Hetch Hetchy Regional Water System

Operated by the San Francisco Public Utilities Commission

SFPUC Commission Workshop:

Climate Change and the Regional Water System

October 29, 2021

Services of the San Francisco Public Utilities Commission

Today’s Topics and Panel Members

- SFPUC Panel Discussion
  - History of Climate Analysis for Regional Water System
  - Observations of Climate Change in RWS Watersheds
  - Using and Developing New Forecasting Tools
  - Engagement and Collaborations around Climate Science
  - Overview of the Long-term Vulnerability Assessment
- Panel Members
  - Alexis Dufour, Water Resources Engineer, Hydrology and Water Systems group
  - David Behar, Climate Program Director
  - Dr. Casey Brown, University of Massachusetts – Amherst

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History of Climate Change Analysis

WSIP Climate Change Analysis (PEIR)
2007

SFPUC Water Utility Climate Change Summit and creation of WUCA
2007

Potential Impacts of Climate Change on Water Quality
2009

Sensitivity of Upper Tuolumne River Flows to Climate Change Scenarios
2009-2012

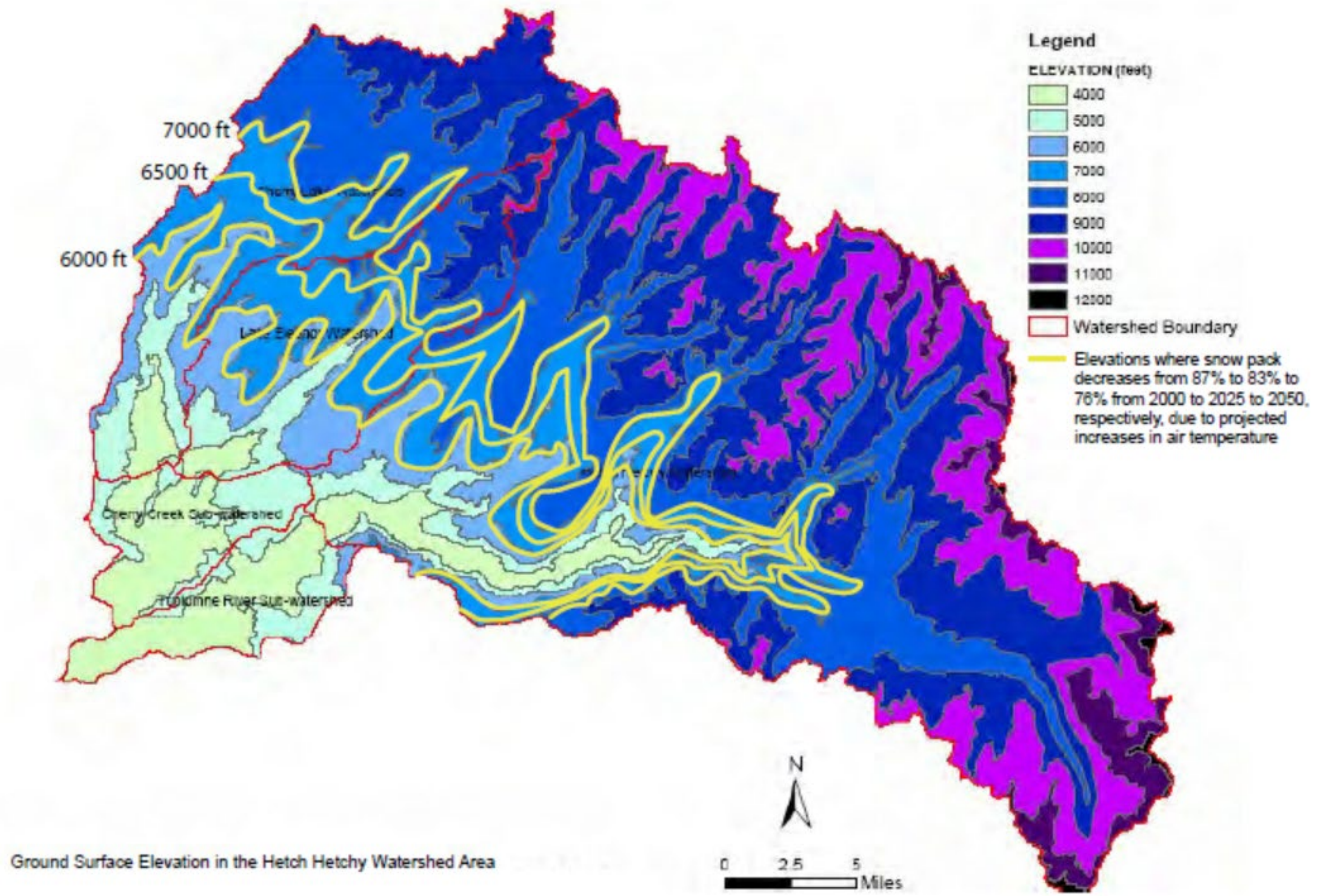
Long-Term Vulnerability Assessment
2017-2021

Mapping Climate-Related Risks and Opportunities to Water Utility Business Functions
2019-2021

Watershed lands carbon sequestration evaluation
2019-2022

2005 **2010** **2015** **2020** **2025**

WSIP Climate Change Analysis (PEIR)



The change in snowline that would result from the projected rise in temperature of 3 deg C between 2000 and 2050

Sensitivity of Upper Tuolumne River Flow to Climate Change Scenarios

- Joint study with Turlock Irrigation District
- Up to +5 deg Celsius and -15% precipitation change were studied in 18 climate scenarios
- Climate change effects will be most serious in dry years
- Snow accumulation is reduced and snow melts earlier in the spring
- The distribution of runoff will shift, with winter and early spring runoff increasing and late spring and summer runoff decreasing
- While temperature increases alone have an effect, the most significant effects are seen when temperature increases and precipitation decreases

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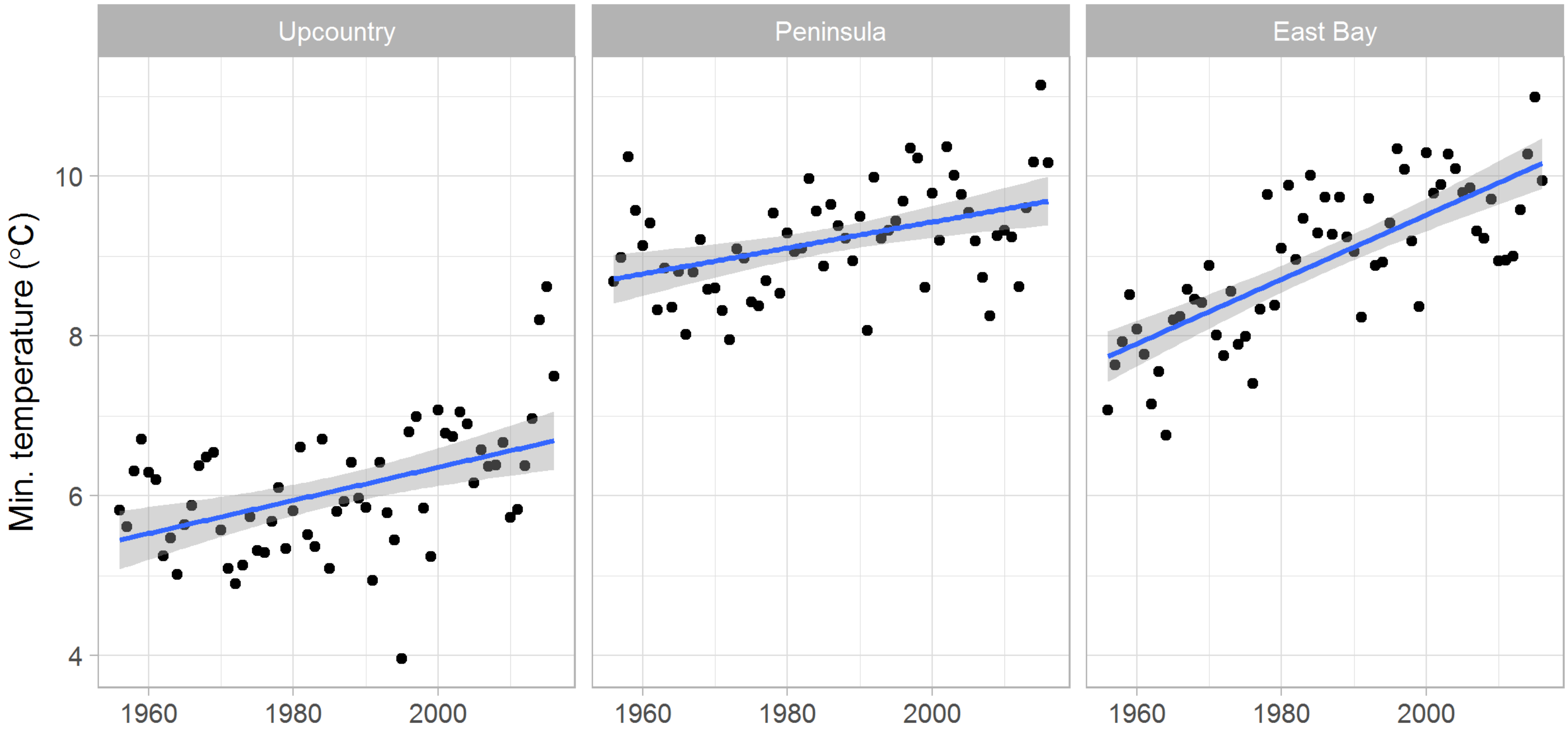
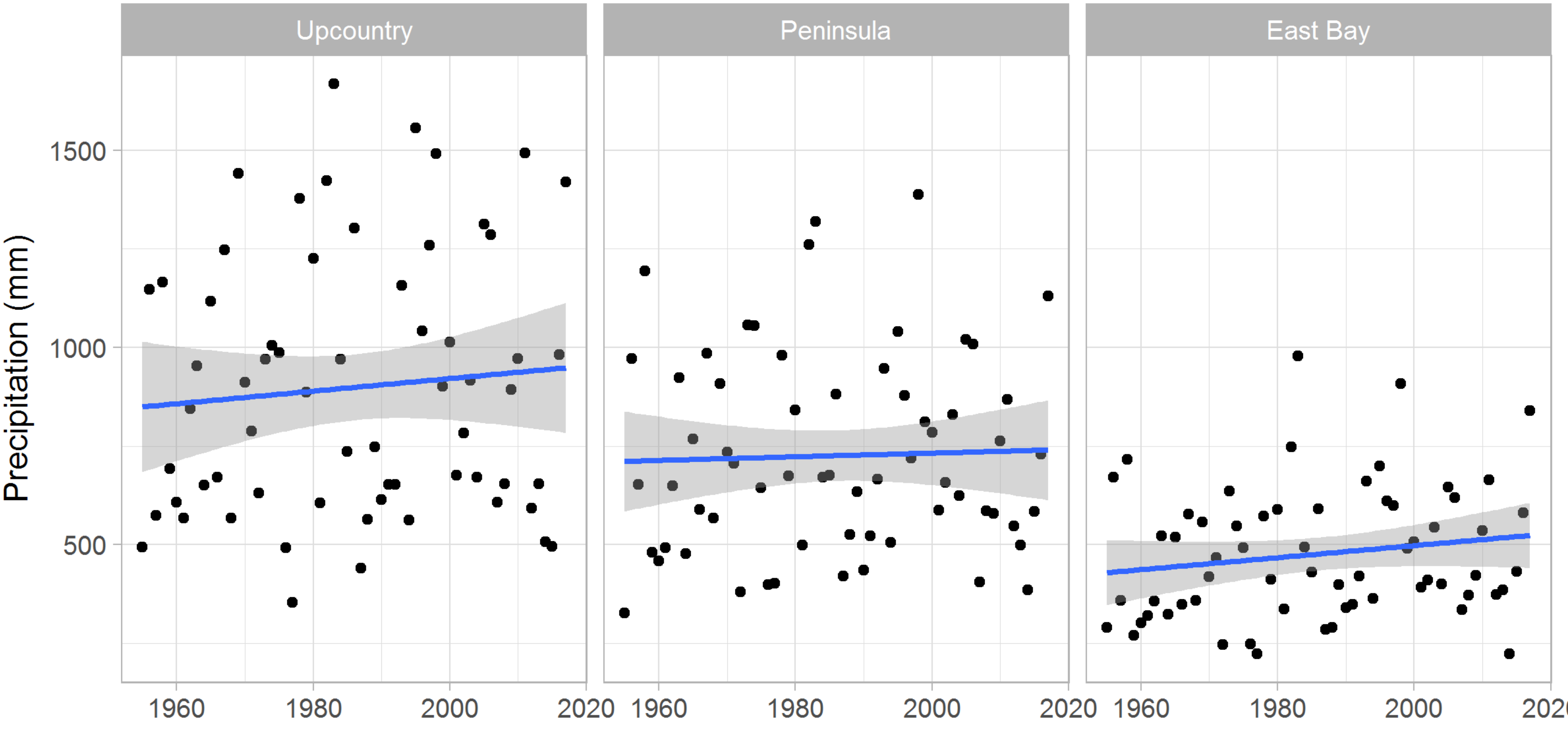
Observations of Climate Change in Regional Water System Watersheds

