Water Quality Analysis of Zinc in Northeast River, Cecil County, Maryland

FINAL

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List of Abbreviations

AVS	Acid Volatile Sulfide
CBL	Chesapeake Biological Laboratory
cm	Centimeter
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
ERL	Effects Range Low
ERM	Effects Range Median
HAC	Hardness Adjusted Criteria
LEL	Lowest-observed Effects Limit
LSD	Least Significant Difference
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MET	Minimum Effects Threshold
MRLC	Multi Resolution Land Cover
mg/l	Milligrams per Liter
NPDES	National Pollution Discharge Elimination System
NWS	National Weather Service
Pb	Lead
PEC	Probable Effects Concentration
PEL	Probable Effects Limit
ppt	Parts per Thousand
SCS	Soil Conservation Service
SEL	Severe Effects Limit
SEM	Simultaneously Extracted Metals
SHA	State Highway Administration
SQG	Sediment Quality Guideline
SSURGO	Soil Survey Geographic
TEC	Threshold Effects Concentration
TEL	Threshold Effects Limit
TET	Toxic Effects Threshold
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
Zn	Zinc

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.

Northeast River (basin code 02-13-06-08), located in Cecil County, was identified on the State's list of WQLSs as impaired by nutrients (1996 listing), suspended sediments (1996 listing), zinc (Zn), (1996 listing), lead (Pb) (1996 listing), and impacts to biological communities (2002 listing). All impairments were listed for the tidal waters except for impacts to biological communities, which are listed for the non-tidal region. Code of Maryland Regulations (COMAR) 26.08.02.03-1-B(3)(g) defines the Elk River area, which includes the Northeast River, as a fresh waterbody. This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life criteria and designated uses associated with Zn are being met in the Northeast River. The information (P. Jiapizian, personal communication 2001) used for listing Zn 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, including hardness data, which shows that the aquatic life uses and criteria are being met in the Northeast River watershed, and 303(d) impairment listings associated with Zn are not supported by the analyses contained herein. The analyses support the conclusion that a TMDL for Zn is not necessary to achieve water quality standards. Barring the receipt of any contradictory data, this report will be used to support the removal of the Northeast River from Maryland's list of WQLSs for Zn 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 suspended sediments, Pb and impacts to biological communities will be addressed separately at a future date. A TMDL for nutrients was completed in 2004.

Although the information supporting this water quality analysis demonstrates that toxic impairments due to Zn are not likely, there is also a realization that some sediment toxicity exists as evidenced by the results of the 28 day amphipod (L. plumulosus) sediment toxicity tests. The State will therefore remove Zn as an impairing substance, but the segment will remain on the list (2006 303(d) list, Part V) for aquatic life use impairments due to sediment toxicity (unidentified contaminants). Although Zn will be removed as an impairing substance, Pb remains on the list. This will require the State to perform additional studies in this WQLS to assess the contributions of Pb to sediment toxicity, and if necessary, identify and assess the contributions of previously unidentified contaminant(s) responsible for causing the observed sediment toxicity. The new listing will be available for public review in the late fall 2005. Finally, although the waters of the Northeast River watershed do not display signs of toxic impairments due to Zn, the State

reserves the right to require additional pollution controls in the Northeast River watershed if evidence suggests that Zn 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 those standards, which result in standards being met; or 4) correction to errors made in the initial listing.

Northeast River (basin code 02-13-06-08) was identified on the State's 1996 303(d) list as impaired by nutrients, suspended sediments, lead (Pb) and zinc (Zn) with an additional listing of impacts to biological communities in 2002. All impairments were listed for the tidal waters except for the impacts to biological communities, which are listed for the non-tidal region. Code of Maryland Regulations (COMAR) defines the Elk River area, which includes the Northeast River, as a fresh waterbody. The Maryland Surface Water Use Designation (COMAR 26.08.02.08G(2)(g)) for the Northeast River is Use I – water contact recreation, fishing, and protection of aquatic life and wildlife

The informational basis (P. Jiapizian, personal communication, 2001) for this listing contended that mean levels of Pb and Zn exceeded the EPA chronic aquatic life criteria for Pb, and both the acute and chronic criteria for Zn at the time of listing (1996). Although criteria were "exceeded", several methodological flaws in the monitoring and listing assessment used in 1996 exist. First, unfiltered (total metals) samples were compared to dissolved criteria. Second, current criteria for Zn 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 ½ 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 Zn have appropriate detection limits that are well below their respective criteria values.

A Water Quality Analysis (WQA) of Zn for the tidal waters of Northeast River was conducted by the Maryland Department of the Environment (MDE) using recent water column chemistry data, sediment chemistry data and sediment toxicity data. A data solicitation for these metals was conducted by MDE and all readily available data from the past five years was considered. Results show no impairment for Zn. This report will be used to support the removal of the 8-digit basin from Maryland's list of WQLSs for Zn. Accordingly TMDLs for Zn are not required

for Northeast River. The listings for suspended sediments, Pb and impacts to biological communities will be addressed separately at a future date. A TMDL for nutrients was completed in 2004.

