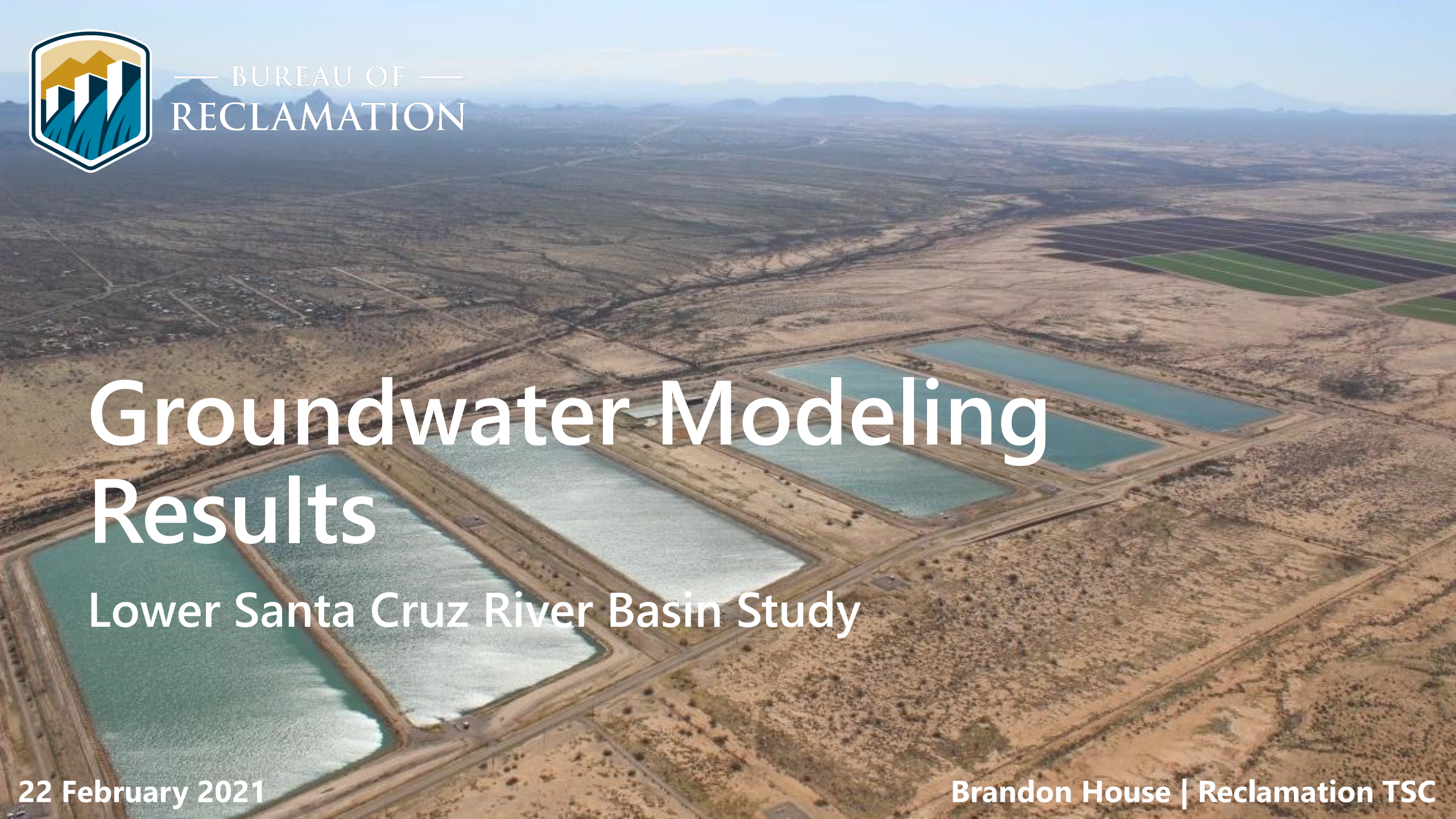


BUREAU OF RECLAMATION

Groundwater Modeling Results

Lower Santa Cruz River Basin Study

22 February 2021

Brandon House | Reclamation TSC

Outline

- Scenarios and introduction
- Groundwater model inputs for scenarios
- Results from scenario runs
- Comparison of scenario results

Supply-Demand Basin Study Scenarios

A. Official Projections: Medium, mixed-density growth and Current climate

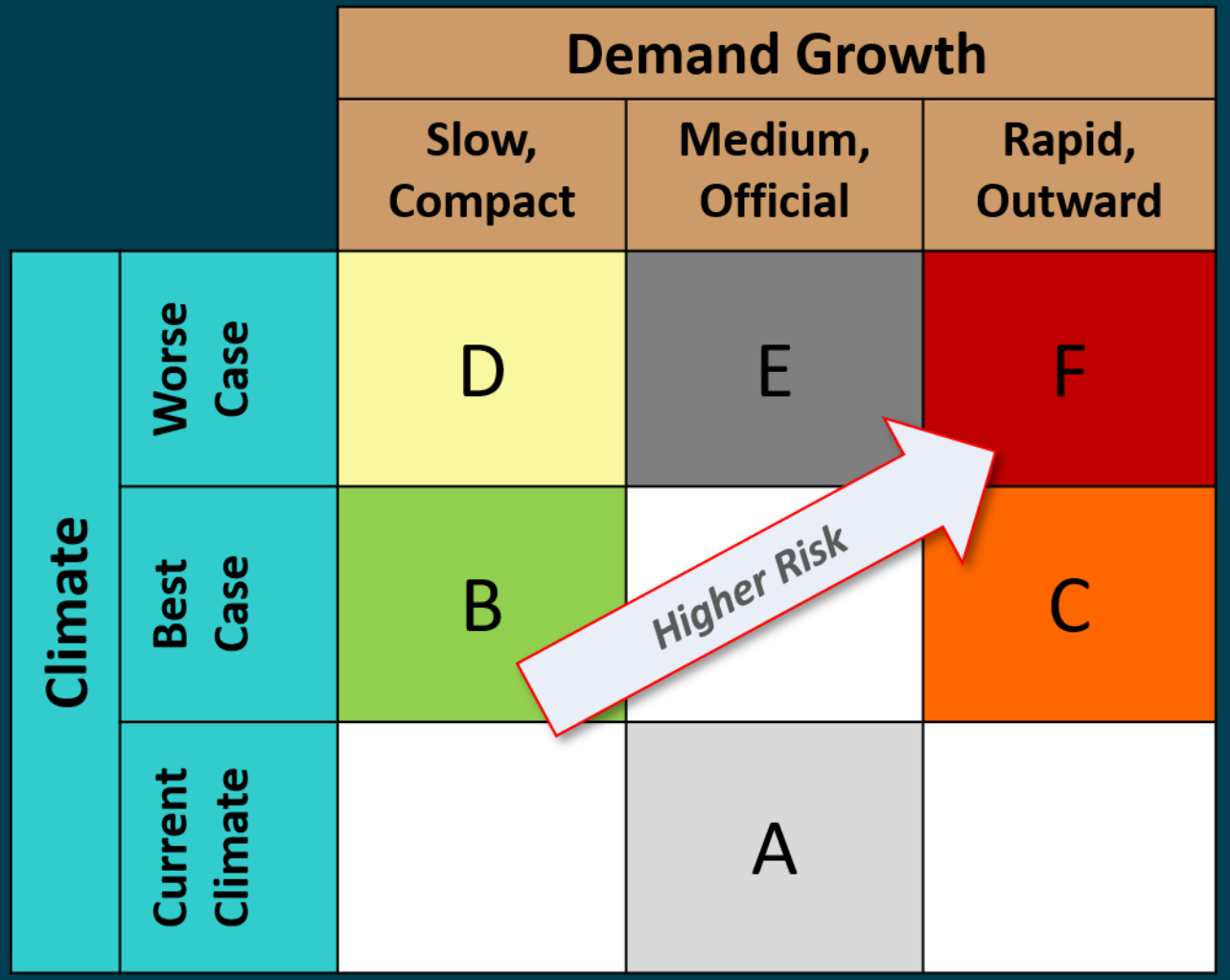
B. Slow, compact growth and Best Case climate

C. Rapid, outward growth and Best Case climate

D. Slow, compact growth and Worse Case climate

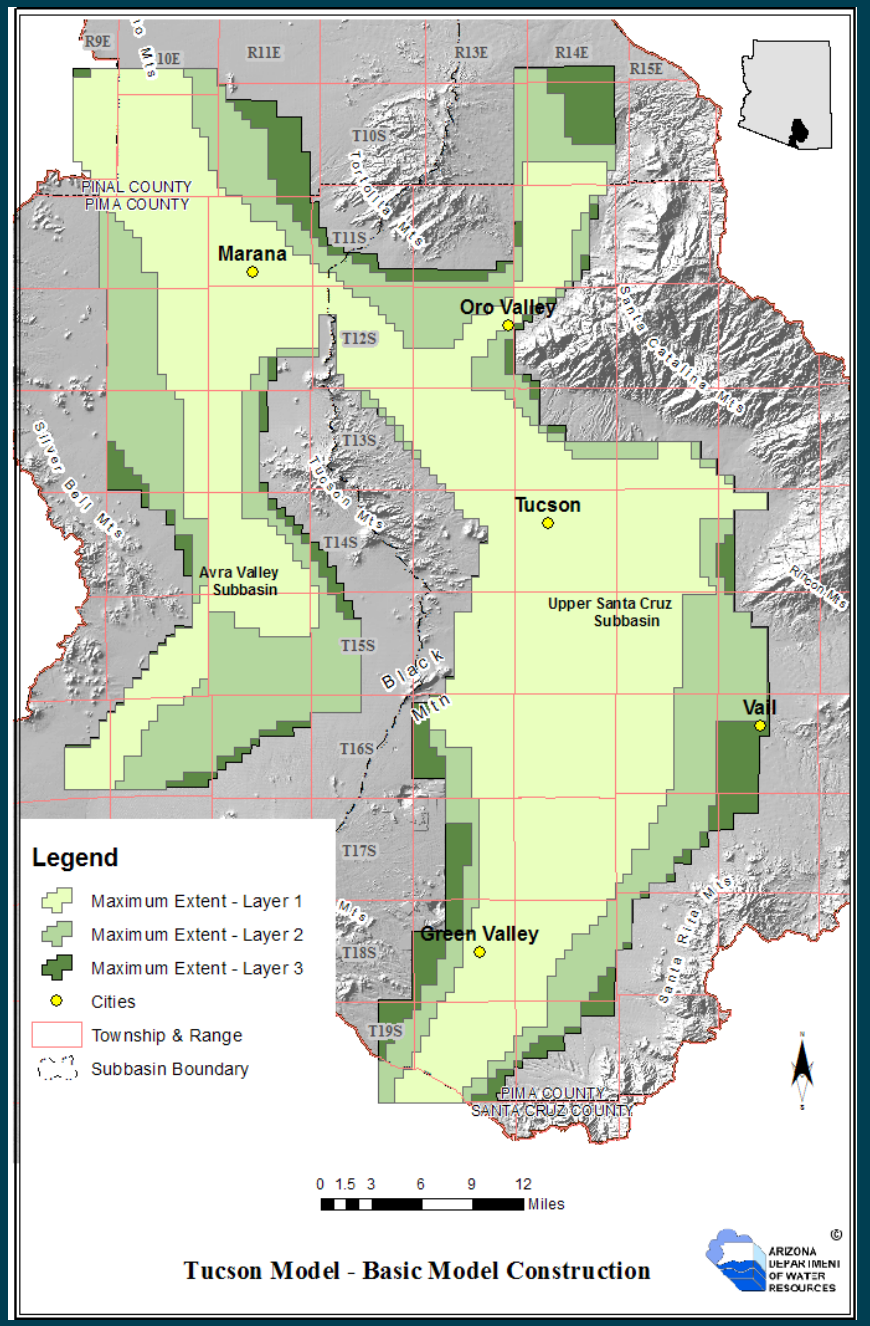
E. Official Projections and Worse Case climate

F. Rapid, outward growth and Worse Case climate



TAMA Groundwater Model

- Developed by ADWR (2013) using MODFLOW
- Solved annually 1940-2010
- Three Layers
  - Based on geology
- Half-mile by half-mile grid cell resolution



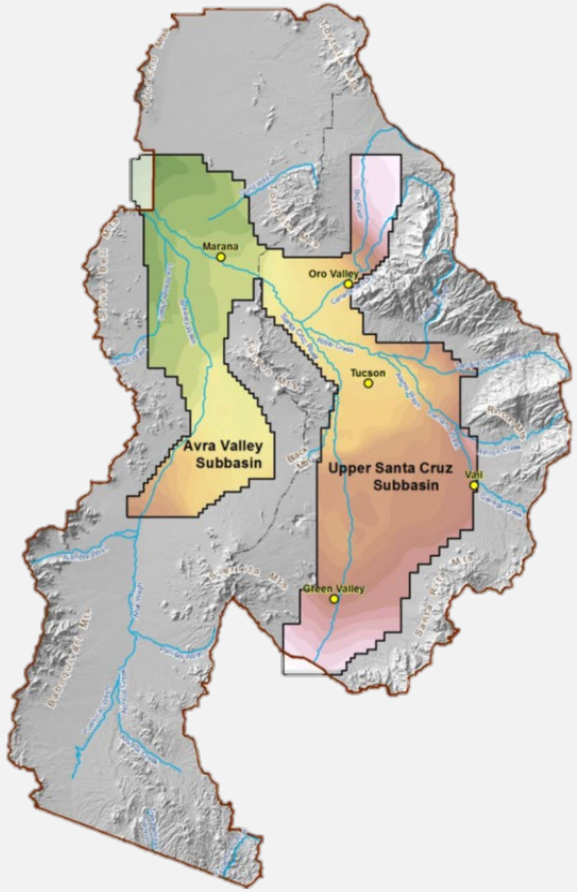
Mason, D., & Hipke, W. (2013). *Regional groundwater flow model of the Tucson Active Management Area, Arizona*. (24), 97.

Groundwater Model Components

Inflows

- Mountain Front Recharge
- Stream Infiltration
- Underflow from other basins
- Artificial Recharge (CAP and effluent)
- Incidental Recharge

ADWR TAMA Groundwater Model



Outflow

- Pumping (Municipal, Industrial, Agricultural)
- Evapotranspiration by Riparian Areas
- Underflow to other basins

Drivers:

Primarily Socio-Economic Forces | Primarily Climate | Estimated within Model

Groundwater Model Components - Constants

Inflows

- Mountain Front Recharge
- Stream Infiltration
- Underflow from other basins
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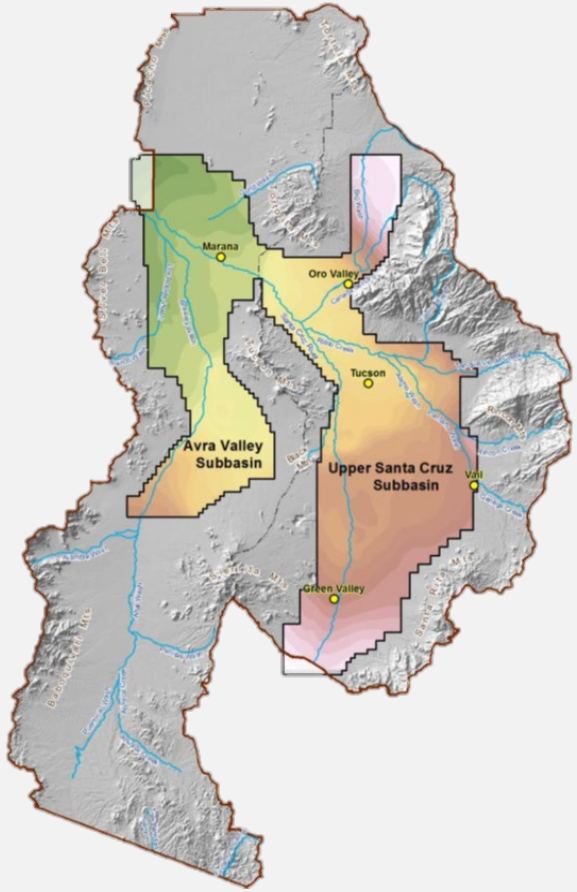
- Incidental Recharge

ADWR TAMA Groundwater Model



Outflow

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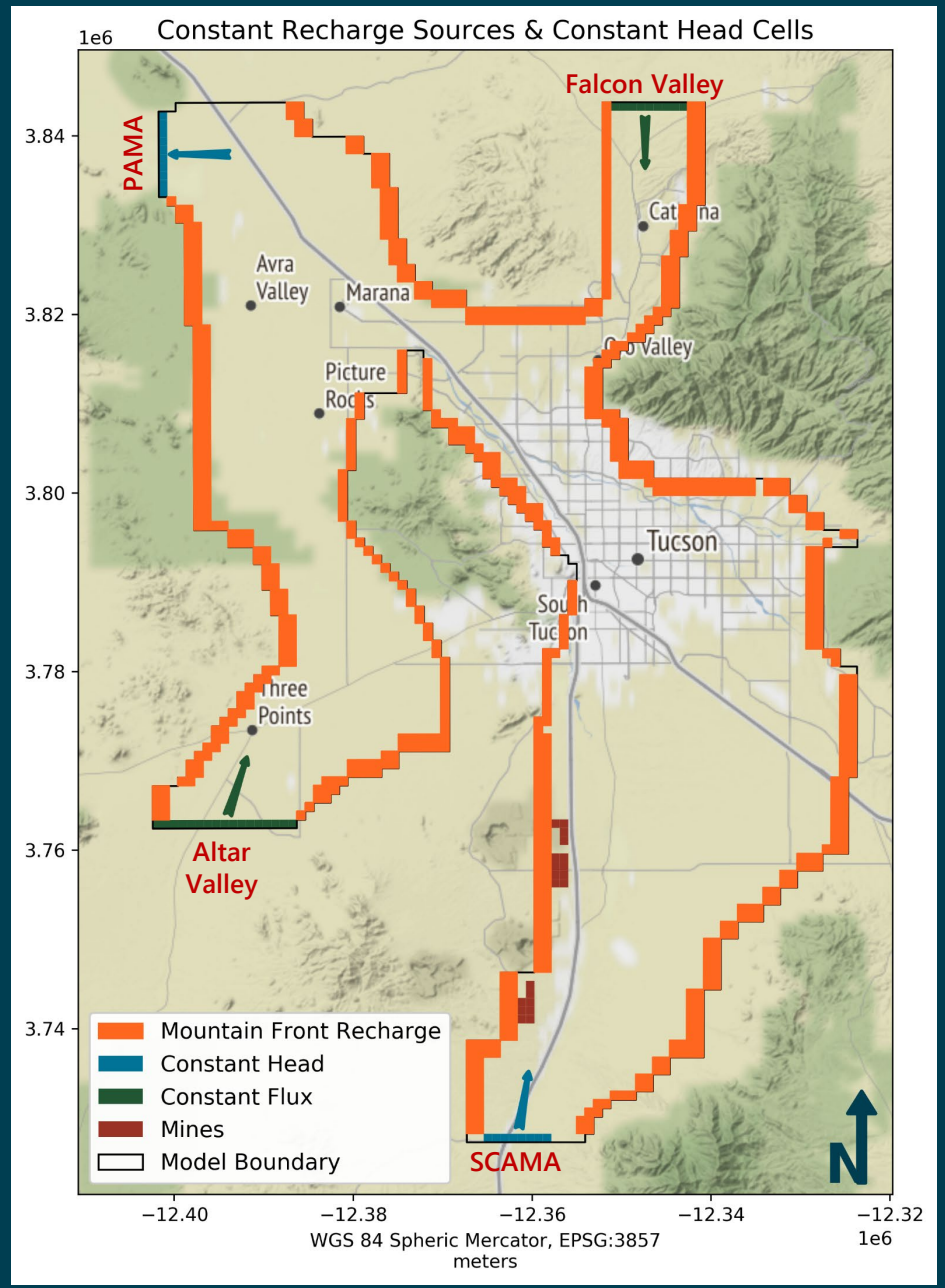
- Underflow to other basins

Drivers:

Primarily Socio-Economic Forces | Primarily Climate | Estimated within Model

Constant Groundwater Elev. & Recharge

- Constant Elev. Boundaries
  - Flow into TAMA from SCAMA (~20 TAF/yr)
  - Flow from TAMA into PAMA (~-26 TAF/yr)
- Underflow (10 TAF/yr)
  - Altar & Falcon Valleys
- Mountain Front Recharge (27 TAF/yr)
  - Excludes recharge from major streams
- Mine Tailings Ponds (8 TAF/yr)



