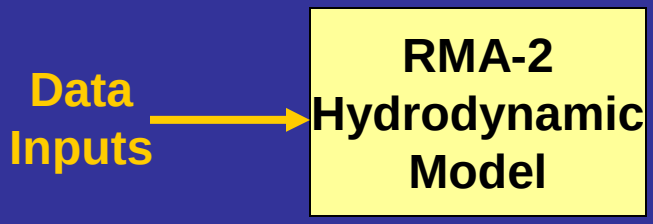
Hydrodynamic and Water Quality Modeling

Town Of Orleans

Wastewater Management Validation & Design Committee

June 10, 2009

SMAST Linked Model



Source: Model Diagram and Operation Description, K. Bosma, Woods Hole Group, May 2009

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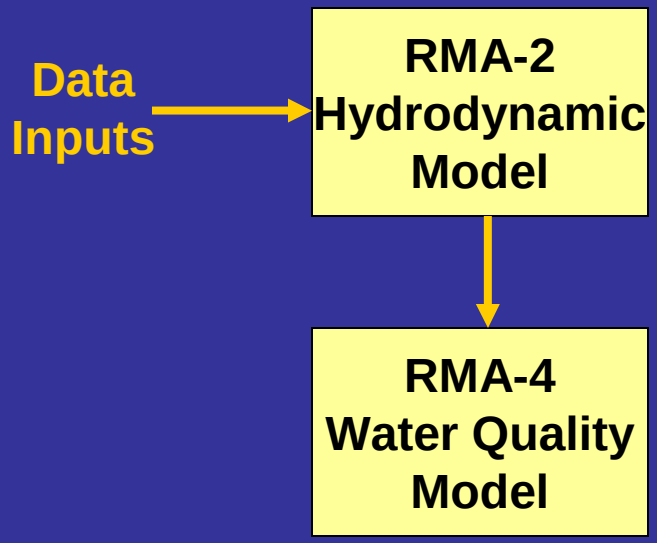

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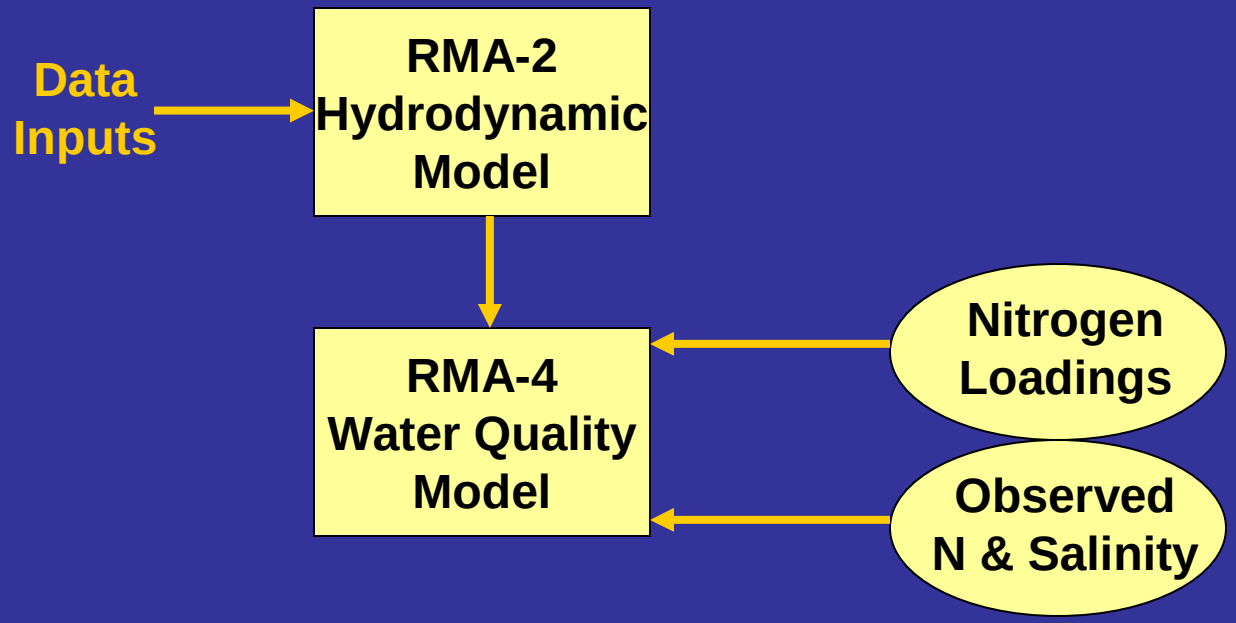

