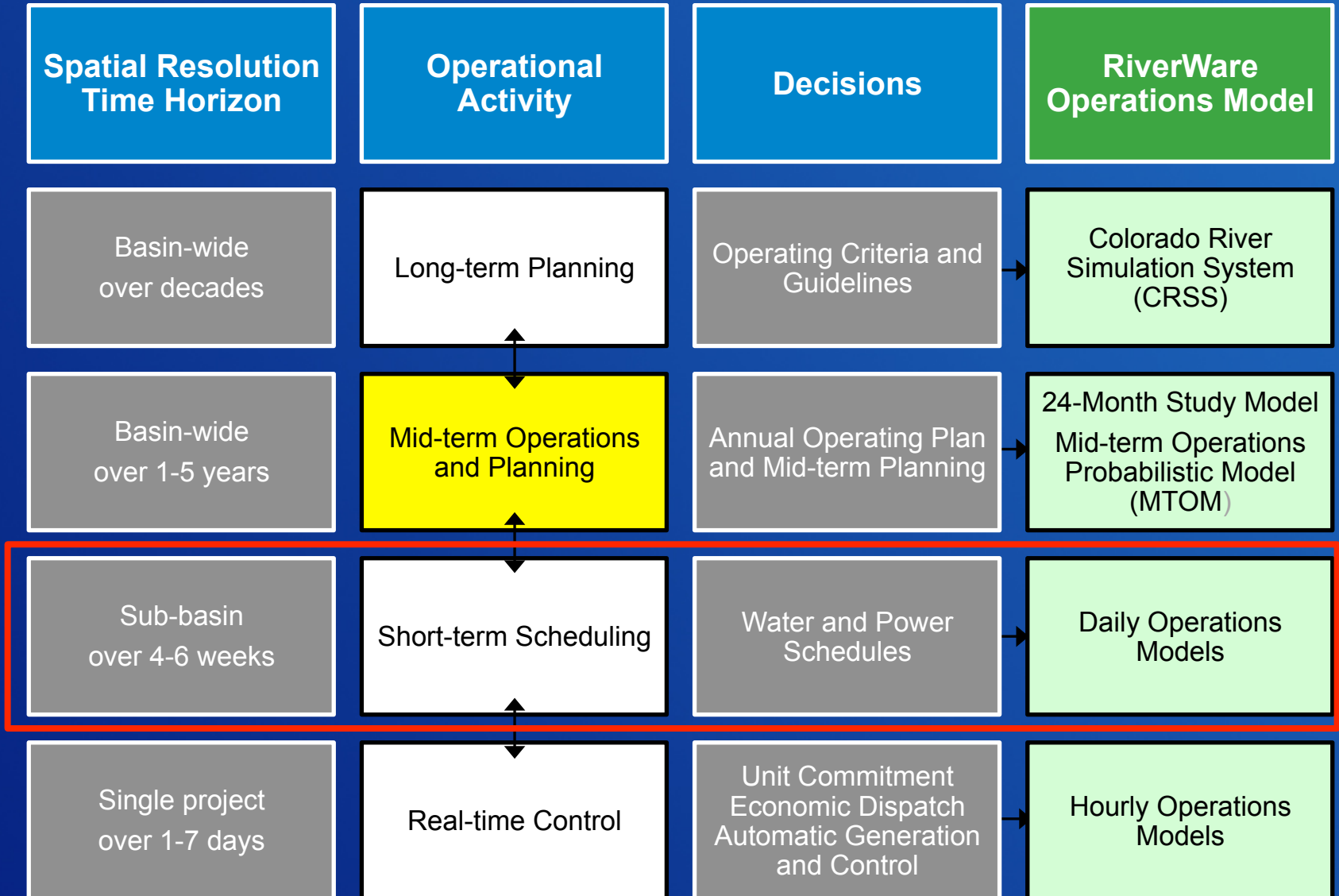
Note: Official Min, Most, and Max Probable forecasts
“extended” to 5 years by repeating the last year

