Benthic TMDL Development

Stressor Analysis Report

for North River

Augusta and Rockingham Counties, Virginia

Submitted by:

Virginia Department of Environmental Quality

Prepared by:

Department of Biological Systems Engineering

Virginia Tech

Revised: September 30, 2005

VT-BSE Document No. 2005-0009

Project Personnel

Virginia Tech, Department of Biological Systems Engineering

Brian Benham, Assistant Professor and Extension Specialist: Project Director
Gene Yagow, Research Scientist: Project Manager
Mohammad Al-Smadi, Graduate Research Assistant
Rebecca Zeckoski, Research Associate

Virginia Department of Environmental Quality (VADEQ)

Robert Brent, Project Coordinator
Sandra Mueller
Jutta Schneider
Bill Van Wart
Gary Flory

Virginia Department of Conservation and Recreation (VADCR)

Jason Ericson

North River TMDL Steering Committee

James Shiflet (DEQ)
Gary Flory (DEQ)
Kevin K. Craun (Farmer)
John Sponaugle (Farmer)
Dick Patton (USFS)
Ned Davis (City of Staunton)
Rick Blackwell (Blackwell Engineering)
Jean Andrews (Augusta Co. Service Authority)
Tom Womble (Town of Bridgewater)
Pete Hawes (concrete manufacturer)
Tom Gathright (retired USGS)
Robert Brent (DEQ)
Gene Yagow (VT)
Becky Zeckoski (VT)

For additional information, please contact:

Virginia Department of Environmental Quality

Water Quality Assessment Office, Richmond: Sandra Mueller, (804) 698-4324
Valley Regional Office, Harrisonburg: Robert Brent, (540) 574-7848

Table of Contents

List of Tables

List of Figures

1.0 Introduction

North River was originally listed as impaired due to water quality violations of the general aquatic life (benthic) standard in Virginia's 1996 Section 303(d) Total Maximum Daily Load Priority List and Report. As a result, the Environmental Protection Agency (EPA) added this stream to the 1998 consent order requiring a TMDL by 2010. During the 2000, 2002, and 2004 assessment periods, the stream was assessed by VADEQ as being fully supportive of its Aquatic Life Use, and therefore, "non-impaired" (VADEQ, 2004). Since EPA has placed a higher requirement for removing a previously impaired stream segment from the list than for current listings, this segment remained on the 2004 303(d) list in assessment category 5A – an impaired water requiring a TMDL. This report documents the prior impairment on this North River segment, describes the most probable stressor causing that impairment, and demonstrates that the previous impairment on North River was the result of impairments on upstream tributaries that are being addressed through existing TMDL studies. This stressor analysis, therefore, supports the reclassification of this segment to category 4A – TMDL not required, because a TMDL is already in place.

The Virginia Department of Environmental Quality (VADEQ) has delineated the benthic impairment on North River (stream segment VAV-B23R-NTH01) as a stream length of 16.32 miles. The impaired stream segment begins at the confluence of the North River with Cooks Creek and extends downstream to its confluence with the South River, as shown in Figure 1-1. The South River flows into the South Fork of the Shenandoah River, which flows into the Potomac River and eventually enters the Chesapeake Bay. The watershed defined by the downstream extent of the impaired segment includes 815.6 mi^2. The watershed straddles the border between Augusta and Rockingham counties in the Shenandoah Valley of Virginia, and includes the city of Staunton and most of the city of Harrisonburg. The source of impairment was originally listed as "unknown".

The assessment of the North River stream segment was based on monitoring at DEQ station 1BNTH014.48, located 14.48 miles above the watershed outlet. Since sources of impairment are generally located upstream from the point of assessed impairment, a watershed was delineated upstream from station 1BNTH014.48, as shown in Figure 1-2, consisting of 375.2 mi^2. This watershed, referred to as B23ax North River, was then used as the basis for the stressor analysis in this report and the area in which to look for probable causes of the impairment.

The B23ax North River watershed contains all of the following 14-digit state hydrologic unit watersheds: B16-B22, B24-B27, and the upstream portion of watershed B23 (B23a). Within the area draining to station 1BNTH014.48, 6 major tributaries have been listed with benthic impairments – Muddy Creek, Cooks Creek, Blacks Run, Beaver Creek, Mossy Creek, and Pleasant Run, as shown in Figure 1-3. Five of these have had TMDL studies completed and the sixth – Beaver Creek – is no longer impaired and has been approved for reclassification by EPA. More details on these TMDLs are included as part of the stressor analysis.

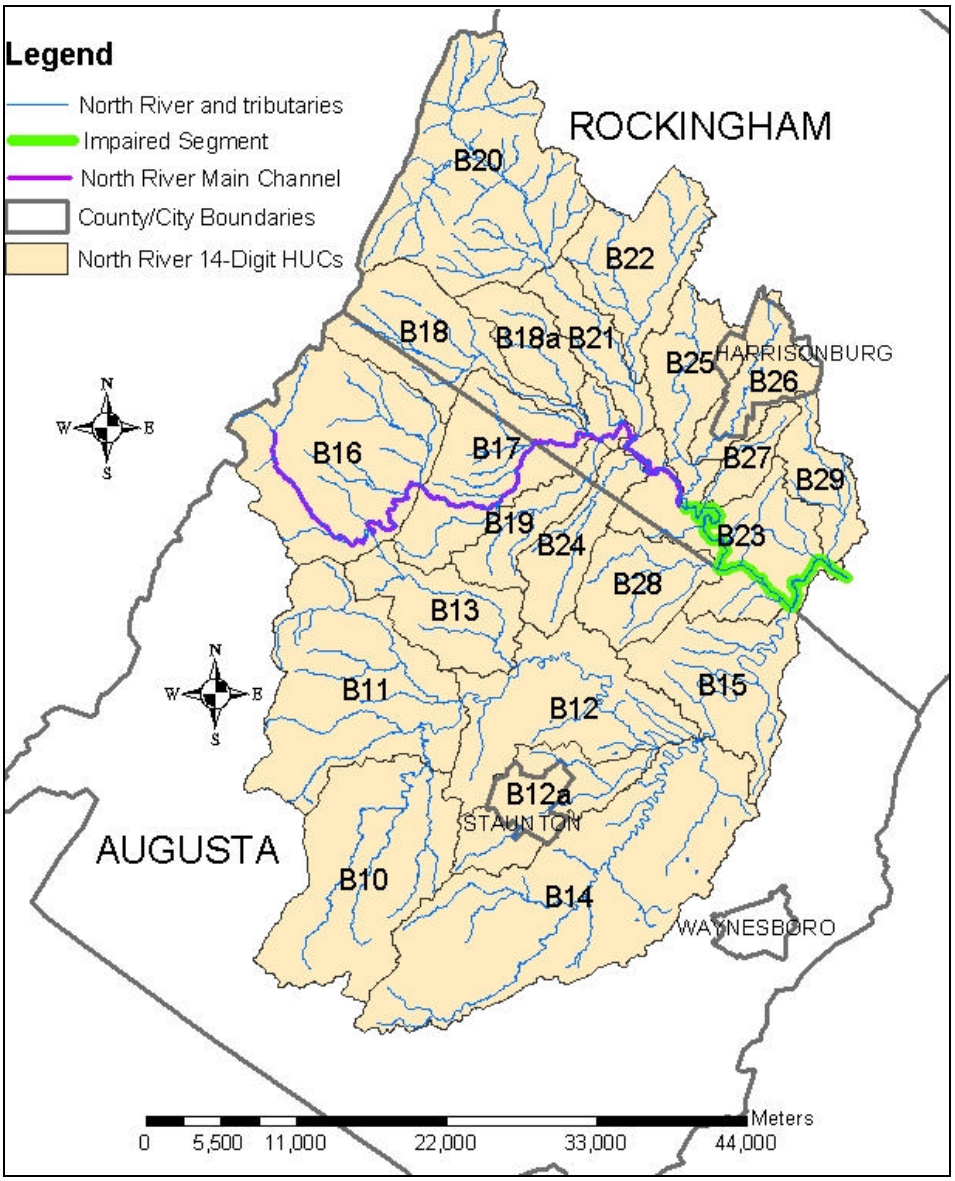

Figure 1-1. North River Watershed, Augusta and Rockingham Counties

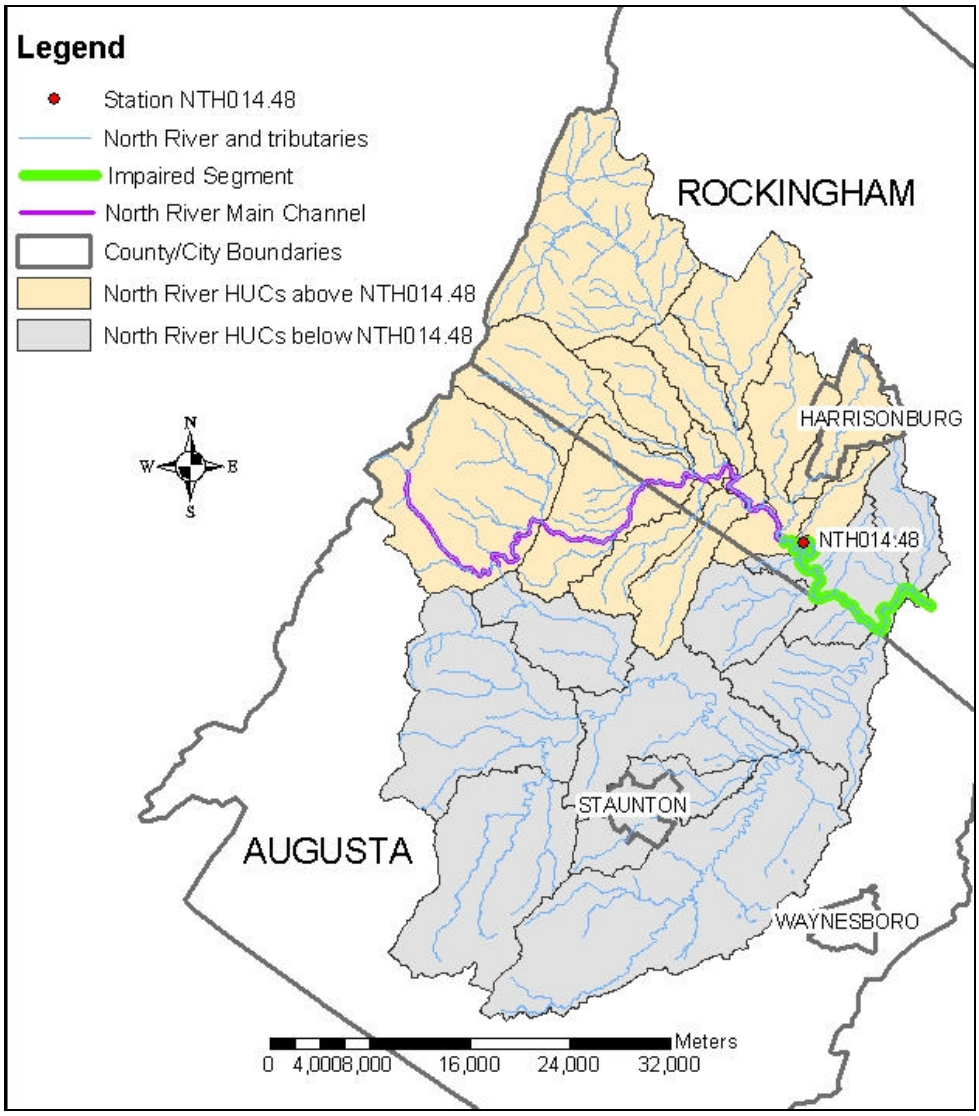

Figure 1-2. North River Watershed above and below Station NTH014.48

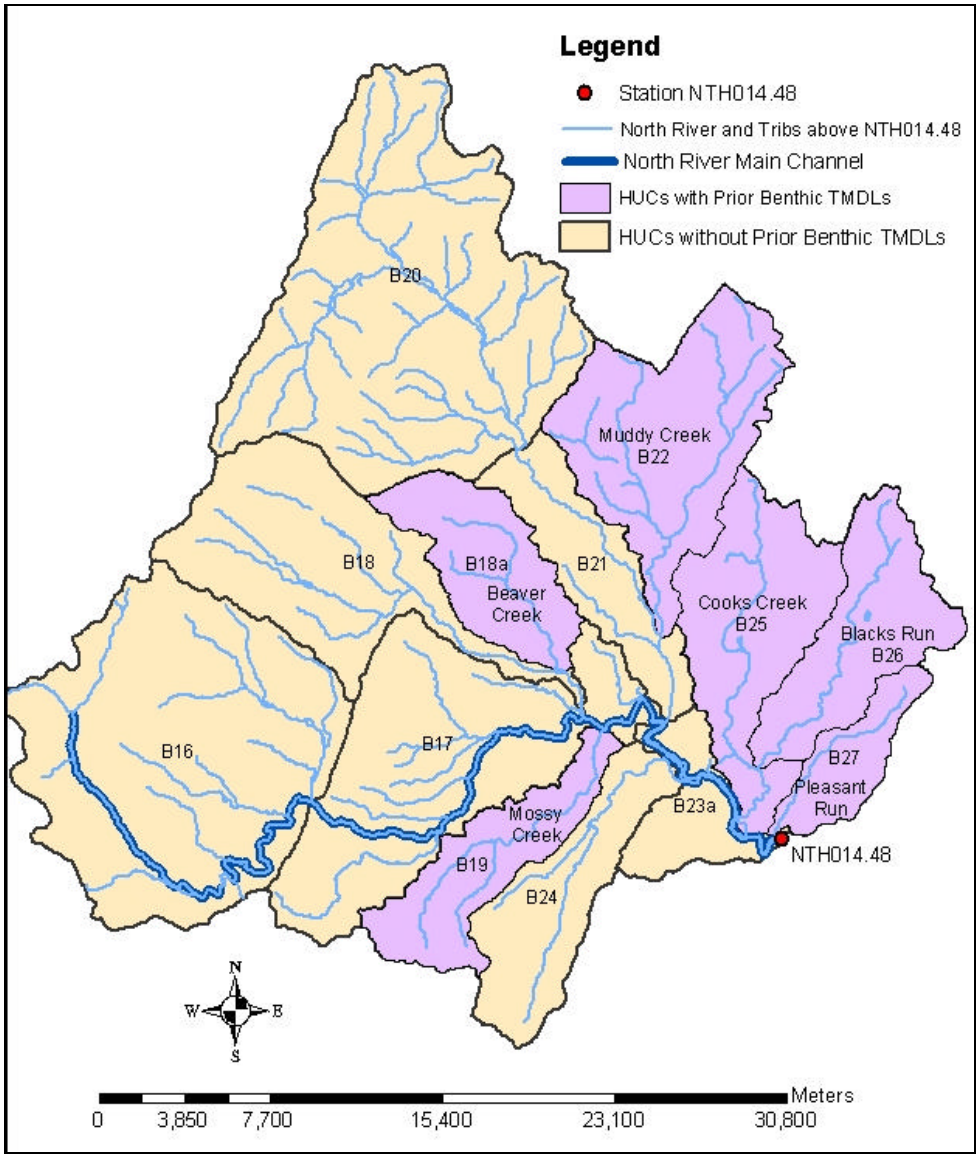

Figure 1-3. The B23ax North River Watershed

2.0 Data Sources Used in Stressor Identification

The 2002 303(d) Impaired Waters Fact Sheet (VADEQ, 2002a) states that the North River segment VAV-B23R_NTH01A00 was "partially supporting" of its Aquatic Life Use in 1998, and "fully supporting" in 2002. The source of impairment on North River was listed as "unknown". In order to investigate and verify the stressor(s) that may have caused the benthic impairment, available bioassessment data, water quality data, special study data, permitted point source permitted data, and reports from upstream segments with TMDLs developed for benthic impairments were all obtained and evaluated. The extent and content of these data sources are summarized in Table 2-1.

