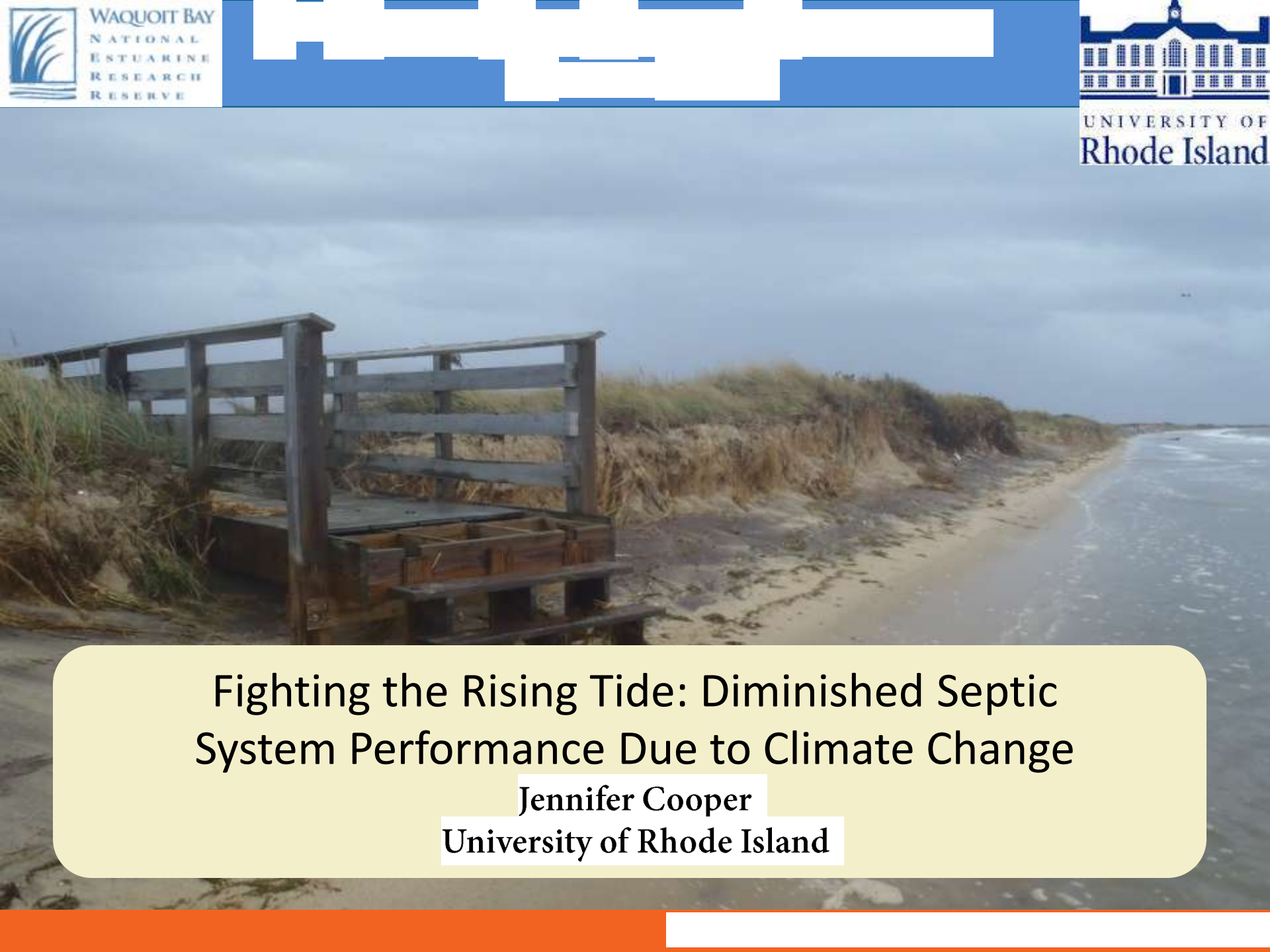

Fighting the Rising Tide: Diminished Septic System Performance Due to Climate Change

Jennifer Cooper
University of Rhode Island

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- RI Agricultural Experiment Station
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- URI Sea Grant
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- URI Undergraduate Research Awards

Research Team:

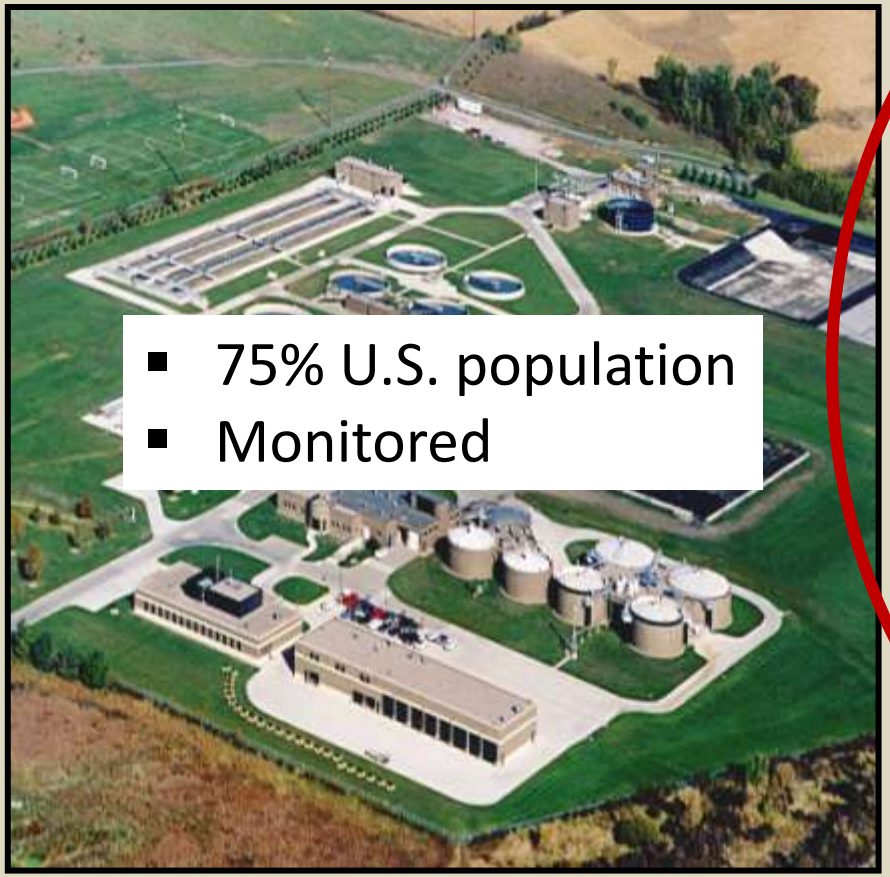
- Jose Amador – NRS
- Tom Boving – GEO
- George Loomis – NRS & NEOWTC
- Dave Kalen – NRS & NEOWTC
- Ivan Morales – Ph.D. student

Undergraduate Helpers:

- Juliana DeLuca
- Ethan Sneesby
- Joshua Sargent
- Ian Rambo
- Rachel Naylor
- Faith Anderson

