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Addendum to
"Determination of Nitrogen Thresholds and Nitrogen Load Reductions for Green Hill and Ninigret Ponds, October 2006"

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Background

This addendum summarizes recent revisions made to specific technical aspects of a 2006 DEM report titled "Determination of Nitrogen Thresholds and Nitrogen Load Reductions for Green Hill and Ninigret Ponds". The purpose of the 2006 report was to evaluate methods of determining nitrogen loading "thresholds" in estuaries and to apply what was determined to be the best of these evaluated methods to Green Hill and eastern Ninigret Ponds. This analysis was done as part of a comprehensive watershed management project conducted by the Horsley Witten Group for DEM, the Salt Ponds Coalition, and EPA. The goal of the project was to guide residents, watershed groups, and local, state, and federal entities on how to reduce both nutrient and bacteria loadings to Green Hill and eastern Ninigret Ponds. The final report titled "Final Watershed Management Plan for Green Hill and eastern Ninigret Ponds", or referred to herein as WMP is available at: http://www.horsleywitten.com/pubs/Final_Watershed_Mgmt_Plan.pdf.

The nitrogen analysis portion of the WMP plan included a synthesis of available in-pond, tributary, and groundwater nutrient data and a nitrogen loading and threshold assessment for the ponds. DEM completed the "threshold" assessment which was then reviewed by a technical advisory committee (TAC) (as part of the WMP development). Since an accurate assessment and estimate of the carrying capacity load can be a very complex undertaking, requiring significant hydrodynamic and water chemistry data, it was agreed by members of the WMP TAC that a less robust but still scientifically valid method to determine nitrogen loading thresholds for the ponds would be sufficient to provide a reasonable estimate of the nitrogen reductions that would be required to bring the ponds back to a more acceptable level of aquatic health. This approach is summarized below.

Original Nitrogen Loading Analysis Methodology

DEM's original assessment of nutrient reductions for improvement and restoration of water quality in Green Hill Pond was based on the determination of an Eutrophication Index (EI) score as developed primarily by Dr. Joe Costa in 1999 (http://www.buzzardsbay.org/bbpnitro.htm). The EI scoring methodology uses dissolved oxygen (DO), secchi disk depth, dissolved inorganic nitrogen (DIN), chlorophyll-a concentrations, and total organic nitrogen (TON) analytical data to determine the level of eutrophication within a given waterbody. Each of these 5 parameters is used to calculate a score, by category, between 0 and 100 points. The 0 and 100 point values are designed to rank the water quality of the specific waterbody relative to what would be expected in a similar pristine environment. The resultant score for each parameter is then averaged together to produce an overall EI score. Costa employed this methodology, combined with actual nutrient loading rates to coastal ponds around Buzzards Bay, and developed a relationship between loading rate and EI score. DEM's initial assessment in 2006 was that an 80% reduction in nutrient loading to Green Hill Pond was needed to gain a goal of "good" water quality, which was interpreted as an EI score of 65.

This initial determination was based on water quality data at four locations in Green Hill Pond during 2000 and 2001. The samples consisted of those collected by the Salt Pond Coalitions "Pond Watchers"

volunteer monitoring group as well as RIDEM's deployment of a continuous dissolved oxygen sensor during neap tidal cycles in August 2000 and 2001. The analysis was limited such that an EI value was only calculated for the years 2000 and 2001. Very limited dissolved oxygen and secchi disk depth data existed for years 2002 through 2006, limiting the accurate calculation of an EI value for these years.

This initial load reduction estimate was reviewed by members of the WMP TAC which included representatives from the Towns of Charlestown and South Kingstown, EPA, URI researchers, the Salt Ponds Coalition, the RI Coastal Resources Management Council (CRMC) as well as staff from the Horsley Witten Group. At the time, it was agreed that the approach was technically sound and represented the best estimate given the data availability and existing resources. It was also agreed by members of the TAC that this estimate could and should, as resources allowed and additional data became available, be modified. Table 1 summarizes allowable nitrogen loadings to Green Hill Pond and eastern Ninigret Pond as calculated by DEM in 2006.

