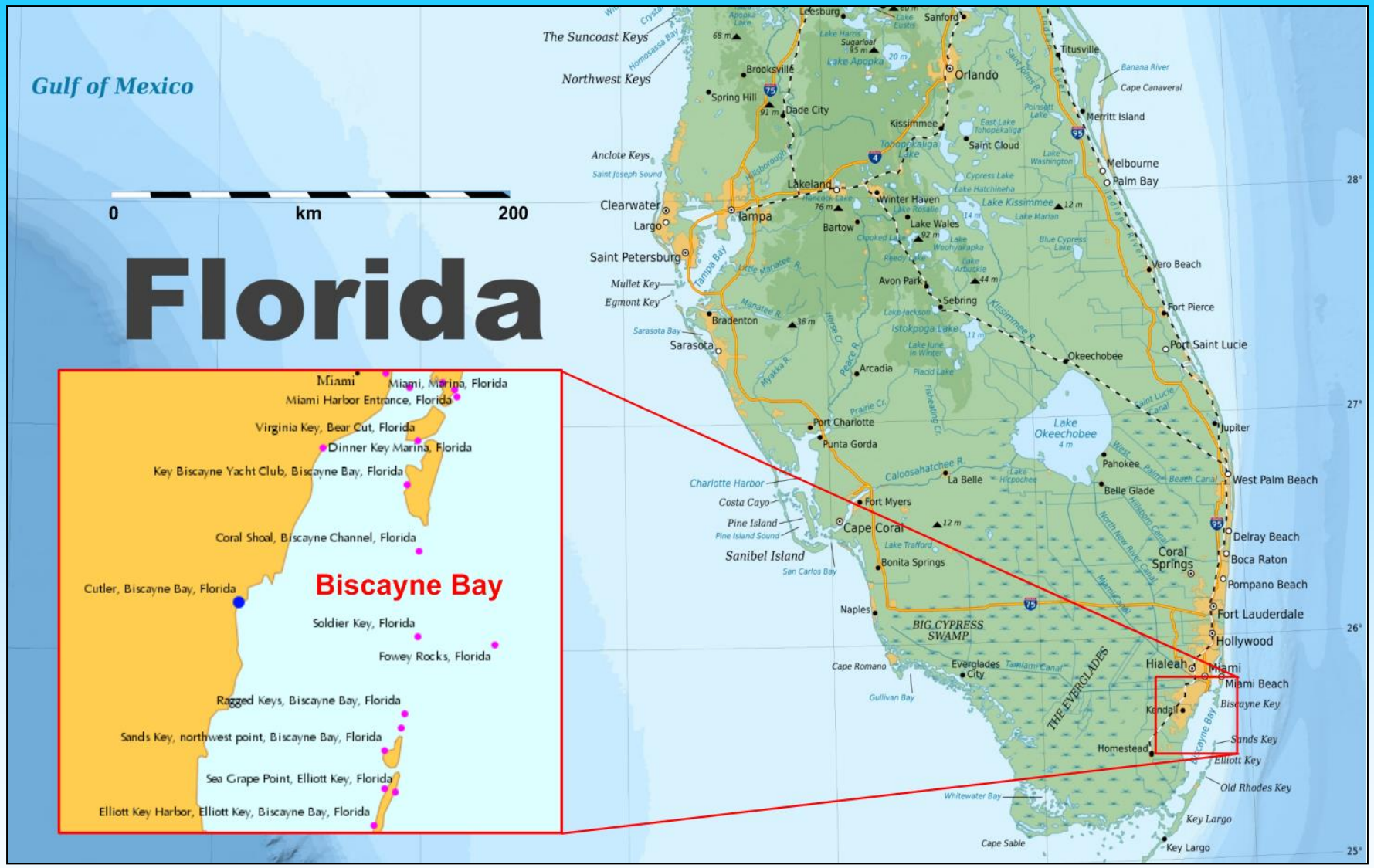
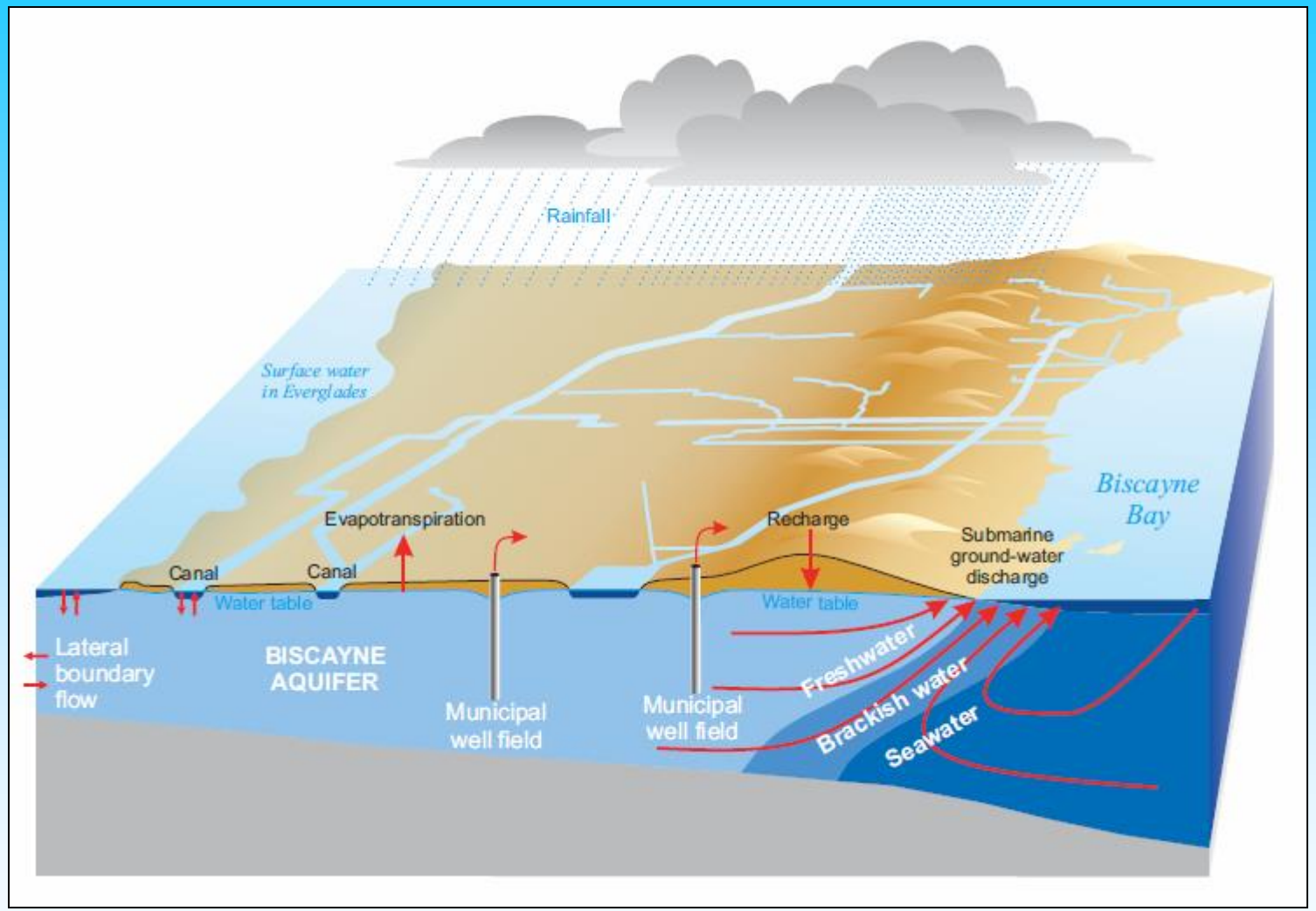
The case of Biscayne Bay and Aquifer near Miami, Florida: Density driven flow of sea water or gravitationally driven discharge of saline groundwater?

