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Memorandum

May 13, 2020

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, Fall 2019

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 fall 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, 2019a, and 2019b). 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 and fall 2016, spring 2017, spring and fall 2018, and spring 2019 are presented on the results tables (Tables 2 through 4, Table 6 and Table 7) for comparison to data collected during the fall 2019 sampling event. The 2019 sampling event was conducted on September 18, 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

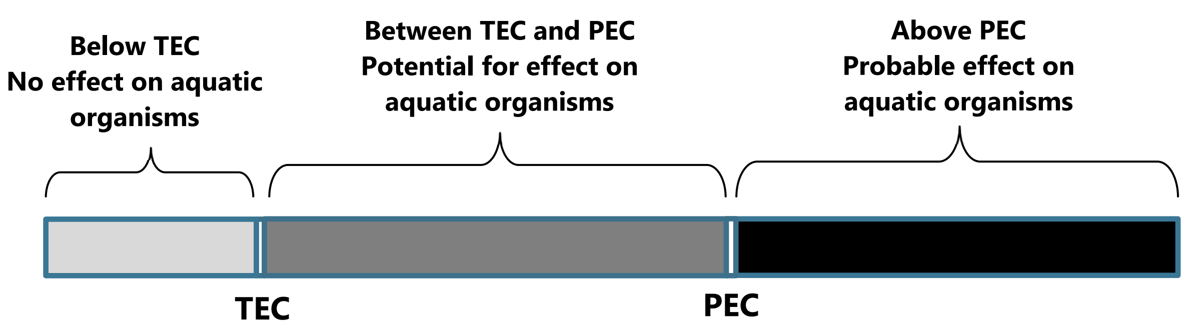
The methods and procedures for the collection of field samples, sampling schedule, rationale for the sampling design, and design assumptions for locating and selecting environmental samples were carried out in accordance with the Sampling and Analysis Plan (Anchor QEA 2015) and the methods used for the Pearce Creek DMCF Exterior Monitoring Program (Anchor QEA 2016a, 2016b, 2017a, 2017b, 2018, 2019a, 2019b). 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 fall 2019, sample RB-01 was composed of 1.5% gravel, 96.2% sand, 2.3% silts and clays. Sample RB-02 was composed of 7.9% gravel, 88.8% sand, and 3.3% 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 1.7 milligrams per kilogram (mg/kg) at RB-01 and 1.3 mg/kg at RB-02. TKN concentrations at RB-01 and RB-02 were 130 mg/kg. The ammonia concentration at RB-01 was 11 mg/kg. Ammonia was not detected at RB-02. Total phosphorus was 14 mg/kg at RB-01 and 18 mg/kg at RB-02. Sulfide was not detected at either location. Nutrient concentrations in the fall 2019 sampling event were all within the range of the six previous sampling events (spring 2016, fall 2016, spring 2017, spring 2018, fall 2018, and spring 2019).

Of the 13 tested metals, 9 were detected in at least one sample. Mercury, selenium, 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 (64 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 values at RB-01 were substantially less than hardness values reported at RB-02 (64 mg/L versus 660 mg/L). 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 6.4 mg/L at RB-01 and 7 mg/L at RB-02. Ammonia was detected at a concentration of 0.11 mg/L at RB-01 and was not detected at RB-02. The nitrate concentration was 0.9 mg/L at both RB-01 and RB-02. Nutrient concentrations in the fall 2019 sampling event generally fall within the range of concentrations from the previous six sampling events (spring and fall 2016, spring 2017, spring and fall 2018, and spring 2019) at RB-01 and RB-02.

Of the 16 tested metals, eight were detected in one or both surface water samples (aluminum, antimony, arsenic, copper, iron, manganese, nickel, and zinc). 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 six 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 Table 4. The salinity measured at both RB-01 and RB-02 was 3.3 parts per thousand (ppt; Table 1); therefore, both locations were classified as oligohaline (bottom salinity ranging from 0.5 to 5 ppt).

