SARASOTA BAY
Numeric Nutrient Criteria:
Task 2 – Downstream Protection Values

Draft Letter Memorandum

Prepared for:

Sarasota Bay Estuary Program

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FOREWORD

This letter memo was produced in partial fulfillment of SBEP Contract 2011SBEP04 - Development of Numeric Nutrient Criteria for Sarasota Bay, Task 2.

ACKNOWLEDGEMENTS

We wish to thank the partners of the Sarasota Bay Estuary Program (SBEP) for the numerous conversations providing direction and insight into concerns regarding numeric nutrient criteria establishment and appropriate methodology for developing the proposed criteria. We would particularly like to thank the following individuals who serve on the water quality subcommittee of the Technical Advisory Committee: Mark Alderson, Dr. Jay Leverone, Jack Merriam, Rob Brown, Lizanne Garcia, Kris Kaufmann, Veronica Craw, John Ryan, Gary Serviss, Amber Whittle, Pete Wenner, Charles Kovach, and Jon Perry.

EXECUTIVE SUMMARY

The Sarasota Bay Estuary Program (SBEP) has recommended numeric nutrient criteria to the U.S. Environmental Protection agency (EPA). These criteria are specific to the segments of the SBEP area and are expressed as annual total nitrogen (TN) concentrations. EPA has noted its intention to express the numeric nutrient criteria for the SBEP area as TN and total phosphorus (TP) concentrations and loads. Therefore, segment-specific TN and TP concentrations and loads have been developed. This is in keeping with recognition of the importance of maintaining consistency with existing management goals.

After the establishment of nutrient criteria for the segments of the SBEP area, the next logical step is to extend these criteria up into the tributaries that drain to the segments. Downstream Protection Values (DPVs) are defined by EPA as those water quality criteria in flowing waters that ensure protection of designated uses in the downstream estuarine waters as required by the Clean Water Act under 40 CFR 131.10(b). In the case of the SBEP area, the SBEP has recommended numeric nutrient criteria to EPA for the segments in the SBEP area (Janicki Environmental, 2010a). The criteria, as proposed to EPA, are segment-specific and are expressed as annual total nitrogen (TN) and total phosphorus (TP) loads. These TN and TP loads are those for the Reference Period of 2001-2005, which was chosen because it was determined to be protective of water quality and seagrass in the segments.

The approach EPA is considering for the development of DPVs is based on protective TN and TP loads. For the terminal reaches of tributaries that drain to a segment, these protective loads can be divided by the average flow entering the estuary to arrive at nutrient criteria (DPVs) for TN and TP concentrations in the tributaries that discharge into the estuary.

The following conclusions can be drawn from the analyses and results of this letter memorandum:

- Though EPA has decided to delay promulgation of DPVs until 2011, DPVs will be required for all tributaries that flow into the SBEP area.
- The water quality within the tributaries must be protective of the downstream estuarine waters.
- Sufficient water quality data do not exist for several of these systems, making it impossible to develop defensible criteria using stressor-response relationships.
- If the chlorophyll threshold and nutrient criteria for a segment are being met, it logically follows that the water quality in the terminal reaches (i.e., "pour points") are collectively protective of the downstream estuarine receiving waterbody (i.e., the segment) and therefore assessment of DPV compliance is not necessary.
- Due to the disconnect present in the protective load approach for SBEP segments, if DPV compliance is necessary, the preferred method is to use the reference period approach.

The preferred method for assessment of DPV compliance is to use the reference period approach. The tributary-specific proposed TN and TP DPVs for the tributaries of the SBEP area based on the Reference Period approach are:

- Bowlees Creek TN = 1.45 mg/L TP = 0.32 mg/L
- Hudson Bayou TN = 0.89 mg/L TP = 0.75 mg/L
- Philippi Creek TN = 1.04 mg/L TP = 0.32 mg/L

- Matheny Creek TN = 1.17 mg/L TP = 0.41 mg/L
- Elligraw Bayou TN = 1.46 mg/L TP = 0.39 mg/L
- Clowers Creek TN = 1.24 mg/L TP = 0.35 mg/L
- Catfish Creek TN = 1.35 mg/L TP = 0.26 mg/L
- North Creek TN = 1.46 mg/L TP = 0.34 mg/L

1.0 Introduction and Objectives

The Florida Department of Environmental Protection (FDEP) began development of numeric nutrient standards in December 2001. The FDEP formed a technical advisory committee and an agency work group to assist in identifying appropriate nutrient standards. FDEP conducted a number of workshops and meetings as well as several studies since 2002.

In 2008, several environmental groups filed suit against the U. S. Environmental Protection Agency (EPA) in Federal Court alleging that EPA had determined in 1998 that Florida's current narrative nutrient standard did not comply with the Clean Water Act and that EPA had not established numeric nutrient standards pursuant to Section 303(c)(4)(B) of the Clean Water Act. As a consequence of this lawsuit, EPA sent FDEP a letter on January 14, 2009 finding that FDEP's narrative nutrient standard did not comply with the Clean Water Act and directing the State of Florida to develop its own numeric nutrient standards for rivers and lakes by January 2010 and estuarine and coastal waters by January 2011 or EPA would adopt its own nutrient standards. In August 2009, these groups and EPA agreed to a Consent Decree formally establishing these deadlines and that EPA will be responsible for establishing these criteria.

The Sarasota Bay Estuary Program (SBEP) has recommended numeric nutrient criteria to EPA (Janicki Environmental, 2010a). These criteria are specific to the segments of the SBEP area (Figure 1) and are expressed as annual total nitrogen (TN) concentrations. EPA has noted its intention to express the numeric nutrient criteria for the SBEP area as TN and total phosphorus (TP) concentrations and loads. Therefore, segment-specific TP concentrations and TN and TP loads were developed as part of Task 1 of the current work order (Janicki Environmental, 2010b). This is in keeping with recognition of the importance of maintaining consistency with existing management goals.

After the establishment of nutrient criteria for the estuarine Sarasota Segments, the next logical step is to extend these criteria up into the tributaries that drain to the estuary. Downstream Protection Values (DPVs) are defined by EPA as those water quality criteria in flowing waters that ensure protection of designated uses in the downstream estuarine waters as required by the Clean Water Act under 40 CFR 131.10(b). EPA previously proposed TN DPVs based on protective estuarine TN loads, with the DPVs being expressed as TN concentrations in the upstream reaches (EPA, 2010a). However, as noted in the March 17, 2010 letter from Peter Silva, EPA Assistant Administrator:

> "the Agency has decided to delay finalizing promulgation of the "downstream protection values," or DPVs with respect to downstream estuary protection and to address this issue in the 2011 estuary and coastal rulemaking."

The objective of Task 2 of this work order is to develop proposed DPVs for tributaries within the Sarasota Bay Estuary Program jurisdictional area. The remainder of this document contains: a summary of the proposed EPA approach for developing DPVs (Section 2), a description of Sarasota Bay and its tidal tributaries (Section 3), a summary of the proposed DPVs (Section 4), and literature cited (Section 5).

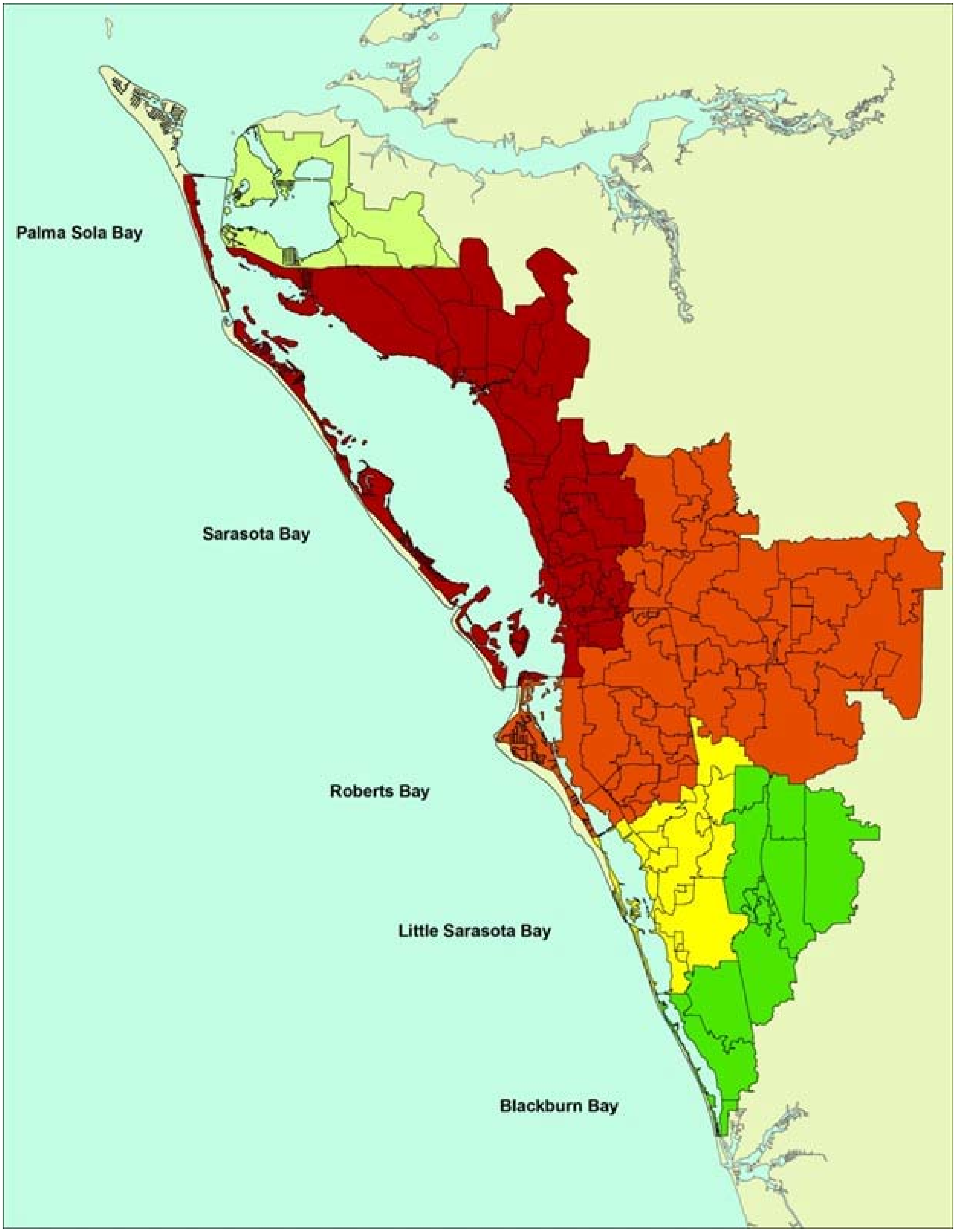


Figure 1. Sarasota Bay Estuary Program segments.

2.0 EPA Approach to DPV Development

EPA is considering three basic approaches for the development of numeric nutrient criteria in Florida waters:

1. reference condition approach,
2. stressor-response models, and
3. water quality simulation models.

Each of these approaches has inherent strengths and weaknesses.

The reference condition approach can be further divided into two different approaches, the historical and comparative reference approaches. The historical reference approach is a strong candidate if sufficient data are available for the waterbody of interest during a minimally-impacted Reference Period. If sufficient data are not available for the waterbody for a minimally-impacted Reference Period, it is possible to use the comparative reference approach. The comparative reference approach consists of using data from a minimally-impacted waterbody that is similar to the waterbody for which criteria are being developed. Obviously, the historical reference approach is superior to the comparative reference approach because it is based on data from the waterbody of interest for a minimally-impacted period. It is important to point out that the historical reference condition could be the current condition if the current condition is deemed minimally-impacted and is supporting balanced, natural populations of aquatic flora and fauna.

The second approach is stressor-response models, or regression models. Regression models are used to relate the response variable to one or more explanatory variables. If statistically significant relationships can be developed between the response variable and explanatory variable(s), the relationships can be used to estimate the value of the response variable that is associated with a particular explanatory variable (i.e., a target or standard). For example, if a statistically defensible relationship is developed between TN concentration and chlorophyll *a* concentration in a waterbody, a TN concentration (criterion) can be estimated for the desirable chlorophyll *a* concentration (i.e., the chlorophyll *a* water quality standard). Similar to the historical reference approach, sufficient data are required to develop robust stressor-response relationships. One major strength of regression models is the ability to not only predict the response variable that corresponds to a desirable condition in the explanatory variable, but also to estimate the uncertainty associated with the predictions of the response variable. One drawback for the purpose of development of nutrient criteria is that the relationships, while statistically significant, may not be very strong. This leads to wide confidence intervals and a relationship which may not be useful for development of nutrient criteria. Also, many times a statistically significant relationship between the response variable and the explanatory variable(s) does not exist. This may be due to the lack of a statistical relationship between the variables or because of the highly complex nature of the waterbody and the physical, chemical, biological and ecological processes that occur on varying spatial and temporal scales.

The third approach for DPV development consists of water quality simulation models. These are highly complex, data intensive models that are used to simulate physical, chemical, and biological processes in the watershed and receiving waterbodies. As with the regression models, these models can be used to estimate the TN concentration (criterion) that is associated with the desirable chlorophyll concentration (standard). One of the major strengths of these models is the ability to predict water quality over large spatial and temporal scales. One of the major weaknesses of these models is the amount of data that is required to develop and run these models. Fortunately, many of the systems in Florida have been modeled in the past using various models (watershed, hydrodynamic, and water quality).

Above, the three approaches that EPA intends to use to develop nutrient criteria for Florida waters, including tributaries that drain to estuaries, have been discussed. Before continuing, it is important to define the different portions of the tributary that will be used for criteria development. The tributaries have been divided into two sections, the terminal reach and the upstream reach. The terminal reach connects the upstream, freshwater section of the tributary to the downstream estuary. The upstream reach of the tributary is the freshwater portion of the tributary that drains the upstream watershed and connects to the terminal reach. The point where the terminal reach enters the estuary is referred to as the "pour point" (i.e., the point where the terminal reach of the tributary "pours" into the estuary). As discussed by Hagy (2010), "the EPA is considering approaches for developing criteria for all locations in a watershed, including the "pour point" (i.e., where water enters the estuary), and the upstream locations. As part of this approach, EPA is considering approaches that would account for retention and/or loss of TN and TP within the stream network."

Though any of the three approaches discussed above can be used to develop criteria, the goal of the process is consistent among approaches. As stated in EPA (2010b):

> "The DPV criteria will be computed such that the TN and TP discharged from a stream, after accounting for any expected losses during transport, will not contribute a disproportionate fraction of the maximum TN or TP loading protective of water quality standards in the estuarine receiving water. The proportionate fraction will be based on the fraction of total freshwater flow contributed by the reach."

The protective TN and TP loads are defined as those TN and TP loads from the watershed that are "needed to support balanced natural populations of aquatic flora and fauna in estuarine waters" (EPA, 2010b). For the terminal reach of tributaries in Florida, EPA is proposing to divide these protective loads by the average flow entering the estuary to arrive at terminal reach DPVs expressed as TN and TP concentrations (Figure 2). Further, DPVs can be developed for the upstream reaches by taking into account the loss or retention of nutrients in the stream network due to a series of physical, chemical, and biological processes. As discussed in Hagy (2010), EPA is considering a different approach for south Florida due to the highly altered and controlled canal systems in south Florida. For south Florida EPA is considering expressing DPVs as loading limits as opposed to concentrations. Also, in south Florida, EPA may choose to apply DPVs exclusively to terminal reaches, instead of the entire system (Hagy 2010).

The equation suggested by EPA (2010b) to calculate terminal reach DPVs is the following:

$$\bar{C}_T = \frac{\bar{L}}{\bar{Q}}$$

where: $\bar{C}_T$ = average concentration specified as the terminal reach DPV,
$\bar{L}$ = the average loading rate that is protective of the designated uses in the receiving waterbody (i.e., the estuary or segment), and
$\bar{Q}$ = the average freshwater inflow to the receiving waterbody.

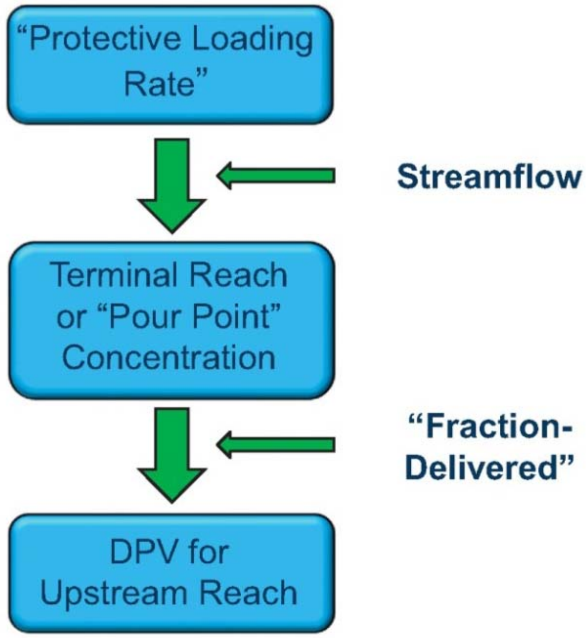


Figure 2. Major steps involved in development of numeric nutrient criteria for TN and TP in streams and rivers protective of water quality in downstream estuaries (from Hagy 2010).

These DPVs are expressed as concentrations from the terminal reaches, or "pour point" concentrations, that are protective of the designated uses in the downstream estuarine receiving waters. Because of this fact, the protective load ($\bar{L}$) is the loading from the ***watershed only*** and therefore does not include loads that are discharged or fall directly on the surface of the segments. Therefore, the loads which are not included in the watershed loads consists of dry and wet atmospheric deposition to the surface of the segments and point sources that discharge directly to the segments. Similarly, the average freshwater inflows ($\bar{Q}$) consist of the freshwater inflows from the watershed, which excludes rainfall and point source discharges directly to the estuary.

EPA's proposed approach based on the calculation of $\bar{C}_T$ may have some shortcomings. In cases where multiple tributaries deliver loads to the estuarine waterbody, this approach assumes that all terminal reaches would have the same DPV. Clearly, factors other than anthropogenic factors can influence nutrient concentrations in stream channels. The result could be that while the downstream waterbody is meeting its criterion, an exceedance could still be manifest in one or more terminal reaches. This issue is discussed further in Section 4.

