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CAPE COD COMMISSION

Cape Cod 208 -Wide Water Quality Planning
Panel on Technologies

Wednesday, November 6, 2013
Innovation Room, Cape Cod Commission
10 am

Meeting Agenda

10:00	Welcome, Update on 208 Plan
10:10	Triple Bottom Line model – EPA and Industrial Economics, presentation and discussion
11:10	USGS/APCC Sea Level Rise study – presentation
11:30	Break
11:45	Response to Panel comments on Technologies Matrix
12:45	Public Comments
1:00	Adjourn

COUNTY OF BARNSTABLE MASSACHUSETTS

Cape Cod Triple-Value Simulation

Applying System Dynamics Modeling to the Nutrient Pollution Problem on Cape Cod

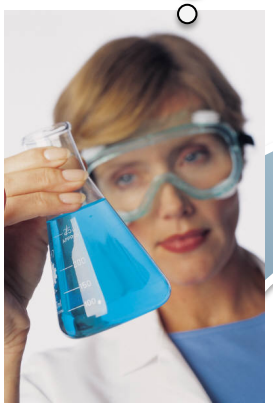
Systems Thinking is a Sustainability Assessment Tool

Systems Models Support Decision Making by Bridging Science, Policy, and Human Values

What do we know today, and what are the unknowns?

What are our goals and options?

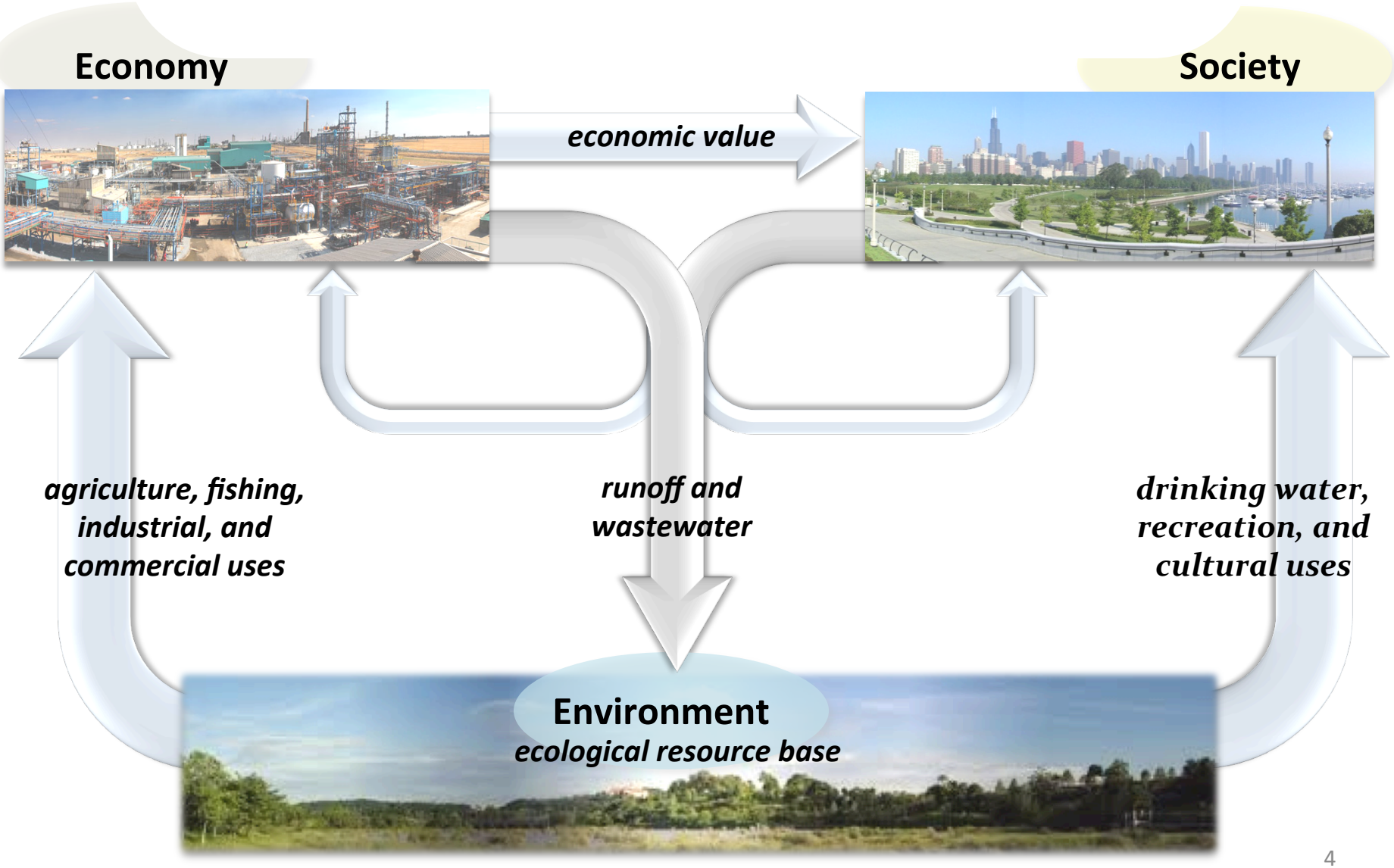
What do we care about most?



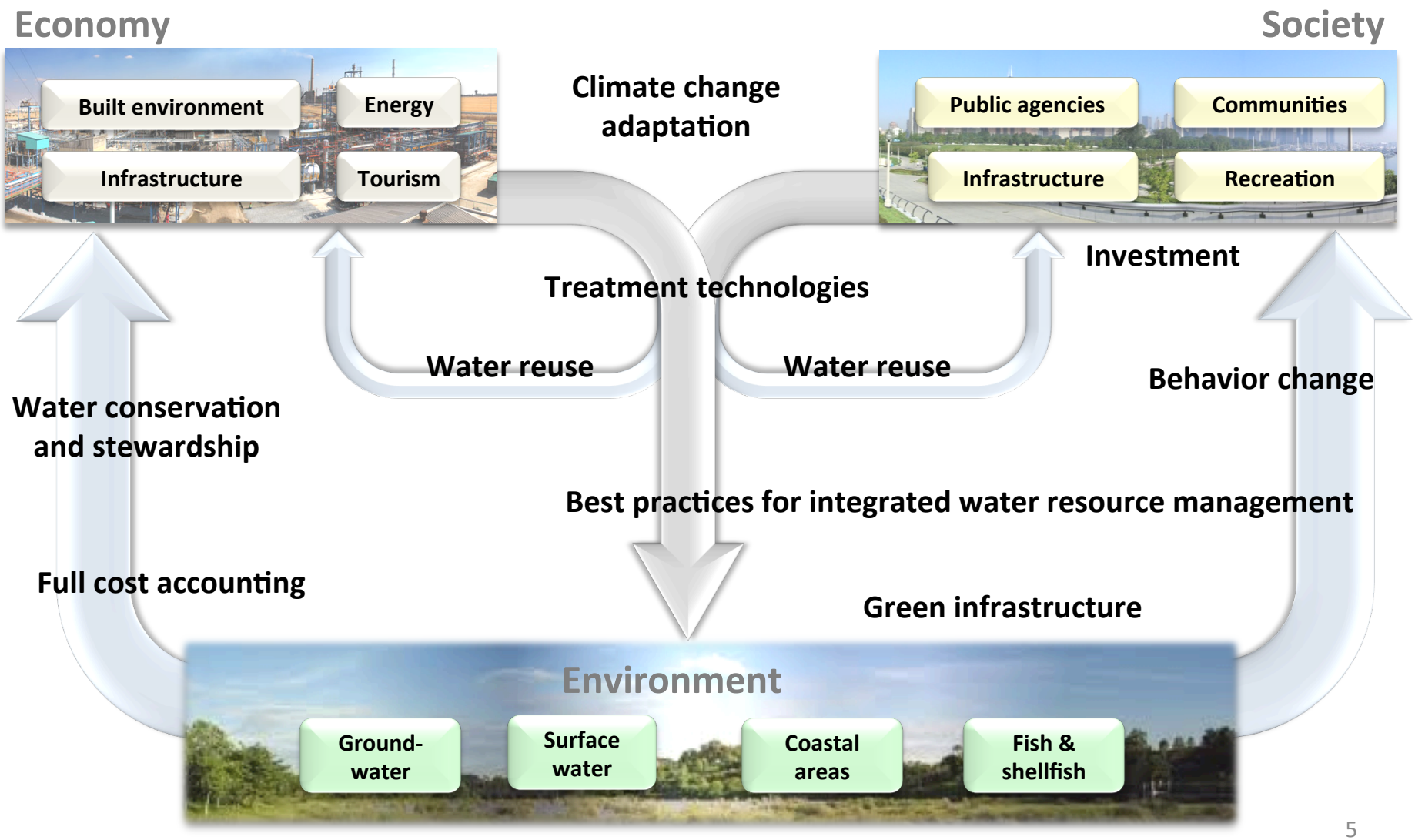
Systems Model

How should we proceed given the uncertainties and ambiguities?

