LOUISIANA WATER RESOURCES ASSESSMENT FOR SUSTAINABILITY AND ENERGY MANAGEMENT

Scott A. Hemmerling, F. Ryan Clark, and Harris C. Bienn

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ACKNOWLEDGEMENTS

- DNR Office of Conservation
  - Gary Snellgrove
  - Matt Reonas
- CPRA
  - Wes Leblanc
- Technical Coordination Team
  - David Borrok
  - Charles Demas
  - Gary Hanson
  - John Lovelace
- Pierre Sargent

PROJECT GOALS

- Establishing a standardized set of measures: evaluating regional water supply
- Setting baseline water budgets - groundwater and surface water
- Set up a process
  - Convert available types of water data into a more universal format
  - Create modular framework
    - Tested in areas with sufficient data and existing tools
    - Capable of use in sparser data areas
    - More refined tools and data can be substituted

PROJECT PROCESS

- Develop a Framework using available data that it useful to decision makers
- Gage the sustainability of water resources in light of present and projected uses

<u>Sustainability</u>: A balance between use and supply that causes no further impairment to water resources, and maintains or improves the current health of these systems

- Develop a system for analyzing and communicating these facts and figures to the public and key water managers around the state

PROJECT ACTIVITIES

Activity 1

Develop a Framework for appraising the health and sustainability of Louisiana’s water resources.

Activity 2

Review of Data Sources/Availability and select certain hydrologic units for detailed assessment.

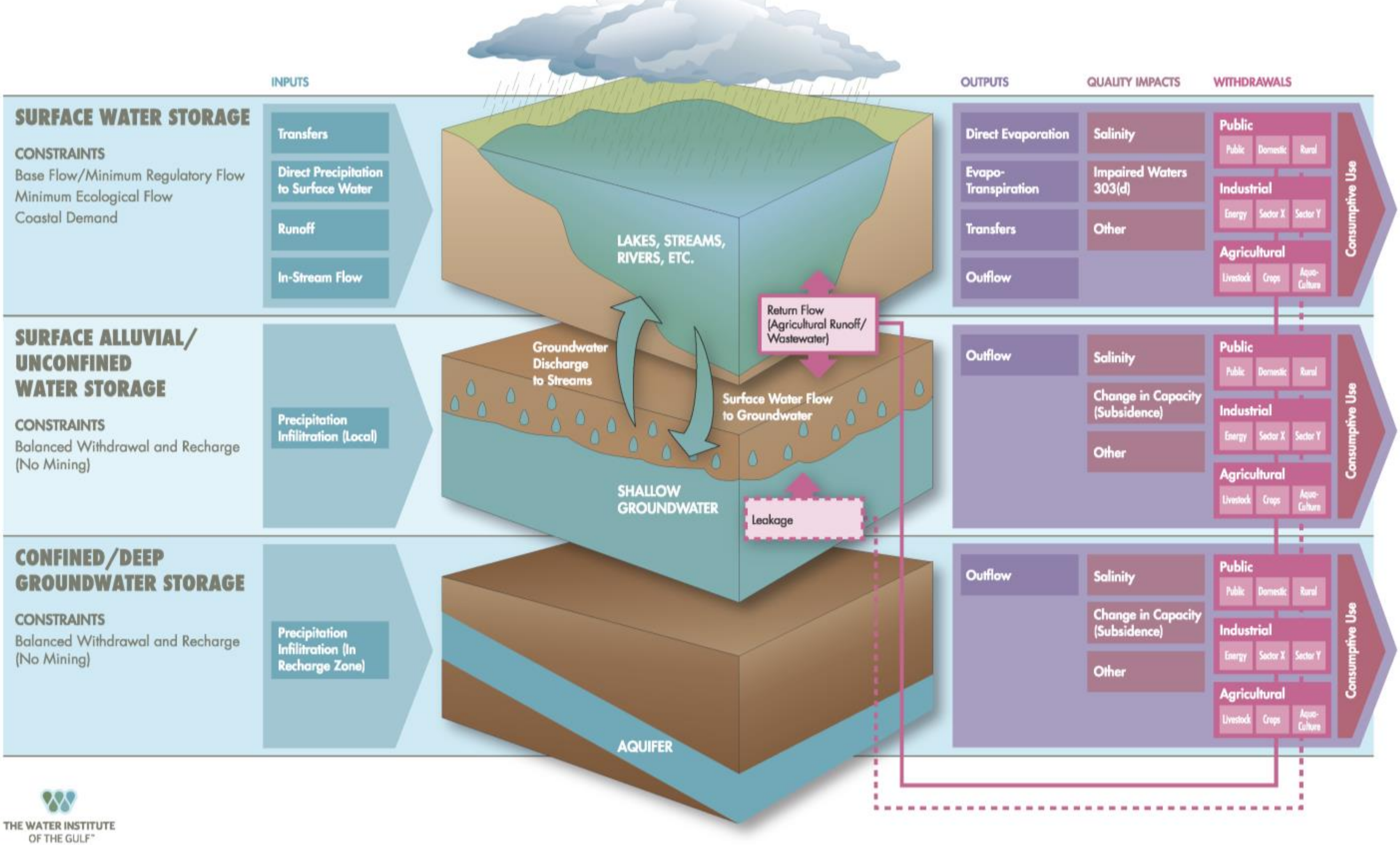
Activity 3

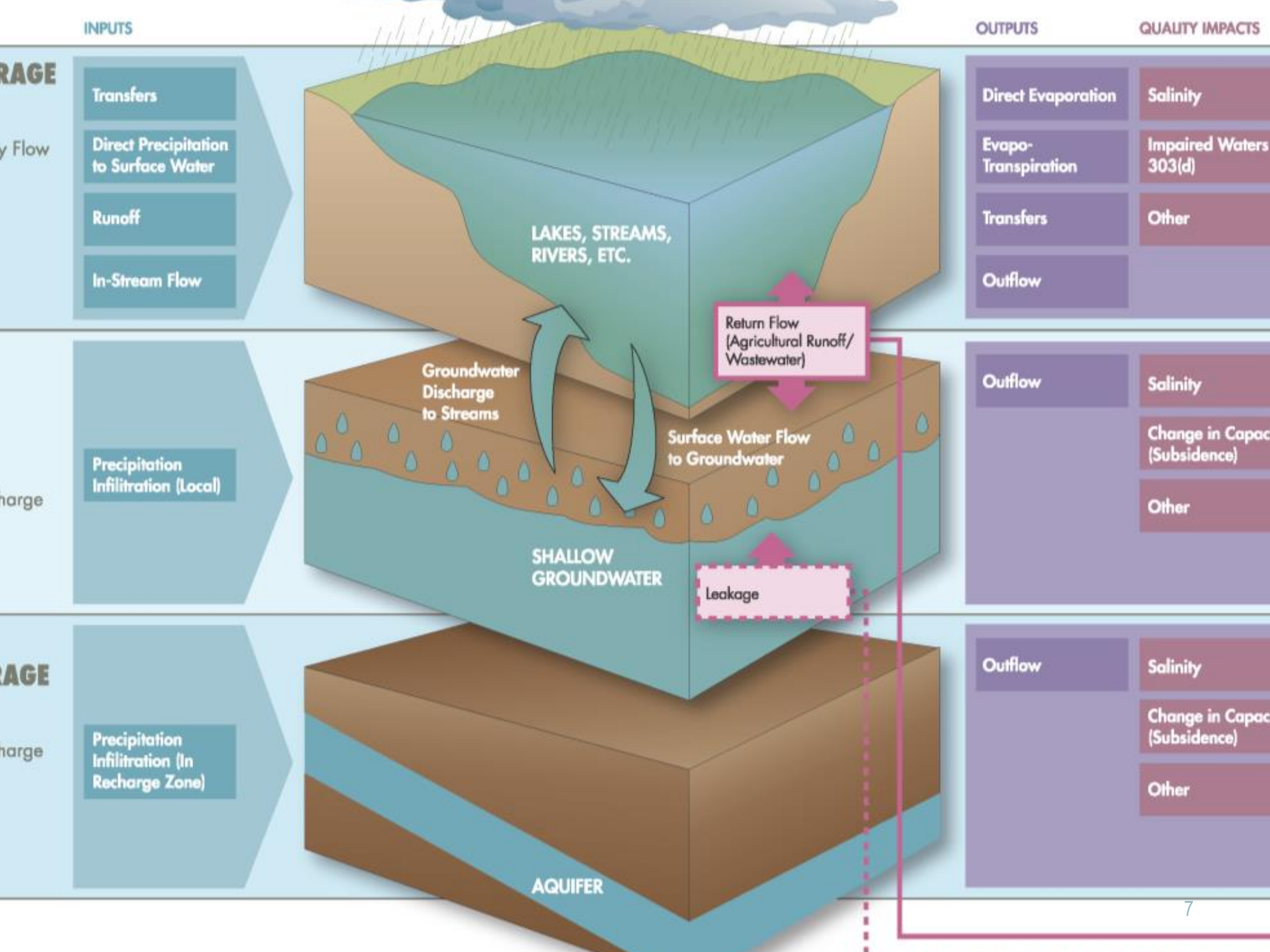
Conduct the appraisal of the hydrologic units selected though application of the Framework.

Activity 4

Prepare a report that describes the Framework, its application to specific selected hydro units, and the resulting assessment of water resources sustainability.

