Water Quality Analysis of Cadmium and Lead for the Middle River in Baltimore County, Maryland

FINAL

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List of Abbreviations

CBL	Chesapeake Biological Laboratory
Cd	Cadmium
cm	Centimeter
COMAR	Code of Maryland Regulations
Cu	Copper
CWA	Clean Water Act
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
HAC	Hardness Adjusted Criteria
MDE	Maryland Department of the Environment
mg/l	Milligrams per Liter
Ni	Nickel
NPDES	National Pollution Discharge Elimination System
Pb	Lead
ppt	Parts per Thousand
SCS	Soil Conservation Service
SSURGO	Soil Survey Geographic
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WER	Water Effects Ratio
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. For each WQLS, 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.

The Middle River (basin code 02-13-08-07), located in Baltimore County, MD, was identified on the State's list of WQLSs as impaired by nutrients (1996 listing), suspended sediments (1996 listing), copper (Cu) (1998 listing), nickel (Ni) (1998 listing), cadmium (Cd) (2002 listing), and lead (Pb) (2002 listing). All impairments were listed for the tidal waters. The listings for Cu and Ni were based on an analysis using salt water criteria. Code of Maryland Regulations (COMAR) defines the Middle River as a fresh waterbody. When applying freshwater criteria, Middle River was found not to be impaired by Cu or Ni, therefore these impairments were removed from the list of WQLSs when it was updated in 2002.

The listings for Cd and Pb were based on an analysis of 1992-1993 water column data using fresh water criteria assuming a hardness of 100 mg/l. This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life criteria for Cd and Pb and the designated uses supported by those criteria are being met in the Middle River. The analyses support the conclusion that TMDLs for Cd and Pb are not necessary to achieve water quality standards in this case. Barring the receipt of any contradictory data, this report will be used to support the removal of the Middle River from Maryland's list of WQLSs for Cd and Pb when the Maryland Department of the Environment (MDE) proposes the revision of Maryland's 303(d) list for public review in the future. The nutrient and suspended sediment impairments will be addressed separately at a future date.

Although the tidal waters of the Middle River do not display signs of toxic impairments due to Cd or Pb, the State reserves the right to require additional pollution controls in the Middle River watershed if evidence suggests that Cd or Pb from the basin are 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) of 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 an 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 those standards, which result in standards being met; or 4) correction to errors made in the initial listing.

The Middle River (basin code 02-13-08-07) was identified on the State's 1996 303(d) list as impaired by nutrients and suspended sediment, with copper (Cu) and nickel (Ni) impairments added to the list in 1998, and cadmium (Cd) and lead (Pb) added to the list in 2002. All impairments were listed for the tidal waters. The listings for Cu and Ni were based on an analysis using salt water criteria. Code of Maryland Regulations (COMAR) defines the Middle River as a fresh waterbody. When applying freshwater criteria, Middle River was found not to be impaired by Cu or Ni, therefore these listings were deleted when the 303(d) list was revised in 2002. The listings for Cd and Pb were based on an analysis of 1992-1993 water column data using fresh water criteria at a standard hardness of 100 mg/l. A water quality analysis (WQA) of Cd and Pb for the tidal waters of Middle River was performed using recent water column and sediment toxicity data. Results show no impairment for Cd or Pb. The non-tidal streams are not listed for Cd or Pb, therefore they are not addressed in the WQA. The nutrient and suspended sediment impairments will be addressed separately at a future date.

The remainder of this report lays out the general setting of the waterbody within the Middle River watershed, presents a discussion of the water quality characterization process, and provides conclusions with regard to the characterization. The most recent data establishes that the Middle River is achieving water quality standards for Cd and Pb.

2.0 GENERAL SETTING

Middle River is a wide, shallow tidal estuary that extends southeastward approximately four miles from Eastern Boulevard in Baltimore County before entering the Chesapeake Bay. Adjacent watersheds include the Gunpowder River to the northeast and the Back River to the southwest. The Middle River watershed is located in urban and suburban portions of southeastern Baltimore County, Maryland (see Figure 1). The watershed area covers 5,888 acres.