by
K. Udo Weyer
WDA Consultants Inc. Calgary
weyer@wda-consultants.com

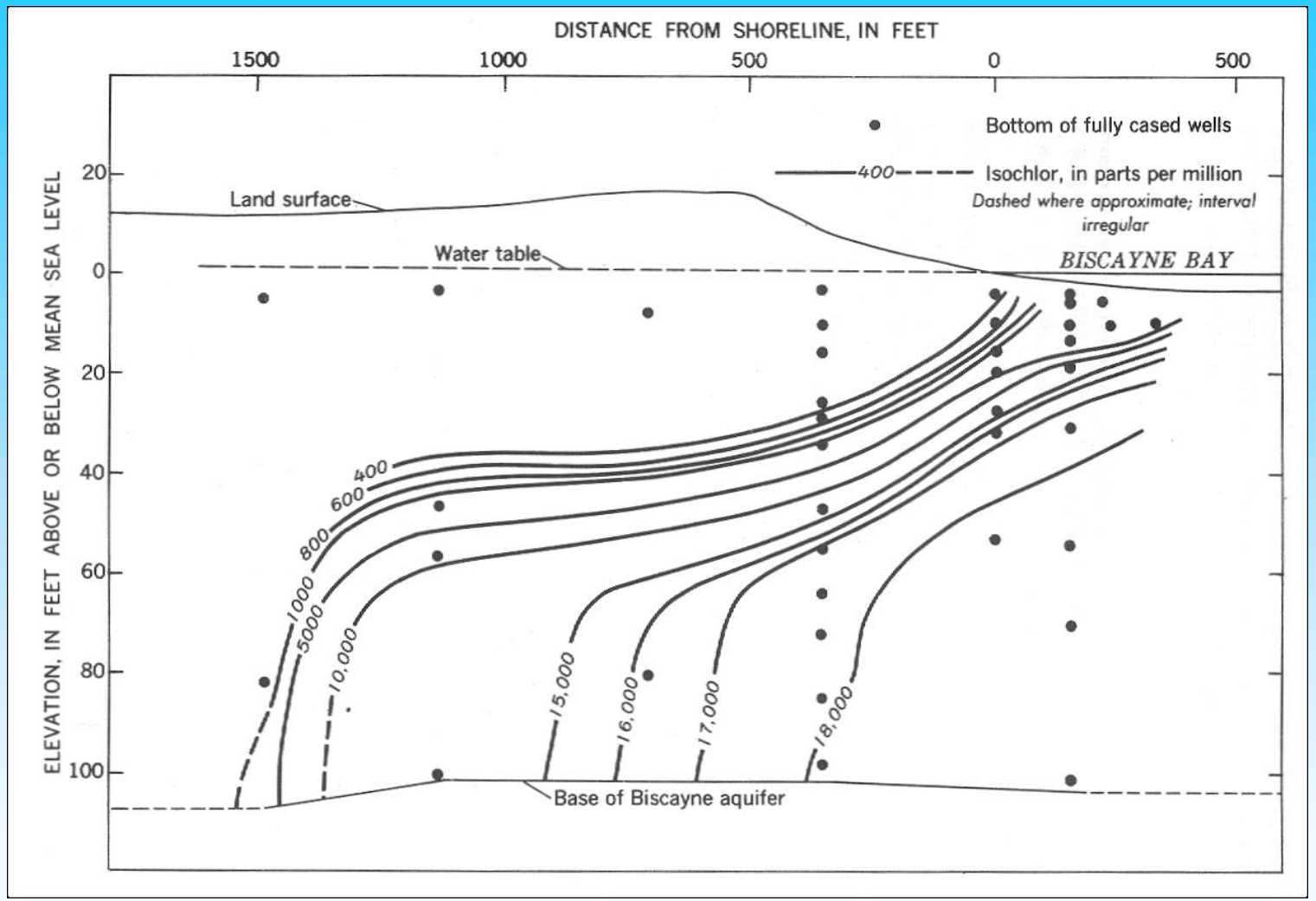
43rd IAH Congress
le Corum , Montpellier, France
Sep 25-29, 2016



Map source: http://ontheworldmap.com/usa/state/florida/florida-physical-map.html
Inset: http://tides.mobilegeographics.com/locations/1456.html



Langevin, 2001, Fig. 15

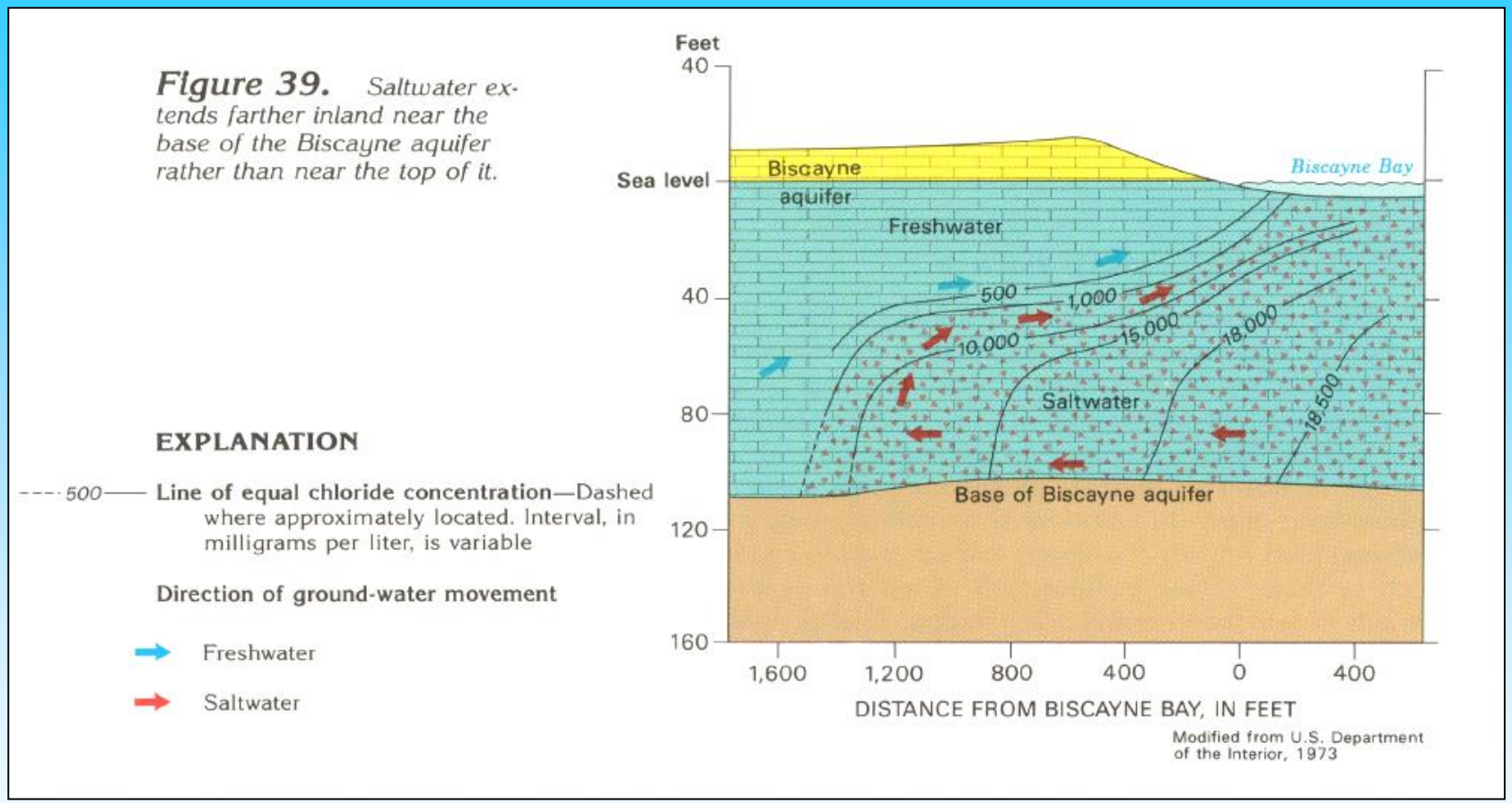


Cooper et al., 1964, Fig. 5

Biscayne aquifer: lines of equal chloride concentration (in ppm)

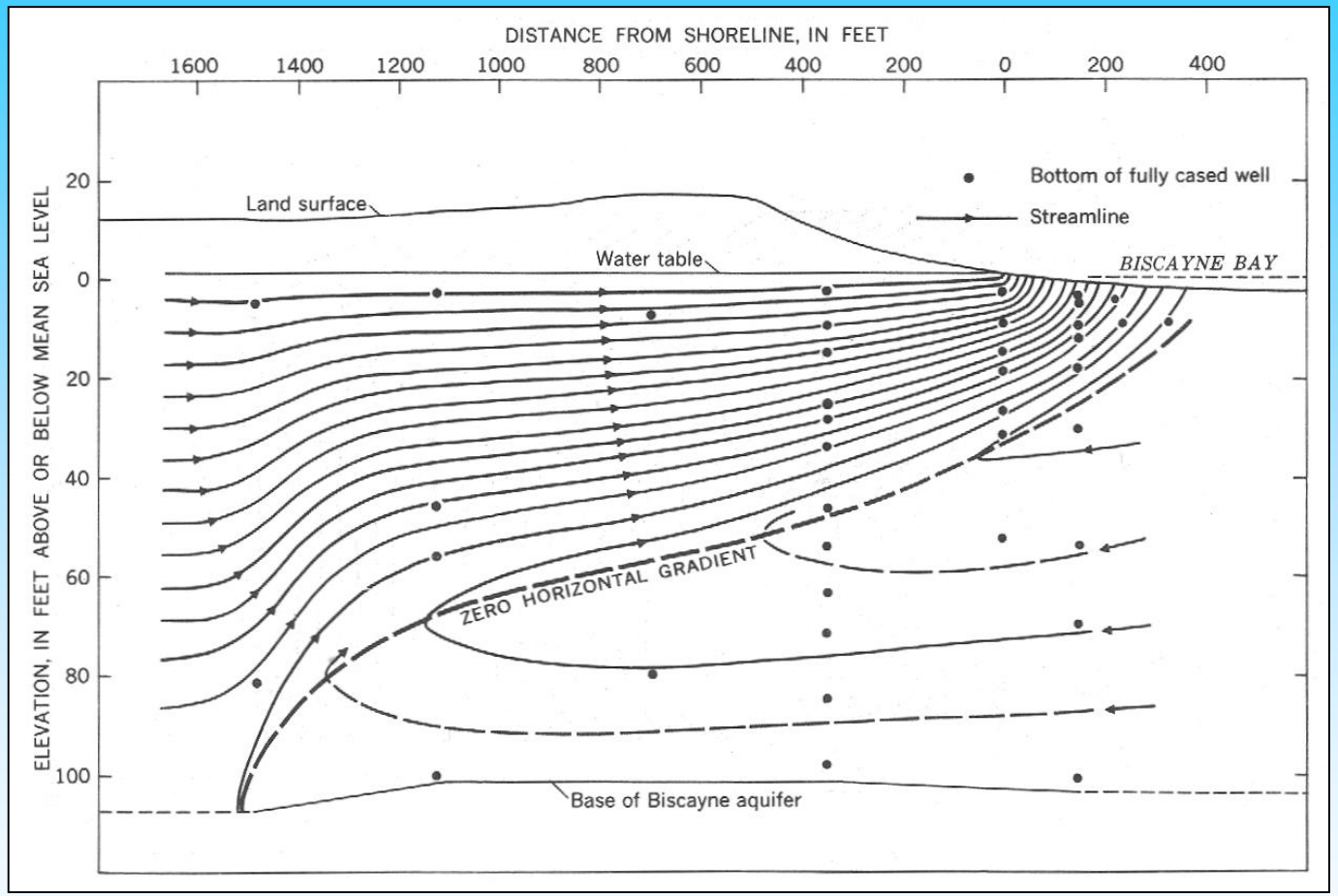
Clearly the chemical data show:

It is a seawater wedge!
It is a case of density-driven flow!
It is an example of a convection cell!



