DRAFT Total Maximum Daily Load (TMDL) Study For Dissolved Oxygen and Nutrients in the Contoocook River (Jaffrey to Peterborough)

Prepared by:

State of New Hampshire
Department of Environmental Services
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May 2006

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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(Jaffrey to Peterborough)

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INTRODUCTION

1.1 Background

Section 303(d) of the federal Clean Water Act (CWA), requires each state to submit a list (commonly called the 303(d) List), every two years to the U.S. Environmental Protection Agency (EPA). The 303(d) List must include all surface waters that are:

1. impaired or threatened by a pollutant or pollutant(s)
2. not expected to meet water quality standards within a reasonable time even after application of best available technology standards for point sources or best management practices for nonpoint sources and
3. require development and implementation of a comprehensive water quality study (i.e., called a Total Maximum Daily Load or TMDL study) that is designed to meet water quality standards.

As implied above, TMDLs are required for every surface water included on a State's 303(d) List. In general, the TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollutant sources and instream water quality conditions so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources.

1.2 Purpose of this Study

The primary purpose of this study is to prepare TMDLs for pollutants causing dissolved oxygen and/or chlorophyll a impairments (i.e., water quality standard violations) in the Contoocook River from Jaffrey to Peterborough (hereinafter referred to as the upper Contoocook River) so that water quality standards can ultimately be attained. Specific objectives of this study include the following:

1. Determine the existing sources and loadings of pollutants causing dissolved oxygen and nutrient related chlorophyll a violations in the upper Contoocook River [i.e., carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen (NH_3-N), total phosphorus (TP) and phytoplankton chlorophyll a (chl a) from sources such as wastewater treatment facilities].
2. Determine the allowable loadings of these pollutants (i.e., TMDLs) that will meet water quality standards and protect downstream interests and uses.
3. Determine the necessary load reductions from the various sources to achieve water quality standards.
4. Based on the TMDL, provide recommended NPDES permit effluent limits for the Jaffrey Wastewater Treatment Facility (WWTF).
5. Provide a recommended plan for implementing the TMDL, in phases, with the ultimate goal of attaining dissolved oxygen and chlorophyll a water quality standards in the future.

A list of the impaired waterbody segments (i.e., assessment units) within the TMDL study area is provided in section 2.2.

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PROBLEM STATEMENT

2.1 Study Area / Waterbody Description

As shown in Figure 2-1, the focus area for this TMDL includes approximately 9.5 miles of the Contoocook River and extends from the outlet at Cheshire Pond in Jaffrey to just downstream of the North Village dam in Peterborough. The watershed includes approximately 126.9 square miles of watershed area and begins at an elevation of 965 feet and ends at an elevation of 694 feet. Land uses in the watershed are shown on Figure 2-2 and are from the New Hampshire Land Cover Assessment which categorizes land cover and land use into 23 classes, based largely on the classification of Landsat Thematic Mapper (TM) imagery taken between 1990 and 2001 (NH GRANIT, 2001). Table 2-1 lists the different land use categories and the percentages of each found in the subwatershed of this study area. In general, most of the watershed is relatively undeveloped with less than 15 percent classified as urban or agriculture. Most urbanized areas are located in relatively close proximity to the Contoocook River mainstem.

The river in the focus area flows predominantly from south to north, is characterized by a well defined channel comprised of pools and riffles, three impoundments behind dams and four significant tributaries (Town Farm Brook, Gridley Brook, Meadow Brook and Nubanusit Brook). Within three miles upstream of the Cheshire Dam, there are three more dams on the mainstem. A schematic of the Upper Contoocook River showing the dams, tributaries, point sources, sampling stations and river reaches used in the QUAL2E model is provided in Figure 4-1.

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Figure 2-1: Major Features and Sampling Location Map

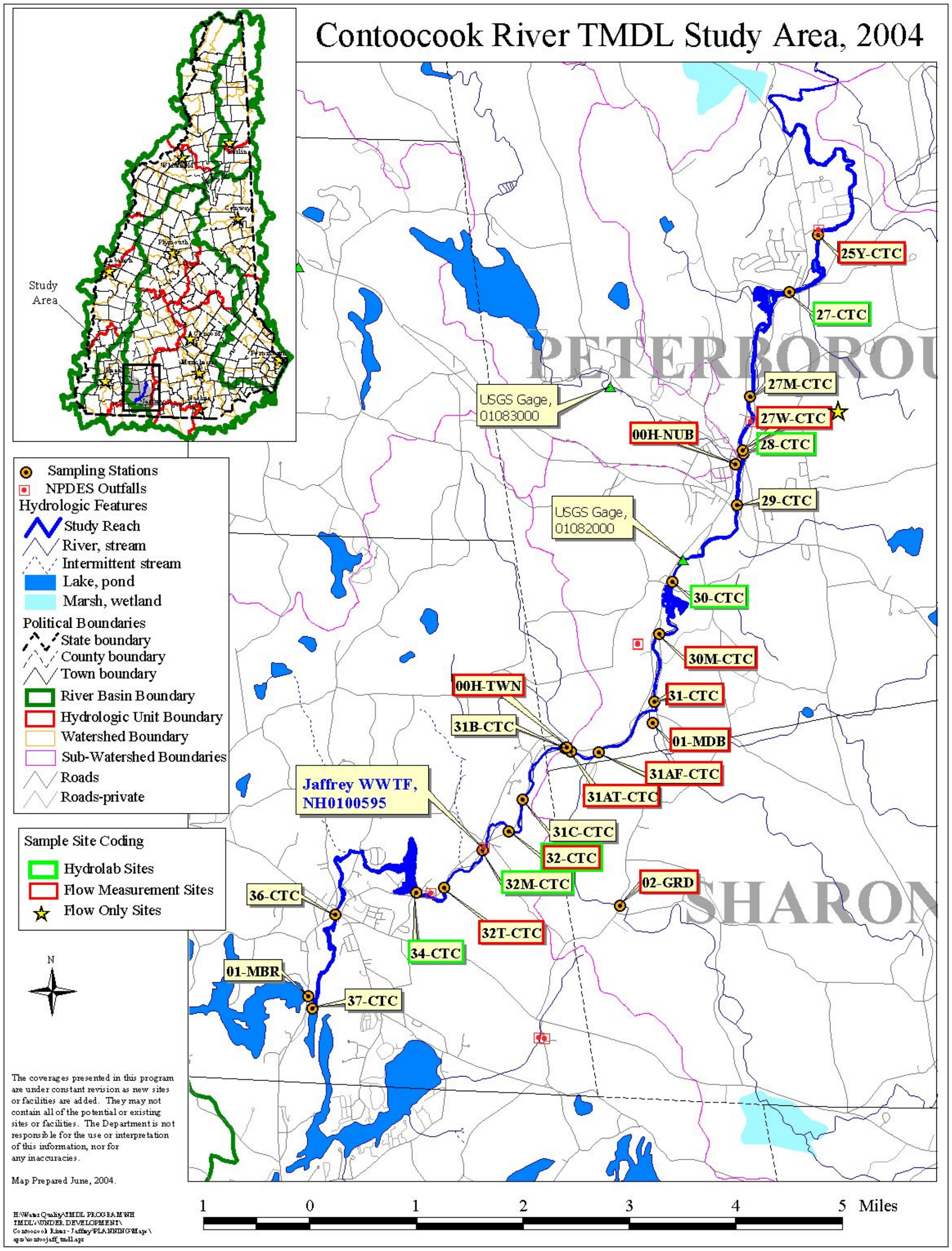

Figure 2-2: Land Use Map

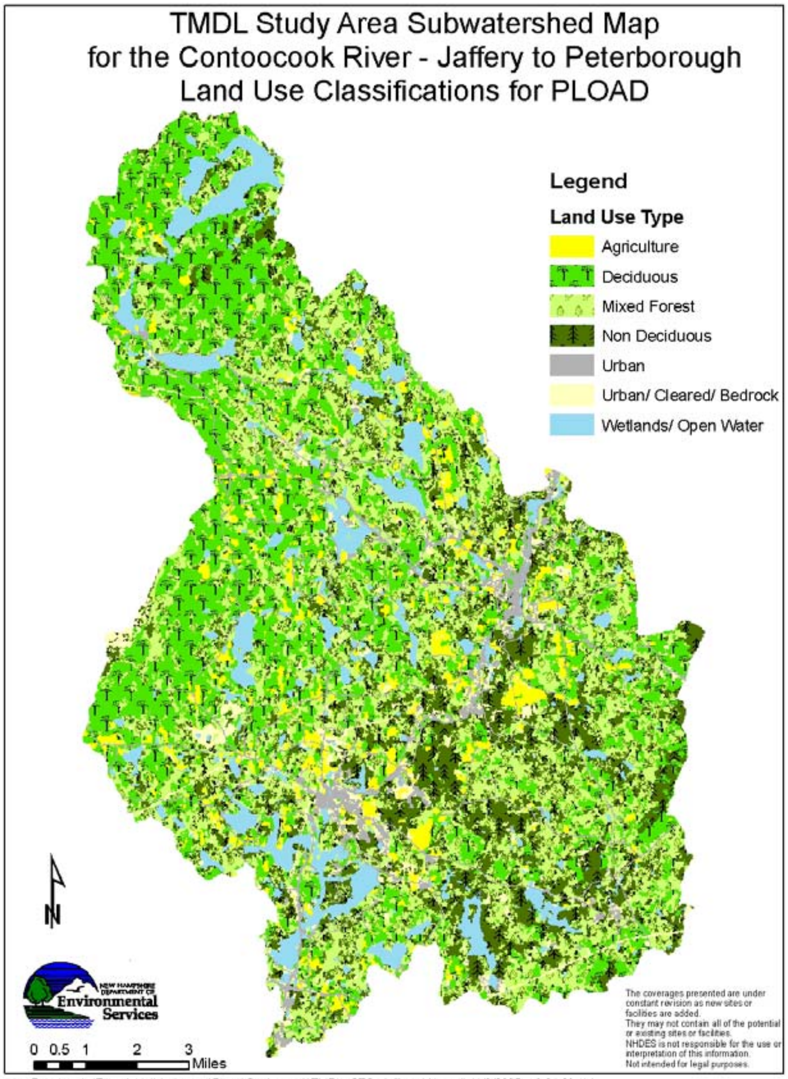

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Table 2-1: Land Uses in the Study Area

DECRIPTION OF LAND USE TYPE	Square Miles	Percent of Total
Agriculture	5.9	4.7%
Deciduous	36.7	28.9%
Mixed Forest	38.2	30.1%
Non Deciduous	23.8	18.8%
Urban	6.8	5.4%
Urban/ Cleared/Bedrock	4.3	3.4%
Wetlands/ Open Water	11.1	8.7%
Total	**126.9**	**100.0%**

2.2 Impaired Waterbody Assessment Units

Table 2-2 shows the river segments (or Assessment Units (AUs)) in the upper Contoocook River that were included on the 2006 303(d) List of impaired waters submitted to EPA for final approval on March 31, 2006. This table also shows the pollutants causing impairment and the designated uses that are impaired. A map showing the location of the impaired AUs is provided in Figure 2-3. The list of the current impairments presented in Table 2-2 was prepared in accordance with New Hampshire's 2006 Consolidated Assessment and Listing Methodology (NHDES, 2005).

Of the 11 AU's within the study area that were modeled, 9 of the AU's are currently listed as impaired, some for more than one pollutant of concern. As shown in Table 2-2, causes of impairment include dissolved oxygen, phosphorus, chlorophyll a, Escherichia coli, pH and copper. In addition, all surface waters in New Hampshire (as well as many other surface waters in the northeast) are also impaired for fish consumption due to atmospheric deposition of mercury. This is based on a statewide fish consumption advisory issued in 1994 due to elevated levels of mercury in fish tissue.

This TMDL study specifically addresses the following causes of impairment: dissolved oxygen, phosphorus and chlorophyll-a. Other TMDLs will need to be developed in the future to address the remaining impairments. NHRIV700030104-03 is listed as impaired because of measured dissolved oxygen violations. All other dissolved oxygen, phosphorus and chlorophyll a impairments are based on predicted water quality violations from modeling conducted for this study. Because they are based on predictions rather than ambient measurements, they are listed as threatened rather than impaired in accordance with the assessment methodology (NHDES, 2006) The modeling runs used to determine the threatened waters are discussed in section 5.3.

Table 2-2: 2006 303(d) List of Impaired Waters for the "Upper" Contoocook River

Assessment Unit ID	Assessment Unit Name	Model Reaches[1]	Designated Use	Pollutant of Concern	Pollutant – Assessed Category[2]	Measured WQS Violation	Threatened[3]
NHRIV700030101-16	Contoocook River, CWF	2, 3, 4, 5, & 6	Aquatic Life	Copper	4B-T		Y
				Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-T		Y
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Escherichia coli	5-M	Y	
				Phosphorus (Total)	5-T		Y
NHRIV700030101-17	Contoocook River, CWF	6 & 7	Aquatic Life	Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-T		Y
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Phosphorus (Total)	5-T		Y
NHRIV700030104-03	Contoocook River, CWF	8, 9, 10, & 11	Aquatic Life	Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-P	Y	Y

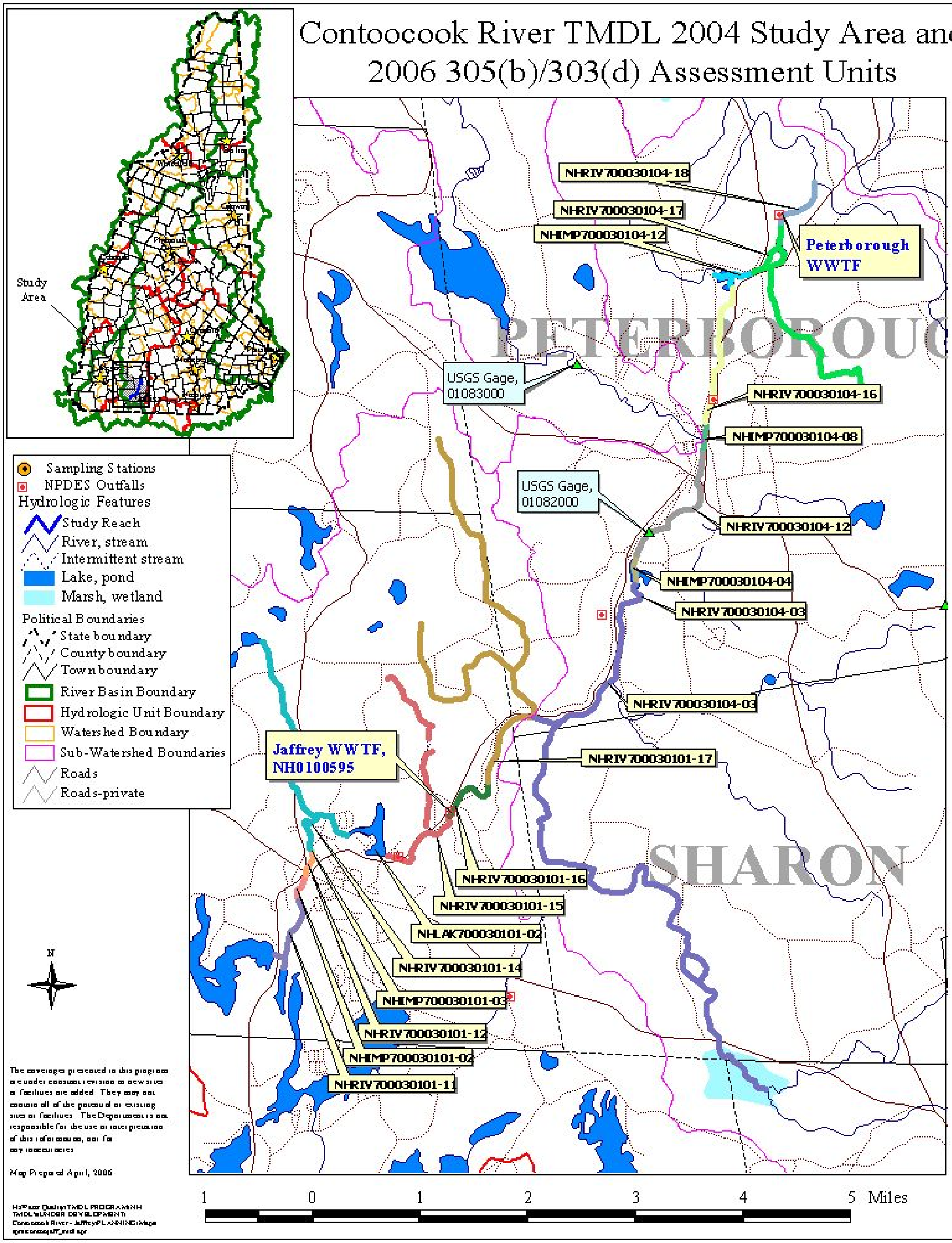
Assessment Unit ID	Assessment Unit Name	Model Reaches[1]	Designated Use	Pollutant of Concern	Pollutant – Assessed Category[2]	Measured WQS Violation	Threatened[3]
				pH	5-P	Y	
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Phosphorus (Total)	5-T		Y
NHIMP700030104-04	Contoocook River, IMP, CWF	8 & 11	Aquatic Life	Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-T		Y
				pH	5-M	Y	
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Phosphorus (Total)	5-T		Y
NHRIV700030104-12	Contoocook River, CWF	13	Aquatic Life	Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-T		Y
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Phosphorus (Total)	5-T		Y
NHIMP700030104-08	Contoocook River, IMP, CWF	14	Aquatic Life	Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-T		Y
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Phosphorus (Total)	5-T		Y
NHRIV700030104-16	Contoocook River, CWF	15 & 16	Aquatic Life	Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-T		Y
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Phosphorus (Total)	5-T		Y
NHIMP700030104-12	CONTOOCOOK RIVER, IMP	16	Aquatic Life	Dissolved Oxygen Saturation	5-T		Y
				Oxygen, Dissolved	5-T		Y
				Phosphorus (Total)	5-T		Y
			Primary Contact Recreation	Chlorophyll-a	5-T		Y

Assessment Unit ID	Assessment Unit Name	Model Reaches[1]	Designated Use	Pollutant of Concern	Pollutant – Assessed Category[2]	Measured WQS Violation	Threatened[3]
				Phosphorus (Total)	5-T		Y
NHRIV700030104-17	Contoocook River, CWF	17	Aquatic Life	pH	5-M	Y	
			Primary Contact Recreation	Chlorophyll-a	5-T		Y
				Escherichia coli	5-M	Y	
				Phosphorus (Total)	5-T		Y

Notes:
1- Model reaches reported are best match
2- Pollutant – Assessed Category is based upon the
- 4B-T – Parameter is impaired but does not require development of a TMDL because other pollution control requirements are reasonably expected to result in attainment of the water quality standard in the near future. Additionally, the impairment is based upon a WWTF in significant non-compliance with its NPES permit and no on measured instream concentration.
- 5-M – Parameter is impaired and requires a TMDL (5). The degree of exceedance of the WQ criteria is small (M).
- 5-P – Parameter is impaired and requires a TMDL (5). The degree of exceedance of the WQ criteria is severe (P).
- 5-T – Parameter is threatened and requires a TMDL (5). The impairment is based upon a calibrated water quality model that predicts exceedance of the WQ criteria at full design flow and limiting conditions (T).

3- Threatened means that either an effluent parameter is in significant non-compliance with the approved NPDES permit (4B-T) and/or a calibrated water quality model indicates that under full design flow and limiting conditions the NPDES permit would result in WQS exceedances (5-T).

Figure 2-3 Location of 303(d) Listed Waters in the "Upper" Contoocook River.



3 Applicable Water Quality Standards and Targets

3.1 Water Quality Standards - Overview

In general, water quality standards provide the baseline quality that all surface waters of the State must meet in order to protect their intended uses. They are the "yardstick" for identifying where water quality violations exist and for determining the effectiveness of regulatory pollution control and prevention programs.

Env-Ws 1700 includes the State's surface water quality regulations (NHDES, 1999). A downloadable copy of the regulations may be obtained from www.des.state.nh.us/wmb/wmbrules.htm.

The standards are composed of three parts: designated uses, water quality criteria, and antidegradation. Each of these components is briefly discussed below.

Designated Uses

All surface waters of the State are either classified as Class A or B, with the majority of waters being Class B. DES maintains a list that includes a narrative description of all the legislative classified waters. Designated uses represent the desired uses that a waterbody should support. As indicated below, State statute RSA 485-A:8 is quite general with regards to designated uses for New Hampshire surface waters.

Classification	Designated Uses as described in RSA 485-A:8
Class A -	These are generally of the highest quality and are considered potentially usable for water supply after adequate treatment. Discharge of sewage or wastes is prohibited to waters of this classification.
Class B -	Of the second highest quality, these waters are considered acceptable for fishing, swimming and other recreational purposes, and, after adequate treatment, for use as water supplies.

Further review and interpretation of the regulations (Env-Ws 1700), however, reveals that the general uses can be expanded and refined to include the seven specific designated uses shown in Table 3-1. These uses must be protected in New Hampshire surface waters.

Water Quality Criteria

The second major component of the water quality standards is the "criteria". Criteria are designed to protect the designated uses of all surface waters and may be expressed in either numeric or narrative form. A waterbody that meets the criteria for its assigned classification is considered to meet its intended use. Water quality criteria for each classification may be found in RSA 485-A:8, I-V and in the State's surface water quality regulations (NHDES, 1999).

Antidegradation

The third component of water quality standards is antidegradation which are provisions designed to preserve and protect the existing beneficial uses and to minimize degradation of the State's surface waters. Antidegradation regulations are included in Part Env-Ws 1708 of the State's surface water quality regulations (NHDES, 1999). According to Env-Ws 1708.03, antidegradation applies to the following:

- Any proposed new or increased activity, including point and nonpoint source discharges of pollutants that would lower water quality or affect the existing or designated uses;
- a proposed increase in loadings to a waterbody when the proposal is associated with existing activities;
- an increase in flow alteration over an existing alteration; and
- all hydrologic modifications, such as dam construction and water withdrawals.

Table 3-1: Designated Uses for New Hampshire Surface Waters

Designated Use	DES Definition	Applicable Surface Waters
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers	All tidal surface waters
Drinking Water Supply	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.	All surface waters
Primary Contact Recreation (i.e. swimming)	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

3.2 Pollutants of Concern that Require a TMDL

As discussed in Section 2.2, the upper Contoocook River is listed as impaired for dissolved oxygen, phosphorus and chlorophyll a. To achieve water quality standards, it will be necessary to establish and implement TMDLs for total phosphorus (TP), carbonaceous biochemical oxygen demand (CBOD), ammonia-nitrogen (NH_3-N) and phytoplankton chlorophyll a (chl a). Reasons why these pollutants were selected are provided below:

Surface waters must contain sufficient levels of dissolved oxygen to support aquatic life such as fish. Primary pollutants impacting dissolved oxygen in surface waters include CBOD and nutrients (phosphorus and nitrogen).

CBOD is a measure of the oxygen demand caused by microbial degradation of organic matter in surface water. Sources of organic matter can include wastewater treatment facilities (WWTF) discharges, stormwater runoff, wetlands and fallen leaves. Organic matter which settles on the river bottom can consume oxygen at the sediment interface and contribute to what is called the sediment oxygen demand or SOD. Surface waters with high SOD can lower dissolved oxygen levels in the water column above.

Nutrient and algal loadings control the amount of algal growth in surface waters. Algal concentrations are often expressed in terms of chlorophyll a, which is a substance that all algal contain. Algae that are unattached and suspended in the water column are termed phytoplankon and algae that are attached to surfaces such as the river bottom or substrate are termed periphyton. It is well documented that phosphorus is the limiting nutrient impacting algal growth in most freshwaters. Consequently most efforts to control algal focus on reducing phosphorus loadings. Although control of phosphorus is important, it is also important to evaluate algal loadings coming directly from WWTF discharges. As will be shown, the concentration of algae in WWTF effluent can be a major source of algae in downstream receiving waters.