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MTOM Output: Ensemble vs Discrete



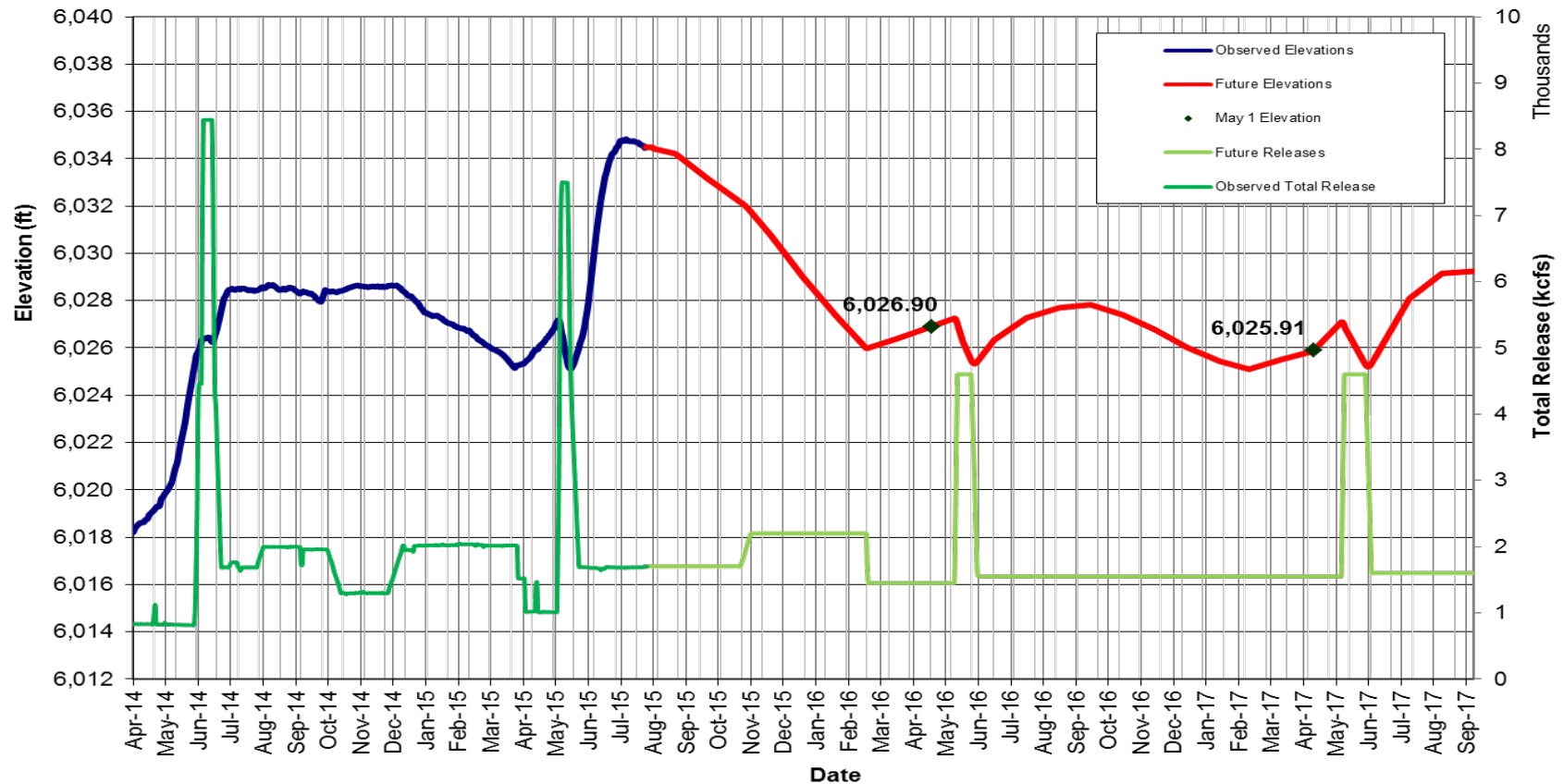
