TECHNICAL MEMORANDUM
MAURICE RIVER ARSENIC INVESTIGATION
VINELAND, NEW JERSEY
WORK ASSIGNMENT SERAS-185

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1.0 INTRODUCTION

1.1 Purpose

This technical memorandum presents the results of a three-year study of the Maurice River, Blackwater Branch and Union Lake (Maurice River system). Data included in this report were collected from July 2012 through August 2014. The purpose of this investigation was to:

1) Assess extent of contamination (current sediment/arsenic loading in the Maurice River),

2) Assess arsenic transport or arsenic flux through the Maurice River System, and

3) Evaluate high-use areas along Maurice River and Union Lake for potential threats to human health and the ecological systems.

The methodology used for this investigation was specified in the Work Assignment (WA) provided by the U.S. Environmental Protection Agency (EPA)/Environmental Response Team (ERT). All data collected during this investigation were incorporated into a Scribe file and summarized in the tables and figures included in this report.

1.2 Site Background

The Maurice River is located adjacent to the Vineland Chemical Company located in Vineland, New Jersey (Cumberland County). The Vineland Chemical Company was added to the National Priorities List (NPL) on September 1, 1984 because of hazardous chemicals found in the soil and groundwater. From 1949 to 1994, this 54-acre facility manufactured arsenic-based herbicides which have contaminated the nearby Blackwater Branch and approximately eight miles of the Maurice River to Union Lake. The lower Maurice River system extends 26 miles from Union Lake to the Delaware Bay. Approximately 57,000 people depend on the groundwater system in the area for drinking water, either through private or municipal wells. The groundwater is contaminated with organic and inorganic arsenic, along with some minor amounts of other metals.

In 1992 and 1993, EPA removed hazardous chemicals stored on the site and boarded up abandoned buildings. By 2004, EPA had demolished all abandoned buildings on-site. EPA constructed a soil washing facility that processed 70 tons of soil per hour as part of Operable Unit 1. To address contaminated groundwater, EPA constructed a system to pump out and treat approximately two million gallons of contaminated groundwater (Operable Unit 2). As part of Operable Unit 2 (OU2), from 2003 to 2007, 400,000 tons of sediment from the Blackwater Branch floodplain were excavated and treated in the on-site washing facility. After backfilling, the Blackwater Branch stream channel and floodplain should have been restored to levels that are protective of public health and environment. As of Spring 2012, all remediation of the channel and wetland floodplain have been completed and the areas restored. Work under the Blackwater Branch and the Maurice River are a part of Operable Unit 3 (OU3) River Areas. Operable Unit 4 (OU4) includes evaluation of Union Lake.

1.3 Maurice River Watershed

The Maurice River Watershed (including the study area) is located in the Atlantic Coastal Plain province and Coastal Plain Sole-Source Region (Wilber and Johnson, 1940; Hoffman, 1999). The watershed lies within an important recharge area for the regional Cohansey-Kirkwood Aquifer system, a primary

groundwater resource that provides greater than 50 percent (%) of the potable water for Cumberland, Cape May and Atlantic Counties (Hoffman, 1999; Sugarman, 2001).

The Maurice River Watershed, drains approximately 384 square miles of the eastern portions of Salem and Gloucester Counties, and all of Cumberland County (Figure 1). The watershed is characterized by low relief with the topography sloping gently to the southwest toward the Delaware Bay (Bay). Topographic relief in the watershed ranges from 130 feet above sea level in the headwaters to near sea level in the wetlands along the shoreline of the Bay.

The Maurice River (River) is the primary hydraulic feature in the watershed, extending approximately 30 miles down gradient from the headwaters in Salem and Gloucester Counties, through Cumberland County, and eventually discharges into the Bay at the town of Port Norris. The River flows in a southerly direction with stream flow contribution coming from a number of tributaries. The land where the former Vineland Chemical company was located, is on the Blackwater Branch tributary about one mile upstream of the confluence with the River. Approximately 7.5 miles downriver of the confluence, the River discharges into the Union Lake reservoir, a public recreational area (Figure 1). Union Lake is approximately six miles long with the dam located near the town of Millville. Water flows over the dam's spillway into the downstream reach of the River.

1.4 Geologic History

The local geologic and hydrostratigraphic units of the study area are summarized in Table 1. The Modern alluvium that fills the Maurice River Watershed is characterized as very clean silt, sand and pebble quartz that were deposited as fluvial channel (gravel and sand) or overbank deposits (silt and clay). The alluvial material was locally derived from the Cape May and Bridgeton Formations and to a lesser extent the Cohansey Formation (Rooney, 1971; Cauller and Carlton, 2005).

The Cape May and Bridgeton Formations are non-marine terrace deposits, composed of unconsolidated sands that were laid during the Pleistocene glacial event when sea levels were near their lowest (Rooney, 1971). The Cape May and Bridgeton Formations unconformably overlie the Cohansey Formation, the only Tertiary Marine formation exposed in the study area.

The Cohansey Formation marks the lowstand of a marine regression that occurred in the upper Tertiary. The Cohansey Formation represents deposition in a near shore marine environment, as characterized by very clean medium to coarse sands. Conformably underlying the Cohansey Formation is the Kirkwood Formation, which was deposited in shallow marine environment near or below the wave base. The Kirkwood Formation as characterized by clean silt to medium sand. Conformably underlying the Kirkwood Formation is the Piney Point Formation that is characterized by fine to coarse grain quartz sand mixed with lesser amounts of glauconite (green clay). Deposition of the Piney Point Formation marks a decline in sea level and increase in sediment load. The lower most Vincentown Formation is a fossiliferous glauconite clay and silt to fine quartz sand that was deposited in a moderately deep, sediment starved environment.

1.5 Operable Unit 3 Requirements and Previous Studies

Operable Unit 3 (OU3) is defined in the EPA Record of Decision (ROD) as the River Areas Sediments located hydraulically down gradient of the Vineland Chemical Plant or Operable Unit 1 (EPA, 1989). The first portion of the ROD specifies the removal and treatment of submerged sediments in the Blackwater Branch and exposed sediments in the Blackwater Branch floodplains adjacent to and downstream of the Vineland Chemical Company plant site. From 2003 to 2007, EPA excavated and

treated 400,000 tons of sediment from the Blackwater Branch floodplain in the on-site washing facility. After backfilling, the Blackwater Branch stream channel and floodplain should have been restored to levels that are protective of public health and environment. As of spring 2012, all wetland floodplain sections of the Blackwater Branch have been restored.

The ROD states that after the channel and wetland restoration of the Blackwater Branch (OU3) and stopping the flow of arsenic-contaminated groundwater from the Vineland Chemical Company plant site (OU2), a three year period for natural river flushing will be implemented. After this period, if the sediments are no longer contaminated with arsenic above the action level or if the levels remain above the action limit but with an acceptable public health risk no remediation will be performed

Natural river flushing will allow the submerged, arsenic-contaminated sediments in the Maurice River to be flushed clean through natural processes. If, after this period, the submerged sediments are no longer contaminated with arsenic above the action level, no remediation will be performed in the river. The ROD specified an arsenic cleanup level of 120 milligrams per kilograms (mg/kg) for submerged sediments and level of 20 mg/kg for floodplains area.

The ROD also specifies that a "mass balance of arsenic coming in and out of the (Maurice River) basin will be determined to aid in the assessment of the river's natural flushing mechanisms." The mass balance study, sediment and water sampling will be used to support decisions regarding the extent of remediation necessary in the Maurice River Basin.

After stopping the flow of arsenic-contaminated groundwater from the Vineland Chemical Company plant site to the Maurice River system (OU2), but prior to the completion of the remediation of the Blackwater Branch channel and wetland, an arsenic mass balance study was conducted (Foster Wheeler, 1996). Arsenic flux estimates were obtained for total (unfiltered) and dissolved (filtered) arsenic along with discharge rates at four stations along the Maurice River. Below is a summary of the arsenic flux rates obtained during this investigation. These averages were calculated based on 15 to 22 measurements (depending on the station) over a two-year period from 1992 to 1993. Data were divided between normal flow events and storm flow events.

Arsenic Flux (Total Arsenic)	Garden Rd	Station #1 (Confluence of BWB and Maurice River)	Station #2 (Below Almond Beach Spillway)	Station #3 (Sherman Ave)
Normal Flow				
Average Discharage (cfs)	116	15.6	131	228
Arerage Arensic Flux Flux (g/s)	0.002	0.079	0.065	0.077
Average Arsenic Flux (kg/year)	63	2,493	2,051	2,430
Average Water Arsenic (µg/L)	4.3	186	20.2	13.4
Storm Flow				
Average Discharge (cfs)	122	16.2	146	265
Average Arsenic Flux (g/s)	0.005	0.092	0.093	0.10
Average Arsenic Flux (kg/year)	158	2,903	2,935	3,156
Average Water Arsenic (µg/L)	6.0	213	26.7	13.9

cfs = cubic feet second; g/s = grams per second; kg = kilogram; µg/L = micrograms per liter; BWB = Blackwater Branch

During normal flow events the total arsenic flux ranged from as low as 2,051 kilograms per year (kg/year) at Station #2 (Below the Almond Beach Spillway) to 2,493 kg/year at Station #1 (Confluence of Blackwater Branch and Maurice River). During storm flow measurements there was an increase in discharge and surface water arsenic concentrations resulting in increased arsenic flux rates from 16% at Station #1 (Confluence of Blackwater Branch and Maurice River) to 43% at Station #2 (Below Almond Beach Spillway).

Unfiltered samples provided information on the total arsenic flux consisting of the suspended load and dissolved/adsorbed phases; while the filtered samples provided information on the dissolved/adsorbed phase flux. The results show that under normal flow conditions, 56 to 75% of the total arsenic flux is transported in solution as either dissolved or adsorbed phase (Foster Wheeler, 1996).

2.0 METHODOLOGY

2.1 Sediment Arsenic Loading

Sediment arsenic loading was evaluated over a three-year period between 2012 and 2014 in the Maurice River from the confluence with the Blackwater Branch to the upper reaches of Union Lake above the low head dam. Upstream reference samples were collected on the Maurice River at Garden Road and the Blackwater Branch near North Delsea Drive.

Several methods were used to assess arsenic concentrations in the surficial subsurface sediments (arsenic sediment loading) and to assess the sediment characteristics. Table 2 provides a breakdown of the number of samples collected for each sampling event by matrix during the 3-year investigation.

2.1.1 Surficial Sediment Samples

Surface sediments were collected from depths between 0 and 6 inches using a petite ponar dredge. The sediments collected from the petite ponar dredge were placed directly into a dedicated aluminum pan. The sediment was thoroughly mixed and then placed in a labeled glass jar for analysis. All surficial sediments collected during the three-year investigation were analyzed for arsenic; a subset of these samples collected during Year 1 of the investigation were also analyzed for grain size. Locations selected for grain size analysis were chosen based on the presence of enough sample material to perform the analysis, and on visual inspection of the cores (professional judgment). Table 3 and Figure 2 provide a summary of the number of surficial sediment samples collected by Area.

During Year 1 of the investigation transect lines were set up and sampled at Alliance Beach area, the first area sampled. Transect lines that were aligned perpendicular to the two shorelines and ran east to west across the river were spaced approximately 30 feet apart. To expedite the sampling time at the remaining areas (Almond Beach and BA Beach) sample locations were not selected along transects but rather were selected to obtain adequate and complete coverage throughout the sample area. This methodology was carried through the remaining two years of the investigation (Year 2 and Year 3).

The results of the Year 1 sampling indicated that most samples consisting primarily of sand were also associated with very low arsenic concentrations. Based on that information, Year 2 sampling focused on locations that had higher percentages of silt/clay and lower percentages of sand/gravel. Sediment characteristics (see Section 2.1.2) were collected at all locations, but a sample was not analyzed for arsenic if upon collection it could be seen to contain a larger percentage of gravel or

sand. During the third year, samples were collected and submitted for arsenic analysis at all locations regardless of grain size characteristics. Also during Year 3, sampling teams returned to a hot spot identified in Year 1, located in the Alliance Beach area. Fifteen additional samples were collected within 100 feet of the hot spot. These samples were used to delineate the hot spot and to determine if the hot spot was an isolated point or consistent with the surrounding sediments.

Year 1 focused on three areas, the Alliance Beach area, the Almond Beach area and the BA Beach area plus a limited number of samples were collected from two reference areas (Blackwater Branch upstream/up gradient of the Vineland Chemical site and the Maurice River near Garden Road upstream of the confluence with the Blackwater Branch). In Year 2 sampling continued at the Almond Beach area and the Utility Access area, Sherman Ave to Union Lake area, the Northeast Cove area and Union Lake Low Head Dam area. In Year 3 sampling was continued at Alliance Beach, Almond Beach, Utility Access Areas, and Sherman Ave to Union Lake. The Floodplain Areas and the Northwest Cove of Union Lake were also sampled. Below is a summary of annual sampling by area; for specific numbers of sediment samples collected by area see Table 3.

Location	Year 1	Year 2	Year 3
Blackwater Branch (Reference Area)	X	X	-
Garden Road (Reference Area)	-	X	-
Confluence	X	-	-
Alliance Beach	X	-	X
Floodplain Areas	-	-	X
Almond Beach	X	X	X
BA Beach	X	-	-
Utility Access Areas	-	X	X
Sherman Ave to Union Lake	-	X	X
Northeast Cove	-	X	-
Northwest Cove	-	-	X
Low Head Dam	-	X	-

"X" = Sampled; "-" = Not Sampled

2.1.2 Surficial Sediment Characteristics

Sediment characteristics were assessed by measuring sediment thickness and visually classifying the sediment type (e.g. silt/sand/clay/gravel). Water depth measurements were collected using a stadia survey rod by placing the bottom of the rod on top of the soft sediments without putting pressure on the rod to sink into the sediment. This measurement was then recorded into a site log book. Sediment thickness was collected by hammering a solid 6 foot x ¼ inch diameter rod into the sediment until refusal. The stick-up height (direct read from the stadia rod) was subtracted from 6 feet and then recorded in the site logbook. All logbook data was imported into SCRIBE.

2.1.3 Subsurficial Sediment Samples

Subsurface sediments were collected by hammering polycarbonate core tubes into the sediment bed to the desired depth or until refusal. Once at the final depth, the core tube was capped and withdrawn from the sediment. Once the bottom of the core was at the sediment water interface, it was also capped and the sample brought to a staging area. In the staging area, the cores were allowed to settle and the standing water above the sediment was drained by drilling a small hole above the sediment water interface. Once the standing water was removed, the core was sectioned

and sampled. Each interval was placed in a dedicated aluminum pan and thoroughly mixed. The sample was transferred to a labeled glass jar and submitted for analysis.

During this investigation, two types of subsurface sediment core samples were collected. In Year 1, cores were collected to assess the vertical extent of arsenic contamination and obtain dating information using Cesium-137 isotope analysis. These samples were collected by hammering a polycarbonate core to a maximum depth of five feet below the sediment surface or until refusal was obtained. The cores were separated into six inch (") intervals (A = 0-6", B = 6-12", C = 12-18", D = 18-24", E = 24-30", etc.); compression was assumed to be equal throughout the length of the core. If there was insufficient sample in any of the 0.5-foot intervals, the depth intervals were composited prior to analysis.

Each sample interval was placed into an aluminum pan, homogenized, placed into a labeled sample container and was submitted for arsenic analysis. Sediment core samples were collected at nineteen locations (seven at Alliance Beach area, six at Almond Beach area, three at Below Almond Beach Spillway area and three at the BA Beach area). The samples collected from the Below Almond Beach Spillway area were collected from each of three consecutive small sediment islands (sediment depositional areas) located immediately below the spillway; the remaining core samples were collected from sediment depositional areas characterized by soft silts and clays. At six locations sediment samples were also collected for Cesium-137 analysis. Cesium-137 analysis was used to gain perspective on when the sediments were deposited. Table 4 provides a summary of the number of subsurface core samples collected during each year of the investigation.

During Year 3 of the study, mixed cores were collected to assess the grain size distribution and their associated arsenic concentrations. These core samples were collected by pushing a core into the sediment to a maximum depth of five feet below the sediment surface or until refusal. Multiple cores were collected at each sample location until sufficient volume was obtained for analysis. Cores at each location were composited into a plastic bucket and mixed. The samples were submitted to the EPA Department of Environmental Science and Assessment (DESA) laboratory for processing. The DESA laboratory separated each sample into three fractions (pore water, sands and silts/clays). Each fraction was analyzed separately for arsenic concentration.

2.2 Arsenic Flux via Surface Water

To evaluate migration of arsenic being transported by surface water through the Maurice River system, flow rates and associated arsenic surface water concentrations (total and dissolved) were assessed at six locations (AF2 – Garden Road/Maurice River Upstream Reference, AF3 – Alliance Beach, AF4 – Almond Beach below the spillway, AF5 – Sherman Ave; BFB – Confluence of the Maurice River and the Blackwater Branch; Figure 3) on the Maurice River and one location on the Blackwater Branch (AF1 – Garden Road/Blackwater Branch Reference Location; Figure 3). AF1 was used as the upstream reference for the Blackwater Branch and AF2 was used as the upstream reference for the Maurice River. A total of five sampling events were conducted over the 3-year investigation as shown in Figure 3 and summarized below:

Sample Location	Location Description	July 2012	October 2012	May 2013	October 2013	July 2014	August 2014
AF1	Blackwater Branch @ N. Delsea Drive (Reference)	X	X	X	X	X	-

Sample Location	Location Description	July 2012	October 2012	May 2013	October 2013	July 2014	August 2014
AF2	Maurice River @ Garden Road (Reference)	X	X	X	X	X	-
BWB	Confluence of Blackwater Branch and Maurice River	-	-	-	-	-	X
AF3	Maurice River @ Alliance Beach	X*	X	-	X	X	-
AF4/ AF4A	Maurice River @ Almond Beach (below spillway)	X	X	X	X	X	-
AF5	Maurice River @ Sherman Ave.	X	X	-	X	X	-

"X" = Sampled; "-" = Not Sampled

*Water Samples were collected but water flow data was not collected

At each location, a transect line was set up across the river, by stretching a survey tape from bank to bank. Water depths and water velocities were measured at fixed intervals along the transect line. The number of measurements taken was dependent on the width of the river at each location. Water depth was measured with a survey rod to the nearest 0.1-foot and water velocities were measured using a portable electromagnetic flowmeter, which was calibrated and used as per the manufacturer's operations manual. Typically, water depths were measured along the transect at three depths at each measurement point: 6" below the surface, 6" above the bottom and mid-depth. Fewer velocity measurements were made for shallow locations where these depth intervals would overlap.

Water quality parameters (temperature, pH, dissolved oxygen, conductivity, oxidation reduction potential [ORP] and turbidity) were measured using a Horiba U-52 (operated in accordance with the manufacturer's operations manual) and recorded in a site log book. Evenly spaced surface water samples were collected at two to three locations (depending on stream width) along each transect. Two samples were collected at each location, one for total arsenic and one for dissolved arsenic. Water samples were collected from approximately 2-feet below the surface of the river, directly into a sample container. The sampler approached the transect line/sample location from a downstream direction to avoid disturbing sediments prior to collecting the surface water sample. Samples analyzed for dissolved arsenic were filtered using a 0.45 micron (μm) filter. Samples were preserved to a pH less than (<) 2 using 40% nitric acid and then submitted to the laboratory for arsenic analysis.

During the first arsenic flux water sampling event (July 2012) water samples and water quality parameters were collected from immediately below the Almond Beach Spillway (AF4), but a transect was not set up to measure cross section area or flow rates. For subsequent sampling events, the location was moved approximately 200 feet downstream and was changed from AF4 to AF4A. Due to high water levels in the Maurice River, location A5 could not be sampled during the May 2013 sampling event. Location BWB was sampled once in August 2014 and no other stations were sampled during that event. An additional round of water sampling will be conducted in Fall 2015.

Field data for each of the sampling events were tabulated and cross sections were drawn for each transect for each sampling event. To calculate the cross-sectional area for each transect, geometric approximations were used. The average stream velocity was multiplied by the cross-sectional area to calculate a total discharge for each transect. The total discharge multiplied by the average dissolved and

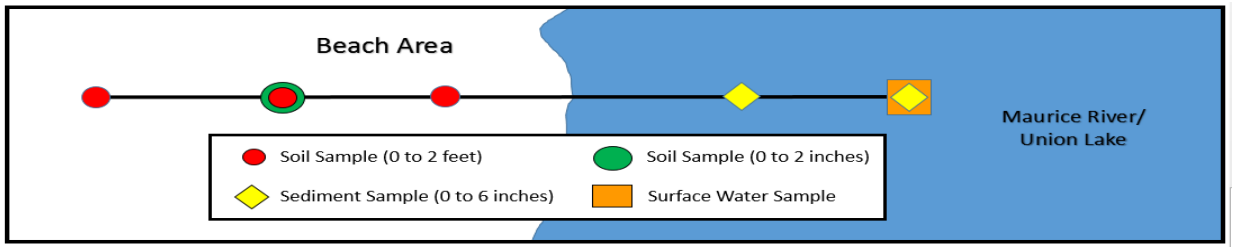
total arsenic concentration provided the mass flux of arsenic at each transect during each of the two sampling events.

2.3 Human Health Risk Assessment Data

To evaluate potential human health risk, soil (primarily beach sand), sediment and surface water samples were collected from high-use areas. Sampling was performed at the following locations as shown in Figure 4:

1) Alliance Beach (Maurice River)
2) Almond Beach (Maurice River)
3) BA Beach (Maurice River)
4) Union Lake Sailing and Tennis Club (Union Lake)
5) New Jersey Department of Environmental Protection (DEP) Boat Launch (Union Lake)
6) Sharp Street Beach (Union Lake)

As specified by EPA Region 2, the following methodology was followed to assess the risk to human health from exposure to arsenic in surface water, sediment or beach sand (soil) at each of six areas listed above. At each beach location, transects were set up from the top of the beach extending into the Maurice River or Union Lake. Along each transect, three beach sand (soil) samples were collected at three locations evenly spaced along the transect. At the first (top of transect) and third point (at water line) a single soil sample was collected (0 to 2 feet). At the second point (mid-distance on beach), two soil samples were collected (0 to 2 feet and 0 to 2 [Year 1] or 0 to 6 [Years 2 and 3] inches). The fourth and fifth location along the transect were in the water; the fourth in about 1.5 feet of water and fifth in about 3 feet of water. At both the fourth and fifth locations, a sediment sample was collected; surface water samples were only collected from the fifth location along the transect. Figure 5 and below (for a single transect) contain a general sampling schematic showing how the transects were set up and detailing the samples that were collected at each sample point along the transect.



Since the area at the DEP boat launch was a paved area with very limited beach/water access, transects were not used at this location and only a limited number of sediment and surface water samples were collected.

Beach soil samples were collected from the first three points along each transect either using a dedicated acetate sleeve for the 0 to 2 foot samples or a dedicated plastic scoop for the 0 to 2 inch (Year 1) or 0 to 6 inch (Year 2 and Year 3) samples. The sample was placed in a dedicated aluminum pan, homogenized, and transferred to labeled glassware. At the fourth point along the transect a sediment sample was collected using a ponar dredge, placed in an aluminum pan, homogenized, and transferred to labeled glassware. At the fifth point along the transect a sediment sample (as described above) and surface water samples were collected. The first water sample was an undisturbed water sample, collected before any disturbance in the water. Sediment was then agitated using the sampler's foot, and a disturbed surface water sample was collected. Water samples were collected directly into the sampling containers. Both

the disturbed and undisturbed samples were submitted for total and dissolved arsenic analysis. Water samples for dissolved metals analysis were filtered using a 0.45 micron mesh in the field and preserved with nitric acid to a pH < 2. Water samples were collected prior to the sediment sampling. All soil, sediment and surface water samples were submitted to a laboratory for arsenic analysis.

Water quality measurements were collected in each sample area using a Horiba U-52 (operated in accordance with the manufacturer's operations manual) and recorded in a site log book.

2.4 Ecological Risk Study

Below is a summary of methodology used to collect data for the Ecological Risk Study (Appendix A).

2.4.1 Sediment Toxicity

Twenty-six bulk sediment samples were collected for toxicity testing by Lockheed Martin/SERAS and United States Fish and Wildlife (US FWS) personnel on July 30 and July 31, 2015. Sufficient sediment to fill a 2.5 gallon High-Density Polyethylene (HDPE) bucket was collected at twenty-six locations selected based on availability of sediment and previous sampling results, with the intent of collecting a gradient of arsenic concentrations (Figure 6). Sediment from Union Lake was collected using a ponar dredge deployed from a pontoon boat. Sediment at most of the river locations, including two upstream reference samples (near Garden Road), were collected by ponar dredge or posthole digger. Buckets were labeled, closed, and put on ice prior to be being brought back to DESA in Edison, New Jersey (NJ). Subsamples were collected from each of the twenty-six samples and submitted for laboratory analysis of total arsenic with a 1 mg/kg reporting limit (RL) with a quick turnaround (five business days). Based on these results, ERT and US FWS personnel selected sixteen of the twenty-six samples to be used for the toxicity testing. Seven of these toxicity testing sample locations were in the Maurice River, eight locations were from Union Lake, and one sample location was from the upstream reference area. The designated sample location and associated sediment arsenic concentrations for the 16 toxicity testing samples are presented in Table 5. Samples selected for toxicity testing were submitted for analysis of Target Analyte List (TAL) metals, semivolatile organic compounds (SVOCs) and pesticides/polychlorinated biphenyls (PCBs). Summary statistics for COPCs measured in these sediment samples are presented in Table 6.

Solid-phase sediment toxicity bioassays using *Hyalella azteca* (28-day) and *Chironomus dilutus* (10-day) were conducted as per U.S. EPA toxicity testing guidelines (U.S. EPA, 2000). Endpoints measured were survival, weight, and biomass. Toxicity testing was performed by American Aquatic Testing, Inc. of Allentown, Pennsylvania (PA). Each sediment toxicity test consisted of five replicates per sample location using 100% site sediment (no sediment dilutions). A laboratory control test was performed concurrently using sediment collected from Spruce Run Reservoir (Clinton, NJ). The Aquatic Toxicity Testing Report provided by American Aquatic Testing, Inc. is included in Appendix B.

2.4.2 Benthic Community Analysis

A benthic macroinvertebrate survey was conducted at five sampling locations along the Maurice River as per SERAS Standard Operating Procedure (SOP) #2054 *Benthic Macroinvertebrate Sampling* (SERAS, 2003) and Barbour *et al.* (1999). One of these five locations (BCS-01 = Ref) was located upstream of the area of impact (near Garden Road), and the other four locations were from downstream areas of potential impact along the Maurice River. These locations were BSC-02

at ALL (off of Eppinger Avenue), BCS-03 in the vicinity of ALM, BCS-04 near Sherman Avenue, and BCS-05 along the power lines and accessed by permission of the water treatment plant (Figure 6). Collection of benthic macroinvertebrates in Union Lake was unsuccessful due to lack of suitable habitat and was abandoned after two sampling efforts.

Benthic macroinvertebrate collection commenced on October 29, 2013. Three replicates were collected at each location. Replicate locations were selected at random from areas of roughly equivalent habitat near the original sample. An NJ DEP Biological Field Observation and Data Sheet was completed for each benthic macroinvertebrate sampling location.

The collection procedure employed a long-handled, D-frame net, measuring approximately 45 centimeters (cm) wide and 20 cm tall, with 500 µm mesh. The stream bottom within the lower net frame was disturbed to a depth of approximately 5 cm. Dislodged organisms and debris were swept into the net by the current. Following this, clean water was carefully poured or swept through the net to wash away fine sediment particles. Alternatively, and more commonly, the net was moved upstream along emergent or submergent vegetation along the stream edges. Organisms dislodged by the movement were trapped in the net. Debris and organisms in the net were transferred to a white plastic tray. Much of the larger debris (stones, twigs, large leaves) was carefully removed and the rest of the organisms and some vegetative material were placed into polyethylene sample bottles. Samples were preserved with 70% isopropyl alcohol and delivered to the ERT/SERAS Biology Laboratory for further sorting and identification to the lowest taxonomic level possible. Sampling and processing of the samples followed SERAS SOP # 2054, *Benthic Macroinvertebrate Sampling*.

2.4.3 Fish Sampling

Fish were collected in June of 2009, and in June and July of 2011 and 2013 for the ecological risk assessment (ERA) by DESA (Figure 7). Fish were collected for whole body tissue analysis in the Maurice River above the Blackwater Branch confluence (ABC), the Maurice River below the Blackwater Branch confluence (BBC), and the Union Lake headwater area. In 2013, fish were collected in the Blackwater Branch upstream of the former facility.

Red breast sunfish (*Lepomis auritus*; 2009 and 2011) and pumpkinseed (*Lepomis gibbosus*; 2013) were collected from the Maurice River ABC. Fish species collected from the Maurice River BBC were red breast sunfish (2009, 2011 and 2013), and yellow perch (*Perca flavescens*; 2009). Fish species collected in the Blackwater Branch in 2013 were creek chubsucker (*Erimyzon oblongus*; 2013) and mudminnow (*Umbra spp.*; 2013). Fish species collected in the Union Lake headwater area for the ERA were white perch (*Morone americana*; 2009), channel catfish (*Ictalurus punctatus*; 2009), pumpkinseed (2013) and golden shiners (*Notemigonus crysoleucas*; 2013).

All fish tissue samples collected in 2009 were analyzed as composites of three to five individuals, whereas fish collected in 2011 and 2013 were submitted as individual discrete samples for analysis. Whole body fish were submitted for arsenic analysis and speciation. Fish collected in 2009 were analyzed for inorganic arsenic, trivalent arsenic (As[III]), pentavalent arsenic (As[V]), dimethylarsinic acid [DMA] and monomethylarsonic acid [MMA]. Fish collected in 2011 and 2013 were submitted for whole body analysis of total arsenic, inorganic arsenic, As(III), and As(V). For all three sampling events, the concentration of As(V) was calculated by subtracting the analytical result for As(III) from the analytical result for inorganic arsenic. Summary statistics for total and inorganic arsenic in fish tissue are presented in Table 7.

2.5 Sedflume Study

Lockheed Martin SERAS contracted Sea Engineering, Inc. (SEI) to conduct a Sedflume analysis on 15 sediment cores obtained from Union Lake and Maurice River in Millville, New Jersey (Appendix C). Sampling was performed by LM SERAS, EPA and SEI personnel in May 2013. A total of 15 cores were collected in water depths ranging between 0.30 meters (m) and 6.1 m. The primary objective of this work was to characterize the erosion properties and physical characteristics of the lake and rivers sediments. The cores were eroded to determine erosion rates as a function of shear stress and depth into core. In addition, cores were sub-sampled during the analysis to determine sediment bulk density, loss on ignition fraction and particle size distributions at specific depths within the core.

2.6 LTFATE Surface Water Modeling System

The modeling of the arsenic transport in the Maurice River system using the Long-term Fate of Dredged Material (LTFATE) surface water modeling system (see Appendix D for a detailed description of LTFATE) is being performed to evaluate the effectiveness of the planned three-year flushing period for the Maurice River system following remediation of the contaminated sediments and floodplain soils in the contaminated portion of the Blackwater Branch watershed. LTFATE contains dynamically-linked three-dimensional (3D) hydrodynamic and transport modules. The transport modules used in this modeling study are the mixed sediment transport and contaminant transport modules. This model could also be used to evaluate the relative differences in the rates of decline over a multi-decadal time period of the arsenic contamination in the Maurice River system between the proposed remedial measures.

One of the primary objectives of all modeling studies at contaminated sediment sites should be to use the requisite site-specific data to constrain model inputs to the greatest extent possible because it reduces the uncertainty in model predictions and increases model reliability (Hayter *et al*., 2014). As such, the data requirements for LTFATE, as for all multi-dimensional transport models, is significant. The table below contains a list of data that are required for performing modeling of arsenic transport in the Maurice River system.

Required Data for Modeling Arsenic Transport

Hydrodynamic Data	Measurement Technique
Bathymetric Surveys	*Perform bathymetric surveys at selected transects along Maurice River and in Union Lake*: These surveys would be used to determine the differences in the bathymetry along these transects between the bathymetric survey performed in the early 1990s and that to be performed in 2012 or 2013. These new surveys would also be used to update the existing model grid of the Maurice River system that was developed by Hayter and Gu (1998).
Velocity Measurements	*Measure cross-sectional velocity profiles at two locations along the Maurice River between the Blackwater Branch confluence and Union Lake during the rising limbs of two different high flow events on the Maurice River*: These measurements would be used to perform the essential tasks of calibrating and validating the hydrodynamic model in LTFATE.
Sediment Transport Data	**Measurement Technique**
Composition of the sediment	*Collect grab samples of the surface sediment at a minimum of three*

bed	*locations along each river and lake transect that was surveyed in the early 1990s*: The grain size distribution (GSD) of the inorganic sediments and the percentage of organic matter would be determined for each grab sample. These data would allow the existing spatially varying sediment composition to be represented in the sediment transport model in LTFATE.
Suspended Sediment Concentration (SSC) time series	*Measure the SSC time series near the model grid upstream boundary on the Maurice River and at (at least) one of the bridges where velocity measurements are to be made over two high flow events*: These measurements would be used to perform the essential tasks of calibrating and validating the sediment transport model in LTFATE and in constructing the upstream boundary conditions for the sediment transport model for these two high flow events.
Erodibility of the fine-grain and mixed sediments	*Measure the erosion rates, bulk densities, and GSD of fine-grain and mixed sediment at the surface and with depth in sediment cores collected at different locations in the Blackwater Branch, Maurice River and Union Lake*: These site-specific data would be used to specify the erosion rates of both surficial and buried fine-grain and mixed sediments as a function of the applied bed shear stress and sediment bulk densities in the sediment transport model in LTFATE. A SEDFLUME study (see Appendix C) was conducted in 2013 to measure these data.
Arsenic Related Data	**Measurement Technique**
Particulate and Dissolved *As* concentrations in the bottom sediment and floodplain soils	*Determine particulate and dissolved As concentrations at the surface and with depth in sediment cores collected at different locations in the Blackwater Branch, Maurice River and Union Lake*: These data would be used to initialize the horizontally and vertically varying *As* concentrations in the contaminant transport model in LTFATE.
Particulate and dissolved *As* concentration time series	*Measure these As concentration time series near the model grid upstream boundary on the Maurice River and at (at least) one of the bridges where velocity measurements are to be made over two high flow events*: These measurements would be used to perform the essential tasks of calibrating and validating the contaminant transport model in LTFATE and in constructing the upstream boundary conditions for the contaminant transport model for these two high flow events.
Partition coefficient and desorption rate	*Measure the As partition coefficients on suspended sediments and bed sediments as well as the desorption rates of particulate As from suspended sediments to the water column and from bed sediments to pore water*: These site-specific measurements are needed to reduce the uncertainty in the contaminant transport model in LTFATE that would result if literature values were used for these parameters.
Groundwater Flux of Dissolved *As* along the Blackwater Branch to the Maurice River system	*Measure the average post-remediation flux of dissolved As via groundwater along the Blackwater Branch to the overlying water in Blackwater Branch and the Maurice River*: Determination of this average flux of dissolved *As*, which would be

	added as a source term in the dissolved contaminant transport equation solved by the contaminant transport model in LTFATE, will help improve the accuracy of the simulations of *As* transport and fate using the LTFATE modeling system.

At present, the LTFATE model is under development by the US Army Corps of Engineers Engineer (ACOE) Research and Development Center. These tasks include grid development, calibration and validation of the hydrodynamic model, calibration and validation of the mixed sediment transport model, and calibration and validation of the arsenic transport model. Final model runs are scheduled to be initiated in early fiscal year (FY) 2015. To support the surface water transport modeling being performed with LTFATE, a watershed loading model is also being developed using the USEPA Basins model. Output from the Basins model is being used to provide the fluxes of water and suspended sediment at the open water boundaries of the Maurice River arsenic transport model.

2.6 Positional Data

The position of all sample locations were obtained using differentially corrected global positioning system (GPS). Where possible, the data were downloaded directly from the GPS and verified. Errors in the GPS data were corrected when possible and the verified GPS data were imported into the Scribe Database.

2.7 Sample Management

During the first year all sample management was performed by Lockheed Martin SERAS personnel. During the second and third year, sample management was performed both by DESA and Lockheed Martin SERAS personnel. Most of the field sample management was performed by DESA with their data imported to the master SCRIBE Database being managed by Lockheed Martin SERAS. After the data was imported to the master SERAS SCRIBE database and as time and budget allowed, most errors, omissions and inconsistences in the DESA database were corrected. All environ-numeric data collected for this investigation is included in the SCRIBE file.

3.0 RESULTS

3.1 Sediment Arsenic Loading

Sediment arsenic loading was evaluated over a three-year period between 2012 and 2014 in the Maurice River from the confluence with the Blackwater Branch to the upper reaches of Union Lake above the low head dam. Upstream reference samples were collected on the Maurice River at Garden Road and the Blackwater Branch near North Delsea Drive. Most of the sediment and samples were analyzed for arsenic and a small percentage were also analyzed for grain size and Cesium-137. A majority of the samples collected were submerged surficial sediment samples, but a limited number of core samples and floodplain soil samples were also collected.

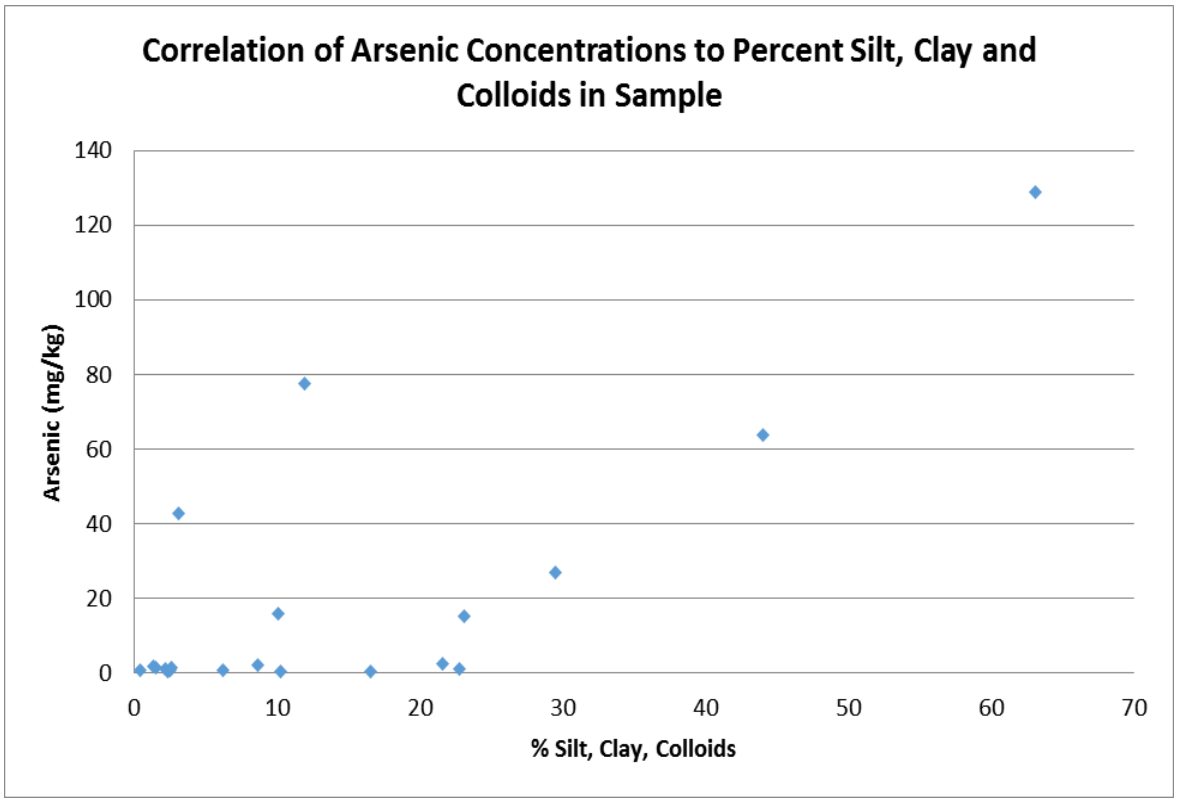
Sediment characteristics were assessed by measuring sediment thickness and visually classifying the sediment type (e.g. silt/sand/clay/gravel). Relative sediment thicknesses were assessed by hammering a solid 6 foot x ¼ inch diameter rod into the sediment until refusal. Since refusal could be caused by anything such as buried debris, tightly packed sand, gravel or rock, the information should be viewed with discretion although generally depositional fine grained sediment beds were associated with greater relative thicknesses compared to higher energy sandy or gravely sections of the river.

3.1.1 *Surficial Sediment Samples*

Surficial sediments (0 to 6 inches) were collected from submerged sediments in the Blackwater Branch, the Maurice River and the headwaters of Union Lake. The arsenic concentrations in the surficial sediments are summarized in Tables 8 to 10 for Years 1 to 3, respectively and as an overview in Figure 8 (detailed in Figures 8A to 8C). Figures 9 through 16 separate the data on a per area per year basis and include relative sediment thickness measurements obtained from the field data.

Based on data observed during the first year of sampling (low arsenic concentration in sediments with high percentages of gravel and/or sand), samples containing a high percentage of gravel and/or sand were not submitted for analysis during the second year investigation. During the third year, as was done in the first year, samples were submitted for analysis regardless of grain size.

A random subset of samples collected from the Alliance, Almond and BA Beaches were analyzed for grain size to compare their arsenic concentrations to the assessed silt/clay, sand and gravel fractions. The grain size results with the corresponding arsenic concentrations are shown in Table 11. As shown below, there is a relationship between the percent of fine grained (silts/clays) material in the sample and the arsenic concentration. .

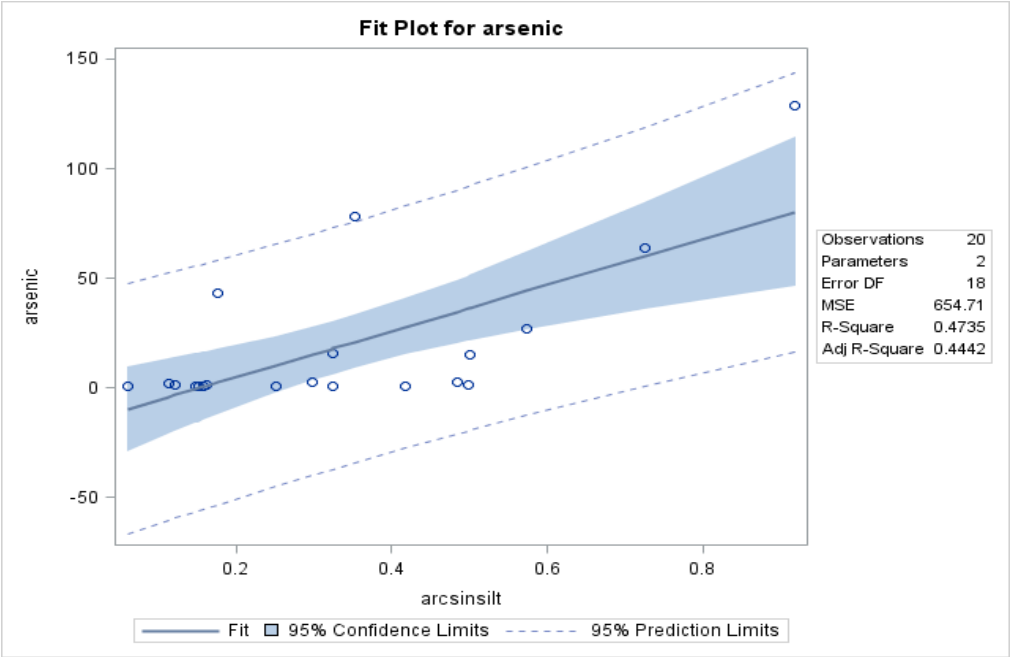


The results also indicate arsenic concentrations are more likely to be elevated when the silt/clay fraction of the sediments increases above 20%.

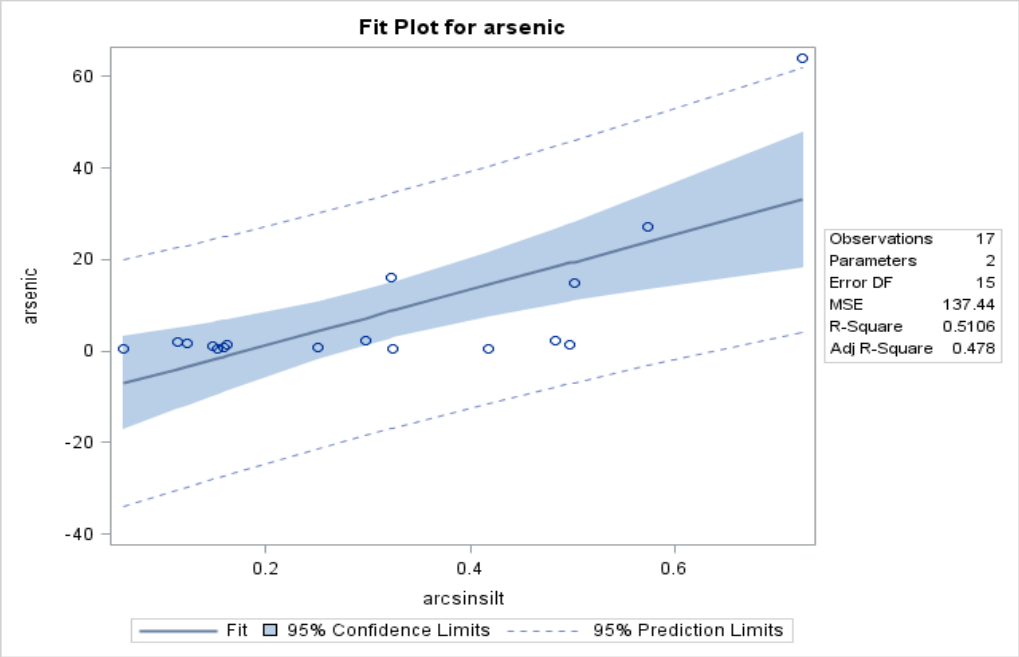
Because a probable relationship between grain size and arsenic concentration had been observed, surface sediment arsenic concentrations across the three years of sampling were grouped based on observed sediment characteristics (gravel and sand compared to silts/clays/detritus). ProUCL 5.0

software was used to graphically explore distribution characteristics. Q-Q Plots, histograms, and box plots were generated to visualize arsenic concentrations based on sediment characteristics from upstream through downstream locations. The results indicated arsenic preferential partition in the finer grain portion of the fluvium.

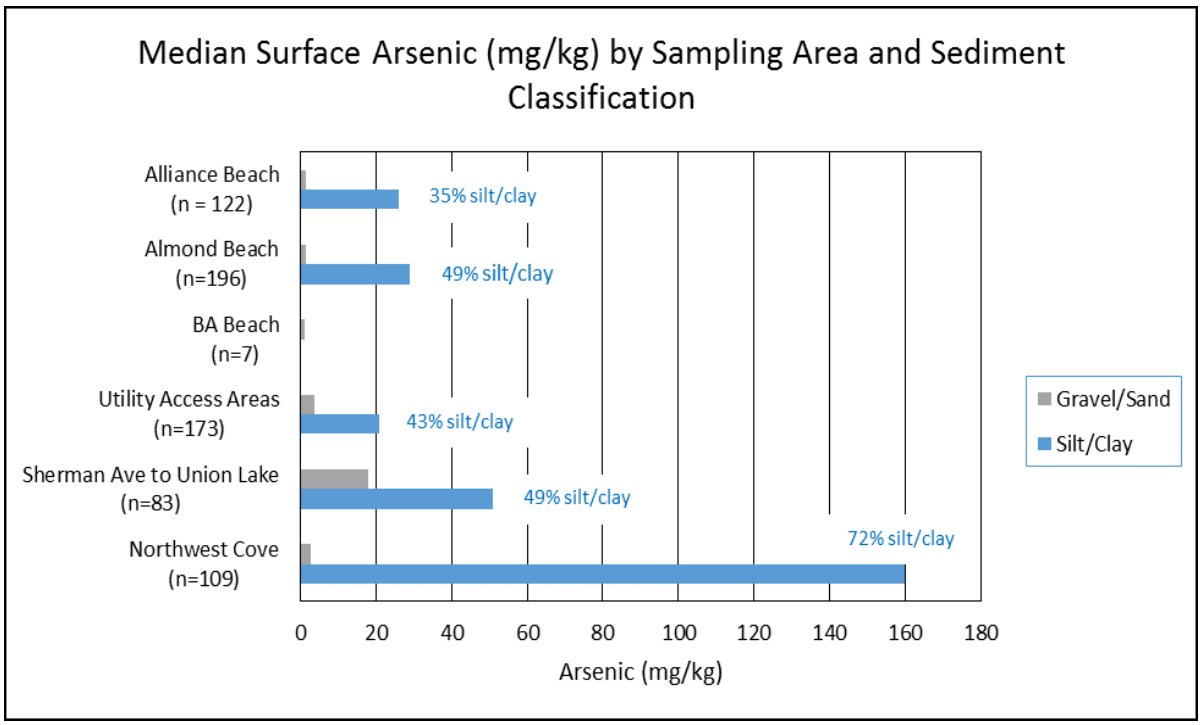
Correlation and regression analysis of arsenic concentrations versus % Silt, Clay and Colloids was run using SAS version 9.0 software. Analysis indicated a statistically significant relationship exists (probability value <0.0001) and a correlation coefficient (r) = 0.74804. Classic analysis of percent/proportional data calls for a data transformation which takes the inverse sine of the square root of the percentage. This transformation was performed on the %Silt, Clay and Colloids, followed by a linear regression analysis on the transformed data (arcsinsilt). The regression is depicted below.



Fit and diagnostic statistics were evaluated for outliers, patterns in the residuals, and for points that may carry extreme leverage in the placement of the regression line. One data point arsenic = 109, carries more influence than all other points driving the placement of the regression line; Cooks-D >3.5. When this point is removed, sample size decreased to 19 and the R-square value dropped to 0.1968, verifying the extreme influence it has on the model. Examination of residuals also indicated the presence of two potential outliers (arsenic = 43 and arsenic = 78). Removal of these two potential outliers resulted in the following model with R-square = 0.5106.



A horizontal bar chart depicting the increased arsenic concentration within silts/clays/detritus as compared to gravel/sand is presented below. The areas are listed in the bar chart from upstream (top of chart) to downstream (bottom of chart) with bars representing median arsenic concentrations. The percent of surface sediment samples collected and classified as silts/clay per area are identified on the chart. Although there is an apparent increasing concentration with distance downstream of the source, this trend is more so related to increasing percentage of fine grained materials from Sherman Ave to the low head dam on Union Lake.



The ROD specified sediment cleanup levels of 120 mg/kg of arsenic for submerged sediments within the channel of the Blackwater Branch and 20 mg/kg of arsenic in the exposed sediments in wetlands adjacent to the Blackwater Branch (EPA 1989). The arsenic concentrations in the surficial sediments were compared to these cleanup numbers in Table 12. All of the sediments collected from the Maurice River and Union Lake were compared to the 120 mg/kg cleanup value for submerged sediments; the 18 floodplain soil samples were compared to the 20 mg/kg exposed sediment cleanup value.

Overall 15% of the sediment samples exceeded the cleanup value specified in the ROD. Exposed sediments (floodplain soil samples) had the highest exceedance rate with 56% of the samples exceeding the 20 mg/kg cleanup value. High exceedance rates were also observed in the sediment samples collected in the Northeast Cove (48%), Union Lake Low Head Dam (42%), Northwest Cove (41%) and stretch of the Maurice River between Sherman Ave and Union Lake (15%). With the exception of the stretch of the river between Sherman Ave and Union Lake, other areas on the Maurice River had very low exceedance rates of the ROD cleanup numbers, Confluence of the Blackwater Branch and Maurice River (0%), Alliance Beach (3%), Almond Beach (7%), BA Beach (0%) and Utility Access Areas (5%). The locations in these areas that contained sediments above the ROD cleanup level were limited to isolated hotspots in thick depositional sections of the river characterized by fine grained sediments.

Overall comparisons of cleanup exceedances between years is not possible since only one area (Almond Beach) was sampled all three years; only a limited number of samples were collected Year 1 and sample selection was biased (to avoid analyzing samples characterized with high percentages of sand and gravel) during Year 2.

3.1.1.1 Hot Spot Delineation

During Year 1 of the investigation, it was observed that only two of the surficial sediment samples collected in the Alliance Beach Area had arsenic concentrations exceeding 80 mg/kg, location A1-7E-.5 (129 mg/kg) and A1-10E.40 (324 mg/kg). This data is included in Table 8 and Figure 9A. To assess this isolated hot spot, fourteen additional surficial sediments were collected during the Year 3 investigation within 75 feet of the hot spot observed during the Year 1 sampling event. These samples ranged in arsenic concentrations from not detected at 0.38 mg/kg to 180 mg/kg (Table 10 and Figure 9B). The samples collected closest to the original hot spot in the fine grained sediments had the highest concentrations of arsenic and samples collected to the east and south within coarser sediments towards the middle of the channel had the lowest arsenic concentrations.

3.1.1.2 Floodplain Samples

Eighteen samples were collected to assess the arsenic concentration in floodplain soils/exposed sediments. Three transects were sampled in an area located between Alliance Beach Area and the Almond Beach Area (Figure 10 and Table 10). The overall average arsenic concentration in the floodplains samples was 34 mg/kg (range = 2.6 to 79 mg/kg) and 9 of the 18 samples exceeded the exposed sediment cleanup level of 20 mg/kg specified in the ROD.

3.1.2 ***Subsurface Sediment Samples***

Subsurface sediment samples were collected in Year 1 and Year 3 of the investigation. The subsurface samples collected during Year 1 were used to assess the vertical distribution of arsenic

within the sediments and the subsurface samples collected during Year 3 were to assess the arsenic concentration within the sample factions within the sediments (porewater, sands and silts/clays).

3.1.2.1 Vertical Extent of Contamination Core Samples

Nineteen core samples were collected from the Maurice River from Alliance Beach to BA Beach. The cores were driven to a depth of five feet below the top of the sediment surface or until refusal. The cores were divided into 0.5 foot intervals and each interval was analyzed separately unless there was insufficient sample volume, then two intervals were combined. At six of the locations a second core was also collected for Cesium-137 analysis (see below). Subsurface sediment arsenic concentrations are included in Figures 9A (Alliance Beach), 11A (Almond Beach), 12 (Below Almond Beach Spillway) and Figure 13 (BA Beach) and summarized in Table 13. In general the highest arsenic concentrations decreased with depth. The highest arsenic concentrations were found in the top interval (0 to 0.5-feet) in about 31% of the core samples and in the top first or second interval (0 to 1-foot) in about 52% of the core samples.

Cesium-137 exists in the atmosphere as a by-product of aboveground nuclear weapons testing. The radioactive isotope is used to date fine-grain sediments. Cesium-137 first occurred in the atmosphere in approximately 1952, and peaked between 1963 and 1964. Cesium-137 strongly absorbs to fine-grain sediments and can used to determine the time of exposer to the atmosphere or burial.

Analytical results for Cesium-137 are listed on Table 14 and are shown in Figure 17. At five of the six locations arsenic concentrations and Cesium-137 were strongly related, as Cesium-137 concentrations increased so did sediment arsenic concentrations. This indicates that the highest levels of arsenic were deposited in the river sediment at the same time the highest levels of Cesium-137 were deposited in the river, during the early to mid-1960s.

3.1.2.2 Mixed Core Samples

Fifteen samples were collected from the Alliance, Almond and BA Beaches, and Utility Access areas, and analyzed for grain size. The silt/clay and sand fractions were then analyzed separately for arsenic concentration with the results shown in Table 15. The analytical results indicate the silt/clay faction contains up to 32 times greater concentrations of arsenic than the coarser sand faction. Porewater samples were also extracted from the core and arsenic concentrations in the porewater ranged from below the reporting limit (1 microgram per Liter [µg/L]) in five of the porewater samples to 280 µg/L in a sample collected at ALL-COR504-Y3. These samples or the data derived from the analysis should be viewed with discretion since overall they contain a much lower percent of silt/clays (< 6% silt) than other samples collected on the site. Also, note that the percentages of each fraction does not add up to 100% implying that some of the total mass was lost during sample processing.

3.2 Arsenic Flux via Surface Water

At five stations on the Maurice River and Blackwater Branch, three of which matched the locations sampled by Foster Wheeler (1996), surface water arsenic (total and dissolved) concentrations and river discharge rates were measured (Figure 18).

Location	SERAS Station Name	Foster Wheeler (1996) Station Name
Blackwater Branch @ N Delsea Drive (Reference)	AF1	NS
Maurice River @ Garden Road (Reference)	AF2	Garden Road
Confluence of Maurice River and Blackwater Branch	BWB	Station 1
Maurice River at Alliance Beach	AF3	NS
Maurice River below Almond Beach Spillway	AF4/AF4A	Station 2
Maurice River at Sherman Ave	AF5	Station 3

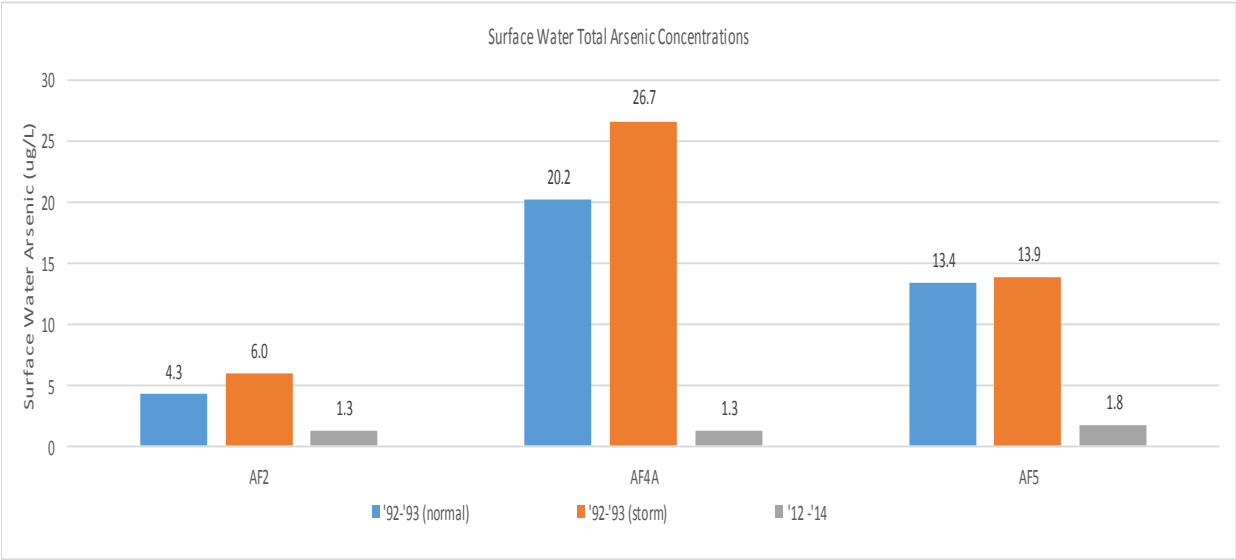
The total and dissolved surface water arsenic concentrations obtained during each of the SERAS sampling events is summarized in Table 16. Five sampling events were conducted between 2012 and 2014 although discharge rates were not calculated for AF4 during the first sampling event (July 2012) or at AF5 during the third sampling event (May 2013). Station BWB was only sampled once during August 2014. River discharges were calculated for each SERAS sampling event based on depth profiles (channel area) and water flow rates (Figures 18 to 23). Using the river discharge rates and surface water arsenic concentrations surface water arsenic flux rates were calculated for each sample event (Table 17). For sampling events when the surface water arsenic concentrations were below the reporting limit, the reporting limit was used in the arsenic flux calculations. These values are proceeded with the "<" symbol and represent the maximum arsenic flux since the actual arsenic flux can't be calculated. These actual arsenic flux values may be much lower.

During the first round of sampling (July 2012), a reporting limit of 2.78 µg/L was provided by the laboratory and arsenic was not detected in any of the surface water samples. For subsequent sampling events, lower arsenic reporting limits were obtained from the laboratory and arsenic was present in detectable concentrations in 21 of the 42 surface water samples collected, although arsenic was never detected at station AF1. Overall the surface water arsenic concentrations and arsenic flux rates were related to the river discharge rates, as the discharge rates increased so did the arsenic surface water concentrations and the arsenic flux rates.

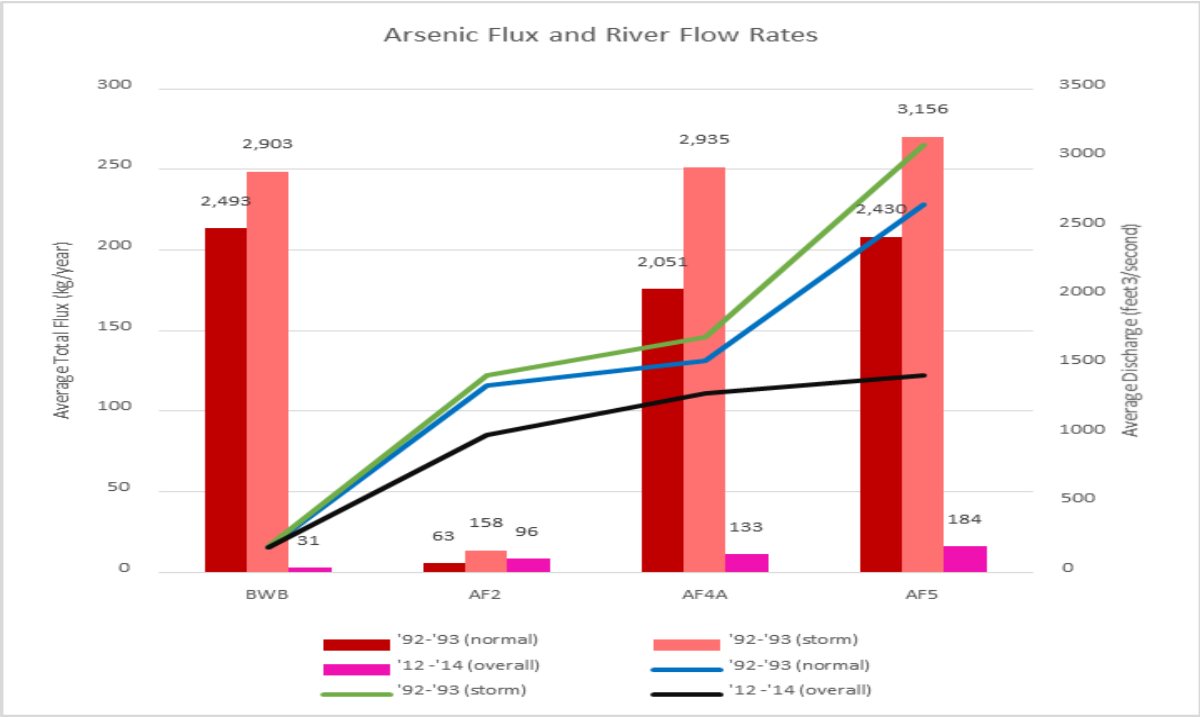
To evaluate whether arsenic was primarily being transported in the dissolved phase or suspended phase the percent of arsenic in the dissolved phase was calculated; the higher the percentage the greater the percentage of arsenic was moving in the dissolved phase. A 100% would mean that all of the arsenic was being transported in the dissolved phase and 0% in the suspended phase. The calculations were done using all samples collected at the arsenic flux stations where arsenic was detected in the dissolved phase and in the suspended phase (Table 18).

Arsenic was primarily being transported in the dissolved phase, when evaluating all samples collected at the arsenic flux stations 76% of the arsenic was being transported in the dissolved phase and 24% was being transported in the suspended phase. These results are consistent with data previously obtained on the site (Foster Wheeler 1996).

The data collected by SERAS during this investigation were compared to previous site data collected in 1992 and 1993 (Foster Wheeler, 1996) at four stations. The data collected between 1992 and 1993 was collected after OU2 was completed and the flow of arsenic-contaminated groundwater from the Vineland Chemical Company plant site to the Maurice River system was stopped, but prior to the completion of the remediation of the Blackwater Branch channel and wetland. The data collected between 1992 and 1993 was classified as either normal flow conditions or storm flow conditions.



Overall, when comparing total surface water arsenic concentrations during this sampling event to data collected in 1992 and 1993, much lower surface water arsenic concentrations were detected (see Figure above) in the more recent samples. At station AF4 (Almond Beach below Almond Beach Spillway) the average total surface water concentration was 1.3 µg/L during this investigation (2012 to 2014), but averaged 20.2 µg/L under normal flow conditions and 26.7 µg/L during storm flow conditions during the 1992 to 1993 sampling events (Foster Wheeler, 1996). A similar trend was observed at station AF5 (Sherman Ave) which averaged 1.8 µg/L during the 2012 to 2014 sampling events and 13.4 µg/L and 13.9 µg/L during the 1992 to 1993 sampling events, during normal and storm water flow conditions respectively.



The figure above compares average arsenic flux rates and river discharge rates between this investigation and the 1992 to 1993 investigation. When comparing the four stations that overlapped between both investigations, all stations but AF2 (upstream reference on Maurice River at Garden Road) had arsenic flux rates much lower in 2012 and 2014 compared to the 1992 to 1993 data. The arsenic flux rates at AF2 were consistent during both investigations ranging from 63 to 158 kg/year. At station BWB located at the confluence of the Blackwater Branch and the Maurice River the arsenic flux rates were two orders of magnitude lower in 2012 to 2014 compared to the 1992 to 1993 data; arsenic flux rates were an average 31 kilograms per year (kg/year) in the 2012 to 2014 data compared to 2,493 kg/year and 2,903 in the 1992 to 1993 data during normal flow and storm water flows, respectively. AF4 and AF5 were both an order of magnitude lower in the 2012 to 2014 data compared to the 1992 to 1993 data.

3.3 Water Quality

Water quality data were collected at each of the arsenic flux stations and each of the human health beach areas and is summarized in Table 19.

3.4 Human Health Risk Assessment Data

Soil (beach sand), sediment and surface water samples were collected at five beaches (Alliance, Almond, BA, Sharp Street [SSB], Union Lake Tennis and Sailing Club [ULSTC]) and one public boat launch (DEP Boat Launch) during three sampling events (July 2012, August 2013, July 2014). A schematic of the sampling methodology for the five beaches can be found on Figure 5. Because most of the DEP Boat Launch property was paved, covered with rip rap or heavily vegetated, restricting access, only one sediment and surface water sample was collected in July 2012; and three sand samples and one surface water were collected in August 2013. No samples were collected from the DEP Boat Launch in July 2014.

Surface water samples are summarized in Table 20 and sediment and soil samples are summarized in Table 21. For the July 2012 sampling event, arsenic was not detected in any of the surface water samples collected at the beaches along the Maurice River, but was detected in 100% of the surface water samples collected in Union Lake and at SSB. For the 2013 and 2014 sampling events, arsenic was detected in all but one sample (dissolved arsenic, undisturbed sediment, BA Beach). This can be attributed to the higher RL of 2.78 µg/L for the 2012 sampling analysis. A lower RL (≤1 µg/L) was requested for the 2013 and 2014 sampling events resulting in the larger percentage of detects. Total and dissolved arsenic was consistently higher across all surface water samples (disturbed and undisturbed sediment) collected from ULSTC, SSB and the DEP Boat Launch as compared to Alliance Beach, Almond Beach and BA Beach.

Combining data from all three years, total arsenic collected prior to disturbing the sediments ranged from: non-detect to 1.8 µg/L at Alliance Beach; non-detect to 2 µg/L at Almond Beach; non-detect to 1.5 µg/L at BA Beach; 5.39 to 19 µg/L at the DEP Boat Launch; 4.4 to 6.7 µg/L at ULSTC; and 4.5 to 6.97 µg/L at SSB (Table 22). Total arsenic results collected after disturbing the sediments at each location ranged from: non-detect to 2.1 µg/L at Alliance Beach; non-detect to 7.35 µg/L at Almond Beach; non-detect to 17 µg/L at BA Beach; 12 to 15 µg/L at the DEP Boat Launch; 5.2 to 12 µg/L at ULSTC; and 4.7 to 6.65 µg/L at SSB.

For dissolved arsenic, combined data collected from the three sampling events indicated a similar pattern to total arsenic results. Concentration ranges were higher in surface water samples collected from the DEP Boat Launch, ULSTC and SSB for samples collected prior to and after sediments were disturbed at each location (Table 22). For samples collected prior to disturbing the sediments dissolved arsenic ranged from: non-detect to 1.8 µg/L at Alliance Beach; non-detect to 1.8 µg/L at Almond Beach; non-detect to

1.2 µg/L at BA Beach; 4.3 to 5.73 µg/L at the DEP Boat Launch; 3.9 to 5.67 µg/L at ULSTC; and 4 to 5.83 µg/L at SSB. Dissolved arsenic results collected after disturbing the sediments at each location ranged from: non-detect to 1.9 µg/L at Alliance Beach; non-detect to 2.2 µg/L at Almond Beach; non-detect to 1.4 µg/L at BA Beach; 4.29 to 4.5 µg/L at the DEP Boat Launch; 3.8 to 5.4 µg/L at ULSTC; and 4.1 to 5.38 µg/L at SSB.

For the soil (beach sand) and sediment samples, neither matrix had consistently higher arsenic concentrations along each transect (Table 23) or at each beach (Table 24), regardless of the collection year. For Year 1, the soil and sediment samples with the highest arsenic concentrations were collected at ULSTC with a soil concentration of 4.6 mg/kg and sediment concentration of 8.6 mg/kg. In Year 2, the soil sample with the highest concentration in soil was collected at the DEP Boat Launch (15 mg/kg) and the sediment sample with the highest arsenic concentration was collected at ULSTC (6.2 mg/kg). In Year 3, the highest arsenic concentration in soil was 2.8 mg/kg from a sample collected at Almond Beach, and in sediment was 190 mg/kg from a sample collected at BA Beach.

Descriptive statistics per year, beach and matrix (soil, sediment) are presented on Table 24. Analytical results for field duplicates were averaged prior to computing the summary statistics. Additionally, to be consistent with procedures followed in earlier reports and maintain comparability, means were calculated using a value of ½ the reporting limit for non-detects. 95% upper confidence limits (UCLs) were computed using ProUCL. The UCLs recommended by ProUCL are also presented on Table 25.

At the midpoint of each beach sand transect, a surface sample was collected (at a depth of 0 to 2 inches in Year 1 and 0 to 6 inches in Years 2 and 3) and another sample was collected at a depth of 0 to 2 feet. Summary statistics for the surface sand samples are presented in Table 25. Statistical tests ($\alpha = 0.05$) conducted using ProUCL indicated that: in Year 1 arsenic concentrations in the 2-foot core samples collected at Almond Beach and Sharp Street Beach are significantly higher (Student t-tests) than surface sand arsenic concentrations; in Year 2 arsenic in core samples was significantly higher (t-test with unequal variances) than surface samples at ULSTC; and in Year 3 arsenic in core samples was significantly higher than surface samples at Alliance Beach (Gehan Test).

3.5 Ecological Risk Study

For the ERA, the ecosystem potentially at risk was identified as the aquatic community within Blackwater Branch, the Maurice River, and the Union Lake headwater area. Terrestrial receptors which obtain prey items from the Maurice River watershed are also of potential concern. A full description of the data and methods utilized to assess potential risk to ecological receptors can be found in the ERA Report, Appendix A. Four Exposure Areas (EAs) were identified based on distance from the source area and fate and transport mechanisms for arsenic within the aquatic system: the Maurice River ABC (reference), the Blackwater Branch (reference), the Maurice River BBC, and the headwater area of Union Lake.

The Assessment Endpoints (AEs) selected for the ERA were the survival, growth and reproduction of aquatic organisms (benthic macroinvertebrates and fish) and piscivorous birds and mammals. Measures of exposure and effects (also called measurement endpoints) represent quantifiable ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the AEs (U.S. EPA 1992, 1997). Three types of measures were utilized in the ERA:

- Predicted Risks (Hazard Quotients [HQs]),
- Site-specific toxicity tests, and
- Observations of population and community demographics.

Because Site-specific toxicity tests and community surveys incorporate Site-specific factors that may influence bioavailability and toxicity of arsenic, these measures provide the strongest weight of evidence (WOE) regarding potential ecological risks at this Site (as opposed to predicted risks or HQs). Conclusions from the ERA are described below.

3.5.1 *Evaluation of Risk to Aquatic Ecological Receptors*

Five lines of evidence were to evaluate risks to aquatic receptors in the

- HQ values based on measured surface water concentrations,
- HQ values based on measured sediment concentrations,
- Solid-phase sediment bioassay results,
- Benthic macroinvertebrate community survey metrics, and
- HQ values based on measured fish tissue concentrations.

None of the calculated HQs for surface water exceeded 1.0 (Table 26). Measured concentrations of arsenic in dissolved surface water samples were an order of magnitude below the chronic AWQC. The maximum measured concentration of arsenic in surface water was at a sampling location in the Maurice River BBC; total arsenic in a disturbed sample was 17 µg/L, well below the chronic AWQC of 150 µg/L. Therefore, potential risk to aquatic receptors from exposure to surface water in all four EAs is minimal.

Mean and 95UCL arsenic concentrations measured in sediment in the Maurice River BBC and the Union Lake headwater area exceeded the PEC, a concentration above which adverse effects on biota are probable (HQs of 5.2 and 6.6 in the Maurice River BBC and the Union Lake headwater area, respectively, calculated using 95UCL arsenic concentrations) (Table 26). There is calculated risk to aquatic receptors from exposure to Site-related arsenic in sediment in these two EAs. The HQs calculated for arsenic in the upstream reference samples did not exceed 1.0, supporting the conclusion that downstream exposures have been increased due to Site-related releases.

Significant mortality and significantly reduced growth of *H. azteca* was observed in three of the toxicity test samples. Significantly reduced growth of *C. dilutus* was also observed in three of the downstream toxicity test samples (Table 27). While growth of either organism was not correlated with sediment arsenic concentrations, survival of *H. azteca* was strongly negatively correlated with increasing arsenic concentrations in sediment ($r = -0.682$; $p = 0.004$) (Table 28). There is potential risk to aquatic receptors based on this line of evidence.

The benthic invertebrate community in the Maurice River and Union Lake is diverse with high numerical abundance and is indicative of a healthy and robust ecosystem. The community is largely composed of insect larva with smaller numbers of adult insects, crustaceans, mollusks and annelids. In particular, a large, diverse number of sensitive taxa were collected throughout the study area including mayflies, stoneflies, and caddisflies. In addition, multiple generations of long lived taxa were present suggesting that reproductive success is common and unimpaired.

Measured concentrations of arsenic in fish tissue did not exceed the NOEC tissue concentration (Table 29). Risk to fish due to arsenic bioaccumulation is negligible.

3.5.2 *Evaluation of Risk to Piscivorous Birds and Mammals*

Potential risks to birds and mammals were evaluated using dietary exposure models rather than based on direct contact with abiotic media. Birds and mammals are upper trophic level consumers that are exposed to arsenic via ingestion of contaminated food items, surface water, or incidental soil/sediment ingestion; the ingestion exposure pathway is the primary exposure route for these receptors.

Results from HQ calculations for dietary exposure of piscivorous birds and mammals to arsenic are presented in Table 30. All NOAEL-based HQs are less than 1.0 for all exposure scenarios. Therefore, there is no model-calculated risk to piscivorous receptors from dietary exposure to arsenic under any exposure scenario.

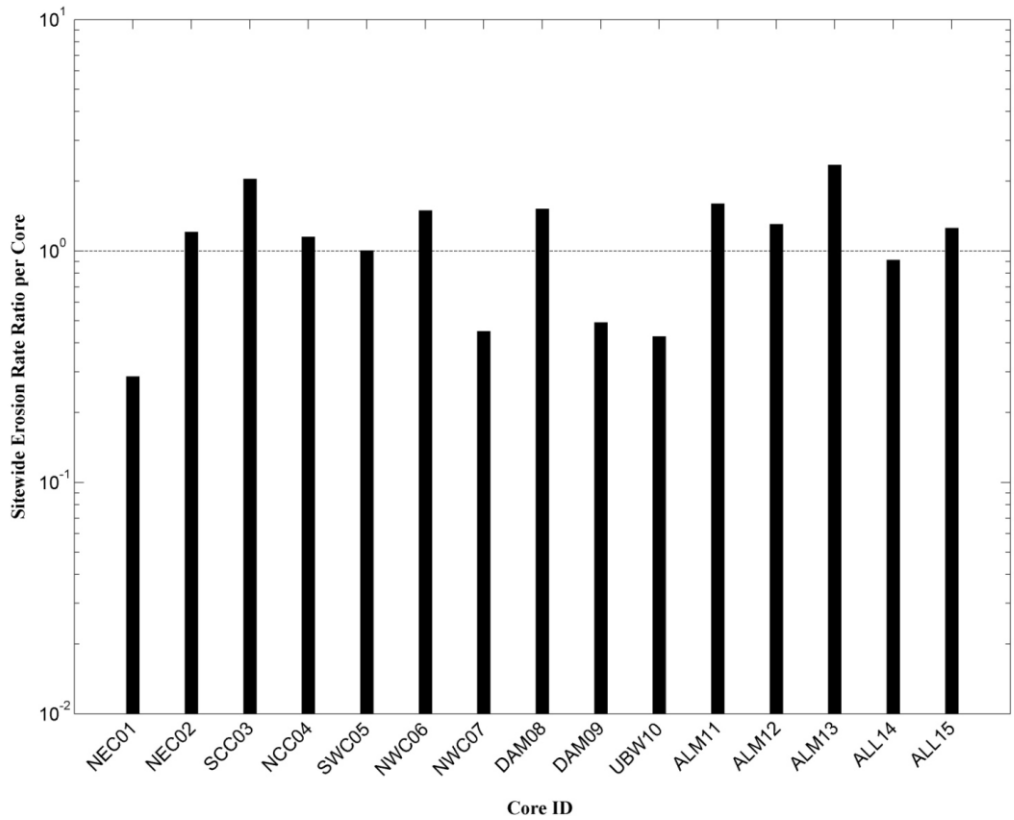
Only one line of evidence (the HQ approach) was used for evaluating potential risks to birds and mammals from arsenic in Site-impacted environmental media. Therefore, risk conclusions must be recognized as uncertain, and additional studies would be needed to determine if the HQ predictions are accurate. There is no model-calculated risk to piscivorous receptors from dietary exposure to arsenic, the primary COPC of concern at this Site.

3.6 Sedflume Study

A Sedflume analysis was conducted on 15 cores obtained from the Maurice River and Union Lake (Appendix C). The primary goal of this study was to characterize the erosion properties and physical characteristics of the lake and rivers sediments. The cores were eroded to determine erosion rates as a function of shear stress and depth into core. In addition, cores were sub-sampled during the analysis to determine sediment bulk density, loss on ignition and particle size distributions at specific depths within the core. Critical shear stresses were calculated from the erosion rate data for five intervals in each core, ranging from 0.1 pascal (Pa) to 1.78 Pa. The presence of organic material such as detritus, woody debris, and leafs had a noticeable effect on erosion. The Sedflume analysis provided a quantification of the overall effect of the organic material on sediment erosion characteristics. When high concentrations of organic material were present in a core, erosion was often dominated by the mobilization of large chunks of material as organic pieces lifted from the test section taking sediment along with them.

Even though organic material effected erosion, most cores stiffened with depth. This trend is common for sites with cohesive sediments. Cohesive sediments will often self-compact due to overlying material. Compaction reduces the potential for sediment mobility. However, Sedflume results must be analyzed in conjunction with other system characteristics, such as hydrodynamic forcing, to assess overall site stability and sediment transport trends.

To better visualize the relative erodibility of the sediment at the locations where cores were recovered, the ratio of the mean erosion rate of each core (core vertically averaged erosion rate) to the average mean erosion rate of all cores at the site was calculated and plotted below (see Appendix C for additional details).



The dashed line denotes a site-wide average erosion rate ratio of 1.0. A ratio above this line generally means the core is more susceptible to erosion than those below. It is important to note that this does not take into account the hydrodynamic forces or sediment coarsening processes that are responsible for net in-situ transport. Overall, there is no easily discernable spatial pattern in the erosion potential of the sites sediments.

3.7 LTFATE Surface Water Modeling System

At present, the LTFATE model is under development by the US ACOE Engineer Research and Development Center.

4.0 CONCLUSIONS

Arsenic concentration in the Maurice River System was related to sediment grain size. Arsenic concentrations were more likely to be elevated when the silt/clay fraction of the sediments increases above 20% and arsenic preferentially partitioned in the finer grain portion of the fluvium. Although there was an apparent increasing concentration with distance downstream of the source, this trend is more so related to increasing percentage of fine grained materials from Sherman Ave to the low head dam on Union Lake than specifically related to distance downstream of the source. Mixed sediment core samples collected during Year 3 of the investigation indicated the silt/clay faction is up to 32 times greater than the coarser sand faction.

Overall 15% of the sediment samples exceeded the cleanup value specified in the ROD (120 mg/kg for submerged sediments and 20 mg/kg for exposed sediments). A majority of the sediment samples exceeding the ROD cleanup levels were in areas (Northeast Cove 48%, Union Lake Low Head Dam 42%,

Northwest Cove 41% and stretch of the Maurice River between Sherman Ave and Union Lake 15%) in the southern portion of the Maurice River system below Sherman Avenue. The areas (Confluence 0%, Alliance Beach 3%, Almond Beach 7%, BA Beach 0% and Utility Access Areas 5%) sampled between the confluence of the Maurice River and the Blackwater Branch and Sherman Avenue were characterized with low exceedance rates of the ROD cleanup levels. The observed exceedances were limited to isolated hot spots that were validated by Hot Spot Delineation sampling conducted in Year 3. A limited number (n = 18) of floodplain samples were collected during this investigation, but a high percentage of these samples did exceed the lower ROD cleanup value of 20 mg/kg. Additional sampling would be needed to further assess the site-wide arsenic concentrations in the exposed wetland sediments. Based on subsurface core sediment sampling performed during Year 1 of the investigation, it was observed that arsenic concentrations were generally highest in the top 1-foot of the sediments and as depth increased, arsenic concentration tended to decrease. Cesium-137 dating of these core samples also indicated that the highest levels of arsenic were deposited in the river sediment at the same time the highest levels of Cesium-137 were deposited in the river, during the early to mid-1960s.

Surface water arsenic concentrations and discharges were measured at six stations on the Maurice River and Blackwater Branch, up to five times per station between Year 1 and Year 3 of the investigation. Four of the stations corresponded to data collected between 1992 and 1993 (Foster Wheeler, 1996). Between the sampling conducted in the early 1990s and the data collected during this investigation, there was a decrease in surface water total arsenic concentrations. Mean total surface water arsenic concentration decreased from 202 µg/L (normal flow) and 267 µg/L (storm flow) in the samples collected between 1992 and 1993 to 13 µg/L in the samples collected during this investigation at downstream station AF4A (Below Almond Beach Spillway). Mean total surface water arsenic concentratons decreased from 134 µg/L (normal flow) and 139 µg/L (storm flow) to 18 µg/L in the samples collected during this investigation at downstream station AF5 (Sherman Ave). Using river discharge rates and surface water arsenic concentrations, total arsenic flux rates were calculated. All stations but AF2 (upstream reference on Maurice River at Garden Road) had arsenic flux rates much lower in 2012 and 2014 compared to the 1992 to 1993 data. The arsenic flux rates at AF2 were consistent during both investigations ranging from 63 to 158 kg/year. At the station BWB, located at the confluence of the Blackwater Branch and the Maurice River, the arsenic flux rates were two orders of magnitude lower in 2012 to 2014 compared to the 1992 to 1993 data; arsenic flux rates were an average 31 kg/year in the 2012 to 2014 data compared to 2,493 kg/year and 2,903 in the 1992 to 1993 data during normal flow and storm water flows, respectively. AF4 and AF5 were both an order of magnitude lower in the 2012 to 2014 data compared to the 1992 to 1993 data. The surface water data and arsenic flux rates indicate the cleanup and remediation of the site and the Blackwater Branch floodplain drastically reduced the amount of arsenic entering and moving through the Maurice River system. Although the amount of arsenic entering and moving through the system has been reduced since the cleanup there is still an increasing trend of arsenic flux rates in a downstream direction. This indicates that although at a lower rate, arsenic is still moving through (or being flushed from) the Maurice River. Overall 76% (range 51% to 100%) of the arsenic moving through the Maurice River system is in the dissolved phase.

Soil (beach sand), sediment and surface water samples were collected at 5 beaches (Alliance, Almond, BA, Sharp Street [SSB], Union Lake Tennis and Sailing Club [ULSTC]) and one public boat launch (DEP Boat Launch) for Human Health Risk Assessment. The data was summarized in tabular format and evaluated statistically. This data was collected for use in a future Human Health Risk Assessment if it is determined necessary. Without following the strict process of a Human Health Risk Assessment, a determination of risk cannot be made.

Overall, surface water sample analysis showed consistently higher total and dissolved arsenic concentrations collected in the lower stretches of the Maurice River (ULSTC, SSB and DEP Boat Launch) as compared to the upper stretches (Alliance Beach, Almond Beach and BA Beach) for both

collection methods (disturbed and undisturbed). In the upper stretches of the river, average total arsenic concentrations for sample collection after disturbing the sediment ranged between non-detect and 3.85 µg/L at Alliance Beach; non-detect and 9.8 µg/L at Almond Beach; and non-detect and 9.8 µg/L at BA Beach (the average was driven up by 1 high concentration sample, 17 µg/L). Average total arsenic concentrations in surface water for disturbed sediment samples ranged from 5.3 µg/L to 10.29 µg/L at ULSTC and from 5.43 µg/L to 6.52 µg/L at SSB.

Comparison of beach sand and sediment analytical results did not indicate consistent patterns of arsenic contamination along transects or within beaches, regardless of the collection year. For Year 1 the maximum arsenic concentration for sand was in a sample collected at Almond Beach (2.5 mg/kg) and for sediment at ULSTC (8.6 mg/kg). The highest arsenic concentration in sand was found at the DEP Boat Launch (15 mg/kg) and in sediment at ULSTC (6.2 mg/kg) in Year 2. For Year 3 the maximum arsenic concentration for sand was in a sample collected at Almond Beach (2.8 mg/kg) and for sediment at BA Beach (190 mg/kg). Statistical comparisons indicated significantly higher average arsenic concentrations in mixed core samples collected from 0 to 2 feet as compared to surface samples for Almond Beach and SSB (Year 1), ULSTC (Year 2), and Alliance Beach (Year 3).

Data collected during this investigation along with fish sampling performed by DESA was used in an ERA. Several lines of evidence were used to assess the risk to aquatic receptors in aquatic habitat areas potentially impacted by arsenic from the Vineland Chemical Company Site. Total and dissolved arsenic concentrations in surface water were well below the chronic AWQC for aquatic life. Although arsenic concentrations in sediment exceeded screening benchmarks, more weight should be placed on lines of evidence that incorporate Site-specific measures of arsenic bioavailability and toxicity, and that examine concentrations in and effects on actual organisms collected from the EAs (fish and benthic macroinvertebrates) or observations of organisms directly exposed to Site-impacted media (sediment toxicity tests). Arsenic concentrations in fish tissue were below tissue concentrations reported to be associated with adverse effects on fish growth, reproduction or survival. Mortality observed in solid-phase toxicity tests was correlated with sediment arsenic concentrations. Arsenic concentrations where mortality was significant were at the high end of the range of concentrations measured in the Maurice River BBC and the Union Lake headwater area. Although significant impacts on growth were observed in both invertebrate species utilized in the toxicity tests, the observed impacts were not correlated with sediment arsenic concentrations, or with any other detected COPCs that exceeded PEC screening concentrations.

Only one line of evidence (the HQ approach) was used to assess the risk to piscivorous birds and mammals exposed to arsenic present in sediment, surface water and prey tissue. This line of evidence suggests negligible risk from dietary exposure of piscivorous receptors to arsenic. Hazard quotient values (both comparison to benchmarks and dietary exposure models) are based on predictive models, and are subject to the uncertainties inherent in both the estimates of exposure and the estimates of toxicity benchmarks. Therefore, HQ values should be interpreted as estimates rather than highly precise values. Site-specific lines of evidence such as toxicity testing and direct observations on the structure and function of a receptor community are evaluated to refine the risk estimates.

All three lines of evidence were evaluated at this Site. Although comparison of sediment concentrations to sediment benchmarks indicated potential risk to aquatic organisms, comparison of surface water concentrations to screening benchmarks and comparison of measured fish tissue concentrations to critical tissue concentrations (CTCs) indicated no potential risk to aquatic organisms. Mortality was only observed in the toxicity tests at exposure concentrations near the highest concentrations measured in the river and headwater area; potential localized adverse effects may occur where the maximum sediment arsenic concentrations are found. The benthic invertebrate community in the Maurice River and Union Lake is very diverse with high numerical abundance and is indicative of a healthy and robust ecosystem.

The community is largely composed of insect larva with smaller numbers of adult insects, crustaceans, mollusks and annelids. In particular, a high diversity of sensitive taxa were collected throughout the study area including mayflies, stoneflies, and caddisflys. In addition, multiple generations of long lived taxa were present suggesting that reproductive success is common and unimpaired. Dietary exposure models using arsenic concentrations measured in fish captured on-Site indicate no risk to upper trophic level receptors. Because the majority of the lines of evidence used to evaluate potential risk to ecological receptors in the Maurice River and Union Lake headwater area yield similar conclusions, confidence in the conclusion is greatly increased.

A Sedflume analysis was conducted on 15 cores obtained from the Maurice River and Union Lake (Appendix C) with the primary goal to characterize the erosion properties and physical characteristics of the lake and rivers sediments. Even though organic material effected erosion, most cores stiffened with depth. This trend was common for sites with cohesive sediments. Cohesive sediments will often self-compact due to overlying material. Compaction reduces the potential for sediment mobility. However, Sedflume results must be analyzed in conjunction with other system characteristics, such as hydrodynamic forcing, to assess overall site stability and sediment transport trends.

The data collected during this investigation has been provided to US ACOE Engineer Research and Development Center personnel and a LTFATE model is currently under development.

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TABLES

Table 1. Summary of the Geologic and Hydrostratigraphic Units
Maurice River Site, Year 1
Vineland, New Jersey

System	Series	Formation	Description	Hydrostratigraphy
Quaternary	Holocene	Modern	Silt, sand and gravel with some mud laid down in modern streams as channel and overbank deposits	Water table aquifer that is locally hydraulically connected to the Cohansey-Kirkwood Aquifer System
	Pleistocene	Cape May	Heterogeneous light colored quartz sand and gravel with some clay	Locally hydraulically connected to the Cohansey-Kirkwood Aquifer System
Tertiary	Miocene	Bridgeton	Arkosic clay - silt - sand - gravel	
		Cohansey	Medium to coarse clean quartz sand with some pebbles and local discontinuous clay beds	Cohansey-Kirkwood Aquifer System
		Kirkwood	Clayey silt to fine quartz sand with abundant fossils	
	Oligocene-Eocene	Piney Point	Fine to coarse quartz sand with a glauconite (green clay) matrix	Secondary aquifer that is locally important in Cumberland County
	Paleocene	Vincentown	Fossiliferous glauconite (green) clay with some silt to fine quartz sand	Leaky Aquitard

Modified from Sugarman (2001)

Table 2. Summary of the Number of Samples by Matrix
Maurice River Site
Vineland, New Jersey

Event	Date	Surface Water Samples	Sediment Samples	Soil Samples
Water Column Sampling				
Year 1 Round 1	July 2012	30	-	-
Year 1 Round 2	October 2012	30	-	-
Year 2 Round 1	May 2013	24	-	-
Year 2 Round 2	October 2013	34	-	-
Year 3 Round 1	July 2014	24	-	-
Year 3 Round 2 (BWB)	August 2014	6	-	-
Sediment Arsenic Loading				
Year 1 Surfacial Sediments	July 2012	-	78	-
Year 1 Cores (19 Locations)	July 2012	-	134	-
Year 2 Surfacial Sediments	May/July 2013	-	138	-
Year 3 Surfacial Sediments	July/August	-	625	-
Year 3 Floodplain Samples	July 2014	-	-	18
Year 3 Mixed Cores (15 Locations)	July 2014	15	45	-
Human Health Risk Assessment				
Year 1	July 2012	64	30	61
Year 2	August 2013	64	28	61
Year 3	July 2014	64	32	64
Toxicity Testing	July 2013	-	116	-
TOTALS		355	1,226	204

Table 3. Summary of Surficial Sediment Samples by Area
Maurice River Site
Vineland, New Jersey

Area	Year 1	Year 2	Year 3	Total
Blackwater Branch (Reference)	1	1	0	2
Garden Road (Reference)	0	1	0	1
Confluence	4	0	0	4
Alliance Beach	30	0	98	128
Floodplain Areas	0	0	18	18
Almond Beach	18	23	173	214
BA Beach	10	0	0	10
Utility Access Areas	0	30	163	193
Below Sherman Ave	0	32	79	111
Northeast Cove	0	27	0	27
Northwest Cove	0	0	110	110
Low Head Dam	0	24	0	24
TOTALS	**63**	**138**	**641**	**842**

Table 4. Summary of Core Samples by Area
Maurice River Site
Vineland, New Jersey

Area	Year 1 - Vertical Profiling Cores*	
	Locations	Samples
Alliance Beach	7	34
Almond Beach	6	39
Sediment Islands	3	14
BA Beach	3	23
TOTALS	19	110

*During Year 1, cores were collected to assess the vertical extent of arsenic contamination and obtain dating information using Cesium-137 isotope analysis.

Area	Year 3 - Mixed Cores**	
	Locations	Samples
Alliance Beach	5	15
Almond Beach	5	15
Sediment Islands	1	3
BA Beach	4	12
TOTALS	15	45

**During Year 3, mixed cores were collected to assess the grain size distribution and their associated arsenic concentrations.

Table 5. Arsenic in Sediment Samples Selected for Toxicity Testing
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Location	Arsenic (mg/kg dw)
TOX-SED-002 (Upstream Reference Control)	1.1
TOX-SED-014	31
TOX-SED-013	33
TOX-SED-019	33
TOX-SED-022	79
TOX-SED-025	110
TOX-SED-016	190
TOX-SED-011	220
TOX-SED-012	230
TOX-SED-005	280
TOX-SED-017	290
TOX-SED-009	380
TOX-SED-007	390
TOX-SED-006	430
TOX-SED-018	890
TOX-SED-015	1000

mg/kg dw = milligrams per kilogram dry weight

Table 6. Summary Statistics for Detected Analytes in Sediment Samples Submitted for Toxicity Testing
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Analyte	Mean (mg/kg dw)	SD	Minimum (mg/kg dw)	Maximum (mg/kg dw)	Detection Frequency	TEC (mg/kg dw)	PEC (mg/kg dw)
Inorganics							
Aluminum	6940.0	5636.5	1100	17000	15 / 15	–	–
Arsenic	305.7	291.9	31 [A]	1000	15 / 15	9.79	33
Barium	147.7	123.8	4.8	320	14 / 15	–	–
Beryllium	1.1	1.1	0.115	2.9	9 / 15	–	–
Cadmium	1.5	1.4	0.145	3.8	12 / 15	0.99	4.98
Calcium	1813.9	1557.4	59	4700	15 / 15	–	–
Chromium	50.3	45.9	5.3	140	15 / 15	43.4	111
Cobalt	14.7	15.0	1.2	56	13 / 15	–	–
Copper	17.4	14.8	3	43	15 / 15	31.6	149
Iron	21226.7	22278.4	1600	57000	15 / 15	–	–
Lead	74.9	72.7	10	220	15 / 15	35.8	128
Magnesium	445.3	403.4	51	1100	15 / 15	–	–
Manganese	135.9	105.1	23	360	15 / 15	–	–
Nickel	17.5	17.3	0.95	45	13 / 15	22.7	48.6
Potassium	175.3	164.9	29.5	480	11 / 15	–	–
Vanadium	55.3	63.2	5.9	190	15 / 15	–	–
Zinc	113.7	111.0	4.1	300	15 / 15	121	459
Pesticides/PCBs							
Aroclor-1260	0.103	0.1	0.0305	0.27	3 / 14	0.0598	0.676
Semi-Volatile Organic Compounds							
Acetophenone	0.363	0.235	0.100	0.750	4 / 14	–	–
Bis(2-ethylhexyl)phthalate	0.392	0.231	0.100	0.750	1 / 14	–	–

Shading indicates concentration exceeds the TEC
Shading indicates concentration exceeds the PEC

Screening benchmark for total PCBs used for individual aroclors
[A] Arsenic measured in the upstream reference sample (TOX-SED-002) was 1.1 mg/kg

mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation
TEC = Threshold effect concentration
PEC = Probable effect concentration
PCB = Polychlorinated biphenyl

Table 7. Summary Statistics for Total and Inorganic Arsenic in Fish Tissue Samples
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Exposure Area	Total Arsenic Concentration (mg/kg ww)				Detection Frequency	95UCL		Exposure Point Concentration (mg/kg ww)	
	KM Mean	SD	Minimum	Maximum		Value	Statistic	Value	Rationale
Maurice River ABC	0.117	0.072	0.031	0.222	6 / 6	0.176	95% Student's-t UCL	0.176	95UCL
Blackwater Branch	0.159	0.057	0.101	0.238	4 / 4	0.226	95% Student's-t UCL	0.226	95UCL
Maurice River BBC	0.270	0.147	0.155	0.496	6 / 6	0.391	95% Student's-t UCL	0.391	95UCL
Union Lake Headwater	0.388	0.147	0.204	0.561	6 / 6	0.51	95% Student's-t UCL	0.51	95UCL

Exposure Area	Inorganic Arsenic Concentration (mg/kg ww)				Detection Frequency	95UCL		Exposure Point Concentration (mg/kg ww)	
	KM Mean	SD	Minimum	Maximum		Value	Statistic	Value	Rationale
Maurice River ABC	0.011	0.006	0.005	0.018	7 / 9	0.0139	95% KM (BCA) UCL	0.0142	95UCL
Blackwater Branch	0.006	0.001	0.005 (U)	0.007	3 / 4	–	–	0.007	Maximum
Maurice River BBC	0.161	0.153	0.061	0.644	16 / 16	0.238	95% Adjusted Gamma UCL	0.238	95 UCL
Union Lake Headwater [1]	0.180	0.143	0.021	0.494	18 / 18	0.238	95% Student's-t UCL	0.238	95UCL

[1] Includes fish captured at location NUL (North Union Lake) in 2009
mg/kg ww = milligrams per kilogram wet weight
KM mean = Kaplan Meier mean
SD = standard deviation
95% KM (BCA) UCL = UCL based on bias-corrected accelerated bootstrap method
95% KM (Chebyshev) UCL = UCL based on Kaplan-Meier method using the Chebyshev inequality
95% Student's-t UCL = UCL based on Student's-t statistic
ABC = Above Blackwater Branch confluence
BBC = BelowBlackwater Branch confluence
U indicates no detected at indicated reporting limit

Table 8. Surficial Sediment Samples (0 to 6") - Year 1
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
Blackwater Branch @ N. Delsea Drive	185-0705	9/27/2012	1.0	Field Sample	Reference Area (N. Delsea Ave)
Confluence Downstream EAST	185-0704	9/27/2012	2.4	Field Sample	Confluence
Confluence Downstream WEST	185-0703	9/27/2012	1.9	Field Sample	Confluence
Confluence Upstream EAST	185-0702	9/27/2012	0.6	Field Sample	Confluence
Confluence Upstream WEST	185-0701	9/27/2012	1.6	Field Sample	Confluence
A1-1.0	185-0001	7/10/2012	0.6 U	Field Sample	Alliance Beach
A1-1.50	185-0002	7/10/2012	0.5	Field Sample	Alliance Beach
A1-1.75	185-0003	7/10/2012	2.5	Field Sample	Alliance Beach
A1-10E.10	185-0023	7/10/2012	0.5	Field Sample	Alliance Beach
A1-10E.40	185-0024	7/10/2012	2.3	Field Sample	Alliance Beach
A1-10W.0	185-0025	7/10/2012	324	Field Sample	Alliance Beach
A1-11E.10	185-0026	7/10/2012	0.6	Field Sample	Alliance Beach
A1-11E.30	185-0027	7/10/2012	0.8	Field Sample	Alliance Beach
SD-FD-02	185-0152	7/10/2012	0.6	Field Duplicate	Alliance Beach
A1-12E.20	185-0028	7/10/2012	0.6 U	Field Sample	Alliance Beach
A1-13E.10	185-0029	7/10/2012	0.6 U	Field Sample	Alliance Beach
A1-13E.20	185-0030	7/10/2012	0.6 U	Field Sample	Alliance Beach
A1-2.10	185-0004	7/10/2012	27	Field Sample	Alliance Beach
A1-2.20	185-0005	7/10/2012	11	Field Sample	Alliance Beach
A1-2.80	185-0006	7/10/2012	2.3	Field Sample	Alliance Beach
A1-2.90	185-0007	7/10/2012	2.8	Field Sample	Alliance Beach
A1-3.30	185-0008	7/10/2012	64	Field Sample	Alliance Beach
A1-4.50	185-0009	7/10/2012	0.6 U	Field Sample	Alliance Beach
A1-4.70	185-0010	7/10/2012	0.6 U	Field Sample	Alliance Beach
A1-5.0	185-0011	7/10/2012	16	Field Sample	Alliance Beach
A1-5.80	185-0012	7/10/2012	0.6	Field Sample	Alliance Beach
A1-6.30	185-0013	7/10/2012	56	Field Sample	Alliance Beach
SD-FD-01	185-0151	7/10/2012	73	Field Duplicate	Alliance Beach
A1-6.40	185-0014	7/10/2012	1.7	Field Sample	Alliance Beach
A1-6.50	185-0015	7/10/2012	43	Field Sample	Alliance Beach
A1-7E.-5	185-0016	7/10/2012	129	Field Sample	Alliance Beach
A1-7W.0	185-0018	7/10/2012	2.6	Field Sample	Alliance Beach
A1-7W.-5	185-0017	7/10/2012	60	Field Sample	Alliance Beach
A1-8W.16	185-0019	7/10/2012	2.6	Field Sample	Alliance Beach
A1-9E.30	185-0020	7/10/2012	2.0	Field Sample	Alliance Beach
A1-9W-10	185-0021	7/10/2012	0.7	Field Sample	Alliance Beach
A1-9W-20	185-0022	7/10/2012	3.4	Field Sample	Alliance Beach

Table 8. Surficial Sediment Samples (0 to 6") - Year 1
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
A2-12	185-0033	7/11/2012	1.3	Field Sample	Almond Beach
A2-17	185-0034	7/11/2012	57	Field Sample	Almond Beach
A2-2	185-0031	7/11/2012	44	Field Sample	Almond Beach
A2-22	185-0035	7/11/2012	1.5	Field Sample	Almond Beach
A2-27	185-0036	7/11/2012	78	Field Sample	Almond Beach
A2-32	185-0037	7/11/2012	2.6	Field Sample	Almond Beach
A2-37	185-0038	7/11/2012	1.5	Field Sample	Almond Beach
A2-43	185-0039	7/11/2012	1.0	Field Sample	Almond Beach
A2-48	185-0040	7/11/2012	6.3	Field Sample	Almond Beach
A2-53	185-0041	7/11/2012	60	Field Sample	Almond Beach
A2-57	185-0042	7/11/2012	1.2	Field Sample	Almond Beach
A2-6	185-0032	7/11/2012	43	Field Sample	Almond Beach
A2-62	185-0043	7/11/2012	0.8 U	Field Sample	Almond Beach
A2-67	185-0044	7/11/2012	0.6 U	Field Sample	Almond Beach
A2-72	185-0045	7/11/2012	1.4	Field Sample	Almond Beach
A2-77	185-0046	7/11/2012	16	Field Sample	Almond Beach
A2-82	185-0047	7/11/2012	4.7	Field Sample	Almond Beach
A2-87	185-0048	7/11/2012	15	Field Sample	Almond Beach
A4-01	185-0049	7/12/2012	1.3	Field Sample	BA Beach
A4-06	185-0050	7/12/2012	15	Field Sample	BA Beach
A4-12	185-0051	7/12/2012	0.8	Field Sample	BA Beach
A4-16	185-0052	7/12/2012	0.9	Field Sample	BA Beach
SD-FD-03	185-0153	7/12/2012	1.2	Field Duplicate	BA Beach
A4-23	185-0053	7/12/2012	1.2	Field Sample	BA Beach
A4-27	185-0054	7/12/2012	0.8 U	Field Sample	BA Beach
A4-32	185-0055	7/12/2012	1.2	Field Sample	BA Beach
A4-37	185-0056	7/12/2012	0.9 U	Field Sample	BA Beach
A4-42	185-0057	7/12/2012	4.0	Field Sample	BA Beach

U = Not detected above analytical detection method
mg/kg = milligrams per kilogram

*Arsenic Color Key:

green: < 10 mg/kg
yellow: 10 - 20 mg/kg
orange: 20 - 100 mg/kg
red: > 100 mg/kg

*Color classification of arsenic concentrations are a relative break-out of concentration and not indicative of action levels.

Note:
In Year 1, all samples collected were analyzed regardless of sediment type (gravel, sand, silt, clay, etc)

Table 9. Surficial Sediment Samples (0 to 6") -Year 2
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
SBWC-1	185-0507	5/14/2013	1.0	Field Sample	Reference Area (N. Delsea Ave)
SGAR-1	185-0508	5/14/2013	1.1	Field Sample	Reference Area (Garden Rd)
A2-007	A2-FS13-SED-007	7/31/2013	38	Field Sample	Almond Beach
A2-100	A2-FS13-SED-100	7/29/2013	3.5 U	Field Sample	Almond Beach
A2-100	A2-FS13-SED-100D	7/29/2013	3.7 U	Field Sample	Almond Beach
A2-103	A2-FS13-SED-103	7/29/2013	2.9	Field Sample	Almond Beach
A2-107	A2-FS13-SED-107	7/29/2013	110	Field Sample	Almond Beach
A2-108	A2-FS13-SED-108	7/29/2013	0.86 U	Field Sample	Almond Beach
A2-114	A2-FS13-SED-114	7/29/2013	6.1	Field Sample	Almond Beach
A2-118	A2-FS13-SED-118	7/29/2013	1400	Field Sample	Almond Beach
A2-123	A2-FS13-SED-123	7/29/2013	91	Field Sample	Almond Beach
A2-127	A2-FS13-SED-127	7/29/2013	390	Field Sample	Almond Beach
A2-131	A2-FS13-SED-131	7/30/2013	94	Field Sample	Almond Beach
A2-135	A2-FS13-SED-135	7/30/2013	12	Field Sample	Almond Beach
A2-138	A2-FS13-SED-138	7/30/2013	5.6	Field Sample	Almond Beach
A2-143	A2-FS13-SED-143	7/30/2013	2.3	Field Sample	Almond Beach
A2-148	A2-FS13-SED-148	7/30/2013	3.1	Field Sample	Almond Beach
A2-200	A2-FS13-SED-200	7/29/2013	0.56 U	Field Sample	Almond Beach
A2-206	A2-FS13-SED-206	7/29/2013	44	Field Sample	Almond Beach
A2-209	A2-FS13-SED-209	7/29/2013	1.8 U	Field Sample	Almond Beach
A2-214	A2-FS13-SED-214	7/29/2013	110	Field Sample	Almond Beach
A2-219	A2-FS13-SED-219	7/29/2013	7.4	Field Sample	Almond Beach
A2-221	A2-FS13-SED-221	7/29/2013	790	Field Sample	Almond Beach
A2-225	A2-FS13-SED-225	7/29/2013	9.2	Field Sample	Almond Beach
A2-229	A2-FS13-SED-229D	7/29/2013	0.60 U	Field Duplicate	Almond Beach
A2-229	A2-FS13-SED-229	7/29/2013	0.62 U	Field Sample	Almond Beach
A8-001	A8-FS13-SED-001	7/31/2013	100	Field Sample	Utility Access Areas
A8-006	A8-FS13-SED-006	7/31/2013	28	Field Sample	Utility Access Areas
A8-007	A8-FS13-SED-007	7/31/2013	1.8	Field Sample	Utility Access Areas
A8-007	A8-FS13-SED-007D	7/31/2013	1.8	Field Sample	Utility Access Areas
A8-015	A8-FS13-SED-015	7/31/2013	11	Field Sample	Utility Access Areas
A8-021	A8-FS13-SED-021	7/31/2013	40	Field Sample	Utility Access Areas
A8-025	A8-FS13-SED-025	7/31/2013	140	Field Sample	Utility Access Areas
A8-028	A8-FS13-SED-028	7/31/2013	9.6	Field Sample	Utility Access Areas
A8-033	A8-FS13-SED-033	7/31/2013	120	Field Sample	Utility Access Areas
A8-038	A8-FS13-SED-038	7/31/2013	24	Field Sample	Utility Access Areas
A8-042	A8-FS13-SED-042	7/31/2013	2.1	Field Sample	Utility Access Areas
A8-047	A8-FS13-SED-047	7/31/2013	3.0	Field Sample	Utility Access Areas
A8-051	A8-FS13-SED-051	7/31/2013	9.3	Field Sample	Utility Access Areas
A9-001	A9-FS13-SED-001	7/31/2013	1.9	Field Sample	Utility Access Areas
A9-010	A9-FS13-SED-010	7/31/2013	23	Field Sample	Utility Access Areas
A9-013	A9-FS13-SED-013	7/31/2013	70	Field Sample	Utility Access Areas
A9-014	A9-FS13-SED-014	7/31/2013	1.4	Field Sample	Utility Access Areas
A9-015	A9-FS13-SED-015	7/31/2013	0.62 U	Field Sample	Utility Access Areas
A9-020	A9-FS13-SED-020	7/31/2013	61	Field Sample	Utility Access Areas
A9-021	A9-FS13-SED-021D	7/31/2013	24	Field Sample	Utility Access Areas
A9-021	A9-FS13-SED-021	7/31/2013	29	Field Sample	Utility Access Areas
A9-027	A9-FS13-SED-027	7/31/2013	3.2	Field Sample	Utility Access Areas
A9-029	A9-FS13-SED-029	7/31/2013	3.1	Field Sample	Utility Access Areas
A9-030	A9-FS13-SED-030	7/31/2013	15	Field Sample	Utility Access Areas
A9-034	A9-FS13-SED-034	7/31/2013	17	Field Sample	Utility Access Areas

Table 9. Surficial Sediment Samples (0 to 6") -Year 2
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	(mg/kg)	Sample Type	Location Description
A9-036	A9-FS13-SED-036	7/31/2013	8.8	Field Sample	Utility Access Areas
A9-037	A9-FS13-SED-037	7/31/2013	11	Field Sample	Utility Access Areas
A9-045	A9-FS13-SED-045	7/31/2013	21	Field Sample	Utility Access Areas
A9-046	A9-FS13-SED-046	7/31/2013	13	Field Sample	Utility Access Areas
A9-050	A9-FS13-SED-050	7/31/2013	17	Field Sample	Utility Access Areas
A6-001	A6-NEC-FS13-SED-001	6/5/2013	22	Field Sample	Sherman Ave to Union Lake
A6-002	A6-NEC-FS13-SED-002	6/5/2013	140	Field Sample	Sherman Ave to Union Lake
A6-003	A6-NEC-FS13-SED-003	6/5/2013	190	Field Sample	Sherman Ave to Union Lake
A6-004	A6-NEC-FS13-SED-004D	6/5/2013	180	Field Duplicate	Sherman Ave to Union Lake
A6-004	A6-NEC-FS13-SED-004	6/5/2013	190	Field Sample	Sherman Ave to Union Lake
A6-005	A6-NEC-FS13-SED-005	6/5/2013	140	Field Sample	Sherman Ave to Union Lake
A6-006	A6-NEC-FS13-SED-006	6/5/2013	150	Field Sample	Sherman Ave to Union Lake
A6-008	A6-NEC-FS13-SED-008	6/5/2013	38	Field Sample	Sherman Ave to Union Lake
A6-010	A6-NEC-FS13-SED-010	6/5/2013	26	Field Sample	Sherman Ave to Union Lake
A6-013	A6-NEC-FS13-SED-013	6/5/2013	19	Field Sample	Sherman Ave to Union Lake
A6-014	A6-NEC-FS13-SED-014	6/5/2013	29	Field Sample	Sherman Ave to Union Lake
A6-015	A6-NEC-FS13-SED-015	6/5/2013	220	Field Sample	Sherman Ave to Union Lake
A6-018	A6-NEC-FS13-SED-018	6/5/2013	29	Field Sample	Sherman Ave to Union Lake
A6-019	A6-NEC-FS13-SED-019	6/5/2013	320	Field Sample	Sherman Ave to Union Lake
A6-200	A6-NEC-FS13-SED-200	6/5/2013	11	Field Sample	Sherman Ave to Union Lake
A6-209	A6-NEC-FS13-SED-209	6/5/2013	17	Field Sample	Sherman Ave to Union Lake
A6-219	A6-NEC-FS13-SED-219	6/5/2013	7.9	Field Sample	Sherman Ave to Union Lake
A6-222	A6-NEC-FS13-SED-222	6/5/2013	6.7	Field Sample	Sherman Ave to Union Lake
A6-228	A6-NEC-FS13-SED-228	6/5/2013	93	Field Sample	Sherman Ave to Union Lake
A6-229	A6-NEC-FS13-SED-229	6/5/2013	110	Field Sample	Sherman Ave to Union Lake
A6-234	A6-NEC-FS13-SED-234	6/5/2013	27	Field Sample	Sherman Ave to Union Lake
A6-235	A6-NEC-FS13-SED-235	6/5/2013	14	Field Sample	Sherman Ave to Union Lake
A6-241	A6-NEC-FS13-SED-241	6/5/2013	79	Field Sample	Sherman Ave to Union Lake
A6-301	A6-FS13-SED-301	7/30/2013	29	Field Sample	Sherman Ave to Union Lake
A6-307	A6-FS13-SED-307	7/30/2013	72	Field Sample	Sherman Ave to Union Lake
A6-313	A6-FS13-SED-313	7/30/2013	28	Field Sample	Sherman Ave to Union Lake
A6-315	A6-FS13-SED-315	7/30/2013	310	Field Sample	Sherman Ave to Union Lake
A6-318	A6-FS13-SED-318	7/30/2013	79	Field Sample	Sherman Ave to Union Lake
A6-322	A6-FS13-SED-322	7/30/2013	49	Field Sample	Sherman Ave to Union Lake
A6-326	A6-FS13-SED-326	7/30/2013	17	Field Sample	Sherman Ave to Union Lake
A6-330	A6-FS13-SED-330	7/30/2013	59	Field Sample	Sherman Ave to Union Lake
A6-334	A6-FS13-SED-334	7/30/2013	63	Field Sample	Sherman Ave to Union Lake
A6-337	A6-FS13-SED-337	7/30/2013	34	Field Sample	Sherman Ave to Union Lake
A5-NEC-007	A5-NEC-FS13-SED-007	6/4/2013	140	Field Sample	Northeast Cove
A5-NEC-009	A5-NEC-FS13-SED-009	6/4/2013	130	Field Sample	Northeast Cove
A5-NEC-016	A5-NEC-FS13-SED-016	6/4/2013	88	Field Sample	Northeast Cove
A5-NEC-017	A5-NEC-FS13-SED-017	6/4/2013	230	Field Sample	Northeast Cove
A5-NEC-018	A5-NEC-FS13-SED-018	6/4/2013	170	Field Sample	Northeast Cove
A5-NEC-019	A5-NEC-FS13-SED-019	6/4/2013	200	Field Sample	Northeast Cove
A5-NEC-020	A5-NEC-FS13-SED-020D	6/4/2013	210	Field Duplicate	Northeast Cove
A5-NEC-020	A5-NEC-FS13-SED-020	6/4/2013	590	Field Sample	Northeast Cove
A5-NEC-021	A5-NEC-FS13-SED-021	6/4/2013	200	Field Sample	Northeast Cove
A5-NEC-022	A5-NEC-FS13-SED-022	6/4/2013	41	Field Sample	Northeast Cove
A5-NEC-023	A5-NEC-FS13-SED-023	6/4/2013	23	Field Sample	Northeast Cove
A5-NEC-203	A5-NEC-FS13-SED-203	6/4/2013	5.7	Field Sample	Northeast Cove
A5-NEC-206	A5-NEC-FS13-SED-206	6/4/2013	6.3 J	Field Sample	Northeast Cove
A5-NEC-208	A5-NEC-FS13-SED-208	6/4/2013	6.4	Field Sample	Northeast Cove

Table 9. Surficial Sediment Samples (0 to 6") -Year 2
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	(mg/kg)	Sample Type	Location Description
A5-NEC-216	A5-NEC-FS13-SED-216	6/4/2013	4.5 U	Field Sample	Northeast Cove
A5-NEC-217	A5-NEC-FS13-SED-217	6/4/2013	1.1 U	Field Sample	Northeast Cove
A5-NEC-223	A5-NEC-FS13-SED-223	6/4/2013	31	Field Sample	Northeast Cove
A5-NEC-228	A5-NEC-FS13-SED-228D	6/4/2013	11	Field Duplicate	Northeast Cove
A5-NEC-228	A5-NEC-FS13-SED-228	6/4/2013	12	Field Sample	Northeast Cove
A5-NEC-240	A5-NEC-FS13-SED-240	6/4/2013	180	Field Sample	Northeast Cove
A5-NEC-242	A5-NEC-FS13-SED-242	6/4/2013	170	Field Sample	Northeast Cove
A5-NEC-244	A5-NEC-FS13-SED-244	6/4/2013	43	Field Sample	Northeast Cove
A5-NEC-421	A5-NEC-FS13-SED-421	6/4/2013	40	Field Sample	Northeast Cove
A5-NEC-424	A5-NEC-FS13-SED-424	6/5/2013	90	Field Sample	Northeast Cove
A5-NEC-432	A5-NEC-FS13-SED-432	6/5/2013	340	Field Sample	Northeast Cove
A5-NEC-446	A5-NEC-FS13-SED-446	6/5/2013	39	Field Sample	Northeast Cove
A5-NEC-452	A5-NEC-FS13-SED-452	6/5/2013	360	Field Sample	Northeast Cove
A5-NEC-455	A5-NEC-FS13-SED-455	6/5/2013	410	Field Sample	Northeast Cove
A5-NEC-465	A5-NEC-FS13-SED-465	6/5/2013	440	Field Sample	Northeast Cove
ULD-001	ULD-FS13-SED-001	6/6/2013	8.0	Field Sample	Low Head Dam
ULD-002	ULD-FS13-SED-002	6/6/2013	12	Field Sample	Low Head Dam
ULD-003	ULD-FS13-SED-003	6/6/2013	6.9	Field Sample	Low Head Dam
ULD-004	ULD-FS13-SED-004	6/6/2013	11	Field Sample	Low Head Dam
ULD-005	ULD-FS13-SED-005	6/6/2013	16	Field Sample	Low Head Dam
ULD-006	ULD-FS13-SED-006	6/6/2013	4.4	Field Sample	Low Head Dam
ULD-007	ULD-FS13-SED-007	6/6/2013	5.9	Field Sample	Low Head Dam
ULD-008	ULD-FS13-SED-008	6/6/2013	52	Field Sample	Low Head Dam
ULD-009	ULD-FS13-SED-009	6/6/2013	22	Field Sample	Low Head Dam
ULD-010	ULD-FS13-SED-010	6/6/2013	63	Field Sample	Low Head Dam
ULD-013	ULD-FS13-SED-013	6/6/2013	43	Field Sample	Low Head Dam
ULD-016	ULD-FS13-SED-016	6/6/2013	10	Field Sample	Low Head Dam
ULD-019	ULD-FS13-SED-019	6/6/2013	51	Field Sample	Low Head Dam
ULD-022	ULD-FS13-SED-022	6/6/2013	120	Field Sample	Low Head Dam
ULD-024	ULD-FS13-SED-024	6/6/2013	120	Field Sample	Low Head Dam
ULD-026	ULD-FS13-SED-026	6/6/2013	58	Field Sample	Low Head Dam
ULD-102	ULD-FS13-SED-102	6/6/2013	260	Field Sample	Low Head Dam
ULD-105	ULD-FS13-SED-105	6/6/2013	1300	Field Sample	Low Head Dam
ULD-108	ULD-FS13-SED-108	6/6/2013	330	Field Sample	Low Head Dam
ULD-111	ULD-FS13-SED-111	6/6/2013	390	Field Sample	Low Head Dam
ULD-117	ULD-FS13-SED-117D	6/6/2013	320	Field Duplicate	Low Head Dam
ULD-117	ULD-FS13-SED-117	6/6/2013	510	Field Sample	Low Head Dam
ULD-120	ULD-FS13-SED-120	6/6/2013	380	Field Sample	Low Head Dam
ULD-123	ULD-FS13-SED-123	6/6/2013	570	Field Sample	Low Head Dam
ULD-126	ULD-FS13-SED-126	6/6/2013	320	Field Sample	Low Head Dam

U = Not detected above analytical detection method
J = Estimated value
mg/kg = milligrams per kilogram

*Arsenic Color Key:	
green: < 10 mg/kg	*Color classification of arsenic concentrations
yellow: 10 - 20 mg/kg	are a relative break-out of concentration
orange: 20 - 100 mg/kg	and not indicative of action levels.
red: > 100 mg/kg	

Note:
In Year 2, gravel and sand samples collected were returned to the river without being analyzed. Silty samples were analyzed for arsenic.