Warming in SFPUC Watersheds



Annual averages of daily minimum temperatures across the Upcountry, Peninsula, and East Bay regions

Precipitation in SFPUC Watersheds – No Trend

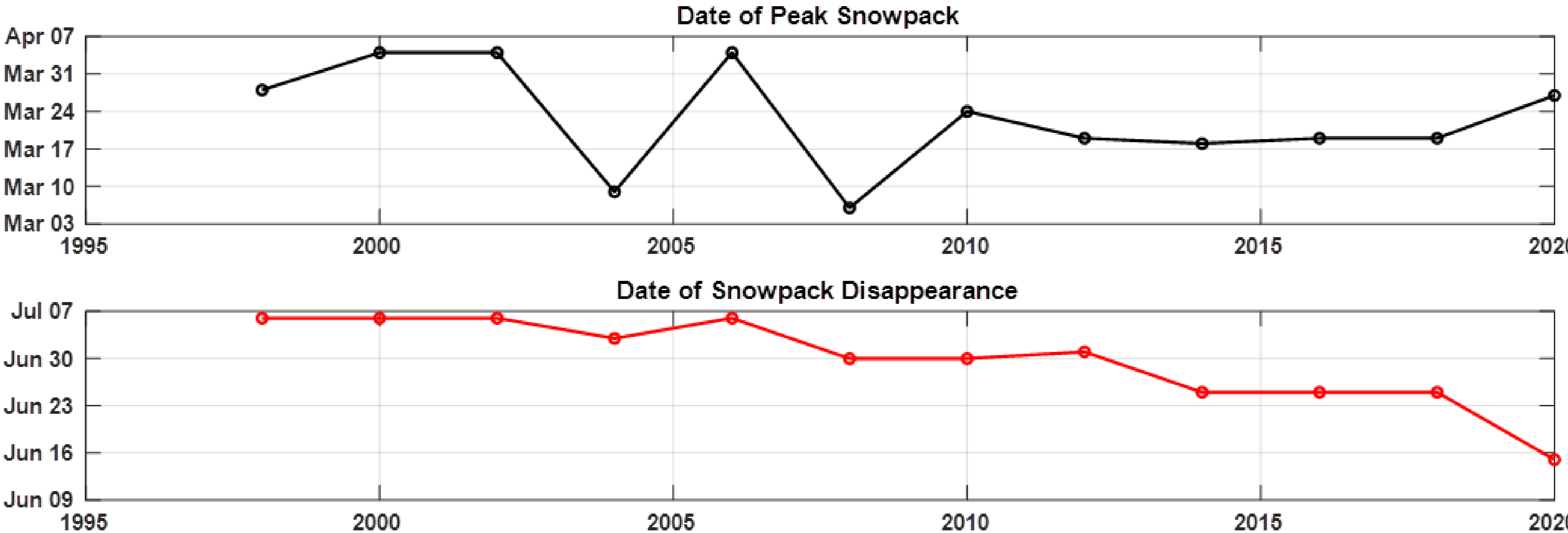


Annual precipitation across the Upcountry, Peninsula, and East Bay regions

Change in Snowpack in SFPUC Watersheds

- We observe a trend in earlier snow disappearance in the past 30 years by 15 – 20 days
- We observe a greater portion of our annual water available to the City on the Tuolumne River occurring prior to June 15, presumably due to earlier snowmelt

Change in Snowpack in SFPUC Watersheds



Dates of peak snowpack and snow disappearance in the Upcountry watersheds (10-year moving window from 1988-1998 to 2010-2020)

- No clear trend in peak date but the date of snow disappearance is earlier

2018 Moccasin Reservoir Extreme Precipitation Event

March 22, 2018

- 3 inches in 4 hours (unusual)
- Moccasin Diversion Dam overtopped (not too unusual)
- Inflows ~16,000 cfs (unheard of)
- Inflows exceeded the probable maximum flood (hard to imagine)

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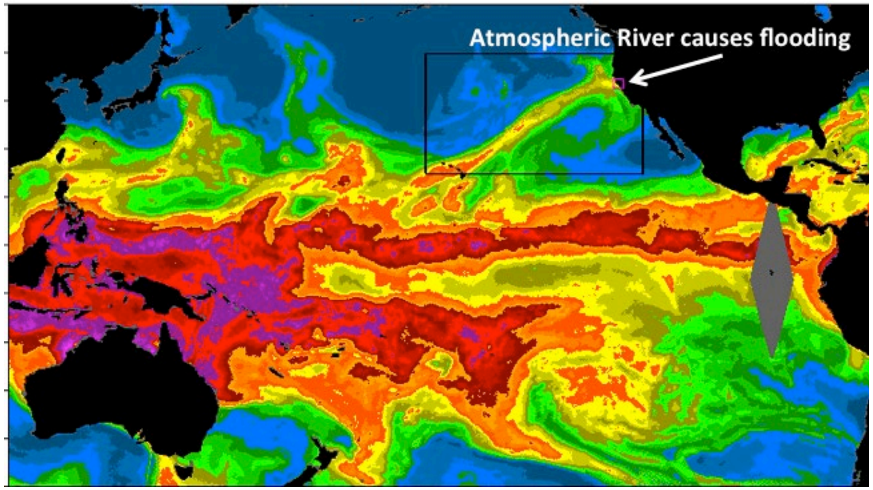
Using and Developing New Forecasting Tools

AQPI – Advanced Quantitative Precipitation Information

- Improve prediction of precipitation, streamflow, and storm surge in San Francisco Bay Area
- NOAA, academic institutions and local partners funded by Cal DWR

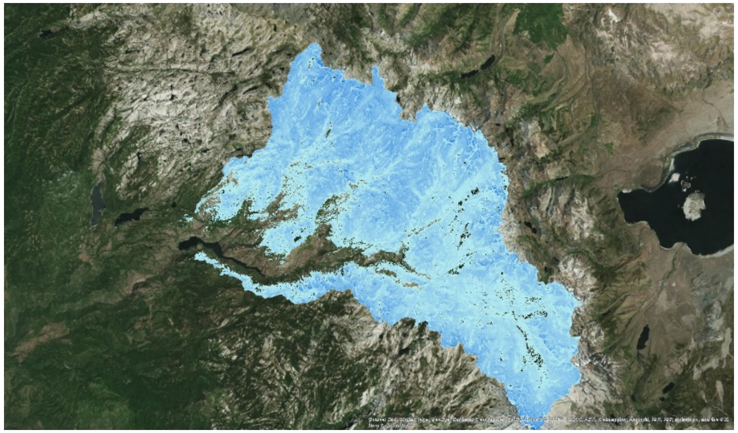


FIRO – Forecasted Informed Reservoir Operations

- Combines weather and inflow forecasting with operational restrictions to guide reservoir operations
- Implemented at Hetch Hetchy, Cherry and Calaveras Reservoirs
- Allows for flexible operations to maximize carryover storage
- Ongoing effort at multiple dams in California

ASO – Airborne Snow Observatory

- A coupled imaging spectrometer and scanning lidar system, mounted on airplane
- The scanning lidar determines snow depth
- Calculation of Snow Water Equivalent (SWE)
- Since WY 2013
- Forecast seasonal water supply from snowmelt



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Engagement with Climate Science and Climate Change Collaborations

Engagement with Climate Science and Climate Change Collaborations

National

Water Utility Climate Alliance

Regional

Bay Area Climate Adaptation Network (BayCAN)

City

Sea Level Rise Committee

SFPUC

Climate Change Collaboration and Coordination Committee

National: Water Utility Climate Alliance

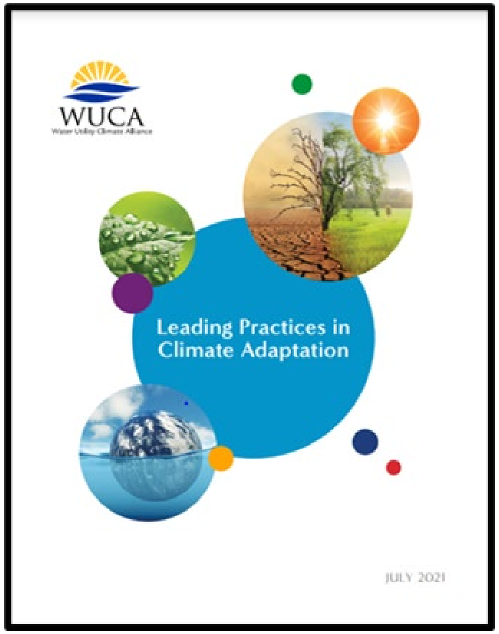
www.wucaonline.org

Founded 2007

Collaboratively advancing water utility climate change adaptation

National: WUCA

- **Leading Practices in Climate Adaptation**
- Piloting Utility Modeling Applications
- Business Function Mapping
- Embracing Uncertainty
- Engineering Case Studies
- Extreme Heat Case Studies
- Climate Resilience Trainings