Operational Decision-making Hierarchy



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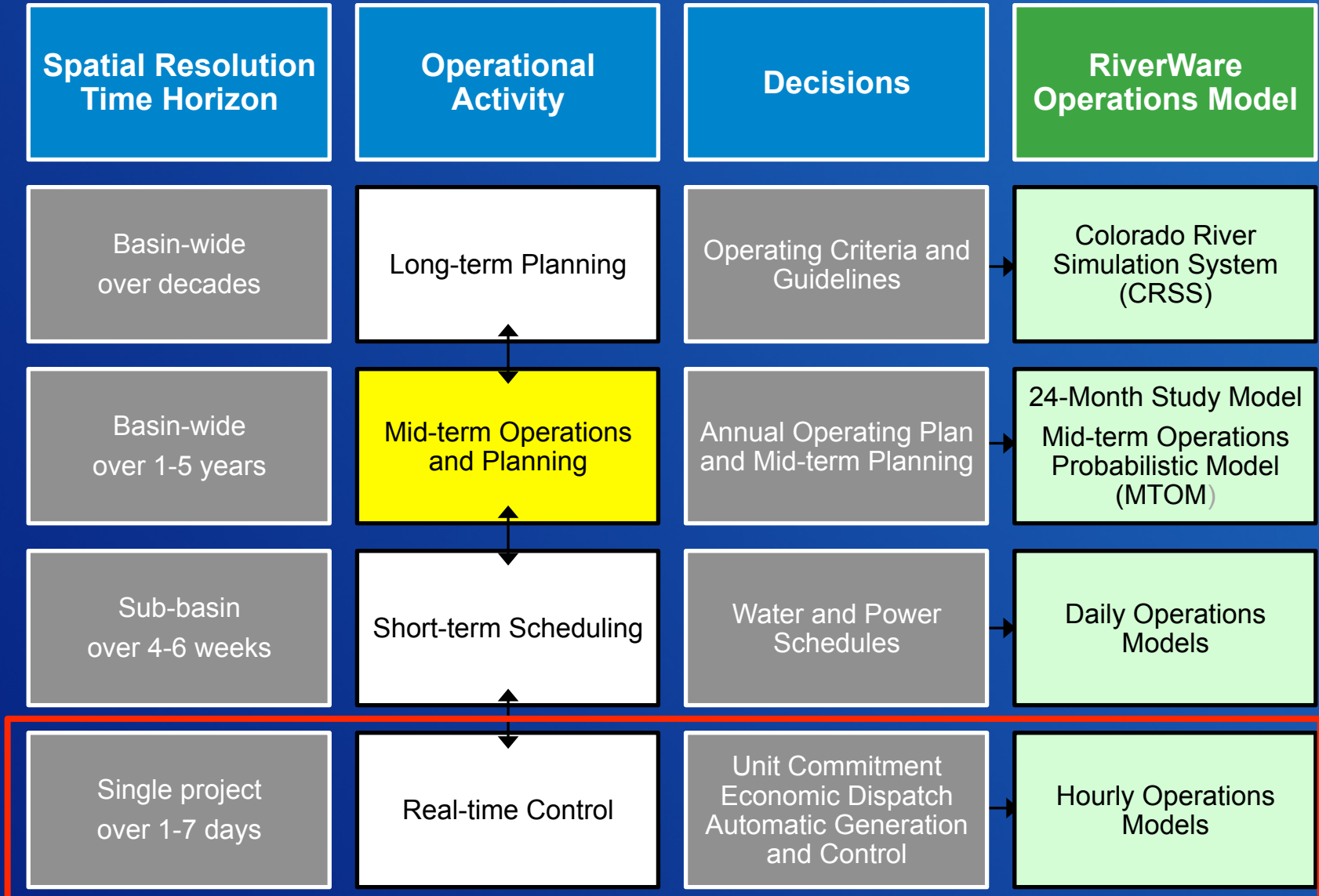
Daily Operation Model Output

