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Memorandum

November 14, 2019

To: Kristen Keene, Maryland Department of Transportation Maryland Port Administration
Cassandra Carr, Maryland Environmental Service

From: Karin Olsen, PG, Anchor QEA, LLC

Re: Elk River Sampling – River Beach Samples

Program Overview

On behalf of the Maryland Department of Transportation Maryland Port Administration (MDOT MPA) and the Maryland Environmental Service (MES), sampling was conducted at two River Beach locations in the nearshore Elk River to assess the environmental conditions in the vicinity of the Pearce Creek Dredged Material Containment Facility (DMCF) Exterior Monitoring Area (Figure 1). The River Beach sampling efforts were initiated in 2016 based on environmental concerns expressed by citizen members of the Pearce Creek Implementation Committee. The purpose of this Memorandum is to summarize the results of the spring 2019 sediment quality characterization, water quality characterization, benthic community sampling, and benthic bioassay sampling for each of the two locations (Figure 2).

Technical Approach

The data collection and analytical approach for the River Beach locations was consistent with the Pearce Creek DMCF Exterior Monitoring Program (Anchor QEA 2016a, 2016b, 2017a, 2017b, 2018, and 2019). 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. Data collected during previous sampling events in spring 2016, fall 2016, spring 2017, spring 2018, and fall 2018 are presented on the results tables (Tables 2 through 4, Table 6 and Table 7) for comparison to data collected during the spring 2019 sampling event. The 2019 sampling event was conducted on May 22, 2019.

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 (TSS), 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 (USEPA) *National Recommended Water Quality Criteria* (2018) 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 total abundance, number of taxa, species richness, evenness, Shannon-Wiener Species Diversity Index, Simpson's Dominance Index, percent abundance of pollution indicative species, percent abundance of deep deposit feeders, and tolerance score.

Benthic Bioassays

Sediment from one location was submitted for benthic bioassay testing. Benthic bioassays were used to evaluate if the sediments were acutely toxic to organisms living in the sediments. Bioassays were 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 were statistically compared to the survival data in control sediment. A control sediment is a non-impacted sediment sample that is used to evaluate the results of a test.

Field Investigation

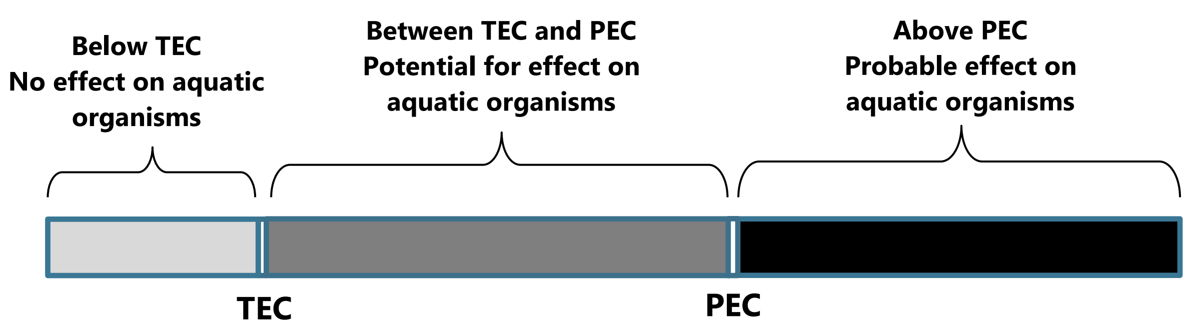
The methods and procedures for the collection of field samples, sampling schedule, rationale for the sampling design, and design assumptions for locating and selecting environmental samples were carried out in accordance with the Sampling and Analysis Plan (Anchor QEA 2015) and the methods used for the Pearce Creek DMCF Exterior Monitoring Program (Anchor QEA 2016a, 2016b, 2017a, 2017b and 2018). 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 dredged material inflow location for the Pearce Creek DMCF (location RB-01), and one location (location RB-02) was located approximately 1/3 mile downstream of RB-01. 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 shown on 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. In spring 2019, sample RB-01 was composed of 2.2% gravel, 96.5% sand, and 1.3% clay. Sample RB-02 was composed of 5.4% gravel, 93.5% sand, and 1.2% silts and clays. TOC and nutrient concentrations were low at both locations. TOC was not detected in either sample. Nitrate + nitrite was detected at a concentration of 1.2 milligrams per kilogram (mg/kg) at RB-01 and 1.4 mg/kg at RB-02. TKN concentrations at RB-01 and RB-02 were 160 mg/kg and 200 mg/kg, respectively. The ammonia concentration at RB-01 was 9.5 mg/kg. Ammonia was not detected at RB-02. Total phosphorus was 49 mg/kg at RB-01 and 24 mg/kg at RB-02. Sulfide was detected at RB-01 at a concentration of 16 mg/kg and was not detected at RB-02. Nutrient concentrations in the spring 2019 sampling event were all within the range of the five previous sampling events (spring 2016, fall 2016, spring 2017, spring 2018, and fall 2018).