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
ALL-001-Y3	ALL-FS14-SED-001-SLM	7/14/2014	1.2	Field Sample	Alliiance Beach
ALL-002-Y3	ALL-FS14-SED-002-SLM	7/14/2014	1.1	Field Sample	Alliiance Beach
ALL-003-Y3	ALL-FS14-SED-003-SLM	7/14/2014	0.83	Field Sample	Alliiance Beach
ALL-004-Y3	ALL-FS14-SED-004-SLM	7/14/2014	1.1	Field Sample	Alliiance Beach
ALL-005-Y3	ALL-FS14-SED-005-SLM	7/14/2014	0.76	Field Sample	Alliiance Beach
ALL-006-Y3	ALL-FS14-SED-006-SLM	7/14/2014	0.53 J	Field Sample	Alliiance Beach
ALL-007-Y3	ALL-FS14-SED-007-SLM	7/14/2014	5.0	Field Sample	Alliiance Beach
ALL-008-Y3	ALL-FS14-SED-008-SLM	7/14/2014	1.4	Field Sample	Alliiance Beach
ALL-009-Y3	ALL-FS14-SED-009-SLM	7/14/2014	1.6	Field Sample	Alliiance Beach
ALL-010-Y3	ALL-FS14-SED-010-SLM	7/14/2014	1.3	Field Sample	Alliiance Beach
ALL-011-Y3	ALL-FS14-SED-011-SLM	7/14/2014	16	Field Sample	Alliiance Beach
ALL-012-Y3	ALL-FS14-SED-012-SLM	7/14/2014	2.0	Field Sample	Alliiance Beach
ALL-013-Y3	ALL-FS14-SED-013-SLM	7/14/2014	1.8	Field Sample	Alliiance Beach
ALL-014-Y3	ALL-FS14-SED-014-SLM	7/14/2014	3.2	Field Sample	Alliiance Beach
ALL-015-Y3	ALL-FS14-SED-015-SLM	7/14/2014	0.65	Field Sample	Alliiance Beach
ALL-016-Y3	ALL-FS14-SED-016-SLM	7/14/2014	40	Field Sample	Alliiance Beach
ALL-017-Y3	ALL-FS14-SED-017-SLM	7/14/2014	1.3	Field Sample	Alliiance Beach
ALL-018-Y3	ALL-FS14-SED-018-SLM	7/14/2014	1.5	Field Sample	Alliiance Beach
ALL-019-Y3	ALL-FS14-SED-019-SLM	7/14/2014	1.3	Field Sample	Alliiance Beach
ALL-020-Y3	ALL-FS14-SED-020-SLM	7/15/2014	1.4	Field Sample	Alliiance Beach
ALL-021-Y3	ALL-FS14-SED-021-SLM	7/15/2014	1.4	Field Sample	Alliiance Beach
ALL-022-Y3	ALL-FS14-SED-022-SLM	7/15/2014	1.4	Field Sample	Alliiance Beach
ALL-023-Y3	ALL-FS14-SED-023-SLM	7/15/2014	50	Field Sample	Alliiance Beach
ALL-024-Y3	ALL-FS14-SED-024-SLM	7/15/2014	4.1	Field Sample	Alliiance Beach
ALL-025-Y3	ALL-FS14-SED-025-SLM	7/15/2014	2.7	Field Sample	Alliiance Beach
ALL-026-Y3	ALL-FS14-SED-026-SLM	7/15/2014	1.2	Field Sample	Alliiance Beach
ALL-027-Y3	ALL-FS14-SED-027-SLM	7/15/2014	0.91	Field Sample	Alliiance Beach
ALL-028-Y3	ALL-FS14-SED-028-SLM	7/15/2014	0.47 U	Field Sample	Alliiance Beach
ALL-029-Y3	ALL-FS14-SED-029-SLM	7/15/2014	0.75	Field Sample	Alliiance Beach
ALL-030-Y3	ALL-FS14-SED-030-SLM	7/15/2014	1.0	Field Sample	Alliiance Beach
ALL-031-Y3	ALL-FS14-SED-031-SLM	7/15/2014	0.82	Field Sample	Alliiance Beach
ALL-032-Y3	ALL-FS14-SED-032-SLM	7/15/2014	3.4	Field Sample	Alliiance Beach
ALL-034-Y3	ALL-FS14-SED-034-SLM	7/15/2014	2.2	Field Sample	Alliiance Beach
ALL-035-Y3	ALL-FS14-SED-035-SLM	7/15/2014	1.3	Field Sample	Alliiance Beach
ALL-036-Y3	ALL-FS14-SED-036-SLM	7/15/2014	2.2	Field Sample	Alliiance Beach
ALL-101-Y3	ALL-FS14-SED-101-SLM	7/15/2014	5.5	Field Sample	Alliiance Beach
ALL-102-Y3	ALL-FS14-SED-102-SLM	7/15/2014	340	Field Sample	Alliiance Beach
ALL-103-Y3	ALL-FS14-SED-103-SLM	7/15/2014	1.3	Field Sample	Alliiance Beach
ALL-104-Y3	ALL-FS14-SED-104-SLM	7/15/2014	1.6	Field Sample	Alliiance Beach
ALL-105-Y3	ALL-FS14-SED-105-SLM	7/15/2014	8.8	Field Sample	Alliiance Beach
ALL-106-Y3	ALL-FS14-SED-106-SLM	7/15/2014	18	Field Sample	Alliiance Beach
ALL-107-Y3	ALL-FS14-SED-107-SLM	7/15/2014	0.42	Field Sample	Alliiance Beach
ALL-108-Y3	ALL-FS14-SED-108-SLM	7/15/2014	0.80	Field Sample	Alliiance Beach
ALL-109-Y3	ALL-FS14-SED-109-SLM	7/15/2014	1.1	Field Sample	Alliiance Beach
ALL-110-Y3	ALL-FS14-SED-110-SLM	7/15/2014	8.5	Field Sample	Alliiance Beach
ALL-111-Y3	ALL-FS14-SED-111-SLM	7/15/2014	33	Field Sample	Alliiance Beach
ALL-201-Y3	ALL-FS14-SED-201-SLM	7/14/2014	1.0	Field Sample	Alliiance Beach
ALL-202-Y3	ALL-FS14-SED-202-SLM	7/14/2014	1.6	Field Sample	Alliiance Beach
ALL-203-Y3	ALL-FS14-SED-203-SLM-FD	7/14/2014	18	Field Duplicate	Alliiance Beach
ALL-203-Y3	ALL-FS14-SED-203-SLM	7/14/2014	22	Field Sample	Alliiance Beach
ALL-204-Y3	ALL-FS14-SED-204-SLM	7/14/2014	78	Field Sample	Alliiance Beach
ALL-205-Y3	ALL-FS14-SED-205-SLM	7/14/2014	3.1	Field Sample	Alliiance Beach
ALL-206-Y3	ALL-FS14-SED-206-SLM	7/14/2014	0.72	Field Sample	Alliiance Beach
ALL-207-Y3	ALL-FS14-SED-207-SLM	7/14/2014	5.6	Field Sample	Alliiance Beach
ALL-208-Y3	ALL-FS14-SED-208-SLM	7/14/2014	15	Field Sample	Alliiance Beach
ALL-209-Y3	ALL-FS14-SED-209-SLM	7/14/2014	1.5	Field Sample	Alliiance Beach
ALL-210-Y3	ALL-FS14-SED-210-SLM	7/14/2014	1.2 J	Field Sample	Alliiance Beach
ALL-211-Y3	ALL-FS14-SED-211-SLM	7/14/2014	3.4	Field Sample	Alliiance Beach
ALL-212-Y3	ALL-FS14-SED-212-SLM	7/14/2014	51	Field Sample	Alliiance Beach
ALL-213-Y3	ALL-FS14-SED-213-SLM	7/14/2014	1.5	Field Sample	Alliiance Beach
ALL-215-Y3	ALL-FS14-SED-215-SLM	7/14/2014	92	Field Sample	Alliiance Beach
ALL-216-Y3	ALL-FS14-SED-216-SLM	7/14/2014	57	Field Sample	Alliiance Beach

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
ALL-218-Y3	ALL-FS14-SED-218-SLM	7/14/2014	6.0	Field Sample	Alliiance Beach
ALL-219-Y3	ALL-FS14-SED-219-SLM	7/14/2014	0.82	Field Sample	Alliiance Beach
ALL-220-Y3	ALL-FS14-SED-220-SLM	7/14/2014	1.3	Field Sample	Alliiance Beach
ALL-221-Y3	ALL-FS14-SED-221-SLM-FD	7/14/2014	1.4	Field Duplicate	Alliiance Beach
ALL-221-Y3	ALL-FS14-SED-221-SLM	7/14/2014	2.6	Field Sample	Alliiance Beach
ALL-222-Y3	ALL-FS14-SED-222-SLM	7/15/2014	1.3	Field Sample	Alliiance Beach
ALL-223-Y3	ALL-FS14-SED-223-SLM	7/15/2014	1.5	Field Sample	Alliiance Beach
ALL-224-Y3	ALL-FS14-SED-224-SLM	7/15/2014	33	Field Sample	Alliiance Beach
ALL-225-Y3	ALL-FS14-SED-225-SLM	7/15/2014	3.8	Field Sample	Alliiance Beach
ALL-226-Y3	ALL-FS14-SED-226-SLM	7/5/2014	14	Field Sample	Alliiance Beach
ALL-227-Y3	ALL-FS14-SED-227-SLM	7/15/2014	0.74	Field Sample	Alliiance Beach
ALL-228-Y3	ALL-FS14-SED-228-SLM	7/15/2014	1.0	Field Sample	Alliiance Beach
ALL-229-Y3	ALL-FS14-SED-229-SLM	7/15/2014	0.84	Field Sample	Alliiance Beach
ALL-230-Y3	ALL-FS14-SED-230-SLM	7/15/2014	0.46	Field Sample	Alliiance Beach
ALL-231-Y3	ALL-FS14-SED-231-SLM	7/15/2014	0.41 U	Field Sample	Alliiance Beach
ALL-232-Y3	ALL-FS14-SED-232-SLM	7/15/2014	21	Field Sample	Alliiance Beach
ALL-233-Y3	ALL-FS14-SED-233-SLM	7/15/2014	3.3	Field Sample	Alliiance Beach
ALL-235-Y3	ALL-FS14-SED-235-SLM	7/15/2014	1.2	Field Sample	Alliiance Beach
ALL-236-Y3	ALL-FS14-SED-236-SLM	7/15/2014	43	Field Sample	Alliiance Beach
ALL-237-Y3	ALL-FS14-SED-237-SLM	7/15/2014	0.44	Field Sample	Alliiance Beach
ALL-112-Y3	ALL-FS14-SED-112-SLM	7/16/2014	55	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-113-Y3	ALL-FS14-SED-113-SLM	7/16/2014	26	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-114-Y3	ALL-FS14-SED-114-SLM	7/16/2014	120	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-115-Y3	ALL-FS14-SED-115-SLM	7/16/2014	38	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-116-Y3	ALL-FS14-SED-116-SLM	7/16/2014	180	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-117-Y3	ALL-FS14-SED-117-SLM	7/16/2014	79	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-118-Y3	ALL-FS14-SED-118-SLM	7/16/2014	110	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-119-Y3	ALL-FS14-SED-119-SLM	7/16/2014	50	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-120-Y3	ALL-FS14-SED-120-SLM	7/16/2014	12	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-121-Y3	ALL-FS14-SED-121-SLM	7/16/2014	0.38 U	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-122-Y3	ALL-FS14-SED-122-SLM	7/16/2014	1.5	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-123-Y3	ALL-FS14-SED-123-SLM	7/16/2014	0.40 U	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-124-Y3	ALL-FS14-SED-124-SLM	7/16/2014	20	Field Sample	Alliance Beach (Hot Spot Delineation)
ALL-125-Y3	ALL-FS14-SED-125-SLM	7/16/2014	15	Field Sample	Alliance Beach (Hot Spot Delineation)
AAB-FP-601-1-04.5-Y3	AAB-FS14-SOL-601-1-04.5	7/14/2014	48	Field Sample	Floodplain Assessment
AAB-FP-602-1-14.5-Y3	AAB-FS14-SOL-602-1-14.5	7/14/2014	79	Field Sample	Floodplain Assessment
AAB-FP-603-1-24.5-Y3	AAB-FS14-SOL-603-1-24.5	7/14/2014	58	Field Sample	Floodplain Assessment
AAB-FP-604-1-34.5-Y3	AAB-FS14-SOL-604-1-34.5	7/14/2014	15	Field Sample	Floodplain Assessment
AAB-FP-605-1-44.5-Y3	AAB-FS14-SOL-605-1-44.5	7/14/2014	9.7	Field Sample	Floodplain Assessment
AAB-FP-606-1-54.5-Y3	AAB-FS14-SOL-606-1-54.5	7/14/2014	69	Field Sample	Floodplain Assessment
AAB-FP-607-2-02-Y3	AAB-FS14-SOL-607-2-02	7/14/2014	2.6	Field Sample	Floodplain Assessment
AAB-FP-608-2-12-Y3	AAB-FS14-SOL-608-2-12	7/14/2014	57	Field Sample	Floodplain Assessment
AAB-FP-609-2-22-Y3	AAB-FS14-SOL-609-2-22	7/14/2014	43	Field Sample	Floodplain Assessment
AAB-FP-610-2-32-Y3	AAB-FS14-SOL-610-2-32	7/14/2014	47	Field Sample	Floodplain Assessment
AAB-FP-611-2-42-Y3	AAB-FS14-SOL-611-2-42	7/14/2014	4.5	Field Sample	Floodplain Assessment
AAB-FP-612-2-52-Y3	AAB-FS14-SOL-612-2-52	7/14/2014	44	Field Sample	Floodplain Assessment
AAB-FP-613-3-03.5-Y3	AAB-FS14-SOL-613-3-03.5	7/14/2014	20	Field Sample	Floodplain Assessment
AAB-FP-614-3-13.5-Y3	AAB-FS14-SOL-614-3-13.5	7/14/2014	9.4	Field Sample	Floodplain Assessment
AAB-FP-615-3-23.5-Y3	AAB-FS14-SOL-615-3-23.5	7/14/2014	15	Field Sample	Floodplain Assessment
AAB-FP-616-3-33.5-Y3	AAB-FS14-SOL-616-3-33.5	7/14/2014	16	Field Sample	Floodplain Assessment
AAB-FP-617-3-43.5-Y3	AAB-FS14-SOL-617-3-43.5	7/14/2014	7.3	Field Sample	Floodplain Assessment

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
AAB-FP-618-3-53.5-Y3	AAB-FS14-SOL-618-3-53.5	7/14/2014	63	Field Sample	Floodplain Assessment
ALM-003-Y3	ALM-FS14-SED-003-SLM	7/15/2014	1.1	Field Sample	Almond Beach
ALM-004-Y3	ALM-FS14-SED-004-SLM	7/15/2014	1.9	Field Sample	Almond Beach
ALM-005-Y3	ALM-FS14-SED-005-SLM	7/15/2014	15	Field Sample	Almond Beach
ALM-006-Y3	ALM-FS14-SED-006-SLM	7/15/2014	0.84	Field Sample	Almond Beach
ALM-007-Y3	ALM-FS14-SED-007-SLM-FD	7/15/2014	4.4	Field Duplicate	Almond Beach
ALM-007-Y3	ALM-FS14-SED-007-SLM	7/15/2014	4.4	Field Sample	Almond Beach
ALM-008-Y3	ALM-FS14-SED-008-SLM	7/15/2014	0.72 U	Field Sample	Almond Beach
ALM-009-Y3	ALM-FS14-SED-009-SLM-FD	7/15/2014	0.67 U	Field Duplicate	Almond Beach
ALM-009-Y3	ALM-FS14-SED-009-SLM	7/15/2014	0.70 U	Field Sample	Almond Beach
ALM-010-Y3	ALM-FS14-SED-010-SLM	7/15/2014	29	Field Sample	Almond Beach
ALM-011-Y3	ALM-FS14-SED-011-SLM-FD	7/15/2014	130	Field Duplicate	Almond Beach
ALM-011-Y3	ALM-FS14-SED-011-SLM	7/15/2014	79	Field Sample	Almond Beach
ALM-012-Y3	ALM-FS14-SED-012-SLM	7/15/2014	43	Field Sample	Almond Beach
ALM-013-Y3	ALM-FS14-SED-013-SLM	7/15/2014	540	Field Sample	Almond Beach
ALM-014-Y3	ALM-FS14-SED-014-SLM	7/15/2014	82	Field Sample	Almond Beach
ALM-015-Y3	ALM-FS14-SED-015-SLM	7/15/2014	29	Field Sample	Almond Beach
ALM-016-Y3	ALM-FS14-SED-016-SLM	7/15/2014	2.6	Field Sample	Almond Beach
ALM-018-Y3	ALM-FS14-SED-018-SLM	7/15/2014	7.8	Field Sample	Almond Beach
ALM-019-Y3	ALM-FS14-SED-019-SLM-FD	7/16/2014	3.8	Field Duplicate	Almond Beach
ALM-019-Y3	ALM-FS14-SED-019-SLM	7/16/2014	2.5	Field Sample	Almond Beach
ALM-020-Y3	ALM-FS14-SED-020-SLM	7/16/2014	4.3	Field Sample	Almond Beach
ALM-021-Y3	ALM-FS14-SED-021-SLM	7/16/2014	130	Field Sample	Almond Beach
ALM-022-Y3	ALM-FS14-SED-022-SLM	7/16/2014	24	Field Sample	Almond Beach
ALM-023-Y3	ALM-FS14-SED-023-SLM	7/16/2014	0.59 U	Field Sample	Almond Beach
ALM-024-Y3	ALM-FS14-SED-024-SLM-FD	7/16/2014	2.8	Field Duplicate	Almond Beach
ALM-024-Y3	ALM-FS14-SED-024-SLM	7/16/2014	2.0	Field Sample	Almond Beach
ALM-025-Y3	ALM-FS14-SED-025-SLM	7/16/2014	1.6	Field Sample	Almond Beach
ALM-026-Y3	ALM-FS14-SED-026-SLM	7/16/2014	31	Field Sample	Almond Beach
ALM-027-Y3	ALM-FS14-SED-027-SLM	7/16/2014	13	Field Sample	Almond Beach
ALM-028-Y3	ALM-FS14-SED-028-SLM	7/16/2014	26	Field Sample	Almond Beach
ALM-029-Y3	ALM-FS14-SED-029-SLM	7/16/2014	6.5	Field Sample	Almond Beach
ALM-030-Y3	ALM-FS14-SED-030-SLM	7/16/2014	43	Field Sample	Almond Beach
ALM-032-Y3	ALM-FS14-SED-032-SLM	7/16/2014	44	Field Sample	Almond Beach
ALM-033-Y3	ALM-FS14-SED-033-SLM	7/16/2014	170	Field Sample	Almond Beach
ALM-034-Y3	ALM-FS14-SED-034-SLM	7/16/2014	0.91	Field Sample	Almond Beach
ALM-035-Y3	ALM-FS14-SED-035-SLM	7/16/2014	3.6	Field Sample	Almond Beach
ALM-036-Y3	ALM-FS14-SED-036-SLM	7/16/2014	41	Field Sample	Almond Beach
ALM-037-Y3	ALM-FS14-SED-037-SLM	7/16/2014	37	Field Sample	Almond Beach
ALM-038-Y3	ALM-FS14-SED-038-SLM	7/16/2014	0.63	Field Sample	Almond Beach
ALM-039-Y3	ALM-FS14-SED-039-SLM	7/16/2014	0.55 J	Field Sample	Almond Beach
ALM-041-Y3	ALM-FS14-SED-041-SLM	7/16/2014	0.51	Field Sample	Almond Beach
ALM-042-Y3	ALM-FS14-SED-042-SLM	7/16/2014	25	Field Sample	Almond Beach
ALM-043-Y3	ALM-FS14-SED-043-SLM	7/16/2014	0.71 U	Field Sample	Almond Beach
ALM-044-Y3	ALM-FS14-SED-044-SLM	7/16/2014	17	Field Sample	Almond Beach
ALM-045-Y3	ALM-FS14-SED-045-SLM	7/16/2014	6.2	Field Sample	Almond Beach
ALM-046-Y3	ALM-FS14-SED-046-SLM	7/16/2014	36	Field Sample	Almond Beach
ALM-047-Y3	ALM-FS14-SED-047-SLM	7/16/2014	26	Field Sample	Almond Beach
ALM-048-Y3	ALM-FS14-SED-048-SLM	7/16/2014	1.1	Field Sample	Almond Beach
ALM-049-Y3	ALM-FS14-SED-049-SLM	7/16/2014	0.77	Field Sample	Almond Beach
ALM-050-Y3	ALM-FS14-SED-050-SLM	7/16/2014	8.1	Field Sample	Almond Beach
ALM-051-Y3	ALM-FS14-SED-051-SLM	7/16/2014	0.99	Field Sample	Almond Beach
ALM-052-Y3	ALM-FS14-SED-052-SLM	7/16/2014	10	Field Sample	Almond Beach
ALM-053-Y3	ALM-FS14-SED-053-SLM	7/16/2014	2.8	Field Sample	Almond Beach
ALM-054-Y3	ALM-FS14-SED-054-SLM	7/16/2014	2.2	Field Sample	Almond Beach
ALM-055-Y3	ALM-FS14-SED-055-SLM	7/16/2014	13	Field Sample	Almond Beach
ALM-056-Y3	ALM-FS14-SED-056-SLM	7/16/2014	160	Field Sample	Almond Beach
ALM-057-Y3	ALM-FS14-SED-057-SLM	7/16/2014	0.89	Field Sample	Almond Beach
ALM-058-Y3	ALM-FS14-SED-058-SLM-FD	7/16/2014	1.4	Field Duplicate	Almond Beach
ALM-058-Y3	ALM-FS14-SED-058-SLM	7/16/2014	1.5	Field Sample	Almond Beach
ALM-059-Y3	ALM-FS14-SED-059-SLM	7/16/2014	0.64	Field Sample	Almond Beach
ALM-060-Y3	ALM-FS14-SED-060-SLM	7/16/2014	1.3	Field Sample	Almond Beach
ALM-061-Y3	ALM-FS14-SED-061-SLM	7/16/2014	1.5	Field Sample	Almond Beach
ALM-062-Y3	ALM-FS14-SED-062-SLM	7/16/2014	0.98	Field Sample	Almond Beach
ALM-063-Y3	ALM-FS14-SED-063-SLM	7/16/2014	6.3	Field Sample	Almond Beach
ALM-064-Y3	ALM-FS14-SED-064-SLM	7/16/2014	2.6	Field Sample	Almond Beach

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
ALM-065-Y3	ALM-FS14-SED-065-SLM	7/16/2014	1.0	Field Sample	Almond Beach
ALM-066-Y3	ALM-FS14-SED-066-SLM	7/16/2014	17	Field Sample	Almond Beach
ALM-067-Y3	ALM-FS14-SED-067-SLM	7/16/2014	4.4	Field Sample	Almond Beach
ALM-068-Y3	ALM-FS14-SED-068-SLM	7/16/2014	2.4	Field Sample	Almond Beach
ALM-069-Y3	ALM-FS14-SED-069-SLM	7/16/2014	1.5	Field Sample	Almond Beach
ALM-070-Y3	ALM-FS14-SED-070-SLM	7/16/2014	69	Field Sample	Almond Beach
ALM-071-Y3	ALM-FS14-SED-071-SLM	7/16/2014	320	Field Sample	Almond Beach
ALM-072-Y3	ALM-FS14-SED-072-SLM	7/16/2014	17	Field Sample	Almond Beach
ALM-073-Y3	ALM-FS14-SED-073-SLM	7/16/2014	730	Field Sample	Almond Beach
ALM-074-Y3	ALM-FS14-SED-074-SLM	7/16/2014	130	Field Sample	Almond Beach
ALM-101-Y3	ALM-FS14-SED-101-SLM	7/15/2014	160	Field Sample	Almond Beach
ALM-102-Y3	ALM-FS14-SED-102-SLM	7/15/2014	21	Field Sample	Almond Beach
ALM-103-Y3	ALM-FS14-SED-103-SLM	7/15/2014	1.6	Field Sample	Almond Beach
ALM-104-Y3	ALM-FS14-SED-104-SLM	7/15/2014	0.79	Field Sample	Almond Beach
ALM-106-Y3	ALM-FS14-SED-106-SLM	7/15/2014	11	Field Sample	Almond Beach
ALM-107-Y3	ALM-FS14-SED-107-SLM	7/15/2014	1.1	Field Sample	Almond Beach
ALM-108-Y3	ALM-FS14-SED-108-SLM	7/15/2014	0.57 U	Field Sample	Almond Beach
ALM-109-Y3	ALM-FS14-SED-109-SLM	7/15/2014	15	Field Sample	Almond Beach
ALM-110-Y3	ALM-FS14-SED-110-SLM	7/15/2014	5.7	Field Sample	Almond Beach
ALM-111-Y3	ALM-FS14-SED-111-SLM	7/15/2014	0.81	Field Sample	Almond Beach
ALM-112-Y3	ALM-FS14-SED-112-SLM	7/15/2014	2.4	Field Sample	Almond Beach
ALM-113-Y3	ALM-FS14-SED-113-SLM	7/15/2014	85	Field Sample	Almond Beach
ALM-114-Y3	ALM-FS14-SED-114-SLM	7/15/2014	18	Field Sample	Almond Beach
ALM-115-Y3	ALM-FS14-SED-115-SLM	7/15/2014	3.0	Field Sample	Almond Beach
ALM-116-Y3	ALM-FS14-SED-116-SLM	7/15/2014	0.86 J	Field Sample	Almond Beach
ALM-117-Y3	ALM-FS14-SED-117-SLM	7/15/2014	0.83	Field Sample	Almond Beach
ALM-118-Y3	ALM-FS14-SED-118-SLM	7/15/2014	17	Field Sample	Almond Beach
ALM-119-Y3	ALM-FS14-SED-119-SLM	7/15/2014	0.71	Field Sample	Almond Beach
ALM-120-Y3	ALM-FS14-SED-120-SLM-FD	7/15/2014	1.1	Field Duplicate	Almond Beach
ALM-120-Y3	ALM-FS14-SED-120-SLM	7/15/2014	1.1	Field Sample	Almond Beach
ALM-201-Y3	ALM-FS14-SED-201-SLM	7/15/2014	22	Field Sample	Almond Beach
ALM-203-Y3	ALM-FS14-SED-203-SLM-FD	7/15/2014	0.68	Field Duplicate	Almond Beach
ALM-203-Y3	ALM-FS14-SED-203-SLM	7/15/2014	0.59 U	Field Sample	Almond Beach
ALM-204-Y3	ALM-FS14-SED-204-SLM	7/15/2014	0.84	Field Sample	Almond Beach
ALM-205-Y3	ALM-FS14-SED-205-SLM	7/15/2014	0.62 U	Field Sample	Almond Beach
ALM-206-Y3	ALM-FS14-SED-206-SLM	7/15/2014	62	Field Sample	Almond Beach
ALM-207-Y3	ALM-FS14-SED-207-SLM	7/15/2014	47	Field Sample	Almond Beach
ALM-208-Y3	ALM-FS14-SED-208-SLM	7/15/2014	0.68 J	Field Sample	Almond Beach
ALM-209-Y3	ALM-FS14-SED-209-SLM	7/15/2014	13	Field Sample	Almond Beach
ALM-210-Y3	ALM-FS14-SED-210-SLM	7/15/2014	4.2	Field Sample	Almond Beach
ALM-211-Y3	ALM-FS14-SED-211-SLM	7/15/2014	0.73	Field Sample	Almond Beach
ALM-212-Y3	ALM-FS14-SED-212-SLM	7/15/2014	0.61 UJ	Field Sample	Almond Beach
ALM-213-Y3	ALM-FS14-SED-213-SLM	7/15/2014	0.58 U	Field Sample	Almond Beach
ALM-214-Y3	ALM-FS14-SED-214-SLM	7/15/2014	0.72	Field Sample	Almond Beach
ALM-215-Y3	ALM-FS14-SED-215-SLM	7/15/2014	2.6	Field Sample	Almond Beach
ALM-216-Y3	ALM-FS14-SED-216-SLM	7/15/2014	54	Field Sample	Almond Beach
ALM-217-Y3	ALM-FS14-SED-217-SLM	7/15/2014	45	Field Sample	Almond Beach
ALM-218-Y3	ALM-FS14-SED-218-SLM	7/15/2014	0.65	Field Sample	Almond Beach
ALM-219-Y3	ALM-FS14-SED-219-SLM	7/15/2014	0.65 U	Field Sample	Almond Beach
ALM-220-Y3	ALM-FS14-SED-220-SLM	7/15/2014	0.60 U	Field Sample	Almond Beach
ALM-221-Y3	ALM-FS14-SED-221-SLM-FD	7/15/2014	0.62 U	Field Duplicate	Almond Beach
ALM-221-Y3	ALM-FS14-SED-221-SLM	7/15/2014	0.61 U	Field Sample	Almond Beach
ALM-222-Y3	ALM-FS14-SED-222-SLM	7/15/2014	35	Field Sample	Almond Beach
ALM-223-Y3	ALM-FS14-SED-223-SLM	7/15/2014	3.4	Field Sample	Almond Beach
ALM-224-Y3	ALM-FS14-SED-224-SLM	7/15/2014	0.60 U	Field Sample	Almond Beach
ALM-225-Y3	ALM-FS14-SED-225-SLM	7/15/2014	1.2	Field Sample	Almond Beach
ALM-226-Y3	ALM-FS14-SED-226-SLM	7/15/2014	0.80	Field Sample	Almond Beach
ALM-227-Y3	ALM-FS14-SED-227-SLM	7/15/2014	2.9	Field Sample	Almond Beach
ALM-228-Y3	ALM-FS14-SED-228-SLM	7/16/2014	56	Field Sample	Almond Beach
ALM-229-Y3	ALM-FS14-SED-229-SLM	7/16/2014	62	Field Sample	Almond Beach
ALM-230-Y3	ALM-FS14-SED-230-SLM	7/16/2014	0.60	Field Sample	Almond Beach
ALM-231-Y3	ALM-FS14-SED-231-SLM	7/16/2014	12	Field Sample	Almond Beach
ALM-232-Y3	ALM-FS14-SED-232-SLM	7/16/2014	4.7	Field Sample	Almond Beach
ALM-233-Y3	ALM-FS14-SED-233-SLM	7/16/2014	8.9	Field Sample	Almond Beach
ALM-234-Y3	ALM-FS14-SED-234-SLM	7/16/2014	0.64 U	Field Sample	Almond Beach
ALM-235-Y3	ALM-FS14-SED-235-SLM	7/16/2014	52	Field Sample	Almond Beach

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
ALM-236-Y3	ALM-FS14-SED-236-SLM	7/16/2014	34	Field Sample	Almond Beach
ALM-237-Y3	ALM-FS14-SED-237-SLM	7/16/2014	9.5	Field Sample	Almond Beach
ALM-238-Y3	ALM-FS14-SED-238-SLM	7/16/2014	6.7	Field Sample	Almond Beach
ALM-239-Y3	ALM-FS14-SED-239-SLM	7/16/2014	17	Field Sample	Almond Beach
ALM-240-Y3	ALM-FS14-SED-240-SLM	7/16/2014	0.60	Field Sample	Almond Beach
ALM-241-Y3	ALM-FS14-SED-241-SLM-FD	7/16/2014	10	Field Duplicate	Almond Beach
ALM-241-Y3	ALM-FS14-SED-241-SLM	7/16/2014	7.3	Field Sample	Almond Beach
ALM-242-Y3	ALM-FS14-SED-242-SLM	7/16/2014	12	Field Sample	Almond Beach
ALM-243-Y3	ALM-FS14-SED-243-SLM	7/16/2014	9.6	Field Sample	Almond Beach
ALM-244-Y3	ALM-FS14-SED-244-SLM	7/16/2014	24	Field Sample	Almond Beach
ALM-245-Y3	ALM-FS14-SED-245-SLM	7/16/2014	4.8	Field Sample	Almond Beach
ALM-246-Y3	ALM-FS14-SED-246-SLM	7/16/2014	0.60 U	Field Sample	Almond Beach
ALM-247-Y3	ALM-FS14-SED-247-SLM	7/16/2014	0.68	Field Sample	Almond Beach
ALM-248-Y3	ALM-FS14-SED-248-SLM	7/16/2014	1.0 J	Field Sample	Almond Beach
ALM-249-Y3	ALM-FS14-SED-249-SLM	7/16/2014	9.8	Field Sample	Almond Beach
ALM-250-Y3	ALM-FS14-SED-250-SLM	7/16/2014	1.0	Field Sample	Almond Beach
ALM-251-Y3	ALM-FS14-SED-251-SLM	7/16/2014	1.6	Field Sample	Almond Beach
ALM-252-Y3	ALM-FS14-SED-252-SLM	7/16/2014	15	Field Sample	Almond Beach
ALM-253-Y3	ALM-FS14-SED-253-SLM	7/16/2014	1.7	Field Sample	Almond Beach
ALM-254-Y3	ALM-FS14-SED-254-SLM	7/16/2014	0.63	Field Sample	Almond Beach
ALM-255-Y3	ALM-FS14-SED-255-SLM	7/16/2014	2.2 J	Field Sample	Almond Beach
ALM-256-Y3	ALM-FS14-SED-256-SLM	7/16/2014	10	Field Sample	Almond Beach
ALM-257-Y3	ALM-FS14-SED-257-SLM	7/16/2014	35	Field Sample	Almond Beach
ALM-258-Y3	ALM-FS14-SED-258-SLM	7/16/2014	650	Field Sample	Almond Beach
ALM-259-Y3	ALM-FS14-SED-259-SLM	7/16/2014	3.0	Field Sample	Almond Beach
ALM-260-Y3	ALM-FS14-SED-260-SLM	7/16/2014	72	Field Sample	Almond Beach
ALM-261-Y3	ALM-FS14-SED-261-SLM-FD	7/16/2014	140	Field Duplicate	Almond Beach
ALM-261-Y3	ALM-FS14-SED-261-SLM	7/16/2014	140	Field Sample	Almond Beach
ALM-262-Y3	ALM-FS14-SED-262-SLM	7/16/2014	36	Field Sample	Almond Beach
ALM-263-Y3	ALM-FS14-SED-263-SLM	7/16/2014	460	Field Sample	Almond Beach
ALM-264-Y3	ALM-FS14-SED-264-SLM	7/16/2014	21	Field Sample	Almond Beach
ALM-265-Y3	ALM-FS14-SED-265-SLM	7/16/2014	47	Field Sample	Almond Beach
ALM-266-Y3	ALM-FS14-SED-266-SLM	7/16/2014	49	Field Sample	Almond Beach
ALM-267-Y3	ALM-FS14-SED-267-SLM	7/16/2014	6.9	Field Sample	Almond Beach
ALM-268-Y3	ALM-FS14-SED-268-SLM	7/16/2014	69	Field Sample	Almond Beach
ALM-269-Y3	ALM-FS14-SED-269-SLM	7/16/2014	74	Field Sample	Almond Beach
ALM-270-Y3	ALM-FS14-SED-270-SLM	7/16/2014	5.2	Field Sample	Almond Beach
ALM-271-Y3	ALM-FS14-SED-271-SLM	7/16/2014	22	Field Sample	Almond Beach
ALM-272-Y3	ALM-FS14-SED-272-SLM	7/16/2014	0.65 J	Field Sample	Almond Beach
ALM-273-Y3	ALM-FS14-SED-273-SLM	7/16/2014	38	Field Sample	Almond Beach
ALM-274-Y3	ALM-FS14-SED-274-SLM	7/16/2014	0.66 U	Field Sample	Almond Beach
ALM-275-Y3	ALM-FS14-SED-275-SLM	7/16/2014	560	Field Sample	Almond Beach
ALM-276-Y3	ALM-FS14-SED-276-SLM	6/16/2014	560	Field Sample	Almond Beach
ALM-277-Y3	ALM-FS14-SED-277-SLM	7/16/2014	45	Field Sample	Almond Beach
ALM-279-Y3	ALM-FS14-SED-279-SLM	7/17/2014	9.6	Field Sample	Almond Beach
ALM-280-Y3	ALM-FS14-SED-280-SLM	7/17/2014	110	Field Sample	Almond Beach
ALM-281-Y3	ALM-FS14-SED-281-SLM-FD	7/17/2014	5.0	Field Duplicate	Almond Beach
ALM-281-Y3	ALM-FS14-SED-281-SLM	7/17/2014	4.5	Field Sample	Almond Beach
ALM-282-Y3	ALM-FS14-SED-282-SLM	7/17/2014	37	Field Sample	Almond Beach
ALM-283-Y3	ALM-FS14-SED-283-SLM	7/17/2014	28	Field Sample	Almond Beach
ALM-284-Y3	ALM-FS14-SED-284-SLM	7/17/2014	0.53 U	Field Sample	Almond Beach
ALM-285-Y3	ALM-FS14-SED-285-SLM	7/17/2014	4.4	Field Sample	Almond Beach
ALM-286-Y3	ALM-FS14-SED-286-SLM	7/17/2014	6.2	Field Sample	Almond Beach
ALM-287-Y3	ALM-FS14-SED-287-SLM	7/17/2014	0.40 U	Field Sample	Almond Beach
NPL-201-Y3	NPL-FS14-SED-201-SLM-FD	7/21/2014	32	Field Duplicate	Utility Access Areas
NPL-201-Y3	NPL-FS14-SED-201-SLM	7/21/2014	37	Field Sample	Utility Access Areas
NPL-202-Y3	NPL-FS14-SED-202-SLM	7/21/2014	6.5	Field Sample	Utility Access Areas
NPL-203-Y3	NPL-FS14-SED-203-SLM	7/21/2014	0.63 U	Field Sample	Utility Access Areas
NPL-204-Y3	NPL-FS14-SED-204-SLM	7/21/2014	0.70 J	Field Sample	Utility Access Areas
NPL-205-Y3	NPL-FS14-SED-205-SLM	7/21/2014	3.5	Field Sample	Utility Access Areas
NPL-206-Y3	NPL-FS14-SED-206-SLM	7/21/2014	0.73	Field Sample	Utility Access Areas
NPL-207-Y3	NPL-FS14-SED-207-SLM	7/21/2014	1.0	Field Sample	Utility Access Areas
NPL-208-Y3	NPL-FS14-SED-208-SLM	7/21/2014	2.5	Field Sample	Utility Access Areas
NPL-209-Y3	NPL-FS14-SED-209-SLM	7/21/2014	7.2	Field Sample	Utility Access Areas
NPL-210-Y3	NPL-FS14-SED-210-SLM	7/21/2014	0.59	Field Sample	Utility Access Areas
NPL-211-Y3	NPL-FS14-SED-211-SLM	7/21/2014	100	Field Sample	Utility Access Areas

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
NPL-212-Y3	NPL-FS14-SED-212-SLM	7/21/2014	1.6	Field Sample	Utility Access Areas
NPL-213-Y3	NPL-FS14-SED-213-SLM	7/21/2014	0.65 U	Field Sample	Utility Access Areas
NPL-214-Y3	NPL-FS14-SED-214-SLM	7/21/2014	21	Field Sample	Utility Access Areas
NPL-215-Y3	NPL-FS14-SED-215-SLM	7/21/2014	0.81	Field Sample	Utility Access Areas
NPL-216-Y3	NPL-FS14-SED-216-SLM	7/21/2014	16	Field Sample	Utility Access Areas
NPL-217-Y3	NPL-FS14-SED-217-SLM	7/21/2014	4.1	Field Sample	Utility Access Areas
NPL-218-Y3	NPL-FS14-SED-218-SLM	7/21/2014	0.82	Field Sample	Utility Access Areas
NPL-220-Y3	NPL-FS14-SED-220-SLM	7/21/2014	0.89	Field Sample	Utility Access Areas
NPL-221-Y3	NPL-FS14-SED-221-SLM-FD	7/21/2014	0.70 U	Field Duplicate	Utility Access Areas
NPL-221-Y3	NPL-FS14-SED-221-SLM	7/21/2014	0.66 U	Field Sample	Utility Access Areas
NPL-222-Y3	NPL-FS14-SED-222-SLM	7/21/2014	0.75 U	Field Sample	Utility Access Areas
NPL-223-Y3	NPL-FS14-SED-223-SLM	7/21/2014	0.89	Field Sample	Utility Access Areas
NPL-224-Y3	NPL-FS14-SED-224-SLM	7/21/2014	33	Field Sample	Utility Access Areas
NPL-225-Y3	NPL-FS14-SED-225-SLM	7/21/2014	1.6	Field Sample	Utility Access Areas
NPL-226-Y3	NPL-FS14-SED-226-SLM	7/21/2014	0.60 U	Field Sample	Utility Access Areas
NPL-228-Y3	NPL-FS14-SED-228-SLM	7/21/2014	16	Field Sample	Utility Access Areas
NPL-229-Y3	NPL-FS14-SED-229-SLM	7/21/2014	2.4	Field Sample	Utility Access Areas
NPL-230-Y3	NPL-FS14-SED-230-SLM	7/21/2014	0.65	Field Sample	Utility Access Areas
NPL-231-Y3	NPL-FS14-SED-231-SLM	7/21/2014	1.1	Field Sample	Utility Access Areas
NPL-232-Y3	NPL-FS14-SED-232-SLM	7/21/2014	3.2	Field Sample	Utility Access Areas
NPL-233-Y3	NPL-FS14-SED-233-SLM	7/21/2014	0.69	Field Sample	Utility Access Areas
NPL-234-Y3	NPL-FS14-SED-234-SLM	7/21/2014	9.4	Field Sample	Utility Access Areas
NPL-235-Y3	NPL-FS14-SED-235-SLM	7/21/2014	0.69 U	Field Sample	Utility Access Areas
NPL-236-Y3	NPL-FS14-SED-236-SLM	7/21/2014	0.61 U	Field Sample	Utility Access Areas
NPL-237-Y3	NPL-FS14-SED-237-SLM	7/21/2014	0.76 J	Field Sample	Utility Access Areas
NPL-238-Y3	NPL-FS14-SED-238-SLM	7/21/2014	21	Field Sample	Utility Access Areas
NPL-239-Y3	NPL-FS14-SED-239-SLM	7/22/2014	120	Field Sample	Utility Access Areas
NPL-240-Y3	NPL-FS14-SED-240-SLM	7/22/2014	0.71	Field Sample	Utility Access Areas
NPL-241-Y3	NPL-FS14-SED-241-SLM	7/22/2014	0.75	Field Sample	Utility Access Areas
NPL-242-Y3	NPL-FS14-SED-242-SLM-FD	7/22/2014	41	Field Duplicate	Utility Access Areas
NPL-242-Y3	NPL-FS14-SED-242-SLM	7/22/2014	39	Field Sample	Utility Access Areas
NPL-243-Y3	NPL-FS14-SED-243-SLM	7/22/2014	0.59	Field Sample	Utility Access Areas
NPL-244-Y3	NPL-FS14-SED-244-SLM	7/22/2014	0.63 U	Field Sample	Utility Access Areas
NPL-245-Y3	NPL-FS14-SED-245-SLM	7/22/2014	4.0	Field Sample	Utility Access Areas
NPL-246-Y3	NPL-FS14-SED-246-SLM	7/22/2014	0.69 U	Field Sample	Utility Access Areas
NPL-247-Y3	NPL-FS14-SED-247-SLM	7/22/2014	6.6	Field Sample	Utility Access Areas
NPL-248-Y3	NPL-FS14-SED-248-SLM	7/22/2014	270	Field Sample	Utility Access Areas
NPL-249-Y3	NPL-FS14-SED-249-SLM	7/22/2014	0.92	Field Sample	Utility Access Areas
NPL-250-Y3	NPL-FS14-SED-250-SLM	7/22/2014	3.0	Field Sample	Utility Access Areas
NPL-252-Y3	NPL-FS14-SED-252-SLM	7/22/2014	4.4	Field Sample	Utility Access Areas
NPL-253-Y3	NPL-FS14-SED-253-SLM	7/22/2014	3.1	Field Sample	Utility Access Areas
NPL-255-Y3	NPL-FS14-SED-255-SLM	7/22/2014	33	Field Sample	Utility Access Areas
NPL-256-Y3	NPL-FS14-SED-256-SLM	7/22/2014	52	Field Sample	Utility Access Areas
NPL-257-Y3	NPL-FS14-SED-257-SLM	7/22/2014	86	Field Sample	Utility Access Areas
NPL-258-Y3	NPL-FS14-SED-258-SLM	7/22/2014	0.92	Field Sample	Utility Access Areas
NPL-259-Y3	NPL-FS14-SED-259-SLM	7/22/2014	0.73	Field Sample	Utility Access Areas
NPL-260-Y3	NPL-FS14-SED-260-SLM	7/22/2014	17	Field Sample	Utility Access Areas
NPL-261-Y3	NPL-FS14-SED-261-SLM-FD	7/22/2014	9.1	Field Duplicate	Utility Access Areas
NPL-261-Y3	NPL-FS14-SED-261-SLM	7/22/2014	11	Field Sample	Utility Access Areas
NPL-262-Y3	NPL-FS14-SED-262-SLM	7/22/2014	0.60 U	Field Sample	Utility Access Areas
NPL-263-Y3	NPL-FS14-SED-263-SLM	7/22/2014	32	Field Sample	Utility Access Areas
NPL-264-Y3	NPL-FS14-SED-264-SLM	7/22/2014	0.68 U	Field Sample	Utility Access Areas
NPL-265-Y3	NPL-FS14-SED-265-SLM	7/22/2014	9.6	Field Sample	Utility Access Areas
NPL-266-Y3	NPL-FS14-SED-266-SLM	7/22/2014	1.4	Field Sample	Utility Access Areas
NPL-267-Y3	NPL-FS14-SED-267-SLM	7/22/2014	0.69 U	Field Sample	Utility Access Areas
NPL-268-Y3	NPL-FS14-SED-268-SLM	7/22/2014	28	Field Sample	Utility Access Areas
NPL-269-Y3	NPL-FS14-SED-269-SLM	7/22/2014	0.71 U	Field Sample	Utility Access Areas
NPL-270-Y3	NPL-FS14-SED-270-SLM	7/22/2014	3.0	Field Sample	Utility Access Areas
NPL-271-Y3	NPL-FS14-SED-271-SLM	7/22/2014	1.7	Field Sample	Utility Access Areas
NPL-272-Y3	NPL-FS14-SED-272-SLM	7/22/2014	8.7	Field Sample	Utility Access Areas
NPL-273-Y3	NPL-FS14-SED-273-SLM	7/22/2014	0.63 U	Field Sample	Utility Access Areas
NPL-274-Y3	NPL-FS14-SED-274-SLM	7/22/2014	0.98	Field Sample	Utility Access Areas
NPL-275-Y3	NPL-FS14-SED-275-SLM	7/22/2014	1.9	Field Sample	Utility Access Areas
NPL-276-Y3	NPL-FS14-SED-276-SLM	7/22/2014	0.64 U	Field Sample	Utility Access Areas
NPL-277-Y3	NPL-FS14-SED-277-SLM	7/22/2014	0.80 U	Field Sample	Utility Access Areas
NPL-278-Y3	NPL-FS14-SED-278-SLM	7/22/2014	6.0	Field Sample	Utility Access Areas

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
NPL-279-Y3	NPL-FS14-SED-279-SLM	7/22/2014	0.67 U	Field Sample	Utility Access Areas
NPL-280-Y3	NPL-FS14-SED-280-SLM	7/22/2014	0.79 J	Field Sample	Utility Access Areas
NPL-281-Y3	NPL-FS14-SED-281-SLM-FD	7/22/2014	950	Field Duplicate	Utility Access Areas
NPL-281-Y3	NPL-FS14-SED-281-SLM	7/22/2014	200	Field Sample	Utility Access Areas
NPL-282-Y3	NPL-FS14-SED-282-SLM	7/22/2014	0.82	Field Sample	Utility Access Areas
NPL-283-Y3	NPL-FS14-SED-283-SLM	7/22/2014	3.0	Field Sample	Utility Access Areas
NPL-284-Y3	NPL-FS14-SED-284-SLM	7/22/2014	67	Field Sample	Utility Access Areas
NPL-285-Y3	NPL-FS14-SED-285-SLM	7/22/2014	0.71	Field Sample	Utility Access Areas
NPL-286-Y3	NPL-FS14-SED-286-SLM	7/22/2014	0.54 U	Field Sample	Utility Access Areas
NPL-287-Y3	NPL-FS14-SED-287-SLM	7/22/2014	0.64	Field Sample	Utility Access Areas
NPL-288-Y3	NPL-FS14-SED-288-SLM	7/22/2014	0.72 U	Field Sample	Utility Access Areas
NPL-290-Y3	NPL-FS14-SED-290-SLM	7/22/2014	0.70 J	Field Sample	Utility Access Areas
NPL-291-Y3	NPL-FS14-SED-291-SLM	7/22/2014	28	Field Sample	Utility Access Areas
NPL-292-Y3	NPL-FS14-SED-292-SLM	7/22/2014	0.73 U	Field Sample	Utility Access Areas
NPL-293-Y3	NPL-FS14-SED-293-SLM	7/22/2014	0.62 U	Field Sample	Utility Access Areas
NPL-294-Y3	NPL-FS14-SED-294-SLM	7/22/2014	1.3	Field Sample	Utility Access Areas
NSL-101-Y3	NSL-FS14-SED-101-FPE	7/21/2014	87	Field Sample	Utility Access Areas
NSL-102-Y3	NSL-FS14-SED-102-FPE-FD	7/21/2014	100	Field Duplicate	Utility Access Areas
NSL-102-Y3	NSL-FS14-SED-102-FPE	7/21/2014	94	Field Sample	Utility Access Areas
NSL-103-Y3	NSL-FS14-SED-103-FPE	7/21/2014	92	Field Sample	Utility Access Areas
NSL-104-Y3	NSL-FS14-SED-104-FPE	7/21/2014	7.1	Field Sample	Utility Access Areas
NSL-105-Y3	NSL-FS14-SED-105-FPE	7/21/2014	7.9	Field Sample	Utility Access Areas
NSL-106-Y3	NSL-FS14-SED-106-FPE	7/21/2014	5.5	Field Sample	Utility Access Areas
NSL-107-Y3	NSL-FS14-SED-107-FPE	7/21/2014	23	Field Sample	Utility Access Areas
NSL-108-Y3	NSL-FS14-SED-108-FPE	7/21/2014	21	Field Sample	Utility Access Areas
NSL-109-Y3	NSL-FS14-SED-109-FPE	7/21/2014	41	Field Sample	Utility Access Areas
NSL-110-Y3	NSL-FS14-SED-110-FPE	7/21/2014	270	Field Sample	Utility Access Areas
NSL-111-Y3	NSL-FS14-SED-111-FPE	7/21/2014	160	Field Sample	Utility Access Areas
NSL-112-Y3	NSL-FS14-SED-112-FPE	7/21/2014	68	Field Sample	Utility Access Areas
NSL-113-Y3	NSL-FS14-SED-113-FPE	7/21/2014	350	Field Sample	Utility Access Areas
NSL-114-Y3	NSL-FS14-SED-114-FPE	7/21/2014	9.6	Field Sample	Utility Access Areas
NSL-115-Y3	NSL-FS14-SED-115-FPE	7/21/2014	19	Field Sample	Utility Access Areas
NSL-116-Y3	NSL-FS14-SED-116-FPE	7/21/2014	76	Field Sample	Utility Access Areas
NSL-117-Y3	NSL-FS14-SED-117-FPE-FD	7/21/2014	13	Field Duplicate	Utility Access Areas
NSL-117-Y3	NSL-FS14-SED-117-FPE	7/21/2014	12	Field Sample	Utility Access Areas
NSL-118-Y3	NSL-FS14-SED-118-FPE	7/21/2014	5.3	Field Sample	Utility Access Areas
NSL-119-Y3	NSL-FS14-SED-119-FPE	7/21/2014	14	Field Sample	Utility Access Areas
NSL-120-Y3	NSL-FS14-SED-120-FPE	7/21/2014	3.2	Field Sample	Utility Access Areas
NSL-121-Y3	NSL-FS14-SED-121-FPE	7/21/2014	37	Field Sample	Utility Access Areas
NSL-122-Y3	NSL-FS14-SED-122-FPE	7/21/2014	18	Field Sample	Utility Access Areas
NSL-123-Y3	NSL-FS14-SED-123-FPE	7/21/2014	8.7	Field Sample	Utility Access Areas
NSL-124-Y3	NSL-FS14-SED-124-FPE	7/21/2014	14	Field Sample	Utility Access Areas
SPL-014-Y3	SPL-FS14-SED-014-SLM	7/22/2014	7.0	Field Sample	Utility Access Areas
SPL-015-Y3	SPL-FS14-SED-015-SLM	7/22/2014	100	Field Sample	Utility Access Areas
SPL-016-Y3	SPL-FS14-SED-016-SLM	7/22/2014	11	Field Sample	Utility Access Areas
SPL-017-Y3	SPL-FS14-SED-017-SLM	7/22/2014	7.9	Field Sample	Utility Access Areas
SPL-018-Y3	SPL-FS14-SED-018-SLM-FD	7/22/2014	7.8	Field Duplicate	Utility Access Areas
SPL-018-Y3	SPL-FS14-SED-018-SLM	7/22/2014	9.6	Field Sample	Utility Access Areas
SPL-019-Y3	SPL-FS14-SED-019-SLM	7/22/2014	5.5	Field Sample	Utility Access Areas
SPL-020-Y3	SPL-FS14-SED-020-SLM	7/22/2014	8.6	Field Sample	Utility Access Areas
SPL-021-Y3	SPL-FS14-SED-021-SLM	7/22/2014	28	Field Sample	Utility Access Areas
SPL-022-Y3	SPL-FS14-SED-022-SLM	7/22/2014	5.5	Field Sample	Utility Access Areas
SPL-023-Y3	SPL-FS14-SED-023-SLM	7/22/2014	15	Field Sample	Utility Access Areas
SPL-024-Y3	SPL-FS14-SED-024-SLM	7/22/2014	12	Field Sample	Utility Access Areas
SPL-025-Y3	SPL-FS14-SED-025-SLM	7/22/2014	9.8	Field Sample	Utility Access Areas
SPL-027-Y3	SPL-FS14-SED-027-SLM	7/22/2014	8.3	Field Sample	Utility Access Areas
SPL-028-Y3	SPL-FS14-SED-028-SLM	7/22/2014	57	Field Sample	Utility Access Areas
SPL-029-Y3	SPL-FS14-SED-029-SLM	7/22/2014	5.6	Field Sample	Utility Access Areas
SPL-030-Y3	SPL-FS14-SED-030-SLM	7/22/2014	170	Field Sample	Utility Access Areas
SPL-031-Y3	SPL-FS14-SED-031-SLM	7/22/2014	2.5	Field Sample	Utility Access Areas
SPL-032-Y3	SPL-FS14-SED-032-SLM	7/22/2014	13	Field Sample	Utility Access Areas
SPL-033-Y3	SPL-FS14-SED-033-SLM	7/22/2014	3.5	Field Sample	Utility Access Areas
SPL-034-Y3	SPL-FS14-SED-034-SLM	7/22/2014	9.3	Field Sample	Utility Access Areas
SPL-035-Y3	SPL-FS14-SED-035-SLM	7/22/2014	4.7	Field Sample	Utility Access Areas
SPL-036-Y3	SPL-FS14-SED-036-SLM	7/22/2014	2.9	Field Sample	Utility Access Areas
SPL-037-Y3	SPL-FS14-SED-037-SLM	7/22/2014	1.2	Field Sample	Utility Access Areas

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
SPL-038-Y3	SPL-FS14-SED-038-SLM	7/22/2014	4.5	Field Sample	Utility Access Areas
SPL-039-Y3	SPL-FS14-SED-039-SLM	7/22/2014	18	Field Sample	Utility Access Areas
SPL-040-Y3	SPL-FS14-SED-040-SLM	7/22/2014	19	Field Sample	Utility Access Areas
SPL-041-Y3	SPL-FS14-SED-041-SLM	7/22/2014	16	Field Sample	Utility Access Areas
SPL-042-Y3	SPL-FS14-SED-042-SLM	7/22/2014	3.6	Field Sample	Utility Access Areas
SPL-043-Y3	SPL-FS14-SED-043-SLM	7/22/2014	2.0	Field Sample	Utility Access Areas
SPL-044-Y3	SPL-FS14-SED-044-SLM	7/22/2014	3.1	Field Sample	Utility Access Areas
SPL-045-Y3	SPL-FS14-SED-045-SLM-FD	7/22/2014	10	Field Duplicate	Utility Access Areas
SPL-045-Y3	SPL-FS14-SED-045-SLM	7/22/2014	5.3	Field Sample	Utility Access Areas
SPL-046-Y3	SPL-FS14-SED-046-SLM	7/22/2014	5.3	Field Sample	Utility Access Areas
SPL-047-Y3	SPL-FS14-SED-047-SLM	7/22/2014	2.8	Field Sample	Utility Access Areas
SPL-048-Y3	SPL-FS14-SED-048-SLM	7/22/2014	5.7	Field Sample	Utility Access Areas
SPL-049-Y3	SPL-FS14-SED-049-SLM	7/22/2014	1.8	Field Sample	Utility Access Areas
SPL-050-Y3	SPL-FS14-SED-050-SLM	7/22/2014	6.6	Field Sample	Utility Access Areas
SPL-051-Y3	SPL-FS14-SED-051-SLM	7/22/2014	3.4	Field Sample	Utility Access Areas
SPL-052-Y3	SPL-FS14-SED-052-SLM	7/22/2014	10	Field Sample	Utility Access Areas
SPL-053-Y3	SPL-FS14-SED-053-SLM	7/22/2014	4.0	Field Sample	Utility Access Areas
SPL-054-Y3	SPL-FS14-SED-054-SLM	7/22/2014	1.0	Field Sample	Utility Access Areas
SPL-055-Y3	SPL-FS14-SED-055-SLM	7/22/2014	0.65 U	Field Sample	Utility Access Areas
SPL-056-Y3	SPL-FS14-SED-056-SLM	7/22/2014	1.8	Field Sample	Utility Access Areas
SPL-057-Y3	SPL-FS14-SED-057-SLM	7/22/2014	2.6	Field Sample	Utility Access Areas
SPL-058-Y3	SPL-FS14-SED-058-SLM	7/22/2014	18	Field Sample	Utility Access Areas
SPL-059-Y3	SPL-FS14-SED-059-SLM	7/22/2014	0.74 J	Field Sample	Utility Access Areas
SPL-060-Y3	SPL-FS14-SED-060-SLM	7/22/2014	0.80	Field Sample	Utility Access Areas
SPL-061-Y3	SPL-FS14-SED-061-SLM	7/22/2014	3.7	Field Sample	Utility Access Areas
SPL-062-Y3	SPL-FS14-SED-062-SLM	7/22/2014	2.3	Field Sample	Utility Access Areas
SPL-063-Y3	SPL-FS14-SED-063-SLM-FD	7/22/2014	0.97	Field Duplicate	Utility Access Areas
SPL-063-Y3	SPL-FS14-SED-063-SLM	7/22/2014	1.2	Field Sample	Utility Access Areas
SPL-064-Y3	SPL-FS14-SED-064-SLM	7/22/2014	6.9	Field Sample	Utility Access Areas
SHR-001-Y3	SHR-FS14-SED-001	7/24/2014	79	Field Sample	Sherman Ave to Union Lake
SHR-002-Y3	SHR-FS14-SED-002	7/24/2014	14	Field Sample	Sherman Ave to Union Lake
SHR-003-Y3	SHR-FS14-SED-003	7/24/2014	21	Field Sample	Sherman Ave to Union Lake
SHR-004-Y3	SHR-FS14-SED-004	7/24/2014	20	Field Sample	Sherman Ave to Union Lake
SHR-005-Y3	SHR-FS14-SED-005	7/24/2014	8.3	Field Sample	Sherman Ave to Union Lake
SHR-007-Y3	SHR-FS14-SED-007	7/24/2014	12	Field Sample	Sherman Ave to Union Lake
SHR-009-Y3	SHR-FS14-SED-009	7/24/2014	17	Field Sample	Sherman Ave to Union Lake
SHR-010-Y3	SHR-FS14-SED-010	7/24/2014	7.8	Field Sample	Sherman Ave to Union Lake
SHR-011-Y3	SHR-FS14-SED-011	7/24/2014	14	Field Sample	Sherman Ave to Union Lake
SHR-012-Y3	SHR-FS14-SED-012	7/24/2014	4.7	Field Sample	Sherman Ave to Union Lake
SHR-013-Y3	SHR-FS14-SED-013	7/24/2014	19	Field Sample	Sherman Ave to Union Lake
SHR-014-Y3	SHR-FS14-SED-014	7/24/2014	11	Field Sample	Sherman Ave to Union Lake
SHR-015-Y3	SHR-FS14-SED-015	7/24/2014	310	Field Sample	Sherman Ave to Union Lake
SHR-016-Y3	SHR-FS14-SED-016	7/24/2014	240	Field Sample	Sherman Ave to Union Lake
SHR-017-Y3	SHR-FS14-SED-017	7/24/2014	1.6	Field Sample	Sherman Ave to Union Lake
SHR-018-Y3	SHR-FS14-SED-018	7/24/2014	36	Field Sample	Sherman Ave to Union Lake
SHR-019-Y3	SHR-FS14-SED-019	7/24/2014	61	Field Sample	Sherman Ave to Union Lake
SHR-051-Y3	SHR-FS14-SED-051	8/28/2014	8.8	Field Sample	Sherman Ave to Union Lake
SHR-052-Y3	SHR-FS14-SED-052	8/28/2014	17	Field Sample	Sherman Ave to Union Lake
SHR-053-Y3	SHR-FS14-SED-053	8/28/2014	42	Field Sample	Sherman Ave to Union Lake
SHR-054-Y3	SHR-FS14-SED-054	8/28/2014	11	Field Sample	Sherman Ave to Union Lake
SHR-054-Y3	SHR-FS14-SED-054-FD	8/28/2014	9.1	Field Sample	Sherman Ave to Union Lake
SHR-055-Y3	SHR-FS14-SED-055	8/28/2014	20	Field Sample	Sherman Ave to Union Lake
SHR-056-Y3	SHR-FS14-SED-056	8/28/2014	29	Field Sample	Sherman Ave to Union Lake
SHR-057-Y3	SHR-FS14-SED-057	8/28/2014	13	Field Sample	Sherman Ave to Union Lake
SHR-058-Y3	SHR-FS14-SED-058	8/28/2014	65	Field Sample	Sherman Ave to Union Lake
SHR-059-Y3	SHR-FS14-SED-059	8/28/2014	15	Field Sample	Sherman Ave to Union Lake
SHR-060-Y3	SHR-FS14-SED-060	8/28/2014	210	Field Sample	Sherman Ave to Union Lake
SHR-061-Y3	SHR-FS14-SED-061	8/28/2014	30	Field Sample	Sherman Ave to Union Lake
SHR-063-Y3	SHR-FS14-SED-063	8/28/2014	67	Field Sample	Sherman Ave to Union Lake
SHR-064-Y3	SHR-FS14-SED-064	8/28/2014	6.2	Field Sample	Sherman Ave to Union Lake
SHR-065-Y3	SHR-FS14-SED-065	8/28/2014	15	Field Sample	Sherman Ave to Union Lake
SHR-066-Y3	SHR-FS14-SED-066	8/28/2014	130	Field Sample	Sherman Ave to Union Lake
SHR-067-Y3	SHR-FS14-SED-067	8/28/2014	0.57 U	Field Sample	Sherman Ave to Union Lake
SHR-068-Y3	SHR-FS14-SED-068	8/28/2014	19	Field Sample	Sherman Ave to Union Lake
SHR-069-Y3	SHR-FS14-SED-069	8/28/2014	26	Field Sample	Sherman Ave to Union Lake
SHR-201-Y3	SHR-FS14-SED-201	7/24/2014	51	Field Sample	Sherman Ave to Union Lake

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
SHR-202-Y3	SHR-FS14-SED-202-FD	7/24/2014	20	Field Duplicate	Sherman Ave to Union Lake
SHR-202-Y3	SHR-FS14-SED-202	7/24/2014	18	Field Sample	Sherman Ave to Union Lake
SHR-203-Y3	SHR-FS14-SED-203	7/24/2014	10	Field Sample	Sherman Ave to Union Lake
SHR-204-Y3	SHR-FS14-SED-204	7/24/2014	26	Field Sample	Sherman Ave to Union Lake
SHR-206-Y3	SHR-FS14-SED-206	7/24/2014	25	Field Sample	Sherman Ave to Union Lake
SHR-208-Y3	SHR-FS14-SED-208	7/24/2014	29	Field Sample	Sherman Ave to Union Lake
SHR-209-Y3	SHR-FS14-SED-209	7/24/2014	17	Field Sample	Sherman Ave to Union Lake
SHR-210-Y3	SHR-FS14-SED-210	7/24/2014	110	Field Sample	Sherman Ave to Union Lake
SHR-211-Y3	SHR-FS14-SED-211	7/24/2014	20	Field Sample	Sherman Ave to Union Lake
SHR-212-Y3	SHR-FS14-SED-212	7/24/2014	390	Field Sample	Sherman Ave to Union Lake
SHR-213-Y3	SHR-FS14-SED-213	7/24/2014	100	Field Sample	Sherman Ave to Union Lake
SHR-214-Y3	SHR-FS14-SED-214	7/24/2014	20	Field Sample	Sherman Ave to Union Lake
SHR-215-Y3	SHR-FS14-SED-215	7/24/2014	47	Field Sample	Sherman Ave to Union Lake
SHR-216-Y3	SHR-FS14-SED-216	7/24/2014	55	Field Sample	Sherman Ave to Union Lake
SHR-217-Y3	SHR-FS14-SED-217	7/24/2014	44	Field Sample	Sherman Ave to Union Lake
SHR-218-Y3	SHR-FS14-SED-218	7/24/2014	91	Field Sample	Sherman Ave to Union Lake
SHR-252-Y3	SHR-FS14-SED-252	8/28/2014	32	Field Sample	Sherman Ave to Union Lake
SHR-253-Y3	SHR-FS14-SED-253	8/28/2014	13	Field Sample	Sherman Ave to Union Lake
SHR-255-Y3	SHR-FS14-SED-255	8/28/2014	18	Field Sample	Sherman Ave to Union Lake
SHR-256-Y3	SHR-FS14-SED-256	8/28/2014	750	Field Sample	Sherman Ave to Union Lake
SHR-257-Y3	SHR-FS14-SED-257	8/28/2014	15	Field Sample	Sherman Ave to Union Lake
SHR-258-Y3	SHR-FS14-SED-258	8/28/2014	15	Field Sample	Sherman Ave to Union Lake
SHR-260-Y3	SHR-FS14-SED-260	8/28/2014	93	Field Sample	Sherman Ave to Union Lake
SHR-261-Y3	SHR-FS14-SED-261	8/28/2014	180	Field Sample	Sherman Ave to Union Lake
SHR-262-Y3	SHR-FS14-SED-262	8/28/2014	33	Field Sample	Sherman Ave to Union Lake
SHR-262-Y3	SHR-FS14-SED-262-FD	8/28/2014	21	Field Sample	Sherman Ave to Union Lake
SHR-265-Y3	SHR-FS14-SED-265	8/28/2014	35	Field Sample	Sherman Ave to Union Lake
SHR-266-Y3	SHR-FS14-SED-266	8/28/2014	18	Field Sample	Sherman Ave to Union Lake
SHR-267-Y3	SHR-FS14-SED-267	8/28/2014	16	Field Sample	Sherman Ave to Union Lake
SHR-268-Y3	SHR-FS14-SED-268	8/28/2014	4.0	Field Sample	Sherman Ave to Union Lake
SHR-269-Y3	SHR-FS14-SED-269	8/28/2014	73	Field Sample	Sherman Ave to Union Lake
SHR-270-Y3	SHR-FS14-SED-270	8/28/2014	15	Field Sample	Sherman Ave to Union Lake
SHR-271-Y3	SHR-FS14-SED-271	8/28/2014	50	Field Sample	Sherman Ave to Union Lake
SHR-271-Y3	SHR-FS14-SED-271-FD	8/28/2014	52	Field Sample	Sherman Ave to Union Lake
SHR-272-Y3	SHR-FS14-SED-272	8/28/2014	43	Field Sample	Sherman Ave to Union Lake
SHR-273-Y3	SHR-FS14-SED-273	8/28/2014	18	Field Sample	Sherman Ave to Union Lake
SHR-274-Y3	SHR-FS14-SED-274	8/28/2014	150	Field Sample	Sherman Ave to Union Lake
NWC-001-Y3	NWC-FS14-SED-001-SLM	7/17/2014	0.94	Field Sample	Northwest Cove
NWC-002-Y3	NWC-FS14-SED-002-SLM	7/17/2014	2.0	Field Sample	Northwest Cove
NWC-003-Y3	NWC-FS14-SED-003-SLM	7/17/2014	0.74 U	Field Sample	Northwest Cove
NWC-004-Y3	NWC-FS14-SED-004-SLM	7/17/2014	25	Field Sample	Northwest Cove
NWC-005-Y3	NWC-FS14-SED-005-SLM	7/17/2014	0.77 U	Field Sample	Northwest Cove
NWC-006-Y3	NWC-FS14-SED-006-SLM	7/17/2014	15	Field Sample	Northwest Cove
NWC-007-Y3	NWC-FS14-SED-007-SLM	7/17/2014	0.79	Field Sample	Northwest Cove
NWC-008-Y3	NWC-FS14-SED-008-SLM	7/17/2014	17	Field Sample	Northwest Cove
NWC-009-Y3	NWC-FS14-SED-009-SLM	7/17/2014	0.88	Field Sample	Northwest Cove
NWC-010-Y3	NWC-FS14-SED-010-SLM	7/17/2014	33	Field Sample	Northwest Cove
NWC-011-Y3	NWC-FS14-SED-011-SLM	7/17/2014	0.77 U	Field Sample	Northwest Cove
NWC-012-Y3	NWC-FS14-SED-012-SLM	7/17/2014	88	Field Sample	Northwest Cove
NWC-013-Y3	NWC-FS14-SED-013-SLM-FD	7/17/2014	5.1	Field Duplicate	Northwest Cove
NWC-013-Y3	NWC-FS14-SED-013-SLM	7/17/2014	5.7	Field Sample	Northwest Cove
NWC-014-Y3	NWC-FS14-SED-014-SLM	7/17/2014	100	Field Sample	Northwest Cove
NWC-015-Y3	NWC-FS14-SED-015-SLM	7/17/2014	0.67 U	Field Sample	Northwest Cove
NWC-016-Y3	NWC-FS14-SED-016-SLM	7/17/2014	35	Field Sample	Northwest Cove
NWC-017-Y3	NWC-FS14-SED-017-SLM	7/17/2014	27	Field Sample	Northwest Cove
NWC-018-Y3	NWC-FS14-SED-018-SLM	7/17/2014	2.1	Field Sample	Northwest Cove
NWC-019-Y3	NWC-FS14-SED-019-SLM	7/17/2014	6.0	Field Sample	Northwest Cove
NWC-020-Y3	NWC-FS14-SED-020-SLM	7/18/2014	59	Field Sample	Northwest Cove
NWC-021-Y3	NWC-FS14-SED-021-SLM	7/18/2014	48	Field Sample	Northwest Cove
NWC-022-Y3	NWC-FS14-SED-022-SLM	7/18/2014	210	Field Sample	Northwest Cove
NWC-023-Y3	NWC-FS14-SED-023-SLM	7/18/2014	260	Field Sample	Northwest Cove
NWC-024-Y3	NWC-FS14-SED-024-SLM	7/18/2014	280	Field Sample	Northwest Cove
NWC-025-Y3	NWC-FS14-SED-025-SLM	7/18/2014	38	Field Sample	Northwest Cove
NWC-026-Y3	NWC-FS14-SED-026-SLM	7/18/2014	96	Field Sample	Northwest Cove
NWC-027-Y3	NWC-FS14-SED-027-SLM	7/18/2014	870	Field Sample	Northwest Cove
NWC-028-Y3	NWC-FS14-SED-028-SLM	7/18/2014	580	Field Sample	Northwest Cove

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
NWC-029-Y3	NWC-FS14-SED-029-SLM	7/18/2014	180	Field Sample	Northwest Cove
NWC-030-Y3	NWC-FS14-SED-030-SLM-FD	7/18/2014	150	Field Duplicate	Northwest Cove
NWC-030-Y3	NWC-FS14-SED-030-SLM	7/18/2014	160	Field Sample	Northwest Cove
NWC-031-Y3	NWC-FS14-SED-031-SLM	7/18/2014	53	Field Sample	Northwest Cove
NWC-032-Y3	NWC-FS14-SED-032-SLM	7/18/2014	9.9	Field Sample	Northwest Cove
NWC-033-Y3	NWC-FS14-SED-033-SLM	7/18/2014	9.7	Field Sample	Northwest Cove
NWC-034-Y3	NWC-FS14-SED-034-SLM	7/18/2014	220	Field Sample	Northwest Cove
NWC-150-Y3	NWC-FS14-SED-150-SLM	7/17/2014	200	Field Sample	Northwest Cove
NWC-151-Y3	NWC-FS14-SED-151-SLM	7/17/2014	320	Field Sample	Northwest Cove
NWC-152-Y3	NWC-FS14-SED-152-SLM	7/17/2014	270	Field Sample	Northwest Cove
NWC-153-Y3	NWC-FS14-SED-153-SLM	7/17/2014	220	Field Sample	Northwest Cove
NWC-155-Y3	NWC-FS14-SED-155-SLM	7/17/2014	190	Field Sample	Northwest Cove
NWC-156-Y3	NWC-FS14-SED-156-SLM	7/17/2014	210	Field Sample	Northwest Cove
NWC-157-Y3	NWC-FS14-SED-157-SLM-FD	7/17/2014	170	Field Duplicate	Northwest Cove
NWC-157-Y3	NWC-FS14-SED-157-SLM	7/17/2014	200	Field Sample	Northwest Cove
NWC-158-Y3	NWC-FS14-SED-158-SLM	7/17/2014	200	Field Sample	Northwest Cove
NWC-159-Y3	NWC-FS14-SED-159-SLM	7/17/2014	130	Field Sample	Northwest Cove
NWC-160-Y3	NWC-FS14-SED-160-SLM	7/17/2014	110	Field Sample	Northwest Cove
NWC-161-Y3	NWC-FS14-SED-161-SLM-FD	7/17/2014	190	Field Duplicate	Northwest Cove
NWC-161-Y3	NWC-FS14-SED-161-SLM	7/17/2014	160	Field Sample	Northwest Cove
NWC-162-Y3	NWC-FS14-SED-162-SLM	7/17/2014	100	Field Sample	Northwest Cove
NWC-163-Y3	NWC-FS14-SED-163-SLM	7/17/2014	190	Field Sample	Northwest Cove
NWC-164-Y3	NWC-FS14-SED-164-SLM	7/17/2014	250	Field Sample	Northwest Cove
NWC-165-Y3	NWC-FS14-SED-165-SLM	7/17/2014	200	Field Sample	Northwest Cove
NWC-166-Y3	NWC-FS14-SED-166-SLM	7/17/2014	220	Field Sample	Northwest Cove
NWC-167-Y3	NWC-FS14-SED-167-SLM	7/17/2014	41	Field Sample	Northwest Cove
NWC-168-Y3	NWC-FS14-SED-168-SLM-FD	7/18/2014	260	Field Duplicate	Northwest Cove
NWC-168-Y3	NWC-FS14-SED-168-SLM	7/18/2014	390	Field Sample	Northwest Cove
NWC-169-Y3	NWC-FS14-SED-169-SLM	7/18/2014	200	Field Sample	Northwest Cove
NWC-170-Y3	NWC-FS14-SED-170-SLM	7/18/2014	220	Field Sample	Northwest Cove
NWC-171-Y3	NWC-FS14-SED-171-SLM	7/18/2014	440	Field Sample	Northwest Cove
NWC-172-Y3	NWC-FS14-SED-172-SLM	7/18/2014	440	Field Sample	Northwest Cove
NWC-173-Y3	NWC-FS14-SED-173-SLM	7/18/2014	220	Field Sample	Northwest Cove
NWC-174-Y3	NWC-FS14-SED-174-SLM	7/18/2014	210	Field Sample	Northwest Cove
NWC-175-Y3	NWC-FS14-SED-175-SLM	7/18/2014	180	Field Sample	Northwest Cove
NWC-176-Y3	NWC-FS14-SED-176-SLM	7/18/2014	21	Field Sample	Northwest Cove
NWC-177-Y3	NWC-FS14-SED-177-SLM	7/18/2014	60	Field Sample	Northwest Cove
NWC-178-Y3	NWC-FS14-SED-178-SLM	7/18/2014	40	Field Sample	Northwest Cove
NWC-179-Y3	NWC-FS14-SED-179-SLM	7/18/2014	79	Field Sample	Northwest Cove
NWC-180-Y3	NWC-FS14-SED-180-SLM	7/18/2014	34	Field Sample	Northwest Cove
NWC-181-Y3	NWC-FS14-SED-181-SLM	7/18/2014	220	Field Sample	Northwest Cove
NWC-182-Y3	NWC-FS14-SED-182-SLM	7/18/2014	360	Field Sample	Northwest Cove
NWC-183-Y3	NWC-FS14-SED-183-SLM	7/18/2014	3.5	Field Sample	Northwest Cove
NWC-184-Y3	NWC-FS14-SED-184-SLM	7/18/2014	13	Field Sample	Northwest Cove
NWC-185-Y3	NWC-FS14-SED-185-SLM	7/18/2014	14	Field Sample	Northwest Cove
NWC-186-Y3	NWC-FS14-SED-186-SLM	7/18/2014	12	Field Sample	Northwest Cove
NWC-187-Y3	NWC-FS14-SED-187-SLM-FD	7/18/2014	14	Field Duplicate	Northwest Cove
NWC-187-Y3	NWC-FS14-SED-187-SLM	7/18/2014	18	Field Sample	Northwest Cove
NWC-188-Y3	NWC-FS14-SED-188-SLM	7/18/2014	58	Field Sample	Northwest Cove
NWC-189-Y3	NWC-FS14-SED-189-SLM	7/18/2014	8.7	Field Sample	Northwest Cove
NWC-201-Y3	NWC-FS14-SED-201-SLM-FD	7/17/2014	0.68 U	Field Duplicate	Northwest Cove
NWC-201-Y3	NWC-FS14-SED-201-SLM	7/17/2014	1.5	Field Sample	Northwest Cove
NWC-202-Y3	NWC-FS14-SED-202-SLM	7/17/2014	4.9	Field Sample	Northwest Cove
NWC-203-Y3	NWC-FS14-SED-203-SLM	7/17/2014	0.67 U	Field Sample	Northwest Cove
NWC-204-Y3	NWC-FS14-SED-204-SLM	7/17/2014	17	Field Sample	Northwest Cove
NWC-205-Y3	NWC-FS14-SED-205-SLM	7/17/2014	48	Field Sample	Northwest Cove
NWC-206-Y3	NWC-FS14-SED-206-SLM	7/17/2014	2.2	Field Sample	Northwest Cove
NWC-207-Y3	NWC-FS14-SED-207-SLM	7/17/2014	150	Field Sample	Northwest Cove
NWC-208-Y3	NWC-FS14-SED-208-SLM	7/17/2014	0.68 U	Field Sample	Northwest Cove
NWC-209-Y3	NWC-FS14-SED-209-SLM	7/17/2014	170	Field Sample	Northwest Cove
NWC-210-Y3	NWC-FS14-SED-210-SLM	7/17/2014	0.80 J	Field Sample	Northwest Cove
NWC-211-Y3	NWC-FS14-SED-211-SLM	7/17/2014	180	Field Sample	Northwest Cove
NWC-212-Y3	NWC-FS14-SED-212-SLM	7/17/2014	0.83	Field Sample	Northwest Cove
NWC-213-Y3	NWC-FS14-SED-213-SLM	7/17/2014	88	Field Sample	Northwest Cove
NWC-214-Y3	NWC-FS14-SED-214-SLM	7/17/2014	1.9	Field Sample	Northwest Cove
NWC-215-Y3	NWC-FS14-SED-215-SLM	7/17/2014	120	Field Sample	Northwest Cove

Table 10. Surficial Sediment Samples (0 to 6") - Year 3
Maurice River
Vineland, New Jersey

Sample Location	Sample Number	Date	Arsenic (mg/kg)	Sample Type	Location Description
NWC-216-Y3	NWC-FS14-SED-216-SLM	7/17/2014	2.7	Field Sample	Northwest Cove
NWC-217-Y3	NWC-FS14-SED-217-SLM	7/17/2014	5.3	Field Sample	Northwest Cove
NWC-218-Y3	NWC-FS14-SED-218-SLM	7/17/2014	2.5	Field Sample	Northwest Cove
NWC-219-Y3	NWC-FS14-SED-219-SLM	7/17/2014	53	Field Sample	Northwest Cove
NWC-220-Y3	NWC-FS14-SED-220-SLM	7/17/2014	1.6	Field Sample	Northwest Cove
NWC-221-Y3	NWC-FS14-SED-221-SLM-FD	7/17/2014	19	Field Duplicate	Northwest Cove
NWC-221-Y3	NWC-FS14-SED-221-SLM	7/17/2014	16	Field Sample	Northwest Cove
NWC-222-Y3	NWC-FS14-SED-222-SLM	7/18/2014	270	Field Sample	Northwest Cove
NWC-223-Y3	NWC-FS14-SED-223-SLM	7/18/2014	270	Field Sample	Northwest Cove
NWC-224-Y3	NWC-FS14-SED-224-SLM	7/18/2014	10	Field Sample	Northwest Cove
NWC-225-Y3	NWC-FS14-SED-225-SLM	7/18/2014	320	Field Sample	Northwest Cove
NWC-226-Y3	NWC-FS14-SED-226-SLM	7/18/2014	0.87 U	Field Sample	Northwest Cove
NWC-227-Y3	NWC-FS14-SED-227-SLM	7/18/2014	73	Field Sample	Northwest Cove
NWC-228-Y3	NWC-FS14-SED-228-SLM	7/18/2014	120	Field Sample	Northwest Cove
NWC-229-Y3	NWC-FS14-SED-229-SLM	7/18/2014	75	Field Sample	Northwest Cove
NWC-230-Y3	NWC-FS14-SED-230-SLM	7/18/2014	160	Field Sample	Northwest Cove
NWC-231-Y3	NWC-FS14-SED-231-SLM	7/18/2014	370	Field Sample	Northwest Cove
NWC-232-Y3	NWC-FS14-SED-232-SLM	7/18/2014	120	Field Sample	Northwest Cove
NWC-233-Y3	NWC-FS14-SED-233-SLM	7/18/2014	27	Field Sample	Northwest Cove
NWC-234-Y3	NWC-FS14-SED-234-SLM	7/18/2014	310	Field Sample	Northwest Cove
NWC-235-Y3	NWC-FS14-SED-235-SLM	7/18/2014	0.60 U	Field Sample	Northwest Cove
NWC-236-Y3	NWC-FS14-SED-236-SLM	7/18/2014	190	Field Sample	Northwest Cove

U = Not detected above analytical detection method
J = Estimated value
mg/kg = milligrams per kilo

Arsenic Color Key:
- green: < 10 mg/kg
- yellow: 10 - 20 mg/kg
- orange: 20 - 100 mg/kg
- red: > 100 mg/kg

*Color classification of arsenic concentrations are a relative break-out of concentration and not indicative of action levels.

Note:
In Year 3, all samples collected were analyzed regardless of sediment type (gravel, sand, silt, clay, etc)

Table 11. Summary of Grain Size Distribution versus Arsenic Concentration - July 2012
Maurice River Site, Year 1
Vineland, New Jersey

Sample Area	Location	Arsenic* (mg/kg)	% Gravel	% Sand	% Silt, Clay, Colloids
Blackwater Branch (Reference)	Upstream @ N. Delsea Drive	1.0	1.3	96.5	2.2
Confluence Maurice River and Blackwater Branch	Confluence Downstream EAST	2.4	3.6	74.7	21.6
Confluence Maurice River and Blackwater Branch	Confluence Downstream WEST	1.9	1.4	97.3	1.3
Confluence Maurice River and Blackwater Branch	Confluence Upstream EAST	0.63	44.2	55.5	0.37
Confluence Maurice River and Blackwater Branch	Confluence Upstream WEST	1.6	0	98.6	1.5
Alliance Beach	A1-1.0	0.556 U	10.6	87.2	2.3
Alliance Beach	A1-2.10	27	0.09	70.4	29.5
Alliance Beach	A1-3.30	64	0.94	55.1	44
Alliance Beach	A1-7E.-5	129	0.01	36.9	63.1
Alliance Beach	A1-9W-10	0.70	19.6	77.9	2.5
Alliance Beach	A1-10E.10	0.54	0.2	83.3	16.5
Alliance Beach	A1-10E.40	2.3	2.5	88.9	8.6
Alliance Beach	A1-12E.20	0.567 U	0.0	89.8	10.2
Almond Beach	A2-6	43	1.6	95.4	3.1
Almond Beach	A2-27	78	4.1	84	11.9
Almond Beach	A2-37	1.5	0.08	97.3	2.6
Almond Beach	A2-77	16	7.9	82	10.1
BA Beach	A4-01	1.3	0.07	77.2	22.8
BA Beach	A4-06	15	0.13	76.8	23.1
BA Beach	A4-16	0.87	0.0	93.8	6.2

U = Not detected above analytical detection method
mg/kg = milligrams per kilogram
% = percent
*Arsenic Color Key: green: < 10 mg/kg; yellow: 10 - 20 mg/kg; orange: 20 - 100 mg/kg; red: > 100 mg/kg

Note:
Color classification of arsenic concentrations are a relative break-out of concentration and not indicative of action levels.

Table 12. Surficial Sediment Samples Exceeding ROD Cleanup Numbers by Location and Year
Maurice River
Vineland, New Jersey

Sample Area	Year 1			Year 2			Year 3			Combined		
	# Exceed ROD Cleanup Level*	Number of Samples	% Exceeding Cleanup	# Exceed ROD Cleanup Level*	Number of Samples	% Exceeding Cleanup	# Exceed ROD Cleanup Level*	Number of Samples	% Exceeding Cleanup	# Exceed ROD Cleanup Level*	Number of Samples	% Exceeding ROD Cleanup
Reference Area (N. Delsea Ave)	-	-	-	0	1	0%	-	-	-	0	1	0%
Reference Area (Garden Rd)	0	1	0%	0	1	0%	-	-	-	0	2	0%
Confluence	0	4	0%	-	-	-	-	-	-	0	4	0%
Alliance Beach	2	30	7%	-	-	-	1	80	1%	3	110	3%
Floodplain Assessment	-	-	-	-	-	-	10	18	56%	10	18	56%
Almond Beach	0	18	0%	3	23	13%	13	173	8%	16	214	7%
BA Beach	0	9	0%	-	-	-	-	-	-	0	9	0%
Utility Access Areas	-	-	-	2	30	7%	7	163	4%	9	193	5%
Sherman Ave to Union Lake	-	-	-	8	32	25%	8	73	11%	16	105	15%
Northeast Cove (Union Lake)	-	-	-	13	27	48%				13	27	48%
Northwest Cove (Union Lake)	-	-	-	-	-	-	45	109	41%	45	109	41%
Union Lake Dam (Low Head Dam)	-	-	-	10	24	42%	-	-	-	10	24	42%
Area Totals	2	62	3%	36	138	26%	84	616	14%	122	816	15%

*ROD cleanup level for OU2 for submerged sediments was 120 mg/kg and for exposed sediment was 20 mg/kg
Submerged sediment criterea (120 mg/kg) would be representitive of all Sample Areas except for the Floodplain Assessment Area
Data summarizes all surficial (0 to 6") sediment samples and does not include duplicate samples

Table 13. Subsurface Sediment Core Samples - July 2012 Sampling Results
Maurice River Site, Year 1
Vineland, New Jersey

Sample Area	Sample Location	Sample Depth Interval (feet)	Arsenic* (mg/kg)
Alliance Beach	A1-10E.0A	0-0.5	**7.96**
Alliance Beach	A1-10E.0B	0.5-1	5.17
Alliance Beach	A1-10E.0C	1-1.5	0.606 U
Alliance Beach	A1-10E.0D	1.5-2	0.604 U
Alliance Beach	A1-10E.0EF	2-3	0.613 U
Alliance Beach	A1-12E.40A	0-0.5	**28.2**
Alliance Beach	A1-12E.40B	0.5-1	4.51
Alliance Beach	A1-12E.40C	1-1.5	0.66 U
Alliance Beach	A1-12E.40D	1.5-2	0.613 U
Alliance Beach	A1-3.10A	0-0.5	**114**
Alliance Beach	A1-3.10B	0.5-1	101
Alliance Beach	A1-3.10C	1-1.5	103
Alliance Beach	A1-3.10D	1.5-2	39.8
Alliance Beach	A1-3.10EF	2-3	16.3
Alliance Beach	A1-5.70A	0-0.5	0.837 U
Alliance Beach	A1-5.70B	0.5-1	0.746
Alliance Beach	A1-5.70B (DUP)	0.5-1	0.714
Alliance Beach	A1-5.70C	1-1.5	0.72
Alliance Beach	A1-5.70D	1.5-2	**0.861**
Alliance Beach	A1-6.60A	0-0.5	31.3
Alliance Beach	A1-6.60B	0.5-1	**95.7**
Alliance Beach	A1-6.60C	1-1.5	4.65
Alliance Beach	A1-6.60D	1.5-2	0.693 U
Alliance Beach	A1-6.60E	2-2.5	0.678 U
Alliance Beach	A1-6.80A	0-0.5	4.48
Alliance Beach	A1-6.80B	0.5-1	14.1
Alliance Beach	A1-6.80C	1-1.5	**16.6**
Alliance Beach	A1-6.80D	1.5-2	3.71
Alliance Beach	A1-6.80E	2-2.5	4.6
Alliance Beach	A1-8E.-5A	0-0.5	35.7
Alliance Beach	A1-8E.-5B	0.5-1	99.6
Alliance Beach	A1-8E.-5C	1-1.5	**108**
Alliance Beach	A1-8E.-5D	1.5-2	28.4

Table 13. Subsurface Sediment Core Samples - July 2012 Sampling Results
Maurice River Site, Year 1
Vineland, New Jersey

Sample Area	Sample Location	Sample Depth Interval (feet)	Arsenic* (mg/kg)
Almond Beach	A2-4C	0-0.5	**103**
Almond Beach	A2-4B	0.5-1	31.1
Almond Beach	A2-4C	1-1.5	35.3
Almond Beach	A2-4D	1.5-2	3.94
Almond Beach	A2-4EF	2-3	6.22
Almond Beach	A2-50A	0-0.5	0.711
Almond Beach	A2-50B	0.5-1	0.821
Almond Beach	A2-50C	1-1.5	0.71
Almond Beach	A2-50D	1.5-2	1.91
Almond Beach	A2-50EF	2-3	**6.32**
Almond Beach	A2-53A	0-0.5	**71.1**
Almond Beach	A2-53B	0.5-1	49.1
Almond Beach	A2-53C	1-1.5	12.5
Almond Beach	A2-53D	1.5-2	0.681 U
Almond Beach	A2-53EF	2-3	0.636 U
Almond Beach	A2-5A	0-0.5	48.8
Almond Beach	A2-5B	0.5-1	16.4
Almond Beach	A2-5C	1-1.5	5.41
Almond Beach	A2-5D	1.5-2	**79.6**
Almond Beach	A2-5EF	2-3	70.4
Almond Beach	A2-5GH	3-4	4.38
Almond Beach	A2-65A	0-0.5	0.616 U
Almond Beach	A2-65B	0.5-1	0.652 U
Almond Beach	A2-65C	1-1.5	**3.94**
Almond Beach	A2-65D	1.5-2	2.19
Almond Beach	A2-65EF	2-3	0.773
Almond Beach	A2-65EF (DUP)	3-4	0.617 U
Almond Beach	A2-65G	3-3.5	0.583 U
Almond Beach	A2-8A	0-0.5	1.72
Almond Beach	A2-8B	0.5-1	13.2
Almond Beach	A2-8C	1-1.5	**127**
Almond Beach	A2-8D	1.5-2	94.1
Almond Beach	A2-8EF	2-3	6.16
Almond Beach	A2-8GH	3-4	45.4
Almond Beach	A2-8GH (DUP)	3-4	26.2
Almond Beach	A2-8IJ	4-5	1.22

Table 13. Subsurface Sediment Core Samples - July 2012 Sampling Results
Maurice River Site, Year 1
Vineland, New Jersey

Sample Area	Sample Location	Sample Depth Interval (feet)	Arsenic* (mg/kg)
Below Almond Rd. Spillway	A3-01A	0-0.5	4.62
Below Almond Rd. Spillway	A3-01B	0.5-1	**10.2**
Below Almond Rd. Spillway	A3-01C	1-1.5	6.46
Below Almond Rd. Spillway	A3-01D	1.5-2	2.66
Below Almond Rd.Spillway	A3-01D (DUP)	1.5-2	2.79
Below Almond Rd. Spillway	A3-02A	0-0.5	5.71
Below Almond Rd. Spillway	A3-02B	0.5-1	2.05
Below Almond Rd. Spillway	A3-02C	1-1.5	0.543 U
Below Almond Rd. Spillway	A3-02C (DUP)	1-1.5	1.42
Below Almond Rd. Spillway	A3-02D	1.5-2	7.09
Below Almond Rd. Spillway	A3-02EF	2-3	**21.5**
Below Almond Rd. Spillway	A3-03A	0-0.5	**5.34**
Below Almond Rd. Spillway	A3-03B	0.5-1	4.34
Below Almond Rd. Spillway	A3-03C	1-1.5	2.16
Below Almond Rd. Spillway	A3-03C (DUP)	1-1.5	1.16
Below Almond Rd. Spillway	A3-03D	1.5-2	2.89
Below Almond Rd. Spillway	A3-03EF	2-3	1.89
BA Beach	A4-06A	0-0.5	4.09
BA Beach	A4-06B	0.5-1	16.9
BA Beach	A4-06C	1-1.5	**42.1**
BA Beach	A4-06D	1.5-2	7.68
BA Beach	A4-06EF	2-3	1.58 U
BA Beach	A4-10A	0-0.5	**68.6**
BA Beach	A4-10B	0.5-1	1.58
BA Beach	A4-10C	1-1.5	0.572 U
BA Beach	A4-16A	0-0.5	2.42
BA Beach	A4-16A (DUP)	0-0.5	1.27
BA Beach	A4-16B	0.5-1	**10.8**
BA Beach	A4-16C	1-1.5	2.84
BA Beach	A4-16D	1.5-2	1.47
BA Beach	A4-16EF	2-3	0.531 U
BA Beach	A4-16GH	3-4	0.547 U
BA Beach	A4-16IJ	4-5	0.542 U

U = Not detected above analytical detection method
DUP = Duplicate Sample
mg/kg = milligrams per kilogram
*Bold font indicates greatest concentration in core

Arsenic Color Key:

green: < 10 mg/kg	Color classification of arsenic concentrations
yellow: 10 - 20 mg/kg	are a relative break-out of concentration
orange: 20 - 100 mg/kg	and not indicative of action levels.
red: > 100 mg/kg	

Table 14. Summary of Cesium-137 and Arsenic Concentrations in Sediment Cores - July 2012
Maurice River Site, Year 1
Vineland, New Jersey

Sample Area	Location	Sample Depth (feet)	Arsenic* (mg/kg)	Cs-137 (pCi/g) ± *2 Sigma Uncertainty*
Alliance Beach	A1-10E.0A	0 - 0.5	7.96	0.041 ± *0.008*
Alliance Beach	A1-10E.0B	0.5 - 1	5.17	-0.001 ± *0.024*
Alliance Beach	A1-10E.0C	1 - 1.5	0.606 U	0.011 ± *0.011*
Alliance Beach	A1-10E.0D	1.5 - 2	0.604 U	-0.01 ± *0.009*
Alliance Beach	A1-10E.0E	2 - 2.5	0.613 U	-0.008 ± *0.015*
Alliance Beach	A1-10E.0F	2.5 - 3		0.002 ± *0.001*
Alliance Beach	A1-12E.40A	0 - 0.5	28.2	0.313 ± *0.05*
Alliance Beach	A1-12E.40B	0.5 - 1	4.51	0.02 ± *0.022*
Alliance Beach	A1-12E.40C	1 - 1.5	0.66 U	0 ± *0.018*
Alliance Beach	A1-12E.40D	1.5 - 2	0.613 U	-0.001 ± *0.011*
Almond Beach	A2-53A	0 - 0.5	71.1	0.544 ± *0.07*
Almond Beach	A2-53B	0.5 - 1	49.1	0.054 ± *0.011*
Almond Beach	A2-53C	1 - 1.5	12.5	-0.005 ± *0.008*
Almond Beach	A2-53D	1.5 - 2	0.681	-0.004 ± *0.013*
Almond Beach	A2-53E	2 - 2.5	0.636 U	-0.017 ± *0.02*
Almond Beach	A2-53F	2.5 - 3		0.001 ± *0*
Almond Beach	A2-8A	0 - 0.5	1.72	0.017 ± *0.018*
Almond Beach	A2-8B	0.5 - 1	13.2	0.024 ± *0.006*
Almond Beach	A2-8C	1 - 1.5	127	0.021 ± *0.017*
Almond Beach	A2-8D	1.5 - 2	94.1	0.029 ± *0.02*
Almond Beach	A2-8E	2 - 2.5	6.16	0.028 ± *0.018*
Almond Beach	A2-8F	2.5 - 3		-0.023 ± *0.008*
Almond Beach	A2-8G	3 - 3.5	45.4	0.165 ± *0.036*
Almond Beach	A2-8H	3.5 - 4		0.026 ± *0.02*
Almond Beach	A2-8IJ	4 - 5	1.22	NA
Below Almond Rd. Spillway	A3-01A	0 - 0.5	4.62	0.015 ± *0.007*
Below Almond Rd. Spillway	A3-01B	0.5 - 1	10.2	0.035 ± *0.008*
Below Almond Rd. Spillway	A3-01C	1 - 1.5	6.46	0.014 ± *0.002*
Below Almond Rd. Spillway	A3-01D	1.5 - 2	2.66	0.006 ± *0.01*
BA Beach	A4-16A	0 - 0.5	2.42	0.046 ± *0.038*
BA Beach	A4-16B	0.5 - 1	10.8	0.001 ± *0.068*
BA Beach	A4-16C	1 - 1.5	2.84	0.013 ± *0.006*
BA Beach	A4-16D	1.5 - 2	1.47	0.018 ± *0.008*
BA Beach	A4-16E	2 - 2.5	0.531 U	-0.013 ± *0.036*
BA Beach	A4-16F	2.5 - 3		0.002 ± *0.01*
BA Beach	A4-16G	3 - 3.5	0.547 U	0.019 ± *0.014*
BA Beach	A4-16H	3.5 - 4		-0.001 ± *0.015*
BA Beach	A4-16I	4 - 4.5	0.542 U	0.017 ± *0.03*
BA Beach	A4-16J	4.5 - 5		-0.001 ± *0.012*
BA Beach	A4-16K	5 - 5.5	NA	-0.017 ± *0.009*

NA = Not Analyzed
U = Not detected above analytical detection method
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram

*Arsenic Color Key:		
	green: < 10 mg/kg	orange: 20 - 100 mg/kg
	yellow: 10 - 20 mg/kg	red: > 100 mg/kg

Color classification of arsenic concentrations are a relative break-out of concentration and not indicative of action levels.

Table 15. Mixed Core Samples Grain Size Distribution and Arsenic Concentration by FRaction
Maurice River, Year 3
Vineland, New Jersey

Location	Grain Size FRaction				Arsenic Concentration By FRaction		
	% Clay & Colloids	% Silt	% Sand	% Gravel & Larger	Pore Water (µg/L)	Sand (mg/kg)	Silt/Clay (mg/kg)
ALL-COR-501-Y3	1.4		81.9	9.4	13	12	70
ALL-COR-502-Y3	4.9	0.8	85.9	0.3	120	8.6	71
ALL-COR-503-Y3	0.1	0.2	85.7	4.8	1.0 U	0.92	1.2
ALL-COR-504-Y3	1.8	3.9	86.1	0.3	280	1.3	42
ALL-COR-505-Y3	0.1	0.1	30.6	64	1.0 U	0.8	1.1
ALM-COR-101-Y3	2	0.3	91	1.3	270	1.4	44
ALM-COR-102-Y3	0.1	0.3	99.9	0.1	1.9	0.94	0.93
ALM-COR-103-Y3	0.1	0.5	68.9	18	1.8	0.65 U	0.66 U
ALM-COR-104-Y3	4.3	0.3	74.5	13	97	14	440
ALM-COR-105-Y3	0.2		71.4	3.3	1.0 U	0.94 J	0.86
BAB-RA-105-Y3	0.2	0.4	11.1	74	1.6	0.69 J	0.7
NPL-COR-101-Y3	2		60.9	20	3.1	0.62 U	0.4 U
NPL-COR-102-Y3	0.1	0.6	48.3	34	0.83 U	0.61 U	0.62
NPL-COR-103-Y3	0.1	0.3	86.6	4.6	1.0 U	0.85	0.86
NPL-COR-104-Y3	4.2		88.2	0.1	9.9	0.71 U	14

U = Not detected above analytical detection method
mg/kg = milligrams per kilogram; µg/L micrograms per liter

Arsenic Color Key:

green: < 10 mg/kg	Color classification of arsenic concentrations
yellow: 10 - 20 mg/kg	are a relative break-out of concentration
orange: 20 - 100 mg/kg	and not indicative of action levels.
red: > 100 mg/kg	

Table 16. Summary of Surface Water Samples Collected for Arsenic Flux Study
Maurice River Site
Vineland, New Jersey

	Year 1 July 2012			Year 1 October 2012			Year 2 May 2013			Year 2 October 2013			Year 3 July 2014			Year 3 August 2014		
	Arsenic (µg/L)		Average Total Discharge	Arsenic (µg/L)		Average Total Discharge	Arsenic (µg/L)		Average Total Discharge	Arsenic (µg/L)		Average Total Discharge	Arsenic (µg/L)		Average Total Discharge	Arsenic (µg/L)		Average Total Discharge
Sample Location	Total	Dissolved	(ft^3/sec)	Total	Dissolved	(ft^3/sec)	Total	Dissolved	(ft^3/sec)	Total	Dissolved	(ft^3/sec)	Total	Dissolved	(ft^3/sec)	Total	Dissolved	(ft^3/sec)
AF1-01	2.78 U	2.78 U		1.00 U	1.00 U		1	1 U		0.4 U	0.4 U		1 U	1 U				
AF1-02	2.78 UJ	2.78 U	6.5	1.00 U	1.00 U	8.3	1 U	1 U	14.4	0.4 U	0.4 U	5.6	-	-	7.5			
AF1-03	2.78 U	2.78 U		1.00 U	1.00 U		1 U	1 U		0.4 U	0.4 U		-	-				
AF2-01	2.78 U	2.78 U		1.00 U	1.00 U		1.3	1 U		0.58	0.4		1	1 U				
AF2-02	2.78 U	2.78 U	38.9	1.20	1.00 U	46.5	1.2	1 U	197.6	0.56	0.44	69.4	1 U	1 U	75			
AF2-02 (DUP)	2.78 U	2.78 U		-	-		-	-		-	-		-	-				
AF2-03	2.78 U	2.78 U		1.00 U	1.00 U		1.5	1		0.57	0.4		1 U	1 U				
AF3-01	2.78 U	2.78 U		1.00 U	1.00 U		1.4	1.3		0.79	0.45		1.1	1 U				
AF3-01 (DUP)	-	-		-	-		1 U	1.2		-	-		-	-				
AF3-02	2.78 U	2.78 U	67.2	1.00 U	1.00 U	69.1	1.3	1.1	187.2	0.68	0.48	71.8	1.2	1	85.4			
AF3-02 (DUP)	-	-		2.00 U	2.00 U		-	-		-	-		-	-				
AF3-02	-	-		-	-		-	-		0.76	-		-	-				
AF3-03	2.78 U	2.78 U		1.00 U	1.00 U		1.6	1.1		0.75	0.5		1.1	1.1				
AF4-01	2.78 U	2.78 U																
AF4-02	2.78 U	2.78 U	-															
AF4-03	2.78 U	2.78 U																
AF4a-01				1.00 U	1.00 U		1.5	1.1		0.76	0.55		1.2	1				
AF4a-01 (DUP)				-	-	54.0	-	-	207.8	0.71	0.47	81.3	-	-	100			
AF4a-02				2.00 U	2.00 U		1.7	1.1		0.68	0.55		-	-				
AF4a-03				2.00 U	2.00 U		1.5	1.1		0.81	0.56		-	-				
AF5-01	2.78 U	2.78 U		2.00 U	2.00 U					1.1	0.68		1.1	1.4				
AF5-01 (DUP)	-	-		-	-					0.96	0.7		-	-				
AF5-02	2.78 U	2.78 U	109.3	2.00 U	2.00 U	95.7				0.99	0.51	140.8	1.2	1.3	143.8			
AF5-03	2.78 U	2.78 U		2.00 U	2.00 U					0.94	0.43		1.2	1.3				
AF5-03	-	-		-	-					1	-		-	-				
BWB-006																2.4	1.9	
BWB-008																2.2	1.8	15.2
BWB-023																2.3	1.9	
BWB-108																2.3	1.9	

U or UJ = Not detected above analytical detection method
DUP = Duplicate Sample
µg/L = micrograms per liter
Note: Following the July 2012 sampling event and the determination that the laboratory detection limit was too high to measure the arsenic in the samples, a laboratory which could achieve lower detection limits was contracted for subsequent sampling events.

