DRAFT

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ANCHOR QEA

Memorandum

April 14, 2017

To: Kristen Keene, Maryland Environmental Service

From: Karin Olsen, P.G. Anchor QEA

Re: Elk River Sampling – River Beach Samples

Program Overview

On behalf of the Maryland Department of Transportation's Port Administration (MPA) and the Maryland Environmental Service (MES), sampling was conducted at two River Beach locations in the nearshore Elk River to assess the existing environmental conditions. The River Beach sampling efforts were initiated based on environmental concerns expressed by citizen members of the Pearce Creek Implementation Committee (PCIC). The purpose of this Memorandum is to summarize the results of the fall 2016 sediment quality characterization, water quality characterization, benthic community sample, and benthic bioassay sampling for each of the two locations (Figure 1).

Technical Approach

The data collection and analytical approach for the River Beach locations was consistent with the Pearce Creek Dredged Material Containment Facility (DMCF) Exterior Monitoring Program (Anchor QEA 2016). The River Beach samples function as a discrete sample set and will be evaluated independently from the samples collected in conjunction with the Pearce Creek DMCF Exterior Monitoring Program.

Sediment Quality Characterization

Undisturbed sediments were collected from the sediment-water interface to a depth of 6 inches using a Ponar grab sampler. Samples were submitted for metals, grain size, moisture content, specific gravity, total organic carbon (TOC), nitrate+nitrite, total Kjeldahl nitrogen (TKN), ammonia, total phosphorus, and sulfide. Chemical concentrations in bulk sediment samples were compared to sediment quality guidelines for freshwater samples (MacDonald et al. 2000).

Water Quality Monitoring

Surface water samples were collected from the mid-depth of the water column. Samples were submitted for dissolved metals, total suspended solids, phosphorus, hardness, ammonia, nitrate, and TKN analysis. Physical parameters, including temperature, dissolved oxygen (DO), pH, and salinity, were also recorded at each sampling location. Chemical concentrations in the surface water samples were compared to the U.S. Environmental Protection Agency's (USEPA) (2016) and the State of

Maryland Code of Regulations (COMAR 26.08.02.03-2) freshwater acute water quality criteria for aquatic life.

Benthic Community Sampling

Benthic community (bottom-dwelling organisms) samples were collected to determine community composition, abundance (number of benthic organisms), and diversity (number of different types of species). The results were used to calculate benthic community metrics, including the number of unique taxa, species abundance, Shannon-Wiener Species Diversity Index, abundance of pollution-indicative taxa, abundance of pollution-sensitive taxa, abundance of carnivore and omnivore taxa, tolerance, evenness, species richness, and Simpson's Dominance Index.

Benthic Bioassays

Sediment from one location was submitted for benthic bioassay testing. Benthic bioassays were acute, 10-day whole sediment tests using the freshwater amphipod *Hyalella azteca*. Testing was conducted according to the USEPA's *Methods for Measuring the Toxicity and Bioaccumulation of Sediment Associated Contaminants with Freshwater Invertebrates* (USEPA 2000). *Hyalella azteca* survival data for the whole sediment bioassays was statistically compared to the survival in control sediment. A control sediment is a non-impacted sediment sample that that is used to evaluate the results of a test.