Of the 13 tested metals, 10 were detected in at least one sample. Mercury, silver, and thallium were not detected at either location. Metal concentrations at both locations were low and well below the

TECs. Concentrations in both samples generally fell within the range of, or were less than, concentrations reported in the previous sampling events (Table 2).

Water Quality Characterization

Analytes detected in the surface water were compared to the USEPA and State of Maryland freshwater acute and chronic water quality criteria. Criteria were derived from the USEPA *National Recommended Water Quality Criteria* (USEPA 2018) 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 (60 milligrams per liter [mg/L]), which 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 and TKN were not detected at either location. The TSS concentration was 4 mg/L at RB-01 and 5.4 mg/L at RB-02. Ammonia was detected at a concentration of 0.048 mg/L at RB-01 and was not detected at RB-02. The nitrate concentration was 1.4 mg/L at both RB-01 and RB-02. Nutrient concentrations in the spring 2019 sampling event generally fall within the range of concentrations from the previous five sampling events (spring 2016, fall 2016, spring 2017, spring 2018, and fall 2018) at RB-01 and RB-02.

Of the 16 tested metals, five were detected in one or both surface water samples (antimony, arsenic, copper, manganese, and nickel). None of the metals were detected at concentrations that exceeded acute or chronic freshwater criteria. Metal concentrations in both samples generally fell within the range of, or were less than, concentrations reported in the previous five sampling events (Table 3).

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 measure salinity at both RB-01 and RB-02 was 0.12 parts per thousand (ppt; Table 1); therefore, both locations were classified as freshwater (bottom salinity ranging from 0 to 0.5 ppt). 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 community metrics are summarized in Table 6.

Total benthic abundance (total number of organisms per square meter [m^2]) was 2,892 organisms/m^2 at RB-01 and 11,066 organisms/m^2 at RB-02 (Table 6). Twenty-six benthic taxa were collected from the River Beach locations (Table 5). Eighteen taxa were collected at RB-01: Diptera (11 taxa), Isopoda (2 taxa), Tubificida (3 taxa), and Bivalves (2 taxa). Twenty-three taxa were collected at RB-02: Diptera (15 taxa), Isopoda (2 taxa), Gastropoda (1 taxon), Bivalves (1 taxon), and Tubificida (4 taxa). Tubificidae without capilliform were the dominant taxa at both RB-01 and 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. The species richness at RB-01 was 2.8 and the species richness at RB-02 was 2.7. Species richness values were comparable with, if not slightly greater than, values observed in previous years (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 at RB-01 and RB-02 were 0.80 and 0.49, respectively. The evenness value at RB-01 were greater than those observed in all five previous monitoring events. Evenness at RB-02, while greater than the fall 2018 monitoring event, was still less than the spring 2016, fall 2016, spring 2017, and spring 2018 monitoring events (Table 6).

The Shannon-Wiener Species Diversity Index takes into account species richness and species evenness, with higher values indicating a more diverse benthic community. Location RB-01 and RB-02 had a Shannon-Wiener Species Diversity Indices of 3.1 and 2.1, respectively which were within the range of Indices observed in the previous five monitoring events (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 0.15 at RB-01 and 0.18 at RB-02 (Table 6), both of which are lower than the values observed during previous monitoring events.

Results for the benthic community evaluation for spring 2019 were generally consistent with the results for the five previous sampling events (spring 2016, fall 2016, spring 2017, spring 2018, and fall

2018; Table 6). The benthic metrics were within the range of those observed in the previous four sampling events (Table 6), indicating that while the species composition of the benthic community changes seasonally in response to temperature, salinity, and dissolved oxygen fluctuations, the overall health of the benthic community is stable.