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

2.0 GENERAL SETTING

The Northeast River watershed is located in the extreme reaches of the Maryland Portion of the upper Chesapeake Bay watershed (Figure 1). It is located in Cecil County and is bounded by the Principio Creek watershed to the west and by the Elk River to the east. Northeast River is tidal (fresh) as far north as the Town of North East, where the head of tide intersects the fall line at the confluence of two major streams, the Northeast Creek and the Little Northeast Creek. The fall line intersects most of the central watershed, transversing both the Northeast Creek to the west, and Little Northeast Creek just to the east. The tidal segment of the Northeast River differs from a true estuary in that there is little intrusion of salt from the lower Chesapeake for the majority of the year; thus, there is neither longitudinal nor lateral distribution of salinity. This atypical tidal exchange produces unusual salinity distributions within the Northeast River. The watershed zone is predominately rural in nature (Figure 2), consisting mainly of animal operations (dairy cows and beef cattle farms) with fields dedicated to feed production. Farms are generally quite large in the region. Limited rural residential uses are present, and the communities of North East and Charlestown, where some impervious surfaces and the Northeast River WWTP are located, are the major urban areas.

The geology and topography, specifically the presence of steep slopes, makes the area very different from that seen throughout the nearby upper Eastern Shore. The steep slope topography and hard rock streambed strata, combined with an abrupt drop to the head of tide, augment the depositional character of Northeast River's tidal zone. Limited commercial fishing is conducted in the tidal zone of the Northeast River. Recreational fishing and general water contact recreation can be found most of the year.

The tidal portion of the river is approximately 5.9 miles (9.4 km) in length, from its confluence with Chesapeake Bay. The depths of the river range from about 6 inches (0.15 m) in the headwaters to greater than 13-15 feet (3.9-4.5 m) at the middle of the river. At the mouth of the river, the depth ranges from 6-7 feet (1.8-2.1 m). The Northeast River watershed has an area of approximately 45,557 acres or 184.4 square kilometers. The land uses in the watershed consist of forest and other herbaceous (18,709 acres or 41.1 %), mixed agriculture (18,680 acres or 41.0%), water (132.5 acres or 0.3%), and urban (8,035 acres or 17.6%) (see Figure 2). These land uses are based on 2000 Maryland Department of Planning (MDP) land use/land cover data and Pennsylvania Multi Resolution Land Cover (MRLC) Data. Figure 3 shows the relative amounts of the different land uses for the entire watershed including the portion of Pennsylvania.

