



— BUREAU OF —
RECLAMATION

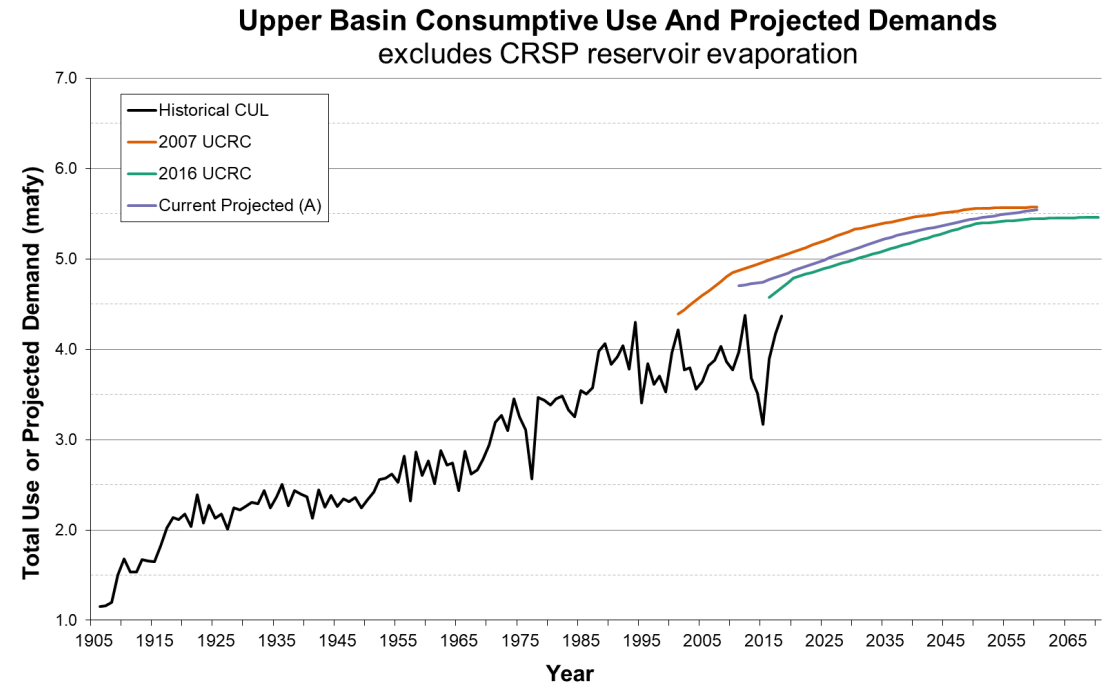
January 2021 CRSS Updates

February 16, 2021

Stakeholder Modeling Work Group Webinar

Presentation Outline

- Select CRSS changes
- Incorporating the 2016 Upper Colorado River Commission (UCRC) demand schedule
 - Process of incorporating UCRC schedule into CRSS
 - Demand projection differences
 - CRSS projections – Comparison of 2007 and 2016 UCRC demand schedules
- Next steps



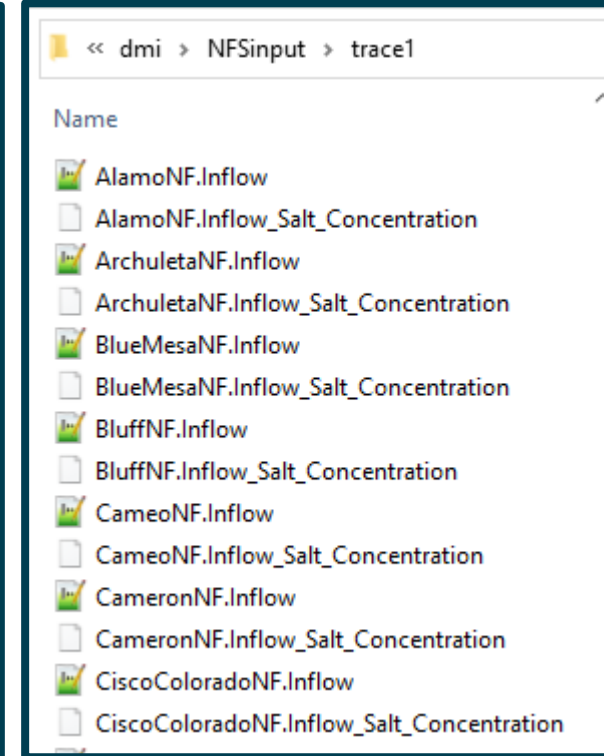
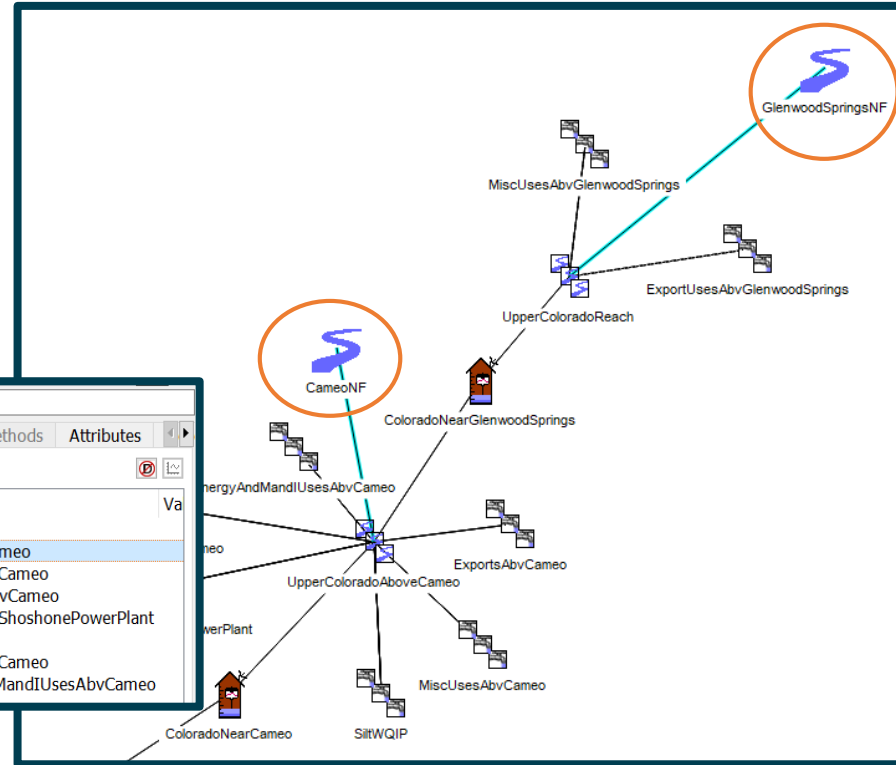
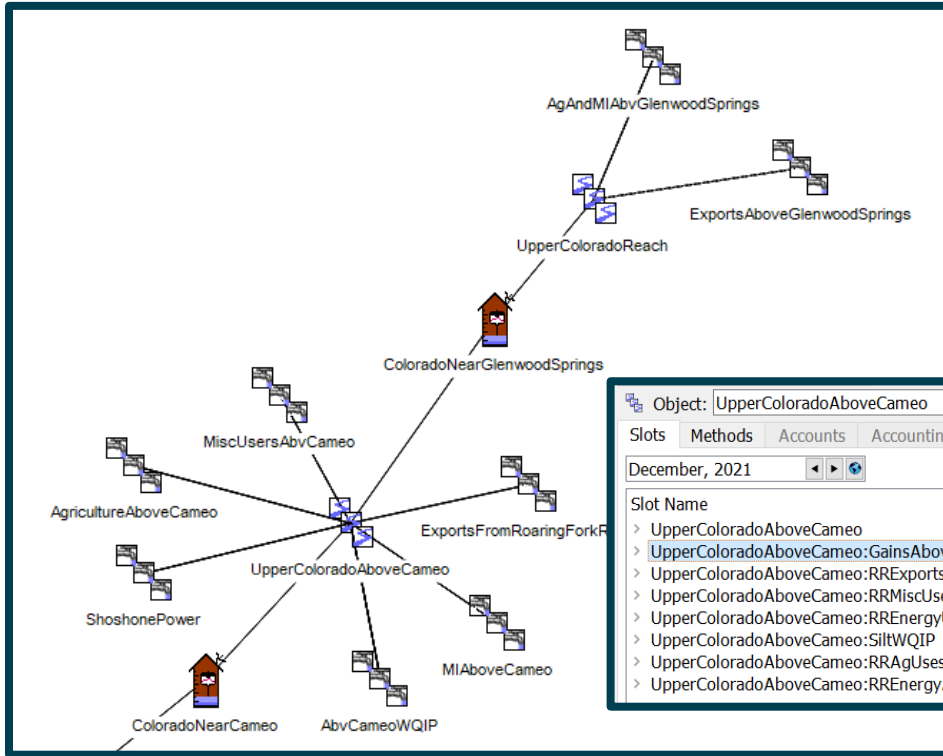
Select CRSS Changes



Added Natural Inflow Objects

August 2020 CRSS

January 2021 CRSS



- Does not affect results
- Explicitly show the inflow locations in CRSS
- Should not have to change these object names again
- Input files used with previous versions are now incompatible with CRSS v5.x



Shortage Related Bug in Revert to 2007 FEIS No Action Alternative Ruleset

- “Monthly Absolute Protection (Level 2) Shortage for ICS” rule was never executing successfully
- This affects results beyond 2026 when using the Revert to 2007 FEIS No Action Alternative ruleset



Changed Evaporation Scaling Factors From Monthly Slots to Annual Slots

- Scaling factors are used to modify reservoir evaporation for anticipated changes in future temperature and precipitation
- Values are 0 for scenarios that use historical hydrology and non-zero for scenarios that use climate change-based hydrology
- Method used to develop these scaling factors results in annual scaling factors
- Modified slots in CRSS to be annual instead of monthly
 - Less data imported each trace -> faster
- All files in \$CRSS_DIR/dmi/Evap and \$CRSS_DIR/dmi/CMIP3Evap changed from monthly to annual

August 2020 CRSS

Slot Viewer (1 Month)

File Edit View TimeStep I/O

Evap.FontenelleCoef

Value: 0 NONE Jan 2021

Month	Evap	.FontenelleCoef	None
02-2021	0.00	I	
03-2021	0.00	I	
04-2021	0.00	I	
05-2021	0.00	I	
06-2021	0.00	I	
07-2021	0.00	I	
08-2021	0.00	I	
09-2021	0.00	I	
10-2021	0.00	I	
11-2021	0.00	I	
12-2021	0.00	I	
01-2022	0.00	I	
02-2022	0.00	I	

Show: Description

Evap.FontenelleCoef [@ 24:00 January 2021]
1 value: 0.00 [NONE]

January 2021 CRSS

Slot Viewer (1 Year)

File Edit View TimeStep I/O

Evap.FontenelleCoef

Value: 0 NONE 2022

Year	Evap	.FontenelleCoef	None
2021	0.00	I	0
2022	0.00	I	0
2023	0.00	I	0
2024	0.00	I	0
2025	0.00	I	0
2026	0.00	I	0
2027	0.00	I	0
2028	0.00	I	0
2029	0.00	I	0
2030	0.00	I	0
2031	0.00	I	0
2032	0.00	I	0
2033	0.00	I	0

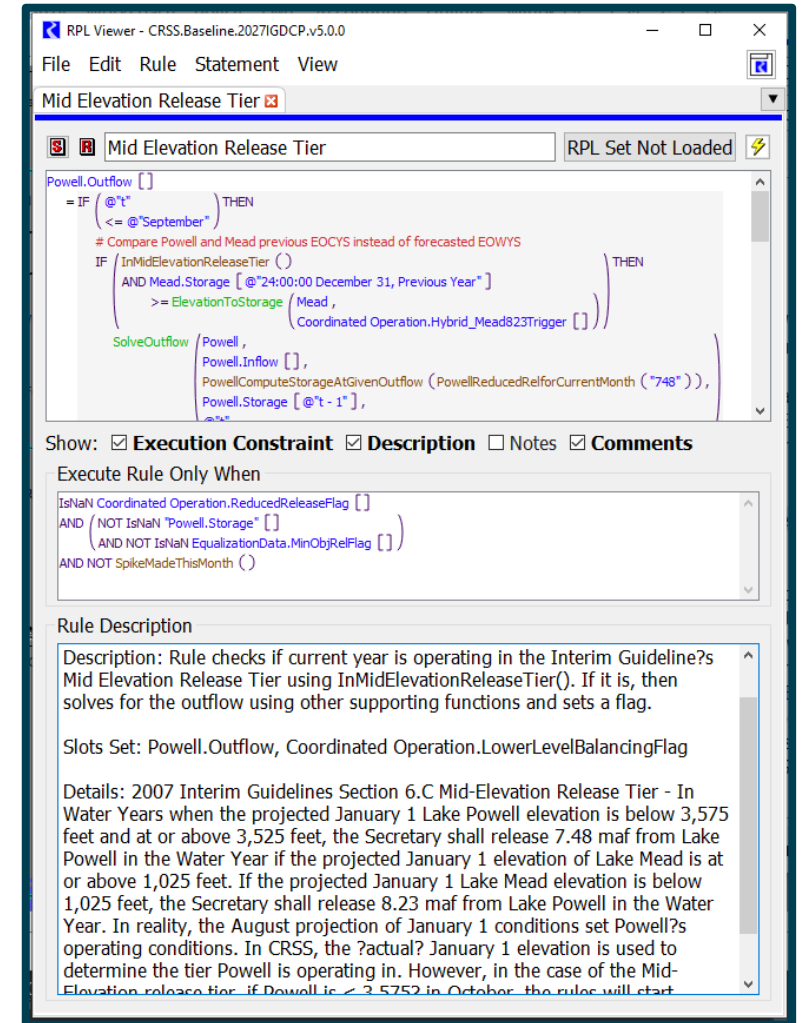
Show: Description

Evap.FontenelleCoef [@ 24:00 December 2021]
1 value: 0.00 [NONE] (Priority 0)



Other Changes

- All references to “VIC” were changed to “CMIP3”
 - DMIs
 - MRMs
 - Control files
 - RiverSMART file
- Added more documentation
 - Powell rules
 - Other UB rules
 - Mead flood control functions
- Other updates documented in [CRSS.ModelingAssumptionsAndUpdates.Jan2021.v2.pdf](#)



The screenshot displays the RPL Viewer interface for the 'Mid Elevation Release Tier' rule. The main window shows the rule's logic, which includes a conditional statement for the month of September and a call to the 'InMidElevationReleaseTier' function. Below the rule logic, the 'Execute Rule Only When' section contains several conditions, including checks for 'Coordinated Operation.ReducedReleaseFlag' and 'Powell.Storage'. The 'Rule Description' section provides a detailed explanation of the rule's purpose, stating that it checks if the current year is operating in the Interim Guideline's Mid Elevation Release Tier and solves for the outflow using other supporting functions. The 'Slots Set' includes 'Powell.Outflow' and 'Coordinated Operation.LowerLevelBalancingFlag'. The 'Details' section provides further context, mentioning the 2007 Interim Guidelines Section 6.C and the specific release rates (7.48 maf and 8.23 maf) based on Lake Powell's elevation.

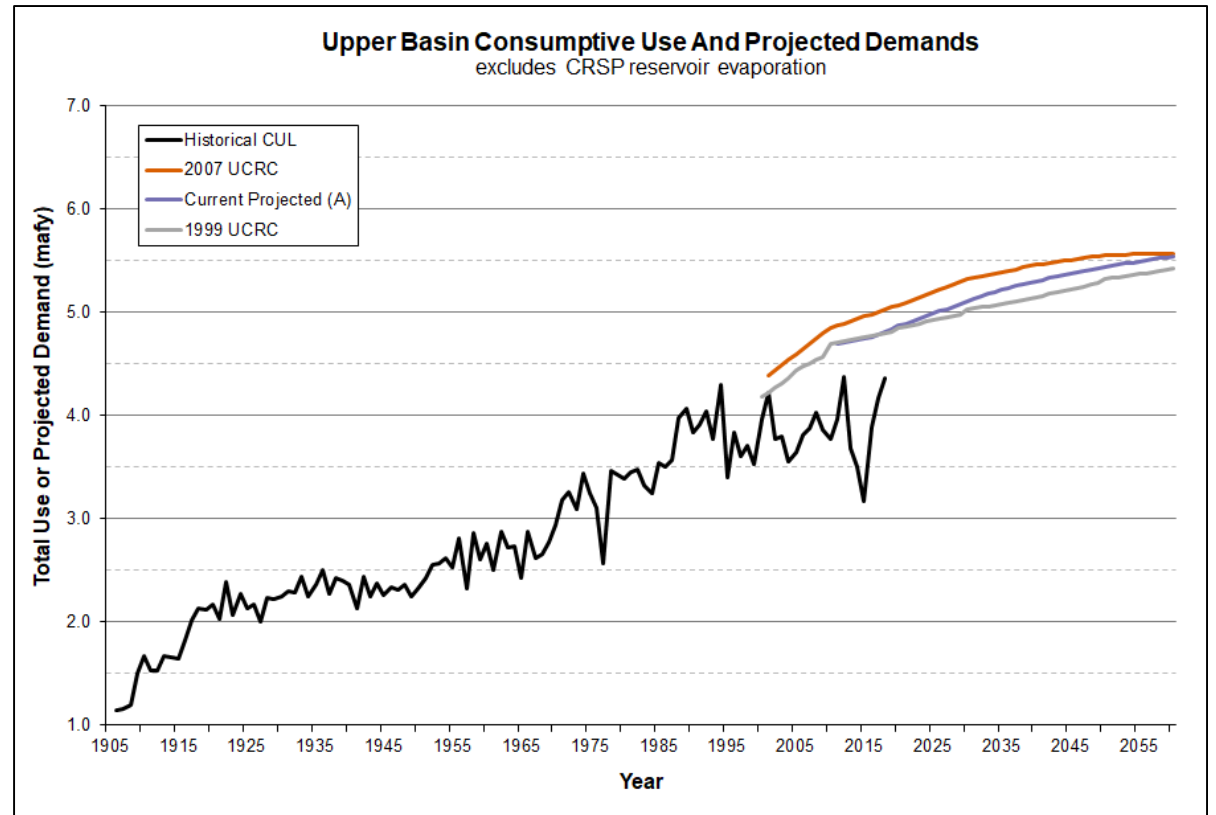


Process of incorporating UCRC schedule into CRSS



Previous Upper Basin Demand Schedules

- 1999 UCRC schedule – used in the 2007 Interim Guidelines FEIS
- 2007 UCRC schedule – used in official CRSS projections and many other projects since 2008
- 2012 Basin Study demand scenarios – developed 6 different demand scenarios. “Scenario A”, i.e., “Current Projected” used for several different projects since the Basin Study.
 - Modeling that supported the development of the DCP used the Current Projected demand schedule.



Process Steps

- Develop new Upper Basin layout in CRSS (Redesign)
 - Get buy-in from Upper Basin states and tribes
- Apply Redesign to Upper Basin in CRSS
 - Send each state's Redesign layout to state for review
- Obtain 2016 Upper Colorado River Division States Current and Future Depletion Demand Schedule (2016 UCRC schedule)
- Work with each state to assist them in disaggregating their 2016 UCRC schedule temporally and spatially to the Redesign layout
- Ensure Upper Basin tribal demands are represented to approximate 2017 Tribal Water Study depletions
- Implement Redesign in official CRSS model and import 2016 UCRC schedule demands



Upper Colorado River Division States Current and Future Depletion Demand Schedule^{1,2}

Total Upper Colorado River Division States

ITEM	YEAR						
	Current/Historical	2020	2030	2040	2050	2060	2070
Agriculture – Irrigation & Stock	2,968	3,036	3,051	3,073	3,078	3,080	3,082
<i>Potential Agriculture-Irrigation & Stock</i>		0	5	5	10	10	0
Municipal/Industrial	124	149	168	183	200	209	217
<i>Potential Municipal/Industrial</i>		3	6	14	18	21	16
Self-Served Industrial	12	12	12	12	12	12	12
<i>Potential Self-Served Industrial</i>		0	0	0	0	0	0
Energy	152	157	167	178	193	198	203
<i>Potential Energy</i>		5	10	10	15	10	0
Minerals	53	57	65	73	81	94	103
<i>Potential Minerals</i>		2	8	17	26	31	33
Export	1,019	1,050	1,123	1,179	1,258	1,310	1,423
<i>Potential Export</i>		50	75	100	125	100	0
Ute Indian Settlement³	0	25	65	112	146	146	146
Reservoir Evaporation (in-state)	208	208	208	208	208	208	208
<i>Potential Reservoir Evaporation</i>		0	0	0	0	0	0
TOTAL Forecasted Depletions	4,536	4,753	4,963	5,165	5,368	5,428	5,442
Shared CRSP Evap (0.520maf) ⁴	520	520	520	520	520	520	520
TOTAL	5,056	5,273	5,483	5,685	5,888	5,948	5,962

*December 31, 2016
(units: 1,000 acre-feet)*

¹This depletion schedule does not attempt to interpret the Colorado River Compact, the Upper Colorado River Basin Compact, or any other element of the “Law of the River”. This schedule should not be construed as an acceptance of any assumption that limits the Upper Colorado River Basin’s depletions.

²This depletion schedule is for planning purposes only. It is not a tabulation or determination of water rights or actual uses.

³The Ute Indian Settlement is part of Utah’s depletion.

⁴“Shared CRSP Evap” refers to evaporation from the reservoirs constructed under the Colorado River Storage Project (CRSP) Act that are used to regulate compact deliveries at Lee Ferry and generate CRSP hydroelectric power. These include Lake Powell, Flaming Gorge Reservoir, and the Aspinall Unit. This evaporation amount is the anticipated long-term average. Evaporation will vary annually depending on reservoir storage and climatic conditions.