WATER BUDGET FRAMEWORK





INPUTS
OUTPUTS
QUALITY IMPACTS
RAGE
y Flow
Transfers
Direct Precipitation to Surface Water
Runoff
In-Stream Flow
LAKES, STREAMS, RIVERS, ETC.
Direct Evaporation
Evapo-Transpiration
Transfers
Outflow
Salinity
Impaired Waters 303(d)
Other
Return Flow (Agricultural Runoff/ Wastewater)
Groundwater Discharge to Streams
Surface Water Flow to Groundwater
harge
Precipitation Infiltration (Local)
SHALLOW GROUNDWATER
Leakage
Outflow
Salinity
Change in Capac (Subsidence)
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Precipitation Infiltration (In Recharge Zone)
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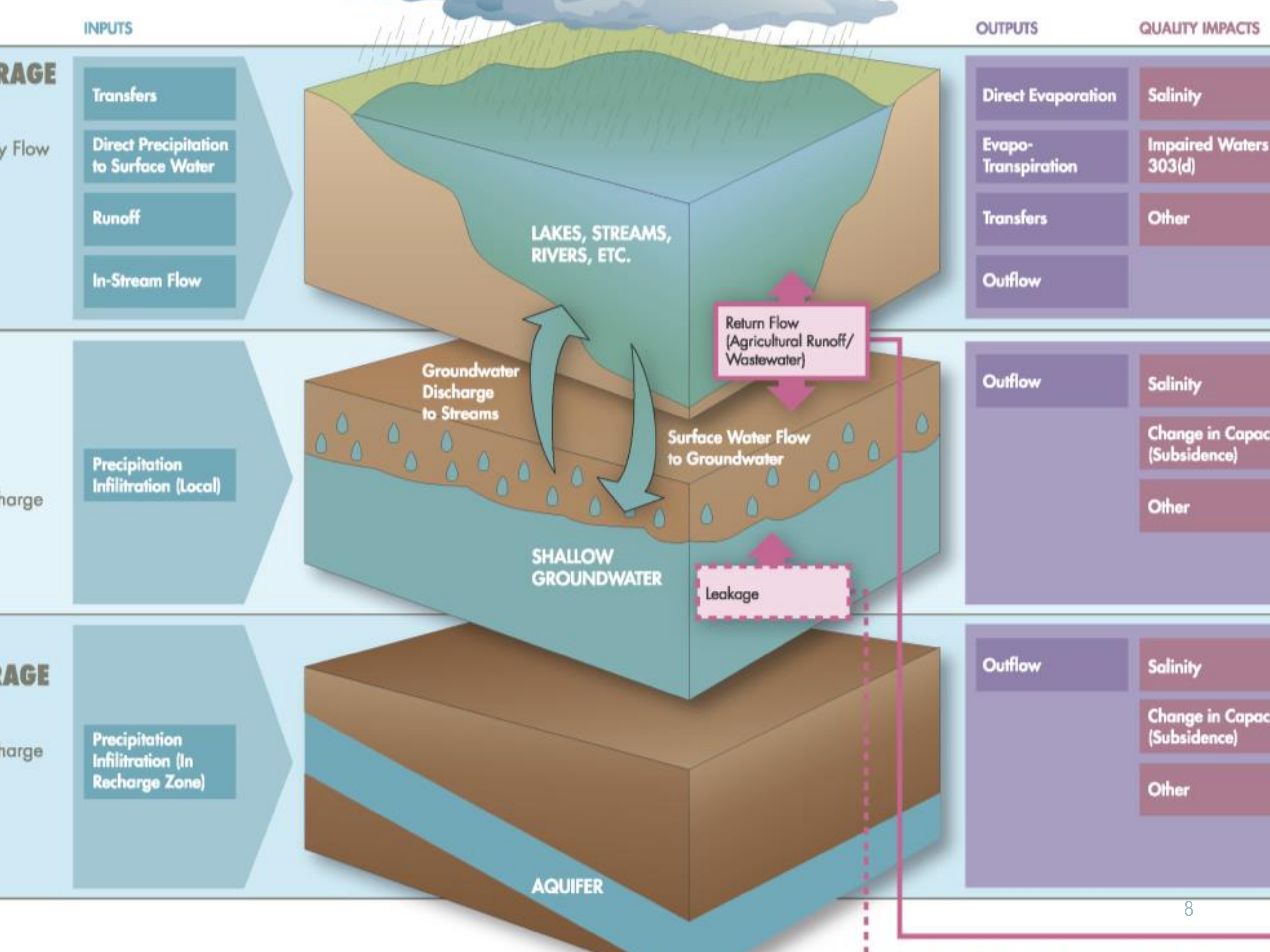

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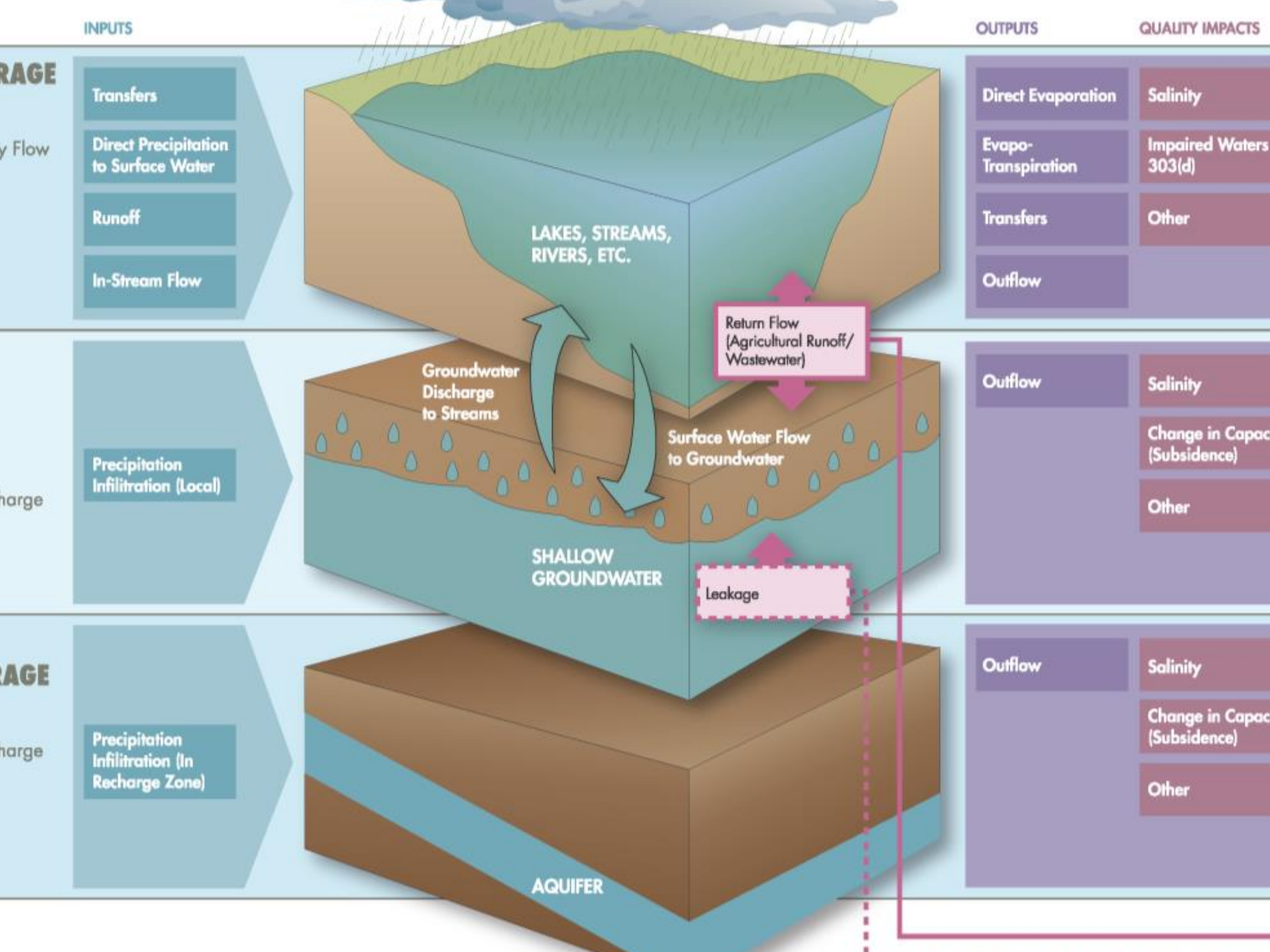

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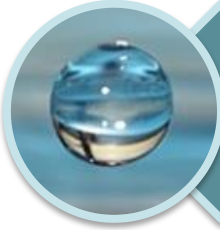
FRAMEWORK APPLICATION



Apply framework to pilot study area (SWLA)

