

# The Fate of Onsite Septic System Nitrogen Discharges in Groundwater of the Hood Canal Basin

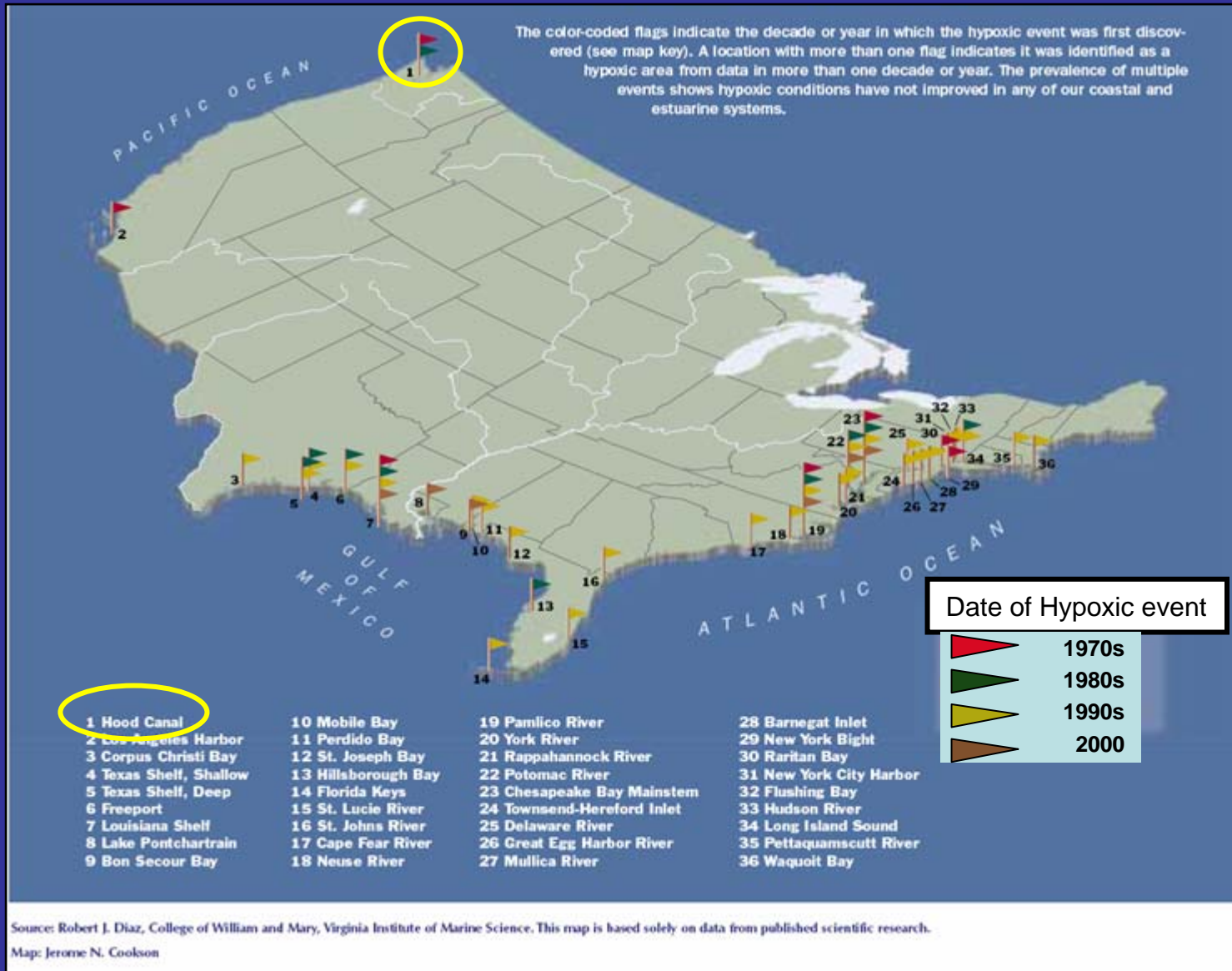
Julie Horowitz, Bryan Atieh, Garrett Leque,  
Mark Benjamin, Michael Brett

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# The Story...

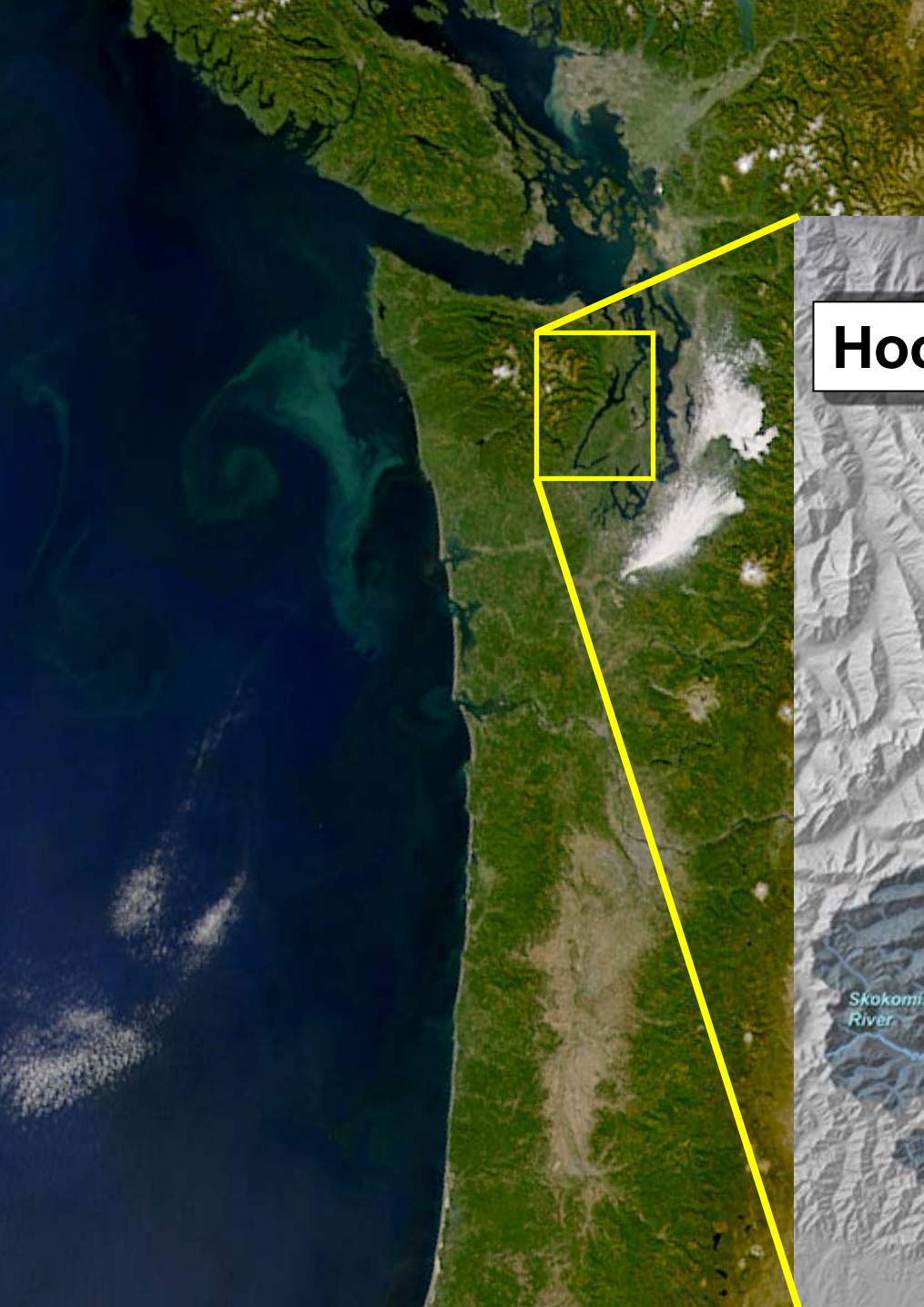
- Eutrophication and low dissolved oxygen
- Hood Canal
- Onsite Septic Systems (OSS) as a potential source of nitrogen loading
- Denitrification – the key variable in determining the nitrogen load
- Measuring denitrification in the Hood Canal basin
- Substantial spatial and temporal variability in denitrification