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. However, for the spring 2019 sampling event, both locations were comprised primarily of coarse-grained material – RB-01 was 98.7% sand and gravel and RB-02 was 98.9% sands and gravel. Even though the substrate at both locations was coarse-grained, bioassay was conducted on both River Beach locations to evaluate site conditions for benthic organisms.

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 is used to evaluate the results of a test. Mean survival of *Hyalella azteca* exposed for 10 days to the River Beach sediment sample locations was 100% and 96% at RB-01 and RB-02. The survival result was not statistically different ($p=0.05$) from the mean survival in the control sediment (100%). Therefore, the sediment sample collected from location RB-01 and RB-02 was unlikely to cause adverse effects to benthic organisms.

Benthic bioassay results for the spring 2019 samples were comparable with the results for spring 2016, fall 2016, spring 2017, spring 2018 and fall 2018, with samples from each event indicating that the sediment samples collected from locations RB-01 and RB-02 are unlikely to cause adverse effects to benthic organisms.

Summary

Sampling was conducted for two River Beach locations in the nearshore Elk River to evaluate existing conditions for sediment quality, surface water quality, benthic community, and benthic bioassays. Data collected during this investigation was compared to the previous sampling events (spring 2016, fall 2016, spring 2017, spring 2018, and fall 2018) to identify any trends or changes in sediment quality, surface water quality, benthic community, and benthic bioassays. The data collected as part of this investigation will also be compared to future data collection.

References

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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, 2018. National Recommended Water Quality Criteria. Accessed: August 28, 2018. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.

Figures

LEGEND:

Exterior Monitoring Area

Pearce Creek DMCF

NOTE:
1. Base map courtesy of ESRI and its data suppliers (2017).

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Miles

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Figure 1
Site Location Map
Spring 2019 Monitoring Report
Pearce Creek DMCF Exterior Monitoring Program

LEGEND:

Sample Locations

Pearce Creek Dredged Material Containment Facility

NOTE:
1. Aerial imagery: NAIP 2017.

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Feet

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Figure 2
Pearce Creek Beach Sampling Locations
Spring 2019 Monitoring Report
Pearce Creek DMCF Exterior Monitoring Program

Tables

Table 1
Sample Collection and Water Quality Parameters

Location	Date	Time (EST)	Northing[a]	Easting[a]	Water Depth (feet)	Temperature (°C)	Salinity (ppt)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	pH
RB-01	5/22/2019	11:45	645717.644	1599561.802	4.9	20.1	0.12	9.45	5.1	7.51
RB-02	5/22/2019	10:00	645057.921	1597969.131	4.5	18.9	0.12	9.57	6.4	7.63

Notes:

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

EST: Eastern Standard Time

mg/L: milligram per liter

NTU: Nephelometric Turbidity Unit

ppt: part per thousand

Sample data recorded from middle depth location.