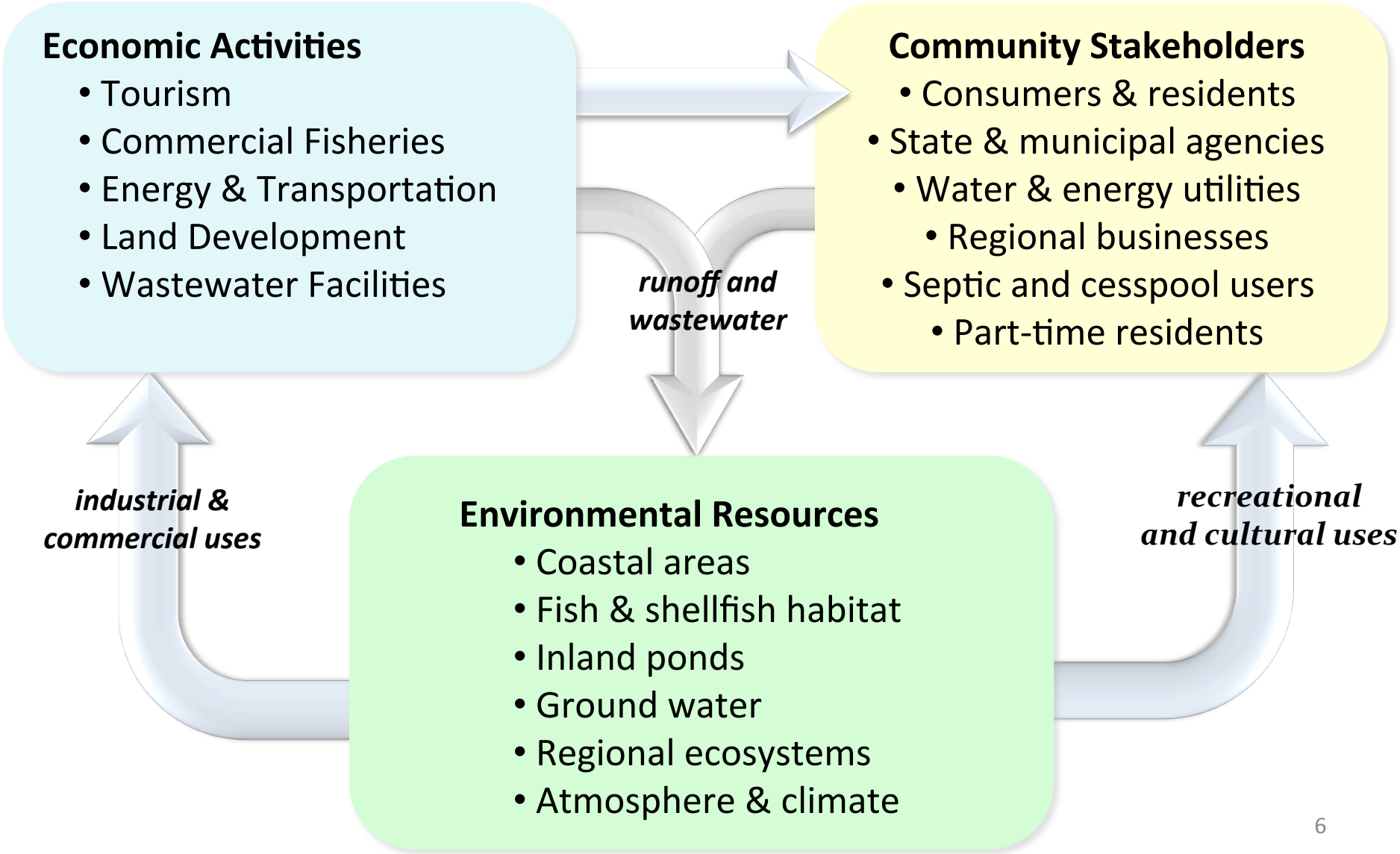
“Triple Value” Framework



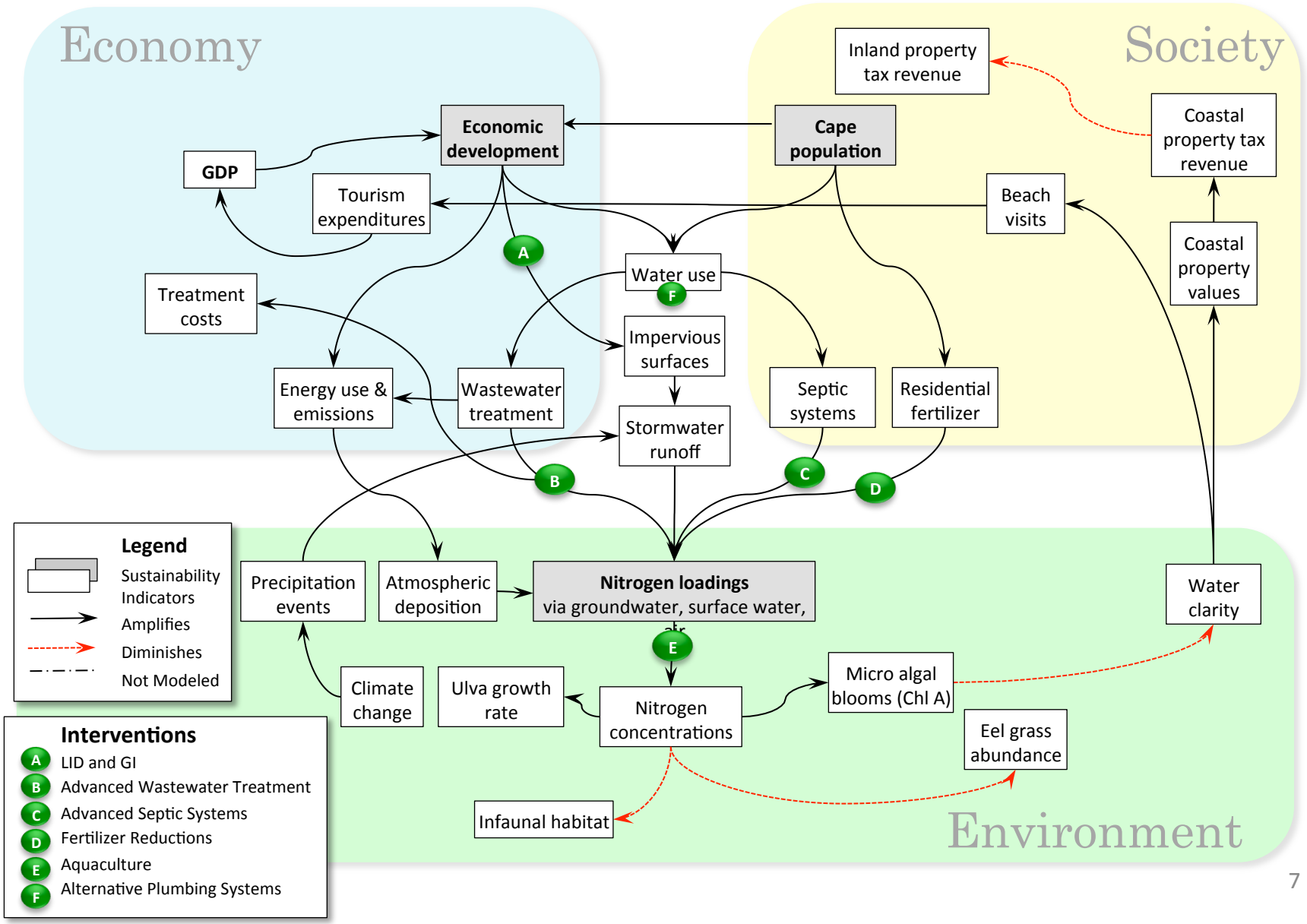
Potential Interventions to Improve Sustainability of Water Resources



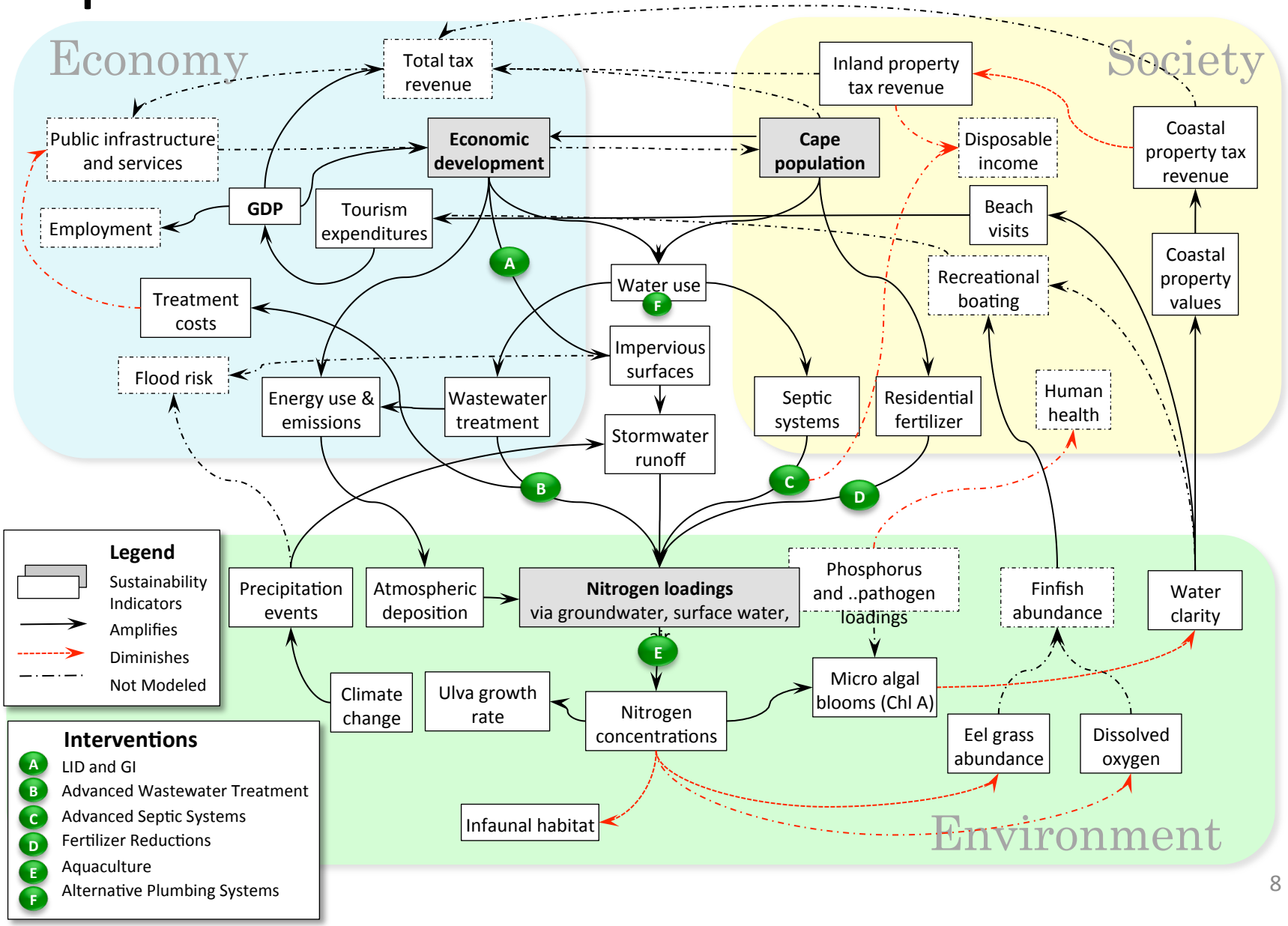
Modeling the Cape Cod System with a Triple Value Simulation (3VS) Model



Cape Cod 3VS Schematic: Initial Model



Cape Cod 3VS Schematic: Planned Model



Cape Cod 3VS Model: Data Sources

- The 3VS model relies on multiple data sources. Examples include:

Variable	Source
Nitrogen Loadings	Watershed MVP model, Massachusetts Estuaries Project (MEP) Watershed Reports
Nitrogen Concentration and Environmental Quality Indicators by Embayment	MEP Watershed Reports
Real Estate Value	2010 Census
Regional GDP by Industry Category, including Output, Earnings, and Employment	Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS), Stats Cape Cod
Treatment Costs	Watershed MVP model

Example Questions for the 3VS Model to Address

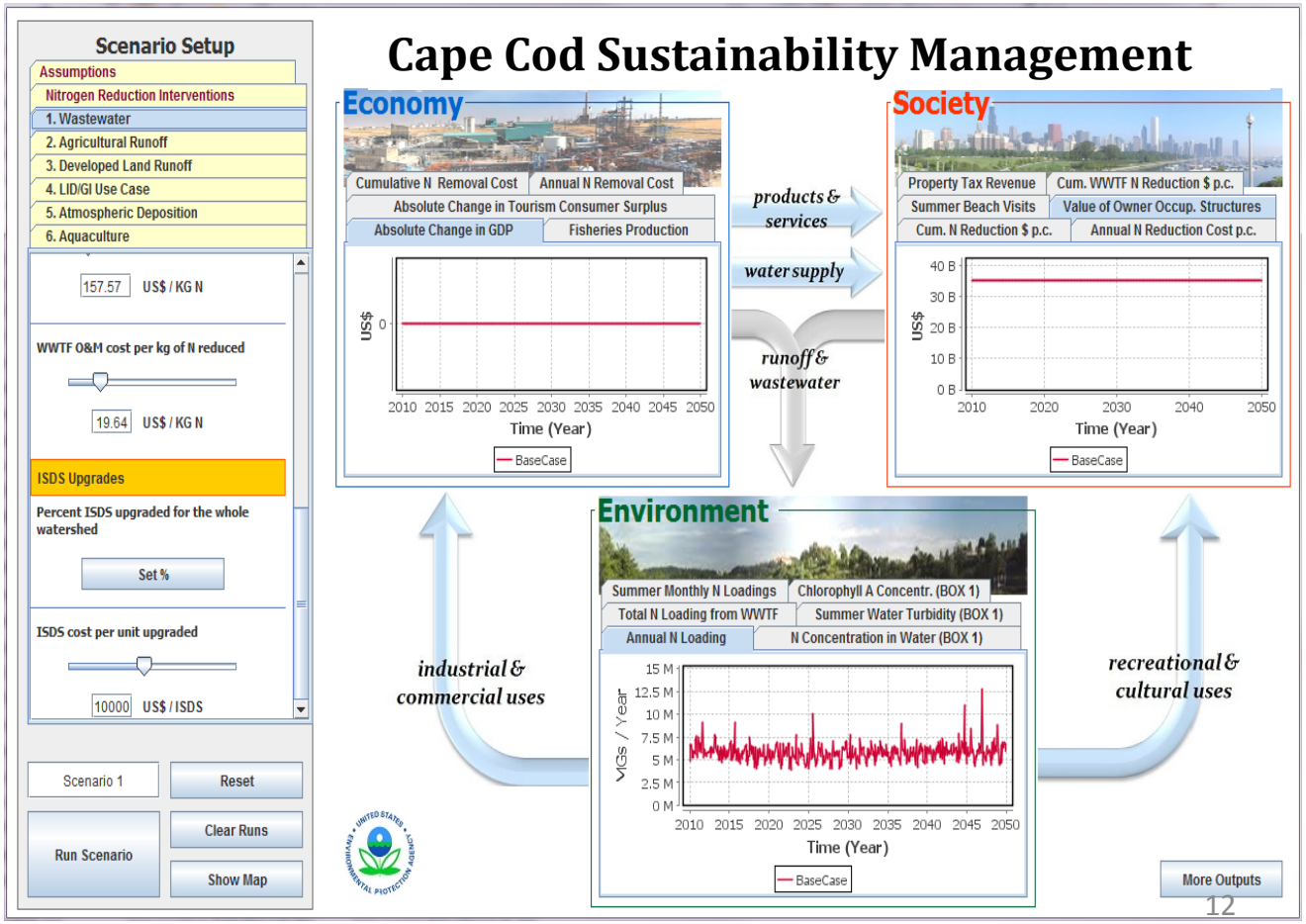
- In the absence of additional interventions, how would future projected growth in N loadings impact housing values, employment, income, and seasonal economic activity?
- What is the cost per capita of different combinations of interventions that can meet TMDLs for embayments around the Cape?
- How might climate change affect the viability and effectiveness of different approaches to nutrient management?
- What is the return on investment (or impact on employment) for a given set of approaches to nutrient management?