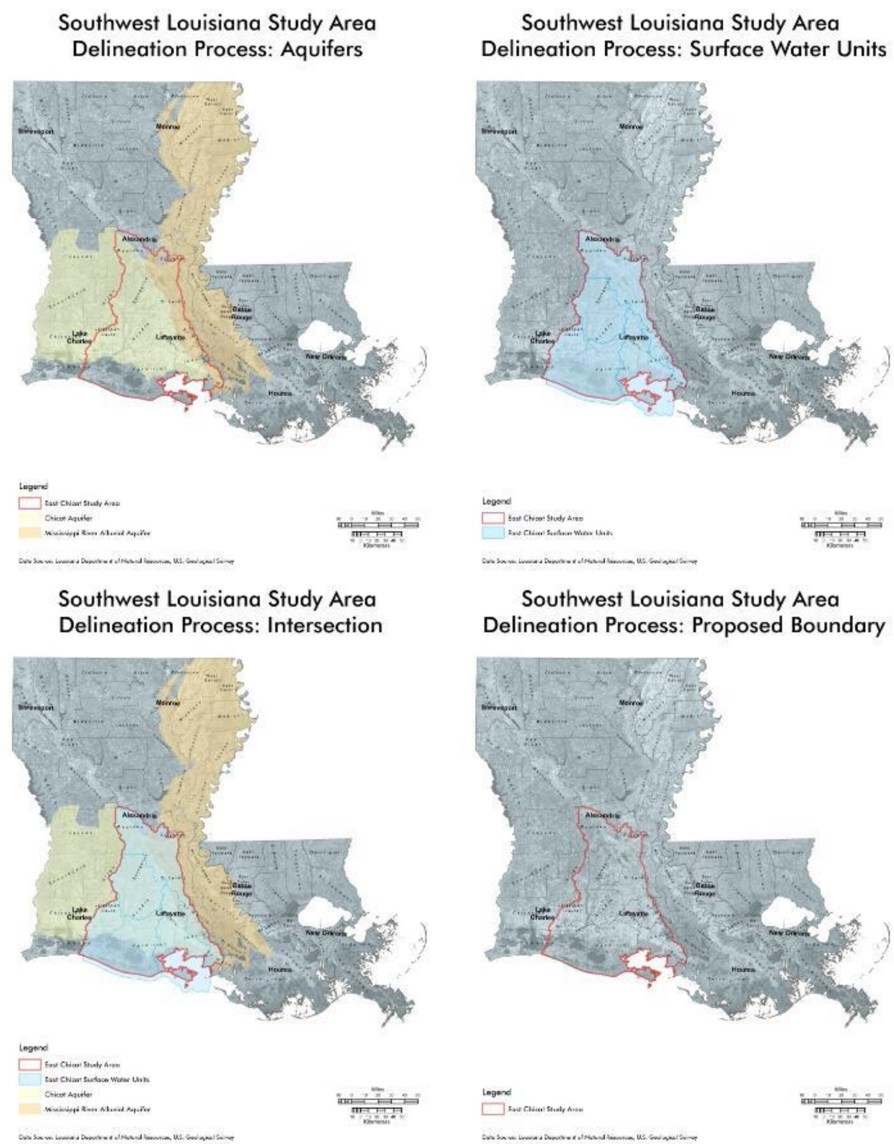
Estimates of surface and groundwater supply and usage

Projections of future supply and usage

Apply framework to NWLA and SELA study areas

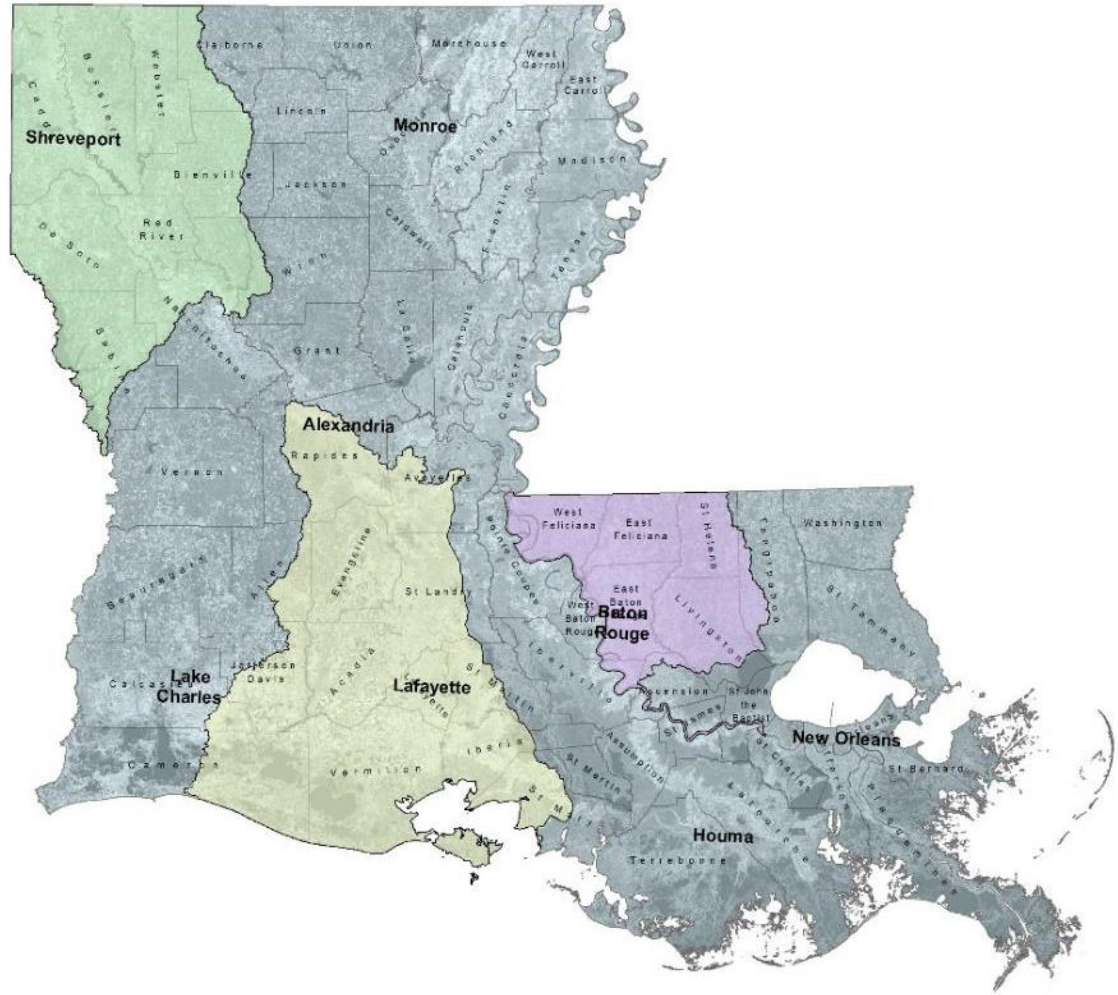
SELECTING STUDY AREAS

- Extent of water bearing units
  - Surface water Cataloguing Units (HUC8)
  - Groundwater aquifers
- Water demand
- Data availability



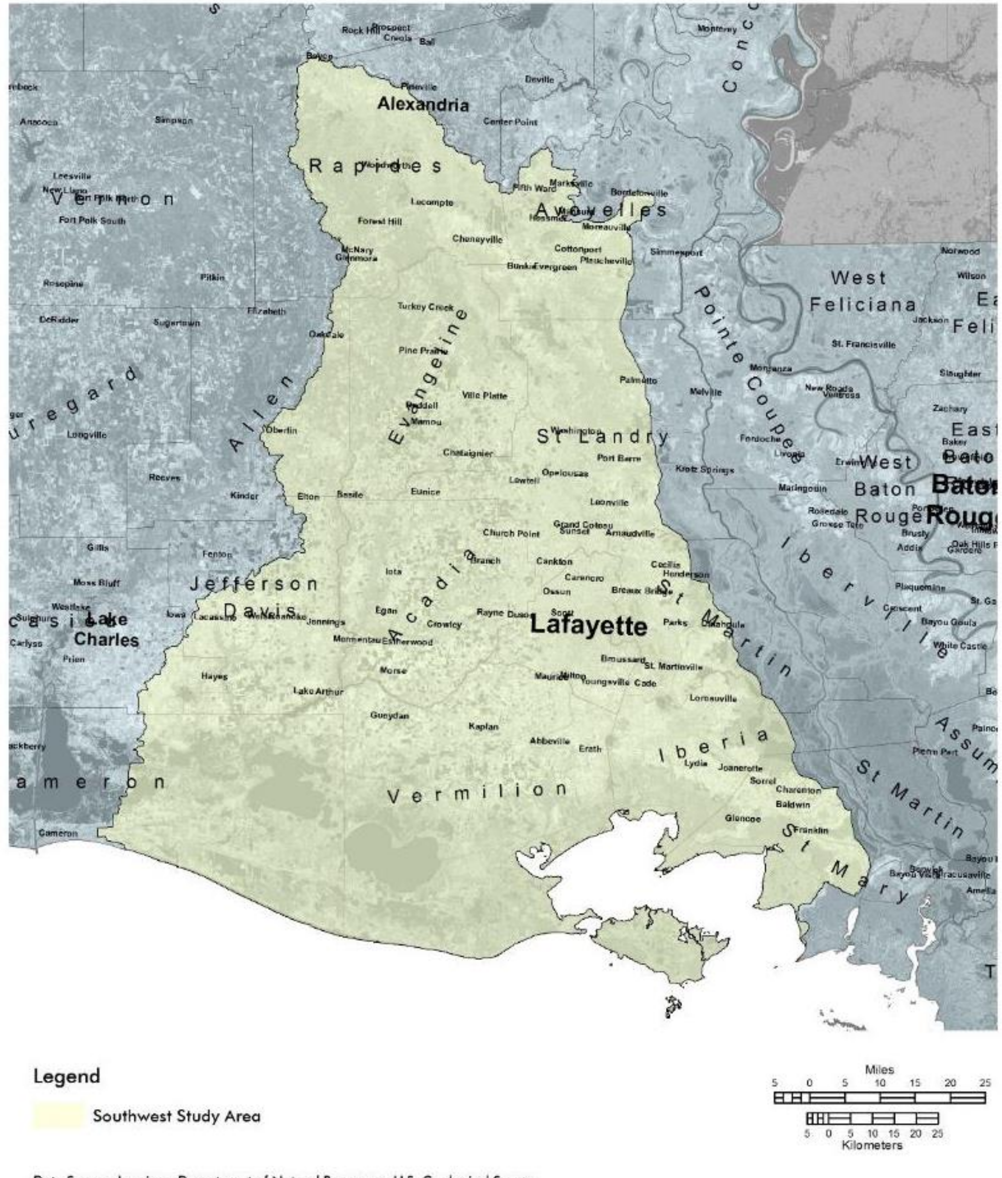
SELECTED STUDY AREAS

- SWLA - East Chicot Aquifer Area
- NWLA - Carrizo-Wilcox Aquifer Area
- SELA - West Southern Hills Aquifer Area
- Chosen for:
  - Data availability
  - Mix of uses
  - Existing supply/ demand imbalances
  - Cover different parts of state/ unique issues