Groundwater Model Components

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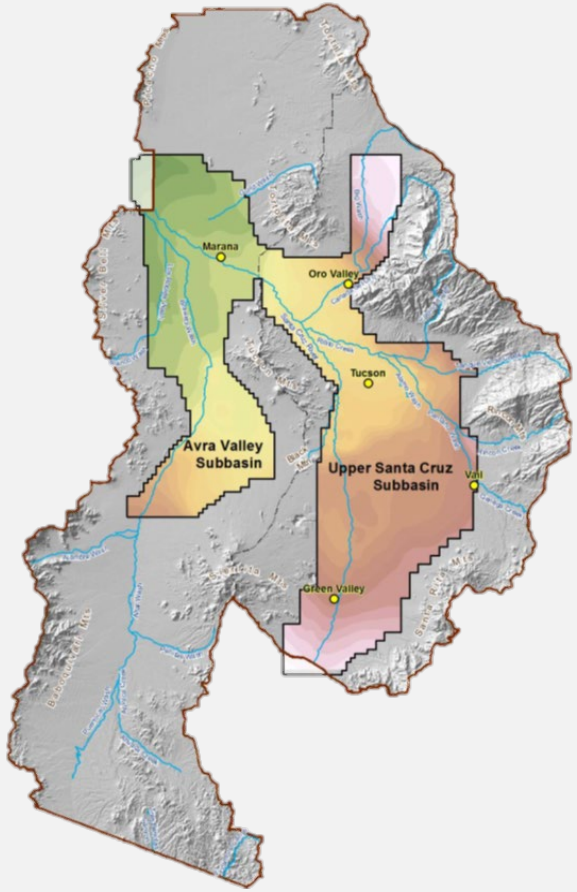


Outflow

- Pumping (Municipal, Industrial, Agricultural)
- Evapotranspiration by Riparian Areas
- Underflow to other basins

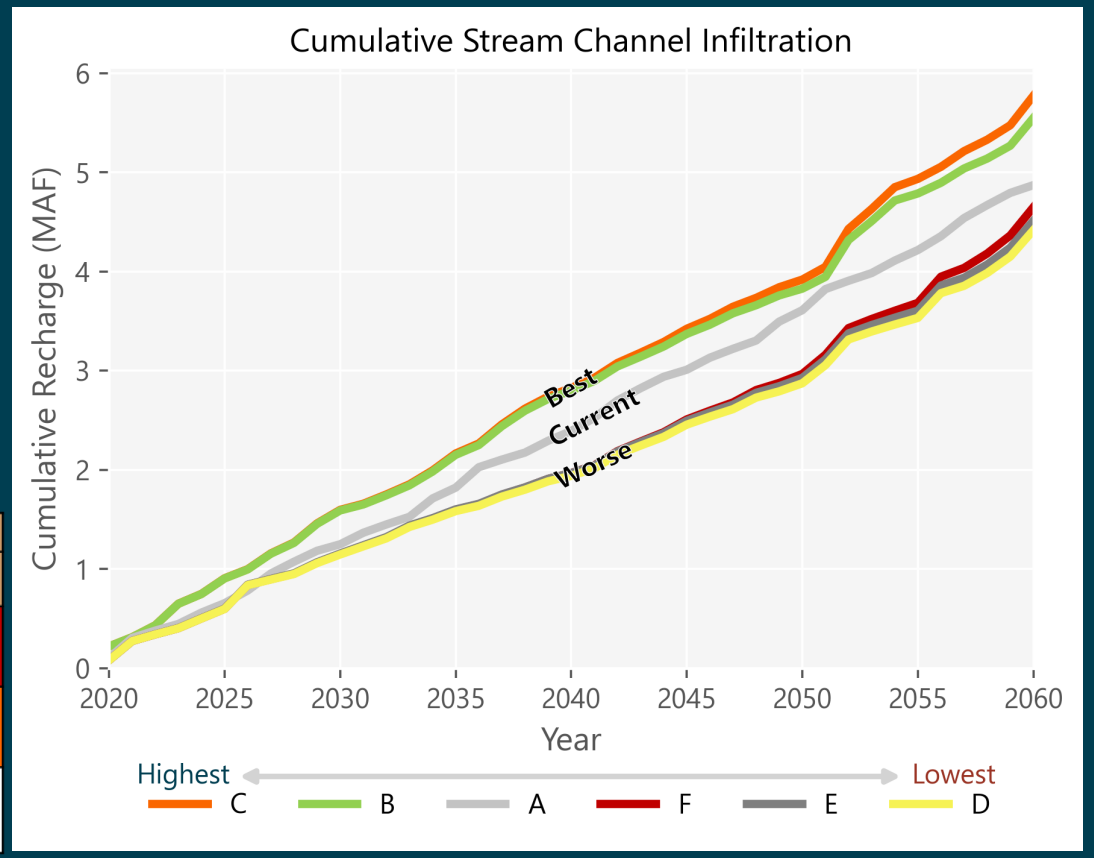
Drivers:

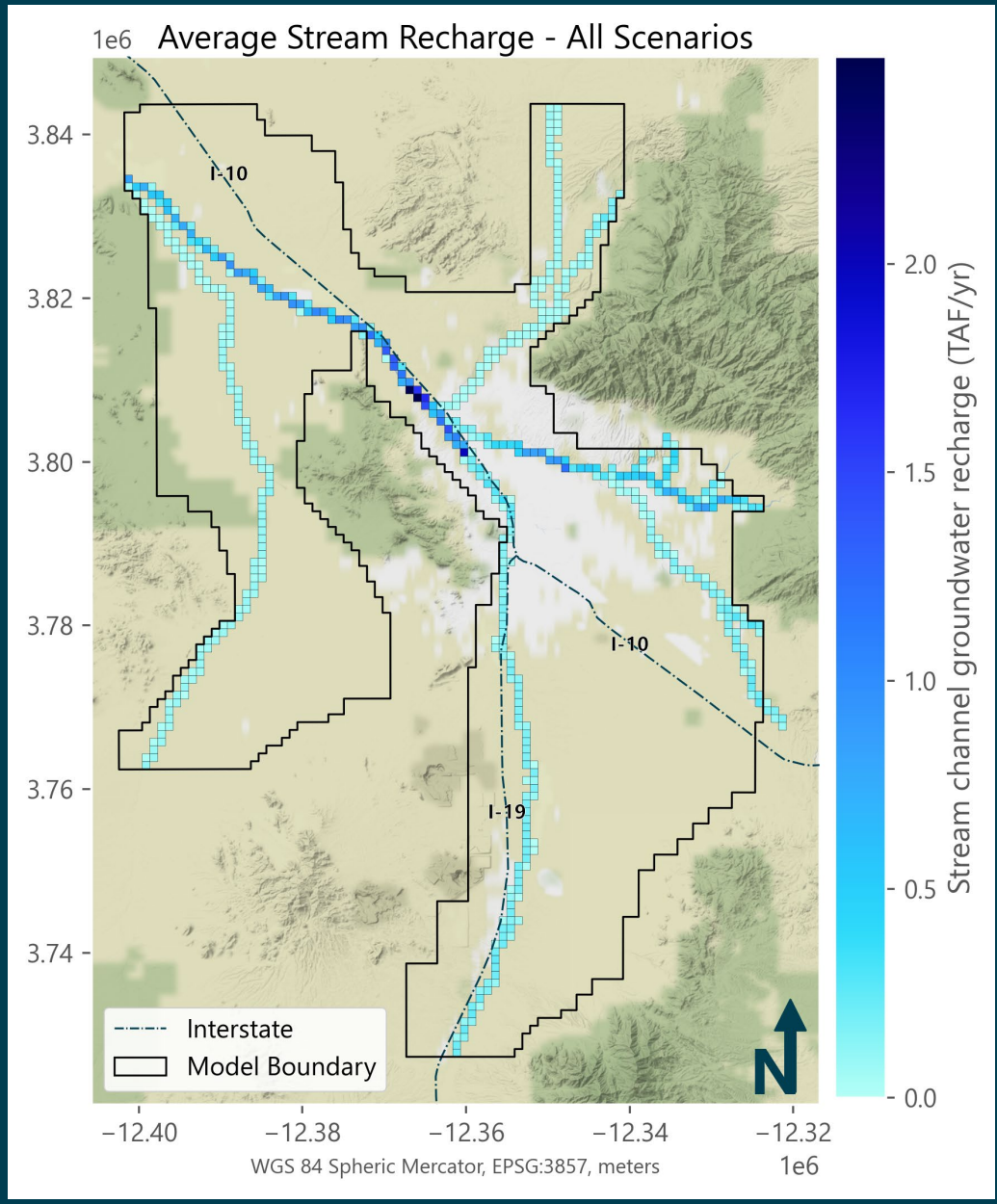
Primarily Socio-Economic Forces | Primarily Climate | Estimated within Model

Stream Channel Infiltration

- Wastewater discharge projections from CAP
- Streamflow from climate projections and historic simulation

Climate	Demand Growth: Slow, Compact	Demand Growth: Medium, Official	Demand Growth: Rapid, Outward
Worse Case	D	E	F
Best Case	B		C
Current Climate		A	





Groundwater Model Components

Inflows

- Mountain Front Recharge
- Stream Infiltration
- Underflow from other basins
- Artificial Recharge (CAP and effluent)
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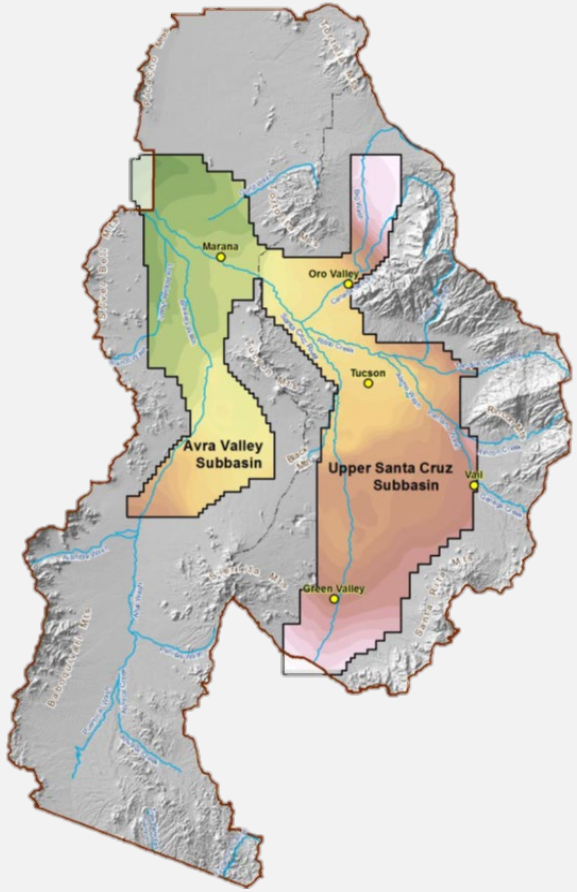
ADWR TAMA Groundwater Model



Outflow

- Pumping (Municipal, Industrial, Agricultural)
- Evapotranspiration by Riparian Areas
- Underflow to other basins

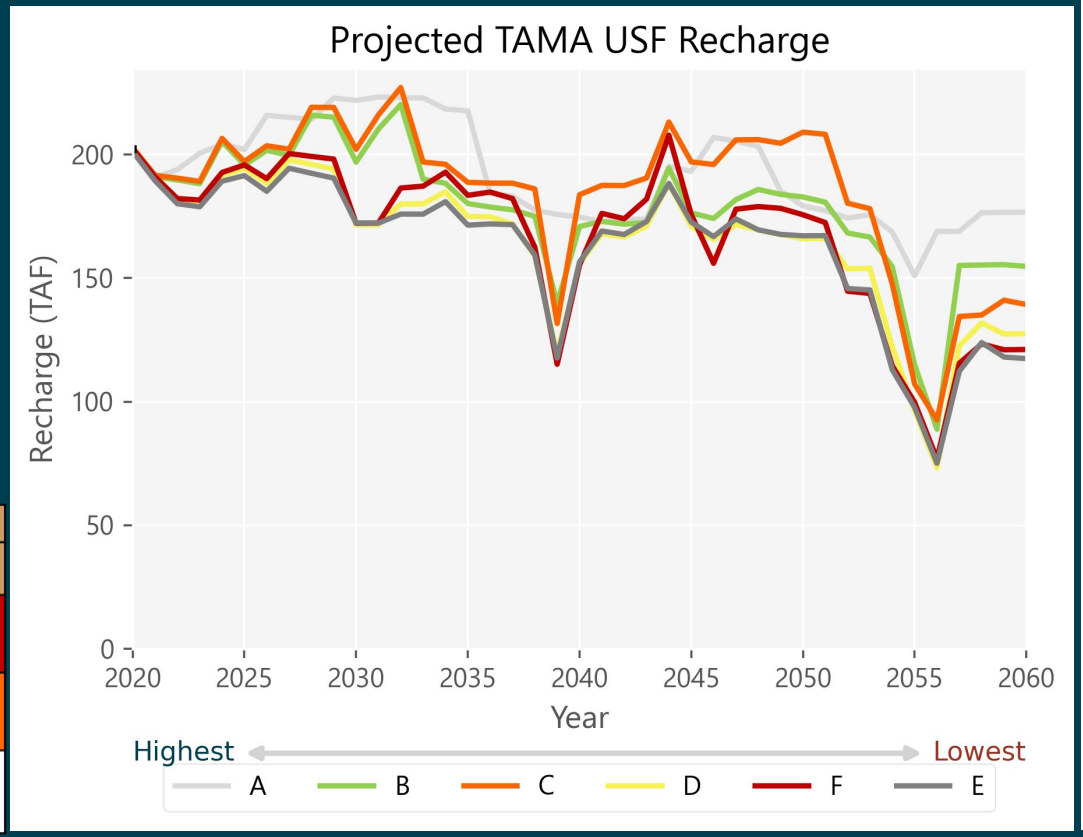
Drivers:

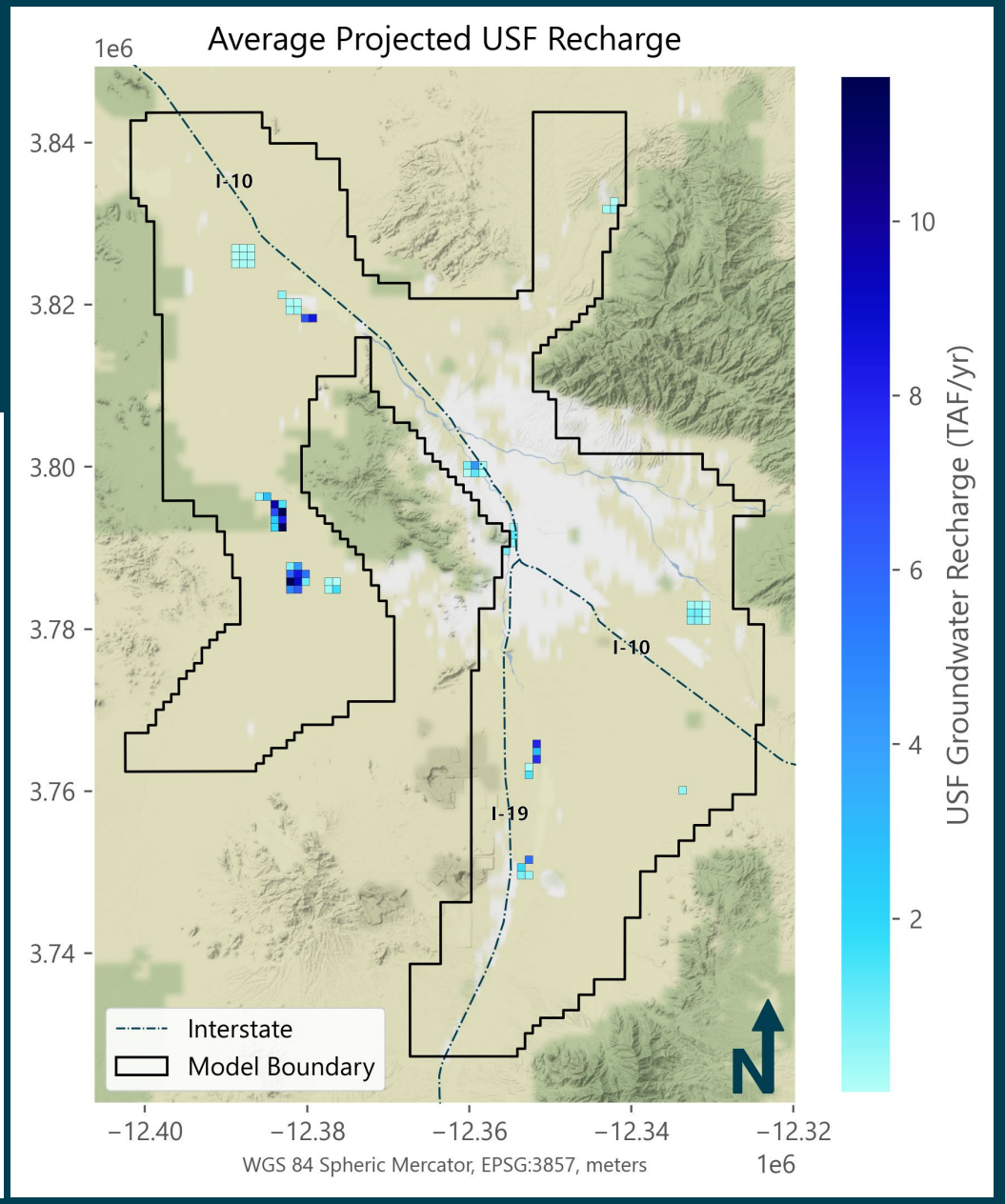
Primarily Socio-Economic Forces | Primarily Climate | Estimated within Model

Underground Storage Facilities (USF) Recharge

- Recharge projections from CAP

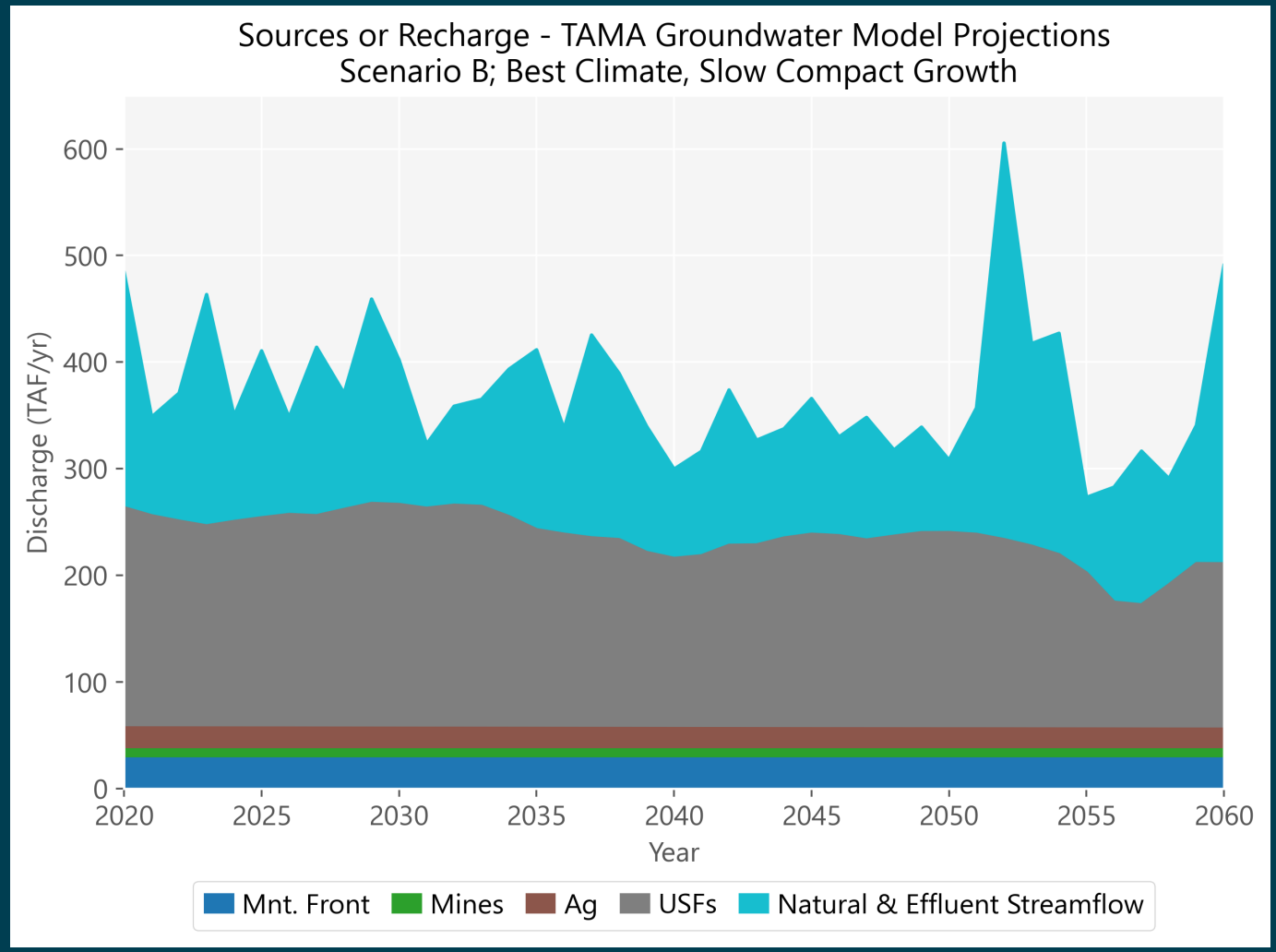
Climate	Demand Growth: Slow, Compact	Demand Growth: Medium, Official	Demand Growth: Rapid, Outward
Worse Case	D	E	F
Best Case	B		C
Current Climate		A	