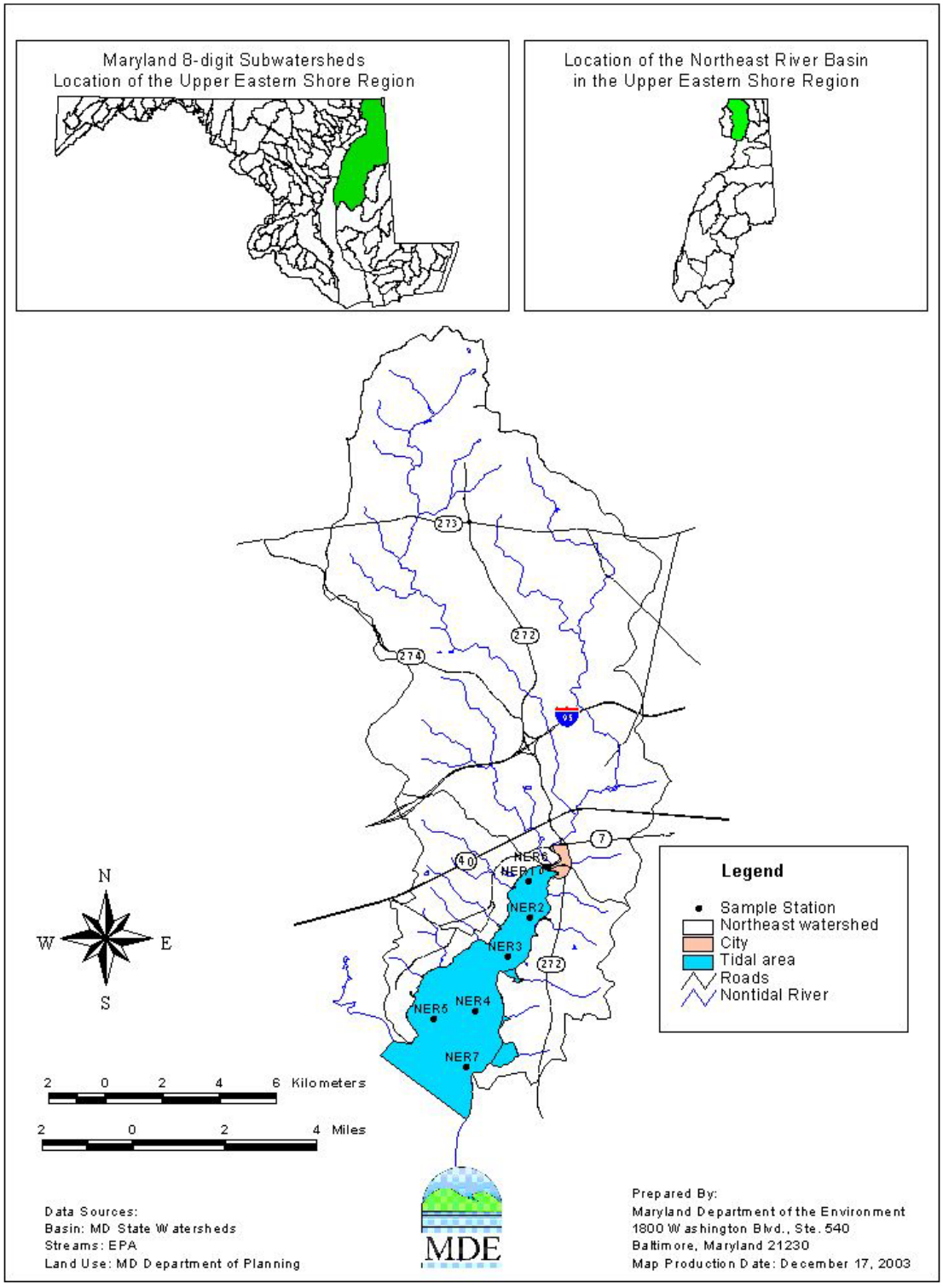

Figure 1: Location Map of the Northeast River Drainage Basin

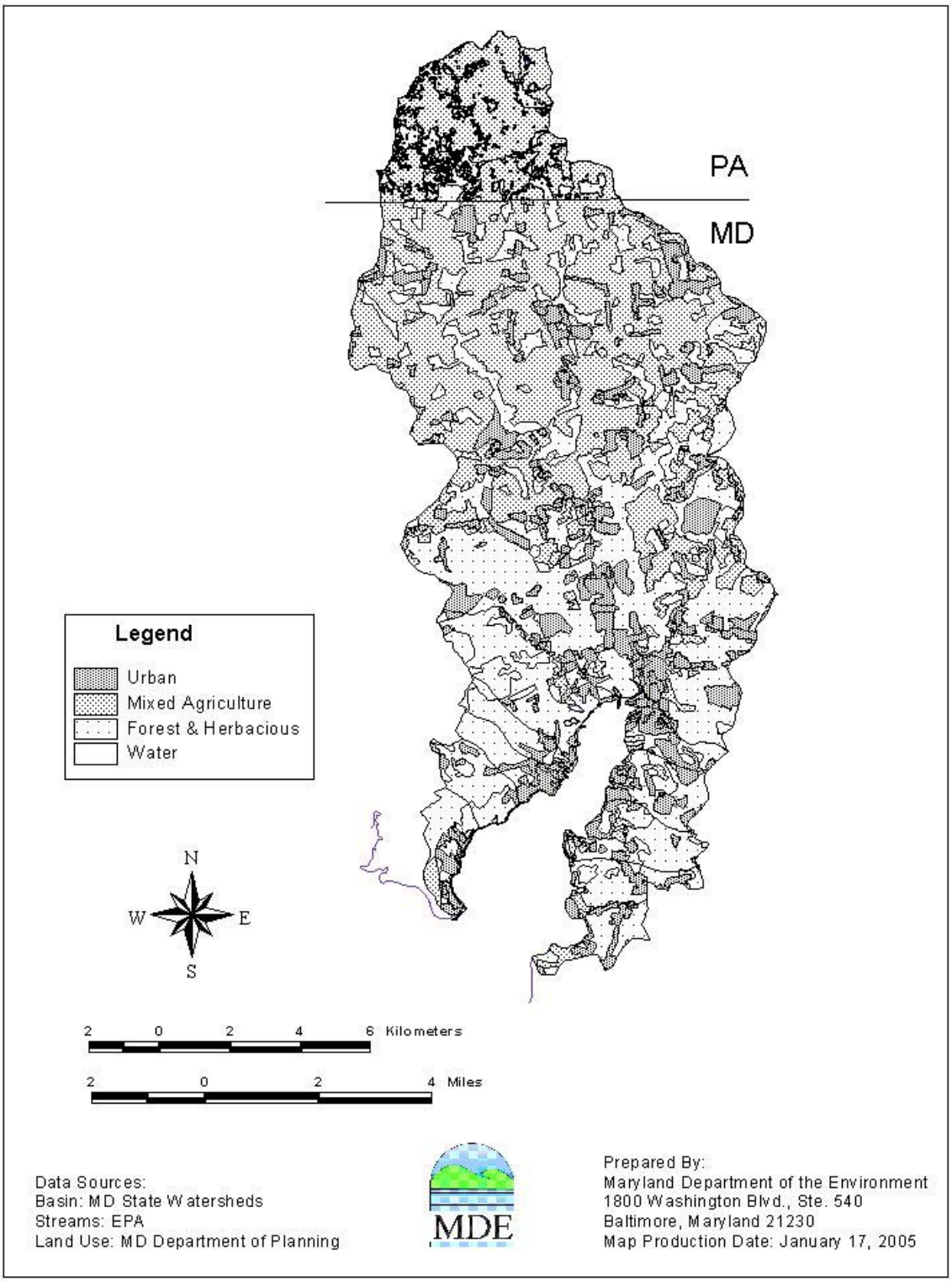

Figure 2: Land Use Map of the Northeast River Drainage Basin

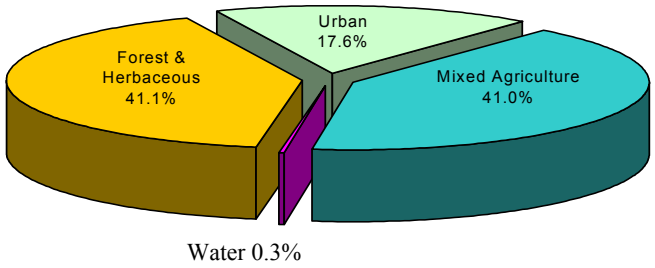

Figure 3: Proportions of Land Use in the Northeast River Drainage Basin

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 26.08.02.08G(2)(g)) for the Northeast River is Use I – water contact recreation, fishing, and protection of aquatic life and wildlife. COMAR 26.08.02.03-1(B)(3)(g) defines the tidal region of the Northeast River basin considered in this WQA as being freshwater. Salinity concentrations for the Northeast River are below 1ppt, thus it is a freshwater body and freshwater criterion may be applied. The freshwater aquatic life criteria (default hardness = 100 mg/L) for Zn are displayed below in Table 1 (COMAR 26.08.02.03-2G). The water column data presented in Section 3.1, Table 5, shows that concentrations of Zn in the water column do not exceed water quality criterion. An ambient sediment bioassay conducted by the University of Maryland Wye Research Center and sediment chemistry analysis conducted by the University of Maryland Center for Environmental Science (UMCES) in the Northeast River establishes that there is no toxicity in the sediment bed as a result of Zn contamination. The water column and sediment in the Northeast River are therefore, not impaired by Zn. Thus the designated uses are supported and the water quality standard is being met.

Water column surveys, used to support this WQA, were conducted by UMCES at seven stations throughout the Northeast River estuary from March 2003 to September 2003. The sampling dates were as follows: 3/11/03 (winter dry weather); 4/15/03 (spring wet weather); 7/15/03 (summer dry weather); 9/15/03 (summer wet weather).