PILOT STUDY AREA: SWLA

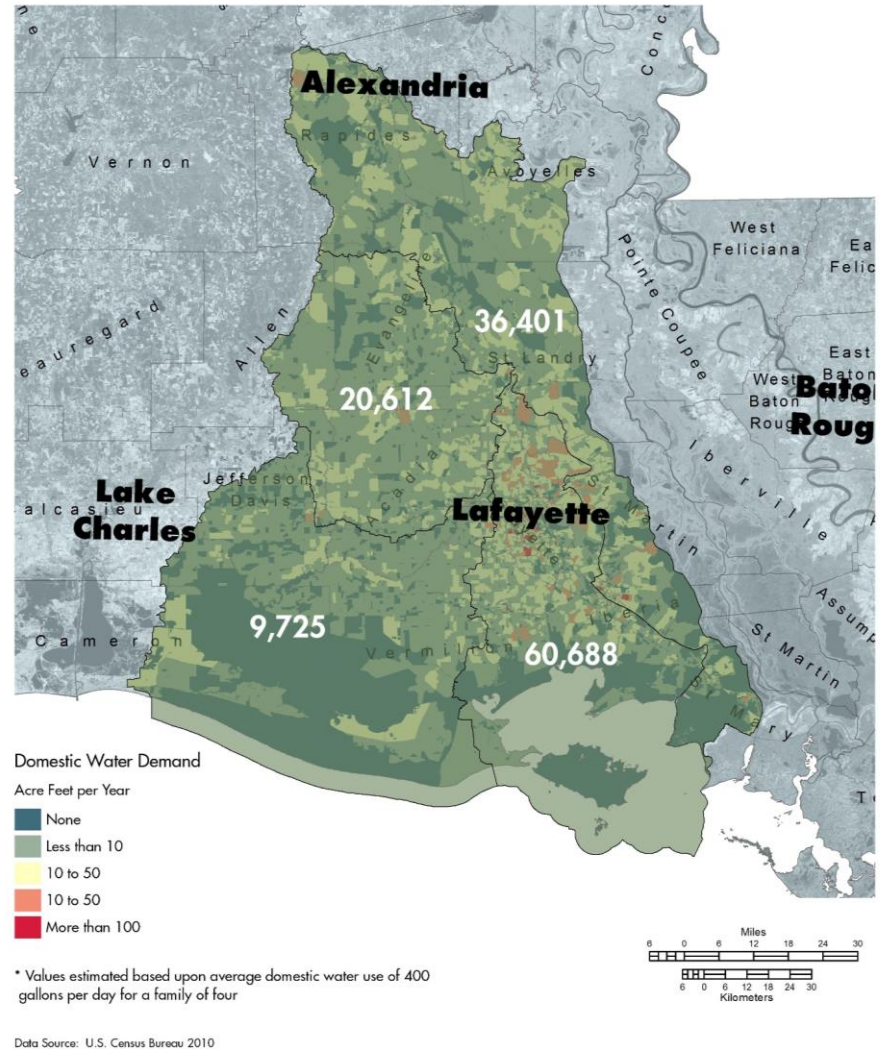
- East Chicot Aquifer Area
- Surface water basins:
  - Bayou Teche
  - Vermilion River
  - Mermentau River
- mix of demand uses
  - Agriculture (including rice)
  - Livestock
  - Industry
  - Urban/rural domestic
  - Coastal



PILOT STUDY AREA: SWLA

Hydrologic Unit	Number of Households	Estimated Freshwater Demand (acre-feet/year)	Number of Public Supply Systems	Population Served	Number of Domestic Water Wells
Bayou Teche	81,241	36,401	56	199,533	2,107
Vermilion	135,446	60,688	112	446,824	9,428
Mermentau Headwaters	46,004	20,612	30	124,201	2,209
Mermentau	21,704	9,725	16	44,294	4,271

Estimated Annual Household Demand for Fresh Water by HUC8 (2010)



WATER BALANCE EQUATION

$$P + Q_{in}^{tot} = ET + Q_{ua} + Q_{out}^{tot}$$

$$\boldsymbol{P + Q_{in}^{sw} + Q_{in}^{gw} = ET^{sw} + ET^{gw} + ET^{uz} + Q_{ua}^{sw} + Q_{ua}^{gw} + Q_{out}^{gw} + Q_{out}^{sw}}$$

$$Q_{in}^{sw} = RO + Q_{in}^{bf} + Q_{in}^{streams} + Q_{in}^{transfers} + Q_{in}^{return\ flow\ ag} + Q_{in}^{return\ flow\ ww}$$

$$Q_{in}^{gw} = Q_{in}^{gw\ surface\ al} + Q_{in}^{gw\ unconf} + Q_{in}^{gw\ conf}$$

$$Q_{out}^{sw} = Q_{out}^{streams} + WD_{out}^{sw}$$

$$Q_{out}^{gw} = (Q_{out}^{gw\ al} + Q_{out}^{gw\ unconf} + Q_{out}^{gw\ conf}) + (WD_{out}^{gw\ al} + WD_{out}^{gw\ unconf} + WD_{out}^{gw\ conf})$$

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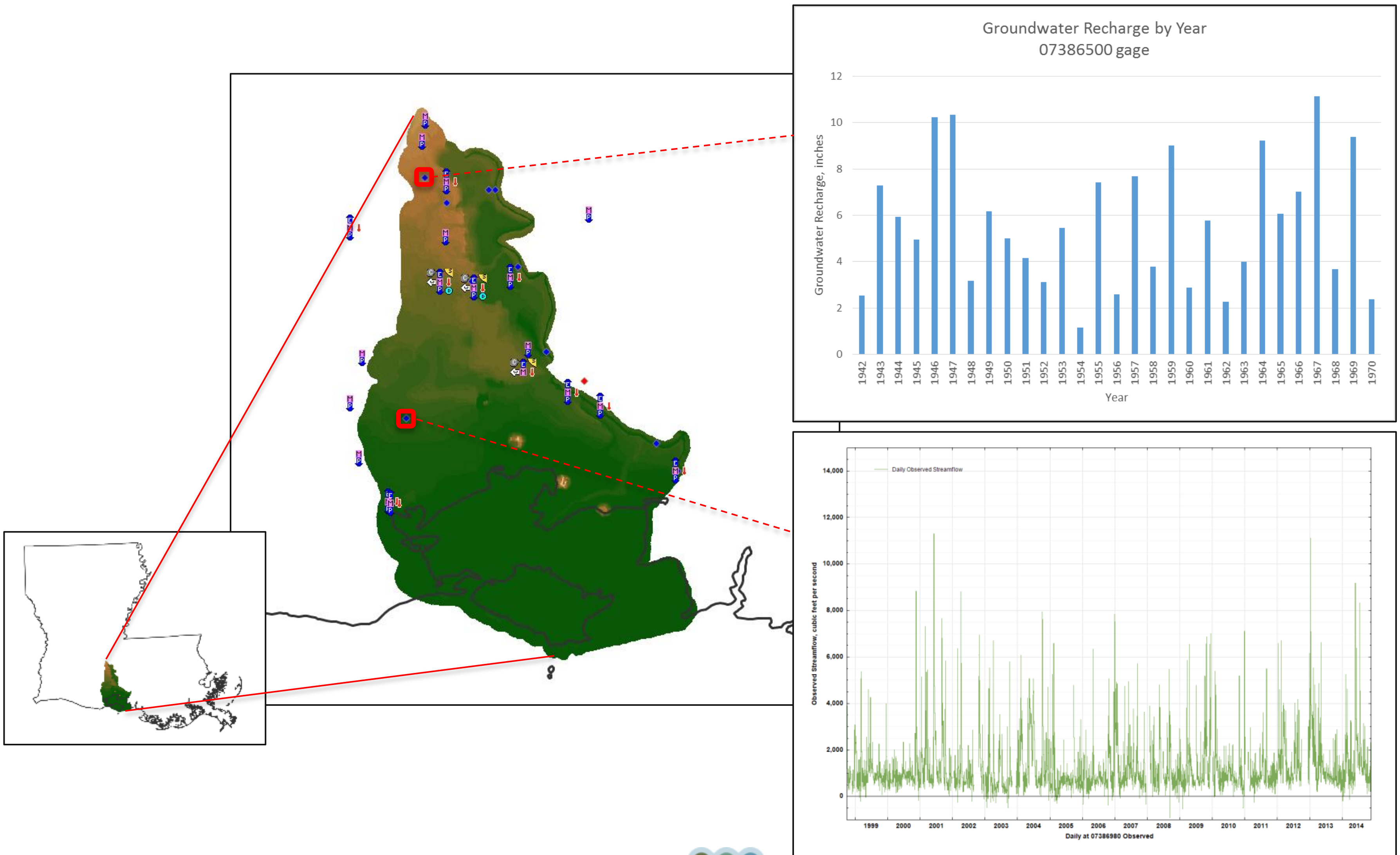
USGS GROUNDWATER TOOLBOX