3.0 Proposed Estuarine Criteria for Sarasota Bay

As discussed above, the DPVs for a system are to be estimated as the nutrient concentrations in a tributary that are protective of the designated uses of the estuarine receiving waterbody. Before discussing DPVs for the tributaries, an understanding of the SBEP segments and the estuarine criteria developed for these segments is required. To this end, the proposed criteria for the segments of the SBEP are discussed in this section.

3.1 Proposed Sarasota Segment-specific Nutrient Criteria

As discussed above, EPA is considering developing DPVs based on loads from the watershed that are "needed to support balanced natural populations of aquatic flora and fauna in estuarine waters" (EPA, 2010b). Therefore, before DPVs can be developed, estuarine nutrient loading limits (protective loads) must be determined. In the case of the SBEP area, the SBEP has recommended numeric nutrient criteria to EPA for the segments of the SBEP area (Janicki Environmental 2010a). The criteria, as proposed to EPA, are segment-specific (Figure 1) and are expressed as annual TN and TP loads. These TN and TP loads are those for the Reference Period of 2001-2005, which was chosen because it was determined to be protective of water quality and seagrass in the segments.

	TN	TP
• Palma Sola Bay	= 41.3 tons/year	7.1 tons/year
• Sarasota Bay	= 211.8 tons/year	31.5 tons/year
• Roberts Bay	= 213.3 tons/year	42.4 tons/year
• Little Sarasota Bay	= 40.8 tons/year	7.4 tons/year
• Blackburn Bay	= 55.4 tons/year	9.3 tons/year

These criteria represent the protective loads to the segments according to the EPA definition (EPA, 2010b), and include the total nutrient loadings to the estuary. Therefore, as discussed above in Section 2, in order to arrive at the protective loads from the watershed, the direct loads to segments (atmospheric deposition to the segments) must be subtracted from these total segment loads.

4.0 Development of DPVs

The proposed DPVs for the tributaries within the SBEP area watershed are based on two separate methods, the method presented by EPA (EPA, 2010b; Hagy, 2010) and the Reference Period approach. The proposed DPVs for the terminal reaches of the tributaries, along with a comparison of the proposed DPVs relative to observed data, are presented below for the two separate methods.

4.1 Proposed DPVs for Terminal Reaches Based on the Protective Load Approach

As was suggested by EPA (2010b), the DPVs for the terminal reaches of tributaries were calculated by dividing the segment annual Protective Load by the average freshwater inflow. As discussed in Section 3.1, the segment Protective Loads were developed for the Reference Period (2001-2005). The segment-specific protective watershed loads were calculated by taking the segment Protective Load (Section 3.1) and subtracting out loads that occur directly to the estuary (wet and dry deposition directly to the surface of the segments and point sources that discharge directly to the segments). The segment-specific protective watershed loads are:

	TN	TP
• Palma Sola Bay	= 32.0 tons/year	6.6 tons/year
• Sarasota Bay	= 161.6 tons/year	30.9 tons/year
• Roberts Bay	= 210.3 tons/year	42.4 tons/year
• Little Sarasota Bay	= 36.1 tons/year	7.3 tons/year
• Blackburn Bay	= 54.0 tons/year	9.3 tons/year

These Protective Loads were applied to the equation ($\bar{C}_T = \frac{\bar{L}}{\bar{Q}}$) proposed by Hagy (2010) by dividing the Protective Loads ($\bar{L}$) by the annual average freshwater inflows ($\bar{Q}$) for the Reference Period (2001-2005) to arrive at segment-specific DPVs. Because loadings have been estimated for all segments, segment-specific DPVs have been calculated for all segments. The proposed TN and TP DPVs for the segments are presented in Table 1.

Table 1. Proposed DPVs for TN and TP in Sarasota Segment terminal reaches.

Segment	TN DPV (mg/L)	TP DPV (mg/L)
Palma Sola Bay	1.42	0.29
Sarasota Bay	1.47	0.28
Roberts Bay	1.38	0.28
Little Sarasota Bay	1.31	0.27
Blackburn Bay	1.42	0.24

4.2 Comparison of Proposed DPVs Based on the Protective Load Approach to Observed TN and TP Concentrations in Terminal Reaches

Ambient nutrient concentration data are not available for each of the terminal reaches within the SBEP area. There are eight tributaries with sufficient nutrient concentration data (i.e., at least four samples per year) that drain to three of the five segments. In Palma Sola Bay and Blackburn Bay there are no terminal reaches with adequate nutrient concentration data. These tributaries with sufficient data and their associated segments are:

- Sarasota Bay
  - Bowlees Creek
  - Hudson Bayou
- Roberts Bay
  - Philippi Creek
  - Matheny Creek
- Little Sarasota Bay
  - Elligraw Bayou
  - Clowers Creek
  - Catfish Creek
  - North Creek

The observed water quality stations used for the analysis are presented in Figures 3 through 5 for Sarasota Bay, Roberts Bay, and Little Sarasota Bay, respectively. Time series plots of the monthly average TN and TP concentrations by terminal reach are presented for the tributaries listed above in Attachment 1. The plots are presented with the same vertical scales so that they may be easily compared.

With the exception of Bowlees Creek, which has sufficient data for the entire 1992-2009 period, the other tributaries have large data gaps. In general, all tributaries have lower TN and TP concentrations relative to Bowlees Creek.

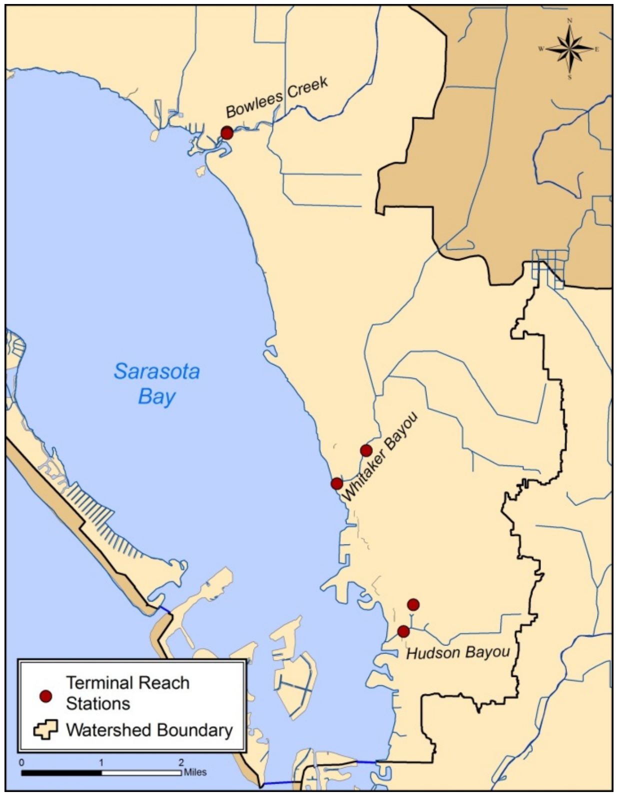


Figure 3. Terminal reach water quality stations in Sarasota Bay.

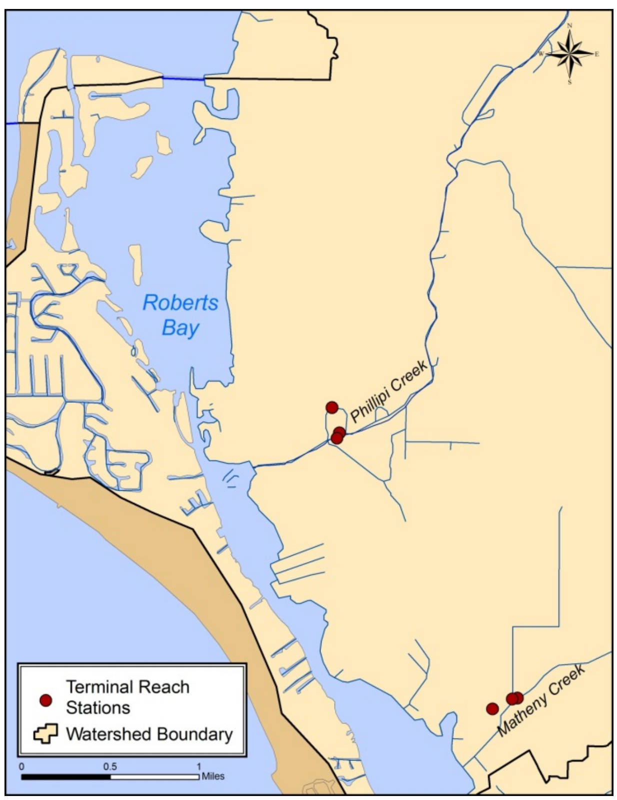


Figure 4. Terminal reach water quality stations in Roberts Bay.

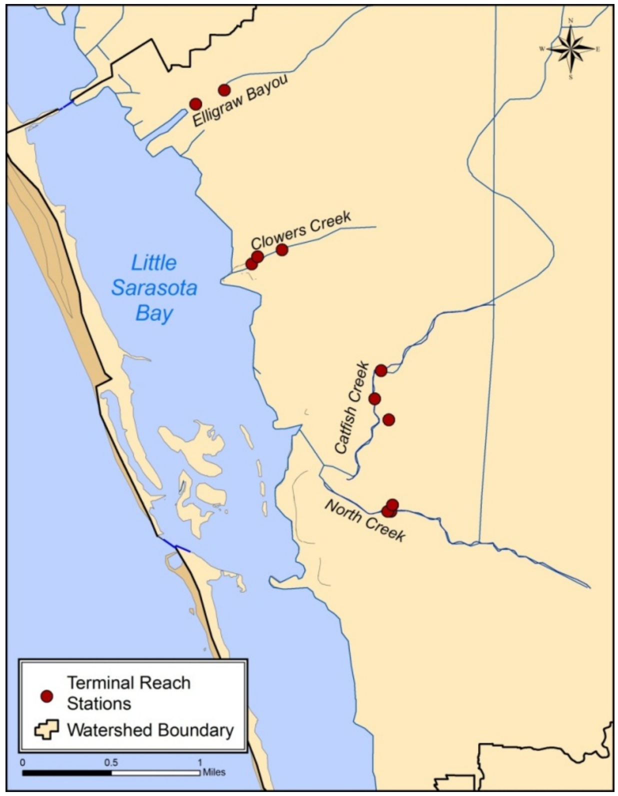


Figure 5. **Terminal reach water quality stations in Little Sarasota Bay.**

As discussed above, the proposed DPVs are segment-specific based on the protective watershed nutrient and hydrologic loads in the individual segments. Therefore, all tributaries in a segment have the same DPVs. The proposed TN and TP DPVs for the terminal reaches of tributaries in the SBEP area are presented in Table 2.

Table 2. Proposed TN and TP DPVs for the eight terminal reaches within the SBEP area with available ambient TN and TP concentration data.

Terminal Reach	Segment	TN DPV (mg/L)	TP DPV (mg/L)
Bowlees Creek	Sarasota Bay	1.47	0.28
Hudson Bayou	Sarasota Bay	1.47	0.28
Philippi Creek	Roberts Bay	1.38	0.28
Matheny Creek	Roberts Bay	1.38	0.28
Elligraw Bayou	Little Sarasota Bay	1.31	0.27
Clowers Creek	Little Sarasota Bay	1.31	0.27
Catfish Creek	Little Sarasota Bay	1.31	0.27
North Creek	Little Sarasota Bay	1.31	0.27

The annual geometric mean TN and TP concentrations (2000-2009) for the terminal reaches of the eight tributaries are presented in Figures 6 through 13 along with the proposed DPVs based on the Protective Load approach. Of the eight terminal reaches with sufficient data, three terminal reaches had annual geometric mean TP concentrations that would have resulted in exceedances during the recent period (2005-2009) based on either of the proposed temporal assessment schemes (1 in 3 years or 2 in 5 years). The terminal reaches with TP exceedances are Hudson Bayou, Elligraw Bayou, and North Creek. Because the DPVs are calculated based on the Protective Load to the entire segment, it is not surprising to find that some DPVs for individual tributaries may not meet the segment level DPVs even though the downstream segment is meeting its criterion. This may be due to differences in geology (Terziotti *et al.* 2010) or landuse, or the presence of point sources near water quality sampling locations. While the annual geometric mean TP concentrations in these terminal reaches are greater than the proposed DPVs for Sarasota Bay (Hudson Bayou) and Little Sarasota Bay (Elligraw Bayou and North Creek), these elevated concentrations are not leading to a deterioration in water quality in Sarasota Bay or Little Sarasota Bay. In fact, in recent years TP concentrations in these segments have been declining and are below the proposed nutrient criteria for the segments (Janicki Environmental 2010a).

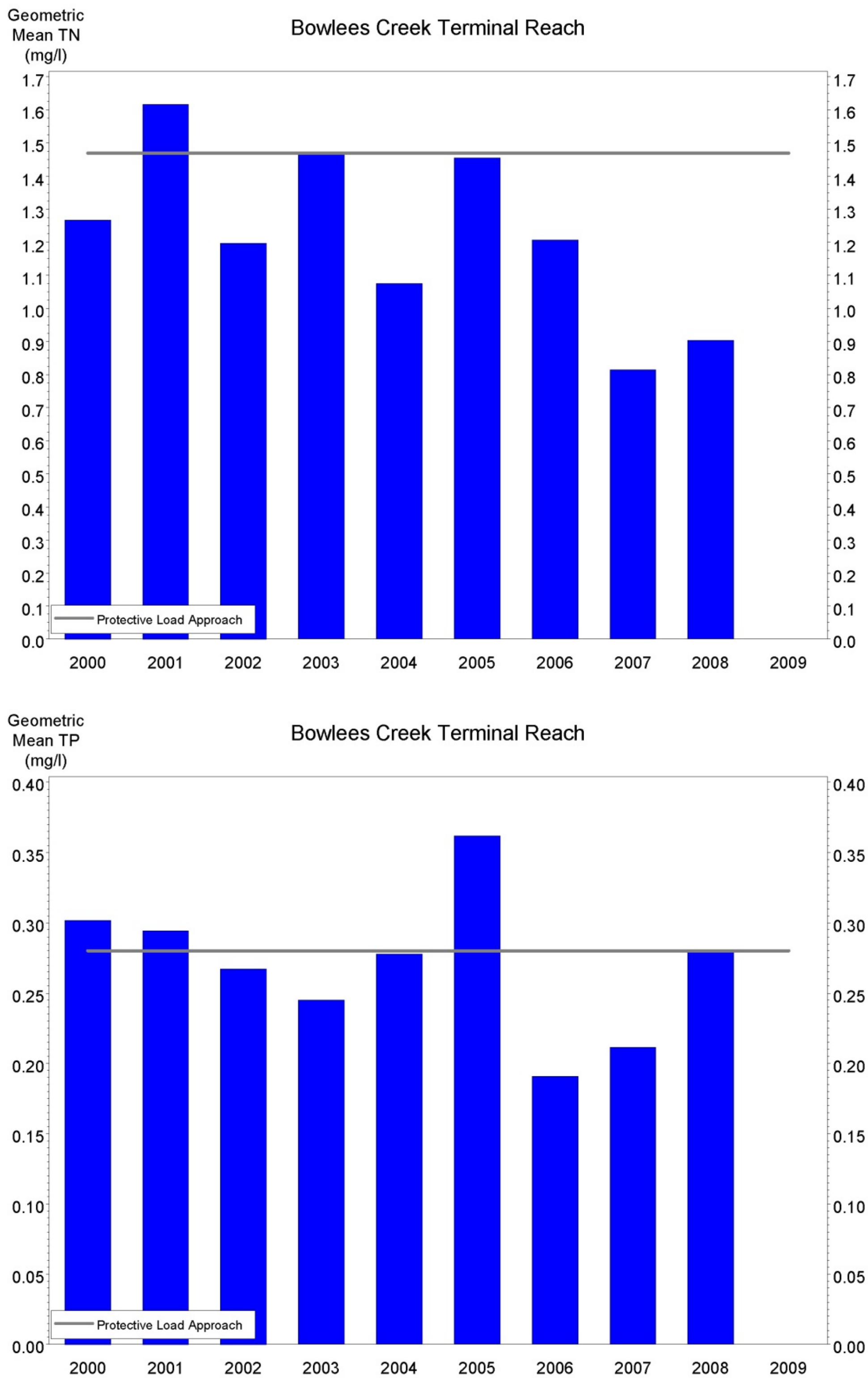


Figure 6. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in Bowlees Creek (Sarasota Bay).

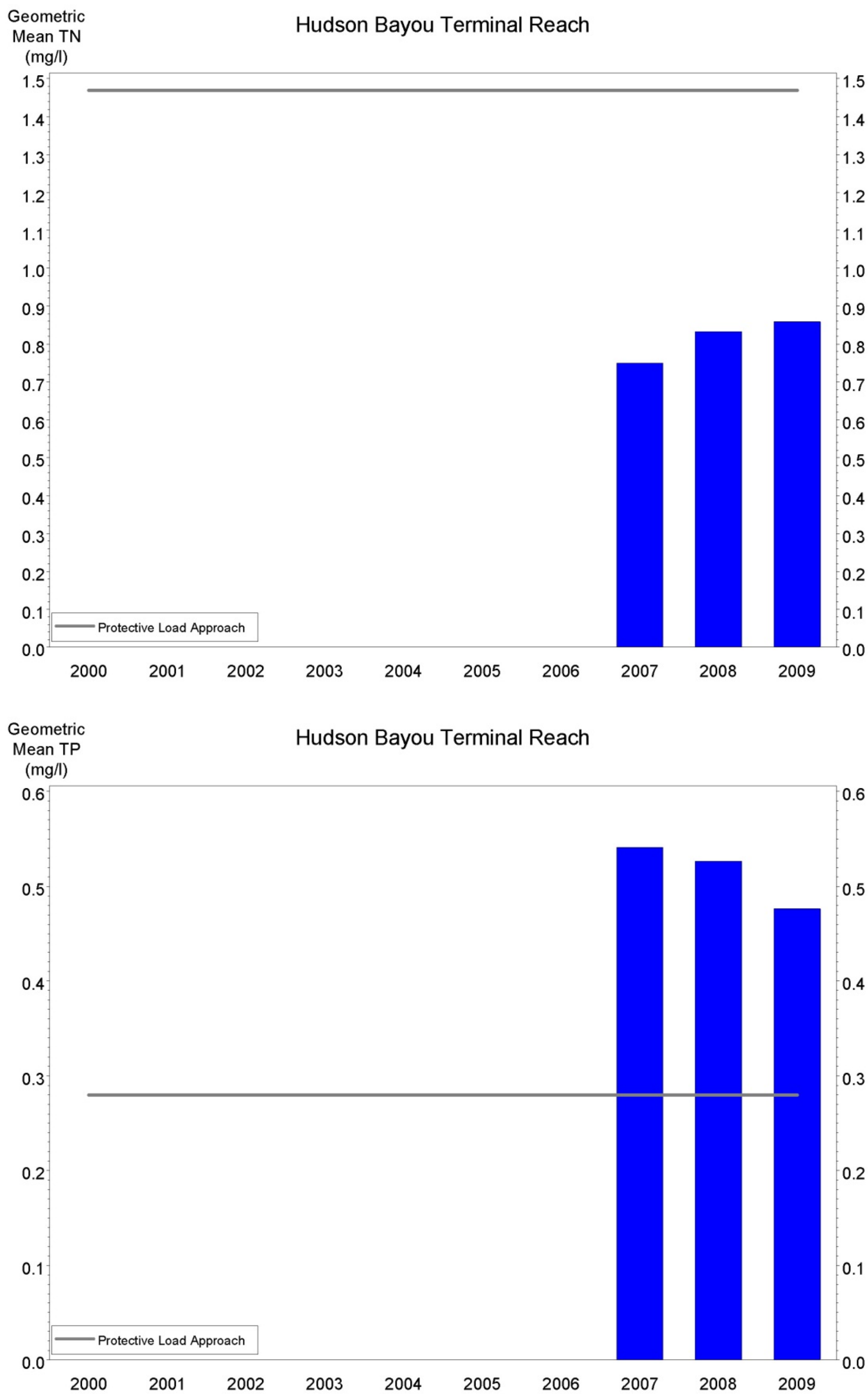


Figure 7. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in Hudson Bayou (Sarasota Bay).