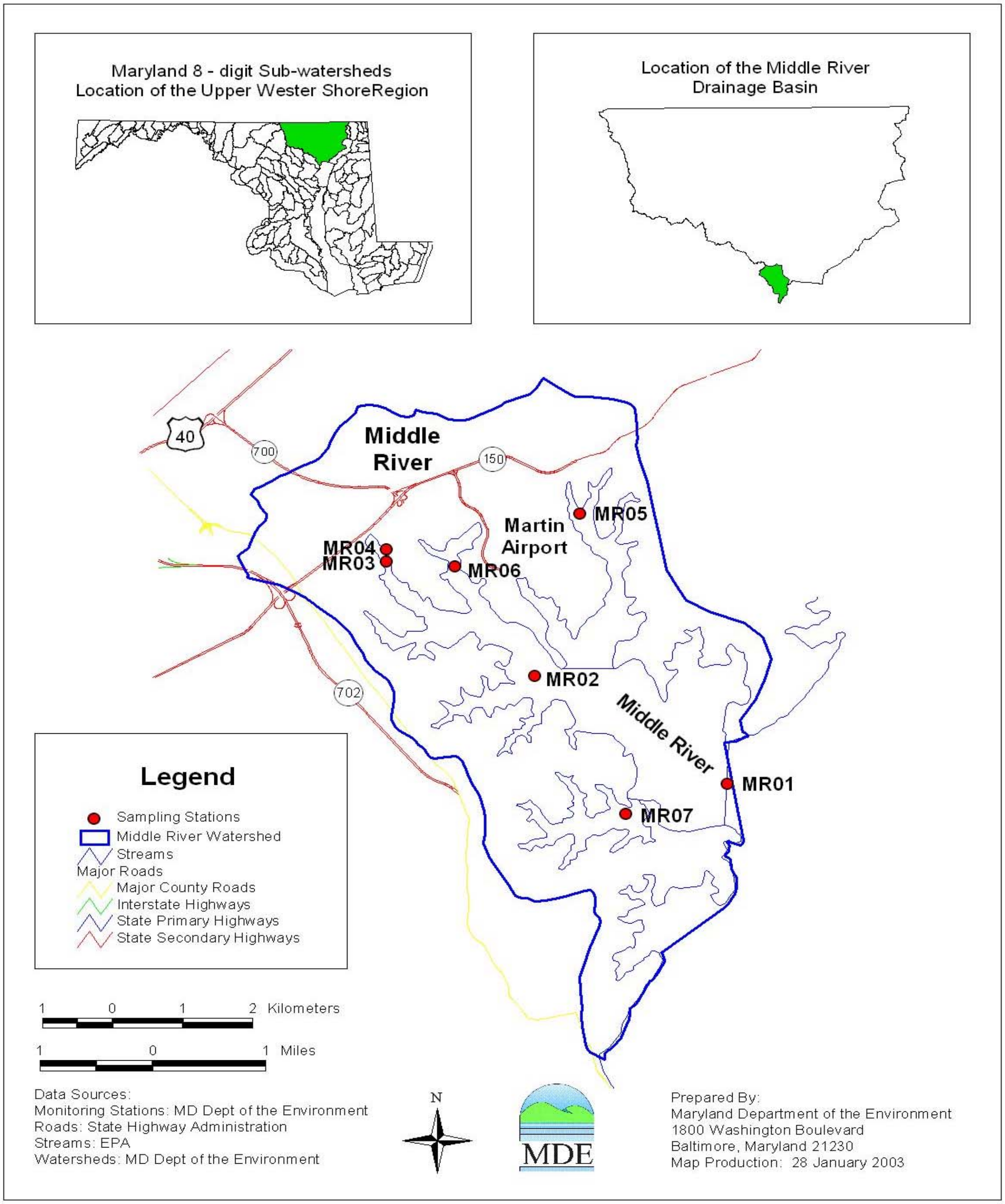

Figure 1: Watershed Map of the Middle River

The Middle River watershed is located entirely within the Atlantic Coastal Plain physiographic province, an area characterized by a relatively flat wedge of unconsolidated sediments, including gravel, sand, silt, and clay, that dip eastward at a low angle. Topography within the watershed is gently rolling to flat. The watershed slopes in a southeastward direction, from just north of Eastern Boulevard down to sea level. Although the maximum elevation within the watershed is approximately 1,000 feet, most elevations are less than 50 feet.

