Keeping Pace with Evolving Climate Science

Planning for Climate Change at the Philadelphia Water Department

Julia Rockwell, PWD

SE PA-AWWA Spring Conference

April 12, 2024

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Disclaimer

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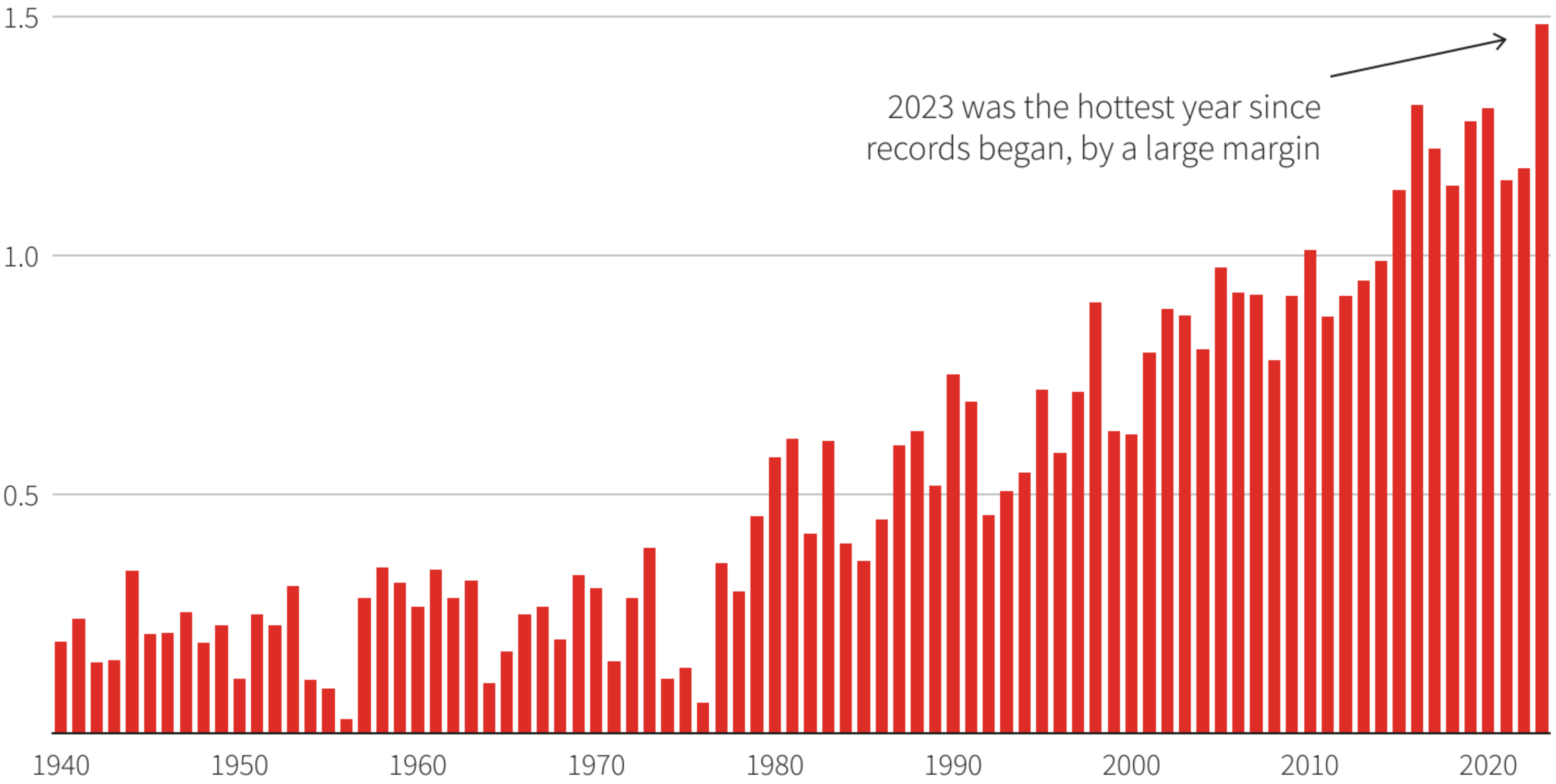
Presentation Overview

1. 2023 climate-related highlights
2. Climate change adaptation planning at PWD: approaches & examples
3. Key takeaways and lessons learned thus far

2023 Climate Highlights

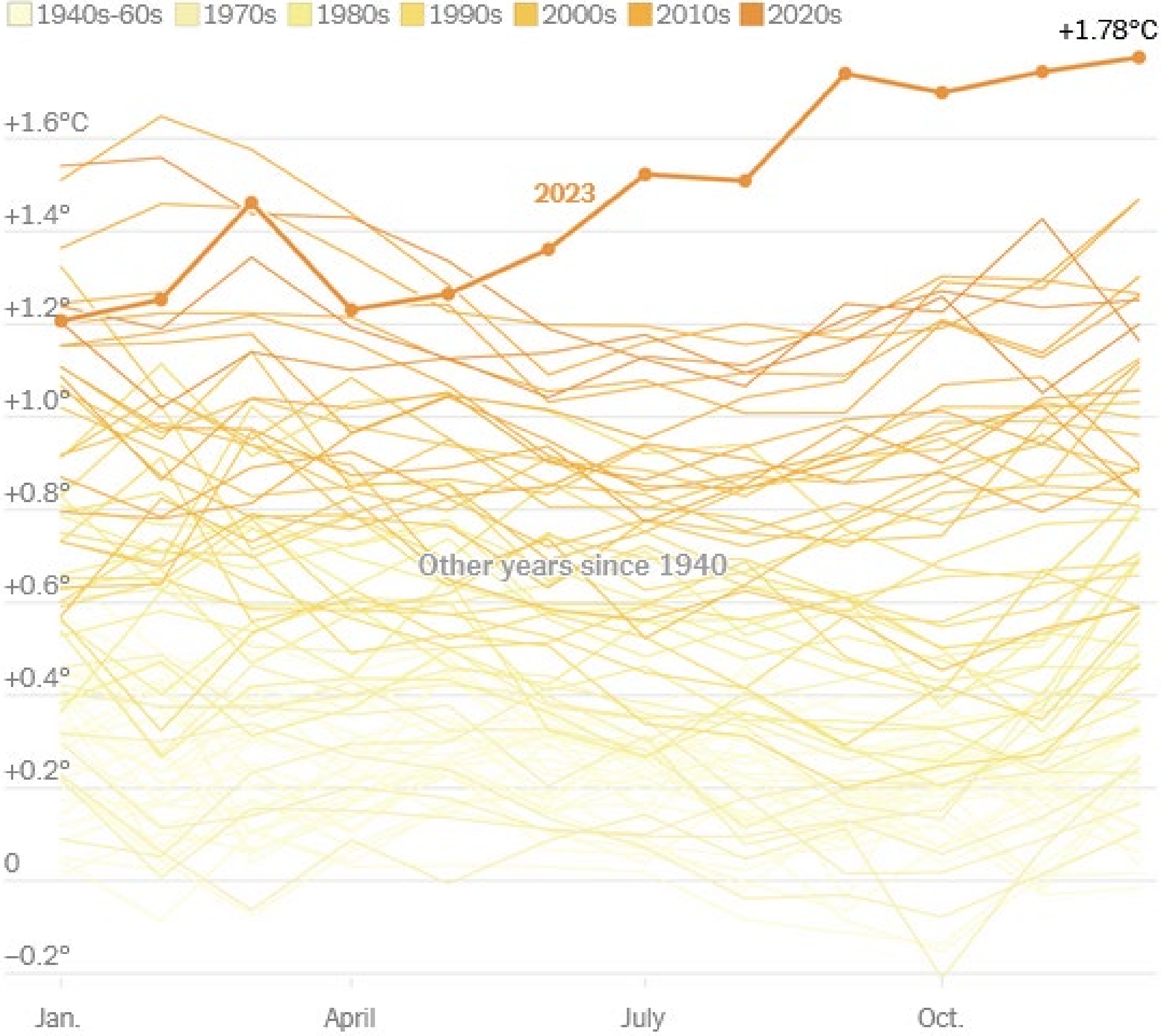
2023 was the world's hottest year on record

Global surface temperature increase versus the average during the 1850-1900 pre-industrial period (°C)



Source: Copernicus Climate Change Service/ECMWF

Monthly global temperature compared with pre-industrial levels



Source: Copernicus/ECMWF

ipcc https://www.ipcc.ch/report/sixth-assessment-report-cycle/

AR6 Synthesis Report: Climate Change 2023

REPORT

This Synthesis Report (SYR) of the IPCC Sixth Assessment Report (AR6) summarizes the ***state of knowledge*** *of climate change, its widespread* ***impacts and risks,*** *and climate change* ***mitigation and adaptation****.*

The IPCC finalized the Synthesis Report for the Sixth Assessment Report during the Panel's 58th Session held in Interlaken, Switzerland from 13 - 19 March 2023.

