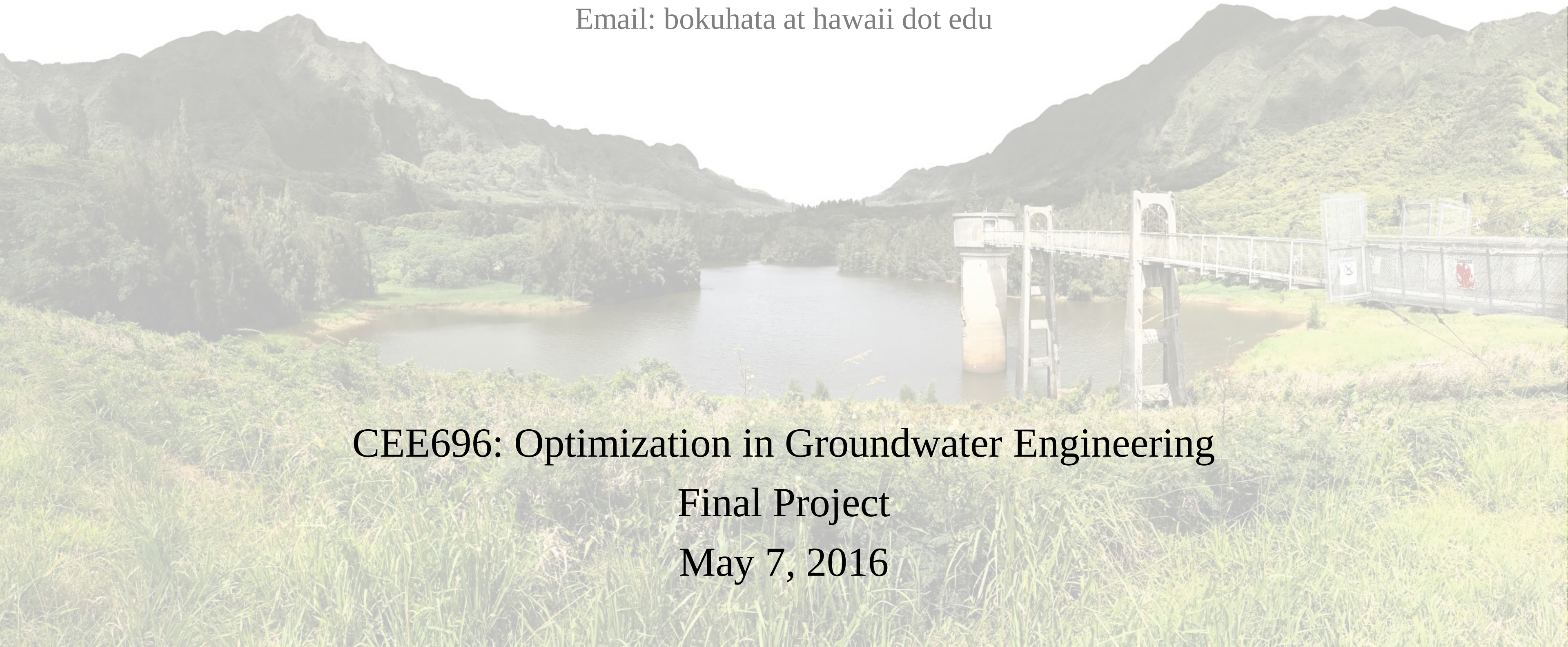
Preliminary optimization of groundwater pumping in Nu‘uanu Valley