The watershed is almost entirely underlaid by the Patapsco formation, which consists of sand facies that are well sorted, medium to fine grained quartz sand with local deposits of quartz gravel and clays. Clay facies within the Patapsco formation are typically buff, red-yellow and brown mottled kaolinitic clays. A small portion of the watershed, located near the junction of Eastern and Martin Boulevards, is underlaid by the Arundel formation consisting of clay and sand facies. The Arundal formation may include localized deposits of clays, silts, sands, and gravels (Camp, Dresser, McGee, 1997).

The watershed is comprised primarily of B, C and D type soils. Soil type is categorized by four hydrologic soil groups developed by the Soil Conservation Service (SCS). The definitions of the groups are as follows (SCS, 1976):

> 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.

The soil distribution within the watershed is approximately 1% soil group A, 20% soil group B, 58% soil group C and 21% soil group D. Soil data was obtained from Soil Survey Geographic (SSURGO) coverages created by the National Resources Conservation Service.

The Middle River watershed consists primarily of older residential development intermixed with commercial and industrial areas. Large forested tracts of land remain interspersed throughout the entire watershed and relatively rural lands occupy many locations in the lower portions of the watershed surrounding the mouth of the River (see Figure 2). No major point sources discharge Cd or Pb within the watershed. The land use distribution in the watershed is approximately 67.2 % urban, 25.7 % forest/herbaceous, 4.5% agricultural and 2.5 % water (Maryland Department of Planning, 2000).