Table 17. Arsenic Flux Summary Along Maurice River Transects
Maurice River Site
Vineland, New Jersey

Transect	AF1				
Date	7/2012	10/2012	5/2013	10/2013	7/2014
Total Area (feet^2)	**25.8**	**31.9**	**29.36**	**25.53**	**20.2**
Average Velocity (feet/second)	**0.3**	**0.3**	**0.5**	**0.2**	**0.4**
Average Total Discharge (feet^3/second)	**6.5**	**8.3**	**14.4**	**5.6**	**7.5**
Average Dissolved Arsenic Concentration (micrograms/liter)	2.78U	1.00U	1.00U	0.40U	1.00U
Average Total Arsenic Concentration (micrograms/liter)	2.78U	1.00U	1.00	0.40U	1.00U
Average Dissolved Arsenic Flux (kilograms/year)	**<16**	**<7**	**<12.9**	**<2.02**	**<7**
Average Total Arsenic Flux (kilograms/year)	**<16**	**<7**	**12.9**	**<2.02**	**<7**

Transect	AF2				
Date	7/13/2012	10/2/2012	5/2013	10/2013	7/2014
Total Area (feet^2)	**105**	**108.1**	**224.5**	**100.59**	**111.9**
Average Velocity (feet/second)	**0.4**	**0.4**	**0.9**	**0.7**	**0.7**
Average Total Discharge (feet^3/second)	**38.9**	**46.5**	**197.6**	**69.4**	**75.0**
Average Dissolved Arsenic Concentration (micrograms/liter)	2.78U	1.00U	1.00	0.40	1.00U
Average Total Arsenic Concentration (micrograms/liter)	2.78U	1.06	1.33	0.57	1.00U
Average Dissolved Arsenic Flux (kilograms/year)	**<98**	**<44**	**176.4**	**24.9**	**<67**
Average Total Arsenic Flux (kilograms/year)	**<98**	**<44**	**234.8**	**35.3**	**<67**

U = Not detected above analytical reporting limit
ft^3=cubic feet

Table 16. Arsenic Flux Summary Along Maurice River Transects
Maurice River Site
Vineland, New Jersey

Transect	AF3				
Date	7/13/2012	10/2/2012	5/2013	10/2013	7/2014
Total Area (feet^2)	**64**	**65.2**	**127.35**	**71.1**	**81.32**
Average Velocity (feet/second)	**1.1**	**1.1**	**1.5**	**1.0**	**1.1**
Average Total Discharge (feet^3/second)	**67.2**	**69.1**	**187.2**	**71.8**	**85.4**
Average Dissolved Arsenic Concentration (micrograms/liter)	2.78U	1.00U	1.17	0.48	1.00
Average Total Arsenic Concentration (micrograms/liter)	2.78U	1.00U	1.37	0.75	1.13
Average Dissolved Arsenic Flux (kilograms/year)	**<167**	**<63**	**195.7**	**30.8**	**76.3**
Average Total Arsenic Flux (kilograms/year)	**<167**	**<63**	**229.1**	**48.1**	**86.2**

Transect	AF4A			
Date	10/2/2012	5/2013	10/2013	7/2014
Total Area (feet^2)	**87.8**	**164.9**	**84.3**	**95.3**
Average Velocity (feet/second)	**0.6**	**1.3**	**1.0**	**1.1**
Average Total Discharge (feet^3/second)	**54.0**	**207.8**	**81.3**	**100.0**
Average Dissolved Arsenic Concentration (micrograms/liter)	1.66U	1.23	0.54	1.00
Average Total Arsenic Concentration (micrograms/liter)	1.66U	1.57	0.74	1.20
Average Dissolved Arsenic Flux (kilograms/year)	**<79**	**228.5**	**39.1**	**89.4**
Average Total Arsenic Flux (kilograms/year)	**<79**	**291.6**	**54.0**	**107.3**

U = Not detected above analytical reporting limit
ft^3=cubic feet

Table 16. Arsenic Flux Summary Along Maurice River Transects
Maurice River Site
Vineland, New Jersey

Transect	AF5			
Date	7/13/2012	10/2/2012	10/2013	7/2014
Total Area (feet^2)	**73.9**	**67.6**	**76.9**	**66.3**
Average Velocity (feet/second)	**1.5**	**1.4**	**1.8**	**2.2**
Average Total Discharge (feet^3/second)	**109.3**	**95.7**	**140.8**	**143.8**
Average Dissolved Arsenic Concentration (micrograms/liter)	2.78U	2.00U	0.54	1.17
Average Total Arsenic Concentration (micrograms/liter)	2.78U	2.00U	1.00	1.33
Average Dissolved Arsenic Flux (kilograms/year)	**<271**	**<170**	**67.8**	**150.3**
Average Total Arsenic Flux (kilograms/year)	**<271**	**<170**	**125.8**	**170.9**

Transect	BWB
Date	8/2014
Total Area (feet^2)	**10.3**
Average Velocity (feet/second)	**1.5**
Average Total Discharge (feet^3/second)	**15.2**
Average Dissolved Arsenic Concentration (micrograms/liter)	1.87
Average Total Arsenic Concentration (micrograms/liter)	2.30
Average Dissolved Arsenic Flux (kilograms/year)	**25.5**
Average Total Arsenic Flux (kilograms/year)	**31.3**

U = Not detected above analytical reporting limit
ft^3=cubic feet

Table 18. Surface Water Total and Dissolved Arsenic Concentrations and % Dissolved Phase Arsenic
Maurice River Site
Vineland, New Jersey

Location	Sample Date	Dissolved Arsenic	Total Arsenic	Percent % Dissolved Phase
AF2-02	10/30/2013	0.44	0.56	78.6%
AF2-03	5/14/2013	1.0	1.5	66.7%
AF3-01	5/14/2013	1.3	1.4	92.9%
AF3-01	10/30/2013	0.45	0.79	57.0%
AF3-02	5/14/2013	1.1	1.3	84.6%
AF3-02	10/30/2013	0.48	0.68	70.6%
AF3-03	5/14/2013	1.1	1.6	68.8%
AF3-03	10/30/2013	0.50	0.75	66.7%
AF3-102-Y3	7/25/2014	1.0	1.2	83.3%
AF3-103-Y3	7/25/2014	1.1	1.1	100.0%
AF4-01	5/14/2013	1.1	1.5	73.3%
AF4-02	5/14/2013	1.5	1.7	88.2%
AF4-03	5/14/2013	1.1	1.5	73.3%
AF4-101-Y3	7/25/2014	1.0	1.2	83.3%
AF4-102-Y3	7/25/2014	1.0	1.2	83.3%
AF4a-01	10/30/2013	0.55	0.76	72.4%
AF4a-02	10/30/2013	0.55	0.68	80.9%
AF4a-03	10/30/2013	0.56	0.81	69.1%
AF5-01	10/30/2013	0.68	1.1	61.8%
AF5-02	10/30/2013	0.51	1.0	51.5%
AF5-03	10/30/2013	0.43	0.94	45.7%
AF5-101-Y3	7/25/2014	1.1	1.4	78.6%
AF5-102-Y3	7/25/2014	1.2	1.3	92.3%
AF5-103-Y3	7/25/2014	1.2	1.3	92.3%
BWB-006	8/27/2014	1.9	2.4	79.2%
BWB-008	8/27/2014	1.8	2.2	81.8%
BWB-023	8/27/2014	1.9	2.3	82.6%
Mean Total Arsenic % Dissolved Phase				**76.3%**

Table 19. Summary of Surface Water Quality Data
Maurice River Site
Vineland, New Jersey

Location	Sample Date	Temperature (^{o}C)	pH (units)	Dissolved Oxygen (mg/L)	Conductivity (mS/cm)	ORP (mV)
AF1	13-Jul-12	18.0	8.4	12.7	0.113	212
AF2	13-Jul-12	22.6	6.9	11.5	0.125	128
AF3	13-Jul-12	22.6	6.6	12.0	0.120	149
AF4	13-Jul-12	24.0	6.3	15.8	0.880	164
AF5	13-Jul-12	22.9	6.6	12.2	0.154	152
SSB 1-5	25-Jul-12	27.3	7.4	12.2	0.133	194
SSB 2-5	25-Jul-12	27.4	6.0	13.1	0.134	201
SSB 3-5	25-Jul-12	27.5	6.2	11.3	0.134	185
SSB 4-5	25-Jul-12	27.7	6.1	11.4	0.134	99
ULSTC 1-5	25-Jul-12	26.3	5.3	13.8	0.134	158
ULSTC 2-5	25-Jul-12	26.4	5.5	14.8	0.135	82
ULSTC 3-5	25-Jul-12	26.6	5.6	15.5	0.133	120
AF1	2-Oct-12	15.7	7.0	9.0	0.109	163
AF2	2-Oct-12	17.6	6.8	9.4	0.123	116
AF3	2-Oct-12	17.8	6.5	10.5	0.125	146
AF4	2-Oct-12	18.0	6.5	13.4	0.126	146
AF5	2-Oct-12	17.4	6.5	10.4	0.156	131
ALM 1-5	1-Aug-13	22.0	6.7	6.9	0.098	200
ALM 2-5	1-Aug-13	21.9	7.0	8.0	0.099	185
ALM 3-5	1-Aug-13	22.0	7.3	7.2	0.099	184
ALL 1-5	1-Aug-13	22.0	6.4	7.6	0.098	221
ALL 2-5	1-Aug-13	21.8	6.3	7.0	0.097	219
ALL 3-5	1-Aug-13	21.8	6.3	6.9	0.098	220
AF1	14-May-13	11.1	8.1	8.7	0.120	129
AF2	14-May-13	12.3	7.1	9.3	0.111	132
AF3	14-May-13	13.7	-	10.4	0.115	175
AF4A	14-May-13	15.0	-	11.6	0.115	157
AF1	16-May-13	15.8	5.5	8.4	0.120	186
AF2	16-May-13	17.9	5.5	9.5	0.110	176
AF3	16-May-13	17.8	5.9	10.2	0.112	156
AF4A	16-May-13	17.9	7.0	10.4	0.114	224
AF5	16-May-13	18.6	5.7	10.0	0.132	166
SSB 1-5	8-Aug-13	24.6	6.5	7.8	0.105	285
SSB 2-5	8-Aug-13	24.7	6.4	7.5	0.105	309
SSB 3-5	8-Aug-13	25.2	6.3	7.0	0.104	317
ULSTC 1-5	8-Aug-13	24.0	6.7	7.5	0.120	268
ULSTC 2-5	8-Aug-13	24.1	6.3	10.0	0.104	281
ULSTC 3-5	8-Aug-13	24.1	6.3	6.4	0.104	297
BAB 1-5	8-Aug-13	22.7	6.2	7.2	0.105	279
BAB 2-5	8-Aug-13	22.7	6.9	6.9	0.105	247
DEPBL	8-Aug-13	25.2	6.3	7.0	0.104	317

AF1 = Blackwater Creek at N. Delsea Drive
AF2 = Maurice River at Garden Road
AF3 = Maurice River at Alliance Beach
AF4 = Maurice River at Almond Beach
AF5 = Maurice River at W. Sherman Avenue
SSB = Sharp Street Beach
ULSTC = Union Lake Sailing and Tennis Club

^{o}C = degrees Centigrade
mg/L = milligrams per Liter
mS/cm = milliSiemens per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Units

Table 19. Summary of Surface Water Quality Data
Maurice River Site
Vineland, New Jersey

Location	Sample Date	Temperature (^{o}C)	pH (units)	Dissolved Oxygen (mg/L)	Conductivity (mS/cm)	ORP (mV)
AF1	30-Oct-13	12.1	6.6	8.5	0.115	168
AF2	30-Oct-13	11.1	6.3	13.4	0.120	177
AF3	30-Oct-13	11.8	6.1	-	0.123	196
AF4A	30-Oct-13	11.8	6.0	12.7	0.124	205
AF5	30-Oct-13	12.3	6.2	10.5	0.153	130
SSB 104/105	23-Jul-14	25.8	5.3	8.5	0.142	223
SSB 204/205	23-Jul-14	26.0	5.3	8.1	0.141	212
SSB 304/305	23-Jul-14	26.2	5.2	8.5	0.141	204
SSB 404/405	23-Jul-14	26.2	5.5	8.5	0.141	204
ULSTC 104/105	23-Jul-14	27.6	5.8	8.1	0.141	156
ULSTC 204/205	23-Jul-14	28.1	5.5	8.1	0.141	156
ULSTC 304/305	23-Jul-14	27.0	5.4	8.6	0.141	196
BAB 104/105	23-Jul-14	24.6	5.9	7.9	0.129	138
BAB 204/205	23-Jul-14	24.6	5.2	8.2	0.129	165
BAB 304/305	23-Jul-14	24.6	5.1	8.3	0.129	169
ALM 104/105	24-Jul-15	22.9	5.2	8.6	0.128	156
ALM 204/205	24-Jul-14	22.9	5.4	8.1	0.129	146
ALM 304/305	24-Jul-14	22.9	5.5	7.9	0.131	137
ALL 104/105	24-Jul-14	22.5	5.4	9.4	0.128	155
ALL 204/205	24-Jul-14	22.5	5.3	8.3	0.128	159
AL 304/305	24-Jul-14	22.4	5.5	8.0	0.128	149
AF1	24-Jul-14	16.2	4.9	7.9	0.121	182
AF2	24-Jul-14	20.6	5.2	8.2	0.126	151
AF3	24-Jul-14	21.8	5.5	9.6	0.127	135
AF4A	24-Jul-14	21.5	5.6	8.7	0.127	135
AF5	24-Jul-14	21.6	5.6	9.3	0.152	102

AF1 = Blackwater Creek at N. Delsea Drive
AF2 = Maurice River at Garden Road
AF3 = Maurice River at Alliance Beach
AF4 = Maurice River at Almond Beach
AF5 = Maurice River at W. Sherman Avenue
SSB = Sharp Street Beach
ULSTC = Union Lake Sailing and Tennis Club

^{o}C = degrees Centigrade
mg/L = milligrams per Liter
mS/cm = milliSiemens per centimeter
mV = millivolts
NTU = Nephelometric Turbidity Units

Table 20. Summary Surface Water Samples Collected for the Human Health Risk Assessment
Maurice River Site
Vineland, New Jersey

YEAR 1					YEAR 2					YEAR 3				
	Total Arsenic (µg/L)		Dissolved Arsenic (µg/L)			Total Arsenic (µg/L)		Dissolved Arsenic (µg/L)			Total Arsenic (µg/L)		Dissolved Arsenic (µg/L)	
Year 1 Sample Location	Undisturbed Sediment Surface Water	Disturbed Sediment Surface Water	Undisturbed Sediment Surface Water	Disturbed Sediment Surface Water	Year 2 Sample Location	Undisturbed Sediment Surface Water	Disturbed Sediment Surface Water	Undisturbed Sediment Surface Water	Disturbed Sediment Surface Water	Year 3 Sample Location	Undisturbed Sediment Surface Water	Disturbed Sediment Surface Water	Undisturbed Sediment Surface Water	Disturbed Sediment Surface Water
ALL 1-5	2.78 U	2.78 U	2.78 U	2.78 U	ALL 2 1-5	1.7	1.7	1.8	1.5	ALL-RA-105-Y3	1.3	1.3	1.1	1
ALL 1-5 (DUP)	2.78 U	2.78 U	2.78 U	2.78 U										
ALL 2-5	2.78 U	2.78 U	2.78 U	2.78 U	ALL 2 2-5	1.7	1.9	1.4	1.5	ALL-RA-205-Y3	1.3	1.6	1	1
ALL 3-5	2.78 U	2.78 U	2.78 U	2.78 U	ALL 2 3-5	1.6	2.1	1.5	1.9	ALL-RA-305-Y3	1.3	1.3	1	1
ALM 1-5	2.78 U	2.78 U	2.78 U	2.78 U	ALM 2 1-5	1.9	2.3	1.8	2	ALM-RA-105	1.3	2.4	1.1	1.1
					ALM 2 1-5 (DUP)	-	1.9	-	-					
ALM 2-5	2.78 U	2.78 U	2.78 U	2.78 U	ALM 2 2-5	2	2.1	1.7	2.1	ALM-RA-205	1.3	1.3	1.1	1.1
ALM 3-5	2.78 U	2.78 U	2.78 U	2.78 U	ALM 2 3-5	2	6.3	1.8	2.2	ALM-RA-305	1.3	1.3	1.1	1.1
					ALM 2 3-5 (DUP)	-	8.4	-	-					
BA 1-5	2.78 U	2.78 U	2.78 U	2.78 U	BA 2 1-5	1.5	1.4	1 U	1	BAB-RA-105	1.3	2.6	1.2	1.1
					BA 2 2-5	1.4	1.5	1	1.1	BAB-RA-205	1.4	17	1.1	1.4
DEPBL	5.39	12	5.73	4.29	DEPBL 2 1-1	19	15	4.3	4.5					
ULSTC 1-5	6.24	11.9	5.44	4.9	ULSTC 2 1-5	6.7	12	5.2	5.1	ULS-RA-105	4.4	5.4	4	4
ULSTC 2-5	5.96	10.3	5.67	5.2	ULSTC 2 2-5	6.4	8.8	5.1	4.9	ULS-RA-205	4.5	5.3	3.9	3.8
ULSTC 3-5	6.1	8.67	5.64	5.2	ULSTC 2 3-5	6.5	7.6	4.8	5.4	ULS-RA-305	4.9	5.2	3.9	4
SSB 1-5	5.63	6.38	5.83	5.27	SSB 2 1-5	7	6.4	4.3	4.3	SSB-RA-105	4.5	5.6	4	4.2
					SSB 2 1-5 (DUP)	6.7	6.9	4.6	4.5					
SSB 2-5	5.43	6.31	5.68	5.38	SSB 2 2-5	6.4	6.5	4.9	4.9	SSB-RA-205	4.5	4.9	4	4.1
SSB 3-5	5.11	5.09	4.94	5.01	SSB 2 3-5	6.5	6.4	4.9	4.7	SSB-RA-305	5.5	4.7	4.1	4.1
SSB 4-5	6.97	5.84	5.5	5.19						SSB-RA-405	4.7	6.7	4.3	4.2
										SSB-RA-405 (dup)	4.7	6.3	--	--

ALL = Alliance Beach
ALM = Almond Beach
BA = BA Beach
SSB = Sharp Street Beach
ULSTC = Union Lake Sailing and Tennis Club
DEPBL = Department of Environmental Protection Boat Launch
µg/L = micrograms per liter
U indicates not detected at indicated detection limit
J = Estimated value
DUP = Field duplicate

Table 21. Summary Soil Samples Collected for the Human Health Risk Assessment
Maurice River Site
Vineland, New Jersey

	July 2012				August 2013				July 2014			
		Arsenic (mg/kg)				Arsenic (mg/kg)				Arsenic (mg/kg)		
Sample Area	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)
Alliance Beach	ALL 1-1	0.99 J			ALL 2 1-1	0.87			ALL-RA-101-Y3	0.65 U		
Alliance Beach	ALL 1-2	0.7 J	0.42 J		ALL 2 1-2	0.59 U	0.53 U		ALL-RA-102-Y3	0.56 U	0.59 U	
Alliance Beach					ALL 2 1-2 (FD)	0.6 U						
Alliance Beach	ALL 1-3	0.45 J			ALL 2 1-3	0.47 U			ALL-RA-103-Y3	0.82		
Alliance Beach					ALL 2 1-3 (FD)	0.48 U						
Alliance Beach	ALL 1-4			0.4 J	ALL 2 1-4			0.49 U	ALL-RA-104-Y3			0.61 U
Alliance Beach	ALL 1-5			0.55 J	ALL 2 1-5			0.49 U	ALL-RA-105-Y3			1.8
Alliance Beach	ALL 2-1	0.9 J			ALL 2 2-1	0.55 U			ALL-RA-201-Y3	1.2		
Alliance Beach	ALL 2-2	0.48 J	0.48 J		ALL 2 2-2	0.52 U	0.53 U		ALL-RA-202-Y3	1	0.81	
Alliance Beach	ALL 2-3	0.44 J			ALL 2 2-3	0.53 U			ALL-RA-203-Y3	0.52 U		
Alliance Beach	ALL 2-4			0.61 J	ALL 2 2-4			0.49 U	ALL-RA-204-Y3			0.68 U
Alliance Beach	ALL 2-5			1.1 J	ALL 2 2-5			0.61	ALL-RA-205-Y3			1.6
Alliance Beach	ALL 3-1	0.43 J			ALL 2 3-1	0.53 U			ALL-RA-301-Y3	0.59		
Alliance Beach	ALL 3-2	0.75	0.86		ALL 2 3-2	0.6	0.49 U		ALL-RA-302-Y3	1	0.63	
Alliance Beach	ALL 3-3	0.64			ALL 2 3-3	0.56 U			ALL-RA-303-Y3	0.62 U		
Alliance Beach	ALL 3-4			0.37	ALL 2 3-4			0.72	ALL-RA-304-Y3			1.6
Alliance Beach	ALL 3-5			1.4	ALL 2 3-5			0.65	ALL-RA-305-Y3			1.2
Almond Beach	ALM 1-1	0.58			ALM 2 1-1	1.1 J			ALM-RA-101-Y3	1.6		
Almond Beach	ALM 1-2	1.3	0.39		ALM 2 1-2	1.4	1.6		ALM-RA-102-Y3	0.65 U	0.63 U	
Almond Beach	ALM 1-3	1.9			ALM 2 1-3	2.4			ALM-RA-103-Y3	1.7		
Almond Beach									ALM-RA-103-Y3 (FD)	1.3		
Almond Beach	ALM 1-4			0.33	ALM 2 1-4			0.73 U	ALM-RA-104-Y3			0.58 U
									ALM-RA-104-Y3 (FD)			0.71 U
Almond Beach	ALM 1-5			0.88	ALM 2 1-5			0.65 U	ALM-RA-105-Y3			1.6
Almond Beach	ALM 1-5 (FD)			0.87 J+								
Almond Beach	ALM 2-1	2.4			ALM 2 2-1	0.61 U			ALM-RA-201-Y3	2.1		
Almond Beach	ALM 2-2	1.9	0.45		ALM 2 2-2	2	0.63 U		ALM-RA-202-Y3	1.8	0.57 U	
Almond Beach	ALM 2-3	1.6			ALM 2 2-3	2.6			ALM-RA-203-Y3	2.8		
Almond Beach	ALM 2-4			0.35	ALM 2 2-4			0.73 U	ALM-RA-204-Y3			0.66 U
Almond Beach	ALM 2-4 (FD)			0.33 J+								
Almond Beach	ALM 2-5			0.35	ALM 2 2-5			0.73 U	ALM-RA-205-Y3			0.63 U
Almond Beach	ALM 3-1	1.7			ALM 2 3-1	0.78 J			ALM-RA-301-Y3	2.3		
Almond Beach	ALM 3-2	2.5	0.26		ALM 2 3-2	1	0.62 U		ALM-RA-302-Y3	1.4	0.73 U	
Almond Beach	ALM 3-3	0.98 J+			ALM 2 3-3	1.7			ALM-RA-303-Y3	2.3		
Almond Beach	ALM 3-4			0.33 U	ALM 2 3-4			0.68 U	ALM-RA-304-Y3			0.74 U
Almond Beach	ALM 3-5			0.37 J+	ALM 2 3-5			3.6	ALM-RA-305-Y3			0.62 U

Table 21. Summary Soil Samples Collected for the Human Health Risk Assessment
Maurice River Site
Vineland, New Jersey

	July 2012				August 2013				July 2014			
		Arsenic (mg/kg)				Arsenic (mg/kg)				Arsenic (mg/kg)		
Sample Area	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)
BA Beach	BA 1-1	0.73 J+			BA 2 1-1	0.65 U			BAB-RA-101-Y3	0.63 U		
BA Beach	BA 1-2	0.46 J+	0.33 J+		BA 2 1-2	0.64 U	0.65 U		BAB-RA-102-Y3	0.58 U	0.68 U	
BA Beach	BA 1-3	0.66 J+			BA 2 1-3	0.66 U			BAB-RA-103-Y3	0.56 U		
BA Beach	BA 1-4			0.48 J+	BA 2 1-4			0.61 U	BAB-RA-104-Y3			0.59 U
BA Beach									BAB-RA-104-Y3 (FD)			0.63 U
BA Beach	BA 1-5			0.46 J+	BA 2 1-5			0.64 U				
BA Beach	BA 2-1	0.36 J+			BA 2 2-1	0.59 U			BAB-RA-201-Y3	0.62 U		
BA Beach	BA 2-2	0.34 J+	0.33 J+		BA 2 2-2	0.58 U	0.54 U		BAB-RA-202-Y3	0.64 U	1.1	
BA Beach					BA 2 2-2 (FD)		0.54 U					
BA Beach	BA 2-3	0.59 J+			BA 2 2-3	1.1			BAB-RA-203-Y3	0.6 U		
BA Beach	BA 2-4			0.58 J+	BA 2 2-4			0.58 U	BAB-RA-204-Y3			17
BA Beach	BA 2-5			0.6 J+	BA 2 2-5			0.74 U	BAB-RA-205-Y3			1.6
BA Beach									BAB-RA-301-Y3	0.56 U		
BA Beach									BAB-RA-302-Y3	0.55 U	0.63 U	
BA Beach									BAB-RA-303-Y3	0.53 U		
BA Beach									BAB-RA-304-Y3			190
BA Beach									BAB-RA-305-Y3			6
DEP Boat Launch	DEPBL 1-1			2.4 J	DEPBL 2 1-1	3.3			DEPBL 2 1-1			
DEP Boat Launch					DEPBL 2 2-1	15			DEPBL 2 2-1			
DEP Boat Launch					DEPBL 2 2-2	7.2			DEPBL 2 2-2			
ULSTC	ULSTC 1-1	1.2			ULSTC 2 1-1	1.3 J			ULS-RA-101-Y3	0.93		
ULSTC	ULSTC 1-2	4.7	1.2		ULSTC 2 1-2	1.4 J	1.2 J		ULS-RA-102-Y3	1		
ULSTC	ULSTC 1-2 (FD)	4.5 J+			ULSTC 2 1-2 (FD)		1.1 J		ULSTC 2 1-2 (FD)			
ULSTC	ULSTC 1-3	1.4			ULSTC 2 1-3	1.8			ULS-RA-103-Y3	1.2		
ULSTC	ULSTC 1-4			1.4	ULSTC 2 1-4			1.9	ULS-RA-104-Y3			0.9
ULSTC	ULSTC 1-5			5.5	ULSTC 2 1-5			6.2	ULS-RA-105-Y3			2.8
ULSTC	ULSTC 2-1	0.87			ULSTC 2 2-1	0.7 U			ULS-RA-201-Y3	0.86		
ULSTC	ULSTC 2-2	0.77	1.7		ULSTC 2 2-2	0.83 J	1.1		ULS-RA-202-Y3	0.57		
ULSTC	ULSTC 2-2 (FD)	1.5 J+										
ULSTC	ULSTC 2-3	1			ULSTC 2 2-3	1.6			ULS-RA-203-Y3	0.8		
ULSTC	ULSTC 2-4			3	ULSTC 2 2-4			2.5	ULS-RA-204-Y3			0.88
ULSTC	ULSTC 2-5			7.2	ULSTC 2 2-5			4.9	ULS-RA-205-Y3			3.8
ULSTC	ULSTC 3-1	0.82			ULSTC 2 3-1	1.3			ULS-RA-301-Y3	0.81		
ULSTC	ULSTC 3-2	1.1	2.1		ULSTC 2 3-2	1.3 J	1.1		ULS-RA-302-Y3	0.88 J		
ULSTC	ULSTC 3-3	0.96			ULSTC 2 3-3	1.9			ULS-RA-303-Y3	0.81		
ULSTC	ULSTC 3-4			1.8	ULSTC 2 3-4			3.6	ULS-RA-304-Y3			1
ULSTC	ULSTC 3-5			8.6	ULSTC 2 3-5			4.3	ULS-RA-305-Y3			4

Table 21. Summary Soil Samples Collected for the Human Health Risk Assessment
Maurice River Site
Vineland, New Jersey

	July 2012				August 2013				July 2014			
		Arsenic (mg/kg)				Arsenic (mg/kg)				Arsenic (mg/kg)		
Sample Area	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)	Sample Location	Soil (0 to 2 feet)	Soil (0 to 2 inches)	Sediment (0 to 6 inches)
Sharp Street Beach	SSB 1-1	0.71			SSB 2 1-1	0.77 U			SSB-RA-101-Y3	0.67		
Sharp Street Beach	SSB 1-1 (FD)	0.81 J+							SSB-RA-101-Y3	0.63		
Sharp Street Beach	SSB 1-2	0.87	0.35		SSB 2 1-2	1.3	0.79 U		SSB-RA-102-Y3	0.65	1.2	
Sharp Street Beach	SSB 1-3	0.64			SSB 2 1-3	0.74 U			SSB-RA-103-Y3	1.1		
Sharp Street Beach					SSB 2 1-4			1	SSB 2 1-4			31
Sharp Street Beach	SSB 1-4			2.1	SSB 2 1-4 (FD)			0.89				
Sharp Street Beach	SSB 1-5			2.3	SSB 2 1-5			1.4	SSB 2 1-5			4.3
Sharp Street Beach	SSB 2-1	1.5			SSB 2 2-1	1.1			SSB-RA-201-Y3	1.4		
Sharp Street Beach	SSB 2-2	0.94	0.32		SSB 2 2-2	0.8 J	0.75 U		SSB-RA-202-Y3	0.8	0.84	
Sharp Street Beach	SSB 2-3	1			SSB 2 2-3	0.67 U			SSB-RA-203-Y3	0.6 U		
Sharp Street Beach	SSB 2-4			4	SSB 2 2-4			1.1	SSB 2 2-4			4.7
Sharp Street Beach	SSB 2-5			2.2	SSB 2 2-5			0.9	SSB 2 2-5			2.1
Sharp Street Beach	SSB 3-1	1.7			SSB 2 3-1	1.4			SSB-RA-101-Y3	1.1		
Sharp Street Beach	SSB 3-2	2.1	0.31		SSB 2 3-2	0.68 U	0.66 U		SSB-RA-302-Y3	1.4	0.92	
Sharp Street Beach									SSB-RA-302-Y3 (FD)		0.94	
Sharp Street Beach	SSB 3-3	1.5			SSB 2 3-3	4.2			SSB-RA-303-Y3	0.63 U		
Sharp Street Beach	SSB 3-4			5	SSB 2 3-4			3.4	SSB 2 3-4			6.2
Sharp Street Beach	SSB 3-5			1.6	SSB 2 3-5			3.9	SSB 2 3-5			2.2
Sharp Street Beach	SSB 4-1	1.2 J							SSB-RA-401-Y3	1.3		
Sharp Street Beach	SSB 4-2	0.85 J	0.28 J						SSB-RA-402-Y3	0.9		
Sharp Street Beach	SSB 4-3	0.54 J							SSB-RA-403-Y3	0.88		
Sharp Street Beach	SSB 4-4			8.1 J					SSB-RA-404-Y3			1.4
Sharp Street Beach	SSB 4-5			3.6 J					SSB-RA-405-Y3			6.1

mg/kg = milligrams per kilogram
J , J^+= Estimated Value
FD = field duplicate
U indicates not detected at indicated detection limit
ULSTC =Union Lake Sailing and Tennis Club
DEP = Department of Environmental Protection

Table 22. Data Summary for Total and Dissolved Arsenic in Surface Water Samples Collected for the Human Health Risk Assessment
Maurice River Site
Vineland, New Jersey

Sample Area	YEAR 1 TOTAL ARSENIC - SURFACE WATER										YEAR 2 TOTAL ARSENIC - SURFACE WATER										YEAR 3 TOTAL ARSENIC - SURFACE WATER									
	Undisturbed Sediments					Disturbed Sediments					Undisturbed Sediments					Disturbed Sediments					Undisturbed Sediments					Disturbed Sediments				
	Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)		
	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average
Alliance Beach	0 / 3	0	—	1.39 U	—	0 / 3	0	—	1.39 U	—	3 / 3	100	1.6	1.8	1.7	3 / 3	100	1.7	2.1	1.9	3 / 3	100	1.3	1.3	1.3	3 / 3	100	1.3	1.6	1.45
Almond Beach	0 / 3	0	—	1.39 U	—	0 / 3	0	—	1.39 U	—	3 / 3	100	1.9	2	1.967	5 / 5	100	1.9	7.35	3.85	3 / 3	100	1.3	1.3	1.3	3 / 3	100	1.3	2.4	1.67
BA Beach	0 / 2	0	—	1.39 U	—	0 / 2	0	—	1.39 U	—	2 / 2	100	1.4	1.5	1.45	2 / 2	100	1.4	1.5	1.45	2 / 2	100	1.3	1.4	1.35	2 / 2	100	2.6	17	9.8
DEP Boat Launch	1 / 1	100	—	5.39	—	1 / 1	100	—	12	—	1 / 1	100	--	19	--	1 / 1	100	--	15	--										
Sharp Street Beach	4 / 4	100	5.11	6.97	5.785	4 / 4	100	5.09	6.38	5.91	4 / 4	100	6.4	6.85	6.583	4 / 4	100	6.4	6.65	6.52	5 / 5	100	4.5	5.5	4.8	5 / 5	100	4.7	6.5	5.43
ULSTC	3 / 3	100	5.96	6.24	6.1	3 / 3	100	8.67	11.9	10.29	3 / 3	100	6.4	6.7	6.533	3 / 3	100	7.6	12	9.457	3 / 3	100	4.4	4.9	4.6	3 / 3	100	5.2	5.4	5.3

Sample Area	YEAR 1 DISSOLVED ARSENIC - SURFACE WATER										YEAR 2 DISSOLVED ARSENIC - SURFACE WATER										YEAR 3 DISSOLVED ARSENIC - SURFACE WATER									
	Undisturbed Sediments					Disturbed Sediments					Undisturbed Sediments					Disturbed Sediments					Undisturbed Sediments					Disturbed Sediments				
	Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)			Detection Frequency		Concentration (µg/L)		
	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average	Detects/Total n	(%)	Minimum	Maximum	Average
Alliance Beach	0 / 3	0	—	1.39 U	—	0 / 3	0	—	1.39 U	—	3 / 3	100	1.4	1.8	1.567	3 / 3	100	1.5	1.9	1.633	3 / 3	100	1	1.1	1.03	3 / 3	100	1	1	1
Almond Beach	0 / 3	0	—	1.39 U	—	0 / 3	0	—	1.39 U	—	3 / 3	100	1.7	1.8	1.767	3 / 3	100	2	2.2	2.1	3 / 3	100	1.1	1.1	1.1	3 / 3	100	1.1	1.1	1.1
BA Beach	0 / 2	0	—	1.39 U	—	0 / 2	0	—	1.39 U	—	1 / 2	50	1 U	1	0.75	1 / 1	100	--	1.1	--	2 / 2	100	1.1	1.2	1.15	2 / 2	100	1.1	1.4	1.25
DEP Boat Launch	1 / 1	100	—	5.73	—	1 / 1	100	—	4.29	—	1 / 1	100	--	4.3	--	1 / 1	100	--	4.5	--										
Sharp Street Beach	4 / 4	100	4.94	5.83	5.49	4 / 4	100	5.01	5.38	5.21	4 / 4	100	4.45	4.9	4.75	4 / 4	100	4.3	4.667	4.9	4 / 4	100	4	4.3	4.10	4 / 4	100	4.1	4.2	4.15
ULSTC	3 / 3	100	5.44	5.67	5.58	3 / 3	100	4.9	5.2	5.1	3 / 3	100	4.8	5.2	5.03	3 / 3	100	4.9	5.4	5.133	3 / 3	100	3.9	4	3.93	3 / 3	10	3.8	4	3.93

n = sample size
% = percent
µg/L = micrograms per liter
U indicates not detected at indicated detection limit
DEP = Department of Environmental Protection
ULSTC = Union Lake Sailing and Tennis Club

Table 23. Data Summary for Arsenic in Beach Sand and Sediment Samples Collected for the Human Health Risk Assessment
Maurice River Site
Vineland, New Jersey

YEAR 1

Sample Area	Beach Sand						Sediment					
	Detection Frequency		Concentration (mg/kg dry wt.)				Detection Frequency		Concentration (mg/kg dry wt.)			
	Detects/Total n	(%)	Minimum	Maximum	Average	95% UCL	Detects/Total n	(%)	Minimum	Maximum	Average	95% UCL
Alliance Beach	9 / 9	100	0.43	0.99	0.64	0.772	6 / 6	100	0.37	1.4	0.74	1.082
Almond Beach	9 / 9	100	0.58	2.5	1.65	2.039	5 / 6	83	0.165	0.875	0.405	0.827 [1]
BA Beach	6 / 6	100	0.34	0.73	0.52	0.656	4 / 4	100	0.46	0.6	0.53	—
ULSTC	9 / 9	100	0.77	4.6	1.41	3.173 [2]	6 / 6	100	1.4	8.6	4.6	7.029
Sharp Street Beach	12 / 12	100	0.54	2.1	1.13	1.379	8 / 8	100	1.6	8.1	3.6	5.051
DEP Boat Launch	—	—	—	—	—	—	1 / 1	100	—	2.4	—	—

YEAR 2

Sample Area	Beach Sand						Sediment					
	Detection Frequency		Concentration (mg/kg dry wt.)				Detection Frequency		Concentration (mg/kg dry wt.)			
	Detects/Total n	(%)	Minimum	Maximum	Average	95% UCL	Detects/Total n	(%)	Minimum	Maximum	Average	95% UCL
Alliance Beach	2 / 9	22	0.48U	0.87	0.37	0.645 [3]	3 / 6	50	0.49U	0.72	0.43	0.667 [3]
Almond Beach	8 / 9	89	0.61U	2.6	1.48	1.954 [3]	1 / 6	17	0.65U	3.6	0.893	--
BA Beach	1 / 6	17	0.59U	1.1	0.44	--	0 / 4	0	0.58U	0.74U	--	--
ULSTC	1 / 9	11	0.7U	1.9	1.31	1.597 [3]	6 / 6	100	1.9	6.2	3.9	1.165
Sharp Street Beach	5 / 9	56	0.67U	4.2	1.14	5.128 [4]	6 / 6	100	0.9	3.9	1.9	3.047
DEP Boat Launch	3 / 3	100	3.3	15	8.5	--	-- / --	--	--	--	--	--

YEAR 3

Sample Area	Beach Sand						Sediment					
	Detection Frequency		Concentration (mg/kg dry wt.)				Detection Frequency		Concentration (mg/kg dry wt.)			
	Detects/Total n	(%)	Minimum	Maximum	Average	95% UCL	Detects/Total n	(%)	Minimum	Maximum	Average	95% UCL
Alliance Beach	5 / 9	56	0.52U	1.2	0.64	0.921 [4]	4 / 6	67	0.61U	1.8	1.14	1.69 [4]
Almond Beach	8 / 9	89	0.65U	2.8	1.79	2.223 [4]	1 / 6	17	0.62U	1.6	0.547	--
BA Beach	0 / 9	0	0.53U	0.64U	--	--	4 / 6	67	0.59U	190	35.87	101.6 [4]
ULSTC	9 / 9	100	0.57	1.2	0.87	0.979	6 / 6	100	0.88	4	2.2	3.452
Sharp Street Beach	10 / 12	83	0.6U	1.4	0.90	1.108 [4]	8 / 8	100	1.4	31	7.3	23.2 [5]
DEP Boat Launch												

Notes:
Results for field duplicates were averaged prior to computing statistics.
Means were calculated using a value of 1/2 the reporting limit for non-detects.
Year 1 95% UCL values listed are those recommeded by ProUCL Version 4.1.
Year 2 and 3 95% UCL values listed are those recommended by ProUCL Version 5.0
UCLs are 95% Student's t-UCLs unless otherwise noted by the superscripts below:
[1] 95% Kaplan-Meier (Chebyshev) UCL
[2] 95% Chebyshev (mean,sd) UCL
[3] 95% Kaplan-Meier (t) UCL
[4] 95% GROS Adjusted GAMMA UCL
[5] 95% H-UCL

n = sample size
mg/kg dry wt = milligrams per kilogram dry weight
UCL = upper confidence limit
% = percent
ULSTC =Union Lake Sailing and Tennis Club
DEP = Department of Environmental Protection
U indicates not detected at indicated detection limit

Table 24. Data Summary for Arsenic in Beach Sand and Sediment Samples, by Location along Transect
Maurice River Site
Vineland, New Jersey

YEAR 1							YEAR 2							YEAR 3						
Sample Area	Matrix	Detection Frequency		Concentration (mg/kg dry wt.)			Sample Area	Matrix	Detection Frequency		Concentration (mg/kg dry wt.)			Sample Area	Matrix	Detection Frequency		Concentration (mg/kg dry wt.)		
		Detects/Total n	(%)	Minimum	Maximum	Average			Detects/Total n	(%)	Minimum	Maximum	Average			Detects/Total n	(%)	Minimum	Maximum	Average
Alliance Beach	Sand	3 / 3	100	0.43	0.99	0.77	Alliance Beach	Sand	1 / 3	33	0.53U	0.87	0.47	Alliance Beach	Sand	2 / 3	67	0.65U	1.2	0.71
	Sand	3 / 3	100	0.48	0.75	0.64		Sand	1 / 3	33	0.52U	0.6	0.39		Sand	2 / 3	67	0.56U	1	0.76
	Sand	3 / 3	100	0.44	0.64	0.51		Sand	0 / 3	0	0.48U	0.56U	--		Sand	1 / 3	33	0.52U	0.82	0.46
	Sediment	3 / 3	100	0.37	0.61	0.46		Sediment	1 / 3	33	0.49U	0.72	0.40		Sediment	1 / 3	33	0.61U	1.6	0.75
	Sediment	3 / 3	100	0.55	1.4	1.02		Sediment	2 / 3	67	0.49U	0.65	0.50		Sediment	3 / 3	100	1.2	1.8	1.53
Almond Beach	Sand	3 / 3	100	0.58	2.4	1.56	Almond Beach	Sand	2 / 3	67	0.61U	1.1	0.73	Almond Beach	Sand	3 / 3	100	1.6	2.3	2.00
	Sand	3 / 3	100	1.3	2.5	1.90		Sand	3 / 3	100	1	2	1.47		Sand	2 / 3	67	0.65U	1.8	1.18
	Sand	3 / 3	100	0.98	1.9	1.49		Sand	3 / 3	100	1.7	2.6	2.23		Sand	3 / 3	100	1.5	2.8	2.20
	Sediment	2 / 3	67	0.165	0.34	0.28		Sediment	0 / 3	0	0.68U	0.73U	--		Sediment	0 / 3	0	0.66U	0.74U	--
	Sediment	3 / 3	100	0.35	0.875	0.53		Sediment	1 / 3	33	0.65U	3.6	1.43		Sediment	1 / 3	33	0.62U	1.6	--
BA Beach	Sand	2 / 2	100	0.36	0.73	0.55	BA Beach	Sand	0 / 2	0	0.59U	0.65U	--	BA Beach	Sand	0 / 3	0	0.56U	0.63U	--
	Sand	2 / 2	100	0.34	0.46	0.40		Sand	0 / 2	0	0.58U	0.64U	--		Sand	2 / 3	67	0.59U	6	3.80
	Sand	2 / 2	100	0.59	0.66	0.63		Sand	1 / 2	50	0.66U	1.1	--		Sand	0 / 3	0	0.53U	0.6U	--
	Sediment	2 / 2	100	0.48	0.58	0.53		Sediment	0 / 2	0	0.58U	0.61U	--		Sediment	0 / 3	0	0.55U	0.64U	--
	Sediment	2 / 2	100	0.46	0.6	0.53		Sediment	0 / 2	0	0.64U	0.74U	--		Sediment	2 / 3	67	0.61U	190	103.50
ULSTC	Sand	3 / 3	100	0.82	1.2	0.96	ULSTC	Sand	2 / 3	67	0.7U	1.3	0.98	ULSTC	Sand	3 / 3	100	0.81	0.93	0.87
	Sand	3 / 3	100	0.77	4.6	2.16		Sand	3 / 3	100	0.83	1.4	1.18		Sand	3 / 3	100	0.57	1	0.82
	Sand	3 / 3	100	0.96	1.4	1.12		Sand	3 / 3	100	1.6	1.9	1.77		Sand	3 / 3	100	0.8	1.2	0.94
	Sediment	3 / 3	100	1.4	3	2.07		Sediment	3 / 3	100	1.9	3.6	2.67		Sediment	3 / 3	100	0.88	1	0.93
	Sediment	3 / 3	100	5.5	8.6	7.10		Sediment	3 / 3	100	4.3	6.2	5.13		Sediment	3 / 3	100	2.8	4	3.53
Sharp Street Beach	Sand	4 / 4	100	0.76	1.7	1.29	Sharp Street Beach	Sand	2 / 3	67	0.77U	1.4	0.96	Sharp Street Beach	Sand	4 / 4	100	0.65	1.4	1.11
	Sand	4 / 4	100	0.85	2.1	1.19		Sand	2 / 3	67	0.68U	1.3	0.81		Sand	4 / 4	100	0.65	1.4	0.94
	Sand	4 / 4	100	0.54	1.5	0.92		Sand	1 / 3	33	0.67U	4.2	1.64		Sand	2 / 4	50	0.6U	1.1	0.65
	Sediment	4 / 4	100	2.1	8.1	4.80		Sediment	3 / 3	100	0.945	3.4	1.82		Sediment	4 / 4	100	1.4	31	10.83
	Sediment	4 / 4	100	1.6	3.6	2.43		Sediment	3 / 3	100	0.9	3.9	2.07		Sediment	4 / 4	100	2.1	6.1	3.68
DEP Boat Launch	Sediment	1 / 1	100	—	2.4	—	DEP	Sand	2 / 2	100	3.3	15	9.15	DEP						
								Sand	1 / 1	100	7.2	7.2	--							
								Sand												

n = sample size
mg/kg dry wt = milligrams per kilogram dry weight
% = percent
ULSTC =Union Lake Sailing and Tennis Club
DEP = Department of Environmental Protection Boat Launch

Field duplicates were averaged prior to computing summary statistics.
Means were calculated using a value of 1/2 the reporting limit for non-detects.

Table 25. Data Summary for Arsenic in Beach Sand Samples
Maurice River Site
Vineland, New Jersey

YEAR 1						
Location	Surface Sand Samples (0-2 inches)					Mixed Core Samples (0-2 feet)
	Detection Frequency		Concentration (mg/kg dry wt.)			
	Detects/Total n	(%)	Minimum	Maximum	Average	
Alliance Beach	3 / 3	100	0.42	0.86	0.59	0.64
Almond Beach	3 / 3	100	0.26	0.45	0.37	**1.65**
BA Beach	2 / 2	100	0.33	0.33	0.33	0.52
ULSTC	3 / 3	100	1.2	2.1	1.63	1.41
Sharp Street Beach	4 / 4	100	0.28	0.35	0.32	**1.13**

YEAR 2						
Location	Surface Sand Samples (0-6 inches)					Mixed Core Samples (0-2 feet)
	Detection Frequency		Concentration (mg/kg dry wt.)			
	Detects/Total n	(%)	Minimum	Maximum	Average	
Alliance Beach	2 / 3	0	0.49U	0.53U	--	0.57
Almond Beach	1 / 3	33	0.62U	1.6	0.95	1.47
BA Beach	0 / 2	0	0.54U	0.65U	--	--
ULSTC	3 / 3	100	1.1	1.15	1.12	**1.77**
Sharp Street Beach	0 / 3	0	0.66U	0.79U	--	0.93

YEAR 3						
Location	Surface Sand Samples (0-6 inches)					Mixed Core Samples (0-2 feet)
	Detection Frequency		Concentration (mg/kg dry wt.)			
	Detects/Total n	(%)	Minimum	Maximum	Average	
Alliance Beach	2 / 3	67	0.59U	0.81	0.58	**0.76**
Almond Beach	0 / 3	0	0.57U	0.73U	0.32	1.18
BA Beach	1 / 4	33	0.63U	1.1	0.59	0.30
ULSTC	3 / 3	100	0.84	1.2	0.99	0.82
Sharp Street Beach	1 / 3	25	0.53U	0.68	0.39	0.94

n = sample size
mg/kg dry wt = milligrams per kilogram dry weight
% = percent
ULSTC = Union Lake Sailing and Tennis Club
U indicates not detected at indicated detection limit
Field duplicates were averaged prior to computing summary statistics.
Means were calculated using a value of 1/2 the reporting limit for non-detects.

Year 1 Notes:
Bold indicates arsenic concentration measured in 0-2 foot core significantly higher than concentration in 0-2 inch depth interval.
(Almond Beach and Sharp Street Beach: t-test, α=0.05)

Year 2 Notes:
Statistical comparison of surface sand and mixed core samples was only performed for ULSTC;
the remaining locations had an insufficient number of detected concentrations to perform a reliable comparison.
Bold indicates arsenic concentration measured in 0-2 foot core significantly higher than concentration in 0-6 inch depth interval.
(ULSTC: t-test for unequal variances, α = 0.05)

Year 3 Notes:
Average Mixed Core < Average Surface Sand for ULSTC and BA Beach
Statistical comparison of surface sand and mixed core samples was only performed for Alliance Beach;
the remaining locations had an insufficient number of detected concentrations to perform a reliable comparison.
Bold indicates arsenic concentration measured in 0-2 foot core significantly higher than concentration in 0-6 inch depth interval.
(Alliance Beach: Gehan test, α = 0.05)

Table 26. Screening Results for Aquatic Receptors from Direct Contact with Surface Water and Sediment, 95UCL and Mean Measured Concentrations
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Exposure Area	Acute Aquatic Screening Level	95UCL Concentration	Hazard Quotient (HQmax)	Mean Concentration	Hazard Quotient (HQmean)	Chronic Aquatic Screening Level	95UCL Concentration	Hazard Quotient (HQmax)	Mean Concentration	Hazard Quotient (HQmean)
Surface Water (µg/L)										
Dissolved										
Maurice River ABC	340	U (4)	0.01	2.58	0.01	150	U (4)	0.03	2.58	0.02
Blackwater Branch	340	U (1.39)	0.00	U (0.64)	0.00	150	U (1.39)	0.01	U (0.64)	0.00
Maurice River BBC	340	1.414	0.00	1.55	0.00	150	1.414	0.01	1.55	0.01
Union Lake Headwaters	340	U (4)	0.01	3.80	0.01	150	U (4)	0.03	3.80	0.03
Dissolved, Disrupted										
Maurice River ABC	340	–	–	–	–	150	–	–	–	–
Blackwater Branch	340	–	–	–	–	150	–	–	–	–
Maurice River BBC	340	1.536	0.00	1.37	0.00	150	1.536	0.01	1.37	0.01
Union Lake Headwaters	340	–	–	–	–	150	–	–	–	–
Sediment (mg/kg)										
Maurice River ABC	33	5.779	0.2	3.7	0.1	9.79	5.779	0.6	3.7	0.4
Blackwater Branch	33	1.02	0.0	–	–	9.79	1.02	0.1	–	–
Maurice River BBC	33	172.9	5.2	49.02	1.5	9.79	172.9	17.7	49.02	5.0
Union Lake Headwaters	33	217.9	6.6	136.2	4.1	9.79	217.9	22.3	136.2	13.9

– = Not analyzed
Surface water samples were not collected from the Blackwater Branch exposure area
Shading indicates calculated HQ greater than 1.0
U indicates not detected; indicated value is 1/2 the reporting limit
µg/L = micrograms per liter
mg/kg = milligrams per kilogram

Table 27. Solid-Phase Toxicity Test Results
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Sample	Sample Area	Arsenic (mg/kg)	*Hyalella azteca*		*Chironomus dilutus*	
			Mean % Survival	Mean Dry Weight	Mean % Survival	Mean Dry Weight
Lab control	NA	NA	96%	0.18	92%	0.92
Tox Sed 002	Reference	1.1	96%	0.15	88%	0.68
Tox Sed 005	Union Lake Dam	280	100%	0.17	94%	0.76
Tox Sed 006	Union Lake Dam	430	96%	0.09	86%	0.67
Tox Sed 007	Union Lake Dam	390	92%	0.10	82%	0.72
Tox Sed 009	Union Lake Dam	380	86%	0.14	90%	0.69
Tox Sed 011	Union Lake Dam	220	88%	0.20	90%	0.69
Tox Sed 012	Union Lake Dam	230	92%	0.18	90%	0.76
Tox Sed 013	Union Lake Dam	33	100%	0.15	88%	0.71
Tox Sed 014	Union Lake Dam	31	88%	0.16	92%	0.66
Tox Sed 015	Almond Beach	1,000	20%	–	92%	0.49
Tox Sed 016	Almond Beach	190	80%	0.09	90%	0.67
Tox Sed 017	Almond Beach	290	80%	0.08	92%	0.72
Tox Sed 018	Almond Beach	890	66%	–	88%	0.68
Tox Sed 019	Almond Beach	33	90%	0.17	86%	0.80
Tox Sed 022	Almond Beach	79	88%	0.11	86%	0.53
Tox Sed 025	Almond Beach	110	72%	–	88%	0.50

Shading indicates statistically different from the Reference area

Table 28. Correlation of Selected Inorganic Sediment Concentrations with Toxicity Testing Endpoints
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Analyte	Mean (mg/kg)	Maximum (mg/kg)	*H. azteca* survival			*H. azteca* growth			*C. dilutus* growth		
			r	p-value	n	r	p-value	n	r	p-value	n
Arsenic	305.7	1000	-0.682	0.004	16	-0.377	0.205	13	-0.264	0.324	16
Chromium	50.3	140	0.006	0.983	16	-0.213	0.484	13	0.085	0.753	16
Lead	74.9	220	0.180	0.505	16	-0.149	0.627	13	0.240	0.371	16
Zinc	113.7	300	0.307	0.248	16	0.034	0.912	13	0.385	0.141	16

Shading indicates concentration exceeds the Threshold Effect Concentration
Shading indicates concentration exceeds the Probable Effect Concentration

Significant at $p \leq 0.01$
mg/kg = milligrams per kilogram

Percent survival data were transformed prior to running statistical tests
r = Pearson Correlation Coefficient
n = sample size

Table 29. Comparison of 95UCL and Mean Measured Total Arsenic Concentrations in Fish Tissue with Critical Tissue Concentrations
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Exposure Area	Lowest Observed Effect Concentration (mg/kg ww)	95UCL Concentration (mg/kg ww)	Hazard Quotient (HQmax)	KM Mean Concentration (mg/kg ww)	Hazard Quotient (HQmean)	No Observed Effect Concentration (mg/kg ww)	95UCL Concentration (mg/kg ww)	Hazard Quotient (HQmax)	KM Mean Concentration (mg/kg ww)	Hazard Quotient (HQmean)
Maurice River ABC	4.3	0.176	0.0	0.117	0.0	0.69	0.176	0.3	0.117	0.2
Blackwater Branch	4.3	0.226	0.1	0.159	0.0	0.69	0.226	0.3	0.159	0.2
Maurice River BBC	4.3	0.3	0.1	0.225	0.1	0.69	0.3	0.4	0.225	0.3
Union Lake Headwaters	4.3	0.51	0.1	0.388	0.1	0.69	0.51	0.7	0.388	0.6

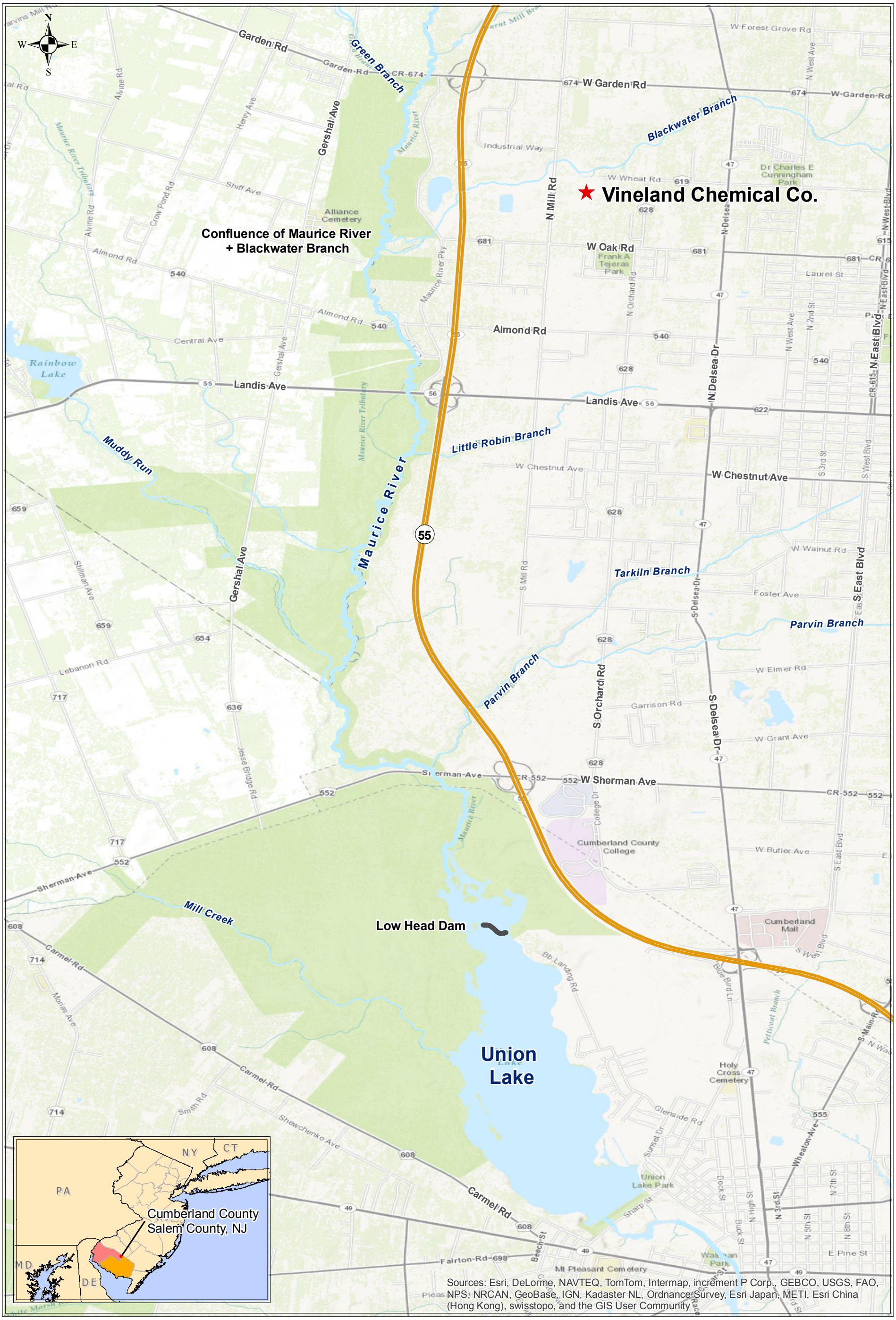
95UCL = 95% upper confidence limit
mg/kg ww = milligrams per kilogram wet weight
HQ = Hazard Quotient
ABC = Above Blackwater Branch confluence
BBC = Below Blackwater Branch Confluence
KM = Kaplan Meier

Table 30. Summary of Total HQs Calculated for Piscivorous Birds and Mammals
Maurice River Site - Ecological Risk Assessment
Vineland, New Jersey

Location	Analyte	Conservative Exposure Scenario						Representative Exposure Scenario					
		Belted Kingfisher		Osprey		Mink		Belted Kingfisher		Osprey		Mink	
		LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL
Maurice River ABC	Arsenic	0.08	0.11	0.02	0.03	0.02	0.10	0.02	0.03	0.01	0.01	0.00	0.01
Blackwater Branch	Arsenic	0.10	0.14	0.03	0.04	0.02	0.12	0.03	0.04	0.01	0.01	0.00	0.02
Maurice River BBC	Arsenic	0.20	0.28	0.06	0.09	0.05	0.27	0.05	0.07	0.02	0.02	0.01	0.03
Union Lake Headwater	Arsenic	0.25	0.36	0.08	0.11	0.07	0.34	0.07	0.11	0.03	0.04	0.01	0.05
Maurice River ABC	Inorganic Arsenic	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Blackwater Branch	Inorganic Arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maurice River BBC	Inorganic Arsenic	0.13	0.19	0.04	0.06	0.04	0.18	0.03	0.04	0.01	0.02	0.00	0.02
Union Lake Headwater	Inorganic Arsenic	0.14	0.20	0.04	0.06	0.04	0.20	0.04	0.06	0.01	0.02	0.01	0.03

ABC = Above Blackwater Branch confluence
BBC = Below Blackwater Branch confluence
LOAEL = Lowest observed adverse effect concentration
NOAEL = No observed adverse effect concentration

FIGURES



Base map created using ESRI World Topographic Map, Sample location GPS survey data from 2014

Map Creation Date: 12 August 2015

Coordinate system: GCS North American 1983
Datum: NAD83
Units: Feet

0 3,500 7,000 Feet

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Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-185

Figure 1
Area Overview
Maurice River Investigation
Vineland, NJ

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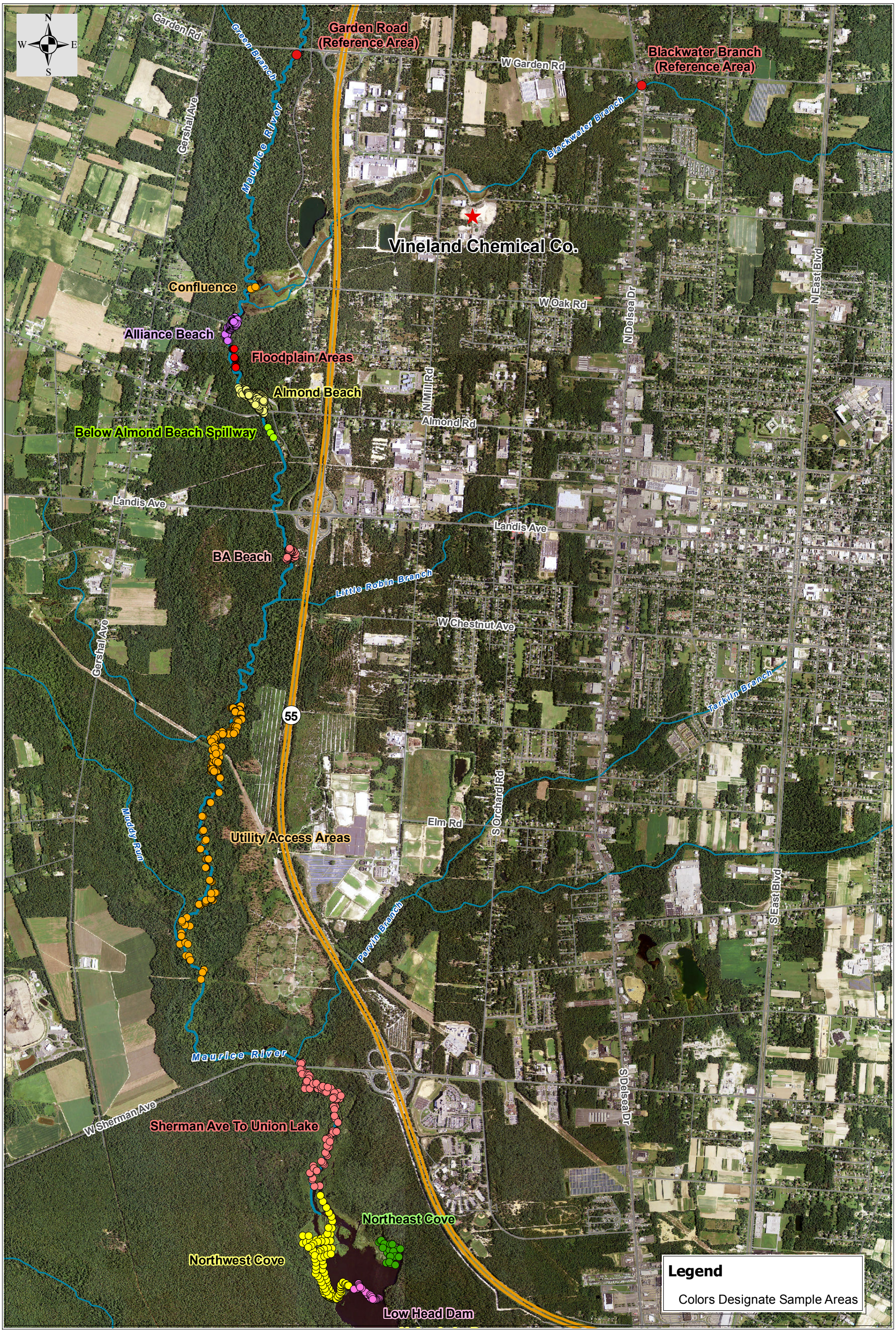

Base map created using NAIP Imagery from USGS, Sample location GPS survey data from 2012, 2013, 2014.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 2,400 4,800 Feet

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W.A.# 0-185

Figure 2
Sediment Sampling Areas and Sampling Density
Year 1, Year 2 and Year 3
Maurice River Investigation
Vineland, NJ

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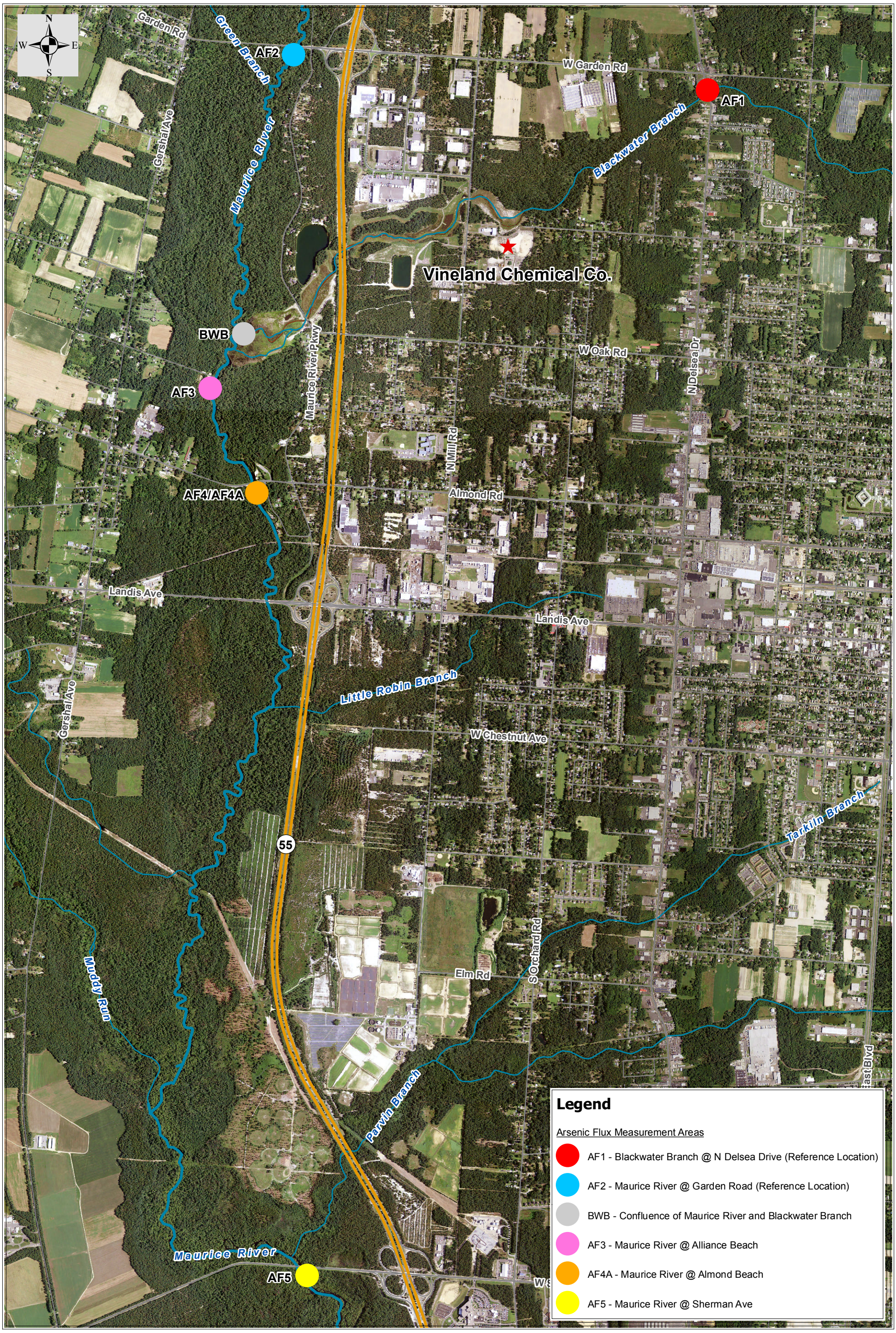

Base map created using NAIP Imagery from USGS, Sample location GPS survey data from 2012, 2013, 2014.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 2,000 4,000 Feet

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Figure 3
Water Column Sampling Areas
Year 1, Year 2 and Year 3
Maurice River Investigation
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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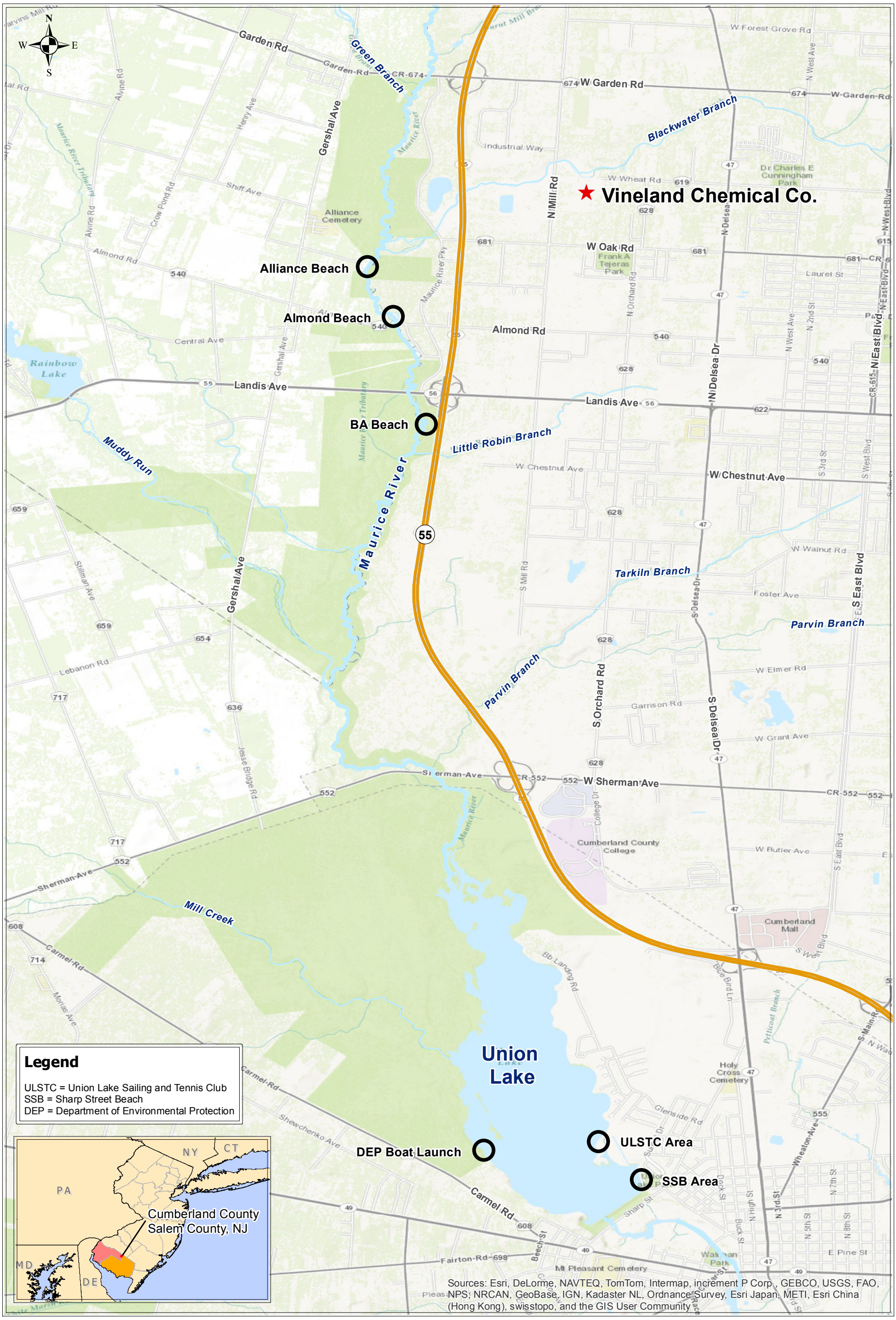

Base map created using ESRI World Topographic Map, Sample location GPS survey data from 2012, 2013, 2014.

Map Creation Date: 12 August 2015

Coordinate system: GCS North American 1983
Datum: NAD83
Units: Feet

0 3,500 7,000
Feet

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W.A.# 0-185

Figure 4
Human Health Risk Assessment Areas
Maurice River Investigation
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
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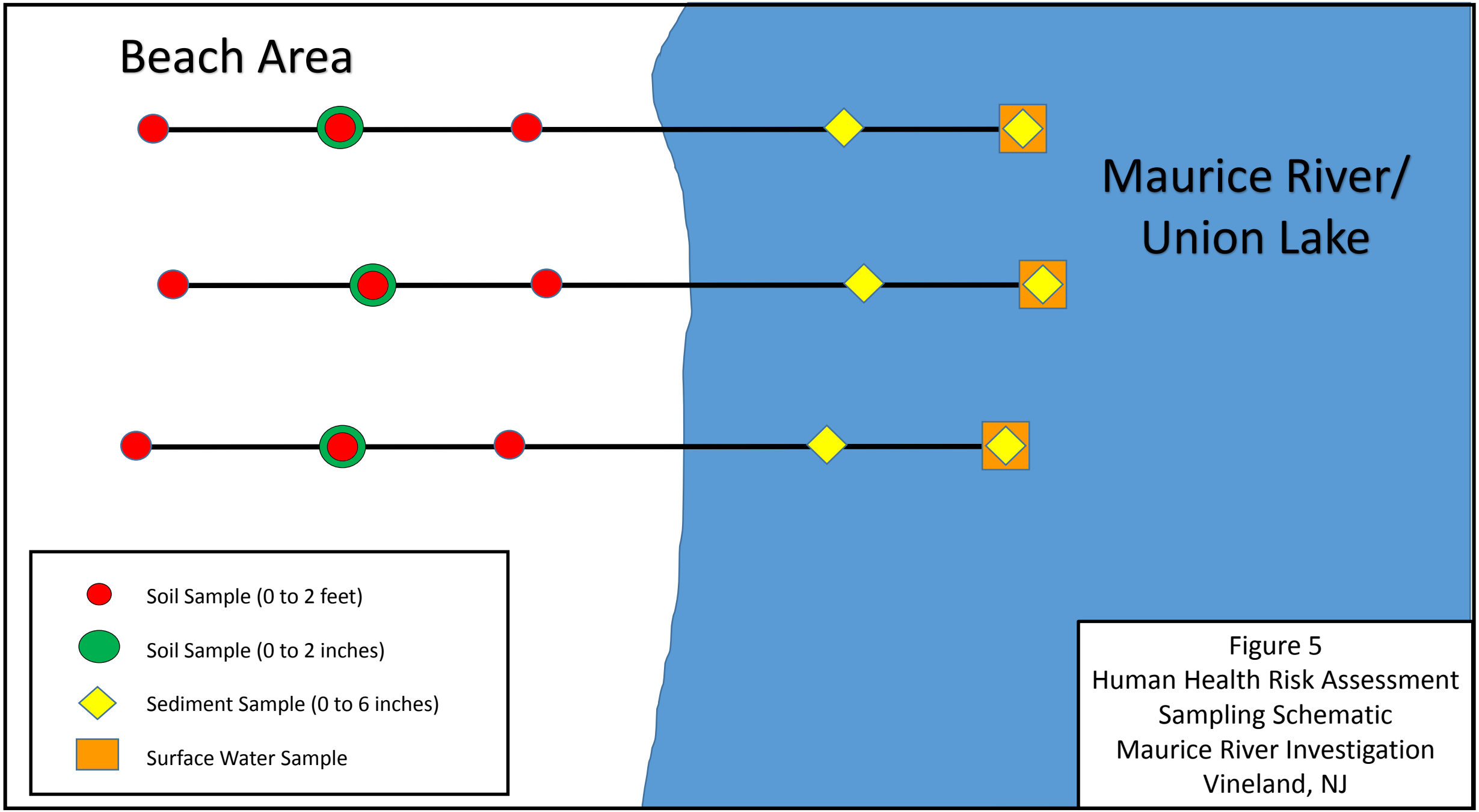
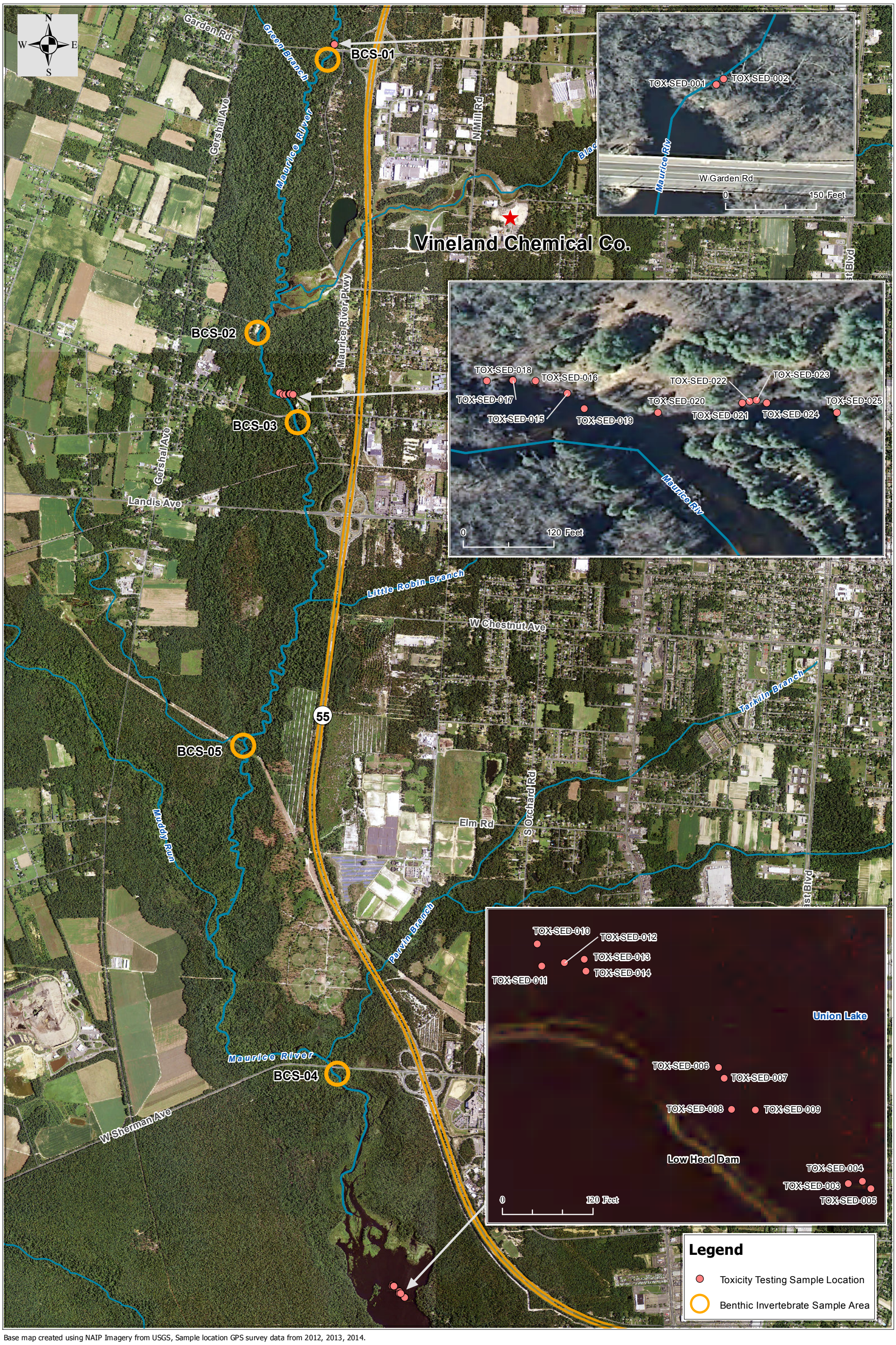


Figure 5
Human Health Risk Assessment
Sampling Schematic
Maurice River Investigation
Vineland, NJ



Base map created using NAIP Imagery from USGS, Sample location GPS survey data from 2012, 2013, 2014.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 2,400 4,800 Feet

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Figure 6
Ecological Sample Locations
Year 1, Year 2 and Year 3
Maurice River Investigation
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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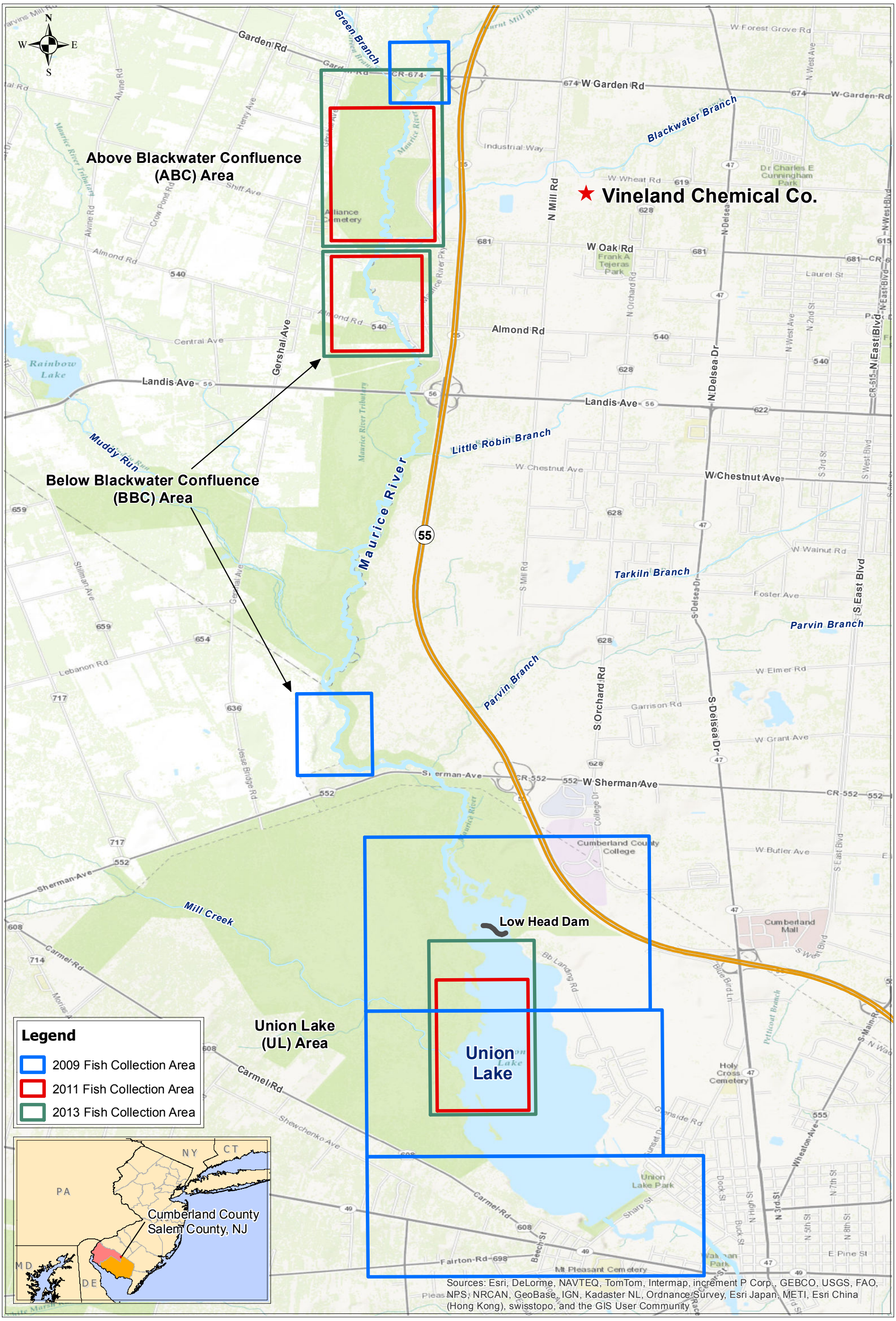

Base map created using ESRI World Topographic Map, Sample location GPS survey data from 2009, 2011, 2013.

Map Creation Date: 12 August 2015

Coordinate system: GCS North American 1983
Datum: NAD83
Units: Feet

0 3,500 7,000 Feet

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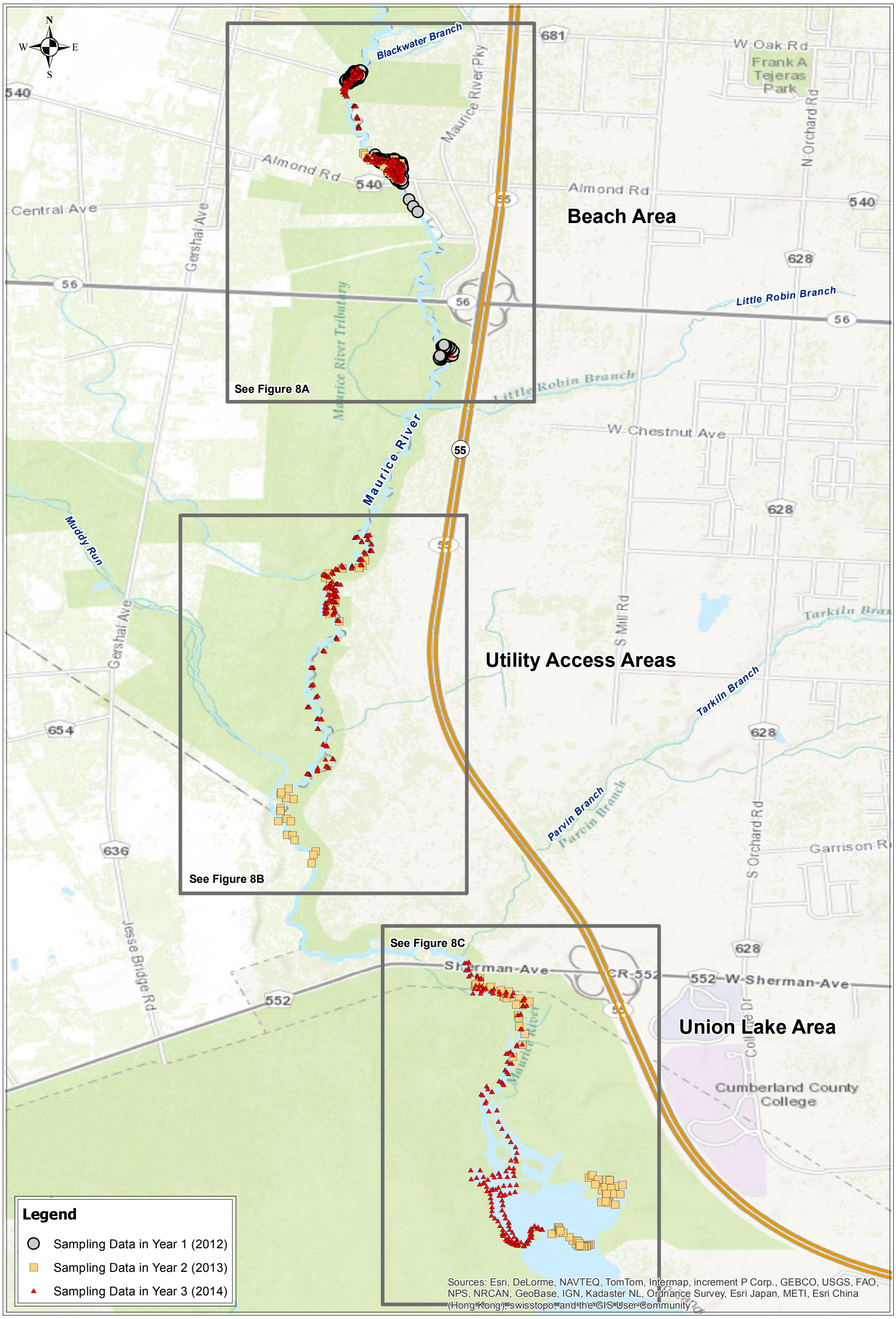
Figure 7
Fish Sampling Areas
Maurice River Investigation
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \Y3R_Report_2015\185_Y3R2015_f7_Y1Y2Y3_FishSampling_Locations_f7.mxd



Base map created using ESRI World Topographic Map, Sample location GPS survey data from 2012, 2013, 2014.

Map Creation Date: 12 August 2015

Coordinate system: GCS North American 1983
Datum: NAD83
Units: Feet

0 2,000 4,000 Feet

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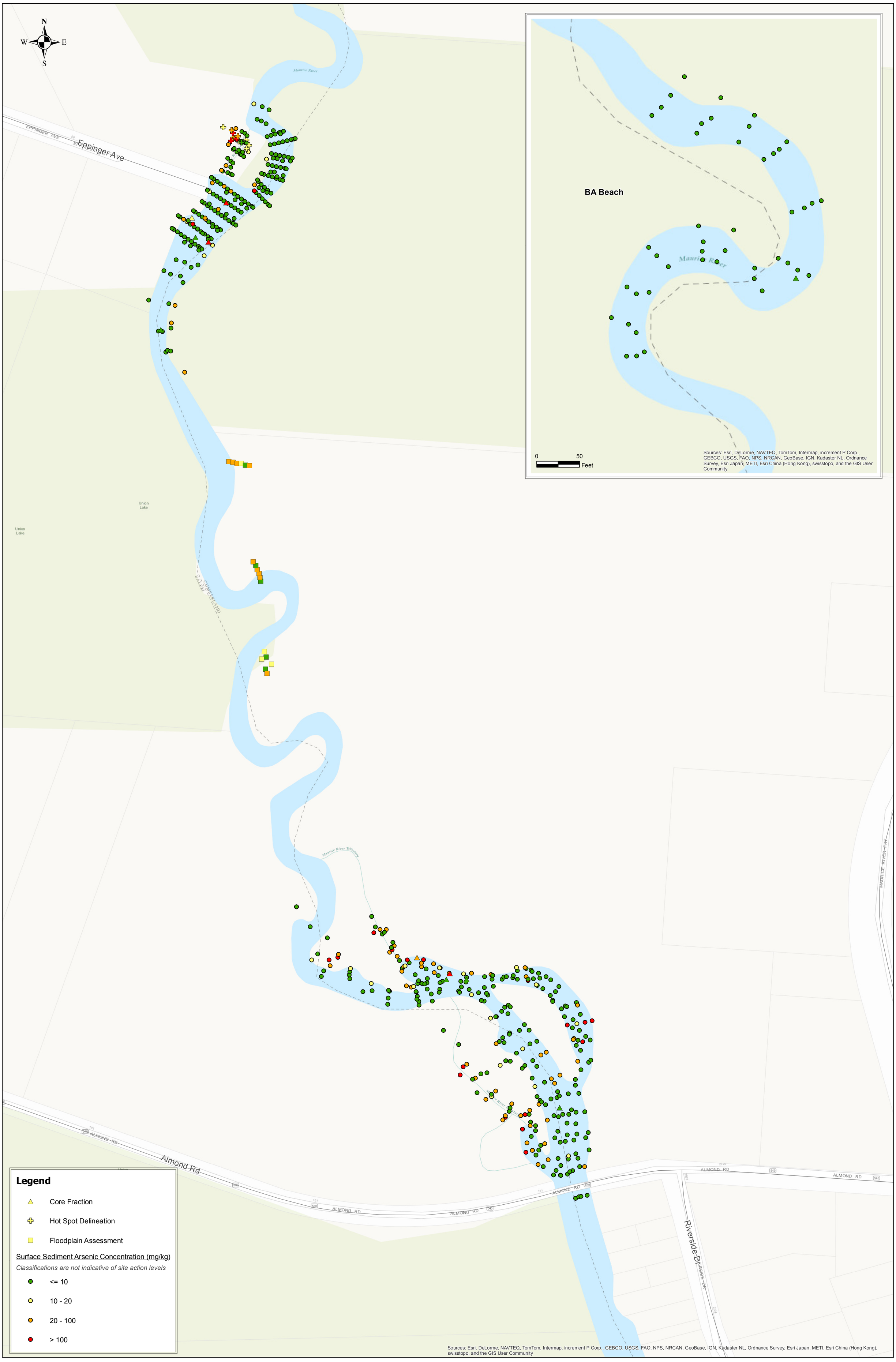
Figure 8
Sediment Arsenic Loading Areas
Year 1, Year 2 and Year 3
Maurice River Investigation
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \Y3R_Report2015\185_Y3R2015_f8_Y1Y2Y3_Sediment_Arsenic_LoadingAreas_f8.mxd



Base map created using ERRI World Topo Map, sample location GPS survey data and sampling result data from 2012, 2013 and 2014.

Map Creation Date: 16 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site\Y3R_Report_2015\185_Y3R2015_f8A_Y1Y2Y3_SAloading_BeachAreas_Dsize_f8A.mxd

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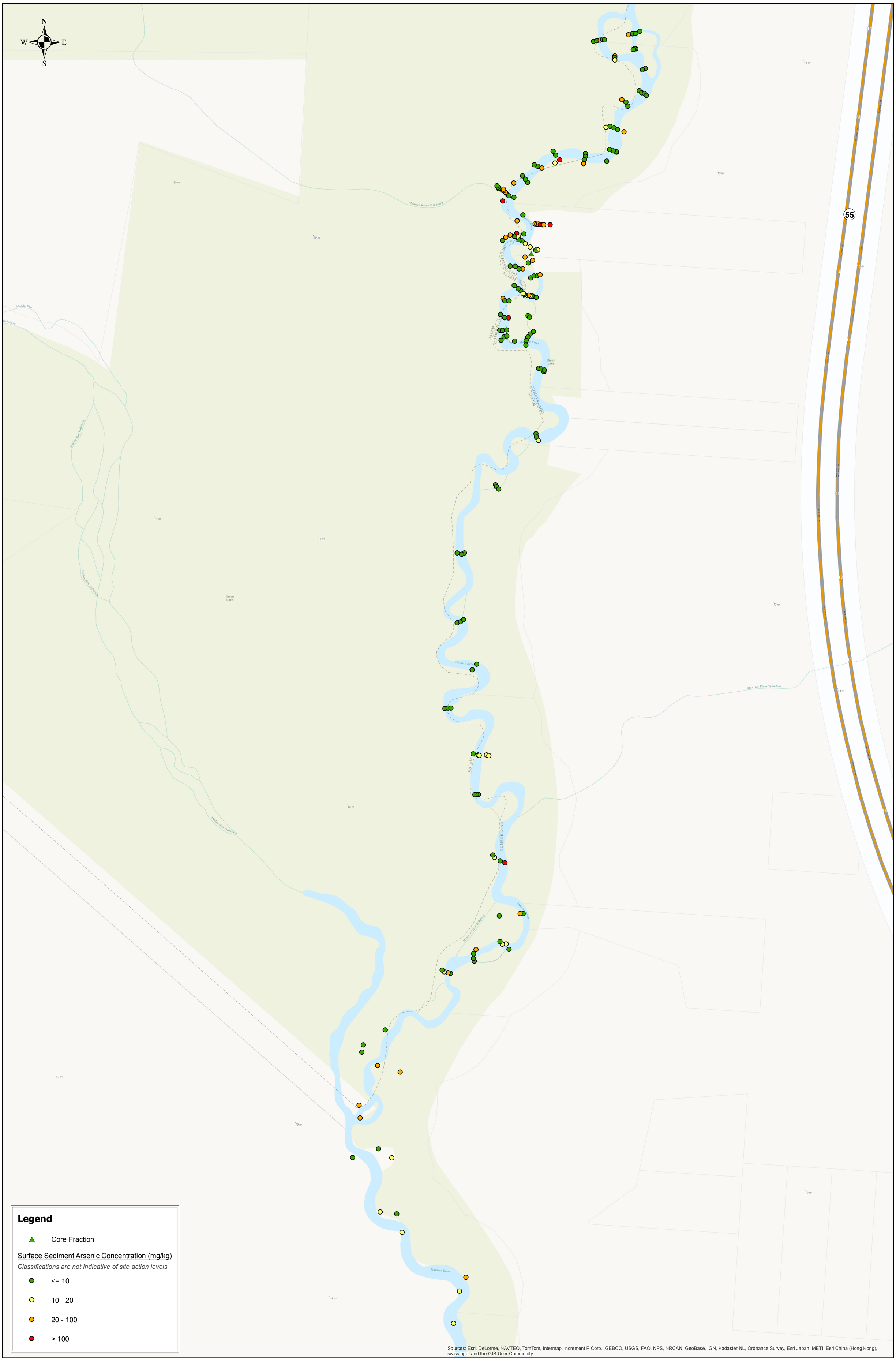
Figure 8A
Sediment Arsenic Loading - Beach Areas
Year 1, Year 2 and Year 3
Maurice River Investigation
Vineland, New Jersey



Base map created using ERRI World Topo Map, sample location GPS survey data and sampling result data from 2012, 2013 and 2014.

Map Creation Date: 16 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

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MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site\Y3R_Report_2015\185_Y3R2015_f8B_Y2Y3_SAloading_UtilityAccessAreas_Dsize_f8B.mxd

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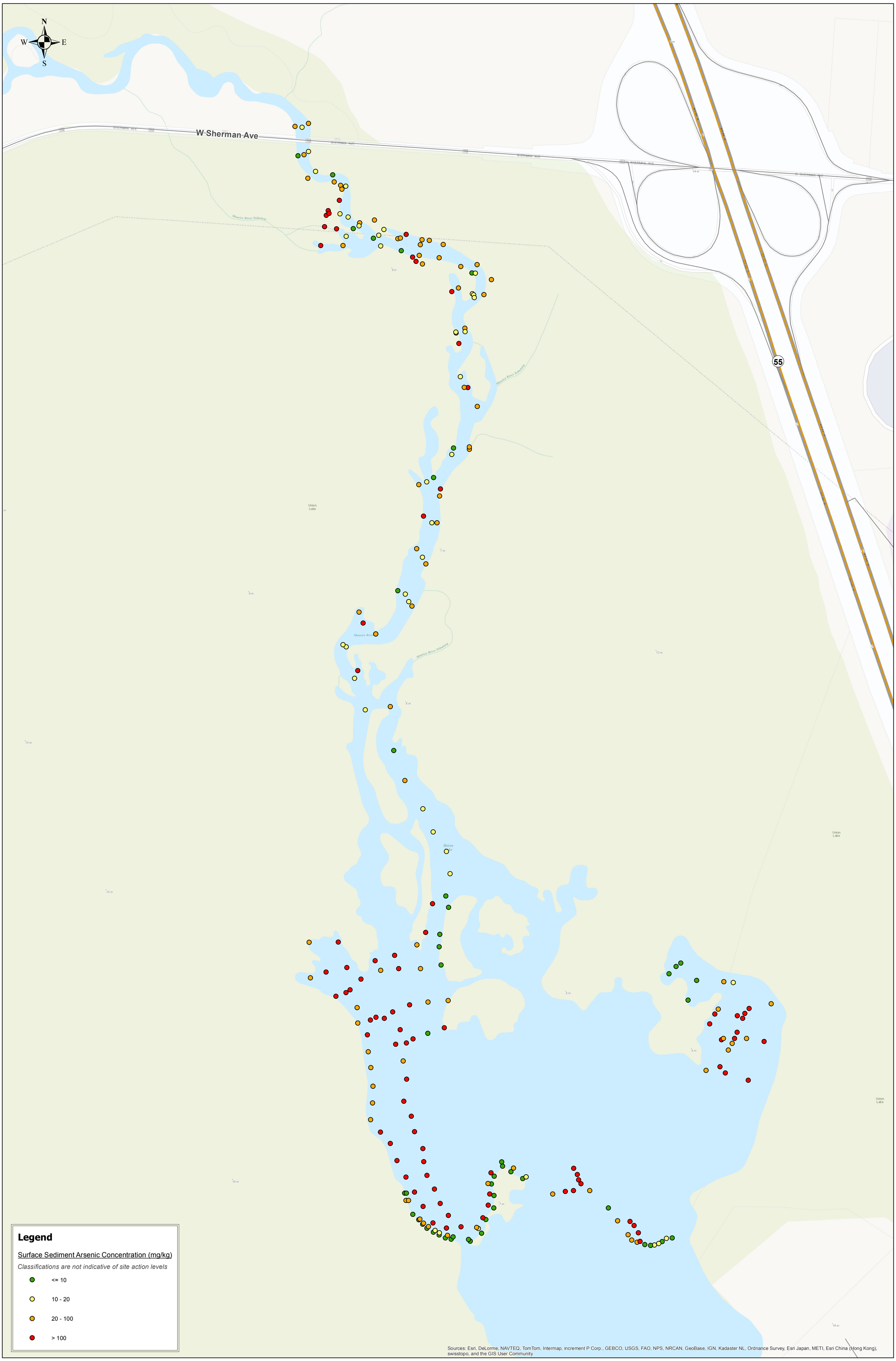
Figure 8B
Sediment Arsenic Loading - Utility Access Areas
Year 2 and Year 3
Maurice River Investigation
Vineland, New Jersey



Base map created using ERRI World Topo Map, sample location GPS survey data and sampling result data from 2013.

Map Creation Date: 16 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 240 480 Feet

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site\Y3R_Report_2015\185_Y3R2015_f8C_Y2Y3_SAloading_UnionLakeArea_Dsize_f8C.mxd

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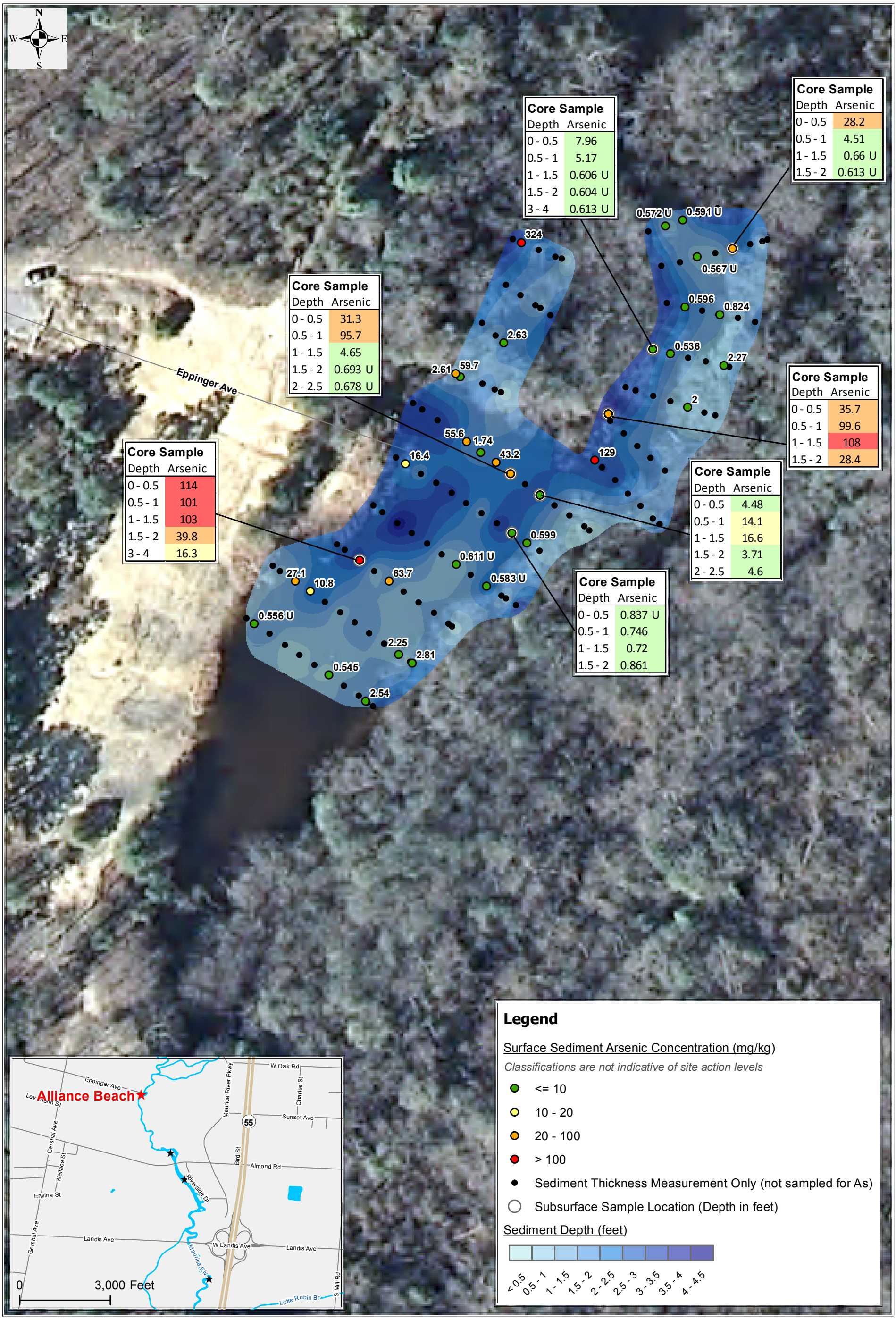
Figure 8C
Sediment Arsenic Loading - Union Lake Area
Year 2 and Year 3
Maurice River Investigation
Vineland, New Jersey



Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2012

Map Creation Date: 24 September 2013

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 50 100
Feet

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Figure 9A
Sediment Arsenic Loading - Alliance Beach
Maurice River Investigation
Year 1
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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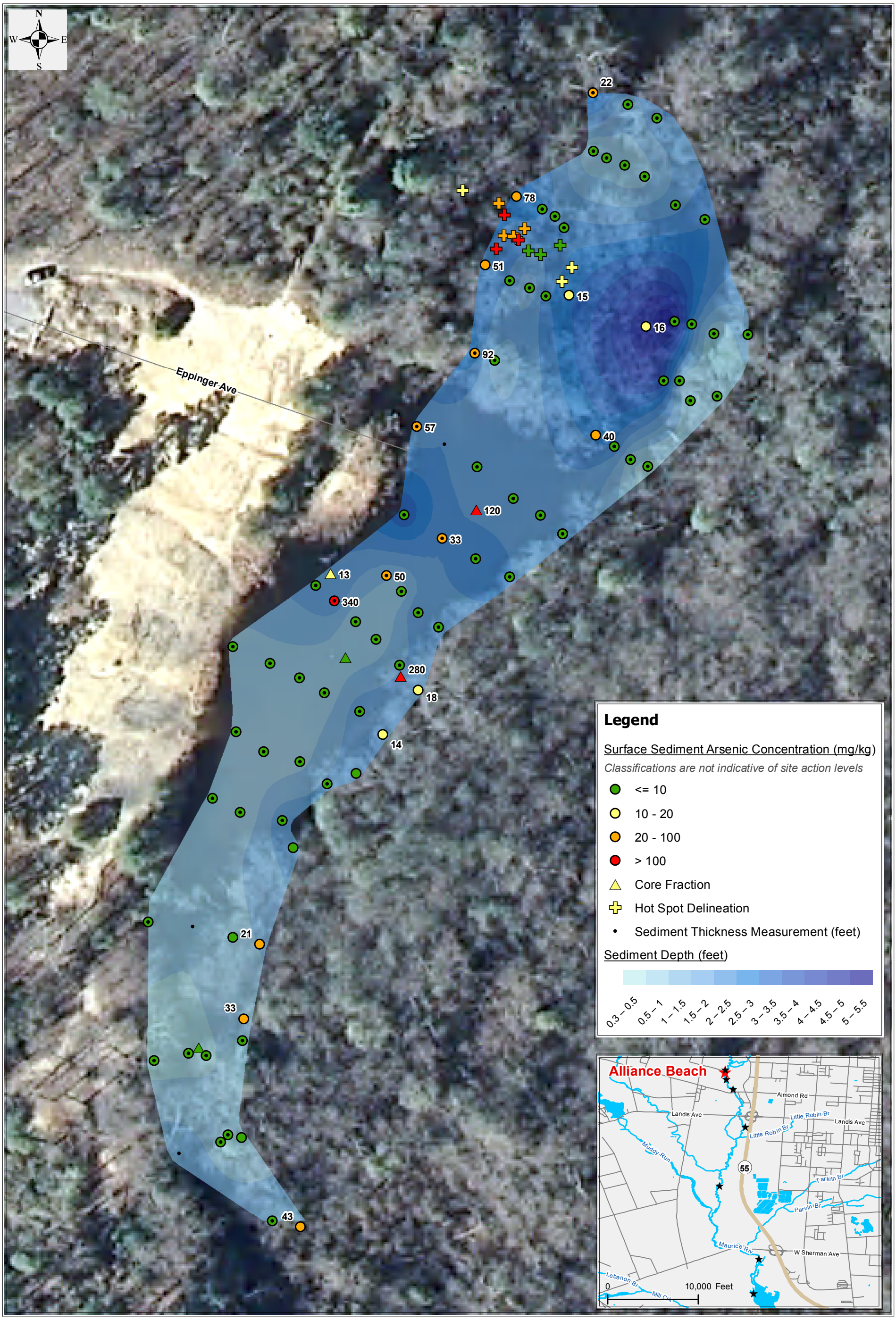

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sample location GPS survey data and sampling result data from 2014

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 50 100
Feet

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Figure 9B
Sediment Arsenic Loading - Alliance Beach
Maurice River Investigation
Year 3
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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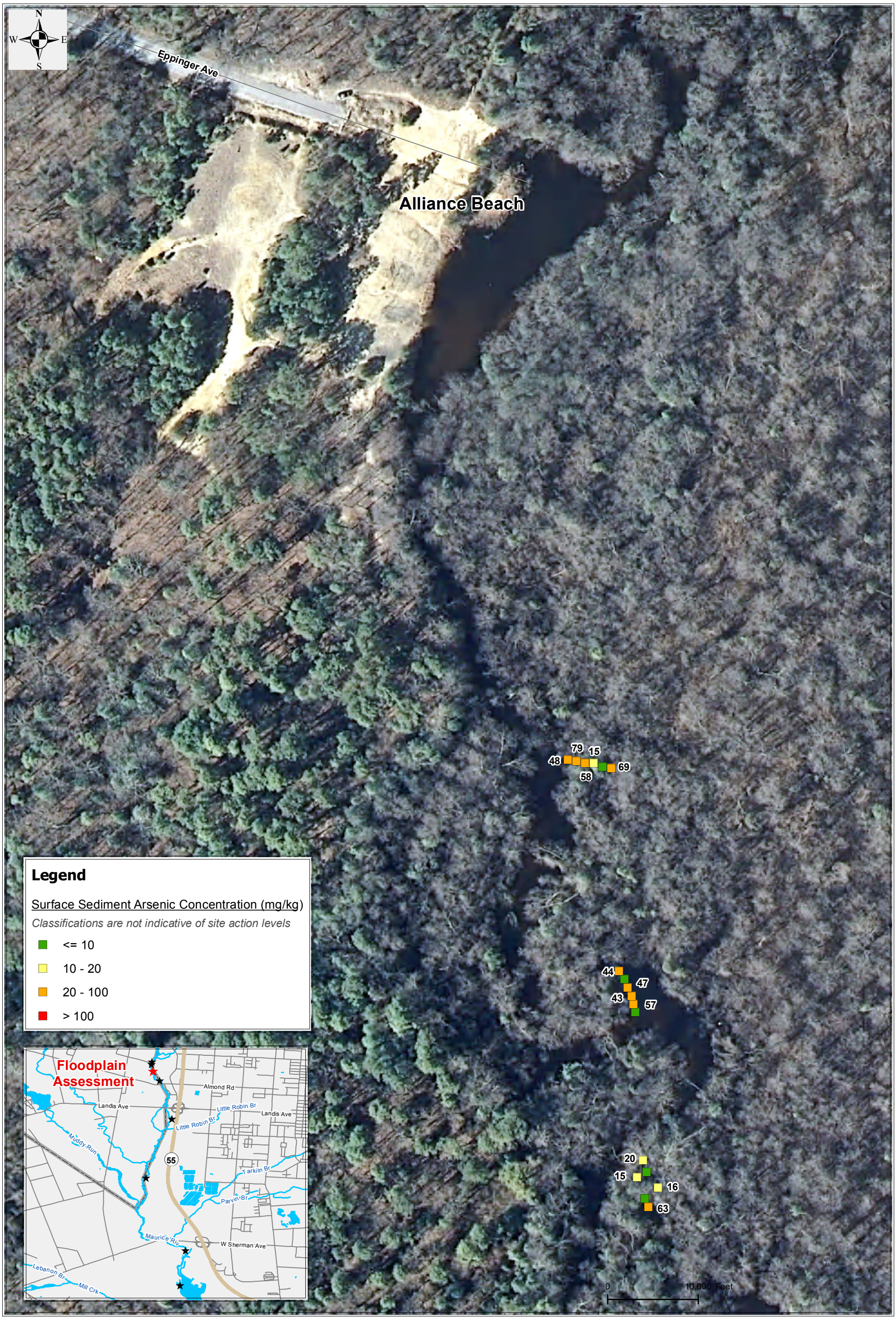

Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2014.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 100 200 Feet

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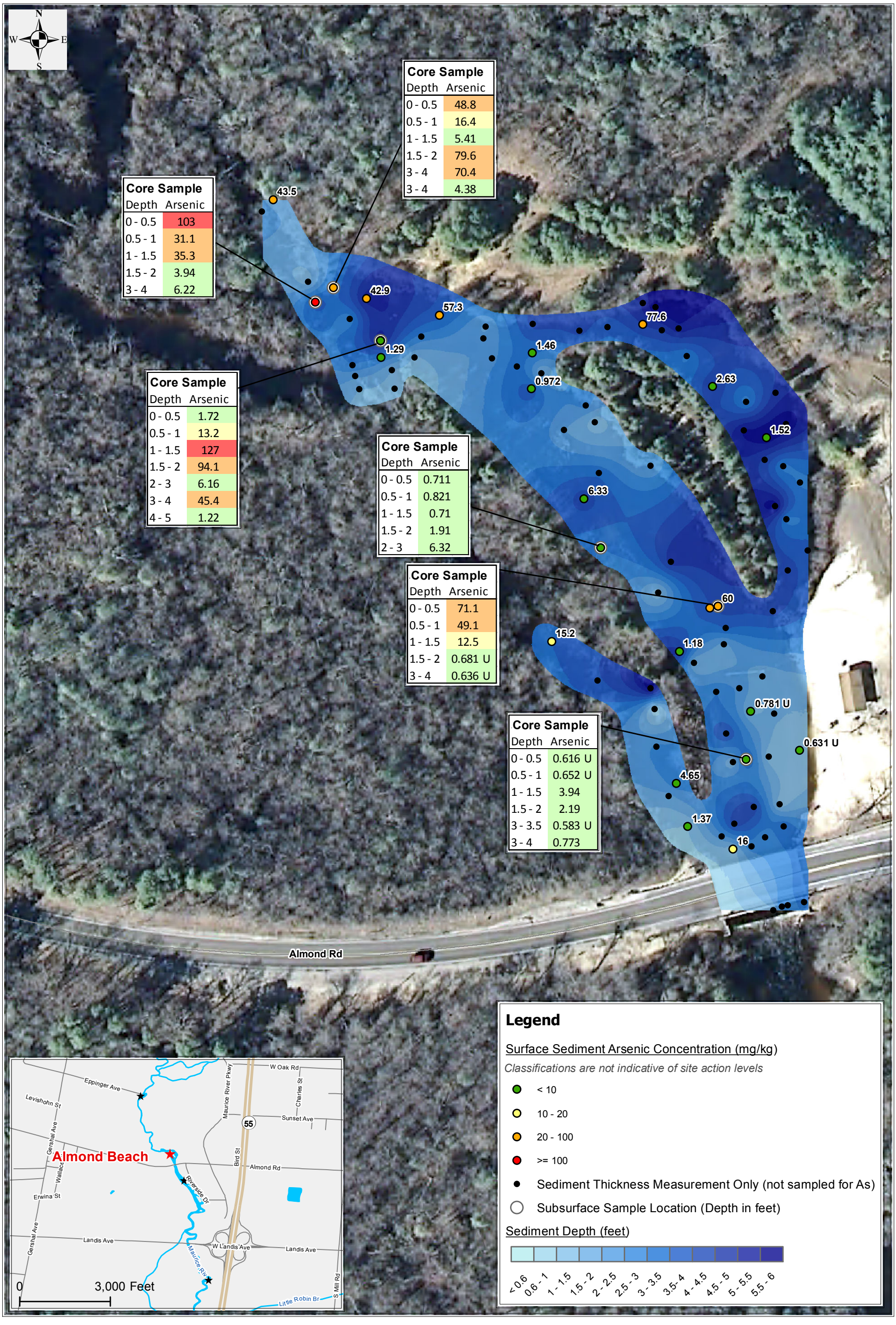
Figure 10
Sediment Arsenic Loading - Floodplain Assessment
Maurice River Investigation
Year 3
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \Y3R_Report_2015\185_Y3R2015_f10_Y3_SALoading_Floodplain_Assessment_f10.mxd



Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2012.

Map Creation Date: 24 September 2013

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 80 160 Feet

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Figure 11A
Sediment Arsenic Loading - Almond Beach
Maurice River Investigation
Year 1
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
\Y3R_Report_2015\185_Y3R2015_f11A_Y1_SALoading_Area2_AlmondBeach_f11A

Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2013.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 80 160
Feet

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Figure 11B
Sediment Arsenic Loading - Almond Beach
Maurice River Investigation
Year 2
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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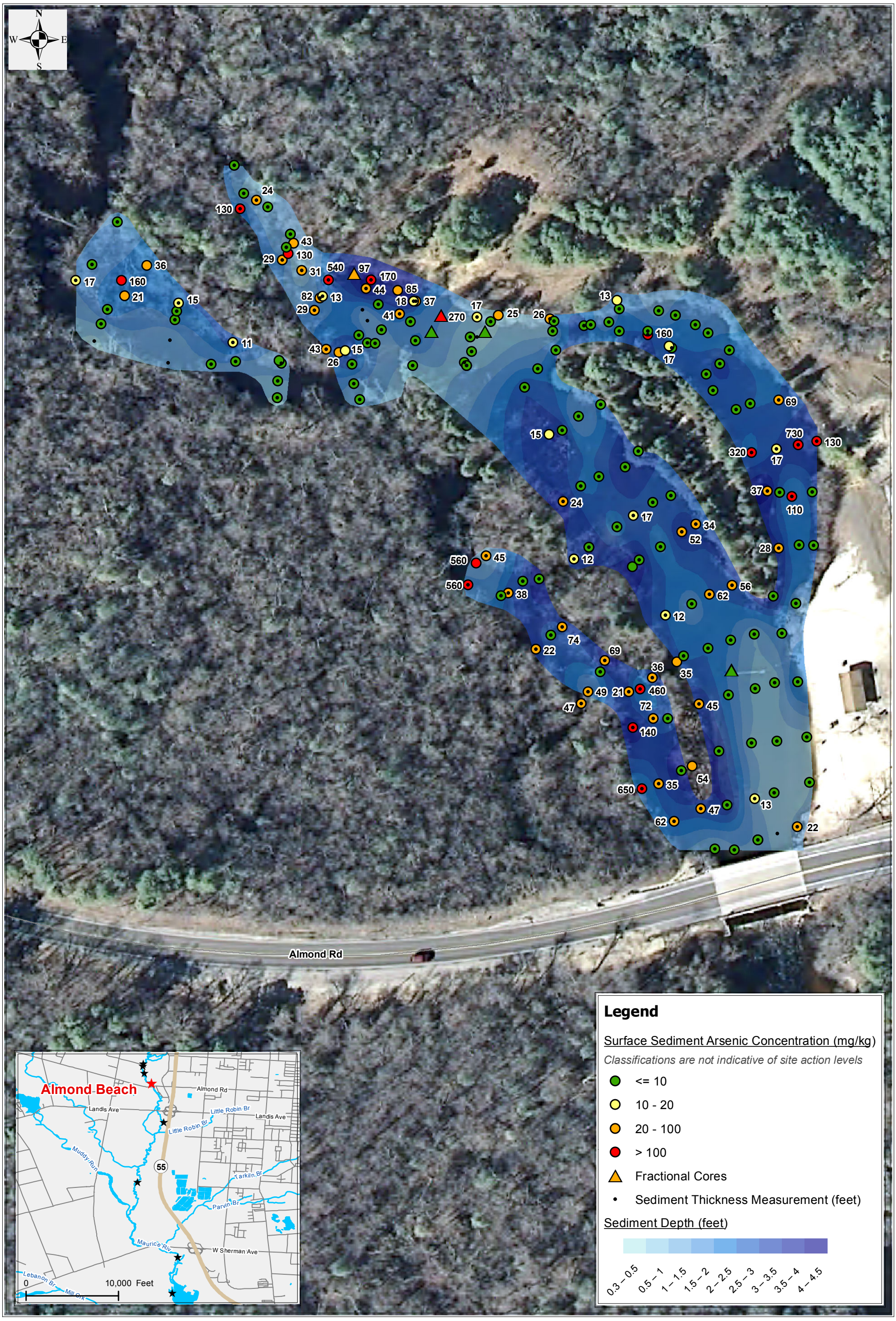

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sample location GPS survey data and sampling result data from 2014.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 80 160
Feet

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Figure 11C
Sediment Arsenic Loading - Almond Beach
Maurice River Investigation
Year 3
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2012.

Map Creation Date: 24 September 2013

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 60 120
Feet

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Figure 12
Sediment Arsenic Loading
Below Almond Beach Spillway
Maurice River Investigation
Year 1
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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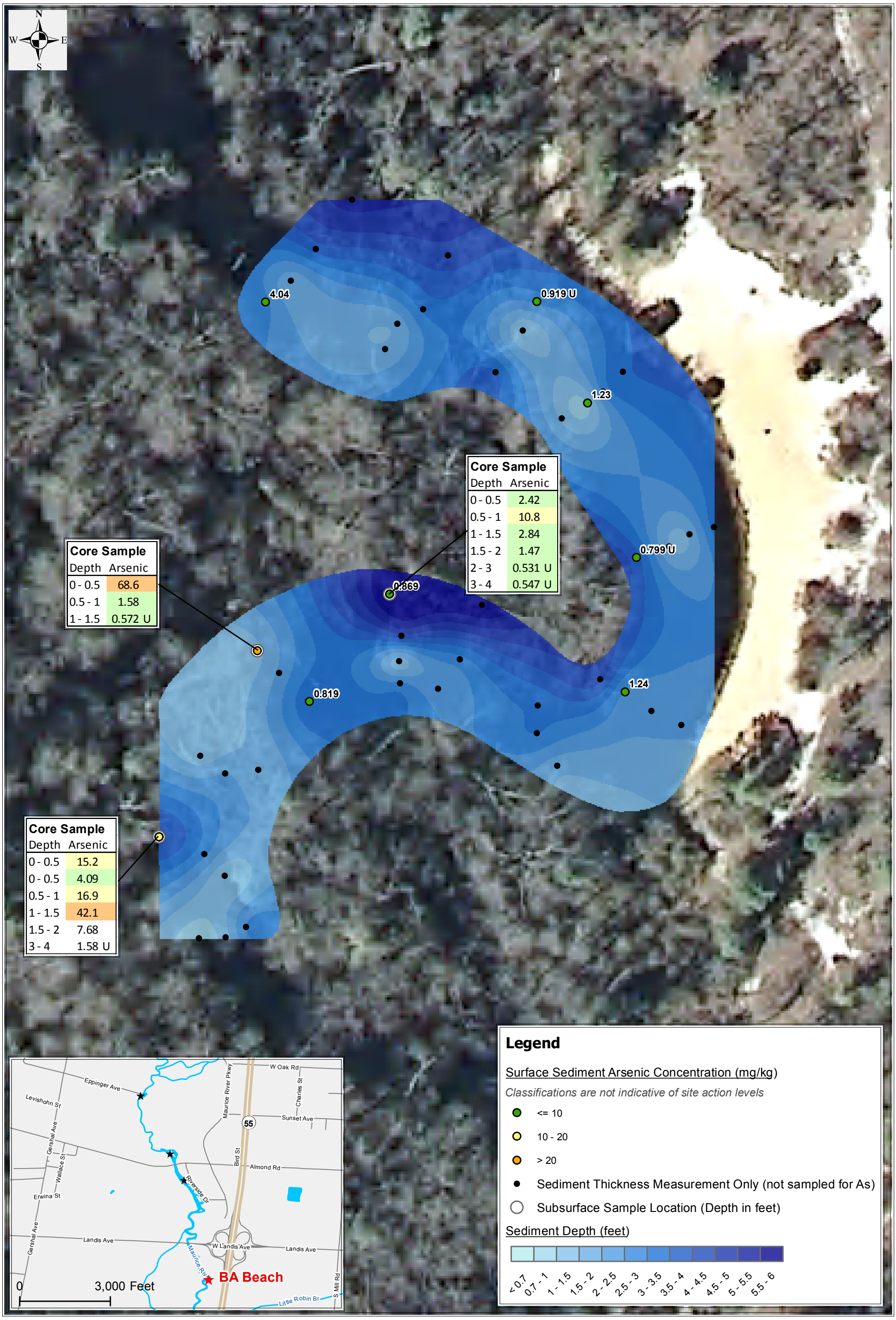

Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2012.