User Interaction with Cape Cod 3VS

- Users can define scenarios in the model, selecting different combinations of policy alternatives.
- The model will simulate the scenario and project results 30 years into the future.
- Users can compare model outputs across multiple scenarios, including the "No Action" scenario.
  - No new treatment beyond existing systems
  - Maintenance and replacement costs for existing systems
  - Projected growth in population and land development
- Two Options for interacting with the model:
  - Dashboard Interface
  - CCC Watershed MVP Model

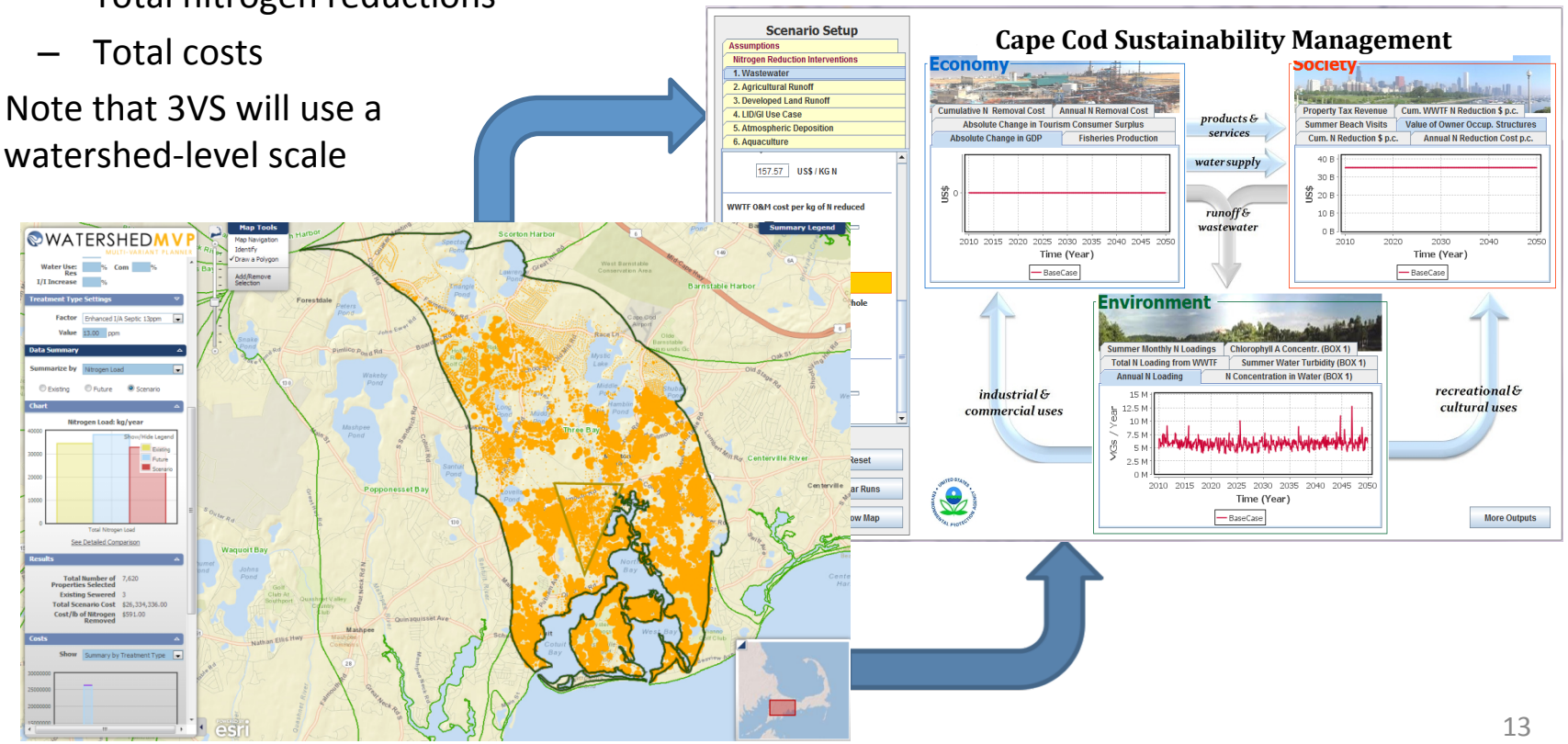
User Interaction with 3VS:
Option 1. Interactive "Dashboard" Interface

- Users set scenarios for pre-defined areas (towns or watersheds) or select pre-made scenarios.
- Scenario parameters include policy interventions, unit costs, and assumptions (e.g., precipitation).
- Interface has sliders and graph inputs for defining scenarios.
- Dashboard presents results for several indicators.



User Interaction with 3VS:
Option 2. Watershed MVP

- Users can choose specific treatment technologies in Watershed MVP and apply them to an area defined by a polygon
- Outputs from Watershed MVP can then be used as inputs into 3VS
  - Treatment technologies
  - Total nitrogen reductions
  - Total costs
- Note that 3VS will use a watershed-level scale



Cape Cod 3VS Model, Phase 1:
No Action Scenario

- Population growth and economic development drive increased wastewater N loadings.
- N loadings increase N concentrations in embayments, leading to degraded marine environmental quality.
- Poor environmental quality reduces the attractiveness of beach visits and boating trips , as well as coastal property value.
- Reduced tourism leads to loss of jobs. Lost tax revenue from tourism and property taxes increases the tax burden on local residents.

Cape Cod 3VS Model, Phase 2:
Evaluation of Policy Interventions

- Policy interventions simulated in the model will include:
  - Advanced septic systems
  - Centralized wastewater treatment
  - Alternative water systems*
  - Low-impact development
- For each intervention, the model will simulate:
  - Direct effects (nitrogen reduction and cost)
  - Indirect effects (environmental, social, and economic impacts)
  - Life-cycle impacts (costs and benefits of materials and processes used)

*Examples include waste-reduction toilets and next-generation on-site treatment systems

Example Scenario Summary:
No Action (Three Bays Watershed)

Sector	Indicator	Direction of Impact	Interpretation
Environment	Total N Loadings from wastewater	↑	Increased by growing population
	N Concentration in Water	↑	Increased by higher N loadings from wastewater
	Micro Algal Blooms	↑	Increased by higher N concentration in water
	Eel Grass Abundance	↔	Already not present in Three Bays system
	Water Clarity	↓	Reduced by higher micro algal blooms
Society	Coastal Property Values	↓	Reduced by lower water clarity in embayments
	Beach Visits	↓	Reduced by lower water clarity in embayments
	Disposable Income	↓	Reduced by lower GDP and by shifting tax burden to local residents and inland property owners
Economy	Tourism Expenditures	↓	Reduced by lower beach visits
	GDP	↓	Reduced by lower tourism expenditures
	Tax Revenue	↔	Reduced by lower tourism expenditures; increased by shifting tax burden to local residents and inland property owners
↑: Increase ↓: Decrease ↔: Ambiguous Impact			

Note: Table presents likely results of an example scenario, not actual modeled results.

Example Scenario Summary:
Advanced Septic Systems (Three Bays Watershed)

Sector	Indicator	Direction of Impact	Interpretation
Environment	Total N Loadings from wastewater	↓	Reduced by advanced septic systems
	N Concentration in Water	↓	Reduced by lower N loadings from wastewater
	Micro Algal Blooms	↓	Reduced by lower N concentration in water
	Eel Grass Abundance	↑	Increased by lower N concentration in water
	Water Clarity	↑	Increased by lower micro algal blooms
Society	Coastal Property Values	↑	Increased by higher water clarity in embayments
	Beach Visits	↑	Increased by higher water clarity in embayments
	Disposable Income	↔	Increased by higher GDP; reduced by costs of advanced septic systems.
Economy	Tourism Expenditures	↑	Increase d by higher beach visits
	GDP	↑	Increased by higher tourism expenditures
	Tax Revenue	↑	Increased by higher GDP and higher coastal property values
↑: Increase ↓: Decrease ↔: Ambiguous Impact			

Note: Table presents likely results of an example scenario, not actual modeled results.

Notes and Limitations

- Appropriate scale (local/municipal/county) of the model depends on types of questions asked by users and availability of data.
  - Some questions require a local focus, while others are county level.
  - Some data sources have a finer degree of resolution than others.
- High degree of uncertainty for some key relationships in the model (e.g., impact of poor environmental quality on tourism).
  - Even if the precise scale of impacts is not known, the model can illustrate a range of downstream effects reflecting different impacts within a likely range.

Your Input Is Needed!