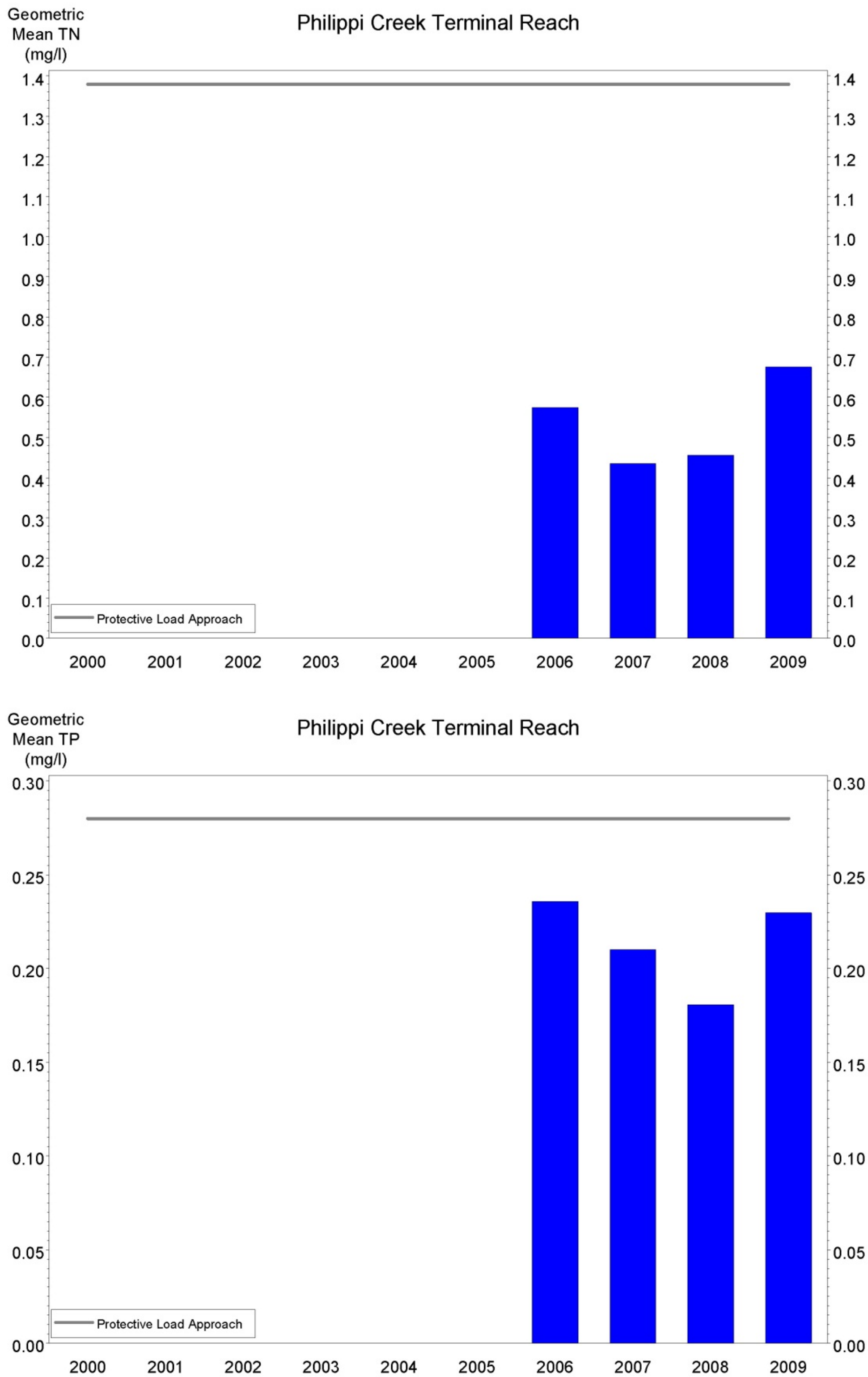


Figure 8. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in Philippi Creek (Roberts Bay).

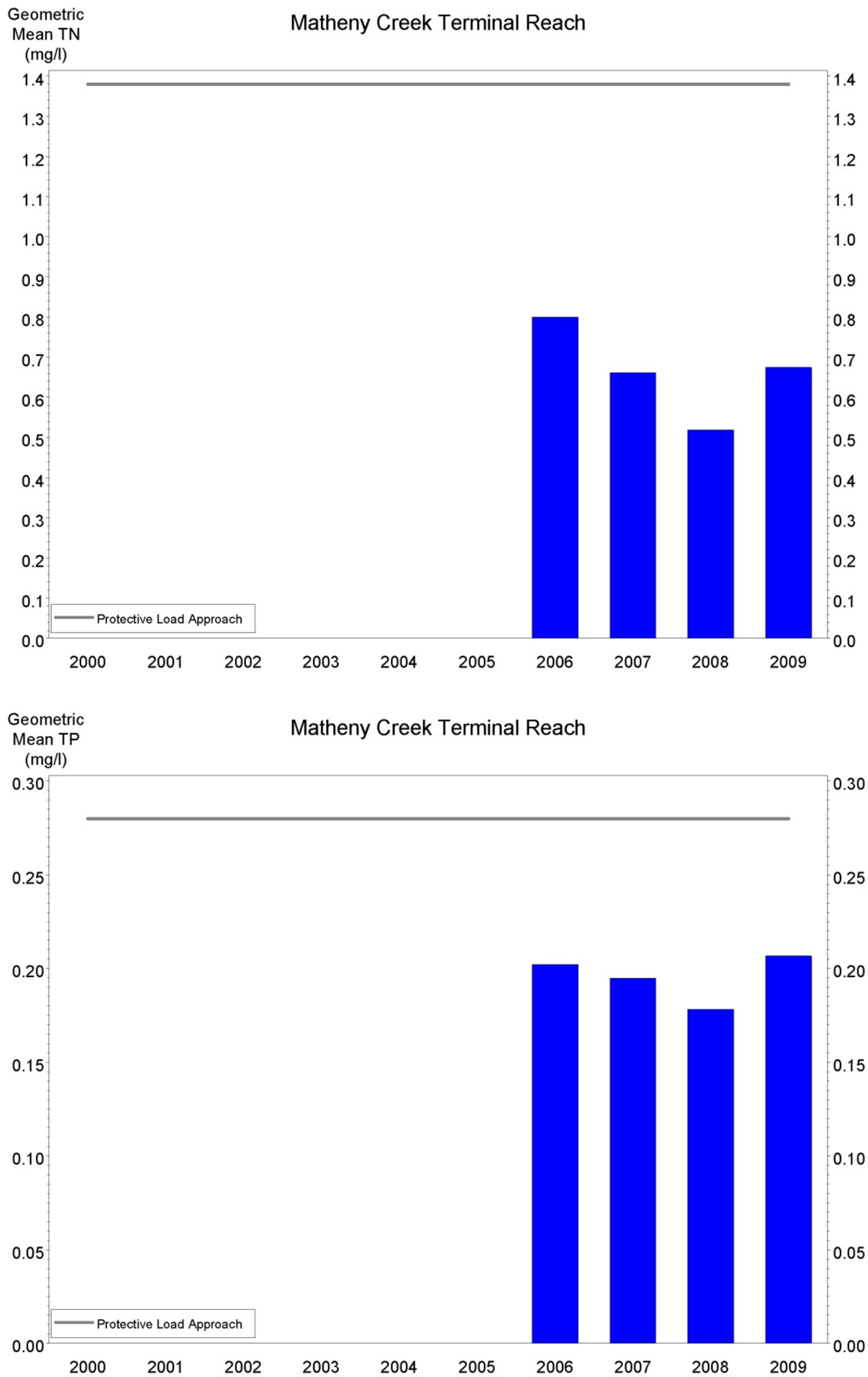


Figure 9. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in Matheny Creek (Roberts Bay).

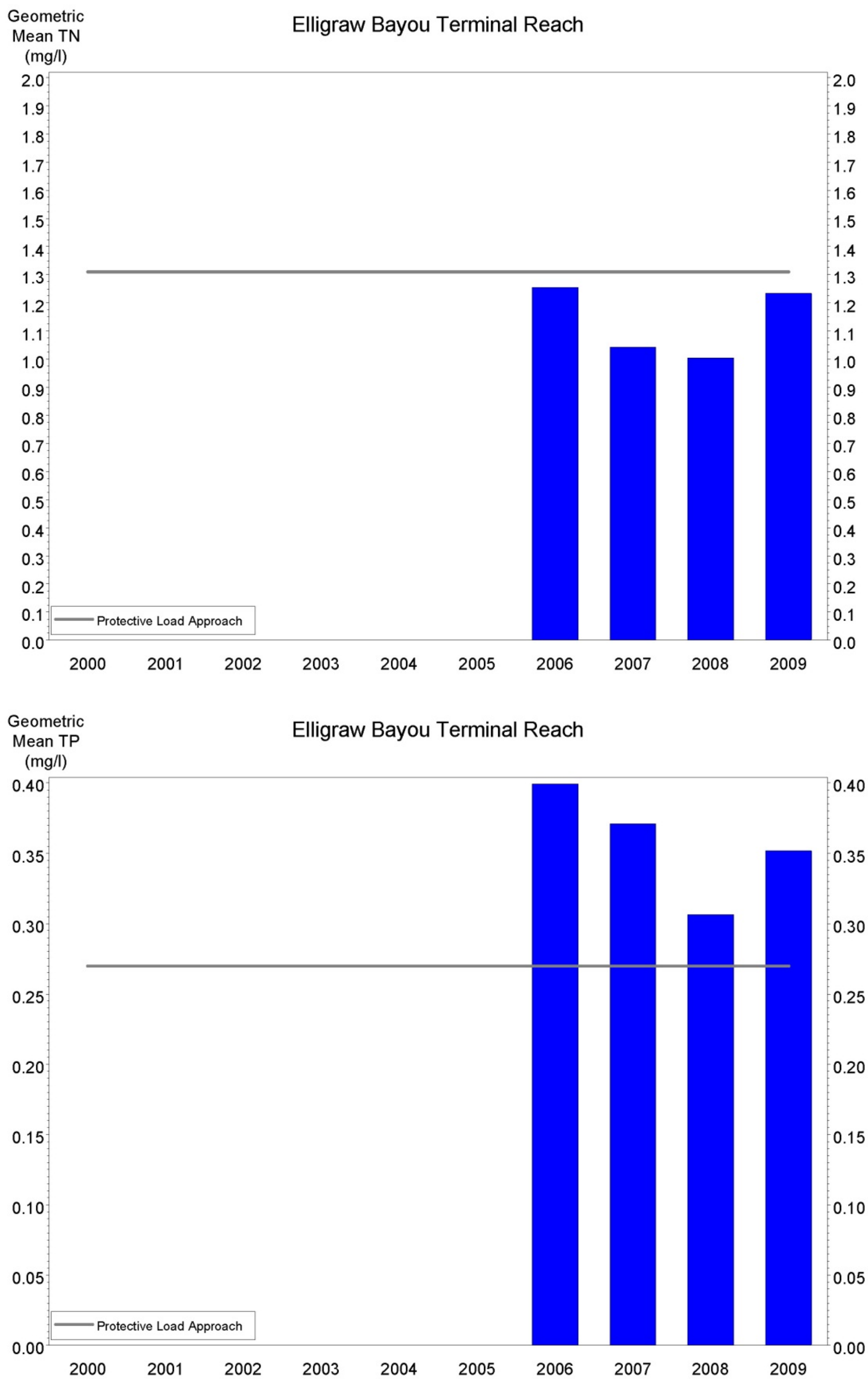


Figure 10. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in the Elligraw Bayou (Little Sarasota Bay).

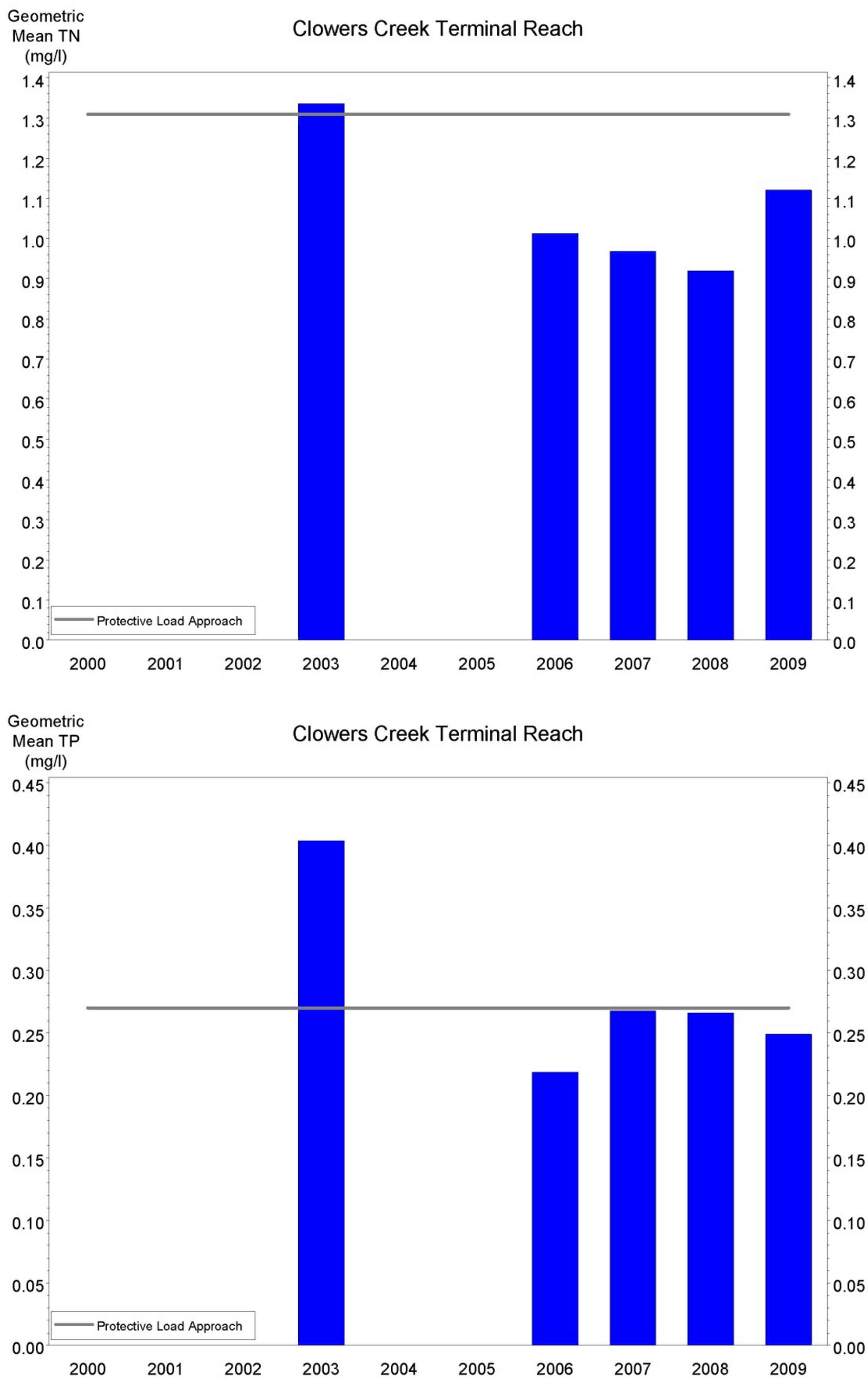


Figure 11. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in the Clowers Creek (Little Sarasota Bay).