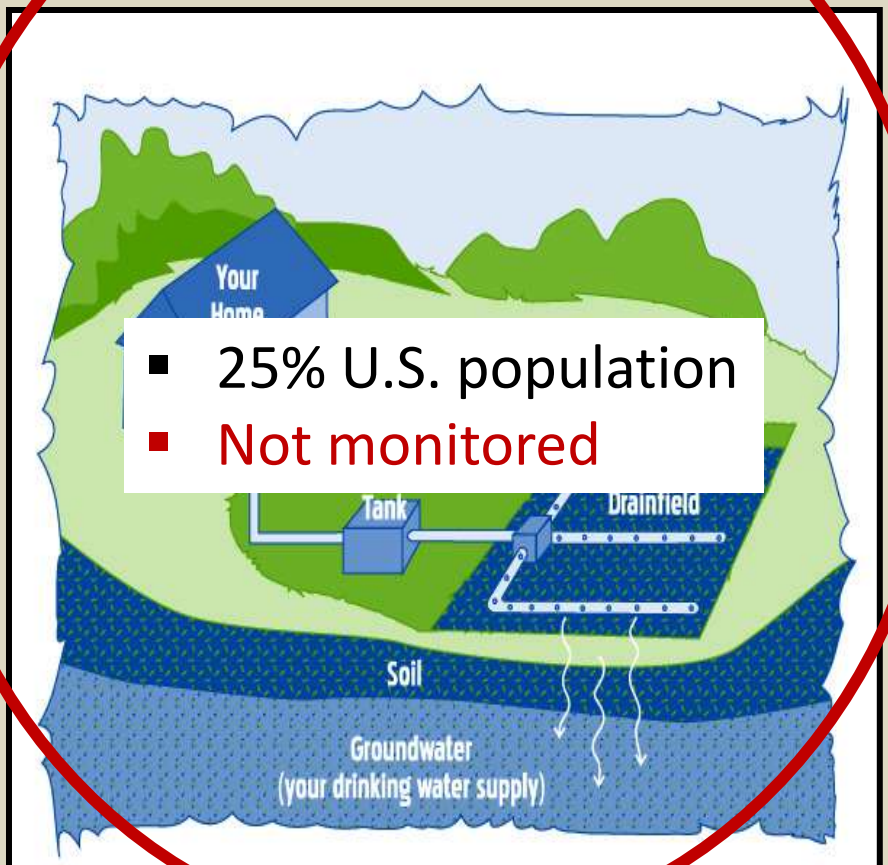
How We Treat Human Waste

Wastewater Treatment Plants



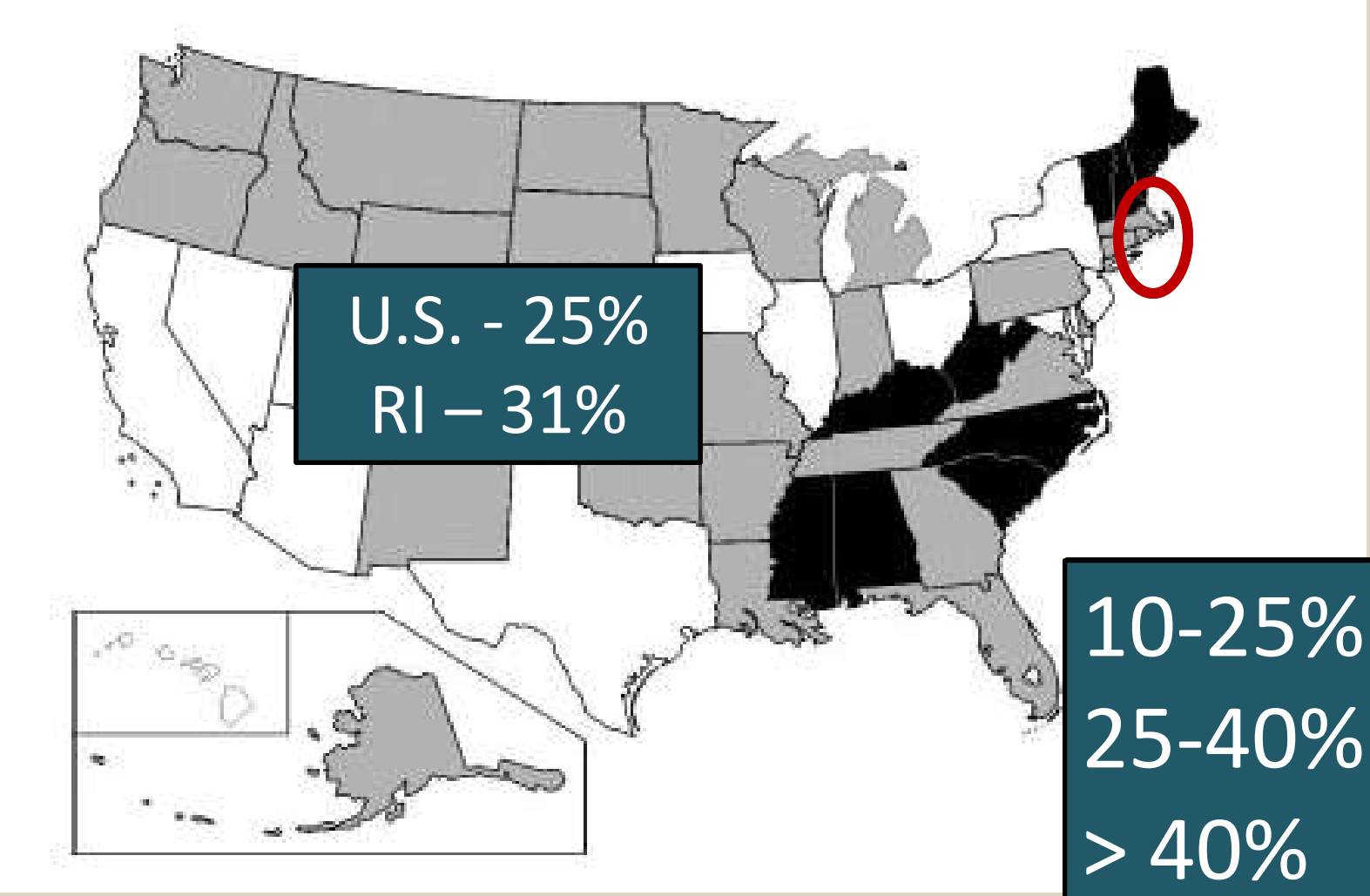
- 75% U.S. population
- Monitored

Septic Systems



- 25% U.S. population
- Not monitored

Distribution of OWTS in the United States



The Problems

Microorganisms:

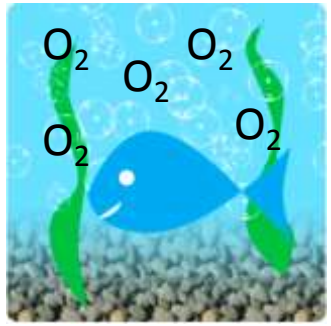
- Bacteria
- Viruses
- Protozoan
- Worms

Nutrients-N&P:

- Eutrophication
  - Fresh – P
  - Coastal – N
- Anoxia

BOD:

- Low O_2/Anoxia



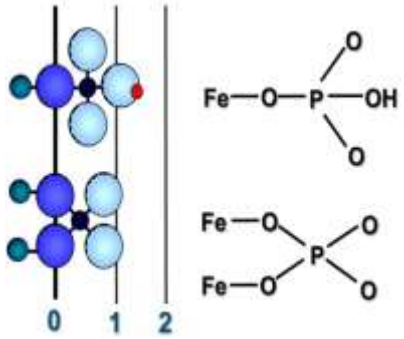
OWTS Drainfield Treatment

Microorganisms:

- Predation
- Adsorption/ filtration

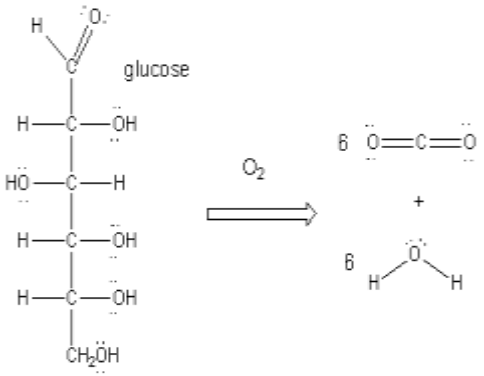
Nutrients:

- Phosphorus
  - Fe/Al hydroxides
  - Adsorption/ precipitation
- Nitrogen
  - Nitrification
  - Denitrification



BOD:

- Microbial degradation

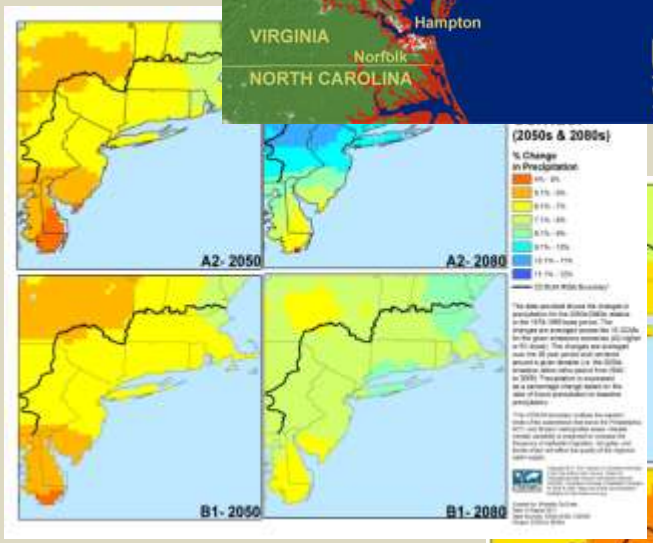


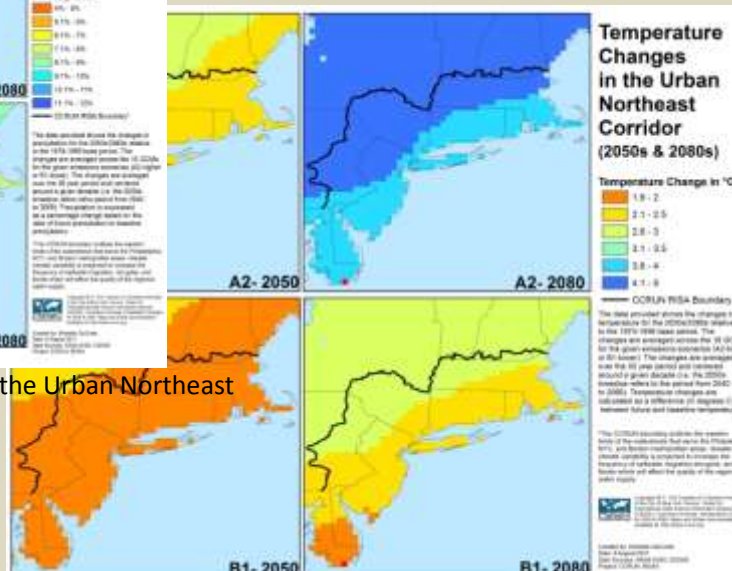
Climate Change - Northeast

Intergovernmental Panel on Climate Change (2013 report):

100 year predictions (Northeast) –

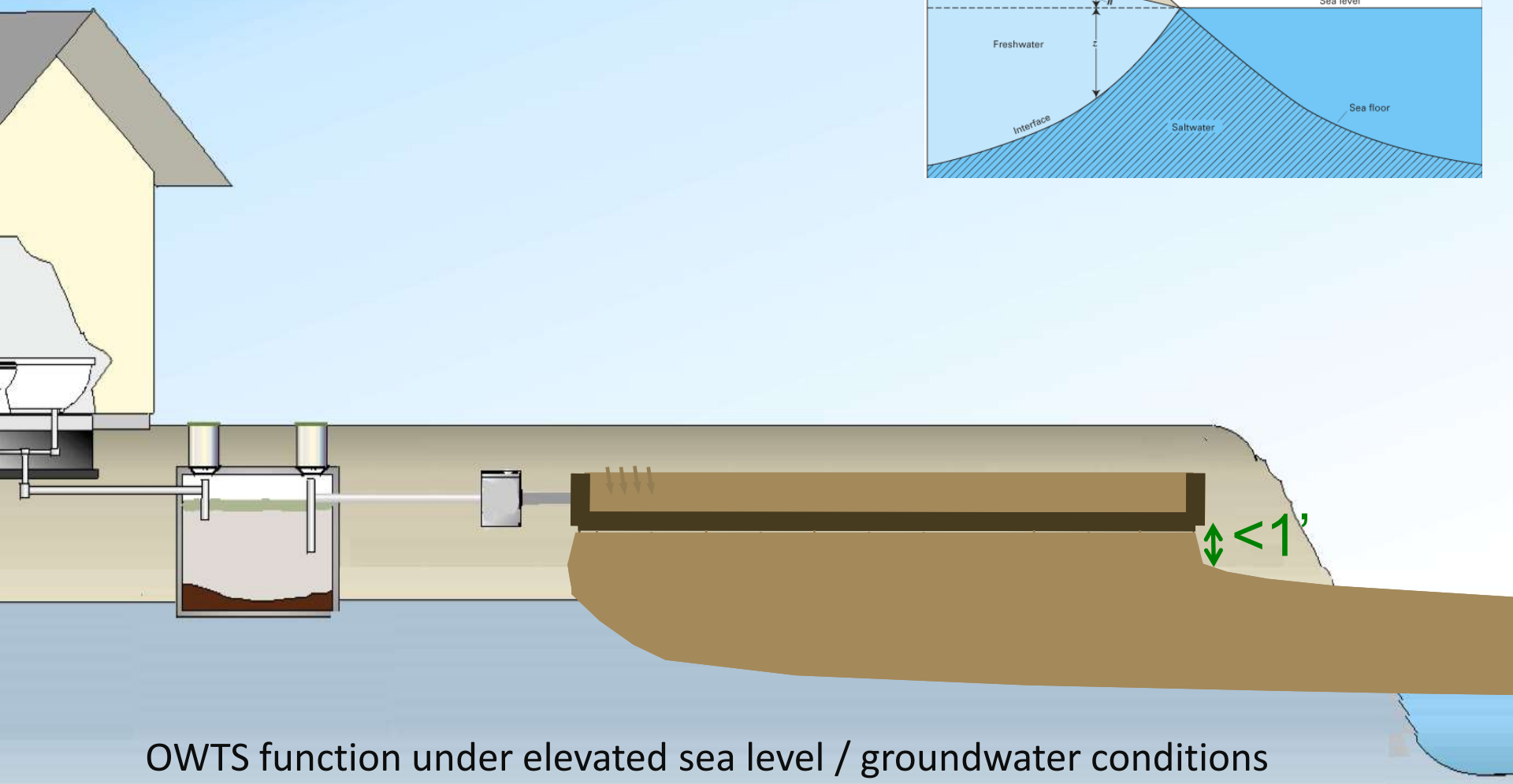
- Sea levels rise 3-5 ft.
- Increased precipitation
- Elevated temperature 2-5°C





