Risk Study Phase IV Updates

Hydros Consulting
July 18, 2023

COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

Colorado Risk Study and Related Activities

Colorado Risk Study Timeline:

Phase I (2016); Phase II (2017-2018); Phase III (2019-2020)

Risk Study Updates (Phase IV)

1. Review Phase III
2. StateMod Re-Analysis of Pre/Post Compact Consumptive Use Estimates in Colorado
    1. Post-1922 curtailment volume
    2. interannual and sub-basin variability
3. Updates to “Big River” Risk Analyses
    1. Colorado TMDs
    2. 2050 Incremental Depletions (Basin-Wide)
    3. Powell, Mead and Lee Ferry Outcomes

Headlines and Executive Summary
(but you can't leave yet)

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- Hydrology is (still) #1 indicator of system "health" and catalyst for risk to Colorado River water users
- Increasing demands in Upper Basin = increasing risk of potential shortage / volume of curtailment
- Increases in Trans-Mountain Diversion (TMD) demands will not be fully satisfied if/as hydrology worsens, resulting in drawdown of west slope TMD storage reservoirs.
- Maintaining Powell elevation of 3500' (above mean sea level) under existing operational policy (2007 Interim Guidelines) and under continued aridification puts entire burden of risk on Upper Basin

Analysis of Colorado's Compact Consumptive Use (Pre-22/Post-22)

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- Simplifying assumptions and aggregated water rights in State Model resulted in over-estimation in Phase III (2019) results:
  - Overestimated total Consumptive Use in Colorado
  - Overestimated Pre-1922 Compact Consumptive Use
- StateMod "fixes" necessitated reanalysis of Phase III consumptive use results.

Analysis of Colorado's Pre-22/Post-22 Compact Consumptive Use

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Comparison of Phase III and Phase IV Results

Consumptive Use (AF/yr)	Phase III	Phase IV	Change
Pre-Compact	1.6 MAF	1.3 MAF	(-300) Kaf
Post-Compact	0.932 MAF	1.07 MAF	140 Kaf
Total CU	2.53 MAF	2.37 MAF	(-160) Kaf

Takeaway: Less consumptive use overall, and less pre-compact consumptive use

Analysis of Colorado's Pre-22/Post-22 Compact Consumptive Use

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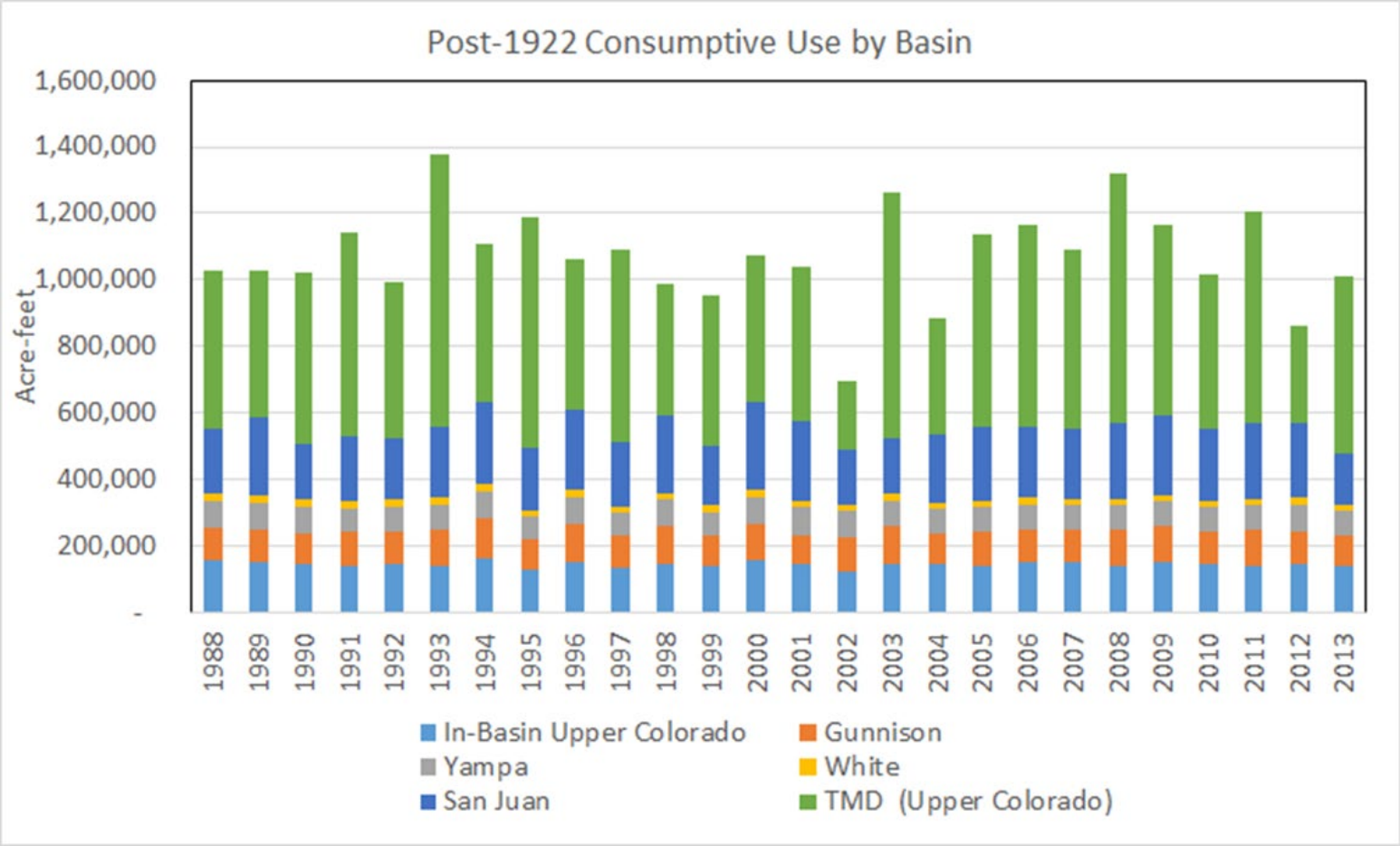
Basin	Pre-Compact Depletions				Post-Compact Depletions			
	Average Volume (AF)		As % Total		Average Volume (AF)		As % Total	
	Phase III	Phase IV	Phase III	Phase IV	Phase III	Phase IV	Phase III	Phase IV
Yampa	138,544	120,037	8.7%	9.2%	58,438	76,799	6.3%	7.2%
White	50,173	41,609	3.1%	3.2%	11,887	20,328	1.3%	1.9%
Upper Colorado: In-Basin	574,997	390,900	35.9%	30.0%	94,400	143,614	10.1%	13.4%
Upper Colorado: TMD	19,173	19,368	1.2%	1.5%	531,816	519,535	57.1%	48.6%
Gunnison	495,147	438,290	30.9%	33.7%	57,271	101,377	6.1%	9.5%
Southwest	322,561	292,187	20.2%	22.4%	178,157	207,920	19.1%	19.4%
Total	1,600,594	1,302,391	100%	100%	931,969	1,069,573	100%	100%

Interannual Variability in Post-Compact (Post-1922) Consumptive Use

- AVERAGE Post-compact consumptive use is ~1.0MAF/yr
- But… significant year-to-year variability



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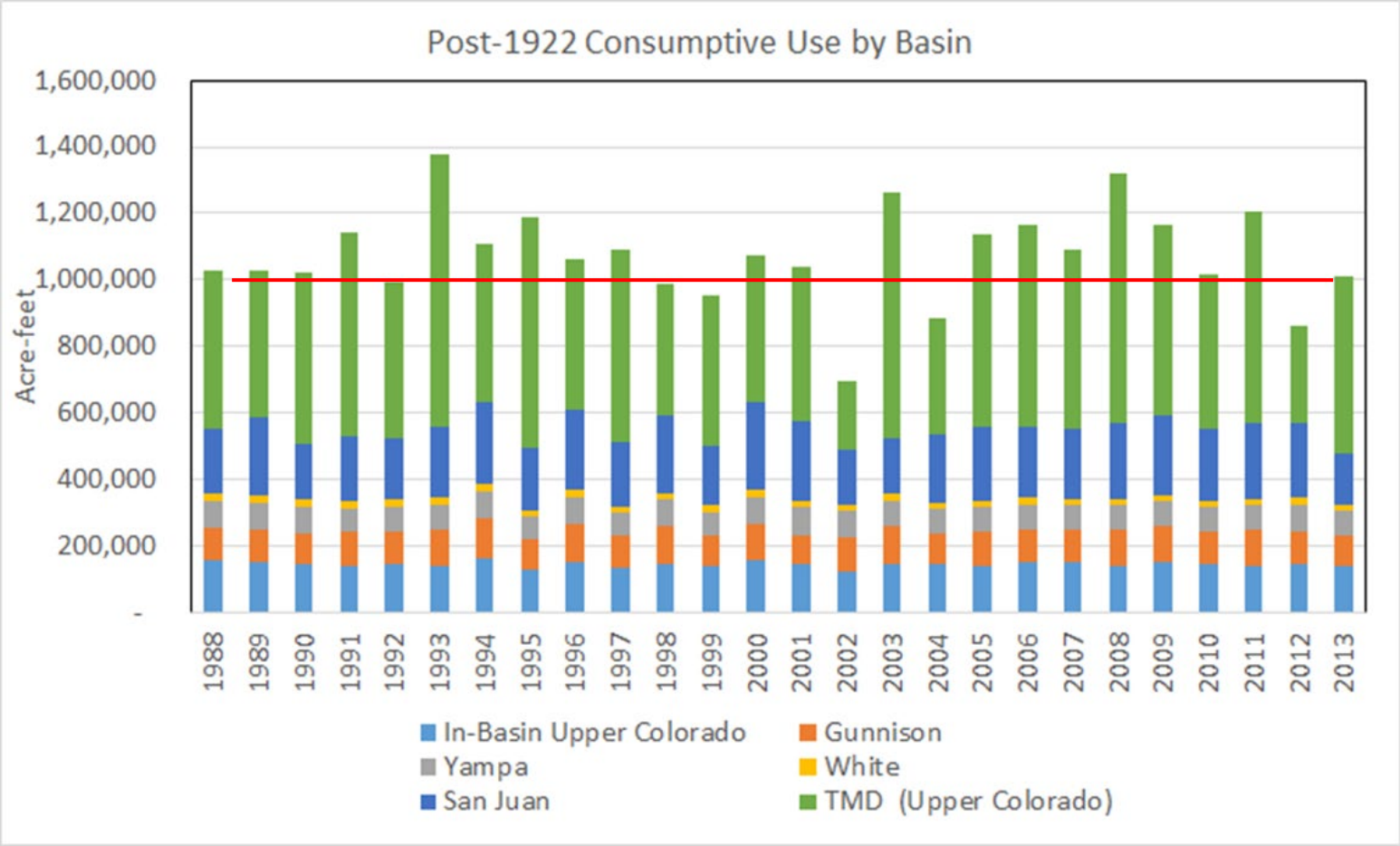

