SUSTAINING SCIOTO

MID-OHIO REGIONAL PLANNING COMMISSION

SUSTAINING
SCIOTO

INVESTING TODAY. PRESERVING TOMORROW.

Ohio Environmental Professionals Network Breakfast
January 13, 2015

Agenda

- Project Overview
- Watershed/Climate Change Model Results
- Vulnerability Assessment
  - Sector based vulnerabilities
- Development of Adaptive Management Strategies
  - Strategy evaluation metrics, costs, time frame
  - Definition of High priority strategies
- Conclusions & Regional Considerations

SUSTAINING SCIOTO PARTNERS

USGS
science for a changing world

Del-Co Water Company, Inc.
40 Years
1973–2013

The City of Columbus
Michael B. Coleman, Mayor
Department of Public Utilities

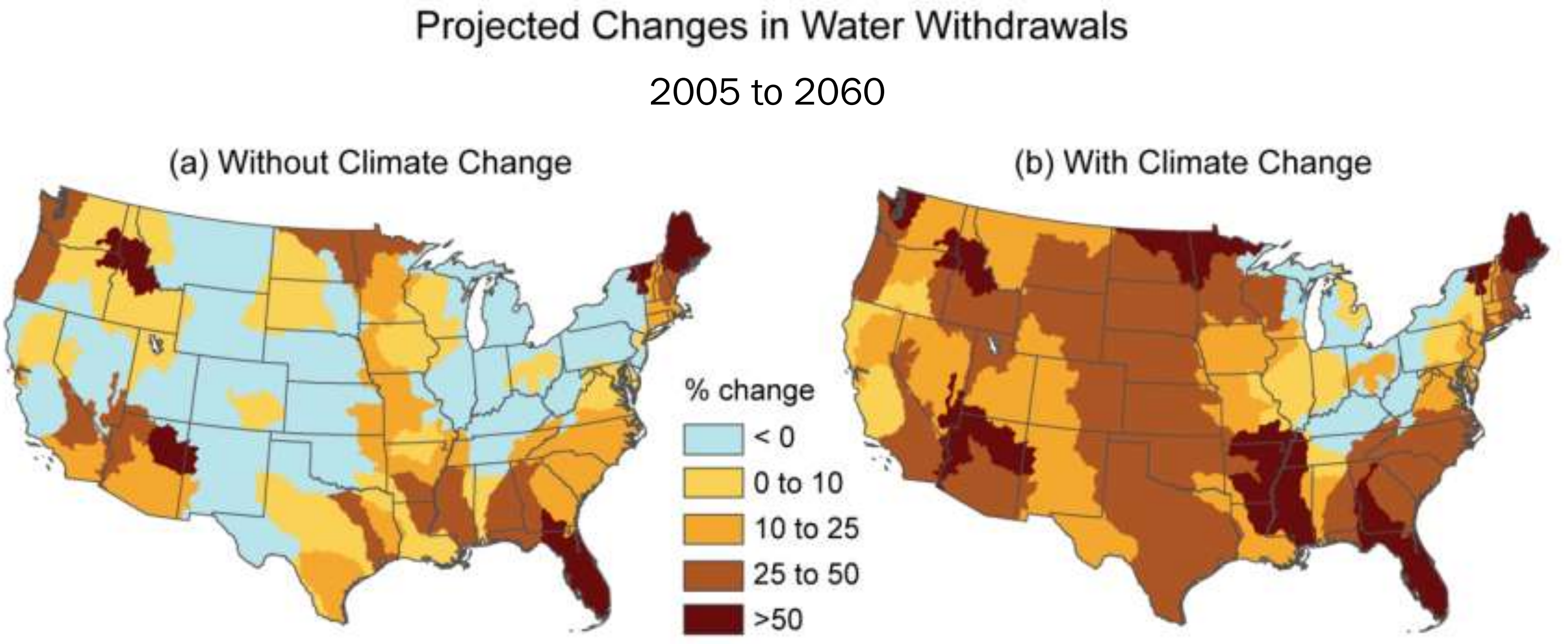
Water Research Foundation℠

morpc
Mid-Ohio Regional Planning Commission

Brown and Caldwell

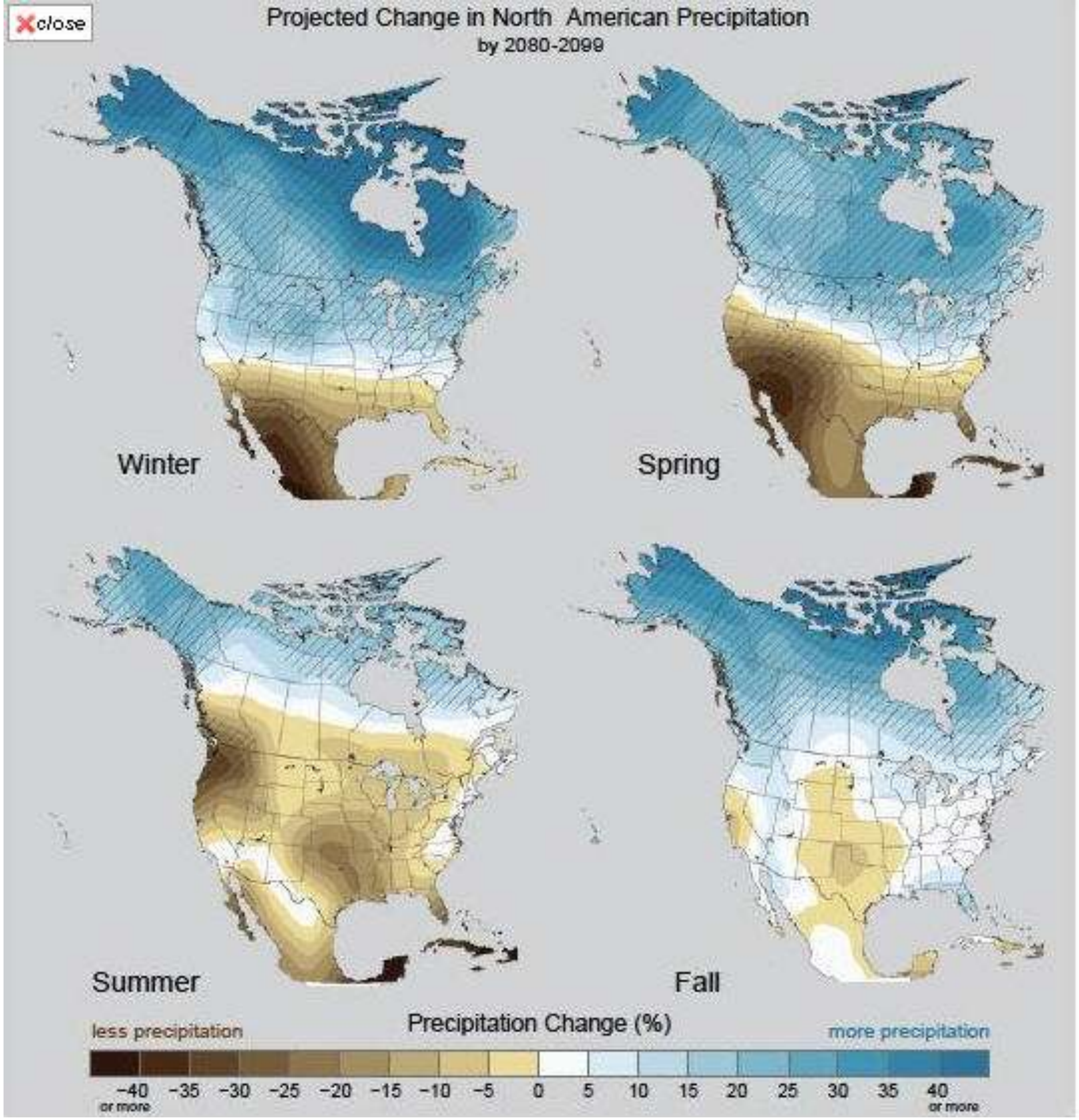
Ohio Water Development Authority

What prompted study?



Source: Brown, T. C., R. Foti, and J. A. Ramirez, 2013: Projecting fresh water withdrawals in the United States under a changing climate. Water Resources Research, 49, 1259-1276

The Need to Prepare for Future Weather Extremes

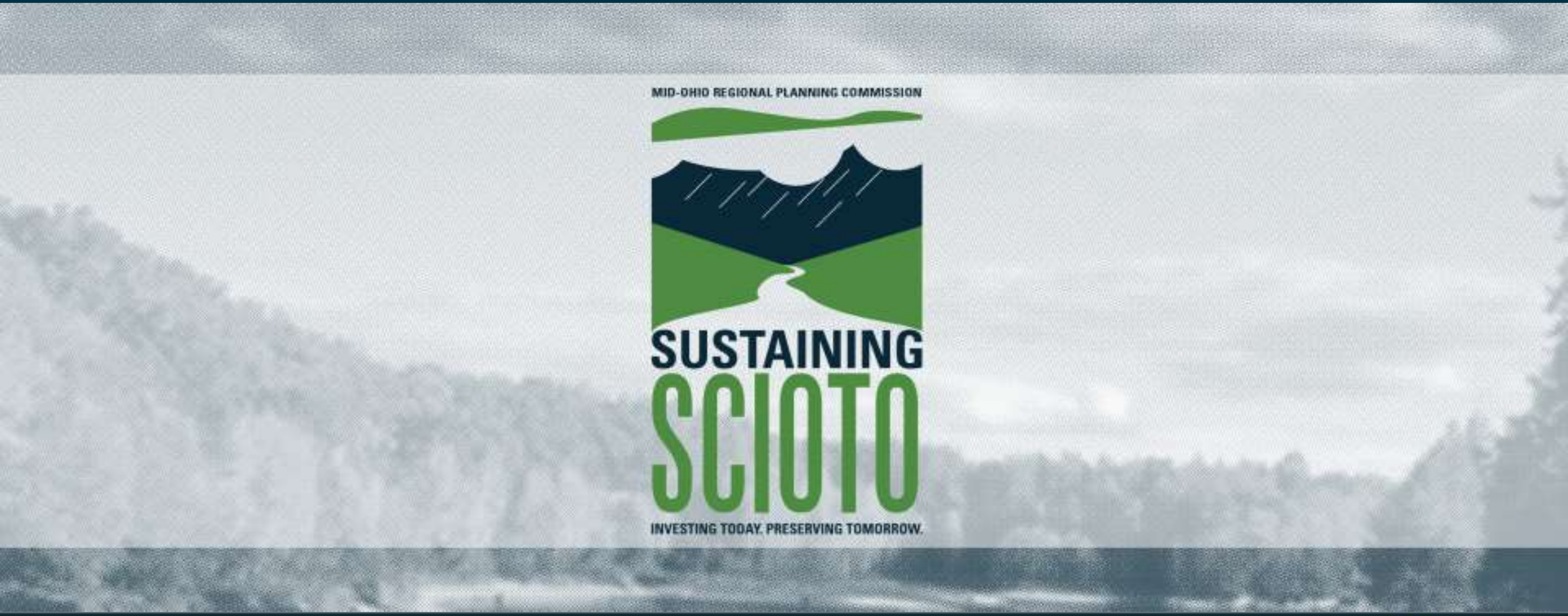


Ohio precipitation could increase 5-15% in winter & spring, decline 10% in summer by 2080-2099.

THE PAST ≠ THE FUTURE
2014

WHAT IS SUSTAINING SCIOTO?

- *Models the effects of climate change on the Upper Scioto River Basin*
- *Uses technical data, climate modeling, and stakeholder input*
- *Develops an adaptive management plan for the region*



UPPER SCIOTO RIVER BASIN

- 3,200 square mile watershed
- Provides drinking water for nearly 2 million
- Provides 85% of the region's surface water supply

Sustaining Scioto Study Area

Two-Phased Project Approach

- Phase I –
  - Development of a model to assess the impacts of changing weather patterns on water resources.
  - Model developed by the USGS specifically for the Upper Scioto watershed.
- Phase II –
  - Develop an adaptive management plan using the results of the model and input from a broadly based Stakeholder Advisory Committee.

Upper Scioto River Basin - Hydrologic Effects of Potential Changes in Climate, Water Use, and Land Cover

MID-OHIO REGIONAL PLANNING COMMISSION

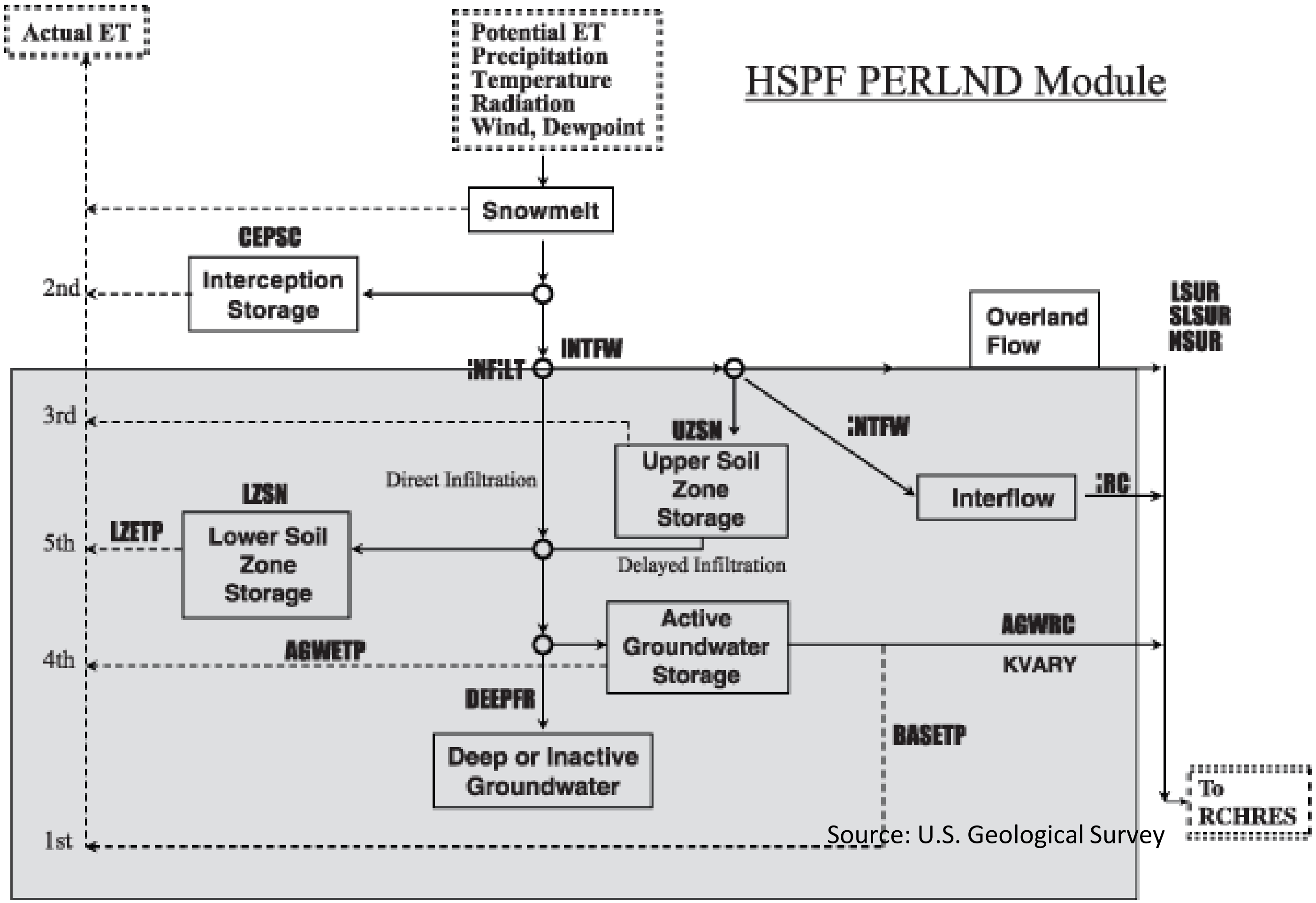
SUSTAINING SCIOTO

INVESTING TODAY. PRESERVING TOMORROW.

