

# Nitrogen Inputs & Pleasant Bay Data

Town of Orleans  
Wastewater Management Validation & Design  
Committee

June 10, 2009

# Sources of Nitrogen

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- Natural Background
- Land Use
  - Natural Precipitation [Undeveloped Land, Ponds]
  - Lawn Fertilizer
  - Roof Runoff
  - Road Runoff
- Septic Systems
- Direct Atmospheric Deposition [Estuary]
- Benthic Flux (Sediment)

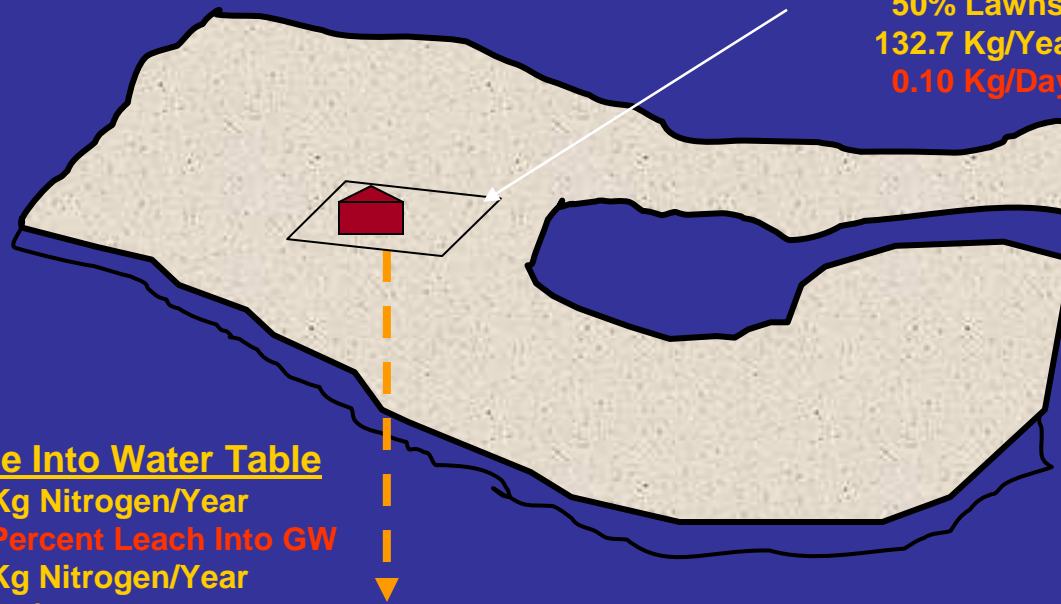
# Land Use

# Lawn Fertilizer

## Arey's Pond Illustration

### Lawn

5,000 Sq. Ft./House  
15 Lbs Nitrogen/Year/House  
6.81 Kg Nitrogen/Year/House  
39 Houses + 22 Condos (No Fert.)  
205,000 Sq. Ft. Lawn Area  
50% Lawns Fertilized [W-P: 100%]  
132.7 Kg/Year  
0.10 Kg/Day (April – September)



### Drainage Into Water Table

132.7 Kg Nitrogen/Year  
25 Percent Leach Into GW  
33.2 Kg Nitrogen/Year  
0.09 Kg/Day

# Sources of Nitrogen

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- Septic Systems
- Benthic Flux (Sediment)

# Pleasant Bay Orleans Nitrogen Contributions

- Nitrogen inputs from Orleans into Pleasant Bay by source are shown in the table.

Source	Totals Kg/Day	Percent
<b>Natural Background</b>	<b>5.15</b>	<b>NA</b>
<b>Present Land Use</b>	<b>6.99</b>	<b>7.63</b>
<b>Septic Systems</b>	<b>22.63</b>	<b>24.7</b>
<b>Direct Precipitation</b>	<b>5.89</b>	<b>6.43</b>
<b>Benthic Flux</b>	<b>56.14</b>	<b>61.24</b>
<b>Total</b>	<b>91.61</b>	<b>100.00</b>

Source: "Massachusetts Estuaries Project, Linked Watershed Model...Orleans, Chatham, Brewster and Harwich, Massachusetts", U. Mass. Dartmouth, SMAST, May 2006, Table ES-1a, page ES-11.

# Septic Systems

## General Analysis

- An initial estimate of the fulltime equivalent occupancy in Orleans is:

Type Housing	Occupancy	Percent	Average Occupancy
Year-round [1]	2.30	50	<b>1.15</b>
Seasonal [2]	1.15	50	<b>0.58</b>
Total/Average		100	<b>1.73</b>

[1] Assume average occupancy for Orleans of 2.3 persons equivalent fulltime persons per year.

[2] 3 bedroom house; 2 persons/bedroom; 10 weeks/year.  $(2 \times 3 \times 10)/52 = 1.15$  equivalent fulltime persons per year

# Septic Systems

## Arey's Pond Occupancy

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- The estimated equivalent fulltime occupancy by property type in Arey's Pond watershed, as obtained by survey:

Property Use	Survey
Year-round	2.46
Seasonal	0.77

# Septic systems

## Arey's Pond Occupancy

- An estimate of the fulltime equivalent occupancy in the Arey's Pond watershed has been obtained by survey:

Type Housing	Occupancy	Percent	Average Occupancy
Year-round [1]	2.46	30	<b>0.74</b>
Seasonal [2]	0.77	70	<b>0.54</b>
Total/Average		100	<b>1.28</b>

[1] Reflects occupancy and housing type information shown in previous table.

[2] Reflects occupancy and housing type information shown in previous table.

