Deltas in Times of Climate Change Rotterdam 2010

Connecting world science and deltas

Facing Up to the Future

Challenges of Water Supply under Sea Level Rise

Rotterdam, The Netherlands

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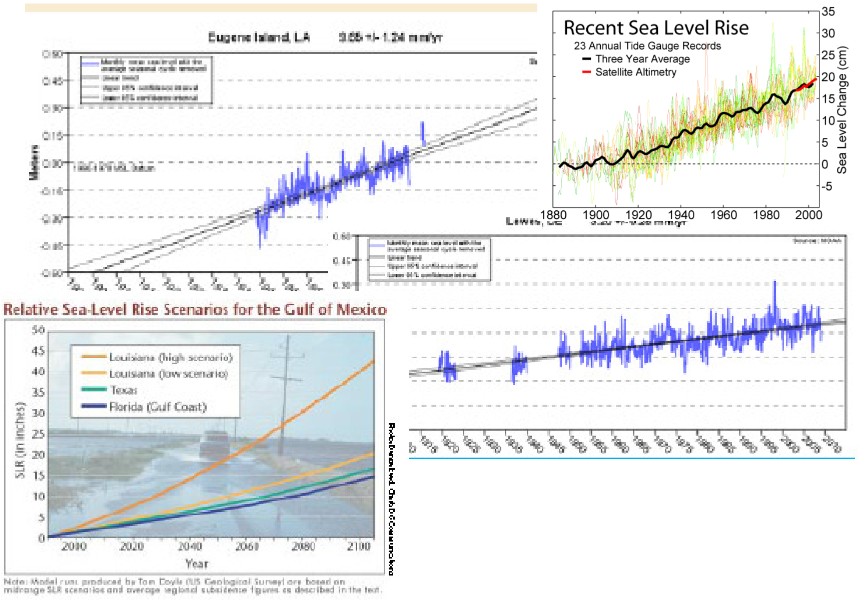
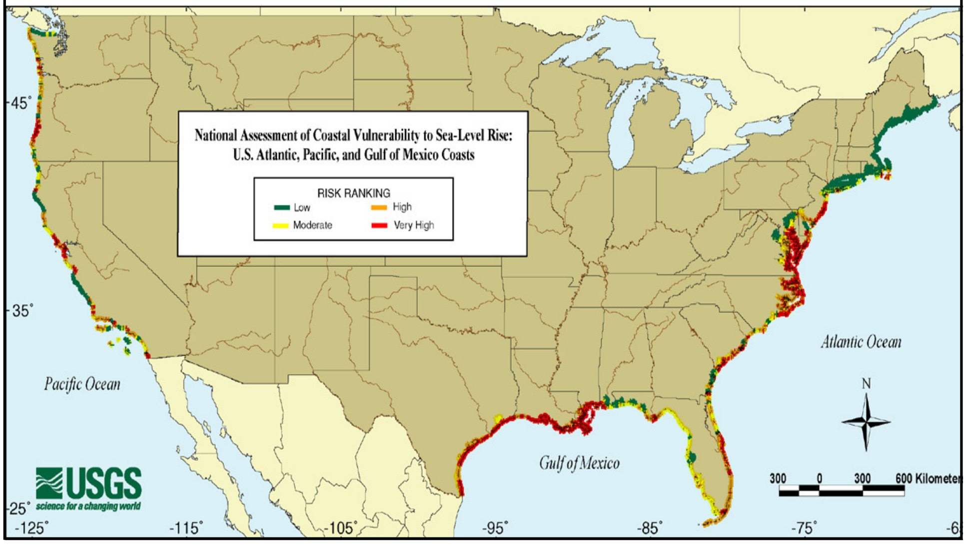
Sea Level Rise Is Real