Table 1: Numeric Water Quality Criteria*

Metal	Fresh Water Aquatic Life Acute Criteria (µg/l)	Fresh Water Aquatic Life Chronic Criteria (µg/l)
Zn	120	120

*Criteria based on default hardness of 100 mg/L

Sediment bulk samples were also collected on 7/15/03 and 9/15/03 at each station. Sediment samples were chemically analyzed for total metals in the sediment, dissolved metals in the porewater and toxicity using a standard EPA 28 day amphipod test. Table 2 shows the list of stations with their geographical coordinates. The station locations are presented in Figure 4.

Table 2: Sample Stations for Northeast River

Station	Latitude	Longitude
NER1	39.589	-75.957
NER2	39.578	-75.956
NER3	39.565	-75.966
NER4	39.548	-75.979
NER5	39.546	-75.996
NER6	39.593	-75.950
NER7	39.531	-75.983

For the water quality evaluation, a comparison is made between Zn dissolved water column concentrations and fresh water aquatic life chronic criterion, the most stringent of the numeric water quality criterion for Zn. Water hardness concentrations were obtained for each station to adjust the fresh water aquatic life criteria that water were established at a default hardness of 100 mg/l for Zn (COMAR 26.08.02.03-1-B(3)(g)).

The State uses water hardness adjustment to calculate fresh water aquatic life chronic criteria for those metals (Zn) whose 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. 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 criterion (EPA, July 2002). A lower limit may result in criteria that is less protective of the water quality standard. In analyses where available hardness data indicates a value below 25 mg/L, the Department may perform additional analyses to insure data quality objectives for the assessments were met. When data is of questionable quality, the Department will take additional samples to establish the validity of the initial assessment.