National: WUCA

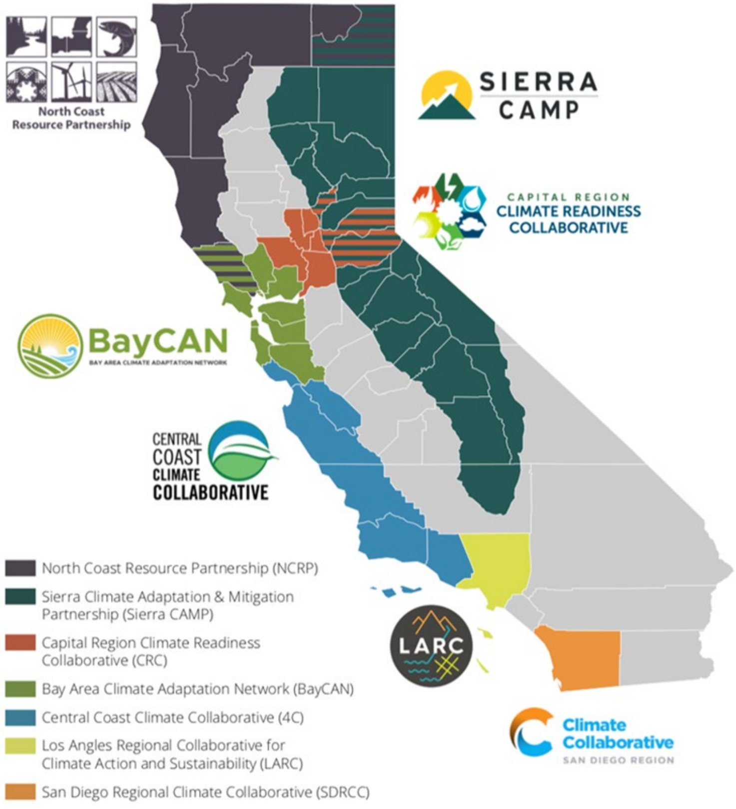
Leading Practices in Climate Adaptation

Goal: develop a set of versatile Leading Practices, grounded in WUCA experiences, that spur innovations within and across utilities and with the adaptation community more broadly.

Path: gather and share WUCA's experiences to help develop and implement climate change adaptation more effectively.

Regional: BayCAN

- BayCAN currently has 43 member organizations, including 21 local governments and 9 CBOs
- Part of a larger network of 7 collaboratives from California
  - Alliance of Regional Collaboratives for Climate Adaptation (ARCCA) →
- www.baycanadapt.org



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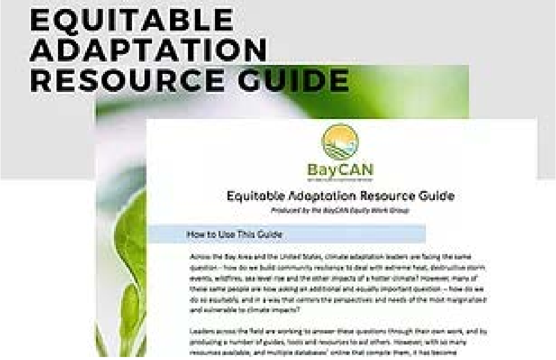
Regional: BayCAN
Key Focus Area: Equitable Adaptation

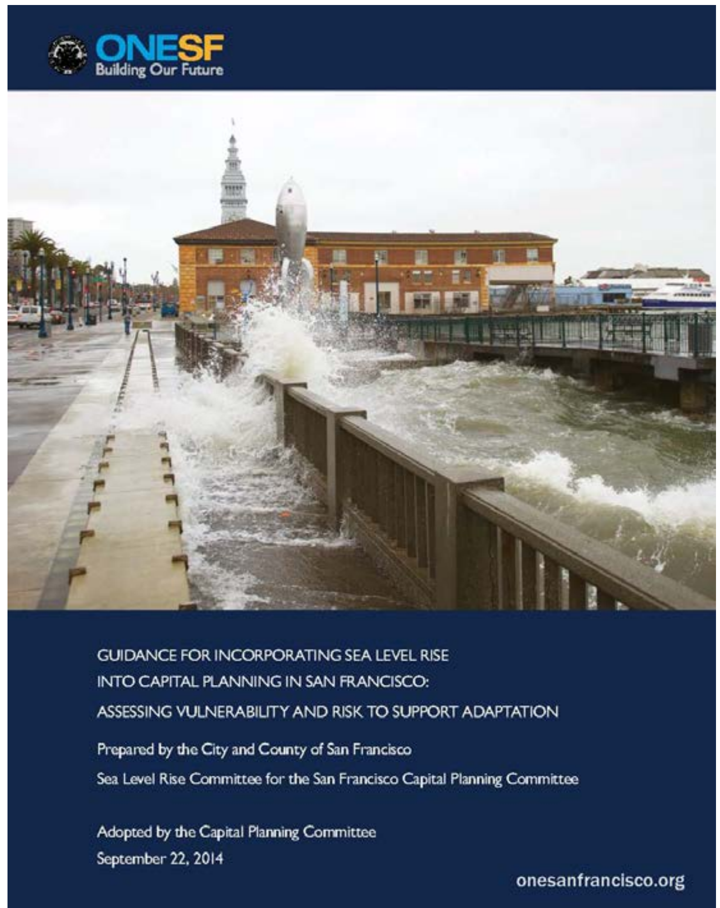
"...help the Bay Area respond effectively and equitably to the impacts of climate change..."



City: Sea Level Rise

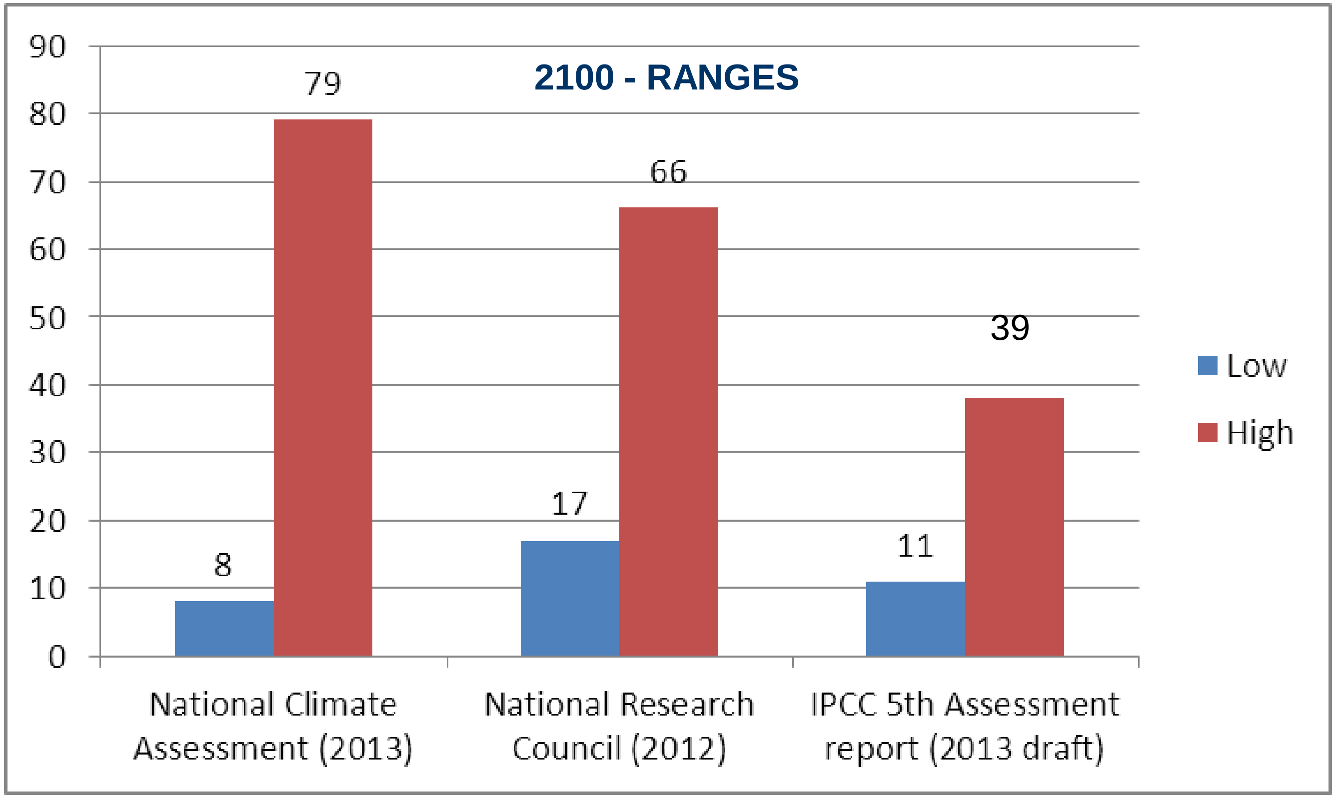
San Francisco's first sea level rise policy -
Adopted September 22, 2014 (Rev 2015, 2020)

"Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco"



City: Sea Level Rise

Sea Level Rise Science Circa 2013: A Range of Ranges



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City: Sea Level Rise

Sea Level Rise Projections (2015 Revision)

Year	Projections Likely levels of SLR	Ranges Unlikely but possible SLR
2030	6 in	12 in
2050	11 in	24 in
2100	36 in	66 in

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City: Inundation Maps – Created by SFPUC for the SSIP

77" Above MHHW:

36" SLR + 100-YR Storm Surge

City: Sea Level Rise Checklist

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ONESF
Building Our Future

CAPITAL PLANNING PROGRAM

EDWIN M. LEE
Mayor

NAOMI M. KELLY
City Administrator

BRIAN STRONG
Director of Capital Planning

Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco
Sea Level Rise Checklist (Version 2.0)

This checklist should be used in conjunction with the SLR Guidance document ("Guidance") for use by City departments to guide the evaluation of capital planning projects in light of sea level rise.

Pre-Checklist check:

The checklist is only required if the following 3 conditions are ALL met. If the answer is 'No' to ANY of these questions, do not complete the SLR checklist. The pre-checklist should be retained for your records.

1. ***Project has a location identified*** *(some projects are so early in planning that they do not yet have a specific location within CCSF)* Yes ___ No ___

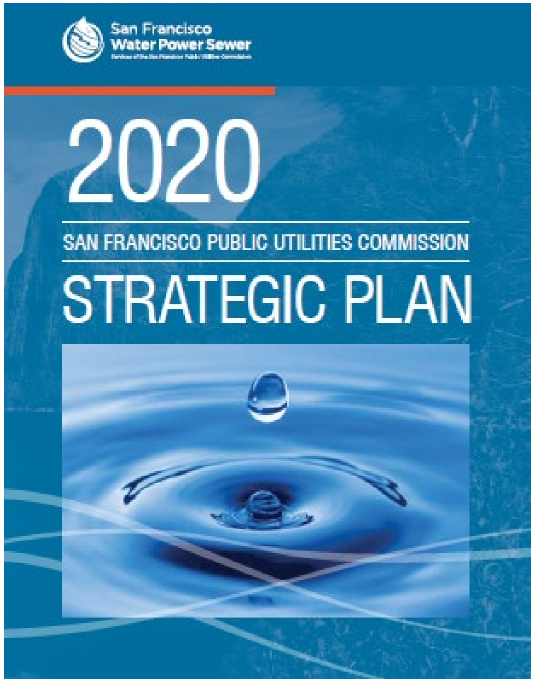
2. ***Project is within the SLR Vulnerability Zone*** Yes ___ No ___
(see the Supplementary Document "SLR Vulnerability Zone Map" at: http://onesanfrancisco.org/staff-resources/sea-level-rise-guidance/; contact Hemiar Alburati (hemiar.alburati@sfgov.org) to request a Geodatabase (GIS file) of the SLR Vulnerability Zone Map (overlaid on San Francisco base layers).

