FORECASTING CLIMATE CHANGE SEA LEVEL RISE (SLR) IMPACTS ON SALT WATER INTRUSION (SWI) IN THE BISCAYNE AQUIFER, THE SOLE SOURCE OF WATER SUPPLY TO MIAMI-DADE COUNTY, FLORIDA, AND EVERGLADES SUBSURFACE

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2011 AEESP Education and Research Conference, July 10-12, 2011, University of South Florida, Tampa, FL

SFWMD, 2011

(NGM, 2011)

(ZIMBIO, 2011)

OUTLINE

Downtown Miami, FL (Marrero, 2011).

FRAMEWORK

OBJECTIVE

INTRODUCTION

METHODOLOGY

RESULTS & DISCUSSION

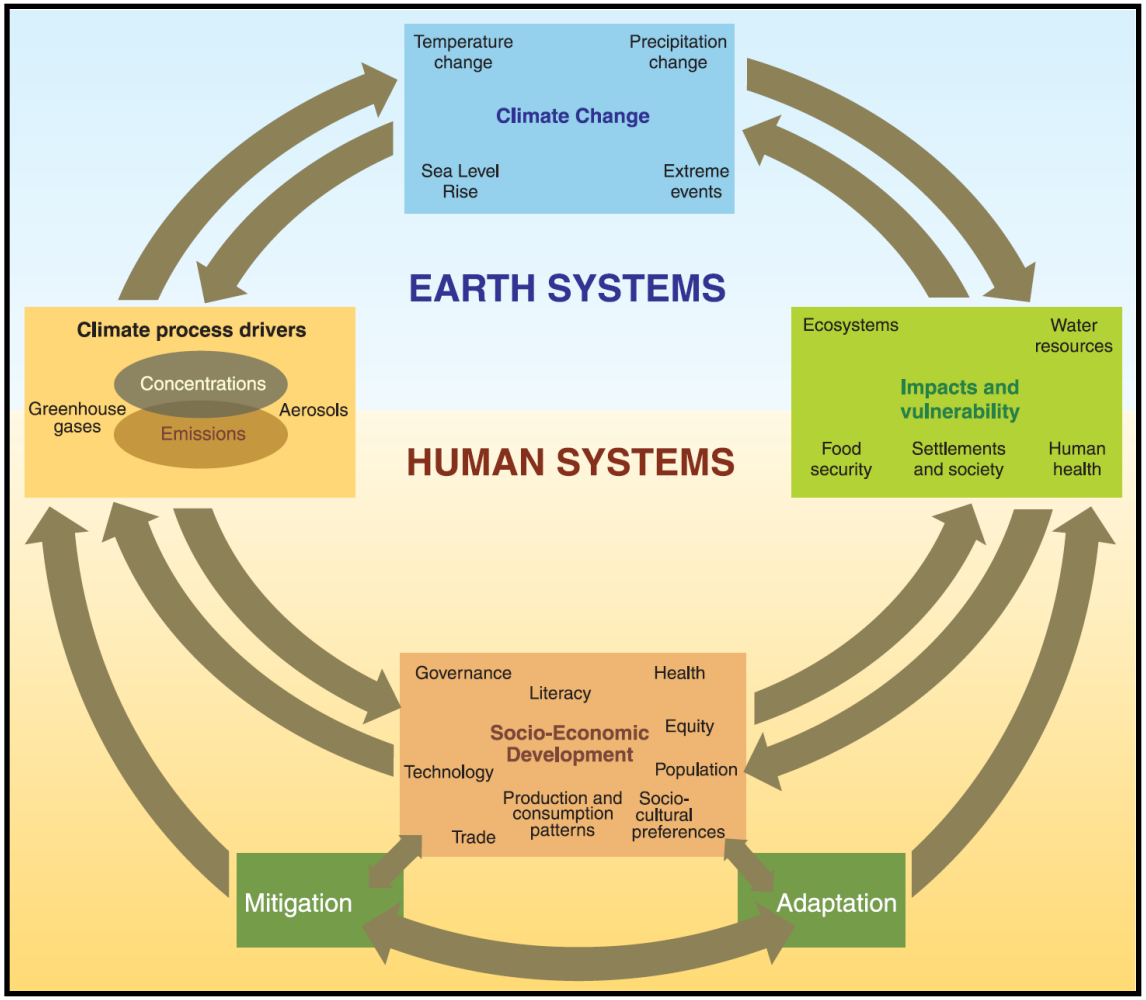
CONCLUSIONS

REFERENCES

Shark Valley, ENP (Marrero, 2011).

Wildlife, ENP (Marrero, 2011).

FRAMEWORK



IPCC Working Group II Climate change 2007: Synthesis Report, Valencia, Spain, November 12-17, 2007

OBJECTIVE

To develop an assessment of the extent of saltwater intrusion (SWI), including shifts in the halocline location from scenarios based on SLR projections and Biscayne Aquifer characteristics and hydrogeologic controls.

Wild Life, ENP. (Marrero 2011)

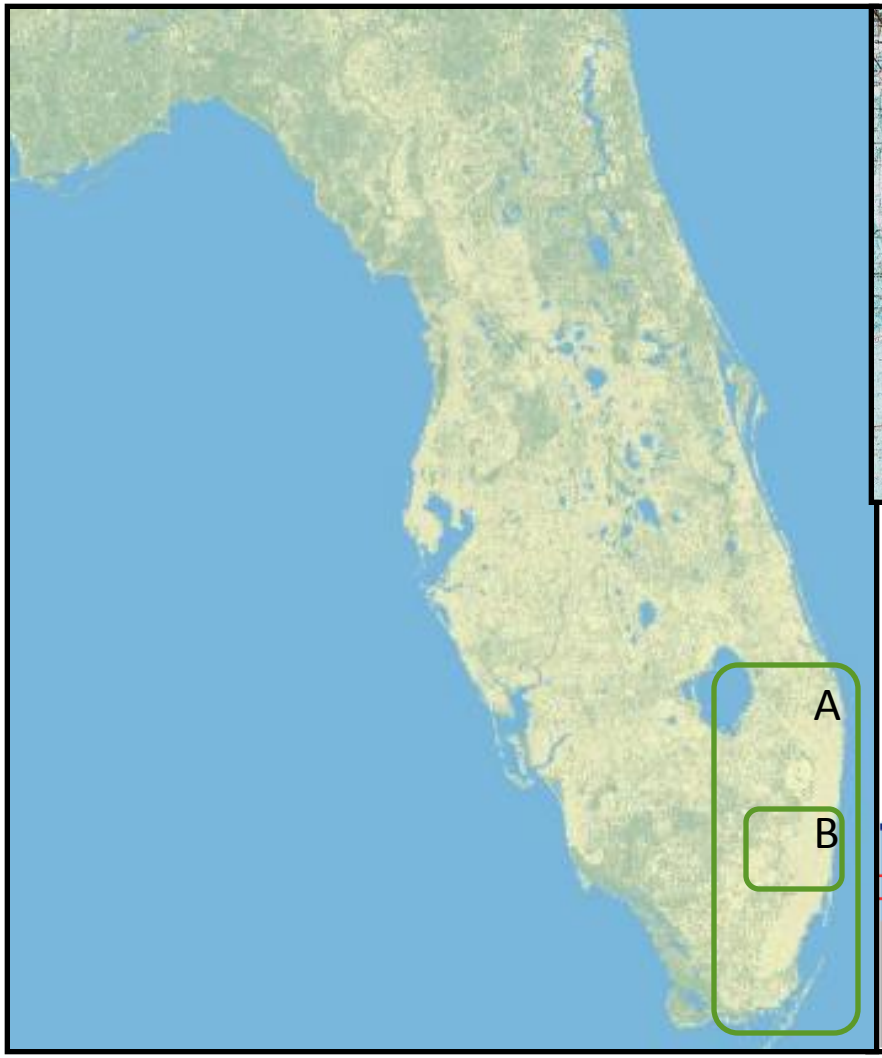
SFWMD, 2011

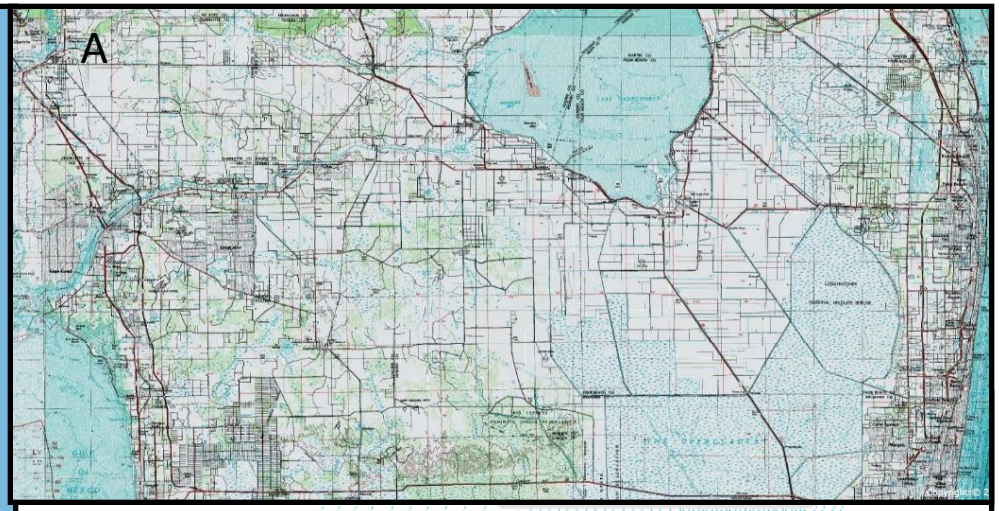
SFWMD, 2008

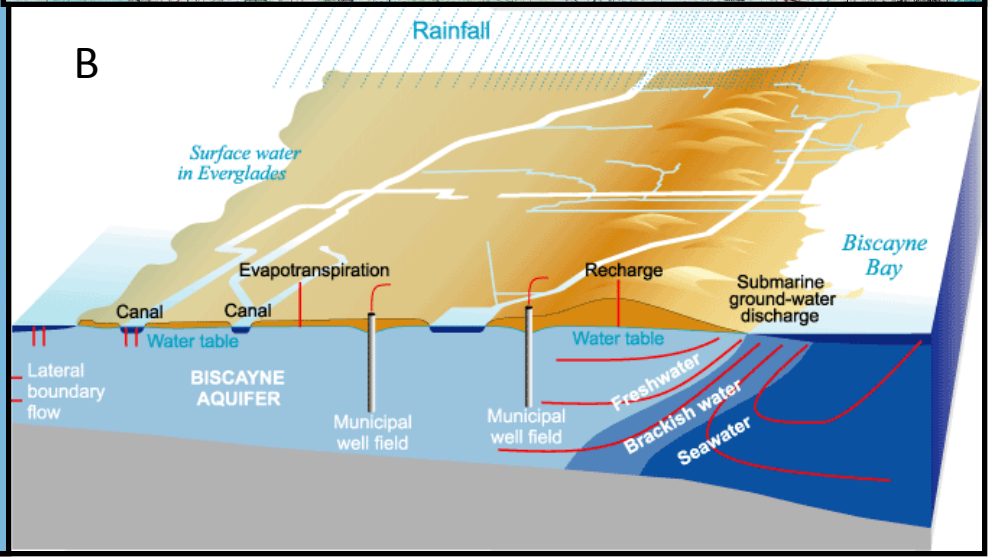
THE SETTING

- South Florida (Miami-Dade, Broward, Palm Beach and Monroe Counties): vulnerable location and topographic elevation (mostly < 7 M above MSL; most Everglades basin < 3 m above MSL)
- Biscayne Aquifer: sole source of water supply
- Complex public and private infrastructure to ensure water supply and flood control - regional habitability
- Tourism = f (coastal resources, beaches)