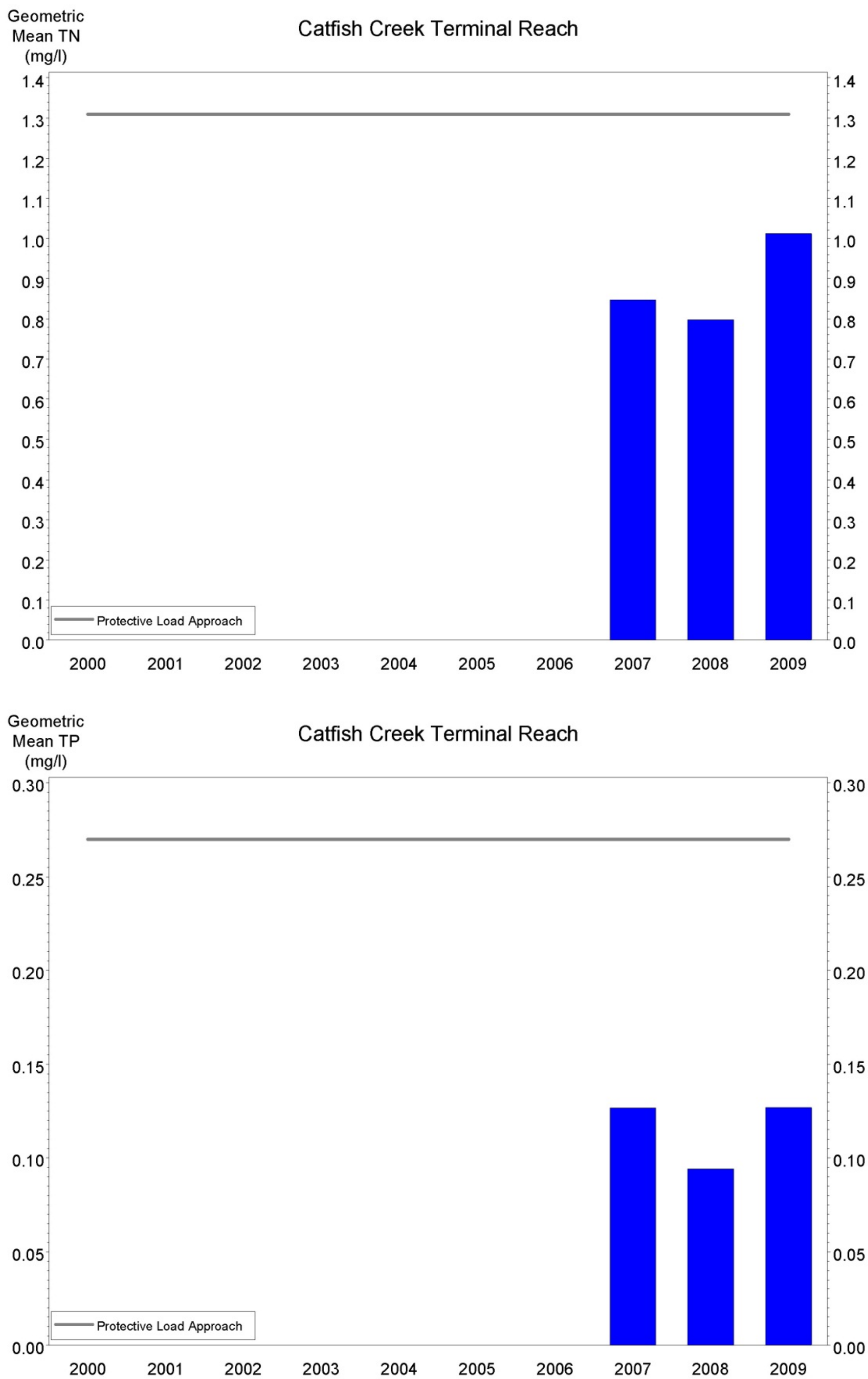


Figure 12. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in Catfish Creek (Little Sarasota Bay).

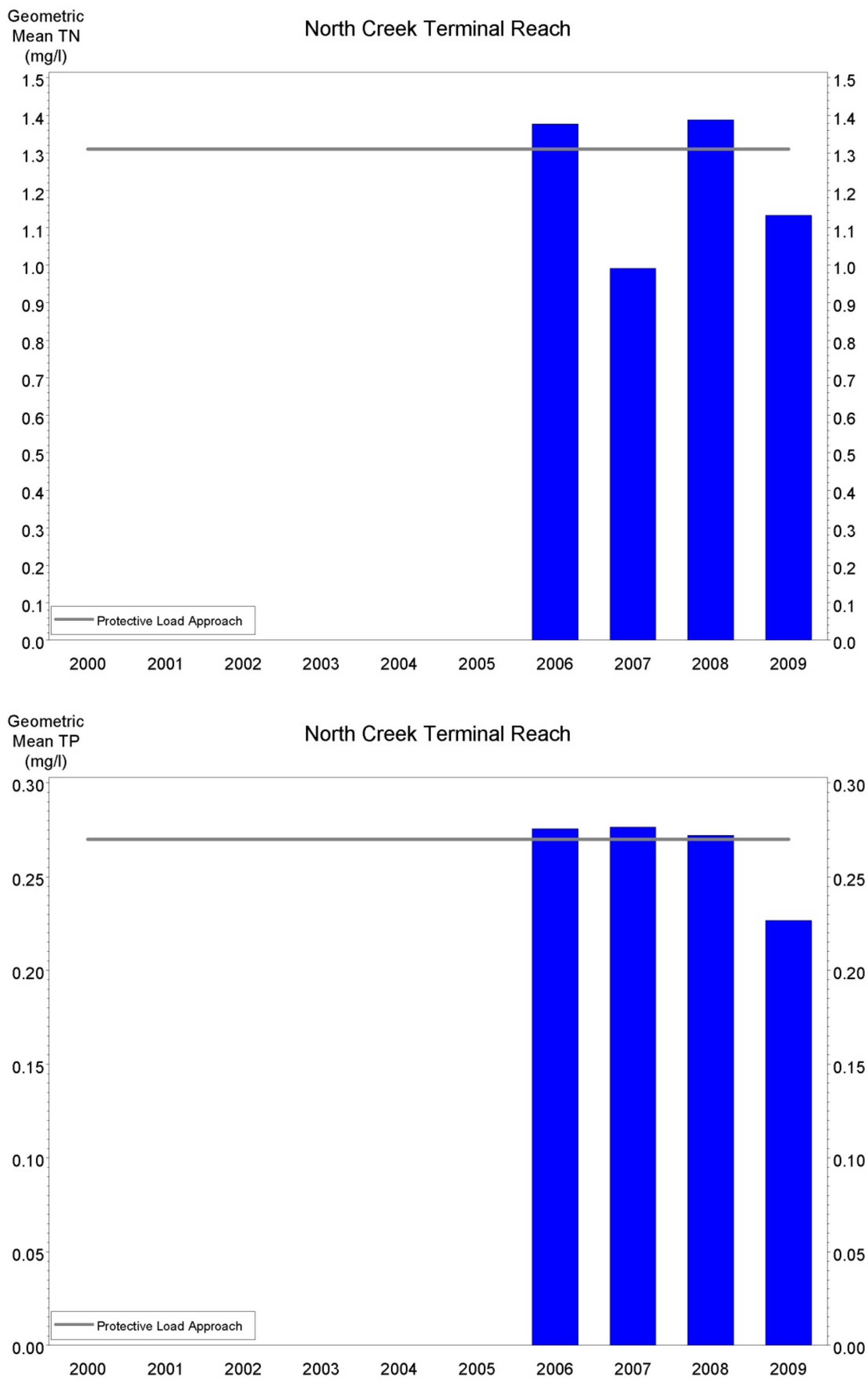


Figure 13. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Protective Load approach to the annual geometric means observed in North Creek (Little Sarasota Bay).

4.3 Proposed DPVs for Terminal Reaches Based on the Reference Period Approach

An alternative to the approach suggested by EPA (2010b) is to use the Reference Period approach to develop DPVs for the terminal reaches of tributaries in the SBEP area. This approach was employed to develop nutrient criteria for the segments in the SBEP area (Janicki Environmental 2010a). However, because adequate water quality data were not available for the terminal reaches of tributaries in the study area for the period 2001-2005, the Reference Period was expanded to include 2001-2008. It should be noted that the segments were meeting water quality criteria during this expanded Reference Period, thus justifying the expanded Reference Period. The proposed Reference Period approach consists of estimating the tributary-specific TN and TP **targets** (values at this level or below indicate desirable conditions) for the Reference Period. After the targets are calculated, the year-to-year variability in TN and TP concentrations is estimated by calculating the standard deviation of the annual TN and TP concentrations. The mean and standard deviation by terminal reach are presented in Table 3 for TN and TP.

Table 3. Means and standard deviations of TN and TP in terminal reaches.

	Mean (mg/l)		Standard Deviation (mg/l)	
Terminal Reach	**TN**	**TP**	**TN**	**TP**
Bowlees Creek	1.22	0.26	0.24	0.06
Hudson Bayou	0.81	0.51	0.07	0.24
Philippi Creek	0.54	0.21	0.51	0.10
Matheny Creek	0.66	0.20	0.50	0.22
Elligraw Bayou	1.13	0.36	0.33	0.03
Clowers Creek	1.07	0.28	0.17	0.07
Catfish Creek	0.89	0.12	0.46	0.15
North Creek	1.22	0.26	0.24	0.07

4.4 Comparison of Proposed DPVs Based on the Reference Period Approach to Observed TN and TP Concentrations in Terminal Reaches

As discussed in Section 4.2, ambient nutrient concentration data are not available for all of the terminal reaches within the SBEP area. There are eight tributaries with sufficient nutrient concentration data (i.e., at least four samples per year) that drain to three of the segments (see Section 4.2).

The observed water quality stations used for the analysis are presented in Figures 3 through 5 for Sarasota Bay, Roberts Bay, and Little Sarasota Bay, respectively. As discussed above, the proposed DPVs based on the Reference Period approach are tributary-specific. As was done previously for development of nutrient criteria in the segments (Janicki Environmental 2010a), the **threshold** was calculated by summing the TN and TP target and the standard deviation of the long-term TN and TP concentrations. The proposed TN and TP DPVs based on the Reference Period approach for the terminal reaches of tributaries in the SBEP area are presented in Table 4.

Table 4. Proposed TN and TP DPVs based on the Reference Period approach for the eight terminal reaches within SBEP area with available ambient TN and TP concentration data.			
Terminal Reach	**Segment**	**TN DPV (mg/L)**	**TP DPV (mg/L)**
Bowlees Creek	Sarasota Bay	1.45	0.32
Hudson Bayou	Sarasota Bay	0.89	0.75
Philippi Creek	Roberts Bay	1.04	0.32
Matheny Creek	Roberts Bay	1.17	0.41
Elligraw Bayou	Little Sarasota Bay	1.46	0.39
Clowers Creek	Little Sarasota Bay	1.24	0.35
Catfish Creek	Little Sarasota Bay	1.35	0.26
North Creek	Little Sarasota Bay	1.46	0.34

The annual geometric mean TN and TP concentrations (2000-2009) for the terminal reaches of the eight tributaries are presented in Figures 14 through 21 along with the proposed DPVs based on the Reference Period approach. Unlike the Protective Load approach, no terminal reach had annual geometric mean TN or TP concentrations that would have resulted in exceedances during the recent period (2005-2009) based on Reference Period approach, regardless of the proposed temporal assessment scheme (1 in 3 years or 2 in 5 years). This is consistent with the findings of Janicki Environmental (2010a) with regard to the segments, where TN and TP concentrations in these segments have been meeting the proposed nutrient criteria in recent years (Janicki Environmental 2010a).

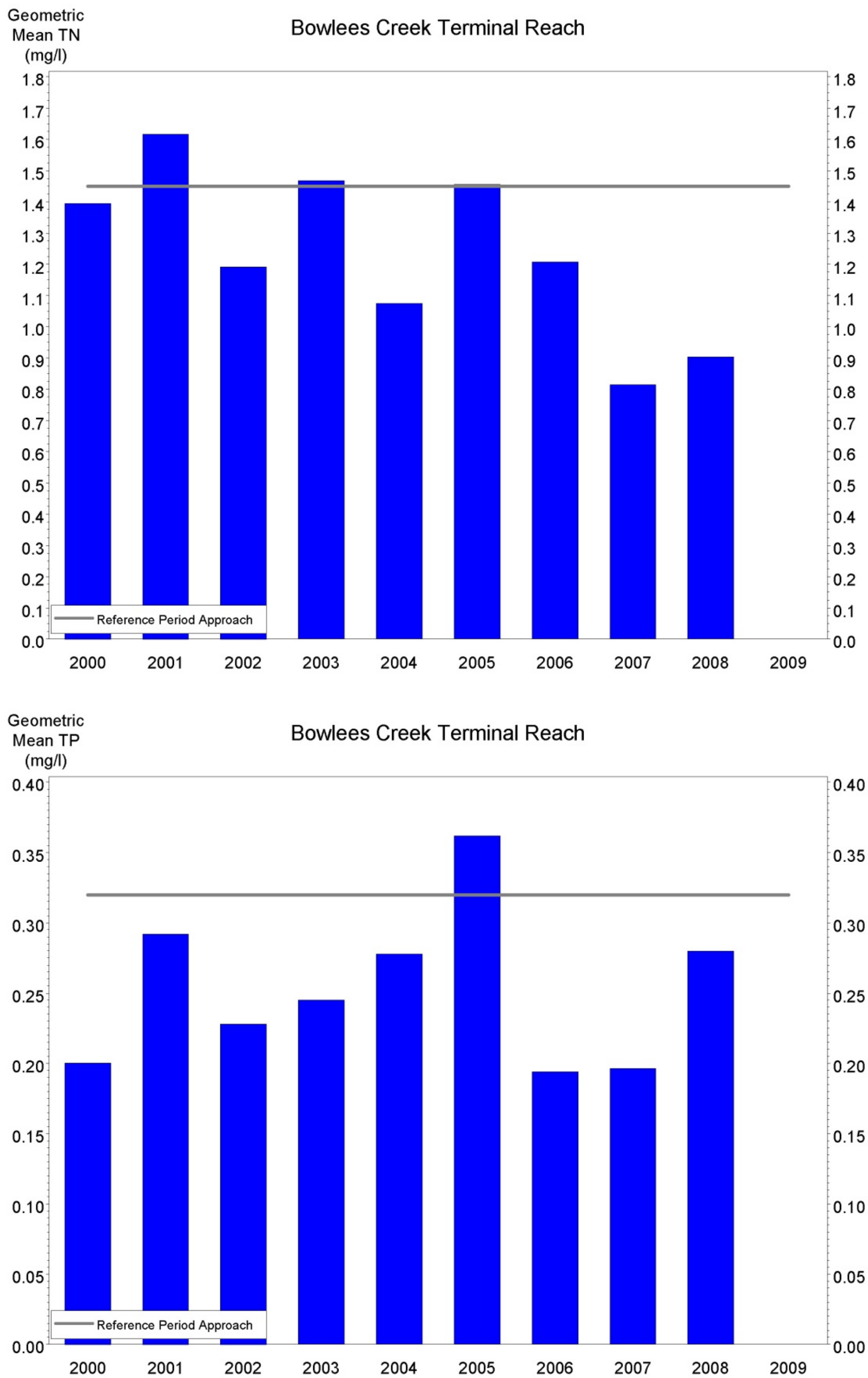


Figure 14. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in Bowlees Creek (Sarasota Bay).

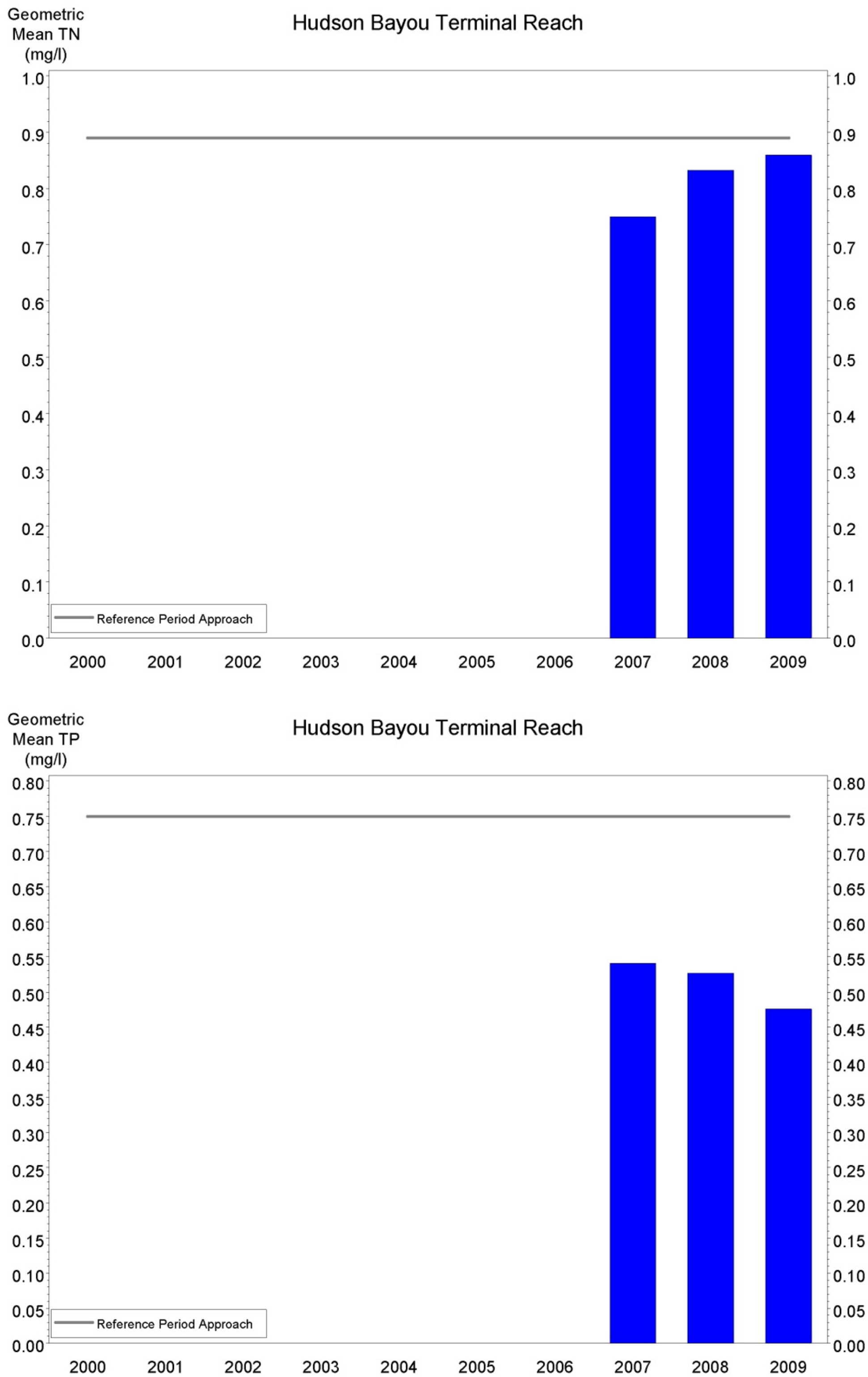


Figure 15. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in Hudson Bayou (Sarasota Bay).