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

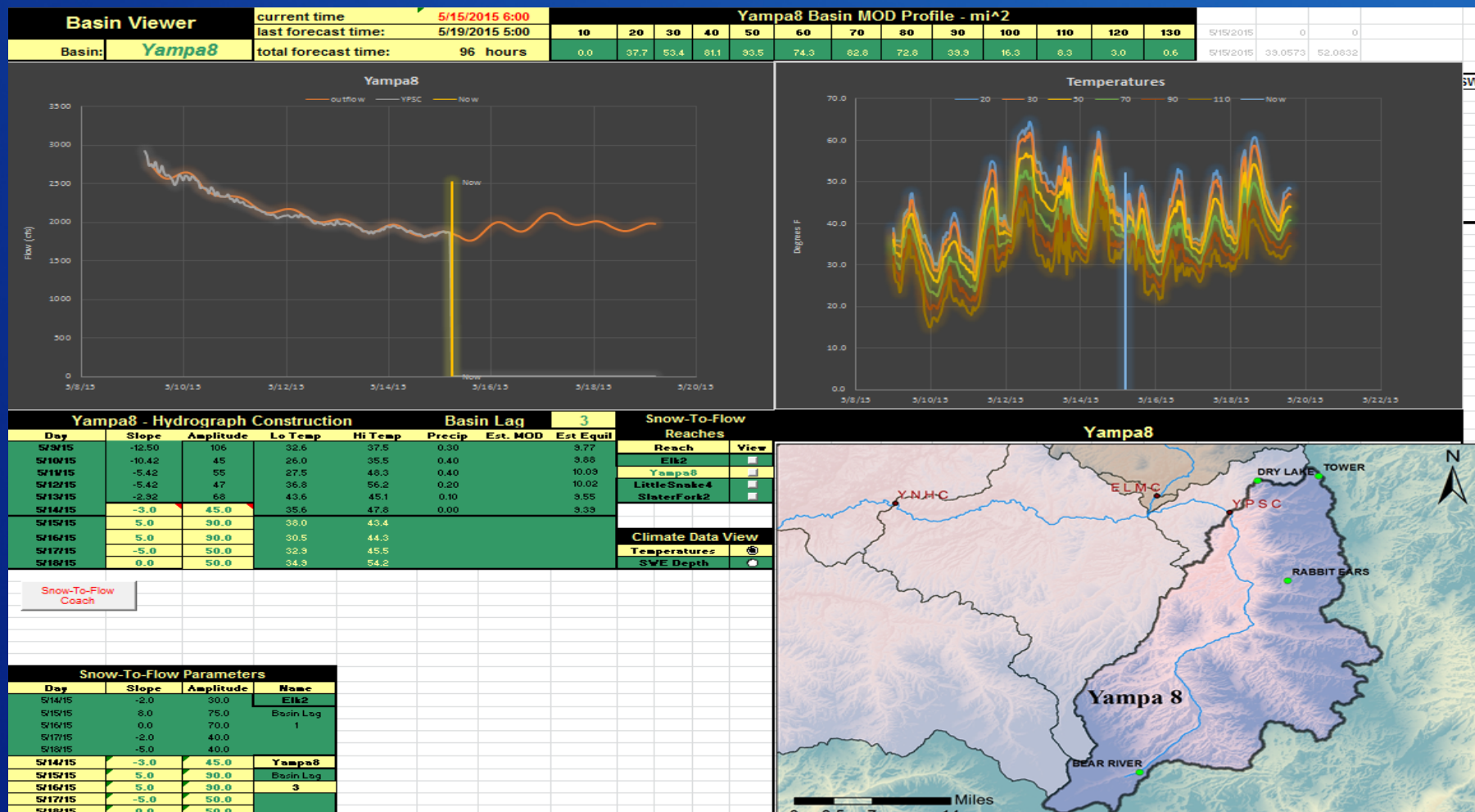


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Operational Decision-making Hierarchy