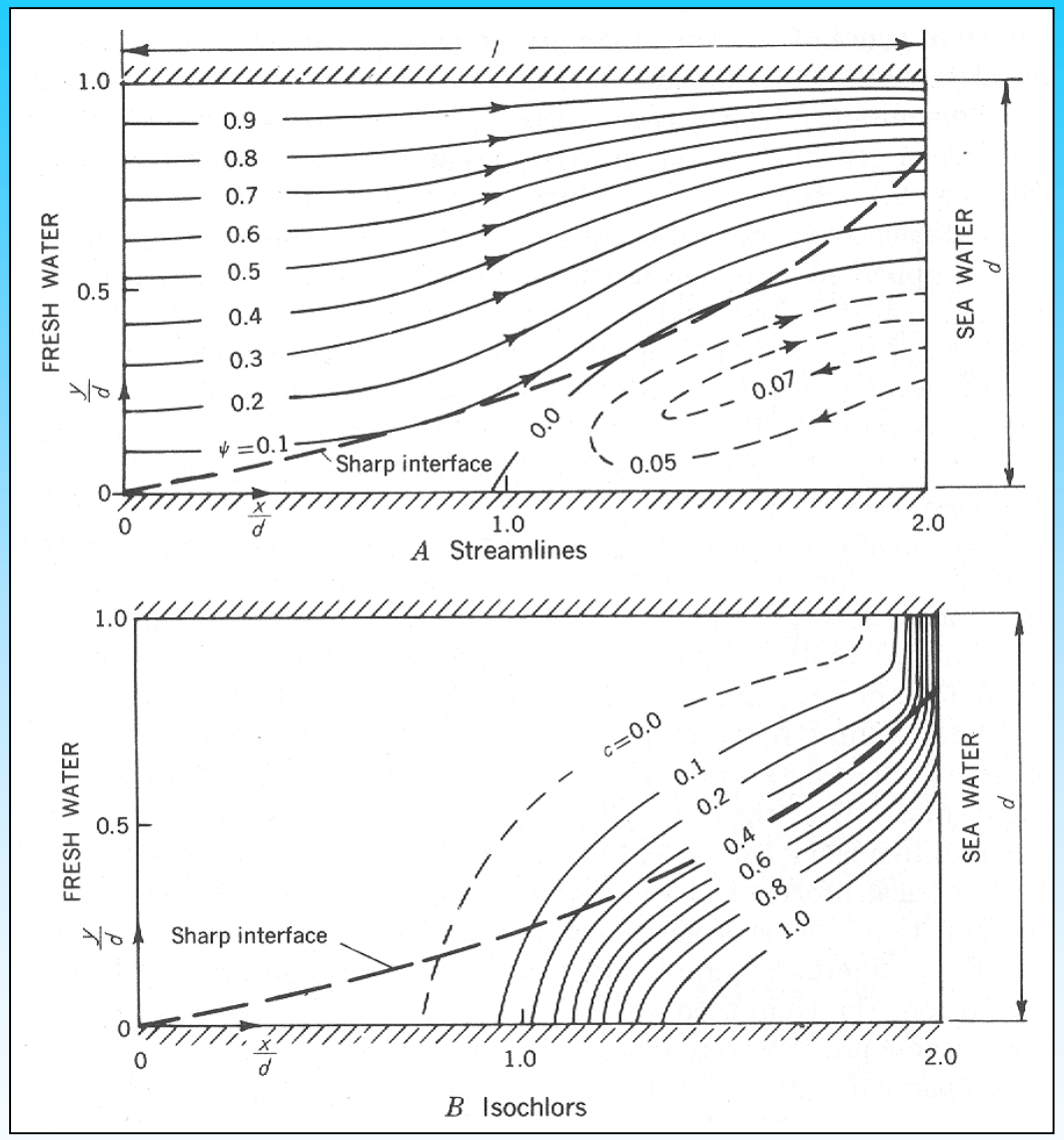
Miller, 1990, Fig. 39

Presumed convective flow



Cooper et al., 1964, Fig. 19

Streamlines with presumed seawater intrusion

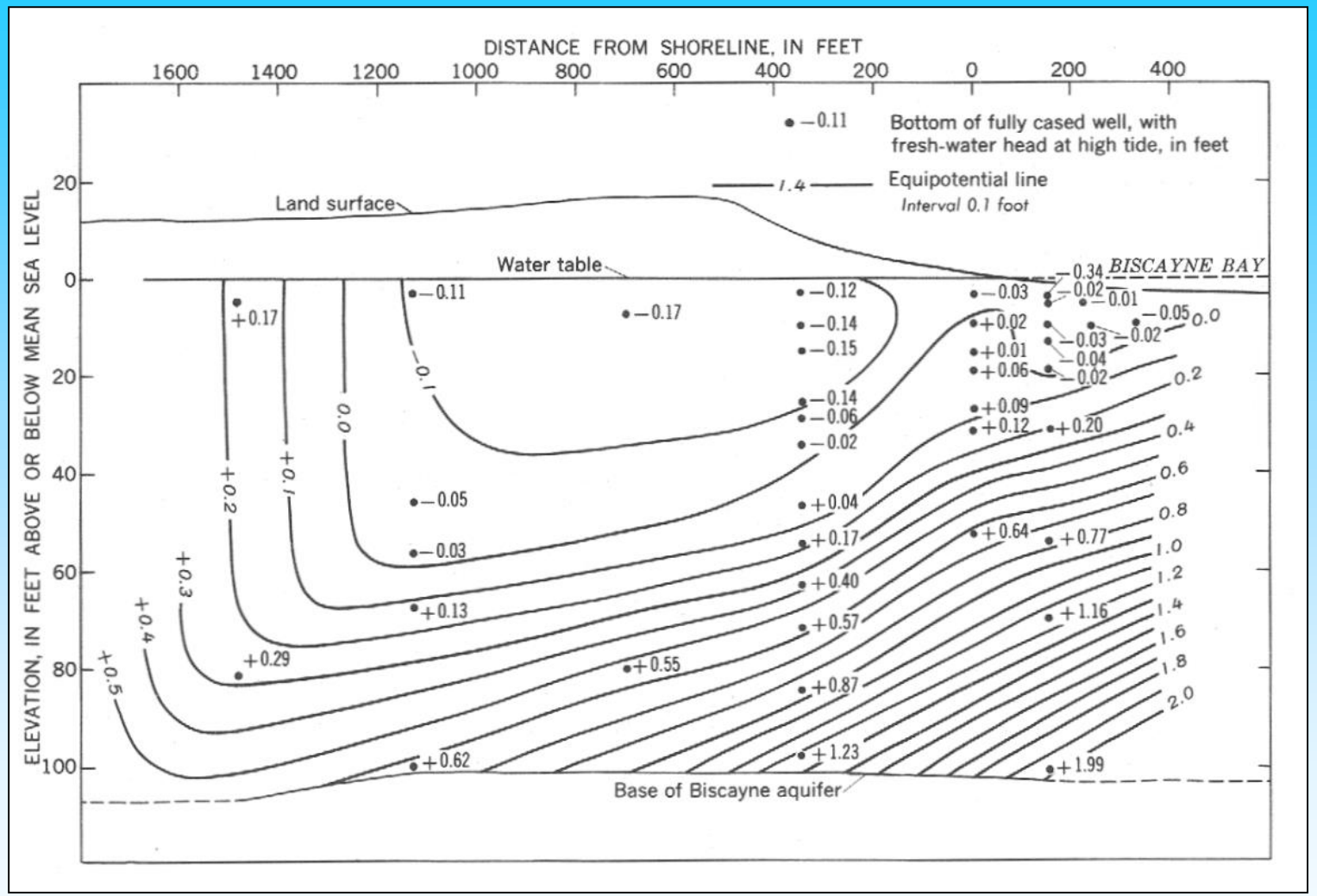


Cooper et al., 1964, Fig. 34

The Henry Problem

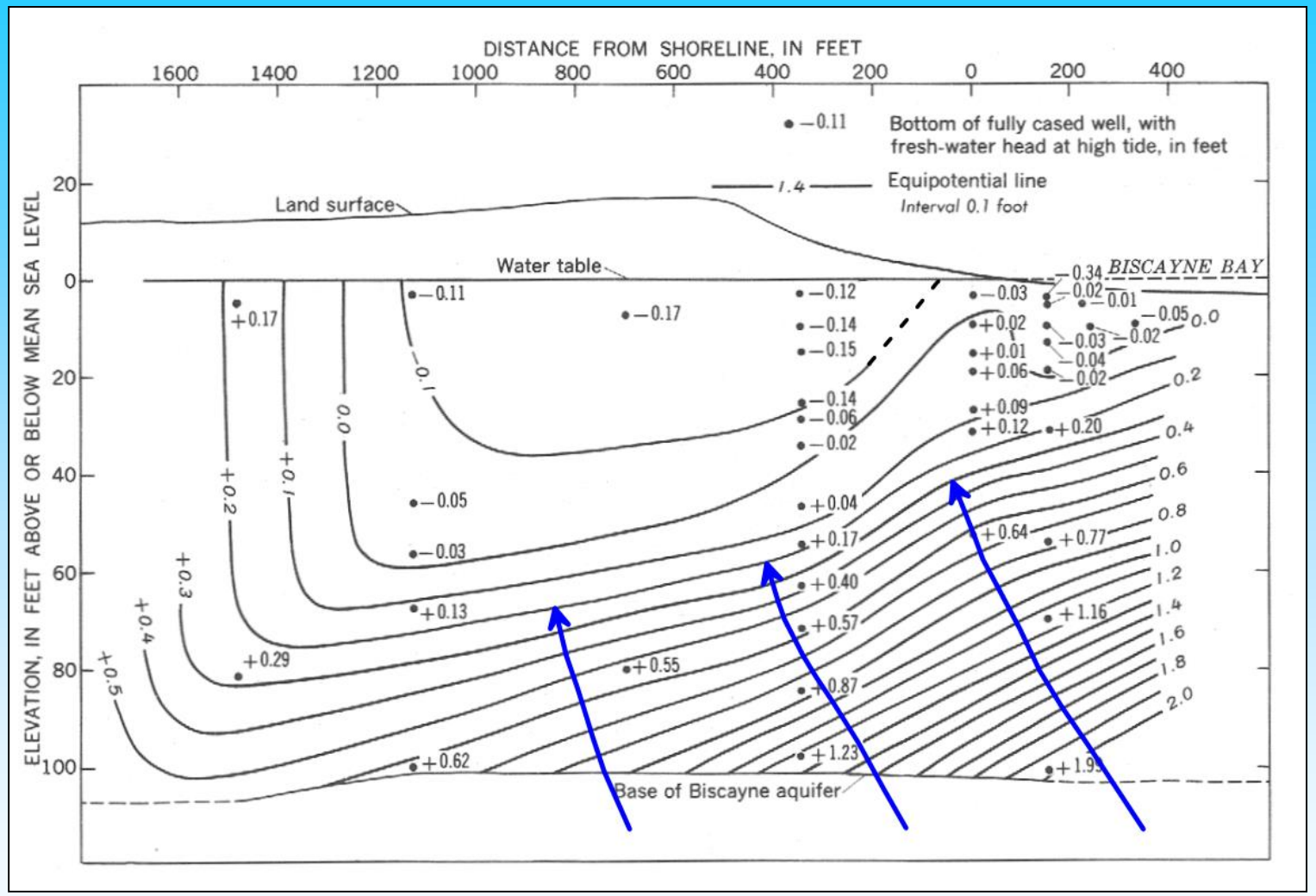
Numerical concept of the Biscayne aquifer system: boundary conditions, streamlines, and isochlors

Why continue? Everything is quite clear,
The chemical data show it.
Nevertheless, let’s look at the head data.