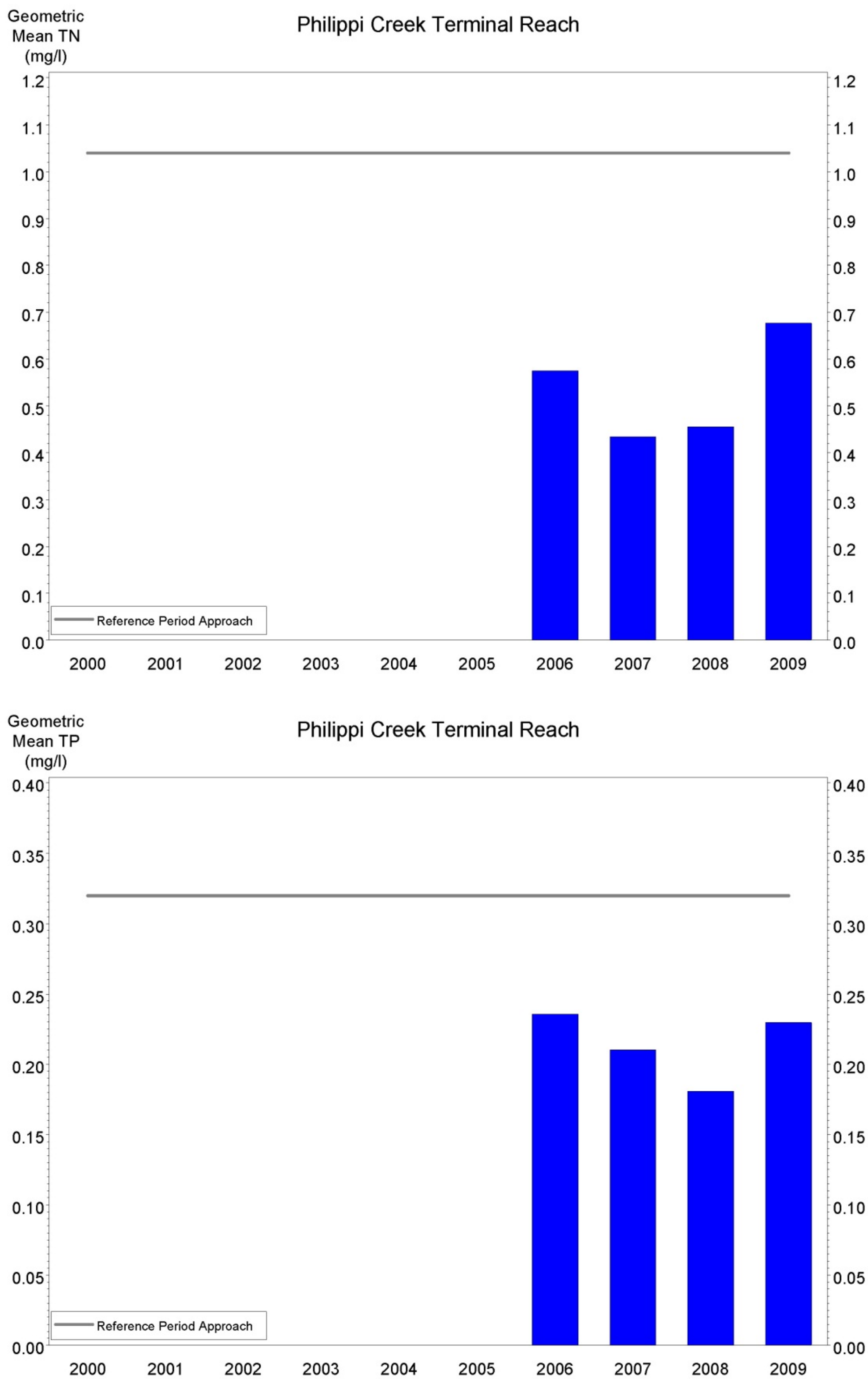


Figure 16. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in Philippi Creek (Roberts Bay).

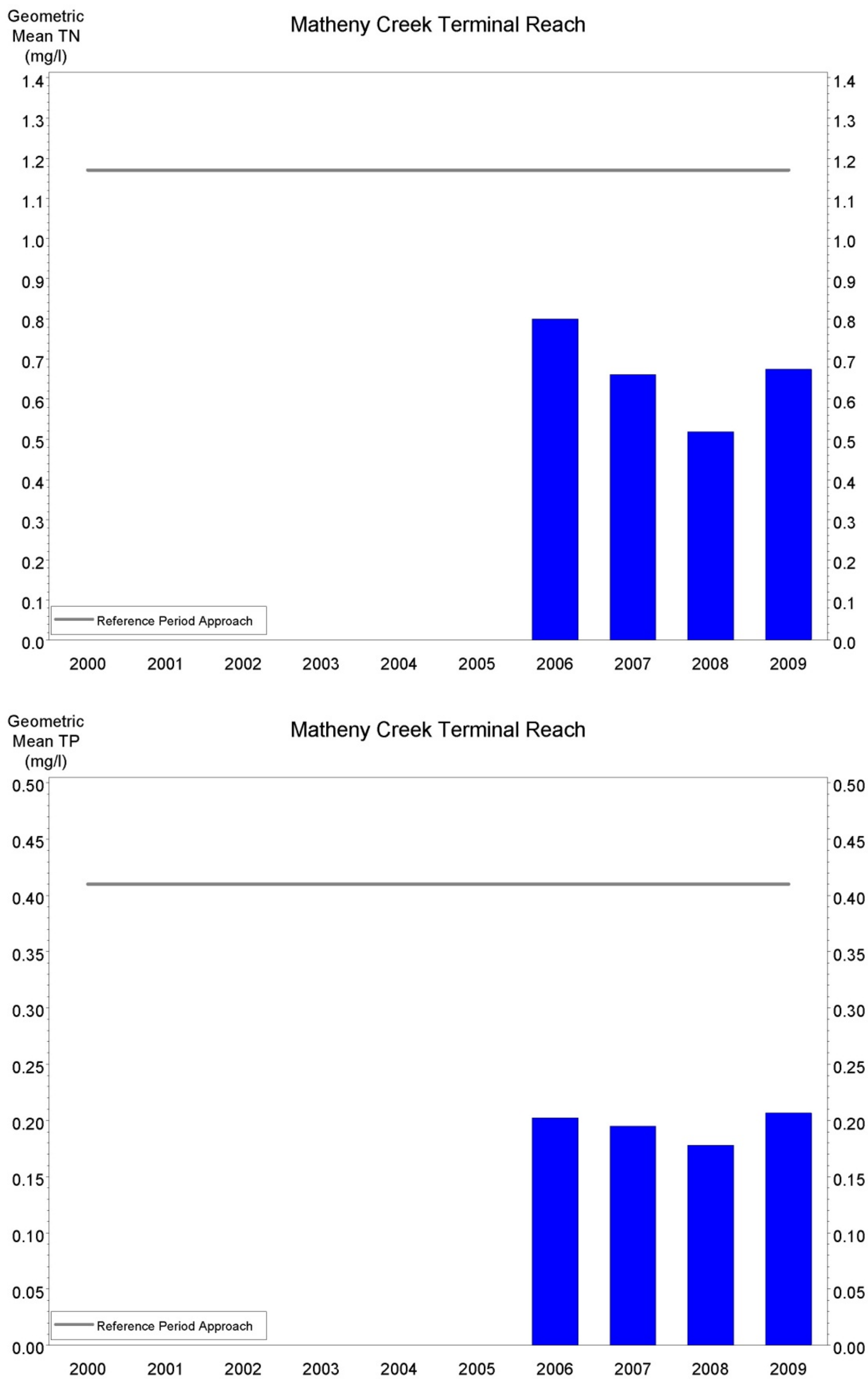
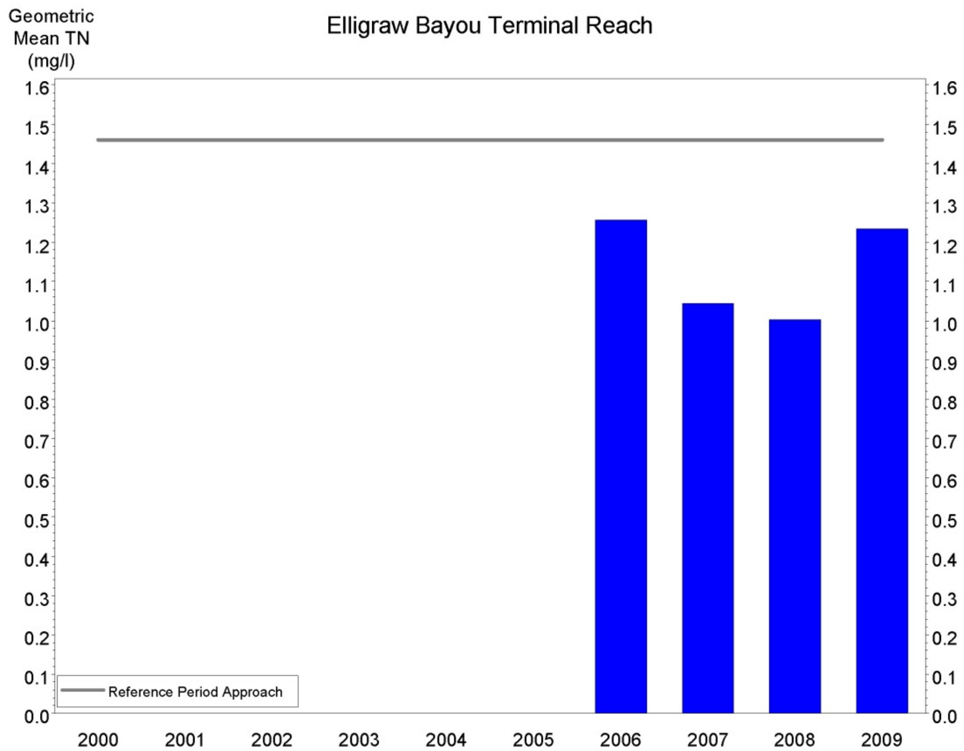


Figure 17. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in Matheny Creek (Roberts Bay).



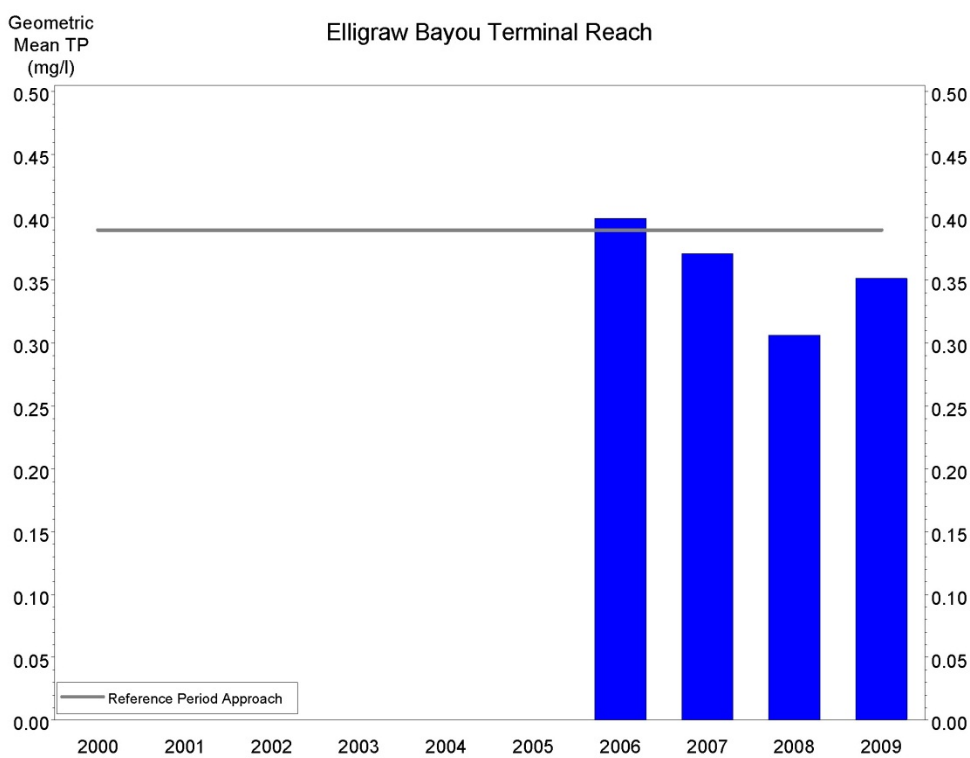
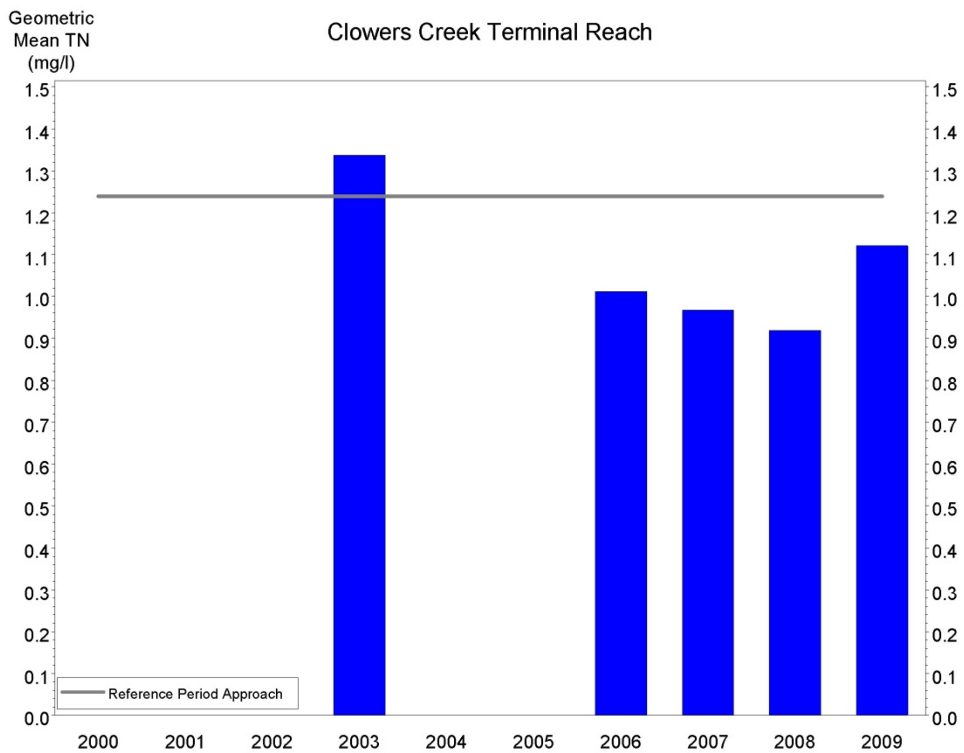


Figure 18. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in the Elligraw Bayou (Little Sarasota Bay).



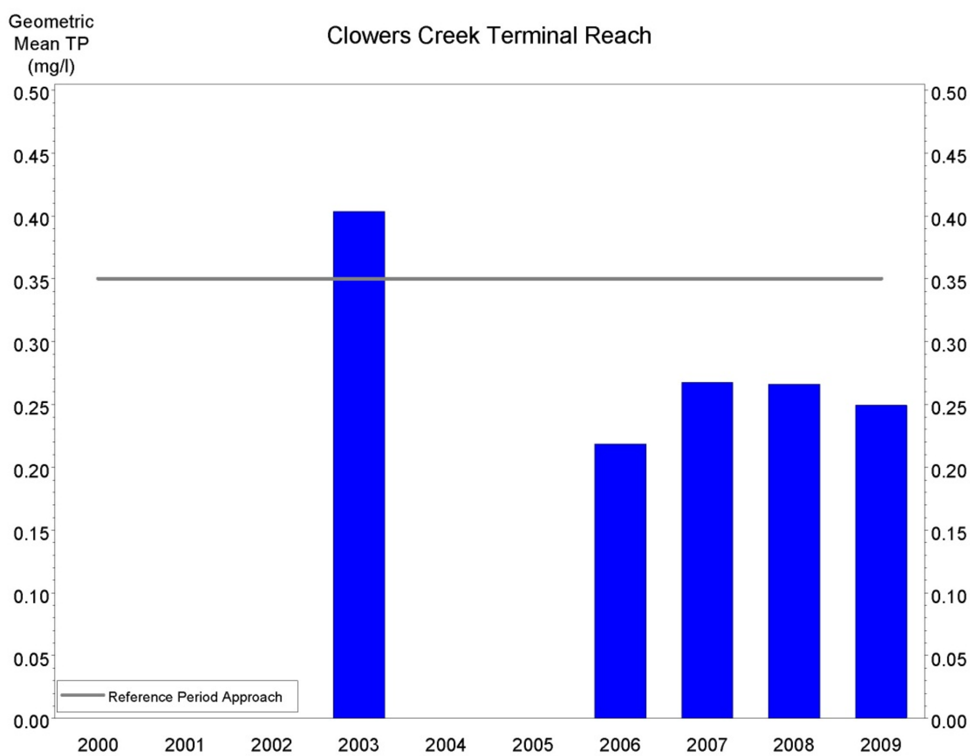


Figure 19. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in the Clowers Creek (Little Sarasota Bay).