Map Creation Date: 24 September 2013

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 40 80
Feet

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Figure 13
Sediment Arsenic Loading - BA Beach
Maurice River Investigation
Year 1
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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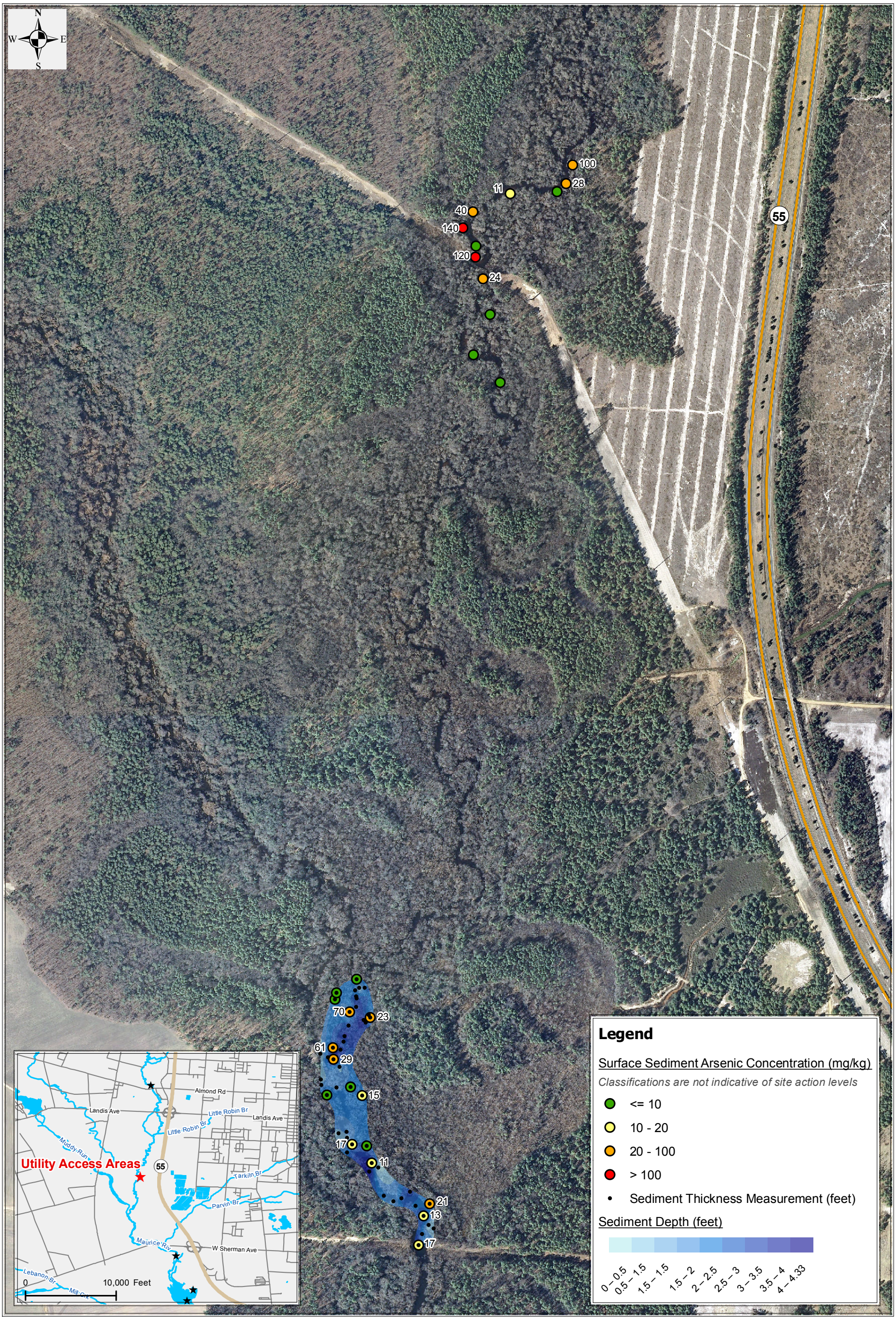

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sample location GPS survey data and sampling result data from 2014

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 560 1,120
Feet

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Figure 14A
Sediment Arsenic Loading - Utility Access Area
Maurice River Investigation
Year 2
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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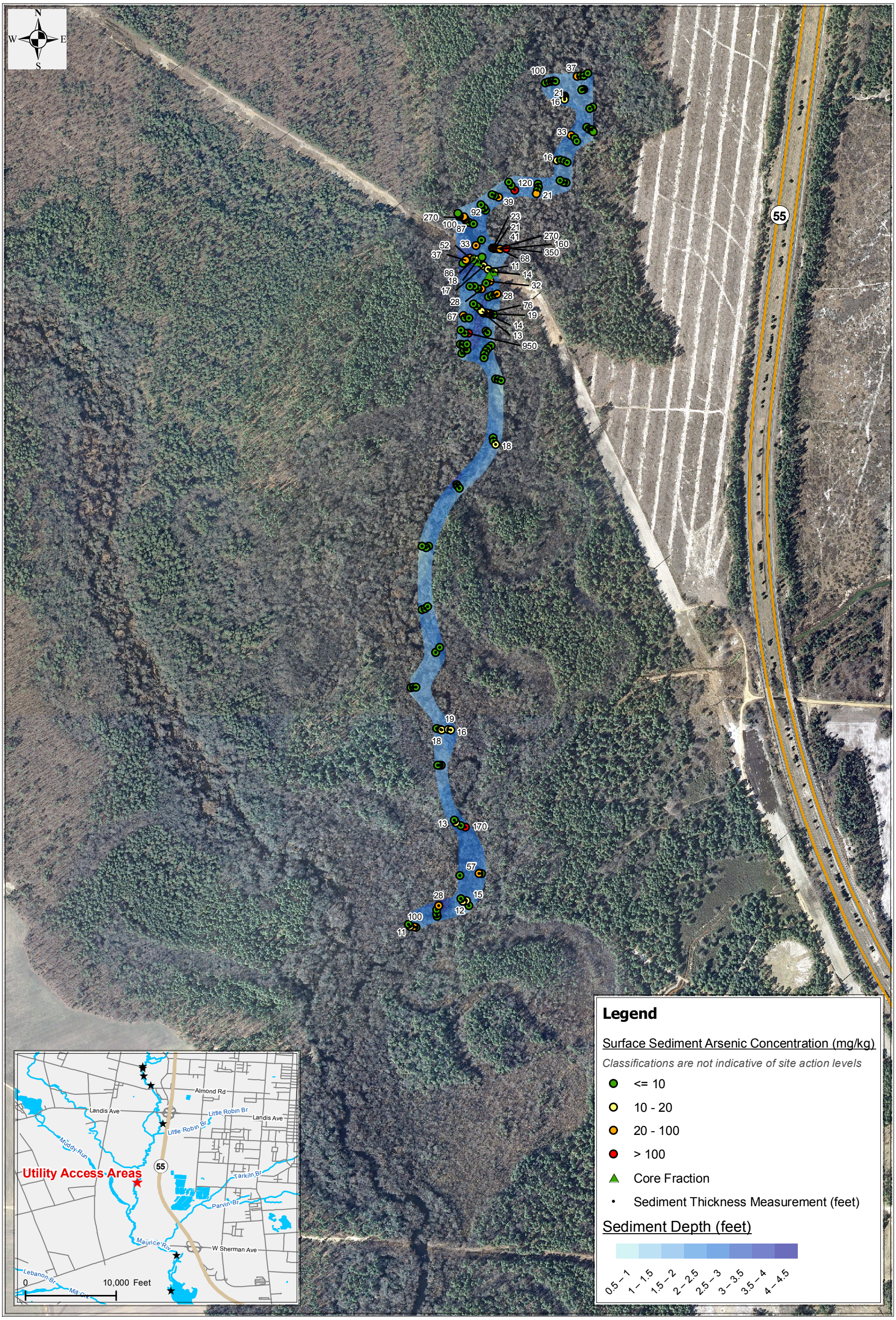

Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2014.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 560 1,120
Feet

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Figure 14B
Sediment Arsenic Loading - Utility Access Area
Maurice River Investigation
Year 3
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site
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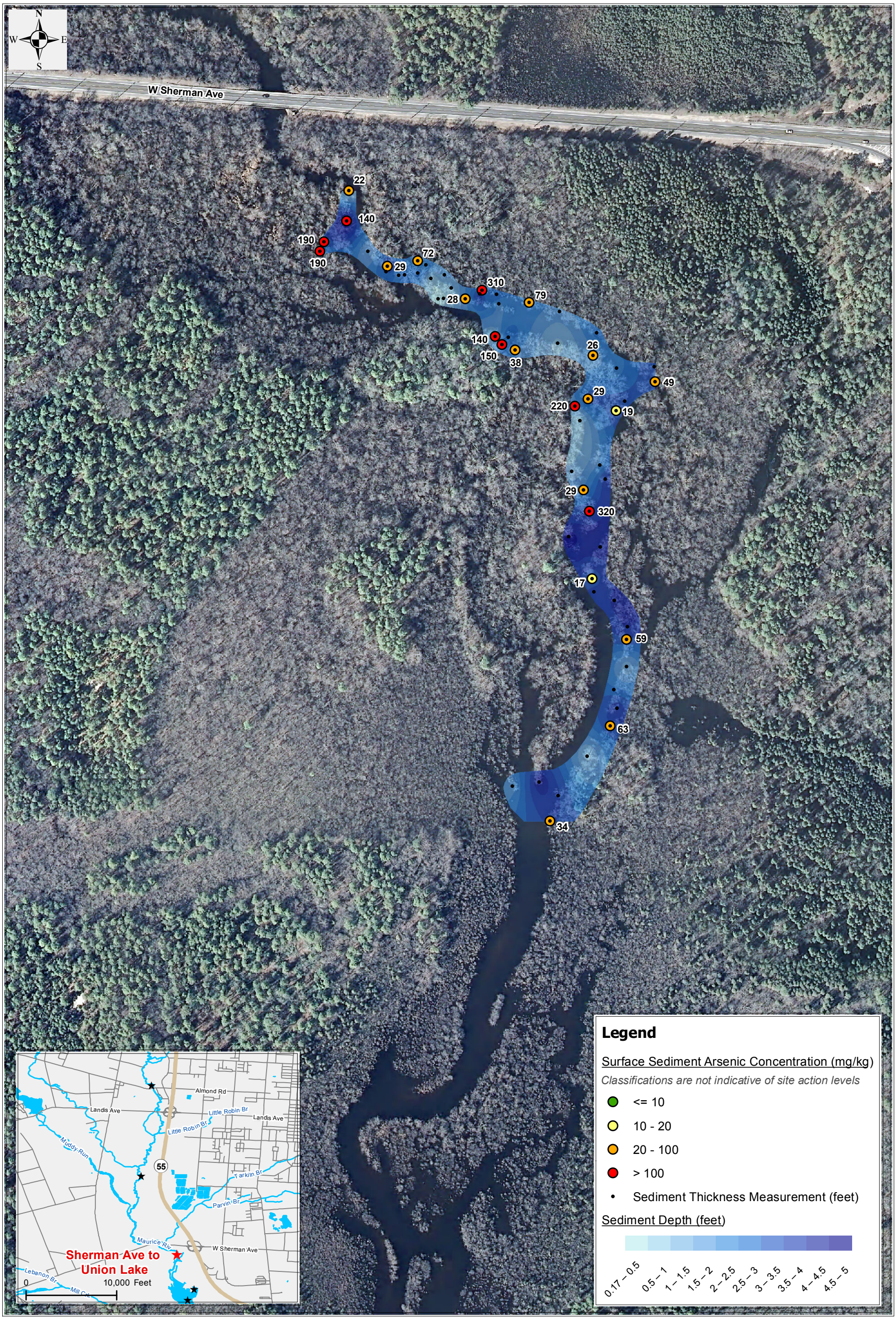

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sample location GPS survey data and sampling result data from 2013.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 250 500 Feet

Data: g:\arcviewprojects\SERAS01\00-185
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_ShermanAve_UnionLake_f15A.mxd

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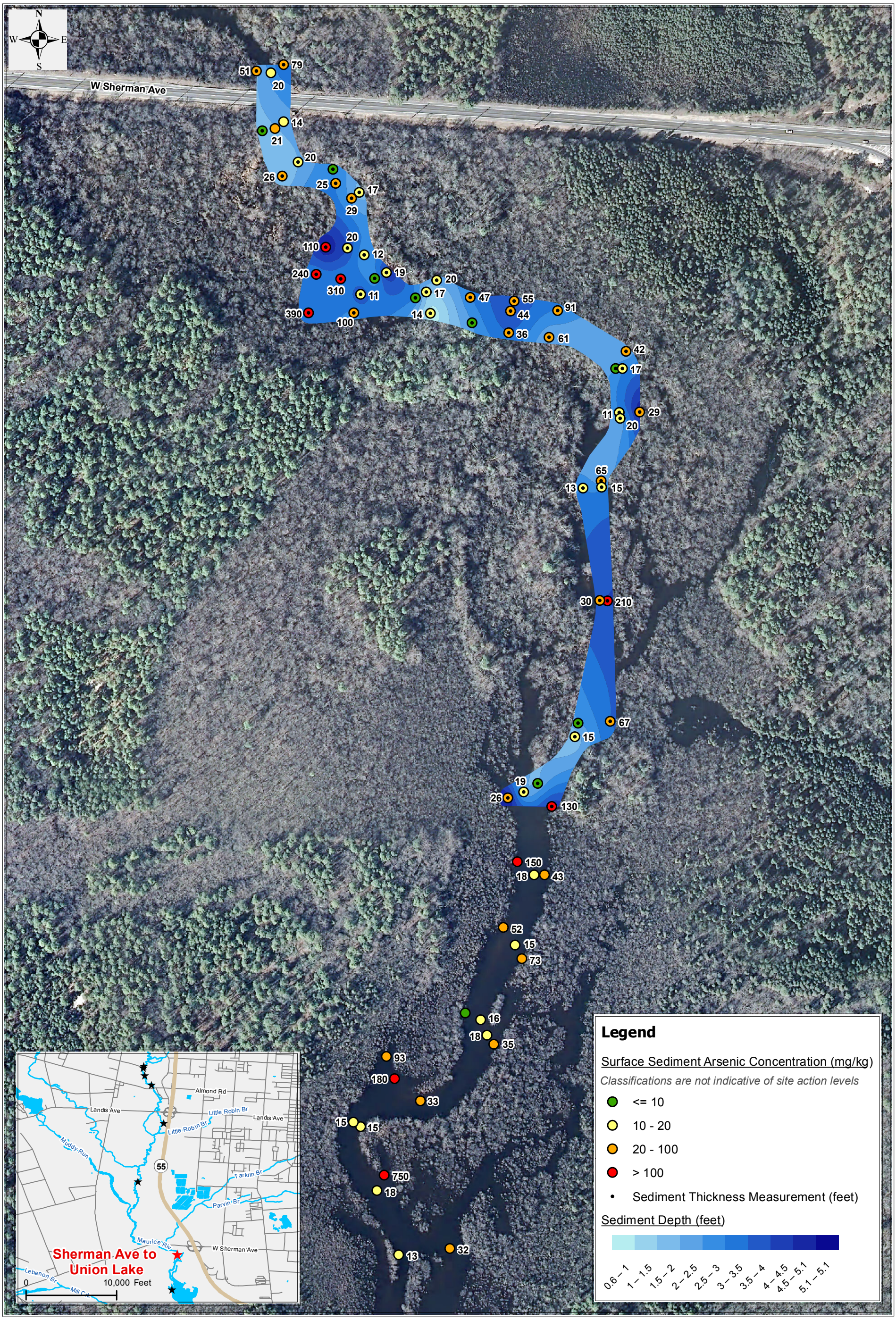
Figure 15A
Sediment Arsenic Loading - Sherman Ave to Union Lake
Maurice River Investigation
Year 2
Vineland, NJ



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sample location GPS survey data and sampling result data from 2014.

Map Creation Date: 12 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 250 500 Feet

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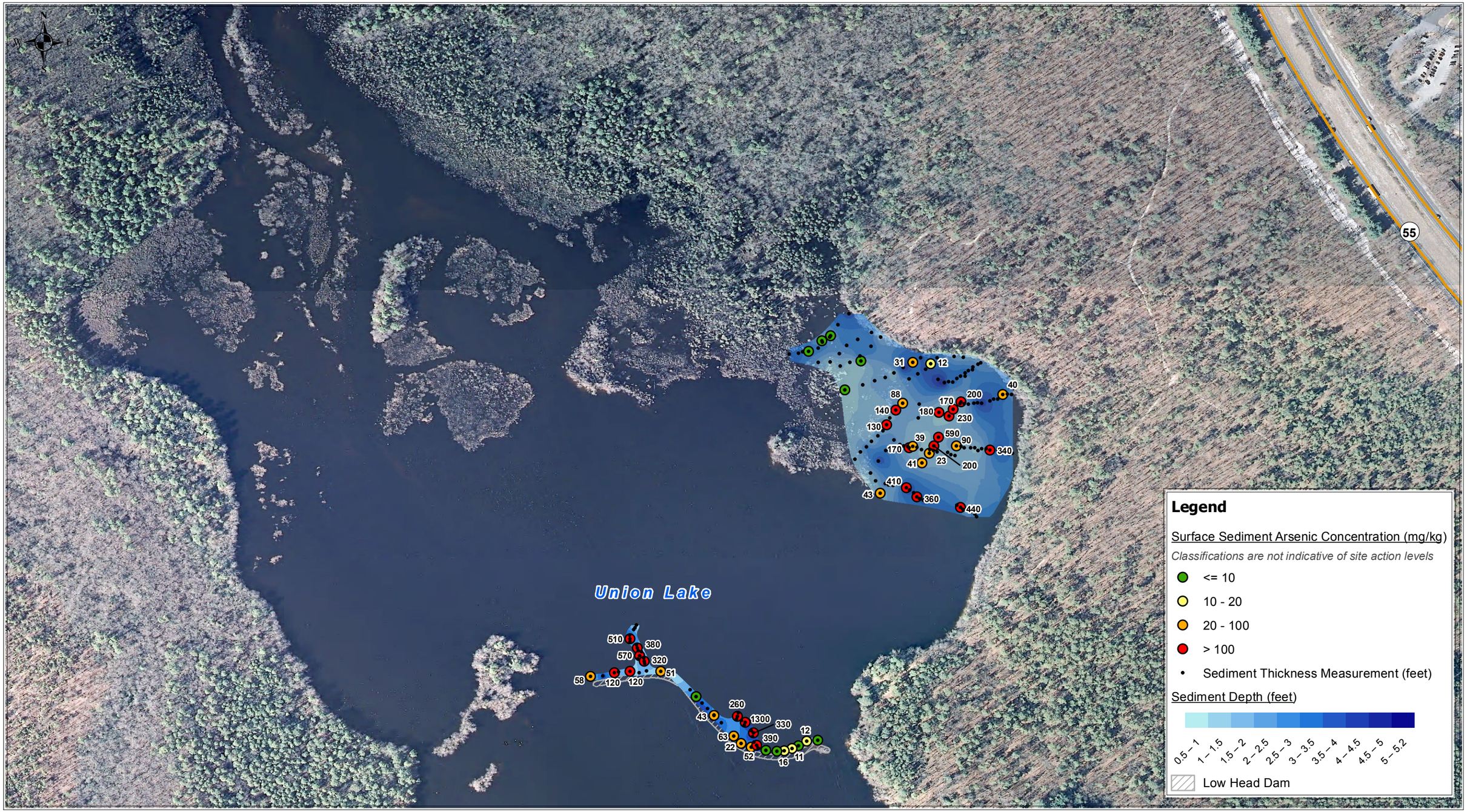
W.A.# 0-185

Figure 15B
Sediment Arsenic Loading - Sherman Ave to Union Lake
Maurice River Investigation
Year 3
Vineland, NJ



Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2013.

Map Creation Date: 16 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

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0 350 700 Feet

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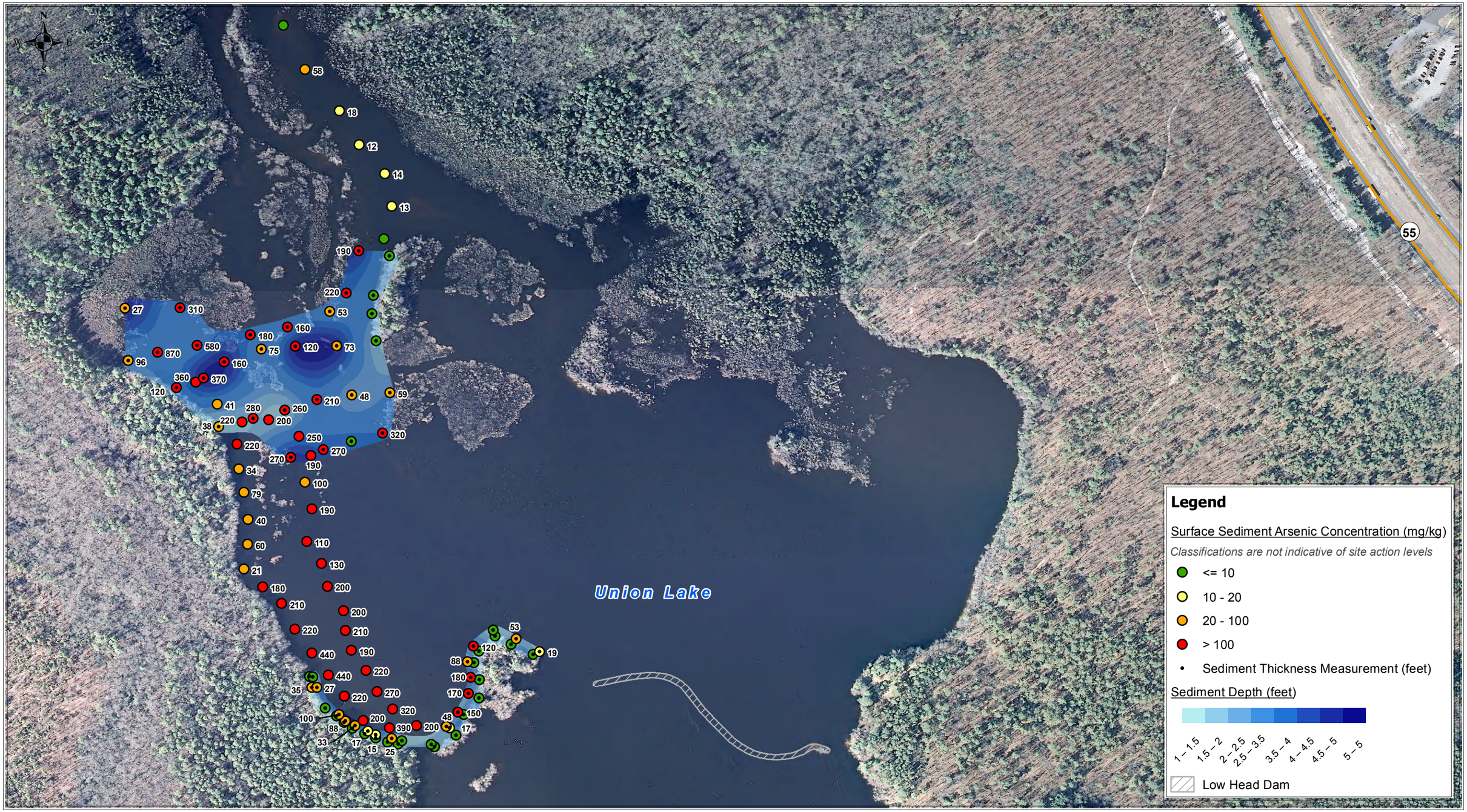
W.A.# 0-185

Figure 16A
Sediment Arsenic Loading -
Northeast Cove and Union Lake Dam
Maurice River Investigation
Year 2
Vineland, NJ



Base map created using 2007 orthoimagry data from NJGIN,
sample location GPS survey data and sampling result data from 2014.

Map Creation Date: 16 August 2015

Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

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MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site\Y3R_Report_2015\185_Y3R2015_f16B_Y3_SALoading_Area9_Northwest_Cove_f16B.mxd

0 350 700 Feet

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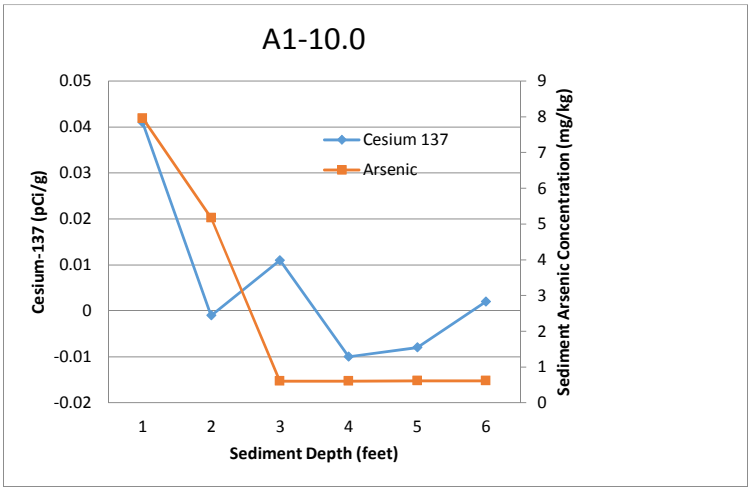
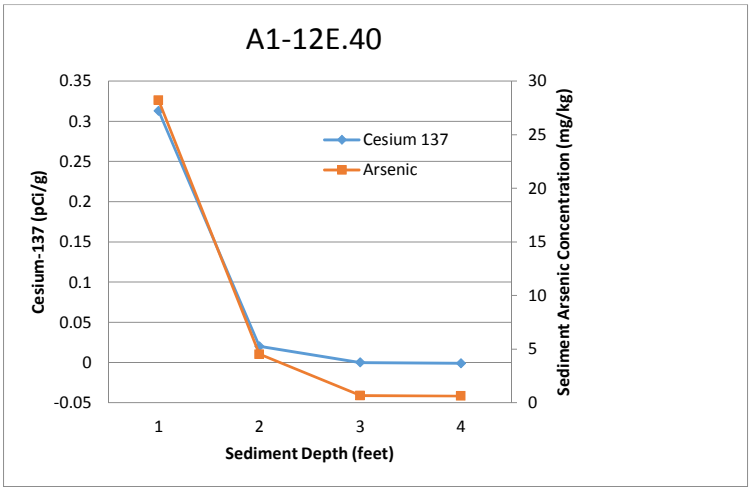
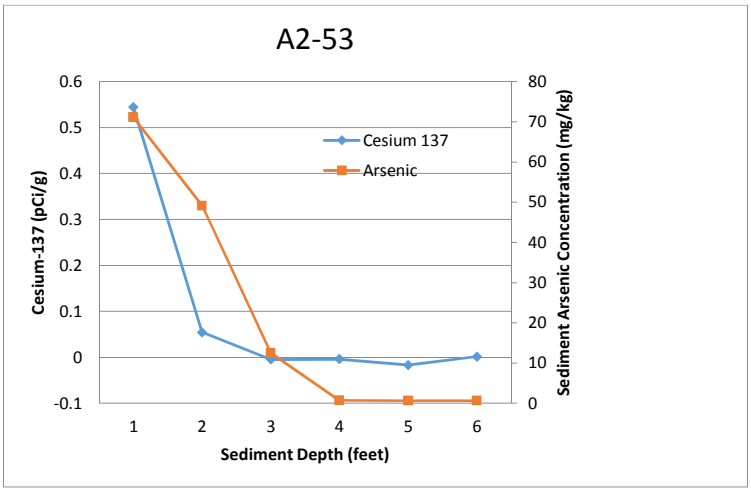
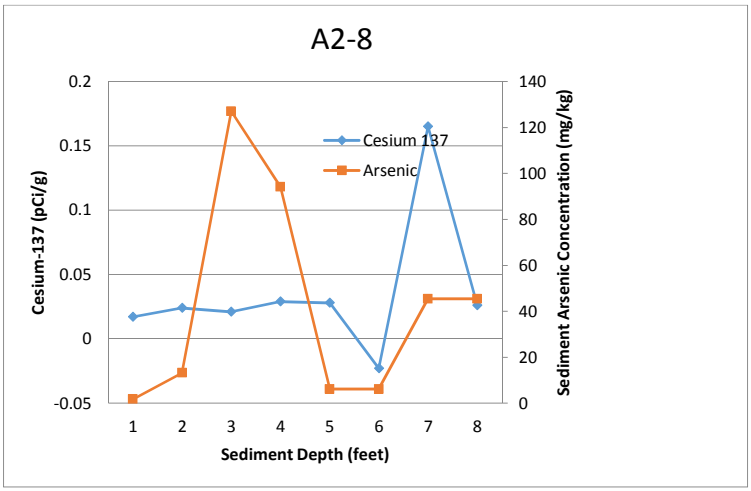
Figure 16B
Sediment Arsenic Loading - Northwest Cove
Maurice River Investigation
Year 3
Vineland, NJ









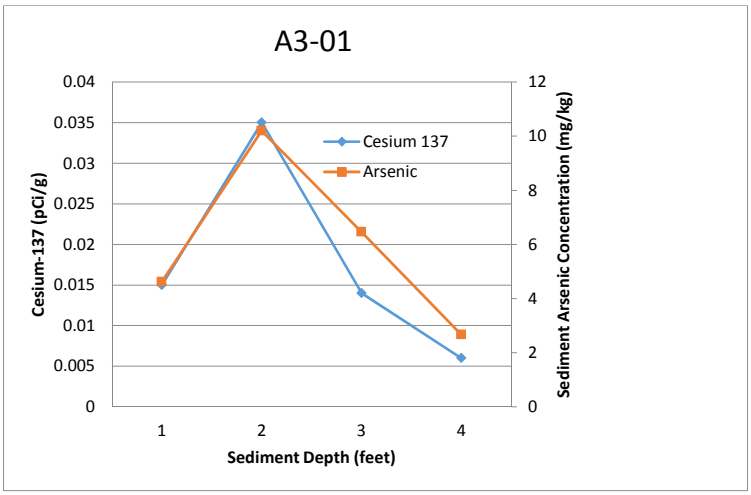
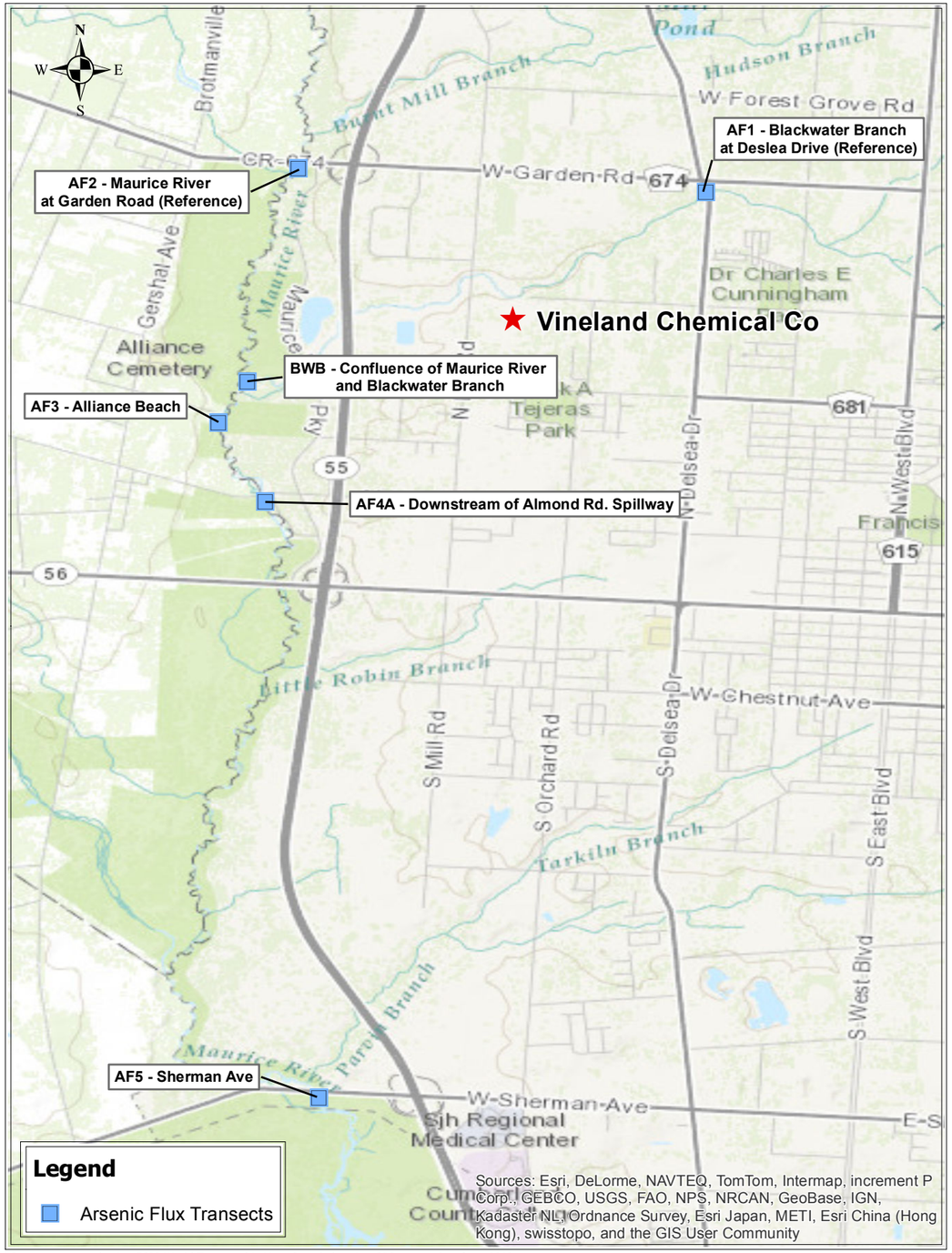


Figure 17
Relationship Between Cesium-137 and Sediment Arsenic Concentrations
Maurice River Investigation
Vineland, NJ



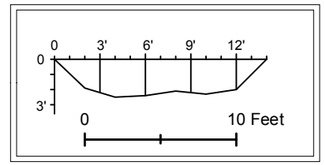
Base map created using ESRI World Topographic Map, Sample location GPS survey data from 2012

Map Creation Date: 13 Octoberr 2015

Coordinate system: GCS North American 1983
Datum: NAD83
Units: Feet

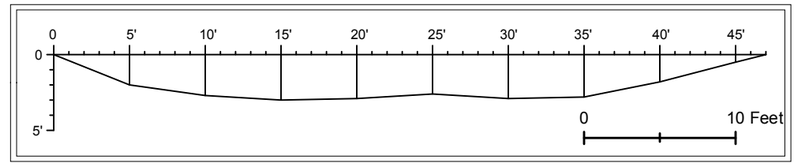
0 4,000 8,000 Feet

AF1 - Blackwater Branch at Deslea Drive (Reference)



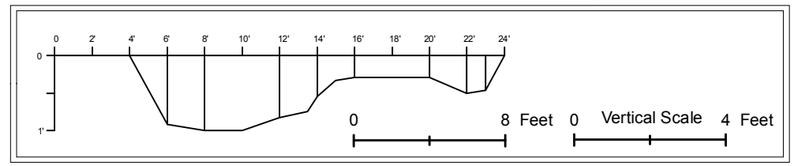
See Figure 19

AF2 - Maurice River at Gaden Road (Reference)



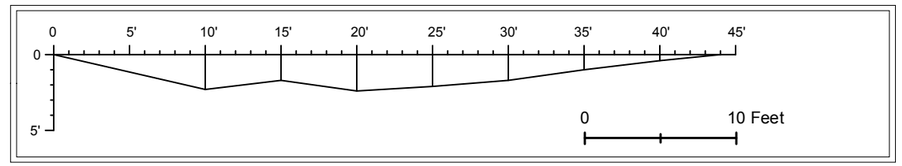
See Figure 20

BWB - Confluence of Maurice River and Blackwater Branch



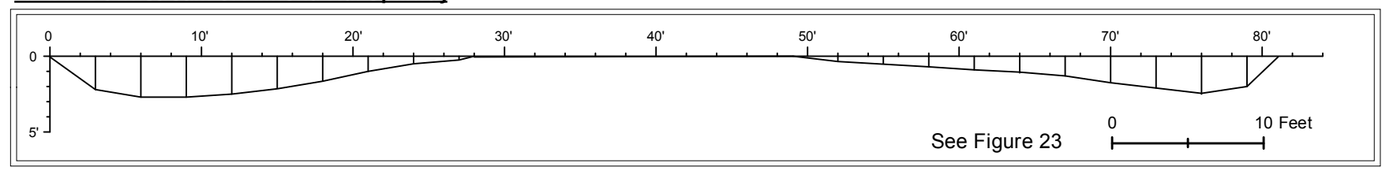
See Figure 21

AF3 - Alliance Beach



See Figure 22

AF4A - Downstream of Almond Rd. Spillway



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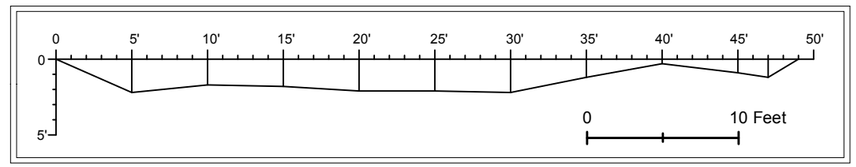
AF5- Sherman Ave



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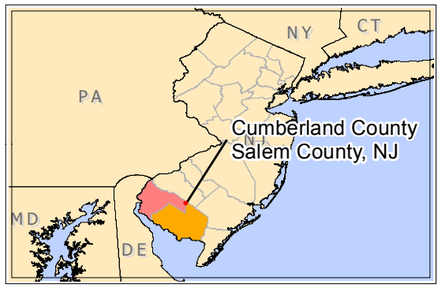

Note:
Comparable Scales Across All Location

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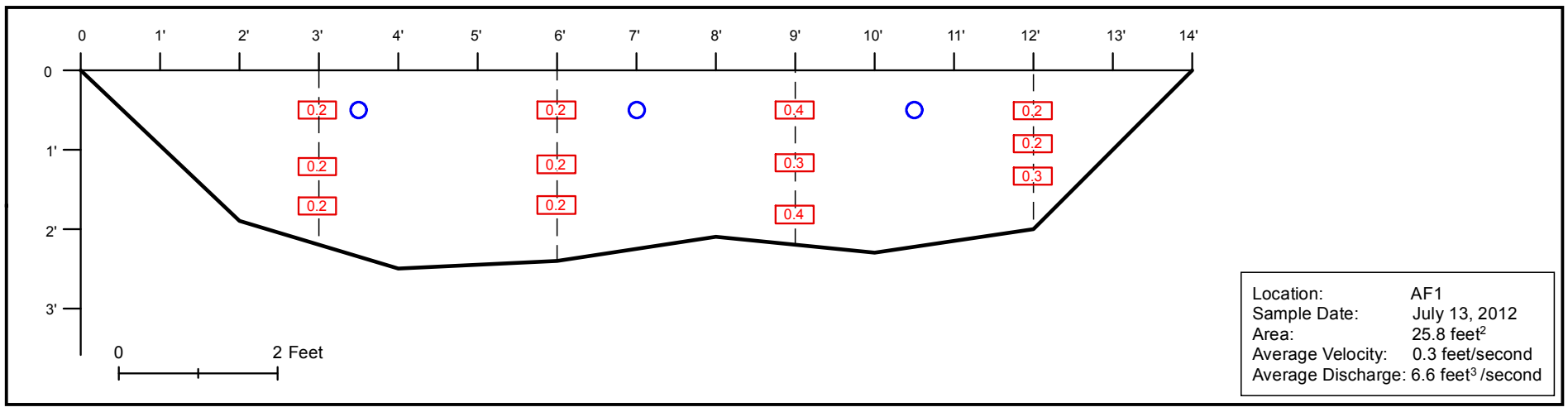
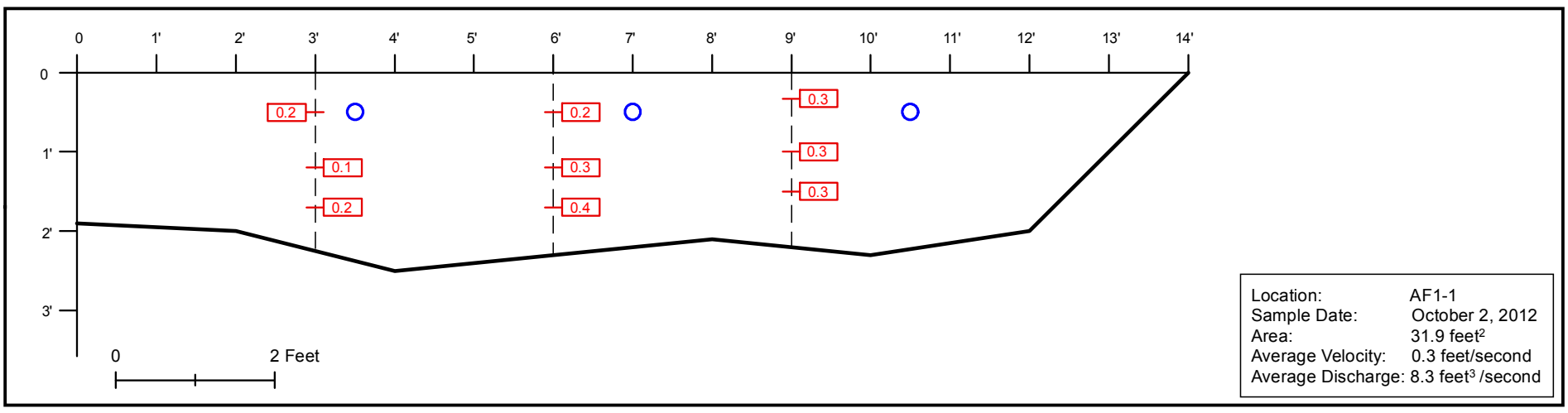
Figure 18
Sample Area and Arsenic Flux Cross Sections
Maurice River Arsenic Flux Investigation
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site\Y3R_Report_2015\185_Y3R2015_f18_Y1Y2Y3_SampleArea_AF_CrossSection_f18

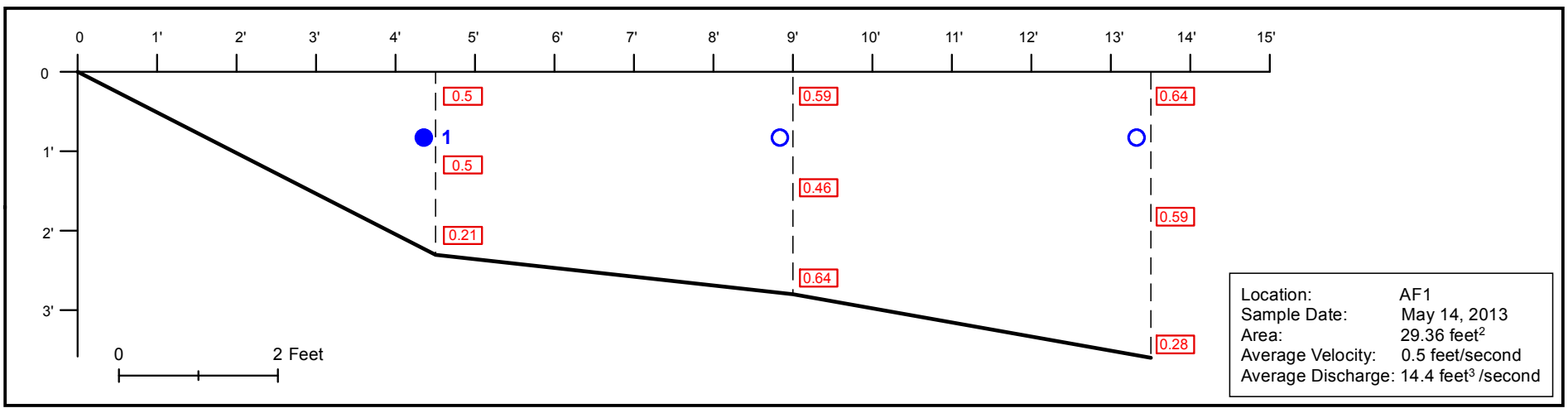
AF1 - Blackwater Branch at Delsea Drive (Reference)
River Bathymetric Measurement
Flow Measurements at Depth
Water Sampling for Total and Dissoved Arsenic



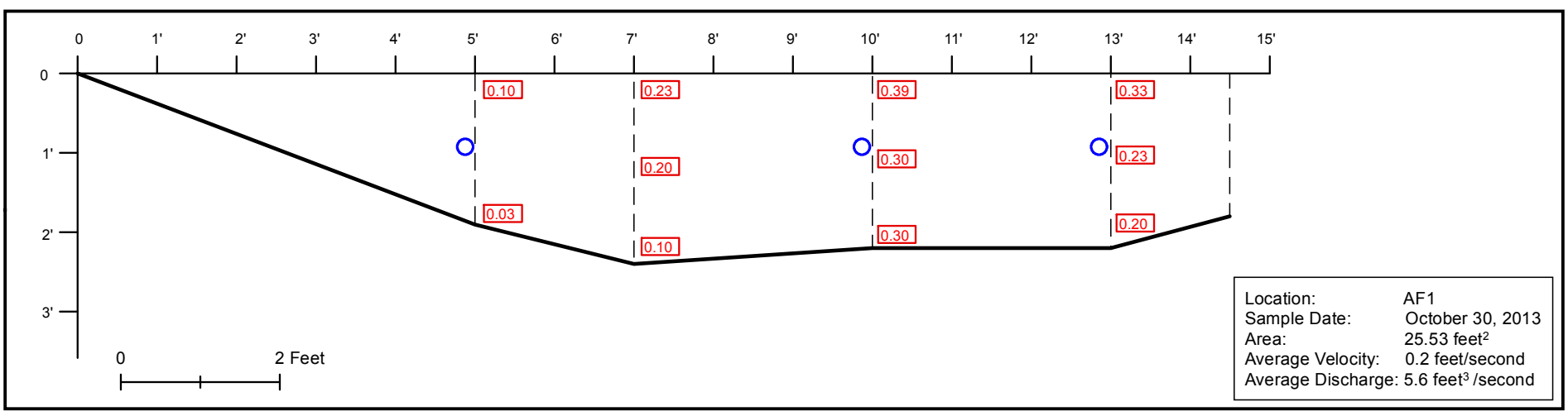
Location: AF1
Sample Date: July 13, 2012
Area: 25.8 feet^2
Average Velocity: 0.3 feet/second
Average Discharge: 6.6 feet^3 /second



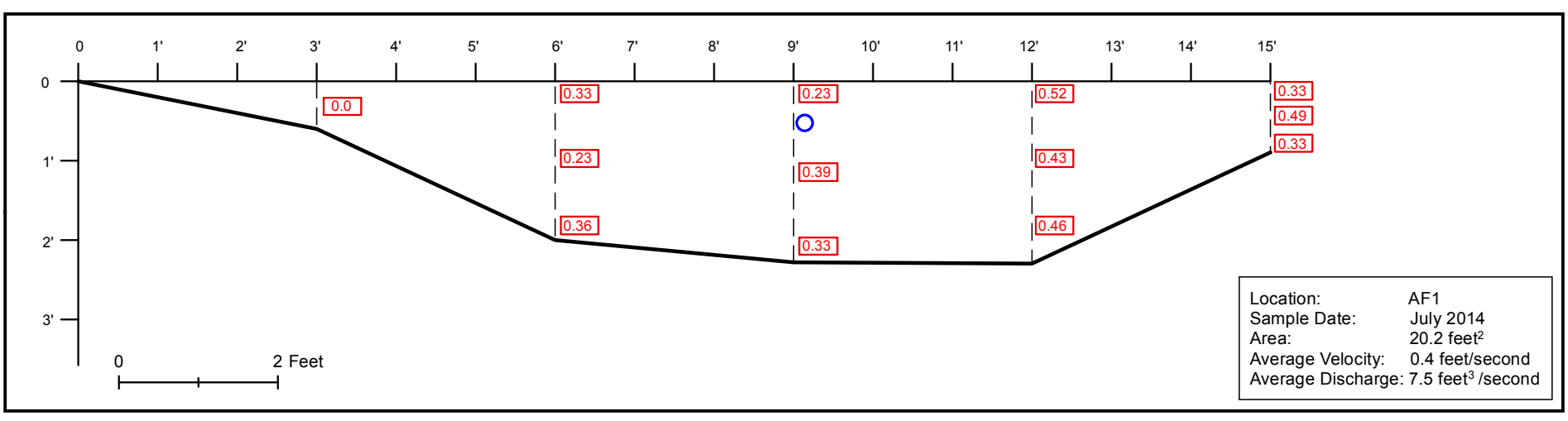
Location: AF1-1
Sample Date: October 2, 2012
Area: 31.9 feet^2
Average Velocity: 0.3 feet/second
Average Discharge: 8.3 feet^3 /second



Location: AF1
Sample Date: May 14, 2013
Area: 29.36 feet^2
Average Velocity: 0.5 feet/second
Average Discharge: 14.4 feet^3 /second



Location: AF1
Sample Date: October 30, 2013
Area: 25.53 feet^2
Average Velocity: 0.2 feet/second
Average Discharge: 5.6 feet^3 /second



Location: AF1
Sample Date: July 2014
Area: 20.2 feet^2
Average Velocity: 0.4 feet/second
Average Discharge: 7.5 feet^3 /second

○ = Non-detect
● = Total Arsenic Concentration in µg/L (ppb)

Map Creation Date: 02 October 2015

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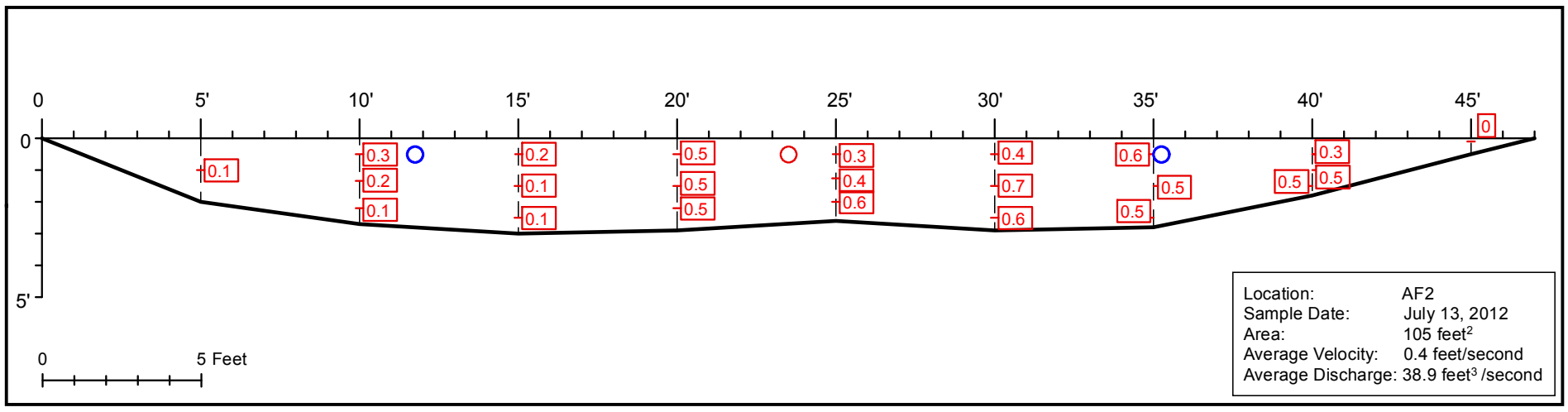
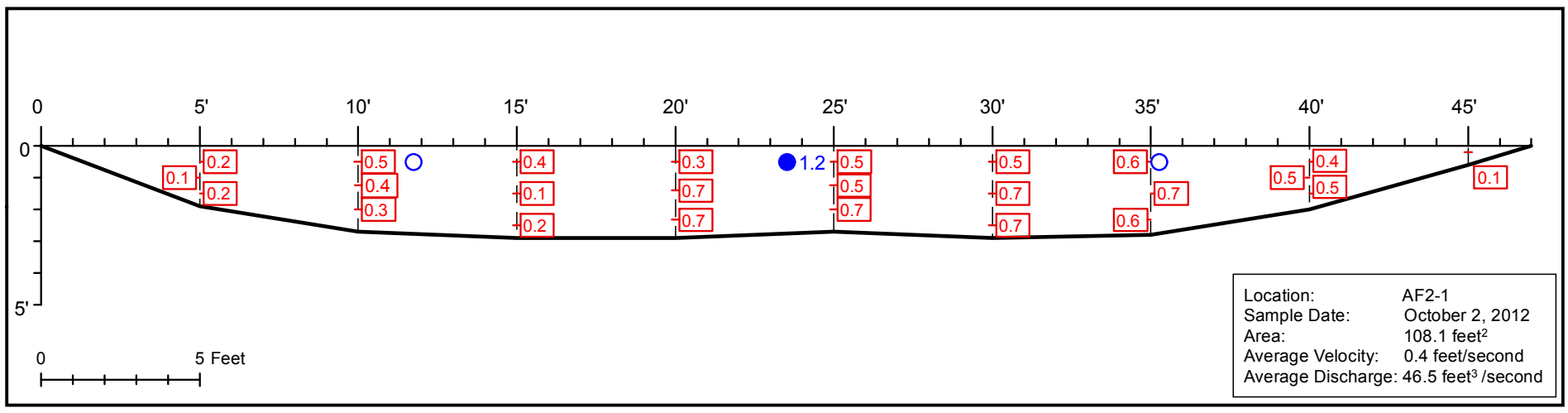
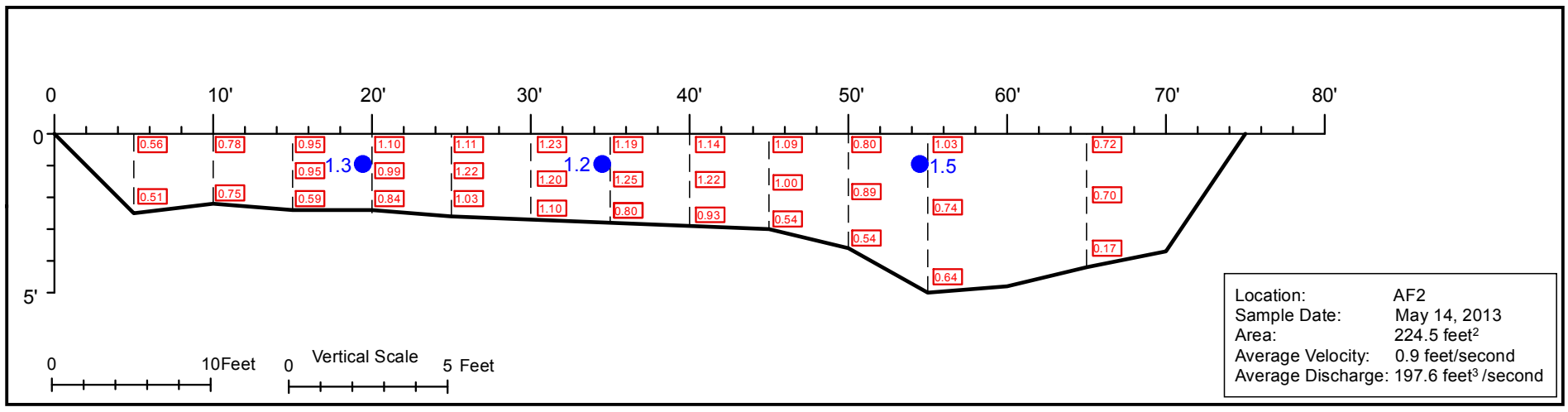
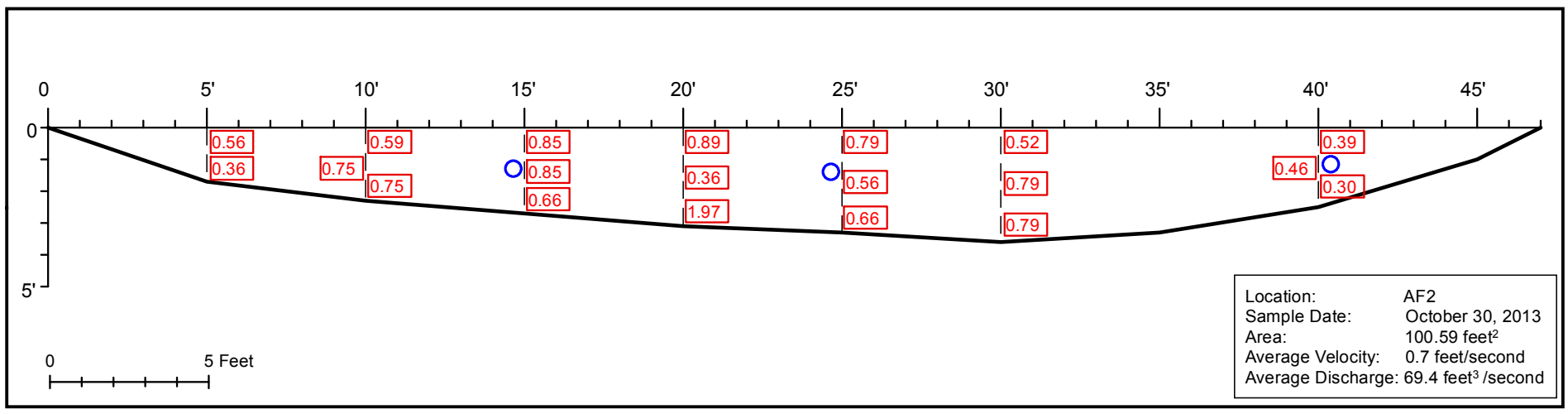
Figure 19
Arsenic Flux Stream Cross Section
Maurice River Investigation
Vineland, NJ

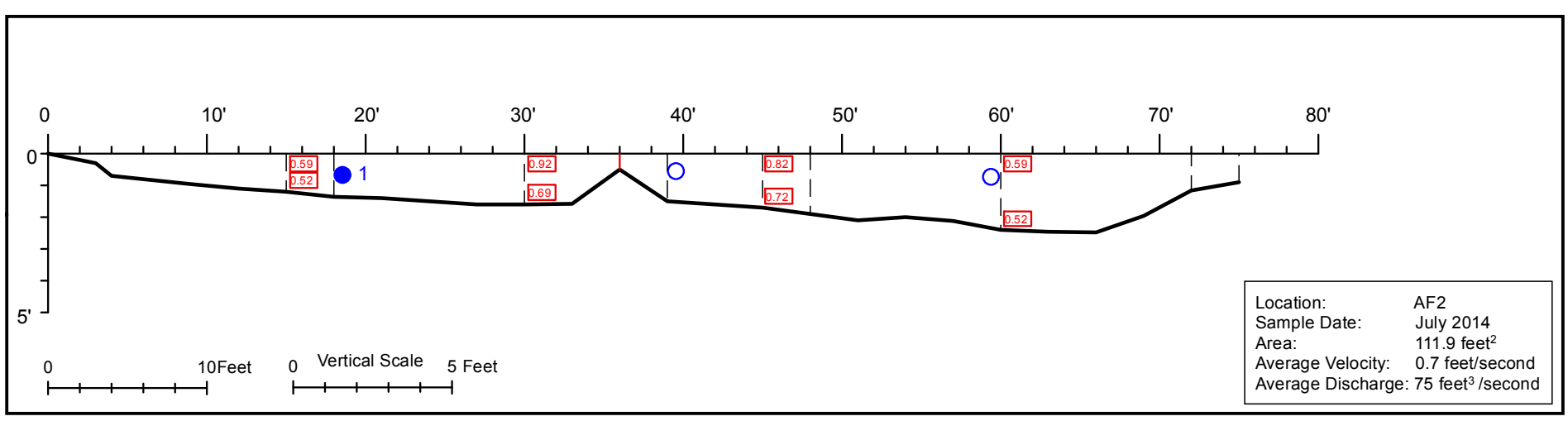
AF2 - Maurice River at Garden Road (Reference)
River Bathymetric Measurement
Flow Measurements at Depth
Water Sampling for Total and Dissoved Arsenic











○ = Non-detect
● = Total Arsenic Concentration in µg/L (ppb)

Map Creation Date: 02 October 2015

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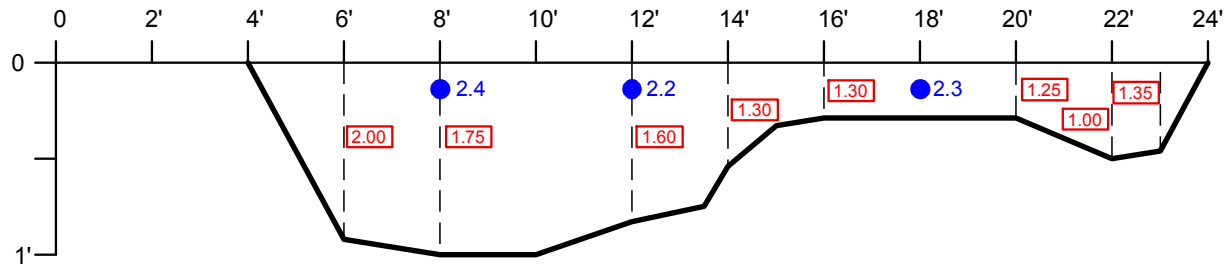
Figure 20
Arsenic Flux Stream Cross Section
Maurice River Investigation
Vineland, NJ

BWB - Confluence of Maurice River and Blackwater Branch
River Bathymetric Measurement
Flow Measurements at Depth
Water Sampling for Total and Dissoved Arsenic



Location: AF5
Sample Date: October 30, 2013
Area: 76.9 feet^2
Average Velocity: 1.8 feet/second
Average Discharge: 140.8 feet^3 /second

0 4 Feet

Vertical Scale 0 1 Feet

○ = Non-detect
● = Total Arsenic Concentration in µg/L (ppb)

Map Creation Date: 02 October 2015

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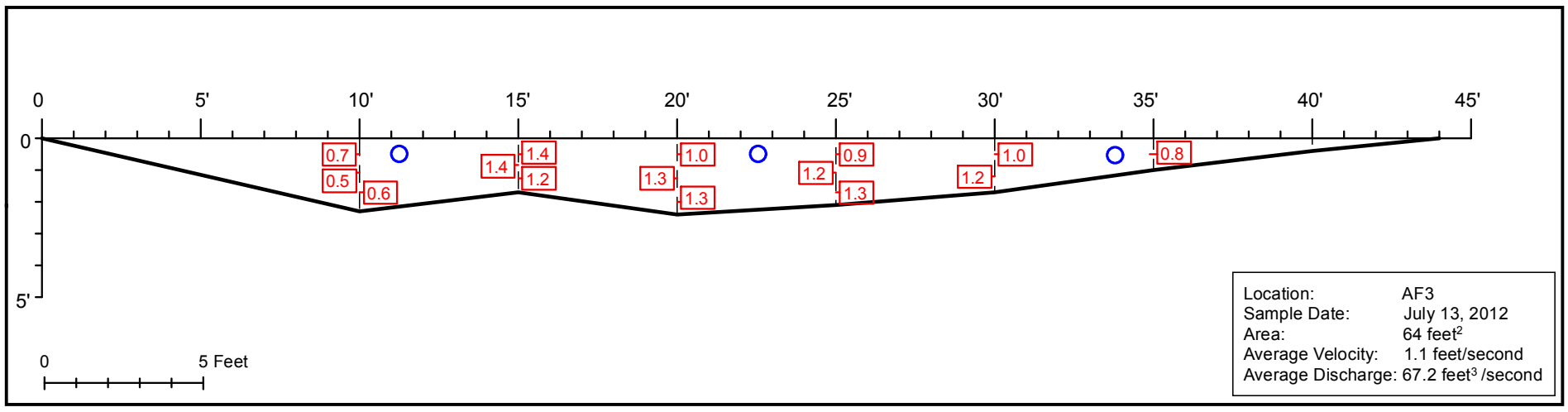
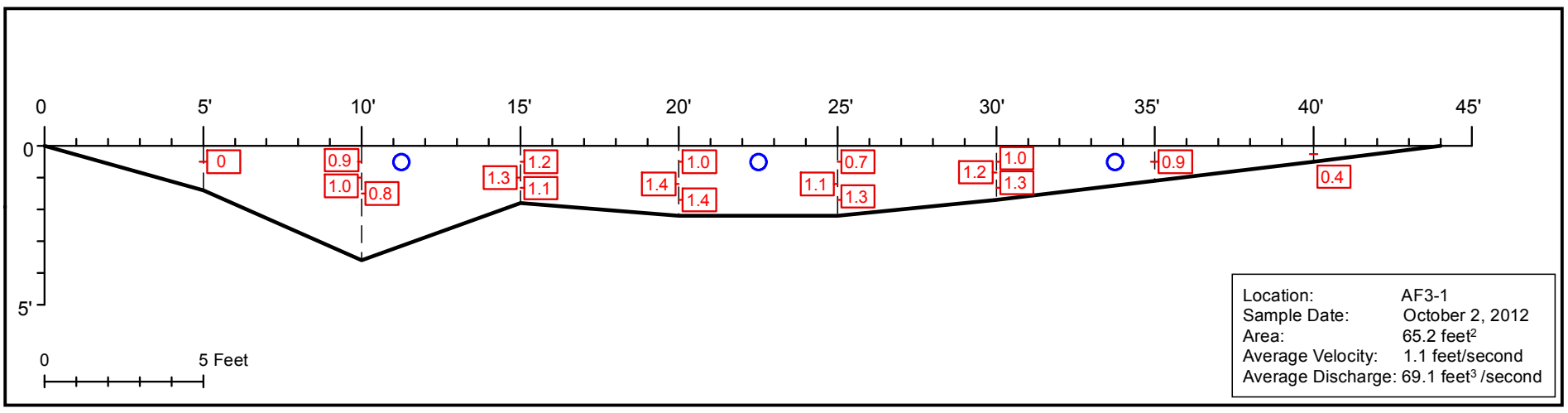
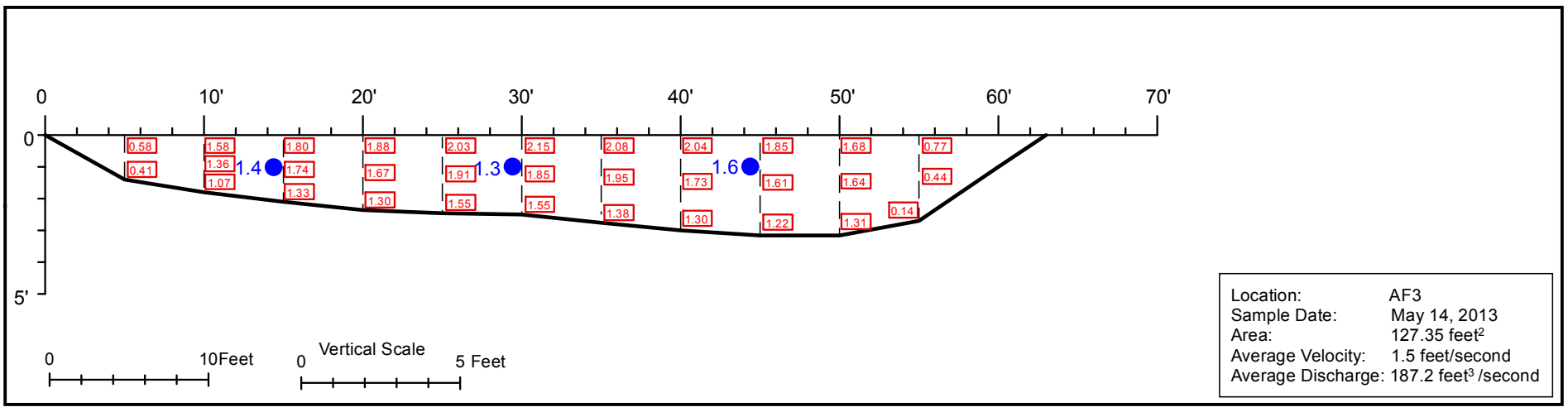
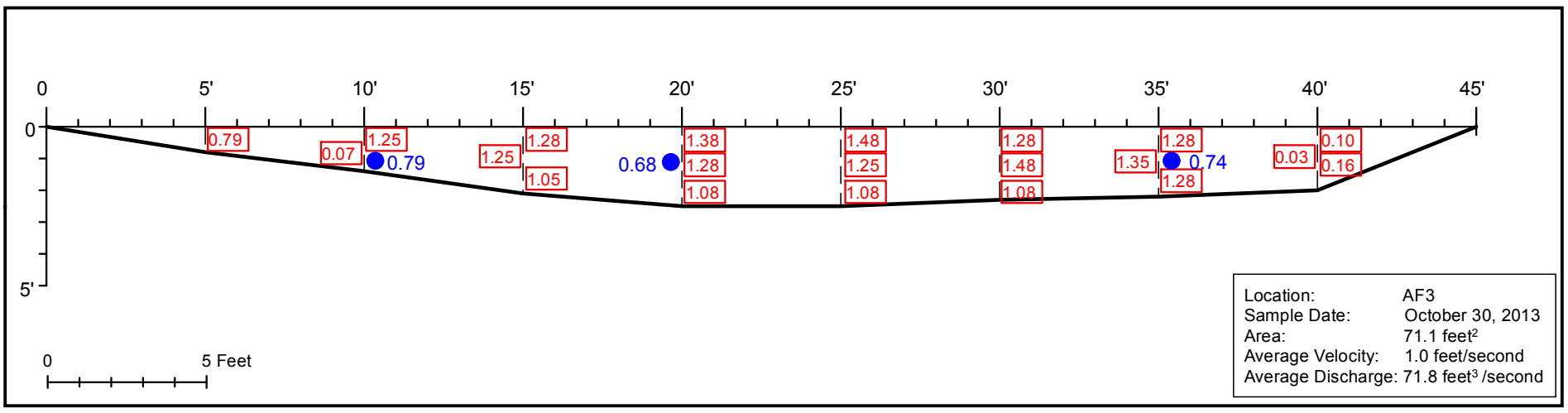
Figure 21
Arsenic Flux Stream Cross Section
Maurice River Investigation
Vineland, NJ

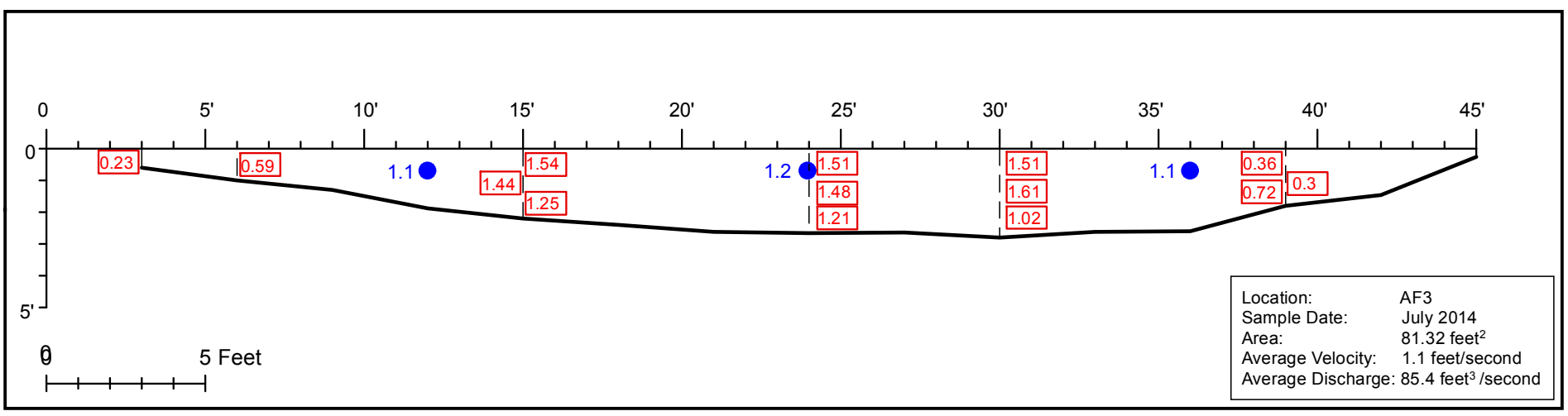
AF3 - Alliance Beach
River Bathymetric Measurement
Flow Measurements at Depth
Water Sampling for Total and Dissoved Arsenic











○ = Non-detect
● = Total Arsenic Concentration in µg/L (ppb)

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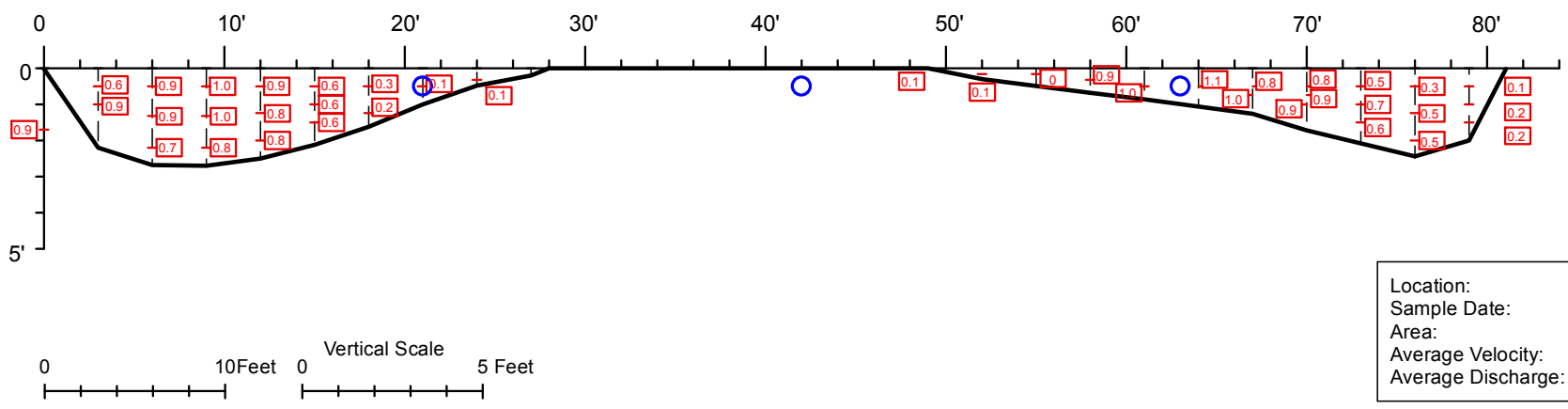
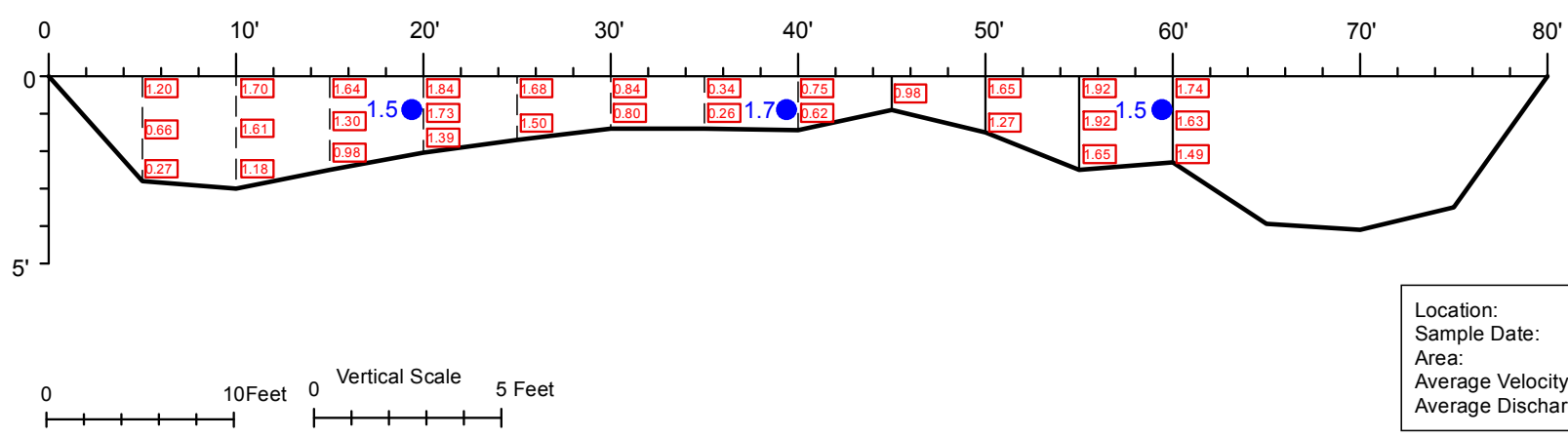
Figure 22
Arsenic Flux Stream Cross Section
Maurice River Investigation
Vineland, NJ

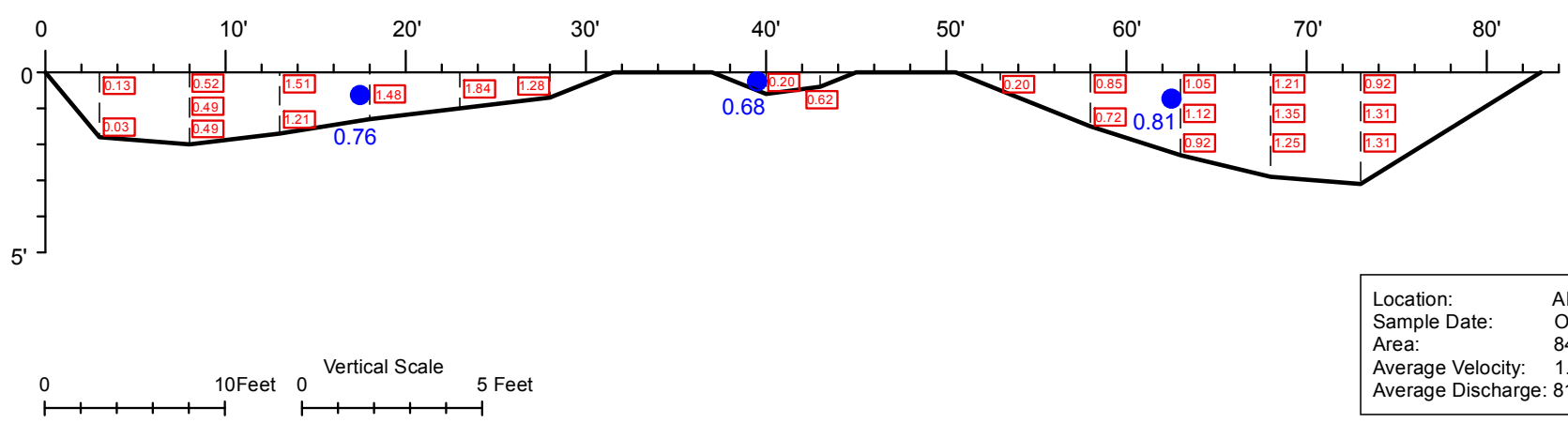
AF4A - Downstream of Almond Rd. Spilway
River Bathymetric Measurement
Flow Measurements at Depth
Water Sampling for Total and Dissoved Arsenic



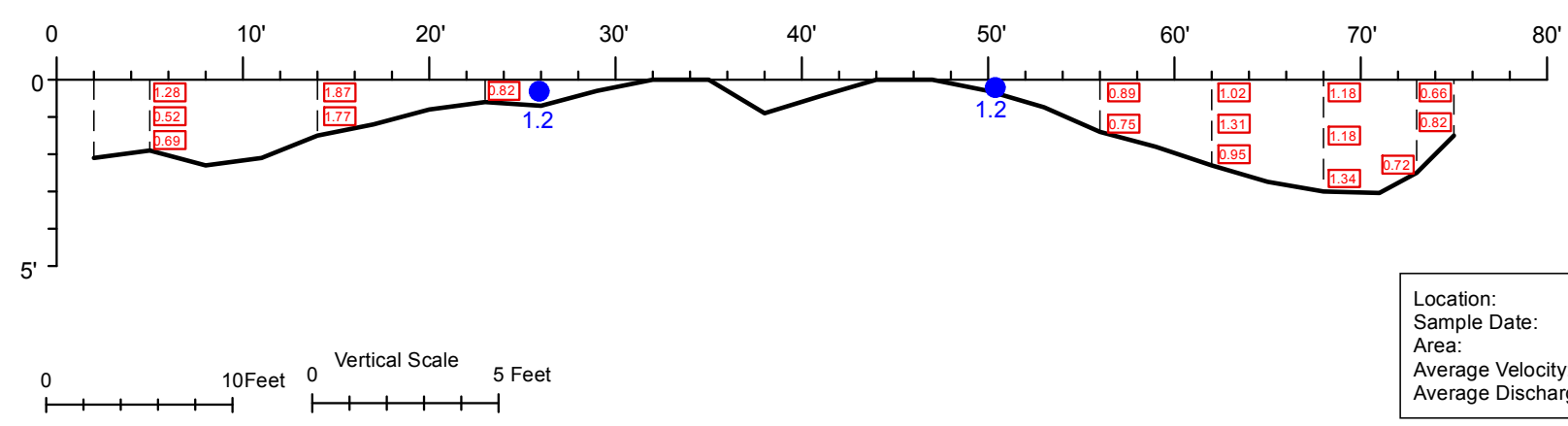
Location: AF4A
Sample Date: October 2, 2012
Area: 87.8 feet^2
Average Velocity: 0.6 feet/second
Average Discharge: 54 feet^3 /second



Location: AF4A
Sample Date: May 14, 2013
Area: 164.9 feet^2
Average Velocity: 1.3 feet/second
Average Discharge: 207.8 feet^3 /second



Location: AF4A
Sample Date: October 30, 2013
Area: 84.3 feet^2
Average Velocity: 1.0 feet/second
Average Discharge: 81.3 feet^3 /second



Location: AF4A
Sample Date: July 2014
Area: 95.3 feet^2
Average Velocity: 1.1 feet/second
Average Discharge: 100.0 feet^3 /second

○ = Non-detect
● = Total Arsenic Concentration in µg/L (ppb)

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Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \Y3R_Report_2015\185_Y3R2015_f23_Y1Y2Y3_AF4A_2012_2013_2014_f23.mxd

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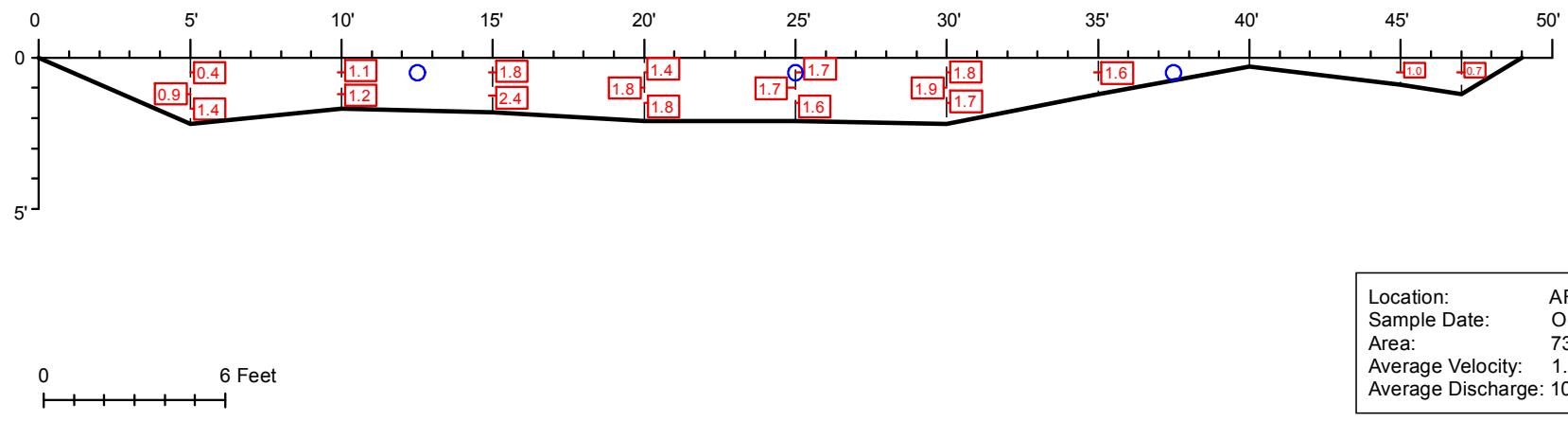
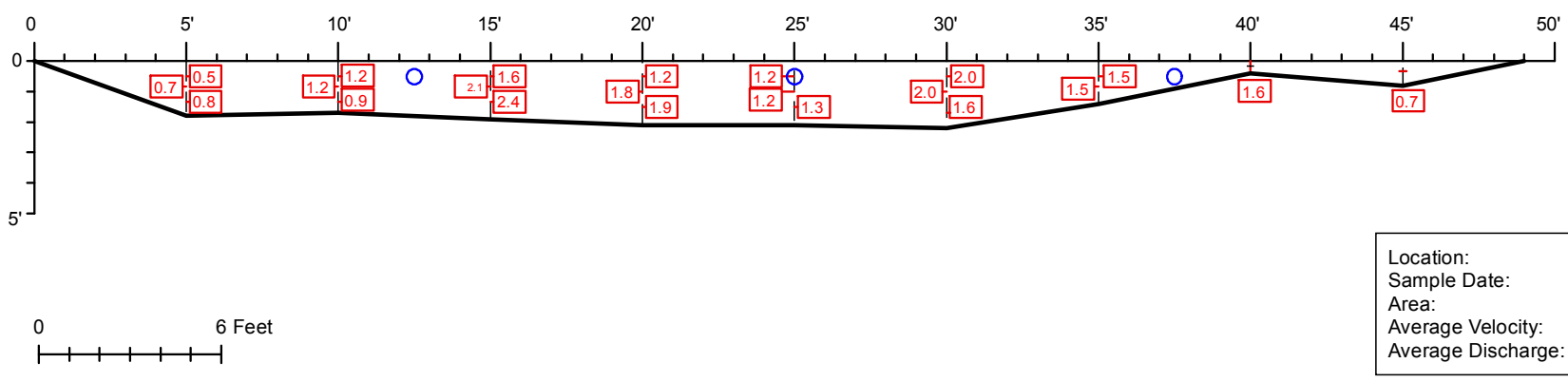
Figure 23
Arsenic Flux Stream Cross Section
Maurice River Investigation
Vineland, NJ

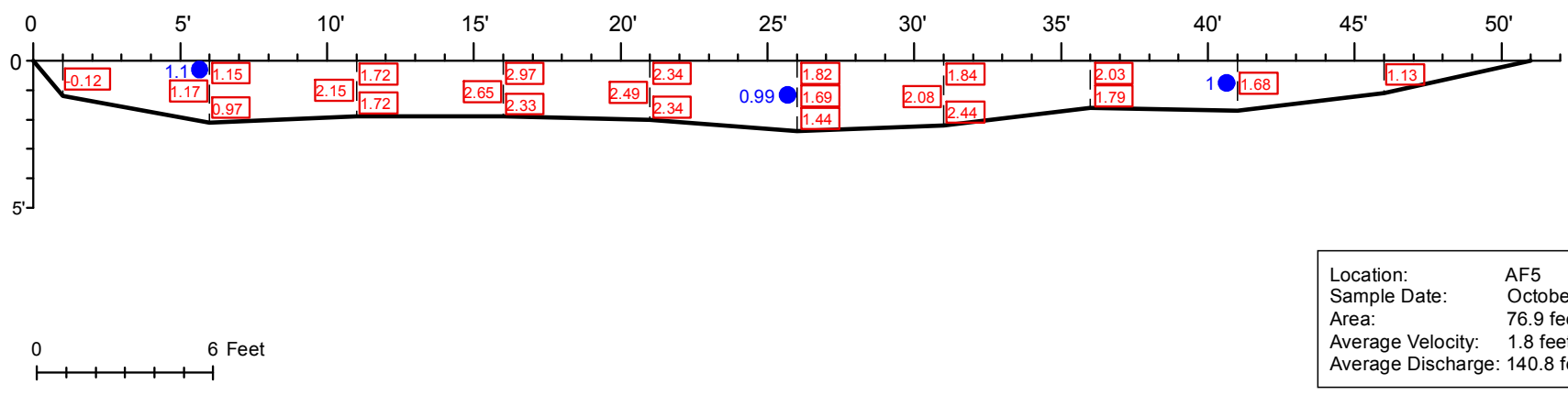
AF5 - Sherman Avenue
River Bathymetric Measurement
Flow Measurements at Depth
Water Sampling for Total and Dissoved Arsenic



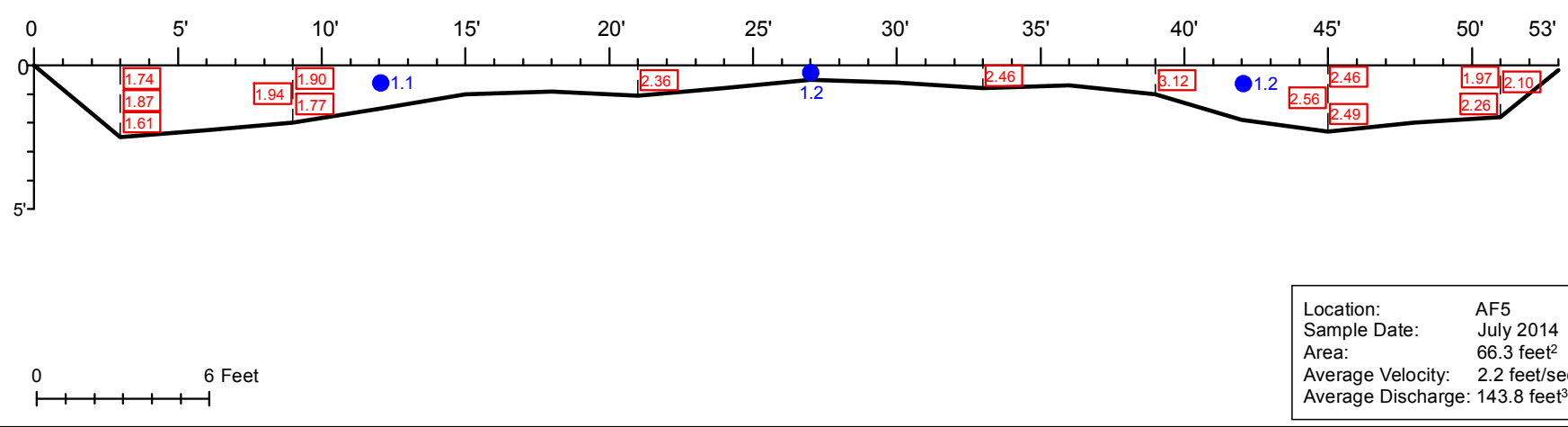
Location: AF5
Sample Date: October 2, 2012
Area: 73.9 feet^2
Average Velocity: 1.5 feet/second
Average Discharge: 109.3 feet^3 /second



Location: AF5-1
Sample Date: May 14, 2013
Area: 67.6 feet^2
Average Velocity: 1.4 feet/second
Average Discharge: 95.7 feet^3 /second



Location: AF5
Sample Date: October 30, 2013
Area: 76.9 feet^2
Average Velocity: 1.8 feet/second
Average Discharge: 140.8 feet^3 /second



Location: AF5
Sample Date: July 2014
Area: 66.3 feet^2
Average Velocity: 2.2 feet/second
Average Discharge: 143.8 feet^3 /second

○ = Non-detect
● = Total Arsenic Concentration in µg/L (ppb)

Map Creation Date: 02 October 2015

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \Y3R_Report_2015\185_Y3R2015_f24_Y1Y2Y3_AF5_2012_2013_2014_f24.mxd

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Figure 24
Arsenic Flux Stream Cross Section
Maurice River Investigation
Vineland, NJ

Appendix A

Ecological Risk Study

ECOLOGICAL RISK ASSESSMENT
VINELAND CHEMICAL SUPERFUND SITE
OPERABLE UNIT 3 – RIVER AREAS
VINELAND, NEW JERSEY

October 2015

U.S. EPA Work Assignment Number: 0-185
Lockheed Martin Work Order Number: SER00102
U.S. EPA Contract Number: EP-W09-031

Prepared for:
Tom Kady
EPA/ERT

Prepared by:
SRC/SERAS

FOR 10/16/15

Karen Kracko
Ecological Risk Assessor

Date

10/16/15

Scott Grossman
Task Leader

Date

10/16/15

Kevin Taylor
SERAS Program Manager

Date

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LIST OF ACRONYMS AND ABBREVIATIONS

ABC	Above Blackwater Branch confluence
AE	assessment endpoint
AFDW	ash free dry weight
ALL	Alliance Beach
ALM	Almond Beach
As	arsenic
As(III)	trivalent arsenic
As(V)	pentavalent arsenic
AUF	area use factor
AWQC	Ambient Water Quality Criteria
BB	Blackwater Branch
BBC	Below Blackwater Branch confluence
BERA	baseline ecological risk assessment
BW	body weight
C	Concentration
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
C_F	concentration in food
cm	centimeter
COPC	contaminant of potential concern
CSM	conceptual site model
Cr	chromium
CTC	critical tissue concentration
DEP	Department of Environmental Protection
DESA	Division of Environmental Science and Assessment
DMA	dimethyarsinic acid
EA	exposure area
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	ecological risk assessment
ERAGS	Ecological Risk Assessment for Superfund
ERT	Environmental Response Team
FWS	Fish and Wildlife Service
HDPE	High Density Polyethylene
HQ	Hazard Quotient
IR	Ingestion rate
kg	kilogram
kg/day	kilograms per day
KM	Kaplan Meier
km	kilometer
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
mg/kg	milligrams per kilogram

mg/kgBW/day	milligrams per kilogram body weight per day
MMA	monomethylarsonic acid
MSL	mean sea level
ND	not detected
NJ	New Jersey
NOAEL	no observable adverse effect level
NOEC	No observed effect concentration
OU	Operable Unit
PA	Pennsylvania
Pb	lead
PCB	polychlorinated biphenyls
PEC	Probable effect concentration
r	Pearson correlation coefficient
RL	reporting limit
ROS	Regression on order statistics
SERAS	Scientific, Engineering, Response and Analytical contract
SLERA	screening level ecological risk assessment
SOP	standard operating procedure
SQG	sediment quality guideline
SVOC	Semi-volatile organic compound
TAL	Target Analyte List
TEC	Threshold effect concentration
TRV	toxicity reference value
U.S.	United States
WA	Washington
WOE	Weight of Evidence
ww	wet weight
Zn	zinc
%	percent
µg/L	micrograms per liter
µm	micron
95UCL	95% upper confidence limit

1.0 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This document is an Ecological Risk Assessment (ERA) for the Vineland Chemical Superfund Site (Site) located in Vineland, New Jersey (NJ). The purpose of the ERA is to describe the likelihood, nature, and extent of adverse effects that may occur in ecological receptors exposed to environmental contaminants of potential concern (COPCs) on-site or in areas impacted by the Site under present conditions. This ERA, along with other relevant information, will be used by risk managers to decide whether remedial actions beyond those that have already been implemented are needed to protect ecological receptors from adverse effects attributable to Site-related environmental COPCs.

1.2 OVERVIEW OF THE ECOLOGICAL RISK ASSESSMENT PROCESS

The United States (U.S.) Environmental Protection Agency (EPA) has developed an 8-step process for conducting ecological risk assessments (U.S. EPA 1997; U.S. EPA 1998) at Superfund sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The first two steps are screening-level evaluations that result in a screening level ecological risk assessment (SLERA). The screening steps in the SLERA are intentionally simplified and conservative, and have as their primary goal the identification of exposure scenarios that are clearly not associated with risk. Elimination of these scenarios allows subsequent data collection and evaluation efforts to focus on exposure scenarios that are of potential concern.

The remaining sixsteps are intended to support the development of the baseline ecological risk assessment (BERA). Step 3 (problem formulation) is a systematic planning step that identifies the goals and focus of the BERA (U.S. EPA 1997). Step 4 includes the design of additional studies that are needed to support the BERA. These studies are implemented in Steps 5 and 6, and the resulting data are used to generate the risk assessment (Step 7), which in turn helps guide risk management decision-making (Step 8).

It is important to realize that the eight steps in the ERA process are not intended to represent a linear sequence of mandatory tasks. Rather, some tasks may proceed in parallel, some tasks may be performed in a phased or iterative fashion, and some tasks may be judged unnecessary at certain sites.

1.3 DOCUMENT ORGANIZATION

In addition to this introduction, the report is organized into the following sections:

> **Section 2.** Site Characterization summarizes the location, history, and environmental setting of the Site.

Section 3. Summary of Available Data describes the data sets available for performing the BERA.

Section 4. The Problem Formulation step includes a summary of preliminary findings and conclusions, refinement of the conceptual site model (CSM), identification of the assessment and measurement endpoints, and a description of the basic methods used in the ERA.

Section 5. Analysis presents the technical evaluation of existing and potential exposure and ecological effects at the Site

Section 6. The Risk Evaluation for Aquatic Receptors presents the ecological risk characterization for benthic macroinvertebrates and fish.

Section 7. The Evaluation of Risks to Piscivorous Birds and Mammals presents the ecological risk characterization for the belted kingfisher (*Megaceryle alcyon*), osprey (*Pandion haliaetus*), and mink (*Neovison vison*).

Section 8. The Uncretainty Analysis describes the assumptions made while conducting this ERA, and discusses the uncertainty associated with the assumptions and methods used.

Section 9. The Conclusion section summarizes the results of the effects characterization and the calculated risks

Section 10. This section provides citations for all data, methods, studies, and reports utilized in the ERA.

All tables and figures are presented at the end of the document.

2.0 SITE CHARACTERIZATION

2.1 SITE OVERVIEW

The Vineland Chemical Company was a 54-acre manufacturing facility located in Cumberland County, NJ. The facility was involved in the production of arsenical herbicides, fungicides, and biocides since 1949. Arsenical feedstock compounds were historically stored in unprotected piles that resulted in soil and groundwater contamination in the vicinity of the Site. Runoff during storm events and the recharge of arsenic-bearing groundwater has contaminated the adjacent watershed, including soil, sediment, and surface waters of nearby waterways such as Blackwater Branch, Maurice River, and Union Lake. The remedial approach for these downstream waterways is to complete sediment remediation activities in a phased manner. The initial remedy addressed sediment in the Blackwater Branch, and may include sediment in the Maurice River after further monitoring and evaluation. Sediment excavation and backfilling all along the Blackwater Branch has been completed and Atlantic white cedar (*Chamaecyparis thyoides*) wetlands restoration activities have also been completed. The wetlands will continue to be monitored (U.S. EPA Region 2 2012).

The objective of the current study is to evaluate the impacts of completed remedial activities (Plant Site Source Control, Plant Site Management of Migration, and Blackwater Branch Remedial Activities) on arsenic contamination in the Maurice River. Focused sampling was conducted to determine whether arsenic is being released from river sediments or waters in quantities that may be adversely impacting recreational use areas or environmental resources. Data from the current study is being used to assess any human health and/or ecological risks associated with the sediments and surface waters and to develop a hydraulic flow model for the river to estimate arsenic flux in the river over time. This report evaluates ecological risks associated with sediment and surface water in the Blackwater Branch, Maurice River, and the headwater area of Union Lake (Operable Unit [OU] 3 for this Site).

2.1.2 Physical Setting

The Site is located in the Atlantic Coastal Plain physiographic province. The area is characterized geologically by a thick sequence of Cretaceous to Recent age sediment (sand, gravel, silt and clay) which overlies the Precambrian bedrock basement. Soils in the general area of the Site are marine deposits. The area near the former plant is essentially a level plain, sloping from northwest to southeast with topographic variations from 60 to 80 feet above mean sea level (MSL) to just below 30 feet MSL near Union Lake (U.S. EPA Region 2 2011).

2.2 ECOLOGICAL SETTING

The Blackwater Branch of the Maurice River flows northeast to southwest, in proximity to, and partially through, the former plant Site. A floodplain lies immediately adjacent to the Blackwater Branch along the entire length of the tributary extending to the Maurice River. The Maurice River flows in a southerly direction approximately six miles to its confluence with Union Lake.

A broad floodplain also borders the Maurice River (U.S. EPA Region 2 2011). The lower Maurice River system extends 26 miles from Union Lake to the Delaware Bay (U.S. EPA Region 2 2014).

The Maurice River ranges from 10 to 15 meters in width with a maximum observed depth of two meters. Surface hydrology of the study area is characterized by relatively closely-spaced, parallel flowing tributaries that enter the Maurice River at consistent acute angles. As a result of the very low topographic gradient in the region, the Maurice River is relatively slow moving and shallow. No well-defined riffle areas exist and the flow is mostly laminar. The channel consists of a network of braided rivulets in places and the river banks are well defined and undercut in places. An extensive littoral zone is present and the river banks are completely forested with a canopy cover ranging from 20 to 60 percent (%). The substrate typically consists of sand to silt-sized particles and submerged and emergent macrophytes are common. River water is generally transparent, while appearing light brown to tea-colored (Pinelands Commission 1980). This coloration results from an abundance of organic iron complex that is derived from the oxidation of iron ions dissolved in the groundwater that mix with the decomposing plant materials upon entering surface water. Surface water in the region is low in hardness, alkalinity, and suspended and dissolved solids. It is acidic and is nutrient poor.

The riparian area is typically vegetated with a secondary growth forest. Atlantic white cedar, red maple (*Acer rubrum*), bay magnolia (*Magnolia virginiana*), and pitch pine (*Pinus rigida*) are the dominant canopy species. Blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), American holly (*Ilex opaca*), mountain laurel (*Kalmia latifolia*), and spice bush (*Lindera benzoin*) are present in the understory. Agriculture, consisting of vegetables, fruit orchards, and nursery stock, is common throughout the region.

2.3 SITE HISTORY

The Vineland Chemical Company manufactured arsenic-based herbicides from 1950 to 1994 on a 54-acre site located in the City of Vineland, NJ. Prior to 1977, by-product arsenic salts were stored in open piles and in chicken coops. Arsenic contamination was found in an adjacent wetland (the Blackwater Branch), surface and subsurface soil, groundwater, the Maurice River and Union Lake. The cleanup approach identified for the Site involved immediate actions at the former plant site and four long-term remedial phases (OUs 1 through 4) focusing on source control, contaminant migration management, and the cleanup of marsh/river and lake sediment.

OU1 involved remediation of soil at the former manufacturing plant. Approximately 94% of the contaminated soil was treated and returned to the Site as clean backfill, while the remainder was shipped to an off-site landfill. Clean topsoil was used to restore the Site to grade and support re-vegetation. The remedy selected for OU2 was removal and on-site treatment of arsenic-contaminated groundwater, and discharge to surface water. Operation of the groundwater treatment plant began in 2000 and is ongoing; the plant has been operated by the NJ Department of Environmental Protection (DEP) since October of 2014 (U.S. EPA Region 2 2011; U.S. EPA Region 2 2014).

This ERA evaluates risk to ecological receptors in OU3 (River Areas – Blackwater Branch and the Maurice River) as part of a three-year monitoring study of the Maurice River. This study began in the summer of 2012 to assess the natural flushing abilities of the river. High concentrations of arsenic were identified in exposed and submerged sediment along the entire stretch of the Blackwater Branch from the main plant area to its confluence with the Maurice River. Excavation of contaminated sediment from Blackwater Branch was completed in2012. Environmental restoration of the stream corridor and wetlands began in 2007 and was completed in 2012. Wetland restoration activities included the creation of Atlantic white cedar wetlands along major sections of the Blackwater Branch; additional native wetland shrubs and grasses were also planted (U.S. EPA Region 2 2013).

The type and extent of cleanup for the Maurice River depends on the results of this study (U.S. EPA Region 2 2014).

2.4 BASIS FOR ECOLOGICAL CONCERN

Surface runoff from the former plant Site and the recharge of arsenic-bearing groundwater has contaminated soil, sediment, and surface waters of nearby waterways including Blackwater Branch, Maurice River, and Union Lake. Although contaminated sediment has been removed from the Blackwater Branch, arsenic-contaminated sediment is present in the Maurice River and in Union Lake. There may still be limited groundwater discharge from the Site to the Maurice River. Aquatic receptors and semi-aquatic receptors that forage in the contaminated waterways may be exposed to site-related COPCs as detailed in Section 4.1.

3.0 SUMMARY OF AVAILABLE DATA

The objective of the field sampling effort described below was to generate Site-specific abiotic and biological data to define current ecological risks associated with exposure to surface water and sediment in Blackwater Branch, the Maurice River, and the Union Lake headwater area.

Surface water, sediment, toxicity testing and benthic macroinvertebrate samples were collected by the U.S. EPA Environmental Response Team (ERT), the U.S. Fish and Wildlife Service (FWS) and Scientific, Engineering, Response and Analytical (SERAS) contract personnel. Fish and surface water and sediment samples from the fish collection areas were collected by U.S. EPA Region 2 and NJ DEP Fish and Wildlife Division personnel.

Arsenic concentrations in sediment and surface water samples were measured by the U.S. EPA Region 2 Laboratory (Division of Environmental Services and Assessment [DESA]) located in Edison, NJ. Speciation of arsenic in fish tissue was performed by the Brooks Rand Laboratory in Seattle, Washington (WA). Analysis of lipids in tissue was performed by Fremont Analytical in Seattle, WA. These data are summarized in Tables 3-1 through 3-5 and discussed in the following sections.

3.1 SURFACE WATER

Co-located surface water and sediment samples were collected within each of the fish collection areas in 2009, 2011 and 2013 (Figure 3-1). Surface water samples were also collected at beach areas along the Maurice River in 2012, 2013 and 2014 (Alliance Beach [ALL], Almond Beach [ALM], and BA Beach [BA]; Figure 3-1). Additional sediment samples were collected in the northern portion of Union Lake in 2013 and 2014; no co-located surface water samples were collected at these locations (Figure 3-1).

Surface water samples were collected using a peristaltic pump with dedicated tubing (ERT 1994a). At each sampling location, one sample was collected for analysis of total arsenic, and a second was filtered through a 0.45 micrometer (µm) filter and submitted for dissolved arsenic analysis. In addition to the two surface water samples collected for total and dissolved metals analysis, two additional samples (filtered and non-filtered) were collected following agitation of the sediment (disruption). Based on historic data, arsenic contamination is sediment-driven; arsenic is generally not detected in water samples collected before agitation of sediment (U.S. EPA Region 2 2011). Surface water (total, dissolved, disturbed total, and disturbed dissolved) samples were submitted for analysis of arsenic. Lower detection limits were requested for arsenic in water samples for the 2013 sampling event than were used in previous sampling events. Summary statistics and 95% upper confidence limit (95UCL) values and were calculated using ProUCL V5.0 (U.S. EPA 2013). Summary statistics for arsenic in surface water were calculated and are presented in Table 3-1.

Mean concentrations are Kaplan Meier (KM) means calculated using ProUCL 5.0, which incorporates not detected (ND) values into the calculation of the mean. For surface water

samples, the reporting limit (RL) for arsenic in some previous sampling events was 8 micrograms per liter (µg/L), versus 1 µg/L in other events. KM means calculated for these surface water samples were equal to means calculated using only detected data (top portion of Table 3-1). To account for the high RLs in some samples, mean values were also calculated using a value of half the RL for NDs (lower portion of Table 3-1). To be conservative, the highest calculated mean values (KM mean or one half the RL substituted) were used in the screening tables and the dietary exposure models.

For this ERA, site-specific data are available for total, and dissolved metals in surface water. Toxicity to aquatic receptors from exposure to surface water is dominated by the concentration of dissolved chemicals (U.S. EPA 1993). Screening benchmarks were compared with the measured dissolved and disturbed dissolved arsenic concentrations. Disrupted total arsenic concentrations were used to evaluate exposure of piscivorous birds and mammals to drinking water.

3.2 SEDIMENT

Sediment samples were collected at the surface water sample locations at a depth of 0 to 6 inches using a core sampler or a ponar dredge (ERT 1994b). Additional surface sediment samples were also collected at locations where surface water samples were not collected (Figure 3-1). Samples were submitted for total arsenic and grain size analysis. Summary statistics for arsenic in surface sediment were calculated and are presented in Table 3-2.

3.3 SEDIMENT SAMPLES FOR TOXICITY TESTING

Twenty-six bulk sediment samples were collected for toxicity testing by Lockheed Martin/SERAS and US FWS personnel on July 30 and July 31, 2015. Sufficient sediment to fill a 2.5 gallon High-Density Polyethylene (HDPE) bucket was collected at twenty-six locations selected based on availability of sediment and previous sampling results, with the intent of collecting a gradient of arsenic concentrations (Figure 3-2). Sediment from Union Lake was collected using a ponar dredge deployed from a pontoon boat. Sediment at most of the river locations, including two upstream reference samples (near Garden Road) were collected by ponar dredge or posthole digger. Buckets were labeled, closed, and put on ice prior to be being brought back to DESA in Edison, New Jersey. Subsamples were collected from each of the twenty-six samples and submitted for analysis of total arsenic with a 1mg/kg RL using a quick turnaround (five business days). Based on these results, ERT and US FWS personnel selected sixteen of the twenty-six samples to be used for the toxicity testing. Seven of these toxicity testing sample locations were in the Maurice River, eight locations were from Union Lake, and one sample location was from the upstream reference area. The designated sample location and associated sediment arsenic concentrations for the 16 toxicity testing samples are presented in Table 3-3. Samples selected for toxicity testing were submitted for analysis of Target Analyte List (TAL) metals, semivolatile organic compounds (SVOCs) and pesticides/polychlorinated biphenyls (PCBs). Summary statistics for detected COPCs measured in these sediment samples are presented in Table 3-4.

Solid-phase sediment toxicity bioassays using *Hyalella azteca* (28-day) and *Chironomus dilutus* (10-day) were conducted as per U.S. EPA toxicity testing guidelines (U.S. EPA 2000). Endpoints measured were survival, weight, and biomass. Toxicity testing was performed by American Aquatic Testing, Inc. of Allentown, Pennsylvania (PA). Each sediment toxicity test consisted of five replicates per sample location using 100% site sediment (no sediment dilutions). A laboratory control test was performed concurrently using sediment collected from Spruce Run Reservoir (Clinton, NJ).

3.4 BENTHIC MACROINVERTEBRATES

A benthic macroinvertebrate survey was conducted at five sampling locations along the Maurice River as per SERAS Standard Operating Procedure (SOP) #2054 *Benthic Macroinvertebrate Sampling* (SERAS 2003) and Barbour *et al.* (1999). One of these five locations (BCS-01 = Ref) was located upstream of the area of impact (near Garden Road), and the other four locations were from downstream areas of potential impact along the Maurice River. These locations were BSC-02 at ALL (off of Eppinger Avenue), BCS-03 in the vicinity of ALM, BCS-04 near Sherman Avenue, and BCS-05 along the power lines and accessed by permission of the water treatment plant (Figure 3-2).

Collection of benthic macroinvertebrates in Union Lake was unsuccessful due to lack of suitable habitat; collection attempts were abandoned after two sampling efforts. The substrate in the Union Lake headwater area graded from coarse sand at the northern end to a fine sand at the southern end. The substrate in the littoral area was littered with shells of *Corbicula fluminea*. *Anodonta* sp. was also present, but in fewer numbers.

Benthic macroinvertebrate collection commenced on October 29, 2013. Habitat with similar physical characteristics (i.e. substrate, vegetation, and water velocity) was sampled at all locations. Three replicates were collected at each location. Replicate locations were selected at random from areas of roughly equivalent habitat near the original sample. A NJ DEP Biological Field Observation and Data Sheet was completed for each benthic macroinvertebrate sampling location (Appendix A).

The collection procedure employed a long-handled dip net, measuring approximately 30 centimeters (cm) high, by 25 cm wide, with 0.5 µm mesh openings. In order to collect a quantitative sample and permit comparison of locations, an equivalent level of effort (in terms of time and area sampled) was expended at all sampling locations. A sample area of approximately 0.75 square meters was disturbed for 30 seconds. Organisms were collected by disturbing the substrate and vegetation upstream of the sampler, and dislodged organisms were swept into the net by the current and action of the sampler. Faunal collections were given a cursory examination in the field, and large debris and stones separated from the organisms. The remaining material was placed in 32 ounce jars and preserved with a 70% isopropyl alcohol solution (Barbour *et al.* 1999; SERAS 2003). Samples delivered to the ERT/SERAS Biology Laboratory for further sorting and identification. Sampling and processing of the samples followed SERAS SOP # 2054, *Benthic Macroinvertebrate Sampling*.

In the laboratory, organisms were separated from detritus using wet sieving techniques (Jonasson 1985). The organisms were identified to the lowest taxonomic level practical (Edmunds *et al.* 1976; Wiggins 1977; Pennak 1978; Merritt and Cummins 1984). Varying levels of taxonomic resolution were attained; separations ranged from order to genus, with most identifications made to the generic level. The size and life history stage, number of individuals, level of effort required, and state of taxonomic knowledge of the group determined the level of identification. These data are presented and discussed in Section 6.5.

Benthic macroinvertebrate tissue samples were also collected and frozen for potential future tissue analysis of total arsenic.

3.5 FISH

Fish were collected in June of 2009, and in June and July of 2011 and 2013 for the ERA. Fish were collected for whole body tissue analysis in the Maurice River above the Blackwater Branch confluence (ABC), the Maurice River below the Blackwater Branch confluence (BBC), and the Union Lake headwater area. In 2013, fish were collected in the Blackwater Branch upstream of the former facility (Figure 3-3).

Red breast sunfish (*Lepomis auritus*; 2009 and 2011) and pumpkinseed (*Lepomis gibbosus*; 2013) were collected from the Maurice River ABC. Fish species collected from the Maurice River BBC were red breast sunfish (2009, 2011 and 2013), and yellow perch (*Perca flavescens*; 2009). Fish species collected in the Blackwater Branch in 2013 were creek chubsucker (*Erimyzon oblongus*) and mudminnow (*Umbra spp.*). Fish species collected in the Union Lake headwater area for the ERA were white perch (*Morone americana*; 2009), channel catfish (*Ictalurus punctatus*; 2009), pumpkinseed (2013) and golden shiners (*Notemigonus crysoleucas*; 2013). Whole body fish were submitted for arsenic analysis and speciation.

All fish tissue samples collected in 2009 were analyzed as composites of three to five individuals, whereas fish collected in 2011 and 2013 were submitted as individual discrete samples for analysis. Fish collected in 2009 were analyzed for inorganic arsenic, trivalent arsenic (As[III]), pentavalent arsenic (As[V]), dimethylarsinic acid [DMA] and monomethylarsonic acid [MMA]. Fish collected in 2011 and 2013 were submitted for whole body analysis of total arsenic, inorganic arsenic, As(III), and As(V). For all three sampling events, the concentration of As(V) was calculated by subtracting the analytical result for As(III) from the analytical result for inorganic arsenic. Summary statistics for total and inorganic arsenic in fish tissue are presented in Table 3-5.

4.0 PROBLEM FORMULATION

The data described in Section 3.0 were used to conduct an ERA for Backwater Branch, the Maurice River and the Union Lake headwater area. During problem formulation, the scope and goals of the ERA are defined (Step 3 of the ERA process outlined in the Ecological Risk Guidance for Superfund [ERAGS]) (U.S. EPA 1997). During this step, COPCs, their fate and transport pathways and ecological effects are identified; complete exposure pathways are determined; assessment endpoints (AEs), measures of exposure and effects, and surrogate ecological receptor species are selected; and the CSM is refined. Each of these is described below.

4.1 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

As discussed in Section 2.3, the Vineland Chemical Company produced arsenical herbicides, fungicides, and biocides. Arsenical feedstock compounds were historically stored in unprotected piles that resulted in soil and groundwater contamination in the vicinity of the Site. Runoff during storm events and the recharge of arsenic-bearing groundwater have contaminated the adjacent watershed, including sediment and surface waters of nearby waterways such as Blackwater Branch, Maurice River, and Union Lake.

Numerous studies have documented elevated concentrations of arsenic in soil, groundwater, agitated surface water, and sediment in Blackwater Branch, the Maurice River, and Union Lake (U.S. EPA 1989; EA Engineering Science and Technology Inc. 2010; U.S. EPA Region 2 2011). Based on existing data, arsenic has been identified as the primary COPC at this Site in the following forms: inorganic As, As(III), As (V), DMA, and MMA. Sediment, surface water and fish tissue samples were therefore submitted for arsenic analysis.

4.2 CHARACTERIZATION OF THE ECOLOGICAL EFFECTS OF THE COPCS

The primary ecological effects of interest for the COPC at this Site are direct toxicity; bioaccumulation within the food chain; and adverse effects on the survival, growth or reproduction of potentially exposed ecological receptors. Direct toxicity of measured arsenic concentrations in sediment was evaluated by screening against the consensus-based Sediment Quality Guidelines (SQG) (MacDonald *et al.* 2000), and direct toxicity of arsenic in surface water was evaluated by screening measured dissolved concentrations against Ambient Water Quality Criteria (AWQC) (U.S. EPA 2015). The screening values used for sediment and surface water are presented in Table 4-1.

A literature search was conducted to obtain information on the effects of exposure to arsenic on survival, growth, and reproduction of ecological receptors. This search identified the toxic mechanism for arsenic, and evaluated exposure-response data. No observed effect concentrations (NOECs) and lowest observed effect concentrations (LOECs) for tissue concentrations associated with adverse effects in fish, and no observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs) for dietary concentrations associated with adverse

effects in avian and mammalian receptors were identified. Table 4-2 presents the toxicity reference values (TRVs) (NOEC and LOEC tissue effect concentrations for fish and NOAEL and LOAEL dietary effect concentrations for avian and mammalian receptors) selected for use in this ERA. Table 4-3 presents a summary of studies reviewed to derive the NOEC and LOEC TRVs for fish tissue. Studies reviewed to select TRVs for birds and mammals are described in Appendix B.

4.3 CONCEPTUAL SITE MODEL

The CSM (Figure 4-1) incorporates information about the Site, COPC fate and transport, potential ecological receptors and exposure pathways. These are discussed separately below.

4.3.1 COPC Fate and Transport

Historic pesticide production at the Site has resulted in release of arsenic to the environment. Runoff during storm events led to the presence of Site-related arsenic in surface soil, surface water, sediment, and groundwater in the vicinity of the Site and in adjacent downstream waterways.

4.3.2 Ecosystems Potentially at Risk/Complete Exposure Pathways

The ecosystem potentially at risk at this Site is the aquatic community within Blackwater Branch, the Maurice River, and the Union Lake headwater area. Benthic organisms inhabit the sediment and directly absorb COPCs through contact with sediment particles and interstitial water, as well as through ingestion of contaminated food items and incidental ingestion of sediment. Fish can absorb COPCs present in the water column through dermal exposure and through respiration. Fish may also be exposed to COPCs through the ingestion of food items and incidental ingestion of sediment.

Terrestrial receptors which obtain prey items from the Maurice River are also of potential concern. Birds and mammals that utilize the Maurice River as a foraging area may be exposed to COPCs through dermal contact with bank or floodplain soil, sediment and surface water, through ingestion of contaminated food items or incidental ingestion of soil or sediment, and through ingestion of surface water.

Each of the receptors identified above may be exposed to Site-related COPCs by one or more exposure pathways, including ingestion of contaminated prey or surface water, incidental ingestion of contaminated sediment or soil, and direct contact with contaminated soil, sediment surface water, or pore water. Pathways that are considered most likely to be complete and significant are indicated in the CSM in Figure 4-1 by solid black circles; these pathways were evaluated quantitatively. Boxes with an open circle indicate pathways that are most likely complete and with significant exposure, but for which toxicological data are not available to evaluate them quantitatively. Boxes with an “X” indicate pathways that are most likely complete, but for which exposure is likely to be minor in comparison with other pathways that were

evaluated quantitatively. Open boxes indicate pathways that are either not complete or are judged to be minor or negligible.

4.3.4 Exposure Areas

Four Exposure Areas (EAs) were identified for this site: the Maurice River ABC (reference), Blackwater Branch (BB) (reference), the Maurice River BBC, and the Union Lake headwater area. Discussed in previous sections of this ERA, these EAs are shown in Figure 3.3.

4.4 SELECTION OF AES AND MEASURES OF EXPOSURE AND EFFECTS

Assessment endpoints are explicit expressions of the ecological resources that are to be protected. Valuable ecological resources include those without which ecosystem function would be significantly impaired or those providing critical resources (e.g., habitat). Because it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem on-Site, appropriate selection and definition of AEs is critical to focus the ERA on particular representative components of the ecosystem that could be adversely affected by the COPCs associated with the Site. The AEs selected for this ERA are the survival, growth and reproduction of aquatic organisms (benthic macroinvertebrates and fish) and piscivorous birds and mammals, and are summarized below and in Table 4-4.

Measures of exposure and effects (also called measurement endpoints) represent quantifiable ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the AEs (U.S. EPA 1992, 1997). In general, measures of exposure and effects can be divided into three basic categories, as follows:

- Predicted Risks (Hazard Quotients [HQs]),
- Site-specific toxicity tests, and
- Observations of population and community demographics.

For this risk assessment, all three types of measures were utilized. Risk questions and measures of exposure/effects were selected based on the complete exposure pathways identified in the CSM (Figure 4-1). Because Site-specific toxicity tests and benthic macroinvertebrate community surveys incorporate Site-specific factors that may influence bioavailability and toxicity of arsenic, these measures provide the strongest weight of evidence (WOE) regarding potential ecological risks at this Site (as opposed to predicted risks or HQs).

Each AE, along with the selected measurement endpoint(s), is described below and shown in Table 4-4.

4.4.1 AE #1: Survival, Growth and Reproduction of Benthic Macroinvertebrates

Many benthic macroinvertebrate species are detritus feeders. The role of invertebrates in recycling organic material contributes to the productivity of aquatic ecosystems by mineralizing

nutrients, making them available for plant production. They also make sediment and detrital carbon available to higher trophic levels, as many invertebrates serve as an important food source for fish and other higher trophic level organisms. COPCs present in Blackwater Branch, the Maurice River, and the Union Lake headquarters may adversely affect the viability of benthic invertebrates, which may in turn have adverse impacts on other trophic levels. Survival, growth, and reproduction of benthic macroinvertebrates were selected as an AE for this ERA.

Risk question: Are concentrations of COPCs in sediment and surface water sufficient to adversely affect the survival, growth, or reproduction of benthic macroinvertebrates?

Measure of effects: The mean and maximum measured concentrations of arsenic in sediment and surface water were compared with screening benchmark values (MacDonald *et al.* 2000; U.S. EPA 2015) (Table 4-1).

Measure of effects: Solid-phase sediment toxicity bioassays using *Hyalella azteca* (28-day) and *Chironomus dilutus* (10-day) were conducted. Survival, weight, and biomass in downstream sediment, a reference area sediment, and a control sediment were monitored.

Measure of effects: Benthic macroinvertebrate community samples were collected. Benthic community metrics in samples collected from the Maurice River and from the Union Lake headwater area were compared with benthic community metrics in samples from the reference area.

4.4.2 AE #2: Survival, Growth and Reproduction of Fish

Fish are important in the flow of energy through ecosystems. Fish consume plants, invertebrates and other fish, and are an important food source for higher trophic level organisms. Since the number of organisms supported at any position in a food chain depends on the energy supply available and the density of predators, the role of energy transfer played by fish is integral to the productivity of an aquatic ecosystem.

Fish may be directly exposed to COPCs in sediment, surface water, and discharging groundwater. Fish in Blackwater Branch, the Maurice River, or the Union Lake headwaters were identified as receptors of interest due to their role in energy flow and materials cycling, as a food source for higher trophic level organisms, and their potential exposure to COPCs. Survival, growth, and reproduction of fish were selected as an AE for this ERA.

Risk Question: Are concentrations of arsenic in surface water or sediment high enough to adversely affect the survival, growth, or reproduction of fish?

Measure of effects: The mean and 95UCL or maximum measured concentrations of arsenic in surface water and sediment were compared with screening benchmark values (AWQC for aquatic life) (U.S. EPA 2015) and consensus-based sediment screening benchmarks (MacDonald *et al.* 2000).

Risk Question: Are concentrations of arsenic in fish tissue high enough to adversely affect their survival, growth, or reproduction?

Measure of Exposure/Effects: Measured arsenic concentrations in fish tissue were compared with TRVs reported in the literature associated with adverse effects (Table 4-2).

4.4.3 AE #3: Survival, Growth and Reproduction of Piscivorous Birds and Mammals

Foraging of piscivorous birds and mammals represents a pathway by which nutrients and energy are transferred from aquatic to terrestrial ecosystems. There is a close relationship between terrestrial and aquatic ecosystems due to the nutrient and energy flow between them. Nutrients enter aquatic ecosystems via surface water runoff, stream input, and water infiltration through the soil. Energy enters aquatic ecosystems via sunlight and biological inputs such as detritus and leaves. Nutrients and energy are used to fix carbon in the production of plant and animal biomass, and are transferred from aquatic to terrestrial ecosystems through the food chain. Nutrient and energy cycles between aquatic and terrestrial systems are delicately balanced. Since nutrients and energy are limiting factors in the production of an ecosystem, the transfer of energy from an aquatic to a terrestrial system and back is essential.

Because piscivorous birds and mammals are upper trophic level predators, they are susceptible to COPCs which bioaccumulate or biomagnify in the organisms upon which they feed. Fish have been shown to accumulate certain COPCs that are present in aquatic ecosystems. Therefore, birds or mammals that consume fish have the potential to accumulate large concentrations of COPCs in their tissues. Survival, growth and reproduction of piscivorous birds and mammals were identified as an AE for this ERA.

Risk Question: Are dietary exposure concentrations of arsenic high enough to cause adverse effects to piscivorous birds and mammals?

Measure of Effects: The mean and 95UCL or maximum concentration of arsenic measured in forage fish tissue collected from Blackwater Branch, the Maurice River, and the Union Lake headwater area were used in dietary exposure models to calculate dietary exposure concentrations for piscivorous birds and mammals. Receptor species representative of the feeding guilds identified as AEs for this ERA were selected based on their potential to utilize the Site, their observed presence on-Site, potential exposure to Site-related COPCs based on feeding habits or habitat utilization, and the availability of data to determine exposure parameters. The receptor species selected as surrogates representative of piscivorous birds and mammals are the belted kingfisher (*Ceryle alcyon)*, the osprey (*Pandion haliaetus*) and the mink (*Neovison vison*). The calculated dietary exposure concentrations were compared with TRVs obtained from the literature for birds and mammals (Table 4-2).