USGS Modeling

- Hydrologic model for the Upper Scioto River basin
- Calibrated based on historical observed data
- Simulate runoff characteristics for climatic conditions that are projected to occur in the future
  - Temperature
  - Precipitation
  - Evapotranspiration
  - With and without anticipated population growth and development

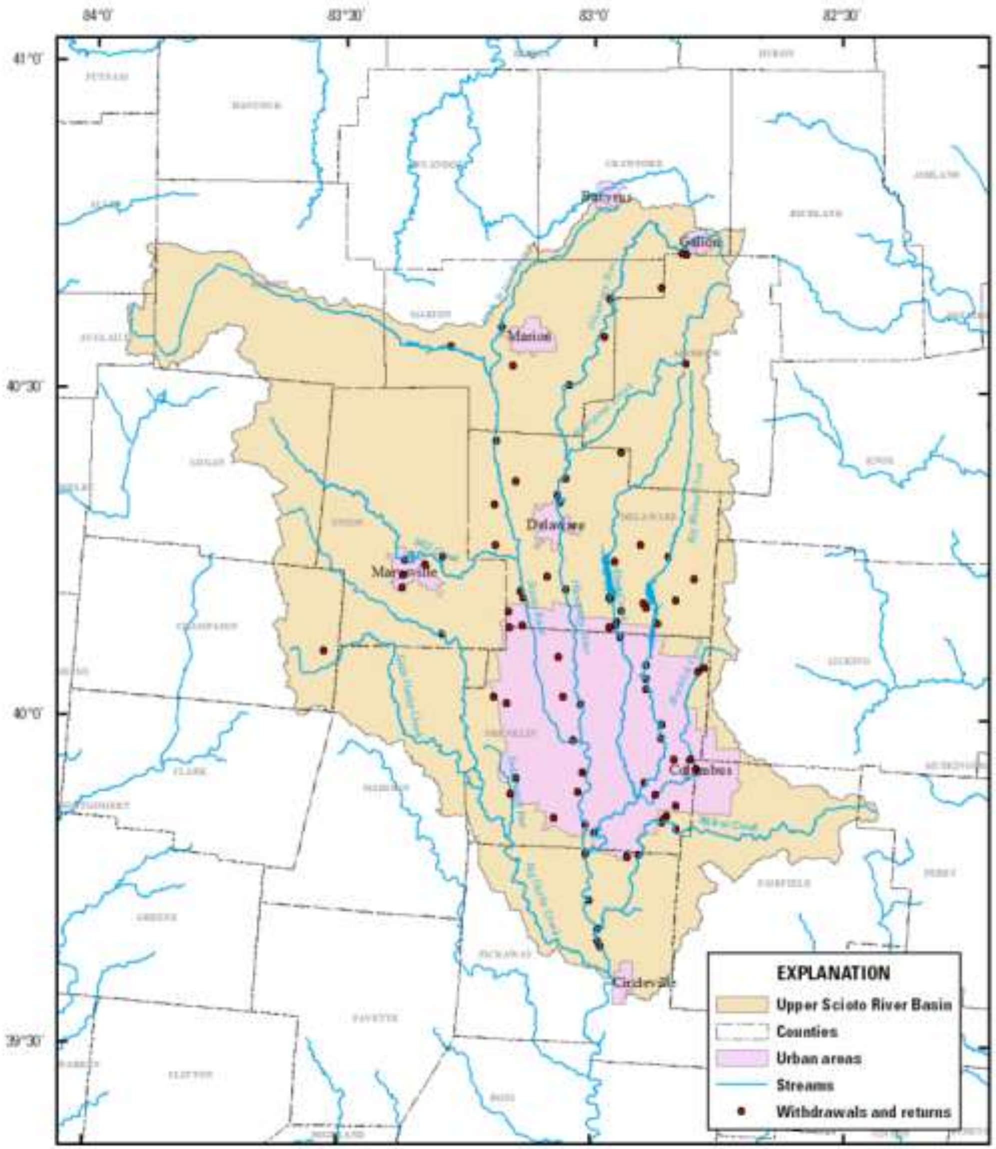
Hydrologic model



Source: U.S. Geological Survey

Water withdrawals and returns

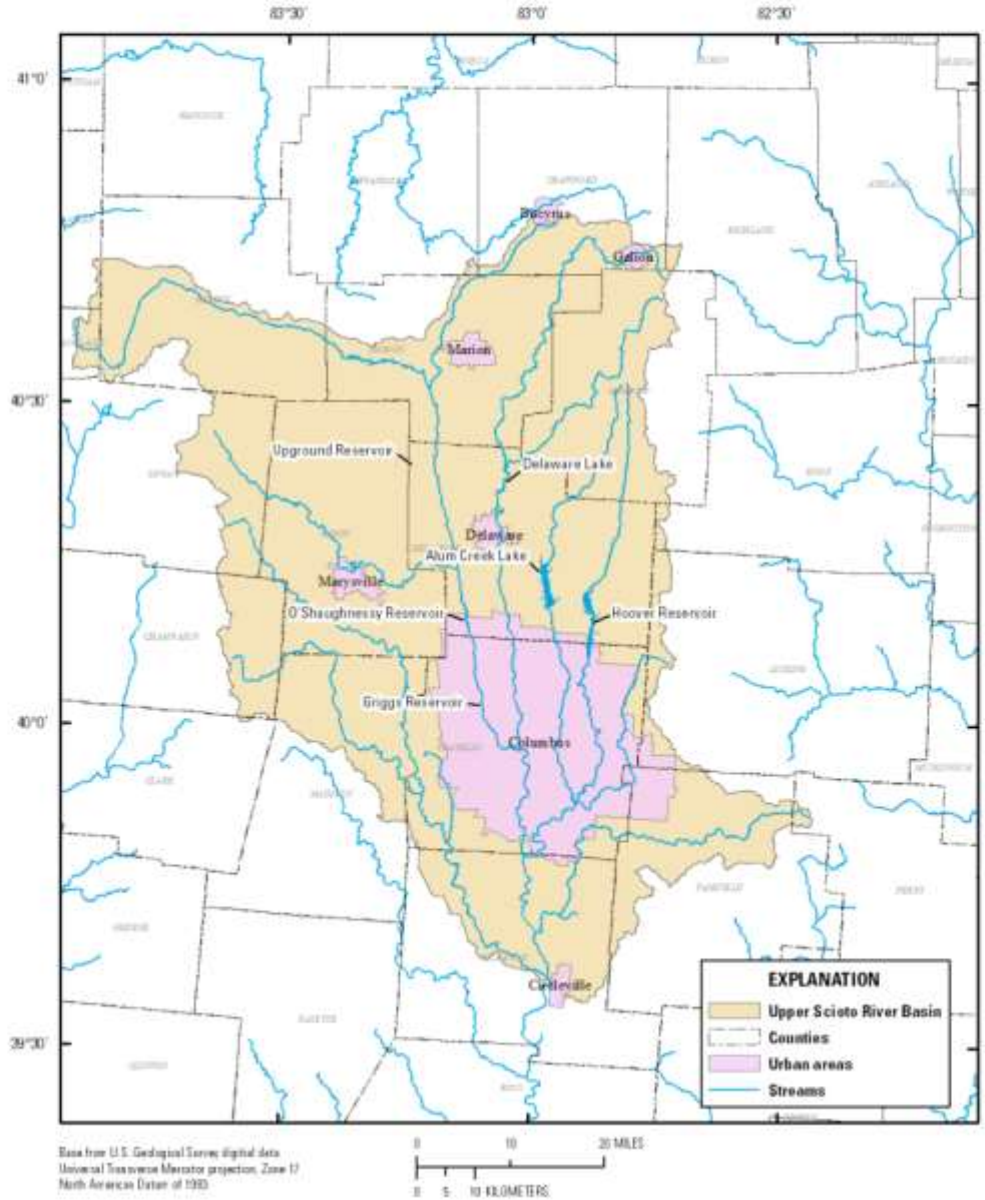
- Modeled a total of 83 surface-water withdrawals and 38 return flows



Base from U.S. Geological Survey digital data
Universal Transverse Mercator projection, Zone 17
North American Datum of 1983

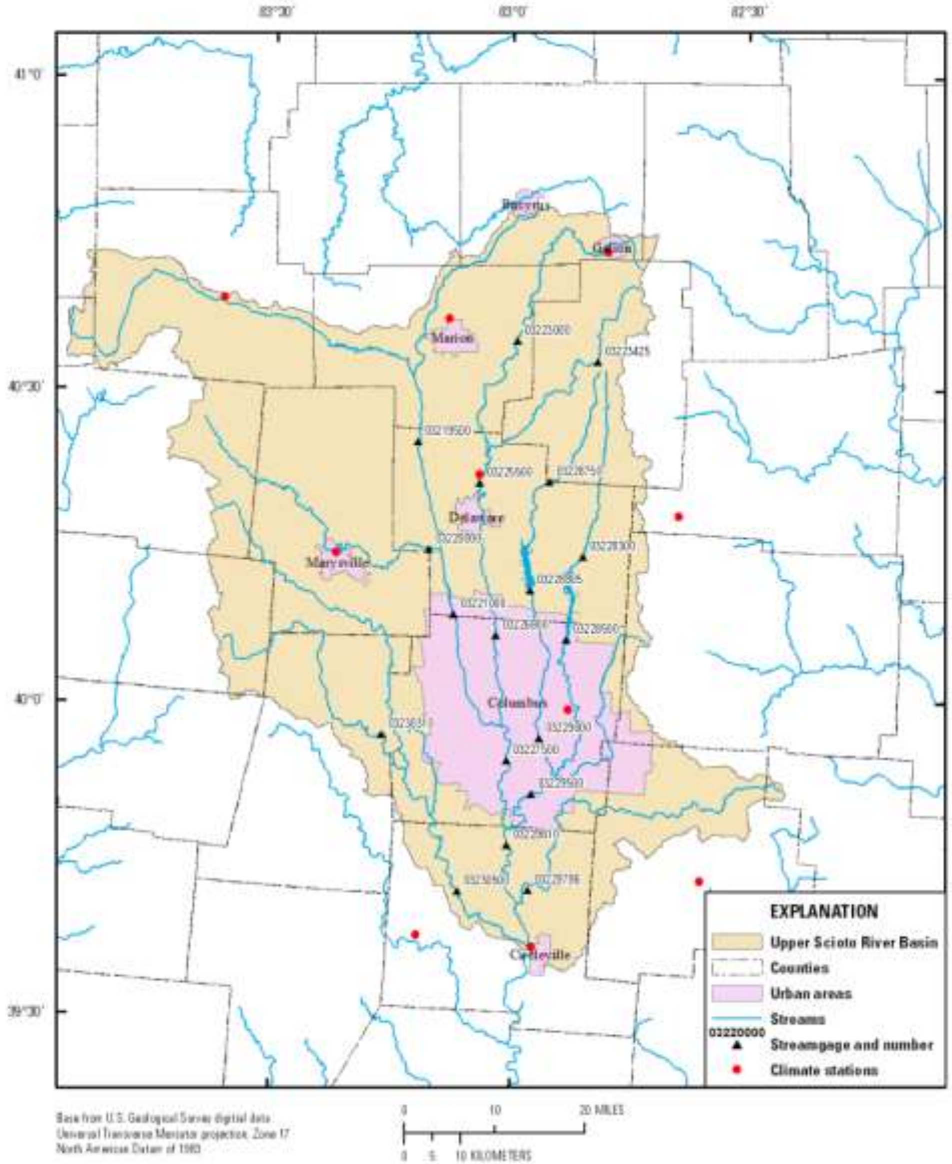
Reservoirs

- Modeled operation of 5 in-line reservoirs and 3 upground reservoirs
- Reservoirs are operated for water supply and/or flood control



