Amendment to the
Northeast, Upper Raritan, Sussex County and
Upper Delaware Water Quality Management Plans

Total Maximum Daily Load Report
For the
Non-Tidal Passaic River Basin
Addressing Phosphorus Impairments

Watershed Management Areas 3, 4 and 6

Proposed: May 7, 2007
Established:
Approved:
Adopted:

New Jersey Department of Environmental Protection
Division of Watershed Management
P.O. Box 418
Trenton, New Jersey 08625-0418

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1.0 Executive Summary

This Total Maximum Daily Load (TMDL) document addresses phosphorus impairments in the non-tidal Passaic River basin, i.e., the river and its tributaries upstream of Dundee Dam, including the Wanaque Reservoir. On July 5, 2005 the Department proposed two TMDL amendments to address phosphorus in the Passaic River basin. One document addressed the Wanaque Reservoir and the Passaic River and tributaries upstream of the confluence of the Pompton and Passaic Rivers. Because of the diversion of water from the Passaic and Pompton Rivers to the Wanaque Reservoir, the Wanaque Reservoir TMDL proposed phosphorus load and wasteload allocations in the Passaic River basin upstream of the confluence of Passaic and Pompton Rivers. The other July 5, 2005 proposal addressed Pompton Lake and its drainage area and provided inputs to the Wanaque Reservoir TMDL. At that time, the Department believed that proceeding with these TMDLs would expedite attainment of water quality improvement in the Passaic River basin, in which phosphorus reductions had been stayed as a result of a settlement agreement between the Department and various wastewater treatment facilities in the basin. The Department received comments on these proposals, primarily with regard to the water quality endpoint in the Wanaque Reservoir, the mass balance model used to estimate phosphorus loadings to the reservoir, the cost to achieve the wasteload allocations assigned to wastewater treatment facilities, and the feasibility of achieving the nonpoint source load reductions specified in the TMDLs. As noted in the July 5, 2005 proposal of the Wanaque Reservoir TMDL, the Department was concurrently engaged in a basin-wide study that included extensive water quality monitoring and development of dynamic flow and water quality models. The intent of the basin-wide study was to identify in-stream critical locations, in addition to the Wanaque Reservoir, that would need phosphorus load reductions in order to attain Surface Water Quality Standards. It was recognized that an outcome of the basin-wide study could be a refinement of the load and wasteload allocations identified in the July 5, 2005 proposals. In light of delays in establishing the July 5, 2005 proposals, completion of the basin-wide study and in consideration of the comments received, the Department has determined that integration of the basin-wide study with relevant findings of the July 5, 2005 proposals is the most efficient means to achieve water quality objectives in the Passaic River basin. Therefore, the July 5, 2005 proposals will not be established. This comprehensive TMDL document, in combination with the companion TMDL document addressing Pompton Lake and its drainage area, is proposed to address the non-tidal Passaic River basin impairments identified in Tables 1 and 2.

In accordance with Section 305(b) and 303(d) of the Federal Clean Water Act (CWA), the State of New Jersey, Department of Environmental Protection (Department) is required to assess the overall water quality of the State's waters and identify those waterbodies with a water quality impairment for which TMDLs may be necessary. A TMDL is developed to identify all the contributors of a pollutant of concern and the load reductions necessary to meet the Surface Water Quality Standards (SWQS) relative to that pollutant. The Department fulfills its assessment obligation under the CWA through the Integrated Water Quality Monitoring and Assessment Report, which includes the Integrated List of Waterbodies (303(d) list) and is issued biennially. The *2004 Integrated List of Waterbodies* was adopted by the Department on October 4, 2004 (36 NJR 4543(a)) as an amendment to the Statewide Water Quality Management Plan, as part of the Department's continuing planning process pursuant to the Water Quality Planning Act at N.J.S.A.58:11A-7 and the Statewide Water Quality Management Planning rules at N.J.A.C. 7:15-6.4(a).

The *2004 Integrated List of Waterbodies* identified 17 impaired segments in the non-tidal Passaic River basin as impaired for phosphorus based on in-stream concentrations of total phosphorus in excess of 0.1 mg/l. In addition, 9 stream segments were placed on Sublist 3 because additional information was needed in order to fully assess the status of the waterbodies. The Wanaque Reservoir, although not listed as impaired on the *2004 Integrated List*, had been identified as a critical location that needed to be considered in the development of TMDLs for the impaired stream segments that are a source of phosphorus load to the reservoir. In addition, water quality data evaluated for the TMDL indicate exceedances of the numeric water quality criterion for phosphorus. The Department has recently proposed the *2006 Integrated List of Waterbodies*, which identifies impairments based on HUC 14 Assessment Units rather than stream segments associated with discrete monitoring locations. This change in assessment methodology allows establishment of a stable base of assessment units for which the attainment or non-attainment status of all designated uses within each subwatershed or assessment unit will be identified. Tables 1 and 2 and Figure 1 below show the relevant listings and their priority ranking as they appear on the 2004 and the proposed 2006 *Integrated Lists*. Table 2 also includes the intended action for each assessment unit as a result of the TMDL studies.

Table 1. Stream segments identified on Sublists 3 and 5 of the *2004 Integrated List* assessed for phosphorus impairment.

WMA	Site Id #	Station Name/Waterbody	2004 list TP status	Priority Ranking*
03	01388910	Pompton River at Rt 202 in Wayne	Sublist 5	Medium
03	01388100	Ramapo River at Dawes Highway	Sublist 5	Medium
03	01387500	Ramapo River near Mahwah	Sublist 5	Medium
03	01387014	Wanaque River at Pompton Lakes	Sublist 5	Medium
03	01387000	Wanaque River at Wanaque	Sublist 5	Medium
03	01382800	Pequannock River at Riverdale	Sublist 3	NA
03	01388720	Pompton River Trib at Ryerson Rd	Sublist 3	NA
04	01389880	Passaic River at Elmwood Park (combined with Passaic River at Merlot Ave in Fairlawn - 01389870)	Sublist 5	High

04	01389500	Passaic River at Little Falls (combined with Passaic River at Singac - 01389130)	Sublist 5	High
04	01389005	Passaic River Below Pompton River at Two Bridges	Sublist 5	High
04	01389138	Deepavaal Brook at Fairfield	Sublist 3	NA
04	01389860	Diamond Brook at Fair Lawn	Sublist 3	NA
04	01389600	Peckman River at West Paterson	Sublist 3	NA
04	01389080	Preakness Brook near Little Falls	Sublist 3	NA
06	01378855	Black Brook at Madison	Sublist 5	High
06	01379200	Dead River near Millington	Sublist 5	High
06	EWQ0231	Passaic River at Eagle Rock Ave in East Hanover	Sublist 5	High
06	01382000	Passaic River at Two Bridges	Sublist 5	High
06	01379500	Passaic River near Chatham	Sublist 5	High
06	01379000	Passaic River near Millington	Sublist 5	High
06	01381200	Rockaway River at Pine Brook	Sublist 5	High
06	01381500	Whippany River at Morristown	Sublist 5	High
06	01381800	Whippany River near Pine Brook	Sublist 5	Medium
06	01379530	Canoe Brook near Summit	Sublist 3	NA
06	01379800	Green Pond Brook at Dover	Sublist 3	NA
06	01379853	Rockaway River at Blackwell St	Sublist 3	NA

* Priority Ranking is only assigned to waterbodies that are on Sublist 5

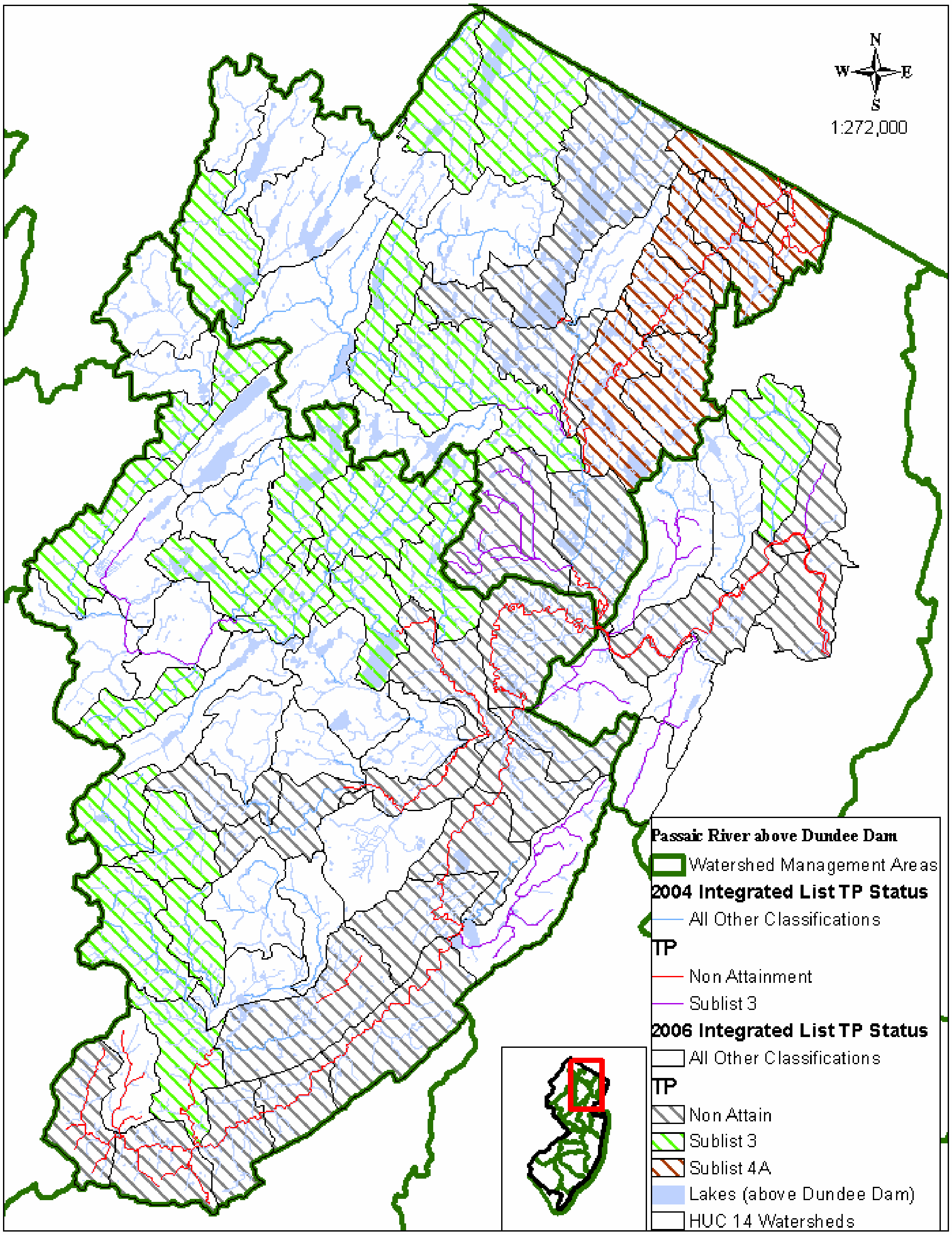
Table 2. Assessment Units Analyzed from the Proposed *2006 Integrated List*

WMA	Assessment Unit ID	Assessment Unit Name	Status of TP Assessment	Priority Ranking	Proposed Action
03	Wanaque Reservoir-03	Wanaque Reservoir-03	Sublist 3	NA	Propose TMDL
03	02030103070020	Belcher Creek (Pinecliff Lake & below)	Sublist 3	NA	WLAs and LAs assigned per Greenwood Lake TMDL
03	02030103070010	Belcher Creek (above Pinecliff Lake)	None	NA	WLAs and LAs assigned per Greenwood Lake TMDL
03	02030103070030	Wanaque R/Greenwood Lk (abv Monks gage)	Sublist 3	NA	WLAs and LAs assigned per Greenwood Lake TMDL
03	02030103070070	Wanaque R/Posts Bk (below reservoir)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
03	02030103110010	Lincoln Park tribs (Pompton River)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
03	02030103110020	Pompton River	Impaired	High	WLAs and LAs assigned per Passaic TMDL
03	02030103050080	Pequannock R (below Macopin gage)	Sublist 3		WLAs and LAs assigned per Passaic TMDL
03	02030103070060	Meadow Brook/High Mountain Brook	None		WLAs and LAs assigned per Passaic TMDL
03	02030103070050	Wanaque Reservoir (below Monks gage)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
03	02030103100010	Ramapo R (above 74d 11m 00s)	Sublist 4A[*]	NA	Addressed in companion TMDL for Pompton Lake
03	02030103100040	Ramapo R (Bear Swamp Bk thru Fyke Bk)	Sublist 4A[*]	NA	Addressed in companion TMDL for Pompton Lake
03	02030103100030	Ramapo R (above Fyke Bk to 74d 11m 00s)	Sublist 4A[*]	NA	Addressed in companion TMDL for Pompton Lake
03	02030103100020	Masonicus Brook	Sublist 4A[*]	NA	Addressed in companion TMDL for Pompton Lake
03	02030103100050	Ramapo R (Crystal Lk br to Bear Swamp Bk)	Sublist 4A[*]	NA	Addressed in companion TMDL for Pompton Lake
03	02030103100070	Ramapo R (below Crystal Lake bridge)	Sublist 4A[*]	NA	Addressed in companion TMDL for Pompton Lake
03	02030103100060	Crystal Lake/Pond Brook	Sublist 4A[*]	NA	Addressed in companion TMDL for Pompton Lake
03	02030103070040	West Brook/Burnt Meadow Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
03	02030103050030	Pequannock R (above Oak Ridge Reservoir outlet)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
03	02030103050060	Pequannock R (Macopin gage to Charlotteburg)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
03	02030103050010	Pequannock R (above Stockholm/Vernon Rd)	None	NA	WLAs and LAs assigned per Passaic TMDL
03	02030103050020	Pacock Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
03	02030103050040	Clinton Reservoir/Mossmans Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
03	02030103050050	Pequannock R (Charlotteburg to Oak Ridge)	None	NA	WLAs and LAs assigned per Passaic TMDL
03	02030103050070	Stone House Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
04	Dundee Lake-04	Dundee Lake-04	Sublist 3	NA	Propose TMDL
04	02030103120070	Passaic R Lwr (Fair Lawn Ave to Goffle)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
04	02030103120100	Passaic R Lwr (Goffle Bk to Pompton River)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
04	02030103120080	Passaic R Lwr (Dundee Dam to F.L. Ave)	Impaired	High	WLAs and LAs assigned per Passaic TMDL

04	02030103120050	Goffle Brook	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
04	02030103120040	Molly Ann Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
04	02030103120030	Preakness Brook / Naachtpunkt Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
04	02030103120060	Deepavaal Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
04	02030103120020	Peckman River (below CG Res trib)	None	NA	WLAs and LAs assigned per Passaic TMDL
04	02030103120010	Peckman River (above CG Res trib)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103040010	Passaic R Upr (Pompton R to Pine Bk)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103030170	Rockaway R (Passaic R to Boonton dam)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103020100	Whippany R (Rockaway R to Malapardis Bk)	Impaired	High	WLAs and LAs assigned per Passaic TMDL; DO eliminated as basis of impairment
06	02030103010180	Passaic R Upr (Pine Bk br to Rockaway)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010170	Passaic R Upr (Rockaway to Hanover RR)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103020040	Whippany R(Lk Pocahontas to Wash Val Rd)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103020050	Whippany R (Malapardis to Lk Pocahontas)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010160	Passaic R Upr (Hanover RR to Columbia Rd)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010150	Passaic R Upr (Columbia Rd to 40d 45m)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010060	Black Brook (Great Swamp NWR)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010130	Passaic R Upr (40d 45m to Snyder Ave)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010080	Dead River (above Harrisons Brook)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010120	Passaic R Upr (Snyder to Plainfield Rd)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010110	Passaic R Upr (Plainfield Rd to Dead River)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103010100	Dead River (below Harrisons Brook)	Impaired	High	WLAs and LAs assigned per Passaic TMDL
06	02030103030160	Montville tribs.	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103010010	Passaic R Upr (above Osborn Mills)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103010020	Primrose Brook	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103010070	Passaic R Upr (Dead R to Osborn Mills)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103020080	Troy Brook (above Reynolds Ave)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103020030	Greystone / Watnong Mtn tribs	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103020090	Troy Brook (below Reynolds Ave)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103020060	Malapardis Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103010140	Canoe Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103020070	Black Brook (Hanover)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103010030	Great Brook (above Green Village Rd)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103010040	Loantaka Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103010050	Great Brook (below Green Village Rd)	None	NA	WLAs and LAs assigned per Passaic TMDL

06	02030103010090	Harrisons Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030030	Rockaway R (above Longwood Lake outlet)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030110	Beaver Brook (Morris County)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030120	Den Brook	None		WLAs and LAs assigned per Passaic TMDL
06	02030103030130	Stony Brook (Boonton)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030040	Rockaway R (Stephens Bk to Longwood Lk)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030140	Rockaway R (Stony Brook to BM 534 brdg)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030150	Rockaway R (Boonton dam to Stony Brook)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030080	Mill Brook (Morris Co)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103020010	Whippany R (above road at 74d 33m)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103020020	Whippany R (Wash. Valley Rd to 74d 33m)	Sublist 3	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030010	Russia Brook (above Milton)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030020	Russia Brook (below Milton)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030050	Green Pond Brook (above Burnt Meadow Bk)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030100	Hibernia Brook	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030060	Green Pond Brook (below Burnt Meadow Bk)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030070	Rockaway R (74d 33m 30s to Stephens Bk)	None	NA	WLAs and LAs assigned per Passaic TMDL
06	02030103030090	Rockaway R (BM 534 brdg to 74d 33m 30s)	None	NA	WLAs and LAs assigned per Passaic TMDL
* The above Sublist 4A listings on the 2006 *Integrated List of Waterbodies* were classified based on a proposed TMDL that was not established. TMDLs for these listings are addressed in the companion TMDL report for Pompton Lake and its drainage area.					

Figure 1. Passaic River above Dundee Dam with the *2004 and 2006 Integrated Lists* Phosphorus Assessments



The non-tidal Passaic River Basin TMDLs are based on an integration of water quality and hydrodynamic models. A water quality model, Water Quality Analysis Simulation Program 7.0 (WASP 7), and a flow model, Diffusion Analogy Surface-Water Flow Model (DAFLOW), were used to simulate water quality and flow in the non-tidal Passaic River and its major tributaries: Dead River, Whippany River, Rockaway River, Pompton River mainstem, Ramapo River downstream of Pompton Lake, Wanaque River downstream of the Wanaque Reservoir, a small stream segment of the Pequannock River, Singac Brook, and Peckman River. The WASP 7 model is a dynamic compartment model that can be used to predict a variety of water quality responses due to natural phenomena and man-made pollution for diverse aquatic systems, such as rivers, reservoirs, lakes, and coastal waters (Omni Environmental, 2007). DAFLOW model is a one-dimensional transport model designed to simulate flow by solving the diffusion analogy form of the flow equation. DAFLOW was developed by USGS and enhanced by USGS for this TMDL study (Spitz, 2007). A graphical watershed model integration tool (WAMIT) was developed for data sharing and model input calculation between WASP 7 and DAFLOW (Omni Environmental, 2007). Outside of the domain of the WASP 7/DAFLOW model, a mass balance model (Najarian, 2005) was used to simulate daily loads of total phosphorus and orthophosphorus. A reservoir model, Laterally Averaged - Wind and Temperature Enhanced Reservoir Simulation (LA-WATERS), was used to model the water quality of the Wanaque Reservoir based on loading inputs from the other models and in consideration of diversions into the Wanaque Reservoir. The LA-WATERS model and subsequent analyses link phosphorus loading with chlorophyll-a response in the Wanaque Reservoir and includes a hydrothermal component and water quality modules, which were successfully calibrated to the Wanaque Reservoir using data collected as part of the Wanaque South water supply project (Najarian Associates, 1988), and subsequently re-validated (Najarian Associates, 2000).

For assessment purposes, a waterbody is deemed impaired with respect to phosphorus when phosphorus levels exceed the numeric criteria in the Surface Water Quality Standards (SWQS). Under this approach, the narrative exception to applicability of the numeric criterion in streams and other narrative criteria are not assessed prior to listing. The SWQS allow for development of watershed or site specific criteria where appropriate to protect designated uses. Through this TMDL study, it was determined that the in-stream numeric criterion does not apply within the WASP 7/DAFLOW modeled domain because monitoring and simulation demonstrate that phosphorus is not rendering the waters unsuitable for the designated uses. For these assessment units, phosphorus will be removed as a basis of impairment in the next Integrated List. Critical locations where phosphorus is causing excessive primary productivity were identified to be the Wanaque Reservoir and Dundee Lake. As part of this TMDL proposal, the Department is proposing watershed criteria in accordance with N.J.A.C. 7:9B-1.5(g)3 in these locations, as the best means to ensure protection of the designated uses. The watershed criteria are proposed in terms of a seasonal average concentration (June 15-September 1) of the response indicator, chlorophyll-a. The proposed criteria are tailored to the unique characteristics of each critical location and are proposed as a seasonal average of 10 μg/L chlorophyll-a in the Wanaque Reservoir and a seasonal average of 20 μg/L chlorophyll-a in Dundee Lake. As the result of this TMDL study, phosphorus will not be considered as a basis for non-attainment in these waterbodies in the next Integrated List. One location, Whippany River (Rockaway R to Malapardis Bk), is listed as impaired for dissolved oxygen. Through this TMDL study it has been determined that the low dissolved oxygen levels observed are due to natural conditions. Therefore, in this location dissolved oxygen will be removed as a basis of impairment in the next Integrated List.

The wasteload allocations for wastewater treatment facilities needed to meet the watershed criteria at Wanaque Reservoir and Dundee Lake are based on a long term average year-round effluent concentration of 0.4 mg/l of total phosphorus for most wastewater discharges (see Table 14 and discussion for exceptions). The Department intends to establish monthly average, concentration-only effluent limits that will apply year round for the identified wastewater dischargers using the methodology in the USEPA's *Technical Support Document for Water Quality-Based Toxics Control* (USEPA, 1991), assuming a 4 times per month sampling frequency and a coefficient of variation of 0.6. With these inputs, this methodology produces a monthly average effluent limit of 0.76 mg/l. Dischargers below the confluence of the Pompton and Passaic Rivers will receive this limit, which apply from May through October. Dischargers in the Greenwood Lake drainage area will retain the WLAs and associated effluent limits established in the Greenwood Lake TMDL (NJDEP 2004). Three dischargers that contribute loads outside the boundaries of the model domain are assigned a wasteload allocation consistent with the conditions in the current permits in order to maintain boundary conditions. Nonpoint and stormwater point source load reductions are also required in order to achieve the water quality targets in the study area. The percent reduction for these sources ranges from 54 to 80 percent and will be achieved through measures identified in the implementation section. Subject to the constraints of achieving the specified load reductions, attaining the watershed criteria in the Wanaque Reservoir and Dundee Lake, and accomplishing needed upgrades within the compliance schedule established in the discharge permits, modification of wasteload allocations and load allocations may be accomplished through water quality trading. EPA has awarded a Targeted Watershed Grant to Rutgers University to facilitate water quality trading in the Passaic River basin. This study is expected to identify suitable trading ratios within the Passaic River basin.

This TMDL Report is consistent with US EPA's May 20, 2002 guidance document entitled, *Guidelines for Reviewing TMDLs under Existing Regulations Issued in 1992* (Sutfin, 2002), which describes the statutory and regulatory requirements for approvable TMDLs. This TMDL shall be proposed and, upon approval by EPA, adopted by the Department as an amendment to the Northeast, Upper Raritan, Sussex County and Upper Delaware Water Quality Management Plans (WQMP) in accordance with N.J.A.C. 7:15-3.4 (g).

2.0 Introduction

In accordance with Section 303(d) of the Federal Clean Water Act (CWA) (33 U.S.C. 1315(B)), the State of New Jersey is required biennially to prepare and submit to the USEPA a report that identifies waters that do not meet or are not expected to meet SWQS after implementation of technology-based effluent limitations or other required controls. This report is commonly referred to as the 303(d) List. In accordance with Section 305(b) of the CWA, the State of New Jersey is also required biennially to prepare and submit to the USEPA a report addressing the overall water quality of the State's waters. This report is commonly referred to as the 305(b) Report or the Water Quality Inventory Report. The Integrated Water Quality Monitoring and Assessment Report combines these two assessments and assigns waterbodies to one of five sublists on the Integrated List of Waterbodies. Sublists 1 through 4 include waterbodies that are generally unimpaired (Sublist 1 and 2), have limited assessment or data availability (Sublist 3), or are impaired due to pollution rather than pollutants or have had a TMDL or other enforceable management measure approved by EPA (Sublist 4). Sublist 5 constitutes the traditional 303(d) list for waters impaired or threatened by one or more pollutants, for which a TMDL may be required. For the non-tidal portion of the Passaic River basin, the *2004 Integrated List of Waterbodies* identified 17 impaired segments and 9 segments that had limited assessment or data availability.

The proposed *New Jersey 2006 Integrated Water Quality Monitoring and Assessment Report* identifies impairments based on designated use attainment and then lists the parameters responsible for the non-attainment of the designated use. The assessments are conducted for each of the seven categories of designated use, which include aquatic life, recreational use (primary and secondary contact), drinking water, fish consumption, shellfish harvesting (if applicable), agricultural water supply use and industrial water supply use. The proposed *2006 Integrated Water Quality Monitoring and Assessment Report* assessment units addressed in this TMDL report are identified in Table 2, along with the assessment status with respect to the parameter total phosphorus. The complete assessment status of the assessment units in Table 2 are identified in Appendix C.

