Tools to Assist Cape Cod Communities Reach Sustainable Nutrient Reduction Goals - Technologies Matrix and Adaptive Management Practices

New England Water Environment Association

January 26, 2015

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Project Director

AECOM

Scope of Services

Client: Country of Barnstable
acting through the Cape
Cod Commission

Project Name: 208 Water Quality
Management
Plan Update

Nature of Services: Planning Phase Engineering
Support

Schedule: June 2013 - Present

Organizations and Individuals

Cape Cod Commission

Cape Cod Water Protection Collaborative

Consensus Building Institute

Offshoots, Inc.

Water Resources Associates

Watershed Working Groups

AECOM Technical Services, Inc.

Beacon Strategies Group

Creative Strategies & Communications

New England Waste Systems

Regina Villa Associates, Inc.

Scott Horsley

The Abrahams Group

Mark Fahey Website Design

Agenda

1 - Background and Problem

2 - Tools

3 - Technologies Matrix

4 - Example

5 - Adaptive Management

6 - Questions

Background and Problem

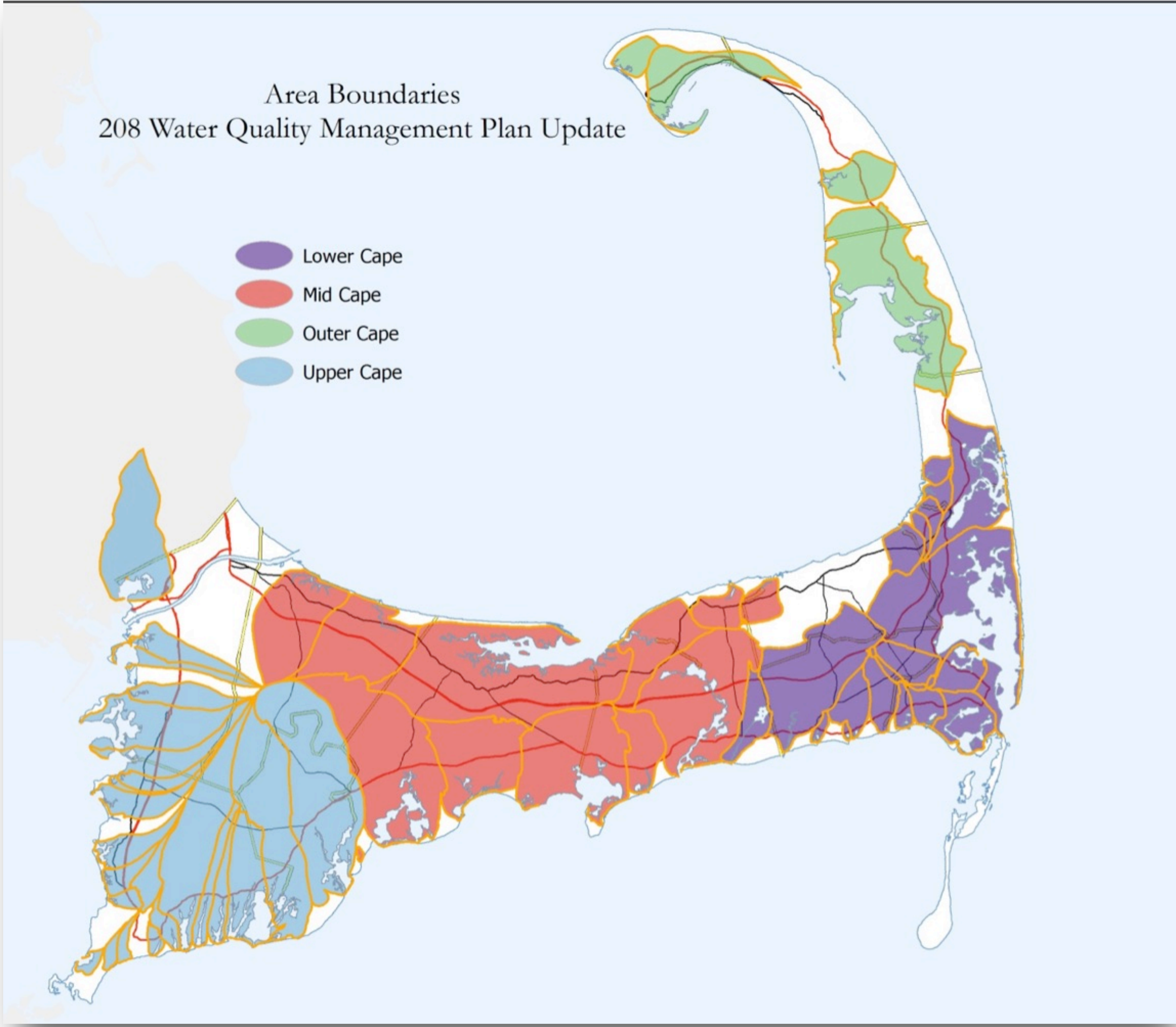
Background

- 105 Watersheds
- 57 Embayment Watersheds
- 994 Ponds
- Sole Source Aquifer
- Development over Time
- Increased Nutrient Loads
- MEP Studies and TMDLs
- Section 208 Update