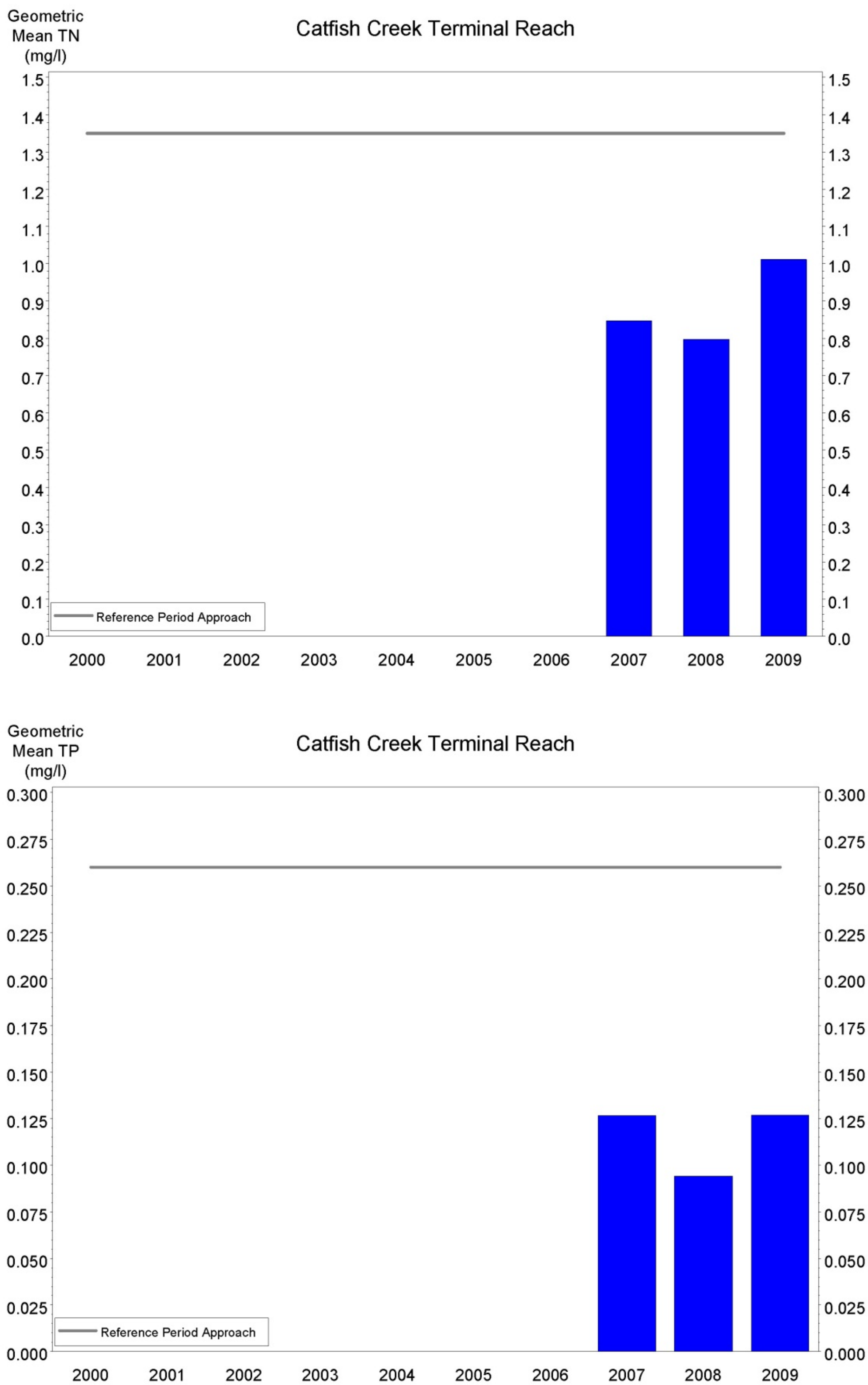


Figure 20. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in Catfish Creek (Little Sarasota Bay).

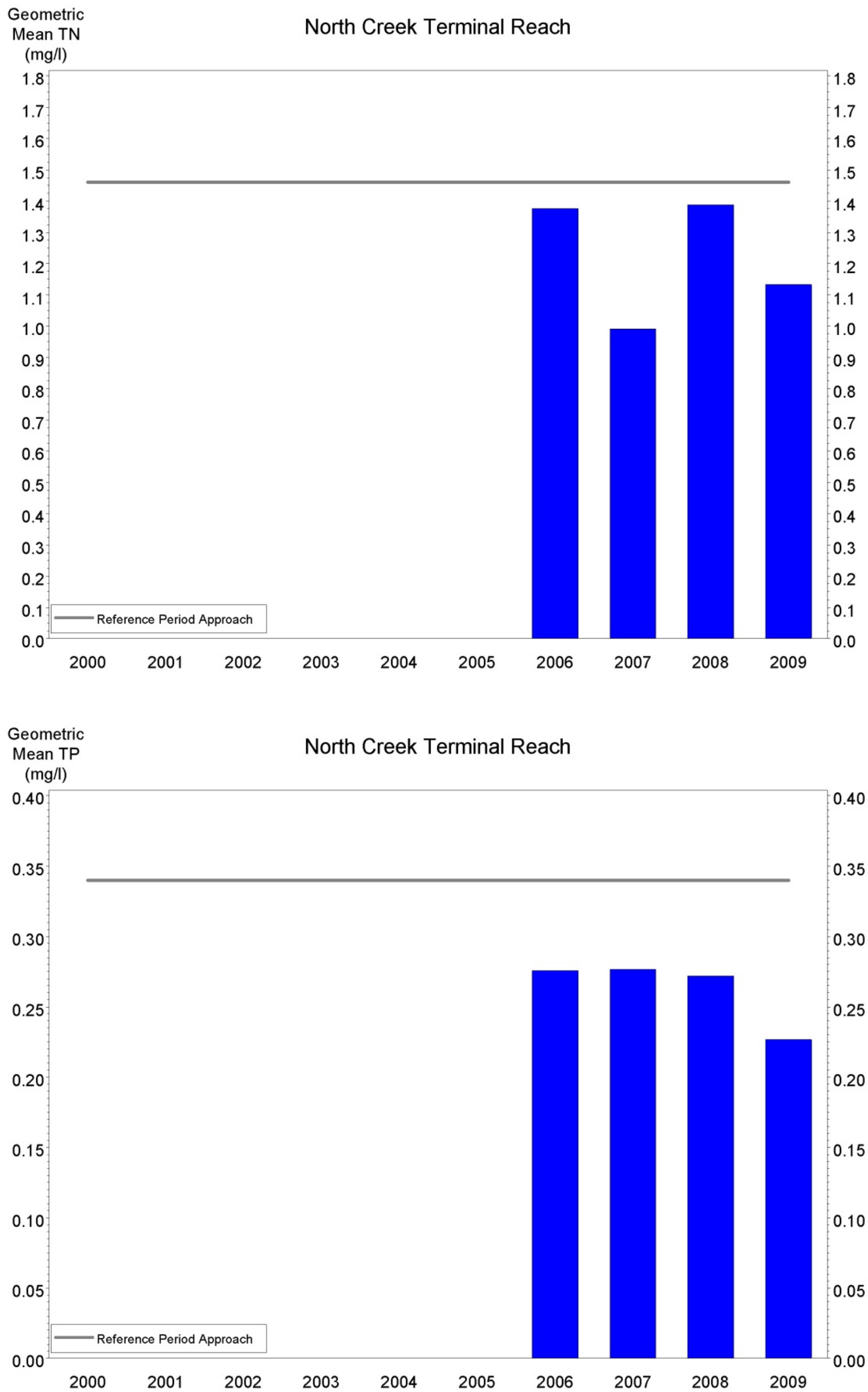


Figure 21. Comparison of proposed interim TN (upper panel) and TP (lower panel) DPVs based on the Reference Period approach to the annual geometric means observed in North Creek (Little Sarasota Bay).

4.5 Comparison of Proposed DPVs to Promulgated TN and TP Instream Protective Values (IPVs)

As stated in EPA (2010b), "For a given waterbody, the annual geometric mean of TN or TP concentrations shall not exceed the applicable criterion concentration more than once in a three-year period." The proposed DPVs for the SBEP area terminal reaches can be compared to the Instream Protective Values (IPVs) recently promulgated by EPA (2010b). These IPVs for all of Florida are included in Table 5 for reference, however only the Peninsula IPVs (shaded values) apply to streams in the Sarasota Bay Estuary Program area.

Table 5. EPA's Numeric Criteria for Florida streams (from Table B-1 of EPA 2010b).

Nutrient Watershed Region	TN IPV (mg/L)	TP IPV (mg/L)
Panhandle West	0.67	0.06
Panhandle East	1.03	0.18
North Central	1.87	0.30
West Central	1.65	0.49
Peninsula	1.54	0.12

Comparison of the proposed DPVs based on the Protective Load approach and the IPVs(Table 6) indicates that the promulgated IPVs are greater than the proposed DPVs for TN in all segments, suggesting that the proposed IPVs would not be stringent enough for TN in the terminal reaches of the SBEP area. With regard to TP, the promulgated IPVs are significantly less than the proposed DPVs in all segments based on the Protective Load approach. The promulgated IPVs would lead to exceedances in all terminal reaches of the Sarasota Bay Estuary Program area despite the fact that TP concentrations in the segments are below the proposed nutrient criteria (Janicki Environmental 2010a).

Table 6. Proposed DPVs based on the Protective Load approach for TN and TP in Sarasota Segment terminal reaches and EPA's promulgated IPVs.

Segment	TN DPV (mg/L)	TN IPV (mg/L)	TP DPV (mg/L)	TP IPV (mg/L)
Palma Sola Bay	1.42	1.54	0.29	0.12
Sarasota Bay	1.47	1.54	0.28	0.12
Roberts Bay	1.38	1.54	0.28	0.12
Little Sarasota Bay	1.31	1.54	0.27	0.12
Blackburn Bay	1.42	1.54	0.24	0.12

Comparison of the proposed DPVs based on the Reference Period approach and IPVs (Table 7) indicates that the promulgated IPVs are greater than the proposed DPVs for TN in all segments, suggesting that the proposed IPVs would not be stringent enough for TN in the terminal reaches of the Sarasota Bay Estuary Program area. With regard to TP, the promulgated IPVs are significantly less than the proposed DPVs in all segments based on the Reference Period approach. The proposed IPVs would lead to exceedances in all terminal reaches of the SBEP area despite the fact that TP concentrations in the segments have been lower than the proposed nutrient criteria (Janicki Environmental 2010a).

Table 7. Proposed TN and TP DPVs based on the Reference Period approach for the eight terminal reaches and EPA promulgated IPVs.				
Terminal Reach	**TN DPV (mg/L)**	**TN IPV (mg/L)**	**TP DPV (mg/L)**	**TP IPV (mg/L)**
Bowlees Creek	1.45	1.54	0.32	0.12
Hudson Bayou	0.89	1.54	0.75	0.12
Philippi Creek	1.04	1.54	0.32	0.12
Matheny Creek	1.17	1.54	0.41	0.12
Elligraw Bayou	1.46	1.54	0.39	0.12
Clowers Creek	1.24	1.54	0.35	0.12
Catfish Creek	1.35	1.54	0.26	0.12
North Creek	1.46	1.54	0.34	0.12

4.6 Recommended Protocol for Assessing DPV Compliance

As discussed above, the proposed, terminal reach DPVs based on the Reference Period approach are tributary-specific and resulted in no exceedances in the recent period (2005-2009). This approach is therefore consistent with the results of an assessment of nutrient criteria for the segments which also resulted in no exceedances for the same period (Janicki Environmental 2010a). However, DPVs were not calculated for terminal reaches in Palma Sola and Blackburn bays because of a lack of water quality data.

As loading estimates are available for all segments of the SBEP area, DPVs based on the Protective Load approach were calculated for all five SBEP segments. However, the same segment-specific DPVs were applied to all terminal reaches within a segment. The proposed terminal reach DPVs based on the Protective Load approach are exceeded for TP in three cases, Hudson Bayou, Elligraw Bayou, and North Creek. Hudson Bayou drains to Sarasota Bay, while Elligraw Bayou and North Creek drain to Little Sarasota Bay. These exceedances are despite the fact that both Sarasota Bay and Little Sarasota Bay are meeting their nutrient criteria during the same period. Given this disconnect between the DPVs based on the Protective Load approach and the segment nutrient criteria, the following approach for assessing compliance with DPVs in the Sarasota Bay Estuary Program area is proposed.

Conceptually, assessment of compliance with a DPV necessarily should require consideration of the water quality conditions in the downstream estuarine receiving waterbody (i.e., the segment). Therefore, the initial step in the proposed approach is an annual examination of the ambient water quality condition in the segment relative to the proposed chlorophyll threshold and nutrient criteria. If the chlorophyll threshold and nutrient criteria are being met, it logically follows that the water quality in the terminal reaches (i.e., "pour points") are collectively protective of the downstream estuarine receiving waterbody. Therefore, further analysis of the terminal reach water quality data may not be necessary. However, if exceedances are documented in the annual examination of ambient water quality in the segment, further analysis of water quality in the terminal reaches is required to attempt to identify the cause of the exceedance. The preferred method to identify the tributaries that would be responsible for the exceedence is to use the Reference Period approach. For streams that do not have adequate data, an average should be calculated for nearby streams to serve as a proxy until sufficient data area available.

5.0 Conclusions

The following conclusions can be drawn from the analyses and results discussed above:

- Though EPA has decided to delay promulgation of DPVs until 2011, DPVs will be required for all tributaries that flow into segments of the SBEP area.
- The water quality within the tributaries must be protective of the downstream estuarine waters.
- Sufficient water quality data do not exist for several of these systems, making it impossible to develop defensible criteria using stressor-response relationships.
- If the chlorophyll threshold and nutrient criteria for a segment are being met, it logically follows that the water quality in the terminal reaches (i.e., "pour points") are collectively protective of the downstream estuarine receiving waterbody (i.e., the segment) and therefore assessment of DPV compliance is not necessary.
- Due to the disconnect present in the protective load approach for SBEP segments, if DPV compliance is necessary, the preferred method is to use the reference period approach.

The preferred method for assessment of DPV compliance is to use the reference period approach. The tributary-specific proposed TN and TP DPVs for the tributaries of the SBEP area based on the Reference Period approach are:

- Bowlees Creek TN = 1.45 mg/L TP = 0.32 mg/L
- Hudson Bayou TN = 0.89 mg/L TP = 0.75 mg/L
- Philippi Creek TN = 1.04 mg/L TP = 0.32 mg/L
- Matheny Creek TN = 1.17 mg/L TP = 0.41 mg/L
- Elligraw Bayou TN = 1.46 mg/L TP = 0.39 mg/L
- Clowers Creek TN = 1.24 mg/L TP = 0.35 mg/L
- Catfish Creek TN = 1.35 mg/L TP = 0.26 mg/L
- North Creek TN = 1.46 mg/L TP = 0.34 mg/L

6.0 Literature Cited

Hagy, J. 2010. Chapter 6: Numeric Nutrient Criteria Development for Protection of Downstream Estuaries. Presented to the EPA Science Advisory Board, December 13-14, 2010. Washington, D.C.

Janicki Environmental, Inc. 2010a. Recommended Numeric Nutrient Criteria for Sarasota Bay. Prepared for Sarasota Bay Estuary Program.

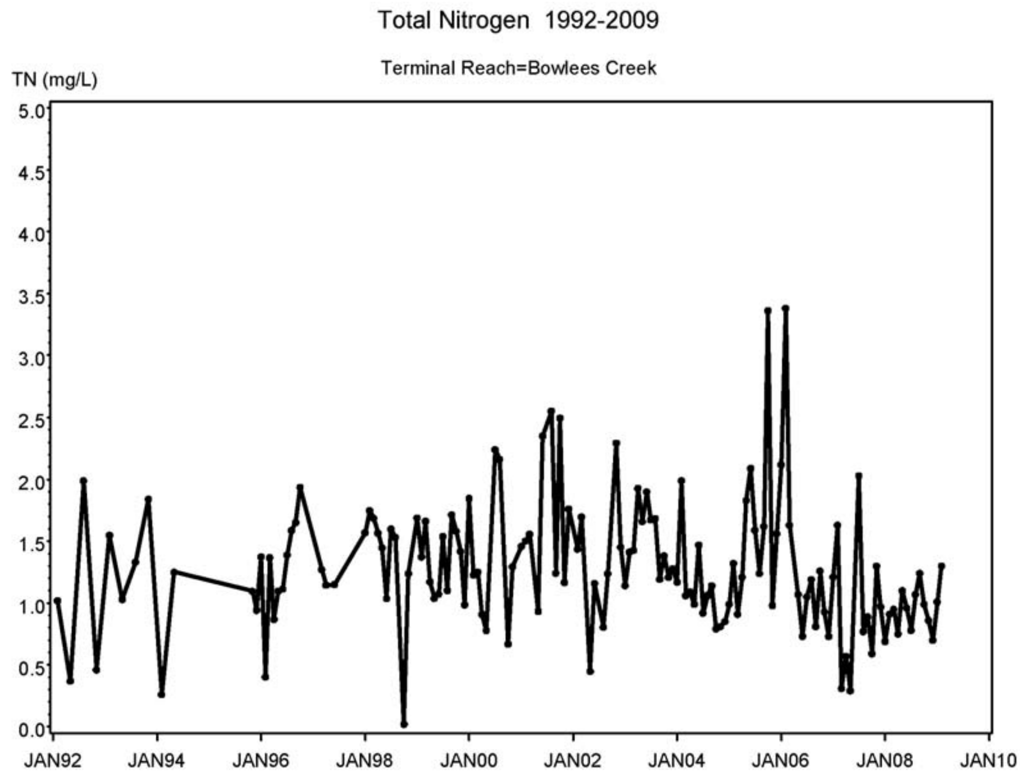
Janicki Environmental, Inc. 2010b. Sarasota Bay Numeric Nutrient Criteria: Task 1 – TN and TP Concentrations. Draft Letter Memorandum. Prepared for Sarasota Bay Estuary Program.

U.S. Environmental Protection Agency (EPA). 2010a. Water Quality Standards for the State of Florida's Lakes and Flowing Waters. Proposed Rule. 40 CFR Part 131. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2010b. Water Quality Standards for the State of Florida's Lakes and Flowing Waters. Final Rule. 40 CFR Part 131. Washington, D.C.

