WATER STRESS IN FLORIDA

GII WORKSHOP

UNIVERSITY OF INDONESIA

CARDIFF UNIVERSITY UNIVERSITY OF FLORIDA

OCTOBER 2015

Introduction and Overview of Florida Water

- Focus on quantity
- Average of 50" of rainfall per year

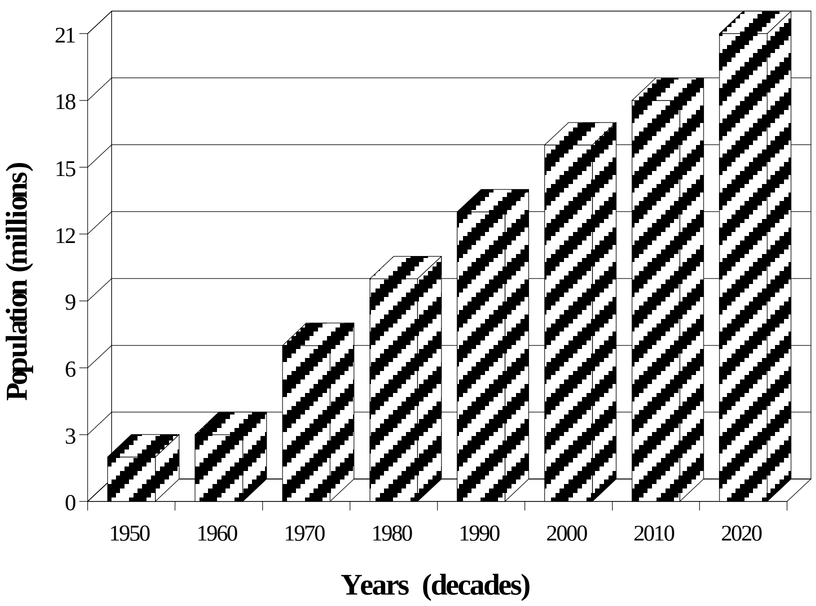
- Florida groundwater aquifers for potable water and irrigation
- Apalachicola-Chattahoochee-Flint (ACF) watershed

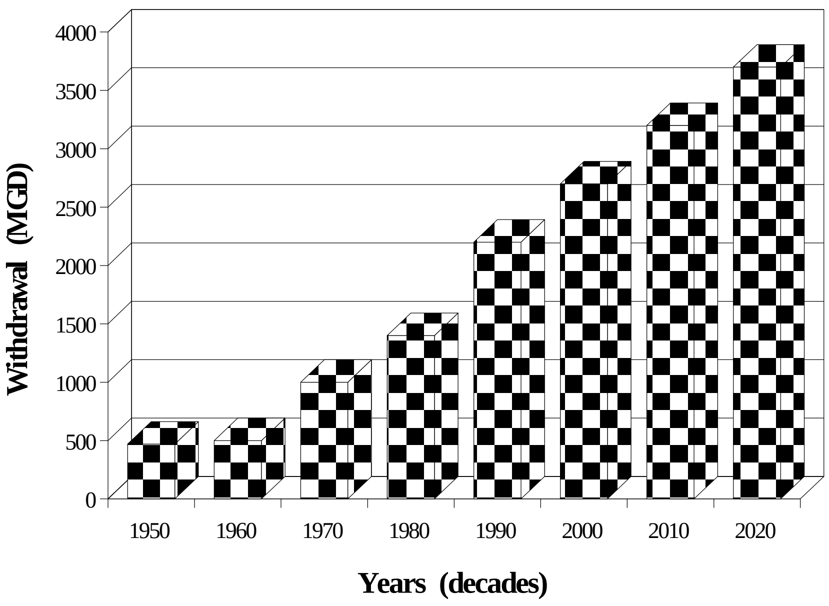
Floridan Aquifer System

- Approximately 100,000 square miles in area
- One of the most productive aquifer systems in the world
- Principal source of water supply for potable, industrial use, and irrigation in the region
- Used by several large cities such as Savannah, GA, Tallahasee, Jacksonville, Orlando, and St. Petersburg, FL

Water Resources in Florida

- Use of potable water in Florida increased a factor of 6 in the last 90 years with 25% of the increase occurring in the last 25 years





Aquifer Water Resources in Florida

- Rainfall within the Floridan aquifer area ranges from 50" to about 80" per year in Georgia mountains
- Recharge is about 20" per year in south-central Georgia
- About 5-13" of the 50" average annual rainfall in Forida infiltrates and recharges the aquifer

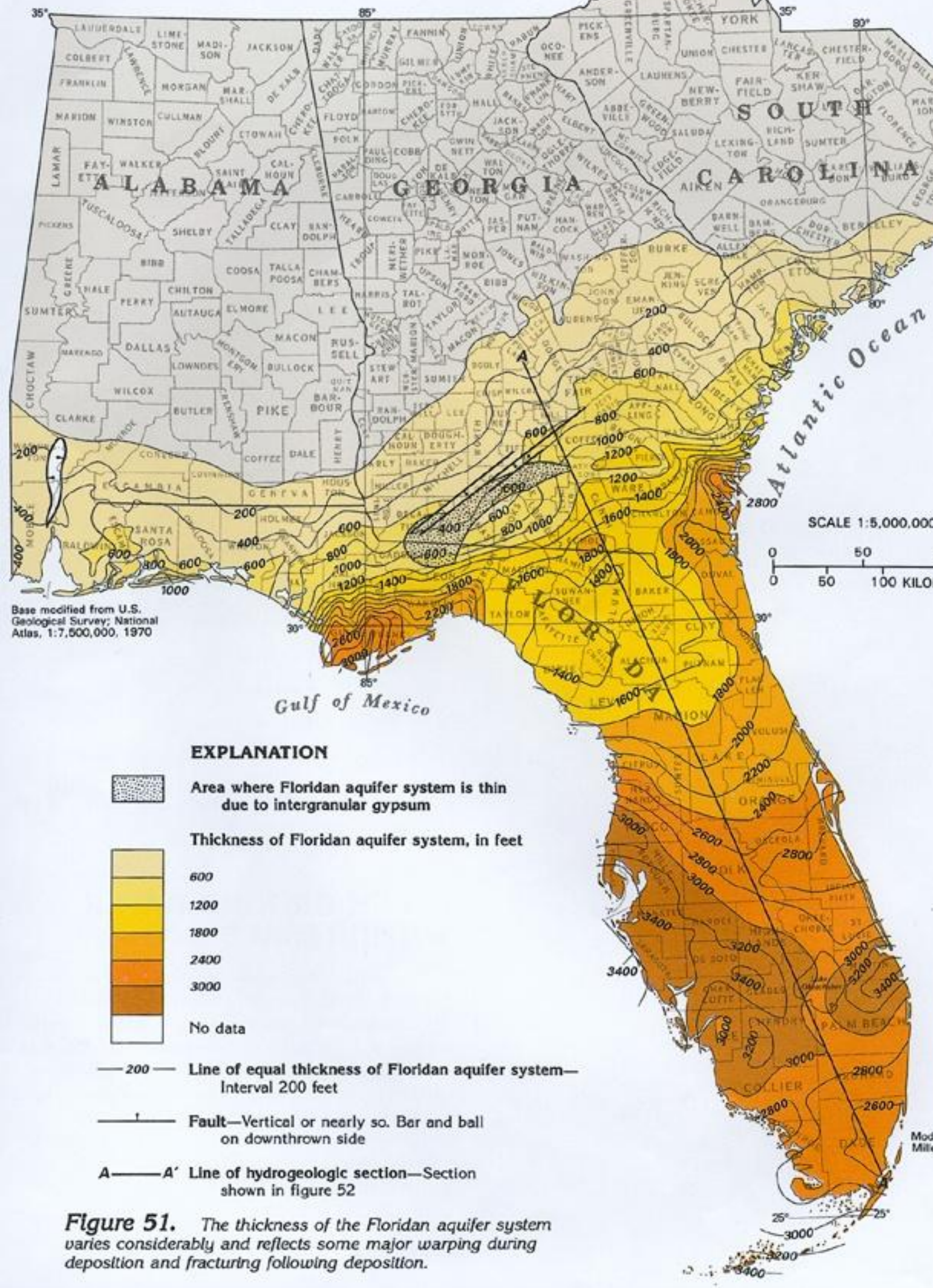


Figure 51. *The thickness of the Floridan aquifer system varies considerably and reflects some major warping during deposition and fracturing following deposition.*