# U.S. Coastal 'Dead Zones' Associated with Human Activity

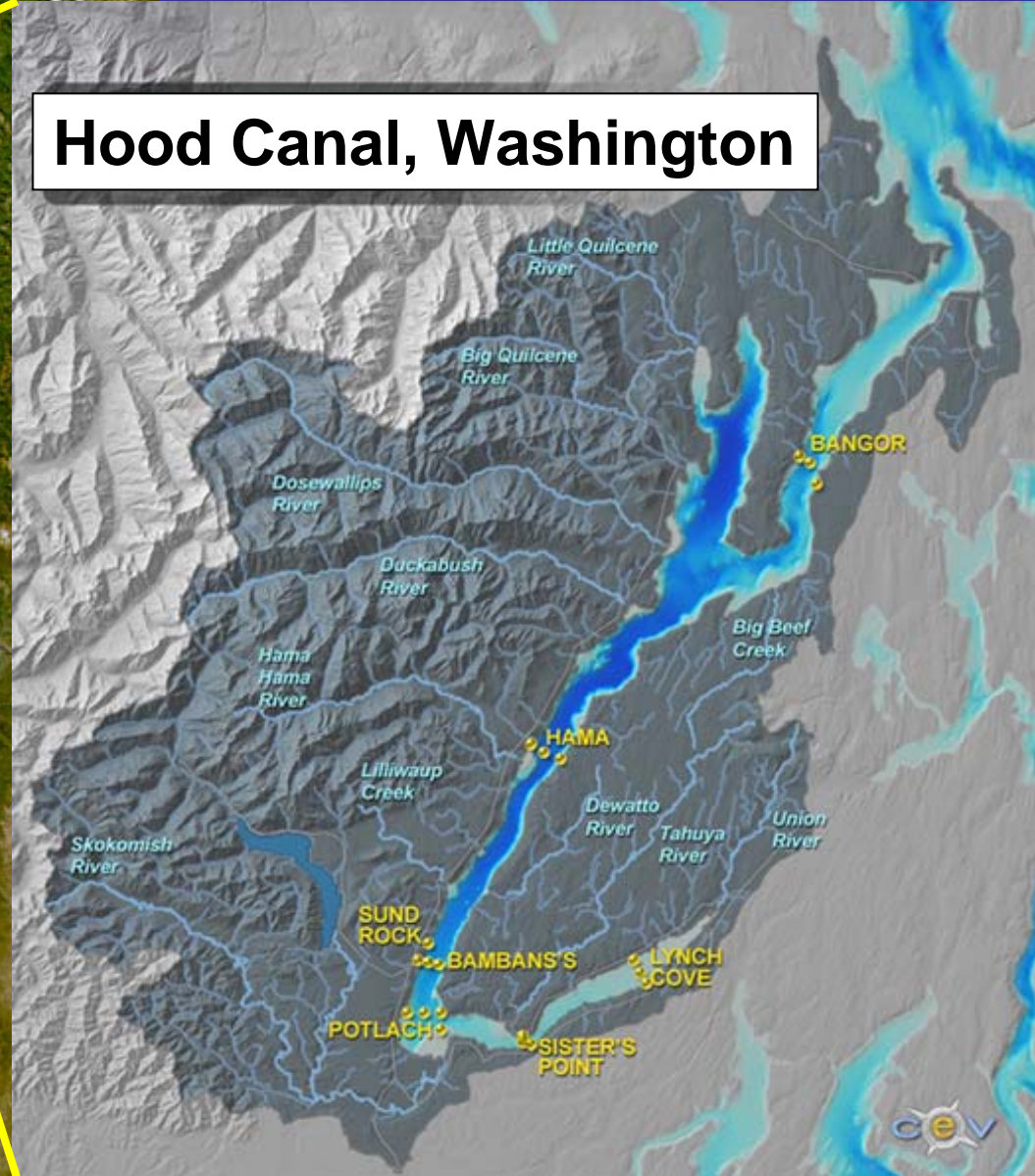


Source: *America's Oceans: Charting a Course for the Sea Change.*

Pew Ocean Commission report June, 2003

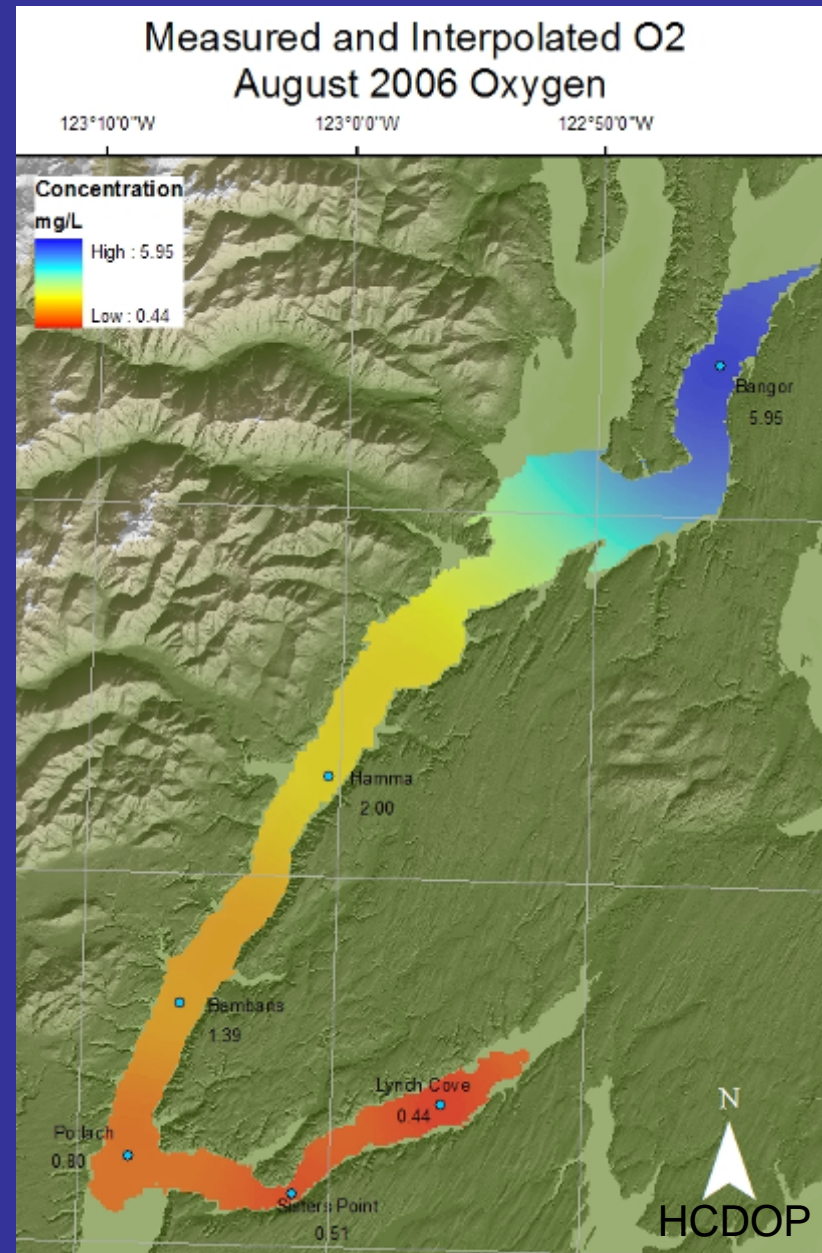


# Hood Canal, Washington



# Eutrophication in Hood Canal

Hood Canal is an estuary where OSS N loading may exacerbate eutrophication.



# What could affect oxygen ?

Change light availability:  
more sun

Change nutrient availability:

septics, forest, runoff, pet waste, lawns

Change ocean input:

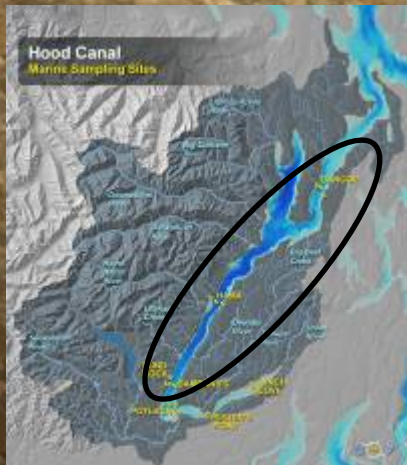
O<sub>2</sub>, density

Change organic biomass/production:

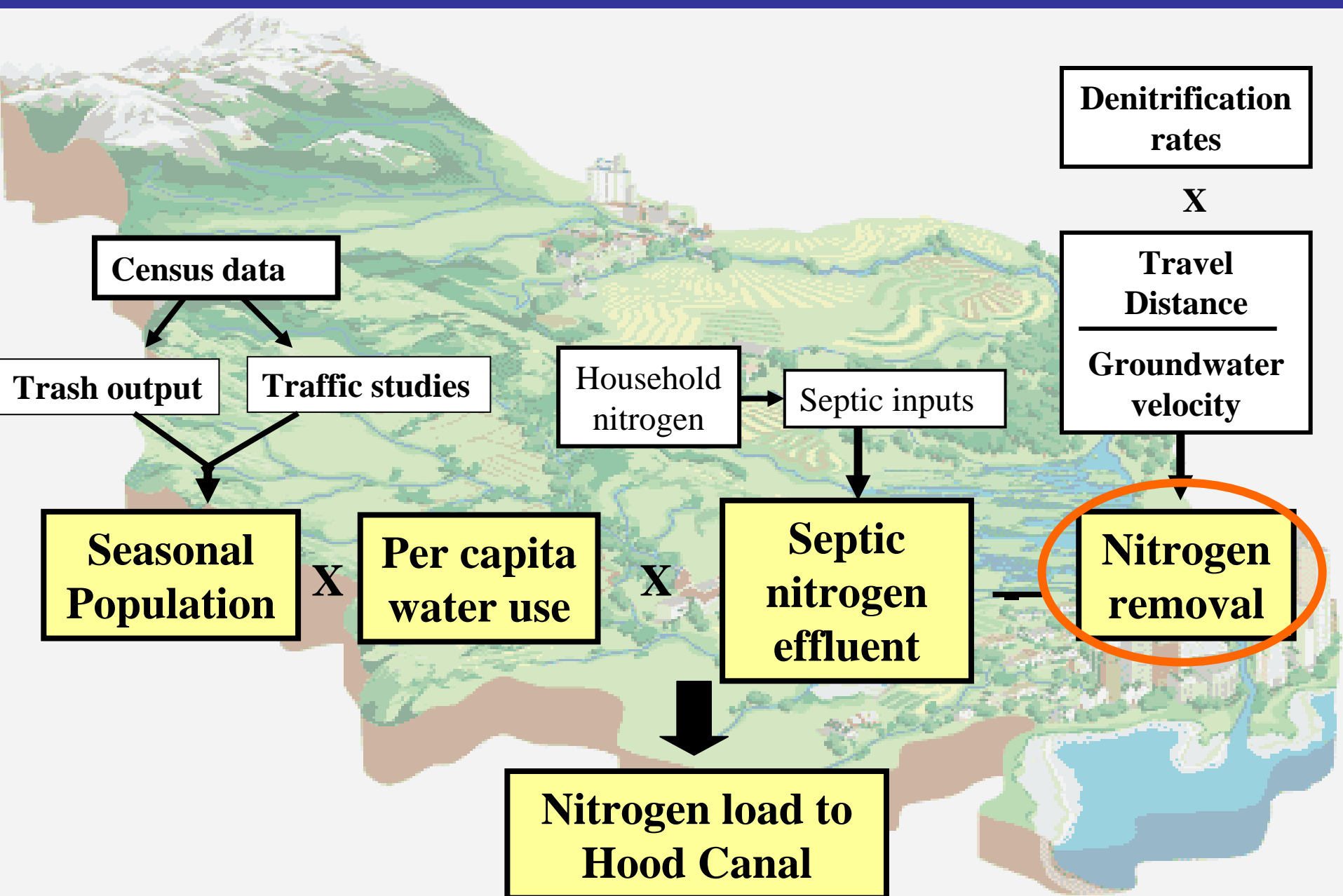
better growing conditions, carcasses

Change river input:

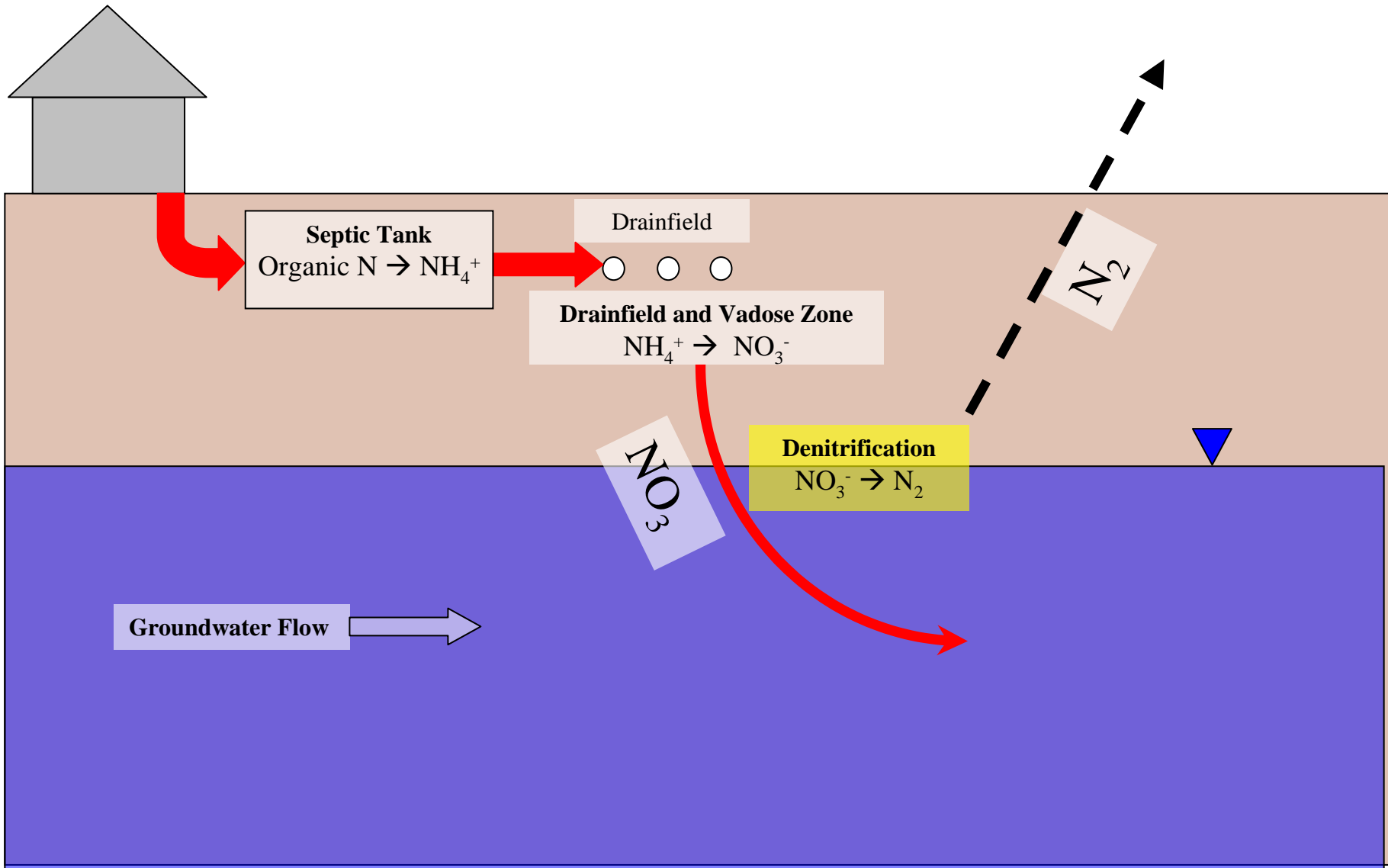
flushing, stratification



# Loading from OSS to Hood Canal



# Nitrogen Fate and Transport



# Denitrification

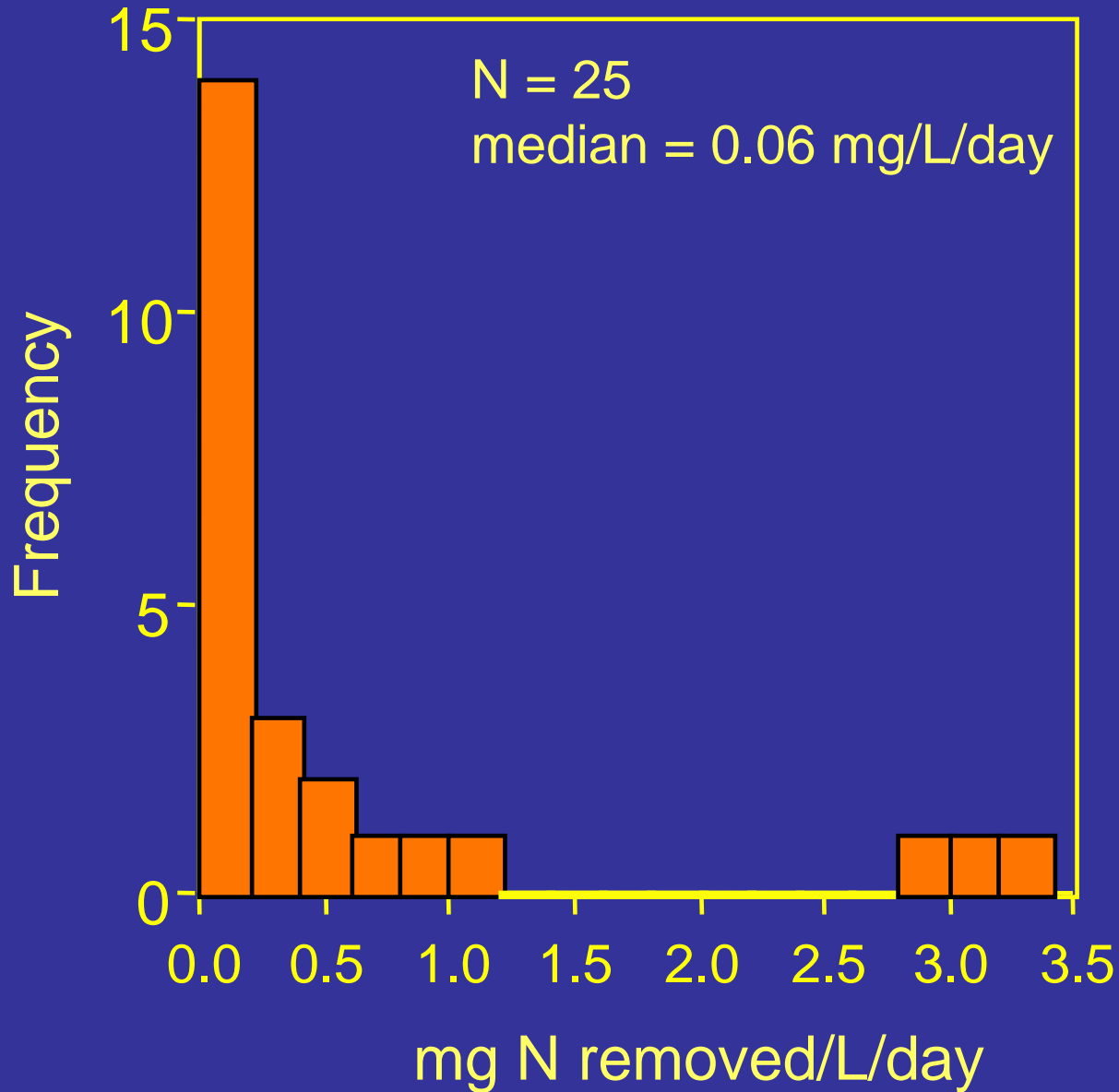
➤ Denitrification is the primary N removal process.