Upper Colorado River Division States Current and Future Depletion Demand Schedule^{1,2} Wyoming³

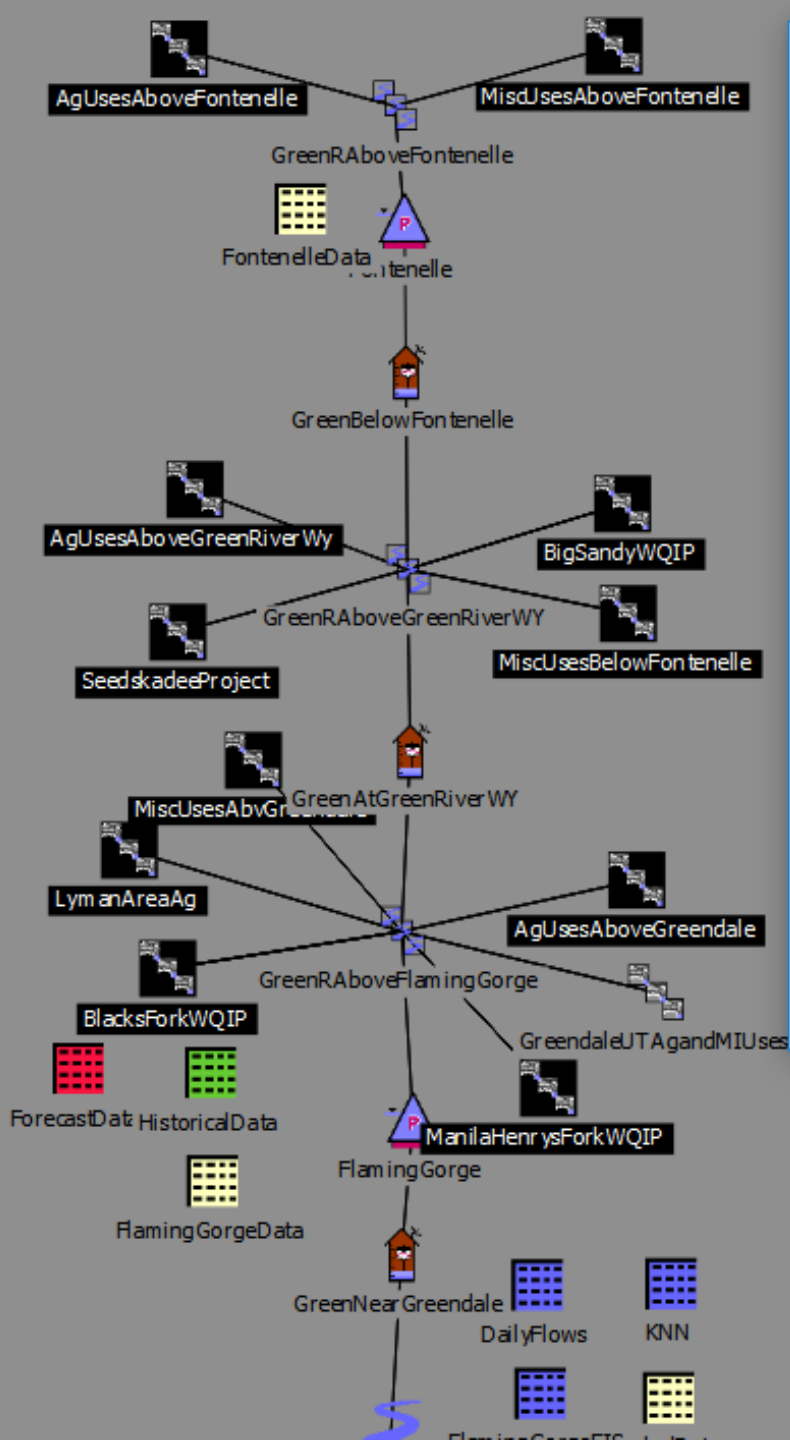
ITEM	YEAR						
	Current/Historical	2020	2030	2040	2050	2060	2070
Agriculture – Irrigation & Stock	444	445	447	449	451	453	455
<i>Potential Agriculture-Irrigation & Stock</i>		0	0	0	0	0	0
Municipal/Industrial	16	20	23	25	27	29	31
<i>Potential Municipal/Industrial</i>		3	6	9	13	16	16
Self-Served Industrial	0	0	0	0	0	0	0
<i>Potential Self-Served Industrial</i>		0	0	0	0	0	0
Energy	28	28	28	28	28	28	28
<i>Potential Energy</i>		0	0	0	0	0	0
Minerals	19	20	23	26	29	32	35
<i>Potential Minerals</i>		2	8	14	21	27	33
Export	13	14	16	19	21	23	23
<i>Potential Export</i>		0	0	0	0	0	0
Reservoir Evaporation (in-state)	27	27	27	27	27	27	27
<i>Potential Reservoir Evaporation</i>		0	0	0	0	0	0
TOTAL Forecasted Depletions	546	558	578	597	616	635	648

*December 31, 2016
(units: 1,000 acre-feet)*

¹This depletion schedule does not attempt to interpret the Colorado River Compact, the Upper Colorado River Basin Compact, or any other element of the “Law of the River”. This schedule should not be construed as an acceptance of any assumption that limits the Upper Colorado River Basin’s depletions.

²This depletion schedule is for planning purposes only. It is not a tabulation or determination of water rights or actual uses.

³Wyoming’s Current/Historic Agriculture Consumptive Use was calculated using a Penman-Monteith procedure. The 2007 estimates were calculated using a Blaney-Criddle procedure. This change in methodology primarily accounts for the increase in estimated consumptive use from irrigated lands. There has been no documented actual increase in consumptive use over this time frame. We do believe the Penman-Monteith methodology is more accurate than Blaney-Criddle.



Slot Viewer

File Edit View TimeStep I/O Adjust

Selected Slot:

Value: acre-ft/month Alt Units Jan 2021

	AgUsesAboveFontenelle :AgAbvFontenellePL .Diversion Schedule acre-ft/month	AgUsesAboveFontenelle :AgAbvFontenellePL .Depletion Schedule acre-ft/month
01-2021	0 I	0 I
02-2021	0 I	0 I
03-2021	0 I	0 I
04-2021	0 I	0 I
05-2021	46309 I	23155 I
06-2021	120404 I	60202 I
07-2021	162083 I	81041 I
08-2021	101881 I	50940 I
09-2021	32417 I	16208 I
10-2021	0 I	0 I
11-2021	0 I	0 I

Show: Description

Modeling Wyoming's water use in CRSS:

- 14 Aggregate Diversions
- 61 Water Users
- Data at monthly timestep



Old Layout

- Project-based names
- Online Depletion Classes
- Multiple water users for the same water use sector

The screenshot shows the 'Object Viewer' application window. On the left, a tree view displays a hierarchy of objects, with 'HaydenCraigThermalMisc' highlighted in a red box. On the right, the 'Object: HaydenCraigThermalMisc' is selected, and the 'Slots' tab is active. The date is set to 'December, 2020'. A table lists the slots for this object, with several entries highlighted in red boxes:

Slot Name	Value	Units
HaydenCraigThermalMisc		
HaydenCraigThermalMisc:EnergyAnticip		
HaydenCraigThermalMisc:1971CompStudyMandI		
HaydenCraigThermalMisc:MineralsCurrent		
HaydenCraigThermalMisc:EnergyCurrent		
HaydenCraigThermalMisc:YampaReservoirEvap		
HaydenCraigThermalMisc:MandIAnticip		
HaydenCraigThermalMisc:MineralsAnticip		
HaydenCraigThermalMisc:1971CompStudyFandW		
HaydenCraigThermalMisc:JuniperCrossMtnHydro		

At the bottom of the window, the 'Order' dropdown is set to 'Default'.

New Layout

- Sector-based names
- No online depletion classes
- One water user per water use sector
- Layout allows for better salinity modeling

The screenshot displays the Object Viewer software interface. On the left, a hierarchical tree shows the structure of water use objects. A red box highlights a section of the tree including 'AgUsesAbvMaybell', 'YampaRiver', 'MiscUsesYampaRiver', and 'ExportUsesYampaRiver'. On the right, the 'Object Viewer' window is open, showing the 'MiscUsesYampaRiver' object selected. The 'Slots' tab is active, displaying a table with the following data:

Slot Name	Value	Units
MiscUsesYampaRiver		
MiscUsesYampaRiver: MandI		
MiscUsesYampaRiver: Evaporation		

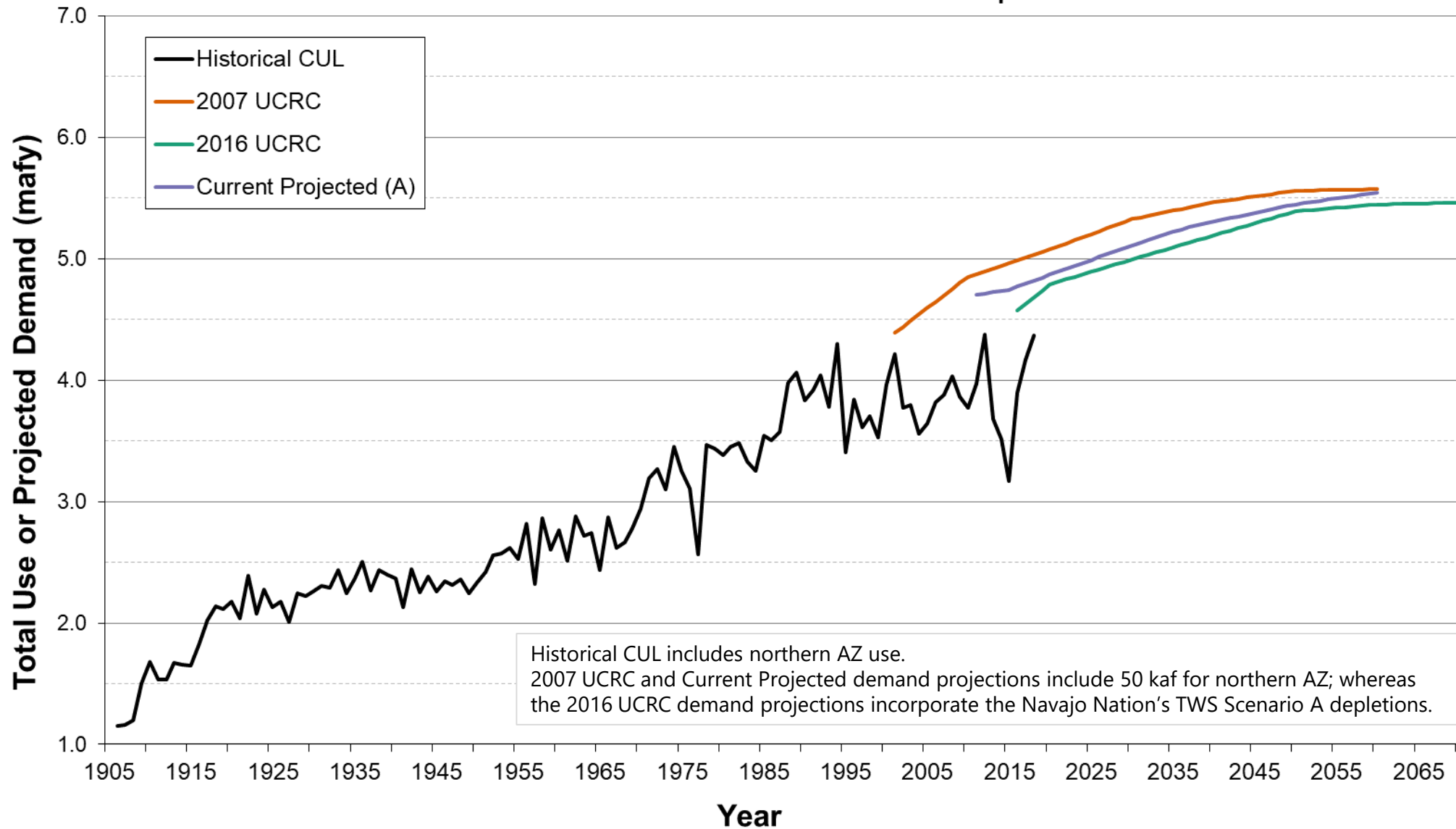
The 'MandI' and 'Evaporation' slots are highlighted with red boxes. The 'Order' dropdown is set to 'Default'.

Demand Projection Differences



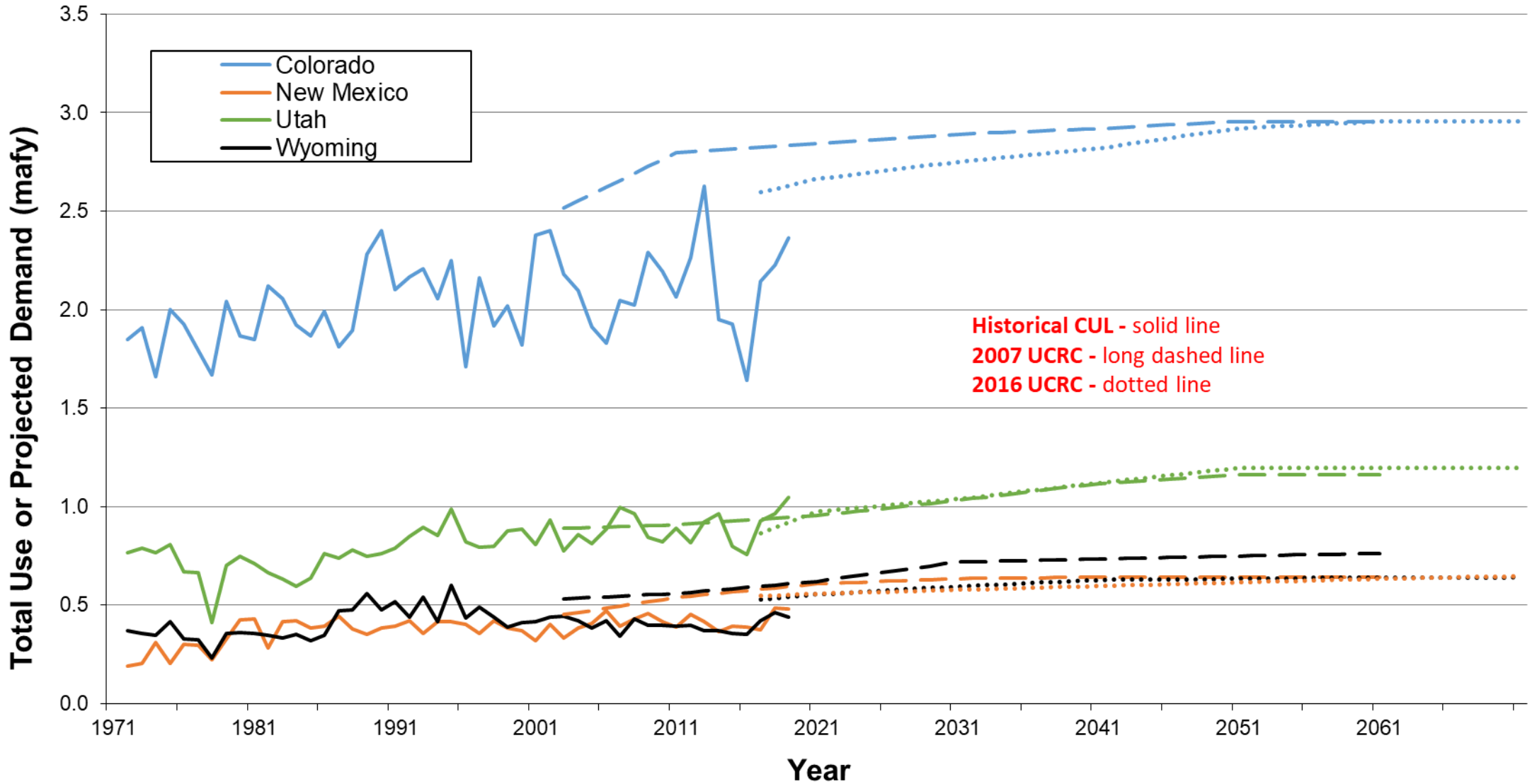
Upper Basin Consumptive Use And Projected Demands

excludes CRSP reservoir evaporation



Upper Basin States Consumptive Use And Projected Demands

excludes CRSP reservoir evaporation



Monthly Distribution Coefficients

- Monthly distribution coefficients are used to disaggregate from annual to monthly demands
- Coefficients vary by sector and sub-basin
- Monthly distribution of demands can affect modeled use and shortages
- Monthly distributions coefficients are being reviewed by the states and modifications are expected before the January official run

Average monthly distribution coefficients



CRSS Projections – Comparison of 2007 and 2016 UCRC Demand Schedules

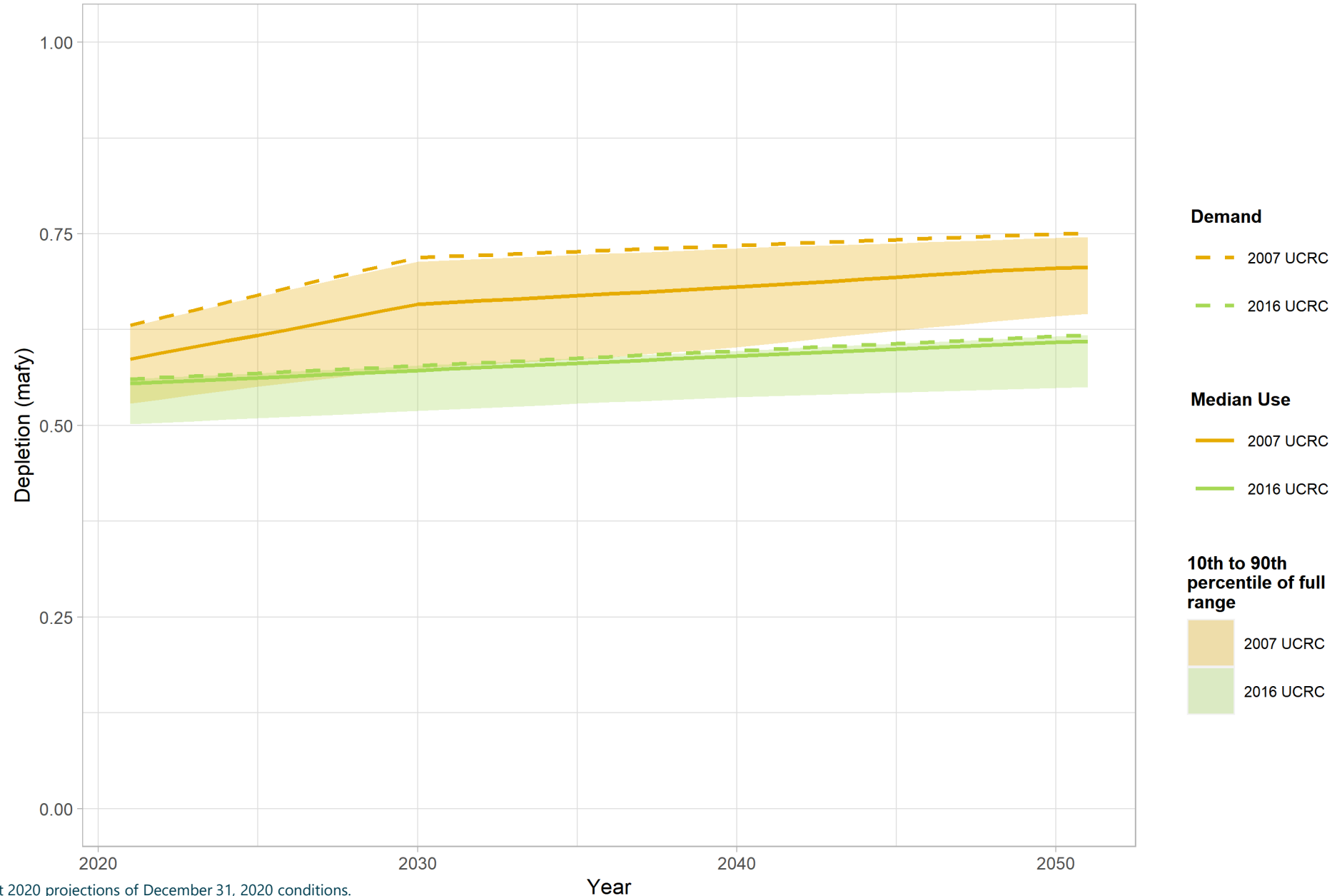


Modeling Assumptions

- CRSS is initialized with end-of-December 2020 reservoir conditions, 2021 Lake Powell operating tier, and 2021 Lake Mead operating condition from the August 2020 24-Month Study projection based on the Colorado Basin River Forecast Center's most probable inflow sequence
- Comparisons are made using the "Stress Test Hydrology", i.e., the index sequential method (ISM) applied to the 1988-2018 historical record
 - Results for the "Full Hydrology" (ISM applied to 1906-2018) are provided as supplementary material
- All runs assume the 2007 Interim Guidelines, Lower Basin Drought Contingency Plan, Upper Basin Drought Operations, and Minute 323 are in place through 2060



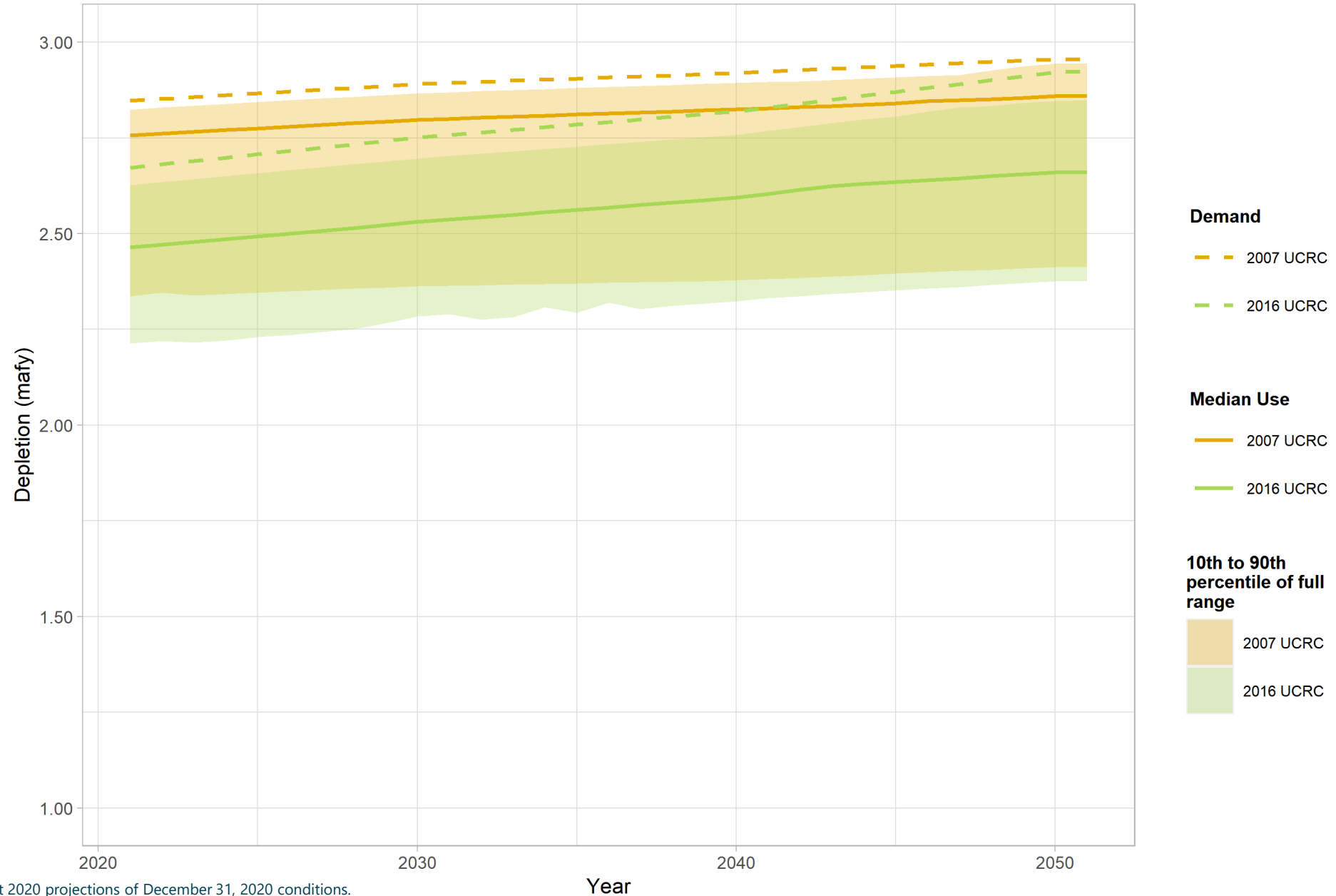
Modeled Annual Consumptive Use - Wyoming



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).