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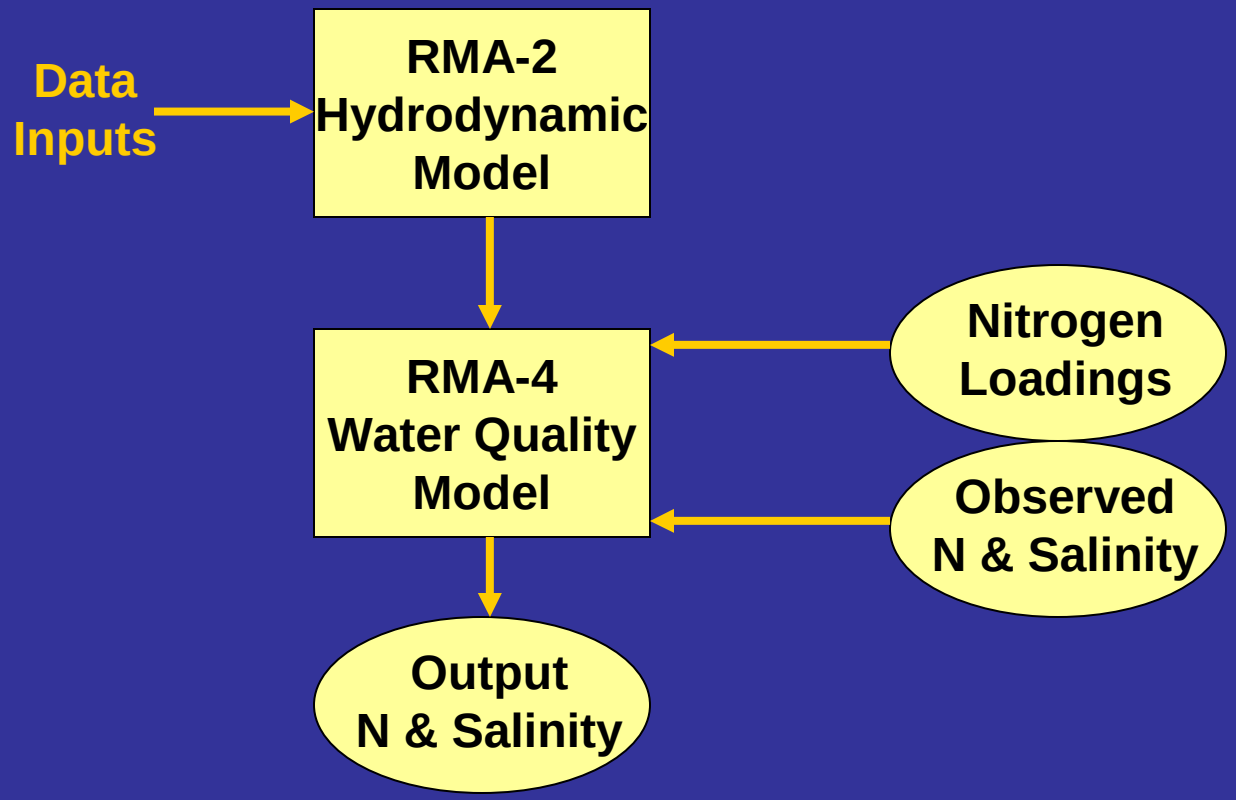

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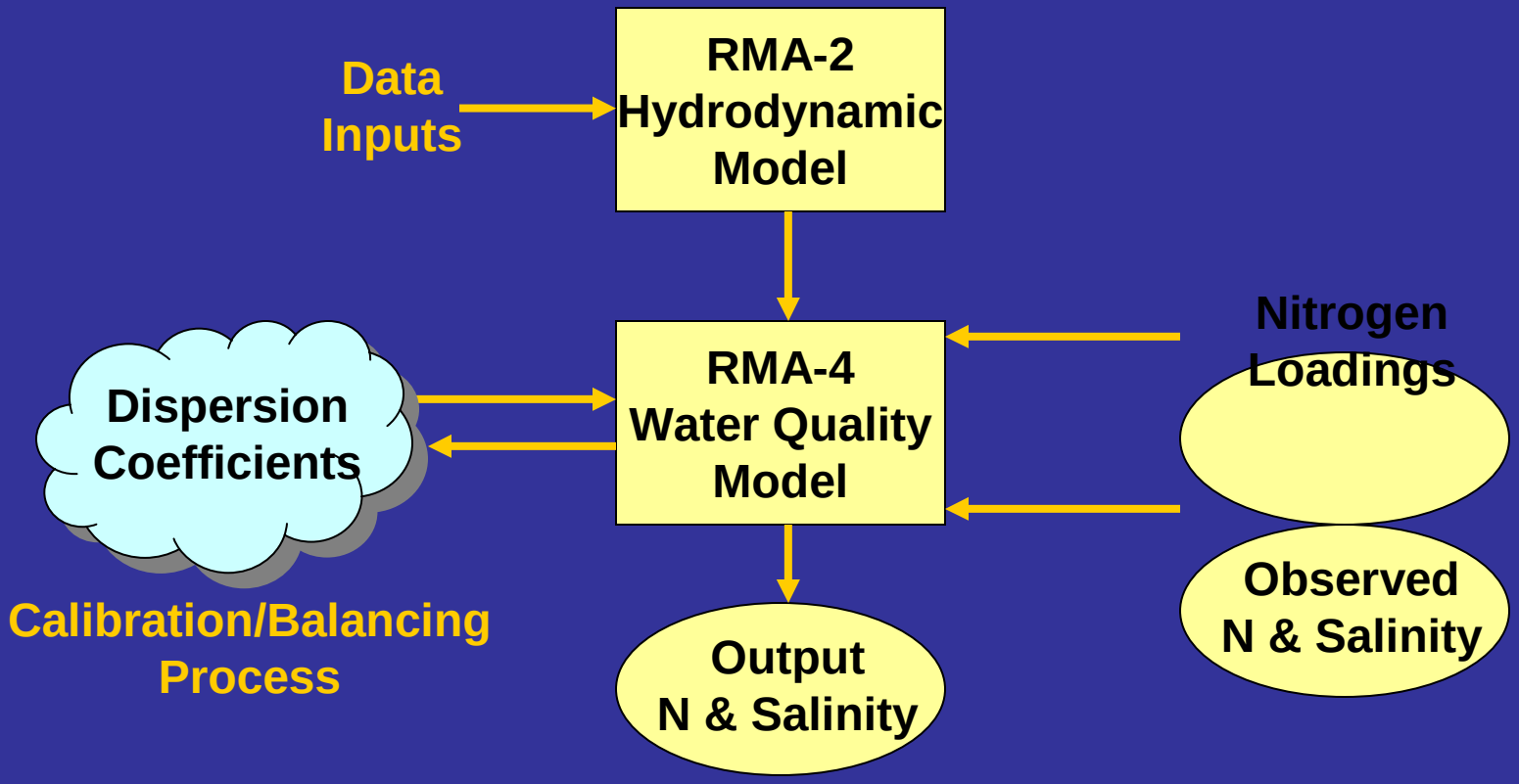

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Data, Estimates and Measurements

“Variance” or “Margin of Error”

vs.

