Amendment to the Upper Delaware Water Quality Management Plan and Sussex County Water Quality Management Plan

Total Maximum Daily Loads for Phosphorus to Address Four Impaired Assessment Units in the Pequest River Watershed

Northwest Water Region
Watershed Management Area 1
Pequest River, Beaver Creek and Bear Creek Watersheds

Drainage Area Identifications: HUCs
02040105090020-01, 02040105090030-01, 02040105090010-01, 02040105070060-01

Proposed: June 7, 2010
Established: September 9, 2010
Approved: September 29, 2010
Adopted: June 20, 2011

New Jersey Department of Environmental Protection
Bureau of Environmental Analysis & Restoration

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1.0 Executive Summary

In accordance with Sections 305(b) and 303(d) of the Federal Clean Water Act (CWA), the State of New Jersey, Department of Environmental Protection (Department) developed the *2008 New Jersey Integrated Water Quality Monitoring and Assessment Report* assessing the overall water quality of the State's waters and, in Sublist 5 of the *Integrated List of Waters*, identifying the list of impaired waters by pollutant in each Hydrologic Unit Code (HUC) 14 assessment unit. Sublist 5 constitutes the list of Water Quality Limited Waters required under Section 303(d) of the CWA. A Total Maximum Daily Load (TMDL) is required to be prepared for those waters on the 303(d) list. 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 adopted and the Environmental Protection Agency (EPA) approved the *2008 Integrated List of Waters*, which formed the basis for the initial analysis of phosphorus impairment in the Pequest River watershed.

Table 1 shows the phosphorus impairments, as indicated by the presence of total phosphorus (TP) concentrations in excess of the numeric criterion, as they appear on the *2008 Integrated List of Waters* for the Pequest River watershed. This report addresses these impairments.

Specifically, this report adopts TMDLs to address the phosphorus impairments upstream of and including HUC 14 No. 02040105090030-01 (i.e., Pequest River, Furnace Brook to Cemetary Road). The Pequest River below Furnace Brook (02040105090060-01), the only remaining HUC 14 listed for TP impairment within the Pequest Watershed, will be addressed in a subsequent TMDL study because additional evaluation of sources is needed. Other listed impairments within the Pequest River watershed will be addressed in subsequent TMDL evaluations.

The target for the TMDL calculations is attainment of the total phosphorus numeric criterion of 0.1 mg/l in each of the impaired assessment units within the Pequest River basin addressed by this study. Point and nonpoint source reductions needed to achieve the numeric criterion of 0.1 mg/l TP were calculated. Land use load reductions, which are important during runoff producing conditions, were calculated using the Flow-Integrated Reduction of Exceedances (FIRE) method, which uses a regression analysis to determine the land use load reduction, including a margin of safety (MOS). An overall land use load percent reduction of 52.8% was calculated in order to attain the TP numeric criterion. Wastewater treatment loads which occur under all conditions and are the dominant source during the design low flow condition were calculated using a mass balance approach. The Wasteload Allocation (WLA) for Allamuchy Township STP is 1.32 kg/day in summer and 1.94 kg/day in winter. The WLA for the Warren County MUA-Oxford STP is 1.08 kg/day in summer and 1.99 kg/day in winter. The WLA for the Pequest Fish Hatchery was based on the long term average effluent flow of 8.82 MGD and effluent quality of 0.12 mg/l of TP and is 4.01 kg/day year round. Other wastewater discharges located in the boundary areas are part of the load allocation attributed to boundary inputs to the study area. Loads from these facilities must be maintained so as to achieve no measurable change in the boundary concentrations.

Table 1 Assessment Units Listed as Impaired for TP on *2008 Integrated List of Waters* Addressed in this TMDL Report

Assessment Unit ID	Assessment Unit Name	Station ID	Designated Use/Pollutant(s) Impairment on 2008 303(d) List	HUC size (acres)
02040105090030-01	Pequest River (Furnace Brook to Cemetery Road)	01445500 01445430 1-PEQ-2 HQ Site 5 HQ Site 6	Aquatic Life/TP, TSS	5,270
02040105090020-01	Pequest River (Cemetery Road to Drag Strip)	01445430	Aquatic Life /TP	4,891
02040105090010-01	Pequest River (Drag Strip to below Bear Swamp)	HQ Site 4	Aquatic Life /TP	6,079
02040105070060-01	Pequest River (below Bear Swamp to Trout Brook)	HQ Site 2 HQ Site 3	Aquatic Life /TP	4,034
Total area of impaired assessment units				20,274

This TMDL report includes implementation strategies to achieve SWQS for phosphorus. The TMDLs in this report were proposed as amendments to the appropriate areawide Water Quality Management (WQM) plans in accordance with N.J.A.C. 7:15-6. A public hearing was held and public comment was received. The response to comments provided by the public is included in Section 10, Public Participation. The USEPA approved the TMDLs in this report on September 29, 2010. The adopted TMDLs are amendments to the Upper Delaware Water Quality Management Plan and Sussex County Water Quality Management Plan. This TMDL report was developed consistent with EPA's May 20, 2002 guidance document entitled: "*Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992*," (Sutfin, 2002)

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 in 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, have had a TMDL developed or will be addressed by other enforceable management measures 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. 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 waterbody can assimilate without violating a state's water quality standards and allocates that amount to known point and nonpoint sources in the form of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, while providing for an implicit or explicit margin of safety (MOS).

The *New Jersey 2008 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, drinking water, fish consumption, shellfish harvesting (if applicable), agricultural water supply use and industrial water supply use. As shown in Table 1, the *2008 Integrated List of Waters* identifies Aquatic Life as the designated use for which there is non-attainment status for the assessment units addressed in this Report. The parameters identified as responsible for this non-attainment status are noted for each of the subject assessment units.

This report adopts four TMDLs to address the phosphorus impairments upstream of and including HUC 02040105090030-01 (Pequest River Furnace Brook to Cemetary Road). The TMDL implementation plan includes management approaches to reduce phosphorus loadings from various sources, some of which extend beyond the impaired assessment units, which are necessary in order to attain the applicable SWQS for phosphorus in the assessment units addressed by these TMDLs. In the next Integrated List of Waters, phosphorus will not be a basis of impairment in the four assessment units addressed through these TMDLs.

There are other impairments in the Pequest River watershed that are not addressed in these TMDLs. Because there is insufficient water quality data at this time, the phosphorus impairment of assessment unit 02040105090060-01 will be addressed in a later TMDL study. The Pequest River (Furnace Brook to Cemetery Road) assessment unit, ID# 02040105090030-01 is also listed for TSS and the Pequest River (below Furnace Brook) assessment unit, ID# 02040105090060-01 is also listed for pH, Temperature, TSS, and Arsenic. These assessment units will remain on Sublist 5 with respect to these pollutants, which will be addressed in future TMDLs. In September 2003 USEPA approved a fecal coliform TMDL for the segment identified as Pequest River at Pequest (01445500), which is within the study area of these TMDLs.

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:

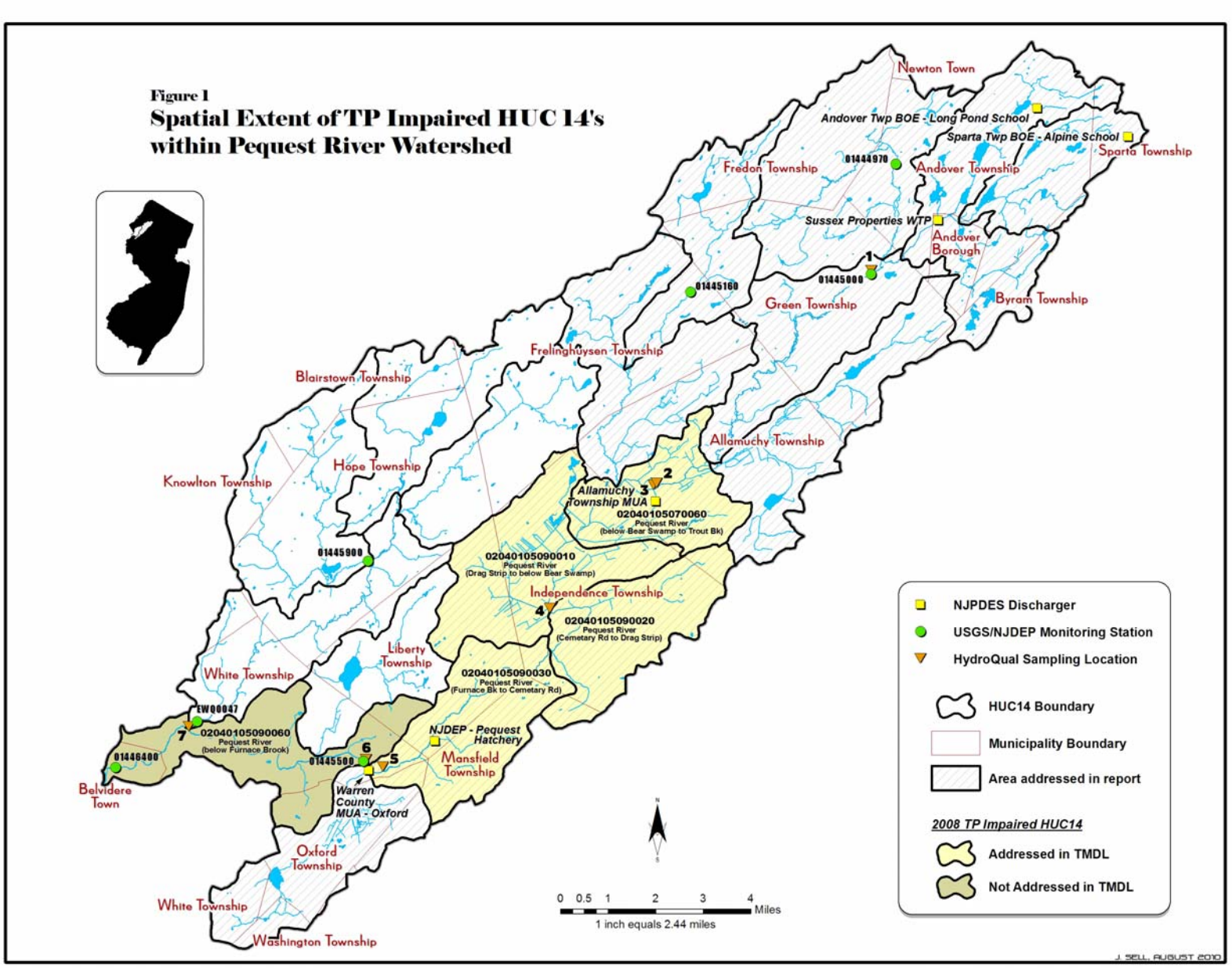
1. Identification of waterbody (ies), pollutant of concern, pollutant sources and priority ranking.
2. Description of applicable water quality standards and numeric water quality target(s).
3. Loading capacity – linking water quality and pollutant sources.
4. Load allocations.
5. Waste load allocations.
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 Pollutant of Concern, Applicable Surface Water Quality Standards and Area of Interest

3.1 Pollutant of Concern

The pollutant of concern for these TMDLs is total phosphorus. Where phosphorus concentrations exceeded the numeric criteria in the New Jersey's SWQS, found at N.J.A.C. 7-9B et seq., they were identified as impaired with respect to that parameter, as reported in the *2008 Integrated List of Waters*. Figure 1 depicts the spatial extent of these impairments according to the *2008 Integrated List of Waters*. All of the listed impairments have a medium to high priority ranking as described in the 2008 *Integrated List of Waters*.

Figure 1 Spatial Extent of TP Impaired HUC 14s within Pequest River Watershed



3.2 Applicable Surface Water Quality Standards

Most of the impaired segments addressed in this report are classified as Fresh Water 2 (FW2), either Non-Trout (NT) or Trout Maintenance (TM). A small portion of Pequest River watershed is classified as Fresh Water 1 (FW1) or FW1 TM. In addition, portions of the watershed are designated as Category 1 (C1) (see Figure 6 and Table 10). As stated in N.J.A.C. 7:9B-1.14(d) of the SWQS for FW2 waters, the standards for phosphorus are as follows:

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

Also as stated in N.J.A.C. 7:9B-1.5(g):

> Nutrient policies are as follows:
>
> 1. These policies apply to all FW waters of the State.
> 2. Except as due to natural conditions, nutrients shall not be allowed in concentrations that render the waters unsuitable for the existing or designated uses due to objectionable algal densities, nuisance aquatic vegetation, abnormal diurnal fluctuations in dissolved oxygen or pH, changes to the composition of aquatic ecosystems, or other indicators of use impairment caused by nutrients.
> 3. The Department may develop watershed-specific translators or site-specific criteria through a Total Maximum Daily Load (TMDL). Site specific criteria shall be incorporated at N.J.A.C.7:9B-1.14(g).
> 4. The Department shall establish water quality-based effluent limits for nutrients, in addition to or more stringent than the effluent standard in N.J.A.C. 7:14A-12.7, as necessary to meet a wasteload allocation established through a TMDL, or to meet the criteria at N.J.A.C. 7:9B-1.14(d)5.
> 5. Activities resulting in the nonpoint discharge of nutrients shall implement the best management practices determined by the Department to be necessary to protect the existing or designated uses.

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

a) Maintenance, migration and propagation of the natural and established aquatic biota;
b) Primary contact recreation;
c) Industrial and agricultural water supply;
d) 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

e) Any other reasonable uses.

In all FW1 waters, the designated uses are N.J.A.C. 7:9B-1.12 (a):

1. Set aside for posterity to represent the natural aquatic environment and its associated biota;
2. Primary contact recreation;
3. Maintenance, migration and propagation of the natural and established aquatic biota; and
4. Any other reasonable uses.

For waters designated as C1 Waters, from N.J.A.C. 7:9B-1.4 Definitions:

"Category One waters" means those waters designated for protection from measurable changes in water quality based on exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s) to protect their aesthetic value (color, clarity, scenic setting) and ecological integrity (habitat, water quality, and biological functions).

3.3 Area of Interest

Description of Pequest River Watershed

The Pequest River watershed is one of several subwatersheds that comprise the Upper Delaware River Watershed. The Pequest River watershed encompasses 157 square miles in Sussex and Warren Counties. The following 17 municipalities are located within the sub-watersheds that are addressed in this report: Belvidere Township, Sparta Township, Andover Township, Newton Town, Fredon Township, Andover Borough, Byram Township, Green Township, Allamuchy Township, Frelinghuysen Township, Hope Township, Independence Township, Liberty Township, White Township, Mansfield Township, Oxford Township and Washington Township. The Pequest River begins just south of Newton and flows 32 miles to the Delaware River at Belvidere. There are many small lakes and ponds within the watershed, the majority of which are located in the headwaters. The Pequest River watershed is located in the Highlands physiographic province. The topography forms a broad highland belt broken with intermountain valleys. The ridges are underlain chiefly with Precambrian gneisses and schists, while the long narrow valleys are underlain chiefly with fault block inliers of Paleozoic Kittatinny Limestone and Martinsburg shale (NJRC&D, 2001).

Land Uses

Land cover in the Pequest River watershed is primarily forested with significant agricultural and scattered suburban development located along the Route 94 corridor. The most heavily forested areas are within Jenny Jump State Forest, a portion of Allamuchy State Park, Pequest Wildlife Management Area, and Whittingham Wildlife Management Area. Bear Swamp, an extensive area of wetlands, is located in the upper portion of the watershed.

Agriculture is a significant land use, with the region leading the state in production of dairy, cattle, field corn and eggs. According to the November 2001 report entitled, *Setting of the Upper Delaware Watershed* prepared by the North Jersey Resource Conservation and Development (NJRC&D), the biggest change in land use during the years 1986-1995/97 was a 2.4% increase in urban land, resulting

primarily from converted farmland. *The Riparian Zones in the Upper Delaware Watershed* technical report, also from the NJRC&D, rates the relative health of riparian zones within the Pequest River watershed as 75% good to excellent. The 2002 land uses in the Pequest River watershed are depicted in Figure 2 and the distribution of land use within the area addressed in this TMDL study is summarized in Table 2.

Figure 2 2002 Land Uses / Land Cover for the Pequest River Watershed

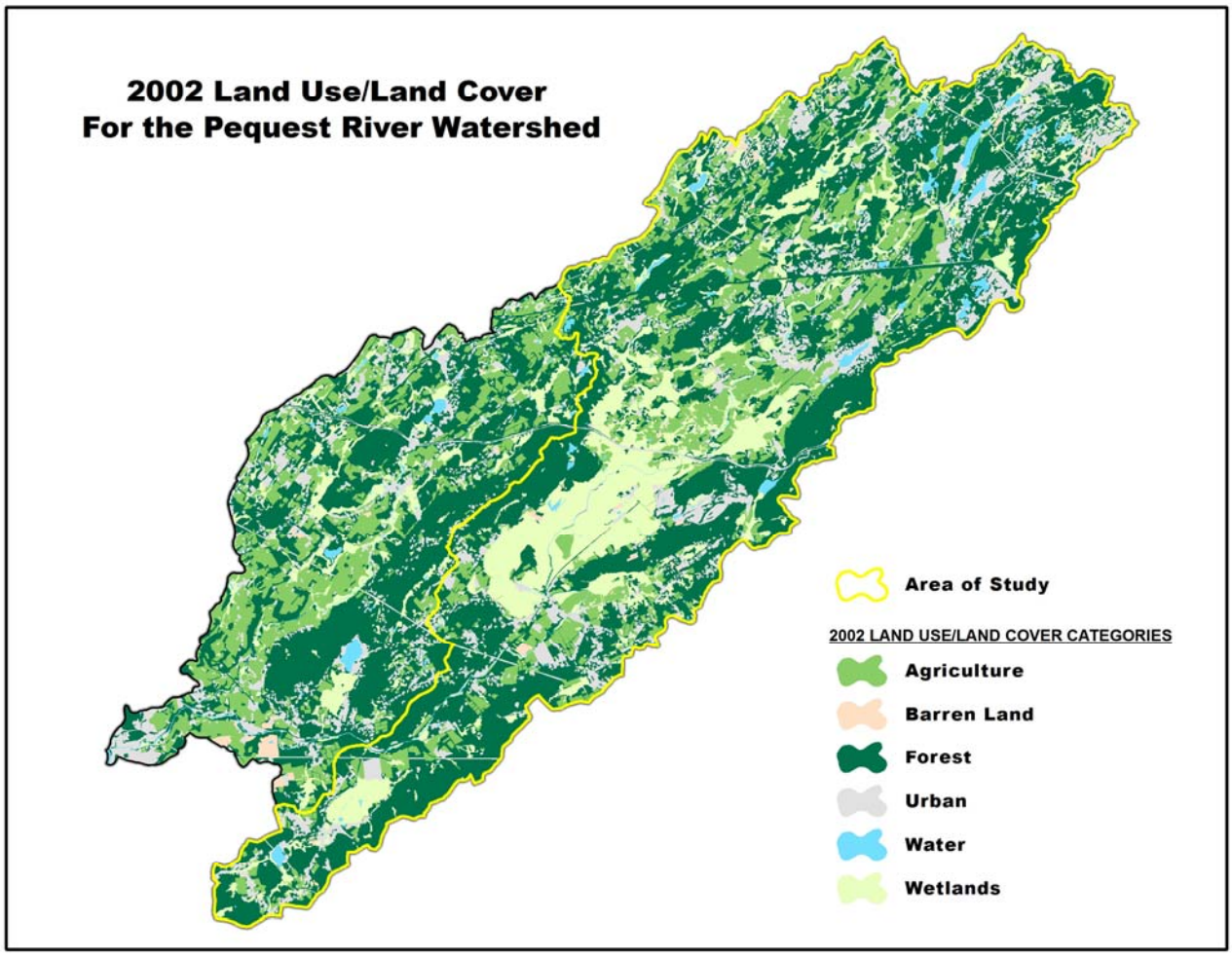


Table 2 Summary of 2002 Land Uses and Land Covers contributing land use loads to the Study Area

TYPE	Area (acres)	Area (Sq miles)	Percent (%)
AGRICULTURE	11,076	17	16.3%
BARREN LAND	384	1	0.6%
FOREST	32,871	51	48.4%
URBAN*	9,648	15	14.2%
WATER	1,281	2	1.9%
WETLANDS	12,634	20	18.6%
Grand Total	**67,894**	**106**	**100.0%**

***includes residential, industrial and commercial land uses**

These TMDLs address 4 assessment units that have been listed as impaired for phosphorus within the Upper Delaware Water Region. However, the entire drainage area contributing to the most downstream station used to characterize these assessment units, the Pequest River at Pequest (station ID 01445500) will be affected by the implementation plan addressing stormwater point sources and nonpoint sources. This contributory drainage area totals 106 sq. miles and encompasses 12 HUC 14 drainage areas. The spatial extent of the impaired segments and the contributory drainage areas are depicted in Figure 1, and a list of the assessment units addressed under the TMDL or the TMDL implementation plan is provide in Appendix B.

4.0 Water Quality Analysis

A summary of all the water quality data used in the TMDL analysis is provided in Table 3, raw data is provided in Appendix G. The United States Geological Survey (USGS) in collaboration with the Department collected water quality data at three monitoring locations along the Pequest River: Pequest River at Huntsville (01445000), Pequest River at Pequest (01445500) and Pequest River at Belvidere (01446400). As part of the Existing Water Quality (EWQ) monitoring network, (now called Supplemental Ambient Surface Water Monitoring Network (SASWMN)), the Department also collected water quality samples at three locations, Pequest River at Pequest, Pequest River at Townsbury and Beaver Brook at Route 618 in Sarepta, from 2000 to 2004; and, Furnace Brook at Pequest sampled from 2005 through 2009. These sampling stations are shown on Figures 1 as "USGS/NJDEP monitoring stations".

In addition, on behalf of two wastewater dischargers, a Phosphorus Evaluation Study entitled "*Pequest River Sampling Program Results and Phosphorus Evaluations,"* prepared by HydroQual, was submitted to the Department. The purpose of this study was to determine whether phosphorus is rendering the waterbodies unsuitable for the designated uses. The spatial extent of the study included the area affected by Allamuchy Township STP and Warren County MUA – Oxford STP. The study reach extends 25.8 miles, from Pequest Road/Sutton Road Crossing, upstream to Schmidt Lane (off route 46). The most upstream station, Site 1, is coincident with USGS Station 01445000 (Pequest River at Huntsville). Site 7, the most downstream station, is located just above the confluence of Beaver Brook and is outside the spatial extent of the TMDL study. Sites 2 and 3 are located upstream and downstream of the Allamuchy Township STP, respectively. Sites 5 and 6 are located upstream and downstream of the Warren County MUA - Oxford STP, respectively. Site 6 is just upstream of

Furnace Brook, and few hundred feet from USGS Station 01445500 (Pequest River at Pequest). As part of this study, a synoptic sampling consisting of 20 sampling events taken during the summers of 2004 and 2005 was performed at all seven sites under low flow conditions; Figure 3 shows the average total phosphorus concentrations for sites 1 through 6, with error bars. All seven of these sampling stations are shown on Figure 1 as "HydroQual Sampling Stations".