Table 1. Allowable nitrogen loadings to Green Hill Pond and eastern Ninigret Pond (DEM, 2006)

Waterbody	Current EI Index	Corresponding Nitrogen Loading Rate (mg/m3-Vr)	Current Estimated Annual Nitrogen Load (kg)	EI Goal for SRPW waters in RI	Corresponding Nitrogen Loading Rate Goal (mg/m3-Vr)	Allowable Annual Nitrogen Load (kg)	Required Percent Nitrogen Reduction
Green Hill Pond	45	250	13,783	65	50	2,757	80%
Eastern Ninigret Pond	67	47	36,008	65	50	38,306	None*

* Reductions in the nitrogen load to Green Hill Pond would also reduce nitrogen loadings to eastern Ninigret Pond.

Revised Nutrient Loading Analysis Methodology

Following completion of the WMP, the Town of South Kingstown proceeded to amend its Wastewater Facilities Plan to include wastewater treatment and nutrient control for the Green Hill Pond and eastern Ninigret pond watershed areas-per recommendations of the WMP. A draft Wastewater Facilities Plan was prepared by Woodard & Curran in association with James J. Geremia & Associates, Inc., Stone Environmental, Inc. and Applied Science Associates, Inc. (herein referred to as the "Project Team"). As part of the nutrient control portion of the Facilities Plan, the Town had asked Applied Science Associates (ASA) to revisit DEM's nitrogen loading analysis. ASA worked collaboratively with DEM to obtain and summarize additional existing data and recalculate the Eutrophication Index value for Green Hill Pond. ***The remainder of this memo summarizes the modifications to the original 2006 analysis and presents a revised percent nitrogen reduction for Green Hill Pond. To date, these revisions represent a best estimate of current water quality conditions and nitrogen load reductions necessary to reduce eutrophication and improve the aquatic health of Green Hill Pond.***

As stated earlier, the EI scoring methodology uses dissolved oxygen (DO), secchi disk depth, dissolved inorganic nitrogen (DIN), chlorophyll-a concentrations, and total organic nitrogen (TON) analytical data to determine the level of eutrophication within a given waterbody. Each of these 5 parameters is used to calculate a score, by category, between 0 and 100 points. The 0 and 100 point values are designed to rank the water quality of the specific waterbody relative to what would be expected in a similar pristine environment. Each parameter is given equal weight when calculating the average EI score. The resultant score for each parameter is then averaged together to produce an overall EI score.

For the purposes of the original nutrient loading analysis, RIDEM was interested in establishing a modified EI method that could be applied to the other South Shore Salt Ponds, therefore any modifications should be broadly applicable to all ponds. According to Dr. Joe Costa (personal communication), in developing the Eutrophication Index they were looking to create a framework to

reflect the EI values associated with various water quality conditions and that the index was intended to be applicable to embayments with similar water quality and physical characteristics and not necessarily adjusted to embayment-specific limitations. It was not intended that all embayments could achieve a 100-point scale for all metrics, and that in fact for some embayments, a score of 65 would be considered quite good. We believe that modifications proposed by ASA and agreed to by RIDEM are consistent with the Buzzards Bay approach.

Overall Modifications

Data Expansion

DEM and ASA agreed that locating additional data and calculating an EI index for all years in which water chemistry data were available would provide a more robust assessment of the overall health of Green Hill Pond. Additional data sources for 1999, 2000, as well as data for 2002 through 2007 were incorporated into the most recent EI calculations.

Modification of Original Buzzards Bay Approach

ASA reviewed the original Buzzards Bay approach in depth, including investigation of the original dataset used, and found that the relationship between loading rates and EI scores as published did not correspond to the data presented (The regression was manually drawn with no equation describing the relationship). ASA subsequently developed a different approach for calculating the nutrient reductions needed to achieve the desired water quality goal for Green Hill Pond. In ASA's modified approach, an overall EI score was calculated from the initial dataset and a straight reduction in the analytical nitrogen concentrations (DIN and TON), leaving all other parameters constant, was used to calculate theoretical EI scores associated with the applied nutrient reductions. ASA stated, and DEM concurred, that this approach was a conservative estimate of the needed nutrient reductions, as a reduction in nutrient loading will also lead to improvements in other EI metrics. The overall 8-year average EI calculated for Green Hill Pond was re-calculated by ASA to be 42.9.