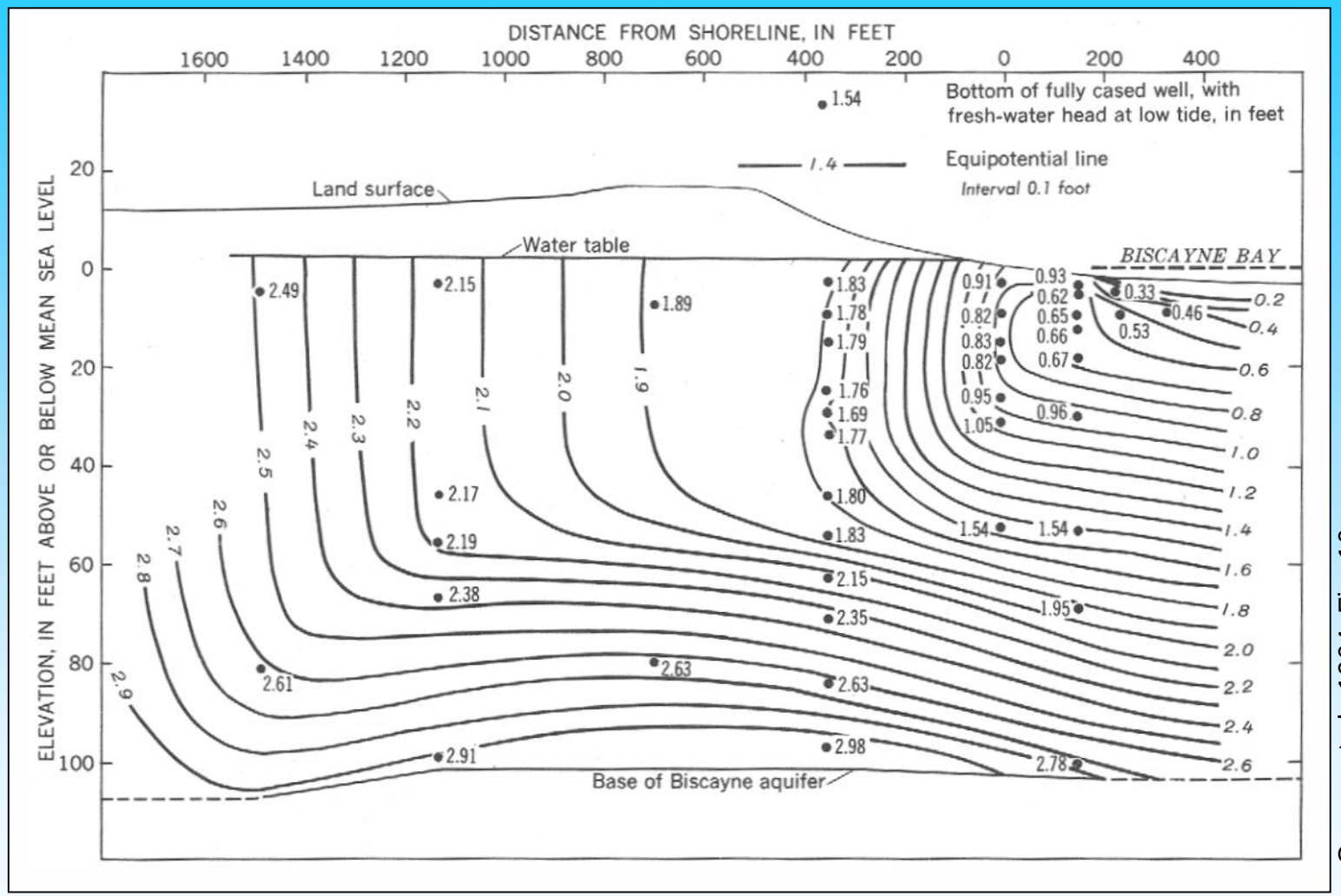
Cooper et al., 1964, Fig. 15

Lines of equal head measured at high tide, Biscayne field site



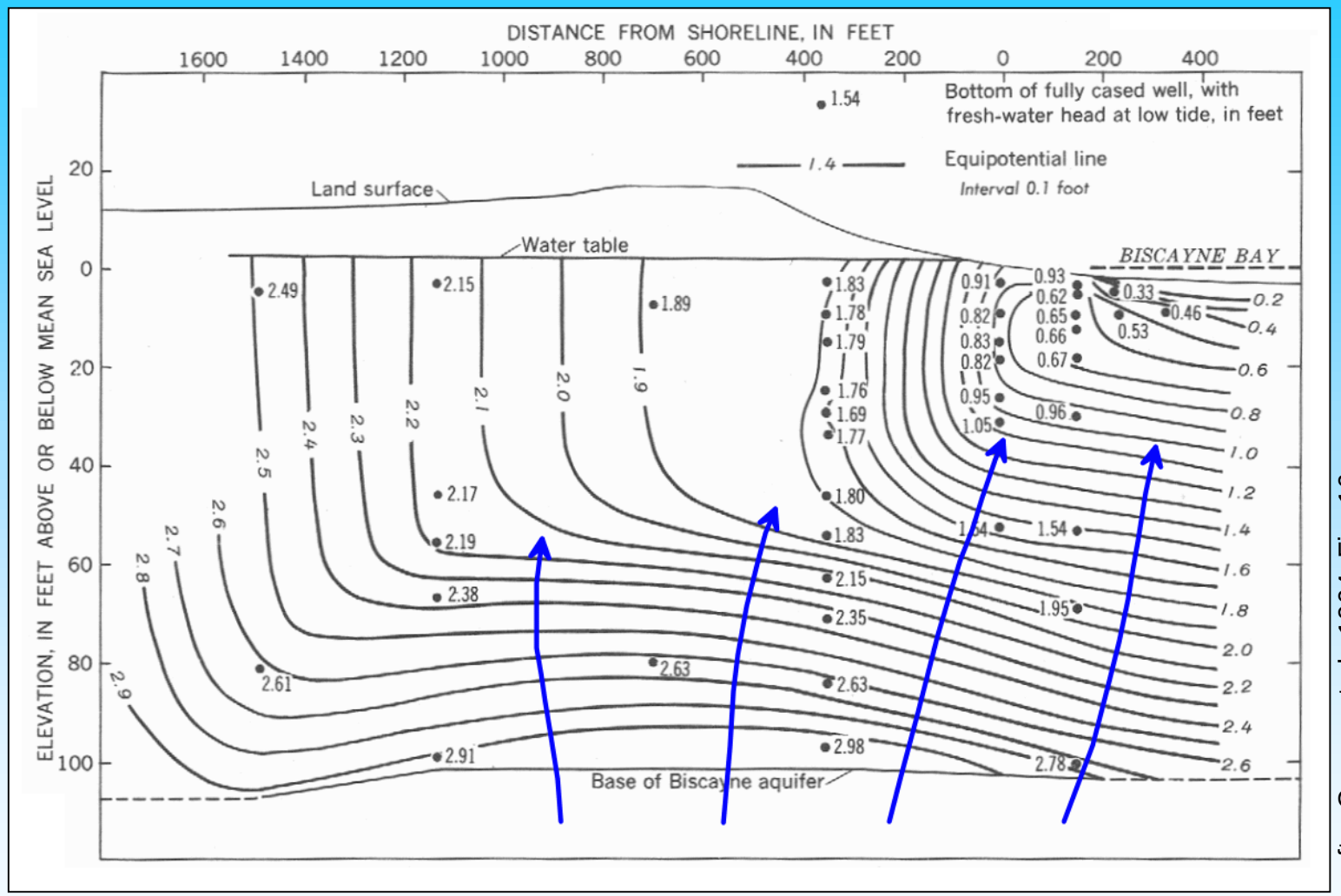
after Cooper et al., 1964, Fig. 15

Flow lines of saline groundwater corresponding to equal head lines at high tide



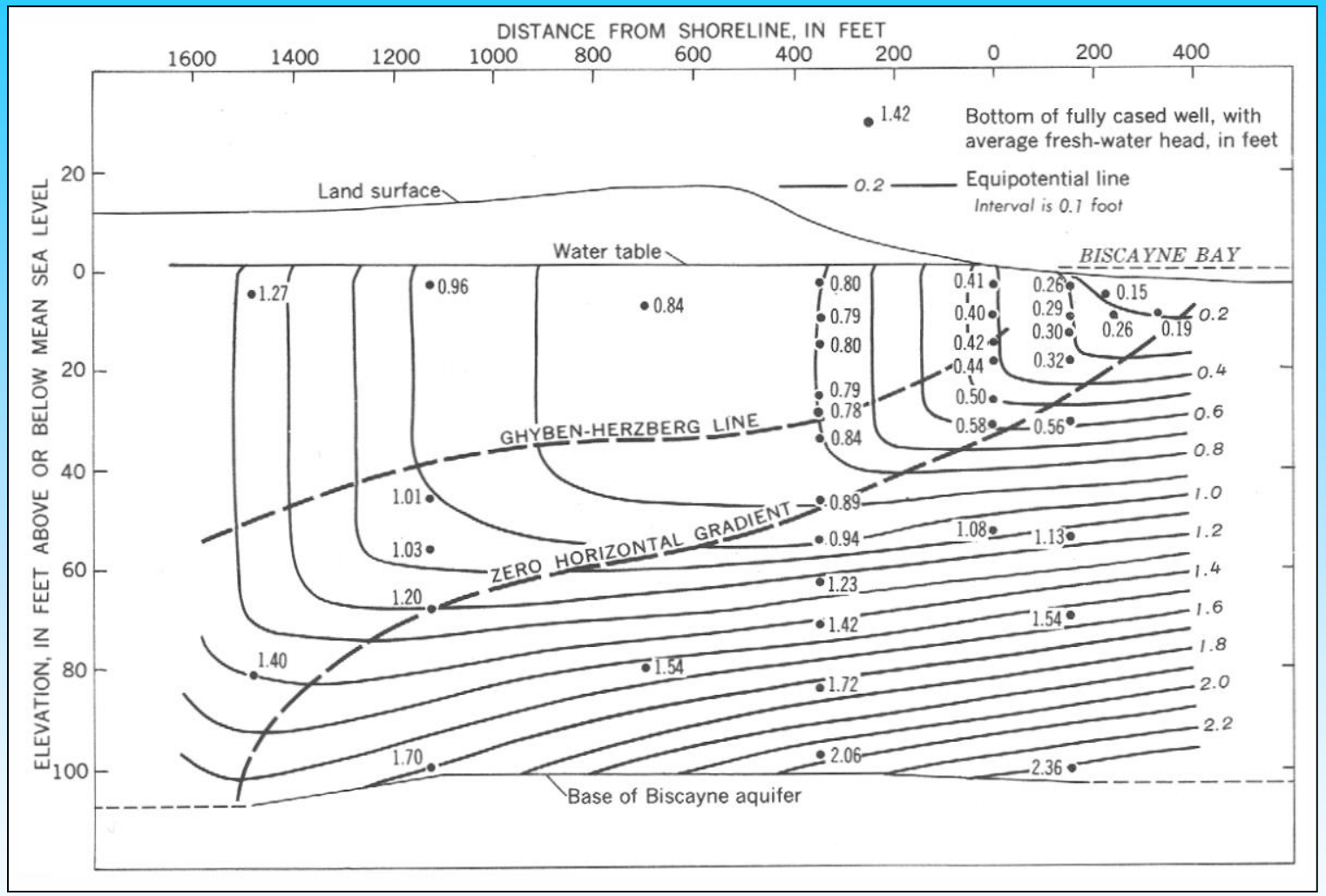
Cooper et al., 1964, Fig. 16