Total benthic abundance (total number of organisms per square meter [m^2]) was 1,697 organisms/m^2 at RB-01 and 2,117 organisms/m^2 at RB-02 (Table 4). Twenty-four benthic taxa were collected from the River Beach locations (Table 4). Twenty-one taxa were collected at RB-01: Diptera (13 taxa), Oligochaete (3 taxa), Bivalves (2 taxa), Crustacea (1 taxon), Isopoda (1 taxon), and Polychaete (1 taxon). Fourteen taxa were collected at RB-02: Diptera (6 taxa), Oligochaete (3 taxa), Isopoda (1 taxon), Bivalves (1 taxon), Polychaete (1 taxon), 1 Nemetera (1 taxon), Trichoptera (1 taxon). Tubificidae were the dominant taxa at both RB-01 and RB-02.

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 4.0 and the species richness at RB-02 was 2.3. Species richness values were comparable with, if not slightly greater than, values observed in previous years (Table 4).

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 0.78 and 0.68, respectively. The evenness values at RB-01 and RB-02 were comparable to those observed in all six previous monitoring events (Table 4).

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 3.3 and 2.4, respectively which were within the range of Indices observed in the previous monitoring events (Table 4).

Simpson’s Dominance Index measures the diversity of a sample, with a lower value indicating a more diverse community. Simpson’s Dominance Index was 0.14 at RB-01 and 0.30 at RB-02 (Table 4), both of which are lower than the values observed during previous monitoring events.

Results for the benthic community evaluation for fall 2019 were generally consistent with the results for the six previous sampling events (spring 2016, fall 2016, spring 2017, spring 2018, fall 2018 and spring 2019; Table 4). The benthic metrics were within the range of those observed in the previous six sampling events (Table 4), 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 fall 2019 sampling event, both locations were comprised primarily of coarse-grained material – RB-01 was 97.7% sand and gravel and RB-02 was 96.7% 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 5). 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 98% and 100% at RB-01 and RB-02. The survival result was not statistically different (p=0.05) from the mean survival in the control sediment (94%). 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 fall 2019 samples were comparable with the results for spring and fall 2016, spring 2017, spring and fall 2018, and spring 2019, 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 and fall 2016, spring 2017, spring and fall 2018, and spring 2019) and will be compared to any potential future data collection efforts to identify any trends or changes in sediment quality, surface water quality, benthic community, and benthic bioassays. The data collected over the course of this monitoring program will be analyzed and used to determine the need for additional monitoring events in the future.

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.

Anchor QEA, 2017a. *Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program: Monitoring Report – Fall 2016*. Prepared for Maryland Port Administration and Maryland Environmental Service. April 2017.

Anchor QEA, 2017b. *Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program: Monitoring Report – Spring 2017*. Prepared for Maryland Port Administration and Maryland Environmental Service. December 2017.

Anchor QEA, 2018. *Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program: Monitoring Report – Spring 2018*. Prepared for Maryland Port Administration and Maryland Environmental Service.

Anchor QEA, 2019a. *Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program: Monitoring Report – Fall 2018*. Prepared for Maryland Port Administration and Maryland Environmental Service.

Anchor QEA, 2019b. *Pearce Creek Dredged Material Containment Facility Exterior Monitoring Program: Monitoring Report – Spring 2019*. Prepared for Maryland Port Administration and Maryland Environmental Service.

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.