Table 2-1. Inventory of Data Used in North River Stressor Identification

Data Type	Collection Period	No.	Description
VADEQ Benthic Samples			
NTH014.48	10/1994 – 10/2004	13	Benthic species distribution Rapid Bioassessment Protocol (RBP II) metrics, scores, and ratings (Barbour et al., 1999) Stream Condition Index (SCI) scores and ratings (Tetra Tech, 2002) Habitat assessment scores
CWP050.66[1]	05/1995 – 09/2004	16 13	Stream Condition Index (SCI) scores and ratings (Tetra Tech, 2002) Habitat assessment scores
NTH014.48 and 6 upstream stations			Average benthic species distributions
VADEQ Ambient Water Quality Samples			
NTH014.08	01/1990 – 03/2004	157	Monthly ambient physical and chemical water quality data.
NTH014.48 and 6 upstream stations			Value ranges for select ambient chemical water quality parameters.
Other VADEQ Monitoring Data			
Stream sediment tests for metals	08/1999 and 10/2001	2	Periodic sediment toxicity tests for a range of pesticides, metals, and other toxic substances
Diurnal DO test	07/24-30/2004	1	Continuous 10-min interval monitoring of dissolved oxygen and temperature over 4 days.
305(b) Monitored Exceedences			
NTH014.08	1998, 2000, 2002		Summary of biennial water quality exceedences.
VADEQ Permitted Point Sources			
VPDES Dischargers		6	Summary of major permitted discharges and average reported concentrations from monthly DMRs
Summary of Other Permit Dischargers			Industrial, construction, household 1000-gpd, mixed concrete, carwash dischargers, and CAFOs.
Upstream Stream Segments with TMDLs for Benthic Impairments			
		5	% reductions from TMDL reports, preliminary modeled loads and reductions at NTH014.48

[1] CWP050.66 is the Cowpasture River that served as the biological reference site for the RBP II scoring.

2.1. DEQ Benthic Data

- Biological monitoring data was obtained from VADEQ in the form of Virginia's Environmental Data Analysis System (EDAS) database, as well as periodic spreadsheets for more recent samples.
- The benthic monitoring station – NTH014.48 –was not collocated with the ambient monitoring station – NTH014.08, which was slightly downstream.
- Since 2001, all 5 RBP II ratings (Table 2-2 and Figure 2-1) have shown slight or no impairment, while SCI scores on 4 of the 5 sampling dates (Figure 2-2) were marginally non-impaired with only one score in the impaired range.
- The dominant species of benthic macroinvertebrates have typically been *elmidae*, *pleuroceridae*, and *chironomidae* (Table 2-3). The average percentage of pollution-tolerant organisms (Tolerance Values = 8) has decreased from 14.1% per sample in the pre-BNR period to 7.9% in the post-BNR period.
- Table 2-4 lists selected nearby upstream benthic stations for comparison of species distribution. Of these upstream stations, some are impaired and others non-impaired. Average species distributions at each of these stations are given in Table 2-5, with stations listed in the upstream order of their location with respect to station NTH014.48. The total taxa and proportion of dominant taxon at NTH014.48 have been more similar to those at the non-impaired, than at the impaired, sites. The impaired sites in this area tend to have higher total taxa numbers due primarily to a skewed population with larger numbers of the dominant taxon.

Table 2-2. North River RBPII Metrics, Scores, and Assessment Ratings at Station NTH014.48
2002 305(b) Assessment Period

	Spring 1994	Fall 1994	Spring 1995	Fall 1995	Fall 1998	Spring 1999	Fall 1999	Spring 2000	Fall 2001	Spring 2002	Fall 2003	Spring 2004	Fall 2004	MAIS Metric Score Categories		
	06/11/94	**10/04/94**	**05/01/95**	**10/19/95**	**10/06/98**	**05/24/99**	**10/28/99**	**05/17/00**	**10/02/01**	**05/22/02**	**10/29/03**	**05/07/04**	**10/26/04**			
RBP II Metric	**Metric Values**													Poor	Moderate	Best
Taxa Richness	18	19	19	18	12	14	15	11	16	14	14	13	12			
MFBI	4.87	4.88	5.53	5.88	5.04	5.13	5.46	5.34	5.15	4.97	4.71	5.02	4.40	= 5.56	4.22 - 5.55	= 4.21
SC/CF	0.67	2.18	0.91	1.63	0.32	0.67	2.27	1.74	2.26	0.63	2.31	1.36	5.25			
EPT/Chi Abund	1.24	2.18	0.90	2.44	3.75	0.84	0.43	0.19	6.83	0.97	3.29	1.73	7.00			
% Dominant	28.57	20.77	28.68	20.19	34.82	25.12	25.89	50.00	22.12	28.45	26.06	29.81	28.57			
EPT Index	8	7	7	6	5	5	5	4	7	8	7	4	5			
Comm. Loss Index	0.56	0.63	0.63	0.67	0.67	0.36	0.13	0.73	0.28	0.64	0.29	0.23	0.50			
SH/Tot	0.06	0.01	0.01	0.00	0.05	0.02	0.00	0.00	0.00	0.01	0.01	0.00	0.00			
Biological Condition Score	26	26	18	26	28	28	32	16	32	28	40	38	30			
% of Reference	56.52	54.17	39.13	56.52	60.87	70.00	84.21	38.10	80.00	66.67	90.91	82.61	65.22			
RBP II Assessment	**Slight**	**Slight**	**Moderate**	**Slight**	**Slight**	**Slight**	**No Impact**	**Moderate**	**Slight**	**Slight**	**No Impact**	**No Impact**	**Slight**			
MAIS Metric																
% Haptobenthos	57.9	60.8	48.1	44.2	75.0	74.4	49.1	42.8	67.54	56.0	74.6	68.3	84.9	= 52	53 - 83	= 84
SCI Scores		67.0	56.2	57.4	51.7	51.9	52.5	38.6	63.5	56.7	62.5	50.9	61.3	< 56.3		> 61.9
SCI Assessment		Non-Impaired	Impaired	Uncertain	Impaired	Impaired	Impaired	Impaired	Non-Impaired	Uncertain	Non-Impaired	Impaired	Uncertain			

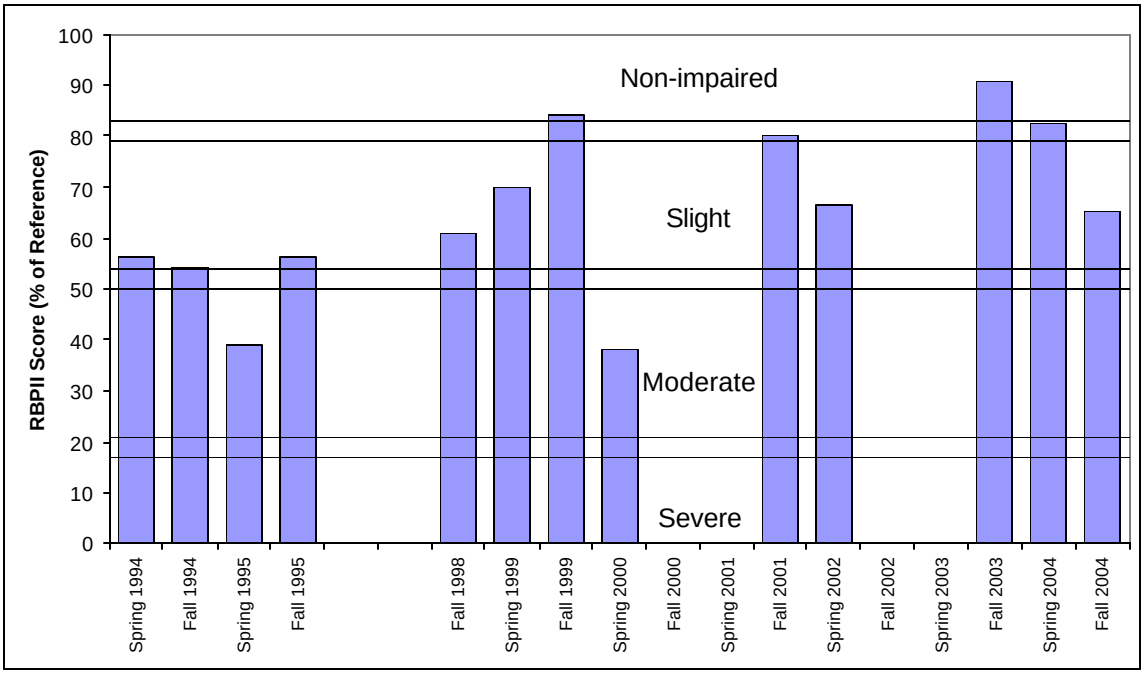

Figure 2-1. North River RBPII Assessment Ratings at NTH014.48

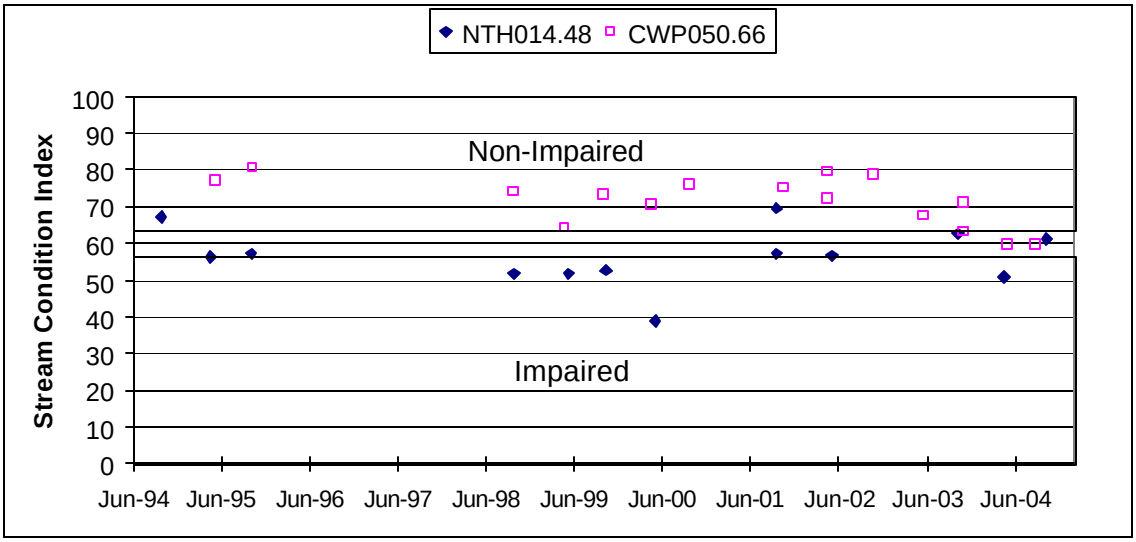

Figure 2-2. North River and Biological Reference Stream Condition Index (SCI) Scores

Table 2-3. North River Station NTH014.48 Benthic Species Distribution By Sample Date

Final ID	Tolerance Value	Sampling Dates												Total Individuals	Pre-BNR (% of Total)	Post-BNR (% of Total)
		10/04/94	05/01/95	10/19/95	10/06/98	05/24/99	10/28/99	05/17/00	10/02/01*	05/22/02	10/29/03	05/07/04	10/26/04			
Glossosomatidae	0								0/1		1			1	0.0%	0.2%
Brachycentridae	1	1			6	3				1				11	0.9%	0.2%
Capniidae	1										1			1	0.0%	0.2%
Gomphidae	1													0	0.0%	0.0%
Perlidae	1	1							0/1					1	0.1%	0.0%
Athericidae	2													0	0.0%	0.0%
Isonychiidae	2	3	2	4	1		2		2/4	3	4		9	28	1.4%	3.3%
Leptophlebiidae	2													0	0.0%	0.0%
Peltoperlidae	2													0	0.0%	0.0%
Perlodidae	2													0	0.0%	0.0%
Taeniopterygidae	2													0	0.0%	0.0%
Aeshnidae	3	1		1										2	0.2%	0.0%
Helicopsychidae	3		1	2		1			0/1					4	0.4%	0.0%
Hydrobiidae	3													0	0.0%	0.0%
Philopotamidae	3	2								1				3	0.2%	0.2%
Tipulidae	3		1			2								3	0.3%	0.0%
Baetidae	4	12	6		7			6	1/7	12	1	8	1	53	3.2%	4.6%
Caenidae	4								0/1					0	0.0%	0.0%
Elmidae	4	27	13	10	20	25	21	13	22/34	21	37	8	34	229	14.5%	20.8%
Ephemerellidae	4		8	1		16	4	3	11/14	5	20	31	25	113	4.1%	16.8%
Ephemeridae	4		1											1	0.1%	0.0%
Heptageniidae	4	9	11	6	7	4	2	1	16/10	3	7	5	5	60	4.9%	4.2%
Leptoceridae	4			1										1	0.1%	0.0%
Pleuroceridae	4	26	6	17	7	35	21	29	17/27	12	27	5	24	209	15.0%	14.1%
Psephenidae	4	2	2	1		6	2	3	0/10		2	1		19	1.9%	0.6%
Tricorythidae	4	1												1	0.1%	0.0%
Calopterygidae	5						1		0/1					1	0.1%	0.0%
Cambaridae	5	1												1	0.1%	0.0%
Corydalidae	5	1			1				0/1					2	0.2%	0.0%
Dryopidae	5		1											1	0.1%	0.0%
Hydrachnidae	5	1		2										3	0.3%	0.0%
Hydrophilidae	5					1	1							2	0.2%	0.0%
Ancylidae	6													0	0.0%	0.0%
Ceratopogonidae	6													0	0.0%	0.0%
Chironomidae (A)	6	15	37	8	15	42	29	76	8/5	33	13	26	6	300	21.1%	16.2%
Dytiscidae	6								1/0					0	0.0%	0.0%
Empididae	6										1	2		3	0.0%	0.6%
Hydropsychidae	6	9	8	8	39	12	3	5	12/15	5	12	1	2	104	9.0%	4.2%
Hydroptilidae	6						2			2				4	0.2%	0.4%
Simuliidae	6	2	11	1	4	52		11	2/0	15		10	1	107	7.6%	5.4%
Ephydridae	7						1							1	0.1%	0.0%
Haliplidae	7													0	0.0%	0.0%
Hirudinidae	7													0	0.0%	0.0%
Planorbidae	7													0	0.0%	0.0%
Siphlonuridae	7													0	0.0%	0.0%
Asellidae	8			21					6/2				1	22	2.3%	0.2%
Corbiculidae	8		2	3		5	6	3				3		22	1.8%	0.6%
Dendrocoelidae	8													0	0.0%	0.0%
Enchytraeidae	8		3											3	0.3%	0.0%
Haplotaxidae	8				1									1	0.1%	0.0%
Lumbriculidae	8	2	2	2						1	1	1	1	10	0.6%	0.8%
Naididae	8							2						2	0.2%	0.0%
Physidae	8													0	0.0%	0.0%
Planariidae	8	14	11	15	4	3	14		29/16	2	15	3	10	91	7.7%	6.2%
Sphaeriidae	8	1												1	0.1%	0.0%
Chironomidae (B)	9	1	4											5	0.5%	0.0%
Coenagrionidae	9			1			3		3/4					4	0.7%	0.0%
Tubificidae	10													0	0.0%	0.0%
Total Abundance		132	130	104	112	207	112	152	136	116	142	104	119	110	100.0%	100.0%
RBP II Rating		Slight	Moderate	Slight	Slight	Slight	No Impact	Moderate	Slight	Slight	No Impact	No Impact	Slight			

* - Two samples taken on same date.