# Arey's Pond

## Comparison of Estimates

- Estimates of fulltime equivalent occupancy in the Arey's Pond watershed are compared:

Property Use	Survey	Non-Survey	Total [2]
CCC Database			113.0
Wright-Pierce [1]			132.8
WMV&DC	41.2	33.1	74.3

[1] Includes almost 20 additional people compared to CCC calculation. The data, which are unexplained, represent an average of 5 fulltime equivalent persons per property on 4 properties.

[2] Does not include Arey's Pond boatyard.

# Septic Systems

## Arey's Pond Water Use

- Water use determined by the survey is higher than the value assumed by SMAST:

Source	Unit Consumption (Gals/Day/Person)
SMAST/CCC Database & Wright-Pierce	64
WMV&DC Survey [1]	91

[1] Based on actual metered water consumption and occupancy provided by surveys.

# Pleasant Bay Orleans Nitrogen Contributions

- Nitrogen inputs from Orleans into the Pleasant Bay System by source are shown in the table.

Source	Totals	Percent
Meetinghouse Pond	21.15	23
Namequoit River	17.83	19
The River - Lower	16.60	18
Pochet Neck	9.40	10
The River - Upper	9.32	10
Arey's Pond	7.48	8
Pah Wah Pond	5.57	6
Lonnies Pond	4.26	5
<b>Total</b>	<b>91.61</b>	<b>100</b>

60%

Source: "Massachusetts Estuaries Project, Linked Watershed Model...Orleans, Chatham, Brewster and Harwich, Massachusetts", U. Mass. Dartmouth, SMAST, May 2006, Table ES-1a, page ES-11.

# Summary

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- The fulltime equivalent occupancy in the Arey's Pond watershed is approximately 70 percent of the number assumed by SMAST. Nitrogen input accordingly.
- The survey should be expanded to other watersheds, such as Meetinghouse Pond, Namequoit River, and the lower portion of The River

# Nitrogen Inputs

## Arey's Pond

Source	Arey's Pond <sup>1</sup> (Kg/Day)	Alternate-Estimate (Kg/Day)
Natural Background	0.47	Not Avail.
Land Use	0.53	0.34
Lawn Fertilizer		0.090
Road and Roof Runoff		0.085
Natural Precipitation		0.160
<b>Septic Systems</b>	<b>0.78</b>	<b>0.42 to 0.58</b>
Atmospheric Deposition	0.18	0.13
<b>Total Input</b>	<b>1.96</b>	<b>0.89 to 1.05</b>
<b>Benthic Flux</b>	<b>6.00</b>	<b>6.00</b>
<b>Total Load</b>	<b>7.96</b>	<b>6.89 to 7.07</b>
<b>Ratio Benthic to Septic</b>	<b>7.69</b>	<b>10.34 to 14.29</b>

[1] "Massachusetts Estuaries Project, Linked Watershed Model...Orleans, Chatham, Brewster and Harwich, Massachusetts", U. Mass. Dartmouth, SMAST, May 2006, Table ES-1a, page ES-11.

# Benthic Flux

- SMAST estimates that benthic flux is major source of nitrogen input. Data for Orleans are shown in the table.

Source	Flux (Kg/Day)	Percent
Natural Background	5.15	NA
Land Use	6.99	7.6
Septic systems	22.63	24.7
Acid Rain	5.89	6.4
<b>Benthic Flux</b>	<b>56.10</b>	<b>61.2</b>
Total	91.61	100.0

# Benthic Flux

## Ratios

- Benthic flux ratio to all septic inputs varies by watershed:

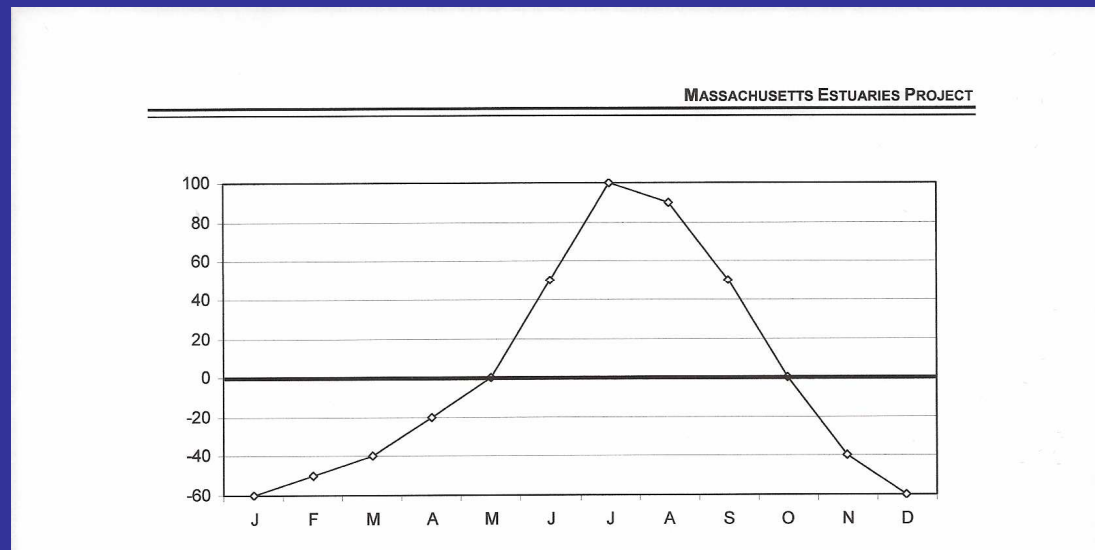
[1] “Massachusetts Estuaries Project, Linked Watershed Model...Orleans, Chatham, Brewster and Harwich, Massachusetts”, U. Mass. Dartmouth, SMAST, May 2006, Table ES-1a, page ES-11.