“Biases”

SMAST Linked Model

- "Variance" or "Margin of Error" of +/- 20%

- Random, minor errors not exceeding 20% are within the model variance

Model Reliability and Bias

The complexities of the Pleasant Bay estuarine system may exceed the linked model's capability to reliably predict nitrogen behavior.

Model Reliability and Bias

Pleasant Bay is a complex estuarine system:

- Large, shallow lagoons
- Connecting rivers
- Drowned kettle ponds

Total Nitrogen vs. Bioactive Nitrogen

- All other MEP reports based on total nitrogen
- Model calibration failed for total nitrogen in Bassing Harbor
- Basis switched to bioactive nitrogen for Pleasant Bay

Model Reliability and Bias

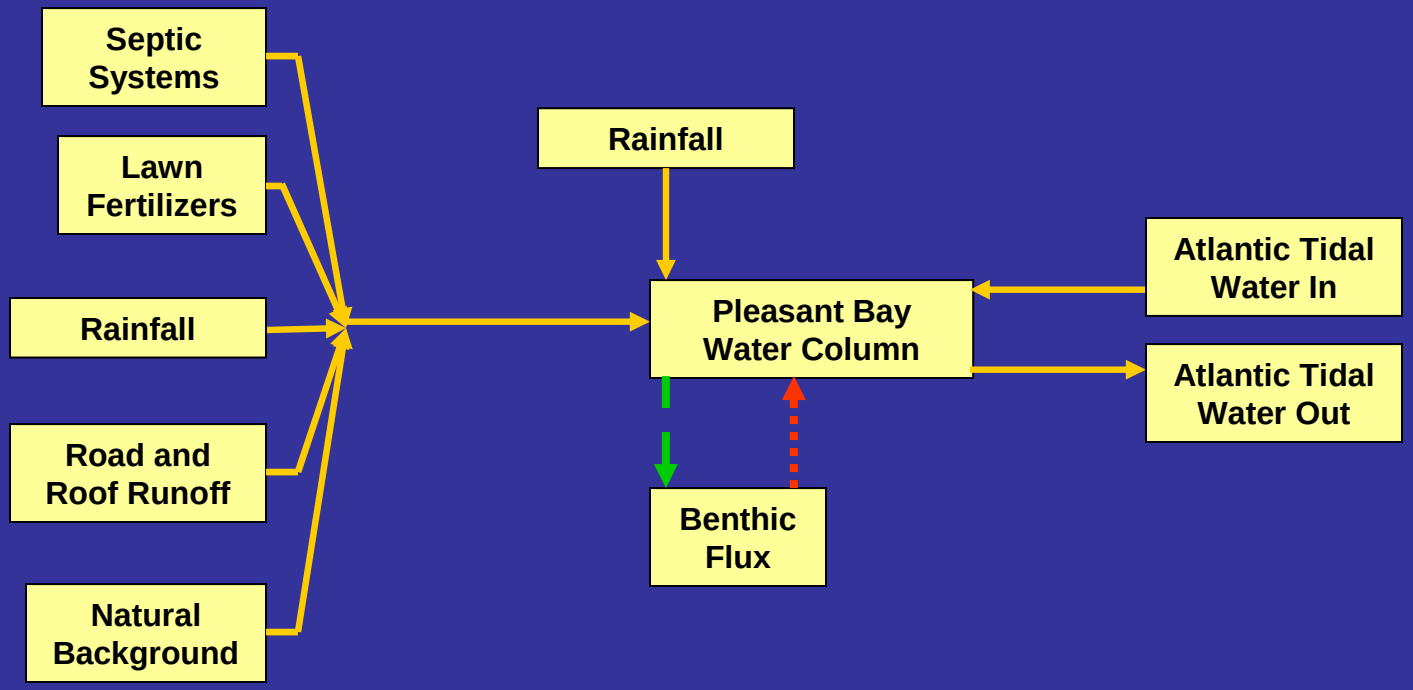
- Dispersion coefficients for Pleasant Bay exceed guidelines – greater than 20% bias
- Orleans drowned kettle ponds stratified – greater than 20% bias

Nitrogen Mass Balance

- Nitrogen in Pleasant Bay waters
- On a steady-state daily basis:

Nitrogen Input - Nitrogen output = 0

Overall Nitrogen Balance for Pleasant Bay



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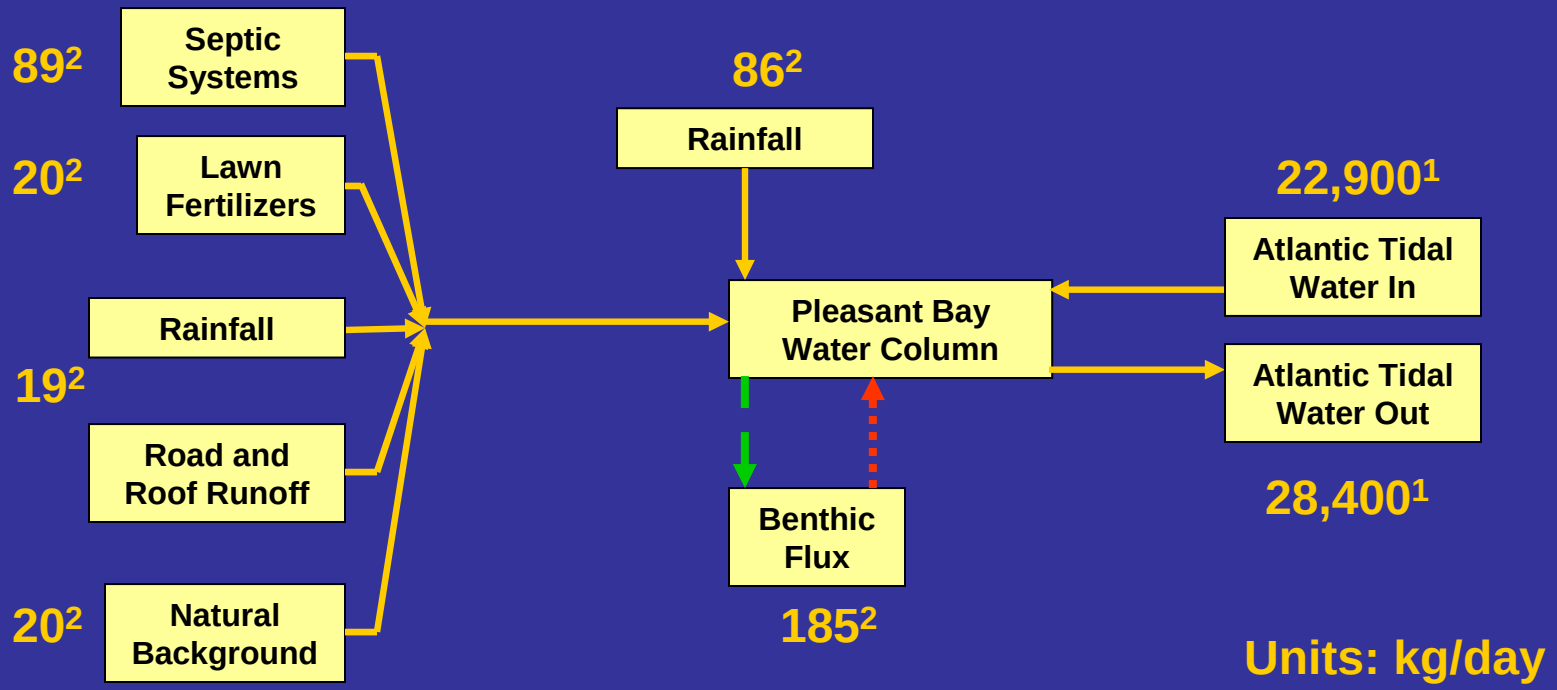

[1] Pleasant Bay Report , May 2006, p133 & p127
[2] Pleasant Bay Report, May 2006, Exec Summary, Table ES-1b

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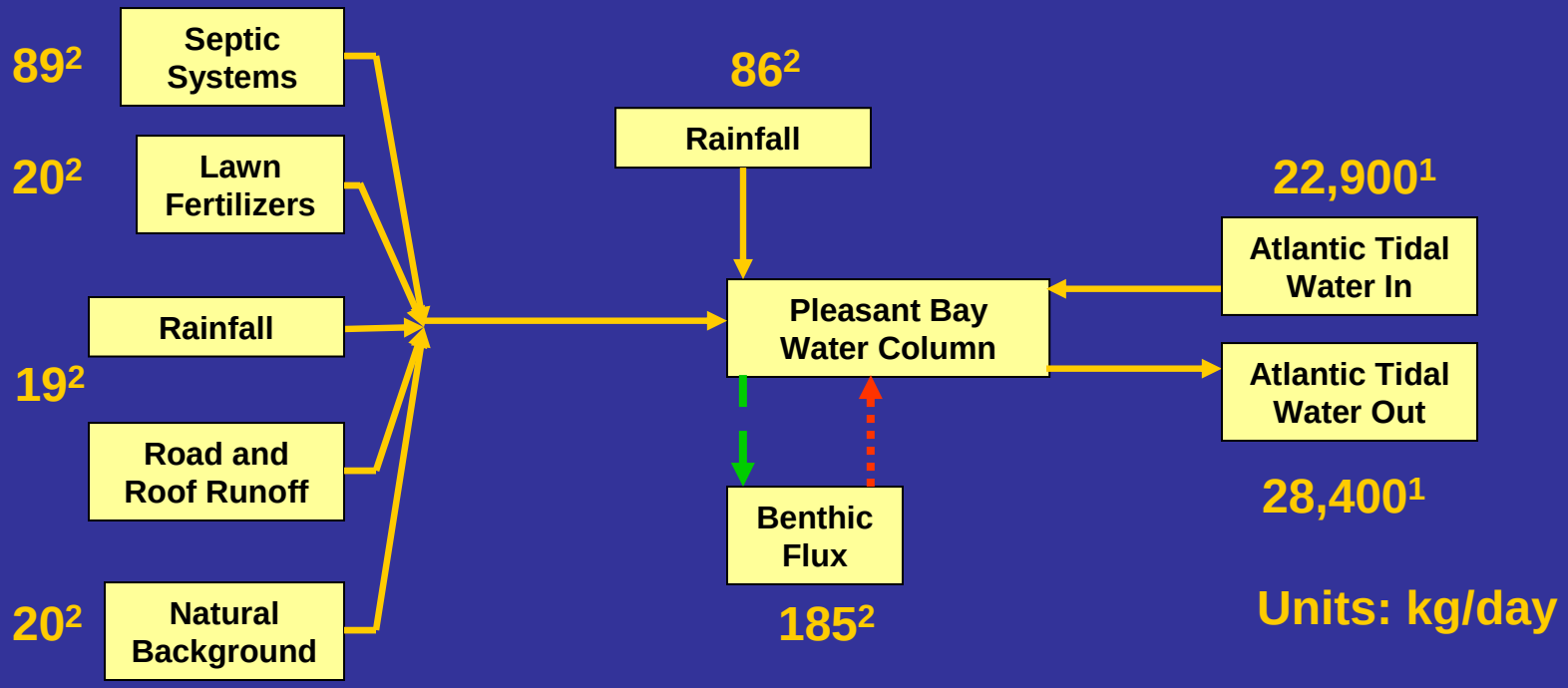

