



Interagency Task Force Meeting

Nov 29, 2018, 9:00 a.m. to 12:00 p.m.

Missouri Water Resources Plan

Agenda

- 9:00 Welcome and Opening Remarks
- 9:05 Introductions
- 9:10 Quantification of Planning Scenario Drivers
- 9:30 Scenario Planning – Water Supply Shortages
- 11:00 Infrastructure Update
- 11:30 Technical Workgroups Update
- 11:40 Question and Answer Session
- 11:50 Next Meeting
- 12:00 Adjourn



Introductions



Proposed Scenarios for Missouri Plan

Missouri Planning Scenarios

Scenario	M&I Demands	Ag Demands	Climate	Water Treatment Level	Supply Constraints	Reservoir Regulations
Business-As-Usual	<ul style="list-style-type: none"> • Baseline M&I demands • Baseline Rural demands 	<ul style="list-style-type: none"> • Med Ag irrigation • Med Ag processing 	<ul style="list-style-type: none"> • Historical temperatures • Historical precipitation 	<ul style="list-style-type: none"> • Existing water treatment levels 	<ul style="list-style-type: none"> • No water supply constraints 	<ul style="list-style-type: none"> • No re-allocation of USACE reservoirs for supply • Existing permitting process for new reservoirs
Strong Economy/ High Water Stress	<ul style="list-style-type: none"> • High M&I demands • Higher Rural demands 	<ul style="list-style-type: none"> • High Ag irrigation • Med-High Ag processing 	<ul style="list-style-type: none"> • Hotter temperatures • Lower rainfall 	<ul style="list-style-type: none"> • High increase in water treatment levels 	<ul style="list-style-type: none"> • Interstate diversions out of Missouri River Basin • Limitations on GW (select areas) • Prolonged supply disruption on River intakes 	<ul style="list-style-type: none"> • Limited re-allocation of USACE reservoirs for supply • Streamlined permitting process for new reservoirs
Substantial Agricultural Expansion	<ul style="list-style-type: none"> • Baseline M&I demands • Baseline Rural demands 	<ul style="list-style-type: none"> • Med Ag irrigation • Highest Ag processing 	<ul style="list-style-type: none"> • Warmer temperatures • Greater rainfall 	<ul style="list-style-type: none"> • Moderate increase in water treatment levels 	<ul style="list-style-type: none"> • Interstate diversions out of Missouri River Basin • Limitations on GW (select areas) 	<ul style="list-style-type: none"> • Limited re-allocation of USACE reservoirs for supply • Existing permitting process for new reservoirs
Weak Economy/ Low Water Stress	<ul style="list-style-type: none"> • Low M&I demands • Baseline Rural demands 	<ul style="list-style-type: none"> • Med Ag irrigation • Med Ag processing 	<ul style="list-style-type: none"> • Warmer temperatures • Greater rainfall 	<ul style="list-style-type: none"> • Existing water treatment levels 	<ul style="list-style-type: none"> • No water supply constraints 	<ul style="list-style-type: none"> • No re-allocation of USACE reservoirs for supply • Existing permitting process for new reservoirs



Quantification of Scenario Planning Drivers

Scenario Drivers

- M&I Demands
- Agricultural Demands
- Climate
- Supply Constraints
- Water Treatment Levels
- Regulations

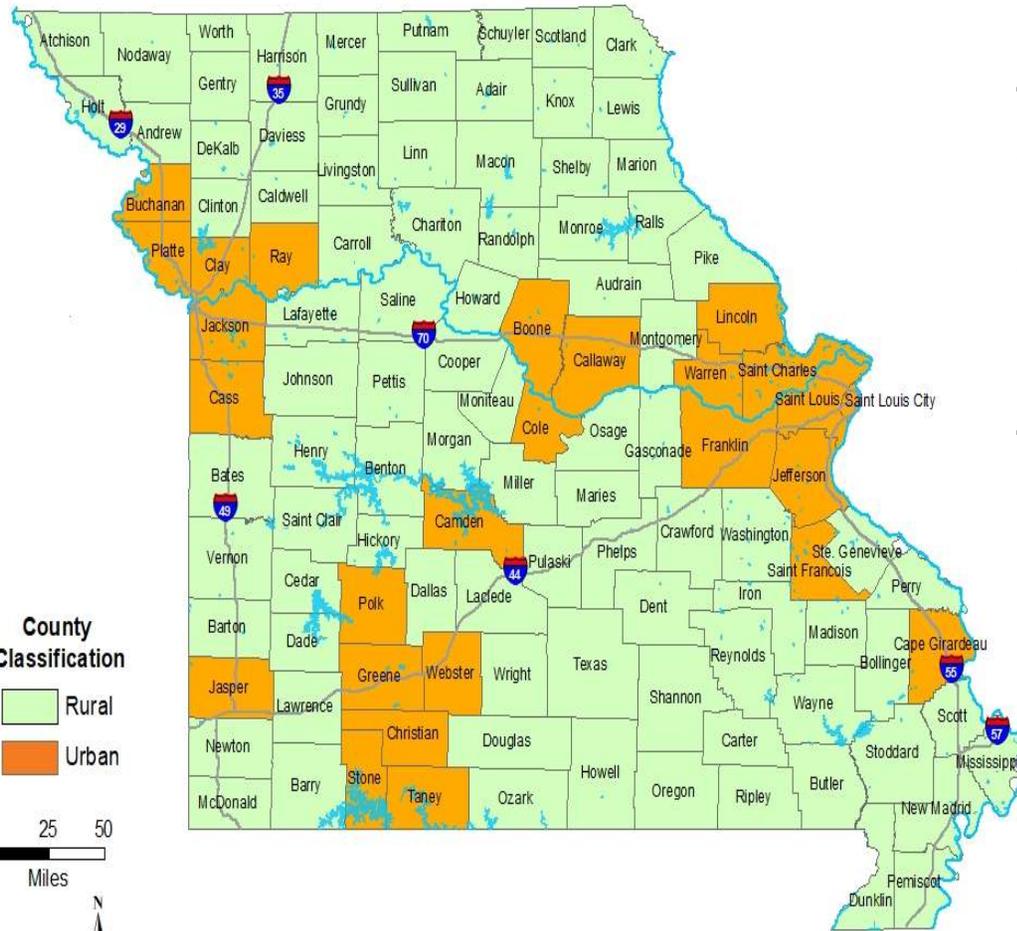


Missouri Planning Scenarios for Drought-of-Record Conditions

Scenario	M&I Demands	Ag Demands	Climate	Supply Constraints	Overall Impact to Surface Water Supply and Demands		Percent Change from Baseline	
					Category	Statewide (mgd)	Statewide (%)	
Business-As-Usual	Baseline M&I and Baseline Rural Demands	Med Ag Irr and Med Ag Processing	Historical T and P	Reservoir Sedimentation <i>8.9% Reduction in Flow</i>	M&I Demands:	52	<i>no change from normal</i>	
					Ag Demands:	27		
					Supply (streamflow):	14,299		
					Missouri River flow:	16,320		
Strong Economy/High Water Stress	High M&I and Higher Rural Demands <i>M&I Demands +25%</i> <i>Rural Demands +10%</i>	High Ag Irr and Med-High Ag Processing	Hotter T and Lower P	Reservoir Sedimentation and Interstate Diversions out of Missouri River <i>14% Reduction in Flow</i>	M&I Demands:	68	31%	
					Ag Demands:	81	200%	
					Supply (streamflow):	12,804	10%	
					Missouri River flow:	14,274	13%	
Substantial Agricultural Expansion	Baseline M&I and Baseline Rural Demands	Med Ag Irr and Highest Ag Processing	Warmer T and Greater P	Reservoir Sedimentation and Interstate Diversions out of Missouri River <i>14% Reduction in Flow</i>	M&I Demands:	54	4%	
					Ag Demands:	19	30%	
					Supply (streamflow):	15,973	12%	
					Missouri River flow:	14,274	13%	
Weak Economy/Low Water Stress	Low M&I and Baseline Rural Demands <i>M&I Demands -10%</i> <i>Rural Demands +10%</i>	Med Ag Irr and Med Ag Processing	Warmer T and Greater P	Reservoir sedimentation <i>8.9% Reduction in Flow</i>	M&I Demands:	49	6%	
					Ag Demands:	19	30%	
					Supply (streamflow):	15,973	12%	
					Missouri River flow:	16,320	0%	

Note: Limitations on Groundwater and Prolonged Supply Disruptions on River Intakes are also part of some scenarios

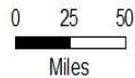
Urban/Rural County Classification



***Classification ONLY used for the purpose of assessing additional population growth (beyond the baseline population projections) used in the water demand forecast**

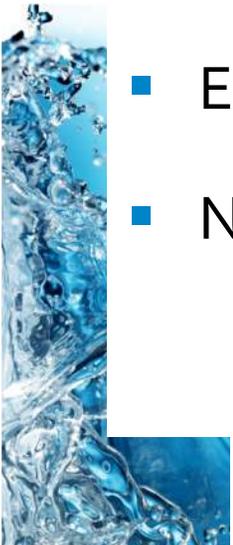
County Classification

- Rural
- Urban



Business-As-Usual Scenario

- Baseline M&I demands
- Baseline rural demands
- Medium agriculture irrigation (baseline)
- Medium agriculture processing (baseline)
- Historical temperature and precipitation levels
- Existing water treatment levels
- No water supply constraints



Strong Economy / High Water Stress Scenario Methods and Assumptions

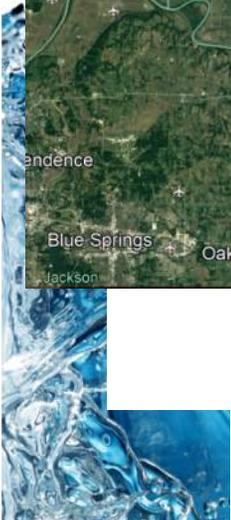
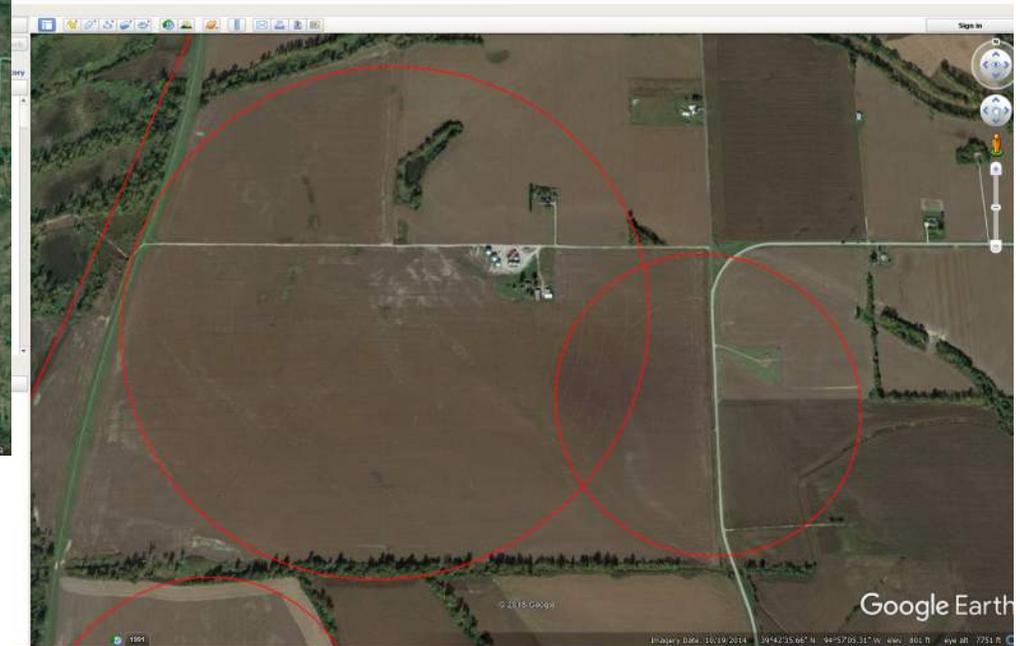
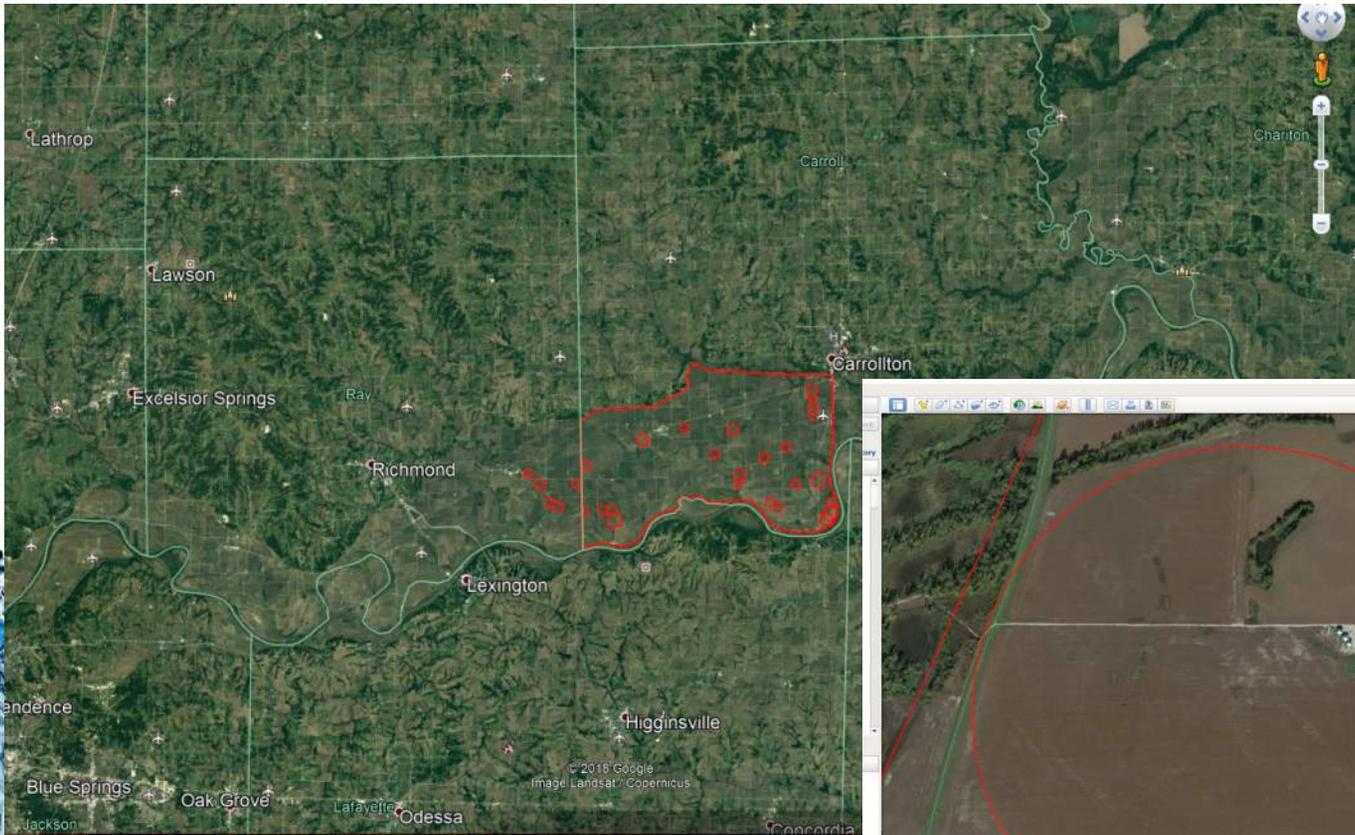
- Additional population growth by 2060:
 - +25% in urban counties
 - +10% in rural counties
- Applies to these sectors:
 - Major Water Systems (by major water system)
 - Self-supplied Residential and Minor Systems (at the county level)
 - Self-supplied Non-residential
 - Agriculture Irrigation
- Sources of water are assumed equal to 2016 proportions
- Hotter temperatures and lower rainfall trends