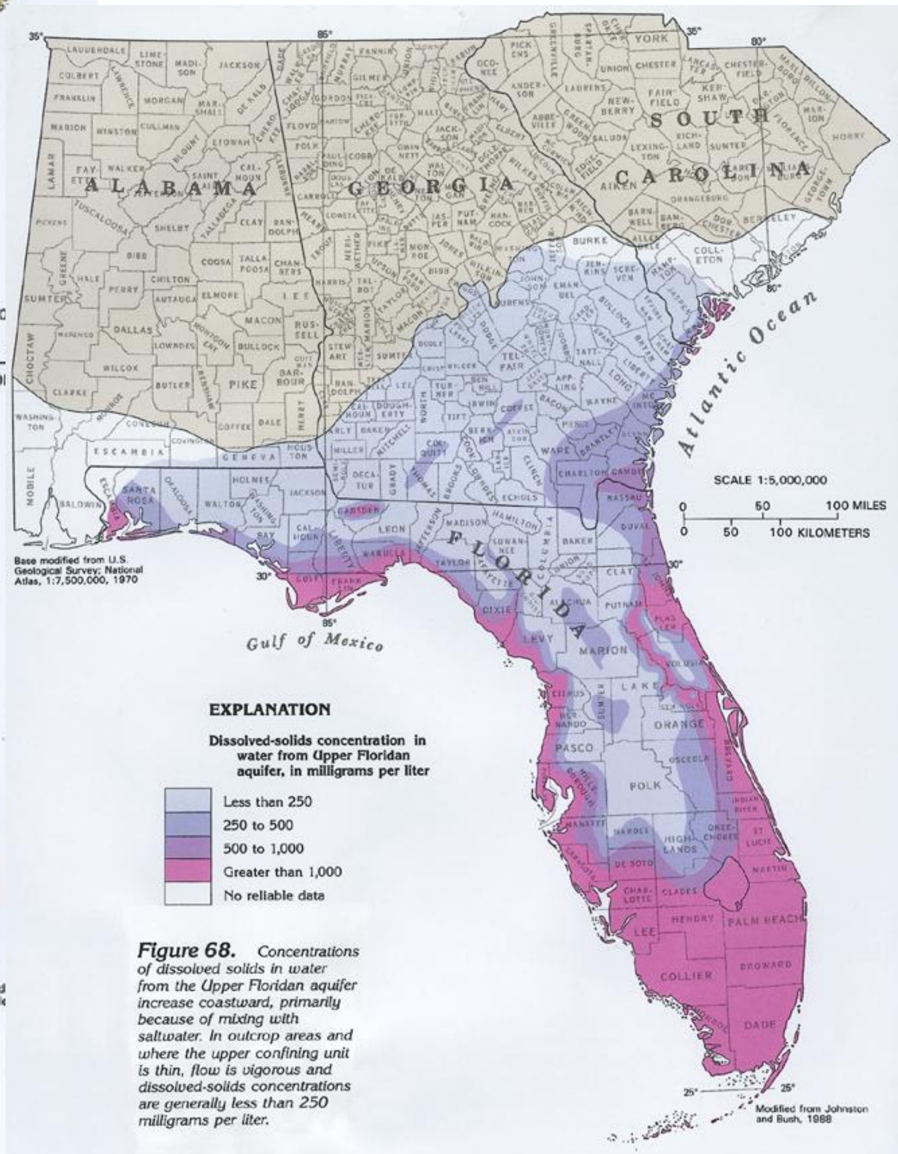
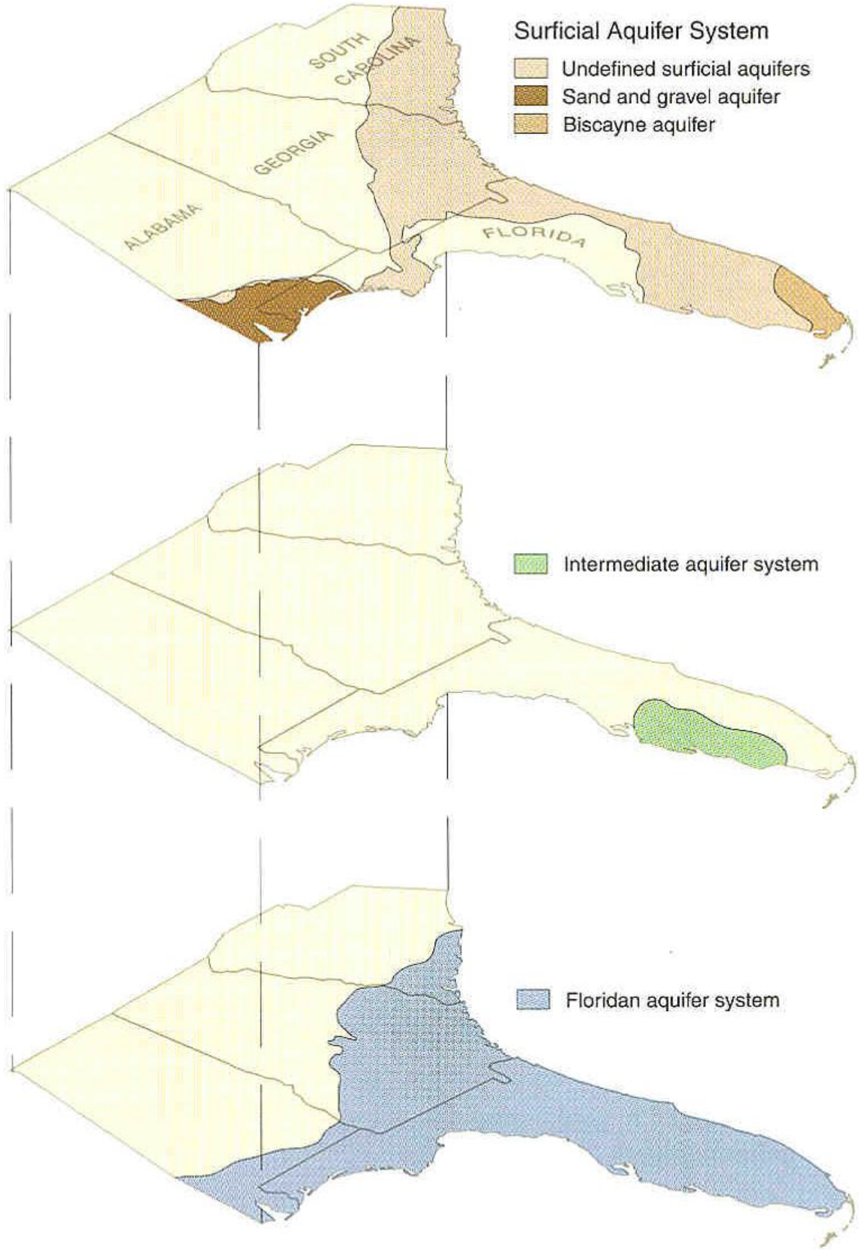
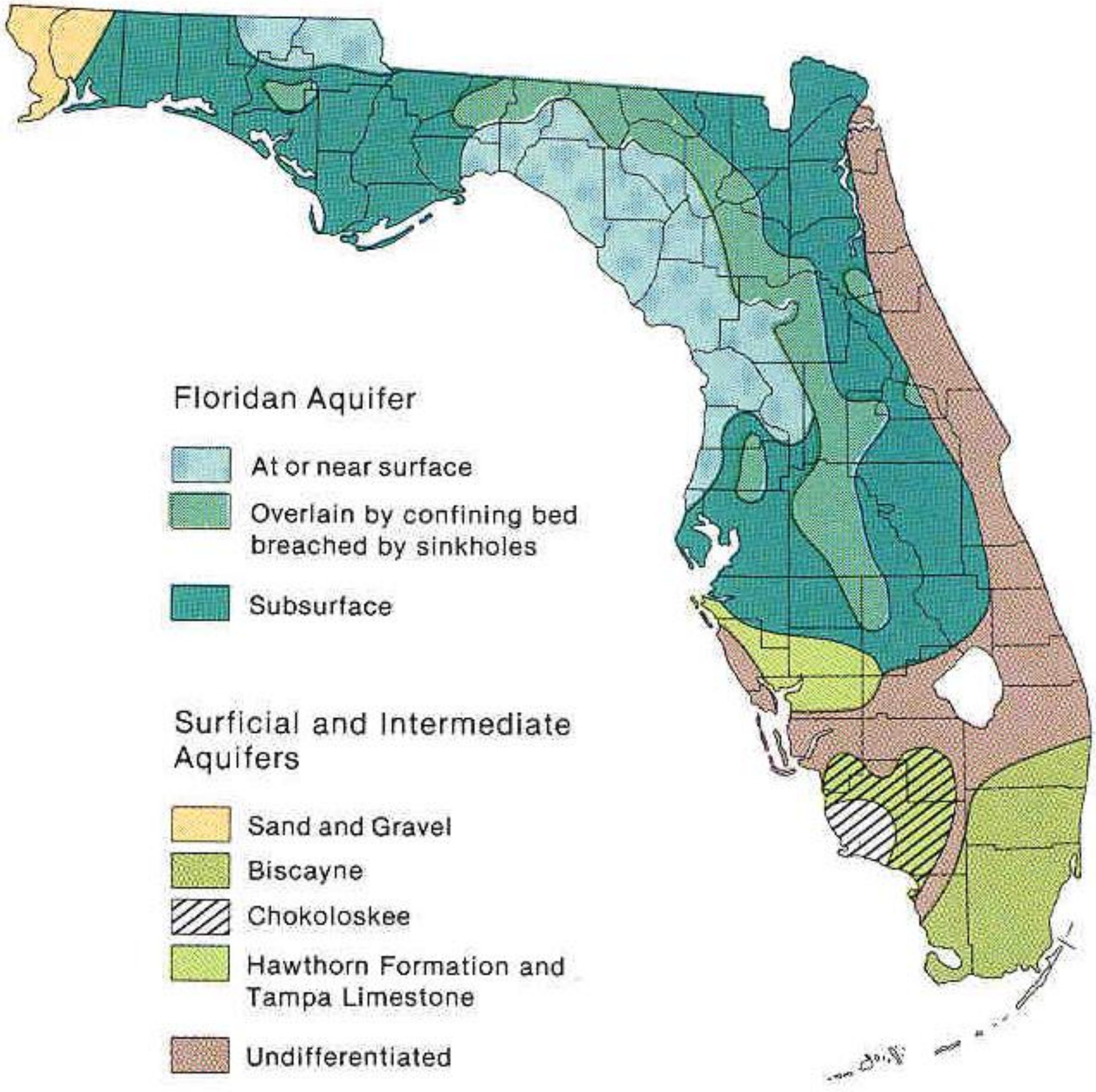


Figure 68. *Concentrations of dissolved solids in water from the Upper Floridan aquifer increase coastward, primarily because of mixing with saltwater. In outcrop areas and where the upper confining unit is thin, flow is vigorous and dissolved-solids concentrations are generally less than 250 milligrams per liter.*

Sequence of Aquifers



Primary Groundwater Sources



Floridan Aquifer System

Basic information from the US Geological Survey

- Withdrawls in 2000: 3,640 MGD
  - Equals about 5% of all aquifer withdrawals in the US
  - Equals about 20% of the total discharge from the aquifer
  - Pre-development, 90% of flow was to springs and streams
- In 2000:
- 76% of withdrawals were in FL
- 53% of withdrawals were for irrigation
- 37% of withdrawals were for public supply
  - 87% of public supply withdrawals were in FL
- 10% of withdrawals were for self-supplied industrial uses

Objective and Approach

- Develop an impact assessment model for water resources in the built environment.
- Model impacts of the built environment on water resources.

Florida Model Application

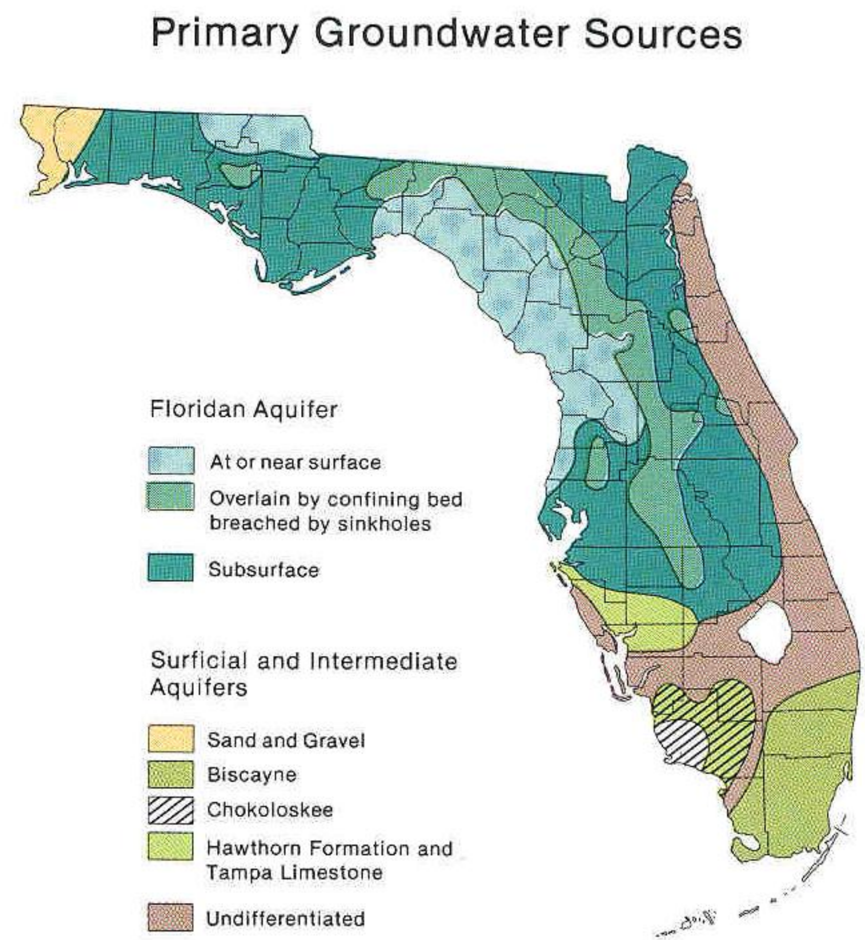
Data sources

USGS HU level data source:

- Parcel level land use: Florida Geographic Data Library

County level data sources:

- Annual (1995-2005) average precipitation: NOAA
- Annual (2000) withdrawals by type: USGS (Marella 2004)
- Annual (2000) waste water generated by type: USGS (Marella 2004)



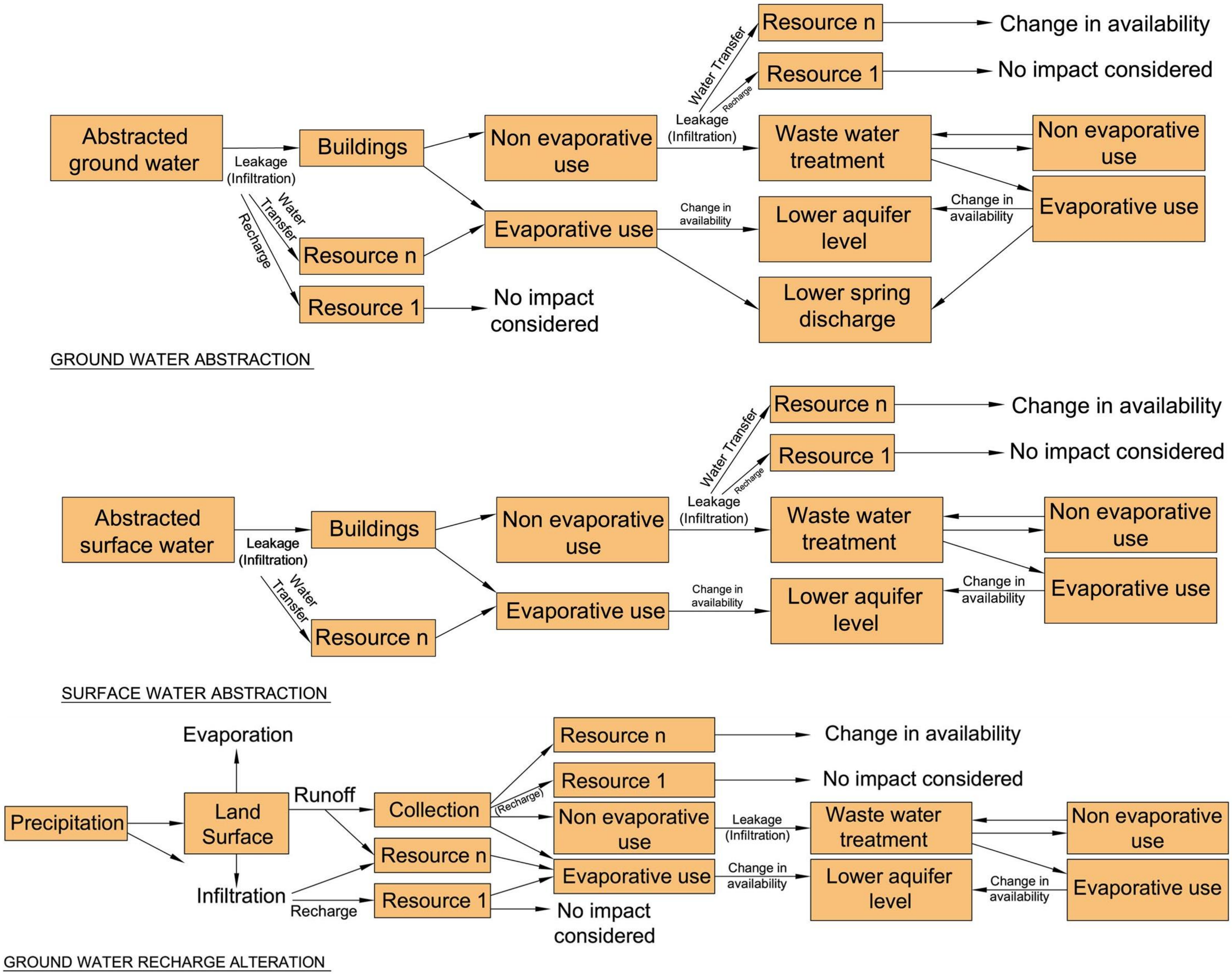
USGS 1980

Florida's Hydrological Unit sub-regions

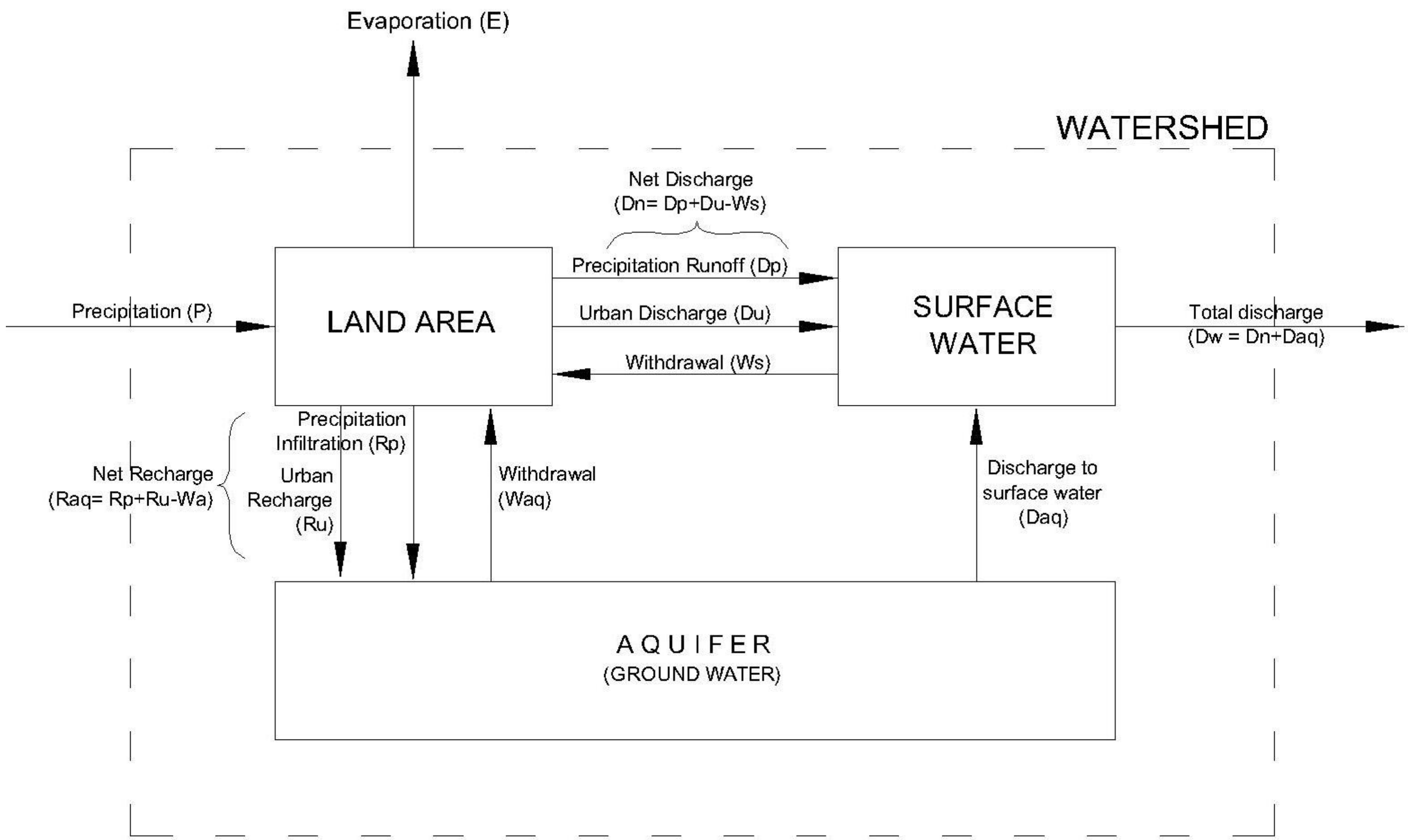
Methodology

- Water pathway analysis
  - Withdrawal from aquifers and surface water for both consumptive and non-consumptive uses
    - including utilities such as electricity generation and services such as building HVAC (heating, ventilating and air conditioning)
  - Changes in land cover (infiltration, runoff and evapo-transpiration).

- System analysis
  - Inflows and outflows of water to aquifers and their associated streams.



Water pathway analysis



Impact indicators:

Impact on Aquifer = Raq (developed)/ Raq (pristine)

Impact on Surface water resource = Dw (developed)/ Dw (pristine)

Assumption: Water entering aquifer leaves the aquifer with no change in storage.

0308, St. Johns Hydrological Unit

Conditions	Waq	Rp	Ru	Raq	Raq (dev.)/ Raq (Pris.)	Ws	Dp	Du	Dn	Dw	Dw (dev.) / Dw (Pris.)
Developed	172,471					69,988					
Pristine	0					0					

All values in Mgal/ year

Withdrawal by county and type:

- Ground and fresh surface water
- Public supply and self supply
- Domestic, commercial, industrial and power plants

0308 , St. Johns Hydrological Unit

Conditions	Waq	Rp	Ru	Raq	Raq (dev.)/ Raq (Pris.)	Ws	Dp	Du	Dn	Dw	Dw (dev.) / Dw (Pris.)
Developed	172,471					69,988					
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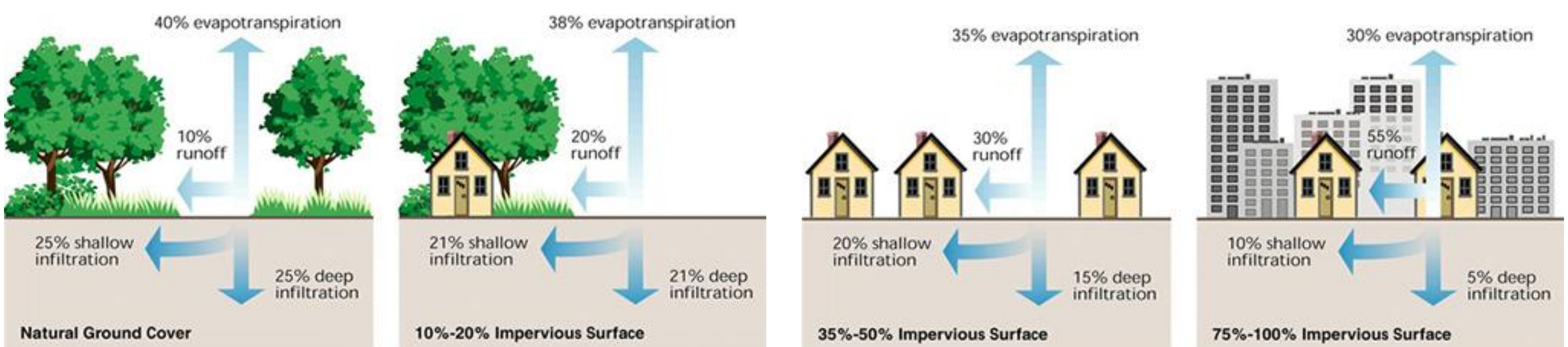