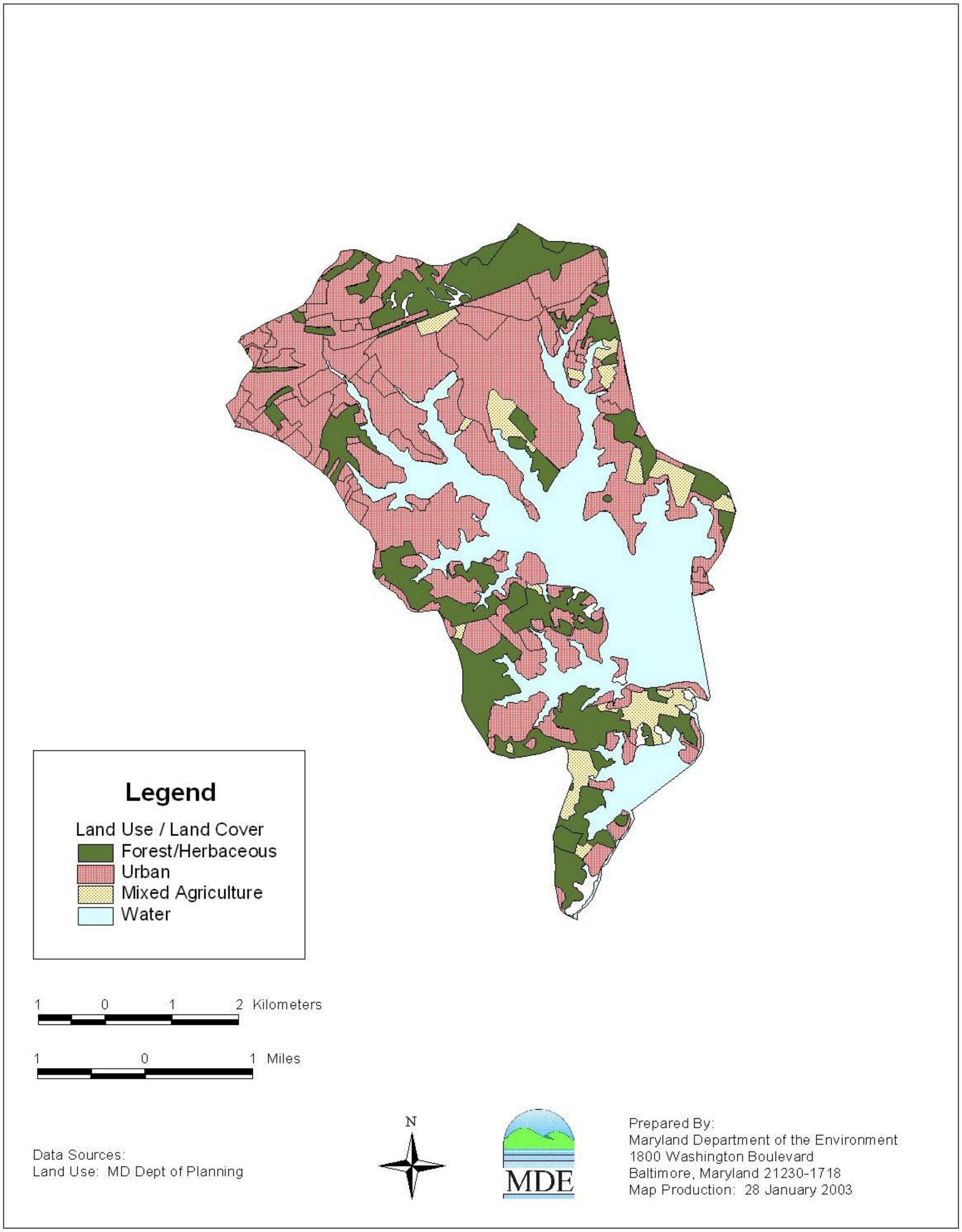

Figure 2: Land Use Map of Middle River Watershed

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 (COMAR 26.08.02.08I) for the Middle River is Use I inside a line from Log Point to Turkey Point and Use II outside. Use I surface waters are designated for water contact recreation, fishing, and protection of aquatic life while Use II includes an additional designation of shellfish harvesting. COMAR 26.08.02.03-1(B)(3)(i) defines all waters within the Gunpowder River basin (02-13-08), which includes the Middle River, as being freshwater.* The freshwater aquatic life criteria for Cd and Pb are displayed below in Table 1 (COMAR 26.08.02.03-2G). The water column data presented in Section 3.1, Table 5 through Table 9, show that concentrations of Cd and Pb in the water column do not exceed water quality criteria. An ambient sediment bioassay conducted in Middle River establishes that there is no toxicity in the sediment bed (Fisher, 2002). Sediment chemistry analysis was not conducted because toxicity was not observed in the ambient sediment bioassay. The water column and sediment in the Middle River are therefore not impaired by Cd or Pb, thus the designated uses are supported and the water quality standard is being met for these substances.

Table 1: Numeric Water Quality Criteria (Cd and Pb)

Metal	Fresh Water Aquatic Life Acute Criteria (µg/l)	Fresh Water Aquatic Life Chronic Criteria (µg/l)
Cd	4.3	2.2
Pb	65	2.5

Water column surveys conducted at five stations (MR01 thru MR05) in the Middle River estuary from May 2001 to April 2002 were used to support these WQAs. For every sample, dissolved concentrations of Cd and Pb were determined. Sediment samples were also collected at all five stations used in the water column surveys as well as two additional stations (MR06 and MR07) for the sediment bioassay. Table 2 shows the list of stations with their geographical coordinates and descriptive location in the Middle River. Refer back to Figure 1 for the station locations.

* Even though COMAR 26.08.02.03-1(B)(3)(i) defines the Middle River as a freshwater body, significant variability in salinity concentrations were found during the water column survey. A comparison of Cd and Pb concentrations with saltwater aquatic life criteria was also conducted based on new EPA guidance and no exceedances occurred.