Lines of equal head measured at low tide, Biscayne field site



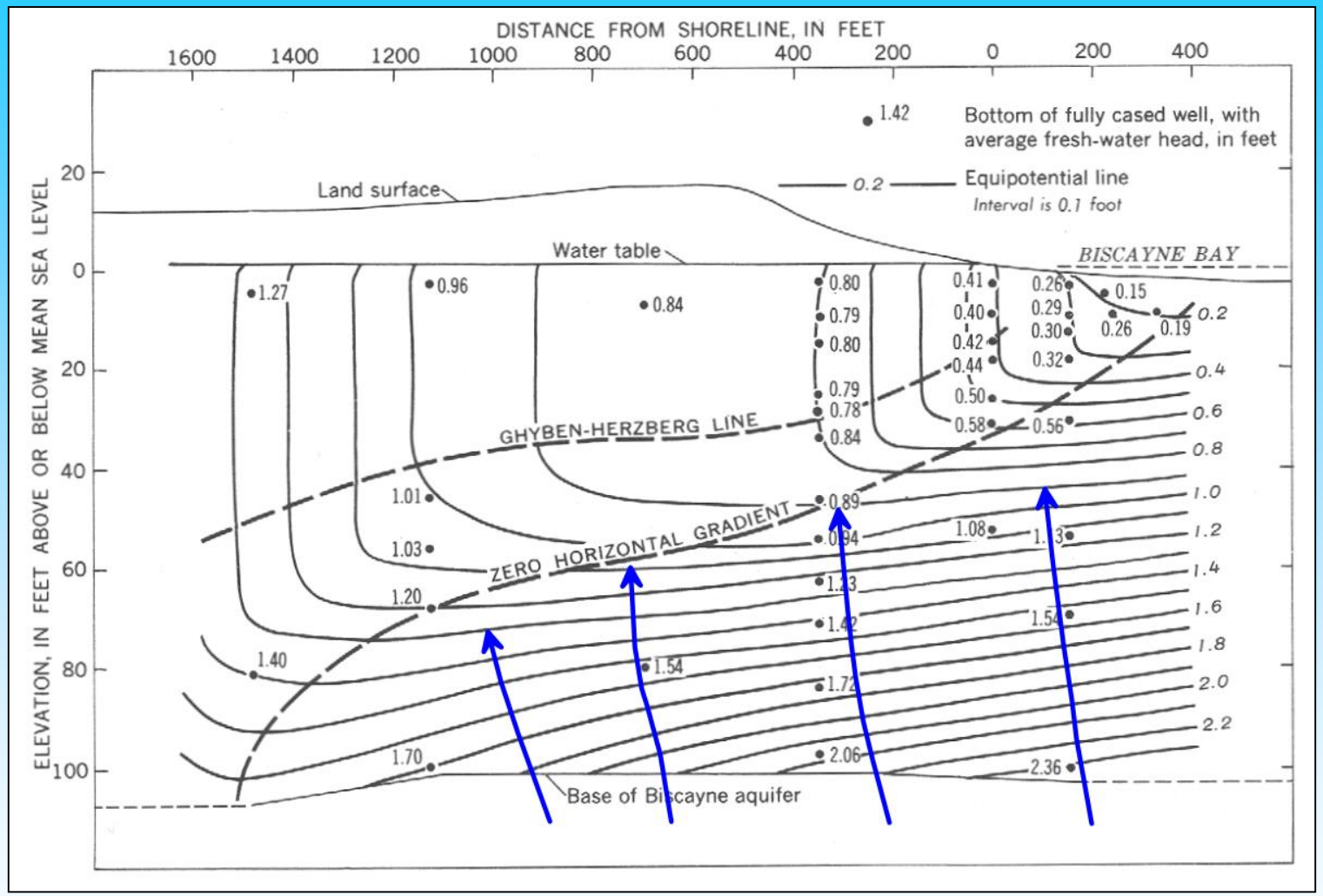
after Cooper et al., 1964, Fig. 16

Flow lines of saline groundwater corresponding to equal head lines at low tide



Cooper et al., 1964, Fig. 17

Lines of equal average head, Biscayne field site

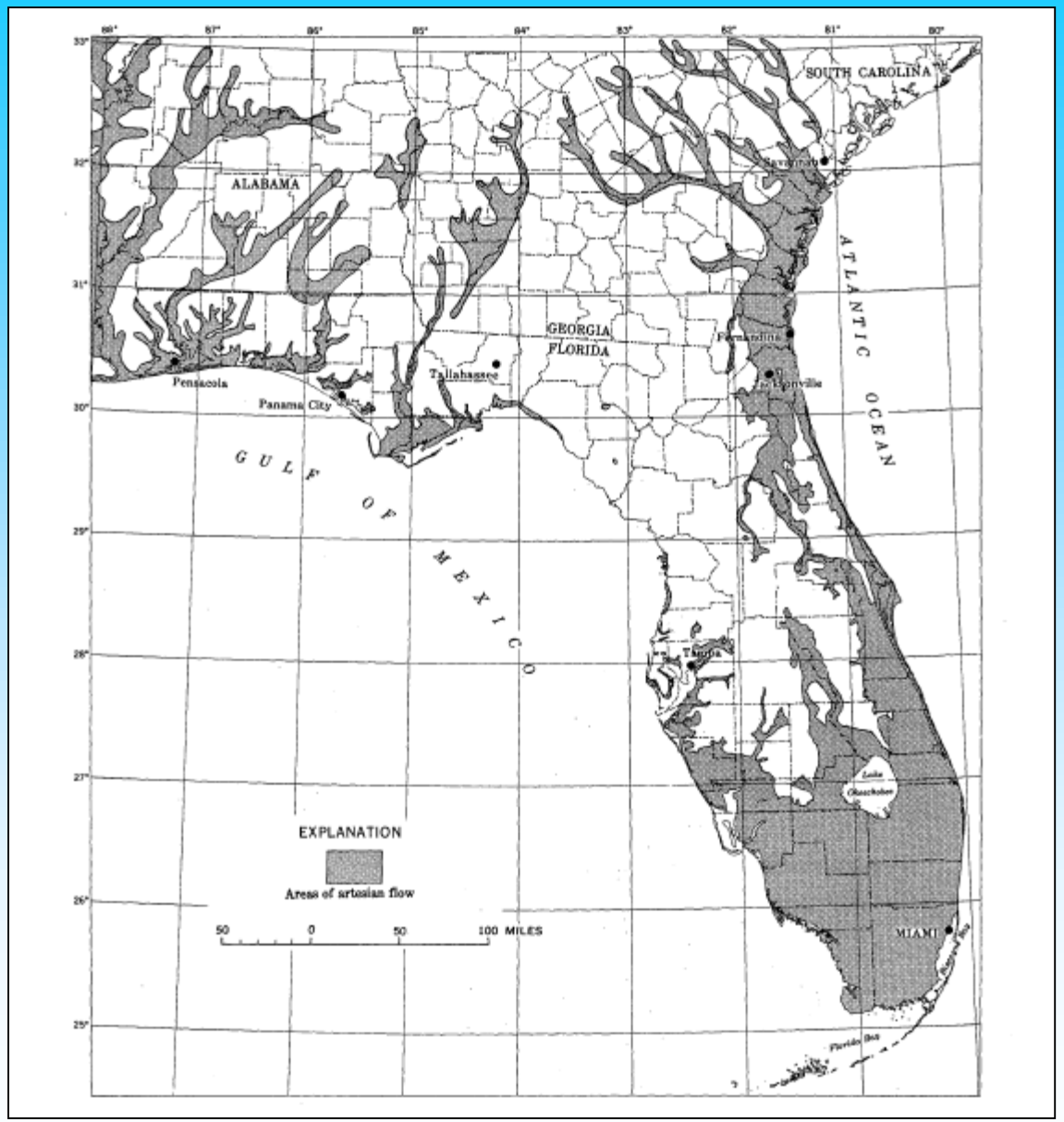


after Cooper et al., 1964, Fig. 17