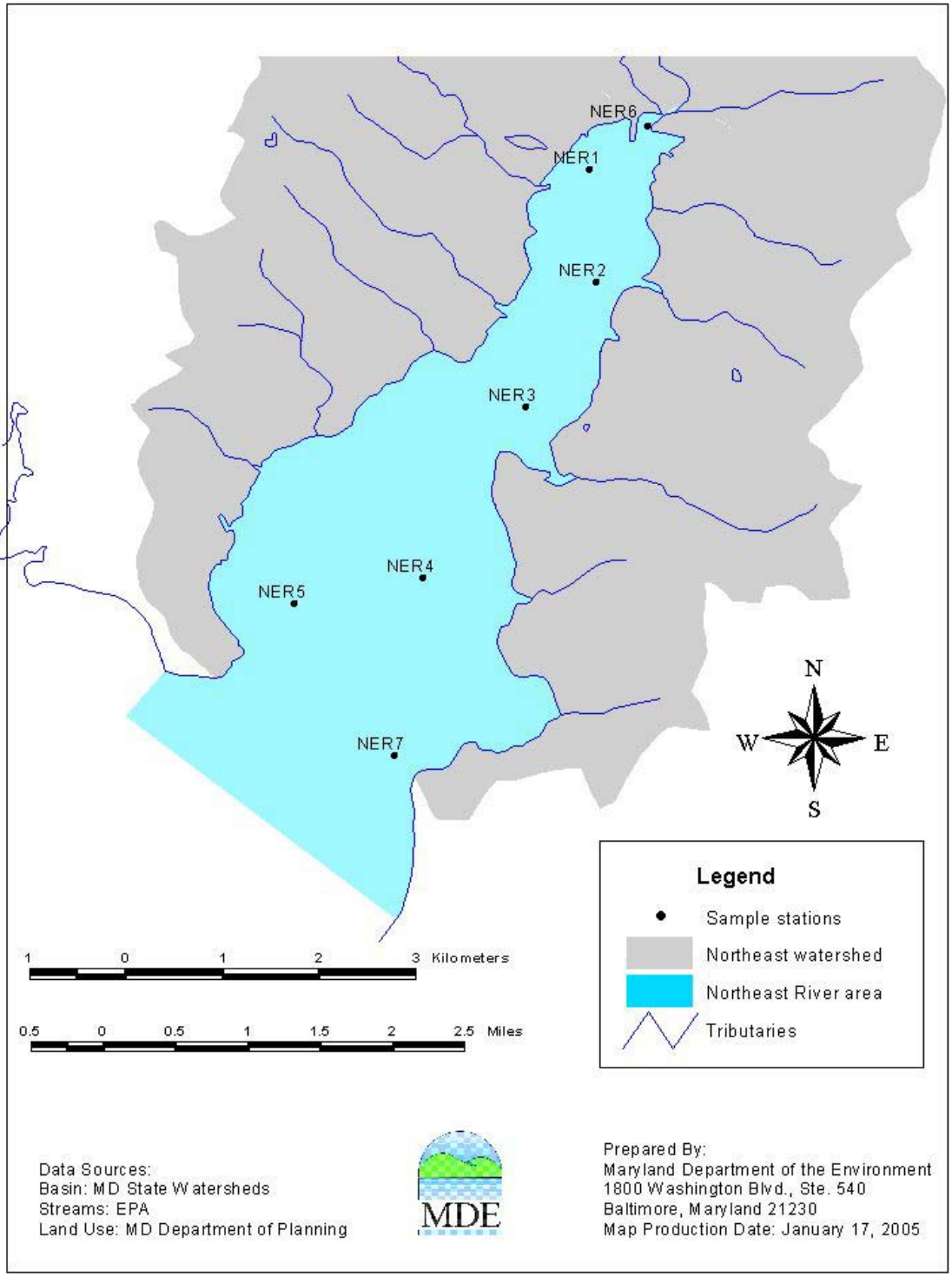

Figure 4: Northeast River Sample Station Location Map

Under circumstances where a water quality criterion exceedance is the result of a hardness adjustment below 25 mg/l, the state will perform a scientific review of the following conditions to determine if the exceedance is valid:

A. Presence/absence of sensitive species in the waterbody of concern.
B. 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.

This review is necessary because of the scientific uncertainty existing for hardness-toxicity relationships below 25 mg/l due to limited toxicity test data used to develop the relationship.

The HAC equation for Zn is as follows (EPA, 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 HAC parameters for Zn are presented in Table 3 (EPA, 2002).

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

Chemical	Slope (m)	Y Intercept (b)	Conversion Factor (CF)
Zn	0.8473	0.884	0.986 – for HAAC
			0.978 – for HACC

HAAC – Hardness Adjusted Acute Criterion
HACC – Hardness Adjusted Chronic Criterion

3.1 WATER COLUMN EVALUATION

A data solicitation for metals was conducted by MDE, and all readily available data from the past five years was considered in the WQA. The water column data is presented in Table 4 for each station and is evaluated using the fresh water hardness adjusted chronic criteria (Baker, 2004). Table 4 displays hardness (mg/l), detection limit (µg/l), sample concentration (µg/l) and criteria (µg/l) by sampling date. For example, in Table 4 for the sampling date of 7/15/03 at station NER1 the hardness is 28.5 mg/l, the hardness-adjusted chronic criterion for Zn is 40.78 µg/l and the Zn sample concentration is 0.65 µg/l. The Zn water column data is also presented in Figure 5.

Table 4: Northeast River Water Column Data (Zn)

Station	Hardness (mg/l)	Sampling Date	Detection Limit (µg/l)	Sample (µg/l)	Criteria* (µg/l)
NER1	20.25	03/11/2003	0.08	7.95	30.53
	23.55	04/15/2003		1.5	34.7
	28.5	07/15/2003		0.65	40.78
	30.3	09/15/2003		ND	42.96
NER2	23.1	03/11/2003	0.08	7.95	34.13
	24.6	04/15/2003		0.88	36
	24	07/15/2003		0.52	35.26
NER3	29.4	03/11/2003	0.08	8.09	41.87
	25.05	04/15/2003		0.64	36.56
	27	07/15/2003		0.57	38.96
	31.5	09/15/2003		0.34	44.39
NER4	34.35	03/11/2003	0.08	3.22	47.77
	24.3	04/15/2003		2.4	35.63
	33	07/15/2003		0.45	46.18
NER5	36.9	03/11/2003	0.08	2.46	50.76
	24.45	04/15/2003		1.19	35.85
	32.1	07/15/2003		0.43	45.11
NER6	17.55	03/11/2003	0.08	6.35	27.04
	27	04/15/2003		2.49	38.96
	25.05	07/15/2003		0.47	36.56
	30.15	09/15/2003		0.46	42.78
NER7	25.35	03/11/2003	0.08	2.6	36.93
	24.45	04/15/2003		1.59	35.82
	30	07/15/2003		0.47	42.59
	27.9	09/15/2003		0.65	40.05

* Fresh Water Aquatic Life Chronic Criterion (hardness adjusted)
ND - Not detected

The range of concentrations for Zn sampled in the field survey is as follows:

Zn = ND to 8.09 µg/l

Hardness ranged from 17.55 mg/l to 36.9 mg/l. The observed concentrations for Zn in the water column were between 4 and 10 X lower than their respective hardness-adjusted freshwater CCC, on average, for each sample.