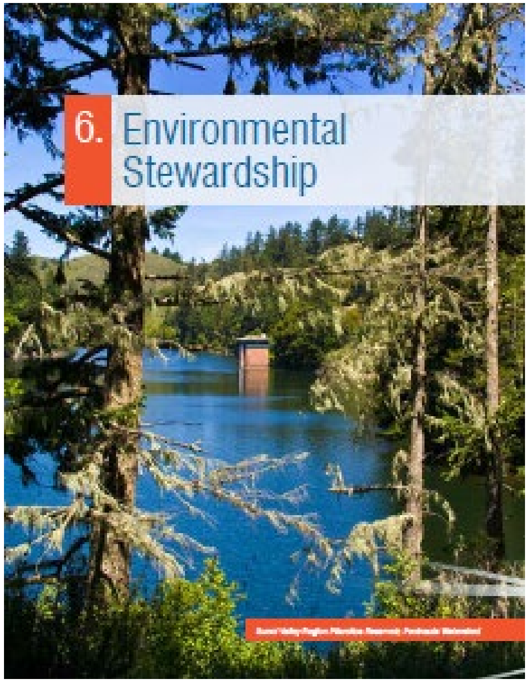
3. ***Anticipated total project costs***[1] ***equal or exceed 5 million dollars*** Yes ___ No ___

Department Name:	
Project Name:	
Project ID:	
Name of Project Mgr:	
Name of Preparer:	

PUC: Climate Change Coordination and Collaboration Committee ("C5")

"Develop, coordinate, and communicate a comprehensive and consistent approach to mitigate and adapt to climate change."





PUC: C5 Activities

- Lunch and Learns (pre-Covid):
  - California 4th Assessment (Lawrence Berkeley Lab, Climate Readiness Institute)
  - Climate Justice (US Water Alliance, SFPUC)
  - Financial markets approach to climate preparedness (Moody's Investor Services, Allied Public Risk, Environmental/Social/Governance (ESG) investor, SFPUC)
- Inventory climate related projects at SFPUC and assemble annual Multi-Enterprise Climate Change Report to Commission
- Presentations from SFPUC and CCSF staff on projects underway
- Climate change policy and implementation plan for SFPUC
  - Draft policy approved by Executive team
  - Developing implementation plan for consideration by Executive team
  - Commission consideration of policy and implementation plan targeted for Spring 2022

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Long-Term Vulnerability Assessment

IDENTIFYING LONG-TERM VULNERABILITIES FOR THE SFPUC REGIONAL WATER SYSTEM

Casey Brown
Director, Hydrosystems Group
University of Massachusetts

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

Long-term Vulnerability Assessment Approach

- Provide a comprehensive understanding of water system performance under a wide range of uncertainties
- Explore a range of plausible futures rather than relying on a “best guess” prediction
- Focus on addressing vulnerabilities and building robustness
- Provide a framework for evaluating water supply portfolios and operations

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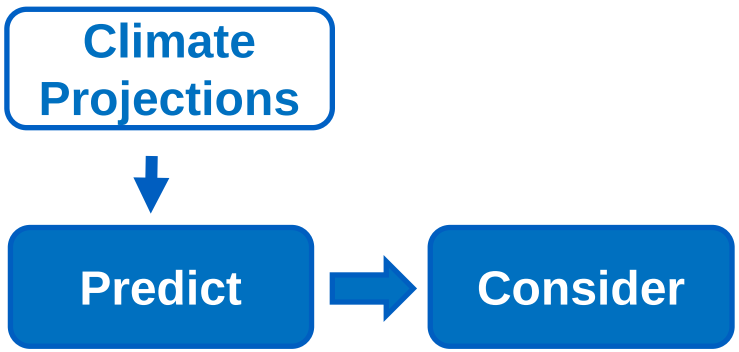
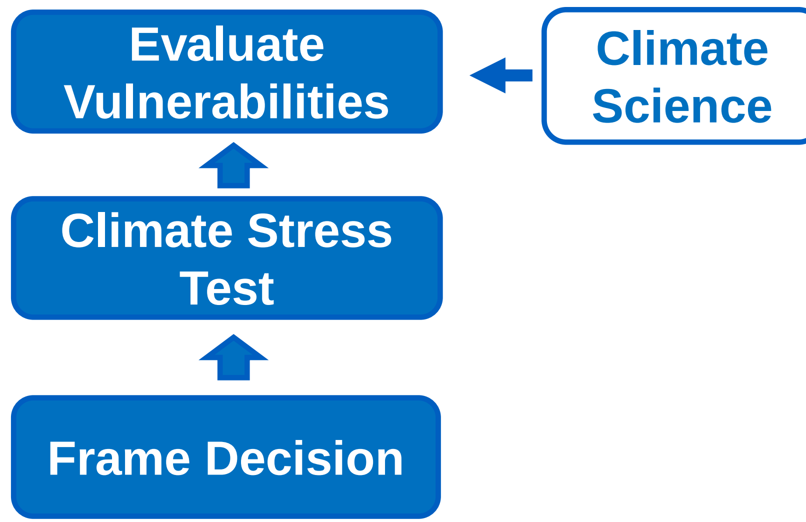
How does Climate Science Inform Decisions?

Top Down Impact Studies



Can my system be impacted by Climate Change?

Adaptation Decisions



How is my system vulnerable?

Should I take action? Which action?

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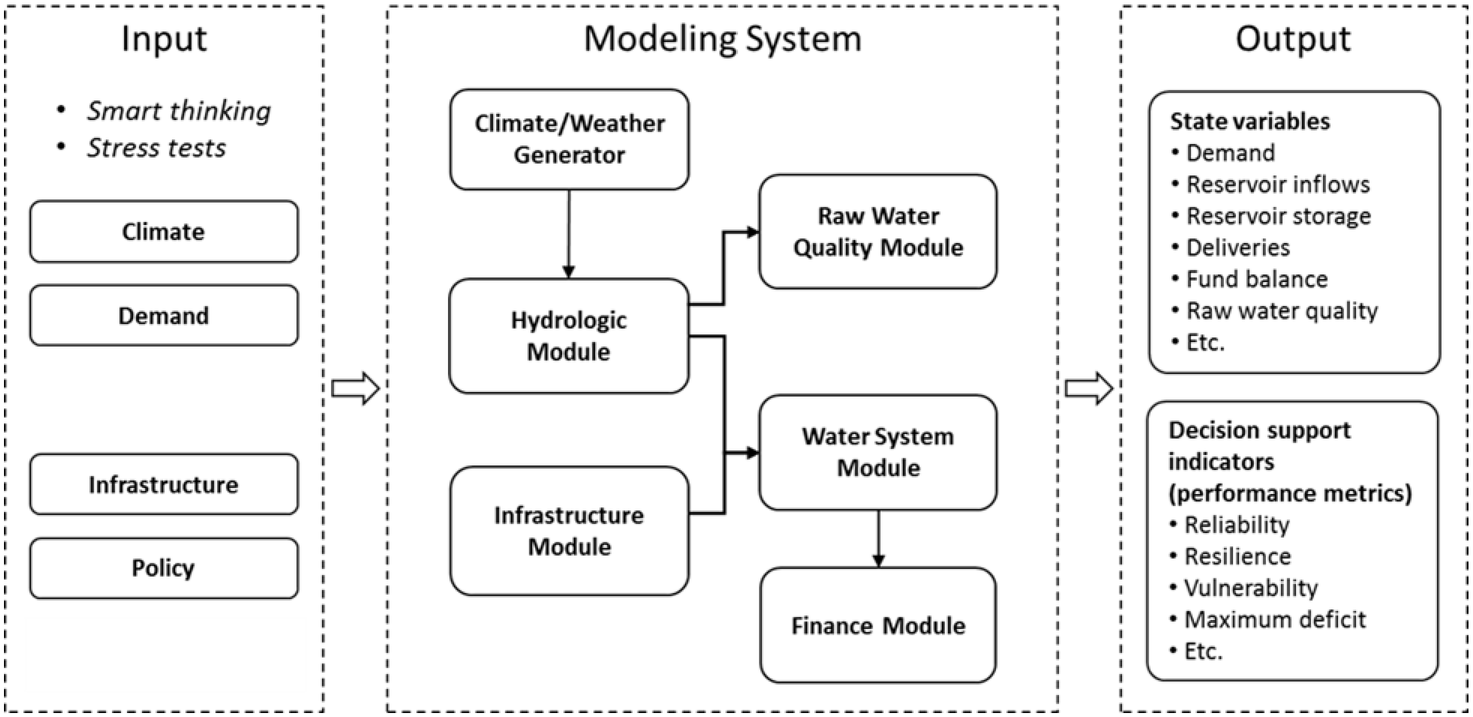
Motivating Questions

- Under what conditions and when will the RWS no longer meet system performance criteria over the planning horizon 2020 to 2070?
- Is climate change the most important driver of vulnerability for the RWS and if not, what is?

New Tools for Future Planning



Why is future climate uncertain?

- Unknown future Greenhouse Gas (GHG) emissions

  → Less influential at local scale

- Unknown response of the climate system to GHG emissions

  → Test scenarios of warming and precipitation change

- Natural climate variability

  → Test scenarios of variability

How does climate change affect water supply?

