Water Quality Analysis of Cadmium in Lower North Branch Potomac River, Allegany County, Maryland

FINAL

DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard, Suite 540
Baltimore MD 21230-1718

Submitted to:

Watershed Protection Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

July 2006

EPA Submittal: July 14, 2006
EPA Approval: August 16, 2006

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ANOVA	Analysis of Variance
Cd	Cadmium
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DNR	Maryland Department of Natural Resources
EPA	Environmental Protection Agency
HAC	Hardness Adjusted Criteria
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mg/l	Milligrams per Liter
NRCS	National Resource Conservation Service
SCS	Soil Conservation Service
SD	Significant Difference
SHA	State Highway Administration
SQG	Sediment Quality Guideline
STATSGO	State Soil Geographic
TMDL	Total Maximum Daily Load
UMCES	University of Maryland Center for Environmental Sciences
USGS	United States Geological Survey
WQA	Water Quality Analysis
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. This list of impaired waters is commonly referred to as the "303(d) list". For each WQLS, the State is to either establish a Total Maximum Daily Load (TMDL) for the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met.

Lower North Branch Potomac River (basin code 02141001), located in Allegany County, Maryland, was identified on the State's list of WQLSs as impaired by cadmium (Cd) (1996 listing), sediments (1996 listing), nutrients (1996 listing), low pH (1996 listing), fecal coliform (2002) and impacts to biological communities (2002 listing). The information used for listing Cd is suspect due in part to sampling and analysis methods available at the time, and assessment inconsistencies that led to the listing in 1996.

This report provides an analysis of recent monitoring data, which shows that the aquatic life criteria and designated uses associated with Cd are being met in the Lower North Branch Potomac River watershed, and that the 303(d) impairment listings associated with Cd are not supported by the analyses contained herein. The analyses support the conclusion that a TMDL for Cd is not necessary to achieve water quality standards. Barring the receipt of contradictory data, this report will be used to support a Cd listing change for the Lower North Branch Potomac River from Category 5 ("waterbodies impaired by one or more pollutants requiring a TMDL") to Category 2 ("Surface waters that are meeting some standards and have insufficient information to determine attainment of other standards"), when the Maryland Department of the Environment (MDE) proposes the revision of Maryland's 303(d) list for public review in the future. The listings for sediments, nutrients, low pH, fecal coliform and impacts to biological communities will be addressed separately at a future date.

Although the waters of the Lower North Branch Potomac River watershed do not display signs of toxic impairments due to Cd, the State reserves the right to require additional pollution controls in the Lower North Branch Potomac River watershed if evidence suggests that Cd from the basin is contributing to downstream water quality problems.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and U.S. Environmental Protection Agency (EPA)'s 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. This list of impaired waters is commonly referred to as the "303(d) list". For each WQLS, the State is to either establish a Total Maximum Daily Load (TMDL) for the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met.

A segment identified as a WQLS may not require the development and implementation of a TMDL if current information contradicts the previous finding of impairment. The most common factual scenarios obviating the need for a TMDL are as follows: 1) more recent data indicating that the impairment no longer exists (i.e., water quality criteria are being met); 2) more recent and updated water quality modeling demonstrates that the segment is now attaining criteria; 3) refinements to water quality criteria or the interpretation of standards, which result in standards being met; or 4) correction to errors made in the initial listing.

Lower North Branch Potomac River (basin code 02141001) was identified on the State's list of WQLSs as impaired by cadmium (Cd) (1996 listing), sediments (1996 listing), nutrients (1996 listing), low pH (1996 listing), fecal coliform (2002 listing) and impacts to biological communities (2002 listing).

In 2001, former Maryland Department of the Environment (MDE) Water Quality Standards section head, Paul Jiapizian, provided documentation summarizing the basis for the Cd listing. An analysis of historical water quality data demonstrated that mean levels of Cd exceeded both the EPA acute and chronic aquatic life criteria for CN at the time of listing (1996). Although criteria were "exceeded", there were several methodological flaws in the monitoring and listing assessment applied in 1996. First, unfiltered (total metals) samples were compared to dissolved metals criteria. Second, current criteria for Cd rely on a hardness correction – since no hardness data existed, criteria thresholds using a 100 mg/l "default" hardness value were used for the assessment. Finally, station means for each analyte were calculated setting non-detects at half the detection limit. While this procedure may have been appropriately conservative at the time, the sensitivity of analytical instrumentation has improved dramatically, and samples taken currently for Cd have appropriate detection limits that are well below their respective criteria values.

A Water Quality Analysis (WQA) of Cd for Lower North Branch Potomac River was conducted by MDE using recent water column chemistry data and sediment toxicity data to determine if an impairment currently exists. The listings for sediments, nutrients, low pH, fecal coliform and impacts to biological communities will be addressed separately at a future date.

The remainder of this report lays out the general setting of the waterbody within the Lower North Branch Potomac River watershed, presents a discussion of the water quality characterization process, and provides conclusions with regard to the characterization.

2.0 GENERAL SETTING

Location

The North Branch of the Potomac River forms the border between Maryland and West Virginia from its origin at the Fairfax Stone downstream to its confluence with the South Branch of the Potomac. The Lower North Branch of the Potomac River is defined as the reach between its confluence with the Savage River and the South Branch of the Potomac River (Figure 1). Wills Creek flows through the town of Cumberland discharging into the Lower North Branch. The drainage area of the Lower North Branch Potomac River watershed is 73,144 acres.

Geology/Soils

The Lower North Branch Potomac River watershed is situated within the Ridge and Valley Provinces in western Maryland. The surficial geology of the Ridge and Valley Provinces is characterized by strongly folded and faulted sedimentary rock, producing a rugged surface terrain. Folding has produced elongated arches across the region which expose Devonian rock at the surface. The topography in the watershed is often steep and deeply carved by winding streams, with elevations ranging up to 2,800 feet.

The Lower North Branch Potomac River watershed is comprised of several different soil series including the Ernest and Allegheny series. The Ernest soil series consists of deep, moderately well-drained, loamy soils. These nearly level to moderately steep soils formed in materials that accumulated at the base of the steeper slopes. Ernest soils have moderately slow permeability and a moderate available moisture capacity. The Allegheny soil series consists of deep, well-drained, loamy soils that formed in old sediments deposited by streams. These gently soils are on high bottoms and terraces along rivers. Some of the terraces are several hundred feet above the streams. Allegheny soils have moderate permeability and moderate available moisture capacity (Natural Resources Conservation Service (NRCS), 1977).

Land use

The land use in the Lower North Branch Potomac River watershed is predominantly forest. There are 54,057 (75.0%) acres of park and forest lands evenly dispersed throughout the watershed. The watershed contains 7,305 acres (10.1%) of residential land use and 2,352 acres (3.3%) of commercial land use. The only major community is the City of Cumberland. Crops and pasture land uses are dispersed through out the watershed, constituting 4,902 acres (6.8%) and 3,462 acres (4.8%), respectively. The land use distribution is based on 2002 Maryland Department of Planning (MDP) land use/land cover data. The Lower North Branch Potomac River land use coverage is displayed in Figure 2.

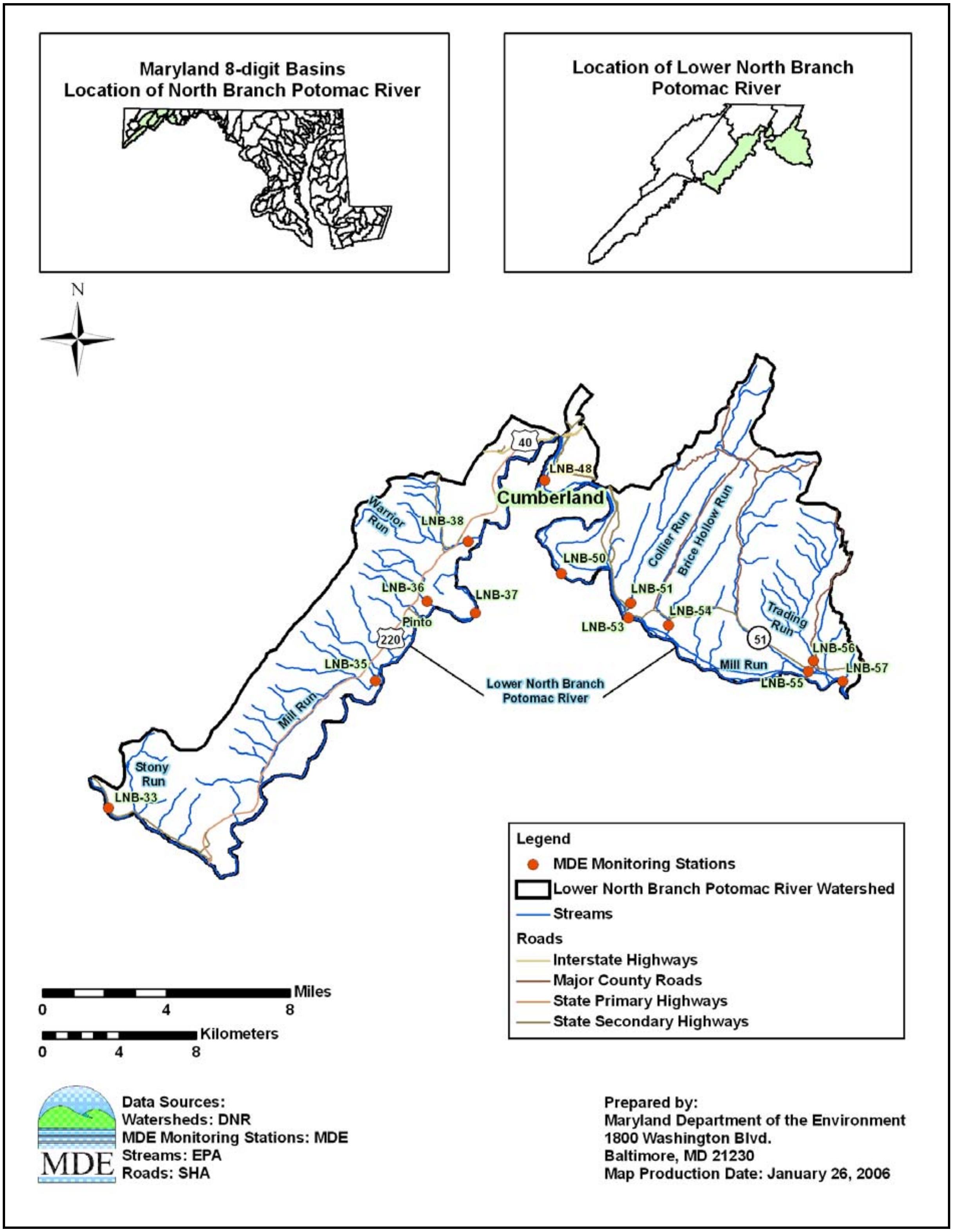

Figure 1: Location Map of the Lower North Branch Potomac River Watershed

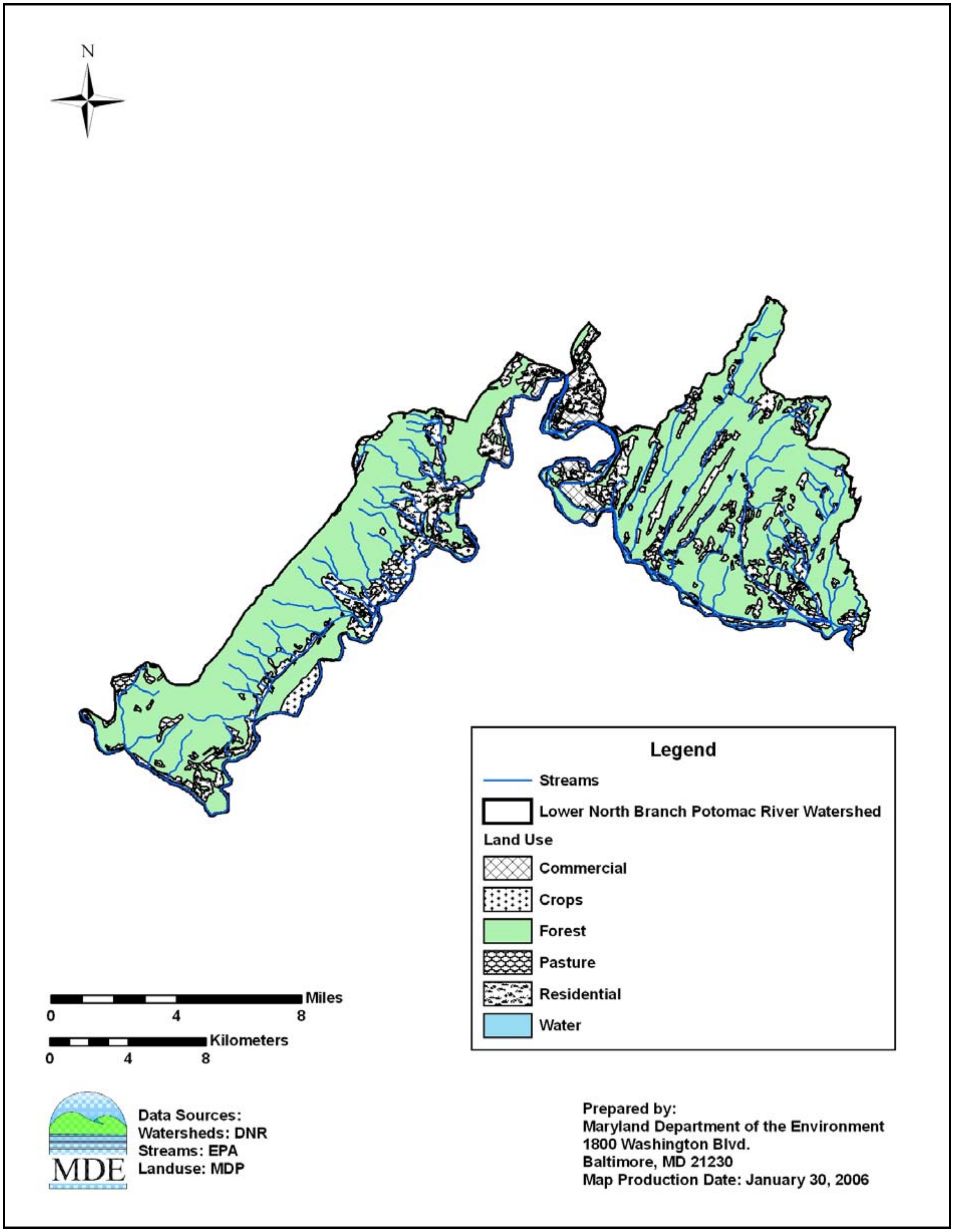

Figure 2: Land Use Map of the Lower North Branch Potomac River Watershed

3.0 WATER QUALITY CHARACTERIZATION

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 different designated uses may differ and are dependent on the specific designated use(s) of a waterbody. Maryland's water quality standards presently include numeric criteria for metals and other toxic substances based on the need to protect aquatic life, wildlife and human health. Water quality standards for toxic substances also address sediment quality to ensure the bottom sediment of a waterbody is capable of supporting aquatic life, thus protecting the designated uses.

The Maryland Surface Water Use Designation for the Lower North Branch Potomac River (mainstem) is Use I-P, , *Water Contact Recreation and Protection of Nontidal Warmwater Aquatic Life and Public Water Supply* (Code of Maryland Regulations (COMAR) 26.08.02.08 (R)(1)). All other tributaries of the Lower North Branch Potomac River are designated Use III-P, *Nontidal Cold Water and Public Water Supply* (COMAR 26.08.02.08 (R)(4)). The aquatic life and human health criteria for Cd, which protect these uses, are displayed below in Table 1 (COMAR 26.08.02.03-2G).

Table 1: Numeric Water Quality Criteria

Criteria	**Freshwater Aquatic Life* Acute (µg/l)**	**Freshwater Aquatic Life* Chronic (µg/l)**	**Human Health (Water + Organism) (µg/l) (10^{-5} risk level)**	**Human Health (Organism) (µg/l) (10^{-5} risk level)**
Cd	2	0.25	5	-

*Aquatic Life Criteria based on default hardness of 100 mg/l

Water column surveys, used to support this WQA, were conducted by the University of Maryland Center for Environmental Sciences (UMCES) - Appalachian Laboratory at 13 stations throughout the Lower North Branch Potomac River watershed in October 2004 and May 2005. Sediment bulk samples were collected at four stations, LNB-33, LNB-37, LNB-53 and LNB-57. Sediment samples were analyzed for toxicity using a standard EPA freshwater 10-day amphipod test. Table 2 shows the list of stations with their geographical coordinates (See Figure 1 for locations).

Table 2: Sample Stations for the Lower North Branch Potomac River

Station	Latitude	Longitude	Station Description
LNB-33	39.470	-79.034	North Branch Potomac River upstream of Stony Run
LNB-35	39.534	-78.875	Mill Run
LNB-36	39.571	-78.842	Unnamed Tributary to North Branch Potomac River at Pinto
LNB-37	39.566	-78.815	North Branch Potomac River downstream of Pinto
LNB-38	39.602	-78.819	Warrior Run
LNB-48	39.628	-78.774	North Branch Potomac River upstream of Cumberland
LNB-50	39.585	-78.761	North Branch Potomac River downstream of Cumberland
LNB-51	39.571	-78.721	Collier Run
LNB-53	39.566	-78.721	North Branch Potomac River near confluence of Collier Run
LNB-54	39.561	-78.698	Brice Hollow Run
LNB-55	39.542	-78.611	Mill Run
LNB-56	39.546	-78.608	Trading Run
LNB-57	39.536	-78.591	North Branch Potomac River downstream of Trading Run

For the water column evaluation, a comparison is made between Cd dissolved water column concentrations and the freshwater aquatic life chronic criterion, the most stringent of the numeric water quality criteria for Cd. Water hardness concentrations were obtained for each station to adjust the freshwater aquatic life criteria that were listed based on a default hardness of 100 mg/l.

MDE calculates freshwater aquatic life criteria as a function of a hardness adjustment formula for metals, where toxicity is a function of total hardness. According to EPA's National Recommended Water Quality Criteria (EPA, November 2002), allowable hardness values must fall within the range of 25 - 400 mg/l. When the measured hardness exceeds 400 mg/l, MDE will use this value as an upper limit when calculating the hardness adjusted criteria (HAC). EPA's Office of Research and Development does not recommend a lower limit on hardness for adjusting criterion (EPA, July 2002). A lower limit may result in criteria that are less protective of the water quality standard. In analyses where available hardness data indicates a value below 25 mg/l, MDE may perform additional analyses to insure data quality objectives for the assessments were met. When data are of questionable quality, MDE will take additional samples to establish the validity of the initial assessment.

The HAC equation for metals is as follows (EPA, November 2002):

$$HAC = e^{(m[\ln (Hardness(mg/l))]+b)} * CF$$

Where,
HAC = Hardness Adjusted Criteria (µg/l)
m = slope
b = y intercept
CF = Conversion Factor (conversion from totals to dissolved numeric criteria)

The chronic HAC parameters for Cd are presented in Table 3 (EPA, November 2002).

Table 3: HAC Parameters (Freshwater Aquatic Life Chronic Criteria)

Chemical	Slope (m)	y Intercept (b)	Conversion Factor (CF)
Cd	0.7409	-4.719	1.102 - ln(hardness)*0.0418

The water column evaluation and sediment quality evaluation are presented in Section 3.1 and 3.2, respectively.

3.1 Water Column Evaluation

MDE conducted a data solicitation for metals and considered all readily available data from the past five years in the WQA. The water column data are presented in Table 4 for each station and evaluated using the freshwater aquatic life chronic criteria (Morgan, 2005). Table 4 displays hardness (mg/l), dissolved Cd sample concentrations (µg/l) and Cd criteria (µg/l). The water column data are also displayed in Figure 3.

Table 4: Lower North Branch Potomac River Water Column Data (Cd)

Station	Date	Hardness (mg/l)	Cd Concentration (µg/l)	Cd Criteria* (µg/l)
LNB-33	Oct-04	219.6	< 0.038	0.42
	May-05	158.3	0.088	0.34
LNB-35	Oct-04	84.8	< 0.038	0.22
	May-05	46.0	< 0.038	0.14
LNB-36	Oct-04	77.6	< 0.038	0.21
	May-05	75.6	< 0.038	0.20
LNB-37	Oct-04	217.6	< 0.038	0.42
	May-05	159.4	0.059	0.34
LNB-38	Oct-04	165.5	< 0.038	0.35
	May-05	83.8	< 0.038	0.22
LNB-48	Oct-04	214.5	< 0.038	0.42
	May-05	143.0	< 0.038	0.32
LNB-50	Oct-04	205.3	0.109	0.41
	May-05	144.0	< 0.038	0.32
LNB-51	Oct-04	86.8	< 0.038	0.22
	May-05	61.3	< 0.038	0.18
LNB-53	Oct-04	201.2	< 0.038	0.40
	May-05	146.1	< 0.038	0.32
LNB-54	Oct-04	93.0	< 0.038	0.23
	May-05	72.5	< 0.038	0.20
LNB-55	Oct-04	98.1	< 0.038	0.24
	May-05	77.6	< 0.038	0.21
LNB-56	Oct-04	114.4	< 0.038	0.27
	May-05	96.0	< 0.038	0.24
LNB-57	Oct-04	193.1	< 0.038	0.39
	May-05	135.9	< 0.038	0.30

*Freshwater Aquatic Life Hardness Adjusted Chronic Criterion

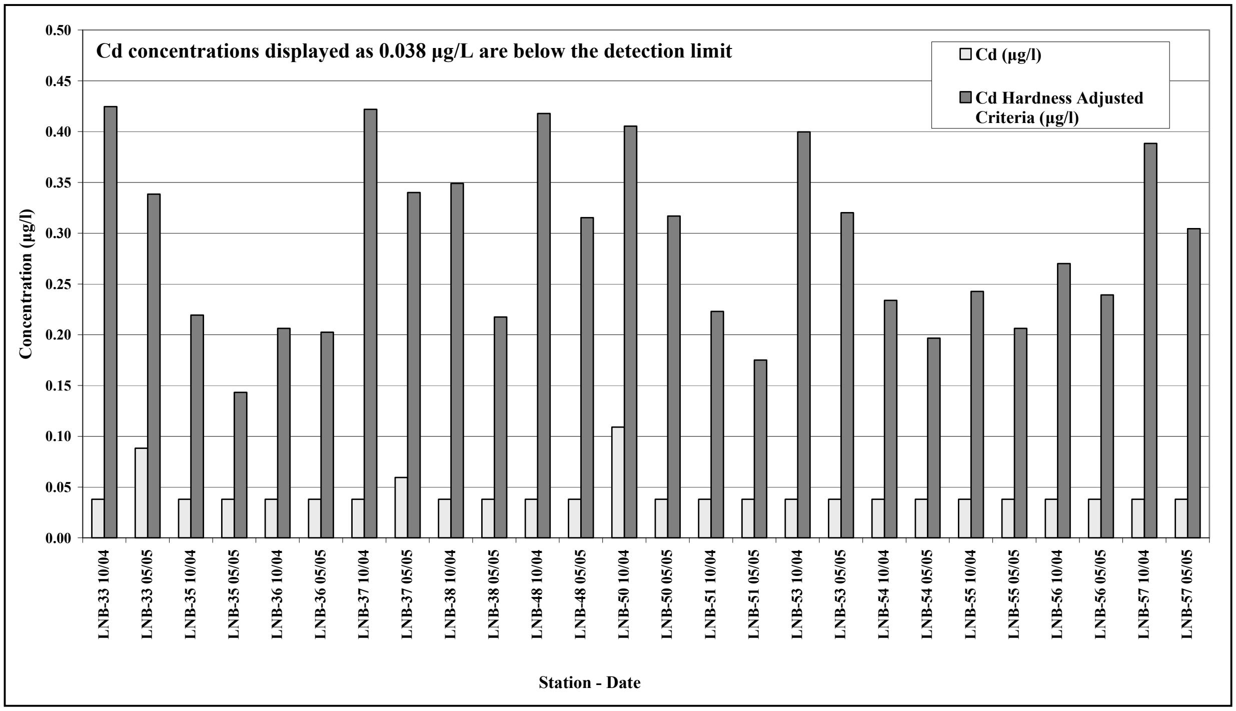

Figure 3: Lower North Branch Potomac River Water Column Data (Cd)

The method detection limit for Cd analysis is 0.038 µg/l. Concentrations of Cd in the water column are no greater than 0.109 µg/l. Twenty-three of the twenty-six samples are below the detection limit of 0.038 µg/l. All concentrations are well below their associated freshwater aquatic life hardness adjusted chronic criteria for Cd.

3.2 Sediment Quality Evaluation

Sediment quality in the Lower North Branch Potomac River watershed was evaluated using a 10-day whole sediment test with the freshwater amphipod *Hyalella azteca* (Fisher, 2005*)*. This species was chosen because of its ecological relevance to the waterbody of concern. *Hyalella azteca* is an EPA-recommended test species for assessing the toxicity of freshwater (EPA, 2000). Four surficial sediment samples were collected in October 2004 using a petite ponar dredge (top 2 cm) in the Lower North Branch Potomac River watershed. Control sediments were collected from Bigwood Cove, Wye River, from a depositional area previously characterized as low in contaminants (Fisher, 2005). Refer to Figure 1 for the station locations. The results are presented in Table 5. Eight replicates containing ten amphipods each were exposed to the contaminated sediment samples, as well as a control sediment sample, for testing. The table displays average amphipod survival (%) and average amphipod growth (mg dry weight).

Table 5: Lower North Branch Potomac River Sediment Toxicity Test Results

Sample	Amphipod Survival (#)	Amphipod Growth (mg)	Average Amphipod Survival (%) (SD)*	Average Amphipod Growth (mg) (SD)*
Control A	10	0.093	91.3 (8.35)	0.11 (0.009)
Control B	9	0.099		
Control C	9	0.113		
Control D	9	0.103		
Control E	8	0.113		
Control F	10	0.112		
Control G	8	0.121		
Control H	10	0.116		
LNB-33 A	10	0.167	96.3 (5.18)	0.15 (0.011)
LNB-33 B	10	0.142		
LNB-33 C	9	0.132		
LNB-33 D	10	0.144		
LNB-33 E	10	0.148		
LNB-33 F	9	0.138		
LNB-33 G	9	0.147		
LNB-33 H	10	0.138		
LNB-37 A	7	0.096	83.8 (10.61)	0.12 (0.021)
LNB-37 B	7	0.151		
LNB-37 C	9	0.141		
LNB-37 D	9	0.1		
LNB-37 E	10	0.147		
LNB-37 F	9	0.122		
LNB-37 G	8	0.11		
LNB-37 H	8	0.118		
LNB-53 A	10	0.143	88.8 (18.85)	0.15 (0.017)
LNB-53 B	10	0.144		
LNB-53 C	5	0.114		
LNB-53 D	10	0.141		
LNB-53 E	9	0.152		
LNB-53 F	10	0.173		
LNB-53 G	7	0.161		
LNB-53 H	10	0.148		
LNB-57 A	10	0.161	98.6 (3.78)	0.16 (0.013)
LNB-57 B	10	0.18		
LNB-57 D	10	0.173		
LNB-57 E	10	0.162		
LNB-57 F	9	0.154		
LNB-57 G	10	0.138		
LNB-57 H	10	0.16		

*SD-Significant Difference

The test considers two performance criteria: survival and growth. For the test to be valid the average survival of control sediment samples must be greater than 80% and there must be measurable growth.

Survival of amphipods in the field sediment samples was not significantly less than the average survival demonstrated in the control sediment sample. The average survival for the control sediment sample was 91.3%. The average survival for all field sediment samples ranged between 83.8% and 98.6%. No sediment samples in the Lower North Branch Potomac River exhibited toxicity contributing to mortality.

Average amphipod growth for all field sediment samples was greater than the control sediment sample. The control sediment sample exhibited an average final dry weight of 0.11 mg, in contrast to a range of 0.12 mg to 0.16 mg average final dry weight for field sediment samples. Thus, no samples exhibited toxicity contributing to growth inhibition.

4.0 CONCLUSION

The WQA establishes that the water quality standard for Cd is being met in the Lower North Branch Potomac River watershed. The water column data collected in October 2004 and May 2005 at thirteen monitoring stations (presented in Section 3.1, Table 4) shows that concentrations of Cd in the water column do not exceed the water quality criterion. An ambient sediment bioassay conducted in the Lower North Branch Potomac River, by the University of Maryland Wye Research Center, established that there is no toxicity in the sediment as a result of Cd or other toxics contamination. Therefore, the water column and sediment in the Lower North Branch Potomac River are not impaired by Cd. Thus, the designated uses are supported and the water quality standard is being met.

Barring the receipt of contradictory data, this report will be used to support a Cd listing change for the Lower North Branch Potomac River from Category 5 ("waterbodies impaired by one or more pollutants requiring a TMDL") to Category 2 ("Surface waters that are meeting some standards and have insufficient information to determine attainment of other standards"), when MDE proposes the revision of Maryland's 303(d) list for public review in the future. Although the waters of the Lower North Branch Potomac River watershed do not display signs of toxic impairments due to Cd, the State reserves the right to require additional pollution controls in the Lower North Branch Potomac River watershed if evidence suggests that Cd from the basin is contributing to downstream water quality problems.

REFERENCES

COMAR 26.08.02.03-2G. Numerical Criteria for Toxic Substances in Surface Waters.

COMAR 26.08.02.08(R)(1) & (R)(4). *Stream Segment Designations***.**

Fisher, D., Yonkos, L., Ziegler, G., Shepard, M. *Toxicity of Sediment Samples from the North Branch of the Potomac River using the Freshwater Amphipod Hyalella Azteca 10-day Whole Sediment Survival and Growth Test*. University of MD, Wye Research and Education Center, January, 2005.

Maryland Department of Planning, 2002 Land Use, Land Cover Map Series. 2002.

Maryland Department of the Environment. *2004 List of Impaired Surface Waters [303(d) List] and Integrated Assessment of Water Quality in Maryland: Submitted in Accordance with Sections 303(d) and 305(b) of the Clean Water Act.* April 2004.

Morgan, R.P., Baker, J.E. *2005 North Branch Potomac River Chemical Contaminant Study*. University of MD, Appalachian Laboratory. January 2006.

Natural Resources Conservation Service (NRCS). *Soil Survey of Allegany County, MD*, 1977.

U.S. Environmental Protection Agency. *Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates.* Second ed. EPA/600/R-99/064, Duluth, MN. 192 pp. 2000.

U.S. Environmental Protection Agency. *Consolidated Assessment and Listing Methodology: Toward a Compendium of Best Practices*. 1st edition. July 2002.

U.S. Environmental Protection Agency. *National Recommended Water Quality Criteria: 2002*. EPA-822-R-02-047. November 2002.

Appendix A

FINAL

WREC-05-01

Toxicity of Sediment Samples from the North Branch of the Potomac River Using the Freshwater Amphipod *Hyalella azteca* 10-d Whole Sediment Survival and Growth Test

Prepared by:

Daniel J. Fisher, Ph.D.
G.P. Ziegler, M.S.
L.T. Yonkos, M.S.

The University of Maryland
Wye Research and Education Center
Queenstown, Maryland

January, 2005

Prepared for:

Dr. Ray Morgan, Co-Principal Investigator (North Branch Potomac River Survey)
Professor, Appalachian Laboratory
The University of Maryland Center for Environmental Science
Frostburg, Maryland

ABSTRACT

The University of Maryland Wye Research and Education Center was contacted to conduct whole sediment toxicity tests on sediments from the North Branch of the Potomac River by Dr. Ray Morgan of the Appalachian Laboratory, The University of Maryland Center for Environmental Science in Frostburg, Maryland. Toxicity was assessed using the U.S. Environmental Protection Agency's freshwater amphipod *Hyalella azteca* 10-d survival and growth test. The sediments were not sieved prior to test initiation. The endpoints of the test were survival and growth (dry weight). There were no sediments that caused reduced amphipod survival or growth when compared to the control sediment amphipod data. Average control amphipod survival was 91.3%, while average control amphipod dry weight was 0.11 mg. These tests passed the test performance requirements with control amphipod survival above 80% and measurable growth in the control amphipods over 10 days. The average survival for the 10 Upper Potomac sites was 91.9%, while the average control amphipod dry weight for these sites was 0.15 mg.

INTRODUCTION

The University of Maryland Wye Research and Education Center (WREC) was contacted by Dr. Ray Morgan of the Appalachian Laboratory, The University of Maryland Center for Environmental Science, Frostburg, Maryland to conduct whole sediment toxicity tests on sediments from the North Branch of the Potomac River using the freshwater amphipod *Hyalella azteca*. The North Branch of the Potomac River is defined as the river stretch between the Preston County, West Virginia and Garrett County, Maryland (39.125E N 79.4922E W) border and the confluence of the North and South branches of the Potomac (39.528E N 78.5873E W) near Oldtown, Maryland. The toxicity tests were in support of the North Branch Potomac River Survey.

MATERIALS AND METHODS

Sample Sites

Sediment samples were tested from ten sites in the North Branch of the Potomac River and a negative control sediment from Bigwood Cove, Wye River, Maryland for sediment toxicity. The sample designations were: UNB-01, UNB-09, UNB-20, UNB-31, LNB-33, LNB-37, WC-40, WC-42, LNB-53, and LNB-57.

Sediment Toxicity Tests

A 10-d amphipod whole sediment toxicity test method was used for this study. The tests were conducted using the *Hyalella azteca* procedure outlined in the most recent U.S. Environmental Protection Agency (U.S. EPA, 2000) method document. A summary of the method is presented in Table 1. Dr. Ray Morgan's group collected and shipped all of the sediments to WREC. The sediments were shipped on October 20, 2004 and received at the WREC on October 21, 2004. The samples were kept in coolers on ice during collection and shipping. Upon receipt the samples were stored in the dark at 4EC prior to test initiation at WREC. The sediment samples were not sieved before testing. Sediment tests were initiated on November 2, 2004 and completed on November 12, 2004. The endpoints measured were survival and growth (dry weight) at the end of 10 days. Due to a problem in the laboratory two test beakers were lost during the tests (UNB-31 Replicate G and LNB-57 Replicate C). Because of this there were not equal numbers of replicate beakers at each site at the end of the test.

Data were analyzed in accordance with procedures outlined in the U.S. EPA (2000) method. The statistical package SigmaStat 3.2® was used to analyze the data. Survival data were arcsine square-root transformed prior to analysis. The data were analyzed by comparing the endpoints in the various treatments with the endpoints in the control. Data were assessed for normality and homogeneity of variance using the Kolmogorov-Smirnov Test and the Levene Median Test, respectively (alpha = 0.05). Transformed survival data were not normal so a Kruskal-Wallace One Way ANAOVA on Ranks was performed. Growth data were normal and homogeneous. Because of the unequal replicate sizes, a Bonferroni's Test was used to compare treatment mean growth against the control mean growth.

RESULTS AND DISCUSSION

Water Quality

Average water quality data for each sediment test treatment are presented in Table 2. The lowest dissolved oxygen concentration of 3.1 mg/L recorded during the test was in overlying water in a test beaker from site LNB-37. All dissolved oxygen minimum values were above the minimum of 2.5 mg/L required by the method (U.S. EPA, 2000). Porewater and overlying water ammonia concentrations were all low, where measurable, and well below levels thought to be toxic (U.S. EPA, 2000). Porewater was only measured from Control, UNB-01 and UNB-09 sediments. Sufficient porewater could not be collected from the other sediments due to their sandy nature.

Sediment Toxicity Tests

The toxicity test met the acceptability criteria established by the U.S. EPA (2000) (Table 1). Survival in the control sediment was 91.3% and growth was measurable. The average amphipod dry weight at the end of the test (0.11 mg) in the control treatment was significantly greater than the dry weight of a representative sample of the test amphipods at test initiation (0.04 mg). The comparison was made using a two sample *t*-test.

Results showed that no sediments from the North Branch of the Potomac caused significant reductions in amphipod survival or growth (dry weight) compared to the laboratory control (Table 3). Notice that all of the treatments had amphipod dry weights that were greater than the laboratory control animals, with the largest amphipods from site WC-40. Amphipods from this site were 4.25 times bigger than at the beginning of the test. Amphipods from the control treatment were 2.75 times bigger than the amphipods at the start of the test. All of the test samples had significant amounts of organic material, including organic debris, compared to our laboratory control. This could have served as an additional food source for the amphipods.

The average amphipod survival for the ten Upper Potomac sites was 91.9%. Survival ranged from 83.8% at LNB-37 to 98.6 at LNB-57. The average control amphipod dry weight for these sites was 0.15 mg with a range from 0.13 mg at UNB-09 to 0.17 mg at WC-40.

LITERATURE CITED

U.S. EPA. 2000. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. Second ed. EPA/600/R-99/064. U.S. Environmental Protection Agency, Duluth, MN. 192 pp.

Table 1. Test conditions for 10-d whole sediment toxicity tests with *Hyalella azteca*.

1. Test type	Whole sediment, static renewal of overlying water
2. Temperature	23 ± 1EC
3. Overlying water	95:5 well water/saltwater mix
4. Renewal of overlying water	2 volume additions/d using automatic renewal system
5. Light	Wide-spectrum fluorescent lights, 100 to 1000 lux
6. Photoperiod	16:8 (L/D)
7. Test chamber	300 mL lip-less beaker with screened hole for water renewal (Randomly assigned on test table)
8. Sediment volume	100 ml
9. Overlying water volume	175 ml
10. Size and life stage of amphipods	7- to 14-d old; size sorted on nested 710 and 500 Φm mesh sieves
11. Number of organisms/replicate	10 (Randomly assigned to test replicates)
12. Number of replicates	8
13. Feeding	1.0 ml YCT daily
14. Aeration	none
15. Water quality	Alkalinity, hardness, and total ammonia at beginning and end of test. Temperature, D.O., and pH daily. Porewater ammonia in dummy beaker at test initiation.
16. Test duration	10 d
17. Endpoints	Survival and growth
18. Performance criteria	Control survival $\geq$ 80% Measurable growth in control amphipods

Table 2. Water chemistry summary for the 2004 North Branch Potomac River 10-d amphipod *Hyalella azteca* sediment toxicity test conducted 11/02-11/12/04 [mean (S.D.) unless otherwise stated].

Station	DO mg/L	pH range	Temp °C	Conductivity µmhos	Alkalinity mg/L $CaCO_3$	Hardness mg/L $CaCO_3$	Ammonia (mg/L) Overlying day 0	Ammonia (mg/L) Overlying day 10	Ammonia (mg/L) Porewater day 0
Control	6.7 (0.48)	7.71-8.29	22.4 (0.57)	2300 (141.4)	105 (7.1)	266 (25.5)	0.6	0.4	4
UNB-01	5.4 (1.10)	7.24 - 7.78	22.2 (0.59)	2350 (70.7)	283 (130.8)	274 (48.1)	0.2	0.5	3
UNB-09	5.5 (0.99)	7.46 - 7.96	22.3 (0.61)	2325 (106.1)	143 (24.7)	314 (8.5)	0.2	0.1	2
UNB-20	5.9 (1.02)	7.54 - 8.01	22.2 (0.64)	2350 (70.7)	138 (31.8)	298 (53.7)	<0.1	0.2	*
UNB-31	5.7 (0.88)	7.62 - 8.07	22.2 (0.56)	2350 (70.7)	270 (148.5)	316 (5.7)	<0.1	0.3	*
LNB-33	5.2 (1.01)	7.36 - 7.80	22.3 (0.59)	2350 (70.7)	158 (10.6)	304 (22.6)	0.3	0.4	*
LNB-37	3.9 (0.92)	7.07 - 7.59	22.2 (0.63)	2350 (70.7)	153 (31.8)	294 (19.8)	0.7	1.4	*
WC-40	5.4 (0.90)	7.58 - 8.01	22.2 (0.60)	2350 (70.7)	168 (3.5)	304 (22.6)	<0.1	0.2	*
WC-42	5.8 (1.00)	7.56 - 7.91	22.2 (0.56)	2350 (70.7)	158 (10.6)	314 (8.5)	0.3	0.2	*
LNB-53	4.7 (1.04)	7.33 - 7.91	22.3 (0.67)	2350 (70.7)	143 (17.7)	312 (11.3)	0.3	0.9	*
LNB-57	5.0 (0.86)	7.32 - 7.86	22.2 (0.63)	2350 (70.7)	140 (7.1)	292 (5.7)	0.6	0.6	*

* Unmeasured due to insufficient porewater sample

Table 3. Upper Potomac River amphipod *Hyalella azteca* 10 day survival and growth sediment test results (11/02-11/12/04). An * indicates a treatment significantly < the control (% = 0.05).

Treatment REP	# Surviving amphipods	0 Rep. dry wt. (mg)	0 Treatment % Survival (SD)	0 Treatment mg. dry wt. (SD)
Control A	10	0.093	91.3 (8.35)	0.11 (0.009)
Control B	9	0.099		
Control C	9	0.113		
Control D	9	0.103		
Control E	8	0.113		
Control F	10	0.112		
Control G	8	0.121		
Control H	10	0.116		
UNB-01 A	9	0.159	92.5 (7.07)	0.15 (0.006)
UNB-01 B	10	0.154		
UNB-01 C	10	0.149		
UNB-01 D	10	0.152		
UNB-01 E	8	0.140		
UNB-01 F	9	0.154		
UNB-01 G	9	0.156		
UNB-01 H	9	0.159		
UNB-09 A	10	0.114	92.5 (8.86)	0.13 (0.014)
UNB-09 B	9	0.146		
UNB-09 C	10	0.147		
UNB-09 D	8	0.121		
UNB-09 E	8	0.110		
UNB-09 F	10	0.138		
UNB-09 G	10	0.127		
UNB-09 H	9	0.129		
UNB-20 A	10	0.161	85.0 (13.09)	0.16 (0.015)
UNB-20 B	8	0.166		
UNB-20 C	10	0.177		
UNB-20 D	7	0.151		
UNB-20 E	10	0.155		
UNB-20 F	8	0.174		
UNB-20 G	7	0.131		
UNB-20 H	8	0.168		

Table 3. Continued

Treatment REP	# Surviving amphipods	0 Rep. dry wt. (mg)	0 Treatment % Survival (SD)	0 Treatment mg. dry wt. (SD)
UNB-31 A	10	0.166	94.3 (9.76)	0.15 (0.011)
UNB-31 B	8	0.156		
UNB-31 C	10	0.132		
UNB-31 D	10	0.146		
UNB-31 E	10	0.149		
UNB-31 F	10	0.137		
UNB-31 G	Replicate lost			
UNB-31 H	8	0.149		
LNB-33 A	10	0.167	96.3 (5.18)	0.15 (0.011)
LNB-33 B	10	0.142		
LNB-33 C	9	0.132		
LNB-33 D	10	0.144		
LNB-33 E	10	0.148		
LNB-33 F	9	0.138		
LNB-33 G	9	0.147		
LNB-33 H	10	0.138		
LNB-37 A	7	0.096	83.8 (10.61)	0.12 (0.021)
LNB-37 B	7	0.151		
LNB-37 C	9	0.141		
LNB-37 D	9	0.100		
LNB-37 E	10	0.147		
LNB-37 F	9	0.122		
LNB-37 G	8	0.110		
LNB-37 H	8	0.118		
WC-40 A	10	0.144	93.8 (9.16)	0.17 (0.012)
WC-40 B	10	0.176		
WC-40 C	10	0.157		
WC-40 D	8	0.171		
WC-40 E	10	0.180		
WC-40 F	8	0.159		
WC-40 G	10	0.172		
WC-40 H	9	0.158		

Table 3. Continued

Treatment REP	# Surviving amphipods	0 Rep. dry wt. (mg)	0 Treatment % Survival (SD)	0 Treatment mg. dry wt. (SD)
WC-42 A	10	0.159	93.8 (10.61)	0.16 (0.015)
WC-42 B	7	0.150		
WC-42 C	9	0.180		
WC-42 D	10	0.167		
WC-42 E	10	0.158		
WC-42 F	10	0.155		
WC-42 G	9	0.191		
WC-42 H	10	0.152		
LNB-53 A	10	0.143	88.8 (18.85)	0.15 (0.017)
LNB-53 B	10	0.144		
LNB-53 C	5	0.114		
LNB-53 D	10	0.141		
LNB-53 E	9	0.152		
LNB-53 F	10	0.173		
LNB-53 G	7	0.161		
LNB-53 H	10	0.148		
LNB-57 A	10	0.161	98.6 (3.78)	0.16 (0.013)
LNB-57 B	10	0.180		
LNB-57 C	Replicate lost			
LNB-57 D	10	0.173		
LNB-57 E	10	0.162		
LNB-57 F	9	0.154		
LNB-57 G	10	0.138		
LNB-57 H	10	0.160		
Day 0 amphipod A[1]	10	0.042		0.04 (0.002)
Day 0 amphipod B	10	0.042		
Day 0 amphipod C	10	0.039		
Day 0 amphipod D	10	0.042		
Day 0 amphipod E	10	0.042		
Day 0 amphipod F	10	0.039		
Day 0 amphipod G	10	0.039		
Day 0 amphipod H	10	0.037		

[1]These are the dry weights of the amphipods at day 0 used to determine if there was measurable growth in the control amphipods as compared to the control amphipod weights at day 10.