Table 2
Analytical Results for Sediment Samples

Analyte	Units	TEC	PEC	River Beach Location 1						River Beach Location 2					
				Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019
Physical Characteristics															
Gravel	%	--	--	**9.4**	**40.4**	**1.4**	**0.8**	**0**	**2.2**	**7.8**	**17.0**	**9.6**	**15.1**	**17.4**	**5.4**
Sand	%	--	--	**20.7**	**59**	**97**	**97.2**	**97.3**	**96.5**	**91**	**81.5**	**87.1**	**84.1**	**76.3**	**93.5**
Silt	%	--	--	**37**	**0.4**	**0.02**	**0.4**	**1.1**	0.01 U	**0.4**	**0.9**	**1.7**	**0**	**5.1**	**0.4**
Clay	%	--	--	**32.9**	**0.2**	**1.6**	**1.6**	**0.5**	**1.3**	**0.8**	**0.6**	**1.6**	**0.8**	**1.3**	**0.8**
Specific Gravity	--	--	--	**2.64**	**2.67**	**2.68**	**2.67**	**2.68**	**2.68**	**2.69**	**2.66**	**2.67**	**2.67**	**2.65**	**2.68**
Nutrients															
Total Organic Carbon	%	--	--	**2.9**	**0.17**	**0.62**	**0.33**	**0.19**	0.14 U	**0.15**	**0.15**	0.13 U	**0.23**	**0.15**	0.13 U
Nitrate + Nitrite	mg/kg	--	--	**4.2**	1.3 U	1.3 J	**1.5**	**1.6**	**1.2 J**	**1.6**	**0.58 J**	1.2 U	**2**	**1.1 J**	**1.4**
Total Kjeldahl Nitrogen	mg/kg	--	--	**2,200**	**140 J**	**390 U**	**200 J**	**150 J**	**160 J**	**210**	**96 J**	200 U	**540**	**300**	**200**
Ammonia	mg/kg	--	--	**150**	**10**	**20**	**8.9 J**	7.8 U	**9.5 J**	12 U	**8.2**	**10.0**	8.2 U	6.7 U	13 U
Total Phosphorus	mg/kg	--	--	**620**	**31**	**78**	**51**	**58**	**49**	**42**	**31**	**30**	**33**	**17**	**24**
Sulfide	mg/kg	--	--	**460**	38 U	73 U	25 J	41 U	**16 J**	**9.8 J**	**9.1 J**	38 U	**22 J**	36 U	39 U
Metals															
Antimony	mg/kg	--	--	**0.29**	**0.11 J**	**0.11 J**	**0.30**	**0.077 J**	**0.062 J**	**0.077 J**	**0.05 J**	**0.029 J**	**0.061 J**	**0.053 J**	0.13 U
Arsenic	mg/kg	9.79	33	**7.1**	**1.9**	**1.3**	**1.1**	**1.0**	**0.7**	**0.82**	**0.50**	**0.47**	**0.45**	**0.57**	**0.65**
Beryllium	mg/kg	--	--	**1.3**	**0.4**	**0.21**	**0.14**	**0.1**	**0.1**	**0.08**	**0.059 J**	**0.054 J**	**0.066 J**	**0.18**	**0.036 J**
Cadmium	mg/kg	0.99	4.98	**0.31**	**0.21**	**0.043 J**	**0.042 J**	**0.055 J**	**0.021 J**	**0.013 J**	**0.21**	**0.017 J**	**0.014 J**	**0.029 J**	**0.012 J**
Chromium	mg/kg	43.4	111	**29**	**7.4**	**8.6**	**5.7**	**6.3**	**6.0**	**4.3**	**4.7**	**3.5**	**3.8**	**18**	**3.5**
Copper	mg/kg	31.6	149	**21**	**1.8**	**2.3**	**1.8**	**3.3**	**1.6**	**1.6**	**1.1**	**0.93**	**1.2**	**5.3**	**0.78**
Lead	mg/kg	35.8	128	**32**	**1.5**	**5.1**	**5.1**	**3.7**	**3.5**	**2**	**1.6**	**1.6**	**1.7**	**5.3**	**1.5**
Mercury	mg/kg	0.18	1.06	**0.08**	0.019 U	0.041 U	0.041 U	0.025 U	0.021 U	**0.0042 J**	0.02 U	0.02 U	0.022 U	0.02 U	0.02 U
Nickel	mg/kg	22.7	48.6	**33**	**3.1**	**4.1**	**4.1**	**2.7**	**2.6**	**1.4**	**1.1**	**1.2**	**1.4**	**2.5**	**1.4**
Selenium	mg/kg	--	--	**1.6**	**0.5**	**0.25 J**	**0.25 J**	**0.087 J**	**0.25 J**	**0.091 J**	**0.19 J**	**0.12 J**	**0.07 J**	**0.082 J**	**0.15 J**
Silver	mg/kg	--	--	**0.25**	**0.008 J**	**0.12 U**	**0.12 U**	**0.038 J**	0.07 U	**0.0053 J**	**0.008 J**	0.063 U	0.071 U	0.061 U	0.064 U
Thallium	mg/kg	--	--	**0.15**	**0.0049 J**	**0.012 J**	**0.012 J**	**0.018 J**	0.07 U	**0.0063 J**	**0.0036 J**	**0.0036 J**	0.071 U	**0.0083 J**	0.064 U
Zinc	mg/kg	121	459	**120**	**13**	**19**	**9.7**	**11**	**10**	**5.1**	**5.2**	**5.1**	**5.1**	**8.3**	**4.9**

Notes:

Bold indicates detected constituents.

