Water Quality Analysis of Eutrophication for the Cabin John Creek Basin in Montgomery County, Maryland

FINAL

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Submitted to:

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BOD	Biochemical Oxygen Demand
BSID	Biological Stressor Identification
CES	Coastal Environmental Services
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DNR	Department of Natural Resources
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mg/l	Milligrams Per Liter
mi^2	Square Miles
NPDES	National Pollution Discharge Elimination System
NRCS	National Resources Conservation Service
SCS	Soil Conservation Service
SSURGO	Soil Survey Geography
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSI	Trophic State Index
USGS	United States Geological Survey
WQLS	Water Quality Limited Segment
µg/l	Micrograms Per Liter

EXECUTIVE SUMMARY

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, listed in the Integrated Report of Surface Water Quality in Maryland (Integrated Report), the State is to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2007).

The Maryland Department of the Environment (MDE) has identified the non-tidal waters of Cabin John Creek, a Use I-P waterbody [Code of Maryland Regulations (COMAR) 26.08.02.08O], in the State's 303(d) List as impaired by nutrients (1996), sediments (1996), fecal bacteria (2002) and impacts to biological communities (2006). All impairments are listed for non-tidal streams. The 1996 nutrients listing were refined in the *2008 Integrated Report of Surface Water Quality in Maryland* (Integrated Report) and phosphorus was identified as the specific impairing substance. Consequently, for the purpose of this report the terms nutrients and phosphorus will be used interchangeably. . The 2008 *Integrated Report* Assessment Unit ID for this listing is: MD-02140207. A TMDL for fecal bacteria was completed in 2006. The listings for suspended sediments and impacts to biological communities will be addressed separately at a future date.

A data solicitation for information pertaining to pollutants, including nutrients, in the Cabin John creek basin was conducted by MDE in September 2005, and all readily available data from the past five years have been considered. Currently, there are no specific numeric criteria for nutrients in Maryland's water quality standards. Nutrients typically do not have a direct impact on aquatic life; rather, they mediate impacts through excessive algal growth leading to low dissolved oxygen. Therefore, the evaluation of potentially eutrophic conditions due to nutrient over-enrichment will be based on whether nutrient-related parameters (i.e., dissolved oxygen levels and chlorophyll *a* concentrations) are found to impair designated uses in the Cabin John (in this case, water contact recreation, protection of aquatic life and public water supply).

Recently, MDE developed a biological stressor identification (BSID) methodology to identify the most probable cause(s) of the existing biological impairments in Maryland 8-digit watersheds based on the suite of available physical, chemical, and land use data (MDE 2009a). The BSID analysis for the Cabin John Creek watershed indicates inorganic pollutants and flow/sediment stressors are associated with impacts to biological communities; these findings will be addressed separately. The BSID analysis did not identify any nutrient stressors present and/or nutrient stressors showing a significant association with degraded biological conditions (MDE 2009b). The results of the BSID study, combined with the analysis of recent water quality data presented in this report, indicate that the Cabin John Creek watershed is not being impaired by nutrients.

This WQA supports the conclusion that a TMDL for nutrients is not necessary to achieve nutrient related water quality standards in Cabin John Creek. Although the waters of the Cabin John Creek watershed do not display signs of eutrophication, the State reserves the right to

require future controls in the watershed if evidence suggests that nutrients from the basin are contributing to downstream water quality problems. Additional reductions may also be required by the forthcoming Chesapeake Bay TMDL, currently under development.

Barring the receipt of contradictory data, this report will be used to support a revision of the nutrients (i.e., phosphorus) listing for the Cabin John watershed, from Category 5 ("waterbody is impaired, does not attain the water quality standard, and a TMDL is required") to Category 2 ("waterbodies meeting some [in this case nutrients-related] water quality standards, and have insufficient data to determine attainment of other standards") when MDE proposes the revision of the Integrated Report.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, listed in the Integrated Report of Surface Water Quality in Maryland (Integrated Report), the State is to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2007).

A segment identified as a WQLS may not require the development and implementation of a TMDL if more recent information invalidates previous findings. The most common scenarios that would eliminate the need for a TMDL are: 1) analysis of more recent data indicating that the impairment no longer exists (i.e., water quality standards are being met); 2) results of more recent and updated water quality modeling which demonstrates that the segment is attaining standards; 3) refinements to water quality standards or to the interpretation of those standards, accompanied by analysis demonstrating that the standards are being met; or 4) identification and correction of errors made in the initial listing.

Cabin John Creek (basin number 02-14-02-07) has been designated a Use I-P waterbody [Code of Maryland Regulations (COMAR) 26.08.02.08O]. The Maryland Department of the Environment (MDE) has identified the non-tidal waters of Cabin John Creek in the State's Integrated Report as impaired by the following: nutrients (1996); sediments (1996); bacteria (2002); and impacts to biological communities (2006). The 1996 nutrients listing was refined in the *2008 Integrated Report of Surface Water Quality in Maryland* and phosphorus was identified as the specific impairing substance. Consequently, for the purpose of this report the terms nutrients and phosphorus will be used interchangeably. The 2008 *Integrated Report* Assessment Unit ID for this listing is: MD-02140207. A TMDL for fecal bacteria was completed in 2006. The listings for sediments, and impacts to biological communities, will be addressed separately at a future date.

This report provides an analysis of recent data that supports the removal of the nutrients (phosphorus) listing for the Cabin John Creek watershed when MDE proposes the revision of the State's Integrated Report. The remainder of this report lays out the general setting of the Cabin John Creek watershed area and presents a discussion of the water quality characteristics in the basin in terms of the existing water quality standards relating to nutrients. This analysis supports the conclusion that the waters of the Cabin John Creek watershed do not display signs of eutrophication or nutrient over-enrichment.