READ THE REPORT

CORE WRITING TEAM

WMO UNEP

COP28 Agreement Signals “Beginning of the End” of the Fossil Fuel Era

13 December 2023

UN Climate Press Release

United Nations Climate Change Conference (COP28):

- Released the first ever Global Stocktake, which will inform the next round of climate action plans under the Paris Agreement
- Calls on all parties to reduce dependence on fossil fuels
- 118 countries agreed to triple renewables and double energy efficiency by 2030

U.S. Global Change Research Program

Fifth National Climate Assessment (NCA5)

Released November 14th, 2023 (https://nca2023.globalchange.gov). Key takeaways include:

- Climate change will continue to cause profound changes in the water cycle
- Extreme events are becoming more frequent and severe
- Effective adaptation requires centering around equity

Claire Seaman, Imagining Climate Resiliency in the Pacific Northwest
(2021, oil on canvas)

Simona Clausnitzer, In the Eye of the Storm
(2020, linocut print)

Rapidly Evolving Science

The Washington Post

HIDDEN PLANET

Octopuses help solve a long-standing mystery of West Antarctica demise

By Kasha Patel

December 21, 2023 at 4:16 p.m. EST

Turquet's octopuses (Pareledone turqueti) can reveal changes about Antarctica's past through their DNA. (Dave Barnes, BAS)

Climate change in Philadelphia

- Precipitation ↑
- Sea level ↑
- Extreme storm events ↑
- Air Temperature ↑
- Droughts ↑ ↓ —

Coming in 2024!

Updated climate science and projections from our Office of Sustainability, based on the latest set of global climate models

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Climate Adaptation Planning at PWD

Philadelphia Water Department

Combined Utility for 1.7M Customers

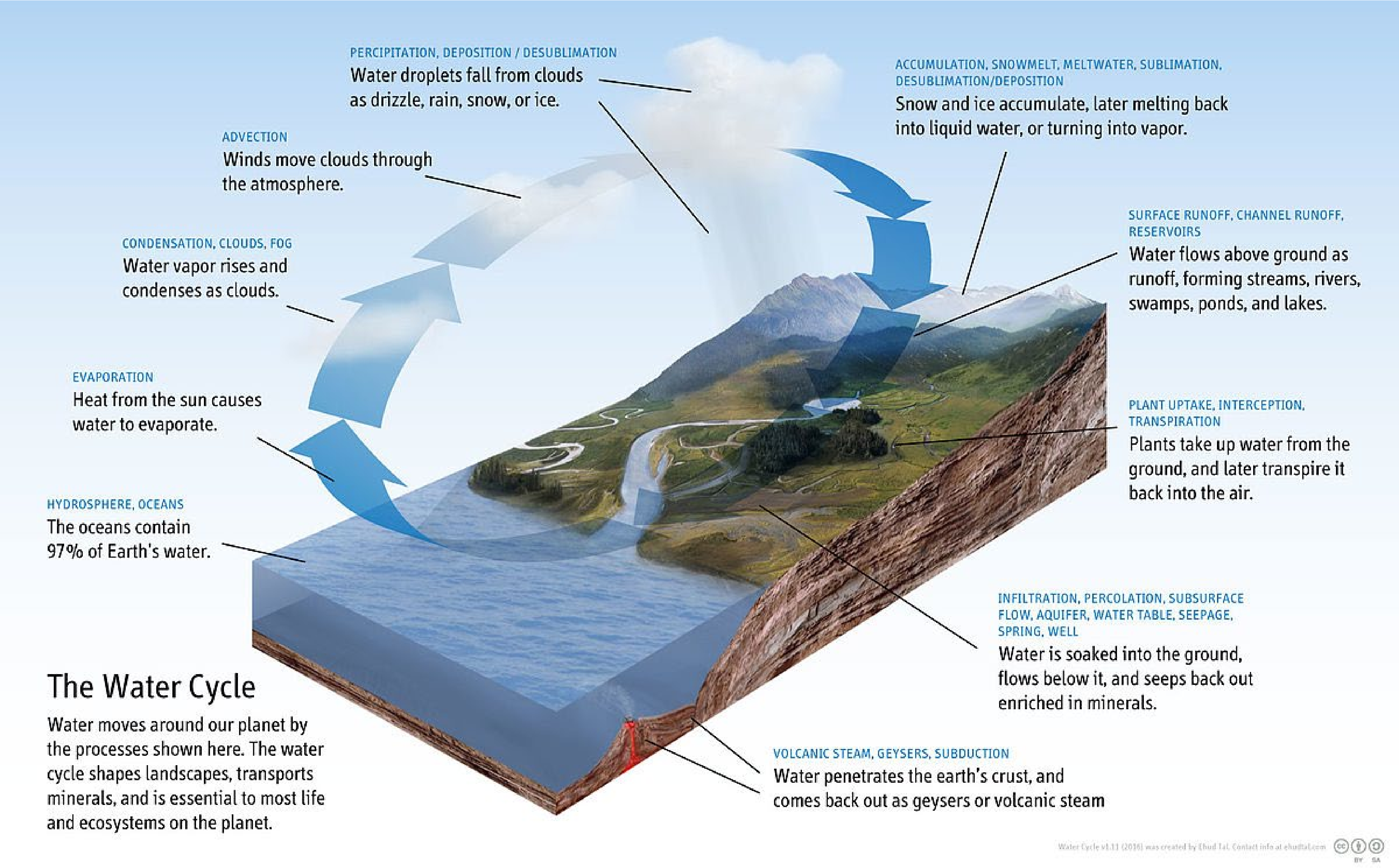
Protecting Water Resources

Stormwater
Storage & Management
60% Combined, 40% Separate

Drinking Water
Source Water Protection
Treatment & Delivery
300+ MGD

Wastewater
Collection & Treatment
522+ MGD

A warming planet means a changing water cycle



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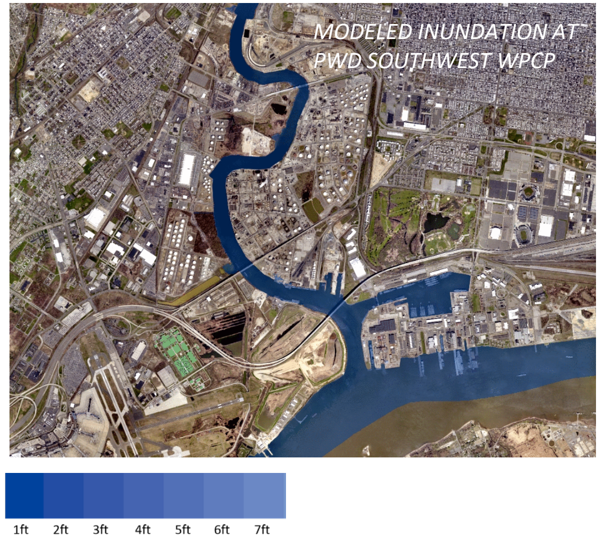
A warming planet also means a changing *urban* water cycle



The Urban One Water Cycle

Drinking Water Supply

Drinking Water Treatment

Drinking Water Distribution

Customer Use

Wastewater/ Stormwater Collection

Stormwater Management

Wastewater Treatment

Receiving Waters

Adapted from 'The Urban Water Cycle' by Robert B. Sowby

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Primary Strategies to Ensure Climate Resilience

Mainstreaming

Generating **actionable science and tools** and **mainstreaming** the use of climate projections in all planning and design processes

Assessing & Addressing Risks

Carrying out **risk assessments** and identifying specific adaptation strategies to reduce climate-related risks

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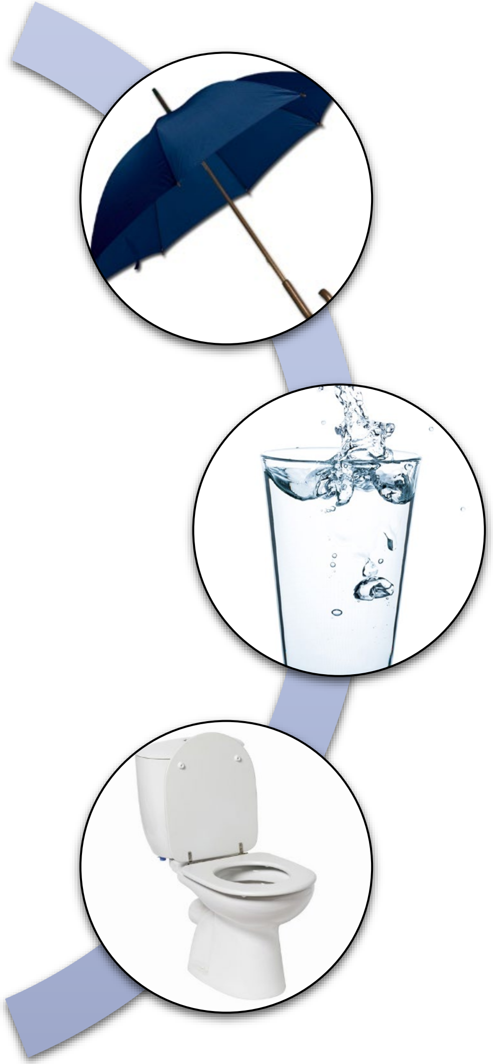
Mainstreaming increases resilience of core services

- Water Revitalization Plan
- Wastewater Master Plan
- Stormwater Obligations
  - Green City, Clean Waters
  - MS4 Planning
- Capital Planning
- Source Water Protection & Planning
- Water Supply Planning