Field Investigation

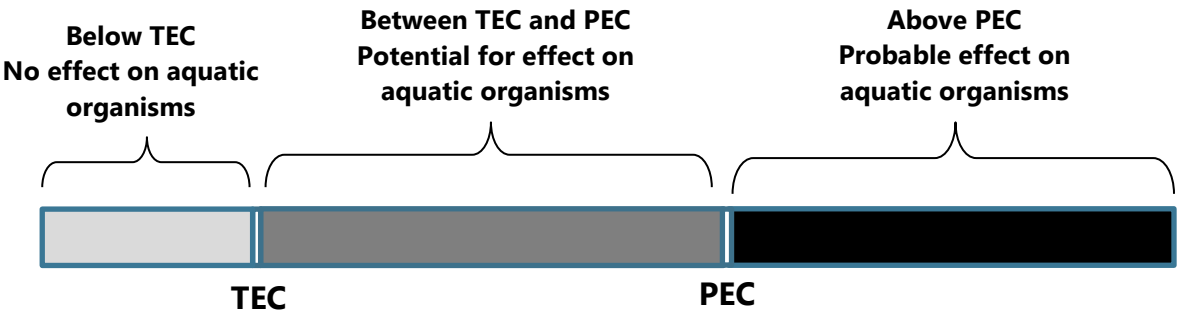
The methods and procedures for the collection of field samples, sampling schedule, rationale for the sampling design, and design assumptions for locating and selecting environmental samples were carried out in accordance with the Sampling and Analysis Plan (Anchor QEA 2015) and the methods used for the Pearce Creek DMCF Exterior Monitoring Program (Anchor QEA 2016a,b, c). Sampling procedures were consistent with USEPA protocols or other approved sample collection standards. A complete list of analytes, target detection limits, and analytical methodologies is provided in the Sampling and Analysis Plan (Anchor QEA 2015).

Two River Beach (RB) sampling locations were included in this investigation. One location was near the future dredged material inflow location for the Pearce Creek DMCF (location RB-01), and one location (location RB-02) was near the area where Stemmers Run discharges into the Elk River. Sampling locations were determined in the field using a Trimble ProXRS Differential Global Positioning System (DGPS) with an accuracy of 1 to 3 meters (m). Northing and easting coordinates for the sampling locations are provided in Table 1 and are shown in Figure 2.

Sediment Quality Characterization

Concentrations of detected analytes in sediment samples were compared to consensus-based sediment quality guidelines for freshwater sediment, where available (MacDonald et al. 2000). Threshold effect concentrations (TECs) and probable effect concentrations (PECs) are derived based on empirical data from laboratory and field studies (MacDonald et al. 2000). The TEC values represent concentrations below which adverse biological effects are unlikely, and PEC values represent concentrations above which adverse biological effects are probable (MacDonald et al. 2000). Concentrations that are between the TEC and PEC represent the concentrations at which adverse biological effects might occur, as shown below.

Data Evaluation Using Sediment Quality Guidelines



Results of the sediment quality characterization are summarized in Table 2. Sample RB-01 was composed of 40% gravel, 59% sand and less than 0.5% silts and clays. Sample RB-02 was composed of 17% gravel and 82% sand and less than 1% silts and clays. TOC and nutrient concentrations were low at both locations. TOC was detected at concentrations of 0.17% and 0.15% at RB-01 and RB-02, respectively. Nitrate + nitrite was not detected at RB-01 and was detected at an estimated concentration of 0.58 mg/kg at RB-02. TKN concentration was estimated to be 140 mg/kg at RB-01 and 96 mg/kg at RB-02. Ammonia was detected at RB-01 (10 mg/kg) and at RB-02 (8.2 mg/kg). Total phosphorus was 31 mg/kg at both locations. Sulfide was detected at RB-02 (9.1 mg/kg) but not at RB-01.

Twelve of the 13 tested metals were detected in both sediment samples. Mercury was the only metal not detected, and it was not detected at either location. Metal concentrations at both locations were low, and well below the TECs.

Water Quality Characterization

Analytes detected in the surface water were compared to the USEPA and the State of Maryland freshwater acute and chronic water quality criteria. Criteria were derived from the USEPA *National*

Recommended Water Quality Criteria (USEPA 2016) and the Code of Maryland Regulations (COMAR 26.08.02.03-2). For dissolved metals, the State of Maryland freshwater water quality criteria for the protection of aquatic life are the same as the USEPA criteria (Table 3) and are directly comparable to the results.

The State of Maryland allows, but does not require, that freshwater criteria be adjusted based on water hardness. The freshwater water quality criteria for the protection of aquatic life for cadmium, chromium, copper, lead, nickel, and zinc were calculated using the minimum hardness value (880 mg/L) and was applied to both samples as a conservative evaluation of water quality. The hardness-adjusted criteria were more conservative than the non-adjusted values for the surface water samples.