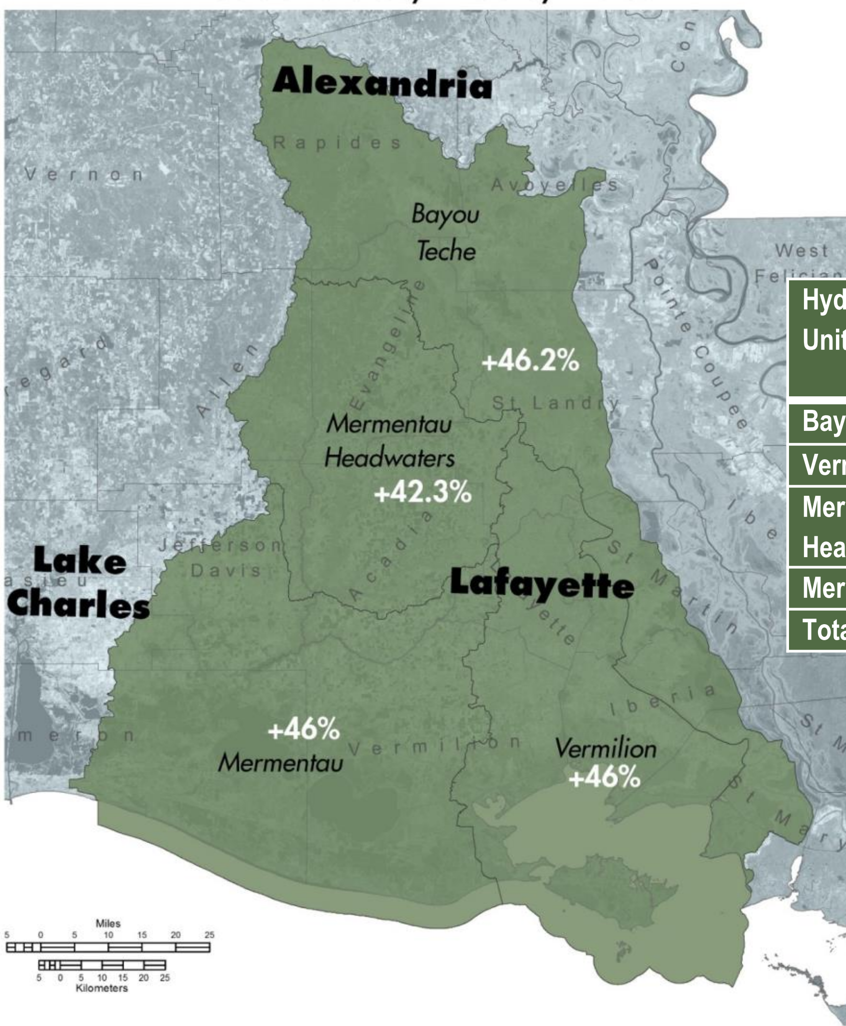
USGS GROUNDWATER TOOLBOX

- Estimate components of streamflow:
  - base flow
  - runoff
- Also used to estimate:
  - Precipitation
  - Groundwater recharge (near surface)
  - Evapotranspiration
- Adapted to include:
  - Deep aquifer recharge from precipitation infiltration in recharge zone, and from vertical leakage

Water Budget Component	Method of Analysis	Framework Variable
Precipitation	NOAA NCDC observed daily precipitation data, in inches, retrieved with the USGS Groundwater Toolbox (PRCP dataset)	P
Streamflow	USGS NWIS daily mean streamflow data retrieved with the USGS Groundwater Toolbox	Q_{out}^{sw}
Base flow	Average of the six hydrograph-separation methods calculated with the USGS Groundwater Toolbox	Q_{out}^{bf}
Runoff	Streamflow minus base flow	RO
Recharge	Calculated using the RORA method provided with the USGS Groundwater Toolbox	$Q_{out}^{gw\ al}$
Evapotranspiration, total	Calculation method 1: Precipitation minus streamflow	ET
Evapotranspiration, total (alternate method, not used in budget)	Calculation method 2: From regression model developed by Sanford & Selnick (2012) and NOAA NCDC data retrieved with the USGS Groundwater Toolbox	ET 2
Evapotranspiration, groundwater	Calculated as recharge minus base flow	ET^{gw}
Evapotranspiration, near surface	Calculated as total evapotranspiration (method 1) minus evapotranspiration from the groundwater system	$ET^{uz}+ ET^{sw}$
Percent of HUC in high recharge Area	Calculated with ArcGIS (ESRI 2011)	% SWgwrcg
Infiltration coefficient	Average of values from Delin & Risser (2007)	INF
Deep Aquifer Recharge from rainfall in recharge zone	Recharge above (Etgw+Qbf) x (%SWgwrcg) x infiltration coefficient (INF)	$Q_{in}^{gw\ unconf}$
Deep Aquifer Recharge from vertical leakage coefficient	L'vovich (1979), and Doll & Fiedler (2008)	RCvlCoeff
Percent of HUC not in Chicot high recharge area	Calculated with ArcGIS (ESRI 2011)	%swgwvl
Deep Aquifer Recharge from vertical leakage	Recharge above (Etgw+Qbf) x (%SWgwrvl) x vertical leakage coefficient (RCvlCoeff)	$_{in}^{gw\ surface\ a}$
Surface Water and Groundwater Withdrawals	Values obtained from USGS Water Use in Louisiana (Sargent et al., 2011)	WD_{out}^{sw}, WD_{out}^{gw}
Return Flow (leakage and runoff)	WD*Consumptive Use Coefficients obtained from USGS National Water Summary (Carr et al., 1987) and Lawrence Livermore National Laboratory (Smith et al., 2011)	$Q_{in}^{return\ flow}$
Consumptive Use	WD - Qsw in (return flow)	WD - $Q_{in}^{return\ flow}$
Return Flow	Discharge values obtained from USEPA Permit Compliance System (PCS) and Integrated Compliance Information System (ICIS)	$_{n}^{return\ flow\ w}$

WATER BALANCE RESULTS

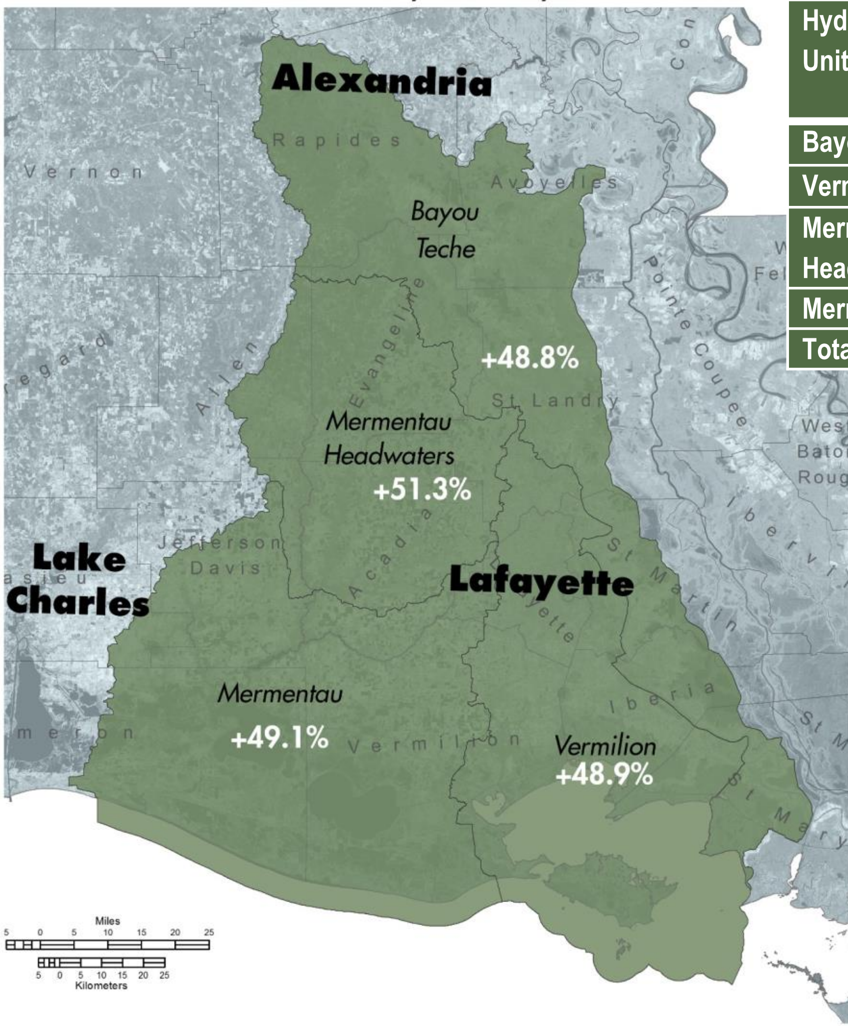
Total Water Balance in Southwest Louisiana Study Area by HUC8



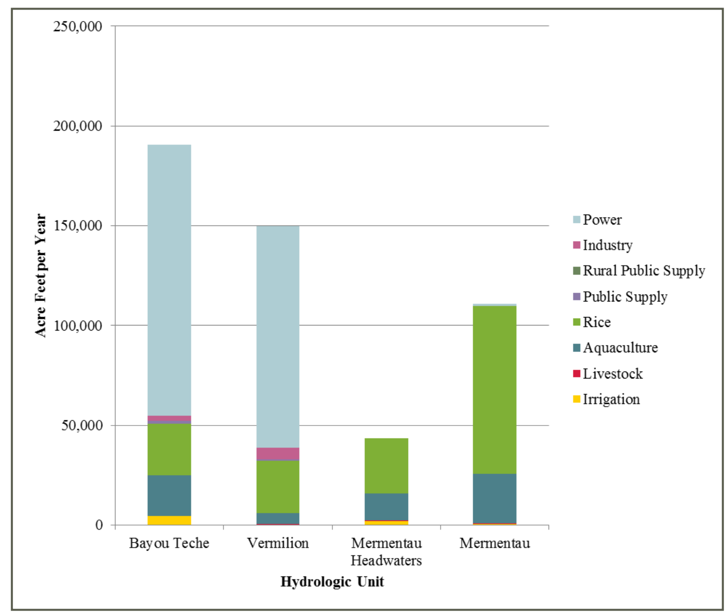
Hydrologic Unit	Total Water Inflow (acre-feet/year)	Total Water Outflow (acre-feet/year)	Unallocated Water (acre-feet/year)	Percent Change
Bayou Teche	5,639,321	3,034,498	2,604,823	+46.2%
Vermilion	4,385,187	2,367,734	2,017,454	+46.0%
Mermentau Headwaters	3,409,647	1,967,600	1,442,046	+42.3%
Mermentau	6,031,189	3,257,310	2,773,880	+46.0%
Total	19,465,344	10,627,142	8,838,203	+45.4%