Alluvial Land in Missouri



Evaluation of Alluvial Farmland Currently Irrigated (outside of Bootheel region)



Weak Economy / Low Water Stress Scenario Methods and Assumptions

- Reduction in population growth by 2060:
 - -10% in urban counties
 - Baseline growth in rural counties
- Applies to these sectors:
 - Major Water Systems
- All other sector demands assumed at baseline
- Sources of water are assumed equal to 2016 proportions
- Warmer temperatures and more rainfall

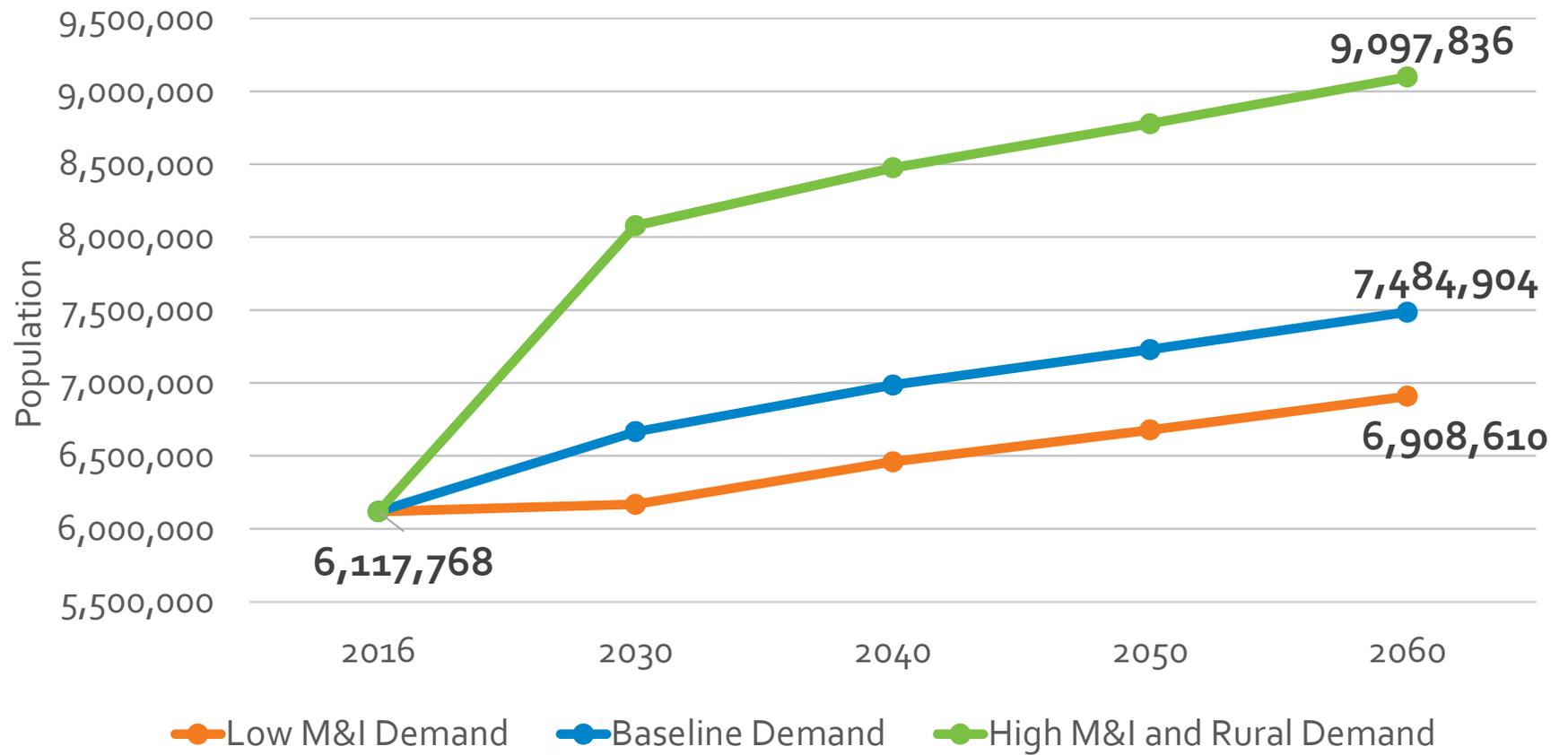


Substantial Agriculture Expansion Methods and Assumptions

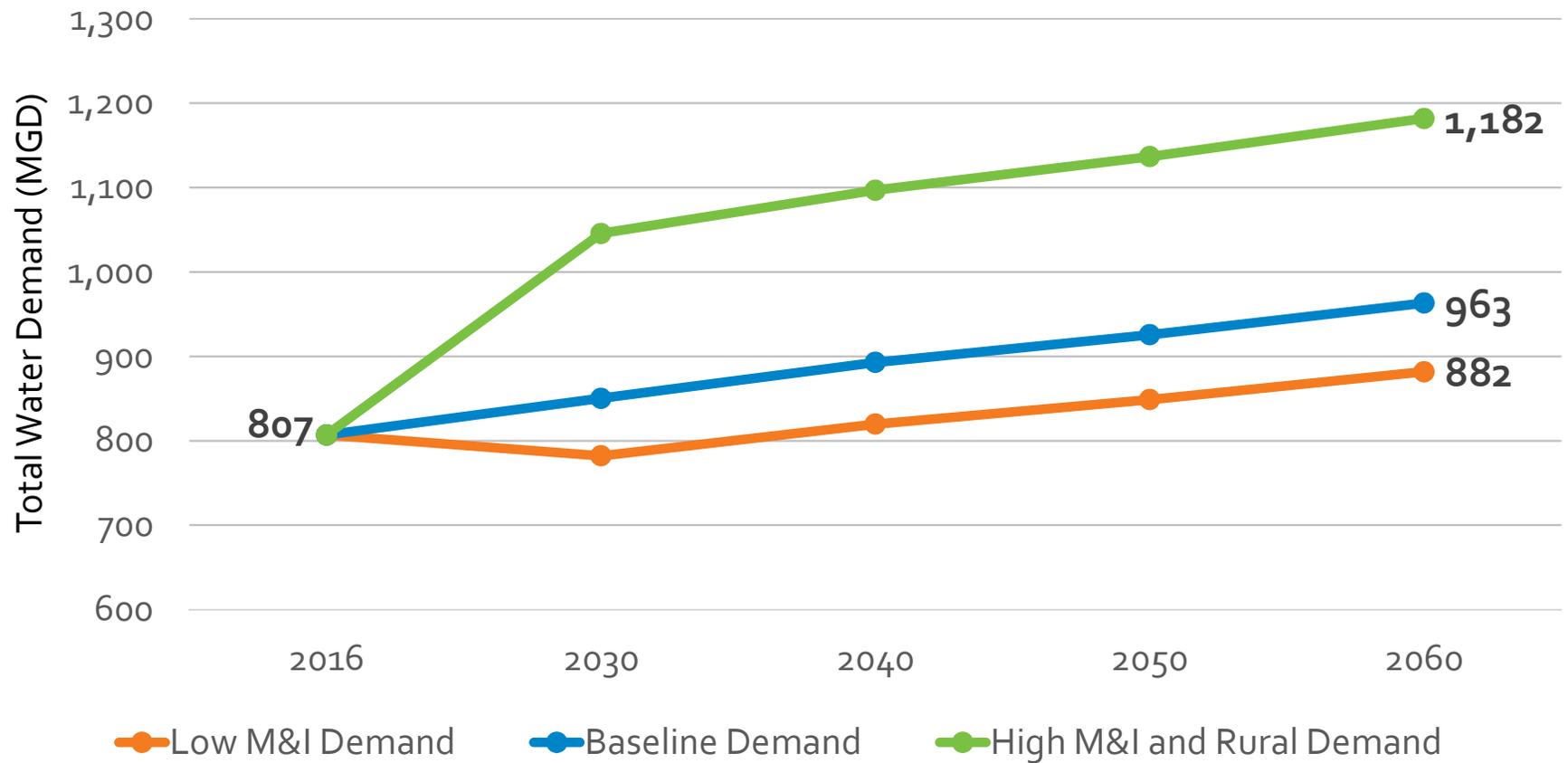
- Applies to two sectors:
 - Self-supplied Nonresidential (by agriculture industry)
 - Agriculture Irrigation
- Baseline demands for all other sectors
- Sources of water are assumed equal to 2016 proportions



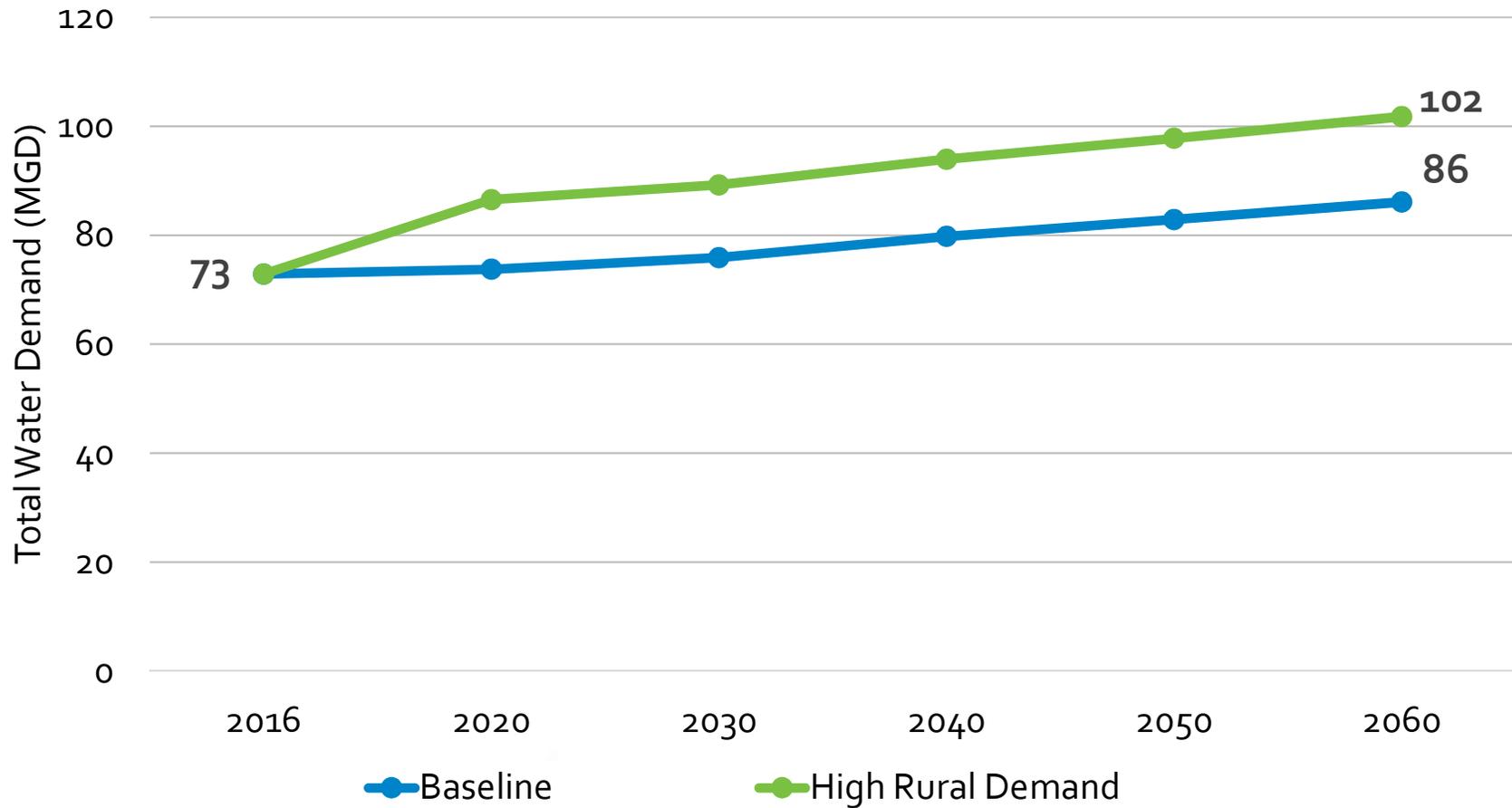
Population Projection Scenarios



Major Water Systems Demand by Scenario



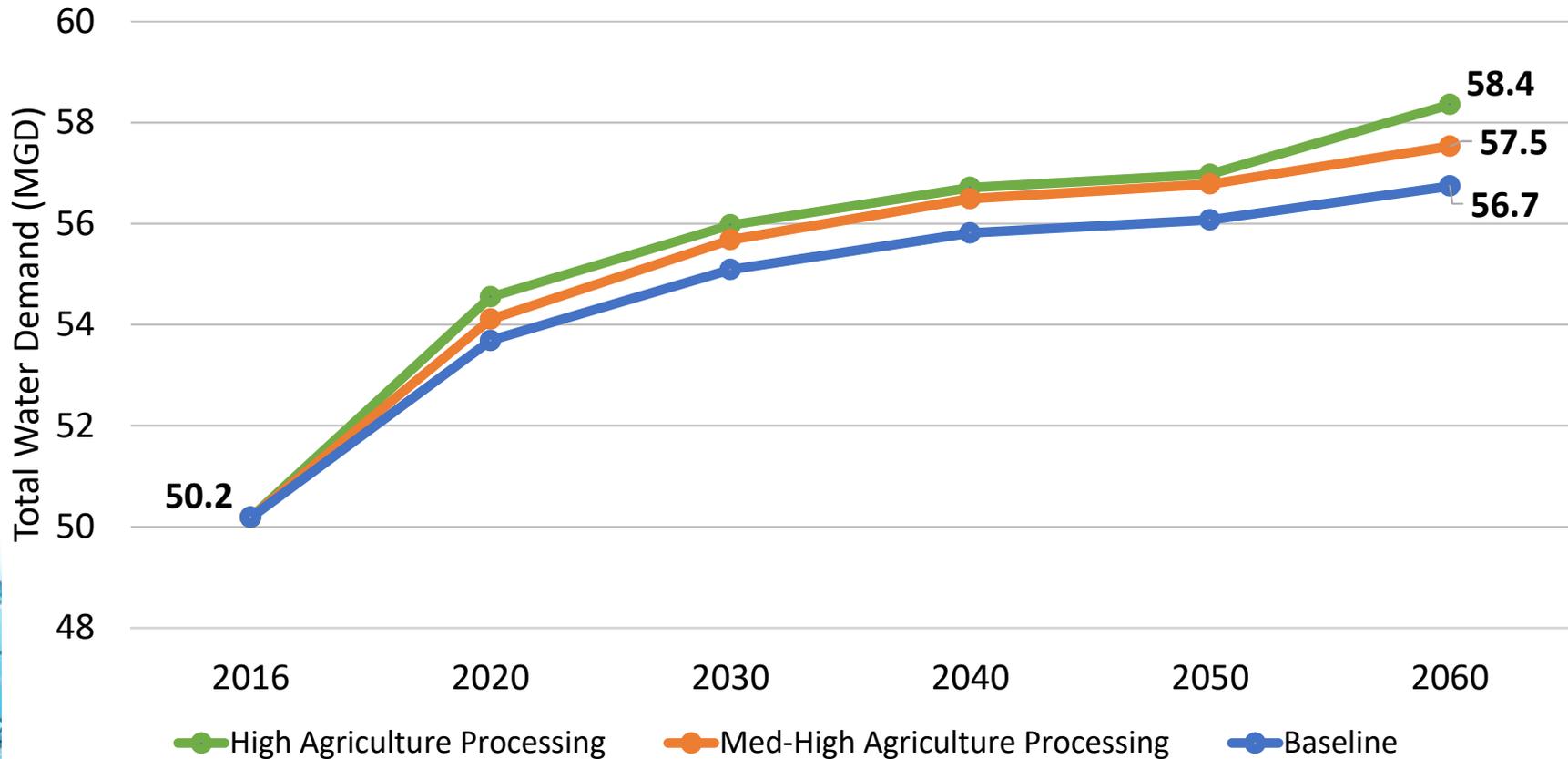
Self-Supplied Residential and Minor Systems



Note: Low Rural Demands were not calculated since they were not part of an scenario.