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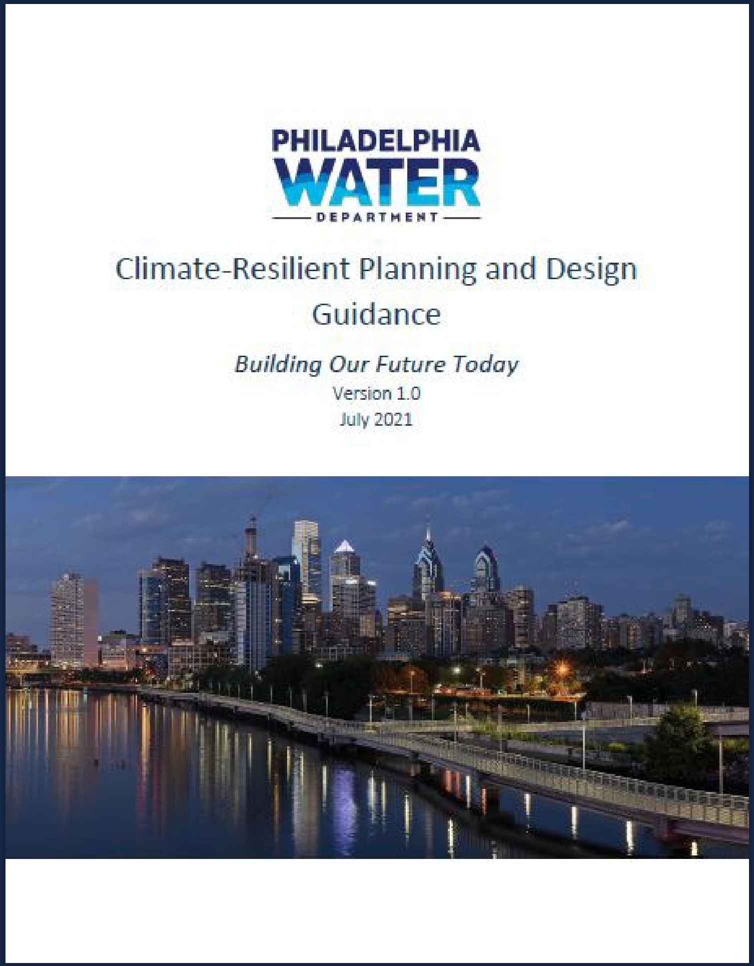
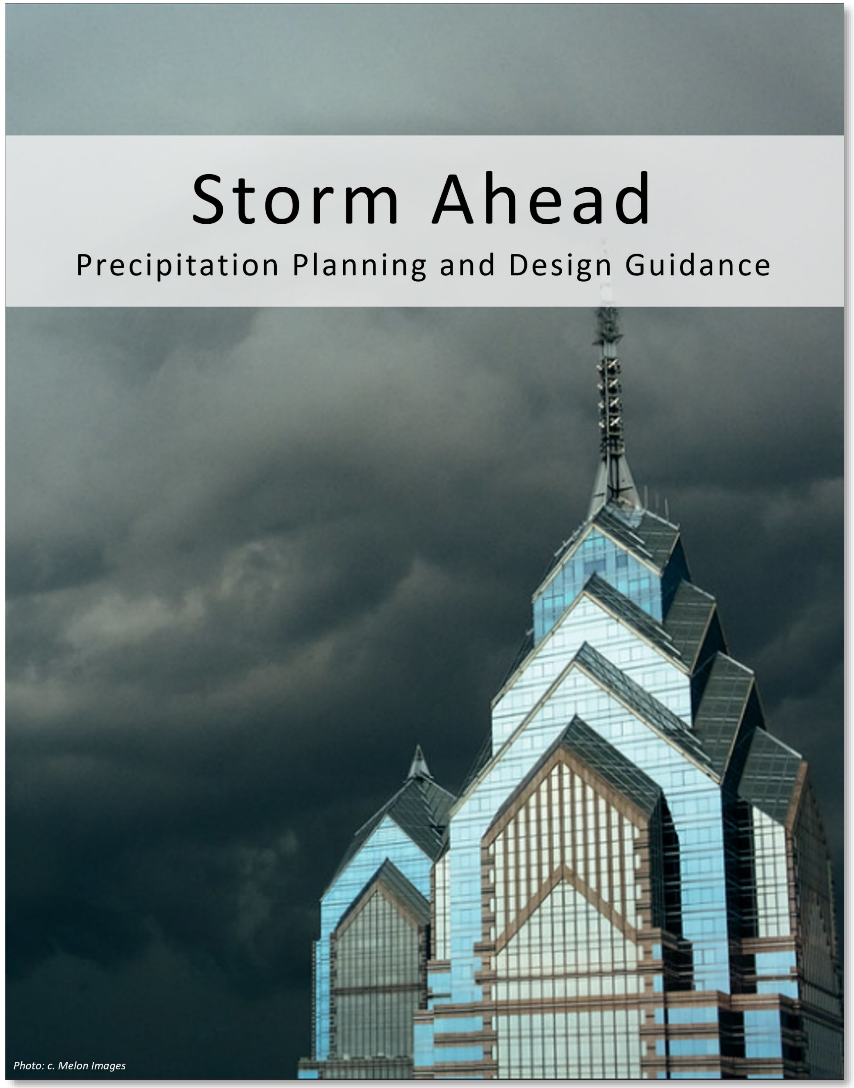
PWD Climate-Resilient Planning & Design Guidance

- PWD's fundamental reference document for **mainstreaming** the use of climate change information at PWD
- Provides guidance on what climate change projections PWD staff and consultants should use in infrastructure planning and design processes
- Department-wide policy requiring use of the Guidance document was established in January 2022
- This is a **living document** that reflects the latest science, projections and tools. V1.1 update released this year (2024)



Extreme Precipitation Analysis

- **The issue:** Global Climate Models (GCMs) underestimate precipitation extremes
- Identified as ‘area for future consideration’ in Version 1.0 of PWD’s *Climate-Resilient Planning and Design Guidance*
- Starting point: extensive literature research



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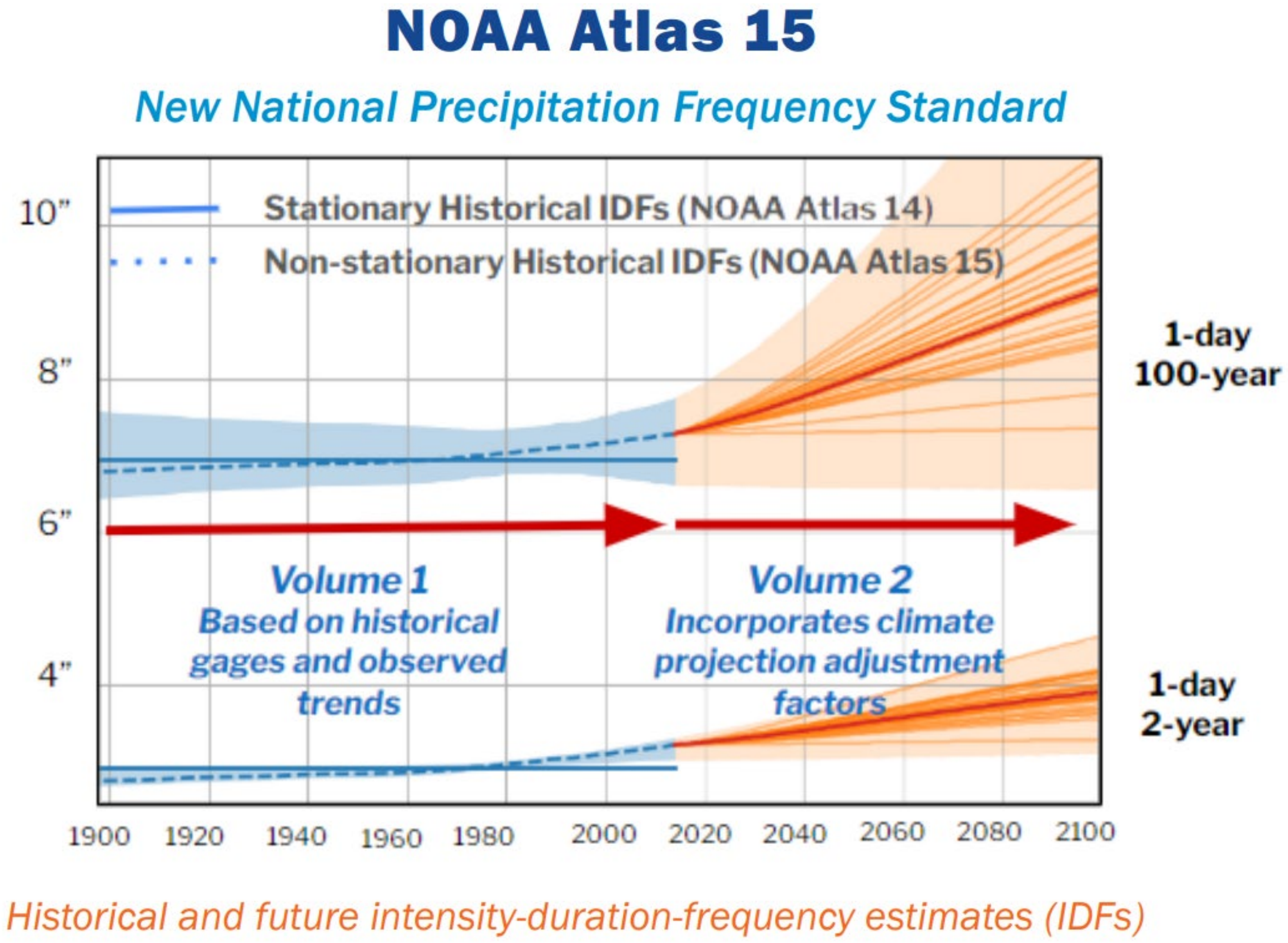
Atlas 15 is on the horizon, but still a few years away from completion