Algae serve as both a source and sink of dissolved oxygen. During daylight hours, algae produce oxygen through photosynthesis and there is often a net increase in oxygen. At other times, however, oxygen levels tend to decrease as a result of algal respiration and microbial degradation of the dead algae. Dead algae that settle on the river bottom, is a form of organic matter that can increase the SOD and result in lower levels of oxygen in the water column. In addition to its impact on dissolved oxygen and aquatic life, algae can also impact recreational uses such as swimming. That is high levels of algae can decrease water clarity, make channel bottoms slippery and, in general, make a water less safe and appealing for recreational uses.

Lastly, WWTF discharges often contain relatively high levels of ammonia. Oxidation of ammonia to nitrite and nitrate is another important potential sink of oxygen especially in receiving waters such as the upper Contoocook River. In addition to decreasing oxygen levels, ammonia can also be toxic to aquatic life if levels are allowed to exceed water quality criterion for the protection of aquatic life.

In summary, to meet water quality standards in the upper Contoocook River for dissolved oxygen and algae, it is necessary to specify allowable loadings (i.e., TMDLs) for CBOD, TP, NH_3-N and Phytoplankton Chl a. Control of CBOD and NH_3-N is necessary to meet dissolved oxygen standards and to protect aquatic life. Control of NH_3-N is also necessary to protect aquatic life from potentially toxic effects of ammonia. Control of TP and Phytoplankton Chl a is necessary to control the amount of algae in the Contoocook River so that dissolved oxygen and algae criteria are met for the protection of aquatic life and recreational uses respectively.

3.3 Applicable Water Quality Criteria from Regulations (Env-Ws 1700)

The Contoocook River in the study area is a Class B surface water. According to the NH Fish and Game Department (NHFG) the mainstem is not considered a cold water fishery, however some of the tributaries are. Even though it is not a cold water fishery, NHFG annually stocks the mainstem and tributaries with Atlantic salmon fry which spend two years in the watershed before heading to the ocean (personal communication with Bill Ingham of the NHFG). With this in mind, applicable water quality standards from the New Hampshire Surface Water Quality Regulations (Env-Ws 1700) for dissolved oxygen, nutrients (phosphorus, nitrogen and ammonia) and algae, include the following:

3.3.1 Dissolved Oxygen (Env-Ws 1700)

Env-Ws 1703.07 Dissolved Oxygen.

(b) Except as naturally occurs, or in waters identified in RSA 485-A:8, III, or subject to (c) below, class B waters shall have a dissolved oxygen content of at least 75% of saturation, based on a daily average, and an instantaneous minimum dissolved oxygen concentration of at least 5 mg/l.

(d) Unless naturally occurring or subject to (a) above, surface waters within the top 25 percent of depth of thermally unstratified lakes, ponds, impoundments and reservoirs or within the epilimnion shall contain a dissolved oxygen content of at least 75 percent saturation, based on a daily average and an instantaneous minimum dissolved oxygen content of at least 5 mg/l. Unless naturally occurring, the dissolved oxygen content below those depths shall be consistent with that necessary to maintain and protect existing and designated uses.

3.3.2 Nutrients and Algae (Env-Ws 1700)

Env-Ws 1703.14 Nutrients

(b) Class B waters shall contain no phosphorus or nitrogen in such concentrations that would impair any existing or designated uses, unless naturally occurring.

(c) Existing discharges containing either phosphorus or nitrogen which encourage cultural eutrophication shall be treated to remove phosphorus or nitrogen to ensure attainment and maintenance of water quality standards.

(d) There shall be no new or increased discharge of phosphorus into lakes or ponds.

(e) There shall be no new or increased discharge(s) containing phosphorus or nitrogen to tributaries of lakes or ponds that would contribute to cultural eutrophication or growth of weeds or algae in such lakes and ponds.

Env-Ws 1703.19 Biological and Aquatic Community Integrity

(a) The surface waters shall support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

(b) Differences from naturally occurring conditions shall be limited to non-detrimental differences in community structure and function.

Env-Ws 1702.07 "Biological integrity" means the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

Env-Ws 1702.13 "Community" means one or more populations co-occurring in surface waters.

Env-Ws 1702.15 "Cultural eutrophication" means the human-induced addition of wastes containing nutrients to surface waters which results in excessive plant growth and/or a decrease in dissolved oxygen.

3.3.3 Ammonia (Env-Ws 1700)

Env-Ws 1703.25 includes freshwater acute and chronic aquatic life criteria for ammonia which are pH dependent. Shortly after New Hampshire’s surface water quality regulations (Env-Ws 1700) were adopted, EPA published revised ammonia criteria which include acute criteria that are pH dependent and chronic criteria that are pH and temperature dependent (USEPA, 1999).

Since 1999, NPDES permits have been issued using the revised ammonia criteria based on Env-Ws 1704.01(c) which allows the department to use alternative site specific criteria when new information not included in the development of the criteria, is available. Excerpts from Env-Ws 1704.01 are provided below and ammonia criteria from EPA’s 1999 guidance are provided in Table 3-2. The acute values shown in Table 3-2 are based on salmonids being present and the chronic values are based on early life stages being present. Justification for this is based on conversations with the NH Fish and Game Department (NHFG). As previously mentioned, the NHFG does not consider the mainstem of the Contoocook River to be a cold water fishery, however some of the tributaries are cold water fisheries. Even though the mainstem is not a cold water fishery, NHFG annually stocks the mainstem and tributaries with Atlantic salmon fry which spend two years in the watershed before heading to the ocean. Consequently, to protect the salmon fry, acute ammonia criteria must be based on salmonids being present and chronic criterion must be protective of early life stages.

Env-Ws 1704 ALTERNATIVE SITE SPECIFIC CRITERIA

Env-Ws1704.01Purpose The purpose of this part is to develop a procedure for determining alternative site specific criteria in the following cases:

(a) For toxic substances not listed in Env-Ws 1703.21 through Env-Ws 1703.32;

(b) Where site specific information is available which substantiates the use of different criteria; or

(c) Where new information, not considered in the development of the criteria, is available.

Table 3-2: Ammonia Criteria from USEPA, 1999.

pH	Acute Criteria mg NH_3-N/L	Chronic Criteria mg NH_3-N/L							
		Temperature, degrees C							
		0	14	16	18	20	22	24	26
6.5	32.6	6.67	6.67	6.06	5.33	4.68	4.12	3.62	3.18
6.6	31.3	6.57	6.57	5.97	5.25	4.61	4.05	3.56	3.13
6.7	29.8	6.44	6.44	5.86	5.15	4.52	3.98	3.50	3.07
6.8	28.1	6.29	6.29	5.72	5.03	4.42	3.89	3.42	3.00
6.9	26.2	6.12	6.12	5.56	4.89	4.30	3.78	3.32	2.92
7.0	24.1	5.91	5.91	5.37	4.72	4.15	3.65	3.21	2.82
7.1	22.0	5.67	5.67	5.15	4.53	3.98	3.50	3.08	2.70

3.3.4 Assimilative Capacity (Env-Ws 1700)

Env-Ws 1702.03 "Assimilative capacity" means the amount of a pollutant or pollutants that can safely be released to a waterbody without causing violations of applicable water quality criteria or negatively impacting uses.

Env-Ws 1705.01 Assimilative Capacity. Except for combined sewer overflows where 99 percent of the assimilative capacity shall be used to determine compliance, not less than 10 percent of the assimilative capacity of the surface water shall be held in reserve to provide for future needs.

3.3.5 Critical River Flow at which Criteria Apply (Env-Ws 1700)

Env-Ws 1705.02 Low Flow Conditions.

(a) The flow used to calculate permit limits shall be as specified in (b) through (d) below.

(d) For rivers and streams, the 7Q10 flow shall be used to apply aquatic life criteria and human health criteria for non-carcinogens.

3.4 Applicable Water Quality Criteria from the CALM

The Consolidated Assessment and Listing Methodology (CALM) describes the process used by DES to assess NH surface waters in accordance with current water quality standards for 305(b) reporting and 303(d) listing purposes. The CALM is updated every two years. A draft of the 2006 CALM was made available for public comment. A copy of the final 2006 CALM (NHDES, 2005) is available at www.des.state.nh.us/wmb/swqa.

The CALM includes quantification of narrative criterion in Env-Ws 1700 to facilitate assessments and determination of impaired waters. Such quantitative interpretations are considered part of New Hampshire's water quality standards. Pertinent numeric criteria from the CALM that aren't already addressed in Section 3.2 are provided below.

3.4.1 Phytoplankton Chlorophyll a (CALM)

According to the 2006 CALM (NHDES, 2005), the maximum phytoplankton chlorophyll a level in fresh surface waters to protect primary contact recreation uses is 15 ug/L. This numeric criterion is quantitative interpretation of the narrative criterion included in Env-Ws 1703.14(b) and Env-Ws 1703.14(e).

3.4.2 Periphyton Chlorophyll a (future CALM)

In addition to phytoplankton chlor a, future versions of the CALM are expected to include numeric criterion for bottom attached algae, or periphyton. It is expected that the criterion will specify a maximum of 9.4 mg/ft2 of periphyton chlor a, which is consistent with what literature suggests as the threshold when primary contact recreation (or aesthetic values) begin to be impaired (USEPA, 2000). This numeric criterion is quantitative interpretation of the narrative criterion included in Env-Ws 1703.14(b) and Env-Ws 1703.14 (e).

3.5 Water Quality Targets to Protect Downstream Interests / Uses

In addition to the above, it is prudent to also set water quality targets at the downstream end of the TMDL to make sure that the TMDL does not cause problems further downstream or result in unreasonably high background conditions at downstream wastewater treatment facilities. This is a concern to downstream WWTFs because higher background levels can result in more stringent WWTF effluent limits.

For this TMDL, downstream levels are of most concern because of their potential impact on the Peterborough WWTF and Powder Mill Pond. The study area for this TMDL ends just upstream of the location of the Peterborough WWTF outfall. Powder Mill Pond is located approximately 6 miles downstream from the Peterborough WWTF. A TMDL from the Peterborough WWTF to just downstream of the Antrim WWTF, (i.e., the mid-Contoocook River TMDL) is scheduled to be completed in 2007. Downstream conditions from this TMDL will be used as a background conditions for the mid-Contoocook River TMDL in 2007. As previously stated, background conditions can significantly impact Peterborough's WWTF effluent limits. Background conditions are also of concern to Powder Mill Pond because it is currently listed as impaired for dissolved oxygen and phytoplankton chlorophyll a on the 2006 303(d) list. This is another reason why it is important to make sure that the downstream levels from this TMDL, (which will serve as background levels for the mid-Contoocook TMDL in 2007), are maintained a reasonable levels.

When conducting TMDLs on different sections of a river in different years, sampling results are typically used as the basis for establishing background conditions. Consistent with past practice, this is how downstream target values were established for this TMDL. Table 3-3 shows sampling results for dissolved oxygen, CBODU, TP, and Phytoplankton Chl a at Station 25Y-Ctc which is located at the downstream end of this TMDL (i.e., Reach 17) and just upstream of the Peterborough WWTF. Values for the same parameters, but upstream of the Jaffrey WWTF are also shown for comparison. The target values selected for this study to protect downstream users and interests are shown in the column labeled "Reach 17 Target Value Used in Analysis". As shown, the target values in Reach 17 are comparable to those background levels used in this study upstream of the Jaffrey WWTF with the exception of TP. TP levels upstream of Jaffrey were approximately 15 ppb whereas the target value based on measured values upstream of the Peterborough WWTF is 28 ppb.

Table 3-3: Downstream (Reach 17) Water Quality Targets for DO, CBODU, TP and Phyto Chl a

Sample Date	Upstream of Jaffrey WWTF Station 32M-Ctc	Upstream of Peterborough WWTF Station 25Y-Ctc (Reach 17)	Reach 17 Target Value Used in Analysis
Dissolved Oxygen (Ave Daily % Saturation)			
8/4/2004	79.9%	79.9%	
8/11/2004	81.7%	81.4%	
8/14/2002		87.0%	**≥ 82.8%**
8/22/2002	Not representative of steady state conditions		
Average	80.8%	82.8%	
CBODU (mg/L)			
8/4/2004	1.6	2.9	
8/11/2004	2.2	0.6	
8/14/2002		1.4	**≤ 2.0**
8/22/2002	Not representative of steady state conditions		
Average	1.9	1.7	
TP (ug/L)			
8/4/2004	16.0	31.0	
8/11/2004	15.0	28.0	
8/14/2002		35.0	**≤ 28.0**
8/22/2002	Not representative of steady state conditions		
Average	15.5	31.3	
Phytoplankton Chl a (mg/L)			
8/4/2004	2.3	2.7	
8/11/2004	2.2	1.6	
8/14/2002		1.4	**≤ 2.0**
8/22/2002	Not representative of steady state conditions		
Average	2.2	1.9	

3.6 Summary of TMDL Water Quality Criteria and Targets

Based on the information provided in the previous sections, a summary of the water quality criteria and targets used for this TMDL is provided in Table 3-4 below. As shown, a margin of safety (MOS) has been applied to the water quality criteria. This was done to account for uncertainty in the model used to develop this TMDL (see section 8.1) and to help ensure that the loadings recommended in this TMDL will meet water quality standards. The MOS was not applied to the downstream (Reach 17) targets as these are not actual water quality standards. That is, the downstream targets are values which should be met but can be slightly exceeded if deemed appropriate. Since there is some flexibility associated with meeting the target values inclusion of a MOS was not considered necessary.

Table 3-4: Summary of TMDL Water Quality Criteria and Targets

Parameter	Units	Target without Margin of Safety (MOS)	MOS[3]	Water Quality Criteria and Targets Used in TMDL
Average Daily Dissolved Oxygen [1,4]	%	≥ 75	10%	≥ 77.5
Instantaneous Minimum Dissolved Oxygen [1,4]	mg/L	≥ 5.0	10%	≥ 5.33
Chronic Ammonia Nitrogen [1,2,4]	mg/L	2.71	10%	2.4
Acute Ammonia Nitrogen [1,2,4]	mg/L	21.69	10%	19.28
Phytoplankton chlor a [1,4]	ug/L	≤ 15	10%	≤ 13.5
Periphyton chlor a [1,4]	mg/ft^2	≤ 9.3	10%	≤ 8.4
Downstream Targets (Reach 17)				
Reach 17 Ave Daily DO	%	≥ 82.8	0%	≥ 82.8
Reach 17 CBODU	mg/L	≤ 2.0	0%	≤ 2.0
Reach 17 TP	ug/L	≤ 28	0%	≤ 28
Reach 17 Phytoplankton Chl a	ug/L	≤ 2.0	0%	≤ 2.0

Note:

1. Dissolved Oxygen criteria apply at all depths in rivers and streams and within the top 25 percent of depth of thermally unstratified lakes, ponds, impoundments and reservoirs or within the epilimnion (per Env-Ws 1703.07(d) – see section 3.3.1).
2. There are currently no known violations of ammonia toxicity criterion. Consequently, it is necessary to reserve 10 % of the assimilative capacity for future growth in accordance with Env-Ws 1705.01. This is accomplished by multiplying the criterion by 0.9.
3. A margin of safety (MOS) of 10% is factored into water quality criteria to account for sampling error and model uncertainty. The MOS was not applied to the downstream targets as these are targets and not actual water quality standards.
4. Calculations:

   Average Daily DO: 75+ 0.1x(100-75) = 77.5%

   Minimum DO (based on DO saturation of 8.26 mg/L at critical temperature of 25 deg C – see section 3.3.1): 5 + 0.1x(8.26-5.0) = 5.33 mg/L

   Chronic NH_3-N (based on critical temperature of 25 deg C and pH of 7.0 – see Note 2 for assimilative capacity factor of 0.9,

   Table 3-2 for NH3-N criteria and Table 3-5 for pH):
   0.9 x 3.01 – 0.1x 3.01 = 2.40 mg/L

   Acute NH_3-N (based on pH of 7.0 - see Note 2 for assimilative capacity factor of 0.9, Table 3-2 for NH3-N criteria and Table 3-5 for pH):
   0.9 x 24.1 – 0.1x 24.1 = 19.28 mg/L

   Phyto chl a: 15 – (0.1 x 15) = 13.5 ug/L

   Periphyton : 9.3 – (0.1x9.3) = 8.4 mg/ft^2

Table 3-5: Contoocook River pH Downstream of Jaffrey WWTF

Approximate Distance Downstream of Jaffrey WWTF (miles)	Station ID	Average pH	Count of pH
0.05	32A-CTC	6.75	2
0.36	32-CTC	6.78	6
0.74	31C-CTC	7	2
1.48	31B-CTC	7	2
1.95	31A-CTC	6.95	2
2.48	31-CTC	6.9	2
3.67	30-CTC	6.13	9
	Average	6.6	25

Note: For ammonia criteria, use pH of 7.0 (average of 6 samples 0.74 to 1.95 miles downstream of Jaffrey WWTF).

4

EXISTING POINT AND NONPOINT SOURCE LOADS

4.1 Existing Point Sources (PS) –General Description

Point sources (PS) are discernable, confined, and discrete conveyances such as the discharge from the effluent pipes of wastewater treatment plants. In addition, discrete stormwater discharges from municipal separate storm sewer systems (MS4) covered by the Phase II stormwater program regulations are considered point sources by EPA. All point source discharges must have a State Surface Water Discharge permit and a federal National Pollution Discharge Elimination (NPDES) discharge permit.

The only significant point source discharge to the Contoocook River in the study area is the Jaffrey municipal wastewater treatment facility (WWTF) (see Figure 2-1). The Jaffrey WWTF is a 1.25 million gallons per day (mgd), secondary wastewater treatment plant that discharges to the Contoocook River.

The towns of Jaffrey and Peterborough are not covered by the EPA Phase II Small Municipal Separate Storm Sewer System (MS4) General Permit. Therefore stormwater runoff from these communities is categorized as a nonpoint source in this TMDL.

4.2 Existing Non-Point Sources (NPS) – General Description

In general, non-point sources (NPS) of pollutants are pollutant sources other than point sources. Compared to point sources, NPSs of pollution are diffuse and more difficult to quantify. Examples of NPSs include stormwater runoff not covered under the NPDES MS4 General Stormwater permit and other diffuse sources such as groundwater and failed septic systems.

The major nonpoint source associated with this TMDL is stormwater runoff from surrounding land uses. Potential groundwater sources of pollutants include the closed/capped Jaffrey municipal landfill, and the New Hampshire Ball Bearing Superfund clean up site in Peterborough (see Figure 2-1).

Wildlife can also be a form of nonpoint source pollution. In the vicinity of the Cheshire Pond dam, large amounts of goose droppings have been observed. Such droppings contain significant amounts of organic matter which, when degraded by microbes, can reduce oxygen levels in the surrounding surface waters.

4.3 Methodology for Calculating Existing Load Contributions (Component Analysis)

4.3.1 Model Selection – QUAL2E

Because of the complex interactions between dissolved oxygen, CBOD, nutrients and algae it is necessary to use a water quality model to determine existing and allowable loadings that will result in attainment of water quality standards. For this study, the QUAL2E model was used. QUAL2Ev5 is a one dimensional stream water quality model that can simulate the major reactions of nutrient cycles, algal production (phytoplankton and periphyton), benthic (i.e., sediment) and carbonaceous oxygen demand, atmospheric reaeration and their effects on the dissolved oxygen balance. The model is applicable to branched stream networks that are well mixed and it can simulate up to 17 water quality constituents. It assumes the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (longitudinal axis of the stream) and allows for multiple discharges, withdrawals, tributary flows, and incremental inflow and outflow. The use of QUAL2E as a water quality planning tool is well documented (Brown, 2003). Calibration and verification of the model is discussed in the next section.

4.3.2 QUAL2E – Calibration and Verification

Once an appropriate model has been chosen, the model must be calibrated. Typically, this is accomplished by collecting two sets of data under differing flow conditions. One data set is picked for calibration and input into the model. Model variables are then adjusted until a good fit between observed and predicted data is obtained. Using the calibration model variables, the second (i.e., verification) data set is then input to see how well the observed and predicted data match and to verify that the model reasonably simulates river water quality under various conditions. If there is good agreement with the verification data set, the model is said to be calibrated. Once calibrated, other conditions of river flow, water temperature and wastewater pollutant loadings can be simulated to predict the effect of these changes on river water quality. A complete description of how the QUAL2E model was calibrated for this study is provided in Appendix A. A copy of the river schematic showing the sampling stations, major sources, dams and river reaches is provided in Figure 4-1.

4.3.3 Base Condition for Calculating Existing Loads

Once the model is calibrated, a base condition is then established to determine the relative contribution of pollutant loads from the various sources under existing conditions. In general this was done by averaging the source inputs in the calibration and verification runs and then adjusting the river flow and water temperature to reflect conditions when dissolved oxygen is likely to be lowest and algal growth the highest. Such conditions are called worse case or critical conditions and are discussed in detail in section 5.1 Details regarding modeling input for the base condition are provided in section 5.2. A copy of the model input file for the base condition is provided in Appendix D.

4.3.4 Determination of Percent Contribution of PS and NPS Loads (Component Analysis)

To determine the percent contribution of point source (PS) and nonpoint source (NPS) loads at various points along the river, a component analysis was conducted. This was accomplished by doing the following:

- Selecting a parameter that could potentially impact dissolved oxygen or algal levels (TP, NH3-N, Chl a, or CBODU)
- Selecting a source (WWTF, tributaries, headwater, or incremental inflow)
- Setting the selected parameter concentration equal to zero for the selected source
- Comparing the model output to the base condition discussed in section 4.3.3 to determine the percent contribution of the parameter attributable to that source at various locations along the river
- Repeating the process for the other sources and parameters

4.4 <u>Component Analysis Results</u>

Results of the component analysis are presented in Table 4-1 through Table 4-4 and in graphical form (pie charts) below each table. As previously mentioned, the Jaffrey WWTF is the only point source in the study area. All other sources (tributaries, headwater and incremental inflow) are considered nonpoint sources.