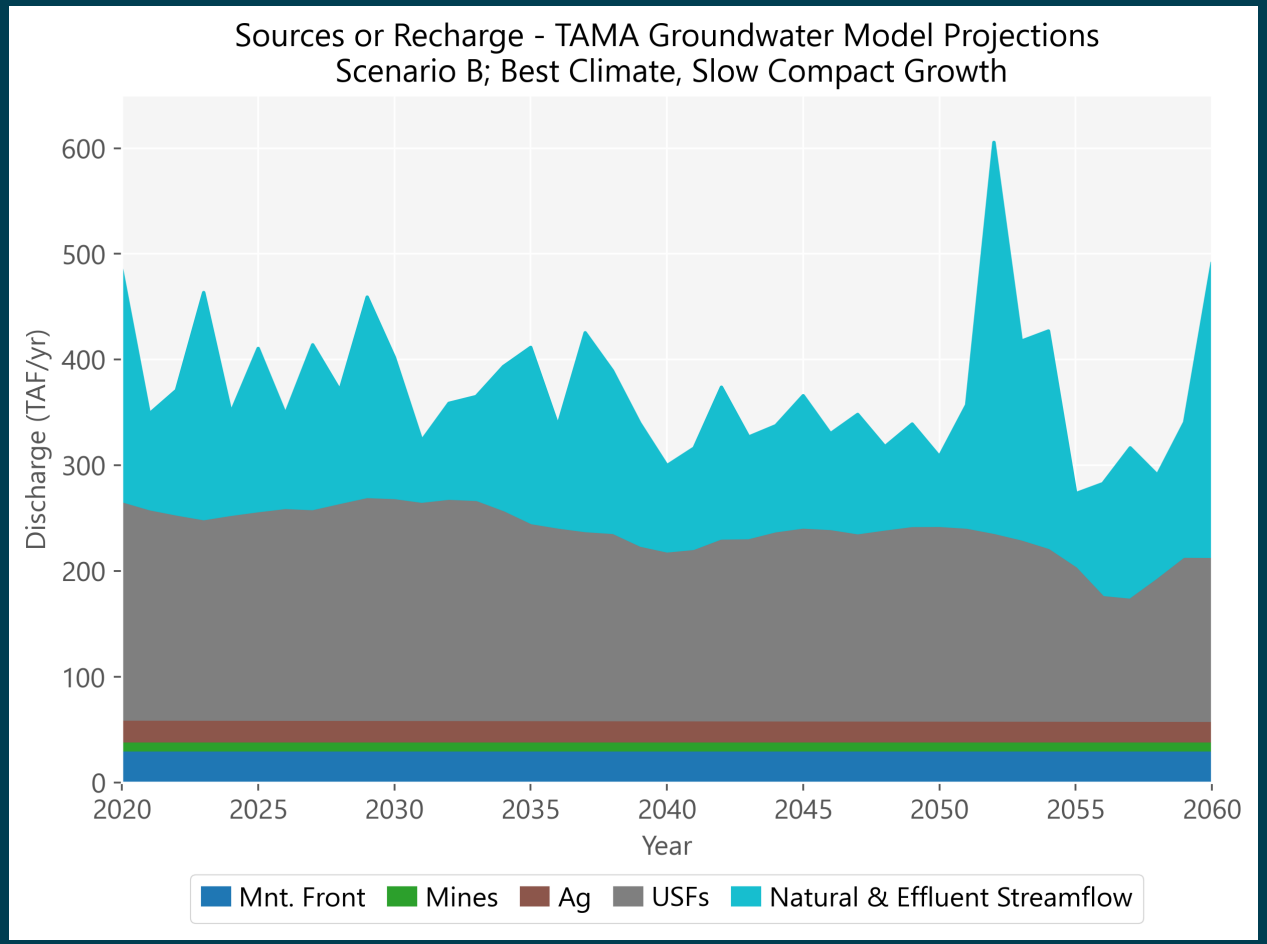
Major Sources of Recharge

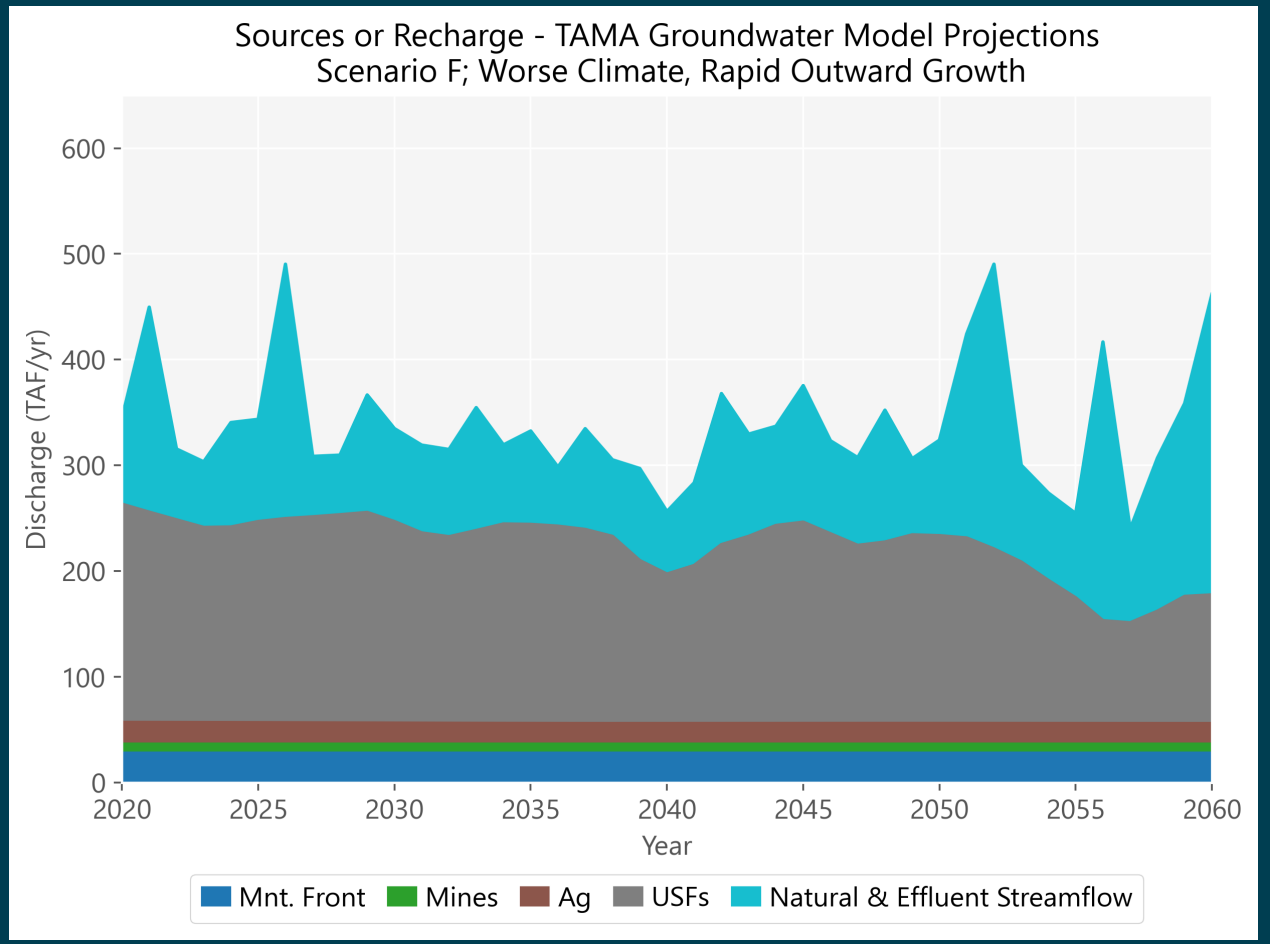
- Constant Rates:
  - Mountain front recharge
  - Mine tailings ponds
- Variable Rates:
  - Ag (Commercial, Tribal, IGFR)
  - USFs (CAP and effluent sources)
  - Natural streamflow based on climate projections and projections of effluent discharge to Santa Cruz River



Major Sources of Recharge continued

- Compare low risk (Scn. B) vs. high risk (Scn. F)

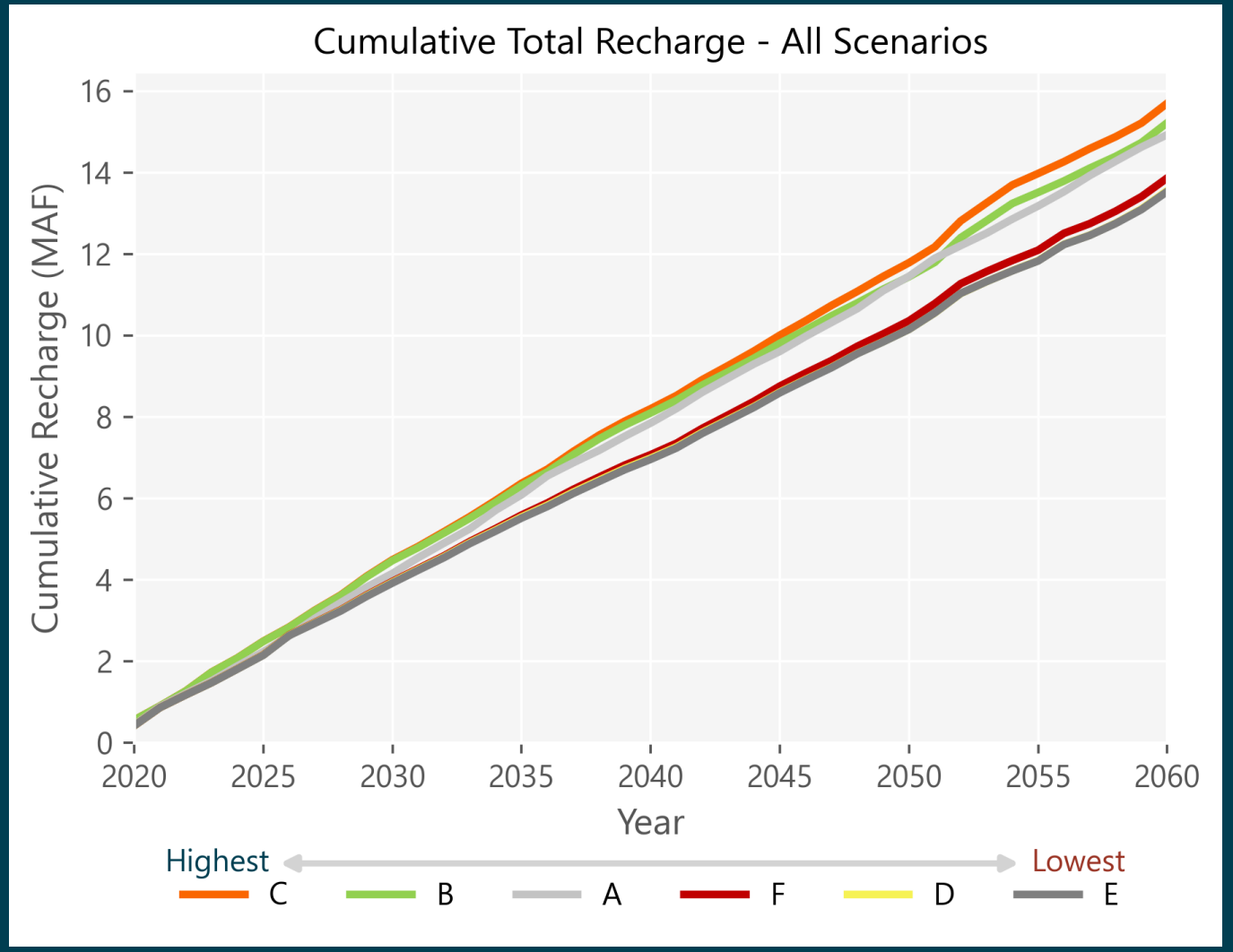




Groundwater Recharge Projections

- Total recharge from:
  - Streamflow, USFs, WWTP Discharge, Ag, Mountain fronts, and Mine tailings ponds
- Typical High Rate (Scenario C): 370 TAF/yr
- Typical Low Rate (Scenario E): 315 TAF/yr

Climate	Demand Growth: Slow, Compact	Demand Growth: Medium, Official	Demand Growth: Rapid, Outward
Worse Case	D	E	F
Best Case	B		C
Current Climate		A	



Groundwater Model Components

Inflows

- Mountain Front Recharge
- Stream Infiltration
- Underflow from other basins
- Artificial Recharge (CAP and effluent)
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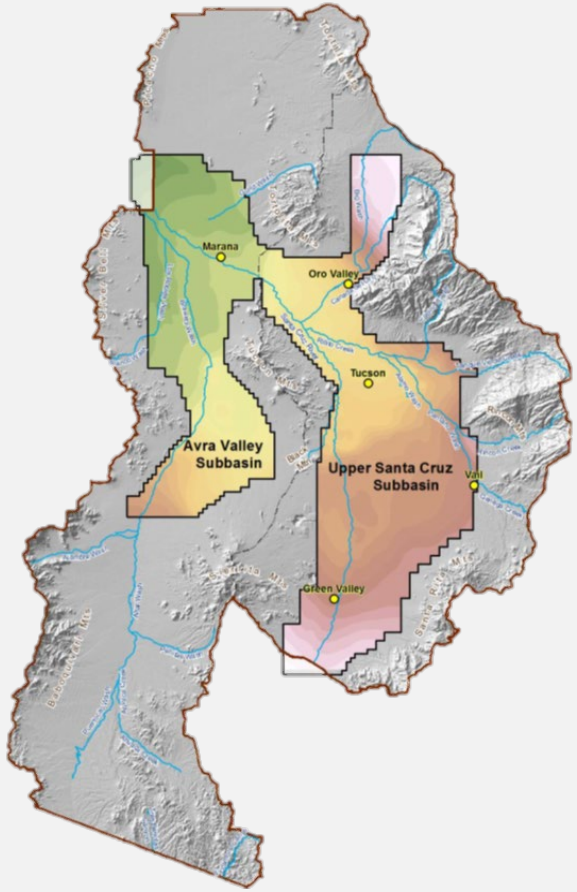
ADWR TAMA Groundwater Model



Outflow

- Pumping (Municipal, Industrial, Agricultural)
- Evapotranspiration by Riparian Areas
- Underflow to other basins

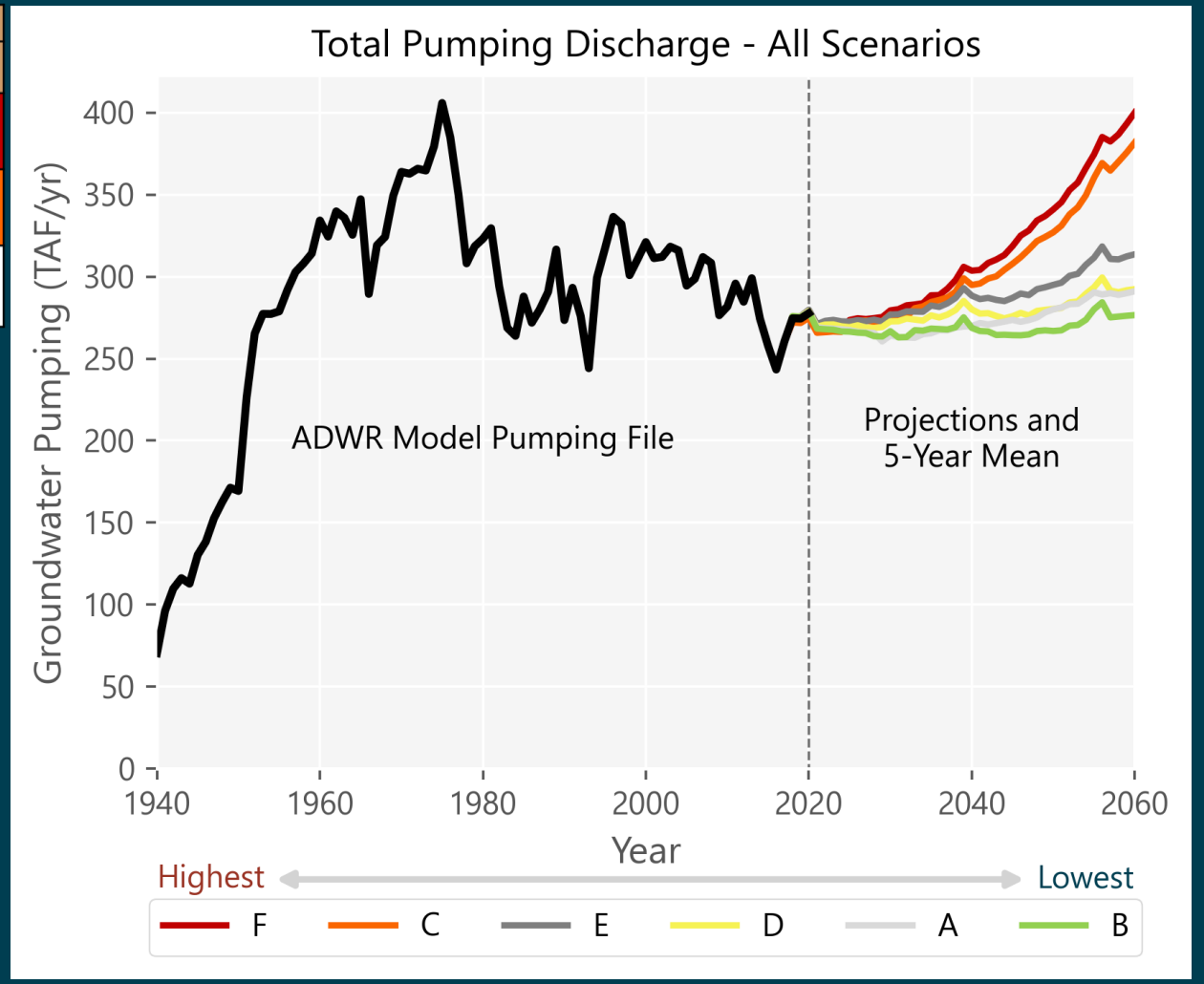
Drivers:

Primarily Socio-Economic Forces | Primarily Climate | Estimated within Model

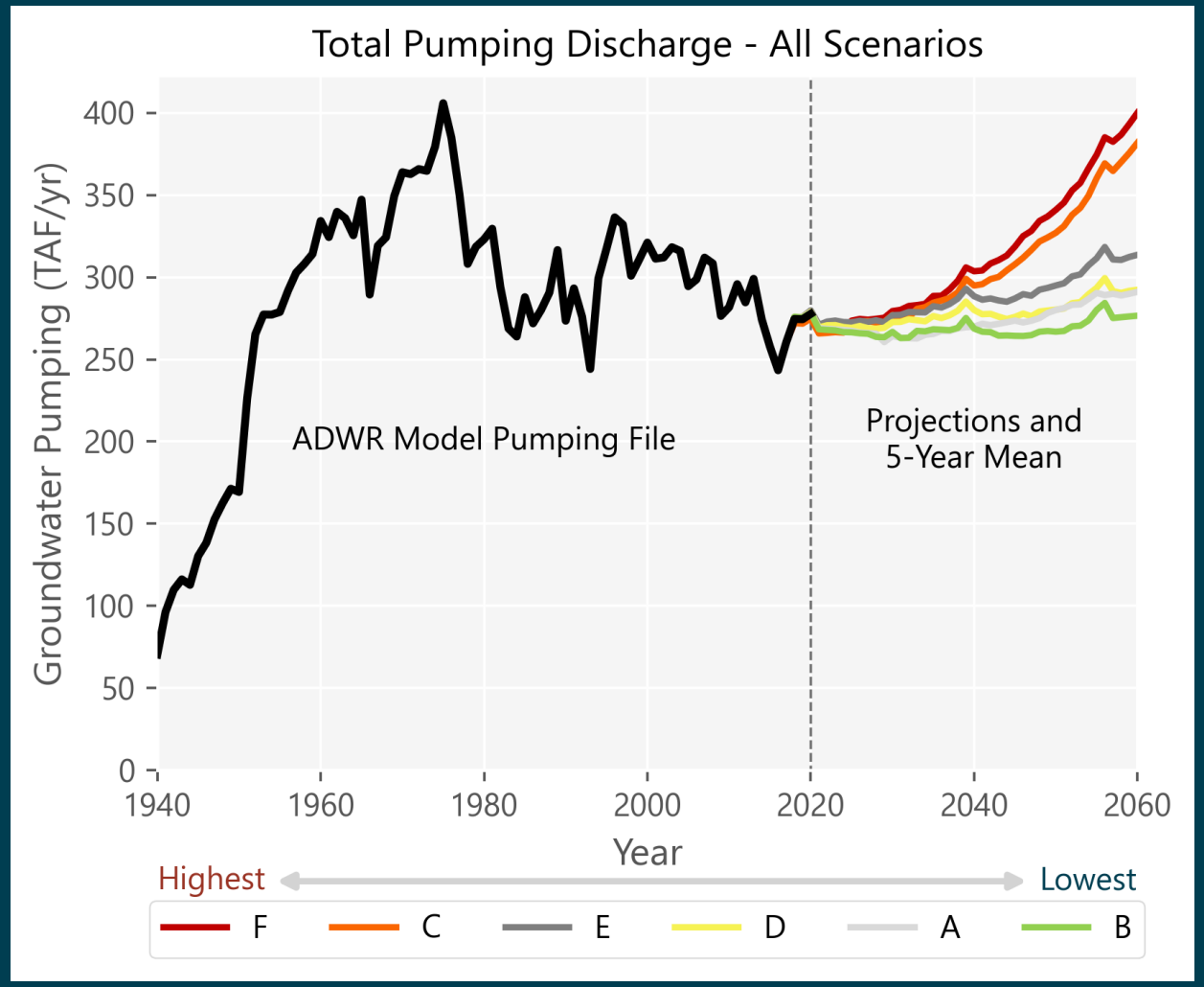
Pumping Projections

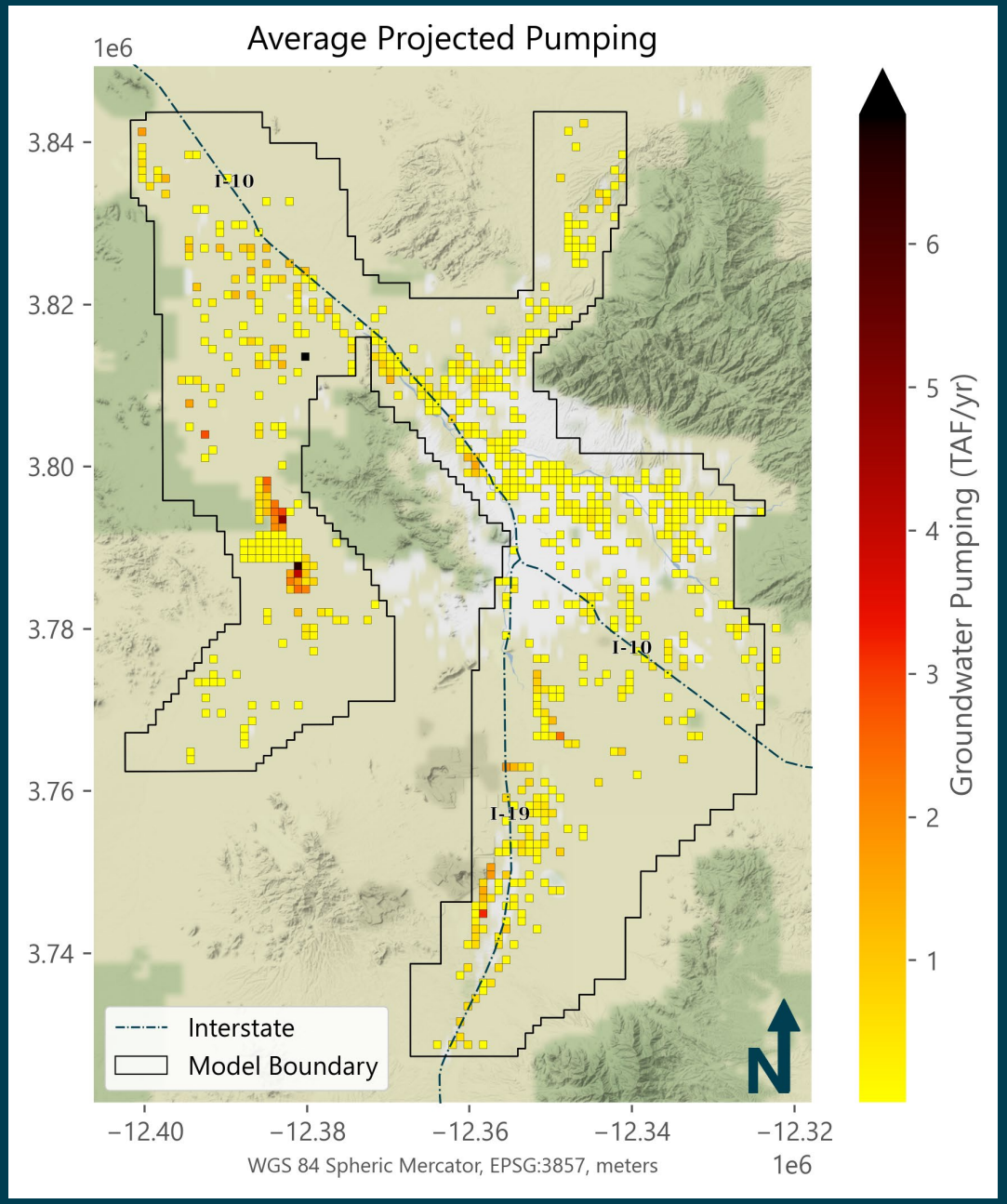
- Projections to 2060 (inside TAMA) include:
  - Municipal
  - Agricultural
  - Stored Water Recovery (Nevada, Phoenix)
  - Mining (Scns. C & F)
- Constant Pumping
  - 5-yr historic average (industrial, turf, some municipal, and ag outside TAMA)

Climate	Demand Growth: Slow, Compact	Demand Growth: Medium, Official	Demand Growth: Rapid, Outward
Worse Case	D	E	F
Best Case	B		C
Current Climate		A	



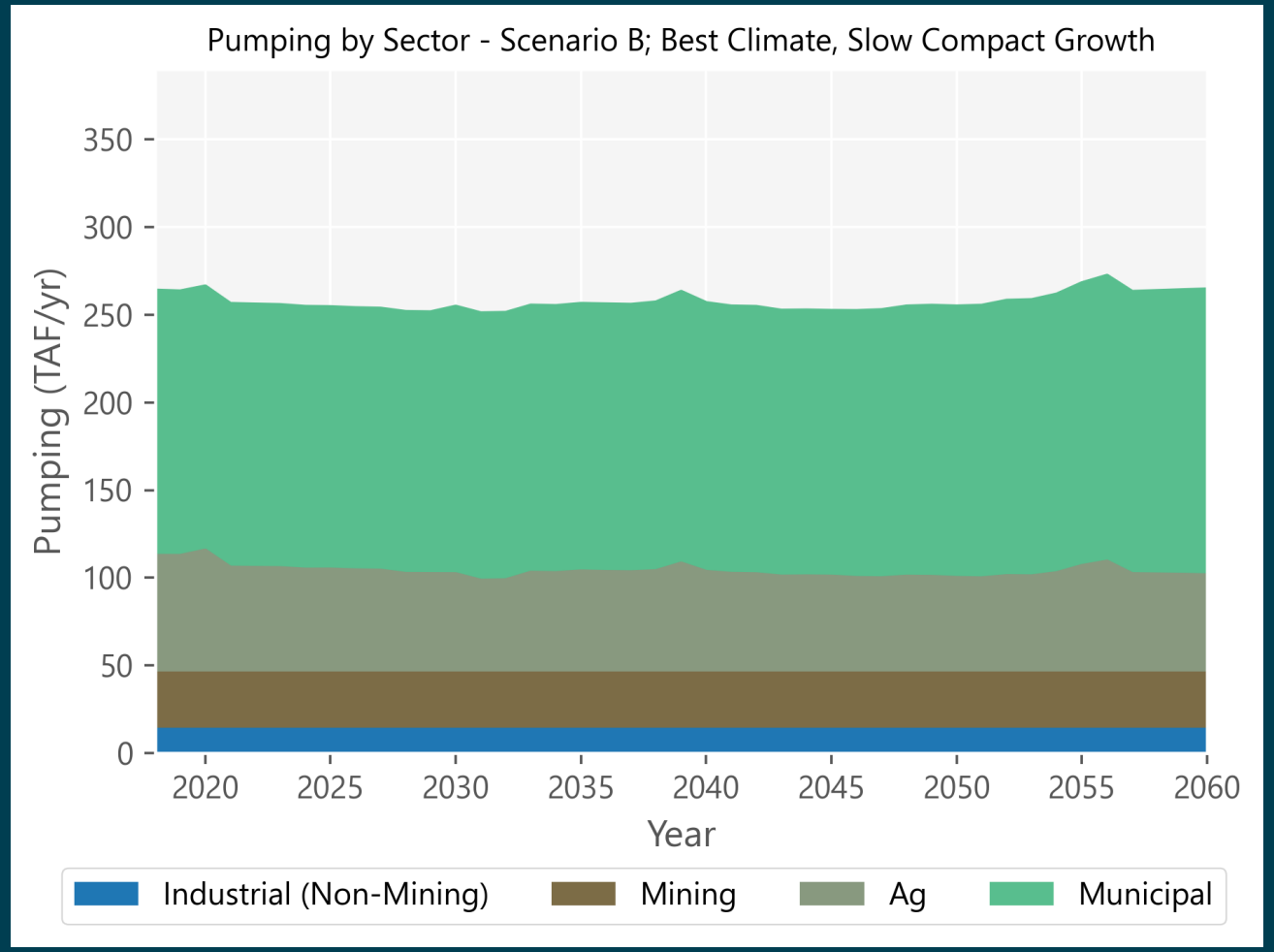
Pumping Projections





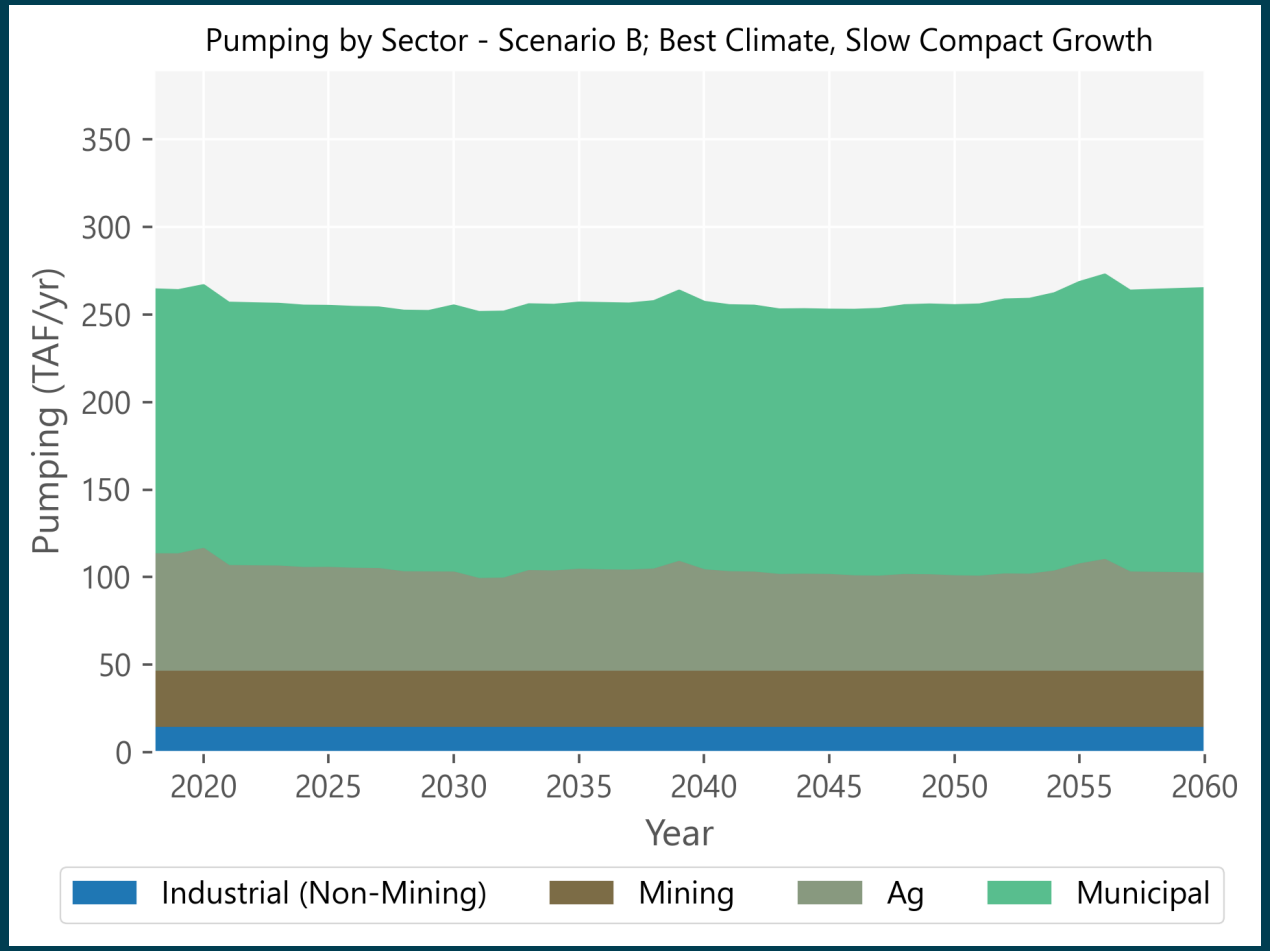
Pumping Projections by Sector, Scenario B

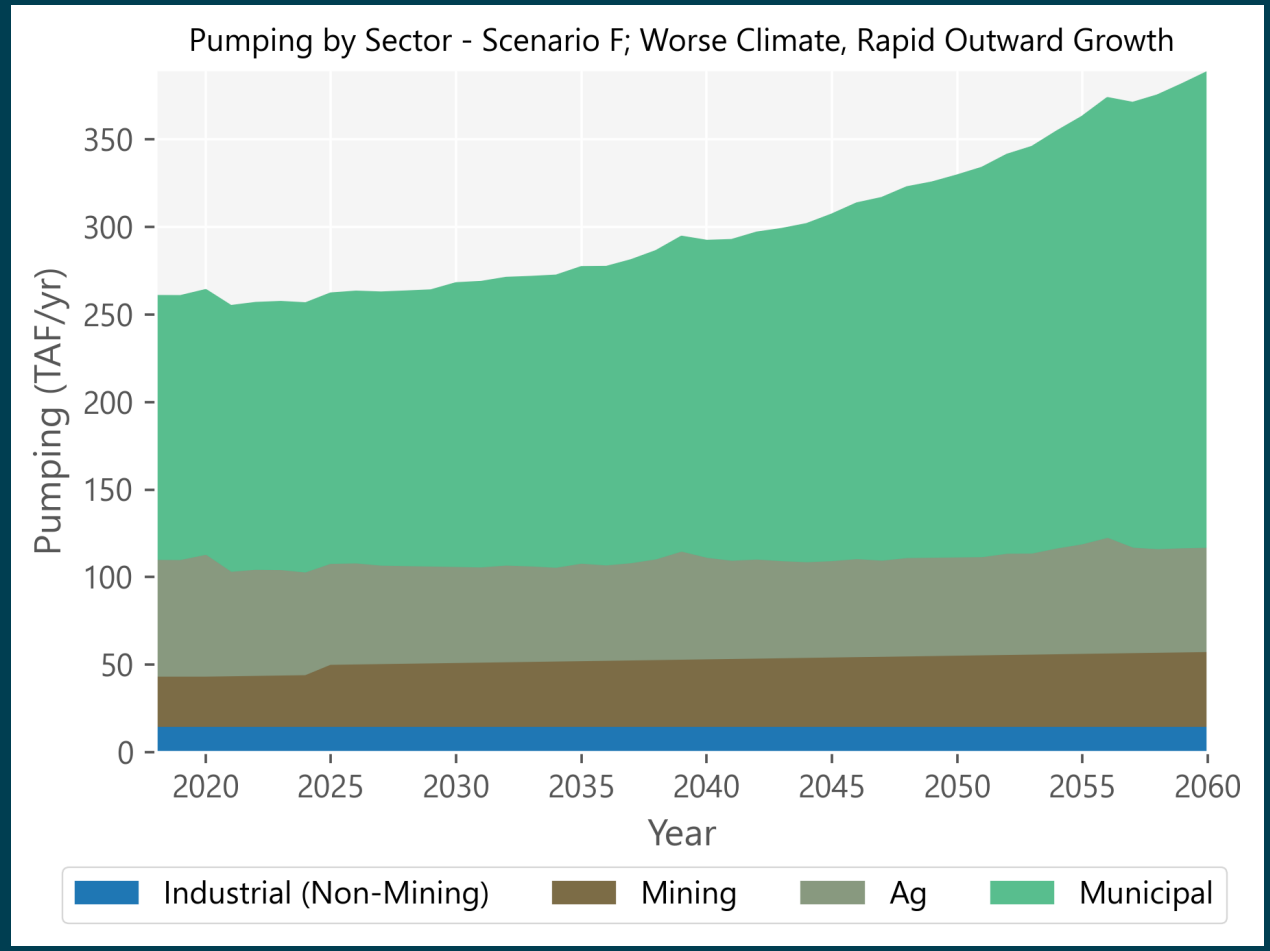
- Municipal
  - Municipal water providers
  - Exempt wells
  - Stored water recovery
- Agricultural
  - Irrigation districts
  - Tribes
  - Individual rights
- Mining
  - Constant
- Industrial
  - General industrial, turf facilities



Comparison of Pumping Projections

- Compare low risk (Scn. B) vs. high risk (Scn. F)





Groundwater Model Components

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- Mountain Front Recharge
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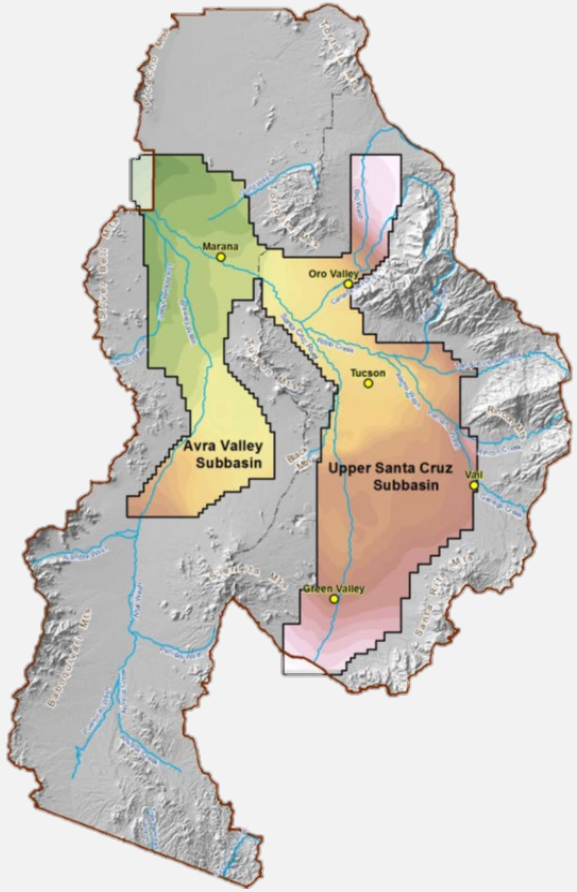
ADWR TAMA Groundwater Model



