

## Capstone

- Draft tonight (I'll review over the next 5 days)
- Final presentations and report due on 12/11
  - Presentations 7 pm 12/11 in HLS 366
  - 10 minutes per team
  - Don't mess up on the timing!
  - Practice!
- Make it educational and fun for your classmates!

## You conquered snakes, spiders, other worlds in the transition to Jupyter

- You took on the challenge of Jupyter notebooks and you excelled!
- You demonstrated your ability to learn with minimal guidance
- You are a great class! Thank you!
- Juan, Cynthia, and Zoe are amazing people and outstanding teachers



- At least 1.8 billion people use a source of drinking water contaminated with feces
- More than 80% of wastewater is discharged without any pollution removal

**Statistics Progress in Puerto Rico** *Hurricane Maria Update*

Signs of recovery

Cell service	5%	61%	92%
Potable water	44%	69%	83%
Patients cared for by hospital	—	6,100	33,165
Open ATMs	114	1,047	1,160
Generators	10	148	423
Gas Stations	40%	78%	84%
Power	0%	21%	41%
Installation of Blue Roof	0	439	5,975

1 DAY 30 DAYS 45 DAYS  
# of days after Maria made landfall

FEMA

## SDG 6.1: By 2030, safe and affordable drinking water for all

- Some three in ten people (2.3 billion) lack access to safe and readily available water at home
- Additional 1.2 billion from population growth gives 3.5 billion need water by 2030
  - 267 million people per year! (1 Indonesia/year)
  - At 3 mL/s per person we need 800,000 L/s per year of new installed capacity

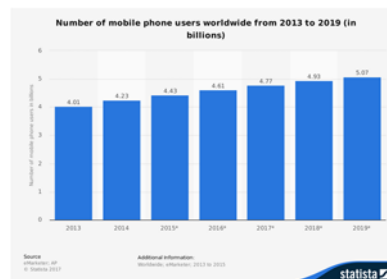
## SUSTAINABLE DEVELOPMENT GOAL 6

Ensure availability and sustainable management of water and sanitation for all

## US Water Infrastructure

- [ASCE Infrastructure Grade](#) is D+
- What you've learned in this course is completely applicable to designing new and upgrading existing water treatment infrastructure anywhere on this planet
- US water treatment infrastructure is far from optimally designed
- Most sedimentation tanks don't even have floc blankets!

## One billion new cell phone users in 6 years!



## Mobile phones and safe water in Honduras

### mobile phone

- 8.63% of income
- \$15.66 per month

- 90% of the population has a cell phone

### safe water on tap

- 1.1% of income
- \$1 per month O&M
- \$1 for capital costs

- Perhaps 50%? (no good data)

Lack of a mechanism to recover capital cost is one impediment to the spread of safe water on tap.

## The proven strategy in early industrialized countries is

- Centralized (community scale) water treatment
- Distribution system that brings safe water to each household
- Safe water on tap



Why don't countries prioritize building water supply systems and drinking water treatment plants?

## Traditional solutions aren't performing well in the Global South

### Decentralized – household and Kiosk

- Don't provide water access
- No monitoring
- Require every household to invest time in maintenance and operation



### Centralized – Municipal scale “advanced technologies”

- High part count = high failure rate
- High capital and maintenance costs
- High energy use
- Poor water quality



## Centralized water has a bad reputation!

- "...relying only on time- and resource-intensive **centralized** solutions such as piped, treated water will leave hundreds of millions of people without safe water far into the future.
- Self-sustaining, **decentralized** approaches to making drinking water safe, including point-of-use chemical and solar disinfection, safe water storage, and behavioral change, have been widely field-tested."