NOAA_Atlas_15_Flyer.pdf (weather.gov)

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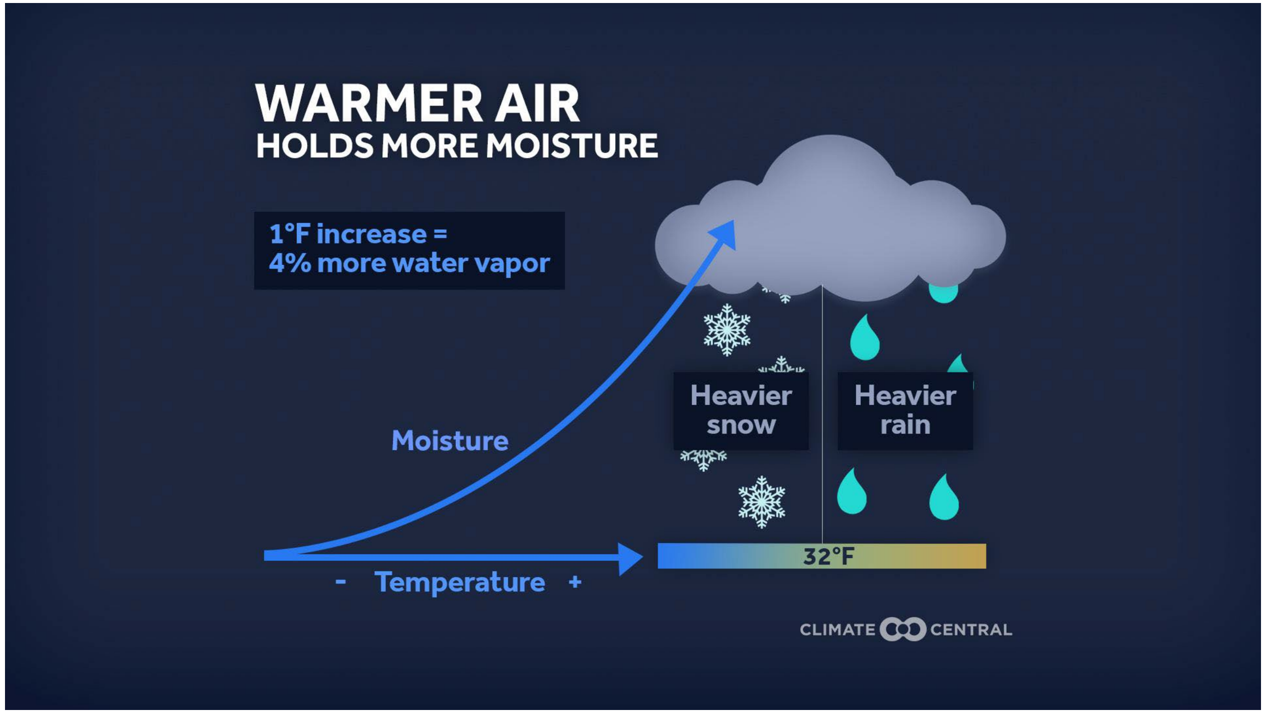
A temperature-based approach

Atmospheric holding capacity



- Modeling and data trends in extreme rainfall are now documenting **~7% per degree Celsius increase** at the daily scale (**Clausius-Clapeyron principle**)
- But recent research indicates *intensification can be greater than 7% per degree Celsius* **('Super Clausius-Clapeyron')**
- IPCC6 Report and scientific literature indicate:
  - Greater temperature increases = larger precipitation intensity/volume increases
  - Shorter duration events **and** less frequent events = larger intensity/volume increases

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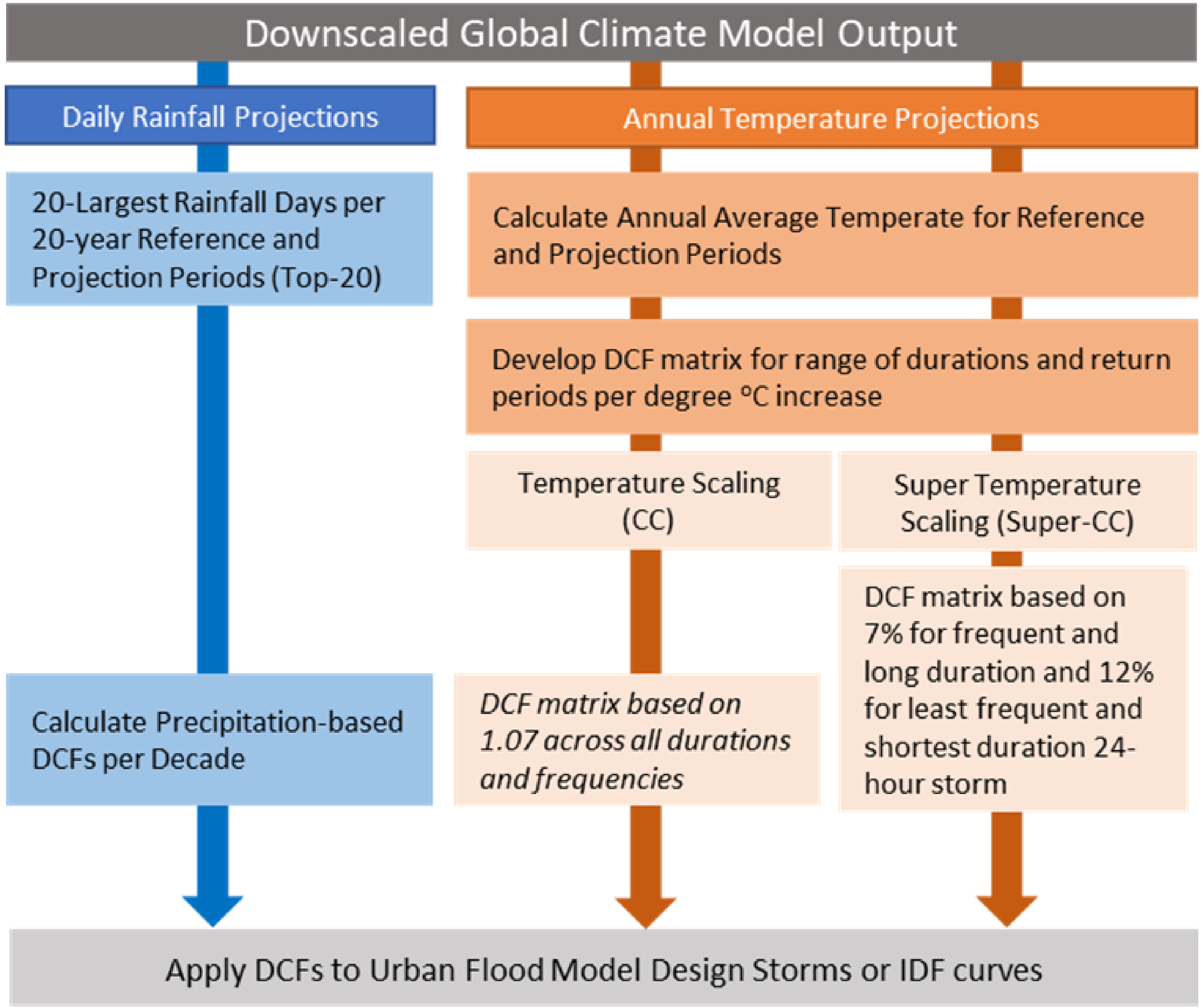
Extreme Precipitation Analysis



- CCAP and our consultant, CDM Smith, ultimately developed three methods to estimate increases in extreme rainfall (Low, Mid, High)
  - Low approach still relies on rainfall projections
  - Mid and High methods use temperature-based approach, that relies on more accurate GCM temperature output
  - RCP8.5 Emission Scenario