Monitoring data from the above described sources has shown total phosphorus (TP) to exceed the Department's Surface Water Quality Standards numeric criterion of 0.1 mg/l at all mainstem stations except Pequest River at Huntsville (USGS/EWQ 01445000 and HydroQual Site 1). TP levels and frequency of exceedance increase below the Allamuchy Township STP.

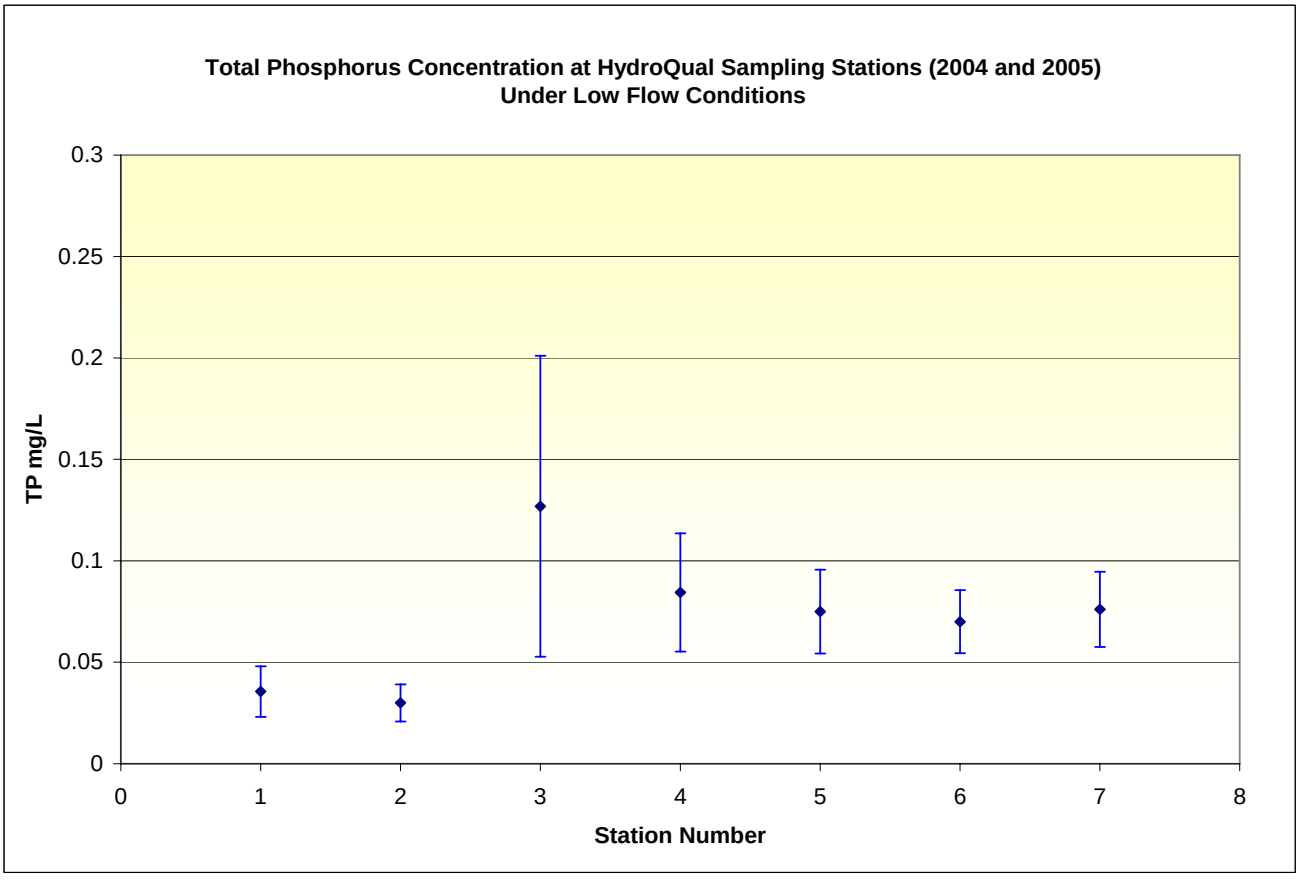
High concentrations of TP at Pequest River at Pequest and Pequest River at Townsbury were observed over a wide range of flows, which illustrates that both point source and nonpoint sources contribute to the TP exceedances along the river mainstem.

Table 3 Summary of the Data Collected by Different Groups along the Pequest River

Station ID	Name	Sampling date	No. of samples	Exceedance
USGS 01445000	Pequest River at Huntsville	1999-2000	4	0%
EWQ 01445000	Pequest River at Huntsville	2000-02	8	0%
HydroQual Site 1	Pequest River at Huntsville	2004-05 Summer	20	0%
HydroQual Site 2	Pequest River upstream of Allamuchy STP	2004 summer	15	6.7%
HydroQual Site 3	Pequest River downstream of Allamuchy STP	2004	15	66.7%
HydroQual Site 4	Pequest River downstream of Bear Swamp	2004-05	20	40%
01445430 EWQ	Pequest River at Townsbury	2002-04	8	50%
HydroQual Site 5	Pequest River upstream of Oxford STP	2004-05	20	30%
HydroQual Site 6	Pequest River (downstream of Oxford STP & upstream of Furnace Bk)	2004-5	20	15%
EWQ 01445495	Furnace Brook at Pequest	2005-2009	14	7%

EWQ 01445500	Pequest River at Pequest (downstream of Furnace Bk)	2000-02	8	75%
USGS 01445500	Pequest River at Pequest same as EWQ 01445500 (downstream of Furnace Bk)	1991-1997	31	29%
HydroQual Site 7	Pequest River upstream of confluence with Beaver Brook (upstream of Beaver Bk)	2004-05	20	35%
EWQ0047	Beaver Brook at Rt 618 in Sarepta	2000-2002	8	0%
USGS 01446400	Pequest River at Belvidere (downstream of Beaver Bk)	1997-2004	28	25%

Figure 3 Total Phosphorus Concentrations at the Sites Monitored by HydroQual Under Low Flow Condition



As part of the Phosphorus Evaluation Study conducted by HydroQual, both phytoplankton and periphyton chlorophyll-a samples as well as diurnal dissolved oxygen (DO) measurements were

evaluated. Despite the fact that recommended sampling conditions for periphyton were not met for some of the sampling events, periphyton chlorophyll-a concentrations at multiple stations exceeded the Phosphorus Evaluation Technical Manual threshold for individual samples (> 200 mg/m2). In addition, Stations 5 and 6 showed algal biomass seasonal average in excess of the Phosphorus Evaluation Technical Manual criterion (> 150 mg/m2), see Appendix G.

Analysis of the diurnal DO data shows no violation of the 24-hour average or minimum DO criteria; however, the diurnal DO swing exceeded 3 mg/l, which is indicative of photosynthesis activity. It should be noted that the 70 percent low flow requirement was not always met during the study. This means that the actual critical conditions may not have been captured.

It is reasonable to conclude that phosphorus is the limitng nutrient because the total inorganic nitrogen (TIN) and dissolved reactive phosphorus (DRP) ratio is greater than 5 (TIN/DRP >5). Based on the stoichiometric relationship between nitrogen and phosphorus, this ratio suggests that reducing TP will reduce the level of primary productivity observed in the watershed.

To summarize: TP concentrations within the Pequest River basin exceed the 0.1 mg/l numeric criterion, over-enrichment by TP is rendering the waters unsuitable for designated uses, and TP is the limiting nutrient. Therefore, in accordance with the Surface Water Quality Standards (SWQS), the TP numeric criterion of 0.1 mg/l is applicable for the subject waters. Based on best available information, the target for these TMDLs is the existing numeric criterion of 0.1 mg/l.

5.0 Source Assessment

In order to evaluate and characterize phosphorus loadings in the waterbodies of interest in these TMDLs, and thus propose proper management responses, source assessments are needed. Source assessments include identifying the types of sources and their relative contributions to phosphorus loadings.

5.1 Assessment of Point Sources

For the purposes of TMDL development, point sources include domestic and industrial wastewater treatment plants that discharge to surface water, 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.

NJPDES permitted dischargers that contribute phosphorus loads within the impaired drainage area are listed in Table 4 and include the following dischargers: Allamuchy Township STP, Pequest State Fish Hatchery, and Warren County Municipal Utilities Authority – Oxford STP. Multiple years of Discharge Monitoring Report (DMR) data were obtained to quantify the loading from these point sources, which is summarized in Table 4. The location of the facilities is shown in Figure 1.

There are two existing dischargers in the headwaters of the Pequest River that contribute to the boundary load entering the impaired assessment units. These dischargers are located about thirteen miles upstream of the first impaired assessment unit and are identified as the Andover Township Board of Education - Long Pond School and Sparta Alpine School. These two dischargers have a combined

long term average TP loading of 14.48 kg/year. This is based on the last ten years of data (2000 through 2010) for flow and TP concentration. The Andover Township Board of Education - Long Pond School averages are 0.002 MGD and 0.476 mg/l TP and the Sparta Alpine School averages are 0.002 MGD and 0.603 mg/l TP. These facilities discharge to an unimpaired assessment unit, where the observed TP concentration is on the order of 0.03 mg/l. This concentration was the basis for calculating the boundary load to the impaired assessment. The load contributed by these facilities is *de minimis* and will be included in the load allocation portion of the TMDL. These facilities will be required to achieve no measurable change in water quality compared to the existing load in order to maintain the boundary condition.

Two other dischargers: Sussex County Municipal Utilities Authority - Andover STP, and Oxford Textiles Inc. Facility discharge into the Pequest River headwaters and Furnace Brook, respectively. The Sussex County MUA facility is not currently active; however, a NJPDES permit was issued for this facility. This discharge would be located in the unimpaired assessment unit upstream of the impaired assessment unit, and so would also be part of the load allocation associated with the boundary load. Oxford Textiles has not been in full operation since 2003. Should these dischargers become active, the discharger must demonstrate that the load to be discharged would cause no measurable change in water quality in order to maintain the boundary load and achieve the TMDL. These dischargers are shown in Figure 1.

Tier A municipalities located within the Pequest River watershed are listed in Appendix C. Like nonpoint sources, stormwater point sources derive their pollutant load from land surface runoff and load reduction is accomplished through BMPs. Therefore, this point source will be evaluated along with the nonpoint sources, although a WLA will be assigned.

Table 4 NJPDES Permitted Wastewater Discharges Located within the Impaired Assessment Units Addressed in This Report

Facility	Permit #	Receiving Waterbody/ Categories	Permitted		Reporting Period	Average of MOAV from Reporting Period			
			Discharge (MGD)	TP (mg/l)		Discharge (MGD)	Flow (cfs)	TP (mg/l) (min–max)	Load (kg/day)
Allamuchy Twp STP	NJ0020605	Pequest River FW2-NT	0.6	1.5 monthly avg. (adjudicated)	2/2004-7/2007	0.34	0.53	3.04 (1.8-4.4)	3.75
Pequest State Fish Hatchery	NJ0033189	Pequest River FW2-TM(C1)	8.8*	Interim 1 /monthly avg. 2 /daily max	7/2000-2/2010	8.82	13.65	0.12 (0.05-0.35)	4.00
				Final starting 6/1/2011 0.1 monthly avg.					
Warren County MUA, Oxford STP	NJ0035483	Pequest River FW2-TM(C1)	0.5	1.2 monthly avg. (adjudicated)	7/2000-7/2007	0.32	0.51	2.51 (0.76-3.9)	3.17
TOTAL						**9.48**	**14.69**		**10.92**

*reflects the long term average discharge

Notes:

1. Pequest State Fish Hatchery: a) Monthly Average Flow calculated based on the 10-year period of reported (DMR) average monthly discharge in MGD;
2. Allamuchy Township STP: a) Monthly average flow calculated based on 4-year period of reported (DMR) average monthly discharge in MGD, February 2004 through July 2007); b) Phosphorus average load and average concentration calculated as an average of all 42 monthly averages of the reporting period from February 2004 through July 2007;
3. Warren County MUA - Oxford STP: a) Monthly average flow calculated based on the 7- year period of reported (DMR) average monthly discharge in MGD, (July 2000 through July 2007); b) Phosphorus average concentration calculated as an average of 84 monthly average concentrations as reported from July 2000 through July 2007;
4. Receiving water categories updated as Last Amended N.J.A.C. 7:9B on 1/4/2010.

5.2 Assessment of Nonpoint Sources

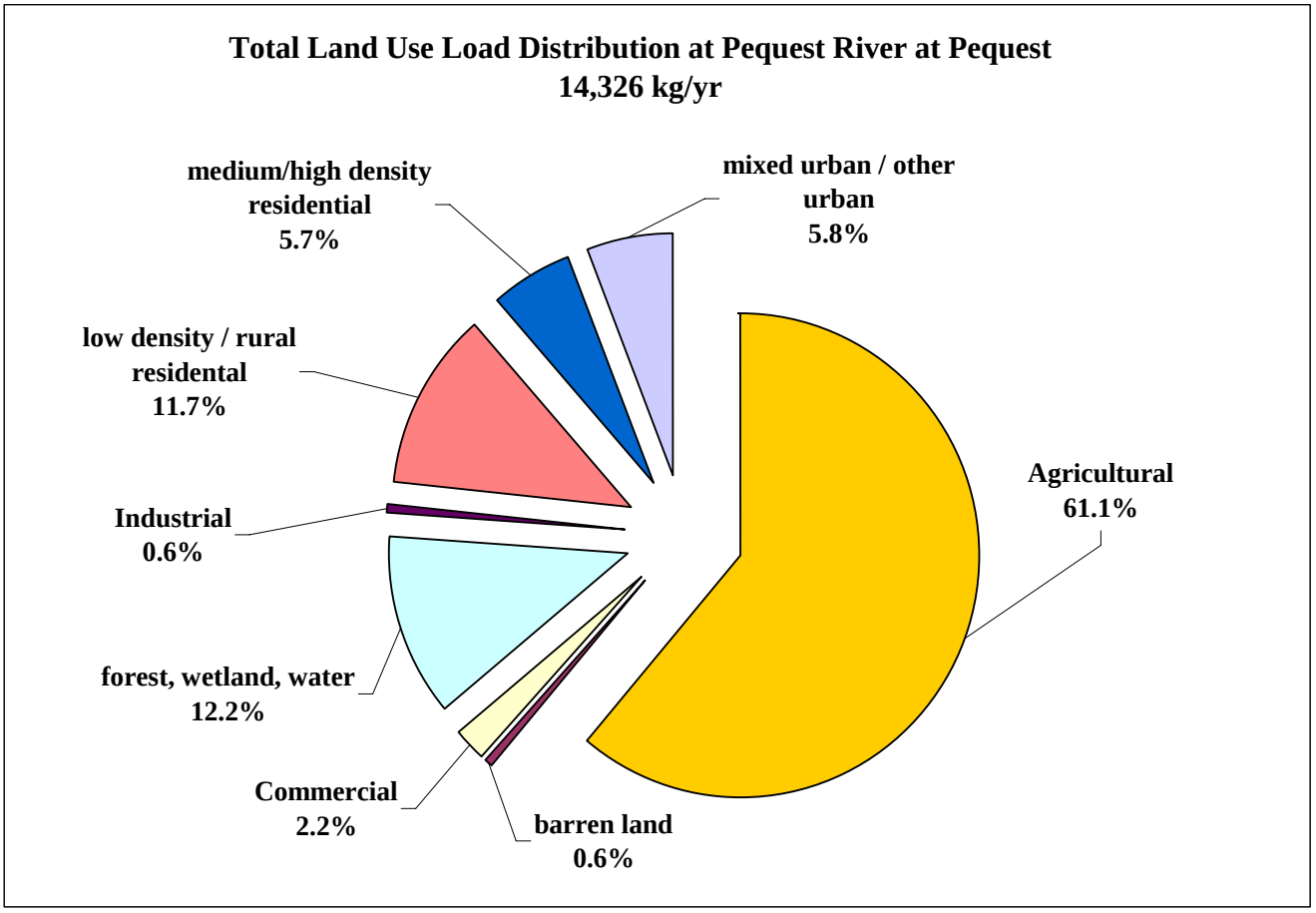
For the purposes of TMDL development, potential nonpoint sources include stormwater discharges that are not subject to regulation under NPDES, such as Tier B municipalities, which are regulated under the NJPDES municipal stormwater permitting program, and direct stormwater runoff from land surfaces, as well as malfunctioning sewage conveyance systems, failing or inappropriately located septic systems, and direct contributions from wildlife, livestock and pets. Of these potential sources, those sources in the study area include stormwater from Tier B municipalities and direct stormwater runoff from land. Tier B municipalities within the drainage area are identified in Appendix C. Land uses are depicted in Figure 2 and summarized in Table 2.

The total phosphorus load in the impaired assessment units and the larger contributory drainage area is contributed by stormwater point sources and nonpoint sources, referred to collectively as land use loads. These loads are effectively estimated using the Unit Areal Load (UAL) method, which applies pollutant export coefficients to the land use patterns within the watershed, as described in USEPA's Clean Lakes Program guidance manual (Reckhow, 1979b). The Department selected export coefficients for land use categories based on a review of an extensive database, provided in Appendix A. The Department's 2002 land use coverage was the source for the land use information and the pairing of land uses based on the 2002 LU/LC codes with the export coefficient categories can be found in Appendix A. Based on the UAL loading method, an average annual land use loading of 14,326 kg/year was estimated at the Pequest River at Pequest location.

Because of the wealth of in-stream water quality data at this location, the accuracy of this overall nonpoint source load could be checked. To do so involved calculating a load using actual concentrations and observed flows at the Pequest River at Pequest station and subtracting the relevant wastewater discharge loads. The loads from the Warren County MUA – Oxford STP and Pequest Fish Hatchery were deducted in their entirety because of their close proximity to the monitoring station, less than a few hundred feet and within a mile, respectively; no significant attenuation would occur over such short distances. For this exercise, the load from the treatment facilities beyond the study area boundary were assumed to be *de minimis* and the Allamuchy Township STP load was assumed to fully attenuate prior to reaching the Pequest River at Pequest station. The amount of flow and load attributed to the Warren County MUA – Oxford STP and the Pequest Fish Hatchery was estimated using the monthly average flows and concentrations as reported in the DMRs for the same month when the stream samples were collected. If no data was available for a specific month from the DMRs, the average load and flow listed in Table 4 were used. The land use load estimated at Pequest River at Pequest using this method was 14,620 kg/year. This is within 2.1 percent of the estimated loading based on the UAL method. The sensitivity of the result to the assumption of full attenuation of the Allamuchy Township STP load was checked. If it were instead assumed that 70% of the Allamuchy Township STP load reached the Pequest River at Pequest station, the calculated nonpoint source load would be 13,610 or 95% of UAL estimate. Therefore, the UAL method of estimating flows is reliable and was used because it permits a disaggregation of the land use load among the contributing land use types.

The land use distribution for the entire drainage area terminating at the Pequest River at Pequest station is provided in Table 2 and depicted in Figure 2. The associated land use loads, using the loading coefficients, is provided in Figure 4.

Figure 4 Current Land Use Load distribution at Pequest River at Pequest



Based on this distribution, the current nonpoint source load, which is the load attributed to Agricultural, Forest/Wetland/Water and Barren Land Uses, is 10,594 kg/yr TP. Similarly, the point source load, which is the load attributed to Mixed Urban/Other Urban, Medium/High Density Residential, Low Density/Rural Residential, Industrial and Commercial Land Uses, is 3732 kg/yr TP, with the total land use load contributed by point (regulated stormwater) and nonpoint sources equal to 14,326 kg/yr.

6.0 TMDL Calculations

The target for the TMDL calculations is attainment of the total phosphorus numeric criterion of 0.1 mg/l in each of the impaired assessment units within the Pequest River basin addressed by this study. Point and nonpoint source reductions needed to achieve the numeric criterion of 0.1mg/l TP were calculated, as described in the following sections. Land use load reductions, which are important during runoff producing conditions, were calculated using the Flow-Integrated Reduction of Exceedances (FIRE) method, which uses a regression analysis to determine the land use load reduction needed to attain the SWQS under a range of flow conditions. Refer to Appendix E for an explanation of the method. Wastewater treatment loads which occur under all conditions and are the dominant source during the design low flow condition were calculated using a mass balance approach.

6.1 FIRE method to estimate Land Use Load Percent Reduction:

The most downstream assessment unit in the study area is the Pequest River (Furnace Brook to Cemetery Road) 02040105090030-01. This assessment unit was assessed to determine the current land use load contribution and the load reduction needed to achieve the TP numeric criteria of 0.1 mg/l. As described in section 5.2 Assessment of Nonpoint Sources, the current land use load was estimated using the UAL method. The FIRE method was used to determine the percent reduction of the land use loads needed to meet the water quality standard at the two monitoring stations that are within the impaired assessment unit, Pequest River at Pequest and Pequest River at Townsbury, to determine the percent reduction needed to attain the TP criterion within the assessment unit, including a margin of safety (MOS). Because two stations are used to assess water quality within this assessment unit, it is necessary to determine which station would be the limiting station, requiring the greater reduction in land use loads.

FIRE Analysis at Pequest River at Pequest, Station USGS ID No. 01445500

In order to isolate the land use load reduction needed at this station, the loads from the Warren County MUA- Oxford and the Pequest Fish Hatchery wastewater treatment dischargers are subtracted from the river flow and load. The load from the Allamuchy Township STP and those located beyond the study boundary were assumed to have a negligible effect on the land use load analysis. After subtracting the TP load contributions of Warren County MUA- Oxford STP and the Pequest Fish Hatchery discharges from the river flow and load, the resultant FIRE analysis for Pequest River at Pequest is summarized in Table 5 below. The adjusted flow and concentration and the regression line of calculated land use load exceedance with comparison to the target loading line are shown in Appendix E-2.

Table 5 Summary FIRE Output for Exceedances at Pequest River at Pequest, Station ID No. 01445500

Results from Regression Analysis	
Target Loading Slope	= 0.2447
Exceedance Regression Slope	= 0.3710
Upper 95% Confidence Limit of Slope	= 0.4534
Overall Percent Load Reduction	= 46.02%

Applying these results, the reductions needed to achieve SWQS for phosphorus within and upstream of the Assessment Unit 02040105090030-01 (Pequest River Furnace Brook to Cemetery Road), are as follows:

The Target Load (lb/day) to achieve the SWQS is given by:

Target Load (kg/day) = flow (cfs) * 0.2447

Based on the regression line, the required TP Load Reduction to achieve the SWQS is:

$$(1-\frac{0.2447}{0.3710})x100\% = 0.3404x100\% = 34.04\%$$

Reducing the existing loading by the required reduction yields a loading capacity of 9449.43kg/yr, which is 65.96% (100%-34.04%) of the current loading.