Source : Consortium for Climate Risk in the Urban Northeast

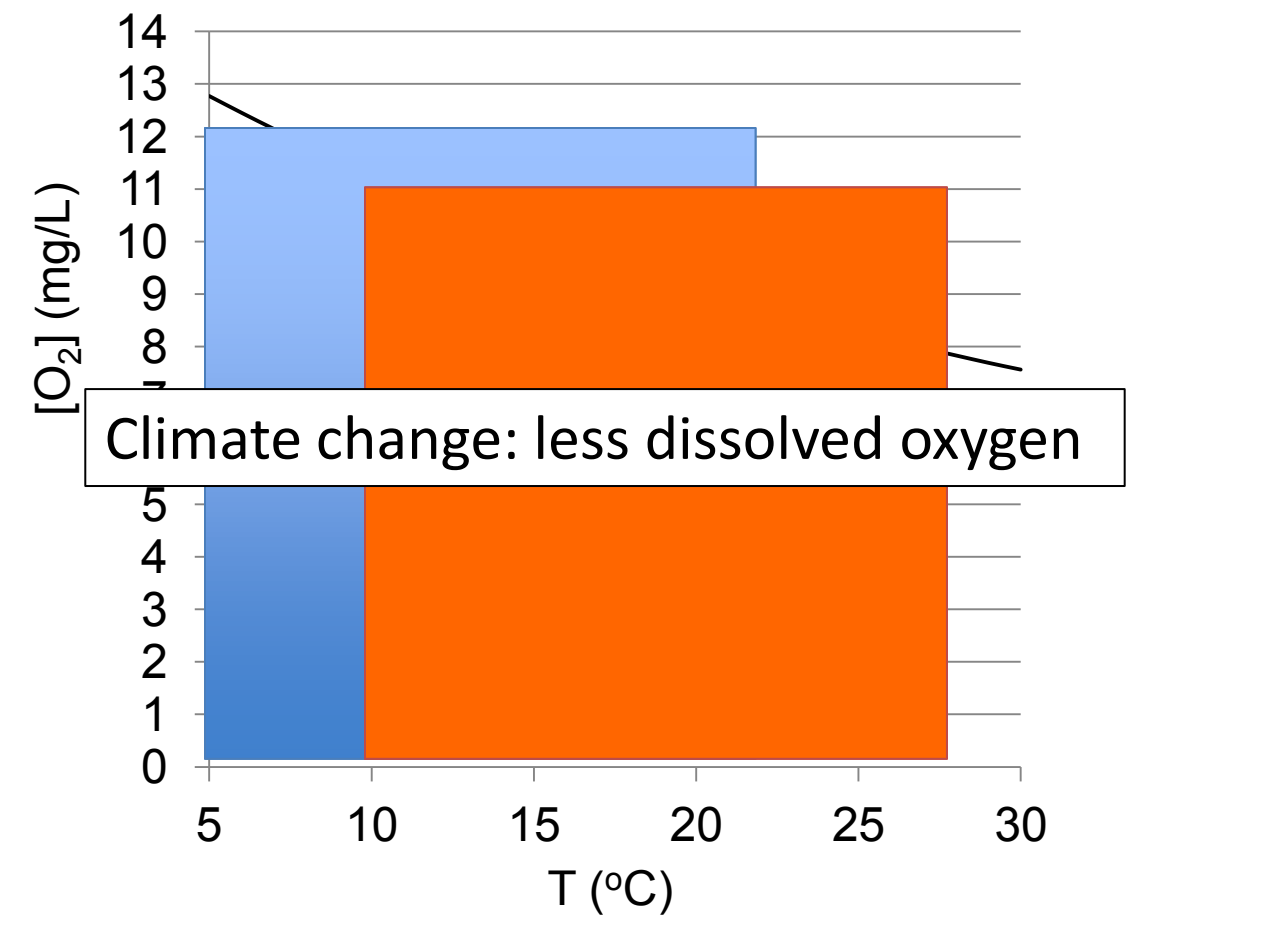
Chronic Effects of Climate Change



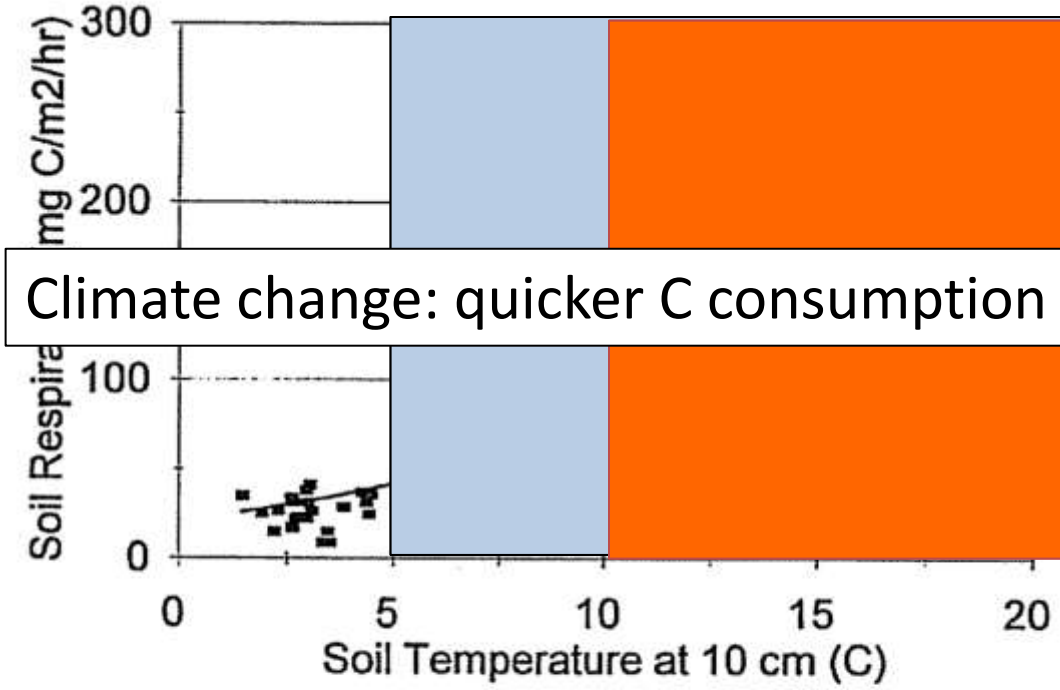
OWTS function under elevated sea level / groundwater conditions