- Dominant 2 organisms/sample

Table 2-4. Station NTH014.48 and Select Upstream Benthic Stations

Upstream Order	Benthic Station ID	Stream Name	No. of Samples
1	NTH014.48	NORTH RIVER	13
2	PLE000.08	Pleasant Run	12
3	NTH015.45	NORTH RIVER	1
4	BLK000.08	Blacks Run	4
5	CKS003.04	Cooks Creek	14
6	NTH016.45	NORTH RIVER	3
7	DUR000.11	Dry River	9

Figure 2-3. North River and Select Upstream Benthic Stations

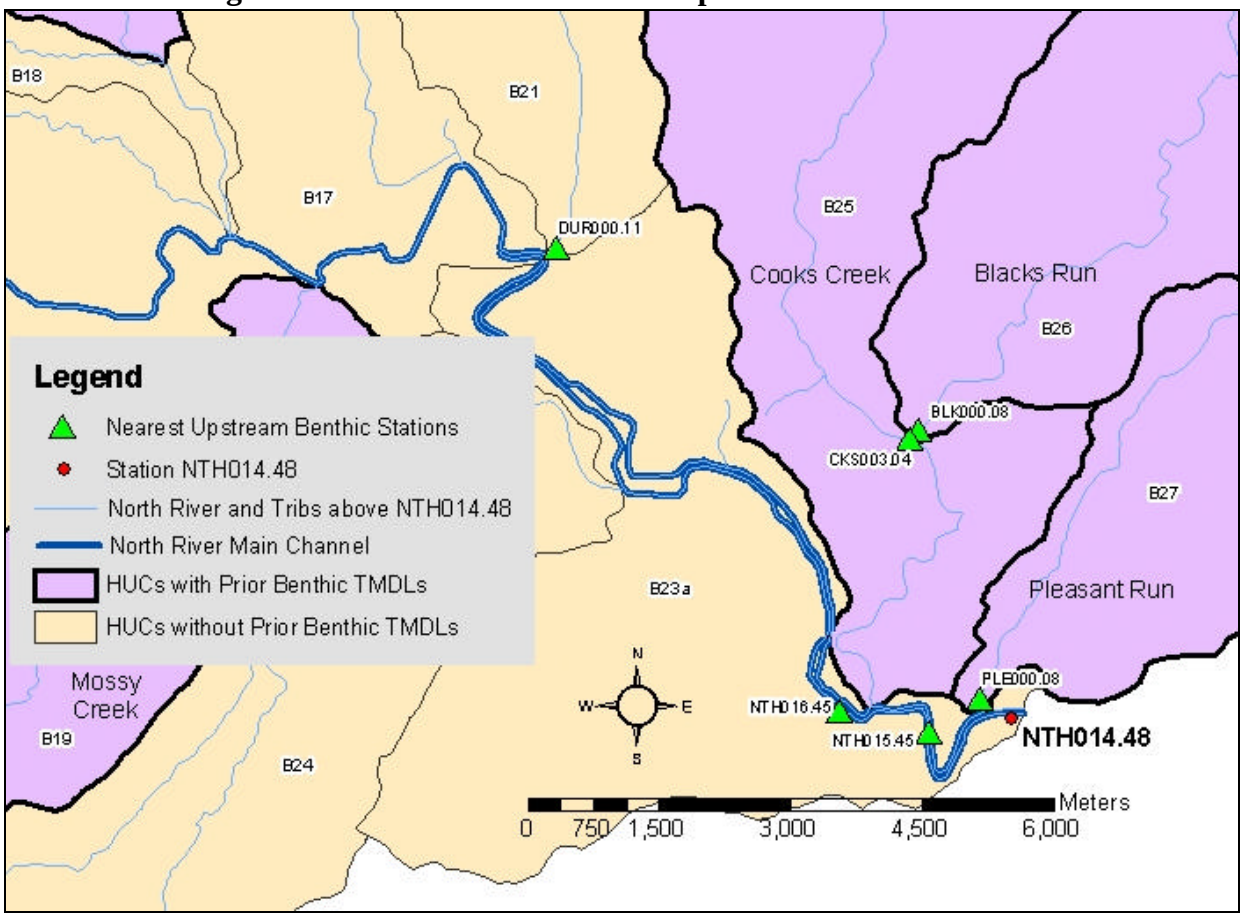

Table 2-5. Average Benthic Species Distributions at North River and Upstream Stations

Upstream Order:		1		2	3	4	5	6	7
	Tolerance	1BNTH014.48		1BPLR000.08	1BNTH015.45	1BBLK000.08	1BCKS003.04	1BNTH016.45	1BDUR000.11
FinalID	Value	Pre-BNR	Post-BNR	Impaired	Non-Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Glossosomatidae	0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Brachycentridae	1	1.3	0.3	0.0	0.0	0.0	0.0	1.7	1.6
Capniidae	1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Gomphidae	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Perlidae	1	0.2	0.0	0.0	1.0	0.0	0.0	1.7	0.1
Athericidae	2	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.2
Isonychiidae	2	1.9	4.0	0.0	17.0	0.0	0.0	10.3	12.1
Leptophlebiidae	2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Peltoperlidae	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Perlodidae	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Taeniopterygidae	2	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Aeshnidae	3	0.3	0.0	0.0	0.0	0.0	0.1	0.3	0.0
Helicopsychidae	3	0.6	0.0	0.0	0.0	0.0	0.0	0.3	0.9
Hydrobiidae	3	0.0	0.0	10.5	0.0	0.0	0.0	0.0	0.0
Philopotamidae	3	0.3	0.3	0.0	1.0	0.0	0.0	4.0	4.2
Tipulidae	3	0.4	0.0	0.1	0.0	0.3	0.1	0.7	1.2
Baetidae	4	4.4	5.5	0.1	1.0	1.8	2.6	2.0	4.8
Caenidae	4	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.7
Elmidae	4	19.6	25.0	0.5	9.0	41.5	14.4	16.7	7.3
Ephemerellidae	4	5.6	20.3	0.0	39.0	0.8	0.0	3.0	2.3
Ephemeridae	4	0.1	0.0	0.0	0.0	0.0	0.0	1.7	0.7
Heptageniidae	4	6.6	5.0	0.0	20.0	0.0	0.1	12.0	18.3
Leptoceridae	4	0.1	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Pleuroceridae	4	20.4	17.0	0.8	11.0	0.0	0.0	16.0	0.0
Psephenidae	4	2.6	0.8	0.0	0.0	0.0	0.0	1.7	3.0
Tricorythidae	4	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.4
Calopterygidae	5	0.2	0.0	0.0	0.0	0.0	0.8	1.3	0.0
Cambaridae	5	0.1	0.0	0.0	0.0	0.0	0.9	0.7	0.3
Corydalidae	5	0.3	0.0	0.0	0.0	0.3	0.0	0.3	0.4
Dryopidae	5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Hydrachnidae	5	0.4	0.0	0.7	0.0	0.5	0.4	1.0	0.4
Hydrophilidae	5	0.3	0.0	0.0	0.0	3.0	1.4	0.7	0.0
Ancylidae	6	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.0
Ceratopogonidae	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Chironomidae (A)	6	28.6	19.5	11.2	10.0	148.0	50.5	7.7	25.8
Dytiscidae	6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Empididae	6	0.0	0.8	0.0	0.0	2.8	0.4	0.0	0.0
Hydropsychidae	6	12.2	5.0	0.2	1.0	2.8	2.4	4.7	26.3
Hydroptilidae	6	0.3	0.5	0.0	1.0	4.3	2.8	0.0	5.0
Simuliidae	6	10.3	6.5	9.5	0.0	38.5	15.6	6.7	6.8
Ephydridae	7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Haliplidae	7	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
Hirudinidae	7	0.0	0.0	0.6	0.0	0.0	0.1	0.0	0.0
Planorbidae	7	0.0	0.0	7.5	0.0	0.0	5.0	0.0	0.0
Siphlonuridae	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Asellidae	8	3.1	0.3	116.9	0.0	0.0	12.8	21.3	0.7
Corbiculidae	8	2.4	0.8	0.0	1.0	4.8	1.1	5.0	0.0
Dendrocoelidae	8	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Enchytraeidae	8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Haplotaxidae	8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lumbriculidae	8	0.8	1.0	1.5	0.0	0.5	2.1	3.0	0.8
Naididae	8	0.3	0.0	0.2	0.0	15.0	8.3	0.0	0.3
Physidae	8	0.0	0.0	0.3	0.0	0.0	0.7	0.3	0.2
Planariidae	8	10.4	7.5	18.9	5.0	9.5	22.6	11.0	3.1
Sphaeriidae	8	0.1	0.0	3.5	0.0	0.8	16.6	0.0	0.0
Chironomidae (B)	9	0.6	0.0	0.8	0.0	0.0	2.4	3.3	0.0
Coenagrionidae	9	0.9	0.0	0.1	0.0	1.5	0.6	0.0	0.7
Tubificidae	10	0.0	0.0	0.3	0.0	0.0	3.8	0.0	0.1
No. of Samples/Station		8	4	12	1	4	14	3	9
Average Abundance/Sample		**136**	**120**	**184**	**118**	**277**	**169**	**141**	**130**

NTH014.48 = North River station with impairment
PLR000.08 = Pleasant Run
NTH015.45 = North River above North River WWTF
BLK000.08 = Blacks Run
CKS003.04 = Cooks Creek
NTH016.45 = North River upstream non-impaired station
DUR000.11 = Dry River

2.2. DEQ Habitat Data

- Habitat data collected as part of the biological monitoring were also obtained from DEQ through the EDAS database for historical samples and through periodic updates for more recent samples (Table 2-6 and Figure 2-4).
- The Cowpasture River station CWP050.66 was used as the biological reference station for North River station NTH014.48. Historically, channel alteration, channel flow status, velocity/depth regime, and sediment deposition metrics have all tracked very similarly for NTH014.48 and its reference (Figure 2-4). Trend lines were added to this figure for the other habitat metrics to emphasize increasing trends over time.
- The total habitat score has shown an increasing trend over the entire period (Table 2-6), with the exception of the most recent sample which showed a very large decrease (9) in the Riparian Vegetation score together with moderate decreases (3) in Channel Alteration and Bank Stability.

Table 2-6. North River Habitat Evaluation Summary

2002 305(b) Assessment Period

Habitat Metrics	Sampling Dates											
	10/04/94	05/01/95	10/19/95	10/06/98	05/24/99	10/28/99	05/17/00	10/02/01	05/22/02	10/29/03	05/07/04	10/26/04
Channel Alteration	18	18	18	15	10	18	19	19	19	19	20	17
Bank Stability	10	10	12	12	11	11	17	17	18	14	18	15
Bank Vegetation	12	12	10	18	11	13	17	17	17	18	17	16
Embeddedness	10	10	10	19	12	10	15	12	13	13	14	13
Channel Flow Status	20	20	20	19	20	19	20	17	19	20	19	18
Riffle Stability	12	12	10	17	15	15	18	15	16	18	16	16
Riparian Vegetation	8	6	8	9	3	6	11	15	16	12	17	8
Sediment Deposition	14	12	16	14	15	13	15	14	15	16	14	15
Epifaunal Substrate	12	14	16	17	17	17	18	16	16	16	17	17
Velocity/Depth Regime	16	16	14	19	17	19	18	19	19	16	18	16
Total Habitat Score	**132**	**130**	**134**	**159**	**131**	**141**	**168**	**161**	**168**	**162**	**170**	**151**

- Scores of 10 or below indicate "Poor" or "Marginal" habitat.

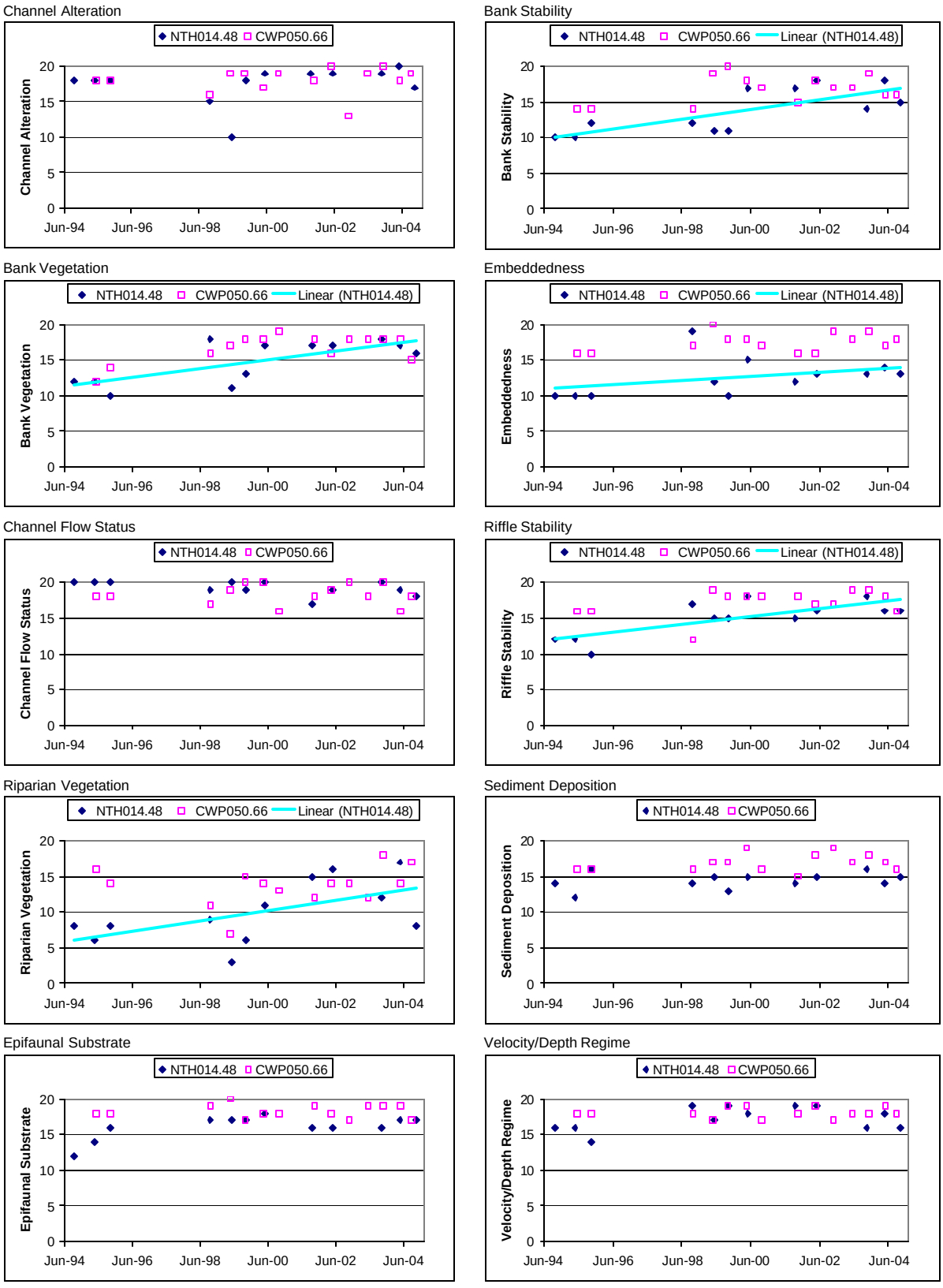

Figure 2-4. North River Habitat Assessment Metric Scores
(Poor= 0-5; Marginal= 6-10; Sub-optimal= 11-15; Optimal= 16-20)

2.3. DEQ Ambient Data – NTH014.08

- Monthly ambient water quality monitoring has been conducted at station NTH014.08 (slightly downstream from benthic station NTH014.48) since January 1978. Plots on monthly sample data since January 1990 are shown in Figure 2-5.
- Chemical parameters included various forms of nitrogen and phosphorus – ammonia-N, TKN, nitrate-N, ortho-P, and total phosphorus (TP); dissolved oxygen; various forms of solids – total dissolved solids, volatile solids, total suspended solids, and volatile suspended solids; alkalinity; turbidity; chlorides; sulfates; and chlorophyll A. Field physical parameters included temperature, pH, and conductivity.
- Where applicable, minimum and/or maximum water quality standards are indicated on the plots.
- Most of the water quality parameters appear to be within expected ranges. No violations of temperature, pH, or DO water quality standards have been noted; and only 2 out of 125 samples of ammonia-N since July 1992 have exceeded its standard. Total phosphorus does not have a standard, but 65 out of 126 samples exceeded DEQ's threshold for designating "threatened waters". Nitrate-N levels are also considerably elevated.
- The North River WWTF underwent an upgrade in 2001 and converted to biological nutrient removal (BNR). Several instances of elevated TKN and TP may have occurred during construction of, and transition to, the new system.