Using the upper 95% confidence limit of regression line to provide a margin of safety results in a TP load reduction requirement of:

$$(1-\frac{0.2447}{0.4534})x100\% = 0.4602x100\% = 46.02\%$$

Applying this reduction to the existing load yields an allowable load of 53.98% (100%-46.02%) of the current loading (53.98% of 14,326 kg/yr) which is equal to 7733.2 kg/yr. There are a number of land uses from which a reduction in current load is not readily accomplished, i.e. forest, water, wetlands, and barren land. The current loads for these land uses were carried over entirely as a component of the future load allocations. This means that the required reduction in land use loads must be obtained from those land uses that contribute anthropogenic loads, i.e., urban and agricultural. After setting the existing load as equal to the future load for forest, water, wetlands and barren land, the sum of the unadjusted land use loads is removed from the total allowable future land use load leaving the final allocable land use load to be allocated among urban and agricultural land uses. The final allocable land use load is applied to each land use category in proportion to the amount of each land use in the watershed.

With the total land use load from forest, wetland and barren land equal to 1838 kg/yr, the total existing land use load equal to 14,326 kg/yr, and the allocable load equal to 7733.2 kg/yr, the revised overall percent reduction applied to urban and agricultural land uses is calculated as follows: (1- (7733.2-1838)/(14326-1838))*100 = 52.79%. This reduction is rounded to 52.8% for ease of calculation in Table 7.

As stated above, the wastewater dischargers outside the boundary of the study were assumed to have a negligible effect on the outcome. This assumption was based on the small size of the facilities and the considerable distance from the discharge locations to the station. The Allamuchy Township STP does contribute a significant load and flow compared to the boundary discharges, but it is also a considerable distance from the station. Therefore, the sensitivity of the outcome to the assumption that the Allamuchy Township STP loads would have a negligible effect on the land use load analysis was tested. The FIRE analysis was rerun at this station based on three different loading scenarios from the Allamuchy Township STP, allowing for varying degrees of attenuation. As shown in Table E-2-2 in Appendix E-2, Scenario 1 assumes that 100% of the Allamuchy Township STP reaches this station; Scenario 2 assumes 70%; and Scenario 3 assumes 0%. The required percent reductions are 45.32%,

45.54%, and 46.02% respectively. Given the insignificant difference in the range of percent reduction required, Scenario 3 was selected as providing a more conservative land use load reduction requirement.

FIRE analysis at Pequest River at Townsbury, Station ID No. 01445430

For this station, the observed river flow and concentration were used without adjustment. This is because the Warren County MUA-Oxford STP and Pequest Fish Hatchery are located downstream of the station and the loads from the Allamuchy Township STP have a negligible effect on the outcome of the FIRE analysis. The FIRE analysis is summarized in Table 6 below and Figure D-2-2 in Appendix E-2. Also, Table E-2-3 in Appendix E-2 summarizes the phosphorus exceedance at this station.

Table 6 Summary of FIRE Output for Exceedances at Pequest River at Townsbury (Station ID 01445430)

Results from Regression Analysis	
Target Loading Slope	**= 0.2447**
Exceedance Regression Slope	**= 0.3257**
Upper 95% Confidence Limit of Slope	**= 0.4344**
Overall Percent Load Reduction	**= 43.7%**

As shown in the Table 6, the overall percent reduction required from the FIRE analysis at Pequest River at Townsbury is 43.7%, compared to the 46.02% obtained for Pequest River at Pequest. The Pequest River at Pequest station requires a larger percent reduction to attain SWQS.

As indicated, some land uses respond more readily to reduction strategies than others. This results in an approach in which the overall land use load reduction required to attain SWQS is obtained by increasing the load reduction required from those land uses (urban and agricultural) and holding the remaining land uses (forest, wetlands, water and barren land) constant. This step in adjusting land use load reductions was applied to the land use distribution within the drainage area of the Pequest at Townsbury station to ensure that any differences in land use distribution between the two drainage areas did not affect the outcome of the limiting location analysis. Based on the results, provided in Appendix E, Pequest at Pequest remains the more limiting location within the assessment unit and was used to calculate the TMDL.

Table 7 summarizes the allocation of land use load capacity among the land use categories, differentiating those land uses that receive a WLA from those that receive a LA. Distinguishing between WLAs and LAs by land use type is explained below under TMDL allocations.

Table 7 Allocation of Land Use Loads at Pequest River at Pequest

Land Use	Current Load kg/yr	Allocation of Loading Capacity kg/yr	Allocation Expressed as a Daily Load (kg/day)	Allocation Type	Percent Reduction Applied
Agricultural	8,757	4,133	11.3	LA	52.8%
Commercial	318	150	0.4	WLA	52.8%
Industrial	86	40	0.1	WLA	52.8%
low density / rural residential	1,679	793	2.2	WLA	52.8%
medium/high density residential	817	386	1.1	WLA	52.8%
mixed urban / other urban	832	386	1.1	WLA	52.8%
forest, wetland, water	1,751	1,751	4.8	LA	-
barren land	86	86	0.2	LA	-
Sum		7,733	21.2		
MOS		1,716	4.7		
TOTAL	14,326	9,449	25.9		

6.2 Mass Balance Calculation to Determine the WLA for the Wastewater Treatment Discharges

A mass-balance analysis was used to calculate the wasteload allocations for each wastewater treatment facility needed to meet the in-stream phosphorus criterion of 0.1 mg/l TP in the impaired assessment units.

The basic mass-balance equation is as follows:

$$Q_u * C_u + Q_e * C_e = Q * C$$

Where:

Q_u = upstream flow, cfs
C_u = upstream total phosphorus (background) concentration, mg/l
Q_e = plant effluent flow, cfs
C_e = plant phosphorus effluent concentration, mg/l
Q = downstream flow ($Q_u + Q_e$), cfs
C = downstream concentration, 0.10 mg/l

In order to perform the mass-balance calculations, the background concentration upstream of Warren County MUA-Oxford STP, Allamuchy Township STP, and Pequest Fish Hatchery has to be established. The water quality data described in Section 4.0, including baseflow concentrations measured as part of the water quality data collected by HydroQual under 70th percentile low flow (base flow) conditions and other low flow sampling done by NJDEP/USGS, was used to quantify the background concentration upstream of each of the dischargers. Under baseflow conditions, the observed water quality is mainly due to groundwater, sediment re-suspension sources and wastewater treatment discharges; land use loads are insignificant.

As indicated in section 5.1, this analysis assumes that the baseflow boundary condition upstream of Allamuchy Township STP will remain the same. In summary, the overall load is small relative to other sources and attenuates significantly before it reaches the study area boundary because of the distance (13 miles) as well as intervening impoundments and wetland areas.

The analysis begins at the most upstream impaired assessment unit, into which the Allamuchy Township STP discharges. The background concentration upstream of this discharger was estimated using the extensive water quality data taken at Pequest River at Huntsville (USGS 01445000) and Sites 1 & 2 (HydroQual). As previously stated, these data were collected under low flow conditions during 1999 through 2005 and show a consistent concentration of 0.03 mg/l TP (data values provided in Appendix G). Therefore, a TP background concentration of 0.03 mg/l was used to characterize the background concentration upstream of this discharger.

The Qu term takes on two values because there are separate 7Q10 values available for winter and summer. For this analysis the summer season includes May through October, and the winter season includes November through April. Solving the mass balance equation for C_e which in this case is the Allamuchy Township STP phosphorus effluent concentration in mg/l TP, results in a required summer effluent quality of 0.58 mg/l based on the following inputs:

Qu = 6.4 cfs 7Q10 flow at Pequest River at Allamuchy (summer)
C_u = 0.03 mg/l
Q_e = 0.6 MGD (0.93 cfs), NJPDES permitted flow
Q = (Q_u +Q_e), 7.33 cfs downstream of Allamuchy
C = 0.10 mg/l - in-stream total phosphorus criterion
Ce = Allamuchy Township STP effluent concentration

Using the winter 7Q10 of 10 cfs, the required effluent quality is 0.85 mg/l. WLAs calculated for this facility based on the facility permitted flow and the calculated effluent qualities for summer and winter are 1.32 kg/day and 1.94 kg/day, respectively.

Moving to the next downstream discharger, the Pequest Fish Hatchery, the background concentration upstream of this discharger was calculated based on the TP data sampled at Site 4. In order to represent the TMDL condition under which the Allamuchy Township STP TP load will be reduced, the existing load was subtracted from the river load and substituted with the calculated TMDL load. An attenuation factor of 0.30 (meaning 70% of the load remains) was applied to the Allamuchy Township STP load. This factor was based on AVGWLF, 2007, which contains a recommended reduction coefficient. Use of this coefficient is supported by analysis of the data at sites 3 and 4. The average TP concentration at Site 3 is 0.127 mg/l and 0.084mg/l at Site 4, which results in an attenuation factor of 0.33 between the two sites. The smaller attenuation factor was used as a conservative assumption. The average existing TP concentration at site 4 was 0.084 mg/l; under the TMDL condition and accounting for the noted attenuation factor, the average TP is estimated to be 0.060 mg/l. This value was used as the background TP concentration upstream of the Pequest Fish Hatchery.

The Pequest Fish Hatchery employs best management practices to control phosphorus concentrations. Groundwater is withdrawn and used in a pass-through operation to maintain the fish that are cultivated at the hatchery. The facility currently discharges TP at a low concentration, with a long term average concentration of 0.12 mg/l. Further, analysis of the water quality data sampled at Site 4 and Site 5, located upstream and downstream of the Pequest Fish Hatchery, respectively, shows a downward trend in the TP concentrations, an average of 0.11 mg/l TP is observed at Site 4 compared to an average TP

concentration of 0.09 mg/l at Site 5, which illustrates that the Pequest Fish Hatchery flow provides dilution of the upstream load, see Figure 3. Therefore, the WLA assigned to the Pequest Fish Hatchery is based on maintaining the long term average concentration and flow, 0.12 mg/l and 8.82 MGD, respectively, for a WLA of 1463.7 kg annually, which can be expressed as a daily load of 4.01 kg/day.

The TMDL condition TP concentration downstream of the Pequest Fish Hatchery was calculated. The Qu was estimated by taking the 7Q10 value for Pequest River at Pequest and subtracting major intervening inputs from Furnace Brook and the Warren County MUA-Oxford STP. The Furnace Brook 7Q10 flow was also estimated based on the drainage area ratio method (ratio of Furnace Brook drainage area to the total contributing drainage area upstream of Pequest River at Pequest station – drainage area of Furnace Brook/drainage of Pequest River at Pequest x 100 = 7.7/106 x 100= 7.26%) and was verified using available flow data. Using the drainage area method, a summer 7Q10 flow of 1.3 cfs was estimated (7.26% of 18 cfs) and a winter 7Q10 of 2.03 cfs (7.26% of 28 cfs). This result was verified using flow data measured since 2005 (21 flow measurements at Furnace Brook). The percent of Furnace Brook flow to Pequest flow was 6.35%. The more conservative value, which, in this case, is the one based on the drainage area ratio, was used to estimate the 7Q10 at Furnace Brook.

As indicated, the total phosphorus WLA assigned to the Pequest Fish Hatchery is based on maintaining the existing long term average (LTA) TP load. A total phosphorus WLA of 4.01 kg/day (1463.7 kg/yr) was calculated based on the LTA TP concentration of 0.12 mg/l and the LTA flow rate of 8.82 MGD (13.65 cfs). The DMR data from July 2000 through February 2010 were used for this analysis.

The inputs for the mass balance calculation are as follows:

Q_u = 15.93 cfs upstream flow under 7Q10 summer conditions, and 25.2 winter*
C_u = 0.060 mg/l TP (calculated upstream concentration based on the Site 4 data)
Q_e = 13.65 cfs (Pequest Fish Hatchery LTA flow rate based on 10 years of DMR data)
Ce =0.12 mg/l (Pequest Fish Hatchery LTA TP conc. based on 10 years of DMR data)
Q = (Q_u +Q_e), 29.58 cfs under summer condition, and 38.85 cfs winter
C = TP mg/l downstream concentration at Site 5

* Flow just upstream of Pequest Fish Hatchery (Q_u) under 7Q10 conditions = 7Q10 at Pequest River at Pequest excluding 7Q10 flow of Furnace Brook and effluent flow of Warren County MUA--Oxford STP. The 7Q10 flow at Pequest River at Pequest (station ID 01445500) was calculated by USGS (R. Edward Hickman, USGS, Written communication, August 2008) without the Pequest Fish Hatchery, which adds a large amount of ground water to the system. The summer 7Q10 is 18 cfs and the winter 7Q10 is 28 cfs. The downstream flow (Q) is the sum of both the upstream flow and the Pequest Fish Hatchery flow. Therefore, the summer flow just upstream of Pequest Fish Hatchery (Q_u) under 7Q10 summer conditions = 18-.77-1.3 = 15.93cfs; and under winter conditions, the flow upstream of Pequest Fish Hatchery (Q_u) = 28-.77-2.03 = 25.2cfs

Solving the mass balance equation above for C, the downstream TP concentration at Site 5 is 0.088 mg/l, which becomes the Cu term for the next segment.

Solving the mass balance equation for C_e for the Warren County MUA-Oxford STP phosphorus effluent concentration in mg/l TP requires a summer effluent quality of 0.57 mg/l to attain SWQS based on the following inputs:

Q_u = 29.58 cfs summer, and 38.85 cfs winter - the flows as calculated downstream of Pequest Fish Hatchery
C_u = 0.088 mg/l and 0.081mg/l winter
Q_e = 0.5 MGD (0.77 cfs) – Warren County MUA--Oxford STP permitted discharge
Q = (Q_u +Q_e), 30.35cfs summer and 39.62 cfs winter flow
C = 0.10 mg/l - in-stream total phosphorus criterion
Ce = Oxford effluent concentration

A summer Wasteload Allocation (WLA), based on the facility permitted flow and an effluent concentration of 0.57mg/l is calculated to be 1.08 kg/day. Similarly, a winter WLA is calculated to be 1.99 kg/day based on winter 7Q10 of 28 cfs and winter phosphorus effluent concentration of 1.05 mg/l. A summary of the mass-balance calculations is provided in Appendix D.

6.3 Summary of TMDL Allocations

WLAs are established for all point sources, while LAs are established for nonpoint sources, as these terms are defined in "Source Assessment." For point sources other than stormwater, individual WLAs are assigned. For stormwater point sources, both WLAs and LAs are expressed as percent reductions based on land use for particular stream segments, and are differentiated as discussed below.

There are three existing wastewater treatment discharges located within the impaired assessment units and addressed under this study: Warren County MUA--Oxford STP, Allamuchy Township STP and Pequest River Trout Hatchery. The derivation of the WLAs for these facilities is provided above. No explicit MOS was reserved from the loading capacity with respect to wastewater discharges; instead, a series of conservative assumptions serve as an implicit MOS, as described in the MOS section. Remaining wastewater discharges, two existing (Andover Township Board of Education - Long Pond School and Sparta Alpine School) and two inactive (Sussex County Municipal Utilities Authority - Andover STP, and Oxford Textiles Inc. Facility), discharge upstream of the boundaries of the study area and are part of the load allocation. These facilities will be required to maintain effluent quality so as to result in no measurable change in water quality at the point of entry into impaired assessment units.

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 land use source categories as shown in Table 8. 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 residential, commercial, industrial and mixed urban runoff source 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.

Table 8 Distribution of WLAs and LAs Among Land Use Source Categories

Land Use Source category	TMDL allocation type
medium / high density residential	WLA
low density / rural residential	WLA
commercial	WLA
industrial	WLA
Mixed urban / other urban	WLA
agricultural	LA
forest, wetland, water	LA
barren land	LA

Loading reductions for all land use loading sources were derived using the FIRE method, as described above. This method includes an explicit MOS.

A summary of the wasteload allocations (WLA) and load allocations (LA) for sources within the study area drainage area, as well as the MOS, are presented in Table 9, and shown in Figure 5.

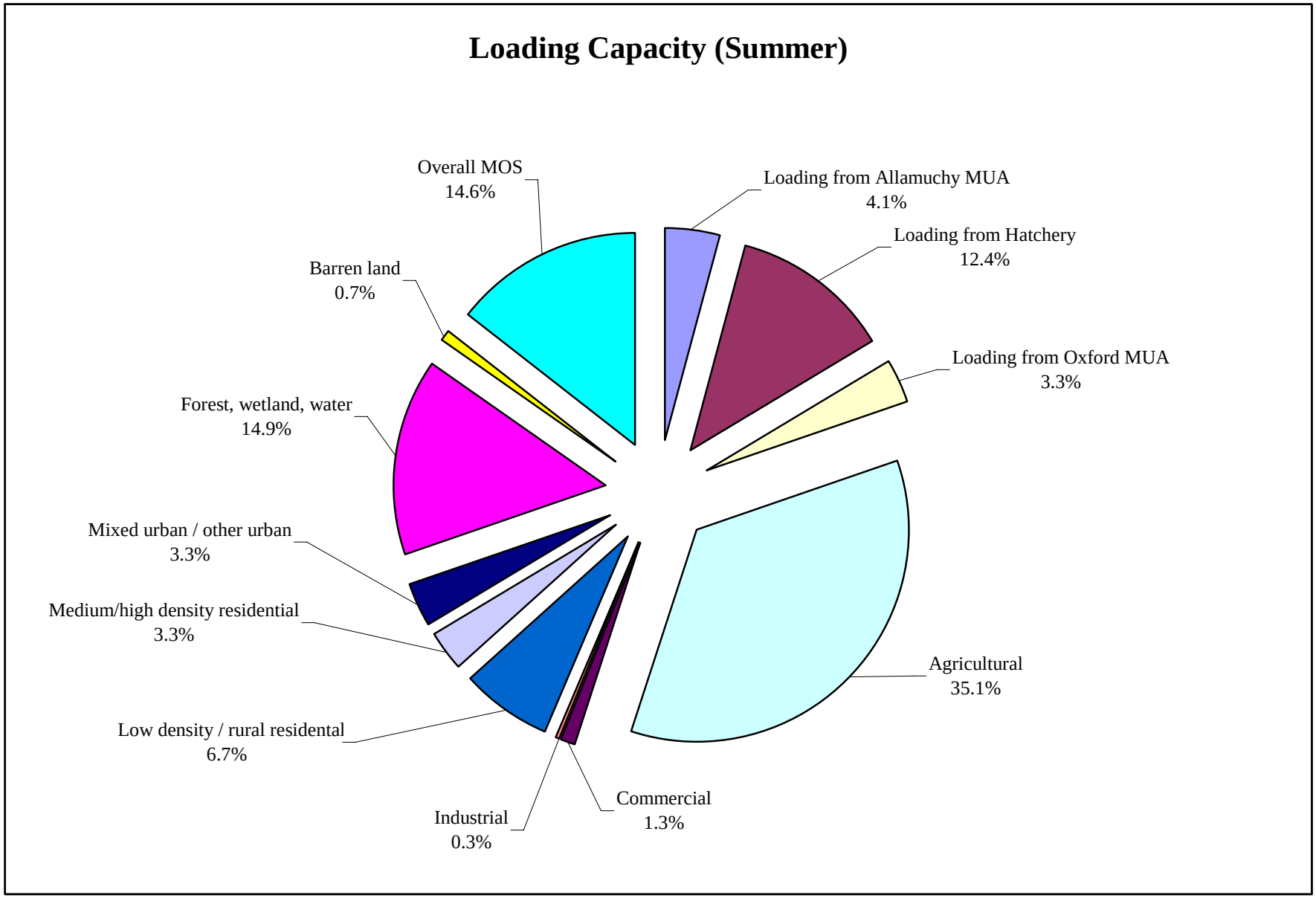
Table 9 Overall Loading Capacity at Pequest River at Pequest

Category	WLA/LA	Current Load (kg/day)	TMDL (kg/day)		Reduction		Percentage of Overall Load Capacity	
			Summer	Winter	Summer	Winter	Summer	Winter
Traditional NPDES PS WLAs								
Loading from Allamuchy	WLA	4.02	1.32	1.94	67%	52%	4.1%	5.7%
Loading from Hatchery	WLA	3.99	4.01	4.01	N/A	N/A	12.4%	11.8%
Loading from Oxford	WLA	3.06	1.08	1.99	65%	35%	3.3%	5.9%
Margin of Safety	Implicitly Determined with Conservative Assumptions*							
Subtotal			6.41	7.94			19.8%	23.5%
Land Use Loads								
Commercial	WLA	0.87	0.41	0.41	52.8%	52.8%	1.3%	1.2%
Industrial	WLA	0.23	0.11	0.11	52.8%	52.8%	0.3%	0.3%
Low density / rural residential	WLA	4.60	2.17	2.17	52.8%	52.8%	6.7%	6.4%
Medium / high density residential	WLA	2.24	1.06	1.06	52.8%	52.8%	3.3%	3.1%
Mixed urban / other urban	WLA	2.28	1.08	1.08	52.8%	52.8%	3.3%	3.2%
Agricultural	LA	23.99	11.32	11.32	52.8%	52.8%	35.1%	33.5%

Forest, wetland, water	LA	4.80	4.80	4.80	0.0%	0.0%	14.9%	14.2%
Barren land	LA	0.24	0.24	0.24	0.0%	0.0%	0.7%	0.7%
Margin of Safety			4.70	4.70			14.6%	13.9%
Land Use Loads Subtotal		39.25	25.89	25.89			80.2%	76.5%
Total		50.32	32.30	33.82				

*The conservative assumptions used to determine the implicit Margin of Safety are provided in Section 6.

Figure 5 Loading Capacity Distribution at Pequest at Pequest for the Summer Months



6.4 Seasonal Variation, Critical Conditions and Margin of Safety (MOS)

A flow-integrated regression technique is applied to determine the loading reductions required of land use loads for the study area. The analytical technique used to calculate the TMDL considers the entire range of flows and all seasons for which total phosphorus data were collected. In this way, seasonal variation and critical conditions are incorporated into the analysis, thereby implicitly representing all seasons and hydrological conditions. The loading reduction on land use loads calculated to attain SWQS will do so under all conditions, according to the data available. The wastewater treatment facility contributions become significant under low flow conditions. Therefore, the low flow threshold at which the SWQS apply, which is the 7Q10, was the flow used in the mass balance method to calculate the WLAs for these facilities. This ensures that the SWQS will be achieved under this critical condition, when nonpoint source loads are negligible.

A MOS accounts for uncertainty in the linkage between the model and the observed water quality. 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. For the nonpoint source reduction estimates, using the FIRE method, an explicit MOS is incorporated as follows: The loading capacity is the remaining load after taking the percent reduction based on the slopes of exceedance regression line and the target line. A more stringent percent loading reduction is estimated by taking the difference between the slopes of the upper 95 percent confidence limit of the exceedance regression line and the target loading. What is left after applying the "higher" reduction is assigned as the allocable load. The difference between the loading capacity and the allocable load is reserved as the MOS.

The difference between the loading capacity and the allocable loading provides an explicit MOS (9449.43-7733.2 = 1716.2kg/yr), which is 11.98% (65.96%-53.97%) of current loading and 18.17% (11.98%/65.96%) of the loading capacity. Mathematically, the MOS, as a percent of loading capacity, can also be calculated using the difference between the slopes of the exceedance regression and the upper 95% confidence limit of the exceedance regression:

MOS as percent of loading capacity =

$$(1-\frac{0.3710}{0.4534})x100\% = 0.1817x100\% = 18.17\%$$

The MOS incorporated in the point source analysis is implicit and relies on using conservative assumptions in the mass balance analysis. As described above, these include: 1) using a smaller 7Q10 flow for the Furnace Brook tributary input; 2) treating TP as a conservative substance except between Allamuchy Township STP and Pequest Fish Hatchery; and 3) use of the smaller attenuation factor relative to the Allamuchy Township MUA STP load reaching the Pequest Fish Hatchery.