CDM Smith

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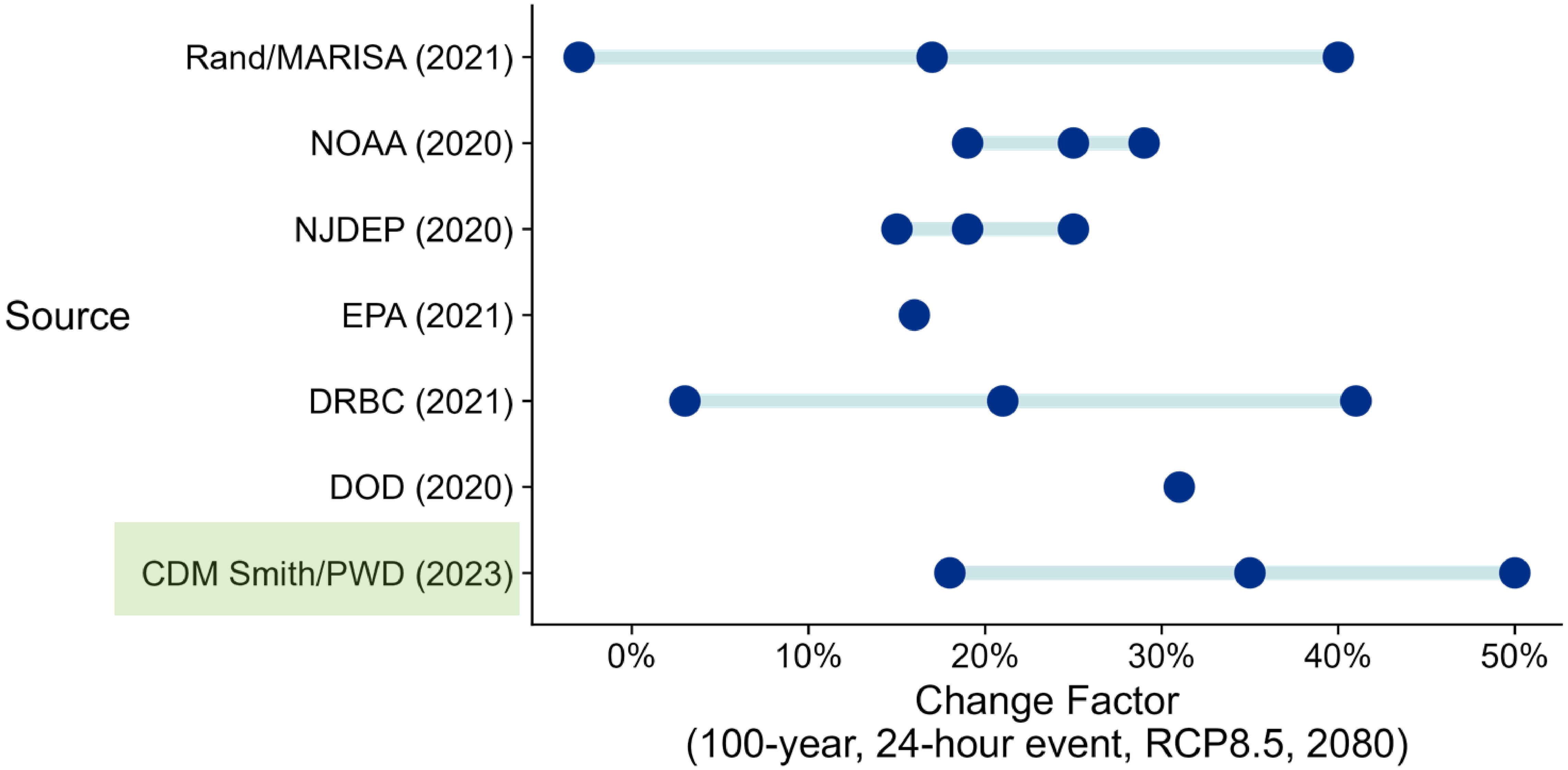
Results: Precipitation Delta Change Factors

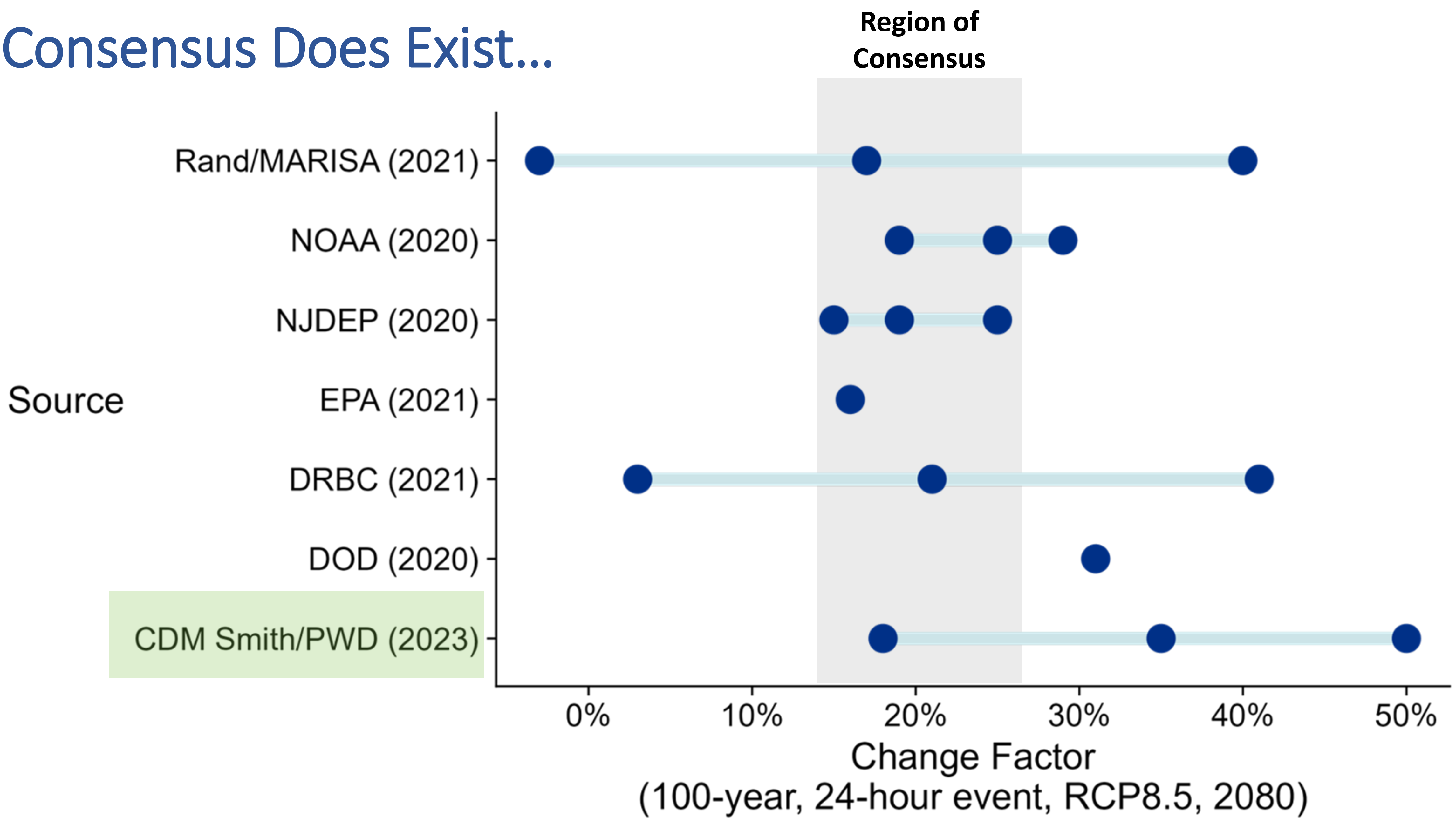
CCAP DCF Estimates for 100-yr				
	C-C		Super C-C	
Duration	2050s	2080s	2050s	2080s
1-hour	1.23	1.35	1.39	1.60
2-hour	1.23	1.35	1.38	1.58
3-hour	1.23	1.35	1.37	1.56
6-hour	1.23	1.35	1.35	1.54
12-hour	1.23	1.35	1.34	1.52
24-hour	1.23	1.35	1.33	1.50

CCAP Depth Estimates for a 24-hr Duration					
		C-C		Super C-C	
Return Period(yr.)	Baseline Depth(in)	Depth in 2050s (in)	Depth in 2080s(in)	Depth in 2050s (in)	Depth in 2080s(in)
100	9.13	11.23	12.35	12.13	13.73