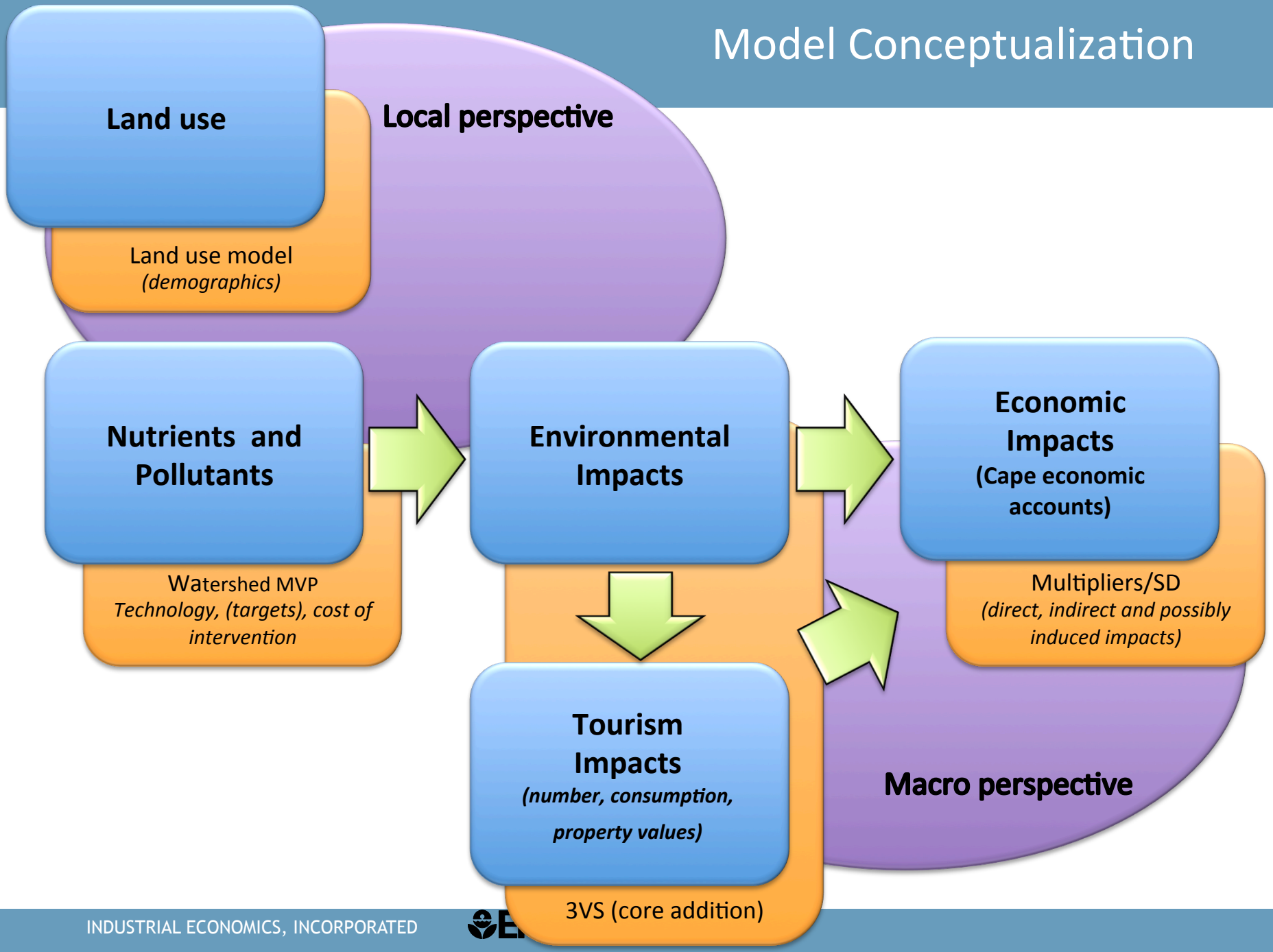
- What are your questions and concerns about water quality management and sustainable development in Cape Cod?
- What policy interventions or economic, social, and environmental indicators would you like to see included in the model?
- Do you know of additional data sources that could provide information on additional policies or indicators?

Cape Cod 3VS Model Update

November 6, 2013

INDUSTRIAL ECONOMICS, INCORPORATED

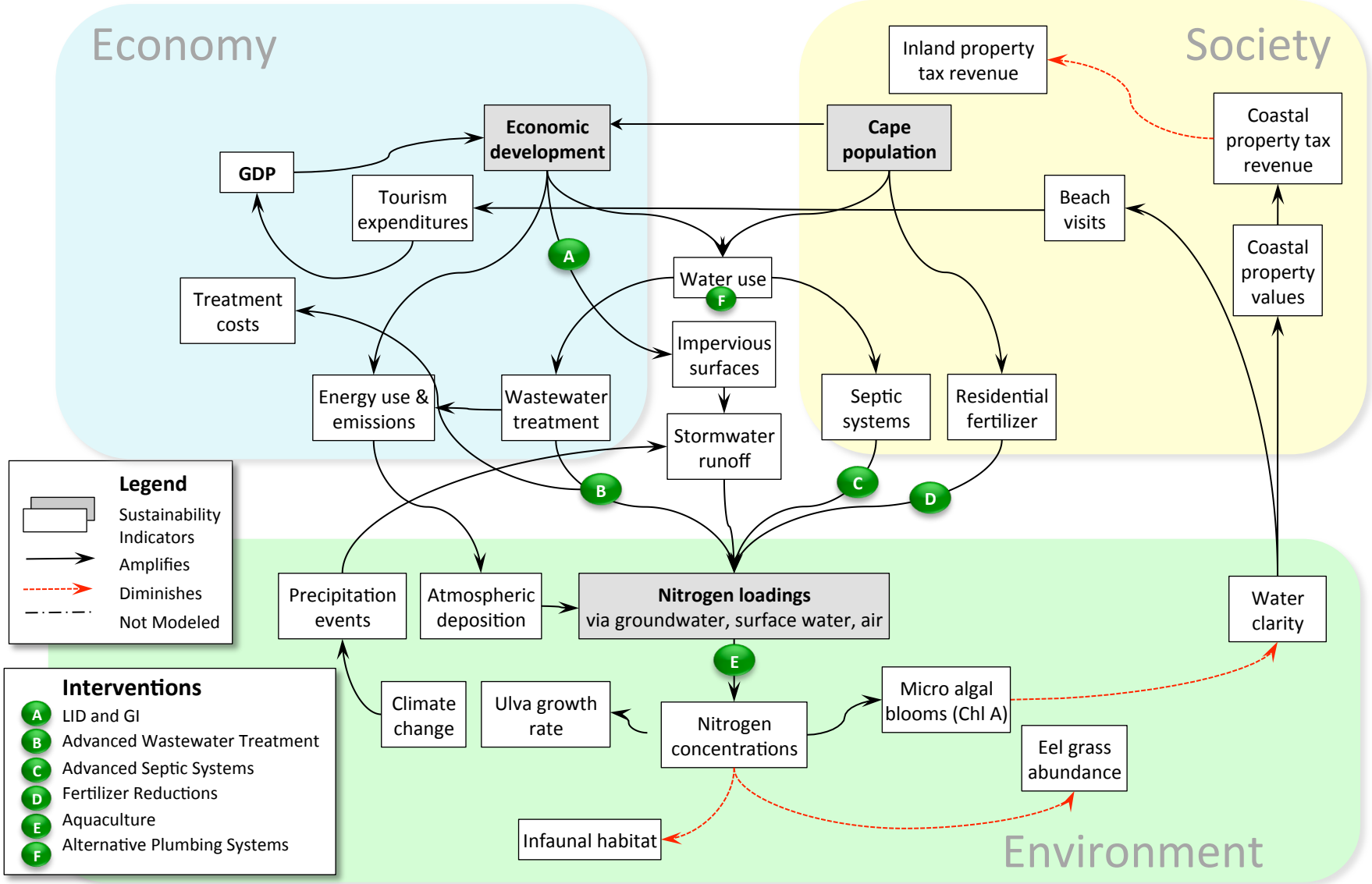
Model Conceptualization



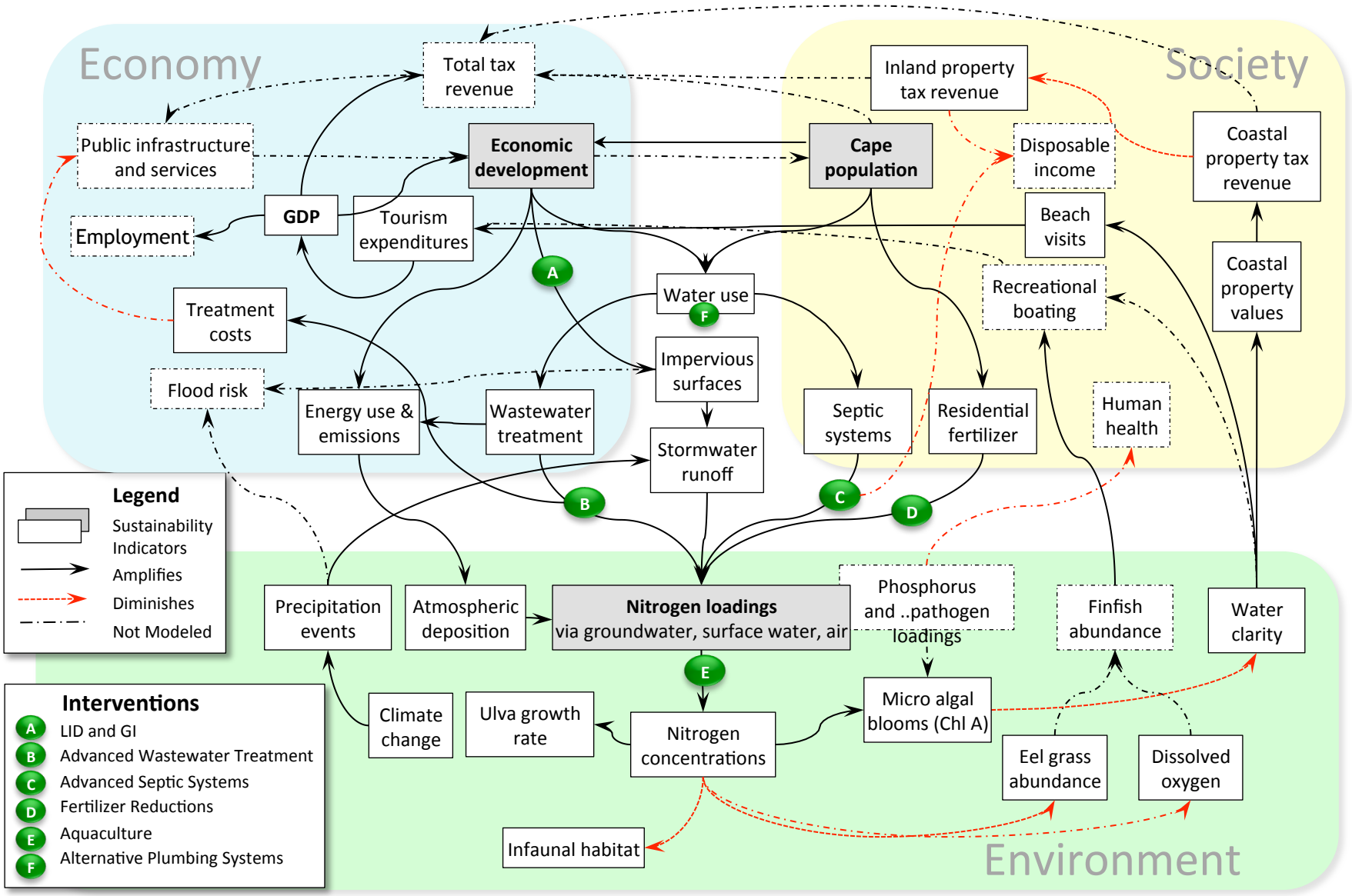
Prototype Model Review

- Phase 1 of the model will include:
  - No Action scenario with "Current" and "Buildout" Nitrogen loadings from Barnstable
  - Nitrogen concentrations by watershed
  - Environmental indicators, based on Narragansett Bay relationships and Massachusetts Estuaries Program (MEP) reports
  - Economic impacts, based on Narragansett Bay relationships and Cape Cod economic data
- Model features to be added in later versions include:
  - Policy intervention scenarios
  - Pathogen and phosphorus loadings
  - EPA ORD's work on alternate treatment systems and life-cycle analysis
  - Detailed cost and affordability data
  - Seasonality in economic and social indicators
  - Resilience of policy interventions to climate change