Total Nitrogen In = 148 + 86 + 185 + 22,900 = 23,319 kg/day

[1] Pleasant Bay Report, May 2006, p133 & p127
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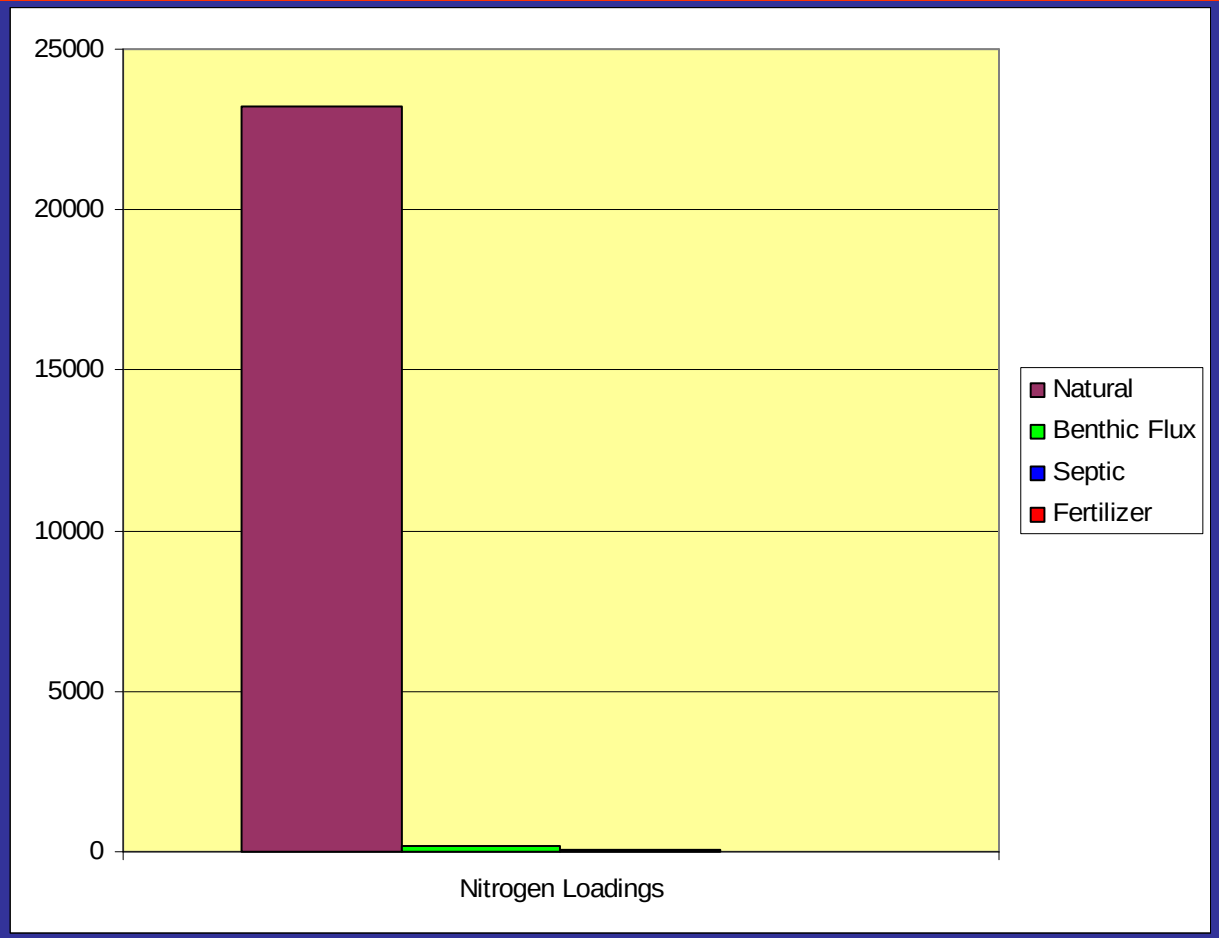
Overall Nitrogen Balance for Pleasant Bay