Receptor species representative of the feeding guilds identified as AEs for this ERA were selected based on their potential to utilize the site, potential exposure to Site-related COPCs based on

feeding habits or habitat utilization, and the availability of data to determine exposure parameters. Life history information and exposure profiles for the selected receptor species can be found in Appendix C. Life history parameters from published literature sources that were selected for use in the dietary exposure models are presented in Table 4-5.

5.0 ANALYSIS PHASE

The analysis phase is Step 6 of the eight-step Superfund process (U.S. EPA 1997), and is the technical evaluation of existing and potential exposure and ecological effects at the Site. The analysis phase examines the two primary components of risk: exposure and effects. The objective is to determine or predict ecological responses under Site-specific exposure conditions.

5.1 CHARACTERIZATION OF EXPOSURE

The 95UCL and the mean of the arsenic concentrations measured in sediment, surface water and fish tissue were identified as the exposure point concentrations (EPCs) for this ERA. In accordance with current EPA guidance (U.S. EPA 2002), 95UCL values were derived using ProUCL V5.0 (U.S. EPA 2013). This software calculates UCLs for a data set using several different strategies, evaluating NDs using regression on order statistics (ROS). The software evaluates the alternative calculations and recommends the 95UCL that is considered preferable based on the properties of the data set. If a 95UCL could not be calculated or if the 95UCL was greater than the maximum measured value, the maximum measured concentration was used as the EPC.

Mean concentrations are Kaplan Meier (KM) means calculated using ProUCL 5.0, which incorporates not detected (ND) values into the calculation of the mean. For surface water samples, the reporting limit (RL) for arsenic in some previous sampling events was 8 micrograms per liter (µg/L), versus 1 µg/L in other events. KM means calculated for these surface water samples were equal to means calculated using only detected data. To account for the high RLs in some samples, mean values were also calculated using a value of half the RL for non-detects. To be conservative, the highest calculated mean values (KM mean or one half the RL substituted) were used in the screening tables and the dietary exposure models. Mean, maximum and 95UCL arsenic concentrations measured in surface water, sediment samples and fish collected from the Maurice River are summarized in Tables 3-1, 3-2 and 3-5.

For this ERA, four EAs were identified: the Maurice River ABC, Blackwater Branch, the Maurice River BBC, and the headwater area of Union Lake.

Eight species of fish were collected from the Blackwater Branch, the Maurice River, and the Union Lake headwater area for whole body analysis (Figure 3-3) as part of the 2009, 2011 and 2013 field investigations. Fish species used for whole-body analysis were pumpkinseed and red breast sunfish (Maurice River ABC); creek chubsucker and mud minnows (Blackwater Branch), red breast sunfish and yellow perch (Maurice River BBC); and pumpkinseed, white perch, channel catfish and bluegill sunfish (Union Lake headwater area). The fish tissue COPC concentrations used for exposure calculations were the mean measured concentration and the 95UCL (wet weight; ww) of arsenic in fish (Table 3-5).

Fish tissue TRVs (Table 4-2) were used to evaluate risk to fish in each of the EAs. Maximum and mean arsenic (the only COPC measured) in forage fish collected from the Maurice River and

the Union Lake headwater area were compared with tissue concentrations of arsenic reported in the literature that were associated with an adverse biological response. A literature search was conducted to locate studies that identified adverse effects in fish and reported whole-body tissue concentrations at which those effects were observed. Only studies where exposure occurred via water or diet, and where the observed adverse effects were on growth, reproduction or survival were summarized. As was done by Meador *et al.* (2002), the tissue concentration identified as the 10th percentile of the adverse effect concentrations reported in the compiled studies was selected as the residue effect threshold, or critical tissue concentration (CTC) (Meador *et al.* 2008). The tissue concentrations identified with the 10th percentile of the LOECs and NOECs reported in these studies were 4.3 mg/kg ww and 0.69 mg/kg ww, respectively (Table 4-2). The LOEC and NOEC values utilized in this calculation are summarized in Appendix D.

For terrestrial receptors (e.g., piscivorous birds and mammals), two separate EPC calculations were performed. Mean and 95UCL or maximum concentrations measured in surface water and surface sediment samples collected in the four EAs were calculated (Tables 7-2, 7-3, 7-4 and 7-5). Whole-body tissue samples of forage fish collected in 2009, 2011 and 2013 were used for the dietary exposure models in this ERA. Remediation of Blackwater Branch to Mill Road was completed in 2007, and remediation of downstream sections of Blackwater Branch was started in mid-2008 (U.S. EPA Region 2 2012). All remediation within Blackwater Branch was completed by 2011 (U.S. EPA Region 2 2011). The 2009 fish were included in this analysis, as remediation of the most contaminated section of Blackwater Branch nearest the Site was complete. Although all remedial activities were not complete in 2009, inclusion of the 2009 fish provides a conservative estimate of exposure. Total and inorganic arsenic were analyzed in fish tissue collected in 2011 and 2013, while inorganic arsenic was analyzed in fish collected in 2009. Dietary exposure models (described in Section 7) utilized both total arsenic and inorganic arsenic measured in fish (Table 3-5).

5.2 CHARACTERIZATION OF ECOLOGICAL EFFECTS

The analyses conducted to characterize potential effects from exposure to sediment, surface water, and fish at this Site to aquatic and piscivorous ecological receptors are described in Sections 6.0 and 7.0, respectively.

6.0 RISK EVALUATION FOR AQUATIC RECEPTORS

As discussed in Section 3, Site-related arsenic in Blackwater Branch, the Maurice River, and the headwater area of Union Lake may be of concern to a variety of aquatic receptors, including benthic and aquatic macroinvertebrates, and fish. As shown in the CSM (Figure 4-1), the exposure pathways of primary concern for exposure of aquatic receptors include:

- Direct contact with arsenic in surface water. This pathway is applicable to fish and benthic organisms that reside in the upper portion of the sediment substrate.

- Direct contact with arsenic in sediment. This pathway is most applicable to benthic invertebrate species that live within the sediment substrate, but is also evaluated for fish that may have direct contact with sediment.

- Uptake of arsenic into fish tissue. Uptake of arsenic can be via direct contact with surface water, ingestion of food or surface water, or incidental ingestion of sediment.

Section 6.2 presents an evaluation of risks to aquatic receptors from exposure to surface water, and Section 6.3 presents the evaluation of risks from exposure to sediment. Section 6.4 discusses the toxicity test results, and Section 6.5 presents the results of the benthic macroinvertebrate community survey. Section 6.6 presents the evaluation of risk to fish based on comparison of measured COPC concentrations in fish tissue with concentrations cited in the literature associated with adverse effects on growth, reproduction or survival of fish.

6.1 HQ APPROACH

An HQ is the ratio of the estimated exposure of a receptor at a site to a benchmark exposure that is believed to be without significant risk of unacceptable adverse effect on survival, growth, or reproduction. Conservative benchmark values (NOECs) can be used to ensure that potential ecological threats are not overlooked. Chronic NOECs (or NOAELs) are exposure concentrations at which ecological effects are not expected. Chronic LOECs (or LOAELs) are exposure concentrations above which adverse effects can be expected. The HQ is calculated as:

$$HQ = \text{Exposure Concentration} / \text{Benchmark}$$

Exposure may be expressed in a variety of ways, including:

- Concentration in an environmental medium (water, sediment, soil, diet),
- Concentration in the tissues of an exposed receptor, and/or
- Amount of chemical ingested by a receptor.

In all cases, the benchmark toxicity value must be of the same type as the exposure estimate.

If the value of a calculated HQ is less than or equal to 1.0, risks to exposed organisms are thought to be minimal. If the HQ exceeds 1.0, the risk of adverse effects in exposed organisms may be of potential concern, with the probability and/or severity of adverse effect tending to increase as the value of the HQ increases[1].

In addition, HQ results may also be interpreted by comparing HQ values on-site to HQ values at a reference location (an area with similar habitat that has not been impacted by the Site). In general, this allows for two inferences. First, if HQ values at the Site are higher than HQ values at reference locations, this supports the conclusion that exposures at the Site have been increased due to Site-related COPCs. Second, if HQ values at reference locations tend to be substantially higher than 1.0, this suggests that exposure or toxicity values used in the HQ calculations might be somewhat over-conservative, since risks are not generally expected to be substantial in reference areas.

6.1.1 HQ-Based Risk Interpretation

- If neither the NOEC- or LOEC-based (or NOAEL- or LOAEL-based) HQs were greater than or equal to 1.0, it was concluded that there is no model-calculated risk to the given receptor.

- If the NOEC- or NOAEL-based HQ was greater than or equal to 1.0 but the LOEC- or LOAEL-based HQ was less than one, it was concluded that model-calculated risk could not be determined.

- A COPC concentration was considered to demonstrate model- calculated risk to the given receptor if both the NOEC- or NOAEL-based HQ and LOEC- or LOAEL-based HQ were greater than or equal to 1.0.

6.2 EVALUATION OF RISK FROM EXPOSURE TO SURFACE WATER

Site-specific data are available for total, disturbed and dissolved metals in surface water. Toxicity to aquatic receptors from exposure to surface water is dominated by the concentration of dissolved chemicals (U.S. EPA 1993), since chemicals that are adsorbed onto particulate matter may be less toxic than the dissolved forms. Therefore, all evaluations of exposure and risk for metals in water presented below are based on the dissolved metal concentration measured in surface water.

Conservative benchmark values (AWQC) were used in the HQ calculations to ensure that potential ecological threats were not overlooked. The benchmarks are acute and chronic NOECs, or the highest exposure concentrations at which acute or chronic ecological effects are not

[1] This is also dependent on the measured effect that a TRV or screening benchmark is based on. An HQ calculated using a TRV where the LOAEL is complete reproductive failure should be interpreted differently from a LOAEL TRV based on a statistically significant difference in egg production between test organisms and control birds.

expected. The mean used in the screening calculation is the highest mean (either the KM mean, top portion of Table 3-1 or the mean calculated using a value of half the reporting limit for NDs, bottom portion of Table 3-1). The surface water means were calculated two ways due to the high RLs in Year 1 (8 µg/L versus 1 µg/L); all surface water results in Year 1were ND. The mean calculated using the KM method was equal to the mean calculated using only detected results. The half the RL substitution method was added to conservatively account for the ND results when evaluating risk.

The results of the screen for exposure of aquatic receptors to COPCs in surface water are presented in Table 6-1. Calculated HQs were less than 1.0 for all four EAs (Table 6-1). The maximum measured dissolved concentration of arsenic in surface water was 3.6 µg/L in a sample collected in the Union Lake headwater area (Table 3-1), well below the chronic screening value for aquatic life (150 µg/L).

6.3 EVALUATION OF RISKS FROM EXPOSURE TO SEDIMENT

95UCL and mean COPC concentrations in sediment were screened against the consensus-based probable effect concentration (PEC) and threshold effect concentrations (TEC) values for sediment (MacDonald *et al.* 2000). If a 95UCL could not be calculated or if the 95UCL was greater than the maximum measured value, the maximum measured concentration was used as the EPC. Mean concentrations are KM means calculated using ProUCL 5.0, which incorporates ND values into the calculation of the mean.

The results of the screen for exposure of aquatic receptors to chemicals in sediment are presented in Table 6-2. Mean and 95UCL concentrations of arsenic in sediment in the Maurice River BBC and in the Union Lake headwater area exceeded the PEC screening benchmark (Table 6-2). The mean and 95UCL concentrations of arsenic in sediment in the Maurice River ABC and in Blackwater Branch were lower than the TEC screening benchmark.

6.4 SEDIMENT BIOASSAY RESULTS

6.4.1 *Hyalella azteca* 28-day test

Of the sixteen samples from the OU3 study area that were tested, significant mortality compared with mortality in the reference area sample was only observed in three of the downstream sediment samples (Tox-Sed 015, 018, and 025; Table 6-3). Eighty % mortality was observed in the sample with the highest arsenic concentration (1000 milligrams per kilogram [mg/kg]), while 34% mortality was observed in the sample with the second highest arsenic concentration (890 mg/kg). Percent survival data was transformed prior to calculating statistics. Mortality was strongly correlated with increasing arsenic concentration in sediment (Pearsons correlation coefficient [r] = -0.682; arsenic versus percent survival; probability [p] = 0.004) (Table 6-4).

Growth in site sediment samples compared with growth in the reference area sample was significantly reduced in three of the downstream samples (Tox-Sed 006, 016, and 017; Table 6-

3). Growth was not evaluated in samples where significant mortality was observed. Growth was not correlated with sediment arsenic concentration (r = -0.377) (Table 6.4). Statistical results and scatterplots are presented in Appendix E.

6.4.2 *Chironomus dilutus* 10-day test

Surivival of *C. dilutus* in all downstream samples was similar to reference survival. Growth (measured as ash free dry weight [AFDW]) of *C. dilutus* in samples collected at locations Tox Sed 15, 22 and 25 was significantly lower than growth of midges in the reference sediment (Table 6-3). The lowest growth was observed in the sample with the highest arsenic concentration (1000 mg/kg); however growth did not correlate with sediment arsenic (r = -0.264) (Table 6-4). Statistical results and scatterplots are presented in Appendix E.

6.4.3 Correlation of Toxicity Test Results with Other Analytes

Table 3-4 presents the analytical results from the sediment samples used for the bioassays. Aroclor 1260 was the only pesticide/PCB detected (three of fourteen samples), and acetophenone and bis(2-ethylhexyl)phthalate were the only SVOCs detected (four and one of fourteen samples, respectively) in the toxicity samples. The maximum measured concentration of Aroclor 1260 did not exceed the PEC; no PEC was available for the two detected SVOCs. The maximum measured concentration of four inorganics exceeded the PEC value (arsenic, chromium [Cr], lead [Pb] and zinc [Zn]). Correlation analyses were run to determine whether there was any relationship between the measured Cr, Pb or Zn concentrations in sediment and growth or survival. The measured Cr, Pb and Zn concentrations in toxicity test sediment were not significantly correlated with the observed effects on growth or survival (Table 6-4).

6.5 BENTHIC COMMUNITY SURVEY RESULTS

The benthic invertebrate community in the Maurice River and Union Lake is very diverse with high numerical abundance and is indicative of a healthy and robust ecosystem. The community is largely composed of insect larva with smaller numbers of adult insects, crustaceans, mollusks and annelids. In particular, a large, diverse number of sensitive taxa were collected throughout the study area including mayflies, stoneflies, and caddisflies. In addition, multiple generations of long lived taxa were present suggesting that reproductive success is common and unimpaired. At any particular sampling location high numbers of taxa and individuals were observed. However, there was high variability between sample replicates at all locations as well as between locations. This shift in taxonomic composition and numeric abundance was not a result of a wholesale shift or reduction in major taxonomic groups, but rather a partial exchange of one taxa for another. The variations generally reflect the diversity of habitat types within the hydrosystem and the multi-habitat sampling technique used.

6.6 EVALUATION OF RISKS BASED ON FISH TISSUE CONCENTRATIONS

Studies reviewed to develop the fish CTC for arsenic and reported effects are described in detail in Appendix C.

The results of the comparison of measured concentrations of arsenic in fish tissue with NOEC and LOEC concentrations are presented in Table 6-5. Calculated HQs were less than 1.0 for all four EAs (Table 6-5). The maximum measured arsenic concentration (0.644 mg inorganic arsenic/kg ww) was measured in yellow perch collected from the Maurice River BBC in 2009 (Table 3-5); this concentration was below the NOEC concentration (0.69 mg/kg ww).

6.7 WEIGHT OF EVIDENCE EVALUATION FOR AQUATIC RECEPTORS

Five lines of evidence are available to evaluate risks to aquatic receptors in this ERA:

- HQ values based on measured surface water concentrations,
- HQ values based on measured sediment concentrations,
- Solid-phase sediment bioassay results,
- Benthic macroinvertebrate community survey metrics, and
- HQ values based on measured fish tissue concentrations.

None of the calculated HQs for surface water exceeded 1.0. Measured concentrations of arsenic in dissolved surface water samples were an order of magnitude below the chronic AWQC. The maximum measured concentration of arsenic in surface water was at a sampling location in the Maurice River BBC; total arsenic in a disturbed sample was 17 µg/L, well below the chronic AWQC of 150 µg/L. Therefore, potential risk to aquatic receptors from exposure to surface water in all four EAs is minimal.

Mean and 95UCL arsenic concentrations measured in sediment in the Maurice River BBC and the Union Lake headwater area exceeded the PEC, a concentration above which adverse effects on biota are probable (HQs of 5.2 and 6.6 in the Maurice River BBC and the Union Lake headwater area, respectively, calculated using 95UCL arsenic concentrations). There is calculated risk to aquatic receptors from exposure to Site-related arsenic in sediment in these two EAs. The HQs calculated for arsenic in the upstream reference samples did not exceed 1.0, supporting the conclusion that downstream exposures have been increased due to Site-related releases.

Significant mortality and significantly reduced growth of *H. azteca* was observed in three of the toxicity test samples. Significantly reduced growth of *C. dilutus* was also observed in three of the downstream toxicity test samples. While growth of either organism was not correlated with sediment arsenic concentrations, mortality of *H. azteca* was strongly correlated with increasing arsenic concentrations in sediment. There is potential risk to aquatic receptors based on this line of evidence.

The benthic invertebrate community in the Maurice River and Union Lake is very diverse with high numerical abundance and is indicative of a healthy and robust ecosystem. The community is largely composed of insect larva with smaller numbers of adult insects, crustaceans, mollusks and

annelids. In particular, a large, diverse number of sensitive taxa were collected throughout the study area including mayflies, stoneflies, and caddisflies. In addition, multiple generations of long lived taxa were present suggesting that reproductive success is common and unimpaired.

Measured concentrations of arsenic in fish tissue did not exceed the NOEC tissue concentration. Risk to fish due to arsenic bioaccumulation is negligible.

7.0 EVALUATION OF RISKS TO PISCIVOROUS BIRDS AND MAMMALS

Potential risks to birds and mammals were evaluated using dietary exposure models rather than based on direct contact with abiotic media, as was done for aquatic receptors (Section 6.0). Birds and mammals are upper trophic level consumers that are exposed to COPCs via ingestion of contaminated food items, surface water, or incidental soil/sediment ingestion; the ingestion exposure pathway is the primary exposure route for these receptors.

7.1 HQ APPROACH FOR DIETARY EXPOSURE

7.1.1 HQ Calculation

The equation used for calculation of an HQ value for exposure of a wildlife receptor to a chemical by ingestion of an environmental medium is:

$$HQ_{i,j,r} = \frac{C_{i,j} \cdot (IR_{j,r} / BW_r) \cdot AUF_r}{TRV_{i,r}}$$

where:

$HQ_{i,j,r}$	=	HQ for exposure of receptor "r" to chemical "i" in medium "j",
$C_{i,j}$	=	Concentration of chemical "i" in medium "j" (mg/kg),
$IR_{j,r}$	=	Intake rate of medium “j” by receptor “r” (kg per day [kg/day]),
BW_r	=	Body weight of receptor "r" (kg),
AUF_r	=	Area Use Factor of receptor “r”. This is the fraction of the receptor’s home range that is included within the EA being evaluated. If the calculated AUF is greater than 1, a value of 1 is used, and
$TRV_{i,r}$	=	Oral toxicity reference value for chemical "i" in receptor "r" (mg/kgBW/day).

Because wildlife receptors are exposed to more than one environmental medium, the total hazard quotient (HQ_t) for a receptor for a specific chemical is calculated as the sum of HQs across all relevant media:

$$HQ_{t\ i,j,r} = \sum HQ_{i,j,r}$$

where:

HQ_t	=	Total Hazard Quotient of receptor “r” to chemical “i” in all media (e.g., soil, sediment, surface water, food items), and
$HQ_{i,j,r}$	=	HQ for exposure of receptor "r" to chemical "i" in medium "j"

7.1.2 Toxicity Reference Values

The data used to derive TRVs for piscivorous birds and mammals are described in Appendix B. In general, wildlife TRVs were selected to represent relevant toxicity endpoints for population sustainability (growth, reproduction, mortality). Two types of TRVs were identified: those based on a NOAEL, and those based on a LOAEL. Ideally, TRVs used in the HQ calculations are selected for each individual feeding guild that is evaluated. However, because TRVs are typically not available for each feeding guild, this ERA uses more generic TRVs that are based on all birds or all mammals.

The NOAEL-based and LOAEL-based TRVs selected for use in the dietary exposure models are summarized in Table 4-2.

7.1.3 Selection of Representative Indicator Species

It is not feasible or necessary to evaluate exposures and risks for each avian and mammalian species potentially present at a site. Rather, receptors may be grouped into feeding guilds (groups of species with generally similar behaviors and feeding patterns), and one or more representative species within the feeding guild can be used as a surrogate to represent the entire guild (U.S. EPA 1997). Factors considered in the choice of the representative species included trophic level, feeding habits, and the availability of life history information. The species selected to serve as surrogate receptors for this ERA are mink, belted kingfisher and osprey. The mink was selected as a surrogate to model the effects of contaminants on a mammalian piscivore. It is recognized that mink may not actually occur within the study area, however the Site is well within the recorded range for mink, and mink are known to use similar habitat for feeding (Linscombe *et al.* 1982). Mink have been documented to utilize suitable habitat even if it occurs in urbanized areas (Mech 2003). Belted kingfisher and osprey were selected as surrogate species to model effects of arsenic exposure on an avian piscivore. Both species were observed in the EAs during field activities.

7.1.4 Exposure Factors

Exposure parameters and dietary intake factors for each representative species were derived from peer-reviewed literature sources. The exposure parameters selected for each wildlife receptor are detailed in Appendix C, and are summarized in Table 4-5. Wildlife exposure factors were selected to represent average year-round adult exposures. In some cases, no quantitative data could be located, so professional judgment was used in selecting exposure parameters.

Two exposure scenarios were evaluated for each receptor, a conservative exposure scenario (maximum or 95UCL measured COPC concentration, highest ingestion rate, lowest body weight) and a representative exposure scenario (KM mean COPC concentration, and the midpoint of the cited range for ingestion rates and body weights).

An AUF of 1 was used for all dietary exposure model calculations. Each of the EAs is at least 3 kilometers (km) stream length; both the mink and the belted kingfisher could obtain all of their forage within the identified EAs. A home range could not be located for osprey; it was conservatively assumed that osprey could obtain all of their forage within the identified EAs.

7.1.5 Exposure Areas

Surface runoff, discharge of contaminated groundwater, and downstream transport of contaminated sediment are the primary transport pathways at this site. Based on distance from the Site, the water bodies near the site may have been impacted to different degrees, therefore the following EAs for piscivorous receptors that are exposed primarily or entirely along creeks and rivers were identified for this ERA:

- Maurice River ABC
- Blackwater Branch
- Maurice River BBC
- Union Lake headwater area

7.1.6 Exposure Point Concentrations

The sediment and water EPCs used in the dietary exposure models were calculated using all surface water and surface sediment samples collected within each EA in the 2009 fish sampling event, the 2011 fish sampling event, the 2013 fish sampling event, and the 2012, 2013 and 2014 3-year monitoring study. Total concentrations from the disturbed surface water samples were used.

Forage fish were collected from three of the aquatic EAs in 2009, 2011 and 2013; forage fish were only collected from the Blackwater Branch in 2013. Fish collected in 2011 and 2013 were analyzed for total and inorganic arsenic, while fish collected in 2009 were only analyzed for inorganic arsenic. Sample sizes were sufficient to calculate a 95UCL for all three EAs.

Two exposure scenarios were evaluated for each receptor, a conservative exposure (95UCL or maximum measured COPC concentration, highest ingestion rate, lowest body weight) and a representative exposure scenario (KM mean COPC concentrations, and the midpoint of the cited range for ingestion rates and body weights). EPCs for semi-aquatic receptors are given in Table 7-1.

7.2 EVALUATION OF RISKS FROM DIETARY EXPOSURE FOR PISCIVOROUS BIRDS AND MAMMALS

Hazard quotient calculations for piscivorous birds and mammals are presented in Tables 7-2 to 7-4. As shown, all NOAEL-based HQs are less than 1.0. Therefore, there is no model-calculated risk to piscivorous receptors from dietary exposure to arsenic under any exposure scenario.

7.3 WEIGHT OF EVIDENCE EVALUATION FOR BIRDS AND MAMMALS

Only one line of evidence (the HQ approach) was used for evaluating potential risks to birds and mammals from arsenic in Site-impacted environmental media. Therefore, risk conclusions must be recognized as uncertain, and additional studies would be needed to determine if the HQ predictions are accurate.

There is no model-calculated risk to piscivorous receptors from dietary exposure to arsenic, the primary COPC of concern at this Site.

8.0. UNCERTAINTY ANALYSIS

Uncertainties and limitations are inherent in all ERAs and need to be considered when interpreting results. Knowledge of the sources of uncertainty, how the ERA dealt with them, and an understanding of the magnitude of the effects resulting from them allows for informed management decisions. The nature and magnitude of uncertainty depends on the amount and quality of data available, the degree of knowledge concerning the Site conditions, and the assumptions made to perform the ERA. Within this ERA, decisions regarding the direction of uncertainty erred towards the conservative; however, there are some instances for which insufficient information was available to estimate the direction of the uncertainty. The uncertainties related to problem formulation, exposure characterization, effects characterization, and risk characterization are discussed in the following sections.

8.1 PROBLEM FORMULATION

There are several sources of uncertainty within the problem formulation phase of the ERA. These include: the selection of AEs, and assumptions made within the CSM.

The selection of appropriate AEs and the surrogate receptor species used to characterize risk is a critical step within the problem formulation of an ERA. If a particular AE or receptor that may potentially be exposed to Site-related contaminants is overlooked or not identified, there will be an underestimation of risk. Within this ERA, surrogate receptor species were selected with the intent of targeting highly exposed, sensitive species. The uncertainty associated with the selection of species is often in the direction of over-estimation of risk for most species included within the assessment endpoint; however, it is possible that a species not selected as a receptor or individual organisms could have higher exposures than those calculated within this ERA.

The CSM presents the pathways by which contaminants are released from source areas and receptors are exposed. However, some exposure pathways are difficult to evaluate, or information does not exist to allow for a quantitative evaluation of exposure from particular exposure pathways. Within this ERA, dermal and inhalation exposure pathways are not addressed quantitatively. It is believed that these exposure pathways are not substantive relative to other exposure pathways (e.g., ingestion).

8.2 CHARACTERIZATION OF EXPOSURE

The uncertainties associated with exposure characterization include: quality of the data available; exposure parameters used in the dietary exposure models; exposure pathways not retained for quantitative evaluation; selection of representative species; exposure route assumptions; and the speciation of inorganic COPCs.

Arsenic was not detected in some sediment, surface water or fish tissue samples. In samples where it was not detected, conservative assumptions were made to account for the ND values. Mean concentrations are KM means calculated using ProUCL 5.0, which incorporates ND values

into the calculation of the mean. For surface water samples, the RL for arsenic in some previous sampling events was 8 µg/L, versus 1 µg/L in other events. KM means calculated for these surface water samples were equal to means calculated using only detected data. To account for the high RLs in some surface water samples, mean values were also calculated using a value of half the RL for NDs. To be conservative, the highest calculated mean values were used in the screening tables and the dietary exposure models. This approach may overestimate risk.

Certain assumptions were made relating to several exposure parameters that deviated from the information developed within the life history profiles of the receptors. For the AUF, which is the foraging area utilized by the receptor for the exposure model, a factor of 1.0 was applied. This assumption may overestimate the actual exposure of the selected receptors.

Contaminants in food items were assumed to exhibit 100% absorption efficiency; the risk estimated from dietary exposure is based on administered dose, not absorbed dose. This conservative assumption may overestimate actual risk to the receptors.

Modeling the dietary component of exposure of the avian and mammalian receptors utilized maximum and mean contaminant levels in food items. For this ERA, only collection of fish tissue samples was performed to estimate the Site-specific bioaccumulation of contaminants. It was assumed that these data are representative of the bioaccumulation within all the creeks and rivers that may have been impacted by theSsite and therefore appropriate for use in the exposure assessment. Data limitations related to variations in tissue concentrations due to seasonal changes, bioaccumulation in species not captured in this sampling effort, and specific exposure/bioaccumulation relationships could not be evaluated. The direction of the uncertainty due to these data limitations cannot be conclusively stated.

There is very little information available in the literature regarding the rates of incidental soil ingestion by wildlife species. The uncertainty related to incidental soil ingestion could either underestimate or overestimate exposure depending upon the species.

The dietary exposure models used simplified diets of one item with a static ingestion rate; in reality, each receptor organism's diet is varied, and the ingestion rate varies with food availability and metabolic needs (such as during growth of young and periods of metabolic stress). While reliance on a single forage item is not realistic over long time periods or even a growing season, it may not be implausible within the time frame relevant to the toxic mechanism of the contaminants. Organisms do not use the environment uniformly, but rather forage where food is most readily available to them. For this reason, the use of a single food item may not dramatically over-estimate exposure but also should not under-estimate actual exposures within relevant time frames.

It is widely recognized that bioavailability and toxicity can vary dramatically as a function of the speciation and/or partitioning of inorganic COPCs. Information was available for arsenic speciation in fish tissue. Inorganic arsenic is the most toxic form of arsenic. Dietary exposure

models were run using both total and inorganic arsenic in fish. It is unlikely that risk from dietary exposure to arsenic is substantively underestimated.

Fish were collected in 2009, 2011 and 2013. Remediation of Blackwater Branch to Mill Road was completed in 2007, and remediation of downstream sections of Blackwater Branch was started in mid-2008 (U.S. EPA Region 2 2012). All remediation within Blackwater Branch was completed by 2011 (U.S. EPA Region 2 2011). The 2009 fish were included in this analysis, as remediation of the most contaminated section of Blackwater Branch nearest the Site was complete. Although all remedial activities were not complete in 2009, inclusion of the 2009 fish likely provides a conservative estimate of exposure.

Total and inorganic arsenic were analyzed in fish tissue collected in 2011 and 2013, while inorganic arsenic was analyzed in fish collected in 2009. The sample size for calculating an EPC for total arsenic was limited in some EAs. Additionally, composite fish samples were analyzed in 2009 while individual fish were analyzed in 2011 and 2013. Within a data set, all samples should be either composite or discrete when calculating a 95UCL. The effects of including the different types of samples on the calculated EPC is unknown.

8.3 CHARACTERIZATION OF EFFECTS

Screening benchmarks are conservative estimates of chronic NOEC values assumed to be protective of most ecological receptors. Screening ecotoxicity values are used to ensure that potential risk is not underestimated. The screening benchmarks used to evaluate potential risk from direct contact with surface water and sediment (AWQC and the TEC values) may overestimate potential risk.

The fish CTC for arsenic was derived using studies that reported both a whole body arsenic concentration and an adverse effect concentration for growth, reproduction or survival of fish. The number of studies available for deriving CTCs is limited, however a systematic review process was followed to minimize the potential for under-estimating the toxicity of arsenic to fish.

Not all TRVs for birds and mammals represent the same degree of certainty. TRVs are primarily derived from laboratory animal studies. TRVs for this ERA were selected through a systematic process to minimize the potential for under-estimating the toxicity of COPCs to the AEs. A literature search was conducted to determine the chronic toxicity of arsenic when ingested by the indicator species. If no toxicity values could be located for the receptor species, values reported for a closely related species were used. All studies were critically reviewed to determine whether study design and methods were appropriate. When several toxicity values were reported for a receptor species, the most conservative value that resulted in an ecologically significant adverse effect was selected for use in the risk calculations, regardless of toxic mechanism. Toxicity values obtained from long-term feeding studies were used in preference to those obtained from single dose oral studies. No other safety factors were incorporated into this ERA.

Estimates of effect concentrations including NOAELs and LOAELs derived from the literature have inherent uncertainty. These values are reflective of the experimental design. For example, within a particular toxicity study the reported LOAEL and/or NOAEL is dependent upon the exposure levels selected within the study design. It is not known within these studies how much lower the "true" LOAEL may be or how much higher the "true" NOAEL may be. However, this uncertainty is believed to be relatively minor compared to other sources of uncertainty within the risk calculations of the ERA.

Error can be introduced by use of invalid assumptions in the CSM. Conservative assumptions were made in light of the uncertainty associated with the risk assessment process. This was done to minimize the possibility of concluding that no risk is present when a threat actually does exist (i.e., to eliminate false negatives). Whenever possible, risk calculations were based on conservative values. For example, LOAELs used to calculate HQs were the lowest values found in the literature for effects on growth, reproduction or survival, regardless of toxic mechanism.

9.0 CONCLUSION

Three AEs were selected to evaluate risk to ecological receptors at this Site: survival, growth and reproduction of benthic invertebrates, fish, and piscivorous birds and mammals.

Several lines of evidence were available to assess the risk to aquatic receptors in aquatic habitat areas potentially impacted by arsenic from the Vineland Chemical Company Site. Total and dissolved arsenic concentrations in surface water were well below the chronic AWQC for aquatic life. Although arsenic concentrations in sediment exceeded screening benchmarks, more weight should be placed on lines of evidence that incorporate Site-specific measures of arsenic bioavailability and toxicity, and that examine concentrations in and effects on actual organisms collected from the EAs (fish and benthic macroinvertebrates) or observations of organisms directly exposed to Site-impacted media (sediment toxicity tests). Arsenic concentrations in fish tissue were below tissue concentrations reported to be associated with adverse effects on fish growth, reproduction or survival. Mortality observed in solid-phase toxicity tests was correlated with sediment arsenic concentrations. Arsenic concentrations where mortality was significant were at the high end of the range of concentrations measured in the Maurice River BBC and the Union Lake headwater area. Although significant impacts on growth were observed in both invertebrate species utilized in the toxicity tests, the observed impacts were not correlated with sediment arsenic concentrations, or with any other detected COPCs that exceeded PEC screening concentrations.

Only one line of evidence (the HQ approach) was used to assess the risk to piscivorous birds and mammals exposed to arsenic present in sediment, surface water and prey tissue. This line of evidence suggests negligible risk from dietary exposure of piscivorous receptors to arsenic.

Hazard quotient values (both comparison to benchmarks and dietary exposure models) are based on predictive models, and are subject to the uncertainties inherent in both the estimates of exposure and the estimates of toxicity benchmarks. Therefore, HQ values should be interpreted as estimates rather than highly precise values. Site-specific lines of evidence such as toxicity testing and direct observations on the structure and function of a receptor community are evaluated to refine the risk estimates. All three lines of evidence were evaluated at this Site. Although comparison of sediment concentrations to sediment benchmarks indicated potential risk to aquatic organisms, comparison of surface water concentrations to screening benchmarks and comparison of measured fish tissue concentrations to CTCs indicated no potential risk to aquatic organisms. Mortality was only observed in the toxicity tests at exposure concentrations near the highest concentrations measured in the river and headwater area; potential localized adverse effects may occur where the maximum sediment arsenic concentrations are found. The benthic invertebrate community is very diverse with high numerical abundance, and is indicative of a healthy and robust ecosystem. The community is largely composed of insect larva with smaller numbers of adult insects, crustaceans, mollusks and annelids. Highly diverse sensitive taxa (mayflies, stoneflies, and caddisflys) were present in samples collected in potentially impacted downstream areas. Multiple generations of long lived taxa were present suggesting that reproductive success is common and unimpaired. Dietary exposure models using arsenic

concentrations measured in fish captured on-Site indicate no risk to upper trophic level receptors. Because the majority of the lines of evidence used to evaluate potential risk to ecological receptors in the Maurice River and Union Lake headwater area yield similar conclusions, confidence in the conclusion is greatly increased. The results of this ERA suggest that completed remedial activities at the Site are having a positive effect on arsenic concentrations in the Maurice River.

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Table 3-1. Summary Statistics for Arsenic in Surface Water Samples
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Exposure Area	Total Detected Arsenic Concentration (µg/L)				Detection Frequency	95UCL		Exposure Point Concentration (µg/L)	
	KM Mean	SD	Minimum	Maximum		Value	Statistic	Value	Rationale
Total									
Maurice River ABC	1.40	–	1.4	1.4	3 / 8	–	–	1.4	Max
Blackwater Branch	1.00	–	–	–	1 / 13	–	–	1	Max
Maurice River BBC	1.55	0.26	1.3	2	20 / 32	1.64	95% KM (BCA) UCL	1.64	95UCL
Union Lake Headwater	4.60	–	4.6	4.6	1 / 3	–	–	4.6	Max
Dissolved									
Maurice River ABC	1.17	0.06	1.1	1.2	3 / 6	–	–	1.2	Max
Blackwater Branch	–	–	–	–	0 / 13	–	–	U (1.39)	Max
Maurice River BBC	1.30	0.29	1	1.8	18 / 31	1.414	95% KM (% Bootstrap) UCL	1.414	95UCL
Union Lake Headwater	3.60	–	3.6	3.6	1 / 2	–	–	3.6	Max
Total, Disrupted									
Maurice River ABC	1.70	0.44	1.4	2.2	3 / 6	–	–	2.2	Max
Blackwater Branch	–	–	–	–	– / –	–	–	–	–
Maurice River BBC	2.69	3.57	1.3	17	20 / 31	3.643	95% KM (BCA) UCL	3.643	95UCL
Union Lake Headwater	4.70	–	4.7	4.7	1 / 2	–	–	4.7	Max
Dissolved, Disrupted									
Maurice River ABC	–	–	–	–	– / –	–	–	–	–
Blackwater Branch	–	–	–	–	– / –	–	–	–	–
Maurice River BBC	1.37	0.43	1	2.2	17 / 25	1.536	95% KM (BCA) UCL	1.536	95UCL
Union Lake Headwater	–	–	–	–	– / –	–	–	–	–

KM means calculated including NDs where the reporting limit was 8 µg/L (2009 and 2011 samples) were equal to means calculated using only detected values. Below, means were calculated using a value of 1/2 the RL to conservatively account for the uncertainty associated with the higher reporting limits.

Exposure Area	Total Arsenic Concentration (µg/L)				Detection Frequency	95UCL		Exposure Point Concentration (µg/L)	
	Mean [A]	SD	Minimum	Maximum		Value	Statistic	Value	Rationale
Total									
Maurice River ABC	3.03	1.35	1.4	U (4)	3 / 8	–	–	U (4)	Max
Blackwater Branch	0.68	0.46	U (0.2)	U (1.39)	1 / 13	–	–	U (1.39)	Max
Maurice River BBC	1.82	0.87	1.3	U (4)	20 / 32	1.559	95% KM (BCA) UCL	1.559	95UCL
Union Lake Headwater	4.20	0.35	4	4.6	1 / 3	–	–	4.6	Max
Dissolved									
Maurice River ABC	2.58	1.55	1.1	U (4)	3 / 6	–	–	U (4)	Max
Blackwater Branch	0.64	0.45	U (0.2)	U (1.39)	0 / 13	–	–	U (1.39)	Max
Maurice River BBC	1.55	0.87	0.5	U (4)	18 / 31	1.315	95% KM (t) UCL	1.315	95UCL
Union Lake Headwater	3.80	0.28	3.6	U (4)	1 / 2	–	–	U (4)	Max
Total, Disrupted									
Maurice River ABC	2.85	1.29	1.4	U (4)	3 / 6	–	–	U (4)	Max
Blackwater Branch	–	–	–	–	– / –	–	–	–	–
Maurice River BBC	2.76	2.97	1.3	17	20 / 31	3.454	95% KM (BCA) UCL	3.454	95UCL
Union Lake Headwater	4.35	0.49	4	4.7	1 / 2	–	–	4.7	Max
Dissolved, Disrupted									
Maurice River ABC	–	–	–	–	– / –	–	–	–	–
Blackwater Branch	–	–	–	–	– / –	–	–	–	–
Maurice River BBC	1.37	0.35	1	2.2	17 / 25	1.402	95% KM (BCA) UCL	1.402	95UCL
Union Lake Headwater	–	–	–	–	– / –	–	–	–	–

[A] Mean was calculated using a value of 1/2 the reporting limit for non-detects

µg/L = micrograms per liter
95UCL = 95% upper confidence limit
95% KM (BCA) UCL = UCL based on bias-corrected accelerated bootstrap method
95% KM (t) UCL = UCL based on Kaplan-Meier method using the t-distribution cutoff value
95% KM (% Bootstrap) UCL = UCL based on percentile bootstrap method
U = not detected at indicated reporting limit
Max = maximum
SD = standard deviation
Surface water samples were not collected at the Blackwater Branch Sampling location
ABC = Above Blackwater Branch confluence
BBC = BelowBlackwater Branch confluence

Table 3-2. Summary Statistics for Total Arsenic in Sediment Samples
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Exposure Area	Total Arsenic Concentration (mg/kg dw)				Detection Frequency	95UCL (mg/kg dw)		Exposure Point Concentration (mg/kg dw)	
	KM Mean	SD	Minimum	Maximum		Value	Statistic	Value	Rationale
Maurice River ABC	3.7	3.5	U (0.68)	8.6	8 / 10	5.779	95% KM (t) UCL	5.779	95UCL
Blackwater Branch	1.02	–	–	–	1 / 1	–	–	1.02	Maximum
Maurice River BBC	49.02	205.8	U (0.29)	1000	43 / 70	172.9	97.5% KM (Chebyshev) UCL	172.9	95UCL
Union Lake Headwater	136.2	165.5	U (0.6)	1100	146 / 157	217.9	97.5% KM (Chebyshev) UCL	217.9	95UCL

mg/kg dw = milligrams per kilogram dry weight
95UCL = 95% upper confidence limit
95% KM (Chebyshev) UCL = UCL based on Kaplan-Meier method using the Chebyshev inequality
95% KM (t) UCL = UCL based on Kaplan-Meier method using the t-distribution cutoff value
KM mean = Kaplan Meier mean
SD = standard deviation
ABC = Above Blackwater Branch confluence
BBC = BelowBlackwater Branch confluence

Table 3-3. Arsenic in Sediment Samples Selected for Toxicity Testing
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Location	Arsenic (mg/kg dw)
TOX-SED-002 (Upstream Reference Control)	1.1
TOX-SED-014	31
TOX-SED-013	33
TOX-SED-019	33
TOX-SED-022	79
TOX-SED-025	110
TOX-SED-016	190
TOX-SED-011	220
TOX-SED-012	230
TOX-SED-005	280
TOX-SED-017	290
TOX-SED-009	380
TOX-SED-007	390
TOX-SED-006	430
TOX-SED-018	890
TOX-SED-015	1000

mg/kg dw = milligrams per kilogram dry weight

Table 3-4. Summary Statistics for Detected Analytes in Sediment Samples Submitted for Toxicity Testing
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Analyte	Mean (mg/kg dw)	SD	Minimum (mg/kg dw)	Maximum (mg/kg dw)	Detection Frequency	TEC (mg/kg dw)	PEC (mg/kg dw)
Inorganics							
Aluminum	6940.0	5636.5	1100	17000	15 / 15	–	–
Arsenic	305.7	291.9	31 [A]	1000	15 / 15	9.79	33
Barium	147.7	123.8	4.8	320	14 / 15	–	–
Beryllium	1.1	1.1	0.115	2.9	9 / 15	–	–
Cadmium	1.5	1.4	0.145	3.8	12 / 15	0.99	4.98
Calcium	1813.9	1557.4	59	4700	15 / 15	–	–
Chromium	50.3	45.9	5.3	140	15 / 15	43.4	111
Cobalt	14.7	15.0	1.2	56	13 / 15	–	–
Copper	17.4	14.8	3	43	15 / 15	31.6	149
Iron	21226.7	22278.4	1600	57000	15 / 15	–	–
Lead	74.9	72.7	10	220	15 / 15	35.8	128
Magnesium	445.3	403.4	51	1100	15 / 15	–	–
Manganese	135.9	105.1	23	360	15 / 15	–	–
Nickel	17.5	17.3	0.95	45	13 / 15	22.7	48.6
Potassium	175.3	164.9	29.5	480	11 / 15	–	–
Vanadium	55.3	63.2	5.9	190	15 / 15	–	–
Zinc	113.7	111.0	4.1	300	15 / 15	121	459
Pesticides/PCBs							
Aroclor-1260	0.103	0.1	0.0305	0.27	3 / 14	0.0598	0.676
Semi-Volatile Organic Compounds							
Acetophenone	0.363	0.235	0.100	0.750	4 / 14	–	–
Bis(2-ethylhexyl)phthalate	0.392	0.231	0.100	0.750	1 / 14	–	–

Shading indicates concentration exceeds the TEC
Shading indicates concentration exceeds the PEC

Screening benchmark for total PCBs used for individual aroclors
[A] Arsenic measured in the upstream reference sample (TOX-SED-002) was 1.1 mg/kg

mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation
TEC = Threshold effect concentration
PEC = Probable effect concentration
PCB = Polychlorinated biphenyl

Table 3-5. Summary Statistics for Total and Inorganic Arsenic in Fish Tissue Samples
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Exposure Area	Total Arsenic Concentration (mg/kg ww)				Detection Frequency	95UCL		Exposure Point Concentration (mg/kg ww)	
	KM Mean	SD	Minimum	Maximum		Value	Statistic	Value	Rationale
Maurice River ABC	0.117	0.072	0.031	0.222	6 / 6	0.176	95% Student's-t UCL	0.176	95UCL
Blackwater Branch	0.159	0.057	0.101	0.238	4 / 4	0.226	95% Student's-t UCL	0.226	95UCL
Maurice River BBC	0.270	0.147	0.155	0.496	6 / 6	0.391	95% Student's-t UCL	0.391	95UCL
Union Lake Headwater	0.388	0.147	0.204	0.561	6 / 6	0.51	95% Student's-t UCL	0.51	95UCL

Exposure Area	Inorganic Arsenic Concentration (mg/kg ww)				Detection Frequency	95UCL		Exposure Point Concentration (mg/kg ww)	
	KM Mean	SD	Minimum	Maximum		Value	Statistic	Value	Rationale
Maurice River ABC	0.011	0.006	0.005	0.018	7 / 9	0.0139	95% KM (BCA) UCL	0.0142	95UCL
Blackwater Branch	0.006	0.001	0.005 (U)	0.007	3 / 4	–	–	0.007	Maximum
Maurice River BBC	0.161	0.153	0.061	0.644	16 / 16	0.238	95% Adjusted Gamma UCL	0.238	95 UCL
Union Lake Headwater [1]	0.180	0.143	0.021	0.494	18 / 18	0.238	95% Student's-t UCL	0.238	95UCL

[1] Includes fish captured at location NUL (North Union Lake) in 2009
mg/kg ww = milligrams per kilogram wet weight
KM mean = Kaplan Meier mean
SD = standard deviation
95% KM (BCA) UCL = UCL based on bias-corrected accelerated bootstrap method
95% KM (Chebyshev) UCL = UCL based on Kaplan-Meier method using the Chebyshev inequality
95% Student's-t UCL = UCL based on Student's-t statistic
ABC = Above Blackwater Branch confluence
BBC = BelowBlackwater Branch confluence
U indicates no detected at indicated reporting limit

Table 4-1. Screening Benchmarks Selected for Use in this Ecological Risk Assessment
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Analyte	Surface Water, chronic (µg/L)	Surface Water, acute (µg/L)	Sediment, TEC (mg/kg)	Sediment, PEC (mg/kg)
Arsenic	150	340	9.79	33

µg/L = micrograms per liter
mg/kg = milligrams per kilogram

Surface water screening benchmarks are the National Recommended Ambient Water Quality Criteria. U.S. EPA. (2015, Monday, September 15, 2015). "National Recommended Water Quality Criteria." http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.

Sediment screening benchmarks are the Sediment Quality Guidelines (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.

µg/L = micrograms per liter
mg/kg = milligrams per kilogram
TEC = Threshold effect concentration
PEC = Probable effect concentration

Table 4-2. Toxicity Reference Values Selected for Use in this Ecological Risk Assessment
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Analyte	Tissue Concentration (mg/kg ww)	
	LOEC	NOEC
Arsenic, Fish	4.3	0.69

mg/kg ww = milligrams per kilogram wet weight
LOEC = Lowest observed effect concentration
NOEC = No observed effect concentration

Analyte	Dietary Concentration (mg/kg/day)	
	LOAEL	NOAEL
Arsenic, Bird	2.3	1.6
Arsenic, Mammal	9.63	1.91

mg/kg/day = milligrams per kilogram body weight per day
LOAEL = Lowest observed adverse effect concentration
NOAEL = No observed adverse effect concentration

Table 4-3. Critical Tissue Concentrations Cited for Fish Exposed to Arsenic
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Common name	Scientific name	NOEC (mg/kg ww)	LOEC (mg/kg ww)	NOEC (mg/kg dw)	LOEC (mg/kg dw)	Route of exposure	Life stage	Duration of Exposure	Observed effect	Reference
Bluegill	*Lepomis macrochirus*	1.8	11.7			water, diet, sediment	juvenile	16 weeks	Reduced growth and survival	Gilderhus 1966
Bluegill	*Lepomis macrochirus*	1.51	5.6			water, diet, sediment	juvenile	16 weeks	Reduced growth and survival	Gilderhus 1966
Bluegill	*Lepomis macrochirus*	0.97	2.24			water, diet, sediment	juvenile	16 weeks	Reduced growth	Gilderhus 1966
Bluegill	*Lepomis macrochirus*	0.52	0.97			water, diet, sediment	juvenile	16 weeks	Reduced survival	Gilderhus 1966
Bluegill	*Lepomis macrochirus*	0.49	0.76			water, diet, sediment	adult	16 weeks	abnormal ovary and oocyte development	Gilderhus 1966
Rainbow trout	*Onchorhynchus mykiss*	0.25	1.2			water	fingerling	11 weeks	survival	McGeachy and Dixon 1990
Rainbow trout	*Onchorhynchus mykiss*		2.8			water	fingerling	11 weeks	LD28	McGeachy and Dixon 1990
Rainbow trout	*Onchorhynchus mykiss*	0.45	1.7			water	fingerling	11 weeks	survival	McGeachy and Dixon 1990
Rainbow trout	*Onchorhynchus mykiss*		3.4			water	fingerling	11 weeks	LD7	McGeachy and Dixon 1990
Tilapia	*Oreochromis mossambicus*		4.8		19.1	water	9 month males	4 week	growth	Tsai et al. 2012
Rainbow trout	*Onchorhynchus mykiss*	1.15		4.6			parr	28 days	survival	Spehar et al. 1980
Killifish	*Fundulus heteroclitus*		11.24			water		96 hours	survival -- LD70 for naïve fish	Shaw et al. 2007
Killifish	*Fundulus heteroclitus*		5.99			water		96 hours	survival -- LD20 for pre-acclimated fish	Shaw et al. 2007
Rainbow trout	*Onchorhynchus mykiss*	0.69	6.65	2.76	26.6	Diet	fry	67 days	Reduced growth	Hansen et al. 2004
Rainbow trout	*Onchorhynchus mykiss*	0.69	5.075	2.76	20.3	Diet	fry	67 days	Reduced growth	Hansen et al. 2004
Rainbow trout	*Onchorhynchus mykiss*	0.69	5.975	2.76	23.9	Diet	fry	67 days	Reduced growth	Hansen et al. 2004
Rainbow trout	*Onchorhynchus mykiss*	2.325	4.425	9.3	17.7	diet	juvenile	28 days	25 or greater reduction in growth	Erickson et al. 2011
Rainbow trout	*Onchorhynchus mykiss*	2.05	4.3	8.2	17.2	water plus diet	juvenile	28 days	25 or greater reduction in growth	Erickson et al. 2011
Rainbow trout	*Onchorhynchus mykiss*	2.05	4.575	8.2	18.3	diet	juvenile	28 days	25 or greater reduction in growth	Erickson et al. 2011
Rainbow trout	*Onchorhynchus mykiss*	2.05	8	8.2	32	water plus diet	juvenile	28 days	25 or greater reduction in growth	Erickson et al. 2011
	10th percentile	0.69	4.30							

Critical tissue concentrations cited in mg/kg dw were converted to wet weight using a percent solids value of 25% cited for bony fish (U.S. EPA 1993)
LOEC = Lowest Observed Effect Concentration
NOEC = No Observed Effect Concentration
mg/kg ww = milligrams per kilogram wet weight
mg/k dw = milligrams per kilogram dry weight
LD 50 = Dose lethal to 50% of exposed fish

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Table 4-4. Assessment Endpoints and Measures of Exposure and Effects for the Maurice River Ecological Risk Assessment
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Assessment Endpoint	Measures of Exposure/Effects	Surrogate Receptor Species
Survival, growth and reproduction of benthic invertebrates	Compare mean and maximum measured concentrations of COPCs in sediment and surface water to screening benchmark values	NA
	Toxicity tests were conducted; survival and growth of benthic invertebrates in site sediment and in a control sediment was evaluated	
	A benthic community survey was conducted; density and diversity in site-impacted streams will be compared with a suitable reference area.	
Survival, growth and reproduction of fish	Compare mean and 95UCL or maximum measured concentrations of COPCs in sediment and surface water to screening benchmark values	NA
	Mean and 95 UCL or maximum concentrations of COPCs measured in fish tissue were compared with fish tissue concentrations reported in the literature associated with adverse effects.	
Survival, growth and reproduction of piscivorous birds and mammals	Mean and 95UCL or maximum concentrations of COPCs measured in fish tissue were used in food chain models to calculate dietary exposure of selected receptor species. Calculated dietary exposure concentrations were compared with TRVs for COPCs obtained from the literature for birds and mammals.	Belted Kingfisher, Osprey Mink

COPC = Contaminant of Potential Concern
TRV = Toxicity Reference Value
95UCL = 95% upper confidence limit
NA = Not applicable
Sediment Quality Guidelines (McDonald et al. 2000) and National Ambient Water Quality Criteria will be used to evaluate risk to aquatic receptors

Table 4-5. Life History Exposure Parameters for Food Chain Model Receptor Species
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Receptor	Exposure Scenario	Body Weight (kg)	Water Ingestion Rate (L/day)	Food Ingestion Rate (kg/day ww)	Sediment Ingestion Rate (kg/day dw)	Home Range (km stream length)	Dietary Composition (%)		
							Fish	Plant	Invertebrate
Belted Kingfisher	Conservative	0.1043	0.013	0.1007	0.000043	0.3893	100	0	0
	Representative	0.1493	0.0165	0.0573	0.000024	2.485	100	0	0
Osprey	Conservative	1.35	0.072	0.3993	0.000168	NA	100	0	0
	Representative	1.613	0.081	0.2212	0.000093	NA	100	0	0
Mink	Conservative	0.39	0.084	0.4083	0.00022	0.75	100	0	0
	Representative	1.079	0.0664	0.2326	0.00012	2.929	100	0	0

kg = kilogram
kg/day ww = kilograms per day wet weight
kg/day dw = kilograms per day dry weight
km = kilometer
L/day = Liters per day
% = percent
Sources for the exposure parameters are provided in Appendix A

Table 6-1. Screening Results for Aquatic Receptors from Direct Contact with Surface Water, 95UCL and Mean Measured Concentrations
Ecological Risk Assessment
Vineland Chemical Site

Exposure Area	Acute Aquatic SW Screening Level (µg/L)	95UCL or Maximum Concentration (µg/L)	Hazard Quotient (HQmax)	Mean Concentration (µg/L)	Hazard Quotient (HQmean)	Chronic Aquatic SW Screening Level (µg/L)	95UCL or Maximum Concentration (µg/L)	Hazard Quotient (HQmax)	Mean Concentration (µg/L)	Hazard Quotient (HQmean)
Dissolved										
Maurice River ABC	340	U (4)	0.01	2.58	0.01	150	U (4)	0.03	2.58	0.02
Blackwater Branch	340	U (1.39)	0.00	U (0.64)	0.00	150	U (1.39)	0.01	U (0.64)	0.00
Maurice River BBC	340	1.414	0.00	1.55	0.00	150	1.414	0.01	1.55	0.01
Union Lake Headwaters	340	U (4)	0.01	3.80	0.01	150	U (4)	0.03	3.80	0.03
Dissolved, Disrupted										
Maurice River ABC	340	–	–	–	–	150	–	–	–	–
Blackwater Branch	340	–	–	–	–	150	–	–	–	–
Maurice River BBC	340	1.536	0.00	1.37	0.00	150	1.536	0.01	1.37	0.01
Union Lake Headwaters	340	–	–	–	–	150	–	–	–	–

– = Not analyzed
Surface water samples were not collected from the Blackwater Branch exposure area
The maximum EPCs from Table 3-1 were selected for this screen. For dissolved samples, the maximum values were the EPCs calculated using a value of 1/2 the reporting limit for non-detects
U = not detected at the indicated value which is 1/2 the reporting limit
µg/L = micrograms per liter
HQ = Hazard quotient
95UCL = 95% upper confidence limit

Table 6-2. Screening Results for Aquatic Receptors from Direct Contact with Sediment, 95UCL and Mean Measured Concentrations
Ecological Risk Assessment
Vineland Chemical Site

Exposure Area	Probable Effect Concentration (mg/kg)	95UCL Concentration (mg/kg)	Hazard Quotient (HQmax)	KM Mean Concentration (mg/kg)	Hazard Quotient (HQmean)	Threshold Effect Concentration (mg/kg)	95UCL Concentration (mg/kg)	Hazard Quotient (HQmax)	KM Mean Concentration (mg/kg)	Hazard Quotient (HQmean)
Maurice River ABC	33	5.779	0.2	3.7	0.1	9.79	5.779	0.6	3.7	0.4
Blackwater Branch	33	1.02	0.0	–	–	9.79	1.02	0.1	–	–
Maurice River BBC	33	172.9	**5.2**	49.02	**1.5**	9.79	172.9	**17.7**	49.02	**5.0**
Union Lake Headwaters	33	217.9	**6.6**	136.2	**4.1**	9.79	217.9	**22.3**	136.2	**13.9**

Bold text, shading indicates HQ greater than 1.0

mg/kg = milligrams per kilogram
KM = Kaplan Meier
95UCL = 95% upper confidence limit
Note: 95UCLs are computed using the KM mean

Table 6-3. Solid-Phase Toxicity Test Results
Ecological Risk Assessment
Vineland Chemical Site

Endpoint	Lab control	Tox Sed 002	Tox Sed 005	Tox Sed 006	Tox Sed 007	Tox Sed 009	Tox Sed 011	Tox Sed 012	Tox Sed 013	Tox Sed 014	Tox Sed 015	Tox Sed 016	Tox Sed 017	Tox Sed 018	Tox Sed 019	Tox Sed 022	Tox Sed 025
Sample Location	NA	Reference	Union Lake Dam	Union Lake Dam	Union Lake Dam	Union Lake Dam	Union Lake Dam	Union Lake Dam	Union Lake Dam	Union Lake Dam	Almond Beach	Almond Beach	Almond Beach	Almond Beach	Almond Beach	Almond Beach	Almond Beach
(mg/kg dw)	NA	1.1	280	430	390	380	220	230	33	31	1000	190	290	890	33	79	110
Hyalella azteca																	
Mean % Survival	96	96	100	96	92	86	88	92	100	88	20	80	80	66	90	88	72
Mean Dry Weight	0.18	0.146	0.166	0.094	0.103	0.136	0.2	0.178	0.146	0.161	–	0.085	0.076	–	0.171	0.113	–
Chironomus dilutus																	
Mean % Survival	92	88	94	86	82	90	90	90	88	92	92	90	92	88	86	86	88
Mean AFDW	0.921	0.678	0.763	0.672	0.721	0.693	0.694	0.764	0.707	0.662	0.491	0.673	0.724	0.68	0.795	0.53	0.501

Shading indicates statistically different from the Reference area

Table 6-4. Correlation of Selected Inorganic Sediment Concentrations with Toxicity Testing Endpoints
Ecological Risk Assessment
Vineland Chemical Site

Analyte	Mean (mg/kg)	Maximum (mg/kg)	*H. azteca* survival			*H. azteca* growth			*C. dilutus* growth		
			r	p-value	n	r	p-value	n	r	p-value	n
Arsenic	305.7	1000	-0.682	0.004	16	-0.377	0.205	13	-0.264	0.324	16
Chromium	50.3	140	0.006	0.983	16	-0.213	0.484	13	0.085	0.753	16
Lead	74.9	220	0.180	0.505	16	-0.149	0.627	13	0.240	0.371	16
Zinc	113.7	300	0.307	0.248	16	0.034	0.912	13	0.385	0.141	16

Shading indicates concentration exceeds the Threshold Effect Concentration
Shading indicates concentration exceeds the Probable Effect Concentration

Significant at $p \leq 0.01$
mg/kg = milligrams per kilogram

Percent survival data were transformed prior to running statistical tests
r = Pearson Correlation Coefficient
n = sample size

Table 6-5. Comparison of 95UCL and Mean Measured Total Arsenic Concentrations in Fish Tissue with Critical Tissue Concentrations
Ecological Risk Assessment
Vineland Chemical Site

Exposure Area	Lowest Observed Effect Concentration (mg/kg ww)	95UCL Concentration (mg/kg ww)	Hazard Quotient (HQmax)	KM Mean Concentration (mg/kg ww)	Hazard Quotient (HQmean)	No Observed Effect Concentration (mg/kg ww)	95UCL Concentration (mg/kg ww)	Hazard Quotient (HQmax)	KM Mean Concentration (mg/kg ww)	Hazard Quotient (HQmean)
Maurice River ABC	4.3	0.176	0.0	0.117	0.0	0.69	0.176	0.3	0.117	0.2
Blackwater Branch	4.3	0.226	0.1	0.159	0.0	0.69	0.226	0.3	0.159	0.2
Maurice River BBC	4.3	0.3	0.1	0.225	0.1	0.69	0.3	0.4	0.225	0.3
Union Lake Headwaters	4.3	0.51	0.1	0.388	0.1	0.69	0.51	0.7	0.388	0.6

95UCL = 95% upper confidence limit
mg/kg ww = milligrams per kilogram wet weight
HQ = Hazard Quotient
ABC = Above Blackwater Branch confluence
BBC = Below Blackwater Branch Confluence
KM = Kaplan Meier

Table 7-1. Exposure Point Concentrations, By Exposure Area
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Exposure Scenario	Location	Analyte	Exposure Point Concentrations			
			Surface Water (Total, disrupted)	Surface Water (Total, disrupted)	Sediment	Fish [A]
			µg/L	mg/L	mg/kg dw	mg/kg ww
Conservative	Maurice River ABC	Arsenic	4	0.004000	5.779	0.176
	Blackwater Branch	Arsenic	1.39	0.00139	1.02	0.226
	Maurice River BBC	Arsenic	3.454	0.003454	172.9	0.391
	Union Lake Headwater	Arsenic	4.7	0.004700	217.9	0.51
	Maurice River ABC	Inorganic Arsenic	4	0.004000	5.779	0.0142
	Blackwater Branch	Inorganic Arsenic	1.39	0.00139	1.02	0.007
	Maurice River BBC	Inorganic Arsenic	3.454	0.003454	172.9	0.238
	Union Lake Headwater	Inorganic Arsenic	4.7	0.004700	217.9	0.238
Representative	Maurice River ABC	Arsenic	2.85	0.002850	3.7	0.117
	Blackwater Branch	Arsenic	1	0.001	1.02	0.159
	Maurice River BBC	Arsenic	2.762	0.002762	49.02	0.270
	Union Lake Headwater	Arsenic	4.35	0.004350	136.2	0.388
	Maurice River ABC	Inorganic Arsenic	2.85	0.002850	3.7	0.011
	Blackwater Branch	Inorganic Arsenic	1	0.001	1.02	0.0058
	Maurice River BBC	Inorganic Arsenic	2.762	0.002762	49.02	0.161
	Union Lake Headwater	Inorganic Arsenic	4.35	0.004350	136.2	0.180

mg/kg dw = milligrams per kilogram dry weight
mg/kg ww = milligrams per kilogram wet weight
µg/L = micrograms per liter
mg/L = milligrams per liter

[A] Inorganic arsenic was only measured in fish tissue. Total arsenic was measured in sediment and surface water.

Table 7-2. Hazard Quotient Calculations for the Belted Kingfisher
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Conservative Exposure Scenario

INITIAL SETTINGS			0.000043			0.013			100	0.1007			1	0.1043				
Location	Analyte	Conc. In Sediment	Sediment Ingestion Rate	Total Intake through Sediment	Conc. In Surface Water	Water Ingestion Rate	Total Intake through Water	Conc. In Fish	Percent of Diet Fish	Food Ingestion Rate	Total Intake through Food	Total Intake	AUF	Body Weight	Dose	LOAEL	HQ LOAEL	NOAEL	HQ NOAEL
		mg/kg dw	kg/day dw	mg/day	mg/L	L/day	mg/L	mg/kg w.w.		kg/day w.w.	mg/day ww	mg/day		kg	mg/kg/day	mg/kg/day		mg/kg/day	
Maurice River ABC	Arsenic	5.779	0.000043	0.0002485	0.004000	0.013	0.000052	0.176	100	0.1007	0.0177232	0.01802	1	0.1043	0.1728063	2.3	0.08	1.6	0.11
Blackwater Branch	Arsenic	1.02	0.000043	0.00004386	0.001390	0.013	0.00001807	0.226	100	0.1007	0.0227582	0.02282	1	0.1043	0.2187932	2.3	0.10	1.6	0.14
Maurice River BBC	Arsenic	172.9	0.000043	0.0074347	0.003454	0.013	4.4902E-05	0.391	100	0.1007	0.0393737	0.04685	1	0.1043	0.4492167	2.3	0.20	1.6	0.28
Union Lake Headwater	Arsenic	217.9	0.000043	0.0093697	0.004700	0.013	0.0000611	0.51	100	0.1007	0.0513570	0.06079	1	0.1043	0.5828169	2.3	0.25	1.6	0.36
Maurice River ABC	Inorganic Arsenic	5.779	0.000043	0.0002485	0.004000	0.013	0.000052	0.0142	100	0.1007	0.0014299	0.00173	1	0.1043	0.0165910	2.3	0.01	1.6	0.01
Blackwater Branch	Inorganic Arsenic	1.02	0.000043	0.00004386	0.001390	0.013	0.00001807	0.007	100	0.1007	0.0007049	0.00077	1	0.1043	0.0073522	2.3	0.00	1.6	0.00
Maurice River BBC	Inorganic Arsenic	172.9	0.000043	0.0074347	0.003454	0.013	4.4902E-05	0.238	100	0.1007	0.0239666	0.03145	1	0.1043	0.3014976	2.3	0.13	1.6	0.19
Union Lake Headwater	Inorganic Arsenic	217.9	0.000043	0.0093697	0.004700	0.013	0.0000611	0.238	100	0.1007	0.0239666	0.03340	1	0.1043	0.3202052	2.3	0.14	1.6	0.20

Representative Exposure Scenario

INITIAL SETTINGS			0.000024			0.0165			100	0.0573			1	0.1493				
Location	Analyte	Conc. In Sediment	Sediment Ingestion Rate	Total Intake through Sediment	Conc. In Surface Water	Water Ingestion Rate	Total Intake through Water	Conc. In Fish	Percent of Diet Fish	Food Ingestion Rate	Total Intake through Food	Total Intake	AUF	Body Weight	Dose	LOAEL	HQ LOAEL	NOAEL	HQ NOAEL
		mg/kg dw	kg/day dw	mg/day	mg/L	L/day	mg/L	mg/kg w.w.		kg/day w.w.	mg/day ww	mg/day		kg	mg/kg/day	mg/kg/day		mg/kg/day	
Maurice River ABC	Arsenic	3.7	0.000024	8.9136E-05	0.002850	0.0165	4.7025E-05	0.117	100	0.0573	0.0066946	0.00683	1	0.1493	0.0457516	2.3	0.02	1.6	0.03
Blackwater Branch	Arsenic	1.0	0.000024	0.00002448	0.001	0.0165	0.0000165	0.159	100	0.0573	0.0091107	0.00915	1	0.1493	0.0612973	2.3	0.03	1.6	0.04
Maurice River BBC	Arsenic	49.02	0.000024	0.00117648	0.002762	0.0165	4.5572E-05	0.270	100	0.0573	0.0154710	0.01669	1	0.1493	0.1118088	2.3	0.05	1.6	0.07
Union Lake Headwater	Arsenic	136.2	0.000024	0.0032688	0.004350	0.0165	7.1775E-05	0.388	100	0.0573	0.0222515	0.02559	1	0.1493	0.1714138	2.3	0.07	1.6	0.11
Maurice River ABC	Inorganic Arsenic	3.7	0.000024	8.9136E-05	0.002850	0.0165	4.7025E-05	0.011	100	0.0573	0.0006246	0.00076	1	0.1493	0.0050953	2.3	0.00	1.6	0.00
Blackwater Branch	Inorganic Arsenic	1.0	0.000024	0.00002448	0.001	0.0165	0.0000165	0.006	100	0.0573	0.0003323	0.00037	1	0.1493	0.0025005	2.3	0.00	1.6	0.00
Maurice River BBC	Inorganic Arsenic	49.02	0.000024	0.00117648	0.002762	0.0165	4.5572E-05	0.161	100	0.0573	0.0092253	0.01045	1	0.1493	0.0699756	2.3	0.03	1.6	0.04
Union Lake Headwater	Inorganic Arsenic	136.2	0.000024	0.0032688	0.004350	0.0165	7.1775E-05	0.180	100	0.0573	0.0103045	0.01365	1	0.1493	0.0913933	2.3	0.04	1.6	0.06

mg/kg d.w. = milligrams per kilogram dry weight
mg/kg w.w. = milligrams per kilogram wet weight
kg = kilogram
mg/kg/day = milligrams per kilogram body weight per day
µg/L = micrograms per liter

dw = dry weight
ww = wet weight
AUF = Area Use Factor
LOAEL = Lowest observed adverse effect level
NOAEL = No observed advere effect level

HQ = Hazard Quotient
mg/L = milligrams per liter

Table 7-3. Hazard Quotient Calculations for the Osprey
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Conservative Exposure Scenario

INITIAL SETTINGS			0.000168			0.072			100	0.3993			1	1.35					
Location	Analyte	Conc. In Sediment	Sediment Ingestion Rate	Total Intake through Sediment	Conc. In Surface Water	Water Ingestion Rate	Total Intake through Water	Conc. In Fish	Percent of Diet Fish	Food Ingestion Rate	Total Intake through Food	Total Intake	AUF	Body Weight	Dose	LOAEL	HQ LOAEL	NOAEL	HQ NOAEL
		mg/kg dw	kg/day dw	mg/day	mg/L	L/day	mg/L	mg/kg w.w.		kg/day w.w.	mg/day ww	mg/day		kg	mg/kg/day	mg/kg/day		mg/kg/day	
Maurice River ABC	Arsenic	5.779	0.000168	0.00097087	0.004000	0.072	0.000288	0.176	100	0.3993	0.0702768	0.07154	1	1.35	0.0529894	2.3	0.02	1.6	0.03
Blackwater Branch	Arsenic	1.02	0.000168	0.00017136	0.001390	0.072	0.00010008	0.226	100	0.3993	0.0902418	0.09051	1	1.35	0.0670468	2.3	0.03	1.6	0.04
Maurice River BBC	Arsenic	172.9	0.000168	0.0290472	0.003454	0.072	0.00024869	0.391	100	0.3993	0.1561263	0.18542	1	1.35	0.1373498	2.3	0.06	1.6	0.09
Union Lake Headwater	Arsenic	217.9	0.000168	0.0366072	0.004700	0.072	0.0003384	0.51	100	0.3993	0.2036430	0.24059	1	1.35	0.1782138	2.3	0.08	1.6	0.11
Maurice River ABC	Inorganic Arsenic	5.779	0.000168	0.00097087	0.004000	0.072	0.000288	0.0142	100	0.3993	0.0056701	0.00693	1	1.35	0.0051325	2.3	0.00	1.6	0.00
Blackwater Branch	Inorganic Arsenic	1.02	0.000168	0.00017136	0.001390	0.072	0.00010008	0.007	100	0.3993	0.0027951	0.00307	1	1.35	0.0022715	2.3	0.00	1.6	0.00
Maurice River BBC	Inorganic Arsenic	172.9	0.000168	0.0290472	0.003454	0.072	0.00024869	0.238	100	0.3993	0.0950334	0.12433	1	1.35	0.0920958	2.3	0.04	1.6	0.06
Union Lake Headwater	Inorganic Arsenic	217.9	0.000168	0.0366072	0.004700	0.072	0.0003384	0.238	100	0.3993	0.0950334	0.13198	1	1.35	0.0977622	2.3	0.04	1.6	0.06

Representative Exposure Scenario

INITIAL SETTINGS			0.000093			0.081			100	0.2212			1	1.613					
Location	Analyte	Conc. In Sediment	Sediment Ingestion Rate	Total Intake through Sediment	Conc. In Surface Water	Water Ingestion Rate	Total Intake through Water	Conc. In Fish	Percent of Diet Fish	Food Ingestion Rate	Total Intake through Food	Total Intake	AUF	Body Weight	Dose	LOAEL	HQ LOAEL	NOAEL	HQ NOAEL
		mg/kg dw	kg/day dw	mg/day	mg/L	L/day	mg/L	mg/kg w.w.		kg/day w.w.	mg/day ww	mg/day		kg	mg/kg/day	mg/kg/day		mg/kg/day	
Maurice River ABC	Arsenic	3.7	0.000093	0.0003454	0.002850	0.081	0.00023085	0.117	100	0.2212	0.0258435	0.02642	1	1.613	0.0163793	2.3	0.01	1.6	0.01
Blackwater Branch	Arsenic	1.0	0.000093	0.00009486	0.001	0.081	0.000081	0.159	100	0.2212	0.0351708	0.03535	1	1.613	0.0219136	2.3	0.01	1.6	0.01
Maurice River BBC	Arsenic	49.02	0.000093	0.00455886	0.002762	0.081	0.00022372	0.270	100	0.2212	0.0597240	0.06451	1	1.613	0.0399917	2.3	0.02	1.6	0.02
Union Lake Headwater	Arsenic	136.2	0.000093	0.0126666	0.004350	0.081	0.00035235	0.388	100	0.2212	0.0858993	0.09892	1	1.613	0.0613257	2.3	0.03	1.6	0.04
Maurice River ABC	Inorganic Arsenic	3.7	0.000093	0.0003454	0.002850	0.081	0.00023085	0.011	100	0.2212	0.0024111	0.00299	1	1.613	0.0018520	2.3	0.00	1.6	0.00
Blackwater Branch	Inorganic Arsenic	1.0	0.000093	0.00009486	0.001	0.081	0.000081	0.006	100	0.2212	0.0012830	0.00146	1	1.613	0.0009044	2.3	0.00	1.6	0.00
Maurice River BBC	Inorganic Arsenic	49.02	0.000093	0.00455886	0.002762	0.081	0.00022372	0.161	100	0.2212	0.0356132	0.04040	1	1.613	0.0250439	2.3	0.01	1.6	0.02
Union Lake Headwater	Inorganic Arsenic	136.2	0.000093	0.0126666	0.004350	0.081	0.00035235	0.180	100	0.2212	0.0397791	0.05280	1	1.613	0.0327328	2.3	0.01	1.6	0.02

mg/kg d.w. = milligrams per kilogram dry weight
mg/kg w.w. = milligrams per kilogram wet weight
kg = kilogram
mg/kg/day = milligrams per kilogram body weight per day
µg/L = micrograms per liter

dw = dry weight
ww = wet weight
AUF = Area Use Factor
LOAEL = Lowest observed adverse effect level
NOAEL = No observed advere effect level

HQ = Hazard Quotient
mg/L = milligrams per liter

Table 7-4. Hazard Quotient Calculations for the Mink
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Conservative Exposure Scenario

INITIAL SETTINGS			0.00022			0.084			100	0.4083			1	0.39					
Location	Analyte	Conc. In Sediment	Sediment Ingestion Rate	Total Intake through Sediment	Conc. In Surface Water	Water Ingestion Rate	Total Intake through Water	Conc. In Fish	Percent of Diet Fish	Food Ingestion Rate	Total Intake through Food	Total Intake	AUF	Body Weight	Dose	LOAEL	HQ LOAEL	NOAEL	HQ NOAEL
		mg/kg dw	kg/day dw	mg/day	mg/L	L/day	mg/L	mg/kg w.w.		kg/day w.w.	mg/day ww	mg/day		kg	mg/kg/day	mg/kg/day		mg/kg/day	
Maurice River ABC	Arsenic	5.779	0.00022	0.00127138	0.004000	0.084	0.000336	0.176	100	0.4083	0.0718608	0.07347	1	0.39	0.1883799	9.63	0.02	1.91	0.10
		1.02	0.00022	0.0002244	0.001390	0.084	0.00011676	0.226	100	0.4083	0.0922758	0.09262	1	0.39	0.2374794	9.63	0.02	1.91	0.12
Maurice River BBC	Arsenic	172.9	0.00022	0.038038	0.003454	0.084	0.00029014	0.391	100	0.4083	0.1596453	0.19797	1	0.39	0.5076242	9.63	0.05	1.91	0.27
Union Lake Headwater	Arsenic	217.9	0.00022	0.047938	0.004700	0.084	0.0003948	0.51	100	0.4083	0.2082330	0.25657	1	0.39	0.6578610	9.63	0.07	1.91	0.34
Maurice River ABC	Inorganic Arsenic	5.779	0.00022	0.00127138	0.004000	0.084	0.000336	0.0142	100	0.4083	0.0057979	0.00741	1	0.39	0.0189878	9.63	0.00	1.91	0.01
		1.02	0.00022	0.0002244	0.001390	0.084	0.00011676	0.007	100	0.4083	0.0028581	0.00320	1	0.39	0.0082032	9.63	0.00	1.91	0.00
Maurice River BBC	Inorganic Arsenic	172.9	0.00022	0.038038	0.003454	0.084	0.00029014	0.238	100	0.4083	0.0971754	0.13550	1	0.39	0.3474450	9.63	0.04	1.91	0.18
Union Lake Headwater	Inorganic Arsenic	217.9	0.00022	0.047938	0.004700	0.084	0.0003948	0.238	100	0.4083	0.0971754	0.14551	1	0.39	0.3730979	9.63	0.04	1.91	0.20

Representative Exposure Scenario

INITIAL SETTINGS			0.00012			0.0664			100	0.2326			1	1.079					
Location	Analyte	Conc. In Sediment	Sediment Ingestion Rate	Total Intake through Sediment	Conc. In Surface Water	Water Ingestion Rate	Total Intake through Water	Conc. In Fish	Percent of Diet Fish	Food Ingestion Rate	Total Intake through Food	Total Intake	AUF	Body Weight	Dose	LOAEL	HQ LOAEL	NOAEL	HQ NOAEL
		mg/kg dw	kg/day dw	mg/day	mg/L	L/day	mg/L	mg/kg w.w.		kg/day w.w.	mg/day ww	mg/day		kg	mg/kg/day	mg/kg/day		mg/kg/day	
Maurice River ABC	Arsenic	3.7	0.00012	0.00044568	0.002850	0.0664	0.00018924	0.117	100	0.2326	0.0271754	0.02781	1	1.079	0.0257742	9.63	0.00	1.91	0.01
		1.0	0.00012	0.0001224	0.001	0.0664	0.0000664	0.159	100	0.2326	0.0369834	0.03717	1	1.079	0.0344506	9.63	0.00	1.91	0.02
Maurice River BBC	Arsenic	49.02	0.00012	0.0058824	0.002762	0.0664	0.00018339	0.270	100	0.2326	0.0628020	0.06887	1	1.079	0.0638256	9.63	0.01	1.91	0.03
Union Lake Headwater	Arsenic	136.2	0.00012	0.016344	0.004350	0.0664	0.00028884	0.388	100	0.2326	0.0903263	0.10696	1	1.079	0.0991281	9.63	0.01	1.91	0.05
Maurice River ABC	Inorganic Arsenic	3.7	0.00012	0.00044568	0.002850	0.0664	0.00018924	0.011	100	0.2326	0.0025353	0.00317	1	1.079	0.0029381	9.63	0.00	1.91	0.00
		10.2	0.00012	0.001224	0.001	0.0664	0.0000664	0.006	100	0.2326	0.0013491	0.00264	1	1.079	0.0024462	9.63	0.00	1.91	0.00
Maurice River BBC	Inorganic Arsenic	49.02	0.00012	0.0058824	0.002762	0.0664	0.00018339	0.161	100	0.2326	0.0374486	0.04351	1	1.079	0.0403284	9.63	0.00	1.91	0.02
Union Lake Headwater	Inorganic Arsenic	136.2	0.00012	0.016344	0.004350	0.0664	0.00028884	0.180	100	0.2326	0.0418292	0.05846	1	1.079	0.0541817	9.63	0.01	1.91	0.03

mg/kg d.w. = milligrams per kilogram dry weight
mg/kg w.w. = milligrams per kilogram wet weight
kg = kilogram
mg/kg/day = milligrams per kilogram body weight per day
µg/L = micrograms per liter

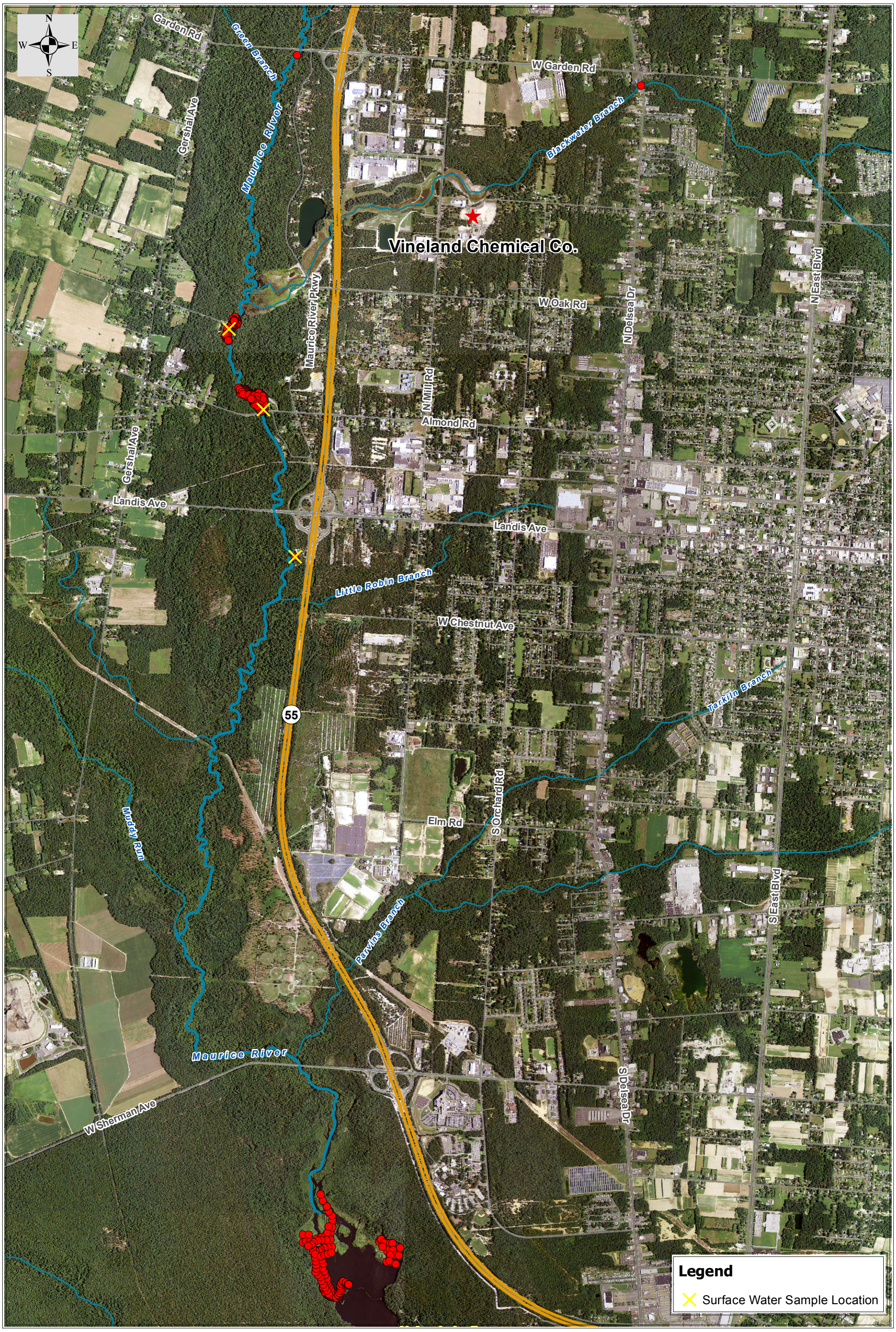
dw = dry weight
ww = wet weight
AUF = Area Use Factor
LOAEL = Lowest observed adverse effect level
NOAEL = No observed advere effect level

HQ = Hazard Quotient
mg/L = milligrams per liter

Table 7-5. Summary of Total Hazard Quotients Calculated for Piscivorous Birds and Mammals
Ecological Risk Assessment
OU3 of the Vineland Chemical Site

Location	Analyte	Conservative Exposure Scenario						Representative Exposure Scenario					
		Belted Kingfisher		Osprey		Mink		Belted Kingfisher		Osprey		Mink	
		LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL
Maurice River ABC	Arsenic	0.08	0.11	0.02	0.03	0.02	0.10	0.02	0.03	0.01	0.01	0.00	0.01
Blackwater Branch	Arsenic	0.10	0.14	0.03	0.04	0.02	0.12	0.03	0.04	0.01	0.01	0.00	0.02
Maurice River BBC	Arsenic	0.20	0.28	0.06	0.09	0.05	0.27	0.05	0.07	0.02	0.02	0.01	0.03
Union Lake Headwater	Arsenic	0.25	0.36	0.08	0.11	0.07	0.34	0.07	0.11	0.03	0.04	0.01	0.05
Maurice River ABC	Inorganic Arsenic	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Blackwater Branch	Inorganic Arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maurice River BBC	Inorganic Arsenic	0.13	0.19	0.04	0.06	0.04	0.18	0.03	0.04	0.01	0.02	0.00	0.02
Union Lake Headwater	Inorganic Arsenic	0.14	0.20	0.04	0.06	0.04	0.20	0.04	0.06	0.01	0.02	0.01	0.03

ABC = Above Blackwater Branch confluence
BBC = Below Blackwater Branch confluence
LOAEL = Lowest observed adverse effect concentration
NOAEL = No observed adverse effect concentration



Base map created using NAIP Imagery from USGS, Sample location GPS survey data from 2012, 2013, 2014.

Map Creation Date: 12 August 2015

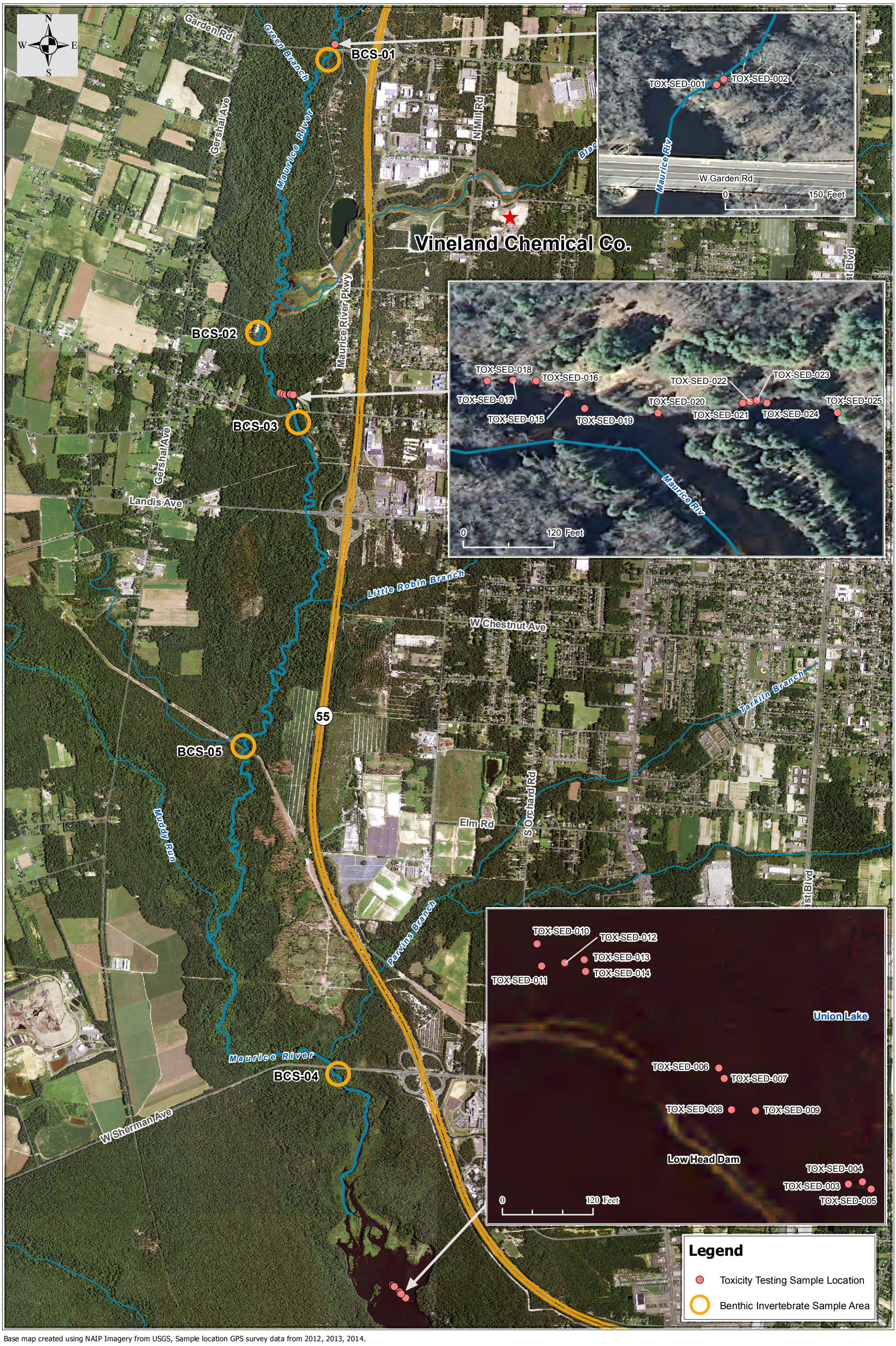
Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 2,400 4,800 Feet

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \ERA_Report_2015\185_ERA2015_f3-1_Y1Y2Y3_Sediment_SurfaceWater _SamplingLocation_f3-1.mxd

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-185

Figure 3-1
Sediment and Surface Water Sampling Locations
Year 1, Year 2 and Year 3
Maurice River Investigation
Vineland, NJ



Base map created using NAIP Imagery from USGS, Sample location GPS survey data from 2012, 2013, 2014.

Map Creation Date: 12 August 2015

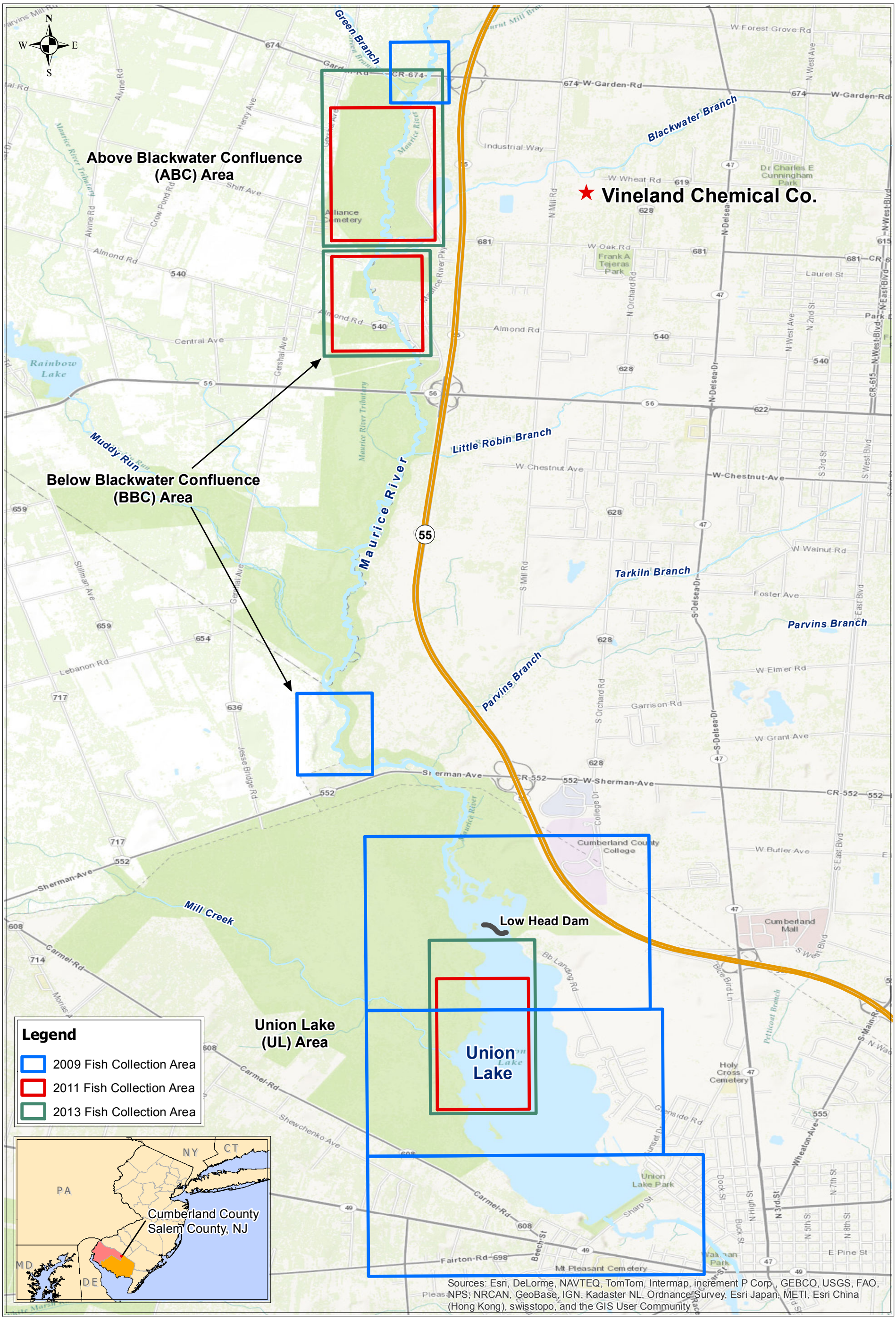
Coordinate system: New Jersey State Plane
FIPS: 2900
Datum: NAD83
Units: Feet

0 2,400 4,800 Feet

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \ERA_Report_2015\185_ERA2015_f3-2_Y1Y2Y3_toxicity_benthicM _SampleLocation_f3-2.mxd

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-185

Figure 3-2
Toxicity Test and Benthic Macroinvertebrate Sampling Locations
Year 1, Year 2 and Year 3
Maurice River Investigation
Vineland, NJ



Base map created using ESRI World Topographic Map, Sample location GPS survey data from 2009, 2011, 2013.

Map Creation Date: 12 August 2015

Coordinate system: GCS North American 1983
Datum: NAD83
Units: Feet

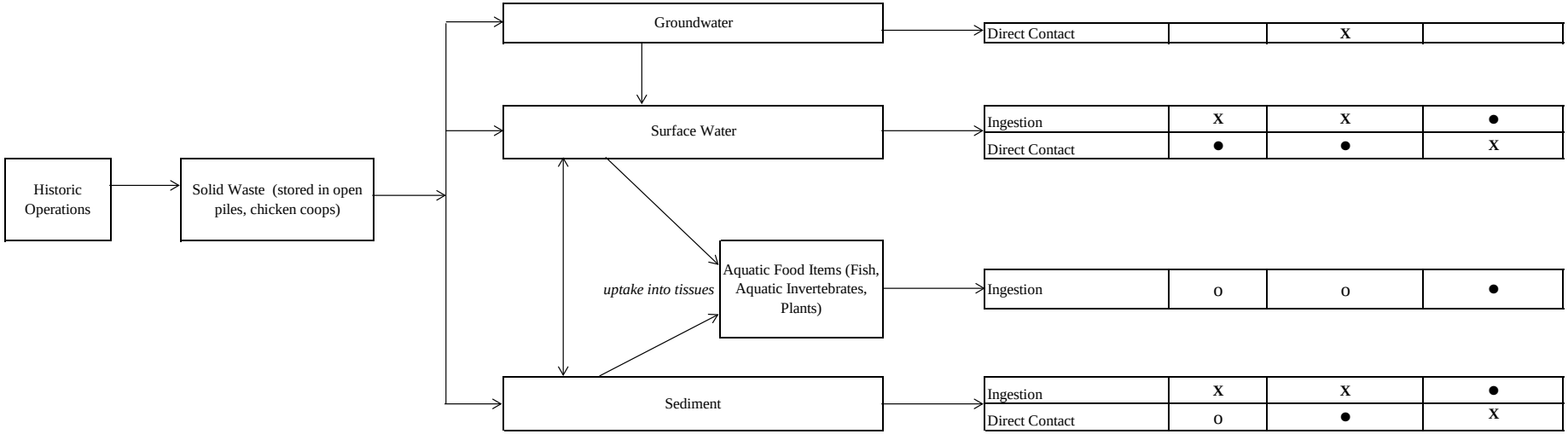
0 3,500 7,000 Feet

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-185

Figure 3-3
Fish Sampling Areas
Maurice River Investigation
Vineland, NJ

Data: g:\arcviewprojects\SERAS01\00-185
MXD file: g:\arcinfoprojects\SERAS01\SER00185_Maurice River_Site \ERA_Report_2015\185_ERA2015_f3-3_3Y_Fish_Sampling_Areas_f3-3.mxd

FIGURE 4-1. Conceptual Site Model for Ecological Exposure in the Maurice River and Union Lake Headwater Area



	Pathway is not complete, no evaluation required
X	Pathway is complete but probably cannot be evaluated quantitatively
●	Pathway is complete and could be significant, quantitative evaluation
o	Pathway is complete, limited quantitative evaluation may be possible

Appendix A
Rapid Bioassessment Protocol Field Data Sheets

NJDEP-BFBM **Biological Field Observations and Data Sheet HIGH Gradient**

Maurice River reference

Date/Time: 10/28/13 1254

Form Completed By: R. Henry

Quad: _____

Twp: _____

County: _____

Bridge # _____

Chemistries

- ____ Temperature (°C)
- ____ Conductivity (umhos)
- ____ DO (mg/L)
- ____ pH (SU units)

Canopy

- [X] Open
- [ ] Mostly Open
- [ ] Partly Open
- [ ] Mostly Closed
- [ ] Closed

Water Clarity

- [X] Clear
- [ ] Slightly Turbid
- [ ] Turbid

Color: Tea

Land Uses

- [ ] Agriculture: Cropland
- [ ] Agriculture: Livestock
- [ ] Commercial
- [ ] Urban
- [X] Suburban
- [ ] Rural
- [X] Forested
- [ ] Industrial
- [ ] Other:

Comments:

Bank Stability

- [X] Good
- [ ] Fair
- [ ] Poor

Stream Flow

- [ ] Slow
- [X] Moderate
- [ ] Fast

25 Width (ft)

3 Depth (ft)

Point Sources

- [ ] Discharges
- [ ] Storm Sewers
- [ ] Other

[ ] Downstream of impoundment

name:

approx. distance:

Substrate

- [ ] cobbles
- [X] gravel / sand
- [X] mud
- [ ] silt
- [X] snags
- [ ] root mats
- [X] undercut banks
- [ ] other: _____

Picture # ____Upstream ____Downstream

Sampling location: ____Upstream ____Downstream

Sampling device (D-Net) Surber Dredge

Present weather conditions: Clear

Previous 24 hr weather event: Clear

Bank Vegetation

- [X] trees
- [X] shrubs
- [X] grasses
- [ ] weeds
- [ ] vines
- [ ] other: _____

Other Observations: check all applicable

- [ ] fish
- [ ] frogs
- [ ] crayfish
- [ ] turtles
- [ ] clams / Unionid mussels
- [ ] Zebra Mussels
- [ ] macrophytes
- [ ] periphytes
- [ ] filamentous algae
- [ ] water fowl
- [ ] beaver dam
- [ ] oil sheen

(Record any other observations here)

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME Maurice River	LOCATION Reference	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
___% ☐	%cloud cover	☐ ___%
☒	clear/sunny	☒

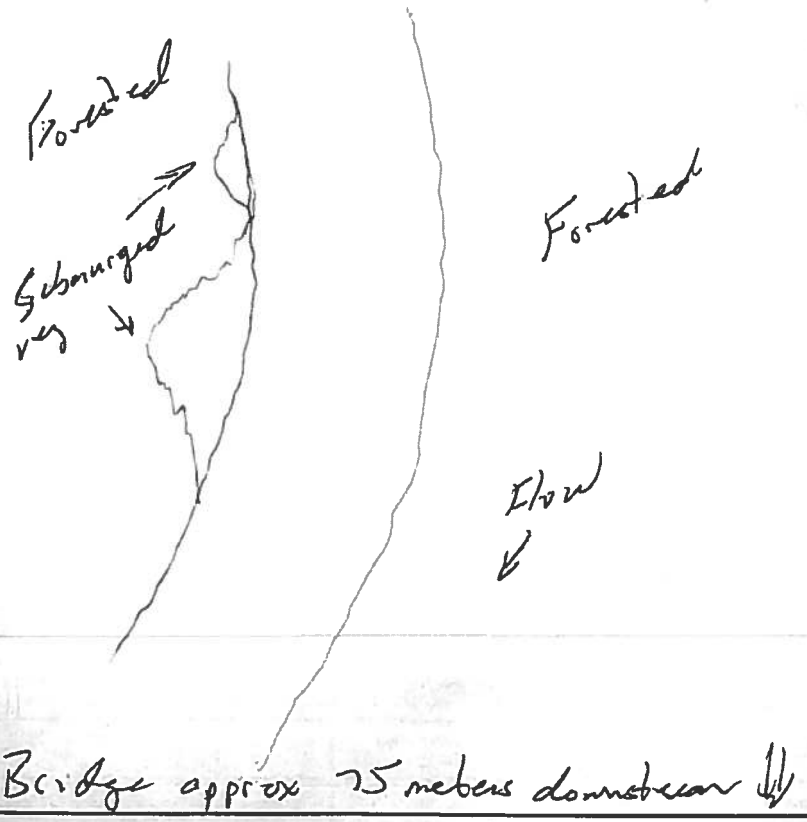
Has there been a heavy rain in the last 7 days? ☐ Yes ☒ No

Air Temperature 55 °C

Other_____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)



STREAM CHARACTERIZATION

Stream Subsystem
☒ Perennial ☐ Intermittent ☐ Tidal

Stream Type
☐ Coldwater ☒ Warmwater

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☒ Mixture of origins
☐ Swamp and bog ☐ Other_____

Catchment Area_____ km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES

Predominant Surrounding Landuse
- [x] Forest
- [ ] Commercial
- [ ] Field/Pasture
- [ ] Industrial
- [ ] Agricultural
- [ ] Other _____
- [x] Residential

Local Watershed NPS Pollution
- [ ] No evidence
- [x] Some potential sources
- [ ] Obvious sources

Local Watershed Erosion
- [ ] None
- [x] Moderate
- [ ] Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
- [x] Trees
- [x] Shrubs
- [ ] Grasses
- [ ] Herbaceous

dominant species present _____

INSTREAM FEATURES

Estimated Reach Length 100 m

Estimated Stream Width 25 m

Sampling Reach Area _____ m^2

Area in km^2 (m^2x1000) _____ km^2

Estimated Stream Depth 1 m

Surface Velocity (at thalweg) _____ m/sec

Canopy Cover
- [x] Partly open
- [ ] Partly shaded
- [ ] Shaded

High Water Mark _____ m

Proportion of Reach Represented by Stream Morphology Types
- [ ] Riffle _____ %
- [ ] Run 100 %
- [ ] Pool _____ %

Channelized
- [ ] Yes
- [x] No

Dam Present
- [ ] Yes
- [x] No

LARGE WOODY DEBRIS

LWD _____ m^2

Density of LWD _____ m^2/km^2 (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
- [x] Rooted emergent
- [x] Rooted submergent
- [ ] Rooted floating
- [ ] Free floating
- [ ] Floating Algae
- [ ] Attached Algae

dominant species present _____

Portion of the reach with aquatic vegetation 15 %

WATER QUALITY

Temperature _____ °C

Specific Conductance _____

Dissolved Oxygen _____

pH _____

Turbidity _____

WQ Instrument Used _____

Water Odors
- [x] Normal/None
- [ ] Sewage
- [ ] Petroleum
- [ ] Chemical
- [ ] Fishy
- [ ] Other _____

Water Surface Oils
- [ ] Slick
- [ ] Sheen
- [ ] Globs
- [ ] Flecks
- [x] None
- [ ] Other _____

Turbidity (if not measured)
- [ ] Clear
- [ ] Slightly turbid
- [ ] Turbid
- [ ] Opaque
- [x] Stained
- [ ] Other _____

SEDIMENT/ SUBSTRATE

Odors
- [x] Normal
- [ ] Sewage
- [ ] Petroleum
- [ ] Chemical
- [ ] Anaerobic
- [ ] None
- [ ] Other _____

Oils
- [x] Absent
- [ ] Slight
- [ ] Moderate
- [ ] Profuse

Deposits
- [ ] Sludge
- [ ] Sawdust
- [ ] Paper fiber
- [ ] Sand
- [ ] Relict shells
- [ ] Other _____

Looking at stones which are not deeply embedded, are the undersides black in color?
- [ ] Yes
- [ ] No
- NA

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	5
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)	90	Marl	grey, shell fragments	
Silt	0.004-0.06 mm	5			
Clay	< 0.004 mm (slick)	5			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations, presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive, embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score _____

NJDEP-BFBM Biological Field Observations and Data Sheet HIGH Gradient

BSC-2 (Springson Ave?)

Date/Time: 10/29/13 14:00
Form Completed By: Christopher Grossman

Quad: _____
Twp: _____
County: _____
Bridge # _____

Chemistries
- ____ Temperature (°C)
- ____ Conductivity (umhos)
- ____ DO (mg/L)
- ____ pH (SU units)

Water Clarity
- [x] Clear
- [ ] Slightly Turbid
- [ ] Turbid

Color: TEA

Bank Stability
- [ ] Good
- [ ] Fair
- [ ] Poor

Stream Flow
- [ ] Slow
- [x] Moderate
- [ ] Fast

4.5 Width (ft)
2 Depth (ft)

Substrate
- [ ] cobbles
- [✓] gravel / sand
- [ ] mud
- [ ] silt
- [ ] snags
- [ ] root mats
- [ ] undercut banks
- [ ] other: _____

Bank Vegetation
- [x] trees 2
- [ ] shrubs
- [ ] grasses
- [x] weeds herbaceous
- [ ] vines
- [ ] other: _____

Canopy
- [ ] Open
- [x] Mostly Open
- [ ] Partly Open
- [ ] Mostly Closed
- [ ] Closed

Land Uses
- [ ] Agriculture: Cropland
- [ ] Agriculture: Livestock
- [ ] Commercial
- [ ] Urban
- [ ] Suburban
- [✓] Rural
- [✓] Forested
- [ ] Industrial
- [✓] Other: SWIMMING AREA OF LAKE

Point Sources
- [ ] Discharges
- [ ] Storm Sewers
- [ ] Other

- [ ] Downstream of impoundment
  - name:
  - approx. distance:

Comments:

Picture # ____Upstream ____Downstream
Sampling location: ____Upstream ____Downstream

Sampling device D-Net Surber Dredge

Present weather conditions: FAIR
Previous 24 hr weather event: FAIR

Other Observations:–check all-applicable
(Record any other observations here)
- [ ] fish
- [ ] frogs
- [ ] crayfish
- [✓] turtles (1)
- [ ] clams / Unionid mussels
- [ ] Zebra Mussels
- [ ] macrophytes
- [ ] periphytes
- [ ] filamentous algae
- [ ] water fowl
- [ ] beaver dam
- [ ] oil sheen
- [✓] TADPOLE
- [✓] SALAMANDER

Field Sheet 10/06

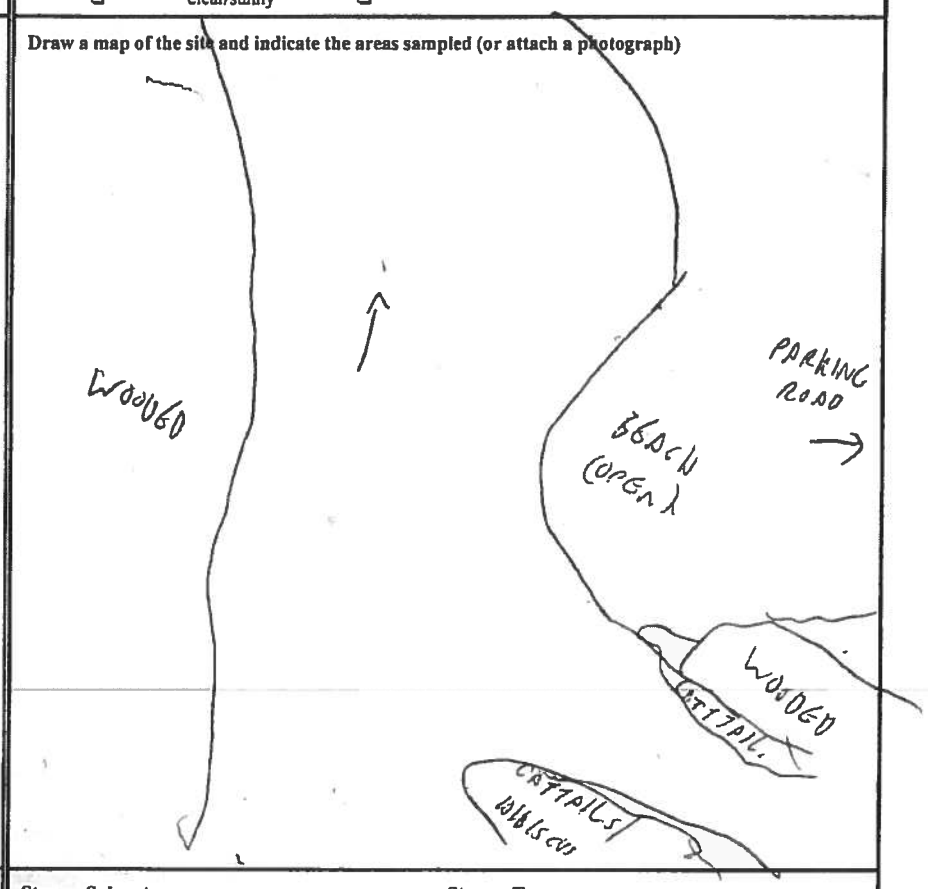
PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME	LOCATION BCS-02 (EPPINGER ALE)	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY C. GUSSMAN	DATE 10/29/13 TIME 2:00 AM (PM)	REASON FOR SURVEY BENTHIC COMMUNITY SURVEY

WEATHER CONDITIONS	**Now**	**Past 24 hours**	**Has there been a heavy rain in the last 7 days?** ☐ Yes ☒ No
	☐ storm (heavy rain)	☐	Air Temperature 20 °C
	☐ rain (steady rain)	☐	
	☐ showers (intermittent)	☐	Other_____
	30 %☒ %cloud cover	☐ ___%	
	☐ clear/sunny	☐	

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)



STREAM CHARACTERIZATION	**Stream Subsystem** ☒ Perennial ☐ Intermittent ☐ Tidal	**Stream Type** ☐ Coldwater ☒ Warmwater
	Stream Origin ☐ Glacial ☐ Non-glacial montane ☐ Swamp and bog ☐ Spring-fed ☒ Mixture of origins ☐ Other_____	**Catchment Area**_____km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☑ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other _____ ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☐ Obvious sources **Local Watershed Erosion** ☐ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☑ Trees ☑ Shrubs ☑ Grasses ☐ Herbaceous PANA **dominant species present** RED MAPLE, MIKO BAK, UNKNOWN CLEMATIS, OAK ASTER – Sing.
INSTREAM FEATURES	**Estimated Reach Length** 100 m **Estimated Stream Width** 14 m **Sampling Reach Area** _____ m² **Area in km² (m²x1000)** _____ km² **Estimated Stream Depth** 0.5 m **Surface Velocity (at thalweg)** _____ m/sec **Canopy Cover** ☑ Partly open ☐ Partly shaded ☐ Shaded **High Water Mark** _____ m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle _____ % ☐ Run 100 % ☐ Pool _____ % **Channelized** ☐ Yes ☑ No **Dam Present** ☐ Yes ☑ No
LARGE WOODY DEBRIS	**LWD** _____ m² MINIMAL **Density of LWD** _____ m²/km² (LWD/ reach area)
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☑ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae MINIMAL **dominant species present** Sagittaria **Portion of the reach with aquatic vegetation** <1 %
WATER QUALITY	**Temperature** _____ °C **Specific Conductance** _____ **Dissolved Oxygen** _____ **pH** _____ **Turbidity** _____ **WQ Instrument Used** _____ **Water Odors** ☑ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other _____ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☑ None ☐ Other _____ **Turbidity (if not measured)** ☑ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other _____
SEDIMENT/ SUBSTRATE	**Odors** ☑ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other _____ **Oils** ☑ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand ☐ Relict shells ☐ Other _____ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	<1
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	25
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)	90	Marl	grey, shell fragments	–
Silt	0.004-0.06 mm	5			
Clay	< 0.004 mm (slick)	5			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY C. GUSSMAN	DATE 10/29/13 TIME 2:00 AM (PM)	REASON FOR SURVEY BENTHIC COMMUNITY ANALYSIS

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion, high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score _____

NJDEP-BFBM Biological Field Observations and Data Sheet HIGH Gradient

ALMOND BEACH
BCS-03

Date/Time: 10/29/31 / 15:00
Form Completed By: C. GUSSMAN

Quad: _____
Twp: _____
County: _____

Bridge # _____

Chemistries
- ____ Temperature (°C)
- ____ Conductivity (umhos)
- ____ DO (mg/L)
- ____ pH (SU units)

Canopy
- [ ] Open
- [✓] Mostly Open
- [ ] Partly Open
- [ ] Mostly Closed
- [ ] Closed

Water Clarity
- [ ] Clear
- [✓] Slightly Turbid
- [ ] Turbid

Color: TEA

Land Uses
- [ ] Agriculture: Cropland
- [ ] Agriculture: Livestock
- [ ] Commercial
- [ ] Urban
- [ ] Suburban
- [✓] Rural
- [✓] Forested
- [ ] Industrial
- [✓] Other: SWIMMING BEACH NEARBY

Comments:

Bank Stability
- [✓] Good
- [ ] Fair
- [ ] Poor

Stream Flow
- [ ] Slow
- [✓] Moderate
- [ ] Fast

Point Sources
- [ ] Discharges
- [ ] Storm Sewers
- [ ] Other

50 Width (ft)
4 Depth (ft)

[ ] Downstream of impoundment
name
approx. distance

Substrate
- [ ] cobbles
- [✓] gravel / sand
- [ ] mud
- [✓] silt
- [ ] snags
- [ ] root mats
- [ ] undercut banks
- [✓] other: DEAD LEAVES

Picture # ____Upstream ____Downstream
Sampling location: ____Upstream ____Downstream

Sampling device D-Net Surber Dredge

Present weather conditions: FAIR
Previous 24 hr weather event: FAIR

Bank Vegetation
- [✓] trees
- [ ] shrubs
- [ ] grasses
- [✓] weeds
- [ ] vines
- [✓] other: EMERGENT

Other Observations: check all applicable
- [ ] fish
- [ ] frogs
- [ ] crayfish
- [ ] turtles
- [ ] clams / Unionid mussels
- [ ] Zebra Mussels
- [ ] macrophytes
- [ ] periphytes
- [ ] filamentous algae
- [ ] water fowl
- [ ] beaver dam
- [ ] oil sheen

(Record any other observations here)

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME MANUELE RIVER	LOCATION ALMOND BEACH (BCS-03)
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY C. GUSSMAN	DATE 10/29/17 TIME 13:00 AM (PM)
REASON FOR SURVEY BENTHIC COMMUNITY SURVEY, As effect	

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
20 % ☑	%cloud cover	☐ ___ %
☑	clear/sunny	☐

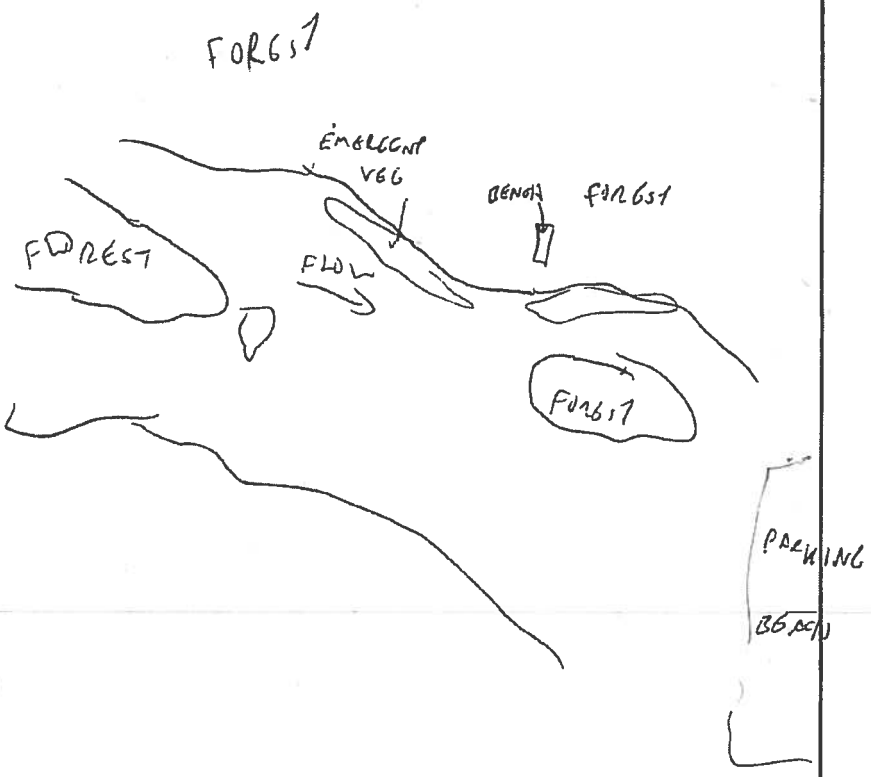
Has there been a heavy rain in the last 7 days? ☐ Yes ☑ No

Air Temperature 19 °C

Other_____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)



STREAM CHARACTERIZATION

Stream Subsystem
☑ Perennial ☐ Intermittent ☐ Tidal

Stream Type
☐ Coldwater ☑ Warmwater

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☑ Mixture of origins
☐ Swamp and bog ☐ Other_____

Catchment Area_____ km^2

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES

Predominant Surrounding Landuse
☑ Forest ☐ Commercial
☐ Field/Pasture ☐ Industrial
☐ Agricultural ☑ Other RECREATION SWIMMING/FISHING
☐ Residential

Local Watershed NPS Pollution
☑ No evidence ☐ Some potential sources
☐ Obvious sources

Local Watershed Erosion
☐ None ☐ Moderate ☐ Heavy

RIPARIAN VEGETATION (18 meter buffer)

Indicate the dominant type and record the dominant species present
☑ Trees ☐ Shrubs ☐ Grasses ☑ Herbaceous
dominant species present Pitch Pine/red maple/white cedar. EMERGENT Juncus & scattered patches of RUSH

INSTREAM FEATURES

Estimated Reach Length 20 m
Estimated Stream Width 3 m
Sampling Reach Area _____ m²
Area in km² (m²x1000) _____ km²
Estimated Stream Depth 1 m (Varies)
Surface Velocity (at thalweg) _____ m/sec

Canopy Cover
☑ Partly open ☐ Partly shaded ☐ Shaded

High Water Mark _____ m

Proportion of Reach Represented by Stream Morphology Types
☐ Riffle _____ % ☐ Run _____ %
☐ Pool _____ %

Channelized ☐ Yes ☐ No

Dam Present ☐ Yes ☐ No

LARGE WOODY DEBRIS

LWD _____ m²
Density of LWD _____ m²/km² (LWD/ reach area)

AQUATIC VEGETATION

Indicate the dominant type and record the dominant species present
☑ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating
☐ Floating Algae ☐ Attached Algae
dominant species present Juncus
Portion of the reach with aquatic vegetation 5 % (Edges)

WATER QUALITY

Temperature _____ °C
Specific Conductance _____
Dissolved Oxygen _____
pH _____
Turbidity _____
WQ Instrument Used _____

Water Odors
☑ Normal/None ☐ Sewage
☐ Petroleum ☐ Chemical
☐ Fishy ☐ Other _____

Water Surface Oils
☐ Slick ☐ Sheen ☐ Globs ☐ Flecks
☑ None ☐ Other _____

Turbidity (if not measured)
☐ Clear ☑ Slightly turbid ☐ Turbid
☐ Opaque ☐ Stained ☐ Other _____

SEDIMENT/ SUBSTRATE

Odors
☑ Normal ☐ Sewage ☐ Petroleum
☐ Chemical ☐ Anaerobic ☐ None
☐ Other _____

Oils
☐ Absent ☐ Slight ☐ Moderate ☐ Profuse

Deposits
☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand
☐ Relict shells ☐ Other _____

Looking at stones which are not deeply embedded, are the undersides black in color?
☐ Yes ☐ No N/A

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	10
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	5
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)	80	Marl	grey, shell fragments	
Silt	0.004-0.06 mm	10			
Clay	< 0.004 mm (slick)	10			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION BCS-03 ALMOND BEACH	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY C. GUSSMAN	DATE 11/29/13 TIME 1:00 AM PM	REASON FOR SURVEY As IMPACT BENTHIC COMMUNITY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 (12) 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal, stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score _____

NJDEP-BFBM Biological Field Observations and Data Sheet HIGH Gradient

BCS-04
SHERMAN AVE
(~100 YDS D.S. of Bridge)

Date/Time: 10/29/13 / 16:30
Form Completed By: C. GUSSMAN

Quad: _____
Twp: _____
County: _____
Bridge # _____

Chemistries
- ____ Temperature (°C)
- ____ Conductivity (umhos)
- ____ DO (mg/L)
- ____ pH (SU units)

Water Clarity
- [ ] Clear
- [x] Slightly Turbid
- [ ] Turbid

Color: TEA

Bank Stability
- [x] Good
- [ ] Fair
- [ ] Poor

Stream Flow
- [ ] Slow
- [x] Moderate
- [ ] Fast

50 Width (ft)
2-3 Depth (ft)

Substrate
- [ ] cobbles
- [x] gravel / sand
- [ ] mud
- [ ] silt
- [ ] snags
- [ ] root mats
- [ ] undercut banks
- [ ] other: _____

Bank Vegetation
- [x] trees
- [x] shrubs
- [x] grasses
- [ ] weeds
- [ ] vines
- [ ] other: _____

Canopy
- [ ] Open
- [x] Mostly Open
- [ ] Partly Open
- [ ] Mostly Closed
- [ ] Closed

Land Uses
- [ ] Agriculture: Cropland
- [ ] Agriculture: Livestock
- [ ] Commercial
- [ ] Urban
- [ ] Suburban
- [ ] Rural
- [x] Forested
- [ ] Industrial
- [x] Other: SHERMAN AVE ~100 YDS AWAY

Point Sources
- [ ] Discharges
- [ ] Storm Sewers
- [x] Other
- [ ] Downstream of impoundment
  - name:
  - approx. distance

Comments:

Picture # ____Upstream ____Downstream
Sampling location: ____Upstream ____Downstream

Sampling device D-Net Surber Dredge

Present weather conditions: FAIR
Previous 24 hr weather event: FAIR

Other Observations: check all applicable
- [ ] fish
- [ ] frogs
- [ ] crayfish
- [ ] turtles
- [ ] clams / Unionid mussels
- [ ] Zebra Mussels
- [ ] macrophytes
- [ ] periphytes
- [ ] filamentous algae
- [ ] water fowl
- [ ] beaver dam
- [ ] oil sheen
- [x] salamanders

(Record any other observations here)

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME MAURICE RIVER	LOCATION BCS-04 (DOWNSTREAM OF SHERMAN AVE)	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS C. GUSSMAN / R. AENEK		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY As impact on BENTHIC COMMUNITY

WEATHER CONDITIONS

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☐	showers (intermittent)	☐
80% ☑	%cloud cover	☐ 0 %
☐	clear/sunny	☐

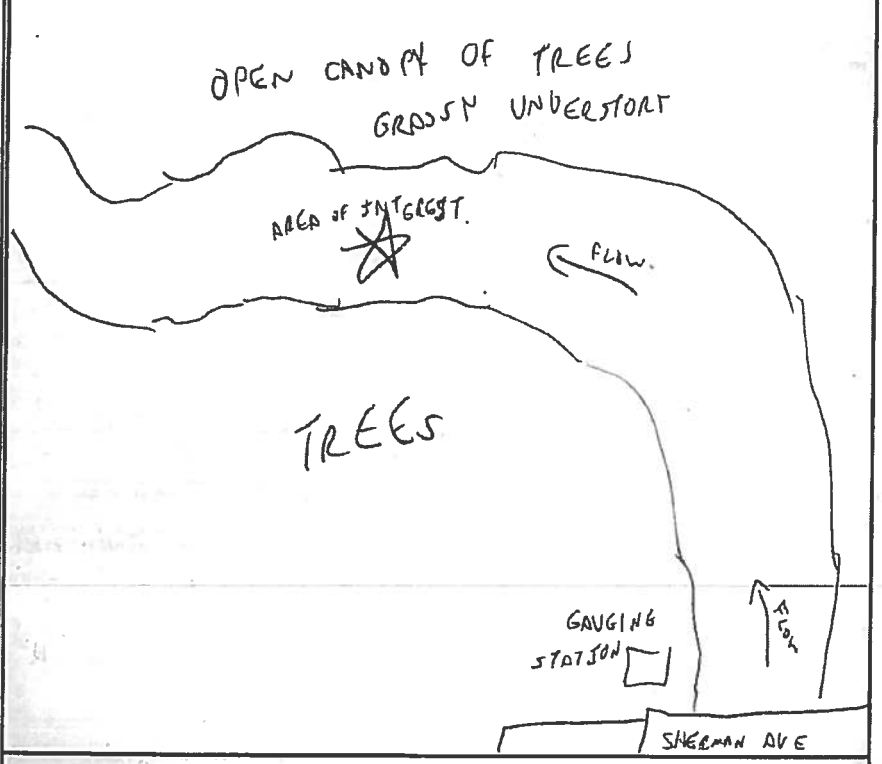
Has there been a heavy rain in the last 7 days? ☐ Yes ☑ No

Air Temperature 15 °C

Other_____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)



STREAM CHARACTERIZATION

Stream Subsystem
☑ Perennial ☐ Intermittent ☐ Tidal

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☑ Mixture of origins
☐ Swamp and bog ☐ Other_____

Stream Type
☐ Coldwater ☑ Warmwater

Catchment Area_____km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☑ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other _____ ☐ Residential **Local Watershed NPS Pollution** ☑ No evidence ☐ Some potential sources ☐ Obvious sources **Local Watershed Erosion** ☑ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☑ Trees ☐ Shrubs ☑ Grasses ☐ Herbaceous **dominant species present** RED MAPLE, ABUNDANT GRASSES ALONG STREAM EDGE
INSTREAM FEATURES	**Estimated Reach Length** 25 m **Estimated Stream Width** 16 m **Sampling Reach Area** _____ m² **Area in km² (m²x1000)** _____ km² **Estimated Stream Depth** 1 m **Surface Velocity (at thalweg)** _____ m/sec **Canopy Cover** ☑ Partly open ☐ Partly shaded ☐ Shaded **High Water Mark** 1 m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle _____ % ☐ Run 100 % ☐ Pool _____ % **Channelized** ☐ Yes ☑ No **Dam Present** ☐ Yes ☑ No
LARGE WOODY DEBRIS	**LWD** _____ m² **Density of LWD** _____ m²/km² (LWD/ reach area)
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **dominant species present** _____ **Portion of the reach with aquatic vegetation** <1 % MINIMAL IN-STREAM VEGETATION
WATER QUALITY	**Temperature** _____ °C **Specific Conductance** _____ **Dissolved Oxygen** _____ **pH** _____ **Turbidity** _____ **WQ Instrument Used** _____ **Water Odors** ☑ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other _____ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☑ None ☐ Other _____ **Turbidity (if not measured)** ☐ Clear ☐ Slightly turbid ☐ Turbid ☑ Opaque ☐ Stained ☐ Other _____
SEDIMENT/ SUBSTRATE	**Odors** ☑ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other _____ **Oils** ☑ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand ☐ Relict shells ☐ Other _____ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	<5
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	<5
Gravel	2-64 mm (0.1"-2.5")	30			
Sand	0.06-2mm (gritty)	50	Marl	grey, shell fragments	
Silt	0.004-0.06 mm	5			
Clay	< 0.004 mm (slick)	5			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME MAURICE RIVER	LOCATION BCS-04 ≈100m downstream of Slaughter Br	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT_____ LONG_____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS C. GUSSMAN / R. HENRY		
FORM COMPLETED BY	DATE 10/29/13 TIME 4:30 AM (PM)	REASON FOR SURVEY As effect on Benthic Community

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	(19) 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 ~~17~~ 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone) *	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0

Total Score _____

* AT AREA OF OBSERVATION

NJDEP-BFBM **Biological Field Observations and Data Sheet HIGH Gradient**

BCS-05
POWER LINES / TREATMENT PLANT

Date/Time: 10/30/13 / 13:30
Form Completed By: C. GUSMAN

Quad: _____
Twp: _____
County: _____

Bridge # _____

Chemistries
- ___ Temperature (°C)
- ___ Conductivity (umhos)
- ___ DO (mg/L)
- ___ pH (SU units)

Water Clarity
- [ ] Clear
- [✓] Slightly Turbid
- [ ] Turbid

Color: TEA

Bank Stability
- [✓] Good
- [ ] Fair
- [ ] Poor

Stream Flow
- [ ] Slow
- [✓] Moderate
- [ ] Fast

40 Width (ft)
2 - 0.5 Depth (ft)

Substrate
- [ ] cobbles
- [✓] gravel / sand
- [ ] mud
- [✓] silt
- [✓] snags
- [ ] root mats
- [ ] undercut banks
- [ ] other: _____

Bank Vegetation
- [✓] trees
- [✓] shrubs
- [ ] grasses
- [✓] weeds
- [ ] vines
- [ ] other: _____

Canopy
- [ ] Open
- [✓] Mostly Open
- [ ] Partly Open
- [ ] Mostly Closed
- [ ] Closed

Land Uses
- [ ] Agriculture: Cropland
- [ ] Agriculture: Livestock
- [ ] Commercial
- [ ] Urban
- [ ] Suburban
- [✓] Rural
- [✓] Forested
- [ ] Industrial
- [✓] Other: FIELDS / POWER LINES NEARBY

Point Sources
- [ ] Discharges
- [ ] Storm Sewers
- [ ] Other

- [ ] Downstream of Impoundment
  - name:
  - approx. distance:

Comments:

Picture # ____Upstream ____Downstream
Sampling location: ____Upstream ____Downstream

Sampling device D-Net Surber Dredge

Present weather conditions: CLOUDY, LIGHT DRIZZLE
Previous 24 hr weather event: FAIR / CLEAR.