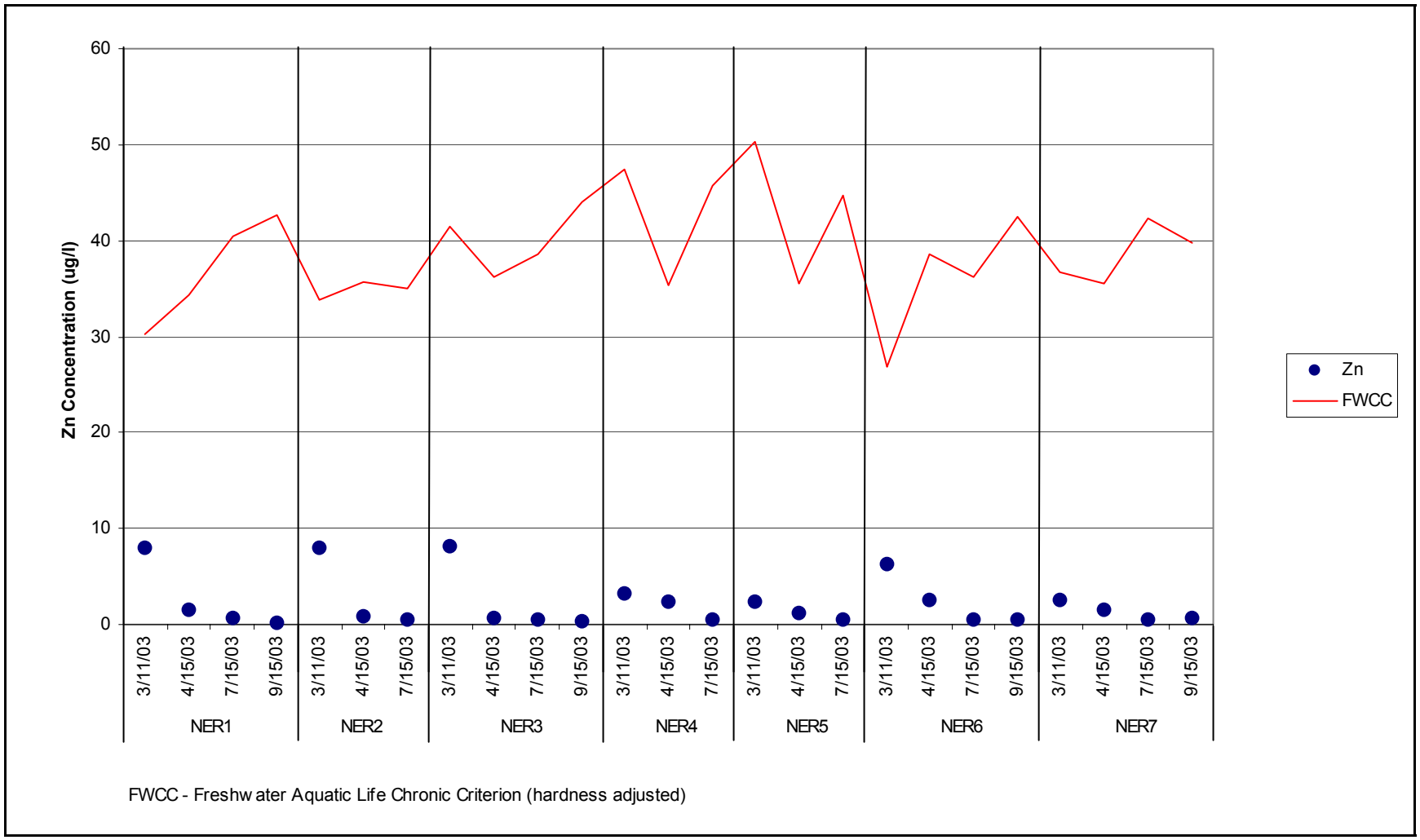

Figure 5: Northeast River Water Column Data (Zn)

3.2 SEDIMENT QUALITY EVALUATION

To complete the WQA, sediment quality in the Northeast River was evaluated using a standard 28-day whole sediment test with the estuarine amphipod *Leptocheirus plumulosus* (Fisher, 2004*)*. 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 on 7/15/03 using a petite ponar dredge (top 2 cm) by in the Northeast River. Control sediments were collected from the Wye River, from a depositional area previously characterized as low in contaminants (Fisher, personal communication). Refer back to Figure 4 for the station locations. The results are presented in Table 6. Five replicates containing twenty amphipods each were exposed to the contaminated sediment, as well as a control sediment, for testing. *Th*e table displays amphipod survival (#), amphipod growth rate (mg/day), neonates (#), average amphipod survival (%), average amphipod growth rate (mg/day) and average amphipod reproduction (neonates per survivor).

The test considers three performance criteria: survival, growth rate, and reproduction. For the test to be valid the survival of control sample replicates must be greater than 80%, and 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 less than the average survival demonstrated in the control samples. This comparison was made using Fisher's Least Significance Difference (LSD) test ($\alpha = 0.05$). The average survival for control samples in the test was 90%. The field sediment sample average survival results were no lower than 83%. No sediment samples in the Northeast River exhibited toxicity contributing to mortality.