Outflow

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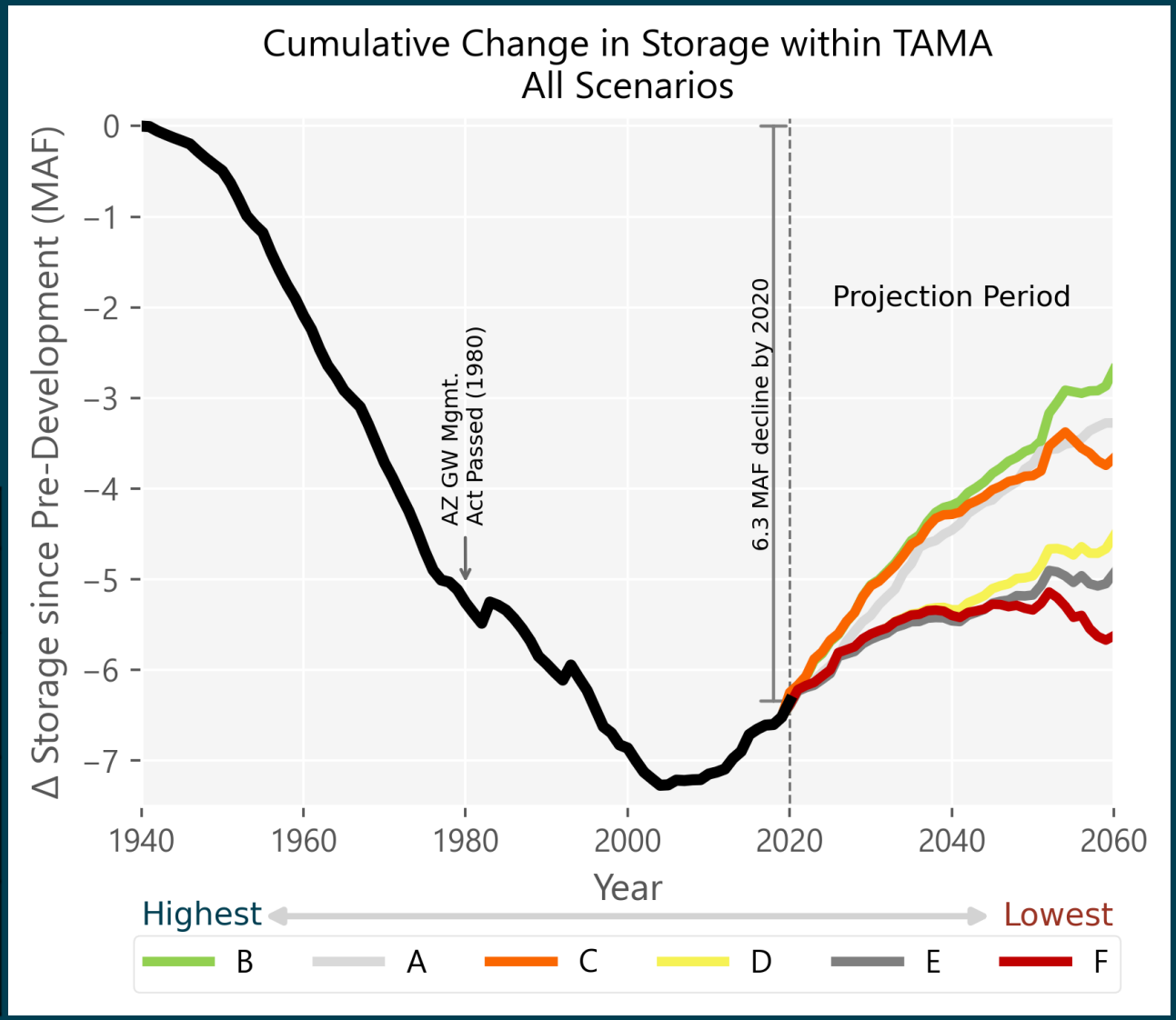
Drivers:

Primarily Socio-Economic Forces | Primarily Climate | Estimated within Model

Groundwater Model Projection Results

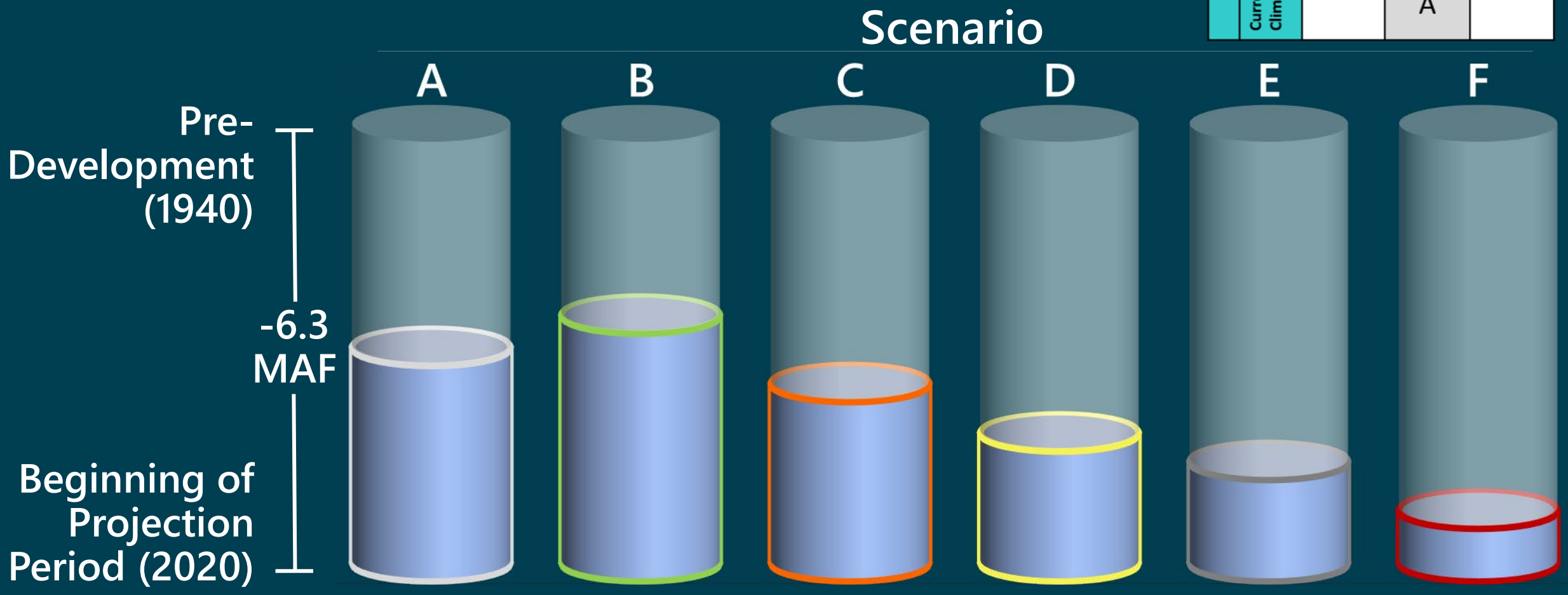
Change in Groundwater Storage 1940 to 2060

Climate	Demand Growth: Slow, Compact	Demand Growth: Medium, Official	Demand Growth: Rapid, Outward
Worse Case	D	E	F
Best Case	B		C
Current Climate		A	

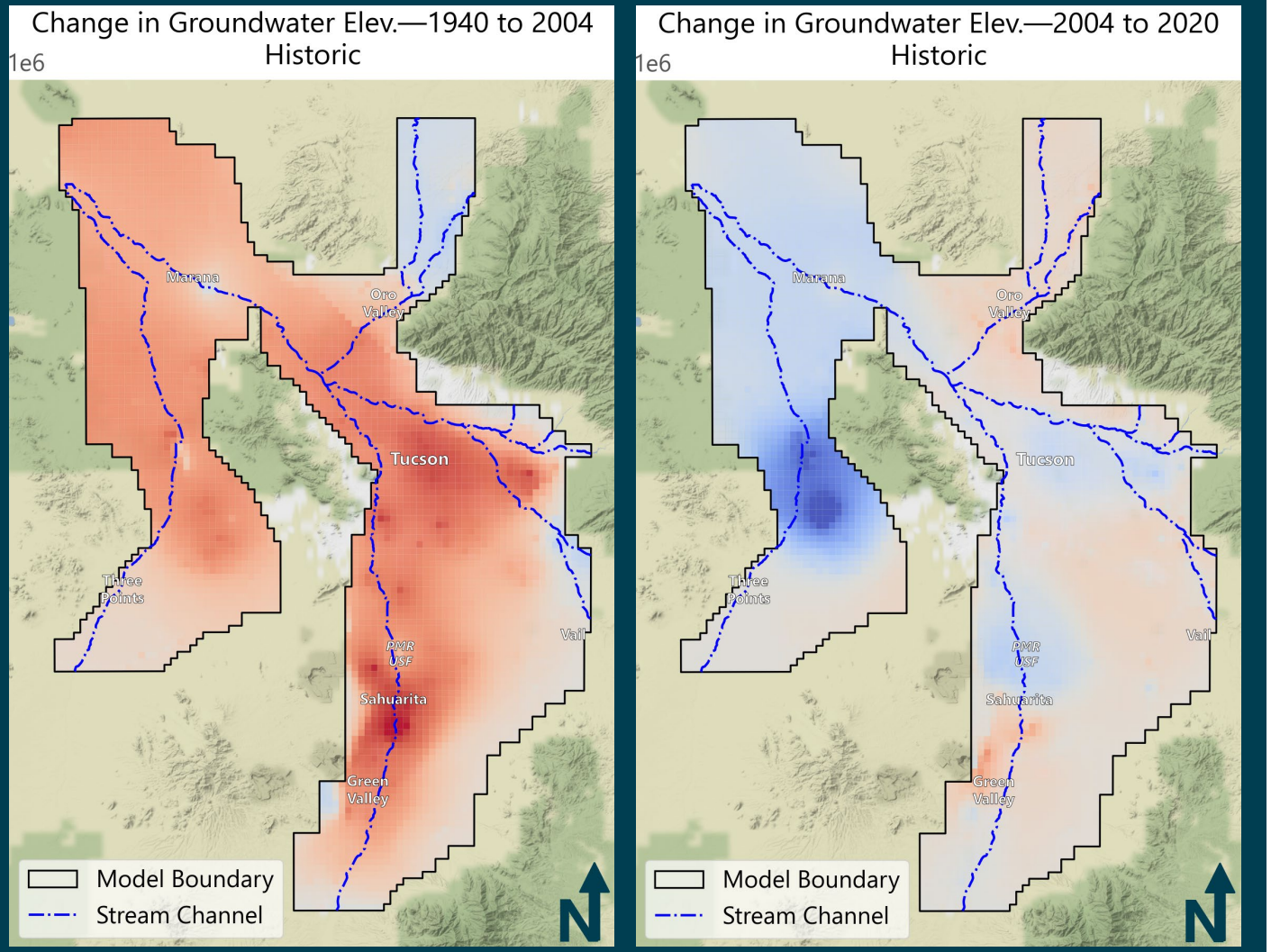


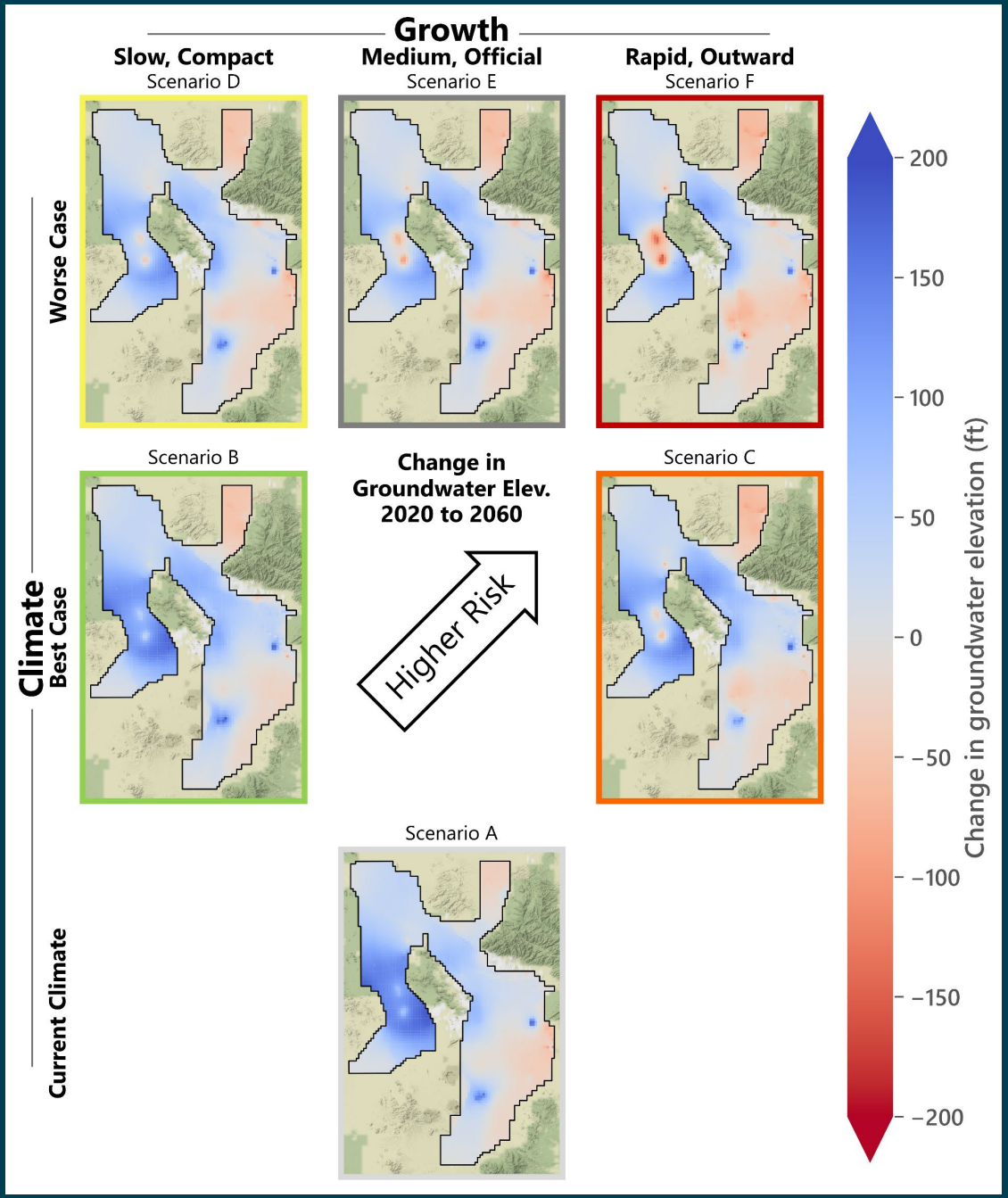
Replenished Groundwater Storage by 2060

Climate	Demand Growth: Slow, Compact	Demand Growth: Medium, Official	Demand Growth: Rapid, Outward
Worse Case	D	E	F
Best Case	B		C
Current Climate		A	



Change in Groundwater Elevation through time





Supply-Demand Basin Study Scenarios, B vs F

A. Official Projections: Medium, mixed-density growth and Current climate

B. Slow, compact growth and Best Case climate

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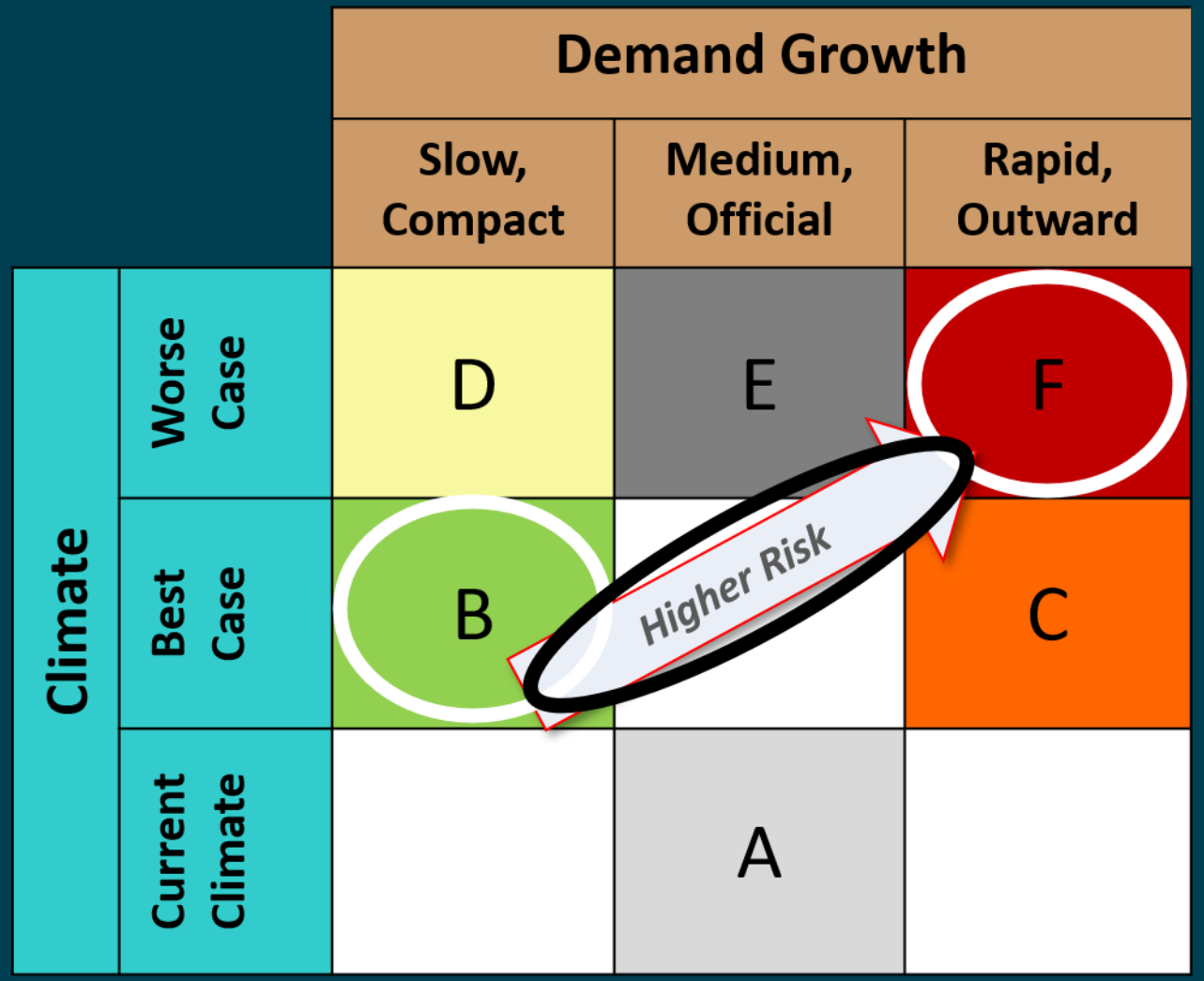
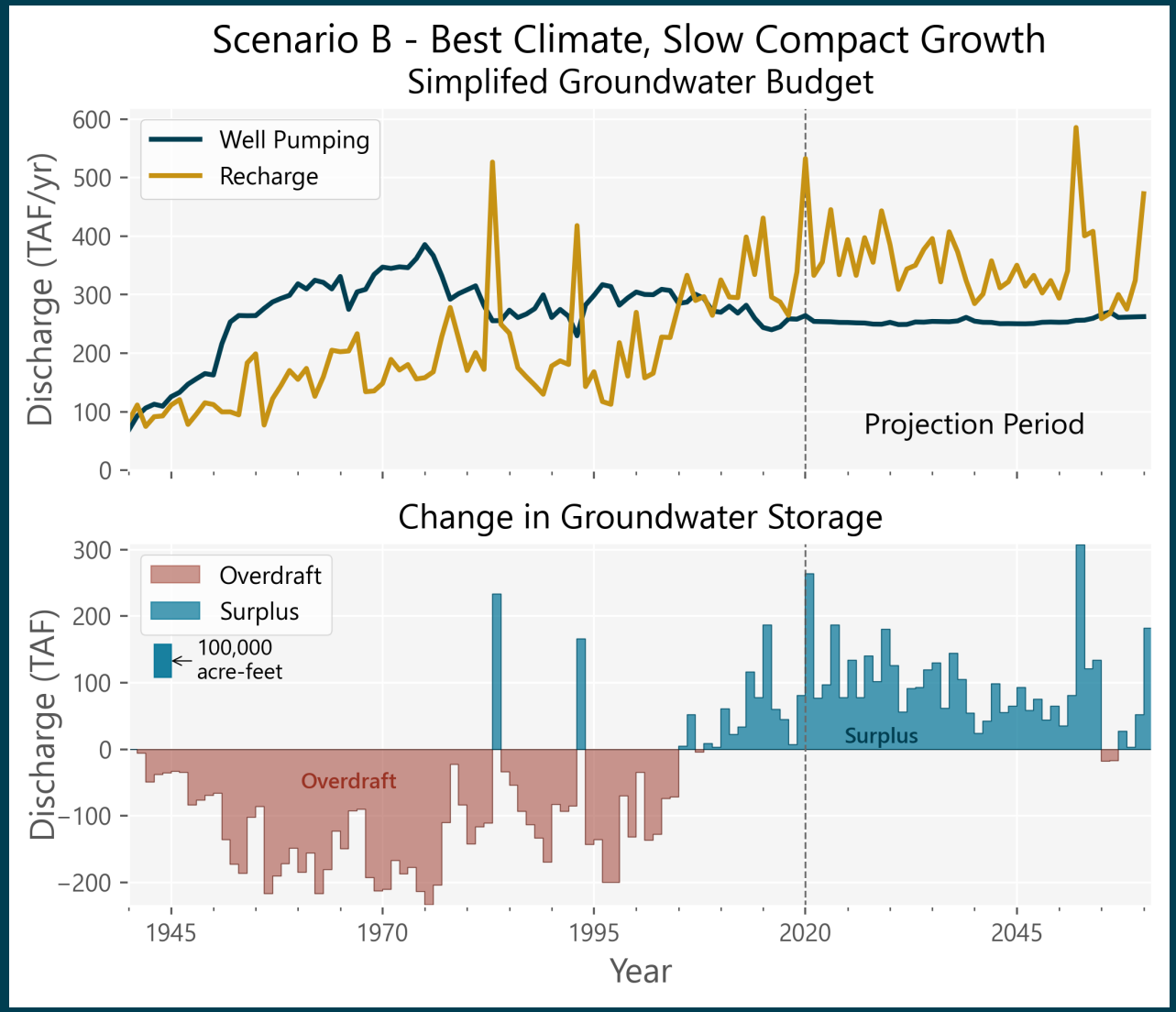
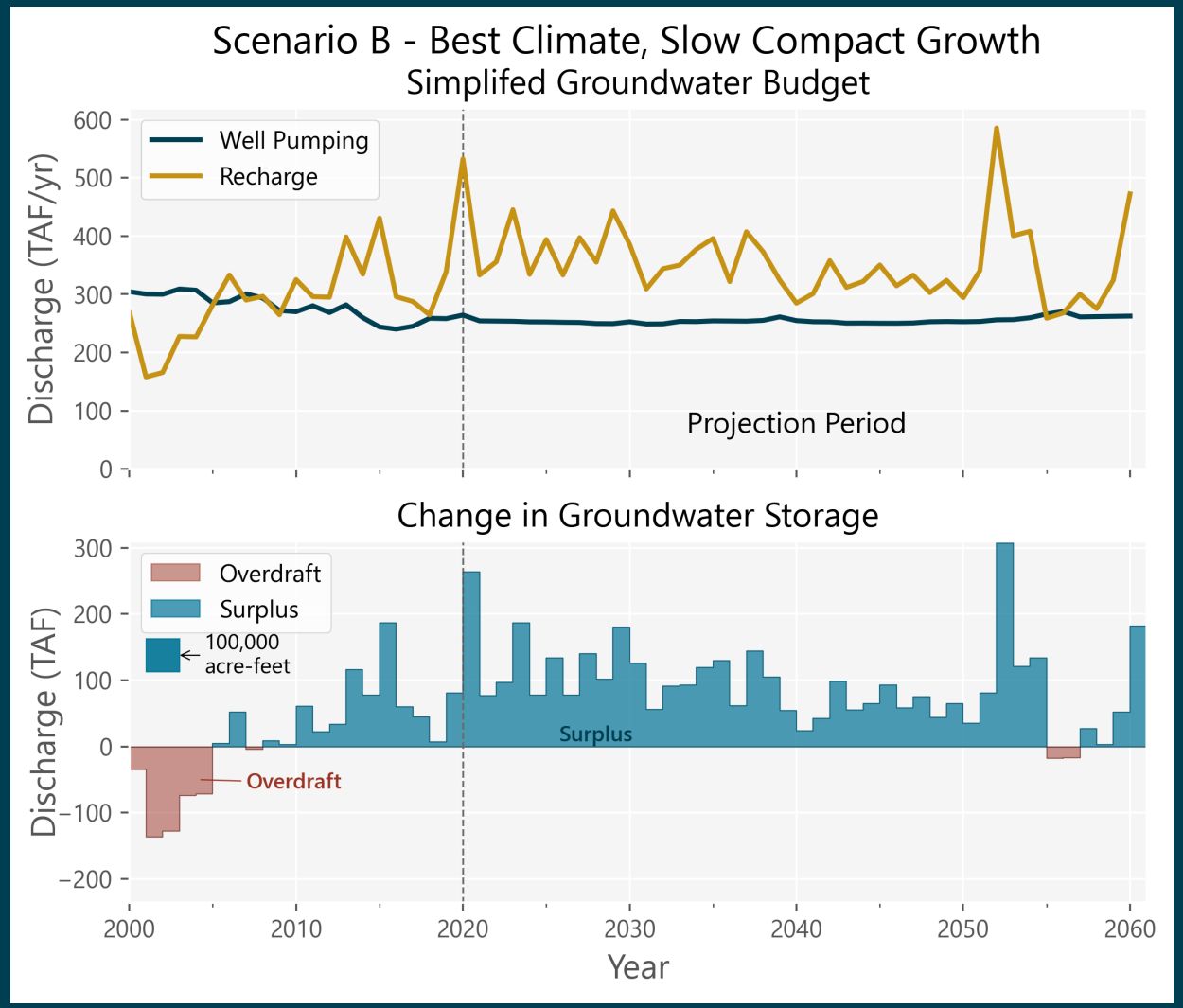


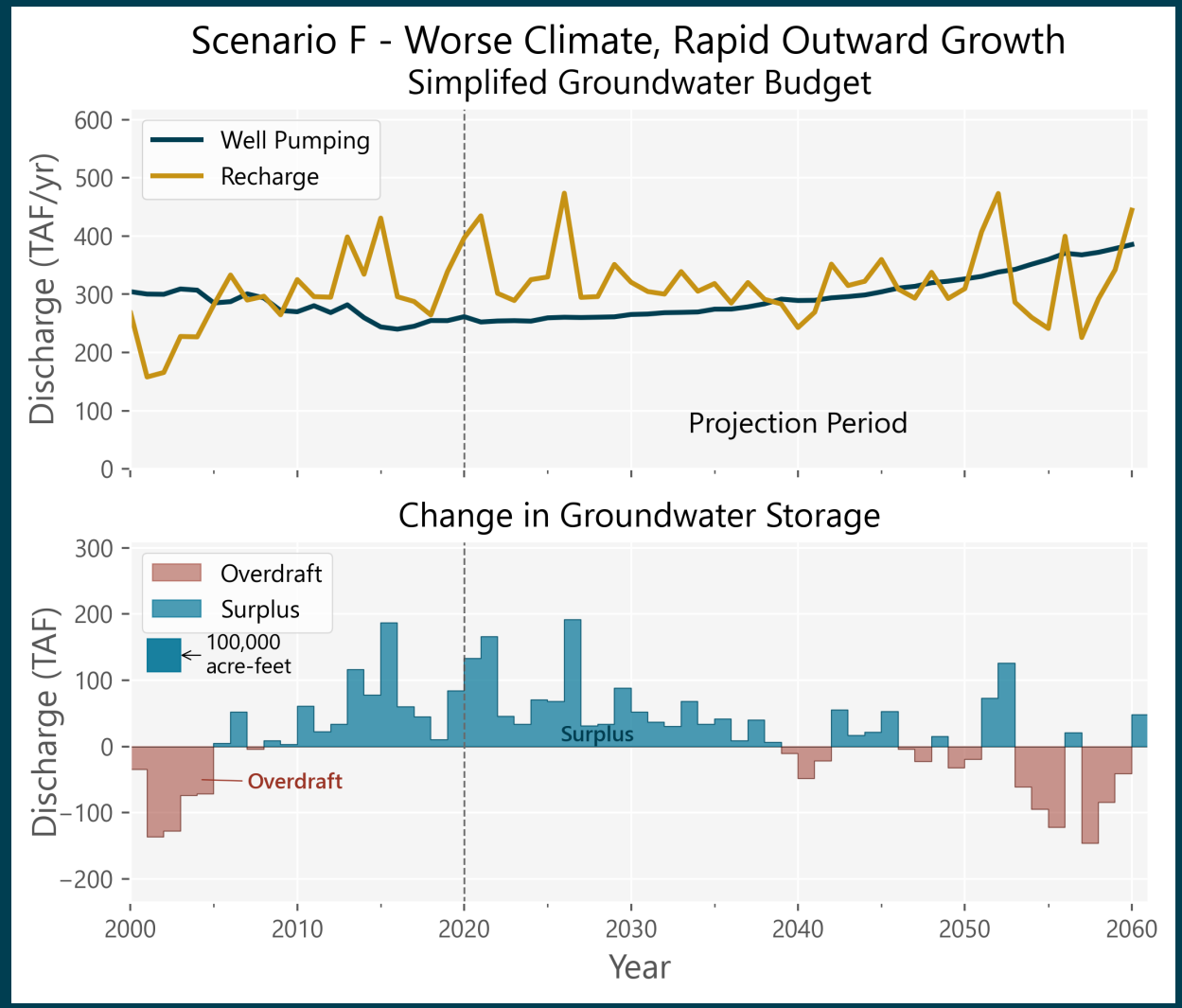
Risk Comparison
TAMA Water Balance

- Minor impacts/discharges excluded from plot
- Outflows remove groundwater
- Inflows add groundwater
- Outflows < Inflows = +ΔStorage = Surplus (Good)
- Outflows > Inflows = -ΔStorage = Overdraft (Bad)