Flow lines of saline groundwater corresponding to average equal head lines

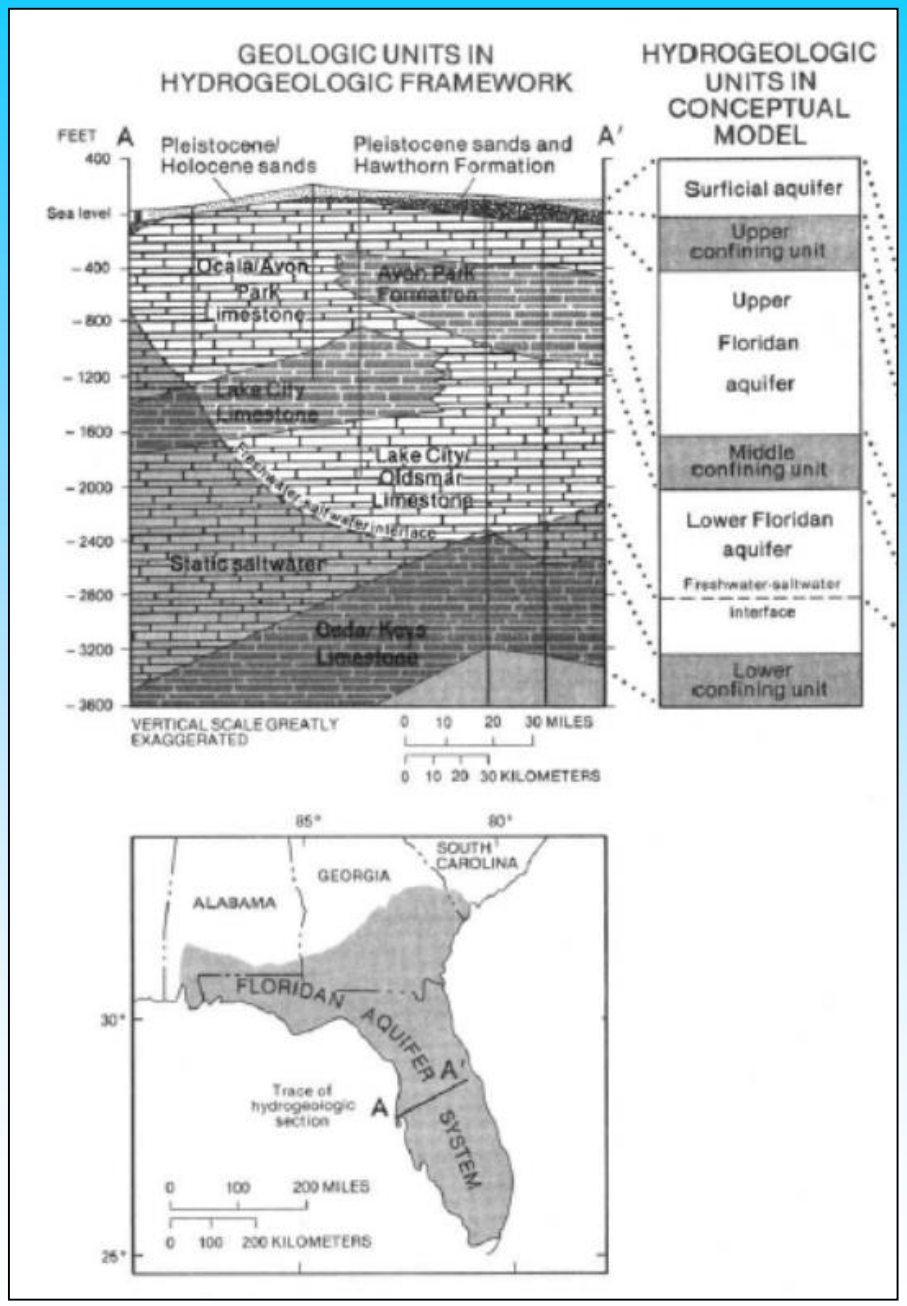
How can the flat Florida topography cause deep groundwater flow systems to bring saline water up to the distant beach areas?

Artesian (flowing) wells are an indicator for groundwater discharge



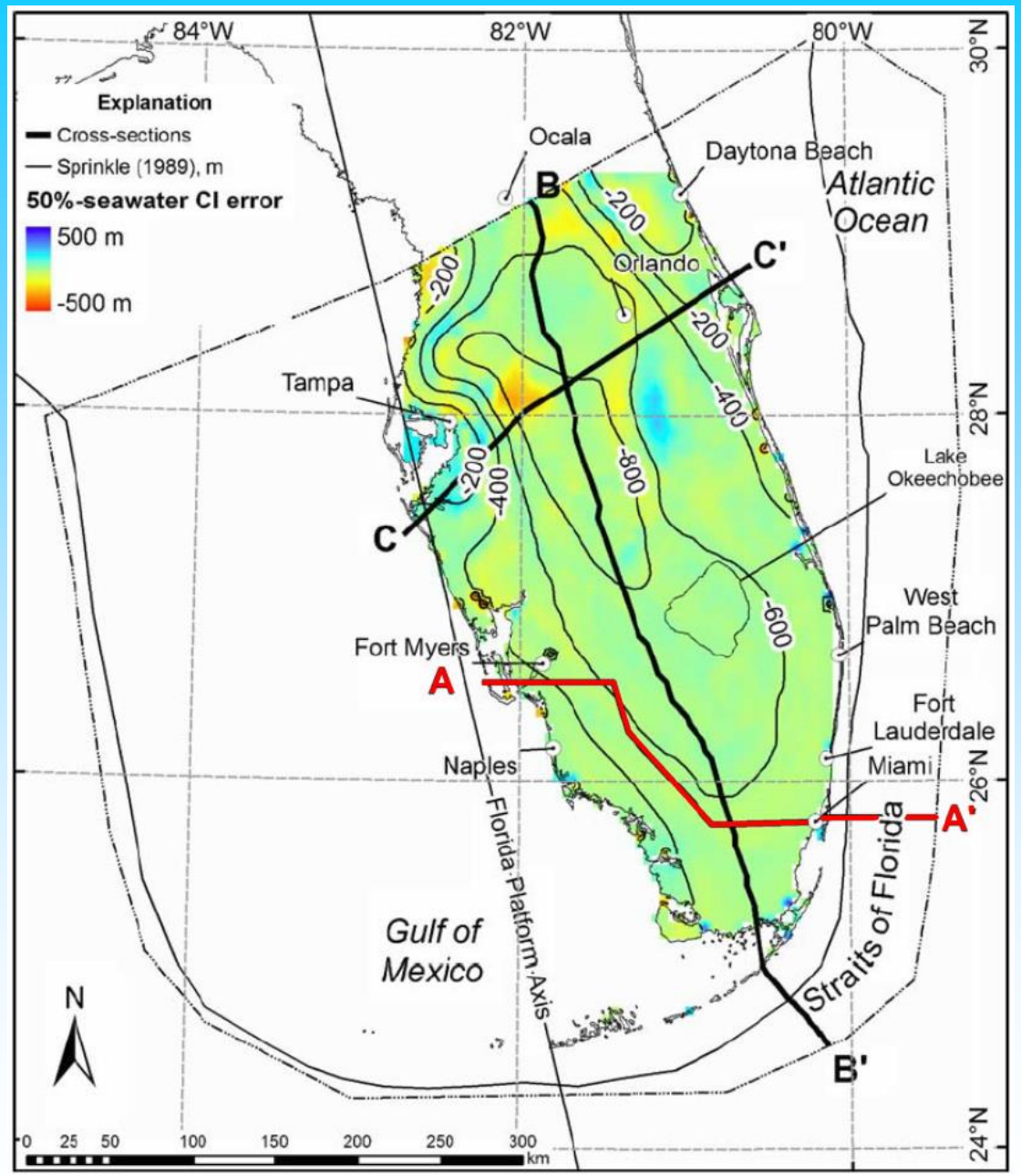
Hatched areas indicate the occurrence of artesian (flowing) wells