The percent of TP contributed by each source is shown in Table 4-1. As indicated, point sources (i.e., the WWTF) contribute between 0 and 97percent and nonpoint sources between 3 and 100 percent of the total TP in the study area. Point source impacts are highest just downstream of the WWTF in Reach 3 (97 percent of total TP). At the end of the study area (Reach 17) the point source contribution drops to 75 percent of the total TP. Upstream of Reach 3, 100 percent of the TP is due to nonpoint sources

Figure 4-1: Schematic used for Modeling the upper Contoocook River

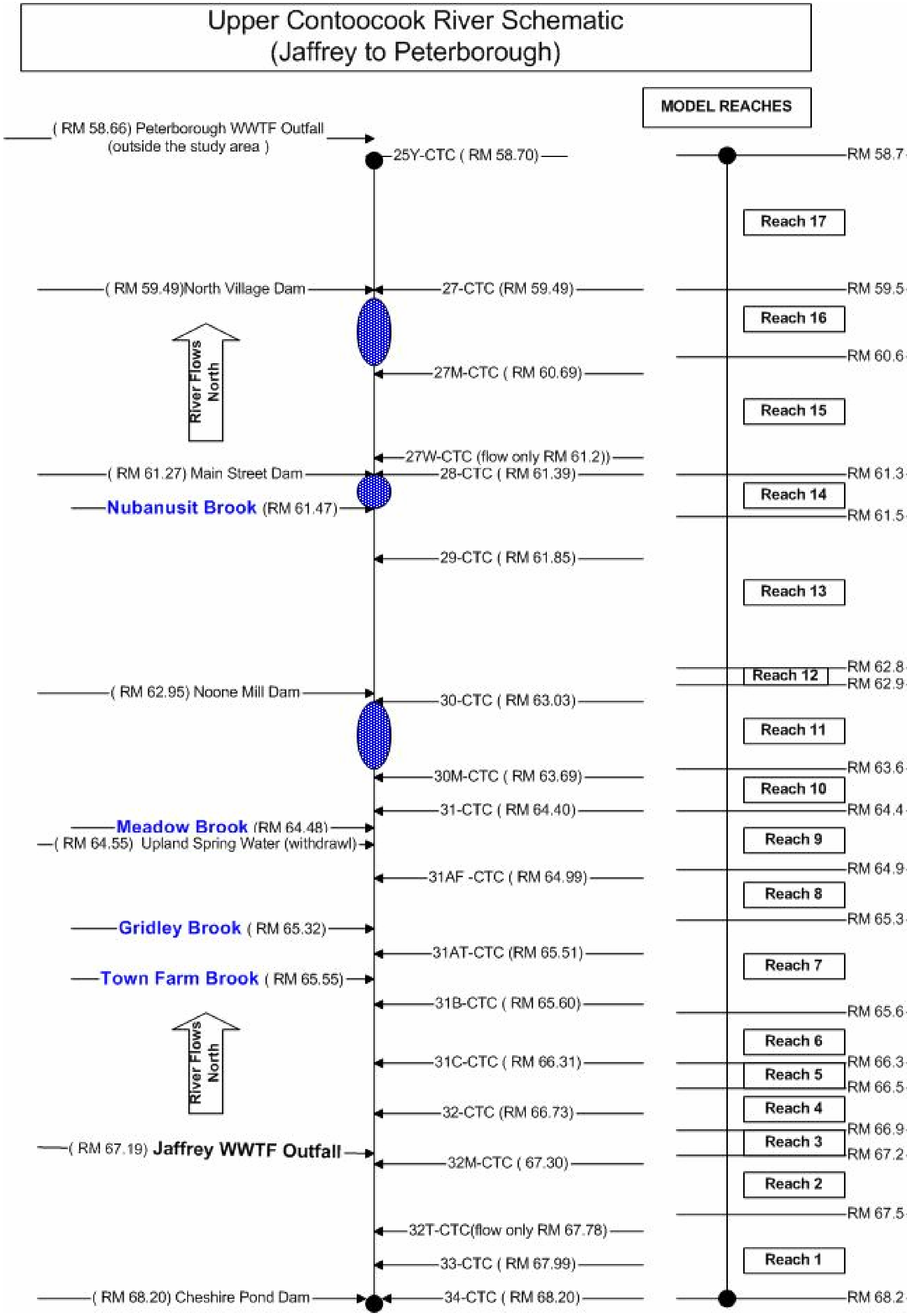
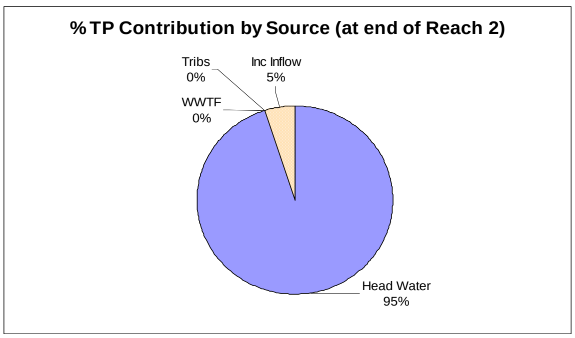
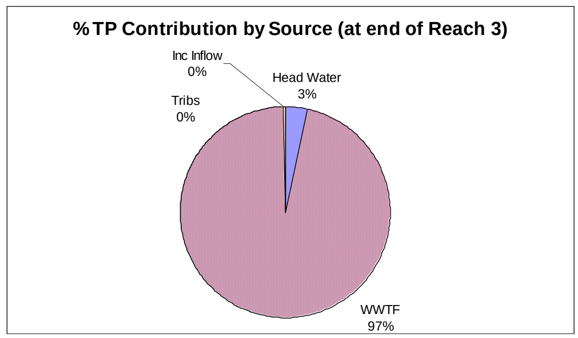
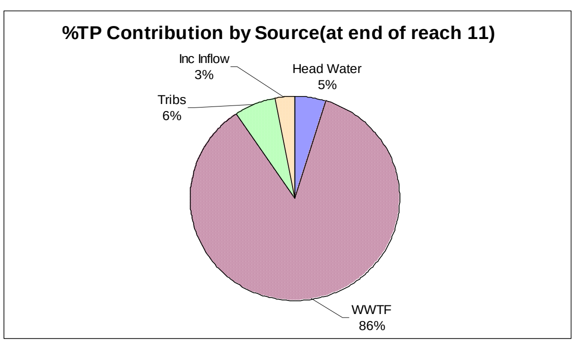


Table 4-1: Percent Contribution by Source; TP

Point Source (PS) and Nonpoint Source (NPS) breakdown of % Contribution						
Location						
End of Reach	**% due to WWTF (PS)**	**% due to Tribs**	**% due to Incremental Inflow**	**% due to Headwater**	**% due to NPS**	**Total**
2	0.0%	0. 0%	5.0%	95.0%	100.0%	100.0%
3	97.0%	0.0%	0.0%	3.0%	3.00%	100.0%
11	86.0%	6.0%	3.0%	5.0%	14.0%	100.0%
17	75.0%	17.0%	8.0%	0.0%	25.0%	100.0%







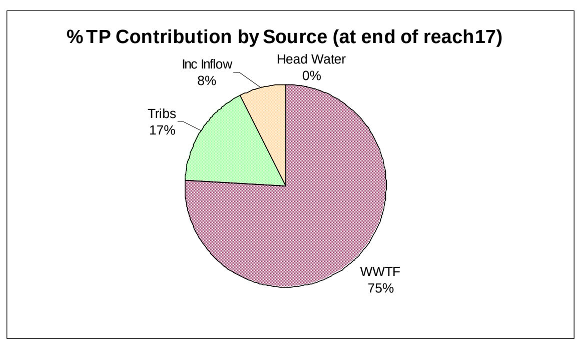
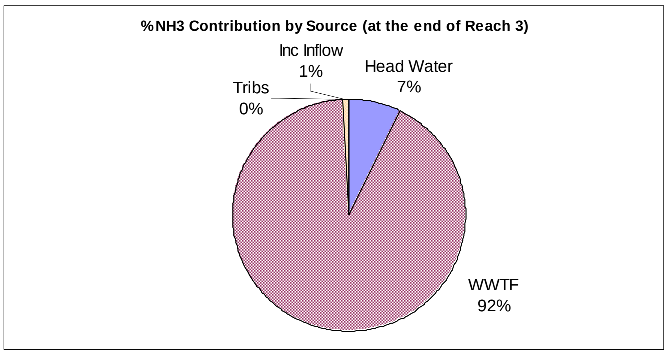
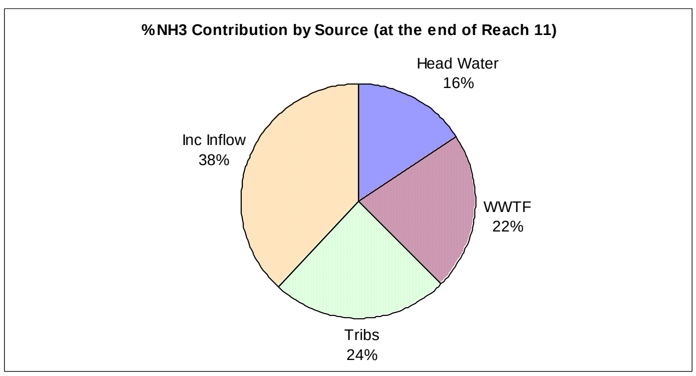


Table 4-2: Percent Contribution by Source; NH3-N

Point Source (PS) and Nonpoint Source (NPS) breakdown of % Contribution						
Location **End of Reach**	**% due to WWTF (PS)**	**% due to Tribs**	**% due to Incremental Inflow**	**% due to Headwater**	**% due to NPS**	**Total**
3	92.0%	0.0%	1.0%	7.0%	8.0%	100.0%
11	22.0%	24.0%	38.0%	16.0%	88.0%	100.0%
17	0.0%	34.0%	44.0%	22.0%	100.0%	100.0%





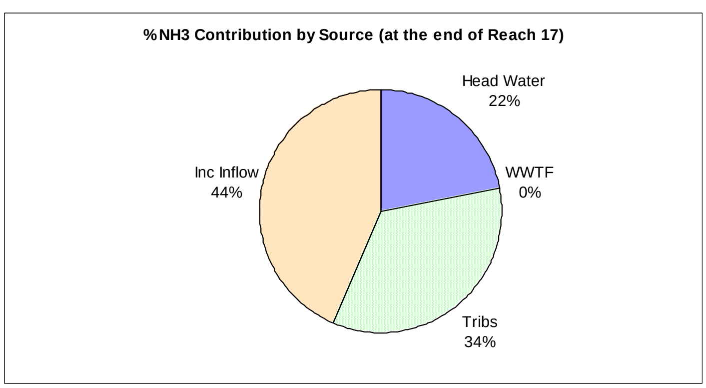
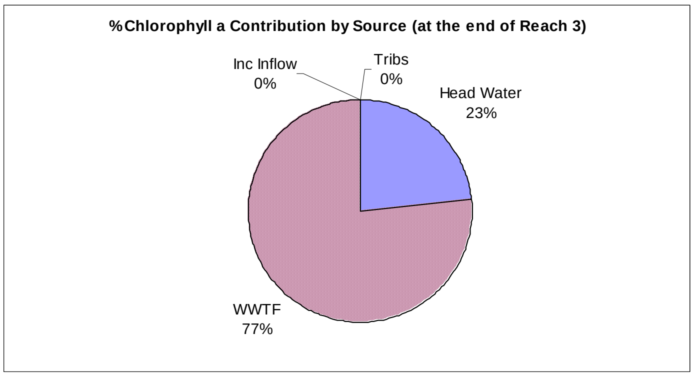
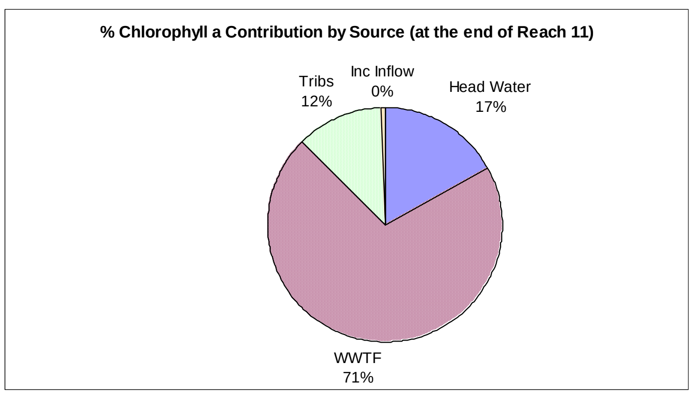


Table 4-3: Percent Contribution by Source; Phytoplankton Chl a

Point Source (PS) and Nonpoint Source (NPS) breakdown of % Contribution						
Location						
End of Reach	**% due to WWTF (PS)**	**% due to Tribs**	**% due to Incremental Inflow**	**% due to Headwater**	**% due to NPS**	**Total**
3	77.0%	0.0%	0.0%	23.0%	23.0%	100.0%
11	71.0%	12.0%	0.0%	17.0%	29.0%	100.0%
17	70.0%	14.0%	5.0%	11.0%	30.0%	100.0%





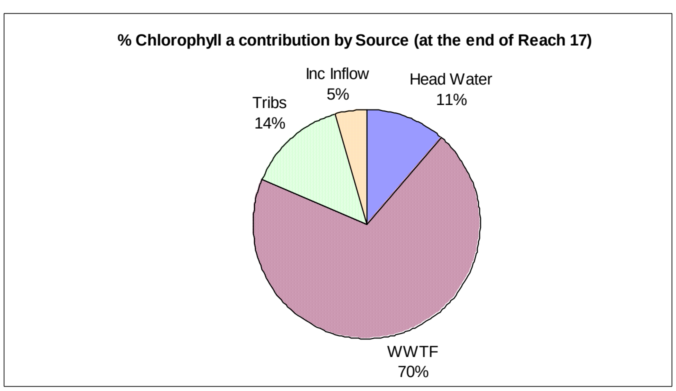
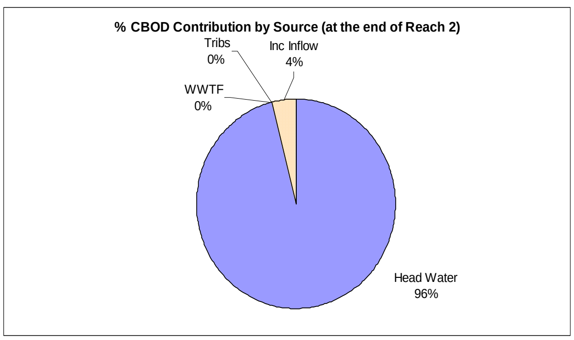
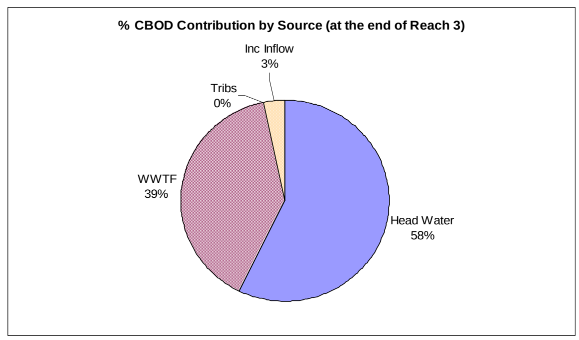
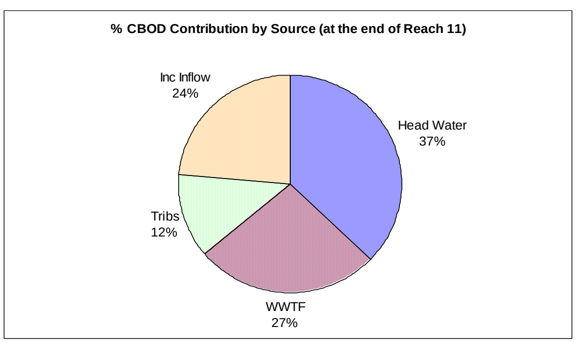


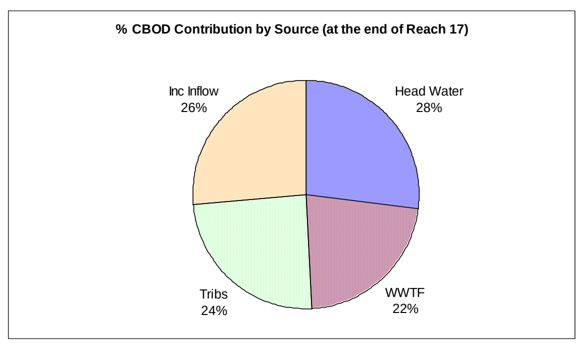
Table 4-4: Percent Contribution by Source; CBODU

Point Source (PS) and Nonpoint Source (NPS) breakdown of % Contribution Summary						
Location						
End of Reach	**% due to WWTF (PS)**	**% due to Tribs**	**% due to Incremental Inflow**	**% due to Headwater**	**% due to NPS**	**Total**
2	0.00%	0.00%	4.0%	96.0%	100.00%	100.00%
3	39.0%	0.00%	3.0%	58.0%	61.0%	100.0%
11	27.0%	12.0%	24.0%	37.0%	73.0%	100.0%
17	22.0%	24.0%	26.0%	28.0%	88.0%	100.0%









The percent of NH3-N contributed by each source is shown in Table 4-2. As indicated, point sources (i.e., the WWTF) contribute between 0 and 92 percent and nonpoint sources between 8 and 100 percent of the total NH3-N from Reach 3 downstream. The effects of point sources are highest just downstream of the WWTF in Reach 3 (92 percent of total NH3-N) and lowest at the end of the study area (0 percent in Reach 11). Upstream of Reach 3, 100 percent of the NH3-N is due to nonpoint sources.

The percent of Phytoplankton Chl a contributed by each source is shown in Table 4-3. As indicated, point sources (i.e., the WWTF) contribute between 70 and 77 percent and nonpoint sources between 23 and 30 percent of the total Phytoplankton Chl a from Reach 3 downstream. The effects of point sources are highest just downstream of the WWTF in Reach 3 (77 percent of total NH3-N) and lowest at the end of the study area (70 percent in Reach 11). Upstream of Reach 3, 100 percent of the Phytoplankton Chl a is due to nonpoint sources.

The percent of CBODU contributed by each source is shown in Table 4-4. As indicated, point sources (i.e., the WWTF) contribute between 0 and 39 percent and nonpoint sources between 61 and 100 percent of the total CBODU in the study area. The effects of point sources are highest just downstream of the WWTF in Reach 3 (39 percent of total CBODU). At the end of the study area (Reach 17) the point source contribution drops to 22 percent of the total CBODU. Upstream of Reach 3, 100 percent of the CBODU is due to nonpoint sources.

5

COMPLIANCE OF EXISTING CONDITIONS

The purpose of this section is to determine if the Contoocook River meets water quality standards under existing WWTF loadings and existing NPDES permit effluent limits for the Jaffrey WWTF.

5.1 Critical Conditions for Determining Compliance

To determine compliance with water quality standards, it is first necessary to establish conditions when standards will most likely not to be met. These are termed worse case or critical conditions. For this TMDL, dissolved oxygen and algae, as well as the pollutants that influence them such as CBODU, NH3 and TP, are the parameters of concern. Violations of dissolved oxygen and algae criteria are most likely to occur during the summer months when river flows are very low and water temperatures are relatively high. Under such conditions of low dilution and high temperature, dissolved oxygen levels are usually the lowest, pollutant concentrations such as CBODU, NH3 and TP are the highest and algal growth is maximized. If modeling shows that water quality standards are met under critical conditions, one can be reasonably confident that standards will be met during all other times of the year.

To simulate critical conditions in the QUAL2E model, river flow, water temperature and photosynthetic active radiation (PAR) values were adjusted as explained below.

5.1.1 Critical River Flow (7Q10)

The river flow selected to represent critical conditions in the model for determining compliance was the average 7-day low flow that occurs on the average once every ten years (also known as the 7Q10 low flow). This flow was chosen to be consistent with Env-Ws 1705.02 (d) of the New Hampshire surface water quality regulations which states that the 7Q10 is the river flow which must be used to establish permit limits for aquatic life and non-carcinogenic human health criterion (see section 3.3.5).

The 7Q10 was estimated by prorating the 7Q10 values at the Henniker, Peterborough and Nubanusit USGS gages to points of interest in the Contoocook watershed using an empirical equation developed by Dingman and Lawlor (Dingman et.al., 1995). First, the 7Q10 flows at the USGS gaging station sites were calculated using Log-Pearson Type III statistics using the gaging station records for years when flow regulation was the same as today. The selected periods of record for each of the USGS gages were as follows: 1951 to 1977 for the Henniker Gage, 1966 to 1977 for the Peterborough Gage, and 1951 to 1989 for the Nubanusit Gage. The resulting 7Q10s were then prorated to points of interest in the watershed using the “Dingman” equation.

The Dingman equation estimates 7Q10 flow in un-gaged, unregulated streams based upon watershed (basin) area, mean basin elevation, and the percent of the basin underlain by coarse-grained stratified drift in contact with streams. This equation was used to estimate 7Q10 stream flow at each wastewater treatment facility outfall, at other points of interest within the TMDL study area, and at each of the USGS gages. These estimates of 7Q10 stream flow (Dingman 7Q10s) were used to prorate the 7Q10 values calculated from the USGS gaging station data to the wastewater plants and other points of interest in the watershed. The 7Q10 for points upstream from the Peterborough gage were estimated by multiplying the 7Q10 at the Peterborough gage (8.11 cfs) by the ratio of the Dingman 7Q10 at the point of interest to the Dingman 7Q10 at the Peterborough gage. For example, the 7Q10 for the Contoocook River at the Jaffrey WWTF outfall was estimated by multiplying the Peterborough gage 7Q10 (8.11 cfs) by the ratio of the Dingman 7Q10 at the Jaffrey WWTF to the Dingman 7Q10 at the Peterborough gage (0.4716), resulting in an estimated 7Q10 just downstream of the Jaffrey WWTF of 3.82 cfs (8.11cfs x 0.4716 = 3.82 cfs). This approach was also followed to estimate the 7Q10 flows in several tributaries within the study area.

The 7Q10 value of 3.82 cfs downstream of the Jaffrey WWTF was held constant in all scenarios to reflect the fact that the Town’s water supply is located in the watershed upstream of the Jaffrey WWTF. That is, the 7Q10 upstream of the WWTF was set equal to 3.82 cfs minus the WWTF flow being simulated. Consequently, the higher the WWTF flow, the lower the upstream 7Q10. This acknowledges that if more water is taken for consumption from the upstream watershed, less water and flow will be available in the Contoocook River upstream of the Jaffrey WWTF. Calculations of the 7Q10 for various WWTF flows are provided in Appendix B.

5.1.2 Critical Water Temperature (25 deg C)

A water temperature of 25 degrees Celsius (C) was selected to represent the critical high water temperature during the summer months. This value has been historically used by NHDES in the past and is representative of some of the highest water temperatures measured in 2004 (see Appendix 2-A of Appendix A).

5.1.3 Critical PAR

Photosynthetically Active Radiation or PAR represents the photosynthetically active fraction of total solar radiation. PAR is positively correlated with algal growth; that is the higher the PAR, the higher the growth rate of algae. It is a function of the total solar radiation which is function of the time of year, the amount of forest canopy and cloud cover and the fraction of total solar radiation which is available for photosynthesis. For this study, the critical PAR was set equal to 994 BTU/ft^2. This was based on July 1, a photosynthetic fraction of 0.44 (Brown, 2003) a forest canopy equal to 0.01 and cloud cover equal to 0.05. A spreadsheet developed by S. Lawrence Dingman (based on Dingman, 1994) was used to calculate total solar radiation. Modifications were made to account for the fraction available for photosynthesis, cloud cover and forest canopy. A copy of the spreadsheet showing these calculations is provided in Appendix C.

5.2 Compliance of Existing Loadings at Critical Conditions

To determine if the Jaffrey WWTF will meet water quality standards under existing loading conditions, the input file for the calibration run discussed in section 4.3.2 was modified as follows.

Headwater, WWTF, incremental inflow and tributary concentrations (with the exception of dissolved oxygen) and the WWTF flow were set equal to the average of the calibration and verification runs. This resulted in a WWTF flow of 0.3 mgd (0.46 cfs). Water temperature, river and tributary flows and PAR were set to values representing critical conditions as discussed in the previous section (25 degrees C, 7Q10 flow and PAR equal to 994 BTUs/ft^2). Dissolved oxygen concentrations at the headwater, WWTF, tributaries and incremental inflow were set equal to the average percent saturation value of the calibration and verification runs multiplied by the dissolved oxygen concentration representing 100 percent saturation at the critical temperature of 25 degrees C (8.26 mg/L). A copy of the model input file is provided in Appendix D.

To determine compliance of existing conditions, results were compared to the actual water quality without a margin of safety (see section 3.6). Plots of dissolved oxygen (mg/L and % saturation), NH3-N, phytoplankton and periphyton are provided below. In addition plots of TP and CBODU are provided for information and comparison to other scenarios presented in this study.

As shown in Figure 5-1, approximately 7 percent (0.4 /9.5) of the study area is predicted to violate the minimum dissolved oxygen criterion of 5 mg/L under existing loadings and critical conditions.

Figure 5-2 shows that approximately 10 percent (0.9 / 9.5) of the study area is predicted to violate the 75 percent average daily dissolved oxygen criterion.

Figure 5-3 shows that the maximum NH3-N concentration is approximately 0.3 mg/L which is well below the criterion of 2.7 ug/L. Phytoplankton and Periphyton Chl a are also predicted to meet their criterion of 15 ug/L and 9.3 mg/ft2 respectively (see Figures 5-4 and 5-5) . The maximum Phytoplankton Chl a value is approximately 11 ug/L and the maximum predicted Periphyton Chl a is approximately 5.8 mg/ft2.

Figure 5-6 and Figure 5-7 show that the maximum TP and CBODU occur just downstream of the WWTF and are approximately 360 ug/L and 3.2 mg/L respectively.