Self-Supplied Nonresidential



Note: It is unknown when new self supplied nonresidential facilities will be brought online therefore is assumed a percentage increase from baseline.



Climate Adjustment Factors for M&I Demands High Water Stress

- Developed using weather-demand regression model specific to MO and climate change model outputs
- Resulting adjustment factors by basin/HUC
- Multiplied by future projections to represent Hot and Dry weather

Basin	HUC ₄	Adjustment Factor for Hot & Dry Weather					
		May	June	July	Aug	Sept	Oct
Upper Mississippi-Salt	711	1.110	1.111	1.113	1.108	1.113	1.122
Upper Mississippi-Kaskaskia-Meramec	714	1.089	1.108	1.113	1.111	1.111	1.111
Lower Mississippi-St. Francis	802	1.089	1.107	1.113	1.113	1.110	1.108
Missouri-Nishnabotna	1024	1.093	1.112	1.119	1.115	1.117	1.122
Chariton-Grand	1028	1.091	1.112	1.117	1.112	1.115	1.123
Gasconade-Osage	1029	1.087	1.109	1.111	1.106	1.111	1.118
Lower Missouri	1030	1.088	1.110	1.112	1.107	1.112	1.120
Upper White	1101	1.087	1.105	1.111	1.111	1.108	1.106
Neosho-Verdigris	1107	1.086	1.107	1.110	1.104	1.108	1.114



Climate Adjustment Factors – Low Water Stress

- Developed using weather-demand regression model specific to MO and climate change model outputs
- Resulting adjustment factors by basin/HUC
- Multiplied by future projections to represent Warm and Wet weather

Basin	HUC ₄	Adjustment Factor for Warm & Wet Weather					
		May	June	July	Aug	Sept	Oct
Upper Mississippi-Salt	711	1.039	1.040	1.044	1.053	1.064	1.062
Upper Mississippi-Kaskaskia-Meramec	714	1.051	1.044	1.045	1.049	1.059	1.068
Lower Mississippi-St. Francis	802	1.057	1.052	1.052	1.056	1.064	1.070
Missouri-Nishnabotna	1024	1.037	1.051	1.058	1.064	1.068	1.062
Chariton-Grand	1028	1.043	1.052	1.056	1.062	1.067	1.065
Gasconade-Osage	1029	1.045	1.052	1.057	1.059	1.067	1.066
Lower Missouri	1030	1.046	1.053	1.058	1.060	1.068	1.067
Upper White	1101	1.056	1.052	1.051	1.055	1.063	1.068
Neosho-Verdigris	1107	1.044	1.052	1.057	1.058	1.066	1.064



Climate / Hydrologic Variability



Climate Variability – Hydrology Projections

- Overall Approach
 - 2060 planning horizon (± 15 years) to align with demand projections
 - Three spatial grid cells to represent statewide General Circulation model (GCM) projections: NW corner, Central and SE corner
 - Use published “gridded runoff” data set to adjust observed stream flows within Hybrid Delta Ensemble (HDe) methodology
 - 9 HUC₄ basins x 2 climate projection ensembles (groups) = 18 new hydrologic traces



Climate Variability – Hydrology Projections

- Spatial representation:
 - 3 General Circulation Model (GCM) grid cells
 - Capturing regional differences in climate projections

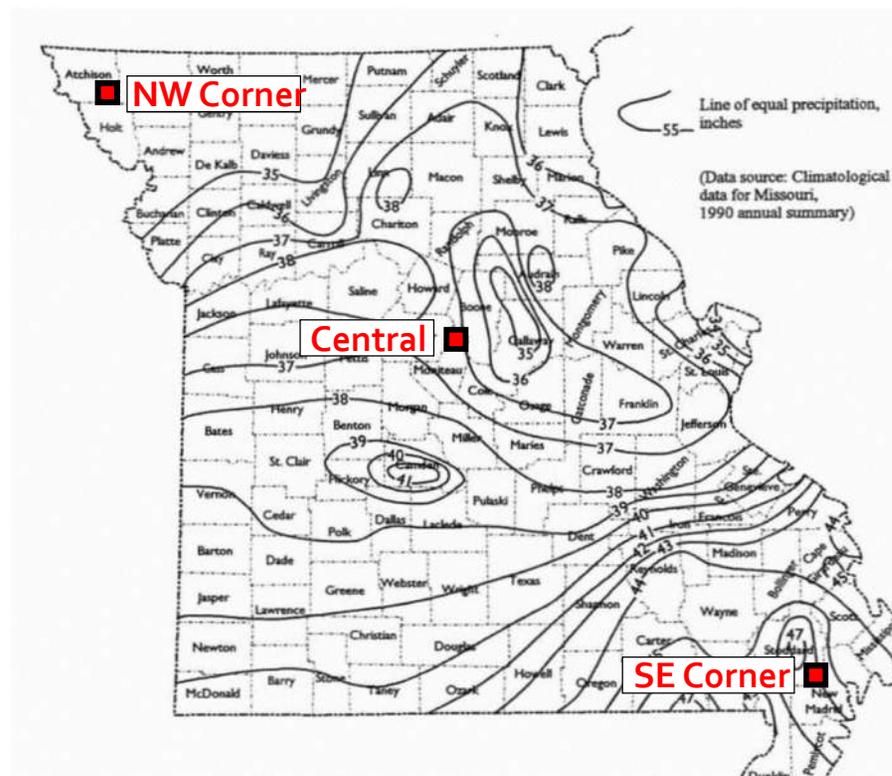
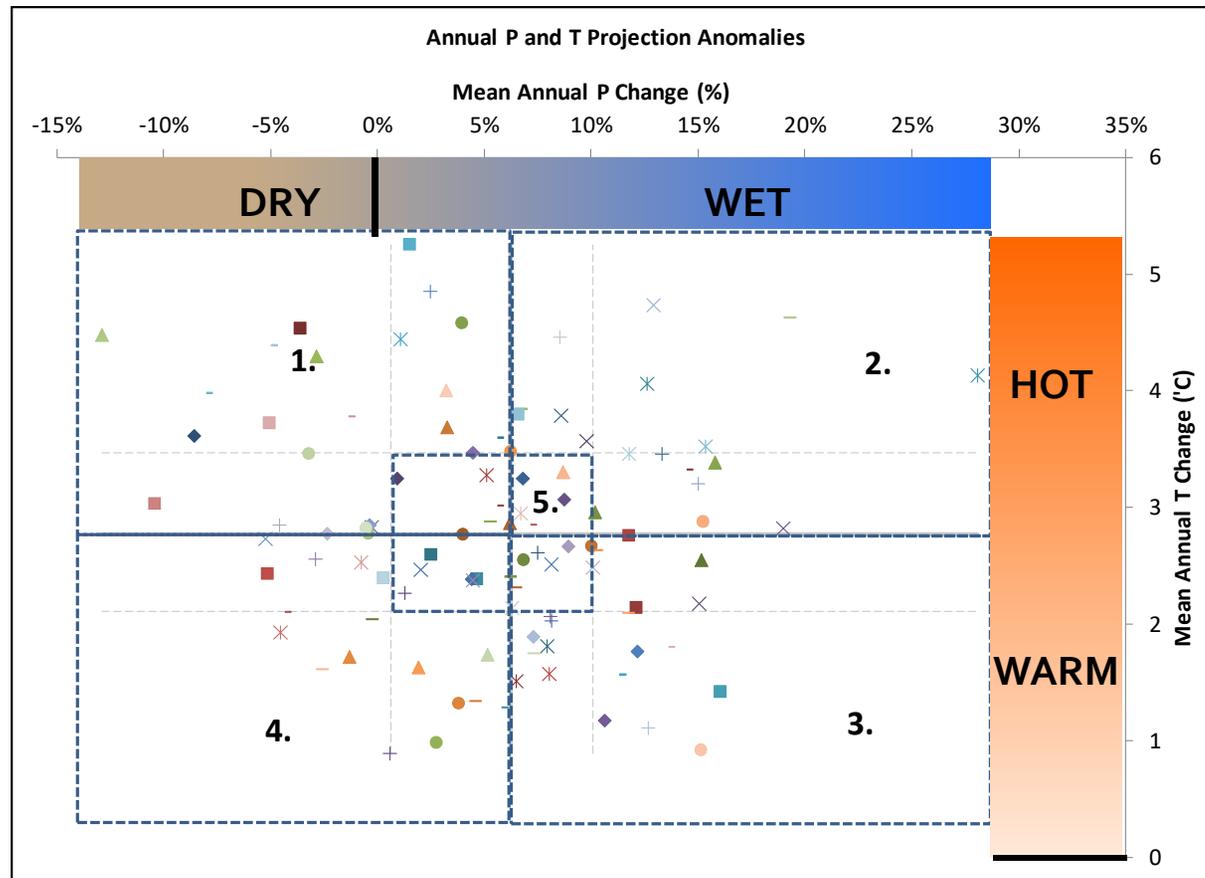


Image of precipitation contours from Surface Water Resources of Missouri, MoDNR, 1995



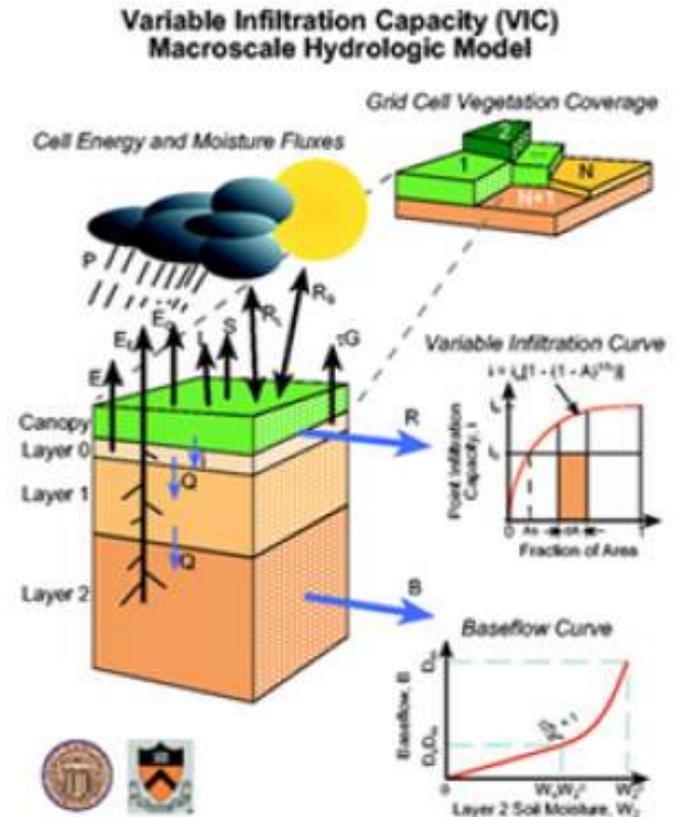
Climate Variability – Hydrology Projections

- Ensembling (grouping): HOT/DRY (1) and WARM/WET (3)
Selected for Scenarios



Climate Variability – Hydrology Projections

- Gridded runoff:
 - Each GCM projection (precipitation and temperature) used as input to macroscale hydrologic model (VIC)
 - Applied for same 1/8th degree grid
 - Spatially distributed; coarsely calibrated at large basin scale
 - Output = monthly runoff (mm) projections for each grid cell; 2000 - 2099



Climate Variability – Hydrology Projections

- Hybrid Delta Ensemble (HDe) method:
 - Delta = modeled future – modeled past (bias)
 - Ensemble (Group) = multiple GCM projections combined (uncertainty)
 - Hybrid = range (percentiles) of delta values for each month



Climate Variability – Demand Projections

- Overall Approach
 - 2060 planning horizon (± 15 years) to align with demand projections
 - Three spatial grid cells to represent statewide GCM projections: NW corner, central, SE corner
 - Use difference in temperature and ratio of precipitation to adjust demands



Climate Variability – Demand Projections

- Example Results

Hot/Dry

	Avg. Temperature Change Term ('C)	Avg. Precipitation Change Factor
Jan	3.57	1.08
Feb	3.21	1.13
Mar	3.15	1.12
Apr	2.92	1.16
May	3.25	1.02
Jun	3.86	0.89
Jul	4.18	0.85
Aug	4.25	0.90
Sep	4.18	0.94
Oct	3.91	0.96
Nov	3.24	1.00
Dec	3.80	1.05

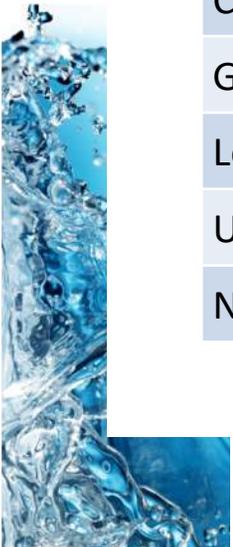
Warm/Wet

	Avg. Temperature Change Term ('C)	Avg. Precipitation Change Factor
Jan	2.16	1.07
Feb	1.89	1.18
Mar	1.79	1.18
Apr	1.79	1.16
May	1.80	1.15
Jun	1.91	1.11
Jul	2.07	1.07
Aug	2.30	1.01
Sep	2.47	1.02
Oct	2.20	1.06
Nov	1.90	1.14
Dec	2.14	1.08



Drought Conditions Streamflow

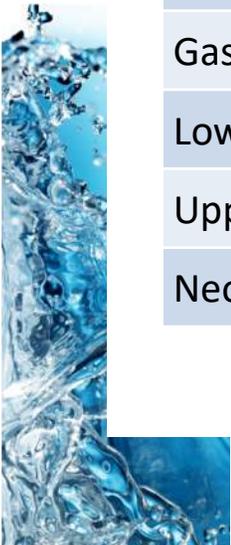
HUC 4	Drought-of-Record Year(s) Used	Percent Difference from Average Year Streamflow
Upper Mississippi-Salt	1954 & 1956	82%
Upper Mississippi- Kaskaskia-Meramec	1954	15%
Lower Mississippi-St. Francis	1954	57%
Missouri-Nishnabotna	1956	42%
Chariton-Grand	1956	81%
Gasconade-Osage	1954	68%
Lower Missouri	1956	95%
Upper White	1954	48%
Neosho-Verdigris	1954 & 1956	87%



Climate Scenarios - Streamflow Adjustments

HUC ₄	Drought-of-Record Streamflow	Hot/Dry Scenario Streamflow	Warm/Wet Scenario Streamflow
Upper Mississippi-Salt	562	436	588
Upper Mississippi- Kaskaskia-Meramec	3,614	3,225	4,199
Lower Mississippi-St. Francis	710	657	685
Missouri-Nishnabotna	893	857	1,114
Chariton-Grand	702	550	779
Gasconade-Osage	2,834	2,532	3,143
Lower Missouri	314	241	356
Upper White	4,407	4,082	4,809
Neosho-Verdigris	262	223	301

Flows in mgd. Flows represent streamflow generated within each HUC₄ and do not include flow from the Missouri or Mississippi rivers coming from out-of-state.