2.0 GENERAL SETTING

Location

The Cabin John Creek watershed is located in southern Montgomery County, Maryland, just northwest of Washington, DC (see Figure 1). The Cabin John Creek watershed encompasses 16,500 acres. The headwaters of Cabin John Creek originate in the City of Rockville. The creek flows south about 10 miles, passing under Interstate 270, through Cabin John Regional Park under the Capital Beltway (I-495), and the historic Cabin John Bridge to its confluence with the Potomac River near the towns of Cabin John and Glen Echo. The watershed is bounded by Rockville Pike (Rte. 355) and Old Georgetown Pike (Rte. 187) to the east and Falls Road (Rte. 189) to the west (Van Ness and Haddaway 1999). The major tributaries of the Creek are Bogley Branch, Booze Creek, Buck Branch, Congressional Branch, Ken Branch, Old Farm Branch, Snakeden Branch and Thomas Branch (also called Beltway Branch).

Geology/Soils

The Cabin John Creek watershed encompasses 16,424 acres (25.7 sq. mi). The watershed lies entirely in the Piedmont physiographic province. This province is characterized by gentle to steep rolling topography, low hills and ridges. The surficial geology is characterized by crystalline igneous and metamorphic rocks of volcanic origin consisting primarily of schist and gneiss.

The Cabin John Creek watershed lies predominantly in the Baile soil series. Soils in this series are fine-loamy, mixed, mesic Typic Ochraquults and are very deep and poorly drained soils (Montgomery County, Maryland Soil Conservation Service, 1995).

The watershed is comprised primarily of B and C type soils with some soil types A and D also present. Soil type is categorized by four hydrologic soil groups developed by the Soil Conservation Service (SCS). The definitions of the groups are as follows:

> Group A: Soils with high infiltration rates, typically deep well-drained to excessively drained sands or gravels.
>
> Group B: Soils with moderate infiltration rates, generally moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
>
> Group C: Soils with slow infiltration rates, mainly soils with a layer that impedes downward water movement or soils with moderately fine to fine texture.
>
> Group D: Soils with very slow infiltration rates, mainly clay soils, soils with a permanently high water table, and shallow soils over nearly impervious material (SCS 1977).

Land Use

The Cabin John watershed contains mostly urban and forest land uses (see Figure 2). The land use distribution in the watershed is approximately 13.6% forest/herbaceous; 86.2% urban; 0.6% agricultural; and 0.2% water (MDP 2002).

Point Sources

There are no municipal or industrial National Pollution Discharge Elimination System (NPDES) or wastewater treatment plants (WWTPs) with permits regulating the discharge of nutrients directly into Cabin John Creek or its tributaries.