- Changing runoff

  → Hydrology model

- Capability of the system to manage runoff changes

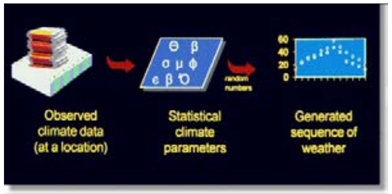
  → Water System model

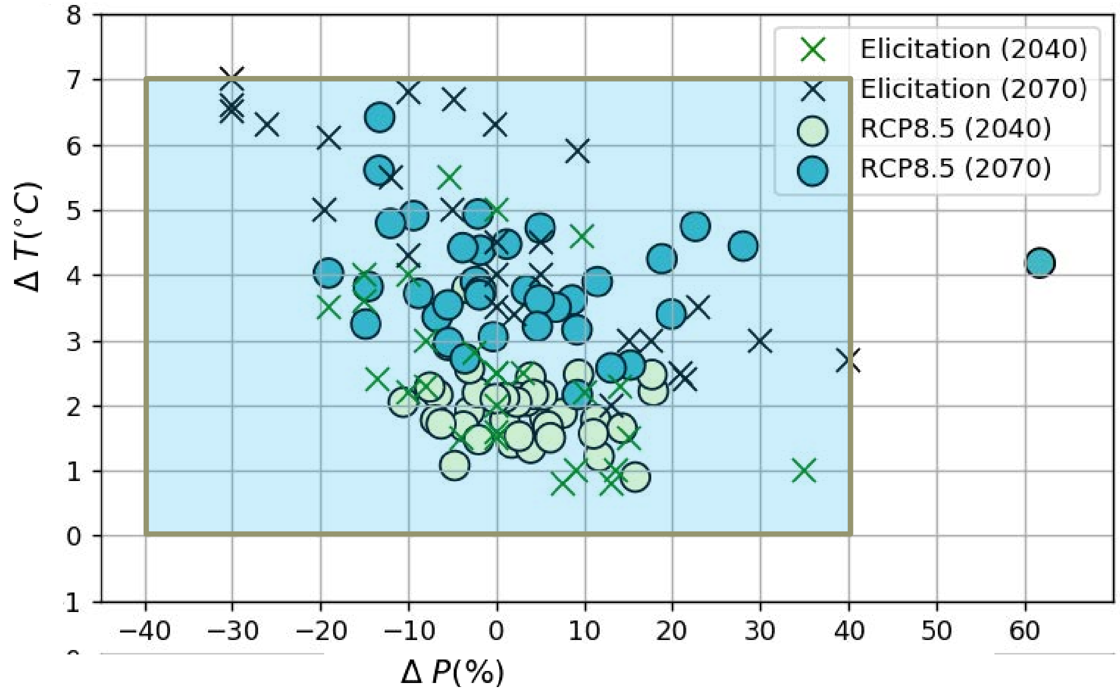
- Other factors (e.g., water rights, water demand, water supply augmentation)

  → Water System model

Climate Stress Test Scenarios

Climate/Weather Generator

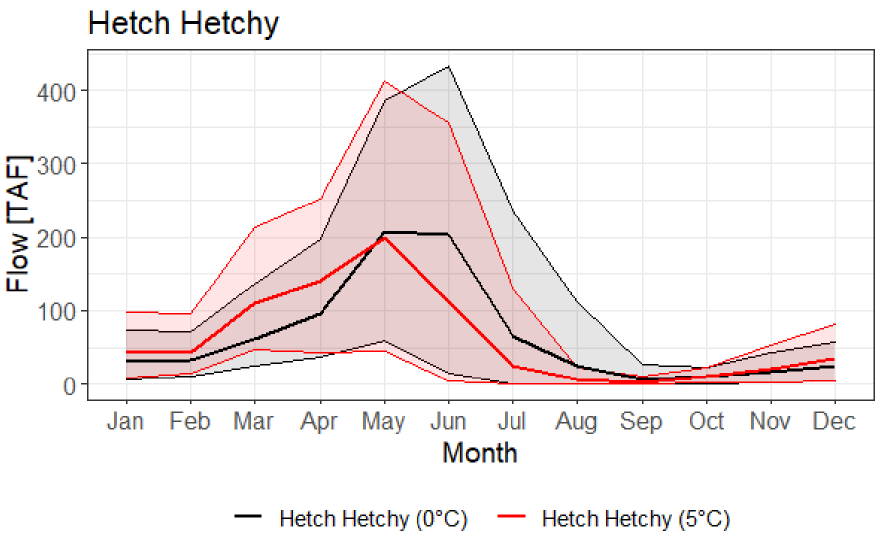


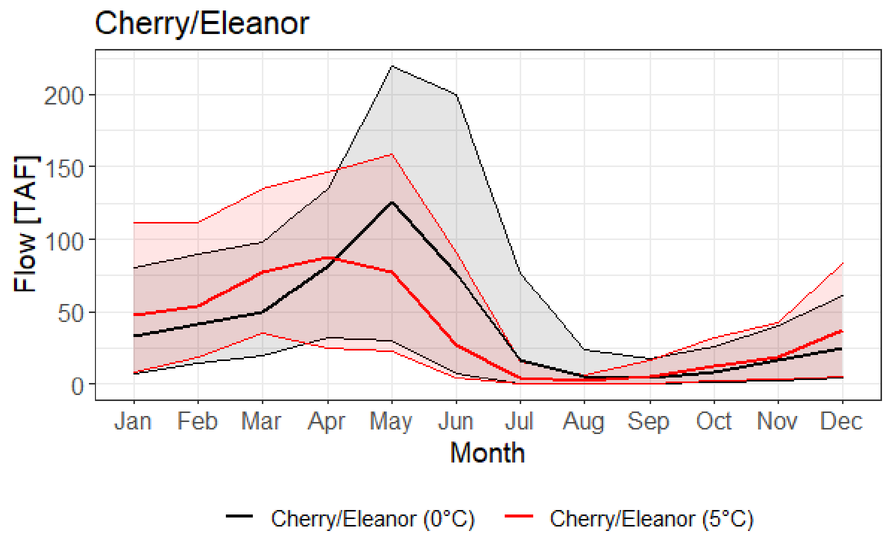


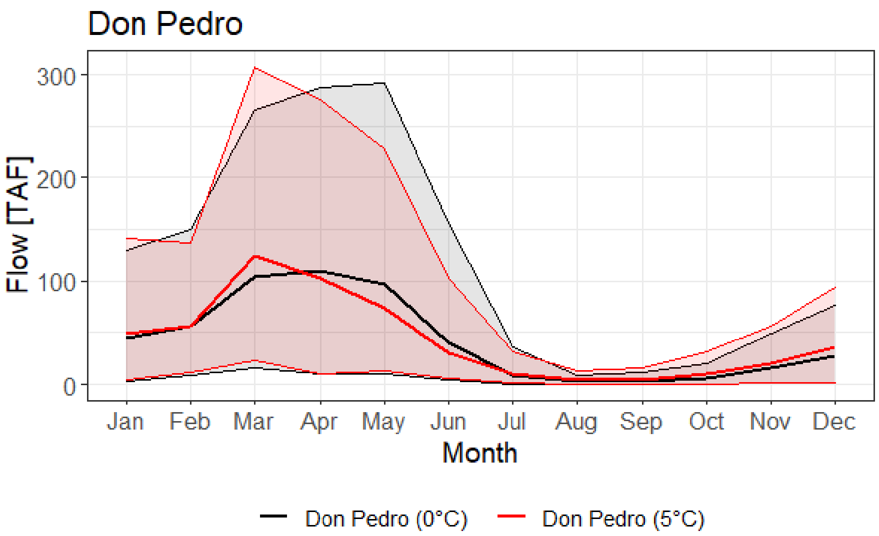
Future Climate Scenarios

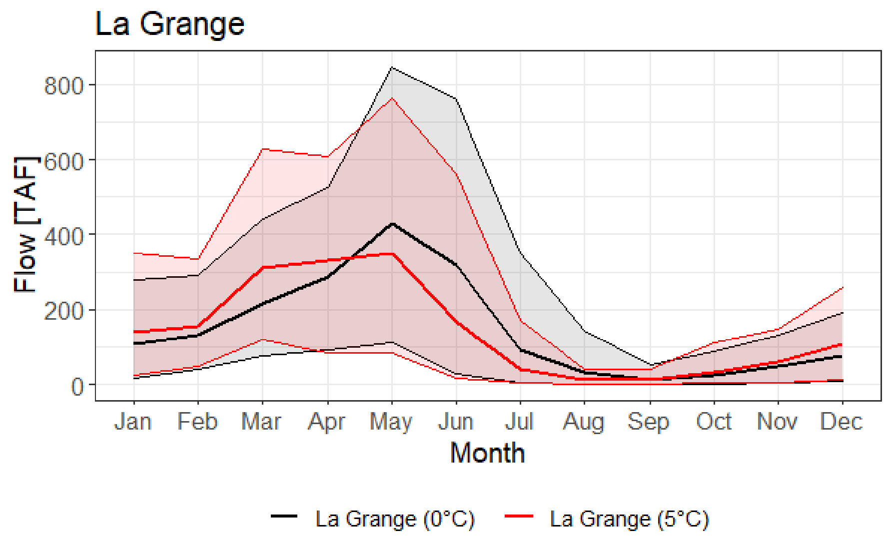
Type of uncertainty	Sampling range	Sample size
Natural climate variability	Stochastic realizations	10 realizations
Changes in mean annual precipitation (%)	-40 % to 40 % with 5% increments	17 change factors
Changes in mean annual temperature (°C)	0 to 7°C with 1°C increments	8 change factors
TOTAL		**1360 climate scenarios**