Source: NEOWTC @ URI

Physical Effects of Rising Temperature



Biological Effects of Rising Temperature



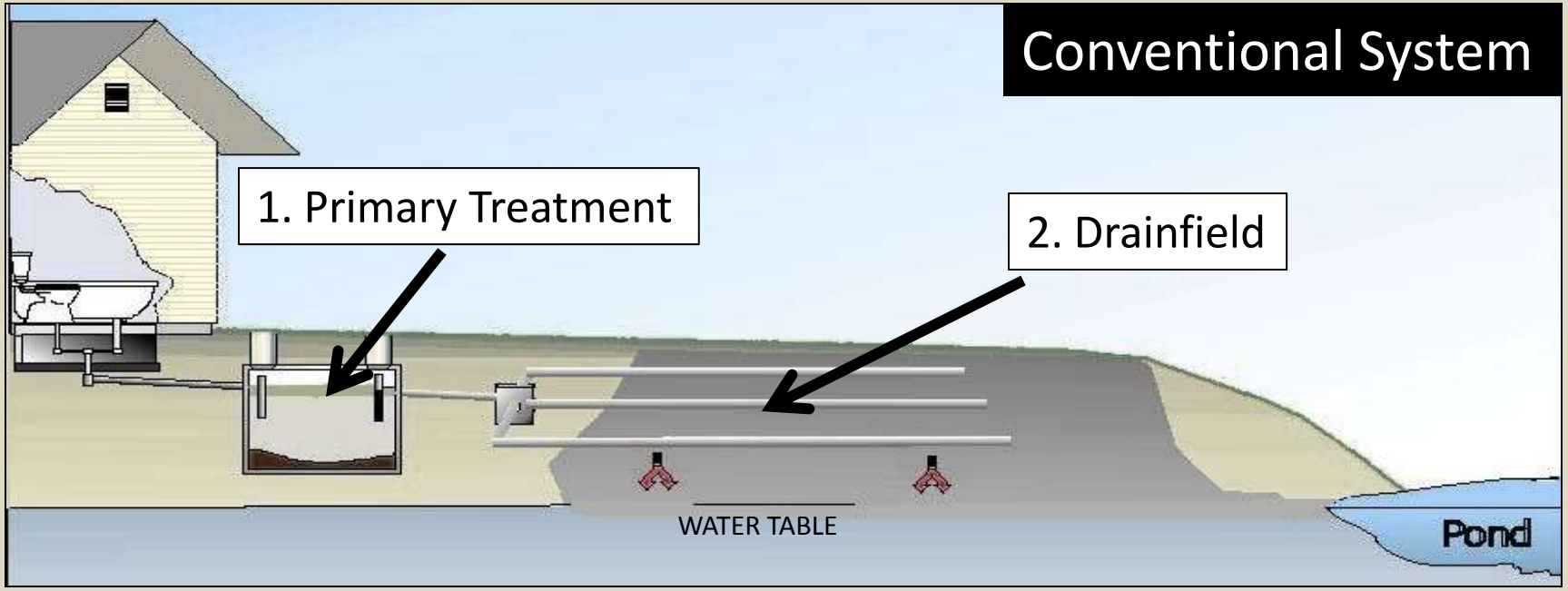
Climate change: quicker C consumption

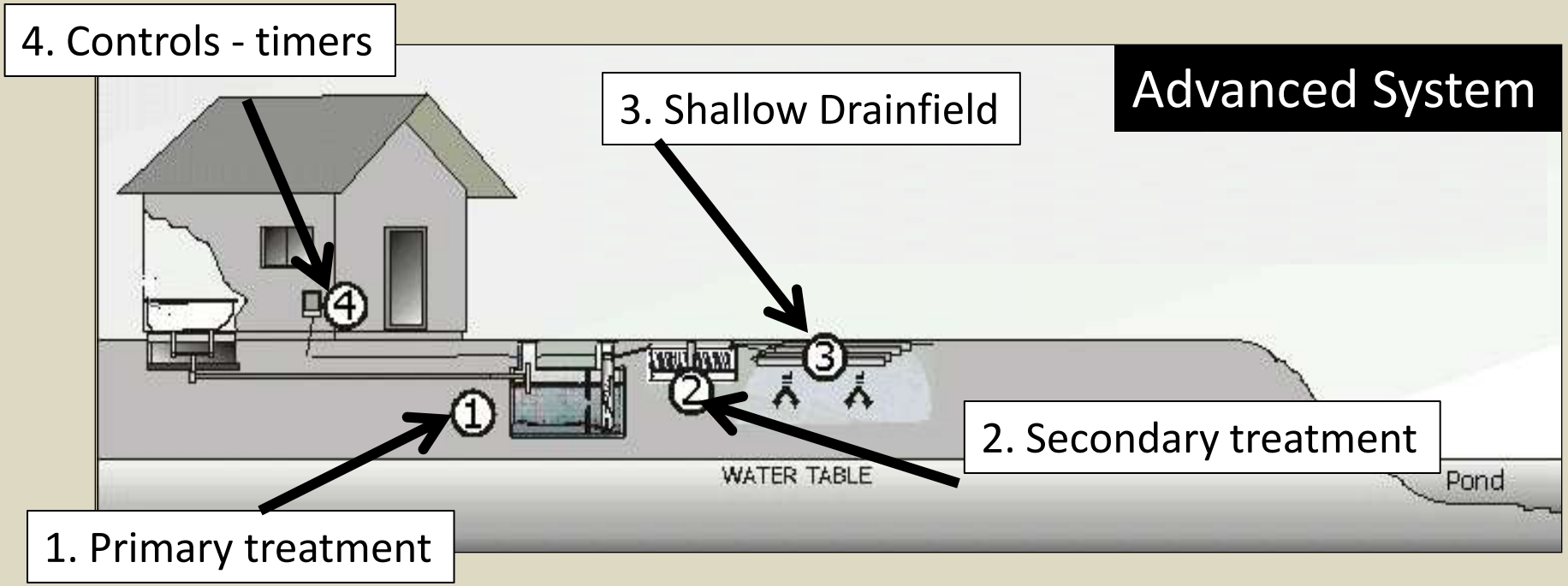
Fig. 4 Seasonal temperature dependence of soil respiration. Each square is a mean of six flux and temperature measurements made at one of the study areas at one date. The fitted function is:. Flux = $21.13 \times e^{(0.1371 \times \text{temp})}$. $R^2 = 0.80$, which is significant at $\alpha = 0.01$ (d.f. = 154).

Davidson et al. (1998)

The Experiment:

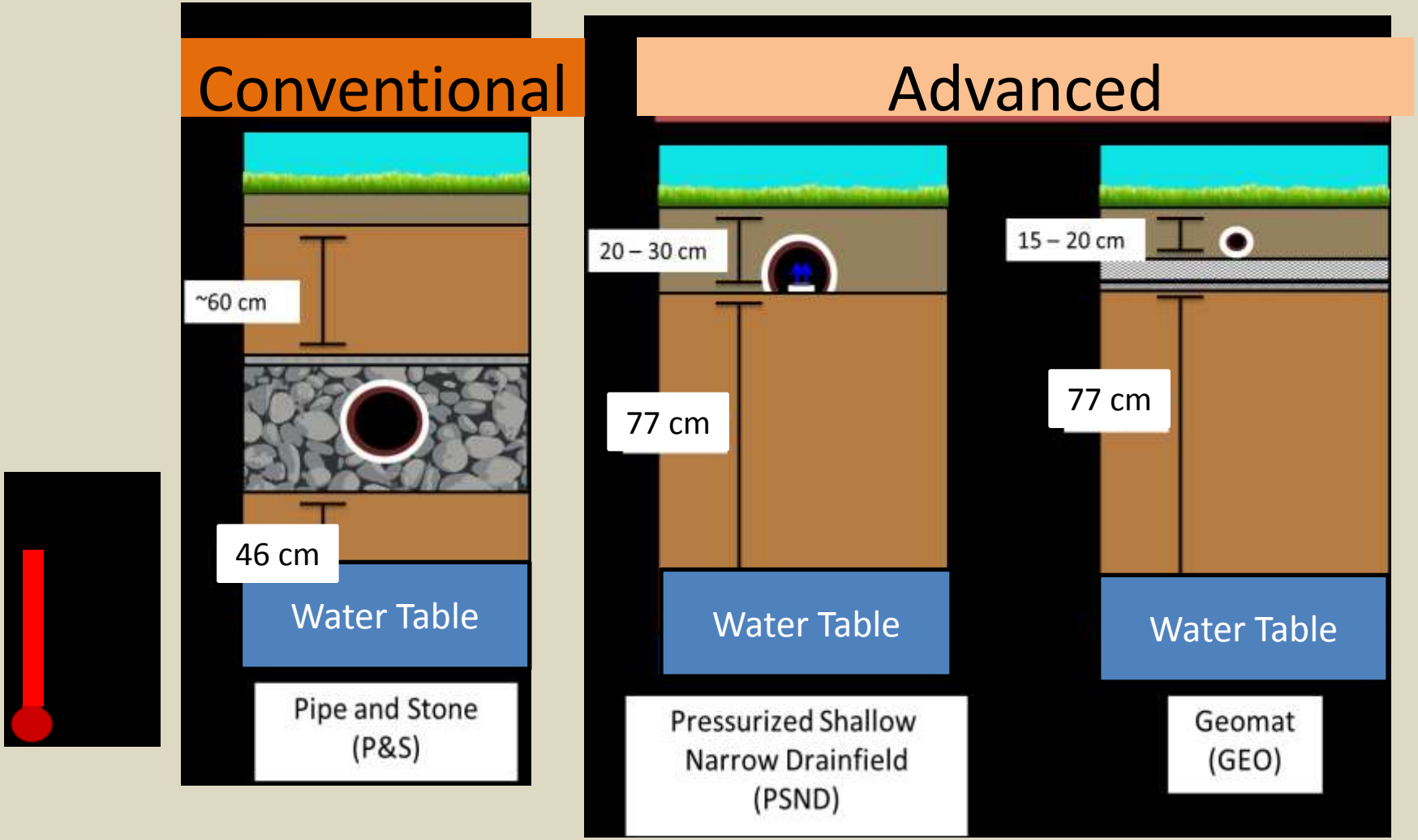
How Will Climate Change Impact OWTS?