Watershed	Ratio [1]
Mtghouse Pond	2.8
<b>Namequoit River</b>	<b>7.3</b>
The River-Lower	3.7
Pochet Neck	NA
The River-Upper	3.0
<b>Arey's Pond</b>	<b>7.7</b>
Pah Wah Pond	2.4
Lonnies Pond	1.0
Average	2.5

# Benthic Flux

## Effect of Time

- SMAST suggests that benthic flux varies by time of year.



[1] “Massachusetts Estuaries Project, Linked Watershed Model...Orleans, Chatham, Brewster and Harwich, Massachusetts”, U. Mass. Dartmouth, SMAST, May 2006, Page 80.

# Benthic Flux

Arey's Pond

- The benthic flux input estimate from Pleasant Bay Report (Page 80):

Month	Days	Factor	Flux (Kg/Day)	Total (Kg)
June	30	0.5	5.996	89.94
July	31	1.0	5.996	185.88
Aug	31	0.9	5.996	167.29
Sept	30	0.5	5.996	89.94
<b>Total</b>				<b>533.04</b>

# Benthic Flux

Arey's Pond

- The total annual septic flux input estimate from Pleasant Bay Report is:

<b>Days</b>	<b>Factor</b>	<b>Flux (Kg/Day) [1]</b>	<b>Total (Kg)</b>
365	1.0	0.778	<b>283.97</b>

[1] "Massachusetts Estuaries Project, Linked Watershed Model...Orleans, Chatham, Brewster and Harwich, Massachusetts", U. Mass. Dartmouth, SMAST, May 2006, Table ES-1a, page ES-11.

# Benthic Flux

Arey's Pond

- A comparison of the nitrogen fluxes is:

Source	Total (Kg)
Sediment Source	533.04
Total Septic Input	283.97
<b>Deficit</b>	<b>249.07</b>

[1] "Massachusetts Estuaries Project, Linked Watershed Model...Orleans, Chatham, Brewster and Harwich, Massachusetts", U. Mass. Dartmouth, SMAST, May 2006, Table ES-1a, page ES-11.

- Benthic flux rates determined in laboratory.
  - Standard equipment and protocols
  - Good replication

- Limitations in benthic flux rate measurements.
  - No illumination
  - Only summer conditions evaluated
  - Nitrogen flux composition not provided
  - Samples from only one summer
  - Only 2 – 3 samples from each sub-embayment; may not be representative

# Benthic Flux

## Measurements

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- With lack of illumination, benthic flux measurements are overstated by 30 percent [WHG. May 7, 2009]<sup>1</sup>

[1] "Peer Review (Independent Technical Review) of The Massachusetts Estuaries Project Report on Pleasant Bay, FINAL REPORT, Woods Hole Group, June 2009.