A TMDL represents the assimilative or carrying capacity of a waterbody, taking into consideration point and nonpoint sources of pollutants of concern, natural background, and surface water withdrawals. A TMDL quantifies the amount of a pollutant a water body can assimilate without violating a state's water quality standards and allocates that load capacity to known point and nonpoint sources in the form of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, a margin of safety (MOS) and, as an option, a reserve capacity (RC).

Recent EPA guidance (Sutfin, 2002) describes the statutory and regulatory requirements for approvable TMDLs, as well as additional information generally needed for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations. The Department believes that the TMDLs in this report address the following items in the May 20, 2002 guideline document:

1. Identification of waterbody(ies), pollutant of concern, pollutant sources and priority ranking.
2. Description of applicable water quality standards and numeric water quality target(s).
3. Loading capacity – linking water quality and pollutant sources.
4. Load allocations.

5. Wasteload allocations.
6. Margin of safety.
7. Seasonal variation.
8. Reasonable assurances.
9. Monitoring plan to track TMDL effectiveness.
10. Implementation (USEPA is not required to and does not approve TMDL implementation plans).
11. Public Participation.

3.0 Pollutants of Concern and Area of Interest

Pollutants of Concern

The primary pollutant of concern for this TMDL study is phosphorus. When present in excessive amounts, phosphorus can lead to excessive primary productivity, in the form of algal and/or macrophyte growth. The presence of excessive plant biomass can, in itself, interfere with designated uses, such as swimming or boating. There are also implications from excessive algae with respect to drinking water use. Algal blooms in raw drinking water sources can cause taste and odor problems and treatment inefficiencies, having a negative impact on conventional treatment at a drinking water system. When algae are present in large amounts purveyors must increase the use of disinfectants and oxidants to treat the algae resulting in an increase in disinfection byproducts such as trihalomethanes, some of which are listed by EPA as likely carcinogens. In addition, the respiration cycle of excessive plant material can cause significant swings in pH and dissolved oxygen, which can result in violation of criteria for these parameters, which can adversely affect the aquatic community. Low dissolved oxygen can result from factors besides the respiration side of the diurnal swing associated with excessive primary productivity, which must be considered when assessing the role of phosphorus in causing observed water quality. For example, biochemical oxygen demand and nitrification of ammonia from wastewater treatment discharges consume dissolved oxygen. Besides anthropogenic sources, the natural process of breaking down normal amounts of plant and animal materials that have settled to the stream bed also consumes oxygen and is known as sediment oxygen demand (SOD). In addition, dissolved oxygen can be naturally low in some areas, such as headwaters, where surface water is derived close to ground water sources, which are low in dissolved oxygen, and have not had time to oxygenate from exposure to the atmosphere. In some parts of the study area, monitoring data and/or model simulations indicate that the dissolved oxygen criteria may not be met during critical conditions. Most of these segments are not identified as non-attaining with respect to dissolved oxygen in the 2004 and 2006 *Integrated Lists* because the non-attainment conditions, including flow and time of day, were extreme and not captured during routine monitoring. However, the non-attainment of dissolved oxygen criteria was determined to be a result of natural conditions, as discussed further below. Therefore, these areas should not be assessed as impaired in the next listing cycle.

The Department has surface water quality standards for phosphorus. As stated in N.J.A.C. 7:9B-1.14(c) of the SWQS for Fresh Water 2 (FW2) waters:

Phosphorus, Total (mg/l):

i. Lakes: Phosphorus as total P shall not exceed 0.05 in any lake, pond, reservoir, or in a tributary at the point where it enters such bodies of water, except where site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3.

ii. Streams: Except as necessary to satisfy the more stringent criteria in paragraph i. above or where site-specific criteria are developed pursuant to N.J.A.C. 7:9B1.5(g)3, phosphorus as total P shall not exceed 0.1 in any stream, unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.

Regarding site specific criteria, N.J.A.C. 7:9B-1.5(g)3 states:

> The Department may establish watershed or site-specific water quality criteria for nutrients in lakes, ponds, reservoirs or streams, in addition to or in place of the criteria in N.J.A.C. 7:9B-1.14, when necessary to protect existing or designated uses. Such criteria shall become part of these Water Quality Standards.

Elaborating on "…render waters unsuitable…" N.J.A.C. 7:9B-1.5(g)2 states:

> Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render the waters unsuitable for the designated uses.

Numerous waterbodies within the Passaic River basin were placed on Sublist 5 in both the 2004 and proposed 2006 *Integrated Lists* (see Tables 1 and 2), based on data showing phosphorus in excess of the numeric in-stream criterion of 0.1 mg/l. However, data are not generally available to assess waterbodies relative to the in-stream narrative exception to applicability of the numeric criterion or with respect to the narrative nutrient criteria. Therefore, the numeric criterion is often the sole basis for listing of a waterbody with respect to phosphorus. One of the objectives of the monitoring program conducted for this TMDL report was to determine if phosphorus was causing excessive productivity.

Appendix E of the *TMDL for Fecal Coliform and an Interim Total Phosphorus Reduction Plan for the Whippany River Watershed* (NJDEP 1999) set forth the salient points supporting the conclusion that the numeric in-stream criterion of 0.1 mg/l did not apply in the Whippany River Watershed because phosphorus was not causing excessive primary productivity and its associated effects. Within the domain of Approach Areas 1 and 3, which are described below, the Department monitored relevant parameters under a range of flow conditions at representative locations. The details of the monitoring program and data generated are provided in the support materials for this TMDL document (TRC Omni, 2004). Diurnal dissolved oxygen and chlorophyll-a are the two parameters that are most illustrative of the effects of phosphorus in the waterbodies. As noted above, excessive productivity will be indicated by high concentrations of chlorophyll-a and diurnal dissolved oxygen patterns that exhibit a large swing and may also entail dissolved oxygen concentration at the bottom of the swing that is below the SWQS. Based on careful evaluation of the data, the Department determined that phosphorus is not responsible for causing excessive primary productivity within streams in the s pecified domain, except in a small portion at the terminis of the Peckman River. Therefore, except in that location, the 0.1 mg/l numeric criterion is not applicable for in-stream locations within the studied area. Phosphorus is causing excessive primary productivity in two locations that are actually or nominally lakes: the Wanaque Reservoir and the impounded portion of the lower Passaic above Dundee Dam, also referred to as Dundee Lake.

More specifically, the data show that the Upper Passaic River basin is significantly influenced by the conditions of the source waters emanating from the Great Swamp, which do not allow much light penetration due to dark color, which in turn inhibits algal growth. In addition, dissolved oxygen starts out low and remains so, with little diurnal swing. Low dissolved oxygen concentrations in the Upper and Middle Passaic River are due to two factors, the conditions of the source waters coming from Great Swamp and the natural levels of SOD. Observed SOD values in these reaches are among the highest values in the basin, as measured in 2004. The high rate of SOD materials in these reaches results from the Great Swamp and other wetlands complexes contributing abundant detritus, as well as the overall low stream velocity, which promotes settling. For example, the Whippany River (Rockaway River to Malapardis Brook; 02030103020100-01) is currently listed as non-attaining for dissolved oxygen. This location fails to meet current water quality criteria for dissolved oxygen. However, this has been determined to be because of natural conditions—dissolved oxygen starts out low, and there is significant natural SOD. Simulation of extreme reduction of phosphorus showed no improvement relative to not violating the minimum daily dissolved oxygen criterion. Therefore, at this location oxygen will be removed as a basis for impairment in the next listing cycle. The middle portion of the Passaic River is transitional with respect to productivity. Here, productivity is increasing, but not yet excessive. In a small portion of this reach, the diurnal dissolved oxygen swings in the critical 2002 summer were approaching 6 mg/l. Simulation of extreme reductions in phosphorus resulted in a slight decrease in the amplitude of the diurnal swing but did not improve the degree of violation of the minimum daily dissolved oxygen criterion (see station Passaic River at Stanley Ave, Chatham, near PA4 Chatham, (Omni Environmental, 2007). It was concluded that the observed and simulated low levels of oxygen were due to natural conditions and these areas should not be assessed as impaired with respect to oxygen in the next Integrated List. At the confluence of the Pompton and Passaic Rivers, the Wanaque South intake diverts water into the Wanaque Reservoir, which is important with respect to the Wanaque Reservoir critical location. This is because phosphorus in the diverted water accumulates and cycles within the impoundment creating the opportunity for excessive primary productivity over the growing season. The Wanaque Reservoir is an important water supply reservoir. During critical periods, such as in 2002, the water in the Reservoir is completely exchanged, that is, more than the entire volume of the Reservoir is filled and then drawn for water supply. The Lower Passaic is notably influenced by phosphorus, with indicators of primary productivity pronounced above Dundee Dam. Here, diurnal dissolved oxygen swings are extreme, with minimum daily averages for dissolved oxygen violated during the critical period, and chlorophyll-a levels are excessive. The waters impounded behind Dundee Dam are also known as Dundee Lake. The dam serves to slightly widen the river for a distance of approximately one mile upstream of the dam. While nominally a lake, the average residence time in the impounded reach is simulated to be only about 1.4 days. Because of its riverine characteristics, absent a watershed criterion, the default in-stream numeric criterion for phosphorus would be more applicable here than the lake criterion.

Because of the unique characteristics of the Wanaque Reservoir and Dundee Lake, the numeric criteria for phosphorus in these impounded areas are not the best indicator for determining when these waters are rendered unsuitable for the designated uses. In these locations, response indicators of excessive phosphorus are a better measure of meeting water quality objectives and supporting designated uses. The water quality responses that were identified as problematic were excessive dissolved oxygen swings at Dundee Lake and excessive chlorophyll-a in both locations. The Department does not have surface water standards for chlorophyll-a. Therefore, pursuant to N.J.A.C. 7:9B-1.5(g)3, the Department is proposing watershed criteria in terms of chlorophyll-a for these two critical locations in the Passaic River basin as part of this TMDL proposal. As discussed below, the proposed criteria are 10 µg/L as a seasonal average (June 15-September 1) in the Wanaque Reservoir and 20 µg/L as a seasonal average in Dundee Lake. Additional discussion of the proposal to establish watershed criteria is provided below and in Appendix E.

Chlorophyll-a is the common translator selected by states (Missouri, Pennsylvania, Oregon , Alabama and Kansas) to address narrative criteria and is supported by EPA in both "*Protocols for Developing Nutrient TMDLs*" First Edition November 1999, which lists chlorophyll-a as a suitable indicator for nutrient TMDLs, and in *"Nutrient Criteria Technical Guidance Manual Lakes and Reservoirs"*, First Edition April 2000. Chlorophyll represents a family of chlorophyll molecules expressed as a, b, c, d. Chlorophyll-a is selected because of its primary role in photosynthesis. Chlorophyll-a is easy to measure and is a useful surrogate for measuring algal biomass, which is either the direct (nuisance algal blooms) or indirect (high/low dissolved oxygen, pH and high turbidity) cause of most problems related to excessive phosphorus enrichment.

In addition to the unique characteristics of the Wanaque Reservoir and Dundee Lake, the Department considered the literature and experience of other states in selecting the site specific criteria for these locations. *The Nutrient Criteria Technical Manual for Lakes and Reservoirs* discusses the relationship between chlorophyll-a and phosphorus and its linkage to biomass. It notes that North Carolina uses a standard of 15 µg/L chlorophyll-a for cold water habitats and 40 µg/L in warm water habitats. It also cites Rascke (1994) who proposed a mean growing season limit of 15 µg/L chlorophyll-a for water supply impoundments in the southeastern United States and a value of 25 µg/L chlorophyll-a for water bodies primarily used for other purposes. The Kansas Department of Health and the Environment has implemented 12 µg/L chlorophyll-a target for domestic water supply reservoirs, with a 10% margin of safety, and 20 µg/l chlorophyll-a for secondary contact recreation lakes, with a 10% margin of safety. TMDLs developed in other states have selected chlorophyll-a levels as the water quality endpoint for the TMDL calculation. For example, TMDLs for Lake Galena, PA, Lake Nockamixon, PA, McDaniel Lake, MO and Federal Council Grove Lake, KS used 10 µg/L as the water quality endpoint. The TMDL prepared for Dutch Fork Lake, PA used a water quality endpoint of 20 µg/L. Several other EPA approved TMDLs for lakes (Green Lane Reservoir, PA TMDL and Lake Weiss, AL TMDL) utilized 20 µg/l for chlorophyll-a as the TMDL water quality target. This survey indicates that chlorophyll-a levels across a range have been selected as protective, based on the water body characteristics and uses.

The Department determined that the Wanaque Reservoir warrants a conservative chlorophyll-a target of 10 µg/L, in consideration of its great capacity to store and cycle phosphorus, its importance as a drinking water supply reservoir as well as its value as a cold-water fishery. The Wanaque Reservoir is large and deep, as described below, and supports trout throughout the fishing season.

Dundee Lake is characterized as a warm water, riverine environment. The water impounded behind Dundee Dam is relatively shallow and has a very short retention time. It is not currently used as a drinking water supply. Because of these characteristics, the Department has determined that a chlorophyll-a target of 20 µg/L is appropriate.

Various seasonal periods were assessed. For both locations, a seasonal average period defined as from June 15 to September 1 was found to provide a conservative outcome in terms of required phosphorus load reductions. This period was selected in order to provide an extra measure of protection for the designated uses.

The waterbodies listed in Tables 1 and 2 have a FW2 classification. Some also carry a C1 classification, as depicted in Figure 5. The designated uses, both existing and potential, that have been established by the Department for waters of the State classified as such are as stated below:

In all FW2 waters, the designated uses are (N.J.A.C. 7:9B-1.12):

1. Maintenance, migration and propagation of the natural and established aquatic biota;
2. Primary and secondary contact recreation;
3. Industrial and agricultural water supply;
4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents) and disinfection; and
5. Any other reasonable uses.

Area of Interest

The spatial focus of this TMDL study is the non-tidal Passaic River basin. This spatial extent includes the stream segments and HUC 14 subwatersheds identified in Tables 1 and 2 and depicted in Figure 1. Some of the HUC 14 subwatersheds have been specifically assessed as impaired with respect to phosphorus. In addition, through this TMDL study, the impounded area behind Dundee Dam, also known as Dundee Lake, and the Wanaque Reservoir have been identified as impaired with respect to phosphorus and will be addressed as well. Unimpaired subwatersheds are included in the study because loadings are taken as inputs to the model domain and WLAs and LAs are established as a result of this study. Multiple approaches to calculating loads are used in this study and the spatial extent of each approach is depicted in Figure 2. Pompton Lake and its drainage area are depicted as within the spatial extent because loadings from this area are inputs to the non-tidal Passaic River basin analysis. However, the Pompton Lake and the associated drainage area are addressed in a companion TMDL report. Greenwood Lake and its associated drainage area are also depicted because loadings are taken as a boundary condition input to this study. However, Greenwood Lake and associated drainage were addressed in a previously established TMDL (NJDEP 2004) that was approved by EPA on September 29, 2004. The Greenwood Lake drainage area, the Pompton Lake drainage area, as well as the remaining direct drainage to the Wanaque Reservoir, are covered under the Greenwood Lake TMDL spatial extent and Approach 2. Except for the direct drainage to the Wanaque Reservoir (Greenwood Lake and Approach 2) and the headwaters taken as boundary conditions (Approach 4), the portion of the study area upstream of the confluence of the Pompton and Passaic Rivers is addressed through Approach 1, which is the integration of the WASP 7/DAFLOW model and the LA-WATERS to establish the load reductions to meet the water quality objective in the Wanaque Reservoir. The portion of the spatial extent below the confluence is addressed through Approach 3, which uses the WASP 7/DAFLOW model to establish the load reductions needed to meet the water quality objective in Dundee Lake. The headwater areas outside the explicit model domain of the WASP 7/DAFLOW model are depicted as Approach 4 and are affected by the TMDL study because loads are contributed at the model boundaries.

Table 3. Sublist 5 and Sublist 3 stream segments in spatial extent of non-tidal Passaic River basin TMDL study

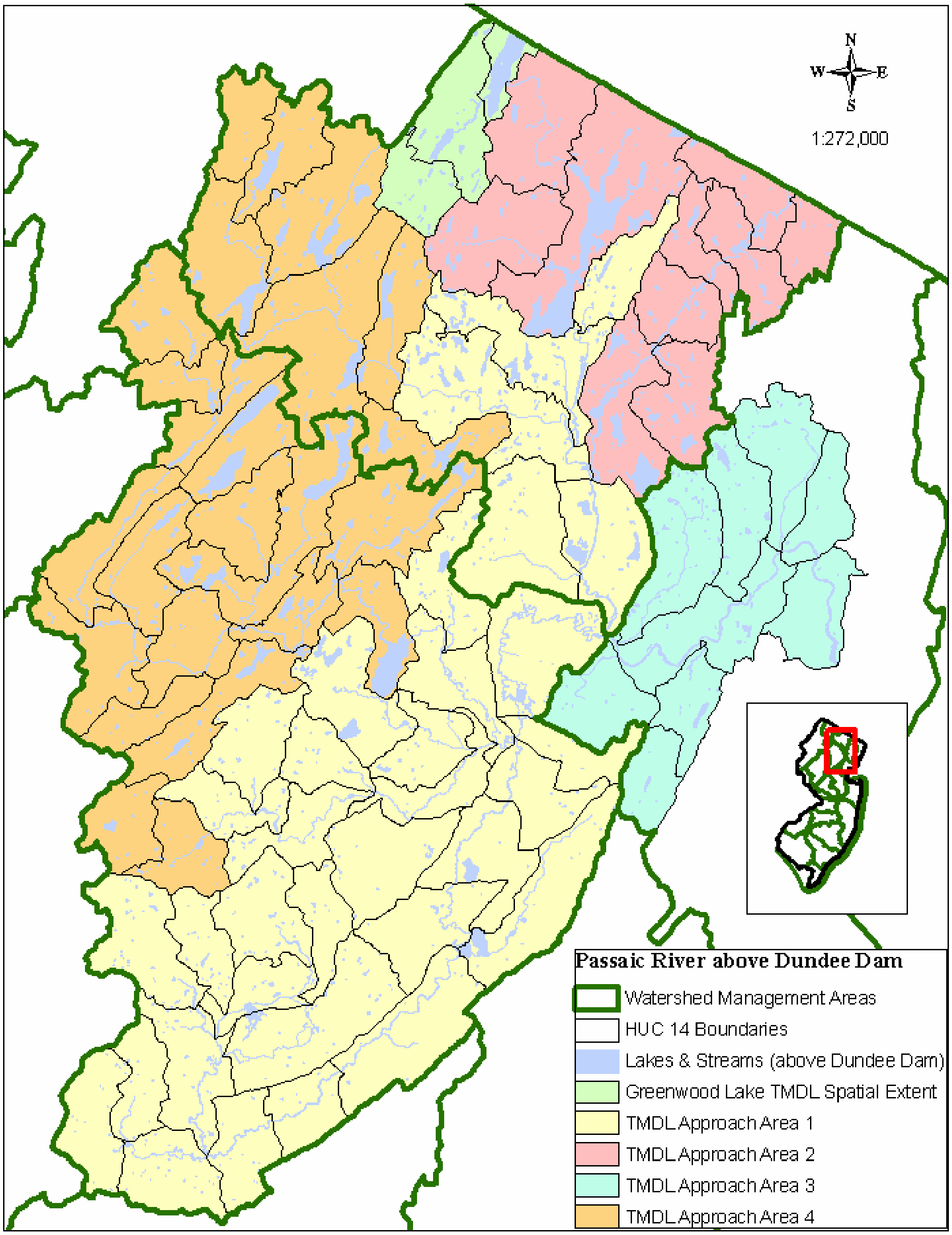
Site ID	Site Location and Waterbody/ General Description	Approx. River Miles
01388910	Pompton River at Rt 202 in Wayne	4.67
01388100	Ramapo River at Dawes Highway	1.88
01387500	Ramapo River near Mahwah	17.73
01387014	Wanaque River at Pompton Lakes	3.32
01387000	Wanaque River at Wanaque	0.55
01389880	Passaic River at Elmwood Park (combined with Passaic River at Merlot Ave in Fairlawn - 01389870)	13.73
01389500	Passaic River at Little Falls (combined with Passaic River at Singac - 01389130)	15.0
01389005	Passaic River Below Pompton River at Two Bridges	1.83
01378855	Black Brook at Madison	2.35
01379200	Dead River near Millington	21.86
EWQ0231	Passaic River at Eagle Rock Ave in East Hanover	10.33
01382000	Passaic River at Two Bridges	14.14
01379500	Passaic River near Chatham	14.90
01379000	Passaic River near Millington	5.17
01381200	Rockaway River at Pine Brook	6.77
01381500	Whippany River at Morristown	0.74
01381800	Whippany River near Pine Brook	6.61
01382800	Pequannock River at Riverdale	3.39
01388720	Pompton River Trib at Ryerson Rd	17.93
01389138	Deepavaal Brook at Fairfield	6.25
01389860	Diamond Brook at Fair Lawn	2.60
01389600	Peckman River at West Paterson	7.66
01389080	Preakness Brook near Little Falls	8.87
01379530	Canoe Brook near Summit	17.60
01379800	Green Pond Brook at Dover	4.48
01379853	Rockaway River at Blackwell St	6.08

Table 4. HUC 14 Assessment Units from proposed *2006 Integrated List* addressed in this and related TMDL studies

WMA	HUC14	Subwatershed Name	Acres	TMDL Approach
03	Wanaque Reservoir-03	Wanaque Reservoir-03	NA	Area 2
03	02030103070020	Belcher Creek (Pinecliff Lake & below)	5782.4	Greenwood Lake
03	02030103070010	Belcher Creek (above Pinecliff Lake)	3480.1	Greenwood Lake
03	02030103070030	Wanaque R/Greenwood Lk (above Monks gage)	9360.3	Greenwood Lake, Area 2
03	02030103070070	Wanaque R/Posts Bk (below reservoir)	6915.9	Area 1
03	02030103110010	Lincoln Park tribs (Pompton River)	8394.4	Area 1
03	02030103110020	Pompton River	6963.2	Area 1
03	02030103050080	Pequannock R (below Macopin gage)	10835.8	Area 1
03	02030103070060	Meadow Brook/High Mountain Brook	3837.5	Area 1
03	02030103070050	Wanaque Reservoir (below Monks gage)	13749.4	Area 2
03	02030103100010	Ramapo R (above 74d 11m 00s)	3721.0	Area 2
03	02030103100040	Ramapo R (Bear Swamp Bk thru Fyke Bk)	3018.1	Area 2
03	02030103100030	Ramapo R (above Fyke Bk to 74d 11m 00s)	4305.5	Area 2
03	02030103100020	Masonicus Brook	2783.2	Area 2
03	02030103100050	Ramapo R (Crystal Lk br to Bear Swamp Bk)	4041.2	Area 2
03	02030103100070	Ramapo R (below Crystal Lake bridge)	7224.0	Area 2
03	02030103100060	Crystal Lake/Pond Brook	5509.0	Area 2
03	02030103070040	West Brook/Burnt Meadow Brook	7570.0	Area 2
03	02030103050030	Pequannock R (above Oak Ridge Res outlet)	6710.2	Area 4
03	02030103050060	Pequannock R(Macopin gage to Charl'brg)	5047.7	Area 4
03	02030103050010	Pequannock R (above Stockholm/Vernon Rd)	3464.2	Area 4
03	02030103050020	Pacock Brook	4590.8	Area 4
03	02030103050040	Clinton Reservoir/Mossmans Brook	8486.6	Area 4
03	02030103050050	Pequannock R (Charlotteburg to Oak Ridge)	11761.1	Area 4
03	02030103050070	Stone House Brook	4677.0	Area 4
04	Dundee Lake-04	Dundee Lake-04	NA	Area 3
04	02030103120070	Passaic R Lwr (Fair Lawn Ave to Goffle)	3590.6	Area 3
04	02030103120100	Passaic R Lwr (Goffle Bk to Pompton R)	7606.2	Area 3
04	02030103120080	Passaic R Lwr (Dundee Dam to F.L. Ave)	4784.0	Area 3
04	02030103120050	Goffle Brook	5657.9	Area 3
04	02030103120040	Molly Ann Brook	4994.2	Area 3
04	02030103120030	Preakness Brook / Naachtpunkt Brook	7121.1	Area 3
04	02030103120060	Deepavaal Brook	4867.7	Area 3
04	02030103120020	Peckman River (below CG Res trib)	3253.3	Area 3
04	02030103120010	Peckman River (above CG Res trib)	3217.2	Area 3
06	02030103040010	Passaic R Upr (Pompton R to Pine Bk)	7602.0	Area 1
06	02030103030170	Rockaway R (Passaic R to Boonton dam)	5138.4	Area 1
06	02030103020100	Whippany R (Rockaway R to Malapardis Bk)	3594.7	Area 1
06	02030103010180	Passaic R Upr (Pine Bk br to Rockaway)	3417.4	Area 1
06	02030103010170	Passaic R Upr (Rockaway to Hanover RR)	4412.7	Area 1
06	02030103020040	Whippany R(Lk Pocahontas to Wash Val Rd)	3594.5	Area 1

06	02030103020050	Whippany R (Malapardis to Lk Pocahontas)	4305.7	Area 1
06	02030103010160	Passaic R Upr (Hanover RR to Columbia Rd)	5479.7	Area 1
06	02030103010150	Passaic R Upr (Columbia Rd to 40d 45m)	5383.1	Area 1
06	02030103010060	Black Brook (Great Swamp NWR)	9089.8	Area 1
06	02030103010130	Passaic R Upr (40d 45m to Snyder Ave)	7958.8	Area 1
06	02030103010080	Dead River (above Harrisons Brook)	4864.6	Area 1
06	02030103010120	Passaic R Upr (Snyder to Plainfield Rd)	3471.7	Area 1
06	02030103010110	Passaic R Upr (Plainfield Rd to Dead R)	4278.7	Area 1
06	02030103010100	Dead River (below Harrisons Brook)	4949.9	Area 1
06	02030103030160	Montville tribs.	5065.5	Area 1
06	02030103010010	Passaic R Upr (above Osborn Mills)	6486.3	Area 1
06	02030103010020	Primrose Brook	3354.2	Area 1
06	02030103010070	Passaic R Upr (Dead R to Osborn Mills)	5694.0	Area 1
06	02030103020080	Troy Brook (above Reynolds Ave)	6439.2	Area 1
06	02030103020030	Greystone / Watnong Mtn tribs	4972.4	Area 1
06	02030103020090	Troy Brook (below Reynolds Ave)	3870.6	Area 1
06	02030103020060	Malapardis Brook	3256.4	Area 1
06	02030103010140	Canoe Brook	7691.3	Area 1
06	02030103020070	Black Brook (Hanover)	6644.3	Area 1
06	02030103010030	Great Brook (above Green Village Rd)	5071.5	Area 1
06	02030103010040	Loantaka Brook	3238.2	Area 1
06	02030103010050	Great Brook (below Green Village Rd)	3296.1	Area 1
06	02030103010090	Harrisons Brook	3485.2	Area 1
06	02030103030030	Rockaway R (above Longwood Lake outlet)	4288.8	Area 4
06	02030103030110	Beaver Brook (Morris County)	9453.2	Area 4
06	02030103030120	Den Brook	5769.4	Area 4
06	02030103030130	Stony Brook (Boonton)	7864.4	Area 4
06	02030103030040	Rockaway R (Stephens Bk to Longwood Lk)	5100.6	Area 4
06	02030103030140	Rockaway R (Stony Brook to BM 534 brdg)	3382.2	Area 4
06	02030103030150	Rockaway R (Boonton dam to Stony Brook)	4417.5	Area 4
06	02030103030080	Mill Brook (Morris Co)	3130.3	Area 4
06	02030103020010	Whippany R (above road at 74d 33m)	3875.7	Area 4
06	02030103020020	Whippany R (Wash. Valley Rd to 74d 33m)	4015.3	Area 4
06	02030103030010	Russia Brook (above Milton)	5478.7	Area 4
06	02030103030020	Russia Brook (below Milton)	3099.4	Area 4
06	02030103030050	Green Pond Brook (above Burnt Meadow Bk)	4721.3	Area 4
06	02030103030100	Hibernia Brook	5074.7	Area 4
06	02030103030060	Green Pond Brook (below Burnt Meadow Bk)	5055.7	Area 4
06	02030103030070	Rockaway R (74d 33m 30s to Stephens Bk)	5825.2	Area 4
06	02030103030090	Rockaway R (BM 534 brdg to 74d 33m 30s)	4692.5	Area 4

Figure 2. Spatial extent of non-tidal Passaic River basin study and related studies with modeling approach applied.