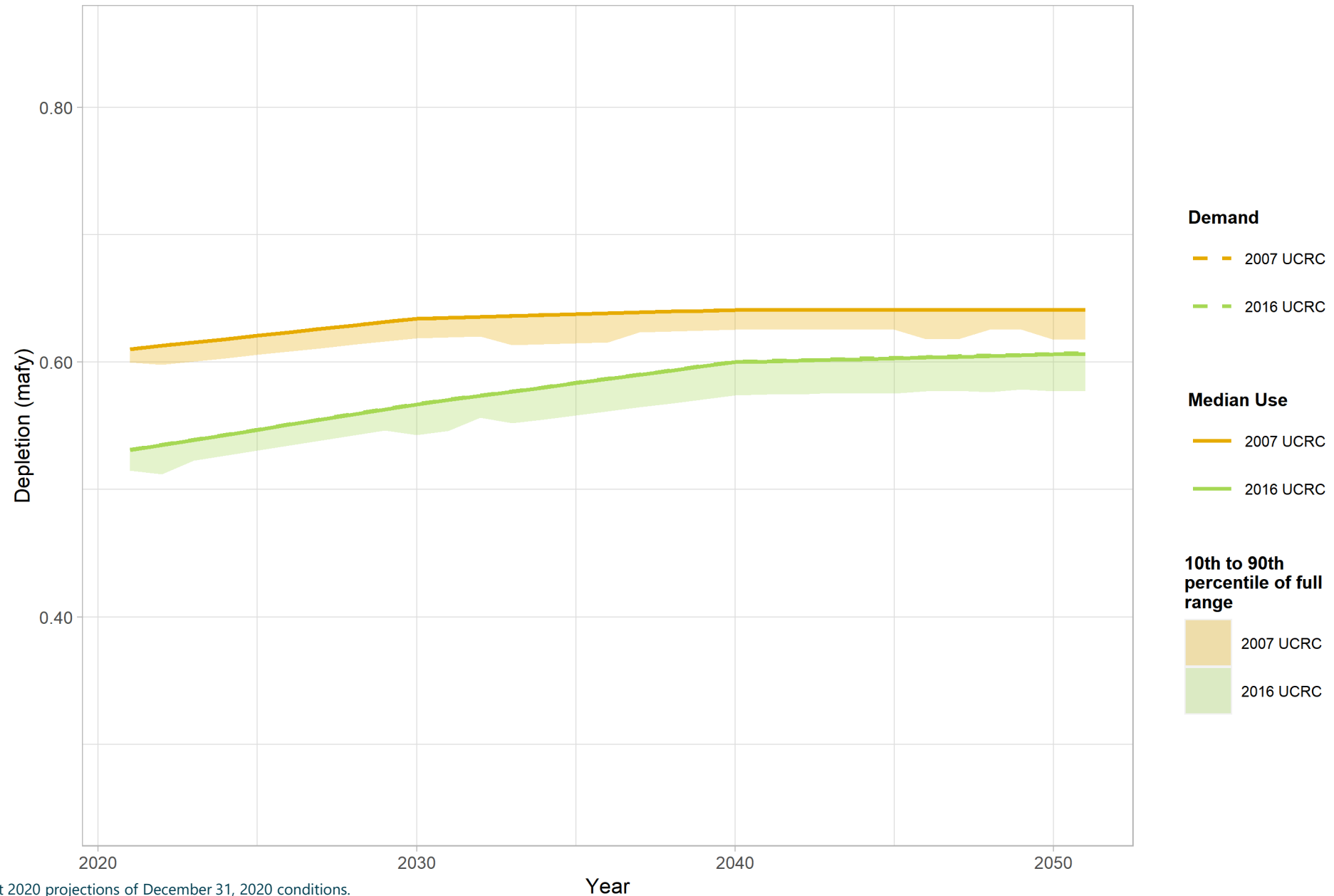
Modeled Annual Consumptive Use - Colorado



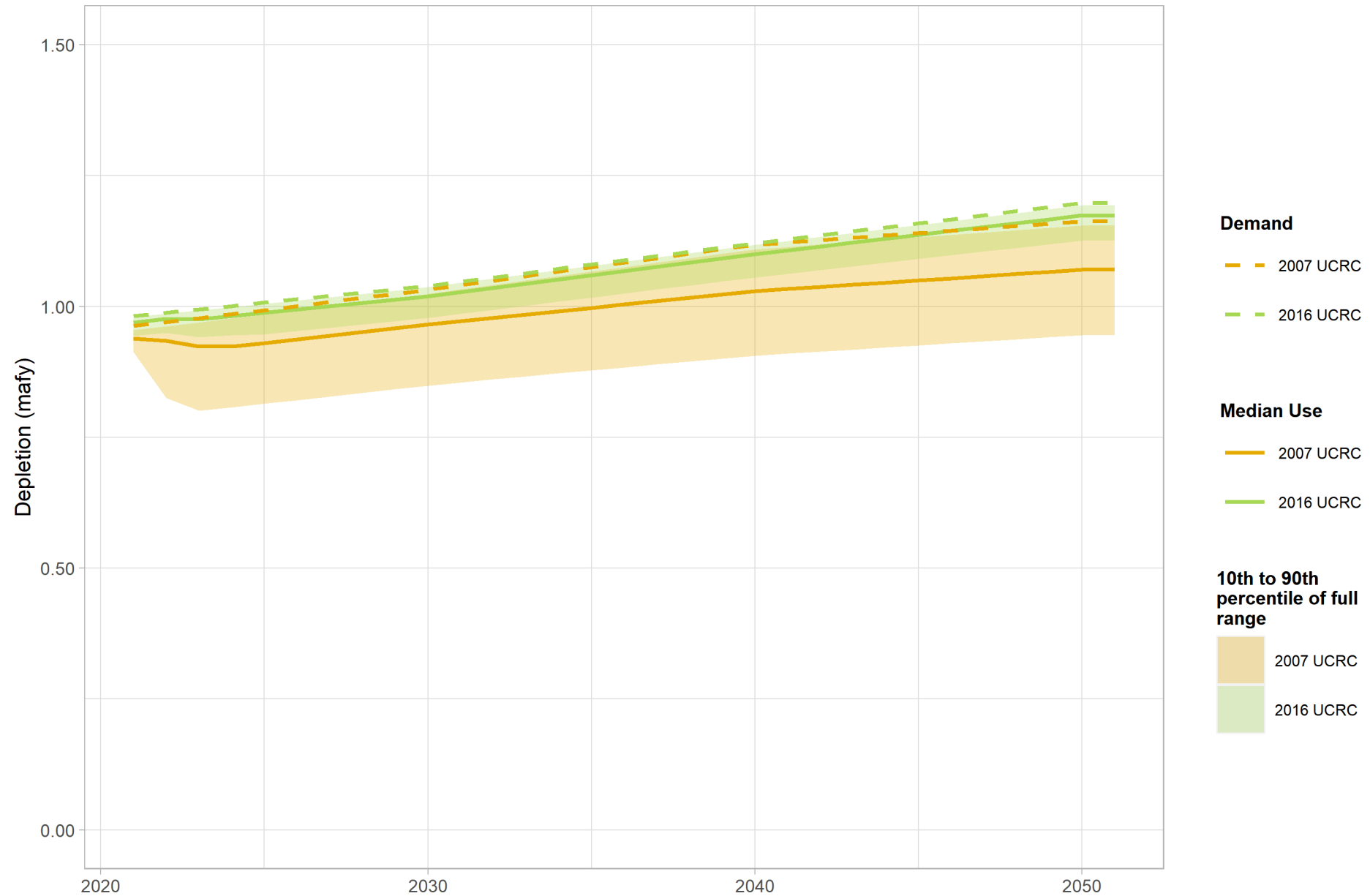
All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).



Modeled Annual Consumptive Use – New Mexico



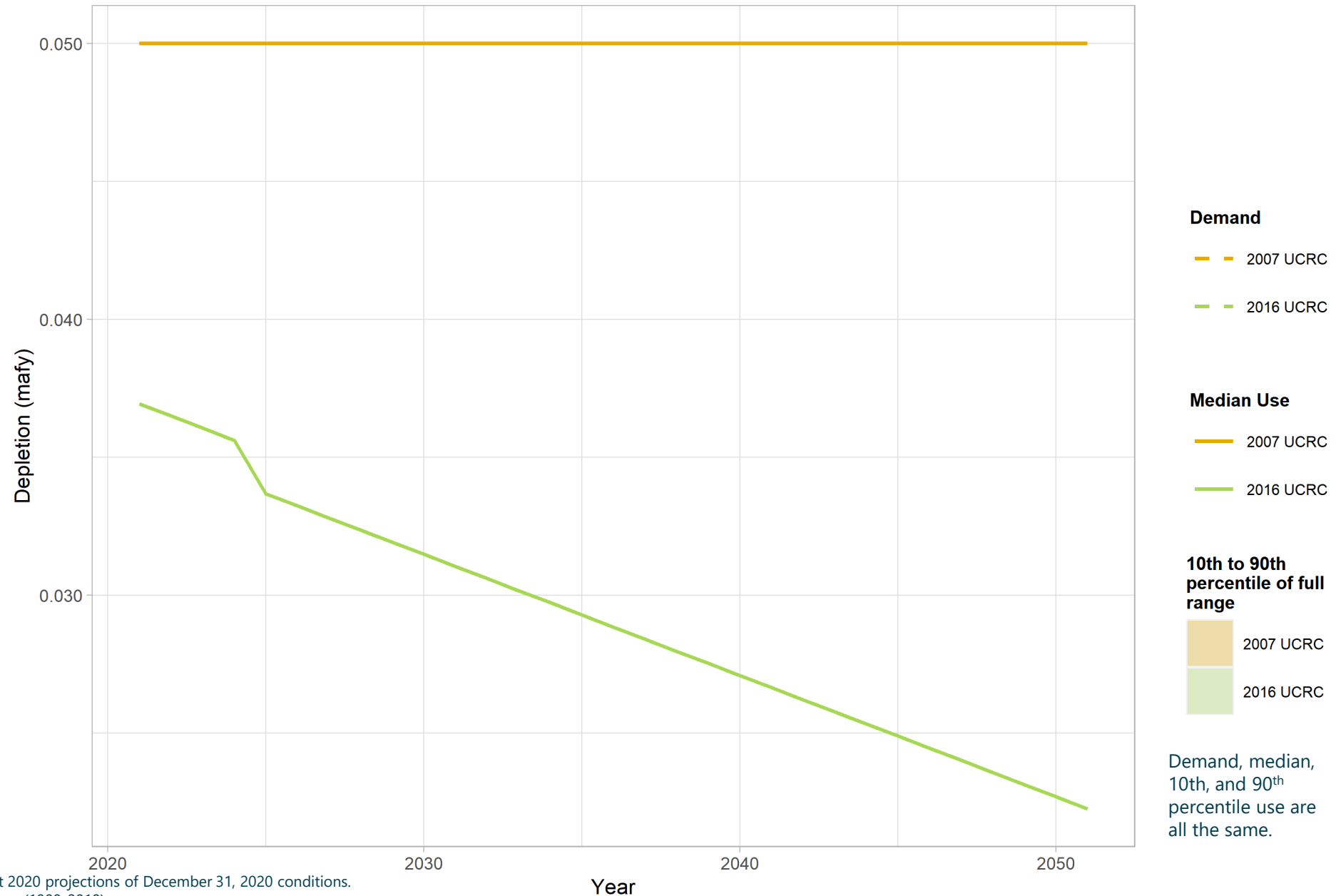
Modeled Annual Consumptive Use - Utah



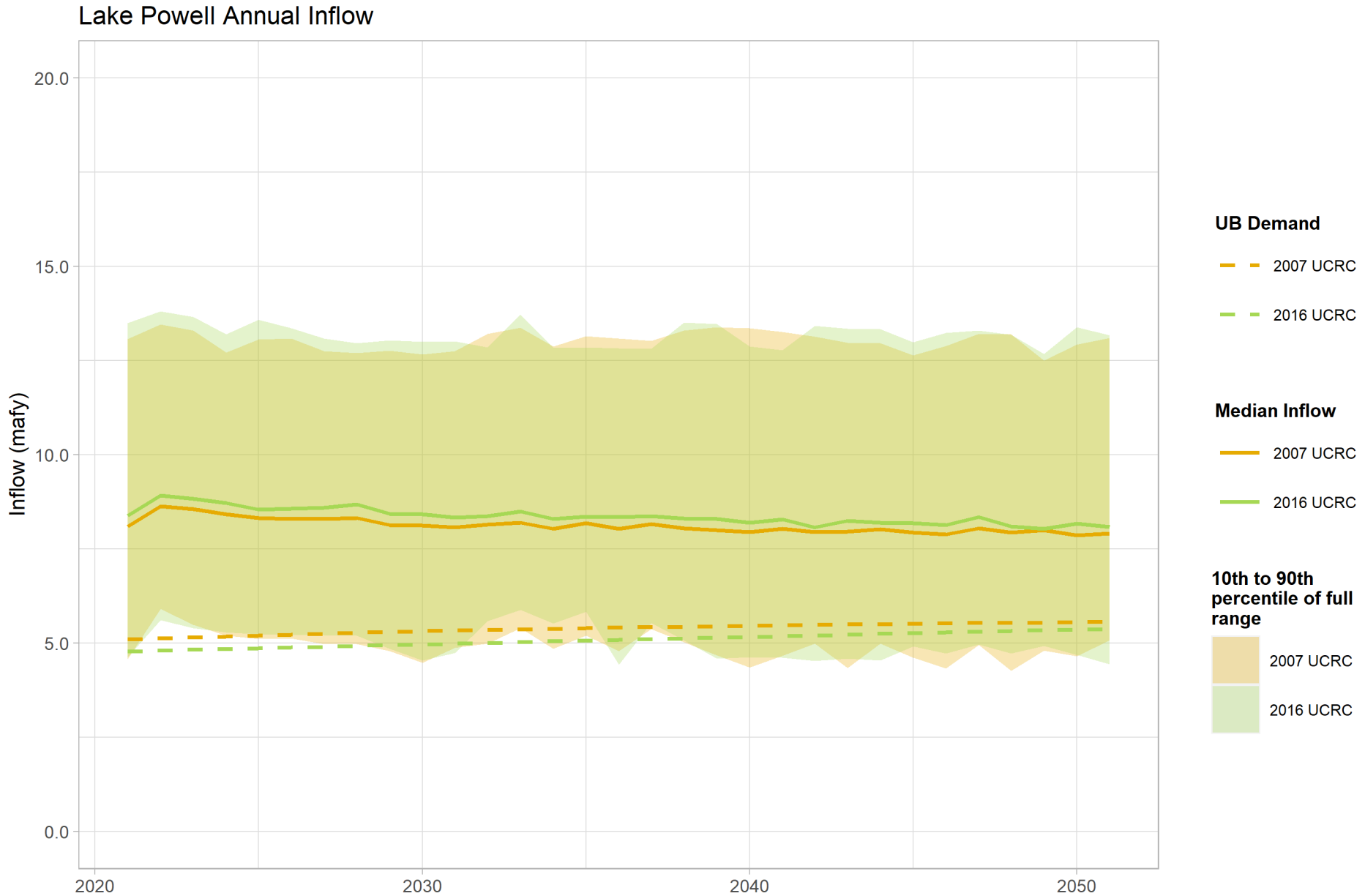
All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).



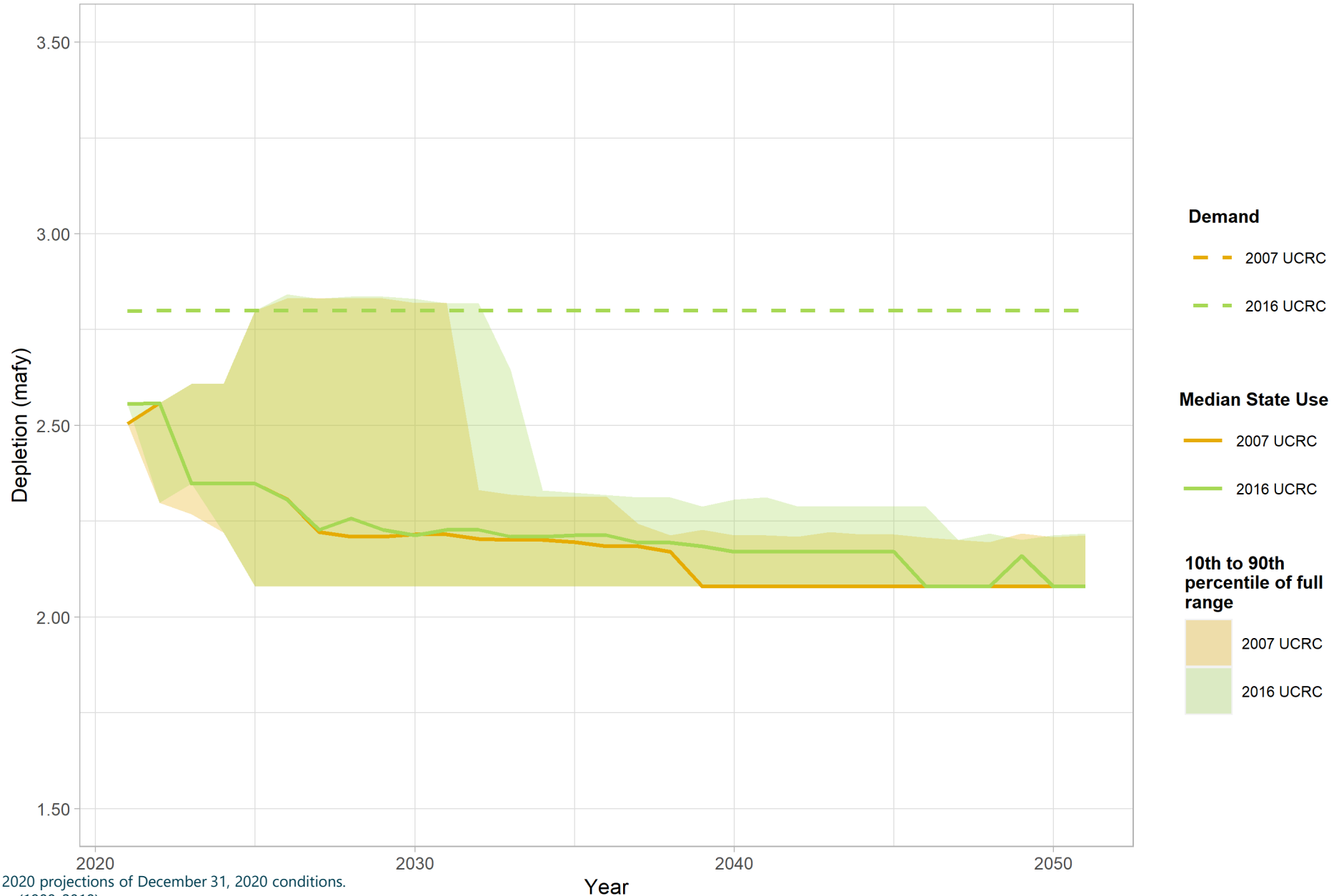
Modeled Annual Consumptive Use – UB Arizona



Lake Powell Annual Inflow



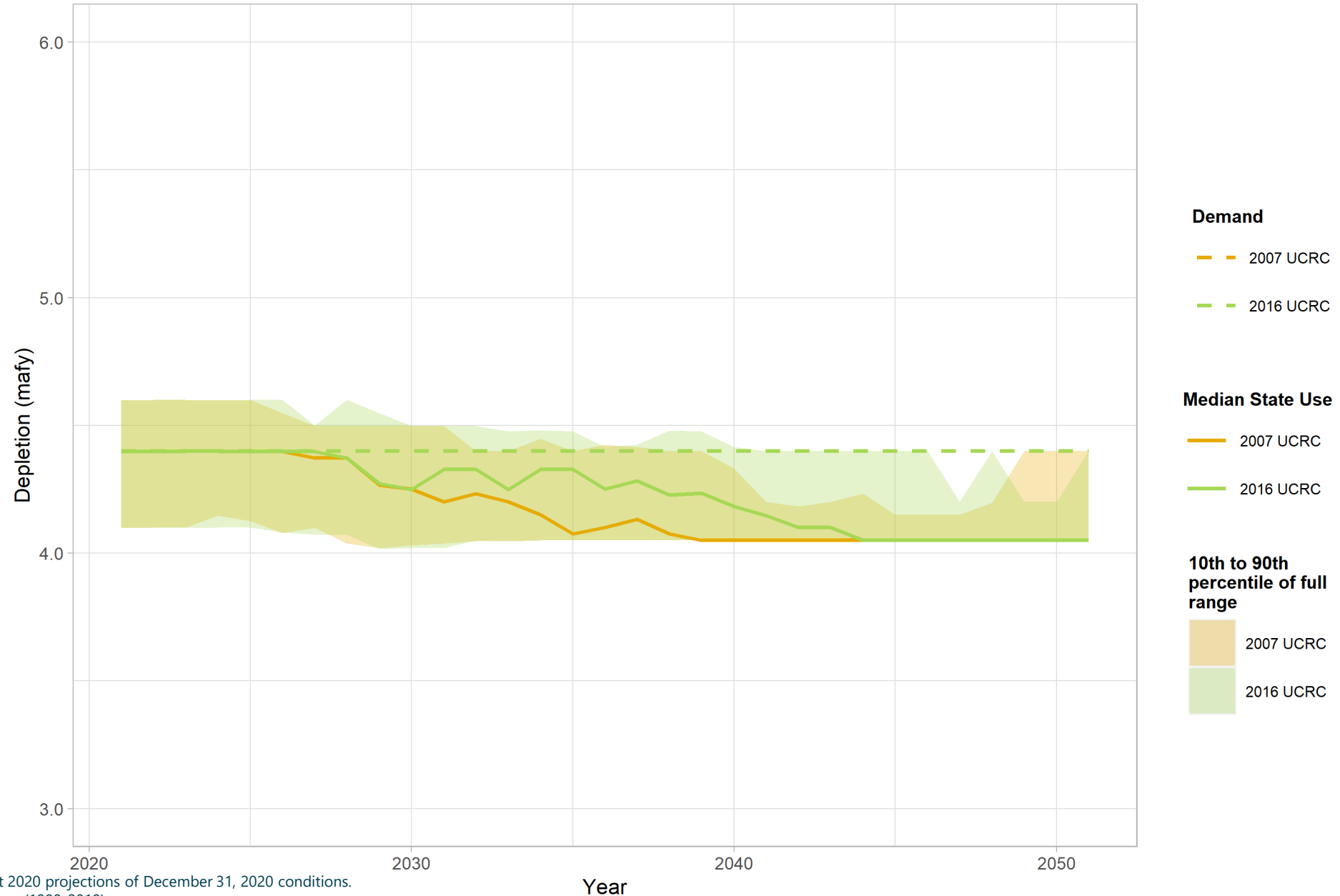
Modeled Annual Consumptive Use – LB Arizona



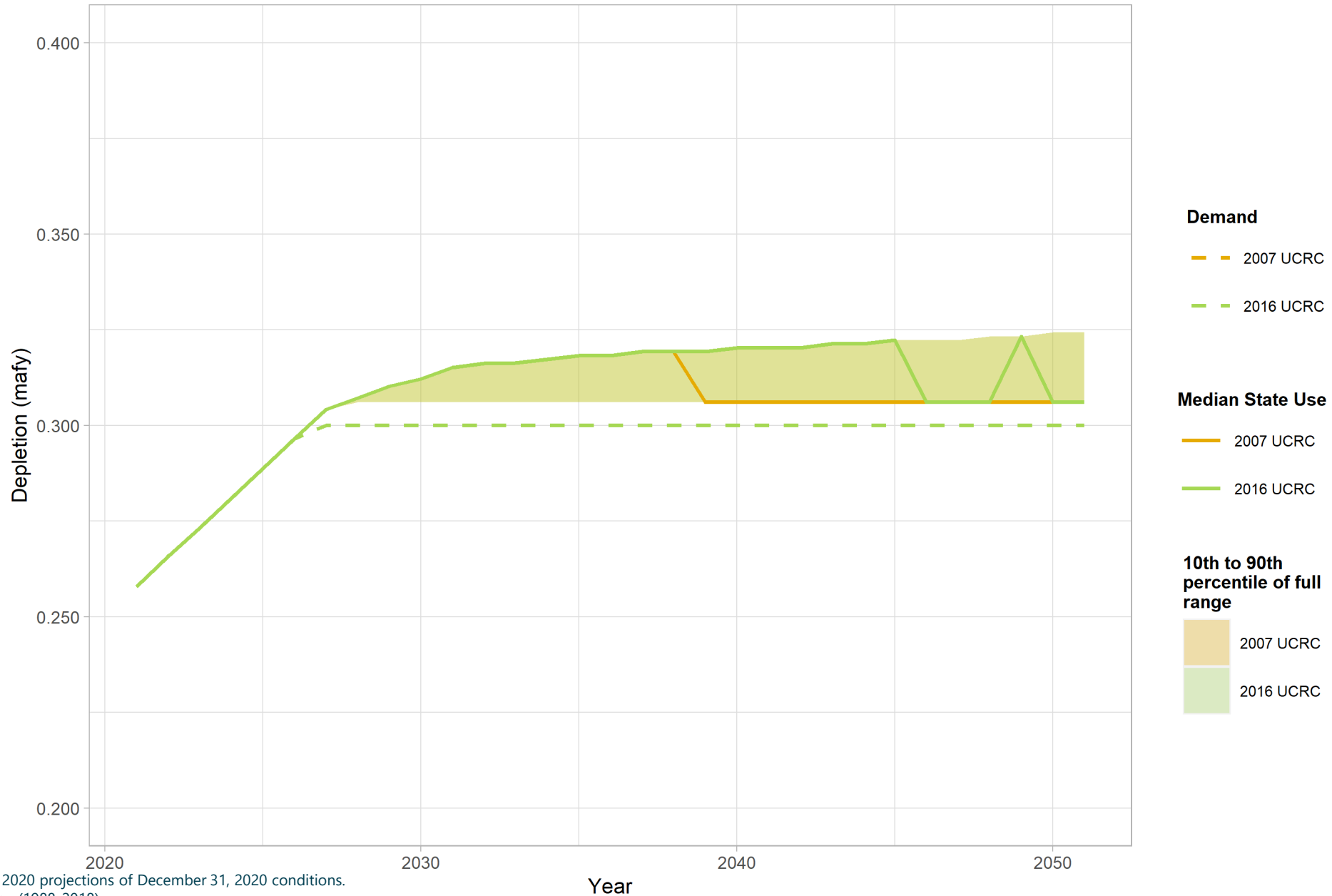
All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).