Figures

LEGEND:

Exterior Monitoring Area

Pearce Creek DMCF

NOTE:

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

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Figure 1

Site Location Map

Fall 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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Figure 2
Pearce Creek Beach Sampling Locations
Fall 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	9/18/2019	1125	645437.888	1599400.533	6.4	23.9	3.31	7.72	4.5	7.58
RB-02	9/18/2019	950	645003.536	1598557.923	4.8	23.9	3.32	7.22	4.7	7.53

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						
				Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Physical Characteristics										
Gravel	%	--	--	**9.4**	**40.4**	**1.4**	**0.8**	**0**	**2.2**	**1.5**
Sand	%	--	--	**20.7**	**59**	**97**	**97.2**	**97.3**	**96.5**	**96.2**
Silt	%	--	--	**37**	**0.4**	**0.02**	**0.4**	**1.1**	0.01 U	**0.5**
Clay	%	--	--	**32.9**	**0.2**	**1.6**	**1.6**	**0.5**	**1.3**	**1.8**
Specific Gravity	--	--	--	**2.64**	**2.67**	**2.68**	**2.67**	**2.68**	**2.68**	**2.67**
Nutrients										
Total Organic Carbon	%	--	--	**2.9**	**0.17**	**0.62**	**0.33**	**0.19**	0.14 U	0.14 U
Nitrate + Nitrite	mg/kg	--	--	**4.2**	1.3 U	1.3 J	**1.5**	**1.6**	**1.2 J**	**1.7**
Total Kjeldahl Nitrogen	mg/kg	--	--	**2,200**	**140 J**	**390 U**	**200 J**	**150 J**	**160 J**	**130 J**
Ammonia	mg/kg	--	--	**150**	**10**	**20**	**8.9 J**	7.8 U	**9.5 J**	**11 J**
Total Phosphorus	mg/kg	--	--	**620**	**31**	**78**	**51**	**58**	**49**	**14**
Sulfide	mg/kg	--	--	**460**	38 U	73 U	25 J	41 U	**16 J**	41 U
Metals										
Antimony	mg/kg	--	--	**0.29**	**0.11 J**	**0.11 J**	**0.30**	**0.077 J**	**0.062 J**	0.14 U
Arsenic	mg/kg	9.79	33	**7.1**	**1.9**	**1.3**	**1.1**	**1.0**	**0.7**	**0.5**
Beryllium	mg/kg	--	--	**1.3**	**0.4**	**0.21**	**0.14**	**0.1**	**0.1**	**0.13**
Cadmium	mg/kg	0.99	4.98	**0.31**	**0.21**	**0.043 J**	**0.042 J**	**0.055 J**	**0.021 J**	**0.023 J**
Chromium	mg/kg	43.4	111	**29**	**7.4**	**8.6**	**5.7**	**6.3**	**6.0**	**5.9**
Copper	mg/kg	31.6	149	**21**	**1.8**	**2.3**	**1.8**	**3.3**	**1.6**	**1.3**
Lead	mg/kg	35.8	128	**32**	**1.5**	**5.1**	**5.1**	**3.7**	**3.5**	**2.2**
Mercury	mg/kg	0.18	1.06	**0.08**	0.019 U	0.041 U	0.041 U	0.025 U	0.021 U	0.022 U
Nickel	mg/kg	22.7	48.6	**33**	**3.1**	**4.1**	**4.1**	**2.7**	**2.6**	**2.2**
Selenium	mg/kg	--	--	**1.6**	**0.5**	**0.25 J**	**0.25 J**	**0.087 J**	**0.25 J**	0.34 U
Silver	mg/kg	--	--	**0.25**	**0.008 J**	**0.12 U**	**0.12 U**	**0.038 J**	0.07 U	0.068 U
Thallium	mg/kg	--	--	**0.15**	**0.0049 J**	**0.012 J**	**0.012 J**	**0.018 J**	0.07 U	0.068 U
Zinc	mg/kg	121	459	**120**	**13**	**19**	**9.7**	**11**	**10**	**6.8**

Notes:

Bold indicates detected constituents.