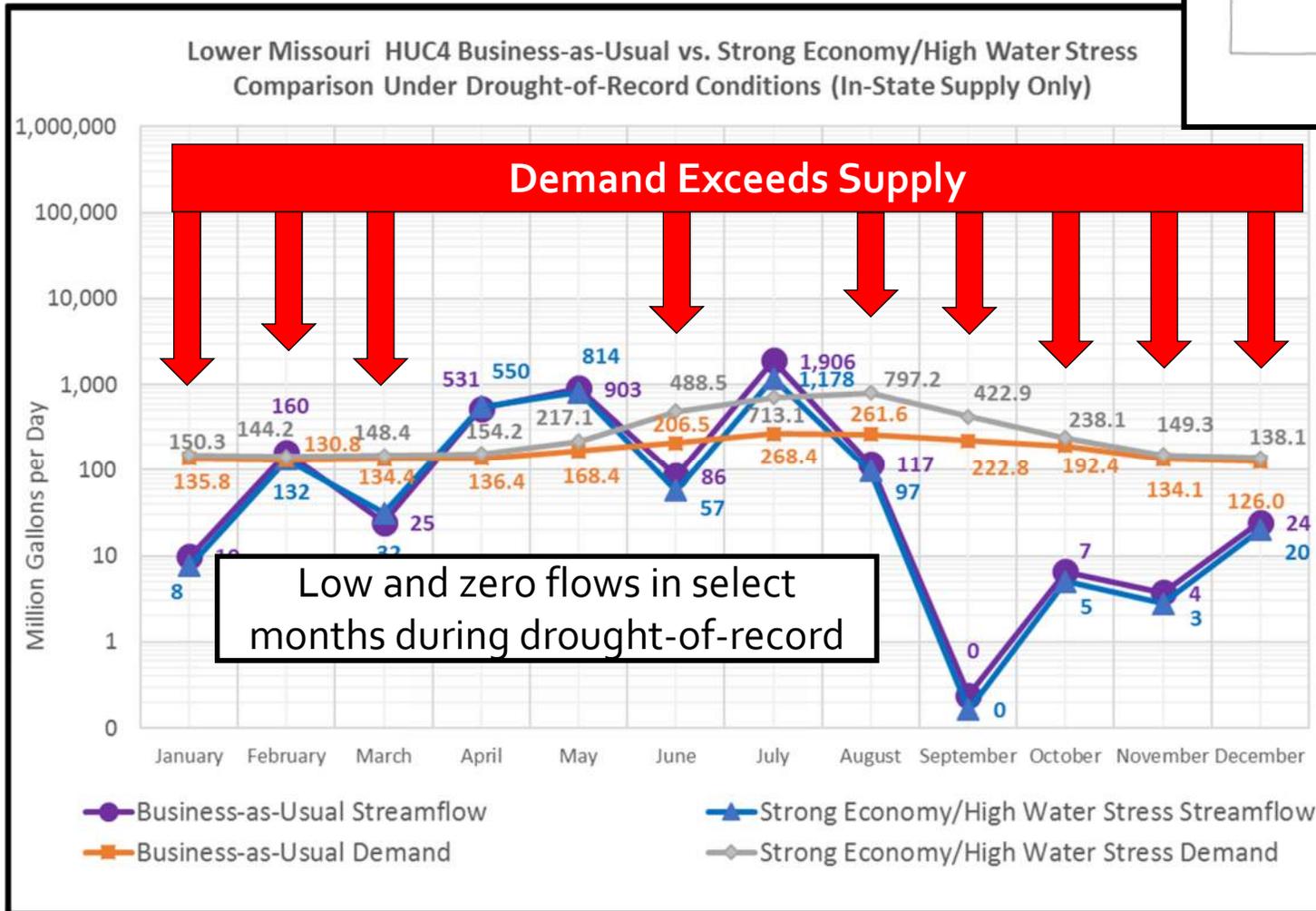
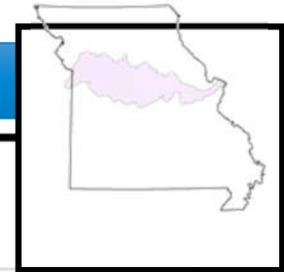
Short Break



Scenario Planning Water Supply Shortages

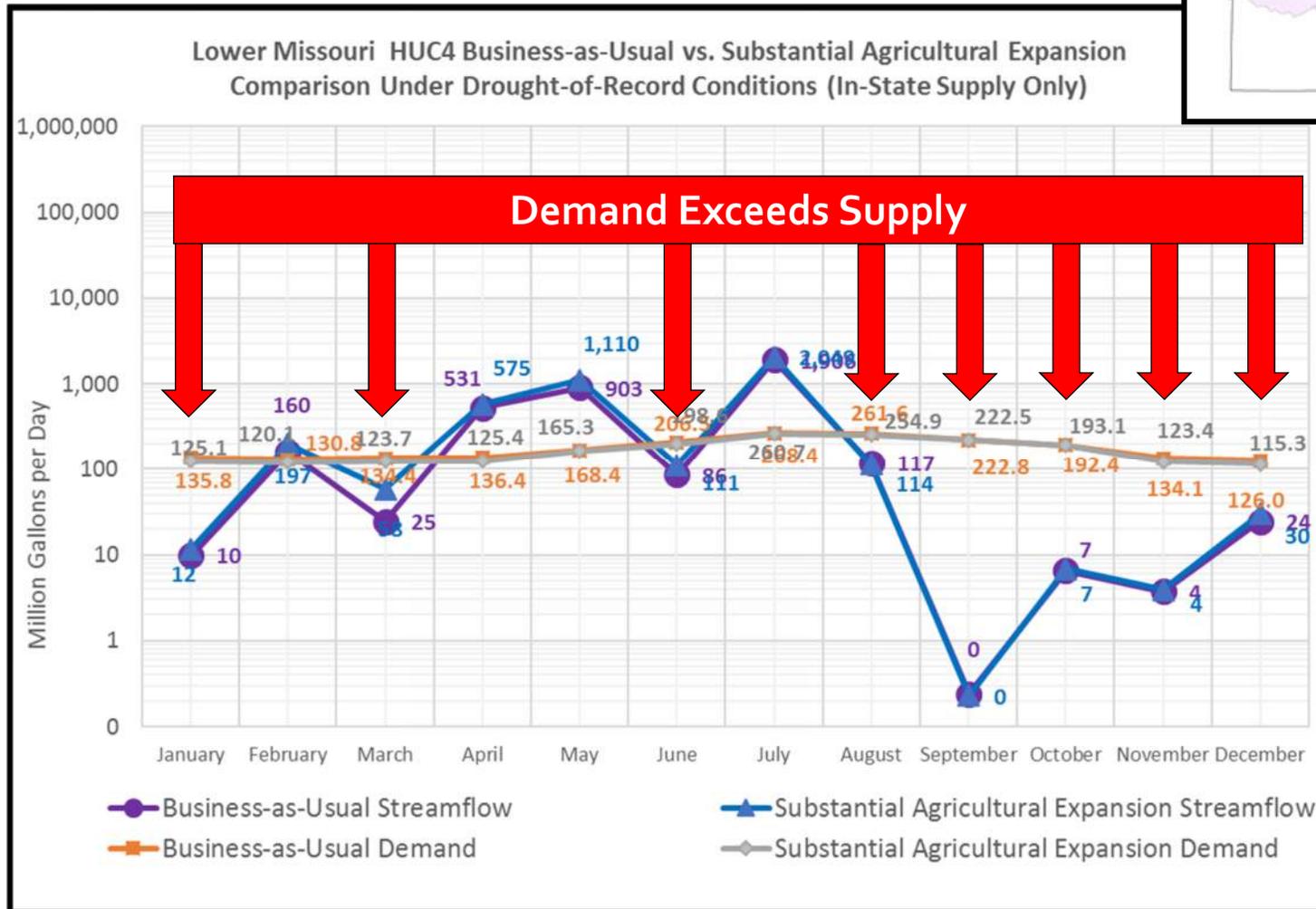
Scenario Results - Surface Water Supply Business-as-Usual vs. Strong Economy/High Water Stress Lower Missouri HUC₄

In-State generated flows only. Excludes demands on Missouri River



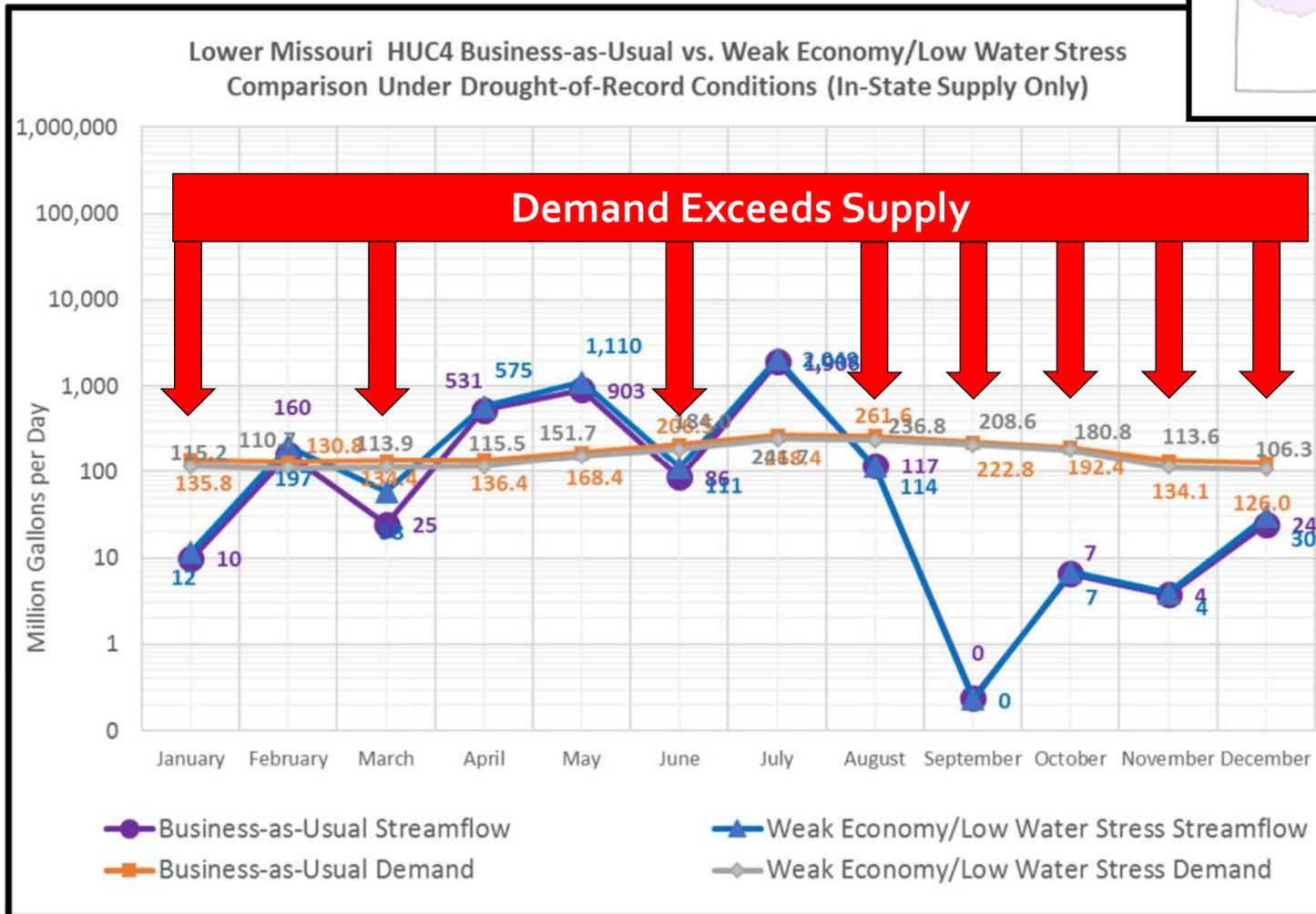
Scenario Results - Surface Water Supply Business-as-Usual vs. Substantial Agricultural Expansion Lower Missouri HUC₄

In-State generated flows only. Excludes demands on Missouri River



Scenario Results - Surface Water Supply Business-as-Usual vs. Weak Economy/Low Water Stress Lower Missouri HUC₄