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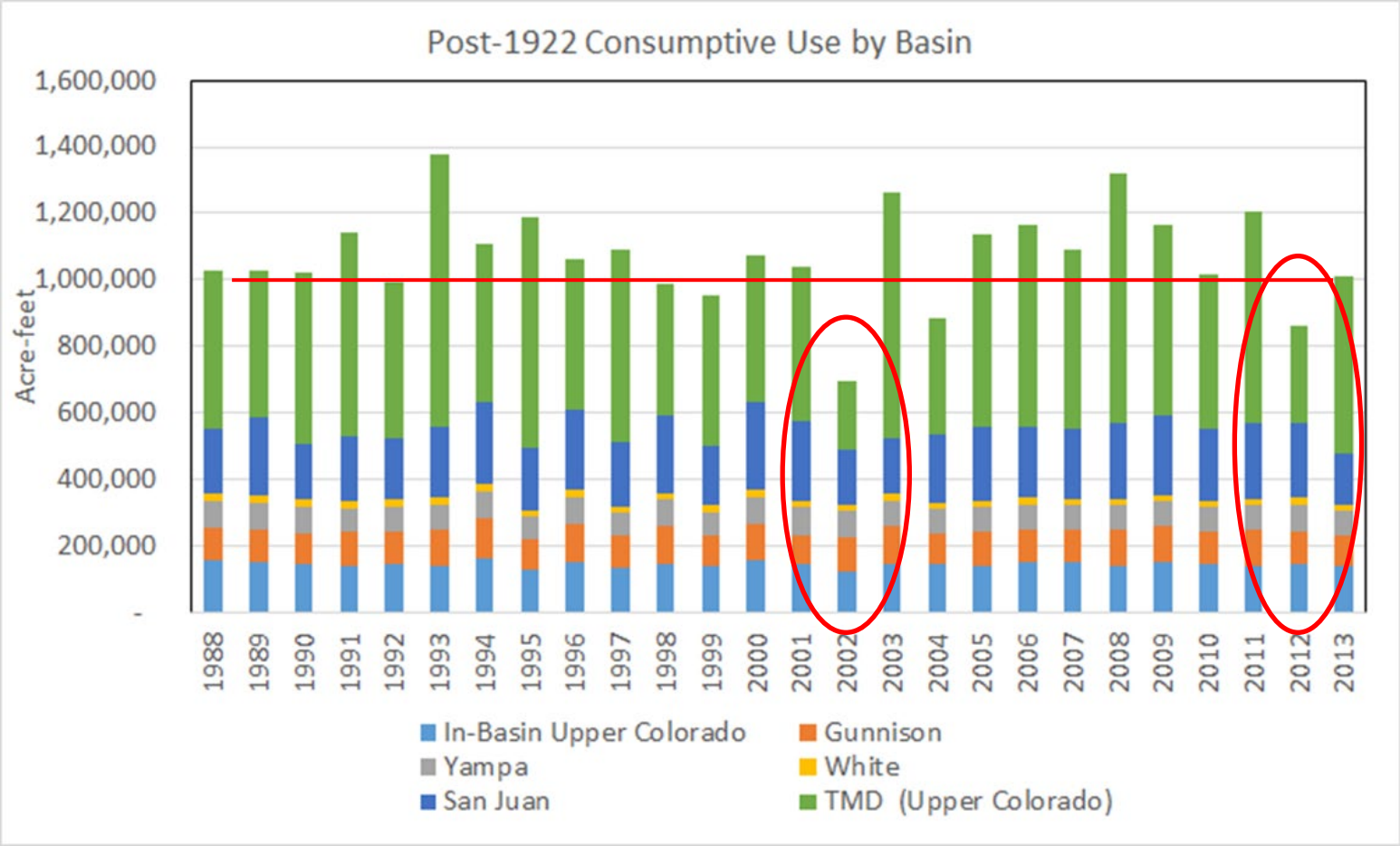

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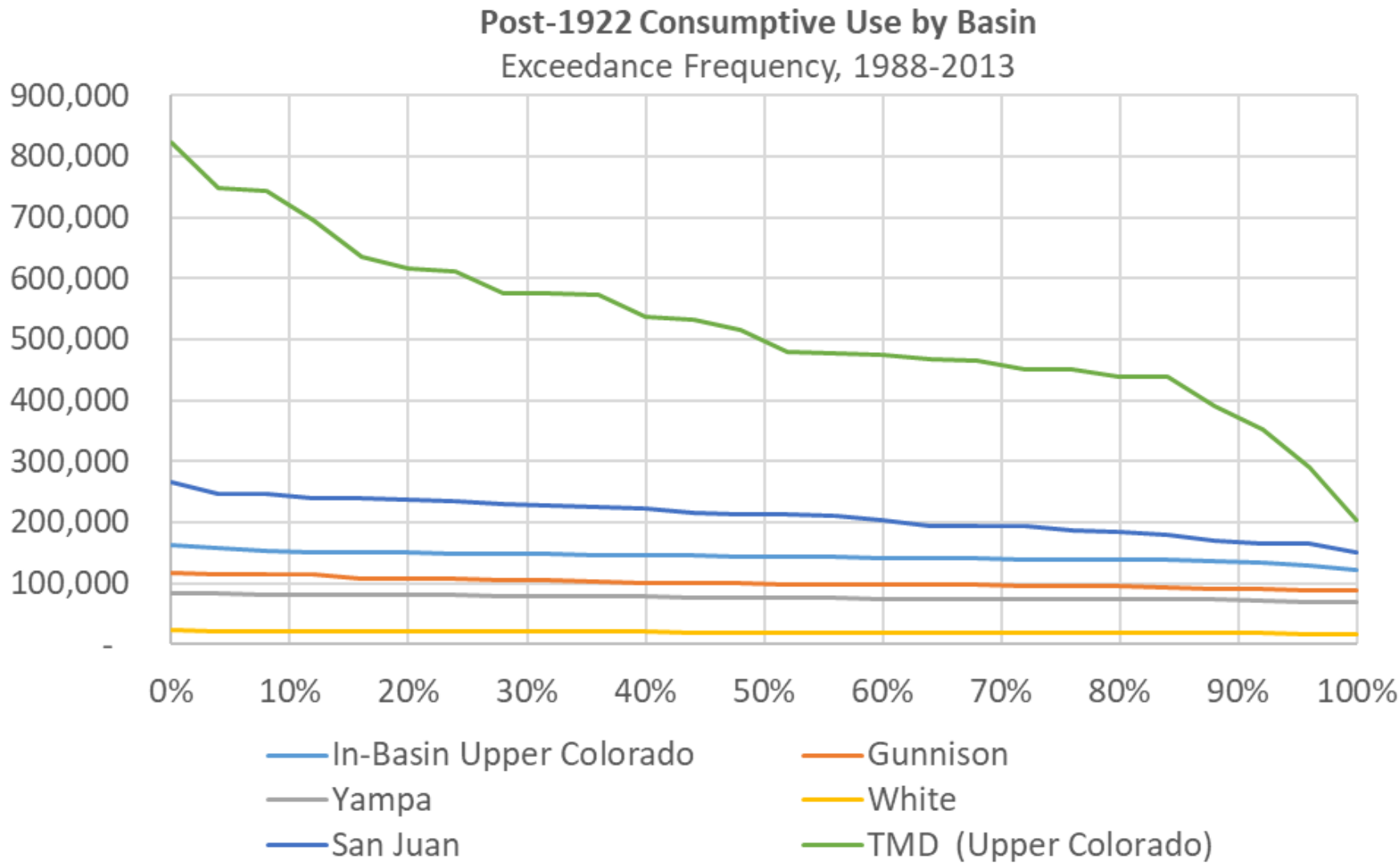

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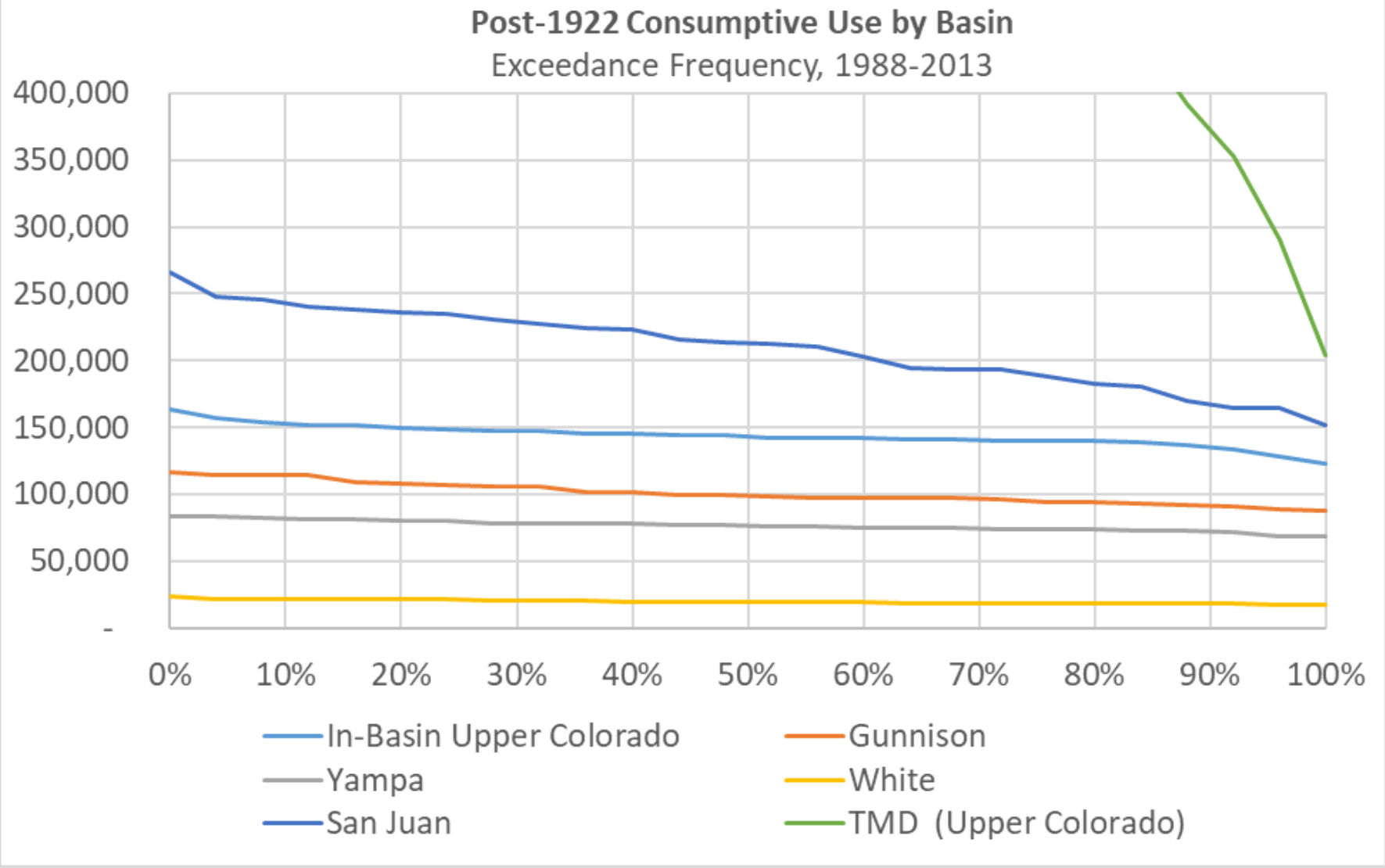