Other Observations: check all applicable
- [ ] fish
- [ ] frogs
- [ ] crayfish
- [ ] turtles
- [ ] clams / Unionid mussels
- [ ] Zebra Mussels
- [ ] macrophytes
- [ ] periphytes
- [ ] filamentous algae
- [ ] water fowl
- [ ] beaver dam
- [ ] oil sheen

(Record any other observations here)

Field Sheet 10/06

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME MAURIGG RIVER	LOCATION BCS_05 (POWER LINES / SEWAGE PLANT)	
STATION # _____ RIVERMILE _____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY C GUSSMAN	DATE 10/30/13 TIME 1:30 AM PM	REASON FOR SURVEY As IMPACT ON BENTHIC COMMUNITY

WEATHER CONDITIONS CLOUD, PERIODIC LIGHT DRIZZLE

Now		Past 24 hours
☐	storm (heavy rain)	☐
☐	rain (steady rain)	☐
☑	showers (intermittent)	☐
100 % ☐	%cloud cover	☐ ___ %
☐	clear/sunny	☐

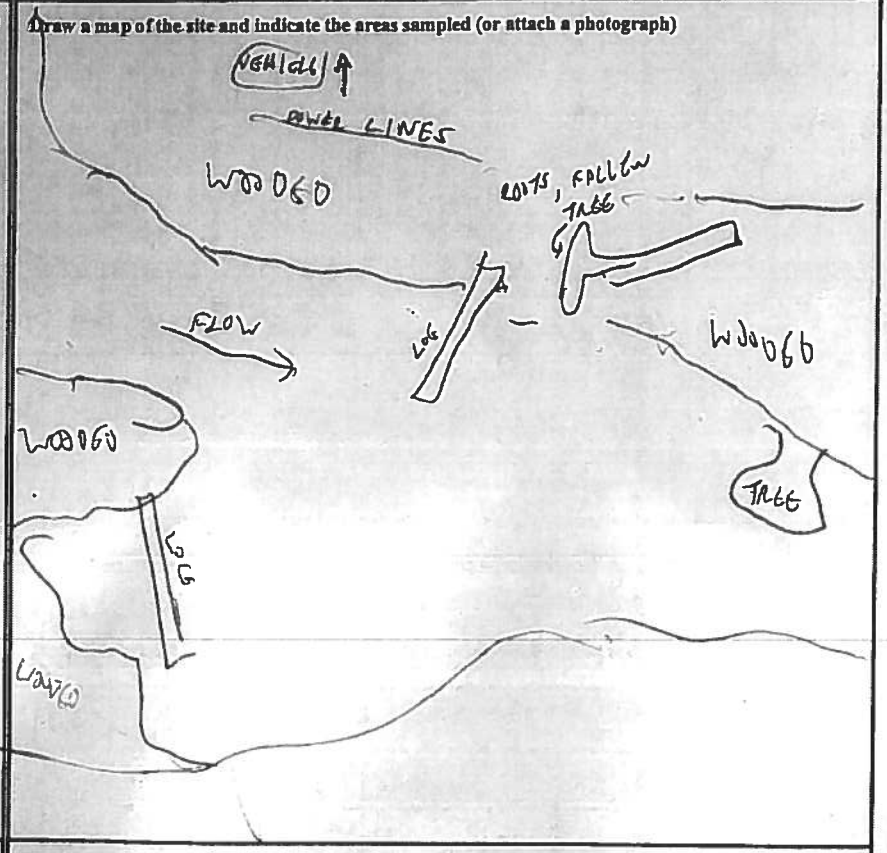
Has there been a heavy rain in the last 7 days? ☑ Yes ☐ No MINIMAL, DRIZZLE

Air Temperature 18 °C

Other _____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)



STREAM CHARACTERIZATION

Stream Subsystem
☑ Perennial ☐ Intermittent ☐ Tidal

Stream Type
☐ Coldwater ☑ Warmwater

Stream Origin
☐ Glacial ☐ Spring-fed
☐ Non-glacial montane ☑ Mixture of origins
☐ Swamp and bog ☐ Other _____

Catchment Area _____ km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☒ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other _____ ☐ Residential **Local Watershed NPS Pollution** ☒ No evidence ☐ Some potential sources ☐ Obvious sources **Local Watershed Erosion** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☒ Trees ☒ Shrubs ☐ Grasses ☐ Herbaceous **dominant species present** OPEN CANOPY RED MAPLE w/ UNDERSTORY SHRUBS
INSTREAM FEATURES	**Estimated Reach Length** 40 m **Estimated Stream Width** 16 m **Sampling Reach Area** _____ m² **Area in km² (m²x1000)** _____ km² **Estimated Stream Depth** _____ m **Surface Velocity (at thalweg)** _____ m/sec **Canopy Cover** ☒ Partly open ☐ Partly shaded ☐ Shaded **High Water Mark** _____ m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle _____ % ☐ Run 70 % ☐ Pool 30 % **Channelized** ☐ Yes ☒ No **Dam Present** ☐ Yes ☒ No
LARGE WOODY DEBRIS	**LWD** ≈ 25 m² **Density of LWD** _____ m²/km² (LWD/ reach area)
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **dominant species present** MINIMAL **Portion of the reach with aquatic vegetation** <1 %
WATER QUALITY	**Temperature** _____ °C **Specific Conductance** _____ **Dissolved Oxygen** _____ **pH** _____ **Turbidity** _____ **WQ Instrument Used** _____ **Water Odors** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other _____ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☒ None ☐ Other _____ **Turbidity (if not measured)** ☐ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other _____
SEDIMENT/ SUBSTRATE	**Odors** ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other _____ **Oils** ☒ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand ☐ Relict shells ☐ Other _____ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No N/A

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			**ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)**		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	10
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	20
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)	60	Marl	grey, shell fragments	
Silt	0.004-0.06 mm	25			
Clay	< 0.004 mm (slick)	15			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME MARRICG RIVER	LOCATION BCS-05 (NEAR POWER LINES/SEWAGE PLANT)	
STATION # _____ RIVERMILE _____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS C. GUSSMAN, R. HENRY		
FORM COMPLETED BY	DATE 10/30/13 TIME 1:30 AM (PM)	REASON FOR SURVEY As IMPACT OF BENTHIC COMMUNITY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable, substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat or vegetation
SCORE	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars, 50-80% of the bottom affected, sediment deposits at obstructions, constrictions, and bends, moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently, pools almost absent due to substantial sediment de sition
SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel, or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments, evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	(8) 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0

Total Score _____

Appendix B
Toxicity Profiles

B.0 DERIVATION OF TOXICITY REFERENCE VALUES

A toxicity reference value (TRV) is a contaminant dose level that is compared with a predicted exposure dose level, calculated based on site-specific data, to assess the presence and degree of risk to a receptor or group of receptors from that contaminant. A TRV is generally based on data from laboratory toxicological evaluations. Usually, two TRVs are used to predict ecological risk, a no observable adverse effect level (NOAEL) and a lowest observable adverse effect level (LOAEL). The NOAEL is the highest dose at which adverse effects are not expected to occur, and the LOAEL is the lowest dose at which adverse effects are expected to occur.

To derive TRVs, a comprehensive literature search was performed to identify studies on the toxicity of contaminants of concern (COCs) to ecological receptors. A variety of databases were searched, including Biological Abstracts, Applied Ecology Abstracts, Chemical Abstract Services, Medline, Toxline, BIOSIS, ENVIROLINE, Current Contents, Hazardous Substances Data Bank (HSDB), Registry of Toxic Effects of Chemical Substances (RTECS), Integrated Risk Information System (IRIS), and the Aquatic Toxicity Information Retrieval Database (AQUIRE).

In addition, a number of secondary literature sources provided summaries or reviews of toxicological literature related to a variety of contaminants. These documents were not used directly to derive TRVs because they do not capture the details of the toxicological methods needed for the selection of technically defensible TRVs. However, these summary documents provided an excellent source for locating original studies that may have been overlooked in the database searches. Examples of such summary documents include Agency for Toxic Substances and Disease Registry (ATSDR) documents, United States (U.S.) Fish and Wildlife Service Contaminant Hazard Reviews, U.S. Environmental Protection Agency (EPA) Great Lakes Water Quality Initiative documents, and U.S. EPA Ambient Water Quality Criteria documents.

Studies that were obviously not useful or appropriate for deriving a TRV were eliminated. A number of criteria were considered when evaluating the appropriateness of using a particular study for deriving a TRV. The most important consideration was the suitability of the test result for evaluating the assessment endpoint. A number of additional criteria were also considered. For example, studies were selected in which the test organism was in as similar a taxonomic grouping as possible to the measurement endpoint species. Exposure doses had to be quantified and effects measured and reported. The exposure duration was preferably either chronic, sub-chronic, or involved a sensitive life stage; multi generational studies were also appropriate. For laboratory studies, the likelihood that a similar result would be obtained if the test were repeated was an additional consideration. Sample sizes had to be adequate and the treatment groups must have been compared to appropriate control groups. At the very least, a negative control had to be included in the study design. In addition, the measured endpoints of the study had to be ecologically relevant. For the purposes of deriving a TRV for an ecological risk assessment, an ecologically relevant endpoint is one which is closely tied to the survival and viability of a population in the field. Usually, the endpoints measured for this purpose were survival, growth, and reproduction. In addition, appropriate statistical analyses must have been performed and the statistical significance reported. Finally, the study design preferably included at least three treatments in addition to any controls which may have been selected.

The selected TRVs were based preferably on high-quality studies which satisfy many or all of the above requirements. From these studies, the lowest concentration that was associated with adverse ecological effects on the test organism was selected as the LOAEL. Studies which reported both a LOAEL and NOAEL were selected over studies which reported only one effect level, due to the uncertainty associated with an unbounded effect level. If only a LOAEL could be identified from the studies, an uncertainty factor of 10 was used to calculate a NOAEL (Dourson and Stara 1983; U.S. EPA 1989; Amdur and Klaasen 1996; Sample et al. 1996). If a LOAEL could not be located for a COC, a median lethal dose (LD_{50}) was selected; a factor of 10 was then used to calculate a LOAEL and a factor of 100 was used to calculate a NOAEL. Professional judgement was used in some cases to select the most appropriate TRV.

The studies that were reviewed to derive toxicity reference values for this risk assessment are described below. Concentrations selected to be used as TRVs are summarized in Table 4.

B.1 ARSENIC

B.1.1 Toxicity to Birds

Wildlife TRVs were derived for arsenic according to Eco-SSL guidance (U. S. EPA 2003). A literature search was conducted, and NOAEL and LOAEL values reported for exposure of birds to arsenic were compiled. A geometric mean of the NOAEL values for growth and reproduction could not be calculated, as only two NOAEL values were available. The NOAEL TRV identified for avian wildlife is 2.24 mg/kgBW/day, the lowest reported NOAEL value for reproduction, growth or survival.

Adult mallard ducks were exposed to four concentrations [0, 25, 100 and 400 mg sodium arsenate/kg diet; 51.35% arsenic (As)] for 115 to 128 days (Stanley *et al.* 1994). Ducklings were placed on the same diet as their parents for 14 days after hatching. At the levels tested in this experiment, dietary As did not affect hatching success or embryo deformities. Duckling production (number of ducklings alive at day 14 for nests producing more than one duckling) was significantly decreased in birds exposed to 400 mg/kg sodium arsenate (205.4 mg/kg As); this exposure concentration was identified as the LOAEL. An ingestion rate of 0.139 kg/day and adult body weight of 1.25 kg (Piccirillo and Quesenberry 1980) were used to convert the mg/kg diet concentrations to units of 5.7 mg/kgBW/day (NOAEL) and 22.8 mg/kgBW/day (LOAEL).

Young male cowbirds were fed a diet containing paris green (copper aceto-arsenite) at concentrations of 0, 25, 75, 225 or 625 mg/kg for seven months (U.S. FWS 1969). All of the birds at the two highest exposure concentrations died. Twenty percent of the birds in the 75 mg/kg (33.26 mg/kg As) exposure group died, but no mortality was observed in the 25 mg/kg (11.09 mg/kg As) exposure group. An ingestion rate of 0.01087 kg/day and body weight of 0.049 kg were used to convert the exposure concentrations to units of mg/kgBW/day. A LOAEL of 7.38 mg/kgBW/day and a NOAEL of 2.46 mg/kgBW/day were calculated based on results of this experiment.

Mallard ducklings were fed diets containing As (as sodium arsenate) at concentrations of 0, 30, 100 or 300 mg/kg for 10 weeks (Camardese *et al.* 1990). Dietary exposure to As at a concentration of 300 mg/kg reduced growth in male ducklings. Growth of female ducklings was significantly different from controls at all dietary exposure concentrations. Based on the ecological significance of the observed effect (reduced growth in female ducklings), an exposure concentration of 30 mg/kg was selected as the LOAEL from this experiment. Body weights of 0.81 and 0.62 kg and ingestion rates of 0.094 and 0.080 kg/day (cited by authors for control and 30 mg/kg 5-week old female ducklings, respectively) were used to convert the exposure concentrations to units of mg/kgBW/day. A LOAEL of 3.9 mg/kgBW/day and an estimated NOAEL of 0.39 mg/kgBW/day were calculated based on results from this experiment.

Thirty-two week old White leghorn hens were fed diets containing arsenic (As from Roxarsone) at nominal concentrations of 0, 11, 22, 44 or 88 mg/kg for four weeks (Chiou *et al.* 1997). Measured As concentrations in the diet were 1.1, 9.1, 21.2, 43.0 and 85.1 mg/kg. Egg production improved in hens fed diets containing As at a concentration of 9.1 mg/kg. Egg production, egg weight, and food intake were significantly reduced in hens exposed to As at concentrations of 43.0 and 85.1 mg/kg. Hens in the 85.1 mg/kg group ceased to produce eggs after two weeks of exposure. Based on the ecological significance

of the observed effect (reproduction), the 43.0 mg/kg exposure concentration was identified as the LOAEL. Body weights of 1.439 and 1.49 kg and ingestion rates of 0.087 and 0.114 kg/day (cited by authors for the 43.0 and 21.2 mg/kg exposure groups, respectively) were used to convert the exposure concentrations to units of mg/kgbW/day. A LOAEL of 2.3 mg/kgBW/day and a NOAEL of 1.6 mg/kgBW/day were calculated based on results of this experiment. Based on the ecological significance of the endpoint (reproduction) and because the LOAEL is the lowest cited adverse effect level for birds, the TRV values from this study will be used to evaluate the risk posed by As to avian receptors.

Camardese, M. B., D. J. Hoffman, L. LeCaptain and G. W. Pendleton (1990). Effects of arsenate on growth and physiology in mallard ducklings. Environ. Toxicol. Chem. **9**(6): 785-796.

Chiou, P. W., K. Chen and B. Yu (1997). Effects of roxarsone on performance, toxicity, tissue accumulation and residue of eggs and excreta in laying hens. Journal of the Science of Food and Agriculture **74**(2): 229-236.

Piccirillo, V. J. and R. P. Quesenberry (1980). Reproductive capacities of control mallard ducks (*Anas platyrhynchos*) during a one-generation reproduction study. Journal of Environmental Pathology and Toxicology **4**: 133-139.

Stanley, T. R., Jr.,, J. W. Spann, G. J. Smith and R. Roscoe (1994). Main and interactive effects of arsenic and selenium on mallard reproduction and duckling growth and survival. Arch Environ. Contam. Toxicol. **26**: 444-451.

U. S. EPA 2003. Attachment 4-5, Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Eco-SSL Standard Operating Procedure (SOP) #6: Derivation of Wildlife Toxicity Reference Value (TRV). OSWER Directive 92857-55.

B.1.2 Toxicity to Mammals

Wildlife TRVs were derived for arsenic according to Eco-SSL guidance (U. S. EPA 2003). A literature search was conducted, and NOAEL and LOAEL values reported for exposure of mammals to antimony were compiled. To derive a wildlife TRV, a minimum of three NOAEL or LOAEL results reported for a least two test species for either growth, reproduction, or survival effects are required. A geometric mean is calculated if three NOAEL results are available for either growth or reproduction effect groups. For arsenic, the geometric mean of the NOAEL values for growth and reproduction was higher than the lowest bounded LOAEL for effects on reproduction, growth or survival. The Eco-SSL mammalian TRV for arsenic was identified as the highest bounded NOAEL below the lowest bounded LOAEL; a NOAEL value of 1.04 mg/kgBW/day was identified.

Mice were administered an oral dose of 5 ppm arsenite in drinking water for three generations (Schroeder and Mitchener 1971). No effects on number of litters, age at first litter, interval between litters, dead litters, offspring deaths or runts were observed. Average litter size was smaller, and an increase in ratio of males to females were noted; no statistical analysis was conducted on these parameters. A water ingestion rate of 0.0075 L/day and adult body weight of 0.032 kg (U.S. EPA 1988) were used to convert

the exposure concentrations to units of mg/kgBW/day. A NOAEL of 1.17 mg/kg BW/day was calculated based on the results of this experiment.

Dogs were fed diets containing sodium arsenite at concentrations of 0, 1, 2, and 4 mg/kgBW/day for 59 days (Neiger and Osweiller 1989). On day 59, the dosage was doubled for the rest of the experiment, which ended on Day 183. Significant dose-dependant decreases in food consumption and body weight were observed in dogs exposed to As at concentrations of 4 and 8 mg/kgBW/day. Weight loss was due to decreased food consumption, not to any direct effect of As. No gross or microscopic lesions were found in livers of any group. The effect concentrations observed in this experiment were not used to derive a TRV for this risk assessment, as a decrease in body weight is not considered an ecologically relevant effect.

Arsenic trioxide was administered to adult female rats (strain Crl:CD^{7}(SD)BR) at concentrations of 0, 1, 2.5, 5 and 10 mg/kgBW/day in conformance with good laboratory practice (GLP) regulations (Stump *et al.* 1998). Arsenic exposure began 14 days prior to mating and continued until gestation day 19. Reduced body weight and food intake were observed in rats exposed at a concentration of 10 mg/kgBW/day; stomach abnormalities such as eroded areas and adhesions were also observed. Fetal weights were reduced and the incidence of two skeletal developmental variations were also increased in the high dose group. The fetal effects were attributed to the effect on fetal weight and were not indicative of teratogenicity. Other intrauterine parameters measured (numbers of corpora lutea, implantation sites, resorptions and viable fetuses) were not affected by treatment. Arsenic-related malformations were not observed at any exposure concentration.

Mice were fed diets containing As (as H_3AsO_4; 52.76% As) at concentrations of 0, 20, 100 or 500 mg/kg (As concentrations of 0, 10.55, 52.76 and 263.8 mg/kg, respectively) for two generations (Hazelton Laboratories 1990). Exposure started 14 weeks pre-mating for the first generation and continued through weaning of pups from the F_1 females. At the highest exposure concentration, lower birth weights, postnatal growth retardation and increased postnatal mortality were observed. Dam survival and weight gain were also affected at this exposure concentration. Growth of second generation males and females was significantly reduced at an exposure concentration of 100 mg/kg. With the exception of a few weeks (66 weeks of food consumption measurements, total), food consumption did not differ significantly between the 20 and 100 mg/kg exposure groups and control animals. Body weights of 31.9 g and 33.72 g, and food ingestion rates of 5.82 g/day and 6.11 g/day (reported for the 100 mg/kg and 20 mg/kg exposure groups, respectively) were used to convert the exposure concentrations to units of mg/kgBW/day. Based on the observed growth effects, a LOAEL of 9.63 mg/kgBW/day and a NOAEL of 1.91mg/kgBW/day were identified. Based on the ecological significance of the endpoint (growth) and because the LOAEL is the lowest cited adverse effect level for mammals, the TRV values from this study will be used to evaluate the risk posed by As to mammalian receptors.

Hazelton Laboratories 1990. Two-Generation Dietary Reproduction Study with Arsenic Acid in Mice. Hazelton Laboratories, Inc. Report HLA 6120-138.

Neiger, R. D. and G. D. Osweiller (1989). Effect of subacute low level dietary sodium arsenite on dogs. Fundam. Appl. Toxicol. **13**: 439-451.

Schroeder, H. A. and M. Mitchener (1971). Toxic effects of trace elements on the reproduction of mice and rats. Arch. Environ. Health **23**: 102-106.

Stump, D. G., K. J. Clevidence, J. F. Knapp, J. F. Holson and C. H. Farr (1998). An oral developmental toxicity study of arsenic trioxide in rats. Teratology **57**: 216-217.

U. S. EPA 2003. Attachment 4-5, Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Eco-SSL Standard Operating Procedure (SOP) #6: Derivation of Wildlife Toxicity Reference Value (TRV). OSWER Directive 92857-55.

U.S. EPA 1988. Recommendations For and Documentation of Biological Values for use in Risk Assessment. United States Environmental Protection Agency. EPA/600/6-87-008.

Appendix C
Life History Profiles

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LIFE HISTORY OF THE BELTED KINGFISHER (C*eryle alcyon*)

The belted kingfisher is a pigeon-sized, territorial bird that is the only kingfisher present throughout most of North America (Bull and Farrand 1977; NGS 1987). During the breeding season, kingfishers occur throughout much of the United States and Canada, excepting high elevation areas. Kingfishers overwinter throughout much of their breeding range, but will migrate if ice accumulation limits food availability. Migrating kingfishers may travel as far south as northern South America (Hamas 1994).

The kingfisher is characterized by a blue-gray back and head with a white collar and stout bill. The male can be identified from the female by a blue-gray band across its breast, whereas the female has a second, rust-colored band across her belly. Kingfishers grow to 11 to 14 inches long from head to tail for both males and females. Rattling calls identify and help the kingfisher aggressively defend its territory (Cassidy 1990).

Belted kingfishers utilize a variety of freshwater and coastal habitats, including ponds, lakes, rivers, streams, reservoirs, large vernal pools, estuaries, and harbors. Kingfishers prefer calm, clear waters free of floating debris and dense aquatic plants. They also require foraging perches along water bodies from which they can hunt (Hamas 1994).

Food items include primarily shallow water fish, although crayfish, frogs, small snakes, salamanders, insects, crabs, and even mice may be consumed (Hayward 1885; Bull and Farrand 1977; Landrum *et al.* 1993). Dives for fish are quick, vertical, and loud. Belted kingfishers are reported to consume fish ranging in size from 2.45 to 17.78 centimeters (cm) in length, with the average size of fish consumed being less than 7.6 cm total length (Salyer and Lagler 1946). Most fish are caught by kingfishers within 60 cm of the water surface (Hamas 1994). It is estimated that a pair of kingfishers with nearly fledged young require approximately 90 fish per day to feed their offspring and themselves (Landrum *et al.* 1993). Vessel (1978) determined that a nestling can consume 11.2 fish per day during its maximum growth stage.

This species is solitary with the exception of the nesting season. Breeding times for this species vary with locale. Unseasonably mild weather may initiate early nesting in the lower United States. The presence of herbaceous cover and good fishing habitat are the basis for the selection of breeding areas and nest sites. Nests consist of stream bank or shoreline burrows, and vary in length depending upon the soil texture. Burrows are typically three to seven feet long (White 1953). Although usually near water, nests have been found up to 1.6 kilometers (km) away from water. A clutch of five to eight eggs are usually laid between early April and mid-June. Incubation lasts for 25 days with nest occupation for an additional 23 days. Both parents incubate the eggs (Bent 1940; Cassidy 1990; Landrum *et al.* 1993). Chicks grow rapidly during the first ten days, reach a maximum weight near the end of the third week of the nestling period, but lose weight before fledging (Vessel 1978; Albano 2000). Young leave the nest after 33 to 38 days. Young are able to capture live prey about a week after fledging. Fledglings remain near the nest and juveniles disperse by mid-summer (Bent 1940; Cassidy 1990; Landrum *et al.* 1993).

Males generally do not readily leave their territories and will remain there throughout the winter as long as ice does not impede fishing. Females typically migrate southward and return to the same mate and

nesting site every year. The likelihood of migration for both males and females appears to depend on the severity of the winter (Landrum *et al.* 1993; Hamas 1994; DeGraaf and Yamasaki 2001).

Predators include raptors, especially accipters and hawks. Belted kingfishers escape predators by diving into the water. Nest predators include mammals and snakes, typically skunks, raccoons, and mink (White 1953; Hamas 1994). Belted kingfishers are relatively short-lived compared to most piscivorous birds. Juvenile mortality is high. If a bird survives to breed in its first year, it might be expected to live to the age of 2 to 3 years. The oldest age recorded by U.S. Fish and Wildlife Service banding records is 3 years, 8 months (Albano 2000; Lane *et al.* 2004). Albano (2000) reported one female that lived to at least 4 years of age.

Exposure Profile

The belted kingfisher was selected as a surrogate to model the effects of contaminants on an upper trophic level aquatic bird species. The belted kingfisher is highly adaptable and the presence of man-induced disturbances would not minimize use of the site by this species. For this risk assessment, conservative exposure parameters are the highest (ingestion rates) or lowest (body weight [BW], home range [HR] size) values located in the literature. Representative exposure parameters are the average or midpoint of the values located for this species.

Reported body weights for adult belted kingfishers range from 104.3 to188.8 grams (g) (Baldwin and Kendeigh 1938; Poole 1938; Hartman 1946; Salyer and Lagler 1946; Murray and Jehl 1964; Alexander 1977; Clench and Leberman 1978; Vessel 1978; Brooks and Davis 1987; Fry and Fry 1992; Hamas 1994; Albano 2000). Body weight varies seasonally. Males are heaviest prior to pair formation, and they lose weight during burrow excavation. Females are heaviest just prior to egg-laying. Both sexes lose weight during the period where they are providing food to nestlings; weight is lowest during the late nestling stage (Albano 2000). A conservative body weight of 104.3 g and a representative body weight of 149.3 g will be used in this risk assessment.

Belted kingfishers feed mainly on shallow water fish, although crayfish, frogs, small snakes, salamanders, insects, crabs, and even mice may also be consumed (Hayward 1885; White 1936; White 1938; Salyer and Lagler 1946; White 1953; Eipper 1956; Alexander 1977). Crayfish have been reported as a substantial component of the kingfisher diet in several studies (Salyer and Lagler 1946; Eipper 1956; Alexander 1977; Steinmetz *et al.* 2003). For this risk assessment, it will be assumed that the diet of a belted kingfisher is comprised of 100 percent (%) fish.

Food ingestion rates reported for adult belted kingfishers range from 0.031 to 0.1009 kilograms per day (kg/day) wet weight (Alexander 1977; Vessel 1978; Kelly 1998). A higher food ingestion rate was reported for a nestling (0.1984 kg/day; White 1936), however only one bird was observed and there is no information on whether the bird was food limited prior to observation; therefore this study was not included. A conservative food ingestion rate of 0.1009 kg/day and a representative food ingestion rate of 0.0574 kg/day will be used for this risk assessment.

The allometric equation developed by (Calder and Braun 1983) was used to estimate the water ingestion

rate using the equation: water ingestion (liters per day; L/day) = 0.059 Wt $^{0.67}$, where Wt. is BW in kg). Using the above body weights, conservative and representative water ingestion rates of 0.013 L/day and 0.0165 L/day were calculated, respectively.

An incidental sediment ingestion rate could not be identified for the belted kingfisher. To evaluate this exposure pathway, a model was developed that predicted the amount of sediment which may be entrained in the digestive system of a fish, the bluegill (*Lepomis machrochirus*). This was assumed to be the primary mechanism by which a piscivorous bird such as the belted kingfisher may incidentally ingest sediment.

Belted kingfishers are reported to consume fish ranging in size from 2.45 to 17.78 cm in length, with the average total length consumed less than 7.6 cm (Salyer and Lagler 1946). In keeping with the conservative approach of this risk assessment, the amount of sediment entrained in fish 178 mm long was predicted. The standard weight of a 178 mm bluegill was calculated to be 122.6 g based on the following algorithm relating length to weight (Hillman 1982):

$$\log \text{Weight (g)} = -5.374 + 3.316 \log \text{Length (mm)}$$

A study evaluating the stomach contents of 153 bluegills reported an average content of detritus and sediment to be 9.6 % of the total diet. A daily food ingestion rate of 1.75 % of the body weight per day has been reported for the bluegill (Kolehmainen 1974). This provides a predicted intake rate of 2.15 g of food per day for a 122.6 g fish. If a conservative assumption is made that 9.6 percent of the food ingested is entirely sediment, it can be predicted that a fish of this size may contain 0.206 g of sediment in its digestive system.

For the purpose of this model, it was assumed that the level of sediment contained in the digestive system of a fish remains constant over time. This value (0.206 g) was divided by the predicted fish body weight (122.6 g) to express sediment entrained in fish digestive systems in units of grams of sediment per gram of fish body weight. This provided a value of 0.0017 g sediment/g body weight. When this value is multiplied by the conservative food ingestion rate of the belted kingfisher on a dry weight basis (25.2 g/day), the predicted sediment ingestion rate for the kingfisher is 0.043 g/day. When this value is multiplied by the representative food ingestion rate of the belted kingfisher on a dry weight basis (14.4 g/day), the predicted sediment ingestion rate for the kingfisher is 0.024 g/day.

Belted kingfishers defend two types of territories: the breeding territory and the foraging territory. The size of the breeding territory and fledging success appear to be related to the concentration of prey (Davis 1982). The home range of this species varies seasonally and is usually reported as meters of shoreline (Landrum *et al.* 1993). Home range sizes ranging from 389.3 to 8045 m of shoreline have been reported for this species (Salyer and Lagler 1946; Cornwell 1963; Davis 1982; Brooks and Davis 1987; Mazeika *et al.* 2006). A conservative home range size of 389.3 m and a representative home range size of 2485 m will be used in this risk assessment.

In summary, the food chain model parameters for the belted kingfisher are as follows:

Conservative Scenario:

BW:	0.1043 kg
[1]Total ingestion:	0.1009 kg/d wet weight
[1]Food ingestion:	0.10073 kg/d wet weight
Water ingestion:	0.013 L/d
Soil ingestion:	0.000043 kg/d dry weight
HR:	389.3 m shoreline

Representative Scenario:

BW:	0.1493 kg
[1]Total ingestion:	0.0574 kg/d wet weight
[1]Food ingestion:	0.0573 kg/d wet weight
Water ingestion:	0.0165 L/d
Soil ingestion:	0.000024 kg/d dry weight
HR:	2485 m shoreline

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[1]The total ingestion rate is the measured (laboratory or field) food ingestion rate cited in the paragraph in the exposure profile. Soil ingestion is generally measured as a percent of food ingestion. Therefore, the food ingestion rate used in the food chain models is considered to be equal to the total ingestion rate (listed above) minus the soil ingestion rate.

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LIFE HISTORY OF THE OSPREY (*Pandion haliaetus*)

Also called a "fish hawk", the osprey is a large, diurnal raptor with long narrow wings, a sharp hooked beak, and powerful talons. Adult ospreys have dark brown backs and upper wing-coverts, and a mostly white breast and belly. The head is mostly white with a dark brown stripe extending from the lores, through the eye, and down the side of the neck. Females are slightly larger than males, and tend to have a fuller and darker chest band (Poole *et al.* 2002; Gibson 2007).

Ospreys are cosmopolitan and are found on every continent except Antarctica. Those that breed in North America and the Caribbean are in the subspecies *P. haliaetus carolinensis*. The North American population breeds from Alaska throughout Canada, and along the east and west coasts to Mexico, the Caribbean, and Florida. The U.S. population is concentrated along the Atlantic Coast, with a secondary concentration in the western Great Lakes states (Poole 1989). In North America, ospreys breeding at latitudes north of northern Florida are migratory. North American osprey winter in South America and the Carribean (Poole *et al.* 2002).

Habitat varies greatly, but is always in association with water; ospreys are found near lakes, rivers, reservoirs, or along coastal waters. Common factors include shallow water and an adequate fish supply within 10 to 20 kilometers (km) of the nest; open nest sites, generally elevated, including artificial structures; and an ice-free season long enough to allow successful fledging of young.

Live fish comprise at least 99 percent (%) of prey items recorded in most published accounts (Ueoka and Koplin 1973; Dunstan 1974; Szaro 1978; Van Daele and Van Daele 1982; McLean and Byrd 1991b; Poole *et al.* 2002; Harmata *et al.* 2007; Johnson *et al.* 2008; Glass and Watts 2009). Ospreys have occasionally been observed taking other prey including birds, small mammals, herptiles, and crustaceans (Wiley and Lohrer 1973; Castrale and McCall 1983; Layher 1984; King 1988; Schultz 1994). Ospreys forage by hovering over water and diving feet first to capture prey. They are opportunistic predators, and hunt whatever fish species is most readily available at a particular time or location. Most fish captured by osprey range from 10 to 30 centimeters (cm) in length (Ueoka and Koplin 1973; Edwards 1988). The osprey is most successful at catching slow-moving fish in shallow waters, or those that remain near the surface. Foraging efforts peak at dawn and dusk, and increase mid-tide. Cloud cover, sun brightness, tidal direction, and precipitation do not affect foraging success, but prey species ecology and water surface conditions do (Swenson 1979; Flemming and Smith 1990; Poole *et al.* 2002; Galarza 2010). All parts of a fish are consumed except large bones; fins and viscera are occasionally discarded (Clancy 2005; Bartosek 2009).

Good nesting sites in proximity to open, shallow water and a plentiful supply of fish are required for reproductive success. Dead trees and man-made structures (i.e. channel markers and duck blinds) are utilized most often for nesting, which may be colonial. Non-migratory populations breed during the winter and migratory populations during the summer. Ospreys are not sexually mature until approximately three years of age, but may not breed until age three to seven, depending on nest site availability. Ospreys are monogamous and return to the same nest site year after year. Previous nests are re-used, and can become quite large. Nests are built at the apex of the chosen site, which makes them more susceptible to wind destruction than most other raptor nests. Nests are generally located within

three to five km of a water body (Johnsgard 1990; Poole *et al.* 2002). Clutch size ranges from one to four eggs, typically three. The osprey is single-brooded, however a replacement clutch may be laid if lost early in incubation. The female is responsible for the larger portion of egg incubation and relies entirely on the male for food collection until the young fledge. Eggs are incubated during daylight hours, and any disturbance causing prolonged absence of the female will result in significant nest failure. Hatching of eggs is asynchronous, resulting in substantial differences in nestling size. Young birds fledge at about seven weeks of age. Family units remain intact near the nest site while fledglings acquire fishing skills (Stinson 1977; Byrd 1978; Palmer 1988; Poole 1989; Reese 1991; Poole *et al.* 2002).

Predators exert a major impact on the nest sites osprey select. Raccoons are an important predator on eggs and young; great blue herons, bald eagles, and owls also prey on nestlings. Adverse weather (cold rains, high winds) can cause high mortality among nestlings and fledglings. Few predators will attack adult osprey; these include great horned owls and eagles. Important sources of post-fledging mortality are impact and gunshot injuries, electrocution, drowning, starvation or respiratory infections (Wiemeyer *et al.* 1987; Palmer 1988; Johnsgard 1990; Poole *et al.* 2002). Mortality is highest the first year of life. Reported survival rates for the first year of life range from 42.7 to 48.5%. Rate of annual survival from years 2 to 18 ranged from 80.4 to 83.8 % (Henny and Wight 1969). The greatest longevity recorded for free-ranging birds is 25 years (Fernie and Reynolds 2005; Patuxent Wildlife Research Center 2010).

Exposure Profile

For this risk assessment, conservative exposure parameters are the highest (ingestion rates) or lowest (body weight [BW], home range [HR] size) values located in the literature. Representative exposure parameters are the average (ingestion rates) or midpoint (body weights) of the values located for this species.

Reported body weights for ospreys range from 1.35 to 2.184 kilograms (kg) (Poole 1938; Hartman 1961; Stinson 1977; Poole 1985; Wasser 1986; Wiemeyer *et al.* 1987; Steidl and Griffin 1991; McLean and Byrd 1991a; Schaadt and Bird 1993; Schultz 1994; Candler and Kennedy 1995; Glass 2008; Johnson *et al.* 2009). Schaadt and Bird (1993) found that asymptotic nestling weights were not significantly different from adult weights (adult females and males, 1.79 and 1.485 kg; asymptotic female and male nestling weights, 1.79 and 1.4995 kg, respectively). Asymptotic nestling body weights are included in the above range, and the calculation of the midpoint of the range. Only adult body weights were used to identify the conservative body weight. A conservative body weight of 1.35 kg and a representative body weight of 1.613 kg will be used in this risk assessment.

Live fish comprise at least 99 % of prey items recorded in most published accounts (Ueoka and Koplin 1973; Dunstan 1974; Szaro 1978; Van Daele and Van Daele 1982; McLean and Byrd 1991b; Johnson *et al.* 2008; Glass and Watts 2009). For this risk assessment, it will be assumed that the diet of an osprey is comprised of 100% fish.

Several studies have reported grams of fish delivered per nestling per day, or grams of fish captured per day by male ospreys during breeding season (Machmer and Ydenberg 1990; Harmata *et al.* 2007; Glass 2008); these values range from 207.2 to 822 grams per day (g/day). These were not utilized to identify a

daily food ingestion rate, as grams of fish captured or delivered to the nest is not necessarily equal to the amount of food consumed per day. Daily food ingestion rates reported for osprey range from 104.1 to 400 g/day (Van Daele and Van Daele 1982; Poole 1985; Schramm *et al.* 1987; Poole 1989; Green and Ydenberg 1994; Arent and Martell 1996; Glass 2008). A conservative food ingestion rate of 0.4 kilograms per day (kg/day) and a representative food ingestion rate of 0.2216 kg/day will be used for this risk assessment.

The allometric equation developed by (Calder and Braun 1983) was used to estimate the water ingestion rate using the equation: water ingestion (liters per day; [L/day]) = 0.059 $Wt^{0.67}$, where Wt. is BW in kg. Using the above body weights, conservative and representative water ingestion rates of 0.072 L/day and 0.081 L/day were calculated, respectively.

An incidental sediment ingestion rate for the osprey was not located in the literature; therefore, a predicted incidental ingestion rate for sediment that may be entrained in the digestive system of prey items was used for this risk assessment. Fish are the primary food source for the osprey; consumption of prey items containing sediment is assumed to be the primary mechanism by which a piscivorous bird such as the osprey would ingest sediment. In this model, the bluegill (*Lepomis machrochirus*) was used to represent fish eaten by the osprey.

Bluegills commonly reach a size of 12 ounces (oz) (Pflieger 1975). From this, the amount of sediment entrained in fish 12 oz (0.340 kg) in weight was predicted. A study evaluating the stomach contents of 153 bluegills reported the diet to contain an average of 9.6% detritus (Kolehmainen 1974). A daily food ingestion rate of 1.75% of the BW per day has been reported for the bluegill (Kolehmainen 1974). From this, the amount of food consumed by a 0.340 kg bluegill is calculated to be 0.00595 kg/day. If the assumptions are made that 9.6% of the material ingested is sediment, and that the amount of sediment contained in the digestive system of a fish remains constant over time, it can be predicted that a fish of this size may contain 0.0005712 kg of sediment in its digestive system. This value (0.0005712 kg) was divided by the predicted fish BW (0.340 kg) to express the sediment entrained in the fish digestive systems as 0.00168 kg sediment per kg fish BW. When this value is multiplied by the conservative and representative dry weight food ingestion rates of the osprey (0.1 kg/day and 0.0554 kg/day, respectively), the predicted sediment ingestion rates for an osprey consuming 100% fish are 0.000168 kg dw/day and 0.000093 kg dw/day.

No information on home range size for the osprey could be located.

In summary, the food chain model parameters for the osprey are as follows:

Conservative Scenario:

BW:	1.35 kg
[2]Total ingestion:	0.4 kg/day wet weight

[2]The total ingestion rate is the measured (laboratory or field) food ingestion rate cited in the paragraph in the exposure profile. Soil ingestion is generally measured as a percent of food ingestion. Therefore, the food ingestion rate used in the food chain models is considered to be equal to the total ingestion rate (listed above) minus the soil ingestion rate.

[1]Food ingestion:	0.39933 kg/day wet weight
Water ingestion:	0.072 L/day
Soil ingestion:	0.000168 kg/day dry weight
HR:	NA

Representative Scenario:

BW:	1.613 kg
[1]Total ingestion:	0.2216 kg/day wet weight
[1]Food ingestion:	0.22123 kg/day wet weight
Water ingestion:	0.081 L/day
Soil ingestion:	0.000093 kg/day wet weight
HR:	NA

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LIFE HISTORY OF THE MINK (*Neovison* [formerly *Mustela*] *vison*)

Mink are distributed over much of boreal North America, southward throughout the eastern United States, and in the west to California, New Mexico, and Texas. They can be found in virtually any habitat containing permanent water but are not commonly found in upland areas (Jones and Birney 1988). Although primarily nocturnal, their activity often extends into midday (Barbour and Davis 1974; Baker 1983; Hoffmeister 1989).

Mink are characterized by dark chestnut brown fur with tails comprising one-third to one-half of their 46 to 70 centimeter (cm) length. The coat is thick and dense, with an oily underfur overlaid by long, coarse guard hairs. Males may weigh twice as much as females. A long neck and thin body are supported by short sturdy legs. An occasional white spot appears on the undersides of the animals, and the ears are short and rounded, lying close to the head. The feet have five webbed toes used for swimming and capturing fish, and anal scent glands are well-developed (Godin 1977; Linscombe *et al.* 1982)

Dens are always near water, usually either in an old muskrat burrow or constructed by the mink (Jones and Birney 1988). Males tend to live in their own burrows that are less elaborate than ones occupied by females (Barbour and Davis 1974). The mink is a constant wanderer, and home ranges (HR) tend to be linear since mink often follow a shoreline (Jones and Birney 1988). Male HRs are notably larger areas than females, with male HRs overlapping one or more female's (Baker 1983). Mink are solitary and mark their territories by spraying (Merritt 1987).

Mink are opportunistic predators, and their diet reflects the availability of seasonally and annually variable food sources (Barbour and Davis 1974). Their ability to feed on a variety of aquatic, semi-aquatic, and terrestrial prey items allow them to adapt to a wide variety of habitat. Their diets may consist of crayfish, muskrats, frogs, fish, snakes, rodents, rabbits, birds, and plants, among other items (Schwartz and Schwartz 1981; Jones and Birney 1988). Crayfish and muskrats are a major portion of the summer diet in many regions of North America (Barbour and Davis 1974; Merritt 1987; Jones and Birney 1988; Fleskes and Klaas 1993); however in the South, frogs, fish, crayfish, insects and clams are more prevalent in the mink's diet (Sealander 1979). They kill larger prey items by biting them on the neck. Females have a difficult time handling larger prey (i.e. muskrats), therefore their diet is usually more limited.

Fish prey size selectivity was not observed by Heggenes and Borgstrom (1988), however fish present in their study area were all less than 15 centimeters (cm) in length (Heggenes and Borgstrom 1988). Erlinge (1969) found that mink preyed upon trout < 15 cm when European otters were present. Winter diet of American mink along two rivers in Spain was evaluated using scats (Bueno 1996); the size of fish consumed was estimated using caudal vertebrae measurements. For mink foraging along a river where river otters were present, approximately 14 % of the fish consumed were less than 5 cm, 20% were 5 to 10 cm in length, and 66% were 10 to 15 cm in length. For mink foraging along a river without otters, 17% of fish consumed were in the 5 to 10 cm size class, 62% were 10 to 15 cm, 7% were 15 to 20 cm, and 10% were greater than 20 cm (fish in this size class were assumed to be carrion by the authors).

Breeding seasons vary regionally, ranging from January to early April, with gestation periods ranging from 39 to 76 days (Soper 1973; Barbour and Davis 1974; Schwartz and Schwartz 1981; Merritt 1987). A single annual litter, highly variable in size (consisting of from 1 to 17 young), may be produced (Schwartz and Schwartz 1981). Average litter sizes vary among regions (Barbour and Davis 1974; Schwartz and Schwartz 1981; Merritt 1987; Jones and Birney 1988; Hoffmeister 1989). Young are weaned between five to six weeks of age, leave the nest at six to eight weeks, and are sexually mature by ten months of age (Schwartz and Schwartz 1981; Merritt 1987).

The mink has several predators. Great horned owls, foxes, lynxes, coyotes, bobcats, wolves and dogs are known to prey on mink (Schwartz and Schwartz 1981; Merritt 1987) and in the Deep South alligators (Soper 1973). Human-caused mortality, especially trapping, is also a significant mortality factor. Mink can live up to 8 years in captivity (Lariviere 1999). Life span in the wild is approximately 3 years; but here have been records of some individuals living up to six years (Mitchell 1961; Schwartz and Schwartz 1981; Merritt 1987).

Exposure Profile

For the purpose of this risk assessment, conservative exposure parameters are the highest (ingestion rates) or lowest (body weight [BW], home range [HR] size) values located in the literature. Representative exposure parameters are the average of the values located for this species. When equations using BWs are used to calculate ingestion, representative ingestion rates (in units of amount ingested per day) are higher than conservative ingestion rates, since the corresponding BWs input into the equation are higher.

The mink was selected as a surrogate to model the effects of contaminants on a mammalian piscivore. It is recognized that mink may not actually occur within the study area, however the site is well within the recorded range for mink, and mink are known to use similar habitat for feeding (Linscombe *et al.* 1982). Mink have been documented to utilize suitable habitat even if it occurs in urbanized areas (Mech 2003).

Reported adult mink body weights range from 0.39 to 2.45 kilograms (kg) (Marshall 1936; Grinell *et al.* 1937; Jackson 1961; Mitchell 1961; Golley 1962; Soper 1973; Aulerich *et al.* 1974; Barbour and Davis 1974; Lowery 1974; Haley 1975; Alexander 1977; Godin 1977; Sealander 1979; Bleavins and Aulerich 1981; Rue 1981; Schwartz and Schwartz 1981; Linscombe *et al.* 1982; Mumford and Whitaker 1982; Watkins *et al.* 1982; Baker 1983; Hornshaw *et al.* 1983; Merritt 1987; Arnold and Fritzell 1987b; Jones and Birney 1988; Aulerich *et al.* 1990; Clode *et al.* 1995; Wamberg *et al.* 1996; Stevens *et al.* 1997; Tauson *et al.* 1998; Brunstrom *et al.* 2001; Millsap *et al.* 2004; Bursian *et al.* 2006; Kidd 2008). The lowest body weight of 0.39 kg was used for the conservative exposure profile. For the representative scenario, the average body weight (1.079 kg) was used.

Mink are opportunistic predators that hunt principally along shorelines and emergent vegetation (U.S. EPA 1993). Seasonal availability and regional preferences govern the primary constituents of the mink=s diet. Mammals, fish and crayfish are usually the most abundant prey items, but amphibians, and young birds are also taken (Grimm and Roberts 1950; Burgess and Bider 1980; Linscombe *et al.* 1982; Merritt 1987). (Arnold and Fritzell 1987a) reported high consumption of avian species when birds were limited in mobility by incubation, brood rearing, or molting. Overall, based on stomach content analysis (%

volume), the dietary composition of the mink consists of 31 percent (%) fish, 40 % mammals, 4% birds, 9% crustaceans, 14% herptiles, 0.7% insects, 0.4% vegetation, and 3% other or unidentified matter (Dearborn 1932; Korschgen 1952; Korschgen 1958; Alexander 1977; Schwartz and Schwartz 1981). For this risk assessment, mink are assumed to be 100% piscivorous.

Food ingestion rates have been measured in several studies (Bleavins and Aulerich 1981; Watkins *et al.* 1982; Aulerich *et al.* 1986; Zielinski 1986; Aulerich *et al.* 1990; Bucci *et al.* 1992; Rouvinen *et al.* 1992; Heaton *et al.* 1995; Wamberg *et al.* 1996; Bursian *et al.* 2006). Reported food ingestion rates range from 0.128 to 0.409 kilograms per day (kg/day) wet weight. A conservative food ingestion rate of 0.409 kg/day and a representative food ingestion rate of 0.234 kg/day were used for this risk assessment.

Water ingestion rates ranging from 49 to 84 milliliters per day (ml/day) have been reported for mink (Wamberg *et al.* 1996; Tauson *et al.* 1998). A water intake rate of 0.133 milliliters per gram body weight (ml/g BW) was reported by (Farrel and Wood 1968), however this value included drinking water and water in food, therefore this value was not included. A conservative water ingestion rate of 0.084 liters per day (L/day) and a representative water ingestion rate of 0.0664 L/day will be used in this risk assessment.

An incidental sediment ingestion rate for the mink was not located in the literature; therefore, a predicted incidental ingestion rate for sediment that may be entrained in the digestive system of prey items was used for this risk assessment. Fish are one of the primary food sources for the mink; consumption of prey items containing sediment is assumed to be the primary mechanism by which a piscivorous mammal such as the mink would ingest sediment. In this model, the bluegill (*Lepomis machrochirus*) was used to represent fish eaten by the mink.

Bluegills commonly reach a size of 12 ounces (oz) (Pflieger 1975). From this, the amount of sediment entrained in fish 12 oz (0.340 kg) in weight was predicted. A study evaluating the stomach contents of 153 bluegills reported the diet to contain an average of 9.6% detritus. A daily food ingestion rate of 1.75% of the BW per day has been reported for the bluegill (Kolehmainen 1974). From this, the amount of food consumed by a 0.340 kg bluegill is calculated to be 0.00595 kg/d. If the assumptions are made that 9.6% of the material ingested is sediment, and that the amount of sediment contained in the digestive system of a fish remains constant over time, it can be predicted that a fish of this size may contain 0.0005712 kg of sediment in its digestive system. This value, 0.0005712 kg, was divided by the predicted fish BW (0.340 kg), to express the sediment entrained in the fish digestive systems as 0.00168 kg sediment per kg fish BW. When this value is multiplied by the conservative and representative food ingestion rates of the mink on a dry weight basis, the predicted sediment ingestion rates for mink consuming 100% fish are approximately 0.00022 kg/day and 0.00012 kg/day dry weight.

Reported HR sizes vary from 7.7 to 6,475 hectares (ha) (Marshall 1936; Mitchell 1961; Rue 1981; Schwartz and Schwartz 1981; Merritt 1987; Arnold and Fritzell 1987a; Arnold and Fritzell 1987b; Jones and Birney 1988; Arnold and Fritzell 1990). A value of 7.7 ha was used as the conservative estimate for HR size, and an average value of 938 ha was used as the representative estimate of HR size.

Mink home range sizes are sometimes reported in terms of shoreline length rather than hectares, as mink primarily utilize narrow strips of land adjacent to water bodies (Stumpf and Mohr 1962; Blundell *et al.* 2001). Linear home range sizes ranging from 0.75 km to 11.04 km have been reported for mink (Dunstone and Birks 1983; Stevens *et al.* 1997; Yamaguchi *et al.* 2004). A value of 0.75 km was used as the conservative estimate for linear home range size, and an average value of 2.929 km was used as a representative estimate for linear home range size.

In summary, the food chain model parameters for the mink are as follows:

Conservative estimates:

Body weight:	0.390 kg
[3]Total ingestion:	0.409 kg/day wet weight
[1]Food ingestion:	0.408313 kg/day wet weight
Water ingestion:	0.084 L/day
Sediment ingestion:	0.00022 kg/day dry weight
Home range size:	7.7 ha
Home range size:	0.75 km stream length

Representative estimates:

Body weight:	1.079 kg
[1]Total ingestion:	0.2326 kg/day wet weight
[1]Food ingestion:	0.233607 kg/day wet weight
Water ingestion:	0.0664 L/day
Sediment ingestion:	0.00012 kg/day dry weight
Home range size:	938 ha
Home range size:	2.929 km stream length

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Appendix D
Critical Tissue Concentrations for Fish

Critical Fish Tissue Concentrations Reported for Arsenic

Common name	Scientific name	Lipid % ww	Lipid % dw	NOEC (mg/kg ww)	LOEC (mg/kg ww)	Geometric mean of NOEC and LOEC	NOEC (mg/kg dw)	LOEC (mg/kg dw)	Route of exposure	Life stage	Duration of Exposure	Duration of experiment	Observed effect	Reference	Notes
Bluegill	Lepomis macrochirus			1.8	11.7				water, diet, sediment	juvenile	16 weeks	16 weeks	Reduced growth and survival	Gilderhus 1966	application of sodium arsenite to exp pond every week
Bluegill	Lepomis macrochirus			1.51	5.6				water, diet, sediment	juvenile	16 weeks	16 weeks	Reduced growth and survival	Gilderhus 1966	application of sodium arsenite to exp pond every 4 weeks
Bluegill	Lepomis macrochirus			0.97	2.24				water, diet, sediment	juvenile	16 weeks	16 weeks	Reduced growth	Gilderhus 1966	single application of sodium arsenite to exp pond
Bluegill	Lepomis macrochirus			0.52	0.97				water, diet, sediment	juvenile	16 weeks	16 weeks	Reduced survival	Gilderhus 1966	single application of sodium arsenite to exp pond every week
Bluegill	Lepomis macrochirus			0.49	0.76				water, diet, sediment	adult	16 weeks	16 weeks	abnormal ovary and oocyte development	Gilderhus 1966	application of sodium arsenite to exp pond every week
rainbow trout	Onchorhynchus mykiss			0.25	1.2				water	fingerling	11 weeks	11 weeks	survival	McGeachy and Dixon 1990	Exposure at 5° C
rainbow trout	Onchorhynchus mykiss				2.8				water	fingerling	11 weeks	11 weeks	LD28	McGeachy and Dixon 1990	Exposure at 5° C
rainbow trout	Onchorhynchus mykiss			0.45	1.7				water	fingerling	11 weeks	11 weeks	survival	McGeachy and Dixon 1990	Exposure at 15° C
rainbow trout	Onchorhynchus mykiss				3.4				water	fingerling	11 weeks	11 weeks	LD7	McGeachy and Dixon 1990	Exposure at 15° C
Tilapia	Oreochromis mossambicus				4.8			19.1	water	9 month males	4 week	4 week	growth	Tsai et al 2012	
Rainbow trout	Onchorhynchus mykiss			1.15			4.6			parr	28 days	28 days	survival	Spehar et al. 1980	No mortality observed at any exposure concentration
Killifish	Fundulus heteroclitus				11.24				water		96 hours	96 hours	survival -- LC70 for naïve fish	Shaw et al 2-007	
Killifish	Fundulus heteroclitus				5.99				water		96 hours	96 hours	survival -- LC20 for pre-acclimated fish	Shaw et al 2-007	
Rainbow trout	Onchorhynchus mykiss			0.69	6.65		2.76	26.6	Diet	fry	67 days	67 days	Reduced growth	Hansen et al. 2004	Lumbriculus exposed to sediment from Galen Creek; trout growth was negatively correlated with arsenic
Rainbow trout	Onchorhynchus mykiss			0.69	5.075		2.76	20.3	Diet	fry	67 days	67 days	Reduced growth	Hansen et al. 2004	Lumbriculus exposed to sediment from Silver Bow Creek; trout growth was negatively correlated with arsenic
Rainbow trout	Onchorhynchus mykiss			0.69	5.975		2.76	23.9	Diet	fry	67 days	67 days	Reduced growth	Hansen et al. 2004	Lumbriculus exposed to sediment from Silver Bow Creek, undepurated; trout growth was negatively correlated with arsenic
Rainbow trout	Onchorhynchus mykiss			2.325	4.425		9.3	17.7	diet	juvenile	28 days	28 days	25 or greater reduction in growth	Erickson et al. 2011	
Rainbow trout	Onchorhynchus mykiss			2.05	4.3		8.2	17.2	water plus diet	juvenile	28 days	28 days	25 or greater reduction in growth	Erickson et al. 2011	
Rainbow trout	Onchorhynchus mykiss			2.05	4.575		8.2	18.3	diet	juvenile	28 days	28 days	25 or greater reduction in growth	Erickson et al. 2011	
Rainbow trout	Onchorhynchus mykiss			2.05	8		8.2	32	water plus diet	juvenile	28 days	28 days	25 or greater reduction in growth	Erickson et al. 2011	
			geo mean	1.288	5.551										
			10th percentile	0.69	4.30										
			25th percentile	0.69	4.5										

If effect concentration was cited in dry weight, a wet weight concentration was calculated using the 75 percent moisure value for bony fish cited in U.S. EPA 1993

Not used -- Reported whole body conc is a mean for all fish used in all treatments

rainbow trout	Onchorhynchus mykiss			0.4		2.3	water	parr	144 hours	144 hours	lc50	Dixon and Sprague 1981

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Appendix E
Toxicity Test Reports, Statistical Analyses

REPORT CERTIFICATION

The following report titled "LOCKHEED MARTIN SERAS SEDIMENT TOXICITY TESTING – *Hyalella azteca*" is an accurate and truthful representation of the toxicity testing which was performed by American Aquatic Testing, Inc., located at 890 North Graham Street Allentown, Pennsylvania. We further certify that we have personally examined and are familiar with the information submitted in this document and based on our inquiry of those individuals immediately responsible for obtaining the information; we believe the submitted information is complete as presented. We are aware that there are significant penalties for submitting false information.

Christopher J. Nally
President, Laboratory Director

Tarmo Pallop
Vice-President, Laboratory Manager

LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING–*Hyalella azteca*

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B. Statistical data for *Hyalella azteca* 28-Day survival and growth test

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LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING–*Hyalella azteca*

INTRODUCTION

During the month of August 2013, samples of sediment were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. These sediment samples were used to perform toxicity tests to determine if the tested matrices represent a significant threat to potential receptor organisms.

The sediment samples from the site were delivered to American Aquatic Testing, Inc. (AAT) and evaluated for toxicity using a 28-day solid phase exposure using the freshwater invertebrate *Hyalella azteca* [1]. Following the exposure period, surviving test organisms from the sediments collected at the site were compared to the off-site reference sediment (location 02) tested under similar conditions. The endpoints used for determination of an impact in the amphipod exposures were mortality, measured as mean survival, and growth, measured as biomass (combined dry weight of surviving test organisms divided by the original number of test organisms exposed).

MATERIALS AND METHODS

Surface sediment samples were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. Station locations were selected to represent areas that may have been impacted by the facility's operations.

Preparation of sediment samples for testing

Samples were collected into 2.5-gallon high-density polyethylene (HDPE) containers and placed on ice after collection. Sediment samples were picked up by AAT personnel on August 24, 2013 and transported on ice. Upon arrival at AAT, the samples were refrigerated until being used for testing on September 6, 2013. These samples were physically screened using a #18 mesh screen to remove large debris and indigenous organisms on September 3, 2013.

Control sediment used to assess the health of the test organisms used for testing was collected from the Spruce Run Reservoir in Clinton, NJ on September 3, 2013 and was screened using a #18 mesh screen to remove large debris and indigenous organisms on September 4, 2013. Screened sediment was placed in a five gallon HDPE container and refrigerated until used for testing on September 6, 2013.

Test organisms

Study amphipods (*Hyalella azteca*) were obtained from stock cultures maintained by ABS, Inc. of Fort Collins, CO several days before testing was to begin to allow for a sufficient acclimation to the laboratory reconstituted fresh water which was used as the overlying water for the exposures. During this time, the organisms were held under conditions similar to that which they would encounter during the test (see Table II). Once daily the amphipods were fed a combination of yeast, cereal leaves and digested trout pellets [2]. At the beginning of the 28-day exposure, the test organisms were 10-14 days old.

A reference toxicant test using potassium chloride as the toxicant was conducted concurrently with the 28-day exposure to verify the health of the lot of organisms used in the sediment test. The 48 hr LC_{50} of 623.4 ppm falls within the acceptable range of the control chart being maintained by AAT for this test species. A copy of the raw data and the control chart are included with the other raw data for this test in Appendix A.

Experimental procedures

The entire sediment exposure series for this project consisted of 16 sediment samples from the Vineland Chemical Site and one of control sediment provided by AAT. Tox-Sed 002 was collected from an off site reference location. Test chambers (300 mL tall form borosilicate glass beakers) were filled with 100 mL of sediment. 175 mL of test water was poured over the sediment gently to cause minimal disturbance. There were five replicate chambers for each sample treatment. Test chambers were allowed to settle for 24 hours prior to test initiation.

After the settling period, the overlying water was siphoned off and fresh laboratory water was introduced, using a small, round HDPE disk suspended over the sediment to deflect the water flow and minimize disturbance to the sediment. At this time, initial physical chemistries were conducted on the overlying water. Alkalinity, ammonia, conductivity, hardness and pH were measured initially, prior to the introduction of test organisms, and at the end of the 28-day exposure for each sample location and the control. The dissolved oxygen and temperature, and pH were also measured initially and every 24 hours thereafter for the duration of the exposure for each sample location and the control.

The exposure period began by placing 10 randomly selected test organisms into each of five replicate chambers for each sample location and the control. Care was taken to ensure that the organisms were released beneath the surface of the overlying water to keep air bubbles from forcing the organisms to the surface. Each test chamber was then fed 0.5 mL of the YCT mixture previously cited and the test chambers were covered. Test conditions are summarized in Table II.

Each day during the exposure period observations of each chamber were carried out to determine the number of organisms dead, swimming, on the surface of the sediment or on the surface of the water. The overlying water was siphoned off twice a day and replaced using laboratory water as a measure to maintain sufficient dissolved oxygen levels. Care was taken to minimize disturbance of the sediment during water renewal.

At the end of the 28-day exposure the final physical chemistries were performed and the test chambers were prepared for the removal of test organisms. Each chamber was gently stirred using a pipette to suspend the sediment in the water column inside the chamber. This slurry was then poured into a #60 mesh sieve (250 μm) and rinsed in a shallow pan of laboratory water to remove the finer grains of the sediment. The remaining contents of the sieve were placed into a second shallow pan of laboratory water over a light table. The remaining contents of the sieve were carefully sorted to find the surviving test organisms in each of the five replicates for each site. All surviving organisms were transferred to a 30 mL soufflé cup for live count verification and preparation for weight analysis.

When all test chambers had been sorted and the number of survivors verified, 0.5 mL of ethanol was added to each soufflé cup to dispatch the organisms. They were then transferred to a previously dried and tared aluminum pan and placed into an oven to dry at 105° C for six hours. Upon removal from the oven, the pans were placed into a dessicator to cool and then were measured to the nearest 0.01 mg.

Data analysis

Data analysis was performed following procedures published by the USEPA [1] using the using the ToxCalc data analysis software published by Tidepool Scientific, Inc., version 5.0.23. Survival data was transformed by arcsine squareroot and then tested for normality using the Shapiro-Wilk's test or the Chi-Square test and for homogeneity of variance using Bartlett's test as appropriate. Normal data distributions were analyzed using Analysis of Variance followed by Dunnett's comparison of means test. Non-normal data or those data sets exhibiting non-homogeneous variances were analyzed using Steel's Many-one Rank test of Wilcoxon Rank Sum as appropriate.

All raw data sheets are located in Appendix A

TABLE I: Summary of Conditions for *Hyalella azteca* Toxicity Test

1.	Test type;	Whole sediment, static, daily renewal
2.	Temperature;	23.0 +/- 1.0° C
3.	Light quality;	Wide-spectrum fluorescent illumination
4.	Light intensity;	50 - 100 foot-candles
5.	Photoperiod;	16 hours light, 08 hours dark
6.	Test chamber size;	300 mL high form borosilicate glass beakers
7.	Sediment volume;	100 mL / replicate
8.	Overlying water volume;	175 mL
9.	Renewal;	2 volume exchanges per day
10.	Age of test organisms;	10 to 14 days
11.	Number organisms / container;	10
12.	Replicates;	05
13.	Feeding;	Yeast, cereal leaves and trout pellets with *Selenastrum capricornutum,* 0.5 mL / day
14.	Aeration;	None unless dissolved oxygen concentrations $\leq$ 40 % saturation, then ~ 100 bubbles / min.
15.	Overlying water;	EPA moderately hard reconstituted water
16.	Test chamber cleaning;	Only if necessary
17.	Overlying water quality;	D. O., pH and temperature daily; alkalinity, ammonia, conductivity and hardness at beginning and end of test
18.	Test duration;	28 days
19.	Effects measured;	Survival and growth (mean dry weight)
20.	Test acceptability;	Minimum control survival 80 %

RESULTS

Effects on survival @ 28 Days using reference sample TOX-SED-002

Raw data are presented in Appendix A. Data were arcsine squareroot transformed. The data were found to be normal in distribution, were tested for homogeneity and found to be homogeneous. It was therefore determined that parametric analyses were appropriate and ANOVA followed by Dunnett's pairwise comparisons were used to determine differences between the survival of organisms in all samples and the control sample.

Results from the analysis, which compared survival in station sediments with survival of organisms exposed to the reference sample (reference sample and control sample were not statistically different), are presented in Table II and in Appendix B.

Of the 15 samples from the study area evaluated, only Tox-Sed 015, 018 and 025 exhibited mortality found to be statistically significant when compared to the reference treatment. These samples were not included in the growth analysis.

Table II. Percent survival of *H. azteca* by replicate chamber & survival comparison using reference sample*

	Sample Identification															
Rep.	Tox Sed 002	Tox Sed 005	Tox Sed 006	Tox Sed 007	Tox Sed 009	Tox Sed 011	Tox Sed 012	Tox Sed 013	Tox Sed 014	Tox Sed 015	Tox Sed 016	Tox Sed 017	Tox Sed 018	Tox Sed 019	Tox Sed 022	Tox Sed 025
A	100	100	100	100	100	80	100	100	100	100	70	90	80	90	80	40
B	90	100	100	80	80	80	80	100	80	100	100	70	80	90	100	70
C	90	100	90	100	80	90	100	100	90	30	70	70	30	100	80	80
D	100	100	100	90	80	90	100	100	90	50	60	70	70	80	90	90
E	100	100	90	90	90	100	80	100	80	00	100	100	70	90	90	80
Mean % Survival	96	100	96	92	86	88	92	100	88	20	80	80	66	90	88	72
Statistically Different from Reference?		no	no	no	no	no	no	no	no	Yes	no	no	Yes	no	no	Yes

* Tox-Sed 002 is off-site reference sediment used for evaluation.

Effects on growth @ 28 Days using reference sample TOX-SED-002

Raw data are presented in Appendix A. Data were data were found to be normal in distribution, were tested for homogeneity and found to be homogeneous. It was therefore determined that parametric analyses were appropriate and ANOVA followed by Dunnett's pairwise comparisons were used to determine differences between the survival of organisms in all samples and the control sample.

Results from the analysis, which compared the biomass, the total weight of surviving test organisms divided by the original number of test organisms in each chamber, in all samples with those of organisms exposed to the reference sample. Data are presented in Table III and Appendix B.

Of the 12 samples evaluated for growth, the samples identified as Tox-Sed 006, Tox-Sed 016 and Tox-Sed 017 all exhibited growth that was found to be statistically significant when compared to the reference treatment.

Table II. Average dry weight (mg) of *h. azteca* by replicate chamber & survival comparison using reference sample*

	Sample Identification												
Rep.	Tox Sed 002	Tox Sed 005	Tox Sed 006	Tox Sed 007	Tox Sed 009	Tox Sed 011	Tox Sed 012	Tox Sed 013	Tox Sed 014	Tox Sed 016	Tox Sed 017	Tox Sed 019	Tox Sed 022
A	0.199	0.203	0.136	0.114	0.115	0.186	0.181	0.122	0.131	0.084	0.107	0.162	0.168
B	0.117	0.198	0.075	0.099	0.223	0.269	0.218	0.147	0.188	0.083	0.090	0.136	0.133
C	0.113	0.113	0.088	0.096	0.862	0.171	0.172	0.135	0.150	0.100	0.076	0.195	0.105
D	0.139	0.139	0.099	0.089	0.110	0.182	0.182	0.152	0.152	0.077	0.061	0.206	0.099
E	0.164	0.164	0.074	0.118	0.148	0.189	0.189	0.173	0.184	0.081	0.047	0.157	0.061
Ave. Dry Weight	0.146	0.166	0.094	0.103	0.136	0.200	0.178	0.146	0.161	0.085	0.076	0.171	0.113
Statistically Different from Reference?		no	Yes	no	no	no	no	no	no	Yes	Yes	no	no

* Tox-Sed 002 is off-site reference sediment used for evaluation.

REFERENCES

[1] **Ingersoll, C.G., G.A. Burton, T.D. Dawson, F.W. Dwyer, D.S. Ireland, R.A. Hoke, N.E. Kemble, D.R. Mount, T.J. Norberg-King, P.K. Sibley, and L. Stahl** 2000 Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates EPA 600/R-99/064. U.S. Environmental Protection, Office of Science and Development, Duluth, MN

[2] **ToxCalc 5.0,** version v5.0.23I-Net data analysis software published by Tidepool Scientific Software, Inc. McKinleyville, CA

APPENDIX A

RAW DATA FOR *Hyalella azteca* 28-DAY

SURVIVAL AND GROWTH TEST

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
Control	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	W	N	N	1M
	C	N	N	N	N	N	N	N	N	N	N	1M	N	N	1M
	D	N	N	N	N	N	N	N	N	N	N	1M	N	N	1M
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	1M	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	2F
	E	N	N	N	N	N	N	N	N	1F	N	N	N	N	N
5	A	N	N	N	N	N	N	N	N	N	N	1F	N	1M	1M
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	1M	1M	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	1M
6	A	N	N	N	N	N	N	N	N	N	N	1M	N	N	1M
	B	N	N	N	N	N	N	N	N	N	N	1M	N	N	2M
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	1F	N
7	A	N	N	N	N	N	N	N	N	N	N	N	1M	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	1M
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	1M	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Initials		TDP	MMS	MMS	TDP	SH	WD	TDP	TDP	TDP	TDP	BD	BD	BD	BD
Date		9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, ~~B=No Observations~~

Comments: N=No observations F=on sediment surface M=swimming W=on water surface

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
~~Control~~ 9	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
11	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	IM	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	IF	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
12	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	IM	N	IM	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	IF	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	IM	N	N	N	N	N	N
13	A	N	N	N	N	N	N	N	N	N	N	N	N	IM	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	IM	N	N
	D	N	N	N	N	N	N	N	IF	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
14	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	IM
Initials		TRP	MK	MK	TRP	SH	WP	TRP	TRP	TRP	TRP	CB	CB	CB	CB
Date		9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, ~~B=No Observations~~

Comments:

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
~~Control~~ 15	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
16	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	2F	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
17	A	N	N	N	N	N	N	N	N	N	N	N	N	N	1M
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	1F	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	1M	N	N	N	N	N	N	N
18	A	N	N	N	N	N	N	N	N	N	N	N	N	1M	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	1W	N	N	N	N	N	N	1M
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
19	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	1M	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Initials		TRD	MK	[illegible]	TRD	SH	[illegible]	TRD	TRD	TRD	TRD	[illegible]	[illegible]	[illegible]	[illegible]
Date		9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, ~~B=No Observations~~

Comments:

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
~~Control~~ 22	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	1M	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	2F	N	N	1F	N	N	N
	D	N	N	N	N	N	N	1F	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
25	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
Initials		TAP	MMF	MMF	TAP	SH	AP	TAP	TAP	TAP	TAP	GL	GL	GL	GL
Date		9/6	9-7	9-8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18 ①	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, B=~~No Observations~~

Comments: ① 09/18 GL

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
Control	A	1M	N	N	N	N	2F	N	1F	2M	1F	3F	1F	N	N	3F 1M	10
	B	N	1M	N	N	1F	7F	N	N	1F	N	2F	N	1M	N	2F	9
	C	N	N	1M	N	N	1F 2M	N	N	2F	N	1M	1F	N	1F	1M	9
	D	1M	N	N	N	N	5F	N	N	N	N	1F	1M	N	1M	1F	10
	E	N	N	N	N	2F	3F	N	N	N	N	1F	1M	N	1M 2F	2F	10
2	A	2M	1M	N	N	N	N	N	1M	1M	N	3F	1F	1F	N	N	10
	B	N	N	N	N	N	N	N	N	2M	N	1F	N	N	N	N	~~8~~ (1)
	C	N	N	N	N	N	N	N	N	N	1M	N	N	1M	1F	N	9
	D	N	N	N	N	N	N	N	N	1F	N	N	1F	2M	2F	N	10
	E	N	1M	N	N	N	N	N	N	N	N	2F	N	2M	1F	N	10
5	A	1F	1M	N	N	N	3M	N	N	N	N	3M	N	2M	1F	N	10
	B	N	N	N	N	N	2F 1M	N	N	N	N	2F	N	2M	1F 3M	N	10
	C	2M	N	N	N	1M	N	N	1F	3M	1F	1M	2M	1F	2F	1M	10
	D	N	N	N	N	N	N	N	1F	N	N	1F	1F	2M	1M	N	10
	E	N	N	N	N	N	1F	1F	N	N	N	N	2M	1F	2F	N	10
6	A	N	2M	N	N	N	1F	1F	N	1F	N	2M	N	1F	1F	N	10
	B	N	N	N	N	N	N	N	N	1F	N	2F	N	N	2F	N	10
	C	1F	N	N	N	N	2F	N	N	1M	1M	1F	2F	N	1F	N	9
	D	N	~~1F~~ N	N	N	N	N	N	N	1F	N	2F	1F	1F	1F 1M	N	10
	E	1M	1M	N	1M	N	N	N	N	2M	N	1F	N	1F	N	N	9
7	A	1M	N	N	N	N	N	N	N	N	N	N	N	N	N	N	10
	B	1M	N	N	N	N	N	1M	N	N	1F	1M	N	N	N	N	8
	C	2M	N	N	N	N	1M	N	N	1M	N	N	N	N	1F	N	~~9~~ (2)
	D	N	1F	N	N	N	N	N	N	2M	1F	N	N	N	N	N	9
	E	N	N	N	N	N	N	N	N	1M	N	1M	N	N	N	N	9
Initials		[illegible]	MP	MP	TPO	TPO	TPO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MP	MP	TPO	TPO	TPO
Date		9/20	9/21	9/22	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments:

(2) 9 [illegible] 10/04
(2) 10

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
9	A	1M	1F	N	N	N	N	N	N	1M	N	N	N	1F	N	1F	10
	B	1M	N	N	N	1F	N	N	1M	1F	N	N	N	N	N	N	8
	C	2M	1M	N	N	N	N	N	N	N	1M	N	N	N	N	N	8
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	8
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1F	9
11	A	2F	N	N	N	1F	N	N	N	1F	1M	N	N	1M	1F	N	8
	B	N	N	N	1F	1F	1F	N	N	N	1M	N	N	2M	2M	N	8
	C	N	N	N	1F	2F	N	N	N	N	N	N	N	2M	1F	N	9
	D	2F	N	N	N	N	1M	N	N	1F	N	2F	N	3M	2F,1M	N	9
	E	N	1M	1F	N	1F	N	N	N	1M	N	N	1F	2M	1F	N	10
12	A	N	2F	N	N	N	N	N	N	N	1M	1M	N	1M	1M	2M	10
	B	N	N	N	N	1F	2F	1F	N	N	N	1M	N	1M	N	N	8
	C	1F	N	N	2F	N	N	N	N	1F	N	N	1F	N	N	N	10
	D	N	N	N	N	N	3F	1F	N	N	N	N	N	2M	1F	N	10
	E	1M	1F	N	N	N	1M,1F	N	N	N	N	1F	N	N	N	N	8
13	A	N	N	N	N	N	3M,2F	1F	N	N	N	2F	1F	1F	2F	N	10
	B	N	N	N	N	N	3F	1F	N	N	N	N	N	1F	N	1M	10
	C	1M	N	N	N	N	N	1F	N	N	N	N	N	1F	2F	2M	10
	D	N	N	N	N	N	2F	N	N	2F	N	N	N	2F	N	1M	10
	E	N	1F	N	N	N	1F,2M	N	N	N	N	N	N	1F	3F	1F	10
14	A	1M	1F	N	N	N	N	N	N	1M	N	N	N	2F	1F	1F	10
	B	1M	1F	N	N	N	1M	N	N	N	1F	1F	N	1F	2F	1M	8
	C	N	N	N	N	N	N	N	N	1F	N	1F	1M	2F	N	N	9
	D	N	1F	N	N	N	N	N	N	N	N	1M	1F	N	1F	1M	9
	E	N	2M	N	N	N	1F	1M	1M	N	1F	N	N	1F	1F	2M	8
Initials		[illegible]	MP	MP	TP	TP	TP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MP	MP	TP	TP	TP
Date		9/20	9/21	9/22	9/23	9/24	9/25	9/26	09/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments:

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
15	A	N	N	N	N	N	N	N	N	N	N	1M	1F	N	N	N	1
	B	N	N	N	N	N	N	N	N	N	1M	1M	1M	N	N	N	1
	C	N	N	N	N	N	N	N	N	N	N	1F	N	1F	N	N	3
	D	1M	N	N	N	N	N	N	N	N	N	N	N	N	N	N	5
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	0
16	A	N	N	1M	N	N	N	N	N	N	N	2F	N	N	N	1M	~~8~~ ①
	B	N	1F	N	N	N	N	N	N	N	1M	N	N	2F	N	N	10
	C	2M	N	N	1F	2F	N	N	N	N	1F	N	N	N	N	N	7
	D	N	2F	N	N	N	N	N	N	2F	N	N	N	N	1F	N	6
	E	N	N	N	2F	N	N	N	N	1F	N	N	N	N	N	N	10
17	A	N	N	N	N	N	N	N	N	N	N	1M	N	N	N	N	9
	B	N	N	2F	1F	N	1M	N	N	N	N	N	N	1M	N	N	7
	C	1M	N	N	N	N	N	N	N	N	1M	1F	N	N	N	N	7
	D	1M	2M	N	1F	N	N	N	N	1M	N	1F	1F	N	N	N	7
	E	2M	1M	N	1M	N	N	N	N	1F	N	N	N	N	1F	N	10
18	A	N	2F	N	N	N	N	N	N	N	N	1M	1F	N	N	N	8
	B	1F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	8
	C	1F	N	N	1F	N	1F	N	N	1F	N	N	N	1M	1M	N	3
	D	N	N	N	N	1F	2W	N	N	N	1M	2F	2M	N	1M	N	7
	E	N	1M	N	N	N	N	N	N	N	N	1F	N	1M	N	N	7
19	A	N	2F	N	N	N	N	N	N	N	N	2F	N	2F	1F	1M, 1F	9
	B	N	N	N	N	N	N	N	N	1M	N	1F	N	N	N	1F	9
	C	N	N	N	N	N	N	N	N	N	N	2M	N	N	1F	1M	10
	D	N	1M	N	1F	N	N	N	N	1M	N	N	N	N	N	N	8
	E	1M	N	N	N	N	N	N	N	N	1F	N	N	1M	N	1M	9
Initials		[illegible]	MD	MD	TPO	TPO	TPO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MD	MD	TPO	TPO	TPO
Date		09/20	9/21	9/22	9/23	9/24	9/25	09/26	09/27	09/28	09/29	09/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments: ① 7 [illegible] 10/04

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
22	A	2F	1M	N	N	N	N	1F	N	N	N	2F	1F	N	1F	1M	8
	B	N	N	N	1F	N	N	1F	N	1F	N	3F	2M	1M	1F	N	10
	C	1M	N	N	N	1F	N	N	N	N	N	1M	N	N	1F	N	8
	D	1F	3M	N	N	1F	N	N	N	N	1M	N	N	N	N	N	9
	E	N	N	N	N	N	N	N	N	N	1M	2M	1M	N	1F	N	9
25	A	N	N	N	N	N	1F	N	N	1F	N	1M	1F	N	N	N	4
	B	N	N	N	N	N	N	N	N	N	N	2F	N	N	1M,1F	N	7
	C	1F	3F	N	N	2F	N	N	N	N	N	1M	N	1M	N	1M	8
	D	1F	N	N	N	N	1F	N	N	N	1M	4M	2M	2F	1F	N	9
	E	1F	2M	N	N	1M	N	N	N	N	1M	1F	N	4M	1F,2M	N	8
\	A																
	B																
	C																
	D																
	E																
\	A																
	B																
	C																
	D																
	E																
\	A																
	B																
	C																
	D																
	E																
Initials		[illegible]	MP	MP	TMD	TMD	TMD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MP	MP	TMD	TMD	TMD
Date		09/20	9/21	9/22	9/23	9/24	9/25	09/26	09/27	09/28	09/29	09/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments:

Client/Toxicant: 48
Project Number: 22-01
Species: N. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	~~C/E IC25 & NOEC calc. weight (mg)~~
control	A	1	0.00671	0.00880	2.09	10	0.209	
	B	2	0.00621	0.00801	1.80	9	0.200	
	C	3	0.00564	0.00737	1.73	9	0.192	
	D	4	0.00714	0.00892	1.78	10	0.178	
	E	5	0.00574	0.00696	1.22	10	0.122	
	~~F~~							
	~~G~~							
	~~H~~							
2	A	6	0.00632	0.00831	1.99	10	0.199	
	B	7	0.00620	0.00725	1.05	9	0.117	
	C	8	0.00627	0.00729	1.02	9	0.113	
	D	9	0.00590	0.00729	1.39	10	0.139	
	E	10	0.00548	0.00712	1.64	10	0.164	
	~~F~~							
	~~G~~							
	~~H~~							
5	A	11	0.00551	0.00754	2.03	10	0.203	
	B	12	0.00696	0.00894	1.98	10	0.198	
	C	13	0.00591	0.00742	1.51	10	0.151	
	D	14	0.00664	0.00791	1.27	10	0.127	
	E	15	0.00717	0.00861	1.44	10	0.144	
	~~F~~							
	~~G~~							
	~~H~~							
6	A	16	0.00644	0.00780	1.36	10	0.136	
	B	17	0.00600	0.00675	0.75	10	0.075	
	C	18	0.00548	0.00627	0.79	9	~~0.158~~ (1)	
	D	19	0.00510	0.00609	0.99	10	0.099	
	E	20	0.00658	0.00725	0.67	9	0.074	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14/13	10/15	10/04	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations: (1) 0.086 ER 10/16

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
7	A	21	0.00552	0.006666	1.14	10	0.114	
	B	22	0.00584	0.006663	0.79	8	0.099	
	C	23	0.00600	0.006960	0.96	10	0.096	
	D	24	0.00674	0.007574	0.80	9	0.089	
	E	25	0.00668	0.007774	1.20	9	0.118	
	~~F~~							
	~~G~~							
	~~H~~							
9	A	26	0.00608	0.007223	1.15	10	0.115	
	B	27	0.00575	0.007753	1.78	8	0.223	
	C	28	0.00603	0.006672	0.69	8	0.086	
	D	29	0.00604	0.006692	0.88	8	0.110	
	E	30	0.00638	0.007771	1.33	9	0.148	
	~~F~~							
	~~G~~							
	~~H~~							
11	A	31	0.00562	0.007111	1.49	8	0.186	
	B	32	0.00602	0.008117	2.15	8	0.269	
	C	33	0.00605	0.007759	1.54	9	0.171	
	D	34	0.00613	0.007777	1.64	9	0.182	
	E	35	0.00578	0.007767	1.89	10	0.189	
	~~F~~							
	~~G~~							
	~~H~~							
12	A	36	0.00633	0.008114	1.81	10	0.181	
	B	37	0.00634	0.008108	1.74	8	0.218	
	C	38	0.00657	0.008829	1.72	10	0.172	
	D	39	0.00656	0.008821	1.65	10	0.165	
	E	40	0.00645	0.007768	1.23	8	0.154	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/15	10/24	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1302
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
13	A	41	0.00590	0.00712	1.22	10	0.122	
	B	42	0.00605	0.00752	1.47	10	0.147	
	C	43	0.00530	0.00665	1.35	10	0.135	
	D	44	0.00626	0.00778	1.52	10	0.152	
	E	45	0.00603	0.00776	1.73	10	0.173	
	~~F~~							
	~~G~~							
	~~H~~							
14	A	46	0.00591	0.00722	1.31	10	0.131	
	B	47	0.00581	0.00731	1.50	8	0.188	
	C	48	0.00627	0.00762	1.35	9	0.150	
	D	49	0.00735	0.00872	1.37	9	0.152	
	E	50	0.00784	0.00931	1.47	8	0.184	
	~~F~~							
	~~G~~							
	~~H~~							
15	A	51	0.00692	0.00707	0.15	1	0.160	
	B	52	0.00759	0.00781	0.22	1	0.220	
	C	53	0.00754	0.00774	0.20	3	0.067	
	D	54	0.00683	0.00736	0.53	5	0.106	
	E	55	0.00735	0.0 —	—	0	—	
	~~F~~							
	~~G~~							
	~~H~~							
16	A	56	0.00812	0.00871	0.59	7	0.084	
	B	57	0.00705	~~0.00840~~ ①	0.83	10	0.083	
	C	58	0.00751	0.00821	0.70	7	0.100	
	D	59	0.00663	0.00709	0.46	6	~~0.078~~ ②	
	E	60	0.00690	0.00771	0.81	10	0.081	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/15	10/04	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations: ① 0.00788 10/14 [illegible]
② 0.077 ER 10/16

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: H azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1340
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
17	A	61	0.00695	0.00791	0.96	9	0.107	
	B	62	0.00651	0.00714	0.63	7	0.090	
	C	63	0.00648	0.00701	0.53	7	0.076	
	D	64	0.00758	0.00801	0.43	7	0.061	
	E	65	0.00673	0.00720	0.47	10	0.047	
	~~F~~							
	~~G~~							
	~~H~~							
18	A	66	0.00706	0.00758	0.52	8	0.066	
	B	67	0.00622	0.00683	0.61	8	0.076	
	C	68	0.00636	0.00662	0.26	3	0.087	
	D	69	0.00649	0.00701	0.52	7	0.074	
	E	70	0.00609	0.00658	0.49	7	0.070	
	~~F~~							
	~~G~~							
	~~H~~							
19	A	71	0.00611	0.00757	1.46	9	0.162	
	B	72	0.00686	0.00808	1.22	9	0.136	
	C	73	0.00697	0.00892	1.95	10	0.195	
	D	74	0.00786	0.00951	1.65	8	0.206	
	E	75	0.00690	0.00821	1.41	9	0.157	
	~~F~~							
	~~G~~							
	~~H~~							
22	A	76	0.00751	0.00885	1.34	8	0.168	
	B	77	0.00715	0.00848	1.33	10	0.133	
	C	78	0.00595	0.00679	0.84	8	0.105	
	D	79	0.00660	0.00749	0.89	9	0.099	
	E	80	0.00630	0.00685	0.55	9	0.061	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/14	10/14	10/18	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: N. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
25	A	81	0.00696	0.00738	0.42	4	0.105	
	B	82	0.00677	0.00726	0.49	7	0.070	
	C	83	0.00590	0.00719	1.29	8	0.161	
	D	84	0.00672	0.00817	1.45	9	0.161	
	E	85	0.00738	0.00873	1.35	8	0.169	
	~~F~~							
	~~G~~							
	~~H~~							
	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							
	A							
	B							
	C							
	D							
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	F							
	G							
	H							
	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/15	10/04	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Job Number: 48-22-01
Species: H. azteca

Start Date & Time: 9-6-13 1355
End Date & Time: 10-4-13 1300

Sediment Test

American Aquatic Testing, Inc.,

Water Change Log/Initial Water Readings/General Testing Information

Test Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Morning change(time)	0810	0745	0800	0910	0845	~~1600~~	8:00	8:00	8:30	7:30	1015	0700	1000	7:00	0730
D.O. mg/L	8.6	8.5	8.6	8.6	8.5	8.5	8.3	8.3	8.4	8.3	8.4	8.3	8.6	8.5	8.4
pH	8.2	8.3	8.3	7.9	7.8	8.0	7.8	8.0	8.0	8.0	8.0	8.1	7.9	8.0	8.0
Temp. (C)	23.0	23.5	23.0	23.0	22.0	23.5	23.5	23.5	23.0	22.5	22.0	22.5	22.0	22.5	22.0
Initials	TAP	MT	MT	TAP	SH	TAP	thd	SH	SH	TAP	[illegible]	[illegible]	[illegible]	thd	[illegible]
Date	9/6	9-7	9-8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	9/19	09/20
Afternoon change(time)	1640	1415	1230	1710	1600	1700	1700	1830	1900	1745	1800	1900	1630	1700	1730
D.O. mg/L	8.5	8.5	8.5	8.4	8.4	8.4	8.3	8.4	8.4	8.4	7.9	8.3	8.5	8.4	8.3
pH	8.0	8.2	8.2	7.9	7.9	7.9	7.9	8.0	7.9	8.0	8.0	8.1	7.8	8.1	8.0
Temp. (C)	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	23.0	22.5	22.5	22.0	22.0	23.0
Initials	[illegible]	MT	MT	TAP	SH	SH	SH	SH	TAP	thd	[illegible]	[illegible]	mp	[illegible]	thd
Date	09/06	9-7	9-8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	9/18	09/18	9/20

Test Day	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Morning change(time)	1010	1000	7:30	7:30	8:00	7:30	7:30	0715	0730	7:30	7:30	7:30	7:30	7:30
D.O. mg/L	8.4	8.4	8.3	8.6	8.5	9.1	8.7	8.6	8.5	8.5	8.5	8.5	8.5	8.5
pH	7.9	7.9	8.0	7.9	8.0	7.3	8.1	8.0	8.1	7.9	7.9	7.7	8.0	7.9
Temp. (C)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	22.5	23.0	23.0	23.0	23.0	23.0
Initials	mp	mp	thd	thd	thd	thd	thd	[illegible]	[illegible]	thd	SH	thd	thd	thd
Date	9/21	9/22	9/23	9/24	9/25	9/26	9/27	09/28	09/29	9/30	10/1	10/2/13	10/3/13	10/4/13
Afternoon change(time)	1630	1700	1720	1700	1640	1615	2029	1530	1245	1745	1500	1615	1830	
D.O. mg/L	8.3	8.3	8.5	8.5	8.5	8.6	8.5	8.4	8.7	8.5	8.4	8.3	8.4	
pH	8.0	8.0	8.0	8.0	7.9	8.0	8.1	8.0	7.9	8.0	7.7	8.1	7.8	
Temp. (C)	22.5	22.0	22.5	23.0	23.0	23.0	23.0	23.5	23.0	22.0	23.0	23.0	23.0	
Initials	mp	MT	SH	thd	SH	[illegible]	[illegible]	SH	SH	[illegible]	SH	SH	SH	
Date	9/21	9-22	9-23	9/24	9/25	09/26	09/27	9/28	9/29	09/30	10/1	10/2	10/3	

Control Sed. collection date/by: 9/3/13 / TAP

Control Sed. sieve date/by: 9/4/13 / TAP

Sieve size used: 1mm

Sample sieve date/by: 9/3/13 / CJN, SH, TD

Sieve size used: 1mm

Organism source: ABS

Test organism Lot number: 1428

Number of animals per chamber: 10

Food Type: flake

Frequency of feeding: every other day

Test Chamber size: 300ml

Test Volume of sediment: 100ml

Test Volume of water: 150ml

Test Duration: 28 days

Test Temperature Range: 23±1°c

① 0830 thd 9/11/13

Client/Toxicant: 48
Job Number: 22-01
Species: H.azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	Control	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	2	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	5	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	6	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	7	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	9	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	11	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	12	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	13	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	14	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	15	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
Dissolved Oxygen (mg/L)	Control	7.2	7.4	7.2	6.6	6.3	6.3	6.2	6.2	6.4	6.3	6.0
	2	7.5	7.7	7.5	6.9	6.5	6.2	6.4	6.4	6.9	6.6	6.0
	5	5.6	5.9	7.3	6.2	6.3	6.0	5.8	6.0	6.6	6.5	5.9
	6	5.5	6.2	7.3	6.6	6.7	6.3	6.3	6.3	6.9	6.7	6.0
	7	5.0	5.8	6.5	6.5	6.7	6.3	6.4	6.5	7.0	6.5	5.9
	9	5.3	5.9	7.1	6.7	6.9	6.3	6.6	6.7	7.2	6.8	6.1
	11	5.8	6.4	7.4	6.6	6.7	6.4	6.5	6.8	7.2	6.8	6.0
	12	5.4	6.0	7.3	6.7	6.6	6.3	6.5	6.8	7.1	6.8	5.8
	13	6.7	7.0	7.3	6.9	6.7	6.4	6.4	6.7	7.2	7.0	5.8
	14	5.5	5.9	7.4	6.5	6.5	6.6	6.1	6.4	6.9	6.7	5.6
	15	7.1	7.2	7.7	6.6	7.0	6.6	6.8	6.9	7.3	7.0	6.1
pH	Control	7.6	7.8	7.7	7.5	7.4	7.4	7.5	7.5	7.6	7.5	7.4
	2	7.5	7.7	7.6	7.6	7.4	7.4	7.5	7.4	7.6	7.5	7.3
	5	7.4	7.7	7.5	7.5	7.4	7.4	7.4	7.4	7.5	7.4	7.2
	6	7.4	7.7	7.5	7.5	7.4	7.4	7.5	7.4	7.5	7.4	7.1
	7	7.5	7.6	7.6	7.5	7.4	7.4	7.4	7.4	7.5	7.4	7.1
	9	7.4	7.7	7.5	7.5	7.4	7.4	7.4	7.3	7.5	7.4	7.1
	11	7.4	7.6	7.5	7.5	7.4	7.4	7.4	7.3	7.4	7.3	7.1
	12	7.4	7.6	7.5	7.5	7.4	7.4	7.4	7.3	7.4	7.3	7.2
	13	7.3	7.6	7.4	7.5	7.4	7.4	7.3	7.3	7.5	7.4	7.2
	14	7.3	7.6	7.4	7.5	7.4	7.4	7.4	7.3	7.5	7.4	7.2
	15	7.4	7.6	7.5	7.5	7.4	7.4	7.5	7.3	7.5	7.4	7.2
	Initials	SH	MM	MM	WHM	SH	MM	SH	SH	SH	thd	[illegible]
	Date	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control	286	278	60	70	130	170	0.13	0.04
2	274	266	50	70	120	120	0.23	0.04
5	274	267	60	60	200	170	0.74	0.01
6	272	268	50	90	90	150	0.19	0.04
7	268	269	60	70	130	120	0.24	0.00
9	266	269	60	90	130	130	0.33	0.02
11	269	269	60	60	110	120	0.39	0.02
12	272	270	80	60	80	110	0.18	0.05
13	272	271	60	70	100	120	0.26	0.00
14	276	269	60	70	190	140	0.41	0.01
15	268	268	70	60	140	160	0.16	0.03
Initials	SH	thd	SH	SH	SH	SH	TLP	TLP
Date	9/6	10/3	9/6	10/4	9/6	10/4	9/6	10/4

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	16	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	17	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	18	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	19	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	22	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	25	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	-											
	-											
	-											
	-											
	-											
Dissolved Oxygen (mg/L)	16	6.9	7.0	7.6	6.9	6.9	6.7	6.8	7.0	7.2	6.7	6.0
	17	7.3	7.5	7.8	6.9	7.1	6.7	6.8	6.8	7.3	6.9	5.8
	18	6.1	6.3	7.6	7.1	7.0	6.9	6.8	6.9	7.3	7.0	5.7
	19	7.2	7.6	7.6	7.1	7.0	6.6	6.6	6.9	7.2	7.0	5.9
	22	8.0	8.1	8.2	7.6	6.9	6.7	7.1	7.2	7.5	7.3	5.8
	25	8.1	8.2	8.2	7.7	7.3	6.9	7.4	7.5	7.7	7.7	5.6
	-											
	-											
	-											
	-											
	-											
pH	16	7.3	7.6	7.4	7.5	7.4	7.4	7.4	7.3	7.4	7.4	7.2
	17	7.4	7.5	7.8	7.5	7.4	7.4	7.4	7.3	7.4	7.4	7.2
	18	7.3	7.5	7.4	7.5	7.4	7.5	7.4	7.3	7.4	7.4	7.1
	19	7.3	7.5	7.4	7.4	7.4	7.4	7.4	7.2	7.4	7.3	7.1
	22	7.4	7.6	7.5	7.4	7.4	7.4	7.4	7.3	7.4	7.4	7.1
	25	7.4	7.6	7.5	7.5	7.4	7.5	7.4	7.3	7.4	7.4	7.1
	-											
	-											
	-											
	-											
	-											
	Initials	SH	MJ	MJ	WHM	SH	MJ	SH	SH	SH	SH	SH
	Date	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	09/15	09/16

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
16	275	270	50	70	100	140	0.11	0.00
17	276	267	60	70	180	160	0.38	0.07
18	261	266	50	80	120	150	0.33	0.09
19	273	267	60	80	170	190	0.50	0.04
22	265	265	50	80	110	130	0.09	0.02
25	259	268	60	60	150	160	0.03	0.02
-								
-								
-								
-								
-								
Initials	SH	MJ	SH	SH	SH	SH	TMP	TMP
Date	9/6	10/3	9/6	10/4	9/6	10/4	9/6	10/4

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 11	12	13	14	15	16	17	18	19	20	21
TEMP (C)	Control	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	2	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	5	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	6	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	7	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	9	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	11	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	12	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	13	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	14	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	15	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
Dissolved Oxygen (mg/L)	Control	6.4	6.5	7.5	6.6	6.4	7.0	6.2	6.1	6.8	6.5	6.8
	2	6.1	6.9	7.3	6.5	6.6	7.5	6.8	6.8	6.7	6.6	6.4
	5	6.4	6.8	7.4	6.6	6.6	7.4	7.3	7.1	6.9	6.5	6.6
	6	6.5	6.9	7.5	6.6	7.1	7.5	7.4	7.0	6.8	6.7	6.4
	7	6.5	7.0	7.3	6.5	7.1	7.7	7.3	7.0	6.8	6.8	6.5
	9	6.5	7.1	7.2	6.6	7.0	7.5	7.5	7.2	6.9	6.7	6.6
	11	6.4	7.0	7.1	6.4	6.8	7.0	7.5	7.2	7.0	6.9	6.7
	12	6.4	6.9	7.2	6.5	6.8	7.2	7.5	7.1	7.0	6.9	6.6
	13	6.7	6.7	7.3	6.6	6.9	7.4	7.5	7.2	7.0	6.9	6.8
	14	6.4	7.2	7.1	6.5	6.8	7.0	7.0	6.7	6.8	6.9	6.7
	15	6.4	7.8	7.2	6.6	7.0	7.0	7.5	7.3	7.1	6.9	6.6
pH	Control	7.4	7.4	7.6	7.5	7.4	7.7	7.6	7.7	7.6	7.6	7.6
	2	7.4	7.4	7.5	7.4	7.4	7.6	7.3	7.6	7.6	7.6	7.4
	5	7.4	7.2	7.5	7.3	7.4	7.6	7.4	7.6	7.6	7.6	7.5
	6	7.4	7.2	7.4	7.4	7.4	7.6	7.3	7.6	7.6	7.6	7.5
	7	7.4	7.4	7.5	7.4	7.4	7.5	7.3	7.5	7.6	7.5	7.5
	9	7.5	7.4	7.4	7.5	7.4	7.5	7.3	7.5	7.5	7.5	7.6
	11	7.4	7.4	7.5	7.4	7.4	7.6	7.3	7.5	7.5	7.5	7.5
	12	7.4	7.4	7.5	7.3	7.3	7.6	7.3	7.5	7.5	7.6	7.5
	13	7.6	7.4	7.4	7.5	7.4	7.6	7.3	7.5	7.5	7.5	7.5
	14	7.5	7.3	7.5	7.5	7.4	7.6	7.3	7.5	7.5	7.6	7.5
	15	7.5	7.3	7.5	7.8	7.4	7.6	7.3	7.5	7.5	7.6	7.5
	Initials	[illegible]	MP	[illegible]	[illegible]	MP	MP	thd	thd	TR	[illegible]	[illegible]
	Date	09/17	9/18	09/19	09/20	9/21	9/22	9/23	9/24	9/25	09/26	9/26

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 11	12	13	14	15	16	17	18	19	20	21
TEMP (C)	16 ~~Control~~	22.6	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.6
	17	22.5	22.5	22.5	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	18	22.5	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	19	22.5	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	22	22.6	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	25	22.5	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
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Dissolved Oxygen (mg/L)	16 ~~Control~~	6.8	7.5	7.3	6.4	7.3	7.3	7.6	7.3	7.0	6.9	6.9
	17	6.4	7.4	7.4	6.5	7.0	7.3	7.6	7.0	7.0	6.9	6.8
	18	6.6	7.2	7.3	6.6	7.0	7.2	7.4	6.9	6.7	7.1	6.9
	19	6.6	7.3	7.3	6.6	7.0	7.1	7.4	7.1	6.9	7.1	6.9
	22	6.9	7.6	7.6	6.9	7.0	7.1	7.5	7.0	7.0	7.2	6.9
	25	7.1	7.6	7.7	7.0	7.2	7.6	7.8	7.3	7.0	7.1	7.2
	–											
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	–											
	–											
	–											
pH	16 ~~Control~~	7.5	7.4	7.5	7.4	7.4	7.6	7.2	7.4	7.5	7.5	7.5
	17	7.5	7.4	7.5	7.4	7.4	7.6	7.3	7.5	7.4	7.5	7.5
	18	7.5	7.2	7.4	7.4	7.4	7.6	7.3	7.4	7.4	7.4	7.5
	19	7.4	7.2	7.5	7.4	7.4	7.6	7.2	7.4	7.3	7.4	7.4
	22	7.4	7.3	7.5	7.3	7.4	7.6	7.3	7.4	7.4	7.4	7.4
	25	7.4	7.3	7.5	7.4	7.4	7.6	7.3	7.4	7.4	7.4	7.4
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	–											
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	–											
	Initials											
	Date	09/17	9/18	09/19	09/20	9/21	9/22	9/23	9/24	9/25	09/26	09/27

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca.