: constituents that exceed probable effect concentration

--: no value

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

mg/kg: milligram per kilogram

PEC: probable effects concentration

TEC: threshold effects concentration

U: compound not detected

Table 3
Analytical Results for Surface Water Samples

Analyte	Unit	Acute Water Quality Criteria	Chronic Water Quality Criteria	River Beach Location 1						River Beach Location 2					
				Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019
Hardness	mg/L	--	--	**86**	**880**	**72**	**86**	**70**	**60**	**86**	**940**	**70**	**86**	**72**	**62**
Total Phosphorus	mg/L	--	--	**0.049 J**	**0.14**	0.1 U	**0.11**	**0.051 J**	0.1 U	0.1 U	**0.1**	**0.037 J**	0.1 U	0.1 U	0.1 U
Total Suspended Solids	mg/L	--	--	**11**	**40**	**8.9**	**39**	**10**	**4**	**8.4**	**22**	**7.1**	**29**	**6.1**	**5.4**
Ammonia	mg/L	--	--	**0.2**	**0.21**	**0.18**	**0.38**	**0.12**	**0.048 J**	**0.15**	**0.16**	**0.16**	**0.21**	**0.051 J**	0.1 U
Total Kjeldahl Nitrogen	mg/L	--	--	5 U	**2.2 J**	**11**	**1.7 J**	5 U	5 U	5 U	**2.2 J**	**3.4 J**	5 U	5 U	5 U
Nitrate	mg/L	--	--	**0.85**	**0.41**	**0.66**	**0.69**	**1.2**	**1.4**	**0.83**	**0.25**	**0.65**	**0.95**	**1.2**	**1.4**
Metals															
Aluminum	µg/L	750	87	**19 J**	**33**	30 U	**190**	**67**	30 U	**16**	**48**	**16 J**	**22 J**	**14 J**	30 U
Antimony	µg/L	--	--	**0.27 J**	**0.61 J**	**1.5 J**	2 U	2 U	**0.39 J**	**0.26 J**	**0.93 J**	**0.98 J**	2 U	2 U	**0.4 J**
Arsenic	µg/L	340	150	**0.83 J**	**0.77 J**	**0.34 J**	**1.4**	**0.65 J**	**0.44 J**	**0.77 J**	**1.3**	**0.41 J**	**1.2**	**0.69 J**	**0.47 J**
Beryllium	µg/L	--	--	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Cadmium[a]	µg/L	1.1	0.49	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chromium[a]	µg/L	375	48.8	**1.3 J**	**0.39 J**	2 U	**2.2**	**1.1 J**	2 U	**1.2 J**	**0.55 J**	2 U	**1.9 J**	**1.1 J**	2 U
Copper[a]	µg/L	8.3	5.8	**1.2 J**	**1.9 J**	2 U	**2**	**1.3 J**	**0.96 J**	**1.3 J**	**2.4**	2 U	**1.7 J**	**1.4 J**	**1.1 J**
Iron	µg/L	--	1,000	**31 J**	**88**	50 U	**460**	**120**	50 U	**28 J**	**51**	**23 J**	**37 J**	**26 J**	50 U
Lead[a]	µg/L	37	1.44	1 U	**0.25 J**	1 U	**0.38 J**	**0.14 J**	1 U	1 U	**0.35 J**	1 U	1 U	**0.15 J**	1 U
Manganese	µg/L	--	--	**3.9 J**	**810**	5 U	**260**	**15**	**2 J**	**4 J**	**43**	**3.2 J**	**5.4**	**8.9**	**19**
Mercury	µg/L	1.40	0.77	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Nickel[a]	µg/L	304	34	**1.2**	**4.6**	**1**	**3.5**	**1.3**	**1**	**1.2**	**2.6**	**0.69 J**	**1.6**	**1.3**	**1.2**
Selenium	µg/L	20	5	5 U	**0.57 J**	5 U	5 U	5 U	5 U	5 U	**0.96 J**	5 U	5 U	5 U	5 U
Silver[a]	µg/L	1.34	--	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**0.3 J**	1 U	1 U	1 U	1 U
Thallium	µg/L	--	--	1 U	1 U	**0.054 J**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Zinc[a]	µg/L	76	77	**4.2 J**	**4.2 J**	5 U	**3.9 J**	**5.1**	5 U	**3.4 J**	**3.5 J**	5 U	5 U	**5.1**	5 U

Notes:

a. Acute and chronic water quality criteria are adjusted for a hardness of 60 mg/L.

Bold indicates detected constituents.