Eric Mintz MD, MPH; Jamie Bartram PhD; Peter Lochery MSc(Eng); and Martin Wenzel MSc



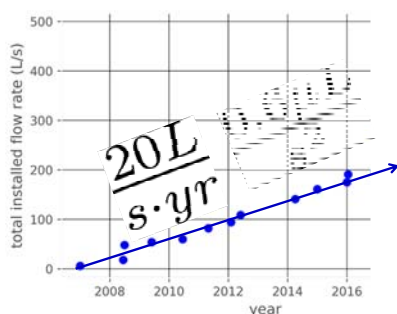
## Centralized water treatment has often failed in the global south

- Frequent failures due to high component count
- Short life of water treatment infrastructure
  - 20 years for high tech plant in Nicaragua
  - About 10 years for high tech plants in Honduras
  - 3 years for high tech plants in Africa (World Bank experience)
- So if you were a politician would you want to invest in water treatment plants?

## Centralized treatment CAN work if we adopt a new approach!

- Engineering that focuses on economics, energy, equality, elegance, and efficacy
- Low cost is possible
  - \$12 per year per person for operation and maintenance
  - \$50 per person for capital costs
  - 3.5 billion need water - \$175 billion capital cost by 2030 (\$13.5 billion/year)
  - Similar to US ice cream purchases
- Centralized can be monitored for safety

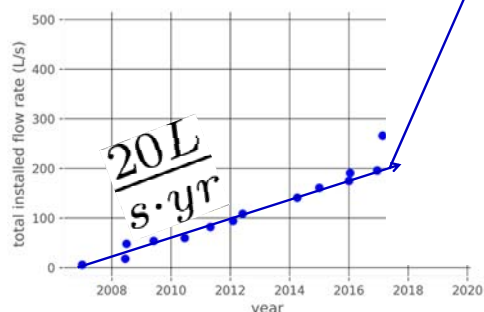
## AguaClara installed capacity is increasing steadily (and slowly)



## Time for acceleration

- We need 800,000 L/s per year of new installed capacity
- AguaClara = 20 L/s per year – need to increase rate by a factor of 40,000
- Disruptive technologies must be at least twice as good as traditional technologies
  - Our ongoing research to improve water treatment technologies is critical to increase the rate
  - Open source engineering is also a disruptive new approach to spreading technologies

The transition is underway with a significant increase in rate!



## Course Reflections?

- What is one thing that you learned in this course that you want to always remember?

## Challenges on the horizon

- **Standard designs** for flow rates from 1 to 240 L/s
- Retrofit designs for larger flat bottom sed tanks (take the case of 10 m square tanks)
- Wide range of water contaminants (expand to fluoride, arsenic, wastewater, reuse)
- Biggest challenge of all – create enough momentum so that new technologies are adopted and sustained

## New Opportunities

- Million village challenge
- Possibly adapted to remove arsenic and fluoride
- Demonstrate new technologies at far lower cost (\$10k rather than \$100+k)



## 120 L/s AguaClara plant (draft design for Gracias, Honduras)



## Connecting Meaning to Graduate School and Professional Careers

- Four steps toward a better world
  1. Measure stuff (often sufficient for a Ph.D.)
  2. Create models of how our universe works (based on observations) (fundamental science)
  3. Invent new solutions based on good models of how our universe works (inventing!)
  4. Engage with the world to implement those solutions (engineering!)
- Our planet needs bold engineers and scientists who engage to create a better world

## M.Eng. in Environmental and Water Resource Engineering

"The Cornell Masters of Engineering program is one of our top recruiting locations. The students are well prepared due to the technical knowledge and analytical problem-solving capabilities which they learn. But it's the self-motivation, oral & written communication skills, team-building and leadership skills which they learn that make them excellent consultants and allow them to quickly progress within our organization. Additionally, those involved with the AguaClara program have a passion for improving quality of life which is essential for being a successful environmental engineer."

-VP at Global Engineering Consulting Firm

Application due date is January 5

## AguaClara Project Teams

- Excellent opportunity to take what you learned in this course and **R**esearch, **I**nv~~e~~nt, **D**esign, and **E**ngage

## Internships

- REU at Cornell
  - Recruiting research team leaders
  - Fluoride removal reactor
- AguaClara Engineer Interns