Results of the water quality characterization are summarized in Table 3. Hardness and nutrients were reported at similar concentrations between both surface water samples. Total phosphorus concentration was 0.14 mg/L at RB-01 and 0.1 mg/L at RB-02. The total suspended solid concentrations was 40 mg/L at RB-01 and 22 mg/L at RB-02, and ammonia was 0.21 mg/L at RB-01 and 0.16 mg/L at RB-02. TKN was estimated to be 2.2 mg/L at both locations and nitrate was 0.41 mg/L at RB-01 and 0.25 mg/L at RB-02.

Twelve of the 16 tested metals were detected in one or both surface water samples (aluminum, antimony, arsenic, chromium, copper, iron, lead, manganese, nickel, selenium, silver, and zinc)**.** Metals were detected at similar concentrations at RB-01 and RB-02, with the exception of manganese which was detected at concentrations twenty times higher at RB-01 (810 µg/L) than at RB-02 (43 µg/L). None of the metals exceeded the acute or chronic freshwater criteria for the protection of aquatic life in either sample.

Benthic Community

Benthic (or bottom-dwelling) organisms are important indicators of stress in aquatic systems because they can integrate the effects of environmental conditions during long periods of time. Benthic organisms are also important food for many fish, providing an important link to higher trophic levels. Most benthic organisms tend to thrive only in some habitats (for example, sandy versus muddy sediments), and groups of benthic organisms collected at sampling locations are generally comprised of species that are adapted to a specific habitat. Sampling locations are considered "normal" or "healthy" when the benthic organisms collected from that location are primarily the species that are specifically adapted to live in that particular habitat.

Results of the benthic community sampling are summarized in Tables 4 and 5. The bottom salinity was 4.61 ppt for the RB-01 location and 4.94 ppt for the RB-02 location (Table 1); therefore, they were both classified as oligohaline habitats (bottom salinity ranging from 0.5 to 5 parts per thousand). A taxonomic list and mean abundance of the benthic fauna collected are presented in

Table 4. A list of the benthic fauna collected in individual replicates collected at each location is provided in Table 5. Benthic metrics are summarized in Table 6.

Total benthic abundance (total number of organisms per m^2) was 1,773 organisms/m^2 at RB-01 and 3,502 organisms/m^2 at RB-02 (Table 6). Eighteen benthic taxa were collected from the River Beach locations (Table 5). Sixteen taxa were collected at RB-01 —Diptera (4 taxa), Oligochaeta (2 taxa), Polychaete (3 taxa), Bivalves (2 taxa), and Crustacea (5 taxa). Twelve taxa were collected at RB-02—Diptera (1 taxa), Crustacea (3 taxa), Bivalves (2 taxa), Polychaete (4 taxa), and Oligochaeta (2 taxa). Polychaetes (*Streblospio benedicti*) was the dominant taxa at RB-01 and Oligochaetes (aquatic worms; *Tubificoides* spp.) were the dominant taxa RB-02 (Table 4).

Species richness is a comparison of how many taxa are in a sample compared to how many individuals are in a sample. Lower values indicate that the total benthic abundance at a location is dominated by a few taxa and does not represent a diverse benthic community. Locations RB-01 and RB-02 had slightly different values for species richness, 3.1 and 2.1, respectively (Table 6).

Evenness is a measure of how evenly the individuals collected at a location are distributed among the taxa collected at that location, with a value of 1 indicating that the individuals are distributed as evenly as possible. Evenness values were similar between locations RB-01 and RB-02, 0.670 and 0.677, respectively (Table 6).

The Shannon-Wiener Species Diversity Index takes into account both species richness and species evenness, with higher values indicating a more diverse benthic community. Location RB-01 had a Shannon-Wiener Species Diversity Index of 2.6 and the value at RB-02 was 2.4, indicating that these locations have diverse benthic communities (Table 6).

Simpson's Dominance Index measures the diversity of a sample, with a lower value indicating a more diverse community. Simpson's Dominance Index was 0.25 at RB-01 and 0.24 RB-02 (Table 6). The low Simpson's Dominance Index value is indicative of high species diversity.