Brytne Okuhata
Email: bokuhata at hawaii dot edu



CEE696: Optimization in Groundwater Engineering

Final Project

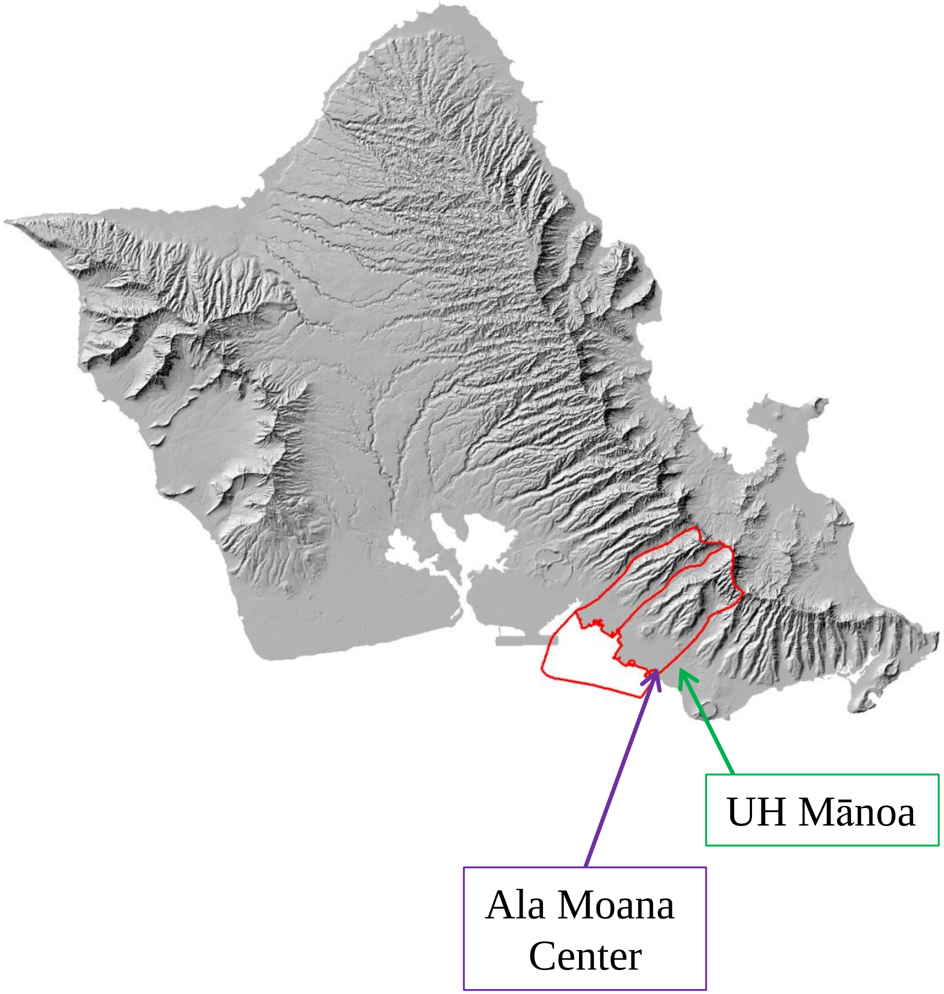
May 7, 2016

Introduction/Motivation

- 99% of Hawaii's domestic freshwater is pumped from groundwater aquifers [1]
- Groundwater resources may decline with climate change while our population continues to increase [2]
- Important to pump a sustainable amount of water
- In order to know how much water can be pumped, we need to understand the local hydrogeology

Study Area

- Nu‘uanu and Kalihi aquifer systems
- Area: 63.8 km^2
- Composed of multiple geologic units: shield-stage Ko‘olau basalt, valley fill alluvium, rejuvenation-stage Honolulu volcanics, caprock [3]