In-State generated flows only. Excludes demands on Missouri River

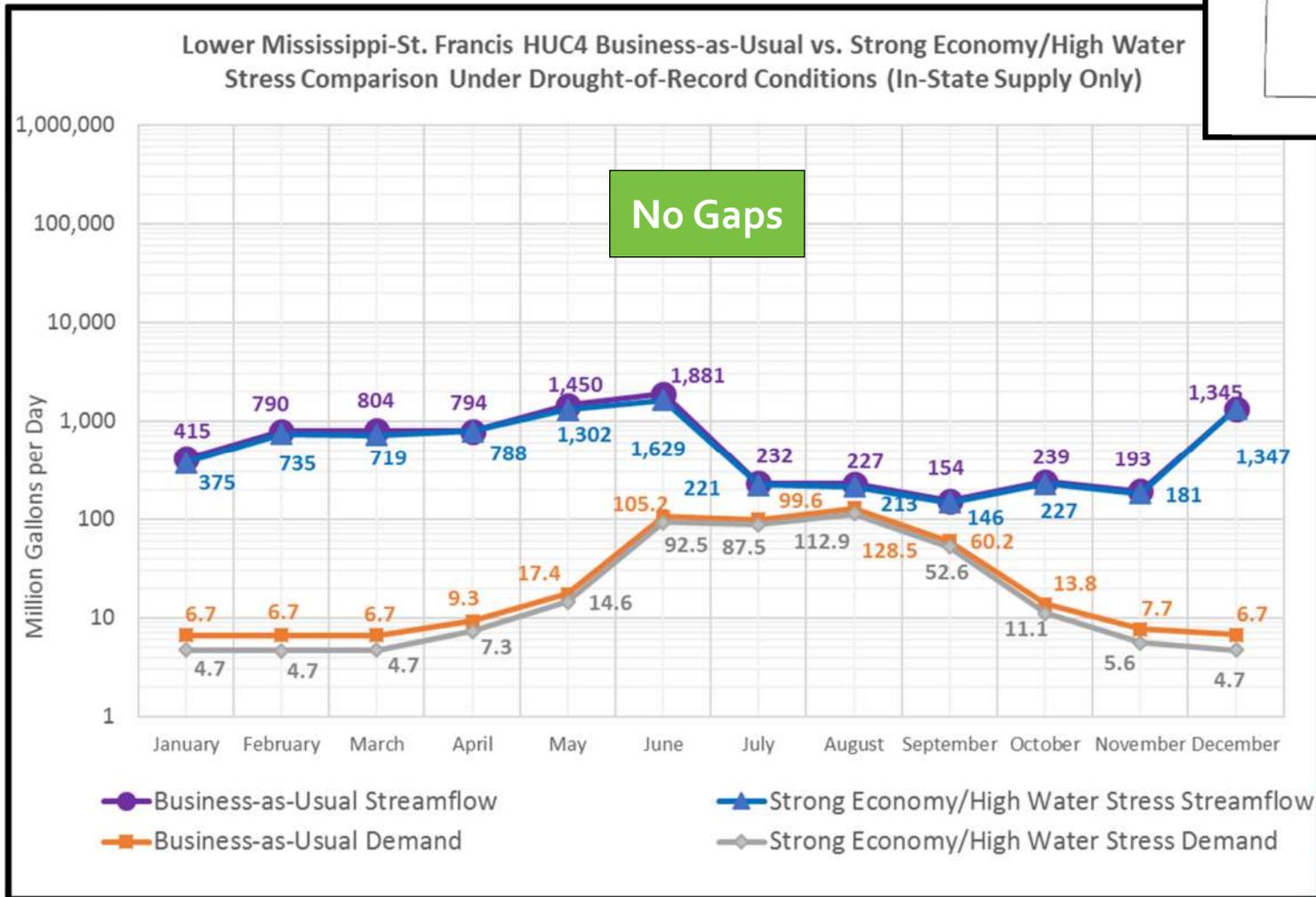


Scenario Results - Surface Water Supply

Business-as-Usual vs. Strong Economy/High Water Stress

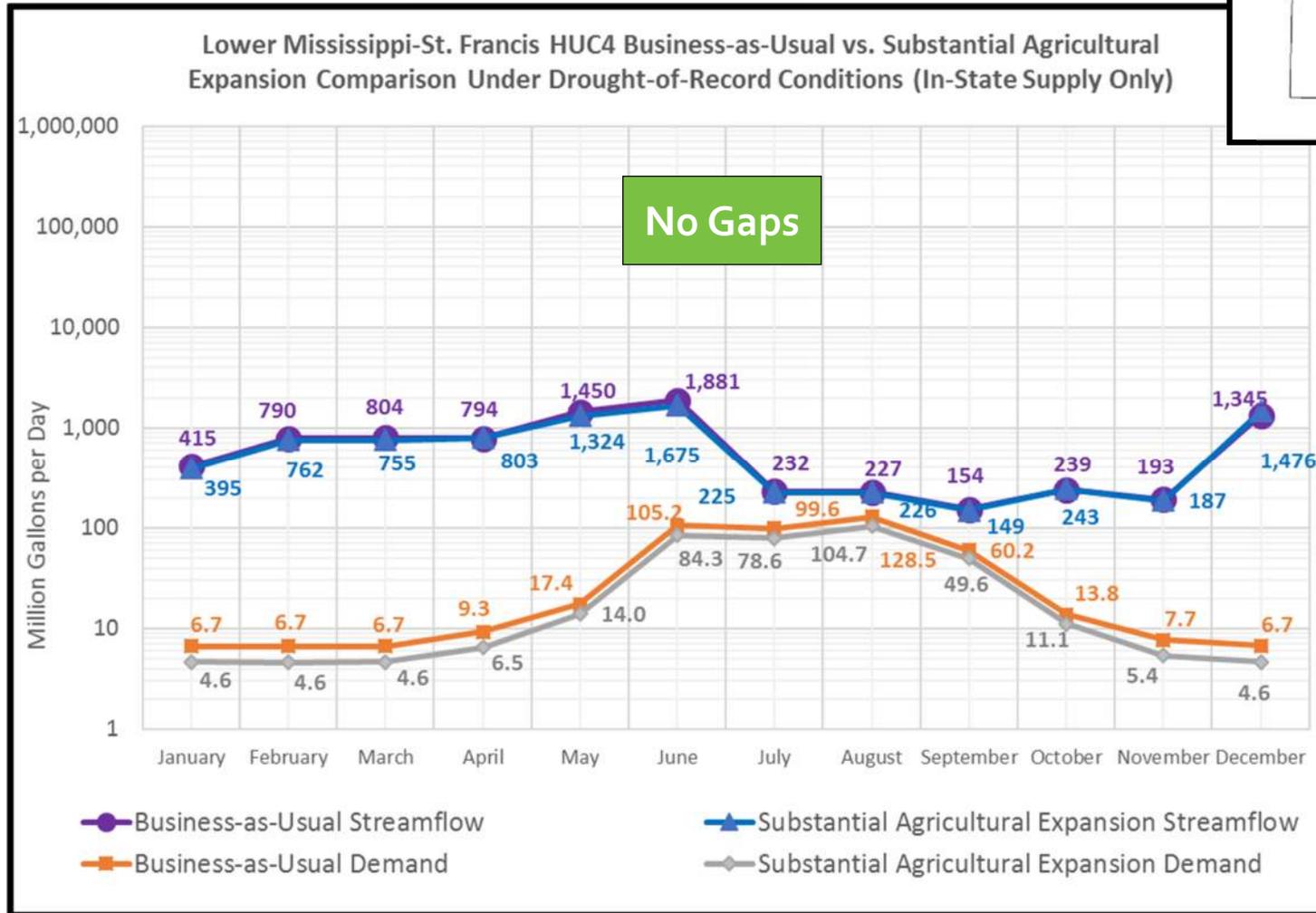
Lower Mississippi-St. Francis HUC₄

In-State generated flows only. Excludes demands on Mississippi River



Scenario Results - Surface Water Supply Business-as-Usual vs. Substantial Agricultural Expansion Lower Mississippi-St. Francis HUC₄

In-State generated flows only. Excludes demands on Mississippi River

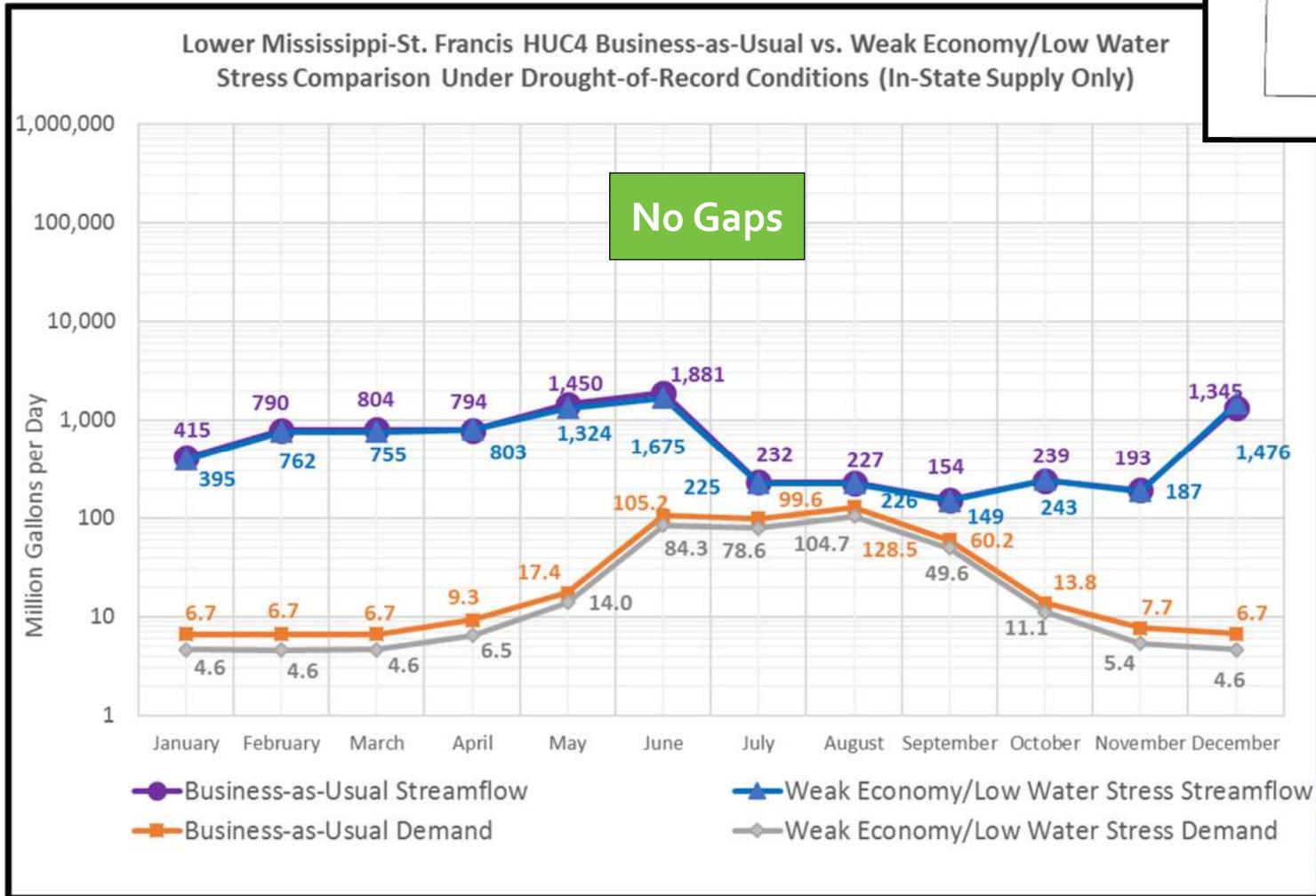


Scenario Results - Surface Water Supply

Business-as-Usual vs. Weak Economy/Low Water Stress

Lower Mississippi-St. Francis HUC₄

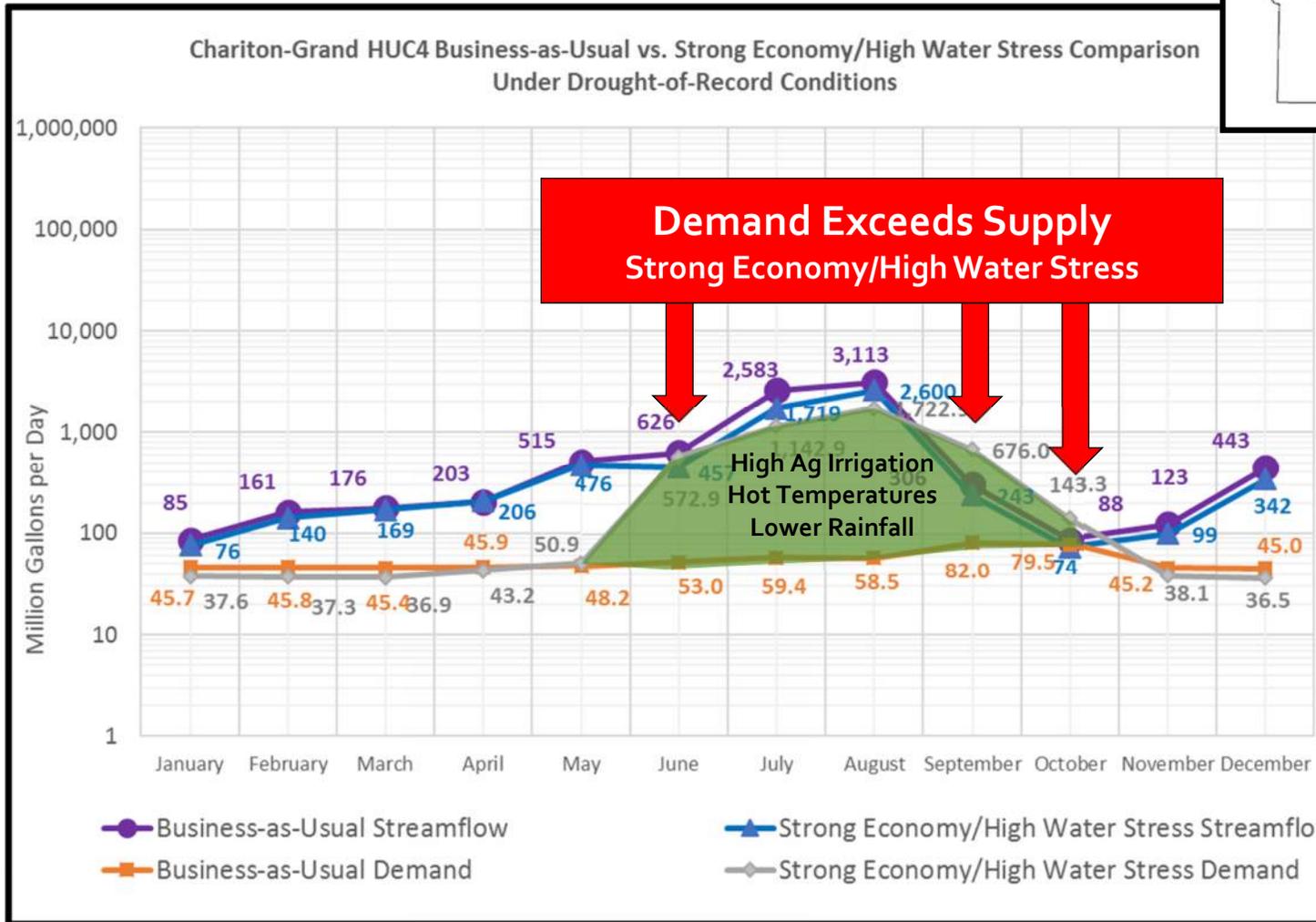
In-State generated flows only. Excludes demands on Mississippi River



