Sustainable Recycled Water Recharge Program

Sustainable Water Project

Current Centralized Water Treatment Systems (CWTS) work in series with wastewater treatment facilities that typically discharge processed effluent into nearby bodies of water. The massive amounts of energy required to meet demand, strain financial resources, and offer no return on investment.

Areas this project is addressing:
Groundwater recharge | Ecological rejuvenation | Economic waste
Demand on CWTS wastewater treatment | Sustainability

Considerations in this project included soil permeability, distance from aquifers, population, and available space.

Knowledge and Skills Gained

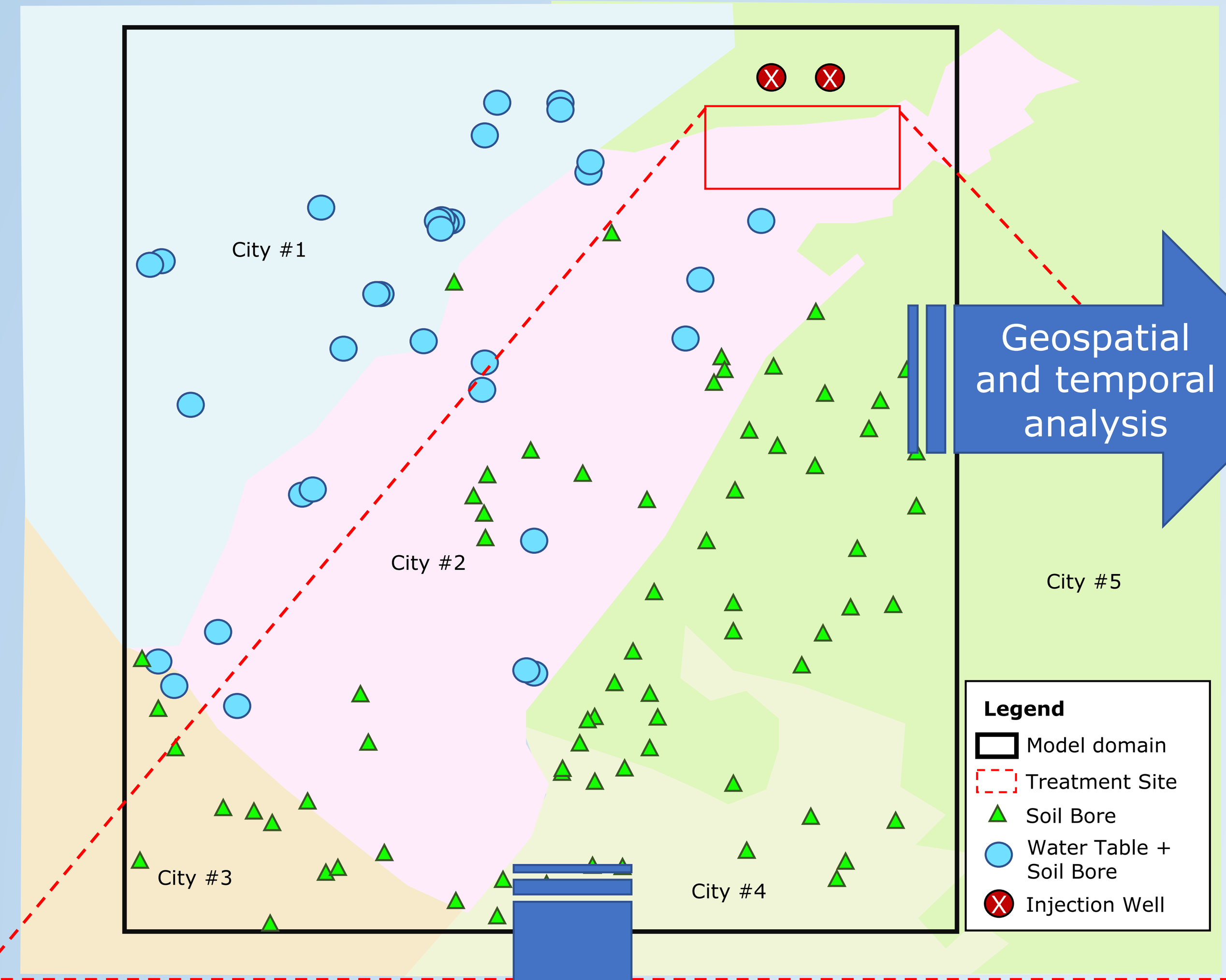
This project improved both collaboration and technical skills listed below:

Collaboration Skills
- Project Management
- Delegation of tasks
- Tracking progress
- Leadership
- Integrating two teams who had separate tasks (Design and Modeling)
- Communication
  - Across disciplines and PE's
  - Used zoom and teams due to COVID-19 restrictions.