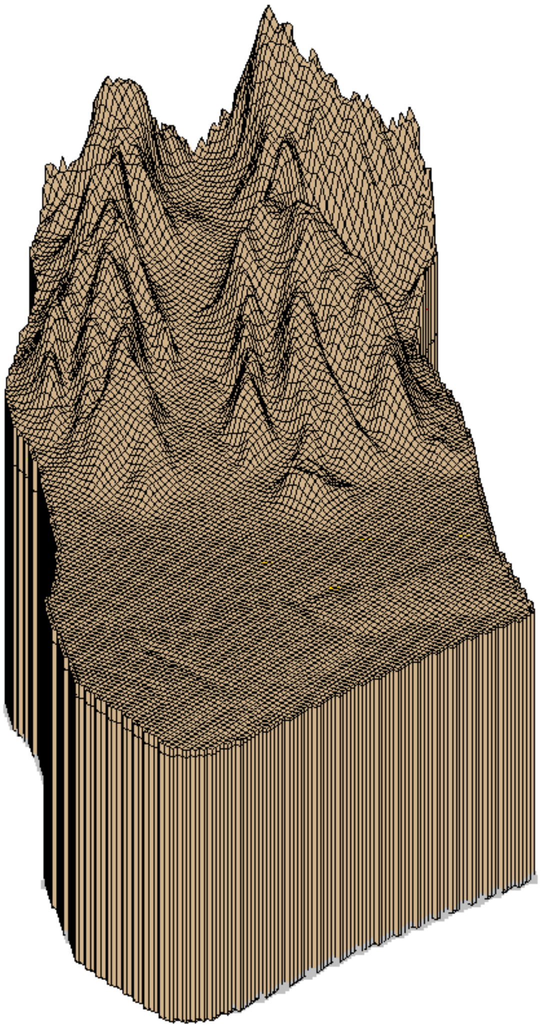


Input Parameters

- Grid: 2 layers
- Top elevation: topography and bathymetry
- Bottom elevation: 1000 meters below msl
- Recharge: 24 MGD = 90,850 m^3/d

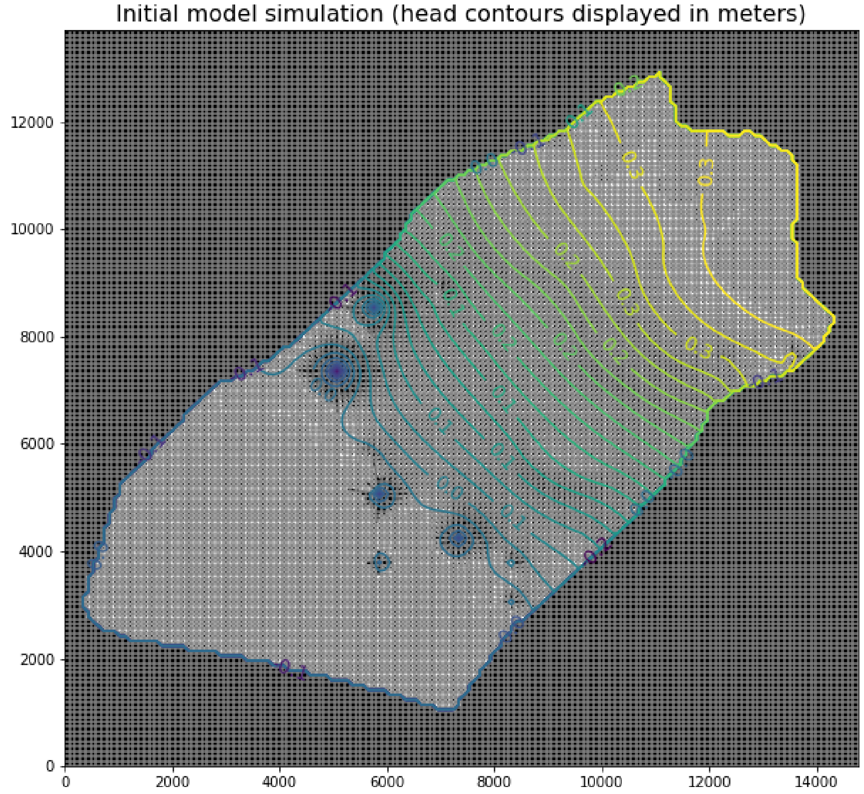
    (simplified from USGS coverage [4])