A linear regression of the resultant EI scores, encompassing the parameter-specific modifications described below showed that a 61% nitrogen reduction was needed to reach the goal of an EI score of 65 if secchi disk data was excluded from the calculation.

Parameter-Specific Modifications

DIN and TON parameters

Review of additional data showed numerous nitrate samples which were reported as non-detectable. It was ultimately decided to replace all non-detect data with the reporting limit value, in order to include the greatest amount of data in the calculation of the EI index.

ASA believed that the 0 and 100 point scales for DIN from the original methodology were not suitable for Green Hill Pond since the analytical detection limits for DIN were significantly greater than the 100 point value originally assigned for this metric. It was proposed by ASA and agreed to by DEM to increase the 100 point value equal to the method detection limits that are associated with the analytical data, and alter the 0 point value to keep the scale equal. The 0-point value for DIN was changed to 11.86 uM and the 100-point value was changed to 2.86 uM.

ASA recommended that an analytical laboratory with more precise method detection limits (MDLs) be used since the URI Watershed Watch Lab, the lab used to analyze all nitrogen data collected by the Salt Pond Watcher volunteers, did not have low enough detection limits. DEM agreed and is presently working with the URI Watershed Watch Laboratory to address this issue.

Other than expanding the water chemistry dataset to include 1999 and 2002-2007, no additional modifications to the TON scale or dataset quality were proposed.

Chlorophyll-a parameter

Other than expanding the chlorophyll-a dataset to include 1999 and 2002-2007, no additional modifications to the chlorophyll-a scale or dataset quality were proposed.

Dissolved Oxygen parameter

The original 2006 EI calculations made by DEM included the use of continuous dissolved oxygen data collected by DEM staff in 2000 and 2001. Continuous 15-minute dissolved oxygen data were collected for a period of approximately 2 weeks during neap tide at several locations in Green Hill and Ninigret Ponds. The mean of the lowest 20% of all values was used as part of the EI calculations.

The dissolved oxygen dataset was subsequently expanded to include in-situ dissolved oxygen measurements made from 2002-2007 by URI Watershed Watch volunteers as well as in-situ measurements made in 1999 by Granger et al. In order to be consistent with methodologies in the Buzzards Bay Approach, the continuous dissolved oxygen data collected by DEM in 2000 and 2001 was culled to include only that data collected between the hours of 6 and 9am. The Project Team recommended deployment of oxygen sensing equipment throughout the summer, during both spring and neap tidal cycles in order to more accurately characterize seasonal variations in the ponds.

Secchi Disc parameter

The original EI calculation included limited secchi disc depth data. For the 2000 EI calculation, the only available secchi disc data was that collected by Salt Pond Coalition volunteers at three stations in Green Hill Pond between 1989 and 1993. Therefore a mean value was calculated from this dataset and used for the 2000 EI calculation. In 2001, Watershed Watch volunteers collected limited secchi disc data at a mid-pond station in Green Hill Pond. The mean value from this dataset was used for the 2001 EI calculation.

ASA proposed to expand the secchi disc dataset to include data collected by Watershed Watch volunteers between 2002 and 2007. Initial analysis of this dataset resulted in the observation that many of the secchi disc depth values were recorded as "on bottom" measurements. Because of this, ASA proposed to modify the 100-point value to match the pond depth such that all measurements recorded as "on bottom" would be given a 100-point value (i.e the highest possible score). ASA further proposed to alter the secchi disk depth scale from the current 0.6 m – 3.0 m range to a more suitable range: 0.6 m – 1.8 m (the estimated maximum depth of the pond). DEM disagreed with these proposed modifications on the grounds that if the secchi disc reaches the bottom and is still visible, then an extinction depth is not able to be determined at that location (i.e. if secchi disc is not extinguished then there is no data point). In addition, it was DEM's position that an on-bottom secchi reading does not necessarily imply high-quality water and therefore should not receive 100-points on the EI scale.