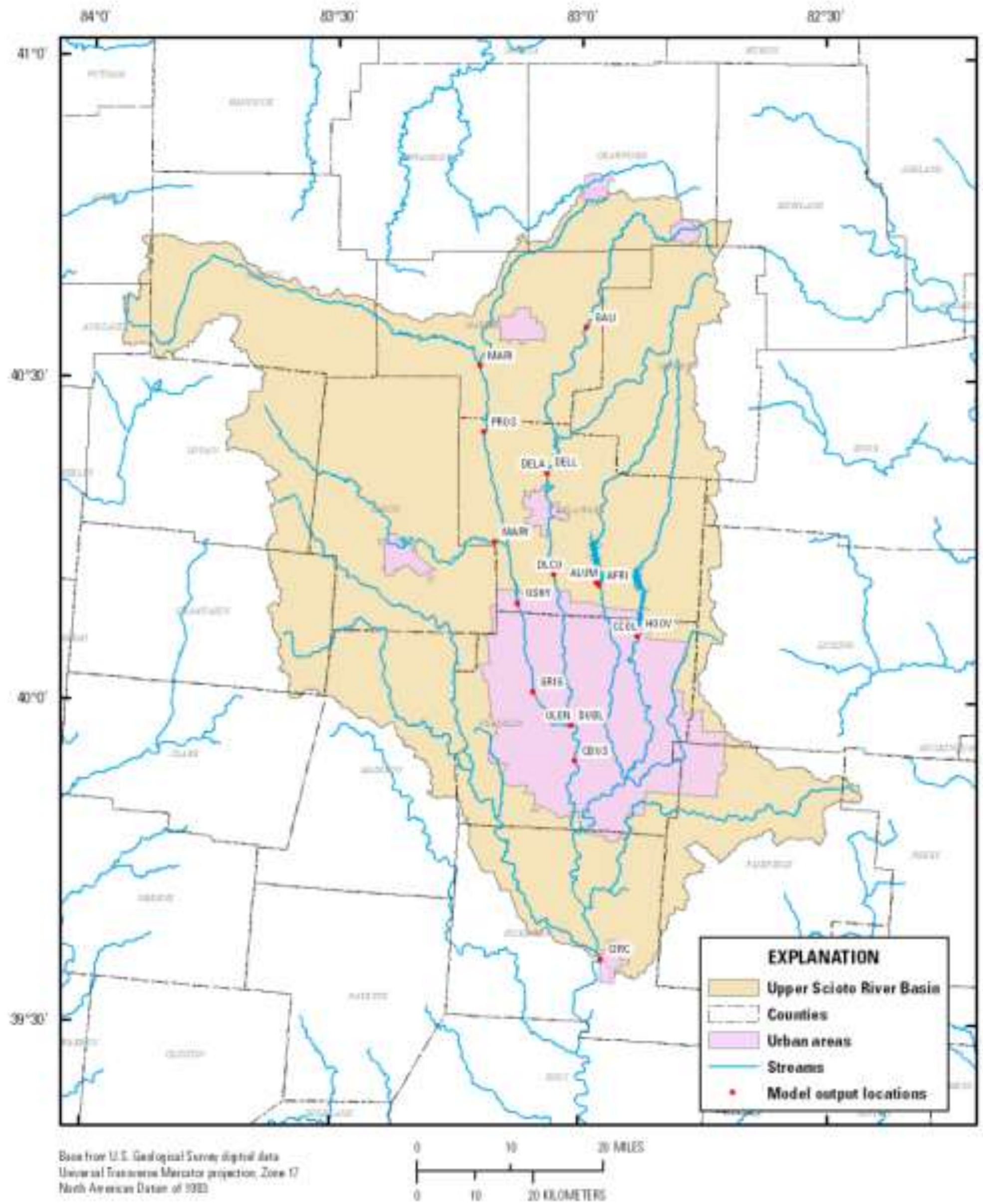
Hydrologic Model

- Model calibrated/ validated based on observed historical climate & streamflow time series data for 1989-2010
- Used data from 10 climate stations and 18 streamgages



Model output locations

- Daily mean simulation results output for the 5 in-line reservoirs and 12 stream sites



Global Climate Model (GCM) Data

- GCM source: Coupled Model Intercomparison Project - Phase 3 (CMIP3)
  - 16 models in CMIP3 data set
  - Native spatial scale = ~ 100 by 150 km (60 x 90 mile) grid cells
  - Downscaled spatial scale = ~ 12 x 12 km (7.5 x 7.5 mile) grid cells
  - Temporal Scale = Monthly for 1950-2099
  - Each model run based on 3 carbon emission scenarios (B1, A1b, A2)

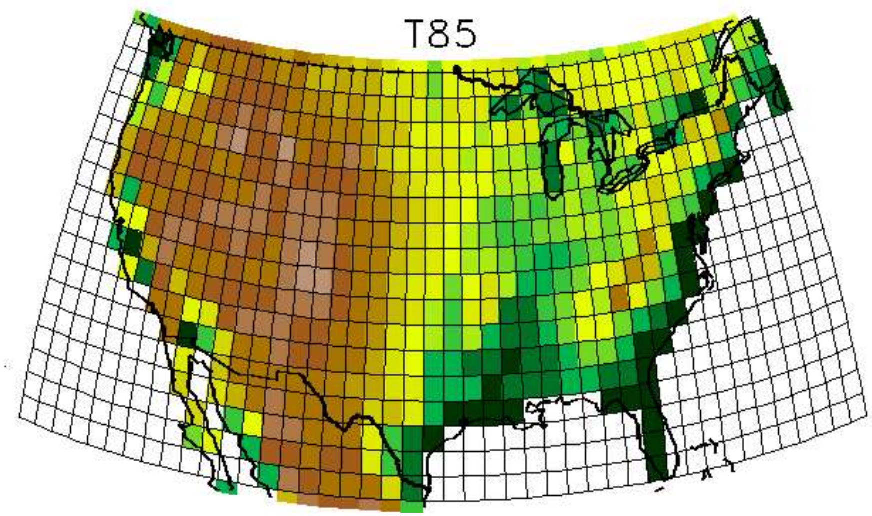
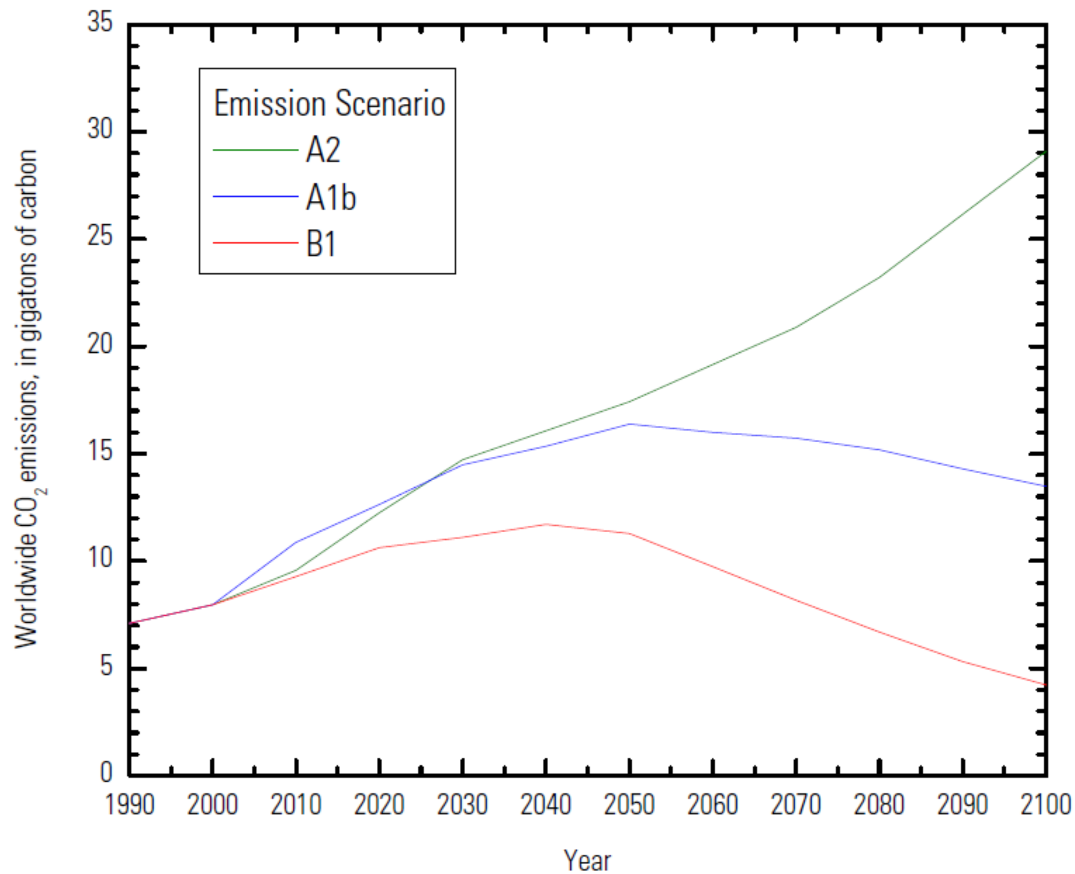


Image source: Warren Washington, NCAR

Carbon emission scenarios

- **A2** – population and CO_2 continuously increasing
- **A1b** – population and CO_2 increasing until 2050, then declining
- **B1** – Not used (too optimistic?)



Source of data: Special Report on Emissions Scenarios (IPCC, 2000)

GCM selection

End of century (2080s) change in temperature

B1

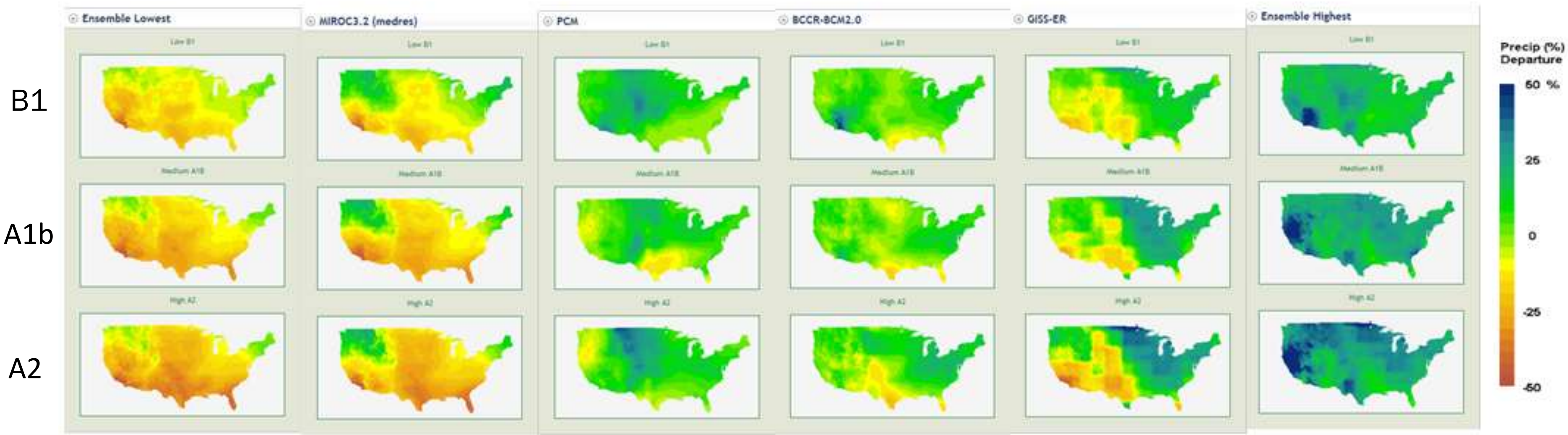
A1b

A2

Source of images: www.climatewizard.org

GCM selection

End of century (2080s) change in precipitation



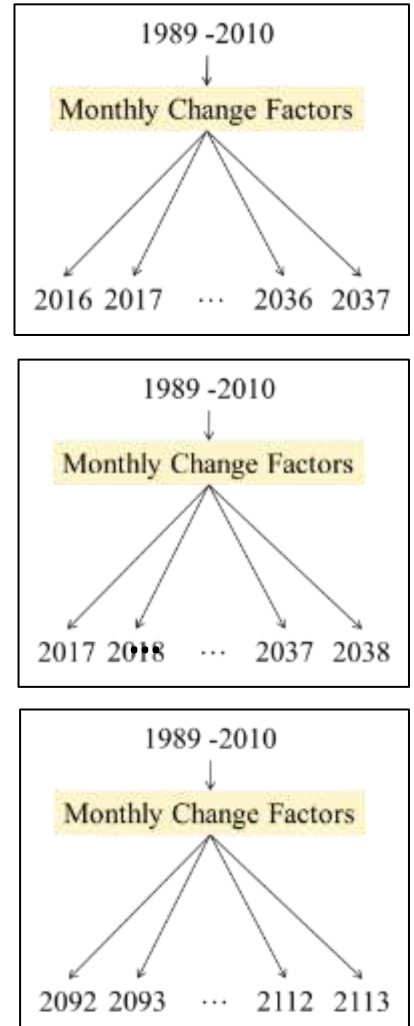
Source of images: www.climatewizard.org

Change factors

- Why? - Monthly time resolution of GCMs not sufficient to model sub-basin processes
- Used monthly "change factors" to create hypothetical future climate series based on historical hourly climate series
- Change factors added to or multiplied by historical data to reflect future changes in precipitation and temperature indicated by GCMs relative to a baseline period (1980-1999)

Created ensembles of future climate time series

- The 1989-2010 historical climate time series used to compute climate time series beginning in 77 future years
- Done for each of 10 climate stations used in the model based on change factors from each of 8 GCM/emission combinations

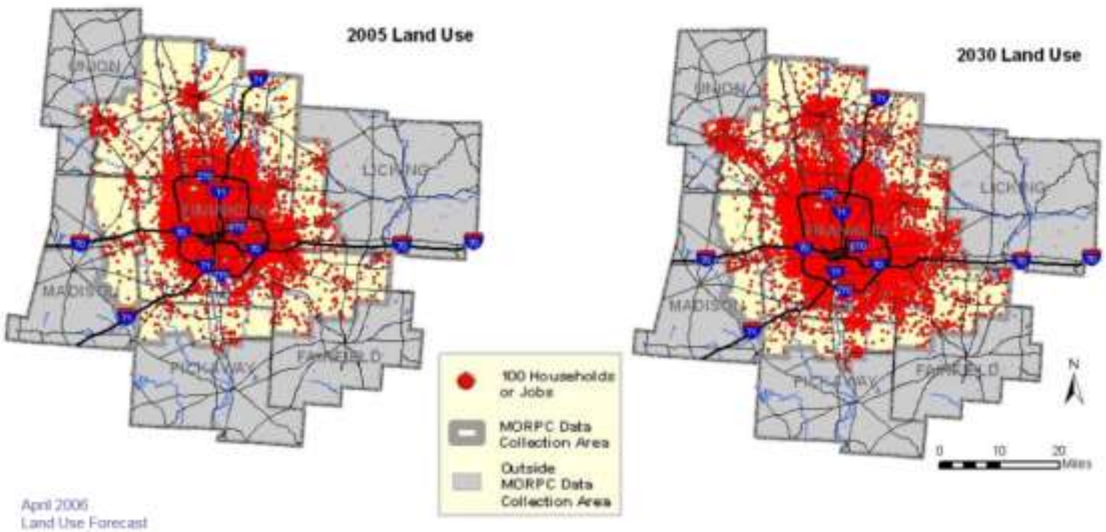


Two modeling scenarios

- **"Level 1"** = climate change + reservoirs
- **"Level 2"** = climate change + reservoirs + build-out