The non-tidal Passaic River basin includes all of Watershed Management Areas 3 and 6, and a portion of Watershed Management Area 4, as described below:

Watershed Management Area 3

Watershed Management Area 3 (WMA 3) includes watersheds that drain the Highlands portion of New Jersey. WMA 3 lies mostly in Passaic County but also includes parts of Bergen, Morris, and Sussex Counties and is comprised of 21 municipalities that lie entirely or partially within the watershed boundary. There are four sub-watersheds in WMA 3: Pompton, Ramapo, Pequannock and Wanaque River watersheds. The Pequannock, Wanaque and Ramapo Rivers all flow into the Pompton River. The Pompton River is, in turn, a major tributary to the Upper Passaic River. WMA 3 contains some of the State's major water supply reservoir systems including the Wanaque Reservoir, the largest surface water reservoir in New Jersey.

The Pequannock River watershed is 30 miles long and has a drainage area of 90 square miles. The headwaters are in Sussex County and the Pequannock River flows east, delineating the Morris/Passaic County boundary line. The Pequannock River joins the Wanaque River and flows to the Pompton River in Wayne Township. Some of the major impoundments within this watershed are Kikeout Reservoir, Lake Kinnelon Reservoir, Clinton Reservoir, Canistear Reservoir, Oak Ridge Reservoir, and Echo Lake Reservoir. The great majority of the land within this watershed is forested and protected for water supply purposes or is parkland.

The Ramapo River and Pompton River watersheds comprise a drainage area of about 160 square miles; 110 square miles of which are in New York State. The Ramapo River flows from New York into Bergen County and enters the Pequannock River to form the Pompton River in Wayne Township. The Ramapo River is 15 miles long on the New Jersey side. The Pompton River, a tributary to the Passaic River, is 7 miles long. Some of the major impoundments within this watershed include Point View Reservoir #1, Pompton Lakes, and Pines Lake. Over one-half of this watershed is undeveloped; however, new development is extensive in many areas.

The Wanaque River watershed has a total drainage area of 108 square miles. The headwaters of the river lie within New York State as a minor tributary to Greenwood Lake (located half in New Jersey and half in New York). The New Jersey portion lies in West Milford, Passaic County. The Wanaque River joins up with the Pequannock River in Riverdale Township. The Wanaque River is 27 miles in length. Some of the major impoundments and lakes with this watershed are the Wanaque Reservoir, Monksville Reservoir, Greenwood Lake, and Arcadia Lake. Most of the land in this watershed is undeveloped, consisting of vacant lands, reservoirs, parks and farms.

The Wanaque Reservoir located in WMA 3 was completed in 1930 to serve as a water supply source to northern New Jersey municipalities. The reservoir is about 6 miles long and one mile wide with an area of 2300 acres of water surface and consists of 8 dams. The supporting documentation for this TMDL, prepared by Najarian Associates, describes the Wanaque Reservoir system as follows:

> The Wanaque and Monksville Reservoirs are owned and operated by the North Jersey District Water Supply Commission (NJDWSC). These two reservoirs comprise one of the largest water supply/storage systems in New Jersey. This system is the primary source of drinking water for much of Passaic, Essex, Bergen and Hudson Counties. Following the completion of the Wanaque South Project in the late 1980s, the long-term safe yield of this combined reservoir system was upgraded to 173 mgd. The system currently provides approximately 160 mgd of potable water supply to its customers (including other water companies).

Table 5. Description of Reservoirs

	Wanaque Reservoir	Monksville Reservoir
Water surface elevation	302.4 ft.	400.0 ft
Capacity of reservoir	29,630 mg	7,000 mg
Area of water surface	2,310 acres	505 acres
Width at widest point	1.2 mi	0.6
Length	6.6 mi	3.3 mi
Average width	0.5 mi	0.2 mi
Greatest depth	90 ft	100 ft
Average depth	37 ft	42 ft
Watershed area	90.1 mi^2	42.2 mi^2

> To maintain this yield, the Wanaque Reservoir utilizes inflows from three separate sources: (1) its natural tributary system, which includes the Monksville Reservoir; (2) the Pompton Lakes intake, which is located on the Ramapo River; and (3) the Two Bridges intake, which is located on the Pompton River about 750 feet upstream from the confluence with the Passaic River. The NJDWSC has the capability of pumping up to 150 mgd from the Pompton Lakes intake, and up to 250 mgd from the Two Bridges intake. By design, when the diversion from the Two Bridges intake exceeds the available flow in the Pompton River, this intake has the ability to reverse flows in the lowermost reach of the Pompton River and tap the locally impounded waters of the Passaic River. Thus, the entire upper Passaic watershed (with a drainage area of 361 square miles) becomes a contributing source to the Reservoir. To maintain water quality and protect users in the downstream portions of the Passaic, Pompton and Ramapo Rivers, the Department has implemented several restrictions on intake usage, including: (a) no diversions during July and August unless there is a declared drought emergency; (b) no diversions from the Pompton Lakes intake when flows in the

Ramapo River are below 40 mgd; and (c) no diversions when flows in the Passaic River at Little Falls are below 17.6 mgd. (modified from Najarian (2005)).

Watershed Management Area 4

Watershed Management Area 4 (WMA 4) includes the Lower Passaic River (from the Pompton River confluence downstream to the Newark Bay) and its tributaries, including the Saddle River. The Saddle River is located in the tidal portion of the Passaic River Watershed, and is outside of the scope of the non-tidal Passaic studies. The WMA 4 drainage area is approximately 180 square miles and lies within portions of Passaic, Essex, Hudson, Morris and Bergen Counties.

The Lower Passaic River watershed originates from the confluence of the Pompton River downstream to the Newark Bay. This 33-mile section meanders through Bergen, Hudson, Passaic, and Essex Counties and includes a number of falls, culminating with the Great Falls at Paterson.

Dundee Lake located in WMA 4 was created as a result of dam erected in 1859 by the Dundee Manufacturing Company replacing a smaller earlier dam, to harness the Passaic's water power and to make the river navigable from Newark to Paterson. The Dundee Dam curves 450 feet across the Passaic River and marks the boundary between the 17-mile tidal stretch of the Lower Passaic River to the river mouth at Newark Bay. Today, Dundee Dam and Lake are co-owned by the North Jersey District Water Supply Commission and the United Water Company. Dundee Lake is currently permitted for industrial water supply withdrawal.

Watershed Management Area 6

Watershed Management Area 6 (WMA 6) represents the area drained by waters from the upper reaches of the Passaic River Basin including the Passaic River from its headwaters in Morris County to the confluence of the Pompton River. Extensive suburban development and reliance upon ground water sources for water supply characterize WMA 6. WMA 6 lies in portions of Morris, Somerset, Sussex and Essex counties and includes the Upper and Middle Passaic River, Whippany River and Rockaway River watersheds.

The Upper Passaic River watershed is approximately 50 miles long and consists of a drainage area approximately 200 square miles in portions of Somerset, Morris, and Essex Counties. This section of the Passaic River is a significant source of drinking water for much of northeastern New Jersey. Major tributaries to the Upper Passaic River include the Dead River, Rockaway River, Whippany River, and Black Brook. The Great Swamp National Wildlife Refuge is located within the Upper Passaic River watershed. Approximately one-half of this watershed is undeveloped, including preserved open space, with the remainder primarily residential and commercial. This watershed is facing significant development pressure.

The Middle Passaic River watershed includes Great Piece Meadows and Deepavaal Brook. The Great Piece Meadows is a freshwater wetland with a drainage area of approximately 12 square miles and is prone to flooding. Various owners privately own the Great Piece Meadows.

The Rockaway River watershed has a drainage area of approximately 133 square miles and is approximately 37 miles long. The Rockaway River flows east to its confluence with the Whippany River at Pine Brook. Major tributaries include Stone Brook, Mill Brook, Beaver Brook, and Den Brook. The land use patterns in this area are complex and include undeveloped areas, parklands, residential development and industrial/commercial uses.

The Whippany River watershed drains approximately 69 square miles and is located entirely within Morris County. The river is approximately 18 miles long and flows to the Passaic River. Two major tributaries are Black Brook and Troy Brook. The population is centered in Morristown, Parsippany-Troy Hills, Hanover Township and East Hanover Township.

Land use in the non-tidal Passaic River basin is depicted in Figure 3 and summarized in Table 6.

Figure 3. 2002 Land Use in the Passaic River above Dundee Dam

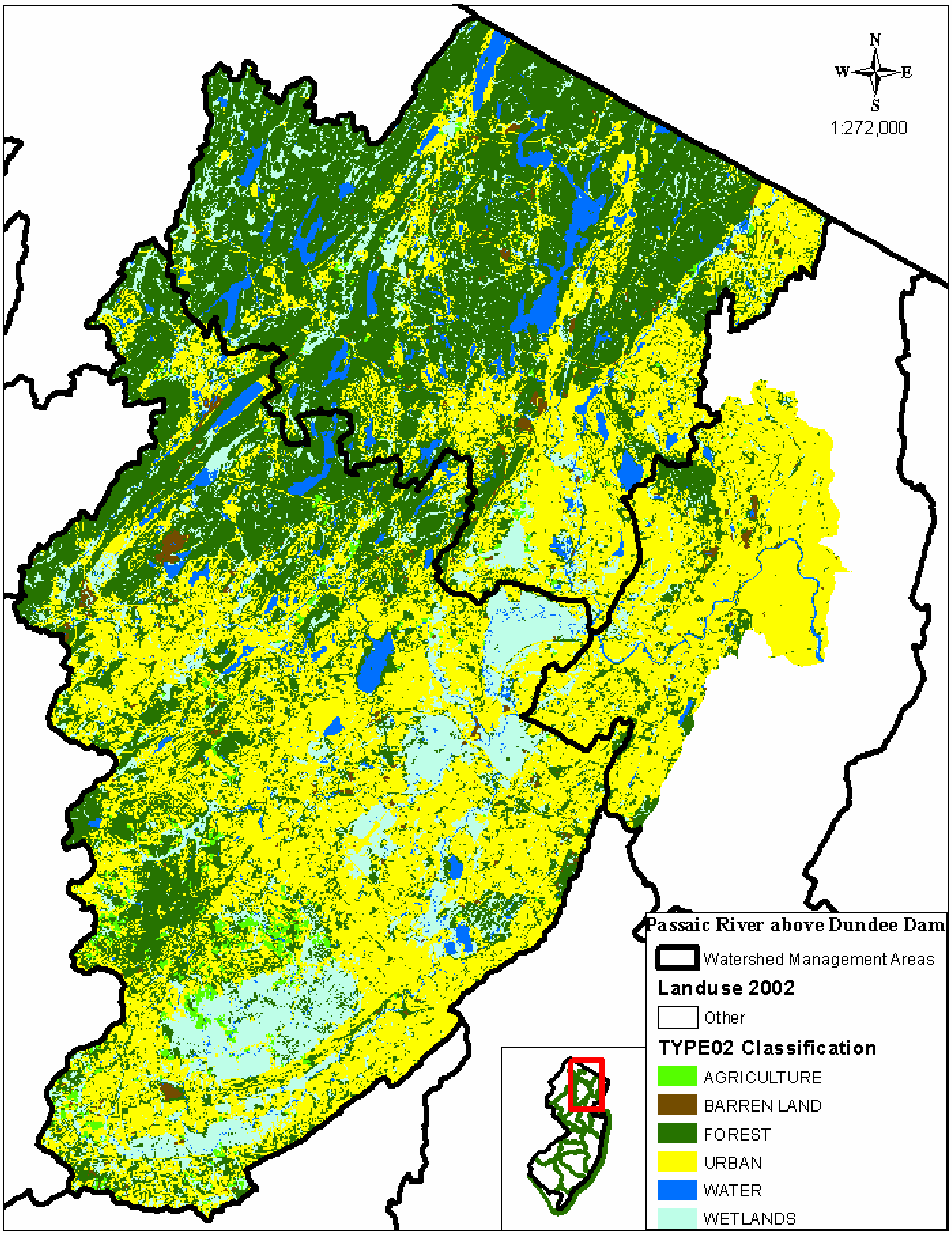


Table 6 . 2002 Land Use in the Passaic River above Dundee Dam

Land Use Classification (TYPE02)	Acres	Percent
Agriculture	281,138	1.8%
Barren Land	377,724	2.4%
Forest	4,221,843	26.8%
Urban	6,308,355	40.1%
Water	545,036	3.5%
Wetlands	4,002,509	25.4%
TOTAL	15,736,605	100%

4.0 Source Assessment

Point Sources

For the purposes of TMDL development, point sources include domestic and industrial wastewater treatment plants that discharge to surface water, combined sewer overflows, as well as stormwater discharges subject to regulation under the National Pollutant Discharge Elimination System (NPDES). This includes facilities with individual or general industrial stormwater permits and Tier A municipalities and state and county facilities regulated under the New Jersey Pollutant Discharge Elimination System (NJPDES) municipal stormwater permitting program. Point sources contributing phosphorus loads within the affected drainage area include the wastewater treatment facilities listed in Table 7 as well as combined sewer overflows and stormwater point sources, including the Tier A municipalities listed in Appendix B. Stormwater point sources, like nonpoint sources, derive their pollutant load from runoff from land surfaces and load reduction is accomplished through BMPs. The distinction is that stormwater point sources are regulated under the Clean Water Act. Combined sewer overflows are found in the City of Paterson within the spatial extent of this TMDL study. The loading from combined sewer overflows was determined and was an input to the water quality model for the study. The contribution from combined sewer overflows was found to be small and reduction of this load would result in no significant difference in the outcome. Therefore, the WLA for this source reflects the existing loading.

The point sources identified in Table 7 will receive individual WLAs. Refer to Figure 4 for location of major point sources. The remaining point sources, which are stormwater point sources, are quantified with the nonpoint sources, as described below, but will be assigned a WLA that will be expressed as a percent reduction based on land use.

Table 7. Permitted Point Sources within the Non-Tidal Passaic River Basin that contribute TP

NJPDES Permit #	Facility Name	DSN	Effluent Permit Conditions (1), (2)			Flow (mgd) (3)	Loading (kg/day) (3)	Permitted Flow (mgd)
			Timeframe	TP (mg/l)	TP (kg/day)			
NJ0002577	NABISCO FAIR LAWN BAKERY	001A & 002A	Monthly Avg. Daily Max.	MR MR	---- ----	--	--	0.385
NJ0003476	EXXONMOBIL RESEARCH & ENGINEERING	005A	Monthly Avg. Daily Max.	1 MR	MR MR	0.0499	0.716	0.29
NJ0020281	CHATHAM HILL SEWAGE TREATMENT	001A	Monthly Avg. Weekly Avg.	---- ----	---- ----	0.0071	0.044	0.03
NJ0020290	CHATHAM TWP MAIN STP	001A	Monthly Avg.	1	----	0.6596	1.495	1
NJ0020427	CALDWELL BORO STP	001A	Monthly Avg. Weekly Avg.	4.2 / 4 MR	MR MR	3.3667	42.887	4.5
NJ0021083	VETERANS ADMIN MEDICAL CENTER-LYONS	001A	Monthly Avg. Weekly Avg.	1 MR	1.51 MR	0.0999	1.528	0.4
NJ0021091	JEFFERSON TWP HIGH-MIDDLE SCHOOL	001A	Monthly Avg. Weekly Avg.	1 1.5	0.1 0.16	0.0101	0.028	0.0275
NJ0021253	RAMAPO-INDIAN HILLS H.S. WTP	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.0068	0.009	0.0336
NJ0021342	OAKLAND-SKYVIEW-HIGH BROOK STP	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.013	0.003	0.023
NJ0021636	NEW PROVIDENCE WWTP	001A	Monthly Avg. Weekly Avg.	---- ----	---- ----	0.0275	0.208	1.5
NJ0022276	STONYBROOK SCHOOL	001A	Monthly Avg. Weekly Avg.	MR [1] MR	MR MR	0.0011	0.004	0.01
NJ0022284	KINNELON TWP HIGH SCHOOL - (4)	001A	Monthly Avg. Weekly Avg.	1 MR	0.113 MR	0.0051	0.037	0.03
NJ0022349	ROCKAWAY VALLEY REG SA	001A	Monthly Avg. Weekly Avg.	3.4 / 3.2 MR	MR MR	9.3	62.724	12
NJ0022489	WARREN TWP STAGE I-II STP	001A	Monthly Avg. Weekly Avg.	4.2 / 3.6 MR	MR MR	0.3344	3.74	0.47
NJ0022497	WARREN TWP STAGE IV STP	001A	Monthly Avg. Weekly Avg.	7.1 / 5.2 MR	MR MR	0.3129	5.857	0.8
NJ0022845	BERNARDS SA - HARRISON BROOK STP	001A	Monthly Avg. Weekly Avg.	5.2 / 5 MR	MR MR	1.7288	26.003	2.5
NJ0023698	POMPTON LAKES BOROUGH MUA	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.7377	0.814	1.2
NJ0024414	W MILFORD SHOPPING CENTER	001A	Monthly Avg. Weekly Avg.	1 MR	0.075 MR	0.0047	--	0.02
NJ0024457	OUR LADY OF THE MAGNIFICENT	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.0009	0.001	0.0012

NJ0024465	LONG HILL TWP-STIRLING HILLS STP	001A	Monthly Avg. Weekly Avg.	4.4 / 3.7 MR	MR MR	0.9091	10.627	0.9
NJ0024490	VERONA TWP STP	004A	Monthly Avg. Weekly Avg.	5.4 / 3.7 MR	MR MR	2.15	3.17	3
NJ0024511	LIVINGSTON TWP STP	001A	Monthly Avg. Weekly Avg.	4.3 / 3.9 MR	68.4/62 MR	2.8492	36.741	4.6
NJ0024902	HANOVER SEWERAGE AUTHORITY	001A	Monthly Avg. Weekly Avg.	5 / 4.5 MR	MR MR	1.9508	28.049	4.61
NJ0024911	MORRIS TWP - BUTTERWORTH STP	001A	Monthly Avg. Weekly Avg.	3.04 / 2.24 MR	MR MR	1.6506	10.773	3.3
NJ0024929	MORRIS TWP - WOODLAND STP	001A	Monthly Avg. Weekly Avg.	1 MR	7.6 MR	1.2567	2.979	2
NJ0024937	MADISON-CHATHAM JT MTG - MOLITOR	001A	Monthly Avg. Weekly Avg.	4.4 / 4 MR	MR MR	2.2971	34.579	3.5
NJ0024970	PARSIPPANY TROY HILLS	001A	Monthly Avg. Weekly Avg.	4.9 / 5 MR	MR MR	12.5092	152.045	16
NJ0025330	CEDAR GROVE TWP STP	001A	Monthly Avg.	4 / 3.5	----	1.21	1.9	2
NJ0025496	MORRISTOWN TOWN STP	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	2.9079	6.917	6.3
NJ0025518	FLORHAM PARK S.A.	001A	Monthly Avg. Weekly Avg.	3.3 / 2.9 MR	MR MR	0.8793	7.566	1.4
NJ0026174	W MILFORD TWP MUA - CRESCENT PARK STP	001A	Monthly Avg. Weekly Avg.	1 MR	---- ----	0.0284	--	0.064
NJ0026514	PLAINS PLAZA SHOPPING CENTER	001A	Monthly Avg. Weekly Avg.	---- ----	---- ----	0.0093	0.206	0.02
NJ0026689	NJDHS-GREYSTONE PARK PSYCH HOSP	001A	Monthly Avg. Weekly Avg.	1 MR	1.51 MR	0.2153	0.195	0.4
NJ0026867	JEFFERSON TWP-WHITE ROCK STP	001A	Monthly Avg. Weekly Avg.	1 MR	0.5 MR	0.0978	0.049	0.1295
NJ0027006	RINGWOOD ACRES STP	001A	Monthly Avg.	1	MR	0.0231	0.037	0.036
NJ0027201	REFLECTION LAKE GARDEN APTS	001A	Monthly Avg. Weekly Avg.	1 MR	0.02 MR	0.0013	--	0.005
NJ0027669	WEST MILFORD TWP MUA - AWOSTING	001A & 002A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.0623	--	0.045
NJ0027677	WEST MILFORD TWP MUA- OLDE MILFORD	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.097	--	0.172
NJ0027685	WEST MILFORD MUA-HIGHVIEW ACRES STP	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.0534	0.105	0.2
NJ0027774	OAKLAND-OAKWOOD KNOLLS WWTP	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.0177	0.003	0.035
NJ0027961	BERKELEY HTS WPCP	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	1.5494	23.018	3.1

NJ0028002	WAYNE TWP - MOUNTAIN VIEW	001A	Monthly Avg. Weekly Avg.	3.4 / 3.1 MR	---- ----	6.79	2.29	13.5
NJ0028291	ISP MANAGEMENT CO INC	001A	Monthly Avg. Weekly Avg.	---- ----	---- ----	--	--	0.05
NJ0028541	WEST MILFORD TWP MUA - BIRCHILL	001A	Monthly Avg. Weekly Avg.	1 MR	---- ----	0.0123	--	0.02
NJ0029386	TWO BRIDGES SEWERAGE AUTHORITY	001A	Monthly Avg. Weekly Avg.	5 / 5.3[1*] MR	MR MR	4.7503	64.459	10
NJ0029432	RINGWOOD BOE - ERSKINE SCHOOL	001A	Monthly Avg. Weekly Avg.	1 MR	---- ----	0.001	--	0.008
NJ0029858	OAKLAND CARE CENTER	001A	Monthly Avg.	1	0.11	0.0239	0.012	0.03
NJ0029912	NJDOT-HARDING REST AREA (Oct-April) - (5)	001A	Monthly Avg. Weekly Avg.	---- ----	---- ----	0.0014	0.007	0.025
NJ0032395	RINGWOOD PLAZA STP	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.0066	0.009	0.0117
NJ0050369	WARREN TWP STAGE V STP	001A	Monthly Avg. Weekly Avg.	7.1 / 5.1 MR	MR MR	0.1377	1.917	0.38
NJ0052256	CHATHAM TWP-CHATHAM GLEN STP	001A	Monthly Avg. Weekly Avg.	4.3 / 3.7 MR	MR MR	0.1214	1.591	0.155
NJ0053112	OAKLAND-CHAPEL HILL ESTATES STP	001A	Monthly Avg. Weekly Avg.	0.05 0.075	0.002 0.003	0.0069	0.001	0.01
NJ0053759	WANAQUE VALLEY REG S.A.	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.9181	1.152	1.25
NJ0080811	RAMAPO RIVER CLUB STP - Oakland Twp Riverbend	001A	Monthly Avg. Weekly Avg.	1 MR	MR MR	0.0696	0.018	0.1137
NJ0104451	BAYER CORPORATION	001A	Monthly Avg. Daily Max.	1 MR	---- ----	--	--	0.216
NJG0108880	PATERSON CITY - 31 CSOS	--	----	----	----	--	--	--

Footnotes:

(1) Current permit requirements as of April 19, 2007.