(green shading): 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 2
Analytical Results for Sediment Samples

Analyte	Units	TEC	PEC	River Beach Location 2 Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Characteristics										
Gravel	**%**	--	--	**7.8**	**17.0**	**9.6**	**15.1**	**17.4**	**5.4**	**7.9**
Sand	**%**	--	--	**91**	**81.5**	**87.1**	**84.1**	**76.3**	**93.5**	**88.8**
Silt	**%**	--	--	**0.4**	**0.9**	**1.7**	0	**5.1**	**0.4**	**2**
Clay	**%**	--	--	**0.8**	**0.6**	**1.6**	**0.8**	**1.3**	**0.8**	**1.3**
Specific Gravity	**--**	--	--	**2.69**	**2.66**	**2.67**	**2.67**	**2.65**	**2.68**	**2.68**
Nutrients										
Total Organic Carbon	%	--	--	**0.15**	**0.15**	0.13 U	**0.23**	**0.15**	0.13 U	0.13 U
Nitrate + Nitrite	mg/kg	--	--	**1.6**	**0.58 J**	1.2 U	**2**	**1.1 J**	**1.4**	**1.3**
Total Kjeldahl Nitrogen	mg/kg	--	--	**210**	**96 J**	200 U	**540**	**300**	**200**	**130 J**
Ammonia	mg/kg	--	--	12 U	**8.2**	**10.0**	8.2 U	6.7 U	13 U	14 U
Total Phosphorus	mg/kg	--	--	**42**	**31**	**30**	**33**	**17**	**24**	**18**
Sulfide	mg/kg	--	--	**9.8 J**	**9.1 J**	38 U	**22 J**	36 U	39 U	40 U
Metals										
Antimony	mg/kg	--	--	**0.077 J**	**0.05 J**	**0.029 J**	**0.061 J**	**0.053 J**	0.13 U	**0.077 J**
Arsenic	mg/kg	9.79	33	**0.82**	**0.50**	**0.47**	**0.45**	**0.57**	**0.65**	**0.64**
Beryllium	mg/kg	--	--	**0.08**	**0.059 J**	**0.054 J**	**0.066 J**	**0.18**	**0.036 J**	**0.15**
Cadmium	mg/kg	0.99	4.98	**0.013 J**	**0.21**	**0.017 J**	**0.014 J**	**0.029 J**	**0.012 J**	**0.016 J**
Chromium	mg/kg	43.4	111	**4.3**	**4.7**	**3.5**	**3.8**	**18**	**3.5**	**8.6**
Copper	mg/kg	31.6	149	**1.6**	**1.1**	**0.93**	**1.2**	**5.3**	**0.78**	**1.1**
Lead	mg/kg	35.8	128	**2**	**1.6**	**1.6**	**1.7**	**5.3**	**1.5**	**3.1**
Mercury	mg/kg	0.18	1.06	**0.0042 J**	0.02 U	0.02 U	0.022 U	0.02 U	0.02 U	0.022 U
Nickel	mg/kg	22.7	48.6	**1.4**	**1.1**	**1.2**	**1.4**	**2.5**	**1.4**	**1.4**
Selenium	mg/kg	--	--	**0.091 J**	**0.19 J**	**0.12 J**	**0.07 J**	**0.082 J**	**0.15 J**	0.33 U
Silver	mg/kg	--	--	**0.0053 J**	**0.008 J**	0.063 U	0.071 U	0.061 U	0.064 U	0.066 U
Thallium	mg/kg	--	--	**0.0063 J**	**0.0036 J**	**0.0036 J**	0.071 U	**0.0083 J**	0.064 U	0.066 U
Zinc	mg/kg	121	459	**5.1**	**5.2**	**5.1**	**5.1**	**8.3**	**4.9**	**5.9**