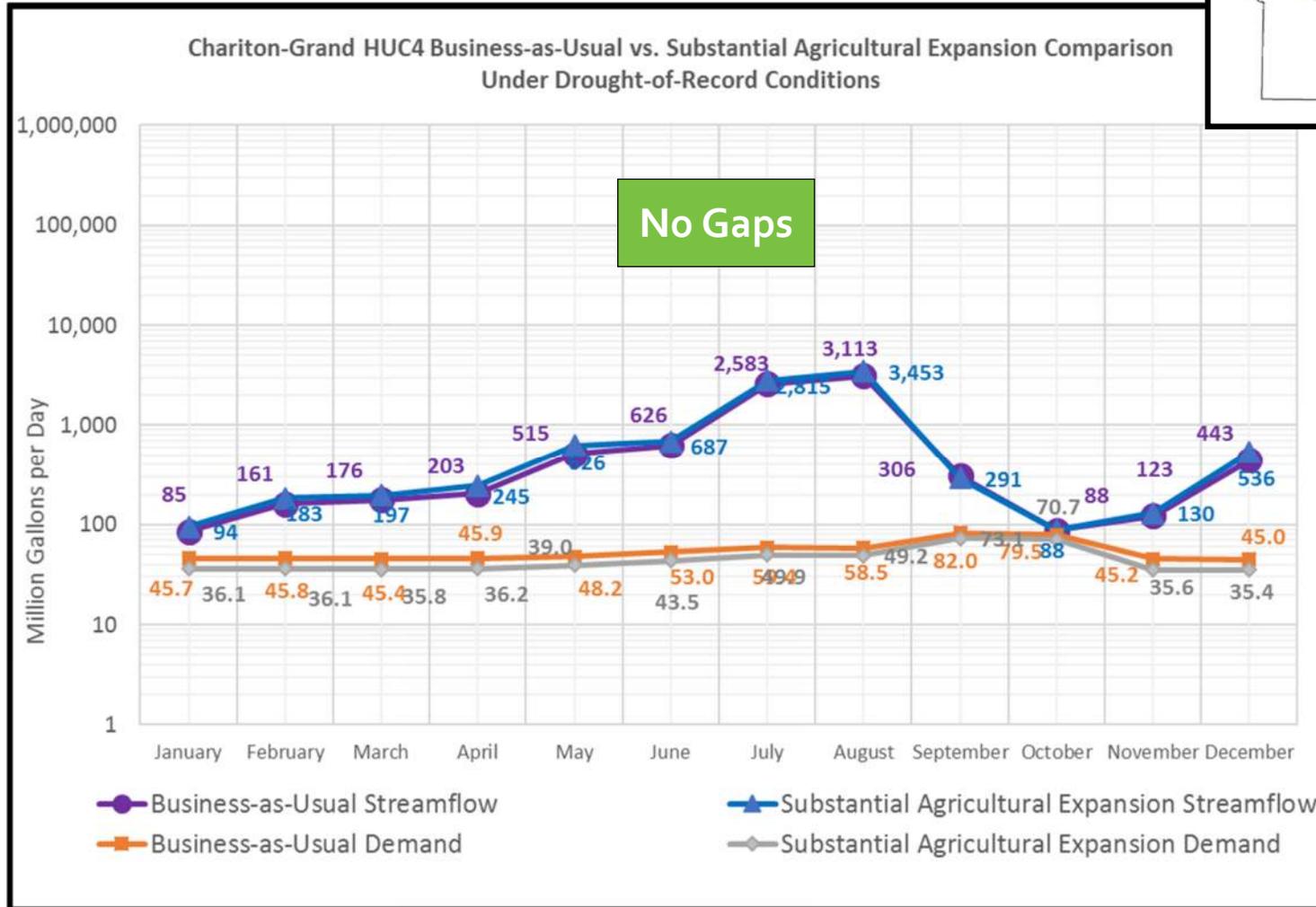
Scenario Results - Surface Water Supply

Business-as-Usual vs. Strong Economy/High Water Stress

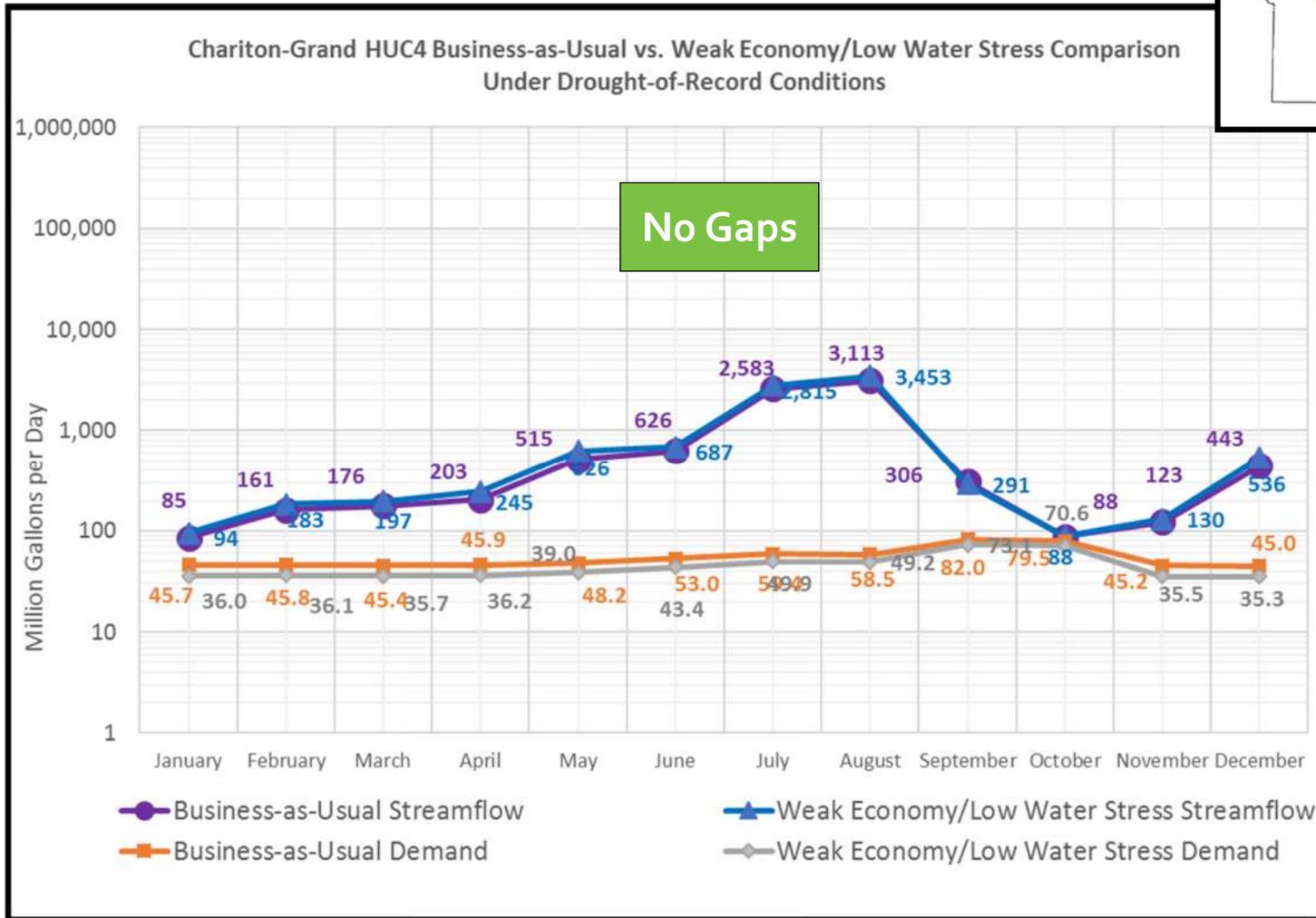
Chariton Grand HUC₄



Scenario Results - Surface Water Supply Business-as-Usual vs. Substantial Agricultural Expansion Chariton Grand HUC₄



Scenario Results - Surface Water Supply Business-as-Usual vs. Weak Economy/Low Water Stress Chariton Grand HUC₄



Business-As-Usual Scenario

Drought-of-Record Conditions Surface Water Generated In-Basin

Surface Water Generated In HUC4/HUC8

Scenario: **Business-as-Usual**

Condition: **Drought-of-Record**

	No Gap
	Basin Demand within 20% of Supply
	Demand Exceeds Supply

In-State generated flows only. Excludes demands on Missouri and Mississippi rivers

HUC4	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
711	Upper Mississippi-Salt												
714	Upper Mississippi-Kaskaskia-Meramec												
802	Lower Mississippi-St. Francis												
1024	Missouri-Nishnabotna												
1028	Chariton-Grand												
1029	Gasconade-Osage												
1030	Lower Missouri												
1101	Upper White												
1107	Neosho-Verdigris												

HUC8	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10280101	Upper Grand												
10280102	Thompson												
10280103	Lower Grand												
10280201	Upper Chariton												
10280202	Lower Chariton												
10280203	Little Chariton												
10290103	Little Osage												

Business-As-Usual Scenario

Drought-of-Record Conditions Surface Water Generated In-Basin

Surface Water Generated In HUC4/HUC8

Scenario: **Business-as-Usual**

Condition: **Drought-of-Record**

	No Gap
	Basin Demand within 20% of Supply
	Demand Exceeds Supply

In-State generated flows only. Excludes demands on Missouri and Mississippi rivers

HUC4	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
711	Upper Mississippi-Salt												
714	Upper Mississippi-Kaskaskia-Meramec												
802	Lower Mississippi-S												
1024	Missouri-Nishnabo												
1028	Chariton-Grand												
1029	Gasconade-Osage												
1030	Lower Missouri												
1101	Upper white												
1107	Neosho-Verdigris												

Gage used had low or zero flow in select months during drought-of-record.

HUC8	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10280101	Upper Grand												
10280102	Thompson												
10280103	Lower Grand												
10280201	Upper Chariton												
10280202	Lower Chariton												
10280203	Little Chariton												
10290103	Little Osage												

Strong-Economy/High Water Stress Scenario

Drought-of-Record Conditions Surface Water Generated In-Basin

Surface Water Generated In HUC4/HUC8

Scenario: **Strong-Economy/High Water Stress**

Condition: **Drought-of-Record**

	No Gap
	Basin Demand within 20% of Supply
	Demand Exceeds Supply

In-State generated flows only. Excludes demands on Missouri and Mississippi rivers

HUC4	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
711	Upper Mississippi-Salt												
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1028	Chariton-Grand												
1029	Gasconade-Osage												
1030	Lower Missouri												
1101	Upper White												
1107	Neosho-Verdigris												

HUC8	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10280101	Upper Grand												
10280102	Thompson												
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10280202	Lower Chariton												
10280203	Little Chariton												
10290103	Little Osage												

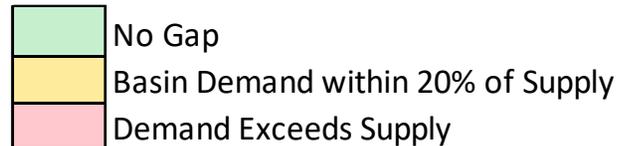
Substantial Agricultural Expansion

Drought-of-Record Conditions Surface Water Generated In-Basin

Surface Water Generated In HUC4/HUC8

Scenario: **Substantial Agricultural Expansion**

Condition: **Drought-of-Record**



In-State generated flows only. Excludes demands on Missouri and Mississippi rivers

HUC4	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
711	Upper Mississippi-Salt	Green											
714	Upper Mississippi-Kaskaskia-Meramec	Green											
802	Lower Mississippi-St. Francis	Green											
1024	Missouri-Nishnabotna	Green											
1028	Chariton-Grand	Green											
1029	Gasconade-Osage	Green											
1030	Lower Missouri	Red	Green	Red	Green	Green	Red	Green	Red	Red	Red	Red	Red
1101	Upper White	Green											
1107	Neosho-Verdigris	Green											

HUC8	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10280101	Upper Grand	Green	Red	Green	Green								
10280102	Thompson	Green	Green	Green									
10280103	Lower Grand	Green	Yellow	Green	Green								
10280201	Upper Chariton	Green	Green	Green									
10280202	Lower Chariton	Green	Green	Green									
10280203	Little Chariton	Green	Red	Red	Green								
10290103	Little Osage	Green	Green	Green									

Weak Economy/Low Water Stress

Drought-of-Record Conditions Surface Water Generated In-Basin

Surface Water Generated In HUC4/HUC8

Scenario: **Weak Economy/Low Water Stress**

Condition: **Drought-of-Record**

	No Gap
	Basin Demand within 20% of Supply
	Demand Exceeds Supply

In-State generated flows only. Excludes demands on Missouri and Mississippi rivers

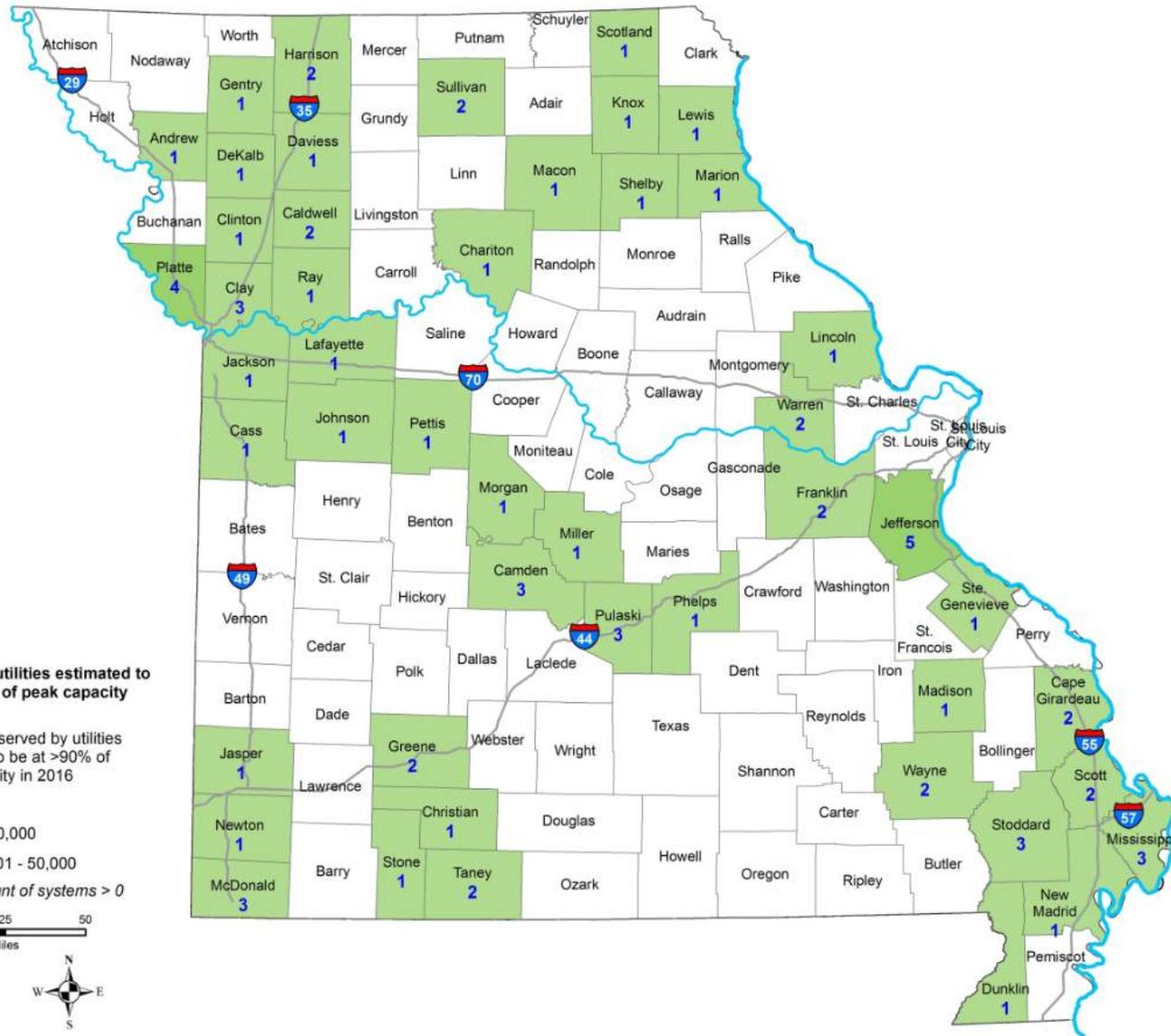
HUC4	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
711	Upper Mississippi-Salt												
714	Upper Mississippi-Kaskaskia-Meramec												
802	Lower Mississippi-St. Francis												
1024	Missouri-Nishnabotna												
1028	Chariton-Grand												
1029	Gasconade-Osage												
1030	Lower Missouri												
1101	Upper White												
1107	Neosho-Verdigris												

HUC8	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10280101	Upper Grand												
10280102	Thompson												
10280103	Lower Grand												
10280201	Upper Chariton												
10280202	Lower Chariton												
10280203	Little Chariton												
10290103	Little Osage												