Springfield, 1966, Fig. 28



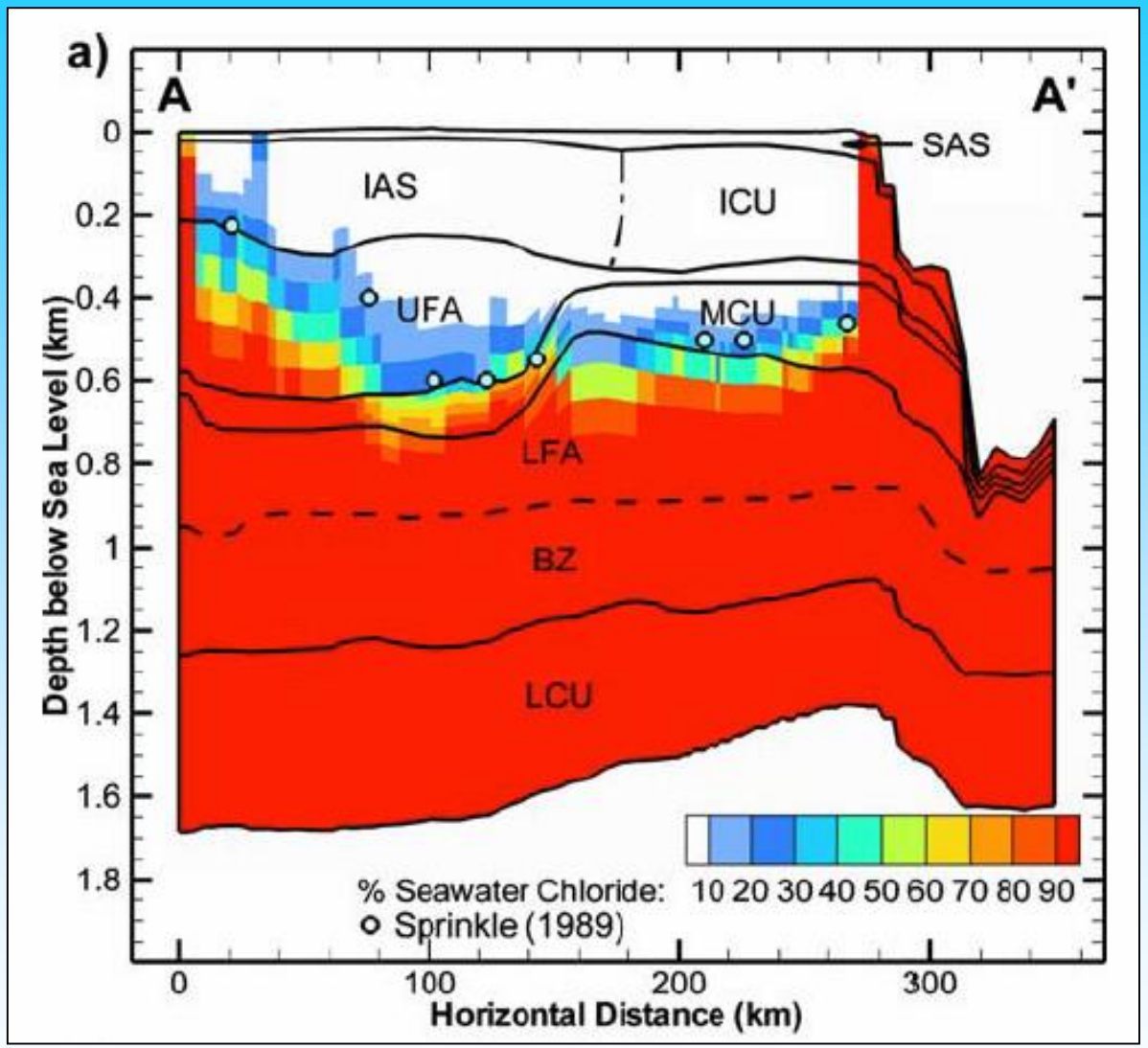
Indications of deep groundwater flow systems in central Florida

Bush and Johnson, 1986, Fig. 9



Location of cross-section A-A' next slide)

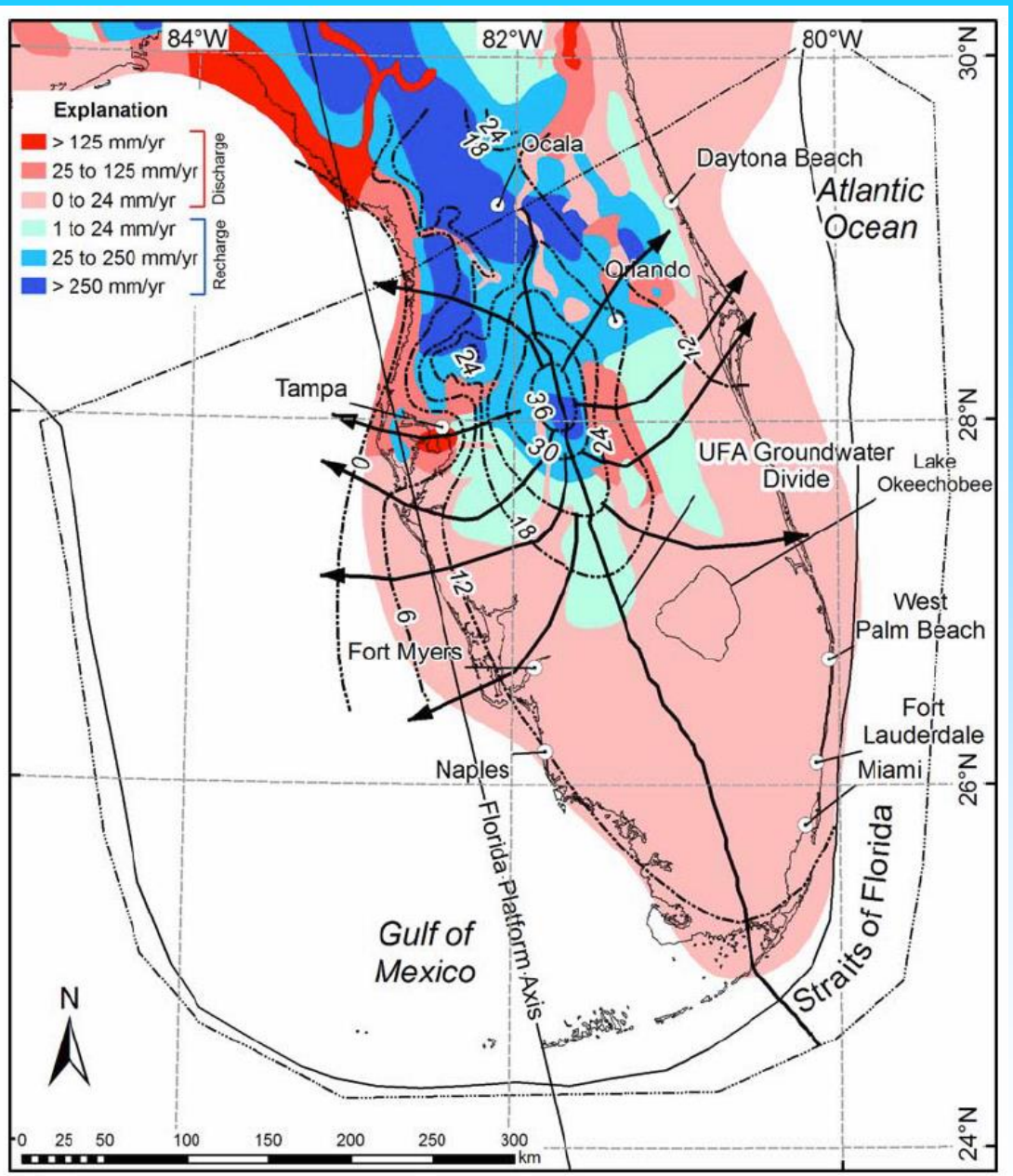
after Hughes, Vacher, and Sanford, 2009, Fig 11