Case: 1 | Case type: 2 | Case type: 3 | Case type: 4

Imperviousness, infiltration, and evapotranspiration by land use type

USEPA 1993

0308 , St. Johns Hydrological Unit

Conditions	Waq	Rp	Ru	Raq	Raq (dev.)/ Raq (Pris.)	Ws	Dp	Du	Dn	Dw	Dw (dev.) / Dw (Pris.)
Developed	172,471	**454,778**				69,988	**1,027,423**				
Pristine	0	**838,261**				0	**502,957**				

All values in Mgal/ year

Precipitation: 50 inches/year (10 year average)

Land use	Area (10^8 m^2)	Case Type	Evapotrans-piration	Deep infiltration	Shallow infiltration	Runoff
Transportation, communication & utilities	11.3	4	106,049	17,674	35,349	194,424
Low density urban	21.0	2	249,582	137,927	137,927	131,359
Medium density urban	19.2	3	210,070	90,030	120,040	180,060
High density urban	20.0	4	187,460	31,243	62,486	343,677
Pristine	71.5	1	894,145	558,840	558,840	223,536
Developed: Recharge, precipitation (**Rp**) = 0.5 x shallow infiltration + deep infiltration = 454,778 Discharge, precipitation (**Dp**) = 0.5 x shallow infiltration + runoff = 1,027,423						
Pristine: Recharge, precipitation (**Rp**) = 0.5 x shallow infiltration + deep infiltration = 838,261 Discharge, precipitation (**Dp**) = 0.5 x shallow infiltration + runoff = 502,957						

0308 , St. Johns Hydrological Unit

Conditions	Waq	Rp	Ru	Raq	Raq (dev.)/ Raq (Pris.)	Ws	Dp	Du	Dn	Dw	Dw (dev.) / Dw (Pris.)
Developed	172,471	454,778	**90,299**			69,988	1,027,423	**128,172**			
Pristine	0	838,261	**0**			0	502,957	**0**			

All values in Mgal/ year

Urban recharge (Ru) consists of:

- Supply pipe leaks
- Waste water pipe leaks
- Domestic irrigation
- Septic systems
- Treated waste water injection
- Waste water reuse (ground application, wetlands, etc.)

Urban discharge (Du) consists of:

- Domestic irrigation
- Cooling water disposal from power plants
- Treated waste water disposal
- Waste water reuse (ground application, wetlands, etc.)

0308 , St. Johns Hydrological Unit

Conditions	Waq	Rp	Ru	Raq	Raq (dev.)/ Raq (Pris.)	Ws	Dp	Du	Dn	Dw	Dw (dev.) / Dw (Pris.)
Developed	172,471	454,778	90,299	**373,606**		69,988	1,027,423	128,172	**1,085,607**		
Pristine	0	838,261	0	**838,261**		0	502,957	0	**502,957**		

All values in Mgal/ year

Net recharge to aquifer, Raq

Net discharge to surface water, Ds

Developed: Raq = Rp + Ru – Waq = 373,606

Dn = Dp + Du – Ws = 1,085,607

Pristine : Raq = Rp + Ru – Waq = 838,261

Dn = Dp + Du – Ws = 502,957

0308 , St. Johns Hydrological Unit

Conditions	Waq	Rp	Ru	Raq	Raq (dev.)/ Raq (Pris.)	Ws	Dp	Du	Dn	Dw	Dw (dev.) / Dw (Pris.)
Developed	172,471	454,778	90,299	373,606		69,988	1,027,423	128,172	1,085,607	**1,458,213**	
Pristine	0	838,261	0	838,261		0	502,957	0	502,957	**1,341,218**	

All values in Mgal/ yearC

Total discharge from hydrological unit (watershed), Dw

Developed: Dw = Raq + Dn = 1,458,213

Pristine : Dw = Raq + Dn = 1,341,218

0308 , St. Johns Hydrological Unit

Conditions	Waq	Rp	Ru	Raq	Raq (dev.)/ Raq (Pris.)	Ws	Dp	Du	Dn	Dw	Dw (dev.) / Dw (Pris.)
Developed	172,471	454,778	90,299	373,606	0.44	69,988	1,027,423	128,172	1,085,607	1,458,213	1.09
Pristine	0	838,261	0	838,261		0	502,957	0	502,957	1,341,218	

All values in Mgal/ year

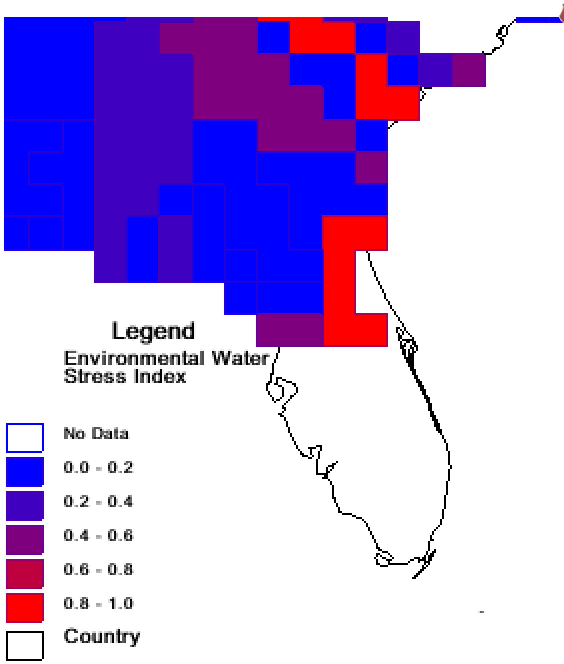
Impact indicators:

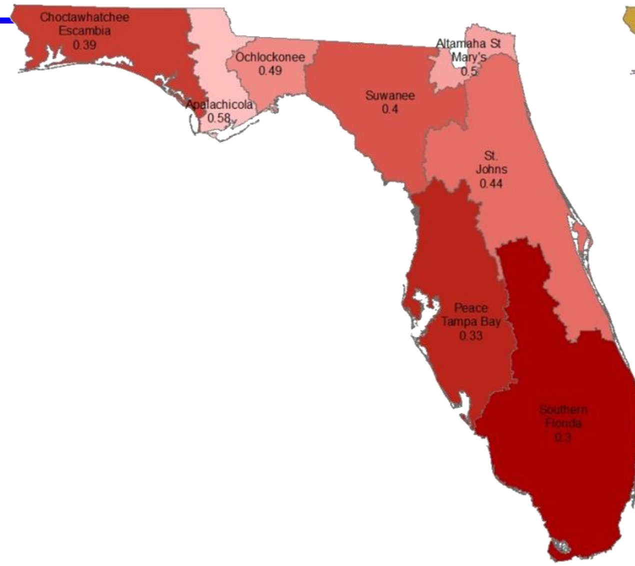
Impact on Aquifer = Raq (developed)/ Raq (pristine) = 0.44

Impact on Surface water resource = Dw (developed)/ Dw (pristine) = 1.09

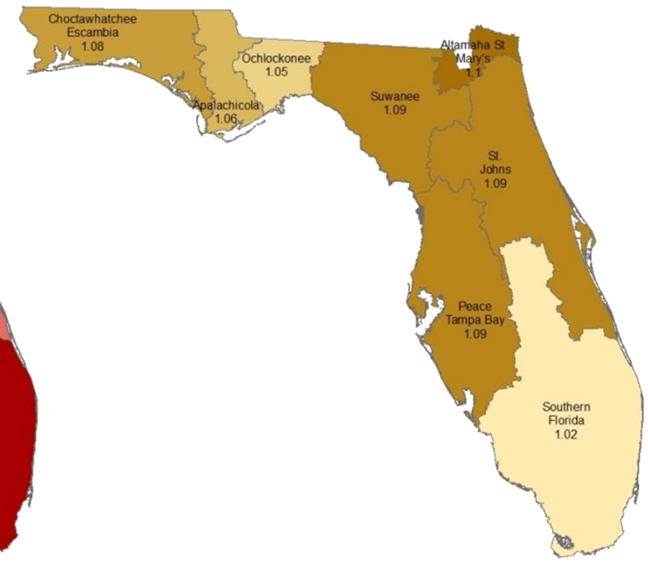
HU Code	Hydrological Unit	Raq (Developed)/ Raq (Pristine)	Dw (Developed)/ Dw (Pristine)
O314	Choctawhatchee Escambia	0.39	1.08
O313	Apalachicola	0.58	1.06
O312	Ochlockonee	0.49	1.05
O311	Suwanee	0.40	1.09
O310	Peace Tampa Bay	0.33	1.09
O309	Southern Florida	0.30	1.02
O308	St. Johns	0.44	1.09
O307	Altamaha St Mary's	0.50	1.10