Benthic Bioassays

Benthic bioassays with whole sediment are designed to determine whether the sediment from each sampling location is likely to produce unacceptable adverse effects on benthic organisms by exposing the organisms to the whole sediment for 10 days. A freshwater amphipod (*Hyalella azteca)* was used in the whole-sediment bioassay.

Hyalella azteca is adapted to live in silty environments, so the toxicity tests are only applicable for fine-grained sediments comprised mostly of silts and clays. For the fall 2016 sampling event, both locations were primarily comprised of coarse grained sands and gravel. Bioassay testing was only conducted at one River Beach location (RB-01), because location RB-02 was comprised almost

entirely of sand (82%). Even though the RB-01 location was composed of primarily coarse grained gravel and sands (99%) the bioassay was still run for consistency with data from previous sampling events.

Results of the benthic bioassays were compared to the results in the control (Table 7). A control sediment is a non-impacted sediment sample that that is used to evaluate the results of a test. Mean survival of *Hyalella azteca* exposed for 10 days to the River Beach sediment was 94%. The survival result was not statistically different (p=0.05) from the mean survival in the control sediment (86%). Therefore, the sediment sample collected from location RB-01 was not acutely toxic to *Hyalella azteca*.

Summary

Sampling was conducted for two River Beach locations in the nearshore Elk River to evaluate existing conditions for sediment quality, surface water quality, and the benthic community. Data collected during this investigation will be compared to data collected in future events to identify trends. Additional sampling will be conducted in the spring of 2017.

References

Anchor QEA (Anchor QEA, LLC), 2015. *Sampling and Analysis Plan, Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program*. Prepared for Maryland Environmental Service. September.

Anchor QEA, 2016a. *Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program: Monitoring Report – Fall 2015*. Prepared for Maryland Port Administration and Maryland Environmental Service. March.

Anchor QEA, 2016b. *Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program: Monitoring Report – Spring 2016*. Prepared for Maryland Port Administration and Maryland Environmental Service. October.

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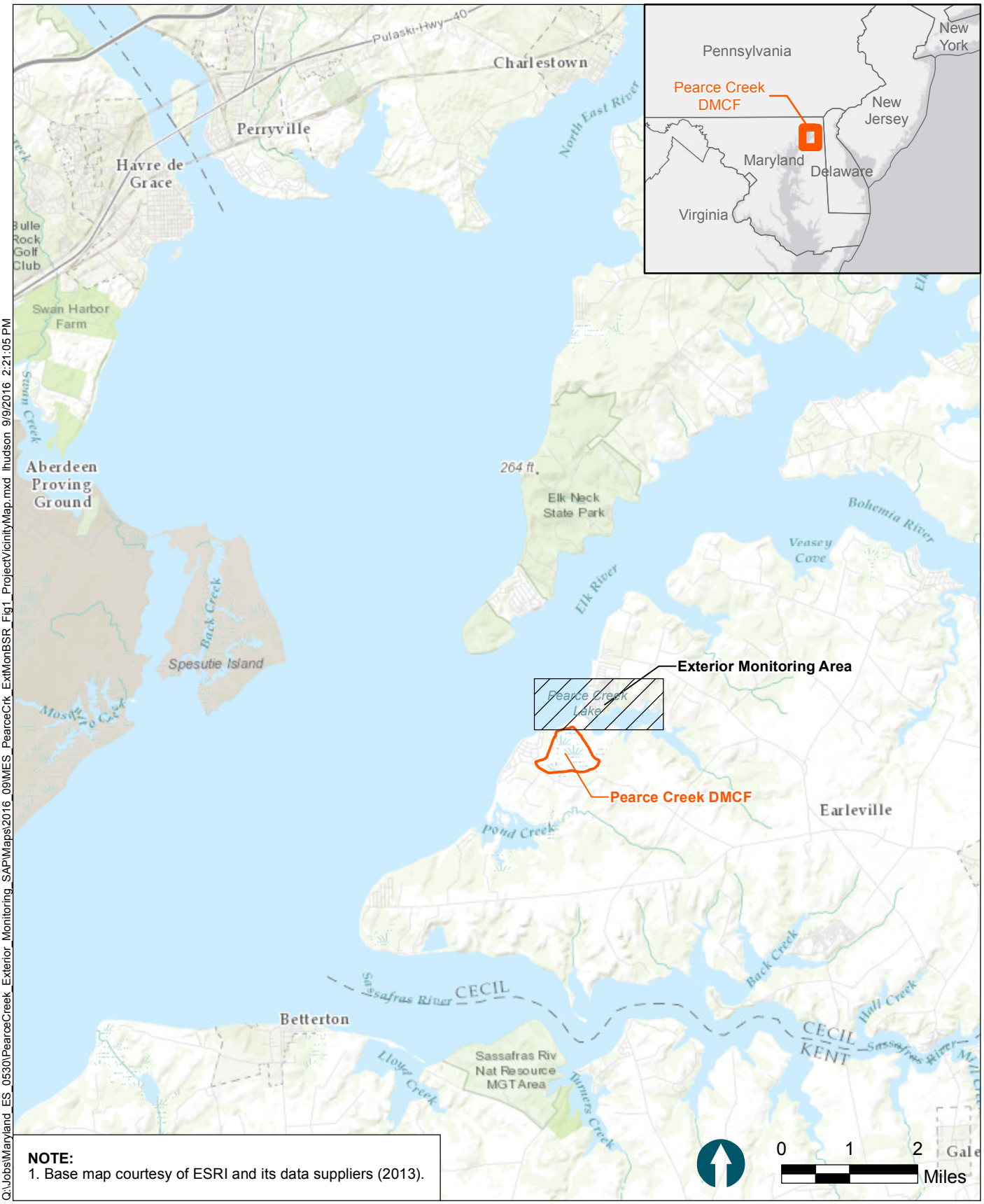
MacDonald, D.D., C.G. Ingersoll, and T.A. Berger, 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Archives of Environmental Contamination and Toxicology* 39:20-31.