Table 2: Water Quality Analysis Stations for Middle River

Station I.D.	GPS Coordinates	Station Description
MR01	39.292 76.384	At river mouth, mid-channel, between Bowley Bar and Boob
MR02	39.307 76.415	At mid-channel, between Wilson Point and Barren Point
MR03	39.323 76.440	At headwaters, mid-channel, off Hawthorne Park Pier
MR04	39.325 76.440	Near MR03
MR05	39.330 76.408	Frog Mortar Creek
MR06	39.322 76.430	Dark Head Creek
MR07	39.288 76.401	Sue Creek

Water column sampling was performed six times at each station from May 2001 to April 2002 to capture seasonal variation. The sampling dates were as follows: 5/21/01 (spring wet weather); 6/14/01 (spring dry weather); 7/26/01 (summer dry weather); 7/30/01 (summer wet weather); 4/5/02 (spring wet weather) and 4/25/02 (spring dry weather).

For the water quality evaluation, a comparison is made between Cd and Pb water column concentrations and fresh water aquatic life chronic criteria, the more stringent of the numericwater quality criteria for Cd and Pb. Hardness concentrations were obtained for each station to adjust the fresh water aquatic life chronic criteria that were established at a hardness of 100 mg/l for Cd and Pb. The State uses hardness adjustment to calculate fresh water aquatic life chronic criteria for Cd and Pb whose toxicity is a function of total hardness. According to EPA's National Recommended Water Quality Criteria (EPA, 2002), allowable hardness values must fall within the range of 25 - 400 mg/L. MDE uses an upper limit of 400 mg/l in calculating the hardness adjusted criteria (HAC) when the measured hardness exceeds this value. Based on technical information, EPA's Office of Research and Development does not recommend a lower limit on hardness for adjusting criteria (EPA, 2002). MDE adopts this recommendation. The HAC equation for Cd and Pb is as follows (EPA, 2002):

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

Where,

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

The HAC parameters for metals are presented in Table 3.

Table 3: HAC Parameters (Fresh Water Aquatic Life Chronic Criteria)

Chemical	Slope (m)	y Intercept (b)	Conversion Factor (CF)
Cd	0.7852	-2.715	1.102 - ln(hardness)*0.0418
Pb	1.2730	-4.705	1.462 - ln(hardness)*0.146

The State performs a scientific review of all data submitted where a water quality criterion exceedance was the result of a hardness adjustment below 50 mg/l. This review is necessary because of the scientific uncertainty existing for hardness-toxicity relationships below 50 mg/l due to:

A. Paucity of toxicity test data below 50 mg/l that was used to develop the relationship between hardness and toxicity.
B. Presence/absence of sensitive species in the waterbody of concern.
C. Existence of other environmental conditions (e.g. high Dissolved Organic Carbon (DOC)), which might mitigate the toxicity of metals due to competitive binding/complexation of metals.

In instances where hardness data is not available, the State will calculate an average of existing hardness concentrations for each station. In applying average hardness, the sampling date for which hardness data is unavailable must not fall during a storm event substantially greater than the sampling dates used to calculate the average. A major rainfall event has the potential to reduce hardness below the average. An analysis of rainfall data from the National Weather Service (NWS) precipitation gauge (0180465) at Baltimore/Washington International Airport (BWI) shows no significant variation in storm events for the sampling dates, thus the average will apply. This is the closest gauge to Middle River and is likely to be representative of the rainfall events that occur within the watershed.

3.1 WATER COLUMN EVALUATION

A data solicitation for metals was conducted by the MDE and all readily available data from the past five years was considered in the WQA. The water column data is presented in Table 5 through Table 9 for each station and is evaluated using the fresh water aquatic life chronic HAC, the more stringent of the numeric water quality criteria for Cd & Pb (Baker, 2002). Each table displays hardness (mg/l), sample concentrations (µg/l) and fresh water chronic HAC (µg/l) by sampling date. For example, in Table 5 for the sampling date of 6/14/01 the hardness is 945 mg/l, the hardness adjusted criterion for Cd is 6.2 µg/l and the Cd sample concentration is 0.06 µg/l. The hardness concentrations reported in bold are for sampling dates in which hardness was not measured and an average value was applied. The detection limits for metals analysis are displayed in Table 4. A hardness limit of 400 mg/l is applied for fresh water HAC as defined by EPA's National Recommended Water Quality Criteria (EPA, 2002).