# Nitrogen Inputs

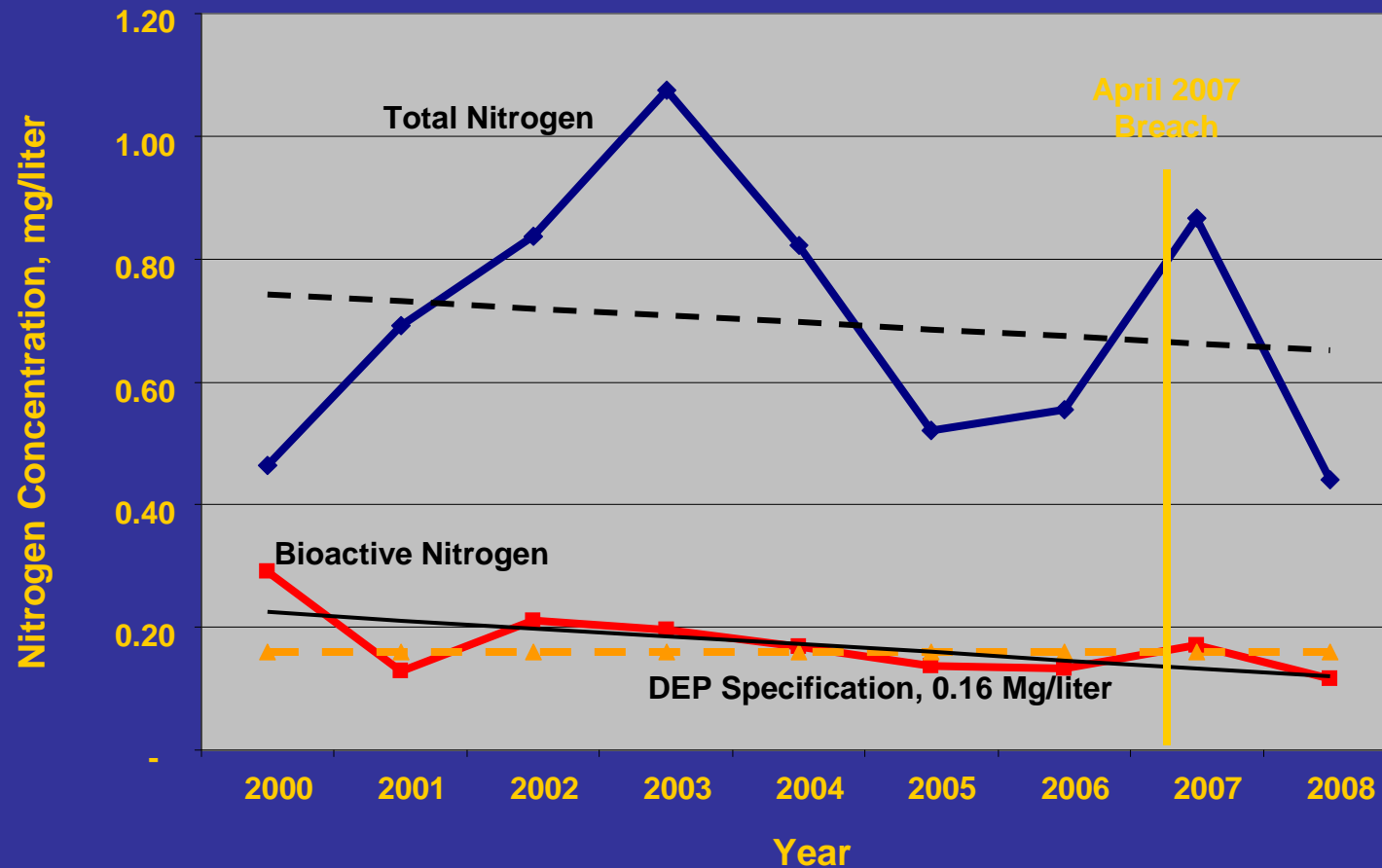
## Arey's Pond

- Table shows nitrogen fluxes with: [1] 70% of septic input; and [2] 30% reduction in benthic flux.
- Total input reduced from 7.96 to 5.6 Kg/Day, an overall **30% reduction**.

Source	SMAST Flux (Kg/Day)	Revised Flux (Kg/Day)
Natural Background	0.47	0.47
Land Use	0.53	0.25
Septic systems	0.78	0.55
Acid Rain	0.18	0.13
Benthic Flux	6.00	4.20
Total	7.96	5.60

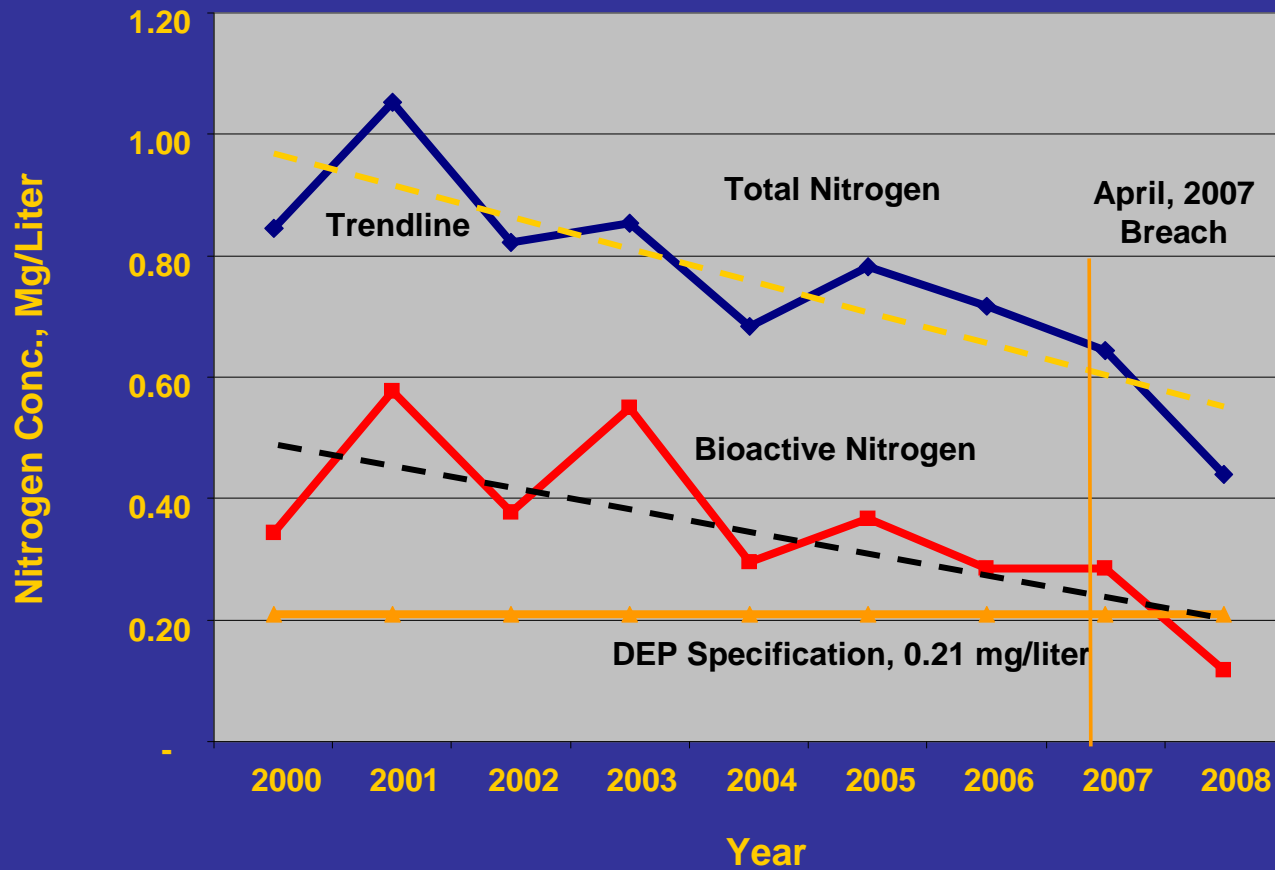
# PBA12 Namequoit Pt.