USEPA, 2000. *Methods for Measuring the Toxicity and Bioaccumulation of Sediment Associated Contaminants with Freshwater Invertebrates, Second Edition*. EPA 600/R-99/064. March 2000.

USEPA, 2016. National Recommended Water Quality Criteria. Cited: September 7, 2016. Available from: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.

FIGURES



NOTE:
1. Base map courtesy of ESRI and its data suppliers (2013).

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Figure 1
Site Location Map
Pearce Creek Beach Sampling
Pearce Creek DMCF Exterior Monitoring Program

Sample Locations

Pearce Creek Dredged Material Containment Facility

0 1,000 2,000

Feet

NOTE:
1. Aerial image courtesy of ESRI and its data suppliers.

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Figure 2
Beach Sampling Locations
Pearce Creek Beach Sampling
Pearce Creek DMCF Exterior Monitoring Program

TABLES

Table 1
Summary of Field Sample Collection and In Situ Water Quality Parameters
Elk River River Beach Locations - Fall 2016

Location	Date	Time (EST)	Northing[a]	Easting[a]	Water Depth (feet)	Temperature (°C)	Salinity (ppt)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	pH
RB-01	9/23/2016	11:15	645611.26	1599613.21	2	24.6	4.61	3.57	66	7.72
RB-02	9/22/2016	10:35	645041.59	1597974.49	1	24.6	4.94	4.43	16	7.13

Notes:

a Coordinates are in Maryland State Plane, North American Datum of 1983.

EST = Eastern Standard Time

mg/L = milligrams per liter

NTU = nephelometric turbidity unit

ppt = parts per thousand

Table 2
Analytical Results for Sediment Samples
Elk River River Beach Locations - Fall 2016