Upcountry Watersheds

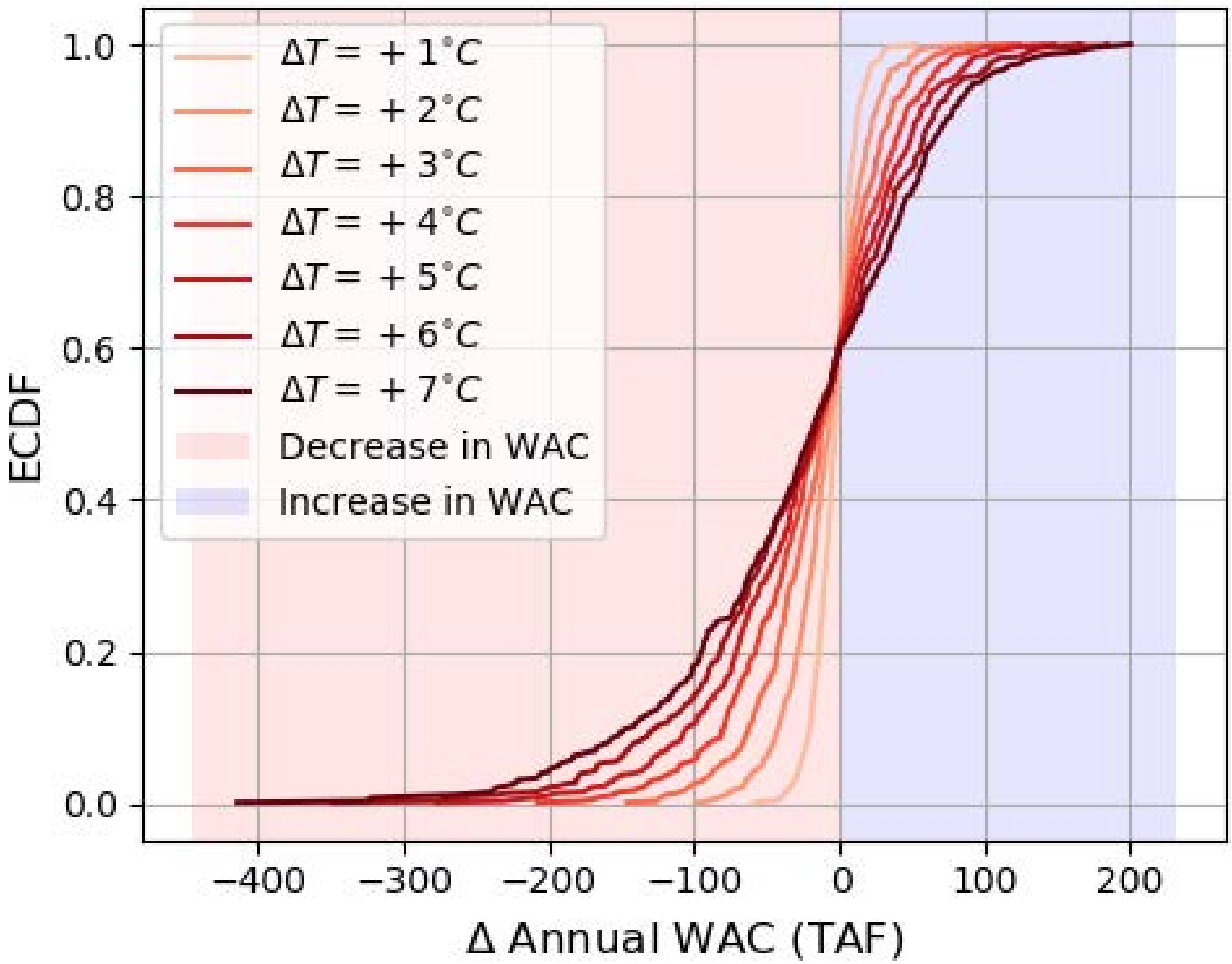






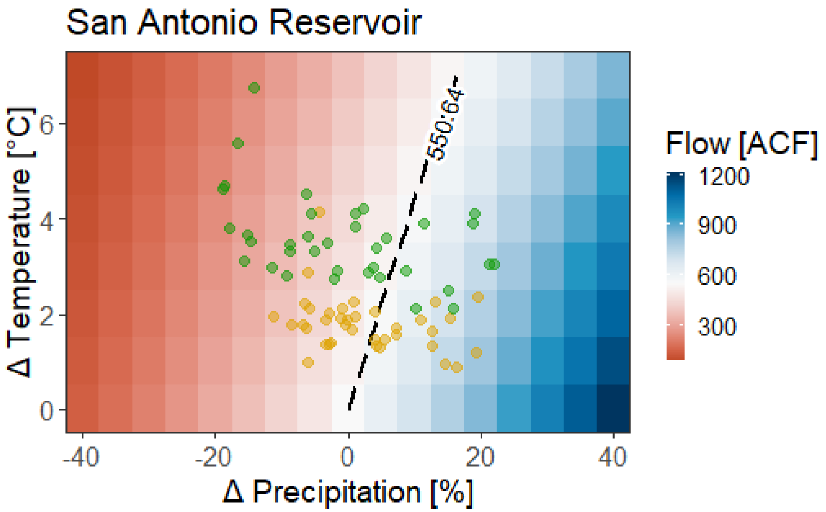


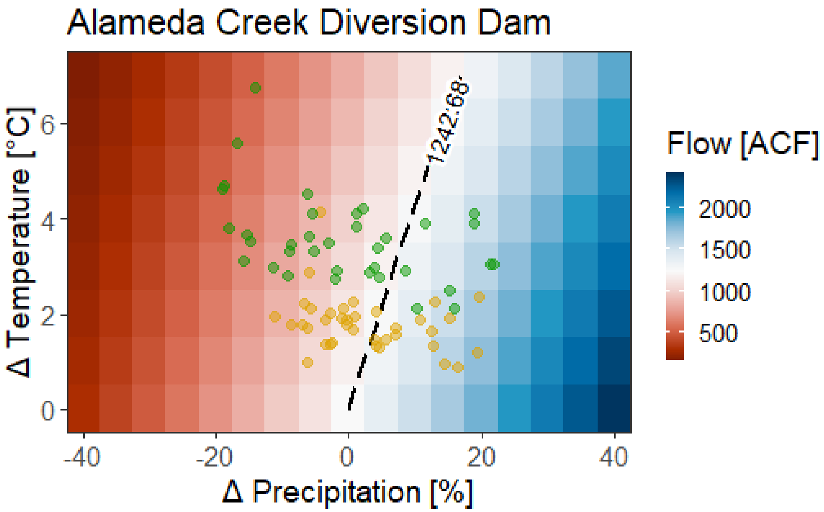
Warming = more variable WAC

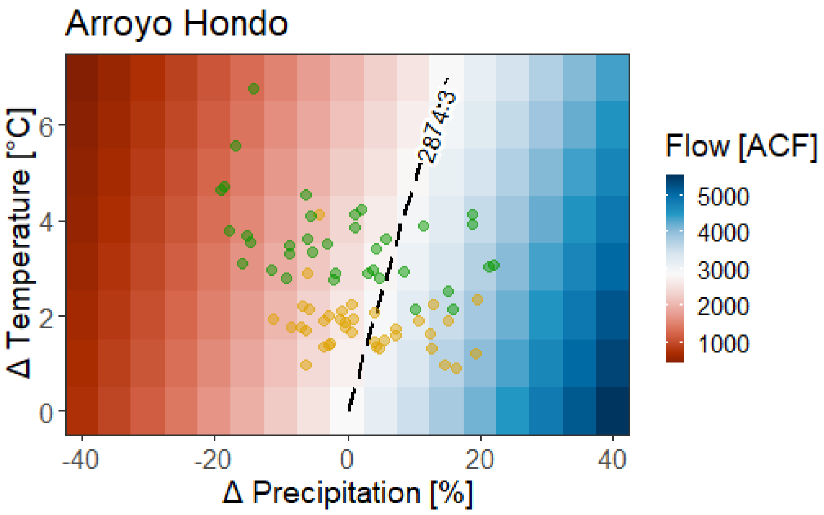


East Bay Watersheds

Warming Reduces Mean Inflow

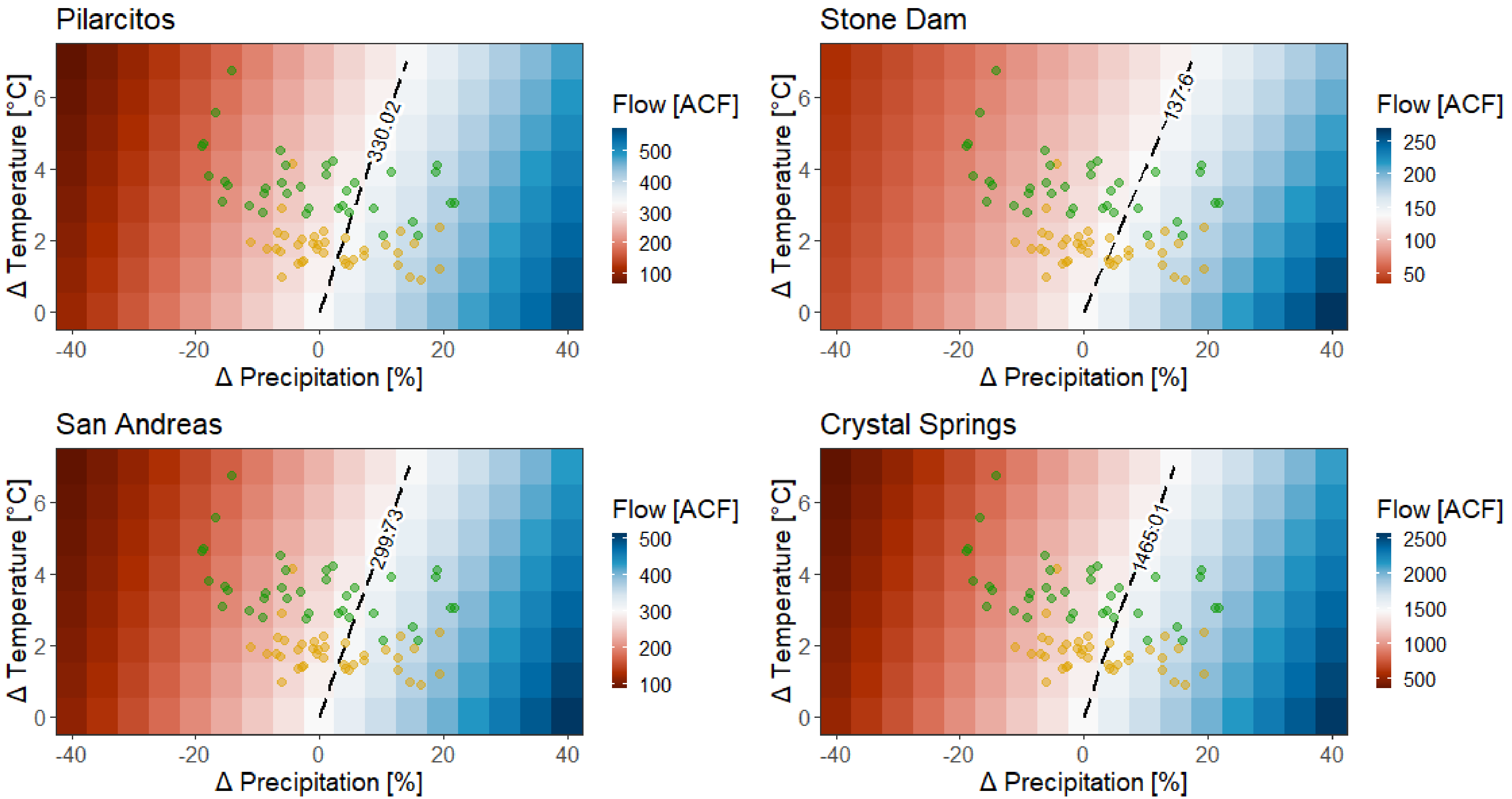






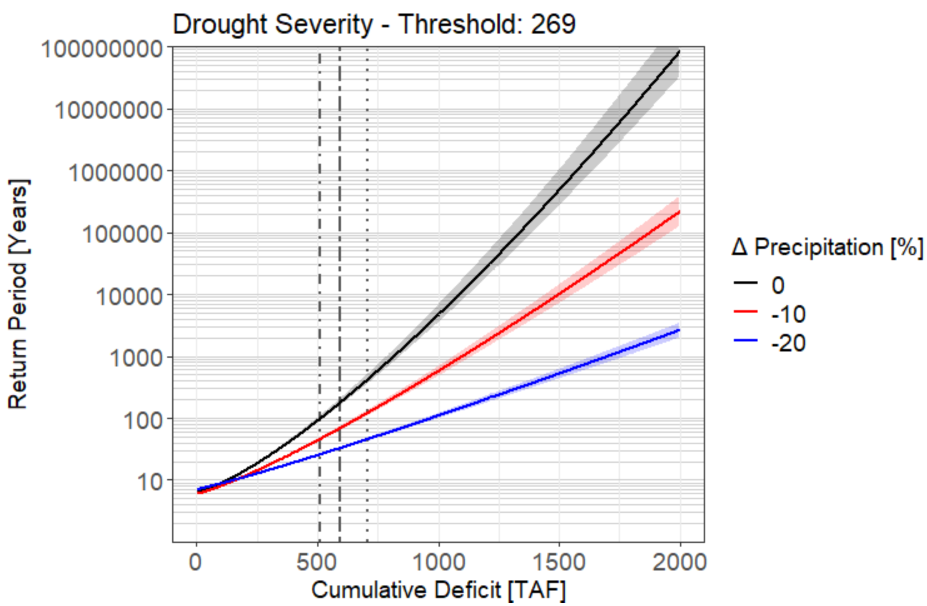
Peninsula Watersheds

Warming Reduces Mean Inflow

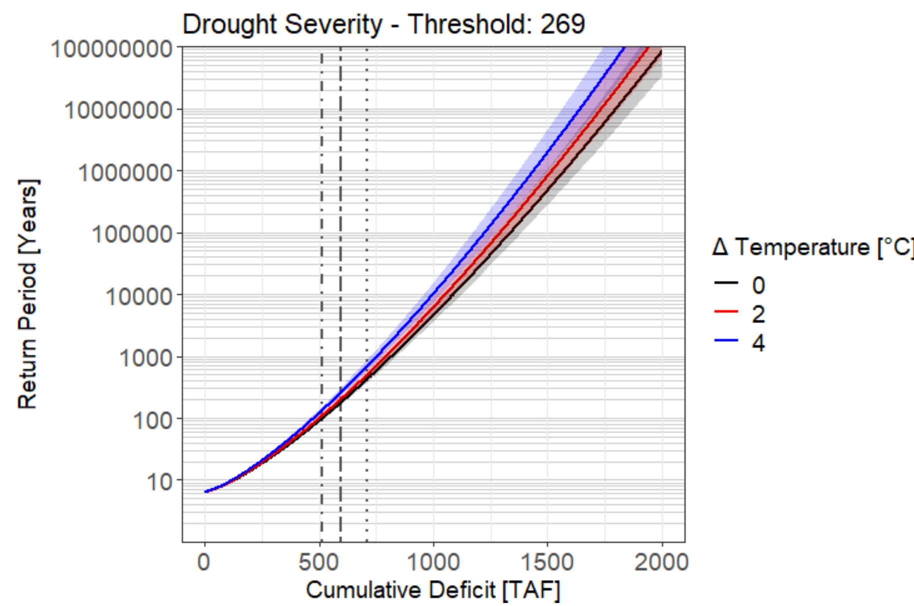


Climate Change Effect on Drought