: constituents that exceed chronic criteria

--: no value

µg/L: microgram per liter

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

mg/L: milligram per liter

U: compound not detected

Table 4
Mean Abundance of Benthic Macroinvertebrates

Species	River Beach Location 1						River Beach Location 2					
	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019
Ameroculodes spp.	0	0	0	0	0	0	25	0	0	0	0	0
Ancylidae	0	0	0	0	0	0	0	0	0	0	6	0
Anthuridae spp.	0	38	0	0	0	0	0	0	0	0	0	0
Apocorophium lacustre	178	108	6	0	0	0	0	229	114	89	6	0
Boccardiella ligerica	0	6	0	0	0	0	0	13	0	0	0	0
Chaoborus punctipennis	0	0	6	0	6	0	0	0	0	0	0	0
Chirodotea almyra	0	0	13	19	25	102	19	0	0	0	0	32
Chironomidae	0	0	0	445	0	191	0	0	0	477	6	305
Chironomini	0	0	0	0	0	38	0	0	0	13	32	51
Chironomus spp.	0	0	25	89	0	331	13	0	25	19	0	114
Cladotanytarsus spp.	0	0	**915**	426	0	470	70	0	**1,068**	1,074	0	852
Coelotanypus spp.	32	0	0	0	6	6	64	6	0	0	6	0
Corbicula fluminea	210	32	229	191	**1,576**	25	267	375	477	909	**4,367**	38
Cricotopus spp.	0	13	0	0	0	19	0	13	6	0	0	64
Cryptochironomus spp.	13	13	6	6	6	0	19	0	0	6	6	76
Cyathura polita	13	534	191	121	553	76	32	782	292	114	578	108
Dicrotendipes spp.	6	0	0	13	0	0	0	0	0	19	13	884
Gastropoda	0	0	0	0	0	0	0	0	0	0	0	6
Ilyodrilus templetoni	0	0	267	0	0	0	0	0	0	0	0	0
Leptocheirus plumulosus	127	0	0	13	0	0	6	0	0	0	0	0
Limnodrilus hoffmeisteri	83	0	0	6	0	0	64	0	0	280	0	38
Lipinella sp.	0	0	0	0	0	6	0	0	0	0	0	13
Marenzelleria viridis	0	0	64	369	13	0	292	114	254	197	0	0
Microtendipes spp.	0	0	0	0	0	0	6	0	0	0	0	0
Naididae spp.	0	6	0	6	0	89	0	0	0	0	0	1157
Orthocladiinae spp.	0	19	0	0	0	6	0	0	0	0	19	25
Orthocladius sp.	0	0	0	0	0	13	0	0	0	0	0	0
Paratanytarsus sp.	0	0	0	32	0	0	0	0	0	0	13	0
Penaeidea spp.	0	6	0	0	0	0	0	0	0	0	0	0
Polydora cornuta	0	13	0	0	0	0	0	25	0	0	0	0
Polypedilum spp.	13	0	0	6	25	210	64	0	0	25	203	1271
Procladius spp.	44	0	0	70	0	19	0	0	0	64	0	95
Pseudochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	13
Rangia cuneata	483	0	57	70	6	38	0	57	13	0	38	0
Rheotanytarsus spp.	0	108	0	0	0	0	0	0	0	0	0	0
Rhithropanopeus harrisii	0	44	0	0	0	0	0	6	0	0	0	0
Saetheria spp.	6	0	0	0	0	0	0	0	0	0	0	0
Streblospio benedicti	0	**667**	0	0	0	0	0	559	0	0	0	0
Tanypodinae	0	0	0	0	0	0	0	0	0	0	0	6
Tanypus spp.	0	0	0	0	0	0	0	0	6	0	0	0
Tanytarsini	0	0	0	0	0	0	0	0	0	25	0	184

Table 4
Mean Abundance of Benthic Macroinvertebrates

Species	River Beach Location 1						River Beach Location 2					
	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019
Tanytarsus sp.	0	0	0	0	0	0	0	0	0	0	0	165
Thienemannimyia gp.	0	0	0	0	0	0	0	0	0	0	25	0
Tribelos	0	0	0	0	0	0	0	0	0	0	6	0
Tubificidae with capilliform	0	0	0	**966**	19	470	**706**	6	305	**2,244**	121	1,436
Tubificidae without capilliform	**642**	57	470	610	489	**782**	686	**1,328**	420	1,468	2,009	**4,132**
Zygoptera	0	0	0	0	0	0	0	0	0	0	6	0