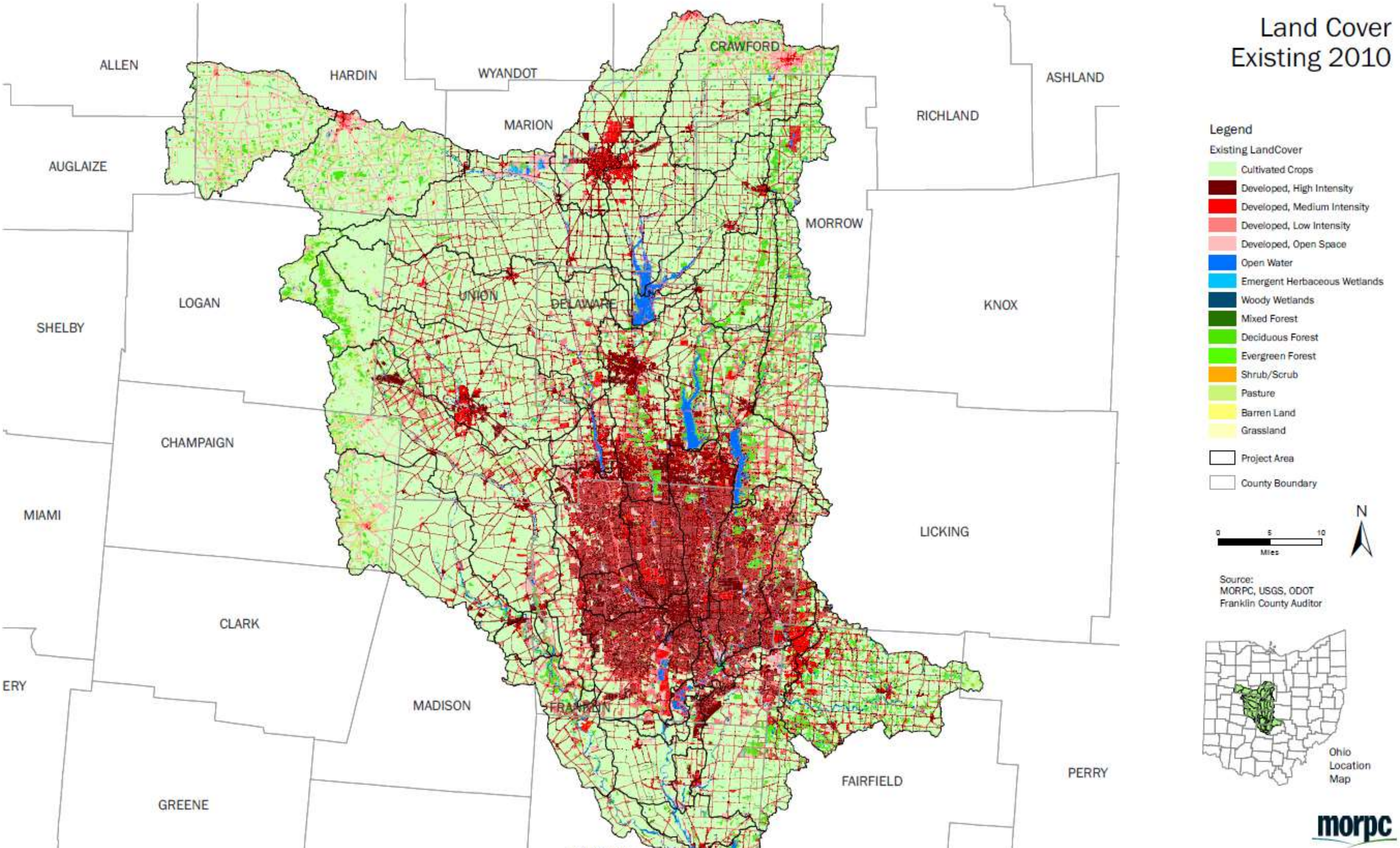
Build-out

- Development-driven changes in land cover and water use
- Future development based on current local zoning and population projections
- Build-out estimated for 2035, 2055, and 2075

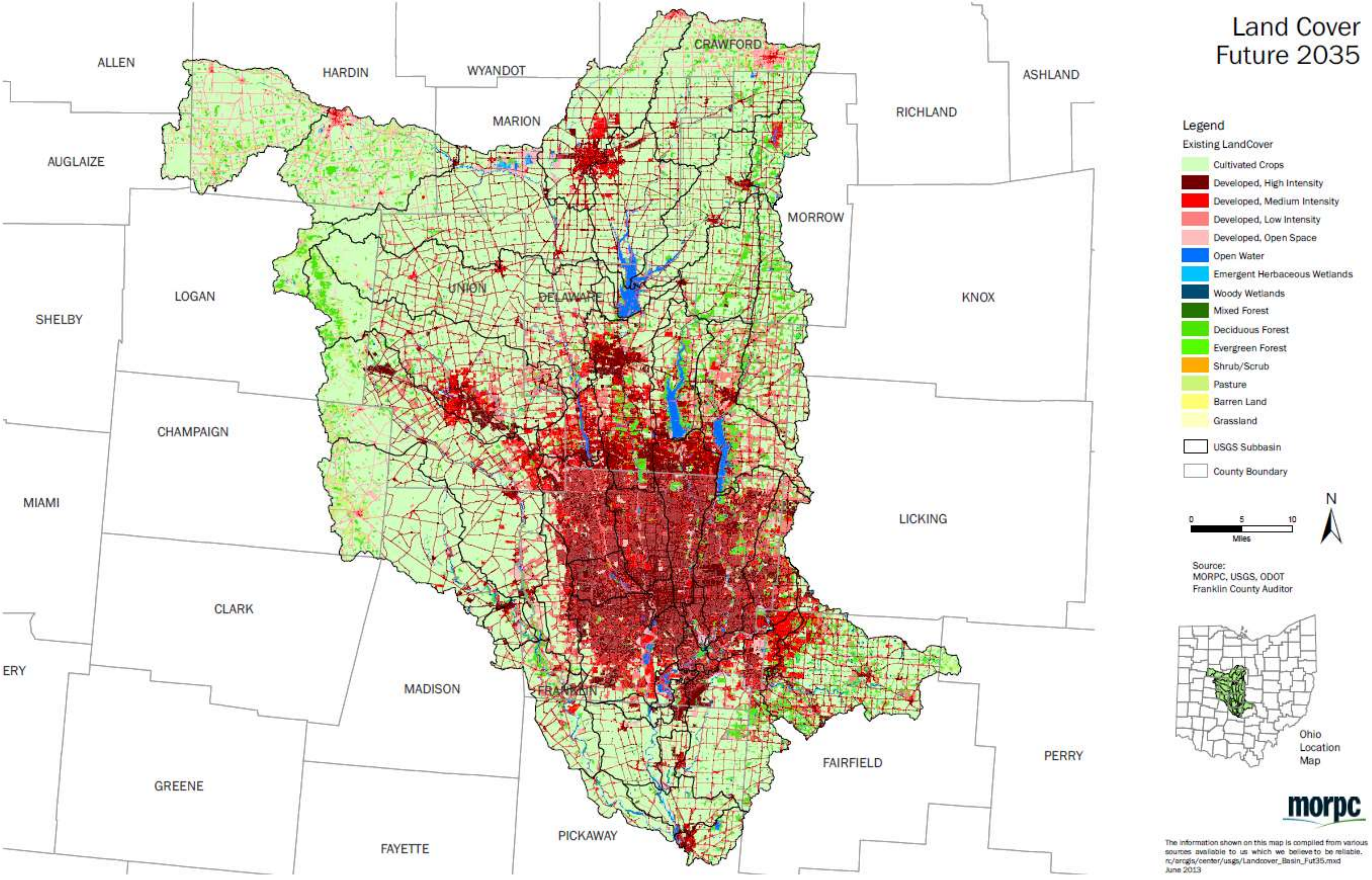


Source: Mid-Ohio Regional Planning Commission

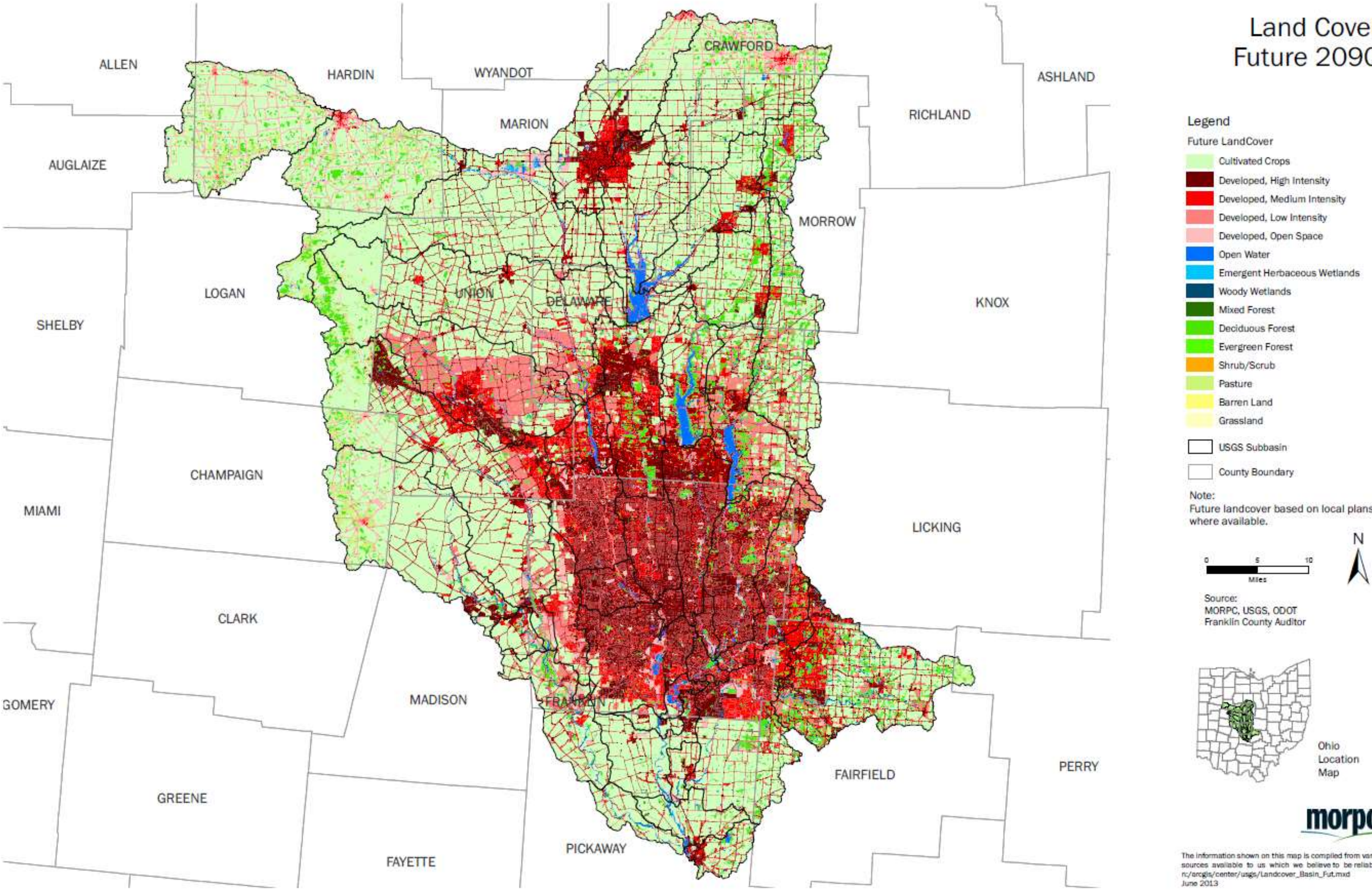
Land Cover Existing 2010



The information shown on this map is compiled from various sources available to us which we believe to be reliable.
n:/arcgis/center/usgs/Lnadcover_Cnty_Ee.mxd.mxd
June 2013


Land Cover
Future 2035
Legend
Existing LandCover
Cultivated Crops
Developed, High Intensity
Developed, Medium Intensity
Developed, Low Intensity
Developed, Open Space
Open Water
Emergent Herbaceous Wetlands
Woody Wetlands
Mixed Forest
Deciduous Forest
Evergreen Forest
Shrub/Scrub
Pasture
Barren Land
Grassland
USGS Subbasin
County Boundary
0 5 10
Miles
N
Source:
MORPC, USGS, ODOT
Franklin County Auditor
Ohio Location Map
The information shown on this map is compiled from various sources available to us which we believe to be reliable.
r:/arcgis/center/usgs/Landcover_Basin_Fut35.mxd
June 2013
ALLEN
HARDIN
WYANDOT
CRAWFORD
ASHLAND
AUGLAIZE
MARION
RICHLAND
MORROW
SHELBY
LOGAN
UNION
DELAWARE
KNOX
CHAMPAIGN
MIAMI
LICKING
CLARK
ERY
MADISON
FRANKLIN
FAIRFIELD
PERRY
GREENE
PICKAWAY
FAYETTE

Land Cover Future 2090

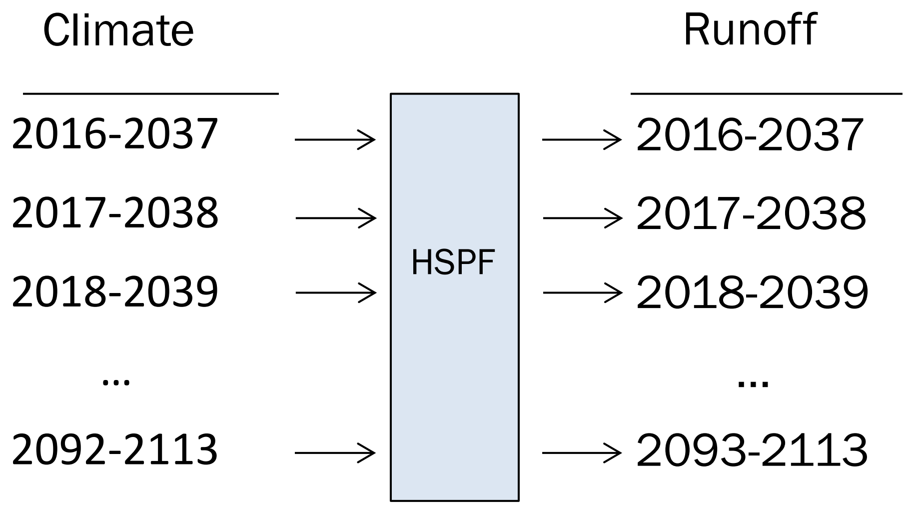


morpc

The information shown on this map is compiled from various sources available to us which we believe to be reliable.
n:/arcgis/center/usgs/Landcover_Basin_Fut.mxd
June 2013

Simulations

- Ensembles of future climate used to simulate ensembles of future hydrology for both level-1 and level-2 scenarios
- In total, more than 1,200 simulations run