Analyte	Units	Threshold Effect Concentration (TEC)	Probable Effect Concentration (PEC)	River Beach Location 1	River Beach Location 2
Physical Characteristics					
Gravel	**%**	--	--	**40.4**	**17.0**
Sand	**%**	--	--	**59**	**81.5**
Silt	**%**	--	--	**0.4**	**0.9**
Clay	**%**	--	--	**0.2**	**0.6**
Specific Gravity	**--**	--	--	**2.67**	**2.66**
Nutrients					
Total Organic Carbon	%	--	--	**0.17**	**0.15**
Nitrate+Nitrite	mg/kg	--	--	1.3 U	**0.58 J**
Total Kjeldahl Nitrogen	mg/kg	--	--	**140 J**	**96 J**
Ammonia	mg/kg	--	--	**10**	**8.2**
Total Phosphorus	mg/kg	--	--	**31**	**31**
Sulfide	mg/kg	--	--	38 U	**9.1 J**
Metals					
Antimony	mg/kg	--	--	**0.11 J**	**0.05 J**
Arsenic	mg/kg	9.79	33	**1.9**	**0.50**
Beryllium	mg/kg	--	--	**0.4**	**0.059 J**
Cadmium	mg/kg	0.99	4.98	**0.21**	**0.21**
Chromium	mg/kg	43.4	111	**7.4**	**4.7**
Copper	mg/kg	31.6	149	**1.8**	**1.1**
Lead	mg/kg	35.8	128	**1.5**	**1.6**
Mercury	mg/kg	0.18	1.06	0.019 U	0.02 U
Nickel	mg/kg	22.7	48.6	**3.1**	**1.1**
Selenium	mg/kg	--	--	**0.5**	**0.19 J**
Silver	mg/kg	--	--	**0.008 J**	**0.008 J**
Thallium	mg/kg	--	--	**0.0049 J**	**0.0036 J**
Zinc	mg/kg	121	459	**13**	**5.2**

Notes:

Bold = detected constituents

= constituents that exceed TECs

= constituents that exceed PECs

-- = no value

B = compound detected in the blank and in the sample

J = estimated value; result is less than the reporting limit but greater than the method detection limit

mg/kg = milligrams per kilogram

U = compound not detected

Table 3
Analytical Results for Surface Water Samples
Elk River River Beach Locations - Fall 2016

Analyte	Unit	Acute	Chronic	River Beach Location 1	River Beach Location 2
Hardness	mg/L	--	--	**880**	**940**
Total Phosphorus	mg/L	--	--	**0.14**	**0.1**
Total Suspended Solids	mg/L	--	--	**40**	**22**
Ammonia	mg/L	--	--	**0.21**	**0.16**
Total Kjeldahl Nitrogen	mg/L	--	--	**2.2 J**	**2.2 J**
Nitrate	mg/L	--	--	**0.41**	**0.25**
Metals					
Aluminum	µg/L	750	87	**33**	**48**
Antimony	µg/L	--	--	**0.61 J**	**0.93 J**
Arsenic	µg/L	340	150	**0.77 J**	**1.3**
Beryllium	µg/L	--	--	1 U	1 U
Cadmium[a]	µg/L	15.6	3.78	1 U	1 U
Chromium[a]	µg/L	1,723	389	**0.39 J**	**0.55 J**
Copper[a]	µg/L	115	73.6	**1.9 J**	**2.4**
Iron	µg/L	--	1,000	**88**	**51**
Lead[a]	µg/L	414	6.65	**0.25 J**	**0.35 J**
Manganese	µg/L	--	--	**810**	**43**
Mercury	µg/L	1.40	0.77	0.2 U	0.2 U
Nickel[a]	µg/L	2,083	324	**4.6**	**2.6**
Selenium	µg/L	20	5	**0.57 J**	**0.96 J**
Silver[a]	µg/L	0.0216	--	1 U	**0.3 J**
Thallium	µg/L	--	--	1 U	1 U
Zinc[a]	µg/L	646	652	**4.2 J**	**3.5 J**

Notes:

a Acute and chronic water quality criteria are adjusted for a hardness of 880 mg/L.