Infrastructure Update

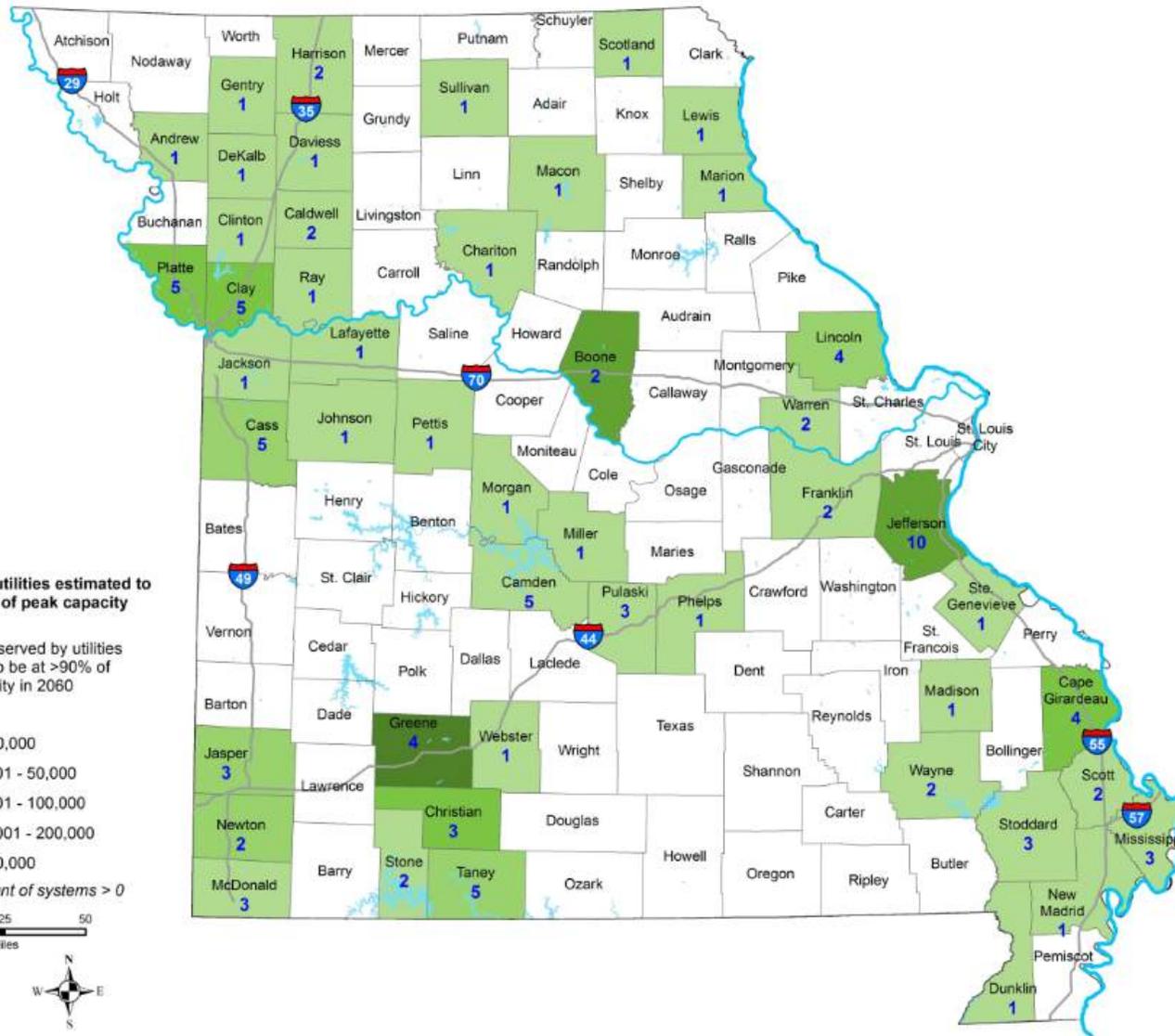
Demand-Driven Growth

Drinking Water Treatment Peak Capacity 2016



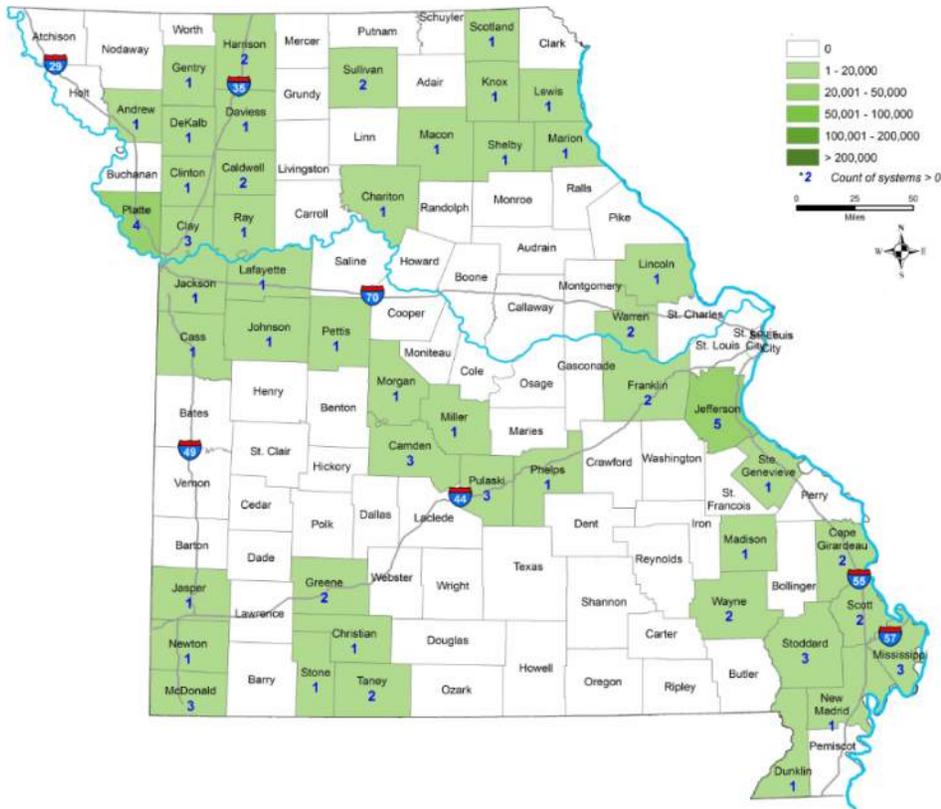
Demand-Driven Growth

Drinking Water Treatment Peak Capacity 2060

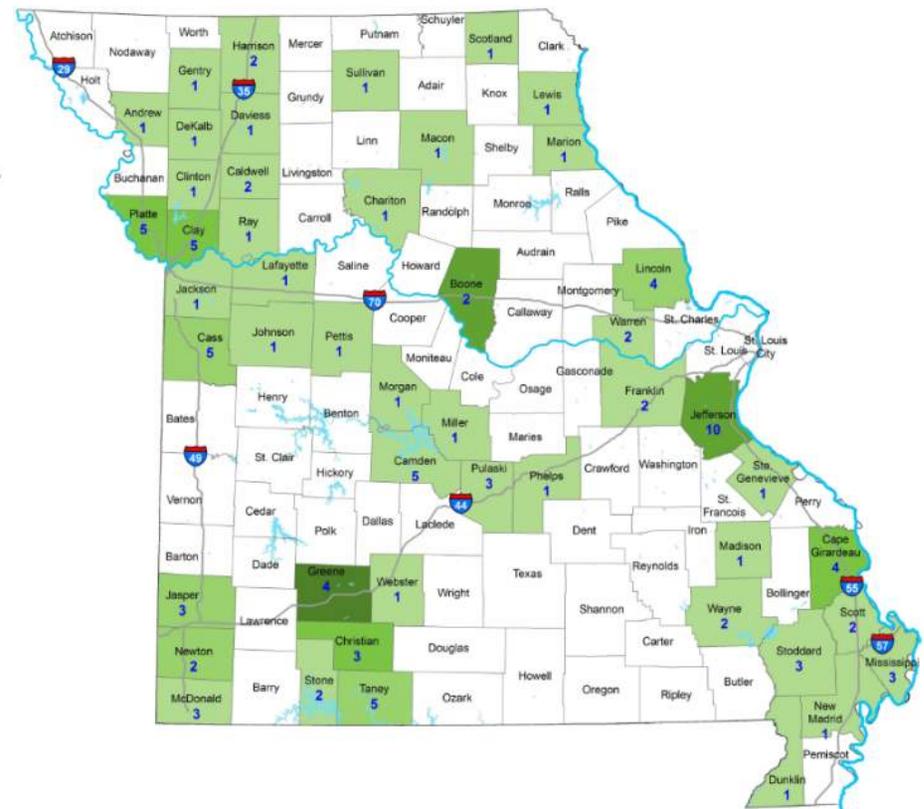


Demand-Driven Growth

Drinking Water Treatment Peak Capacity 2016 versus 2060



2016



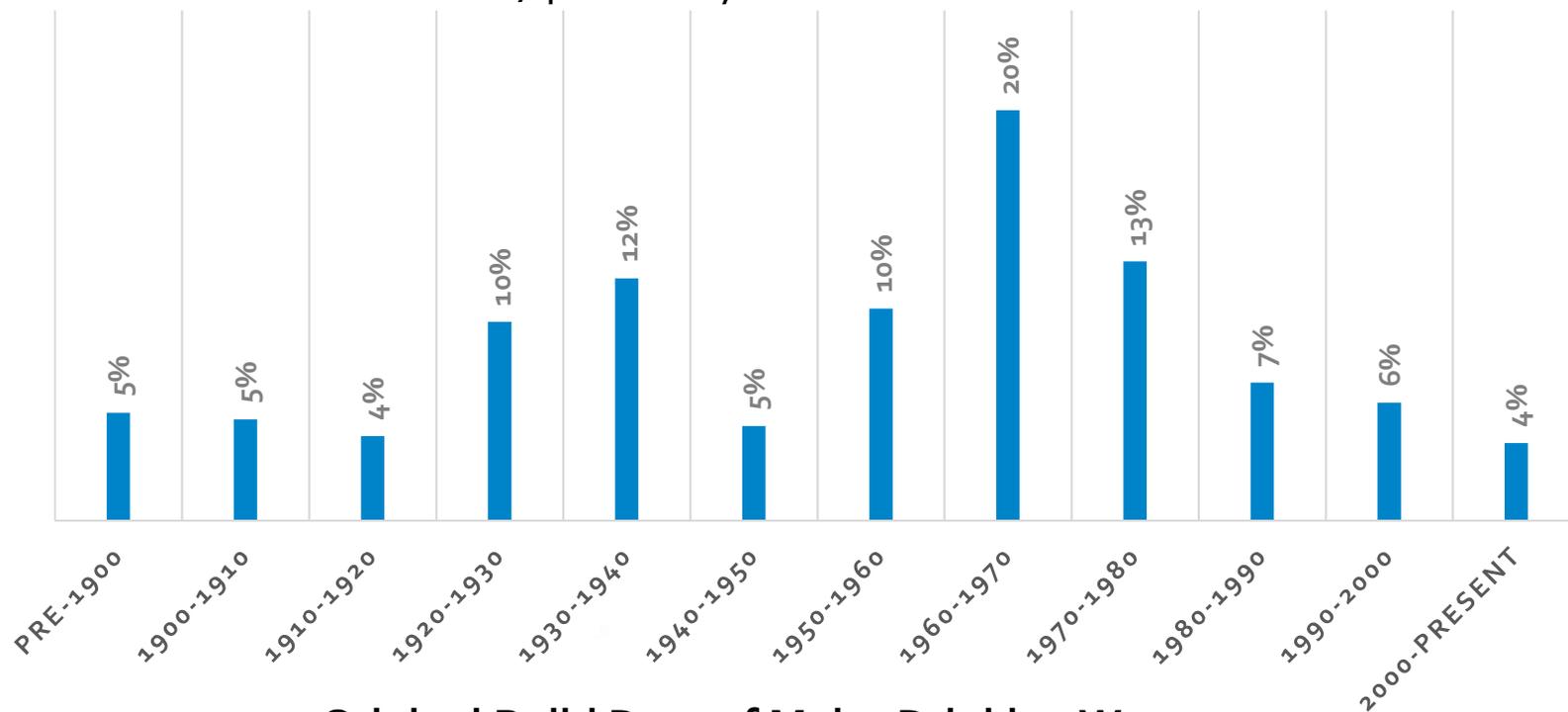
2060



Missouri Drinking Water Pipe Replacement and Age of Systems

Average Nationwide Drinking Water Pipe Replacement Rate: 0.5 percent /year

- Kansas City: 1 percent /year
- St Louis: 0.5 percent /year
- MO American Water: 0.7 percent /year

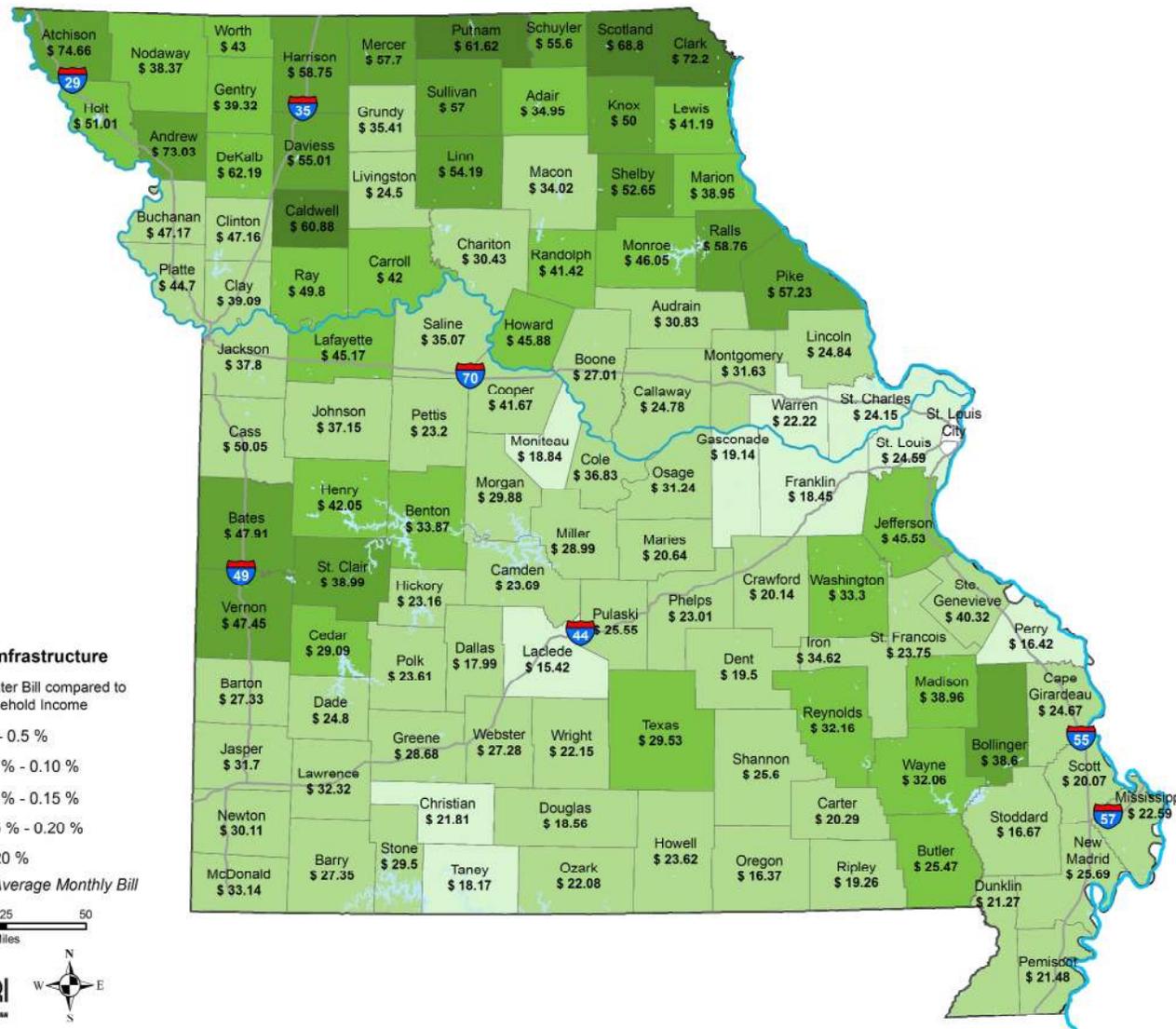


Original Build Date of Major Drinking Water Systems in Missouri

Source: SDWIS

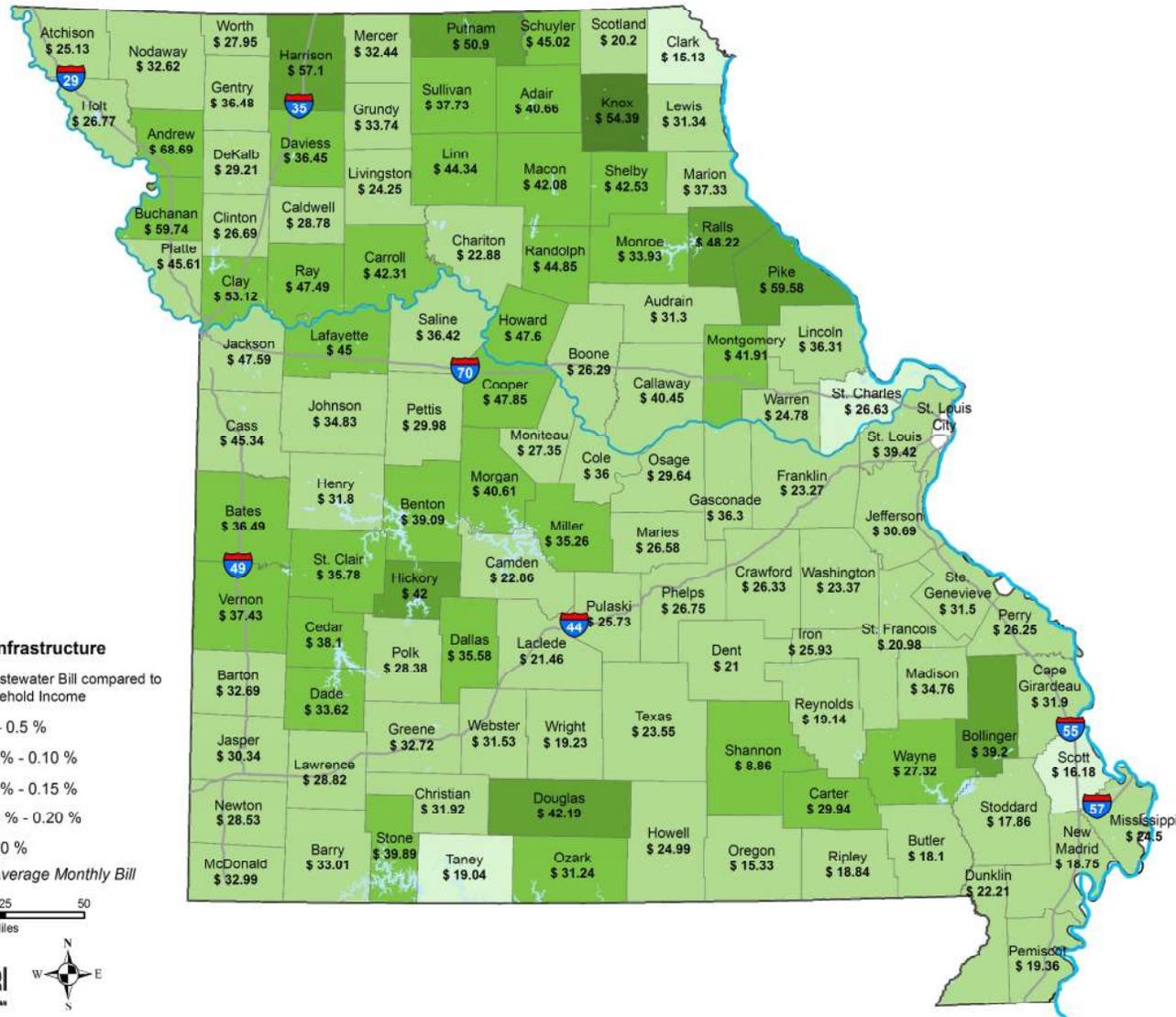


Average Missouri Drinking Water Rates (Reported to MPUA)