6.5 Reserve Capacity

Reserve capacity is an optional means of reserving a portion of the loading capacity to allow for future growth. No explicit reserve capacity is included in this TMDL. Should expansions of existing facilities be warranted in the future, the effluent quality would need to be adjusted to maintain the WLA, unless a revised assessment of water quality is established indicating a different result. New facilities in the boundary areas would need to provide treatment so as to result in no measurable change in water quality upon entering the study area. The land use loading contributions are expected

to remain within the allocation as the primary land use conversion that is likely to occur would be from agriculture to residential, which would produce less phosphorus according to UAL coefficients. Residential loads are expected to be further reduced compared to the coefficients used as the result of stormwater regulation requirements that reduce phosphorus loads from urban land uses, as described under Implementation.

7.0 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, DEP's Supplemental Ambient Surface Water Network (100 stations), has improved spatial coverage for water quality monitoring in New Jersey. The data from these networks have been used to assess the quality of freshwater streams and percent load reductions. The ambient networks will be the means to determine the effectiveness of TMDL implementation and the need for additional management strategies.

8.0 Implementation Plan

For point sources other than stormwater, effluent limits consistent with assigned WLAs will be incorporated into the applicable NJPDES permits. See Table 9 for the list of WLAs.

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, sitting 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 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. Urban and agricultural land use sources must be the focus for implementation. Urban land use will be addressed primarily by stormwater regulation. Agricultural land uses are best addressed by implementation of conservation management practices tailored to each farm. These and other proposed measures are discussed further below.

8.1 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 roughly correspond to the areas regulated under industrial and municipal stormwater programs. The BMPs now required through stormwater permits are generally expected to achieve the required load reductions. The success of these measures will be assessed through follow up monitoring. As needed, through adaptive management, additional measures may need to be identified and included in stormwater permits. Additional measures that may be considered include, for example, more frequent street sweeping and inlet cleaning, or retrofit of stormwater management facilities to include nutrient removal. A more detailed discussion of stormwater source control measures follows.

On February 2, 2004 the Department promulgated two sets of stormwater rules: The Phase II New Jersey Pollutant Discharge Elimination System (NJPDES) Stormwater Rules, N.J.A.C. 7:14A also known as the Municipal Stormwater Regulation Program, and the Stormwater Management Rules, N.J.A.C. 7:8.

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) is 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, 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.

The Stormwater Management Rules establish statewide minimum standards for stormwater management in new development. The Stormwater Management Rules are currently implemented through the Residential Site Improvement Standards (RSIS) and the Department's Division of Land Use Regulation Program (DLUR) 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 from new development. 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

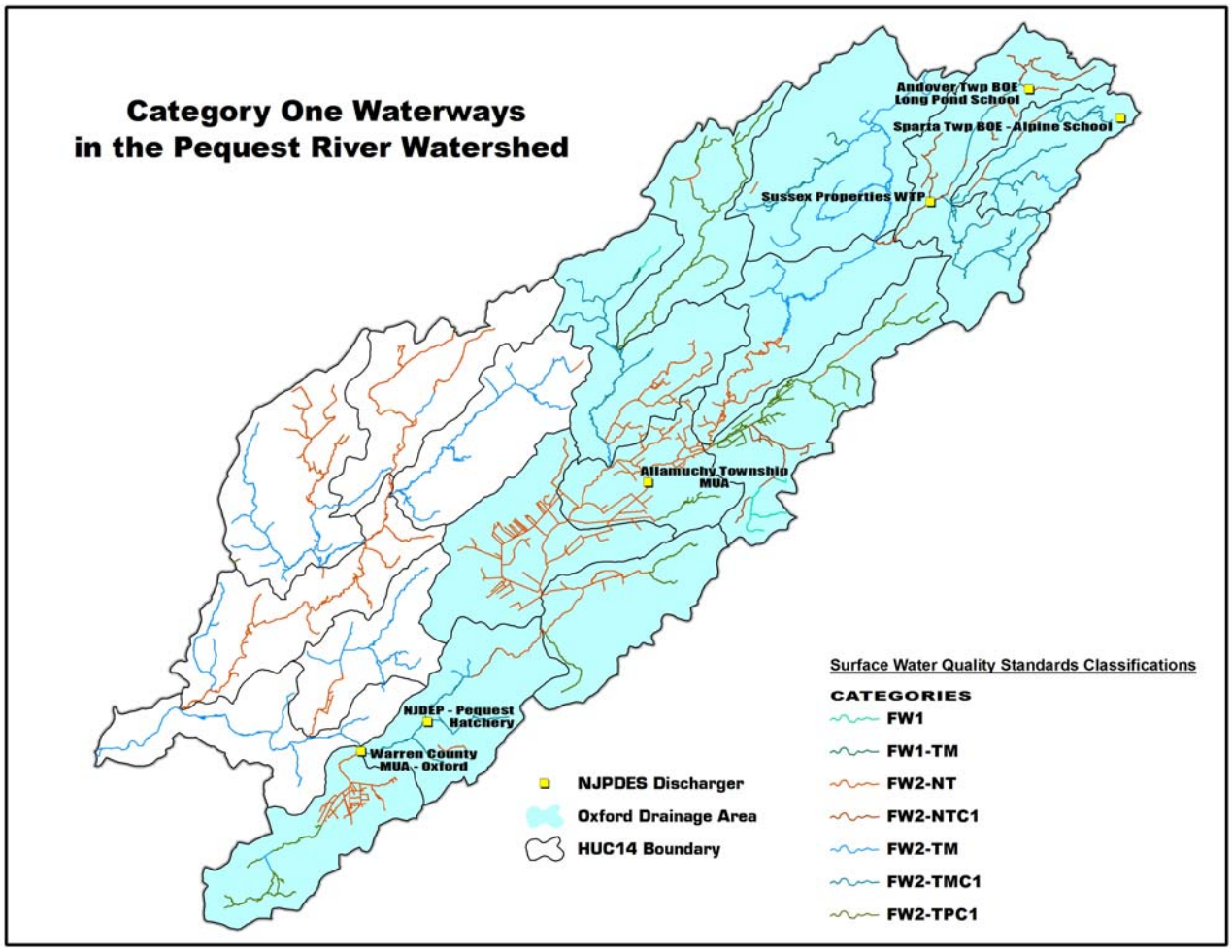
to changes in the design of projects regulated through the RSIS and DLUR, municipalities have been updating their regulatory requirements to provide the additional protections in the Stormwater Management Rules.

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. C1 waters receive the highest form of water quality protection in the state, which prohibits any measurable deterioration in the existing water quality. The current Flood Hazard Area Control Act Rules N.J.A.C. 7:13 extend buffer protection to other waters as well, with the minimum buffer being 50 feet. Table 10 and Figure 6 show the C1 waterways in the impaired watersheds. 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.nj.gov/dep/rules/rules/njac7_9b.pdf.

Table 10 C1 Designated Waterbodies in the Pequest River Watershed

Waterbody	Classification
Pequest River	
(Springdale) - Source to Tranquility bridge, except FW1 segments described below	FW2-TM
(Whittingham) - Northwesterly tributaries, including Big Spring, located within the boundaries of the Whittingham Wildlife Management Area, southwest of Springdale, from their origins to their confluence with the Pequest River	FW1(tm)
(Whittingham) - Stream and tributaries within the Whittingham Wildlife Management Area, except those classified as FW1, above	FW2-TM(C1)
(Vienna) - Tranquility bridge to Lehigh and Hudson River railway bridge	FW2-NT
(Townsbury) - Lehigh and Hudson River railway bridge to the upstream most boundary of the Pequest Wildlife Management Area	FW2-NT(C1)
(Townsbury) - Upstream most boundary of the Pequest Wildlife Management Area boundary to the downstream most boundary of the Pequest Wildlife Management Area	FW2-TM(C1)
(Townsbury) - Downstream most Pequest Wildlife Management Area boundary to Delaware River	FW2-TM
TRIBUTARIES	
(Janes Chapel) - Headwater and tributaries downstream to the upstream boundary of Pequest Wildlife Management Area	FW2-TM
(Townsbury) - Tributaries within the Pequest Wildlife Management Area	FW2-TM(C1)
(Petersburg) - Headwaters and tributaries downstream to Ryan Road bridge	FW2-TP(C1)

Figure 6 Category One Waterways in the Pequest River Watershed



8.2 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 11 Nonpoint Source Management Measures

Source Category	Responses	Potential Responsible Entity	Possible Funding options
Human Sources	Septic system management programs; required in accordance with WQMP rules, N.J.A.C. 7:15	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, State sources

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 systems have not been identified as a significant source in this study. Nevertheless, septic system management programs should be implemented in municipalities with septic system service areas to ensure proper design, installation and maintenance of septic systems. The current WQMP rules require adoption of ordinances for septic system management as part of an approvable county wastewater management plan. 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.

Agricultural Measures

Where the affected watershed contains a high percentage of agricultural land uses, a significant reduction in nonpoint sources of phosphorus can be achieved the implementation of agricultural BMPs.

The 2008 Farm Bill offers many incentives to voluntarily conserve natural resources on privately owned farmland. Conservation provisions help reduce erosion, restore and establish fish and wildlife habitat, and improve water quality. Several of the programs that are available to assist farmers in the development and implementation of conservation management plans and resource management plans are explained below. 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.

Farm and Ranch Lands Protection Program (FRPP)
FRPP provides matching funds to help purchase development rights to keep productive farmland operating in agricultural areas.

Grasslands Reserve program (GRP)
GRP offers private land owners the opportunity to protect, restore and enhance grasslands on their property.

The Conservation Reserve Program (CRP) is designed to provide technical and financial assistance to farmers/producers to address the agricultural impacts on water quality by allowing producers to retire highly erodible or marginal cropland or pasture. 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 federal Farm Service Agency and Natural Resources Conservation Service, signed a $100 million CREP agreement. 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 in order to reduce NPS pollution caused by agricultural runoff to improve water quality. 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. Under NJ CREP, farmers receive financial incentives to voluntarily remove marginal pastureland or cropland from agricultural production and convert the land to native grasses, trees or other vegetation. The vegetation can then serve as a buffer to filter or contain agricultural runoff and prevent it from reaching a waterbody. As of May 4, 2010, twenty-nine NJ CREP contracts have been approved totaling nearly $400,000 within Sussex and Warren Counties. This represents 20 acres of grass filter strips, 20 acres of grassed waterway, and 18.5 acres of riparian forest buffer.

Open Space Preservation

In March 2007, the Department and the New Jersey Natural Lands Trust purchased 288 acres in Frelinghuysen Township in Warren County. The site consists of forested wetlands and expands a greenway that extends from Jenny Jump State Forest in Hope to Allamuchy State Park in Hackettstown. The newly purchased tract is home to a number of rare plants and flowers and the state-endangered bog turtle. It will be managed by New Jersey Natural Lands Trust as part of its current 300-acre Bear Creek Preserve, located in the headwaters of the Pequest River. The site is located in the Pequest River drainage area and met DEP Green Acre criteria to protect environmentally sensitive open space and water resources

Current Implementation Projects

Some specific projects have been funded, using 319(h), CBT and other funds, which are expected to help achieve the needed load reductions. These include:

A Watershed Approach to Riparian Restoration, North Jersey RC&D Council, RP00-101

GIS technology was used in a large scale project designed to both preserve and install riparian buffers throughout WMA 1. Local communities were engaged to advance education and outreach efforts that support the partnerships necessary for successful riparian restoration.

Protecting and Improving Water Quality through Riparian Restoration & Regional Open Space Program, North Jersey RC&D Council, RP01-062

This project used the results of the Upper Delaware Watershed Restoration Strategy to reduce nonpoint pollution and stream habitat degradation. The project focused on implementation of riparian buffers to address water quality and stream habitat concerns and open space and farmland preservation programs in order to protect and preserve water quality. The project was completed on December 31, 2006 and resulted in an overall net reduction in nitrogen of 576.2 lbs/yr; a phosphorus reduction of 214 lbs/yr and sediment reduction of 338.5 lbs/yr as reported by the Department to EPA through its Grants Reporting Tracking System (GRTS).

Mountain Lake & Mountain Lake Brook Nonpoint Source Pollution Control Project, Liberty Township Environmental Commission RP03-047

This project will reduce nonpoint pollution through the implementation of stormwater Best Management Practices (BMPs). The long term goal is to restore water quality to pre-development conditions. BMP effectiveness will be assessed via pre- and post-implementation monitoring. Catch basin filters in conjunction with a vortex-type grit separator unit were installed. A 50 x 75 foot forested riparian buffer was installed at the point where the brook leaves the lake. A dry hydrant was installed to allow firefighters to fill the tanker w/ water without driving down to the river, thereby supporting buffer integrity. Pooper-scooper, no feeding waterfowl, and mandatory septic pumping ordinances were adopted. The project was completed in 2007 and resulted in an overall net reduction in nitrogen of 145.9 lbs/yr; a phosphorus reduction of 5 lbs/yr and sediment reduction of 1.2 tons. As reported by the Department to EPA through GRTS.

RiverSmart Media Campaign

The Upper Delaware Watershed Management Project, with funding assistance from River Network, includes a media campaign with both print advertisements in local papers and public service announcements airing on network television. Developed by River Network, the RiverSmart campaign is aimed at dispelling America's misconceptions regarding river pollution and its effects on clean drinking water, fish and wildlife. RiverSmart encourages individuals to change everyday behaviors to ensure healthy rivers and clean drinking water.

9.0 Reasonable Assurance

Much of the load reduction required will occur as the result of NJPDES regulated sources, either discharges from wastewater treatment facilities or regulated stormwater. Commitment to carry out the

activities described in the implementation plan to reduce phosphorus loads from the other land use sources provides reasonable assurance that the SWQS will be attained for phosphorus in the impaired segments. 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 SWQS or if it will be necessary to consider other approaches, such as use attainability.

10.0 Public Participation

The Water Quality Management Planning Rules at require the Department to initiate a public process prior to the development of each TMDL and to allow public input to the Department on policy issues affecting the development of the TMDL. Further, the Department shall propose each TMDL as an amendment to the appropriate area-wide water quality management plan in accordance with procedures at N.J.A.C. 7:15-6.

As part of the public participation process during the development of these TMDLs, in September 2008, a GIS map of the impaired stream segments and its associated streamsheds was made available on the Department's website for review and comment. Interested parties were encouraged to provide the Department with information about potential sources and/or current nonpoint sources of pollution reduction projects within the impaired streamsheds. In addition, an e-mail notification of the web posting was sent to stakeholders involved in the Department's watershed management efforts.

Notice proposing these TMDLs was published on June 7, 2010 in the New Jersey Register and in three newspapers of general circulation in order to provide the public an opportunity to review the TMDL document and submit formal comments. In addition, a public hearing was held on July 15, 2010 at Warren County Community College, 475 State Route 57 West, Washington, New Jersey 07882. An informal presentation regarding the TMDL study and its findings was followed by the public hearing beginning at 4:00 p.m. Notice of the proposal and hearing was provided to affected dischargers and municipalities in the watershed.

All comments received during the public notice period and at the public hearing were considered in the Department's decision to establish this TMDL. A summary of the comments and responses are provided below. Subsequently, the TMDL was approved by EPA on September 29, 2010 and is adopted as an amendment to the Upper Delaware and Sussex Water Quality Management Plans in accordance with New Jersey's Water Quality Management Planning Rules at N.J.A.C. 7:15-6.

The following entities (listed alphabetically) submitted written and/or oral comments on the proposed TMDLs:

1. Enright, Edward of Cerenzio and Panaro, P.C. for Warren County Municipal Utilities Authority - Oxford STP, Public Hearing, July 15, 2010

2. Kehrberger, Patricia of Hydroqual, Inc. for Warren County Municipal Utilities Authority - Oxford STP, Public Hearing, July 15, 2010 and Letter dated July 30. 2010

3. Sternbenz, Paul M., P.E., Maser Consulting, P.A., Township Engineer for Township of Allamuchy, Letter dated July 30, 2010.

4. Varro, Thomas J., P.E., Chief Engineer, Sussex County Municipal Utilities Authority – Andover STP, Letter dated July 30, 2010.

5. Kratzer, Todd; New Jersey Water Supply Authority, e-mail dated July 15, 2010

A summary of comments on the proposal and the Department's responses to those comments follows. The numbers(s) in brackets at the end of each comment corresponds to the commenter(s) listed above.

Comment 1: Commenter appreciates the TMDL effort to address the phosphorus impairment in the Pequest River. (1, 5)

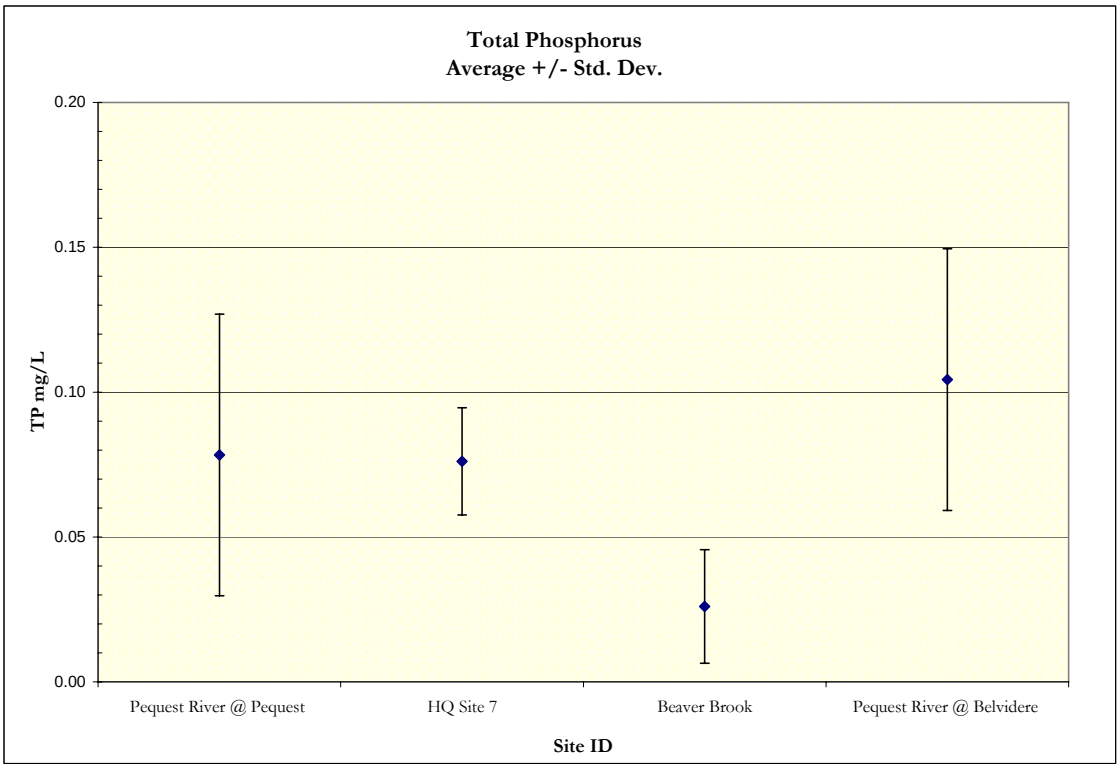
Response to Comment 1: The Department acknowledges the support for the TMDL.

Comment 2: The permit limitations proposed in the TMDL will result in a less costly upgrade for the Warren County Municipal Utilities Authority - Oxford STP compared to that which would have been required to meet the originally proposed phosphorus effluent limitation of 0.1 mg/L, but still represents a major investment that will result in an increased user cost. The TMDL states that the Assessment Unit identified as "Pequest River below Furnace Brook (02040105090060-01)", which is located downstream of the STP, has been deferred because it requires additional study. The completion of a TMDL in the downstream assessment unit may result in greater phosphorus reductions from the STP. Assurance is needed that the investment to achieve the identified limit will not be in vain. (1)

Comment 3: The TMDL is incomplete in that it does not include all total phosphorus impaired waters within the Pequest River watershed. Only 4 out of 5 Assessment Units were addressed. Given the available data, a comprehensive total phosphorus TMDL including all of the total phosphorus impaired Assessment Units appears feasible. The costs for additional data collection may be placed on the Warren County Municipal Utilities Authority. Additionally, the TMDL for the remaining Assessment Unit might result in a more stringent WLA and effluent limits, when it is complete. A more practical procedure would be to complete the TMDL study for the entire Pequest River rather than proceed with the piecemeal approach that the proposed total phosphorus TMDL represents. Based on the amount of available data for the Assessment Unit, there needs to be a credible reason, aside from "needs additional study", to explain why all of the impaired Assessment Units have not been addressed. (2)

Response to Comments 2 and 3: The statement in the TMDL that additional study is required to address the "Pequest River below Furnace Brook (02040105090060-01)" Assessment Unit was based on an evaluation of water quality data sampled within and at the boundary of this assessment unit. The Department found that the data collected to date is insufficient to properly characterize all sources within this assessment unit.

Total phosphorus data was collected under low flow conditions, defined as that flow which is exceeded 70% of the time, at several locations: Pequest River at Pequest (USGS station ID 01445500) located at the boundary of this assessment unit (AU), HydroQual Site 7, Beaver Brook (USGS station ID 01445495), and the most downstream location: Pequest River at Belvidere (USGS station ID 01446400). The graph below shows the total phosphorus concentrations at the sites listed above. Because sampling was done during low flow conditions, storm driven loads can be ignored for this illustration. Starting from the left, with the most upstream location, the total phosphorus concentrations at Pequest River at Pequest were compared to the next downstream location, HydroQual Site 7, and the concentrations were found to be similar, with an average total phosphorus concentration of 0.078 mg/L and 0.076 mg/L, respectively.



Considering the distance of 4.5 miles between these two sites, attenuation of the phosphorus load should result in total phosphorus concentrations at HQ Site 7 that would be notably lower than those at the boundary of this assessment unit. This suggests that there is a source of total phosphorus between these two sites. Proceeding downstream, total phosphorus concentrations from Beaver Brook are quite low; many of the total phosphorus data are below the detection limit. Despite this dilution from a higher quality source, total phosphorus concentrations at Pequest River at Belvidere show an increase, with total phosphorus concentrations exceeding 0.1mg/L. This suggests, again, a source between the confluence of Pequest River and Beaver Brook and the Pequest River at Belvidere site.

The Department concluded that in order to address this remaining impaired assessment unit, additional sampling within this impaired assessment unit is needed to better understand and characterize the sources and the needed reductions. Any additional sampling required to address the remaining impaired assessment unit will not be the obligation of the Warren County MUA. It is not unique to this TMDL to have related downstream impaired assessment units deferred because of a need for further study or to address a downstream assessment unit separately from upstream assessment units. In this latter case, the Department assumes that criteria for the parameter of concern are met at the upstream boundary entering the assessment unit. Because TMDL implementation would attain SWQS, it is expected that no further reduction would be required in upstream areas, particularly since it appears that there is a significant uncharacterized source in the downstream impaired assessment unit. However, no guarantees can be given about future requirements as the Department will need to assess the effectiveness of the TMDL over time and may need to employ adaptive management principles to address lack of success. This could include assigning revised WLAs to upstream sources. In any case, upgrades at this time have value in that they are needed to restore water quality.

Comment 4: The need for applying effluent limits during winter months has not been demonstrated. The Department has demonstrated the applicability of the 0.1 mg/L total phosphorus total phosphorus standard during the summer months, (last 3 paragraphs of Section 4.0). However, during the winter

season, it is common science that phosphorus is not limiting biomass growth and that the impairments characterized by exceedance of the Phosphorus Evaluation Technical Manual criterion, such as high periphyton concentration and diurnal oxygen swings of greater than 3.0 mg/L due to periphyton, will not occur. Periphyton and algae are limited during the winter by low temperature, ice cover, low light and generally higher streamflow. Therefore, the total phosphorus SWQS of 0.1 mg/L should not apply during the winter.

Total phosphorus removal at the Warren County MUA-Oxford STP during the winter months for no corresponding environmental benefit is a wasteful use of Authority resources and actually results in negative environmental impacts (increased sludge, higher effluent TDS, larger carbon footprint, etc.). It is therefore recommended that the winter total phosphorus SWQS in the TMDL be a site-specific total phosphorus winter concentration based on existing water quality with the effluent total phosphorus limit for Oxford Area STP be set at existing effluent quality once the facility is upgraded to meet its appropriately established summer total phosphorus limit. (2)

Comment 5: The use of a total phosphorus goal irrespective of phosphorus availability as a nutrient (organic versus inorganic fraction) might be overly restrictive at the 0.1 mg/l total phosphorus level that the NJDEP is requiring to eliminate stream impairment, and it's possible that this fraction varies with land usage type. (4)

Response to Comments 4 and 5: The Department selected a mass balance approach, coupled with the Flow-Integrated Reduction of Exceedances (FIRE) method, as a cost effective means to provide a science-based outcome that would limit phosphorus removal to that which is needed to meet SWQS, which are expressed as total phosphorus. The approach used in this TMDL cannot be used to substitute an endpoint expressed as various fractions of phosphorus, which would differ from the adopted SWQS. Completion of the TMDL study allows the Department to substitute a TMDL-based water quality based effluent limit in place of the 0.1 mg/L end-of-pipe criterion that would be required for a discharge to an impaired water, absent a TMDL. This was the limit initially applied to the Allamuchy Township, Pequest Fish Hatchery and Warren County MUA—Oxford facilities. This limit was adjudicated and the limit stayed pending completion of this TMDL. The Department is mindful of the need to align requirements for treatment with an associated environmental benefit. To that end, this TMDL provides substantial relief from the initially imposed permit limit and incorporates additional seasonal relief in recognition of the higher 7Q10 flows that occur in winter months. The effects in terms of TDS and additional sludge generation that were cited are associated with selecting chemical precipitation as the phosphorus removal method. These impacts can largely be avoided by selecting biological nutrient removal.

With regard to the water quality endpoint, the TMDL makes clear that the applicable numeric criterion is 0.1 mg/L, which applies year round as long as flows are at the 7Q10 level or higher, in accordance with the Department's promulgated and EPA-approved SWQS. The numeric and narrative criterion are cited in the TMDL at Section 3.2. To define the load reduction to attain the SWQS, a mass balance approach similar to that which was submitted by the Warren County MUA was used. This approach includes data collected by the MUA. As noted above, the Department used season-specific 7Q10 flows to refine the load reductions needed to attain standards. Beyond this, a dynamic water quality model, where model runs can demonstrate the effect of sedimentation, re-suspension and storage of phosphorus and its impact on the water quality during winter months, would be required to demonstrate that it was not necessary to maintain the numeric criterion year round. Absent such a study, it cannot be stated that there would be no environmental benefit to reduction year round nor can it be certain that a site specific criterion would not be more, rather than less, conservative than the

default criterion. In fact, the commenter's statement "during the winter season, it is common science that phosphorus is not limiting biomass growth" is in conflict with the current state of knowledge regarding nutrient dynamics and algal growth. There are studies based on actual data that show significant algal growth during February through early spring. For example, the Department is studying a site (USGS 01400500 Raritan River at Manville NJ) with real-time, continuous monitoring of surface water quality data, including dissolved oxygen as percent saturation. The data from February through March in 2009 and 2010 indicate significant algal productivity. Therefore, it is not appropriate to forego phosphorus reduction in winter months as suggested.

Comment 6: Appendix D. The proposed total phosphorus TMDL includes a mass balance calculation for the winter wasteload allocation that takes into account the higher winter low flow that characterizes the Pequest River. The commenter supports the use of seasonal low flow statistics as a calculation procedure utilized by the Department. (2)
Response to Comment 6: The Department acknowledges the support. Because seasonal statistics were available for 7Q10 in the Pequest River, the Department was able to set loading limits that required a smaller phosphorus reduction in the winter, thereby meeting the surface water quality standard while avoiding unnecessary expenditures for phosphorus removal.

Comment 7: Summer effluent limits should be based on meeting the total phosphorus stream standard of 0.1 mg/L over an appropriate time frame for realizing biological benefits. The 0.1 mg/L total phosphorus surface water quality standard is applied at 7Q10 in the proposed TMDL, Appendix D. The criteria that are to be achieved in the Pequest River are a lowering of seasonally averaged periphyton and a corresponding decrease in diurnal dissolved oxygen. A seasonal low flow condition is the appropriate, site-specific time frame for use in the Pequest Total phosphorus TMDL. A low flow stream condition such as 7Q10 should be used. It is recommended that the Oxford Area total phosphorus limit be based on the summer seasonal low flow, 27 cfs (7Q10, supplied by USGS). The Mass Balance Calculation using 7Q10 results in a summer total phosphorus effluent limit of 1.0 mg/L. See attached Mass Balance Table for the calculation that includes Allamuchy Township Municipal Utilities Authority and the determination of the Pequest total phosphorus downstream of the Pequest River Trout Hatchery. (2)

Response to Comment 7: The criteria described by the commenter are some of those used to determine if the surface water quality standard numeric criterion of 0.1 mg/L is applicable. Reducing the concentration of phosphorus to meet the numeric criterion is expected to address excessive productivity and its associated water quality effects. An appropriate, scientifically determined alternative site specific criterion that would ensure primary productivity is controlled, whenever it may occur, has not been defined. Therefore, the numeric criterion in the surface water quality standard applies and was used to calculate wasteload allocations and load allocations. The TMDL calculations were based on N.J.A.C. 7:14A-13 and are consistent with the Surface Water Quality Standards, N.J.A.C. 7:9B, which require that the numeric criterion of 0.1 mg/L be met at flows of 7Q10 and above. There has been no scientific demonstration by the commenter that the alternative flow condition is an appropriate basis for a site specific criterion that would achieve the narrative component of New Jersey's surface water quality standard for total phosphorus.

Comment 8: The TMDL is incomplete if wasteload allocations for commercial, industrial, and various residential land use acres within each municipality tabulated in Appendix C and listed in Section 3.3 are not calculated and included in the TMDL. Similarly, load allocations for Agriculture Land Use within each municipality tabulated in Appendix C and listed in Section 3.3 should be calculated and included in the TMDL. (2)

Response to Comment 8: The TMDL calculations assigned the allowable total phosphorus loading capacity for each of the land uses at an appropriate level of detail for the TMDL as set forth in Table 9. Refinement in terms of the precise locations and types of best management practices that will serve to implement the TMDL will occur as the Department continues to work with partners to effect watershed restoration.

Comment 9: The Department should keep the phosphorus discharge limit for the Allamuchy Township STP at the interim NJPDES permit limit of 1.5 mg/l and enforce compliance in the summer months only. The chemical treatment cost and changes to the treatment process will be significant and result in increased sewer usage charges to the residents. (3)

Response to Comment 9: The Clean Water Act requires that a TMDL be prepared for each water that is listed as impaired on a state's 303(d) list, which for New Jersey, is Sublist 5 of Integrated List of Waterbodies. The Clean Water Act also requires that the TMDL quantify the amount of a pollutant a waterbody can assimilate without violating a state's water quality standards. This TMDL has calculated what reductions would be needed in order to attain the State's SWQS. The WLAs assigned to each discharger allow for a significantly less stringent effluent limit than was applied in the NJPDES permit (0.1 mg/L end-of-pipe). This revised load reduction was made possible by looking at the system as a whole, factoring in higher 7Q10 flows in winter months and requiring reasonable reduction from stormwater point sources and nonpoint sources in order to attain SWQS. If, despite the significant relief already provided, the reductions required are believed to result in substantial and widespread social and economic impact, the Department provides a mechanism for the regulated entity to pursue relief from the required reduction in the form of a variance, as set forth in the SWQS at N.J.A.C. 7:9B-1.8 and 1.9 (see also N.J.A.C. 7:14A-11.8).

Comment 10: The SCMUA - Andover STP has not been built to date, but, was issued a discharge permit by the Department as a result of water quality analyses submitted to and reviewed by the Department. The commenter expects that the SCMUA - Andover STP will be evaluated in a manner similar to the Andover BOE and Sparta Twp BOE wastewater treatment facilities, wherein the existing total phosphorus load was implicitly included as part of the "boundary condition", such that they can continue to discharge their current total phosphorus load under the TMDL. The "boundary condition" and boundary total phosphorus load measured at the Pequest River at Huntsville station is variable and not a single value. The total phosphorus at Huntsville ranges from 0.02 mg/L to 0.07 mg/L and averages 0.03 mg/L with a standard deviation of +/- 0.012 mg/L. It is requested that the Department consider these statistics when evaluating the SCMUA - Andover STP as to water quality to "preserve the boundary load." The Department's TMDL (See TMDL Figure 3), discusses and uses attenuation in calculations in the development of wasteload allocations for the wastewater treatment facilities discharging to the impaired waters. Attenuation of the Allamuchy STP load is supported with analyses and discussion in Section 6.2 Point Source Assessment. It is anticipated that the Department will use total phosphorus attenuation when assessing the SCMUA - Andover STP discharge of total phosphorus at the "boundary location". (4)

Response to Comment 10: The TMDL requires no measurable change in the water quality at the boundary to the TMDL area, as measured at Huntsville from all upstream dischargers. Because there is no current loading reflected in that boundary condition from the SCMUA - Andover STP, any new load would have to comply with this requirement. It should be noted that this facility proposes to discharge to a C1 water and will also need to comply with antidegradation requirements that apply, which may be more stringent than those of the TMDL. The Department acknowledges the

commenter's statements regarding the variability of the boundary concentration and applicability of attenuation. When calculating the WQBELs for this discharge, the requirements for doing so that are applicable at the time will be applied.

Comment 11: The Andover Planned Unit Development (PUD) will change the land use from agriculture to residential. Will this land use change be taken into account as the nonpoint source reductions required to be accomplished by Andover Township (Tier A Municipality under NJDEP stormwater regulations) and/or Andover Borough (Tier B Municipality) are calculated? Will the Andover PUD's stormwater best management practices that are already a feature of the project be given proper NPS reduction credit? The Department should devise a method of crediting for BMPs that already reduce their runoff load instead of asking them to further reduce their loads when other nonpoint source dischargers with the same land use have not reduced their loads at all. (4)

Response to Comment 11: As stated in the TMDL, the contribution of total phosphorus associated with residential development is less than that associated with agricultural land use. Therefore, it is reasonable to expect that a reduction in land use load will result with this conversion. However, it is important to note the effect of assignment of WLAs and LAs to various land uses in terms of TMDL implementation. The WLAs and LAs are overall reductions needed from the total area of each of the land uses, expected to be attained as described in the implementation section. Of note, there are no new permit requirements identified in the implementation plan with respect to stormwater point sources. Rather, the TMDL states that the existing measures required under the Municipal Stormwater permits, along with implementation of BMPs in agricultural areas to be achieved by working with farmers using various funding sources, are expected to achieve the noted reductions.

Comment 12: The FIRE technique is attractive because of its computational simplicity and its minimal data requirements; however, the simplifying assumptions might not be applicable in every circumstance. In the general sense, the FIRE technique makes several simplifying assumptions that are not always applicable, including:

- fate and transport mechanisms are excluded. In many cases, time of travel and physical/chemical/biological transformations of a constituent significantly influence its impact on the environment. For example, eutrophication is affected by ambient temperature. If all of the exceedance occurred when the temperature was low, algal growth could have a far less significant impact on dissolved oxygen levels than it would if they occurred under higher temperature conditions;
- the load versus flow relationship is assumed to be linear, and the reduction percentage necessary to attain water quality goals is independent of stream flow. Even if this is true, the impairment/flow relationship is often not linear, and the TMDL process is meant to remediate impairment. Again, using eutrophication as an example, higher stream flows often result in increased turbidity, decreased detention time, and increased re-aeration. If the impairment is low dissolved oxygen, higher flows often allow for greater surface transfer of oxygen and reduce the potential for algal growth;
- segregation by land use type is not attempted, and the resulting reductions are applied uniformly independent of land use. The TMDL states that, "since best management practices (BMPs) for nutrients have a wide range of removal efficiencies, a more complex modeling technique would likely not provide a more effective result for implementation of the TMDL than a less-sophisticated approach such as FIRE." The analysis is independent of cost/benefit concerns and assumes that it's equally likely that disparate sources of runoff all have BMPs that allow for the target percent reduction in each water body; and

- the regression line of the exceedance relationship to flow is assumed to pass through the origin of the load versus flow axes. This assumption attributes any deviation from zero nonpoint source load at zero flow to the uncertainty around the slope of the regression line associated with small sample sets. Because the nonpoint source component of the stream data is often derived by subtracting out the estimated point source component (this is the case in the Pequest total phosphorus TMDL), the differences could be attributable to improper point source load assumptions as well. For example, if the intercept is greater than zero, it might be the case that there is more point source load that needs to be removed, and that the original data need to be adjusted to reflect this prior to determination of exceedance. (4)

Response to Comment 12: As the commenter stated, the FIRE method is a simple, cost-effective mathematical approach that allows calculation of the needed reduction to meet the SWQS 0.1 mg/L of total phosphorus in the river system. It can be used when there is a clear numeric objective, without the need for time consuming and costly monitoring and modeling. Once it was established that the numeric criterion is applicable in the Pequest system, a more complex approach that determines fate and transport and the dynamic relationship between nutrient loads and response indicators such as dissolved oxygen and algal density was not needed or required to restore water quality. Attainment of the SWQS numeric criterion of 0.1 mg/L of total phosphorus at 7Q10 is the only target of this TMDL. A linear relationship between impairment and flow was not assumed in this approach. Using this method, a reduction in stormwater associated loads from land uses (stormwater point sources and nonpoint sources) is determined and then is applied to the land uses contributing those loads within the drainage area. The resulting load allocation becomes part of the TMDL. There is no assumption that the required percent reduction will be uniform across all areas within a land use category. Rather, it is expected that the load attributed to a land use category will be achieved by evaluating the land uses in a more specific manner through follow up implementation activities, such as development of watershed restoration plans by the Department or stakeholders using 319(h) and other funding sources. Under such plans, specific areas are aligned with specific BMPs intended to achieve load reductions in a cost effective manner. The sum of the individual reductions is expected to realize the overall load reduction required and, in conjunction with reductions required of traditional point sources (STPs), lead to attainment of the SWQS. This will be evaluated through follow-up monitoring.

The FIRE method is designed to be used in a NPS dominated system. In this TMDL, the adjacency of the point source to the sampling location allows the use of FIRE method by subtracting the point source load from the river load observed. Assuming a zero intercept on the regression line is justified by the fact that the NPS would be zero when the flow is zero. The validity of this assumption, that the origin point falls within the 95^{th} percentile bounds of the regression line's intercept, was checked, successfully, and then a regression line with a zero intercept was developed. The slope of the regression line was compared to the slope corresponding to the standard level to calculate the required reduction on the NPS. The required reduction is determined by the slope of the regression line, not the intercept of the regression line.

Comment 13: The State will do a TMDL implementation for phosphorus with as few as eight samples of flow and total phosphorus. In the case of the Pequest TMDL, one station analyzed has only four samples (see Table E-2-3, Pequest at Townsbury) (4)

Response to Comment 13: The FIRE method result at Pequest at Townsbury is presented only for comparison to the Pequest at Pequest result, because both stations occur within the same assessment unit and the SWQS would need to be met at each in order to establish an effective TMDL. The

analysis for the station Pequest at Townsbury was not used to determine the required load reduction included in the TMDL. Instead, because the data available demonstrated that this site would drive a less stringent reduction than the Pequest at Pequest station, it was the analysis of the downstream station, Pequest at Pequest that was used to set the load reduction. Clearly, if the more stringent reductions are met, the SWQS will be met at the Pequest at Townsbury location as well. As discussed, more detailed identification of implementation measures will be able to pinpoint the location and type of activities needed to achieve the required load reductions.

Comment 14: The FIRE analysis was performed at more than one site, each with limited exceedance data, and the more stringent reduction percentage was applied to the entire river. While the reduction percentages were not terribly different (46.02% for Pequest at Pequest versus 43.7% for Pequest at Townsbury), it might have been better to combine the exceedance data to tighten the 95 percent confidence bounds if it can be assumed that all exceedance data from both sites are from the same population. This can be determined by a statistical comparison of means and standard deviations. (4)

Response to Comment 14: There are two significant point sources located between the Pequest at Townsbury and Pequest at Pequest stations. Therefore, the Department determined that it was not appropriate to combine the data from these two stations' for application of the FIRE method. Using the higher percentage reduction required to attain SWQS at the downstream station is the appropriate approach to insure SWQS are attained at both stations used to assess water quality within this assessment unit.

Comment 15: For watershed areas upstream of Huntsville and in the Furnace Brook watershed, there is no exceedance of the SWQS of 0.1 mg/L in-stream total phosphorus. Since these waters are not impaired for total phosphorus, why must NPS reduction be required of these areas? The required NPS reductions should only be assigned to agriculture, commercial, industrial, and residential land use areas that are impaired for total phosphorus. (4)

Response to Comment 15: The upstream land use from unimpaired assessment units contributes to the load at the downstream impaired locations. It is reasonable to require reductions from anthropogenic sources located outside the impaired area because, if these loadings from the unimpaired watershed were not there, the impairment in downstream locations may be absent or less substantial. Therefore, the FIRE method reduction is applied to all upstream load contribution areas. More detailed implementation planning will establish efficient total phosphorus reductions on a site specific basis.

Comment 16: Based on Table 4, which presents the summary of NJPDES Discharges located within impaired assessment unit, the DMR data for Pequest State Fish Hatchery was accessed through February 2010. Allamuchy and Oxford DMR data were accessed through July 2007. More recent data from the treatment plants should be included in the summary. (2)

Response to Comment 16: The Department designed the DMR query to obtain the effluent quality during the timeframe for the collected in-stream water quality data. Data outside this timeframe would not be reflective of the loadings present at the time stream quality observations were made. For the Pequest Hatchery, the quality of the effluent is nearly at the in-stream numeric criterion, unlike the other wastewater treatment discharges. As a result, it was determined that the WLA for the hatchery should be based on the long term average effluent quality, without requiring further treatment. To do so, a longer-term data base, including data through February 2010, was appropriate.

Comment 17: As reflected in Section 5.2. Assessment of Nonpoint Sources in the TMDL document, the Unit Area Load (UAL) method is used to calculate existing annual total phosphorus nonpoint source load. Additional detail is needed as to how flow and concentration data at Pequest at Pequest were used to develop an "annual" non-point source load to check the UAL result of 14,326 kg/yr total phosphorus. Was a flow duration curve (data available on USGS web-site) used to weight data based on flow? The available flow and concentration data from Huntsville could also be used to develop annual nonpoint source load for comparison to UAL annual load at that location. Similarly, flow and concentration data at Townsbury would provide insight because Huntsville is not impaired and impairment is noted at Townsbury. Just as there is a "wealth of in-stream data" (Paragraph 3) at Pequest at Pequest, there is similar abundance at Belvidere (USGS, NJDEP and HydroQual). The UAL approach could/should be checked at this location because an additional 36.7 sq. mi. of drainage area adds non-impaired flow to the Pequest according to the data summary in Table 3. (EWQ 01445495 Furnace Brook at Pequest 2005-2009 and EWQ0047 Beaver Brook at Rt. 618 in Sarepta 2000-2002). (2)

Response to Comment 17: Flow and concentration were used to compare to the results from the UAL analysis as follows: the total phosphorus concentration collected at the river station was multiplied by the flow collected at the same time to calculate the river load for that specific observation. The point source loads were subtracted from the river load to quantify the NPS load. DMR data for the time frame when the river samples were collected were used to calculate the PS load for each observation. When subtracting the PS load from the river load, zero attenuation was assumed for the load coming out from Hatchery and Oxford and 30 percent attenuation was assumed for the load from Allamuchy given the travel distance. The final NPS load was determined by taking the average of all the "calculated" NPS loads corresponding to each pair of river flow and concentration observations.
All the data collected at all the stations within the watershed, including Pequest at Belvidere, were carefully reviewed when determining the approach for this TMDL development. The Department determined that checking the correspondence with measured and estimated loads at the Pequest at Pequest location was appropriate because of the significant amount of data available and the relative location compared to the drainage area being studied.

Comment 18: In reviewing Appendix G: Pequest Data, HydroQual Site 7 data should be included in Appendix G. Data from NJDEP/USGS at Belvidere and the other sites summarized on Table 3 should also be included in Appendix G. These data are all readily available. (2)

Response to Comment 18: Data from the Department and USGS at Belvidere is outside the TMDL and was not initially included in the document. Please refer to comment/response 3 above. The Department did review the data in making the determination not to address the impairment at Belvidere, pending additional study. This data has been added to the TMDL document as an aid to review by others.

Comment 19: The commenter provided an erratum on the New Jersey Surface Water Quality Standard citation stated in Section 3.2 of the TMDL document (2)

Response to Comment 19: The Department has corrected the citation in the TMDL document to reflect New Jersey's current SWQS
Comment 20: The commenter noted that in the TMDL document that in Table 1 Locations of Stations with Assessment Units that there is a slight misunderstanding as to where the HydroQual stations are relative to Pequest features. The commenter suggested the following language: Going from upstream

to downstream are HQI 5, Oxford Area STP discharge, HQI 6, then Furnace Brook, then USGS 01445500 (Pequest at Pequest), HQI 7, and then Beaver Brook. Therefore, USGS 0144550 is downstream of Furnace Brook and technically downstream of the AU (Furnace Brook to Cemetary Road). HQI 6 should be added to the Furnace Brook to Cemetery Rd AU. USGS 01445500 should be removed from the AU (Cemetary Rd to Drag Strip). (2)

Response to Comment 20: The TMDL document was modified as suggested to improve clarity as to location of the stations.

Comment 21: Figure 1, the Pequest River Location Map is unclear regarding locations of data stations. This is partly due to unclear or unreadable labels. In addition, it would be helpful for all of the HUC 14s shown to be identified, not just the impaired ones. It would also be helpful if the Pequest main stem could be highlighted. (2)

Response to Comment 21: A revised Figure 1 has been included in the TMDL document to address the comment.

Comment 22: Section 4.0, Paragraph 2, HQI 6 is not coincident with the USGS gage. It is located upstream of the gage with Furnace Brook (small drainage area) entering the Pequest in between the two locations. (2)

Response to Comment 22: A clarification was made in the TMDL document to acknowledge the slight separation in the sites.

Comment 23: Table 3 in the TMDL document needs clarification of Station Names regarding location with respect to Pequest, tributary streams and the USGS gages. The commenter suggests the following changes: HQI Site 6 add “upstream of Furnace Bk”, USGS 01445500 and EWQ 01445500 add “downstream of Furnace Bk”, HQI 7 add “upstream of Beaver Bk” and USGS 01446400 add “downstream of Beaver Bk”. (2)

Response to Comment 23: Recommended changes were made to Table 3 to clarify station locations.

Comment 24: The commenter suggests that Figure 3 summarizing the HydroQual data is not clear. The commenter submitted a substitute plot for the Department’s consideration. (2)

Response to Comment 24: Figure 3 was revised in the TMDL document to be more clear. It is comparable to the commenter’s provided figure and the offered assistance is acknowledged.

Comment 25: The Equations at the top of page 53 that represent the loading capacity (LC), allocable loading, and percentage of Margin of Safety (MOS) representing part of the loading capacity could be somewhat confusing and could be reduced to, and presented as only the simpler forms of the equations (i.e., LC = (Slope C/Slope B) x Existing Load; Allocable Loading = (Slope C/Slope A) x Existing Load; and %MOS = (Slope A – Slope B)/Slope A). (5)

Response to Comment 25: From the mathematical calculation perspective, those three equations can be simplified in the way as suggested. But for the reader to understand the physical meaning of each term clearly, the Department believes it is more helpful to present the information step by step as provided.

Comment 26: Figure 1 could provide some clarity to the equations by displaying the areas on the graph represented by Overall Percentage Reduction, Required Percentage Reduction, and MOS. (5)

Response to Comment 26: The Overall Percentage Reduction and Required Percentage Reduction are calculated as the percentages relative to the existing load. MOS is expressed as the percentage of the loading capacity. Since the basis for the percentage is not the same, displaying all three on Figure 1 may cause confusion for the reader in trying to understand the physical meaning of these terms. For this reason, Figure 2 was developed and included in the Appendix. Figure 1 illustrates the slopes that were used to determine the percentage reductions and Figure 2 illustrates how the different percent reductions were used to calculate the loading capacity, the allocable load and the MOS.

Comment 27: Figure 2 should provide a definition for Y_I and Y_{II}. If the areas of each graphic in Figure 2 were displayed on Figure 1 (as suggested above in comments 25, 26 and 27), the second figure may not be necessary. (5)

Response to Comment 27: As indicated in Figure 2,

$$X_I + Y_I = 1$$

$$X_{II} + Y_{II} = 1.$$

In addition,

$$\text{Loading capacity} = \text{Existing Load} * Y_I$$

$$\text{Allocable Load} = \text{Existing Load} * Y_{II}$$

As mentioned above in response to comment 26, Figure 2 was included to provide a clear illustration of how the load capacity, allocable load and MOS were calculated based on the percent reductions derived from the slopes. Since Figure 1 and Figure 2 serve different purposes, both are needed.

Comment 28: Was the Delaware River Basin Commission data collected from 2000 through 2004 for total phosphorus at Orchard Street Bridge in Belvidere (42 data with 17 total phosphorus exceedances) considered for the TMDL? (5)

Response to Comment 28: The Department evaluates all the available relevant data when developing a TMDL. Delaware River Basin Commission data collected at Belvidere was not used in this TMDL since this TMDL addresses the impairments upstream of Oxford and Belvidere is located downstream of Oxford. However, the data was considered in the decision to defer TMDL development in the most downstream assessment unit, pending better characterization of sources above Belvidere.

References:

Barry M. Evans., Arc View Generalized Watershed Loading Function (AVGWLF) Workshop, January 2007.

Kratzer, Todd W., Flow-Integrated Load Reduction Estimation Technique for TMDLs, Water Environment Federation, June 2005.

National Research Council, Assessing the TMDL Approach to Water Quality Management. National Academy Press, Washington, D.C. 2001

New Jersey Department of Environmental Protection. 2008.Surface Water Quality Standards. Water Monitoring and Standards.

New Jersey Department of Environmental Protection. 2008. New Jersey 2008 Integrated Water Quality Monitoring and Assessment Report. Water Monitoring and Standards.

North Jersey Resource Conservation & Development May 2002. Water Quality in the Upper Delaware Watershed; A Technical Report for the Upper Delaware Watershed Management Project

North Jersey Resource Conservation & Development, November 2001. Setting of the Upper Delaware Watershed; A Technical report for the Upper Delaware Watershed Management Project

Regional Planning Partnership Settings Report of the Central Delaware Tributaries, released in November 2001

Sutfin, C.H. May, 2002. Memo: EPA Review of 2002 Section 303(d) Lists and Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992. Office of Wetlands, Oceans and Watersheds, U.S.E.P.A.

Thomann, R.V. and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control, Harper & Row, Publishers, New York.

USEPA. 1997. Compendium of tools for watershed assessment and TMDL development. EPA841-B-97-006. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

U.S.E.P.A., 1999. Protocol for Developing Nutrient TMDLs. Watershed Branch, Assessment and Watershed Protection Division, Washington, DC.

U.S.E.P.A., 2008. Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions

R. Edward Hickman, USGS, Written communication, 7Q10 flow at Pequest River, August 2008

USGS 2004. Water Resource Data New Jersey Water year 2004 Volume 1 Surface-Water Data By G.L. Centinaro, B.T. White, H.L. Hoppe, J.F. Dudek, A.R. Protz, T.J. Reed, J.C. Shvanda, and A.F. Watson. Water-Data Report NJ-04-1

USGS, 2002. Quality of Water in Tributaries to the Upper Delaware River, New Jersey, Water Years 1985-2002 Fact Sheet FS-090-02 version 1.1

Wayland, R.H. III. November 22, 2002. Memo: Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs. Office of Wetlands, Oceans and Watersheds, U.S.E.P.A.

Appendices:

Appendix A Database of Phosphorus Export Coefficients

In December 2001, the Department concluded a contract with the USEPA, Region 2, and a contracting entity, TetraTech, Inc., the purpose of which was to identify export coefficients applicable to New Jersey. As part of that contract, a database of literature values was assembled that includes approximately four-thousand values accompanied by site-specific characteristics such as location, soil type, mean annual rainfall, and site percent-impervious. In conjunction with the database, the contractor reported on recommendations for selecting values for use in New Jersey. Analysis of mean annual rainfall data revealed noticeable trends, and, of the categories analyzed, was shown to have the most influence on the reported export coefficients. Incorporating this and other contractor recommendations, the Department took steps to identify appropriate export values for these TMDLs by first filtering the database to include only those studies whose reported mean annual rainfall was between 40 and 51 inches per year. From the remaining studies, total phosphorus values were selected based on best professional judgment for eight land uses categories.

The sources incorporated in the database include a variety of governmental and non-governmental documents. All values used to develop the database and the total phosphorus values in this document are included in the below reference list and summarized in the table below

Table A-1 Phosphorus Export Coefficient Used with 2002 Land Use Coverage to derive land use loads

land use / land cover	2002 LU/LC codes	UAL (kg TP/ha/yr)	UAL (lb TP/acre/yr)
Mixed density residential	1100	1.2	1.1
medium / high density residential	1110, 1120, 1150	1.6	1.4
low density / rural residential	1130, 1140	0.7	0.6
Commercial/Services	1200, 1211, 1214	2.0	1.8
Industrial	1300, 1500	1.7	1.5
mixed urban / other urban	1400, 1410, 1419, 1440, 1461, 1462, 1463, 1499, 1600, 1700, 1710, 1711, 1741,1750, 1800, 1804, 1810, 1850	1.0	0.8
Agricultural	2100, 2140, 2150, 2200, 2300, 2400	1.5	1.3
Forest, Wetland, Water	4100, 4200, 4300, 4400, 4500, 5000, 6000, 7000 (series)	0.1	0.1
barren land	7000	0.5	0.4
Units:	1 hectare (ha) = 2.47 acres 1 kilogram (kg) = 2.2 pounds (lbs) 1 kg/ha/yr = 0.89 lbs/acre/yr		

Export Coefficient Database Reference List

Allison, F.E., E.M. Roller, and J.E. Adams, 1959. Soil Fertility Studies in Lysimeters Containing Lakeland Sand. Tech. Bull. 1199, U.S. Dept. of Agriculture, Washington, D.C. p. 1-62.

Apicella, G., 2001. Urban Runoff, Wetlands and Waterfowl Effects on Water Quality in Alley Creek and Little Neck Bay. TMDL Science Issues Conference, WEF Specialty Conference.

Athayde, D. N, P. E. Shelly, E. D. Driscoll, D. Gaboury and G.B. Boyd, 1983. Results of the Nationwide Urban Runoff Program: Final Report. USEPA Water Planning Division. Washington, DC.

Avco Economic Systems Corporation, 1970. Storm Water Pollution from Urban Land Activity. Rep.11034 FKL 07/70, Federal Water Qual. Adm., U.S. Dept. of Interior, Washington, D.C. p. 325.

Bannerman, R., K. Baun, M. Bohm, P. E. Hughes, and D. A. Graczyk, 1984. Evaluation of Urban Nonpoint Source Pollution Management in Milwaukme, County, Wisconsin, Report No. PB84-114164, U.S. Environmental Protection Agency, Region V, Chicago, IL.

Bengtson, R.L. and C.E. Carter, 1989. Simulating Soil Erosion in the Lower Mississippi Valley with the CREAMS Model. From: Application of Water Quality Models for Agricultural and Forested Watersheds, edited by D.B. Beasley and D.L Thomas. Southern Cooperative Series Bulletin No. 338.

Broadbent, F.E., and H.D. Chapman, 1950. A Lysimeter Investigation of Gains, Losses and Balance of Salts and Plant Nutrients in an Irrigated Soil. Soil Sci. Soc. Amer. Proc. 14:261-269.

Carter, Gail P., 1998. Estimation of Nonpoint Source Phosphorus and Nitrogen Loads in Five Watersheds in New Jersey's Atlantic Coastal Drainage Basin. Surveying and Land Information Systems, Vol. 58, no 3. pp167-177.

CH2M Hill, 2000. Technical Memorandum 1, Urban Stormwater Pollution Assessment, prepared for North Carolina Department of Environment and Natural Resources, Division of Water Quality.

Claytor, R.A. and T.R. Schueler, 1996. “Design of Stormwater Filtering Systems,” The Center for Watershed Protection, Prepared for Chesapeake Research Consortium, Inc.

Corsi, S.R., D.J. Graczyk, D.W. Owens, R.T. Bannerman, 1997. Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus From Small Watersheds of Wisconsin. USGS FS-195-97.

Delaware Valley Regional Planning Commission, 1977. Average Pollutant Concentrations Associated with Urban Agriculture and Forest Land Use. Working Paper 5.01-1, Extent of NPS Problems.

Eck, P., 1957. Fertility Erosion Selectiveness on Three Wisconsin Soils. Ph. D. Thesis, Univ. of Wisconsin, Madison, WI.

F.X. Brown, Inc., 1993. Diagnostic-Feasibility Study of Strawbridge Lake. FXB Project Number NJ1246-01.

Frink, C.R., 1991. Estimating Nutrient Exports to Estuaries. Journal of Environmental Quality. 20:717-724.

Horner, R., B. W. Mar, L. E. Reinelt, J. S. Richey, and J. M. Lee, 1986. Design of monitoring programs for determination of ecological change resulting from nonpoint source water pollution in Washington State. University of Washington, Department of Civil Engineering, Seattle, Washington.

Horner, R.R., 1992. Water Quality Criteria/Pollutant Loading Estimation/Treatment Effectiveness Estimation. In R.W. Beck and Associates. Covington Master Drainage Plan. King County Surface Water Management Division., Seattle, WA.

Horner, Richard R., Joseph J. Skupien, Eric H. Livingston, and H. Earl Shaver, 1994. Fundamentals of Urban Runoff Management: Technical and Institutional Issues. Prepared by the Terrene Institute, Washington, DC, in cooperation with the U.S. Environmental Protection Agency. EPA/840/B-92/002.

Johnston, W.R., F. Ittihadieh, R.M. Daum, and A.F. Pillsbury, 1965. Nitrogen and Phosphorus in Tile Drainage Effluent. Soil Sci. Soc. Amer. Proc. 29:287-289.

Knoblauch, H.C., L. Kolodny, and G.D. Brill, 1942. Erosion Losses of Major Plant Nutrients and Organic Matter from Collington Sandy Loam. Soil Sci. 53:369-378.

Loehr, R.C., 1974. Characteristics and comparative magnitude of non-point sources. Journal of WPCF 46(11):1849-1872.

Lopes, T.J., S.G. Dionne, 1998. A Review of Semivolatile and Volatile Organic Compounds in Highway Runoff and Urban Stormwater. U.S. Geological Survey, U.S. Department of Interior.

Marsalek, J., 1978. Pollution Due to Urban Runoff: Unit Loads and Abatement Measure, Pollution from Land Use Activities Reference Group. International Joint Commission, Windsor, Ontario.

McFarland, Anne M.S and L. M. Hauck, 2001. Determining Nutrient Export Coefficients and Source Loading Uncertainty Using In-stream Monitoring Data. Journal of the American Water Resources Association, pp. 223, 37. No. 1, February.

Menzel, R. G., E. D. Rhoades, A. E. Olness, and S. J. Smith, 1978. Variability of Annual Nutrient and Sediment Discharges in Runoff from Oklahoma Cropland and Rangeland. Journal of Environmental Quality, 7:401-406.

Mills, W.B., D.B. Porcella, M.J. Ungs, S.A. Gherini, K.V. Summers, L. Mok, G.L. Rupp, G.L. Bowie, 1985. Water Quality Assessment – A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water – Part I and II. EPA-600/6-85-002A&B.

Minshall, N.E., M.S. Nichols, and S.A. Witzel, 1969. Plant Nutrients in Base Flow of Streams in Southwestern Wisconsin. Water Resources. 5(3):706-713.

Mundy, C., M. Bergman, 1998. Technical Memorandum No. 29, The Pollution Load Screening Model: A tool for the 1995 District Water Management Plan and the 1996 Local Government Water Resource Atlases, Department of Water Resources, St. Johns River Water Management District.

NCDWQ, 1998. Neuse River Basinwide Water Quality Plan, Chapter 5, Section A.

Nelson, M.E., 1989. Predicting Nitrogen Concentrations in Ground Water An Analytical Model. IEP, Inc.

Northeast Florida Water Management District, 1994. St. Marks and Wakulla Rivers Resource Assessment and Greenway Protection Plan. Appendix 4.

Northern Virginia Planning District Commission, 1979. Guidebook for Screening Urban Nonpoint Pollution Management Strategies. Prepared for the Metropolitan Washington Council of Governments.

Novotny, V., H. Olem, 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, NY

Omernik, J. M., 1976. The influence of land use on stream nutrient levels, US EPA January. EPA-60/3-76-014

Omni Environmental Corporation, 1991. Literature Search on Stormwater Pollutant Loading Rates. Literature cited from DVRPC 1977; Wanielista et al. 1977; Whipple and Hunter 1977; NVPDC 1980; USEPA 1983; Mills et al. 1985; Nelson 1989; Walker et al. 1989.

Omni Environmental Corporation, 1999. Whippany River Watershed Program Stormwater Model Calibration and Verification Report.

Overcash, M. R., F. J. Humenik, and J. R. Miner, 1983. Livestock Waste Management, Vol. II, CRC Press, Inc., Boca Raton, Florida.

Pacific Northwest Environmental Research Laboratory, 1974. Relationships Between Drainage Area Characteristics and Non-Point Source Nutrients in Streams. Prepared for the National Environmental Research Center, August 1974.

Panuska, J.C. and R.A. Lillie, 1995. Phosphorus Loadings from Wisconsin Watersheds: Recommended Phosphorus Export Coefficients for Agricultural and Forested Watersheds. Research Management Findings, Bureau of Research, Wisconsin Department of Natural Resources, Number 38.

Pitt, R.E., 1991. Nonpoint Source Water Pollution Management. Dep. Civil Eng., Univ. Alabama, Birmingham, AL.

Polls, Irwin and Richard Lanyon, 1980. Pollutant Concentrations from Homogeneous Land Uses. Journal of the Environmental Engineering Division.

Prey, J., D. Hart, A. Holy, J. Steuer, J. Thomas, 1996. A Stormwater Demonstration Project in Support of the Lake Superior Binational Program: Summary. Wisconsin Dept. of Natural Resources. (http://www.dnr.state.wi.us/org/water/wm/nps/tpubs/summary/lakesup.htm)

Rast, W. and G.F. Lee, 1978. Summary Analysis of the North American (U.S. Portion) OECD Eutrophication Project: Nutrient Loading -- Lake Response Relationships and Trophic State Indices., EPA-600/3-78-008.

Reckhow, K.H., M.N. Beaulac and J.T. Simpson, 1980. Modeling of Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. Report No. EPA 440/5-80-011. U.S. EPA, Washington, D.C.

Ryding, S. and W. Rast, 1989. The Control of Eutrophication of Lakes and Reservoirs. Man and the Biosphere Series, United Nations Educational Scientific and Cultural Organization, Paris, France.

Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Prepared for the Metropolitan Washington Council of Governments.

Sonzogni, W.C. and G.F. Lee, 1974. Nutrient Sources for Lake Mendota - 1972. Trans. Wisc. Acad. Sci. Arts Lett. 62:133-164.

Uchrin, C.G. and T.J. Maldanato, 1991. Evaluation of Hydrocarbons in Urban Runoff and in Detention Basins. Water Writes. Water Research Institute, Division of Coastal and Environmental Studies, Rutgers University.

United States Geological Survey, U.S. Department of the Interior, 1998. Comparison of NPDES Program Findings for Selected Cities in the United States, USGS Fact Sheet, January

USEPA, 1987. Guide to Nonpoint Source Pollution Control. U.S. EPA, Criteria and Standards Division, Washington D.C.

USEPA, 1993. Urban Runoff Pollution Prevention and Control Planning (handbook). EPA/625/R-93/004.

USEPA, 2000. Watershed Analysis and Management (WAM) Guide for Tribes. (http://www.epa.gov/owow/watershed/wacademy/wam/)

Uttormark, P.D., J.D. Chapin, and K.M. Green, 1974. Estimating nutrient loadings of lakes from non-point sources. U.S. Environmental Protection Agency, Washington, D.C. 112 p. (WRIL 160609). EPA-660/3-74-020.

Walker, J.F., 1989. Spreadsheet Watershed Modeling for Nonpoint Source Pollution Management in a Wisconsin Basin, Water Resources Bulletin, Vol. 25, no. 1, pp. 139-147.

Wanielista, M.P., Y.A. Yousef, and W.M. McLellon, 1977. Nonpoint Source Effects on Water Quality, Journal Water Pollution Control Federation, Part 3, pp. 441-451.

Washington State Department of Ecology, 2000. Stormwater Management Manual for Western Washington: Volume I Minimum Technical Requirements. Publication No. 99-11.

Weidner, R.B., A.G. Christianson, S.R. Weibel, and G.G. Robeck, 1969. Rural Runoff as a Factor in Stream Pollution. J. Water Pollution. Con. Fed. 36(7):914-924.

Whipple, W. and J.V. Hunter, 1977. Nonpoint Sources and Planning for Water Pollution Control. Journal Water Pollution Control Federation. pp. 15-23.

Whipple, W., et al., 1978. Effect of Storm Frequency on Pollution from Urban Runoff, J. Water Pollution Control Federation. 50:974-980.

Winter, J.G. and H.C. Duthie, 2000. Export Coefficient Modeling to assess phosporus loading in an urban watershed. Journal of American Water Resources Association. Vol. 36 No. 5.

Zanoni, A.E., 1970. Eutrophic Evaluation of a Small Multi-Land Use Watershed. Tech. Completion Rep. OWRR A-014-Wis., Water Resources Center, Univ. of Wisconsin, Madison, WI.

Appendix B Assessment Units Addressed Under the TMDL or the TMDL Implementation Plan

HUC 14	Name of Assessment Unit	Area (sq. mi)	Area (acres)	Stream Miles	TMDL/ Affected*
02040105080010-01	Bear Brook (Sussex/Warren Co)	7.5	4,816	11.4	Affected
02040105070040-01	Pequest River (Trout Brook to Brighton)	8.6	5,524	12.2	Affected
02040105070020-01	New Wawayanda Lake/Andover Pond trib	11.5	7,347	18.5	Affected
02040105070060-01	Pequest R (below Bear Swamp to Trout Bk)	6.3	4,034	22.2	TMDL
02040105070050-01	Trout Brook/Lake Tranquility	9.4	6,033	19.0	Affected
02040105090020-01	Pequest R (Cemetary Road to Drag Strip)	7.6	4,891	6.5	TMDL
02040105070030-01	Pequest River (above Brighton)	13.5	8,611	19.0	Affected
02040105080020-01	Bear Creek	10.8	6,913	18.6	Affected
02040105090030-01	Pequest R (Furnace Brook to Cemetary Road)	8.2	5,270	12.5	TMDL
02040105090050-01	Furnace Brook	7.7	4,939	14.9	Affected
02040105070010-01	Lake Lenape trib	5.4	3,436	9.4	Affected
02040105090010-01	Pequest R (Drag Strip--below Bear Swamp)	9.5	6,079	15.5	TMDL
TOTAL		**106.0**	**67893**	**179.7**	

*"Affected" refers to the TMDL nonpoint source and stormwater reduction implementation plans

Appendix C Municipal Stormwater Permits and Identification of Tier A or B Classification for the Pequest River Watersheds

NJPDES MS4 Permit Number	Municipality	Discharge Type	County
NJG0148181	Allamuchy Township	Tier B	Warren
NJG0152242	Andover Borough	Tier B	Sussex
NJG0153290	Andover Township	Tier A	Sussex
NJG0154440	Belvidere Town	Tier B	Warren
NJG0149209	Byram Township	Tier A	Sussex
NJG0162790	Fredon Township	Tier B	Sussex
NJG0151572	Frelinghuysen Township	Tier B	Warren
NJG0152943	Green Township	Tier B	Sussex
NJG0153001	Hope Township	Tier B	Warren
NJG0153087	Independence Twp	Tier A	Warren
NJG0152285	Liberty Township	Tier B	Warren
NJG0152633	Mansfield Township	Tier A	Warren
NJG0149969	Newton Town	Tier A	Sussex
NJG0151904	Oxford Twp	Tier B	Warren
NJG0148059	Sparta Township	Tier A	Sussex
NJG0150690	Washington Township	Tier B	Warren
NJG0149683	White Township	Tier B	Warren

Appendix D Mass Balance Calculation

Mass-Balance Equation Input Variables	Summer under 7Q10 flow conditions	Winter under 7Q10 flow conditions	Units	Summer TP loading kg/day	Winter TP loading kg/day
Derivation of Effluent TP Concentration for Allamuchy Township STP (NJ0020605)					
Upstream Flow Under 7Q10 Conditions	6.40	10.00			
Upstream TP Concentration	0.03	0.03	mg/l		
Effluent Flow (Permitted Flow)	0.93	0.93	cfs		
Downstream Flow	7.33	10.93	cfs		
Downstream TP Concentration	0.10	0.10	mg/l		
Effluent TP Concentration	**0.58**	**0.85**	**mg/l**	**1.32**	**1.94**
Derivation of TP Concentration Downstream of the Pequest Fish Hatchery (NJ0033189)					
7Q10 Flow at Pequest River at Pequest (Excludes Pequest Fish Hatchery flow) (1)	18.00	28.00	cfs		
Upstream Flow Under 7Q10 Conditions = 7Q10 at Pequest River at Pequest - 7Q10 of Furnace Brook - effluent flow of Oxford MUA) (2)	15.93	25.20	cfs		
Upstream TP Concentration (Based on data sampled at site 4 after applying attenuation of 0.3, and accounting for future upstream TP loading from Allamuchy MUA)	0.06	0.06	mg/l		

Effluent Flow (Permitted Flow of Pequest Fish Hatchery)	13.65	13.65	cfs		
Effluent TP Concentration (Based on the Long Term Average (LTA) of existing DMR data for the Pequest Fish Hatchery)	**0.12**	**0.12**	**mg/l**	**4.01**	**4.01**
Downstream Flow	29.58	38.85	cfs		
TP Concentration Downstream of the Pequest Fish Hatchery	**0.09**	**0.08**	**mg/l**		
Derivation of Effluent TP Concentration for Warren County MUA - Oxford STP (NJ0035483)					
Upstream Flow Under 7Q10 Conditions	29.58	38.85	cfs		
Upstream TP Concentration	0.09	0.08	mg/l		
Effluent Flow (Permitted Flow)	0.77	0.77	cfs		
Downstream Flow	30.35	39.62	cfs		
Downstream TP Concentration	0.10	0.10	mg/l		
Effluent TP Concentration	**0.57**	**1.05**	**mg/l**	**1.08**	**1.99**
(1) 7Q10 Flow at Pequest River at Pequest station ID 01445500 is 18 cfs as summer 7Q10 flow and 28 cfs winter 7Q10 flow, the 7Q10 flow values include Oxford and Allamuchy effluents but excludes the Pequest Fish Hatchery flow; for the analysis, the flow from the Hatchery is added to the 7Q10.					
(2) 7Q10 flow at Furnace Brook was estimated based on drainage area ratio method and verified using limited flow data. Using drainage area method, a summer 7Q10 flow of 1.3cfs was estimated (7.26% of 18cfs) and a winter 7Q10 of 2.03 cfs (7.26% of 28cfs). This result was verified using flow data measured since 2005 (21 flow measurements at Furnace Brook), the percent of Furnace Brook flow to Pequest Flow was 6.35%. To have a conservative assumption, a drainage area ratio was used to estimate the 7Q10 at Furnace Brook.					

Appendix E Flow-Integrated Reduction of Exceedances (FIRE) method

E-1 General Introduction of Flow-Integrated Reduction of Exceedances (FIRE) method

Flow-Integrated Reduction of Exceedance (FIRE) is a regression technique, derived from a load duration method (Stiles 2002) and developed by the Department for data-limited TMDLs where nonpoint and stormwater point sources are predominant, or where wastewater discharge loads can be isolated. For this technique, linear regression is used to develop a flow-integrated relationship between measured pollutant concentrations and the associated flows at a single monitoring site. The method provides an estimation of the needed percent reduction of the current load to avoid the exceedance of the water quality standard. The FIRE method is applied over the entire range of flows, eliminating the need to establish a single target flow to estimate an average annual loading reduction.

For samples with concentrations exceeding the SWQS, the phosphorus load was calculated by multiplying the concentration by the flow. The calculated load and the corresponding flows are plotted. The regression relationship between the load and flow for exceedances is established and the regression line is drawn (Slope B in Figure 1). A zero-intercept for the regression line is assumed. The zero intercept is within the 95 percent confidence interval, so the zero intercept cannot be rejected as the point of origin. In addition, where nonpoint sources dominate or wastewater discharges are segregated from the loads, at zero flow there would be a zero load. The SWQS for TP in streams, a concentration of 0.1 mg/l, determines the target line plotted in Figure 1, with the slope of C. Given lines with a common intercept, the difference between the slopes of the two lines provides the percent load reduction needed to achieve the target (calculated as $\frac{SlopeB - SlopeC}{SlopeB}$). The resultant percent reduction is the same no matter which unit is used to express the load and flow.

The regression line indicates the most likely relationship between the load and flow under the current situation. Nevertheless, statistically, there is an uncertainty associated with this estimated relationship. To account for the uncertainty, the upper 95 percent confidence limit of the regression line is also generated and plotted. This upper 95 percent confidence limit for the regression line provides the upper bound estimation of the slope (Slope A in Figure 1). When comparing Slope A to Slope C, a higher percent reduction would be required to attain the SWQS and is called the overall percent reduction. As Shown in Figure 2, X_I is the required percent reduction based on Slopes B and C and X_{II} is the overall percent reduction based on Slopes A and C. The difference given by these two reductions is used to calculate the MOS as a component of the Loading Capacity. By definition, Loading Capacity is the maximum load the water body can assimilate without violating the SWQS. In this technique, the Loading Capacity is calculated as what remains after applying the required percent reduction on the existing load. The Allocable Load is what remains after applying the overall percent reduction. The difference between the Loading Capacity and Allocable Load is assigned as the MOS.

In other words, the overall reduction equals the required reduction of sources plus the MOS. The percentage of MOS as part of the Loading Capacity can be mathematically calculated based on Slope A and B using the equation of $\frac{SlopeA - SlopeB}{SlopeA}$, as derived below.

Required Percent Reduction = $\frac{SlopeB - SlopeC}{SlopeB}$.

Loading Capacity = $(1-\frac{SlopeB - SlopeC}{SlopeB})$*Existing Load = $\frac{SlopeC}{SlopeB}$*Existing Load

Overall percent reduction = $\frac{SlopeA - SlopeC}{SlopeA}$

Allocable Loading = $(1-\frac{SlopeA - SlopeC}{SlopeA})$ * Existing Load = $\frac{SlopeC}{SlopeA}$*Existing Load

MOS = Loading Capacity – Allocable Loading = $(\frac{SlopeC}{SlopeB}-\frac{SlopeC}{SlopeA})$*Existing Load

Percentage of MOS as part of the Loading Capacity = $\frac{MoS}{LoadingCapapcity}$

$$= \frac{\frac{SlopeC}{SlopeB} - \frac{SlopeC}{SlopeA}}{\frac{SlopeC}{SlopeB}} = \left(\frac{SlopeA \times SlopeC - SlopeB \times SlopeC}{SlopeB \times SlopeA}\right) * \frac{SlopeB}{SlopeC} = \frac{SlopeA - SlopeB}{SlopeA}$$

Knowing this percentage, the MOS can be directly calculated from Loading Capacity without specifying the overall percent reduction. Identifying the overall percent reduction along with the required percent reduction for source loads makes the physical meaning of MOS easier to understand.

The FIRE method provides the needed reduction as the percentage of the current load, not the actual load reduction to achieve the goal. The FIRE method alone cannot quantify the current loading. To do so, another method must be employed. The UAL method is used to quantify the current loading of land use sources. Then, the required percent reduction from FIRE is multiplied by the current loading determined through UAL to provide the required reduction of load in mass per year.

Figure 1 Flow-Integrated Reduction of Exceedances

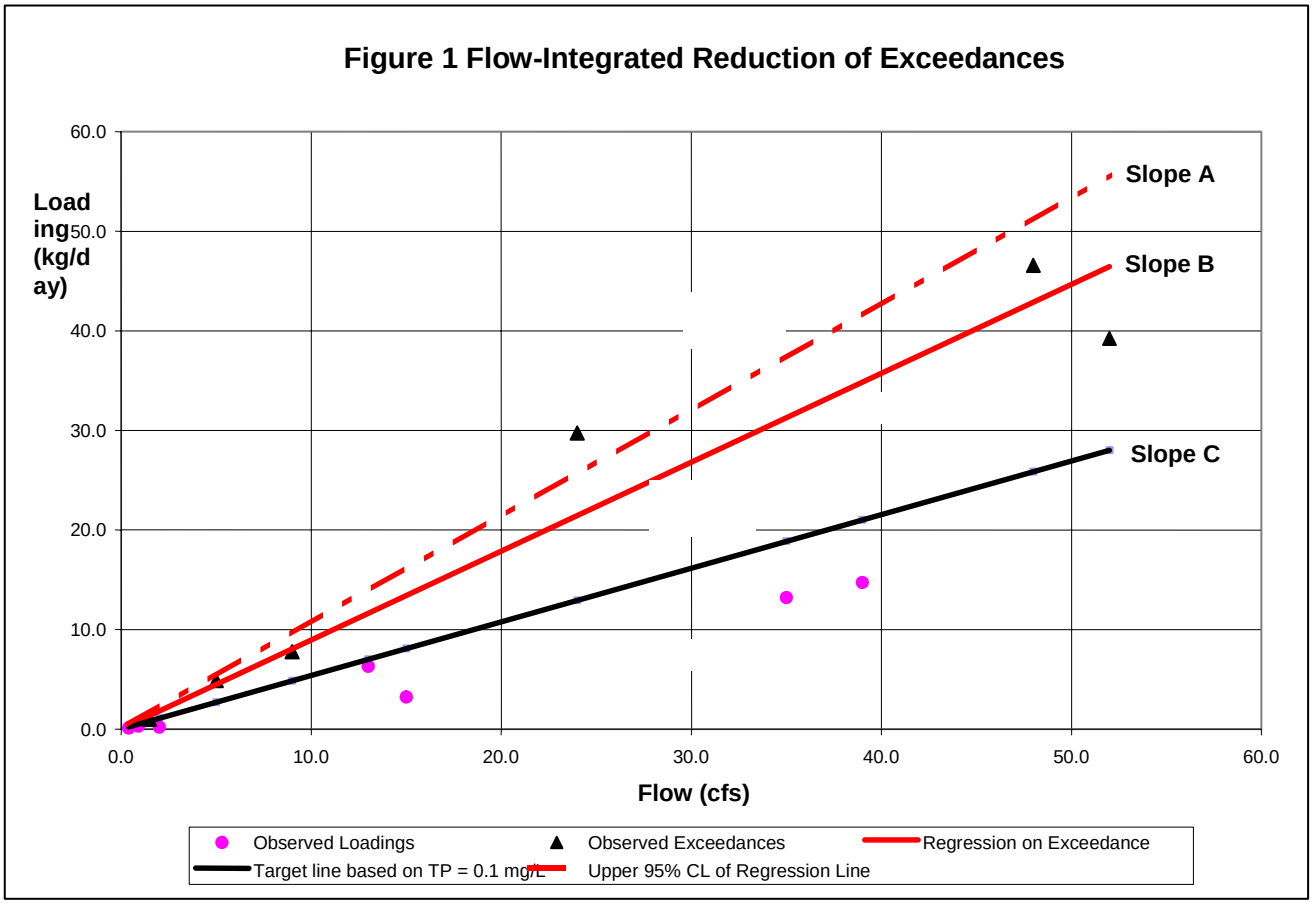
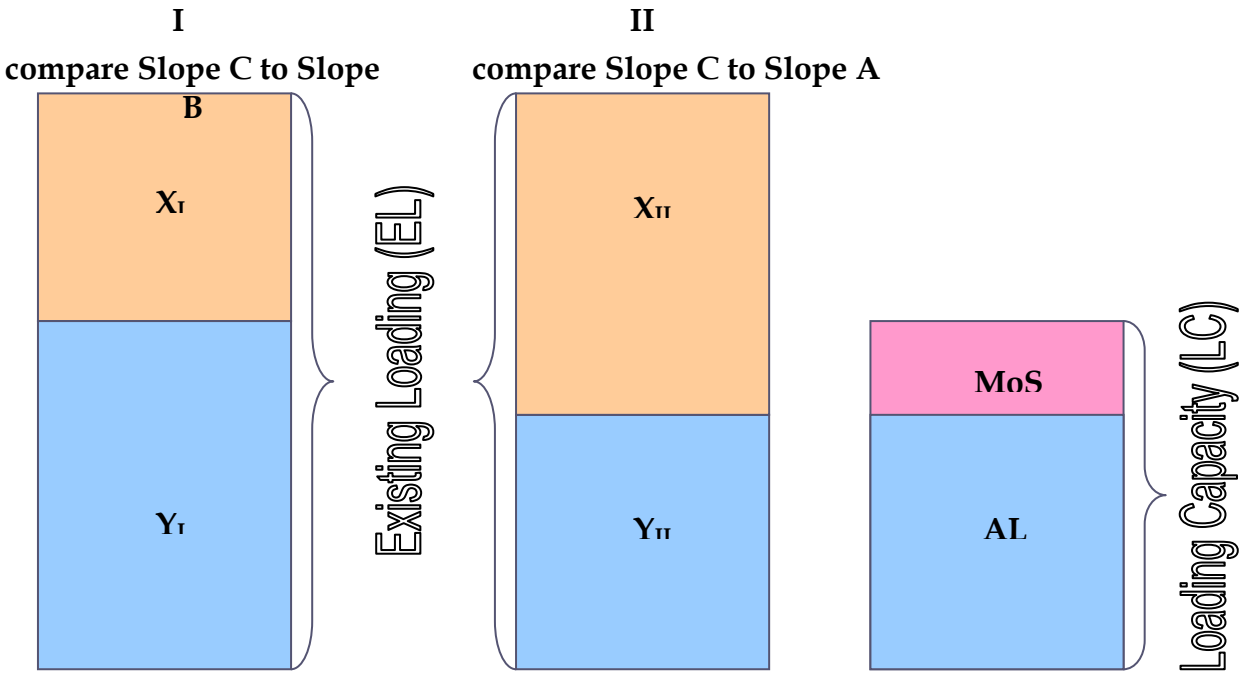


Figure 2 Application of FIRE in TMDL Calculations



X_I = required percent reduction; X_{II} = overall percent reduction
*$X_I + Y_I = 1$; $X_{II} + Y_{II} = 1$

$LC = (1 - X_I) * EL = AL + MoS$; $AL = (1 - X_{II}) * EL$; $MoS = (X_{II} - X_I) * EL$
*AL = Allocable Loading; MoS = Margin of Safety

E-2 Application of FIRE method in this TMDL study

Table E-2-1 Phosphorus Exceedances at Pequest River at Pequest

Date	River flow, cfs	TP Conc, mg/l	Adjusted flow, cfs	Adjusted Conc, mg/l
8/12/1992	64	0.16	51	0.16
3/29/1993	927	0.17	912	0.17
7/29/1993	33	0.4	21	0.41
3/29/1994	1210	0.13	1195	0.13
8/22/1994	243	0.14	231	0.12
1/31/1996	1040	0.12	1027	0.12
4/2/1996	650	0.2	635	0.20
7/28/1999	18	0.56	6	1.48
6/12/2001	136	0.22	124	0.22
7/26/2001	41.5	0.16	29	0.16
10/25/2001	22.5	0.35	9	0.66
5/14/2002	330	0.274	316	0.28
8/19/2002	17	0.486	5	1.02
5/4/2004	284	0.12	273	0.12
5/11/2004	316	0.45	305	0.46

Figure E-2-1 Estimated Percent Reduction for Pequest River at Pequest Using a Regression Method

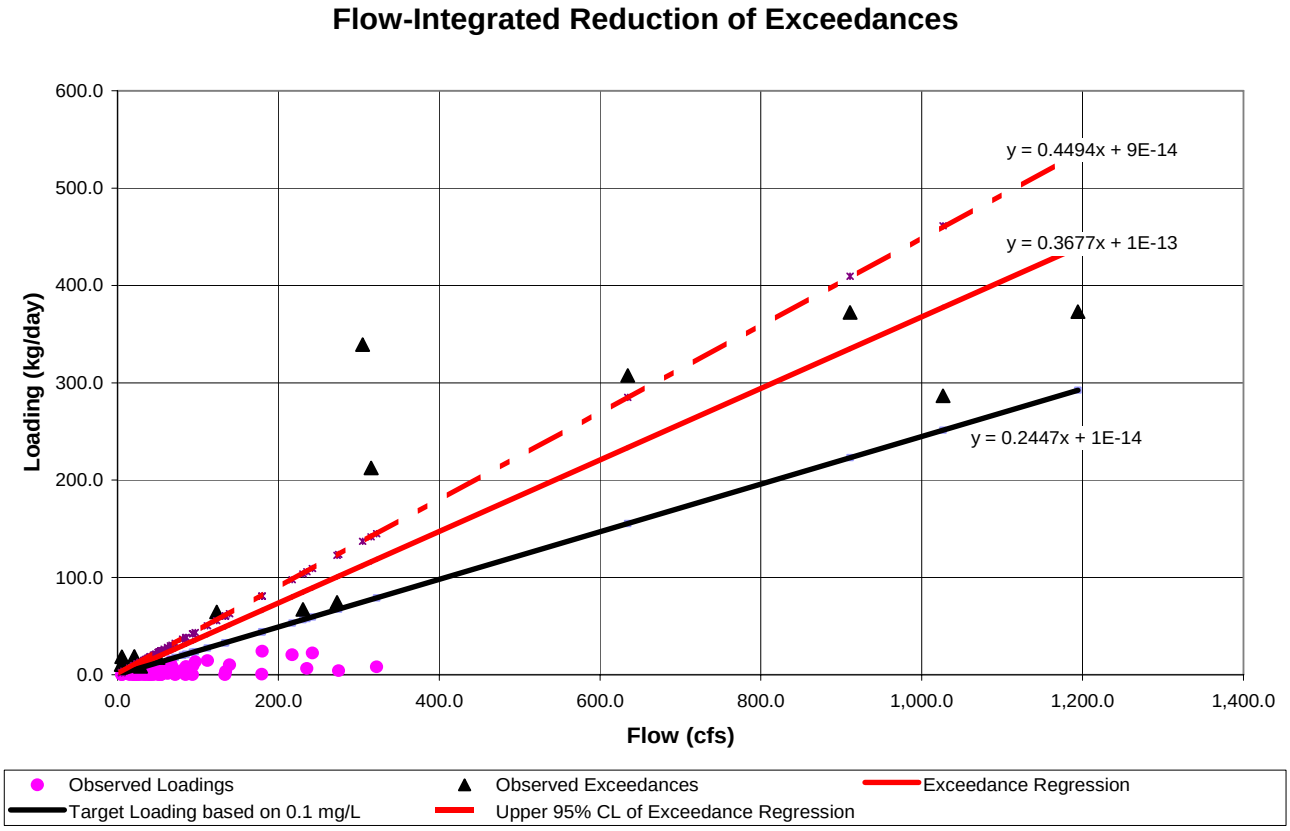


Table E-2-2 Summary of FIRE Method Results under Different Scenarios of Attenuation of the Load from Allamuchy

Result	Scenario 1*	Scenario 2*	Scenario 3*
Target Loading Slope	0.2447	0.2447	0.2447
Exceedance Regression Slope	0.3662	0.3677	0.3710
Upper 95% Confidence Limit of Exceedance Regression Slope	0.4475	0.4494	0.4534
Overall Percent Loading Reduction	45.32%	45.54%	46.02%
Load Capacity as of Current Loading	66.83%	66.55%	65.96%
Margin of Safety (as of Loading Capacity	18.17%	18.17%	18.17%

It is assumed that 100% of Allamuchy load will be transported to Site 6 in Scenario 1, 70% in Scenario 2 and 0% in Scenario 3.

Table E-2-3 Phosphorus Exceedances at Pequest River at Townsbury

Date	Flow, cfs	TP conc mg/l
20-Nov-02	258.0	0.109
24-Jul-03	157.0	0.203
15-Apr-04	420.7	0.133
19-Jul-04	80.7	0.117

Figure E-2-2 Estimated Percent Reduction for the Pequest River at Townsbury Using a Regression Method

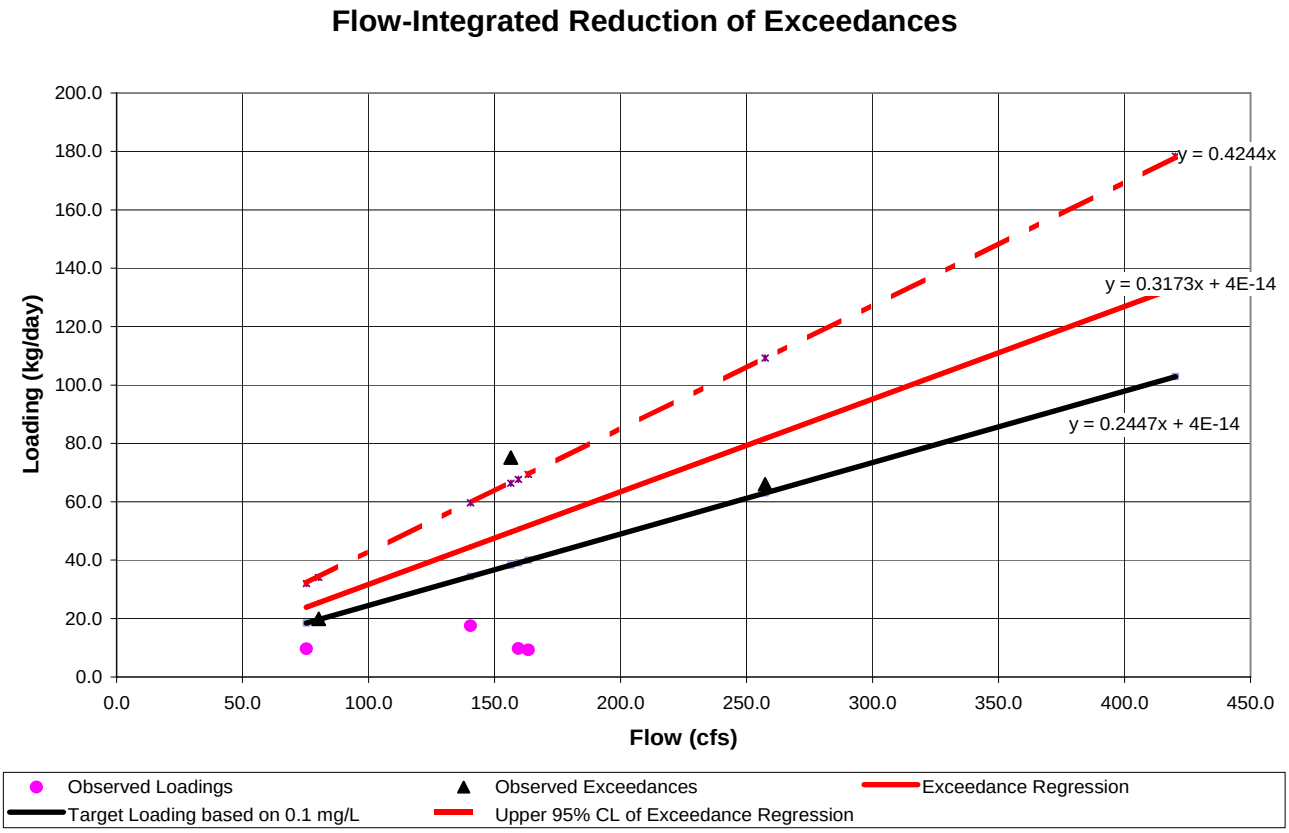


Table E-2-4 Land Use Load Distribution for the Drainage Area of Townsbury

LU category	Current Load, kg/yr	Reduce 52.8%* of the Adjustable Load
Agricultural	8,199	3,870
barren land	76	36
Commercial	271	128
forest, wetland, water	1,495	1,495
Industrial	76	36
low density / rural residental	1,517	716
Medium/high density residential	677	319
mixed urban / other urban	728	343
SUM	13,038	6,944
Equivalent to an overall reduction of	=1-(6944/13038)=	46.7%

***** 52.8% is the needed reduction on the land use load that are readily reduced in order to address the required reduction for Pequest River at Pequest.

E-3. Conversion of FIRE percent reductions to actual reductions in consideration of Land Use load reduction feasibility

The outputs of the FIRE method establish a percent reduction needed to meet the target load (that which will attain the applicable SWQS) and a margin of safety. These values are then applied to the existing land use loadings within the impaired streamshed to determine the load allocations for various land uses.

Existing loads are determined as follows. GIS is used to determine the area in acres of each of the land uses in the impaired watershed. The loading coefficients identified in the TMDL report are applied to the acres of land use to calculate an existing load for each land use in the impaired streamshed. Existing loads for point sources, other than stormwater point sources (essentially, wastewater treatment plants), if any, in the impaired streamshed are calculated using the average flow and concentration data from the discharge monitoring reports for the facilities. This load is added to the existing TP load calculated from land use.

To calculate the overall target load the percent reduction (the difference between the target load and the exceedance regression) as determined through FIRE is applied to the total existing load. The load associated with the margin of safety as determined through FIRE (the difference between the 95% confidence interval and the exceedance regression) is then removed from the overall target load (target loading line), leaving a reduced amount of loading now available to allocate. The load from any discharges is determined by taking the full permitted flow and assigning an effluent concentration. This load is also removed from the potential allocable load leaving a further reduced amount of allocable load for land uses.

There are a number of land uses from which a reduction in current load is not readily accomplished. These land uses include Forest, Water, Wetlands, and Barren land. Typically, the current loads for these land uses as calculated for existing load are carried over entirely as a component of the future loading calculations. Therefore, for these land uses, the existing load and future load are equal. The sum of the unadjusted land use loads is then removed from the reduced allocable land use load leaving the final allocable land use load to be allocated among the land uses that are most amenable to load reduction (urban and agricultural). This final allocable land use load is then applied to each land use category in proportion to the amount of each land use in the watershed.

The final percent reduction is calculated by comparing the final WLA or LA for each land use to the existing loads of those land uses. Because of the adjustments made in removing the loads associated with the MOS, the unadjusted land uses, and discharges, the percent reduction associated with the final allocable land use load is higher than that which appears as an output to FIRE.

Example:

Land- Use	Existing Load	Percent Reduction	Allocation
Agriculture	100	88.85%	11.15
Barren	15	0%	15.00
Commercial	300	88.85%	33.45
Forest	125	0%	125.00
Low Density	40	88.85%	4.46

High Density	250	88.85%	27.88
Other Urban	15	88.85%	1.67
Water	100	0%	100.00
Wetlands	30	0%	30.00
Discharger A	25	0%	25.00
MOS			95.87
TOTAL	**1000**		**469.5**

Output from FIRE

Margin of Safety		**= 20.42%**
Target Loading		**= 46.95%**

Target Load

Target Load = 0.4695 * Existing Load
= 0.4695 * 1000
Target Load = 469.5 lb/yr

Margin of Safety

MOS = 0.2042* Target Load
= 0.2042* 469.5 lb/yr
= 95.87 lb/yr

Allocable Load

AL = Target Load – MOS
= 469.5 –95.87
= 373.63 lb/yr

Allocable Land Use Load

ALUL = AL- Future Discharge Load
= 373.6 – 25
= 348.63 lb/yr

SUM of Unadjusted Land Use Loads

Unadjusted Land use Load = Existing Forest + Water & Wetlands Load + Barren Land Load
= 125 + 100 + 30 + 15
= 270 kg/yr

Final Allocable Land use Load

Final Allocable Land use Load = Allocable Land use Load – Unadjusted Land use Load
= 348.6 – 270
= 78.6 lb/yr

Final Percent Reduction

Final Percent Reduction = 1 – (Final allocable Land use load / Sum of existing load of unadjusted land uses)
= 1 – (78.6/ 15+250+40+300+100)
= 1 – (78.6/705)
= 0.8885
= 88.85 %

Appendix F Data Sources

Geographic Information System (GIS) data from the Department was used extensively to describe the drainage area addressed in this study. The following is the general information regarding the data used to describe the watershed management area:

- GIS file associated with the 2008 Integrated Water Quality Monitoring and Assessment Report, published on July 1, 2009 and created by NJDEP, Water Monitoring & Standards (WMS), Bureau of Water Quality Standards and Assessment (BWQSA) Online at: http://www.state.nj.us/dep/gis/irshp2008.html

- Final version 2002 Landuse/Landcover by Watershed Management Area (WMA) updated as of March 10, 2008 by the NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic information Systems (BGIS), and delineated by watershed management area. Online at http://www.nj.gov/dep/gis/lulc02cshp.html

- NJDEP Stream Network , published 05/01/2008 by the NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA) by basin. Online at: http://www.state.nj.us/dep/gis/strmnet.html

- 14 Digit Hydrologic Unit Code Delineations for New Jersey (Version 20100501) published 5/1/2010 by Department of Environmental Protection (NJDEP), New Jersey Geological Survey (NJGS). Online at:
http://www.state.nj.us/dep/gis/stateshp.html#HUC14

- NJDEP Digital Elevation Grid for New Jersey (10 meter) published 06/01/2002 by NJ Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), and Bureau of Geographic Information Systems (BGIS) by watershed management area. Online at:
http://www.nj.gov/dep/gis/wmalattice.html

- "NJPDES Surface Water Discharges in New Jersey, (1:12,000) Version 20090126", published 1/26/2009 by NJDEP, Environmental Regulation (ER), Division of Water Quality (DWQ), Bureau of Point Source Permitting - Region 1 (PSP-R1). Online at: http://www.state.nj.us/dep/gis/digidownload/zips/statewide/njpdesswd.zip

- NJDEP Surface Water Quality Standards of New Jersey (Edition 201001), published 1/2010 by NJDEP, Division of Land Use Management, Bureau of Freshwater & Biological Monitoring. Online at: http://www.state.nj.us/dep/gis/digidownload/zips/statewide/swqs.zip

- Municipalities of New Jersey (Clipped to Coast), Version 20090116, published 01/216/2009 by NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). Online at:
http://www.state.nj.us/dep/gis/digidownload/zips/statewide/muncoast.zip

Appendix G Water Quality Data

HydroQual Site # 1, Pequest River at Huntsville

Date	Flow (cfs)	TP (mg/l)	Database
11/9/1999		0.01	USGS
2/29/2000		0.03	USGS
5/31/2000		0.02	USGS
9/7/2000		0.02	USGS
2/4/2002	10.4	0.03	EWQ-2000
2/7/2001	51.4	0.03	EWQ-2000
5/13/2002	45.7	0.03	EWQ-2000
5/14/2001	20.1	0.03	EWQ-2000
7/11/2002	7.2	0.03	EWQ-2000
8/28/2001	3.6	0.03	EWQ-2000
10/29/2001	1.6	0.03	EWQ-2000
11/20/2000	12.5	0.03	EWQ-2000
5/4/2004	90.0	0.05	HydroQual
5/11/2004	118.0	0.06	HydroQual
6/22/2004	19.0	0.04	HydroQual
7/1/2004	13.0	0.02	HydroQual
7/7/2004	9.3	0.04	HydroQual
7/22/2004	14.0	0.04	HydroQual
7/26/2004	13.0	0.02	HydroQual
8/4/2004	25.0	0.04	HydroQual
8/10/2004	12.0	0.03	HydroQual
8/12/2004	13.0	0.02	HydroQual
8/20/2004	13.0	0.03	HydroQual
8/30/2004	24.0	0.03	HydroQual
9/3/2004	16.0	0.03	HydroQual
9/8/2004	17.0	0.03	HydroQual
9/14/2004	17.0	0.03	HydroQual

8/5/2005	4.6	0.05	HydroQual
8/12/2005	4.3	0.03	HydroQual
8/19/2005	3.3	0.05	HydroQual
8/26/2005	1.9	0.04	HydroQual
9/23/2005	2.4	0.07	HydroQual

HydroQual Site # 2, Pequest River, upstream of Allamuchy STP

Date	TP Conc. mg/l	Database
5/11/2004	0.18	HydroQual
5/4/2004	0.06	HydroQual
6/22/2004	0.03	HydroQual
7/1/2004	0.02	HydroQual
7/7/2004	0.05	HydroQual
7/22/2004	0.04	HydroQual
7/26/2004	0.02	HydroQual
8/4/2004	0.04	HydroQual
8/10/2004	0.03	HydroQual
8/12/2004	0.03	HydroQual
8/20/2004	0.03	HydroQual
8/30/2004	0.03	HydroQual
9/3/2004	0.02	HydroQual
9/8/2004	0.03	HydroQual
9/14/2004	0.02	HydroQual

HydroQual Site # 3, Pequest River, downstream of Allamuchy STP

Date	TP Conc. mg/l	Database
5/11/2004	0.29	HydroQual
5/4/2004	0.10	HydroQual
6/22/2004	0.13	HydroQual
7/1/2004	0.11	HydroQual
7/7/2004	0.20	HydroQual

7/22/2004	0.32	HydroQual
7/26/2004	0.09	HydroQual
8/4/2004	0.11	HydroQual
8/10/2004	0.13	HydroQual
8/12/2004	0.19	HydroQual
8/20/2004	0.09	HydroQual
8/30/2004	0.03	HydroQual
9/3/2004	0.07	HydroQual
9/8/2004	0.11	HydroQual
9/14/2004	0.07	HydroQual

HydroQual Site # 4, Pequest River, between Allamuchy and Oxford STP

Date	TP Conc. mg/l	Database
5/11/2004	0.55 *	HydroQual
5/4/2004	0.11	HydroQual
6/22/2004	0.07	HydroQual
7/1/2004	0.07	HydroQual
7/7/2004	0.10	HydroQual
7/22/2004	0.07	HydroQual
7/26/2004	0.06	HydroQual
8/4/2004	0.07	HydroQual
8/10/2004	0.07	HydroQual
8/12/2004	0.06	HydroQual
8/20/2004	0.07	HydroQual
8/30/2004	0.06	HydroQual
9/3/2004	0.05	HydroQual
9/8/2004	0.08	HydroQual
9/14/2004	0.06	HydroQual
8/5/2005	0.12	HydroQual
8/12/2005	0.12	HydroQual
8/19/2005	0.12	HydroQual

8/26/2005	0.12	HydroQual
9/23/2005	0.15	HydroQual

* This concentration is treated as an outlier based on statistical analysis. For a total of 20 samples, the one-tailed inverse student's t-distribution is 3.17 with a probability of 0.01. The standard deviation of the samples is 0.107 and the mean is 0.11. (0.11 + 0.107*3.17 = 0.450). Since 0.55 is higher than 0.45, it is reasonable to treat it as an outlier to the dataset.

Pequest River at Townsbury, EWQ Site ID # 01445430

Date	Flow (cfs)	TP (mg/l)	Database
20-Jan-04		0.032	EWQ-2002
27-Jan-03	141	0.059	EWQ-2002
15-Apr-04		0.133	EWQ-2002
21-Apr-03	164	0.03	EWQ-2002
19-Jul-04		0.117	EWQ-2002
24-Jul-03	157.00	0.203	EWQ-2002
23-Oct-03	75.80	0.067	EWQ-2002
20-Nov-02	258.00	0.109	EWQ-2002

HydroQual Site # 5, Pequest River, upstream of Oxford STP

Date	TP Conc, mg/l	Database
5/11/2004	0.38	HydroQual
5/4/2004	0.11	HydroQual
6/22/2004	0.06	HydroQual
7/1/2004	0.04	HydroQual
7/7/2004	0.06	HydroQual
7/22/2004	0.07	HydroQual
7/26/2004	0.07	HydroQual
8/4/2004	0.09	HydroQual
8/10/2004	0.06	HydroQual
8/12/2004	0.11	HydroQual
8/20/2004	0.07	HydroQual
8/30/2004	0.06	HydroQual
9/3/2004	0.06	HydroQual

9/8/2004	0.07	HydroQual
9/14/2004	0.07	HydroQual
8/5/2005	0.10	HydroQual
8/12/2005	0.08	HydroQual
8/19/2005	0.06	HydroQual
8/26/2005	0.11	HydroQual
9/23/2005	0.11	HydroQual

Pequest River at Pequest, USGS /EWQ station ID # 01445500

Date	Flow (cfs)	TP (mg/l)	Database
8/1/1991	39.0	0.05	USGS
10/16/1991	79.0	0.11	USGS
1/29/1992	98.0	0.05	USGS
3/31/1992	250.0	0.03	USGS
6/17/1992	82.0	0.06	USGS
8/12/1992	64.0	0.16	USGS
10/22/1992	51.0	0.03	USGS
1/27/1993	191.0	0.03	USGS
3/29/1993	927.0	0.17	USGS
5/27/1993	107.0	0.10	USGS
7/29/1993	33.0	0.40	USGS
10/20/1993	56.0	0.06	USGS
2/14/1994	127.0	0.09	USGS
3/29/1994	1210.0	0.13	USGS
6/8/1994	94.0	0.08	USGS
8/22/1994	243.0	0.14	USGS
11/3/1994	52.0	0.09	USGS
1/24/1995	229.0	0.06	USGS
3/29/1995	150.0	0.01	USGS
5/18/1995	98.0	0.07	USGS
7/20/1995	47.0	0.09	USGS

11/20/1995	337.0	0.02	USGS
1/31/1996	1040.0	0.12	USGS
4/2/1996	650.0	0.20	USGS
6/11/1996	106.0	0.07	USGS
7/30/1996	106.0	0.02	USGS
10/28/1996	256.0	0.05	USGS
1/22/1997	147.0	0.03	USGS
4/9/1997	291.0	0.02	USGS
6/4/1997	193.0	0.07	USGS
8/4/1997	45.0	0.08	USGS
7/27/1999	18.0	0.11	DEP-Recon
7/28/1999	18.0	0.56	DEP-Recon
7/29/1999	18.0	0.03	DEP-Recon
2/8/2001	155.0	0.05	EWQ-2000
2/20/2002	33.9	0.09	EWQ-2000
5/14/2002	330.0	0.27	EWQ-2000
6/12/2001	136.0	0.22	EWQ-2000
7/26/2001	41.5	0.16	EWQ-2000
8/19/2002	17.0	0.49	EWQ-2000
10/25/2001	22.5	0.35	EWQ-2000
11/16/2000	71.9	0.10	EWQ-2000

HydroQual Site # 6 Pequest River

Date	Flow (cfs)	TP (mg/l)	Database
5/4/2004	284.0	0.12	HydroQual
5/11/2004	316.0	0.45	HydroQual
6/22/2004	73.0	0.06	HydroQual
7/1/2004	66.0	0.04	HydroQual
7/7/2004	66.0	0.06	HydroQual
7/22/2004	53.0	0.07	HydroQual

7/26/2004	64.0	0.09	HydroQual
8/4/2004	60.0	0.08	HydroQual
8/10/2004	54.0	0.06	HydroQual
8/12/2004	62.0	0.08	HydroQual
8/20/2004	54.0	0.07	HydroQual
8/30/2004	82.0	0.09	HydroQual
9/3/2004	67.0	0.05	HydroQual
9/8/2004	71.0	0.07	HydroQual
9/14/2004	68.0	0.06	HydroQual
8/5/2005	42.0	0.06	HydroQual
8/12/2005	39.0	0.07	HydroQual
8/19/2005	38.0	0.10	HydroQual
8/26/2005	34.0	0.07	HydroQual
9/23/2005	31.0	0.09	HydroQual

HydroQual Site #7, Pequest River			
Date	**Flow (cfs)**	**TP (mg/l)**	**Database**
5/11/2004	353.9	0.24	HydroQual
5/4/2004	318.1	0.12	HydroQual
6/22/2004	81.8	0.07	HydroQual
7/1/2004	73.9	0.05	HydroQual
7/7/2004	59.4	0.09	HydroQual
7/22/2004	71.7	0.07	HydroQual
7/26/2004	67.2	0.07	HydroQual
8/4/2004	90.7	0.09	HydroQual
8/10/2004	60.5	0.06	HydroQual
8/12/2004	69.4	0.06	HydroQual
8/20/2004	60.5	0.07	HydroQual
8/30/2004	91.8	0.07	HydroQual
9/3/2004	75.0	0.05	HydroQual
9/8/2004	79.5	0.06	HydroQual

9/14/2004	76.2	0.06	HydroQual
8/5/2005	47.0	0.10	HydroQual
8/12/2005	43.7	0.10	HydroQual
8/19/2005	42.6	0.10	HydroQual
8/26/2005	38.1	0.10	HydroQual
9/23/2005	34.7	0.10	HydroQual

Furnace Brook, EWQ Station # 01445495

Activity Start	TP (mg/l)	Flow (cfs)	Database
7/12/2005 9:00	0.043	4.96	STORET
10/4/2005 9:00	0.042	1.09	STORET
4/6/2006 9:30	0.0509	8.74	STORET
7/13/2006 10:30	0.138	30.2	STORET
10/3/2006 9:30	0.0405	4.38	STORET
1/4/2007 10:00	0.047	15.9	STORET
4/3/2007 9:30	0.0372	14.1	STORET
7/23/2007 9:40	0.0421	3.58	STORET
10/15/2007 9:45	0.0582	4.96	STORET
1/17/2008 10:00	0.0324	9.35	STORET
4/10/2008 9:30	0.0337	12.7	STORET
7/24/2008 9:45	0.0507	7.85	STORET
10/20/2008 10:00	0.0335	0.84	STORET
1/21/2009 10:00	0.0347	6.81	STORET

Pequest River at Belvidere, USGS Station # 01446400

Activity Start	Flow (cfs)	TP (mg/l)	Database
11/12/1997	57	0.04	USGS
2/23/1998	310	0.03	USGS
5/4/1998	464	0.06	USGS
8/10/1998	45	0.04	USGS
11/12/1998	65	0.05	USGS
2/16/1999	242	0.04	USGS

5/12/1999	140	0.07	USGS
8/3/1999	23	0.14	USGS
11/15/1999	125	0.021	USGS
2/22/2000	210	0.039	USGS
5/4/2000	310	0.043	USGS
06/21/00	255		DRBC
07/12/00	124		DRBC
07/26/00	108	0.064	DRBC
8/1/2000	820	0.33	USGS
08/09/00	228		DRBC
08/23/00	173		DRBC
09/13/00	154		DRBC
09/29/00	104		DRBC
11/2/2000	61	0.062	USGS
2/13/2001	258	0.05	USGS
05/10/01	142	0.07	DRBC
5/16/2001	109	0.07	USGS
05/24/01	237	0.21	DRBC
06/07/01	190	0.07	DRBC
06/21/01	151	0.13	DRBC
07/12/01	99	0.11	DRBC
07/26/01	70	0.09	DRBC
08/09/01	49	0.14	DRBC
8/9/2001	38	0.132	USGS
08/22/01	49	0.12	DRBC
09/12/01	43	0.12	DRBC
09/26/01	76	0.19	DRBC
11/7/2001	31	0.22	USGS
2/14/2002	56	0.086	USGS
05/09/02	151	0.08	DRBC

05/23/02	230	0.01	DRBC
5/29/2002	293	0.26	USGS
06/04/02	121	0.08	DRBC
06/20/02	116	0.09	DRBC
07/11/02	62	0.1	DRBC
07/25/02	58	0.13	DRBC
08/08/02	40	0.13	DRBC
8/20/2002	19	0.117	USGS
08/22/02	27	0.13	DRBC
09/12/02	24	0.1	DRBC
09/26/02	25	0.1	DRBC
11/26/2002	260	0.05	USGS
3/4/2003	318	0.063	USGS
05/08/03	200	0.07	DRBC
5/13/2003	200	0.08	USGS
05/22/03	157	0.09	DRBC
06/12/03	667	0.2	DRBC
06/19/03	400	0.07	DRBC
07/10/03	210	0.06	DRBC
07/24/03	290	0.12	DRBC
08/07/03	511	0.15	DRBC
08/21/03	210	0.08	DRBC
9/4/2003	246	0.071	USGS
09/11/03	123	0.07	DRBC
09/24/03	536	0.21	DRBC
11/20/2003	1150	0.31	USGS
2/19/2004	216	0.031	USGS
5/12/2004	427	0.11	DRBC
5/20/2004	254	0.056	USGS
5/26/2004	190	0.11	DRBC

6/9/2004	149	0.09	DRBC
6/23/2004	116	0.06	DRBC
7/14/2004	121	0.1	DRBC
8/4/2004	116	0.1	DRBC
8/11/2004	77	0.05	DRBC
8/25/2004	177	0.09	DRBC
8/31/2004	122	0.067	USGS
9/15/2004	96	0.08	DRBC
9/29/2004	1697	0.22	DRBC
11/8/2004	176	0.024	USGS
2/3/2005	63	0.051	USGS
5/10/2005	215	0.035	USGS
8/4/2005	52	0.086	USGS

Periphyton Biomass Chlorophyll-a Summary

Station ID	**2004 Biomass Chlorophyll-a Summary (mg/m^2)**			**Seasonal Average (mg/m^2)**
	12-Jul-04	**8-Aug-04**	**7-Sep-04**	
Site 1 Pequest at Huntsville (most upstream extent)	23	181	234	146
Site 2 Upstream of Allamuchy STP	68	59	28	51
Site 3 Downstream of Allamuchy STP	63	46	36	48
Site 4 Mid-point between discharges	86	60	56	67
Site 5 Upstream of Oxford STP	67	516	517	333
Site 6 Downstream of Oxford STP	162	235	304	233
Site 7 Downstream Extent	28	67	177	91

Adapted from Table 4 in "Pequest River Sampling Program Results And Phosphorus Evaluations" prepared by HydroQual in December 22, 2004 for Warren County Municipal Utilities Authority.