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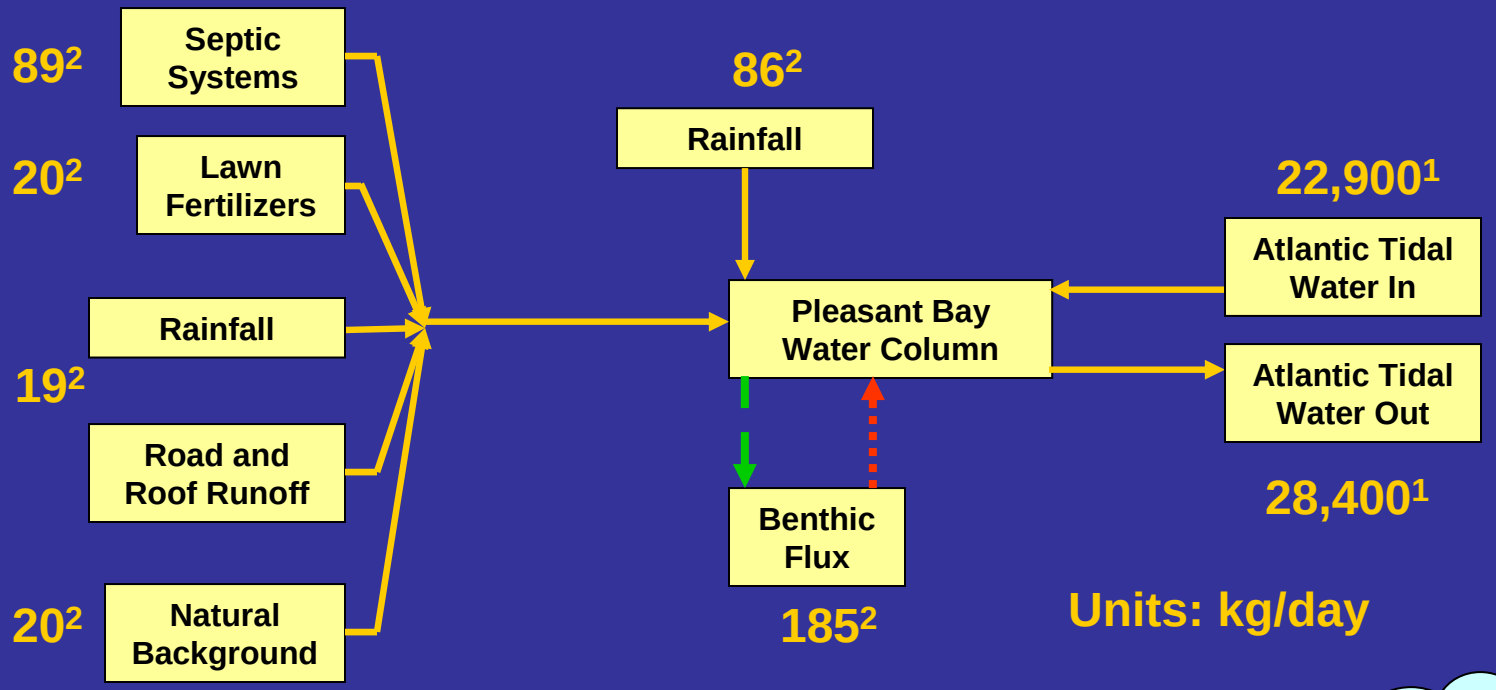

Total Nitrogen In – Total Nitrogen Out = 23,319 – 28,400 = -5,081 kg/day

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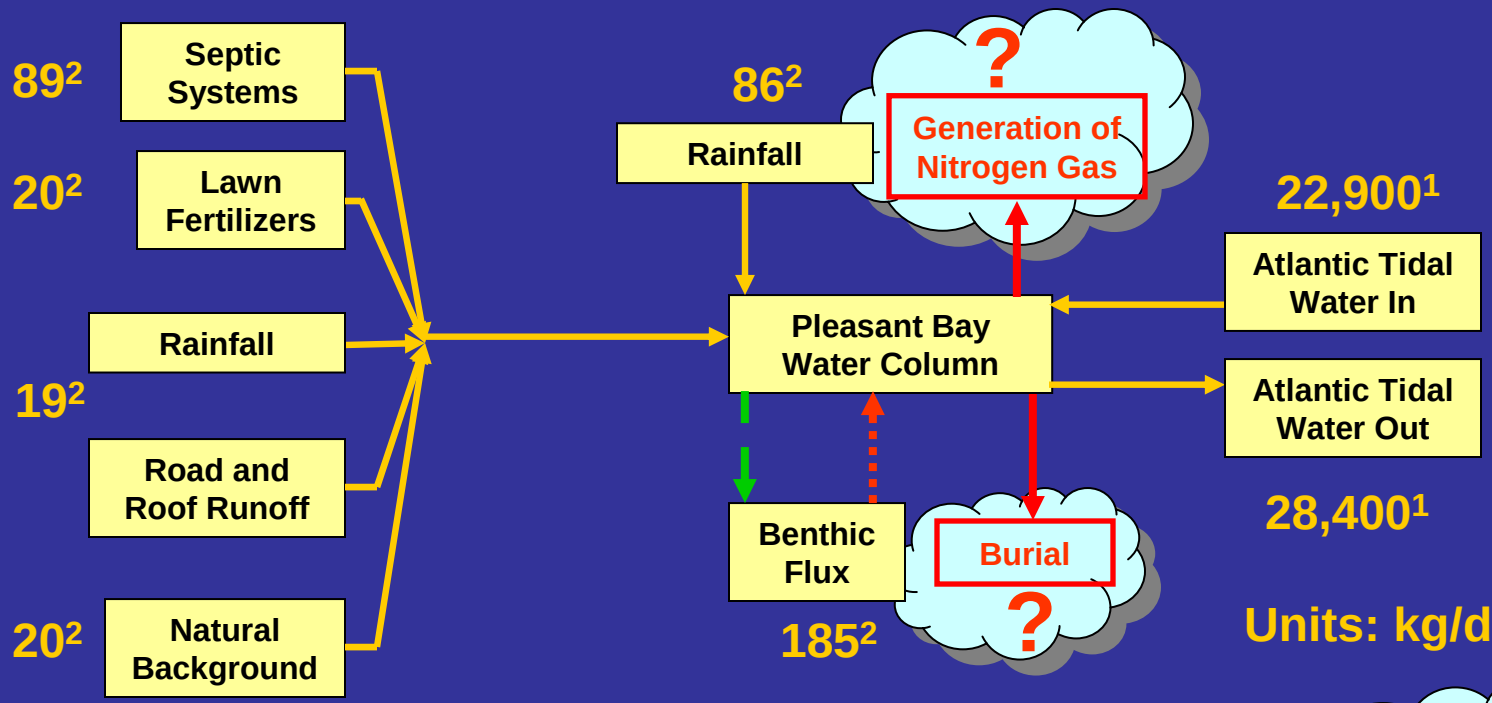