WATER BALANCE RESULTS

Surface Water Balance in Southwest Louisiana Study Area by HUC8

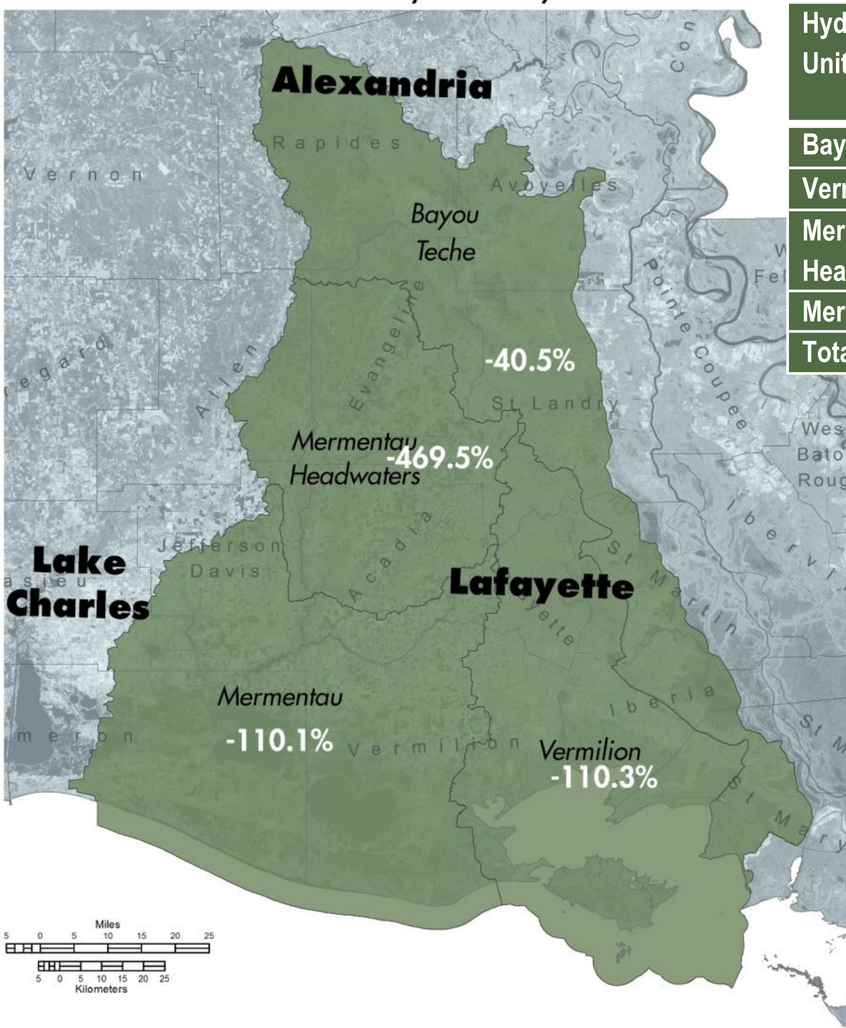


Hydrologic Unit	Total Water Inflow (acre-feet/year)	Total Water Outflow (acre-feet/year)	Unallocated Water (acre-feet/year)	Percent Change
Bayou Teche	5,473,672	2,801,733	2,671,939	+48.8%
Vermilion	4,304,848	2,198,761	2,106,087	+48.9%
Mermentau Headwaters	3,350,916	1,633,156	1,717,760	+51.3%
Mermentau	5,913,295	3,009,574	2,903,721	+49.1%
Total	19,042,731	9,643,224	9,399,507	+49.4%

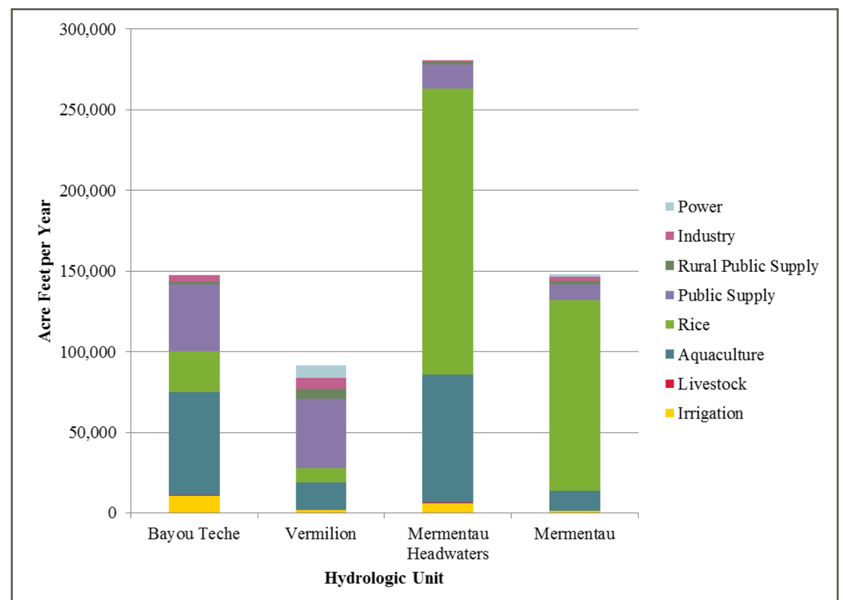


WATER BALANCE RESULTS

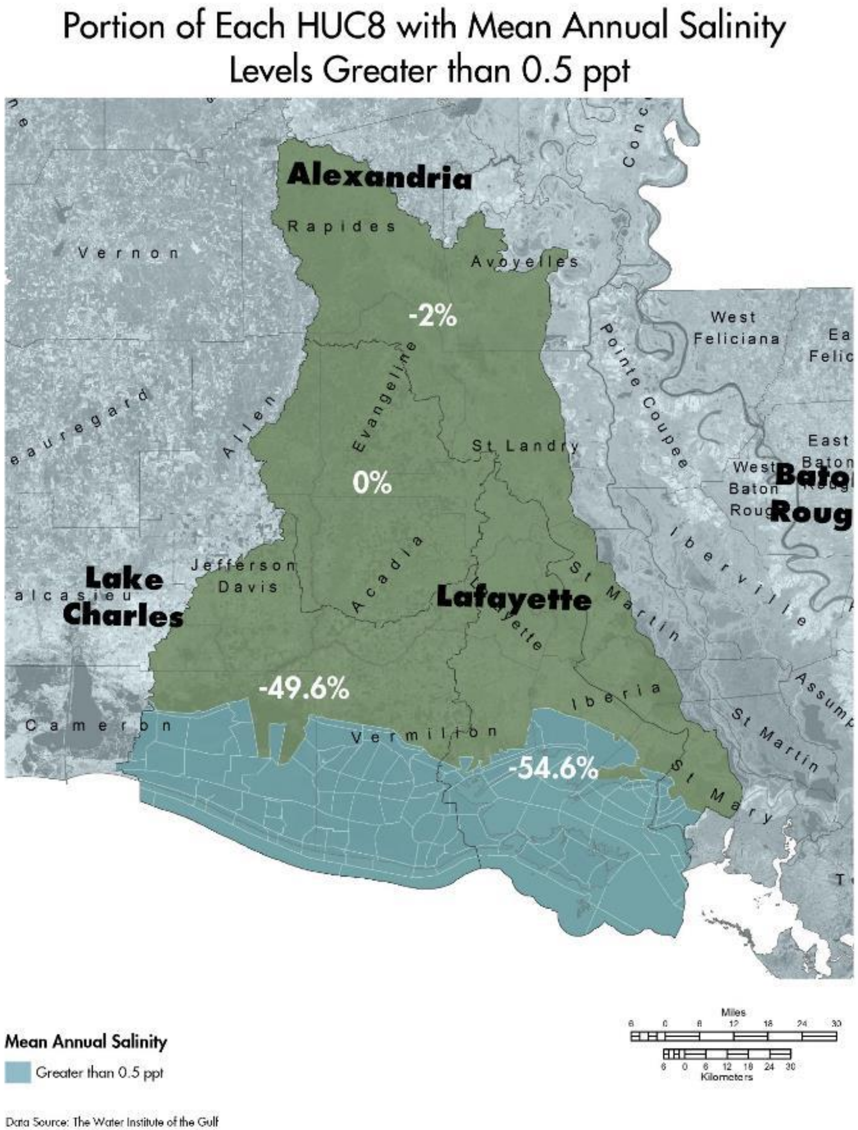
Groundwater Balance in Southwest Louisiana Study Area by HUC8



Hydrologic Unit	Total Water Inflow (acre-feet/year)	Total Water Outflow (acre-feet/year)	Unallocated Water (acre-feet/year)	Percent Change
Bayou Teche	165,649	232,765	-67,116	-40.5%
Vermilion	80,339	168,973	-88,633	-110.3%
Mermentau Headwaters	58,731	334,444	-275,714	-469.5%
Mermentau	117,894	247,736	-129,841	-110.1%
Total	422,613	983,918	-561,304	-132.8%



CONSTRAINTS & QUALITY IMPACTS



SWLA study area surface water balance, including impacts of coastal salinity on water usability