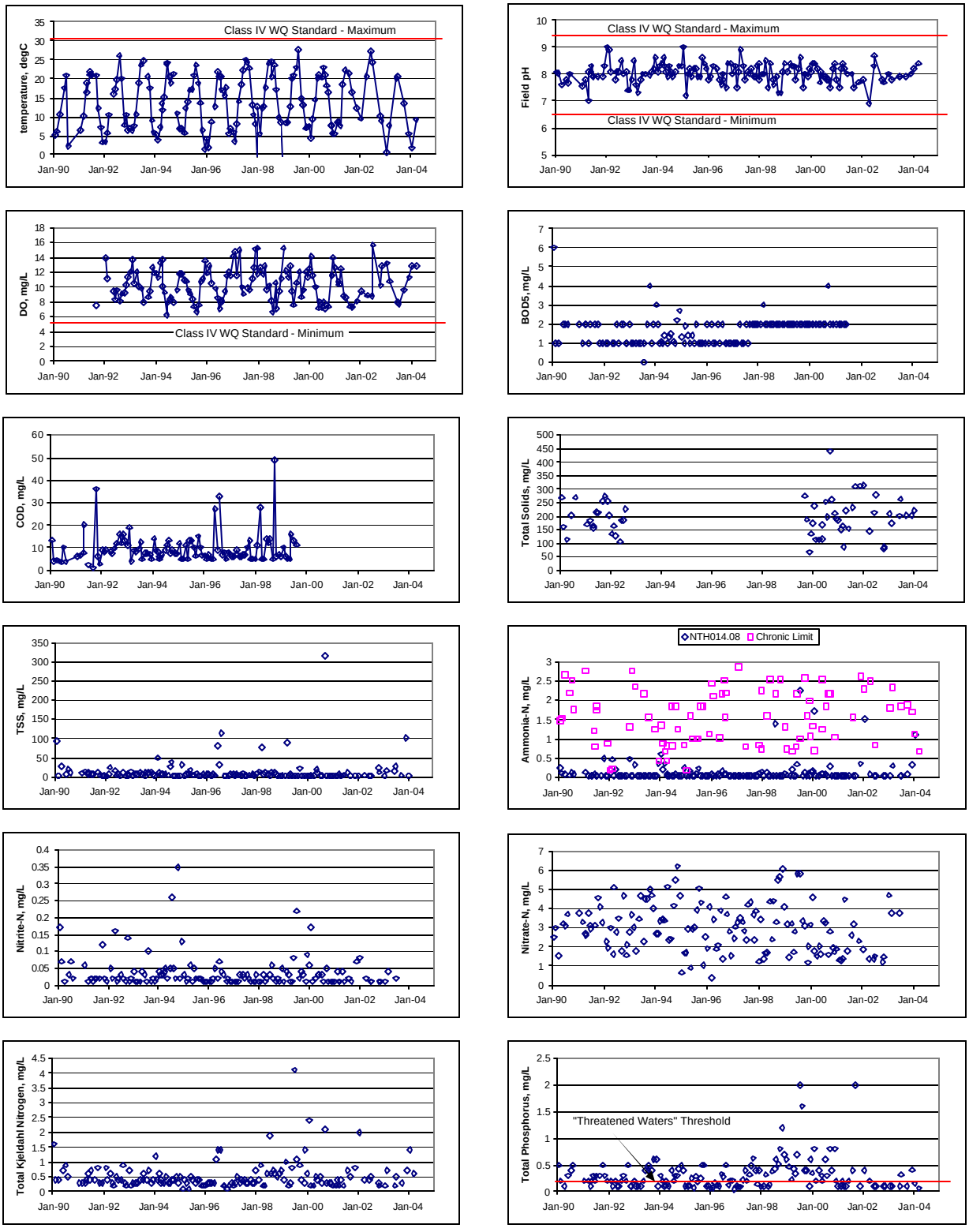

Figure 2-5. Ambient Monitoring Data at Station NTH014.08

2.4. Ambient Parameter Ranges at North River and Upstream Stations

- For comparison during this analysis, ranges of selected parameter values were compared between the North River ambient station NTH014.08 and nearby upstream monitoring stations as listed in Table 2-7.
- Boxplots of select ambient chemical parameters for the individual stations and monitoring periods in Table 2-7 are given in Figure 2-6. The boxplots include parameter value ranges, interquartile ranges, and median values.

Table 2-7. Station NTH014.08 and Nearby Upstream Ambient Monitoring Stations

Upstream Order	Ambient Station ID	Stream Name	Monitoring Period	No. of Samples
1	NTH014.08	NORTH RIVER	01/90 - 03/04	157
2	PLR000.16	Pleasant Run	09/93 - 03/04	122
3	BLK000.38	Blacks Run	12/91 - 06/03	128
4	CKS003.10	Cooks Creek	12/91 - 06/03	126
5	NTH021.00	NORTH RIVER	01/90 - 06/03	145
6	DUR000.02	Dry River	06/93 - 03/04	132

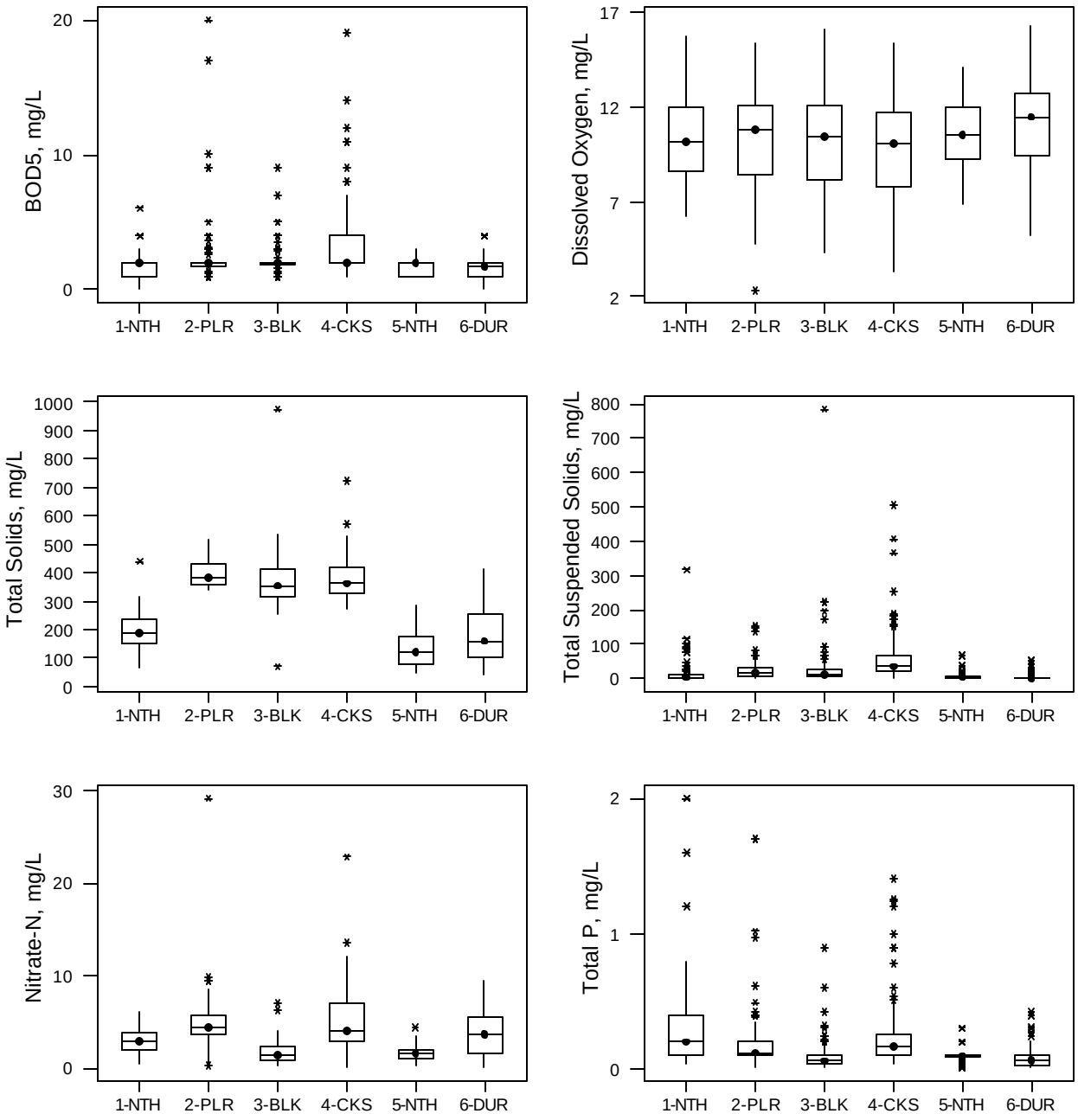

Figure 2-6. Select Ambient Water Quality Parameter Ranges for North River and Nearby Upstream Tributaries

2.5. Stream Sediment Tests for Metals and Toxics

- A single sediment sample has been collected and analyzed from one upstream impaired segment (Blacks Run) for a menu of metals in Table 2-8; poly-aromatic hydrocarbons (PAHs) in Table 2-9; and pesticides and poly-chlorinated biphenyls (PCBs) in Table 2-10. Additional samples from various locations throughout the watershed were analyzed for pesticides and various other compounds of concern in Table 2-11.
- Concentrations reported in blue exceed NOAA's Effects Range-Median, at which levels they have an increased probability of adverse affects on aquatic life.
- Only 1 of the tested substances in Table 2-11 was above its minimum detection limit. Most of the substances, however, have minimum detection limits greater than the consensus-based PECs (MacDonald et al., 2000), meaning that current testing would not detect low level exceedences of these substances.

Table 2-8. DEQ Periodic Channel Bottom Sediment Monitoring for Metals

	Sampling Date	06/21/01			
	DEQ Station	1BBLK003.86			
	Stream Name / Description	Blacks Run near Pleasant Valley Rd bridge	NOAA's Effects Range-Median	NOAA's Effects Range-Low	Freshwater Consensus-Based Probable Effect Concentration
%	TOC[2]	1.13	>>>>>	>>>>>	
	Al	0.48	**	**	
ppm[1] (dry weight basis)	Ag	0.43	3.7	1	
	As	<0.5	70	8.2	33
	Cd	0.36	9.6	1.2	4.98
	Cr	26	370	81	111
	Cu	59	270	34	149
	Hg	1.5	0.71	0.15	1.06
	Ni	14	51.6	20.9	48.6
	Pb	61	223	46.7	128
	Sb	<0.5	**	**	
	Se	<0.5	**	**	
	Tl	<0.3	**	**	
	Zn	149	410	150	459

Table 2-9. DEQ Periodic Channel Bottom Sediment Monitoring for PAHs

	Sampling Date	06/21/01			
	DEQ Station	1BBLK003.86			
	Stream Name / Description	Blacks Run near Pleasant Valley Rd bridge	NOAA's Effects Range-Median	NOAA's Effects Range-Low	Freshwater Consensus-Based Probable Effect Concentration
%	TOC[2]	1.13			
ppb[1]	Total PAH[3]	5927.71	44792	4022	22800
	High MW[4] PAH	5502.68	9600	1700	NA
	Low MW PAH	425.03	3160	552	NA
ppb[1] (dry weight basis)	NAP[5]	10.69	2100	160	561
	NAP 2-Me[6]	10.21	670	70	NA
	NAP 1-Me[7]	6.16	**	**	
	biphenyl	2.33	**	**	
	NAP d-Me[8]	7.97	**	**	
	naphthylene ace~	5.71	640	44	NA
	naphthene ace~	9.89	500	16	NA
	NAP t-Me[9]	3.05	**	**	
	fluorene	14.00	540	19	536
	PHH[10]	280.10	1500	240	1170
	ATH[11]	43.00	1100	85.3	845
	PHH 1-Me	31.92	**	**	
	FTH[12]	808.52	5100	600	2230
	pyrene	688.33	2600	665	1520
	ATH benz(a)	425.28	1600	261	1050
	chrysene	566.53	2800	384	1290
	FTH benzo(b)	656.69	**	**	
	FTH benzo(k)	508.08	**	**	
	pyrene benzo(e)	438.02	**	**	
	pyrene benzo(a)	479.80	1600	430	1450
	perylene	129.51	**	**	
	pyrene IND[13]	345.58	**	**	
	ATH db(a,h)[14]	79.94	260	63.4	NA
	perylene benzo(ghi)	376.40	**	**	

Table 2-10. DEQ Periodic Channel Bottom Sediment Monitoring for PCBs

	Sampling Date	06/21/01			
	DEQ Station	1BBLK003.86			
	Stream Name / Description	Blacks Run near Pleasant Valley Rd bridge	NOAA's Effects Range-Median	NOAA's Effects Range-Low	Freshwater Consensus-Based Probable Effect Concentration
%	TOC[2]	1.13	>>>>>	>>>>>	
ppb[1] (dry weight basis)	Total PCB[3]	37.44	180	22.7	676
	Total Chlordane[4]	39.09	6	0.5	17.6
	Sum DDE[5]	7.55	27	2.2	31.3
	Sum DDD[6]	3.66	20	2	28
	Sum DDT[7]	42.28	7	1	62.9
	Total DDT[8]	53.49	46.1	1.58	572
	Total BDE[9]		**	**	
	HCB[10]	0.97	**	**	
	OCDD[14]	7.91	**	**	

Table 2-11. DEQ Periodic Monitoring of Channel Bottom Sediment

DEQ Station	Sample Date	ALDRIN, SEDIMENT	CHLORDANE TECH MIX & METABS,SEDIMENT	DDD, SEDIMENT	DDE, SEDIMENT	DDT, SEDIMENT	DIELDRIN, SEDIMENT	ENDRIN, SEDIMENT	HEPTACHLOR EPOXIDE, SED	HEPTACHLOR, SEDIMENT	MERCURY, SEDIMENT	PCBS TOTAL, SEDIMENT	PENTACHLOROPHENOL, SEDIMENT	TOXAPHENE, SEDIMENT
		(µG/KG DRY WT)								(µG/L)	(MG/KG AS HG DRY WT)	(µG/KG DRY WT)		(µG/L)
1BNTH000.18	08/02/01	20 U	60 U	30 U	30 U	20 U	20 U	30 U	20 U	20 U	0.1 U	20 U	80 U	120 U
1BNTH007.69	08/02/01	20 U	70 U	30 U	40 U	20 U	20 U	40 U	20 U	20 U	0.1 U	20 U	80 U	130 U
1BNTH014.08	07/02/91	100 U	1 K	0.1 K	0.1 K	0.1 K	0.1 K	0.1 K	100 U	0.1 K	0.5 U	500 U	0.01 K	1 K
	07/31/96	30 U	40 U	10 U	10 U	30 U	10 U	30 U	10 U	10 U	0.3 U	30 U	70 U	150 U
	08/29/00	20 U	80 U	40 U	40 U	40 U	20 U	60 U	20 U	20 U	0.3 U	20 U	100 U	160 U
1BLGC000.96	08/14/96	30 U	40 U	10 U	10 U	30 U	10 U	30 U	10 U	10 U	0.3 U	30 U	70 U	150 U
	09/20/00	40 U	150 U	80 U	80 U	80 U	40 U	110 U	40 U	40 U	0.1 U	40 U	50 U	290 U
1BCKS003.10	07/20/92	100 U	500 U	100 U	100 U	100 U	100 U	100 U	100 U	0.1 K	0.3 U	500 U	50 U	1 K
	07/14/99	30 U	100 U	50 U	50 U	50 U	30 U	80 U	30 U	30 U	0.3 U	30 U	120 U	190 U
1BBLK000.38	07/20/92	100 U	500 U	100 U	100 U	100 U	100 U	100 U	100 U	0.1 K	0.6	500 U	50 U	1 K
	07/14/99	30 U	90 U	50 U	50 U	50 U	30 U	70 U	30 U	30 U	0.3 U	30 U	110 U	170 U
Consensus-Based PEC			**17.6**	**28**	**31.3**	**62.9**	**61.8**	**207**	**16**		**1.06**	**676**		

K - Value is off-scale low. Actual value is unknown, but known to be less than value shown.

U - Value is less than the Minimum Detectable Limit (MDL).

- Exceedence indeterminant since MDL is greater than PEC.

2.6. Diurnal DO Testing

- Continuous monitoring of temperature and dissolved oxygen were conducted at 10-minute intervals over a 4-day period at the ambient monitoring station – NTH014.08.
- Although the dissolved oxygen never violated the dissolved standard of 5.0 mg/L, a diurnal fluctuation amounting to almost 63% of the night time DO levels is evident in Figure 2-7, indicating considerable nutrient enrichment.