➤ Organic N  $\rightarrow$   $\text{NH}_4^+$   $\rightarrow$   $\text{NO}_2^-/\text{NO}_3^- \cdots \rightarrow \text{N}_2$

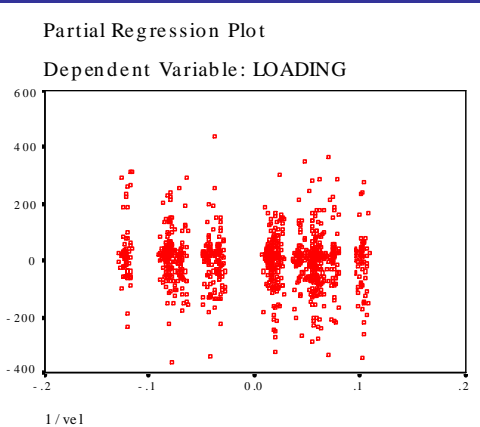
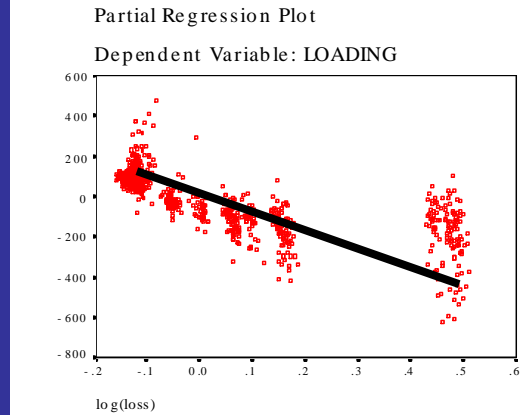
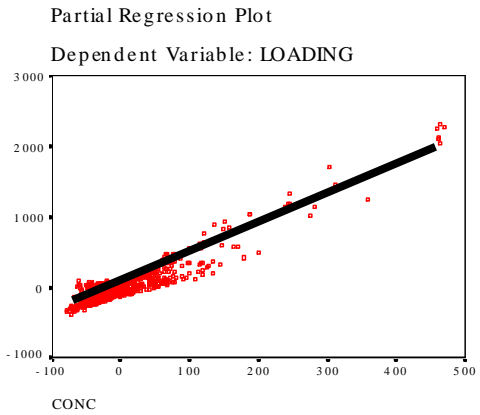
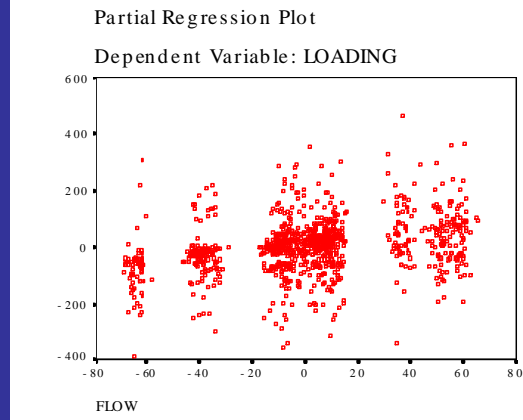
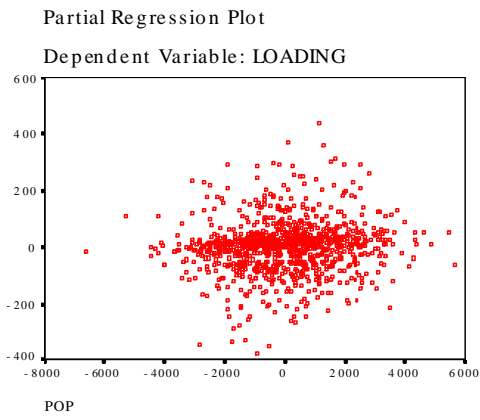
➤ Requirements:

- 1) Denitrifying microbial population
- 2) Anoxic conditions ( $\text{DO} < 0.2 \text{ mg/L}$ )
- 3) Electron donor supply (carbon)