Model Comparison





Aquifer



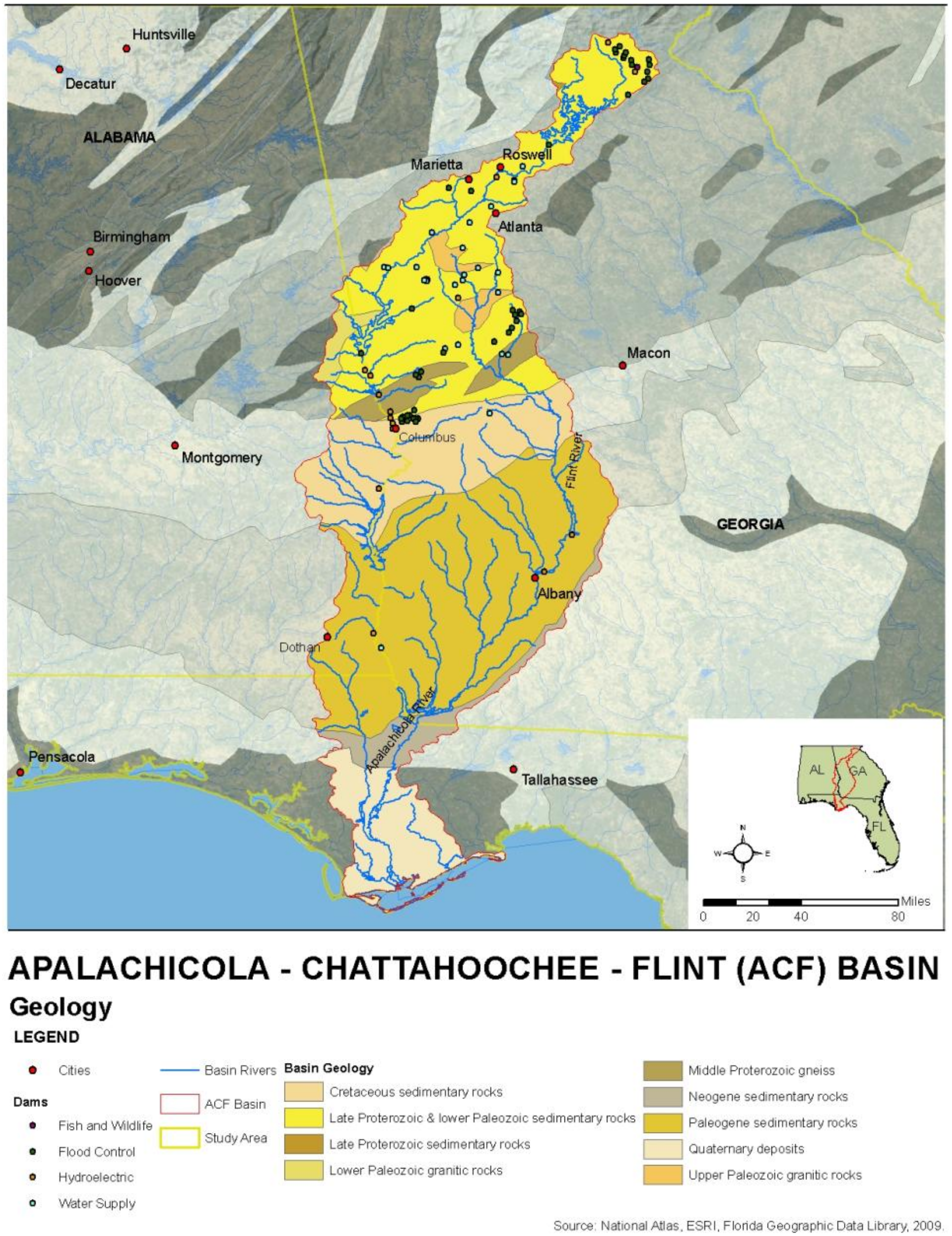
Surface Water

Global Water System Project

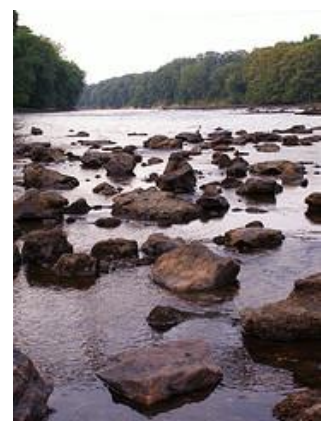
Source: www.atlas.gwsp.org

Impact Indicators

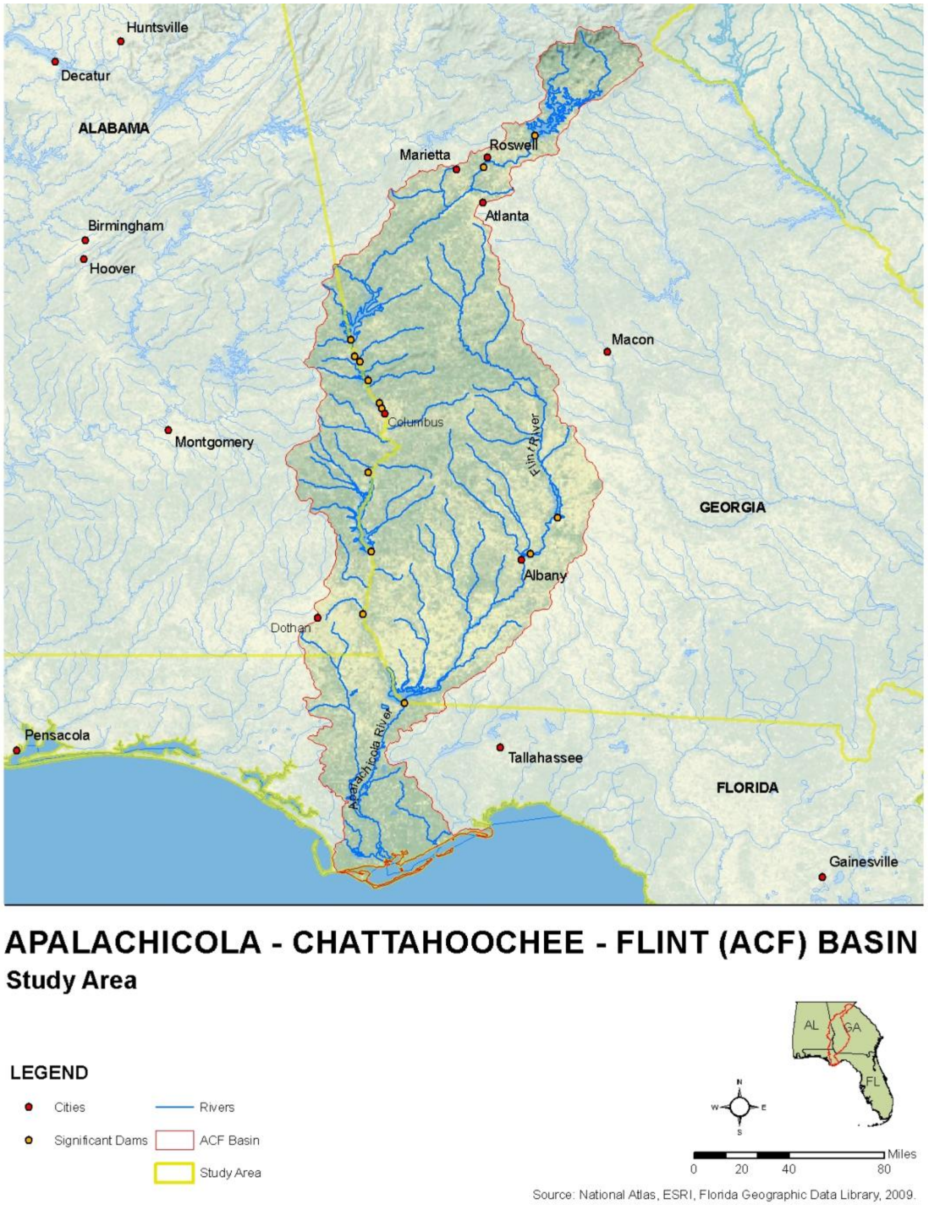
ACF Introduction and Geology



- Geology in the lower Flint River basin provides access to the Floridan aquifer water resources



Introduction – ACF basin snapshot



- **Area**: 19,600 sq. mi. or 12.3 million acres
- **Population**: 1995 - 4 million

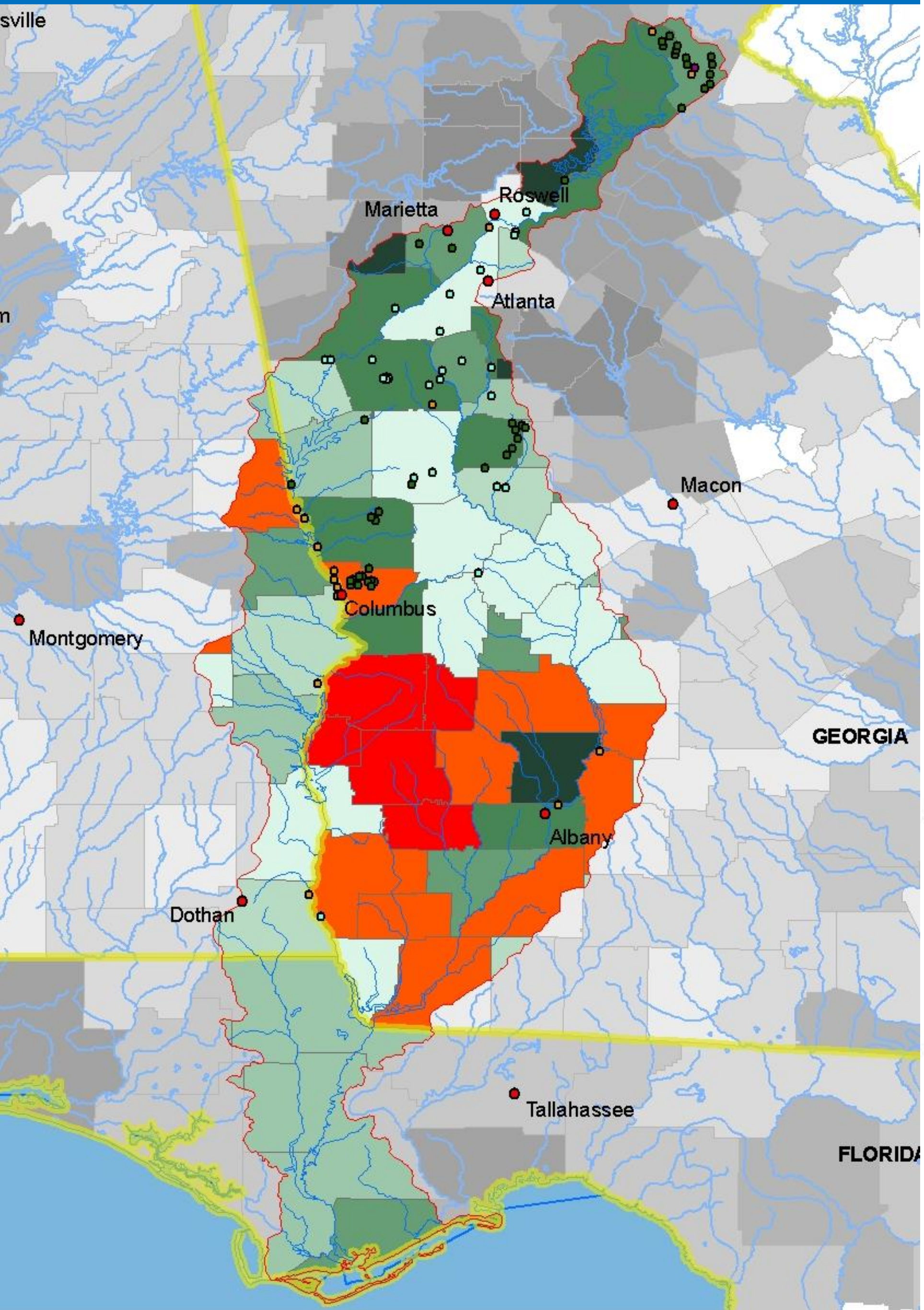
  2050 estimated - 7 million
- **Land use**: 6% residential; 2% commercial; 25% agricultural; balance is mainly undeveloped forested
- **Reservoirs**: hundreds of reservoirs, 16 on the three principal river main stems (11 non-federal and 5 federal)
- **Storage**: W.F. George storage area 45,000 surface acres and Lake Lanier storage area 38,500 surface acres
- **Basin:**

Basin:	Georgia	Alabama	Florida
Population	90%	7%	3%
Basin area	74%	15%	11%
Withdrawals	82%	11%	7%

Source: Presentation to USDA-CSREES, National Water Conference Savannah, GA by Robert Haskell Abrams, Professor of Law, Florida A & M University (January 31, 2007)