Figure 5-1 Existing Loadings; Minimum Dissolved Oxygen

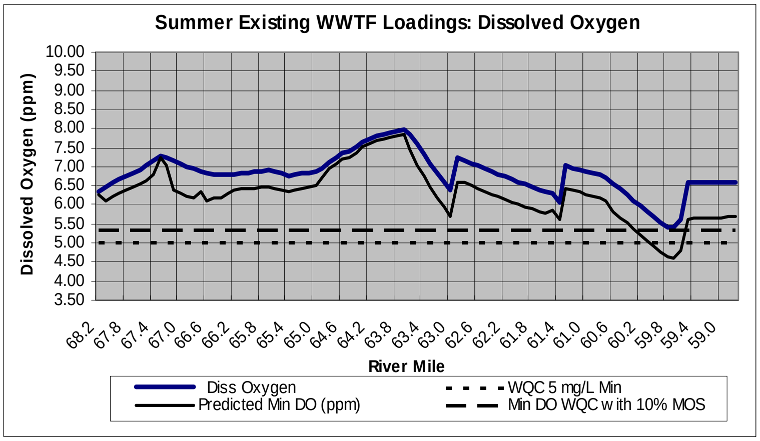


Figure 5-2 Existing Loadings: Average Daily Dissolved Oxygen

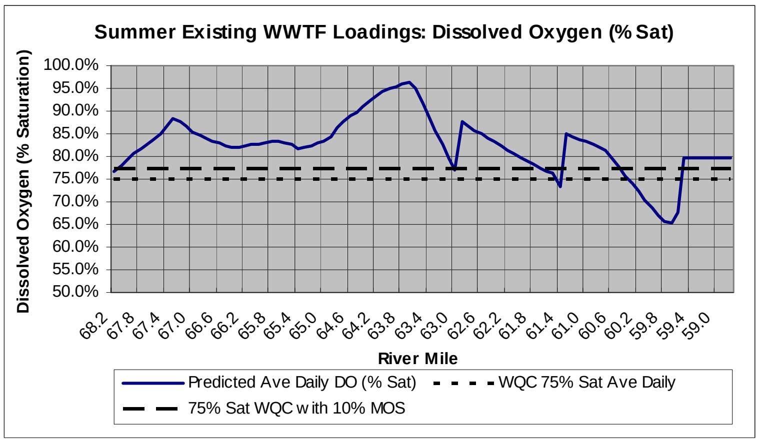
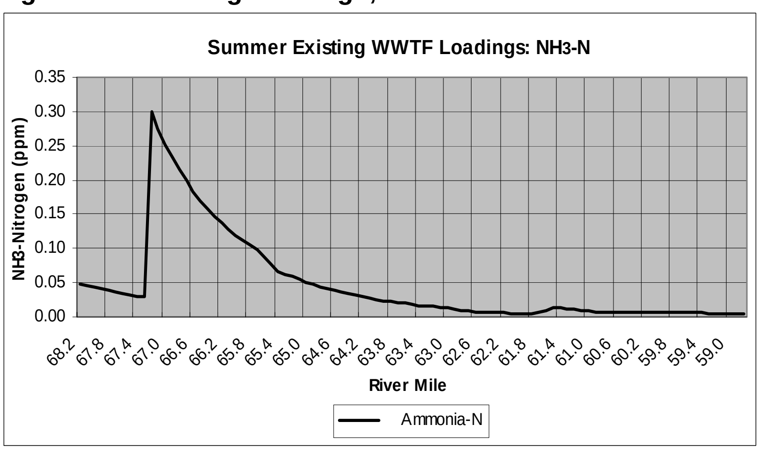


Figure 5-3 Existing Loadings; NH3-N



Note: The chronic NH3-N criterion is 2.7 mg/L (see section 3.6).

Figure 5-4 Existing Loadings; Phytoplankton Chl a

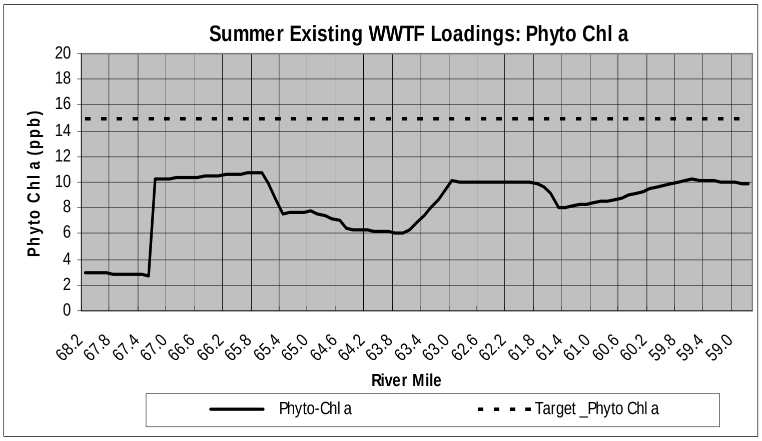


Figure 5-5 Existing Loadings; Periphyton Chl a

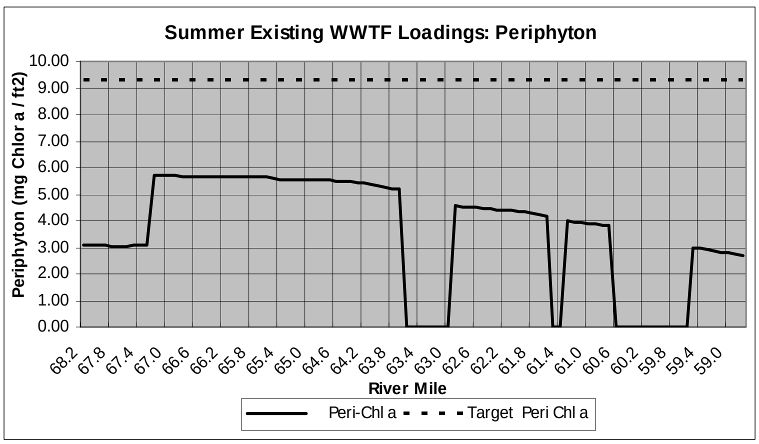


Figure 5-6 Existing Loadings; TP

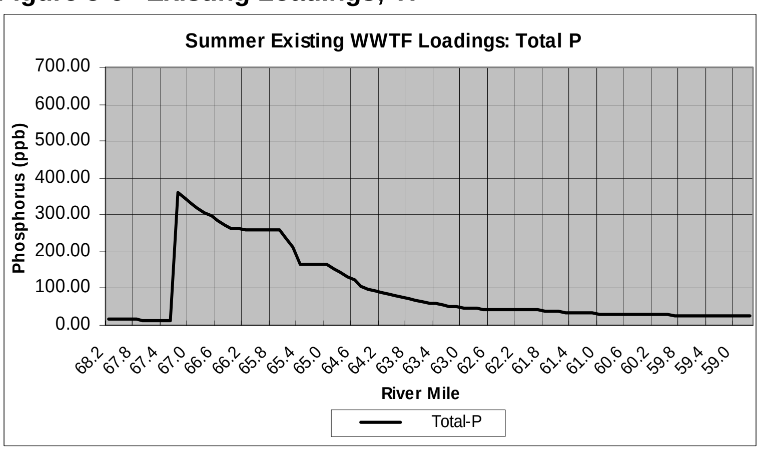
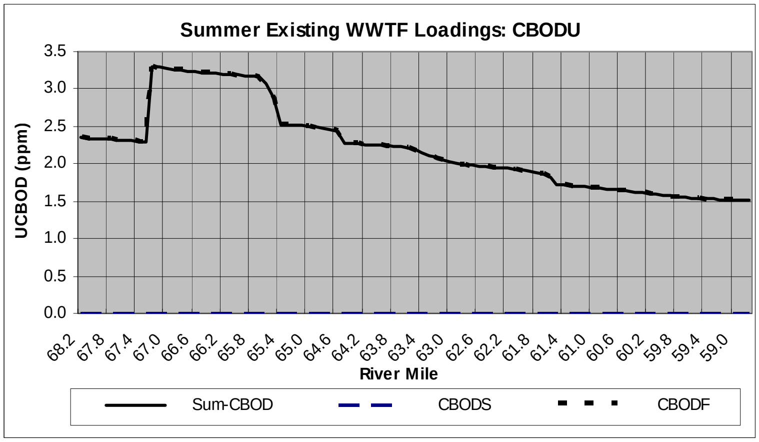


Figure 5-7 Existing Loadings; CBODU



5.3 Compliance of Existing NPDES Permit Loadings at Critical Conditions

A copy of the existing NPDES permit effluent limits for the Jaffrey WWTF is provided in Appendix E. As shown in Table 5-1 below, CBOD5 and NH3-N effluent limits in the permit for the warm weather period are significantly higher than what is currently being discharged. To determine if the Jaffrey WWTF would meet water quality standards under existing NPDES permit loading conditions, the input file for the existing loading under critical conditions discussed in section 5.2 was modified as follows:

The WWTF flow was set equal to the design flow of 1.25 mgd and the 7Q10 river flow upstream of the WWTF was adjusted to reflect the WWTF flow of 1.25 mgd (see section 5.1.1 and Appendix B). The WWTF CBODU and NH3-N loadings were adjusted to reflect the NPDES permitted loadings shown in Table 5-1. One model run was conducted assuming the same WWTF Chl a concentration (61 ug/L) as that used to determine compliance of existing loadings under critical conditions (see section 5.2). As previously mentioned, this was the average of the values measured in 2004 for the calibration and verification runs. This results in a WWTF Chl a loading of 0.6359 lbs/day at a WWTF flow of 1.25 mgd. To account for the probability that WWTF Chl a is variable, a second run was conducted assuming a WWTF Chl a value of 1 ug/L (0.0104 lbs/day). Copies of the input files for both WWTF Chl a scenarios are provided in Appendix F.

Results for both WWTF Chl a scenarios are presented in Figure 5-8 through Figure 5-14. To determine compliance, results were compared to the actual water quality without a margin of safety (see section 3.6). In addition plots of TP and CBODU are provided for information and comparison to other scenarios presented in this study.

As shown in Figure 5-8, approximately 26 percent (2.5/9.5) of the study area is predicted to violate the minimum dissolved oxygen criterion of 5 mg/L under existing NPDES permitted loadings and critical conditions and WWTF Chl a of 0.6359 lbs/day. If the WWTF Chl a is reduced to 0.0104 lbs/day, 63 percent (6 / 9.5) of the study area is predicted to violate the 5 mg/L minimum dissolved oxygen criterion.

Figure 5-9 shows that approximately 28 (2.7/9.5) and 75 (7.1/9.5) percent of the study area are predicted to violate the average daily dissolved oxygen criterion of 75 percent saturation assuming 0.6359 and 0.0104 lbs/day of WWTF Chl a respectively.

Figure 5-10 shows that regardless of the WWTF Chl a loading, only 2 percent (0.2/9.5) of the study area is predicted to violate the chronic NH3-N criterion of 2.7 mg/L.

Figure 5-11 shows that with a WWTF Chl a loading of 0.6359 lbs/day, the Phytoplankton Chl a target of 15 ug/L is violated in 89 percent (8.5/9.5) of the study area with a maximum concentration of approximately 41 ug/L. If the WWTF Chl a is 0.0104 lbs/day, the maximum Phytoplankton Chl a is approximately 6 ug/L which is well below the target of 15 ug/L.

Figure 5-12 shows that regardless of the WWTF Chl a loading, the maximum predicted Periphyton Chl a value is approximately 6 mg/ft2 which is below the maximum target of 9.3 mg/ft2.

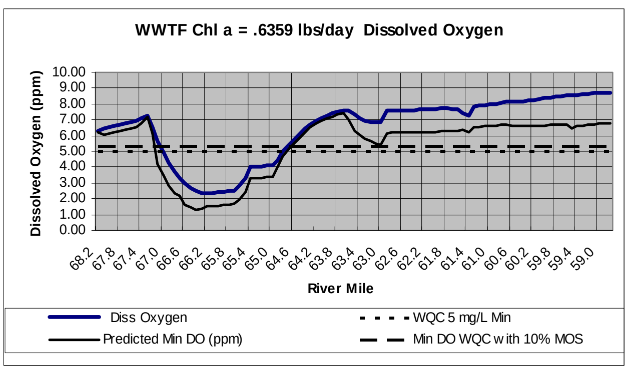
Finally Figure 5-13 and Figure 5-14 show that the maximum TP is approximately 1.4 mg/L and the maximum CBODU is approximately 12.5 mg/L under existing NPDES permitted conditions.

In summary existing NPDES permitted loadings for the Jaffrey WWTF under critical conditions are predicted to violate dissolved oxygen, NH3-N and/or Phytoplankton Chl a water quality criteria in approximately 89 percent (8.5 / 9.5) of the study area. This was the basis for listing many of the segments on the 303(d) list of threatened and impaired waters (see section 2.2). According to the CALM (NHDES, 2005), surface waters may be listed as threatened if a model is calibrated and if the model predicts water quality violations under existing loading conditions, and/or under enforceable pollutant loadings stipulated in a NPDES permit. Such waters are listed as threatened to reflect that fact that the violation is predicted and not based on actual measured in-stream violations.

Table 5-1: Comparison of Existing Loadings with Existing NPDES Permitted Loadings

WWTF Discharge at:	Flow (mgd)	$CBOD_5$ lbs/day	NH_3-N lbs/day
Existing Loadings	0.3	8.1	5.7
Existing NPDES Permit	1.25	73	66

Figure 5-8 Existing NPDES Permit Loadings; Minimum Dissolved Oxygen



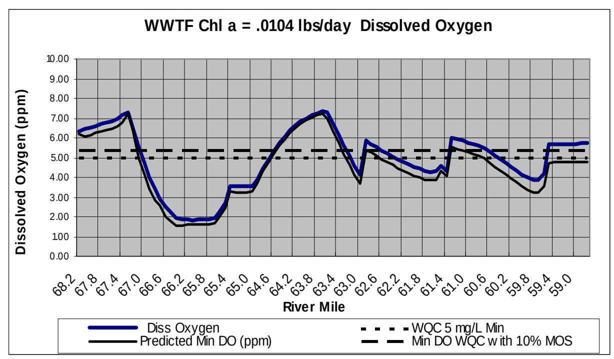
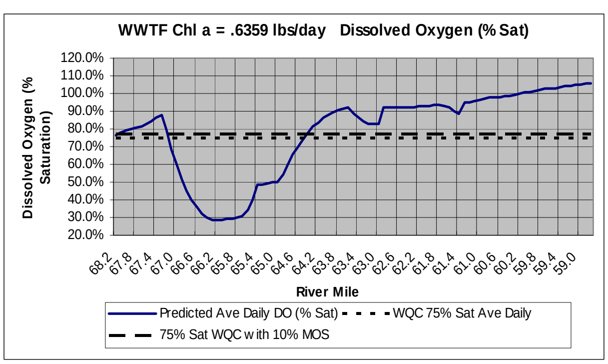


Figure 5-9 Existing NPDES Permit Loadings; Average Daily Dissolved Oxygen



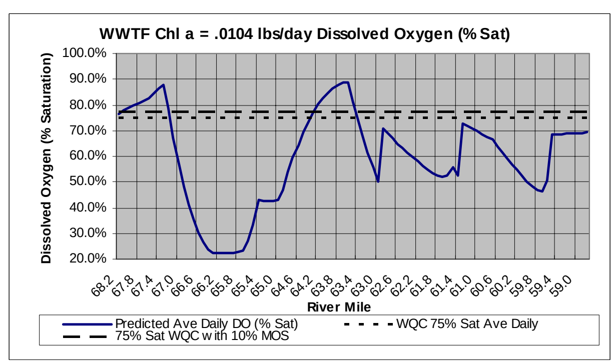
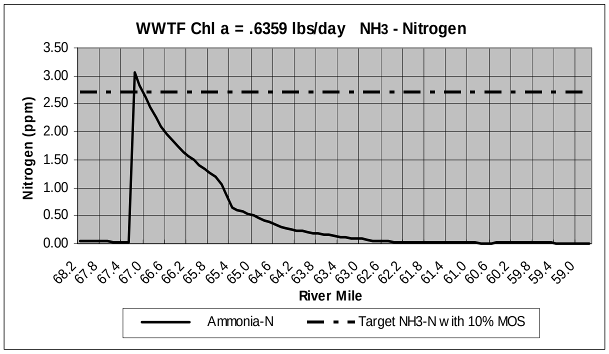


Figure 5-10 Existing NPDES Permit Loadings; NH_3-N



Note: (NH_3 plot is the same for WWTF = .0104 lbs/day)

Figure 5-11 Existing NPDES Permit Loadings; Phytoplankton Chl a

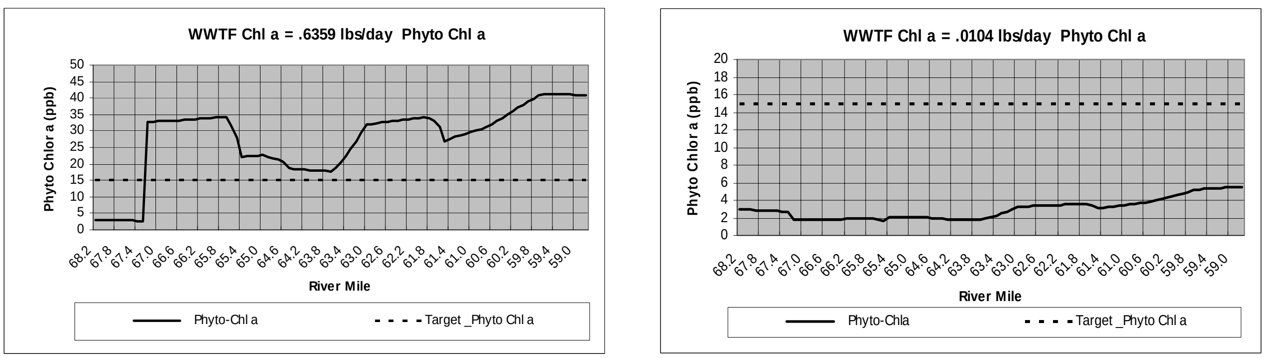


Figure 5-12 Existing NPDES Permit Loadings; Periphyton Chl a

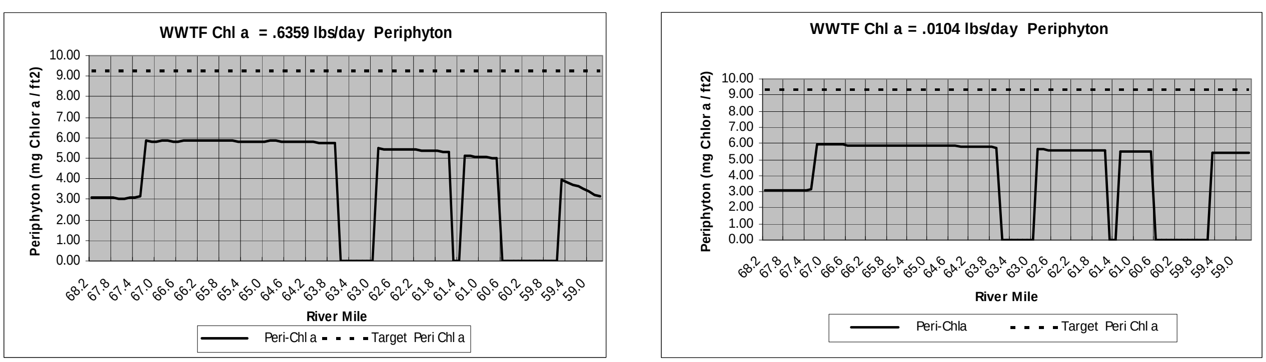


Figure 5-13 Existing NPDES Permit Loadings; TP

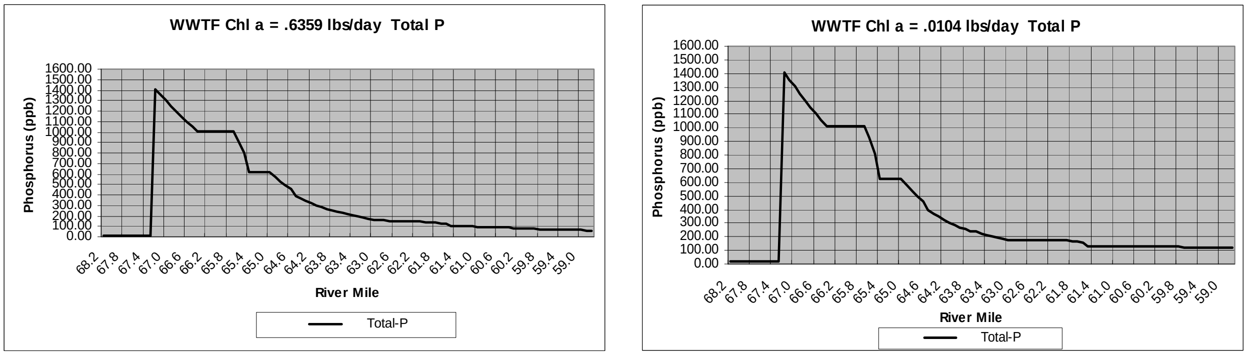
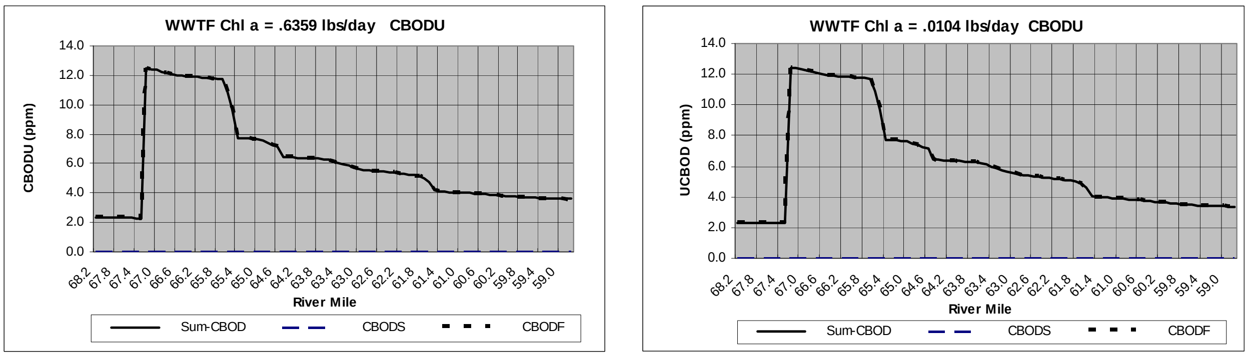


Figure 5-14 Existing NPDES Permit Loadings; CBODU



6

SENSITIVITY ANALYSIS

6.1 Methodology

The purpose of a sensitivity analysis is to identify which model input parameters have the greatest impact on water quality in the Contoocook River and where these impacts occur. This was accomplished by using the model run simulating existing loading conditions at critical conditions described in section 5.2 as the "base" file and varying model parameters one at a time. For this analysis parameters were increased and decreased by 50 percent. For a given water quality consitituent (i.e., dissolved oxygen, TP, etc.), the model is considered to be most sensitive to the input parameters that cause the greatest change in that water quality constituent.

6.2 Sensitivity Results

6.2.1 Dissolved Oxygen

Figure 6-1 through Figure 6-5 show how dissolved oxygen concentrations vary along the 9.5 mile study reach as WWTF CBODU, WWTF NH3-N, WWTF TP, WWTP Chl a and SOD values are increased and decreased by 50 percent from the base condition. To facilitate comparison, Figure 6-6 is also provided which shows side by side comparisons of how dissolved oxygen responds to 50 percent decreases in each parameter at four selected locations (the end of Reach 4, 11, 14 and 16). Reach 4 is a riverine section and Reaches 11, 14 and 16 are impoundments.

As shown in Figure 6-6, dissolved oxygen is most sensitive to changes in SOD and least sensitive to changes in CBODU for the ranges tested. For example, in Reach 16 Figure 6-6 indicates that a 50 percent decrease in SOD results in an increase of approximately 1.6 mg/L of dissolved oxygen.

The figures also show that dissolved oxygen increases as WWTF CBODU, WWTF NH3-N, and SOD decrease and increase as WWTF TP and WWTF Chl a decrease. Changes in SOD, WWTF TP, WWTF Chl a and WWTF CBODU are most prominent in the lower half of the study area where the impoundments are located. This is opposed to WWTF NH3-N which exerts its effect on dissolved oxygen in the first 3 miles downstream of the WWTF, which is before any of the impoundments are reached (see Figure 6-2).