# Denitrification Rates



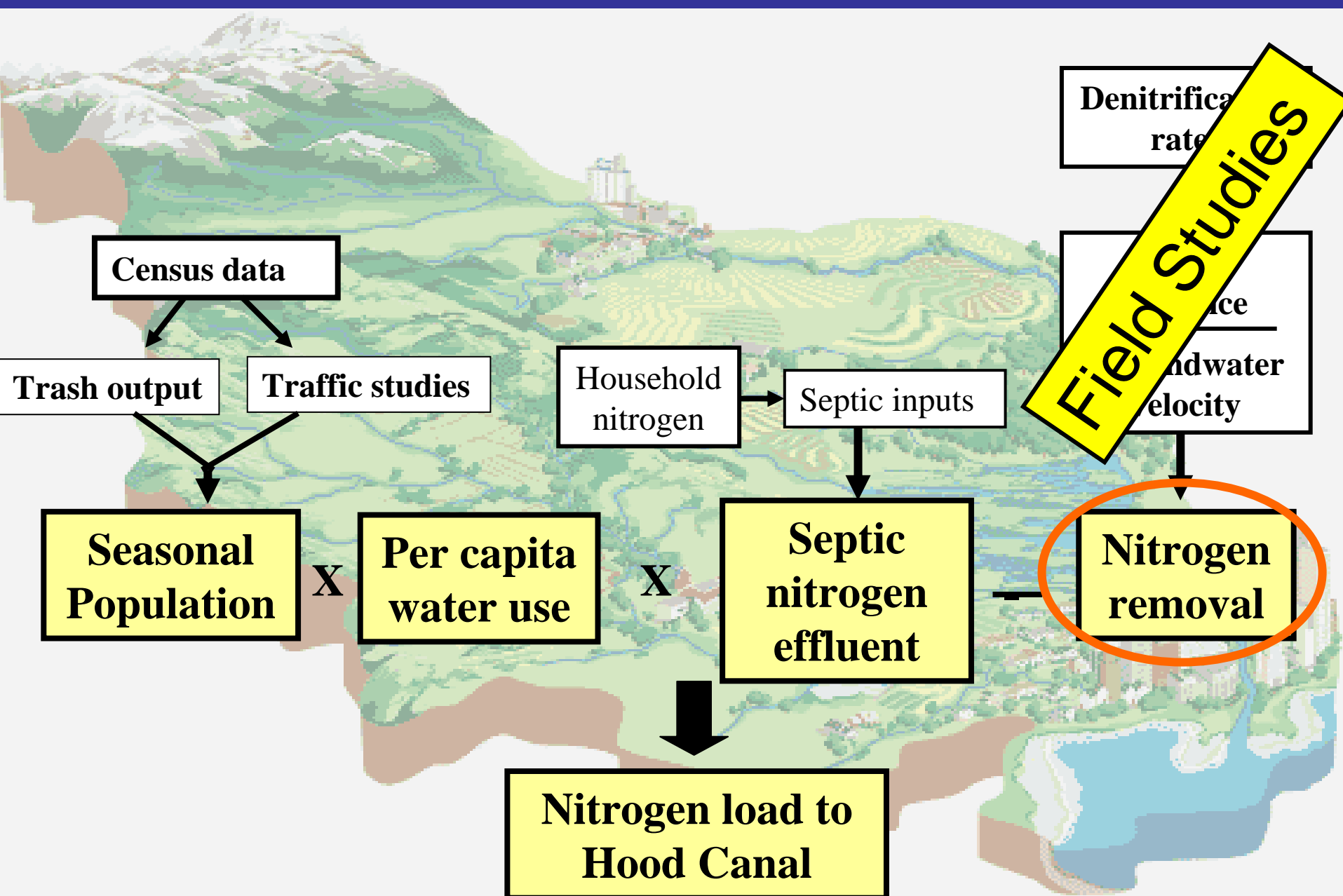
# Model Sensitivity Analysis



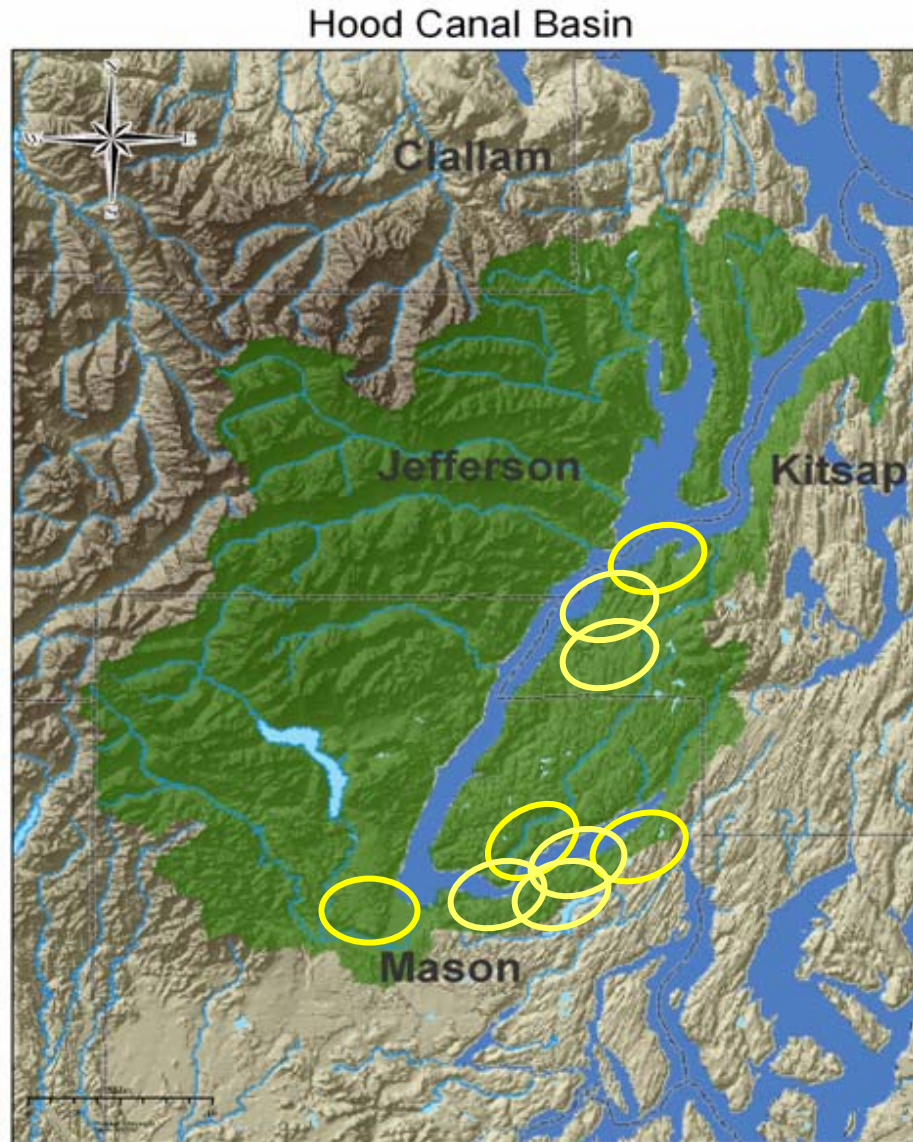
Partial correlation  
r

Population	0.092
Flow	0.315
Concentration	0.946
log(loss rate)	-0.762
1/velocity	-0.089