Consumptive Use Summary

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Total CU	2.53 MAF	2.37 MAF	(-160) KAF

- Post-Compact consumptive uses in Colorado vary between 700 KAF/yr to 1.4MAF/yr depending on hydrologic conditions
- The majority of this variability is due to TMD storage and deliveries, followed by the San Juan/Dolores basins and the In-Basin Upper Colorado.
- Yampa, White, and Gunnison post-compact uses are not as susceptible to changes in hydrologic conditions.
  - *These basins tend to have infrequent calls even in dry years*

MAF: million acre-feet, KAF: thousand acre-feet, TMD: trans-mountain diversion

Updates to "Big River" Analysis

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Updates to Reclamation's Colorado River Modeling tool:

- Colorado River Simulation System (CRSS)
- Trans Mountain Diversion (TMD) representation includes those with storage (*e.g.,* Dillon, Granby) and separates those without storage (*e.g.,* Moffat Tunnel)
- Shortages (esp. in tributaries) better represented
- Previous model bias essentially eliminated, as represented at Lake Powell

Important Notes on TMD demands in this analysis:

- Current (2020) TMD demands are "east-slope hydrology limited"
- 2050 demands are <u>not</u> conditioned on east slope conditions due to projected infrastructure capacity increases by 2050

Updates to "Big River" Analysis

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Key Questions Analyzed:

1. How does increased TMD demand impact the State of Colorado and inflows to and Lake Powell levels?
2. How does projected increased demand in Upper Basin impact Lake Powell and the rest of the Colorado River basin?
3. How has overall Colorado River System risk changed since Phase III?

Trans Mountain Diversions: 2050 Demand Forecast

- TMD demands are forecasted to increase by 110 KAF by 2050 (UCRC 2016); due to known new and existing projects)
  - Represents 70% of forecast increase in demand for Colorado River water within the State of Colorado
  - Other potential projects add another 75KAF by 2050

3 Major contributors:

- Windy Gap Firming (avg ~21 KAF/yr)
- Moffat Expansion (avg ~40 KAF/yr)
- Eagle River (Whitney Res) (avg ~24.5 KAF/yr)

Upper Colorado River Division States
Updated 2016 Current and Future Depletion Demand Schedule [1,2,4]
Colorado
June 14, 2022
(Units: 1,000 acre-feet)

ITEM	YEAR						
	Current/Historic	2020	2030	2040	2050	2060	2070
Agriculture-Irrigation & Stock[3]	1,863	1,863	1,869	1,870	1,876	1,877	1,863
Potential Agriculture-Irrigation & Stock		0	0	0	0	0	0
Municipal/Industrial	61	60	65	65	71	70	71
Potential Municipal/Industrial		0	0	5	5	5	5
Self-Served Industrial	11	11	11	11	11	11	11
Potential Self-Served Industrial		0	0	0	0	0	0
Energy	30	33	40	45	50	55	60
Potential Energy		5	10	10	15	10	0
Minerals	32	35	40	45	50	60	66
Potential Minerals		0	0	3	5	4	0
Export	732	740	775	800	850	900	1,013
Potential Export		50	75	100	125	100	0
Reservoir Evaporation (in-state)	130	130	130	130	130	130	130
Potential Reservoir Evaporation		0	0	0	0	0	0
TOTAL Forecasted Depletions	2,859	2,927	3,015	3,084	3,188	3,222	3,219

Colorado's Depletion Demand Schedule

Hydros Consulting

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Modeling growth in TMD and Upper Basin demands

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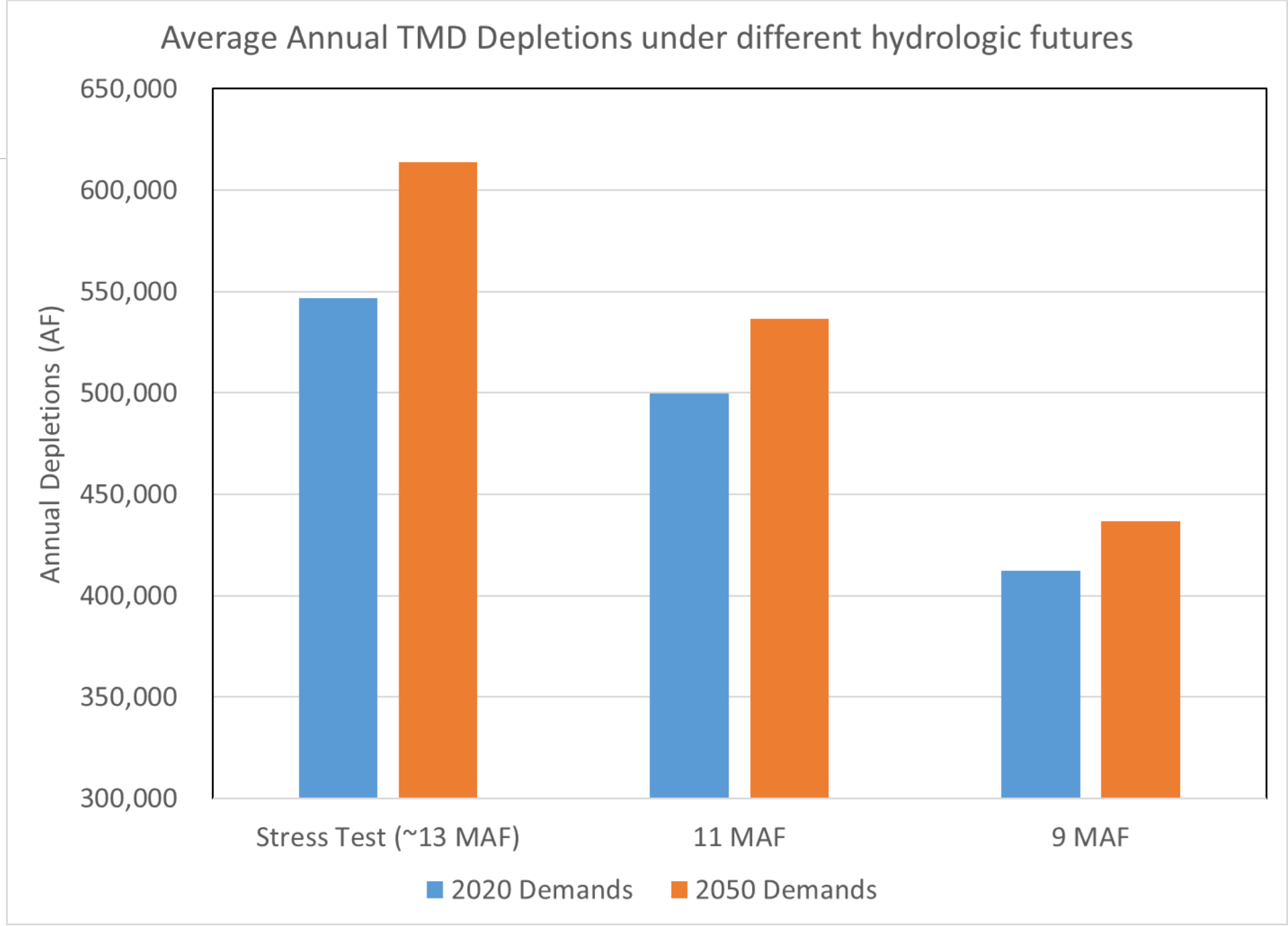
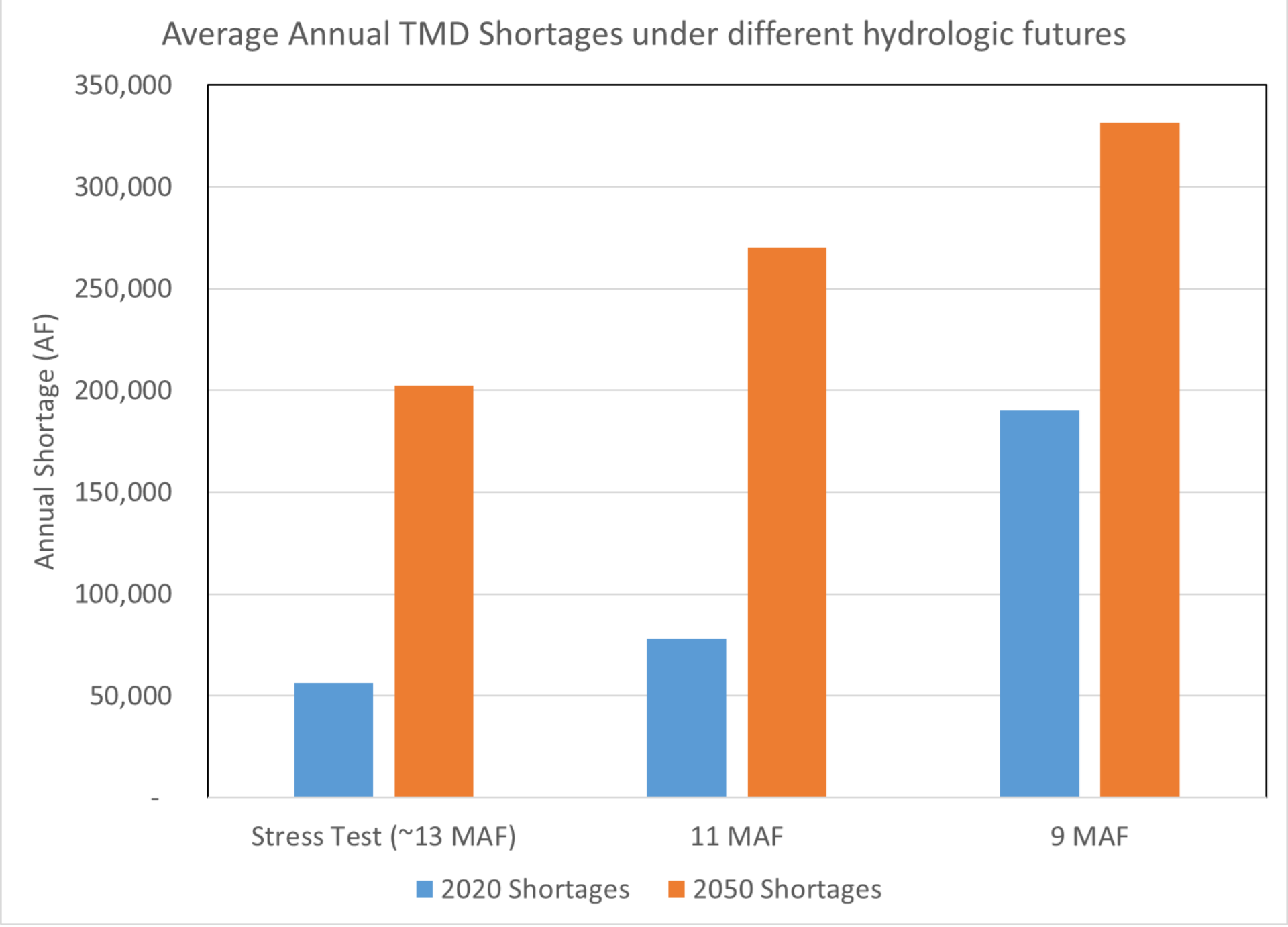
Evaluate TMD depletions and shortages at current (2020) and future (2050) demands using Reclamation's revised model (CRSSv6)