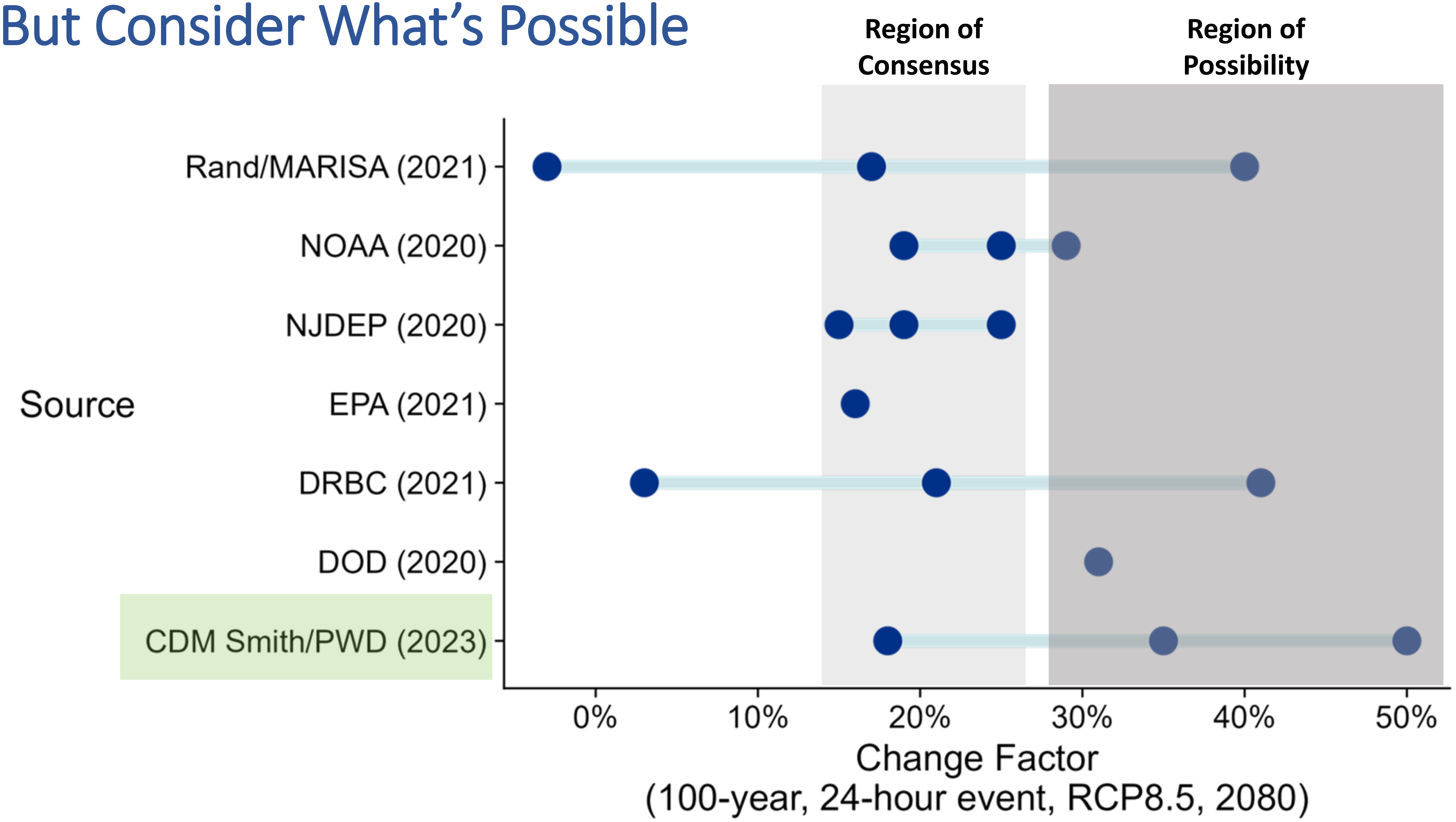
Comparing Results with other Sources



Consensus Does Exist…



…But Consider What's Possible



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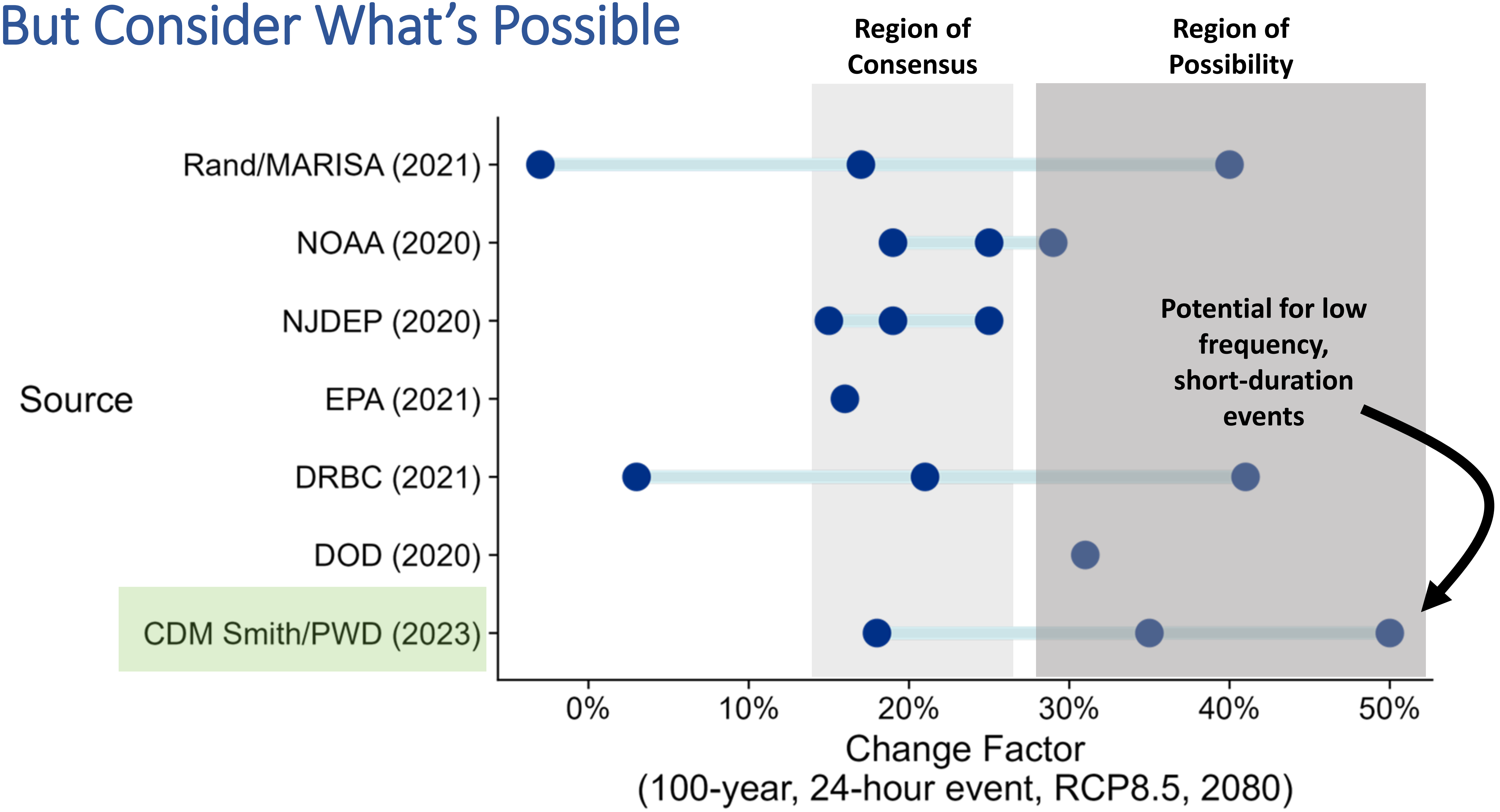

Read the Paper

[Three methods of characterizing climate-induced changes in extreme rainfall: a comparison study | Journal of Water and Climate Change | IWA Publishing (iwaponline.com)]

Volume 14, Issue 11

1 November 2023

CDM Smith

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What risks will water utilities face due to more extreme precipitation events?

Source: The Philadelphia Inquirer. *A $37 million floodwall at the New Jersey American Raritan-Millstone Water Treatment Plant in Bridgewater, NJ successfully withstood a raging torrent last month after the remnants of Hurricane Ida deluged the region.*

Fall 2021: Hurricane Ida impacts PWD infrastructure

How will climate change impact riverine flooding in Philadelphia?

How can riverine flooding risks be addressed in the PWD Water Revitalization Plan, considering climate change impacts and the increasing intensity and frequency of extreme precipitation events?

Belmont Raw Water Pumping Station, September 2, 2021

Riverine Flood Protection

Changing Flood Return Intervals

Flows from Hurricane Ida on the Schuylkill		
Based on outdated flow data (1964 - 2002)	*Based on current flow data from the last 20 years (2000-2021)*	*End-of-century projections using a high emissions scenario*
~65-year event →	**~30-year event** →	**~6-year event**
1.5% chance of occurring in any given year	*3.3% chance of occurring in any given year*	*16.7% chance of occurring in any year*
32% chance of occurring over a 25 year period	*57% chance of occurring over a 25 year period*	*99% chance of occurring over a 25-year period*

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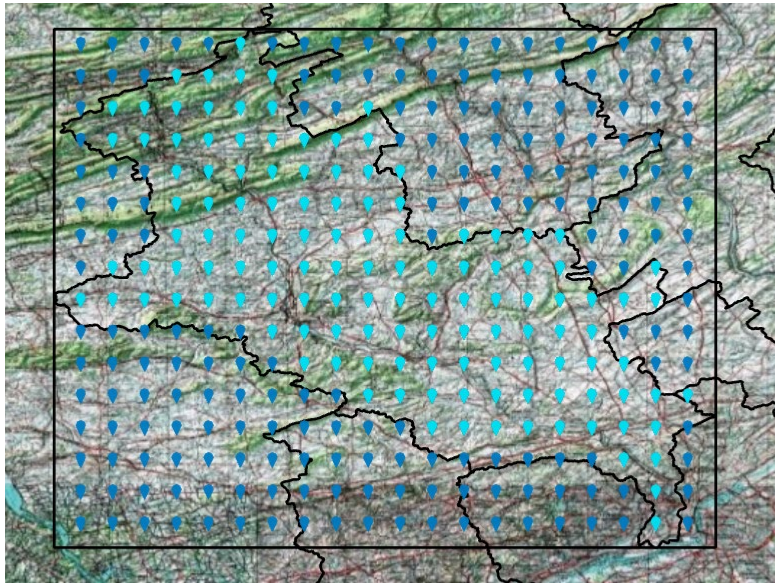
Riverine Design Flood Elevation (DFE) Methodology