Attachment 1

Time Series Plots of TN and TP by Terminal Reach


Total Nitrogen 1992-2009
Terminal Reach=Bowlees Creek
TN (mg/L)
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1.0
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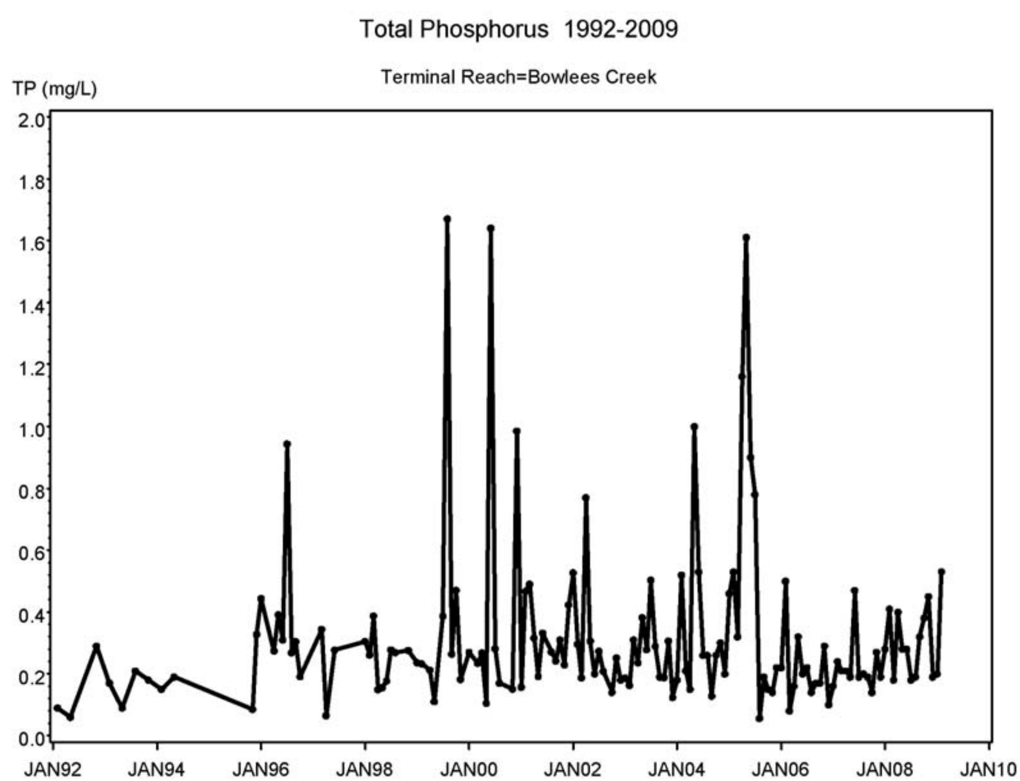
JAN10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Terminal Reach=Bowlees Creek
TP (mg/L)
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1.2
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0.6
0.4
0.2
0.0
JAN92
JAN94
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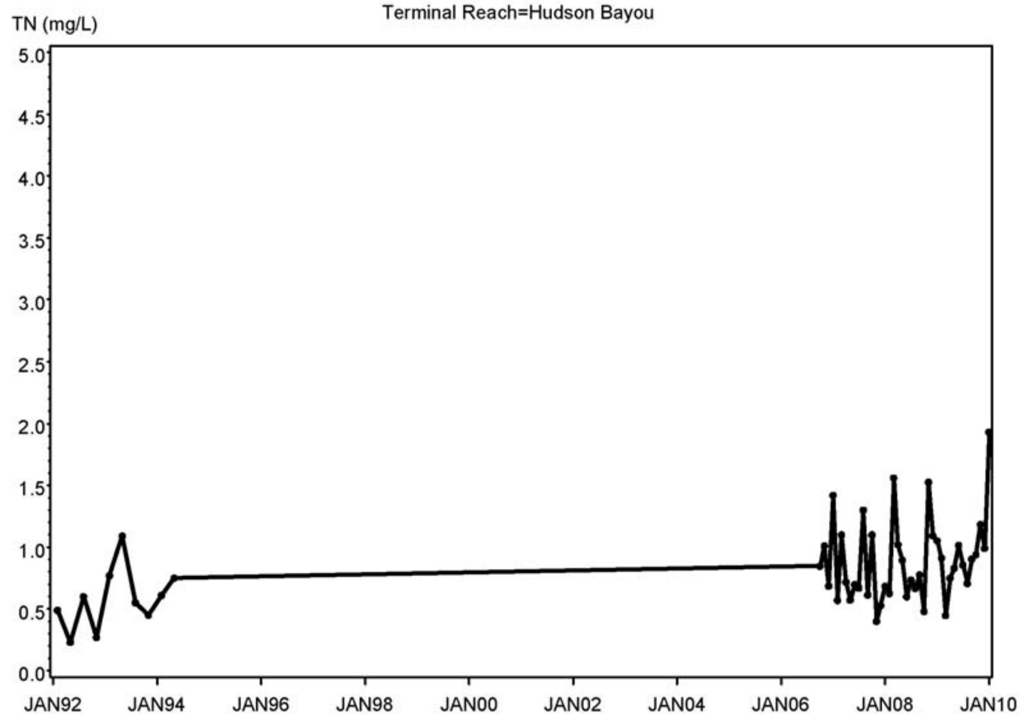
JAN08
JAN10