Table 4: Metals Analysis Detection Limits

Analyte	Detection Limit (µg/L)
Cd	0.001
Pb	0.003

Table 5: Station MR01 Water Column Data

Sampling Date	5/21/01		6/14/01		7/26/01		7/30/01		4/5/02		4/25/02	
Hardness (mg/l)	756		945		1105.5		**951.4**		1098.0		999	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Cd	ND	6.2	0.06	6.2	0.18	6.2	0.32	6.2	0.02	6.2	0.03	6.2
Pb	0.03	10.9	0.02	10.9	0.11	10.9	0.36	10.9	0.02	10.9	0.06	10.9

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected

Table 6: Station MR02 Water Column Data

Sampling Date	5/21/01		6/14/01		7/26/01		7/30/01		4/5/02		4/25/02	
Hardness (mg/l)	652.5		852		990		**874.1**		1369.5		1002	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Cd	ND	6.2	0.16	6.2	0.85	6.2	0.80	6.2	0.03	6.2	0.04	6.2
Pb	0.03	10.9	0.02	10.9	0.21	10.9	0.18	10.9	0.004	10.9	0.07	10.9

Table 7: Station MR03 Water Column Data

Sampling Date	5/21/01		6/14/01		7/26/01		7/30/01		4/5/02		4/25/02	
Hardness (mg/l)	604.5		694.5		912		**841.5**		1401.0		1155	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Cd	ND	6.2	0.07	6.2	0.88	6.2	0.80	6.2	0.13	6.2	0.29	6.2
Pb	0.14	10.9	0.07	10.9	1.02	10.9	0.93	10.9	0.07	10.9	0.26	10.9

Table 8: Station MR04 Water Column Data

Sampling Date	5/21/01		6/14/01		7/26/01		7/30/01		4/5/02		4/25/02	
Hardness (mg/l)	594		690		889.5		**828.8**		1384.5		1141.5	
Analyte	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**
Cd	ND	6.2	0.07	6.2	0.58	6.2	0.76	6.2	0.09	6.2	0.22	6.2
Pb	0.23	10.9	0.08	10.9	0.96	10.9	0.95	10.9	0.07	10.9	0.28	10.9

Table 9: Station MR05 Water Column Data

Sampling Date	5/21/01		6/14/01		7/26/01		7/30/01		4/5/02		4/25/02	
Hardness (mg/l)	595.5		724.5		928.5		**845.3**		1388.3		1132.5	
Analyte	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**	**Sample (µg/l)**	**Criteria* (µg/l)**
Cd	ND	6.2	0.37	6.2	3.38	6.2	3.35	6.2	0.09	6.2	0.23	6.2
Pb	0.13	10.9	0.05	10.9	0.50	10.9	0.41	10.9	0.03	10.9	0.10	10.9

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected

The range of concentrations for Cd and Pb sampled in the field survey are as follows:

Cd = ND to 3.38 µg/l
Pb = 0.004 to 1.02 µg/l

Hardness ranged from 594 mg/l to 1401 mg/l. The concentration ranges of Cd and Pb are well below their associated fresh water aquatic life chronic HAC. The criteria were not exceeded by any of the Cd or Pb samples.

3.2 SEDIMENT TOXICITY EVALUATION

To complete the WQA, sediment quality in the Middle River was evaluated using 28-day survival, growth and reproduction whole sediment tests with the estuarine amphipod *Leptocheirus plumulosus*. This species was chosen because of its ecological relevance to the waterbody of concern. *L. plumulosus* is an EPA-recommended test species for assessing the toxicity of marine and estuarine sediments (EPA, 2001). Seven surficial sediment samples were collected using a petite ponar dredge (top 2 cm) by Chesapeake Biological Laboratory (CBL) from Middle River. The sediment stations corresponded to the five monitoring stations sampled in the water column surveys as well as two additional stations. Refer back to Figure 1 for the station locations. Sediment toxicity test results are presented in Table 10. Twenty amphipods were exposed to the sediment in each sample test. The table displays amphipod survival (#), amphipod growth rate (mg/day), neonates (#), average amphipod survival (%), average amphipod growth rate (mg/day) and average neonates per survivor.