Technical Skills
- Numerical modeling on Linux-based 64-core computing cluster
- MATLAB for pre- and post-processing model inputs and simulations
- ArcMAP for geospatial processing
- ParFlow for 3D hydrologic modeling of groundwater flow (unsaturated and saturated zones)
- Regional specific environmental laws
- Design decentralized treatment facility
- Cost Estimation

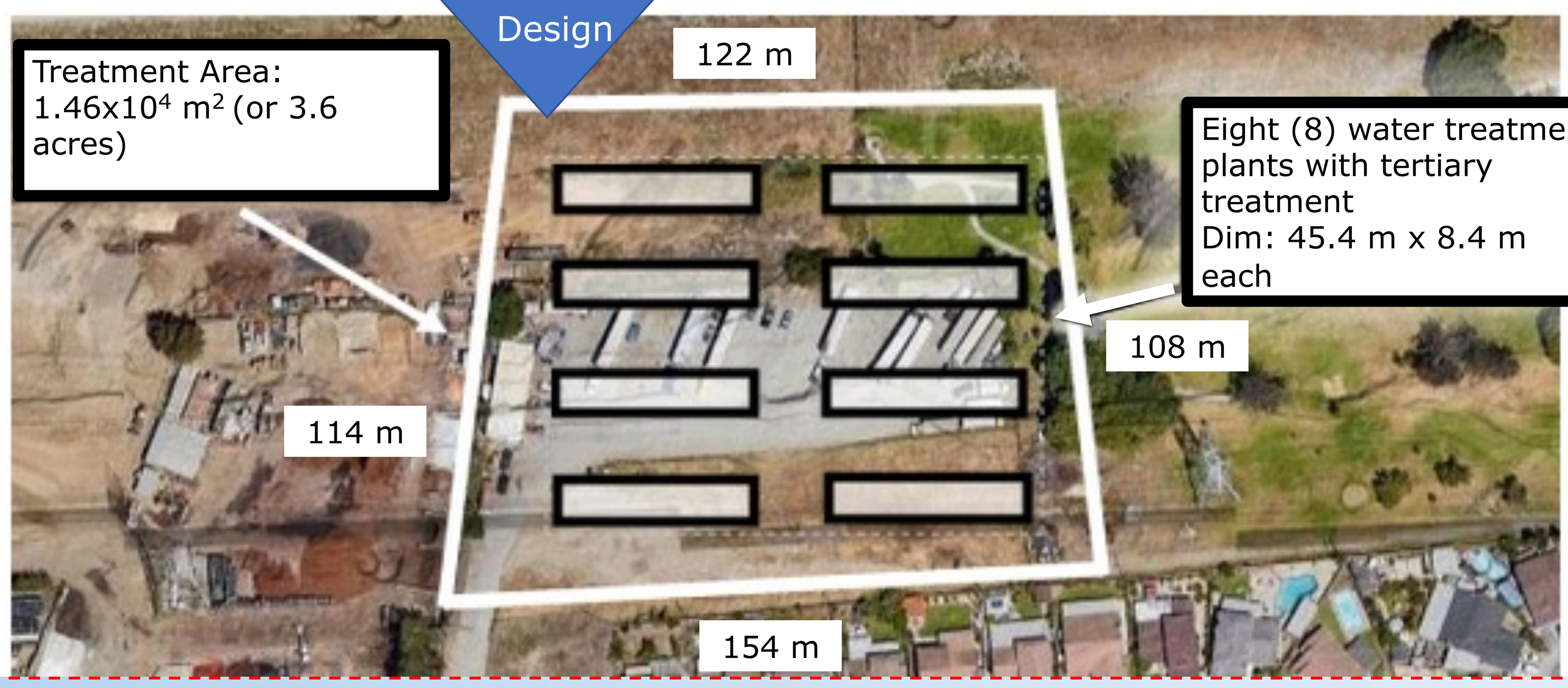