Conventional System
1. Primary Treatment
2. Drainfield
WATER TABLE
Pond


4. Controls - timers
Advanced System
3. Shallow Drainfield
4
3
2
1
2. Secondary treatment
WATER TABLE
Pond
1. Primary treatment

Intact Soil Mesocosms

Present Climate vs. Climate Change

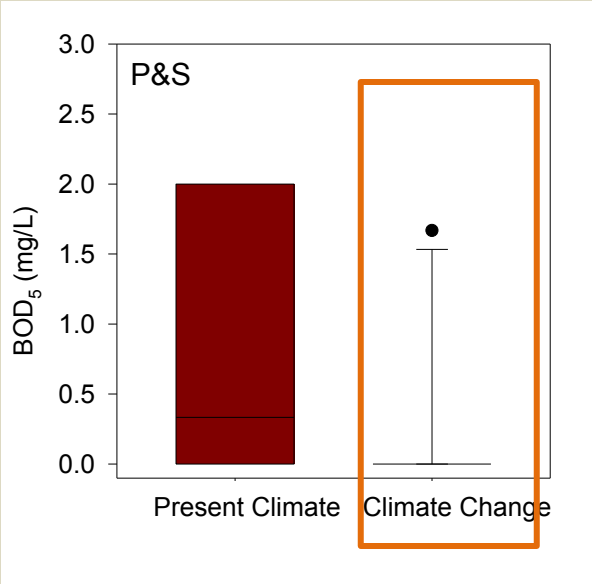


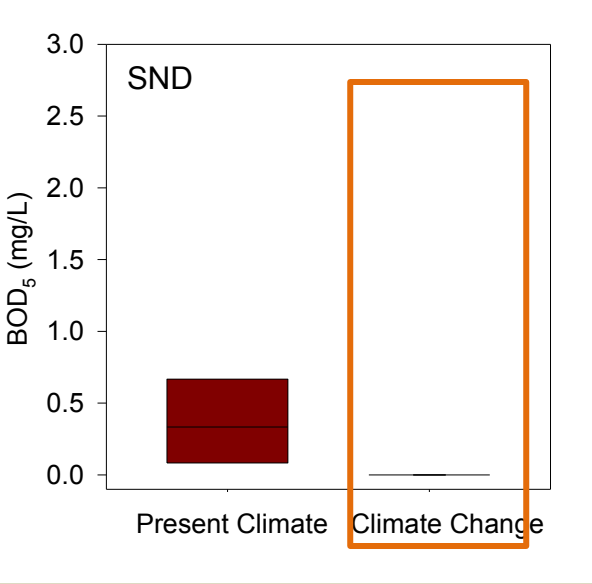
RESULTS

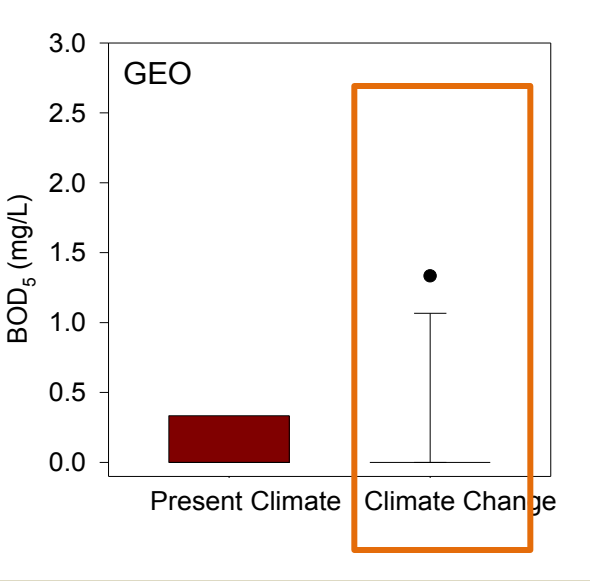
Biochemical Oxygen Demand (BOD)

Conventional

Advanced





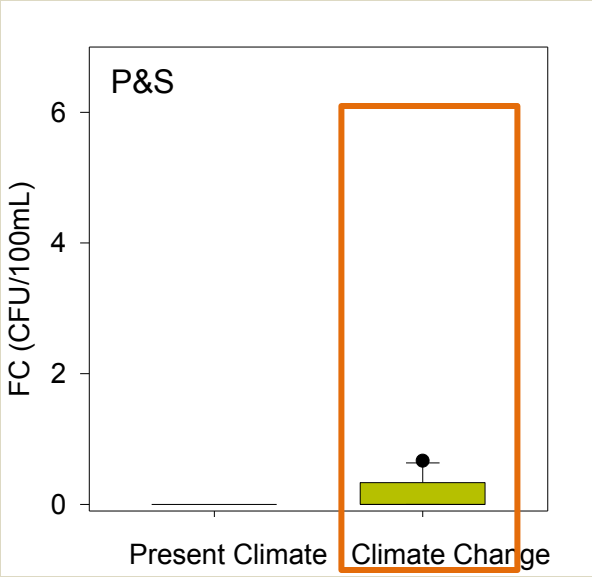


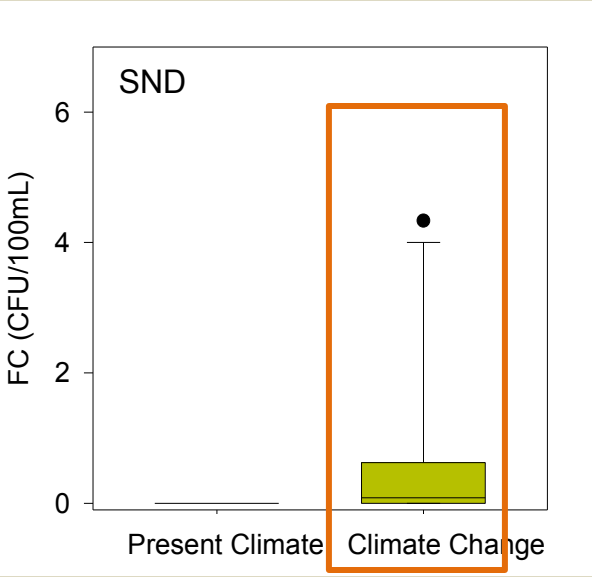
Increased temperature likely speeds microbial C degradation