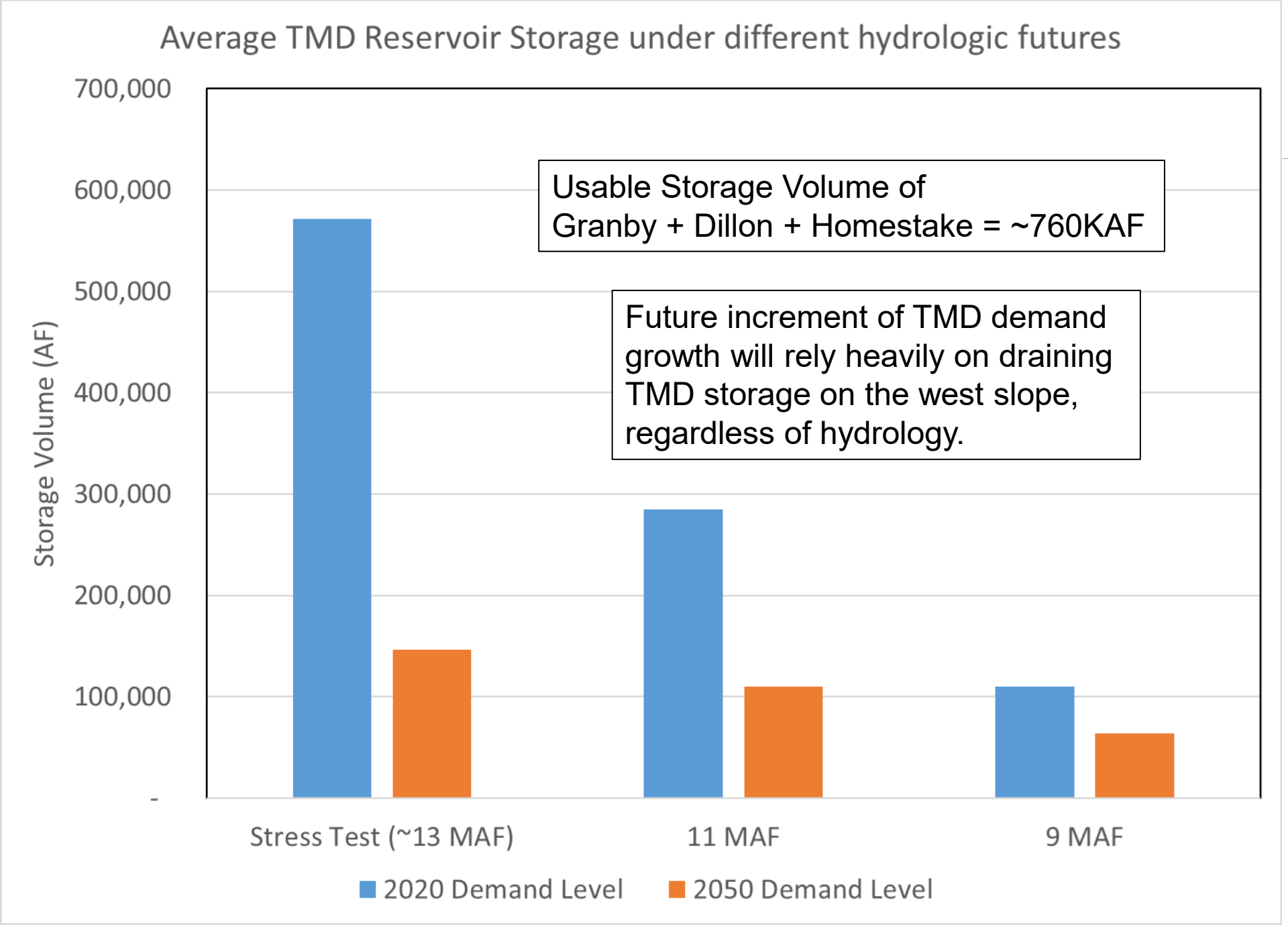
3 Hydrology ensembles (Natural Flows above Lee Ferry):

1. Stress-Test (~13 MAF/yr average)
2. 11 MAF/yr average
3. 9 MAF/yr average

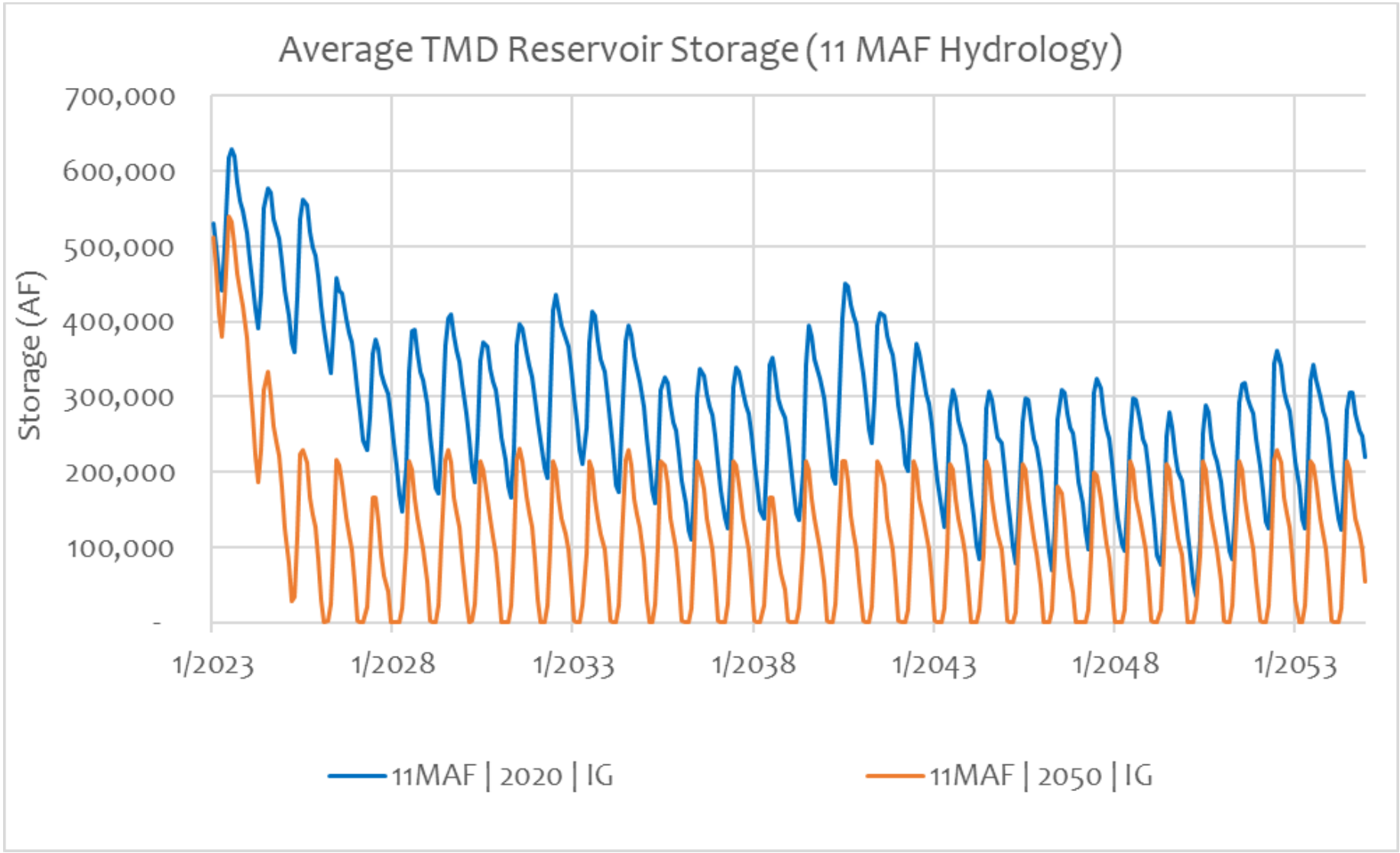
Use these hydrology data sets to simulate conditions at Lakes Powell and Mead as well as Lee Ferry flows under current operating policies


Average Annual TMD Depletions under different hydrologic futures
650,000
600,000
550,000
500,000
450,000
400,000
350,000
300,000
Annual Depletions (AF)
Stress Test (~13 MAF)
11 MAF
9 MAF
2020 Demands
2050 Demands


Average Annual TMD Shortages under different hydrologic futures
350,000
300,000
250,000
200,000
150,000
100,000
50,000
-
Annual Shortage (AF)
Stress Test (~13 MAF)
11 MAF
9 MAF
2020 Shortages
2050 Shortages


Average TMD Reservoir Storage under different hydrologic futures
Storage Volume (AF)
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
Usable Storage Volume of
Granby + Dillon + Homestake = ~760KAF
Future increment of TMD demand growth will rely heavily on draining TMD storage on the west slope, regardless of hydrology.
Stress Test (~13 MAF)
11 MAF
9 MAF
2020 Demand Level
2050 Demand Level

Depletion of TMD Storage under 11 MAF Hydrology (Granby, Dillon, Homestake)



Impacts of TMD growth in Colorado

Takeaways:

1. Current demands and stress-test hydrology is sustainable, but just barely.
2. Current demands and 11 MAF hydrology results in significant reduction in TMD storage and approximately 10% reduction in average deliveries.
3. A 9 MAF future would reduce current yields by 135 KAF/yr
4. Future increment of growth will rely heavily on draining TMD storage on the west slope, regardless of hydrology.