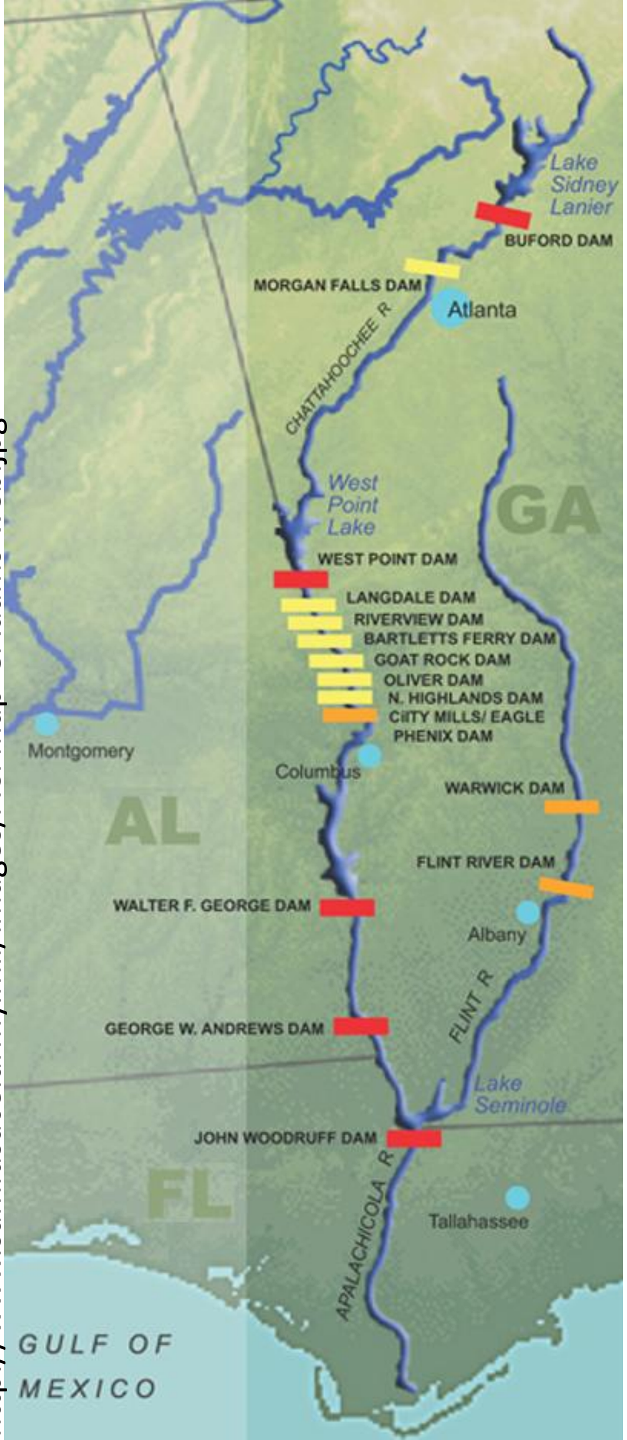
ACF population growth

Projected Population growth 2000 - 2015



SOURCE: USGS POPULATION DATA

http://www.sam.usace.army.mil/images/ACFmap-GAdams-web.jpg



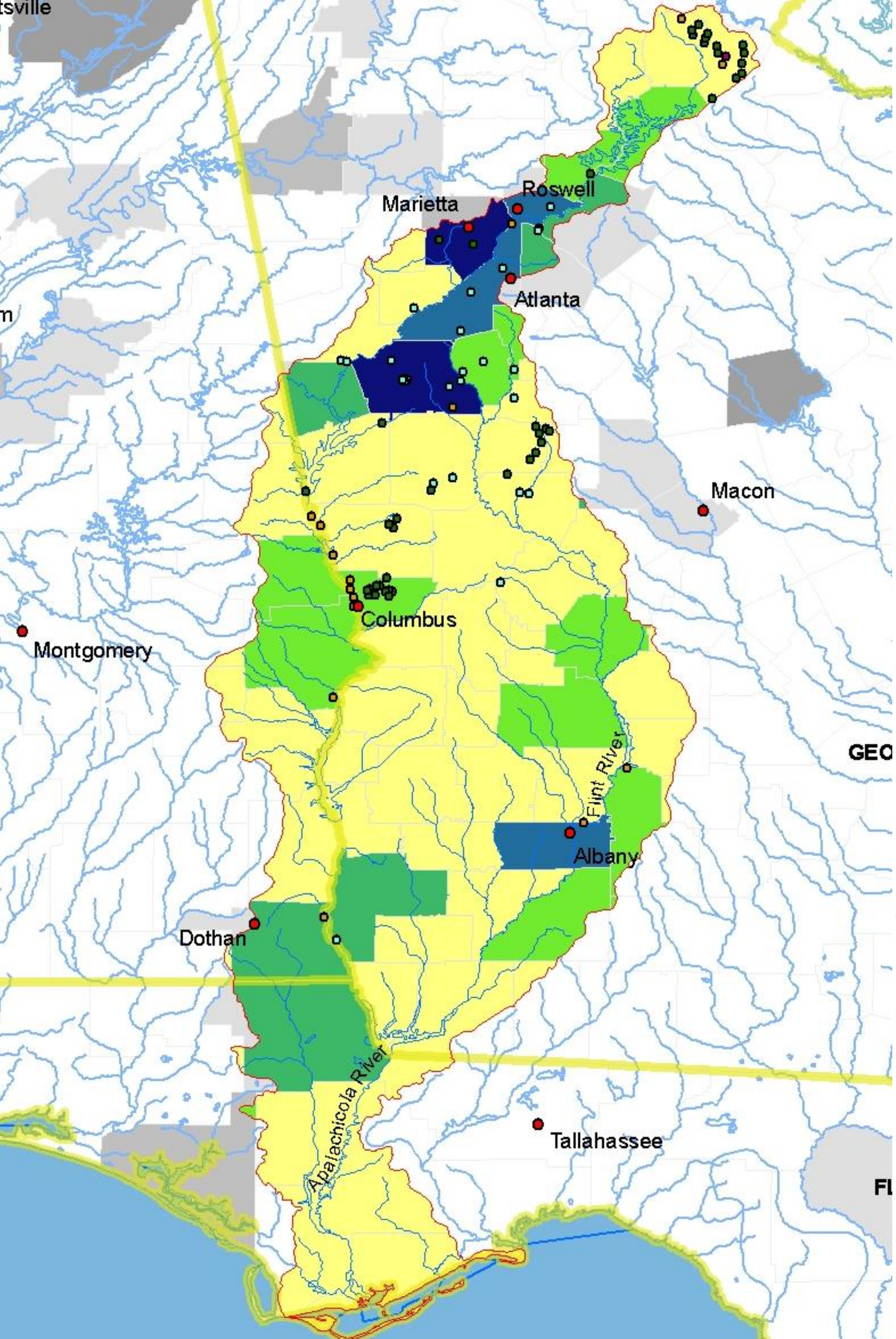
ACF basin – reservoirs and storage

		FULL POOL SURFACE AREA		STORAGE CAPACITY	
CHATTAHOOCHEE RIVER	**DATE**	**ACRES**	**% TOTAL**	**CFS-DAYS**	**%TOTAL**
LANIER	1957	38,520	**22.8%**	583,332	**66.4%**
WEST POINT	1975	25,864	**15.3%**	154,341	**18.7%**
NORTH HIGHLANDS	1900	131	10.0%		0%
OLIVER	1959	2,150	1.3%		0%
BARTLETTS FERRY	1926	5,850	3.5%		0%
GOAT ROCK	1912	1,050	0.06%		0%
LANGDALE	1860	152	0.1%		0%
MORGAN FALLS	1903	580	0.3%		0%
RIVERVIEW	1902	75	0.0%		0%
CITY MILLS	1963	110	0.1%		0%
W.F.GEORGE	1964	45,181	**26.8%**	123,219	**14.9%**
ANDREWS	1963	1540	0.9%		0%
SEMINOLE	1954	37,500	**22.2%**	18,234	**2%**
SUBTOTAL		**158,725**	**94.1%**	**825,892**	**100%**
FLINT RIVER					
LAKE BLACKSHEAR	1903	8,525	5.5%		
LAKE WORTH	1920	1,400	0.8%		
SUBTOTAL		**9,925**	**5.9%**	**0**	
TOTAL		**168,650**			

SOURCE: DR. S. LEITMAN

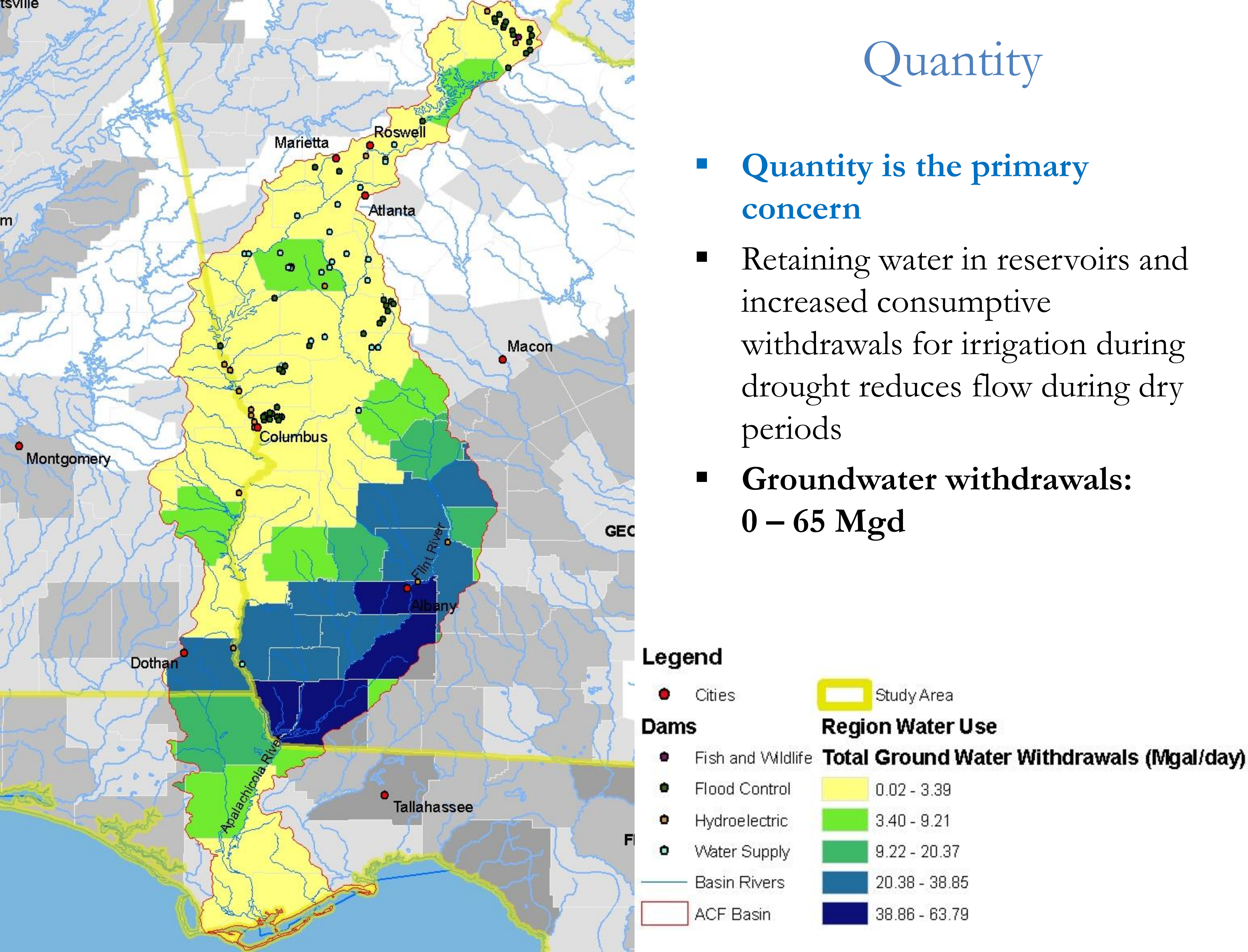
Quantity

- **Quantity is the primary concern**
- Focus has been on managing flow rather than managing demand
- **Surface water withdrawals: 0 – 555 Mgd**

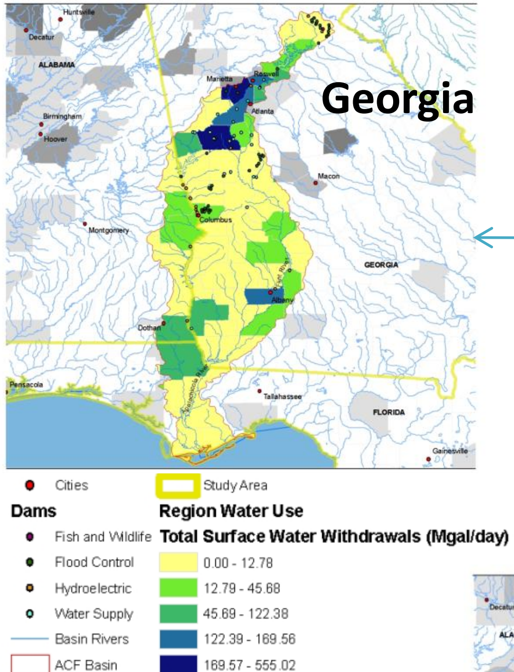


Quantity

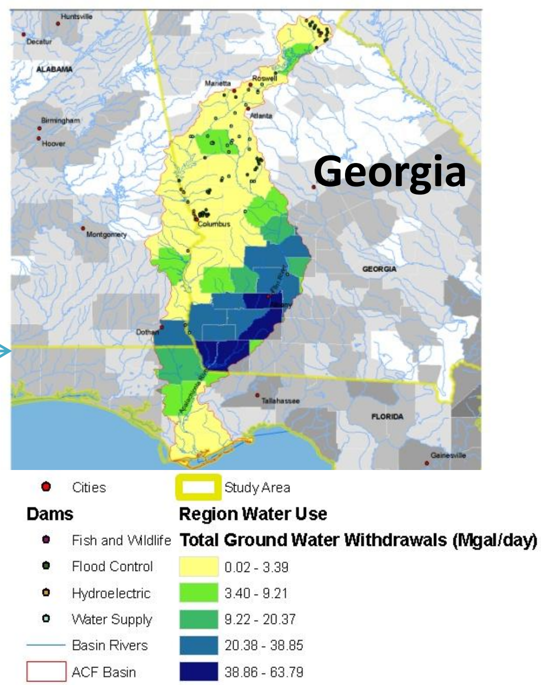
- **Quantity is the primary concern**
- Retaining water in reservoirs and increased consumptive withdrawals for irrigation during drought reduces flow during dry periods
- **Groundwater withdrawals: 0 – 65 Mgd**



Stakeholder interests by State



Total surface water withdrawals



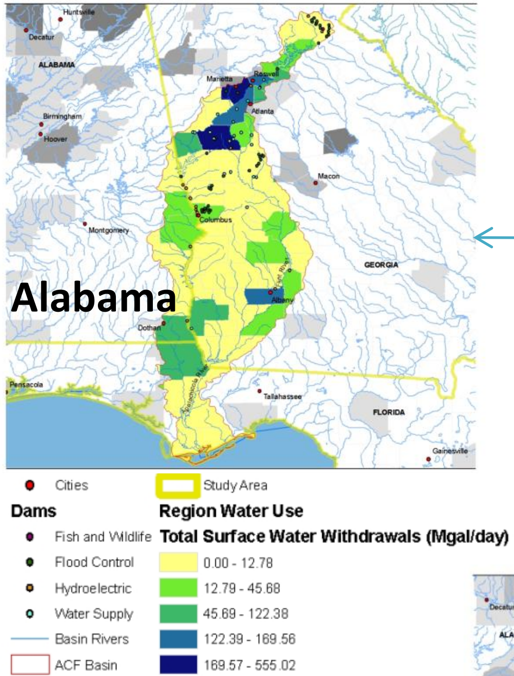
Total ground water withdrawals

Georgia

Secure adequate and non-costly water supply that would not hinder the rapid economic and population growth in the region:

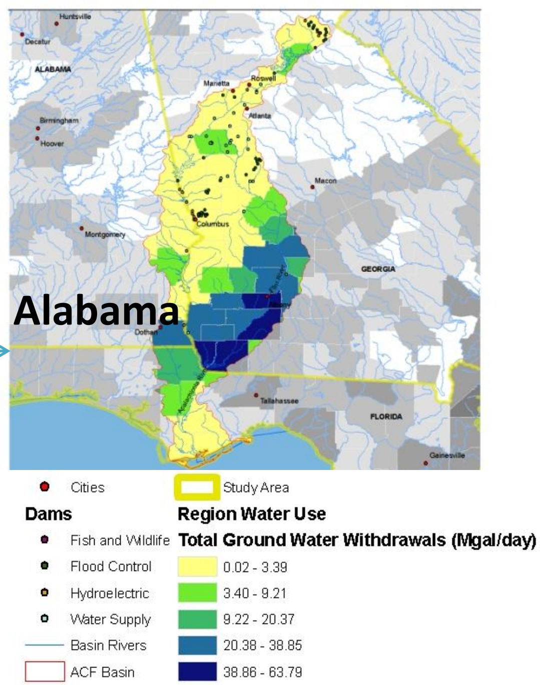
- fulfill metro Atlanta water needs, i.e., major public and industrial supply demands
- keep reservoir storage full to support withdrawals in periods of drought and provide for water-based recreation at other times
- serve southern Georgia agricultural demand
- also interested in hydropower production and commercial navigation

Stakeholder interests by State



Total surface water withdrawals

Total ground water withdrawals

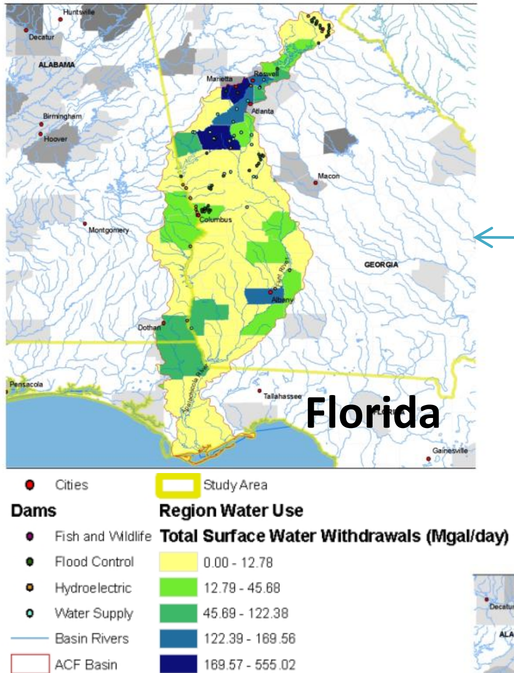


Alabama

Secure sufficient quantity and quality of water that insures healthy downstream flow to attract future economic growth:

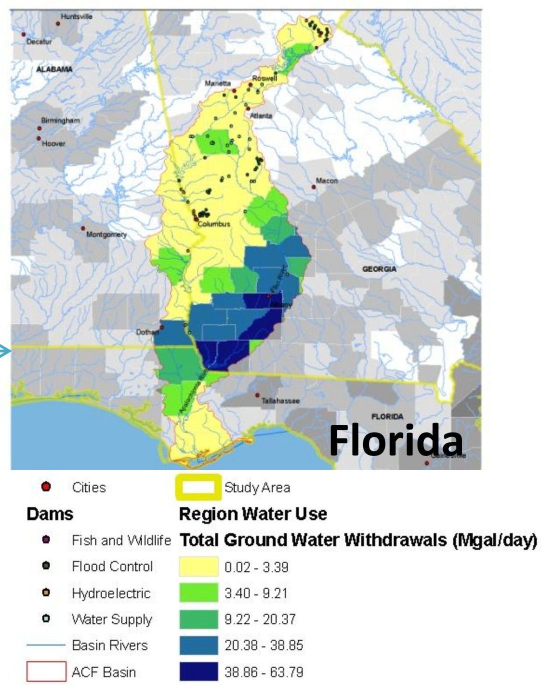
- preserve water withdrawals for increased agricultural and manufacturing development
- serve industrial thermal cooling demand
- long history of favoring management of federal reservoir system to support having a commercial navigation channel in Apalachicola River

Stakeholder interests by State



Total surface water withdrawals

Total ground water withdrawals



Florida

A flow regime that will maintain biological diversity and productivity of Apalachicola Bay:

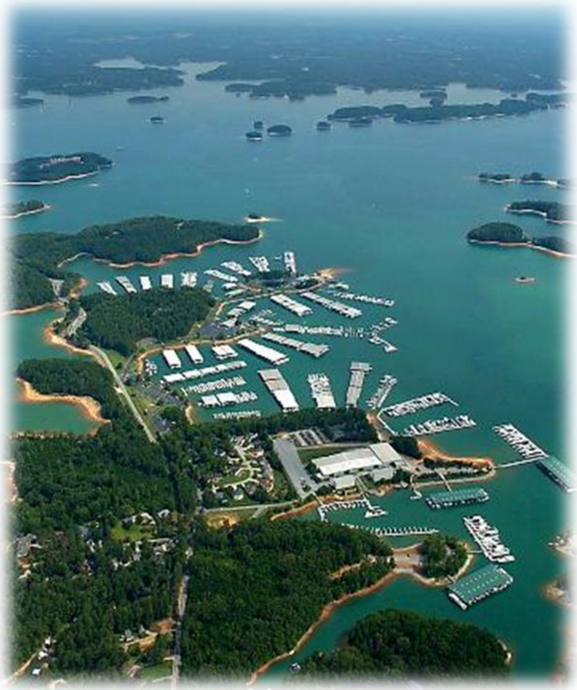
- preserve Apalachicola estuary (resisted dam construction for federal navigational channel)
- preserve the shellfish industry
- serve agricultural demand

Withdrawal by type: Summary

Type	Withdrawal (Mgd)		Total (Mgd)
	Surface	Ground	
Municipal and industrial	735	134	**869**
Industrial self-supplied	161	24	**185**
Irrigation	230	534	**764**
Thermoelectric	1460	1	**1461**
Aquaculture	8	8	**16**
Domestic self-supplied		66	**66**
Total	**2594**	**767**	**3361**

- The USGS has estimated that monthly consumption for the Chattahoochee River Basin above West Point varied from 18 to 34% of total surface water withdrawals.

Water and Ecosystem rights



- Ecosystem rights have limited representation in the discussions to date

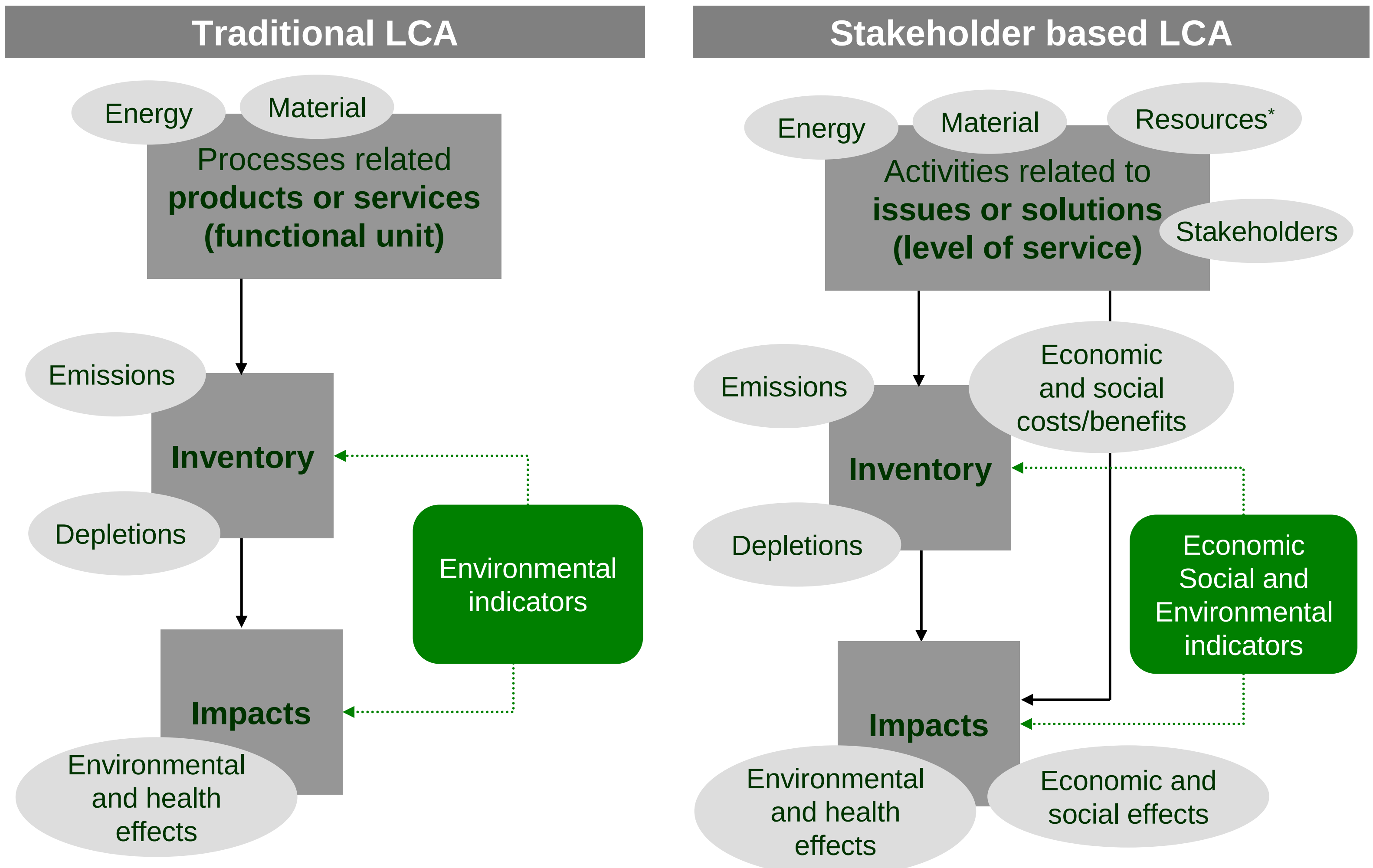
- A management solution to water allocation will need to consider the flow, quality, and quantity of the basin ecologically and as an immovable constant rather than a negotiable commodity.

Conclusions

- Complex water models are needed to more accurately model aquifer flows and determine impacts of development
- Climate change is predicted to have an effect on rainfall
- Multi-decadal rainfall cycles

- The ACF basin requires an integrated study of human and natural systems
- Design systems and management regimes that recognize the equal value of quality of life, economic opportunity, and the necessity for ecosystems to thrive
- Negotiations to date have focused on managing flow rather than reducing demand

Stakeholder-based Life Cycle Assessment



*Resources include financial, institutional, physical, human and natural resource demands

Post-tsunami Reconstruction in Sri Lanka

Reconstruction and Development Agency (RADA) of the Government of Sri Lanka

Collaboration with ETHZ, MIT, and GTZ

Simplified qualitative and qualitative indicators

- Mid point and end point

Flexible analysis

- Generic or detailed level depending on planning situation

Wastewater Treatment Case Study

Grey water

1) discharged to the surface of the household's own plot of land

2) discharged to a nearby canal

3) piped to a treatment plant

Black water

1) discharged to a two chambered septic tank on the household's own plot of land

2) discharged to the nearby canal

3) piped to a treatment plant

Participants

1) Village development committee

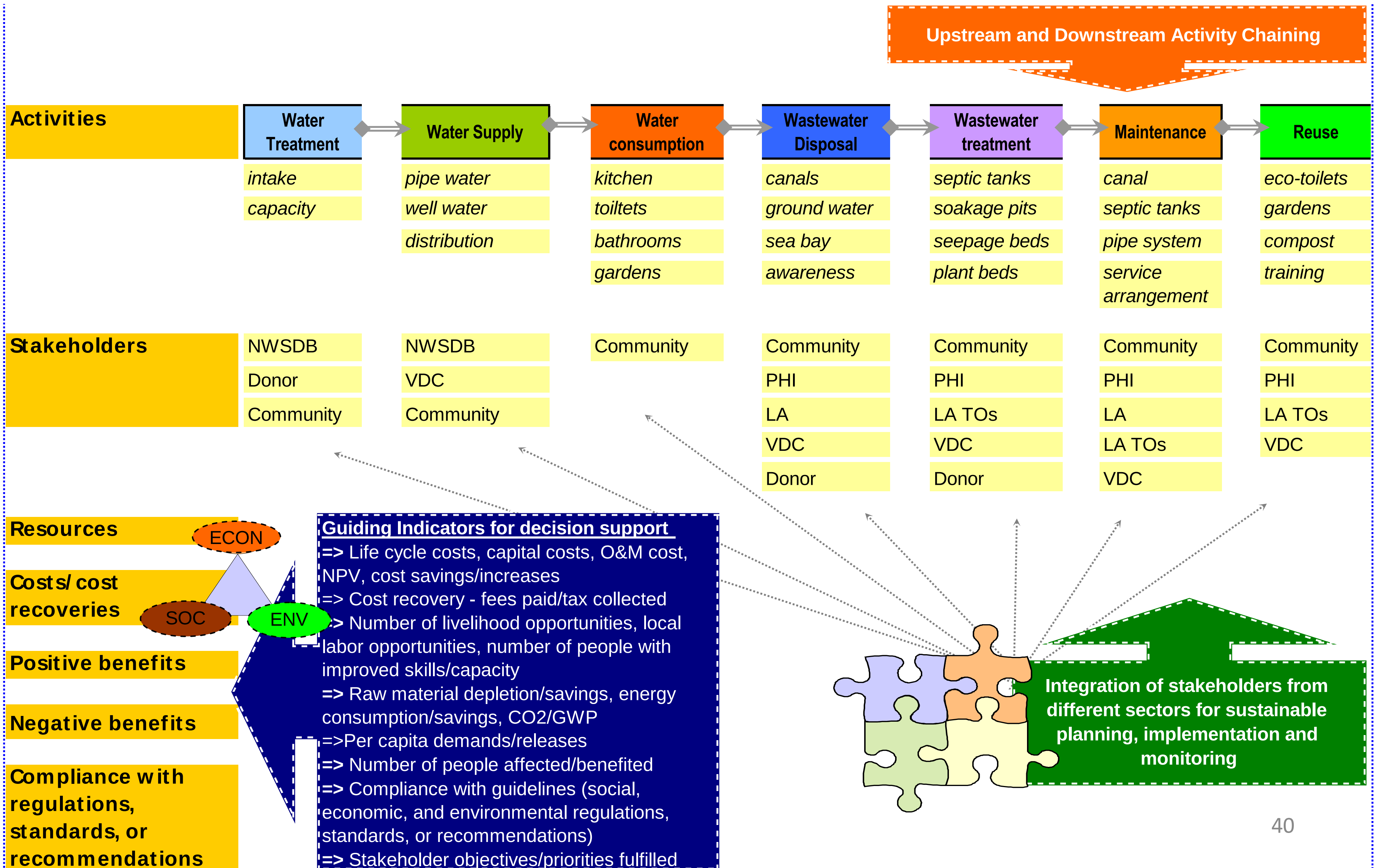
2) Technical officers

3) Public health officers

4) Local authority representatives

Pilot study location: Unawatuna Village

Stakeholder-based LCA framework



Wastewater discharged to canals

	Basic kitchen and bathroom plumbing	Pipe lay till canal	Discharge of wastewater to canal	Maintenance
Economic indicators	Cost of internal plumbing	Pipe cost (own labor) No fees	No cost of disposal Loss of income (affected tourism)	No cost
Social indicators			No. of people benefited with no cost	No. of people affected with diseases No. of people directly affected with bad smell along canal
Environmental indicators	Not connected to safe external plumbing	No pollution in own plot	Discharge load per day Well/shallow tube well water pollution	Canal pollution Mosquito/fly problem (diseases) Eutrification in canal

Wastewater discharged to treatment plant

	Basic kitchen and bathroom plumbing	External plumbing to treatment plant	Design and construction of treatment plant	Disposal to treatment plant	Operations and Maintenance
Economic indicators	Cost of internal plumbing	Cost of external plumbing No fees	Cost of design (consultant fee) Cost of construction Outside skilled labor	Connection fees (not paid)	Treatment O&M cost (no funds) Breakdown repair costs (no funds) Waste water treatments fees (unpaid)
Social indicators			Design within local capacity	No. of people benefited Increased standard of living	Donor objectives not met DS office responsibilities not fulfilled
Environmental indicators	Not connected to safe external plumbing	No pollution in own plot	Discharge load per day Reduced ground water pollution Reduced well water pollution	Reduced canal pollution Reduced own plot pollution Reduced mosquito/fly problem Reduced eutrification in canal	Increased energy use Easier operation from central location

Indicator categories	Indicator	Quantitative/Qualitative aspects
Economic	Capital costs	Quantitative
	Operation and Maintenance costs	Quantitative
	Cost savings/increases	Quantitative
	Cost recoveries – service fees/tax	Quantitative
	NPV	Quantitative/Qualitative
	Number of livelihood opportunities	Quantitative/Qualitative
	Number of local labor opportunities	Quantitative/Qualitative
	Institutional capacities inadequate/adequate	Qualitative
Environmental	Energy consumptions/savings	Quantitative
	Raw material depletions/savings	Quantitative
	CO_2/GWP increases/reductions	Quantitative
	Environmental releases (wastewater, sludge, etc.) increases/reductions	Quantitative/Qualitative
	Contribution to spread of diseases more/less	Quantitative/Qualitative
	Per capita consumption increases/reductions	Quantitative/Qualitative
	Compliance with environmental regulations, standards, or recommendations	Quantitative/Qualitative
Social	Number of people affected/benefited	Quantitative
	Number of people with improved skills and capacity	Quantitative/Qualitative
	Vulnerable group preferences ignored/considered	Qualitative
	Historical/cultural preferences ignored/considered	Qualitative
	Stakeholder objectives unfulfilled/fulfilled	Qualitative
	Compliance with socio-economic regulations, standards, or recommendations	Quantitative/Qualitative
	CBOs inactive/active	Qualitative