Bold = detected constituents

☐ = constituents that exceed chronic criteria

-- = no value

B = compound detected in the blank and in the sample

J = estimated value; result is less than the reporting limit but greater than the method detection limit

U = compound not detected

mg/L = milligrams per liter

µg/L = micrograms per liter

Table 4
Mean Abundance of Benthic Macroinvertebrates
Elk River River Beach Locations - Spring 2016

Species	River Beach Location 1	River Beach Location 2
Anthuridae spp.	38	0
Apocorophium lacustre	108	229
Boccardiella ligerica	6.36	12.7
Coelotanypus spp.	0.0	6.36
Corbicula fluminea	31.8	375
Cricotopus spp.	12.7	0
Cryptochironomus spp.	12.7	0
Cyathura polita	534	782
Marenzelleria viridis	0	114
Naididae spp.	6.36	0
Orthocladiinae spp.	19.1	0
Penaeidea spp.	6.36	0
Polydora cornuta	12.7	25.4
Rangia cuneata	108	57.2
Rheotanytarsus spp.	108	0
Rhithropanopeus harrisii	44	6.36
Streblospio benedicti	**667**	559
Tubificidae with capilliform	0	6.36
Tubificidae without capilliform	57	**1,328**

Notes:
Bold values represent the dominant species at each location.

Table 5
Benthic Community Counts for Locations RB-01 and RB-02
Elk River River Beach Locations - Fall 2016

	River Beach Location 1			River Beach Location 2		
	Replicate A	Replicate B	Replicate C	Replicate A	Replicate B	Replicate C
	RB-01A	RB-01B	RB-01C	RB-02A	RB-02B	RB-02C
Anthuridae spp.	0	6	0	0	0	0
Apocorophium lacustre	5	7	5	18	14	4
Boccardiella ligerica	0	1	0	0	0	2
Coelotanypus spp.	0	0	0	0	1	0
Corbicula fluminea	0	0	5	23	15	21
Cryptochironomus spp.	0	2	0	0	0	0
Cyathura polita	4	43	37	44	43	36
Marenzelleria viridis	0	0	0	5	3	10
Naididae spp.	0	1	0	0	0	0
Orthocladiinae spp.	0	3	0	0	0	0
Penaeidea spp.	0	1	0	0	0	0
Polydora cornuta	0	2	0	2	2	0
Rangia cuneata	11	0	6	3	4	2
Rheotanytarsus spp.	1	15	1	0	0	0
Rhithropanopeus harrisii	0	7	0	1	0	0
Streblospio benedicti	0	103	2	14	37	37
Tubificidae with capilliform	0	0	0	0	0	1
Tubificidae without capilliform	0	6	3	59	46	104

Table 6
Benthic Community Metrics
Elk River River Beach Locations - Fall 2016

Metric	River Beach Location 1	River Beach Location 2
Total Abundance/m^2	1,773	3,502
Infaunal Taxa	15	12
Species Richness (Ludwig-Reynolds)	3.1	2.1
Evenness	0.67	0.68
Shannon-Wiener H' (log base 2)	2.6	2.4
Simpson's Dominance Index	0.25	0.24
Percent Abundance Pollution Indicative Species	43	66
Percent Abundance Deep Deposit Feeders	0	0
Tolerance Score	1.30	4.52

Note:
m^2 = square meters

Table 7
Summary of Test Acceptability Endpoints for Whole Sediment Acute Bioassay for Freshwater Amphipod (*Hyalella azteca*)
Elk River River Beach Locations - Spring 2016

Endpoint/ Measurement	Protocol Criteria	Units	River Beach Location 1
Survival	Mean Laboratory Control	Mean Survival %	94%
	≥ 80%	Protocol Met	Yes
Growth	Measure Positive Growth	Start Dry Weight (mg)	0.017
	End vs. Start of Assay	End Dry Weight (mg)	0.124
		Protocol Met	Yes
Temperature	Mean: 23 °C ± 1 °C	Daily/Hourly	21.3/21.6[a]
	Minimum: 20 °C	Daily/Hourly	20.2/20.1
	Maximum: 26 °C	Daily/Hourly	22.4/22.5
		Protocol Met	No/Yes

Note:
mg = milligram
[a] - The mean temperature meets the protocol requirement when rounded to the whole number indicated in the method, therefore is not considered a protocol deviation. The is no evidence that the slightly low water temperatures had an adverse impact on the results of the test.