Figure 6-1: Sensitivity: WWTF CBODU vs Dissolved Oxygen

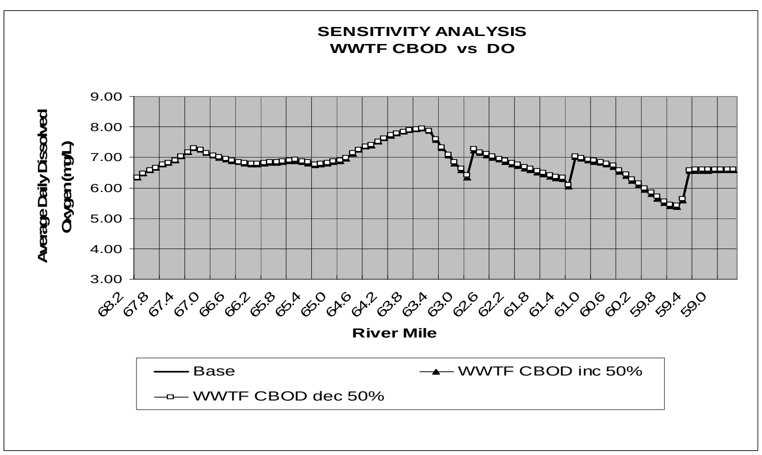


Figure 6-2: WWTF NH3-N vs Dissolved Oxygen

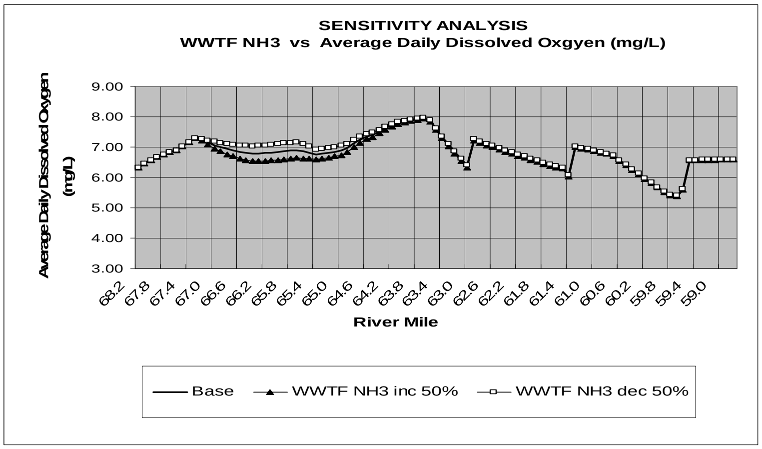


Figure 6-3: Sensitivity: WWTF TP vs Dissolved Oxygen

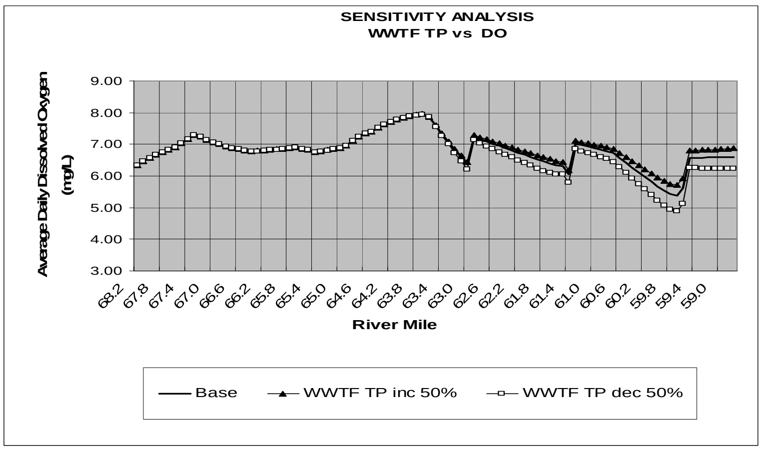


Figure 6-4: Sensitivity: WWTF Chl a vs Dissolved Oxygen

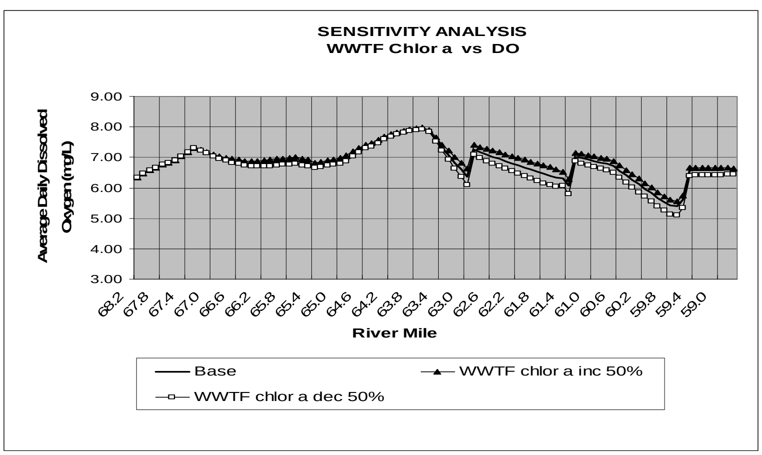


Figure 6-5: Sensitivity: SOD vs Dissolved Oxygen

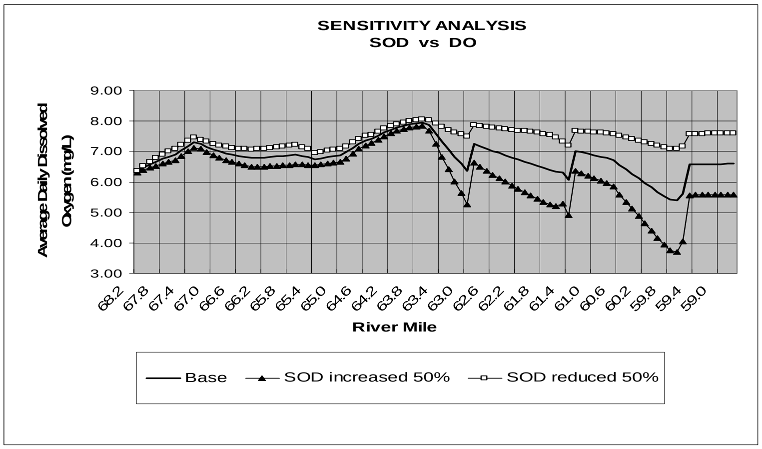
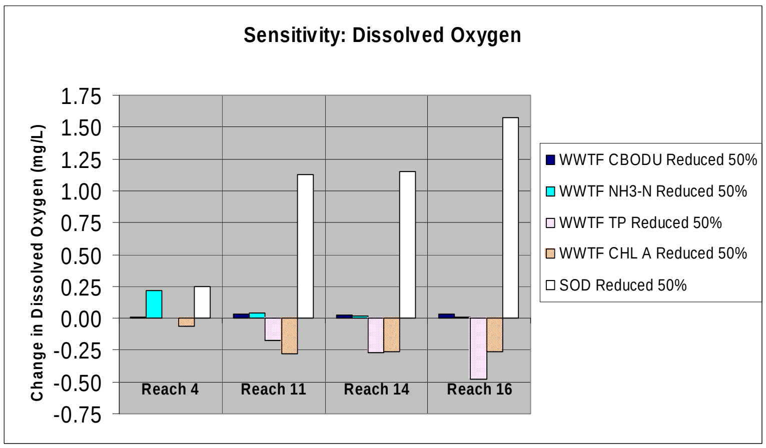


Figure 6-6: Sensitivity Comparison – Dissolved Oxygen



6.2.2 Phytoplankton Chl a

Figure 6-7 through Figure 6-8 show how phytoplankton chl a values change along the 9.5 mile study reach as WWTF TP, WWTF Chl a values are increased and decreased by 50 percent from the base condition. To facilitate comparison, Figure 6-9 is also provided which shows side by side comparisons of how phytoplankton chl a responds to 50 percent decreases in each parameter at four selected locations (the end of Reach 4, 11, 14 and 16). Reach 4 is a riverine section and Reaches 11, 14 and 16 are impoundments.

As shown in these figures, ambient phytoplankton chl a levels decrease as WWTF TP and WWTF Chl a decreases and are most sensitive to changes in WWTF Chl a at the majority of locations downstream of the WWTF. In the last mile or so of the study area, phytoplankton chl a levels are slightly more sensitive to WWTF TP concentrations (see Figure 16, Reach 16).

Figure 6-7: Sensitivity: WWTF TP vs Phytoplankton Chl a

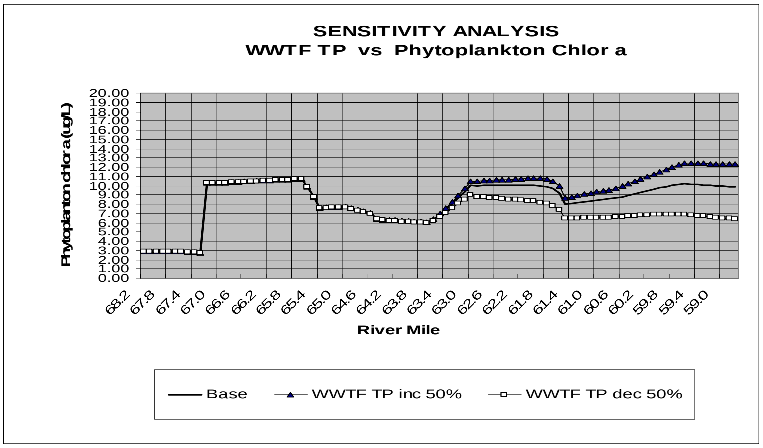


Figure 6-8: Sensitivity: WWTF Chla a vs Phytoplankton Chl a

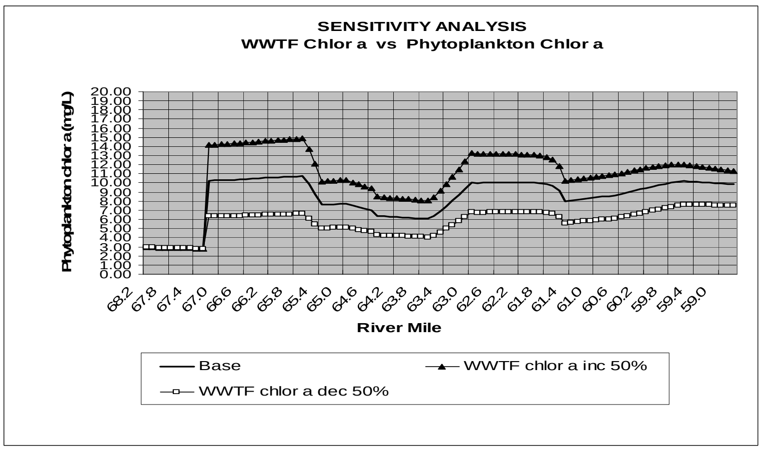
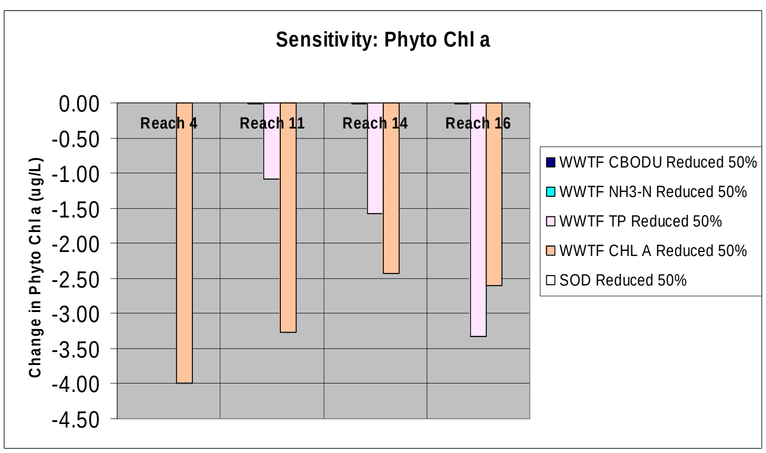


Figure 6-9: Sensitivity Comparison – Phytoplankton Chl a



6.2.3 Periphyton Chl a

Figure 6-10 shows how periphyton chl a values change along the 9.5 mile study reach as WWTF TP values are increased and decreased by 50 percent from the base condition. To facilitate comparison, Figure 6-11 is also provided which shows side by side comparisons of how periphyton chl a responds to 50 percent decreases in each parameter at four selected locations (the end of Reach 4, 11, 14 and 16). Reach 4 is a riverine section and Reaches 11, 14 and 16 are impoundments.

As shown in these figures, ambient periphyton chl a levels decrease as WWTF TP and WWTF NH3-N decreases and are most sensitive to changes in WWTF TP in the riverine sections downstream of the WWTF where conditions are suitable for periphtyon growth.

Figure 6-10: Sensitivity: WWTF TP vs Periphyton Chl a

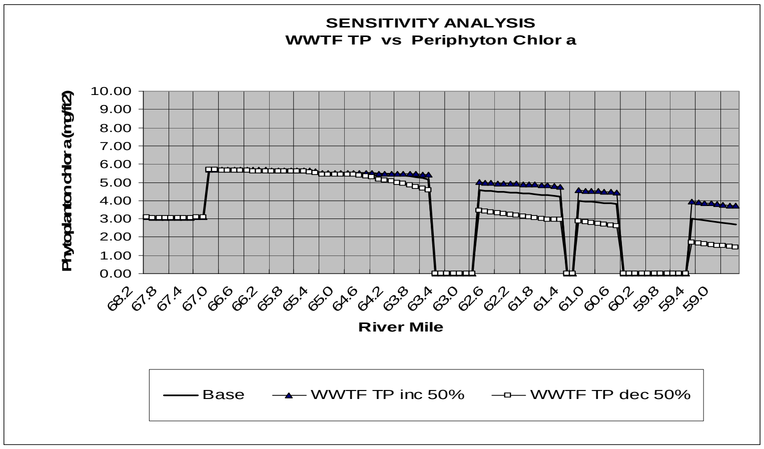
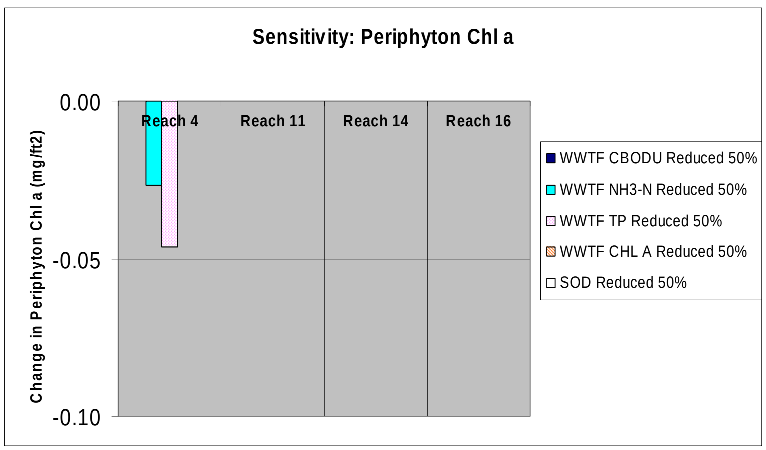


Figure 6-11: Sensitivity Comparison – Periphyton Chl a



6.2.4 CBODU

Figure 6-12shows how ambient CBODU concentrations change along the 9.5 mile study reach as WWTF CBODU values are increased and decreased by 50 percent from the base condition. To facilitate comparison, Figure 6-13 is also provided which shows side by side comparisons of how ambient CBODU concentrations respond to 50 percent decreases in each parameter at four selected locations (the end of Reach 4, 11, 14 and 16). Reach 4 is a riverine section and Reaches 11, 14 and 16 are impoundments.

As shown in these figures, CBODU levels are most sensitive to changes in WWTF CBODU downstream of the WWTF as compared to changes in WWTF TP or WWTF Chl a (see Figure 6-13). As these parameters are decreased, the ambient CBODU concentration also decreases.

Figure 6-12: Sensitivity: WWTF CBODU vs Ambient CBODU

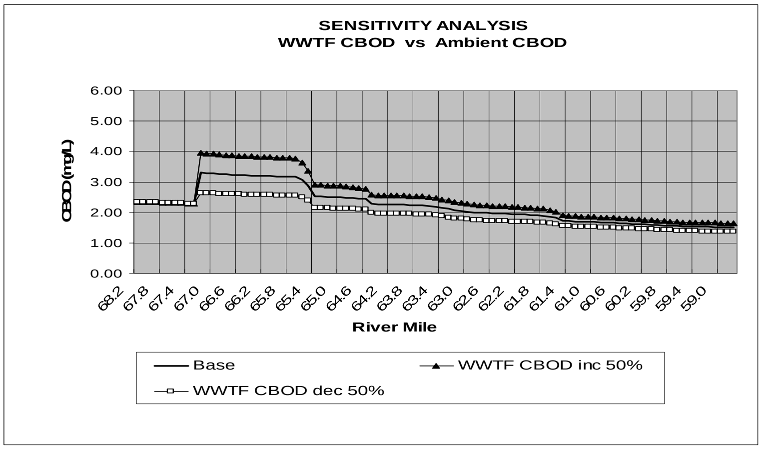
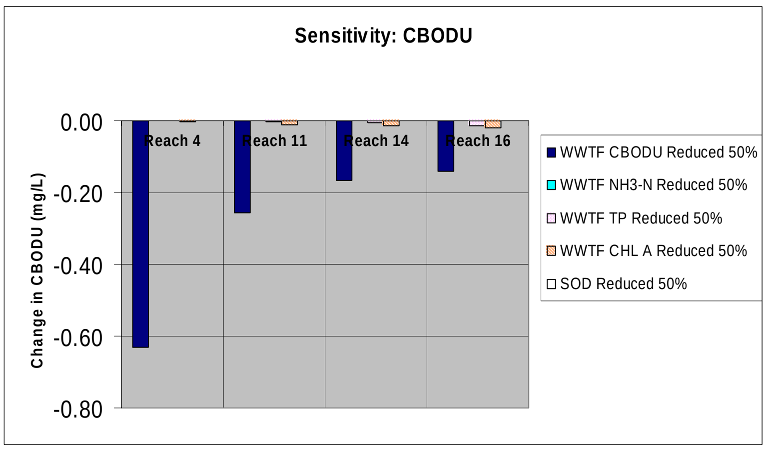


Figure 6-13: Sensitivity Comparison - CBODU



6.2.5 NH3-N

Figure 6-14 shows how ambient NH3-N concentrations change along the 9.5 mile study reach as WWTF CBODU values are increased and decreased by 50 percent from the base condition. To facilitate comparison, Figure 6-15 is also provided which shows side by side comparisons of how ambient NH3-N concentrations respond to 50 percent decreases in each parameter at four selected locations (the end of Reach 4, 11, 14 and 16). Reach 4 is a riverine section and Reaches 11, 14 and 16 are impoundments.

As shown in these figures, ambient NH3-N levels are most sensitive to changes in WWTF NH3-N downstream of the WWTF (see Figure 6-15). As WWTF NH3-N concentrations are decreased, the ambient NH3-N concentration also decreases.

Figure 6-14: Sensitivity: WWTF NH3-N vs Ambient NH3-N

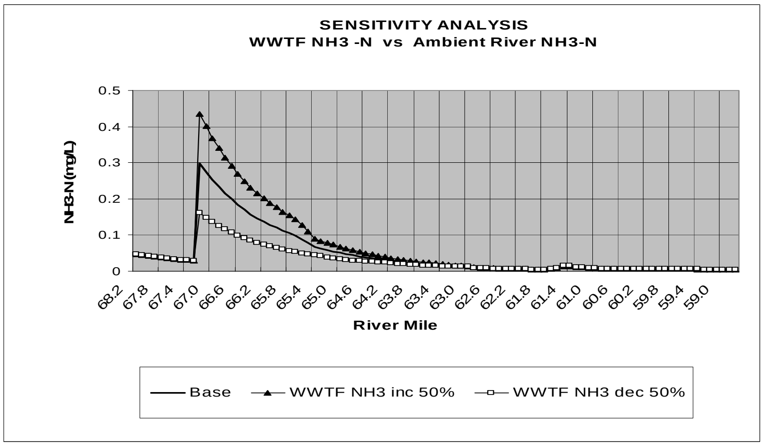
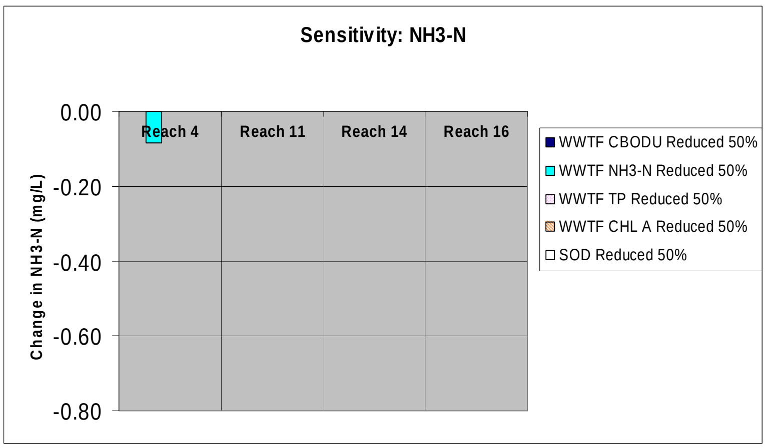


Figure 6-15: Sensitivity Comparison – NH3-N



6.2.6 TP

Figure 6-16 shows how ambient TP concentrations change along the 9.5 mile study reach as WWTF TP values are increased and decreased by 50 percent from the base condition. To facilitate comparison, Figure 6-17 is also provided which shows side by side comparisons of how ambient TP responds to 50 percent decreases in each parameter at four selected locations (the end of Reach 4, 11, 14 and 16). Reach 4 is a riverine section and Reaches 11, 14 and 16 are impoundments.

As shown in these figures, ambient TP levels are most sensitive to changes in WWTF TP downstream of the WWTF as compared to changes in WWTF Chl a (see Figure 6-17). As WWTF TP concentrations decrease, the ambient TP concentration also decreases. However, as WWTF Chl a concentrations decrease, ambient TP concentrations increase.

Figure 6-16: Sensitivity: WWTF TP vs Ambient TP

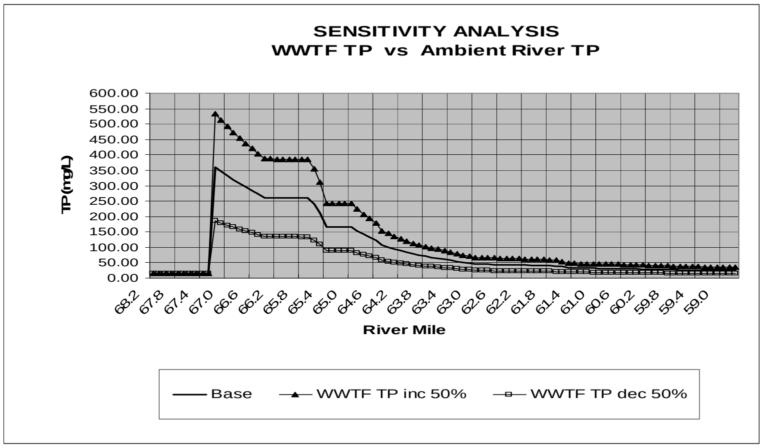
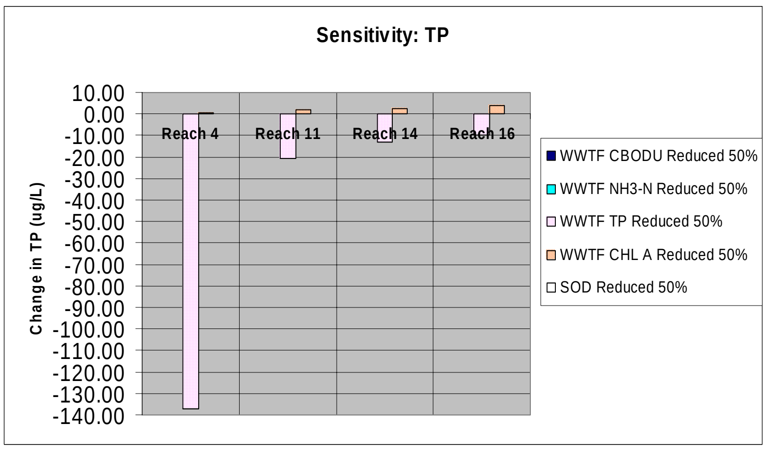


Figure 6-17: Sensitivity Comparison – TP



7 NO WWTF SCENARIO

7.1 Model Input

Before proceeding with modeling to determine WWTF and nonpoint source loadings for the TMDL, it is customary to first simulate conditions without the WWTF (i.e., the No WWTF scenario) to see if water quality standards were likely met before the WWTF was constructed. A copy of the model input file for the No WWTF scenario is provided in Appendix G. In general modeling was based on the input file for the "existing loading under critical conditions" scenario (see section 5.2) with the following exceptions:

- The WWTF flow was set to zero
- The headwater flow was increased by the amount that the WWTF was decreased
- SOD was reduced in accordance with the methodology discussed in section 7.2

7.2 Sediment Oxygen Demand (SOD) Reduction Methodology

As indicated in section 6.2.1, sediment oxygen demand (SOD) is a significant oxygen sink in portions of the Contoocook River. This is especially true in the slow moving impounded areas. Major sources of SOD in aquatic systems include settleable organics which may consist of particulate CBOD, dead phytoplankton, periphyton and macrophytes, leaves from trees and other organics in surface runoff.