(2) Limitations or monitoring requirements <u>with</u> a "/" indicates the following limitations: Summer / Winter. Summer is applicable in the months of May through October. Winter limitations are applicable in the months of November through April. Limitations and monitoring requirements <u>without</u> a "/" apply year-round.

(3) Data summarized October 1, 1999 to November 30, 2003 (Omni Environmental, 2007)

(4) Permit revoked on October 25, 2005, due to connection to the Two Bridges Sewerage Authority W.W.T.P

(5) Permit revoked on September 30, 2003 due to connection to the Morris Township Woodland W.P.C.U.

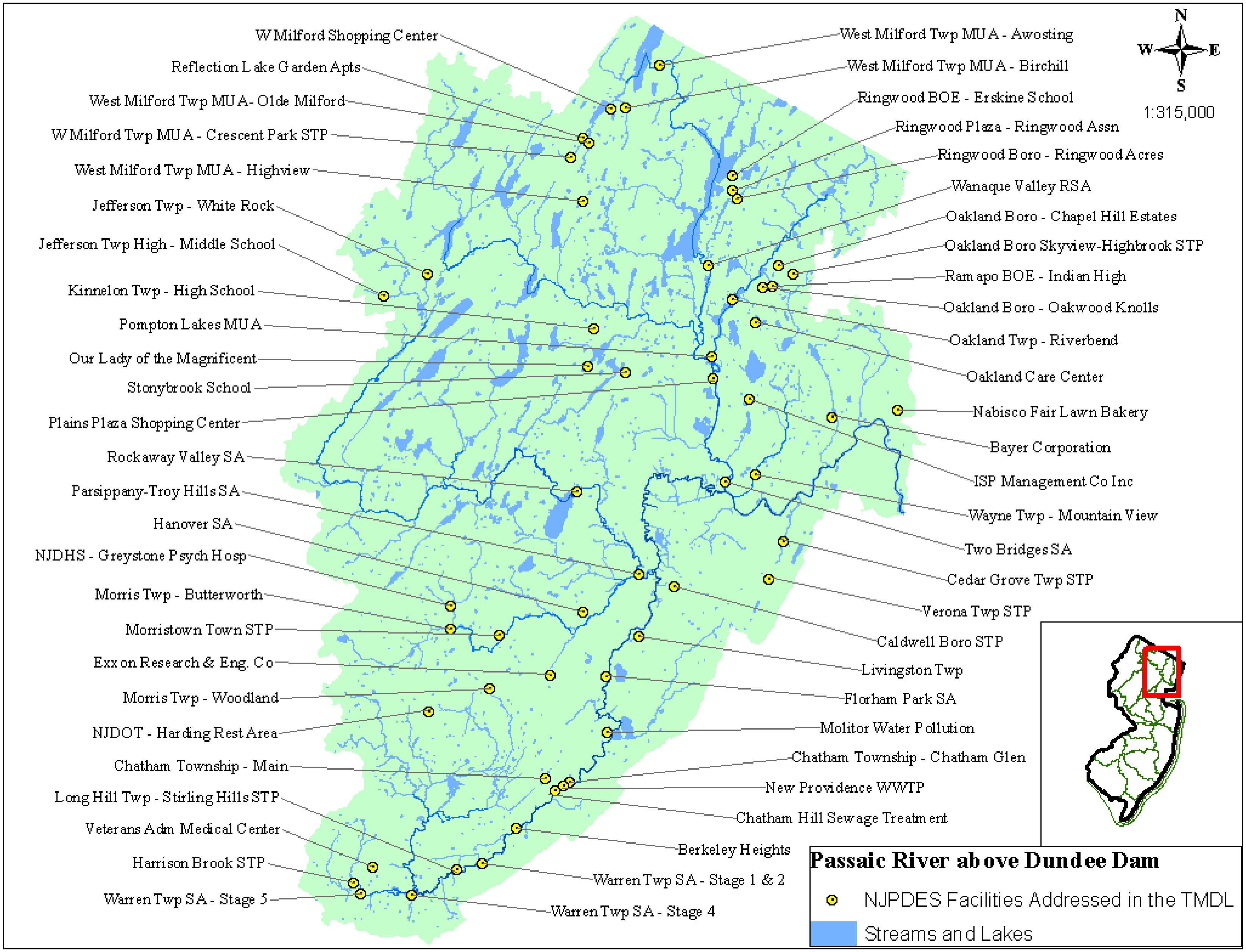
[1] Permit Condition of 1 mg/l for the monthly average TP concentration from January through December will become effective on June 1, 2011.

[1*] Permit Condition of 1 mg/l for the monthly average TP concentration from January through December will become effective at a flow of 9.639.mgd.

MR Monitor and report only.

---- Not required by permit condition.

Figure 4. NJPDES Point Source Discharges of Phosphorus in the Passaic River above Dundee Dam



Nonpoint Sources

For the purposes of TMDL development, potential nonpoint sources include stormwater discharges that are not subject to regulation under NPDES, such as Tier B municipalities, which are regulated under the NJPDES municipal stormwater permitting program, and direct stormwater runoff from land surfaces, as well as malfunctioning sewage conveyance systems, failing or inappropriately located septic systems, and direct contributions from wildlife, livestock and pets. Tier B municipalities in the spatial extent are identified in Appendix B.

Within the WASP7 /DAFLOW modeled domain (Approach areas 1 and 3), nonpoint source contributions as well as storm driven point sources were quantified by separating stream flow into runoff and tributary baseflow. The nonpoint source loads were calculated based on the flow-weighted Event Mean Concentration (fEMCs) for each parameter and sub-basin, tributary baseflow concentrations for tributary baseflows, and an estimate of the individual contribution of surface flow and tributary baseflow from each sub-basin as determined through the hydrograph separation algorithm in WAMIT. The EMCs for NH3-N, NO3-N, OrgN, OrthoP, OrgP, DO and CBODu were calculated by averaging the data collected for this study from each storm event for each station, among storm events for each station, and lastly from different stations for each land use type (Table 8). The land use types are subdivided into residential, commercial, agricultural, forest, wetlands and barren.

Table 8. Runoff EMCs for Each Land Use Category

Constituent	Residential	Commercial	Agriculture	Wetlands	Forest*
NH3-N	0.16	0.21	0.10	0.12	0.04
NO3-N	0.94	0.65	1.42	0.76	0.26
Org-N	1.27	0.90	1.09	1.58	0.54
OrthoP	0.103	0.076	0.261	0.170	0.023
Org-P	0.217	0.149	0.183	0.186	0.064
CBOD5	2.7	4.2	3.8	5.9	1.3

* EMCs for barren land were not available for the storm water sampling events, and were assumed to be the same as forest EMCs.

Using both land use and State Soil Geographic (STASGO) layers, polygons were created consisting of different soil types and land uses. The areas of the polygons were calculated and an area-weighted curve number (CN) value was assigned to each individual polygon. By grouping areas with the same land use type, the area-weighted CN value was calculated based on the area of each polygon. These CN values estimate the amount of runoff flow that is generated by each land type in order to properly weight the EMCs for each sub-basin. Curve numbers were not used to calculate any flows for the model. Flows were provided by DAFLOW and separated into tributary baseflow and runoff. Curve numbers were used only to estimate the proportion of runoff flow that is generated by each land type in order to properly weight the EMCs for each sub-basin.

The tributary baseflow concentrations were not assumed to vary by land use type. Tributary baseflow as defined in this study is not primarily the direct discharge of groundwater to modeled streams. Tributary baseflow also reflects dry-weather discharge of tributaries within each contributing sub-basin. Tributary baseflow concentrations for constituents other than phosphorus are assumed to be constant throughout the basin, while tributary baseflow phosphorus concentrations are assumed to vary by the major stream branches (Tables 9 and 10).

Table 9. Tributary Baseflow Concentrations for Contributing Watersheds

OrthoP (mg/l)	NH3-N (mg/l)	NO3-N (mg/l)	Org-N (mg/l)	CBOD5 (mg/l)	DO (mg/l)
0.04	0.09	0.56	0.09	2.0	3.0

Table 10. Tributary Baseflow Phosphorus Concentrations for Contributing Watersheds

Model Branch Groupings	TP (mg/l)	Ortho P (mg/l)
Forest Dominated (Wanaque River)	0.045	0.021
Major Tributaries (Pequannock, Ramapo, Pompton, Whippany, and Rockaway Rivers)	0.054	0.023
Upper Passaic / Minor Tributaries (Upper and Mid-Passaic River, Dead River, and Singac Brook)	0.063	0.022
Lower Passaic (Lower Passaic and Peckman Rivers)	0.060	0.031

The total volume of water from tributary baseflow and surface flow reaching the streams during a flow model time step (3 hours) is multiplied by the tributary baseflow concentrations and fEMCs to yield the nonpoint source load for each water quality parameter. For more detail on the estimation of nonpoint sources, refer to supporting documentation for this TMDL (Omni Environmental, 2007).

Within the Wanaque Reservoir direct drainage area and Pompton Lake watershed (Approach 2) a similar approach was used to evaluate nonpoint source contributions. Again the basis for this approach was a GIS analysis of the watershed's land uses and gauged USGS flow data, which was separated into baseflow and stormwater runoff components. However, EMCs were developed as part of a multi-year analysis using the unit area load (UAL) methodology rather than by the analysis of storm event water quality data. This approach provided EMCs on a composite basis for each subwatershed. EMCs for total phosphorus ranged from 0.13 mg/l in the more pristine subwatersheds (such as Ringwood Creek) to 0.30 mg/l in a more developed area (such as the Pompton Lakes subwatershed. Baseflow was assigned a constant concentration of 0.01 mg/l TP, which was found to be representative of base flow from a relatively pristine location in the watershed. For more information on this method of estimating nonpoint sources, refer to Najarian, 2005.

Table 11. UALs used to Estimate Land Use Loads

Land Use Categories	UAL Coeff. (kg/hc/yr)	UAL Coeff. (lb/ac/yr)
Low Intensity Residential	0.7	0.623
High Intensity Residential	1.6	1.424
Comm./Ind./Trans	2/1.7/1	1.8/1.5/.9
Mixed Urban/Recreational	1.0	0.890
Crops/Pasture/Hay	1.5	1.335
Deciduous Forest	0.1	0.089
Evergreen Forest	0.1	0.089
Mixed Forest	0.1	0.089
Shrubland	0.1	0.089
Woody Wetlands	0.1	0.089
Herbaceous Wetlands	0.1	0.089
Open Water	0.1	0.089
Disturbed Areas	0.1	0.089

(modified from Najarian 2005)

5.0 Analytical Approach and TMDL Calculation

The non-tidal Passaic River Basin TMDLs are based on an integration of water quality and hydrodynamic models. A water quality model, Water Quality Analysis Simulation Program 7.0 (WASP 7), and a flow model, Diffusion Analogy Surface-Water Flow Model (DAFLOW), were used to simulate water quality and flow in the non-tidal Passaic River and its major tributaries: Dead River, Whippany River, Rockway River, Pompton River mainstem, Ramapo River downstream of Pompton Lake, Wanaque River downstream of the Wanaque Reservoir, a small stream segment of the Pequannock River, Singac Brook, and Peckman River. The WASP 7 model is a dynamic compartment mode that can be used to predict a variety of water quality responses due to natural phenomena and man-made pollution for diverse aquatic systems, such as rivers, reservoirs, lakes, and coastal waters. The model includes time varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange. WASP 7 uses as inputs time series of flow, pollutant loads and several water quality parameters (Omni Environmental, 2007). DAFLOW model is a one-dimensional transport model designed to simulate flow by solving the diffusion analogy form of the flow equation. DAFLOW was developed by USGS and enhanced by USGS for this study (Spitz, 2007). The flow model routes water downstream using time series inputs from streamflow gauges, discharges and diversions and incremental flows from tributaries and subbasins along the mainstem. A graphical watershed model integration tool (WAMIT) was developed for data sharing and model input calculation between WASP 7 and DAFLOW (Omni Environmental 2007). WAMIT includes algorithms to calculate nonpoint source loads as a function of tributary baseflow and surface waters given by a hydrograph separation scheme, sub-basin characteristics and flow-weighted runoff concentrations for different land use types, as described above under nonpoint source loads.

The LA-WATERS (Laterally Averaged - Wind and Temperature Enhanced Reservoir Simulation) model was used to link loading with concentration response in the Wanaque Reservoir. LA-WATERS is a two-dimensional (longitudinal and vertical) hydrothermal/water quality model. It was successfully calibrated to the Wanaque Reservoir using data collected as part of the Wanaque South water supply project (Najarian Associates, 1988), and then re-validated (Najarian Associates, 2000). A detailed description of LA-WATERS is provided in Najarian (1988). A simulation of baseline (existing) conditions was conducted over the selected 10-year period (1993-2002) using water quality data obtained from North Jersey District Water Supply Commission (NJDWSC), USGS and Passaic Valley Water Commission (PVWC), flow data from USGS gauging stations, pumping data from NJDWSC and meteorological data from National Climatic Data Center's Newark International Airport weather station. In response to model inputs, LA-WATERS simulates laterally averaged velocities, water temperature and constituent concentrations at all grid locations for a selected period. Simulated constituents include organic phosphorus, dissolved inorganic phosphorus, particulate inorganic phosphorus, dissolved oxygen, carbonaceous biological oxygen demand, nitrogenous biological oxygen demand and temperature. As indicated, the reservoir endpoint is based on chlorophyll-a concentration. A discussion of the phosphorus – chlorophyll-a relationship in the Wanaque Reservoir is provided in a report addendum (Najarian Associates, 2007).

To conduct future simulations of water quality in the Wanaque Reservoir, loadings were estimated in two ways. A time series of daily in-stream total phosphorus and dissolved phosphorus concentrations developed for Approach Area 1 (Omni 2007), described above, was used with the daily schedule of Wanaque South diversions to develop one portion of the reservoir's loading input. The diversion load from the

Pompton Lakes intake and the reservoir's direct tributary load were developed using a simple mass-balance model. The mass-balance model was based on an input of observed USGS flow data, reported discharger monitoring data and GIS-based non-point source assessment and was verified using an 11-year time series (from 1992 through 2002) of observed in-stream concentrations (Najarian 2005, Litwack et al. 2006).

More detailed discussion on the above models is available in the supporting documents for this TMDL prepared under contract to the Department by Najarian Associates (Najarian 2005 and 2007), Omni Environmental (Omni, 2007), and (Spitz, 2007).

Certain premises were factored into this TMDL study, as follows. TMDLs have been established for Verona Park Lake (NJDEP 2003) and Greenwood Lake (NJDEP 2004), which are within the drainage area for this TMDL study. The loading from the Greenwood Lake drainage area assumes attainment of the SWQS, as specified in that TMDL. Further, water quality modeling of the Peckman River assumes attainment of the SWQS in Verona Park Lake. The companion TMDL document for Pompton Lake and associated drainage area provides inputs to this TMDL study. The Pompton Lake TMDL study includes the Ramapo River, which originates in New York and enters New Jersey with a significant phosphorus load and concentrations in excess of the SWQS. As a boundary condition for the Pompton Lake TMDL study, it was assumed that the water quality will attain New Jersey's SWQS at the border, represented by the quality at the Ramapo at Mahwah monitoring station. As the Ramapo River currently enters New Jersey with phosphorus concentrations in excess of the standards, it will be necessary for New York to implement measures to reduce phosphorus loads in order to realize this boundary condition. Recently, New York issued a permit for the Western Ramapo treatment facility, which is currently under construction. This facility will replace some smaller facilities and, with an effluent limit of 0.2 mg/l, will result in an overall reduction in point source phosphorus load in the Ramapo River. However, it is expected that reductions in NPS will be needed for full attainment of the boundary condition.

Seasonal Variation, Critical Conditions, MOS and Reserve Capacity

A TMDL must account for critical conditions and seasonal variations. The summer season is the critical period for biological activity, algal blooms and associated oxygen effects (excessive swings and/or dips below criterion). Yet winter and early spring are the times when, due to diversions from the Pompton and Passaic Rivers, phosphorus loadings to the Wanaque Reservoir are usually highest. As a result, load reductions must be required year-round for sources that contribute loads to the Wanaque Reservoir. Critical conditions and seasonal variation were addressed through inclusion of a simulation period that included extreme hydrologic conditions, such as the hot, dry summer of WY2001 and the water supply drought of WY2002, during which diversions from the Pompton and Passaic were much greater than normal in winter and spring. In addition, the simulation of future conditions assumes wastewater treatment facilities are at full permitted capacity and that pumping into the Wanaque Reservoir is consistent with the full permitted water supply allocation of 173 mgd. At the Dundee Lake critical location, the critical period is during the growing season. Simulations indicate that phosphorus reductions from wastewater treatment facilities outside the months of May through October have no effect on the observed seasonal average chlorophyll-a levels, due to the riverine nature of Dundee Lake. Therefore, below the confluence of the Pompton and Passaic Rivers, seasonal effluent limits (May through October) are consistent with achieving the watershed criterion for Dundee Lake.

In the development of a TMDL, Section 303(d) of Clean Water Act requires specification of a Margin of Safety (MOS) – an unallocated portion of the assimilative capacity. A MOS is needed to account for a "lack of knowledge concerning the relationship between effluent limitations and water quality" (33 U.S.C. 1313(d)). In particular, a MOS accounts for uncertainties in the loading estimates, physical parameters and the linked models themselves. The MOS, as described in USEPA guidance (Sutfin, 2002), can be either explicit or implicit (i.e., addressed through conservative assumptions used in establishing the TMDL). Reserve capacity is an optional means of reserving a portion of the loading capacity to allow for future growth. An explicit MOS and reserve capacity are included by targeting a chlorophyll-a target below the proposed watershed criteria for the Wanaque Reservoir and Dundee Lake. The allocation of loading capacity, including the WLAs and LAs identified in this report, will achieve a chlorophyll-a level of 9.2 μg/L in the Wanaque Reservoir and 18 μg/L chlorophyll-a in Dundee Lake, on a seasonal average basis. This is compared to the proposed watershed criteria of 10 μg/L and 20 μg/L, respectively in these locations.

Allocation of Loading Capacity

WLAs are established for all point sources, while LAs are established for nonpoint sources, as these terms are defined in "Source Assessment."

Stormwater discharges can be a point source or a nonpoint source, depending on NPDES regulatory jurisdiction, yet the suite of measures to achieve reduction of loads from stormwater discharges is the same, regardless of this distinction. Stormwater point sources receiving a WLA are distinguished from stormwater generating areas receiving a LA on the basis of land use. This distribution of loading capacity between WLAs and LAs is consistent with recent EPA guidance that clarifies existing regulatory requirements for establishing WLAs for stormwater discharges (Wayland, November 2002). Stormwater discharges are captured within the runoff sources quantified according to land use, as described previously. Distinguishing between regulated and unregulated stormwater is necessary in order to express WLAs and LAs numerically; however, "EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability within the system" (Wayland, November 2002, p.1).

Therefore allocations are established according to source categories, with stormwater from urban land use types given wasteload allocations and stormwater from other land use types given load allocations. This demarcation between WLAs and LAs based on land use source categories is not perfect, but it represents the best estimate defined as narrowly as data allow. The Department acknowledges that there may be stormwater sources in the urban land use categories that are not NJPDES-regulated. Nothing in these TMDLs shall be construed to require the Department to regulate a stormwater source under NJPDES that would not already be regulated as such, nor shall anything in these TMDLs be construed to prevent the Department from regulating a stormwater source under NJPDES.

Loads from some land uses, specifically forest, wetland, water and barren land are not readily adjustable. As a result, existing loads from these sources have been set equal to the future loads. Therefore, in order to achieve the overall load reduction required from land uses, the load reduction from land uses for which reduction measures are more practicable must be increased proportionally. Nonpoint source load reductions range from 0 to 82 percent, depending on the Approach Area. Nonpoint source loads were assumed to remain constant from the land areas in Approach Area 4, because this area is a boundary condition for Approach Area 1. Approach Area 1 requires a nonpoint source load reduction of 60 percent. The Greenwood Lake Approach Area has a nonpoint source load reduction of 43 percent in accordance with a previously approved TMDL which, when combined with the required 60 percent reduction in the Wanaque drainage portion of Approach Area 2, yields an overall reduction of 54 percent for that combined area, as reflected in Table 13. The Pompton Lake drainage area requires an 80 percent nonpoint source reduction, as described in the companion TMDL report for that area. The TMDL for Verona Park Lake required an 82% overall TP load reduction.

Allocation of the loading capacity for the two critical locations is presented in Tables 12 and 13. Individual WLAs are set forth in Table 14.

Table 12. Distribution of WLAs and LAs among source categories for the Non-Tidal Passaic River Downstream of Wanaque Reservoir

TP Source	Existing Condition				TMDL Condition			
	Pompton	Upper/Mid Passaic	Lower Passaic	Total (kg/d)	Pompton	Upper/Mid Passaic	Lower Passaic	Total (kg/d)
Headwaters	72	31	5.7	108	26	31	4.9	62
NPS Runoff	29	65	18	113	19	35	7.9	62
NPS Baseflow	7.5	22	6.3	35	7.5	22	6.3	35
CSO Discharges	0	0	4.9	4.9	0	0	4.9	4.9
STP Discharges	61	431	92	584	19	100	29	148
TOTAL (kg/d)	**169**	**549**	**127**	**845**	**71**	**188**	**53**	**312**

Table 13. Distribution of WLAs and LAs among source categories for the Wanaque Reservoir critical location

	Existing Conditions[1] kg TP/day	Existing Conditions[1] % of LC	TMDL Specification kg TP/day	TMDL Specification % of LC	Percent Reduction[2]
Loading Capacity (LC)	58.99	100%	25.14	100%	57%
Point Sources other than Stormwater					
NJPDES Dischargers[3,4]	0.32	0.5%	0.20	0.8%	39%
Loading from Intake Diversions					
Diversions from Ramapo River[5]	3.23	5.5%	0.68	2.7%	79%
Diversions from Two Bridges[6]	37.48	63.5%	11.20	44.6%	70%
Internal Loading					
Sediment/Base Flow	3.14	5.3%	3.14	12.5%	0%
Land Use Surface Runoff[7,8]					
Low Intensity Residential	1.90	3.2%	0.88	3.5%	54%
High Intensity Residential	4.14	7.0%	1.91	7.6%	54%
Commercial/Industrial/Transportation	1.82	3.1%	0.84	3.3%	54%
Mixed Urban/Recreational	0.67	1.1%	0.31	1.2%	54%
Crops/Pasture/Hay	0.56	0.9%	0.25	1.0%	54%
Deciduous Forest	3.37	5.7%	3.37	13.4%	0%
Evergreen Forest	0.34	0.6%	0.34	1.3%	0%
Mixed Forest	0.83	1.4%	0.83	3.3%	0%
Shrubland	0.05	0.1%	0.05	0.2%	0%
Woody Wetlands	0.29	0.5%	0.29	1.2%	0%
Herbaceous Wetlands	0.03	0.1%	0.03	0.1%	0%
Open Water	0.67	1.1%	0.67	2.7%	0%
Disturbed Areas	0.16	0.3%	0.16	0.6%	0%

* an explicit MOS and Reserve Capacity has been specified in terms of chlorophyll-a level achieved compared to target.
1 average annual loads for existing conditions based on 1993-2002 model simulation
2 = 1 - (TMDL load /Existing load)*100
3 WLA derived from NJDEP TMDL study for Greenwood Lake (2004)
4 facilities within Reservoir tributary watershed -- existing condition based on 1997-2000 DMR data
5 diversion load typically equals 3%-5% of the annual river load - for river load see Table 6.2 (Najarian 2005)
6 phosphorus concentrations at diversion intake were computed per Omni Environmental, 2007
7 see Table 6.9 for associated land use areas (Najarian 2005)
8 removal rates are an area-weighted average of the Greenwood Lake watershed (with a NPS removal rate of 43%) and the rest of the Wanaque Reservoir watershed (with a NPS removal rate of 60%)

Table 14. Point Sources assigned individual WLAs for Phosphorus based on TMDL Study

NJPDES Permit Number	Facility Name	Permitted Flow (MGD)	TMDL Wasteload Allocation: Long Term Average Conc. (mg/l TP)	TMDL Wasteload Allocation: Long-Term Average Load (Kg/d TP)
NJ0002577	Nabisco Fair Lawn Bakery (1)	0.385	0.4	0.6
NJ0003476	Exxon Research & Eng Co	0.29	0.4	0.4

NJ0020281	Chatham Hill STP	0.03	0.4	0.05
NJ0020290	Chatham Township – Main (2)	1	0.4	1.5
NJ0020427	Caldwell Boro STP	4.5	0.4	6.8
NJ0021083	Veterans Adm Medical Center	0.4	0.4	0.61
NJ0021091	Jefferson Twp High - Middle School (3)	0.0275	see Table 7 for permit limits	0.04
NJ0021253	Ramapo BOE - Indian High	0.0336	0.4	0.05
NJ0021342	Oakland Boro Skyview-Highbrook STP	0.023	0.4	0.03
NJ0021636	New Providence Boro	1.5	EEQ	de minimus
NJ0022276	Stonybrook School (3)	0.01	see Table 7 for permit limits	0.02
NJ0022349	Rockaway Valley SA	12	0.4	18.2
NJ0022489	Warren Twp SA - Stage 1 & 2	0.47	0.4	0.7
NJ0022497	Warren Twp SA - Stage 4	0.8	0.4	1.2
NJ0022845	Harrison Brook STP	2.5	0.4	3.8
NJ0023698	Pompton Lakes MUA	1.2	0.4	1.8
NJ0024414	W Milford Shopping Center	0.02	0.4	0.03
NJ0024457	Our Lady of Magnificent School	0.0012	0.4	0.002
NJ0024465	Long Hill Twp STP - Stirling Hills	0.9	0.4	1.4
NJ0024490	Verona Twp STP (1)	3	0.4	4.5
NJ0024511	Livingston Twp	4.6	0.4	7.0
NJ0024902	Hanover SA	4.61	0.4	7.0
NJ0024911	Morris Twp – Butterworth	3.3	0.4	5.0
NJ0024929	Morris Twp – Woodland (2)	2	0.4	3.03
NJ0024937	Molitor Water Pollution	3.5	0.4	5.3
NJ0024970	Parsippany-Troy Hills SA	16	0.4	24.2
NJ0025330	Cedar Grove Twp STP (1)	2	0.4	3.0
NJ0025496	Morristown Town STP	6.3	0.4	9.5
NJ0025518	Florham Park SA	1.4	0.4	2.1
NJ0026174	W Milford Twp MUA - Crescent Park STP	0.064	0.4	0.1
NJ0026514	Plains Plaza Shopping Center	0.02	0.4	0.03
NJ0026689	NJDHS – Greystone Psych Hosp	0.4	0.4	0.6
NJ0026867	Jefferson Twp – White Rock (3)	0.1295	see Table 7 for permit limits	0.2
NJ0027006	Ringwood Boro – Ringwood Acres	0.036	0.4	0.05
NJ0027201	Reflection Lake Garden Apts	0.005	0.4	0.01
NJ0027669	West Milford Twp MUA – Awosting	0.045	0.4	0.07
NJ0027677	West Milford Twp MUA- Olde Milford	0.172	0.4	0.26
NJ0027685	West Milford Twp MUA – Highview	0.2	0.4	0.3
NJ0027774	Oakland Boro - Oakwood Knolls	0.035	0.4	0.05
NJ0027961	Berkeley Heights	3.1	0.4	4.7

NJ0028002	Wayne Twp - Mountain View (1)	13.5	0.4	20.4
NJ0028291	ISP Management Co Inc	0.05	Treated at Wayne (NJ0028002)	
NJ0028541	West Milford Twp MUA – Birchill	0.02	0.4	0.03
NJ0029386	Two Bridges SA	10	0.4	15.1
NJ0029432	Ringwood BOE – Erskine School	0.008	0.4	0.01
NJ0029858	Oakland Care Center	0.03	0.4	0.05
NJ0032395	Ringwood Plaza - Ringwood Assn	0.01168	0.4	0.02
NJ0050369	Warren Twp SA - Stage 5	0.38	0.4	0.6
NJ0052256	Chatham Township - Chatham Glen	0.155	0.4	0.23
NJ0053112	Oakland Boro - Chapel Hill Estates	0.01	0.4	0.02
NJ0053759	Wanaque Valley RSA	1.25	0.4	1.9
NJ0080811	Ramapo River Club STP - Oakland Twp Riverbend	0.1137	0.4	0.17
NJ0104451	Bayer Corporation (1)	0.216	0.4	0.33
NJG0108880	Paterson City - 31 CSOs	N/A	N/A	4.9

(1) These dischargers are located in the Lower Passaic River Basin, downstream of the Passaic and Pompton Rivers. Based on the TMDL Analysis, a seasonal effluent limit (May through October) is applicable.
(2) These two facilities are located in the Great Swamp watershed and are included in the Passaic River headwater load allocation. To ensure the boundary condition remains valid, based on the analysis provided in Appendix D (Omni Environmental, 2007), WLAs are established for these facilities based on a LTA of 0.4 mg/l total phosphorus.
(3) These three discharge facilities are located outside model boundaries. Because of the fact that the TP loads generated by these dischargers are insignificant when compared to the boundary loads, the impact of these dischargers is de minimus. For example, assuming no natural TP load attenuation, the average total permitted loads of these facilities is less than 0.03% of the total boundary load. Therefore, the WLAs established for these facilities is based on permitted flow and monthly average concentration in accordance with current permit conditions. The effluent limits set forth in the applicable NJPDES permits will remain in effect.

In a Department review of the active NJPDES surface water point source discharges that contain phosphorus within the Passaic River basin above Dundee Dam, two facilities were found that required further description. The first is New Providence Borough STP (NJ0021636). The New Providence STP is a sanitary wastewater treatment plant that transfers all of the wastewater up to 3.0 MGD to the Joint Meeting of Essex and Union County STP (NJ0024741). The wastewater is discharged to the Passaic River only during heavy wet weather events when wastewater flows are above 3.0 MGD. Because of the intermittent nature of this discharge, the load is de minimus and did not figure into the modeled loads. Therefore, New Providence STP will be assigned a WLA of "0" and will be required to maintain existing effluent quality. Additionally, the facility will not qualify for water quality trading described in the second paragraph below. The second is ISP Management Co. Inc. (NJ0028291), which is an industrial surface water discharge with a sanitary component. Under a Department issued Treatment Works Approval (TWA), the ISP Management Co. Inc. surface water discharge will cease in the near future when the facility ties into the Wayne Twp. Mountain View STP (NJ0028002). Therefore, ISP Management Co. Inc. is addressed within the Wayne Twp. Mountain View STP calculation in the TMDL. Should the ISP Management Co. facility not tie into

Wayne Twp. Mountain View STP, the discharge would be subject to the 0.4 mg/l total phosphorus LTA concentration limit.

The assignment of WLAs to point sources, other than stormwater point sources, is based on each source discharging at the permitted capacity at the same long term average effluent concentration. WLAs must be expressed as a daily load in accordance and with EPA requirements. However, effluent concentrations can and do vary on a daily basis. This variation can occur and still achieve the water quality objective provided that, on balance, reductions in point and nonpoint source loads on a long term basis conform to those needed to attain the watershed criteria, proposed to be established through this TMDL report. Except as noted below, for wastewater treatment facilities within the WASP 7/DAFLOW (Omni Environmental, 2007) and mass balance (Najarian 2005, as amended) model domains, the Department intends to establish year-round concentration-only effluent limits determined by applying EPA's *Technical Support Document for Water Quality-Based Toxics Control* (USEPA, 1991) methodology to the LTA of 0.4 mg/l, assuming a 4 times per month sampling frequency and a coefficient of variation equal to the default value of 0.6. For these facilities, the resulting monthly average effluent limit would be 0.76 mg/l. Treatment facilities below the confluence of the Pompton and Passaic Rivers, as identified in Table 14, qualify for seasonal limits, applicable from May through October, as discussed above. Treatment facilities addressed in the Greenwood Lake TMDL will retain the WLAs and effluent limits set forth in that TMDL report. There are three treatment facilities identified in Table 14 that are outside the model domains. In order to maintain the boundary conditions, these facilities will be assigned a WLA consistent with the current permit limits. While this represents a small increase compared to the existing load contributed by these facilities, both the existing loads and the increased loads are de minimus relative to the overall boundary load (less than 0.03%). In addition, two of the facilities discharge to an impoundment, which would significantly mask any contribution from these facilities.

Dischargers will be allowed to engage in water quality trading negotiations to effect a change in effluent limits, with Department approval. It should be noted that, in June 2005 EPA awarded a Targeted Watershed grant in the amount of $900,000 to Rutgers University for the purpose of developing a water quality trading pilot with respect to the phosphorus impairment in the Passaic River basin. This project has been investigating the options for and overall viability of a trading approach in the Passaic River basin. One outcome of the project will be trading ratios that can be used to easily determine equivalency and allowability of phosphorus trades within and between management zones. Upon approval of this TMDL, interested permittees can proceed to negotiate trades that achieve the desired result in a more cost effective way. For example, it may be more cost effective for a few larger facilities to upgrade to a higher level than for all treatment facilities to upgrade to the same level. Because diversion of Pompton and Passaic River water into the Wanaque Reservoir is a loading source, another option in the portion of the watershed above the confluence of the Pompton and Passaic Rivers is to trade wastewater treatment plant upgrades for treatment of river water by NJDWSC prior to diversion to the reservoir. Any viable trading option would have to ensure that EPA and DEP requirements for trading be met, including ensuring that the watershed criteria in the Wanaque Reservoir and Dundee Lake are met and there is full and enforceable accountability for required load reductions. A trading project must identify the fungible unit of trade and associated value to ensure a level playing field among potential traders. The effectiveness of alternative load reductions with respect to attaining applicable water quality criteria must also be established, as well as a means to ensure the goals of the project are being achieved. The Department must approve the tools that will be used to make these demonstrations before trading can proceed. The Department anticipates allowing 1 year from the date of permit issuance to negotiate trades so that treatment plant upgrades consistent with permit limits are implemented within the compliance schedules that will be set forth in the permits.

6.0 Follow-up Monitoring

The Water Resources Division of the U.S. Geological Survey and the Department have cooperatively operated the Ambient Stream Monitoring Network (ASMN) in New Jersey since the 1970s. The ASMN currently includes approximately 115 stations that are routinely monitored on a quarterly basis. A second ambient monitoring network, NJDEP's Supplemental Ambient Surface Water Network (100 stations), has improved spatial coverage for water quality monitoring in New Jersey. The data from this these networks have been used to assess the quality of freshwater streams and percent load reductions. Through this TMDL, watershed criteria are proposed for the Wanaque Reservoir and Dundee Lake expressed in terms of a seasonal average of chlorophyll-a. Therefore, in order to assess effectiveness of this TMDL, these locations will need to be monitored specifically for chlorophyll-a following implementation of the reductions called for.

7.0 Implementation Plan

Management measures are "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint and stormwater sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint and stormwater source pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives" (USEPA, 1993).

The Department recognizes that TMDLs alone are not sufficient to restore impaired stream segments. The TMDL establishes the required pollutant reduction targets while the implementation plan identifies some of the regulatory and non-regulatory tools to achieve the reductions, matches management measures with sources, and suggests responsible entities for non-regulatory tools. This provides a basis for aligning available resources to assist with implementation activities. Projects proposed by the State, local government units and other stakeholders that would implement the measures identified within the impaired watershed are a priority for available State (for example, CBT) and federal (for example, 319(h)) funds. In addition, the Department's ongoing watershed management initiative will develop detailed watershed restoration plans for impaired stream segments in a priority order that will identify more specific measures to achieve the identified load reductions.

In these impaired watersheds wetlands and forest represent a significant portion of the land use. As discussed under source assessment, loads from these land uses are not readily adjustable. Agricultural land use is a small portion of the current land use. Therefore, urban land use sources must be the focus for implementation. Urban land use will be addressed primarily by stormwater regulation, including requiring adoption of fertilizer management ordinances, as described below. The limited amount of agricultural land uses will be addressed by implementation of conservation management practices tailored to each farm. Other measures are discussed further below.

Stormwater measures

The stormwater facilities subject to regulation under NPDES in this watershed must be assigned WLAs. The WLAs for these point sources are expressed in terms of the required percent reduction for nonpoint sources and are applied to the land use categories that correspond to the areas regulated under industrial and municipal stormwater programs. The BMPs required through stormwater permits, supplemented by the additional measure for fertilizer discussed below, are generally expected to achieve the required load reductions. The success of these and the other strategies described below for nonpoint source load reduction will be assessed through follow up monitoring. As needed, consistent with the concept of adaptive management, other additional measures may need to be identified and included in stormwater permits. Additional measures that may be considered in the future include, for example, more frequent street sweeping and inlet cleaning, or retrofit of stormwater management facilities to provide or enhance nutrient removal. A more detailed discussion of stormwater source control measures follows.

The NJPDES rules for the Municipal Stormwater Regulation Program require municipalities, highway agencies, and regulated "public complexes" to develop stormwater management programs consistent with the NJPDES permit requirements. The stormwater discharged through "municipal separate storm sewer systems" (MS4s) also regulated under the Department's stormwater rules. Under these rules and associated general permits, Tier A municipalities are required to implement various control measures that should substantially reduce phosphorus loadings in the impaired watersheds. These control measures include adoption and enforcement of a pet waste disposal ordinance, prohibiting the feeding of unconfined wildlife on public property, street sweeping, cleaning catch basins, performing good housekeeping at maintenance yards, and providing related public education and employee training. These basic requirements will provide for a measure of load reduction from existing development.

Because most of the land use based phosphorus load reductions must be obtained from urban land uses, an additional measure to reduce the phosphorus load from landscape maintenance is needed in order to effectively reduce the phosphorus load originating from the extensive urban land uses.

Therefore, as identified in Appendix B, most municipalities within the spatial extent of this TMDL study will be required to adopt an ordinance, consistent with a model ordinance provided by the Department, as an additional measure of the Municipal Stormwater Permit. This model ordinance can be viewed at www.state.nj.us/dep/watershedmgt/rules.htm under the section heading Water Quality Management Rules. The additional measure is as follows:

Fertilizer Management Ordinance

Minimum Standard – Municipalities identified in Appendix B shall adopt and enforce a fertilizer management ordinance, consistent with the model ordinance provided by the Department.

Measurable Goal - Municipalities identified in Appendix B shall certify annually that they have met the Fertilizer Management Ordinance minimum standard.

Implementation - Within 6 months from adoption of the TMDL, municipalities identified in Appendix B shall have fully implemented the Fertilizer Management Ordinance minimum standard.

Agricultural and other measures

Generic management strategies for nonpoint source categories, beyond those that will be implemented under the municipal stormwater regulation program, and responses are summarized below.

Table 15. Nonpoint Source Management Measures

Source Category	Responses	Potential Responsible Entity	Possible Funding options
Human Sources	Septic system management programs	Municipalities, residents, watershed stewards, property owner	319(h), State sources
Non-Human Sources	Goose management programs, riparian buffer restoration	Municipalities, residents, watershed stewards, property owner	319(h), State sources
Agricultural practices	Develop and implement conservation plans or resource management plans	Property owner	EQIP, CRP, CREP

Human and Non-Human measures

Where septic system service areas are located in close proximity to impaired waterbodies, septic surveys should be undertaken to determine if there are improper effluent disposal practices that need to be corrected. Septic system management programs should be implemented in municipalities with septic system service areas to ensure proper design, installation and maintenance of septic systems. Where resident goose populations are excessive, community based goose management programs should be supported. Through stewardship programs, areas such as commercial/corporate lawns should be converted to alternative landscaping that minimizes goose habitat and areas requiring intensive landscape maintenance. Where existing developed areas have encroached on riparian buffers, riparian buffer restoration projects should be undertaken where feasible. In the Pompton Lake drainage area an ambitious reduction of nonpoint source loads is called for. In this drainage area restoration of riparian buffers is a focus for implementation of the Pequannock River Temperature TMDLs (NJDEP, 2004). This measure is expected to provide additional load reductions needed to achieve this objective.

Agricultural measures

Several programs are available to assist farmers in the development and implementation of conservation management plans and resource management plans. The Natural Resource Conservation Service is the primary source of assistance for landowners in the development of resource management pertaining to soil conservation, water quality improvement, wildlife habitat enhancement, and irrigation water management. The USDA Farm Services Agency performs most of the funding assistance. All agricultural technical assistance is coordinated through the locally led Soil Conservation Districts. The funding programs include:

The Environmental Quality Incentive Program (EQIP) is designed to provide technical, financial, and educational assistance to farmers/producers for conservation practices that address natural resource concerns, such as water quality. Practices under this program include integrated crop management, grazing land management, well sealing, erosion control systems, agri-chemical handling facilities, vegetative filter strips/riparian buffers, animal waste management facilities and irrigation systems.

The Conservation Reserve Program (CRP) is designed to provide technical and financial assistance to farmers/producers to address the agricultural impacts on water quality and to maintain and improve wildlife habitat. CRP practices include the establishment of filter strips, riparian buffers and permanent wildlife habitats. This program provides the basis for the Conservation Reserve Enhancement Program (CREP).

Conservation Reserve Enhancement Program (CREP) The New Jersey Departments of Environmental Protection and Agriculture, in partnership with the Farm Service Agency and Natural Resources Conservation Service, signed a $100 million CREP agreement earlier this year. This program matches $23 million of State money with $77 million from the Commodity Credit Corp. within USDA. Through CREP, financial incentives are offered for agricultural landowners to voluntarily implement conservation practices on agricultural lands. NJ CREP will be part of the USDA's Conservation Reserve Program (CRP). There will be a ten-year enrollment period, with CREP leases ranging between 10-15 years. The State intends to augment this program to make these leases permanent easements. The enrollment of farmland into CREP in New Jersey is expected to improve stream health through the installation of water quality conservation practices on New Jersey farmland.

Current Implementation Projects

The following projects are either ongoing or are anticipated to be implemented in the TMDL study area. These projects were either funded by the 319(h) grants and/or funding was provided by the Corporate Business Tax and are expected to have an immediate and positive effect on water quality.

1. Rockaway River: Restore 3,000 continuous feet of degraded buffer on Jackson Brook (tributary to Rockaway River) and develop and implement a goose management strategy in Hurd Park, Dover (project ongoing)
2. Rockaway River: Stormwater Wetland Restoration project at the Morris County Department of Public Works (DPW) site in Roxbury to reduce fecal coliform and Total Suspended Solids (TSS) input to the Rockaway River. (work ongoing)

3. Whippany River: Development of ordinances and zoning policies to reduce NPS pollution in municipalities of the Whippany River watershed. (Work completed)
4. Posts Brook: Development of a regional stormwater management plan. (Work ongoing) This project is being rescoped to provide a stormwater implementation project in the Township of West Milford.
5. Visual Assessment of Streams in WMA 3 and ranking for stream restoration; Restoration of Camp Glen Gray, Bergen County Park to address stormwater runoff from erosion sources. (Work completed)
6. Ramapo Reservation Lake: Installation of 1000 feet of riparian buffer restoration. (Completed)
7. Greenwood Lake: Identify stormwater problem areas and based on the identification of "hot spots" implement two retrofits to reduce NPS load, as funds permit. (Work ongoing)
8. Greenwood Lake: Based on Stormwater Plan identified in #7 above additional funding for stormwater implementation is anticipated for the 2007 cycle of 319(h) funding.
9. Belchers Creek: Installation of cross-sectional catch basins to reduce NPS pollutants to Pinecliff Lake. (Work completed)
10. Development of an Onsite Wastewater Treatment Systems Management Plan Greenwood Lake: The New Jersey section of the Greenwood lake watershed is located in West Milford Township. Using 604(b) funds this planning effort will include: the development of a digital database and establishment of a process for the tracking of OWTS; an update of the estimate of the lake's annual phosphorus load originating from the OWTS; Collection of sub-surface soil leachate samples to quantify the phosphorus and fecal coliform entering the lake or its tributaries; identification of potential management measures for the OWTS; an effective, aggressive, pro-active public educational initiative; an implementation schedule including budgetary and technical needs; and the development of an objective and rational prioritization scheme for the OWTS focusing on maintenance, inspection and to varying degrees rehabilitation. The grant provides for identification of potential management measures to address the prioritized OWTS within the planning area to be developed into an OWTS BMP manual. The final task will be the submission of the OWTS Management Plan by the Township to the NJDEP as a proposed amendment to the Northeast Areawide Water Quality Management Plan.
11. Watershed Based Restoration Plan for Molly Ann Brook (ongoing).
12. Verona Park Lake: Installation of 10-foot wide vegetated buffer on the lake shoreline to address large resident goose population. (Work completed)
13. Bee Meadow Pond: Development of goose management plan with 500 feet of shoreline restoration with pre-implementation and post-implementation monitoring. (Post-implementation monitoring is ongoing).

14. East Lake and Bryant's Stream: Riparian restoration on Whippany tributaries. Goose management implementation included (Work completed).
15. Troy Brook: Development of regional stormwater management plan. Characterization and assessment portion has been completed. (Work ongoing).
16. Speedwell Lake: Riparian restoration to address erosion, stormwater and geese. (Work completed).
17. Whippany River: Retrofit an existing stormwater detention basin to reduce NPS load, plant approximately 20,000 square feet of detention basin with native vegetation. (Work completed).
18. Development of a septic management plan in the Greenwood Lake Watershed (work ongoing).
19. Preakness Watershed Plan; offshoot of the Passaic River Priority Stream Segment (Two Bridges to Elmwood Park) Plan. (Work ongoing).
20. Pequannock River Thermal Mitigation, Monitoring and Assessment: This project addressed two nonpoint source areas that are contributing to the increased temperature due to loss or riparian canopy. Riparian restoration was undertaken at Bailey Brook in Bloomingdale and the Pequannock River in Riverdale. Another components of this project were the documentation of areas in the Pequannock River headwaters that are impacted by current or past beaver activity and the collection of flow and temperature data for all significant tributaries in the Lower Pequannock drainage. Identification and mapping of stormwater outfalls in the lower and central Pequannock drainages were also undertaken. The majority of this project is complete, the monitoring is still underway as part of this contract, to ensure a longer term database for temperature in this watershed.
21. A *WMA 3 Restoration Master Plan* was conducted over two years using a visual assessment protocol modified from the USDA methodology. This project was also funded with 319h funding. The project included four sub-watersheds, one of which was the Pequannock. Forty-five sites in the Pequannock Basin were identified for restoration projects. The average score based on the visual assessment for the overall basin was 7.8 SVAP (STREAM VISUAL ASSESSMENT PROTOCOL). Of the 45 sites, 24 scored below the basin average scores. Several of the Pequannock sites were rated as high priority and these sites would be priority sites for future restoration projects. Streambank restoration with replacement canopy would have a mitigating effect on temperature exceedances and limit expose of waterbody to sunlight; thus minimizing the potential for algal growth. An addendum of the final report included a Management Strategy Table with a Habitat Enhancement category. For this category several sites on the Pequannock River and Kanouse Brook have been identified as candidates for habitat restoration and enhancement. As part of the WMA 3 Restoration Master Plan the following sites were identified as containing deficient riparian buffers and these sites

can provide a starting point for addressing riparian corridor restoration on both the mainstem Pequannock and significant tributaries feeding the river:

- Site 142- Pequannock River northwest of Route 23 between old Route 23 and Route 23 Railroad
- Site 143- Pequannock River southwest tributary of Pequannock headwaters at Rt. 23 bridge crossing
- Site 153- Clinton Brook 0.25 miles above Clinton Reservoir
- Site 155- Kanouse Brook, 0.65 miles north of confluence with Pequannock River
- Site 156- Kanouse Brook, 2.2 miles north of confluence with Pequannock River
- Site 158- Clinton Brook, 1.1 miles south of Clinton Reservoir adjacent to LaRue Road
- Site 168- Stone House Brook at confluence with Pequannock River
- Site 172- Pequannock River, 0.8 miles north of confluence with Wanaque
- Site 174- Matthew Brook
- Site 176- Van Dam Brook, Riverdale Town Park
- Site 177- Pequannock River, 0.15 miles north of confluence of Beaver Brook

This list should not be considered inclusive as it was part of a larger project for WMA 3 of which thermal mitigation was not the primary focus; therefore the list should be considered a starting point. The study also looked at ownership of land, and had public lands as a criterion for evaluation. As redevelopment occurs, inclusion of a riparian corridor to provide canopy should be implemented where feasible.

Priority Stream Segment Initiative

In addition to the generic and specific, current and future implementation measures identified above, the Department, through its watershed management program, has undertaken the development of watershed restoration plans for priority stream segments. Each area identifies specific measures and the means to accomplish them for specific impaired pollutant. Priority was based on the following criteria:

- Headwater area;
- Proximity to drinking water supply;
- Proximity to recreation area;
- Possibility of adverse human health conditions;
- Proximity to a lake intake;
- Existence of eutrophication;
- Phosphorus is identified as the limiting nutrient;
- Existence of use impairments;
- Ability to create a measurable change;
- Probability of human source;
- Stream Classifications;
- High success level.

Listed below are priority stream segments projects located within the TMDL Study Area, in which activities are occurring to support the development of watershed restoration plans.

NPS Grant: Demonstration Project to Support TMDL Implementation for the Pequannock River

As identified in the Pequannock River TMDL and the Pequannock River Temperature Impairment Characterization, Assessment and Management Plan discharges into river tributaries from smaller lakes and ponds can contribute to thermal elevation in the Pequannock River and its tributaries. This occurs because impoundments slow flows, expose waters to increased sunlight and release heated surface water from impoundments over spillway outlets. Preliminary sampling by the Pequannock River Coalition has shown that small impoundments do offer a level of temperature stratification within these impoundments that may be utilized to achieve downstream temperature reductions of 3-4 F. This project is a demonstration project and will actually occur on the West Brook in the Township of West Milford. The West Brook is impaired for temperature. The demonstration project will provide siphon piping from bottom water to provide a temperature reduction in the West Brook. This system will be monitored and documented for replication on other waterways.

Passaic River from Two Bridges to Elmwood Park Border

This project involved the development of an in-depth characterization of the current conditions relating to the pollutant of concern, fecal coliform, within the identified stream segment based on available data, and an evaluation and assessment of the findings of that characterization to evaluate and assess the short-term and long-term management measures that will be required to allow the stream to achieve full attainment of its designated uses. A Stream Characterization Report, including cost-benefit analyses, monitoring and modeling as applicable with available funds, identification of data gaps, and recommendations for further work and actions were the principal deliverables.

Future Project Recommendations

1. The development of BMPs and Model ordinances to address the reduction of fecal coliform, and other pollutants associated with non-point sources.
2. The development of a Watershed Management Plan of an associated waterway, Molly Ann Brook, was a direct result of the Characterization and Assessment Report findings.

Rockaway River between Route 80 and Blackwell Street in Dover

The Rockaway River Watershed Cabinet (RRWC) completed a detailed water quality sampling and analysis for a portion of the Rockaway River with a focus on fecal coliform. The RRWC is evaluating a segment of the Rockaway River in Dover Town, Wharton Borough, and Roxbury Township to develop an implementation plan consistent with the NJDEP TMDL and nonpoint source program. The stream segment begins at the Blackwell Street crossing in Dover and continues upstream to the Interstate Highway Route 80 crossing. This four-mile segment flows through developed areas of the towns as well as significant areas of undeveloped forest and wetlands. In this reach, three tributary streams, Jackson Brook, Green Pond Brook and Stephens Brook, join the Rockaway River. The goal of this evaluation was to assist with the identification of impacts to the stream and specifically evaluate nonpoint source pollution sources, storm water runoff concerns, and potential sources of bacteria (fecal coliform).

Future Project Recommendations

1. Construction of wetlands and floodplain restoration along Green Pond Brook. Currently, this area receives surface water runoff from an adjacent roller rink parking lot and surrounding roads. It is assumed that the site historically was a forested floodplain associated with Green Pond Brook. The proposed restoration action will include removal of the root mate, installation of slope stabilization, biodegradable filter fabric and excavation of a series of wetland treatment ponds connected by a meandering channel to treat storm water from a 6-acre drainage area prior to discharge into the Rockaway River. (Work ongoing)

2. Implementation of stormwater BMPs and restoration projects to include Bowlby Pond and Mckeel Brook drainage areas. Restoration activities could include reconnecting the natural drainages, and /or day lighting or improving the outfall channel connection resulting in the reduction of sediments and stream velocities thus by restoring the natural hydrology to the brooks and enhancing the fish and wildlife populations.

3. Development of a Regional Stormwater Management Plan. The plan will be designed to comply with NJDEP Storm water Regulations and permitting requirements to be met by each municipality. The municipalities involved include Dover Town, Wharton Borough, Rockaway, Randolph, Mine Hill, Roxbury and Jefferson Townships.

8.0 Reasonable Assurance

Reasonable assurance that the TMDL will result in attainment of the proposed chlorophyll-a watershed criteria requires both a reduction of the current phosphorus loading and protection against increased phosphorus loading from future development. The above implementation plan describes various management measures that will result in reduced phosphorus loads.

Additionally, NJDEP adopted the Stormwater Management Rules N.J.A.C 7:8, which minimizes the impact of stormwater run-off from new development. The Stormwater Management Rules, N.J.A.C. 7:8, establish statewide minimum standards for stormwater management in new development, and the ability to analyze and establish region-specific performance standards targeted to the impairments and other stormwater runoff related issues within a particular drainage basin through regional stormwater management plans. The Stormwater Management Rules are currently implemented through the Residential Site Improvement Standards (RSIS) and the Department's Land Use Regulation Program (LURP) in the review of permits such as freshwater wetlands, stream encroachment, CAFRA, and Waterfront Development.

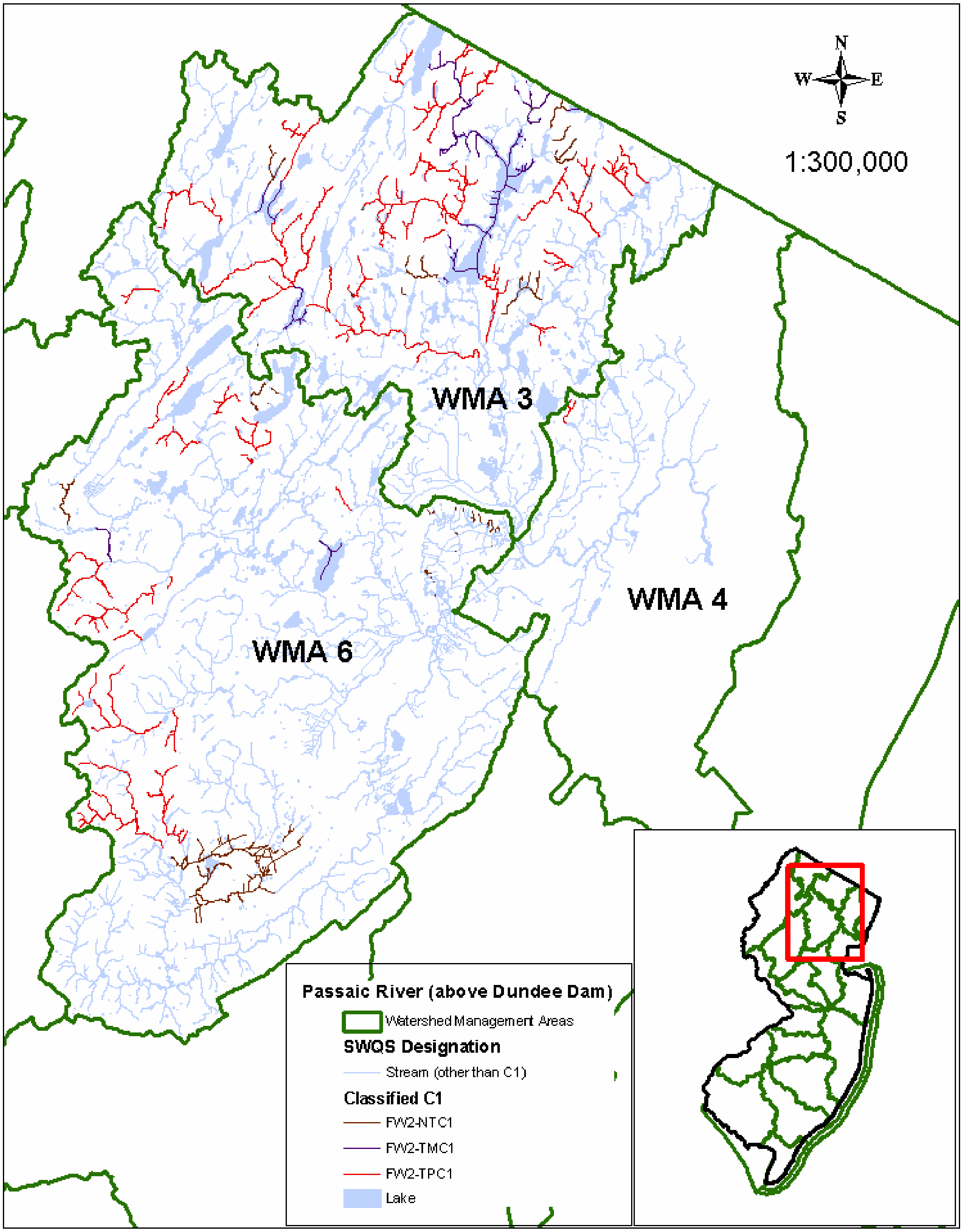
The Stormwater Management Rules focus on the prevention and minimization of stormwater runoff and pollutants in the management of stormwater. The rules require every project to evaluate methods to prevent pollutants from becoming available to stormwater runoff and to design the project to minimize runoff impacts from new development through better site design, also known as low impact development. Some of the issues that are required to be assessed for the site are the maintenance of existing vegetation, minimizing and disconnecting impervious surfaces, and pollution prevention techniques. In addition, performance standards are established to address existing groundwater that contributes to baseflow and aquifers, to prevent increases to flooding and erosion, and to provide water quality treatment through stormwater management measures for TSS and nutrients.

As part of the requirements under the municipal stormwater permitting program, municipalities are required to adopt and implement municipal stormwater management plans and stormwater control ordinances consistent with the requirements of the stormwater management rules. As such, in addition to changes in the design of projects regulated through the RSIS and LURP, municipalities will also be updating their regulatory requirements to provide the additional protections in the Stormwater Management Rules.

Furthermore, the New Jersey Stormwater Management Rules establish a 300-foot special water resource protection area (SWRPA) around Category One (C1) waterbodies and their intermittent and perennial tributaries, within the HUC 14 subwatershed. In the SWRPA, new development is typically limited to existing disturbed areas to maintain the integrity of the C1 waterbody. Category One waters receive the highest form of water quality protection in the state, which prohibits any measurable deterioration in the existing water quality. Definitions for surface water classifications, detailed segment description, and designated uses may be found in various amendments to the Surface Water Quality Standards at http://www.state.nj.us/dep/wmm/sgwqt/sgwqt.html C1 designations within the pertinent portion of the Passaic River watershed are depicted on Figure 5.

Commitment to carry out the activities described in the implementation plan to reduce phosphorus loads, including establishing NJPDES effluent limits for wastewater treatment facilities, the requirements of the Stormwater Management Rules and the Municipal Stormwater Regulation Program, present and future priority stream segment and other projects, provide reasonable assurance that the chlorophyll-a site specific criteria will be attained for phosphorus in the spatial extent of the TMDL study. Follow up monitoring will identify if the strategies implemented are completely, or only partially successful. It will then be determined if other management measures can be implemented to fully attain the chlorophyll-a watershed criteria or if it is necessary to consider other approaches, such as use attainability. Although not currently listed as impaired, as part of this TMDL study, it was determined that a small stretch of the Peckman River at its mouth experiences excessive primary productivity. Nevertheless, this location was not identified as a critical location for which phosphorus reductions would be targeted at this time. This area is under consideration for channel modification as described in a report entitled *Peckman River Basin New Jersey Feasibility Studies for Flood Control and Ecosystem Restoration*, (ACOE, 2002). If the channel modifications were to be implemented, the mouth of the Peckman River may no longer be a site subject to excessive primary productivity. Therefore, WLAs were assigned to Peckman River dischargers as needed to attain the Dundee Lake water quality objectives. The Department will continue to monitor this situation and may determine that more stringent WLAs are needed to attain water quality objectives in the Peckman River.

Figure 5. Category One waterways in WMAs 3, 4, and 6 (as of January 1, 2007)



9.0 Public Participation

In accordance with the Water Quality Management Planning Rules each TMDL shall be proposed by the Department as an amendment to the appropriate areawide water quality management plan(s) in accordance with N.J.A.C. 7:15-3.4(g). N.J.A.C. 7:15-3.4(g)5 states that when the Department proposes to amend an areawide water quality plan on its own initiative, the Department shall give public notice by publication in a newspaper of general circulation in the planning area, shall send copies of the public notice to the applicable designated planning agency, if any, and may hold a public hearing or request written statements of consent as if the Department were an applicant. In addition, the Department is proposing watershed criteria for the Wanaque Reservoir and Dundee Lake. Upon establishment of this TMDL, the Department will establish these watershed criteria in accordance with N.J.A.C. 7:9B-1.5(g)3.

The Department has maintained a long term commitment to the stakeholder process and public participation in the development of this TMDL for the Passaic River Basin. The TMDL was developed with assistance and direct input from stakeholders in Watershed Management Areas 3, 4 and 6.

The stakeholder process in the Passaic River Basin has been continuous for over 13 years. The resulting collaborative restoration process arose out of a 1993 pilot watershed initiative in the Whippany River Watershed (1993 – 2000) and litigation over permit requirements. The Department's early meetings with dischargers in 1996 in response to a settlement agreement over proposed phosphorus permit limits coupled with the Whippany River Watershed Pilot project evolved into a comprehensive watershed management process. This model for watershed management was later refined and replicated throughout the state in twenty watershed management areas (WMAs).

The Department initiated a pilot watershed project in 1993 in the Whippany River Watershed to aid the Department in developing a comprehensive watershed process that could be replicated throughout the state. The 70 square mile Whippany River Watershed lies in the heart of the larger Passaic River Basin and was instrumental in pulling stakeholders with varied interests and backgrounds together to discuss and address issues germane to the Watershed. Stakeholders included: active watershed groups, academics, business, industry, consultants, interested public, purveyors as well as dischargers. The watershed management process has afforded New Jersey a unique opportunity to openly discuss and vet projects that need to be undertaken to ensure New Jersey achieves its statewide "clean and plentiful" water goal.

The Public Advisory Group (PAG), Technical Advisory Committee (TAC) and several subcommittees met for 6 years in an effort to achieve the goal to restore and preserve the value of the Whippany River as a vital natural resource. A main reason that the

Whippany River Watershed was selected as the state's pilot watershed project was because of the number of dischargers located in the watershed. The Department recognized a unique opportunity in having dischargers, purveyors, environmental interest groups, local and state governments come together to vet and resolve issues unique to a specific geographic location. In addition to a replicable format for watershed management, one of several significant outcomes of the pilot watershed process included: the *TMDL for Fecal Coliform and an Interim Total Phosphorus Reduction Plan for the Whippany River Watershed* adopted in December 1999 and its companion document Appendix G, *A Cleaner Whippany River Watershed NPS Pollution Control Guidance Manual for Municipal Officials, Engineers and Department of Public Works, May 2000*. A workshop was held to acquaint municipalities with the best management practices recommended by the Technical Advisory Committee's NPS Workgroup.

During this time, the Department had also been meeting with the dischargers and purveyors in the Passaic River Basin on a regular basis through The Passaic River Task Group (1996 – 1998). The first priority of the Group was common concerns on phosphorus and eutrophication. Originally, the Whippany TMDL was proposed in 1999 to address both fecal coliform and phosphorus. Subsequently, only the fecal TMDL was established, since it was determined that, in the Whippany River, phosphorus was not rendering the waters unsuitable for the designated uses and so no phosphorus impairment was present. The Department did not pursue delisting because the Whippany River is a tributary to the Passaic River Basin wherein total phosphorus had not been assessed with respect to phosphorus rendering waters unsuitable for designated uses and, at a minimum, the Wanaque Reservoir was known to be a critical location of concern with respect to phosphorus loading. Thus, study of the larger area could result in the finding that phosphorus reductions on the Whippany would be needed to achieve water quality objectives in downstream locations.

The Group met through 1998, at which time the Department began a statewide watershed process within each of 20 watershed management areas that had been delineated for this purpose. Consequently, a Public Advisory Committee (PAC) and TAC were initiated for WMA 6. After the completion of the Whippany Fecal TMDL the Department-led Whippany River Watershed PAG and its TAC evolved into the WMA 6 PAC and TAC respectively which, met regularly from 1998-2003. The WMA 6 TAC assumed the mandate to discuss water quality related issues such as TMDL requirements.

In the Fall of 2000, the Department awarded two years worth of grant funding to 16 lead entities to serve as an extension of the Department to facilitate the watershed process for all 20 watershed management areas throughout the state. Deliverables from this statewide process varied; but resulted in the creation of PACs and TACs for WMAs 3 and 4; development of an extensive watershed characterization and assessment for WMAs 3, 4, and 6; creation of water resource based open space plans; and the implementation of numerous streambank restoration projects. At the same time, in order to successfully develop a comprehensive Passaic River Basin TMDL study, a separate committee was charged to focus on nutrient impairments in the Basin. With the Department, the Workgroup prepared the *Technical Approaches to Restore Impaired Waterbodies within the Non-tidal Passaic River Basin,* October 2001. The primary purpose of the report was to memorialize the outcome of the discussions to develop TMDLs and other management responses. The Workgroup continued to meet monthly through 2003.

In 2004, monitoring and initial modeling results from the TMDL work conducted by Quantitative Environmental Analysis, LLC (QEA), Najarian Associates and Omni Environmental, acting under contract to the Department, were shared and made available to the Passaic River Basin stakeholders through several informational sessions. On March 23, 2004, QEA presented their findings from the Ramapo River and Pompton Lakes Study to the WMA 3 PAC. Data exchange meetings based on the information collected by Omni Environmental were held on April 15, 2004, April 27, 2004, and September 28, 2004 and all stakeholders were invited to attend. On November 18, 2004, Najarian Associates presented preliminary findings on the Wanaque TMDL to the Passaic River Basin stakeholders. The Department conducted informal meetings with stakeholders on April 27 and September 28, 2004 to present model calibration and verification. The Department then conducted a meeting on June 23, 2005 with the affected dischargers in the Basin to present the findings from the work completed by Najarian Associates for the Wanaque Reservoir and that portion of the Basin above the confluence of the Pompton and Passaic Rivers.

On July 5, 2005 the Department proposed a Phase 1 Passaic River Study TMDL for phosphorus in the Wanaque Reservoir and a TMDL for Total Phosphorus to Address Pompton Lake and Ramapo River. A public hearing on these TMDLs was held on August 4, 2005 at the Cultural Center at the Lewis Morris County Park in Morristown. Nearly 100 people attended the hearing, some of the specific issues/comments raised are discussed below. After the public meeting at the request of the commenters the Department extended the public comment period until November 21, 2005.

- Applicability of the phosphorus standard as a not to exceed value in the Wanaque Reservoir is inappropriate.

  Based on the thorough monitoring of the Passaic River basin and identification of critical locations and the behavior of response indicators to phosphorus loads through dynamic modeling, watershed criteria for Wanaque Reservoir and Dundee Lake are being proposed through this TMDL report. These criteria are expressed in terms of a seasonal average chlorophyll–a concentration specific to each location.

- Costs associated with treatment for phosphorus removal and longer term implementation consequences such as increase in sludge production and associated cost for removal, chemical usage, and total dissolved solids increases in effluent being discharged to the receiving waters;

  The goal of a TMDL is to identify the load reductions necessary to achieve the SWQS and the designated use of the waterbody. This TMDL has evaluated the Passaic River basin thoroughly and determined where reductions in phosphorus load will result in environmental improvement. Further, watershed criteria proposed through this TMDL provide a fine tuning of the load reductions to achieve results in terms of response indicators. Reductions required are reasonable and achievable. Further, trading is offered as an option to achieve the needed load reductions in the most cost effective manner.

- The LA-WATERS model and water quality data inputs should be made available to the public for use to fully evaluate the TMDL results.

  The LA-WATERS model is a proprietary model and has not been released by the owners, NJDWSC and Najarian Associates. The proprietary nature of the model was known when the TMDL study for the Passaic River basin was initiated. This fact notwithstanding, the Passaic TMDL workgroup endorsed the use of this model, as documented in the public participation process. The LA-WATERS has been peer reviewed and accepted as a valid predictive tool for the Wanaque Reservoir. The simulation outputs compared to actual data have been presented graphically in support documentation for this TMDL, which is sufficient for evaluating the scientific validity of the tool.

- Applicability of Phase I study to headwater dischargers given the in-progress comprehensive Phase II study.

  The Department proposed the Phase I TMDL with initial hopes to jumpstart water quality improvement. However, given delays experienced in finalizing Phase I, the Phase II study has since been completed. The Department has determined that the most efficient means to achieve water quality improvement is to incorporate the relevant portions of the Phase I study into this TMDL document.

- Water supply diversions should be treated as point sources, and the North Jersey District Water Supply Authority should receive a NJPDES permit for adding phosphorus load to the Wanaque Reservoir.

  It has been determined that diversions are not point sources subject to permitting under the National Pollutant Discharge Elimination System permit, as discussed in the August 5, 2005 EPA memorandum, *Agency Interpretation on Applicability of Section 402 of the Clean Water Act to Water Transfers*. Nevertheless, the Department agrees conceptually that a water supply diversion responsible for delivering pollutant loads to a water body should be considered in assigning responsibility for pollutant load reductions necessitated by the act of diverting water. In this case, the load reductions required to achieve the water quality target for the in-stream critical location is the same as that needed to achieve the water quality target in the Wanaque Reservoir. Water quality trading is an option through which NJDWSC can play a role in protecting the water quality of the Wanaque Reservoir, which is affected by the diversion of Pompton and Passaic River water into the reservoir.

- Achieving the 80 percent reduction in NPS called for is unrealistic.

  As discussed in Section 5.0 of this document, this TMDL utilizes EMCs in conjunction with land use distribution and area weighted contributions of stormwater to provide a more precise estimate of the contribution of nonpoint source loadings from the land use. As a result, the final percent reduction is 60 percent or less in most of the drainage area, ranging from 0 to 80 percent. The Department believes the identified measures will attain these load reductions. Follow up monitoring will identify if the strategies implemented through this TMDL are completely, or only partially successful. It will then be determined if other nonpoint source management measures must be implemented to fully attain water quality objectives or if it is necessary to consider other approaches, such as use attainability.

- What are the assurances that New York will attain New Jersey's SWQS at the border, a boundary assumption for the TMDL.

  NJDEP has been in communication with both New York State and US EPA regarding this TMDL and the need for New York to achieve New Jersey's SWQS at the border. Progress has been made with the application of a 0.2 mg/l effluent limit on the Western Ramapo Wastewater treatment facility. It is expected, however, that NPS load reductions also will be needed in order to fully achieve the boundary objective.

- Basin dischargers are receiving special treatment since other dischargers are already receiving permits with 0.1 mg/l phosphorus requirement.

  In March 2003 the Department issued a *Technical Manual for Phosphorus Evaluations for NJPDES Discharge to Surface Water Permits* that provides the necessary guidance to determine if the numeric criterion for phosphorus applies. The "exit ramp protocol" is available to all dischargers who receive a water quality based effluent limit for phosphorus based on the numeric criterion. However, in the Passaic River basin, in response to permit appeals when phosphorus limits were initially imposed there, the Department entered into settlement agreements with Passaic River basin dischargers establishing that the Department will not impose a phosphorus effluent limit until the appropriate limit has been determined through a TMDL. The settlement agreements predate and obviate the application of WQBELs pending the outcome of this TMDL.

For the Phase II study, the Department conducted additional outreach on May 19, 2006 and a presentation was made on behalf of the Department at the October 13, 2006 2nd Passaic River Symposium held at Montclair State University. Most recently the Department met with the dischargers and purveyors on September 11, 2006 to seek input on chlorophyll-a target endpoints for the Wanaque Reservoir and Dundee Lake Dam and to share preliminary findings on load reductions and how these should be translated into effluent limits.

Throughout the development of the TMDLs for the Passaic River Basin input was received through Rutgers New Jersey EcoComplex (NJEC). The Department contracted with the NJEC in August 2001. The NJEC consists of a review panel of New Jersey university professors whose role is to provide comments on the Department's technical approaches for the development of TMDLs and other management strategies. Their comments on the TMDL study have resulted in refinements to the modeling work upon which this TMDL document is based.

Notice proposing the Passaic River basin phosphorus TMDL was published on May 7, 2007 in the New Jersey Register and in a newspaper of general circulation in the affected area in order to provide the public an opportunity to review the TMDL and submit comments. In addition, a public hearing will be held on June 7, 2007 at the Cultural Center at Lewis Morris County Park, 300 Mendham Road, Morristown, NJ 07962-1295. Notice of the proposal and hearing was provided to affected Designated Planning Agencies, municipalities, dischargers, and purveyors in the watershed.

All comments received during the public notice period and at the public hearing for this TMDL study, including the proposed watershed criteria upon which it is based, will become part of the record for this TMDL study and will be considered in the Department's decision to establish the watershed criteria as the applicable SWQS in the Wanaque Reservoir and Dundee Lake, in place of the numeric criteria for phosphorus, and this TMDL study through submittal to EPA Region 2. Once approved by EPA, this TMDL will be adopted as an amendment to the Northeast, Upper Raritan, Sussex County and Upper Delaware WQMPs.

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Appendix B: Municipalities and MS4 Designation in the Passaic River Basin

Municipal Name	County	WMA	Tier A or B	Fertilizer Ordinance
Elmwood Park Borough	BERGEN	4	A	Applicable
Fair Lawn Borough	BERGEN	4	A	Applicable
Franklin Lakes Borough	BERGEN	3, 4	A	Applicable
Garfield City	BERGEN	4	A	Applicable
Glen Rock Borough	BERGEN	4	A	Applicable
Mahwah Township	BERGEN	3	A	Applicable
Midland Park Borough	BERGEN	4	A	Applicable
Oakland Borough	BERGEN	3	A	Applicable
Ramsey Borough	BERGEN	3	A	Applicable
Ridgewood Village	BERGEN	4	A	Applicable
Waldwick Borough	BERGEN	4	A	Applicable
Wyckoff Township	BERGEN	4	A	Applicable
Caldwell Borough	ESSEX	4, 6	A	Applicable
Cedar Grove Township	ESSEX	4	A	Applicable
Essex Fells Borough	ESSEX	4, 6	A	Applicable
Fairfield Township	ESSEX	4, 6	A	Applicable
Livingston Township	ESSEX	6	A	Applicable
Millburn Township	ESSEX	6	A	Applicable
Montclair Township	ESSEX	4	A	Applicable
North Caldwell Borough	ESSEX	4, 6	A	Applicable
Roseland Borough	ESSEX	6	A	Applicable
Verona Township	ESSEX	4, 6	A	Applicable
West Caldwell Township	ESSEX	4, 6	A	Applicable

West Orange Township	ESSEX	4, 6	A	Applicable
Boonton Town	MORRIS	6	A	Applicable
Boonton Township	MORRIS	6	A	Applicable
Butler Borough	MORRIS	3	A	Applicable
Chatham Borough	MORRIS	6	A	Applicable
Chatham Township	MORRIS	6	A	Applicable
Denville Township	MORRIS	6	A	Applicable
Dover Town	MORRIS	6	A	NA
East Hanover Township	MORRIS	6	A	Applicable
Florham Park Borough	MORRIS	6	A	Applicable
Hanover Township	MORRIS	6	A	Applicable
Harding Township	MORRIS	6	B	Applicable
Jefferson Township	MORRIS	3, 6	A	NA
Kinnelon Borough	MORRIS	3, 6	A	Applicable
Lincoln Park Borough	MORRIS	3, 6	A	Applicable
Long Hill Township	MORRIS	6	A	Applicable
Madison Borough	MORRIS	6	A	Applicable
Mendham Borough	MORRIS	6	A	Applicable
Mendham Township	MORRIS	6	A	Applicable
Mine Hill Township	MORRIS	6	A	NA
Montville Township	MORRIS	3, 6	A	Applicable
Morris Plains Borough	MORRIS	6	A	Applicable
Morris Township	MORRIS	6	A	Applicable
Morristown Town	MORRIS	6	A	Applicable
Mount Arlington Borough	MORRIS	6	A	NA
Mountain Lakes Borough	MORRIS	6	A	Applicable
Parsippany-Troy Hills Township	MORRIS	6	A	Applicable
Pequannock Township	MORRIS	3	A	Applicable
Randolph Township	MORRIS	6	A	Applicable
Riverdale Borough	MORRIS	3	A	Applicable
Rockaway Borough	MORRIS	6	A	NA
Rockaway Township	MORRIS	3, 6	A	NA
Roxbury Township	MORRIS	6	A	NA
Victory Gardens Borough	MORRIS	6	A	NA
Wharton Borough	MORRIS	6	A	NA
Bloomingdale Borough	PASSAIC	3	A	Applicable
Clifton City	PASSAIC	4	A	Applicable
Haledon Borough	PASSAIC	4	A	Applicable
Hawthorne Borough	PASSAIC	4	A	Applicable
Little Falls Township	PASSAIC	4	A	Applicable
North Haledon Borough	PASSAIC	4	A	Applicable
Paterson City	PASSAIC	4	A	Applicable
Pompton Lakes Borough	PASSAIC	3	A	Applicable
Prospect Park Borough	PASSAIC	4	A	Applicable
Ringwood Borough	PASSAIC	3	A	Applicable
Totowa Borough	PASSAIC	4	A	Applicable
Wanaque Borough	PASSAIC	3	A	Applicable
Wayne Township	PASSAIC	3, 4	A	Applicable

West Milford Township	PASSAIC	3	A	Applied with Greenwood Lake TMDL
West Paterson Borough	PASSAIC	4	A	Applicable
Bernards Township	SOMERSET	6	A	Applicable
Bernardsville Borough	SOMERSET	6	A	Applicable
Bridgewater Township	SOMERSET	6	A	Applicable
Far Hills Borough	SOMERSET	6	B	Applicable
Warren Township	SOMERSET	6	A	Applicable
Hardyston Township	SUSSEX	3, 6	B	NA
Sparta Township	SUSSEX	6	A	NA
Vernon Township	SUSSEX	3	B	NA
Berkeley Heights Township	UNION	6	A	Applicable
New Providence Borough	UNION	6	A	Applicable
Summit City	UNION	6	A	Applicable

Appendix C: Additional Impairments within TMDL Area

The two tables below identify the assessment units within the TMDL area of interest which have additional impairments not being addressed in the scope of this TMDL.

HUC 14 Assessment Units based on the *2006 Integrated Water Quality Monitoring and Assessment Report*

WMA	Assessment Unit ID	Assessment Unit Name	Parameter
03	02030103050060-01	Pequannock R(Macopin gage to Charl'brg)	Dissolved Oxygen
03	02030103050080-01	Pequannock R (below Macopin gage)	Chlordane, DDX, Mercury
03	02030103050080-01	Pequannock R (below Macopin gage)	PCBs
03	02030103070020-01	Belcher Creek (Pinecliff Lake & below)	Temperature
03	02030103070030-01	Wanaque R/Greenwood Lk(aboveMonks gage)	Unknown Toxic
03	02030103070040-01	West Brook/Burnt Meadow Brook	Temperature
03	02030103070050-01	Wanaque Reservior (below Monks gage)	Dissolved Oxygen, Pathogens, Temperature
03	02030103070060-01	Meadow Brook/High Mountain Brook	Pollutant Unknown
03	02030103070070-01	Wanaque R/Posts Bk (below reservior)	Unknown Toxic
03	02030103100070-01	Ramapo R (below Crystal Lake bridge)	Dissolved Oxygen, pH
03	02030103110020-01	Pompton River	Chlordane, DDX, Lead, Mercury, PCBs, Unknown Toxic
04	02030103120020-01	Peckman River (below CG Res trib)	Dioxin, PCBs, Pollutant Unknown
04	02030103120030-01	Preakness Brook / Naachtpunkt Brook	Pollutant Unknown
04	02030103120040-01	Molly Ann Brook	Pollutant Unknown
04	02030103120050-01	Goffle Brook	Total dissolved solids
04	02030103120060-01	Deepavaal Brook	Pollutant Unknown
04	02030103120070-01	Passaic R Lwr (Fair Lawn Ave to Goffle)	Arsenic, Chlordane, Cyanide, DDX, Dioxin, Mercury, PCBs
04	02030103120080-01	Passaic R Lwr (Dundee Dam to F.L. Ave)	Arsenic, Chlordane, Cyanide, DDX, Dioxin, Mercury, Pathogens, PCBs
04	02030103120100-01	Passaic R Lwr (Goffle Bk to Pompton R)	Arsenic, Cadmium, Chlordane, Chromium, Copper, Cyanide, DDX, Dioxin, Lead, Mercury, Pathogens, PCBs, Silver, Thallium, Zinc
06	02030103010050-01	Great Brook (below Green Village Rd)	Pollutant Unknown

06	02030103010060-01	Black Brook (Great Swamp NWR)	Arsenic
06	02030103010070-01	Passaic R Upr (Dead R to Osborn Mills)	Arsenic, Cyanide
06	02030103010080-01	Dead River (above Harrisons Brook)	Total Suspended Solids
06	02030103010100-01	Dead River (below Harrisons Brook)	Total Suspended Solids
06	02030103010110-01	Passaic R Upr (Plainfield Rd to Dead R)	Arsenic, Copper, Cyanide, Lead, Mercury, Total Suspended Solids
06	02030103010120-01	Passaic R Upr (Snyder to Plainfield Rd)	Arsenic, Copper, Cyanide, Lead, Mercury, Total Suspended Solids
06	02030103010130-01	Passaic R Upr (40d 45m to Snyder Ave)	Arsenic, Copper, Cyanide, Lead, Mercury, Total Suspended Solids
06	02030103010150-01	Passaic R Upr (Columbia Rd to 40d 45m)	Arsenic, Copper, Cyanide, Lead, Mercury, Total Dissolved Solids, Total Suspended Solids
06	02030103010160-01	Passaic R Upr (HanoverRR to ColumbiaRd)	Total Dissolved Solids, Total Suspended Solids
06	02030103010170-01	Passaic R Upr (Rockaway to Hanover RR)	Chlordane, DDX, Mercury, PCBs, Total Dissolved Solids, Total Suspended Solids
06	02030103010180-01	Passaic R Upr (Pine Bk br to Rockaway)	Arsenic, Chlordane, DDX, Mercury, PCBs
06	02030103020010-01	Whippany R (above road at 74d 33m)	Temperature
06	02030103020020-01	Whippany R (Wash. Valley Rd to 74d 33m)	Temperature
06	02030103020100-01	Whippany R (Rockaway R to Malapardis Bk)	Lead
06	02030103030030-01	Rockaway R (above Longwood Lake outlet)	Mercury
06	02030103030040-01	Rockaway R (Stephens Bk to Longwood Lk)	Mercury, Pollutant Unknown
06	02030103030060-01	Green Pond Brook (below Burnt Meadow Bk)	Pollutant Unknown
06	02030103030070-01	Rockaway R (74d 33m 30s to Stephens Bk)	Mercury
06	02030103030090-01	Rockaway R (BM 534 brdg to 74d 33m 30s)	Mercury, Pollutant Unknown
06	02030103030110-01	Beaver Brook (Morris County)	Mercury, pH
06	02030103030130-01	Stony Brook (Boonton)	Pollutant Unknown
06	02030103030140-01	Rockaway R (Stony Brook to BM 534 brdg)	Arsenic, Mercury, PCE/TCE, Pollutant Unknown
06	02030103030150-01	Rockaway R (Boonton dam to Stony Brook)	Arsenic, Mercury, PCE/TCE
06	02030103030170-01	Rockaway R (Passaic R to Boonton dam)	Mercury, PCE/TCE
06	02030103040010-01	Passaic R Upr (Pompton R to Pine Bk)	Arsenic, Chlordane, DDX, Mercury, PCBs

Lake Impairments on the *2006 Integrated Water Quality Monitoring and Assessment Report*

WMA	Assessment Unit ID	Assessment Unit Name	Parameter
03	Bubbling Springs-03	Bubbling Springs-03	Pathogens
03	Canistear Reservoir-03	Canistear Reservoir-03	Mercury
03	Clinton Reservoir-03	Clinton Reservoir-03	Mercury
03	Crystal Lake-03	Crystal Lake-03	Pathogens
03	Echo Lake-03	Echo Lake-03	Mercury
03	Erskine Lake-03	Erskine Lake-03	Pathogens
03	Forest Hill Lake-03	Forest Hill Lake-03	Pathogens
03	Green Turtle Lake-03	Green Turtle Lake-03	Mercury
03	Greenwood Lake-03	Greenwood Lake-03	Mercury
03	Greenwood Lake-03	Greenwood Lake-03	Dissolved Oxygen
03	Greenwood Lake-03	Greenwood Lake-03	Total Suspended Solids
03	Kitchell Lake-03	Kitchell Lake-03	Pathogens
03	Lake Edenwold-03	Lake Edenwold-03	Pathogens
03	Lake Ioscoe-03	Lake Ioscoe-03	Pathogens
03	Lionhead Lake-03	Lionhead Lake-03	Pathogens
03	Monksville Reservoir-03	Monksville Reservoir-03	Mercury

WMA	Assessment Unit ID	Assessment Unit Name	Parameter
03	Oak Ridge Reservoir-03	Oak Ridge Reservoir-03	Mercury
03	Pompton Lake-03	Pompton Lake-03	Mercury
03	Pompton Lake-03	Pompton Lake-03	PCBs
03	Pompton Lake-03	Pompton Lake-03	Dioxin
03	Pompton Lake-03	Pompton Lake-03	DDX
03	Pompton Lake-03	Pompton Lake-03	Chlordane
03	Ramapo Lake-03	Ramapo Lake-03	Mercury
03	Shepherds Lake-03	Shepherds Lake-03	Mercury
03	Skyline Lakes-03	Skyline Lakes-03	Pathogens
03	Wanaque Reservoir-03	Wanaque Reservoir-03	Mercury
04	Dundee Lake-04	Dundee Lake-04	Mercury
04	Toms Lake-04	Toms Lake-04	Pathogens
05	Lake Tappan-05	Lake Tappan-05	Mercury
05	Oradell Reservoir-05	Oradell Reservoir-05	Mercury
06	Boonton Reservoir-06	Boonton Reservoir-06	Chlordane
06	Boonton Reservoir-06	Boonton Reservoir-06	Mercury
06	Boonton Reservoir-06	Boonton Reservoir-06	PCBs
06	Boonton Reservoir-06	Boonton Reservoir-06	Chlordane
06	Boonton Reservoir-06	Boonton Reservoir-06	Dioxin
06	Boonton Reservoir-06	Boonton Reservoir-06	DDX
06	Camp Lewis-06	Camp Lewis-06	Pathogens
06	Cozy Lake-06	Cozy Lake-06	Pathogens
06	Indian Lake-06	Indian Lake-06	Pathogens
06	Intervale Lake-06	Intervale Lake-06	Pathogens
06	Lake Swannanoa-06	Lake Swannanoa-06	Pathogens
06	Morris Co. Park Lake	Morris Co. Park Lake	Pathogens
06	Mountain Lake-06	Mountain Lake-06	Mercury
06	Mountain Lake-06	Mountain Lake-06	Pathogens
06	Parsippany Lake-06	Parsippany Lake-06	Pathogens
06	Pond at Conference Center (Left & Rt.)	Pond at Conference Center (Left & Rt.)	Pathogens
06	Powder Mill Pond-06	Powder Mill Pond-06	Pathogens
06	Rainbow Lakes-06	Rainbow Lakes-06	Pathogens
06	Speedwell Lake-06	Speedwell Lake-06	Mercury
06	Sunrise Lake-06	Sunrise Lake-06	Pathogens
06	Telemark Lake-06	Telemark Lake-06	Pathogens
06	West Lake-06	West Lake-06	Pathogens
06	White Meadow Lake-06	White Meadow Lake-06	Pathogens

Appendix D: TMDLs Completed in the Passaic River Basin

WMA	Stream Segment	Site /Segment ID/ EPA Reach No.	Municipalities in streamshed	County	Parameter(s)
3	Apshawa Brook	PQ15	West Milford Township	Passaic	Temperature
3	Clinton Brook below Clinton Reservoir	PQ16	West Milford Township	Passaic	Temperature
3	Macopin River at Echo Lake	01382410	West Milford Township	Passaic	Temperature
3	Macopin River at Macopin Reservoir	01382450/ PQ 6	West Milford Township	Passaic	Temperature and Fecal Coliform
3	Outlet Trib of Maple Lake	PQ14	Kinnelon Boro	Morris	Temperature
3	Pequannock-Butler	PQ10	Butler Boro		Temperature
3	Pequannock River above Clinton	PQ4	Jefferson and West Milford Townships	Morris & Passaic	Temperature
3	Pequannock River below Clinton	PQ5			Temperature
3	Pequannock River above Macopin	PQ7	Jefferson, Rockaway and West Milford Townships	Morris & Passaic	Temperature
3	Pequannock River above Pacock	PQ1	Hardyston and Vernon Townships	Sussex	Temperature
	Pequannock River below Pacock	PQ3	Hardyston and West Milford Townships	Sussex & Passaic	Temperature
3	Pequannock River at Macopin Intake Dam	PQ8	Bloomingdale, Butler, Pompton, Riverdale and Kinnelon Boros, and Rockaway and West Milford Townships	Morris & Passaic	Temperature
3	Pequannock River at Riverdale	01382800/PQ 11	Bloomdale, Riverdale, Pompton Lakes and Butler Boros	Morris & Passaic	Temperature
3	Pompton River Trib at Ryerson Rd	01388720	Riverdale, Lincoln, and Kinnelon Boros, and Pequannock, Montville and Wayne Townships	Morris & Passaic	Fecal Coliform
3	Ramapo River near Mahwah	01387500	Franklin, Oakland, Ramsey, and Wanaque Boros, and Wayne and Mahwah Townships	Bergen & Passaic	Fecal Coliform
3	Wanaque River at Highland Avenue	01387010	Pompton Lakes and Wanaque Boros	Passaic	Fecal Coliform
3	Verona Park Lake	Lake-01	Verona Boro	Essex	Phosphorus
4	Deepavaal Brook at Fairfield	01389138	Fairfield and West Caldwell Township, and North Caldwell Boro	Essex	Fecal Coliform
4	Diamond Brook at Fair Law	01389860	Fair Lawn, Glen Rock, and Hawthorne Boros, and Ridgewood Village	Bergen & Passaic	Fecal Coliform
4	Goffle Brook at Hawthorne	01389850	Hawthorne and Midland Park Boros, Ridgewood Village,and Wycoff Township	Bergen & Passaic	Fecal Coliform
4	HoHokus Brook at Mouth at Paramus	0139110	Allendale, HoHokus, Glen Rock, Midland Park, and Waldwick Boros, Ridgewood Village, and Passaic City	Bergen & Passaic	Fecal Coliform
4	Passaic R. below Pompton R. at	01389005	Lincoln Park Boro, and Fairfield and Montville Townships	Essex & Morris	Fecal Coliform

	Two Bridges				
4	Passaic River at Little Falls	01389500	Fairfield and Wayne Townships	Essex & Passaic	Fecal Coliform
4	Peckman River at West Paterson	01389600	West Paterson and Verona Boros, and Cedar grove, Little Falls and West Orange Townships	Essex & Passaic	Fecal Coliform
4	Preakness Brook Near Little Falls	01389080	Totowa Boro and Wayne Township	Passaic	Fecal Coliform
4	Ramsey Brook at Allendale	01390900	Allendale and Ramsey Boros, and Mahwah Township	Bergen	Fecal Coliform
4	Saddle River at Fairlawn	01391200	Fair Lawn and Paramus Boros, and Rochelle Park and Saddle Brook Townships	Bergen	Fecal Coliform
4	Saddle River at Lodi	01391500	Allendale, Carlstadt, Fair Lawn, Glen Rock, Ho-Ho-Kus, Lodi, Maywood, Paramus, Waldwick, Wallington, and Woodridge Boros, Ridgewood Village, and Rochelle Park, and Saddle Brook Townships	Bergen	Fecal Coliform
4	Saddle River at Ridgewood	01390500	Ho-Ho-Kus, Montvale, Paramus, Waldwick and Woodcliffe Lake Boros, Ridgewood Village and Upper Saddle River and Mahwah Townships	Bergen	Fecal Coliform
4	West Branch Saddle River at Upper Saddle River	01390445	Mahwah and Upper Saddle River Townships	Bergen	Fecal Coliform
6	Beaver Brook at Rockaway	01380100	Rockaway Boror and Denville, Chatham and Rockaway Townships	Bergen & Morris	Fecal Coliform
6	Black Brook at Madison	01378855	Madison Boro and Chatham Township	Morris	Fecal Coliform
6	Canoe Brook near Summit	01379530	Essex Falls and Roseland Boros, and Livingston, Millburn, and West Orange Townships	Essex	Fecal Coliform
6	Dead River near Millington	01379200	Far Hills Boro and Warren and Bernards Township	Somerset	Fecal Coliform
6	Passaic River at Tempewick Rd near Mendham	01378660	Mendham and Bernardsville Boro, and Mendham, Harding and Bernardsville Townships	Somerset & Morris	Fecal Coliform
6	Passaic River at Two Bridges	01382000	Lincoln Park Boro and Fairfield and Montville Townships	Essex & Morris	Fecal Coliform
6	Passaic River near Chatham	01379500	Chatham, Florham Park, Madison, New Providence and Roseland Boros, Berkeley Heights, Chatham, East Hanover, Harding, Livingston, Long Hill, Millburn, Warren and West Caldwell Townships, and Summit City	Essex, Union, Somerset & Morris	Fecal Coliform
6	Passaic River near Millington	01379000	Bernards and Long Hill Townships	Somerset & Morris	Fecal Coliform
6	Rockaway River at Blackwell Street	01379853	Rockaway, Victory Gardens, and Wharton Boro, and Dover, Mine Hill, Randolph and Rockaway Townships	Morris	Fecal Coliform
6	Rockaway River at Longwood	01379680	Wharton Boro and Dover, Jefferson, Mine Hill, Randolph, Rockaway and Roxbury	Morris	Fecal Coliform

	Valley		Townships		
6	Rockaway River at Pine Brook	01381200	Boonton, Montville and Parsippany-Troy Hills Townships	Morris	Fecal Coliform
6	Stony Brook at Boonton	01380320	Kinnelon Boro and Bernards, Boonton, Long Hill, Montville and Rockaway Townships	Morris & Somerset	Fecal Coliform
6	Whippany River Near Pinebrook	1381800	Morristown, Hanover and East Hanover townships	Morris	Fecal Coliform
6	Whippany River near Morristown	13881500	Morristown, Hanover and East Hanover Townships	Morris	Fecal Coliform

Appendix E

Rationale for Establishing Chlorophyll-a as Watershed Criteria to Protect Designated Uses of the Wanaque Reservoir and Dundee Lake

Background

The non-tidal Passaic River Basin TMDL study includes a system-wide water quality model that is calibrated and validated for nutrients, dissolved oxygen, and water column chlorophyll-a. Continuous simulations from October 1999 to November 2003 were used to account for seasonal variations and a range of hydrologic conditions. Watershed modeling analyses were performed to assess the impact of point and nonpoint source reductions of total phosphorus on dissolved oxygen, phosphorus concentrations, and chlorophyll-a within the model domain and, by linking with the LA-WATERS model, within the Wanaque Reservoir.

A water quality model, Water Quality Analysis Simulation Program 7.0 (WASP 7), and a flow model, Diffusion Analogy Surface-Water Flow Model (DAFLOW), were used to simulate water quality and flow in the non-tidal Passaic River, Pompton River mainstem, Ramapo River downstream of Pompton Lake, Wanaque River downstream of the Wanaque Reservoir, and a small stream segment of the Pequannock River. The WASP 7 model is an enhancement of the original WASP model (Omni Environmental, 2007). WASP 7 is a dynamic compartment mode that can be used for diverse aquatic systems, such as rivers, reservoirs, lakes, and coastal waters. The model helps users to analyze, and predict a variety of water quality responses due to natural phenomena and man-made pollution. DAFLOW model is a one-dimensional transport model designed to simulate flow by solving the diffusion analogy form of the flow equation. DAFLOW was developed by USGS and enhanced by USGS for this TMDL (Spitz, 2007). A graphical watershed model integration tool (WAMIT) was developed for data sharing and model input calculation between WASP 7 and DAFLOW. A reservoir model known as Laterally Averaged - Wind and Temperature Enhanced Reservoir Simulation (LA-WATERS) was used to model the water quality of the Wanaque Reservoir. The LA-WATERS model links phosphorus loading with chlorophyll-a response in the Wanaque Reservoir. It includes a hydrothermal component and water quality modules, which were successfully calibrated to the Wanaque Reservoir using data collected as part of the Wanaque South water supply project (Najarian Associates, 1988), and then re-validated (Najarian Associates, 2000). A mass balance model (Najarian, 2005) was used to simulate daily loads of total phosphorus and orthophosphorus in portions of the study area outside the WASP 7/DAFLOW model domain.

Using these integrated models, several future scenarios were simulated in order to explore the impacts of increases and decreases in phosphorus loads on the key water quality parameters, namely phosphorus concentration, dissolved oxygen, and phytoplankton, measured as water column chlorophyll-a. Critical locations identified through this process were the Wanaque Reservoir and the lower portion of the Passaic River impounded by Dundee Dam, also known as Dundee Lake. Absent watershed or site specific criteria, the applicable Surface Water Quality Standards in these locations include a numeric criterion of 0.05 mg/l of total phosphorus. The comprehensive modeling of the study area both illustrates that an alternative criterion, established in terms of the response indicator, chlorophyll-a, is a better measure of what it takes to achieve water quality objectives and support designated uses in the identified critical locations and allows identification of the value that should apply in each location. Consequently, the target TMDL condition is defined as the phosphorus loading condition that satisfies water quality end points of 20 µg/l and 10 µg/l chlorophyll-a for Dundee Lake and the Wanaque Reservoir, respectively.

Establishing Surface Water Quality Standards

Under the Clean Water Act Section 304(a), EPA issues national criteria recommendations to states and tribes to assist them in developing their water quality standards. When EPA reviews a state or tribal water quality standard for approval under 303(c) of the Clean Water Act, the agency must determine whether the adopted designated uses are consistent with the Clean Water Act requirements and whether the adopted criteria protect the designated use. EPA's regulations encourage states and tribes, when adopting water quality criteria as part of their water quality standards, to employ EPA's Section 304(a) guidance, to modify EPA's 304(a) guidance to reflect site-specific conditions or to use other scientifically defensible methods to derive criteria to protect the designated uses.

To meet the objectives of the Clean Water Act, EPA's implementing regulations specify that states must adopt criteria that contain sufficient parameters to protect existing and designated uses. Designated uses are an element of a water quality standard, expressed as a narrative statement, describing an appropriate intended human and/or aquatic life objective for a water body.

To meet the objective of protecting the designated uses, and in accordance with the Clean Water Act requirement, nutrient criteria development includes:

-Assessment of use impairment, i.e. manifestations of eutrophication, these candidates can be grouped as effect-based variables, also called response indicators. Effect-based variables usually include chlorophyll a, dissolved oxygen, variation in pH, and water clarity. It is expected that assessment will vary based on designated uses.

-Assembly of all relevant information pertaining to establishing a nutrient criteria, e.g. historical and current data water quality data, physical, chemical and biological characteristics, designated uses, and reference sites.

-The selected criteria should result in quantifiable measure.

-The selected criteria should be implementable, and when criteria are met, it is expected that the water quality will support the designated uses.

-Water quality modeling, when necessary, to establish a linkage between overenrichment of nutrient concentration (causal variables of impairment) and nutrient impairment (effect or response variables of nutrient overenrichment). For example, a linkage between chlorophyll-a concentrations (response indicator) and phosphorus concentrations. Such linkage will help to implement the nutrient reduction needed to achieve the effect-based criteria.

-Nutrient enrichment impacts on downstream waterbodies should always be taken into consideration when proposing a site specific criterion.

Based on the above, it is apparent that the nutrient criteria development process can be complex and involve an extensive amount of data, knowledge and resources. At the same time, water quality management requires immediate and adequate measures in protecting water quality until a more comprehensive assessment can done. The Department's strategy has been to establish default numeric criteria based on the EPA publication, *Quality Criteria for Water*, known as the red book, which was published in 1976, and to include several caveats, including a narrative exception for the applicability of the numeric criterion for streams, narrative nutrient policies and the option to establish alternative standards in addition to or in place of the default criteria.

The Department's current Surface Water Quality Standards (SWQS) for phosphorus, as stated in N.J.A.C. 7:9B-1.14(c) of the SWQS for Fresh Water 2 (FW2) waters, are as follows:

> Phosphorus, Total (mg/l):
> i. Lakes: Phosphorus as total P shall not exceed 0.05 in any lake, pond, reservoir, or in a tributary at the point where it enters such bodies of water, except where site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3.
> ii. Streams: Except as necessary to satisfy the more stringent criteria in paragraph i. above or where site-specific criteria are developed pursuant to N.J.A.C. 7:9B1.5(g)3, phosphorus as total P shall not exceed 0.1 in any stream, unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.
>
> Regarding site specific criteria, N.J.A.C. 7:9B-1.5(g) 3 states:
> The Department may establish watershed or site-specific water quality criteria for nutrients in lakes, ponds, reservoirs or streams, in addition to or in place of the criteria in N.J.A.C. 7:9B-1.14, when necessary to protect existing or designated uses. Such criteria shall become part of these Water Quality Standards.
>
> Elaborating on "…render waters unsuitable…" N.J.A.C. 7:9B-1.5(g)2 states:
> Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render the waters unsuitable for the designated uses.

The narrative part of the nutrient criteria above, as well as the nutrient policies, illustrate that the primary goal of the nutrient criteria is to protect designated uses from nutrient related impacts while providing flexibility as to what the measurable criteria might be. This is appropriate because the level of nutrient overenrichment that will produce an observable impact on waterbodies will exhibit a high degree of variability. Factors that impact the degree of nutrient enrichment that is problematic may include temperature, solar radiation, turbidity, residence time, water depth and physical, chemical and biological characteristics of a waterbody, and others. As a result, a single numeric criterion based on a causal parameter will not be the most appropriate measure for all waterbodies. Instead, the most suitable candidate criteria for the representation of water quality that support designated uses may be the response indicators, i.e. chlorophyll-a, diurnal dissolved oxygen, variation in pH, and water clarity. This is consistent with the Clean Water Act (CWA), and the Code of Federal Regulations (CFR) definition of "criteria," which are "elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that support a particular use." When criteria are met, it is expected that the water quality will support the designated use (40 CFR 131.3[b]).

The State has seven categories of designated use, which include aquatic life, recreational use (primary and secondary contact), drinking water, fish consumption, shellfish harvesting (if applicable), agricultural water supply use and industrial water supply use.

In assessing attainment of designated uses, as reflected in the *Integrated Water Quality Monitoring and Assessment Report,* the Department takes the conservative approach of identifying waterbodies as impaired with respect to phosphorus where there is violation of numeric nutrient criteria. However, the Department is aware that what constitutes an impairment is not phosphorus enrichment, by itself, but rather the manifestations of eutrophication that may result when phosphorus causes excessive primary productivity. Specifically, when present in excessive amounts, phosphorus can lead to excessive primary productivity, in the form of algal and/or macrophyte growth. The presence of excessive plant biomass can, in itself, interfere with designated uses, such as swimming or boating. There are also implications from excessive algae with respect to drinking water use. Algal blooms in raw drinking water sources can cause taste and odor problems and treatment inefficiencies, having a negative impact on conventional treatment at a drinking water system. When algae are present in large amounts purveyors must increase the use of disinfectants and oxidants to treat the algae resulting in an increase in disinfection byproducts such as trihalomethanes, some of which are listed by EPA as likely carcinogens. In addition, the respiration cycle of excessive plant material can cause significant swings in pH and dissolved oxygen, which can result in violation of criteria for these parameters, which can adversely affect the remainder of the aquatic community. Finally, excessive algae can affect water column transparency, which would impact recreational, water supply and fishery designated uses.

Selection of response indicator

In 2002, U.S. EPA developed nutrient water quality criteria guidance for lakes and reservoirs for fourteen major Ecoregions of the United States (USEPA 2000b-d). The guidance recommends several candidate nutrient criteria for the protection of designated uses, the recommended candidates include both nutrient concentrations based on reference conditions, and effect-based variables. Those candidates are chlorophyll-a, total phosphorus, total nitrogen, and Secchi depth.

Modeling of the non-tidal Passaic River basin illustrates that phosphorus concentration as a not to exceed value in the critical locations, Wanaque Reservoir and Dundee Lake, is not necessary to achieve acceptable levels of the response indicators dissolved oxygen and chlorophyll-a. Using chlorophyll-a as the measurable criterion to evaluate when nutrients are present in excessive amounts is desirable because chlorophyll-a relates directly to the impairment of uses, as noted above and is easy to measure. Secchi depth was not considered as a candidate because water column transparency could be affected by inorganic suspended solids, color, and there is a weak correlation with nutrient concentrations. Because of the comprehensive water quality modeling developed in this TMDL study, a direct and quantitative linkage has been established between chlorophyll-a and total phosphorus concentrations. This allows identification of the phosphorus reductions needed to achieve a given chlorophyll-a concentration.

Selection of criterion value

Determination of the chlorophyll-a threshold that is appropriate can vary depending on the physical characteristics and the designated uses of a particular waterbody. In order to select the chlorophyll-a threshold to apply to each critical area, five factors were taken into consideration:

1. Designated uses, grouped as recreational, aquatic life, and water supply uses
2. Characteristics of the waterbody, e.g. hydrological characteristics.
3. Assessment of relevant water quality variables associated with the selected criterion, using the non-tidal Passaic River Basin models.
4. Potential to affect downstream waters, using the Passaic River Basin wide models.
5. Relationship to the existing numeric phosphorus criteria.

Most references use a range of values to describe the trophic status of a waterbody. Based on the literature reviewed, there is some consistency on the range of chlorophyll-a levels representing different trophic status of a lake. Chlorophyll-a greater than 20 µg/l is usually used to represent a Mesotrophic to Eutrophic lake status. Moderate levels of primary productivity in a waterbody that is designated for supporting fisheries or aquatic life uses would be beneficial, and levels of chlorophyll-a can be higher for this use than for swimming or drinking water supply uses. The level of primary productivity in a waterbody that is designated for supporting a cold water fishery would be different than for a waterbody designated as warm water fishery. One reason is the sensitivity of a cold water fishery to oxygen levels.

Most of the chlorophyll-a levels cited are based on the observations of what levels are considered to be “undesirable” primarily for recreational and aesthetic designated uses. This approach is highly dependent on the individual observer’s perceptions and responses regarding suitability for use vs. chlorophyll-a concentrations. For example, Texas Water Conservation Association published a study in 2005 *“Development of Use-Based Chlorophyll Criteria for Recreational Uses of Reservoirs.”* The study was based on analysis of approximately 1800 surveys, 16 monitoring sites in 8 reservoirs and 310 sampling events. One of the objectives of the study was to assess the relationship between chlorophyll-a concentrations and suitability for recreational uses. Results of the observer’s responses show great variation with respect to what constitutes use impairment for a given chlorophyll-a concentration. For example a comparable number of those surveyed found a lake with 4 ug/L to be equally suitable to a lake with 35 ug/L chlorophyll-a.

North Carolina State University's watershed information database (http://www.water.ncsu.edu/watershedss/info/algae.html) suggests that a mean growing season limit of 15 µg/l chlorophyll-a is appropriate for drinking water reservoirs, and that a mean growing season limit of 25 µg/l is appropriate to protect all other uses, namely recreational, aesthetic, and aquatic life. However, more and less restrictive values can be found in the literature. The State of Vermont established a chlorophyll-a target of 3 µg/l for Lake Champlain, Vermont, a major recreational, aesthetic, and aquatic life resource. On the other hand, for all water supply impoundments in North Carolina, chlorophyll-a levels may not exceed 40 µg/l at any time; for waters not serving as a water supply; chlorophyll-a may periodically exceed 40 µg/l during the growing season. The State of Oklahoma proposed a chlorophyll-a concentration of 10 µg/L to protect public water supply use.

Two critical locations were identified in the non-tidal Passaic River TMDL: the Wanaque Reservoir and Dundee Lake. The characteristics of these two waterbodies are significantly different.

The Passaic River upstream of Dundee Dam is referred to as Dundee Lake. The aerial photo in Figure 1 shows the portion of the Passaic River designated as Dundee Lake in the NJDEP lakes GIS coverage. A bridge forms the "lake" boundary; however, the Passaic River upstream of the bridge is just as wide as it is downstream, and the Passaic River is deeper for about a mile upstream of the Dundee Dam. The portion of the river that is designated as Dundee Lake includes slightly more than 0.8 miles of river above the dam. The detention time in that portion of the river averages about 1.7 days per mile of river length. Dundee Lake is classified as a warm water fishery and is currently permitted for use as an industrial water supply.

Similar to Dundee Lake, Dutch Fork Lake in Pennsylvania functions somewhere between a lake and a slowly moving stream. Pennsylvania uses a 14 day detention time to distinguish between lakes and flowing waters. Dutch Lake has a detention time of approximately 9 days, while Dundee Lake has an average detention time of 1.4 days. According to the Dutch Fork Lake TMDL (PADEP, 2003, p.5): "Hence, a 10 µg/l chlorophyll-a target, in addition to being infeasible and unachievable, is unnecessarily stringent in what is technically a flowing water. A 20 µg/l seasonal average chlorophyll-a target was used for the purpose of defining a total phosphorus TMDL for Dutch Fork Lake. This will result in a mildly eutrophic classification for Dutch Fork Lake. Given the natural progression of all lakes and the fact that Dutch Fork Lake is 45 years old, Pennsylvania believes this is consistent with water quality standards for the Lake."

The fact that the impoundment of the Passaic River upstream of Dundee Dam constitutes an urban feature with a low detention time argues for using values in the upper end of the literature range. The Passaic River upstream of Dundee Dam has characteristics that are more like a stream than a lake. Absent a watershed criterion, the Department's default stream criterion for phosphorus would be more appropriate than the lake criterion. In 2002 the Department developed a technical manual for NJPDES Discharge to Surface Water Permits, which guides the evaluation of the applicability of the Department's numeric criterion for streams. This manual sets a seasonal average chlorophyll-a of 24 µg/l (seasonal average) and 32 µg/l (max 2-week mean) as the conservative threshold to determine when phosphorus is rendering waters unsuitable for designated uses. Given its characteristics, use of a similar threshold would be suitable for Dundee Lake. To be conservative, the Department proposes a seasonal average of 20 µg/L of chlorophyll-a for Dundee Lake. The seasonal averaging period is from June 15 to September 1. Based on the modeling, this period provides an additional degree of conservatism.

FIGURE 1 : Aerial Photo of Dundee lake

The non-tidal Passaic TMDL water quality modeling study allows assessment of the water quality that would be associated with the proposed chlorophyll-a criterion. The effect of wide range chlorophyll-a concentrations on diurnal dissolved oxygen concentrations were examined under a continuous model simulation of four years, including several critical conditions. Figure 2 below, shows the strong relationship between maximum dissolved oxygen swing and summer average chlorophyll-a for the Passaic River at Dundee Dam (powerful logarithmic relationship with an r^2 near 0.99). Figure 3 shows that both the “24 hr average” and the “not less than” dissolved oxygen criteria are being met under the TMDL simulation period, except for only violation to the not less than 4 mg/l criterion occurred during the drought of 2002 when the criteria was not applicable.

FIGURE 2: Relationship between DO Swing and Chlorophyll-a

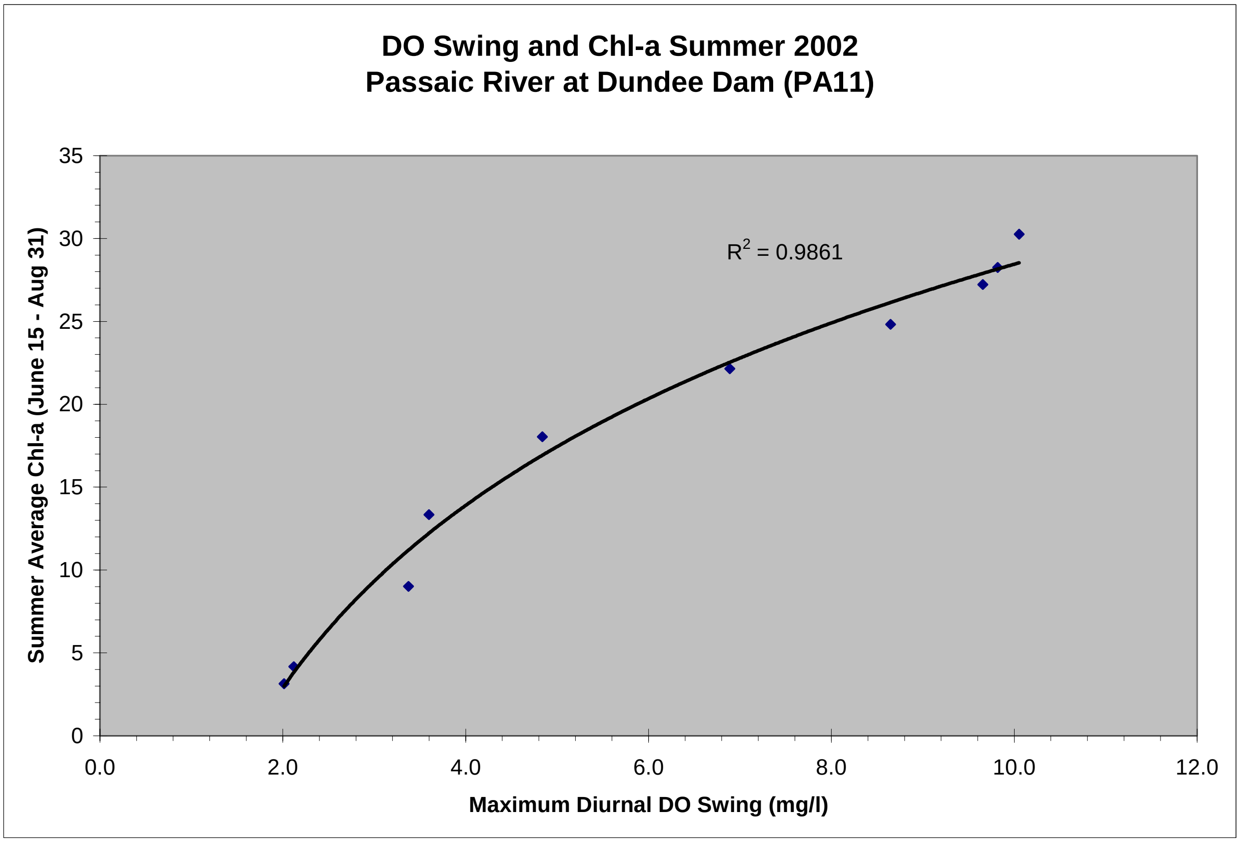
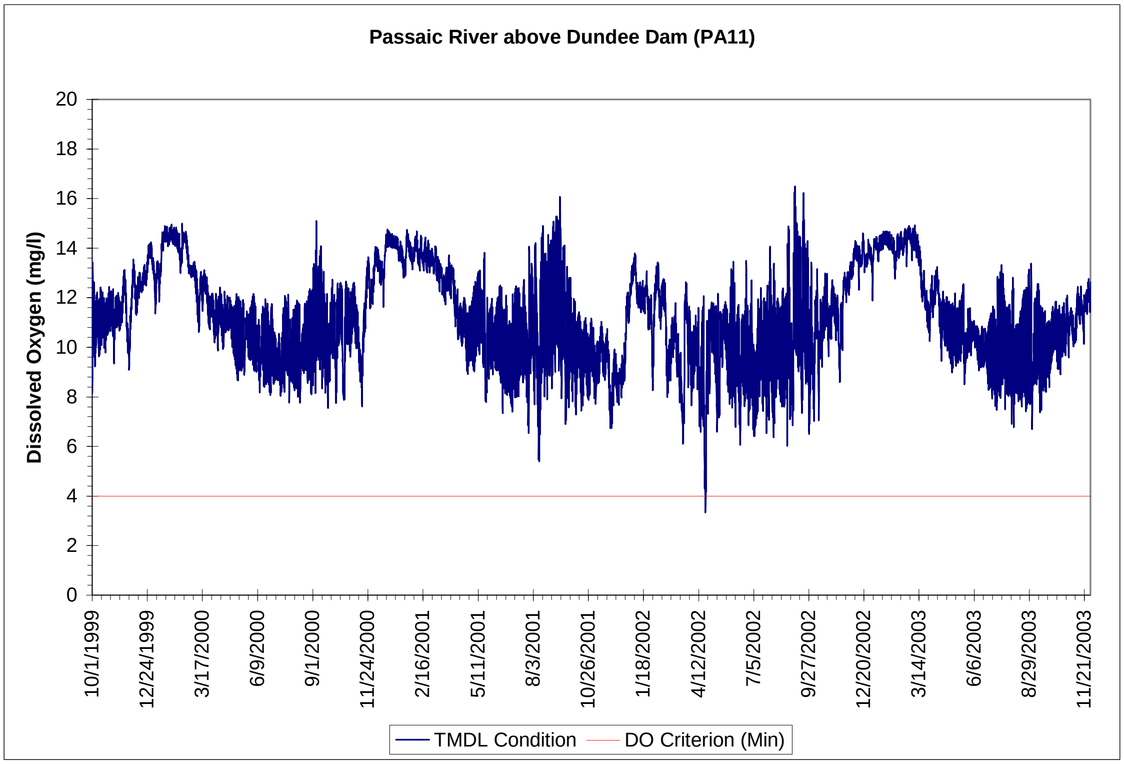
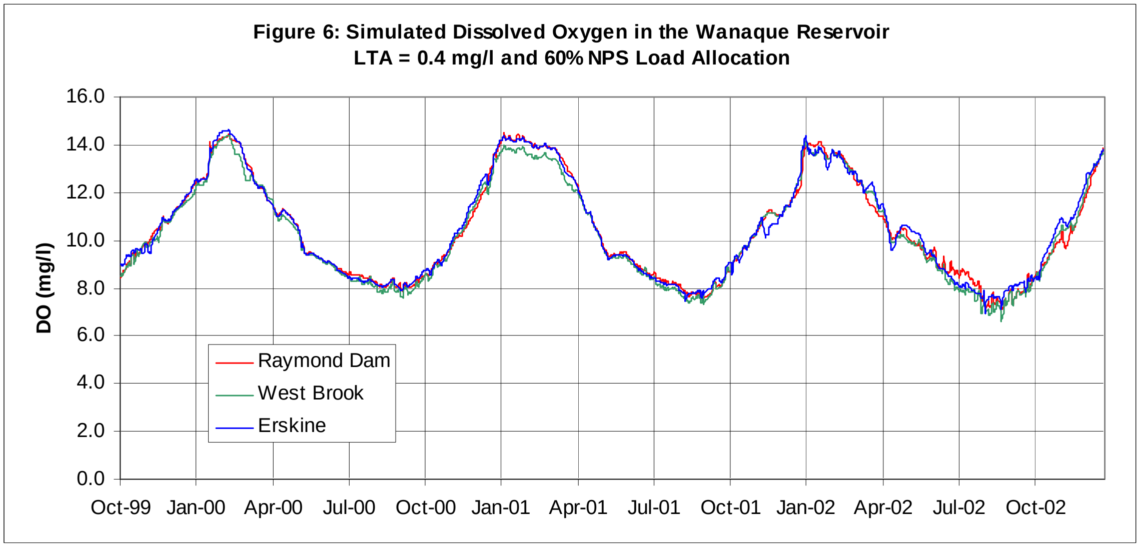


FIGURE 3 TMDL Condition in Passaic River at Dundee Dam – DO



The Wanaque Reservoir is distinctly different than Dundee Lake. The Wanaque Reservoir is large, the largest reservoir in area in New Jersey, and deep (average depth 37 feet, maximum depth 90 feet) and supports trout throughout the fishing season. It serves as a source of drinking water for 4 million people. In consideration of these characteristics, a more conservative chlorophyll-a target of 10 µg/L as a seasonal average is proposed. Evaluating the water quality implications of this target, Figure 4 below shows that both the “24 hr average” and the “not less than” dissolved oxygen criteria are met under the TMDL simulation period for the three locations modeled within the Reservoir.

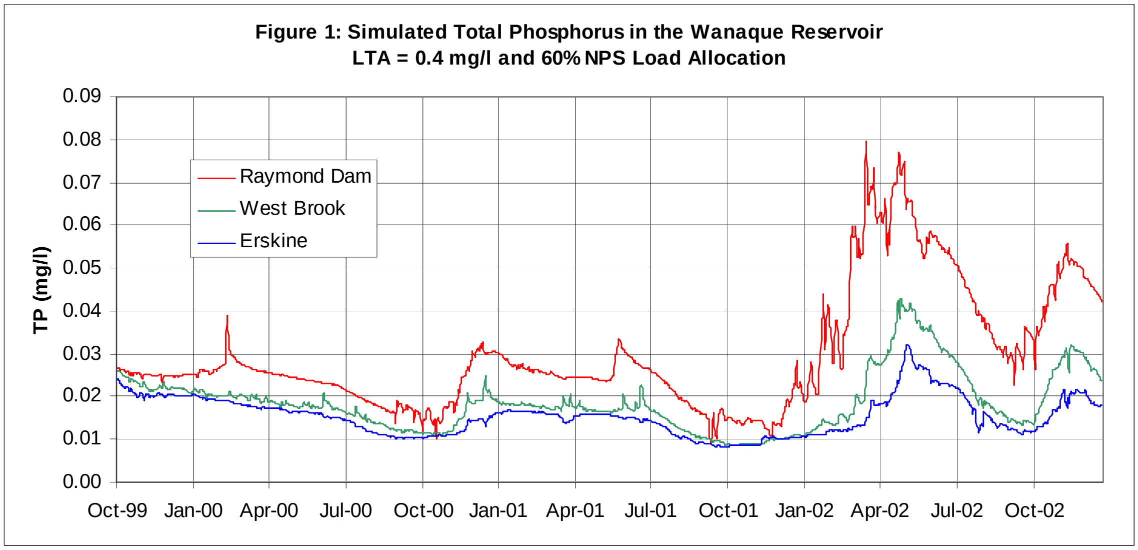
FIGURE 4 Simulated Dissolved Oxygen in the Wanaque Reservoir



Having a comprehensive water quality model allows assessment of downstream effects of a given condition. The modeling effort has identified the critical locations that require phosphorus reductions, as well as the level of phosphorus reduction needed to achieve a specified desired condition. As the study area reaches to the terminus of the non-tidal portion of the river, there is no concern about downstream effects beyond the study area.

Comparing the implications of the proposed chlorophyll-a criteria with the existing total phosphorus criteria shows that, on average, the appropriate default criteria are generally met. Figure 5 shows that the 0.05 µg/l total phosphorus criterion is being met most for most of the model simulations. A mean total phosphorus concentration simulated from October 1999 through October 2002 shows phosphorus well below 0.03 mg/l at all three locations within the reservoir. Total phosphorus concentration exceeded the 0.05 mg/l criteria only during a few months during the drought year of 2002 and only at Raymond Dam.

FIGURE 5: Simulation of Total Phosphorus in the Wanaque Reservoir



Because of the fact that the Passaic River upstream of Dundee Dam is more like a stream than a lake, the total phosphorus concentrations at Dundee Lake were assessed against the stream total phosphorus criteria of 0.1 mg/l. Table 1 summarizes the results of the model simulation under the TMDL and existing conditions. The stream criterion is generally met, with the greatest deviation from the 0.1 mg/l TP criteria observed only during the drought year of 2002.

FIGURE 6 Total Phosphorus Concentrations in the Dundee Lake

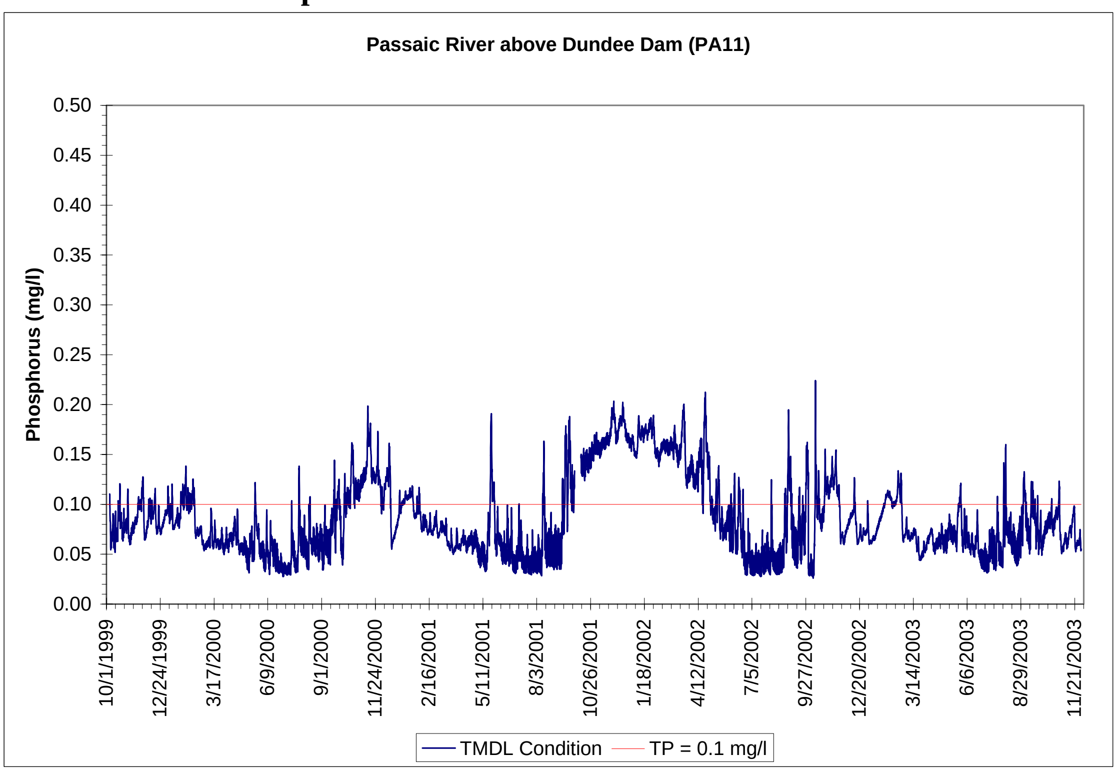


Table 1 Summary

	TP - Existing (mg/l)	TP - TMDL (mg/l)
Entire Time Period		
Count	14,971	14,971
Average	0.33	0.09
90th Percentile	0.56	0.15
Percent Rank 0.1	1%	70%
W/out WY2002		
Count	11,421	11,421
Average	0.28	0.08
90th Percentile	0.46	0.11
Percent Rank 0.1	1%	81%
W/out 2002 Water Supply Emergency		**1/24/2002 - 1/7/2003**
Count	11,531	11,531
Average	0.31	0.08
90th Percentile	0.56	0.14
Percent Rank 0.1	1%	74%