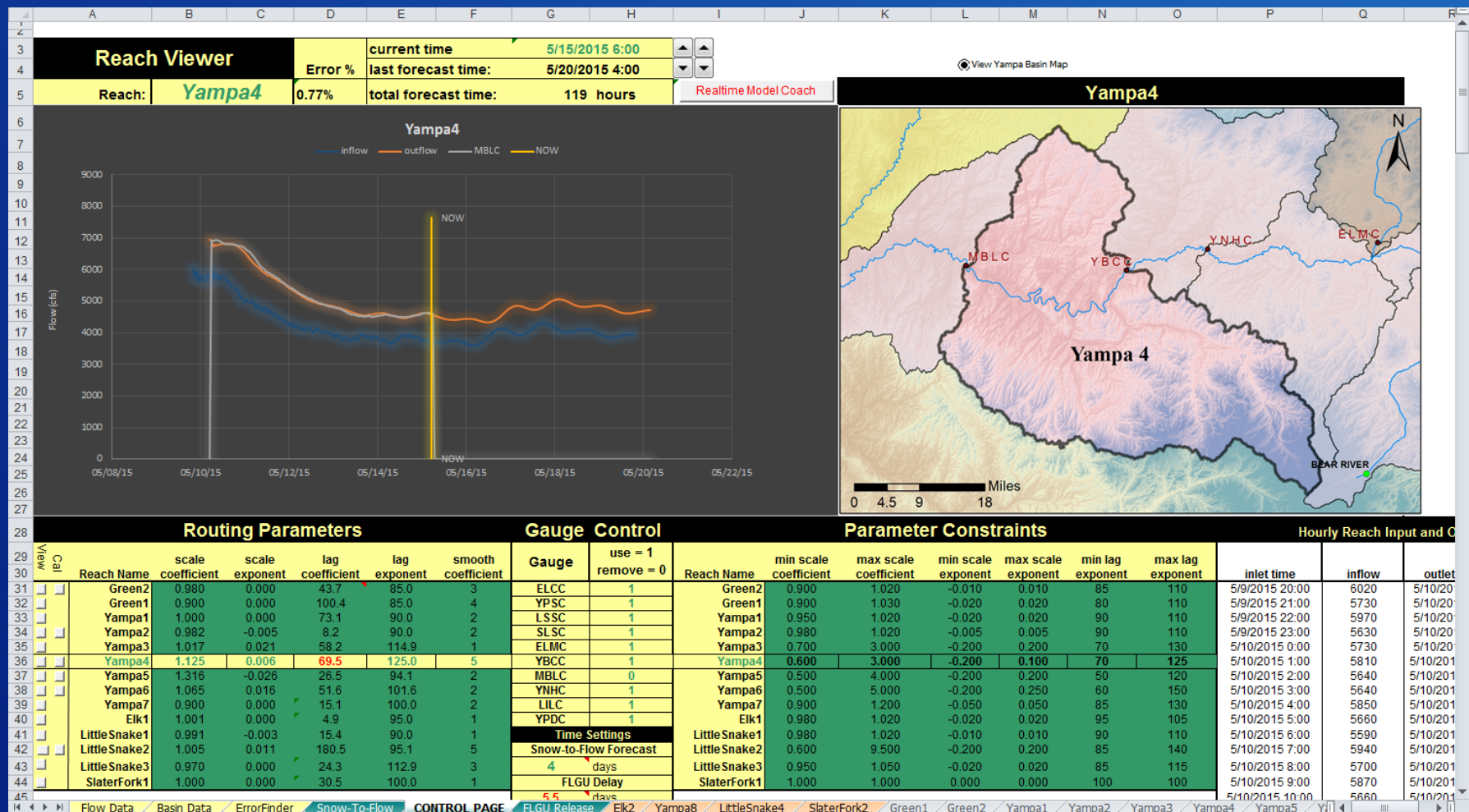


Hourly Yampa and Green River Model

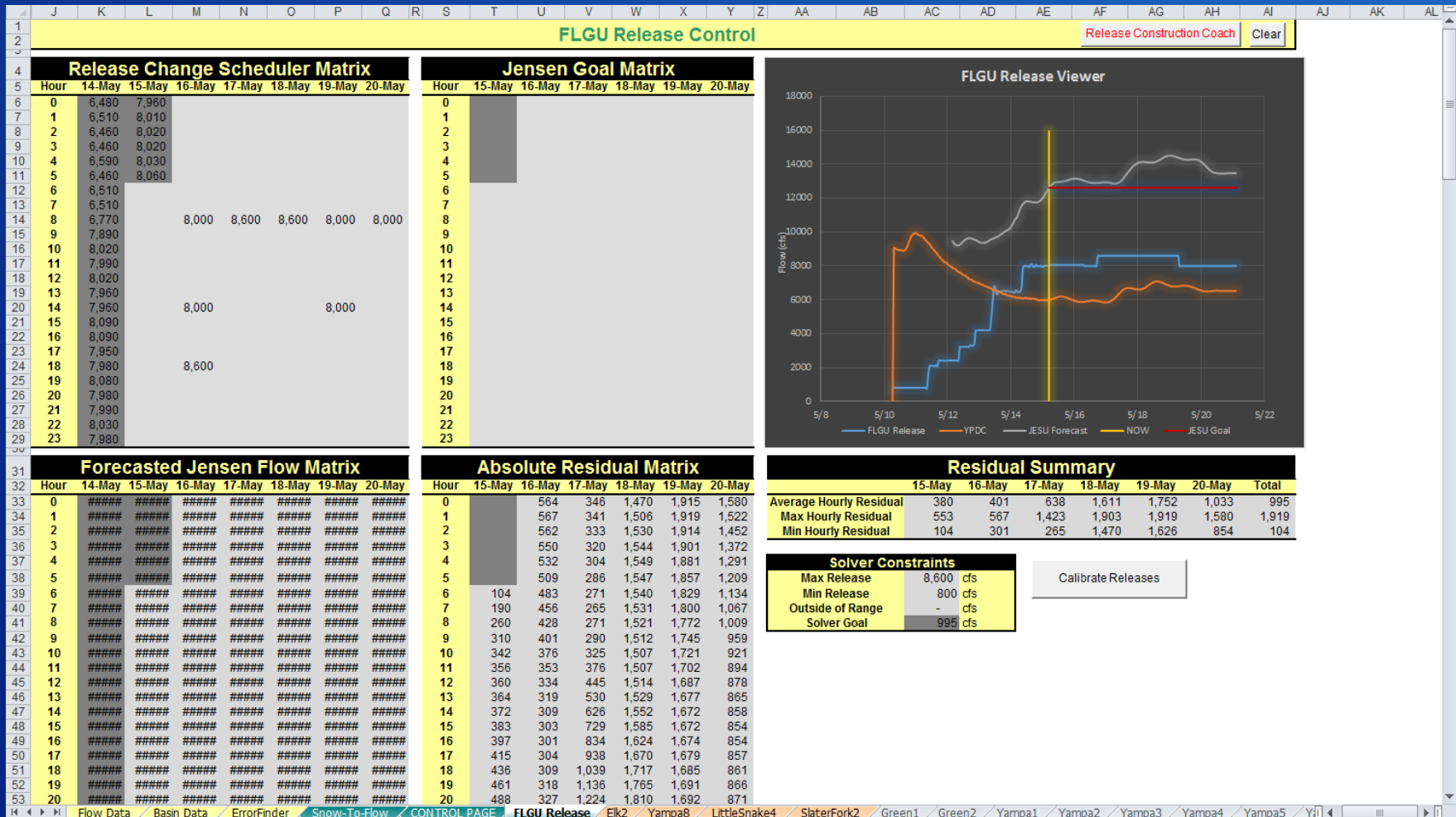


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Hourly Yampa and Green River Model



Hourly Yampa and Green River Model



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

Calibrate Releases

FLGU Release Viewer

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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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