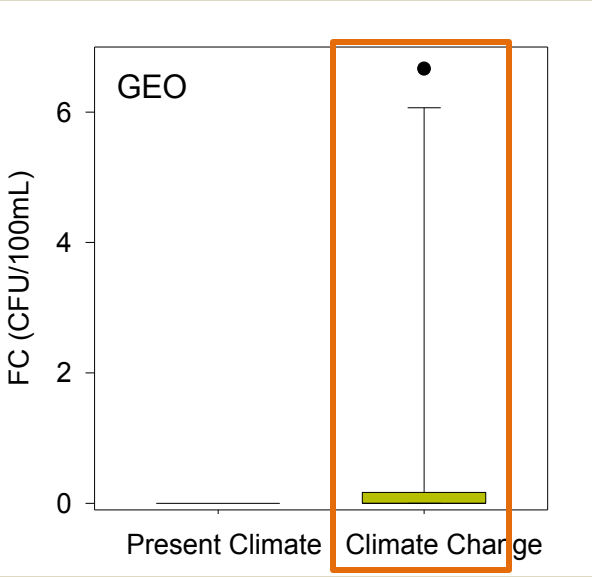
Fecal Coliform Bacteria

Conventional

Advanced







Increased moisture likely diminished microbial attachment

MS2 Bacteriophage - Virus

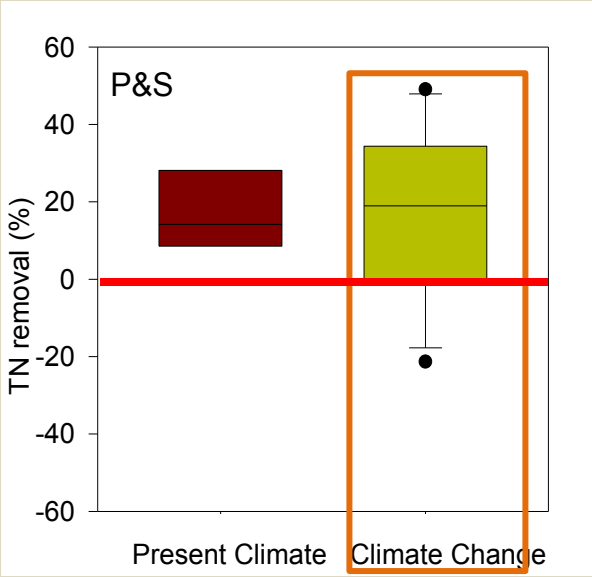
Conventional | Advanced

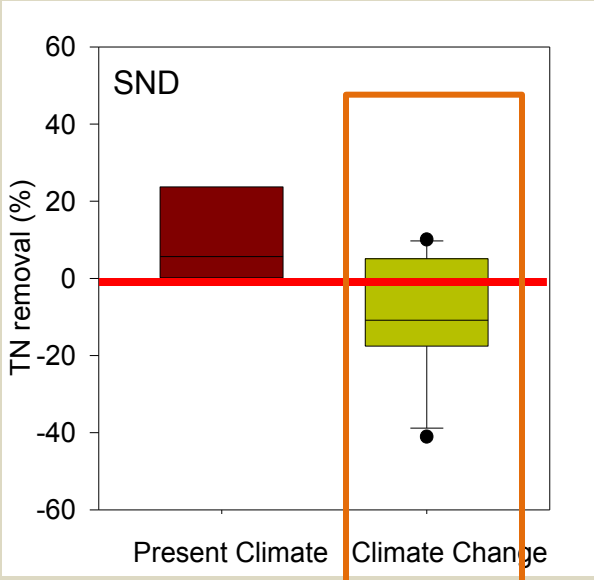
- No virus in output water
  - Present climate and climate change conditions
  - For all drainfield types
- pH more important than wetter/hotter conditions
  - Virus will have (+) charge at drainfield pH (~3.2)
  - Aids in retention to (–) charged soil particles

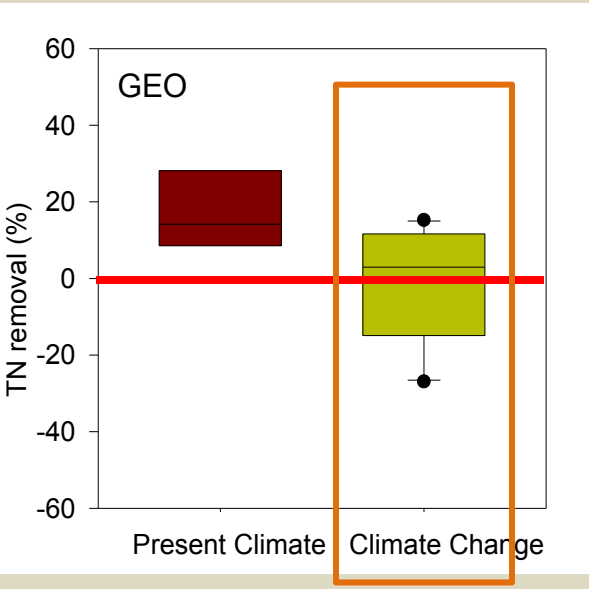
Total Nitrogen

Conventional

Advanced







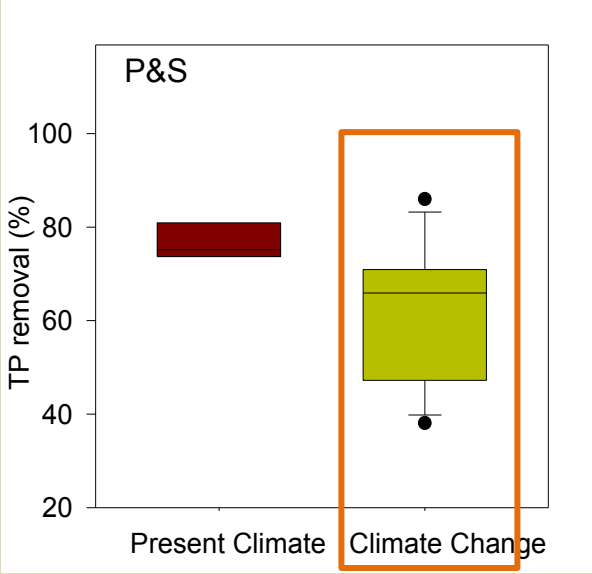
Conv.: Increased moisture, more anoxia, more hetero. denit.

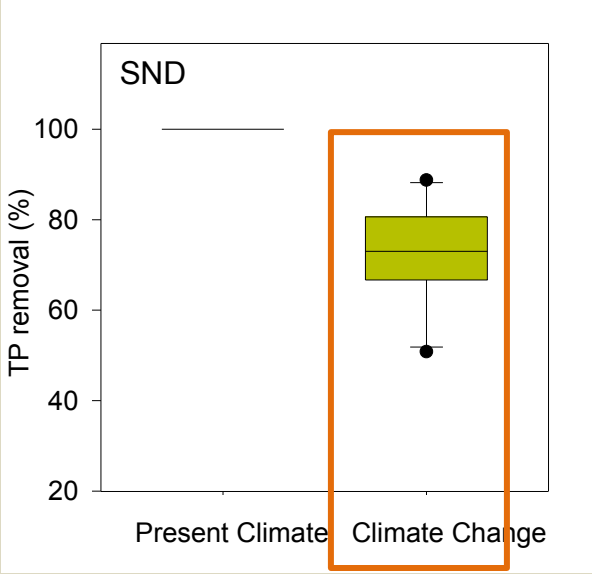
Adv.: Temperature increased C degradation, limited hetero. denit.