Beginning Date & Time: 9-6-13 1358
Ending Date & Time: 10-4-13 1302

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 22	23	24	25	26	27	28	29	30	31	32
TEMP (C)	Control	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	2	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	5	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	6	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	7	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	9	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	11	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	12	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	13	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	14	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	15	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
Dissolved Oxygen (mg/L)	Control	6.0	6.1	6.0	5.7	5.3	4.3	5.1				
	2	5.3	6.3	6.2	6.5	6.1	5.5	5.5				
	5	6.1	6.6	6.7	6.5	6.4	5.8	5.4				
	6	6.0	7.0	7.0	7.1	6.6	6.4	7.1				
	7	6.0	7.0	7.1	6.8	6.4	6.4	6.7				
	9	6.3	7.0	6.9	6.9	6.5	6.4	7.6				
	11	6.9	7.0	7.1	6.9	6.7	6.2	6.8				
	12	6.9	6.6	7.2	6.8	6.3	6.1	7.0				
	13	6.5	6.9	7.2	6.8	6.5	6.3	7.0				
	14	6.9	7.1	6.6	6.7	6.2	6.3	6.5				
	15	6.5	7.0	7.2	6.9	6.8	6.1	6.7				
pH	Control	7.4	7.6	7.2	7.5	7.8	7.6	7.7				
	2	7.3	7.6	7.1	7.5	7.8	7.6	7.7				
	5	7.4	7.5	7.1	7.4	7.8	7.6	7.7				
	6	7.4	7.5	7.3	7.4	7.7	7.6	7.6				
	7	7.3	7.5	7.4	7.4	7.7	7.5	7.5				
	9	7.3	7.5	7.2	7.4	7.6	7.5	7.5				
	11	7.4	7.5	7.2	7.4	7.6	7.5	7.5				
	12	7.3	7.4	7.4	7.3	7.6	7.5	7.5				
	13	7.4	7.5	7.4	7.3	7.6	7.5	7.5				
	14	7.4	7.5	7.4	7.4	7.6	7.5	7.5				
	15	7.4	7.5	7.5	7.4	7.5	7.5	7.5				
	Initials	[illegible]	SH	Thd	SH	SH	SH	SH				
	Date	09/28	9/29	9/30	10/1	10/2	10/3	10/4				

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1305
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 22	23	24	25	26	27	28	29	30	31	32
TEMP (C)	16 ~~Control~~	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	17	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	18	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	19	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	22	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	25	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	–											
	–											
	–											
	–											
	–											
Dissolved Oxygen (mg/L)	16 ~~Control~~	6.4	7.0	7.2	6.4	6.8	6.2	7.0				
	17	6.6	7.1	7.4	7.1	6.7	6.5	6.8				
	18	6.5	7.2	7.0	6.4	6.2	5.4	6.4				
	19	6.3	7.2	7.2	7.0	6.7	6.4	6.9				
	22	6.1	7.2	7.3	7.0	6.5	6.4	6.9				
	25	6.1	6.9	7.1	7.3	6.8	6.4	7.6				
	–											
	–											
	–											
	–											
	–											
pH	16 ~~Control~~	7.4	7.5	7.4	7.3	7.5	7.5	7.5				
	17	7.4	7.5	7.4	7.3	7.6	7.5	7.5				
	18	7.4	7.5	7.4	7.3	7.6	7.4	7.5				
	19	7.4	7.5	7.4	7.3	7.5	7.4	7.5				
	22	7.4	7.5	7.4	7.3	7.5	7.4	7.4				
	25	7.4	7.4	7.4	7.3	7.5	7.4	7.5				
	–											
	–											
	–											
	–											
	–											
	Initials	[illegible]	SH	Thd	SH	SH	SH	SH				
	Date	09/28	9/29	9/30	10/1	10/2	10/3	10/4				

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

APPENDIX B

STATISTICAL DATA FOR *Hyalella azteca* 28-DAY SURVIVAL AND GROWTH TEST

Amphipod Survival, Growth Test Survival

Start Date:	9/6/2013	Test ID:	482201ha	Sample ID:	Lockheed
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

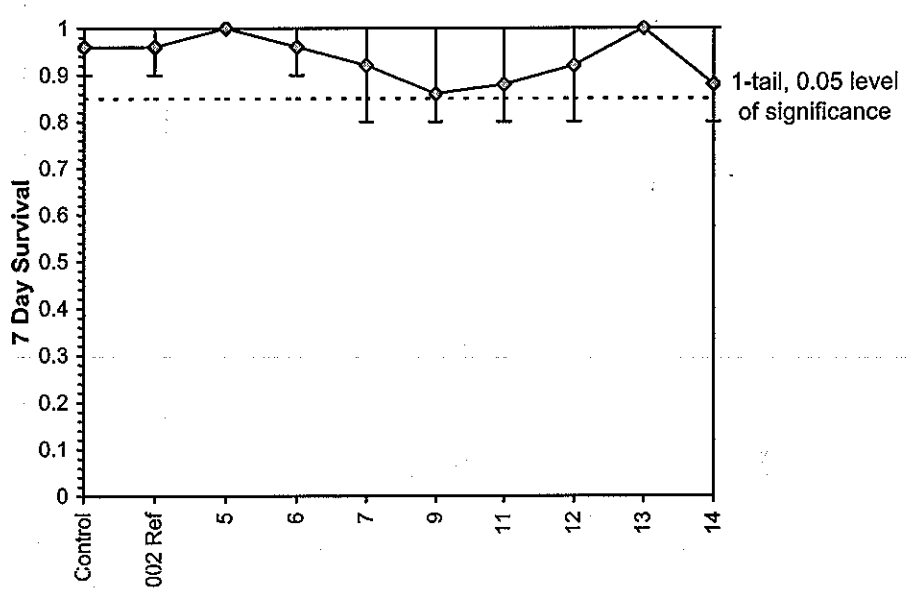
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	1.0000	1.0000
002 Ref	1.0000	0.9000	0.9000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	0.9000	1.0000	0.9000
7	1.0000	0.8000	1.0000	0.9000	0.9000
9	1.0000	0.8000	0.8000	0.8000	0.9000
11	0.8000	0.8000	0.9000	0.9000	1.0000
12	1.0000	0.8000	1.0000	1.0000	0.8000
13	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	0.8000	0.9000	0.9000	0.8000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5			
002 Ref	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5	*		
5	1.0000	1.0417	1.4120	1.4120	1.4120	0.000	5	-0.929	2.480	0.1739
6	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5	0.000	2.480	0.1739
7	0.9200	0.9583	1.2859	1.1071	1.4120	10.026	5	0.869	2.480	0.1739
9	0.8600	0.8958	1.1965	1.1071	1.4120	11.303	5	2.143	2.480	0.1739
11	0.8800	0.9167	1.2249	1.1071	1.4120	10.319	5	1.739	2.480	0.1739
12	0.9200	0.9583	1.2901	1.1071	1.4120	12.944	5	0.809	2.480	0.1739
13	1.0000	1.0417	1.4120	1.4120	1.4120	0.000	5	-0.929	2.480	0.1739
14	0.8800	0.9167	1.2249	1.1071	1.4120	10.319	5	1.739	2.480	0.1739

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.95558	0.926	0.09383	-0.5181
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.10082	0.10605	0.03225	0.0123	0.02257	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

Amphipod Survival, Growth Test Survival

Start Date:	9/6/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

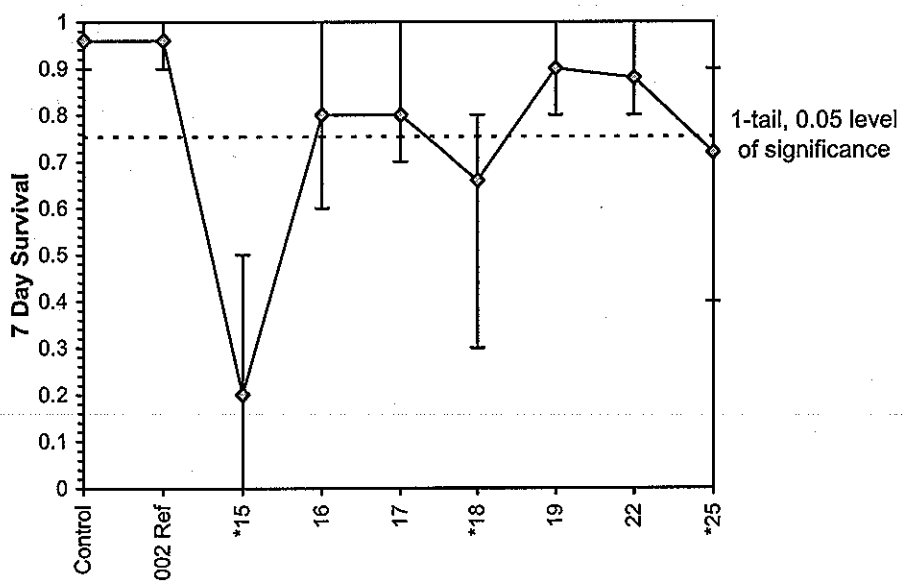
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	1.0000	1.0000
002 Ref	1.0000	0.9000	0.9000	1.0000	1.0000
15	0.1000	0.1000	0.3000	0.5000	0.0000
16	0.7000	1.0000	0.7000	0.6000	1.0000
17	0.9000	0.7000	0.7000	0.7000	1.0000
18	0.8000	0.8000	0.3000	0.7000	0.7000
19	0.9000	0.9000	1.0000	0.8000	0.9000
22	0.8000	1.0000	0.8000	0.9000	0.9000
25	0.4000	0.7000	0.8000	0.9000	0.8000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5			
002 Ref	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5	*		
*15	0.2000	0.2083	0.4335	0.1588	0.7854	57.169	5	7.563	2.443	0.2950
16	0.8000	0.8333	1.1385	0.8861	1.4120	22.254	5	1.725	2.443	0.2950
17	0.8000	0.8333	1.1269	0.9912	1.4120	17.269	5	1.821	2.443	0.2950
*18	0.6600	0.6875	0.9553	0.5796	1.1071	22.804	5	3.243	2.443	0.2950
19	0.9000	0.9375	1.2533	1.1071	1.4120	8.613	5	0.775	2.443	0.2950
22	0.8800	0.9167	1.2249	1.1071	1.4120	10.319	5	1.010	2.443	0.2950
*25	0.7200	0.7500	1.0278	0.6847	1.2490	20.672	5	2.641	2.443	0.2950

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.97431	0.919	-0.0637	-0.3679
Bartlett's Test indicates equal variances (p = 0.44)	6.89042	18.4753		
The control means are not significantly different (p = 1.00)	0	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<15	15			0.19664	0.20684	0.40136	0.03646	5.4E-07	7, 32
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by: ____

Amphipod Survival, GrowthTest-Growth

Start Date:	9/6/2013	Test ID:	482201ha	Sample ID:	Lockheed
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

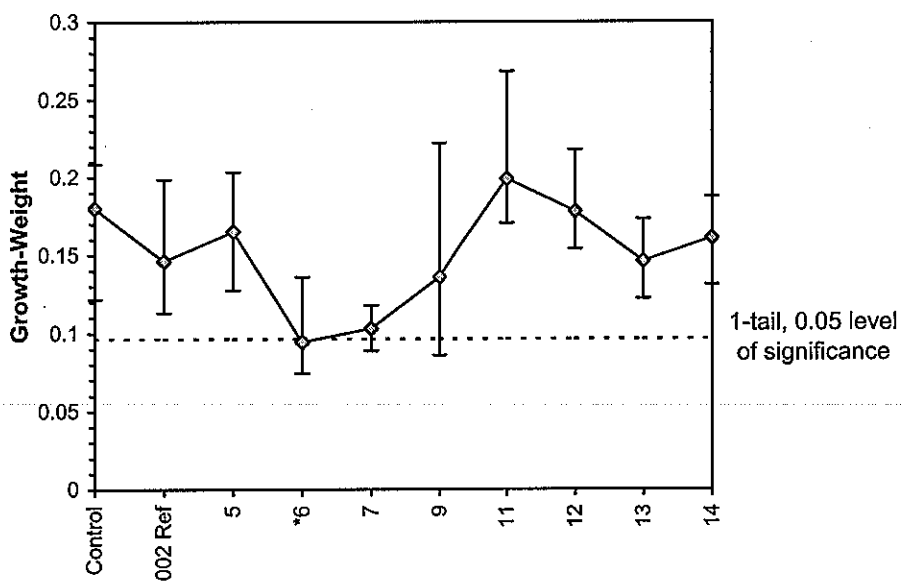
Conc-%	1	2	3	4	5
Control	0.2090	0.2000	0.1922	0.1780	0.1220
002 Ref	0.1990	0.1167	0.1133	0.1390	0.1640
5	0.2030	0.1980	0.1510	0.1270	0.1440
6	0.1360	0.0750	0.0878	0.0990	0.0744
7	0.1140	0.0988	0.0960	0.0889	0.1178
9	0.1150	0.2225	0.0862	0.1100	0.1478
11	0.1863	0.2688	0.1711	0.1822	0.1890
12	0.1810	0.2175	0.1720	0.1650	0.1538
13	0.1220	0.1470	0.1350	0.1520	0.1730
14	0.1310	0.1875	0.1500	0.1522	0.1838

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.1802	1.2312	0.1802	0.1220	0.2090	19.135	5			
002 Ref	0.1464	1.0000	0.1464	0.1133	0.1990	24.411	5	*		
5	0.1646	1.1243	0.1646	0.1270	0.2030	20.632	5	-0.905	2.480	0.0499
*6	0.0944	0.6451	0.0944	0.0744	0.1360	26.839	5	2.582	2.480	0.0499
7	0.1031	0.7041	0.1031	0.0889	0.1178	11.936	5	2.153	2.480	0.0499
9	0.1363	0.9310	0.1363	0.0862	0.2225	38.843	5	0.502	2.480	0.0499
11	0.1995	1.3625	0.1995	0.1711	0.2688	19.715	5	-2.637	2.480	0.0499
12	0.1779	1.2148	0.1779	0.1538	0.2175	13.664	5	-1.563	2.480	0.0499
13	0.1458	0.9959	0.1458	0.1220	0.1730	13.116	5	0.030	2.480	0.0499
14	0.1609	1.0990	0.1609	0.1310	0.1875	14.961	5	-0.720	2.480	0.0499

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.93069	0.926	1.01651	0.96449
Bartlett's Test indicates equal variances (p = 0.28)	9.75161	20.0902		
The control means are not significantly different (p = 0.17)	1.52375	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.0499	0.34086	0.00563	0.00101	1.3E-04	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

Amphipod Survival, Growth Test Growth

Start Date:	9/6/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

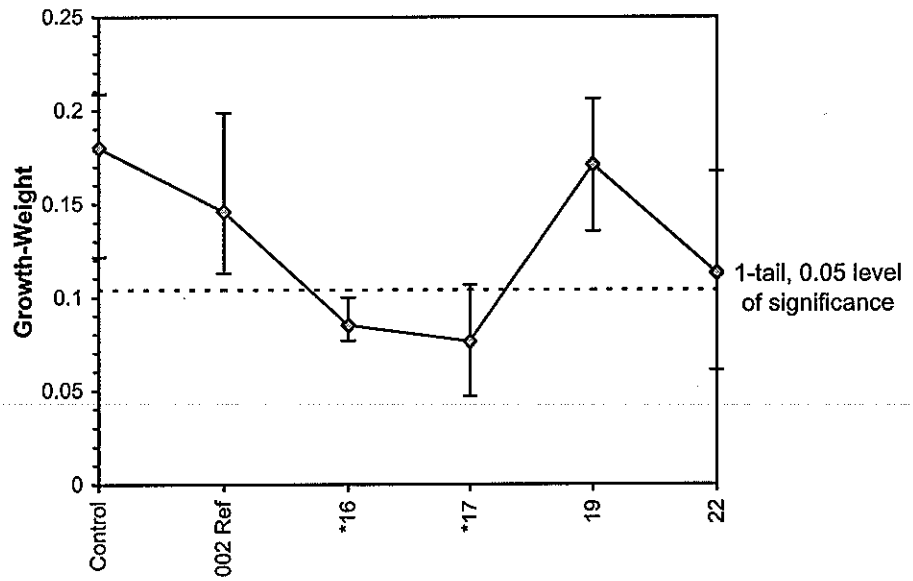
Conc-%	1	2	3	4	5
Control	0.2090	0.2000	0.1922	0.1780	0.1220
002 Ref	0.1990	0.1167	0.1133	0.1390	0.1640
16	0.0843	0.0830	0.1000	0.0767	0.0810
17	0.1067	0.0900	0.0757	0.0614	0.0470
19	0.1622	0.1356	0.1950	0.2063	0.1567
22	0.1675	0.1330	0.1050	0.0989	0.0611

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.1802	1.2312	0.1802	0.1220	0.2090	19.135	5			
002 Ref	0.1464	1.0000	0.1464	0.1133	0.1990	24.411	5	*		
*16	0.0850	0.5805	0.0850	0.0767	0.1000	10.441	5	3.302	2.300	0.0428
*17	0.0762	0.5202	0.0762	0.0470	0.1067	30.720	5	3.776	2.300	0.0428
19	0.1711	1.1690	0.1711	0.1356	0.2063	16.928	5	-1.330	2.300	0.0428
22	0.1131	0.7725	0.1131	0.0611	0.1675	35.161	5	1.790	2.300	0.0428

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.97115	0.888	0.29714	-0.1975
Bartlett's Test indicates equal variances (p = 0.14)	6.87332	13.2767		
The control means are not significantly different (p = 0.17)	1.52375	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<16	16			0.04278	0.2922	0.00812	0.00086	1.9E-04	4, 20
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

APPENDIX C

CHAIN OF CUSTODY DOCUMENTATION

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131004	TOX-FS13-SED-002	TOX-SED-002	Chironomus and Hyalella Tox Tests	Sediment	7/29/2013	15:20	1	2.5 gallon bucket	4 C	N
131005	TOX-FS13-SED-005	TOX-SED-005	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:30	1	2.5 gallon bucket	4 C	N
131006	TOX-FS13-SED-006	TOX-SED-006	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:50	1	2.5 gallon bucket	4 C	N
131007	TOX-FS13-SED-007	TOX-SED-007	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:57	1	2.5 gallon bucket	4 C	N
131008	TOX-FS13-SED-009	TOX-SED-009	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:10	1	2.5 gallon bucket	4 C	N
131009	TOX-FS13-SED-011	TOX-SED-011	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:45	1	2.5 gallon bucket	4 C	N
131010	TOX-FS13-SED-012	TOX-SED-012	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:55	1	2.5 gallon bucket	4 C	N
131011	TOX-FS13-SED-013	TOX-SED-013	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:05	1	2.5 gallon bucket	4 C	N
131012	TOX-FS13-SED-014	TOX-SED-014	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:20	1	2.5 gallon bucket	4 C	N
131013	TOX-FS13-SED-015	TOX-SED-015	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:00	1	2.5 gallon bucket	4 C	N
131014	TOX-FS13-SED-016	TOX-SED-016	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:05	1	2.5 gallon bucket	4 C	N

Special Instructions: ~~Wait~~

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analysis	[signature]	8/29/13	[signature]	8/29/13					[signature]	8/29/13	1500

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131015	TOX-FS13-SED-017	TOX-SED-017	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:15	1	2.5 gallon bucket	4 C	N
131016	TOX-FS13-SED-018	TOX-SED-018	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:10	1	2.5 gallon bucket	4 C	N
131017	TOX-FS13-SED-019	TOX-SED-019	Chironomus and Hyalella Tox Tests	Sediment	7/30/2020	16:55	1	2.5 gallon bucket	4 C	N
131018	TOX-FS13-SED-022	TOX-SED-022	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	08:40	1	2.5 gallon bucket	4 C	N
131019	TOX-FS13-SED-025	TOX-SED-025	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	09:25	1	2.5 gallon bucket	4 C	N

Special Instructions:

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analyses	[illegible]	8/29/13	Diane Higgins	8/29/13			Diane Higgins	8/29	Wesley Morgan	8/29/13	1500

REPORT CERTIFICATION

The following report titled "LOCKHEED MARTIN SERAS SEDIMENT TOXICITY TESTING – *Chironomus dilutus*" is an accurate and truthful representation of the toxicity testing which was performed by American Aquatic Testing, Inc., located at 890 North Graham Street Allentown, Pennsylvania. We further certify that we have personally examined and are familiar with the information submitted in this document and based on our inquiry of those individuals immediately responsible for obtaining the information; we believe the submitted information is complete as presented. We are aware that there are significant penalties for submitting false information.

Christopher J. Nally
President, Laboratory Director

Tarmo Pallop
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LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING – *Chironomus dilutus*

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LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING – *Chironomus dilutus*

INTRODUCTION

During the month of August 2013, samples of sediment were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. These sediment samples were used to perform toxicity tests to determine if the tested matrices represent a significant threat to potential receptor organisms.

The sediment samples from the site were delivered to American Aquatic Testing, Inc. (AAT) and evaluated for toxicity using a 10-day solid phase exposure with the chironomid Chironomus dilutus [1]. Following the exposure period, surviving test organisms from the sediments collected at the site were compared to the off-site reference sediment (location 02) tested under similar conditions. The endpoints used for determination of an impact in the chironomid exposures were mortality, measured as mean survival, and growth measured as ash-free dry weight (AFDW).

MATERIALS AND METHODS

Surface sediment samples were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. Station locations were selected to represent areas that may have been impacted by the facility's operations.

Preparation of sediment samples for testing

Samples were collected into 2.5-gallon high-density polyethylene (HDPE) containers and placed on ice after collection. Sediment samples were picked up by AAT personnel on August 24, 2013 and transported on ice. Upon arrival at AAT, the samples were refrigerated until being used for testing on September 13, 2013. These samples were physically screened using a #18 mesh screen to remove large debris and indigenous organisms on September 3, 2013.

Control sediment used to assess the health of the test organisms used for testing was collected from the Spruce Run Reservoir in Clinton, NJ on September 3, 2013 and was screened using a #18 mesh screen to remove large debris and indigenous organisms on September 4, 2013. Screened sediment was placed in a five gallon HDPE container and refrigerated until used for testing on September 13, 2013.

Test organisms

Test age larvae (2nd and 3rd instar) of the chironomid, *Chironomus dilutus*, were obtained from stock cultures maintained by Aquatic Biosystems, Inc. of Fort Collins, CO and were received in-house prior to testing and were held under conditions similar to that which the larval test organisms would encounter during the test (see Table I).

A reference toxicant test using potassium chloride was conducted concurrently with the initiation of the long term exposure to assess the sensitivity of the lot of organisms used in the sediment test. The 48 hr LC_{50} produced was 3221.9 ppm. This test value falls within the acceptable range of the control chart being maintained by AAT for this test species. A copy of the raw data is provided as Appendix A.

Experimental procedures

The entire sediment exposure series for this project consisted of 16 sediment samples from the Vineland Chemical Site and one of control sediment provided by AAT. Tox-Sed 002 was collected from an off-site reference location. Test chambers (300 mL tall form borosilicate glass beakers) were filled with 100 mL of sediment. Approximately 175 mL of laboratory-produced fresh water (moderately hard reconstituted) was poured over the sediment gently to cause minimal disturbance. There were 5 replicate chambers for each sample treatment. Test chambers were allowed to settle for 24 hours prior to test initiation.

After the settling period, the overlying water was siphoned off and fresh laboratory water was introduced, using a small, round HDPE disk suspended over the sediment to deflect the water flow and minimize disturbance to the sediment. Water quality data including alkalinity, ammonia, conductivity, dissolved oxygen, temperature, pH, and hardness were measured initially on composite water samples from all sites, prior to the introduction of test organisms, and at the end of the long-term exposure for each sample location and the control. The diss. oxygen, pH and temperature were also measured initially and every 24 hours for the duration of the exposure for each sample location and the control. Fresh laboratory water that was used for the daily exchanges was also monitored for dissolved oxygen, pH and temperature at each exchange.

The exposure period began by placing 10 randomly selected test organisms into each chamber. Care was taken to ensure the organisms were released beneath the surface of the overlying water to keep air bubbles from forcing the organisms to the surface. Test chamber organisms were fed once a day during the exposure period with a slurry of dry fish flake food and deionized water to deliver approximately 4 mg/L to each chamber, when food from previous feedings had been consumed. Uneaten food was removed to prevent microbial growth or depressed oxygen concentrations. Test conditions are summarized in Table I.

Observations were made and recorded for each chamber each day during the exposure period to assess organism health. Observations included the number of dead organisms, as well as organisms swimming, on the surface of the sediment, or on the surface of the water. Dissolved oxygen, pH and temperature were measured and recorded each day from a new replicate chamber for each sample and the control. Overlying water (150 mL) was siphoned off twice a day and replaced using reconstituted laboratory water as a measure to maintain sufficient dissolved oxygen levels. Care was taken to minimize disturbance of the sediment during water renewal by using the small HDPE disc.

At day 10, all test chambers from each sample location and the control were prepared for the removal of test organisms. With the overlying water present in each chamber, the top 20% of sediment was gently stirred into suspension. The slurry was then poured into a #60 mesh screen (250 μm) and rinsed in a shallow pan of laboratory water to remove the finer grains of sediment. The sieve was placed into a second shallow pan of water over a light table, and carefully sorted to find surviving test organisms. Using additional laboratory water, this process was repeated two or three times for each replicate until all the sediment had been inspected. All surviving organisms were transferred to a 30 mL soufflé cup for live count verification and preparation for weight determination. Pupae were counted for survival purposes, but were not included in the weight analysis.

When all test chambers from each sample had been sieved and the number of survivors verified, the test organisms were sacrificed using ethanol. The test organisms were immediately placed on tared aluminum weigh pans that had been previously dried for six hours at 105° C, then dried in a muffle furnace at 550° C for two hours, in preparation for AFDW analysis. Weigh pans and test organisms were then dried for six hours at 105° C and then transferred to a desiccator to cool before dry weight determination on September 24, 2013. Following dry weight determination all weigh pans and test organisms were then dried for two hours at 550° C and transferred to a desiccator to cool before AFDW determination on October 14, 2013.

Data analysis

Data analysis was performed following procedures published by the USEPA [1] using the ToxCalc v5.0.23 [2] data analysis software. Survival data, in the form of proportion of survivors in each chamber, was transformed by arcsine squareroot and then tested for normality using the Shapiro-Wilk's test or the Chi-Square test and for homogeneity of variance using Bartlett's test, as appropriate. Analysis of variance (ANOVA) followed by Dunnett's *a posteriori* pairwise comparisons or Steel's Many-One Rank test, as appropriate, to evaluate differences between stations and the control samples.

TABLE I: Summary of Conditions for *Chironomus dilutus* Toxicity Test

1.	Test type;	Whole sediment, static, daily renewal
2.	Temperature;	23.0 +/- 1.0 ° C
3.	Light quality;	Wide-spectrum fluorescent illumination
4.	Light intensity;	50 - 100 foot-candles
5.	Photoperiod;	16 hours light, 08 hours dark
6.	Test chamber size;	300 mL high form borosilicate glass beakers
7.	Sediment volume;	100 mL / replicate
8.	Overlying water volume;	175 mL / replicate
9.	Renewal;	2 volume exchanges per day
10.	Age of test organisms;	2nd and 3rd instar
11.	Number organisms / container;	10
12.	Replicates;	5
13.	Feeding;	4.0 mg/L flake fish food / day, as needed
14.	Aeration;	None unless dissolved oxygen concentrations ≤ 2.5 ppm
15.	Overlying water;	Laboratory reconstituted water
16.	Test chamber cleaning;	Only if necessary
17.	Overlying water quality;	D. O., pH and temperature daily; alkalinity, ammonia, conductivity, hardness & pH at beginning and end of test, D. O., pH and temp. daily on exchange water
18.	Test duration;	10 days
19.	Effects measured @ 10 days;	Percent survival and growth as AFDW
20.	Test acceptability;	Minimum control survival should be ≥70 %, Min. control mean dry weight should be at least 0.6 mg Min. control AFDW should be at least 0.48 mg

RESULTS

Effects on survival @ 10 Days using reference sample TOX-SED-002

Appendix A presents raw data. Data were arcsine square root transformed. The data were found to be normally distributed, were tested for homogeneity of variances using Bartlett's test, and found to be homogeneous. It was therefore determined that parametric analyses were appropriate, Dunnett's Test comparison was used to determine differences between survival of organisms in station sediments and the control sample.

Results from the analysis, which compared survival in station sediments with survival of organisms exposed to the reference sample (reference sample and control sample were not statistically different), are presented in Table II and in Appendix B.

None of the 15 samples from the study area evaluated exhibited mortality found to be statistically significant when compared to the reference treatment.

Table II. Percent survival of *C. dilutus* by replicate chamber & survival comparison using reference sample*

	Sample Identification															
Rep.	Tox Sed 002	Tox Sed 005	Tox Sed 006	Tox Sed 007	Tox Sed 009	Tox Sed 011	Tox Sed 012	Tox Sed 013	Tox Sed 014	Tox Sed 015	Tox Sed 016	Tox Sed 017	Tox Sed 018	Tox Sed 019	Tox Sed 022	Tox Sed 025
A	100	100	90	80	100	90	100	90	90	90	80	90	80	80	80	100
B	90	90	100	90	90	80	80	80	100	90	90	90	90	80	80	80
C	90	80	80	80	90	100	100	90	100	90	100	80	80	100	90	90
D	80	100	80	70	90	90	80	90	80	90	90	100	90	80	90	80
E	100	100	80	90	80	90	90	90	90	100	90	100	100	90	90	90
Mean % Survival	88	94	86	82	90	90	90	88	92	92	90	92	88	86	86	88
Statistically Different from Reference?		no	no	no	no	no	no	no	no	no	no	no	no	no	no	no

* Tox-Sed 002 is off-site reference sediment used for evaluation.

Effects on growth @ 10 days using reference sample TOX-SED-002

Appendix A presents raw data. Data were untransformed. The data were found to be normally distributed, were tested for homogeneity of variances using Bartlett's test, and found to be homogeneous. It was therefore determined that parametric analyses were appropriate, Dunnett's Test comparison was used to determine differences between survival of organisms in station sediments and the control samples.

Results from the analysis, which compared the AFDW in station sediments with the AFDW of organisms exposed to the reference sample, are presented in Table III and in Appendix B. It should be noted here that the reference test organisms were significantly different in average weight from those exposed to the control sediment. However, since there is no minimum weight required by the method, and the survival of reference test organisms was comparable to those of the control exposure the samples were compared to the reference.

Of the 15 samples from the study area evaluated using AFDW, samples identified as Tox-Sed 015, Tox-Sed 022 and Tox-Sed 025 all exhibited growth that was found to be statistically significant when compared to the reference treatment.

Table III. AFDW of *C. dilutus* by replicate chamber & AFDW (mg) comparison using reference sample

	Sample Identification															
Rep.	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed
	2	5	6	7	9	11	12	13	14	15	16	17	18	19	22	25
A	0.700	0.637	0.628	0.643	0.680	0.772	0.788	0.847	0.629	0.560	0.766	0.739	0.773	0.783	0.530	0.581
B	0.680	0.892	0.560	0.653	0.707	0.755	0.865	0.755	0.687	0.453	0.618	0.743	0.573	0.856	0.575	0.466
C	0.686	0.964	0.624	0.615	0.709	0.513	0.672	0.621	0.668	0.472	0.564	0.668	0.671	0.824	0.474	0.477
D	0.505	0.650	0.893	0.987	0.751	0.659	0.830	0.699	0.603	0.499	0.757	0.680	0.764	0.779	0.629	0.501
E	0.820	0.670	0.655	0.708	0.616	0.769	0.663	0.612	0.727	0.468	0.661	0.789	0.618	0.732	0.443	0.523
Ave AFDW	0.678	0.763	0.672	0.721	0.693	0.694	0.764	0.707	0.662	0.491	0.673	0.724	0.680	0.795	0.530	0.501
Statistically Different from Reference?		no	no	no	no	no	no	no	no	YES	no	no	no	no	YES	YES

* Tox-Sed 002 is off-site reference sediment used for evaluation.

REFERENCES

[1] **Ingersoll, C.G., G.A. Burton, T.D. Dawson, F.W. Dwyer, D.S. Ireland, R.A. Hoke, N.E. Kemble, D.R. Mount, T.J. Norberg-King, P.K. Sibley, and L. Stahl** 2000 Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates EPA 600/R-99/064. U.S. Environmental Protection, Office of Science and Development, Duluth, MN

[2] **ToxCalc v5.0.23F** data analysis software published by TidePool Scientific Software McKinleyville, CA

APPENDIX A

RAW DATA FOR *Chironomus dilutus*

10 DAY SEDIMENT TOXICITY TEST

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL COUNT ~~11~~	12	13
Control	A	N	N	N	N	N	2F	N	N	N	N	N	10		
	B	N	N	N	1F	N	H	N	N	N	N	N	9		
	C	N	N	1F	N	N	H	N	N	N	N	N	9		
	D	N	N	1F	N	N	N	N	N	N	1F	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
2	A	N	N	N	1F	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	~~N~~ (1)	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	10		
	E	N	N	N	N	N	N	N	N	N	N	N	8		
5	A	N	N	N	N	N	N	N	N	N	N	N	10		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	~~9~~ (2)		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
6	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	10		
	C	N	N	1F	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	8		
7	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	7		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
Initials		[illegible]	TAP	TAP	[illegible]	[illegible]	[illegible]	[illegible]		MP	MP	[illegible]	TAP		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19		9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity, B=No Observations~~
F - Sediment M - Swimming

Comments:

(1) N MP 9/22

(2) 10 09/23

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL COUNT ~~11~~	12	13
~~Control~~ 9	A	N	N	N	N	N	N	N	N	N	N	N	10		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	9		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	8		
11	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
12	A	N	N	N	N	N	N	N	N	N	N	N	10		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	F	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
13	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	9		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
14	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	10		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
Initials		BD	TDP	TDP	BD	BD	BD	BD	BD	MD	MD	BD	BD		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19	09/20	9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity, B=No Observations~~
F - SEDIMENT M - SWIMMING

Comments:

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL Count ~~11~~	12	13
~~Control~~ 15	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	9		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
16	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
17	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	10		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
18	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
19	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
Initials		[illegible]	TAP	TAP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MJ	MP	[illegible]	TAP		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19	09/20	9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity~~, ~~B=No Observations~~
F- ON SEDIMENT M- SWIMMING

Comments:

Job Number: 48-22-01
Species: ~~C. tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL COUNT 11	12	13
~~Control~~ 22	A	N	N	N	N	N	N	N	N	D	D	N	8		
	B	N	N	N	N	N	N	N	N	D	D	N	8		
	C	N	N	N	N	N	N	N	N	D	D	N	9		
	D	N	N	N	N	N	N	N	N	D	D	N	9		
	E	N	N	N	N	N	N	N	N	D	D	N	9		
25	A	N	N	N	N	N	N	N	N	D	D	N	10		
	B	N	N	N	N	N	N	N	N	D	D	N	8		
	C	N	N	N	N	N	N	N	N	D	D	N	9		
	D	N	N	N	N	N	N	N	N	D	D	N	8		
	E	N	N	N	N	N	N	N	N	D	D	N	9		
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
Initials		[illegible]	TAP	TAP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MM	MO	[illegible]	TAP		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19	09/20	9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity, B=No Observations~~

Comments: F ON SEDIMENT ~~B~~ M - SWIMMING

Client/Toxicant: 48-22-01
Project Number:
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A ① weight of boat (g)	B weight of boat & org. (g)	C (mg)	D	# of surviving org.	E WT OF BOAT & ORG. ASH (g)	F AFDW TOTAL (mg)	G AVE AFDW mg
Control	A	1	0.03025	0.04412	13.87	1.39	10	0.03524	8.88	0.888
	B	2	0.02649	0.03905	12.56	1.40	9	0.03151	7.54	0.838
	C	3	0.02908	0.04075	11.67	1.30	9	0.03307	7.68	0.853
	D	4	0.02645	0.03786	11.41	1.43	8	0.02916	8.70	1.088
	E	5	0.02764	0.04150	13.86	1.39	10	0.03211	9.39	0.939
	~~F~~	~~6~~								
	~~G~~									
	~~H~~									
2	A	6	0.02473	0.03179			9	0.02849	6.30	0.700
	B	7	0.03265	0.03987			9	0.03375	6.12	0.680
	C	8	0.03093	0.03706			8	0.03157	5.49	0.686
	D	9	0.02754	0.03348			10	0.02843	5.05	0.505
	E	10	0.02682	0.03419			8	0.02763	6.56	0.820
	~~F~~									
	~~G~~									
	~~H~~									
5	A	11	0.02734	0.03462			10	0.02825	6.37	0.637
	B	12	0.02657	0.03553			9	0.02750	8.03	0.892
	C	13	0.02685	0.03556			8	0.02785	7.71	0.964
	D	14	0.02475	0.03230			10	0.02580	6.50	0.650
	E	15	0.02638	0.03444			10	0.02772	~~6.68~~ ①	~~0.668~~ ②
	~~F~~									
	~~G~~									
	~~H~~									
6	A	16	0.02594	0.03251			9	0.02686	5.65	0.628
	B	17	0.02982	0.03661			10	0.03101	5.60	0.560
	C	18	0.03104	0.03672			8	0.03173	4.99	0.624
	D	19	0.02586	0.03424			8	0.02707	7.14	0.893
	E	20	0.02688	0.03346			8	0.02822	5.24	0.655
	~~F~~									
	~~G~~									
	~~H~~									
	Initials		thd	thd			[illegible]	[illegible]	[illegible]	[illegible] 10/14
	Date		9/23/13	9/24/13			09/23	10/14	10/14	

E = Original number of organisms at test initiation, adjusted for losses.

Observations: ① PANS ASHED BEFORE WT. 09/23 [illegible]

A - PAN ASH WT. D AVE DRY OF SURV. CON ORG.
B PAN + SURV. ORG. E PAN + SURV ORG AFTER ASHING
C TOTAL DRY WT F ASH FREE DRY WT TOTAL (B-E x 1000)

BasicWT.wk3

① 6.72
② 6.67 } ER 10/16

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	~~(B-A)*1000=C dry weight of (mg)~~	# of surviving org.	E WT OF BOAT & ORG ASH (g)	F AFDW TOTAL (mg)	G AFDW AVE MG
7	A	21	0.02845	0.03458		8	0.02944	5.14	0.643
	B	22	0.02785	0.03502		9	0.02914	5.88	0.653
	C	23	0.02664	0.03265		8	0.02773	4.92	0.615
	D	24	0.02420	0.03254		7	0.02663	6.91	0.987
	E	25	0.02444	0.03234		9	0.02597	6.37 ⑤	~~0.707~~
	~~F~~								
	~~G~~								
	~~H~~								
9	A	26	0.02364	0.03171		10	~~0.02597~~ ②	6.80	0.680
	B	27	0.02702	0.03463		9	~~0.02491~~ ③	6.36	0.707
	C	28	0.02814	0.03579		9	~~0.02827~~ ④	6.38	0.709
	D	29	0.02477	0.03304		9	0.02628	6.76	0.751
	E	30	0.02465	0.03068		8	0.02575	4.93	0.616
	~~F~~								
	~~G~~								
	~~H~~								
11	A	31	0.02496	0.03365		9	0.02670	6.95	0.772
	B	32	0.02407	0.03139		8	0.02535	6.04	0.756
	C	33	~~0.02432~~ ①	0.03318		10	0.02805	5.13	0.513
	D	34	0.02442	0.03163		9	0.02570	5.93	0.659
	E	35	0.02440	0.03302		9	0.02610	6.92	0.769
	~~F~~								
	~~G~~								
	~~H~~								
12	A	36	0.02429	0.03391		10	0.02603	7.88	0.788
	B	37	0.02866	0.03702		8	0.03010	6.92	0.865
	C	38	0.02789	0.03609		10	0.02937	6.72	0.672
	D	39	0.02485	0.03273		8	0.02609	6.64	0.830
	E	40	0.02409	0.03128		9	0.02531	5.97	0.663
	~~F~~								
	~~G~~								
	~~H~~								
	Initials		thd	[illegible]		[illegible]	[illegible]	[illegible]	
	Date		9/23/13	09/24		09/23	10/14	10/14	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

⑤ 0.708 EL 10/14

① 0.02659 thd 9/23/13
② ~~0.024~~ 0.02491
③ 0.02827
④ 0.02941

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	~~(B-A)*1000=C dry weight of organisms (mg)~~	# of surviving org.	E WT OF BOAT & ORG. ASH (g)	F AFDW TOTAL (mg)	G AFDW AVE mg
13	A	41	0.03046	0.03993		9	0.03231	7.62	0.847
	B	42	0.02961	0.03718		8	0.03114	6.04	0.755
	C	43	0.03009	0.03668		9	0.03109	5.59	0.621
	D	44	0.02819	0.03560		9	0.02931	6.29	0.699
	E	45	0.02707	0.03362		9	0.02811	5.51	0.612
	~~F~~								
	~~G~~								
	~~H~~								
14	A	46	0.02367	0.03048		9	0.02482	5.66	0.629
	B	47	0.03121	0.03949		10	0.03262	6.87	0.687
	C	48	0.03298	0.04088		10	0.03420	6.68	0.668
	D	49	0.02883	0.03467		8	0.02985	4.82	0.603
	E	50	0.02943	0.03784		9	0.03080	6.54	0.727
	~~F~~								
	~~G~~								
	~~H~~								
15	A	51	0.02935	0.03520		9	0.03016	5.04	0.560
	B	52	0.03067	0.03639		9	0.03131	4.08	0.453
	C	53	0.03100	0.03590		9	0.03171	4.25	0.472
	D	54	0.02958	0.03464		9	0.03015	4.49	0.499
	E	55	0.02968	0.03498		10	0.03030	4.68	0.468
	~~F~~								
	~~G~~								
	~~H~~								
16	A	56	0.02600	0.03295		8	0.02682	6.13	0.766
	B	57	0.03376	0.04022		9	0.03466	5.56	0.618
	C	58	0.03195	0.03842		10	0.03278	5.64	0.564
	D	59	0.02877	0.03665		9	0.02984	6.81	0.757
	E	60	0.02849	0.03532		9	0.02937	5.95	0.661
	~~F~~								
	~~G~~								
	~~H~~								
	Initials		thd	[illegible]		[illegible]	[illegible]	[illegible]	
	Date		9/23/13	09/24		09/23	10/4	10/4	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C ~~dry weight of organisms (mg)~~	# of surviving org.	E Wt of Boat & ORG ASH g)	F AFDW TOTAL (mg)	G AFDW AVE MG
17	A	61	0.02775	0.03522		9	0.02857	6.65	0.739
	B	62	0.02428	0.03204		9	0.02535	6.69	0.743
	C	63	0.02774	0.03362		8	0.02828	5.34	0.668
	D	64	0.02292	~~0.03367~~ ①		10	0.02387	6.80	0.680
	E	65	0.02511	0.03413		10	0.02624	7.89	0.789
	~~F~~								
	~~G~~								
	~~H~~			②					
18	A	66	0.02404	~~0.03413~~		8	0.02489	6.18	0.773
	B	67	0.02849	0.03436		9	0.02920	5.16	0.573
	C	68	0.02762	0.03362		8	0.02815	5.37	0.671
	D	69	0.02756	0.03524		9	0.02836	6.88	0.764
	E	70	0.02470	0.03158		10	0.02540	6.18	0.618
	F								
	G								
	H								
19	A	71	0.02552	0.03329		8	0.02703	6.26	0.783
	B	72	0.02323	0.03127		8	0.02442	6.85	0.856
	C	73	0.02638	0.03605		10	0.02781	8.24	0.824
	D	74	0.02535	0.03257		8	0.02634	6.23	0.779
	E	75	0.02463	0.03224		9	0.02565	6.59	0.732
	F								
	G								
	H								
22	A	76	0.02252	0.02923		8	0.02499	4.24	0.530
	B	77	0.02888	0.03438		8	0.02978	4.60	0.575
	C	78	0.02741	0.03238		9	0.02811	4.27	0.474
	D	79	0.02552	0.03234		9	0.02626	5.66	0.629
	E	80	0.02620	0.03072		9	0.02673	3.99	0.443
	F								
	G								
	H								
	Initials		thd	[illegible]			[illegible] 10/14	[illegible] 10/14	[illegible] 10/14
	Date		9/23/13	09/24					

E = Original number of organisms at test initiation, adjusted for losses.

Observations: ① 0.03067 → 09/24 [illegible]
② 0.03107 [illegible]

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	~~(B-A)*1000=C dry weight of organisms (mg)~~	# of surviving org.	E WT OF BOAT + ORG ASH g)	F AFDW TOTAL (mg)	G AFDW AVE MG
25	A	81	0.02621	0.03314		10	0.02733	5.81	0.581
	B	82	0.02690	0.03116		8	0.02743	3.73	0.466
	C	83	0.02846	0.03418		9	0.02989	4.29	0.477
	D	84	0.02702	0.03166		8	0.02765	4.01	0.501
	E	85	0.02610	0.03143		9	0.02672	4.71	0.523
	~~F~~								
	~~G~~								
	~~H~~								
	A								
	B								
	C								
	D								
	E								
	F								
	G								
	H								
	A								
	B								
	C								
	D								
	E								
	F								
	G								
	H								
	A								
	B								
	C								
	D								
	E								
	F								
	G								
	H								
	Initials		thd						
	Date		9/23/13	09/24			10/14		

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Start Date & Time: 9-13-13 1900
End Date & Time: 09-23-13 1800

Sediment Test

American Aquatic Testing, Inc.,

Water Change Log/Initial Water Readings/General Testing Information

Test Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Morning change(time)	8:30	0930	7:30	1015	0700	1800	7:30	1030	1040	1000	7:30				
D.O. mg/L	8.3	8.4	8.3	8.4	8.3	8.6	8.5	8.4	8.4	8.4	8.3				
pH	8.0	8.0	8.0	8.0	8.1	7.9	8.0	8.0	7.9	7.9	8.0				
Temp. (C)	23.5	23.0	22.5	22.0	22.5	22.0	22.5	22.0	22.5	23.0	22.5				
Initials	SH	SH	TAP	[illegible]	[illegible]	[illegible]	thd	[illegible]	mp	mp	thd				
Date	9/13	9/14	9/15	09/16	09/17	09/18	9/19	09/20	9/21	9/22	9/23				
Afternoon change(time)	1845	1925	1745	1900	1900	1630	1700	1900	1630	1700					
D.O. mg/L	8.4	8.4	8.4	7.9	8.3	8.5	8.4	8.5	8.3	8.3					
pH	8.0	7.9	8.0	8.2	8.1	7.8	8.1	8.1	8.0	8.0					
Temp. (C)	23.5	23.0	23.0	22.5	22.5	22.0	22.0	22.0	22.5	22.0					
Initials	SH	TAP	thd	[illegible]	[illegible]	mp	[illegible]	[illegible]	mp	mp					
Date	9/13	9/14	9/15	09/16	09/17	9/18	09/19	09/20	9/21	9/22					

Test Day	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Morning change(time)														
D.O. mg/L														
pH														
Temp. (C)														
Initials														
Date														
Afternoon change(time)														
D.O. mg/L														
pH														
Temp. (C)														
Initials														
Date														

Control Sed. collection date/by: 9/3/13 TAP

Control Sed. sieve date/by: 9/4/13 TAP

Sieve size used: 1mm

Sample sieve date/by: 9/3/13 / CSN, SH, TD

Sieve size used: 1mm

Organism source: ABS

Test organism Lot number: 1432

Number of animals per chamber: 10

Food Type: flake

Frequency of feeding: everyday

Test Chamber size: 300ml

Test Volume of sediment: 100ml

Test Volume of water: 150ml

Test Duration: 10 days

Test Temperature Range: 23±1°C

Client/Toxicant: 48
Job Number: 22-01
Species: C. tentans

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	Control	23.5	23.0	22.5	22.5	23.0	22.5	22.5	22.0	23.0	23.0	23.0
	2	23.5	23.0	22.5	22.5	23.0	22.5	22.5	22.0	23.0	23.0	23.0
	5	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	6	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	7	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	9	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	11	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	12	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	13	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	14	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	15	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
Dissolved Oxygen (mg/L)	Control	6.0	5.4	5.4	5.2	4.9	4.8	5.3	5.4	5.2	6.0	6.6
	2	6.0	6.5	5.7	5.6	5.3	5.4	5.0	4.9	5.5	6.1	6.6
	5	4.3	5.0	4.1	5.6	4.3	4.7	5.0	4.8	4.0	5.6	5.8
	6	4.7	4.5	4.2	5.6	4.5	5.4	5.1	5.2	4.2	5.3	6.0
	7	4.4	5.2	4.7	5.6	4.6	5.0	4.1	4.7	4.2	4.9	6.1
	9	4.3	4.7	3.6	5.6	4.9	4.6	4.5	5.1	4.4	5.3	6.0
	11	4.7	5.4	4.5	5.9	4.9	4.8	5.1	6.0	5.0	4.9	6.3
	12	5.5	5.5	4.4	5.7	5.2	4.9	5.3	5.0	5.0	5.3	6.4
	13	5.3	5.2	5.0	5.9	4.7	5.1	5.6	4.7	5.4	5.8	6.6
	14	5.6	5.5	5.1	5.6	4.5	4.7	5.1	5.0	5.0	5.3	6.5
	15	6.2	6.6	5.9	5.9	5.6	6.2	5.4	4.6	5.7	5.9	6.9
pH	Control	7.1	7.3	7.3	7.6	7.6	7.0	7.6	7.5	7.2	7.2	7.3
	2	7.0	7.3	7.3	7.6	7.3	6.9	7.4	7.5	7.2	7.2	7.2
	5	6.8	7.2	7.1	7.7	7.3	6.9	7.3	7.5	7.1	7.3	7.2
	6	6.8	7.1	7.1	7.6	7.3	6.8	7.4	7.4	7.1	7.3	7.2
	7	6.8	7.1	7.1	7.6	7.3	6.9	7.5	7.3	7.0	7.3	7.1
	9	6.8	7.1	7.0	7.6	7.3	6.9	7.4	7.4	7.0	7.3	7.2
	11	6.8	7.1	7.0	7.6	7.3	6.8	7.5	7.5	7.0	7.3	7.1
	12	6.9	7.1	7.0	7.7	7.3	6.8	7.4	7.3	6.9	7.2	7.1
	13	6.8	7.1	7.0	7.7	7.3	6.8	7.4	7.4	6.9	7.3	7.1
	14	6.9	7.0	7.0	7.7	7.3	6.9	7.4	7.4	6.9	7.3	7.1
	15	6.8	7.1	7.0	7.7	7.3	6.9	7.4	7.4	7.0	7.2	7.1
	Initials	SH	SH	thd	[illegible]	[illegible]	MP	[illegible]	[illegible]	MP	MP	thd
	Date	9/13	9/14	9/15	09/16	09/17	9/18	09/18	09/20	9/21	9/22	9/23

Concentration	Cond. (umhos) Initial	Final	Alkalinity (mg/L) Initial	Final	Hardness (mg/L) Initial	Final	Ammonia (mg/L) Initial	Final
Control	291	287	50	90	80	100	0.45	0.01
2	254	266	50	70	70	90	1.26	0.06
5	263	262	50	60	70	80	0.30	0.23
6	259	264	50	40	80	80	0.31	0.09
7	258	268	40	50	80	80	0.35	0.07
9	262	266	40	60	70	80	0.54	0.09
11	258	268	50	60	90	80	0.55	0.05
12	265	270	50	60	80	80	0.43	0.06
13	255	274	50	60	80	90	0.78	0.00
14	269	293	40	60	80	80	0.26	0.04
15	256	286	40	60	70	70	0.23	0.04
Initials	SH	thd	thd	[illegible]	TM	[illegible]	[illegible]	[illegible]
Date	9/13	9/23	9/13	09/23	9/13	09/23	09/13	09/23

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48-~~22-01~~
Job Number: 22-01
Species: C. tentans.

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	16	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	17	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	18	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	19	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	22	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	25	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	-											
	-											
	-											
	-											
	-											
Dissolved Oxygen (mg/L)	16	6.4	5.9	5.7	5.9	5.9	6.1	6.1	5.8	5.7	6.0	7.2
	17	6.3	6.4	5.2	5.9	4.9	6.1	6.3	5.9	5.6	6.4	6.4
	18	6.4	6.4	4.6	5.9	5.2	5.8	6.0	6.0	5.5	5.9	7.0
	19	6.4	6.6	5.4	5.7	5.7	6.8	6.8	6.0	5.5	5.8	6.6
	22	7.5	6.5	6.4	5.9	6.3	6.5	6.5	6.1	6.3	6.9	7.2
	25	7.6	7.0	6.5	6.2	6.5	6.9	7.0	6.3	6.6	7.2	7.6
	-											
	-											
	-											
	-											
	-											
pH	16	6.8	7.0	7.0	7.7	7.3	6.9	7.4	7.4	7.0	7.3	7.1
	17	6.9	7.1	7.0	7.7	7.2	7.0	7.4	7.5	7.0	7.2	7.2
	18	6.7	7.0	6.9	7.7	7.2	6.9	7.4	7.3	7.0	7.3	7.1
	19	6.8	7.0	6.9	7.6	7.3	6.9	7.3	7.4	6.9	7.2	7.2
	22	6.8	7.0	6.9	7.6	7.3	7.0	7.3	7.5	6.9	7.2	7.2
	25	6.8	7.0	7.0	7.7	7.3	7.0	7.3	7.5	7.0	7.2	7.3
	-											
	-											
	-											
	-											
	-											
	Initials	SH	SH	thd	[illegible]	[illegible]	mp	[illegible]	[illegible]	mp	mp	thd
	Date	9/13	9/14	9/15	09/16	09/17	9/18	09/18	09/20	9/21	9/22	9/23

Concentration	Cond. (umhos) Initial	Final	Alkalinity (mg/L) Initial	Final	Hardness (mg/L) Initial	Final	Ammonia (mg/L) Initial	Final
16	267	292	40	70	70	90	0.60	0.04
17	253	285	40	60	70	90	0.33	0.18
18	239	288	40	60	70	80	0.84	0.22
19	245	288	40	60	70	70	0.13	0.17
22	240	287	30	50	60	80	0.04	0.03
25	234	292	30	60	60	80	0.21	0.05
-								
-								
-								
-								
-								
Initials	SH	thd	TMD		TMD	[illegible]	[illegible]	[illegible]
Date	9/13	9/23	9/13		9/13	09/23	09/13	09/23

Comments:

FWSEDPAR.wk3

APPENDIX B

STATISTICAL DATA FOR *Chironomus dilutus*

10 DAY SEDIMENT TOXICITY TEST

Chironomid Survival, Growth Test Survival

Start Date:	9/13/2013	Test ID:	482201cd	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C. dilutus
Comments:					

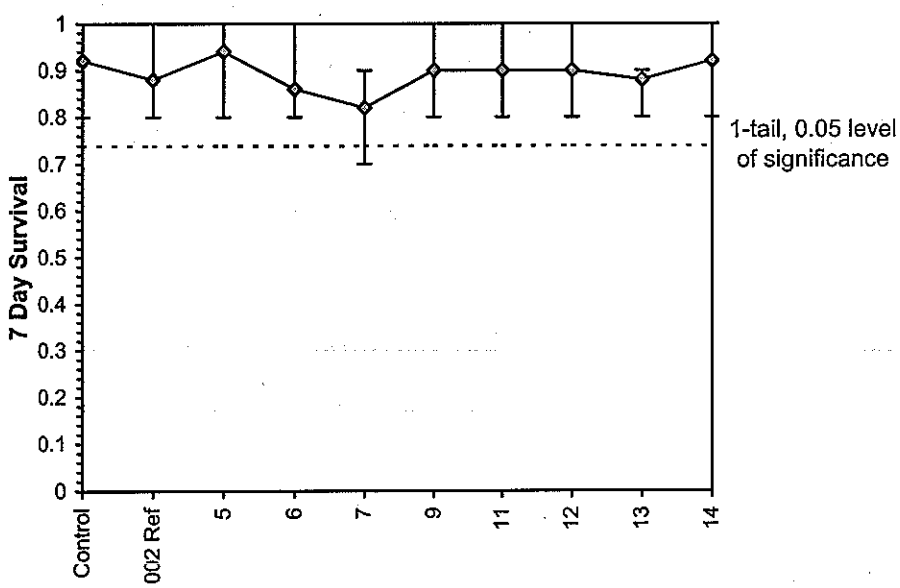
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	0.8000	1.0000
002 Ref	0.9000	0.9000	0.8000	1.0000	0.8000
5	1.0000	0.9000	0.8000	1.0000	1.0000
6	0.9000	1.0000	0.8000	0.8000	0.8000
7	0.8000	0.9000	0.8000	0.7000	0.9000
9	1.0000	0.9000	0.9000	0.9000	0.8000
11	0.9000	0.8000	1.0000	0.9000	0.9000
12	1.0000	0.8000	1.0000	0.8000	0.9000
13	0.9000	0.8000	0.9000	0.9000	0.9000
14	0.9000	1.0000	1.0000	0.8000	0.9000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5			
002 Ref	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	*		
5	0.9400	1.0682	1.3184	1.1071	1.4120	10.436	5	-1.220	2.480	0.1903
6	0.8600	0.9773	1.1965	1.1071	1.4120	11.303	5	0.370	2.480	0.1903
7	0.8200	0.9318	1.1407	0.9912	1.2490	9.612	5	1.097	2.480	0.1903
9	0.9000	1.0227	1.2533	1.1071	1.4120	8.613	5	-0.370	2.480	0.1903
11	0.9000	1.0227	1.2533	1.1071	1.4120	8.613	5	-0.370	2.480	0.1903
12	0.9000	1.0227	1.2575	1.1071	1.4120	12.128	5	-0.425	2.480	0.1903
13	0.8800	1.0000	1.2207	1.1071	1.2490	5.199	5	0.055	2.480	0.1903
14	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5	-0.795	2.480	0.1903

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96077	0.926	0.042	-0.8732
Bartlett's Test indicates equal variances (p = 0.93)	3.05021	20.0902		
The control means are not significantly different (p = 0.47)	0.75516	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.14601	0.16498	0.01329	0.01471	0.52463	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by: _____

Chironomid Survival, Growth Test Survival

Start Date:	9/13/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C. dilutus
Comments:					

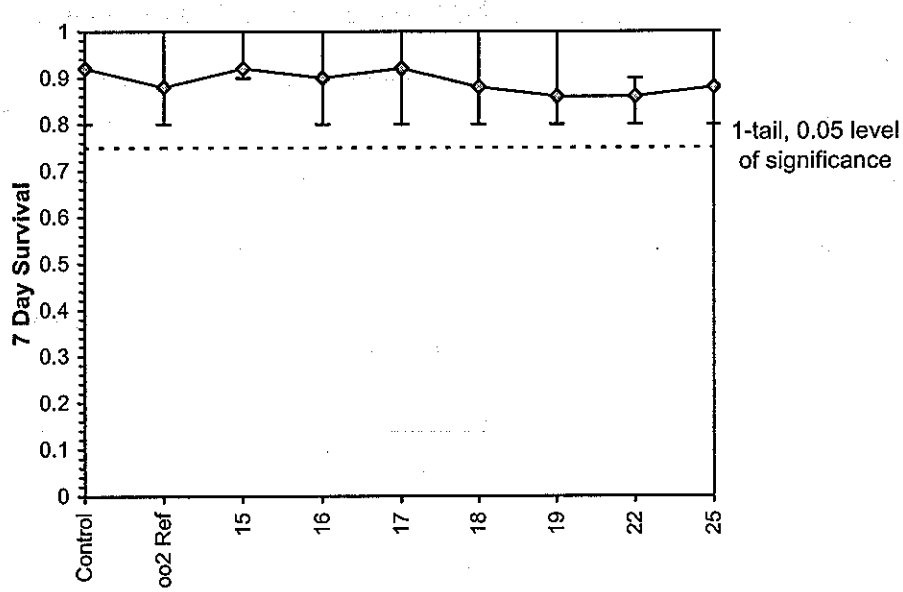
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	0.8000	1.0000
oo2 Ref	0.9000	0.9000	0.8000	1.0000	0.8000
15	0.9000	0.9000	0.9000	0.9000	1.0000
16	0.8000	0.9000	1.0000	0.9000	0.9000
17	0.9000	0.9000	0.8000	1.0000	1.0000
18	0.8000	0.9000	0.8000	0.9000	1.0000
19	0.8000	0.8000	1.0000	0.8000	0.9000
22	0.8000	0.8000	0.9000	0.9000	0.9000
25	1.0000	0.8000	0.9000	0.8000	0.9000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5			
oo2 Ref	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	*		
15	0.9200	1.0455	1.2816	1.2490	1.4120	5.687	5	-0.780	2.443	0.1777
16	0.9000	1.0227	1.2533	1.1071	1.4120	8.613	5	-0.390	2.443	0.1777
17	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5	-0.838	2.443	0.1777
18	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	0.000	2.443	0.1777
19	0.8600	0.9773	1.1965	1.1071	1.4120	11.303	5	0.390	2.443	0.1777
22	0.8600	0.9773	1.1923	1.1071	1.2490	6.519	5	0.448	2.443	0.1777
25	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	0.000	2.443	0.1777

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.93983	0.919	0.44029	-0.6464
Bartlett's Test indicates equal variances (p = 0.92)	2.58194	18.4753		
The control means are not significantly different (p = 0.47)	0.75516	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	>25		4	0.13504	0.15258	0.00622	0.01323	0.84888	7, 32
Treatments vs oo2 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by: _____

Chironomid Survival, Growth Test Growth

Start Date:	9/13/2013	Test ID:	482201cd	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C dilutus
Comments:					

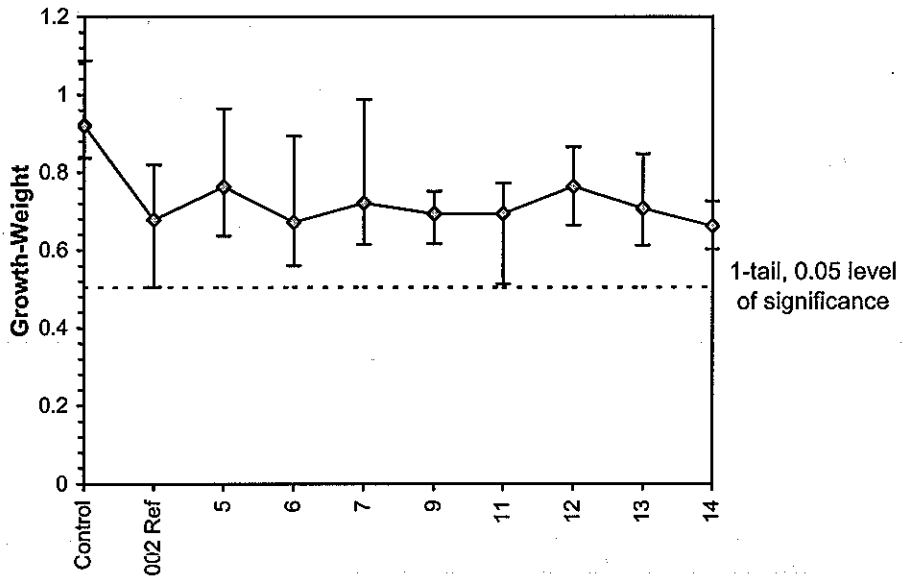
Conc-%	1	2	3	4	5
Control	0.8880	0.8378	0.8533	1.0875	0.9390
002 Ref	0.7000	0.6800	0.6863	0.5050	0.8200
5	0.6370	0.8922	0.9638	0.6500	0.6720
6	0.6278	0.5600	0.6238	0.8925	0.6550
7	0.6425	0.6533	0.6150	0.9871	0.7078
9	0.6800	0.7067	0.7089	0.7511	0.6163
11	0.7722	0.7550	0.5130	0.6589	0.7689
12	0.7880	0.8650	0.6720	0.8300	0.6633
13	0.8467	0.7550	0.6211	0.6989	0.6122
14	0.6289	0.6860	0.6680	0.6025	0.7267

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9211	1.3581	0.9211	0.8378	1.0875	10.943	5			
002 Ref	0.6783	1.0000	0.6783	0.5050	0.8200	16.591	5	*		
5	0.7630	1.1249	0.7630	0.6370	0.9638	20.083	5	-1.207	2.480	0.1742
6	0.6718	0.9905	0.6718	0.5600	0.8925	19.082	5	0.092	2.480	0.1742
7	0.7212	1.0633	0.7212	0.6150	0.9871	21.142	5	-0.611	2.480	0.1742
9	0.6926	1.0211	0.6926	0.6163	0.7511	7.174	5	-0.204	2.480	0.1742
11	0.6936	1.0226	0.6936	0.5130	0.7722	16.029	5	-0.219	2.480	0.1742
12	0.7637	1.1259	0.7637	0.6633	0.8650	12.025	5	-1.216	2.480	0.1742
13	0.7068	1.0421	0.7068	0.6122	0.8467	13.833	5	-0.406	2.480	0.1742
14	0.6624	0.9766	0.6624	0.6025	0.7267	7.330	5	0.226	2.480	0.1742

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96476	0.926	0.60124	0.22939
Bartlett's Test indicates equal variances (p = 0.39)	8.43951	20.0902		
The control means are significantly different (p = 7.03E-03)	3.59488	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.17419	0.25682	0.00686	0.01233	0.80597	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

Chironomid Survival, Growth Test-Growth

Start Date:	9/13/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C dilutus
Comments:					

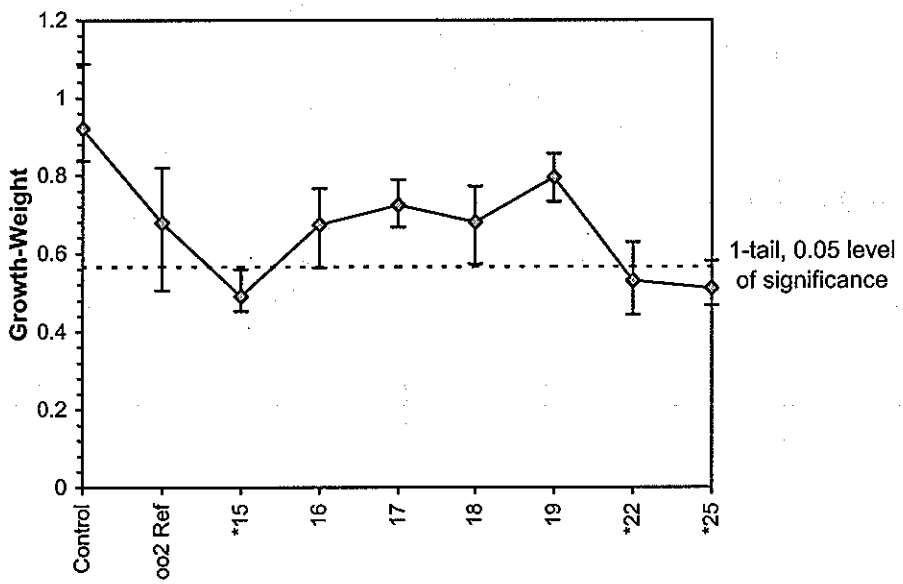
Conc-%	1	2	3	4	5
Control	0.8880	0.8378	0.8533	1.0875	0.9390
oo2 Ref	0.7000	0.6800	0.6863	0.5050	0.8200
15	0.5600	0.4533	0.4722	0.4989	0.4680
16	0.7663	0.6178	0.5640	0.7567	0.6611
17	0.7389	0.7433	0.6675	0.6800	0.7890
18	0.7725	0.5733	0.6713	0.7644	0.6180
19	0.7825	0.8563	0.8240	0.7788	0.7322
22	0.5300	0.5750	0.4744	0.6289	0.4433
25	0.5810	0.4663	0.4767	0.5013	0.5233

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9211	1.3581	0.9211	0.8378	1.0875	10.943	5			
oo2 Ref	0.6783	1.0000	0.6783	0.5050	0.8200	16.591	5	*		
*15	0.4905	0.7232	0.4905	0.4533	0.5600	8.603	5	4.083	2.443	0.1123
16	0.6732	0.9925	0.6732	0.5640	0.7663	13.029	5	0.111	2.443	0.1123
17	0.7237	1.0671	0.7237	0.6675	0.7890	6.891	5	-0.989	2.443	0.1123
18	0.6799	1.0024	0.6799	0.5733	0.7725	12.945	5	-0.036	2.443	0.1123
19	0.7947	1.1718	0.7947	0.7322	0.8563	5.953	5	-2.533	2.443	0.1123
*22	0.5303	0.7819	0.5303	0.4433	0.6289	14.111	5	3.217	2.443	0.1123
*25	0.5097	0.7515	0.5097	0.4663	0.5810	8.948	5	3.666	2.443	0.1123

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.98452	0.919	-0.1619	0.14506
Bartlett's Test indicates equal variances (p = 0.42)	7.11405	18.4753		
The control means are significantly different (p = 7.03E-03)	3.59488	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<15	15			0.11231	0.16559	0.06163	0.00529	2.9E-07	7, 32
Treatments vs oo2 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

APPENDIX C

CHAIN OF CUSTODY DOCUMENTATION

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131004	TOX-FS13-SED-002	TOX-SED-002	Chironomus and Hyalella Tox Tests	Sediment	7/29/2013	15:20	1	2.5 gallon bucket	4 C	N
131005	TOX-FS13-SED-005	TOX-SED-005	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:30	1	2.5 gallon bucket	4 C	N
131006	TOX-FS13-SED-006	TOX-SED-006	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:50	1	2.5 gallon bucket	4 C	N
131007	TOX-FS13-SED-007	TOX-SED-007	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:57	1	2.5 gallon bucket	4 C	N
131008	TOX-FS13-SED-009	TOX-SED-009	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:10	1	2.5 gallon bucket	4 C	N
131009	TOX-FS13-SED-011	TOX-SED-011	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:45	1	2.5 gallon bucket	4 C	N
131010	TOX-FS13-SED-012	TOX-SED-012	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:55	1	2.5 gallon bucket	4 C	N
131011	TOX-FS13-SED-013	TOX-SED-013	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:05	1	2.5 gallon bucket	4 C	N
131012	TOX-FS13-SED-014	TOX-SED-014	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:20	1	2.5 gallon bucket	4 C	N
131013	TOX-FS13-SED-015	TOX-SED-015	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:00	1	2.5 gallon bucket	4 C	N
131014	TOX-FS13-SED-016	TOX-SED-016	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:05	1	2.5 gallon bucket	4 C	N

Special Instructions: ~~Wash~~

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analyses	[signature]	8/29/13	[signature]	8/29/13					[signature]	8/29/13	1500

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131015	TOX-FS13-SED-017	TOX-SED-017	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:15	1	2.5 gallon bucket	4 C	N
131016	TOX-FS13-SED-018	TOX-SED-018	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:10	1	2.5 gallon bucket	4 C	N
131017	TOX-FS13-SED-019	TOX-SED-019	Chironomus and Hyalella Tox Tests	Sediment	7/30/2020	16:55	1	2.5 gallon bucket	4 C	N
131018	TOX-FS13-SED-022	TOX-SED-022	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	08:40	1	2.5 gallon bucket	4 C	N
131019	TOX-FS13-SED-025	TOX-SED-025	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	09:25	1	2.5 gallon bucket	4 C	N

Special Instructions:

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analysis	[illegible]	8/29/13	Diane Higgins	8/29/13			Diane Higgins	8/29	Wendy Mangum	8/29/13	1500

The CORR Procedure

4 With Variables: dilutus azteca_surv azteca_dw arsinazt

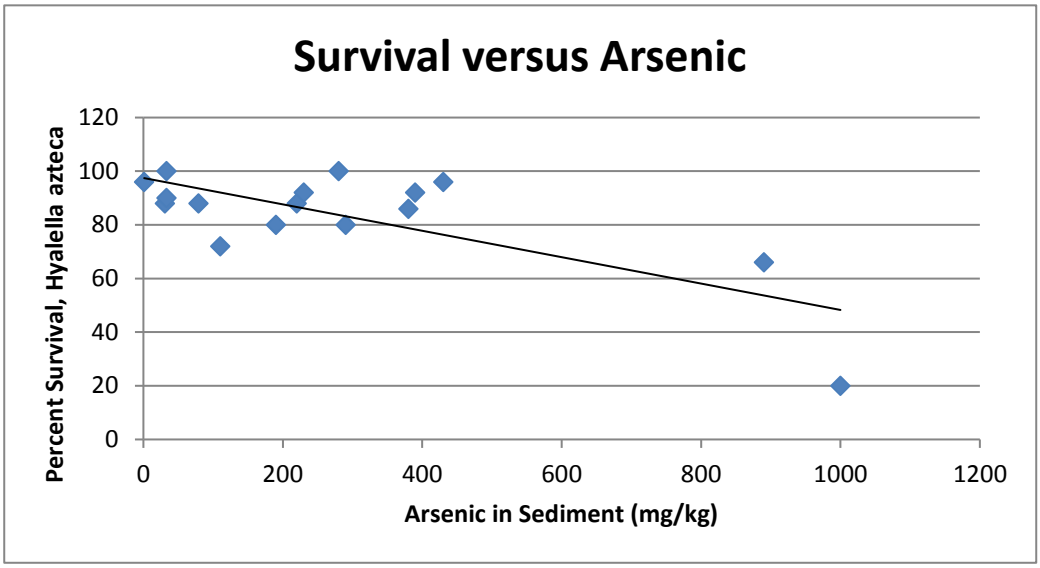
4 Variables: arsenic chromium lead zinc

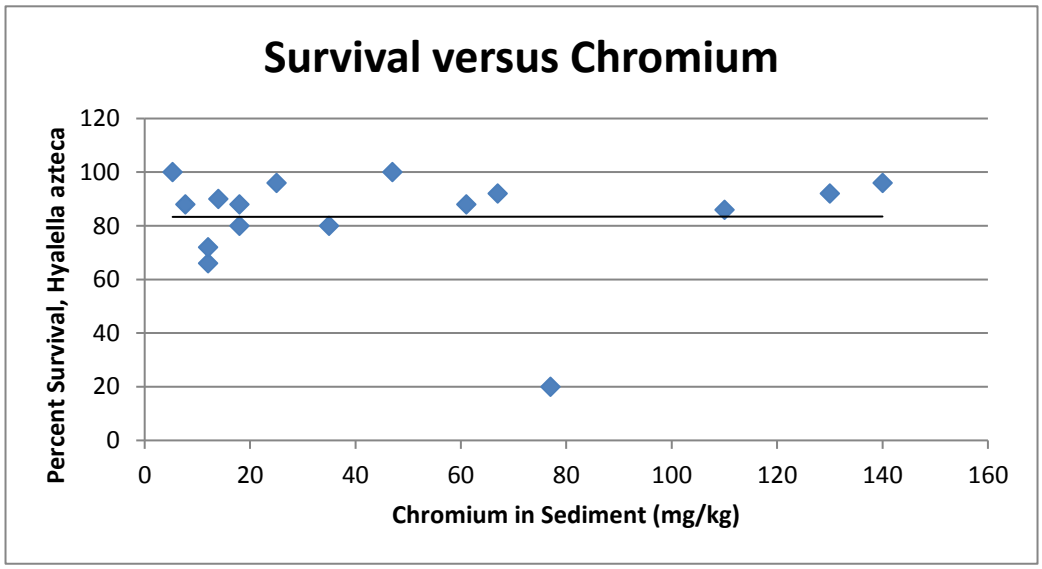
Simple Statistics

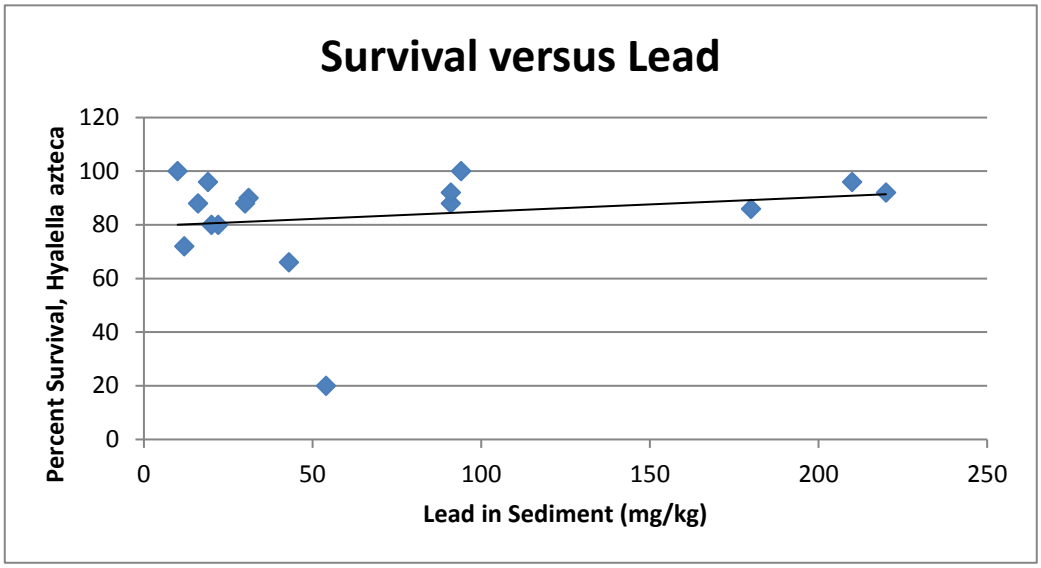
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
dilutus	16	0.67175	0.09000	10.74800	0.49100	0.79500
azteca_surv	16	0.83375	0.19332	13.34000	0.20000	1.00000
azteca_dw	13	0.13654	0.03915	1.77500	0.07600	0.20000
arsinazt	16	1.19847	0.25918	19.17546	0.46365	1.57080
arsenic	16	286.69375	292.09454	4587	1.10000	1000
chromium	16	48.68750	44.78826	779.00000	5.30000	140.00000
lead	16	71.43750	71.65470	1143	10.00000	220.00000
zinc	16	106.80625	110.70774	1709	3.80000	300.00000

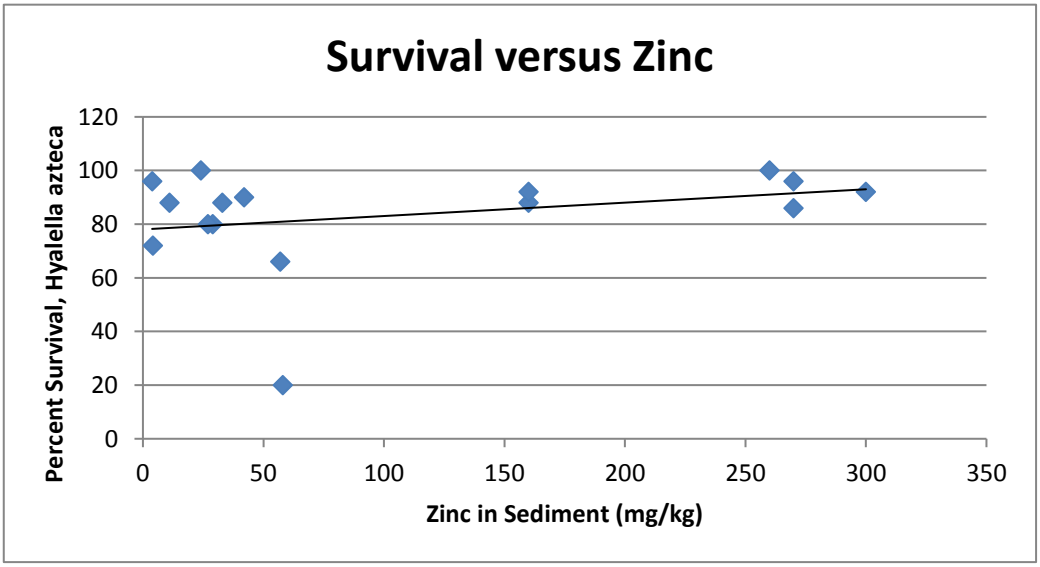
Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

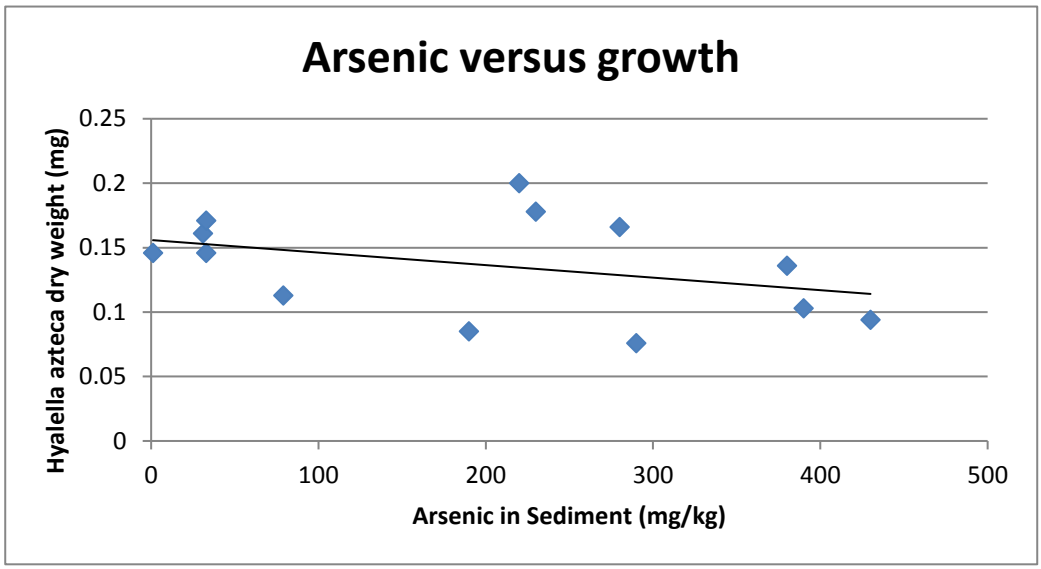
	arsenic	chromium	lead	zinc
dilutus	-0.26377	0.08535	0.23995	0.38490
	0.3236	0.7533	0.3707	0.1410
	16	16	16	16
azteca_surv	-0.74349	0.00235	0.20052	0.28579
	0.0010	0.9931	0.4565	0.2833
	16	16	16	16
azteca_dw	-0.37657	-0.21318	-0.14912	0.03419
	0.2047	0.4844	0.6268	0.9117
	13	13	13	13
arsinazt	-0.68233	-0.00582	0.17982	0.30684
	0.0036	0.9829	0.5051	0.2477
	16	16	16	16

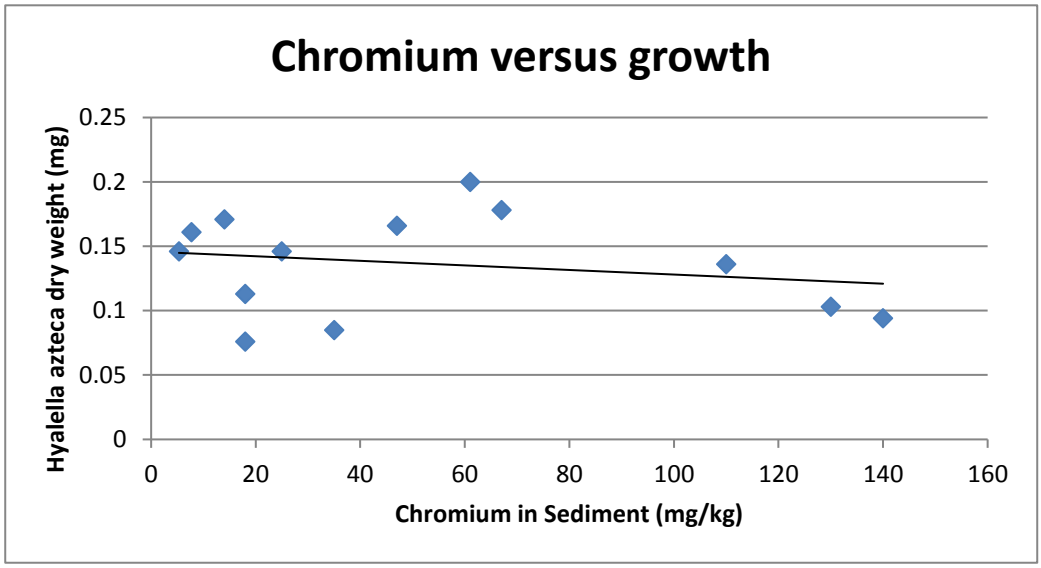

Survival versus Arsenic
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
Arsenic in Sediment (mg/kg)

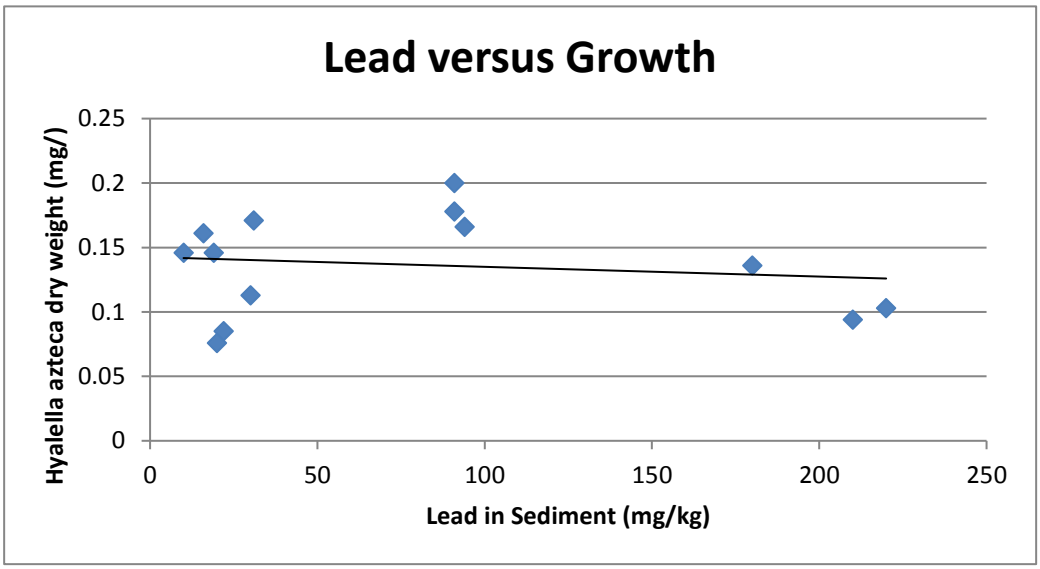

Survival versus Chromium
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
Chromium in Sediment (mg/kg)

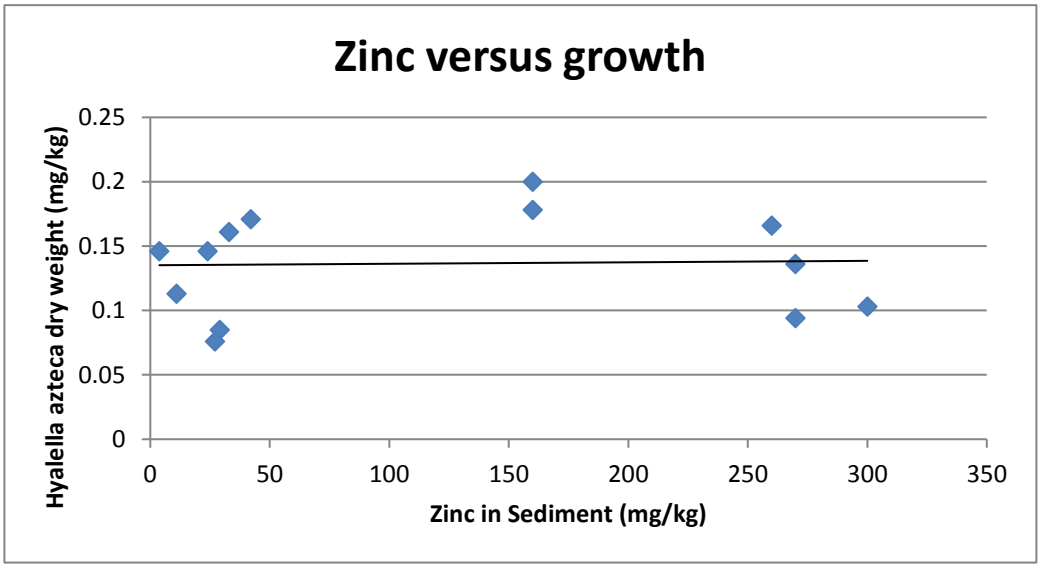

Survival versus Lead
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
50
100
150
200
250
Lead in Sediment (mg/kg)

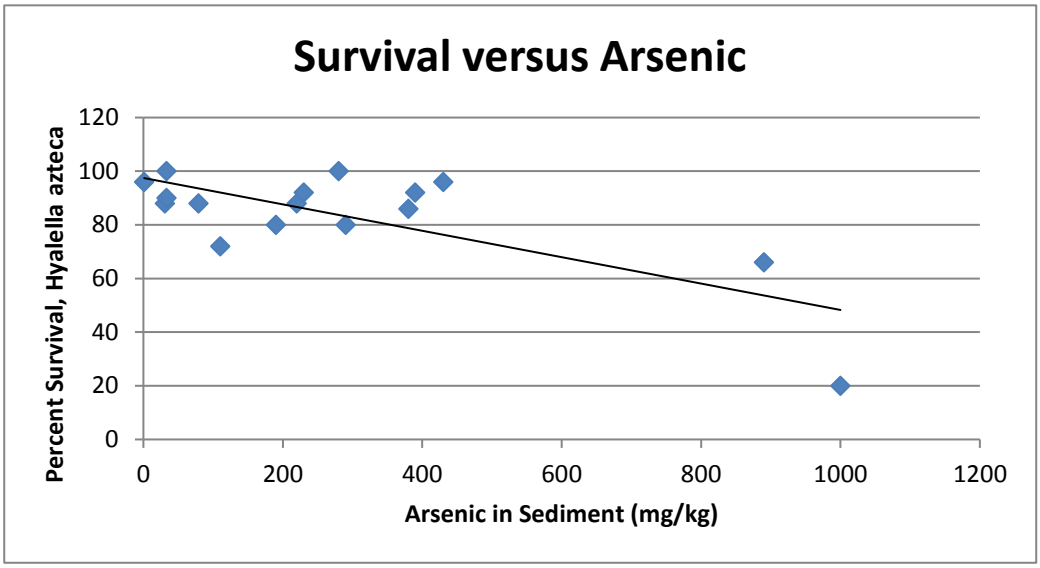

Survival versus Zinc
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
Zinc in Sediment (mg/kg)

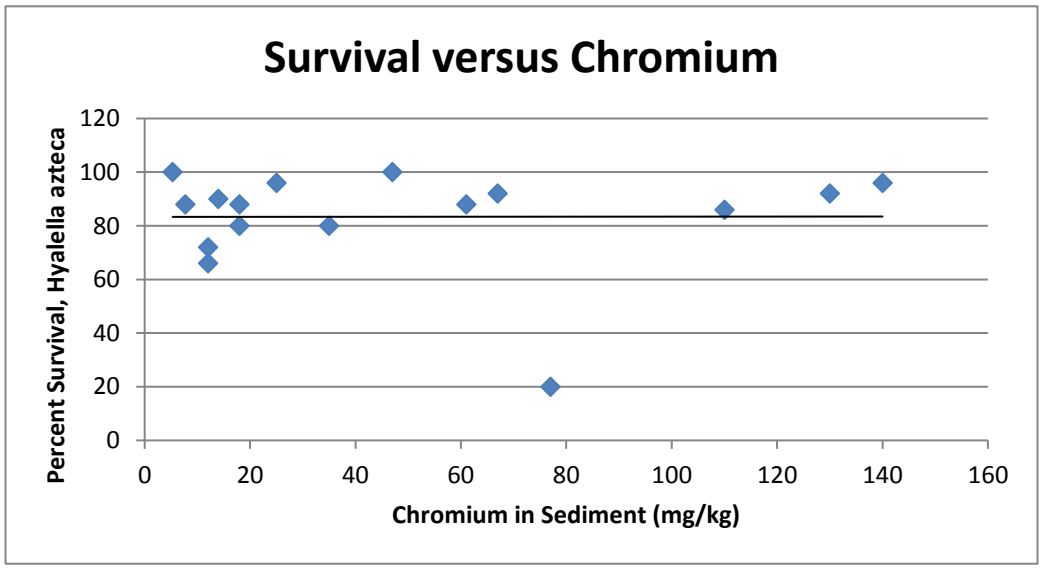

Arsenic versus growth
Hyalella azteca dry weight (mg)
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
Arsenic in Sediment (mg/kg)

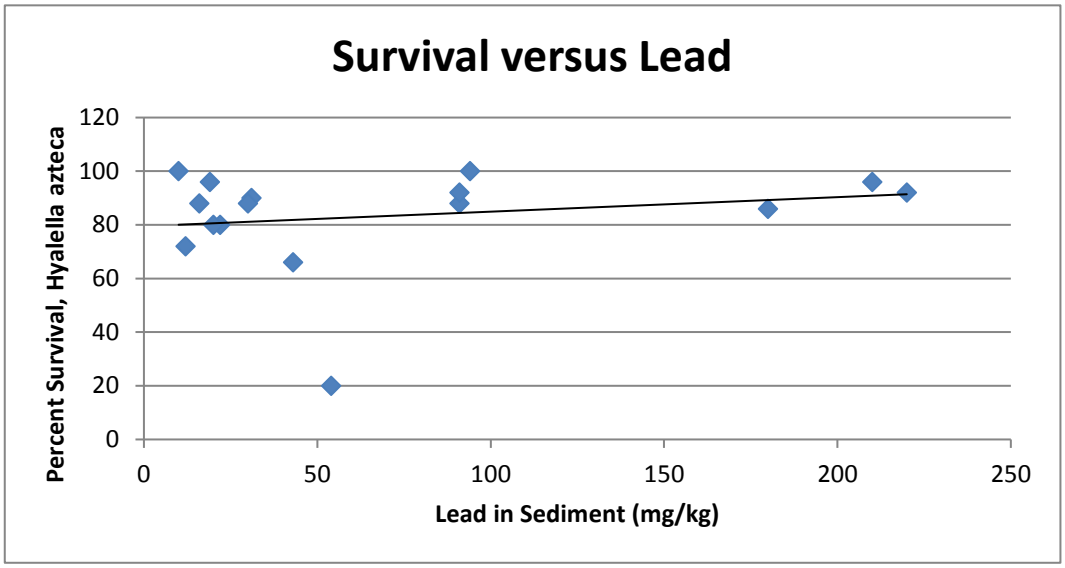

Chromium versus growth
Hyalella azteca dry weight (mg)
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
120
140
160
Chromium in Sediment (mg/kg)

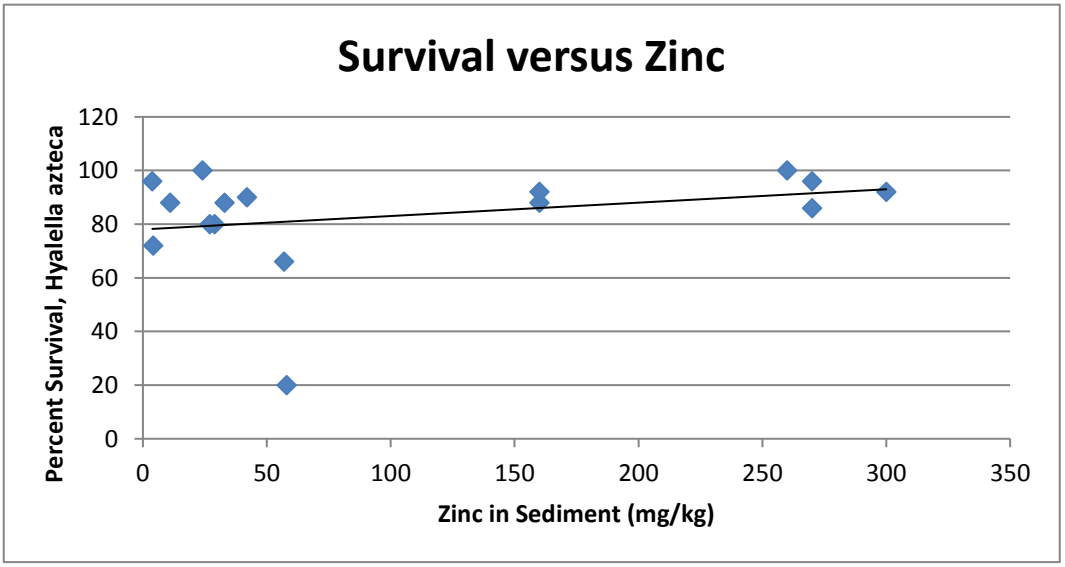

Lead versus Growth
Hyalella azteca dry weight (mg/)
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
Lead in Sediment (mg/kg)


Zinc versus growth
Hyalella azteca dry weight (mg/kg)
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
350
Zinc in Sediment (mg/kg)


Survival versus Arsenic
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
Arsenic in Sediment (mg/kg)


Survival versus Chromium
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
Chromium in Sediment (mg/kg)


Survival versus Lead
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
50
100
150
200
250
Lead in Sediment (mg/kg)


Survival versus Zinc
Percent Survival, Hyalella azteca
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
Zinc in Sediment (mg/kg)

Appendix B

Aquatic Toxicity Testing Report

REPORT CERTIFICATION

The following report titled "LOCKHEED MARTIN SERAS SEDIMENT TOXICITY TESTING – *Chironomus dilutus*" is an accurate and truthful representation of the toxicity testing which was performed by American Aquatic Testing, Inc., located at 890 North Graham Street Allentown, Pennsylvania. We further certify that we have personally examined and are familiar with the information submitted in this document and based on our inquiry of those individuals immediately responsible for obtaining the information; we believe the submitted information is complete as presented. We are aware that there are significant penalties for submitting false information.

Christopher J. Nally
President, Laboratory Director

Tarmo Pallop
Vice-President, Laboratory Manager

LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING – *Chironomus dilutus*

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II.	Percent survival of *C. dilutus* by replicate chamber & survival comparison using reference sample	6
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Appendices

A. Raw data for *Chironomus dilutus* 10-day sediment toxicity test

B. Statistical data for *Chironomus dilutus* 10-day sediment toxicity test

C. Chain of Custody Documentation

LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING – *Chironomus dilutus*

INTRODUCTION

During the month of August 2013, samples of sediment were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. These sediment samples were used to perform toxicity tests to determine if the tested matrices represent a significant threat to potential receptor organisms.

The sediment samples from the site were delivered to American Aquatic Testing, Inc. (AAT) and evaluated for toxicity using a 10-day solid phase exposure with the chironomid Chironomus dilutus [1]. Following the exposure period, surviving test organisms from the sediments collected at the site were compared to the off-site reference sediment (location 02) tested under similar conditions. The endpoints used for determination of an impact in the chironomid exposures were mortality, measured as mean survival, and growth measured as ash-free dry weight (AFDW).

MATERIALS AND METHODS

Surface sediment samples were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. Station locations were selected to represent areas that may have been impacted by the facility's operations.

Preparation of sediment samples for testing

Samples were collected into 2.5-gallon high-density polyethylene (HDPE) containers and placed on ice after collection. Sediment samples were picked up by AAT personnel on August 24, 2013 and transported on ice. Upon arrival at AAT, the samples were refrigerated until being used for testing on September 13, 2013. These samples were physically screened using a #18 mesh screen to remove large debris and indigenous organisms on September 3, 2013.

Control sediment used to assess the health of the test organisms used for testing was collected from the Spruce Run Reservoir in Clinton, NJ on September 3, 2013 and was screened using a #18 mesh screen to remove large debris and indigenous organisms on September 4, 2013. Screened sediment was placed in a five gallon HDPE container and refrigerated until used for testing on September 13, 2013.

Test organisms

Test age larvae (2nd and 3rd instar) of the chironomid, *Chironomus dilutus*, were obtained from stock cultures maintained by Aquatic Biosystems, Inc. of Fort Collins, CO and were received in-house prior to testing and were held under conditions similar to that which the larval test organisms would encounter during the test (see Table I).

A reference toxicant test using potassium chloride was conducted concurrently with the initiation of the long term exposure to assess the sensitivity of the lot of organisms used in the sediment test. The 48 hr LC_{50} produced was 3221.9 ppm. This test value falls within the acceptable range of the control chart being maintained by AAT for this test species. A copy of the raw data is provided as Appendix A.

Experimental procedures

The entire sediment exposure series for this project consisted of 16 sediment samples from the Vineland Chemical Site and one of control sediment provided by AAT. Tox-Sed 002 was collected from an off-site reference location. Test chambers (300 mL tall form borosilicate glass beakers) were filled with 100 mL of sediment. Approximately 175 mL of laboratory-produced fresh water (moderately hard reconstituted) was poured over the sediment gently to cause minimal disturbance. There were 5 replicate chambers for each sample treatment. Test chambers were allowed to settle for 24 hours prior to test initiation.

After the settling period, the overlying water was siphoned off and fresh laboratory water was introduced, using a small, round HDPE disk suspended over the sediment to deflect the water flow and minimize disturbance to the sediment. Water quality data including alkalinity, ammonia, conductivity, dissolved oxygen, temperature, pH, and hardness were measured initially on composite water samples from all sites, prior to the introduction of test organisms, and at the end of the long-term exposure for each sample location and the control. The diss. oxygen, pH and temperature were also measured initially and every 24 hours for the duration of the exposure for each sample location and the control. Fresh laboratory water that was used for the daily exchanges was also monitored for dissolved oxygen, pH and temperature at each exchange.

The exposure period began by placing 10 randomly selected test organisms into each chamber. Care was taken to ensure the organisms were released beneath the surface of the overlying water to keep air bubbles from forcing the organisms to the surface. Test chamber organisms were fed once a day during the exposure period with a slurry of dry fish flake food and deionized water to deliver approximately 4 mg/L to each chamber, when food from previous feedings had been consumed. Uneaten food was removed to prevent microbial growth or depressed oxygen concentrations. Test conditions are summarized in Table I.

Observations were made and recorded for each chamber each day during the exposure period to assess organism health. Observations included the number of dead organisms, as well as organisms swimming, on the surface of the sediment, or on the surface of the water. Dissolved oxygen, pH and temperature were measured and recorded each day from a new replicate chamber for each sample and the control. Overlying water (150 mL) was siphoned off twice a day and replaced using reconstituted laboratory water as a measure to maintain sufficient dissolved oxygen levels. Care was taken to minimize disturbance of the sediment during water renewal by using the small HDPE disc.

At day 10, all test chambers from each sample location and the control were prepared for the removal of test organisms. With the overlying water present in each chamber, the top 20% of sediment was gently stirred into suspension. The slurry was then poured into a #60 mesh screen (250 μm) and rinsed in a shallow pan of laboratory water to remove the finer grains of sediment. The sieve was placed into a second shallow pan of water over a light table, and carefully sorted to find surviving test organisms. Using additional laboratory water, this process was repeated two or three times for each replicate until all the sediment had been inspected. All surviving organisms were transferred to a 30 mL soufflé cup for live count verification and preparation for weight determination. Pupae were counted for survival purposes, but were not included in the weight analysis.

When all test chambers from each sample had been sieved and the number of survivors verified, the test organisms were sacrificed using ethanol. The test organisms were immediately placed on tared aluminum weigh pans that had been previously dried for six hours at 105° C, then dried in a muffle furnace at 550° C for two hours, in preparation for AFDW analysis. Weigh pans and test organisms were then dried for six hours at 105° C and then transferred to a desiccator to cool before dry weight determination on September 24, 2013. Following dry weight determination all weigh pans and test organisms were then dried for two hours at 550° C and transferred to a desiccator to cool before AFDW determination on October 14, 2013.

Data analysis

Data analysis was performed following procedures published by the USEPA [1] using the ToxCalc v5.0.23 [2] data analysis software. Survival data, in the form of proportion of survivors in each chamber, was transformed by arcsine squareroot and then tested for normality using the Shapiro-Wilk's test or the Chi-Square test and for homogeneity of variance using Bartlett's test, as appropriate. Analysis of variance (ANOVA) followed by Dunnett's *a posteriori* pairwise comparisons or Steel's Many-One Rank test, as appropriate, to evaluate differences between stations and the control samples.

TABLE I: Summary of Conditions for *Chironomus dilutus* Toxicity Test

1.	Test type;	Whole sediment, static, daily renewal
2.	Temperature;	23.0 +/- 1.0 ° C
3.	Light quality;	Wide-spectrum fluorescent illumination
4.	Light intensity;	50 - 100 foot-candles
5.	Photoperiod;	16 hours light, 08 hours dark
6.	Test chamber size;	300 mL high form borosilicate glass beakers
7.	Sediment volume;	100 mL / replicate
8.	Overlying water volume;	175 mL / replicate
9.	Renewal;	2 volume exchanges per day
10.	Age of test organisms;	2nd and 3rd instar
11.	Number organisms / container;	10
12.	Replicates;	5
13.	Feeding;	4.0 mg/L flake fish food / day, as needed
14.	Aeration;	None unless dissolved oxygen concentrations ≤ 2.5 ppm
15.	Overlying water;	Laboratory reconstituted water
16.	Test chamber cleaning;	Only if necessary
17.	Overlying water quality;	D. O., pH and temperature daily; alkalinity, ammonia, conductivity, hardness & pH at beginning and end of test, D. O., pH and temp. daily on exchange water
18.	Test duration;	10 days
19.	Effects measured @ 10 days;	Percent survival and growth as AFDW
20.	Test acceptability;	Minimum control survival should be ≥70 %, Min. control mean dry weight should be at least 0.6 mg Min. control AFDW should be at least 0.48 mg

RESULTS

Effects on survival @ 10 Days using reference sample TOX-SED-002

Appendix A presents raw data. Data were arcsine square root transformed. The data were found to be normally distributed, were tested for homogeneity of variances using Bartlett's test, and found to be homogeneous. It was therefore determined that parametric analyses were appropriate, Dunnett's Test comparison was used to determine differences between survival of organisms in station sediments and the control sample.

Results from the analysis, which compared survival in station sediments with survival of organisms exposed to the reference sample (reference sample and control sample were not statistically different), are presented in Table II and in Appendix B.

None of the 15 samples from the study area evaluated exhibited mortality found to be statistically significant when compared to the reference treatment.

Table II. Percent survival of *C. dilutus* by replicate chamber & survival comparison using reference sample*

	Sample Identification															
Rep.	Tox Sed 002	Tox Sed 005	Tox Sed 006	Tox Sed 007	Tox Sed 009	Tox Sed 011	Tox Sed 012	Tox Sed 013	Tox Sed 014	Tox Sed 015	Tox Sed 016	Tox Sed 017	Tox Sed 018	Tox Sed 019	Tox Sed 022	Tox Sed 025
A	100	100	90	80	100	90	100	90	90	90	80	90	80	80	80	100
B	90	90	100	90	90	80	80	80	100	90	90	90	90	80	80	80
C	90	80	80	80	90	100	100	90	100	90	100	80	80	100	90	90
D	80	100	80	70	90	90	80	90	80	90	90	100	90	80	90	80
E	100	100	80	90	80	90	90	90	90	100	90	100	100	90	90	90
Mean % Survival	88	94	86	82	90	90	90	88	92	92	90	92	88	86	86	88
Statistically Different from Reference?		no	no	no	no	no	no	no	no	no	no	no	no	no	no	no

* Tox-Sed 002 is off-site reference sediment used for evaluation.

Effects on growth @ 10 days using reference sample TOX-SED-002

Appendix A presents raw data. Data were untransformed. The data were found to be normally distributed, were tested for homogeneity of variances using Bartlett's test, and found to be homogeneous. It was therefore determined that parametric analyses were appropriate, Dunnett's Test comparison was used to determine differences between survival of organisms in station sediments and the control samples.

Results from the analysis, which compared the AFDW in station sediments with the AFDW of organisms exposed to the reference sample, are presented in Table III and in Appendix B. It should be noted here that the reference test organisms were significantly different in average weight from those exposed to the control sediment. However, since there is no minimum weight required by the method, and the survival of reference test organisms was comparable to those of the control exposure the samples were compared to the reference.

Of the 15 samples from the study area evaluated using AFDW, samples identified as Tox-Sed 015, Tox-Sed 022 and Tox-Sed 025 all exhibited growth that was found to be statistically significant when compared to the reference treatment.

Table III. AFDW of *C. dilutus* by replicate chamber & AFDW (mg) comparison using reference sample

	Sample Identification															
Rep.	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed	Tox Sed
	2	5	6	7	9	11	12	13	14	15	16	17	18	19	22	25
A	0.700	0.637	0.628	0.643	0.680	0.772	0.788	0.847	0.629	0.560	0.766	0.739	0.773	0.783	0.530	0.581
B	0.680	0.892	0.560	0.653	0.707	0.755	0.865	0.755	0.687	0.453	0.618	0.743	0.573	0.856	0.575	0.466
C	0.686	0.964	0.624	0.615	0.709	0.513	0.672	0.621	0.668	0.472	0.564	0.668	0.671	0.824	0.474	0.477
D	0.505	0.650	0.893	0.987	0.751	0.659	0.830	0.699	0.603	0.499	0.757	0.680	0.764	0.779	0.629	0.501
E	0.820	0.670	0.655	0.708	0.616	0.769	0.663	0.612	0.727	0.468	0.661	0.789	0.618	0.732	0.443	0.523
Ave AFDW	0.678	0.763	0.672	0.721	0.693	0.694	0.764	0.707	0.662	0.491	0.673	0.724	0.680	0.795	0.530	0.501
Statistically Different from Reference?		no	no	no	no	no	no	no	no	YES	no	no	no	no	YES	YES

* Tox-Sed 002 is off-site reference sediment used for evaluation.

REFERENCES

[1] **Ingersoll, C.G., G.A. Burton, T.D. Dawson, F.W. Dwyer, D.S. Ireland, R.A. Hoke, N.E. Kemble, D.R. Mount, T.J. Norberg-King, P.K. Sibley, and L. Stahl** 2000 Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates EPA 600/R-99/064. U.S. Environmental Protection, Office of Science and Development, Duluth, MN

[2] **ToxCalc v5.0.23F** data analysis software published by TidePool Scientific Software McKinleyville, CA

APPENDIX A

RAW DATA FOR *Chironomus dilutus*

10 DAY SEDIMENT TOXICITY TEST

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL COUNT ~~11~~	12	13
Control	A	N	N	N	N	N	2F	N	N	N	N	N	10		
	B	N	N	N	1F	N	H	N	N	N	N	N	9		
	C	N	N	1F	N	N	H	N	N	N	N	N	9		
	D	N	N	1F	N	N	N	N	N	N	1F	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
2	A	N	N	N	1F	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	~~N~~ (1)	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	10		
	E	N	N	N	N	N	N	N	N	N	N	N	8		
5	A	N	N	N	N	N	N	N	N	N	N	N	10		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	~~9~~ (2)		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
6	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	10		
	C	N	N	1F	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	8		
7	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	7		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
Initials		[illegible]	TAP	TAP	[illegible]	[illegible]	[illegible]	[illegible]		MP	MP	[illegible]	TAP		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19		9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity, B=No Observations~~
F - Sediment M - Swimming

Comments:

(1) N MP 9/22

(2) 10 09/23

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL COUNT ~~11~~	12	13
~~Control~~ 9	A	N	N	N	N	N	N	N	N	N	N	N	10		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	9		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	8		
11	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
12	A	N	N	N	N	N	N	N	N	N	N	N	10		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	F	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
13	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	9		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
14	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	10		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
Initials		BD	TDP	TDP	BD	BD	BD	BD	BD	MD	MD	BD	BD		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19	09/20	9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity, B=No Observations~~
F - SEDIMENT M - SWIMMING

Comments:

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL Count ~~11~~	12	13
~~Control~~ 15	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	9		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
16	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
17	A	N	N	N	N	N	N	N	N	N	N	N	9		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	10		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
18	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	9		
	C	N	N	N	N	N	N	N	N	N	N	N	8		
	D	N	N	N	N	N	N	N	N	N	N	N	9		
	E	N	N	N	N	N	N	N	N	N	N	N	10		
19	A	N	N	N	N	N	N	N	N	N	N	N	8		
	B	N	N	N	N	N	N	N	N	N	N	N	8		
	C	N	N	N	N	N	N	N	N	N	N	N	10		
	D	N	N	N	N	N	N	N	N	N	N	N	8		
	E	N	N	N	N	N	N	N	N	N	N	N	9		
Initials		[illegible]	TAP	TAP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MJ	MP	[illegible]	TAP		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19	09/20	9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity~~, ~~B=No Observations~~
F- ON SEDIMENT M- SWIMMING

Comments:

Job Number: 48-22-01
Species: ~~C. tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	FINAL COUNT 11	12	13
~~Control~~ 22	A	N	N	N	N	N	N	N	N	D	D	N	8		
	B	N	N	N	N	N	N	N	N	D	D	N	8		
	C	N	N	N	N	N	N	N	N	D	D	N	9		
	D	N	N	N	N	N	N	N	N	D	D	N	9		
	E	N	N	N	N	N	N	N	N	D	D	N	9		
25	A	N	N	N	N	N	N	N	N	D	D	N	10		
	B	N	N	N	N	N	N	N	N	D	D	N	8		
	C	N	N	N	N	N	N	N	N	D	D	N	9		
	D	N	N	N	N	N	N	N	N	D	D	N	8		
	E	N	N	N	N	N	N	N	N	D	D	N	9		
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
Initials		[illegible]	TAP	TAP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MM	MO	[illegible]	TAP		
Date		09/13	9/14	9/15	09/16	09/17	09/18	09/19	09/20	9/21	9/22	09/23	09/23		

Key: D=dead, N=normal activity, ~~A=abnormal activity, B=No Observations~~

Comments: F ON SEDIMENT ~~B~~ M - SWIMMING

Client/Toxicant: 48-22-01
Project Number:
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A ① weight of boat (g)	B weight of boat & org. (g)	C (mg)	D	# of surviving org.	E WT OF BOAT & ORG. ASH (g)	F AFDW TOTAL (mg)	G AVE AFDW mg
Control	A	1	0.03025	0.04412	13.87	1.39	10	0.03524	8.88	0.888
	B	2	0.02649	0.03905	12.56	1.40	9	0.03151	7.54	0.838
	C	3	0.02908	0.04075	11.67	1.30	9	0.03307	7.68	0.853
	D	4	0.02645	0.03786	11.41	1.43	8	0.02916	8.70	1.088
	E	5	0.02764	0.04150	13.86	1.39	10	0.03211	9.39	0.939
	~~F~~	~~6~~								
	~~G~~									
	~~H~~									
2	A	6	0.02473	0.03179			9	0.02849	6.30	0.700
	B	7	0.03265	0.03987			9	0.03375	6.12	0.680
	C	8	0.03093	0.03706			8	0.03157	5.49	0.686
	D	9	0.02754	0.03348			10	0.02843	5.05	0.505
	E	10	0.02682	0.03419			8	0.02763	6.56	0.820
	~~F~~									
	~~G~~									
	~~H~~									
5	A	11	0.02734	0.03462			10	0.02825	6.37	0.637
	B	12	0.02657	0.03553			9	0.02750	8.03	0.892
	C	13	0.02685	0.03556			8	0.02785	7.71	0.964
	D	14	0.02475	0.03230			10	0.02580	6.50	0.650
	E	15	0.02638	0.03444			10	0.02772	~~6.68~~ ①	~~0.668~~ ②
	~~F~~									
	~~G~~									
	~~H~~									
6	A	16	0.02594	0.03251			9	0.02686	5.65	0.628
	B	17	0.02982	0.03661			10	0.03101	5.60	0.560
	C	18	0.03104	0.03672			8	0.03173	4.99	0.624
	D	19	0.02586	0.03424			8	0.02707	7.14	0.893
	E	20	0.02688	0.03346			8	0.02822	5.24	0.655
	~~F~~									
	~~G~~									
	~~H~~									
	Initials		thd	thd			[illegible]	[illegible]	[illegible]	[illegible] 10/14
	Date		9/23/13	9/24/13			09/23	10/14	10/14	

E = Original number of organisms at test initiation, adjusted for losses.

Observations: ① PANS ASHED BEFORE WT. 09/23 [illegible]

A - PAN ASH WT. D AVE DRY OF SURV. CON ORG.
B PAN + SURV. ORG. E PAN + SURV ORG AFTER ASHING
C TOTAL DRY WT F ASH FREE DRY WT TOTAL (B-E x 1000)

BasicWT.wk3

① 6.72
② 6.67 } ER 10/16

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	~~(B-A)*1000=C dry weight of (mg)~~	# of surviving org.	E WT OF BOAT & ORG ASH (g)	F AFDW TOTAL (mg)	G AFDW AVE MG
7	A	21	0.02845	0.03458		8	0.02944	5.14	0.643
	B	22	0.02785	0.03502		9	0.02914	5.88	0.653
	C	23	0.02664	0.03265		8	0.02773	4.92	0.615
	D	24	0.02420	0.03254		7	0.02663	6.91	0.987
	E	25	0.02444	0.03234		9	0.02597	6.37 ⑤	~~0.707~~
	~~F~~								
	~~G~~								
	~~H~~								
9	A	26	0.02364	0.03171		10	~~0.02597~~ ②	6.80	0.680
	B	27	0.02702	0.03463		9	~~0.02491~~ ③	6.36	0.707
	C	28	0.02814	0.03579		9	~~0.02827~~ ④	6.38	0.709
	D	29	0.02477	0.03304		9	0.02628	6.76	0.751
	E	30	0.02465	0.03068		8	0.02575	4.93	0.616
	~~F~~								
	~~G~~								
	~~H~~								
11	A	31	0.02496	0.03365		9	0.02670	6.95	0.772
	B	32	0.02407	0.03139		8	0.02535	6.04	0.756
	C	33	~~0.02432~~ ①	0.03318		10	0.02805	5.13	0.513
	D	34	0.02442	0.03163		9	0.02570	5.93	0.659
	E	35	0.02440	0.03302		9	0.02610	6.92	0.769
	~~F~~								
	~~G~~								
	~~H~~								
12	A	36	0.02429	0.03391		10	0.02603	7.88	0.788
	B	37	0.02866	0.03702		8	0.03010	6.92	0.865
	C	38	0.02789	0.03609		10	0.02937	6.72	0.672
	D	39	0.02485	0.03273		8	0.02609	6.64	0.830
	E	40	0.02409	0.03128		9	0.02531	5.97	0.663
	~~F~~								
	~~G~~								
	~~H~~								
	Initials		thd	[illegible]		[illegible]	[illegible]	[illegible]	
	Date		9/23/13	09/24		09/23	10/14	10/14	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

⑤ 0.708 EL 10/14

① 0.02659 thd 9/23/13
② ~~0.024~~ 0.02491
③ 0.02827
④ 0.02941

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	~~(B-A)*1000=C dry weight of organisms (mg)~~	# of surviving org.	E WT OF BOAT & ORG. ASH (g)	F AFDW TOTAL (mg)	G AFDW AVE mg
13	A	41	0.03046	0.03993		9	0.03231	7.62	0.847
	B	42	0.02961	0.03718		8	0.03114	6.04	0.755
	C	43	0.03009	0.03668		9	0.03109	5.59	0.621
	D	44	0.02819	0.03560		9	0.02931	6.29	0.699
	E	45	0.02707	0.03362		9	0.02811	5.51	0.612
	~~F~~								
	~~G~~								
	~~H~~								
14	A	46	0.02367	0.03048		9	0.02482	5.66	0.629
	B	47	0.03121	0.03949		10	0.03262	6.87	0.687
	C	48	0.03298	0.04088		10	0.03420	6.68	0.668
	D	49	0.02883	0.03467		8	0.02985	4.82	0.603
	E	50	0.02943	0.03784		9	0.03080	6.54	0.727
	~~F~~								
	~~G~~								
	~~H~~								
15	A	51	0.02935	0.03520		9	0.03016	5.04	0.560
	B	52	0.03067	0.03639		9	0.03131	4.08	0.453
	C	53	0.03100	0.03590		9	0.03171	4.25	0.472
	D	54	0.02958	0.03464		9	0.03015	4.49	0.499
	E	55	0.02968	0.03498		10	0.03030	4.68	0.468
	~~F~~								
	~~G~~								
	~~H~~								
16	A	56	0.02600	0.03295		8	0.02682	6.13	0.766
	B	57	0.03376	0.04022		9	0.03466	5.56	0.618
	C	58	0.03195	0.03842		10	0.03278	5.64	0.564
	D	59	0.02877	0.03665		9	0.02984	6.81	0.757
	E	60	0.02849	0.03532		9	0.02937	5.95	0.661
	~~F~~								
	~~G~~								
	~~H~~								
	Initials		thd	[illegible]		[illegible]	[illegible]	[illegible]	
	Date		9/23/13	09/24		09/23	10/4	10/4	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C ~~dry weight of organisms (mg)~~	# of surviving org.	E Wt of Boat & ORG ASH g)	F AFDW TOTAL (mg)	G AFDW AVE MG
17	A	61	0.02775	0.03522		9	0.02857	6.65	0.739
	B	62	0.02428	0.03204		9	0.02535	6.69	0.743
	C	63	0.02774	0.03362		8	0.02828	5.34	0.668
	D	64	0.02292	~~0.03367~~ ①		10	0.02387	6.80	0.680
	E	65	0.02511	0.03413		10	0.02624	7.89	0.789
	~~F~~								
	~~G~~								
	~~H~~			②					
18	A	66	0.02404	~~0.03413~~		8	0.02489	6.18	0.773
	B	67	0.02849	0.03436		9	0.02920	5.16	0.573
	C	68	0.02762	0.03362		8	0.02815	5.37	0.671
	D	69	0.02756	0.03524		9	0.02836	6.88	0.764
	E	70	0.02470	0.03158		10	0.02540	6.18	0.618
	F								
	G								
	H								
19	A	71	0.02552	0.03329		8	0.02703	6.26	0.783
	B	72	0.02323	0.03127		8	0.02442	6.85	0.856
	C	73	0.02638	0.03605		10	0.02781	8.24	0.824
	D	74	0.02535	0.03257		8	0.02634	6.23	0.779
	E	75	0.02463	0.03224		9	0.02565	6.59	0.732
	F								
	G								
	H								
22	A	76	0.02252	0.02923		8	0.02499	4.24	0.530
	B	77	0.02888	0.03438		8	0.02978	4.60	0.575
	C	78	0.02741	0.03238		9	0.02811	4.27	0.474
	D	79	0.02552	0.03234		9	0.02626	5.66	0.629
	E	80	0.02620	0.03072		9	0.02673	3.99	0.443
	F								
	G								
	H								
	Initials		thd	[illegible]			[illegible] 10/14	[illegible] 10/14	[illegible] 10/14
	Date		9/23/13	09/24					

E = Original number of organisms at test initiation, adjusted for losses.

Observations: ① 0.03067 → 09/24 [illegible]
② 0.03107 [illegible]

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: C. ~~tentans~~ dilutus

Beginning Date & Time: 9/13/13 1900
Ending Date & Time: 09-23-13 1800
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	~~(B-A)*1000=C dry weight of organisms (mg)~~	# of surviving org.	E WT OF BOAT + ORG ASH g)	F AFDW TOTAL (mg)	G AFDW AVE MG
25	A	81	0.02621	0.03314		10	0.02733	5.81	0.581
	B	82	0.02690	0.03116		8	0.02743	3.73	0.466
	C	83	0.02846	0.03418		9	0.02989	4.29	0.477
	D	84	0.02702	0.03166		8	0.02765	4.01	0.501
	E	85	0.02610	0.03143		9	0.02672	4.71	0.523
	~~F~~								
	~~G~~								
	~~H~~								
	A								
	B								
	C								
	D								
	E								
	F								
	G								
	H								
	A								
	B								
	C								
	D								
	E								
	F								
	G								
	H								
	A								
	B								
	C								
	D								
	E								
	F								
	G								
	H								
	Initials		thd						
	Date		9/23/13	09/24			10/14		

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Job Number: 48-22-01
Species: C. ~~tentans~~ dilutus

Start Date & Time: 9-13-13 1900
End Date & Time: 09-23-13 1800

Sediment Test

American Aquatic Testing, Inc.,

Water Change Log/Initial Water Readings/General Testing Information

Test Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Morning change(time)	8:30	0930	7:30	1015	0700	1800	7:30	1030	1040	1000	7:30				
D.O. mg/L	8.3	8.4	8.3	8.4	8.3	8.6	8.5	8.4	8.4	8.4	8.3				
pH	8.0	8.0	8.0	8.0	8.1	7.9	8.0	8.0	7.9	7.9	8.0				
Temp. (C)	23.5	23.0	22.5	22.0	22.5	22.0	22.5	22.0	22.5	23.0	22.5				
Initials	SH	SH	TAP	[illegible]	[illegible]	[illegible]	thd	[illegible]	mp	mp	thd				
Date	9/13	9/14	9/15	09/16	09/17	09/18	9/19	09/20	9/21	9/22	9/23				
Afternoon change(time)	1845	1925	1745	1900	1900	1630	1700	1900	1630	1700					
D.O. mg/L	8.4	8.4	8.4	7.9	8.3	8.5	8.4	8.5	8.3	8.3					
pH	8.0	7.9	8.0	8.2	8.1	7.8	8.1	8.1	8.0	8.0					
Temp. (C)	23.5	23.0	23.0	22.5	22.5	22.0	22.0	22.0	22.5	22.0					
Initials	SH	TAP	thd	[illegible]	[illegible]	mp	[illegible]	[illegible]	mp	mp					
Date	9/13	9/14	9/15	09/16	09/17	9/18	09/19	09/20	9/21	9/22					

Test Day	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Morning change(time)														
D.O. mg/L														
pH														
Temp. (C)														
Initials														
Date														
Afternoon change(time)														
D.O. mg/L														
pH														
Temp. (C)														
Initials														
Date														

Control Sed. collection date/by: 9/3/13 TAP

Control Sed. sieve date/by: 9/4/13 TAP

Sieve size used: 1mm

Sample sieve date/by: 9/3/13 / CSN, SH, TD

Sieve size used: 1mm

Organism source: ABS

Test organism Lot number: 1432

Number of animals per chamber: 10

Food Type: flake

Frequency of feeding: everyday

Test Chamber size: 300ml

Test Volume of sediment: 100ml

Test Volume of water: 150ml

Test Duration: 10 days

Test Temperature Range: 23±1°C

Client/Toxicant: 48
Job Number: 22-01
Species: C. tentans

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	Control	23.5	23.0	22.5	22.5	23.0	22.5	22.5	22.0	23.0	23.0	23.0
	2	23.5	23.0	22.5	22.5	23.0	22.5	22.5	22.0	23.0	23.0	23.0
	5	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	6	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	7	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	9	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	11	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	12	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	13	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	14	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	15	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
Dissolved Oxygen (mg/L)	Control	6.0	5.4	5.4	5.2	4.9	4.8	5.3	5.4	5.2	6.0	6.6
	2	6.0	6.5	5.7	5.6	5.3	5.4	5.0	4.9	5.5	6.1	6.6
	5	4.3	5.0	4.1	5.6	4.3	4.7	5.0	4.8	4.0	5.6	5.8
	6	4.7	4.5	4.2	5.6	4.5	5.4	5.1	5.2	4.2	5.3	6.0
	7	4.4	5.2	4.7	5.6	4.6	5.0	4.1	4.7	4.2	4.9	6.1
	9	4.3	4.7	3.6	5.6	4.9	4.6	4.5	5.1	4.4	5.3	6.0
	11	4.7	5.4	4.5	5.9	4.9	4.8	5.1	6.0	5.0	4.9	6.3
	12	5.5	5.5	4.4	5.7	5.2	4.9	5.3	5.0	5.0	5.3	6.4
	13	5.3	5.2	5.0	5.9	4.7	5.1	5.6	4.7	5.4	5.8	6.6
	14	5.6	5.5	5.1	5.6	4.5	4.7	5.1	5.0	5.0	5.3	6.5
	15	6.2	6.6	5.9	5.9	5.6	6.2	5.4	4.6	5.7	5.9	6.9
pH	Control	7.1	7.3	7.3	7.6	7.6	7.0	7.6	7.5	7.2	7.2	7.3
	2	7.0	7.3	7.3	7.6	7.3	6.9	7.4	7.5	7.2	7.2	7.2
	5	6.8	7.2	7.1	7.7	7.3	6.9	7.3	7.5	7.1	7.3	7.2
	6	6.8	7.1	7.1	7.6	7.3	6.8	7.4	7.4	7.1	7.3	7.2
	7	6.8	7.1	7.1	7.6	7.3	6.9	7.5	7.3	7.0	7.3	7.1
	9	6.8	7.1	7.0	7.6	7.3	6.9	7.4	7.4	7.0	7.3	7.2
	11	6.8	7.1	7.0	7.6	7.3	6.8	7.5	7.5	7.0	7.3	7.1
	12	6.9	7.1	7.0	7.7	7.3	6.8	7.4	7.3	6.9	7.2	7.1
	13	6.8	7.1	7.0	7.7	7.3	6.8	7.4	7.4	6.9	7.3	7.1
	14	6.9	7.0	7.0	7.7	7.3	6.9	7.4	7.4	6.9	7.3	7.1
	15	6.8	7.1	7.0	7.7	7.3	6.9	7.4	7.4	7.0	7.2	7.1
	Initials	SH	SH	thd	[illegible]	[illegible]	MP	[illegible]	[illegible]	MP	MP	thd
	Date	9/13	9/14	9/15	09/16	09/17	9/18	09/18	09/20	9/21	9/22	9/23

Concentration	Cond. (umhos) Initial	Final	Alkalinity (mg/L) Initial	Final	Hardness (mg/L) Initial	Final	Ammonia (mg/L) Initial	Final
Control	291	287	50	90	80	100	0.45	0.01
2	254	266	50	70	70	90	1.26	0.06
5	263	262	50	60	70	80	0.30	0.23
6	259	264	50	40	80	80	0.31	0.09
7	258	268	40	50	80	80	0.35	0.07
9	262	266	40	60	70	80	0.54	0.09
11	258	268	50	60	90	80	0.55	0.05
12	265	270	50	60	80	80	0.43	0.06
13	255	274	50	60	80	90	0.78	0.00
14	269	293	40	60	80	80	0.26	0.04
15	256	286	40	60	70	70	0.23	0.04
Initials	SH	thd	thd	[illegible]	TM	[illegible]	[illegible]	[illegible]
Date	9/13	9/23	9/13	09/23	9/13	09/23	09/13	09/23

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48-~~22-01~~
Job Number: 22-01
Species: C. tentans.