Hydrologic Unit	Total Water Inflow (acre-feet/year)	Reduced Water Inflow (acre-feet/year)	Unallocated Water (acre-feet/year)	Percent Change
Bayou Teche	5,473,672	5,364,198	109,474	-2.0%
Vermilion	4,304,848	1,954,401	2,350,447	-54.6%
Mermentau Headwaters	3,350,916	3,350,915	1	0.0%
Mermentau	5,913,295	2,980,300	2,932,995	-49.6%
Total	19,042,731	13,649,814	5,392,917	-28.3%

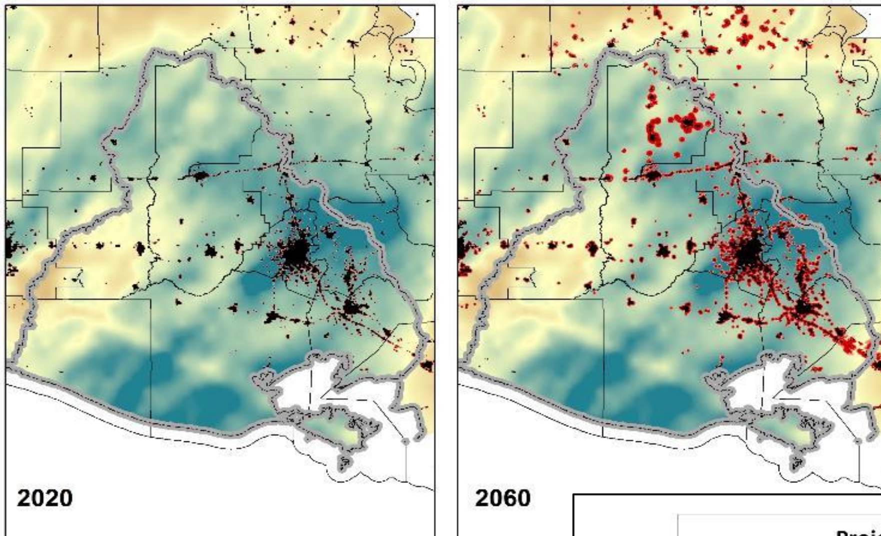
CONSTRAINTS & QUALITY IMPACTS

SWLA study area summary of overall water balance, including impacts of 10% impaired quality on surface water usability

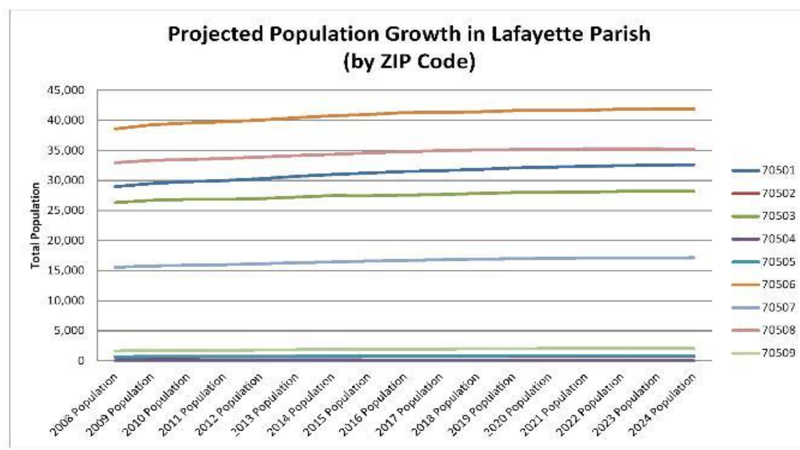
Hydrologic Unit	Total Water Inflow (acre-feet/year)	Reduced Water Inflow (acre-feet/year)	Unallocated Water (acre-feet/year)	Percent Change
Bayou Teche	5,639,321	5,091,954	547,367	-10.7%
Vermilion	4,385,187	3,954,702	430,485	-10.9%
Mermentau Headwaters	3,409,647	3,074,555	335,092	-10.9%
Mermentau	6,031,190	5,439,860	591,330	-10.9%
Total	19,465,345	17,561,071	1,904,273	-10.8%

FUTURE PROJECTIONS

Population Growth Projections in the Southwest Study Area for the Louisiana Water Budget



Data Source: University of California, Santa Barbara

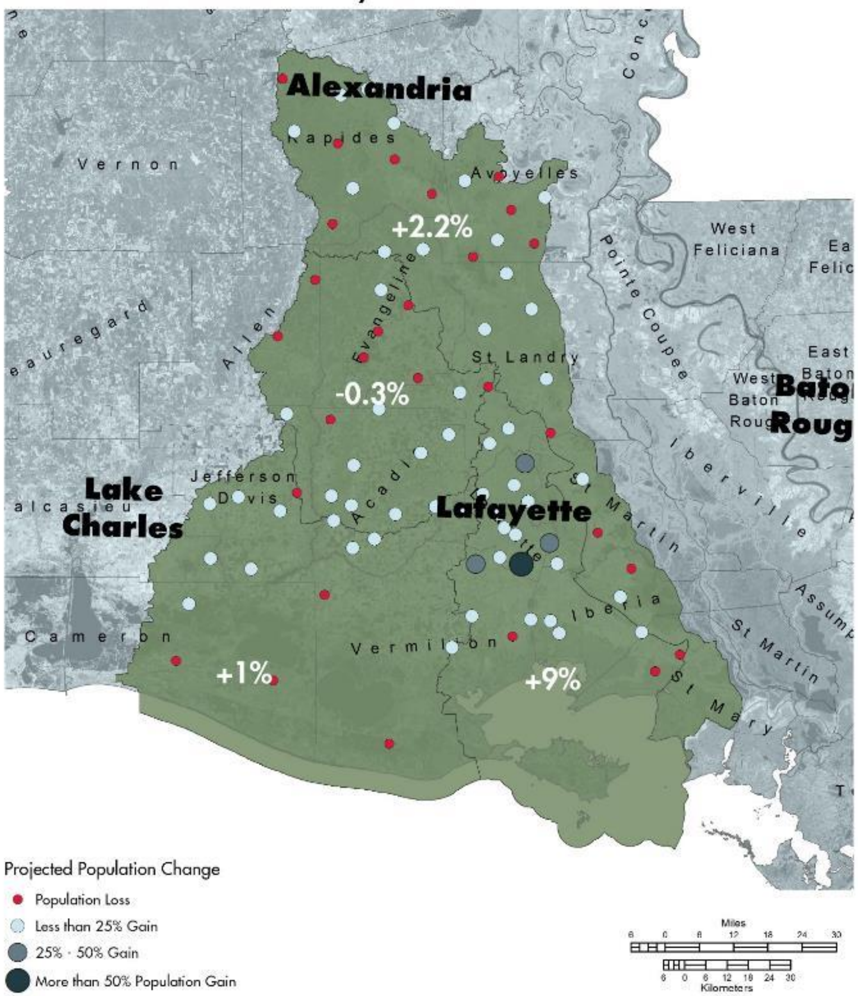


Data Source: Economic Modeling Specialists, International

Impacts of population growth and urbanization on water supply and demand

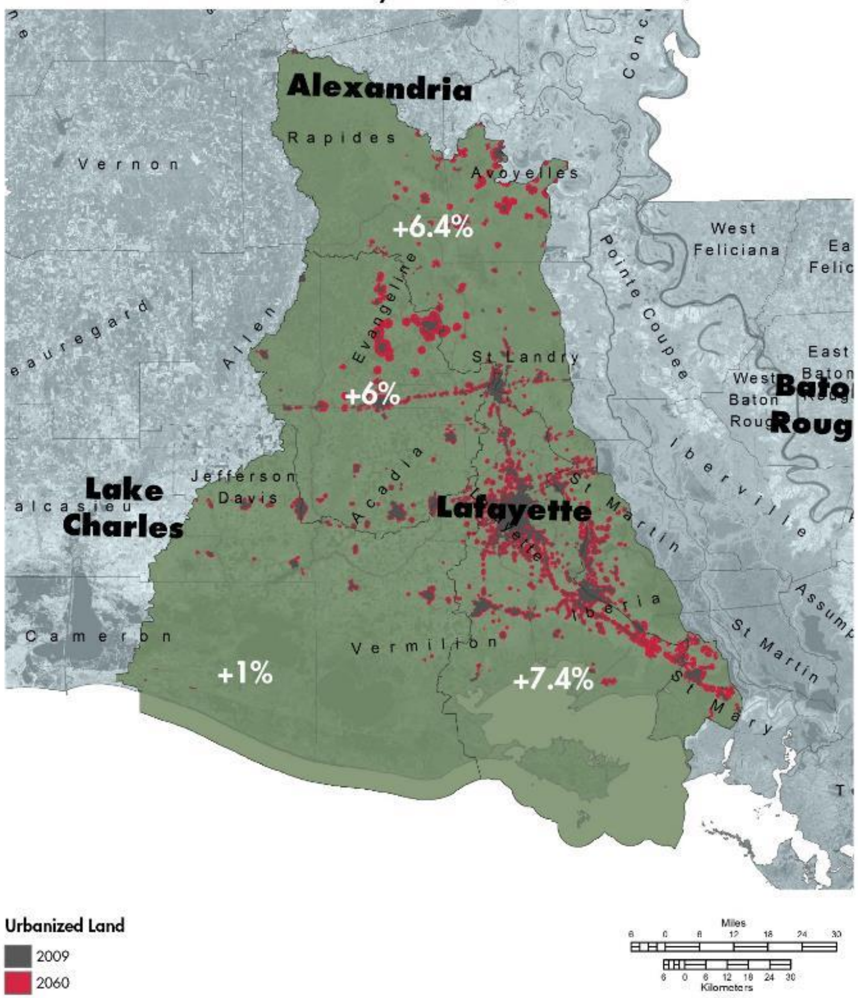
FUTURE PROJECTIONS

Projected 10-year Population Change by ZIP Code



Data Source: Economic Modeling Specialists, International; Lousiana Economic Development