When CBOD, nutrient and algal loads to surface waters are reduced it is reasonable to expect that the SOD will eventually decrease too. Calculation of SOD reductions, however, is challenging because of the many sources mentioned above as well as the fact that high river flow and velocities can relocate SOD deposits downstream. Consequently, the source(s) of SOD can be difficult to identify and may not always be due to sources in the immediate area.

Though challenging, it is nevertheless important to try to quantify the magnitude of SOD change associated with changes in pollutant loadings so that a more realistic estimate of dissolved oxygen can be obtained for the condition being analyzed. To accomplish this, a spreadsheet was developed to estimate the potential change in SOD. A description of the methodology is provided in Appendix H.

In general, the methodology predicts the potential change in SOD due to changes in WWTF CBOD, ambient phytoplankton and periphyton between a reference and test condition (i.e., such as the No WWTF Scenario). The reference condition for this study is the "existing loading at critical conditions" scenario (see section 5.2) as this run is based on the calibrated SOD values. Formulas are provided to convert phytoplankton and periphyton to terms of oxygen demand, similar to CBOD. Changes in oxygen demanding pollutants are then computed upstream of each impoundment and the potential change in the parameters that may contribute to SOD is then expressed in terms of a percent in accordance with the following equation.

$$\frac{(\text{Reference SOD potential} - \text{Test Case SOD potential}) \times 100}{\text{Reference SOD potential}}$$

The calibrated SOD values were then adjusted in the test case based on the percent change in SOD predicted by the SOD reduction model. The test case was then rerun with the revised SOD values to determine the impact of the reduced SODs on dissolved oxygen.

7.3 Results

Modeling results for the No WWTF scenario are presented in Figure 7-1 through Figure 7-7 below. Without the WWTF, maximum NH3-N, Phytoplankton Chl a and Periphyton Chl a are approximately 0.05 mg/L, 1.6 ug/L and 3 mg/ft2 respectively which are all well below the maximum targeted water quality criteria. Maximum CBODU and TP are about 2.3 mg/L and 15 ug/L respectively. Figure 7-1 shows that the minimum dissolved oxygen standard is met when the model is run with SOD reductions. Figure 7-2 indicates that the predicted average daily dissolved oxygen saturation value is approximately 70 percent which is just below the 75 percent average daily dissolved oxygen criterion. Although not quite met, the values are so close that one cannot conclude with certainty (due to the many assumptions used to simulate this condition), that dissolved oxygen standards will not be met if the WWTF did not exist.. Consequently, it is reasonable to conclude that prior to construction of the WWTF, water quality standards were most likely met in the study area.

Figure 7-1: No WWTF Scenario; Minimum Dissolved Oxygen

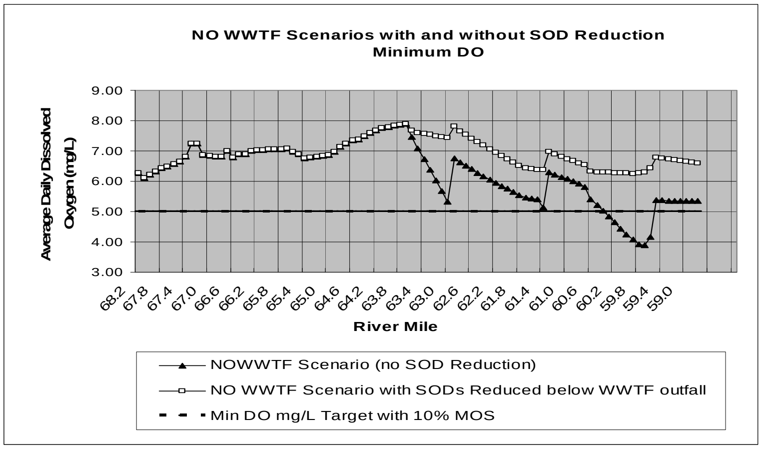


Figure 7-2: No WWTF Scenario; Average Daily Dissolved Oxygen

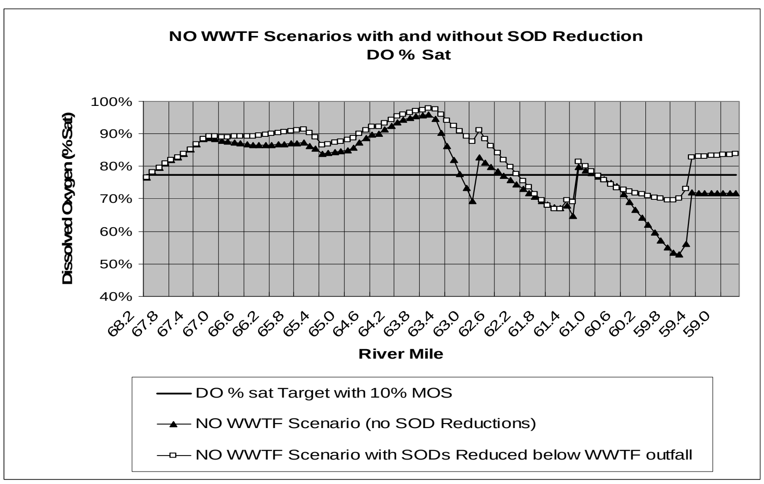


Figure 7-3: No WWTF Scenario; NH3-N

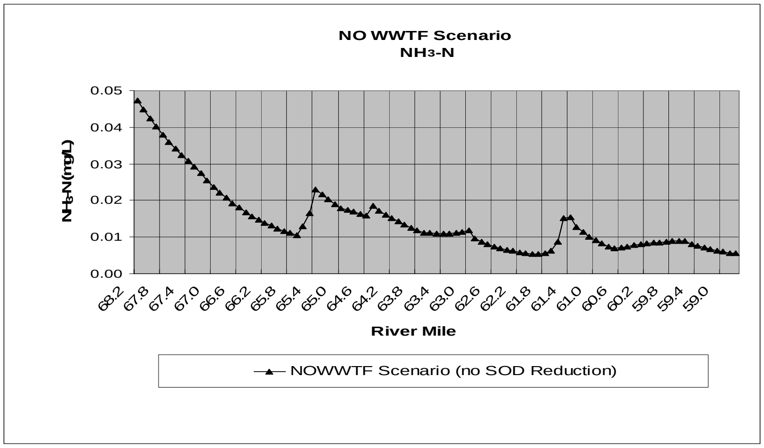


Figure 7-4: No WWTF Scenario; Phytoplankton Chl a

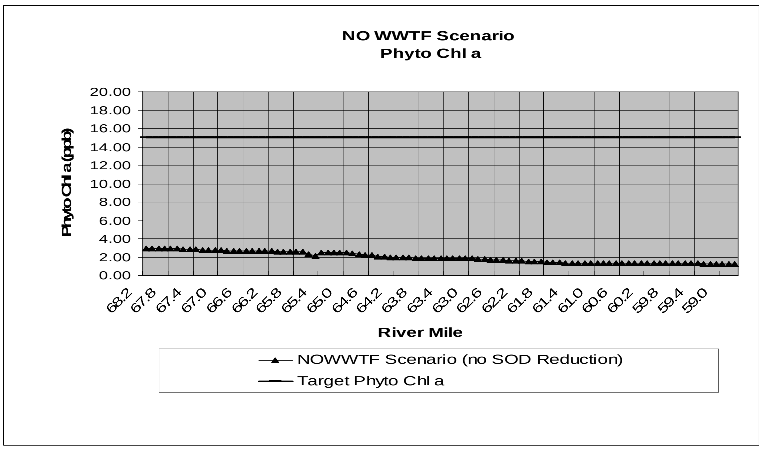


Figure 7-5: No WWTF Scenario; Periphyton Chl a

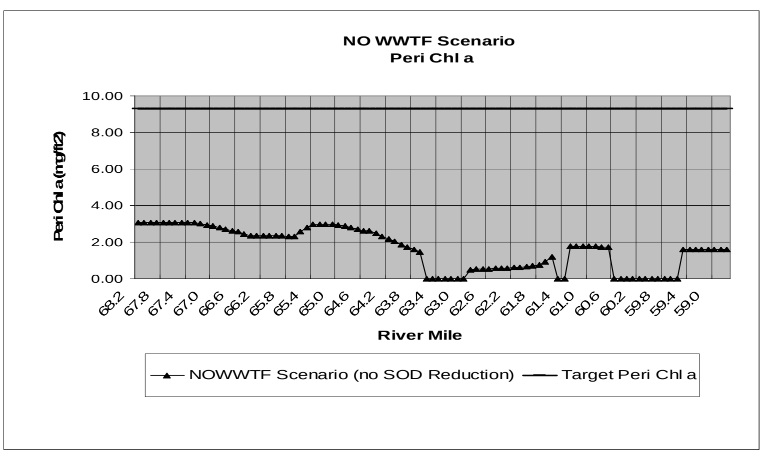


Figure 7-6: No WWTF Scenario; CBODU

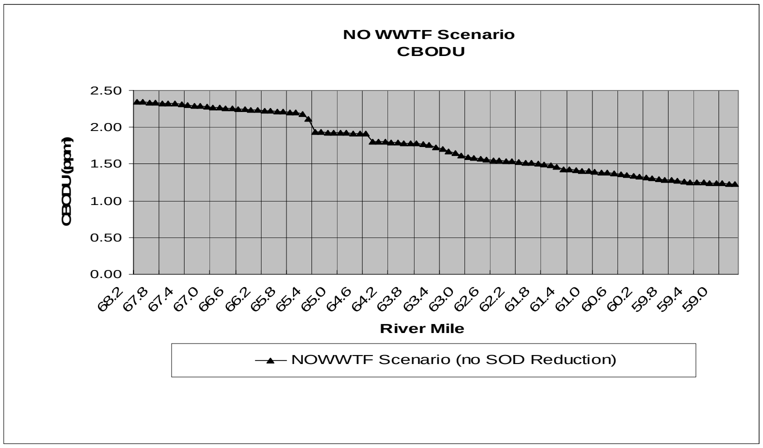
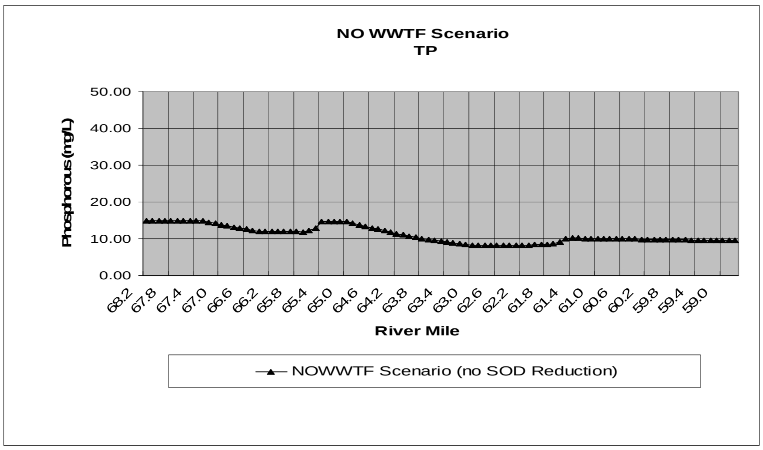


Figure 7-7: No WWTF Scenario; TP



8

TOTAL MAXIMUM DAILY LOAD AND ALLOCATIONS

8.1 Definition of a TMDL and Margin of Safety

According to the 40 CFR Part 130.2, the total maximum daily load (TMDL) for a waterbody is equal to the sum of the individual loads from point sources (i.e. wasteload allocations or WLA's) and load allocations (LAs) from nonpoint sources (including natural background conditions). Section 303 (d) of the Clean Water Act (CWA) also states that the TMDL must be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between limitations and water quality. TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure [40 CFR, Part 130.2 (i)].

In equation form, the TMDL may be expressed as:

$$TMDL = WLA + LA + MOS$$

where:

WLA = Waste Load Allocation (loadings from point sources)
LA = Load allocation (i.e. loadings from nonpoint sources including natural background)
MOS = Margin of Safety

For this TMDL, the Jaffrey WWTF discharge is the only point source or WLA.

A margin of safety (MOS) is required in all TMDL's to account for uncertainties in the pollutant loading analysis. The MOS can be either explicit or implicit. If an explicit MOS is used, a portion of the total allowable loading is actually allocated to the MOS. If the MOS is implicit, a specific value is not assigned to the MOS. Use of an implicit MOS is appropriate when assumptions used to develop the TMDL are believed to be so conservative that they are sufficient to account for the MOS. As discussed in section 3.6 an implicit MOS of 10 percent was used in this TMDL. This was accomplished by increasing the allowable dissolved oxygen criteria and decreasing the criteria for ammonia, phytoplankton and periphyton by 10 percent. In other words, a 10% MOS of safety was applied to the water quality standards to provide added assurance that the water quality standards will be met regardless of the TMDL pollutant combinations selected. Resultant water quality criteria and targets used to develop this TMDL are presented in Table 3-4.

8.2 Seasonal Considerations / Critical Conditions

Seasonal considerations and critical conditions are discussed in section 5.1

8.3 Recommended TMDL

Table 8-1shows the recommended TMDL for CBODU, TP, NH3-N and Phytoplankton Chl a. This TMDL achieves the water quality criteria presented in Table 3-4. Modeling results based on this TMDL are presented in Figure 8-1 through Figure 8-7. All modeling assumed a Jaffrey WWTF design flow of 1.25 mgd and reductions of SOD in accordance with the methodology discussed in section 7.1. Figure 8-2 and Figure 8-4 show the instantaneous minimum and average daily percent dissolved oxygen saturation with and without SOD reductions. A copy of the QUAL2E input file for the recommended TMDL is provided in Appendix I. Headwater conditions correspond to the river flowing over the Cheshire Pond Dam (River Mile 68.2). Inflow refers to the incremental inflow used in the QUAL2E model. As discussed in section 8.1, an implicit margin of safety (MOS) was included; consequently it was not considered necessary to include an explicit MOS. A discussion of the rationale used to select this TMDL is provided in section 8.4.

Table 8-1: Recommended TMDL for CBODU, TP, NH_3-N and Phytoplankton Chl a

	CBODU			
	WLA	LA	MOS	**TMDL**
	lbs/day	lbs/day	lbs/day	**lbs/day**
Jaffrey WWTF	133.4			
Headwater		21.4		
Town Farm Brook		1.7		
Gridley Brook		7.4		
Meadow Brook		3.1		
Nubanusit Brook		21.4		
Inflow		35.1		
Total	**133.4**	**90.2**	**0.0**	**223.7**

	TP			
	WLA	LA	MOS	**TMDL**
	lbs/day	lbs/day	lbs/day	**lbs/day**
Jaffrey WWTF	2.09			
Headwater		0.14		
Town Farm Brook		0.03		
Gridley Brook		0.14		
Meadow Brook		0.06		
Nubanusit Brook		0.27		
Inflow		0.28		
Total	**2.09**	**0.91**	**0.00**	**3.00**

	NH_3 - N			
	WLA	LA	MOS	**TMDL**
	lbs/day	lbs/day	lbs/day	**lbs/day**
Jaffrey WWTF	6.36			
Headwater		0.46		
Town Farm Brook		0.07		
Gridley Brook		0.31		
Meadow Brook		0.19		
Nubanusit Brook		0.88		
Inflow		0.88		
Total	**6.36**	**2.78**	**0.00**	**9.14**

	Phytoplankton Chl a			
	WLA	LA	MOS	**TMDL**
	lbs/day	lbs/day	lbs/day	**lbs/day**
Jaffrey WWTF	0.010			
Headwater		0.027		
Town Farm Brook		0.003		
Gridley Brook		0.029		
Meadow Brook		0.005		
Nubanusit Brook		0.022		
Inflow		0.000		
Total	**0.010**	**0.086**	**0.000**	**0.096**

Figure 8-1: Recommended TMDL: Minimum DO with and without SOD Reduction

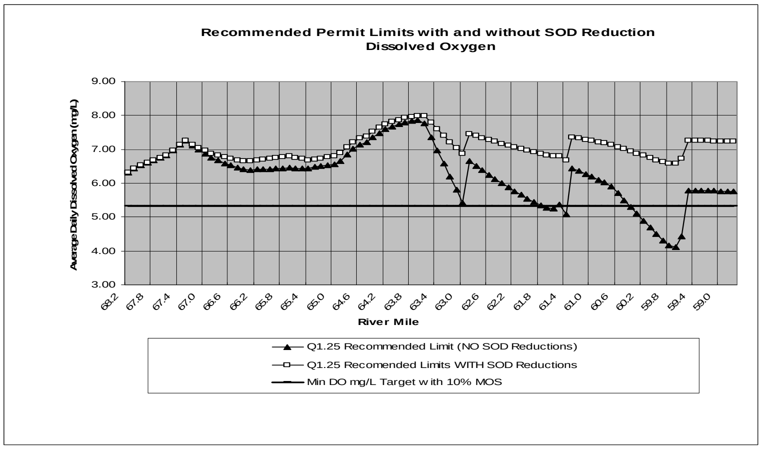


Figure 8-2: Recommended TMDL: Average Daily DO with and without SOD Reduction

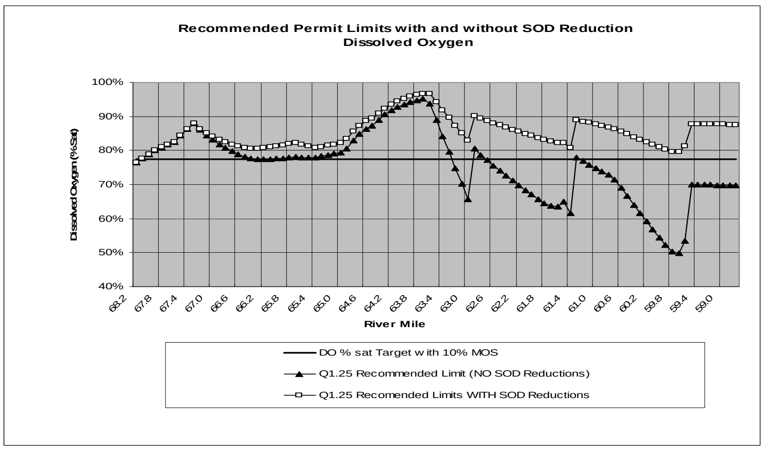


Figure 8-3: Recommended TMDL: CBODU

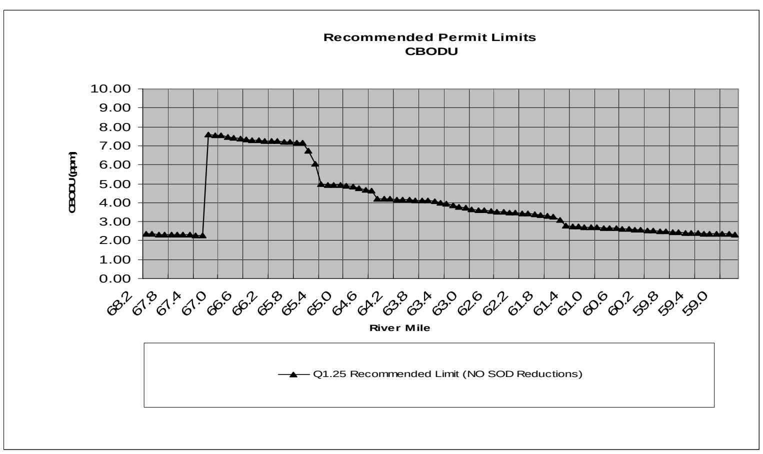
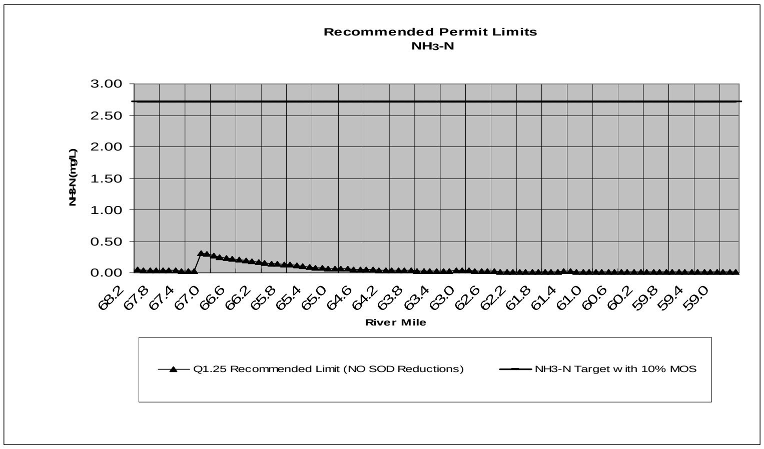


Figure 8-4: Recommended TMDL: NH3-N



Note: Chronic ammonia criterion with 10% MOS is 2.4 mg/L (see Table 3-4)

Figure 8-5: Recommended TMDL: **TP**

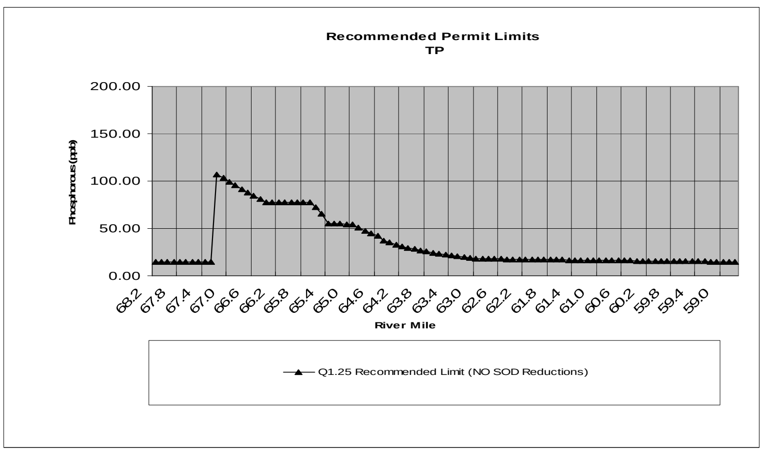


Figure 8-6: Recommended TMDL: Phytoplankton Chl a

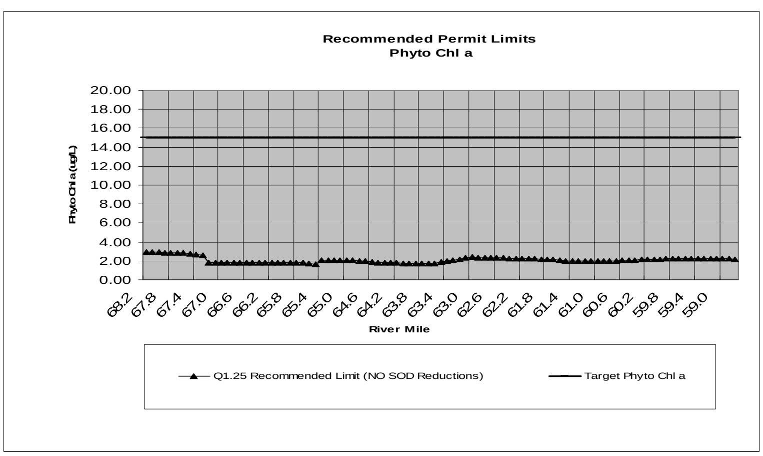
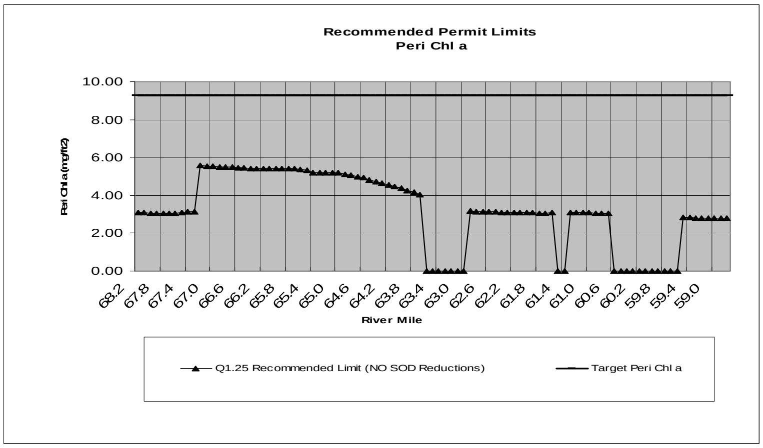


Figure 8-7: Recommended TMDL: Periphyton Chl a



8.4 Rationale for Selecting the Recommended WWTF Loadings

There are multiple combinations of pollutants that will meet the water quality standards and targets established for this TMDL. To help determine the appropriate WWTF loadings, multiple scenarios were run and plotted in various forms to identify relationships and key factors controlling the selection process. All runs assumed critical conditions (see section 5.1) and a WWTF flow of 1.25 mgd. WWTF CBODU scenarios were run at 0, 166.8 and 333.6 lbs /day. WWTF TP scenarios were run at 0, 2.09, 5.21 and 7.01 lbs/day which correspond to WWTF concentrations of 0, 0.2, 0.5 and 0.67 mg/L. (at WWTF flow of 1.25 mgd). The 7.01 lbs /day TP scenario corresponds to the existing mass of TP which is currently being discharged to the river. Finally, WWTF Chl a scenarios were run at 0, 0.0104 and 0.1526 lbs/day. The 0.0104 lbs/day scenario corresponds to 1 ug/L (at 1.25 mgd WWTF flow) and 0.1526 lbs/day represents the mass of currently discharged from the Jaffrey WWTF. For comparison purposes each graph shows the recommended TMDL. Rationale for selecting the recommended WWTF CBODU and NH3-N are presented in section 8.4.1. Similarly, key factors governing the selection of the recommended WWTF TP and Chl a loadings are provided section 8.4.2.