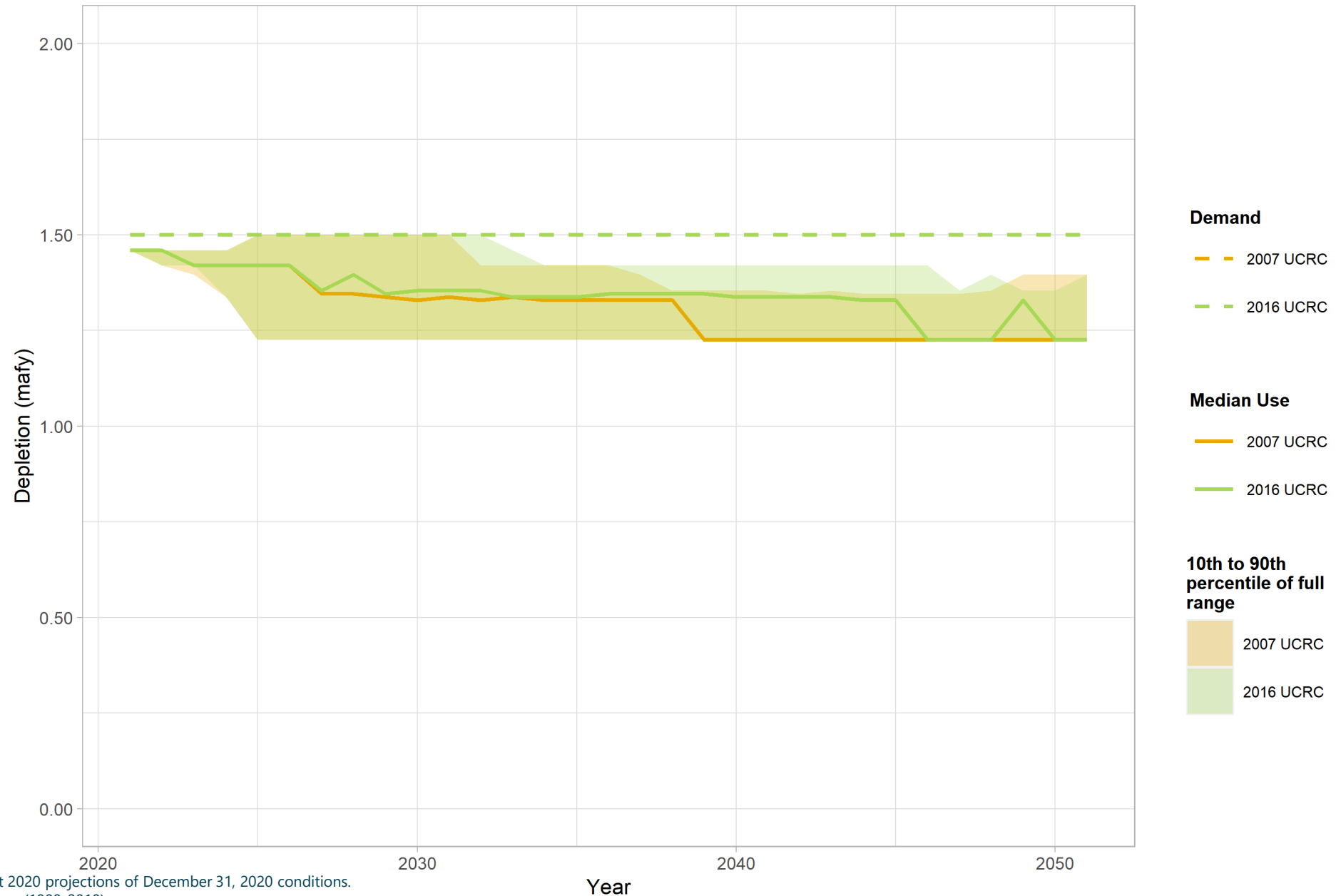
Modeled Annual Consumptive Use – California



Modeled Annual Consumptive Use - Nevada



Modeled Annual Consumptive Use - Mexico

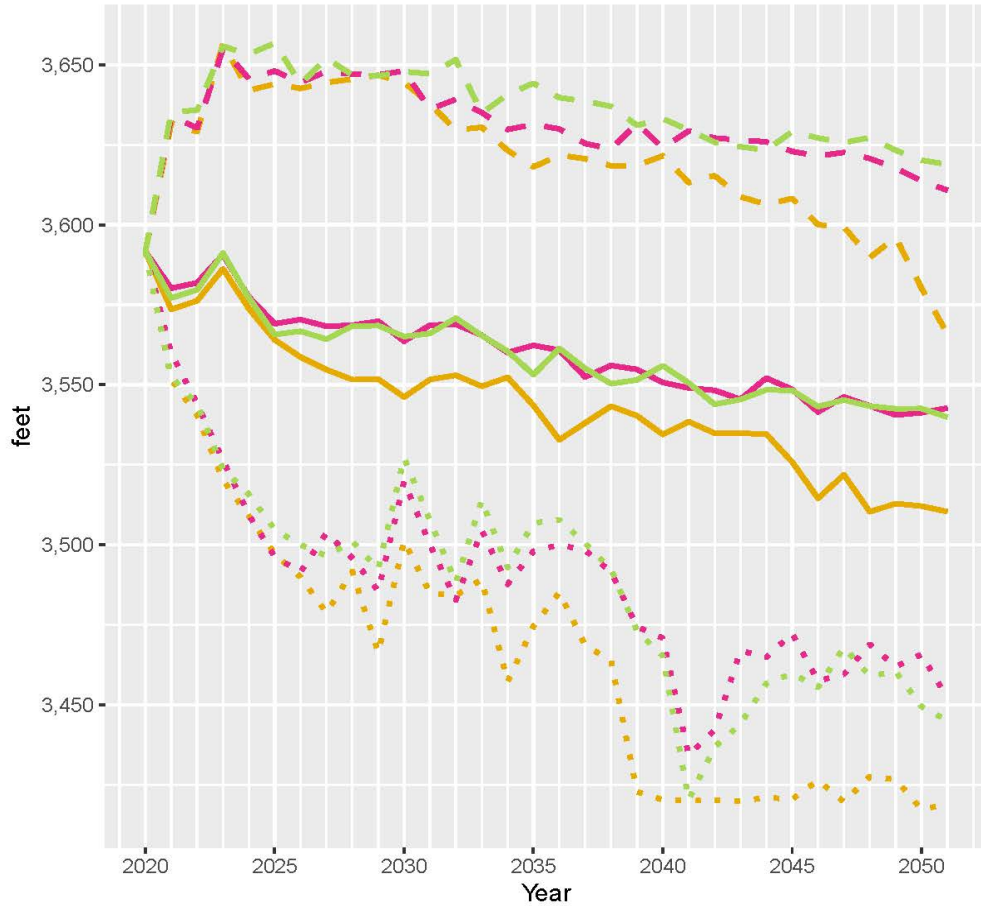


All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

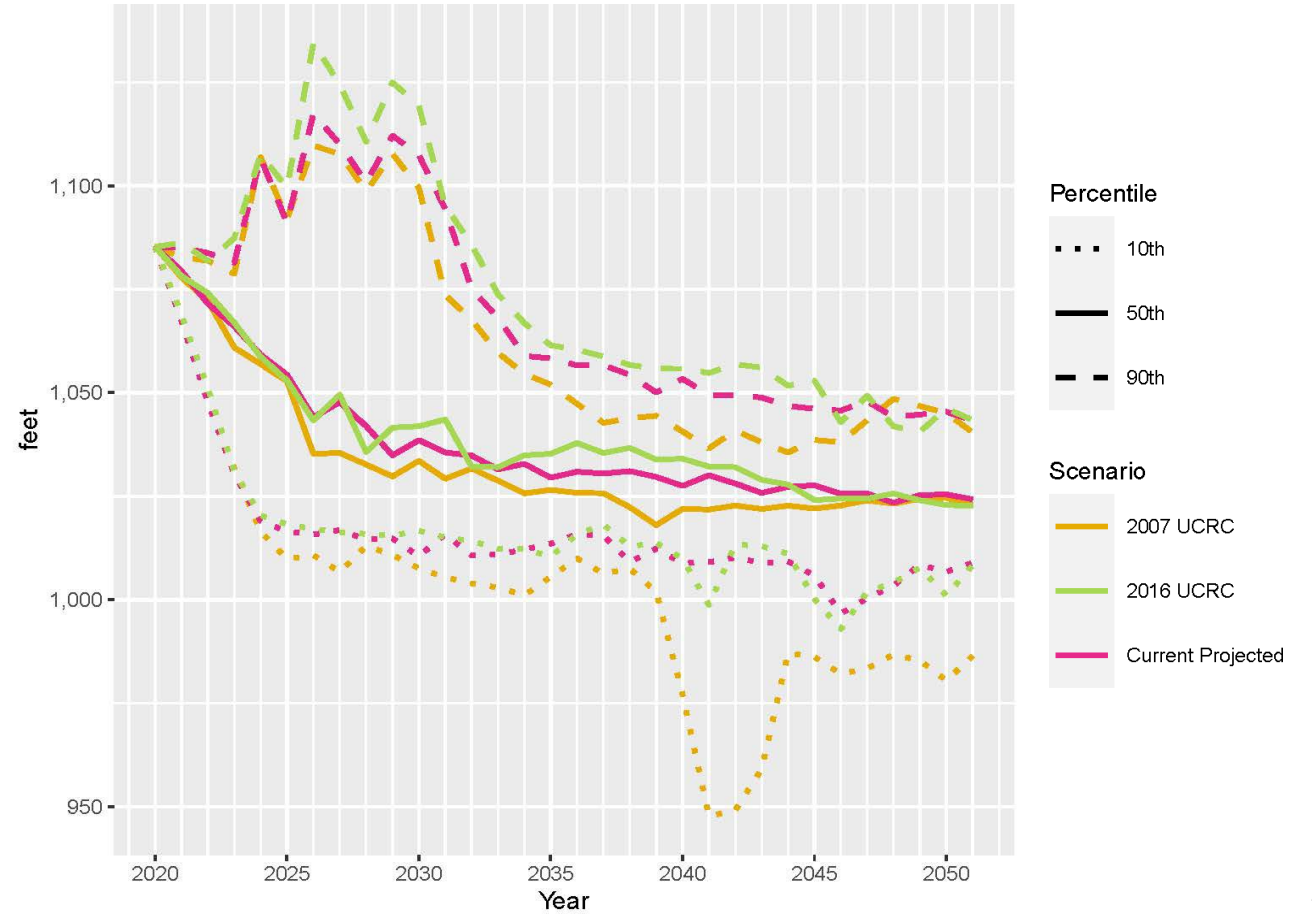


System Conditions – Lakes Powell and Mead

Powell End-of-December Elevation



Mead End-of-December Elevation



Percentile

- • • 10th
- 50th
- - - 90th

Scenario

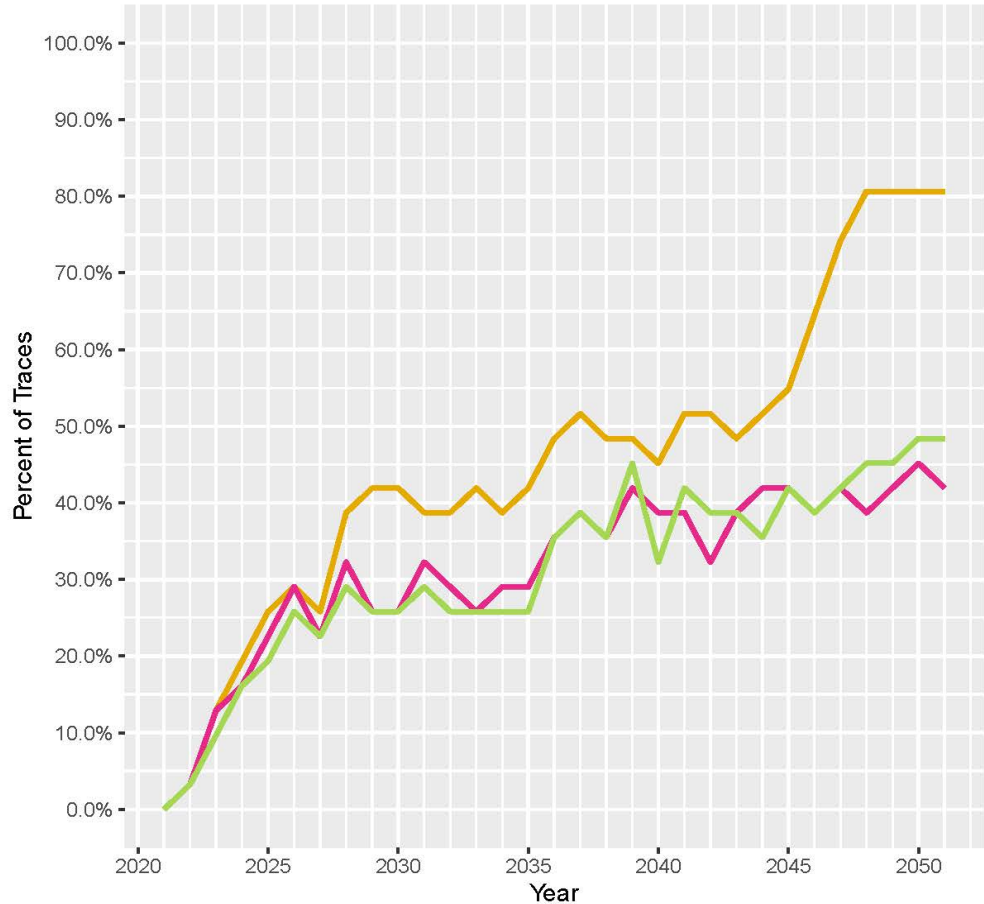
- 2007 UCRC
- 2016 UCRC
- Current Projected

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

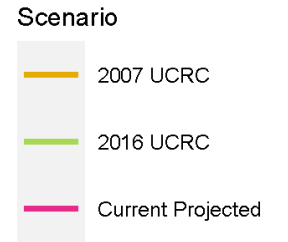
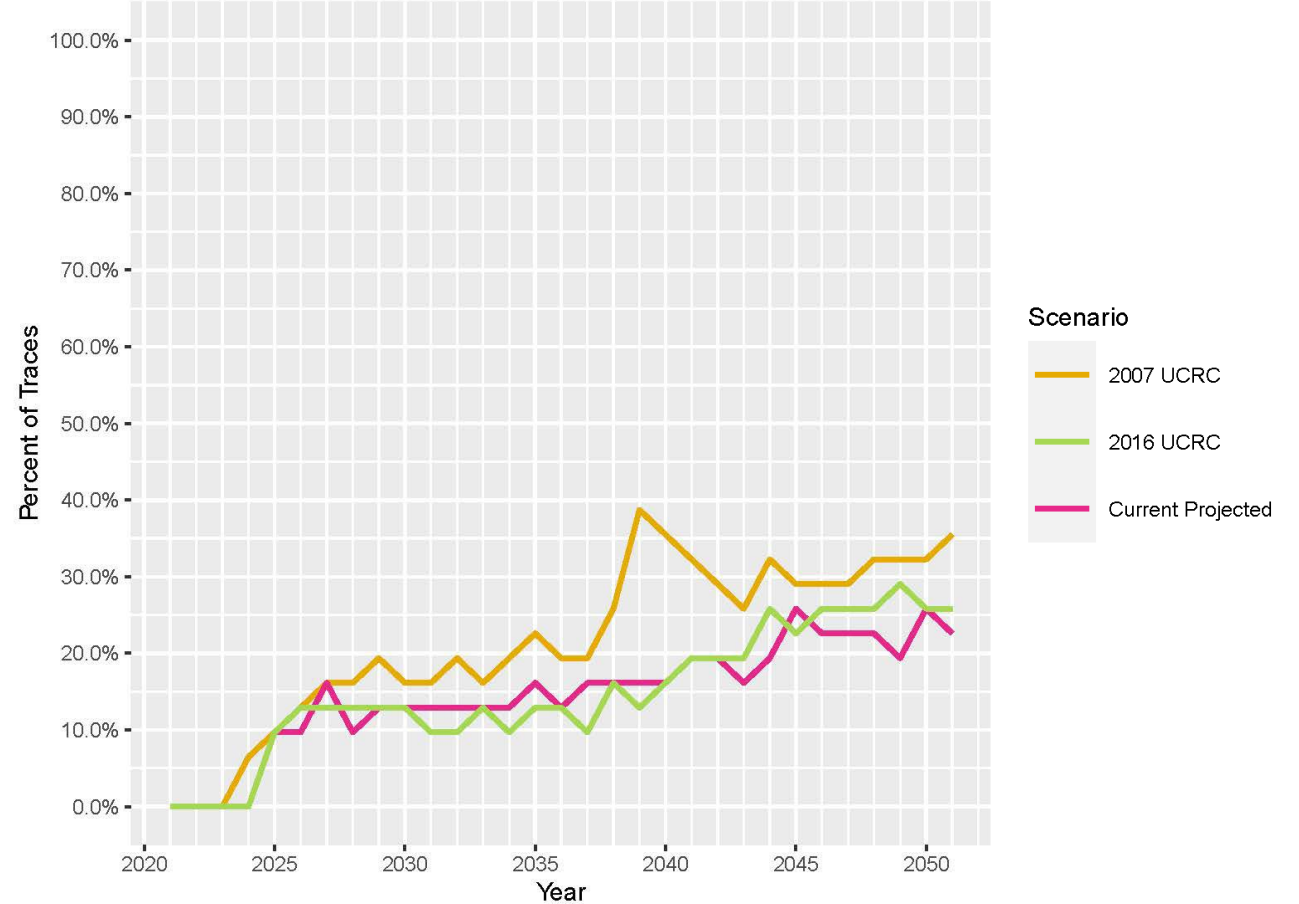


System Conditions – Lake Powell

Powell: Percent of Traces Less than elevation 3,525' in Any Water Year



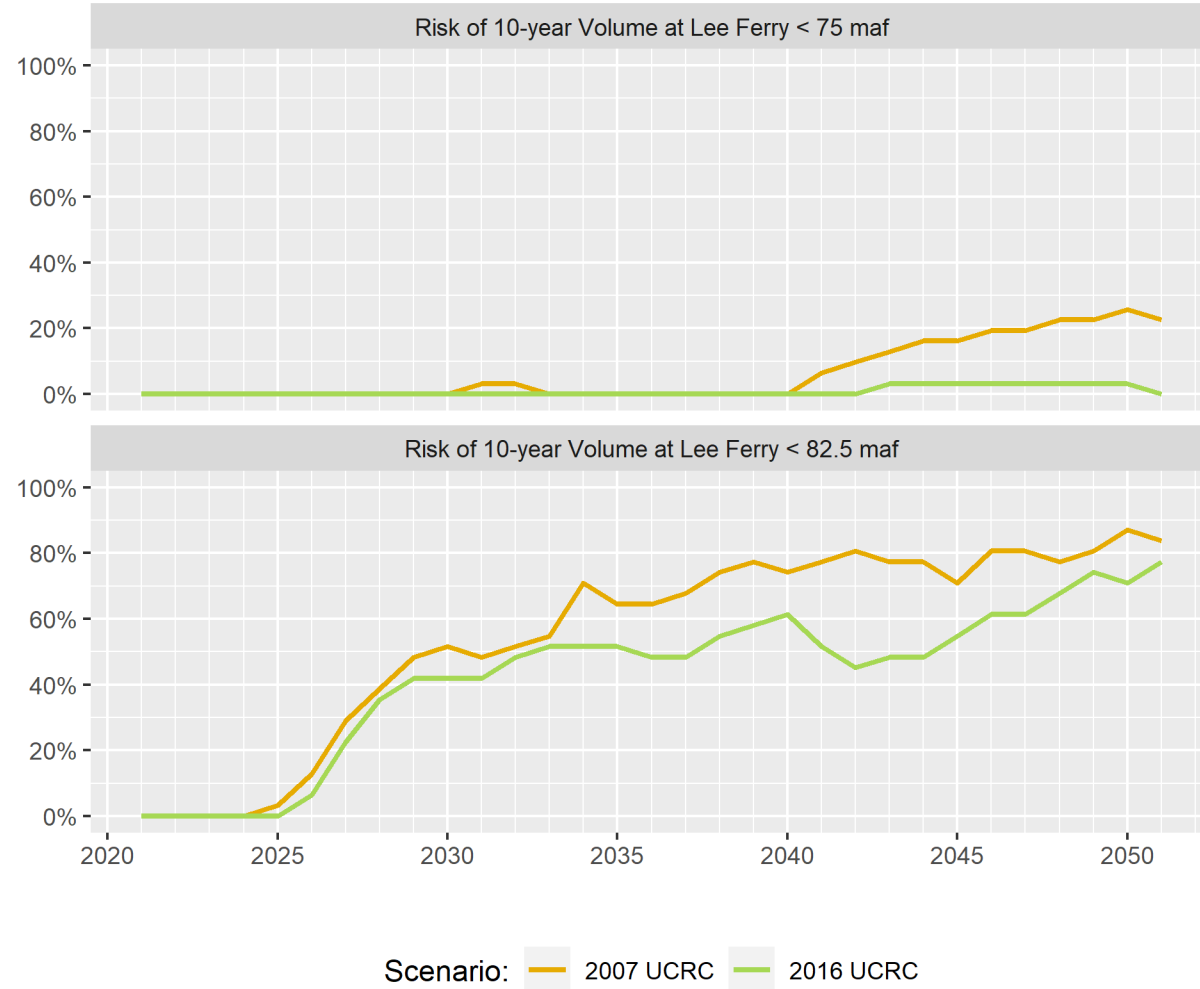
Powell: Percent of Traces Less than Power Pool (elevation 3,490') in Any Water Year



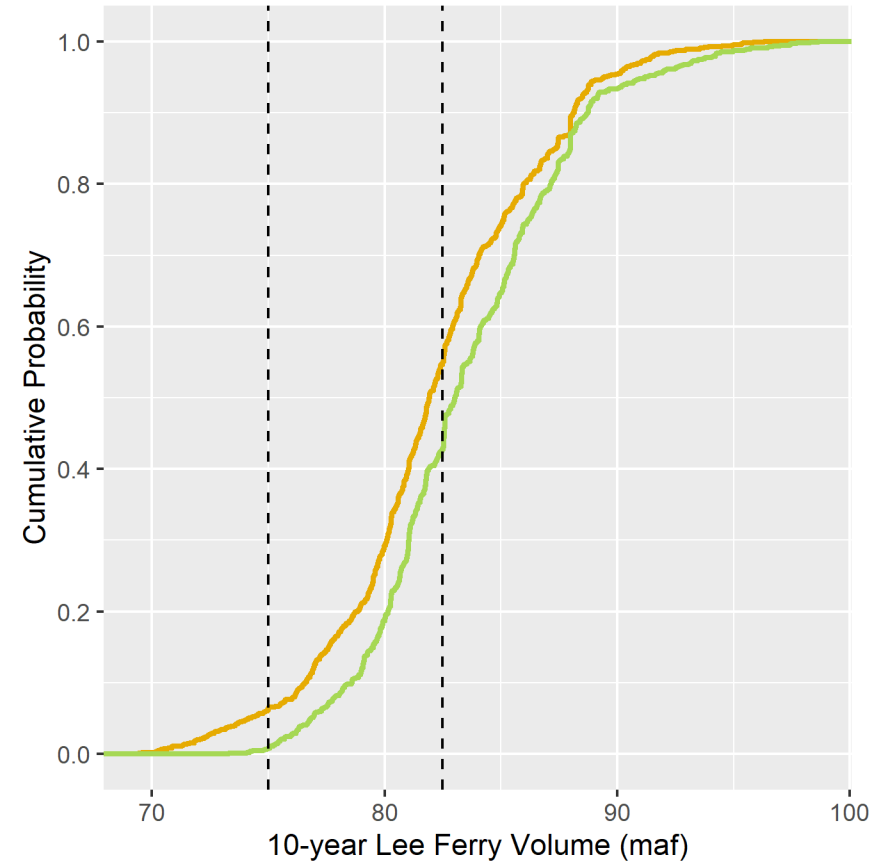
All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).



System Conditions – Lee Ferry 10-year Volume



CDF of Lee Ferry 10-year Volume
2021-2060

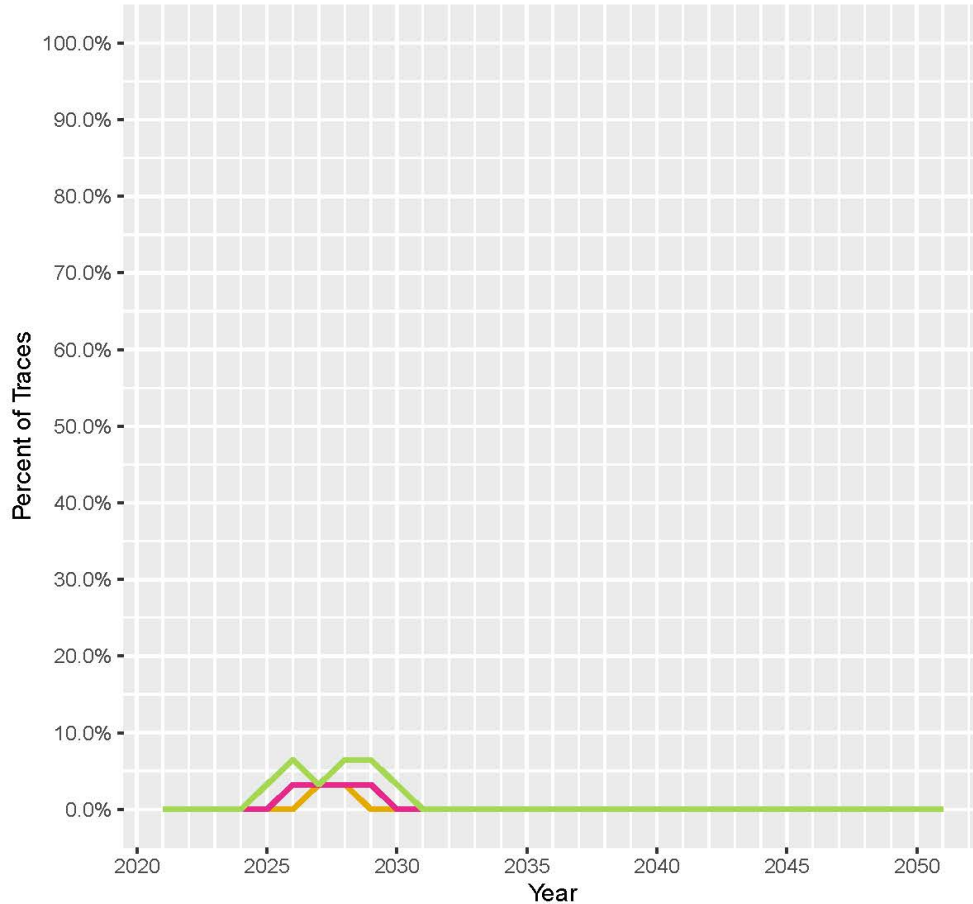


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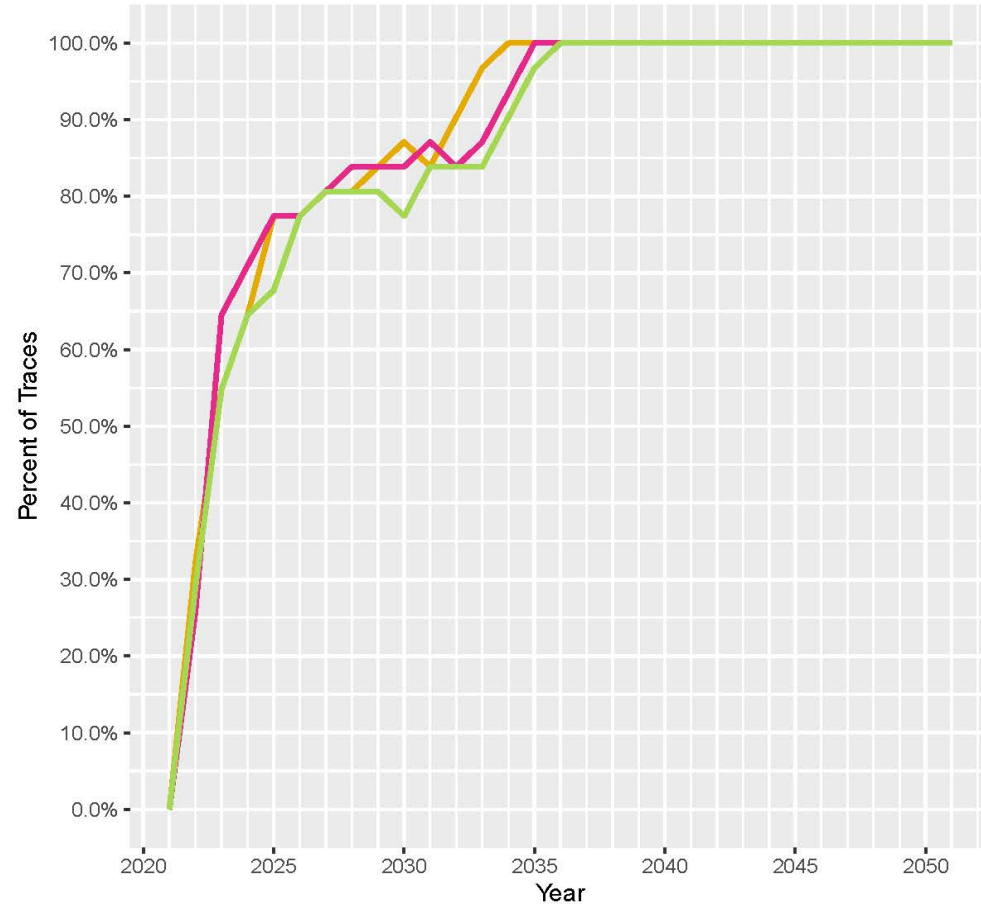


System Conditions – Lower Basin

Lower Basin: Percent of Traces in Surplus Conditions



Lower Basin: Percent of Traces in Shortage Conditions



Scenario

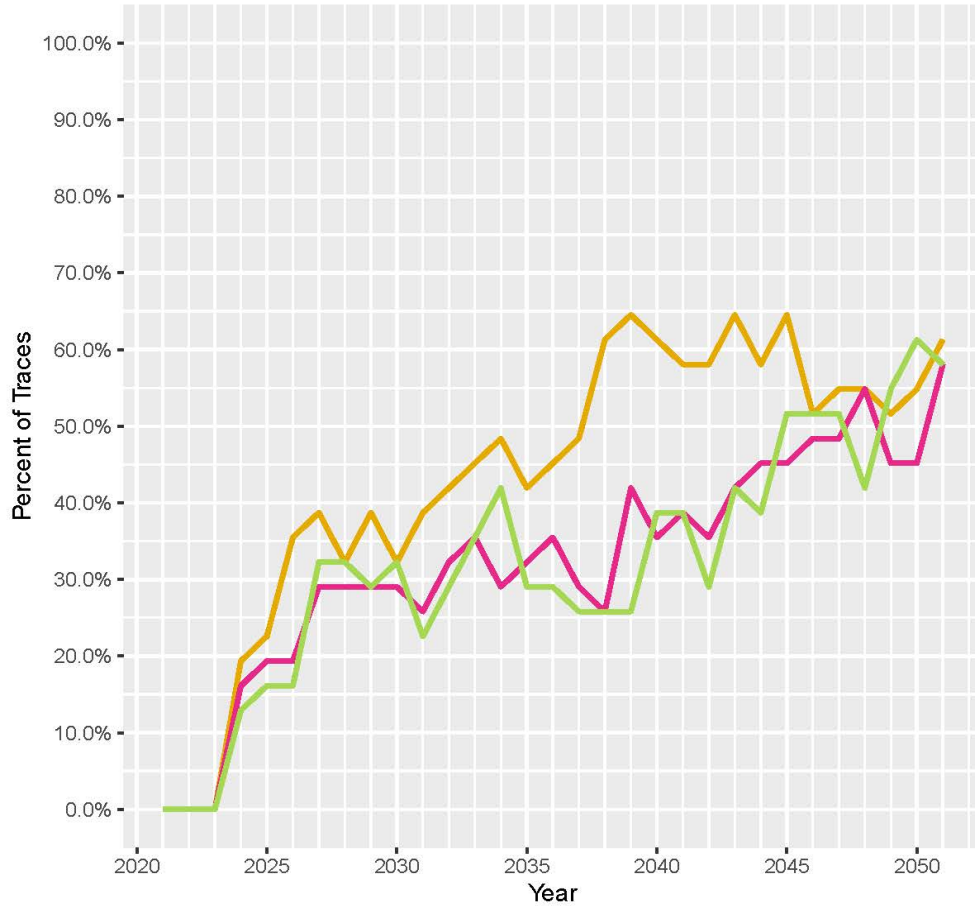
- 2007 UCRC
- 2016 UCRC
- Current Projected

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

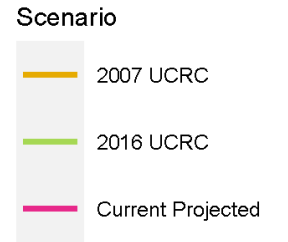
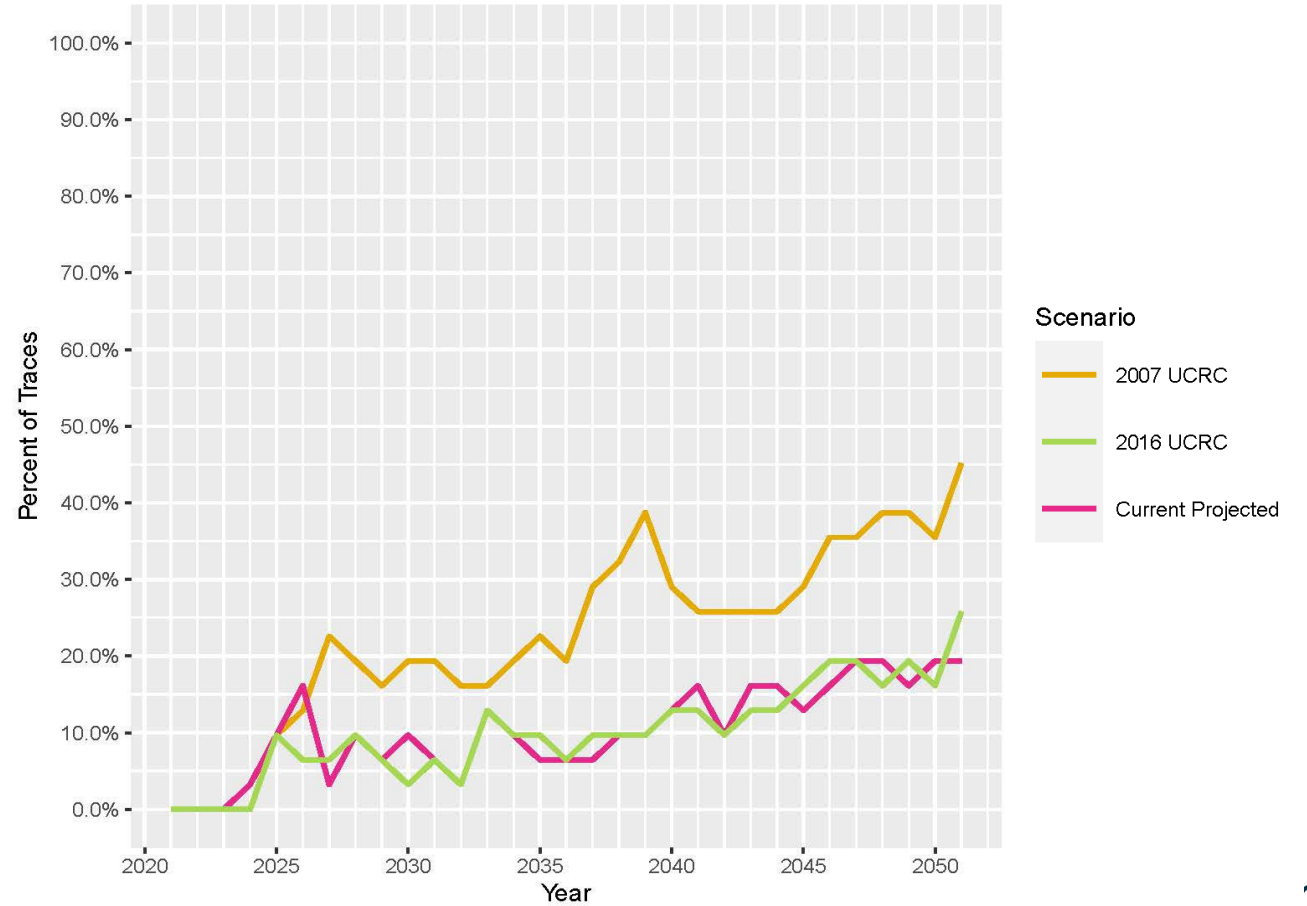


System Conditions – Lake Mead

Mead: Percent of Traces Less than elevation 1,025' in December



Mead: Percent of Traces Less than elevation 1,000' in Any Month

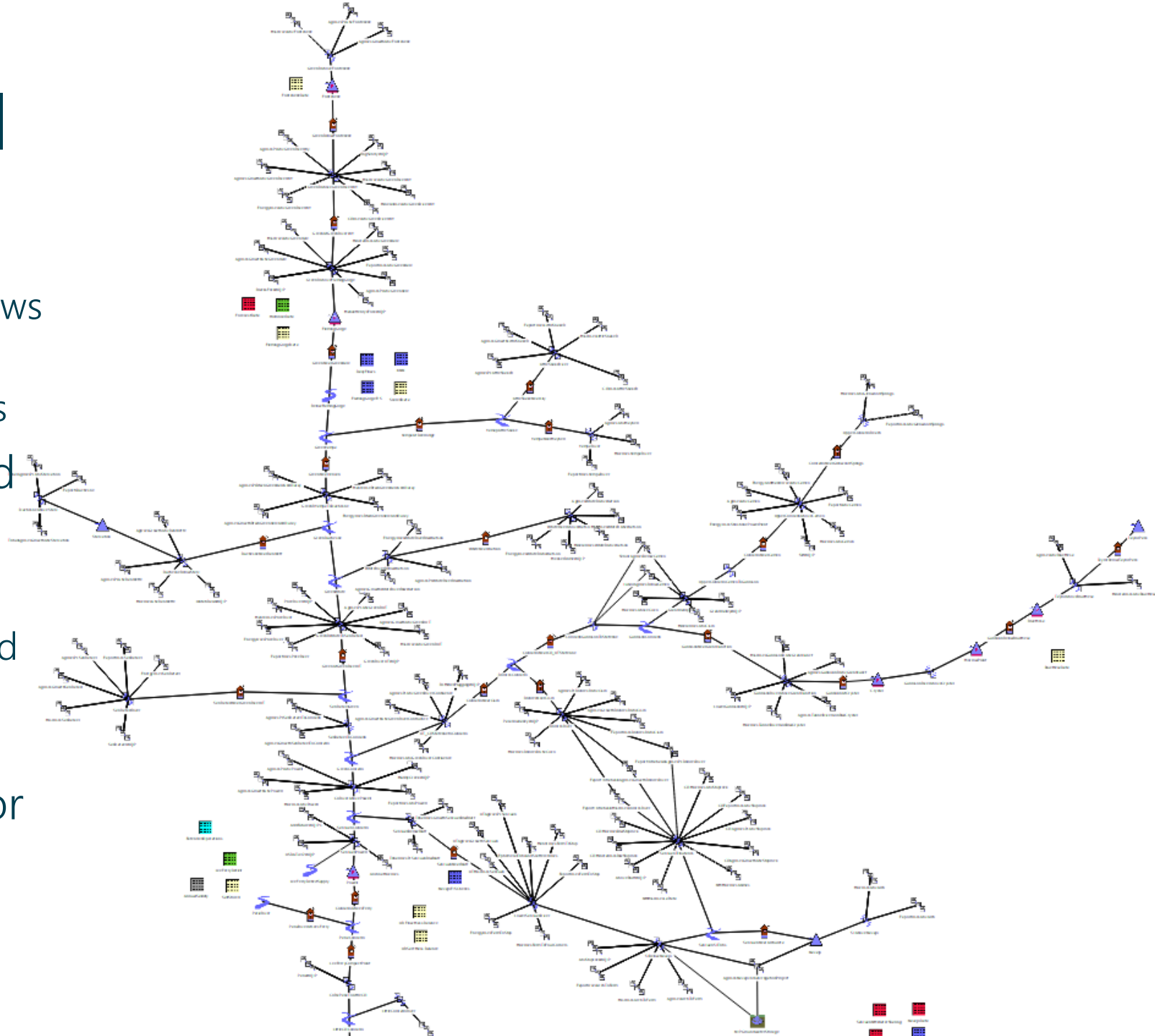


All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).



Verification Model

- Input:
 - 2000-2018 computed natural flows
 - UCRC 2016 demands
 - December 1999 initial conditions
- CRSS calculates depletions and reach outflows
- Compare:
 - Simulated gage flow to observed (USGS gage or reservoir inflow)
 - CRSS sector depletions to CUL
- Post processing code allows for comparison of changes



CRSS Verification Results

2016 UCRC, 2000-2018 CU&L Average Distribution Coefficients

	MAE	Bias	Avg Gage Flow	Gage Error
1 Glenwood	148,582	-135,421	1,458,061	10.2%
2 Cameo	293,139	-293,139	2,475,307	11.8%
4 Blue Mesa*	85,652	-85,652	814,306	10.5%
6 Grand Junction	68,807	-36,826	1,450,922	4.7%
7 Dolores	36,774	25,072	301,956	12.2%
8 CO River at Cisco	327,380	-326,791	3,976,651	8.2%
9 Fontenelle*	74,995	-74,995	1,000,244	7.5%
10 Green River WY	101,102	-97,615	987,126	10.2%
11 Greendale*	115,818	-110,803	1,268,449	9.1%
12 Yampa	22,287	22,287	350,173	6.4%
13 Little Snake	42,512	-39,515	1,019,723	4.2%
14 Duchesne	51,959	37,748	206,993	25.1%
15 White River	7,074	-3,208	419,907	1.7%
16 Green River UT	185,439	-184,584	3,292,730	5.6%
17 San Rafael	20,037	20,037	46,382	43.2%
18 Archuleta*	64,413	-54,911	703,456	9.2%
19 Bluff	124,903	-113,599	976,637	12.8%
20 Lees Ferry*	438,312	-436,295	8,453,263	5.2%

Compared to 2007 UCRC

MAE change	Change in Error
-110,321	-7.6%
-50,334	-2.0%
-28,878	-3.5%
-83,018	-5.7%
-96,895	-32.1%
-297,225	-7.5%
-65,310	-6.5%
-96,902	-9.8%
-11,883	-0.9%
-15,568	-4.4%
-55,980	-5.5%
-53,293	-25.7%
-44,062	-10.5%
-143,814	-4.4%
-14,490	-31.2%
-81,396	-11.6%
-108,536	-11.1%
-497,839	-5.9%

Negative is improvement

- Error and bias improved at all locations



Next Steps

Reclamation incorporated the 2016 UCRC Demand Schedule for the Upper Colorado River Division States (“2016 Schedule”) for the first time in the January 2021 CRSS official model run. The Upper Division States and UCRC assisted with the representation of this new schedule in CRSS. During this process, the need for additional refinements to the representation of Upper Colorado River Basin water use in CRSS was identified. Reclamation is currently working with the Upper Division States and UCRC on such refinements.

- Continue working with Upper Division States and UCRC to refine the representation of Upper Colorado River Basin water use in CRSS
- No major updates to CRSS anticipated before April 2021



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— BUREAU OF —
RECLAMATION

Supplementary

CRSS Projections – Comparison of 2007 and 2016 UCRC Demand Schedules using Full Hydrology

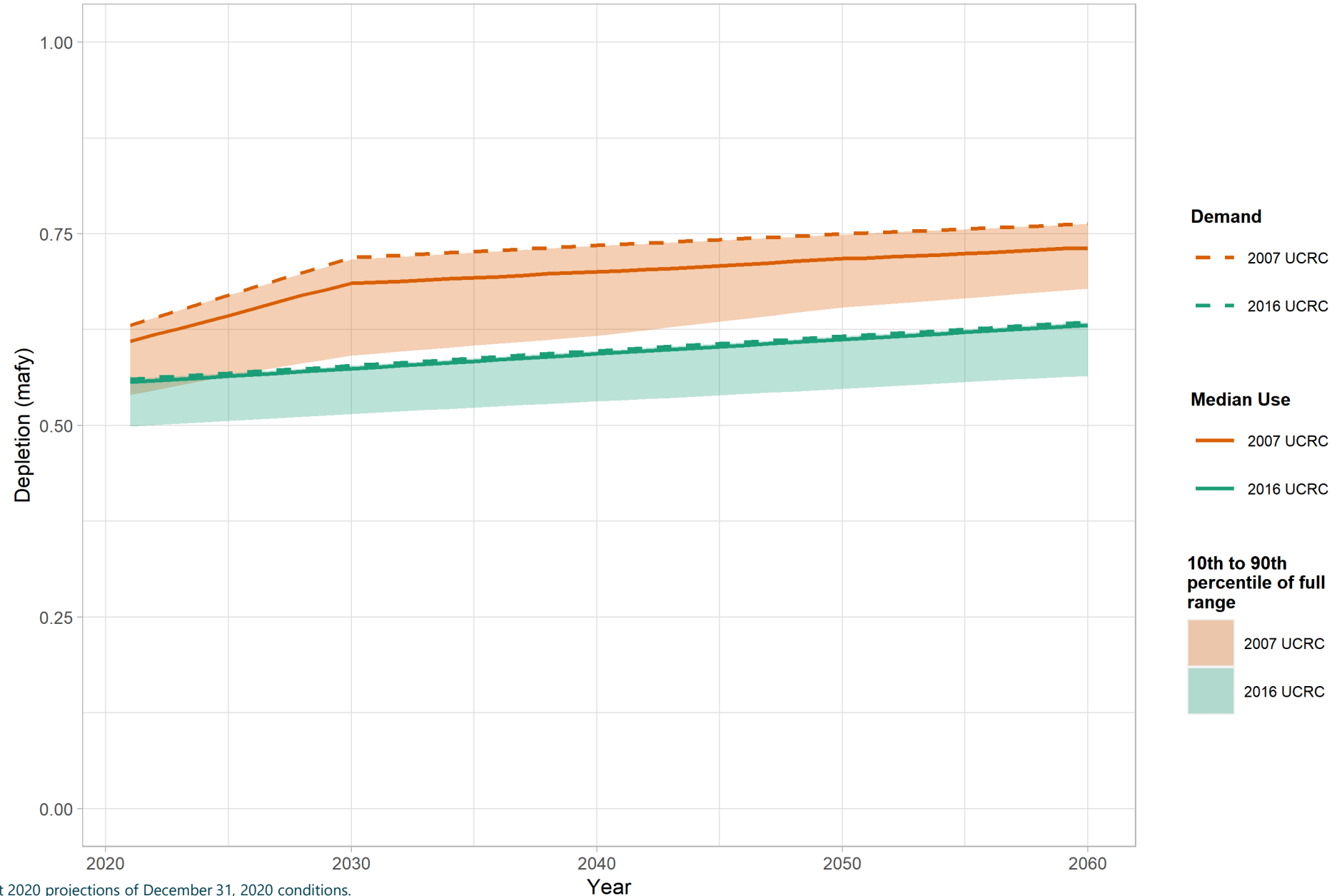


Modeling Assumptions

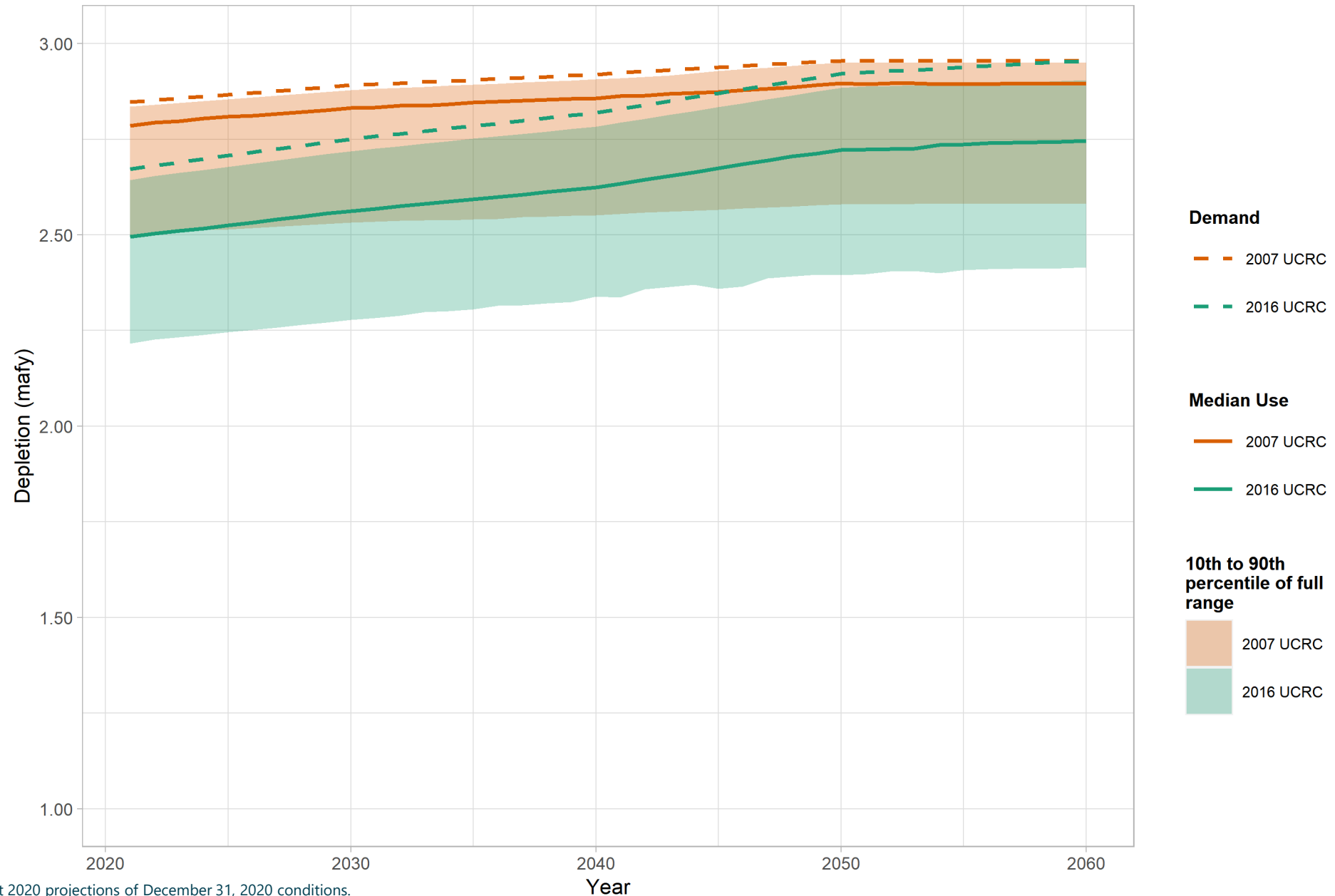
- CRSS is initialized with end-of-December 2020 reservoir conditions, 2021 Lake Powell operating tier, and 2021 Lake Mead operating condition from the August 2020 24-Month Study projection based on the Colorado Basin River Forecast Center's most probable inflow sequence
- Comparisons are made using the "Full Hydrology", i.e., the index sequential method (ISM) applied to the 1906-2018 historical record
 - Results for the "Stress Test Hydrology" (ISM applied to 1988-2018) are provided as supplementary material
- All runs assume the 2007 Interim Guidelines, Lower Basin Drought Contingency Plan, Upper Basin Drought Response Operations, and Minute 323 are in place through 2060



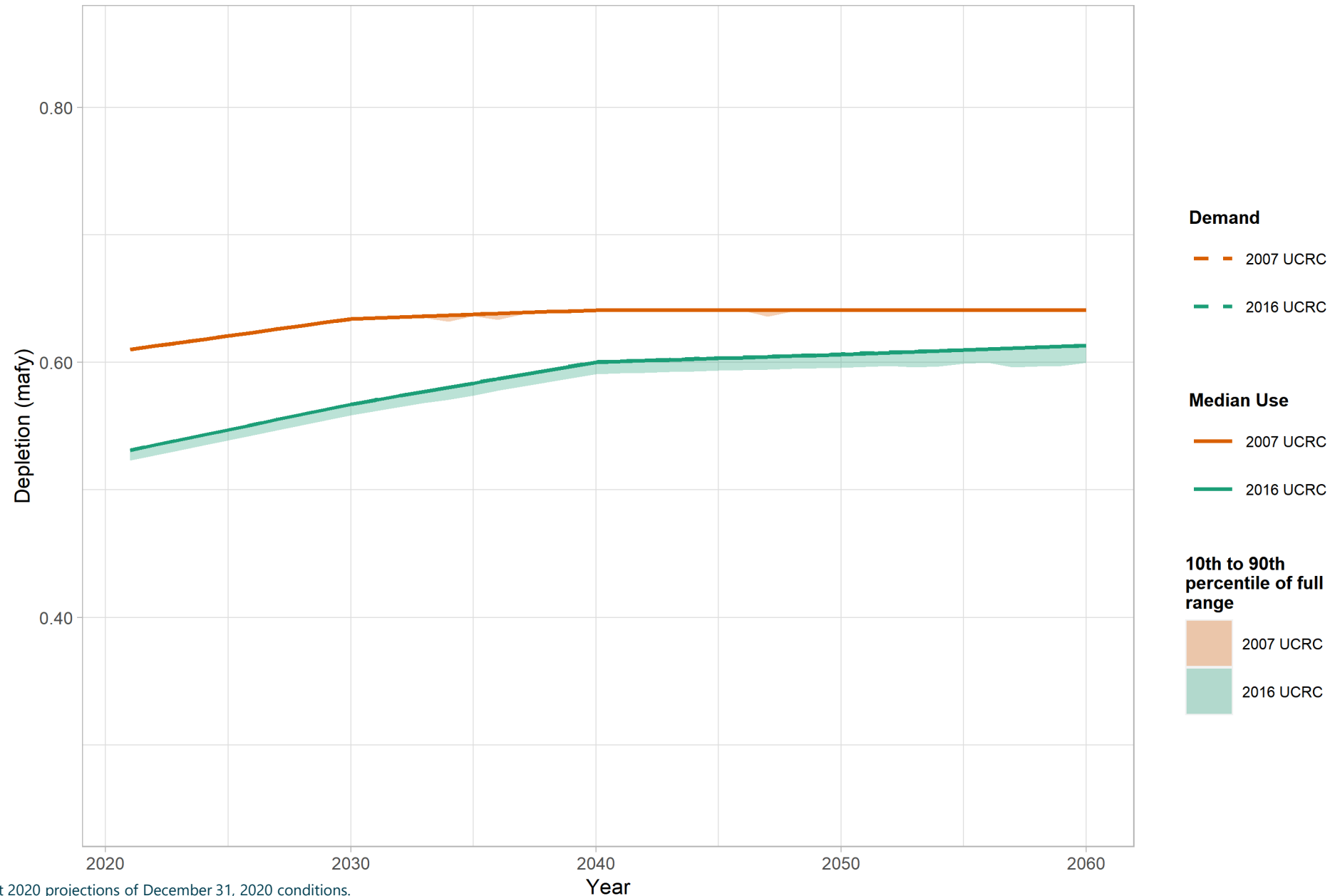
Modeled Annual Consumptive Use - Wyoming



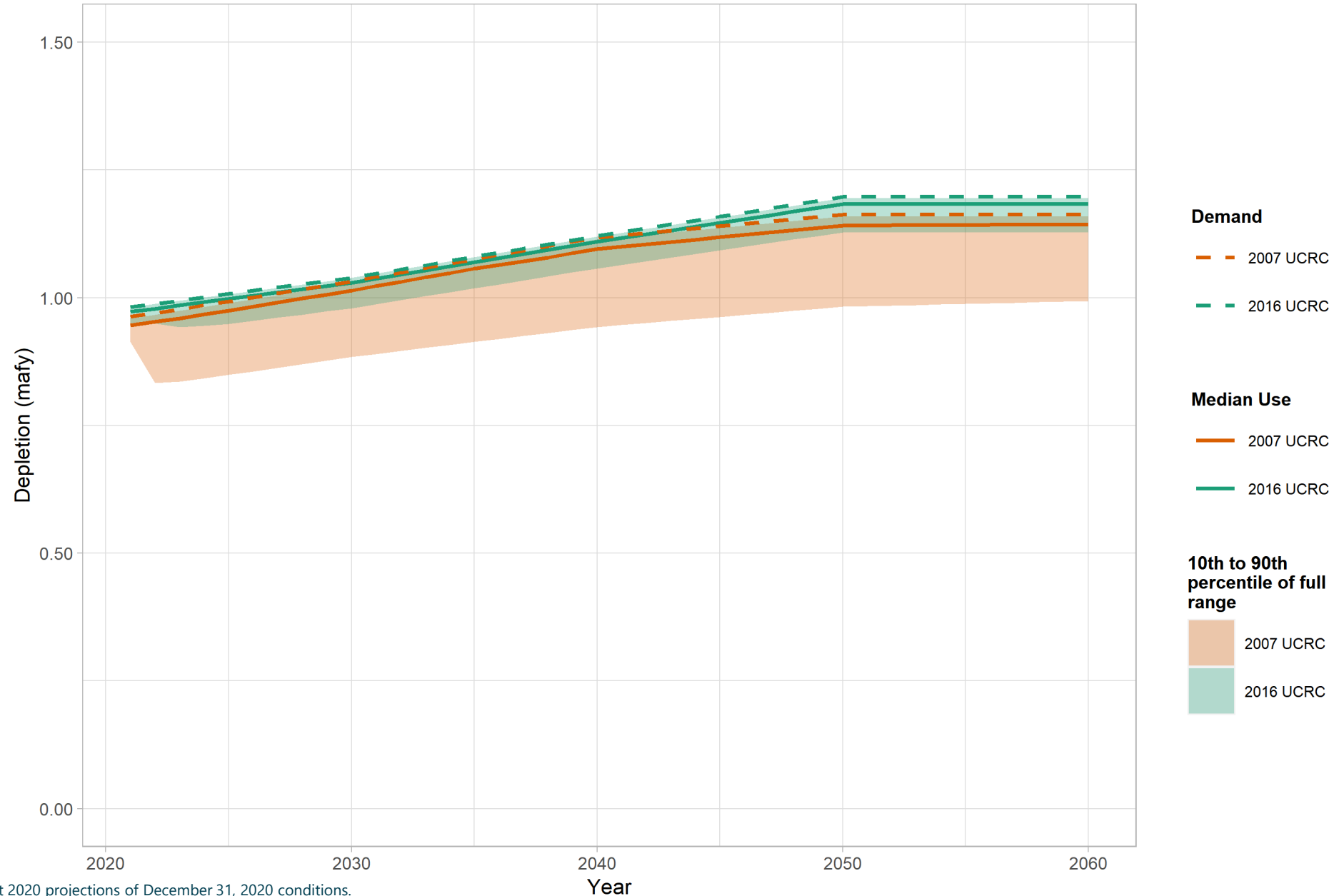
Modeled Annual Consumptive Use - Colorado



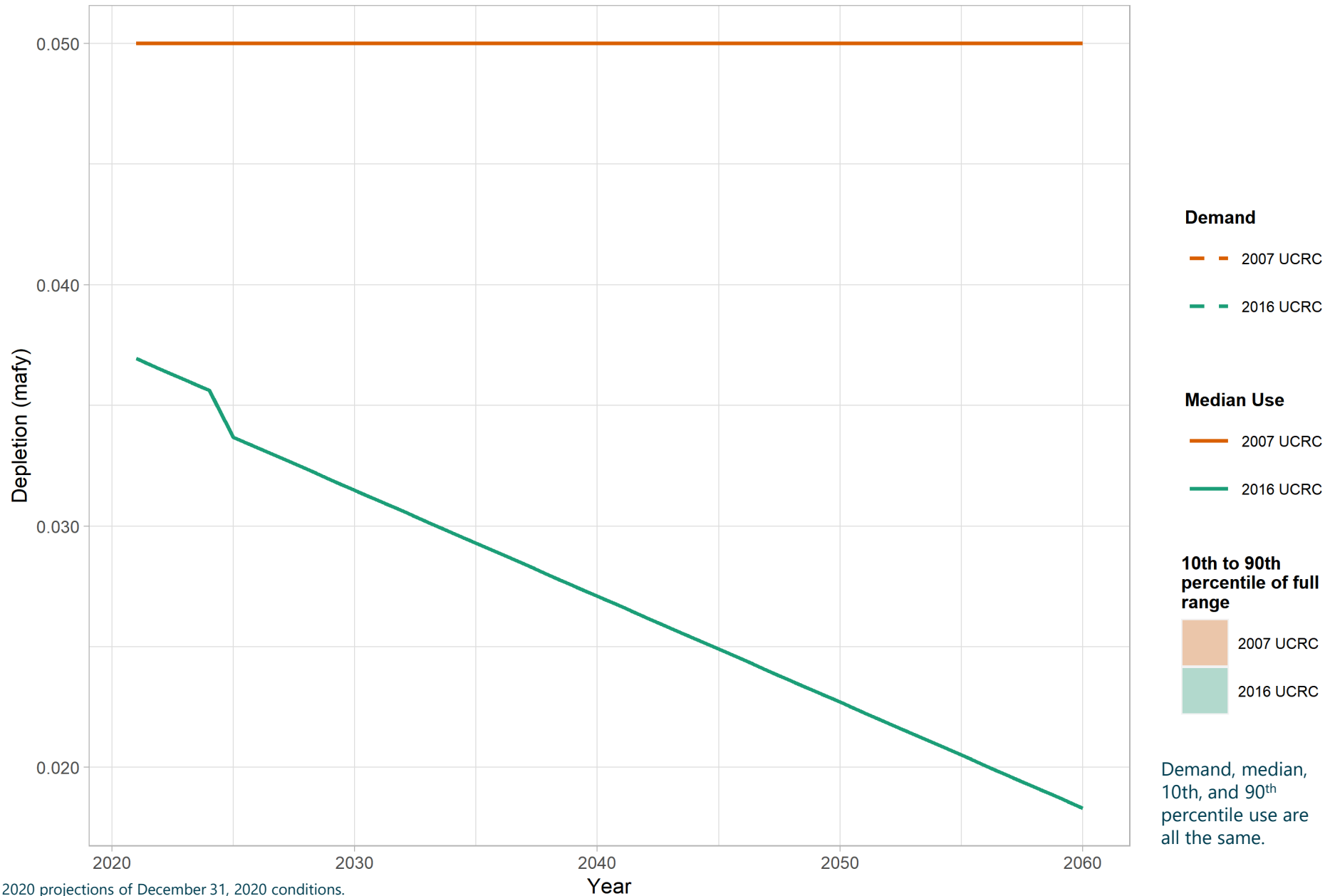
Modeled Annual Consumptive Use – New Mexico



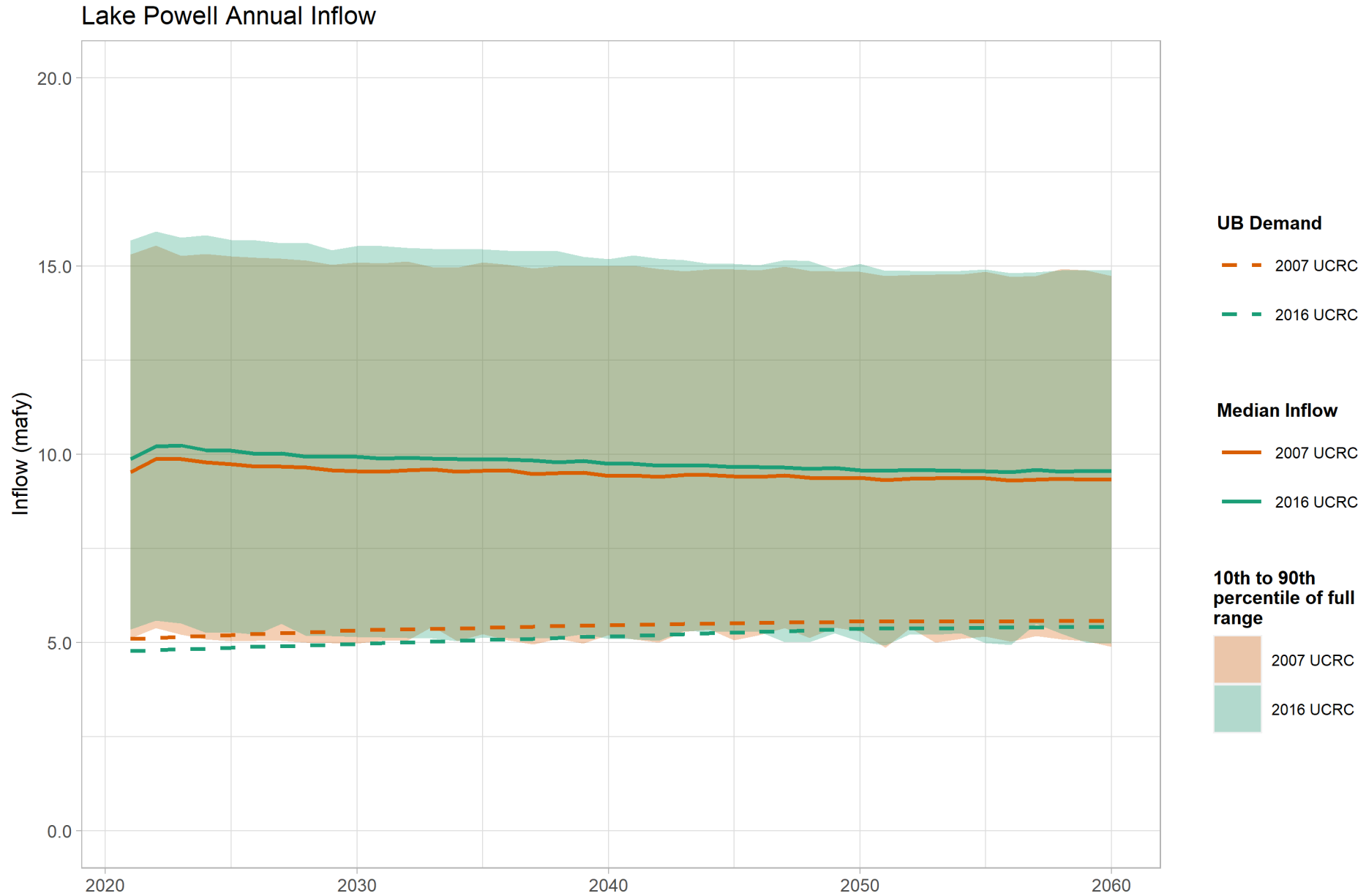
Modeled Annual Consumptive Use - Utah



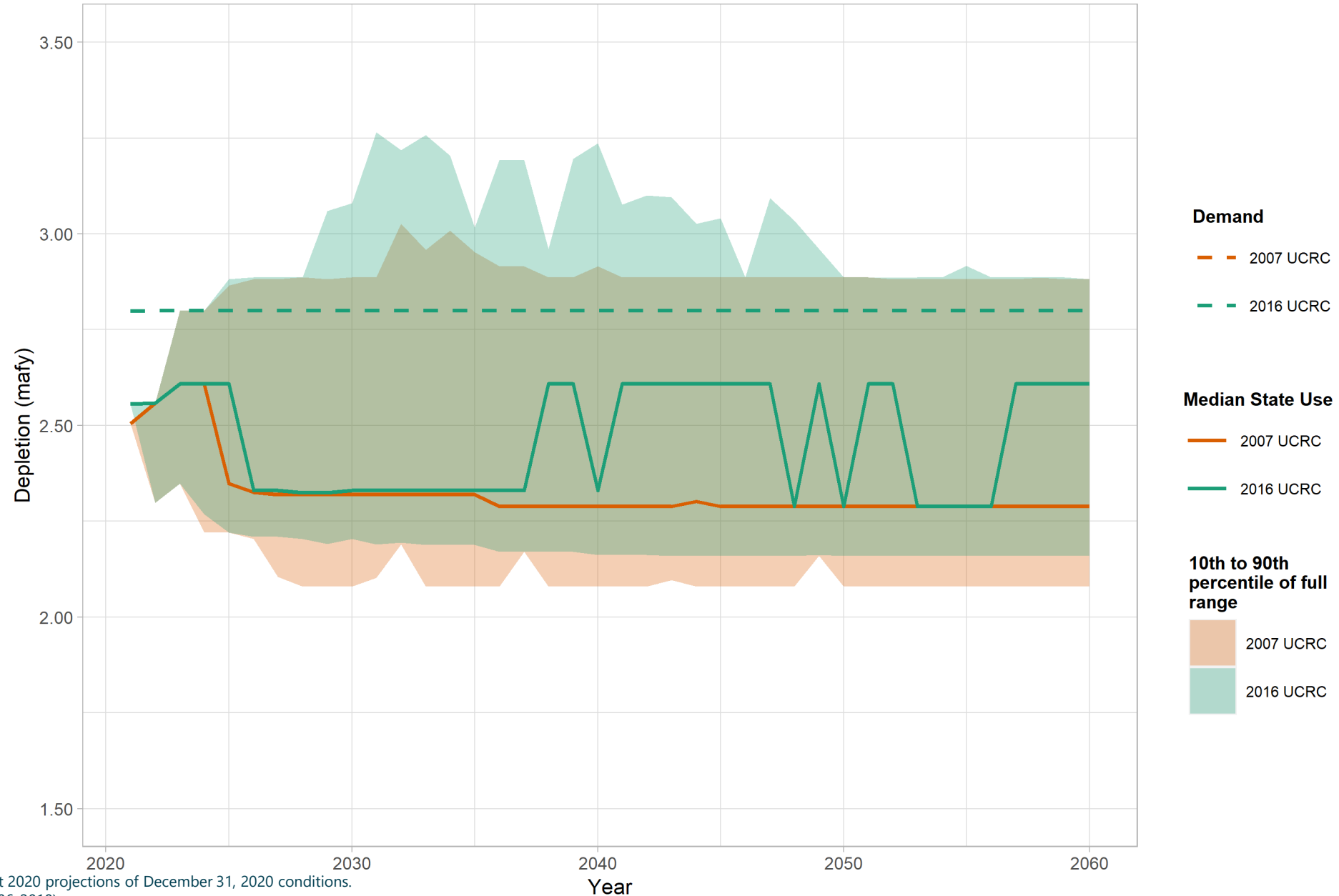
Modeled Annual Consumptive Use – UB Arizona



Lake Powell Annual Inflow



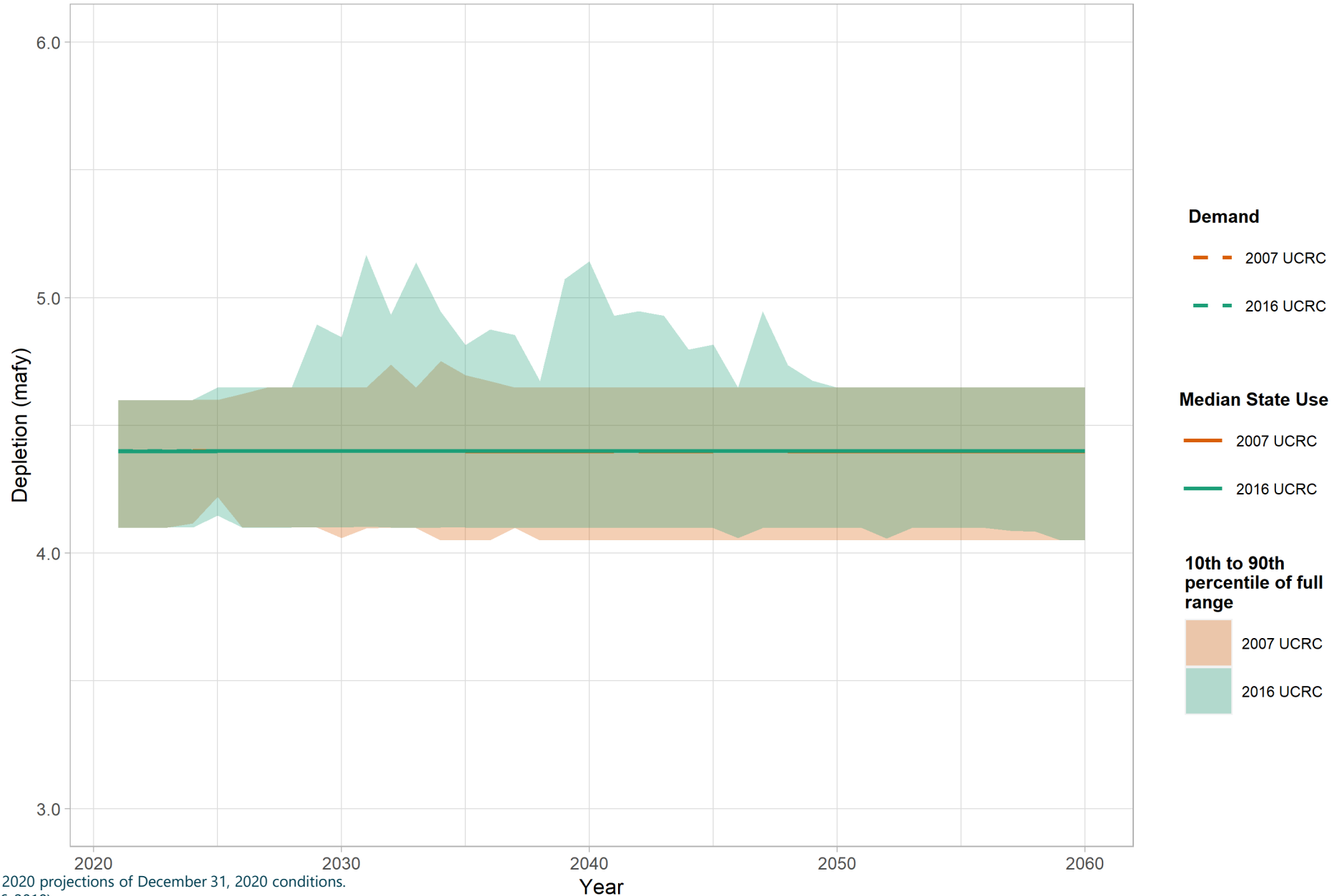
Modeled Annual Consumptive Use – LB Arizona



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).



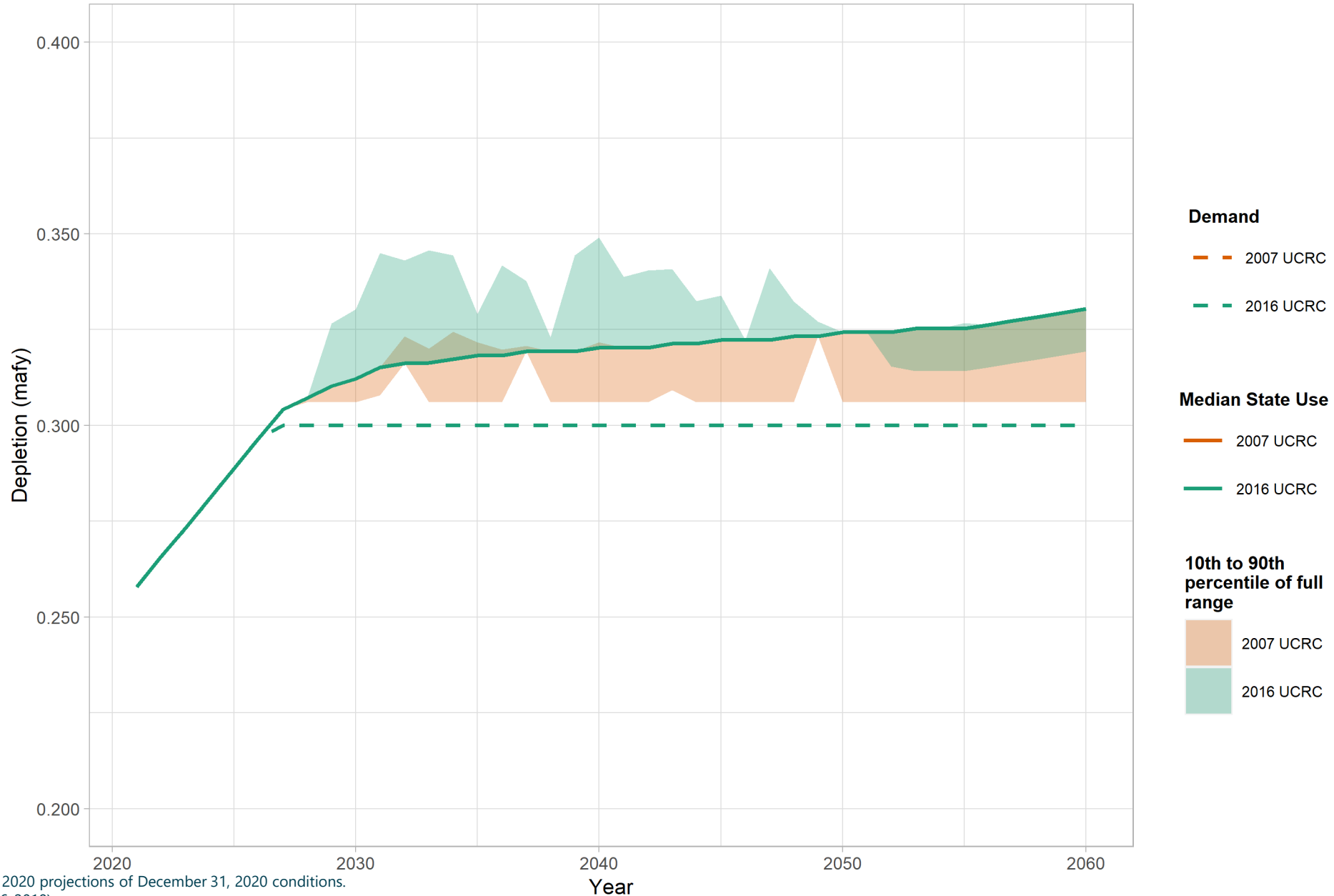
Modeled Annual Consumptive Use – California



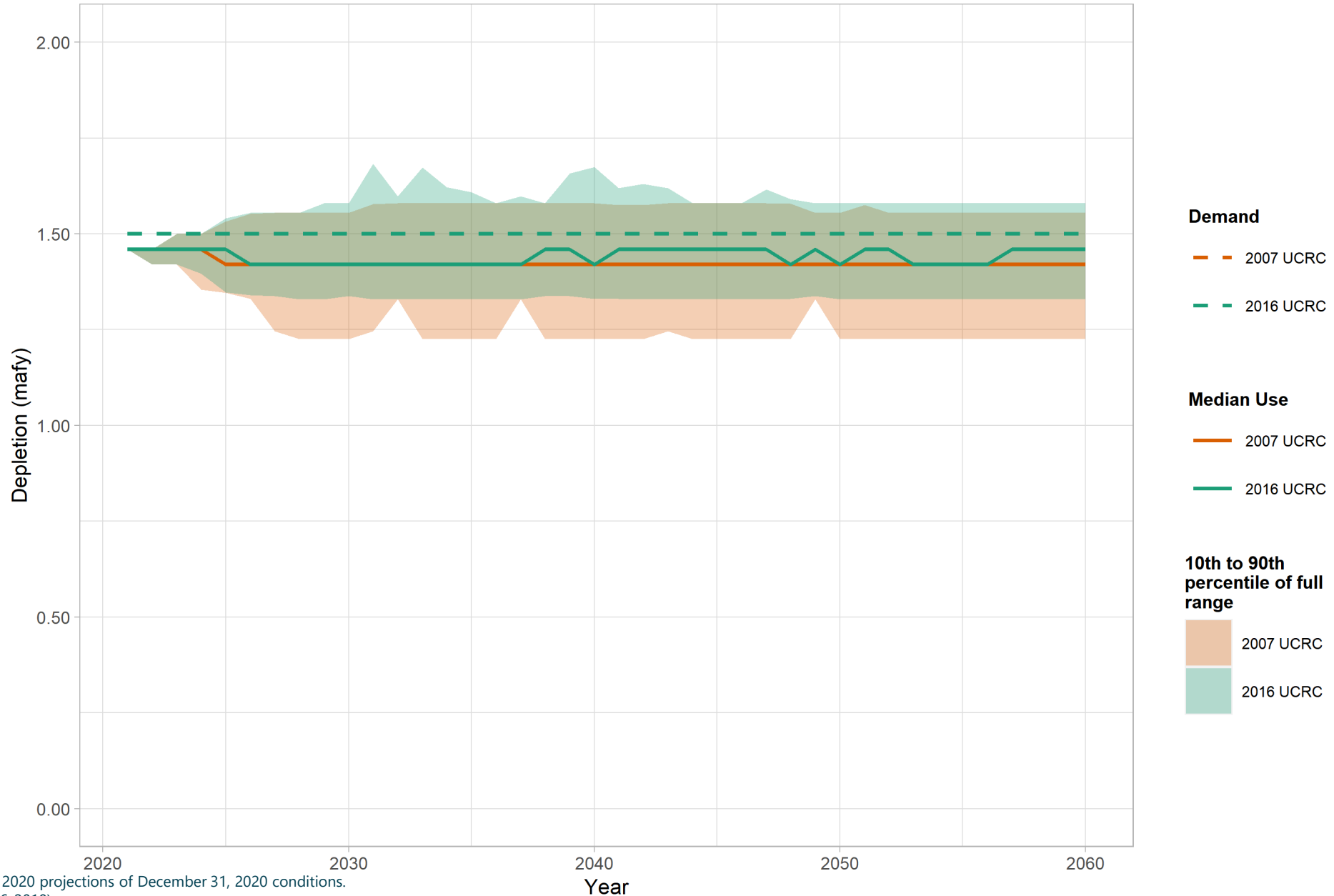
All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).



Modeled Annual Consumptive Use - Nevada



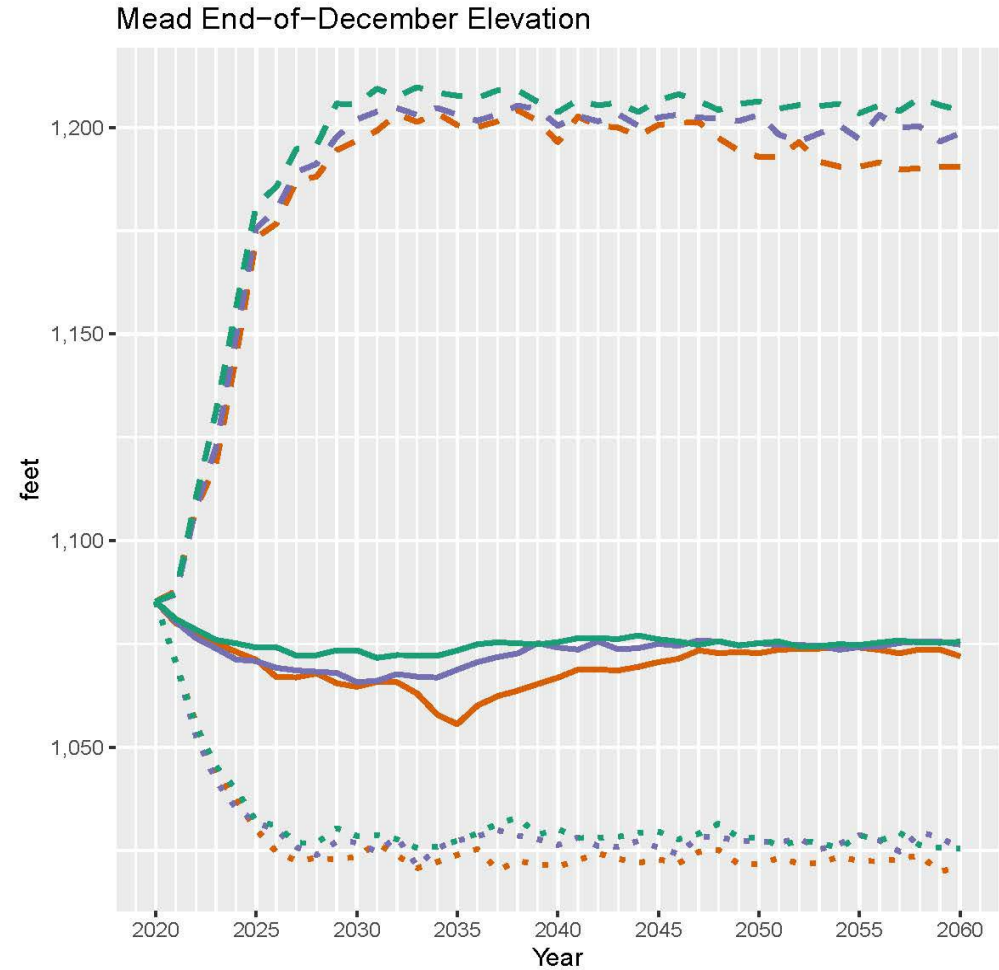
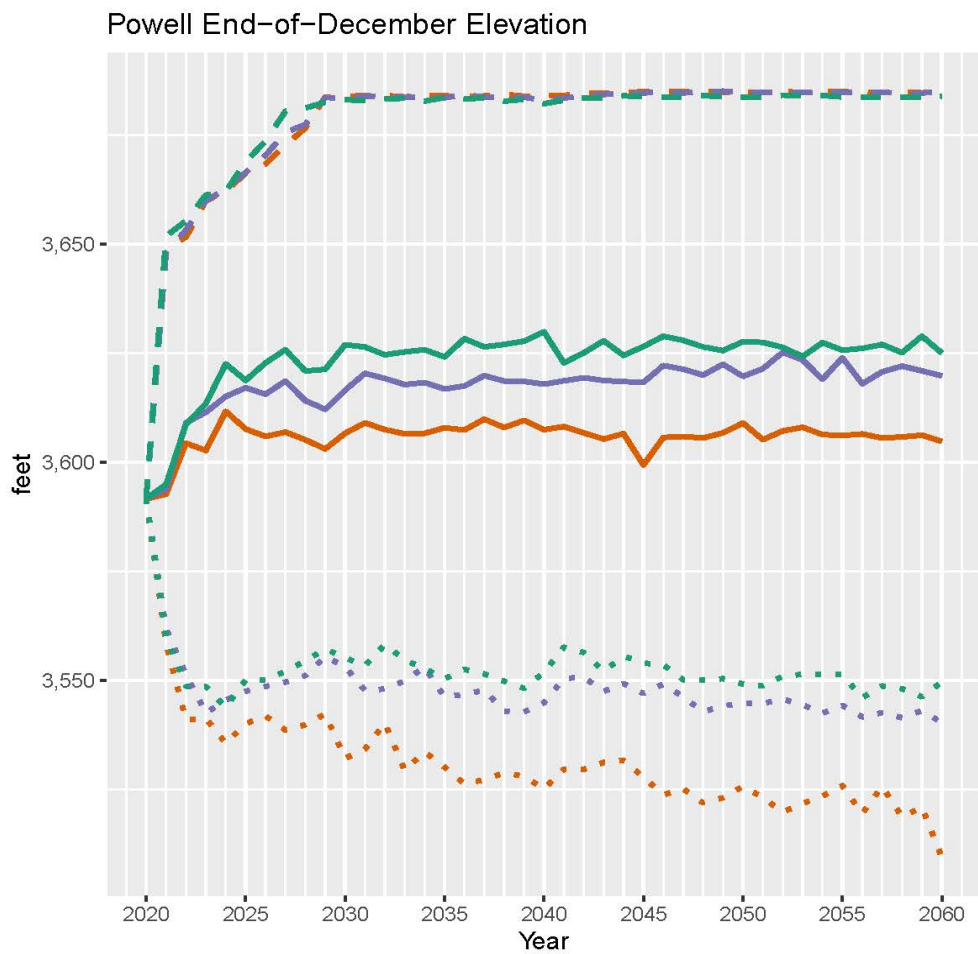
Modeled Annual Consumptive Use - Mexico



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).



