BUREAU OF RECLAMATION

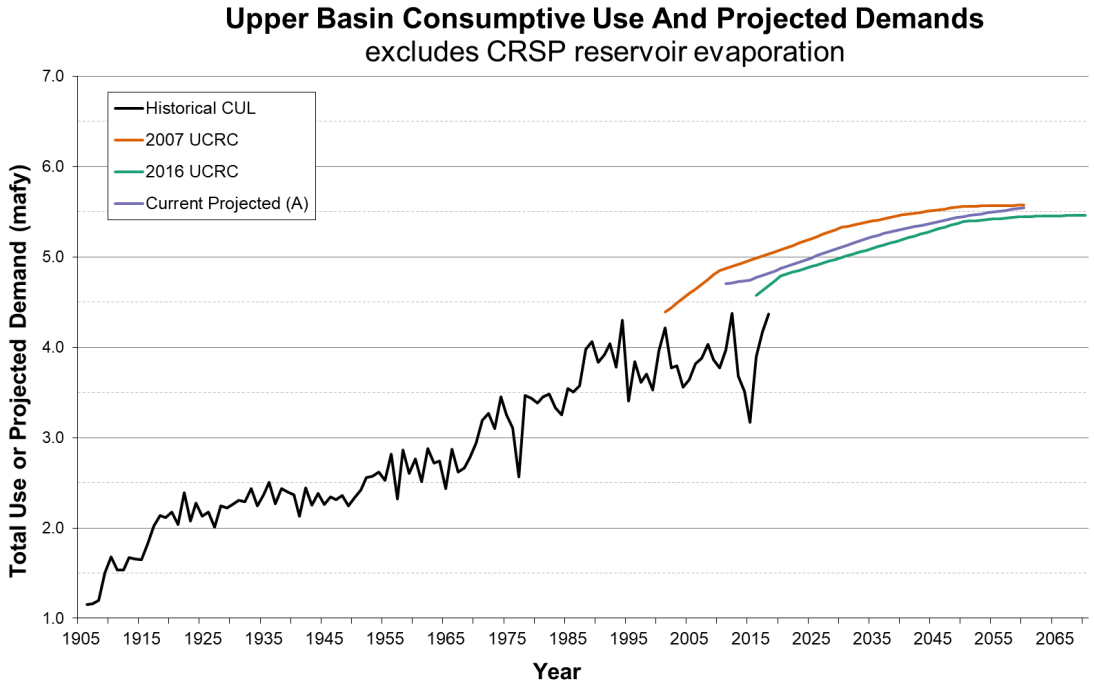
# January 2021 CRSS Updates

## February 16, 2021

### Stakeholder Modeling Work Group Webinar

# Presentation Outline

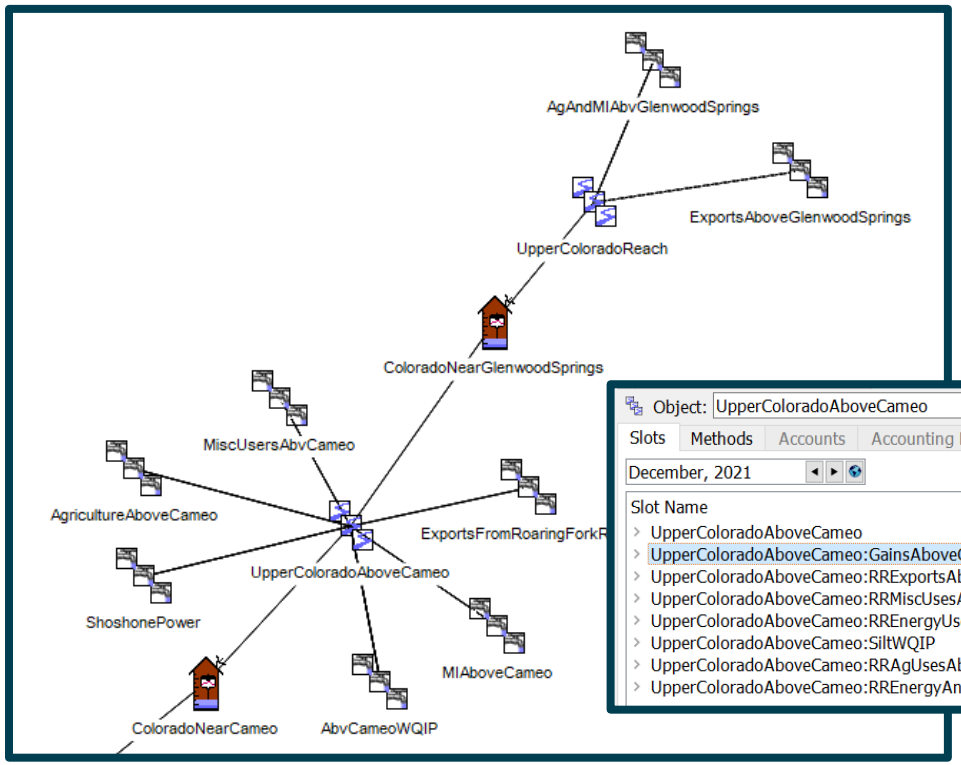
- Select CRSS changes
- Incorporating the 2016 Upper Colorado River Commission (UCRC) demand schedule
  - Process of incorporating UCRC schedule into CRSS
  - Demand projection differences
  - CRSS projections – Comparison of 2007 and 2016 UCRC demand schedules
- Next steps



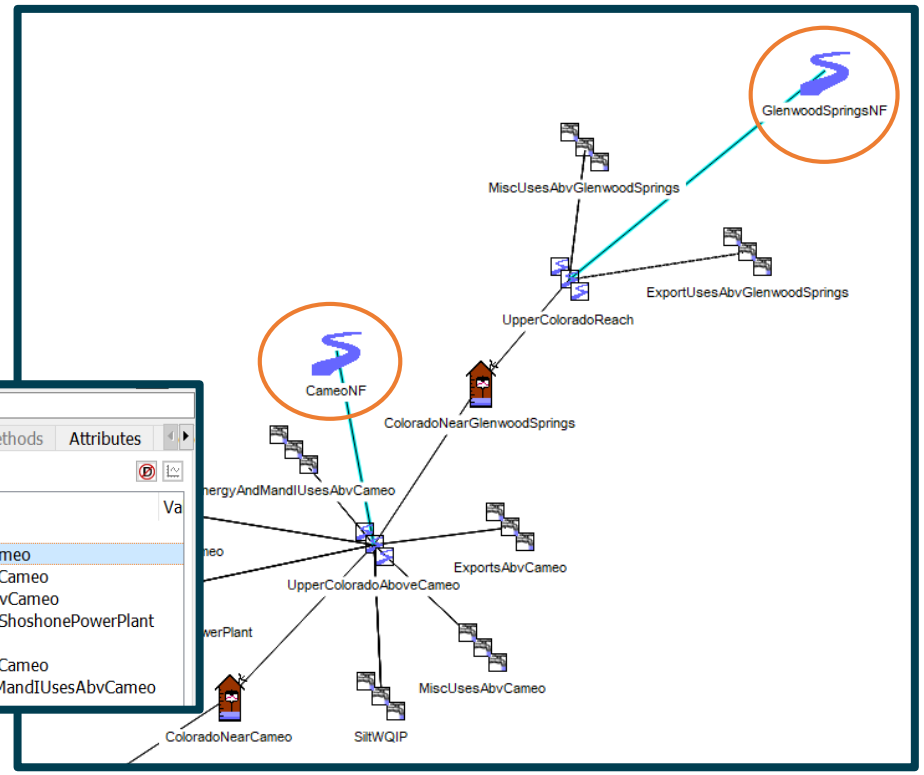
# Select CRSS Changes

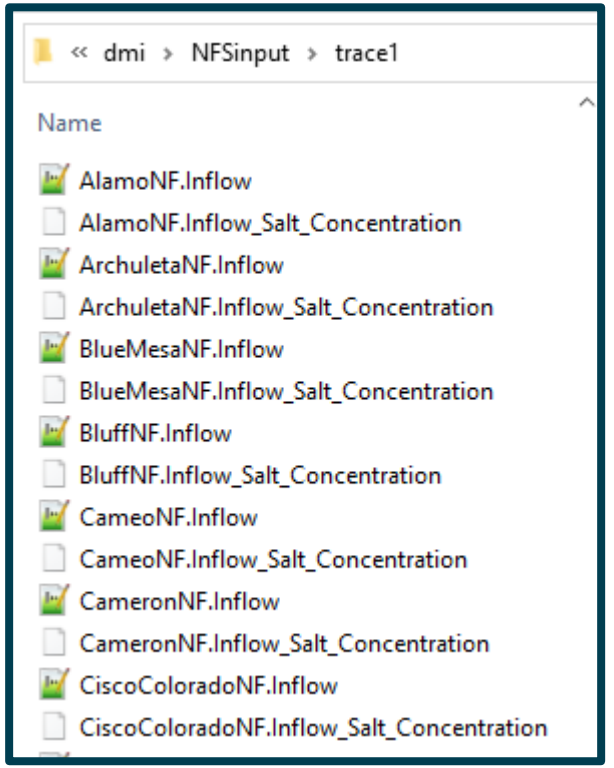
# Added Natural Inflow Objects

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

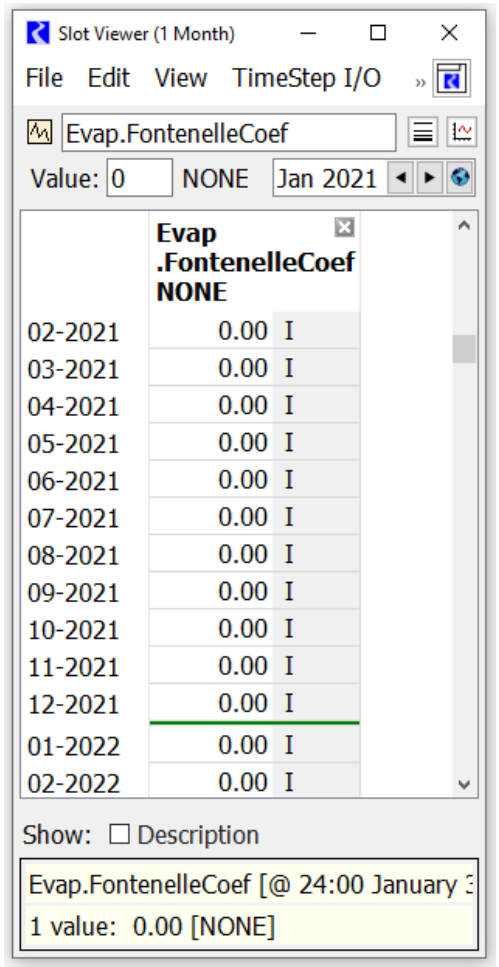
# Shortage Related Bug in Revert to 2007 FEIS No Action Alternative Ruleset

- "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

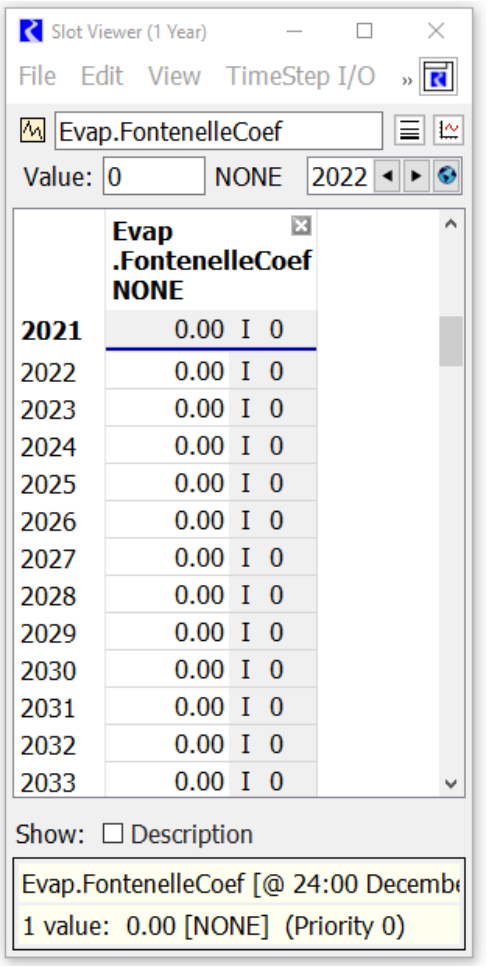
# Changed Evaporation Scaling Factors From Monthly Slots to Annual Slots

- 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

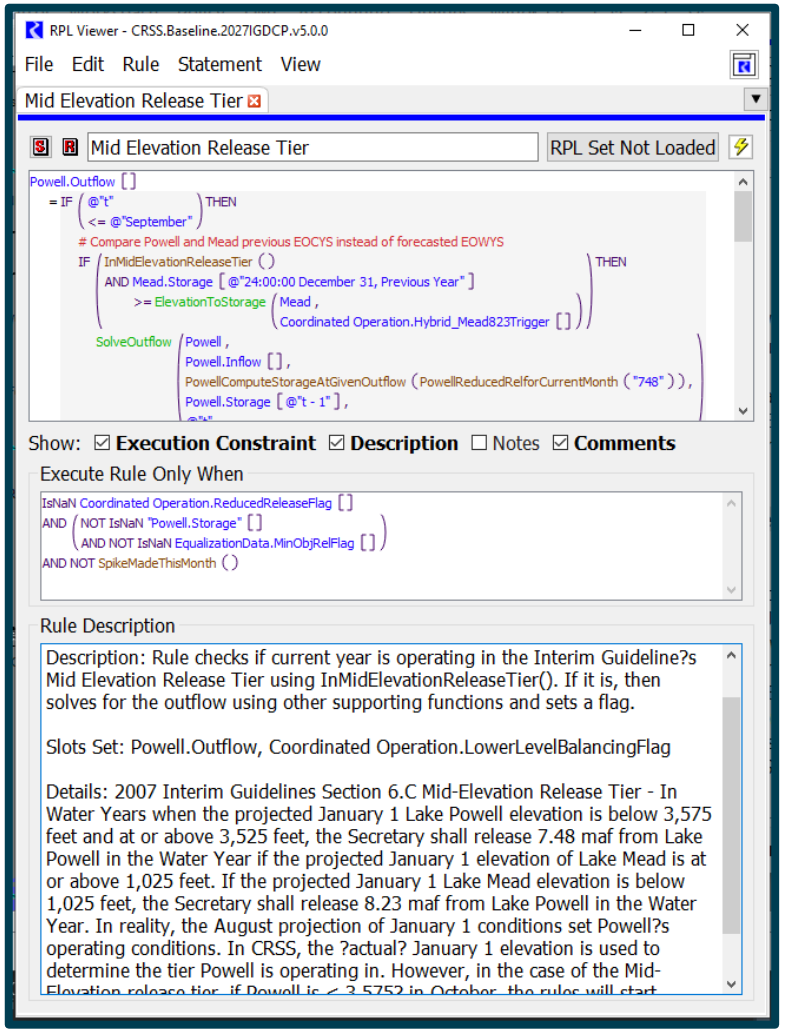



January 2021 CRSS



# Other Changes

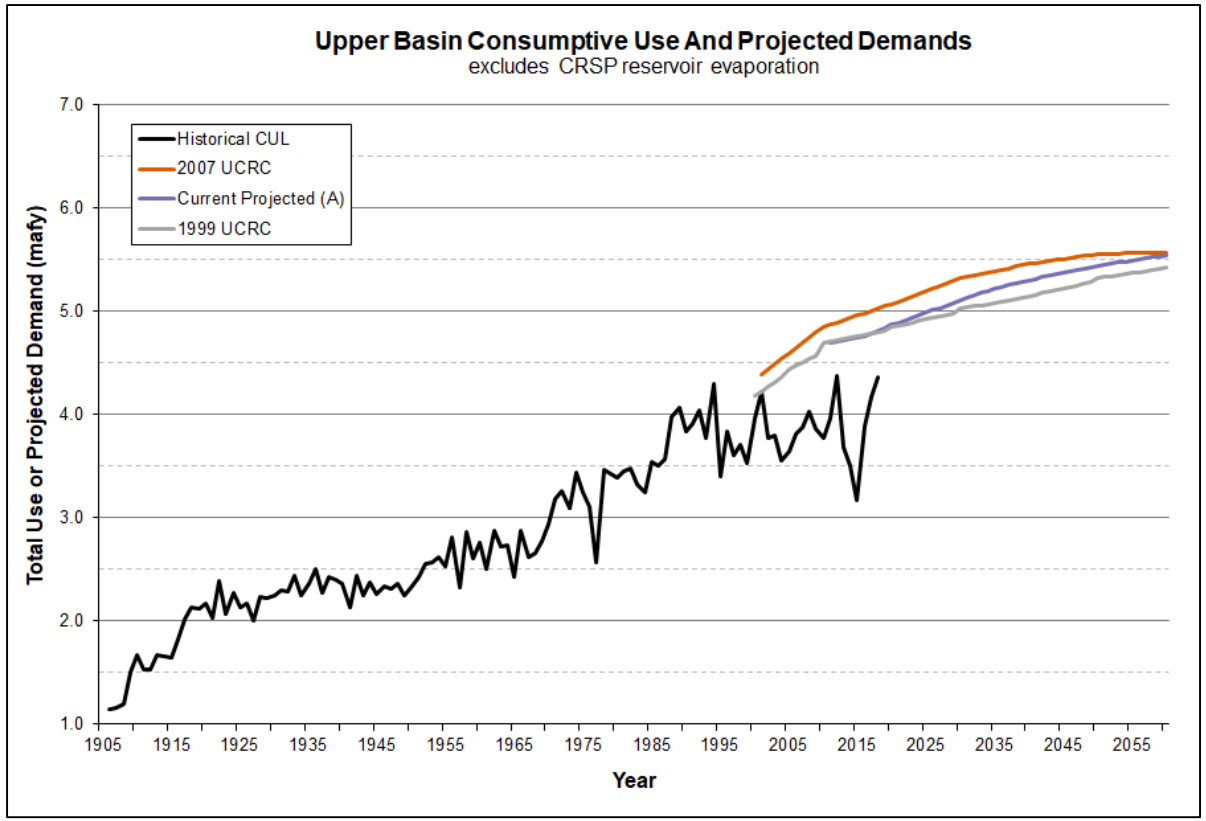
- All references to “VIC” were changed to “CMIP3”
  - DMIs
  - MRMs
  - Control files
  - RiverSMART file
- Added more documentation
  - Powell rules
  - Other UB rules
  - Mead flood control functions
- Other updates documented in CRSS.ModelingAssumptionsAndUpdates.Jan2021.v2.pdf



# 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 Schdule[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 |
| *Potential Agriculture-Irrigation & Stock* | | *0* | *5* | *5* | *10* | *10* | *0* |
| **Municipal/Industrial** | 124 | 149 | 168 | 183 | 200 | 209 | 217 |
| *Potential Municipal/Industrial* | | *3* | *6* | *14* | *18* | *21* | *16* |
| **Self-Served Industrial** | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| *Potential Self-Served Industrial* | | *0* | *0* | *0* | *0* | *0* | *0* |
| **Energy** | 152 | 157 | 167 | 178 | 193 | 198 | 203 |
| *Potential Energy* | | *5* | *10* | *10* | *15* | *10* | *0* |
| **Minerals** | 53 | 57 | 65 | 73 | 81 | 94 | 103 |
| *Potential Minerals* | | *2* | *8* | *17* | *26* | *31* | *33* |
| **Export** | 1,019 | 1,050 | 1,123 | 1,179 | 1,258 | 1,310 | 1,423 |
| *Potential Export* | | *50* | *75* | *100* | *125* | *100* | *0* |
| **Ute Indian Settlement[3]** | 0 | 25 | 65 | 112 | 146 | 146 | 146 |
| **Reservoir Evaporation (in-state)** | 208 | 208 | 208 | 208 | 208 | 208 | 208 |
| *Potential Reservoir Evaporation* | | *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)*

[1]This 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.

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

[3]The 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] Wyoming[3]

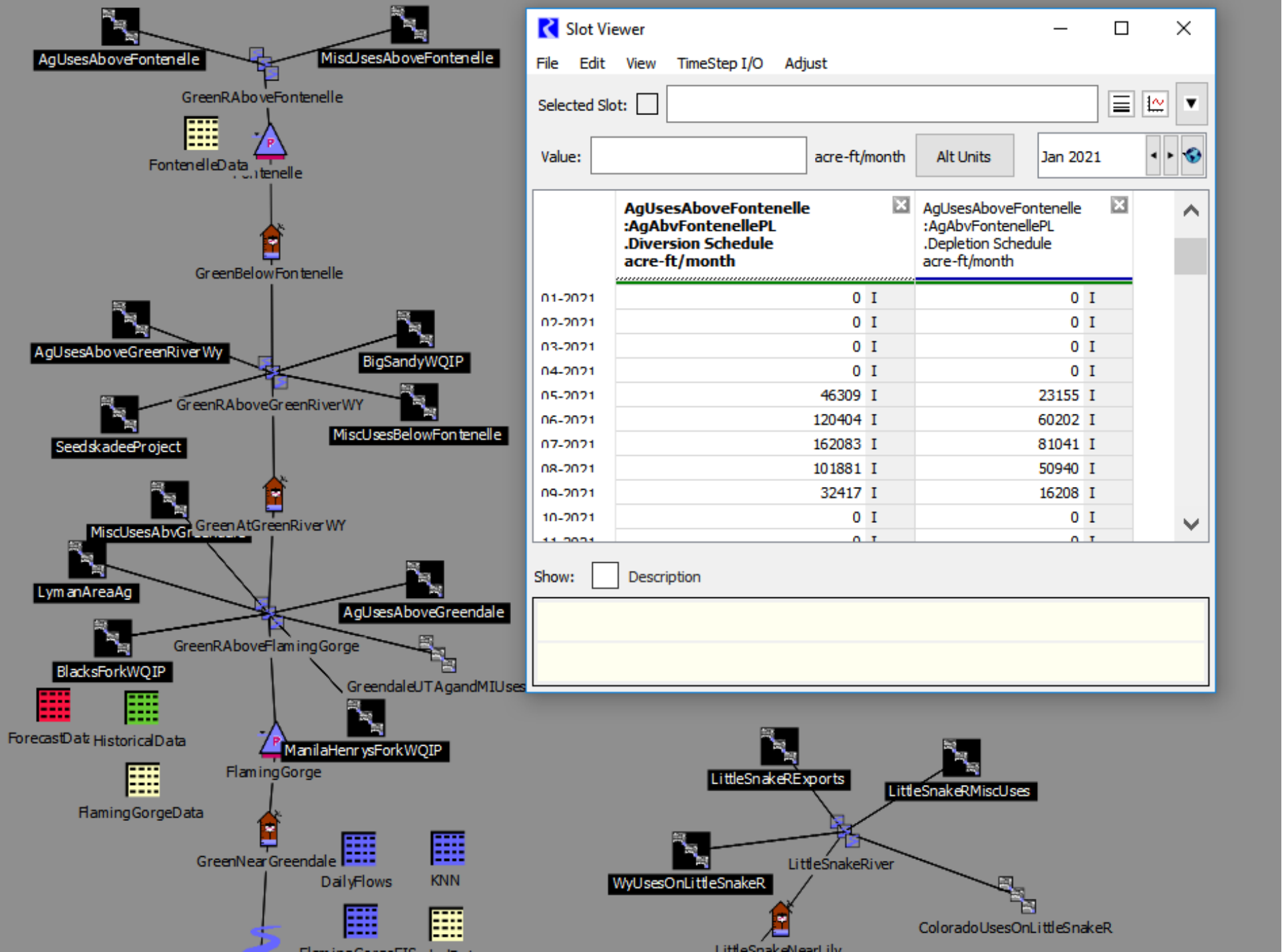
| ITEM | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | Current/Historical | 2020 | 2030 | 2040 | 2050 | 2060 | 2070 |
| **Agriculture – Irrigation & Stock** | 444 | 445 | 447 | 449 | 451 | 453 | 455 |
| *Potential Agriculture-Irrigation & Stock* | | *0* | *0* | *0* | *0* | *0* | *0* |
| **Municipal/Industrial**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

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

[1]This 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.

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

[3]Wyoming'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.

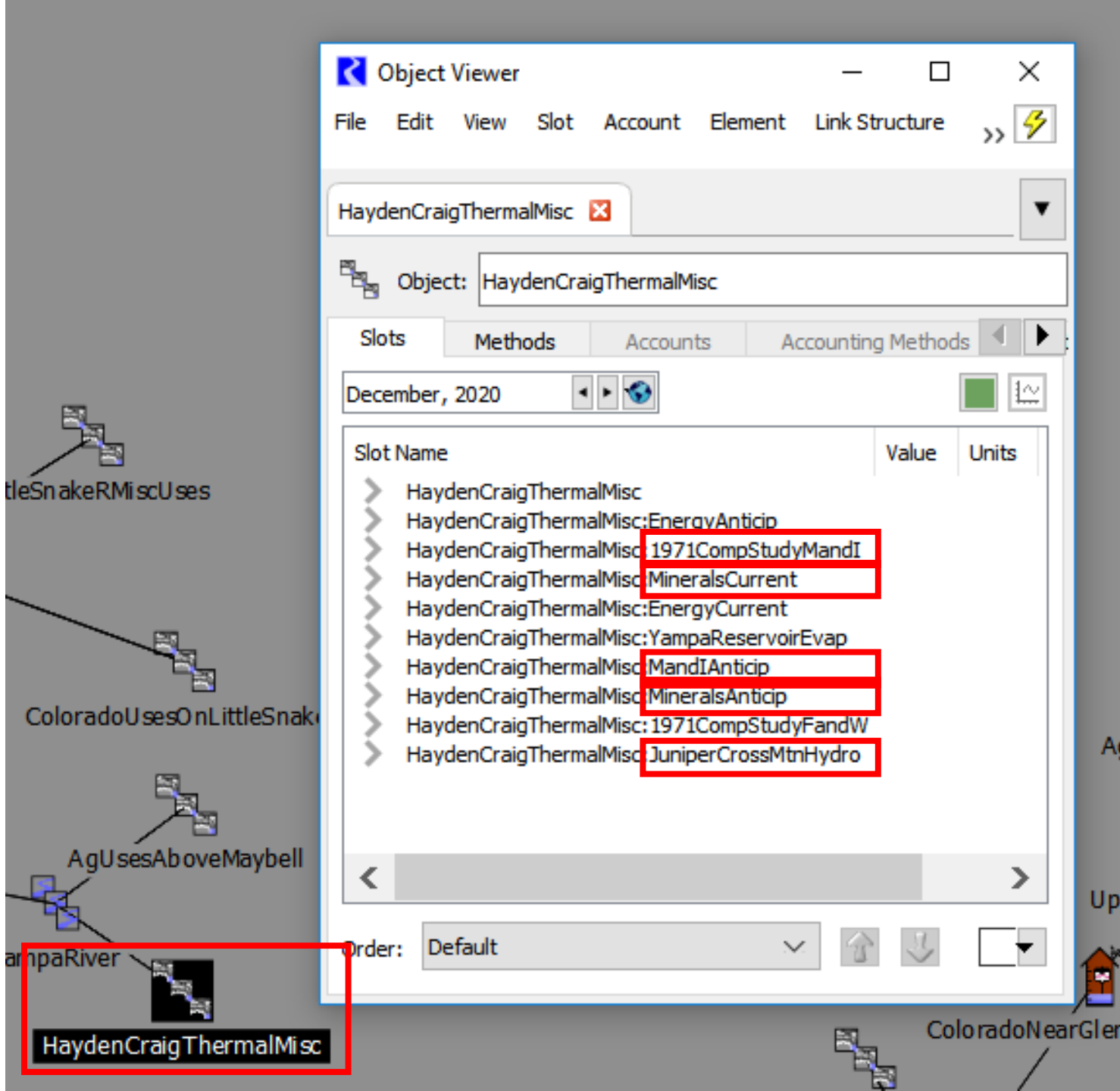



## Modeling Wyoming's water use in CRSS:

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

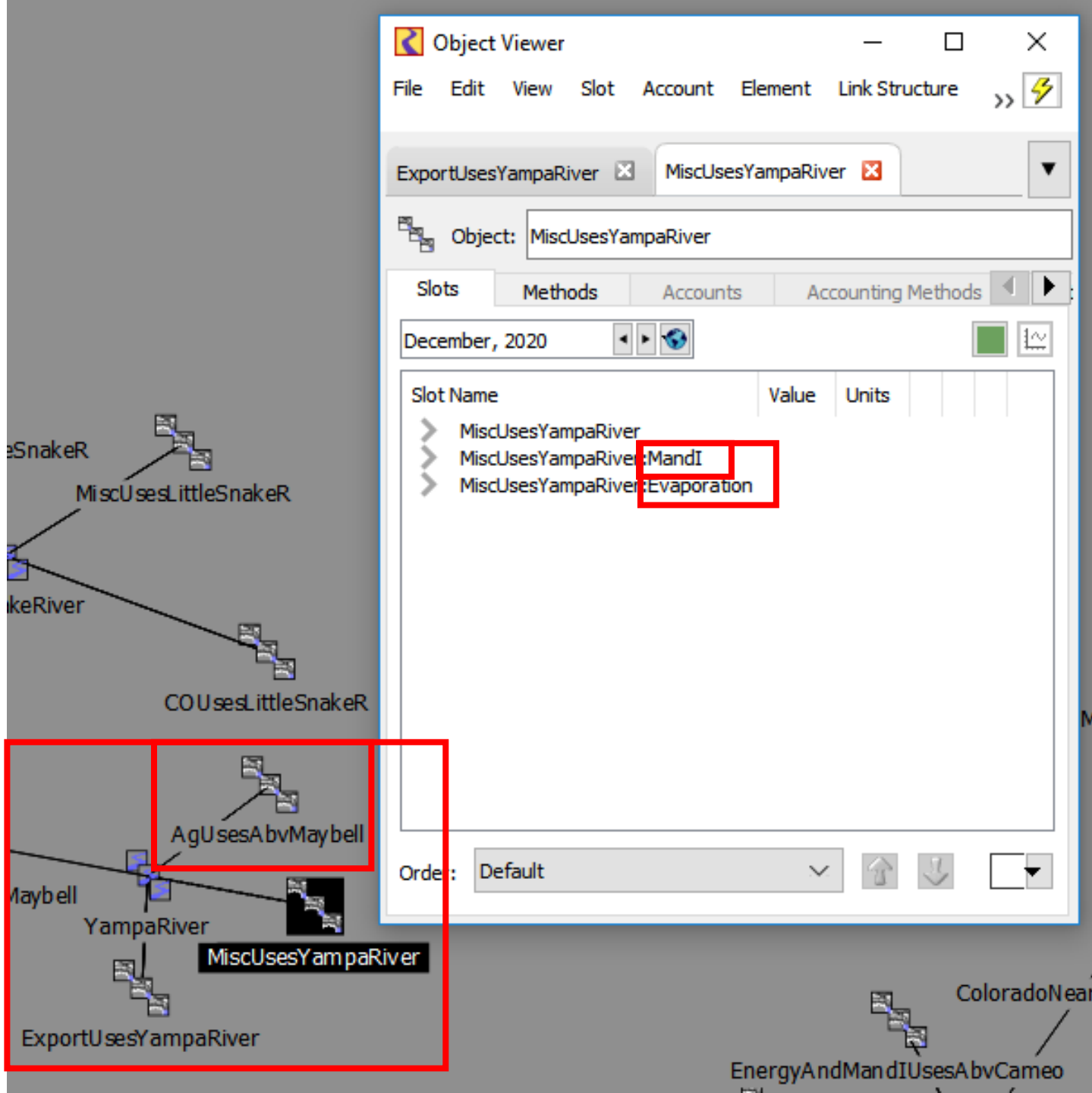
# Old Layout

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



# New Layout

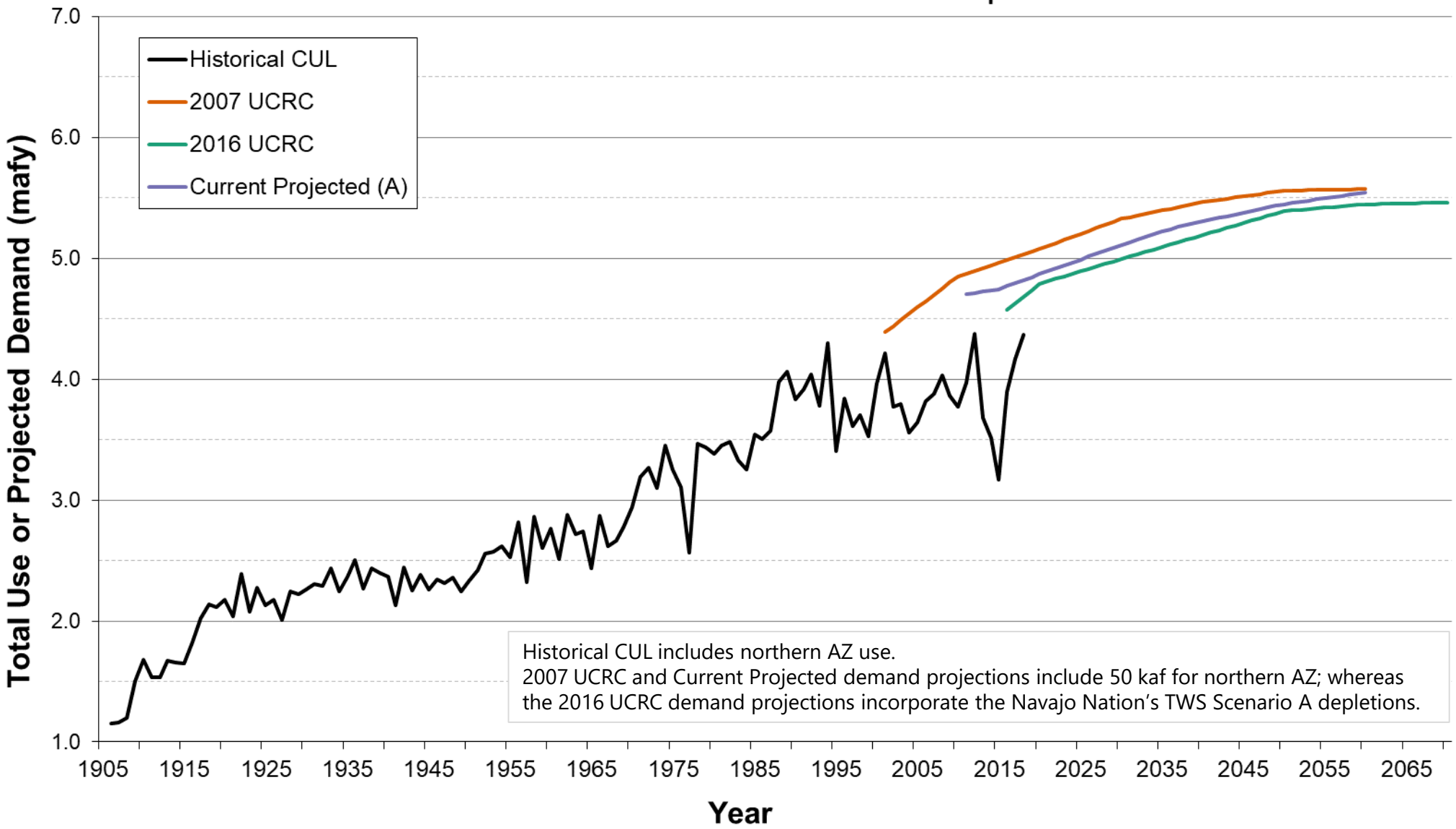
- Sector-based names
- No online depletion classes
- One water user per water use sector
- Layout allows for better salinity modeling



# Demand Projection Differences

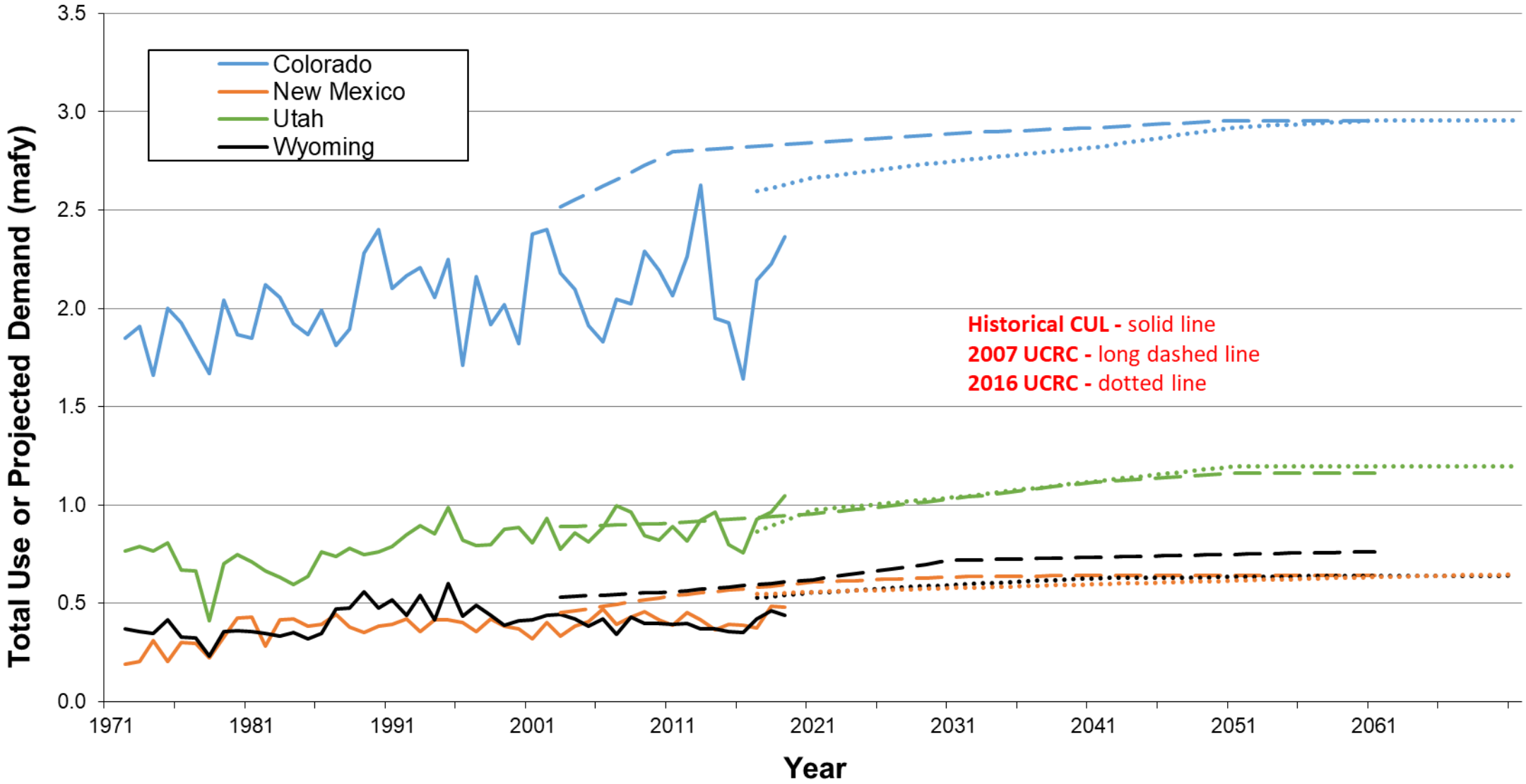
# Upper Basin Consumptive Use And Projected Demands

excludes CRSP reservoir evaporation



# Upper Basin States Consumptive Use And Projected Demands

excludes CRSP reservoir evaporation



# Monthly Distribution Coefficients

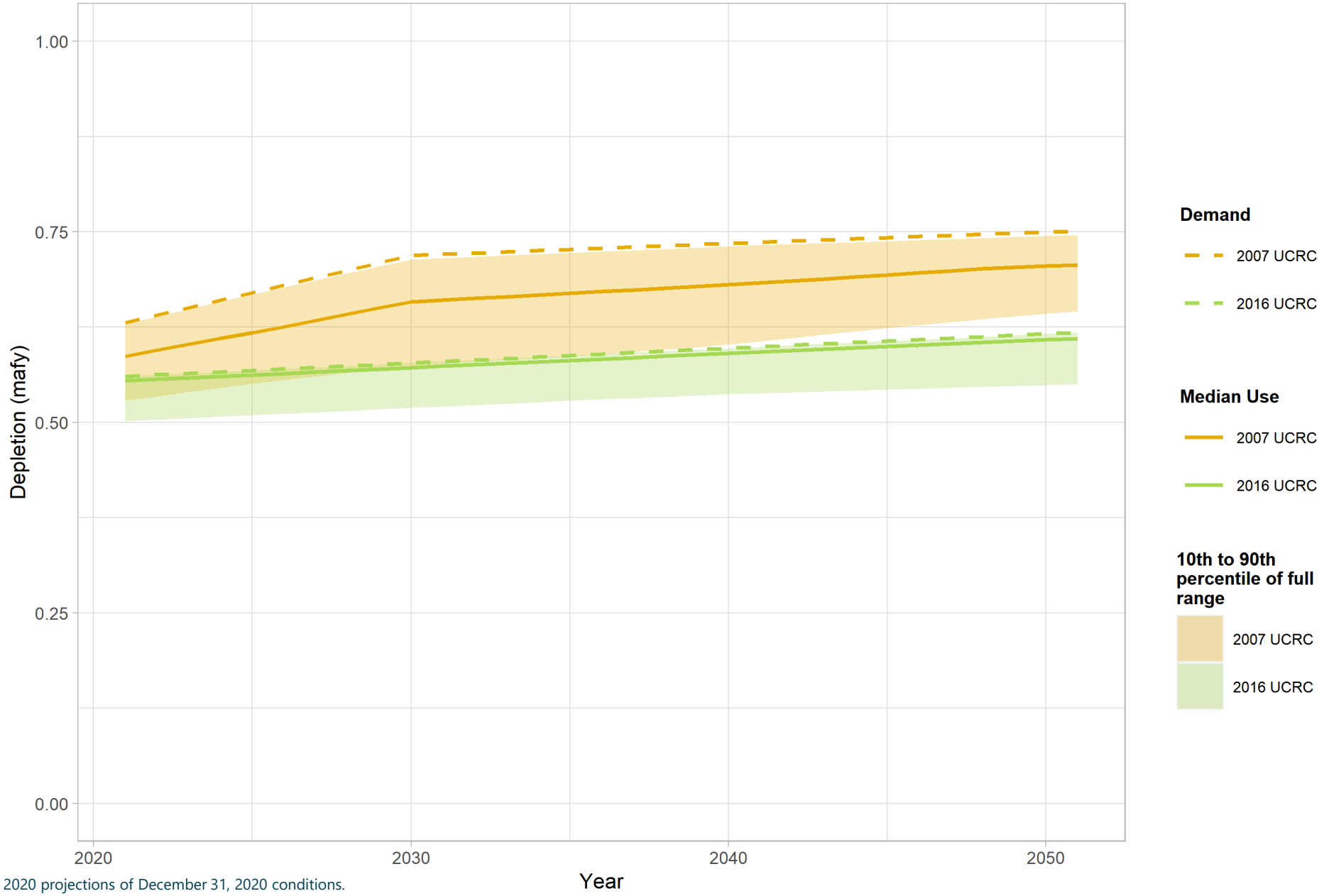
- Monthly distribution coefficients are used to disaggregate from annual to monthly demands
- Coefficients vary by sector and sub-basin
- Monthly distribution of demands can affect modeled use and shortages
- Monthly distributions coefficients are being reviewed by the states and modifications are expected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

# CRSS Projections – Comparison of 2007 and 2016 UCRC Demand Schedules

# Modeling Assumptions

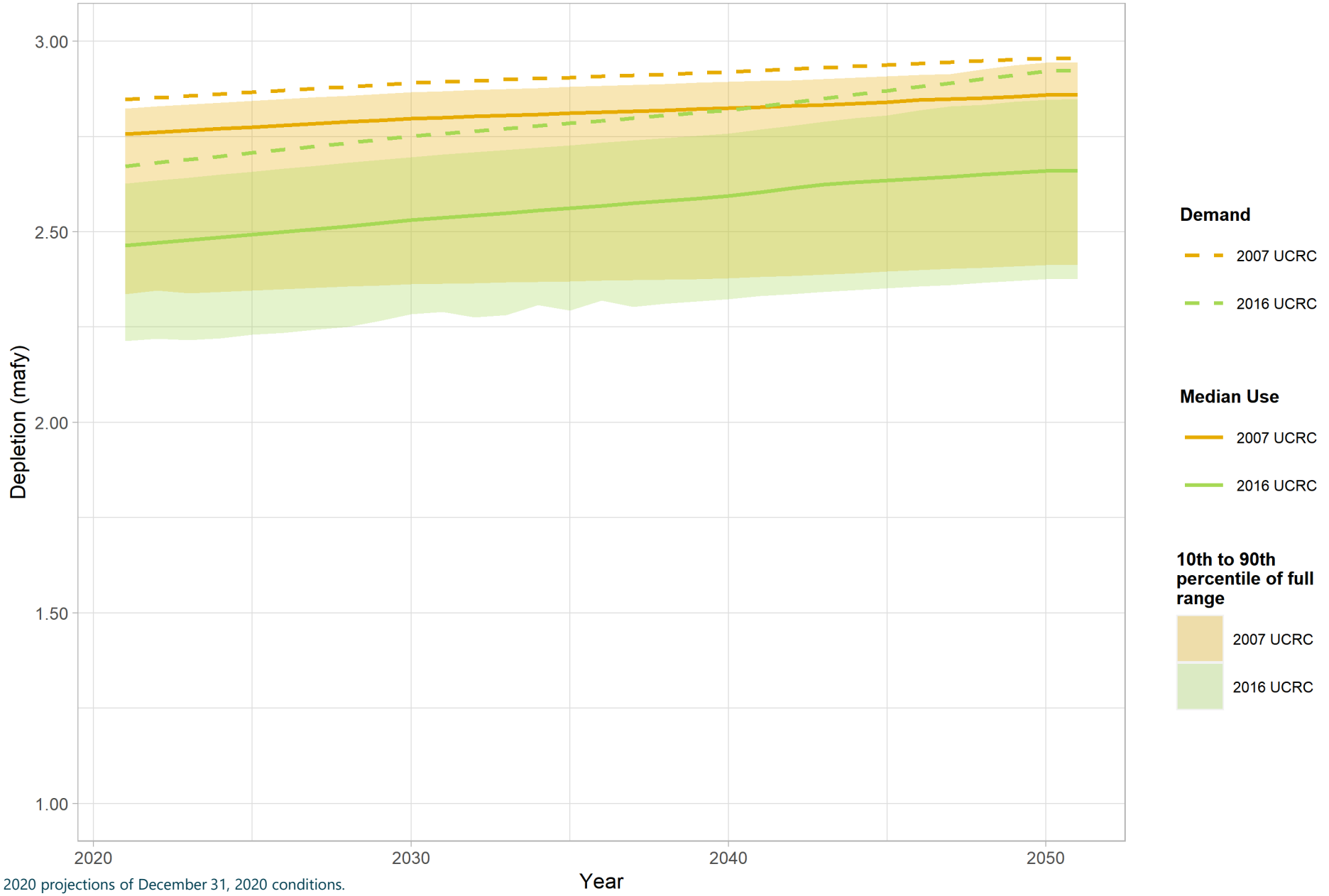
- CRSS is initialized with end-of-December 2020 reservoir conditions, 2021 Lake Powell operating tier, and 2021 Lake Mead operating condition from the August 2020 24-Month Study projection based on the Colorado Basin River Forecast Center's most probable inflow sequence
- Comparisons are made using the "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



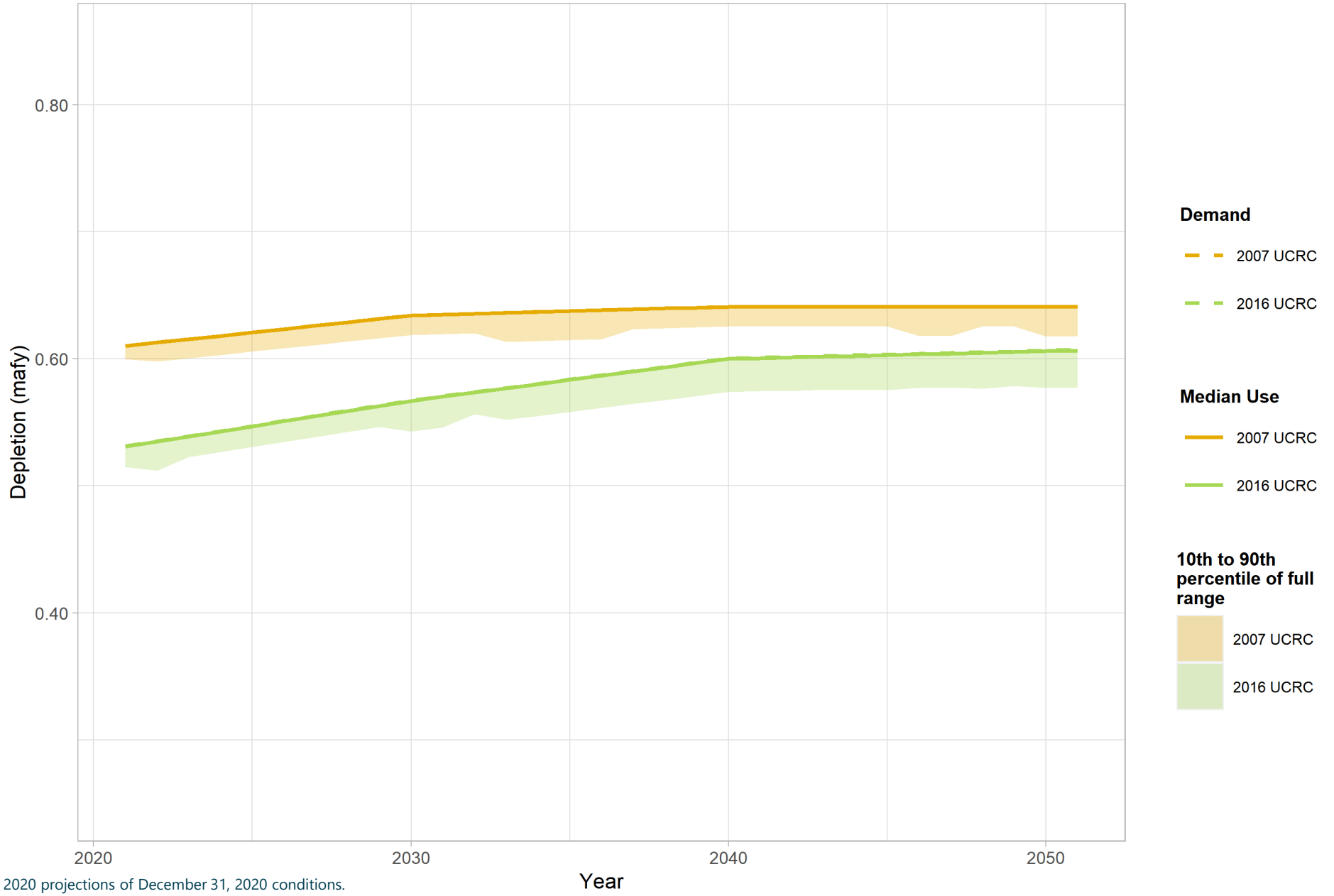

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

# Modeled Annual Consumptive Use - Colorado



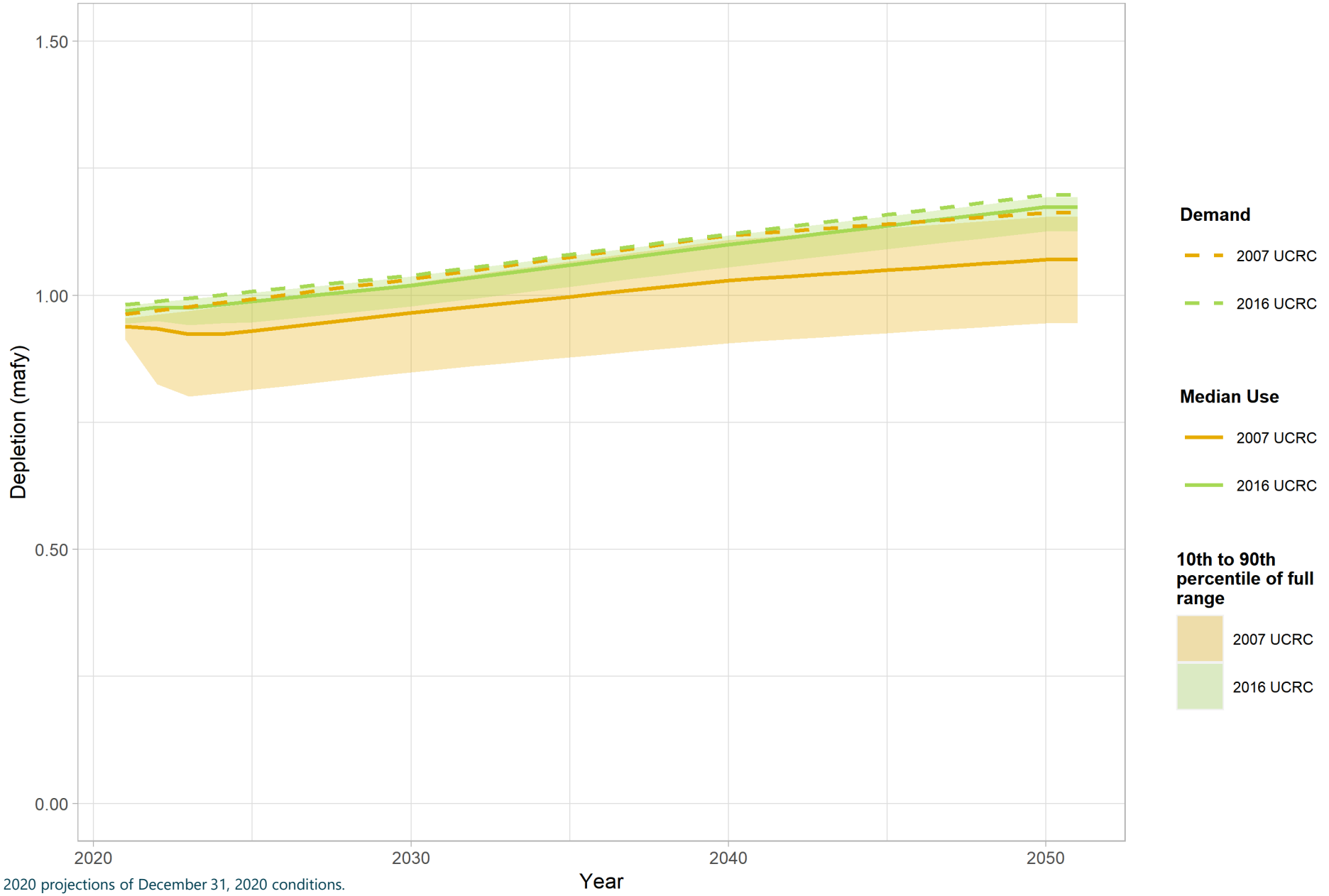

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

# Modeled Annual Consumptive Use – New Mexico



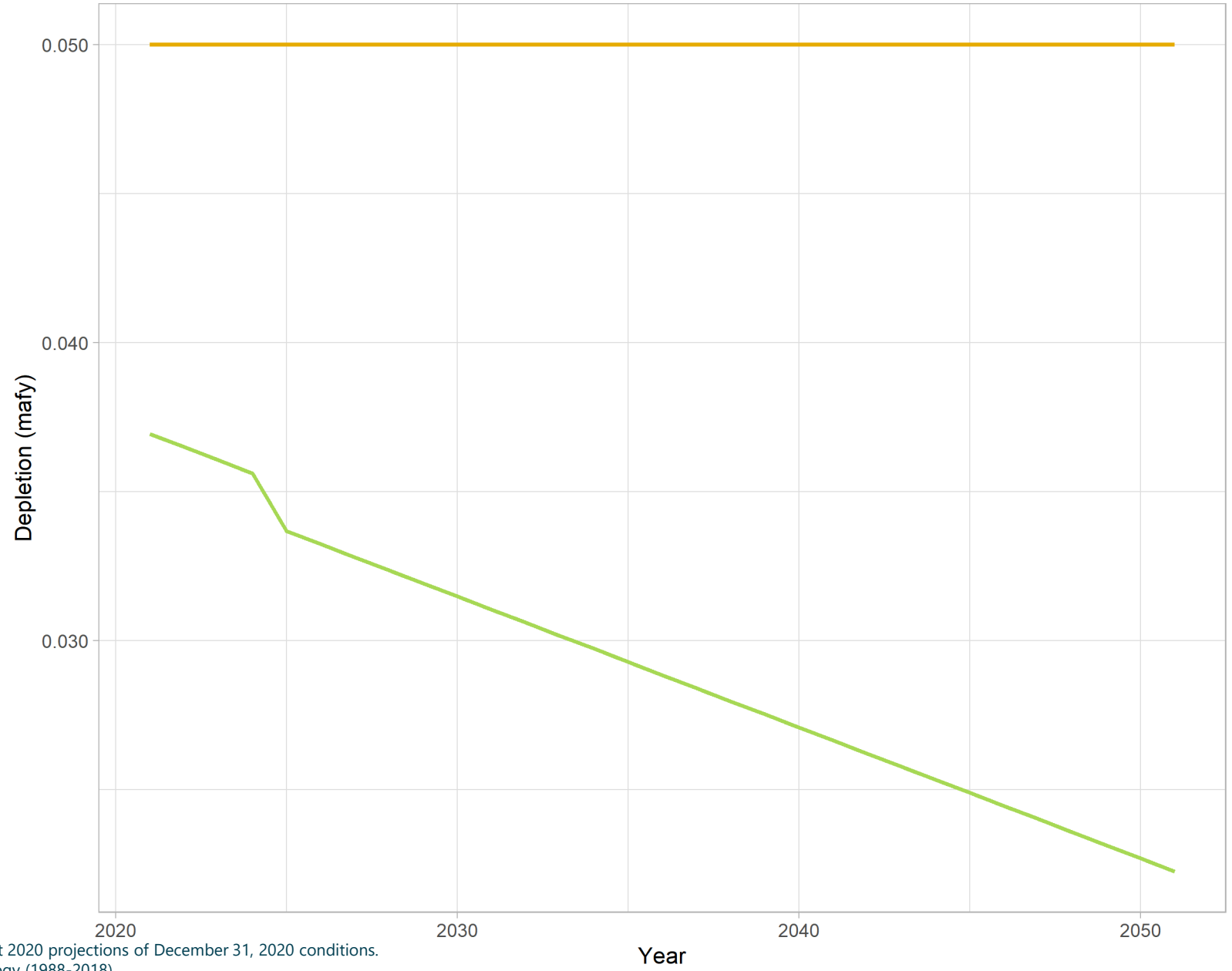

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

# 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




**Demand**

- 2007 UCRC
- 2016 UCRC

**Median Use**

- 2007 UCRC
- 2016 UCRC

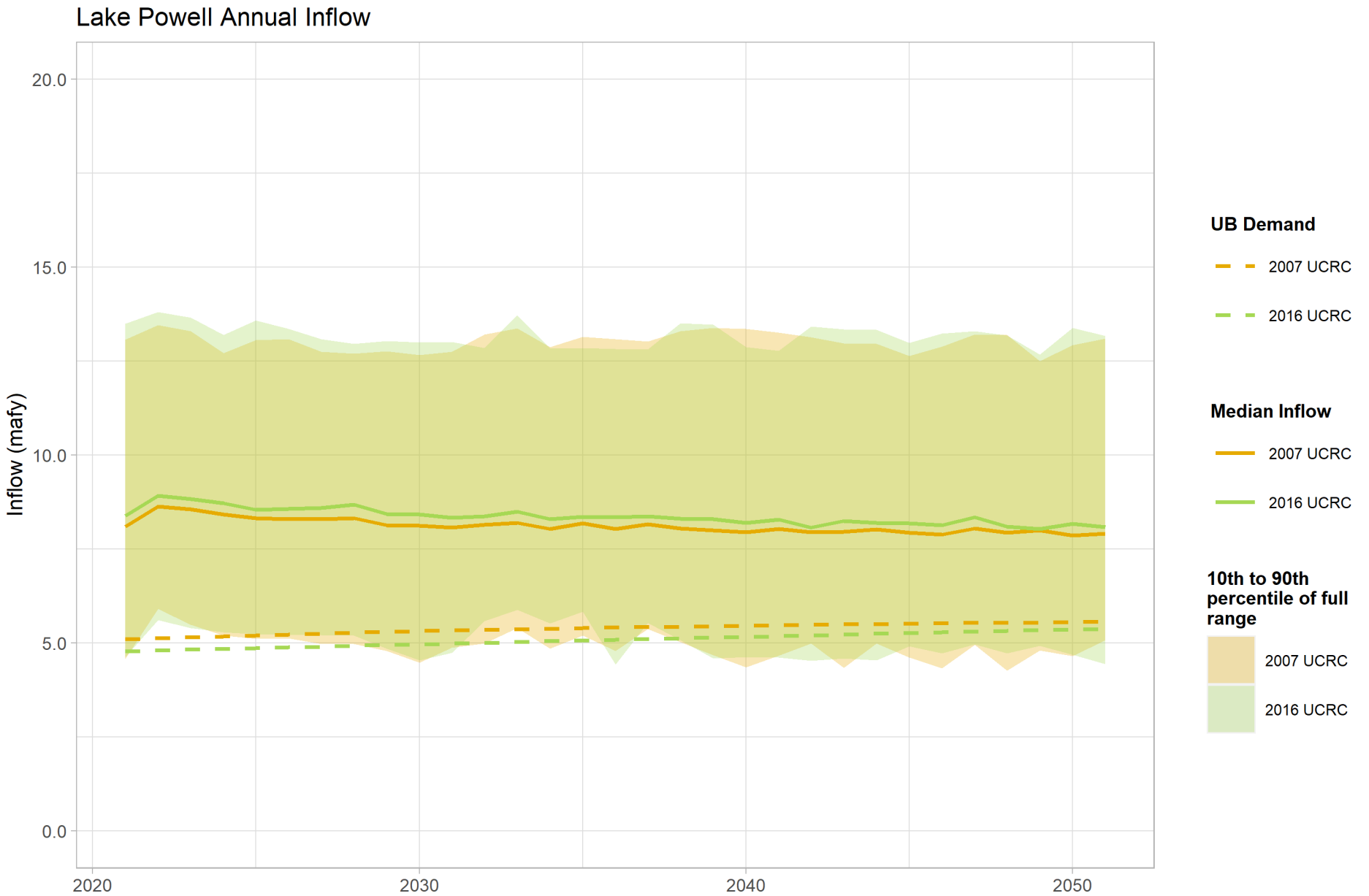
**10th to 90th percentile of full range**

- 2007 UCRC
- 2016 UCRC

Demand, median, 10th, and 90th percentile use are all the same.

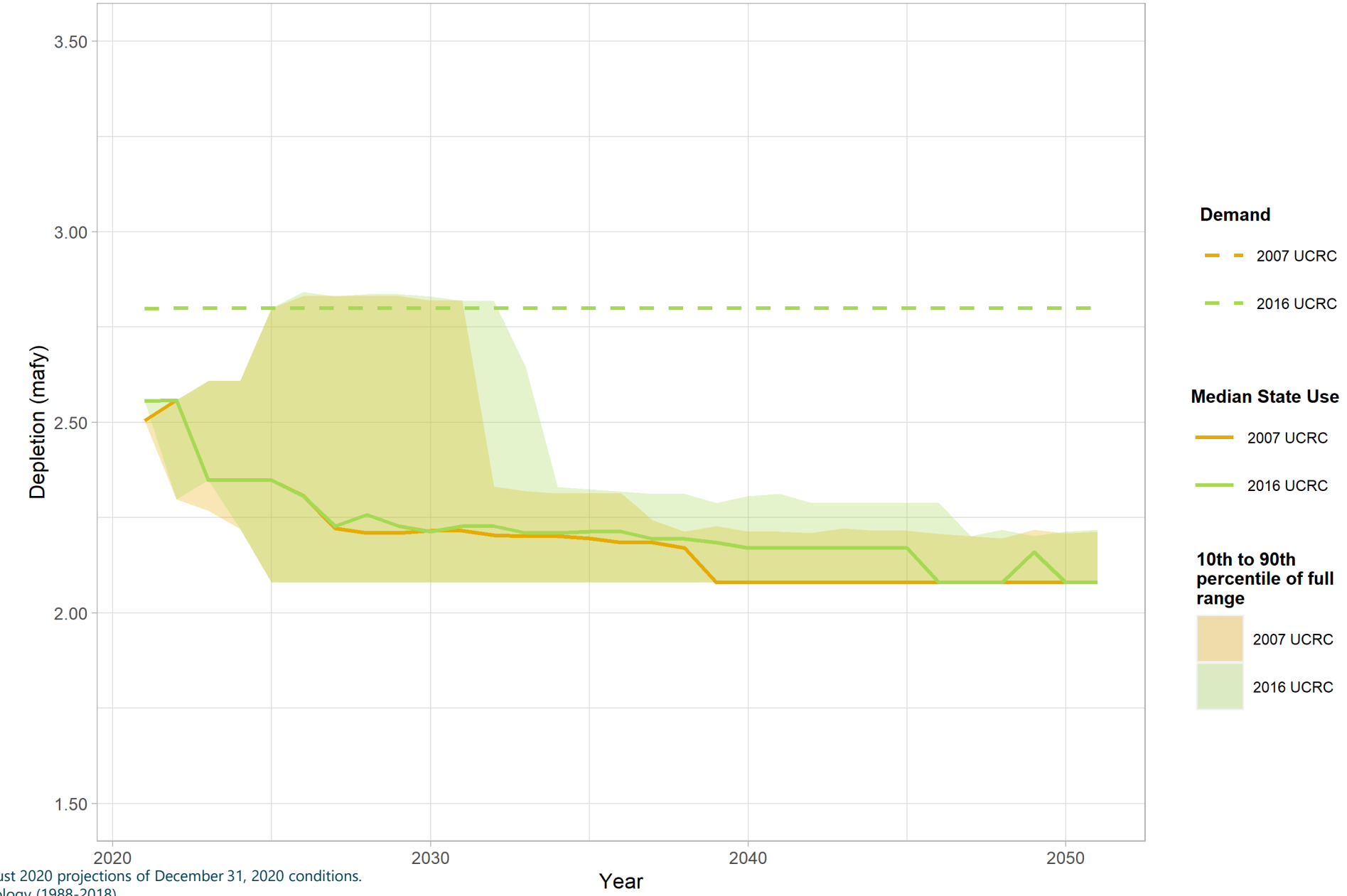
All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

# Lake Powell Annual Inflow



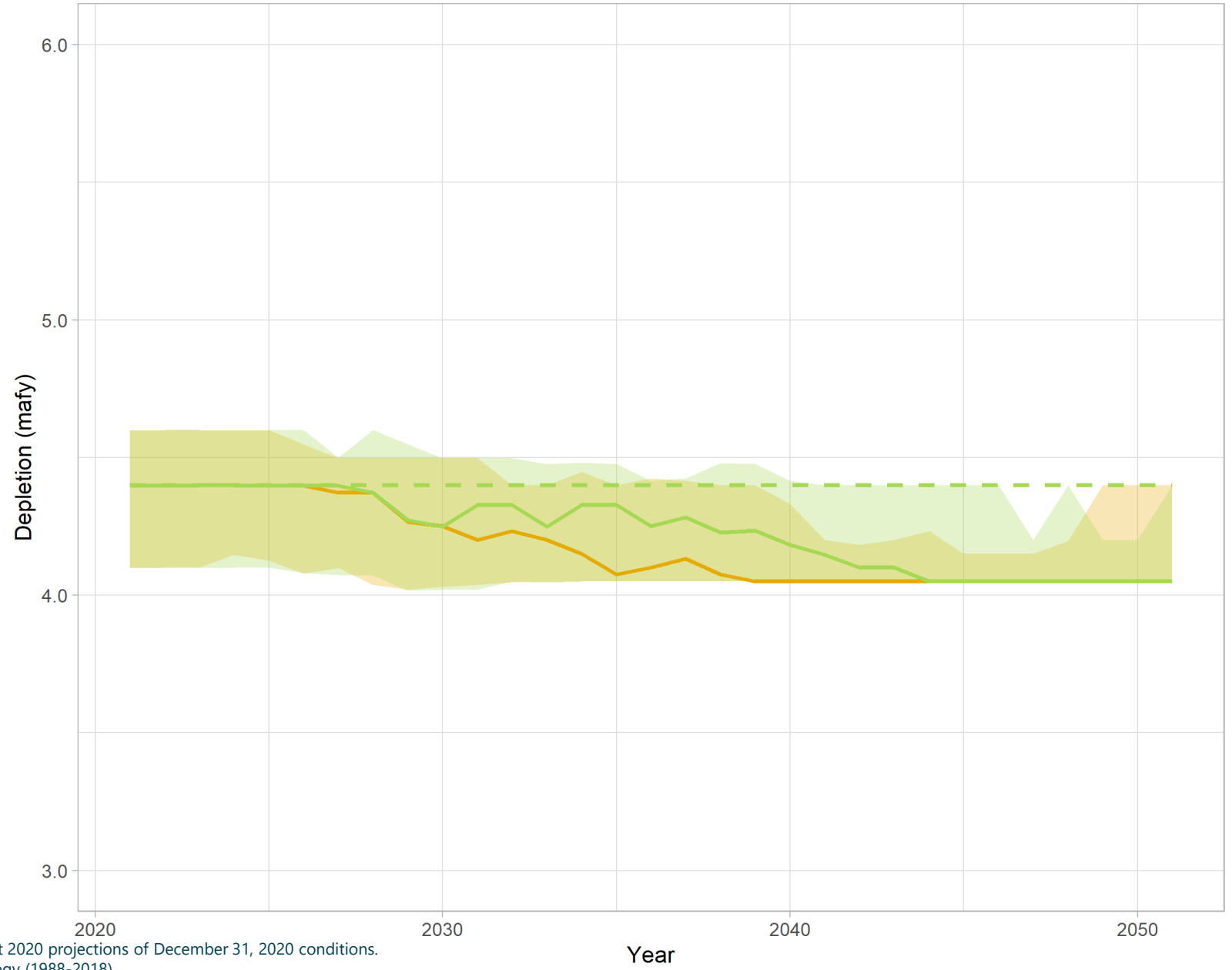

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

# 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




**Demand**

- 2007 UCRC
- 2016 UCRC

**Median State Use**

- 2007 UCRC
- 2016 UCRC

**10th to 90th percentile of full range**

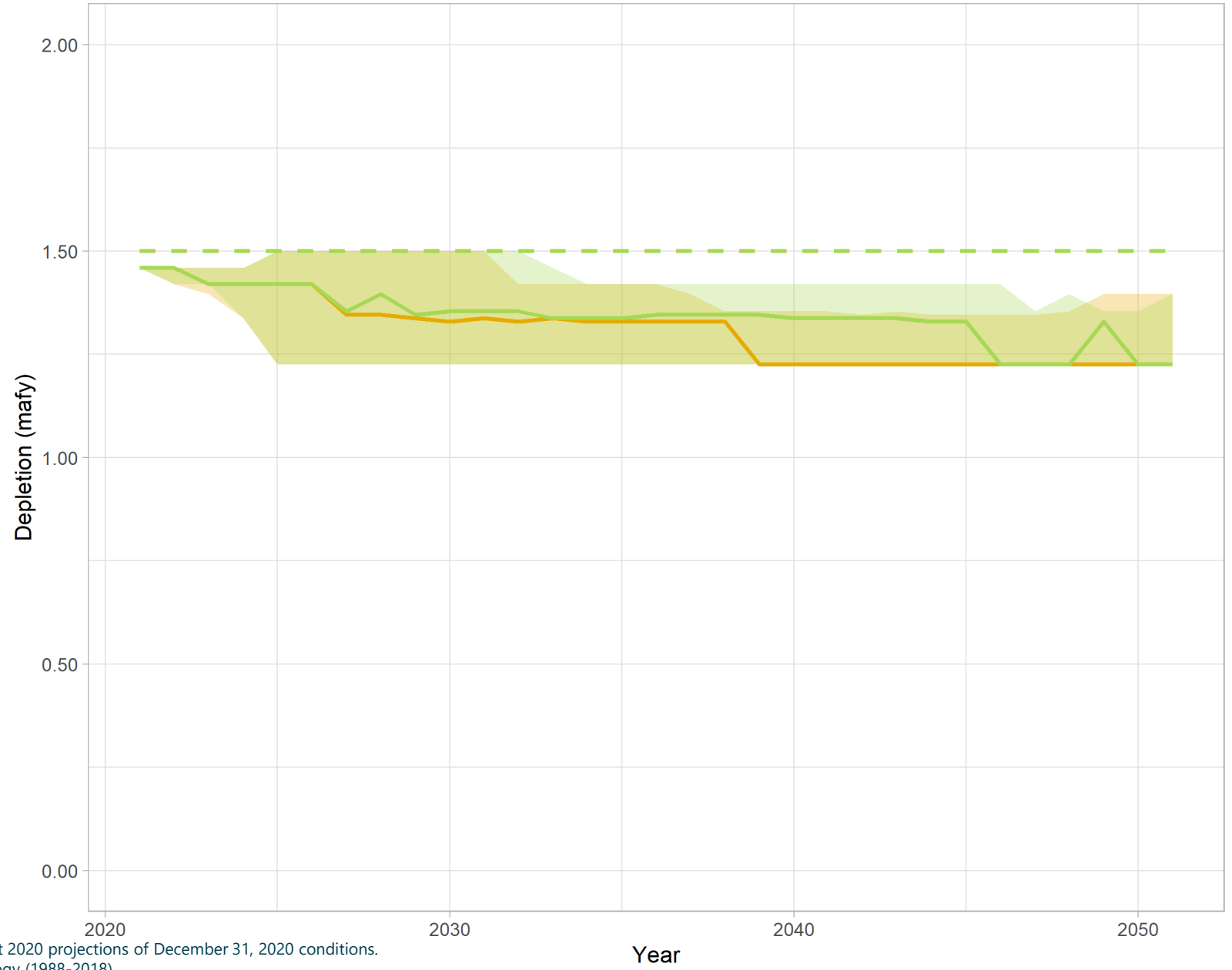
- 2007 UCRC
- 2016 UCRC

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

# Modeled Annual Consumptive Use - Nevada


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

# Modeled Annual Consumptive Use - Mexico




**Demand**

- 2007 UCRC
- 2016 UCRC

**Median Use**

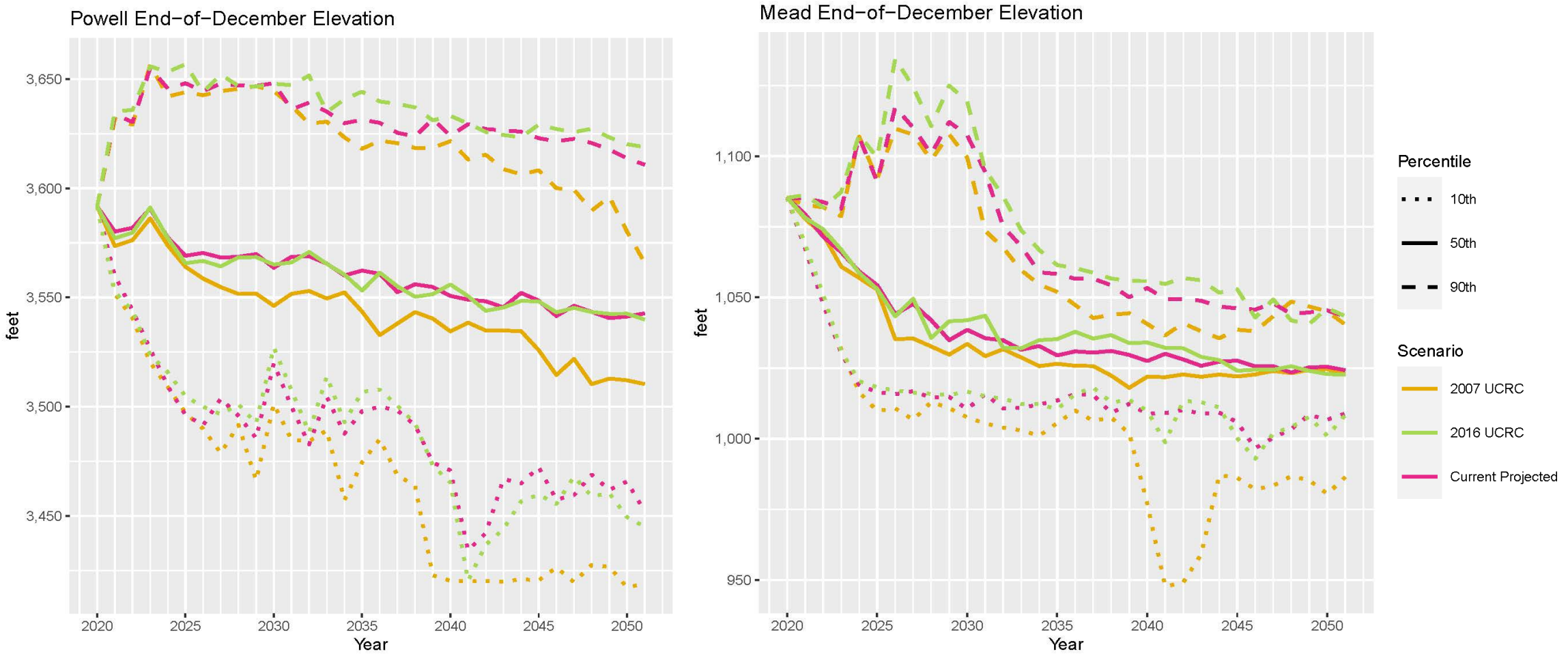
- 2007 UCRC
- 2016 UCRC

**10th to 90th percentile of full range**

- 2007 UCRC
- 2016 UCRC

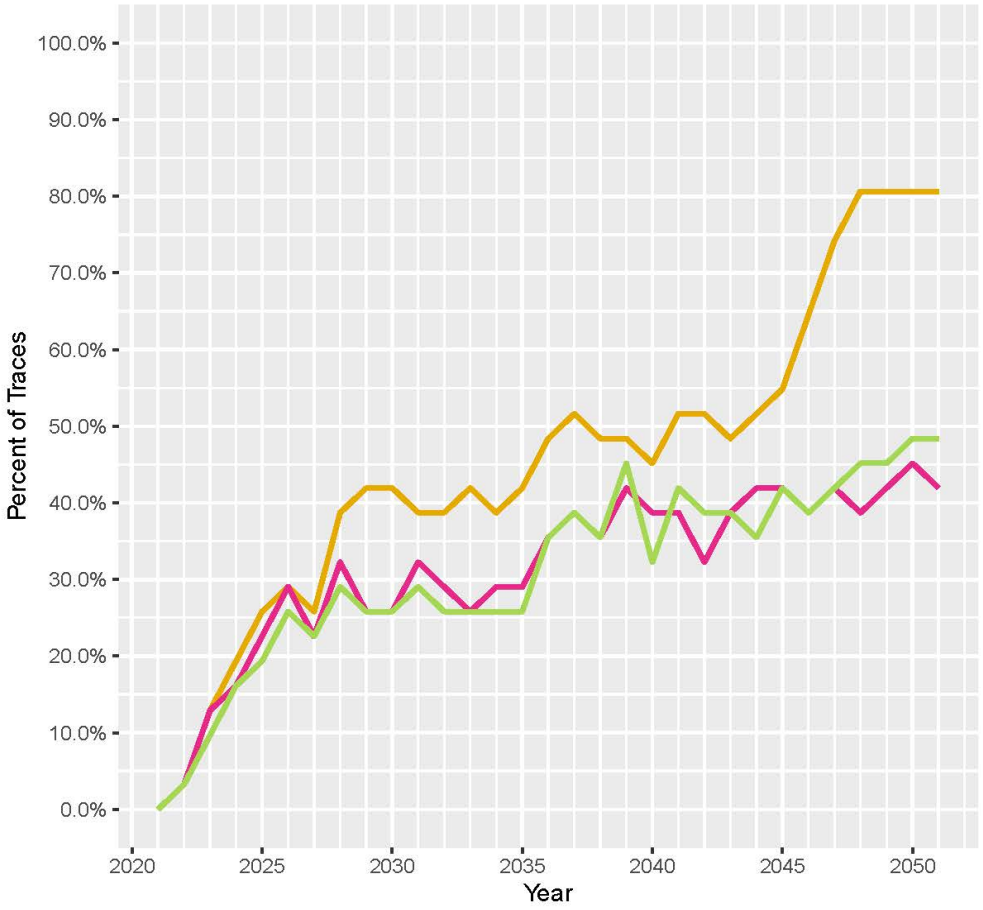
All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

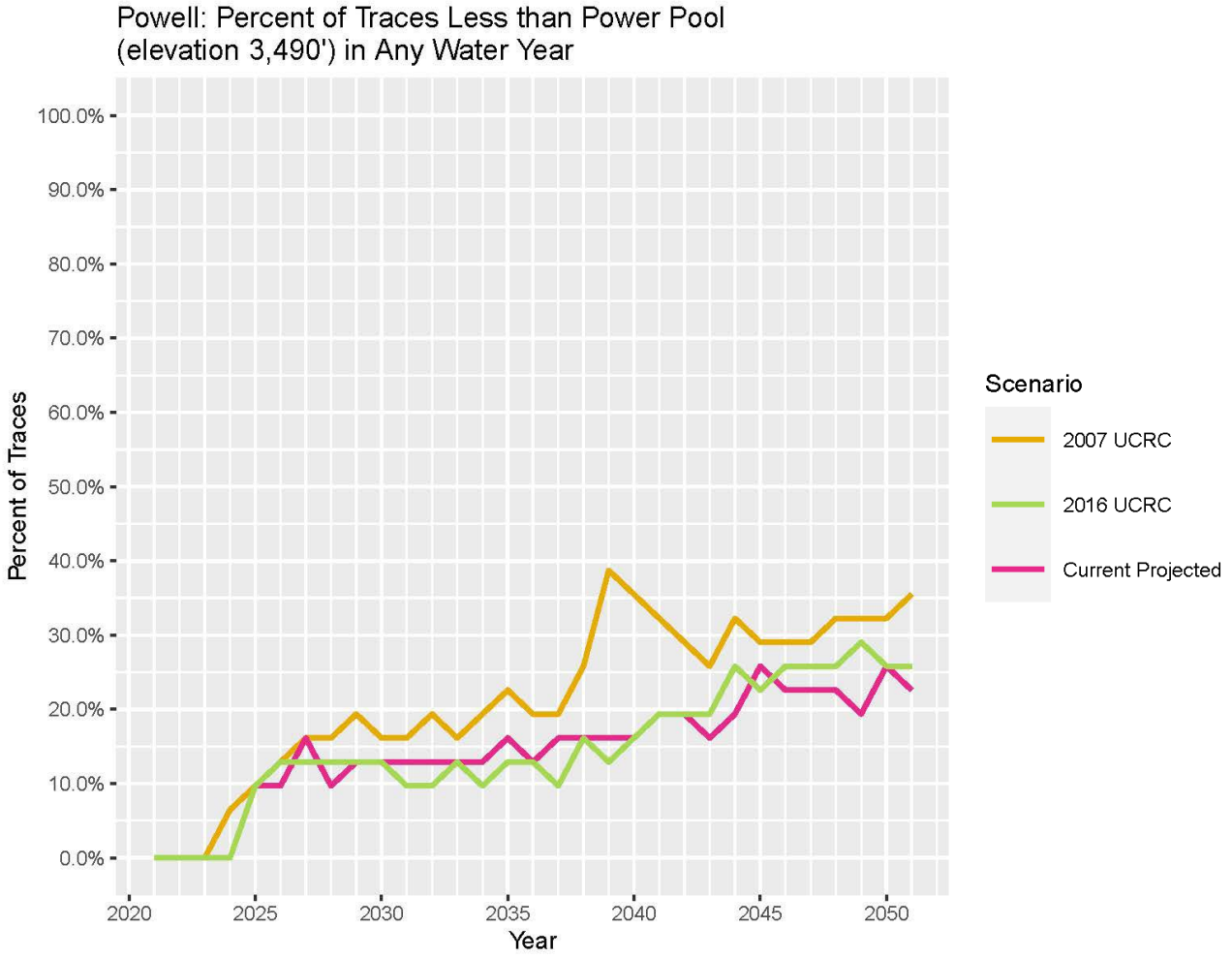
# System Conditions – Lakes Powell and Mead




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

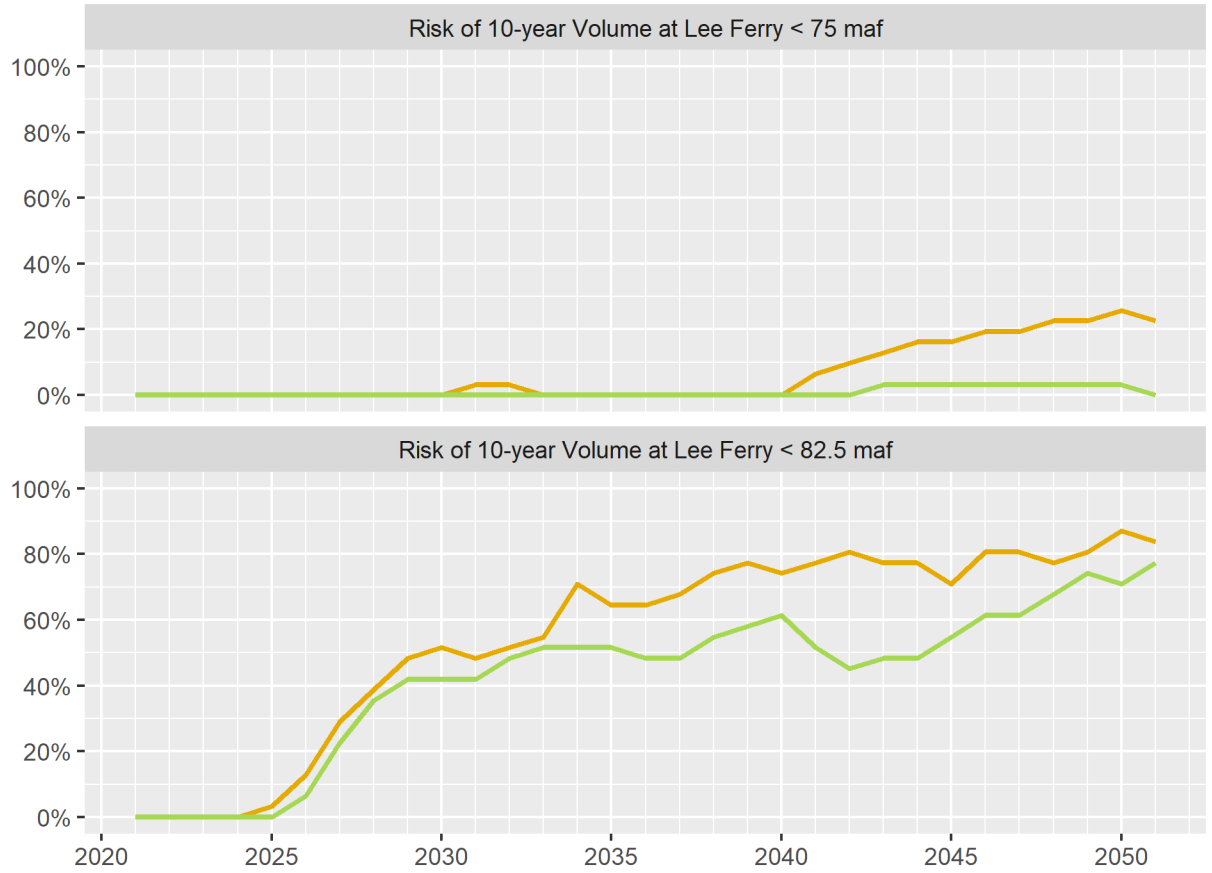
# System Conditions – Lake Powell

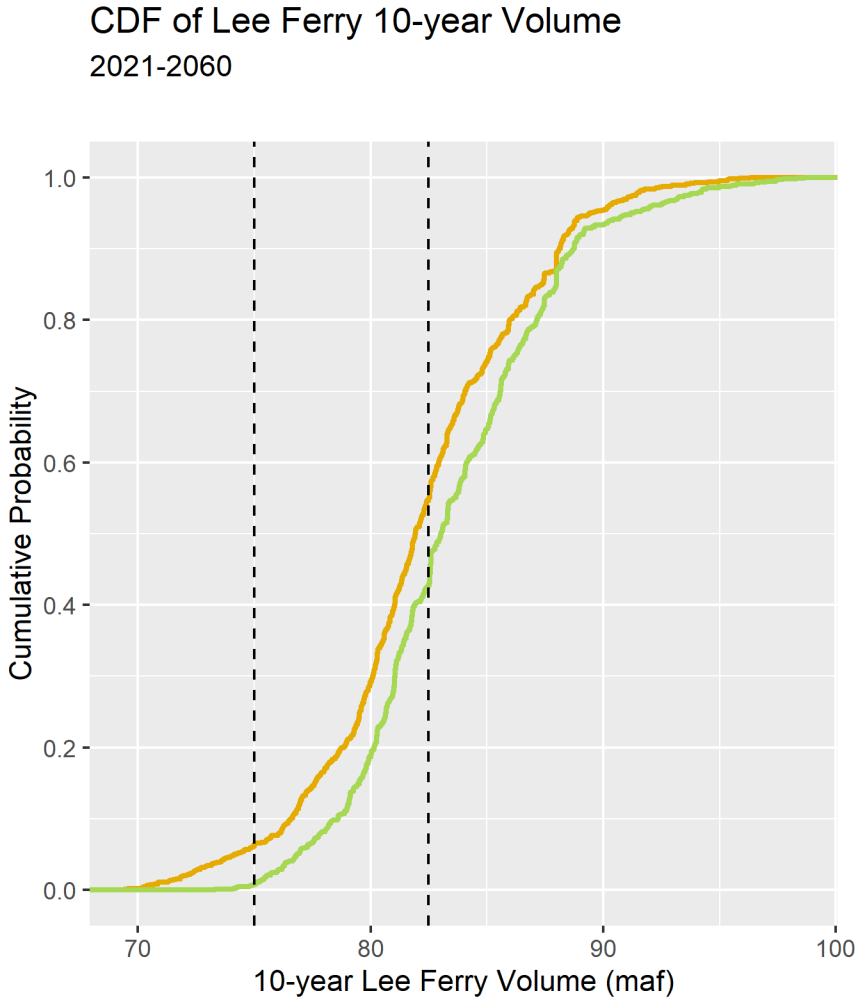



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

# System Conditions – Lee Ferry 10-year Volume



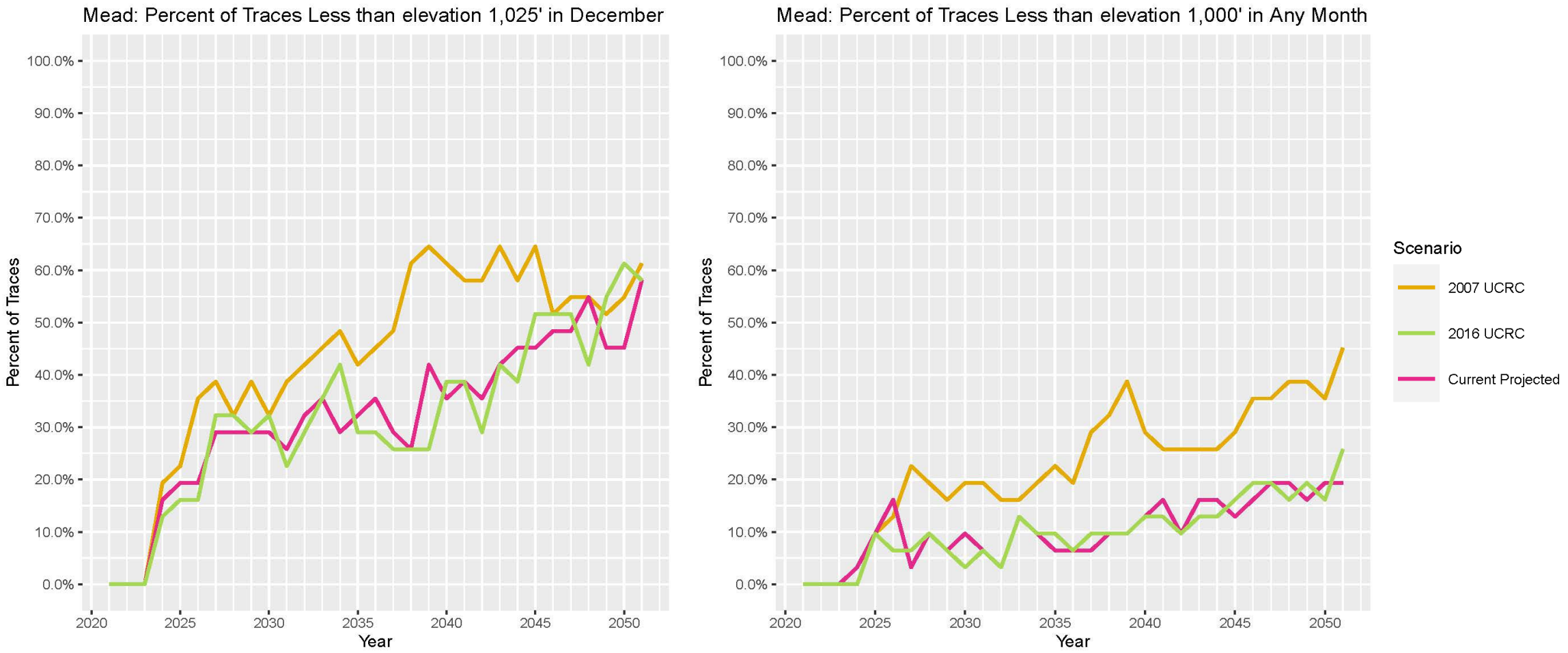




All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Stress Test Hydrology (1988-2018).

# System Conditions – Lower Basin


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

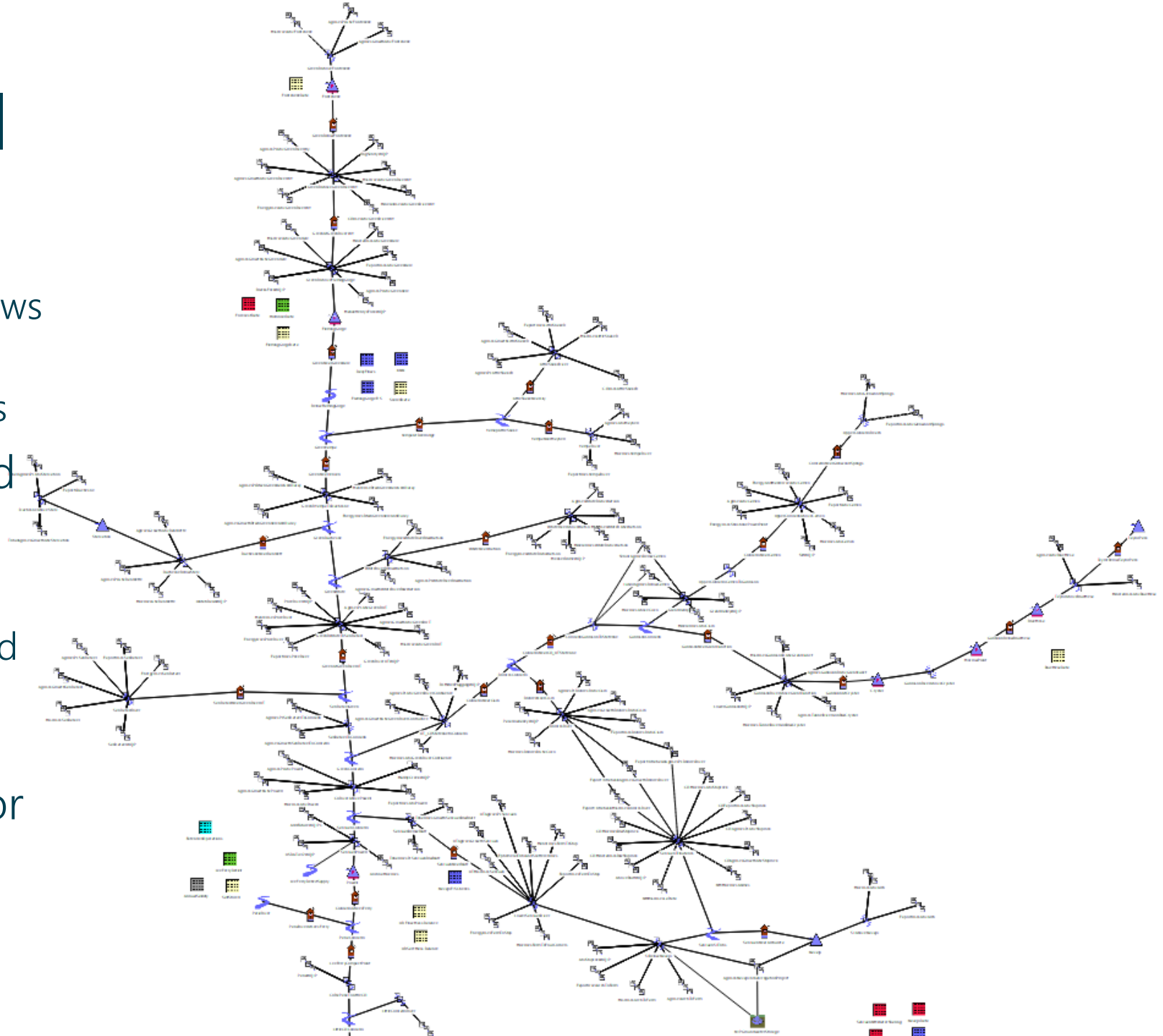
# System Conditions – Lake Mead




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

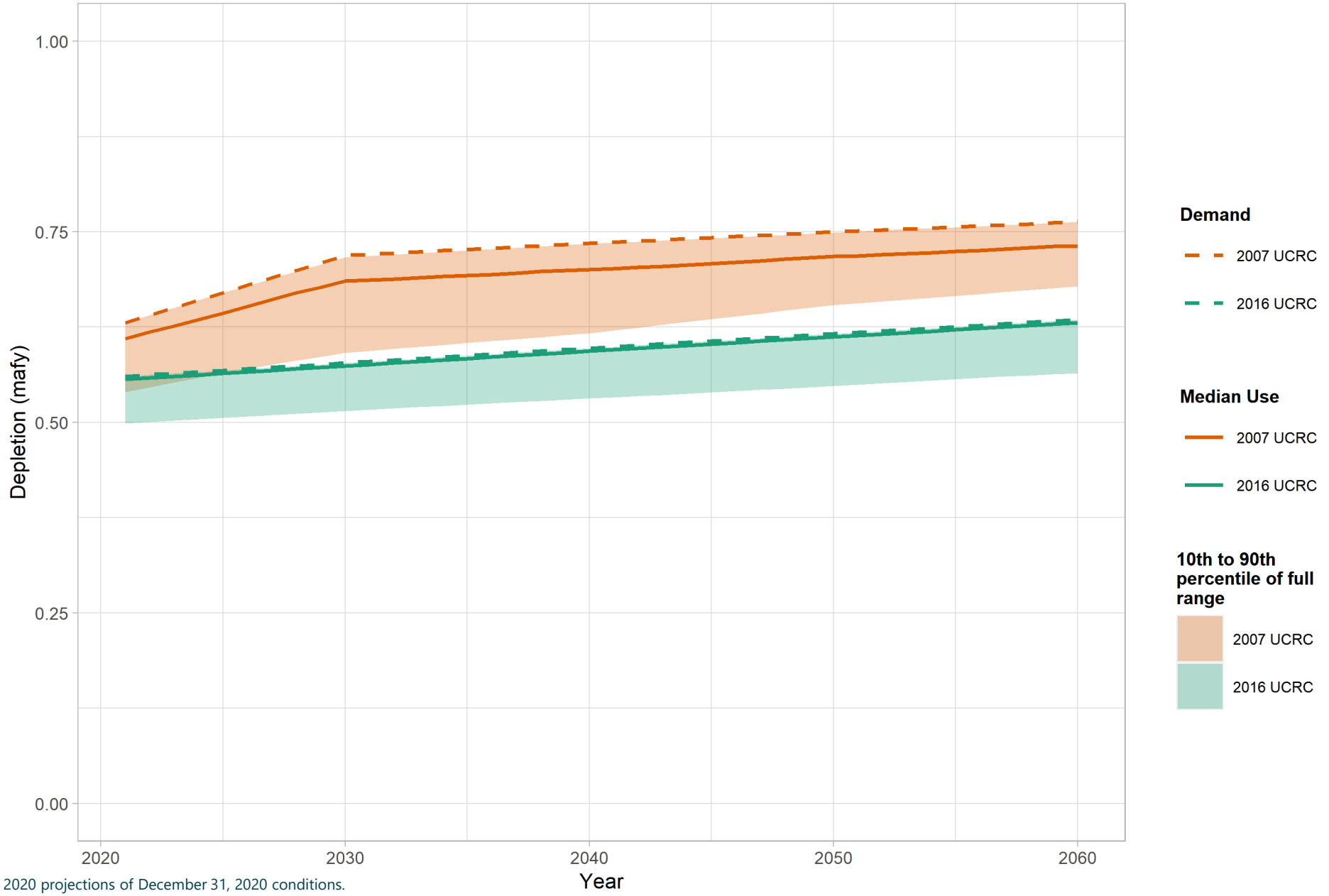
# Supplementary

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

# Modeling Assumptions

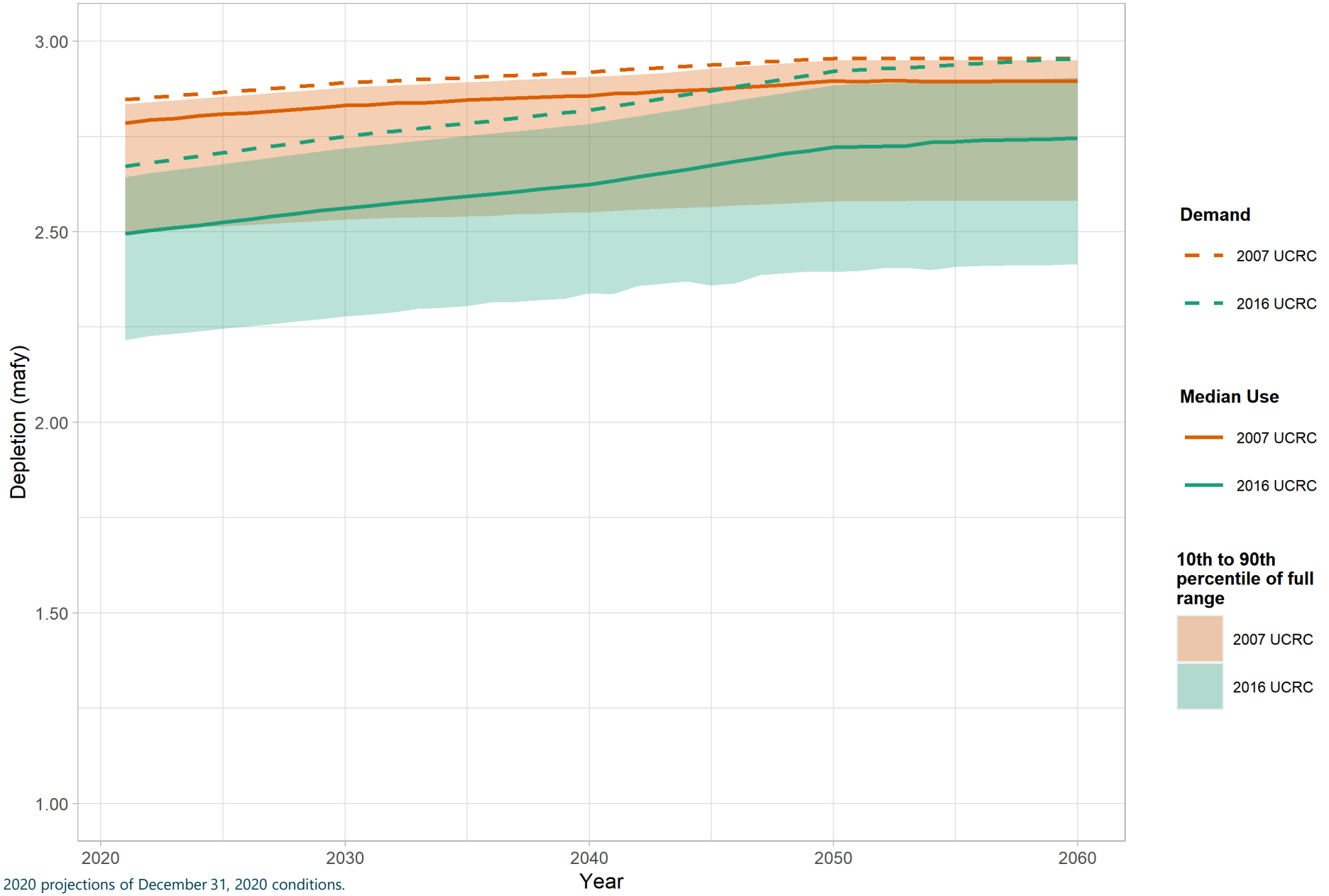
- CRSS is initialized with end-of-December 2020 reservoir conditions, 2021 Lake Powell operating tier, and 2021 Lake Mead operating condition from the August 2020 24-Month Study projection based on the Colorado Basin River Forecast Center's most probable inflow sequence
- Comparisons are made using the "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



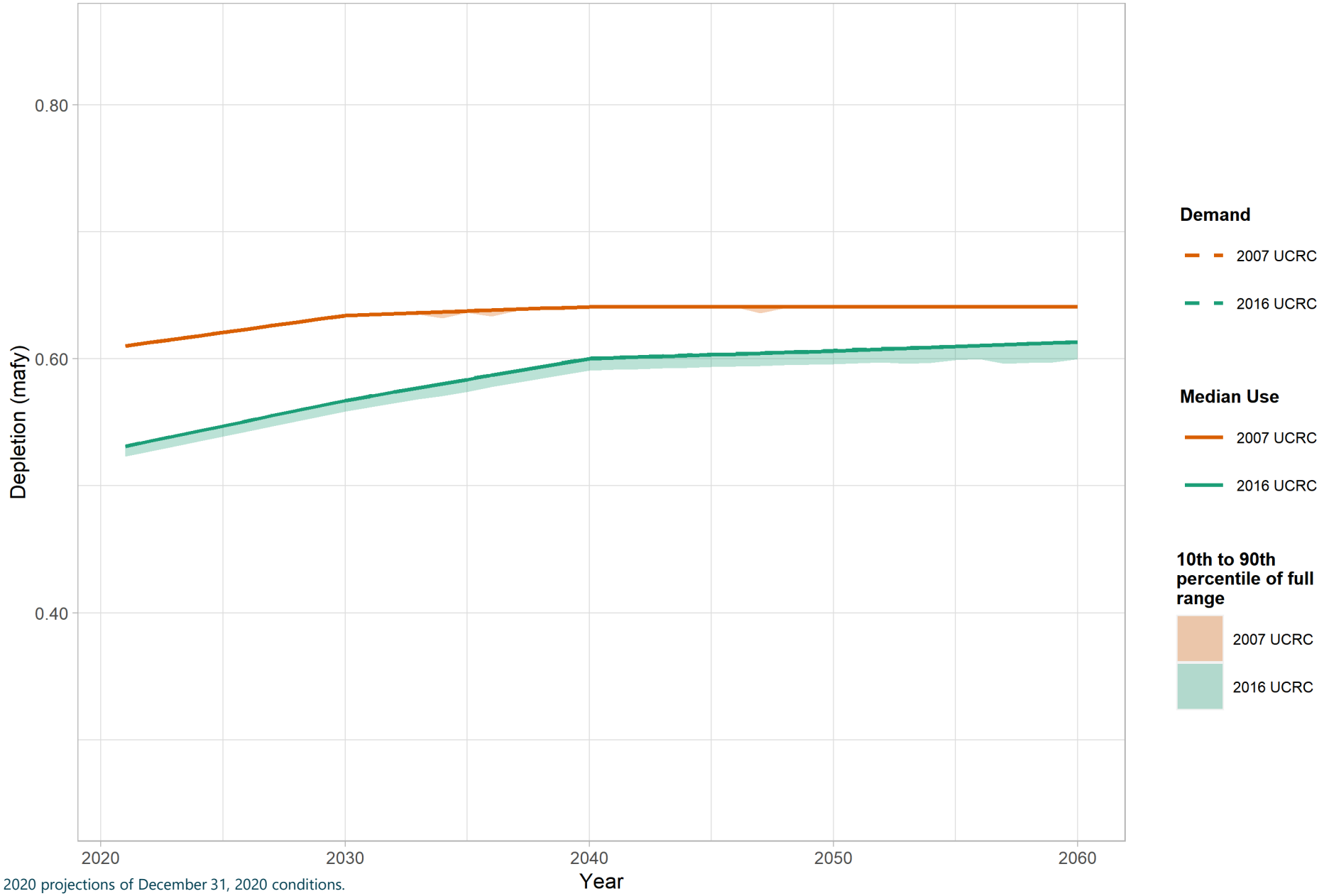

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

# Modeled Annual Consumptive Use - Colorado



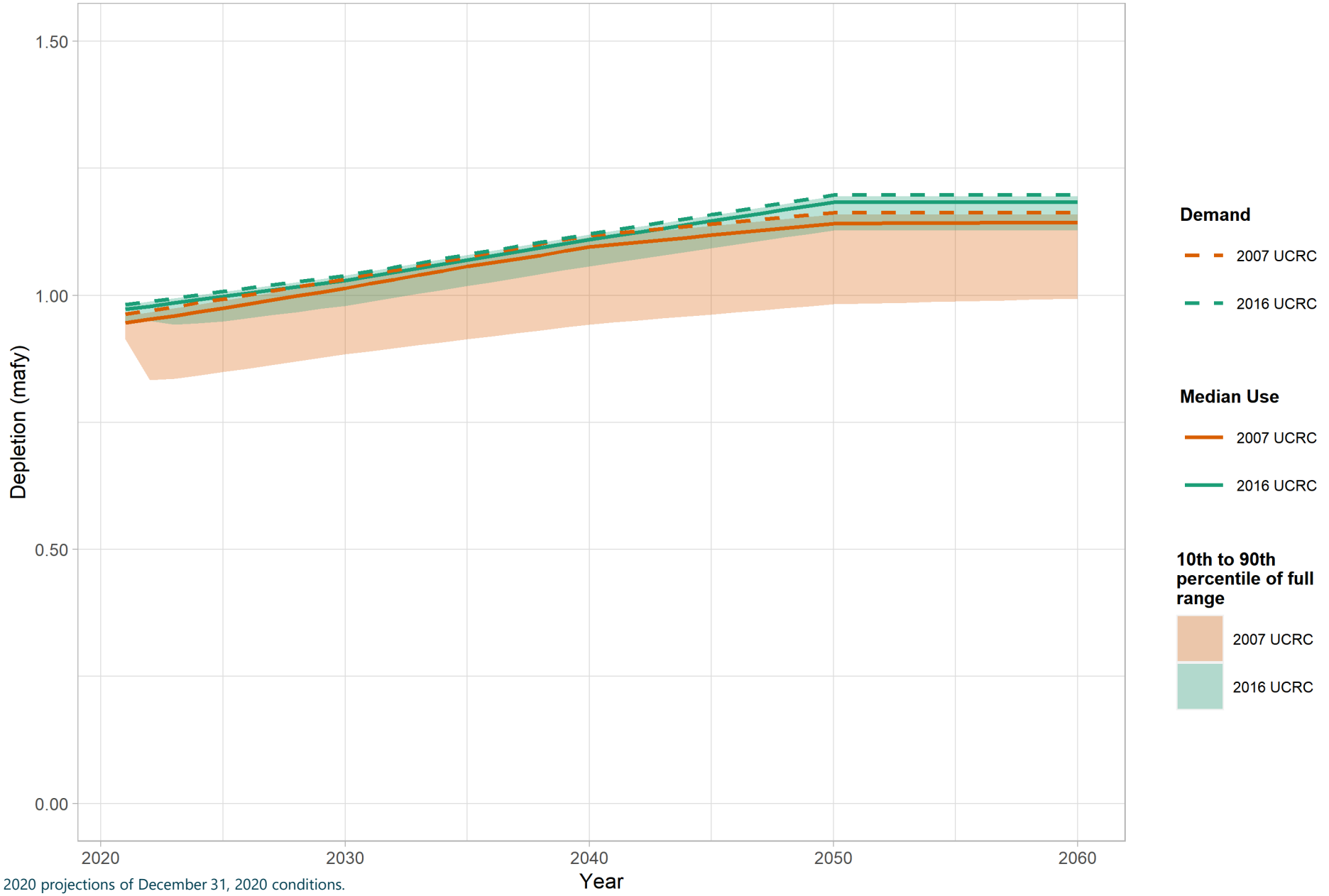

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

# Modeled Annual Consumptive Use – New Mexico



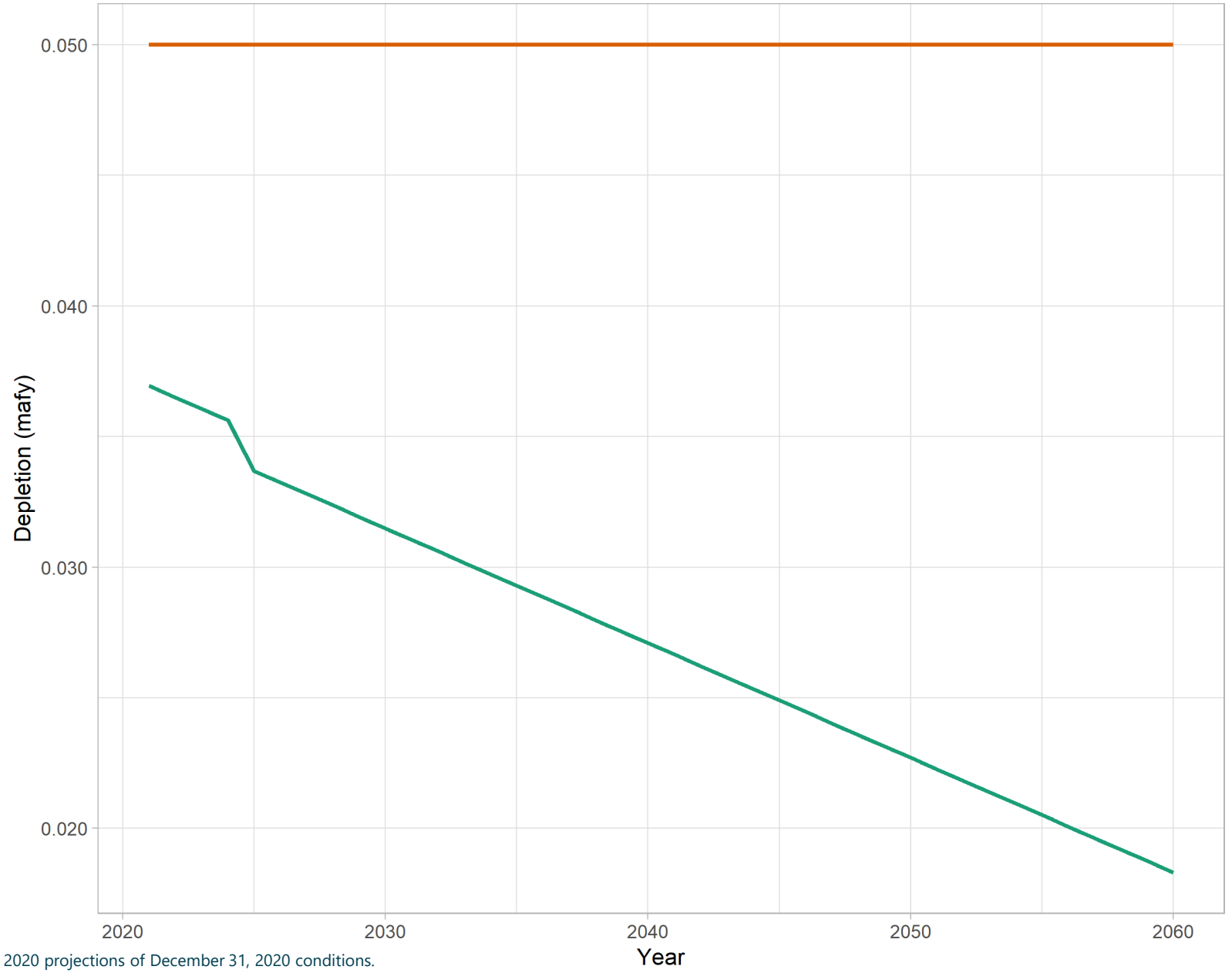

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

# Modeled Annual Consumptive Use - Utah




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

# Modeled Annual Consumptive Use – UB Arizona




**Demand**

2007 UCRC

2016 UCRC

**Median Use**

2007 UCRC

2016 UCRC

**10th to 90th percentile of full range**

2007 UCRC

2016 UCRC

Demand, median, 10th, and 90th percentile use are all the same.

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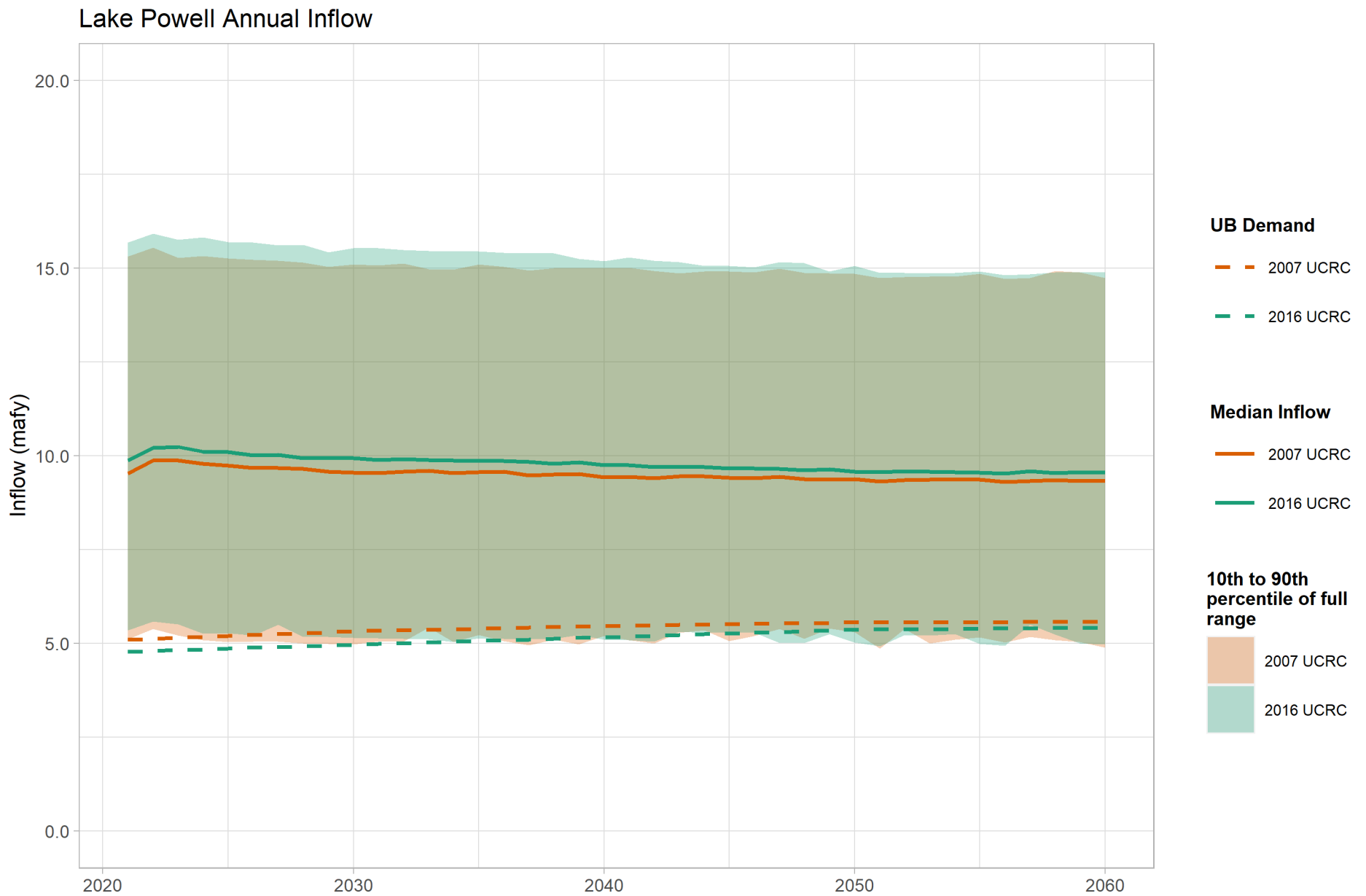
# Lake Powell Annual Inflow

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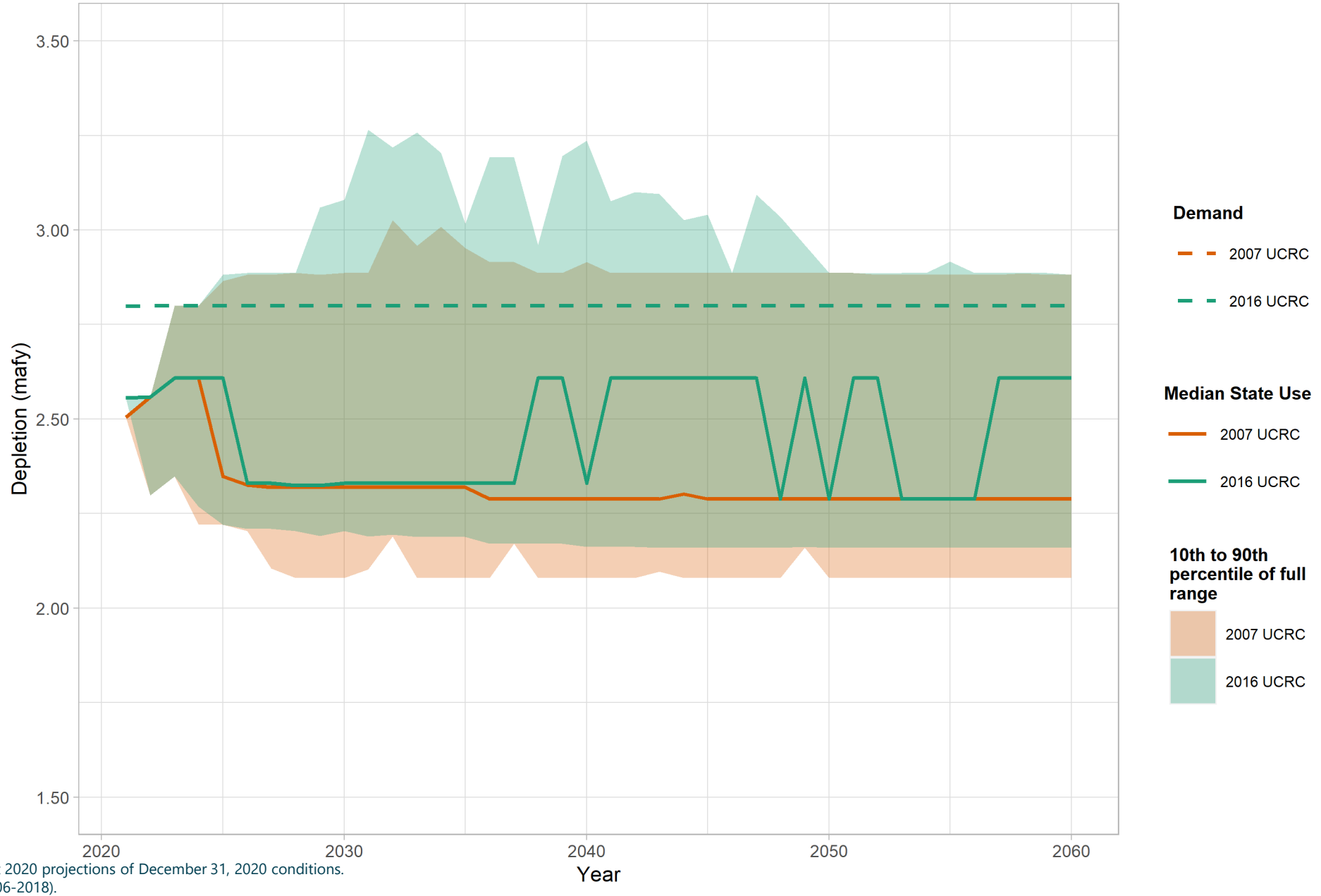
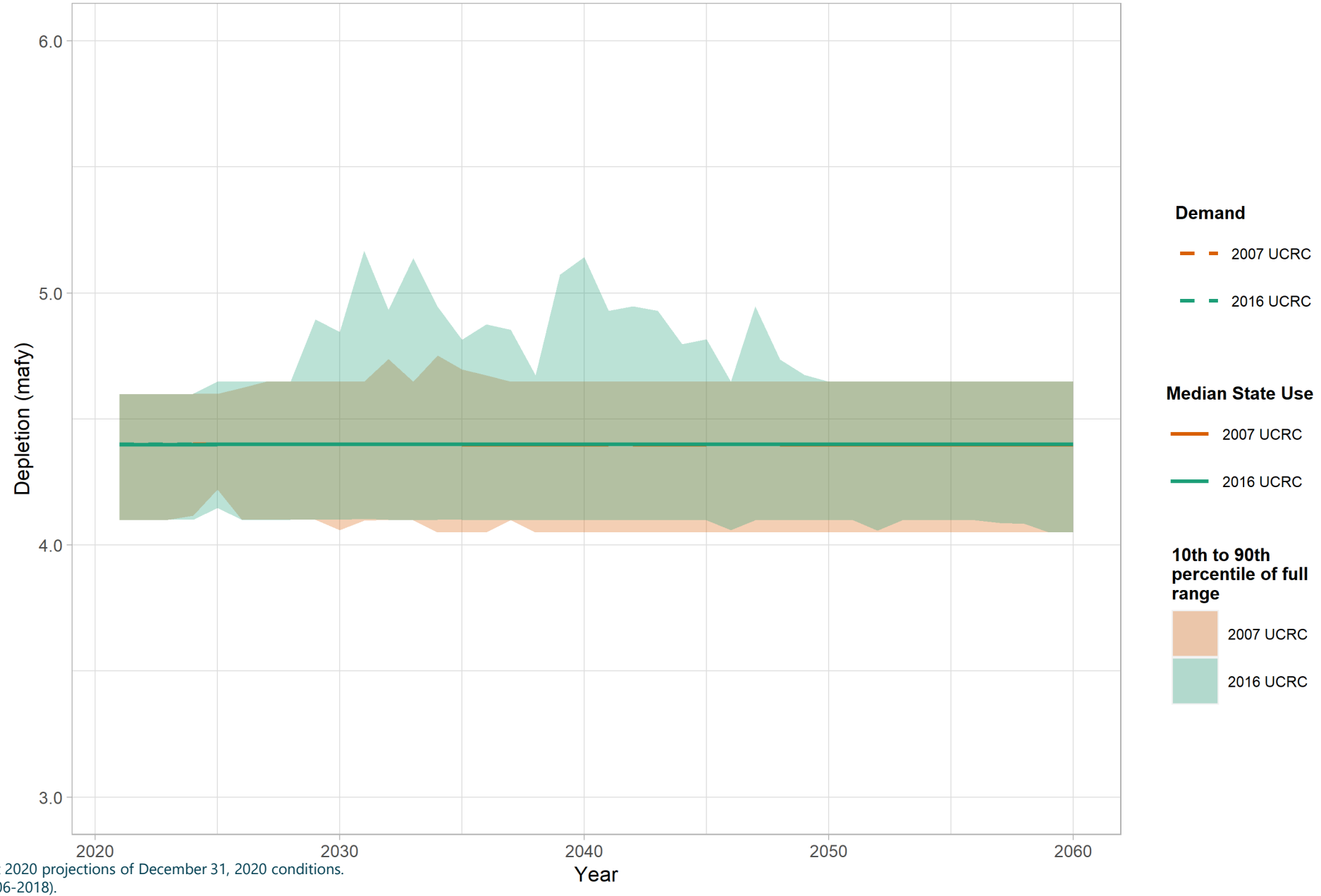
All runs use Full Hydrology (1906-2018).

# Modeled Annual Consumptive Use – LB Arizona



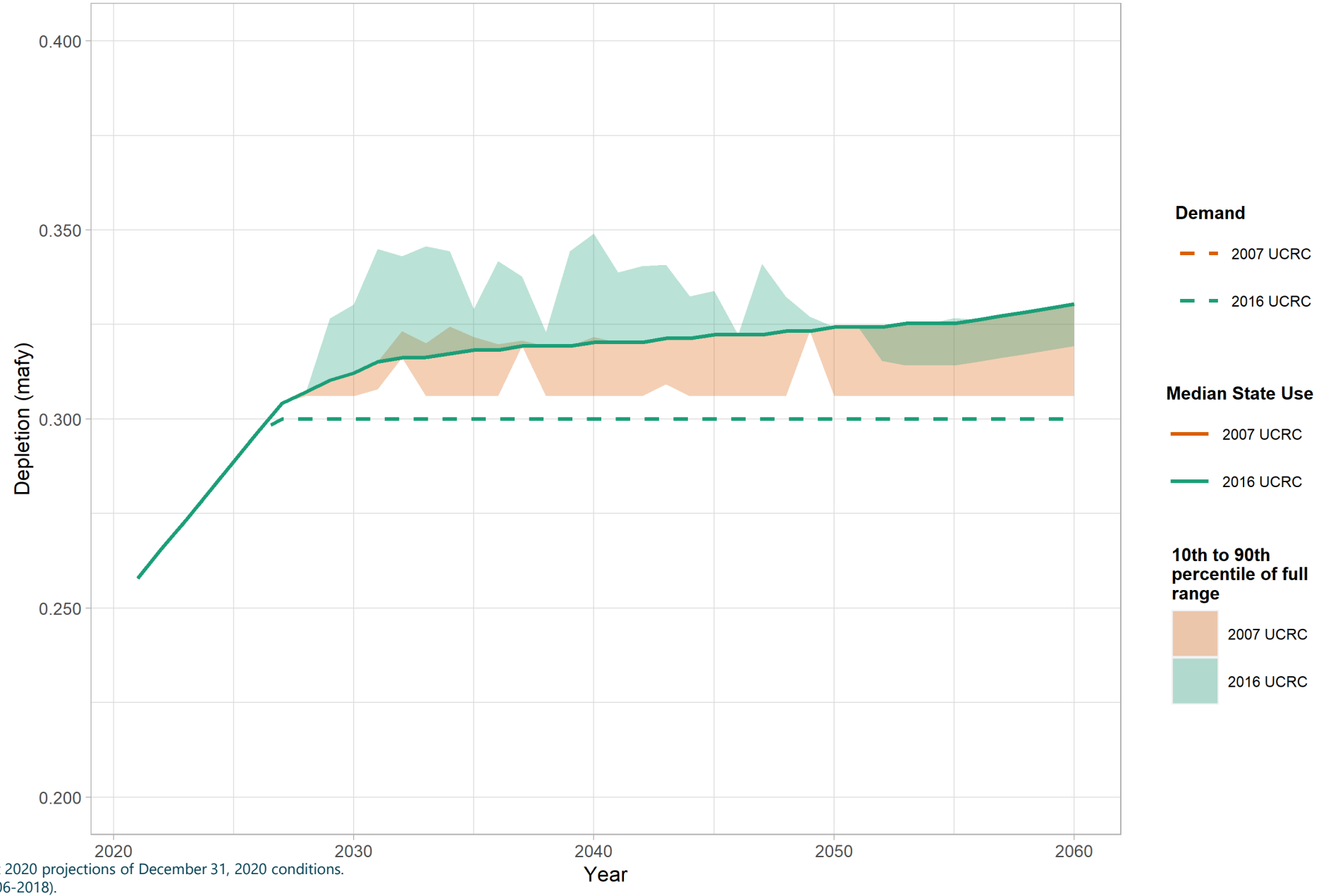

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

# Modeled Annual Consumptive Use – California



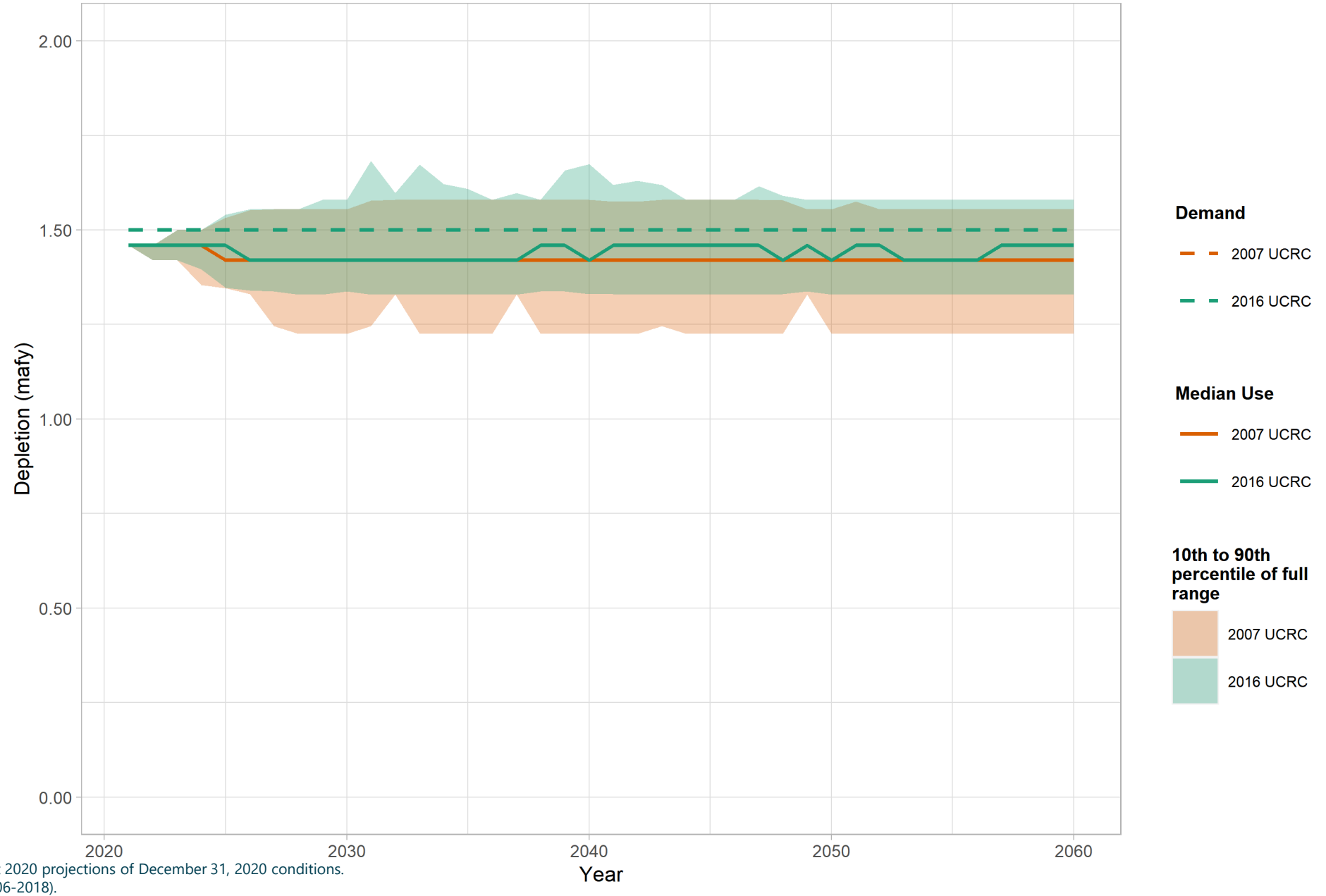

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

# Modeled Annual Consumptive Use - Nevada



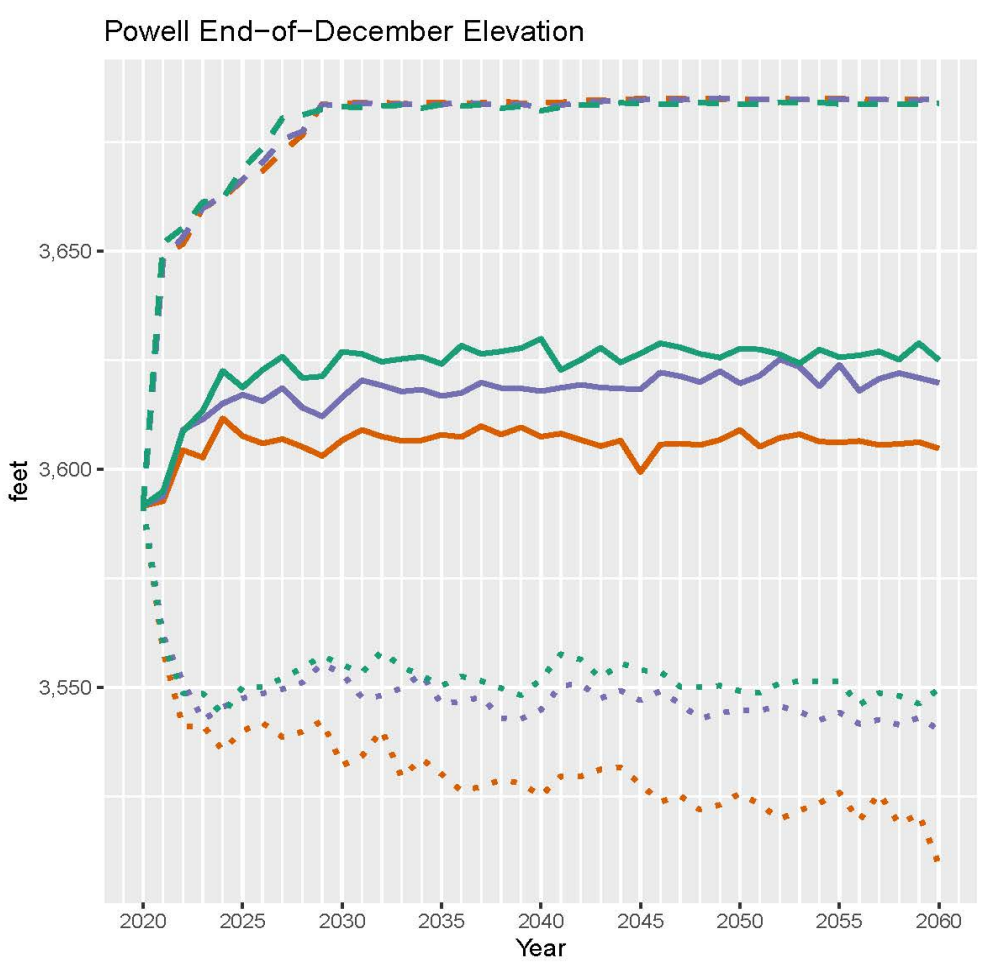

All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

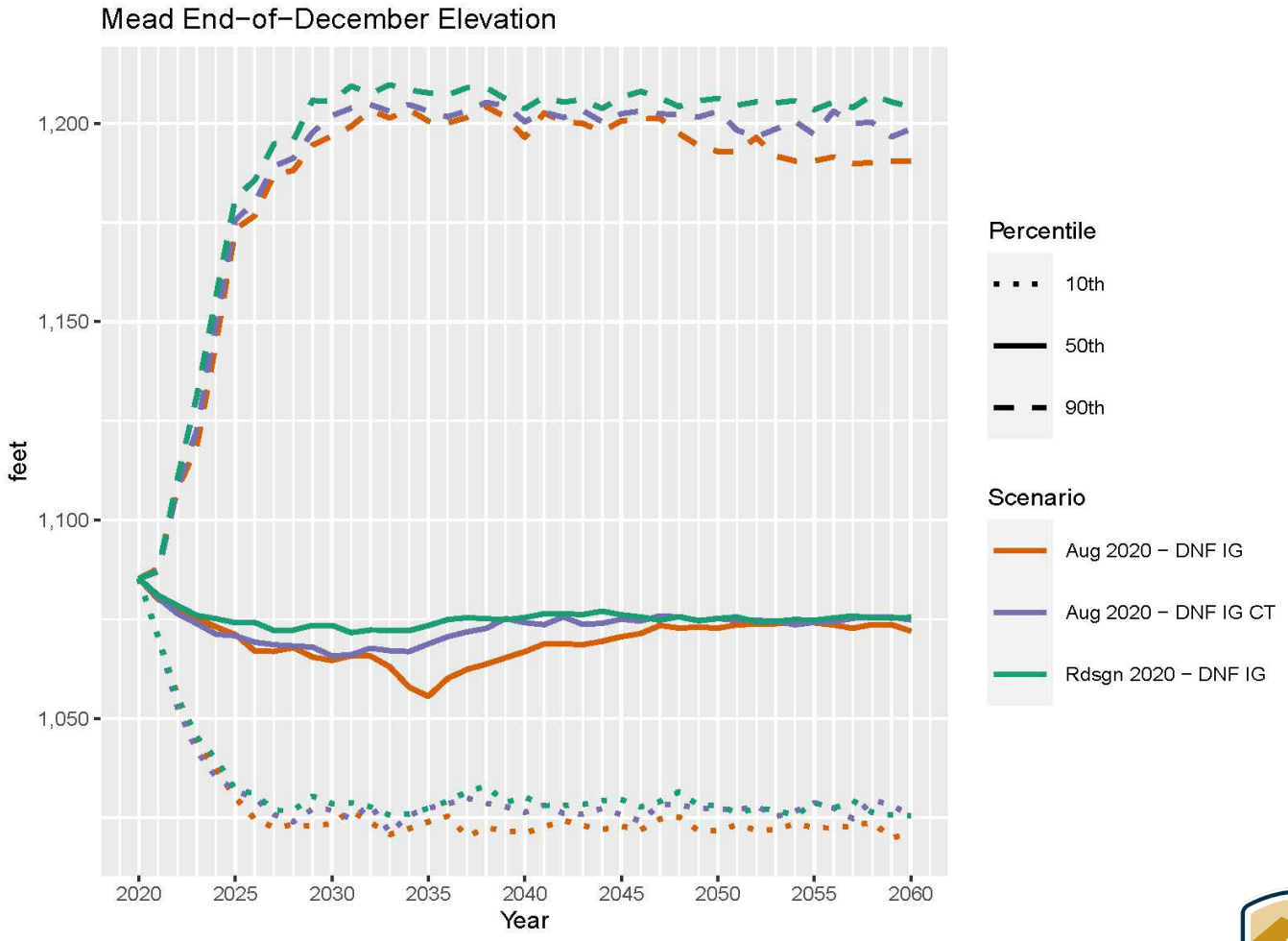
# Modeled Annual Consumptive Use - Mexico




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

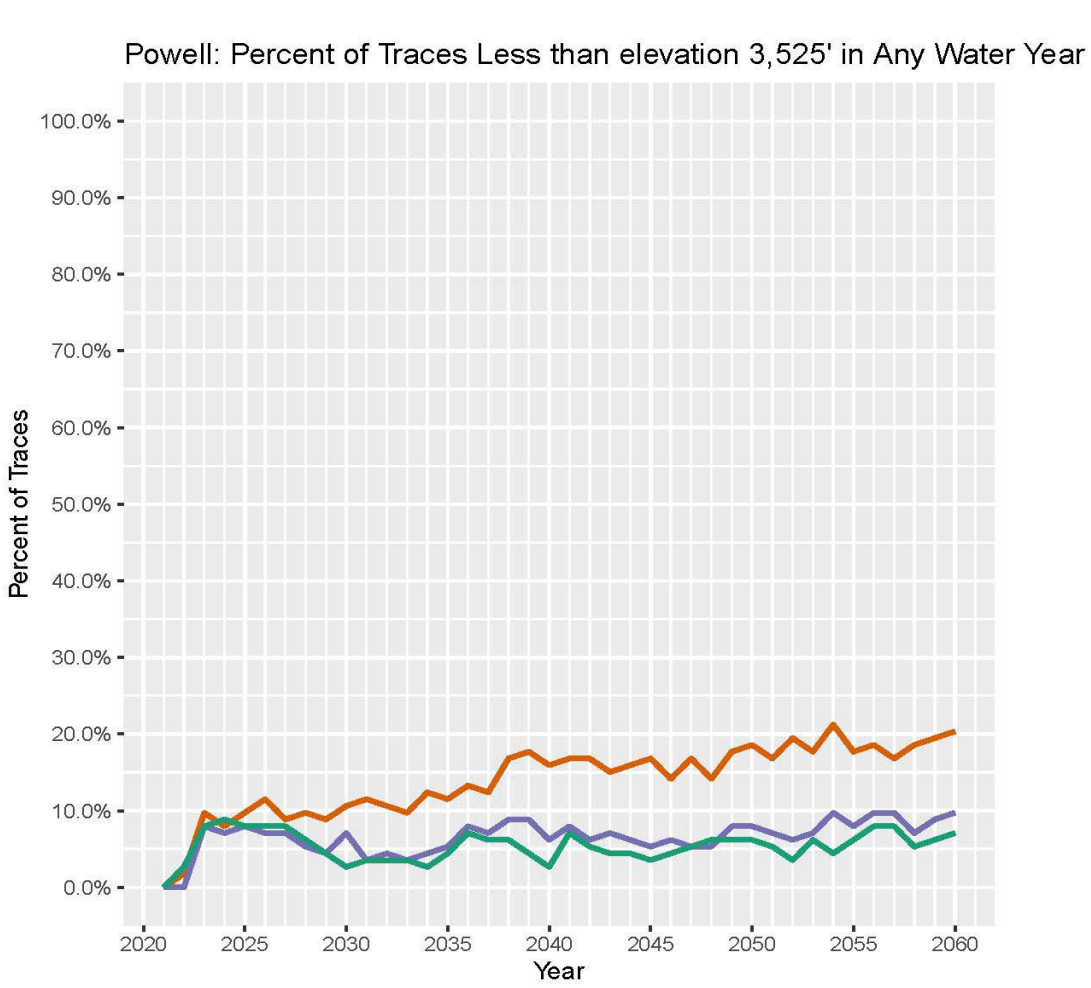
# System Conditions – Lakes Powell and Mead