The test considers three performance criteria, which are survival, growth rate, and reproduction. For the test to be valid the average survival of control sample replicates must be greater than 80%, there must be a measurable growth rate and reproduction of neonates in the control samples. Survival of amphipods in the field sediment samples was not significantly different than the 84% average survival demonstrated in the control samples [$p < 0.05$]. Field sediment sample average survival results were 85, 91, 90, 78, 75, 85, and 85 percent. No sediment samples in the Middle River exhibited toxicity contributing to mortality.

Table 10: Sediment Toxicity Test Results

Sample	Amphipod Survival (#)	Amphipod Growth Rate (mg/day)	Neonates (#)	Average Amphipod Survival (%)	Average Amphipod Growth Rate (mg/day)	Average Neonates/survivor
Control A	18	0.052	61	84	0.046	3.3
Control B	15	0.057	75			
Control C	16	0.05	46			
Control D	20	0.036	80			
Control E	15	0.035	30			
MR-01	17	0.022	5	85	0.035	0.7*
MR-01	17	0.031	0			
MR-01	17	0.049	22			
MR-01	17	0.033	14			
MR-01	17	0.041	21			
MR-02	19	0.055	34	91	0.047	1.5
MR-02	16	0.044	28			
MR-02	20	0.049	33			
MR-02	16	0.053	25			
MR-02	20	0.036	18			
MR-03	18	0.05	66	90	0.049	3.3
MR-03	19	0.055	113			
MR-03	13	0.055	40			
MR-03	20	0.036	20			
MR-03	20	0.048	59			
MR-04	15	0.038	42	78	0.043	3
MR-04	19	0.045	48			
MR-04	15	0.037	12			
MR-04	19	0.04	51			
MR-04	10	0.057	63			
MR-05	17	0.051	32	75	0.047	3.1
MR-05	18	0.044	77			
MR-05	19	0.044	63			
MR-05	10	0.039	24			
MR-05	11	0.059	40			
MR-06	19	0.071	71	85	0.064	3.6
MR-06	15	0.07	49			
MR-06	16	0.056	96			
MR-06	16	0.062	37			
MR-06	18	0.059	46			
MR-07	13	0.056	21	85	0.052	2.7
MR-07	15	0.05	16			
MR-07	19	0.049	107			
MR-07	20	0.048	39			
MR-07	18	0.056	54			

Similarly, measurable amphipod growth rates observed in the field sediment samples, which ranged from 0.035 to 0.049, were not significantly different than the growth rate of 0.046 observed in the control sample [$p < 0.05$] therefore no sediment samples exhibited toxicity contributing to a reduction in growth.

Amphipod reproduction rates were not significantly different than the control samples, with the exception of one station, MR01. The control sample exhibited a reproduction rate of 3.3 neonates per survivor, in contrast to 0.7 neonates per survivor at MR01 [$p< 0.05$]. However, this low reproductive rate is puzzling due to the station's location at the mouth of the Middle River. This station has significant interaction with Chesapeake Bay waters, therefore it is unlikely that this observation is due to potential sources of sediment toxicity originating from the Middle River. The significance of this finding is minimal, because the population dynamics of *L. plumulosus,* as well as most benthic invertebrates, are classified as r strategists. Their population dynamics are characterized by rapid growth in population before falling off rapidly. Due to their opportunistic nature, amphipod species will relocate to regions of reduced population. In addition, sufficient compensatory reproductive capacity exists in the Middle River as demonstrated by amphipod reproduction rates at the remaining six stations.

4.0 CONCLUSION

The WQA shows that water quality standards for Cd or Pb are being achieved. Water column samples collected at five monitoring stations in the Middle River, from May 2001 to April 2002, demonstrate that numeric water quality criteria are being met. Bottom sediment samples collected at seven monitoring stations, and used for bioassay toxicity tests, demonstrate no impacts on survival and growth rates, and reproduction impacts at one of the seven stations. In light of the other information, this one reproduction finding is not considered of significance in regard to a determination of toxicity. Barring the receipt of any contradictory data, this information provides sufficient justification to revise Maryland's 303(d) list to remove Cd and Pb as impairing substances in the Middle River.

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