Problem

- Estuaries Nitrogen Sensitive
- Ponds Phosphorus Sensitive
- Eutrophication
- Economic Impacts (Tourism)
- Cost of Nutrient Removal

WATERSHED SUBGROUPS



Tools

Watershed MVP

- GIS Based
- Parcel Data
- Scenario Planner for Nitrogen Reduction
- Cost Estimate of Scenarios

Watershed Tracker

- Tracks Nitrogen Load
- Existing Watershed and Sub-Watershed Loads
- Target Watershed and Sub-Watershed Loads
- Transfer Loads within Watershed

Tools should be run by a professional with an understanding of the technologies, permitting, and goals of the Town(s)/Watershed Group(s)

Tools (Continued)

<u>Triple Bottom Line (TBL) Model</u>

- Predicts Potential Environmental, Financial, and Social Impacts
- Stakeholders Define Goals
- Input Scenarios
- Moving Towards or Away from Goals

<u>Cost/Revenue Model</u>

- Compares Costs and Revenue Options for Scenarios
- Compares Costs and Revenue of Funding Options

Tools (Continued)

Technology Matrix

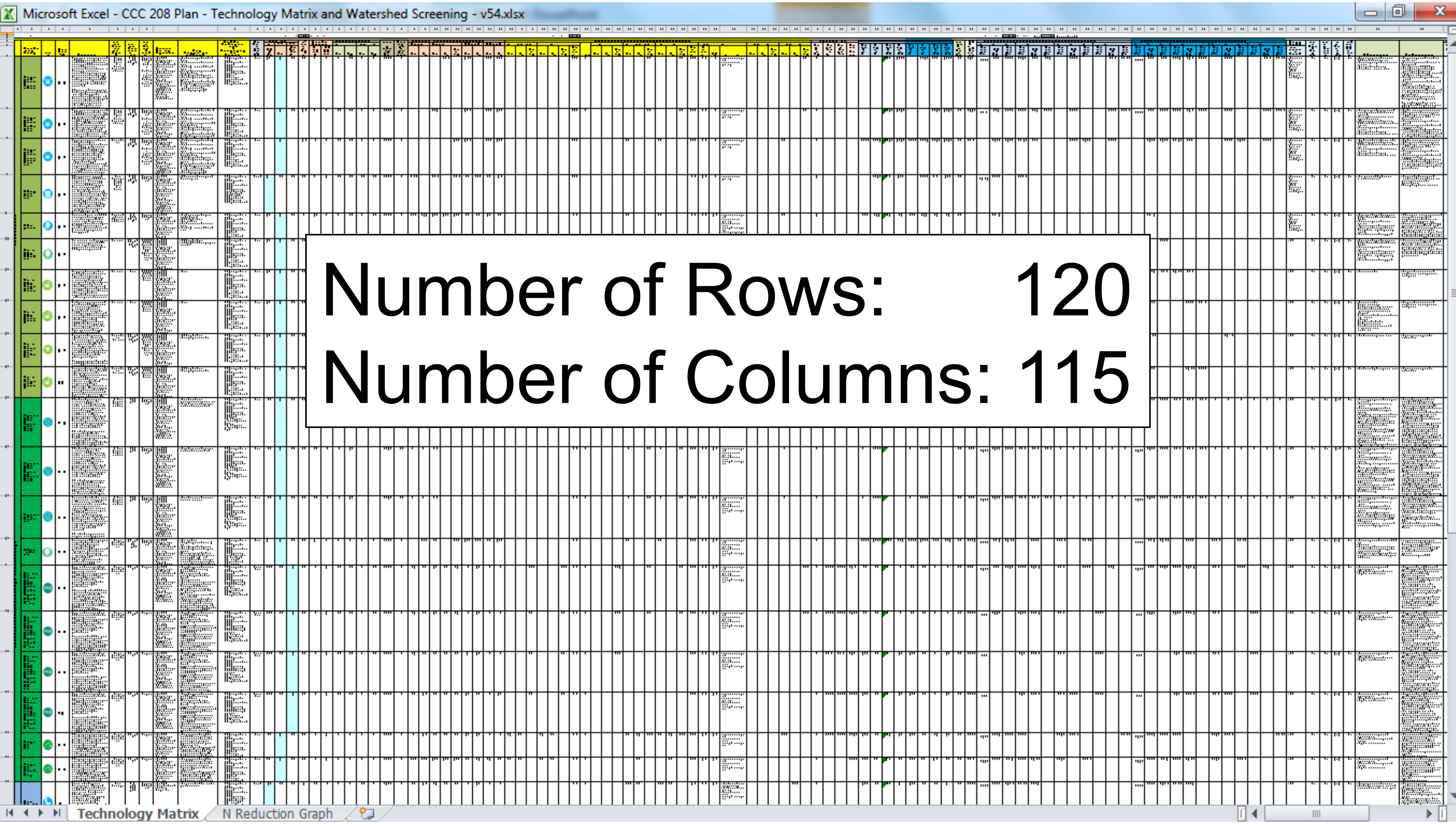
Single Source of Information on Nutrient Reduction Technologies being Considered