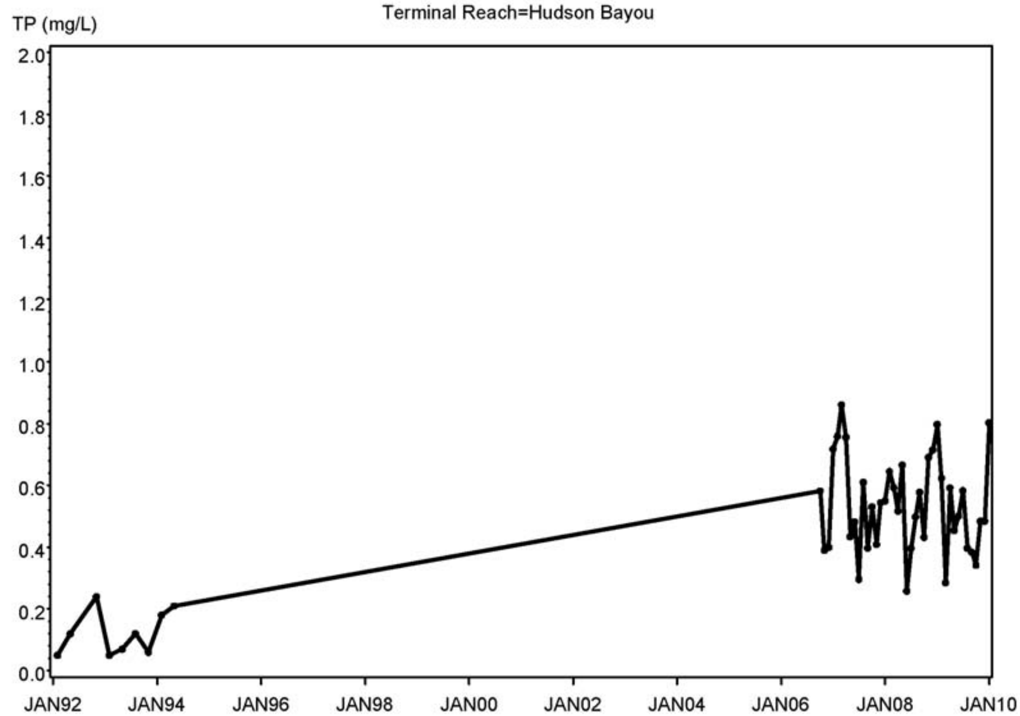
Total Nitrogen 1992-2009

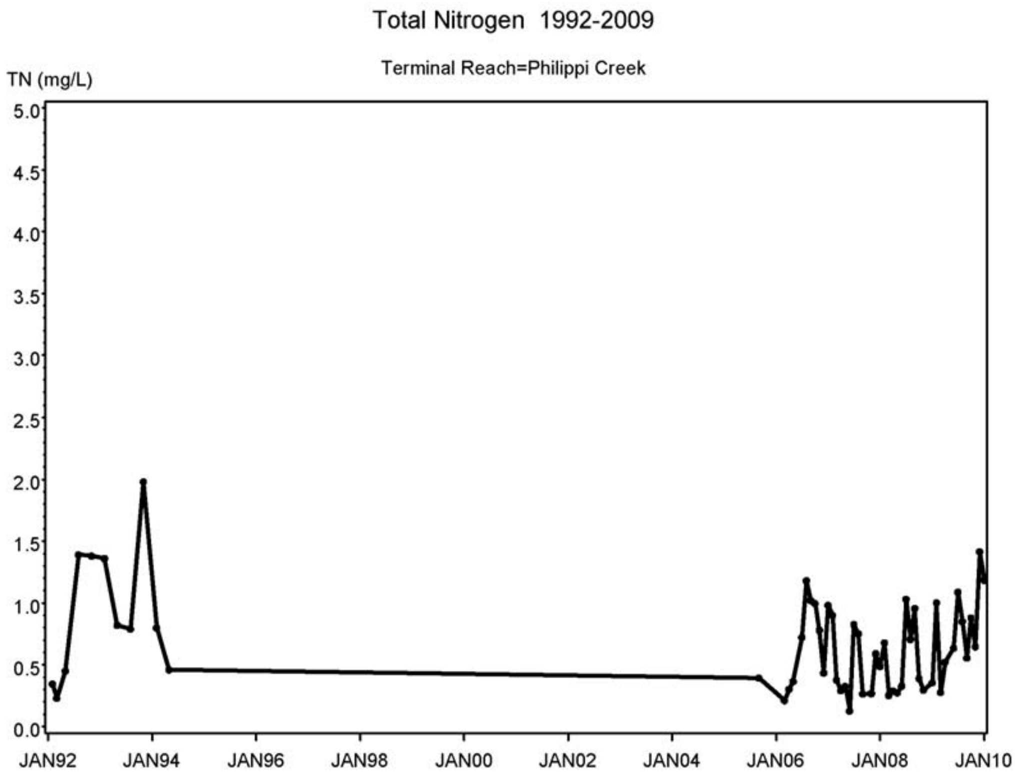
Terminal Reach=Hudson Bayou



Total Phosphorus 1992-2009

Terminal Reach=Hudson Bayou

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Terminal Reach=Philippi Creek
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1.5
1.0
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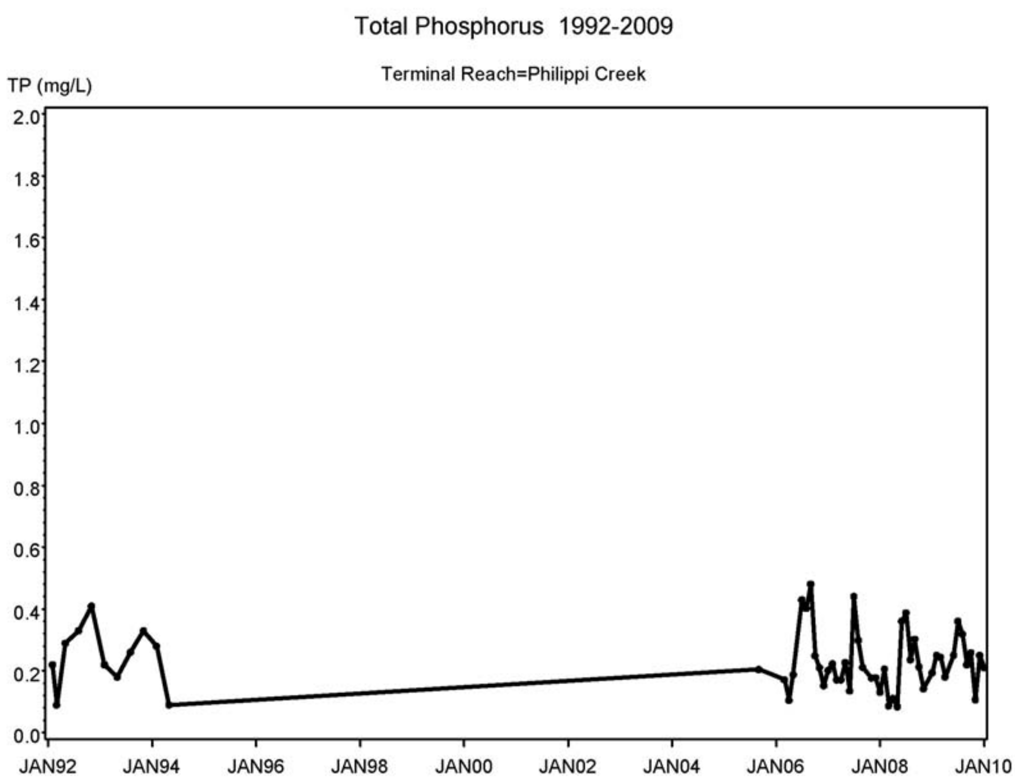
Total Phosphorus 1992-2009
Terminal Reach=Philippi Creek
TP (mg/L)
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0.6
0.4
0.2
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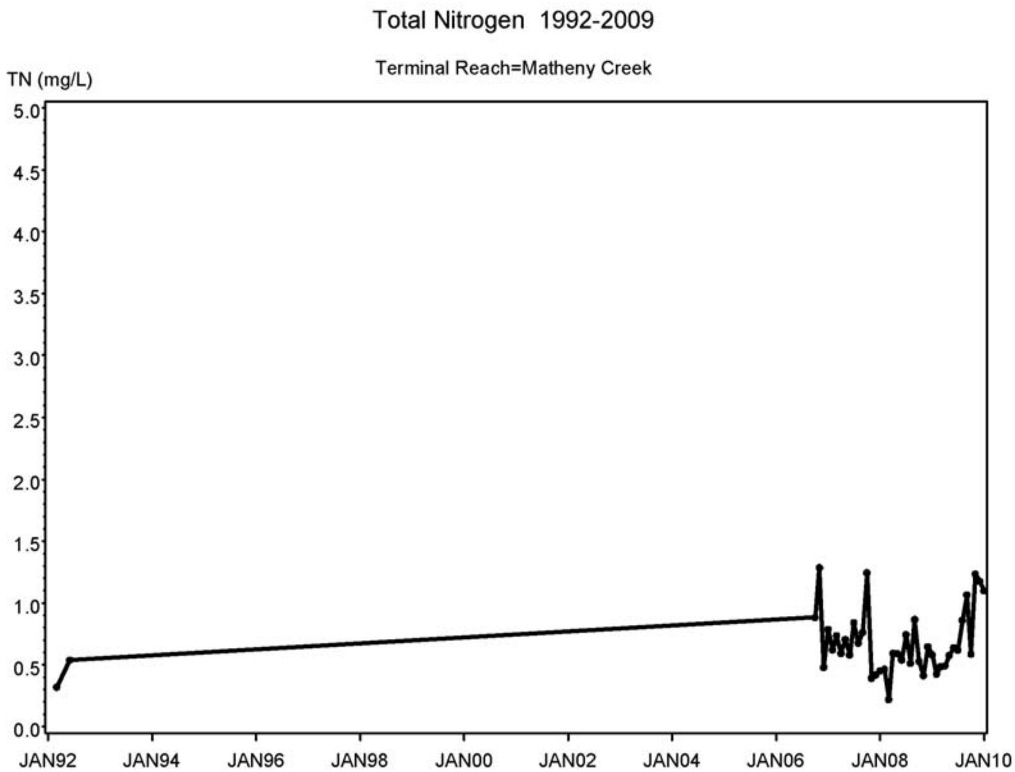
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1.0
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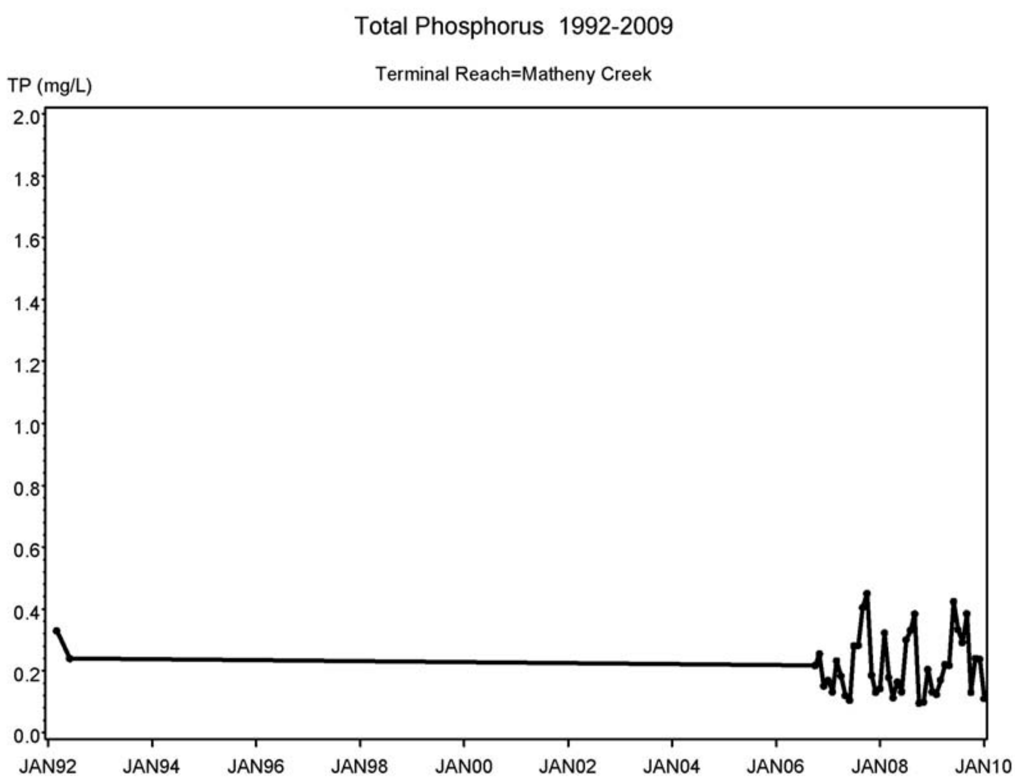
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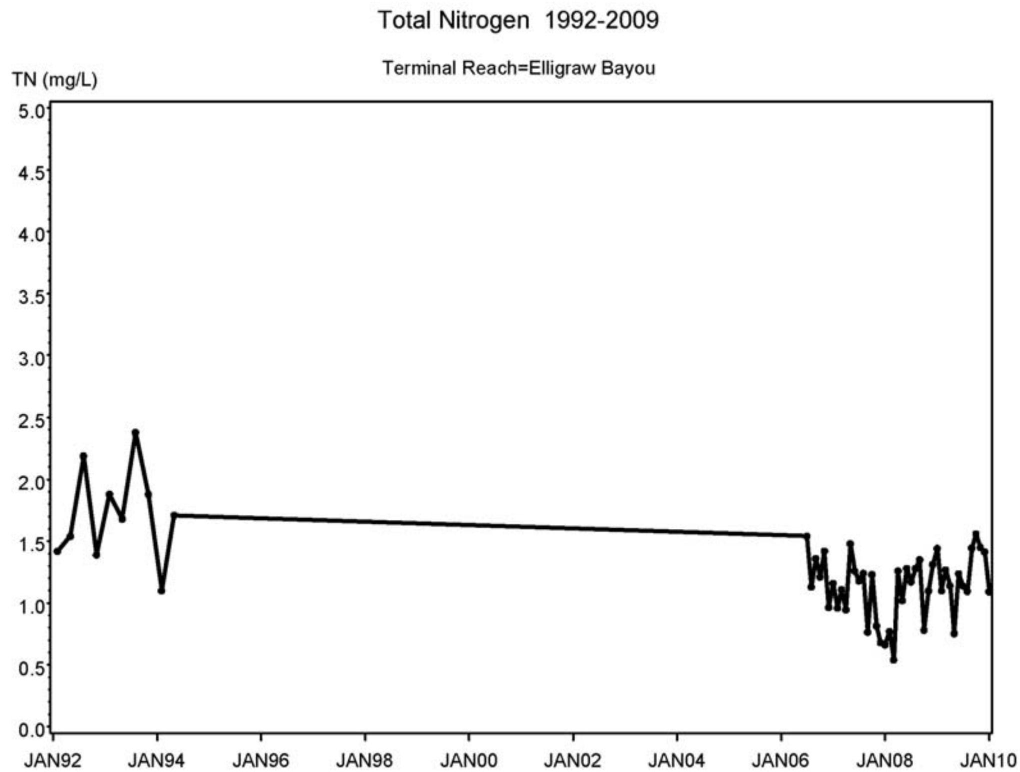
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1.5
1.0
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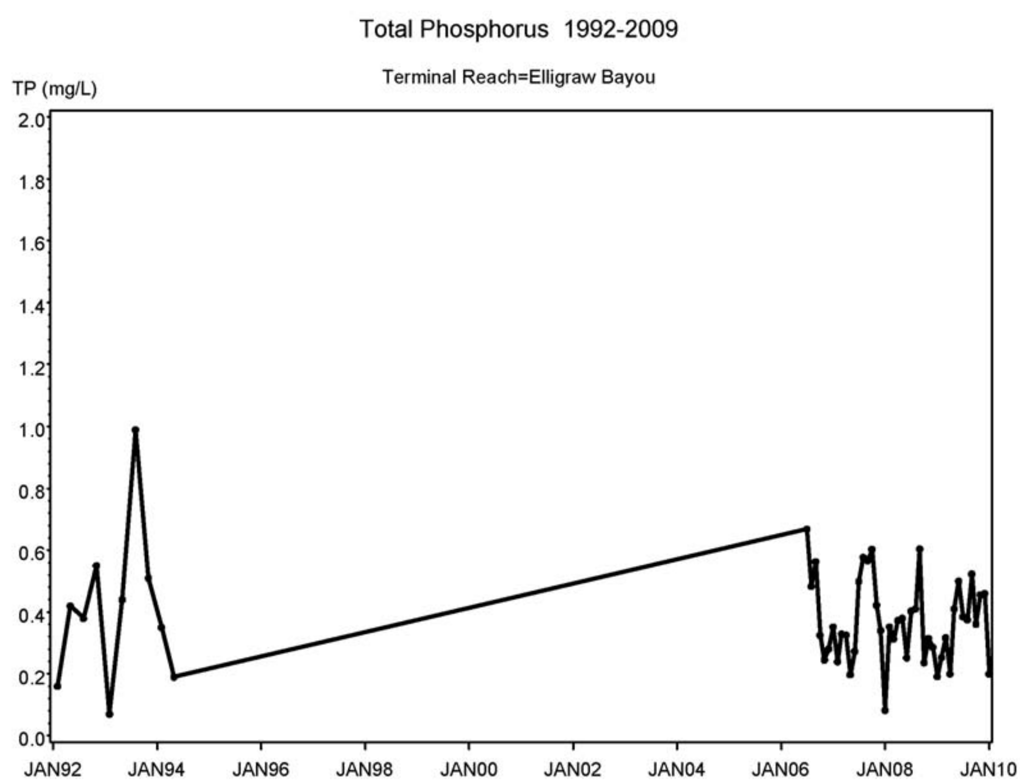
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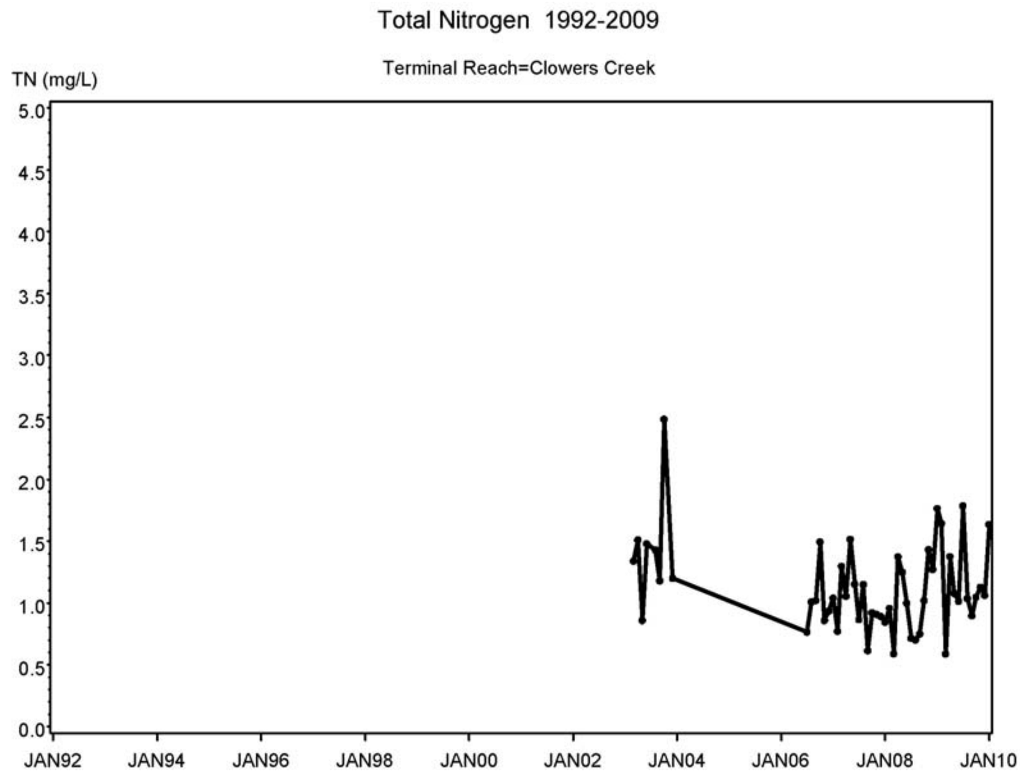
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Terminal Reach=Clowers Creek
TN (mg/L)
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1.0
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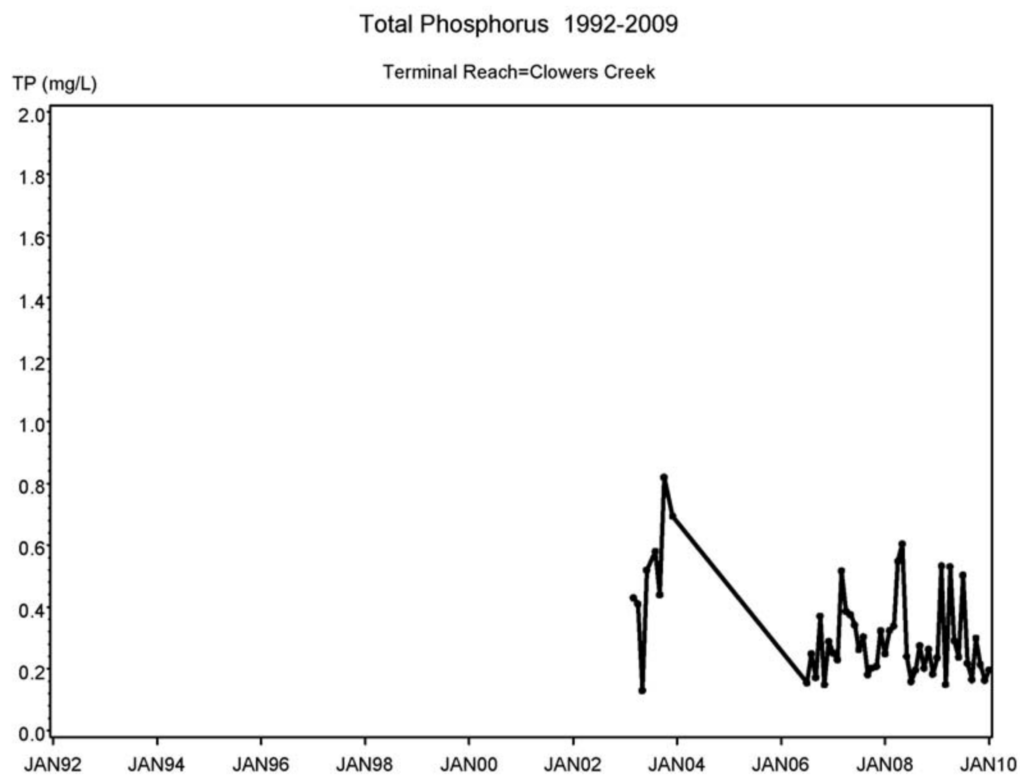
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Terminal Reach=Clowers Creek
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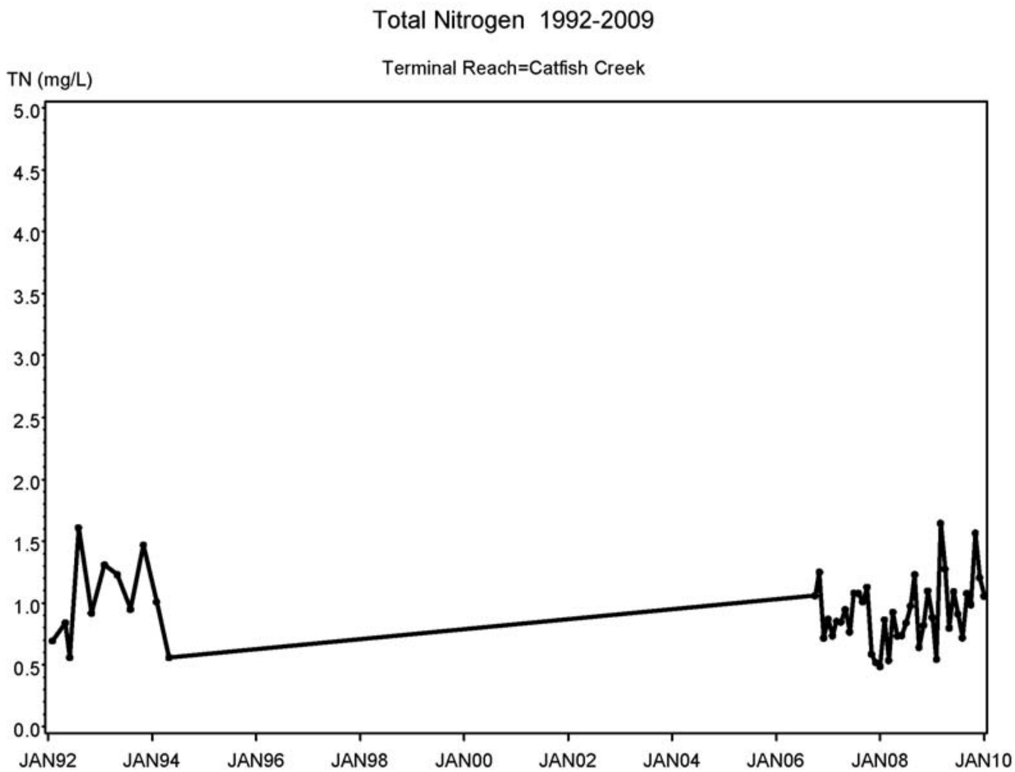
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Terminal Reach=Catfish Creek
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1.0
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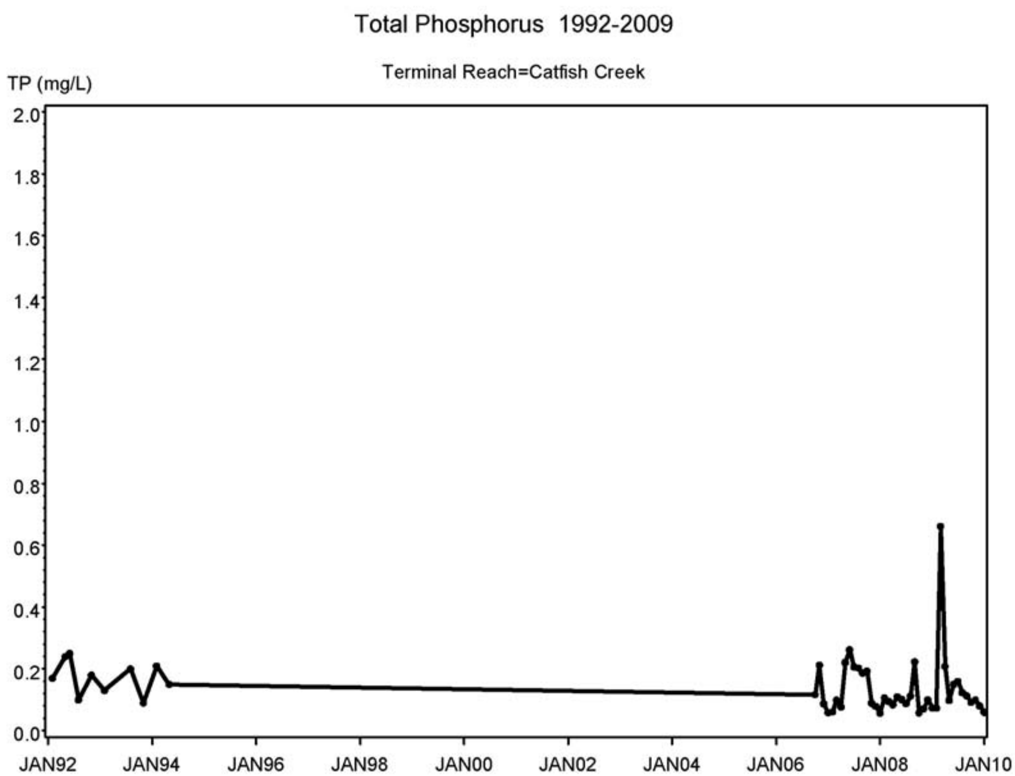
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0.6
0.4
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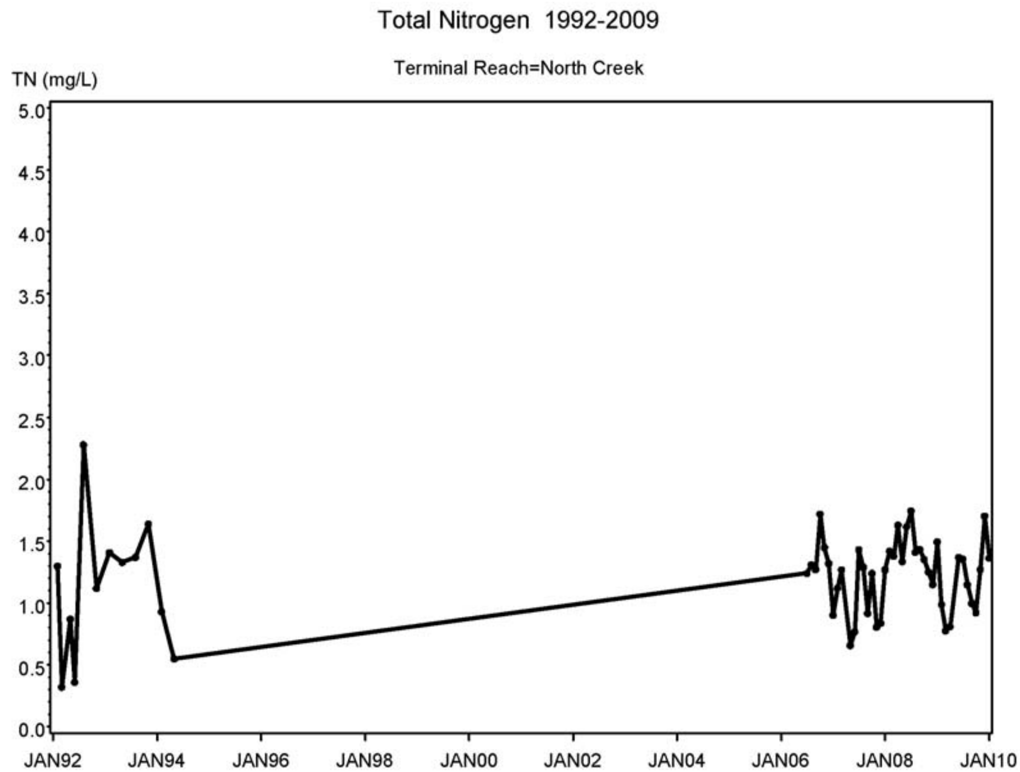
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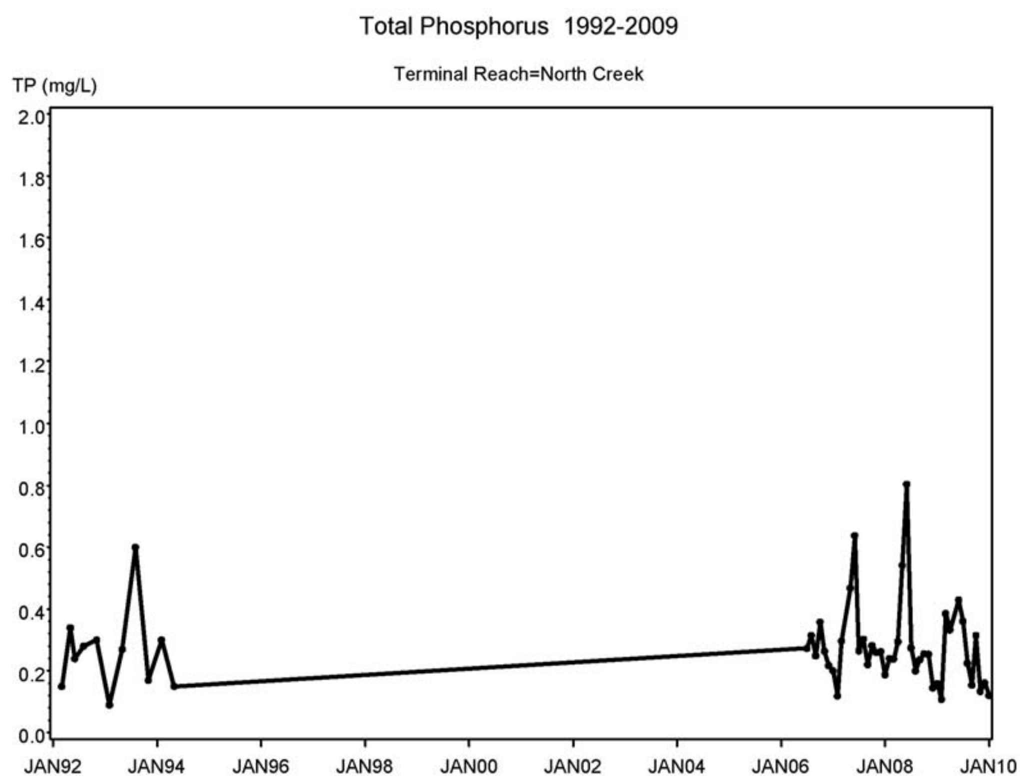
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Terminal Reach=North Creek
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