After discussing this in greater detail with Dr. Joe Costa and others, DEM concluded that there were two options in this case – either utilize an alternate method to assess clarity (e.g. PAR-photosynthetically available radiation) or exclude the secchi disc metric. Given that only limited light intensity (PAR) data are available for Green Hill Pond, DEM recommended that the secchi disc metric be removed from the EI approach for application to Green Hill Pond and other shallow ponds (where extinction of the secchi disc is not achieved). Joe Costa indicated that in this situation he would feel comfortable putting more weight on water chemistry parameters – with nitrogen and chlorophyll being the main parameters of concern. DEM is currently investigating the use of a PAR sensor to collect water clarity data in Green Hill Pond.

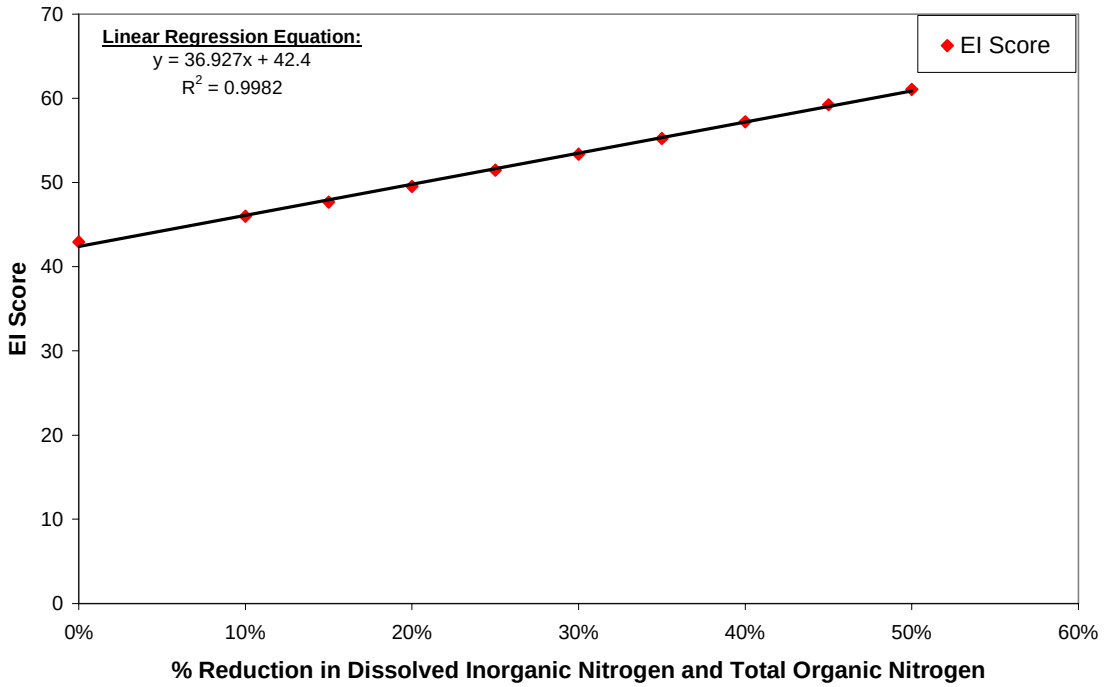
Below are the tabulated data for ASA's determination of the necessary nutrient reductions for Green Hill Pond in order to obtain an EI score of 65. As requested by DEM, secchi disk data were excluded, and all other available and relevant data from 1999 – 2007 included, in the EI calculations. Table 2 presents the eutrophication index (EI) scores calculated for each applied percent nutrient loading reduction (in DIN and total organic nitrogen (TON)) calculated as an overall average of the average values for each EI metric for all available data except the Secchi disk depth data. Figure 1 presents this

data graphically and displays the regression equation used to calculate the percent reduction that theoretically results in a Eutrophication Index of 65 for Green Hill Pond.

Table 2. Projected EI scores resulting from applied reductions in DIN and TON concentrations in Green Hill Pond.

Applied Nutrient Reduction	Resultant EI Score
0	42.9
10%	46.0
15%	47.7
20%	49.5
25%	51.5
30%	53.4
35%	55.2
40%	57.2
45%	59.2
50%	61.1

Figure 1. Projected EI Score as a Function of Percent Nitrogen Reduction (from ASA technical memorandum to RIDEM, November 6, 2007).



As stated earlier, a linear regression of the resultant EI scores, encompassing the parameter-specific modifications described above showed that a 61% nitrogen reduction was needed to reach the goal of an EI score of 65 (including exclusion of the secchi disc depth data).