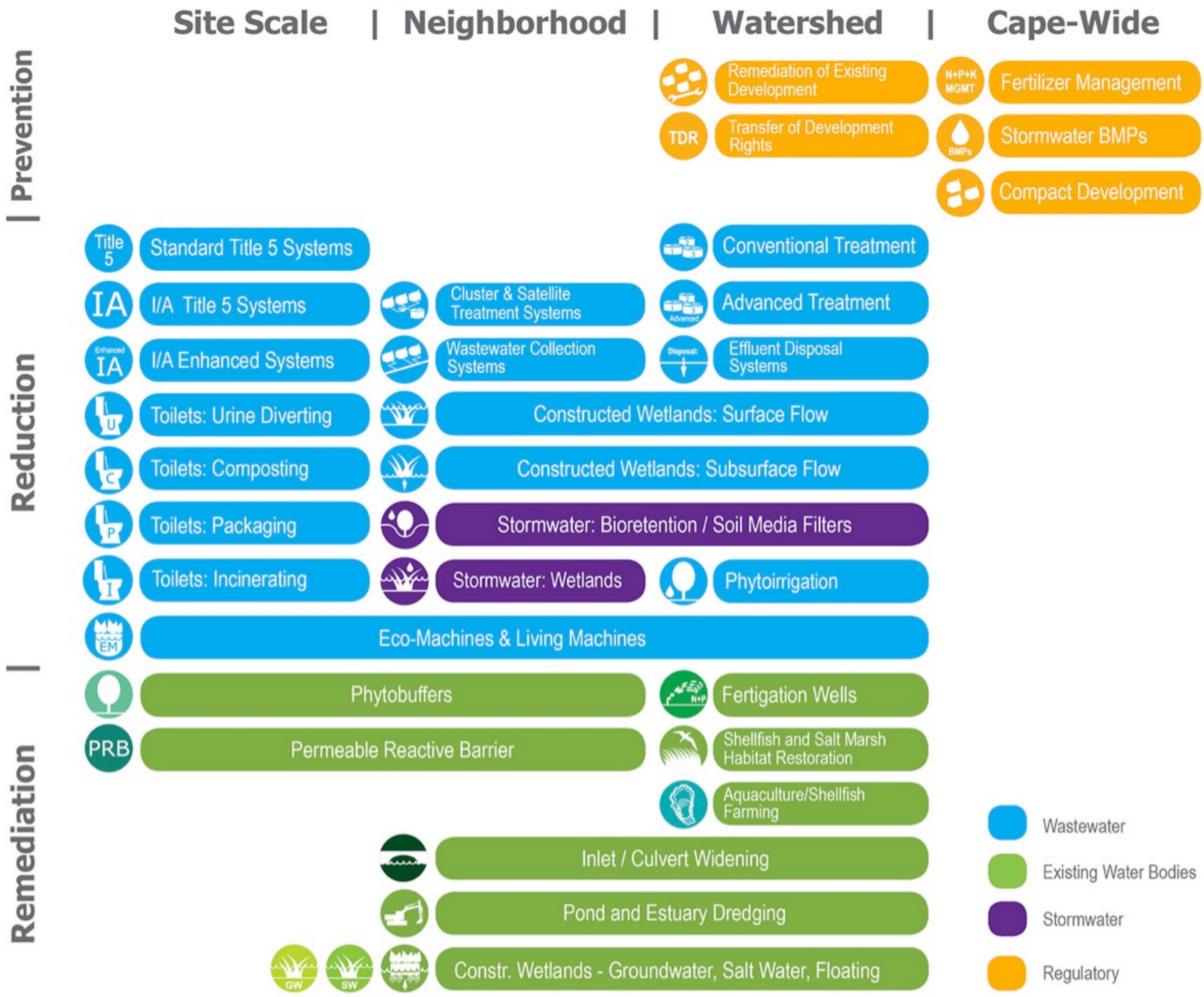
Base for Other Tools

Technologies Contained in the Matrix:

- Traditional Technologies: Cluster, Satellite, Conventional WWTF
- Non-Traditional Technologies: I/A Septic Systems, Fertigation Wells, Permeable Reactive Barriers (PRBs), Aquaculture, Inlet Widening, Inlet Dredging, Floating Constructed Wetlands

Technologies Matrix





Technologies Matrix and Adaptive Management Practices

Technologies Matrix (continued)

- Technology / Strategy
- Description
- Influent Source and Concentration
- Pollutant Treated / Reason for Use
- Potential Permitting Agencies
- Siting Requirements
- Flow and Nutrient Influent Load
- Nutrient Reduction
- Impact on Surface Water Quality
- Nutrient Removed per Year
- Unit Metric
- Reduction per Planning Period
- Construction, Project and O&M Costs
- System Considerations
- Average Life Cycle Cost
- Cost per Kg of Nutrient Reduction
- Advantages / Disadvantages
- Eco Services: Habitat, Green Space, Energy Savings
- Monitoring
- References

Technologies Matrix

Microsoft Excel - CCC 208 Plan - Technology Matrix and Watershed Screening - v54.xlsx

Input Cell

Technology / Strategy	Icon	Technology ID	Description	Influent Source (see Note 1)	Influent Concentration	Pollutant Treated and/or Reason for Use (see Note 2)	Potential Permitting Agencies	Siting Requirements (see Note 3)	Cells That May Require Input for Developing Site Specific Scenarios (Cells Highlighted Light Blue)
Constructed Wetlands - Surface Flow		101	After primary treatment in a septic tank or WWTF or secondary treatment at a WWTF, water is fed into a free water surface (FWS) constructed wetland. Free water constructed wetlands closely mimic the ecosystem of a natural wetland by utilizing water loving plants to filter wastewater through their root zone, a planted medium, and open water zones. FWS wetlands are systems where open water is exposed much like in a natural marsh. The reclaimed water is generally discharged into a leach field or similar system for discharge to the groundwater. The reclaimed water can also be discharged into a water body or used for open space irrigation after treatment. However, more strict permitting and water quality standards must me met if not discharging to groundwater. This technology can be used as an alternative to conventional polishing (i.e. mechanical and/or chemical) of secondary and advanced wastewater treatment.	Septic Tank Effluent Primary Effluent Secondary Effluent	20 - 75 mg/L N 4 - 8 mg/L P	Nitrogen Phosphorus Sediment Reduce amount of Direct Discharge to Groundwater	• MassDEP • Department of Public Works • Board of Health • Conservation Commission • Natural Heritage • The Nature Conservancy • Mass Historical Commission • US Army Corps or Engineers • Division of Marine and Fisheries • US Fish and Wildlife Service • Building Department • Land Owner	• Undeveloped land > 5 Acre. • Outside all wetlands resource areas. • Outside 100 year flood hazard zone. • Groundwater separation - GW depth > 4 feet. • Not within priority habitat areas. • Not within protected open space. • Benefit if site has clay based soils, has disturbed soils, parcel intersects with 50 to 100 foot Buffer zone, has municipal ownership. • No steep topography.	P 2 - Flow per Home (gpd) AN 2 - Project Cost Factor (%) BU 2 - Discount Rate (% APR) BX 2 - Planning Period (Nper in years) N 7 - Acres Q 97 - Influent Nitrogen Load R 97 - Influent Phosphorus Load
Constructed Wetlands - Subsurface Flow		102	After primary treatment in a septic tank or WWTF or secondary treatment at a WWTF, wastewater is treated by pumping water slowly through subsurface gravel beds where it is filtered through plant root zones and soil media. Water flows 3-8" under the surface to prevent public exposure to wastewater and mosquito breeding. A combination of horizontal and vertical flow subsurface systems must be utilized to provide total nitrogen removal. The reclaimed water is generally discharged into a leach field or similar system for discharge to the groundwater. The reclaimed water can also be discharged into a water body or used for open space irrigation after treatment. However, more strict permitting and water quality standards must me met if not discharging to groundwater. This technology can be used as an alternative to conventional polishing (i.e. mechanical and/or chemical) of secondary and advanced wastewater treatment.	Septic Tank Effluent Primary Effluent Secondary Effluent	20 - 75 mg/L N 4 - 8 mg/L P	Nitrogen Phosphorus Reduce amount of Direct Discharge to Groundwater	• MassDEP • Department of Public Works • Board of Health • Conservation Commission • Natural Heritage • The Nature Conservancy • Mass Historical Commission • US Army Corps or Engineers • Division of Marine and Fisheries • US Fish and Wildlife Service • Building Department • Land Owner	• Undeveloped land > 0.5 Acre. • Outside all wetlands resource areas. • Outside 100 year flood hazard zone. • Groundwater separation - GW depth > 4 feet. • Not within priority habitat areas. • Not within protected open space. • Benefit if site has clay based soils, has disturbed soils, parcel intersects with 50 to 100 foot Buffer zone, has municipal ownership. • No steep topography.	P 2 - Flow per Home (gpd) AN 2 - Project Cost Factor (%) BU 2 - Discount Rate (% APR) BX 2 - Planning Period (Nper in years) N 8 - Acres Q 97 - Influent Nitrogen Load R 97 - Influent Phosphorus Load

Technology Matrix | N Reduction Graph

Technologies Matrix

Microsoft Excel - CCC 208 Plan - Technology Matrix and Watershed Screening - v54.xlsx

Flow per Home 160 gpd (see Note 5)

Unit Metric (see Note 13)	Metric Input: Flow – GPD (ADF) (see Note 4)	Metric Input: Area – Acre	Metric Input: Other – Cubic Foot, Liner Foot, Cubic Yard, Curb Mile, Each, Gallon or DTPD	Equivalent Number of Homes (see Note 6)	Influent Load for Calculations (see Note 7): Nitrogen (mg/L)	Influent Load for Calculations (see Note 7): Phosphorous (mg/L)	Nutrient Reduction (Percent Removal) (see Note 8): Nitrogen – Low	Nutrient Reduction: Nitrogen – High	Nutrient Reduction: Phosphorous – Low	Nutrient Reduction: Phosphorous – High	Percent Improvement of N Removal Over Title 5 (Baseline) (see Note 9)	Technology Impact on Surface Water Quality (Phosphorus) (see Note 10)	Nutrient Removed per Year: Nitrogen (Pounds) – Low	Nutrient Removed per Year: Nitrogen (Pounds) – High	Nutrient Removed per Year: Nitrogen (Kilograms) – Low	Nutrient Removed per Year: Nitrogen (Kilograms) – High	Aver
Acres	15,000	1.0	N/A	94	30	6.0	80	95	40	60	78.2%	L	1,095.9	1,301.4	497.1	590.3	
Acres	16,500	1.0	N/A	103	30	6.0	85	95	50	90	82.6%	L	1,280.8	1,431.5	581.0	649.3	

Technology Matrix | N Reduction Graph

Technologies Matrix

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System Design Considerations (see Note 25): Infrastructure to Consider when Designing and Pricing Technology / Strategy	Potential Land Use Implication That May Require Growth Management Modifications	Potential for Revenue Generation	Time for Results to Improve Estuary Water body (Years)	Technology Resilience (see Note 26)	Advantages	Disadvantages	Eco Services (see Note 27): Habitat / Wildlife / Biodiversity Benefit	Eco Services: Green Space / Conservation / Recreation Benefit	Eco Services: Energy Savings / Nutrient Recovery / Recycling Benefit	Eco Services: Flooding / Extreme Events Benefit
• Collection System • Wastewater Treatment • Effluent Disposal • Solids Collection, Treatment and Disposal	Yes	No	1 to 10	No	• Lower capital and annual O&M cost than tertiary treatment. • Easy to integrate public recreation amenities. • Proven Technology. • Suited for ammonia removal.	• Requires larger land area than tertiary treatment. • Disinfection of wetland influent may be required. • May require an NPDES permit. • May require a pilot study, long-term monitoring and reporting. • Vegetation harvesting may need to be performed periodically. • May require fencing and security measures. • May attract water fowl which could only N issue. • These systems on the Cape may need to be lined to prevent complete infiltration and allow time for N removal rather than just putting N into groundwater. • May Need storage of effluent during non-growing season. *Systems not designed to remove phosphorus. Phosphorus removal in these smaller systems requires lengthy retention times and/or use of specialized media to increase sorption **Based on 44,000GPD / 2.08 acre total treatment area for Fields of St Croix constructed wetland system in Lake Elmo, MN	Yes	Yes	Yes	Yes
• Collection System • Wastewater Treatment • Effluent Disposal • Solids Collection, Treatment and Disposal	Yes	No	1 to 10	No	• Very efficient and requires less land area than Free Water Surface wetlands. • Water stays below surface so may not require disinfection. • Lower capital and annual O&M cost than secondary and tertiary treatment. • Easy to integrate public recreation amenities. • Proven Technology. • Suited for nitrate and nitrate removal	• Higher maintenance in first few years. • May require carbon source initially. • Can become clogged over time. Phosphorous removal may decline over time. • May require fencing and security measures. • May attract water fowl which could aggravate N issue. • In addition, on the Cape, these systems may need to be lined to prevent complete infiltration and allow time for N removal rather than just putting N into groundwater.	Yes	Yes	Yes	Yes

Technology Matrix | N Reduction Graph

Technologies Matrix

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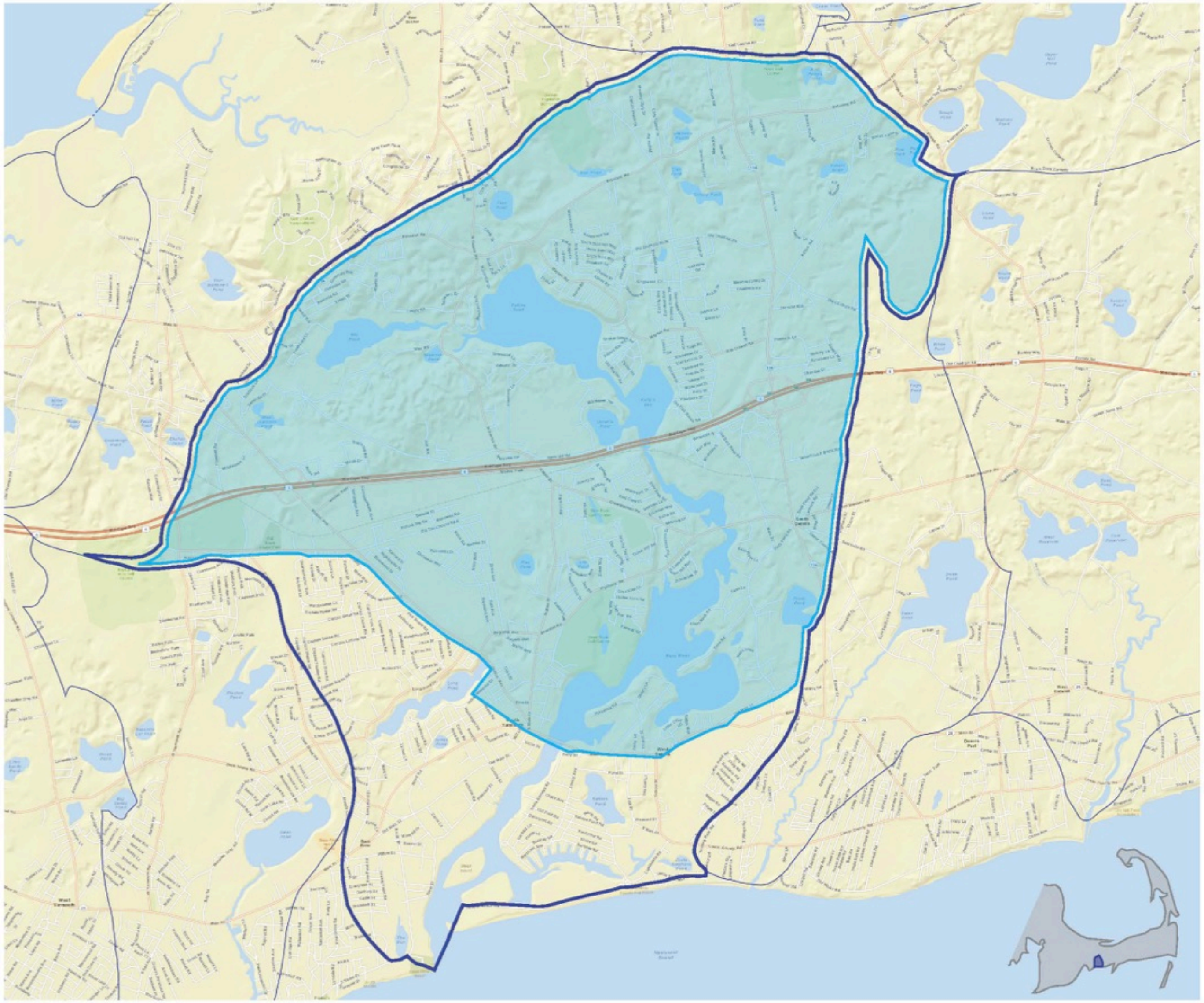
Discount Rate 5.00% (see Note 24) Nper 20 Years (see Note 24)

Technology Efficiency - PV Average Cost for Nutrient Reducing Technology (see Note 31 and Note 32)											
Cost per Pound of Nitrogen Reduction			Cost per Kilogram of Nitrogen Reduction			Cost per Pound of Phosphorous Reduction			Cost per Kilogram of Phosphorous Reduction		
Average Project Cost (PV)	O&M Cost (PV)	Average Life Cycle Cost (PV)	Average Project Cost (PV)	O&M Cost (PV)	Average Life Cycle Cost (PV)	Average Project Cost (PV)	O&M Cost (PV)	Average Life Cycle Cost (PV)	Average Project Cost (PV)	O&M Cost (PV)	Average Life Cycle Cost (PV)
$ 32.6	$ 4.2	$ 36.7	$ 71.8	$ 9.2	$ 81.0	$ 285.2	$ 36.4	$ 321.6	$ 628.7	$ 80.2	$ 708.9
$ 30.5	$ 4.1	$ 34.6	$ 67.2	$ 9.1	$ 76.4	$ 196.1	$ 26.6	$ 222.7	$ 432.2	$ 58.6	$ 490.9

Technology Matrix | N Reduction Graph



1 Sample Cape Cod Subwatershed

TOWN OF YARMOUTH MASSACHUSETTS

MAP 1: TOTAL COLLECTION AREA NECESSARY TO MEET:
Current Nitrogen Removal Needs

NITROGEN CALCULATOR

1 Current N Removal Needs (TMDL)	**+37,400 KG/YR**	**+100%**
2 Additional N Removal Needs		
Failed Title 5 Systems		
Anticipated Growth Areas		
3 Low Barrier Technologies		
Fertilizer Management		
Stormwater BMPs		
4 Watershed Alternative Technologies		
Const. Wetlands - GW		
Const. Wetlands - SW		
Phytobuffer		
Perm. React. Barrier		
Fertigation Wells		
Shellfish Aquaculture		
Inlet Widening		
5 On-Site Alternative Technologies		
I/A Title 5 Systems		
Alt. Toilet Systems		
6 Collection/Sewer	**-37,400 KG/YR**	**-100%**
Remaining Nitrogen to Meet Goal	**0 KG/YR**	**0%**

Indicator Bar

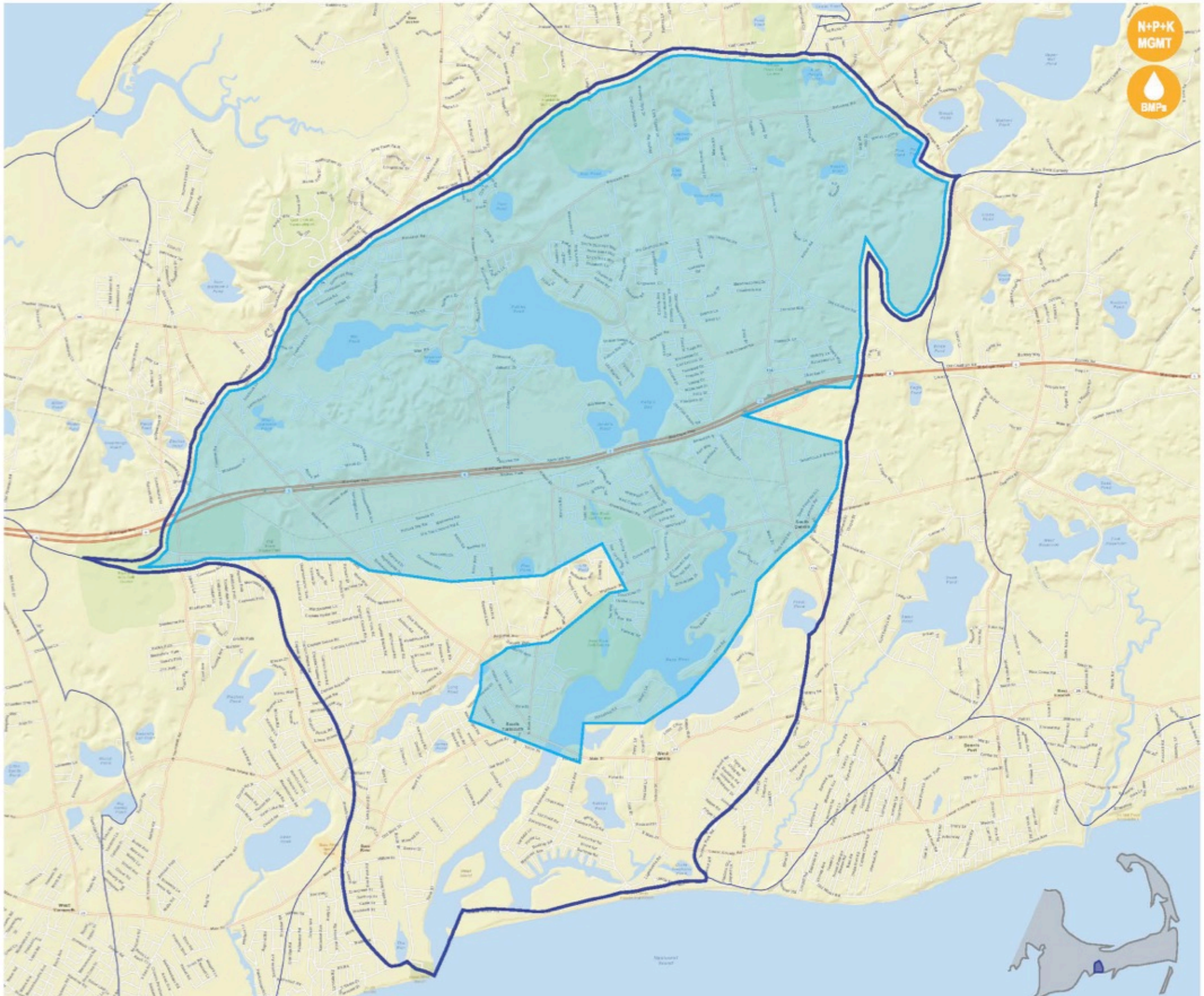
CAPE COD COMMISSION

3225 Main Street - Barnstable, MA 02630
(508) 362-3828 - www.capecodcommission.org

DATE 02.04.14

Draft Watershed Concept Maps

SHEET NUMBER SC-1



3

Sample Cape Cod Subwatershed

TOWN OF YARMOUTH MASSACHUSETTS

MAP 3: TOTAL COLLECTION AREA NECESSARY TO MEET:
Current Nitrogen Removal Needs
+ Additional Future Nitrogen Removal Needs
- Low Barrier Technologies

NITROGEN CALCULATOR

1 Current N Removal Needs (TMDL)	+37,400 KG/YR	+93.5%
2 Additional N Removal Needs	+2,600 KG/YR	+6.5%
Failed Title 5 Systems	+600 KG/YR	+1.5%
Anticipated Growth Areas	+2000 KG/YR	+5%
3 Low Barrier Technologies	-10,000 KG/YR	-25%
Fertilizer Management	-5,000 KG/YR	-12.5%
Stormwater BMPs	-5,000 KG/YR	-12.5%
4 Watershed Alternative Technologies		
Const. Wetlands - GW		
Const. Wetlands - SW		
Phytobuffer		
Perm. React. Barrier		
Fertigation Wells		
Shellfish Aquaculture		
Inlet Widening		
5 On-Site Alternative Technologies		
I/A Title 5 Systems		
Alt. Toilet Systems		
6 Collection/Sewer	-30,000 KG/YR	-75%
Remaining Nitrogen to Meet Goal	0 KG/YR	0%

Indicator Bar
75% Collection | 25% Low Barrier

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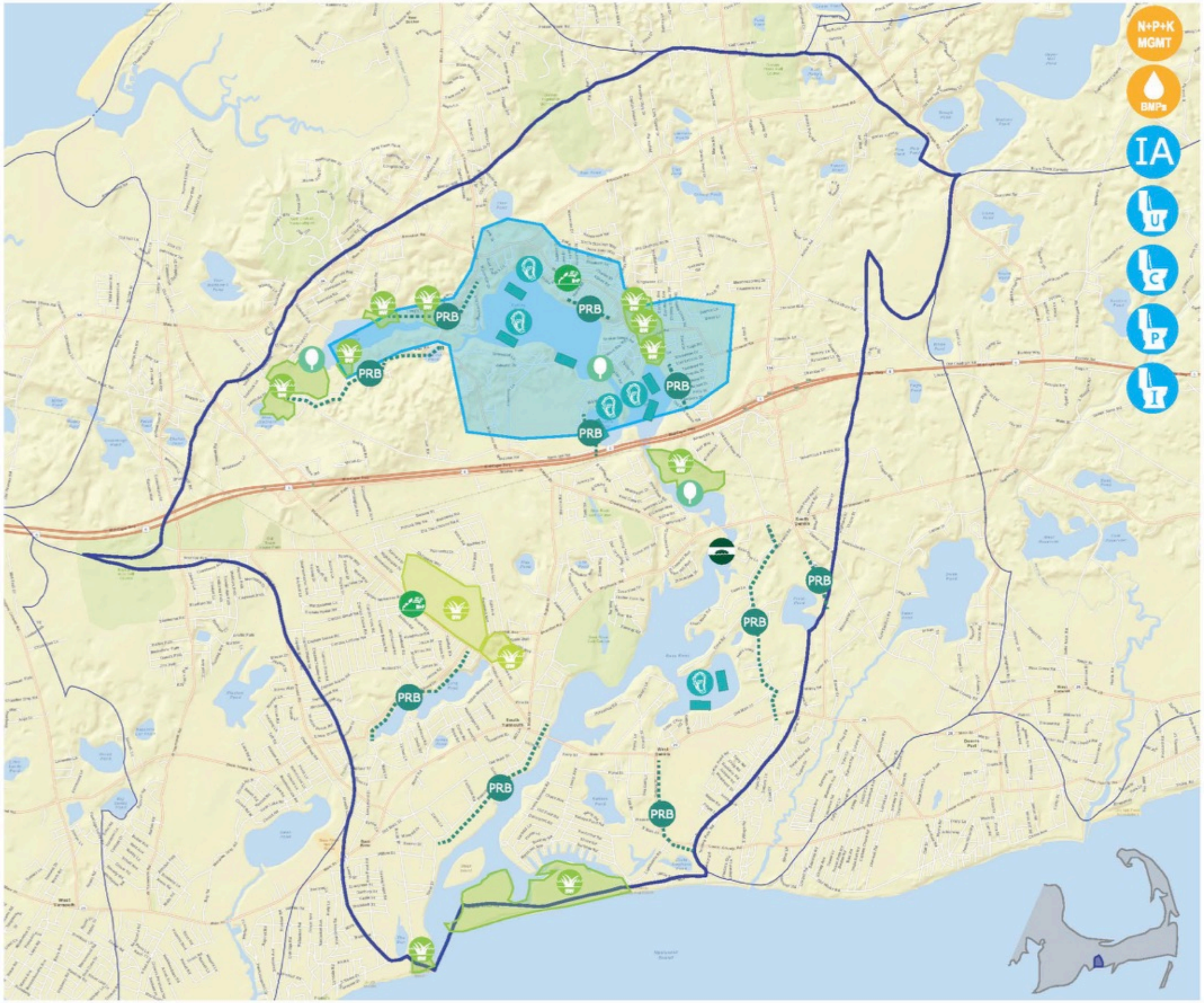
5

Sample Cape Cod Subwatershed

TOWN OF YARMOUTH MASSACHUSETTS

MAP 5: TOTAL COLLECTION AREA NECESSARY TO MEET:
Current Nitrogen Removal Needs
+ Additional Future Nitrogen Removal Needs
- Low Barrier Technologies
- Watershed Alternative Technologies
-On-Site Alternative Technologies



NITROGEN CALCULATOR

1	Current N Removal Needs (TMDL)	+37,400 KG/YR	+93.5%
2	Additional N Removal Needs	+2,600 KG/YR	+6.5%
	Failed Title 5 Systems	+600 KG/YR	+1.5%
	Anticipated Growth Areas	+2000 KG/YR	+5%
3	Low Barrier Technologies	-10,000 KG/YR	-25%
	Fertilizer Management	-5,000 KG/YR	-12.5%
	Stormwater BMPs	-5,000 KG/YR	-12.5%
4	Watershed Alternative Technologies	-22,100 KG/YR	-55.25%
	Const. Wetlands - GW	-3,000 KG/YR	-7.5%
	Const. Wetlands - SW	-4,000 KG/YR	-10%
	Phytobuffer	-100 KG/YR	-.25%
	Fertigation Wells	-600 KG/YR	-1.5%
	Shellfish Aquaculture	-10,000 KG/YR	-25%
	Perm. React. Barrier	-3,900 KG/YR	-9.75%
	Inlet Widening	-500 KG/YR	-1.25%
5	On-Site Alternative Technologies	-2,800 KG/YR	-7%
	I/A Title 5 Systems	-0 KG/YR	-0%
	Alt. Toilet Systems	-2,800 KG/YR	-7%
6	Collection/Sewer	-5,100 KG/YR	-12.75%
	Remaining Nitrogen to Meet Goal	0 KG/YR	0%

Indicator Bar

12.75% Collection | 25% Low Barrier | 55.25% Watershed Alternative | 7% On-site

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Draft Watershed Concept Maps	SHEET NUMBER SC-5

Adaptive Management

Adaptive Management

- A structured approach for meeting water quality goals
- Need to Monitor Technologies
- Assess Monitoring Outcomes
- Review and Evaluate Progress Over Time
- Adapt Management Plan Over Time

Thank You

Questions

New England Water Environment Association

January 26, 2015

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