Engineering Analysis and Modeling

Site Selection and Decentralized Treatment Design

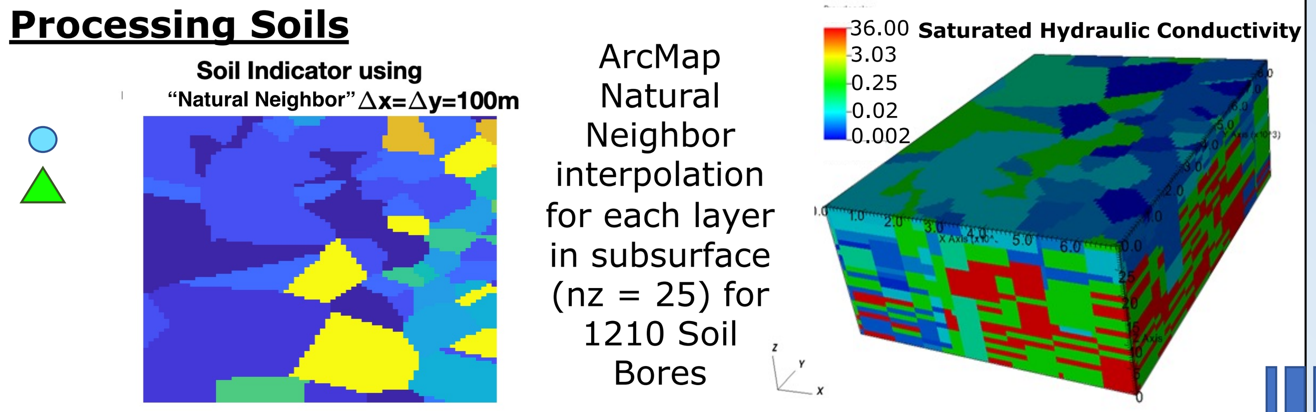


Geospatial and temporal analysis

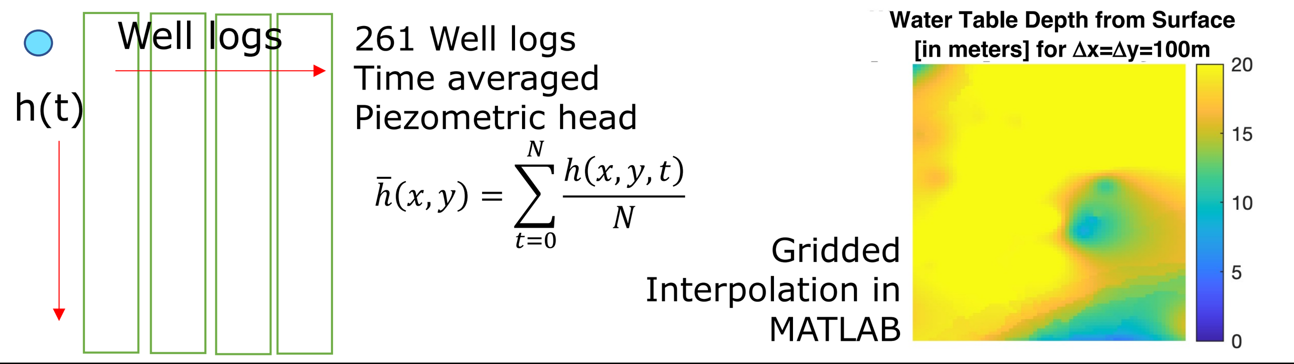
Design



Processing Soils



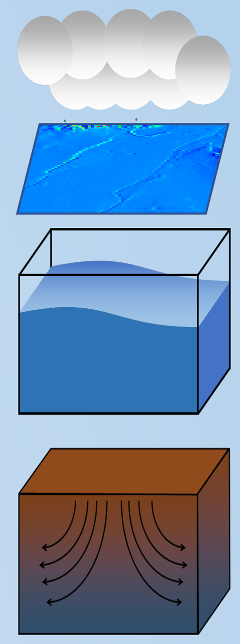
Processing Piezometric Head (Water Table Depth)



$$\bar{h}(x,y) = \sum_{t=0}^{N} \frac{h(x,y,t)}{N}$$

Hydrologic Modeling

ParFlow Hydrologic Model:

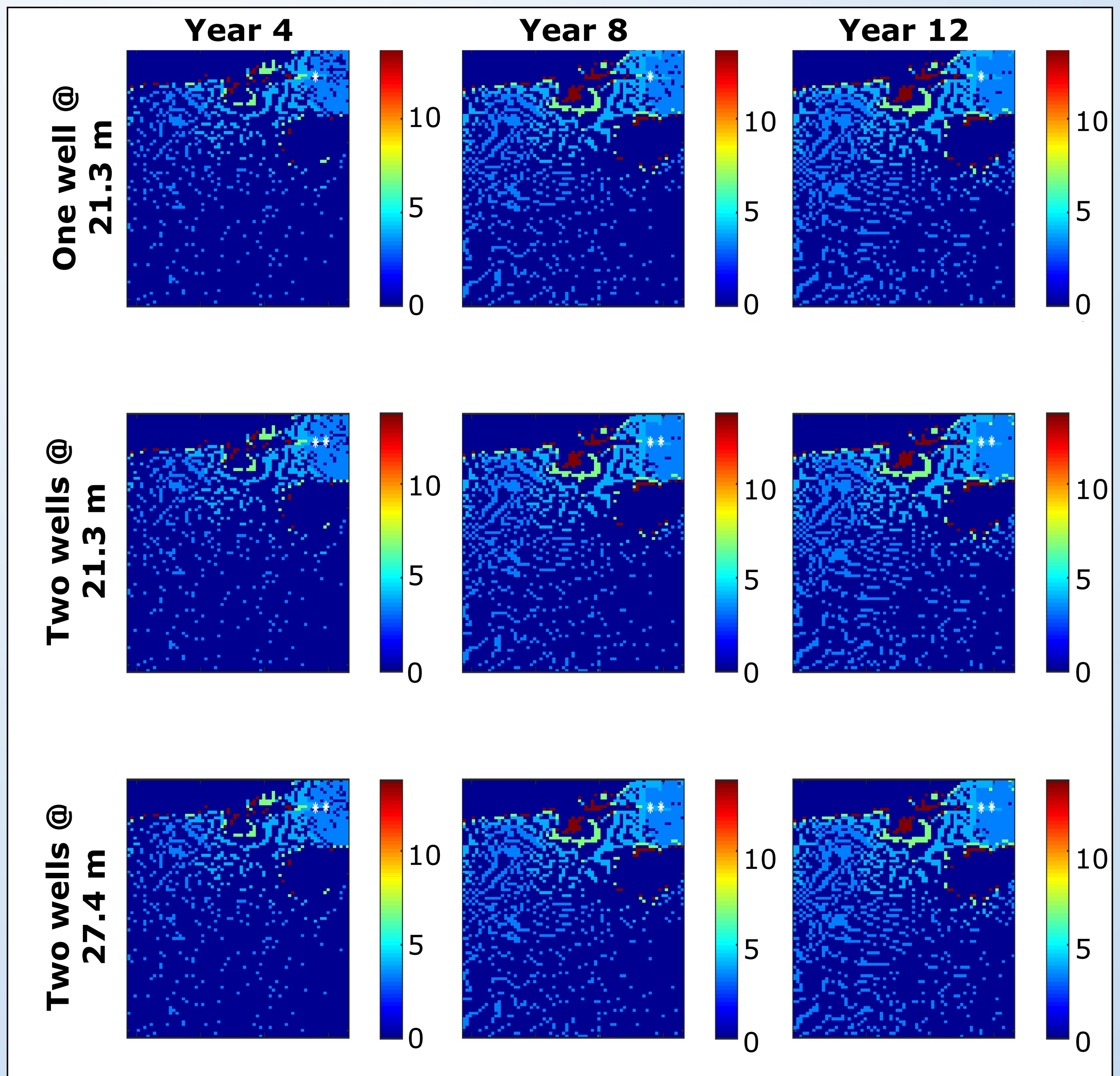


- **Free, Physically-based, Parallel-processing, 3D hydrologic model.**
- Solves the 3D Richard's equation for variable saturation in the subsurface.
- **Required model inputs included:**
  1) Precipitation,
  2) x- and y-directional slopes,
  3) Boundary conditions (piezometric head),
  4) Soil parameterization (saturated K, porosity, van genuchten),
  5) Injection rate for well(s)