- Pumping: 27 wells
- Observation: 95 well levels



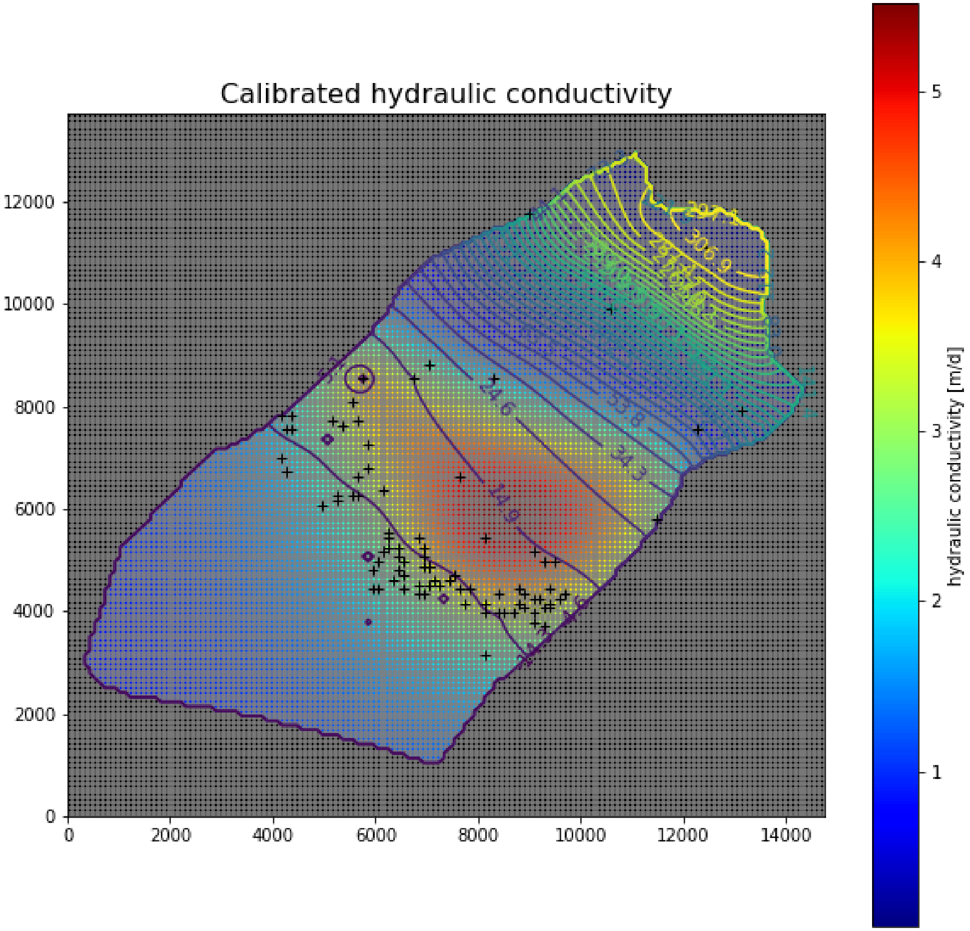
Preliminary Model

- Simulated water levels with no calibration or optimization
- Water levels are much lower than observed levels
- Need to consider heterogeneous hydrologic parameters such as hydraulic conductivity



Hydraulic Conductivity Calibration

- Goal: simulate observed water levels
- hydraulic conductivity (HK) calibrated based on 95 observed water levels
- HK values are low compared to field samples. This is more representative of effective HK.