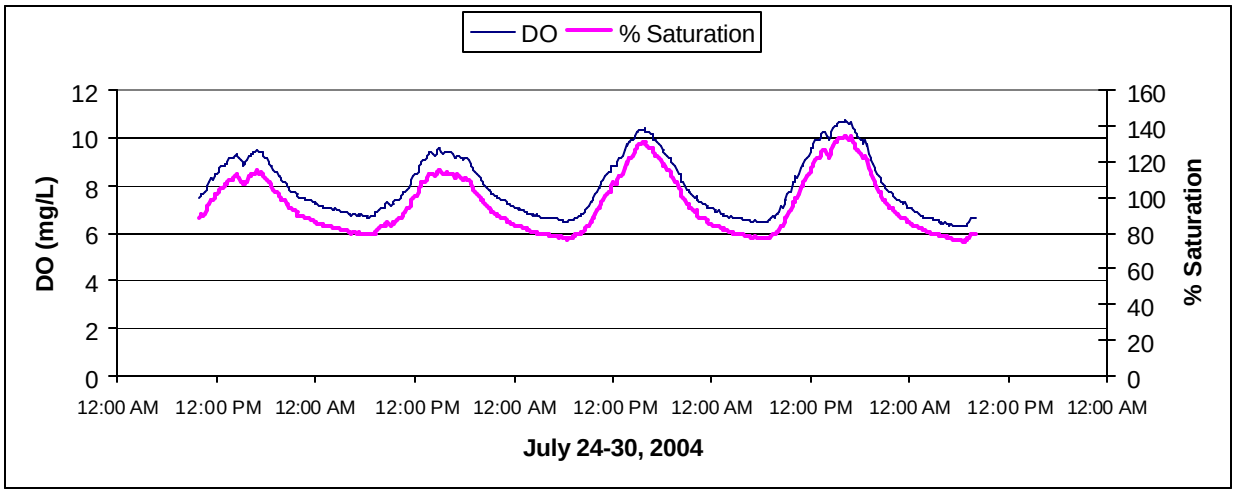

Figure 2-7. Diurnal DO Study at NTH014.08; July 24-30, 2004

2.7. 305(b)/303(d) Combined Report – Monitored Exceedences

- In all three biennial reports between 1998 and 2002 (VADEQ, 1998, 2000, 2002b), no standards exceedences for temperature, DO, or pH were reported for the ambient station on North River (NTH014.08), as shown in Table 2-12 below.
- During the same time, a large number of total phosphorus concentrations were monitored that exceeded DEQ's threshold for "threatened" waters of 0.2 mg/L.
- The fecal coliform violations are being addressed by a companion TMDL study.
- The assessed ratings from DCR's biennial assessment of NPS pollution by state 14-digit watersheds for the outlet watershed are listed in Table 2-13.

Table 2-12. 305(b) / 303(d) Monitored Exceedences at Station 1BNTH014.08

Assessment	Temperature		Dissolved Oxygen		pH		Fecal coliform		Total Phosphorus	
Year	A	B	A	B	A	B	A	B	A	B
1998	0 / 60	0%	0 / 60	0%	0 / 60	0%	33 / 59	56%	27 / 60	45%
2000	0 / 62	0%	0 / 61	0%	0 / 62	0%	27 / 60	45%	32 / 61	52%
2002	0 / 60	0%	0 / 59	0%	0 / 60	0%	20 / 59	34%	39 / 60	65%

A = Number of violations / Total number of samples
B = Violation Rate

Table 2-13. DCR Biennial Watershed NPS Assessment – B23

Year	AGR_N	AGR_P	AGR_S	URB_N	URB_P	URB_S	FOR_N	FOR_P	FOR_S	TOT_N	TOT_P	TOT_S	RIMP	EIMP	LIMP	SWP	IBI
2004	H	H	H	M	M	M	L	L	L	H	M	M	M	N	L	C	D
2002	H	H	H	M	M	M	L	L	L	H	M	M	H	N	L	C	D
2000	H			L			L			H			H	N	--	--	--

Header Codes
AGR - agriculture
URB - urban
FOR - forestry
TOT - total from all land uses
N - nitrogen
P - phosphorus
S - sediment
RIMP - Riverine Impairments
EIMP - Estuarine Impairments
LIMP - Lacustrine Impairments
SWP - Source Water Protection
IBI - mini-Index of Biotic Integrity

Nutrient & Impairment Rank Codes
H - High
M - Medium
L - Low
N - Not Applicable

SWP Codes
A - Very High
B - High
C - Moderate
D - Low
E - None

IBI Codes
A: =16 (Endangered Species Metric = 5)
B: =16 (Endangered Species Metric = 3)
C: 13-15
D: 1-12
E: Insufficient Data

2.8. DEQ Permitted Point Sources

A number of point source discharge permits have been issued by DEQ within the North River watershed. Only those facilities located above benthic station NTH014.48 were considered in the benthic stressor analysis. A summary of the total number and types of permits issued in North River above the benthic station – NTH014.48 – are listed in Table 2-14. Table 2-15 presents more specific information about the 6 facilities with VPDES permits.

Table 2-14. Permit Summary

Permit Type	Above Station 1BNTH014.48
VPDES	6
1000-gpd General Permits	36
Industrial Stormwater	18
Construction Stormwater	42
MS-4	2
Mixed concrete	2
Mining	2
CAFOs	6
Petroleum	2
Car wash	2

Table 2-15. VPDES Permits on North River above Station NTH014.48

VPDES Permit No	Facility Name	Max Design Flow (MGD)	Water Body	Receiving Stream
VA0002313	Valley Poultry Growers Coop (formerly Pilgrims Pride Corporation) - Hinton	1.100	VAV-B22R	Muddy Creek
VA0002674	Harrisonburg WTP	0.349	VAV-B25R	Cooks Creek, U.T.
VA0051420	Bridgewater WTP	0.023	VAV-B17R	North River
VA0060640	North River WWTF	16.000	VAV-B23R	North River
VA0062928	Calvary Mennonite Fellowship	0.005	VAV-B22R	Muddy Creek
VA0090085	Dayton Water Treatment Plant	0.354	VAV-B25R	Cooks Creek

A summary of concentrations from monthly discharge monitoring reports (DMR) sent in to DEQ by the VPDES facilities is given in Table 2-16. The Virginia Poultry Growers Coop (formerly the Pilgrims Pride Corporation) installed a plant upgrade in October 2002 and the North River WWTF underwent an upgrade and conversion to Biological Nitrogen Removal (BNR) in 2001. Therefore, average concentrations are listed separately for the pre and post upgrade periods for each facility. The concentration reductions due to implementation of BNR at the North River WWTF are readily apparent in the plot of monthly DMR concentrations in Figure 2-8. The post-upgrade period at the Virginia Poultry Growers Coop facility resulted in a 68% decrease in nitrate concentrations which has improved to a 78% reduction over the last 3 years, while the post-BNR period at the North River WWTF saw a 58% decrease in TN concentrations and an 84% decrease in TP concentrations over the pre-BNR period. All of the VPDES permit facilities in Table 2-15 and Table 2-16, except the Bridgewater WTP and the North River waste water treatment facility (WWTF), are included in tributary watersheds with impaired stream segments, and therefore are covered under previous TMDL studies.

Table 2-16. Summary of Reported Monthly Discharge Monitoring Reports (DMR) above Station NTH014.48

Permit No	Facility Name	No. of Samples	Design Flow	Average of Monthly DMR Samples						
				Flow_Ave	BOD5_Ave	TSS_Max	TP_Ave	TN_Ave	NO3_Ave	TKN_Ave
			(MGD)	(MGD)	(kg/day)	(mg/L)				
VA0002313	Pilgrims Pride Corporation (pre-upgrade)	34	1.100	0.540	14.55	--	--	--	48.64	2.58
VA0002313	Valley Poultry Growers Coop (post-upgrade)	31		0.711	22.85	--	--	--	15.56	3.24
VA0002313	Valley Poultry Growers Coop (2003-2005)*	17		0.860	22.63	--	--	--	10.56	3.33
VA0002674	Harrisonburg WTP	60	0.349	0.238	--	3.21	--	--	--	--
VA0051420	Bridgewater WTP	63	0.023	0.026	--	2.76	--	--	--	--
VA0060640	North River WWTF (pre-BNR)	43		8.794		3.11	3.77	17.71		
VA0060640	North River WWTF (post-BNR)	41	16.000	11.180	--	3.05	0.60	7.48	--	--
VA0062928	Calvary Mennonite Fellowship	71	0.005	--	--	25.80	--	--	--	--
VA0090085	Dayton Water Treatment Plant	44	0.354	0.310	--	10.19	--	--	--	--

-- Not reported.
* Included in the post-upgrade period.

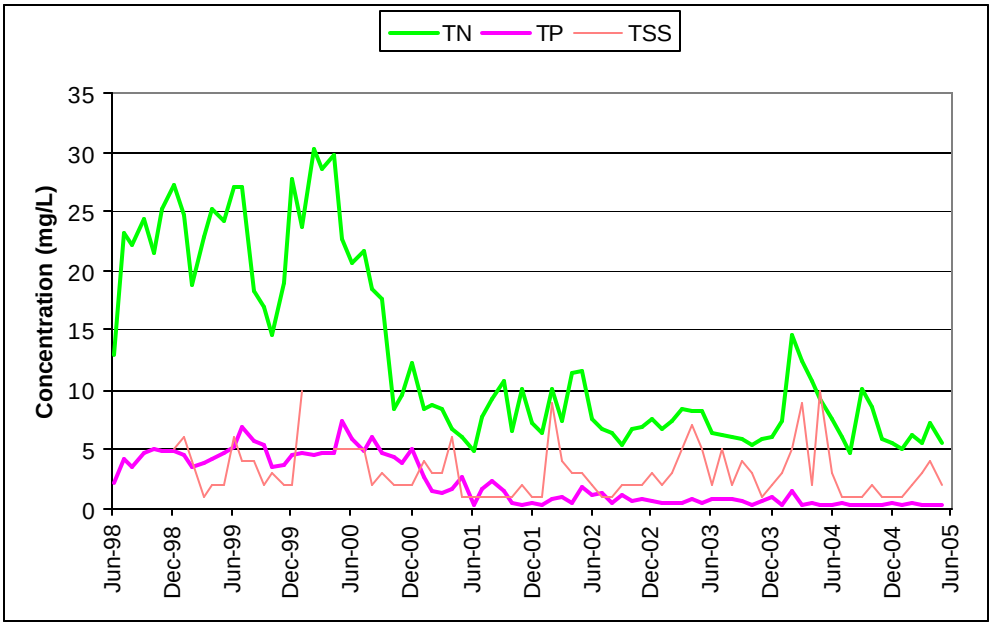

Figure 2-8. North River WWTF – Reported Monthly DMR Concentrations

Table 2-17 details reported incidences of sewage overflows from various points within the distribution network leading to the North River WWTF.

Table 2-17. North River WWTF Documented Overflows and Bypasses (1996-2004)

Date	Location	Comments
09/06/96	North River Pumping Station	9/6/96 6:25pm to 9/7/96 4:30pm; estimated flow of 24 MG; estimated BOD5 load of 9629 KG
09/06/96	Bridgewater Pumping Station	9/6/96 2:00pm to 9/7/96 11:00pm; estimated flow of 24 MG; estimated BOD5 load of 9629 KG
01/98		2 overflows reported during the month; no info on location or volume
02/98		3 overflows reported during the month; no info on location or volume
04/01		1 overflow reported during the month; no info on location or volume
05/22/01	From primary clarifier to North River via stormsewer	estimated flow of 0.069 MG; duration of 50 minutes
05/29/02	From overflowing digester	no discharge to North River
06/25/03	Manhole along Cooks Creek	Reported by local resident as overflowing periodically during month; manhole cover replaced by resident several times; WWTP staff visited site to clear debris
09/03		3 overflows reported during the month; no info on location or volume

2.9. Upstream Segments with TMDLs for Benthic Impairments

- The stream segments upstream from station NTH014.48 that have already had TMDL studies completed for benthic impairments are listed in Table 2-18 together with percent reductions for sediment and/or phosphorus called for in the TMDL studies. TMDL Implementation Plans have already been developed for the benthic impairments in Muddy Creek and Pleasant Run, and are currently being developed for the benthic impairments in Cooks Creek and Blacks Run. TMDL Implementation Plans have also been developed for bacterial impairments in Dry River, Muddy Creek, Mill Creek, and Pleasant Run. The implementation plans for the bacterial and benthic impairments in these watersheds are currently in the process of being implemented and have been the recipient of Clean Water Act Section 319 funds.

Table 2-18. Percent Load Reductions in Upstream TMDLs

ANCODE	Impaired Segment	Segment Length (mi)	Impaired Segment Description	Identified Stressor	Contractor	% Load Reductions in TMDL
B18a	Beaver Creek	2.8	begins at headwaters; ends at confluence with Briery Branch	de-listed	VT BSE	--
B19	Mossy Creek	9.65	begins at headwaters; ends at confluence with North River	sediment	VT BSE	74.9%
B22	Muddy Creek	10.36	begins at headwaters; ends at confluence with Dry River	sediment	Tetra Tech	63%
				phosphorus		67%
B25	Cooks Creek	13.32	begins at headwaters; ends at confluence with North River	sediment	Tetra Tech	68%
				phosphorus		68%
B26	Blacks Run	10.74	begins at headwaters; ends at confluence with Cooks Creek	sediment	Tetra Tech	37%
B27	Pleasant Run	6.3	begins at headwaters; ends at confluence with North River	sediment	Tetra Tech	71%
				phosphorus		66%

- Through the end of 2004, the combined voluntary and cost-shared BMPs in the upstream TMDL watersheds were tracked by Virginia's Department of Conservation and Recreation (DCR) and reported in DEQ's "TMDL Five Year Progress Report" (VADEQ, 2005). (The extent of voluntary BMPs was most likely underestimated for this report as not all voluntary installations met DCR specifications. For example, stream exclusion buffer widths with voluntary fencing installations may be less than the specified 35 feet minimum. While these practices may not achieve the full benefit expected from an approved design, they do provide a significant benefit by eliminating direct deposition and avoiding erosion due to livestock trampling of the banks. Currently, the Shenandoah Valley SWCD is attempting to refine the estimates of voluntary stream exclusion fencing that were installed without cost-share

assistance.) This BMP implementation has been accompanied by reductions in geometric mean bacteria concentrations estimated at 18-60% in the various component sub-watersheds (Table 2-19). While these reductions in bacteria do not directly translate into equal reductions of sediment and phosphorus, all of the listed BMPs will also typically reduce phosphorus loads, and all of the agricultural BMPs except nutrient management are also typically used to reduce sediment loads.

Table 2-19. BMP Implementation Summary for the North River Watershed (2001 – 2004)

Control Measure	Units	Estimated Units Needed 1	Units Completed 2	Percent Completed
Agriculture Program				
Stream Exclusion Fencing	feet	612,480	30,093	5%
Vegetative Cover on Critical Areas	acres	5,154	876	17%
Forested Riparian Buffer	acres	0	10.3	
Nutrient Management Practices	acres	0	358	
Grassed Waterways	feet	0	4,785	
Residential Program				
Septic System Pump Out	system	0	7	
Septic System Repair	system	10	6	
Sewer Connections	system	0	0	
Septic System Installation	system	17	3	
Alternative Waste Treatment System	system	27	3	
Total On-Site System Installation	system	54	12	22%

1 numbers for septic system installation and alternative waste treatment systems are projected measures to correct 6 straight pipes.
2 the units completed column indicates cost-share and voluntary practices

- Preliminary modeling was performed on the individual state hydrologic unit watersheds (also known as HUCs) upstream from station NTH014.48 using the GWLF model. Modeling included: surface runoff loads of sediment and phosphorus; sediment and phosphorus loads from existing VPDES dischargers with reported TP concentrations from DMR reports and 1000-gpd units with general permits; and sediment loads from construction stormwater, mixed concrete, and carwash discharges. Modeling did not include sediment and/or phosphorus loads for point sources not specifically mentioned. Streambank and channel erosion was not simulated as this component was not included in the Tetra Tech studies and was a minor component of the Mossy Creek sediment load. In order to make the modeling across the watershed consistent, the preliminary modeling was performed by evaluating the parameters for all of the contributing area to station NTH014.48 in a similar manner and with the same weather inputs. To calculate the expected load reduction at NTH014.48 due to upstream TMDLs, the percent reductions specified in the TMDL allocations were applied to the modeled pollutant loads from the applicable HUC areas. These upstream loads and reductions are shown in Table 2-20 and are estimated to result in reductions of 41.5% and 38.3%, respectively, in sediment and phosphorus loads at station NTH014.48, after accounting for post-BNR reductions from the North River WWTF.