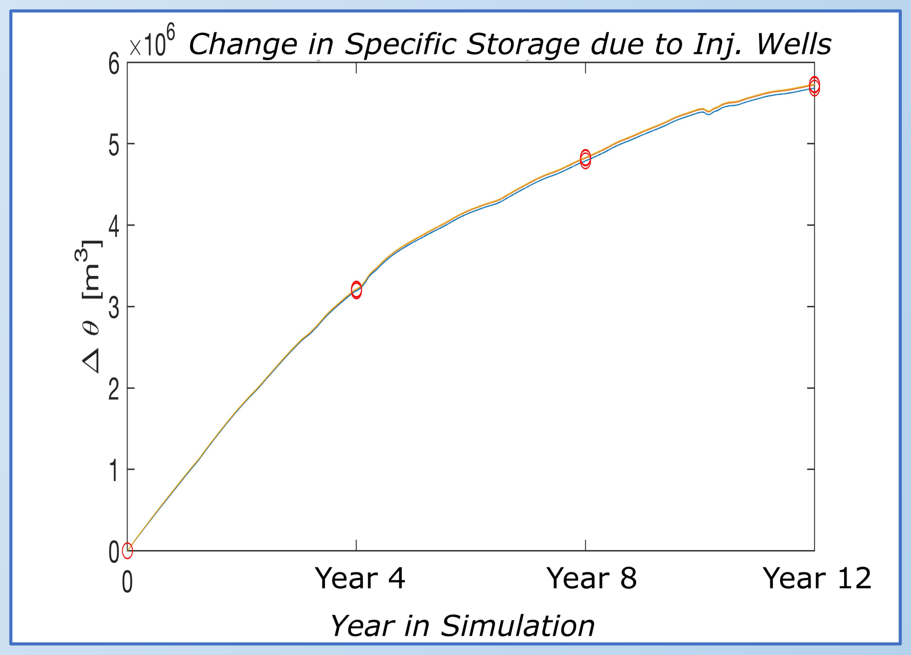
Distributed **pressure** and **saturation** values for each cell in the domain were used to calculate specific storage and changes to water table depth due to injection wells.

~155K computational cells ran on a 64-core linux cluster

Simulation Results:



- 12 year (4383 day) historical period for simulations
- Plots (left) show the change in water table depth due to injection scenarios: $h_{injection}(x,y) - h_{no\ injection}(x,y)$



- All model scenarios show an increase in water table depth due to injection.
- Water moves south towards ocean (minimizing seawater intrusion) with the slope gradient away from injection site.
- By year 12, specific storage increases to almost 6x10⁶ m³.
- Injection depth is not a factor—little variability in injection scenarios.

Treatment Facility:
- The treatment facility sites is 1.46x10⁴ m² (3.6-acres) and consists of eight (8) modular, prefabricated wastewater treatment systems
  - 4 modulars are in parallel
- The site can treat up to 800,000 gallons per day (GPD).

Injection Scenarios:
Three (3) injection scenarios using 15.24 cm (0.5-ft) diameter wells were compared to a *no injection* run:
(1) one well drilled to 21.3 m (70 ft) injecting 800,000 GPD,
(2) two wells drilled to depth of 21.3 m (70 ft) injecting 400,000 GPD each, and
(3) two wells drilled to a depth of 27.4 m (90 ft) injecting 400,000 GPD each.
Modeling showed that one (1) well was capable of injecting at similar rates as three (3), leading the cohort to propose one (1) well.

Multidisciplinary Participation

The modeling and design team included various disciplines and professional engineers in:
- **Civil engineering**
  - Geotechnical, Water Resources, Environmental Engineering
- **Geological Engineering**
- **Geography**
- **Computer science**

Environmental and Public Benefits

Locally Sustainable
- Recharge groundwater and increase surface storage
- Sea water barrier and subsidence prevention

Regional Benefits
- Less dependence on outside sources of water
- Preservation of natural ecosystems

Replicable
- Modular treatment units can be applied anywhere

Conclusion

Impact
- Decentralized treatment plant aids local community
- Provides water to a growing population
- Halts depletion of groundwater table
- Prevents salt water intrusion from ocean and land subsidence.

Future Investment
- Local water treatment cuts transportation costs
- Helps to prevent subsidence in the region
- Creates jobs for the surrounding community

Ergonomics
- Scalable to larger or smaller region of interest
- Prefabricated facility

Global Applications
- Environmentally friendly
- With the observations mentioned the the analysis is repeatable for all regions of the world since ParFlow is a free, open-access software