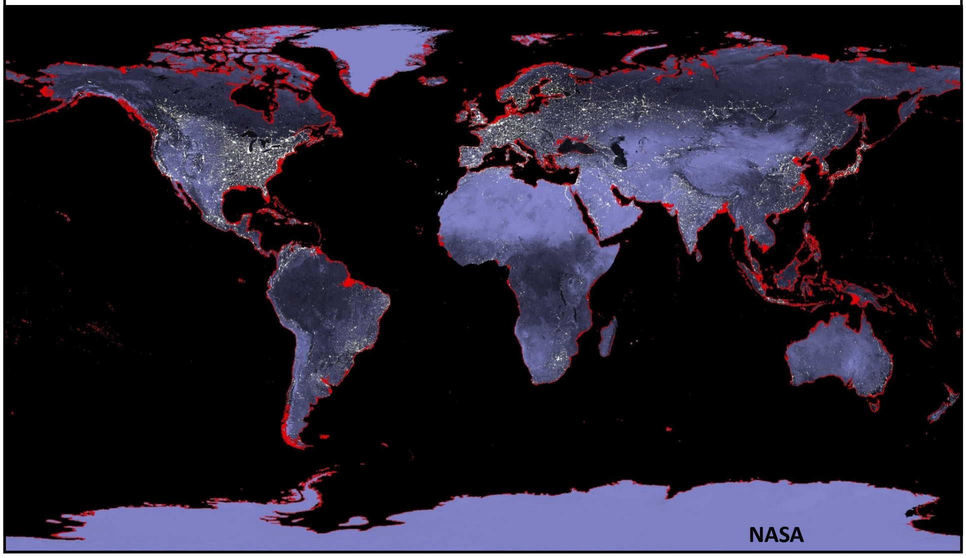
The US Faces Fast Rise



Impacts of Sea Level Rise

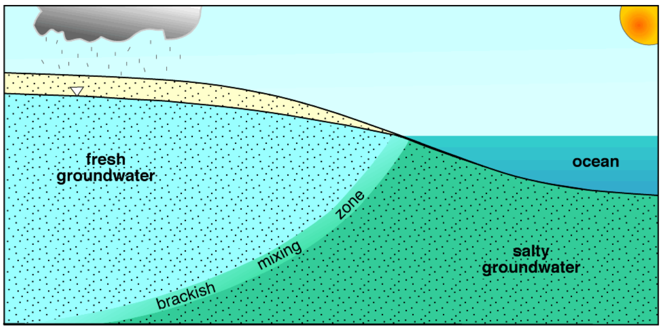
- Inundation of wetlands and developed areas
- Erosion of beaches
- Increase in base level of on existing hurricanes and cyclones
- Increase in salinity content of rivers, bays, estuaries, wetlands, and groundwater
- **Threat to coastal water supplies**

And the Impacts Are Worldwide



Sea Level Rise Impacts on Water Supply

Salt water intrusion into coastal groundwater



Target: Water Supply Wells

Sea Level Rise Impacts on Water Supply

Saltwater wedges in rivers

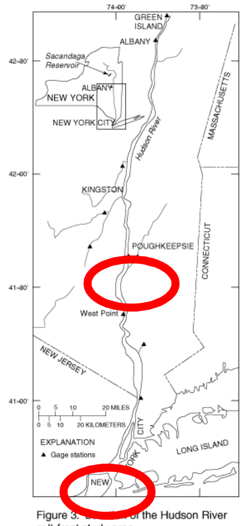
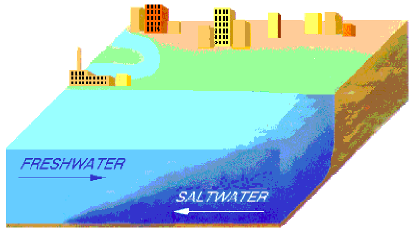


Figure 3 [illegible] of the Hudson River salt-front study area.