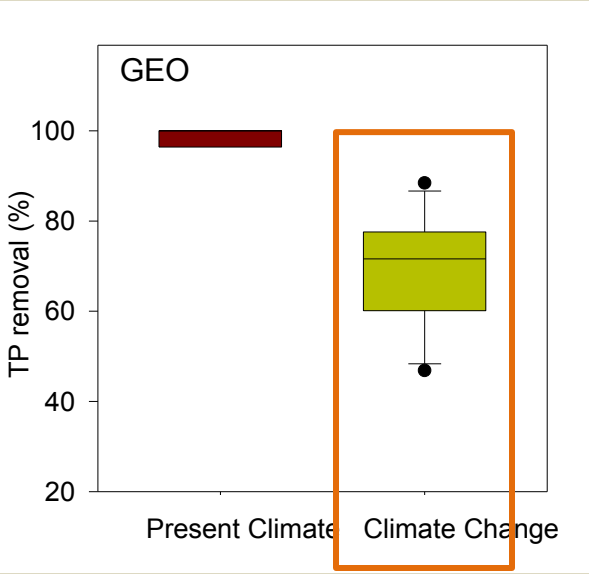
Total Phosphorus

Conventional

Advanced



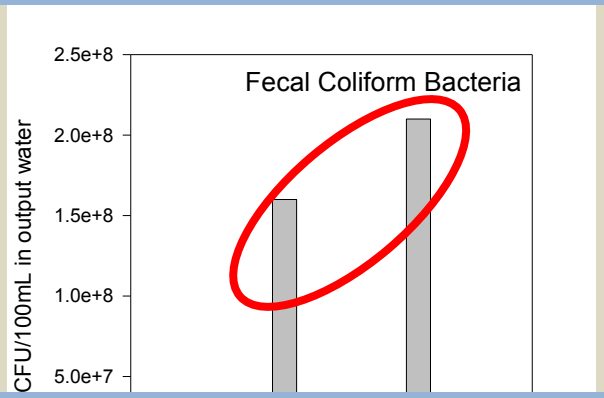


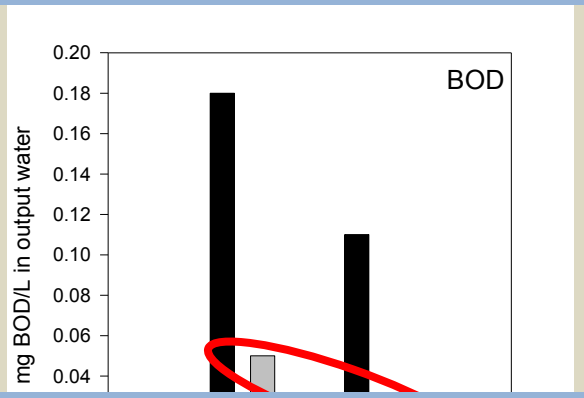


Increased moisture likely caused reduction/dissolution of metals allowed P mobilization

Technology Performance

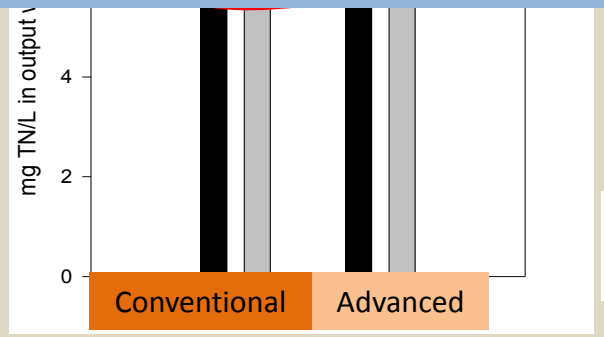
Mass of contaminants released from one year of operation



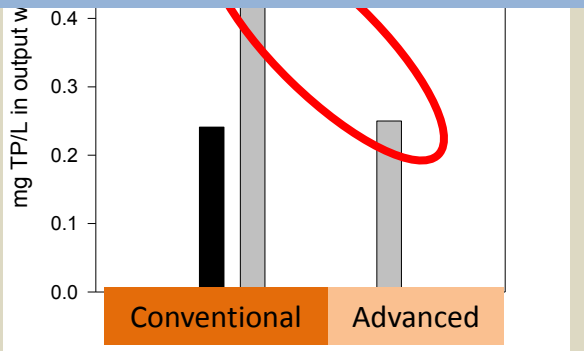


Conventional – better fecal coliform bacteria and total N removal

Advanced – better BOD and total P removal



kg/yr (FC in CFU/yr) in output water

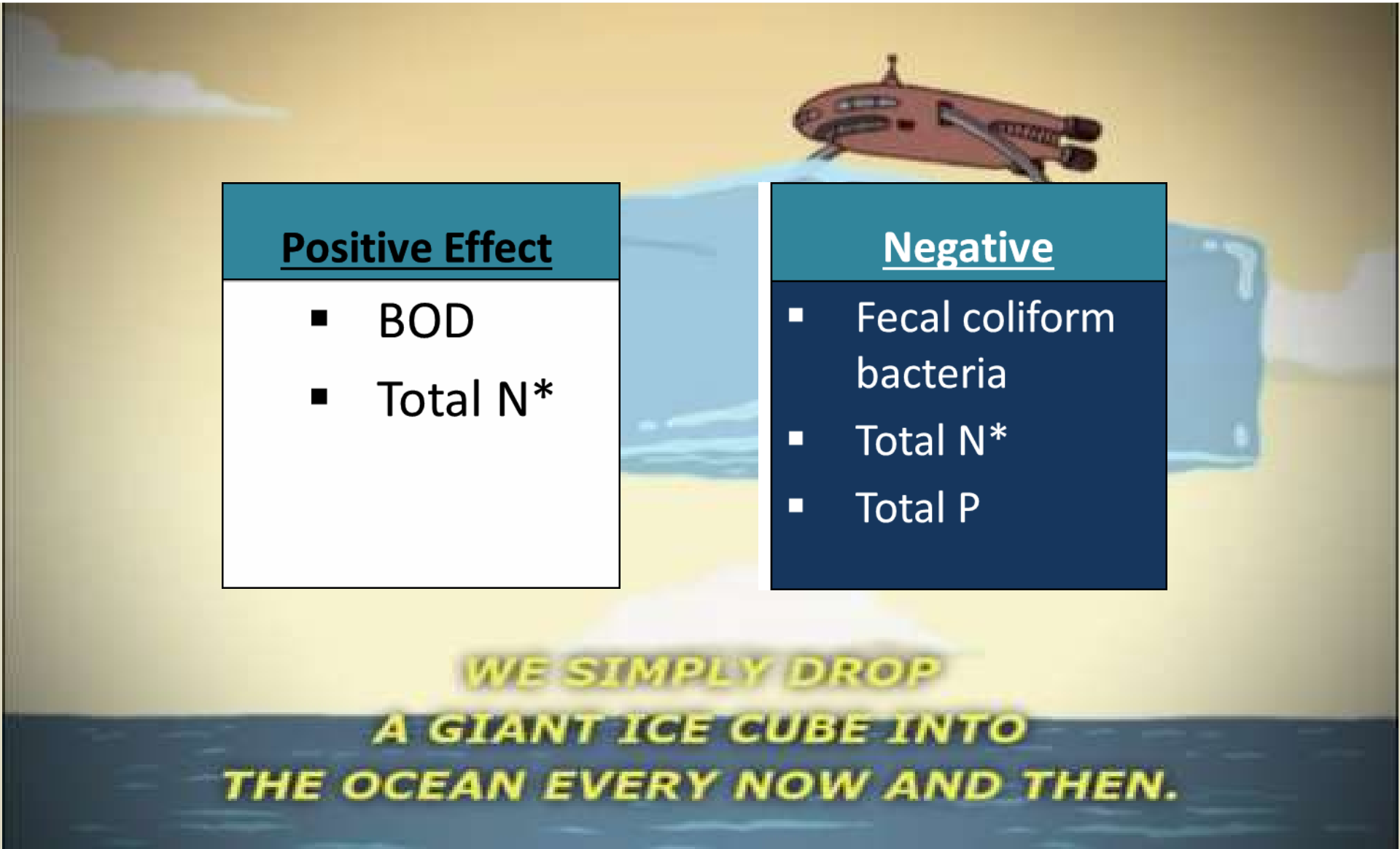


Potential Mitigation Measures

- Organic carbon amendment (e.g. wood chips)

- Pre-treatment – less reliance on soil

Summary Effects of Climate Change



Positive Effect	Negative
▪ BOD ▪ Total N*	▪ Fecal coliform bacteria ▪ Total N* ▪ Total P