Projected Urban Growth in Southwest Louisiana Study Area (2009-2060)



Data Source: North Carolina State University Biodiversity and Spatial Analysis Center

FUTURE PROJECTIONS

SWLA total water balance change under future urbanization scenario

Hydrologic Unit	Change in Groundwater Input (acre-feet/year)	% Change in Groundwater Input	Change in Surface Water Input (acre-feet/year)	% Change in Surface Water Input
Bayou Teche	-1,798	-1.1%	32,743	+0.6%
Vermilion	-70	-0.1%	63,892	+1.5%
Mermentau Headwaters	-105	-0.2%	36,439	+1.1%
Mermentau	-63	-0.1%	9,104	+0.2%

SWLA total water balance change under population growth scenario

Hydrologic Unit	Change in Groundwater Output (acre-feet/year)	% Change in Groundwater Output	Change in Surface Water Output (acre-feet/year)	% Change in Surface Water Output
Bayou Teche	945	+0.6%	34	<0.1%
Vermilion	4,420	+5.5%	40	<0.1%
Mermentau Headwaters	-49	-0.1%	0	0.0%
Mermentau	119	+0.1%	0	0.0%

ENERGY

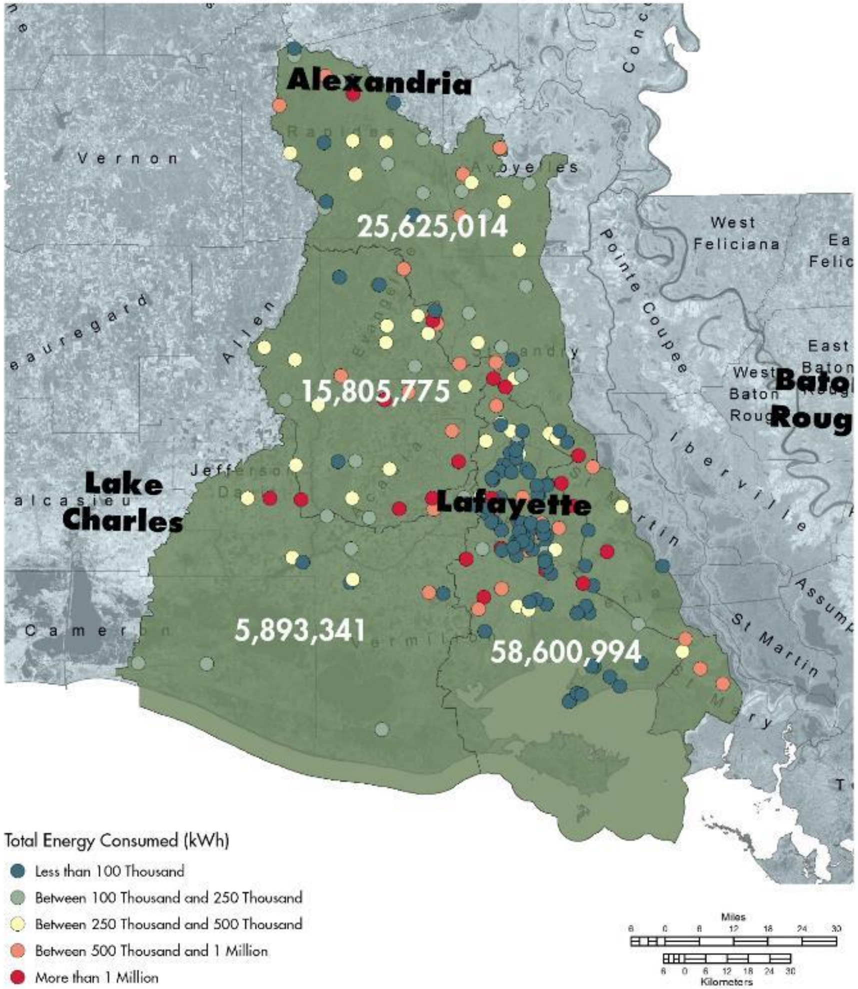
***Embedded Energy*: The amount of energy used to collect, convey, treat, and distribute a unit of water to end users, and the amount of energy that is used to collect and transport used water for treatment prior to safe discharge of the effluent**

Unit Electricity Consumption for Wastewater Treatment by Size of Plant				
Treatment Plant Size	Unit Electricity Consumption (kWh/MM gal)			
	Trickling Filter	Activated Sludge	Advanced Wastewater Treatment	Advanced Wastewater Treatment Nitrification
1 MM gal/day	1,811	2,236	2,596	2,951
5 MM gal/day	978	1,369	1,573	1,926
10 MM gal/day	852	1,203	1,408	1,791
20 MM gal/day	750	1,114	1,303	1,676
50 MM gal/day	687	1,051	1,216	1,588
100 MM gal/day	673	1,028	1,188	1,558
Source: Electric Power Research Institute, 2002				

Unit Electricity Consumption for Surface Water Treatment Plants	
Treatment Plant Size	Unit Electricity Consumption
1 MM gal/day (3,785 m^3/d)	1,483 kWh/MM gal (0.392 kWh/m^3)
5 MM gal/day (18,925 m^3/d)	1,418 kWh/MM gal (0.375 kWh/ m^3)
10 MM gal/day (37,850 m^3/d)	1,406 kWh/MM gal (0.371 kWh/ m^3)
20 MM gal/day (75,700 m^3/d)	1,409 kWh/MM gal (0.372 kWh/ m^3)
50 MM gal/day (189,250 m^3/d)	1,408 kWh/MM gal (0.372 kWh/ m^3)
100 MM gal/day (378,500 m^3/d)	1,407 kWh/MM gal (0.372 kWh/ m^3)
Source: Electric Power Research Institute, 2002	

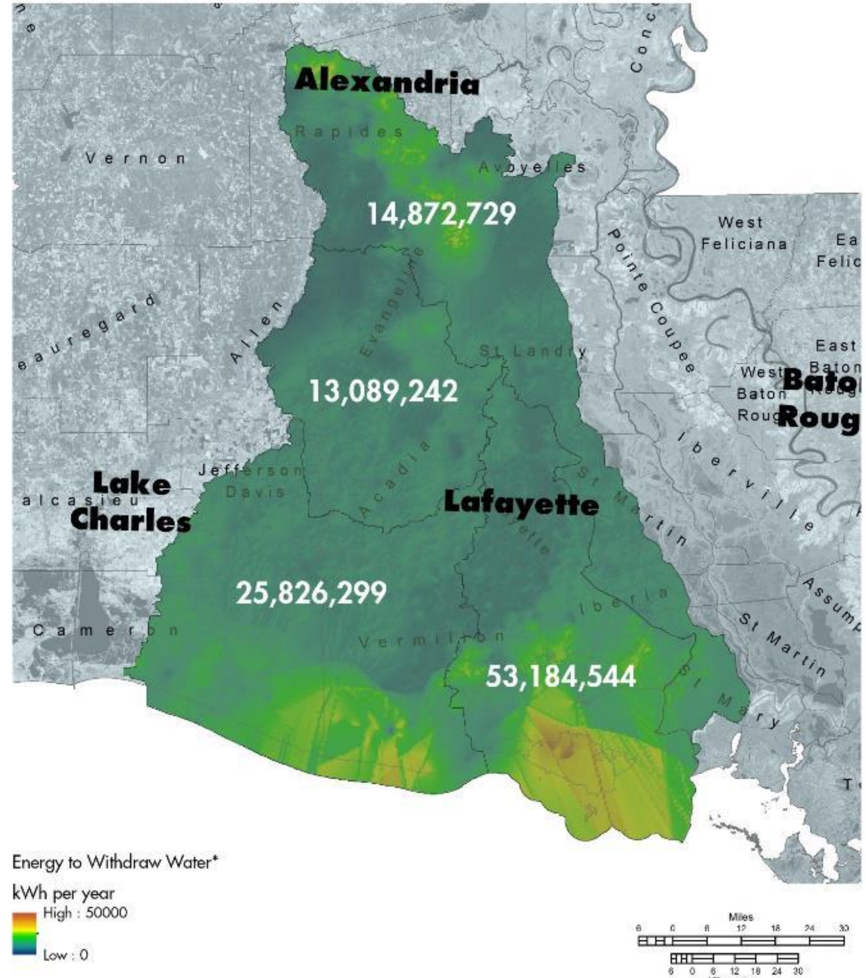
ENERGY

Annual Drinking Water Treatment Energy Used by Public Water Supply Systems



Data Source: Lousiana Department of Natural Resources; Lousiana Department of Health and Hospitals; U.S. Environmental Protection Agency

Estimated Annual Energy Costs to Withdraw Water from Domestic Wells



* Values estimated based upon average domestic water use of 400 gallons per day for a family of four using an electric domestic water well pump using 1.16 kwh per day for each 10 feet of water lift

Data Source: Lousiana Department of Natural Resources; Lousiana Department of Health and Hospitals; U.S. Environmental Protection Agency

SUMMARY

- Created framework for assessment of water supply & demand usable statewide
- Tested on areas with data available, and existing studies for comparison
- Can be applied to other areas of the state with sparser data and fewer existing studies
- Modular, improvable/customizable with new data and tools

PATH FORWARD

- Refine tools
- Refine water use data for each water-use sector
- Annual means → seasonal scale, including seasonality of demand
- Minimum ecological flow estimation (estuarine)

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Please contact us at innovation@thewaterinstitute.org

301 NORTH MAIN STREET, SUITE 2000
BATON ROUGE, LA 70825

(225) 448-2813
WWW.THEWATERINSTITUTE.ORG