	PCST (~13 MAF)		11 MAF		9 MAF	
Average (AF/yr)	TMD Depletions	TMD Shortage	TMD Depletions	TMD Shortage	TMD Depletions	TMD Shortage
2020 Avg	546,613	56,297	499,860	78,055	412,012	190,292
2050 Avg	613,629	202,340	536,447	270,416	436,423	331,579

Updates to “Big River” Risks

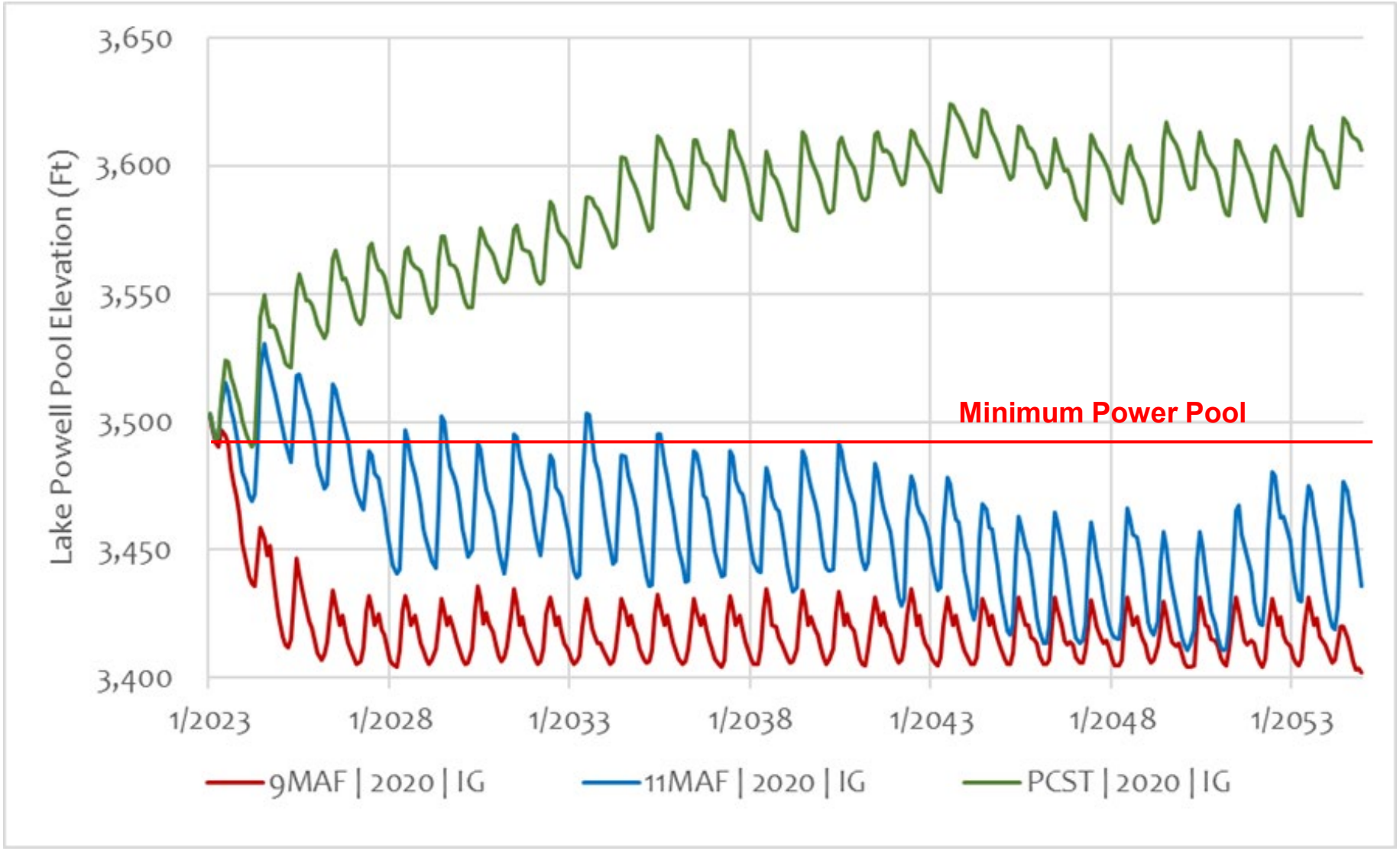
Key Questions:

1. *How do increasing demands by Upper Basin users impact Lake Powell, Lee Ferry, and Lake Mead?*
2. *Under “current” conditions, what is risk of reaching critical thresholds under different hydrologic futures?*
3. *Under current operations (2007 IG) How much additional water is needed to maintain Powell at 3500’?*

Demand Scenarios:

1. Current (2020) demands
2. Upper Basin-Wide 2050 Demands

Risk is still primarily a function of hydrology



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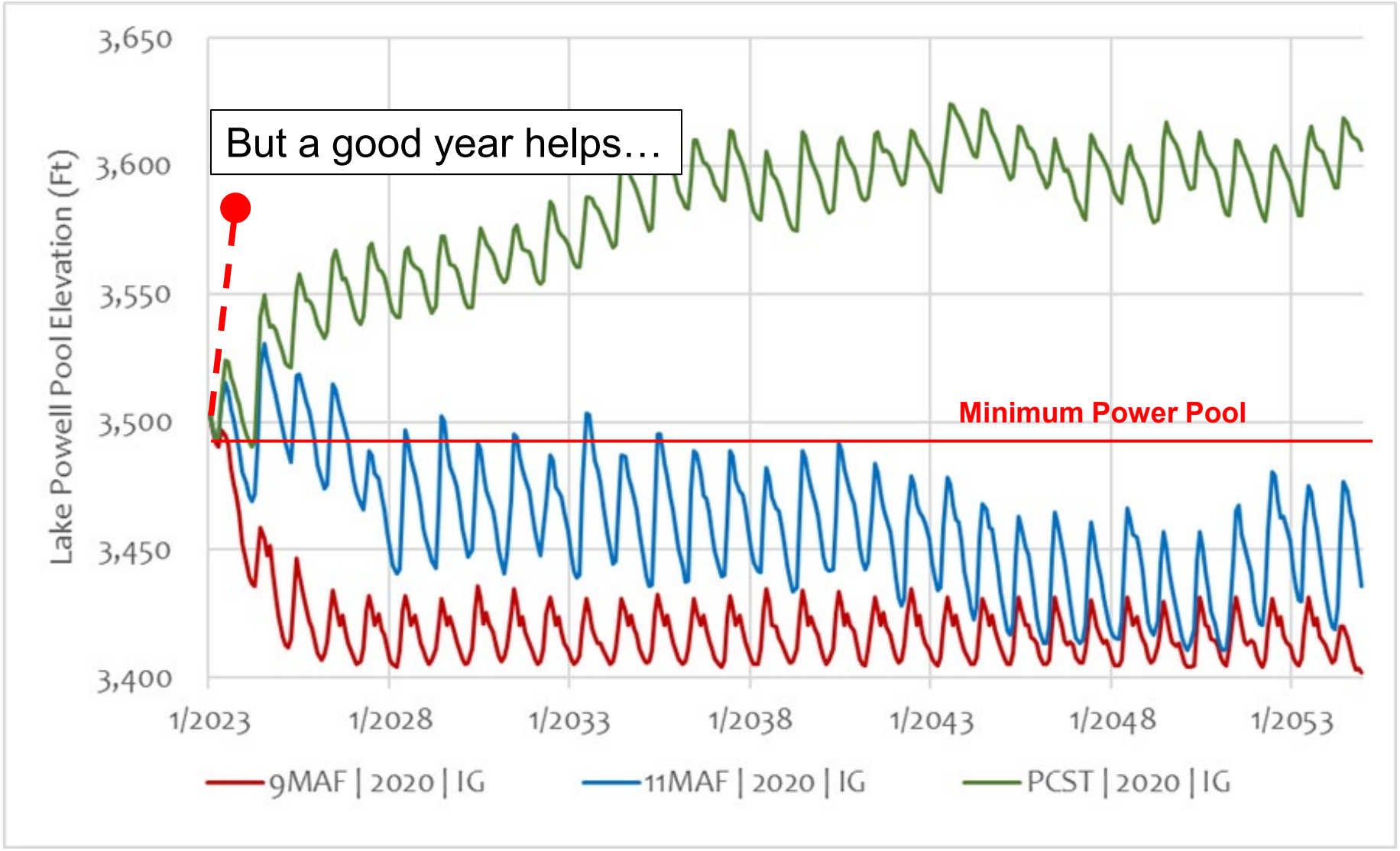
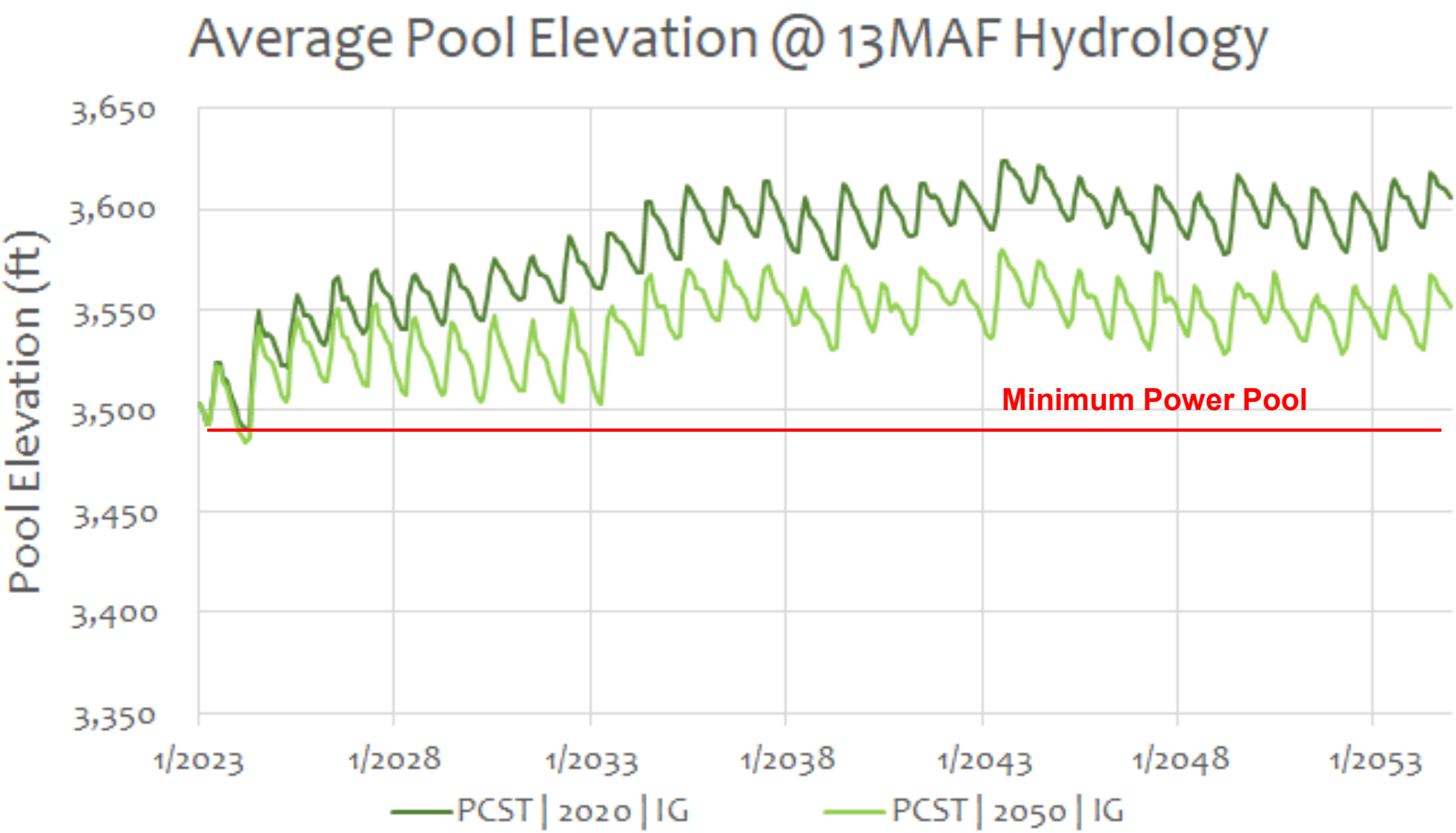