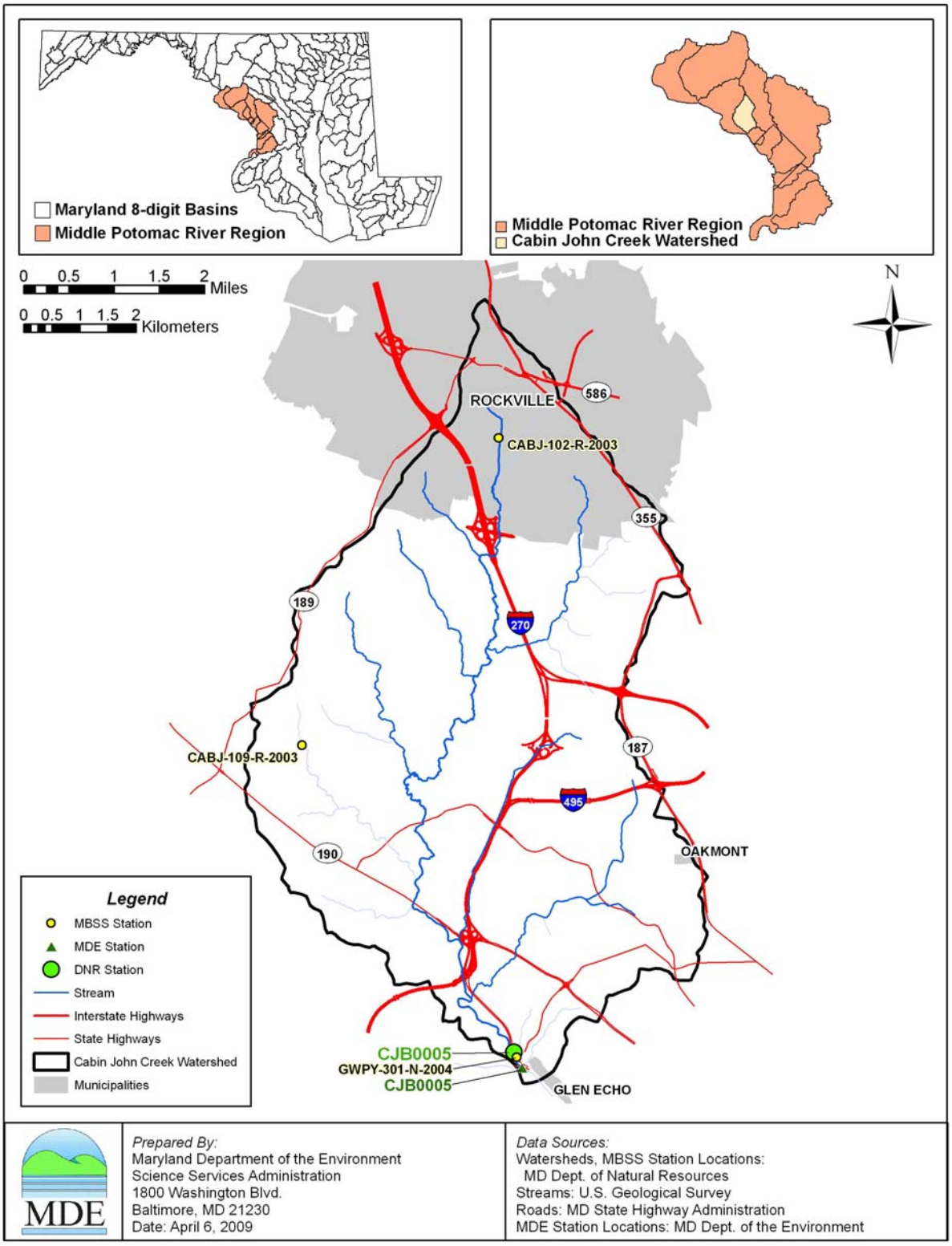

Figure 1: Location Map and Monitoring Stations of the Cabin John Creek Watershed

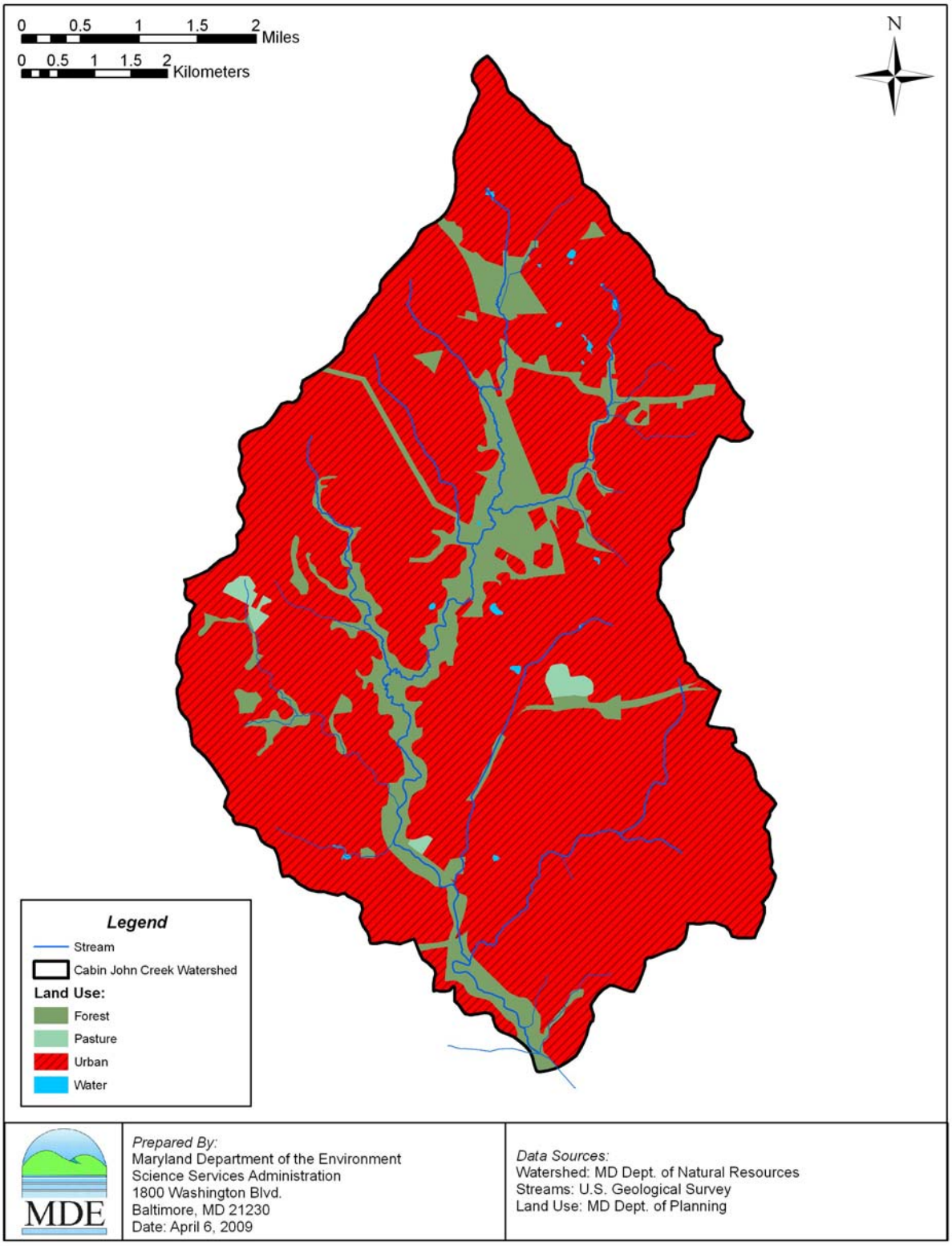

Figure 2: Land Use of the Cabin John Creek Watershed

3.0 WATER QUALITY CHARACTERIZATION

The Maryland Surface Water Use Designation for the Cabin John Creek is Use I-P – *water contact recreation, protection of aquatic life and public water supply* (COMAR 26.08.02.08O). A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include support of aquatic life, primary or secondary contact recreation, drinking water supply, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. The criteria developed to protect the designated use may differ and are dependent on the specific designated use(s) of a waterbody.

Currently, there are no specific numeric criteria for nutrients in Maryland's water quality standards. Therefore, the evaluation of potentially eutrophic conditions due to nutrient over-enrichment will be based on whether nutrient-related parameters (i.e., dissolved oxygen levels and chlorophyll *a* concentrations) are found to impair designated uses in Cabin John Creek. The dissolved oxygen (DO) concentration to protect Use I-P waters "may not be less than 5 milligrams per liter (mg/l) at any time" (COMAR 26.08.02.03-3A(2)). The water quality data presented in this section will show that DO concentrations in the Cabin John and its tributaries meet these criteria, and that Maryland's narrative criteria for chlorophyll *a* are also met.

In addition to the DO and chlorophyll *a* data analysis, the results of a new biological stressor identification (BSID) analysis demonstrate that any biological impairment in the watershed is not caused by nutrient enrichment. Instead, the analysis suggests that the degradation to biological communities in the Cabin John Creek is strongly associated with the extensive urban nature of the watershed, which results in altered hydrology and elevated levels of sulfate, chlorides, and (electrical) conductivity (MDE 2009b).

A data solicitation was conducted in 2005. All readily available water quality data from the past five years have been considered for this analysis. Water quality data from MDE surveys conducted along the Cabin John from October 2000 through October 2003 were used. Maryland Department of Natural Resources (DNR) data used in the analysis were from January 1998 through June 2007. Data from Maryland Biological Stream Survey (MBSS) sampling conducted in June 2003 and August 2004, were also used. Table 1 lists the water quality monitoring stations in the Cabin John Creek watershed with their geographical coordinates. Figures 3 through 6 provide graphical representation of the collected data for the parameters discussed below.