Target: Water Supply Intakes

Sea Level Rise Impacts on Water Supply

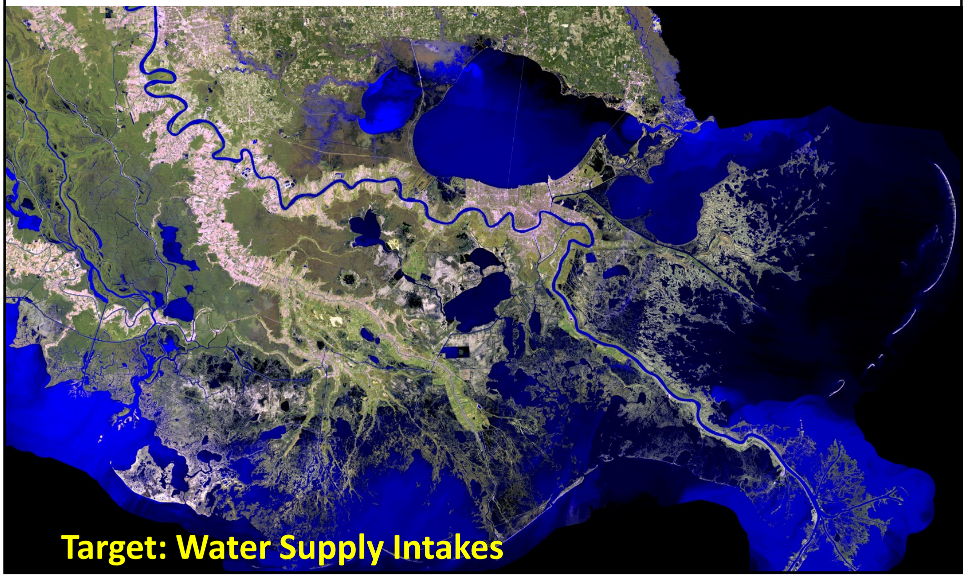
Infrastructure Deterioration

- Flooding of water treatment facilities
- Flooding of desalination plants
- Corrosion of pipes

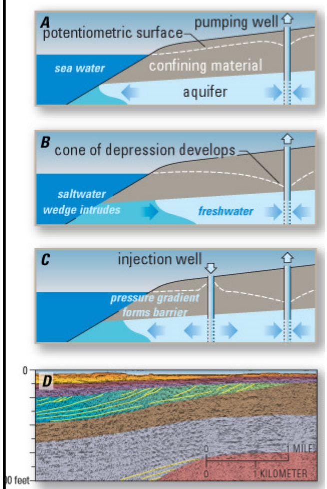


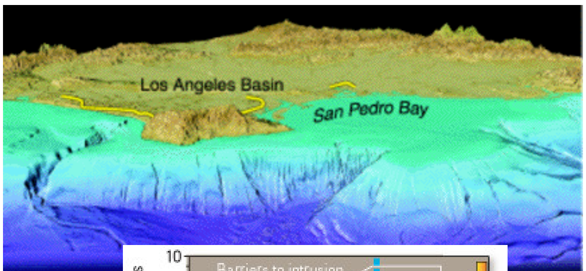
Target: Water Supply Infrastructure

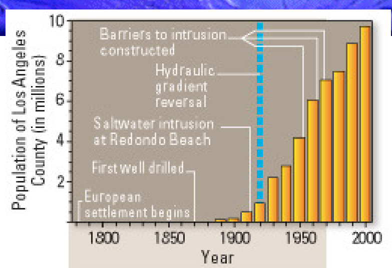
Sea Level Rise Impacts on Water Supply
Loss of Coastal Wetlands