# Loading from OSS to Hood Canal

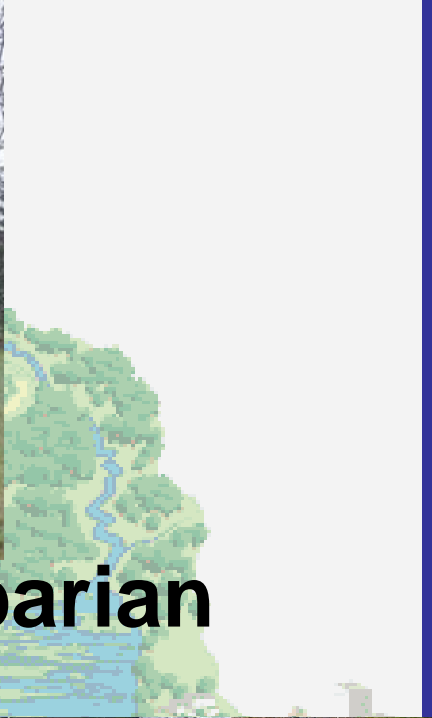


# Field Site Locations



# Site Spatial Variability

**Upland**



**Near-shore and Riparian**

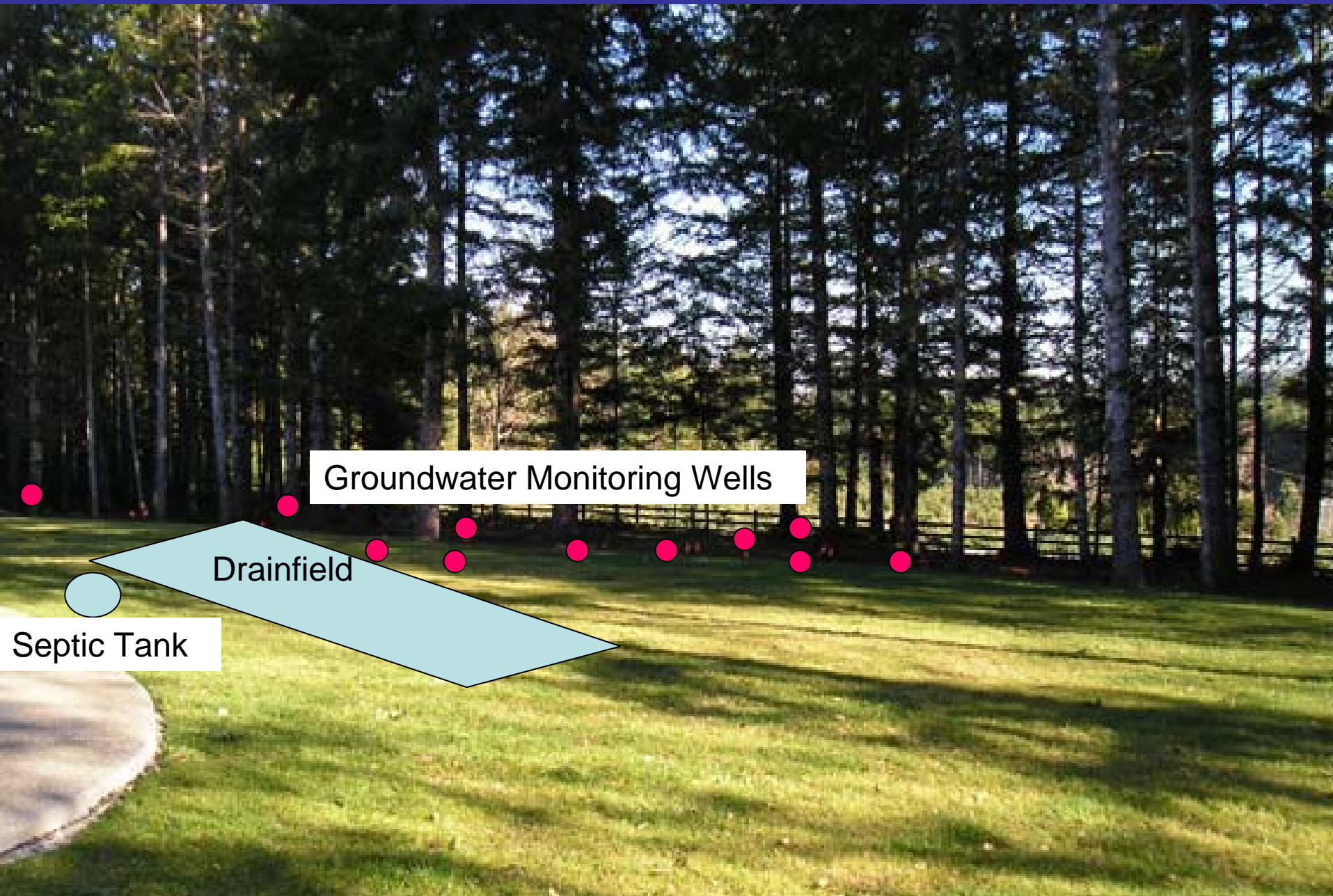


**Shoreline**

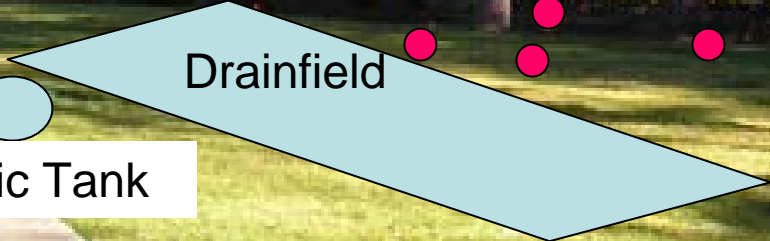
# Well Installation and Sampling



# Field Site Set Up



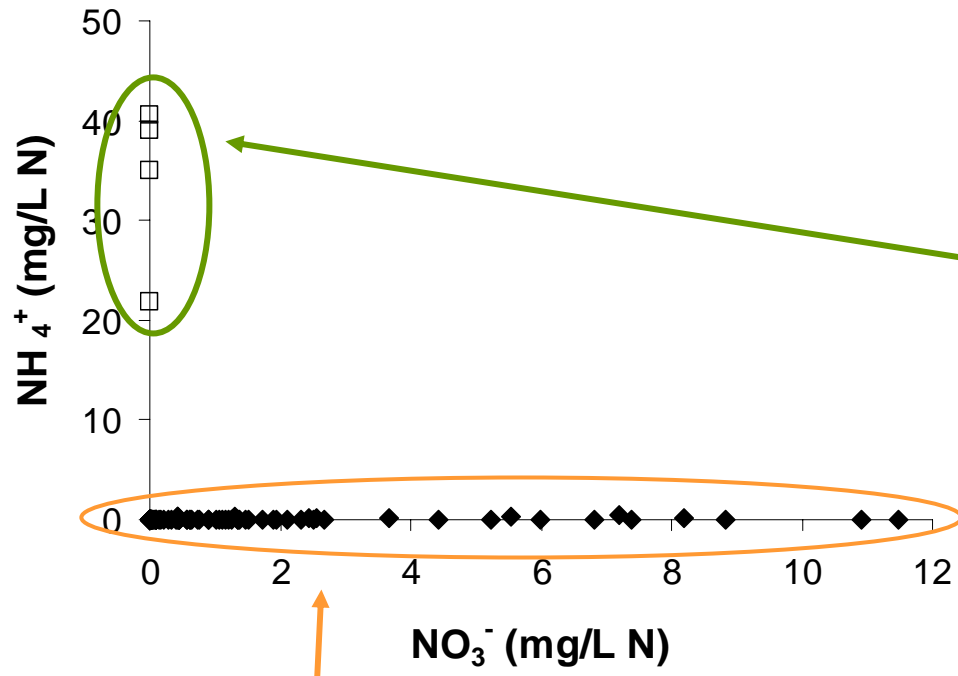
Groundwater Monitoring Wells



Drainfield

Septic Tank

# Nitrogen Speciation: $\text{NH}_4^+ \rightarrow \text{NO}_3^-$

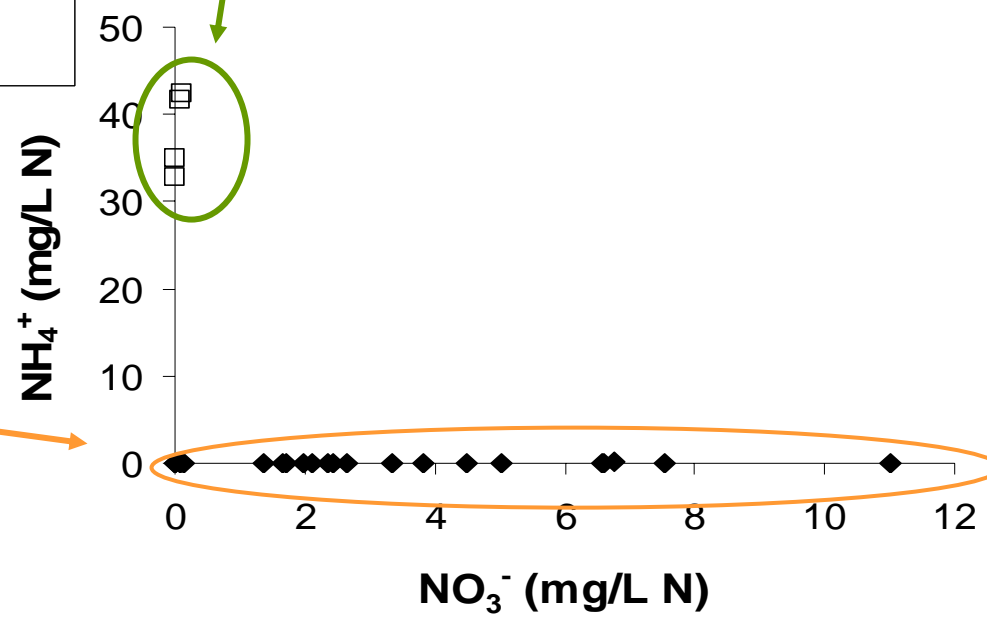


Riparian Site

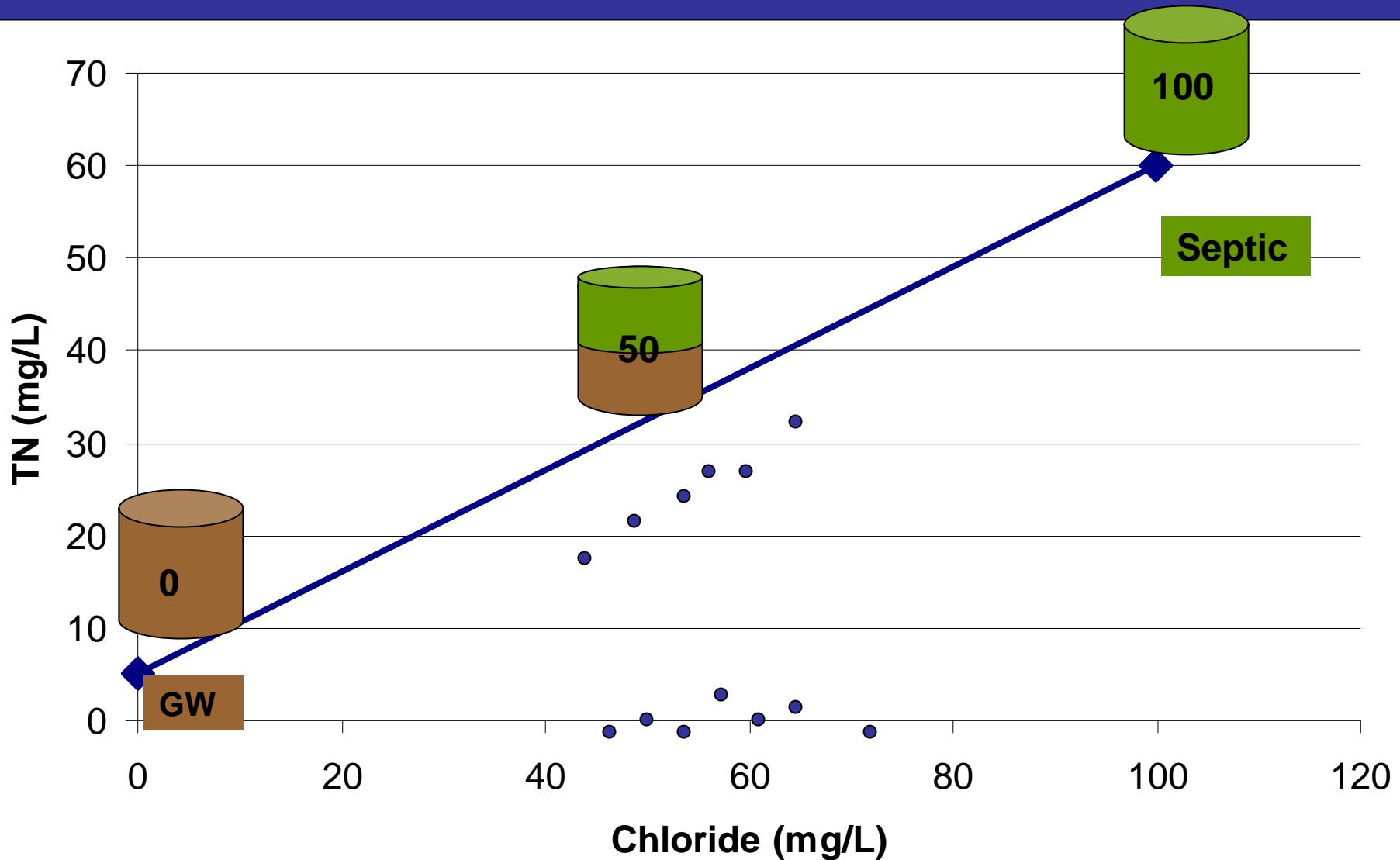
Sampling Wells

Septic

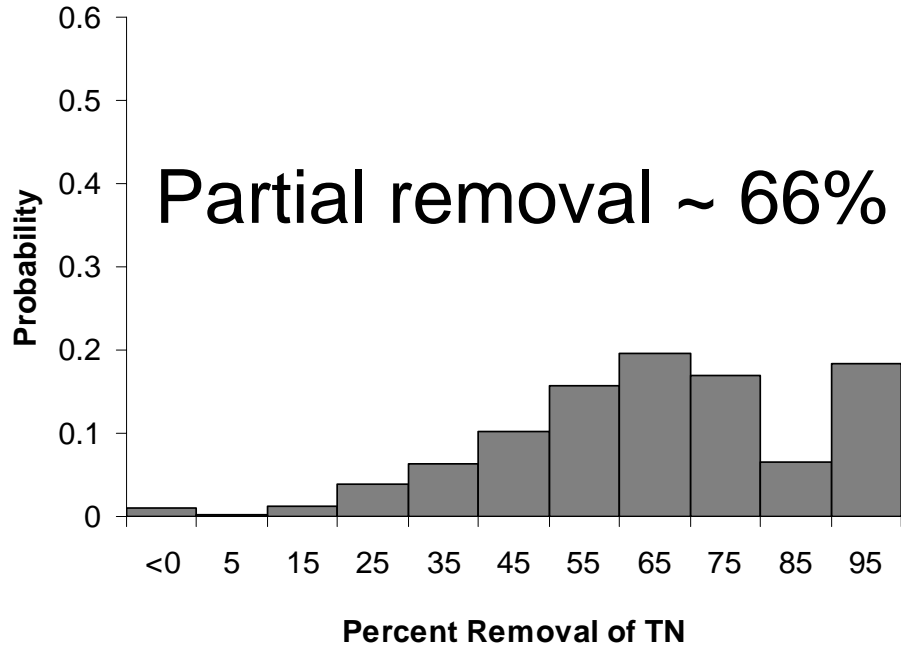
Upland Site



# Modeling of OSS N Removal

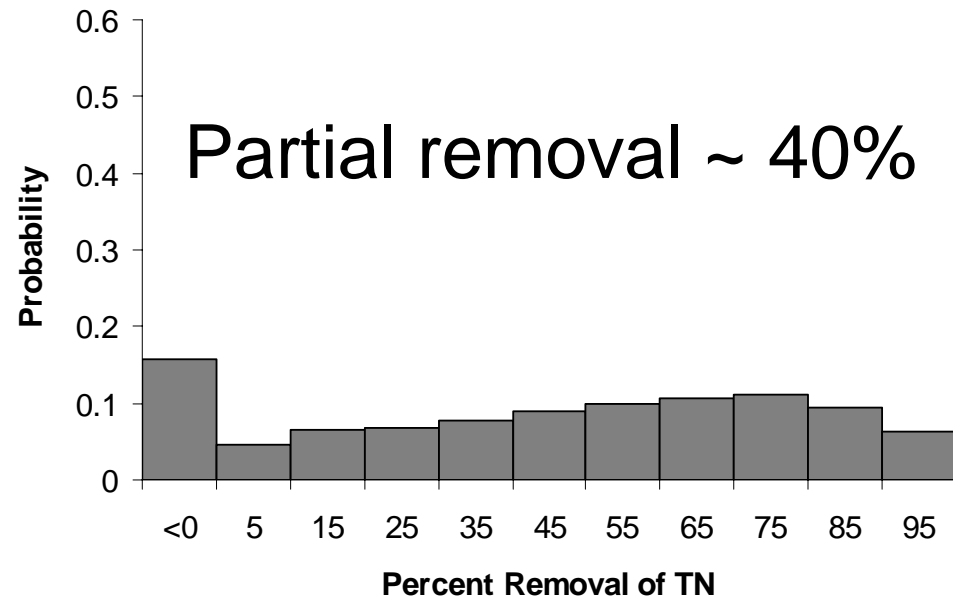


# Upland: Nitrogen Removal

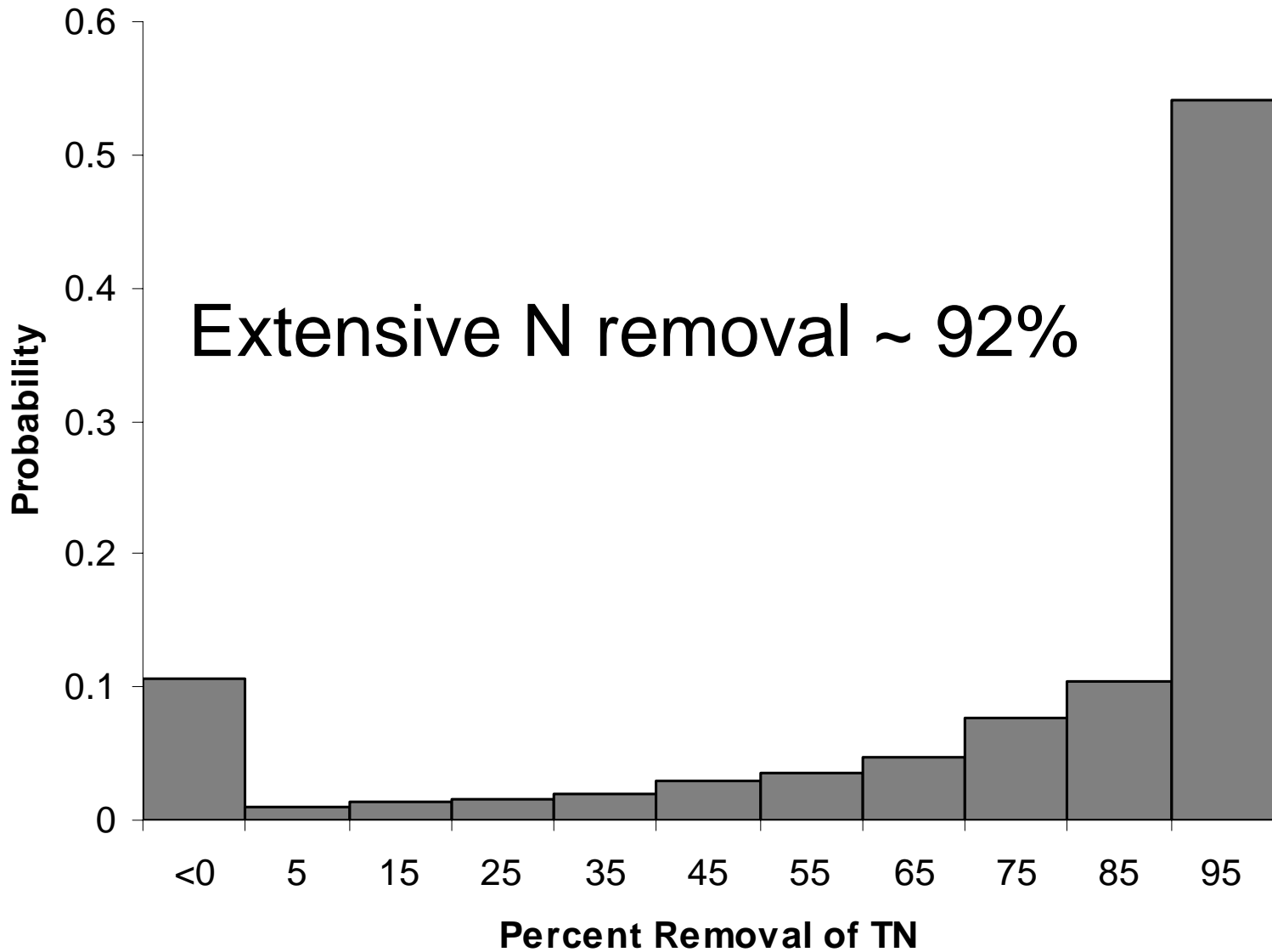


Upland site – Year 1

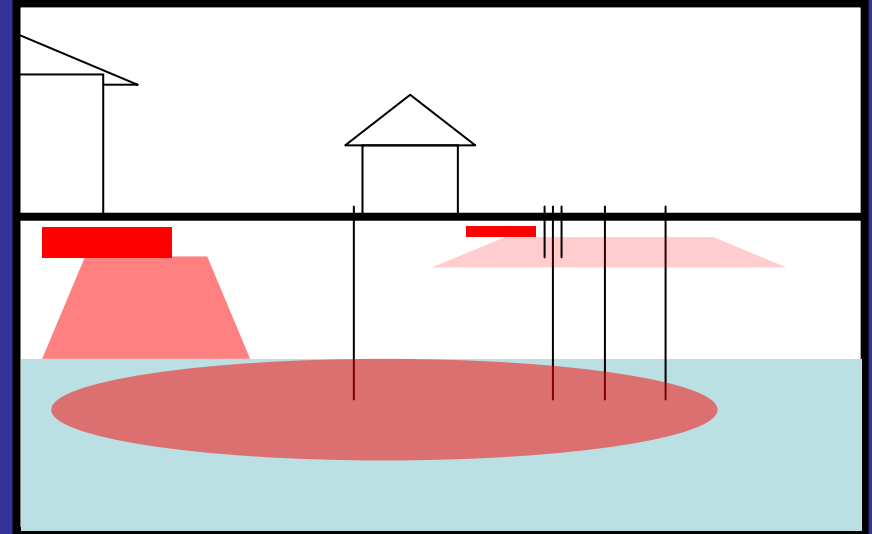
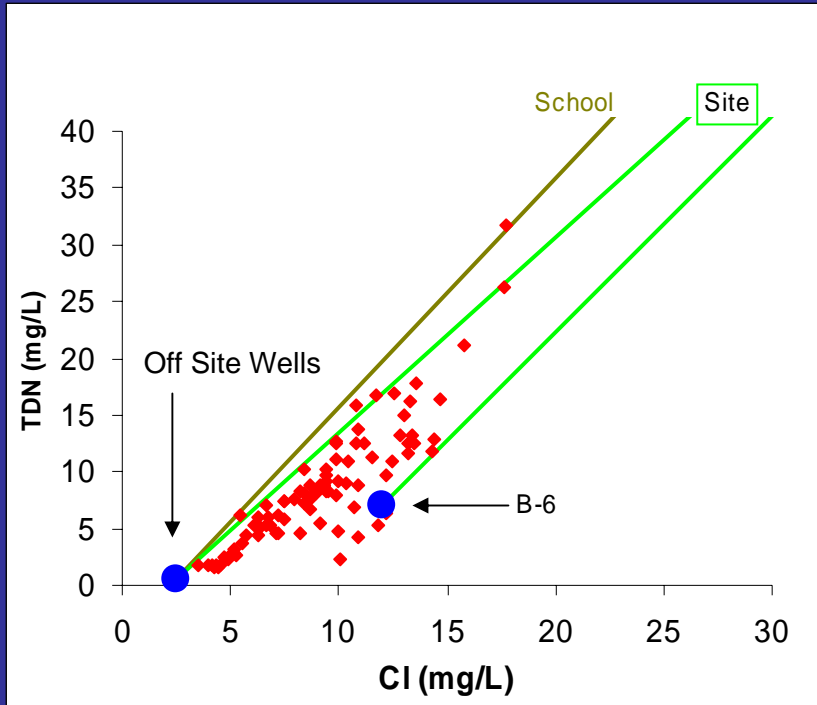
Upland site – Year 2