Processing simulation results

- Omitted first 2 years of results from each simulation (to establish water balance)
- Computed statistics of ensembles based on years with 20 results

Example of results for one GCM/emission scenario at one output location

[..., intervening data not shown; max, maximum; min, minimum; N, number of observations]

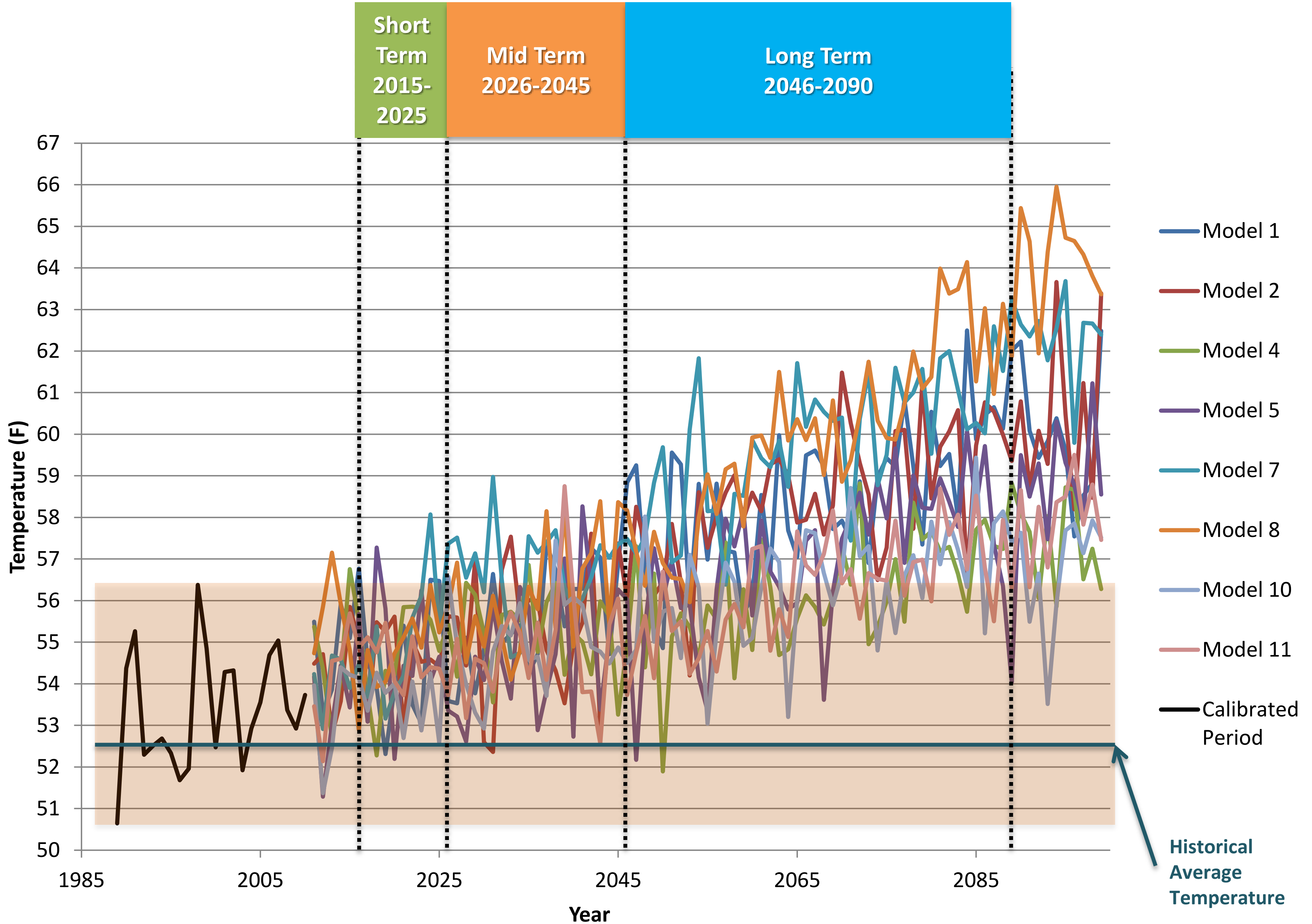
Usable data begin year	Annual Mean Streamflow (in cubic feet per second) for indicated beginning year of simulation										Statistics			
	2016	2017	2018	2019	2020	2021	...	2090	2091	2092	max	min	ensemble mean	N
2018	71.7						...				71.7	71.7	71.7	1
2019	11.6	72.9					...				72.9	11.6	42.3	2
2020	76.0	11.6	73.5				...				76.0	11.6	53.7	3
2021	55.9	86.0	11.6	71.9			...				86.0	11.6	56.4	4
2022	93.9	65.3	87.0	11.7	81.8		...				93.9	11.7	67.9	5
2023	193.8	84.1	63.6	98.9	11.6	80.6	...				193.8	11.6	88.8	6
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2036	91.3	104.9	165.1	102.4	122.9	186.8	...				217.0	11.7	105.2	19
2037	108.4	102.5	111.2	182.6	115.2	136.6	...				230.3	11.7	114.1	20
2038		109.8	105.2	108.4	185.1	114.5	...				225.3	11.7	117.6	20
2039			104.9	95.1	103.2	170.2	...				218.8	11.7	110.5	20
2040				99.4	88.1	98.8	...				200.9	11.7	102.4	20
2041					96.7	66.6	...				193.6	11.7	94.8	20
2042						93.0	...				198.7	11.7	93.7	20
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2092							...	83.0			166.9	11.6	78.5	20
2093							...	11.6	81.2		164.9	11.6	78.4	20
2094							...	61.8	11.6	87.5	163.2	11.6	77.4	20

Analytical products

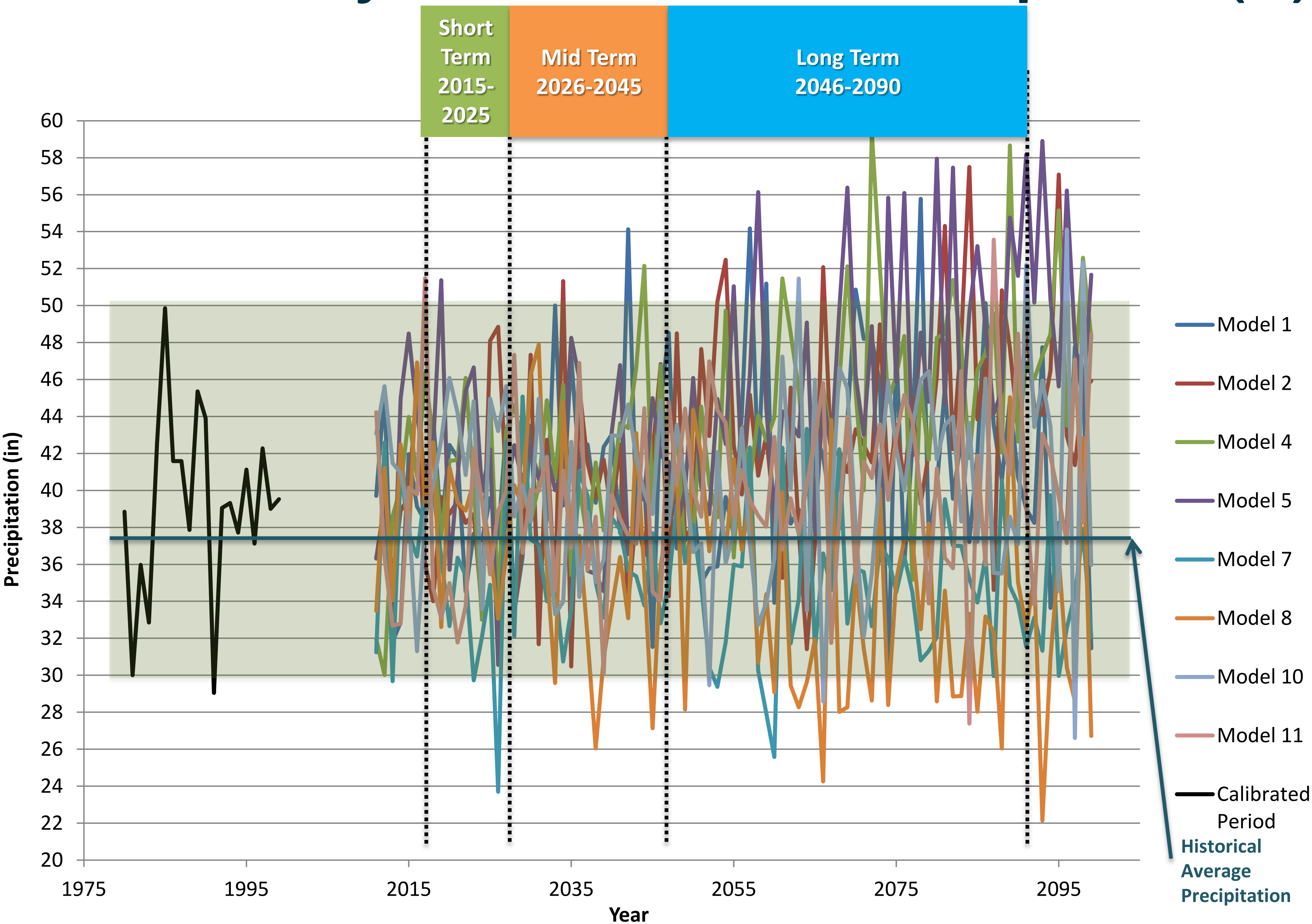
- Simulation results analyzed to provide information on:
  - Trends in annual, seasonal, and monthly streamflows and reservoir water-levels (only level 1)
  - Maximum and minimum 7-, 30-, and 180-day average streamflows and reservoir water-levels
  - Exceedance characteristics of 7- and 30-day average streamflows and reservoir water levels (only level 2)

Some provisional results ...

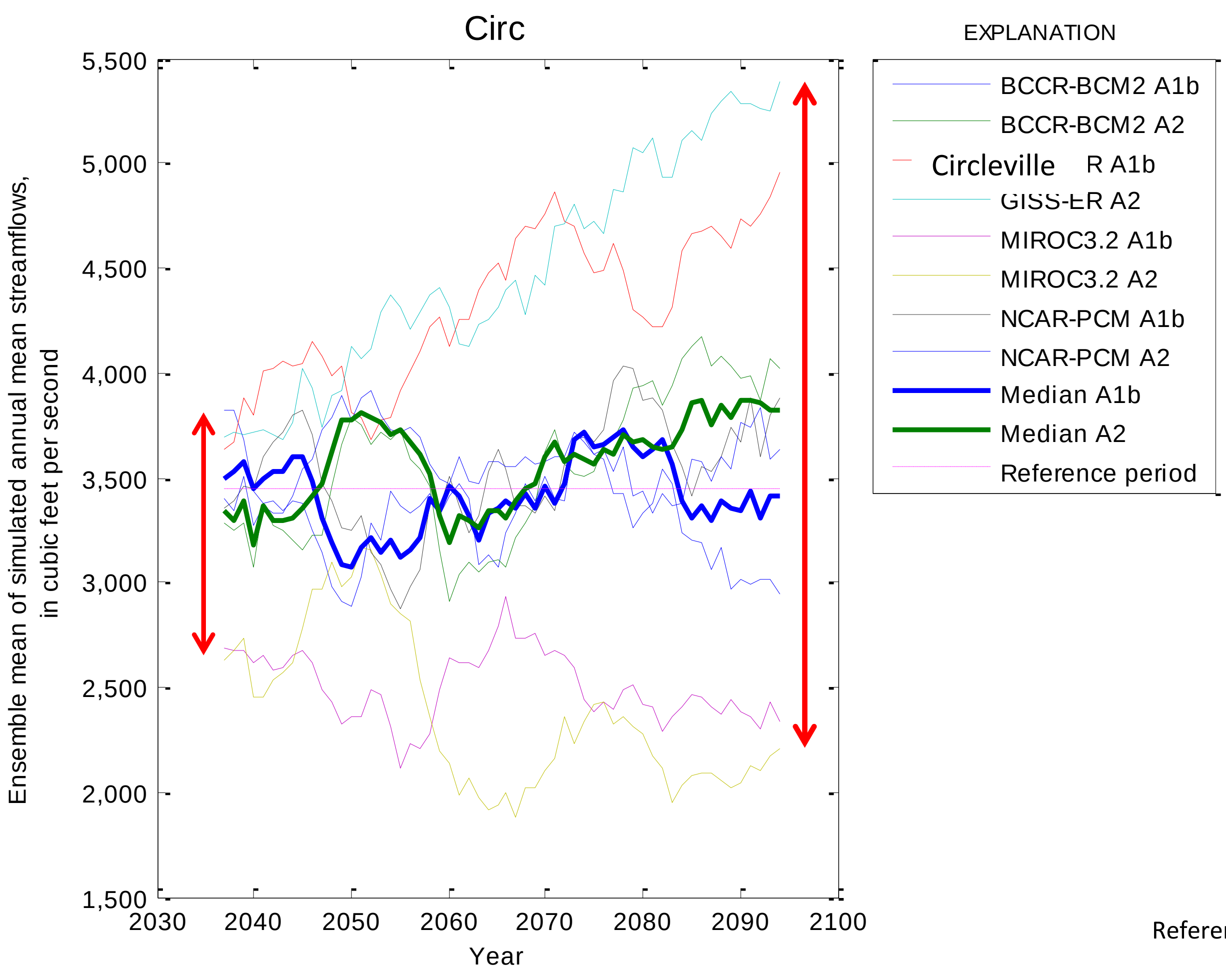
Actual vs Projected Annual Mean Temperature (F)



Actual vs Projected Annual Mean Precipitation (in)