Intrusion is Not a New Problem
It Is Just Going to Get Worse

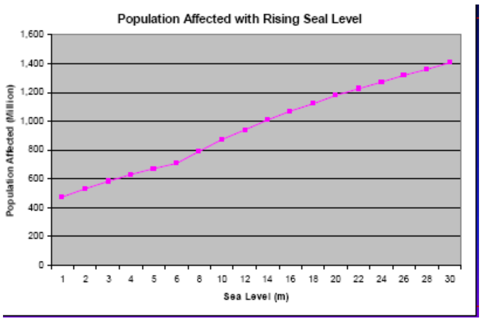






Water Supply Problems Exacerbated by Other Factors

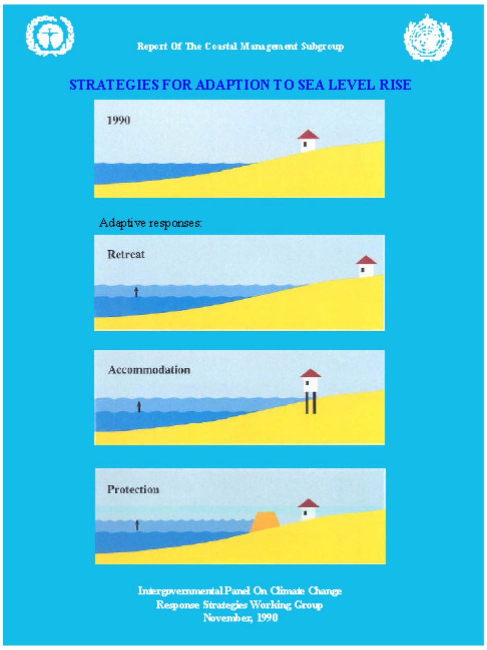
- Population Growth
- Coastal Development
- Attitude



USGS

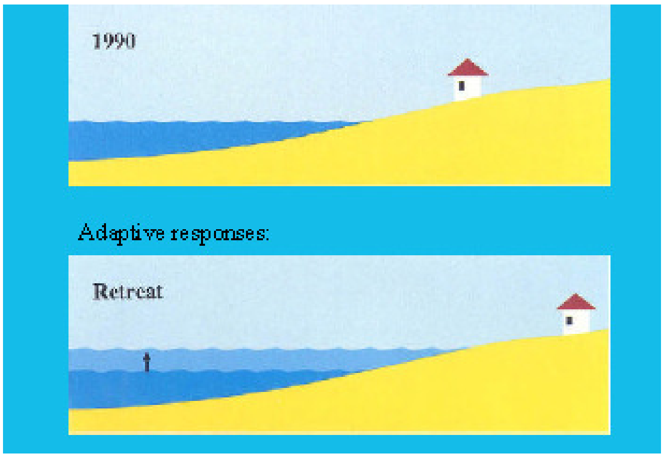
Approaches to Sea Level Rise

- Retreat
- Accommodate
- Protect



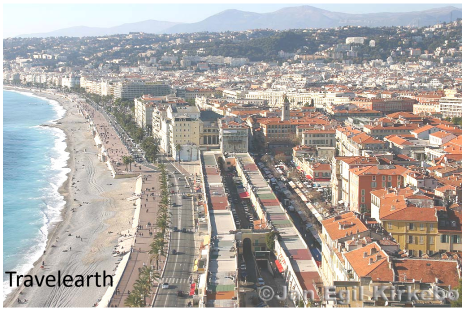
Retreat

- Don't Develop
- Move Back



Accommodation

- Raise land
- Raise structures
- Build dikes/levees
- Direct development away from low areas
- Prohibit development
- Reduce withdrawals
- Desalinate
- Reuse water
- Conserve
- Use economic incentives


Travelearth

Protection

- Install slurry/sheet pile walls
- Build tidal gates
- Enhancing Flows — Where get water?
- Recharge — Where get water?
- Store water — Where get water?

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Data and Modeling Needs
(To be jointly developed by Federal/State/Local Agencies)

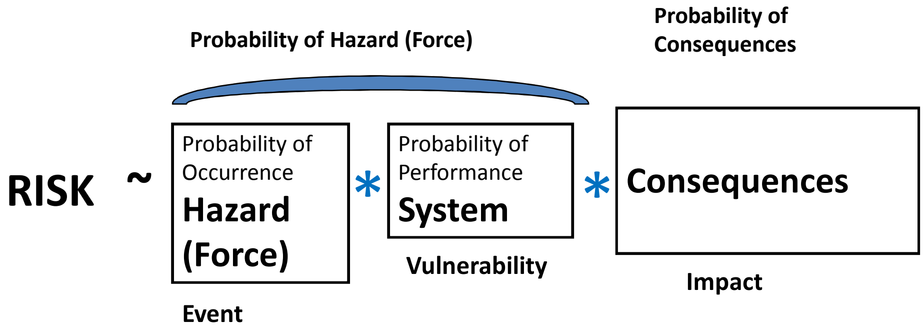
Climate Change Vulnerability	Task
Flood Control	Datum conversion/operating Rules
	Coastal Digital Elevation Models (DEMs)
	Linking canal routing to groundwater models
	Integrated Groundwater/surface water rainfall/runoff module
	Model certification/Peer review
Saltwater Intrusion	Development of density dependent flow model codes
	Model certification/Peer review
	Acquire storm surge results
	Convert county groundwater models
	Apply Sea Level Rise scenarios
Everglades Restoration	Updating 2x2/RSM for NAVD88
	Climate scenario development
	Evaluation of system-wide performance of CERP

Acceptable

~~Best~~

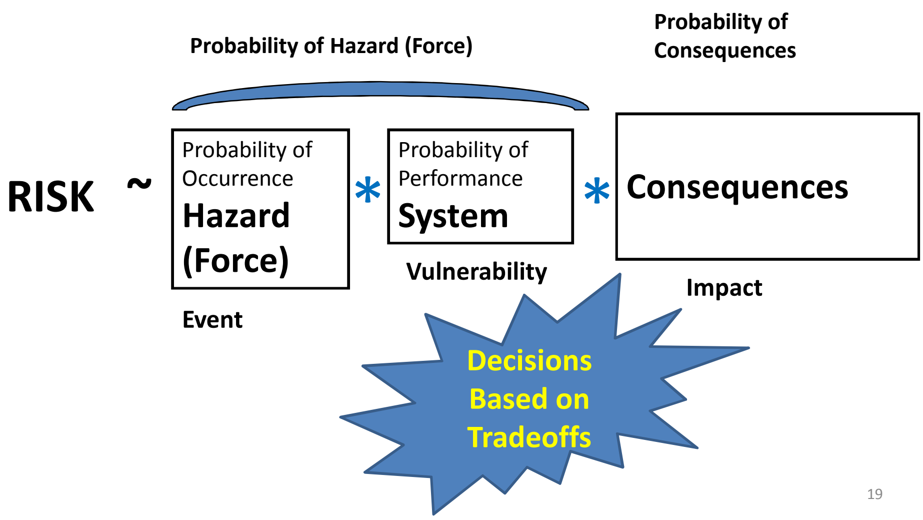
How Do You Choose the ~~Correct~~ Approach?

Analyzing and Managing Risk



18

Managing Risk



19

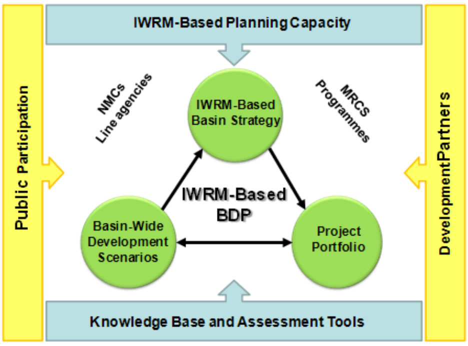
Benefits of Risk Analysis

- Ensure that continued operation is feasible and acceptable
- Allow for objective and consistent assessment of conditions
- Allow for mitigation of unsatisfactory/unacceptable conditions
- Prioritize resources allocation

From US FAA

Analysis of Water Supply Options Must Be Integrated with Planning for other Coastal Challenges

- IWRM, IFM etc
- Water supply solutions may be they the correct ones for water supply but not for the region as a whole

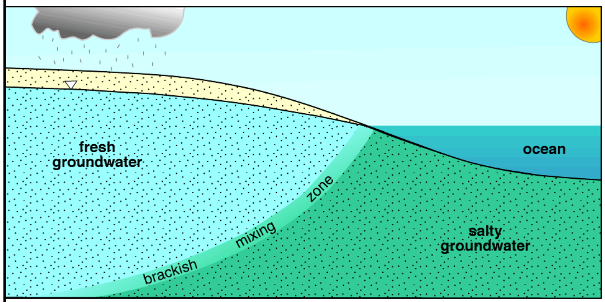


From MRC

Sum

- **Sea level rise is a problem for coastal water supply**
- **The problems can be solved, but protection is not the only approach . We do not need necessarily to "fight on the beaches"**
- **Decisions that are made must be:**
  - **Based on sound science**
  - **Taken within a systems context; water supply is just one element**
  - **Based on continuous and systemic analysis that is more than simply economics**
- **Planners and politicians will be a major part of the total sea level rise mitigation process.**

Travle earth



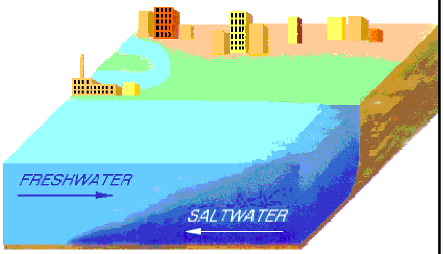
sfwmd

neches

intruding upstream into the Mississippi River. The intrusion of salt water upstream into the Mississippi River is a naturally occuring periodic condition.