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Nitrogen Loading Biases

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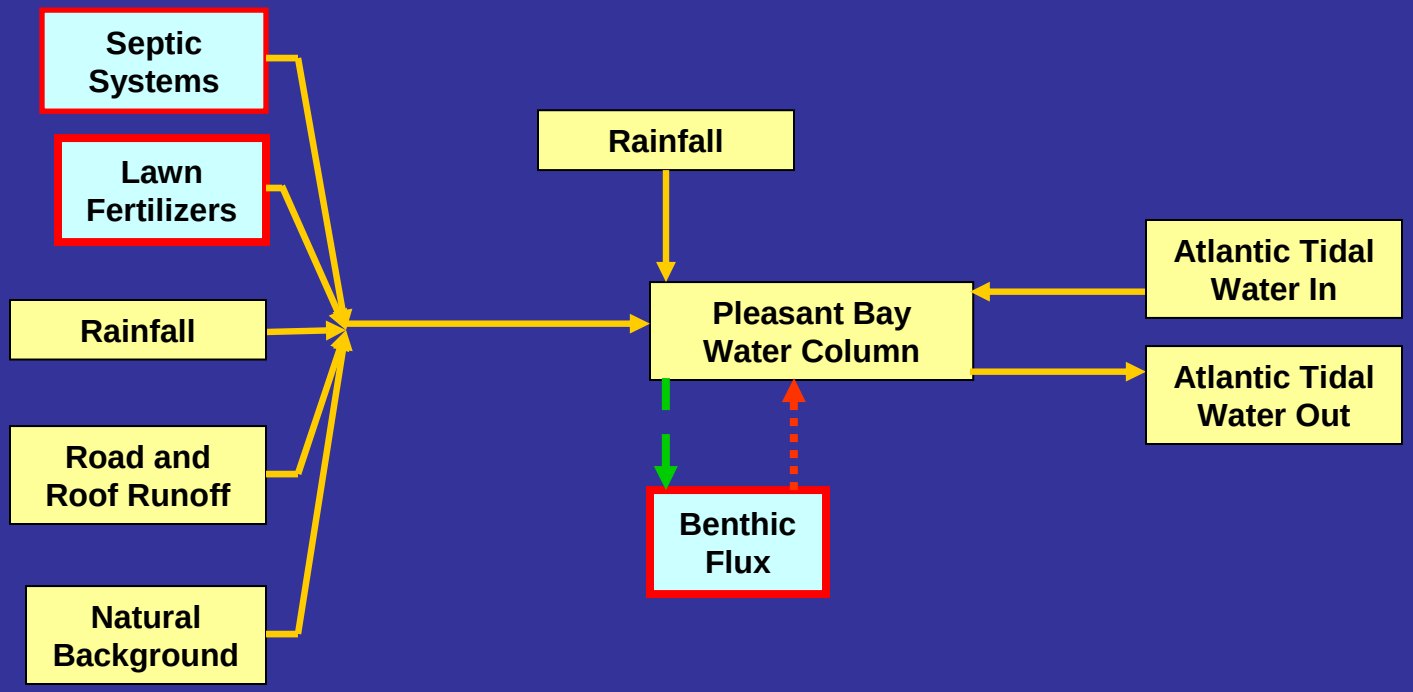


Nitrogen Loading Biases

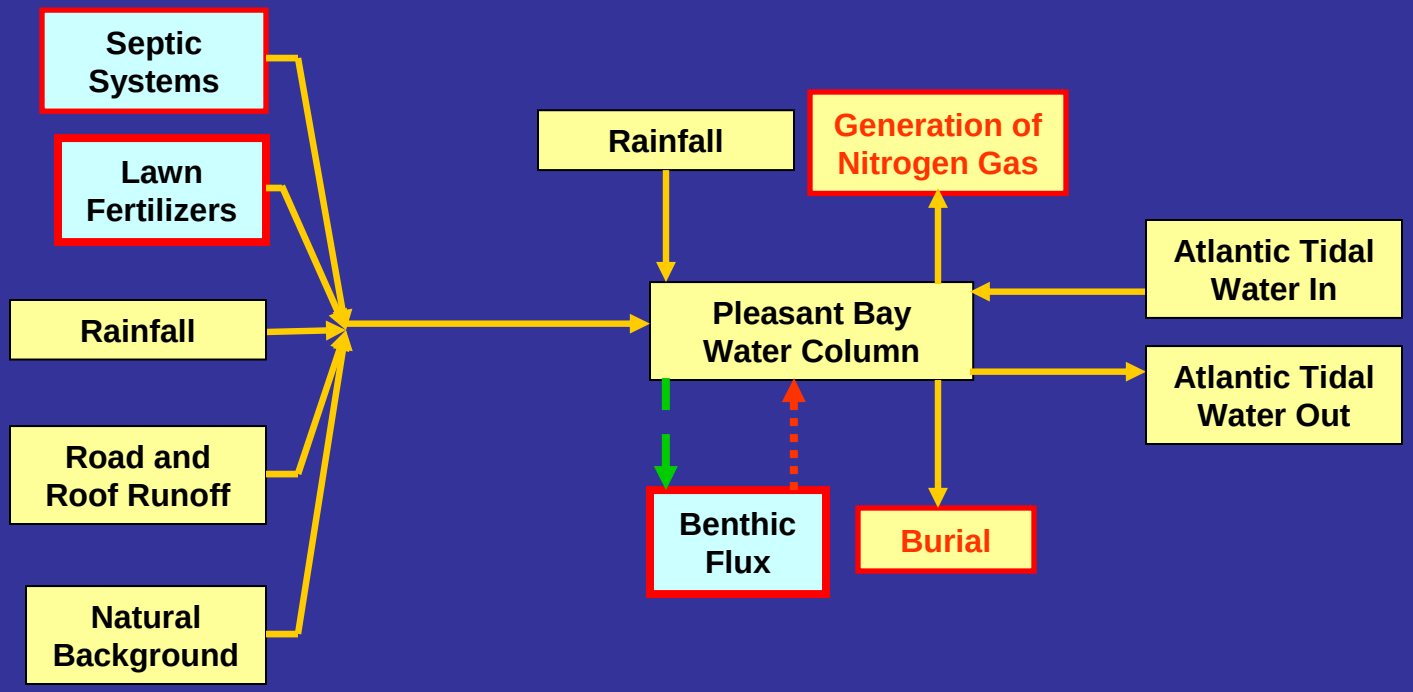
Units = kg/day

Present Total Load

	SMAST	Bias Adjusted
Septic	89[1]	53 to 71
Fertilizer	20[1]	10[2]
Benthic Flux	185[1]	94 to 115
Runoff	19[1]	19[1]
Rainfall	86[1]	86[1]
Total	399[1]	262 to 301

[1] Pleasant Bay Report, May 2006, Exec Summary, Table ES-1b
[2] Petrovic, August 2008

Nitrogen Loading Biases



Nitrogen Loading Biases

Units = kg/day

	Present Total Load	
Septic	89[1]	53 to 71
Fertilizer	20[1]	10[2]
Benthic Flux	185[1]	94 to 115
Runoff	20[1]	20[1]
Atmos. Deposition	86[1]	86[1]
Denitrification & Burial		- 40
Total	399[1]	222 to 261

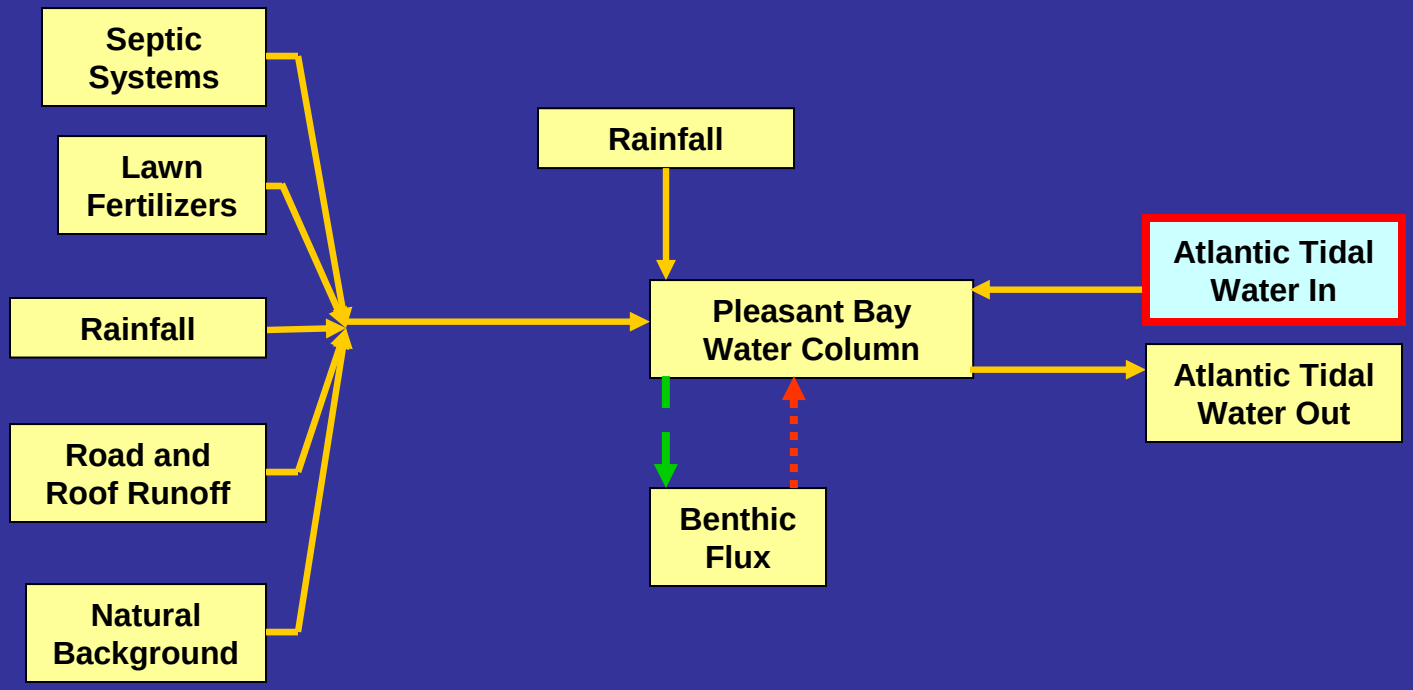
[1] Pleasant Bay Report, May 2006, Exec Summary, Table ES-1b
[2] Petrovic, August 2008

Nitrogen Loading Biases

Units = kg/day

SMAST Present Total Load	399
Septic Nitrogen Reduction	38
Septic Reduction as % Total Load	10%
Present Total Load Bias Adj'd	222 to 300
Present Total Load Reduction	97 to 175
Present Total Load Reduction as % of SMAST Total Load	25 to 44%

Nitrogen Loading Biases



Nitrogen Loading Biases

- SMAST Atlantic background bioactive nitrogen established at 0.094 mg/l based on 2005

- Results at the same sampling location in 2006 and 2007 were 0.079 mg/l and 0.071 mg/l

Nitrogen Loading Biases

- Bias of 20% in the background bioactive nitrogen concentration
- Atlantic background bioactive nitrogen is overstated by 985 to 1510 kg/day
- 26 to 40 times the targeted septic nitrogen reduction

Nitrogen Loading Biases - Summary

- **Biases exceeding 20% identified in SMAST septic, fertilizer, benthic flux and Atlantic background nitrogen loads.**
- **SMAST did not consider nitrogen losses due to denitrification and burial.**

Nitrogen Loading Biases - Summary

- Biases exceed accepted model variance of +/- 20%
- Biases are not random
- Biases all overstate nitrogen loads
- Combined biases are 25% to 44% of the SMAST Total Present Load