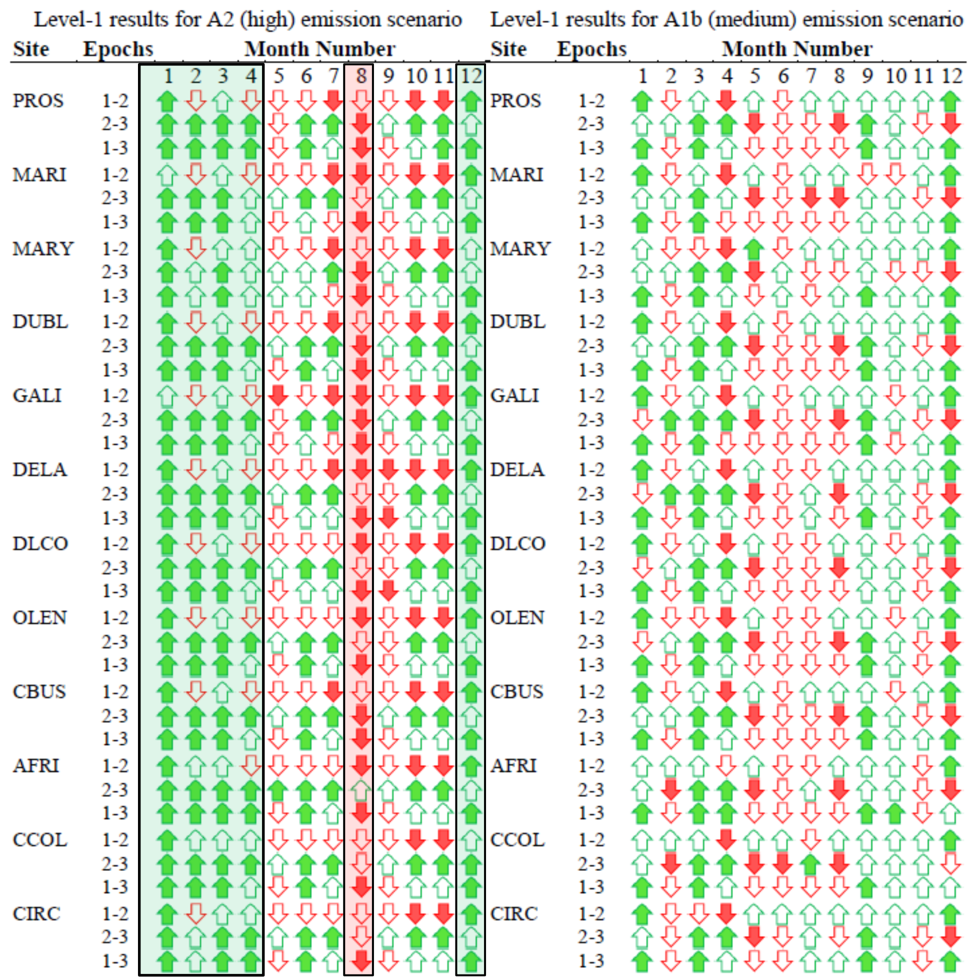
Annual mean streamflows (level 1)



Reference period = 1991-2010

Monthly mean streamflows (level 1)

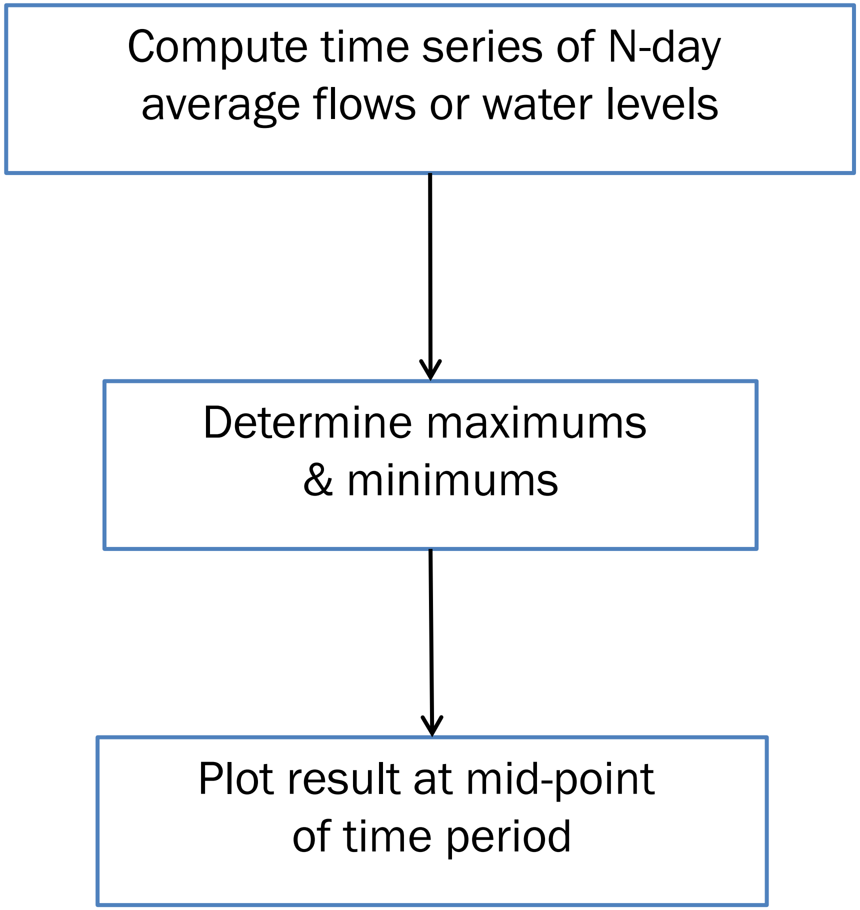
- **Compared epoch medians**
- **A2 results**
  - December-April mean flows generally increasing
  - August mean flows generally decreasing
- **A1b results**
  - Compared to A2 results:
    - Results more mixed and changes more subtle
    - February, June, July, and November had more decreases
    - September had more increases



epoch 1 = 2037-2055, epoch 2 = 2056-2075, epoch 3 =2076-2094

Max/min N-day averages (level 1)

- Computed running average 7-, 30-, and 180-day flows or water levels
- N-day results based on 20-year simulation periods
- N-day values plotted at midpoint of time periods
- N-day values are <u>the highest/lowest in period</u>

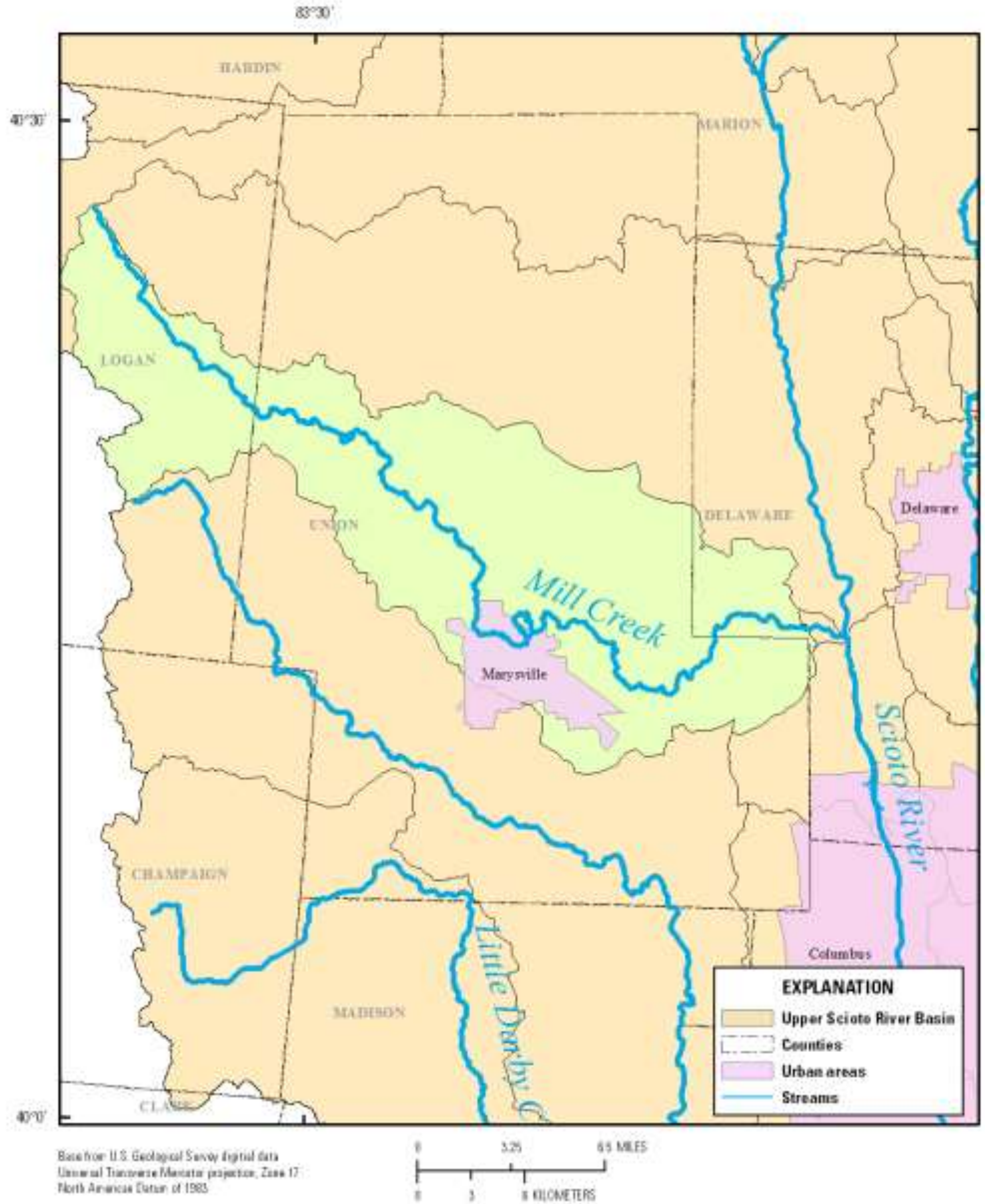


Max/min N-day averages (level 2)

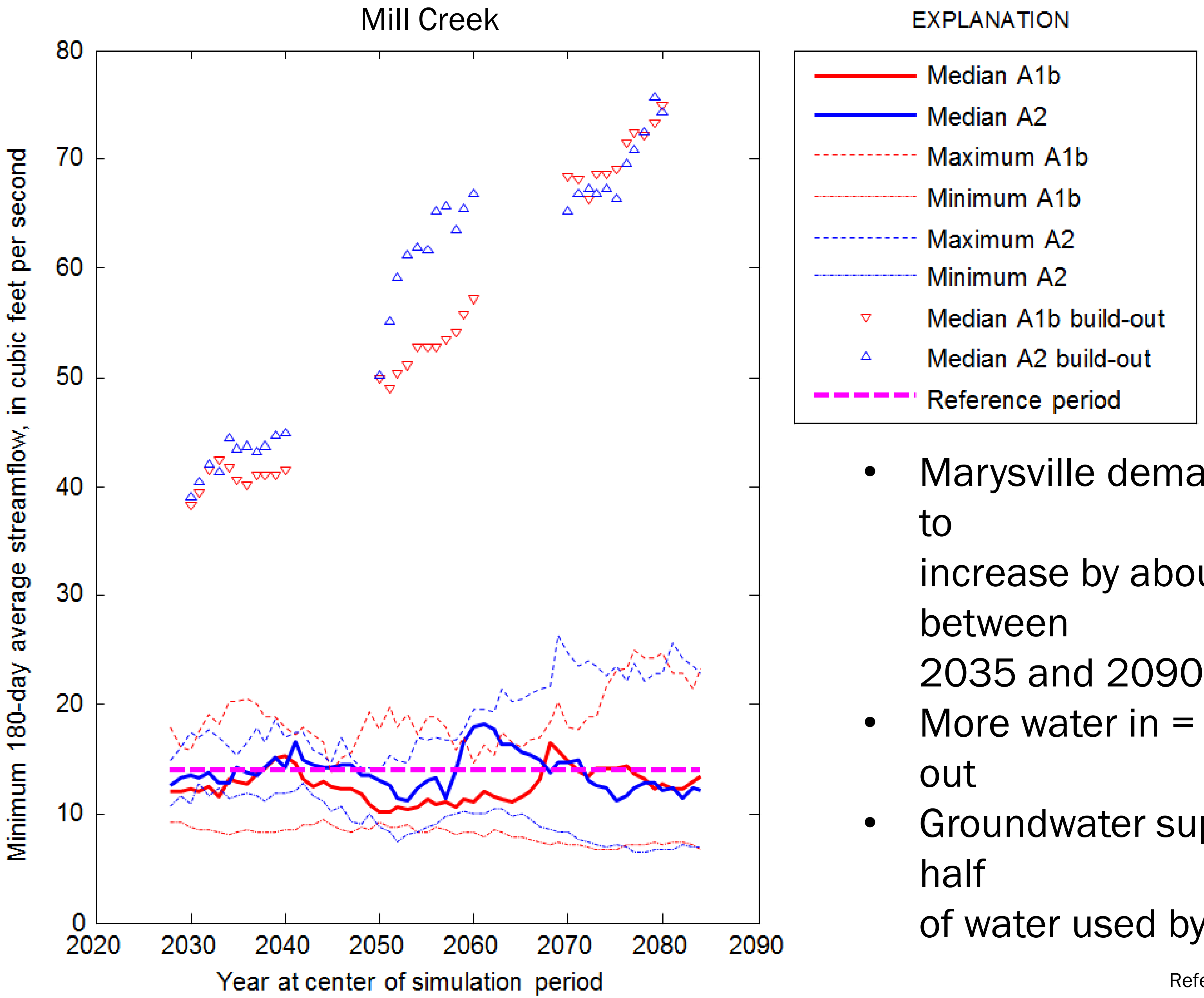
- Level-2 N-day results based on 11-year simulation periods
- Computed only for periods centered within ±5 years of target build-out years (2035, 2055, 2075)
- Results plotted at center of simulation period

▽ Median A1b build-out

△ Median A2 build-out



Base from U.S. Geological Survey digital data
Universal Transverse Mercator projection, Zone 17
North American Datum of 1983



- Marysville demand expected to
  increase by about 250% between
  2035 and 2090
- More water in = more water out
- Groundwater supplies about half
  of water used by Marysville

Reference period = 1991-2010

Project status

- Report on the Upper Scioto River Basin study is awaiting final approval
- Anticipated release this month