But… Demands DO Matter



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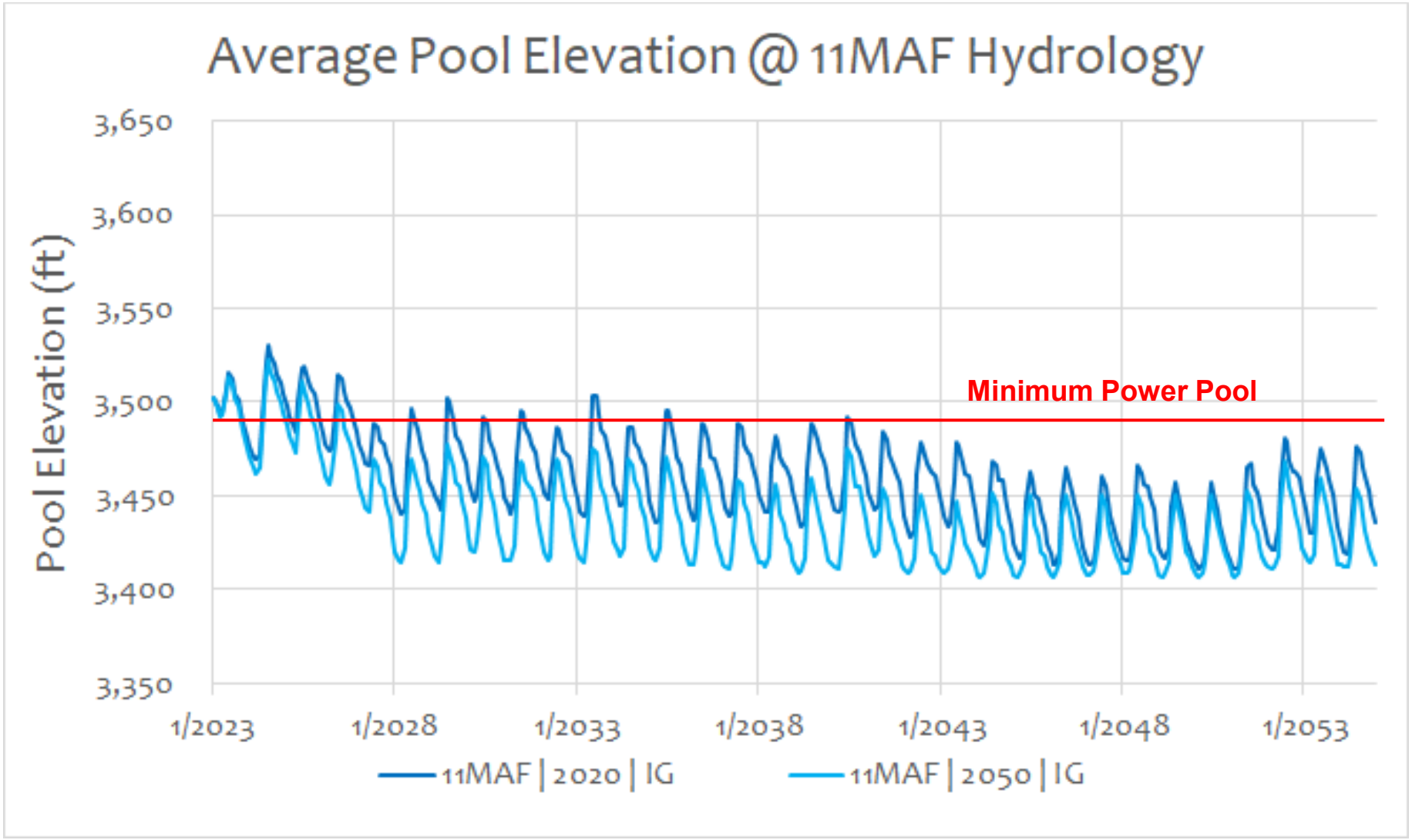
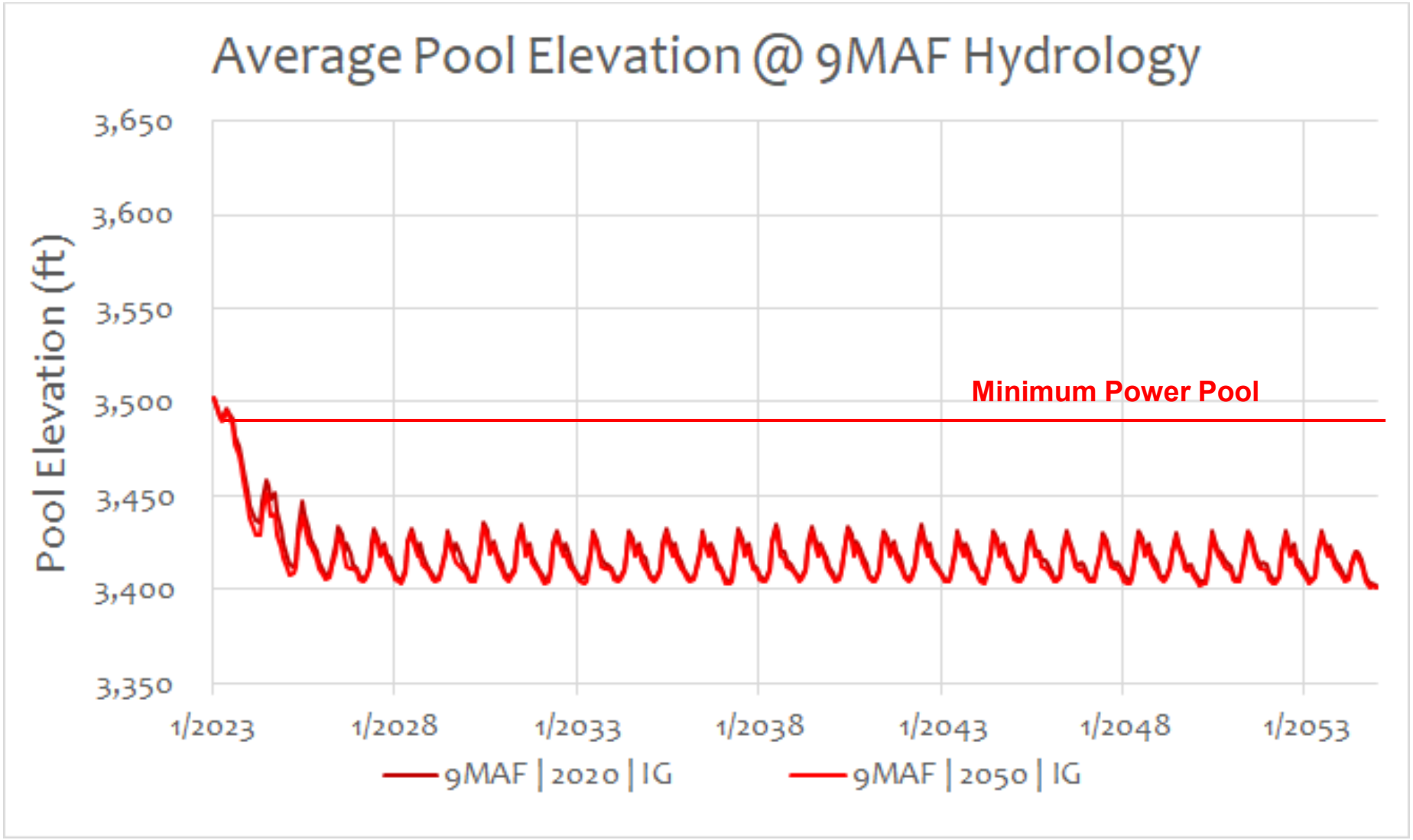
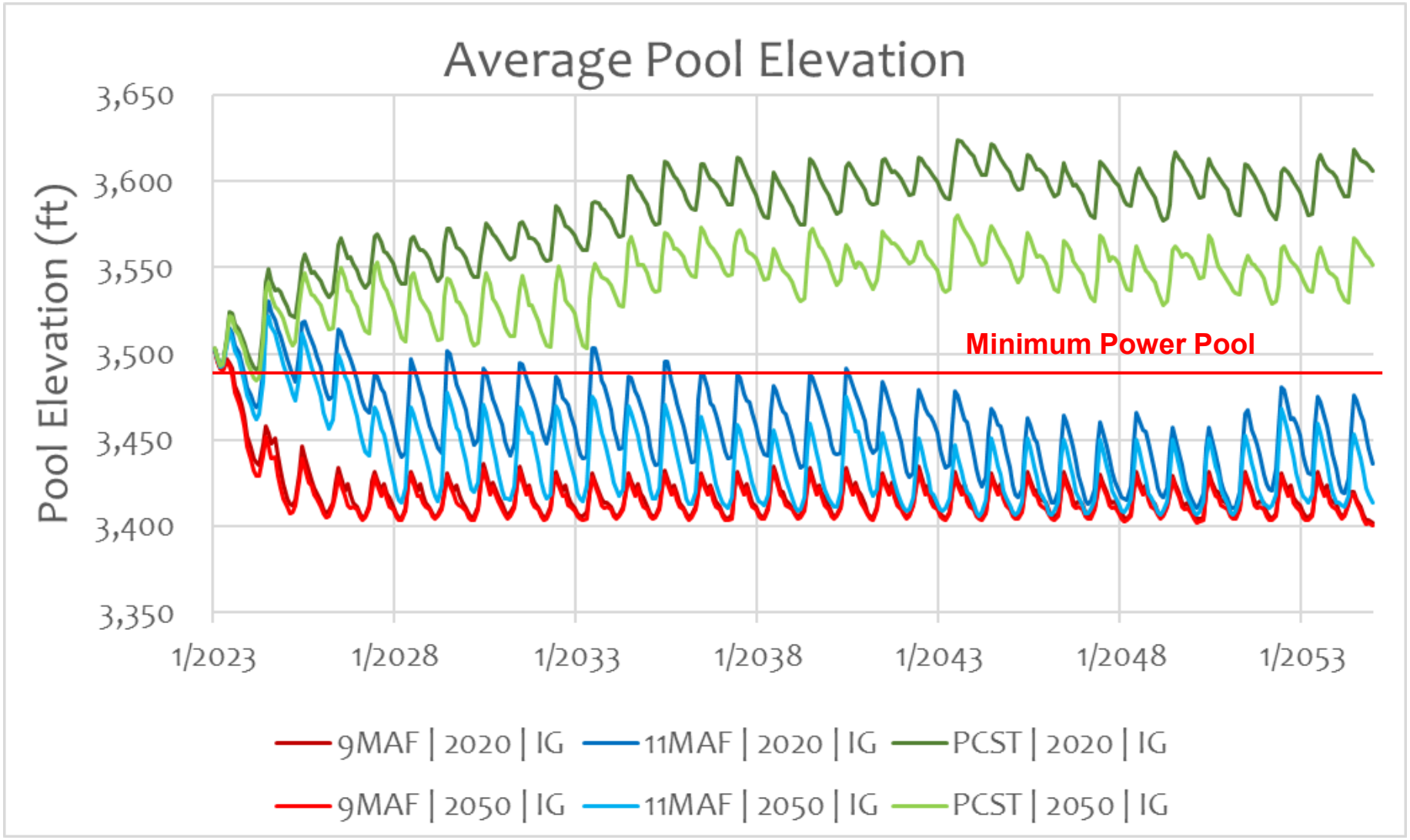