System Conditions – Lakes Powell and Mead



Percentile

- • • 10th
- 50th
- - - 90th

Scenario

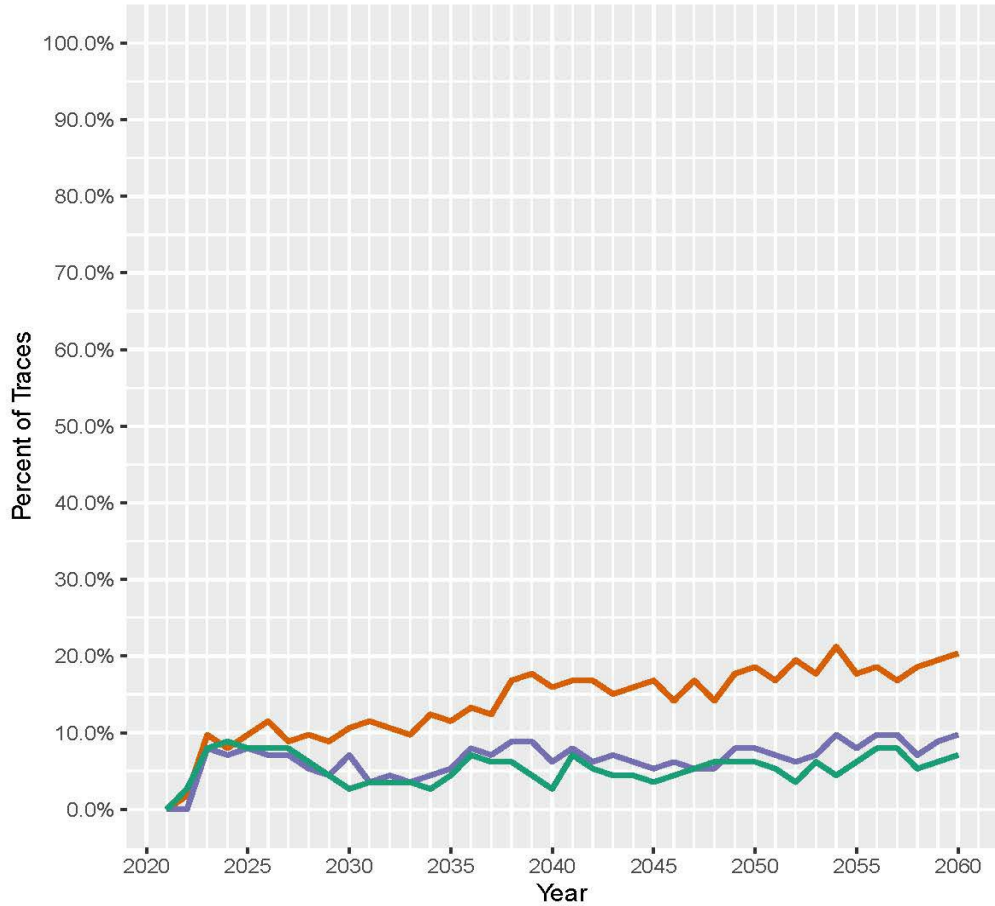
- Aug 2020 – DNF IG
- Aug 2020 – DNF IG CT
- Rdsgn 2020 – DNF IG

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

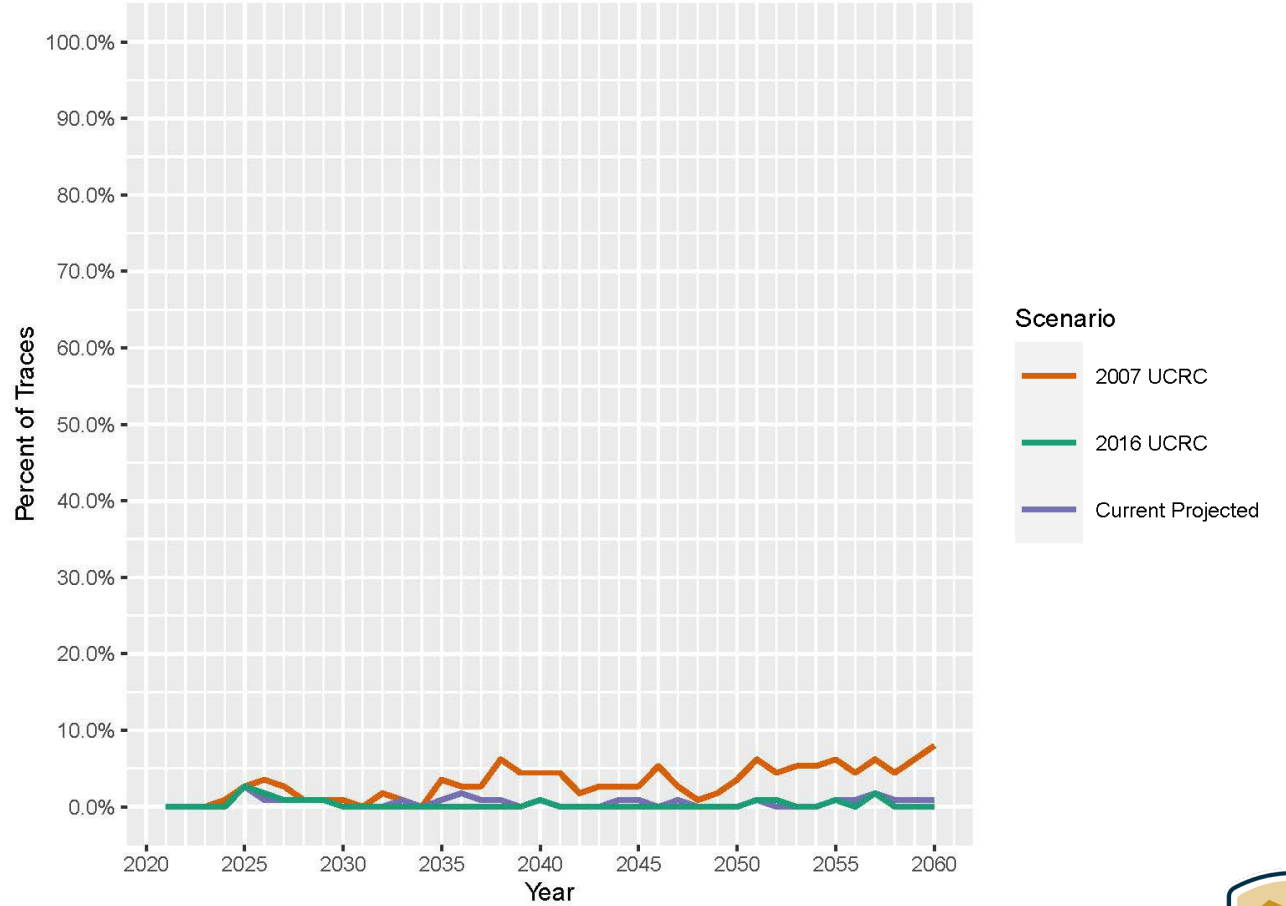


System Conditions – Lake Powell

Powell: Percent of Traces Less than elevation 3,525' in Any Water Year



Powell: Percent of Traces Less than Power Pool (elevation 3,490') in Any Water Year

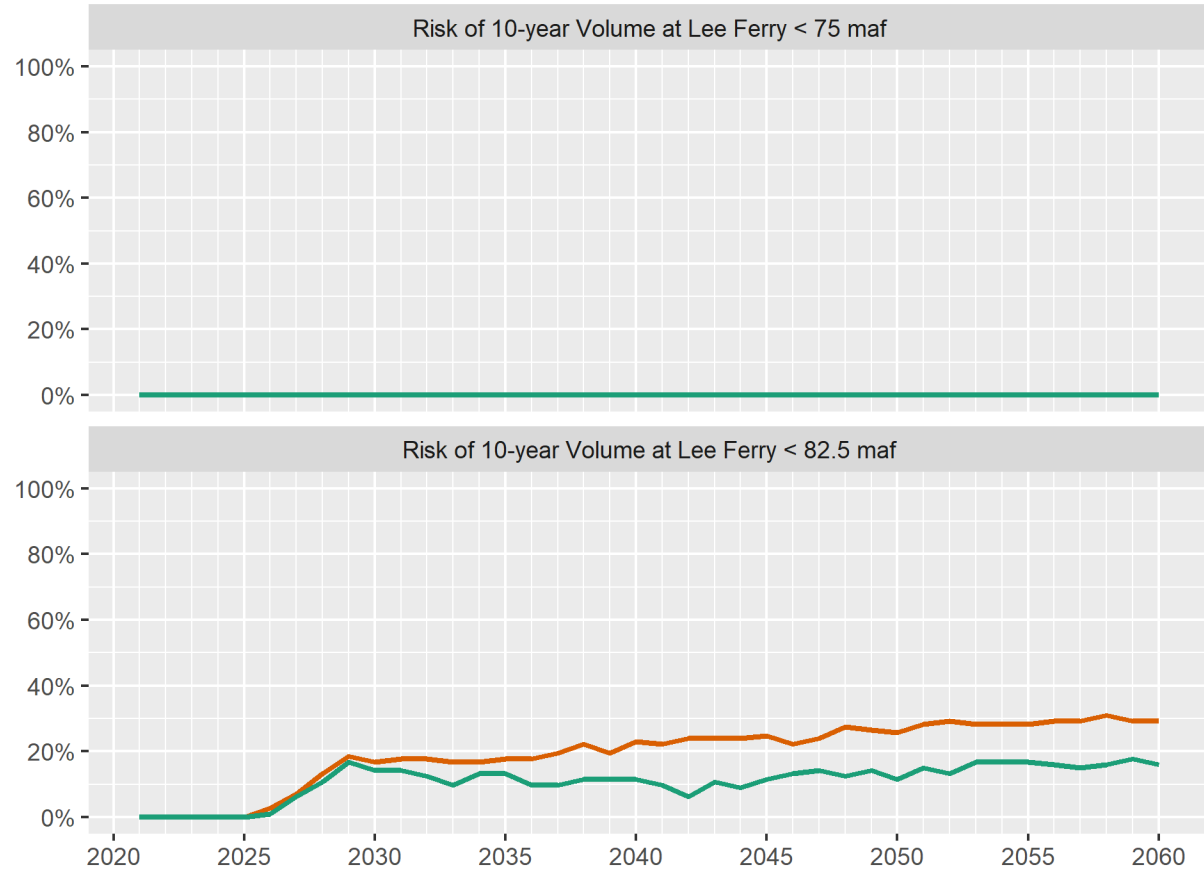


- Scenario**
- 2007 UCRC
 - 2016 UCRC
 - Current Projected

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

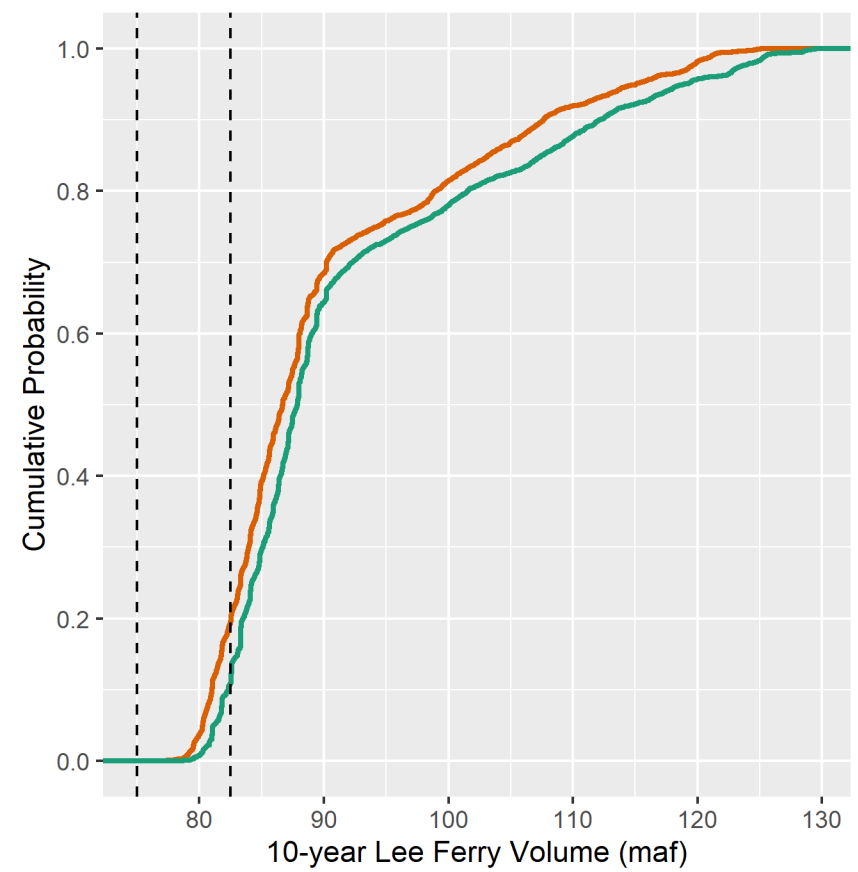


System Conditions – Lee Ferry 10-year Volume



Scenario: — 2007 UCRC — 2016 UCRC

CDF of Lee Ferry 10-year Volume
2021-2060

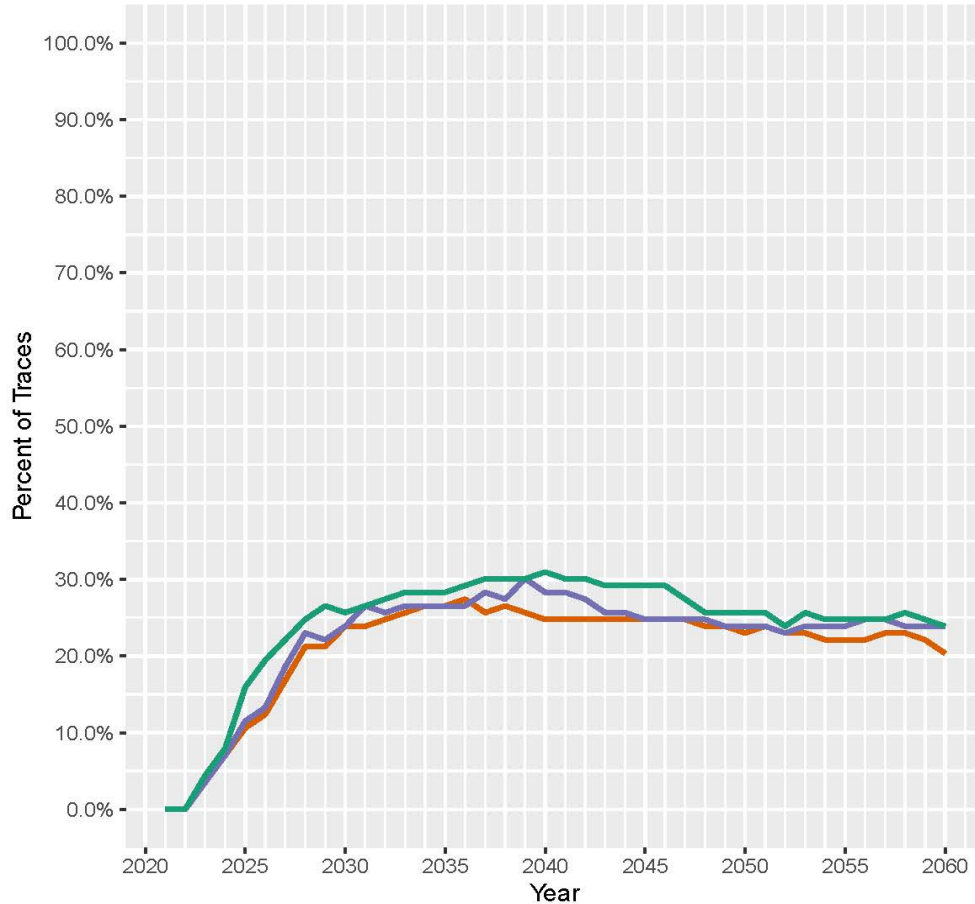


All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

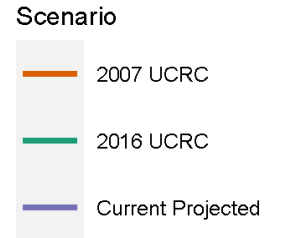
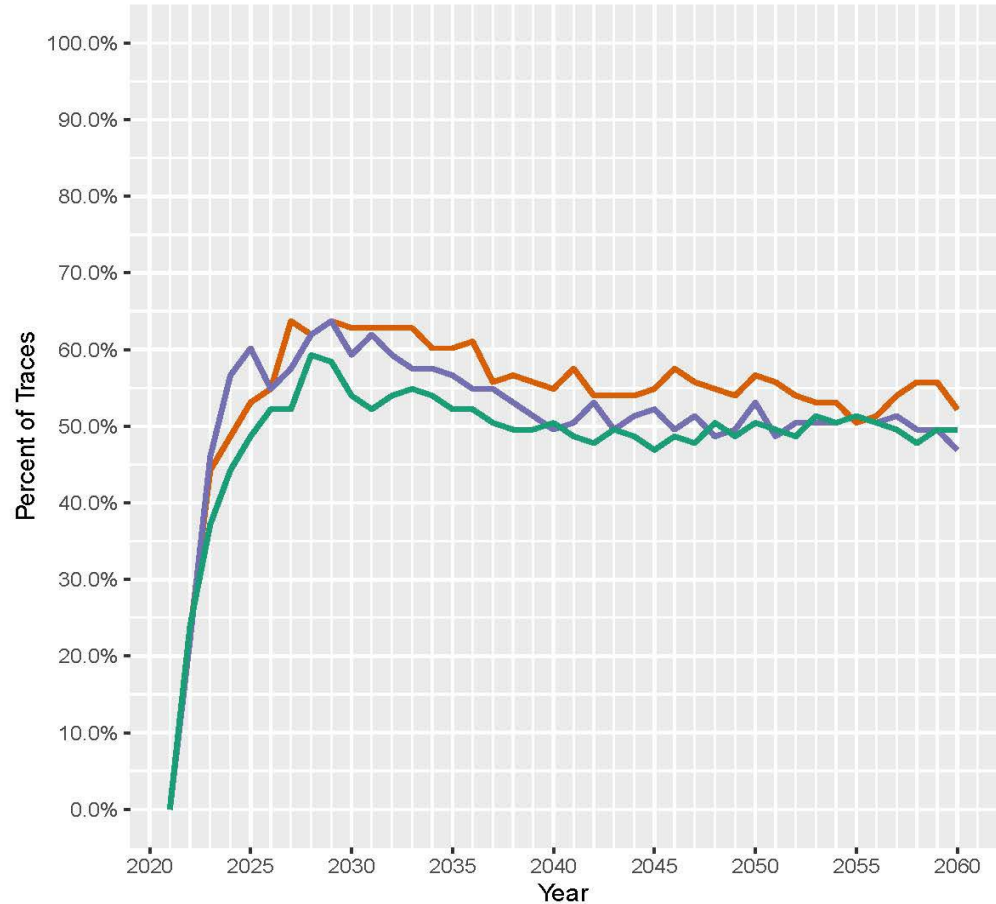


System Conditions – Lower Basin

Lower Basin: Percent of Traces in Surplus Conditions



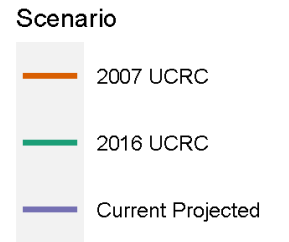
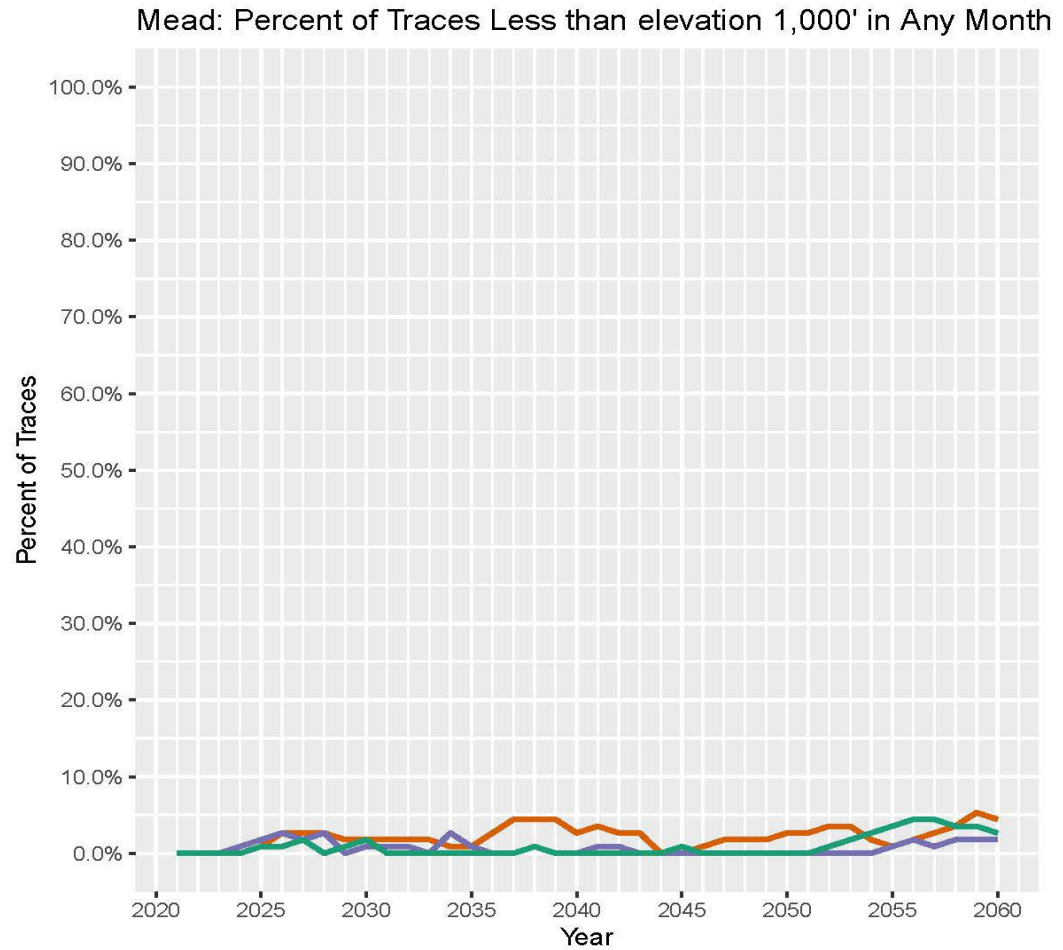
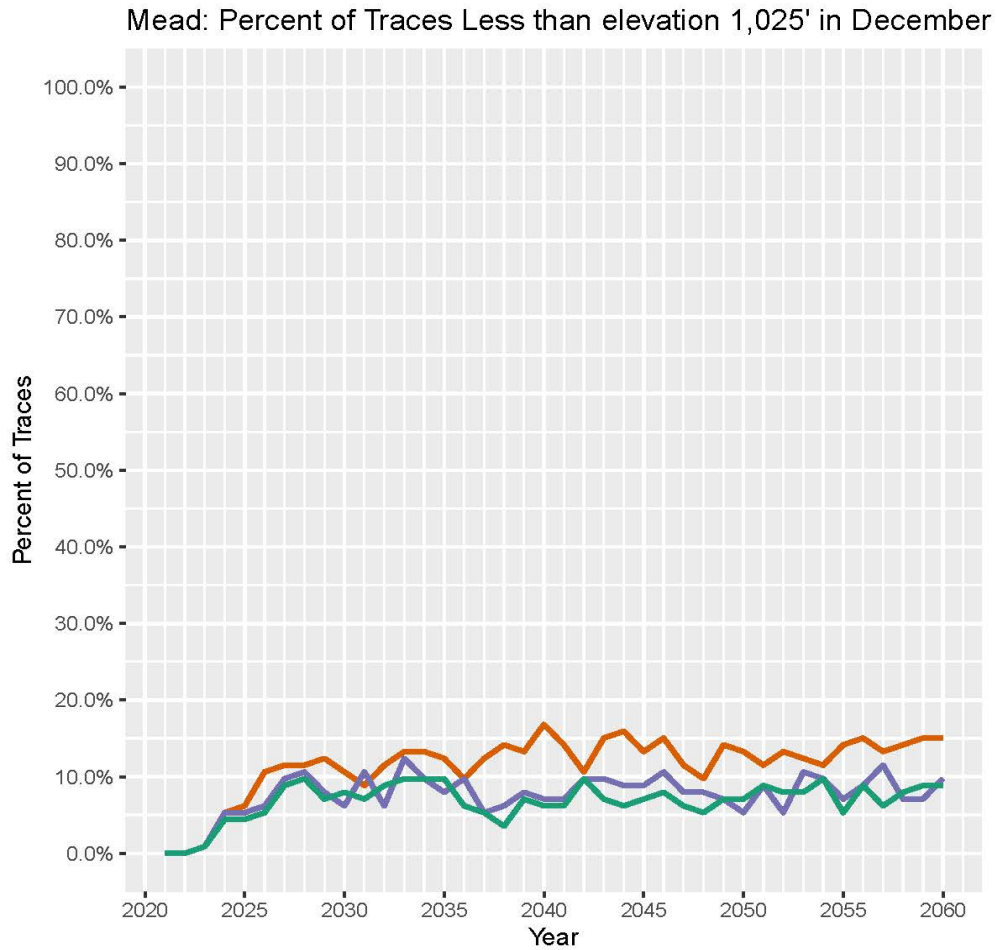
Lower Basin: Percent of Traces in Shortage Conditions



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).



System Conditions – Lake Mead



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