SUSTAINING SCIOTO ADAPTIVE MANAGEMENT PLANNING

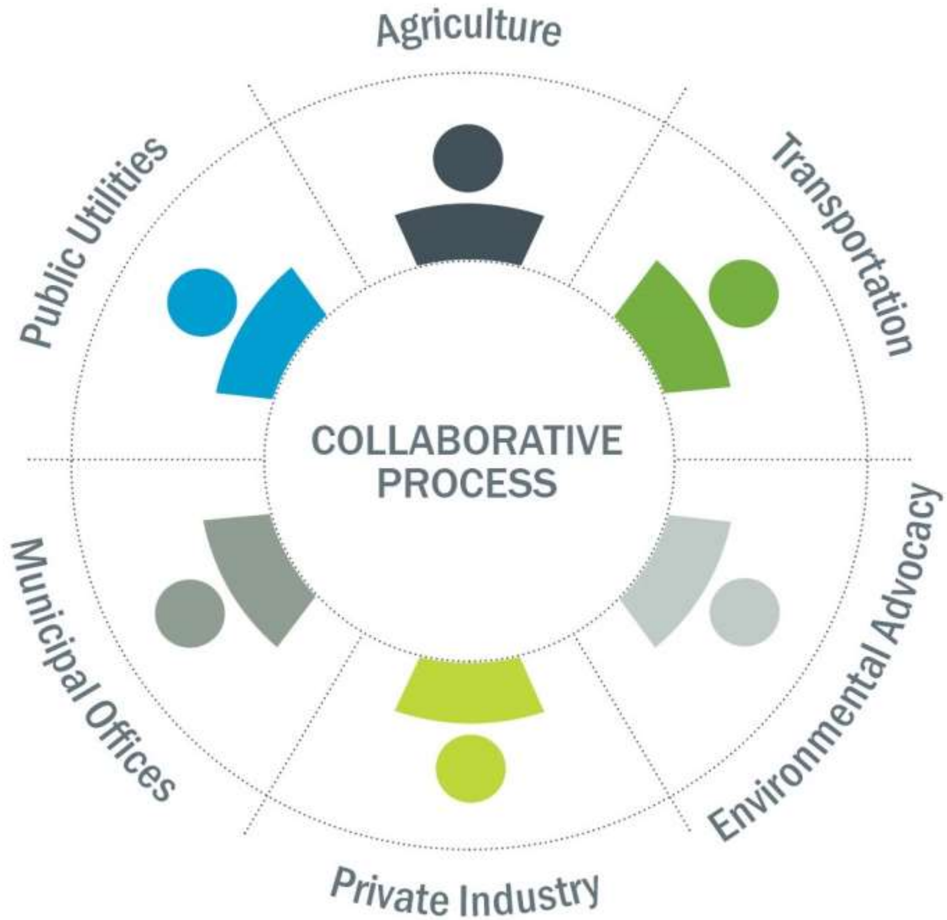
MID-OHIO REGIONAL PLANNING COMMISSION

SUSTAINING SCIOTO

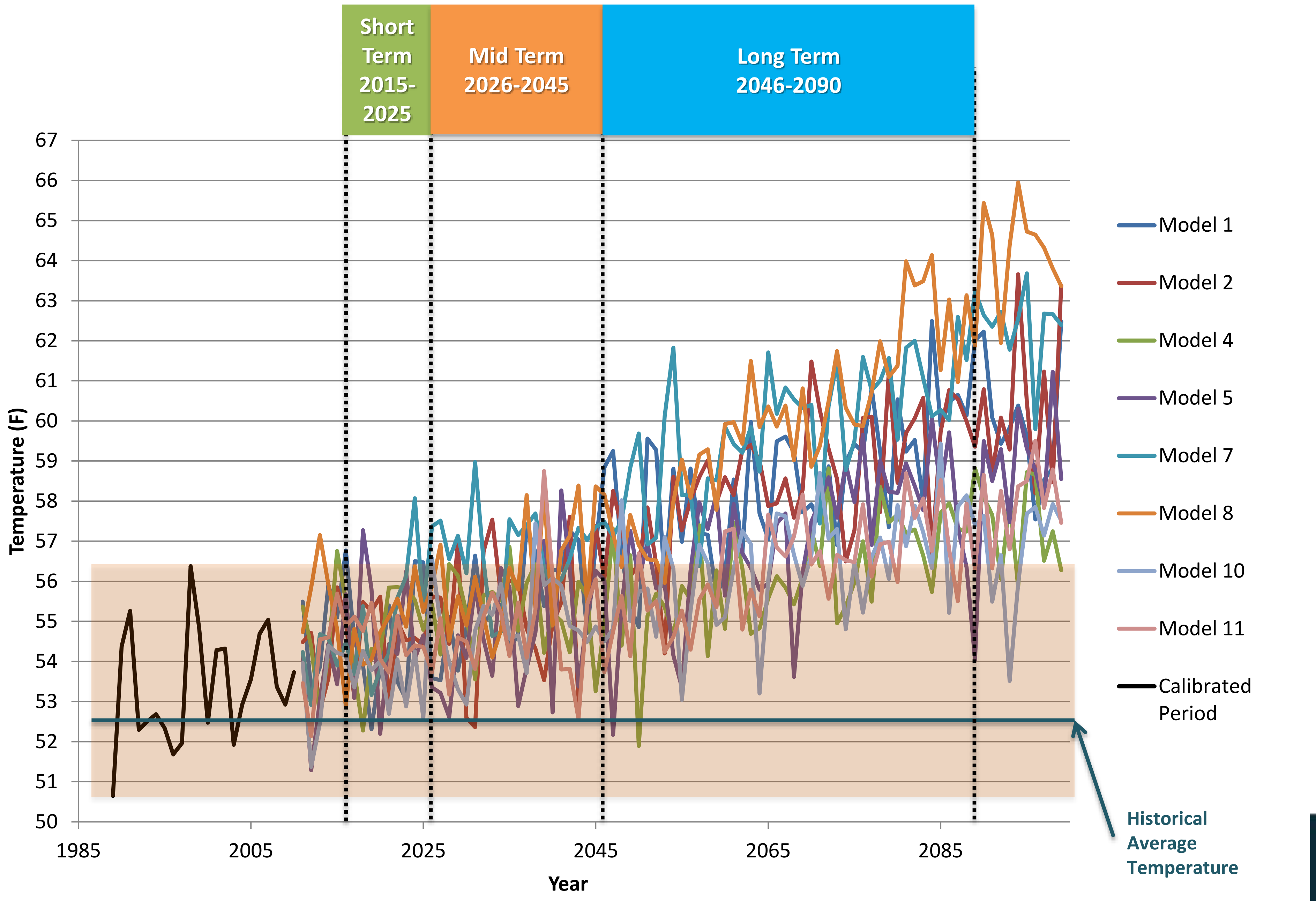
INVESTING TODAY. PRESERVING TOMORROW.

Stakeholder Advisory Committee

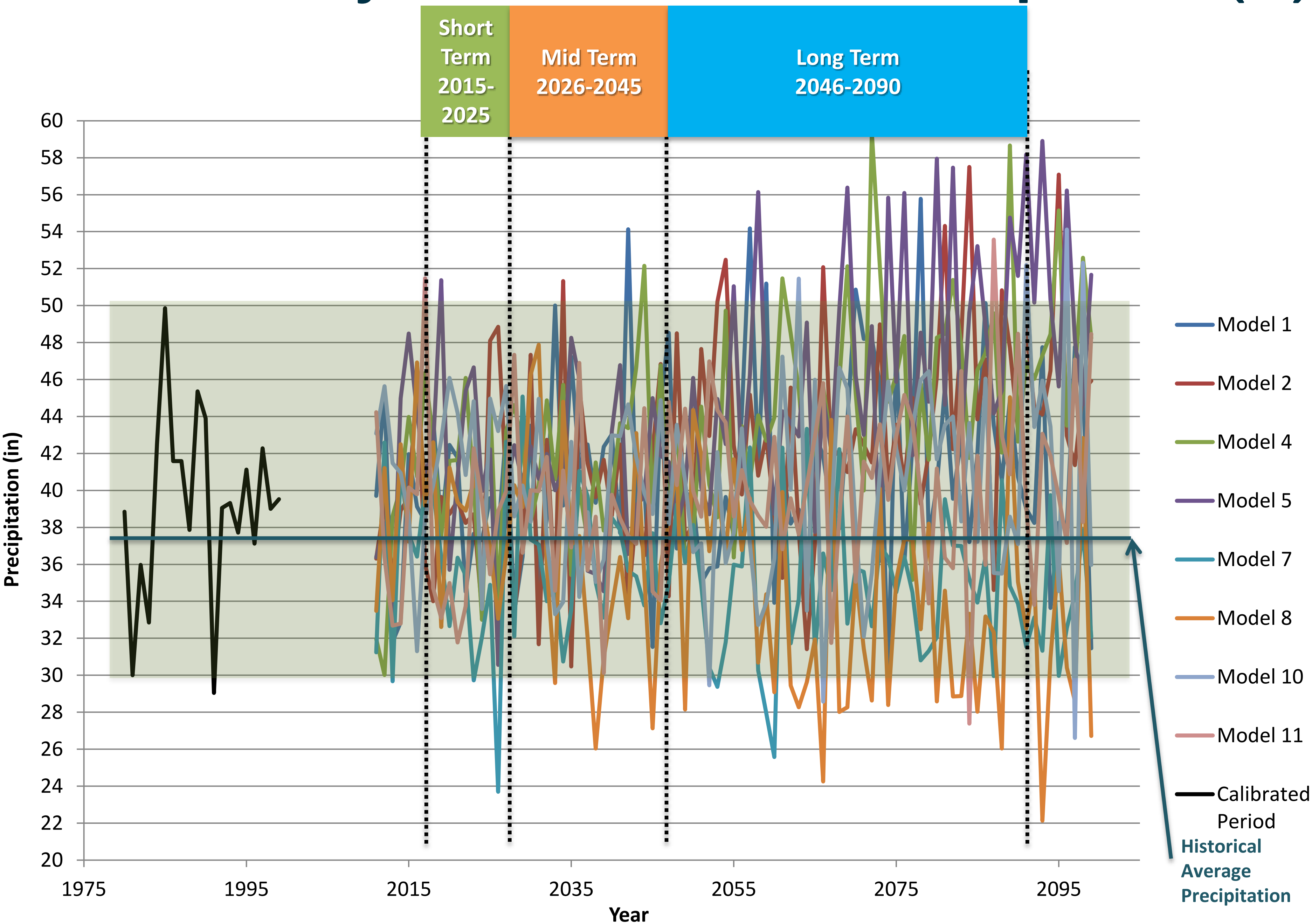
- Input on current and future water needs
- Assess vulnerabilities
- Evaluate adaptive management strategies



Actual vs Projected Annual Mean Temperature (F)



Actual vs Projected Annual Mean Precipitation (in)



CLIMATE & WATERSHED MODEL RESULTS

Short-Term

- 2015 to 2025
- Climate within normal range

Mid-Term

- 2026 to 2045
- Increase in annual average temperature and higher seasonal temp
- Increase variability in flow and precipitation

Long-Term

- 2046 to 2090
- Increased uncertainty – regional development as well as climate
- Increased temperature and variability in flow

Overall Prioritization Methodology

Predicted Changes

Evaluated changing conditions & ranked based on ***LIKELIHOOD*** of occurrence

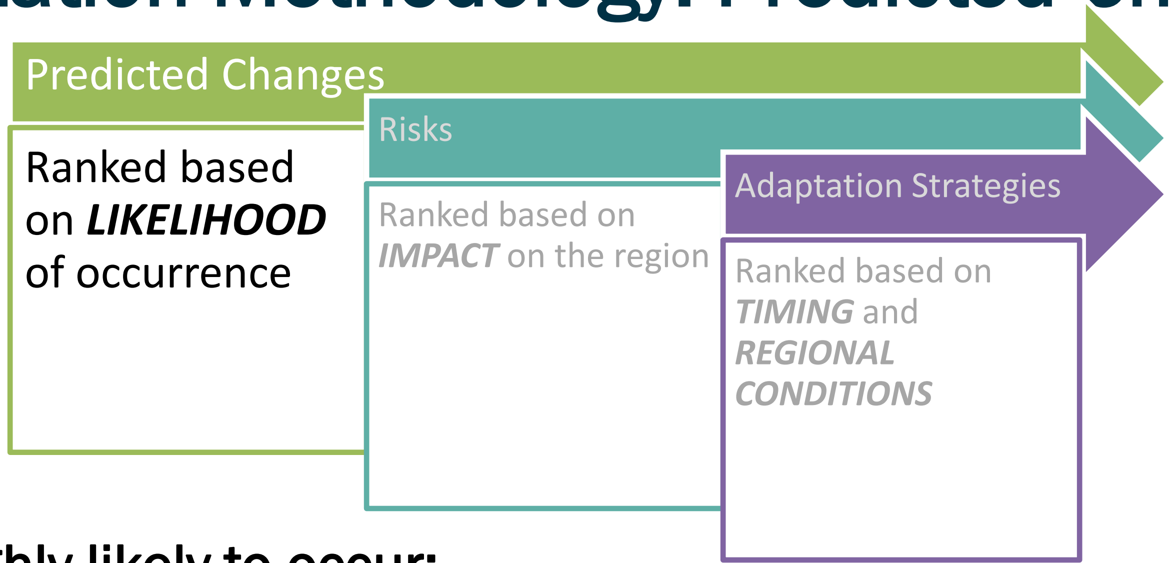
Risks

Ranked based on ***IMPACT*** on the region

Adaptation Strategies

Ranked based on ***TIMING*** and ***REGIONAL CONDITIONS***

Prioritization Methodology: Predicted Changes



- Highly likely to occur:
  - Linked to defined trends from the model results and climate data
- Medium probability of occurrence:
  - Results shown in the models
  - Less distinct trends
  - Associated with build-out or trends in precipitation
- Low probability of occurrence:
  - Not directly predicted by the model results
  - Considered less likely to occur based on the analysis

PREDICTED CHANGES AND THEIR LIKELIHOOD OF OCCURRENCE

No.	Predicted Changes	Likelihood of Occurrence
1	Increased air temperatures/increased incidence of heat waves	High
2	Increased water temperature	High
3	Warmer soil temperatures/decreased soil moisture	High
4	Higher maximum flows (30- and 7-day higher peak river flows)	Medium
5	Extended dry periods/summer drought (decreased minimum 30-day stream flow)	Medium
6	Increased intensity of rain and wind events	Medium
7	Change in vegetation/animal species composition	Low