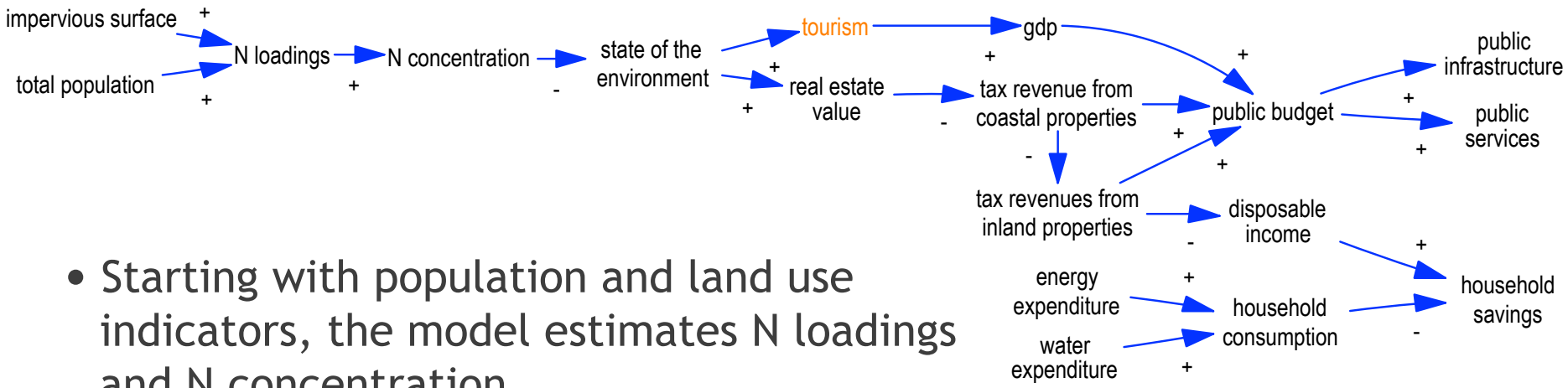
Cape Cod 3VS Schematic: Initial Model



Cape Cod 3VS Schematic: Planned Model



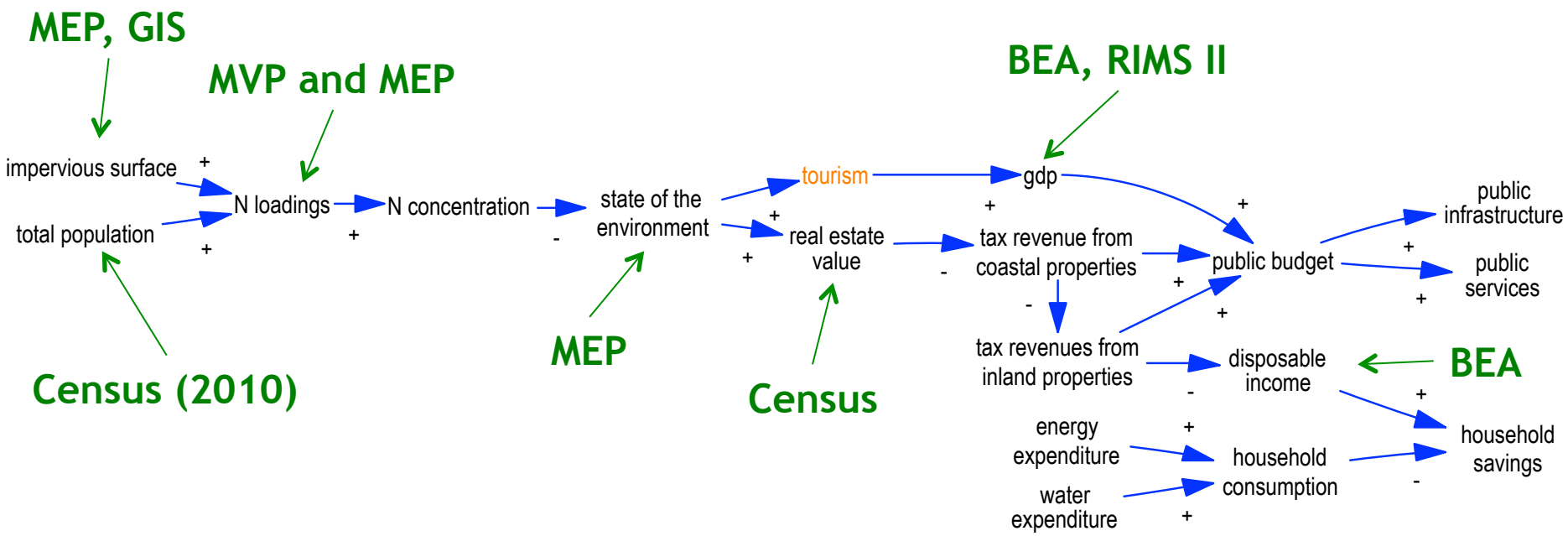
Model Conceptualization: No Action Scenario



- Starting with population and land use indicators, the model estimates N loadings and N concentration.
- N concentration is assumed to be one of the main factors impacting the state of the environment.
- A deterioration of the environment is expected to reduce tourism arrival and expenditure, as well as the value of real estate.
- In this scenario, tax revenues from tourism-related activities would decline, requiring an increase in taxation from other sources (to be paid by residents).
- The macro economic impacts of this development include a reduction in disposable income, and possibly consumption and/or savings.

Model Data Sources

Several data sources are used, and cross-checked for coherence.

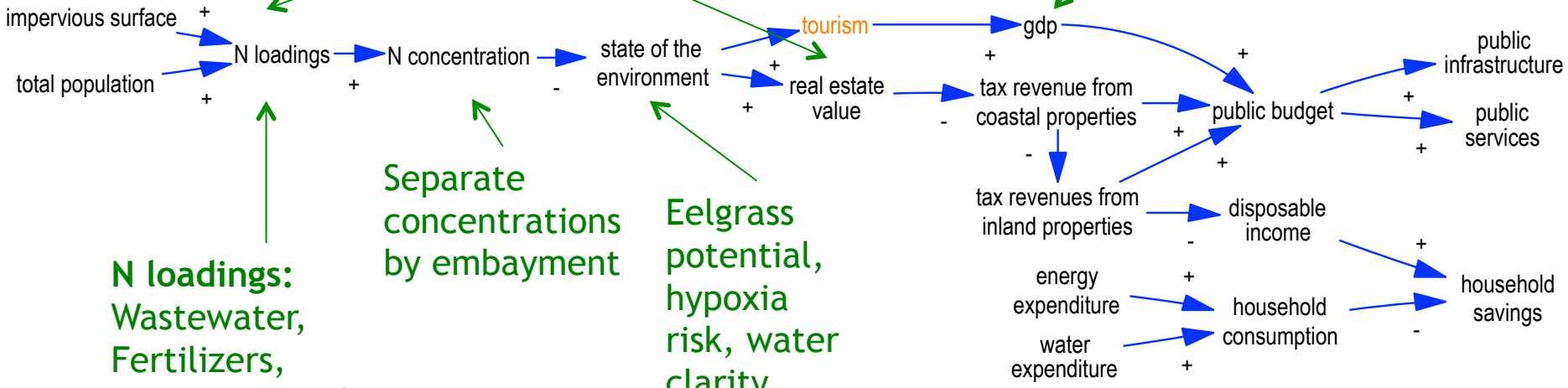


Model Disaggregation

Various layers of disaggregation are represented in the model.

Buildings: Commercial, Residential, Industrial, Other, Vacant (sewered and unsewered)

Economic sectors: Real estate, accommodation and food services, …



N loadings: Wastewater, Fertilizers, Impervous surface, Atmospheric deposition direct to the water body, Natural surfaces.

Separate concentrations by embayment

Eelgrass potential, hypoxia risk, water clarity …

Economic data

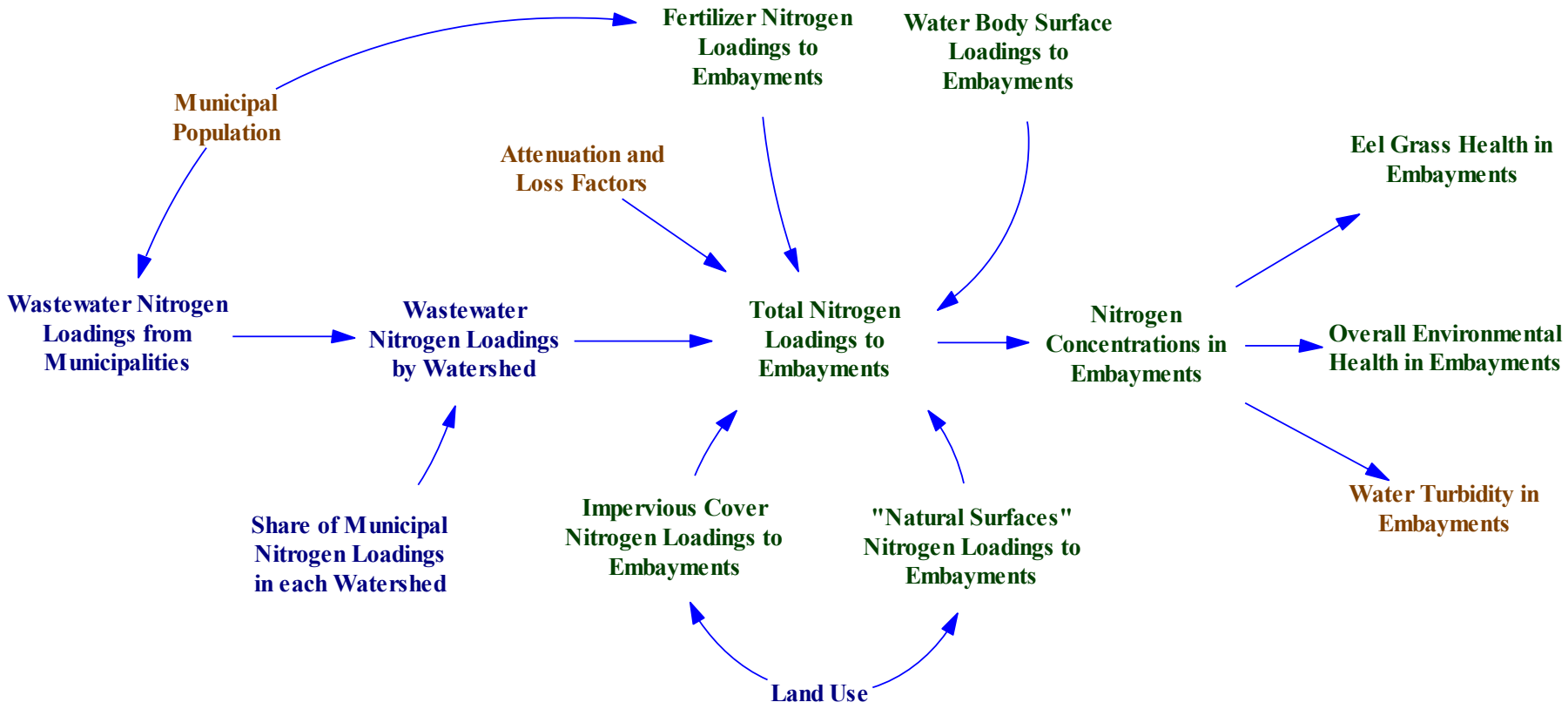
- Barnstable Town data are available for GDP, earning and employment for the period 2001 - 2011 (Source: BEA)
- Among others, the main sectors impacted by the state of the environment and tourism are:
  - Real estate and rental and leasing,
  - Arts, entertainment, and recreation
  - Accommodation and food services
  - Other services, except government
- The model can be calibrated to recreate historical trends endogenously.
- The use of RIMS II multipliers allow us to estimate the cross-sectoral impacts of changes in economic activity, either from investment or from an increase (or reduction) in tourism activity.
  - RIMS II provides both final-demand (output, employment, value added, and earnings) and direct-effect multipliers (earning and employment).

Nitrogen Loadings and Concentration Data

- MEP Reports allow us to relate N loadings from each watershed to changes in N concentrations by embayment
  - Linear equations approved by Brian Howse
  - Will calculate one equation per embayment (average concentrations)
- MVP has loadings data by town, watershed, and subwatershed.
  - Need to estimate factors for translating between MVP and MEP loadings data (including attenuation)
  - Can apportion loadings from one category (town) to another (watershed), based on current loadings
  - MVP scenario outputs must be summarized at the watershed or town level in order to be inputted into 3VS
- Three Bays MEP Report has estimates of unattenuated loadings for other source categories
  - Need to develop equations for estimating loadings endogenously (e.g., from population and imperviousness)

Nitrogen Loadings and Concentration: Conceptualization

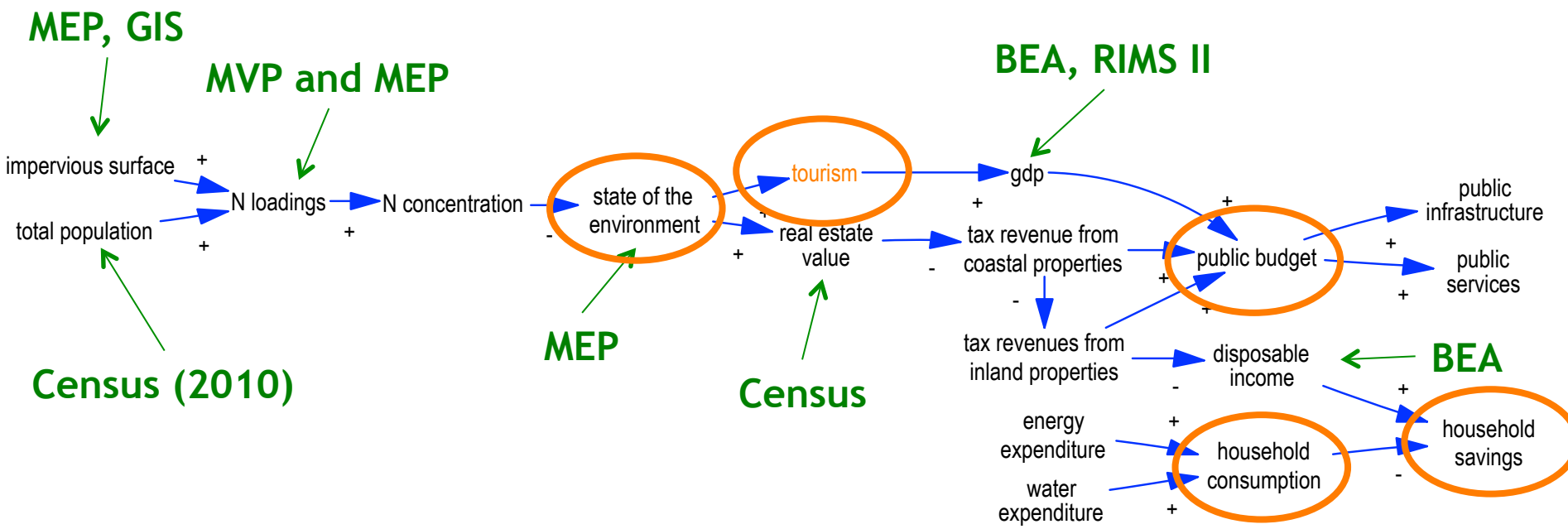
Available data allow us to relate changes in nitrogen loadings to environmental impacts by embayment.



Data Sources: Watershed MVP, MEP Report for 3 Bays Watershed, Other Data Sources

Data gaps

Further research is needed to identify data sources for key variables and relationships.



Next Steps

- Coordination between CCC and modelers to define scope and scale of the 3VS model
  - Ongoing dialogue to ensure that model assumptions and generalizations are appropriate for intended purpose
  - Coordination regarding data gaps and uncertainties
- Modelers will synthesize local data and relationships from published literature/other modeling efforts
- Development of initial model prototype for Phase 1: No Action Alternative
- Identification of policy interventions to be evaluated in Phase 2

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CAPE COD COMMISSION

Cape Cod 208 Water Quality Planning
Panel on Technologies

Minutes – November 6, 2013

The meeting of the Cape Cod 208 Water Quality Planning Panel on Technologies convened on Wednesday, November 6, 2013 at 10:00 a.m. in the Strategic Information Office/Innovation Room, Barnstable, MA.

Panelists Present:	Eric Davidson, Woods Hole Research Center Anamarija Frankic, UMASS Boston Chris Neill, Marine Biological Laboratory (MBL) Sarah Slaughter, Built Environment Coalition
Remote participation via Conference Call:	Patrick Lucey, Aquatex
CCC Staff :	Paul Niedzwiecki, Executive Director Kristy Senatori, Deputy Director Patty Daley, Deputy Director Heather McElroy, Natural Resources Specialist Scott Michaud, Hydrologist Patty Daley, Deputy Director Tom Cambareri, Water Resources Program Manager Erin Perry, Special Projects Coordinator
CCC Consultants:	Tom Parece, AECOM Mark Owen, AECOM Betsy Shreve-Gibb, AECOM
U.S. EPA/Industrial Economics, Inc (IEc):	Johanna Hunter, EPA Robert Adler, EPA Marilyn Ten Brink, EPA Andrea Bassi, IEc (phone) Nadav Tanners, IEc
Association to Preserve Cape Cod:	Jo Ann Muramoto

Welcome, Update on 208 Plan

Paul Niedzwiecki thanked the panel for their participation in this process.

He described the process to date – the Commission finished the second round of stakeholder meetings and have one more round of meetings in December to talk about watershed scenarios. The conversations that have been taking place in the watershed groups have been similar to the conversations you had last meeting on watershed based scenarios.

As we near the end of this round of stakeholder meetings we are in the process of configuring the first 6 months of the next calendar year. We have until June 1st for a draft report. To date, we had wanted to leave the next 6 months open so its form could be informed by the first 6 months of the stakeholder process.

We are holding a meeting on November 13th and inviting everyone involved in the planning process to date. We'll talk about the next steps and how we go from 11 groups to 4 subregional working groups, delineated by watershed. This is really the beginning of the watershed governance discussion. We'll have a draft plan by June 1, with a final plan by January 1 2015. This is our window of opportunity to move forward in a meaningful way to solve the problem.

We think there will be a role for members of this panel to play in the next 6th months and we hope you are willing to stay involved.

Triple Bottom Line model – EPA and Industrial Economics, presentation and discussion

Nadav Tanners, from Industrial Economics, Inc (IEc) talked about the Cape Cod Triple Value Model they are developing. Systems models allow you to bridge science, policy, and human values. They help us understand what we know today, and help identify the key unknowns. They allow communities to evaluate options for meeting defined goals, by testing options and evaluating how successful they might be.

The model is being developed under the triple value framework, with the understanding that the economy and society impact the environment, which impacts the economy and society. As you add detail on the potential interventions for a problem you can start to model the effect of the interventions on the relationships between the environment, society, and the economy.

Nadav showed a simplified schematic of the model - each box in the schematic is a variable and the arrows between the variables represent relationships. Black arrows are direct relationships and red arrows are indirect or diminishing relationships.
This initial model is focused on nitrogen impacts to Cape Cod, but we recognize there are other issues that need to be considered (ex. Phosphorus in freshwater ponds) and those will be addressed in future iterations of the model.

Anamarija Frankic asked what the green circles represent.

Nadav said a that they represent policy options that could be used as interventions.

Anamarija said that it is very important to point out what kind of aquaculture is being used as an intervention. If it's fish, they might increase nitrogen, but if it's shellfish, they will act as a good sink for nitrogen.

Nadav said it is intended to represent shellfish aquaculture, but we can clarify.

An example of one of the relationships in the schematic – Decreased revenue from coastal properties would cause the tax burden to shift to the inland properties.

Nadav discussed the variables and information we are hoping to add to the model. These are variables we are looking for additional data on now and include disposable income, public infrastructure and services, and flood risk, among other variables.

Sarah Slaughter pointed out that there are ways in which aquaculture (and other interventions) can help with economic opportunities. Some interventions may create new jobs, as an example. Are you going to add this?

Nadav said yes, and that we've run out of room here in the schematic, but we plan to include all of this.

Sarah said a lot of employment that has nothing to do with tourism can be generated.

Johanna Hunter asked Sarah if she was talking about an increase in landscape architects, and nursery business as areas where employment might increase?

Sarah said yes, that becomes an interesting piece, in terms of robustness of the local economy.

Anamarija Frankic asked if we considered adding habitat restoration and ecosystem restoration as a first step to consider, as it could be less expensive than some other interventions.

Marilyn Ten Brink said that the presentation represents pieces of what we want to include. We have looked at the entire technologies matrix and much more is included in the full model.

Nadav discussed the data sources used to date, including the Watershed MVP model and 2010 Barnstable County Cost Report, the Massachusetts Estuaries Project reports, the 2010 Census, the Bureau of Economic Analysis, Regional Input-Output Modeling System, and Stats Cape Cod.

Nadav discussed the questions the 3VS model will be designed to address, including:

- In the absence of additional interventions, how would future projected growth in N loadings impact housing values, employment, income, and seasonal economic activity?
- What is the cost per capita of different combinations of interventions that can meet TMDLs for embayments around the Cape?

- How might climate change affect the viability and effectiveness of different approaches to nutrient management?
- What is the return on investment (or impact on employment) for a given set of approaches to nutrient management?

All models are wrong, but some are useful. We are trying to determine what can be useful and how we can develop a model that can be helpful.

Users will interact with the model in the following ways:

- Users can define scenarios in the model, selecting different combinations of policy alternatives.
- The model will simulate the scenario and project results 30 years into the future.
- Users can compare model outputs across multiple scenarios, including the "No Action" scenario.
  - No new treatment beyond existing systems
  - Maintenance and replacement costs for existing systems
  - Projected growth in population and land development

Users will have two options for interacting with the model:

- Dashboard Interface
- CCC Watershed MVP Model

Nadav showed the user interface with the output view on the right side and scenario set up on the left side. He showed a scenario where wastewater infrastructure might be increased by 50% and showed the outputs.

Chris Neill asked what data lies behind the variables, specifically, where does information on beach visits come from?

Nadav said that this information came from a study in the Chesapeake Bay.

Paul Niedzwiecki said that there are studies that show a relationship between water clarity and beach visits.

Chris Neill said that there are a lot of fuzzy connections, especially as it relates to economic activity and property values. You're projecting 30 years out and its very uncertain at this point.

Paul said that this is why the model is iterative. The model is useful now to develop system based hypotheses and to identify questions that need to be studied.

Chris agreed that this is exactly what is useful about it. He would be interested in seeing the inside information behind some of those boxes.

Andrea Bassi said the model could show ranges of results/confidence ranges.

Paul Niedzwiecki said this is consistent with 208 process, which is not to drive to an optimal solution, but to identify a range of approaches.

Patrick Lucey asked if you could run the model with a start date of 1950 and end date of 2010, using known set of conditions, to see how accurate the prediction is?

Andrea Bassi said that they do that to a certain extent. They start simulating in the past, but not back as far as 1950. They initialize the model for 1990 and then use equations from there. It does not start at 2010 as is shown. This helps to identify major inconsistencies.

Patrick said if we get radically different outputs this could give us some insight in to the modeling.

Andrea agreed.

Sarah Slaughter said something interesting to think about is whether some variables are asymptotic. For example, you may only get so many people on Cape Cod because only so many can fit. It will level off eventually. It would be interesting to know what those limits are.

Nadav Tanners said it would be possible to model that.

Sarah provided another example – potentially hitting a limit on space for shellfish.

Andrea Bassi said they model balancing loops. Sometimes you hit limits or thresholds even without identifying them specifically and it can be interesting to see those from the model.

Nadav Tanners said that testing of extreme conditions was carried out for the Narragansett Bay model.

Paul Niedzwiecki said that the Commission worked with IBM and an MIT grad student on the environmental component of a triple value model.

Chris Neill asked if the mode is available and if the panel can we play with it?

Marilyn Ten Brink said that the phase 2 report from Narragansett Bay will be available soon and that it includes the model.

Paul Niedzwiecki said that the technologies panel might be a good group to beta test the model.

Eric Davidson asked if the model will run Cape-Wide or if it will be used in specific watersheds.

Nadav Tanners said that we would be getting to that in the conversation shortly.

Paul Niedzwiecki said that criteria for the consultant working on our financial model is that it should run Cape-Wide, by municipality and by watershed.

Sarah Slaughters asked if there is any tie to the Cape Cod Economic Development Plan. There may be some things that are in that plan that may not be currently captured in the model.

Paul said that there is an economic development strategy for Cape Cod. There will be an update to that plan in the spring and he hopes that the 208 plan drives that discussion. We understand there is a lot of uncertainty in some of the assumptions we are talking about today, but we are looking to refine those assumptions. To help us, we just hired a natural resource economist.

Nadav Tanners described the user interaction options:

Option 1:Interactive Dashboard Interface

- Users set scenarios for pre-defined areas (towns or watersheds) or select pre-made scenarios.
- Scenario parameters include policy interventions, unit costs, and assumptions (e.g., precipitation).
- Interface has sliders and graph inputs for defining scenarios.
- Dashboard presents results for several indicators.

Option 2:Watershed MVP

- Users can choose specific treatment technologies in Watershed MVP and apply them to an area defined by a polygon
- Outputs from Watershed MVP can then be used as inputs into 3VS
    - Treatment technologies
    - Total nitrogen reductions
    - Total costs
- Note that 3VS will use a watershed-level scale – going to watershed level added too much complexity
- Increased costs of treatment and decreased nitrogen loading impacts on economy and society can be seen.

Anamarija Frankic asked if we would be addressing other issues, in addition to nitrogen?

Nadav responded that we would like to add information for pathogens and phosphorus, but getting this data adds to the complexity of the model. For now, we are focused on nitrogen.

Nadav discussed that Phase I of the model will look at the no action scenario. This will consider how population development and other key economic development factors that drive nitrogen loading will impact environmental quality and the economy.

Phase 2 will include an evaluation of policy interventions:

- Policy interventions simulated in the model will include:
    - Advanced septic systems
    - Centralized wastewater treatment
    - Alternative water systems
    - Low-impact development
- For each intervention, the model will simulate:

- Direct effects (nitrogen reduction and cost)
- Indirect effects (environmental, social, and economic impacts)
- Life-cycle impacts (costs and benefits of materials and processes used)

Anamarija Frankic said that the policy interventions identified are very rigid and that restoration should be a priority. Are there any other factors other than eelgrass abundance? Why not use another important biological indicator as a surrogate for biodiversity?

Chris Neill said there are some options for a surrogate, such as macroalgal abundancance. However, there are not a lot of people measuring this frequently enough to be used for this.

Nadav Tanners said that they used eelgrass and infaunal habitat because that was what was used in the Massachusetts Estuaries Project (MEP) reports.

Eric Davidson asked if we could think about indicators that would be easier to obtain on a regular basis. Could we use something like chlorophyll from remote sensing? We already have a lot of data on that and people are collecting it regularly.

Marilyn Ten Brink said they could look in to that.

Rob Adler said that MassDEP uses 3 indicators. You want to be able to use the same indicators that were used to set the total maximum daily load (TMDL). Any others that you think we can derive a relationship from we would also want to add.

Nadav Tanners said that the scale we are concerned with is spatial and temporal. We need to think about how we will model in a way that is consistent with other relationships.

Marilyn Ten Brink said that we need indicators to model, to monitor for adaptive management, and to engage stakeholders.

Anamarija Frankic said that satellite land use cover can tell you how much habitat you have lost.

Nadav Tanners replied that they did use GIS data for the Narragansett Bay model to get a sense of total impervious cover in a watershed.

Sarah Slaughter said that in the last meeting Patrick Lucey mentioned being able to use LIDAE and aerial photography. This might be an interesting way to look at the Cape.

Chris Neill said that another source of data is from citizen monitoring. Buzzards Bay Coalition has been doing this type of monitoring for more than 20 years. They monitor all summer for dissolved oxygen and 4 times a summer for nutrients. We need a way to organize all of the data that is available. Trying to put it into a useable format might be a worthwhile exercise.

Johanna Hunter mentioned the Southeast New England Watershed Restoration Council is looking at integrating projects to address multiple issues. There is a pot of money from Hurrican Sandy funding to look at coastal issues and monitoring is a part of that. It

might be good to bring the group back together to think about monitoring. Are there opportunities right now to get some partners together to frame this? She thinks we should get that conversation going, as adaptive management means that we need to tie monitoring to decision making.

Rob Adler said that all of this needs to get translated down to the local level, because the communities are developing the Comprehensive Wastewater Management Plans (CWMPs). These models help define relationships and help develop solutions. In some cases, they will go back to SMAST reports and look at the same 3 indicators. So, as the Technologies Panel and community moves forward you will want to take a look at other relationships and indicators you want contractors to look at in the long term.

Nadav Tanners summarized the limitations of the model:

- Appropriate scale (local/municipal/county) of the model depends on types of questions asked by users and availability of data.
  - Some questions require a local focus, while others are county level.
  - Some data sources have a finer degree of resolution than others.
- High degree of uncertainty for some key relationships in the model (e.g., impact of poor environmental quality on tourism).
  - Even if the precise scale of impacts is not known, the model can illustrate a range of downstream effects reflecting different impacts within a likely range.

Nadav also discussed that we are looking for the following input:

- What are your questions and concerns about water quality management and sustainable development in Cape Cod?
- What policy interventions or economic, social, and environmental indicators would you like to see included in the model?
- Do you know of additional data sources that could provide information on additional policies or indicators?

Nadav then used a second presentation which was more of an update on model development to date. He said they started with the local perspective and looked at land use and other location specific data.

He emphasized that they are looking to keep the model dynamic and validate all of the relationships and variables.

Phase 1 of the model will include:

- No Action scenario with “Current” and “Buildout” Nitrogen loadings from Barnstable
- Nitrogen concentrations by watershed
- Environmental indicators, based on Narragansett Bay relationships and Massachusetts Estuaries Program (MEP) reports
- Economic impacts, based on Narragansett Bay relationships and Cape Cod economic data

Model features to be added in later versions include:

- Policy intervention scenarios
- Pathogen and phosphorus loadings

- EPA ORD's work on alternate treatment systems and life-cycle analysis
- Detailed cost and affordability data
- Seasonality in economic and social indicators
- Resilience of policy interventions to climate change

Nadav talked in more detail about the no action scenario:

- Starting with population and land use indicators, the model estimates N loadings and N concentration.
- N concentration is assumed to be one of the main factors impacting the state of the environment.
- A deterioration of the environment is expected to reduce tourism arrival and expenditure, as well as the value of real estate.
- In this scenario, tax revenues from tourism-related activities would decline, requiring an increase in taxation from other sources (to be paid by residents).
- The macro economic impacts of this development include a reduction in disposable income, and possibly consumption and/or savings.

He also talked in more detail about data and sources used:

- Barnstable Town data are available for GDP, earning and employment for the period 2001 - 2011 (Source: BEA)
- Among others, the main sectors impacted by the state of the environment and tourism are:
    - Real estate and rental and leasing,
    - Arts, entertainment, and recreation
    - Accommodation and food services
    - Other services, except government
- The model can be calibrated to recreate historical trends endogenously.
- The use of RIMS II multipliers allow us to estimate the cross-sectoral impacts of changes in economic activity, either from investment or from an increase (or reduction) in tourism activity.
    - RIMS II provides both final-demand (output, employment, value added, and earnings) and direct-effect multipliers (earning and employment).
- MEP Reports allow us to relate N loadings from each watershed to changes in N concentrations by embayment
    - Linear equations approved by Brian Howse
    - Will calculate one equation per embayment (average concentrations)
- MVP has loadings data by town, watershed, and subwatershed.
    - Need to estimate factors for translating between MVP and MEP loadings data (including attenuation)
    - Can apportion loadings from one category (town) to another (watershed), based on current loadings
    - MVP scenario outputs must be summarized at the watershed or town level in order to be inputted into 3VS
- Three Bays MEP Report has estimates of unattenuated loadings for other source categories
    - Need to develop equations for estimating loadings endogenously (e.g., from population and imperviousness)

Chris Neill asked what was meant by unattenuated loadings. Aren't we looking at attenuated loadings or what makes it to the water body?

Nadav Tanners replied that contributions from different source categories are from unattenuated loadings. But load to water body is attenuated.

Scott Michaud said that this information is built in to Watershed MVP, so he can help Nadav get the appropriate information using this tool.

Chris Neill said there is less attenuation of septic nitrogen because effluent is injected below zone of root uptake. He suggests keeping one set of coefficients that everyone can agree on, either from nutrient loading models or MEP studies.

Jeff Eagles, from the public, asked how you account for incoming concentration from the ocean if you use a linear equation for nitrogen loading. This changes regularly.

Nadav Tanners said we are not explicitly addressing this, but it could be added if data was available.

Marilyn Ten Brink said that we have data on residence time so when that is a significant variable in a watershed it is included.

Ed Daley, from the public, said that in Pleasant Bay there has been a new breach, which totally changed the hydrodynamics. In this model you are using old data. How can you draw appropriate conclusions using this data?

Scott Michaud said that we are discussing this issue. Nadav is using MEP to set up the model and check the model. This is the best available data at this time.

Ed Daley said that since we are going to be drawing economic conclusions from this model it needs to be current.

Marilyn Ten Brink said this needs a sensitivity analysis. How much information we have and how much more we need are questions that modeling can help us explore.

Eric Davidson said that he thinks this is a fantastic approach and is encouraged to see it happening. An important output is going to be the narratives and not just the graphs and numbers. We need to turn the outputs in to a story that explains it in a way people can understand. We need to explain inputs, assumptions, and outputs. We joked earlier that we would love to play with this, which is a metaphor for work, but relying on a panel of volunteers to work on this is limited. It would behoove us to think more seriously about how to test this model. Do we need RFPs for research groups or stakeholders to do this?

The business as usual scenario needs to focus on the economic and social implications of being forced to use proven technologies in the event that we don't take the initiative to try some other approaches to improve the water quality.

Nadav Tanners discussed the next steps for the 3VS model:

- Coordination between CCC and modelers to define scope and scale of the 3VS model
    - Ongoing dialogue to ensure that model assumptions and generalizations are appropriate for intended purpose
    - Coordination regarding data gaps and uncertainties
- Modelers will synthesize local data and relationships from published literature/other modeling efforts
- Development of initial model prototype for Phase 1: No Action Alternative
- Identification of policy interventions to be evaluated in Phase 2

Anamarija Frankic said that we need to be sure we recognize our audience. We are doing this for them. It's important to hear that there are a lot of links that we should recognize in adaptive management. If thinking changes we need to recognize that. If any other documents or reports have been done and it's been a long period of time since it's been done, we need a feedback loop. What we've seen today is linear. We need to recognize where the weakest links are, where the concerns are and how to adapt model to recognize that.

Nadav Tanners said that the model needs to be general enough yet adaptive. We should show how the breach effect would manifest in particular variables.

USGS/APCC Sea Level Rise study – presentation

Jo Ann Muramoto, from the Association to Preserve Cape Cod (APCC) discussed the USGS/APCC sea level rise study that is under way.

The study will look at how rising sea levels affect wastewater and it's connection to groundwater.

She used New Silver Beach area in Falmouth as an exmple – high ground water was in contact with septic systems in that area.

Sea level is rising and is expected to rise. The rate of this may be higher in northeast than globally. There is a concern and question.

The study area for the project is the Sagamore and Monomoy groundwater lenses on Cape Cod. The study focuses on the mid Cape region and we expect that, as sea level rises, the body of fresh groundwater will rise and cause changes in the position of water table. The effects of this were scoped by USGS based on studies in the outer Cape aquifer and include:

- Changes in altitude of the water table and depth to groundwater
- Changes in volume of baseflow in freshwater streams
- Changes in position of the freshwater/saltwater interface
- Consequences for water resources, habitat, wastewater, stormwater, and infrastructure.

The goals of the project include:

- Model effects of future sea level rise on groundwater, esp. water table, stream flows and position of the freshwater-saltwater interface in the Sagamore and Monomoy flow lenses (Upper and mid-Cape)

- Evaluate impacts of changes on water bodies, wetlands, public watersupplies, septic systems and wastewater management, stormwater management, and infrastructure
- Provide outreach on findings
- Develop recommendations for adaptive measures

USGS Modeling of Aquifer Response to sea level rise will:

- Build on existing models of Cape Cod groundwater
- For several sea level rise scenarios, determine coastline geometry and freshwater-equivalent boundary heads
- Input these into a steady-state numerical model to simulate new freshwater-saltwater interface(s) in the aquifer
- Incorporate simulated interface position into steady-state models of Sagamore and Monomoy flow lenses
- Use long-term historical climate data (precipitation, temperature) to model steady-state recharge stresses for flow lenses
- Simulate water table altitudes, pond levels and stream flows for present-day, low SLR and high SLR scenarios for 3 future years (e.g., 2030, 2060, 2100)
- Create Digital maps of future depth-to-water
- Create cumulative frequency curves showing cumulative % of area with simulated depth-to-water below a given threshold, for current SL, and projected SL positions

Sarah Slaughter said that when you look at high sea level rise, there are a lot of portions on the Cape that are not inhabitable any more. If you have a category 3 or 4 storm the end of the Cape becomes an island. There will be changes in water use, recharge, population and land use. Are you incorporating all of these?

Jo Ann Muramoto said that population and land use will not be accounted for. Recharge will be accounted for since it is a hydrologic model.

Sarah asked if the model would assume no impact from population.

Jo Ann said that we are looking at recharge and calibrating it to the current recharge rate and groundwater system. Historical data on recharge rates will take in to account human influence. Historical data might account for this, but it's a good question.

Sarah Slaughter pointed out that you would see an increase in groundwater pumping. In the worst case scenarios, areas become uninhabitable, so they will not be pumping any more.

Jo Ann said that the location where humans will be living will not be taken in to account. This is a model of physical response, but these things may be considered in a subsequent follow up project. As we get toward the midpoint of the project we'll be looking at what the results are pointing to and developing our next set of questions. This might include what the results imply for the inhabitability of the Cape.

Patrick Lucey said that one of the issues that he has been contemplating on the Cape is this water balance between rise in sea level, changing shallow unconfined aquifer, and the effect of the open linear design of taking water out, using, and discharging it to the

ocean, as well as its potential for reuse. If you lower the amount you need to pump in the first place, where pumping is maintained or increasing because of development, when we experience saltwater intrusion there is less potential for development. This will impact real estate value.

Jo Ann said that one of the basic questions we hope to study will give us an idea of/estimate changes in aerial extent and volume of aquifer. What are some of the changes in the aquifer due to sea level rise. We need to know the size and scope of those changes. Our study is not designed to address these points.

Patrick Lucey said that the reason he raised the the question is because we are grappling with the question of what kind of infrastructure we should be installing. We might make decisions today that make sense but your model might show us that it will be desirable to look at doing it differently.

Jo Ann agreed, this is a possibility. With regards to infrastructure and potential changes in the water table, there are community adaptation measures in response to increasing coastal erosion that simply call for locating wastewater facilities, whatever they may be, away from areas that could be flooded or inundated by storm surges. In terms of the rising water table, we are thinking of potential effects on basements, structural pilings, and foundations. I don't think we need to complete the study to know wastewater facilities need to be located in areas not impacted by sea level rise.

Patrick Lucey said that there is potential for all new buildings to be double plumbed so that non drinking water can be used for other uses. Within 20 or so years they may not be able to supply drinking water to all homes, so new policies might be needed to curtail the use of drinking water.

Jo Ann Muramoto said that they will look at possible regulatory changes and make recommendations for communities. Without doing this specific study for Cape Cod, looking at sub areas of the region, she doesn't think we can predict what the effects will be.

Anamarija Frankic mentioned a recent study on sea level rise on Nantucket and offered to send it to Jo Ann.

Jo Anne mentioned some other studies that USGS is conducting on Aseteague Island on the effects of sea level rise on habitat. This might give us some clues about what we should ask in our Cape Cod study. There is another study, that looks at the effect of sea level rise on the aquifer in Oahu, however, the situation is different there because it is grounded on solid rock. There is also a study in Florida (Miami-Dade area) that she is aware of.

Sarah Slaughter said that the New Jersey Department of Environmental Protection has one too that looks at the aquifer that provides water to coastal communities. The study was started before Hurricane Sandy and they have pulled back and are redoing some of the analysis based on groundwater testing.

Scott Michaud asked when the study is due to be complete.

Jo Ann Muramoto said it is a 3 year project and they expect it to be completed by mid summer 2016. They will likely end up with additional questions and applications and expect those to move forward past 2016.

Chris Neill said that he thinks one of the intersections with the rest of the stuff going on is the prediction of where the high water table is going to be. How might that interface with technologies used to remediate nitrogen? We saw the average water table GIS layers, but it's the periodic water table levels that will bother people. In places where you're thinking of putting in PRBs or phyto remediation, do we know how often the water table will rise or drop? These intersections are very interesting. He suspects there are places where septic is used now, but will eventually no longer be viable.

Jo Ann said that one of their immediate thoughts when scoping the project was what will happen to septic systems as sea level rises and, if the water table rises enough, how long will it take to intersect with septic systems.

Eric Davidson asked if they will have the level of resolution needed to address some of these questions. He asked if they would be able to zero in on a few areas at a finer scale.

Jo Ann said that it is intended to be a regional model over the mid-Cape study area and she is not sure of the minimum resolution of the model.

Scott Michaud said that the regional model is a 400 ft grid, but you can zoom in and refine grid if necessary. It should be adaptable to that.

Chris Neill said he has seen watershed studies where someone looks at transitioning all of the septic systems to sewers in an area to see how sea level rise impacts these scenarios.

Eric Davidson suggests to keep in touch with EPA and the Commission as they focus on specific areas where they want to ask specific questions.

Jo Ann Muramoto said that they are currently focused on developing the model for the region and making sure it works and is properly calibrated. Follow up projects will be needed to apply the model in particular areas to look at particular questions. They are still working on raising funds for USGS to finish study. Managing their work time is very important, however, she appreciates the suggestions and possible applications.

Rob Adler asked if there is value in getting the on-site wastewater system test center involved to look at different kinds of systems.

Chris Neill pointed out that they would need to raise the water table.

Rob said they would also need inundation.

Chris cautioned against studying raised title 5 systems that don't really address nitrogen. Designing something that works only in high water situations is not worth it at this point.

Response to Panel comments on Technologies Matrix

Heather McElroy said that staff and consultants have been absorbing the comments and suggestions we received in these meetings, as well as all of the written comments we received. We put together a response to comments that was provided at the meeting.

Chris Neill said that we need to consider that the array of complexity is overwhelming as we roll out scenarios to watershed groups. People are much happier if they get 5 choices rather than 30. He is worried groups will get bogged down if choices are infinite. You want people to be able to select choices, but maybe scenarios are presented to the groups with a smaller selection of approaches.

Scott Michaud suggested bringing a first cut from staff to the groups and asking stakeholders to weigh in on that.

Sarah said that she likes that we present the scenarios in steps and that we have categorized the approaches. In this way, you work your way up to the approaches that require more funding. The steps make things manageable.

Scott said that there are some communities that have presented a strong preference for one way or another and we'll acknowledge that.

Heather McElroy said that we are trying to sort technologies in to a prioritization process and the information we've received from this panel has helped us in this thought process.

Rob Adler said there is an opportunity that we are looking at a system of systems in each community. I suggested at the last Waquoit/Popponesset meeting that it would be helpful to draft a scope of services for contractors that towns can use.

Sarah Slaughter said that one of the things we also talked about in the first meeting of the panel was that it would be useful if resources were made available to communities that would help them to identify what they should measure moving forward. What information will they need for adaptive management? What are the metrics and who does the measurement? How often do they measure and when?

Scott Michaud said that staff had that discussion around PRBs this morning around this very issue.

Sarah Slaughter said that, in terms of monitoring, IBM and other companies are coming out with new sensors that work in network systemS. There is stuff that is just coming out. If you put out an RFP for a sensor network, it would be interesting to see what you get.

Win Munro, from the public, asked if anyone knows about the costs of this type of equipment.

Sarah Slaughter that each unit (micro sensor) is a fraction of a cent. IBM is collecting data from a range of sensors that are floating in the water column, taking temperature, turbidity, and other measurements.

Eric Davidson said that nitrate and dissolved oxygen data is a little trickier to collect.

Heather McElroy asked everyone to please send any follow up thoughts our way.

Heather summarized potential next steps, including beta testing of the user interface of the 3VS model and discussing indicators for monitoring.

Eric Davidson said that if the Commission or EPA are interested in going down the route of an RFP, he suggests setting up a panel to help design that RFP.

Public Comment

David Dow said perchlorate, contaminants of emerging concern, are regulated in MA, to a maximum level of 2 ppb. The human biomonitoring study found perchlorate in urine and blood serum in 90% of the people tested. It has the same geochemical behavior as nitrate. The MMR is dealing with the impact area plume and one contaminant is perchlorate. David suggested we consider perchlorate as a contaminant of emerging concern. It behaves like nitrate and people are looking at natural attenuation of it. It could be dealt with as part of this process.

Jeff Eagles said he spoke with Nadav during the break and he thinks what he is saying is that MEP data is being used to establish eelgrass as an indicator. He believes this data is not reliable. The photos taken in 1951 are very poor resolution and the measurements done in the 1990s were done with no ground trothing. This is not good information to use as a basis for eelgrass. When you talk about population going forward on the Cape, the demographer who has done the work has identified 6 towns where the number of residences exceeds the number of residents. We've had a declining population and an increase in second homes and that has an impact on the economy as well.

Hilde Maingay said she has a general concern about the discussion. It seems that our society has very little concern about using pure drinking water for flushing. We keep flushing and proposing flushing systems and there is very little concern about resource recovery. The discussion has been about how to get rid of stuff and put it somewhere else. It's a big concern. Ultimately, a society is not sustainable if it throws away resources that are needed for food production. She believes that when sea level rises, we will need to use ecotoilets because they will have no impact on the environment and you can move them within the house and put them in a new house if a house becomes uninhabitable. She feels this has been ignored as a possibility.

Anamarija Frankic said that this needs to be part of adaptive management and she is hopeful that it will be part of that. She understands we can't discuss and address everything, but is curious where we see the panel going next.

Heather McElroy said that we hope to reengage in spring. We will keep in touch between now and the spring and we welcome any input between now and then if the panel is willing to spend more time thinking about this issue.

Ron Zweig said he is impressed with the breadth of what is being discussed. If you go out now in the estuaries it's clear, and within 30 days you will have full load discharged in to the sound or Buzzards Bay. That gets in to the TMDL question, which is looked at

on a year round basis, when the problem is really seasonal. Some approaches can address seasonality (inlet widening, shellfish, etc). If we can cut in to 10-20% of the problem, we may have a big impact. We need to look at the seasonal nature of the problem when we are considering how to approach it.

Ed Daley said that the Commission showed that 30% buildout will have a 40% increase in cost. In our town, we assumed a 26% increase, but we've had a 7% decrease. That's a 30% error. He suggests we need a demographic study to identify what the potential for buildout really is.