8.4.1 Rationale for Selecting WWTF CBODU and NH3-N

WWTF CBODU and NH3-N relationships are shown in Figure 8-8 through Figure 8-17. All runs were based on a WWTF Chl a loading of 0.0104 lbs/day.

Figure 8-9 and Figure 8-10 show the percent change in CBODU and NH3-N from existing conditions respectively. As shown, the recommended CBODU loading of 133.4 lbs/day represents a 412 percent increase and the recommended NH3-N loading represents a 12.8 percent increase in loading to the river as compared to existing conditions.

Figure 8-8 shows the relationship between the mass of WWTF CBODU and mass of WWTF NH3-N. This relationship is based on meeting the dissolved oxygen criteria in the first sag located approximately one mile downstream of the WWTF as this is where ammonia has the greatest impact (see Figure 6-4). As shown the relationship is independent of the WWTF TP loading above 2.09 lbs/day. When TP is reduced from 2.09 to 0 lbs/day approximately 0.5 fewer lbs/day of NH_3-N can be discharged from the WWTF to meet dissolved oxygen criteria for a given mass of CBODU. This is due to less oxygen being available for nitrification of NH_3-N which is a result of less algal growth and oxygen produced from photosynthetic activity when WWTF TP is decreased to zero.

Figure 8-11 and Figure 8-12 show the predicted minimum average daily dissolved oxygen with and without SOD reductions respectively. As shown in Figure 8-11, the minimum average daily dissolved oxygen target of 77.5 percent saturation is not met if the calibrated SOD values are not reduced to account for reductions in pollutants that can contribute to SOD. Without SOD reductions, predicted average daily dissolved oxygen varies from approximately 42 to 56 percent saturation for the range of WWTF TP loadings investigated.

With SOD reductions, Figure 8-12 shows that the minimum average daily dissolved oxygen target of 77.5 percent saturation is met if WWTF CBODU and TP loadings are at or below approximately 166.8 and 2.09 lbs/day respectively. Meeting the minimum average daily dissolved oxygen target was a factor in selecting the recommended WWTF CBODU loading. The lowest predicted average daily dissolved oxygen value is 72 percent saturation which occurs at WWTF CBODU and TP loadings of 333.6 and 7.01 lbs/day respectively.

Figure 8-13 through Figure 8-15 shows the estimated percent SOD reduction in various reaches for the different WWTF CBODU and TP loadings. SOD reductions were based on the model described in section 7.1. From the WWTF to the first impoundment (reaches 3 through 11), Figure 8-13 shows that predicted SOD reductions range from approximately 52 to 77 percent with SOD reductions decreasing with increasing WWTF CBODU and TP loadings.

Figure 8-14 and Figure 8-15 show the estimated SOD reductions in Reaches 12 through 14 and 15 through 16 respectively. As indicated by the vertical lines, SOD reductions in these reaches are predicted to be independent of WWTF CBODU loading. This is because the potential SOD reduction model assumes that SOD reductions due to changes in WWTF CBODU are only realized in the reaches between the WWTF and first impoundment (reaches 3 through 11).

Figure 8-16 and Figure 8-17 show the relationship of WWTF CBODU on Reach 17 average daily dissolved oxygen and CBODU levels respectively for the ranges of WWTF TP investigated. As shown in Figure 8-16, the minimum average daily dissolved oxygen criteria of 82.8 percent saturation is predicted to be met in all cases with a minimum of 82.8 percent saturation at WWTF CBODU and TP loadings of 333.6 and 7.01 lbs/day respectively and a maximum of 91.7 percent saturation at 0 lbs/day of WWTF CBODU and TP.

As shown in Figure 8-17, at the recommended CBODU loading results in 2.3 mg/L CBODU in Reach 17 which is very close to the target of 2 mg/L. Although slightly higher, it is not expected to significantly impact the Peterborough WWTF limits or Powder Mill Pond.

In summary, of all the TMDL targets, the criteria that had the most influence on the recommended WWTF CBODU loading were 1) meeting the target ambient CBODU concentration in Reach 17 and 2) meeting the average daily minimum dissolved oxygen target of 77.5 percent saturation. Once the CBODU was selected, the recommended WWTF NH3-N loading was determined by adjusting the WWTF NH3-N concentration in the model until the minimum average daily dissolved oxygen target in the first sag downstream of the WWTF was met as this is where NH3-N is predicted to have the greatest influence on dissolved oxygen.

Figure 8-8: WWTF CBODU vs WWTF NH3-N

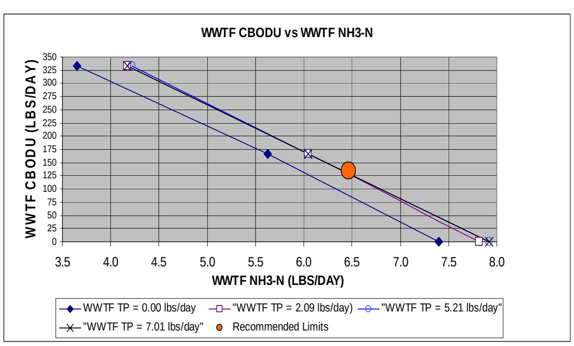


Figure 8-9: WWTF CBODU vs % Change in Existing WWTF CBODU Loading

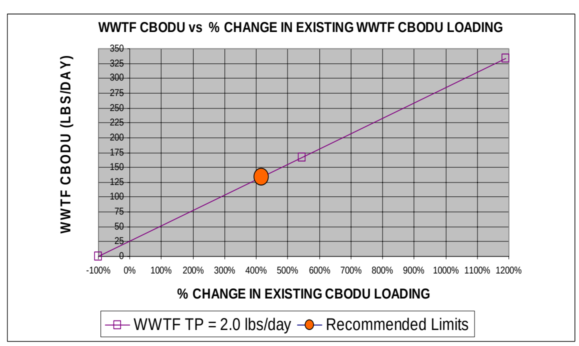


Figure 8-10: WWTF NH3-N vs % Change in Existing WWTF NH3-N Loading

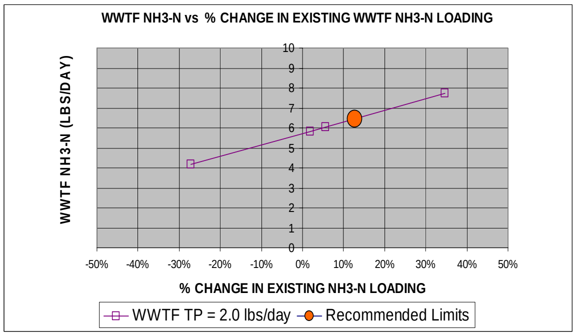


Figure 8-11: WWTF CBODU vs Minimum Average Daily % DO Sat Without SOD Reductions

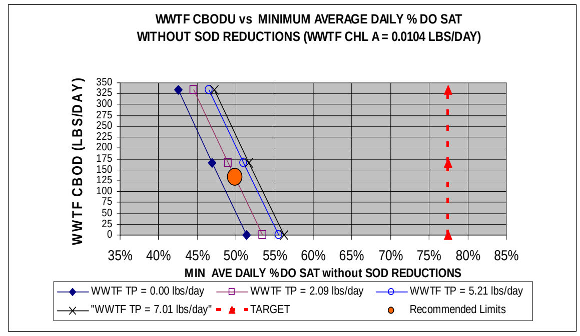


Figure 8-12: WWTF CBODU vs Minimum Average Daily % DO Sat With SOD Reductions

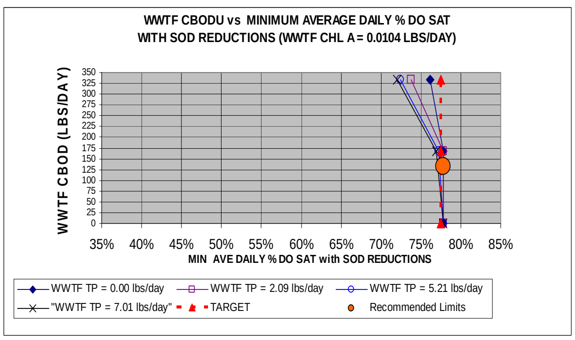


Figure 8-13: WWTF CBODU vs Estimated % SOD Reduction to meet WQS in Reaches 3 -11

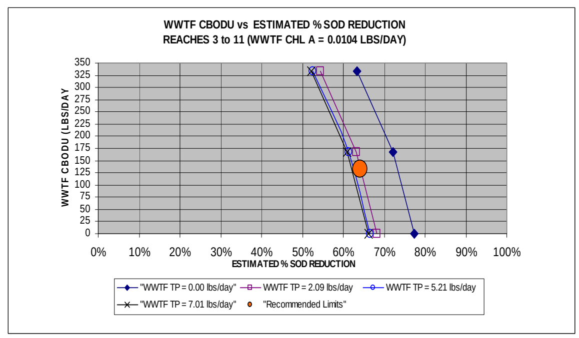


Figure 8-14: WWTF CBODU vs Estimated % SOD Reduction in Reaches 12-14

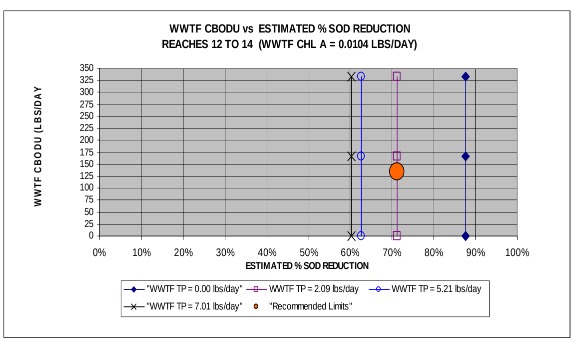


Figure 8-15: WWTF CBODU vs Estimated % SOD Reduction in Reaches 15-16

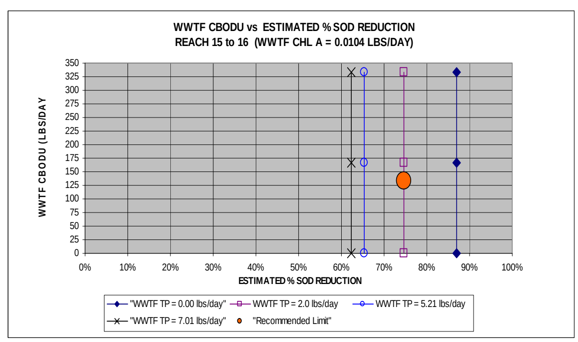


Figure 8-16: WWTF CBODU vs Reach 17 DO

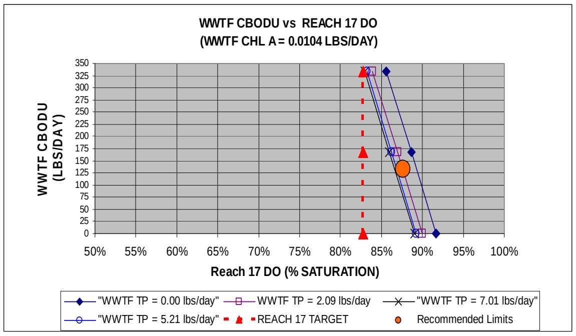
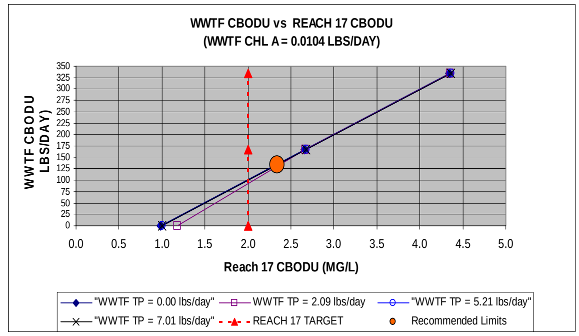


Figure 8-17: WWTF CBODU vs Reach 17 CBODU



8.4.2 Rationale for Selecting Recommended WWTF TP and WWTF Chl a Loadings

WWTF TP and Chl a relationships are shown in Figure 8-18 through Figure 8-28. Modeling conducted to generate these figures was based on a CBODU loading of 166.8 lbs/day.

Figure 8-18 and Figure 8-19 show the relationship between WWTF TP and WWTF Chl a loading and the percent change that they represent as compared to existing conditions. As shown in Figure 8-18, the recommended WWTF TP loading of 2.09 lbs/day represents an approximate 70 percent decrease in WWTF TP loading to the river as compared to existing conditions. Similarly, Figure 8-19 shows that the recommended WWTF Chl a loading of 0.0104 lbs/day represents an approximate 93 percent decrease in WWTF Chl a loading to the river as compared to existing conditions.

Figure 8-20 shows the relationship of WWTF TP loading and maximum predicted ambient phytoplankton chl a levels for various WWTF Chl a loadings. The relatively vertical lines indicate that the maximum ambient phytoplankton levels are not very dependent on the WWTF TP loadings for the ranges investigated (i.e., the maximum change in phytoplankton chl a is less than 1 ug/L for WWTF TP loadings ranging from 0.0 to 7.01 lbs/day). Though not very sensitive to WWTF TP loadings, the same graph shows that the maximum ambient phytoplankton chl a is much more dependent on the WWTF Chl a loadings with maximum ambient phytoplankton chl a levels increasing by approximately 6 ug/L as WWTF Chl a loadings are increased from 0.0104 to 0.1526 lbs/day. Finally Figure 8-18 shows that the maximum ambient phytoplankton chl a target of 13.5 ug/L is met for all combinations of WWTF TP and Chl a loadings investigated with a maximum of approximately 9 ug/L chl a at WWTF TP and Chl a loadings of 7.01 and 0.1526 lbs/day respectively.

Figure 8-21 shows the relationship of WWTF TP loading and maximum predicted periphyton chl a levels for various WWTF Chl a loadings. Before proceeding it is important to recall that predicted periphyton chl a are based on model default values and that since periphyton chl a was not actually measured in the stream the model is not actually calibrated specifically for periphyton chl a. As expected, Figure 8-21 indicates that periphyton levels are independent of WWTF Chl a loadings but are dependent on WWTF TP loadings. As shown in this figure, periphyton chl a levels are predicted to almost double (3.1 to 5.6 mg/ft2) as WWTF TP loadings increase from 0.0 to 2.09 lbs/day. Above 2.09 lbs/day, periphyton levels remain almost constant. This suggests that the periphyton growth is maximized at relatively low TP loadings. Finally Figure 8-21 shows that the maximum ambient periphyton chl a target of 8.4 mg/ft2 is met for all combinations of WWTF TP and Chl a loadings investigated with a maximum of approximately 5.8 mg/ft2 at WWTF TP loading of 7.01 lbs/day respectively.

Figure 8-22 and Figure 8-23 show the relationship of WWTF TP loading and minimum predicted average daily dissolved oxygen levels for various WWTF Chl a loadings with and without SOD reductions respectively. Figure 8-22 shows that without SOD reductions made to account for changes in oxygen demanding pollutants that could impact SOD, the target of 77.5 percent is not met for all combinations of

WWTF TP and Chl a investigated. With SOD reductions, Figure 8-23 shows that the target is met for WWTF Chl a loadings no greater than 0.0104 lbs/day and WWTF TP loadings no greater than approximately 2.09 lbs/day. Meeting the minimum dissolved oxygen target was a major factor for selecting the recommended limits. For the same WWTF Chl a loading (0.0104 lbs/day), the predicted values are slightly less than the 77.5 percent target but greater than the actual water quality criteria of 75 percent for WWTF TP loadings between 2.09 and 7.10 lbs/day. At WWTF Chl a loading of 0.1526 lbs/day, the target is not met for any of the WWTF TP loadings investigated (values range from approximately 63 to 72 percent for WWTF TP loadings of 7.01 and 0.0 lbs/day respectively).

Figure 8-24 through Figure 8-26 show the relationship of WWTF TP and Chl a loadings and the estimated percent SOD reduction in various reaches based on the SOD model described in section 7.1. The figures indicate that both WWTF TP and Chl a loadings significantly impact SOD reductions but that reductions of WWTF Chl a will have a much larger impact for WWTF Chl a loadings greater than approximately 0.0104 lbs/day. Between 0 and 0.0104 lbs/day WWTF Chl a, predicted SOD reductions are estimated to change by less than 4 percent. Increasing the WWTF Chl a from 0.0104 to 0.1526 lbs/day decreases the estimated SOD reduction from 11 to 53 percent. In reaches 12-16 (see Figure 8-25 and Figure 8-26), and assuming a WWTF Chl a loading of 0.0104 lbs/day, decreasing the WWTF TP from 5.21 to 2.09 lbs/day results in an increase in the estimated percent SOD reduction potential of 8 to 10 percent. If the WWTF TP is further decreased to 0.0 lbs/day, the estimated SOD reduction increases by another 13 to 18 percent. This jump in SOD reduction is primarily due to greater reductions in periphyton that are predicted to occur as WWTF TP is lowered below 2.09 lbs/day. The potential for significantly greater SOD reductions at the lower WWTF TP loadings was a factor in selecting the recommended WWTF TP loading of 2.09 lbs/day.

Figure 8-27 shows the relationship of WWTF TP and Chl a with Reach 17 phytoplankton chl a concentrations. At WWTF Chl a loadings less than 0.0104 lbs/day, Figure 8-27 indicates that WWTF TP loadings have a larger impact on Reach 17 chl a levels than WWTF Chl a for the ranges investigated (Reach 17 phytoplankton chl a changes by less than 1 ug/L for this range of WWTF Chl a but increases by approximately 2.8 ug/L as WWTF TP loadings are varied from 0.0 to 7.01 lbs/day). As WWTF Chl a loadings are increased above 0.0104 lbs/day, the WWTF Chl a loadings play a more dominant role in the Reach 17 phytoplankton chl a levels. The target value of 2 ug/L is met for WWTF TP loadings less than approximately 2 lbs/day and WWTF Chl a no greater than 0.0104 lbs/day which was a major factor for selecting the recommended WWTF TP and Chl a loadings of 2.09 and 0.0104 lbs/day respectively.

Finally Figure 8-28 shows the relationship of WWTF TP and Chl a with Reach 17 TP concentrations. As indicated WWTF TP has a greater impact on Reach 17 TP levels than WWTF Chl a for the ranges investigated. The target value of 28 ug/L is met for WWTF TP loadings less than approximately 5.5 lbs/day and WWTF Chl a no greater than 0.0104 lbs/day. For WWTF Chl a levels greater than 0.0104 lbs/day, Figure 8-28 indicates that the WWTF TP loading can exceed 5.5 lbs/day without exceeding the target of 28 ug/L. This phenomenon is most likely due to uptake of TP by phytoplankton and settling of phytoplankton (and associated TP) upstream of Reach 17. At the recommended WWTF TP and Chl a loadings, the predicted TP concentration in Reach 17 is approximately 15 ug/L which is well below the maximum target value of 28 ug/L.

In summary, of all the TMDL targets, the criteria that had the most influence on the selection of the recommended WWTF TP and Chl a loadings were 1) meeting the average daily minimum dissolved oxygen target, 2) minimizing SOD, and 3) meeting the target phytoplankton chl a levels in Reach 17.