Prioritization Methodology: Risks

Predicted Changes

Ranked based on ***LIKELIHOOD*** of occurrence

Risks

Ranked based on ***IMPACT*** on the region

Adaptation Strategies

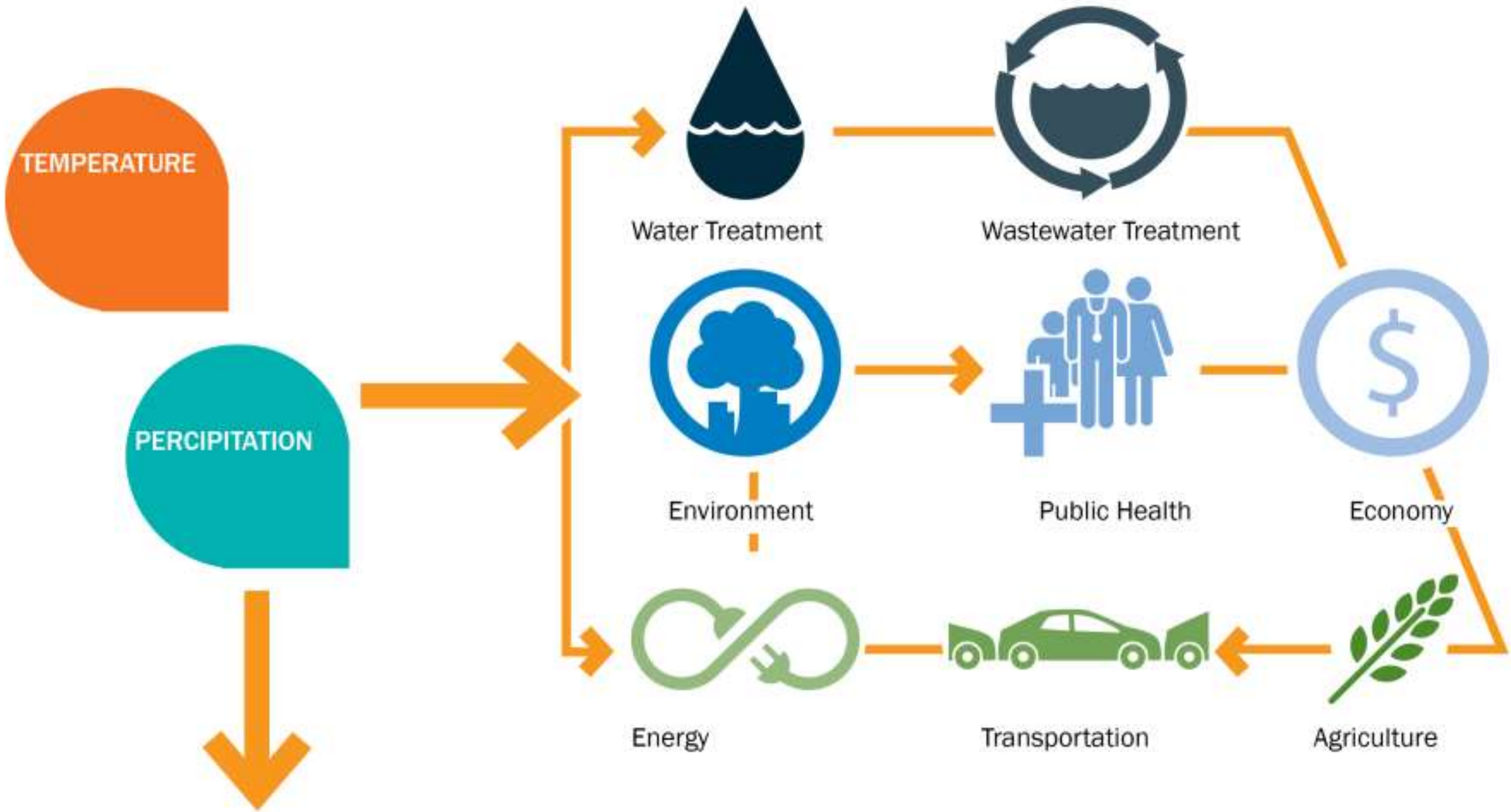
Ranked based on ***TIMING*** and ***REGIONAL CONDITIONS***

Affects Livability of Region

Impacts Quality of Life in Region

Less Impact on Quality of Life in Region

RISKS & IMPACTS



Projected or Potential Future Challenges

Impacted Sectors

Prioritization Methodology: Risks

Vulnerability Scenarios	Affected Sector								
	Water Supply/ Water Quality	Water Treatment	Wastewater Treatment	Public Health	Agriculture	Environment	Economy	Energy	Transportation
Increased Air Temperatures / Increased incidence of heat waves	Increased evaporation, Reduced water volume Increased water demand and demand due to irrigation Increased in-stream TOC Increased nutrient/ pesticide / herbicide runoff due to extended growing season, increased algal blooms Increased watershed erosion	Negatively affects water quality Increased capital investment due to designing for peaking factors Taste and odor concerns, potential for algal toxins Increased chlorine demand, Increase DBPs	Impacts to infrastructure (increased corrosion) Lower flow affects discharge permits and treatment Increase need for odor control	Vector Diseases Increased issues for asthma and allergies Impacts to human mortality, Increase in heat illnesses and stresses on healthcare	Vegetation / Animal species shift Livestock health / mortality Extended/disruptions to growing season Increased use of herbicides/pesticides/ nutrients with longer growing season Increased need for irrigation and controlled drainage	Vegetation / Animal species shift Increased smog / Decreased air quality	Extended recreational season Increased costs for utility services (water, wastewater, and energy) Increased service cost for food Decreased human productivity	Increased energy demand due to air conditioning, increased use of pumps for water / wastewater Decreased efficiency throughout production as temperature rises Increased power disruptions (brownouts)	Increase in road and bridge repairs and disruptions due to heat stress Increased use of private vehicles Change in construction materials for higher temperatures Extended but less efficient construction season
Increased water temperature	Decreased dissolved oxygen Increased release of phosphorus and other pollutants from anoxic zones/sediment Decreased mixing Longer duration of poorer water quality Increased algal blooms including blue greens (potential for increased toxin release)	Taste and odor concerns, potential for algal toxins Increased treatment costs due to algae and potentially algal toxins Increased treatment efficiency	Lower DO / changes in temp require affect wastewater discharge allocation Decreased organics at plant due to DBPs	Increase in waterborne diseases Increased use of disinfectants; increased DBPs	Increased costs to control water quality from fields Treatment and disinfection use increases Energy use for cooling Livestock management and aquaculture	Changes in pH and pollutant toxicity Negative impact on aquatic life diversity and numbers Decreased dissolved oxygen Increase in algal blooms	Algae growth could impact recreational use Increased energy cost due to power plant discharge cooling	Increased cost for energy production because have to cool discharge before released	Limited applicability
Warmer soil temperatures / Decreased soil moisture	Decreased groundwater base flow to streams Reduction/change in vegetative cover Increased watershed erosion Increased in-stream TOC Increased sediment deposition/loss of volume	Increased treatment demands due to lower water WQ Change of frequency in water main breaks in winter	Increased use of effluent sludge on farm fields	Impacts to private water systems	Increased need for irrigation and controlled drainage Vegetation / Animal species shift Increased soil conservation practices Increased need for crop insurance	Vegetation / Animal species shift Increased erosion Increase in invasive species	Negative impact on winter recreational activities if less snow/ice Higher food prices and potential job losses if results in loss of agricultural crops	Increased albedo; greater urban heat island effect leads to increased cooling demands	Reduced salt usage in winter Embankment erosion and damage due dry soils

THREATS & VULNERABILITIES

Prioritization Methodology: Risks

Water Supply/Quality High-Priority Risks		
No.	Predicted Changes	**High Priority Risks**
1	Increased air temperature	Increased nutrient/pesticide/herbicide load due to extended growing season
2	Increased water temperature	Increased algal blooms
5	Higher maximum peak stream flows	Increased TOC, nutrients, turbidity, sediment, and other pollutant loads to surface waters
		Increased algal blooms
		Increased watershed and stream bank erosion
6	Extended dry periods/ summer drought	Decreased reservoir inflow/volume and reduced mixing
		Increased algal blooms
7	Increased intensity of wind and rain events	Increased watershed and stream bank erosion
		Increased TOC, nutrients, turbidity, sediment, and other pollutant loads to surface waters

Prioritization Methodology: Risks

Water Treatment High-Priority Risks		
No.	Predicted Changes	High Priority Risks
1	Increased air temperature	Taste and odor concerns, potential for algal toxins
2	Increased water temperature	Taste and odor concerns, potential for algal toxins
3	Higher maximum peak stream flows	Increased pollutant loads (from increased turbidity, organics, nutrients, microorganisms and other contaminants) in surface waters
4	Increased intensity of wind and rain events	Damage to infrastructure / infrastructure failure including power outages, flooding and intake damages

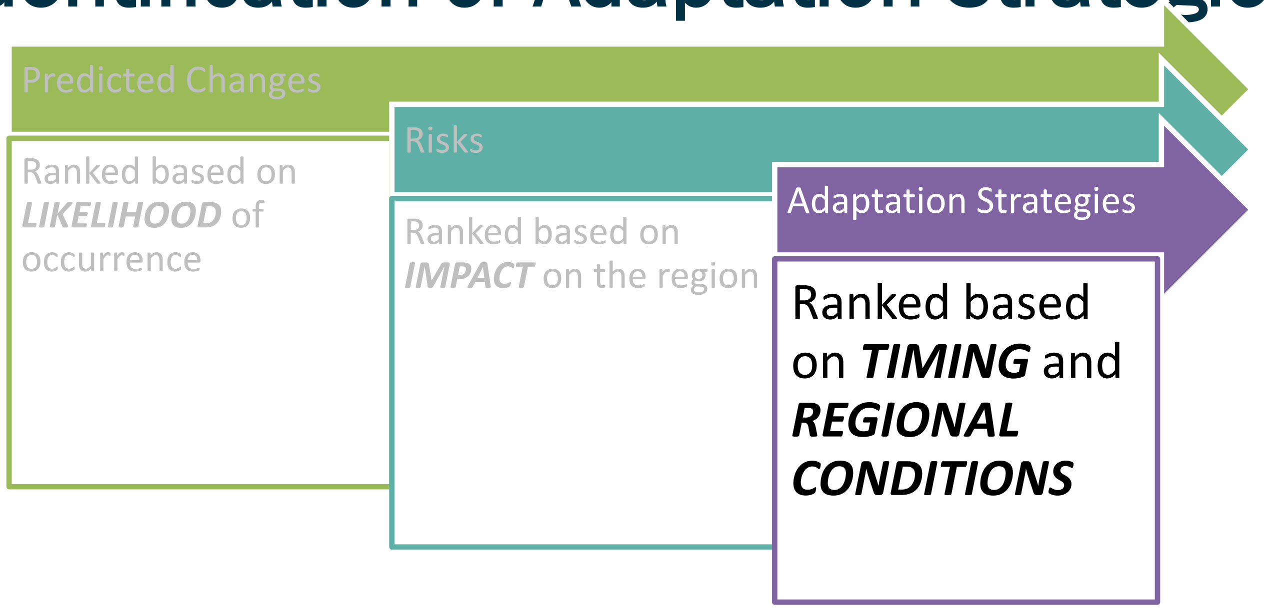
Prioritization Methodology: Risks

Wastewater Utility High-Priority Risks		
No.	Predicted Changes	High Priority Risks
1	Increased water temperature	Lower DO/changes in temperature affect wastewater discharge allocation
2	Increased intensity of wind and rain events	Damage to Infrastructure/infrastructure failure including power outage and flooding
		Increased CSO/SSO discharges

ADAPTIVE MANAGEMENT APPROACH

Iterative Approach:
re-evaluate and adjust as new information becomes available

Identification of Adaptation Strategies



- Types of Strategies:
  - Planning
  - Operational
  - Capital Improvement
- Estimate relative costs: $, $$, $$$
- No Regrets Strategies

ADAPTIVE MANAGEMENT PLANNING

Short Term 2015 – 2025	Mid-Range Term 2026 – 2045	Long-Range Term 2046 – 2090
• Expand monitoring • Increase emergency preparedness • Source Management (Demand) • Regional collaboration & public education	• Regional Water Supply Plan • Groundwater Supply Study • Water reuse • Enhance reservoir capacity • Watershed Management Plan (Nutrient/ Pollutant Reduction) • Re-evaluate climatic conditions	• Implement improvements from mid-range plans • Re-evaluate climatic conditions

SUSTAINING SCIOTO: ADAPTATION STRATEGIES

Recommended Adaptation Strategies for Protecting Water Quality		
Strategy	No Regrets	Cost
Planning and Policy		
Develop Water Quality Monitoring Plan	✓	$
Develop an Agricultural Nutrient Management Program	✓	$
Implement public education on water quality, water supply & climate change impacts	✓	$
Modify local ordinances to promote low impact development, stormwater harvesting/reuse	✓	$
Develop Regional Watershed Management Plan to reduce nutrient runoff	✓	$
Operational		
Implement increased fertilizer reduction programs, revegetation of riparian buffer zones, and other non-structural practices	✓	$$
Capital Improvement		
Implement reservoir capital improvement projects		$$
Implement pollutant reduction projects (BMPs) to reduce pollutants of concern		$$$

SUSTAINING SCIOTO: ADAPTATION STRATEGIES

Mitigating Impact of Damage to Infrastructure / Failure Related to Increased Intensity of Rain and Wind Events		
Strategy	No Regrets	Cost
Planning and Policy		
Evaluate increased wastewater and stormwater storage options for extreme events	✓	$
Update Regional Emergency Preparedness and Response Plans for extreme weather	✓	$
Evaluate wastewater system infrastructure vulnerabilities and needs	✓	$$
Determine appropriate LOS during extreme weather events	✓	$
Develop Emergency Power Plan including backup power supplies	✓	$
Operational		
Establish SOPs for modified treatment plant operation during extreme events		$
Modify local ordinances to require LID, reduce impervious areas, and reuse rainwater	✓	$
Implement backup power supplies at pump stations and treatment facilities		$$
Capital Improvement		
Rehabilitate or replace most vulnerable infrastructure		$$
Set aside land to support future flood-proofing needs (berms, dikes etc.)		$$$
Implement flood control strategies at the WWTP and protect vulnerable infrastructure		$$$
Increase capacity for wastewater and stormwater collection, treatment, and discharge		$$$

RESULTS:
WHAT DOES THIS MEAN FOR CENTRAL OHIO?

- Increased air & water temperature
- Degraded water quality
- Increased potential for both floods & droughts
- More extreme storm events

CHALLENGES:

Challenges to Utilities & Region

- Need for flexibility in operations and management
  - Planning for both drought and extreme floods
- Regional issues may require regional collaboration

CONCLUSIONS:
Adaptive Management Plan for Central Ohio

- Prepare region with No-Regrets strategies
- Short Term:
  - Regional Collaboration & Education
  - Source Resiliency
  - Watershed (WQ) Monitoring
  - Emergency Preparedness
- Update plan over time

CONCLUSION:
WHAT CAN YOU DO?

- Consider impacts and adaptation strategies
- Identify partners and collaborate
- Develop a timeframe and benchmarks
- Consider how this will impact your community

QUESTIONS?

Contact:
David Rutter
Watershed Coordinator
MORPC
T: 614.233.4186
drutter@morpc.org
www.morpc.org/sustainingscioto

MID-OHIO REGIONAL PLANNING COMMISSION
SUSTAINING SCIOTO
INVESTING TODAY. PRESERVING TOMORROW.