Table 2-20. Simulated Loads and Load Reductions in Watershed B23ax

Sub-watershed	Sediment (t/yr)			Phosphorus (kg/yr)		
	Existing	TMDL % Reduction	Loads after TMDLs	Existing	TMDL % Reduction	Loads after TMDLs
B16	394.9		394.9	1,484.2		1,484.2
B17	2,564.3		2,564.3	11,956.5		11,956.5
B18a	733.2		733.2	3,352.4		3,352.4
B18b	1,004.8		1,004.8	3,653.9		3,653.9
B19	2,128.5	74.9%	534.2	9,511.6		9,511.6
B20	314.7		314.7	1,838.2		1,838.2
B21	889.4		889.4	4,839.9		4,839.9
B22	4,020.6	63%	1,487.6	20,521.1	67%	6,772.0
B24	2,717.1		2,717.1	10,839.2		10,839.2
B25	7,735.0	68%	2,475.2	44,753.1	68%	14,321.0
B26	3,407.9	37%	2,147.0	16,792.0	37%	10,579.0
B27	4,323.0	71%	1,253.7	28,196.6	66%	9,586.8
B23a	2,785.9		2,785.9	22,551.7		22,551.7
Loads from Composite Watershed B23ax	**33,019.4**		**19,302.1**	**180,290.4**		**111,286.4**
Expected Load Reductions from Upstream TMDLs			**41.5%**			**38.3%**

2.10. Load Comparisons with Reference Watersheds

Another gauge of the "impairment" of a watershed is a comparison of the unit-area loads with that of a reference watershed. Four watersheds are included - one for comparison with pristine conditions and three with potential use as reference watersheds for the B23ax North River watershed. Two of these watersheds were used as references in previous TMDL studies in the area: Hayes Creek (I34) and the Upper Opequon Creek (B08) have been used as reference watersheds for the Toms Brook (B50), Blacks Run (B26), and Cooks Creek (B25) TMDLs. The other two watersheds – Dry River (B21) and Upper North River (B16) – are two upstream non-impaired watersheds included in the B23ax watershed. Watershed B16 is over 99% forested and represents a pristine condition. As such it is included merely for comparison sake, since the minor loads from such a watershed would not be considered attainable from a watershed with a greater percentage of other land uses. Simulated loads from these five watersheds are shown in Table 2-21 and Table 2-22, respectively, for sediment and phosphorus. Loads from the B23ax North River watershed were calculated for several scenarios – the original Listing scenario (corresponding to pre-BNR conditions at the North River WWTF), a post-BNR scenario, and a post-BNR scenario with reductions from upstream TMDLS, as referenced earlier.

The B23ax North River watershed is much larger than many of the watersheds previously assessed with the reference watershed approach, containing approximately 12 state HUC watersheds versus 1-3 state HUC watersheds in previous watersheds. While there may be uncertainties involved in comparisons of very large watershed with smaller watersheds, the UAL

comparison serves as a useful starting point. As expected, the watershed UALs of both sediment and phosphorus are considerably smaller in the B16 watershed than any of the other watersheds, impaired or not. The B23ax sediment UAL for the Listing conditions is already equal to that of one of the reference watersheds, is smaller than another, and is relatively unaffected by point source contributions. Load reductions estimated from upstream TMDLs reduce B23ax's sediment UAL to a value that is close to the lowest UAL of the 3 potential reference watersheds. The B23ax phosphorus UAL for the Listing conditions is larger than 2 of the 3 potential reference watersheds, and is considerably affected by point source loads. Load reductions estimated from both upstream TMDLs and a BNR upgrade at the North River WWTF produce a phosphorus UAL lower than 2, and in the lowest 10% of the range, of the phosphorus UAL values for the potential reference watersheds. The simulated reductions in sediment and phosphorus due to BNR installation since the original listing and anticipated upstream TMDL implementation, without any additional reductions, produce UALs comparable to the lowest UALs from the three potential reference watersheds.

Table 2-21. Sediment Unit Area Loads (UAL) at NTH014.48 and 4 Potential Reference Watersheds

	Impaired?			Non-impaired			Non-impaired			Non-impaired			Non-impaired		
	North River at NTH014.48 (B23ax)			Dry River at DUR000.11 (B21)			North River at NTH046.75 (B16)			Hayes Creek (I34)			Upper Opequon Creek (B08)		
Land Uses	Sediment (t/yr)	Area (ha)	Sediment UAL (t/ha-yr)	Sediment (t/yr)	Area (ha)	Sediment UAL (t/ha-yr)	Sediment (t/yr)	Area (ha)	Sediment UAL (t/ha-yr)	Sediment (t/yr)	Area (ha)	Sediment UAL (t/ha-yr)	Sediment (t/yr)	Area (ha)	Sediment UAL (t/ha-yr)
Hi-till cropland	12,950.42	2,837.93	4.56	5,428.99	708.15	7.67	28.06	0.47	59.51	421.40	60.34	6.98	9,304.85	401.97	23.15
Lo-till cropland	9,839.46	3,582.13	2.75	2,513.16	712.90	3.53	50.89	1.84	27.59	1,030.57	260.06	3.96	3,237.68	308.04	10.51
Pasture	3,742.26	16,103.65	0.23	794.68	2,792.92	0.28	9.46	20.35	0.46	1,849.73	7,256.81	0.25	4,865.80	4,839.85	1.01
Hay	2,190.50	10,493.40	0.21	964.34	3,076.93	0.31	0.00	0.00	0.00	627.43	2,465.26	0.00	3,532.11	3,488.57	0.00
Transitional	2,801.89	464.55	6.03	150.59	21.15	7.12	455.57	36.90	12.35	28.53	8.12	3.52	3,127.14	174.24	17.95
Forest	1,315.85	58,198.66	0.02	721.01	23,055.65	0.03	810.81	16,700.74	0.05	154.24	10,708.82	0.01	303.93	5,147.91	0.06
Pervious urban	10.77	3,355.53	0.00	1.87	433.79	0.00	0.02	3.14	0.01	0.11	17.98	0.01	3.09	432.37	0.01
Impervious urban	39.42	2,133.39	0.02	4.85	190.73	0.03	0.07	2.10	0.03	0.39	11.99	0.03	9.06	265.04	0.03
Sub-Totals															
Nonpoint Sources (NPS1)	32,890.57	97,169.25	0.34	10,579.50	30,992.22	0.34	1,354.87	16,765.54	0.08	4,112.41	20,789.37	0.20	24,383.67	15,057.99	1.62
Point Sources (PS1)	118.31			19.18			0.00			0.00			8.31		
Post-BNR Point Sources (PS2)	127.63														
Nonpoint Sources with upstream TMDLs (NPS2)	20,970.43		0.22												
Totals															
Listing (NPS1 + PS1)	**33,008.88**		**0.34**	**10,598.68**		**0.34**	**1,354.87**		**0.08**	**4,112.41**		**0.20**	**24,391.98**		**1.62**
post-BNR (NPS1 + PS2)	**33,018.20**		**0.34**												
post-BNR with upstream TMDLs (NPS2 + PS2)	**21,098.06**		**0.22**												

Table 2-22. Phosphorus Unit Area Loads (UAL) at NTH014.48 and 4 Potential Reference Watersheds

	Impaired?			Non-impaired			Non-impaired			Non-impaired			Non-impaired		
	North River at NTH014.48 (B23ax)			Dry River at DUR000.11 (B21)			North River at NTH046.75 (B16)			Hayes Creek (I34)			Upper Opequon Creek (B08)		
Land Uses	Phosphorus (kg/yr)	Area (ha)	Phosphorus UAL (kg/ha-yr)	Phosphorus (kg/yr)	Area (ha)	Phosphorus UAL (kg/ha-yr)	Phosphorus (kg/yr)	Area (ha)	Phosphorus UAL (kg/ha-yr)	Phosphorus (kg/yr)	Area (ha)	Phosphorus UAL (kg/ha-yr)	Phosphorus (kg/yr)	Area (ha)	Phosphorus UAL (kg/ha-yr)
Hi-till cropland	80,375.70	2,837.93	28.32	29,731.74	708.15	41.99	101.80	0.47	215.91	1,356.68	60.34	22.48	26,255.77	401.97	65.32
Lo-till cropland	43,352.53	3,582.13	12.10	12,662.86	712.90	17.76	169.99	1.84	92.18	3,594.83	260.06	13.82	9,318.03	308.04	30.25
Pasture	15,270.72	16,103.65	0.95	3,753.27	2,792.92	1.34	32.85	20.35	1.61	6,592.76	7,256.81	0.91	14,098.78	4,839.85	2.91
Hay	11,126.37	10,493.40	1.06	4,415.56	3,076.93	1.44	0.00	0.00	0.00	2,985.43	2,465.26	0.00	10,975.90	3,488.57	0.00
Transitional	8,377.92	464.55	18.03	498.04	21.15	23.55	1,133.10	36.90	30.71	89.74	8.12	11.06	8,775.89	174.24	50.37
Forest	6,736.40	58,198.66	0.12	4,321.52	23,055.65	0.19	3,653.69	16,700.74	0.22	494.95	10,708.82	0.05	858.82	5,147.91	0.17
Pervious urban	95.96	3,355.53	0.03	17.89	433.79	0.04	1.15	3.14	0.37	2.43	17.98	0.14	61.08	432.37	0.14
Impervious urban	70.95	2,133.39	0.03	8.73	190.73	0.05	0.12	2.10	0.06	0.70	11.99	0.06	16.30	265.04	0.06
Sub-Totals															
Nonpoint Sources (NPS1)	165,406.55	97,169.25	1.70	55,409.60	30,992.22	1.79	5,092.70	16,765.54	0.30	15,117.53	20,789.37	0.73	70,360.58	15,057.99	4.67
Point Sources (PS1)	45,864.12			20.73			0.00			0.00			9,415.86		
Post-BNR Point Sources (PS2)	9,329.39														
Nonpoint Sources with upstream TMDLs (NPS2)	108,246.59		1.11												
Totals															
Listing (NPS1 + PS1)	**211,270.67**		**2.17**	**55,430.32**		**1.79**	**5,092.70**		**0.30**	**15,117.53**		**0.73**	**79,776.45**		**5.30**
post-BNR (NPS1 + PS2)	**174,735.94**		**1.80**												
post-BNR with upstream TMDLs (NPS2 + PS2)	**117,575.98**		**1.21**												

3.0 Analysis of Candidate Stressors

A list of candidate stressors was developed for North River and evaluated to determine the pollutant(s) responsible for the benthic impairment. Candidate stressors included ammonia, pH, sediment, temperature, toxics, nutrients, organic matter, and channel modifications. The potential stressor checklist in Appendix A was used to evaluate known relationships or conditions that may show cause and effect between potential stressors and changes in the benthic community. An outline of available evidence was then summarized in Appendix B as the basis for evaluating the evidence for each potential stressor. Depending on the strength of available evidence, the potential stressors were either "eliminated" or considered as "possible" stressors. During the stressor analysis, it also became clear that many types of evidence support the position that the impaired condition of the B23ax watershed was the result of previously high loads from the North River WWTF and from upstream impairments. The evaluation of each candidate stressor is discussed in the following sections as it affected both the original Listing condition and current conditions.

The state 14-digit watershed containing the impaired segment of North River (B23) is not a headwaters watershed but receives drainage from 19 other upstream HUC watersheds. Since the monitoring station is 14.48 miles upstream from the outlet, however, only the portion of the drainage upstream from the monitoring station (watershed B23ax) was used in the stressor analysis to look for causes of the impairment assessed in 1996 and 1998. The periods of data contributing to the assessments considered in this analysis are shown in Table 3-1. As a large number of both ambient and benthic monitoring stations are located upstream from 1BNTH014.48, summaries from selected upstream stations were also used for parts of this analysis.

Table 3-1. Periods of Data Associated with Individual 305(b) Reports in Virginia

305(b) Report	Period of Data Included in Assessment
1996	04/01/1993 – 03/31/1995
1998	07/01/1992 - 06/30/1997
2000	01/01/1994 – 12/31/1998
2002	01/01/1996 – 12/31/2000
2004	01/01/1998 – 12/31/2002

3.1. Eliminated Stressors

3.1.1. Ammonia

High values of ammonia are toxic to many fish species and may impact the benthic community as well. During the 1996 2-year assessment period, no standard exceedences were recorded, and during the 1998 5-year assessment period, only 1 minor exceedence of 0.47 mg/L occurred on 2/18/92. Two ammonia-N values have exceeded the water quality standard since then (2.25 mg/L on 7/14/99 and 1.71 mg/L on 2/9/00). Over half of the 143 samples taken since July 1990 were at or below the

minimum detection limit (MDL) of 0.04 mg/L. Ammonia could not have caused the 1996 assessment of impairment and it is highly improbable that the one exceedence in 1992 led to the impairment; therefore, ammonia was eliminated as a possible stressor.

3.1.2. pH

Benthic macroinvertebrates require a specific pH range to live and grow. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater, urban runoff, and acid rain can potentially alter in-stream levels of pH.

No exceedences of the Class IV minimum pH standard (6.5) have occurred at station NTH014.08 (Figure 2-5). Interestingly, the farthest upstream station on North River (NTH036.96 in watershed B16) corresponds with a predominantly forested area and had 12 out of 31 samples below the minimum pH standard. However, neither of the two downstream stations – NTH021.00 or NTH014.08 (our station of interest) – had recorded any violations. Therefore pH does not appear to be the cause of the benthic impairment.

3.1.3. Temperature

North River is classified as a Class IV stream with a maximum temperature standard of 31°C. Through Fall 1999, this benthic station had poor habitat scores for riparian vegetation (Table 2-6). While poor riparian vegetation could lead to increased stream temperatures, no violations have ever been recorded for the temperature standard (Figure 2-5). Therefore, temperature does not appear to be the cause of the benthic impairment.

3.1.4. Toxics

Toxic substances are detrimental to all living organisms. Three channel bottom sediment samples from station NTH014.08 were analyzed for a variety of metals and pesticides in 1991, 1996, and 2000 and showed all substances at or below their minimum analytical detection limits (MDL). Concentrations of mercury (Hg), PAHs, PCBs, and DDT in excess of NOAA's Effects Range-Median have been measured in several samples taken in upstream tributaries, but were not detected in any of the samples from station NTH014.08. Other toxic substances certainly may be present, even those that were analyzed for but not detected, as many analyses are performed with MDLs that are far greater than the concentration level related to impacts on aquatic life; however no overt signs of toxicity (e.g. fish kills, low numbers of organisms) have been observed in this segment. The low shredder metric (SH/Tot, Table 2-2) could possibly indicate a toxic effect, but without supporting toxicity evidence, is probably due to a lack of suitable habitat or leaf litter input. Since the total numbers of organisms in each sample have remained fairly constant throughout the period of benthic monitoring, and are similar to numbers of organisms found in upstream "non-impaired" streams, toxicity does not appear to be a cause of the impairment.

3.2. Possible Stressors

3.2.1. Nutrients

Excessive nutrient inputs can lead to excessive algal growth, eutrophication, and low dissolved oxygen concentrations that may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration.