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

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						
				Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Hardness	mg/L	--	--	**86**	**880**	**72**	**86**	**70**	**60**	**64**
Total Phosphorus	mg/L	--	--	**0.049 J**	**0.14**	0.1 U	**0.11**	**0.051 J**	0.1 U	0.1 U
Total Suspended Solids	mg/L	--	--	**11**	**40**	**8.9**	**39**	**10**	**4**	**6.4**
Ammonia	mg/L	--	--	**0.2**	**0.21**	**0.18**	**0.38**	**0.12**	**0.048 J**	**0.11**
Total Kjeldahl Nitrogen	mg/L	--	--	5 U	**2.2 J**	**11**	**1.7 J**	5 U	5 U	5 U
Nitrate+Nitrite	mg/L	--	--	**0.85**	**0.41**	**0.66**	**0.69**	**1.2**	**1.4**	**0.9**
Metals										
Aluminum	µg/L	750	87	**19 J**	**33**	30 U	**190**	**67**	30 U	**19 J**
Antimony	µg/L	--	--	**0.27 J**	**0.61 J**	**1.5 J**	2 U	2 U	**0.39 J**	**0.41 J**
Arsenic	µg/L	340	150	**0.83 J**	**0.77 J**	**0.34 J**	**1.4**	**0.65 J**	**0.44 J**	**0.96 J**
Beryllium	µg/L	--	--	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
Chromium[a]	µg/L	375	48.8	**1.3 J**	**0.39 J**	2 U	**2.2**	**1.1 J**	2 U	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**	**0.97 J**
Iron	µg/L	--	1,000	**31 J**	**88**	50 U	**460**	**120**	50 U	**25 J**
Lead[a]	µg/L	37	1.44	1 U	**0.25 J**	1 U	**0.38 J**	**0.14 J**	1 U	1 U
Manganese	µg/L	--	--	**3.9 J**	**810**	5 U	**260**	**15**	**2 J**	**40**
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
Nickel[a]	µg/L	304	34	**1.2**	**4.6**	**1**	**3.5**	**1.3**	**1**	**1.8**
Selenium	µg/L	20	5	5 U	**0.57 J**	5 U	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
Thallium	µg/L	--	--	1 U	1 U	**0.054 J**	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	**14**

a. Acute and chronic water quality criteria are adjusted for a hardness of 64 mg/L.

Bold indicates detected constituents.

▭: constituents that exceed chronic criteria

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 3
Analytical Results for Surface Water Samples

Analyte	Unit	Acute Water Quality Criteria	Chronic Water Quality Criteria	River Beach Location 2						
				Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Hardness	mg/L	--	--	**86**	**940**	**70**	**86**	**72**	**62**	**660**
Total Phosphorus	mg/L	--	--	0.1 U	**0.1**	**0.037 J**	0.1 U	0.1 U	0.1 U	0.1 U
Total Suspended Solids	mg/L	--	--	**8.4**	**22**	**7.1**	**29**	**6.1**	**5.4**	**7**
Ammonia	mg/L	--	--	**0.15**	**0.16**	**0.16**	**0.21**	**0.051 J**	0.1 U	0.1 U
Total Kjeldahl Nitrogen	mg/L	--	--	5 U	**2.2 J**	**3.4 J**	5 U	5 U	5 U	5 U
Nitrate+Nitrite	mg/L	--	--	**0.83**	**0.25**	**0.65**	**0.95**	**1.2**	**1.4**	**0.93**
Metals										
Aluminum	µg/L	750	87	**16**	**48**	**16 J**	**22 J**	**14 J**	30 U	30 U
Antimony	µg/L	--	--	**0.26 J**	**0.93 J**	**0.98 J**	2 U	2 U	**0.4 J**	**0.43 J**
Arsenic	µg/L	340	150	**0.77 J**	**1.3**	**0.41 J**	**1.2**	**0.69 J**	**0.47 J**	**0.99 J**
Beryllium	µg/L	--	--	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
Chromium[a]	µg/L	375	48.8	**1.2 J**	**0.55 J**	2 U	**1.9 J**	**1.1 J**	2 U	2 U
Copper[a]	µg/L	8.3	5.8	**1.3 J**	**2.4**	2 U	**1.7 J**	**1.4 J**	**1.1 J**	**0.97 J**
Iron	µg/L	--	1,000	**28 J**	**51**	**23 J**	**37 J**	**26 J**	50 U	50 U
Lead[a]	µg/L	37	1.44	1 U	**0.35 J**	1 U	1 U	**0.15 J**	1 U	1 U
Manganese	µg/L	--	--	**4 J**	**43**	**3.2 J**	**5.4**	**8.9**	**19**	**34**
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
Nickel[a]	µg/L	304	34	**1.2**	**2.6**	**0.69 J**	**1.6**	**1.3**	**1.2**	**1.6**
Selenium	µg/L	20	5	5 U	**0.96 J**	5 U	5 U	5 U	5 U	5 U
Silver[a]	µg/L	1.34	--	1 U	**0.3 J**	1 U	1 U	1 U	1 U	1 U
Thallium	µg/L	--	--	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Zinc[a]	µg/L	76	77	**3.4 J**	**3.5 J**	5 U	5 U	**5.1**	5 U	**4.4 J**