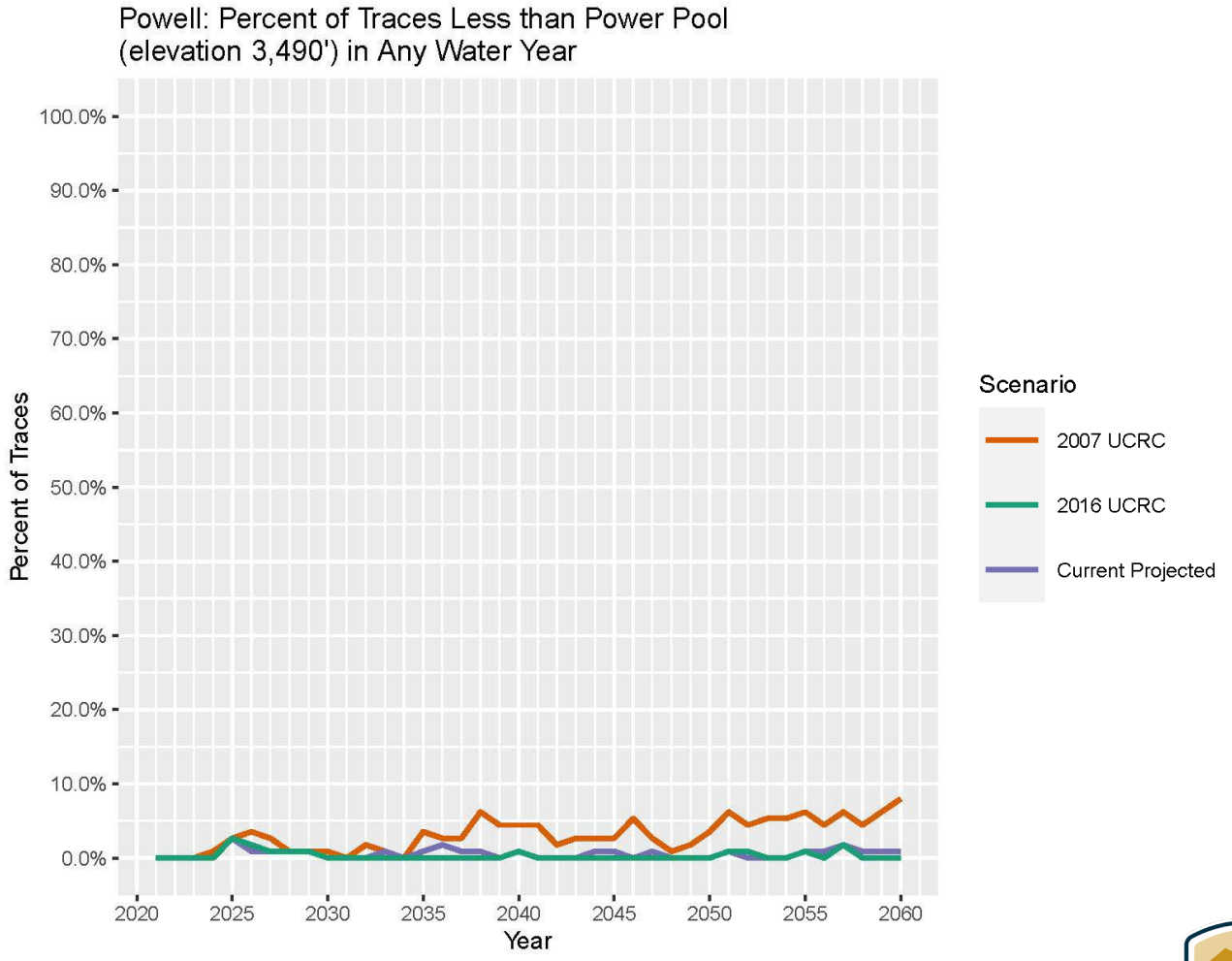



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

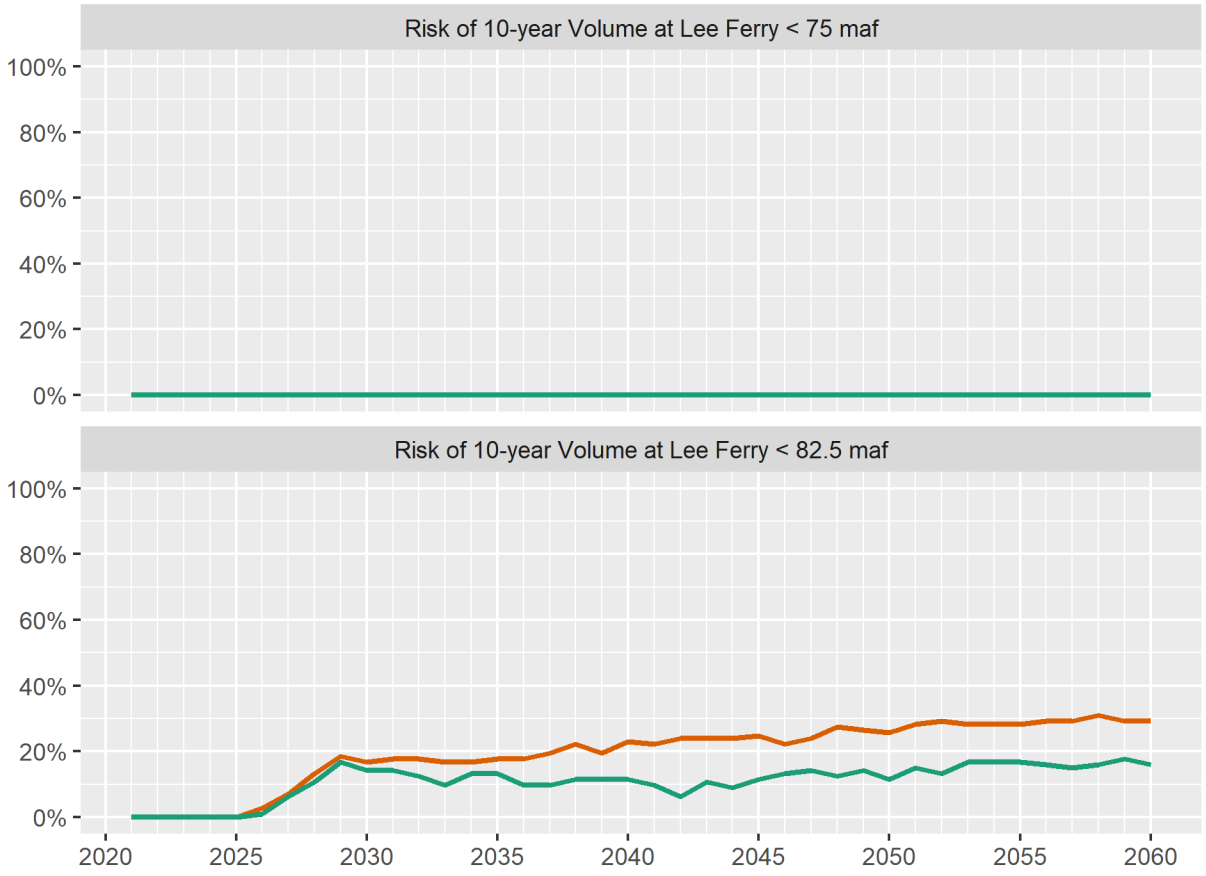
# System Conditions – Lake Powell

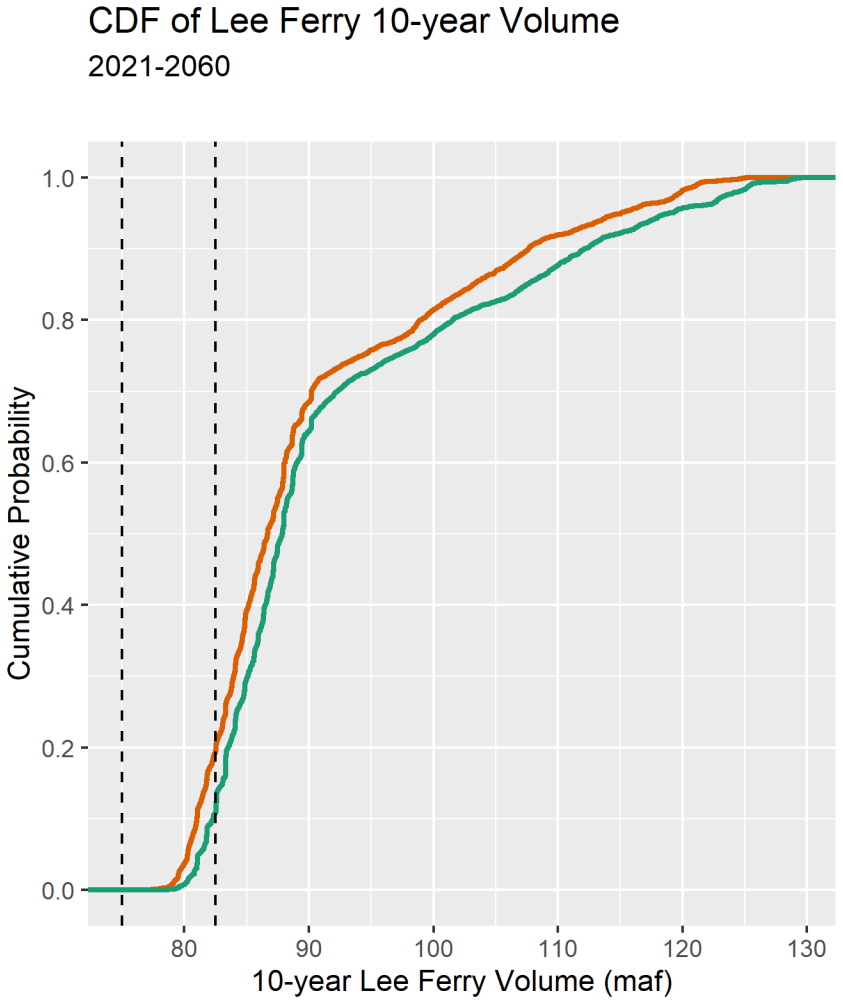



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

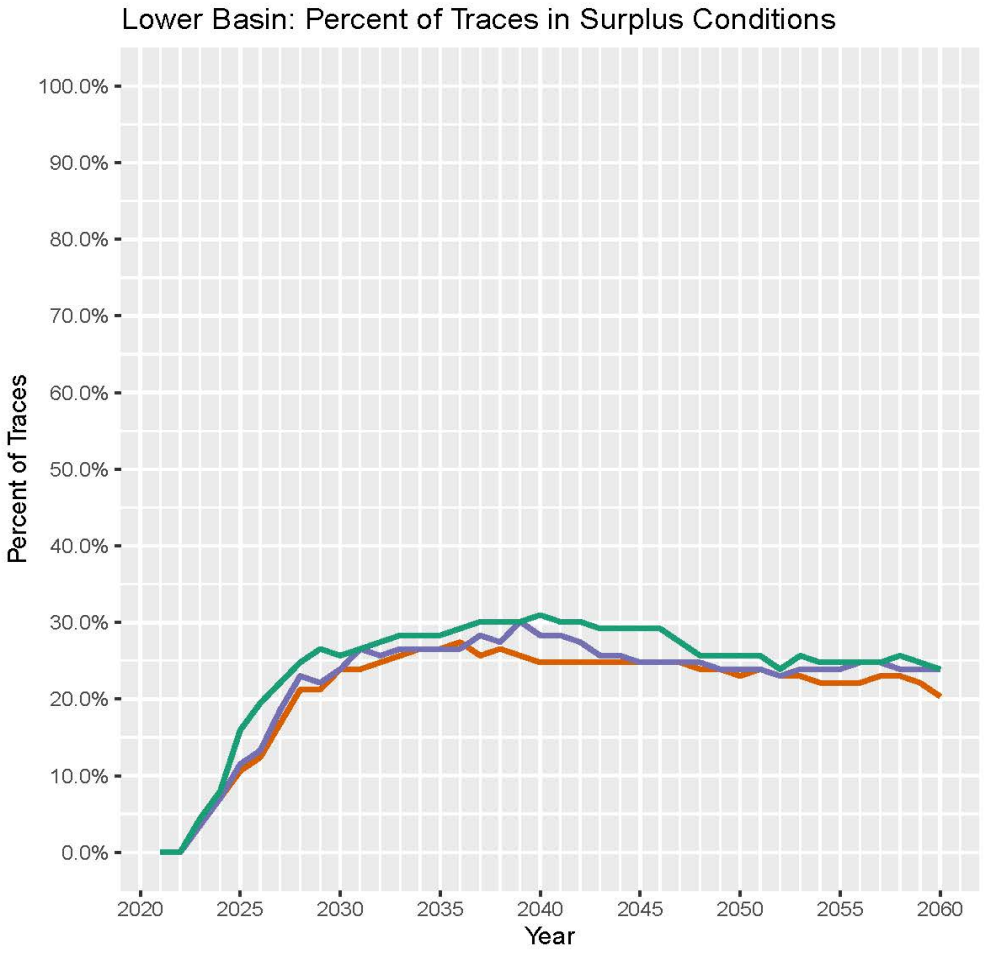
# System Conditions – Lee Ferry 10-year Volume

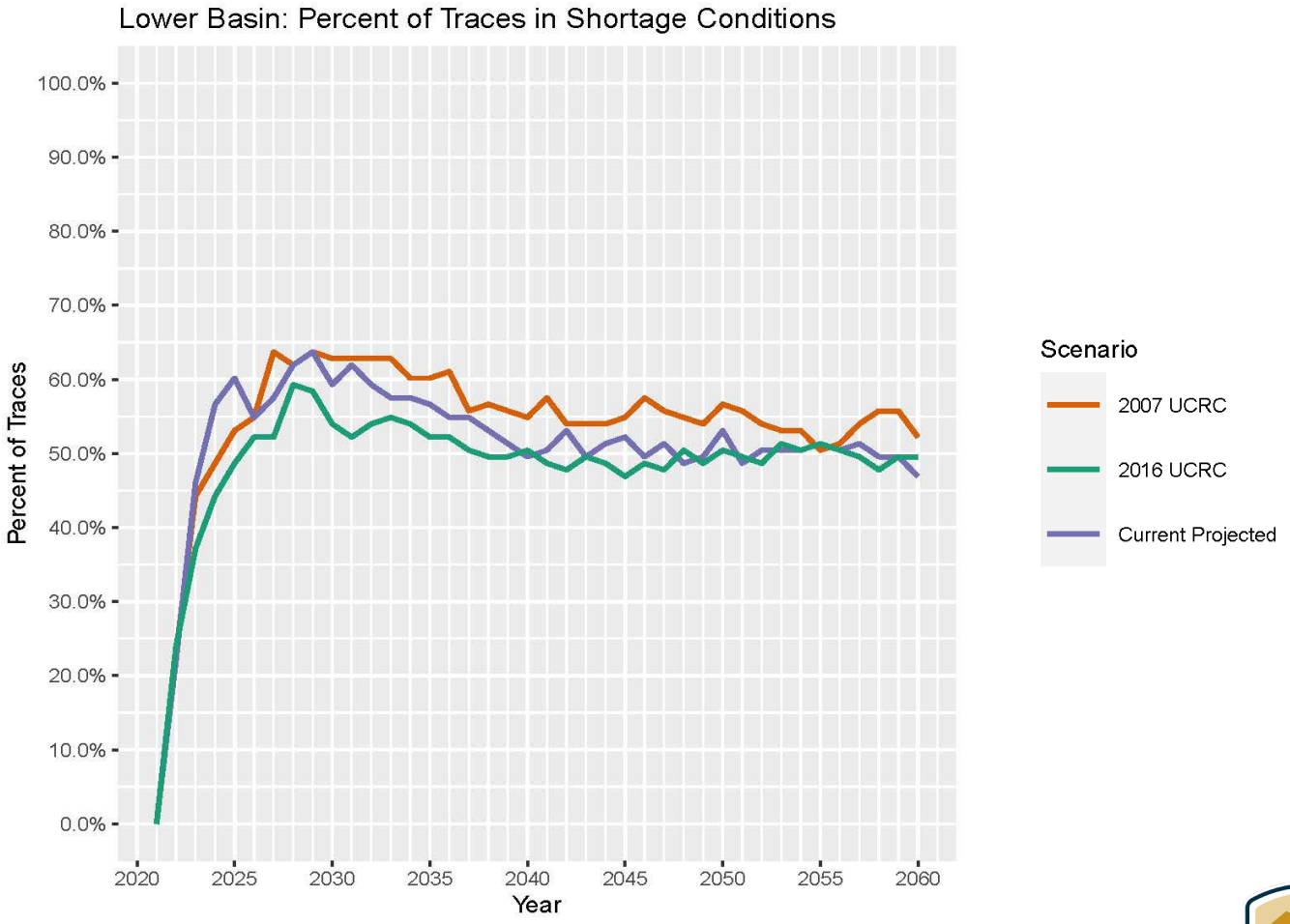



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

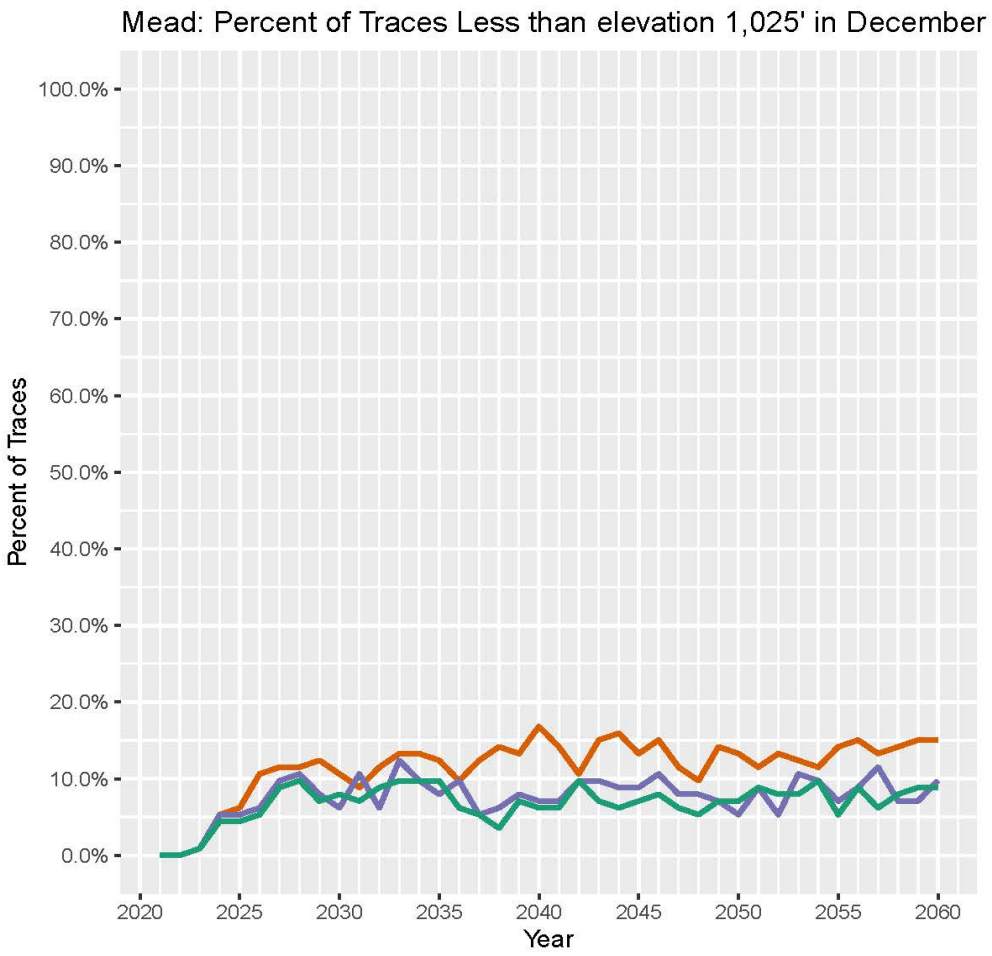
# System Conditions – Lower Basin

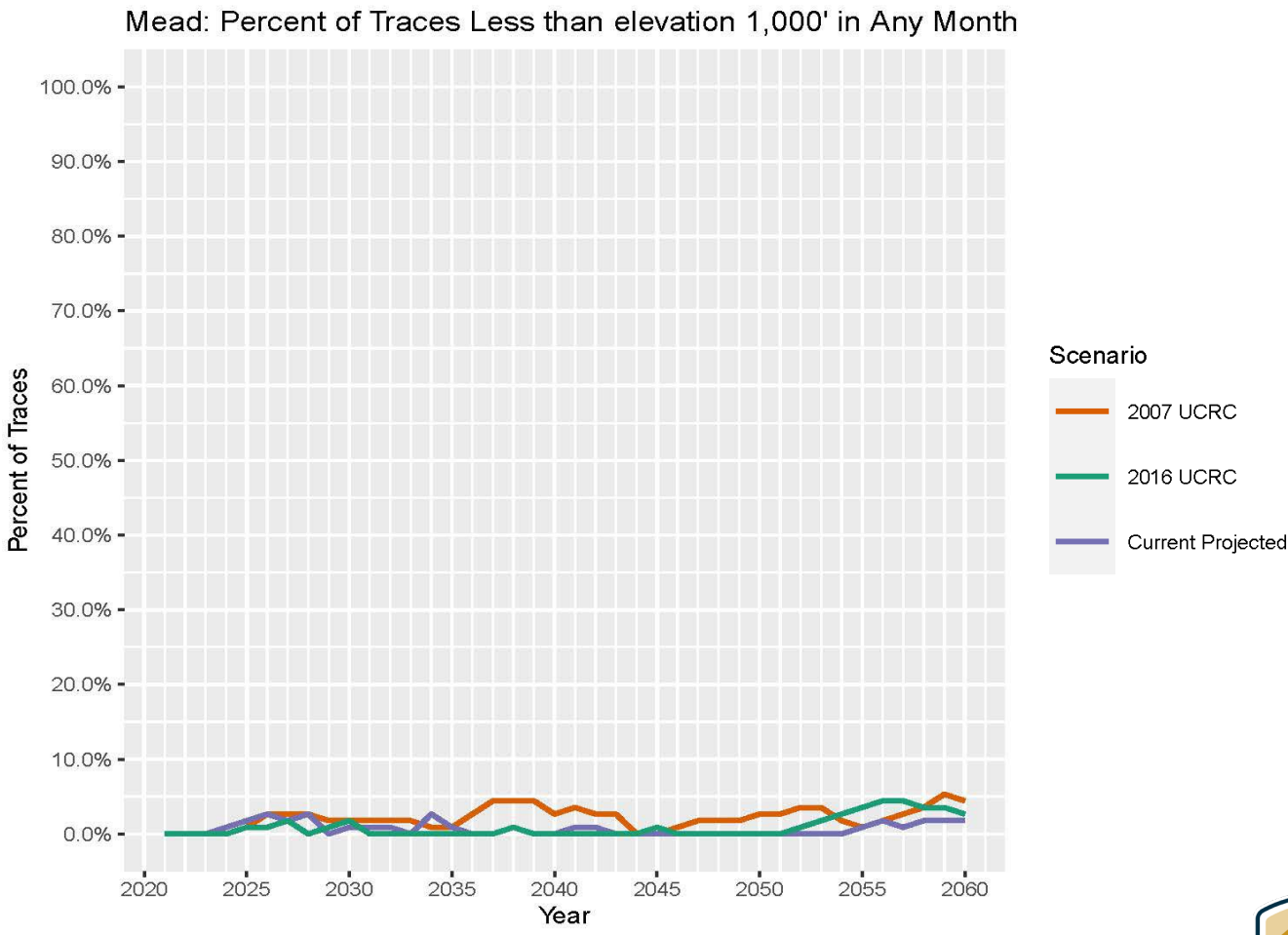



All runs initialized using August 2020 projections of December 31, 2020 conditions.
All runs use Full Hydrology (1906-2018).

# System Conditions – Lake Mead




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