Nutrients have been, and currently are, available in sufficient quantities to support eutrophic conditions, with high levels of both dissolved and total nitrogen and phosphorus. Phosphorus is marginally limiting. Total phosphorus concentrations have exceeded the "threatened" waters threshold of 0.2 mg/L in more than 50% of the 126 samples taken since July 1992 (Figure 2-5). The North River WWTF, sitting less than 0.5 miles upstream from station NTH014.48, is a major factor in these nutrient concentrations. In 2001, the North River WWTF implemented a biological nutrient removal (BNR) process that has had an overall beneficial effect on nutrient levels, with a 58% reduction in average TN concentrations and an 84% decrease in average TP concentrations (Table 2-16). Since January 2002, the number of "threatened" waters TP exceedences monitored at the DEQ monitoring site has also dropped to 3 out of 14 samples, for a 21.4% exceedence rate. While the average TN and TP concentrations from the WWTF have been greatly reduced, concentrations from individual WWTF effluent samples in the post-BNR period have run as high as 14.6 mg/L TN and 1.77 mg/L TP. There are also plenty of pastures with direct access to streams by livestock and their nutrient-laden manure, located primarily in the upstream TMDL watersheds.

The "Moderate" biological impairment ratings that led to the assessment of this segment as "impaired", however, both occurred in the pre-BNR period, with only "Slight" or "No Impact" ratings assessed since then. On the last biological sampling date (10/26/04), an additional sample was collected at a new site just a short distance upstream from the North River WWTF (NTH015.45) for comparison with the main monitoring site (NTH014.48) located just below the WWTF. The locations of the additional monitoring site and the two major VPDES dischargers are shown in Figure 3-1 in relation to the main benthic monitoring station (NTH014.48), and the upstream contributing impaired segments.

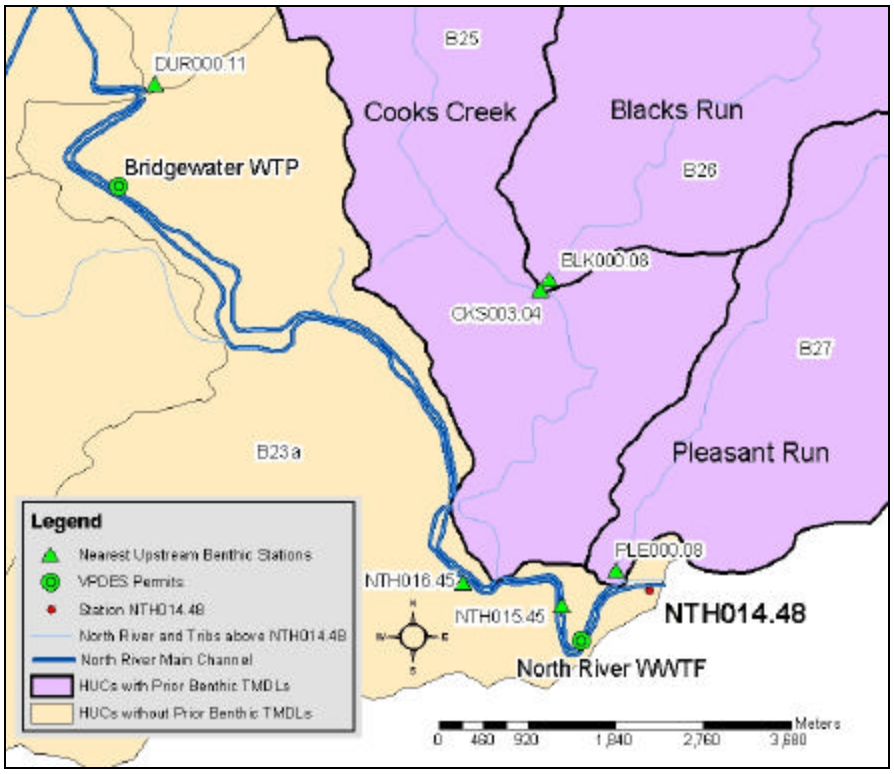

Figure 3-1. Location of VPDES Permits Just Upstream from Station NTH014.48

On October 26, 2004, the upstream site (NTH015.45) had an RBP II score of 87.0 putting it in the "Non-impaired" category, while the downstream site (NTH014.48) had an RBP II score of 65.2 placing it in the "Slight" category. Although these scores are quite different, the individual metric values used to arrive at the overall score are very similar as shown in Figure 3-2 and Figure 3-3.

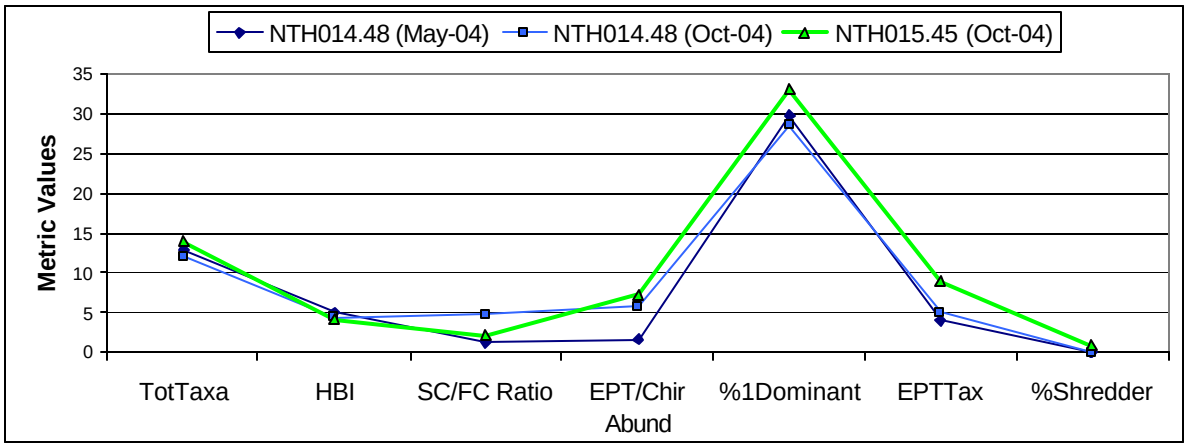

Figure 3-2. Differences in RPB II Metrics at Stations Bracketing North River WWTF

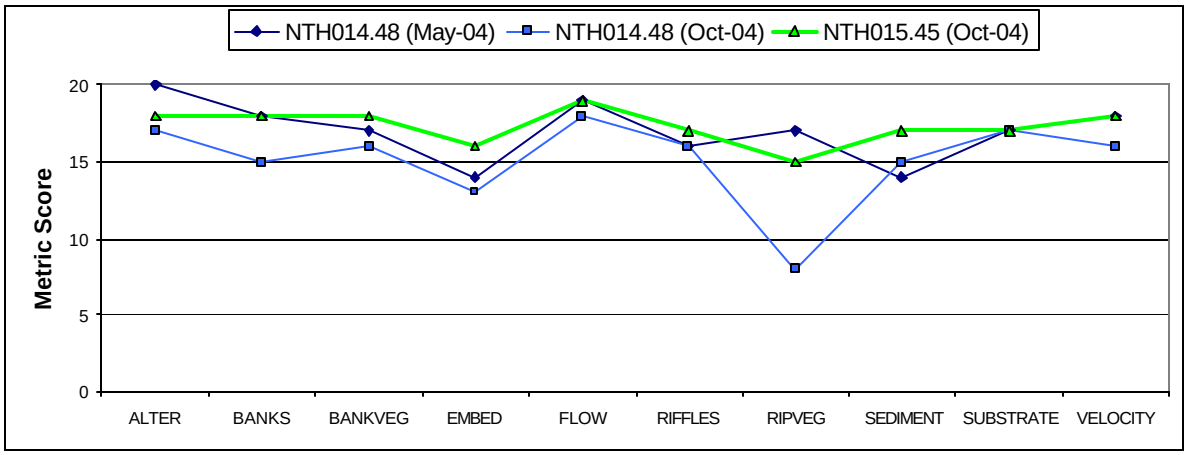

Figure 3-3. Differences in Habitat Metrics at Stations Bracketing North River WWTF

The habitat metrics in Figure 3-3 show a marked decrease in the Riparian Vegetation score between May-04 and Oct-04 at station NTH014.48, with the May-04 score at NTH014.48 slightly higher than the Oct-04 score at NTH015.45. The two major influences on the stream in between these two monitoring points are contributions from the North River WWTF and Pleasant Run. Available data from these two potential sources was used to assess their relative nutrient contributions, as shown in Table 3-2. An ambient water quality sample had been taken on 10/28/04 at mile 0.16 on Pleasant Run, that included a low PO4-P concentration (0.04 mg/L) and an unconfirmed high NO3-N concentration (14.32 mg/L) compared with a 10/10/04 DMR reported value of 0.3 mg/L TP and 8.5 mg/L TN. However, average simulated flow at NTH014.48 amounts to approximately 29.2 MGD, compared with simulated flow of 0.7 MGD from Pleasant Run, and reported flow of 12.2 MGD from the North River WWTF. Daily loads from the WWTF, therefore, are approximately 10 times and 126 times the respective loads of TN and TP coming out of Pleasant Run.

Table 3-2 . Relative Nutrient Contributions Between NTH015.45 and NTH014.48

Sample Date	Location	Concentration				Flow*	Load	
		NO3-N	TN	PO4-P	TP		TN	TP
		(mg/L)				(MGD)	(kg/day)	
10/28/2004	Pleasant Run	14.3		0.04		0.7	37.89	0.11
10/10/2004	North River WWTF (DMR)		8.5		0.3	12.22	393.18	13.88
	Outlet Station NTH014.48					29.2		

* - Average simulated daily flow, except the reported average by the WWTF.

From the macroinvertebrate side, three taxa are often associated with excessive nutrients – *chironomidae*, *hydropsychidae*, and *simuliidae*. Although these taxa were not dominant in the one sample used for the 1996 assessment, and *chironomidae* was only dominant in one of three samples affecting the 1998 assessment (Table 2-3), *chironomidae* were the dominant organism in both samples receiving a "Moderate" rating, although they have also been one of two dominant taxa in samples with "Slight" and "No Impact" ratings as well. The percentage of each of these three taxa, however, has decreased in post-BNR samples relative to pre-BNR samples. Since healthy riparian vegetation can decrease nutrient transport through surface runoff, the improved riparian vegetative cover noted since Spring 2000 in Table 2-6 (with the

exception of the Oct-04 sample) may also help account for the reductions in these nutrient-loving organisms.

The diurnal DO study showed that, while DO levels stayed well above the minimum DO level of 5.0 mg/L, there are large diurnal swings which can indicate excessive nutrients (Figure 2-7). Nutrients, therefore, have been, and quite possibly remain as, a stressor on the benthic community.

3.2.2. Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include agricultural runoff, residential runoff, forestry operations, construction sites, and in-stream disturbances.

As part of the 1996 and 1998 assessments, the habitat metrics assessed included "poor" ratings for bank stability, embeddedness, and riparian vegetation (Table 2-6); and 1 out of 2 1996 scores and 2 out of 3 1998 scores for the RPB II metric – %Haptobenthos (Table 2-2) – were in the poorest range. All of these metrics support sediment as a stressor on the benthic community. Since 2000, these same metrics have greatly improved.

Virginia's Department of Conservation and Recreation (DCR) performs the biennial assessment of NPS pollution potential on a watershed basis in conjunction with the 305(b) report (Table 2-13). DCR rated the watershed corresponding with the impaired segment as a "High" priority for sediment loading in 2000, but reduced the rating to a "Medium" priority in both 2002 and 2004, which further reinforces sediment as a possible stressor in the earlier assessments, with more recent improvements in control of sources of sediment generated from surface runoff. Sediment is further supported as a stressor in light of five upstream watersheds having benthic impairments for which sediment TMDLs have been developed (Table 2-19). The fact that ambient TSS measurements have all been fairly minimal (Figure 2-6) may appear not to support sediment as a stressor, except that most sediment is produced through runoff events, and no storm samples were available to gauge sediment contributions during these conditions. The presence of impervious areas and construction activities around the urban areas also are likely contributing sources. Overall, sediment appears to have been a source of stress in the earlier assessments, but its impact has been reduced in more recent samples as shown by improvements in sediment-related habitat measures.

3.2.3. Organic matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter include wastewater discharges and agricultural and impervious area runoff. Prior to Spring 2000, the modified family biotic index (MFBI) metric had moderate to high scores – generally indicative of organic pollution (Table 2-2). The MFBI scores have decreased since then, indicating reductions in organic loads. *Chironomidae* and *hydropsychidae* represent a sizeable fraction of all

organisms and occasionally are one of the dominant species (Table 2-3); these organisms are often associated with moderate levels of nutrient and/or organic pollution. The presence of the pollution-tolerant species *asellidae* and *planariidae* are also frequently observed, though in low numbers. There are also large livestock populations in the watershed, though they are not as predominant in the B23 watershed as they are upstream. Additionally, a major WWTF sits just 0.5 miles upstream from the monitoring site (Figure 3-1), with occasional sewer overflows. Occasional high measurements of COD were measured in the pre-BNR period, though no measurements are available for comparison in the post-BNR period. While the above evidence supports organic matter as a possible stressor, monthly BOD concentrations are fairly low and no DO standard violations have been reported (Figure 2-5). The evidence suggests that organic matter may have been a minor stressor on the benthic community during the listing period, but currently has a reduced influence as reflected in the improvements in the MFBI index.

4.0 Conclusions

Although a mixture of possible stressors are available in the watershed, the most probable stressors of the benthic community in stream segment VAV-1BNTH014.48-B23R were determined to be sediment and phosphorus. Large diurnal DO swings, high percentages of benthic taxa associated with nutrient pollution (*chironimidae*, *hydropsychidae*, and *simuliidae*), and consistently poor scores for habitat metrics related to sediment formed the basis for this determination. The fact that 5 upstream TMDL watersheds have also determined sediment and/or phosphorus to be the most probable stressors in these component areas further supports the evidence for these two stressors.

The benthic condition at station NTH014.48 has been improving and is currently only a borderline impairment. The following evidence from the stressor analysis supports the improvement in this stream reach:

- Metrics indicative of a previous impairment have improved:
  - The four "poor" habitat metrics related to sediment are showing increasing trends.
  - The average percentage of pollution-tolerant taxa (Tolerance value = 8) has decreased from 14.1% per sample during the pre-BNR period to 7.9% in the post-BNR period.
  - MFBI scores have moderated indicating less organic/nutrient inputs.
- The last 5 single sample benthic RBP II ratings have been either "slight" or "no impact". The last "moderate" single sample rating was in Spring 2000 (5 years ago), which was also prior to the installation of BNR at the North River WWTF.

Improvement in the benthic condition is correlated with, and likely resulted from, improvements already achieved in upstream watersheds and point sources.

- Interim reductions in the large phosphorus loads from the North River WWTF have been accompanied by decreasing percentages of benthic taxa associated with nutrient pollution (*chironimidae*, *hydropsychidae*, and *simuliidae*).
- The initiation of installation of voluntary and cost-shared BMPs in upstream watersheds has corresponded with improvements in the habitat metrics related to sediment.

Additional improvements are already required in the upstream TMDL watersheds which will continue to reduce stressor loads at station NTH014.48.

- The improvements already noticed in the benthic condition have been achieved through point source controls and partial implementation of BMPs called for in the upstream TMDL watersheds.
- BMPs remaining to be implemented include a large portion of the Stream Exclusion Fencing, 83% of the Vegetative Cover on Critical Areas, and 78% of the On-Site Septic System Installations outlined in the TMDL Implementation Plans of the upstream watersheds (VADEQ, 2005).
- Most bacteria TMDL studies in Virginia to date have specified restricting livestock access to streams as one of the measures needed to meet state bacteria standards. Such restrictions will remove not only the bacteria from direct deposition, but also the associated organic matter and nutrients in the manure, and will reduce sediment detachment and streambank erosion associated with livestock stream access. Nine of the thirteen HUC areas upstream from NTH014.48 have TMDLs for bacteria impairments, including 4 watersheds not covered by benthic TMDLs. Therefore, additional sediment and phosphorus load reductions could be expected from livestock exclusion in these areas, as well.

The additional improvements required by existing TMDLs are sufficient to continue improving the benthic condition from the current borderline state to a non-impaired state.