Figure 8-18: WWTF TP vs % Change in Existing WWTF TP LOADING

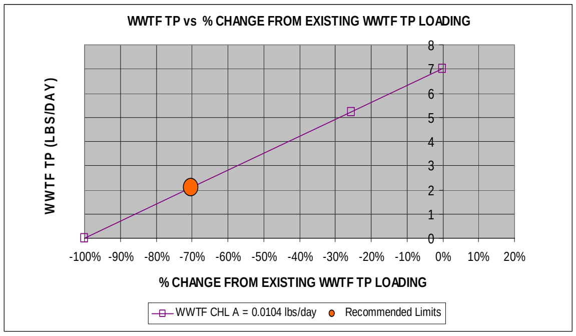


Figure 8-19: WWTF Chl a vs % Change from Existing WWTF Chl a Loading

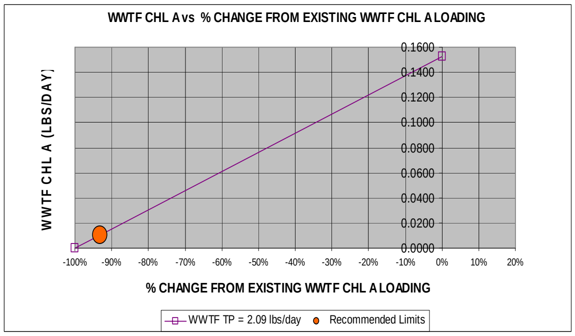


Figure 8-20: WWTF TP vs Maximum Phytoplankton

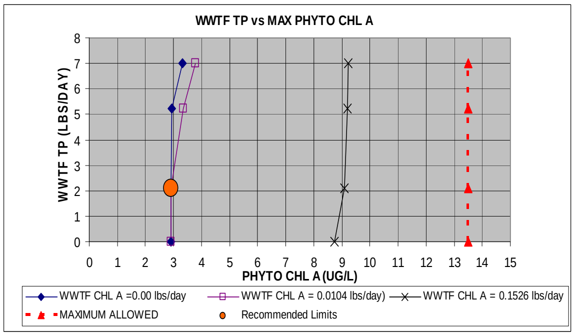


Figure 8-21: WWTF TP vs Maximum Periphyton

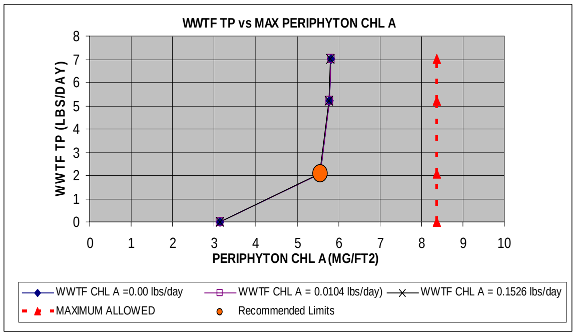


Figure 8-22: WWTF TP vs Minimum Average Daily % DO Saturation without SOD Reductions

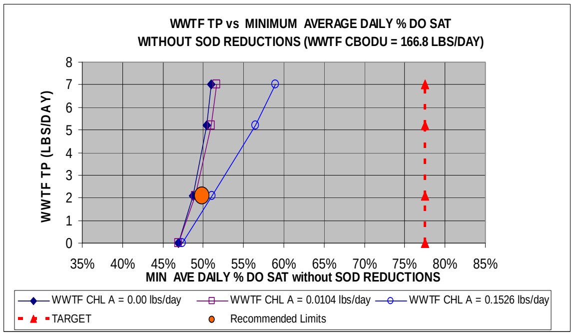


Figure 8-23: WWTF TP vs Minimum Average Daily % DO Saturation with SOD Reductions

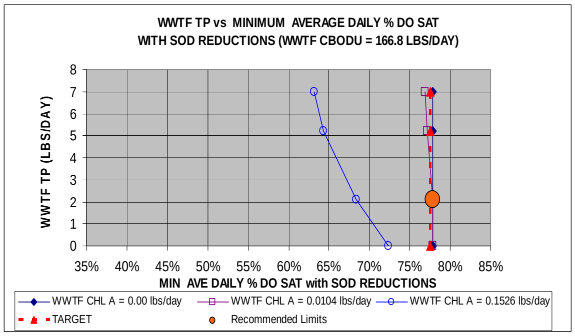


Figure 8-24: WWTF TP vs Estimated % SOD Reduction in Reaches 3 - 11

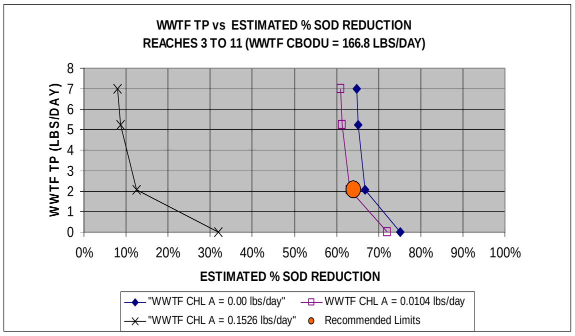


Figure 8-25: WWTF TP vs Estimated % SOD Reduction in Reaches 12 - 14

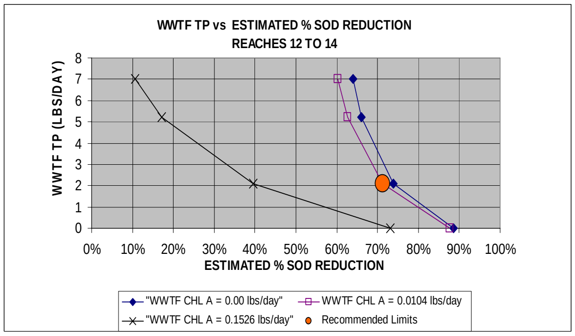


Figure 8-26: WWTF TP vs Estimated % SOD Reduction in Reaches 15 - 16

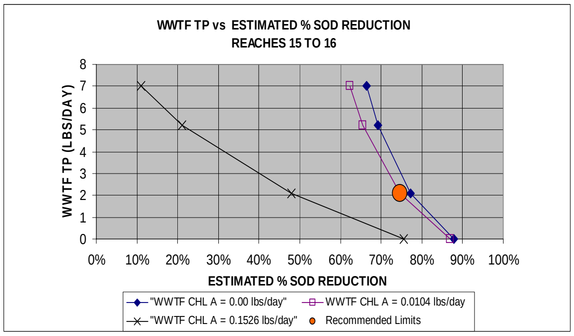


Figure 8-27: WWTF TP vs Reach 17 Phytoplankton Chl a

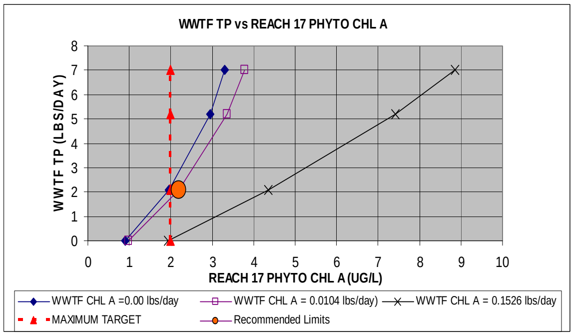
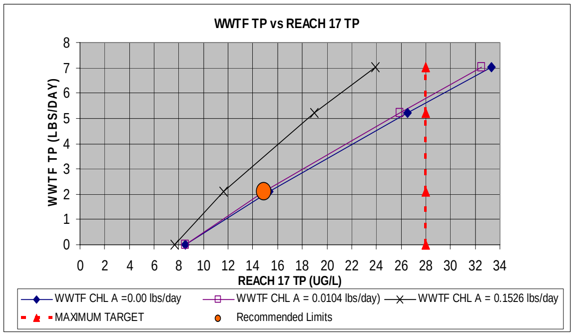


Figure 8-28: WWTF TP vs Reach 17 TP



9

RECOMMENDED WWTF PERMIT LIMITS

9.1 Warm Weather Permit Limits

Based on the TMDL presented in Table 8-1 the following warm weather permit limits are recommended. Table 9-1 shows the permit limits based on the Jaffrey WWTF design flow of 1.25 mgd. At the request of the Town of Jaffrey, Table 9-2 and Table 9-3 are also provided which show recommended permit limits assuming Jaffrey WWTF flows of 1.0 and 0.5 mgd respectively. In all scenarios, loads were kept the same. Consequently, changing the WWTF flow only changed the concentrations. CBOD5 limits were based on the CBODU TMDL loading divided by 3.2, which is average of CBODU/BOD5 ratios from data collected in 2004 (see Table 9-4). Though the measured ratio is based on CBODU/BOD5 instead of CBODU/CBOD5, it is probably very close to the actual CBODU/CBOD5 ratio as most of the BOD in the first 5 days is due to oxidation of carbonaceous material.

Table 9-1: Recommended NPDES Permit Limits – Warm Weather: Q $_{WWTF}$ = 1.25 mgd

Parameter	Warm Weather Limits						
	Max Daily (Report) (mgd)	Ave Monthly (mg/L)	Ave Weekly (mg/L)	Max Daily (mg/L)	Ave Monthly (lbs/day)	Ave Weekly (lbs/day)	Max Daily (lbs/day)
Flow	1.25						
$CBOD_5$		4.0	4.0	6.7	41.7	41.7	69.6
TSS		4.0	4.0	6.7	41.7	41.7	69.6
NH_3-N (May 1 - Sept 30)		0.61	0.61	1.02	6.36	6.36	10.6
TP (April 1 - Oct 31)		0.20		Report	2.09		Report
Dissolved Oxygen (May 1 - Sept 30)	No less than 7.0 mg/L						
Chlorophyll a		0.0010		Report	0.0104		Report

Notes:
1. CBOD5 based on CBODU/$CBOD_5$ ratio of 3.2.
2. WWTF effluent chl a was modeled at 1 ug/L (0.001 mg/L)
3. Average Monthly limits were set equal to Average Weekly limits.
4. Max Daily limits equal 1.67 times the Ave Monthly limit similar to the Max Daily/ Ave Monthly ratio for secondary treatment (50/30).
5. Shaded values are from the TMDL

Table 9-2: Recommended NPDES Permit Limits – Warm Weather: Q $_{WWTF}$ = 1.00 mgd

Parameter	Warm Weather Limits						
	Max Daily (Report) (mgd)	Ave Monthly (mg/L)	Ave Weekly (mg/L)	Max Daily (mg/L)	Ave Monthly (lbs/day)	Ave Weekly (lbs/day)	Max Daily (lbs/day)
Flow	1.00						
$CBOD_5$		5.0	5.0	8.4	41.7	41.7	69.6
TSS		5.0	5.0	8.4	41.7	41.7	69.6
NH_3-N (May 1 - Sept 30)		0.8	0.8	1.3	6.36	6.36	10.6
TP (April 1 - Oct 31)		0.25		Report	2.09		Report
Dissolved Oxygen (May 1 - Sept 30)	No less than 7.0 mg/L						
Chlorophyll a		0.0013		Report	0.0104		Report

Notes:
1. CBOD5 based on CBODU/$CBOD_5$ ratio of 3.2.
2. WWTF effluent chl a was modeled at 1 ug/L (0.001 mg/L)
3. Average Monthly limits were set equal to Average Weekly limits.
4. Max Daily limits equal 1.67 times the Ave Monthly limit similar to the Max Daily/ Ave Monthly ratio for secondary treatment (50/30).
5. Shaded values are from the TMDL

Table 9-3: Recommended NPDES Permit Limits – Warm Weather: Q $_{WWTF}$ = 0.50 mgd

Parameter	Warm Weather Limits						
	Max Daily (Report) (mgd)	Ave Monthly (mg/L)	Ave Weekly (mg/L)	Max Daily (mg/L)	Ave Monthly (lbs/day)	Ave Weekly (lbs/day)	Max Daily (lbs/day)
Flow	0.50						
$CBOD_5$		10.0	10.0	16.7	41.7	41.7	69.6
TSS		10.0	10.0	16.7	41.7	41.7	69.6
NH_3-N (May 1 - Sept 30)		1.5	1.5	2.5	6.36	6.36	10.6
TP (April 1 - Oct 31)		0.50		Report	2.09		Report
Dissolved Oxygen (May 1 - Sept 30)	No less than 7.0 mg/L						
Chlorophyll a		0.0025		Report	0.0104		Report

Notes:
1. CBOD5 based on CBODU/$CBOD_5$ ratio of 3.2.
2. WWTF effluent chl a was modeled at 1 ug/L (0.001 mg/L)
3. Average Monthly limits were set equal to Average Weekly limits.
4. Max Daily limits equal 1.67 times the Ave Monthly limit similar to the Max Daily/ Ave Monthly ratio for secondary treatment (50/30).
5. Shaded values are from the TMDL

Table 9-4: Jaffrey WWTF CBODU/BOD5 Ratios based on 2004 data

Date (Sample type)	BODU	BOD5	CBODU	BODU/BOD5	CBODU/BOD5
8/4/04 (grab)	37.5	7.2	21.5	5.2	3.0
8/4/04 (composite)	32.7	5.4	16.6	6.1	3.1
8/4/04 (grab)	44.4	7.2	24.7	6.2	3.4
8/4/04 (composite)	39.1	14.4	7.9	2.7	0.6 (not included in average)
				Average	~ 3.2

9.2 Cold Weather Permit Limits

Recommended WWTF limits for the cold weather months are shown in Table 9-5. Figure 9-1 through Figure 9-5 show the results of the cold weather permit limit run for dissolved oxygen, NH3-N, Phytoplankton Chl a and Periphyton Chl a. A copy of the input file and PAR worksheet is provided in Appendix J. Modeling to develop cold weather limits were based on input used to develop the warm weather permit limits with the following exceptions:

- The water temperature was set to 14 degrees C which is based on USGS water temperature measurements at the USGS Gage in the Contoocook River below the Hopkinton Dam in West Hopkinton (see Table 9-6).
- The nitrification rate was adjusted from 5/day used for summer modeling to 0.5/day. This was done to reflect the fact that river flows are usually higher during the cold weather months as compared to the warm weather months; consequently during the cold weather period, there should be more dilution and less contact of the water column with the sediments where bacteria responsible for nitrification usually reside.
- Cold weather dissolved oxygen concentrations for the headwater, tributaries and incremental inflows were determined by multiplying the percent saturation values used in the warm weather runs by the dissolved oxygen saturation concentration corresponding to the assumed cold weather water temperature of 14 degrees C. The WWTF dissolved oxygen was set at 8.76 mg/L which is based on a minimum WWTF effluent temperature of 14 degrees C (57.2 degrees F) and 85 percent saturation (0..85 x 10.3 mg/L = 8.76 mg/L).
- CBODU was kept the same and WWTF NH3-N was increased until the average daily dissolved oxygen target of 77.5 percent saturation was met in the first sag downstream of WWTF or until the maximum NH3-N concentration to prevent chronic toxicity due to ammonia was met. Assuming a pH of 7.0 (see section 3.3.3 and 3.4) and water temperatures less than or equal to 14 degrees C, the ambient chronic NH3-N criterion is 5.91 mg/L. Based on a WWTF flow of 1.25 mgd, and 7Q10 river flow of 1.83 cfs, and reserving 10 percent for future reserve in (see section 3.3.4), this translates to a maximum WWTF NH3-N concentration of 10.35 mg/L. As shown in

Tale 9-4, an average monthly permit limit of 7.55 mg/L NH3-N is proposed which indicates that dissolved oxygen governs the WWTF NH3-N permit limit as opposed to the aquatic life chronic toxicity value.

- Photosynthetic active radiation or PAR was set equal to 911 which is based on a calendar date of April 15th. (see calculations in Appendix I).
- SOD was adjusted in accordance with the methodology described in section 7.1.
- WWTF TP was modeled at 0.2 mg/L to reflect what it would be in October when the cold weather period for NH3-N is proposed to begin. As previously mentioned the temperature of 14 degrees was selected for the NH3-N as this isi the highest temperature that is likely to occur during the period October 1 through April 30 (see Table 9-6). For the period of November 1 through March 31, the WWTF TP was increased to 1.0 mg/L to reflect the fact that temperatures are colder (i.e.,less than approximately 4 degrees C per Table 9-6) which will further suppress algal growth; consequently more WWTF TP loading can be allowed. Increasing the WWTF TP to 1.0 mg/L results in a loading of approximately 10.4 lbs/ day of WWTF TP.

Table 9-5 Recommended NPDES Permit Limits – Cold Weather: Q $_{WWTF}$ = 1.25 mgd

Parameter	Cold Weather Limits						
	Max Daily (Report) (mgd)	Ave Monthly (mg/L)	Ave Weekly (mg/L)	Max Daily (mg/L)	Ave Monthly (lbs/day)	Ave Weekly (lbs/day)	Max Daily (lbs/day)
Flow	1.25						
$CBOD_5$		4.0	4.0	6.7	41.7	41.7	69.6
TSS		4.0	4.0	6.7	41.7	41.7	69.6
NH_3-N (Oct 1- April 30)		7.55	7.55	12.61	78.7	78.7	131.4
TP (Nov 1 - March 31)		1.00		Report	10.43		Report
Dissolved Oxygen (Oct 1- April 30)	No less than 8.7 mg/L						
Chlorophyll a		0.001		Report	0.010		Report

Notes:
1. CBOD5 based on CBODU/$CBOD_5$ ratio of 3.2.
2. WWTF effluent chl a was modeled at 1 ug/L (0.001 mg/L)
3. Average Monthly limits were set equal to Average Weekly limits.
4. Max Daily limits equal 1.67 times the Ave Monthly limit similar to the Max Daily/ Ave Monthly ratio for secondary treatment (50/30).

Figure 9-1: Cold Weather Conditions; Minimum Dissolved Oxygen

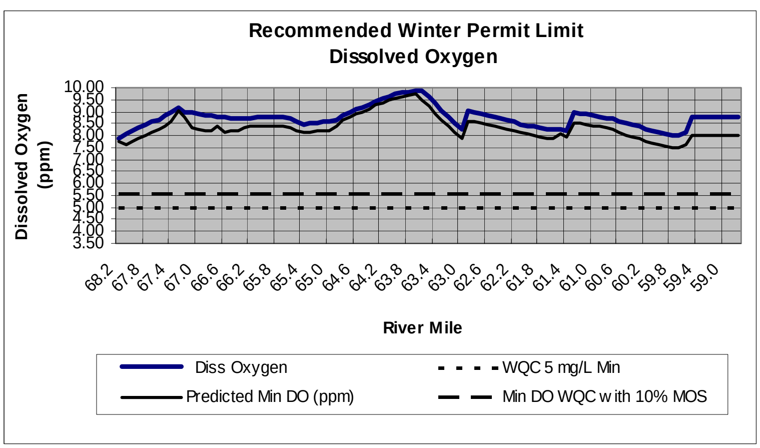


Figure 9-2: Cold Weather Conditions: Average Daily Dissolved Oxygen

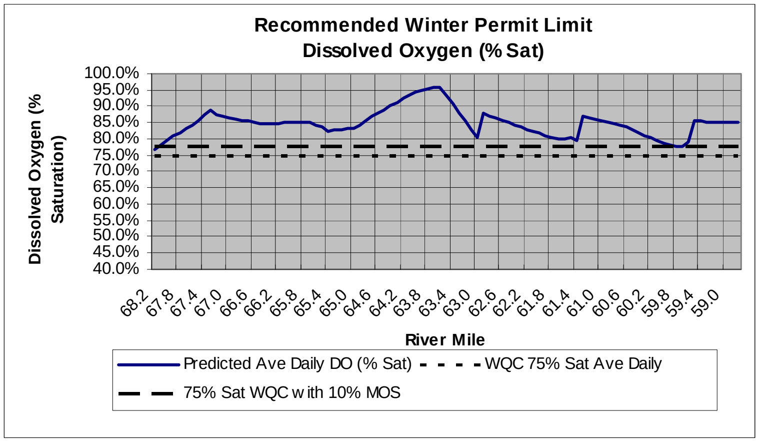


Figure 9-3: Cold Weather Conditions; NH3-N

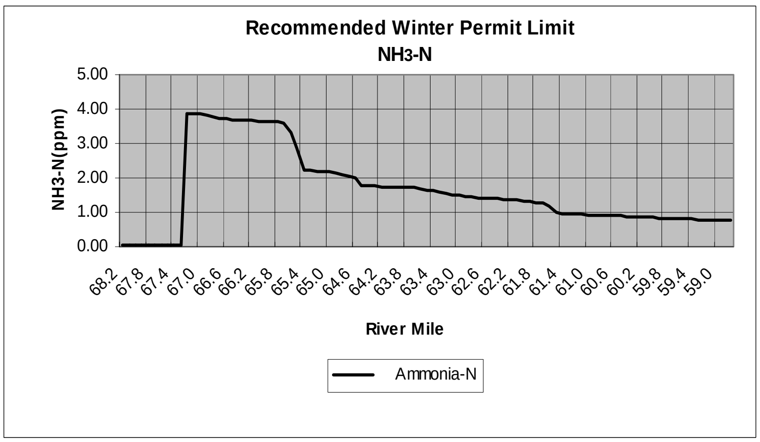


Figure 9-4: Cold Weather Conditions; Phytoplankton Chl a

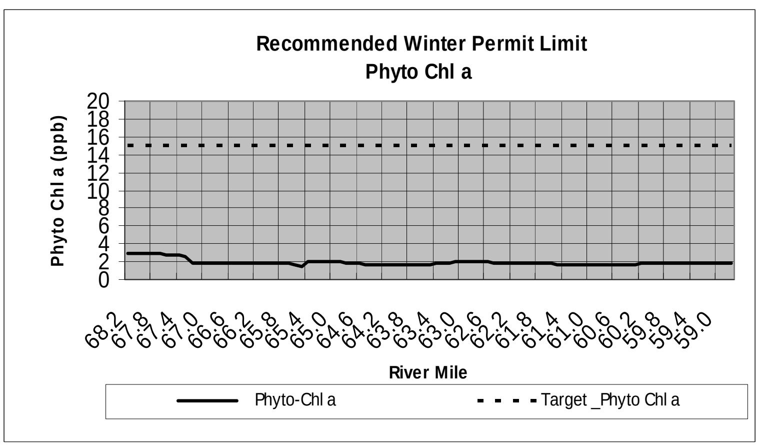


Figure 9-5: Cold Weather Conditions; Periphyton Chl a

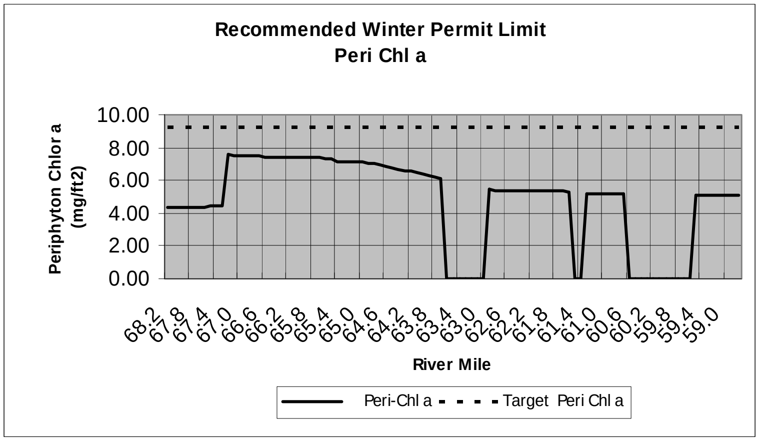


Table 9-6: Water Temperature Statistics based on measurements at USGS Gage 01085500

Water Temperature degrees C				
Month	**Minimum**	**Maximum**	**Average**	**Median**
January	0.0	1.0	0.5	0.5
February	-	-	-	-
March	1.0	4.0	2.5	2.5
April	5.4	7.0	6.1	6.0
May	15.0	18.2	17.0	17.4
June	15.0	22.0	20.2	21.8
July	21.0	27.0	23.9	23.6
August	20.0	26.2	22.8	22.1
September	15.0	20.0	18.3	19.0
October	11.8	13.7	12.5	12.2
November	1.3	8.0	4.1	3.6
December	0.3	0.3	0.3	0.3

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IMPLEMENTATION / REASONABLE ASSURANCE

According to Section 303(d) of the CWA TMDL implementation plans are not required by EPA for TMDL approval. The exception to this is when nonpoint source loadings have been reduced to allow higher point source (i.e. WWTF) loadings. In such cases, reasonable assurance must be provided demonstrating that the proposed reductions in nonpoint sources are achievable. For this TMDL, demonstration of reasonable assurance is not required as nonpoint source loads were not reduced to accommodate point source loadings.

Though implementation plans are not required, a TMDL study is nothing more than a paper exercise if it isn't implemented. Consequently, to kick start restoration efforts, recommendations for implementing this TMDL are provided below. A phased iterative approach is proposed which will likely take several years. Pending the availability of resources, DES will work with the towns of Jaffrey and Peterborough to identify projects and implement actions that are specifically targeted towards reducing the pollutant loading to the river. Examples are provided below:

- Revise the NPDES permit for the Town of Jaffrey WWTF in accordance with the TMDL.
- Upgrade the Jaffrey WWTF as necessary to comply with the revised NPDES permit effluent limits.
- Work with the DES Alteration of Terrain Section to require applicants for a Site Specific Permit (alteration of 2.3 acres or more) within the watershed of the study area to demonstrate per Env-Ws 415.10(d) that development projects do not increase the CBODU and nutrient loadings to the river both during construction and after construction is complete.
- Promote nonstructural best management practices (BMPs) (such as street sweeping, pet waste management).
- Promote public education regarding this TMDL, water quality standards, BMPs and resource protection.
- Manage geese upstream of the Jaffrey WWTF to reduce SOD loading from goose feces; this should improve dissolved oxygen concentrations upstream of the WWTF.
- If dissolved oxygen levels do not improve behind the impoundments after improvements are made at the WWTF, investigate the feasibility and potential benefit of dredging behind the dams to reduce SOD.
- Identify and facilitate the implementation of nonpoint source projects within the watershed that will result in reduced nutrient loading in the river.
- Continue to monitor the water quality in the river and tributaries for progress and compliance with water quality standards.

11

PUBLIC PARTICIPATION

(*This section will be completed after the draft report is released for public comment).*

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12

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APPENDICES

Appendix A	**QUAL2E Calibration / Verification Report**
Appendix B	**7Q10 Calculations for Various WWTF Flows**
Appendix C	**Photosynthetic Active Radiation (PAR) Calculations for Critical Conditions**
Appendix D	**QUAL2E Input Files and Output Plots for Existing Loadings at Critical Conditions**
Appendix E	**Existing NPDES Permit Limits for the Jaffrey WWTF**
Appendix F	**QUAL2E Input Files for Existing NPDES Permit Loadings at Critical Conditions**
Appendix G	**QUAL2E Input File for No WWTF Scenario**
Appendix H	**Methodology for Predicting Potential Changes in Sediment Oxygen Demand (SOD)**
Appendix I	**QUAL2E Input File for Recommended TMDL**
Appendix J	**QUAL2E Input File and PAR Calculations for Cold Weather Scenario**