Table 1: Water Quality Stations in Cabin John Creek Watershed Monitored During 1998-2007

Station ID	Agency/Program	Latitude (Decimal-Degrees)	Longitude (Decimal-Degrees)
CJB0005	MDE	38.9734	-77.1488
CJB0005	DNR/CORE	38.9734	-77.1488
CABJ-102-R-2003	DNR/CORE	39.0700	-77.1500
CABJ-109-R-2003	DNR/MBSS	39.0200	-77.1900
GWPY-301-N-2004	DNR/MBSS	38.9700	-77.1400

3.1 Dissolved Oxygen

DNR samples were taken in the Cabin John from January 1998 through June 2007. MDE samples were taken from October 2000 through October 2003, and MBSS samples were taken in June 2003 and August 2004. Samples taken during the growing season (May through October) show DO concentrations ranging from 7.3 to 12.3 mg/l, with no values found below the DO criterion for Use I-P waters of 5 mg/l. The DO data are presented graphically in Figure 3 and in tabular form in Appendix A.

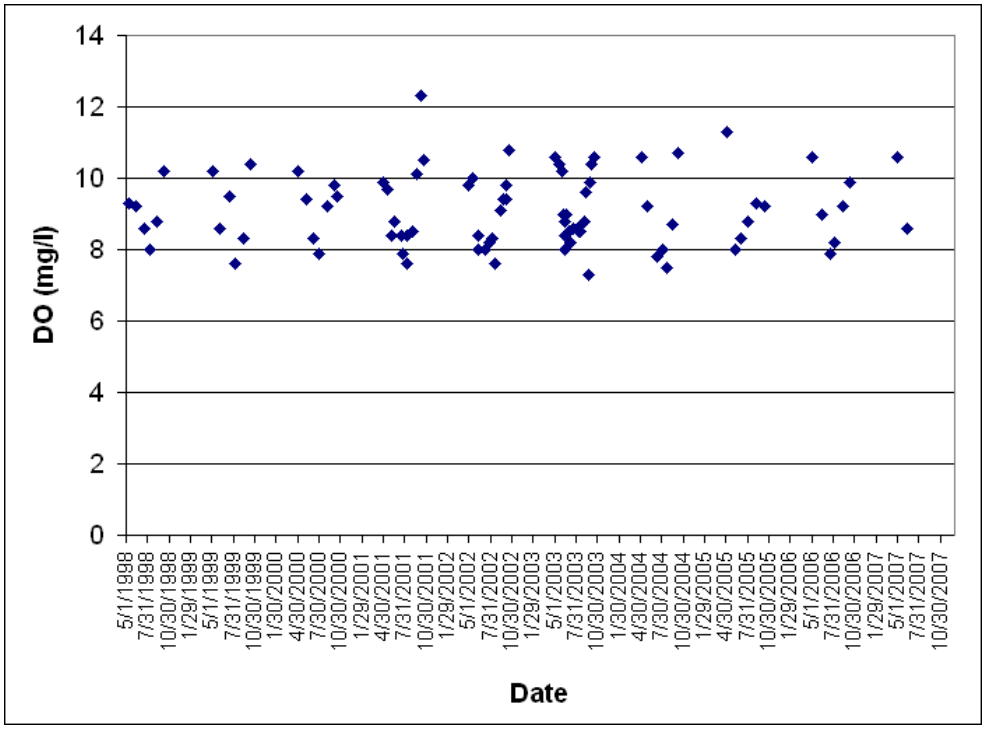

Figure 3: Cabin John Creek Dissolved Oxygen Data for Growing Season Periods May 1998 through October 2007

3.2 Chlorophyll *a*

Currently, Maryland water quality standards do not specify numeric criteria for chlorophyll *a*. However, pollution of waters of the State by any material in amounts sufficient to create a nuisance or interfere with designated uses is prohibited (COMAR 26.08.02.03B(2)). Elevated chlorophyll *a* concentrations, a measure of algal growth, may indicate poor water quality that cannot support a waterbody's designated uses and may constitute a nuisance condition. Nuisance levels of algae can interfere with uses related to recreational activities such as fishing, boating, and aesthetic appreciation. High chlorophyll *a* levels can also present taste, odor, and treatment problems in water supply systems.

Narrative water quality criteria are an important component of the State's water quality standards, but are difficult to incorporate into quantitative water quality or TMDL analyses. In the case of free-flowing non-tidal waters, there is an insufficient understanding of the relationship between chlorophyll *a* concentrations and the waterbody's designated use impairment. However, the Code of Maryland Regulations (COMAR) includes narrative criteria for acceptable chlorophyll *a* levels in tidal waters. Maryland's numeric interpretation of these criteria for application in estuarine waters, adapted from previously approved nutrient TMDLs, is as follows:

> The chlorophyll *a* concentration goal used by the State in estuarine TMDL analyses is based on guidelines set forth by Thomann and Mueller (1987) and by the EPA Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2, Part 1 (1997). The chlorophyll *a* narrative criterion (COMAR 26.08.02.03-3C(10)) states: "Chlorophyll *a* - Concentrations of chlorophyll *a* in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in ecologically undesirable consequences that would render tidal waters unsuitable for designated uses." The Thomann and Mueller guidelines acknowledge that "'Undesirable levels of phytoplankton [chlorophyll *a*] vary considerably depending on water body." MDE has determined, per Thomann and Mueller, that it is acceptable to maintain chlorophyll *a* concentrations below a maximum of 100 µg/L, and to target, with some flexibility depending on waterbody characteristics, a 30-day rolling average of approximately 50 µg/L (with some flexibility depending on waterbody characteristics). (MDE 2006)

Maryland has also developed guidelines for application of the narrative criteria in drinking water reservoirs. The guidelines, adapted from previously approved TMDLs, are as follows:

> The chlorophyll *a* endpoints selected for public water supply reservoirs are (a) a ninetieth-percentile instantaneous concentration not to exceed 30 µg/l in the surface layers, and (b) a 30-day moving average concentration not to exceed 10 µg/l in the surface layers. The concentration of10 µg/l corresponds to a score of approximately 53 on the Carlson's Trophic State Index (TSI). This is at the boundary of mesotrophic and eutrophic conditions, which is an appropriate trophic state at which to manage these reservoirs. Mean chlorophyll *a* concentrations exceeding 10 µg/l are associated with peaks exceeding 30 µg/l, which in turn are associated with a shift to blue-green assemblages, which present taste, odor and treatment problems (Walker 1984). Achieving these chlorophyll *a* endpoints should thus safeguard such reservoirs from nuisance algal blooms. (MDE 2008b)

Using the chlorophyll *a* targets for tidal waters and public water supply reservoirs described above as screening values for non-tidal waters, the following data analysis reflects an absence of excessive algal growth in the Cabin John Creek, as indicated by low chlorophyll *a* concentrations in comparison with those values.

DNR and MDE monitoring data in Cabin John Creek show growing season (May through October) average of 1.97 µg/l. These samples show observed chlorophyll *a* concentrations ranging from 0.25 to 9.87 µg/l, with no values greater than 10 µg/l. These monitoring data values suggest that chlorophyll *a* concentrations are not causing any nuisance in the Cabin John Creek watershed or interfering with its designated uses.

The chlorophyll *a* data are presented graphically in Figure 4 and in tabular form in Appendix A.

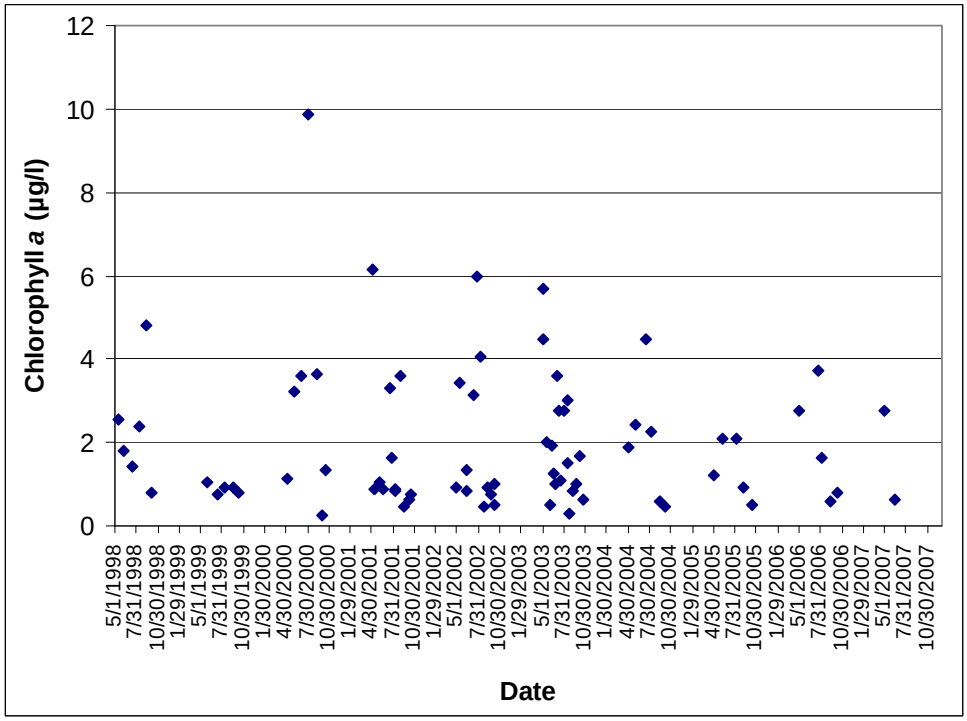

Figure 4: Cabin John Creek Chlorophyll *a* Data for Growing Season Periods May 1998 through October 2007

3.3 Nutrients

In the absence of State water quality standards with specific numeric limits for nutrients, evaluation of potentially eutrophic conditions is based on whether nutrient-related parameters (i.e., dissolved oxygen levels and chlorophyll *a* concentrations) are found to impair the designated uses in the Cabin John Creek watershed (in this case water contact recreation, protection of aquatic life, and public water supply). Consequently, the nutrients data presented in this section are for informational purposes only.

Total nitrogen (TN) and total phosphorus (TP) data for the Cabin John Creek have been collected as part of this study and the results are presented here for informational purposes, graphically in Figures 5 and 6, and in tabular form in Appendix A. In general, DNR, MDE, and MBSS data show TN concentrations during the growing season (May through October) ranging from 0.21 to 3.47 mg/l and TP concentrations ranging from 0.006 to 0.103 mg/l.

In the absence of specific numeric criteria to assess the TP and TN monitoring data results, MDE evaluated these results using its BSID methodology, which compared Cabin John Creek parameters to the results from similar control sites (i.e., watersheds with no biological impairments) and concluded that nutrients are not likely stressors associated with the degraded biological conditions (MDE 2009b). Current DO conditions in Cabin John Creek further support this conclusion.

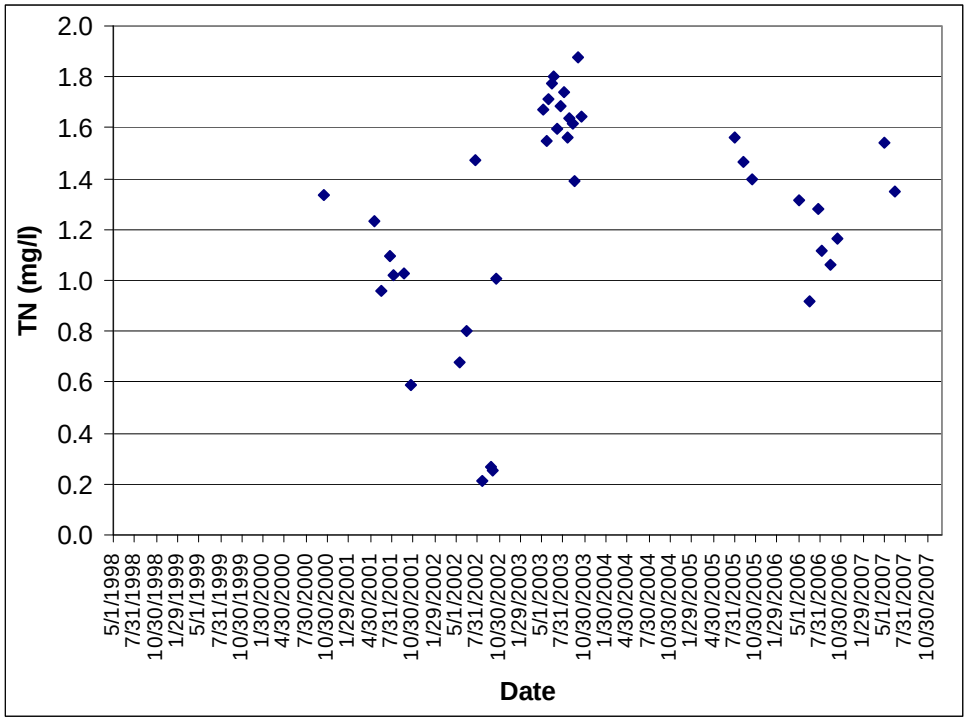

Figure 5: Cabin John Creek Total Nitrogen Data from May 1998 through October 2007

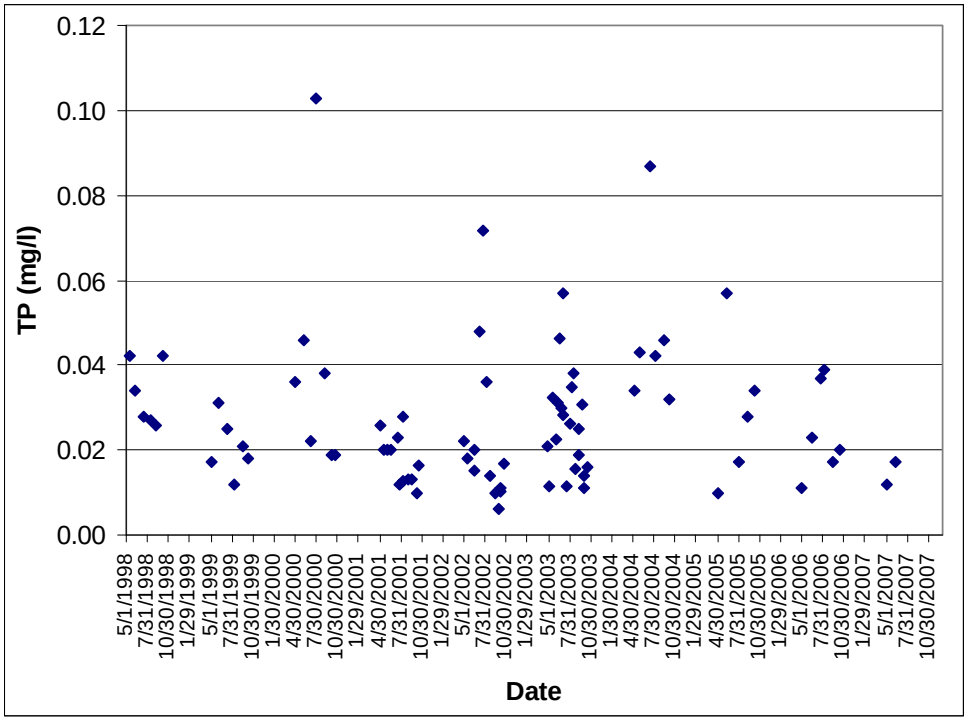

Figure 6: Cabin John Creek Total Phosphorus Data from May 1998 through October 2007

3.4 Biological Stressor Identification Analysis

In the process of evaluating the existing biological impairments, MDE developed a biological stressor identification (BSID) methodology (MDE 2009a). The BSID methodology uses data available from the statewide DNR MBSS. These data are presented in Appendix A. The current MDE biological assessment methodology is a three-step process: (1) a data quality review, (2) a systematic vetting of the dataset, and (3) a watershed assessment that presents the results of this assignment in terms of currently used Integrated Report listing categories.

The BSID analysis for the Cabin John Creek watershed did not identify nutrients as potential stressors or indicate any significant association between current nutrient levels and the degraded biological conditions (MDE 2009b). According to this report, nutrients are not causing any impairment to aquatic life or biological communities in Cabin John Creek. The BSID analysis results suggest rather that biological degradation in Cabin John Creek is strongly associated with the extensive urban nature of the watershed, which has resulted in altered hydrology and elevated levels of sulfate, chlorides, and (electrical) conductivity. As explained in the BSID report, urbanization of landscapes generates broad and inter-related forms of degradation (i.e., hydrological, morphological, and water chemistry) that can affect stream ecology and biological composition. Scientific literature has established a link between highly urbanized landscapes and degradation in the aquatic health of non-tidal stream ecosystems.

4.0 CONCLUSION

Based on the analysis of data presented in the preceding section of this report, indicating that DO and chlorophyll *a* concentrations are meeting water quality criteria, and on the results of the Cabin John Creek BSID analysis, MDE concludes that currently the Cabin John watershed is not being impaired by nutrients. (The BSID analysis for the Cabin John Creek watershed indicates inorganic pollutants and flow/sediment stressors are associated with impacts to biological communities; these findings will be addressed separately.) Barring the receipt of contradictory data, this report will be used to support a revision of the phosphorus listing for the Cabin John Creek watershed, from Category 5 ("waterbody is impaired, does not attain the water quality standard, and a TMDL is required") to Category 2 ("waterbodies meeting some [in this case nutrients-related] water quality standards, and have insufficient data to determine attainment of other standards"), when MDE proposes the revision of Maryland's Integrated Report.

Although the waters of Cabin John Creek do not display signs of eutrophication, the State reserves the right to require future controls if evidence suggests that nutrients from the basin are contributing to downstream water quality problems. Reductions may also be required by the forthcoming Chesapeake Bay TMDL, currently under development and due to be established by EPA by the end of 2010.

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Appendix A – Tabular Water Quality Data

Table A-1: MDE Water Quality Data

Station	Sampling Date	DO (mg/l)	Chlorophyll *a* (µg/l)	TN (mg/l)	TP (mg/l)
CJB0005	10/18/2000	9.5	1.35	1.33	0.019
CJB0005	11/16/2000	12.8		0.59	0.048
CJB0005	12/6/2000	14.1		1.17	0.018
CJB0005	1/10/2001	13.5		2.64	0.039
CJB0005	2/7/2001	13.8	2.39	1.66	0.038
CJB0005	3/21/2001	13.1	140.8	2.6	0.239
CJB0005	4/18/2001	10.5	26.61	1.32	0.073
CJB0005	5/16/2001	9.7	0.90	1.24	0.020
CJB0005	6/20/2001	8.8	0.9	0.96	0.020
CJB0005	7/25/2001	7.9	1.64	1.10	0.012
CJB0005	8/8/2001	7.6	0.90	1.02	0.013
CJB0005	9/19/2001	10.1	0.45	1.03	0.013
CJB0005	10/18/2001	10.5	0.75	0.59	0.016
CJB0005	11/7/2001	11.9	0.60	0.45	0.0018
CJB0005	12/19/2001	13.0	0.60	0.72	0.012
CJB0005	1/24/2002	12.0	2.39	1.57	0.017
CJB0005	2/21/2002	12.3	2.39	1.03	0.007
CJB0005	3/21/2002	11.9	3.74	1.07	0.040
CJB0005	4/18/2002	8.1	2.84	0.58	0.012
CJB0005	5/16/2002	10.0	3.44	0.68	0.018
CJB0005	6/12/2002	8.0	1.35	0.80	0.015
CJB0005	7/25/2002	8.2	5.98	1.47	0.072
CJB0005	8/21/2002	7.6	0.45	0.21	0.014
CJB0005	9/25/2002	9.4	0.75	0.27	0.006
CJB0005	10/7/2002	9.4	0.50	0.25	0.010
CJB0005	10/21/2002	10.8		1.01	0.017
CJB0005	11/6/2002	10.2	1.50	1.42	0.133
CJB0005	11/18/2002	11.6	1.00	0.95	0.085
CJB0005	12/2/2002	13.5		1.51	0.013
CJB0005	12/16/2002	12.2		1.61	0.034
CJB0005	1/6/2003	13.1	1.07	1.73	0.025
CJB0005	1/21/2003	14.0		2.10	0.011
CJB0005	2/3/2003	14.5	4.06	2.15	0.022
CJB0005	3/3/2003	12.9	1.25	1.97	0.045
CJB0005	3/17/2003	11.7	5.48	1.56	0.017
CJB0005	4/21/2003	12.2	4.49	1.28	0.011
CJB0005	5/5/2003	10.6	4.49	1.67	0.011
CJB0005	5/19/2003	10.4	1.99	1.55	0.032
CJB0005	6/2/2003	10.2	0.50	1.71	0.023
CJB0005	6/16/2003	8.8	1.25	1.77	0.046
CJB0005	6/23/2003	9.0	1.00	1.80	0.030
CJB0005	7/7/2003	8.2	2.74	1.59	0.028
CJB0005	7/21/2003	8.6	1.07	1.68	0.012
CJB0005	8/4/2003	8.6	2.74	1.74	0.026
CJB0005	8/18/2003	8.5	2.99	1.56	0.038
CJB0005	8/25/2003	8.7	0.30	1.63	0.016
CJB0005	9/8/2003	8.8		1.62	0.019

Station	Sampling Date	DO (mg/l)	Chlorophyll *a* (µg/l)	TN (mg/l)	TP (mg/l)
CJB0005	9/22/2003	7.3	1.00	1.39	0.031
CJB0005	10/6/2003	10.4	1.68	1.88	0.011
CJB0005	10/20/2003	10.6	0.64	1.65	0.016

Table A-2: DNR Water Quality Data

Station	Sampling Date	DO (mg/l)	Chlorophyll *a* (µg/l)	TN (mg/l)	TP (mg/l)
CJB0005	1/21/1998	14.0	0.97		0.016
CJB0005	2/4/1998	12.1	11.36		0.139
CJB0005	3/4/1998	12.3	2.09		0.042
CJB0005	4/1/1998	9.6	2.31		0.010
CJB0005	5/13/1998	9.3	2.56		0.042
CJB0005	6/10/1998	9.2	1.78		0.034
CJB0005	7/15/1998	8.6	1.43		0.028
CJB0005	8/12/1998	8.0	2.39		0.027
CJB0005	9/9/1998	8.8	4.82		0.026
CJB0005	10/7/1998	10.2	0.80		0.042
CJB0005	11/12/1998	10.9	3.16		0.053
CJB0005	12/10/1998	13.1	5.08		0.018
CJB0005	3/11/1999	14.1	7.48		0.014
CJB0005	4/7/1999	12.0	5.98		0.013
CJB0005	5/5/1999	10.2			0.017
CJB0005	6/2/1999	8.6	1.05		0.031
CJB0005	7/14/1999	9.5	0.75		0.025
CJB0005	8/11/1999	7.6	0.93		0.012
CJB0005	9/15/1999	8.3	0.93		0.021
CJB0005	10/13/1999	10.4	0.80		0.018
CJB0005	11/9/1999	13.0	0.63		0.016
CJB0005	12/1/1999	13.7	0.52		0.010
CJB0005	1/12/2000	12.6	2.09		0.020
CJB0005	2/9/2000	14.7	1.05		0.019
CJB0005	3/8/2000	13.8	2.99		0.025
CJB0005	4/5/2000	11.8	3.69		0.038
CJB0005	5/3/2000	10.2	1.12		0.036
CJB0005	6/7/2000	9.4	3.21		0.046
CJB0005	7/6/2000	8.3	3.59		0.022
CJB0005	8/2/2000	7.9	9.87		0.103
CJB0005	9/6/2000	9.2	3.63		0.038
CJB0005	10/4/2000	9.8	0.25		0.019
CJB0005	11/1/2000	13.0	0.78		0.013
CJB0005	12/6/2000	14.7			0.011
CJB0005	1/3/2001	13.5			0.020
CJB0005	2/7/2001	13.7	3.20		0.030
CJB0005	3/14/2001	12.2	10.91		0.028
CJB0005	4/11/2001	10.4	50.46		0.291
CJB0005	5/2/2001	9.9	6.13		0.026
CJB0005	6/6/2001	8.4	1.05		0.020
CJB0005	7/18/2001	8.4	3.29		0.023
CJB0005	8/8/2001	8.4	0.85		0.028