Similarly, measurable average amphipod reproduction observed in the field sediment samples, which ranged from 1.40 to 2.88 neonates/survivor were not significantly less than the reproduction of 4.25 neonates/survivor observed in the control samples for the test. This comparison was also made using Fisher's LSD test ($\alpha = 0.05$). No sediment samples exhibited toxicity contributing to a lower reproduction.

Average amphipod growth rates were significantly less than the control samples at four stations: NER1, NER2, NER3 and NER7. This comparison was also made using Fisher's LSD test. The control samples exhibited an average growth rate of 0.0728 mg/day, in contrast to 0.0568 mg/day at Station NER1, 0.0454 mg/day at Station NER2, 0.0448 mg/day at Station NER3 and 0.0516 mg/day at Station NER7; since 4/7 (57%) of the stations displayed significant reductions in growth, the Department concluded that one or more contaminants in the sediment were responsible for the observed effect.

Ambient sediment bioassays are only capable of establishing the existence of sediment toxicity, therefore further chemical analyses were required to determine whether Zn contamination was a source of observed sediment toxicity. Bulk sediment chemistry analysis was conducted in order to measure total Zn concentrations within the sediment (Baker, 2004). The sediment concentrations (mg/kg dry weight) and appropriate sediment quality benchmarks are presented in Table 7.

Table 6: Northeast River 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	0.076	37	90	0.0728	4.25
Control B	18	0.084	110			
Control C	19	0.06	91			
Control D	17	0.068	74			
Control E	18	0.076	71			
NER1 A	20	0.041	46	90	**0.0568***	1.93
NER1 B	17	0.057	45			
NER1 C	15	0.059	15			
NER1 D	20	0.069	62			
NER1 E	18	0.058	11			
NER2 A	18	0.047	27	86	**0.0454***	2.01
NER2 B	17	0.048	56			
NER2 C	17	0.046	77			
NER2 D	15	0.035	5			
NER2 E	19	0.051	7			
NER3 A	15	0.043	31	87	**0.0448***	1.40
NER3 B	17	0.047	23			
NER3 C	20	0.054	23			
NER3 D	18	0.036	7			
NER3 E	17	0.044	35			
NER4 A	17	0.046	1	93	0.0594	2.00
NER4 B	20	0.041	26			
NER4 C	18	0.063	91			
NER4 D	20	0.092	26			
NER4 E	18	0.055	41			
NER5 A	19	0.062	83	94	0.0654	2.60
NER5 B	20	0.071	48			
NER5 C	16	0.061	46			
NER5 D	20	0.059	43			
NER5 E	19	0.074	23			
NER6 A	17	0.048	28	83	0.0592	2.88
NER6 B	14	0.073	52			
NER6 C	18	0.077	69			
NER6 D	18	0.058	60			
NER6 E	16	0.04	30			
NER7 A	19	0.063	93	90	**0.0516***	2.64
NER7 B	17	0.044	4			
NER7 C	18	0.035	25			
NER7 D	17	0.076	86			
NER7 E	19	0.04	31			

* Sample toxicity (field value significantly less than control value)

Table 7: Northeast River Sediment Concentrations (Zn)

Station	Date	Compound	Concentration (mg/kg)	Average (mg/kg)	TEC**	ERL**	ERM**	PEC**
NER1	7/15/03	Zn	**100.4***	108.6	121	150	410	460
	9/15/03	Zn	116.8		121	150	410	460
NER2	7/15/03	Zn	**235.9***	190.4	121	150	410	460
	9/15/03	Zn	145.0		121	150	410	460
NER3	7/15/03	Zn	**370.5***	308.7	121	150	410	460
	9/15/03	Zn	247.0		121	150	410	460
NER4	7/15/03	Zn	**290.4**	258.2	121	150	410	460
	9/15/03	Zn	226.0		121	150	410	460
NER5	7/15/03	Zn	**192.8**	181.3	121	150	410	460
	9/15/03	Zn	169.8		121	150	410	460
NER6	7/15/03	Zn	**94.7**	94.7	121	150	410	460
NER7	7/15/03	Zn	**210.2***	146.9	121	150	410	460
	9/15/03	Zn	83.5		121	150	410	460

* Denotes observation of reduced growth in toxicity tests performed on samples collected 7/15/03
**SQGs are defined in Appendix A

Sediment quality guidelines (SQGs) were used in the absence of sediment quality criteria to predict the likelihood of impacts to sediment biota given a specific contaminant concentration observed in the sediment. Numerous organizations have established SQGs for sediment management and ecological risk assessment purposes. Generally, each guideline consists of two levels: a threshold value below which effects are improbable or unlikely (TEC, ERL); and a value at or above which impacts are probable or likely (PEC, ERM). In this analysis, bulk sediment concentrations were compared to various SQGs (ERL, ERM, TEC, PEC) to determine the likelihood for a role in the observed toxicity for Zn The Threshold effects concentration (TEC) and Probable effects concentration (PEC) are consensus based and calculated by taking the geometric mean of multiple threshold SQGs for TECs and probable effects SQGs for PECs (MacDonald et al, 2000).

Although the average Zn concentrations in the bulk sediment are above the TEC and ERL in five of the seven stations, they are below the ERM and PEC in all seven stations. If zinc were the source of the impaired growth, one would expect to see this effect at NER4 (290 mg/kg) and NER5 (193 mg/kg); NER4 was the second highest observed concentration, and NER5 was similar to NER2 (210 ppm), stations where growth impacts were observed. Also, one would not expect to see growth impacts at NER1 (100 mg/kg), since this concentration is below established threshold effects SQG's.