## Nitrogen Data



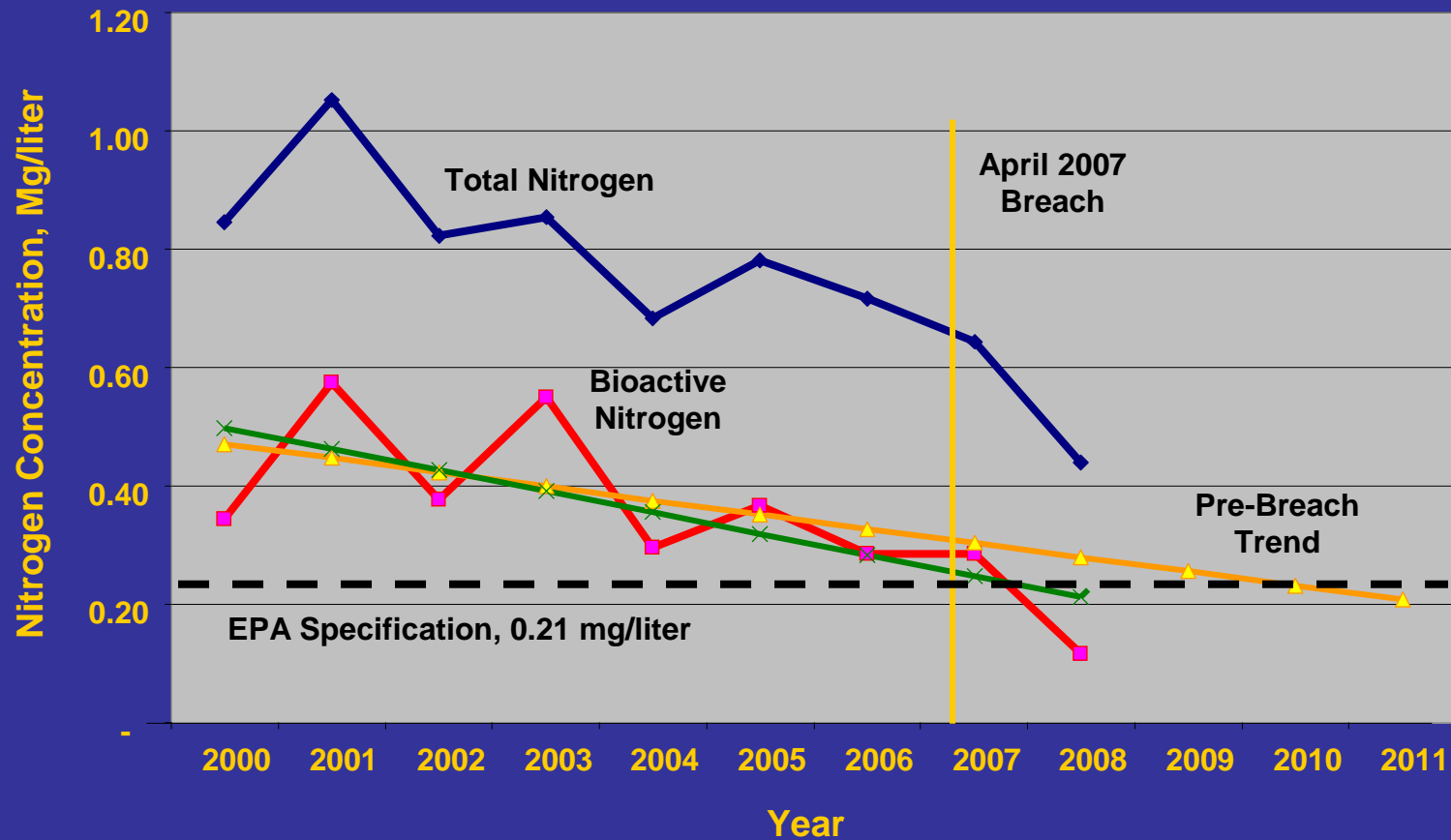
Source: Pleasant Bay Resource Management Alliance

# PBA16 Meetinghouse Pond Nitrogen Data



Source: Pleasant Bay Resource Management Alliance

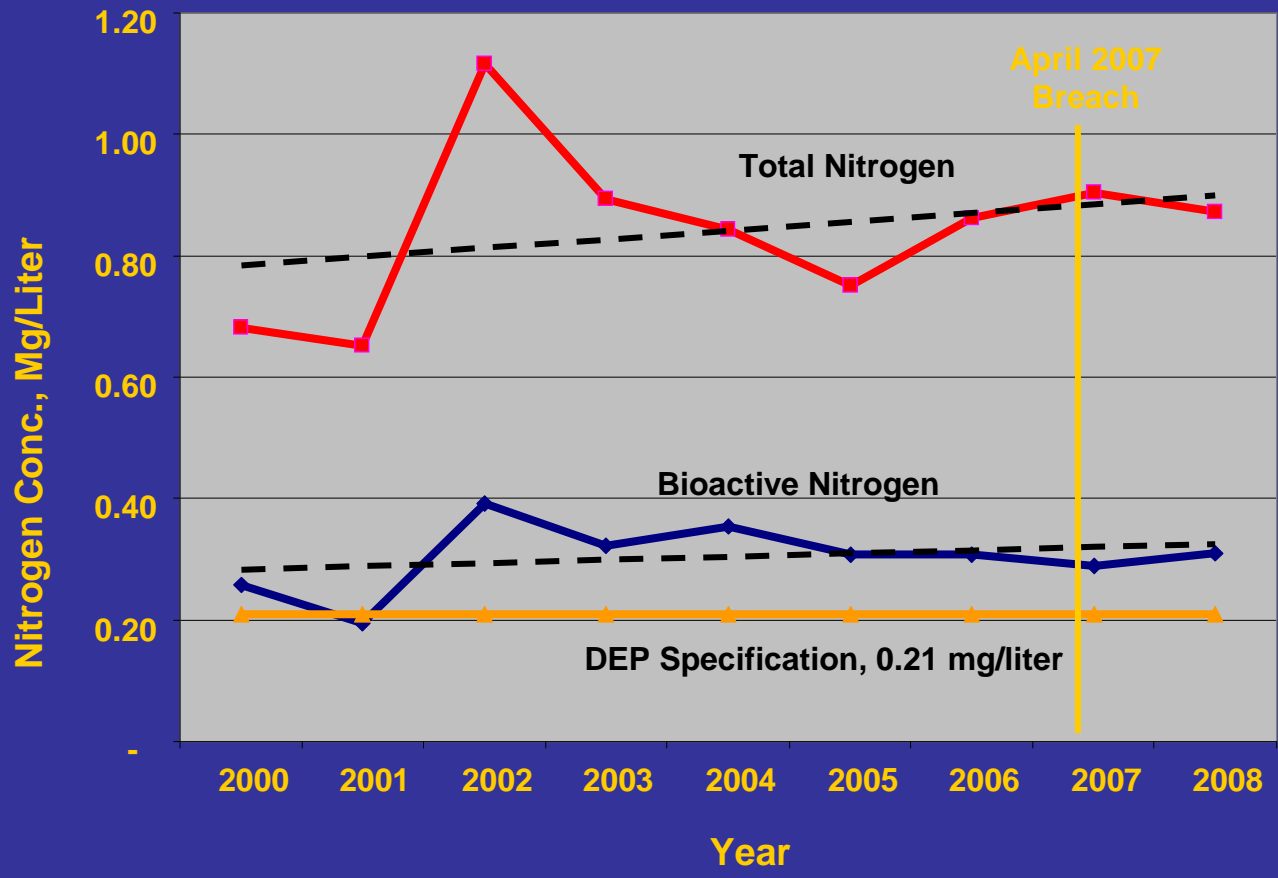
# PBA16 Meetinghouse Pond Nitrogen Data



Source: Pleasant Bay Resource Management Alliance

# PBA15 Lonnie's Pond

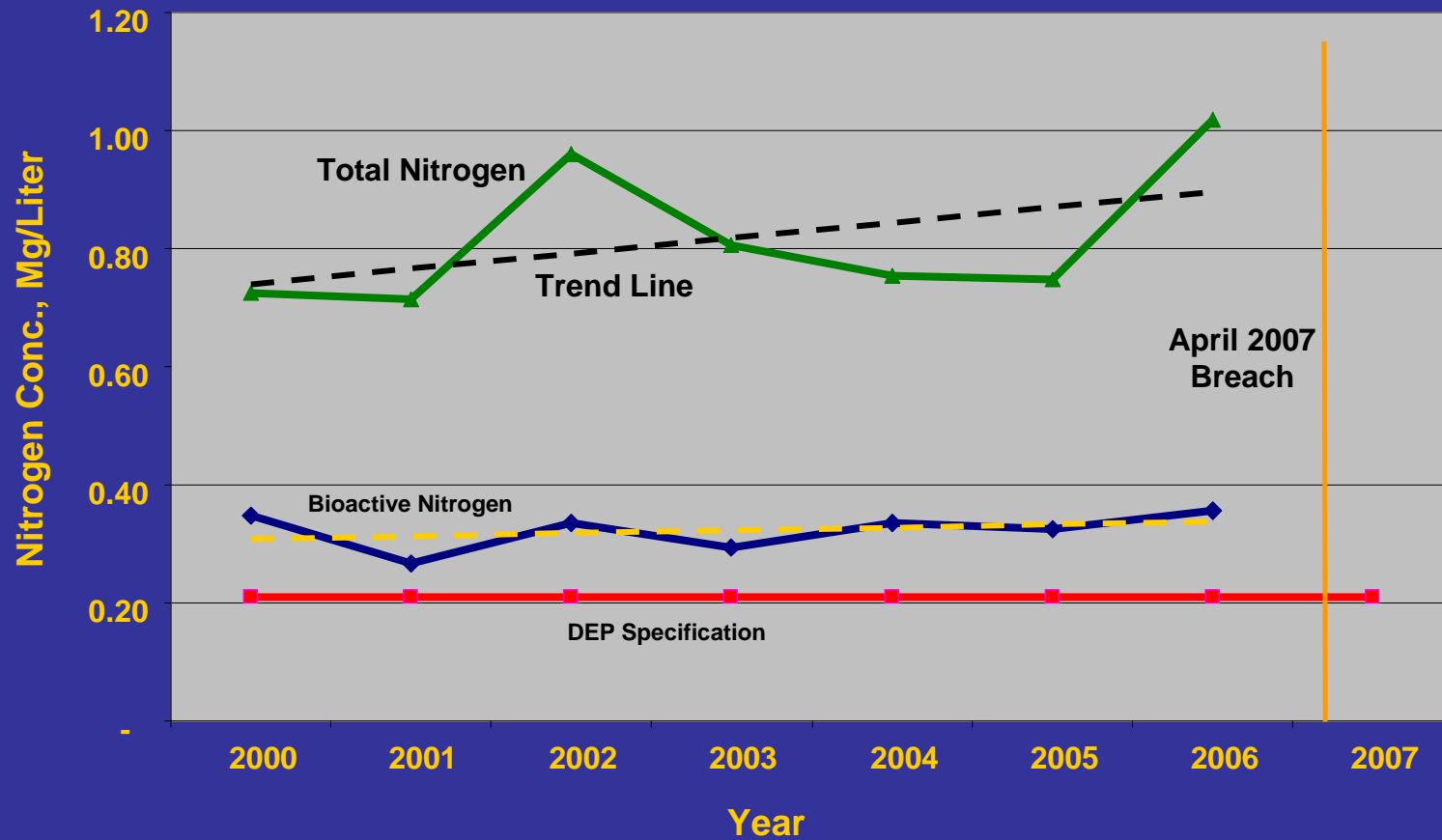
## Nitrogen Data



Source: Pleasant Bay Resource Management Alliance

# PBA14 Arey's Pond

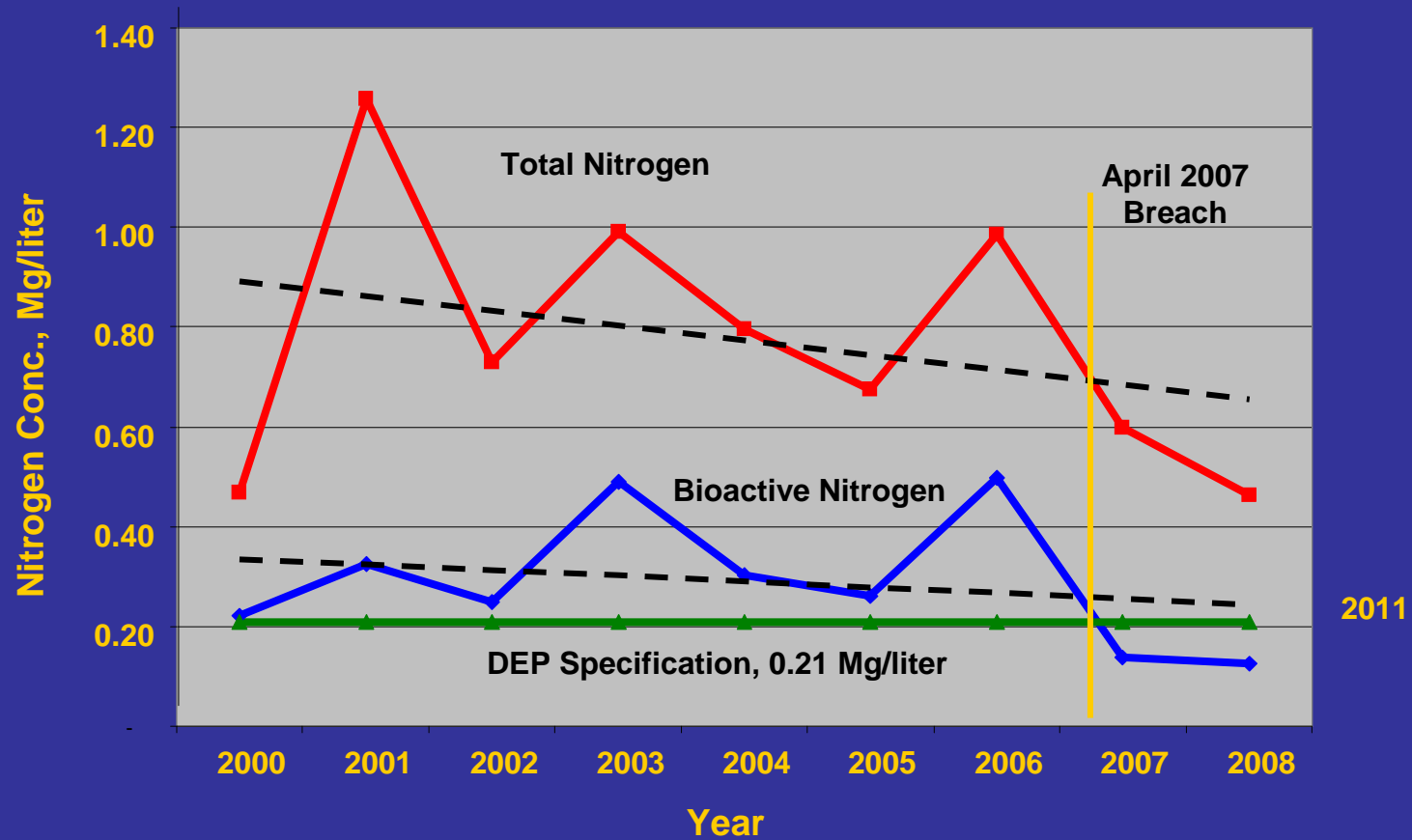
## Nitrogen Data



Source: Pleasant Bay Resource Management Alliance

# PBA11 Pah Wah Pond

## Nitrogen Data



Source: Pleasant Bay Resource Management Alliance

# Summary of Findings

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- The estimated nitrogen input is about 70% of the values used by SMAST.
- Additional surveys should be conducted of the watersheds of the Meetinghouse Pond, Namequoit River and the lower section of The River to validate the nitrogen input estimates.
- The concentrations of bioactive nitrogen at PBA12, Namequoit Point, have met the MA DEP threshold value since 2004.