Average Missouri Wastewater Rates

(Reported to MPUA)



Major Water Infrastructure Projects

Blacksnake Creek
Stormwater
Separation

St Charles 12" Main
Replacement (4M)

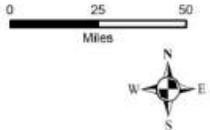
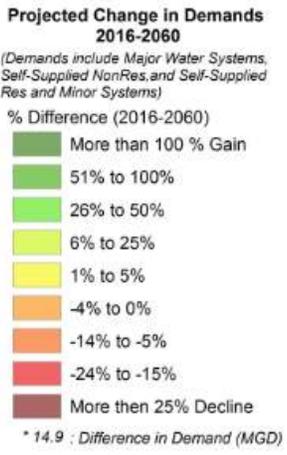
O'Fallon
Distribution System
CIP (>100M)

KC Water/WW
Improvements (~400M)

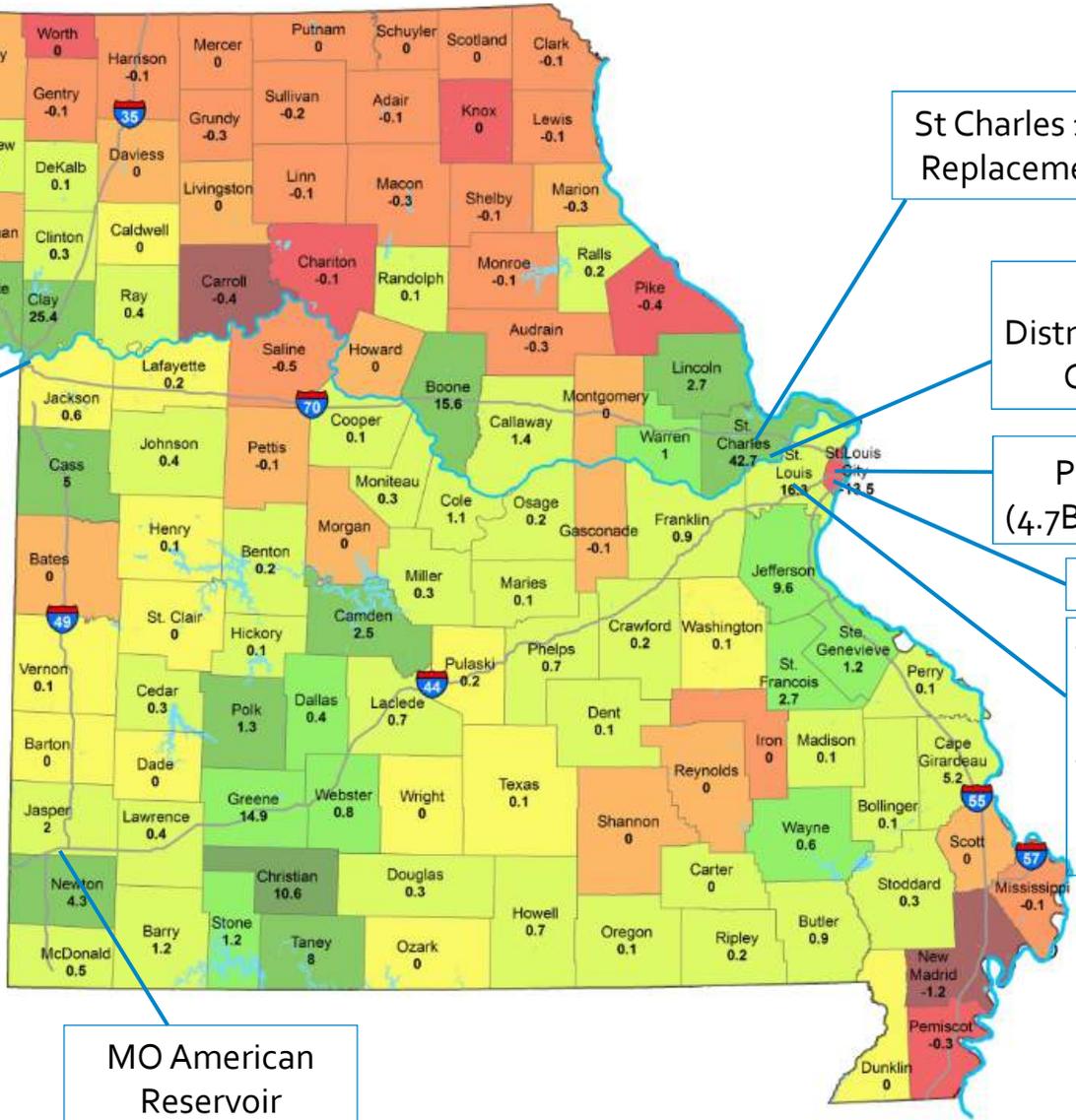
Project Clear
(4.7B over 23 years)

Deer Creek (88M)

- Gravois Trunk Sanitary Storage Facility
- Lower & Middle River Des Peres Storage Tunnel



MO American
Reservoir



Regional Water Infrastructure Projects

East Locust Creek Reservoir Project

Great Northwest Wholesale Water Commission Pipeline

Little Otter Creek Lake Project

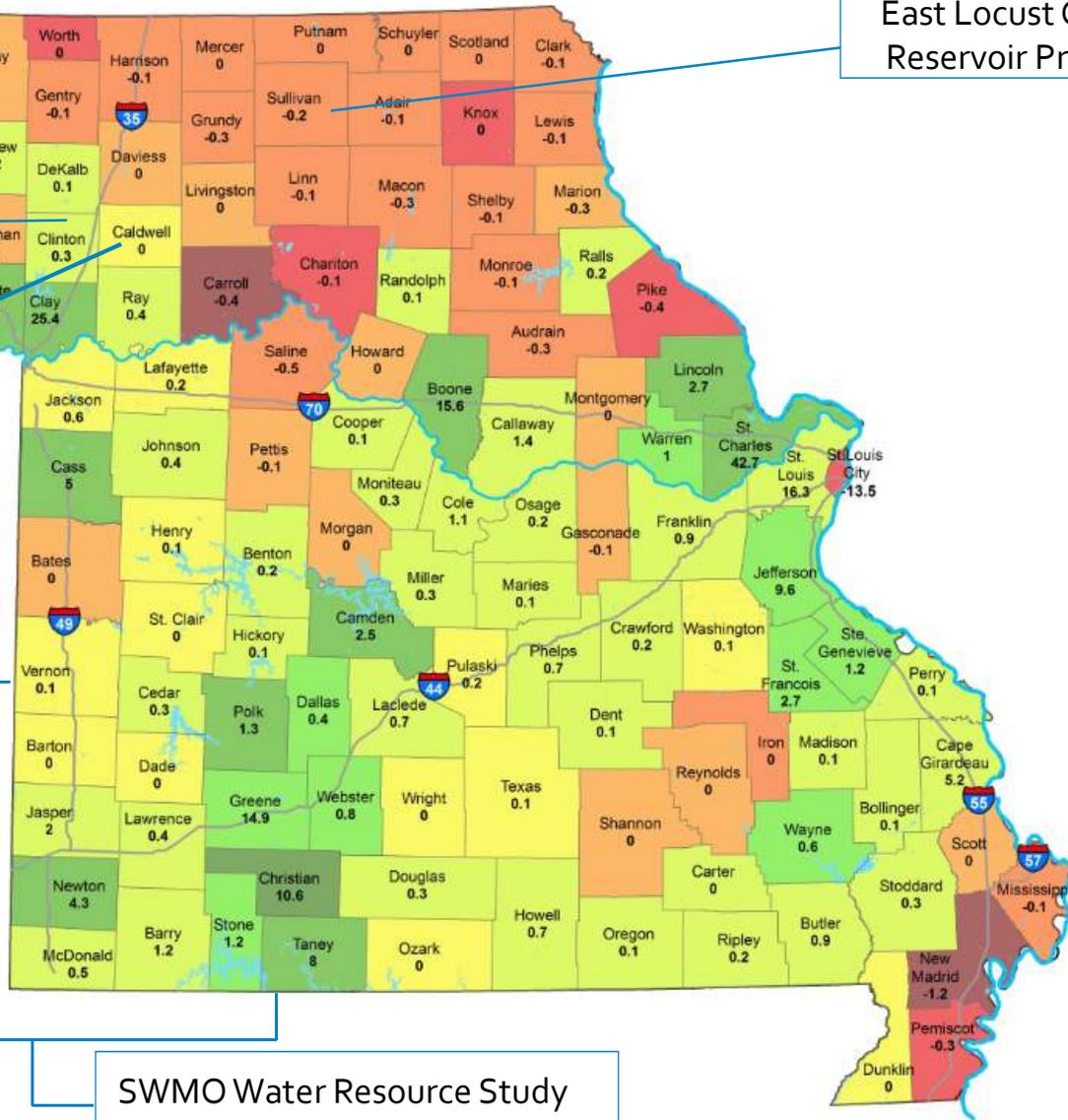
Projected Change in Demands 2016-2060

(Demands include Major Water Systems, Self-Supplied NonRes, and Self-Supplied Res and Minor Systems)

% Difference (2016-2060)

- More than 100 % Gain
- 51% to 100%
- 26% to 50%
- 6% to 25%
- 1% to 5%
- 4% to 0%
- 14% to -5%
- 24% to -15%
- More than 25% Decline

* 14.9 ; Difference in Demand (MGD)



SWMO Water Resource Study



Integrated Water Resource Planning

Greene County
Integrated Water
Resource Plan

Columbia
Integrated Water
Resource Plan

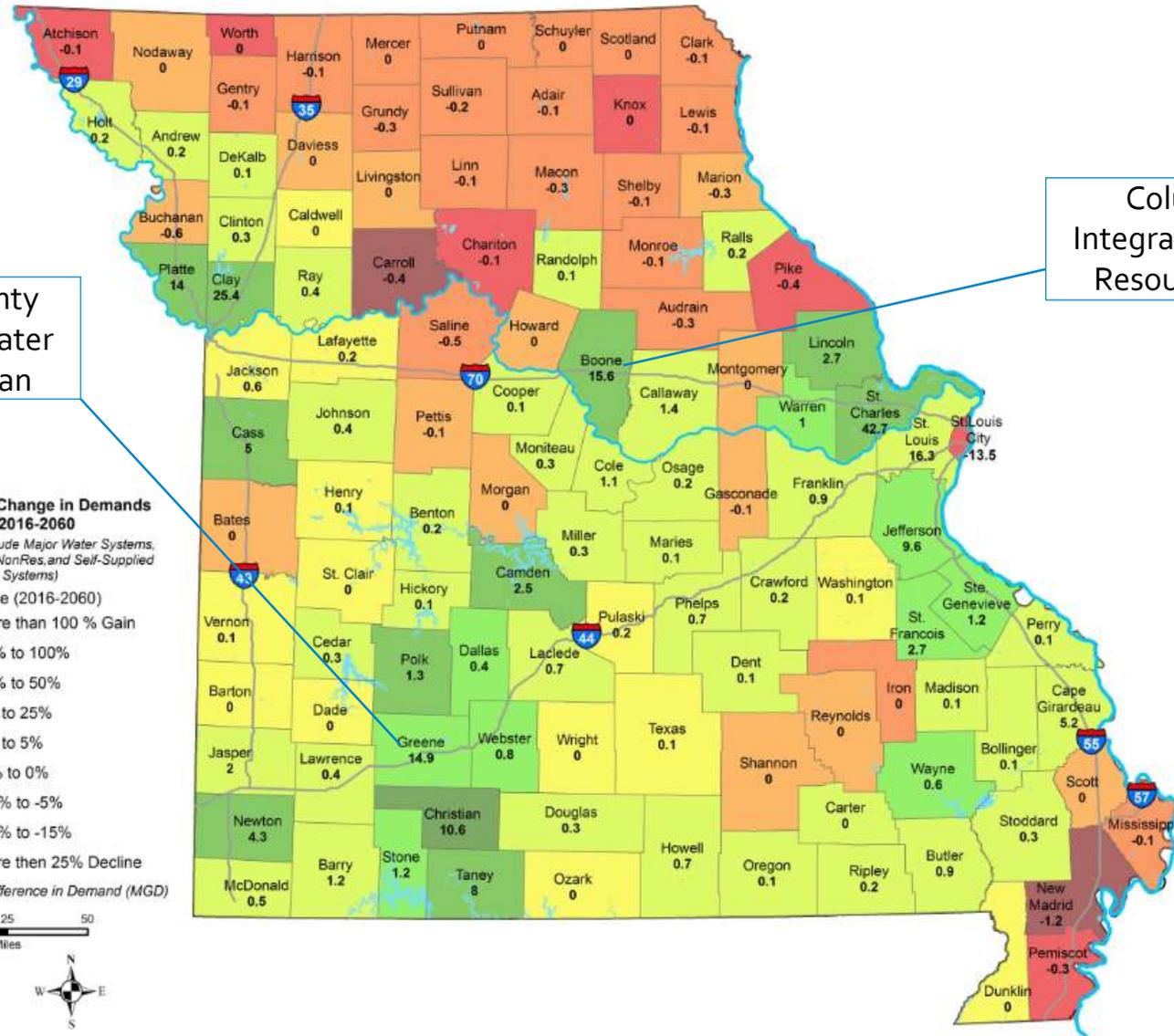
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* 14.9 ; Difference in Demand (MGD)



Technical Workgroup Update



Questions & Discussion



Next Interagency Task Force Meeting

May 30, 2019

9:00 a.m. to 12:00 p.m.

Lewis and Clark State Office Building,
Jefferson City, MO



Thank You