Station	Sampling Date	DO (mg/l)	Chlorophyll *a* (µg/l)	TN (mg/l)	TP (mg/l)
CJB0005	9/5/2001	8.5	3.59		0.013
CJB0005	10/10/2001	12.3	0.62		0.010
CJB0005	11/7/2001	13.3	0.78		0.018
CJB0005	12/5/2001	12.8	1.25		0.018
CJB0005	1/2/2002	14.7	0.30		0.010
CJB0005	2/6/2002	15.7	1.20		0.012
CJB0005	3/6/2002	13.2	2.24		0.024
CJB0005	4/3/2002	11.4	3.92		0.010
CJB0005	5/1/2002	9.8	0.90		0.022
CJB0005	6/12/2002	8.4	0.85		0.020
CJB0005	7/10/2002	8.0	3.14		0.048
CJB0005	8/7/2002	8.3	4.04		0.036
CJB0005	9/11/2002	9.1	0.93		0.010
CJB0005	10/9/2002	9.8	1.00		0.011
CJB0005	11/6/2002	10.9	1.87		0.126
CJB0005	12/4/2002	14.5			0.027
CJB0005	1/8/2003	12.7	0.53		0.018
CJB0005	2/5/2003	14.0	5.08		0.039
CJB0005	3/5/2003	12.1	1.09		0.016
CJB0005	4/2/2003	12.2	4.49		0.016
CJB0005	5/1/2003	10.6	5.68		0.021
CJB0005	6/11/2003	9.0	1.94		0.031
CJB0005	7/2/2003	8.5	3.59		0.057
CJB0005	8/13/2003	8.5	1.50		0.035
CJB0005	9/10/2003	9.6	0.85		0.025
CJB0005	10/1/2003	9.9			0.014
CJB0005	11/12/2003	10.3	5.61		0.159
CJB0005	12/10/2003	12.4	0.75		0.032
CJB0005	1/7/2004	13.7	1.94		0.022
CJB0005	2/11/2004	12.3	2.43		0.035
CJB0005	3/10/2004	12.8	2.74		0.017
CJB0005	4/7/2004	12.0	3.41		0.010
CJB0005	5/5/2004	10.6	1.87		0.034
CJB0005	6/2/2004	9.2	2.43		0.043
CJB0005	7/14/2004	7.8	4.49		0.087
CJB0005	8/4/2004	8.0	2.24		0.042
CJB0005	9/15/2004	8.7	0.60		0.046
CJB0005	10/6/2004	10.7	0.45		0.032
CJB0005	11/3/2004	10.8	0.60		0.015
CJB0005	12/1/2004	10.5	5.98		0.109
CJB0005	1/5/2005	10.8	6.28		0.057
CJB0005	2/9/2005	12.4	4.88		0.024
CJB0005	3/9/2005	13.4	8.72		0.034
CJB0005	4/13/2005	11.7	1.57		0.010
CJB0005	5/4/2005	11.3	1.20		0.010
CJB0005	6/8/2005	8.0	2.09		0.057
CJB0005	7/6/2005	8.3			
CJB0005	8/3/2005	8.8	2.09	1.56	0.017
CJB0005	9/7/2005	9.3	0.91	1.46	0.028
CJB0005	10/12/2005	9.2	0.50	1.40	0.034
CJB0005	11/9/2005	10.7	0.80	1.26	0.029
CJB0005	12/7/2005	13.9	0.64	1.58	0.026

Station	Sampling Date	DO (mg/l)	Chlorophyll *a* (µg/l)	TN (mg/l)	TP (mg/l)
CJB0005	1/4/2006	12.5	2.80	1.56	0.031
CJB0005	2/1/2006	14.3	4.27	1.59	0.049
CJB0005	3/1/2006	14.4	3.14	1.82	0.011
CJB0005	4/12/2006	11.2	3.42	1.14	0.021
CJB0005	5/3/2006	10.6	2.76	1.31	0.011
CJB0005	6/14/2006	9.0		0.92	0.023
CJB0005	7/20/2006	7.9	3.74	1.28	0.037
CJB0005	8/9/2006	8.2	1.64	1.12	0.039
CJB0005	9/13/2006	9.2	0.60	1.06	0.017
CJB0005	10/11/2006	9.9	0.80	1.17	0.020
CJB0005	11/8/2006	10.0	4.49	1.35	0.196
CJB0005	12/6/2006	14.2		1.69	0.007
CJB0005	1/3/2007	12.7	2.39	1.39	0.015
CJB0005	2/7/2007	13.6	4.78	2.33	0.010
CJB0005	3/7/2007	13.9	1.05	1.75	0.010
CJB0005	4/4/2007	10.2	6.88	2.03	0.016
CJB0005	5/2/2007	10.6	2.78	1.54	0.012
CJB0005	6/13/2007	8.6	0.62	1.35	0.017

Table A-3: MBSS Water Quality Data

Station	Stream	Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
CABJ-102-R-2003	Cabin John Creek	6/17/2003	8.0	3.47	0.035
CABJ-109-R-2003	Cabin John Creek UT1	6/17/2003	8.4	0.59	0.016
GWPY-301-N-2004	Cabin John Creek	8/24/2004	7.5	1.63	0.017