# Summary of Findings

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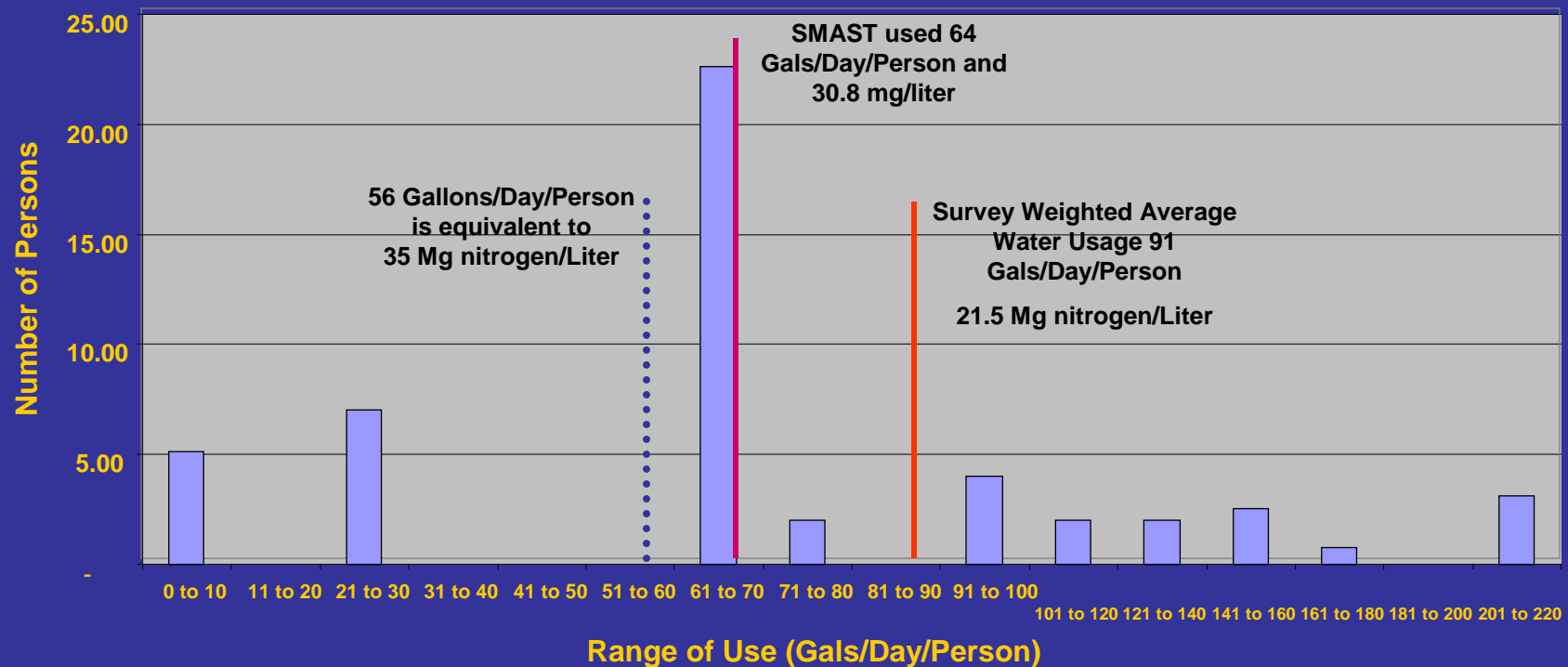
- The concentrations of bioactive nitrogen in Meetinghouse Pond will meet the MA DEP threshold values between 2009 and 2011.
- The concentrations of bioactive nitrogen in Pah Wah Pond will meet the MA DEP threshold values about 2011.
- The concentrations of bioactive nitrogen in Lonnie's and Arey's Pond continue to rise at a slow rate.

The End

# Septic Systems

## Arey's Pond Survey Data

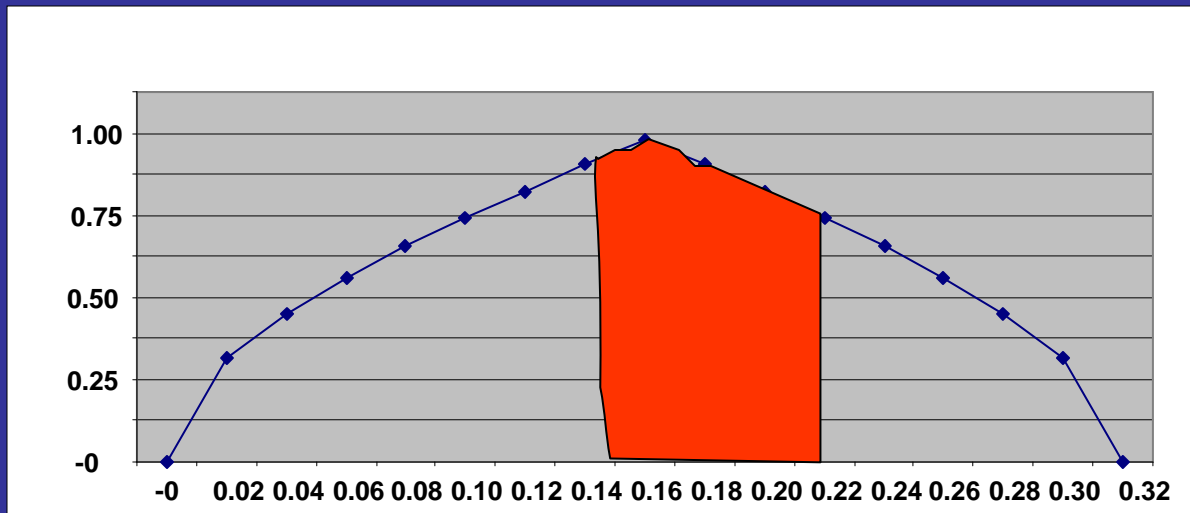
### Estimated Water Use In Arey's Pond Watershed



[1] Database for Arey's Pond Watershed, Cape Cod Commission, Date Unknown.

# Threshold Criteria

## An Illustration



# Benthic Flux

## Sampling Locations

- Benthic flux measurements may vary according to depth and location.
- Where were benthic flux samples taken?