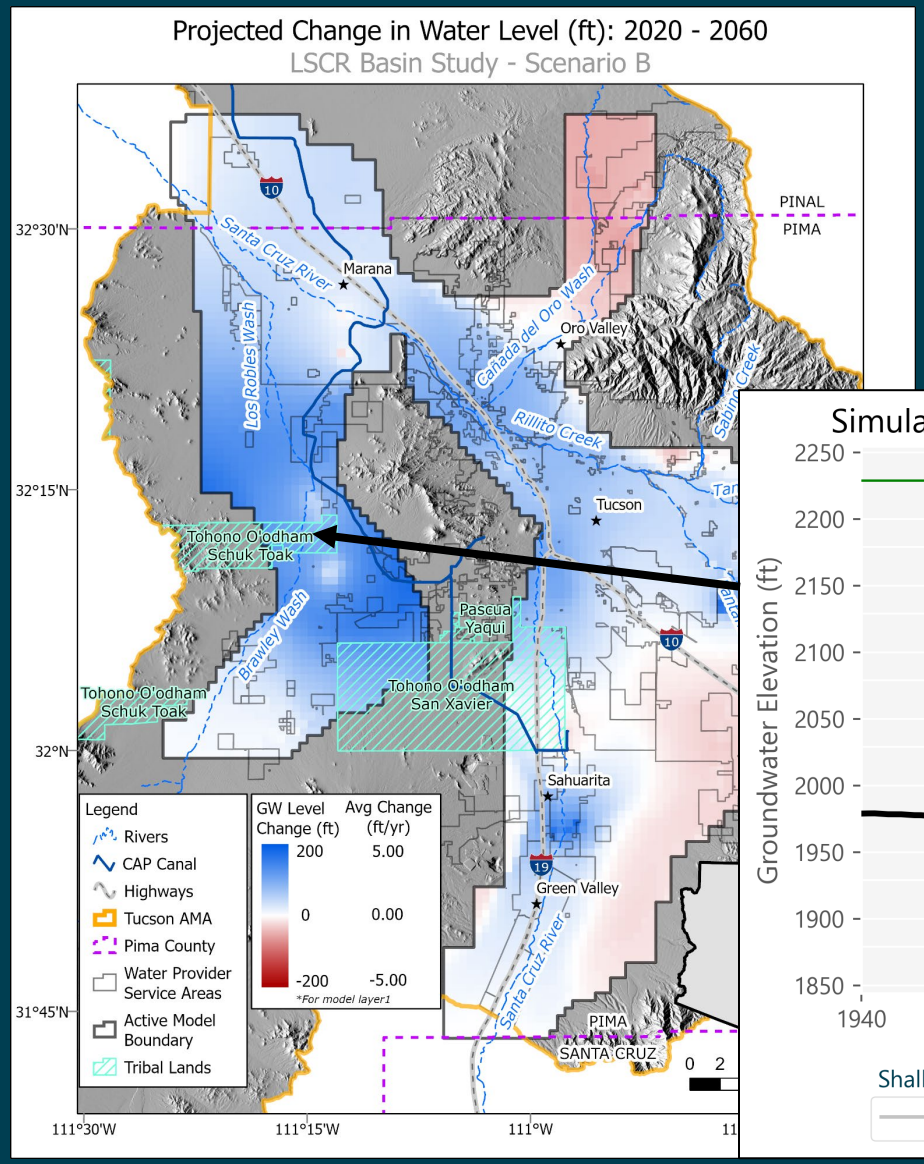


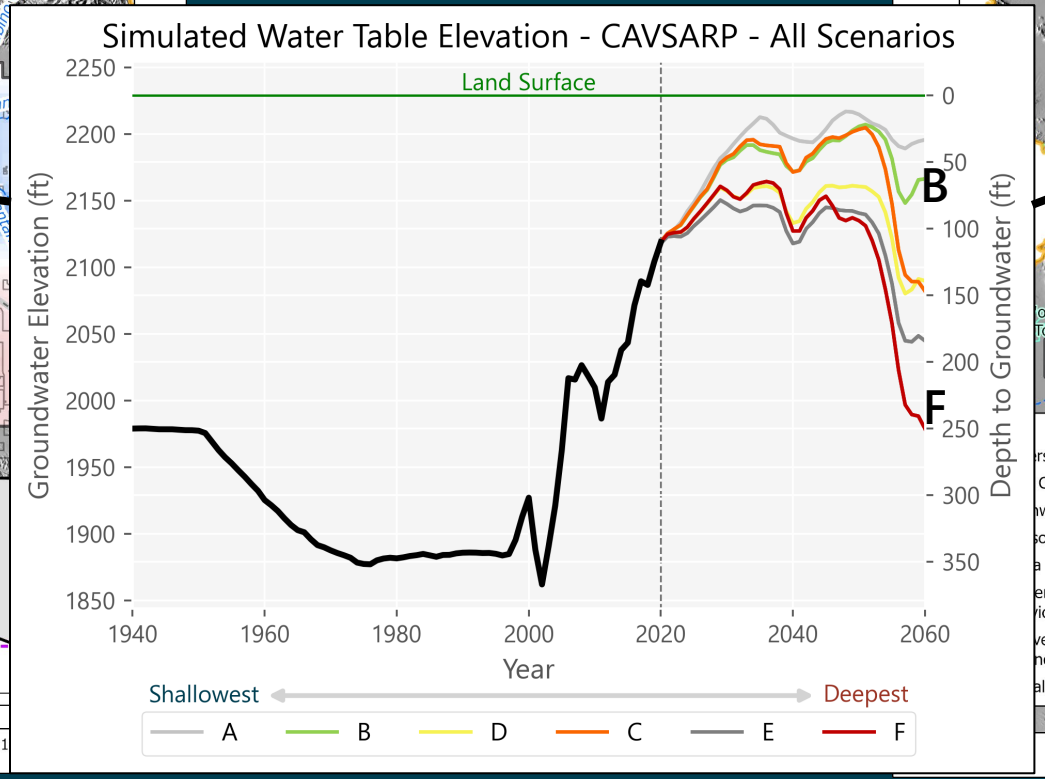
Risk Comparison - TAMA Water Balance

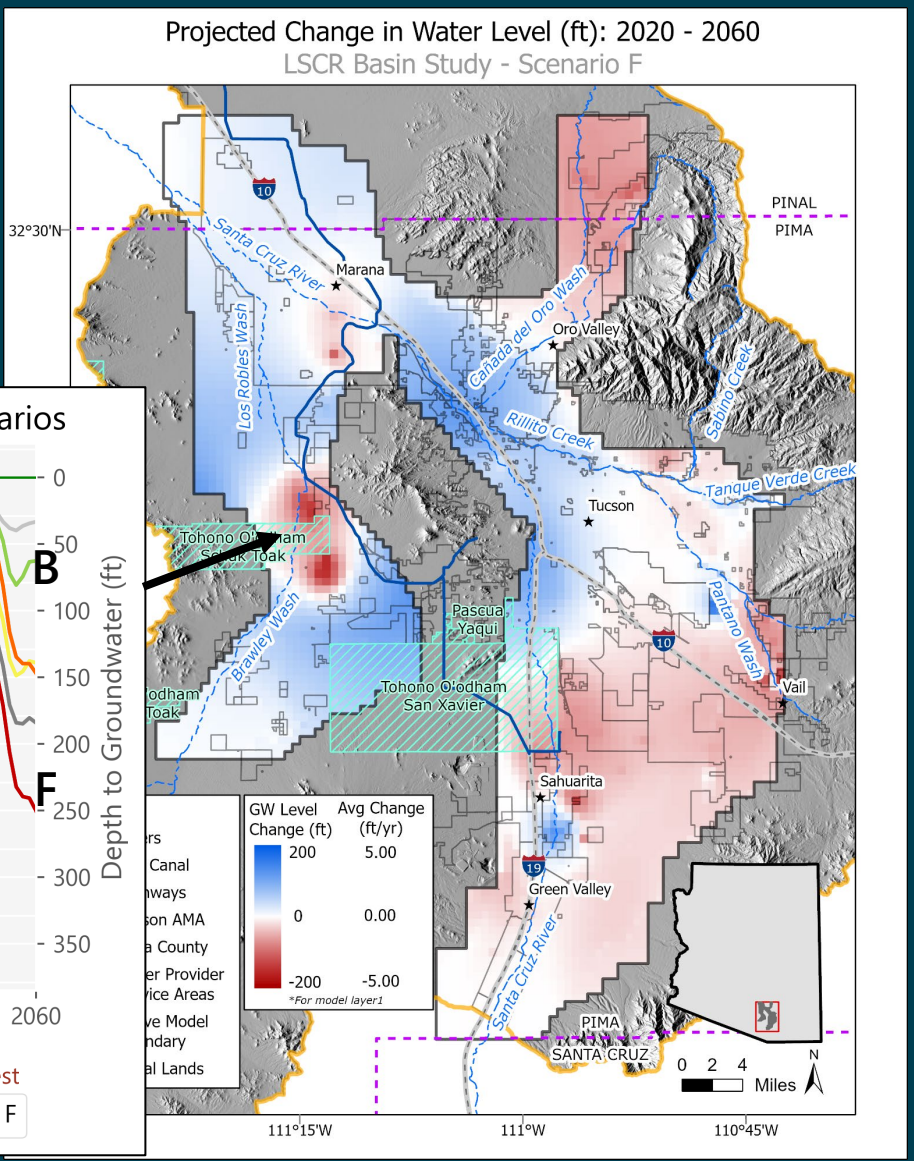




Risk Comparison - Change in Head







Supply-Demand Basin Study Scenarios, D vs. F

A. Official Projections: Medium, mixed-density growth and Current climate

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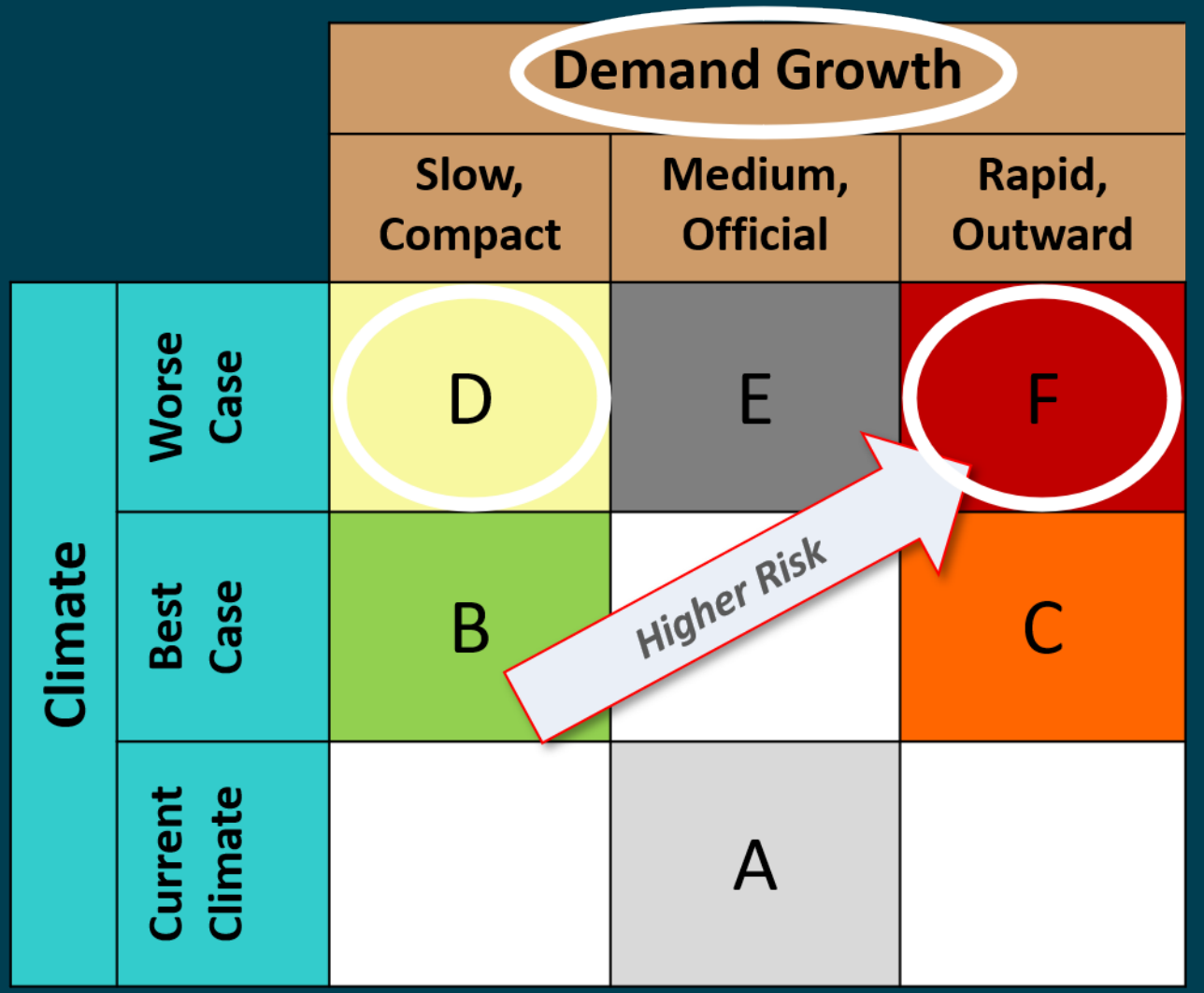
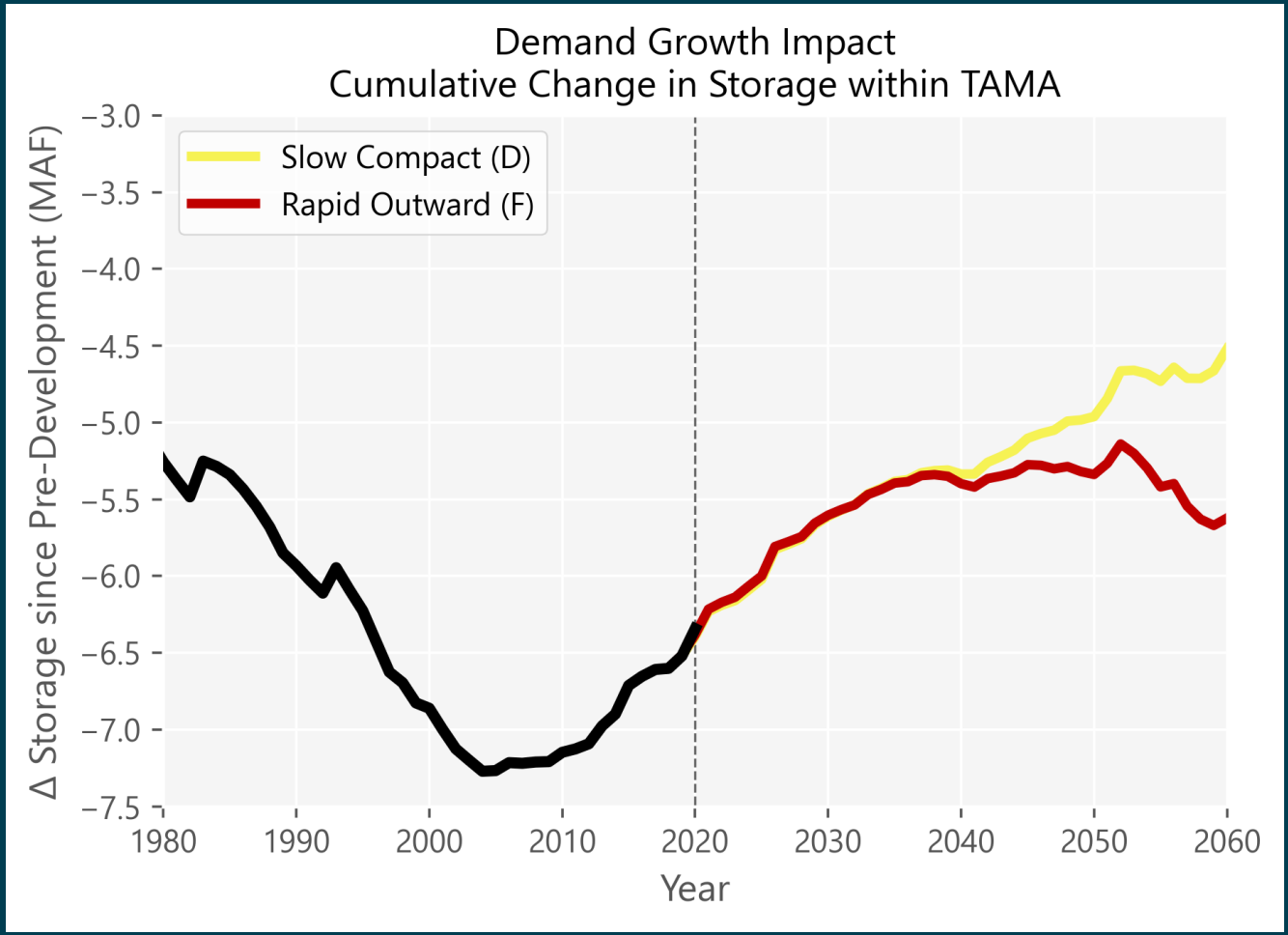
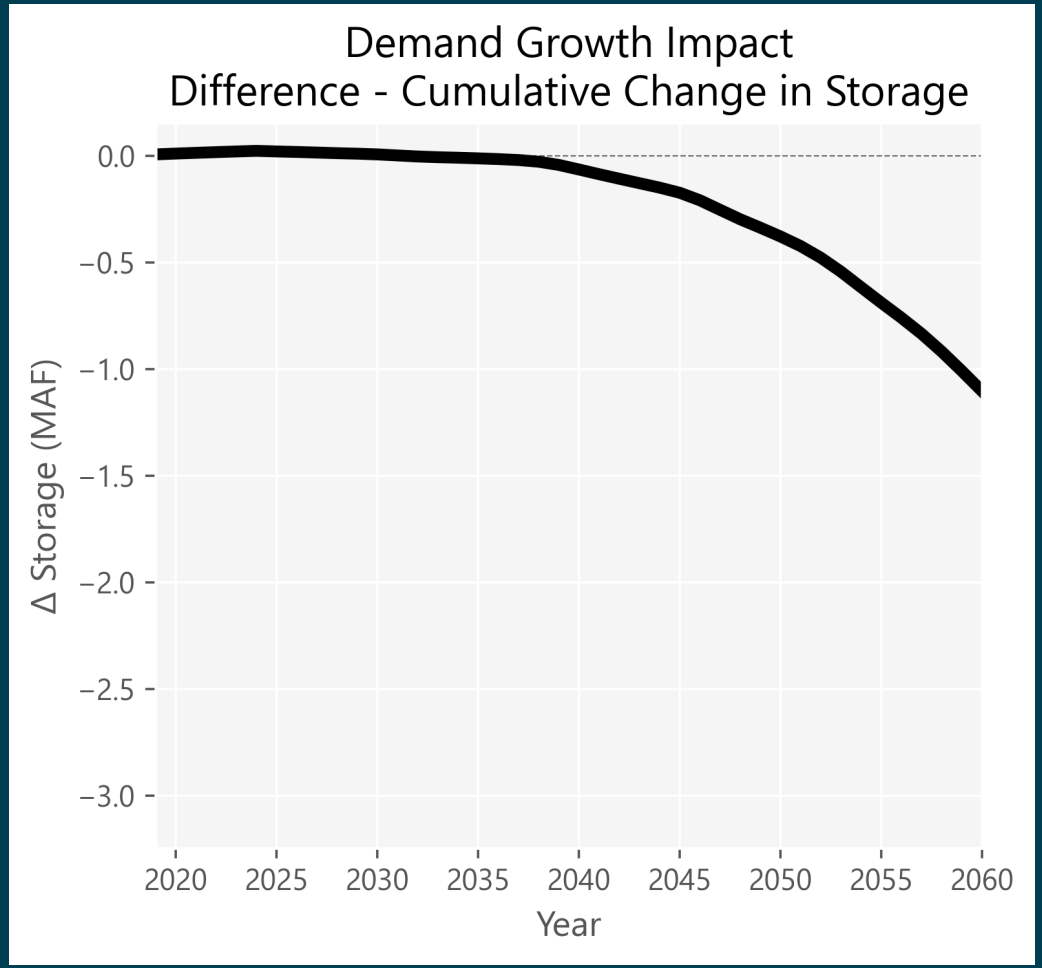
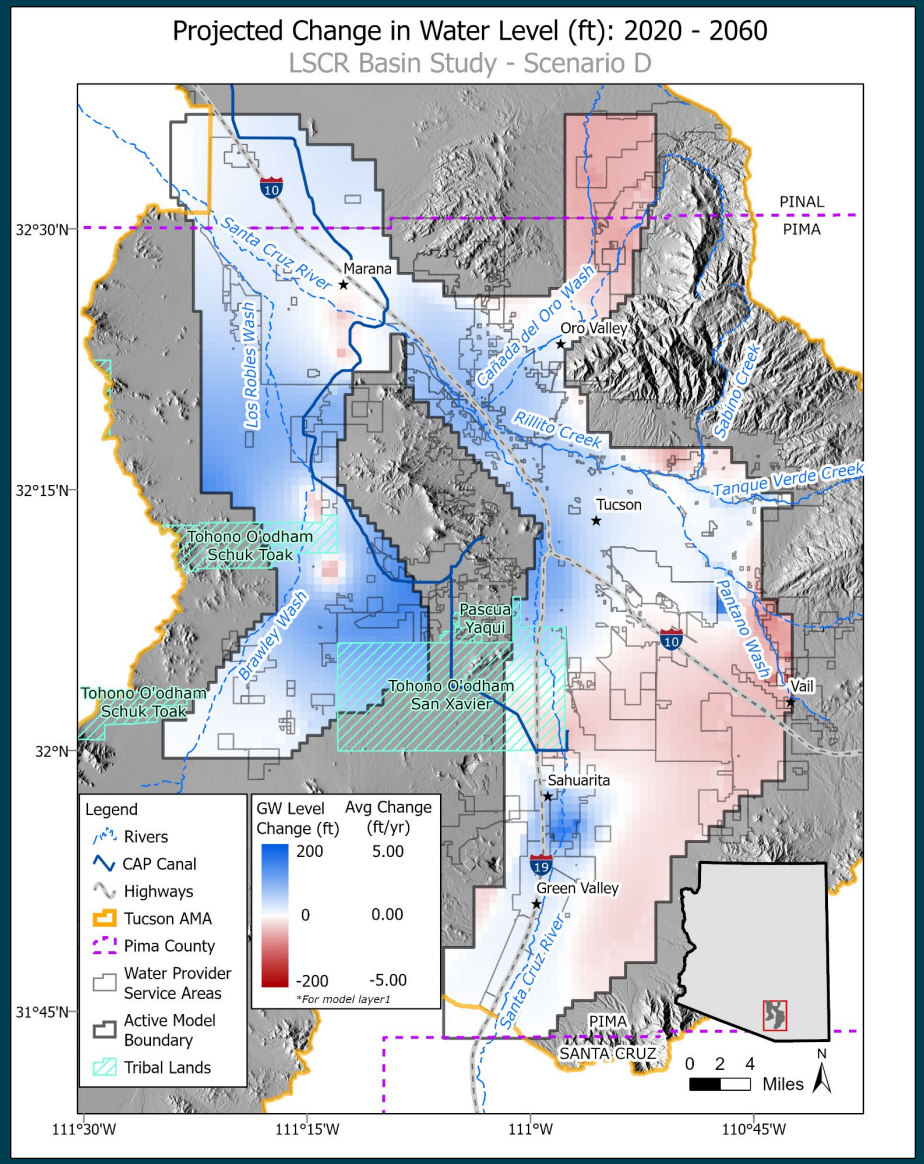


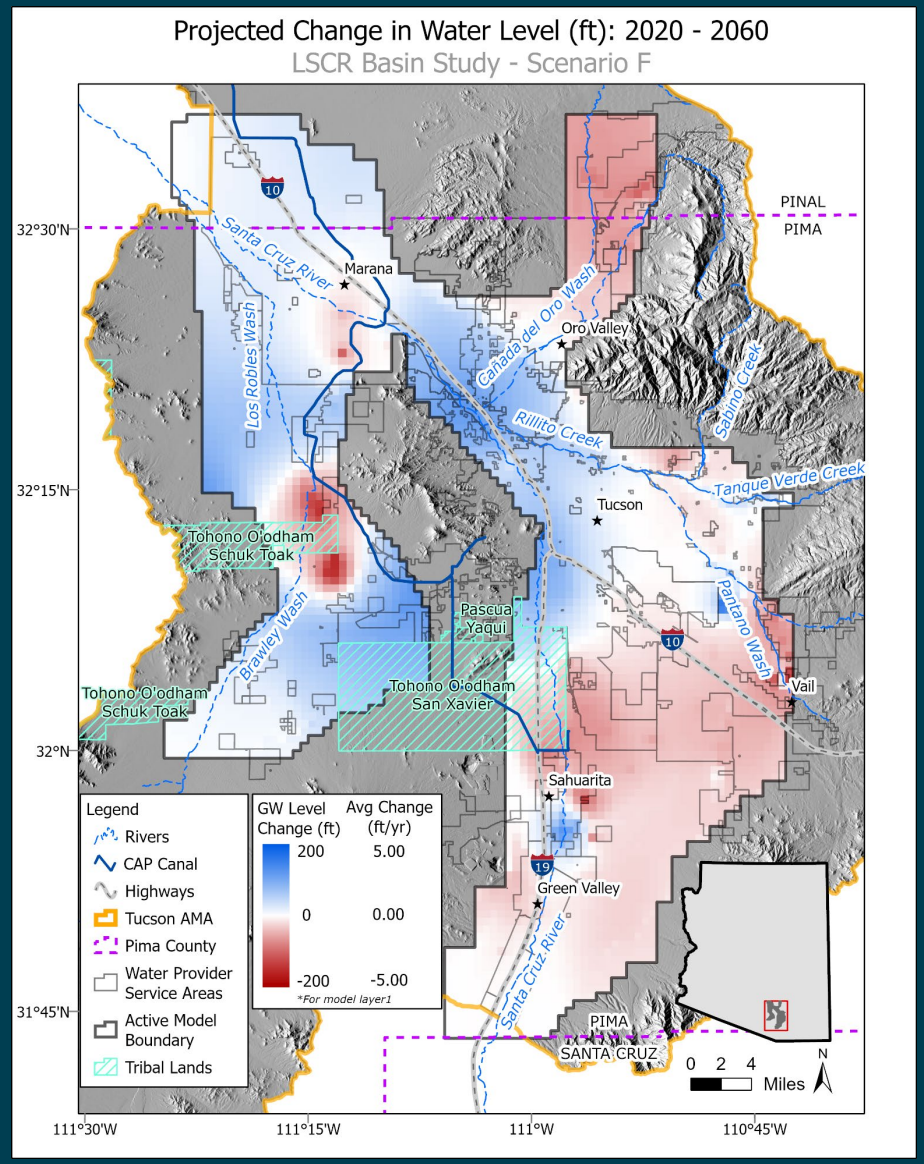
Demand Growth Impact
Change in Groundwater Storage





Demand Growth Impact - Change in Head





Supply-Demand Basin Study Scenarios, C vs. F

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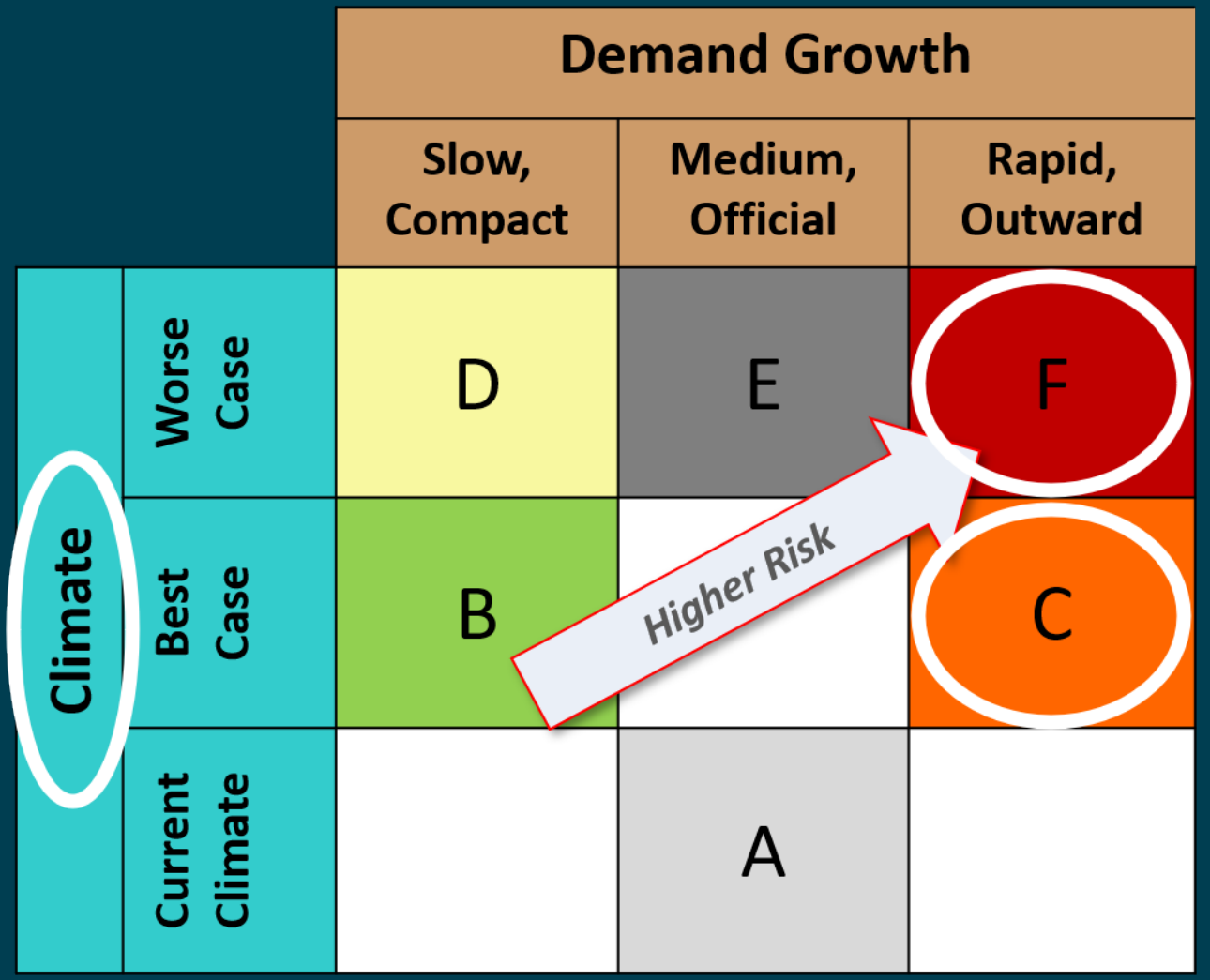
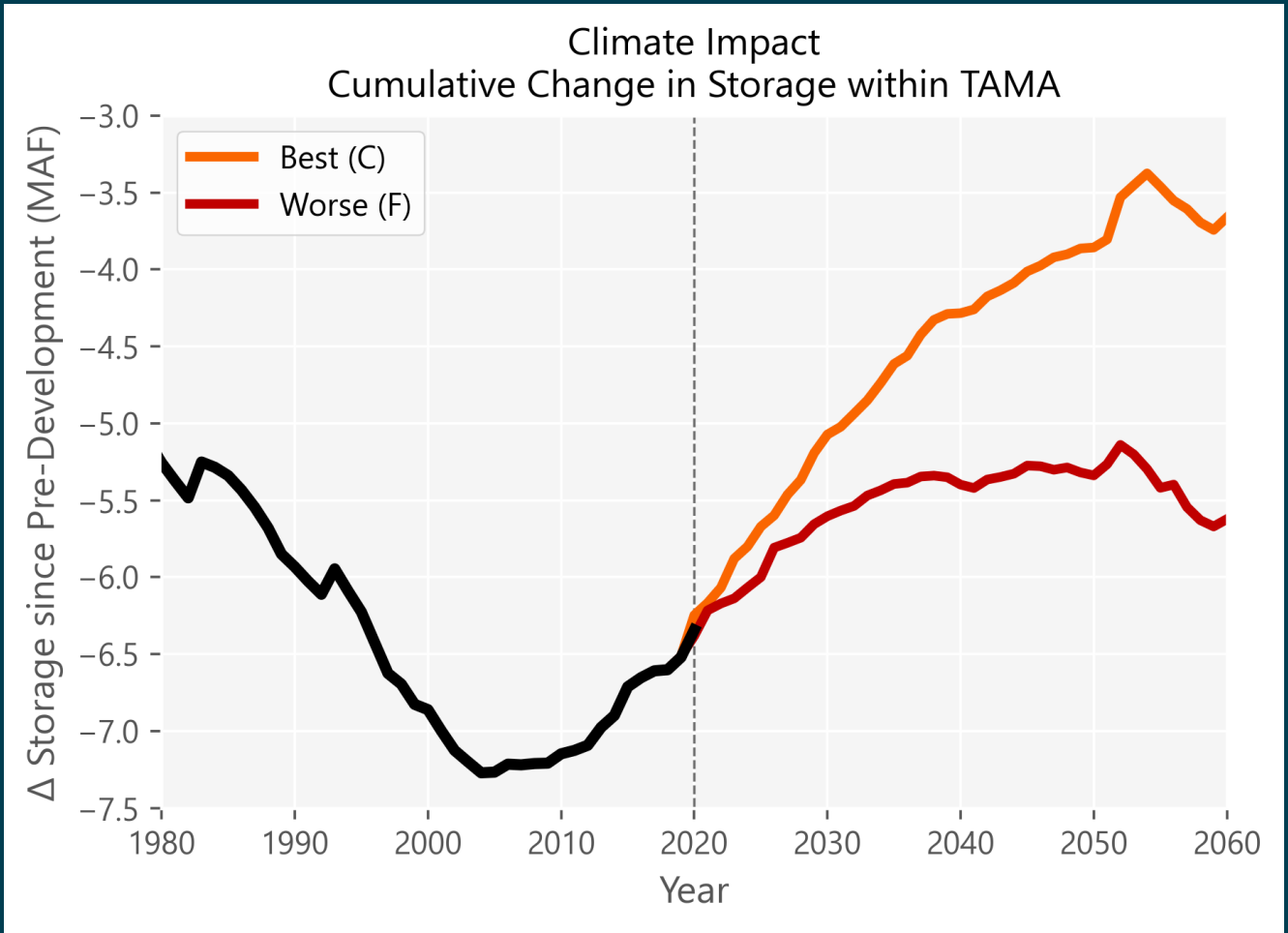
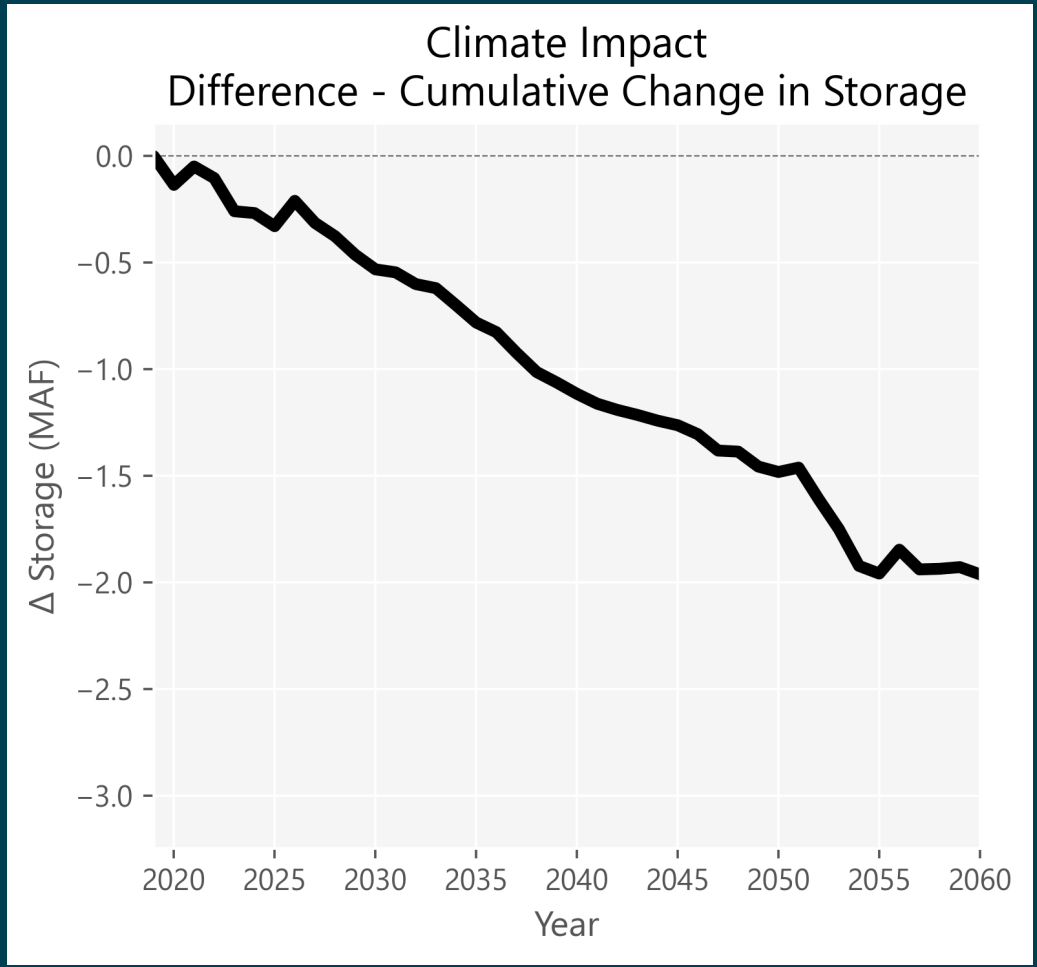
E. Official Projections and Worse Case climate

F. Rapid, outward growth and Worse Case climate

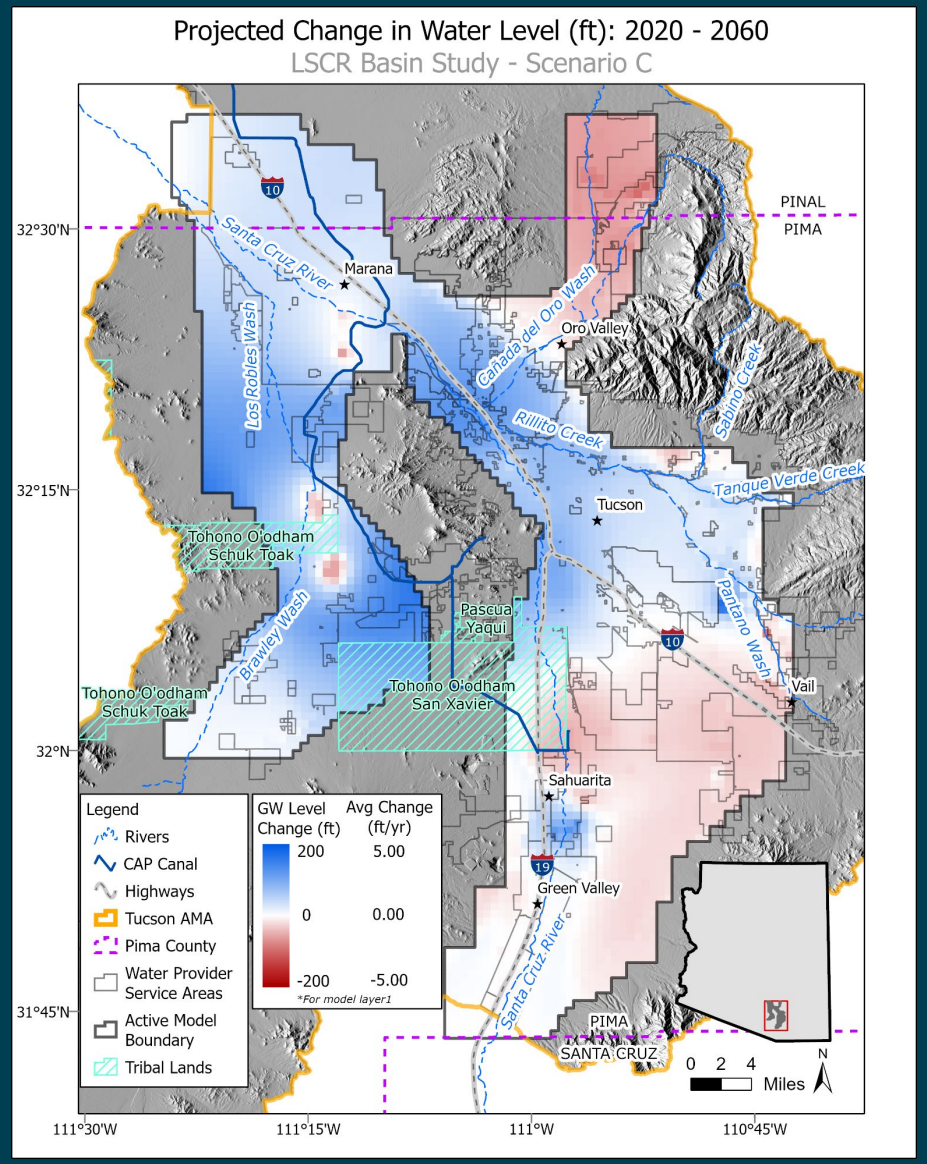


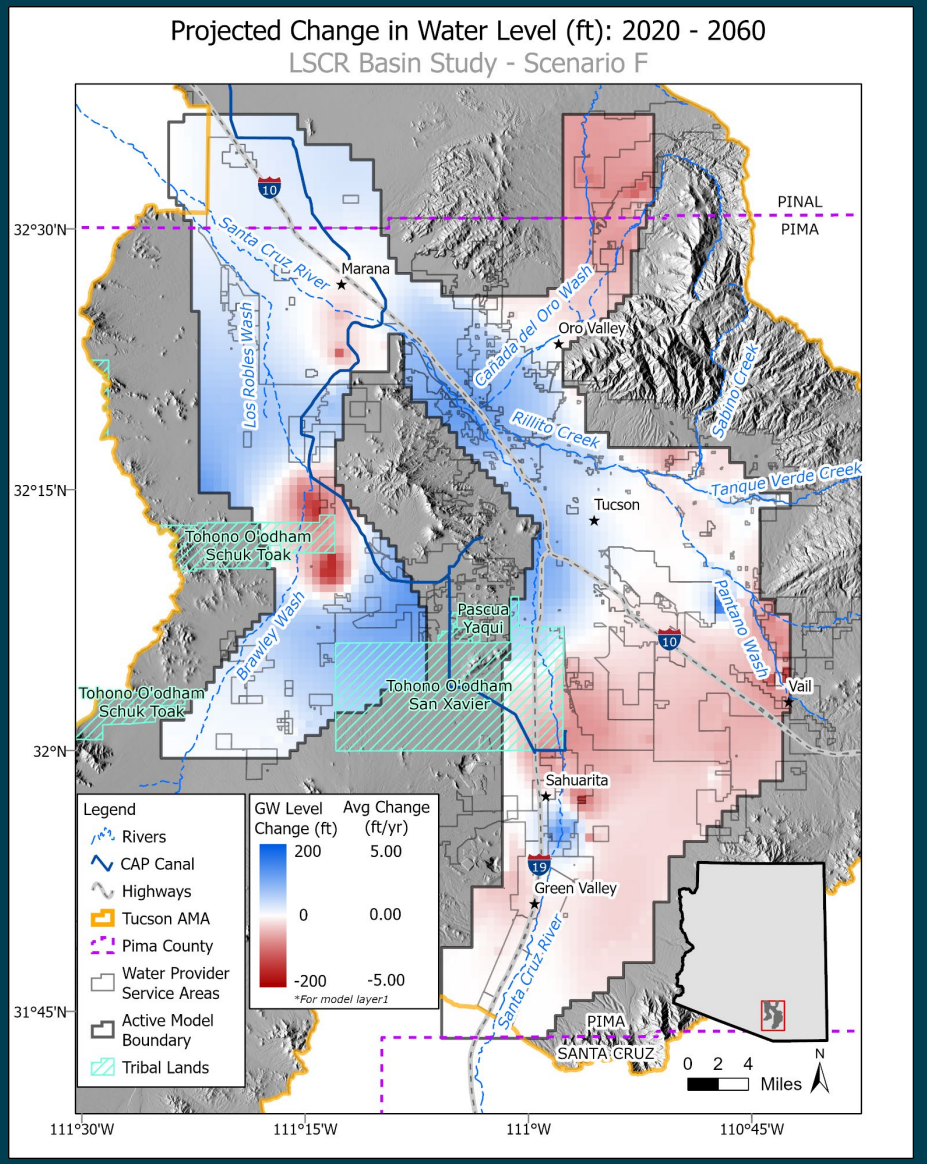
Climate Impact
Change in Groundwater Storage





Climate Impact - Change in Head





Supply-Demand Basin Study Scenarios
B vs. D vs. F

A. Official Projections: Medium, mixed-density growth and Current climate

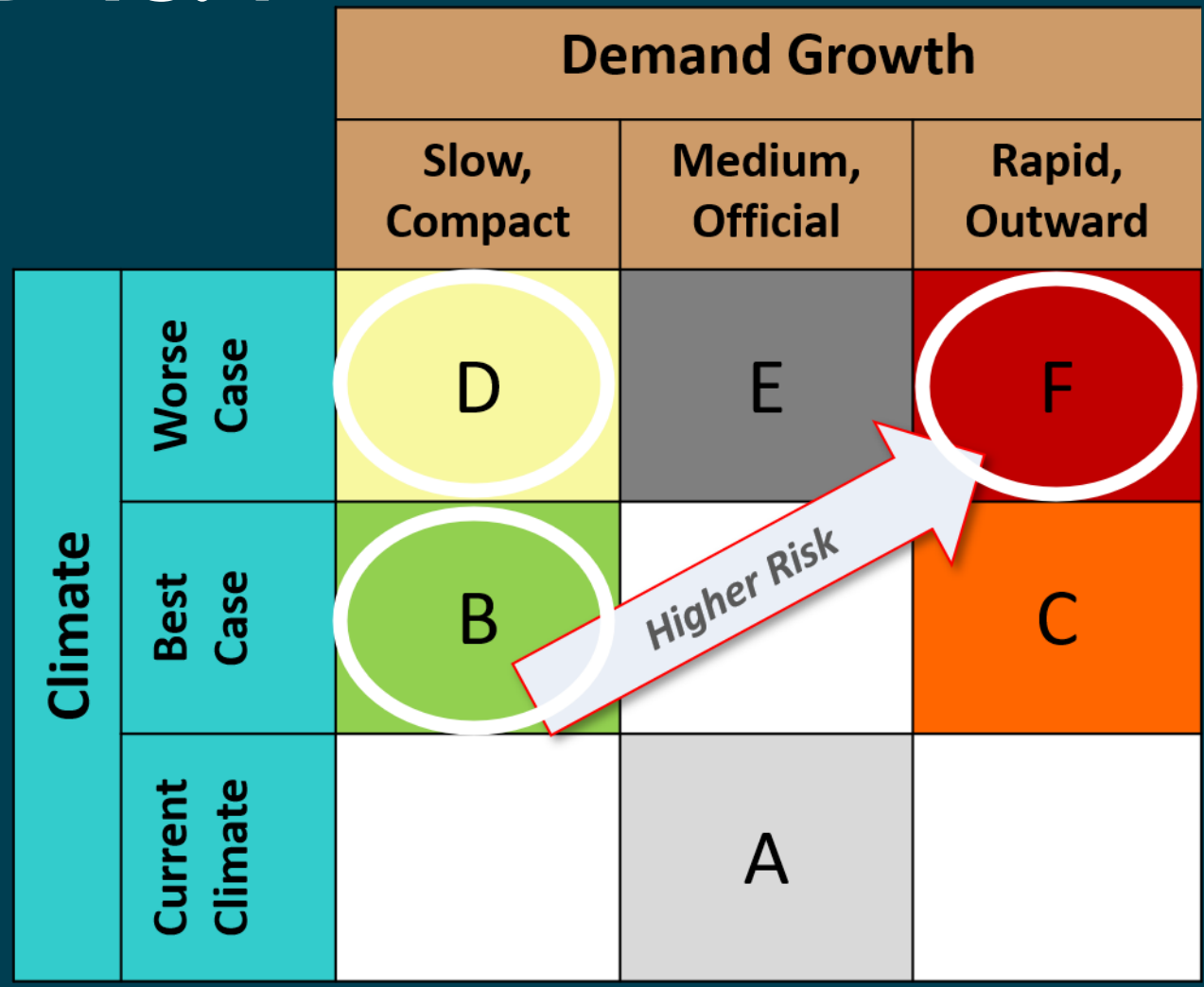
B. Slow, compact growth and Best Case climate

C. Rapid, outward growth and Best Case climate

D. Slow, compact growth and Worse Case climate

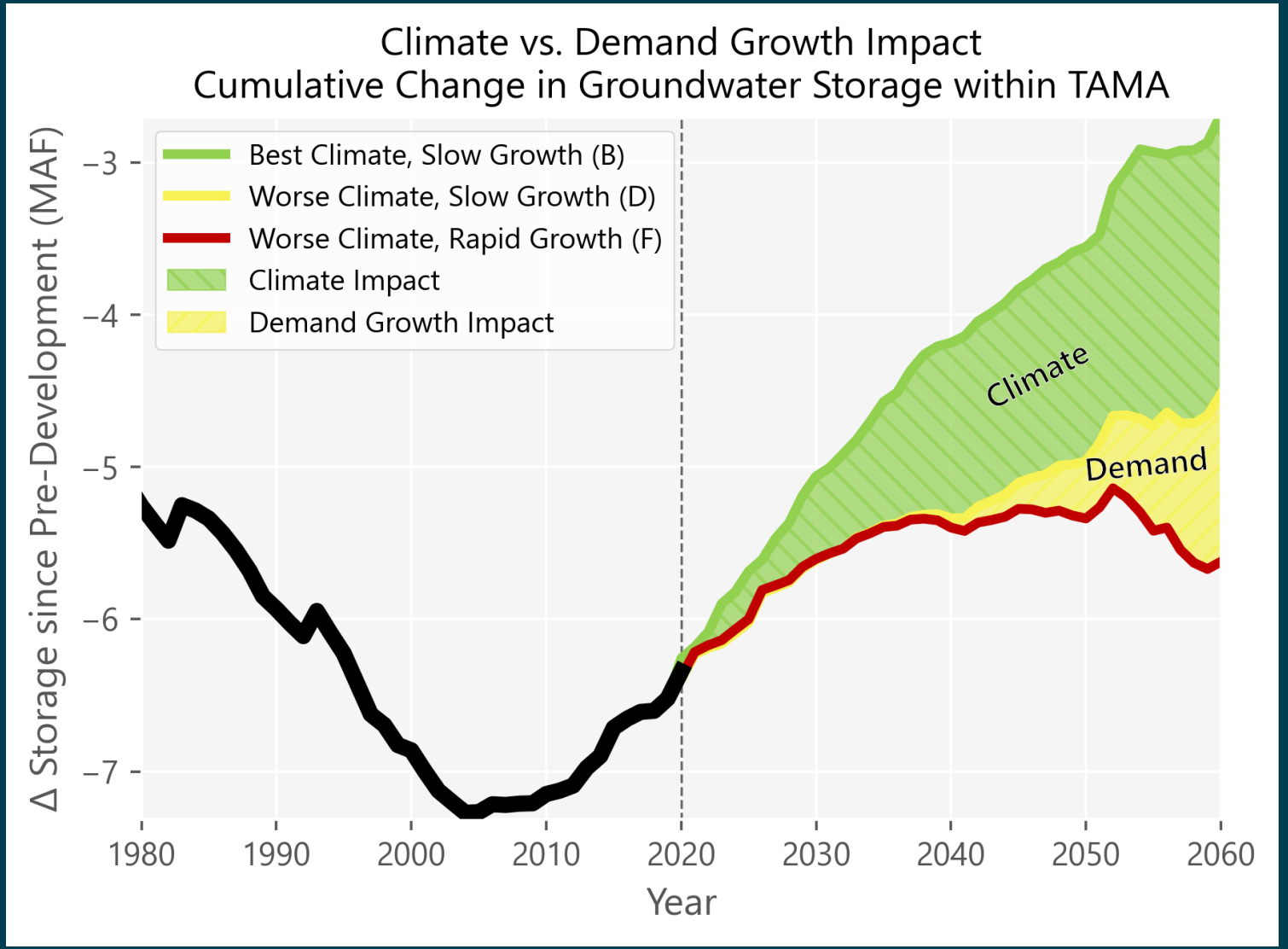
E. Official Projections and Worse Case climate

F. Rapid, outward growth and Worse Case climate



Climate vs. Demand

- Cross-scenario comparison suggests impact of climate (green) has greater influence on groundwater supply future than demand growth (yellow)



Key Takeaways

- Impacts of demand growth are largely driven by local decisions
- Impacts of climate are largely driven by global decisions
- Climate has greater impact than demand growth
- Areas of adaptation (see maps)

Next Steps…

- Identify risks
- Develop/Refine adaptation strategies