Precipitation Change



Temperature Change



Drought Recurrence Interval (years)

Drought Event	Changes in Precipitation		
	0%	-10%	-20%
1976-1977	100	45	25
1987-1992	420	120	45
2012-2015	180	70	35

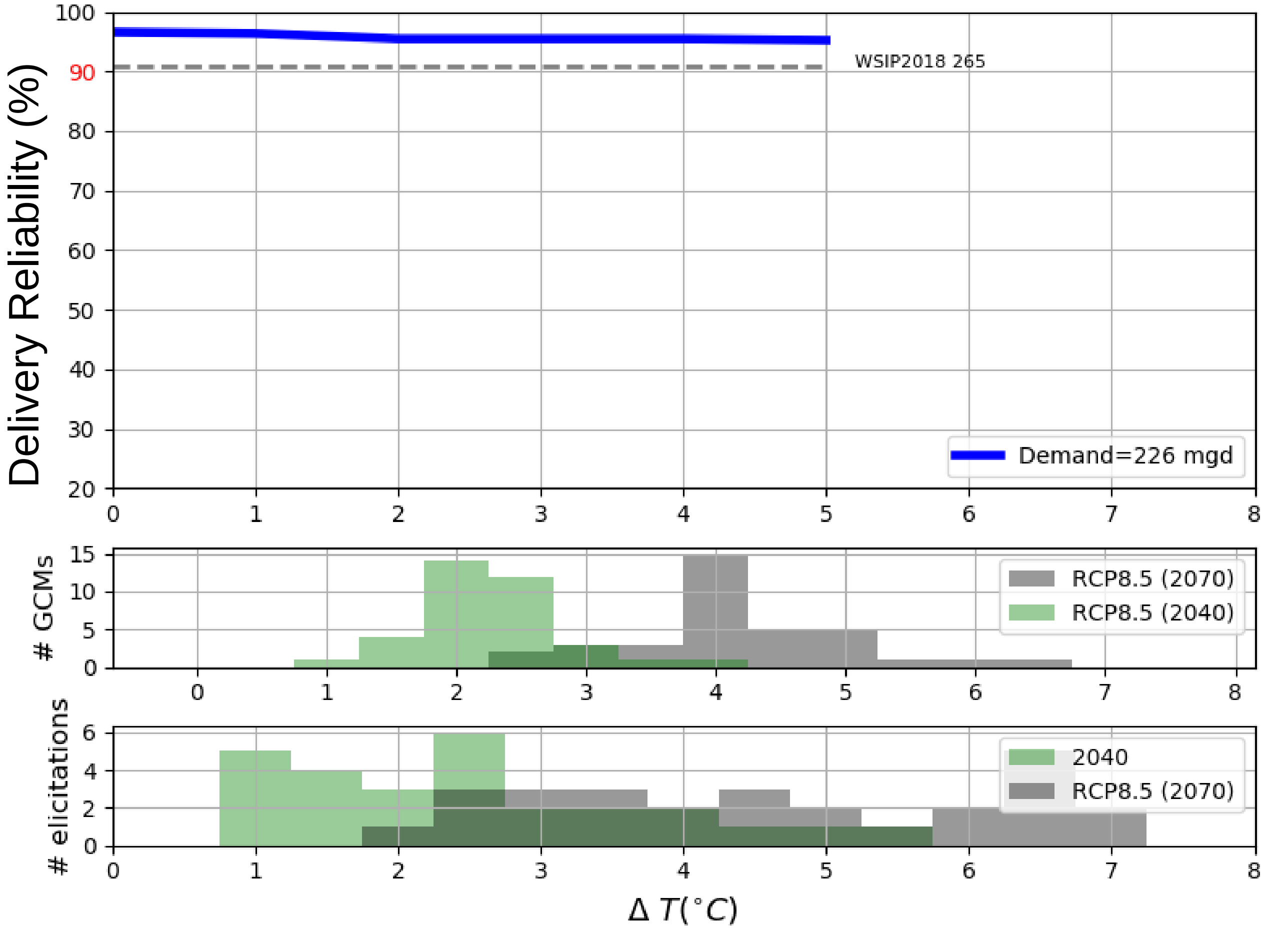
Measuring Performance - Reliability

Reliability of water delivery:

- The frequency of years the system delivers full demand (i.e. no rationing has been applied)
- Target is 90% (1 year of rationing out of 10 on average)

Effect of Temperature

Water delivery reliability is insensitive to temperature change

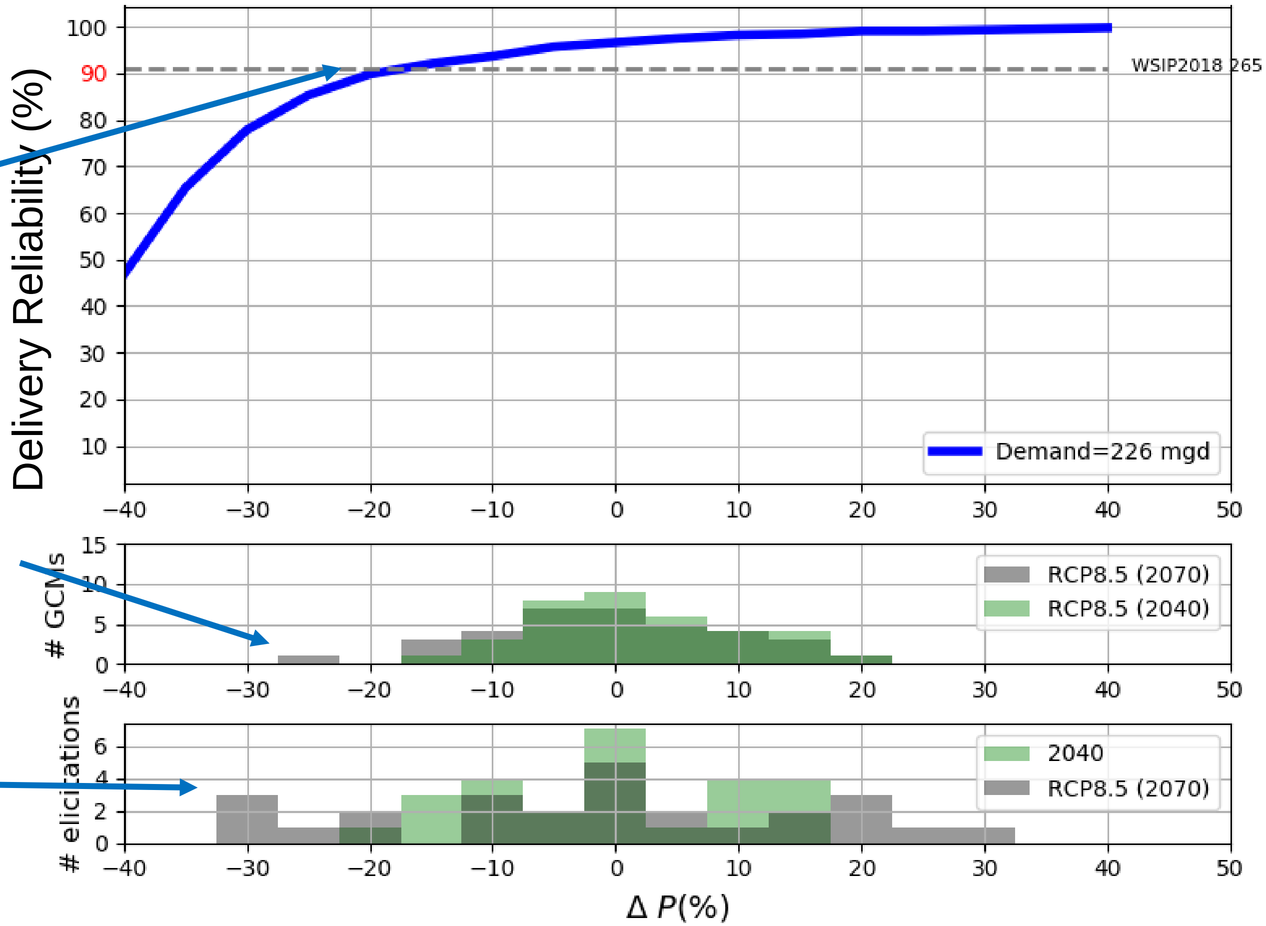


Effect of Precipitation

Vulnerable if precipitation decreases by more than 20%

1 GCM predicts -20% by 2070

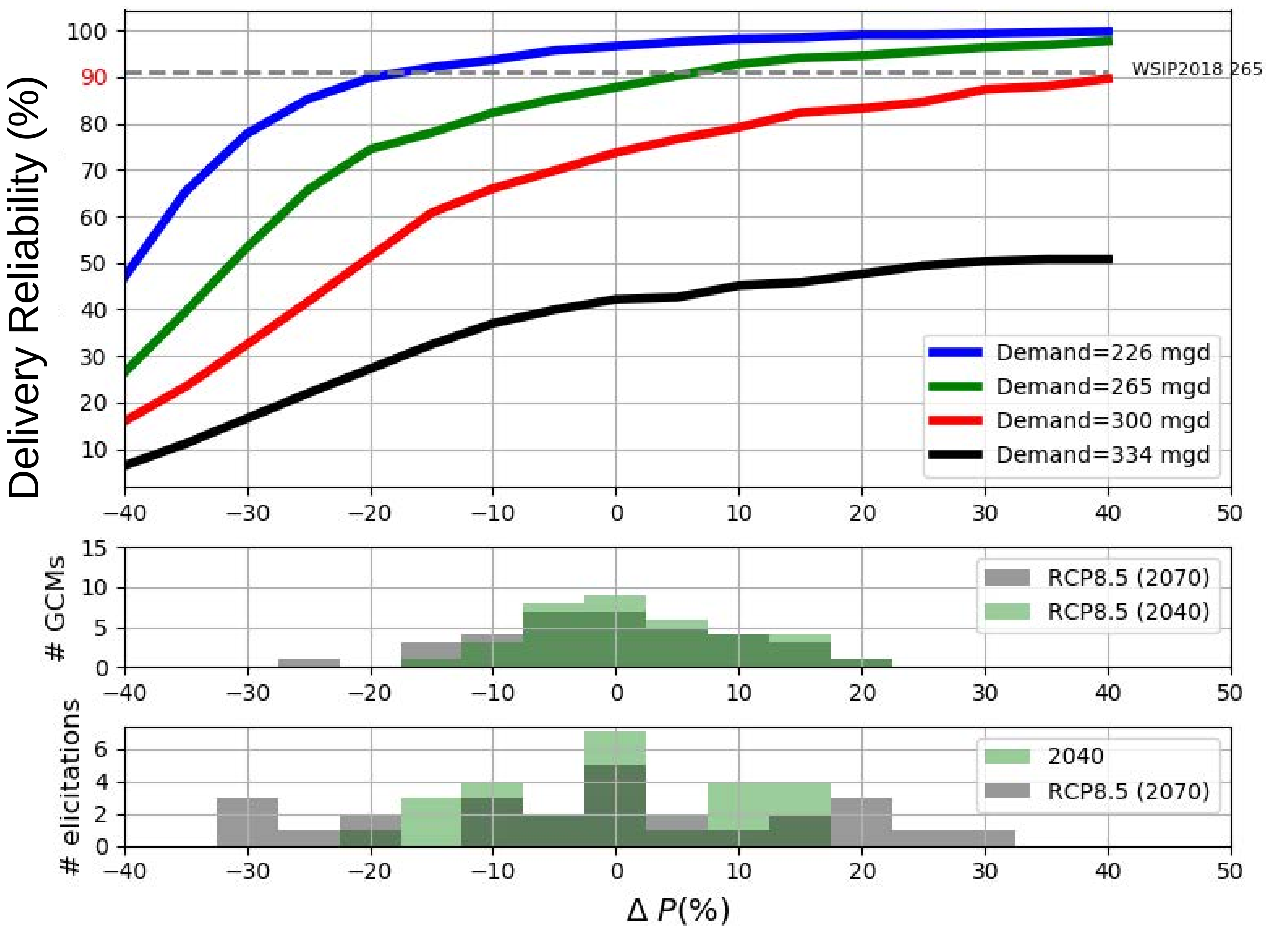
6 expert elicitations predict -20% by 2070



Precipitation and Demand

Very sensitive to changes in demand

- If demand increases by 15%, target not met unless precipitation increases by 5%
- If demand increases by 30%, target cannot be met



Climate and IFRs

- **The State amended Water Quality Control Plant causes a significant increase in frequency of rationing**

- It is an equivalent increase in frequency of rationing as a decrease of 15% in mean annual precipitation from severe climate change

Climate and Infrastructure failures

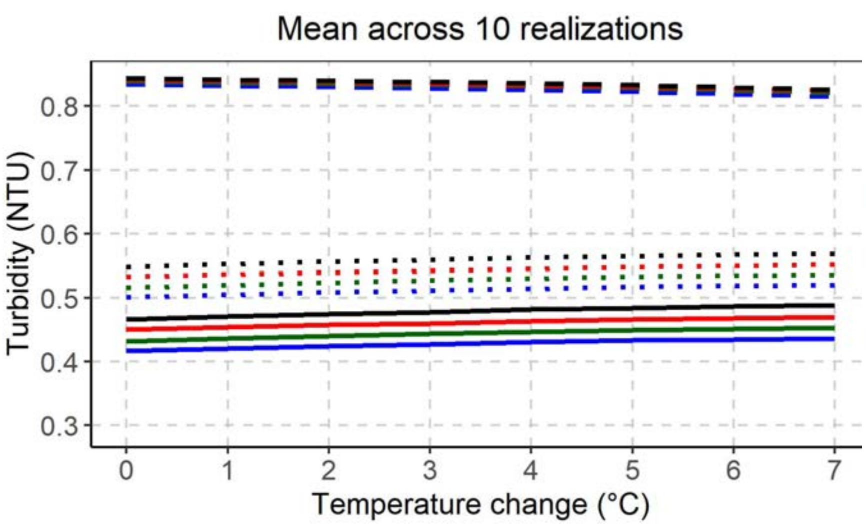
- **Failures** related to **importing water** from the Upcountry are most important

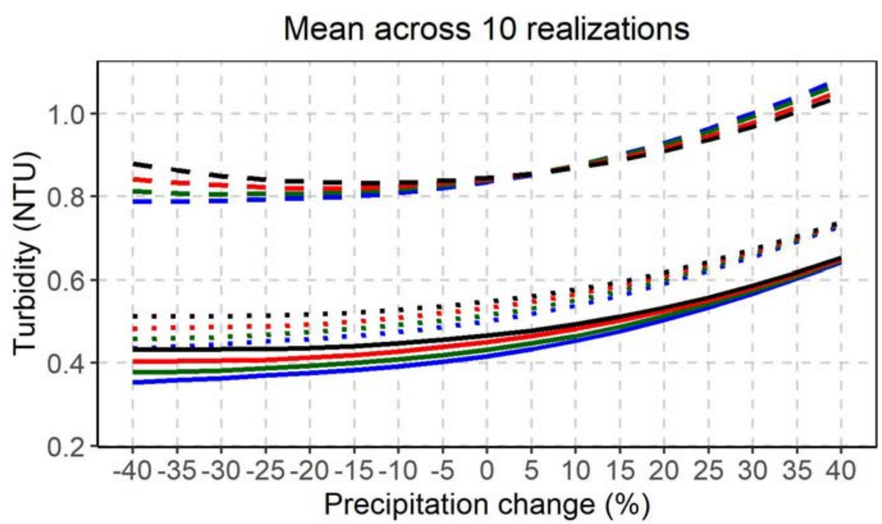
- **Decreases** in precipitation **exacerbate** the vulnerability to infrastructure failure

- **Unplanned outage** of Harry Tracy Water Treatment Plant **caused less vulnerability** to water supply

Raw Water Quality - Turbidity and Total Organic Carbon (TOC)

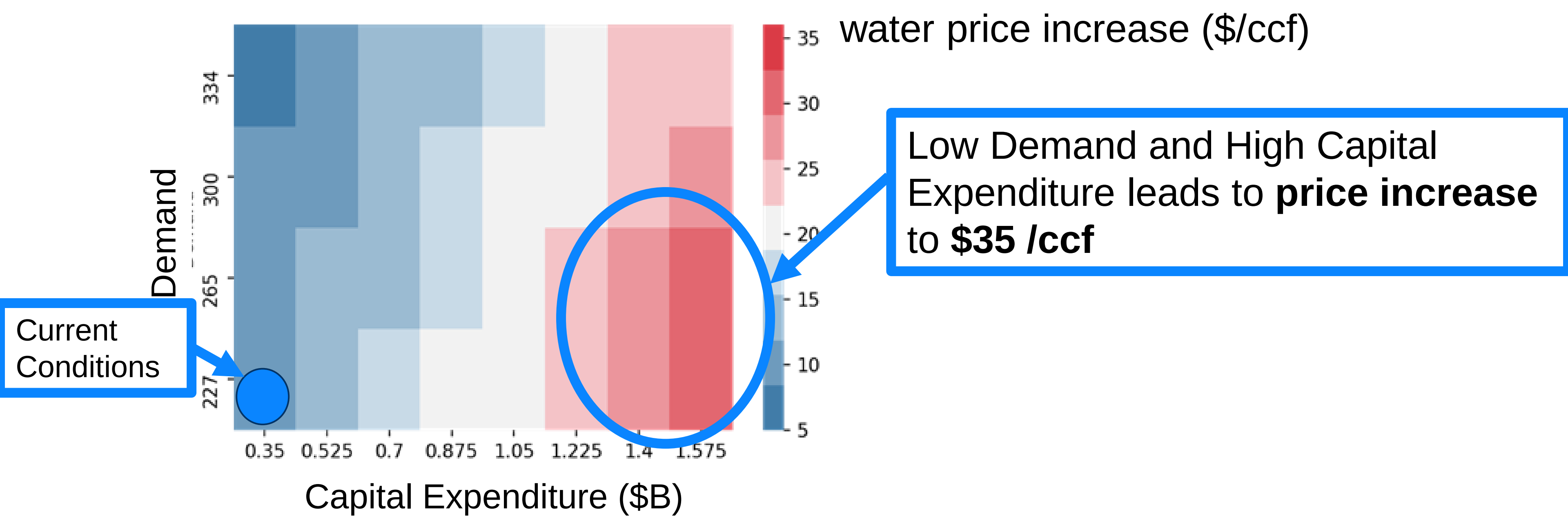
- Turbidity **increases** with **increases** in **mean precipitation**
- TOC was generally **less responsive** to mean climate changes overall
- Overall, **raw water quality deterioration in turbidity or TOC does not appear to be a major concern**





Climate Change and Finance

- If major capital investment is needed, **substantial increases in the price** of water are required
- Increasing demand may offset this effect, but also reduces water supply reliability



Color indicates Price Increase ($/ccf) for Demand and Capital Expenditure changes

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LTVA Conclusions

- The RWS is resilient to changes in mean climate and other external drivers at a baseline demand of 227 mgd
- The RWS faces reliability challenges if mean precipitation decreases by 20% or more
- Such precipitation changes are at the low end of Global Climate Model projections and expert opinions
- Climate change exacerbates impacts from other external drivers of change

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Continuing Preparedness

- Use tools from this Study to evaluate climate change with SFPUC's new alternative water supply projects
- Identify Decision Thresholds and Sign Posts
- Monitor climate changes in SFPUC watersheds and continuously update climate projections and impacts
- Improve SFPUC's hydrologic simulation models

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Concluding Remarks

- We have been studying climate change and its effects in our watersheds for nearly 15 years
- The Long-term Vulnerability Assessment has allowed us to look at a wide range of plausible climate futures in relation to other RWS vulnerabilities
- We have learned that under our current demands and instream flow requirements we are resilient to many possible climate futures, but when combined with other vulnerabilities that resiliency fades
- We now have a framework for continuing to evaluate climate change and updated climate projections, as well as the resiliency of new alternative water supplies
- We will use the information from and the tools developed in the LTVA to inform policy decisions by the Commission

Concluding Remarks

- We will continue to improve the tools, in particular the hydrologic models, used in the LTVA
- Monitoring changes in our watersheds will be critical as we move into the future
- We will continue to be engaged in climate science and collaborations to keep us up to date and responsive to the changing science
- We will continue to use, refine and develop forecasting tools to help us respond to extreme weather events and changes in climate

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Discussion