Downscaled Global Climate Model (GCM) outputs for the Schuylkill River Watershed

Calculate Delta Change Factors (DCFs) to estimate the percent change in future streamflow decade-by-decade

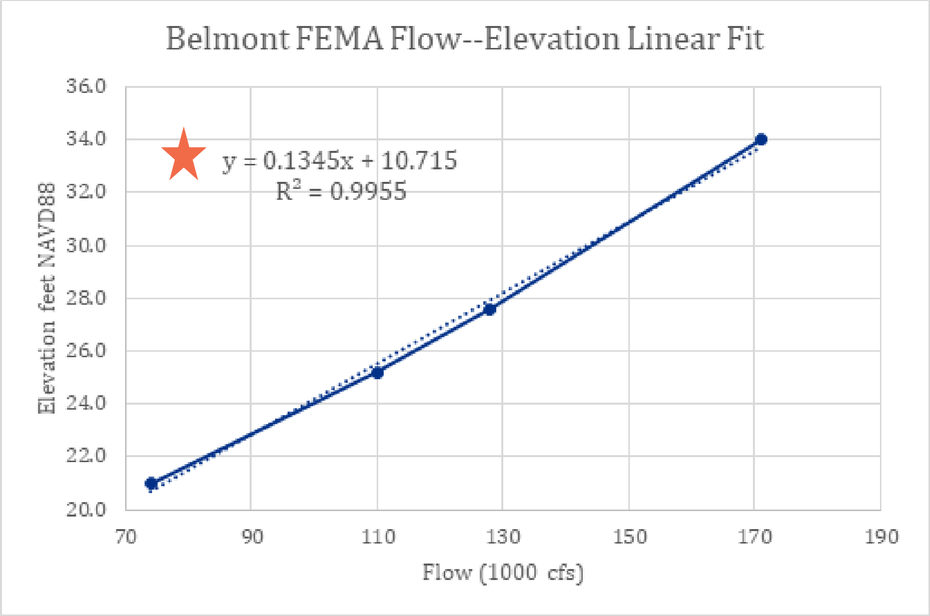


GCM nodes for the Schuylkill River watershed used in calculating DCFs

RCP8.5 Delta Change Factors	
20-year mid-point	Schuylkill Watershed
2020	24%
2030	28%
2040	29%
2050	25%
2060	32%
2070	41%
2080	53%
2090	60%

Future streamflows and elevations

Input climate-adjusted future streamflows in flow-elevation equation to determine future flood elevations



Riverine DFE Results

Schuylkill River at Belmont RWPS

At the Belmont RWPS: Flows and Associated River Elevations for RCP8.5										
		Return interval								
Decade (year)	DCF	10-year		50-year		100-year		500-year		
	RCP8.5	Flow (cfs)	Elev. (ft.) NAVD88	Flow (cfs)	Elev. (ft.) NAVD88	Flow (cfs)	Elev. (ft.) NAVD88	Flow (cfs)	Elev. (ft.) NAVD88
2020	24%	91,969	23.1	136,711	28.9	159,082	32.3	212,523	42.2
2030	28%	94,408	23.4	140,336	29.4	163,300	33.0	218,159	43.4
2040	29%	95,169	23.5	141,467	29.6	164,616	33.2	219,917	43.8
2050	25%	92,250	23.1	137,128	28.9	159,567	32.4	213,172	42.3
2060	32%	97,731	23.8	145,275	30.1	169,047	33.9	225,837	45.1
2070	41%	103,998	24.5	154,592	31.6	179,889	35.8	240,321	48.5
2080	53%	113,308	25.7	168,431	33.8	195,992	38.8	261,833	54.0
2090	60%	118,106	26.3	175,563	35.1	204,291	40.5	272,920	57.0

Orange cells indicate results that are beyond model limits and have a higher degree of uncertainty

~34ft. NAVD88 also corresponds to 500-year floodplain elevation at this location

Riverine DFE Results

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2090	60%	118,106	26.3	175,563	35.1	204,291	40.5	272,920	57.0

	Useful life of asset		
	Near-term *(does not extend beyond 2050)*	Mid-century *(2050-2075)*	End-of-century *(2075+)*
Design Flood Elevation (DFE) (Belmont RWPS, existing site)	Local Regulations *(1.5' above FEMA Base Flood Elevation)*	34 feet NAVD88	34 feet NAVD88 + Adaptive Management Plan (AMP)

CDM Smith

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Riverine DFE Results

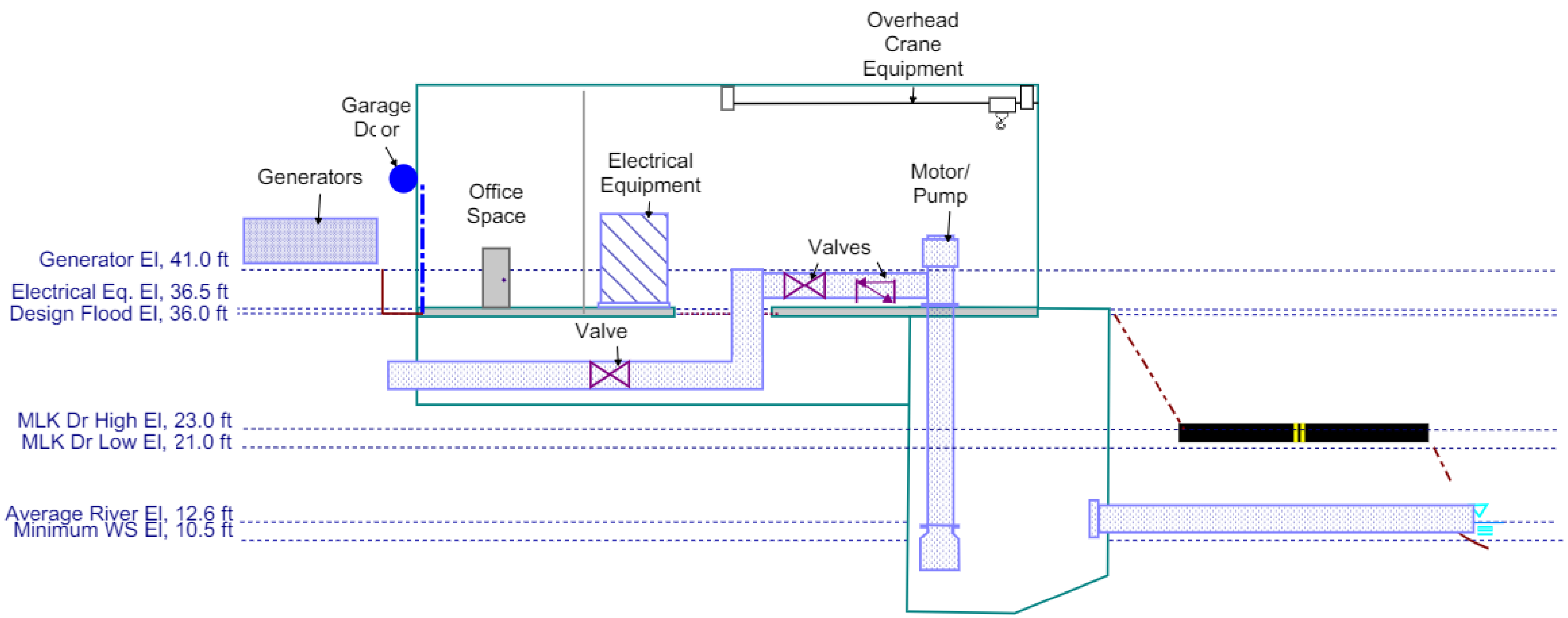
Application to Belmont Raw Water PS Alternatives

Alternative	Near Term (to 2050)	Mid-Century (2050-2075)	End of Century (2075+)
1. Rehabilitation of Existing Pump Station	29.1 feet	34 feet	34 feet + AMP
2. Construction of New 80 MGD Pump Station (North Site)	31.3 feet	36 feet	36 feet + AMP
3. Construction of New 80 MGD Pump Station (South Site)	29.1 feet	34 feet	34 feet + AMP

Potential adaptation measures

Consideration for adaptation measures: an "onion analogy" of layers

- Within the facility: protecting individual assets (e.g., electrical, pumps, distribution pipes)
- Facility interior (facility structure)
- Facility exterior (facility structure)
- Surrounding facility