An analysis of porewater concentrations was also conducted in order to evaluate the concentrations of the readily bioavailable portion of Zn ion in the sediment matrix. The porewater data is presented in Table 8 for each station and is evaluated using the fresh water hardness adjusted chronic criteria (Baker, 2004). This comparison is similar to what was done for the water column. Each table displays the hardness (mg/l), detection limit (µg/l), sample concentration (µg/l) and criteria (µg/l) by sampling date for each station.

Table 8: Northeast River Porewater Data (Zn)

Station	Hardness (µg/l)	Date	Detection Limit (µg/l)	Sample (µg/l)	Criteria* (µg/l)
NER1	28.5	07/15/2003	0.08	7.72	40.45
	30.3	09/15/2003		1.15	42.61
NER2	24	07/15/2003	0.08	3.78	34.97
	24	09/15/2003		1.17	34.97
NER3	27	07/15/2003	0.08	3.55	38.64
	31.5	09/15/2003		0.78	44.03
NER4	33	07/15/2003	0.08	5.05	45.8
	33	09/15/2003		1.15	45.8
NER5	32.1	07/15/2003	0.08	3.92	44.74
	32.1	09/15/2003		1.98	44.74
NER6	25.1	07/15/2003	0.08	6.03	36.26
NER7	30	07/15/2003	0.08	7.71	42.25
	27.9	09/15/2003		10.31	39.73

* Fresh Water Aquatic Life Chronic Criterion (hardness adjusted)

On average, the concentrations of Zn in the porewater were 3-10 times lower than their associated fresh water aquatic life hardness adjusted chronic criterion. No exceedance was observed at any time. Porewater concentrations were highest at stations 1, 6, and 7on 7/15/03 (concurrent with toxicity testing); 2 of 3 stations had no observations of reduced growth.

4.0 CONCLUSION

The WQA establishes that the water quality criteria for Zn is being achieved in the sediment porewater and water column. Water column samples collected from March 2003 to September 2003 at seven monitoring stations in the Northeast River demonstrate that numeric water quality criterion is being met. Surficial sediment samples collected and used for bioassay toxicity tests demonstrate no impacts on amphipod survival and reproduction. Growth rate impacts occur at four stations NER1, NER2, NER3 and NER7. A sediment chemistry analysis demonstrated that Zn concentrations at all stations were below the probable effects concentration 2 stations with sediment Zn concentrations similar to stations where growth rates were reduced did not demonstrate a reduction in growth, and most importantly NER1 demonstrated reduced growth

even though the observed Zn concentration was below the applicable threshold values; therefore it is unlikely that reduced growth was due to the presence of Zn. Given the fact that most organisms have the ability to regulate zinc due to its importance as an essential micronutrient, and that zinc was not found at sediment, water column, or porewater concentrations indicative of probable effects, it is unlikely that zinc played a role in the observed growth rate reductions at NER1, NER2, NER3 and NER7. In addition, a survey of 155 sediment zinc concentrations from other tidal areas of the Chesapeake Bay not impaired by zinc that was performed during the Mid Atlantic Integrated Assessment (1997-1998) show observed concentrations ranging from 5.44-844 mg/kg dry weight (mean = 152 ±141mg/kg dw). Approximately 10% (13/155) of the samples exceeded the highest observed concentration in the Northeast River. Even though Zn is not responsible for the sediment toxicity, the issue still remains, therefore the State will list the segment for aquatic life use impairments due to sediment toxicity (unidentified contaminants) on the 2006 303(d) list, and will remove Zn as an impairing substance in Northeast River. The new listing will be available for public review in the late fall 2005. This will require the State to perform additional studies in this area to identify which contaminants are responsible for causing the observed sediment toxicity. Finally, Pb remains listed as an impairing substance and must be evaluated to assess its role as a potential source of toxicity in the Northeast River.

5.0 REFERENCES

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Appendix A – Sediment Quality Guidelines

ERL - Effects Range Low (Long and Morgan 1991) is the concentration of a chemical in sediment below which toxic effects are rarely observed among sensitive species.

ERM - Effects Range Median (Long and Morgan 1991) is the concentration of a chemical in sediment above which toxic effects are probable among sensitive species.

TEC - Threshold Effects Concentration - Consensus-based (Macdonald et al, 2000): The consensus-based TEC incorporates the Ontario Ministry of the Environment lowest-observed effect levels (LELs): as well as data from up to five other sediment quality guidelines (when available), including TELs, ERLs, TELs for 28 day Hyalella azteca toxicity test, minimal effects thresholds (MET) and chronic equilibrium partitioning thresholds. Consensus-based TECs were calculated by determining the geometric mean of 3 or more of the sediment quality guidelines that were available for a chemical.

PEC - Probable effects concentration - Consensus-based (Macdonald et al, 2000): The consensus-based PEC incorporates the following SQGs (when available): Probable effects level (PEL), Severe effects level (SEL), Toxic effects threshold (TET), ERM and PEL for 28 day Hyalella azteca toxicity test (PEL-HA28). Consensus based PECs were calculated by determining the geometric mean of 3 or more of the sediment quality guidelines that were available for a chemical.