- Preliminary modeling results indicate that even without developing a TMDL for the North River segment, implementation of upstream TMDLs would result in load reductions to the "impaired" segment of North River by 41.5% for sediment and by 38.3% for phosphorus (Table 2-20).
- Model simulations that accounted for the full reductions expected from upstream TMDL watersheds resulted in a simulated sediment unit-area load (UAL) in the B23ax watershed comparable to the lowest UAL of the 3 potential reference watersheds.
- The total benthic organism population is already similar to upstream "non-impaired" segments (Table 2-5) in the following ways:
    - Moderate numbers
    - No highly dominant populations
    - Few highly pollution-tolerant organisms (Tolerance values = 8)

The impairment observed at station NTH014.48, therefore, appears to have been caused by upstream loads of sediment and phosphorus. The benthic condition in the B23ax watershed is improving and corresponds with point source control upgrades and nonpoint source controls beginning to be implemented in upstream watersheds with sediment, phosphorus, and bacteria TMDLs. Model simulations of the B23ax watershed that incorporate the full reductions called for in the upstream TMDLs show that unit-area loads are comparable to those of 3 potential reference watersheds.

Based on the information presented in this stressor identification report and summarized above, a TMDL will not be developed to specifically address the benthic impairment in the North River. The benthic impairment in the North River is believed to result from pollutant contributions by

impaired North River tributaries. The benthic impairment in the North River is believed to be caused by the same pollutants for which TMDLs have been developed in these impaired tributaries. Based on the analysis provided in this report, implementation of TMDLs in the upstream impaired tributaries will result in meeting water quality standards for general aquatic life in the North River. In the 2006 water quality assessment report, therefore, DEQ will be listing the North River stream segment VAV-1BNTH014.48-B23R as a EPA Category 4A water with respect to the general aquatic life standard. A Category 4A water is a water that is impaired, but does not need a TMDL because one or more TMDLs for the identified pollutants have already been completed and approved by EPA. Upstream tributaries with completed TMDLs for benthic impairments include Muddy Creek (phosphorus and sediment), Cooks Creek (phosphorus and sediment), Blacks Run (sediment), Pleasant Run (phosphorus and sediment), and Mossy Creek (sediment).

5.0 Public Participation

Public participation was elicited at every stage in this stressor analysis and reclassification process in order to receive inputs from stakeholders and to apprise the stakeholders of the progress made. Public participation for this process was combined with the public participation efforts associated with the development of a bacteria TMDL for North River.

The first public meeting was held on September 23, 2004 at the John Wayland Elementary School Gym in Bridgewater to inform the stakeholders of the TMDL development process. Copies of the presentation materials were available for public distribution at the meeting. Approximately __ people attended the meeting.

The North River TMDL Steering Committee met on October 14, 2004 at the DEQ Valley Regional Office in Harrisonburg. A presentation was made by the Virginia Tech TMDL team regarding watershed characterization, the proposed modeling approach, and a preliminary assessment of the available monitoring data. Eleven stakeholders attended the meeting and provided comment throughout the meeting.

The results of this stressor analysis report and the decision to change the water quality category designation for North River from 5 to 4A will be presented at the next TMDL Steering Committee meeting and at the final public meeting that cover both the benthic and bacteria impairments on North River, both scheduled for later this fall. Copies of this report will be available at both meetings and on the DEQ web site showing the status of 303(d) listed stream segments. Comments will be solicited from stakeholders at both meetings and for a 30-day comment period following the final public meeting. A summary of all submitted comments and responses to those comments will be prepared and made available on the DEQ website.

6.0 References

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates, and fish. Second Edition. EPA 841-B-99-002. U. S. Environmental Protection Agency. Washington, DC. (http://www.epa.gov/OWOW/monitoring/techmon.html).

MacDonald, D. D., C. G. Ingersoll, and T. A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.

Smith, E. and R. Voshell. 1997. Studies of benthic macroinvertebrates and fish in streams within EPA Region 3 for development of biological indicators of ecological condition. Part I: Benthic macroinvertebrates. Final Report. Virginia Polytechnic Institute and State University. Blacksburg, Virginia.

Tetra Tech. 2002. Draft Report. A Stream Condition Index for Virginia non-coastal streams. Draft 1.0; May 1, 2002. Prepared for US EPA Region 3, Wheeling, WV; US EPA Office of Science and Technology, Washington, DC; and Virginia Department of Environmental Quality, Richmond, Virginia.

VADCR, 2004. Chapter 4.1: Nonpoint Source Assessment, Prioritization, and Activities. Virginia Water Quality Assessment 305(b) Report. Available at: http://192.206.31.57/305b04/npschapt04.pdf. Accessed February 2, 2005.

VADEQ, 1998. Virginia Water Quality Assessment 1998 305(b) Report to the EPA Administrator and Congress for the Period July 1, 1992 to June 30, 1997. Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation. Richmond, Virginia. Available at: http://www.deq.virginia.gov/wqa/305b1998.html.

VADEQ, 2000. Virginia Water Quality Assessment 2000 305(b) Report to the EPA Administrator and Congress for the Period January 1, 1994 to December 31, 1998. Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation. Richmond, Virginia. Available at: http://www.deq.virginia.gov/wqa/305b2000.html.

VADEQ, 2002a. 2002 Part 1A Impaired Waters Fact Sheet. 2002 303(d) Report on Impaired Waters. Appendix A. Richmond, Virginia. Available at: http://www.deq.state.va.us/water/303d.html. Accessed September 2003.

VADEQ. 2002b. 2002 305(b) Water Quality Assessment Report. Richmond, Virginia. Available at: http://www.deq.state.va.us/water/305b.html. Accessed February 2, 2005.

VADEQ. 2004. Virginia Water Quality Assessment 305(b)/303(d) Integrated Report. Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation. Richmond, Virginia. Available at: http://www.deq.state.va.us/wqa/pdf/2004ir/ir2004.pdf. Accessed May 5, 2004.

VADEQ. 2005. TMDL Five-Year Progress Report. Prepared by the Virginia Department of Environmental Quality in cooperation with the Department of Conservation and Recreation and the Department of Mines, Minerals, and Energy. January 2005. Available at: http://www.deq.state.va.us/tmdl/pdf/04prgrpt.pdf. Accessed July 1, 2005.

Appendix A. North River - Potential Stressor Checklist

Ammonia

- High ammonia values (variable pH and temperature dependent WQS)? ....._N__
- Other? (Please describe) Only 2 out of 125 samples with exceedences (07/99 and 02/00).

Nutrients

Benthic Data

- Dominance of *Chironomidae*, *Hydropsychidae* or *Simuliidae* (see Table 2-3)? (may indicate elevated nutrients)....._Y__
- Dominance of algae-eating fish species, e.g. Central Stonerollers? .....____

Habitat Data

- Low Riparian Vegetation habitat score (see Table 2-6)? (may allow increased nutrient inputs from overland flow) All 6 samples through Fall 1999 rated "poor", improved since then....._Y__

Chemical/Physical Data

- N and P ambient data (DEQ) – eutrophic sufficiency levels:
  - Dissolved N conc. > 0.3 mg/L? Average = 2.99 mg/L....._Y__
  - Dissolved ortho-P conc. > 0.01 mg/L? Average = 0.019 mg/L....._Y__
- Limiting nutrient (N:P > 10 indicates P is limiting; N:P < 4 indicates N is limiting.) The average N:P ratio = 11.2 (TN=3.53; TP=0.31), indicating P as the limiting nutrient.
- DEQ Wastewater Facility Sampling Inspection Reports? ....._N__
- Exceedence of DEQ's "threatened waters" TP threshold (Table 2-12)? 65 out of 126 samples exceed threshold!....._Y__

Ancillary Data

- High ranking of Nutrient Loads in DCR's Biennial NPS Assessment (see Table 2-13):
  - High AG_N or _P rating? _Y__
  - High URB_N or _P rating? _M__
  - High FOR_N or _P rating? _L__
  - High TOT_N rating? _Y__ or TOT_P rating? _M__

Field Observations

- Observed growth/slime/algae in streams?.....____

Other? (Please describe)

Organic Matter

Benthic Data

- Moderate to high values of the MFBI metric (>≈5.00) may indicate organic pollution (see Table 2-2)? 8 out of 13 samples were moderate to high. ....._Y_
- Dominance of *Hydropsychidae* or *Simuliidae* organisms (see Table 2-3)? (indicates moderate organic or nutrient pollution)....._N_
- Presence of *Asellidae, Oligochaetae,* or *Tubificidae* organisms (see Table 2-3)?....._Y_
- A low value (<≈0.50) for the SC/CF Ratio metric (see Table 2-2) or a high number of filterer-collectors (FC) indicates availability of suspended Fine Particulate Organic Matter? Only 1 out of 13 samples had low SC/CF ratios....._N_

Chemical/Physical Data

- High TOC values? – (GW criteria = 10 mg/L) ....._____
- High Volatile Solids and high BOD_5 values? (combination indicative of organics)...._N__
- High BOD_5 values? (Chickahominy effluent standard: 6-8 mg/L) ....._N__
- High COD values? (Chickahominy effluent standard: 10 mg/L)..(All pre-BNR!) ....._Y__
- Low DO values (Class V Waters WQS: average 5.0 mg/L)?....._N__
- High levels of TKN relative to nitrate-N indicating larger % organic N? (TKN=0.53; NO3-N=2.99)....._N__

Ancillary Data

- Large diurnal DO fluctuations? (> 1/3 %Saturation)....._Y__

Observations

- Extensive livestock access to streams or observed livestock manure in creeks? ....._Y__

Other? (Please describe) Primarily in upstream bacteria-impaired TMDL watersheds.

pH

- Extreme field pH values? – (normal range: 6.5 – 9.5)....._N__
- Extreme alkalinity values? (Valley & Ridge GW Criteria: 30-500 mg/L)....._N__
- Other? (Please describe)

Sediment

Benthic Data

- Low %Haptobenthos metric (implies a lack of clean, coarse substrates, see Table 2-2)? 4/8 samples through Spring 2000 rated "poor" (= 52%), improved since then. ..... _Y_

Habitat Data

- Habitat Evaluation Scores (0 = worst; 20 = best). Bedload sediment may be indicated by low scores of low bank stability, embeddedness, and/or epifaunal substrate scores (see Table 2-6)? Through Fall 1999, 2/6 rated "poor" for bank stability, 4/6 rated "poor" for embeddedness. ....._Y_

Physical/Chemical Data

- High TSS concentrations or turbidity during runoff events?.....____
- Higher TSS concentrations or turbidity than TMDL reference watershed? .....____
- High TSS concentrations from permitted point sources?..(one minor source from an upstream TMDL subwatershed)....._Y_
- Upstream segments with sediment impairments? 5 sediment TMDLs (benthic impairments) ....._Y_

Ancillary Data

- High ranking of Sediment Loads in DCR's Biennial NPS Assessment (see Table 2-13):
  - High AG_S rating? _Y__
  - High URB_S rating? _M__
  - High FOR_S rating? _L__
  - High TOT_S rating? _M__

- Low Riffle Stability Index (indicating anthropogenic influences)? .....____
- Presence of silt-intolerant fish species? .....____

Field Observations or Reports

- Observed stream embeddedness?.....____
- Observed construction sites?....._Y__
- Observed forest harvesting sites?.....____
- Observed clean-tillage farming? .....____
- Observed livestock access to streams and trampled streambanks? ....._Y__

Other? (Please describe)

Toxics

Benthic Data

- Low Shredder/Total (SH/Tot) metric (see Table 2-2) may indicate toxic affects, especially when adsorbed to the CPOM, or may indicate lack of available habitat? ....._Y__
- Low numbers of total organisms? (see Table 2-3)....._N__

Chemical/Physical Data

- Exceedences of EPA's Aquatic Life or Human Health Criteria? .....____
- Exceedences of Consensus-based Probable Effect Concentrations (PECs) by sediment samples (see Table 2-8, Table 2-9, Table 2-10, and Table 2-11)?....._Y__
- Chlorides (Rappahannock Effluent WQS- 40 mg/L; Chronic Aquatic Life Criteria: chloride - 230 mg/L; total chlorine residual - 11 µg/L) .....____
- Ammonia violations? ....._N__

Permitted Point Source Data

- Permitted Point Source Dischargers (RCRIS, CWNS, or VPDES sites)?....._Y__
- Known or suspected historical users of toxic substances in the watershed? ....._Y__

Ancillary Data

- High mortality rates indicated by EPA laboratory toxicity tests with *Ceriodaphnia* and fathead minnow (or other sensitive species)? .....____
- High % toxicity calculated from STP bench sheets? .....____
- Problems reported in VCE-sponsored County Household WQ Survey?
  During the summer of 1999, a household water sampling and water quality education program was held throughout both Augusta and Rockingham counties. After completion of the general sampling, 21 households were tested for 23 pesticides and other organic chemical compounds…a total of 16 compounds were detected, but none exceeding EPA Advisory or Maximum Contaminant Levels. ....._N__

Field Observations

- Absence of fish?.....____

Other? (Please describe)

Temperature

- High summer water Temperature values? (Class IV Waters WQS = 31°C)....._N__
- Low riparian vegetation score in Habitat Evaluation (see Table 2-6)?....._Y__
- Other? (Please describe) Through Fall 1999, 6/6 "poor" ratings, improved since then.

Other

- Conductance data? (reference watershed screening value < 500 µmhos/cm) .....____
- Other? (Please describe)

Appendix B. Stressor Analysis Evidence Sheet

Ammonia:

- Supportive:
- Non-supportive: Two minor exceedences out of 125 samples. Most values at or below MDL; impairment existed before these exceedences and so are not related.

Nutrients:

- Supportive: Concentrations of both nitrogen and phosphorus are higher than needed for eutrophic conditions; TP concentrations have exceeded the "threatened" waters threshold of 0.2 mg/L in >50% of samples. Frequent dominance of *chironimidae* or *hydropsychidae*. Riparian vegetation habitat metric scored "poor" until Fall 1999, has improved since then. North River WWTF (16.0 MGD) just upstream from monitoring point. High fluctuations in diurnal DO indicate abundant nutrients. High N load rating by DCR's biennial NPS assessment.
- Non-supportive: No DO standard exceedences; major reductions in measured nutrient concentrations since installation of BNR.

Organic Matter:

- Supportive: Moderate to high MFBI values prior to Spring 2000 have decreased since then – high values indicate organic enrichment. Low levels, but frequent occurrences of pollution-tolerant *asellidae* and *planariidae* usually indicative of human sewage. Large upstream livestock populations with stream access. Major WWTF just upstream. Some high pre-BNR COD measurements, but no post-BNR measurements.
- Non-supportive: No monitored exceedences of DO. Typically low BOD concentrations.

pH:

- Supportive: Upstream station NTH036.96 had 12 out of 31 samples with a pH below 6.5.
- Non-supportive: No pH standard exceedences downstream at either NTH021.00 or NTH014.48.

Sediment:

- Supportive: Low %Haptobenthos metric prior to 2000 (4 out of 8 samples rated "poor"), has improved since then. Bank stability and embeddedness metrics were low through Fall 1999, but have improved since then. Five upstream impaired stream segments with sediment TMDLs. DCR biennial NPS assessment of "High" in 2000, improved to "Medium" in both 2002 and 2004.
- Non-supportive: Low ambient TSS and turbidity.

Temperature:

- Supportive: Poor riparian vegetation in the past, which could have impacted stream temperatures in local reaches.
- Non-supportive: No reported exceedences of Class IV water quality standard (31°C).

Toxics:

- Supportive: Low shredder metric (SH/Tot) may indicate a toxic effect or a lack of available habitat, such as leaf inputs from riparian vegetation that has been lacking. Several upstream measurements of mercury, PAHs, PCBs and DDT have exceeded NOAA's Effects Range-Median indicating possible adverse effects on aquatic life, but were taken in 2001, long after impairment had been assessed. The minimum detection limit (MDL) of many substances is higher than the reference consensus-based PECs, so exceedences cannot be evaluated. Many upstream industrial dischargers. No laboratory toxicity tests were run.
- Non-supportive: Fairly constant, diverse benthic communtiy regardless of impairment status. The low number of shredders is more likely due to the reduction in riparian habitat.

Channel Modification:

- Supportive: Increasing impervious areas around Harrisonburg and Staunton. Some hardened channel segments around the urban areas. Livestock areas in many upstream areas contribute to streambank instability, though to a lesser degree in the area directly surrounding the "impaired" segment.
- Non-supportive: