Technical Memorandum

Prepared for: Municipal Alliance for Adaptive Management

Subject: Comments and Recommendations on Great Bay Estuary Monitoring Proposals

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Section 1: Introduction

The Municipal Alliance for Adaptive Management (Municipal Alliance) is committed to engaging in the actions necessary to assist in the management and restoration of the Great Bay Estuary. This commitment is realized through the Municipal Alliance's participation in the optional Adaptive Management Framework set up in the recently promulgated National Pollutant Discharge Elimination System (NPDES) Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities in New Hampshire ("General Permit", NHG58A000). As a component of the Adaptive Management approach, the Municipal Alliance is engaging with the other communities subject to the General Permit, the Piscataqua Region Estuaries Partnership (PREP) and the New Hampshire Department of Environmental Services (DES), and other stakeholders on the management and environmental monitoring objectives currently ongoing for the Great Bay Estuary (GBE). The goal of this engagement is to bolster ongoing monitoring, modeling, and data analysis activities through participation and additional funding to ensure comprehensive understanding of the stressors affecting GBE, their interactions, and to inform proper estuary management approaches.

The initial tasks in developing this Adaptive Management approach were to review documents provided by PREP and DES related to ongoing and planned monitoring activities for GBE; and determine how the Municipal Alliance can best participate to provide the greatest benefit. This technical memorandum (memo) presents comments and questions on the current monitoring proposals and also presents recommendations to the Alliance for the next steps for the Adaptive Management approach. The following documents were reviewed for the initial task:

- General Permit (November 2020)
- Environmental Protection Agency (EPA) Response to Comments on the Draft General Permit
- Integrated Research and Monitoring Plan for PREP (RAMP), Draft (May 2020)
- Piscataqua Region Monitoring Collaborative (PRMC) Research/Monitoring Prospectus, Draft (November 2020)
- PRMC Prospectus Details, version 1 (February 2021)
- Science Activities for 2021 (Budget and Timeline, January 2021) and 2021 Field Season Cost and Activity Update (February 2021)
- Nutrient Budget Model Pre-Proposal (McDowell Proposal)
- Great Bay Estuary Tidal Tributary Monitoring Program (GBETTMP): Quality Assurance Project Plan (QAPP) 2019–2023
- Great Bay Estuary Water Quality Monitoring Program: Quality Assurance Project Plan (QAPP) 2019–2023
- Great Bay Estuary Submerged Aquatic Vegetation (SAV) Monitoring Program for 2019–2023 Quality Assurance Project Plan (QAPP)
- SeagrassNet Monitoring Program 2019–2023: Quality Assurance Project Plan (QAPP)
- Beyond Nitrogen Memo (J. Coon)

The following sections detail comments, questions, and recommendations regarding the Municipal Alliance's involvement in ongoing monitoring activities and associated funding being conducted by PREP and their partners. This is intended to help frame the Adaptive Management framework as part of the General Permit.

Section 2: Observations on Stressor-Eelgrass Linkages

Leading up to the promulgation of the Great Bay General Permit, nitrogen has been the stressor of focus for management of GBE including restoration of eelgrass. The member of the Municipal Alliance have long asserted management and restoration of GBE should include a broader focus, incorporating assessment of all types of potential stressors to eelgrass and other natural resources in GBE. To that end, the Municipal Alliance is interested in understanding if ongoing GBE monitoring activities are set up to allow for a broader understanding of potential stressors affecting GBE. This section summarizes which stressors are and are not being addressed in the PREP monitoring activities scheduled for 2021 and provides insight on how the Municipal Alliance can engage to ensure a broader perspective can be included to bolster GBE management.

The draft RAMP acknowledges the importance of a variety of non-nutrient stressors to eelgrass abundance and health and has developed a list of "monitoring questions" to guide data collection for investigating eelgrass stressors. Because the RAMP is still in development, it is unclear at this time when and how PREP will address many of the eelgrass monitoring questions. The draft Prospectus, which is based on the RAMP, was developed to identify the most "critical activities" and "most relevant" water quality parameters for understanding eelgrass in GBE. The draft Prospectus identified 15 priority science activities (summarized in Table 1 of the draft Prospectus): 13 studies (science activity (SA) #1–#10 and #13–#15), engagement of external advisors (SA #11), and data analysis (SA #12). However, only ten studies (SAs #1–#10) are being considered for 2021 unless additional funding can be secured for the remaining science activities (see Section 4 for further information about 2021 funding gaps and priorities).

PRMC's priority 2021 studies in GBE (as outlined in the draft prospectus) include a variety of water quality and biological programs designed to gather information on chemical, physical, and biological components of GBE. The proposed methods (QAPPs, proposals, etc.) for each of these studies were reviewed, if available, to determine which eelgrass stressors and/or response variables would be measured or modeled for each study. Table 1 is a matrix of the studies included in the draft Prospectus and which GBE stressors will be measured or modeled as part of the study.

The priority studies will collect data related to a broader list of potential stressors than just nitrogen (see Table 1). A wide array of stressors will be measured or modeled overall; however, each of the priority studies mainly focuses on either stressor variables or response variables rather than attempting to collect corresponding stressor and response data together in the same study. Therefore, overall program management, data analysis, and interpretation will be important for making sure linkages between stressors and eelgrass responses are properly evaluated (see Section 5). Descriptions of monitoring programs and objectives provided for this review focused on data collection, but not data analysis or interpretation. This apparent gap was discussed with PREP during our initial conference call on February 19, 2021. PREP acknowledged the discussions over methods and analysis were still ongoing and welcomed the Municipal Alliance's involvement in those discussions.

The stressors included in the priority studies include those typically linked to environmental degradation of eelgrass/seagrass and other estuarine biological communities, but there are some additional stressors that may not be investigated by the priority studies (see Table 1, rows without shading or with only question marks). Information about the role of these additional stressors will be important for a comprehensive understanding of eelgrass dynamics and management options in GBE:

- Epiphytes on eelgrass
- Grazers (both positive and negative effects on eelgrass)
- Invasive species (e.g. the nonindigenous green crab)
- Decline of filter-feeders

- Long-term or large-scale climatic changes

Some stressors will be measured or modeled as part of the priority studies, but with a limited spatial or temporal scope. For the most part, this initial document review focused on identifying which stressors will be included in the priority studies rather than evaluating how well the studies will address the potential role of the stressors (due to limited information about study methods at this time). Nevertheless, it is clear that these stressors will need deeper-dive assessments in future studies before meaningful linkages to eelgrass stress and eelgrass recovery targets can be made:

- Light: Collection of light data should be expanded to a larger spatial range and be collected more frequently with light impacting water quality parameters.
- Habitat limitation: A more detailed assessment of the physical and chemical properties of GBE's benthic environment including bathymetry, hydrodynamics, and sediment quality, sources, and depositional patterns should be conducted.
- Eelgrass reproduction and dispersal: Additional information about the reproductive capacity, seed bank, and seed dispersal ability of GBE eelgrass is needed. More intensive data collection or a dedicated study of eelgrass reproduction should be considered.
- Habitat connectivity: The role of saltmarsh, natural shorelines, and hard clam beds (and loss of these habitats) on eelgrass ecosystems should be expanded beyond the initial study of hardening shorelines.

The priority studies identified in the draft Prospectus will not thoroughly cover every eelgrass stressor in the conceptual model presented in the draft RAMP. While intention to include studies of additional stressors (beyond nitrogen) in future monitoring years is clear in the RAMP and draft prospectus, there is currently very little information about how these stressors will be studied or prioritized. Thus, there are currently some data gaps with respect to eelgrass stressors and PRMC should identify a pathway to address those data gaps well in advance of the next monitoring season. The Municipal Alliance should continue involvement with PRMC to provide input on when and how some potential stressors will be studied in GBE and how to amend currently proposed or ongoing monitoring programs to include direct measurements for these potential stressors, where applicable.

The largest gap affecting the discussion of stressors may not be in the actual data collection, but in data analysis and identifying interactions between the chemical, physical, and biological factors that lead to quantifiable understanding of which stressors play a greater role in affecting eelgrass communities. Studies designed with the ultimate data use in mind as well as coordination across studies to ensure compatibility in scale (temporal and spatial) and methodology will be important for future analysis. As planning and funding decisions continue, there will be opportunities to revise and adapt current and future studies based on available data and recommendations made by the Municipal Alliance. Continued engagement with PREP and PRMC on upcoming meetings/discussions (formal and informal) to develop methods and data analysis and interpretation techniques that will be employed for these programs will benefit the Municipal Alliance.

Table 1. Summary of Eelgrass Stressors and Response Variables Investigated in Proposed 2021 Studies.

		Science Activity (SA) Number*	1	2	3	4	5	6	7	8	9	10	13	14	15
		Study Short Description*	Tier 1 Seagrass	Tier 2 Seagrass	Tier 3 Seagrass	Light Arrays	Estuary WQ	Phyto-plankton ID	Tidal Tributary WQ	Nitrogen Loads	Nutrient Budget, Part 1	Nutrient Budget, Part 2	Phospho-rus Loads	Sediment Loading	Shoreline Harden-ing
Eelgrass Stressors	Water Quality	CDOM (fDOM)										?			
		TSS													
		Turbidity													
		pH													
		Salinity (or SC)													
		Temperature													
		Nitrogen													
		Phosphorus													
		Other WQ parameters													
	Physical/Environmental	Light													
		Sediment quality			?										
		Sediment quantity													
		Carbon (DOC)													
		Silica													
		Residence time													
		Coastal runoff													
		Groundwater inputs													
		Other hydrodynamics													
		Bathymetry													
		Habitat limitation													
		Habitat mosaics													
		Climactic shifts													
	Biological	Phytoplankton													
		Epiphyte load		?											
		Macroalgal competition													
		Grazing (+)													
		Grazing (-)		?											
		Invasive species													
		Wasting disease		?											
Response Variables	Eelgrass (*Zostera marina*)	Areal coverage													
		Distribution													
		Depth distribution													
		Density/% cover													
		Biomass (ABG, BGB)													
		Morphology													
		Growth rate													
		Tissue condition													
		Reproduction													
		Seed bank		?											
		Seed dispersal													

Variable will be monitored and/or modeled as part of the study

** Corresponds to numbering and description in the draft Prospectus and subsequent related documents*

? = unclear if will be part of plan, further information needed

Section 3: Comments and Questions On 2021 Studies

PRMC identified ten studies from the draft Prospectus (SAs #1–#10) that are the highest priority for implementation in 2021 to address science questions related to water quality and eelgrass from the RAMP (dependent on funding availability, see Section 4). The studies focus on data collection for water quality, eelgrass, physical parameters (e.g. light arrays), sediment transport, and nutrient modeling. Review of the RAMP and Prospectus, along with the available QAPPs for the proposed studies led to specific comments and questions regarding the monitoring planned for 2021. Addressing these with PREP and PRMC will help the Municipal Alliance to better understand the studies and the overall approach to addressing eelgrass stressors and how to better engage in the process for effective management outcomes.

The following comments/questions were generated from review of the documents related to the proposed 2021 monitoring activities. They have been grouped by monitoring program area, but share a central theme of better aligning and integrating monitoring activities to develop cause and effect relationships between monitoring components, leading to better management decisions.

Water Quality Monitoring (draft Prospectus SA #5 and SA #7)

The head-of-tide (i.e. tidal tributary) and estuarine monitoring programs are ongoing and generate long-term data sets that are critical for determination of cause-and-effect relationships between stressor and response variables. Continuity of data collection within each of these programs should be maintained. While each of these programs generate important data for management of GBE, the two programs appear to be separate and lack coordination that could potentially benefit identification of interactions and effects of riverine inputs to GBE.

a. Head-of-tide monitoring is conducted over a six month period, while estuarine monitoring is conducted over a ten month period. We recommend aligning the frequency and timing of monitoring between the two studies if possible.

b. Parameter lists between the two water quality monitoring programs are not aligned. Head-of-Tide monitoring parameters should include light measurements, CDOM, turbidity, and chlorophyll-a to allow for comparisons to estuarine measurements.

c. Both water quality programs should include low tide and high tide sampling events each month at all sampling locations.

d. Effort should be made to sample Head-of-tide and estuarine locations on the same day(s) or within the same week to allow for spatial and temporal correlations.

e. Funding priorities list the estuarine water quality data collection and mention adding stations in the tidal Cocheco and Bellamy Rivers for 2021. Does adding these stations include continuous recorders as well as grab samples?

f. Is available funding the major obstacle to aligning these programs, if so, what additional funding would be necessary to make the adjustments to these programs?

Light Arrays (draft Prospectus SA #4)

The draft Prospectus indicates that this study will consist of installation of fixed light arrays at three to four locations to identify trends in light measurements and attenuation over time.

a. How will data from the light arrays be integrated with water quality monitoring data to identify causative links and quantify which stressors are having the greatest effect on light attenuation in GBE?

b. Has PREP considered an intensive (perhaps weekly) light and water quality monitoring program for a single year to develop correlations between parameters and causative links affecting light in GBE? Such correlations may take several years if water quality monitoring is only conducted monthly for 10 months a year. An intensive monitoring program would speed up data collection and analysis, and ultimately lead to more timely understanding of impacts to light in GBE and associated management actions.

Seagrass (draft Prospectus SA #2 and SA #3)

Three seagrass studies will be conducted in 2021. Two studies (Tier 2 and Tier 3) will include field surveys and collection of seagrass samples.

a. The QAPP for the Tier 2 Seagrass Study is still in development and was not available to review as part of this initial task. As a result, it is unclear at this time what data will be collected and how the data collected will tie into other seagrass and water quality monitoring efforts. We recommend the Municipal Alliance continue involvement with PRMC to provide input on the methodology for this study as the QAPP is being developed.

b. The QAPP for the Tier 3 (SeagrassNet) study mentions that sediment samples will be collected and stored for future analysis, which is "not covered under the scope of this project". When and how will these samples be analyzed?

c. Can the Tier 3 workplan be expanded to include measurements and characterization of epiphyte loads on eelgrass? Epiphyte data collected from the same locations every year could provide valuable information about eelgrass stressors.

Phytoplankton Identification (draft Prospectus SA #6)

This study will look for shifts in the composition of the phytoplankton community that are not reflected in chlorophyll-a measurements. As it is currently planned, it appears this study will not include collection of any data that will facilitate assessment of linkages between the causes of phytoplankton community shifts and the effects of phytoplankton community shifts on eelgrass.

a. The basis of this study is that important changes to phytoplankton ecology can occur in response to changes in water column nutrients, sediment loading, or warming waters but the study does not include collection of water quality data alongside the phytoplankton samples. It is noted in the draft Prospectus that samples could be added to the program at an additional cost. What is the cost for this activity?

b. It is unclear if or how phytoplankton community shifts might ultimately impact eelgrass. If this study can be expanded to include measurement of factors that directly relate to eelgrass (presumably light availability), the study would be much more useful for the overall goals of identifying and managing eelgrass stressors.

Section 4: Funding Priorities for 2021

The 2021 monitoring season is rapidly approaching and PREP has secured much of the needed funding to conduct the PRMC science activity priorities for this year, but some funding gaps remain, including for studies that were identified as highest priority for 2021. PREP provided information on its priorities and existing funding gaps as part of our document review. Following review of ongoing monitoring programs and funding gaps for 2021, this memo presents recommendations to the Municipal Alliance on which programs would benefit from additional funding for this year. Prioritization was based on the following criteria:

- Immediate benefit to the development of the Adaptive Management framework
- Continuity of data collection
- Bolstering existing monitoring activities to generate a more comprehensive data set
- Data that benefit future data analysis/modeling activities

The Piscataqua Region Monitoring Collaborative (PRMC) coordinates monitoring and research activities for the GBE and identified funding gaps for its highest priority science activities planned for 2021. Brown and Caldwell reviewed and prioritized PRMC's 2021 funding needs based on the criteria listed above. Filling these funding gaps maintains the continuity of and expands data collection efforts to improve knowledge of stressors to GBE. Understanding limited funded availability, studies 1 – 4 in the table below are the highest priorities for funding in 2021.

Priority Order	Study Name	Total Funding Gap	Running Total	Funds Needed By	Study Description
1	Light Array Deployment and Monitoring	$6,500	$6,500	April	Full deployment of new light monitoring equipment necessary to develop linkages between stressors and eelgrass communities. Partially funded.
2	Estuarine Water Quality Monitoring	$123,845	$130,345	April	Continuation of the ongoing estuarine water quality monitoring for a variety of stressors. Additional funding will be used to expand spatial coverage and increase frequency of data collection. Partially funded.
3	External Advisors	$14,000	$144,345	June	Engagement of subject matter experts (e.g., Jud Kenworthy, Brad Peterson, Brian Howes) to provide important perspectives on Piscataqua Region issues and help guide future study development. Currently unfunded.
4	Tier 1 Eelgrass Monitoring	$10,000	$154,345	June	Additional funds for higher resolution imagery during aerial eelgrass monitoring. Partially funded.
5	Sediment Source and Transport	$40,000	$194,345	July	Collection of sediment cores, bathymetry data, and hydrodynamic modeling to address some potential eelgrass stressors not well covered by the other studies. Currently unfunded.
6	Shoreline Hardening	$12,000	$206,345	July	Document and track shoreline hardening, which has important implications for several potential stressors to eelgrass such as hydrodynamics, sediment transport, and water quality. Currently unfunded.
7	Point Source and Non-Point Source Loading Analysis	$24,000	$230,345	June	Compile existing data to assess total nitrogen loads to GBE. Currently unfunded.
8	Nutrient Budget, Part 2	$15,000	$245,345	June	Hydrodynamic modeling and data collection effort focusing on nitrogen processing in GBE. Partially funded.
	Total	$245,345			

A guarantee of funding for monitoring in 2021 demonstrates the permittees' commitment to engagement in the Adaptive Management Framework and restoration and protection of GBE. This immediate commitment also serves as a bridge to achieving the ultimate goal of addressing future funding needs in a long-term, comprehensive, forward-looking program that prioritizes data collection, analysis, and management activities where the greatest impact can be made toward effective management of GBE.

Section 5: Recommendations for Longer-Term Planning

PREP has been implementing water quality and biological monitoring programs as well as modeling efforts in GBE for years. The effort to date is pivotal to establishing the necessary relationships between stressor and response variables that will ultimately help to develop effective management strategies for GBE and restoration of eelgrass communities. With the implementation of the Adaptive Management Framework in the General Permit and engagement from the Municipal Alliance, there is an opportunity to develop a more robust, comprehensive, and forward-thinking monitoring and analysis program to benefit GBE. A comprehensive monitoring program, focusing on achieving the established goals of the *Great Bay National Estuarine Research Reserve 2020–2025 Management Plan* ("Management Plan", draft version, NOAA 2020) with planning for future years of monitoring, analysis, and management actions would coordinate ongoing efforts and focus monitoring programs and funding opportunities on the singular goal of restoring and protecting GBE.

5.1 Multi-Year Monitoring Plan

During the initial meeting with PREP to discuss the Municipal Alliance's engagement (February 19, 2021, via teleconference), much discussion centered on the current state of monitoring goals and objectives. The Municipal Alliance raised questions over the monitoring objectives listed in the RAMP and Prospectus documents that appeared to focus on identifying trends in individual parameters within GBE, but did not discuss interactions between parameters to an extent that would allow for identification of cause and effect relationships. PREP acknowledged this and stated that efforts were ongoing to develop a comprehensive program document that would address these issues as well as the current process for updating the Management Plan. PREP welcomed and encouraged the involvement of the Municipal Alliance in these efforts.

In addition to the development of a comprehensive monitoring program that encompasses all ongoing monitoring programs in GBE, discussion between the Municipal Alliance and PREP also focused on longer-term planning (3–5 years ahead). All parties agreed there is a need to develop a long-term monitoring plan to coincide with future management goals and allow for stakeholders to prepare funding plans more than one year in advance. This not only benefits the Municipal Alliance in securing funding, but also benefits PREP in planning and coordinating future monitoring and analysis programs.

The Municipal Alliance has a large role to play in this effort, beyond contributing funds to PREP's ongoing programs. The Municipal Alliance's involvement provides perspective from the regulated entities into bay-wide goals and management actions from those who will ultimately implement them. This is necessary to build consensus for current and future actions to benefit the GBE. The Municipal Alliance can assist in the direction and focus of monitoring and analysis programs, as well as set management priorities and timing to achieve program goals. Also, this creates an opportunity for public participation in the management of the natural resource.

5.2 Data Analysis and Modeling Framework

In conjunction with the development of a multi-year monitoring plan, it would be recommended that the partners develop a comprehensive data analysis and modeling framework. The goal of the document would be to anticipate how the partnership will use the data being collected to assess linkages between stressors and responses. Some linkages might be evaluated using empirical data analyses and others through the use of calibrated, deterministic models. To the extent that models will be employed, the framework could identify the basis for model selection and data needs for calibration. Defining the analysis and modeling approach

early in the process is important for ensuring that all major stressor-response linkages can be addressed and that the necessary data are collected.

In summary, recommendations for engagement in the development of a comprehensive monitoring program and long-term planning are:

1. Participate in upcoming meetings or a dedicated workshop regarding the development of a comprehensive monitoring program document. PREP stated the Municipal Alliance and/or their representatives would be invited to attend and participate in upcoming meetings on the topic.
2. Work with PREP to suggest additional GBE endpoints and goals during development of the final version of the updated 2020–2025 Management Plan. PREP stated the opportunity exists to refine and add goals to the Management Plan.
3. Develop specific suggestions for coordinating monitoring and analysis efforts to align with specified Management Plan goals.
4. Generate a long-term planning document for the next 3-5 years detailing monitoring, data analysis, and modeling needs, levels of funding, and tentative responsibilities for implementation. Coordination among the Municipal Alliance and with PREP will be necessary to develop a working document that can be refined over time to reflect funding commitments and changing needs for GBE management.