The river's bottom profile is deeper than the Gulf of Mexico water surface level up to about 15 miles downstream of Natchez, Mississippi. Denser salt water flows upstream along the bottom of the River underneath the less dense fresh river water. Salt water's upriver travel can ultimately affect municipal drinking water and industrial

water supplies ▪



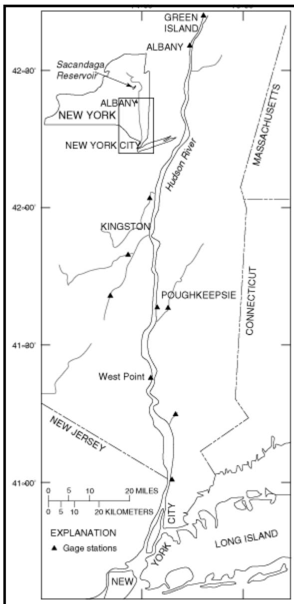
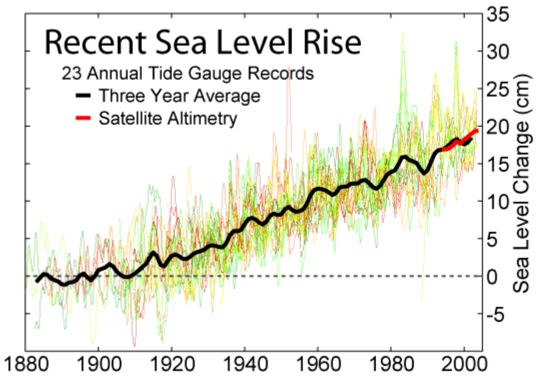


Figure 3. Location of the Hudson River salt-front study area.

DOUGLAS 1997



monitoring, management, and conservation.

Freshwater-Saltwater Interactions

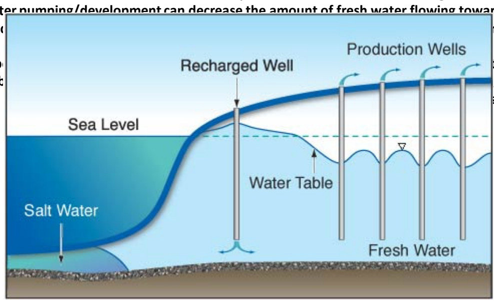
Saltwater intrusion is a major concern commonly found in coastal aquifers around the world. Saltwater intrusion is the induced flow of seawater into freshwater aquifers primarily caused by groundwater development near the coast. Where groundwater is being pumped from aquifers that are in hydraulic connection with the sea, induced gradients may cause the migration of salt water from the sea toward a well, making the freshwater well unusable.

Because fresh water is less dense than salt water it floats on top. The boundary between salt water and fresh water is not distinct; the zone of dispersion, transition zone, or salt-water interface is brackish with salt water and fresh water mixing.

Under normal conditions fresh water flows from inland aquifers and recharge areas to coastal discharge areas to the sea. In general, groundwater flows from areas with higher groundwater levels (hydraulic head) to areas with lower groundwater levels. This natural movement of fresh water towards the sea prevents salt water from entering freshwater coastal aquifers (Barlow, 2003).