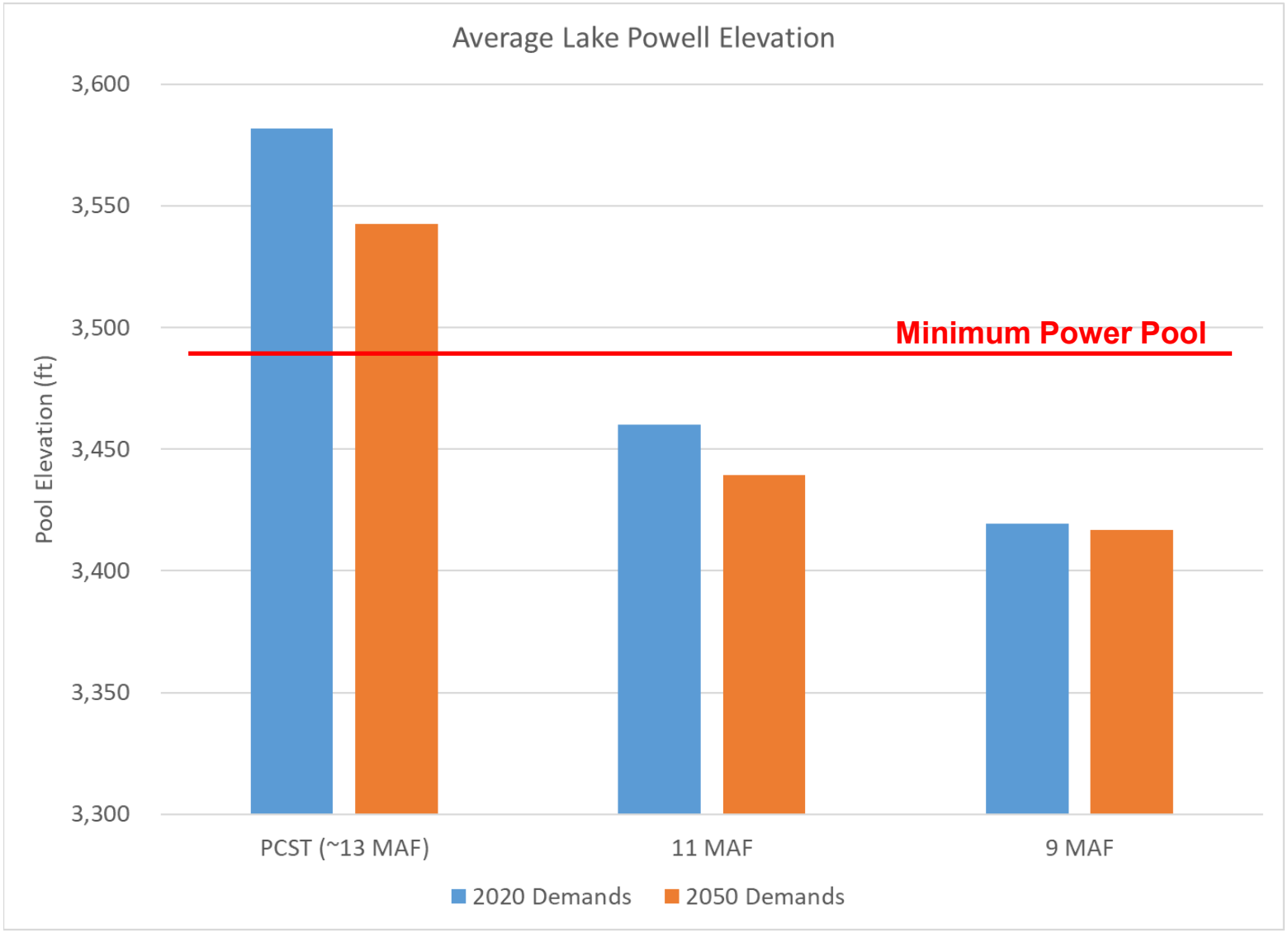
Unless the future is 9 MAF…



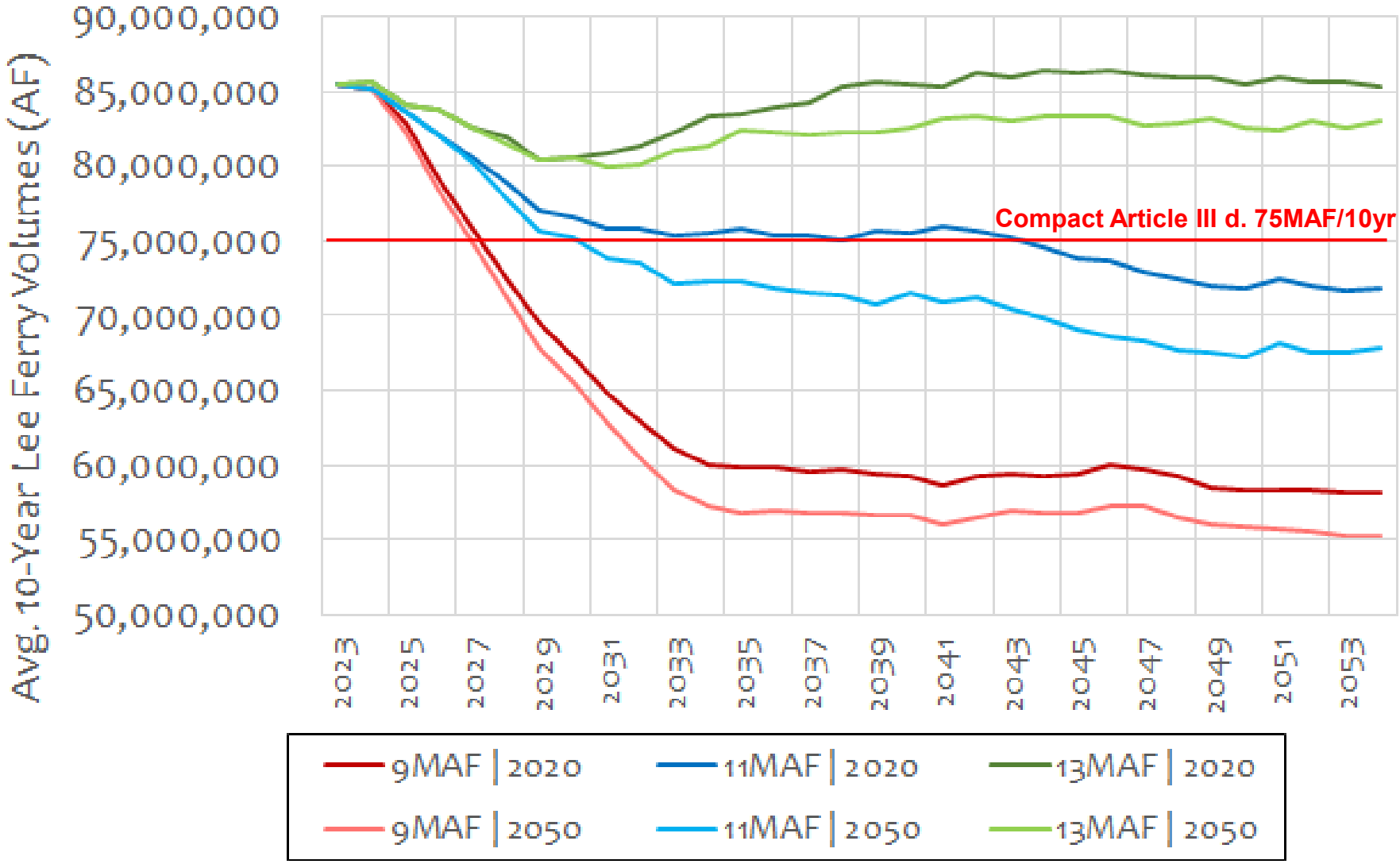
Together… Demands DO Matter



Lake Powell Elevation: Supply and Demand

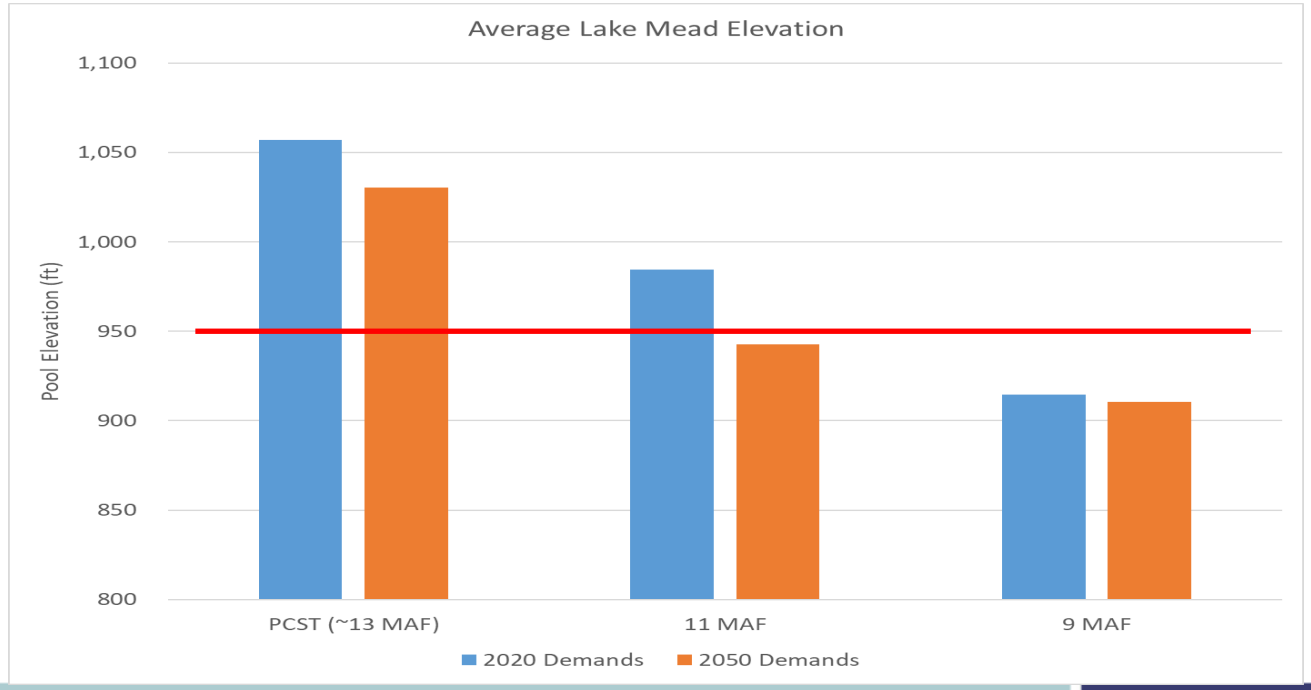


Lee Ferry 10-Year Compact Volumes



Lake Mead Elevation and Lower Basin Shortages

Lower Basin Shortages	Stress Test 13 MAF	11 MAF	9 MAF
2020 Demands	~.75 MAF/yr	~1.5 MAF/yr	~3.0 MAF/yr
2050 Demand	~1.2 MAF/yr	~2.3 MAF/yr	~3.6 MAF/yr



One Last Item:
Reclamation Objective: Lake Powell @ 3500

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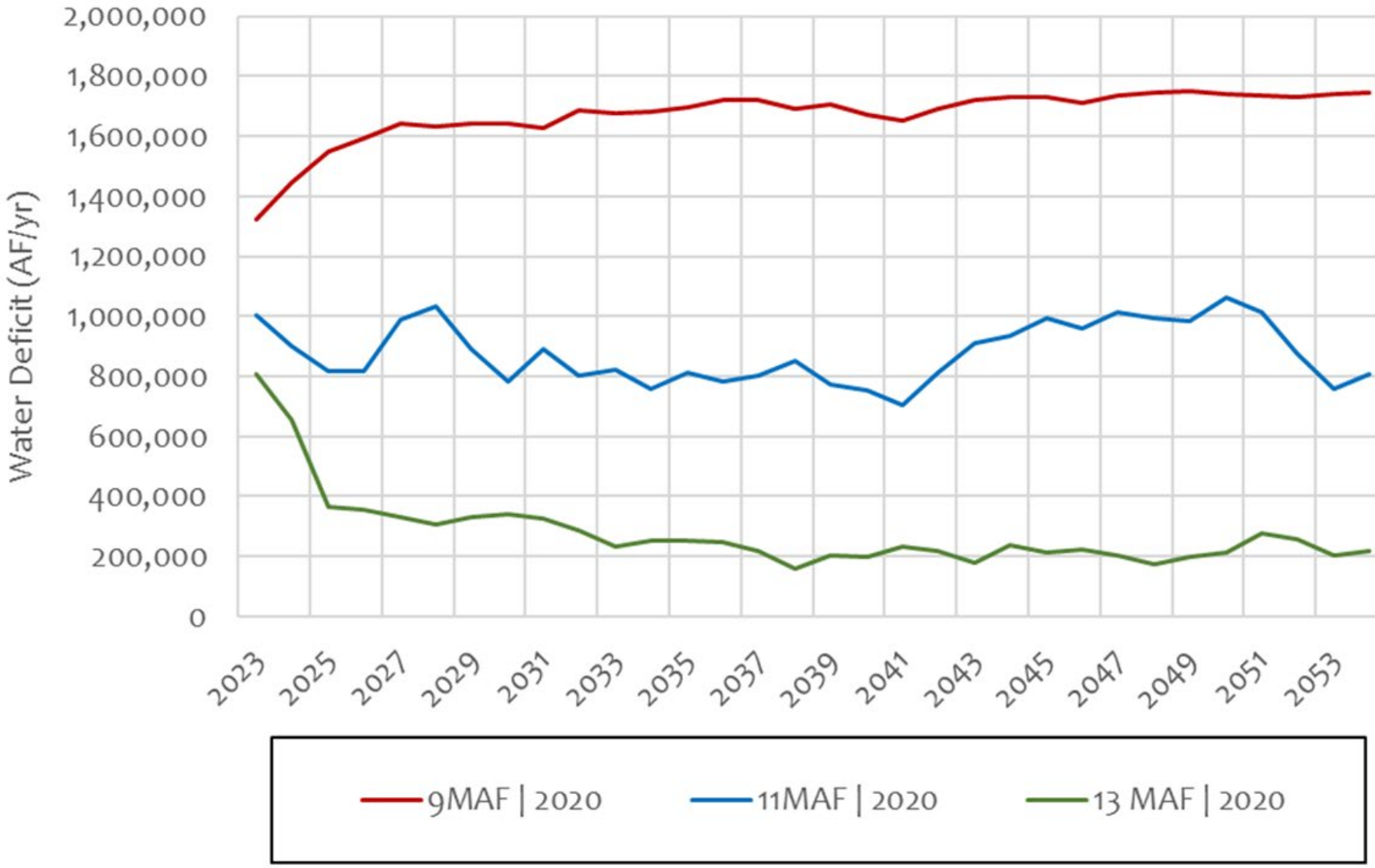
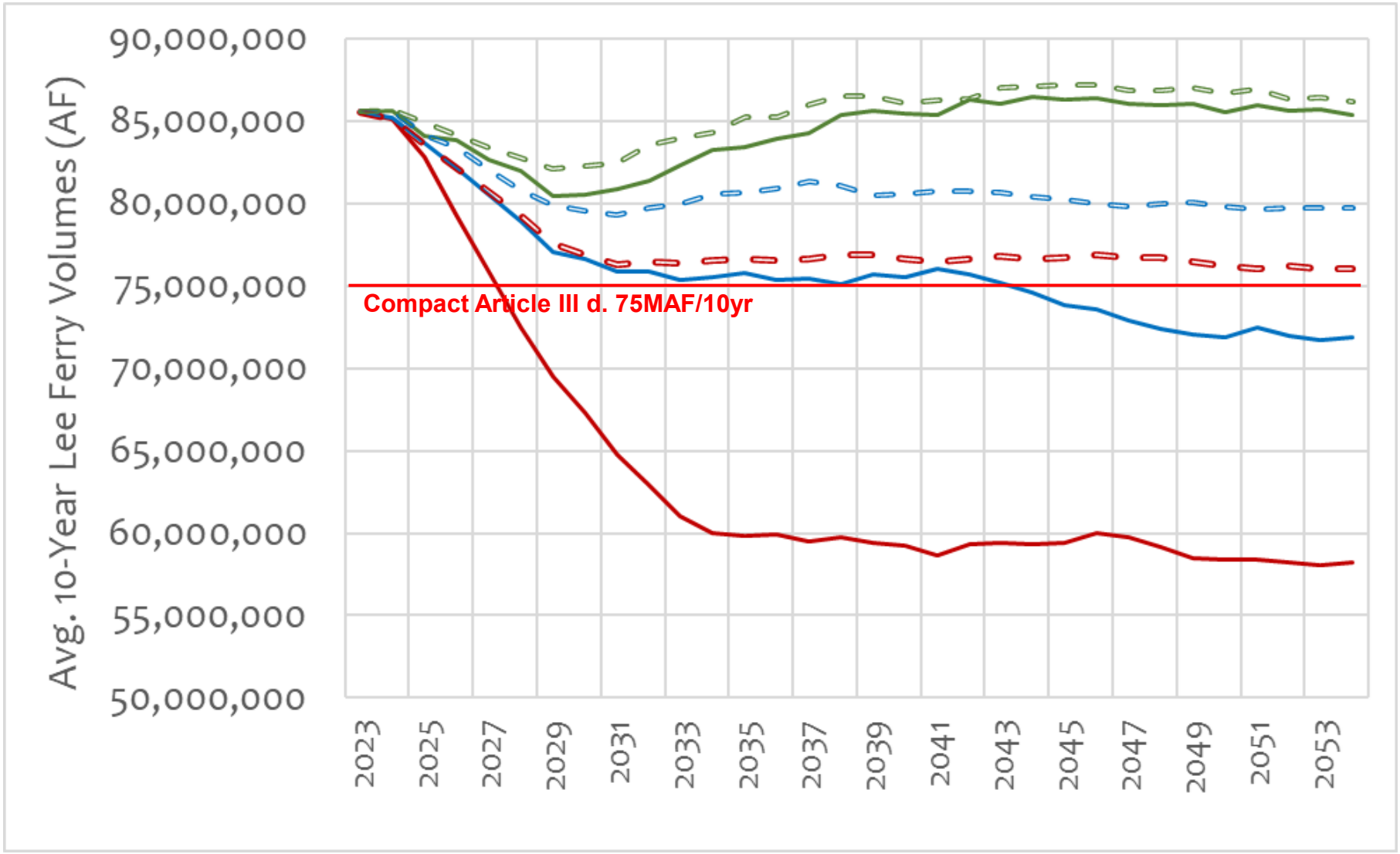
- Reclamation has signaled a desire (and implemented operations) to keep Powell above 3500' elevation
- What would it take to keep Lake Powell above 3500' under these different hydrologic futures?
  - Curtailment?
  - DROA?
  - Other DCP actions?

"Extra" water required to keep Powell above 3500'
Current Demands and Operations (2007 Interim Guidelines)



Lee Ferry Volumes with added "Deficit" Water to maintain Powell @ 3500



Final Takeaway Summary

- Hydrology is (still) #1 indicator of system "health"
  - 13 MAF future only sustainable with elimination of Structural Deficit in Lower Basin
  - 11 MAF future or worse will require additional cuts in use
- Increases in TMD exports will be largely achieved by reductions in west slope TMD storage.
  - Export shortages will increase, particularly under dryer hydrology
  - TMD impacts most noticeable locally, but still contribute to increase risk at Lake Powell / Lee Ferry (as does any increase in consumptive use in UB)
- Increasing demands = increasing risk and volume of curtailment
- Maintaining Powell elevation of 3500 feet of under existing operational policy (2007 Interim Guidelines) and continued aridification puts entire burden on Upper Basin

Parting Shot