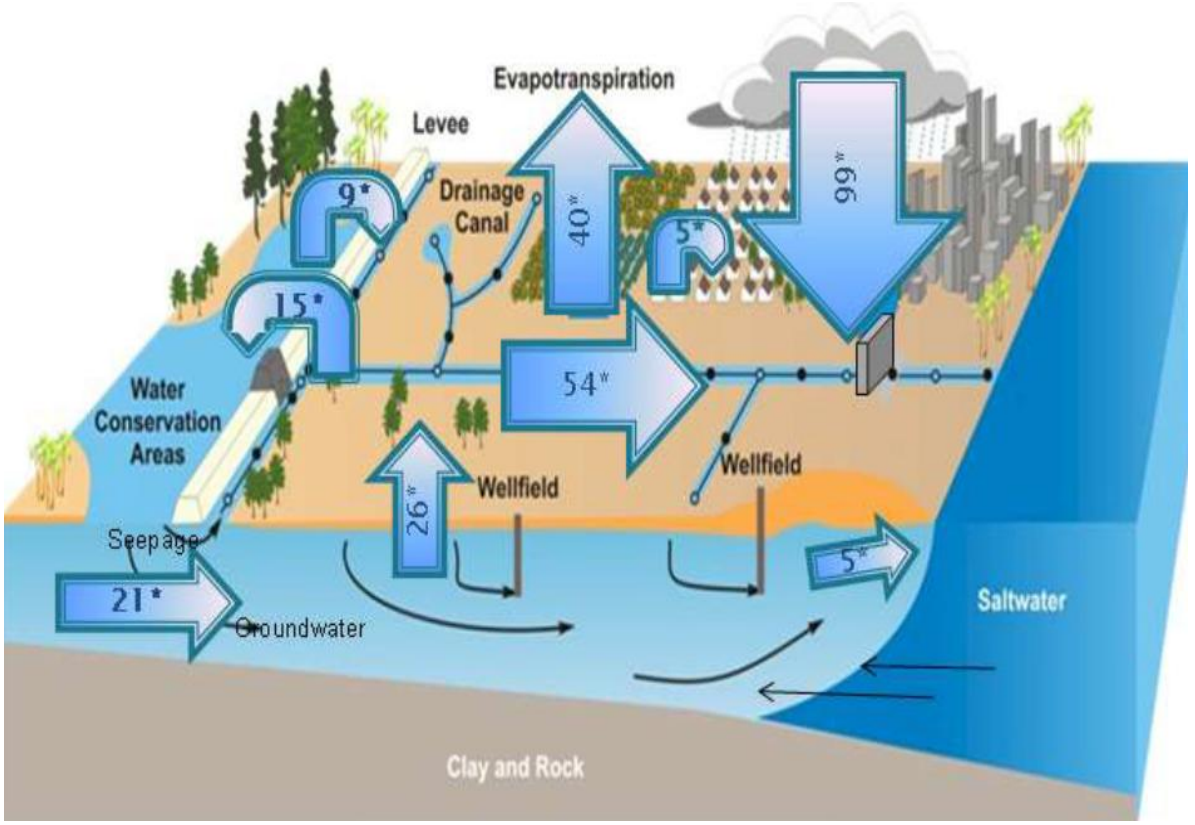
LOCATION, TOPOGRAPHY & POPULATION







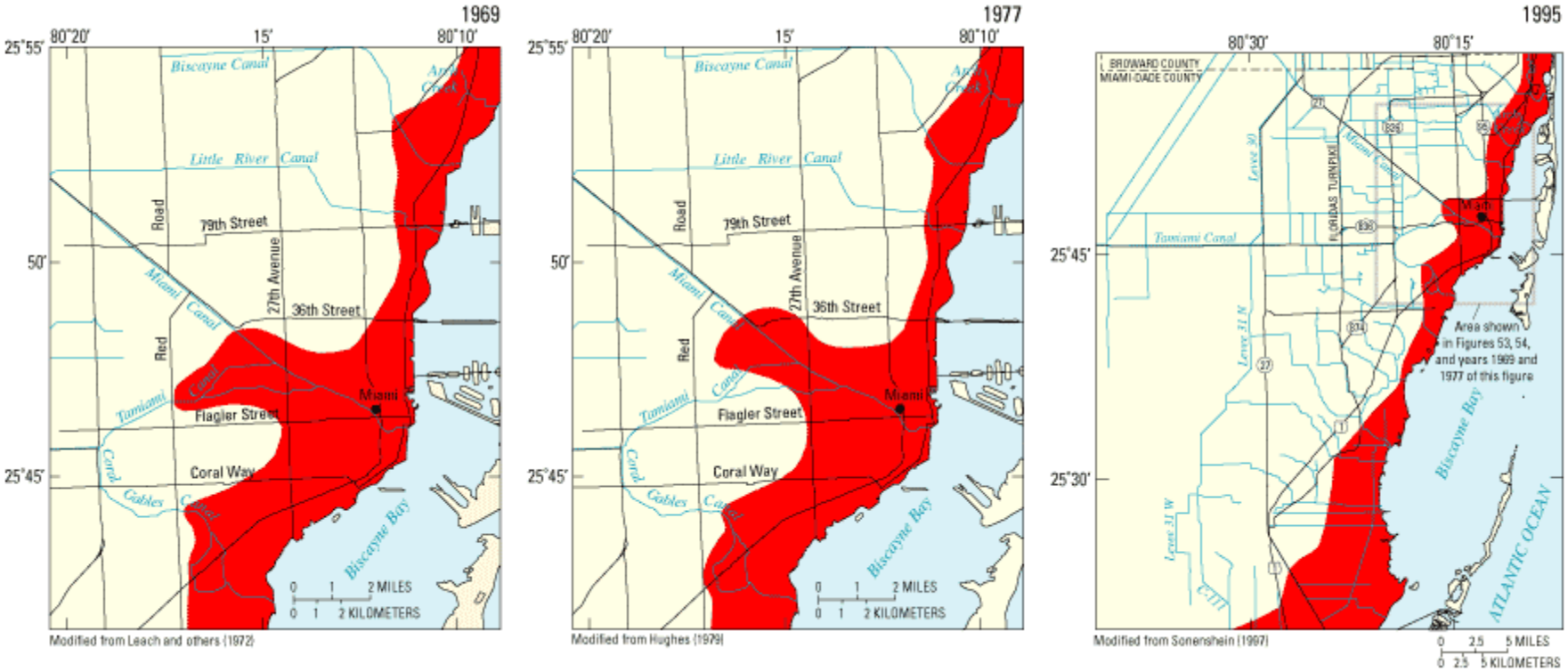
REGIONAL HYDROLOGIC WATER BUDGET



South Florida Water Balance Budget for 1965-2000. (Heimlich et al., 2009)

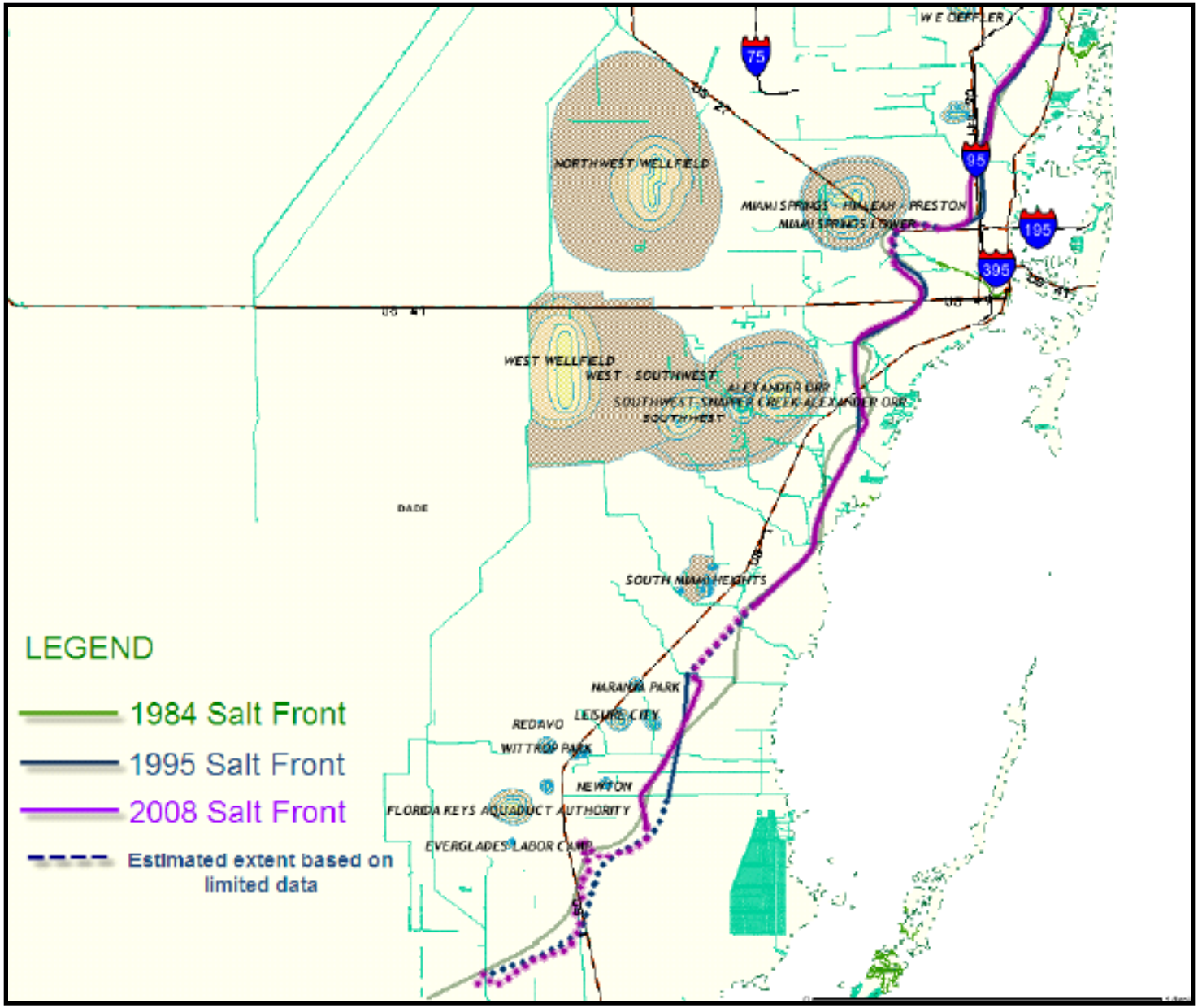
SALT WATER INTRUSION

Salt water intrusion is the encroachment of saline water into fresh groundwater regions in coastal aquifer settings…sea-level rise is expected to result in the inland migration of the mixing zone between fresh and saline water



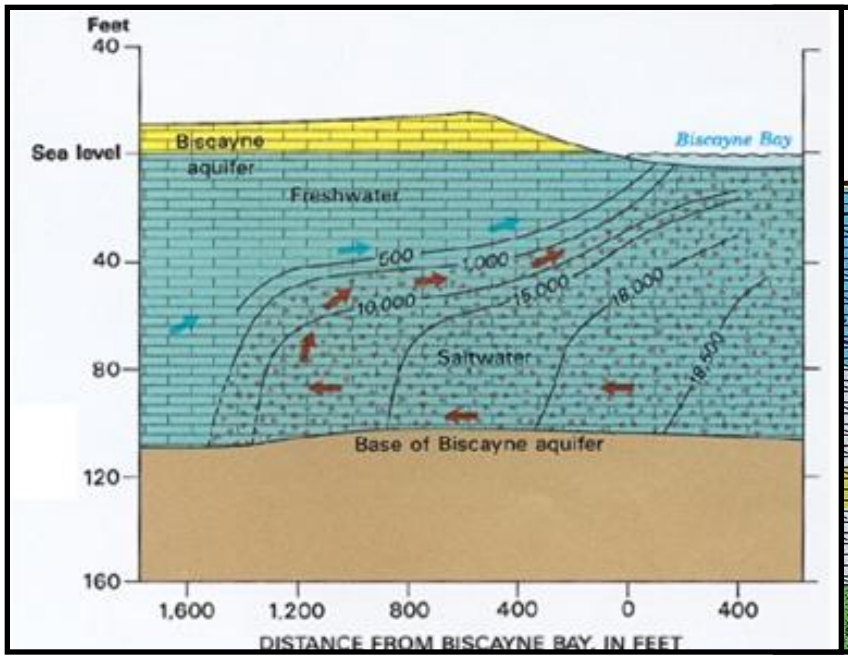
Saltwater Intrusion in Miami-Dade County 1969-1995, (USGS, 2000)

SALTWATER INTRUSION

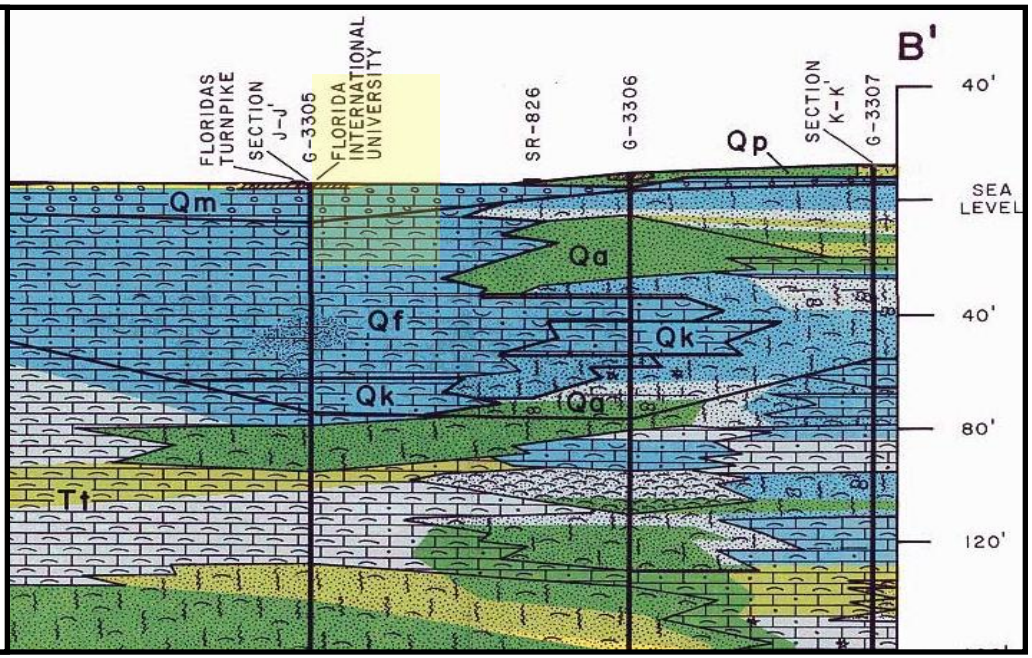


South Florida well fields saltwater intrusion vulnerability and salt front tracks for 1984,1995 and 2008.(Environment, 2011)

BISCAYNE AQUIFER



Conceptual Halocline Location in Biscayne Aquifer (U.S. D.O.I, 1973)

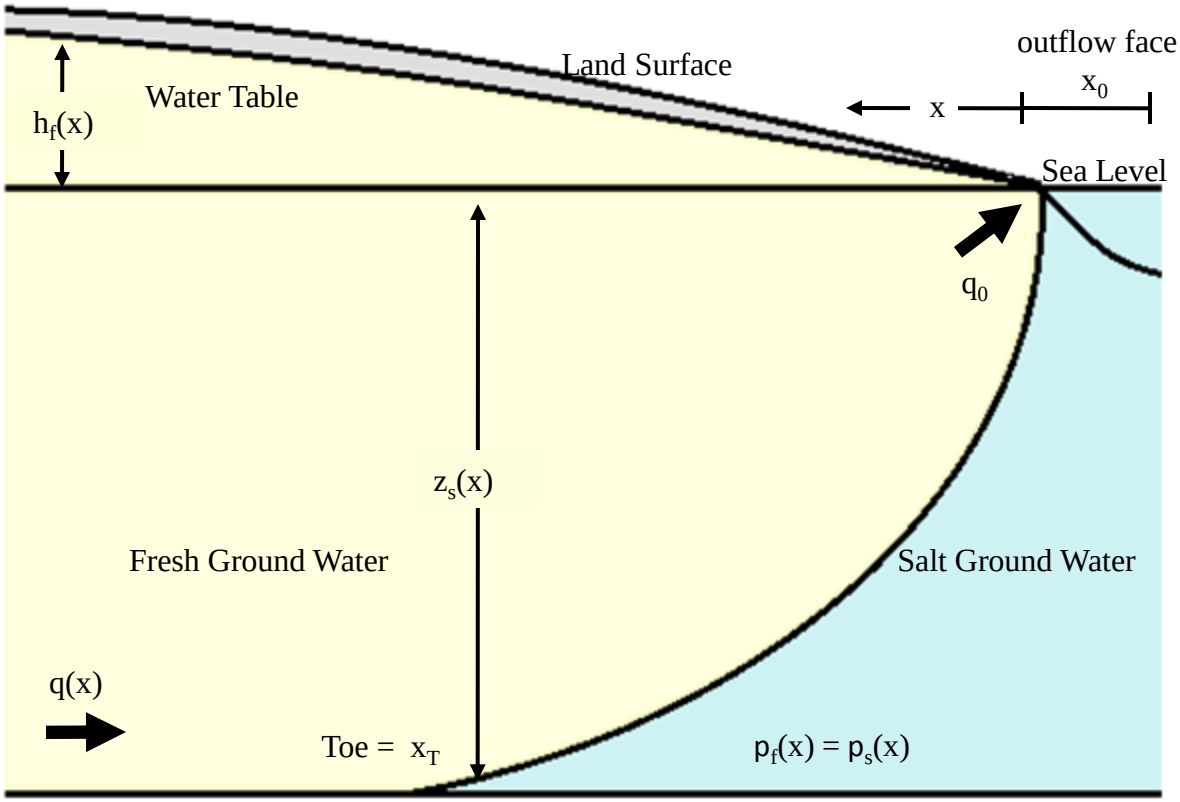


Typical Geological Cross Section of Biscayne Aquifer in MDC (SFWMD, 1991)

- Top of regional surficial aquifer system (175 – 270 feet depth in Miami-Dade County, MDC)
- Unconfined and highly permeable (**T** up to 300,000 ft^2/d), with 80 ft of upper productive interval
- Freshwater seepage toward coastal areas.
- East –West Wedge Shape Characterization
- South Florida main water supply source and sole source of drinking water for MDC

SKETCH OF THE HALOCLINE IN A HOMOGENOUS, ISOTROPIC UNCONFINED AQUIFER AT HYDROSTATIC EQUILIBIRUM IN A COASTAL ZONE

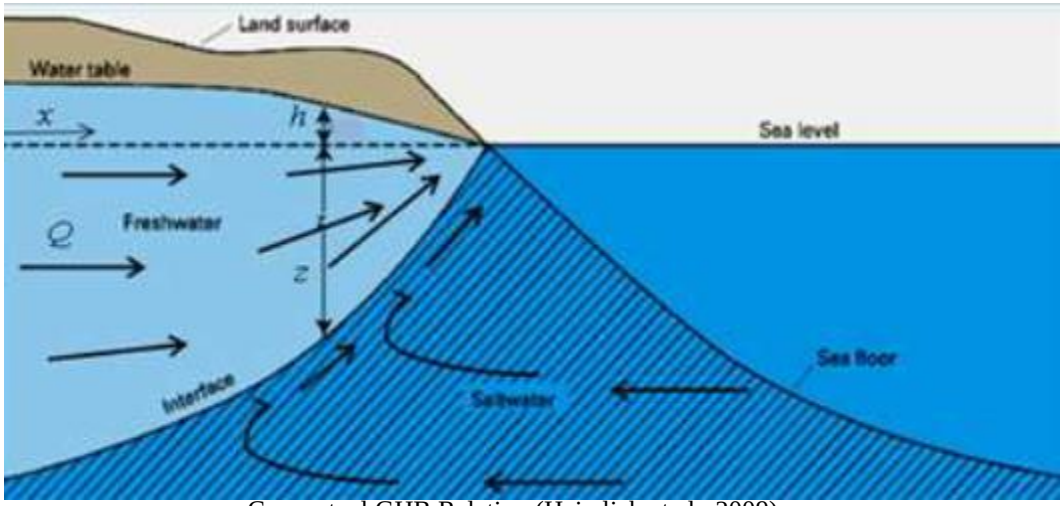
"Salt water and fresh water in a homogeneous unconfined aquifer in a coastal zone are in a hydrostatic state" (Zhou and Ying, 2009).



Amended from Werner and Simmons (2009)

DUPUIT-GHYBEN-HERZBERG RELATION

(1-D, fundamental, analytical steady-state solution)



Conceptual GHB Relation (Heimlich et al., 2009).

$$Z_s(x) = \alpha(h_f(x))$$

$$\alpha = \frac{\rho_f}{\rho_f - \rho_s}$$

$$Z_s(x) = \sqrt{\frac{2\alpha(q(0)(x))}{K}}$$

$$h_f(x) = \sqrt{\frac{2q(0)(x)}{\alpha K}}$$

Where,

$Z_s(x)$ = interface elevation below sea level

$h_f(x)$ = water table elevation above sea level

ρ_f = density of freshwater

ρ_s = density of saltwater

α = density differential coefficient

x = distance from coast

K = hydraulic conductivity

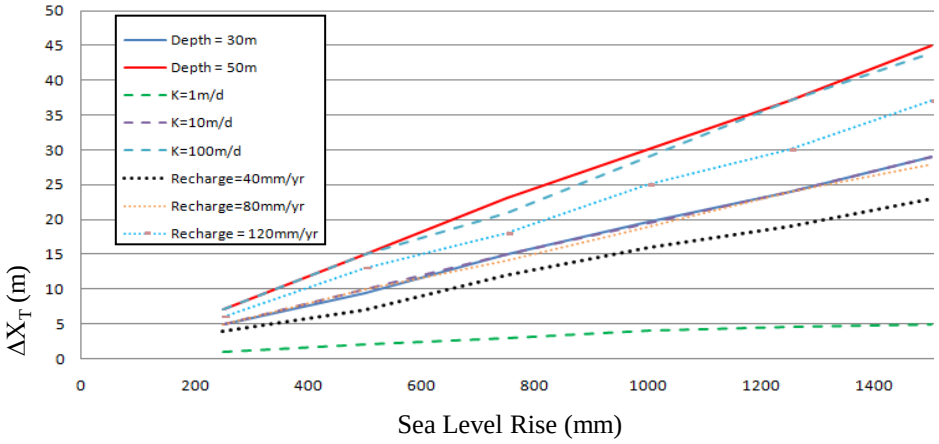
$q(0)$ = ground water discharge per unit length of coast line

INLAND HYDROGEOLOGIC CONTROLS

(Edited from Werner & Simmons, 2009)

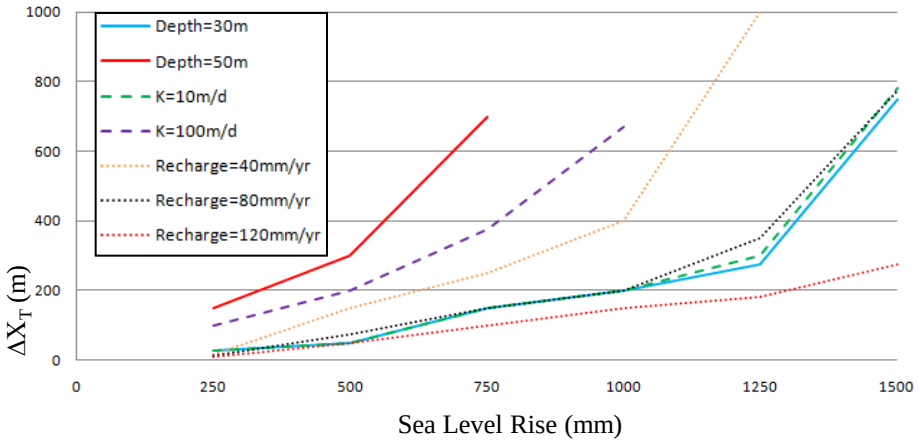
Flux-controlled Case

Discharge is maintained to control halocline's position



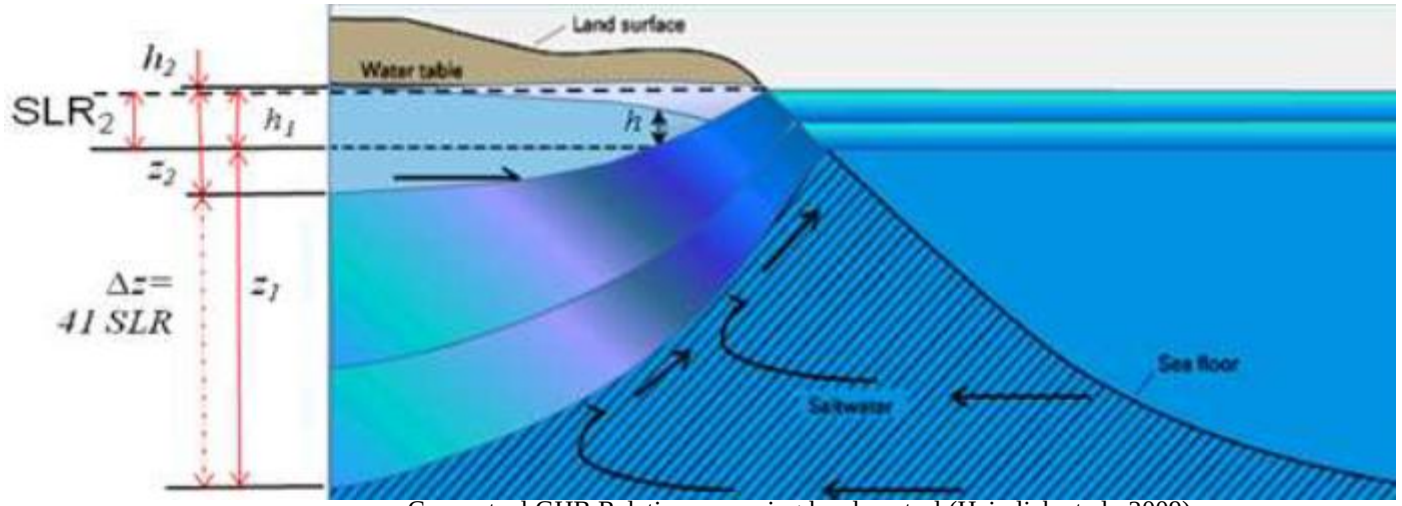
Head-controlled Case

Head in aquifer is maintained regardless of sea level rise



DUPUIT-GHYBEN-HERZBERG RELATION

(Head-Controlled Case - Worse Scenario)



Conceptual GHB Relation assuming head control (Heimlich et al., 2009).

$$\Delta Z_s = -41SLR$$

$$Z_s(x) = \sqrt{\frac{2\alpha(q(0)(x))}{K}} - 41SLR$$

Where;

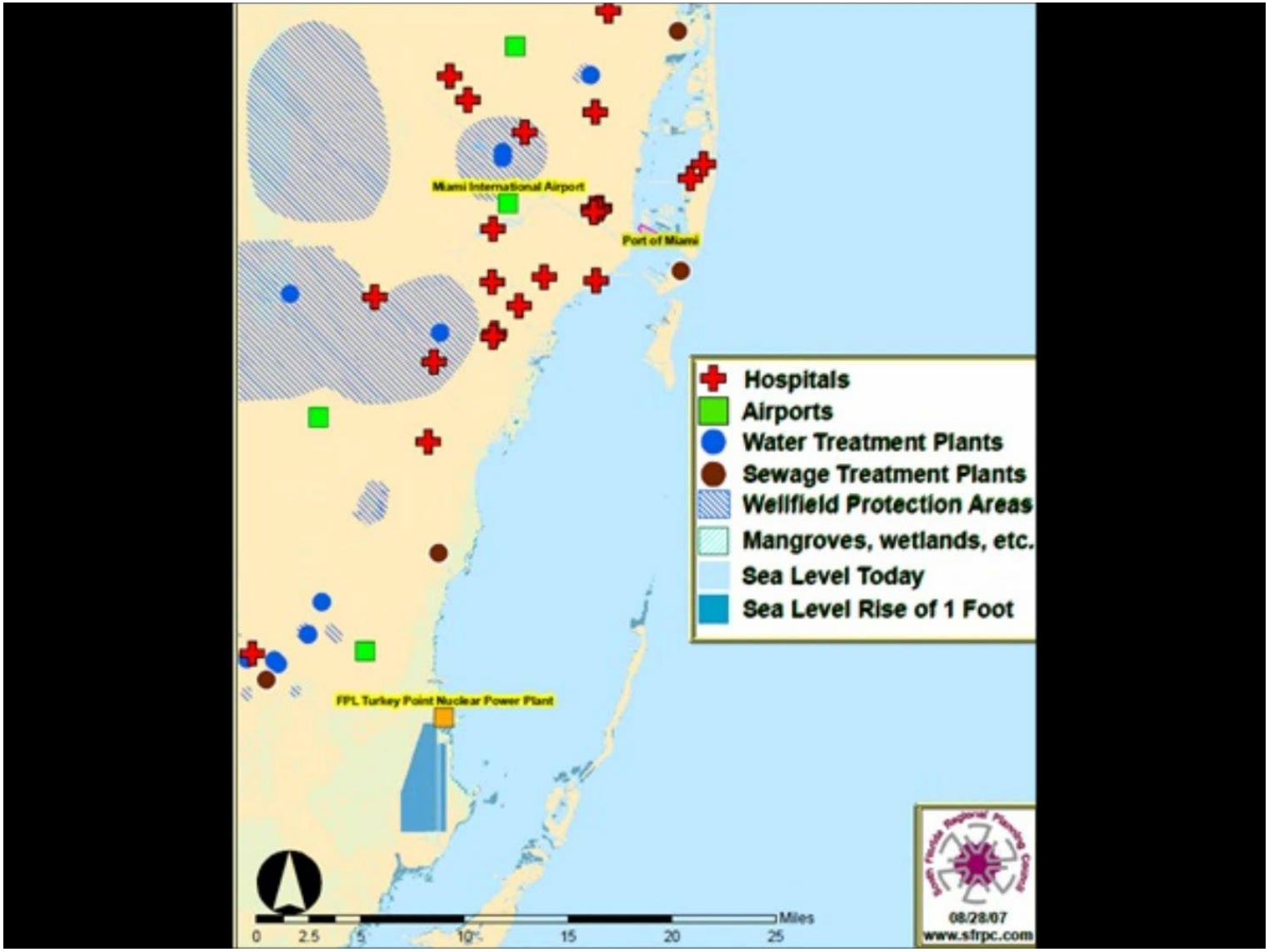
SLR = Sea level rise parameter

ΔZ_s= Change in interface depth as a function of sea level rise.

MODELING

KEY INPUT PARAMETERS		
NAME	RANGE	UNIT
Sea Level Rise	1-3	Feet (ft)
Well Field Limits	3.75-8	Miles (Mi)
Aquifer Recharge (W)	20.9	BGY/100 Sq Mi
Groundwater Seepage	5.2	BGY/100 Sq Mi
Hydraulic Conductivity (K)	K_{min}, K_{max}, K_{ave}	(ft/d)
Density Ratio (α)	33-45	N/A

QUESTIONS


Miami International Airport
Port of Miami
FPL Turkey Point Nuclear Power Plant
Hospitals
Airports
Water Treatment Plants
Sewage Treatment Plants
Wellfield Protection Areas
Mangroves, wetlands, etc.
Sea Level Today
Sea Level Rise of 1 Foot
0 2.5 5 10 15 20 25
Miles
08/28/07
www.sfrpc.com

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