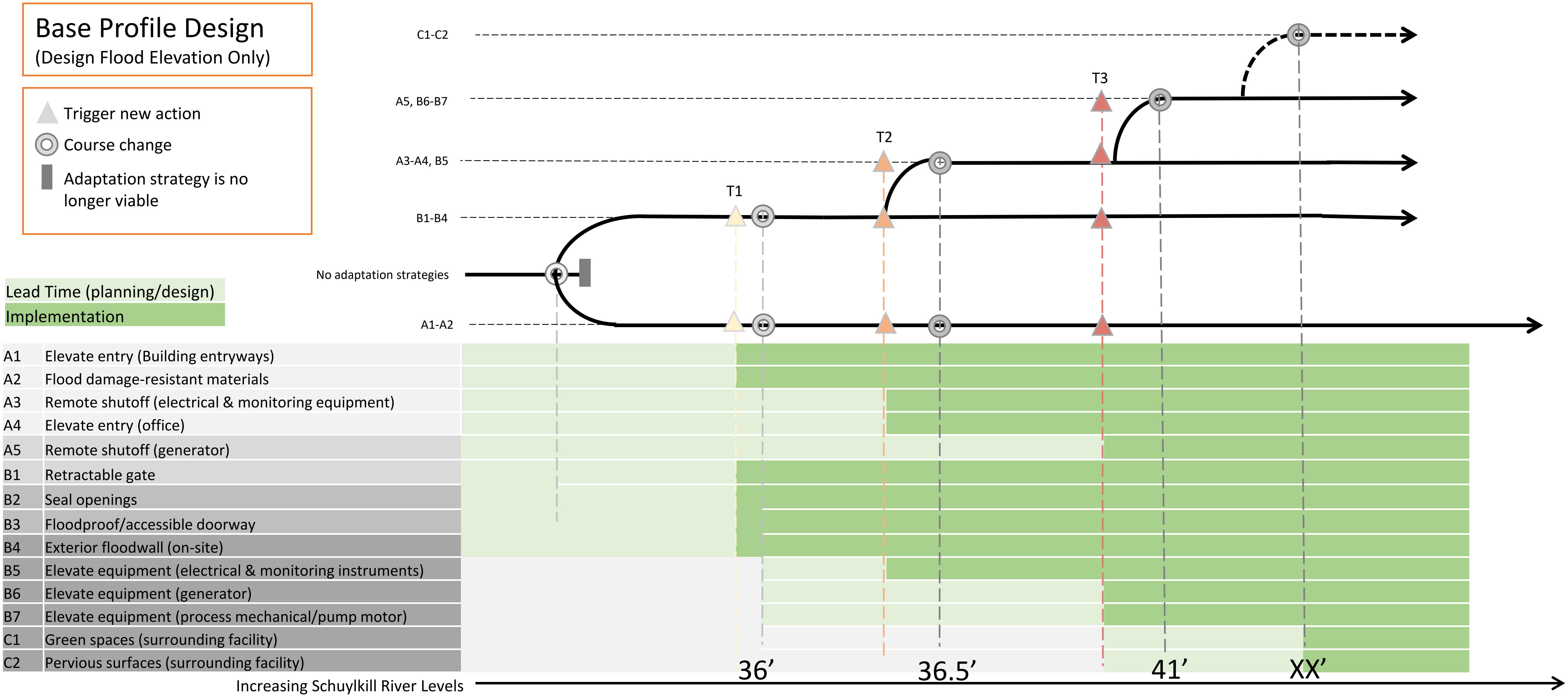
Base Profile: Elevations according to NAVD88

Adaptive Pathway Planning // Schuylkill River Flooding

Brown AND Caldwell

T1	River elevation reaches within X” of DFE level
T2	River elevation reaches within X” of DFE + 6”
T3	River elevation reaches beyond critical asset maximum threshold

Graphic for demonstration purposes only



Flood Resilience & Risk Tolerance

Coastal and Riverine Flooding Applications

Focus near-term investment on a **sitewide mitigation measure** at the DFE.

→

Focus near-term investment on a **sitewide mitigation measure** at a lower elevation than the DFE with **adaptive capacity** to be elevated in the future.

→

Focus near-term investment on **building or asset-specific flood risk mitigation solutions** for most vulnerable assets.

Potentially plan for completion of sitewide protection in the future.

Risk Averse → **Risk Tolerant**

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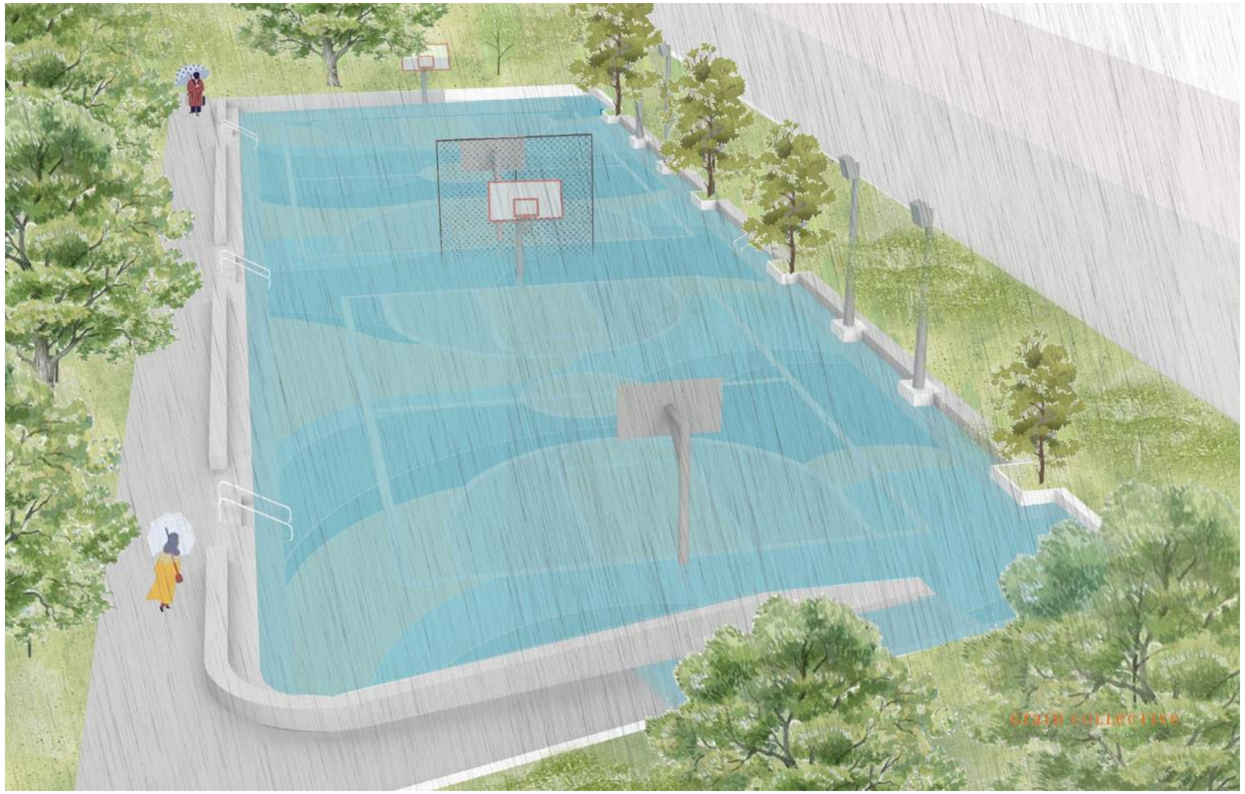
Key Takeaways & Lessons Learned

Adaptation Planning & Risk Reduction

Reduce risks and ensure utilities can:

- Continue meeting evolving and more stringent regulatory requirements
- Maintain high levels of service as infrastructure ages, land develops, environmental conditions change
- Provide equitable service delivery
- Maintain affordability and financial stability



Rendering of Sunken Basketball Court at South Jamaica Houses, Queens, NY

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PWD Takeaways & Lessons Learned: Climate Science

- Considerable effort may be required to make climate science actionable
- …but the adaptation field is rapidly evolving with new tools and resources being released regularly!
- Uncertainty in projections needs to be understood and dealt with by considering the specific application
  - Asset Criticality
  - Asset Useful Service Life
  - Adaptive Capacity
  - Risk Tolerance
- More complex isn't always better

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PWD Takeaways & Lessons Learned: Planning & Implementation

- Don't let perfect be the enemy of progress
- Be prepared for a longer-term, iterative and evolving process.
- Partnerships and forums for info. exchange are crucial
- Staff engagement is key to acceptance and buy-in
- At PWD, a policy was needed to drive change and ensure consistent use of new information

WUCA
Water Utility Climate Alliance

Examples of Key Accomplishments & Products

WUCA
Water Utility Climate Alliance

www.wucaonline.org

- Business Function Mapping
- Leading Practices in Climate Adaptation
- Piloting Utility Modeling Applications
- Embracing Uncertainty
- Engineering Case Studies
- Sea Level Rise Guide
- Climate Resilience Trainings

Water Utility Climate Alliance

Training Materials: Building Resilience to a Changing Climate

View materials from WUCA technical training courses.

Virtual - October 2023

This workshop was designed around a need identified by two WUCA member agencies, the Philadelphia Water Department (PWD) and the NYC Department of Environmental Protection (NYCDEP), to build stronger connections among water agencies and climate scientists who focus their work in the Delaware River Basin.

The workshop increased Basin stakeholders' collective understanding of both water sector and climate change planning challenges and provided tools and case studies on how to overcome these challenges and successfully adapt, even amid deep uncertainty.

Resources

Philadelphia Water Department (PWD) Climate Change Adaptation Program (CCAP)

https://water.phila.gov/sustainability/climate-change/

PWD Climate-Resilient Planning and Design Guidance

(*V1.1 coming soon)

https://water.phila.gov/pool/files/climate-resilient-guidance.pdf

Water Utility Climate Alliance (WUCA)

https://www.wucaonline.org/

Thank You! Questions?

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