# Riparian: Nitrogen Removal

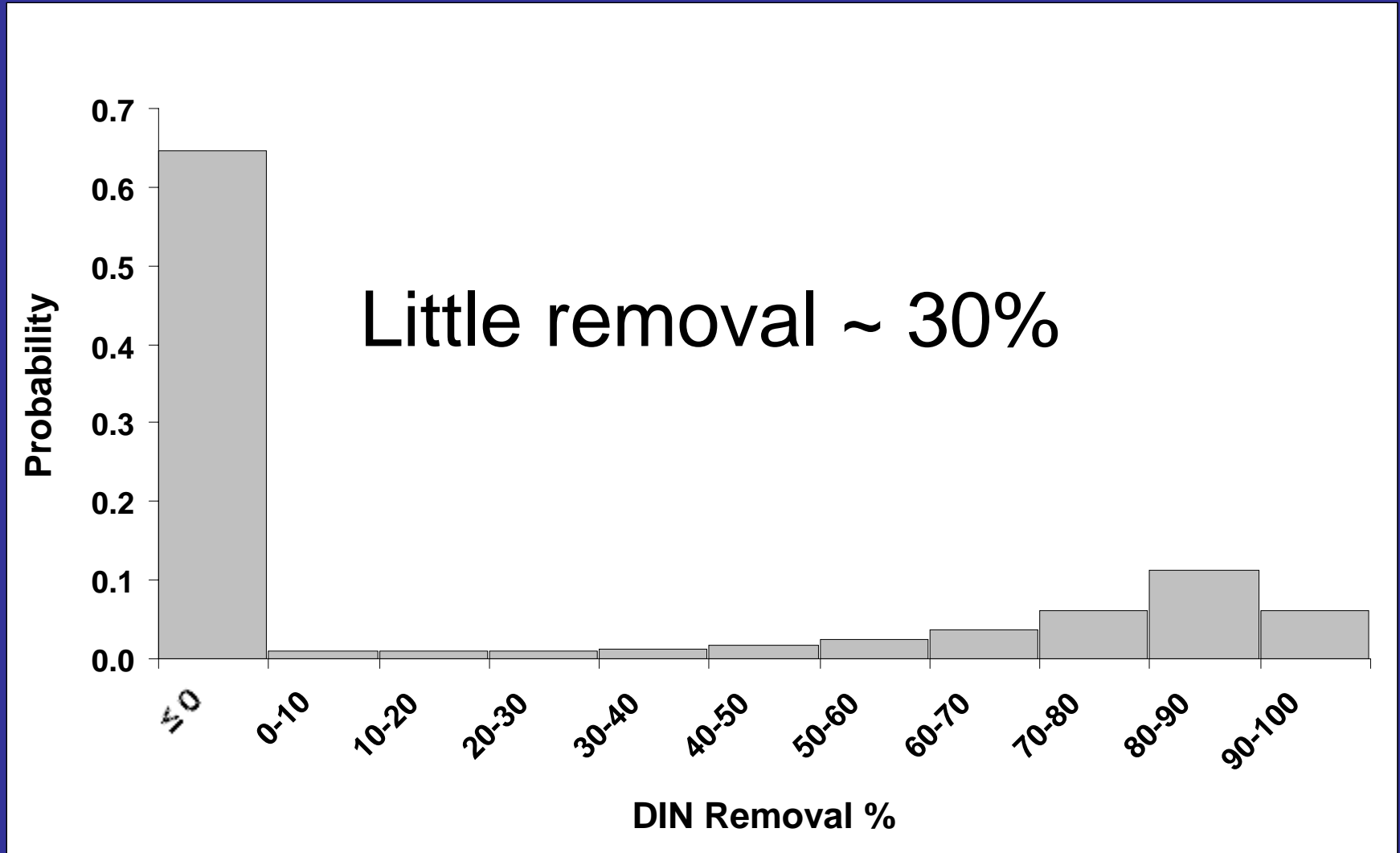


# Near-shore: Nitrogen Removal



- Complicating factors – extent of removal difficult to determine.
- Nitrogen removal likely ~30 %

# Shoreline: Nitrogen Removal



# Challenges

- Groundwater accessibility
- Dilution
- Multiple OSS sources
- Complex geology and groundwater flow paths
- Heterogeneity

# Spatial N Removal Variability

**Upland**

**Partial Removal**

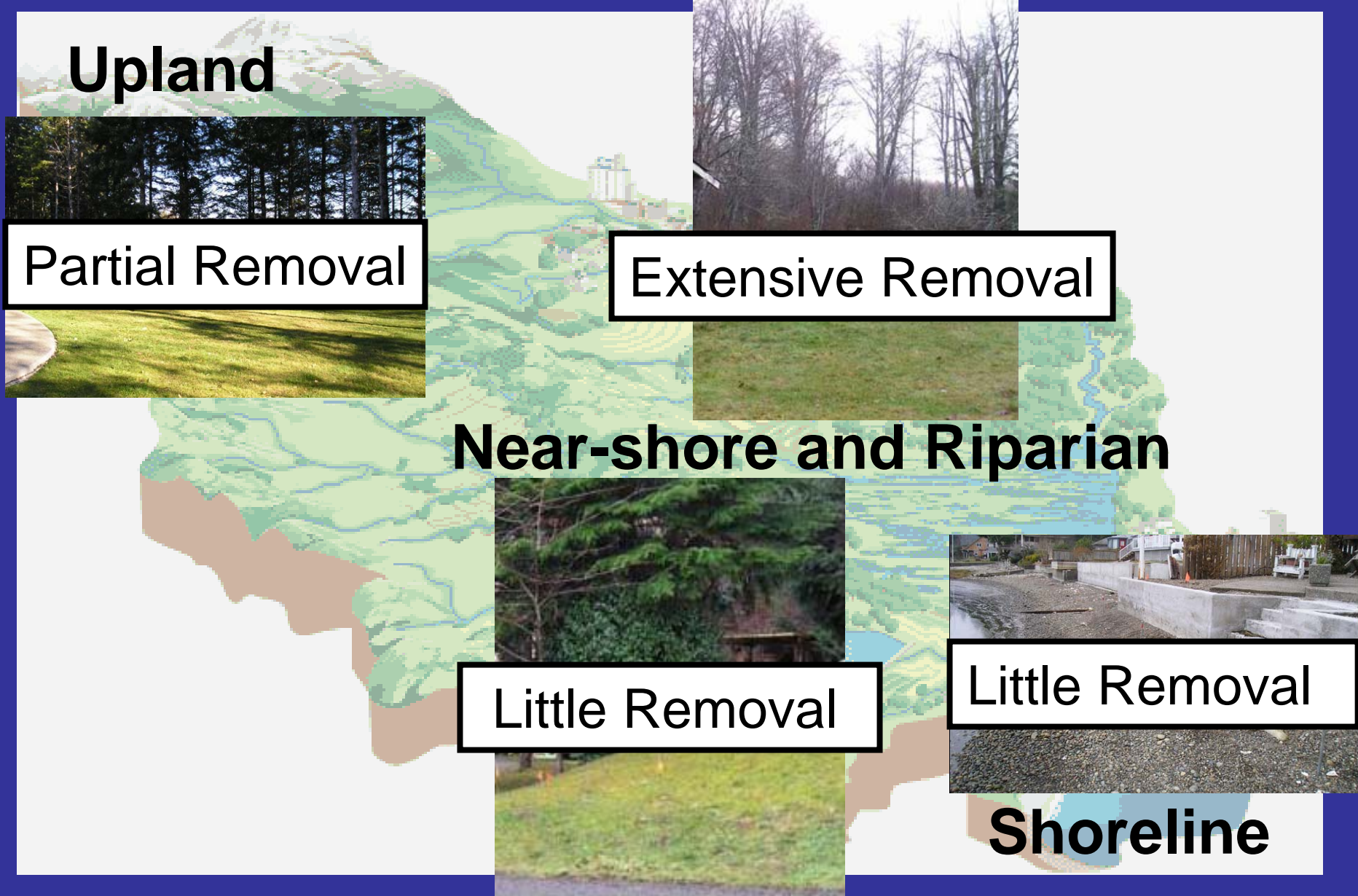
**Extensive Removal**

**Near-shore and Riparian**

**Little Removal**

**Little Removal**

**Shoreline**



# Conclusions

- OSS ammonium is typically converted to nitrate
- Denitrification is occurring in some locations around Hood Canal
- The extent of denitrification varies spatially and temporally
- Further research can be conducted to explore denitrification limiting conditions
- Problems with scaling up and with rates
- Common challenges with denitrification research

This research was funded by the Washington State Legislature, and managed by the Puget Sound Partnership.

This research was conducted in conjunction with the Hood Canal Dissolved Oxygen Program.



Thank you!