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

Table 5
Benthic Community Counts

Species	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
Chiridotea almyra	6	4	6	1	2	2
Chironomidae	8	11	11	16	23	9
Chironomini	0	4	2	4	4	0
Chironomus sp.	27	11	14	5	8	5
Cladotanytarsus sp.	26	25	23	40	72	22
Coelotanypus sp.	0	0	1	0	0	0
Corbicula fluminea	2	0	2	3	3	0
Cricotopus sp.	0	1	2	5	5	0
Cryptochironomus sp.	0	0	0	2	8	2
Cyathura polita	5	3	4	7	6	4
Dicrotendipes sp.	0	0	0	36	77	26
Gastropoda	0	0	0	0	0	1
Limnodrilus hoffmeisteri	0	0	0	0	4	2
Lipinella sp.	1	0	0	2	0	0
Naididae	0	9	5	54	41	87
Orthocladiinae	0	0	1	4	0	0
Orthocladius sp.	0	0	2	0	0	0
Polypedilum sp.	6	14	13	51	120	29
Procladius sp.	0	0	3	3	11	1
Pseudochironomus sp.	0	0	0	2	0	0
Rangia cuneata	2	3	1	0	0	0
Tanypodinae	0	0	0	1	0	0
Tanytarsini	0	0	0	19	4	6
Tanytarsus sp.	0	0	0	0	14	12
Tubificidae with capilliform	13	23	38	84	51	91
Tubificidae without capilliform	32	40	51	183	246	221

Table 6
Benthic Community Metrics

Metric	River Beach Location 1						River Beach Location 2					
	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019
Total Abundance/m^2	1,907	1,773	2,250	3,509	2,727	2,892	2,333	3,502	2,981	7,024	7,462	11,066
Infaunal Taxa	14	15	12	16	11	15	15	12	11	12	16	18
Species Richness (Ludwig-Reynolds)	2.6	3.1	2.3	2.9	2.0	2.8	2.5	2.1	2.0	1.9	2.5	2.7
Evenness	0.739	0.67	0.689	0.778	0.48	0.80	0.732	0.68	0.760	0.769	0.42	0.49
Shannon-Wiener H' (log base 2)	2.7	2.6	2.5	3.1	1.7	3.1	2.7	2.4	2.6	2.8	1.7	2.1
Simpson's Dominance Index	0.21	0.25	0.24	0.15	0.41	0.15	0.21	0.24	0.20	0.19	0.42	0.18
Percent Abundance Pollution Indicative Species	38	43	21	18	18	27	32	66	14	3	26.9	37.7
Percent Abundance Deep Deposit Feeders	38	0	33	45	19	46	62	0	24	57	28.5	48.1
Tolerance Score	5.05	1.30	5.6	5.8	5.6	6.7	8.04	4.52	4.8	7.0	6.75	5.7

Note:

m^2: square meter

Table 7

Summary of Test Acceptability Endpoints for Whole Sediment Acute Bioassay for *Hyalella azteca*

Endpoint/ Measurement	Protocol Criteria	Units	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019
Survival	Mean Laboratory Control	Mean Survival %	94%	94%	94%	91%	91%	100%
	≥ 80%	Protocol Met	Yes	Yes	Yes	Yes	Yes	Yes
Growth	Measure Positive Growth	Start Dry Weight (mg)	0.024	0.017	0.018	0.008	0.0343	0.0258
	End vs. Start of Assay	End Dry Weight (mg)	0.143	0.124	0.147	0.659	0.102	0.134
	Protocol Met		Yes	Yes	Yes	Yes	Yes	Yes
Temperature	Mean: 23 °C ± 1 °C	Daily/Hourly	22.8 / 22.8	21.3 / 21.6	23.3 / 23.4	22.0 / 21.9	22.9 / 20.2	23.4 / 23.4
	Minimum: 20 °C	Daily/Hourly	22.1 / 21.7	20.2 / 20.1	22.9 / 22.9	20.9 / 20.9	22.3 / 18.2	228. / 21.6
	Maximum: 26 °C	Daily/Hourly	23.4 / 23.4	22.4 / 22.5	23.6 / 23.9	22.5 / 23.2	23.3 / 20.9	24.2 / 24.8
	Protocol Met		Yes / Yes	No / Yes	Yes / Yes	Yes / Yes	Yes / No*	Yes / Yes

Note:

mg: milligram

*The hourly temperature measurements recorded for the assay fell below the acceptable thresholds required for the mean and minimum temperatures. However, daily temperature measurements were all within the acceptable range. This deviation had no adverse impact on the outcome of the assay.