Hughes, Vacher, and Sanford, 2009, Fig 12a

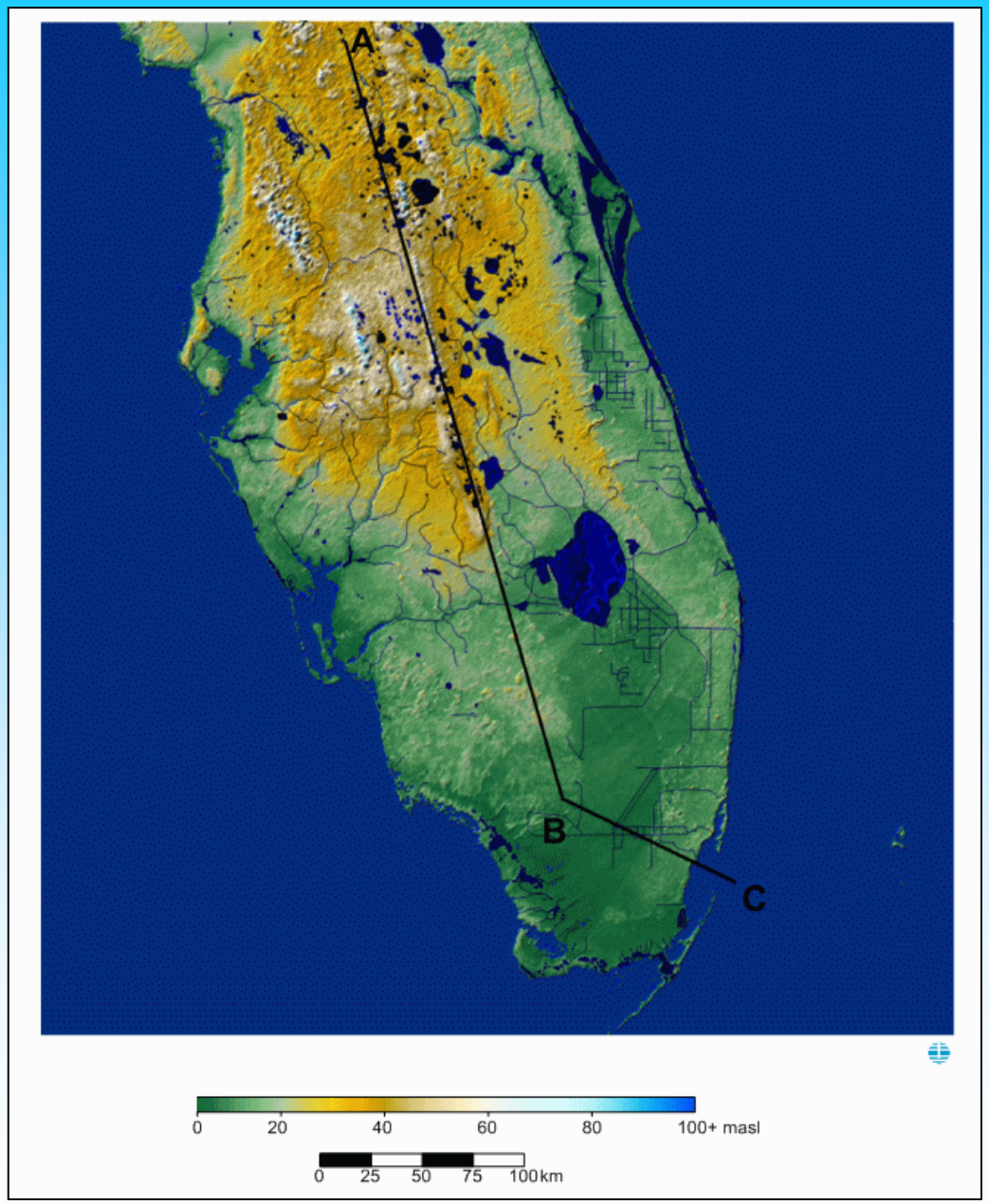
Chloride concentration along cross-section A-A' (location on previous slide)

SAS – Surficial Aquifer System
IAS – Intermediate Aquifer System
ICU – Intermediate Confining Unit
UFA – Upper Floridan Aquifer
MCU – Middle Confining Unit
LFA – Lower Floridan Aquifer
BZ – Boulder Zone
LCU – Lower Confining Unit

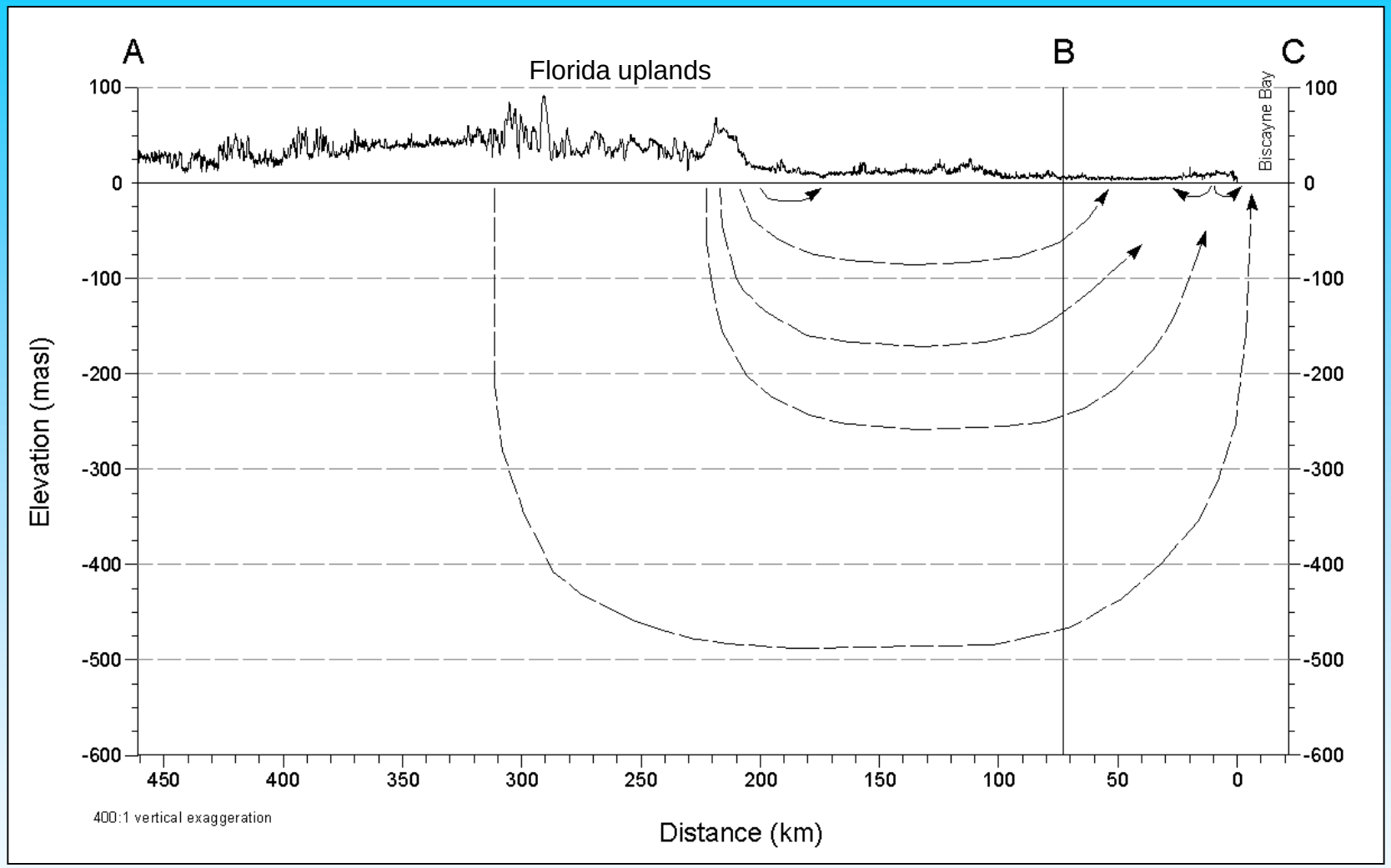


Flow lines in the Upper Florida Aquifer [UFA] system driven by recharge in the central Florida uplands

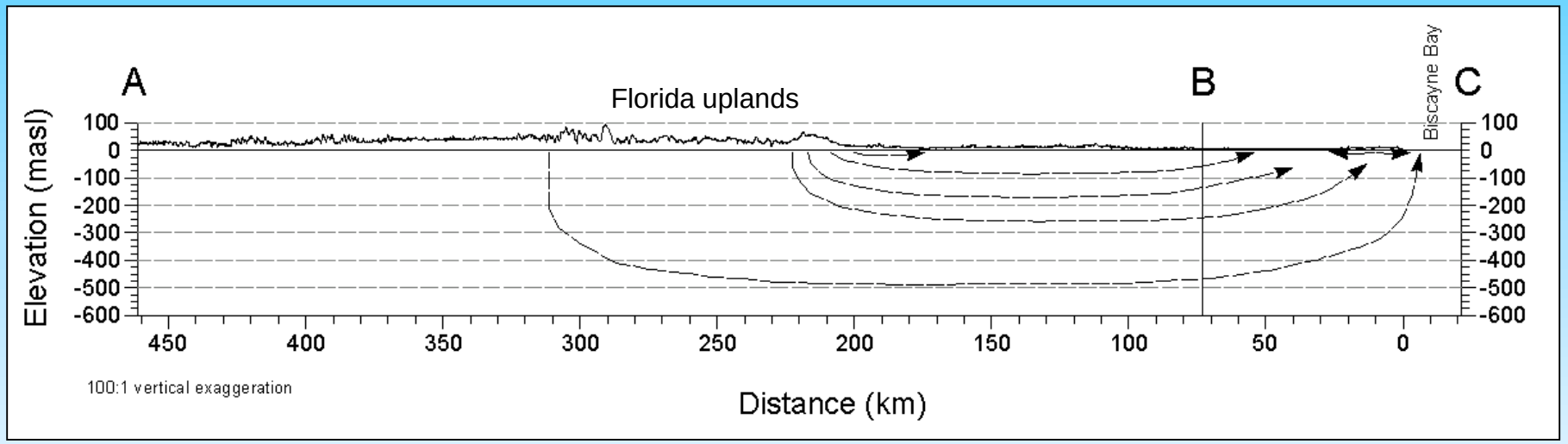
Hughes, Vacher, and Sanford, 2009, Fig 12a



Digital Elevation Model (DEM) of central and south Florida showing trace of cross-section displayed on next two slides



Cross-section of central and south Florida (see location on previous slide). Very schematic outline of flow lines from central uplands to Biscayne Bay. Vertical exaggeration 400:1.



Topographical cross-section of central and south Florida. Very schematic outline of flow lines from central Florida uplands to Biscayne Bay. Vertical exaggeration 100:1.

At the classic site of the ‘Henry Problem’ for density-driven flow there exists no seawater wedge, and, accordingly, no density-driven flow.

The saline zone has been created and is maintained by gravitational discharge of deep saline groundwater.