Optimizing homogeneous pumping rate

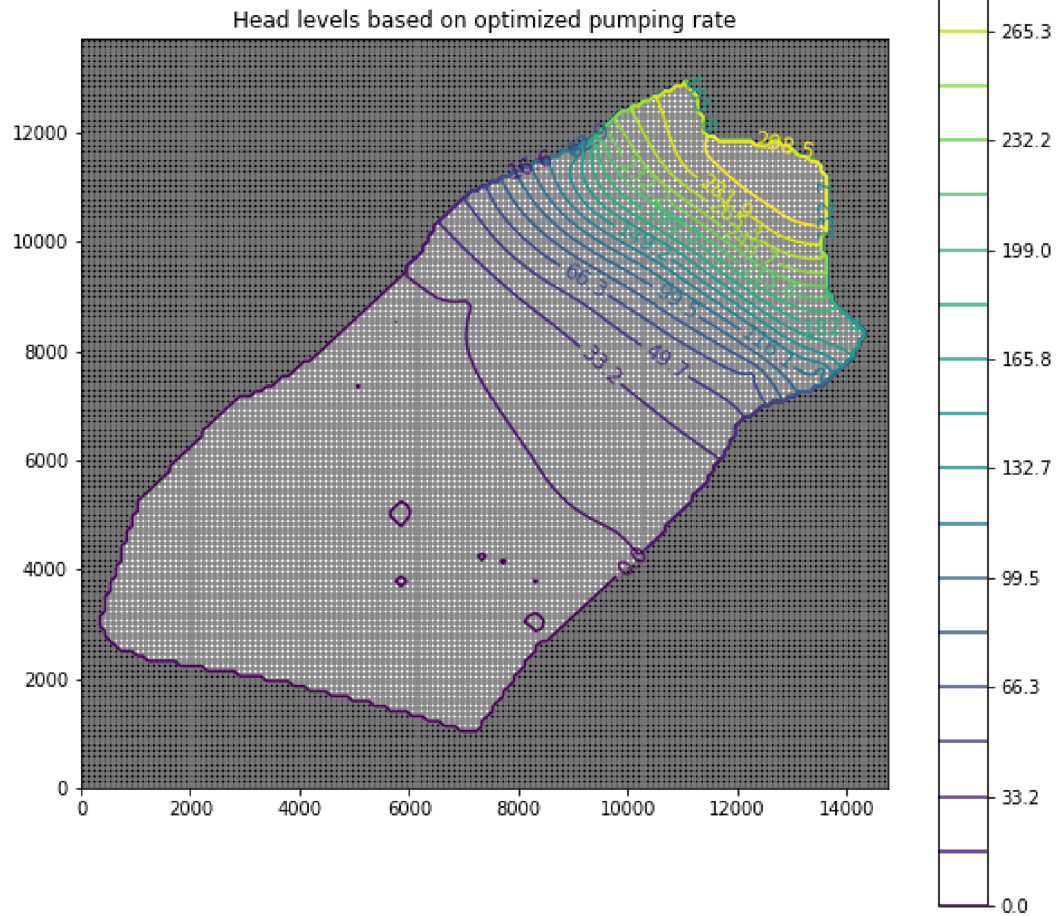
```
observations = np.loadtxt('test4_opt.hob.out', skiprows=1, usecols=[0,1])
obs_head = []
for idx, i in enumerate(observations):
        head = observations[idx][0]
        obs_head.append(head)
min_obs_head = min(obs_head)
```

```
if min_obs_head < 0.:
        penalty = 100000000. * (0.0 – min_obs_head) ** 2
else:
        penalty = 0
```

```
single_optimal_pumping = np.loadtxt('test4_opt.wel', skiprows=3, usecols=[3])
total_optimal_pumping = sum(single_optimal_pumping)
```

Optimization Results

- Optimal pumping rate:
  ~2,495 m^3/d
- Applied to 27 pumping wells
- **Combined optimal pumping:**
  ~ 67,363 m^3/d



References

[1] Gingerich, S.B. and Oki, D.S., 2000. Groundwater in Hawaii. U.S. Geological Survey Fact Sheet. https://pubs.usgs.gov/fs/2000/126/pdf/fs126-00.pdf.

[2] Izuka, S.K., Engott, J.A., Bassiouni, M., Johnson, A.G., Miller, L.D., Rotzoll, K., Mair, A., 2016. Volcanic Aquifers of Hawaii – Hydrogeology, Water Budgets, and Conceptual Models. U.S. Geological Survey Scientific Investigations Report 2015-5164. 158 p.

[3] Wentworth, C.K., 1941. Geology and ground-water resources of the Nuuanu-Pauoa District. Honolulu Board of Water Supply, 218 p.

[4] Engott, J.A., Johnson, A.G., Bassiouni, M., Izuka, S.K., 2015. Spatially Distributed Groundwater Recharge for 2010 Land Cover Estimated Using a Water-Budget Model for the Island of Oahu, Hawaii. U.S. Geological Survey Scientific Investigations Report 2015-5010. 49 p.