a. Acute and chronic water quality criteria are adjusted for a hardness of 64 mg/L

Bold indicates detected constituents.

: constituents that exceed chronic criteria

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
Benthic Community Metrics

Metric	River Beach Location 1						
	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Total Abundance/m^2	1,907	1,773	2,250	3,509	2,727	2,892	1,697
Infaunal Taxa	14	15	12	16	11	15	21
Species Richness (Ludwig-Reynolds)	2.6	3.1	2.3	2.9	2.0	2.8	4.0
Evenness	0.74	0.67	0.69	0.78	0.48	0.80	0.78
Shannon-Wiener H' (log base 2)	2.7	2.6	2.5	3.1	1.7	3.1	3.3
Simpson's Dominance Index	0.21	0.25	0.24	0.15	0.41	0.15	0.14
Percent Abundance Pollution Indicative Species	38	43	21	18	18	27	75
Percent Abundance Deep Deposit Feeders	38	0	33	45	19	46	35
Tolerance Score	5.05	1.30	5.6	5.8	5.6	6.7	6.3

Metric	River Beach Location 2						
	Spring 2016	Fall 2016	Spring 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Total Abundance/m^2	2,333	3,502	2,981	7,024	7,462	11,066	2,117
Infaunal Taxa	15	12	11	12	16	18	14
Species Richness (Ludwig-Reynolds)	2.5	2.1	2.0	1.9	2.5	2.7	2.3
Evenness	0.73	0.68	0.76	0.77	0.42	0.49	0.68
Shannon-Wiener H' (log base 2)	2.7	2.4	2.6	2.8	1.7	2.1	2.4
Simpson's Dominance Index	0.21	0.24	0.20	0.19	0.42	0.18	0.30
Percent Abundance Pollution Indicative Species	32	66	14	3	26.9	37.7	88.0
Percent Abundance Deep Deposit Feeders	62	0	24	57	28.5	48.1	27.9
Tolerance Score	8.04	4.52	4.8	7.0	6.75	5.7	5.4

Note:
m^2: square meter

Table 5

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	Fall 2019
Survival	Mean Laboratory Control	Mean Survival %	94%	94%	94%	91%	91%	100%	94%[b]
	≥ 80%	Protocol Met	Yes	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	0.0234
	End vs. Start of Assay	End Dry Weight (mg)	0.143	0.124	0.147	0.659	0.102	0.134	0.0969
	Protocol Met		Yes	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	22.6 / 22.7
	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	22.8 / 21.6	21.9 / 21.3
	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	23.2 / 23.4
	Protocol Met		Yes / Yes	No / Yes	Yes / Yes	Yes / Yes	Yes / No[a]	Yes / Yes	Yes / Yes

Note:

mg: milligram

a. 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.

b. Mean *Hyalella azeteca* survival was 98% at RB-01 and 100% at RB-02.