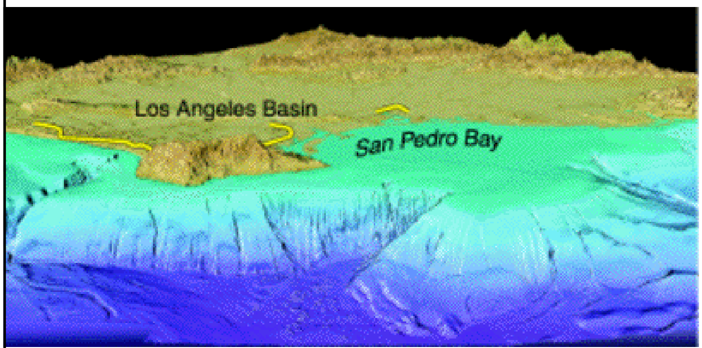
Groundwater pumping/development can decrease the amount of fresh water flowing towards the coastal discharge areas, allowing salt water to be (...) resh water stored in the aquifers is decreased

The Ghyb (...) column of freshwater extending from the water tab (...) g from sea level to that same point on the (...) s of fresh water below sea level.

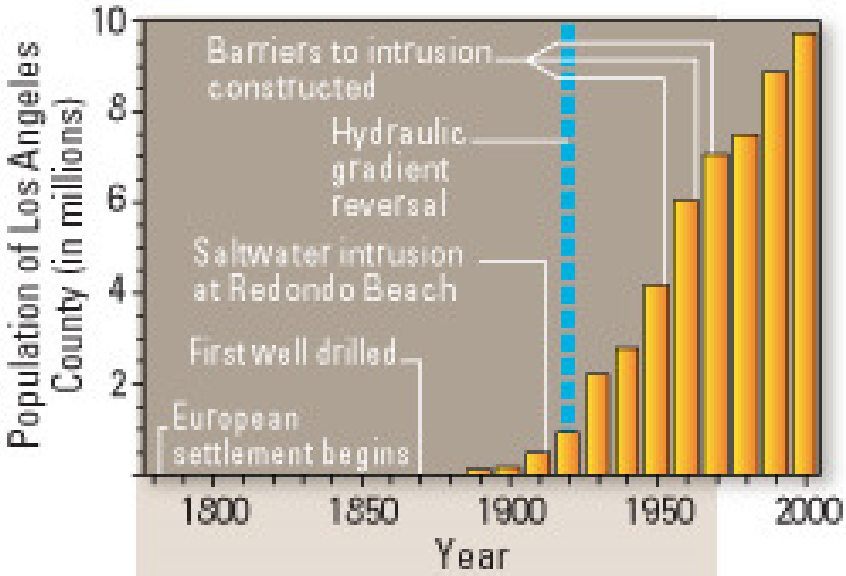


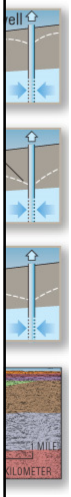
ABSTRACT

One-third of the water supply for coastal areas of Greater Los Angeles comes from local ground-water sources. Saltwater has penetrated a part of the supply, and a significant part of the remaining supply is at risk. U.S. Geological Survey scientists, working in cooperation with local water agencies, are studying the connection between coastal aquifers and the offshore geology to better understand the processes and pathways of saltwater intrusion



Saltwater intrusion in coastal aquifers of Los Angeles County is a result of increasing use the gro





In the late 1800’s, water wells pumped by wind power were first used to tap into the ground water of the Los Angeles Basin (A). This technology provided abundant freshwater for residents of the parched coastal region, allowing for expansive growth of both population and agriculture. Increased pumping through the early 1900’s caused potentiometric levels (the levels to which pressure in the aquifer would make water rise in cased wells) along the coastline to drop below sea level. As a result, a landward-directed pressure gradient caused saltwater to begin invading coastal aquifers as early as the 1920’s (B).
In the 1950’s, sets of closely spaced wells were drilled to inject high-quality freshwater into the ground, creating hydraulic pressure ridges or “barriers” to saltwater intrusion (C). Ideally, these barriers would stem the flow of saltwater into coastal aquifers. However, the barriers are not completely effective.
New studies by the U.S. Geological Survey and its cooperators show that the geology of the Los Angeles Basin is much more complex than originally conceived. A seismic profile from the Port of Long Beach (D) shows the complex geology of the area. The sediment layers, shown as different colors, provide many potential pathways for saltwater intrusion. By understanding this geology, scientists can better determine where and how fast water moves within the various beds of sediment both onshore and offshore.