Beginning Date & Time: 9-13-13 1900
Ending Date & Time: 09-23-13 1800

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	16	23.5	23.0	22.5	22.5	23.0	22.5	22.0	22.0	23.0	23.0	23.0
	17	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	18	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	19	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	22	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	25	23.5	23.0	22.5	22.5	22.5	22.5	22.0	22.0	23.0	23.0	23.0
	-											
	-											
	-											
	-											
	-											
Dissolved Oxygen (mg/L)	16	6.4	5.9	5.7	5.9	5.9	6.1	6.1	5.8	5.7	6.0	7.2
	17	6.3	6.4	5.2	5.9	4.9	6.1	6.3	5.9	5.6	6.4	6.4
	18	6.4	6.4	4.6	5.9	5.2	5.8	6.0	6.0	5.5	5.9	7.0
	19	6.4	6.6	5.4	5.7	5.7	6.8	6.8	6.0	5.5	5.8	6.6
	22	7.5	6.5	6.4	5.9	6.3	6.5	6.5	6.1	6.3	6.9	7.2
	25	7.6	7.0	6.5	6.2	6.5	6.9	7.0	6.3	6.6	7.2	7.6
	-											
	-											
	-											
	-											
	-											
pH	16	6.8	7.0	7.0	7.7	7.3	6.9	7.4	7.4	7.0	7.3	7.1
	17	6.9	7.1	7.0	7.7	7.2	7.0	7.4	7.5	7.0	7.2	7.2
	18	6.7	7.0	6.9	7.7	7.2	6.9	7.4	7.3	7.0	7.3	7.1
	19	6.8	7.0	6.9	7.6	7.3	6.9	7.3	7.4	6.9	7.2	7.2
	22	6.8	7.0	6.9	7.6	7.3	7.0	7.3	7.5	6.9	7.2	7.2
	25	6.8	7.0	7.0	7.7	7.3	7.0	7.3	7.5	7.0	7.2	7.3
	-											
	-											
	-											
	-											
	-											
	Initials	SH	SH	thd	[illegible]	[illegible]	mp	[illegible]	[illegible]	mp	mp	thd
	Date	9/13	9/14	9/15	09/16	09/17	9/18	09/18	09/20	9/21	9/22	9/23

Concentration	Cond. (umhos) Initial	Final	Alkalinity (mg/L) Initial	Final	Hardness (mg/L) Initial	Final	Ammonia (mg/L) Initial	Final
16	267	292	40	70	70	90	0.60	0.04
17	253	285	40	60	70	90	0.33	0.18
18	239	288	40	60	70	80	0.84	0.22
19	245	288	40	60	70	70	0.13	0.17
22	240	287	30	50	60	80	0.04	0.03
25	234	292	30	60	60	80	0.21	0.05
-								
-								
-								
-								
-								
Initials	SH	thd	TMD		TMD	[illegible]	[illegible]	[illegible]
Date	9/13	9/23	9/13		9/13	09/23	09/13	09/23

Comments:

FWSEDPAR.wk3

APPENDIX B

STATISTICAL DATA FOR *Chironomus dilutus*

10 DAY SEDIMENT TOXICITY TEST

Chironomid Survival, Growth Test Survival

Start Date:	9/13/2013	Test ID:	482201cd	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C. dilutus
Comments:					

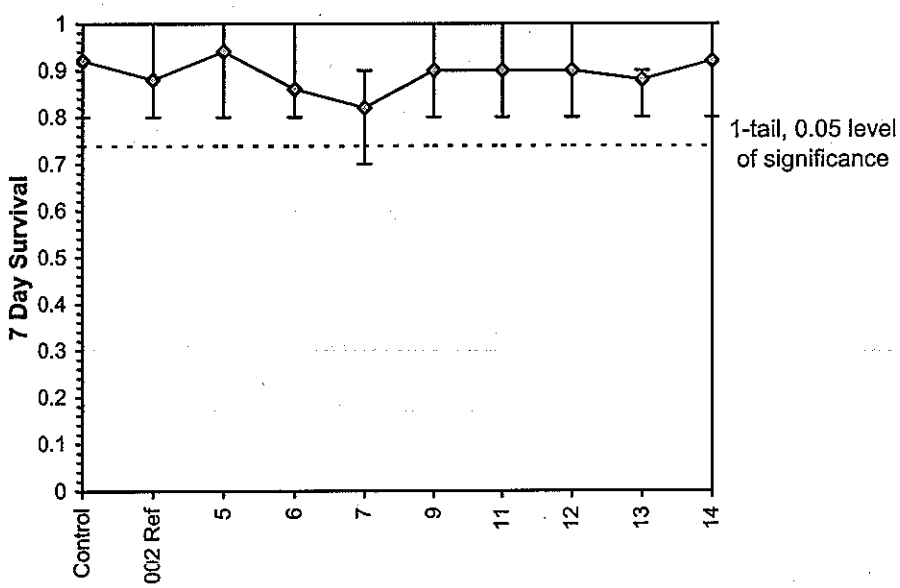
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	0.8000	1.0000
002 Ref	0.9000	0.9000	0.8000	1.0000	0.8000
5	1.0000	0.9000	0.8000	1.0000	1.0000
6	0.9000	1.0000	0.8000	0.8000	0.8000
7	0.8000	0.9000	0.8000	0.7000	0.9000
9	1.0000	0.9000	0.9000	0.9000	0.8000
11	0.9000	0.8000	1.0000	0.9000	0.9000
12	1.0000	0.8000	1.0000	0.8000	0.9000
13	0.9000	0.8000	0.9000	0.9000	0.9000
14	0.9000	1.0000	1.0000	0.8000	0.9000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5			
002 Ref	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	*		
5	0.9400	1.0682	1.3184	1.1071	1.4120	10.436	5	-1.220	2.480	0.1903
6	0.8600	0.9773	1.1965	1.1071	1.4120	11.303	5	0.370	2.480	0.1903
7	0.8200	0.9318	1.1407	0.9912	1.2490	9.612	5	1.097	2.480	0.1903
9	0.9000	1.0227	1.2533	1.1071	1.4120	8.613	5	-0.370	2.480	0.1903
11	0.9000	1.0227	1.2533	1.1071	1.4120	8.613	5	-0.370	2.480	0.1903
12	0.9000	1.0227	1.2575	1.1071	1.4120	12.128	5	-0.425	2.480	0.1903
13	0.8800	1.0000	1.2207	1.1071	1.2490	5.199	5	0.055	2.480	0.1903
14	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5	-0.795	2.480	0.1903

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96077	0.926	0.042	-0.8732
Bartlett's Test indicates equal variances (p = 0.93)	3.05021	20.0902		
The control means are not significantly different (p = 0.47)	0.75516	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.14601	0.16498	0.01329	0.01471	0.52463	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by: _____

Chironomid Survival, Growth Test Survival

Start Date:	9/13/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C. dilutus
Comments:					

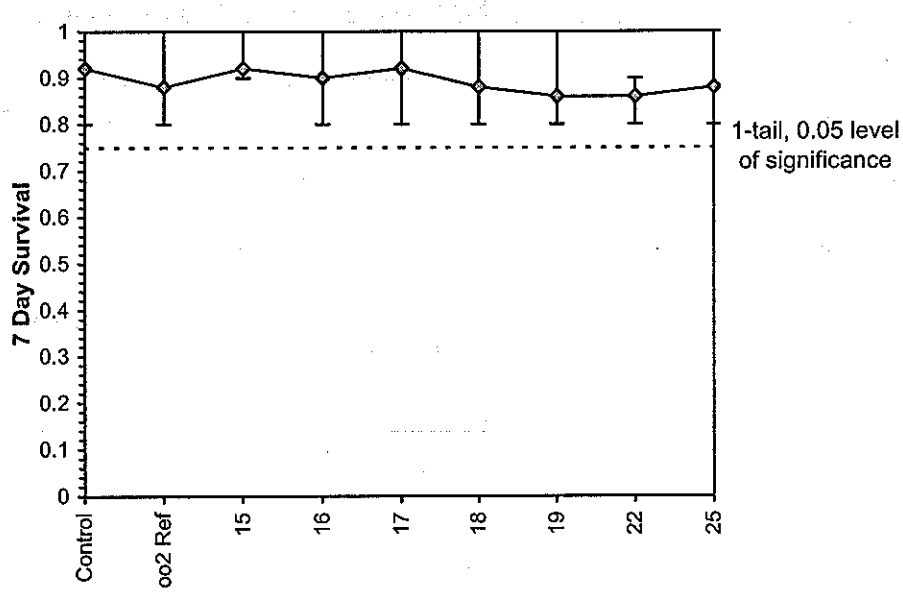
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	0.8000	1.0000
oo2 Ref	0.9000	0.9000	0.8000	1.0000	0.8000
15	0.9000	0.9000	0.9000	0.9000	1.0000
16	0.8000	0.9000	1.0000	0.9000	0.9000
17	0.9000	0.9000	0.8000	1.0000	1.0000
18	0.8000	0.9000	0.8000	0.9000	1.0000
19	0.8000	0.8000	1.0000	0.8000	0.9000
22	0.8000	0.8000	0.9000	0.9000	0.9000
25	1.0000	0.8000	0.9000	0.8000	0.9000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5			
oo2 Ref	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	*		
15	0.9200	1.0455	1.2816	1.2490	1.4120	5.687	5	-0.780	2.443	0.1777
16	0.9000	1.0227	1.2533	1.1071	1.4120	8.613	5	-0.390	2.443	0.1777
17	0.9200	1.0455	1.2859	1.1071	1.4120	10.026	5	-0.838	2.443	0.1777
18	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	0.000	2.443	0.1777
19	0.8600	0.9773	1.1965	1.1071	1.4120	11.303	5	0.390	2.443	0.1777
22	0.8600	0.9773	1.1923	1.1071	1.2490	6.519	5	0.448	2.443	0.1777
25	0.8800	1.0000	1.2249	1.1071	1.4120	10.319	5	0.000	2.443	0.1777

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.93983	0.919	0.44029	-0.6464
Bartlett's Test indicates equal variances (p = 0.92)	2.58194	18.4753		
The control means are not significantly different (p = 0.47)	0.75516	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	>25		4	0.13504	0.15258	0.00622	0.01323	0.84888	7, 32
Treatments vs oo2 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by: _____

Chironomid Survival, Growth Test Growth

Start Date:	9/13/2013	Test ID:	482201cd	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C dilutus
Comments:					

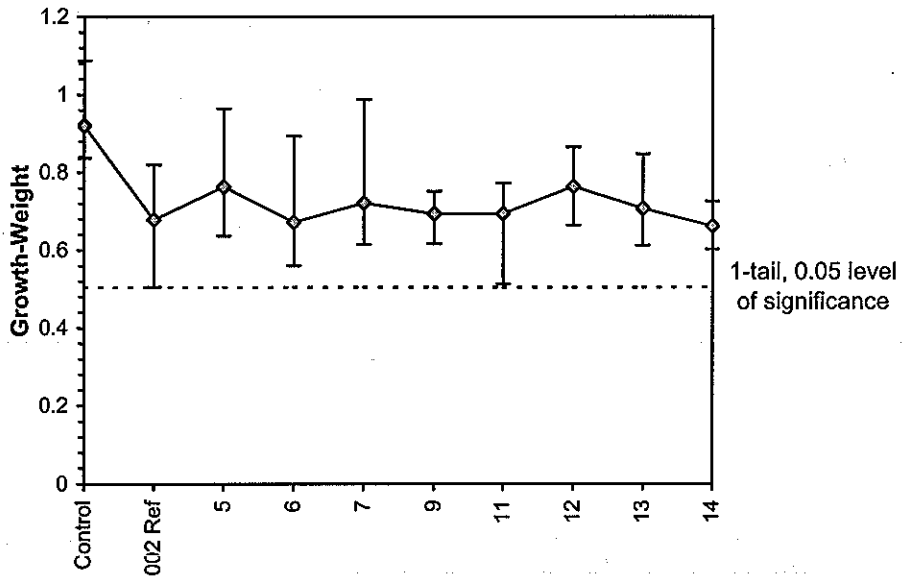
Conc-%	1	2	3	4	5
Control	0.8880	0.8378	0.8533	1.0875	0.9390
002 Ref	0.7000	0.6800	0.6863	0.5050	0.8200
5	0.6370	0.8922	0.9638	0.6500	0.6720
6	0.6278	0.5600	0.6238	0.8925	0.6550
7	0.6425	0.6533	0.6150	0.9871	0.7078
9	0.6800	0.7067	0.7089	0.7511	0.6163
11	0.7722	0.7550	0.5130	0.6589	0.7689
12	0.7880	0.8650	0.6720	0.8300	0.6633
13	0.8467	0.7550	0.6211	0.6989	0.6122
14	0.6289	0.6860	0.6680	0.6025	0.7267

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9211	1.3581	0.9211	0.8378	1.0875	10.943	5			
002 Ref	0.6783	1.0000	0.6783	0.5050	0.8200	16.591	5	*		
5	0.7630	1.1249	0.7630	0.6370	0.9638	20.083	5	-1.207	2.480	0.1742
6	0.6718	0.9905	0.6718	0.5600	0.8925	19.082	5	0.092	2.480	0.1742
7	0.7212	1.0633	0.7212	0.6150	0.9871	21.142	5	-0.611	2.480	0.1742
9	0.6926	1.0211	0.6926	0.6163	0.7511	7.174	5	-0.204	2.480	0.1742
11	0.6936	1.0226	0.6936	0.5130	0.7722	16.029	5	-0.219	2.480	0.1742
12	0.7637	1.1259	0.7637	0.6633	0.8650	12.025	5	-1.216	2.480	0.1742
13	0.7068	1.0421	0.7068	0.6122	0.8467	13.833	5	-0.406	2.480	0.1742
14	0.6624	0.9766	0.6624	0.6025	0.7267	7.330	5	0.226	2.480	0.1742

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96476	0.926	0.60124	0.22939
Bartlett's Test indicates equal variances (p = 0.39)	8.43951	20.0902		
The control means are significantly different (p = 7.03E-03)	3.59488	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.17419	0.25682	0.00686	0.01233	0.80597	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

Chironomid Survival, Growth Test-Growth

Start Date:	9/13/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	9/23/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	C dilutus
Comments:					

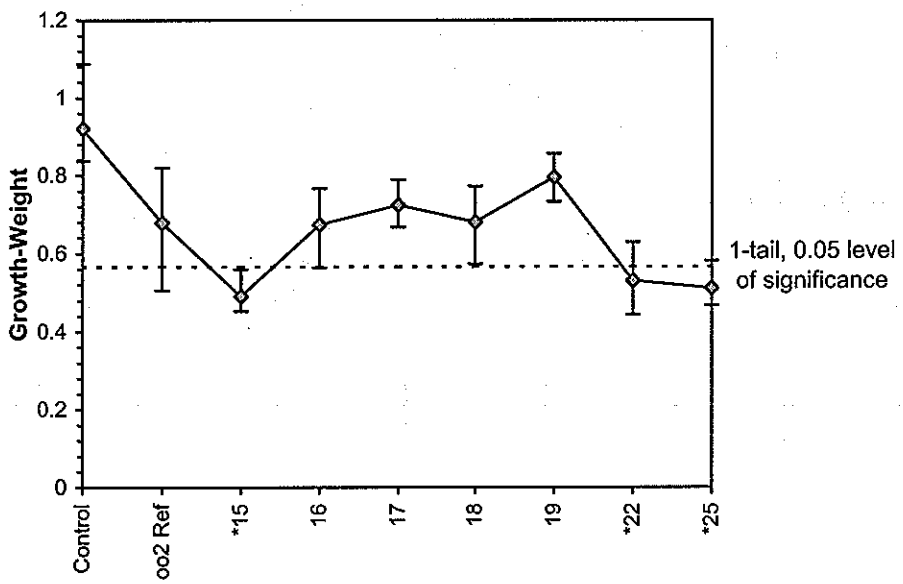
Conc-%	1	2	3	4	5
Control	0.8880	0.8378	0.8533	1.0875	0.9390
oo2 Ref	0.7000	0.6800	0.6863	0.5050	0.8200
15	0.5600	0.4533	0.4722	0.4989	0.4680
16	0.7663	0.6178	0.5640	0.7567	0.6611
17	0.7389	0.7433	0.6675	0.6800	0.7890
18	0.7725	0.5733	0.6713	0.7644	0.6180
19	0.7825	0.8563	0.8240	0.7788	0.7322
22	0.5300	0.5750	0.4744	0.6289	0.4433
25	0.5810	0.4663	0.4767	0.5013	0.5233

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9211	1.3581	0.9211	0.8378	1.0875	10.943	5			
oo2 Ref	0.6783	1.0000	0.6783	0.5050	0.8200	16.591	5	*		
*15	0.4905	0.7232	0.4905	0.4533	0.5600	8.603	5	4.083	2.443	0.1123
16	0.6732	0.9925	0.6732	0.5640	0.7663	13.029	5	0.111	2.443	0.1123
17	0.7237	1.0671	0.7237	0.6675	0.7890	6.891	5	-0.989	2.443	0.1123
18	0.6799	1.0024	0.6799	0.5733	0.7725	12.945	5	-0.036	2.443	0.1123
19	0.7947	1.1718	0.7947	0.7322	0.8563	5.953	5	-2.533	2.443	0.1123
*22	0.5303	0.7819	0.5303	0.4433	0.6289	14.111	5	3.217	2.443	0.1123
*25	0.5097	0.7515	0.5097	0.4663	0.5810	8.948	5	3.666	2.443	0.1123

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.98452	0.919	-0.1619	0.14506
Bartlett's Test indicates equal variances (p = 0.42)	7.11405	18.4753		
The control means are significantly different (p = 7.03E-03)	3.59488	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<15	15			0.11231	0.16559	0.06163	0.00529	2.9E-07	7, 32
Treatments vs oo2 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

APPENDIX C

CHAIN OF CUSTODY DOCUMENTATION

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131004	TOX-FS13-SED-002	TOX-SED-002	Chironomus and Hyalella Tox Tests	Sediment	7/29/2013	15:20	1	2.5 gallon bucket	4 C	N
131005	TOX-FS13-SED-005	TOX-SED-005	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:30	1	2.5 gallon bucket	4 C	N
131006	TOX-FS13-SED-006	TOX-SED-006	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:50	1	2.5 gallon bucket	4 C	N
131007	TOX-FS13-SED-007	TOX-SED-007	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:57	1	2.5 gallon bucket	4 C	N
131008	TOX-FS13-SED-009	TOX-SED-009	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:10	1	2.5 gallon bucket	4 C	N
131009	TOX-FS13-SED-011	TOX-SED-011	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:45	1	2.5 gallon bucket	4 C	N
131010	TOX-FS13-SED-012	TOX-SED-012	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:55	1	2.5 gallon bucket	4 C	N
131011	TOX-FS13-SED-013	TOX-SED-013	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:05	1	2.5 gallon bucket	4 C	N
131012	TOX-FS13-SED-014	TOX-SED-014	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:20	1	2.5 gallon bucket	4 C	N
131013	TOX-FS13-SED-015	TOX-SED-015	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:00	1	2.5 gallon bucket	4 C	N
131014	TOX-FS13-SED-016	TOX-SED-016	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:05	1	2.5 gallon bucket	4 C	N

Special Instructions: ~~Wash~~

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analyses	[signature]	8/29/13	[signature]	8/29/13					[signature]	8/29/13	1500

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131015	TOX-FS13-SED-017	TOX-SED-017	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:15	1	2.5 gallon bucket	4 C	N
131016	TOX-FS13-SED-018	TOX-SED-018	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:10	1	2.5 gallon bucket	4 C	N
131017	TOX-FS13-SED-019	TOX-SED-019	Chironomus and Hyalella Tox Tests	Sediment	7/30/2020	16:55	1	2.5 gallon bucket	4 C	N
131018	TOX-FS13-SED-022	TOX-SED-022	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	08:40	1	2.5 gallon bucket	4 C	N
131019	TOX-FS13-SED-025	TOX-SED-025	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	09:25	1	2.5 gallon bucket	4 C	N

Special Instructions:

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analysis	[illegible]	8/29/13	Diane Higgins	8/29/13			Diane Higgins	8/29	Wendy Mangum	8/29/13	1500

REPORT CERTIFICATION

The following report titled "LOCKHEED MARTIN SERAS SEDIMENT TOXICITY TESTING – *Hyalella azteca*" is an accurate and truthful representation of the toxicity testing which was performed by American Aquatic Testing, Inc., located at 890 North Graham Street Allentown, Pennsylvania. We further certify that we have personally examined and are familiar with the information submitted in this document and based on our inquiry of those individuals immediately responsible for obtaining the information; we believe the submitted information is complete as presented. We are aware that there are significant penalties for submitting false information.

Christopher J. Nally
President, Laboratory Director

Tarmo Pallop
Vice-President, Laboratory Manager

LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING–*Hyalella azteca*

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B. Statistical data for *Hyalella azteca* 28-Day survival and growth test

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LOCKHEED MARTIN SERAS
SEDIMENT TOXICITY TESTING–*Hyalella azteca*

INTRODUCTION

During the month of August 2013, samples of sediment were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. These sediment samples were used to perform toxicity tests to determine if the tested matrices represent a significant threat to potential receptor organisms.

The sediment samples from the site were delivered to American Aquatic Testing, Inc. (AAT) and evaluated for toxicity using a 28-day solid phase exposure using the freshwater invertebrate *Hyalella azteca* [1]. Following the exposure period, surviving test organisms from the sediments collected at the site were compared to the off-site reference sediment (location 02) tested under similar conditions. The endpoints used for determination of an impact in the amphipod exposures were mortality, measured as mean survival, and growth, measured as biomass (combined dry weight of surviving test organisms divided by the original number of test organisms exposed).

MATERIALS AND METHODS

Surface sediment samples were collected from locations in the Maurice River immediately upstream and downstream from the Vineland Chemical Site. Station locations were selected to represent areas that may have been impacted by the facility's operations.

Preparation of sediment samples for testing

Samples were collected into 2.5-gallon high-density polyethylene (HDPE) containers and placed on ice after collection. Sediment samples were picked up by AAT personnel on August 24, 2013 and transported on ice. Upon arrival at AAT, the samples were refrigerated until being used for testing on September 6, 2013. These samples were physically screened using a #18 mesh screen to remove large debris and indigenous organisms on September 3, 2013.

Control sediment used to assess the health of the test organisms used for testing was collected from the Spruce Run Reservoir in Clinton, NJ on September 3, 2013 and was screened using a #18 mesh screen to remove large debris and indigenous organisms on September 4, 2013. Screened sediment was placed in a five gallon HDPE container and refrigerated until used for testing on September 6, 2013.

Test organisms

Study amphipods (*Hyalella azteca*) were obtained from stock cultures maintained by ABS, Inc. of Fort Collins, CO several days before testing was to begin to allow for a sufficient acclimation to the laboratory reconstituted fresh water which was used as the overlying water for the exposures. During this time, the organisms were held under conditions similar to that which they would encounter during the test (see Table II). Once daily the amphipods were fed a combination of yeast, cereal leaves and digested trout pellets [2]. At the beginning of the 28-day exposure, the test organisms were 10-14 days old.

A reference toxicant test using potassium chloride as the toxicant was conducted concurrently with the 28-day exposure to verify the health of the lot of organisms used in the sediment test. The 48 hr LC_{50} of 623.4 ppm falls within the acceptable range of the control chart being maintained by AAT for this test species. A copy of the raw data and the control chart are included with the other raw data for this test in Appendix A.

Experimental procedures

The entire sediment exposure series for this project consisted of 16 sediment samples from the Vineland Chemical Site and one of control sediment provided by AAT. Tox-Sed 002 was collected from an off site reference location. Test chambers (300 mL tall form borosilicate glass beakers) were filled with 100 mL of sediment. 175 mL of test water was poured over the sediment gently to cause minimal disturbance. There were five replicate chambers for each sample treatment. Test chambers were allowed to settle for 24 hours prior to test initiation.

After the settling period, the overlying water was siphoned off and fresh laboratory water was introduced, using a small, round HDPE disk suspended over the sediment to deflect the water flow and minimize disturbance to the sediment. At this time, initial physical chemistries were conducted on the overlying water. Alkalinity, ammonia, conductivity, hardness and pH were measured initially, prior to the introduction of test organisms, and at the end of the 28-day exposure for each sample location and the control. The dissolved oxygen and temperature, and pH were also measured initially and every 24 hours thereafter for the duration of the exposure for each sample location and the control.

The exposure period began by placing 10 randomly selected test organisms into each of five replicate chambers for each sample location and the control. Care was taken to ensure that the organisms were released beneath the surface of the overlying water to keep air bubbles from forcing the organisms to the surface. Each test chamber was then fed 0.5 mL of the YCT mixture previously cited and the test chambers were covered. Test conditions are summarized in Table II.

Each day during the exposure period observations of each chamber were carried out to determine the number of organisms dead, swimming, on the surface of the sediment or on the surface of the water. The overlying water was siphoned off twice a day and replaced using laboratory water as a measure to maintain sufficient dissolved oxygen levels. Care was taken to minimize disturbance of the sediment during water renewal.

At the end of the 28-day exposure the final physical chemistries were performed and the test chambers were prepared for the removal of test organisms. Each chamber was gently stirred using a pipette to suspend the sediment in the water column inside the chamber. This slurry was then poured into a #60 mesh sieve (250 μm) and rinsed in a shallow pan of laboratory water to remove the finer grains of the sediment. The remaining contents of the sieve were placed into a second shallow pan of laboratory water over a light table. The remaining contents of the sieve were carefully sorted to find the surviving test organisms in each of the five replicates for each site. All surviving organisms were transferred to a 30 mL soufflé cup for live count verification and preparation for weight analysis.

When all test chambers had been sorted and the number of survivors verified, 0.5 mL of ethanol was added to each soufflé cup to dispatch the organisms. They were then transferred to a previously dried and tared aluminum pan and placed into an oven to dry at 105° C for six hours. Upon removal from the oven, the pans were placed into a dessicator to cool and then were measured to the nearest 0.01 mg.

Data analysis

Data analysis was performed following procedures published by the USEPA [1] using the using the ToxCalc data analysis software published by Tidepool Scientific, Inc., version 5.0.23. Survival data was transformed by arcsine squareroot and then tested for normality using the Shapiro-Wilk's test or the Chi-Square test and for homogeneity of variance using Bartlett's test as appropriate. Normal data distributions were analyzed using Analysis of Variance followed by Dunnett's comparison of means test. Non-normal data or those data sets exhibiting non-homogeneous variances were analyzed using Steel's Many-one Rank test of Wilcoxon Rank Sum as appropriate.

All raw data sheets are located in Appendix A

TABLE I: Summary of Conditions for *Hyalella azteca* Toxicity Test

1.	Test type;	Whole sediment, static, daily renewal
2.	Temperature;	23.0 +/- 1.0° C
3.	Light quality;	Wide-spectrum fluorescent illumination
4.	Light intensity;	50 - 100 foot-candles
5.	Photoperiod;	16 hours light, 08 hours dark
6.	Test chamber size;	300 mL high form borosilicate glass beakers
7.	Sediment volume;	100 mL / replicate
8.	Overlying water volume;	175 mL
9.	Renewal;	2 volume exchanges per day
10.	Age of test organisms;	10 to 14 days
11.	Number organisms / container;	10
12.	Replicates;	05
13.	Feeding;	Yeast, cereal leaves and trout pellets with *Selenastrum capricornutum,* 0.5 mL / day
14.	Aeration;	None unless dissolved oxygen concentrations $\leq$ 40 % saturation, then ~ 100 bubbles / min.
15.	Overlying water;	EPA moderately hard reconstituted water
16.	Test chamber cleaning;	Only if necessary
17.	Overlying water quality;	D. O., pH and temperature daily; alkalinity, ammonia, conductivity and hardness at beginning and end of test
18.	Test duration;	28 days
19.	Effects measured;	Survival and growth (mean dry weight)
20.	Test acceptability;	Minimum control survival 80 %

RESULTS

Effects on survival @ 28 Days using reference sample TOX-SED-002

Raw data are presented in Appendix A. Data were arcsine squareroot transformed. The data were found to be normal in distribution, were tested for homogeneity and found to be homogeneous. It was therefore determined that parametric analyses were appropriate and ANOVA followed by Dunnett's pairwise comparisons were used to determine differences between the survival of organisms in all samples and the control sample.

Results from the analysis, which compared survival in station sediments with survival of organisms exposed to the reference sample (reference sample and control sample were not statistically different), are presented in Table II and in Appendix B.

Of the 15 samples from the study area evaluated, only Tox-Sed 015, 018 and 025 exhibited mortality found to be statistically significant when compared to the reference treatment. These samples were not included in the growth analysis.

Table II. Percent survival of *H. azteca* by replicate chamber & survival comparison using reference sample*

	Sample Identification															
Rep.	Tox Sed 002	Tox Sed 005	Tox Sed 006	Tox Sed 007	Tox Sed 009	Tox Sed 011	Tox Sed 012	Tox Sed 013	Tox Sed 014	Tox Sed 015	Tox Sed 016	Tox Sed 017	Tox Sed 018	Tox Sed 019	Tox Sed 022	Tox Sed 025
A	100	100	100	100	100	80	100	100	100	100	70	90	80	90	80	40
B	90	100	100	80	80	80	80	100	80	100	100	70	80	90	100	70
C	90	100	90	100	80	90	100	100	90	30	70	70	30	100	80	80
D	100	100	100	90	80	90	100	100	90	50	60	70	70	80	90	90
E	100	100	90	90	90	100	80	100	80	00	100	100	70	90	90	80
Mean % Survival	96	100	96	92	86	88	92	100	88	20	80	80	66	90	88	72
Statistically Different from Reference?		no	no	no	no	no	no	no	no	Yes	no	no	Yes	no	no	Yes

* Tox-Sed 002 is off-site reference sediment used for evaluation.

Effects on growth @ 28 Days using reference sample TOX-SED-002

Raw data are presented in Appendix A. Data were data were found to be normal in distribution, were tested for homogeneity and found to be homogeneous. It was therefore determined that parametric analyses were appropriate and ANOVA followed by Dunnett's pairwise comparisons were used to determine differences between the survival of organisms in all samples and the control sample.

Results from the analysis, which compared the biomass, the total weight of surviving test organisms divided by the original number of test organisms in each chamber, in all samples with those of organisms exposed to the reference sample. Data are presented in Table III and Appendix B.

Of the 12 samples evaluated for growth, the samples identified as Tox-Sed 006, Tox-Sed 016 and Tox-Sed 017 all exhibited growth that was found to be statistically significant when compared to the reference treatment.

Table II. Average dry weight (mg) of *h. azteca* by replicate chamber & survival comparison using reference sample*

	Sample Identification												
Rep.	Tox Sed 002	Tox Sed 005	Tox Sed 006	Tox Sed 007	Tox Sed 009	Tox Sed 011	Tox Sed 012	Tox Sed 013	Tox Sed 014	Tox Sed 016	Tox Sed 017	Tox Sed 019	Tox Sed 022
A	0.199	0.203	0.136	0.114	0.115	0.186	0.181	0.122	0.131	0.084	0.107	0.162	0.168
B	0.117	0.198	0.075	0.099	0.223	0.269	0.218	0.147	0.188	0.083	0.090	0.136	0.133
C	0.113	0.113	0.088	0.096	0.862	0.171	0.172	0.135	0.150	0.100	0.076	0.195	0.105
D	0.139	0.139	0.099	0.089	0.110	0.182	0.182	0.152	0.152	0.077	0.061	0.206	0.099
E	0.164	0.164	0.074	0.118	0.148	0.189	0.189	0.173	0.184	0.081	0.047	0.157	0.061
Ave. Dry Weight	0.146	0.166	0.094	0.103	0.136	0.200	0.178	0.146	0.161	0.085	0.076	0.171	0.113
Statistically Different from Reference?		no	Yes	no	no	no	no	no	no	Yes	Yes	no	no

* Tox-Sed 002 is off-site reference sediment used for evaluation.

REFERENCES

[1] **Ingersoll, C.G., G.A. Burton, T.D. Dawson, F.W. Dwyer, D.S. Ireland, R.A. Hoke, N.E. Kemble, D.R. Mount, T.J. Norberg-King, P.K. Sibley, and L. Stahl** 2000 Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates EPA 600/R-99/064. U.S. Environmental Protection, Office of Science and Development, Duluth, MN

[2] **ToxCalc 5.0,** version v5.0.23I-Net data analysis software published by Tidepool Scientific Software, Inc. McKinleyville, CA

APPENDIX A

RAW DATA FOR *Hyalella azteca* 28-DAY

SURVIVAL AND GROWTH TEST

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
Control	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	W	N	N	1M
	C	N	N	N	N	N	N	N	N	N	N	1M	N	N	1M
	D	N	N	N	N	N	N	N	N	N	N	1M	N	N	1M
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	1M	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	2F
	E	N	N	N	N	N	N	N	N	1F	N	N	N	N	N
5	A	N	N	N	N	N	N	N	N	N	N	1F	N	1M	1M
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	1M	1M	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	1M
6	A	N	N	N	N	N	N	N	N	N	N	1M	N	N	1M
	B	N	N	N	N	N	N	N	N	N	N	1M	N	N	2M
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	1F	N
7	A	N	N	N	N	N	N	N	N	N	N	N	1M	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	1M
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	1M	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Initials		TDP	MMS	MMS	TDP	SH	WD	TDP	TDP	TDP	TDP	BD	BD	BD	BD
Date		9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, ~~B=No Observations~~

Comments: N=No observations F=on sediment surface M=swimming W=on water surface

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
~~Control~~ 9	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
11	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	IM	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	IF	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
12	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	IM	N	IM	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	IF	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	IM	N	N	N	N	N	N
13	A	N	N	N	N	N	N	N	N	N	N	N	N	IM	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	IM	N	N
	D	N	N	N	N	N	N	N	IF	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
14	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	IM
Initials		TRP	MK	MK	TRP	SH	WP	TRP	TRP	TRP	TRP	CB	CB	CB	CB
Date		9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, ~~B=No Observations~~

Comments:

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
~~Control~~ 15	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
16	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	2F	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
17	A	N	N	N	N	N	N	N	N	N	N	N	N	N	1M
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	1F	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	1M	N	N	N	N	N	N	N
18	A	N	N	N	N	N	N	N	N	N	N	N	N	1M	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	1W	N	N	N	N	N	N	1M
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
19	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	1M	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Initials		TRD	MK	[illegible]	TRD	SH	[illegible]	TRD	TRD	TRD	TRD	[illegible]	[illegible]	[illegible]	[illegible]
Date		9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, ~~B=No Observations~~

Comments:

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 0	1	2	3	4	5	6	7	8	9	10	11	12	13
~~Control~~ 22	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	1M	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	2F	N	N	1F	N	N	N
	D	N	N	N	N	N	N	1F	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
25	A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	B	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
\	A														
	B														
	C														
	D														
	E														
Initials		TAP	MMF	MMF	TAP	SH	AP	TAP	TAP	TAP	TAP	GL	GL	GL	GL
Date		9/6	9-7	9-8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18 ①	09/19

Key: D=dead, ~~N=normal activity~~, ~~A=abnormal activity~~, B=~~No Observations~~

Comments: ① 09/18 GL

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
Control	A	1M	N	N	N	N	2F	N	1F	2M	1F	3F	1F	N	N	3F 1M	10
	B	N	1M	N	N	1F	7F	N	N	1F	N	2F	N	1M	N	2F	9
	C	N	N	1M	N	N	1F 2M	N	N	2F	N	1M	1F	N	1F	1M	9
	D	1M	N	N	N	N	5F	N	N	N	N	1F	1M	N	1M	1F	10
	E	N	N	N	N	2F	3F	N	N	N	N	1F	1M	N	1M 2F	2F	10
2	A	2M	1M	N	N	N	N	N	1M	1M	N	3F	1F	1F	N	N	10
	B	N	N	N	N	N	N	N	N	2M	N	1F	N	N	N	N	~~8~~ (1)
	C	N	N	N	N	N	N	N	N	N	1M	N	N	1M	1F	N	9
	D	N	N	N	N	N	N	N	N	1F	N	N	1F	2M	2F	N	10
	E	N	1M	N	N	N	N	N	N	N	N	2F	N	2M	1F	N	10
5	A	1F	1M	N	N	N	3M	N	N	N	N	3M	N	2M	1F	N	10
	B	N	N	N	N	N	2F 1M	N	N	N	N	2F	N	2M	1F 3M	N	10
	C	2M	N	N	N	1M	N	N	1F	3M	1F	1M	2M	1F	2F	1M	10
	D	N	N	N	N	N	N	N	1F	N	N	1F	1F	2M	1M	N	10
	E	N	N	N	N	N	1F	1F	N	N	N	N	2M	1F	2F	N	10
6	A	N	2M	N	N	N	1F	1F	N	1F	N	2M	N	1F	1F	N	10
	B	N	N	N	N	N	N	N	N	1F	N	2F	N	N	2F	N	10
	C	1F	N	N	N	N	2F	N	N	1M	1M	1F	2F	N	1F	N	9
	D	N	~~1F~~ N	N	N	N	N	N	N	1F	N	2F	1F	1F	1F 1M	N	10
	E	1M	1M	N	1M	N	N	N	N	2M	N	1F	N	1F	N	N	9
7	A	1M	N	N	N	N	N	N	N	N	N	N	N	N	N	N	10
	B	1M	N	N	N	N	N	1M	N	N	1F	1M	N	N	N	N	8
	C	2M	N	N	N	N	1M	N	N	1M	N	N	N	N	1F	N	~~9~~ (2)
	D	N	1F	N	N	N	N	N	N	2M	1F	N	N	N	N	N	9
	E	N	N	N	N	N	N	N	N	1M	N	1M	N	N	N	N	9
Initials		[illegible]	MP	MP	TPO	TPO	TPO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MP	MP	TPO	TPO	TPO
Date		9/20	9/21	9/22	9/23	9/24	9/25	9/26	9/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments:

(2) 9 [illegible] 10/04
(2) 10

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
9	A	1M	1F	N	N	N	N	N	N	1M	N	N	N	1F	N	1F	10
	B	1M	N	N	N	1F	N	N	1M	1F	N	N	N	N	N	N	8
	C	2M	1M	N	N	N	N	N	N	N	1M	N	N	N	N	N	8
	D	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	8
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1F	9
11	A	2F	N	N	N	1F	N	N	N	1F	1M	N	N	1M	1F	N	8
	B	N	N	N	1F	1F	1F	N	N	N	1M	N	N	2M	2M	N	8
	C	N	N	N	1F	2F	N	N	N	N	N	N	N	2M	1F	N	9
	D	2F	N	N	N	N	1M	N	N	1F	N	2F	N	3M	2F,1M	N	9
	E	N	1M	1F	N	1F	N	N	N	1M	N	N	1F	2M	1F	N	10
12	A	N	2F	N	N	N	N	N	N	N	1M	1M	N	1M	1M	2M	10
	B	N	N	N	N	1F	2F	1F	N	N	N	1M	N	1M	N	N	8
	C	1F	N	N	2F	N	N	N	N	1F	N	N	1F	N	N	N	10
	D	N	N	N	N	N	3F	1F	N	N	N	N	N	2M	1F	N	10
	E	1M	1F	N	N	N	1M,1F	N	N	N	N	1F	N	N	N	N	8
13	A	N	N	N	N	N	3M,2F	1F	N	N	N	2F	1F	1F	2F	N	10
	B	N	N	N	N	N	3F	1F	N	N	N	N	N	1F	N	1M	10
	C	1M	N	N	N	N	N	1F	N	N	N	N	N	1F	2F	2M	10
	D	N	N	N	N	N	2F	N	N	2F	N	N	N	2F	N	1M	10
	E	N	1F	N	N	N	1F,2M	N	N	N	N	N	N	1F	3F	1F	10
14	A	1M	1F	N	N	N	N	N	N	1M	N	N	N	2F	1F	1F	10
	B	1M	1F	N	N	N	1M	N	N	N	1F	1F	N	1F	2F	1M	8
	C	N	N	N	N	N	N	N	N	1F	N	1F	1M	2F	N	N	9
	D	N	1F	N	N	N	N	N	N	N	N	1M	1F	N	1F	1M	9
	E	N	2M	N	N	N	1F	1M	1M	N	1F	N	N	1F	1F	2M	8
Initials		[illegible]	MP	MP	TP	TP	TP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MP	MP	TP	TP	TP
Date		9/20	9/21	9/22	9/23	9/24	9/25	9/26	09/27	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments:

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
15	A	N	N	N	N	N	N	N	N	N	N	1M	1F	N	N	N	1
	B	N	N	N	N	N	N	N	N	N	1M	1M	1M	N	N	N	1
	C	N	N	N	N	N	N	N	N	N	N	1F	N	1F	N	N	3
	D	1M	N	N	N	N	N	N	N	N	N	N	N	N	N	N	5
	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	0
16	A	N	N	1M	N	N	N	N	N	N	N	2F	N	N	N	1M	~~8~~ ①
	B	N	1F	N	N	N	N	N	N	N	1M	N	N	2F	N	N	10
	C	2M	N	N	1F	2F	N	N	N	N	1F	N	N	N	N	N	7
	D	N	2F	N	N	N	N	N	N	2F	N	N	N	N	1F	N	6
	E	N	N	N	2F	N	N	N	N	1F	N	N	N	N	N	N	10
17	A	N	N	N	N	N	N	N	N	N	N	1M	N	N	N	N	9
	B	N	N	2F	1F	N	1M	N	N	N	N	N	N	1M	N	N	7
	C	1M	N	N	N	N	N	N	N	N	1M	1F	N	N	N	N	7
	D	1M	2M	N	1F	N	N	N	N	1M	N	1F	1F	N	N	N	7
	E	2M	1M	N	1M	N	N	N	N	1F	N	N	N	N	1F	N	10
18	A	N	2F	N	N	N	N	N	N	N	N	1M	1F	N	N	N	8
	B	1F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	8
	C	1F	N	N	1F	N	1F	N	N	1F	N	N	N	1M	1M	N	3
	D	N	N	N	N	1F	2W	N	N	N	1M	2F	2M	N	1M	N	7
	E	N	1M	N	N	N	N	N	N	N	N	1F	N	1M	N	N	7
19	A	N	2F	N	N	N	N	N	N	N	N	2F	N	2F	1F	1M, 1F	9
	B	N	N	N	N	N	N	N	N	1M	N	1F	N	N	N	1F	9
	C	N	N	N	N	N	N	N	N	N	N	2M	N	N	1F	1M	10
	D	N	1M	N	1F	N	N	N	N	1M	N	N	N	N	N	N	8
	E	1M	N	N	N	N	N	N	N	N	1F	N	N	1M	N	1M	9
Initials		[illegible]	MD	MD	TPO	TPO	TPO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MD	MD	TPO	TPO	TPO
Date		09/20	9/21	9/22	9/23	9/24	9/25	09/26	09/27	09/28	09/29	09/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments: ① 7 [illegible] 10/04

Job Number: 48-22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test

American Aquatic Testing, Inc.,

Observations/Live Count

Conc.	Rep.	Day 14	15	16	17	18	19	20	21	22	23	24	25	26	27	Day 28 Observ	Day 28 Final Count
22	A	2F	1M	N	N	N	N	1F	N	N	N	2F	1F	N	1F	1M	8
	B	N	N	N	1F	N	N	1F	N	1F	N	3F	2M	1M	1F	N	10
	C	1M	N	N	N	1F	N	N	N	N	N	1M	N	N	1F	N	8
	D	1F	3M	N	N	1F	N	N	N	N	1M	N	N	N	N	N	9
	E	N	N	N	N	N	N	N	N	N	1M	2M	1M	N	1F	N	9
25	A	N	N	N	N	N	1F	N	N	1F	N	1M	1F	N	N	N	4
	B	N	N	N	N	N	N	N	N	N	N	2F	N	N	1M,1F	N	7
	C	1F	3F	N	N	2F	N	N	N	N	N	1M	N	1M	N	1M	8
	D	1F	N	N	N	N	1F	N	N	N	1M	4M	2M	2F	1F	N	9
	E	1F	2M	N	N	1M	N	N	N	N	1M	1F	N	4M	1F,2M	N	8
\	A																
	B																
	C																
	D																
	E																
\	A																
	B																
	C																
	D																
	E																
\	A																
	B																
	C																
	D																
	E																
Initials		[illegible]	MP	MP	TMD	TMD	TMD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MP	MP	TMD	TMD	TMD
Date		09/20	9/21	9/22	9/23	9/24	9/25	09/26	09/27	09/28	09/29	09/30	10/1	10/2	10/3	10/4	10/4

Key: D=dead, N=normal activity, A=abnormal activity B=no observations

Comments:

Client/Toxicant: 48
Project Number: 22-01
Species: N. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	~~C/E IC25 & NOEC calc. weight (mg)~~
control	A	1	0.00671	0.00880	2.09	10	0.209	
	B	2	0.00621	0.00801	1.80	9	0.200	
	C	3	0.00564	0.00737	1.73	9	0.192	
	D	4	0.00714	0.00892	1.78	10	0.178	
	E	5	0.00574	0.00696	1.22	10	0.122	
	~~F~~							
	~~G~~							
	~~H~~							
2	A	6	0.00632	0.00831	1.99	10	0.199	
	B	7	0.00620	0.00725	1.05	9	0.117	
	C	8	0.00627	0.00729	1.02	9	0.113	
	D	9	0.00590	0.00729	1.39	10	0.139	
	E	10	0.00548	0.00712	1.64	10	0.164	
	~~F~~							
	~~G~~							
	~~H~~							
5	A	11	0.00551	0.00754	2.03	10	0.203	
	B	12	0.00696	0.00894	1.98	10	0.198	
	C	13	0.00591	0.00742	1.51	10	0.151	
	D	14	0.00664	0.00791	1.27	10	0.127	
	E	15	0.00717	0.00861	1.44	10	0.144	
	~~F~~							
	~~G~~							
	~~H~~							
6	A	16	0.00644	0.00780	1.36	10	0.136	
	B	17	0.00600	0.00675	0.75	10	0.075	
	C	18	0.00548	0.00627	0.79	9	~~0.158~~ (1)	
	D	19	0.00510	0.00609	0.99	10	0.099	
	E	20	0.00658	0.00725	0.67	9	0.074	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14/13	10/15	10/04	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations: (1) 0.086 ER 10/16

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
7	A	21	0.00552	0.006666	1.14	10	0.114	
	B	22	0.00584	0.006663	0.79	8	0.099	
	C	23	0.00600	0.006960	0.96	10	0.096	
	D	24	0.00674	0.007574	0.80	9	0.089	
	E	25	0.00668	0.007774	1.20	9	0.118	
	~~F~~							
	~~G~~							
	~~H~~							
9	A	26	0.00608	0.007223	1.15	10	0.115	
	B	27	0.00575	0.007753	1.78	8	0.223	
	C	28	0.00603	0.006672	0.69	8	0.086	
	D	29	0.00604	0.006692	0.88	8	0.110	
	E	30	0.00638	0.007771	1.33	9	0.148	
	~~F~~							
	~~G~~							
	~~H~~							
11	A	31	0.00562	0.007111	1.49	8	0.186	
	B	32	0.00602	0.008117	2.15	8	0.269	
	C	33	0.00605	0.007759	1.54	9	0.171	
	D	34	0.00613	0.007777	1.64	9	0.182	
	E	35	0.00578	0.007767	1.89	10	0.189	
	~~F~~							
	~~G~~							
	~~H~~							
12	A	36	0.00633	0.008114	1.81	10	0.181	
	B	37	0.00634	0.008108	1.74	8	0.218	
	C	38	0.00657	0.008829	1.72	10	0.172	
	D	39	0.00656	0.008821	1.65	10	0.165	
	E	40	0.00645	0.007768	1.23	8	0.154	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/15	10/24	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1302
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
13	A	41	0.00590	0.00712	1.22	10	0.122	
	B	42	0.00605	0.00752	1.47	10	0.147	
	C	43	0.00530	0.00665	1.35	10	0.135	
	D	44	0.00626	0.00778	1.52	10	0.152	
	E	45	0.00603	0.00776	1.73	10	0.173	
	~~F~~							
	~~G~~							
	~~H~~							
14	A	46	0.00591	0.00722	1.31	10	0.131	
	B	47	0.00581	0.00731	1.50	8	0.188	
	C	48	0.00627	0.00762	1.35	9	0.150	
	D	49	0.00735	0.00872	1.37	9	0.152	
	E	50	0.00784	0.00931	1.47	8	0.184	
	~~F~~							
	~~G~~							
	~~H~~							
15	A	51	0.00692	0.00707	0.15	1	0.160	
	B	52	0.00759	0.00781	0.22	1	0.220	
	C	53	0.00754	0.00774	0.20	3	0.067	
	D	54	0.00683	0.00736	0.53	5	0.106	
	E	55	0.00735	0.0 —	—	0	—	
	~~F~~							
	~~G~~							
	~~H~~							
16	A	56	0.00812	0.00871	0.59	7	0.084	
	B	57	0.00705	~~0.00840~~ ①	0.83	10	0.083	
	C	58	0.00751	0.00821	0.70	7	0.100	
	D	59	0.00663	0.00709	0.46	6	~~0.078~~ ②	
	E	60	0.00690	0.00771	0.81	10	0.081	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/15	10/04	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations: ① 0.00788 10/14 [illegible]
② 0.077 ER 10/16

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: H azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1340
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
17	A	61	0.00695	0.00791	0.96	9	0.107	
	B	62	0.00651	0.00714	0.63	7	0.090	
	C	63	0.00648	0.00701	0.53	7	0.076	
	D	64	0.00758	0.00801	0.43	7	0.061	
	E	65	0.00673	0.00720	0.47	10	0.047	
	~~F~~							
	~~G~~							
	~~H~~							
18	A	66	0.00706	0.00758	0.52	8	0.066	
	B	67	0.00622	0.00683	0.61	8	0.076	
	C	68	0.00636	0.00662	0.26	3	0.087	
	D	69	0.00649	0.00701	0.52	7	0.074	
	E	70	0.00609	0.00658	0.49	7	0.070	
	~~F~~							
	~~G~~							
	~~H~~							
19	A	71	0.00611	0.00757	1.46	9	0.162	
	B	72	0.00686	0.00808	1.22	9	0.136	
	C	73	0.00697	0.00892	1.95	10	0.195	
	D	74	0.00786	0.00951	1.65	8	0.206	
	E	75	0.00690	0.00821	1.41	9	0.157	
	~~F~~							
	~~G~~							
	~~H~~							
22	A	76	0.00751	0.00885	1.34	8	0.168	
	B	77	0.00715	0.00848	1.33	10	0.133	
	C	78	0.00595	0.00679	0.84	8	0.105	
	D	79	0.00660	0.00749	0.89	9	0.099	
	E	80	0.00630	0.00685	0.55	9	0.061	
	~~F~~							
	~~G~~							
	~~H~~							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/14	10/14	10/18	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Client/Toxicant: 48
Project Number: 22-01
Species: N. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300
Hatch Date:

American Aquatic Testing, Inc.
Weight Data

Conc.	Rep	Pan #	A weight of boat (g)	B weight of boat & org. (g)	(B-A)*1000=C dry weight of organisms (mg)	D # of surviving org.	C/D mean dry weight (mg)	C/E IC_{25} & NOEC calc. weight (mg)
25	A	81	0.00696	0.00738	0.42	4	0.105	
	B	82	0.00677	0.00726	0.49	7	0.070	
	C	83	0.00590	0.00719	1.29	8	0.161	
	D	84	0.00672	0.00817	1.45	9	0.161	
	E	85	0.00738	0.00873	1.35	8	0.169	
	~~F~~							
	~~G~~							
	~~H~~							
	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							
	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							
	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							
	Initials		thd	[illegible]	[illegible]	[illegible]	[illegible]	
	Date		10/3/13	10/14	10/15	10/04	10/15	

E = Original number of organisms at test initiation, adjusted for losses.

Observations:

BasicWT.wk3

Job Number: 48-22-01
Species: H. azteca

Start Date & Time: 9-6-13 1355
End Date & Time: 10-4-13 1300

Sediment Test

American Aquatic Testing, Inc.,

Water Change Log/Initial Water Readings/General Testing Information

Test Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Morning change(time)	0810	0745	0800	0910	0845	~~1600~~	8:00	8:00	8:30	7:30	1015	0700	1000	7:00	0730
D.O. mg/L	8.6	8.5	8.6	8.6	8.5	8.5	8.3	8.3	8.4	8.3	8.4	8.3	8.6	8.5	8.4
pH	8.2	8.3	8.3	7.9	7.8	8.0	7.8	8.0	8.0	8.0	8.0	8.1	7.9	8.0	8.0
Temp. (C)	23.0	23.5	23.0	23.0	22.0	23.5	23.5	23.5	23.0	22.5	22.0	22.5	22.0	22.5	22.0
Initials	TAP	MT	MT	TAP	SH	TAP	thd	SH	SH	TAP	[illegible]	[illegible]	[illegible]	thd	[illegible]
Date	9/6	9-7	9-8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	09/18	9/19	09/20
Afternoon change(time)	1640	1415	1230	1710	1600	1700	1700	1830	1900	1745	1800	1900	1630	1700	1730
D.O. mg/L	8.5	8.5	8.5	8.4	8.4	8.4	8.3	8.4	8.4	8.4	7.9	8.3	8.5	8.4	8.3
pH	8.0	8.2	8.2	7.9	7.9	7.9	7.9	8.0	7.9	8.0	8.0	8.1	7.8	8.1	8.0
Temp. (C)	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	23.0	22.5	22.5	22.0	22.0	23.0
Initials	[illegible]	MT	MT	TAP	SH	SH	SH	SH	TAP	thd	[illegible]	[illegible]	mp	[illegible]	thd
Date	09/06	9-7	9-8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	09/16	09/17	9/18	09/18	9/20

Test Day	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Morning change(time)	1010	1000	7:30	7:30	8:00	7:30	7:30	0715	0730	7:30	7:30	7:30	7:30	7:30
D.O. mg/L	8.4	8.4	8.3	8.6	8.5	9.1	8.7	8.6	8.5	8.5	8.5	8.5	8.5	8.5
pH	7.9	7.9	8.0	7.9	8.0	7.3	8.1	8.0	8.1	7.9	7.9	7.7	8.0	7.9
Temp. (C)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	22.5	23.0	23.0	23.0	23.0	23.0
Initials	mp	mp	thd	thd	thd	thd	thd	[illegible]	[illegible]	thd	SH	thd	thd	thd
Date	9/21	9/22	9/23	9/24	9/25	9/26	9/27	09/28	09/29	9/30	10/1	10/2/13	10/3/13	10/4/13
Afternoon change(time)	1630	1700	1720	1700	1640	1615	2029	1530	1245	1745	1500	1615	1830	
D.O. mg/L	8.3	8.3	8.5	8.5	8.5	8.6	8.5	8.4	8.7	8.5	8.4	8.3	8.4	
pH	8.0	8.0	8.0	8.0	7.9	8.0	8.1	8.0	7.9	8.0	7.7	8.1	7.8	
Temp. (C)	22.5	22.0	22.5	23.0	23.0	23.0	23.0	23.5	23.0	22.0	23.0	23.0	23.0	
Initials	mp	MT	SH	thd	SH	[illegible]	[illegible]	SH	SH	[illegible]	SH	SH	SH	
Date	9/21	9-22	9-23	9/24	9/25	09/26	09/27	9/28	9/29	09/30	10/1	10/2	10/3	

Control Sed. collection date/by: 9/3/13 / TAP

Control Sed. sieve date/by: 9/4/13 / TAP

Sieve size used: 1mm

Sample sieve date/by: 9/3/13 / CJN, SH, TD

Sieve size used: 1mm

Organism source: ABS

Test organism Lot number: 1428

Number of animals per chamber: 10

Food Type: flake

Frequency of feeding: every other day

Test Chamber size: 300ml

Test Volume of sediment: 100ml

Test Volume of water: 150ml

Test Duration: 28 days

Test Temperature Range: 23±1°c

① 0830 thd 9/11/13

Client/Toxicant: 48
Job Number: 22-01
Species: H.azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	Control	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	2	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	5	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	6	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	7	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.0	22.5	22.5
	9	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	11	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	12	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	13	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	14	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	15	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
Dissolved Oxygen (mg/L)	Control	7.2	7.4	7.2	6.6	6.3	6.3	6.2	6.2	6.4	6.3	6.0
	2	7.5	7.7	7.5	6.9	6.5	6.2	6.4	6.4	6.9	6.6	6.0
	5	5.6	5.9	7.3	6.2	6.3	6.0	5.8	6.0	6.6	6.5	5.9
	6	5.5	6.2	7.3	6.6	6.7	6.3	6.3	6.3	6.9	6.7	6.0
	7	5.0	5.8	6.5	6.5	6.7	6.3	6.4	6.5	7.0	6.5	5.9
	9	5.3	5.9	7.1	6.7	6.9	6.3	6.6	6.7	7.2	6.8	6.1
	11	5.8	6.4	7.4	6.6	6.7	6.4	6.5	6.8	7.2	6.8	6.0
	12	5.4	6.0	7.3	6.7	6.6	6.3	6.5	6.8	7.1	6.8	5.8
	13	6.7	7.0	7.3	6.9	6.7	6.4	6.4	6.7	7.2	7.0	5.8
	14	5.5	5.9	7.4	6.5	6.5	6.6	6.1	6.4	6.9	6.7	5.6
	15	7.1	7.2	7.7	6.6	7.0	6.6	6.8	6.9	7.3	7.0	6.1
pH	Control	7.6	7.8	7.7	7.5	7.4	7.4	7.5	7.5	7.6	7.5	7.4
	2	7.5	7.7	7.6	7.6	7.4	7.4	7.5	7.4	7.6	7.5	7.3
	5	7.4	7.7	7.5	7.5	7.4	7.4	7.4	7.4	7.5	7.4	7.2
	6	7.4	7.7	7.5	7.5	7.4	7.4	7.5	7.4	7.5	7.4	7.1
	7	7.5	7.6	7.6	7.5	7.4	7.4	7.4	7.4	7.5	7.4	7.1
	9	7.4	7.7	7.5	7.5	7.4	7.4	7.4	7.3	7.5	7.4	7.1
	11	7.4	7.6	7.5	7.5	7.4	7.4	7.4	7.3	7.4	7.3	7.1
	12	7.4	7.6	7.5	7.5	7.4	7.4	7.4	7.3	7.4	7.3	7.2
	13	7.3	7.6	7.4	7.5	7.4	7.4	7.3	7.3	7.5	7.4	7.2
	14	7.3	7.6	7.4	7.5	7.4	7.4	7.4	7.3	7.5	7.4	7.2
	15	7.4	7.6	7.5	7.5	7.4	7.4	7.5	7.3	7.5	7.4	7.2
	Initials	SH	MM	MM	WHM	SH	MM	SH	SH	SH	thd	[illegible]
	Date	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control	286	278	60	70	130	170	0.13	0.04
2	274	266	50	70	120	120	0.23	0.04
5	274	267	60	60	200	170	0.74	0.01
6	272	268	50	90	90	150	0.19	0.04
7	268	269	60	70	130	120	0.24	0.00
9	266	269	60	90	130	130	0.33	0.02
11	269	269	60	60	110	120	0.39	0.02
12	272	270	80	60	80	110	0.18	0.05
13	272	271	60	70	100	120	0.26	0.00
14	276	269	60	70	190	140	0.41	0.01
15	268	268	70	60	140	160	0.16	0.03
Initials	SH	thd	SH	SH	SH	SH	TLP	TLP
Date	9/6	10/3	9/6	10/4	9/6	10/4	9/6	10/4

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 0	1	2	3	4	5	6	7	8	9	10
TEMP (C)	16	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	17	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	18	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	19	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	22	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	25	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.0	22.5	22.5
	-											
	-											
	-											
	-											
	-											
Dissolved Oxygen (mg/L)	16	6.9	7.0	7.6	6.9	6.9	6.7	6.8	7.0	7.2	6.7	6.0
	17	7.3	7.5	7.8	6.9	7.1	6.7	6.8	6.8	7.3	6.9	5.8
	18	6.1	6.3	7.6	7.1	7.0	6.9	6.8	6.9	7.3	7.0	5.7
	19	7.2	7.6	7.6	7.1	7.0	6.6	6.6	6.9	7.2	7.0	5.9
	22	8.0	8.1	8.2	7.6	6.9	6.7	7.1	7.2	7.5	7.3	5.8
	25	8.1	8.2	8.2	7.7	7.3	6.9	7.4	7.5	7.7	7.7	5.6
	-											
	-											
	-											
	-											
	-											
pH	16	7.3	7.6	7.4	7.5	7.4	7.4	7.4	7.3	7.4	7.4	7.2
	17	7.4	7.5	7.8	7.5	7.4	7.4	7.4	7.3	7.4	7.4	7.2
	18	7.3	7.5	7.4	7.5	7.4	7.5	7.4	7.3	7.4	7.4	7.1
	19	7.3	7.5	7.4	7.4	7.4	7.4	7.4	7.2	7.4	7.3	7.1
	22	7.4	7.6	7.5	7.4	7.4	7.4	7.4	7.3	7.4	7.4	7.1
	25	7.4	7.6	7.5	7.5	7.4	7.5	7.4	7.3	7.4	7.4	7.1
	-											
	-											
	-											
	-											
	-											
	Initials	SH	MJ	MJ	WHM	SH	MJ	SH	SH	SH	SH	SH
	Date	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	09/15	09/16

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
16	275	270	50	70	100	140	0.11	0.00
17	276	267	60	70	180	160	0.38	0.07
18	261	266	50	80	120	150	0.33	0.09
19	273	267	60	80	170	190	0.50	0.04
22	265	265	50	80	110	130	0.09	0.02
25	259	268	60	60	150	160	0.03	0.02
-								
-								
-								
-								
-								
Initials	SH	MJ	SH	SH	SH	SH	TMP	TMP
Date	9/6	10/3	9/6	10/4	9/6	10/4	9/6	10/4

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 11	12	13	14	15	16	17	18	19	20	21
TEMP (C)	Control	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	2	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	5	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	6	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	7	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	9	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	11	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	12	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	13	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	14	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	15	22.5	22.5	22.6	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
Dissolved Oxygen (mg/L)	Control	6.4	6.5	7.5	6.6	6.4	7.0	6.2	6.1	6.8	6.5	6.8
	2	6.1	6.9	7.3	6.5	6.6	7.5	6.8	6.8	6.7	6.6	6.4
	5	6.4	6.8	7.4	6.6	6.6	7.4	7.3	7.1	6.9	6.5	6.6
	6	6.5	6.9	7.5	6.6	7.1	7.5	7.4	7.0	6.8	6.7	6.4
	7	6.5	7.0	7.3	6.5	7.1	7.7	7.3	7.0	6.8	6.8	6.5
	9	6.5	7.1	7.2	6.6	7.0	7.5	7.5	7.2	6.9	6.7	6.6
	11	6.4	7.0	7.1	6.4	6.8	7.0	7.5	7.2	7.0	6.9	6.7
	12	6.4	6.9	7.2	6.5	6.8	7.2	7.5	7.1	7.0	6.9	6.6
	13	6.7	6.7	7.3	6.6	6.9	7.4	7.5	7.2	7.0	6.9	6.8
	14	6.4	7.2	7.1	6.5	6.8	7.0	7.0	6.7	6.8	6.9	6.7
	15	6.4	7.8	7.2	6.6	7.0	7.0	7.5	7.3	7.1	6.9	6.6
pH	Control	7.4	7.4	7.6	7.5	7.4	7.7	7.6	7.7	7.6	7.6	7.6
	2	7.4	7.4	7.5	7.4	7.4	7.6	7.3	7.6	7.6	7.6	7.4
	5	7.4	7.2	7.5	7.3	7.4	7.6	7.4	7.6	7.6	7.6	7.5
	6	7.4	7.2	7.4	7.4	7.4	7.6	7.3	7.6	7.6	7.6	7.5
	7	7.4	7.4	7.5	7.4	7.4	7.5	7.3	7.5	7.6	7.5	7.5
	9	7.5	7.4	7.4	7.5	7.4	7.5	7.3	7.5	7.5	7.5	7.6
	11	7.4	7.4	7.5	7.4	7.4	7.6	7.3	7.5	7.5	7.5	7.5
	12	7.4	7.4	7.5	7.3	7.3	7.6	7.3	7.5	7.5	7.6	7.5
	13	7.6	7.4	7.4	7.5	7.4	7.6	7.3	7.5	7.5	7.5	7.5
	14	7.5	7.3	7.5	7.5	7.4	7.6	7.3	7.5	7.5	7.6	7.5
	15	7.5	7.3	7.5	7.8	7.4	7.6	7.3	7.5	7.5	7.6	7.5
	Initials	[illegible]	MP	[illegible]	[illegible]	MP	MP	thd	thd	TR	[illegible]	[illegible]
	Date	09/17	9/18	09/19	09/20	9/21	9/22	9/23	9/24	9/25	09/26	9/26

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1355
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 11	12	13	14	15	16	17	18	19	20	21
TEMP (C)	16 ~~Control~~	22.6	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.6
	17	22.5	22.5	22.5	22.6	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	18	22.5	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	19	22.5	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	22	22.6	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	25	22.5	22.5	22.5	22.5	23.0	23.0	23.0	22.5	23.0	22.5	22.5
	–											
	–											
	–											
	–											
	–											
Dissolved Oxygen (mg/L)	16 ~~Control~~	6.8	7.5	7.3	6.4	7.3	7.3	7.6	7.3	7.0	6.9	6.9
	17	6.4	7.4	7.4	6.5	7.0	7.3	7.6	7.0	7.0	6.9	6.8
	18	6.6	7.2	7.3	6.6	7.0	7.2	7.4	6.9	6.7	7.1	6.9
	19	6.6	7.3	7.3	6.6	7.0	7.1	7.4	7.1	6.9	7.1	6.9
	22	6.9	7.6	7.6	6.9	7.0	7.1	7.5	7.0	7.0	7.2	6.9
	25	7.1	7.6	7.7	7.0	7.2	7.6	7.8	7.3	7.0	7.1	7.2
	–											
	–											
	–											
	–											
	–											
pH	16 ~~Control~~	7.5	7.4	7.5	7.4	7.4	7.6	7.2	7.4	7.5	7.5	7.5
	17	7.5	7.4	7.5	7.4	7.4	7.6	7.3	7.5	7.4	7.5	7.5
	18	7.5	7.2	7.4	7.4	7.4	7.6	7.3	7.4	7.4	7.4	7.5
	19	7.4	7.2	7.5	7.4	7.4	7.6	7.2	7.4	7.3	7.4	7.4
	22	7.4	7.3	7.5	7.3	7.4	7.6	7.3	7.4	7.4	7.4	7.4
	25	7.4	7.3	7.5	7.4	7.4	7.6	7.3	7.4	7.4	7.4	7.4
	–											
	–											
	–											
	–											
	–											
	Initials											
	Date	09/17	9/18	09/19	09/20	9/21	9/22	9/23	9/24	9/25	09/26	09/27

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca.

Beginning Date & Time: 9-6-13 1358
Ending Date & Time: 10-4-13 1302

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 22	23	24	25	26	27	28	29	30	31	32
TEMP (C)	Control	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	2	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	5	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	6	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	7	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	9	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	11	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	12	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	13	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	14	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	15	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
Dissolved Oxygen (mg/L)	Control	6.0	6.1	6.0	5.7	5.3	4.3	5.1				
	2	5.3	6.3	6.2	6.5	6.1	5.5	5.5				
	5	6.1	6.6	6.7	6.5	6.4	5.8	5.4				
	6	6.0	7.0	7.0	7.1	6.6	6.4	7.1				
	7	6.0	7.0	7.1	6.8	6.4	6.4	6.7				
	9	6.3	7.0	6.9	6.9	6.5	6.4	7.6				
	11	6.9	7.0	7.1	6.9	6.7	6.2	6.8				
	12	6.9	6.6	7.2	6.8	6.3	6.1	7.0				
	13	6.5	6.9	7.2	6.8	6.5	6.3	7.0				
	14	6.9	7.1	6.6	6.7	6.2	6.3	6.5				
	15	6.5	7.0	7.2	6.9	6.8	6.1	6.7				
pH	Control	7.4	7.6	7.2	7.5	7.8	7.6	7.7				
	2	7.3	7.6	7.1	7.5	7.8	7.6	7.7				
	5	7.4	7.5	7.1	7.4	7.8	7.6	7.7				
	6	7.4	7.5	7.3	7.4	7.7	7.6	7.6				
	7	7.3	7.5	7.4	7.4	7.7	7.5	7.5				
	9	7.3	7.5	7.2	7.4	7.6	7.5	7.5				
	11	7.4	7.5	7.2	7.4	7.6	7.5	7.5				
	12	7.3	7.4	7.4	7.3	7.6	7.5	7.5				
	13	7.4	7.5	7.4	7.3	7.6	7.5	7.5				
	14	7.4	7.5	7.4	7.4	7.6	7.5	7.5				
	15	7.4	7.5	7.5	7.4	7.5	7.5	7.5				
	Initials	[illegible]	SH	Thd	SH	SH	SH	SH				
	Date	09/28	9/29	9/30	10/1	10/2	10/3	10/4				

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

Client/Toxicant: 48
Job Number: 22-01
Species: H. azteca

Beginning Date & Time: 9-6-13 1305
Ending Date & Time: 10-4-13 1300

Freshwater Sediment Test
American Aquatic Testing, Inc.,
Physical / Chemical Parameters

Parameter	Concentration	Day 22	23	24	25	26	27	28	29	30	31	32
TEMP (C)	16 ~~Control~~	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	17	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	18	23.0	23.0	22.5	23.0	23.0	23.0	23.0				
	19	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	22	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	25	23.0	23.0	23.0	23.0	23.0	23.0	23.0				
	–											
	–											
	–											
	–											
	–											
Dissolved Oxygen (mg/L)	16 ~~Control~~	6.4	7.0	7.2	6.4	6.8	6.2	7.0				
	17	6.6	7.1	7.4	7.1	6.7	6.5	6.8				
	18	6.5	7.2	7.0	6.4	6.2	5.4	6.4				
	19	6.3	7.2	7.2	7.0	6.7	6.4	6.9				
	22	6.1	7.2	7.3	7.0	6.5	6.4	6.9				
	25	6.1	6.9	7.1	7.3	6.8	6.4	7.6				
	–											
	–											
	–											
	–											
	–											
pH	16 ~~Control~~	7.4	7.5	7.4	7.3	7.5	7.5	7.5				
	17	7.4	7.5	7.4	7.3	7.6	7.5	7.5				
	18	7.4	7.5	7.4	7.3	7.6	7.4	7.5				
	19	7.4	7.5	7.4	7.3	7.5	7.4	7.5				
	22	7.4	7.5	7.4	7.3	7.5	7.4	7.4				
	25	7.4	7.4	7.4	7.3	7.5	7.4	7.5				
	–											
	–											
	–											
	–											
	–											
	Initials	[illegible]	SH	Thd	SH	SH	SH	SH				
	Date	09/28	9/29	9/30	10/1	10/2	10/3	10/4				

Concentration	Cond. (umhos) Initial	Cond. (umhos) Final	Alkalinity (mg/L) Initial	Alkalinity (mg/L) Final	Hardness (mg/L) Initial	Hardness (mg/L) Final	Ammonia (mg/L) Initial	Ammonia (mg/L) Final
Control								
Initials								
Date								

Comments:

FWSEDPAR.wk3

APPENDIX B

STATISTICAL DATA FOR *Hyalella azteca* 28-DAY SURVIVAL AND GROWTH TEST

Amphipod Survival, Growth Test Survival

Start Date:	9/6/2013	Test ID:	482201ha	Sample ID:	Lockheed
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

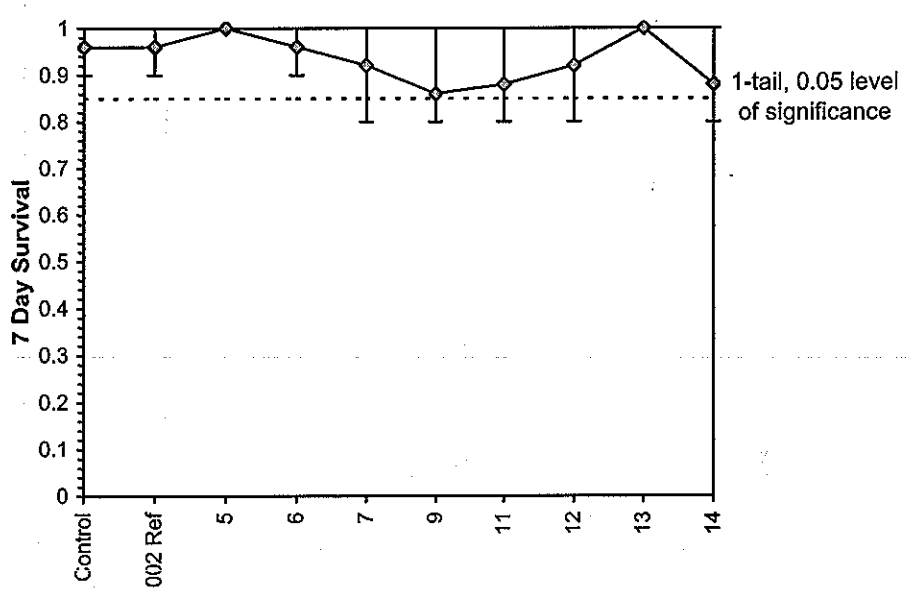
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	1.0000	1.0000
002 Ref	1.0000	0.9000	0.9000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	0.9000	1.0000	0.9000
7	1.0000	0.8000	1.0000	0.9000	0.9000
9	1.0000	0.8000	0.8000	0.8000	0.9000
11	0.8000	0.8000	0.9000	0.9000	1.0000
12	1.0000	0.8000	1.0000	1.0000	0.8000
13	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	0.8000	0.9000	0.9000	0.8000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5			
002 Ref	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5	*		
5	1.0000	1.0417	1.4120	1.4120	1.4120	0.000	5	-0.929	2.480	0.1739
6	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5	0.000	2.480	0.1739
7	0.9200	0.9583	1.2859	1.1071	1.4120	10.026	5	0.869	2.480	0.1739
9	0.8600	0.8958	1.1965	1.1071	1.4120	11.303	5	2.143	2.480	0.1739
11	0.8800	0.9167	1.2249	1.1071	1.4120	10.319	5	1.739	2.480	0.1739
12	0.9200	0.9583	1.2901	1.1071	1.4120	12.944	5	0.809	2.480	0.1739
13	1.0000	1.0417	1.4120	1.4120	1.4120	0.000	5	-0.929	2.480	0.1739
14	0.8800	0.9167	1.2249	1.1071	1.4120	10.319	5	1.739	2.480	0.1739

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.95558	0.926	0.09383	-0.5181
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.10082	0.10605	0.03225	0.0123	0.02257	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

Amphipod Survival, Growth Test Survival

Start Date:	9/6/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

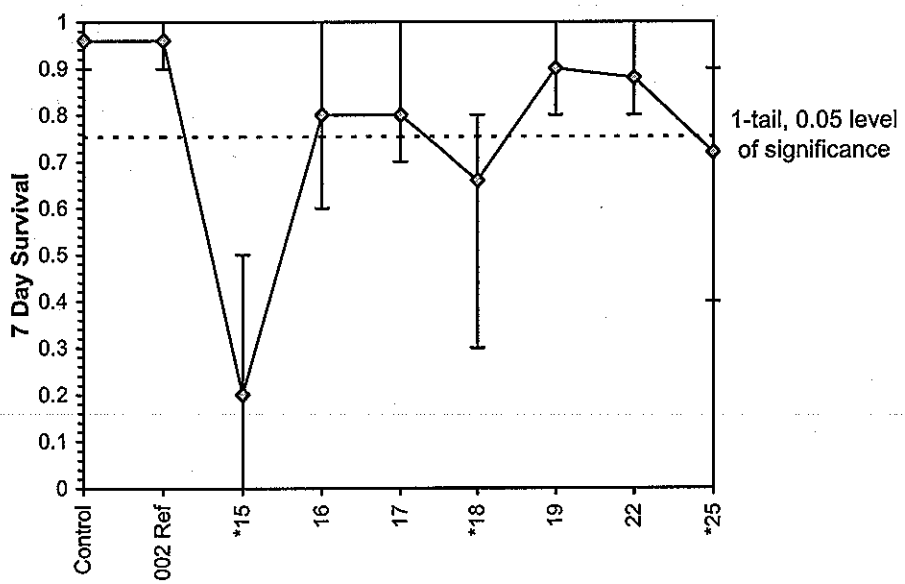
Conc-%	1	2	3	4	5
Control	1.0000	0.9000	0.9000	1.0000	1.0000
002 Ref	1.0000	0.9000	0.9000	1.0000	1.0000
15	0.1000	0.1000	0.3000	0.5000	0.0000
16	0.7000	1.0000	0.7000	0.6000	1.0000
17	0.9000	0.7000	0.7000	0.7000	1.0000
18	0.8000	0.8000	0.3000	0.7000	0.7000
19	0.9000	0.9000	1.0000	0.8000	0.9000
22	0.8000	1.0000	0.8000	0.9000	0.9000
25	0.4000	0.7000	0.8000	0.9000	0.8000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5			
002 Ref	0.9600	1.0000	1.3468	1.2490	1.4120	6.628	5	*		
*15	0.2000	0.2083	0.4335	0.1588	0.7854	57.169	5	7.563	2.443	0.2950
16	0.8000	0.8333	1.1385	0.8861	1.4120	22.254	5	1.725	2.443	0.2950
17	0.8000	0.8333	1.1269	0.9912	1.4120	17.269	5	1.821	2.443	0.2950
*18	0.6600	0.6875	0.9553	0.5796	1.1071	22.804	5	3.243	2.443	0.2950
19	0.9000	0.9375	1.2533	1.1071	1.4120	8.613	5	0.775	2.443	0.2950
22	0.8800	0.9167	1.2249	1.1071	1.4120	10.319	5	1.010	2.443	0.2950
*25	0.7200	0.7500	1.0278	0.6847	1.2490	20.672	5	2.641	2.443	0.2950

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.97431	0.919	-0.0637	-0.3679
Bartlett's Test indicates equal variances (p = 0.44)	6.89042	18.4753		
The control means are not significantly different (p = 1.00)	0	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<15	15			0.19664	0.20684	0.40136	0.03646	5.4E-07	7, 32
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by: ____

Amphipod Survival, GrowthTest-Growth

Start Date:	9/6/2013	Test ID:	482201ha	Sample ID:	Lockheed
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

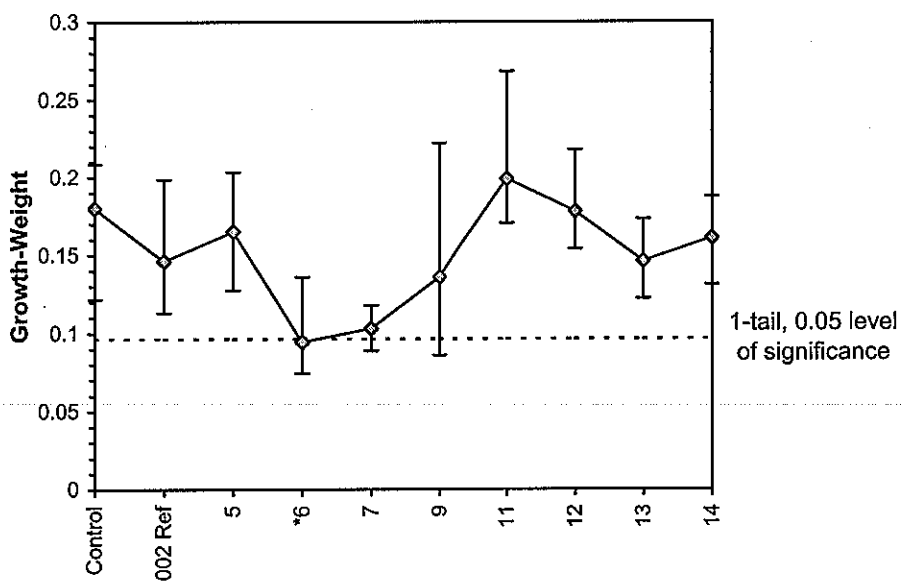
Conc-%	1	2	3	4	5
Control	0.2090	0.2000	0.1922	0.1780	0.1220
002 Ref	0.1990	0.1167	0.1133	0.1390	0.1640
5	0.2030	0.1980	0.1510	0.1270	0.1440
6	0.1360	0.0750	0.0878	0.0990	0.0744
7	0.1140	0.0988	0.0960	0.0889	0.1178
9	0.1150	0.2225	0.0862	0.1100	0.1478
11	0.1863	0.2688	0.1711	0.1822	0.1890
12	0.1810	0.2175	0.1720	0.1650	0.1538
13	0.1220	0.1470	0.1350	0.1520	0.1730
14	0.1310	0.1875	0.1500	0.1522	0.1838

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.1802	1.2312	0.1802	0.1220	0.2090	19.135	5			
002 Ref	0.1464	1.0000	0.1464	0.1133	0.1990	24.411	5	*		
5	0.1646	1.1243	0.1646	0.1270	0.2030	20.632	5	-0.905	2.480	0.0499
*6	0.0944	0.6451	0.0944	0.0744	0.1360	26.839	5	2.582	2.480	0.0499
7	0.1031	0.7041	0.1031	0.0889	0.1178	11.936	5	2.153	2.480	0.0499
9	0.1363	0.9310	0.1363	0.0862	0.2225	38.843	5	0.502	2.480	0.0499
11	0.1995	1.3625	0.1995	0.1711	0.2688	19.715	5	-2.637	2.480	0.0499
12	0.1779	1.2148	0.1779	0.1538	0.2175	13.664	5	-1.563	2.480	0.0499
13	0.1458	0.9959	0.1458	0.1220	0.1730	13.116	5	0.030	2.480	0.0499
14	0.1609	1.0990	0.1609	0.1310	0.1875	14.961	5	-0.720	2.480	0.0499

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.93069	0.926	1.01651	0.96449
Bartlett's Test indicates equal variances (p = 0.28)	9.75161	20.0902		
The control means are not significantly different (p = 0.17)	1.52375	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	14	>14		7.14286	0.0499	0.34086	0.00563	0.00101	1.3E-04	8, 36
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

Amphipod Survival, Growth Test Growth

Start Date:	9/6/2013	Test ID:	482201hab	Sample ID:	LOCKHEED
End Date:	10/4/2013	Lab ID:	AAT, INC	Sample Type:	
Sample Date:		Protocol:	EPAM 94-EPA/600/4-91/003	Test Species:	H azteca
Comments:					

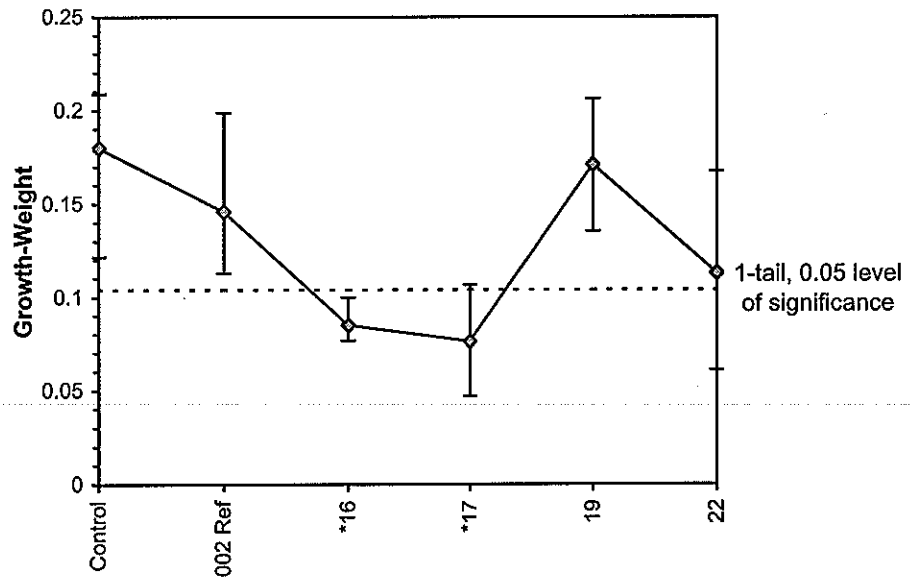
Conc-%	1	2	3	4	5
Control	0.2090	0.2000	0.1922	0.1780	0.1220
002 Ref	0.1990	0.1167	0.1133	0.1390	0.1640
16	0.0843	0.0830	0.1000	0.0767	0.0810
17	0.1067	0.0900	0.0757	0.0614	0.0470
19	0.1622	0.1356	0.1950	0.2063	0.1567
22	0.1675	0.1330	0.1050	0.0989	0.0611

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
Control	0.1802	1.2312	0.1802	0.1220	0.2090	19.135	5			
002 Ref	0.1464	1.0000	0.1464	0.1133	0.1990	24.411	5	*		
*16	0.0850	0.5805	0.0850	0.0767	0.1000	10.441	5	3.302	2.300	0.0428
*17	0.0762	0.5202	0.0762	0.0470	0.1067	30.720	5	3.776	2.300	0.0428
19	0.1711	1.1690	0.1711	0.1356	0.2063	16.928	5	-1.330	2.300	0.0428
22	0.1131	0.7725	0.1131	0.0611	0.1675	35.161	5	1.790	2.300	0.0428

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.97115	0.888	0.29714	-0.1975
Bartlett's Test indicates equal variances (p = 0.14)	6.87332	13.2767		
The control means are not significantly different (p = 0.17)	1.52375	2.30601		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<16	16			0.04278	0.2922	0.00812	0.00086	1.9E-04	4, 20
Treatments vs 002 Ref										

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:

APPENDIX C

CHAIN OF CUSTODY DOCUMENTATION

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131004	TOX-FS13-SED-002	TOX-SED-002	Chironomus and Hyalella Tox Tests	Sediment	7/29/2013	15:20	1	2.5 gallon bucket	4 C	N
131005	TOX-FS13-SED-005	TOX-SED-005	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:30	1	2.5 gallon bucket	4 C	N
131006	TOX-FS13-SED-006	TOX-SED-006	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:50	1	2.5 gallon bucket	4 C	N
131007	TOX-FS13-SED-007	TOX-SED-007	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	11:57	1	2.5 gallon bucket	4 C	N
131008	TOX-FS13-SED-009	TOX-SED-009	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:10	1	2.5 gallon bucket	4 C	N
131009	TOX-FS13-SED-011	TOX-SED-011	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:45	1	2.5 gallon bucket	4 C	N
131010	TOX-FS13-SED-012	TOX-SED-012	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	12:55	1	2.5 gallon bucket	4 C	N
131011	TOX-FS13-SED-013	TOX-SED-013	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:05	1	2.5 gallon bucket	4 C	N
131012	TOX-FS13-SED-014	TOX-SED-014	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	13:20	1	2.5 gallon bucket	4 C	N
131013	TOX-FS13-SED-015	TOX-SED-015	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:00	1	2.5 gallon bucket	4 C	N
131014	TOX-FS13-SED-016	TOX-SED-016	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:05	1	2.5 gallon bucket	4 C	N

Special Instructions: ~~Wait~~

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analysis	[signature]	8/29/13	[signature]	8/29/13					[signature]	8/29/13	1500

48-22-01

USEPA
Lockheed Martin/SERAS
CarrierName: Lab Courier
AirbillNo:

CHAIN OF CUSTODY RECORD
Site # 185
Contact Name: Christopher Gussman
Contact Phone: 732-321-4237

No: 2-082613-092425-0016
Lab: American Aquatic Testing
Lab Contact:
Lab Phone:

Lab #	Sample #	Location	Analyses	Matrix	Collected	Sample Time	Numb Cont	Container	Preservative	MS/MSD
131015	TOX-FS13-SED-017	TOX-SED-017	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:15	1	2.5 gallon bucket	4 C	N
131016	TOX-FS13-SED-018	TOX-SED-018	Chironomus and Hyalella Tox Tests	Sediment	7/30/2013	16:10	1	2.5 gallon bucket	4 C	N
131017	TOX-FS13-SED-019	TOX-SED-019	Chironomus and Hyalella Tox Tests	Sediment	7/30/2020	16:55	1	2.5 gallon bucket	4 C	N
131018	TOX-FS13-SED-022	TOX-SED-022	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	08:40	1	2.5 gallon bucket	4 C	N
131019	TOX-FS13-SED-025	TOX-SED-025	Chironomus and Hyalella Tox Tests	Sediment	7/31/2013	09:25	1	2.5 gallon bucket	4 C	N

Special Instructions:

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time
All/Analyses	[illegible]	8/29/13	Diane Higgins	8/29/13			Diane Higgins	8/29	Wesley Morgan	8/29/13	1500

Appendix C

Union Lake Sedflume Report

Union Lake Sedflume Analysis
Millville, NJ
August 2013

Prepared for:

Lockheed Martin

Prepared by:
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Executive Summary

Morphological bed changes in any aquatic system are dictated by complex and dynamically linked relationships between biological activity, hydrodynamic forcing, and sediment characteristics. When analyzing the sediment transport occurring within a system, numerous variables must be considered; one key aspect is the erosional properties and stability of a site's sediments. Sea Engineering, Inc. (SEI) conducted a Sediment Erosion at Depth Flume (Sedflume) analysis on 15 sediment cores obtained from Union Lake and Maurice River in Millville, NJ. The cores were collected in water depths ranging between 0.30 m to 6.1 m. The primary goal of this work was to characterize the erosion properties and physical characteristics of the sites sediments. The Sedflume analysis determined sediment erosion rates, critical shear stresses, particle sizes and bulk densities at specific down-core depth intervals.

Critical shear stress is a difficult parameter to quantify; for Sedflume analysis it is typically defined as the shear stress required to erode sediment at a rate of 10^{-4}centimeter per second (cm/s) (Roberts et al. 1998). To reduce uncertainty, critical shear stresses were estimated by combining a power law regression analysis with critical shear stress thresholds based on direct erosion rate measurements. Calculated critical shear stresses ranged from 0.1 Pa to 1.78 Pa.

For the cores analyzed, the presence of organic material such as detritus, woody debris, and leafs had a noticeable effect on erosion. When high concentrations of organic material were present in a core, erosion was dominated by the mobilization of large chunks of material as organic pieces lifted from the cores surface also taking sediment. In cores SCC03 and ALL14 however, organic material acted to stiffen the cores. Even though organic material effected erosion, most cores generally stiffened with depth. This trend is common for sites with cohesive sediments. Cohesive sediments will often self-compact due to the weight of overlying material; with the compaction comes reduce potential for sediment mobility. However, Sedflume results must be analyzed in conjunction with other system characteristics, such as hydrodynamic forcing, to assess overall site stability and sediment transport trends.

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Section 1
Introduction to Sedflume

1.1 Introduction

Morphological bed changes in any aquatic system are dictated by complex and dynamically linked relationships between biological activity, hydrodynamic forcing, and sediment characteristics. When analyzing the sediment transport occurring within a system, numerous variables must be considered; one key aspect is the erosional properties and stability of a site's sediments. Sea Engineering, Inc. (SEI) conducted a Sediment Erosion at Depth Flume (Sedflume) analysis on 15sediment cores obtained from Union Lake and Maurice River in Millville, NJ. The cores were collected in water depths ranging between 0.30 m to 6.1 m. The primary goal of this work was to characterize the erosion rates and physical properties of the sediments within the study area. The cores were eroded during the Sedflume analysis to determine erosion rates as a function of shear stress and depth. In addition, each core was sub-sampled to determine sediment bulk density and particle size distribution at specific depths within the core. Critical shear stresses were also deduced for five vertical intervals in each core (unless otherwise stated).The following report outlines the procedures used in the Sedflume analysis, presents the measured data, and provides a description and analysis of the results.

1.2 Core Collection

Fifteen sediment cores were collected by SEI personnel on May 15 and 16, 2013. At each coring location, a differential global positioning system (DGPS) was used to position a vessel at pre-determined fixed sampling stations. The 15 coring locations are shown in Figure 1 though Figure 3, where coring locations are marked by green circles. A pole was attached with clamps to the 10 cm by 15 cm rectangular core. The core tube was lowered into the water and positioned perpendicular to the sediment bed. Pressure was applied by hand until at least 30 cm (approximately) and no more than 60 cm of the core tube penetrated into the sediment bed. The sediment bed at nearly all locations (excluding UBW 10) was soft and required little force to achieve adequate penetration. A valve affixed to the top of the core tube was temporally closed to provide suction when the core was pulled out of the sediment bed.

After cores reached the water surface, they were visually inspected for length and quality. Many of the cores covered were reported to be soft and gelatinous in texture. Undisturbed cores of acceptable length were capped and secured to minimize sediment disturbance from sloshing water and vessel/vehicle motion. Cores were then transferred from the vessel to land, and packed in secure Sedflume core shipping boxes. The cores were shipped to SEI's Sedflume laboratory in Santa Cruz, California. Upon arrival, the cores were again visually inspected to ensure sediment structure and surface had been preserved. The cores were then placed in an ambient water bath for preservation until processing.

Table 1. Sedflume core extraction coordinates, time and date, and water depth.

Core ID	Location	Lat (°N)	Long (°W)	Coring Date	Time (EST)	Depth (m)*
NEC01	Northeast Cove, Upper Union Lake	39.43247	75.06371	5/15/2013	10:40	1.22
NEC02	Northeast Cove, Upper Union Lake	39.43343	75.06475	5/15/2013	11:10	1.22
SCC03	South Center Cove, Upper Union Lake	39.43557	75.06746	5/15/2013	12:20	0.91
NCC04	North Center Cove, Upper Union Lake	39.4363	75.0675	5/15/2013	13:00	0.91
SWC05	Southwest Cove, Lower Union Lake	39.40059	75.05631	5/15/2013	16:05	4.47
NWC06	Northwest Cove, Upper Union Lake	39.43228	75.06872	5/15/2013	17:30	0.91
NWC07	Northwest Cove, Upper Union Lake	39.43142	75.06884	5/15/2013	17:50	0.91
DAM08	Near Union Lake Dam	39.4018	75.05557	5/16/2013	10:00	6.10
DAM09	Near Union Lake Dam	39.40176	75.05539	5/16/2013	10:30	6.10
UBW10	Union Lake Backwater, Maurice River	39.44312	75.06983	5/16/2013	12:10	0.61
ALM11	Almond Beach, Maurice River	39.4969	75.07788	5/16/2013	15:10	0.76
ALM12	Almond Beach, Maurice River	39.49702	75.07729	5/16/2013	16:13	0.61
ALM13	Almond Beach, Maurice River	39.49625	75.07615	5/16/2013	16:56	0.30
ALL14	Alliance Beach, Maurice River	39.5021	75.07936	5/16/2013	17:53	0.61
ALL15	Alliance Beach, Maurice River	39.5016	75.07943	5/16/2013	18:11	0.41

* Water depths are as recorded during core extractions and are not referenced to any datum.

Figure 1. Local-scale map of coring locations in Upper Union Lake.

Figure 2. Local-scale map of coring locations in Lower Union Lake.

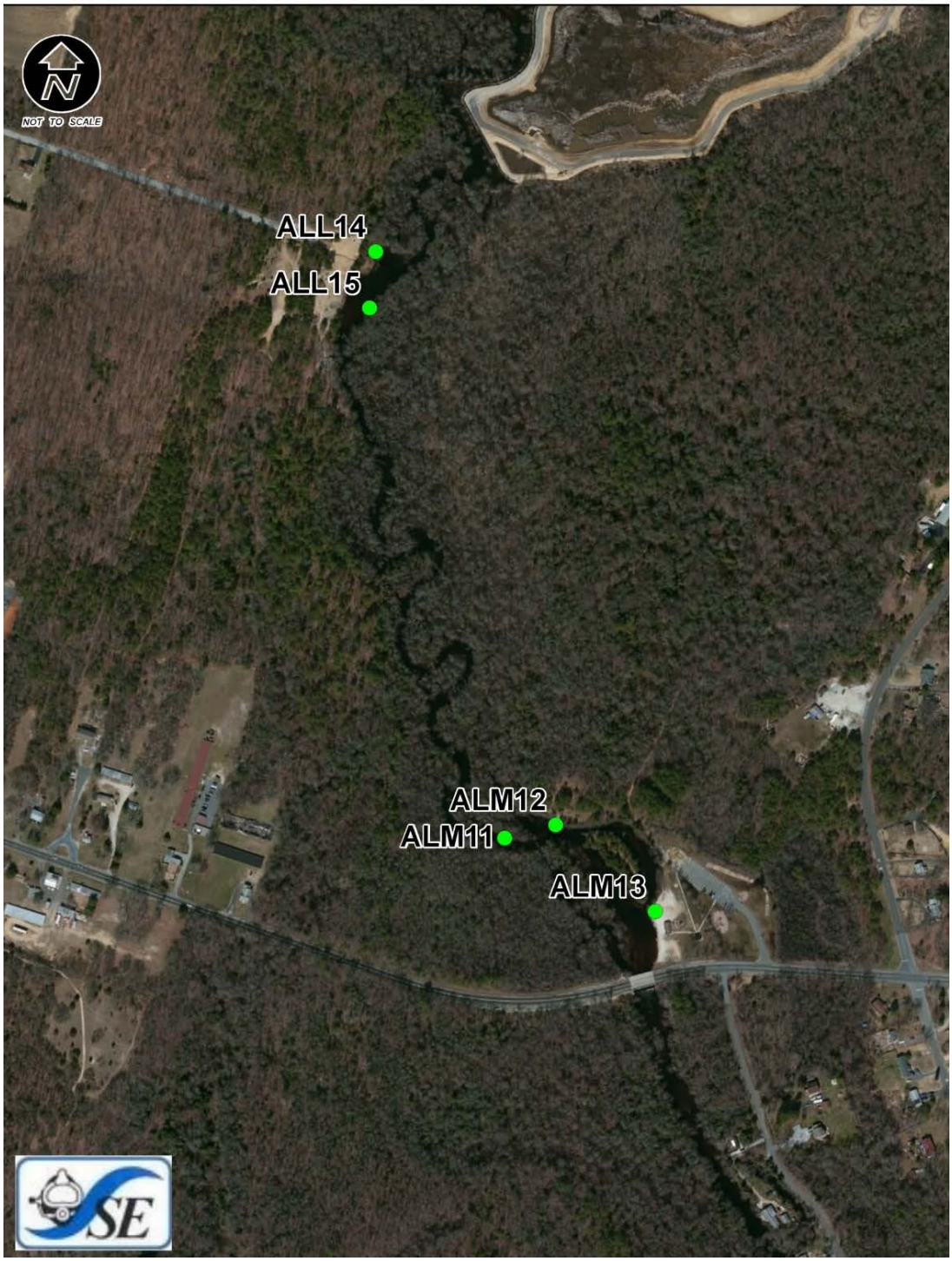

Figure 3. Local-scale map of coring locations in Maurice River.

1.3 Experimental Procedures

A detailed description of Sedflume analysis and its application are given in McNeil et al. (1996) and Roberts et al. (1998). The following sections supplement those reports with a general description of the Sedflume analysis procedures conducted in this study.

1.3.1 Description of Sedflume Setup

A Sedflume is essentially a straight flume with an open bottom section through which a rectangular cross-section core barrel containing sediment can be inserted (schematic shown in Figure 4). The main components of the flume are the water tank, pump, inlet flow converter (which establishes uniform, fully-developed, turbulent flow), the main duct, test section, hydraulic jack and the core barrel containing sediment (Figure 5). The core barrel, test section, flow inlet section, and flow exit section are made of transparent acrylic so the sediment-water interactions can be observed visually. The core barrel has a rectangular cross-section, 10 cm by 15 cm, and a length of 60 cm.

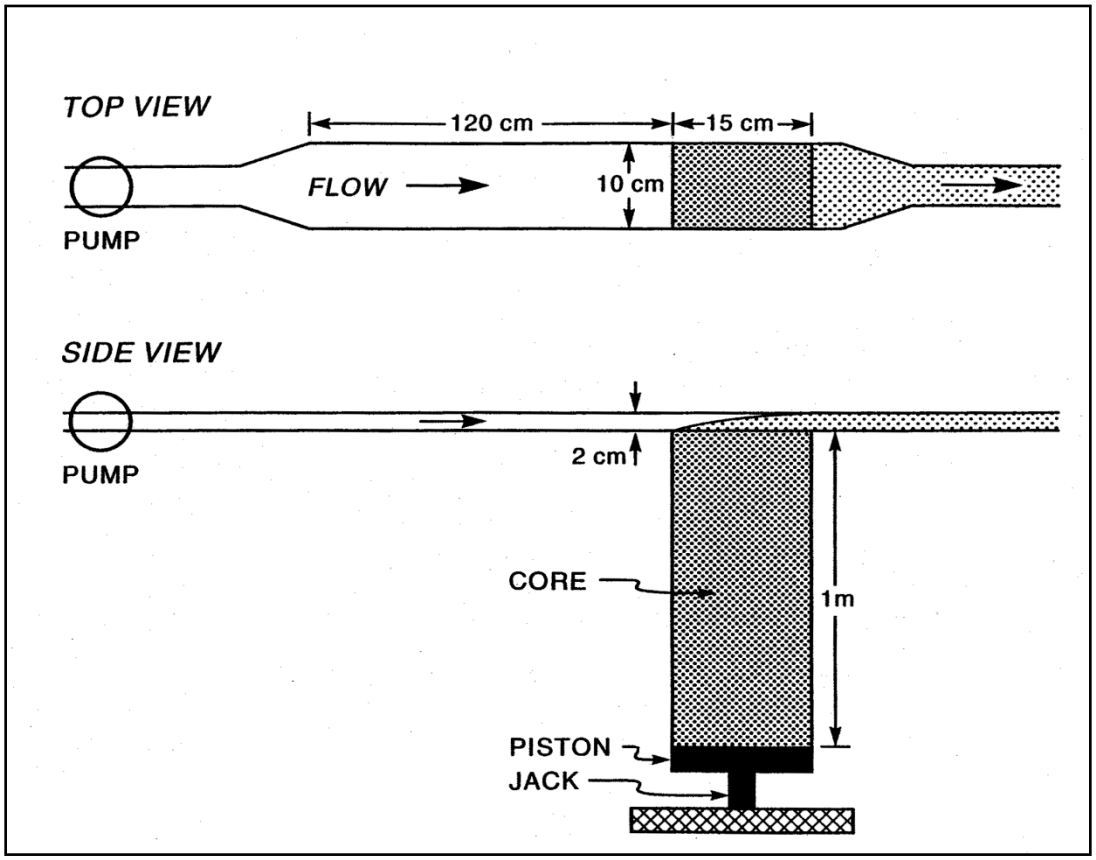

Figure 4. Schematic of the Sedflume setup showing top and side views.

Water is pumped through the system from a 300-gallon storage tank, through a 5 cm diameter pipe, and then through the flow converter into the main duct. This duct is

rectangular, 2 cm in height, 10 cm in width, and 120 cm in length; it connects to the test section, which has the same cross-sectional area (2 cm by 10 cm) and is 15 cm long. The flow converter changes the shape of the cross-section from circular to rectangular while maintaining a constant cross-sectional area. A ball valve regulates the amount of water entering the flume so that the flow rates can be carefully controlled. The flume also has a small valve immediately downstream from the test section that is opened to prevent a pressure vacuum from forming and enhancing erosion.

At the start of each test, a core barrel and the sediment it contains are inserted into the bottom of the test section. The sediment surface is aligned with the bottom of the Sedflume channel. When fully enclosed, water is forced through the duct and test section over the surface of the sediment. The shear stress produced by the flow, and imparted on the particles, causes the sediment to erode. As the sediment on the surface of the core erode, the remaining sediments in the core barrel are slowly moved upward so that the sediment-water interface remains level with the bottom of the flume.

An operator moves the sediment upward using a piston that is inside the core barrel and is controlled by a hydraulic jack with a 1m drive stroke. The jack is driven by the release of pressure that is regulated with a switch and valve system. In this manner, the sediments can be raised and made level with the bottom of the test section. The movement of the hydraulic jack can be controlled for measurable increments as small as 0.5 mm.

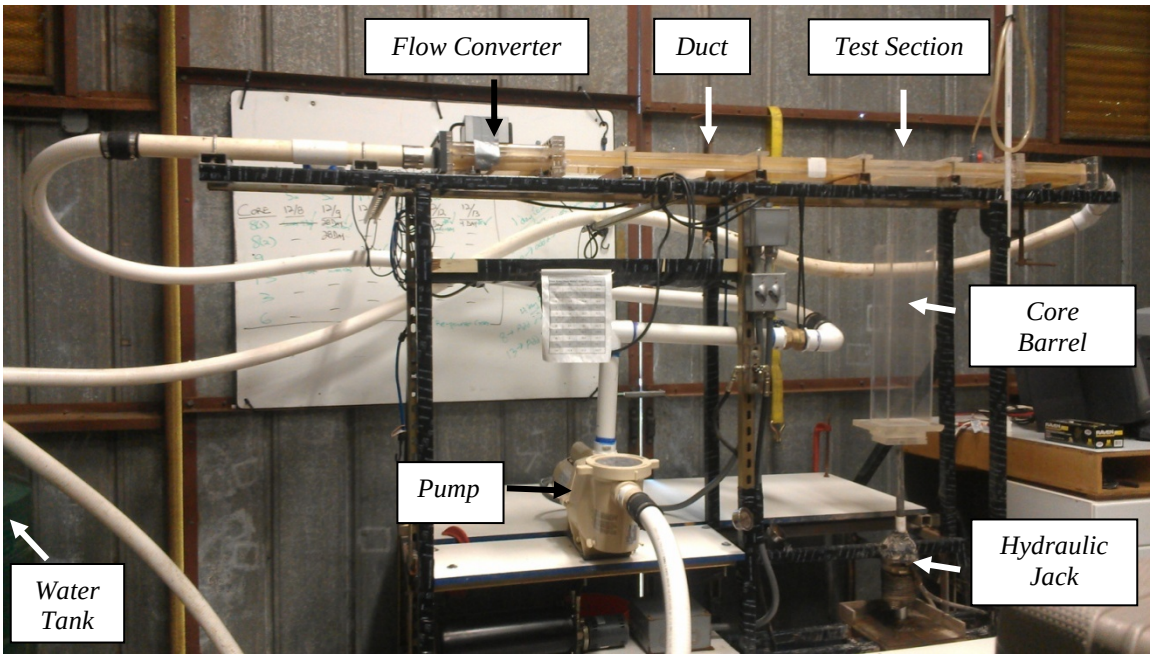

Figure 5. Sedflume in the Santa Cruz, CA, SEI laboratory.

1.3.2 Measurements of Sediment Erosion Rate

At the start of each core analysis an initial reference measurement was made of the starting core length. The flume was then operated at a specific flow rate corresponding to a particular shear stress, and sediment was eroded (McNeil et al., 1996). As erosion proceeded, the core was raised if needed to keep the core's surface level with the bottom of the flume. This continued until 10 minutes had passed, or the core had been raised roughly 2 cm. The erosion rate for the applied shear stress was then calculated as:

$$E = \frac{\Delta z}{T} \qquad [1]$$

E = Erosion rate
Δz = Amount that the sediment was raised during a particular measurement period
T = Measurement time interval

Because material is eroded and the core structure is broken down, repetitive erosion measurements at a given depth are not possible. To best determine the erosion rate at several different shear stresses and depths using only one core, the following procedures were performed for all cores:

1) The core was inserted into the bottom of the Sedflume test section.
2) The total length of sediment in the core barrel was measured and recorded.
3) Two 5-gram (approximately) subsamples of sediment from the core's surface were collected using a clean spoon. Sediment sampling was constrained to the "downstream" (relative to the Sedflume flow direction) end of surface.
4) Various shear stresses where applied to the cores surface from low to high, and sediment erosion was measured if it occurred (0.5 mm of erosion in 10 minutes was considered quantifiable). Applied shear stresses started at 0.1 Pa, and sequentially doubled until a given shear stress caused roughly 2 cm of erosion in 20 seconds. Each shear stress cycle was applied for a minimum of 20 seconds and a maximum of 10 minutes. To the extent possible, no more than 2 cm of sediment was allowed to erode at a single shear stress.
5) Once the threshold of 2 cm of erosion in 20 seconds was met, a new depth interval was started. Steps 3 and 4 were repeated[1]. Also, if the sediment composition changed noticeably in appearance or erosion properties, the depth interval was stopped, sediment sub-samples were collected, and a new depth interval was started (step 4).
6) Up to five depth intervals were tested per core.

[1] If a particular shear stress did not cause any observable erosion over a 10 minute period for consecutive depth intervals (e.g. less than 0.5 mm eroded in 10 minutes), that shear stress was removed from subsequent testing cycles; higher shear stresses were added, as appropriate, to attempt to measure at least 3 erosion rates.

1.3.3 Determination of Critical Shear Stress

The critical shear stress of a sediment bed, τ_{cr}, is the applied shear stress at which sediment motion is initiated. In this study it is operationally defined as the shear stress required to produce 0.001 mm of erosion in 1 second. This represents an erosion rate of 10^{-4} cm/s, or roughly 1 mm of erosion in 15 minutes[2].

Since it is difficult to measure τ_{cr} exactly at the 10^{-4} cm/s threshold, erosion was instead measured over a range of shear stresses designed to bracket the initiation of erosion threshold. The highest applied shear stress where erosion *did not occur* is defined by τ_{no}; and τ_{first} is the lowest applied shear stress where erosion *did occur*.

Using the measured erosion rate data in each depth interval, a power law regression (described below) analysis was employed to determine the shear stress (τ_{power}) required to cause 10^{-4} cm/s of erosion. Assimilating the bracketed shear stress values (τ_{no} and τ_{first}) and τ_{power}, the critical shear stress of each interval was then chosen according to the set of criteria described below:

- If $\tau_{no} \leq \tau_{power} \leq \tau_{first}$, then τ_{power} was the selected critical shear stress, τ_{cr}, for the interval
- If $\tau_{no} \geq \tau_{power}$, then τ_{no} was the selected critical shear stress for the interval
- If $\tau_{power} \geq \tau_{first}$, then τ_{first} was the selected critical shear stress for the interval

where τ_{no} and τ_{first} are determined directly from the Sedflume measurements. The τ_{cr} criteria defined above allowed for selection of critical shear stresses using the power law results where the regression analysis was in agreement with measured erosion rate data.

Power Law Regression

Following the methods of Roberts et al. (1998), the erosion rate for sediments can be approximated by the power law regression:

$$E = A\tau^n \rho^m \qquad [2]$$

E = erosion rate (cm/s)
τ = bed shear stress (Pa)
ρ = sediment bulk density (g/cm^3)
A, n and m = constants that depend on the sediment characteristics

The equation used in the present analysis is an abbreviated variation of Equation 2:

$$E = A\tau^n \qquad [3]$$

[2] Though other definitions of critical shear stress erosion rate thresholds can be argued (and considered valid), the value of 10^{-4} cm/s threshold is used here for consistency with previous Sedflume efforts and in order to keep testing times to a practical duration.

where the constant, *A*, is a function of the sediment bulk density and other difficult properties to measure such as sediment geochemistry and biological influences. The variation of erosion rate with density typically cannot be determined for field sediments due to natural variation in other sediment properties (e.g. mineralogy, particle size and electrochemical forces). Therefore, the density term from the equation above, for a particular interval of approximately constant density, is incorporated into the constant *A*.

For each depth interval, the measured erosion rates (*E*) and applied shear stresses (τ) were used to determine the *A* and *n* constants that provide a best fit power law curve to the data for that interval. Good regression fits of these parameters, where they existed, were then used to estimate the critical shear stress for the respective intervals. A coefficient of determination, r^2, of 0.80 was used as a criteria threshold for acceptance[3].

1.3.4 Measurement of Sediment Bulk Properties

In addition to measuring erosion rates during the analysis, sediment sub-samples were periodically collected at depth to determine the water content (for wet bulk density), particle size distribution, and loss on ignition of the sediments in each core. Sub-samples were collected from the undisturbed core surface (prior to analysis) as well as the sediment surface at the beginning of each subsequent depth interval.

Wet bulk density was determined by water content analysis using methods outlined in Hakanson and Jansson (2002). This was accomplished, first, by measuring the wet and dry weight of the collected sample to determine the water content (*W)* as described in the ASTM standard 2216-05:

$$W = \frac{M_w - M_d}{M_w} \qquad [4]$$

W = water content
M_w = wet weight of sample
M_d = dry weight of sample

Once the water content was calculated, the wet bulk density, ρ_b, was determined from Equation 5:

$$\rho_b = \frac{\rho_w \rho_s}{\rho_w + (\rho_s - \rho_w)W} \qquad [5]$$

ρ_w = density of water (assumed 1 g/cm^3)

[3]The coefficient of determination, r^2, is a function of the *Pearson's r,* which is a measure of the linear dependence (correlation) between two variables. *Pearson's r* can be positive or negative, and is a value between -1 and +1. The more common usage of the correlation coefficient is to square the *Pearson's r*, r^2, and report that value, the coefficient of determination.

ρ_s = density of sediment particle (assumed 2.65 g/cm^3)

Particle size distributions were determined using laser diffraction analysis in the SEI laboratory in Santa Cruz. Sediment samples were dispersed in water and inserted into a Beckman Coulter LS 13 320 laser diffraction particle analyzer. Each sample was analyzed in three 1-minute intervals and the results of the three analyses were averaged.

Loss on ignition *(LOI)* was determined following ASTM D2974 Version C. Samples were first dried in the SEI Laboratory oven to remove moisture (following ASTM 2216-05 recommendations). Then, the samples were placed in a furnace and ignited at 440° C until the mass remained constant (typically 24 hours). The change in mass before and after indicates the fraction of combustible substances within each sub-sample, and can be used qualitatively to evaluate the organic versus inorganic fraction within each:

$$LOI = \frac{M_d - M_{d,combustion}}{M_d} \qquad [6]$$

M_d = dry weight of sample
$M_{d,\ combustion}$ = dry weight of sample after combustion

The relationships used to determine sediment bulk properties are summarized in Table 2.

Table 2. Parameters measured and computed during the Sedflume analysis.

Measurement	Definition	Units	Detection Limit	Internal Consistency
Water Content	$W = \frac{M_w - M_d}{M_w}$	unit-less	0.001 g in sample weight ranging from 1 to 50 g	0 < W < 1
Wet Bulk Density	$\rho_b = \frac{\rho_w \rho_s}{\rho_w + (\rho_s - \rho_w)W}$	g/cm^3	Same as water content	$\rho_w < \rho_b < 2.6\rho_w$
Particle Size Distribution Below 2000 µm	Distribution of particle sizes by volume percentage using laser diffraction	µm	Method Specific	1µm<Grain Size<2000µm
Loss on Ignition	$LOI = \frac{M_d - M_{d,combustion}}{M_d}$	unit-less	Same as water content	Wet and dry mass of sample

W_d = dry weight of sample
Mw = wet weight of sample
Md, combustion = dry weight of sample after combustion
ρ_w = density of water (assumed 1 g/cm^3)
ρ_s = density of sediment particle (assumed 2.65 g/cm^3)

1.3.5 Intra-core and Inter-core Comparisons

A potentially useful method of comparing sediment characteristics at a specific site is to compute *intra*-core and *inter*-core erosion rates. This method provides a means to quantify the erosion rates within each core (intra-core) as well as the general erosion rates of the cores at the site (inter-core).

Intra-core Erosion Rate Ratios

Once the power law regression *A* and *n* coefficients for each depth interval within an individual core were known, the *interval-average* erosion rate for the core was determined using Equation 3 and the logarithmic average of the range of shear stresses tested in the Sedflume analysis[4]. C*ore-average* erosion rates were then computed by:

1) Log-averaging the *A* coefficient values from each depth interval within a core to arrive at an average *A* coefficient for the entire core.
2) Arithmetically averaging the *n* coefficient values from each depth interval within a core to arrive at an average *n* coefficient for the entire core.
3) Solving for the *core-average* erosion rate following Equation 3 and using the log-average of the range of shear stresses applied to the depth interval (1.13 Pa).

An <u>intra-core</u> erosion rate *ratio* was then defined by dividing the *interval-average* erosion rate by the *core-average* erosion rate, providing a quantitative estimation of the relative erosion susceptibility of each depth interval. This method highlights the core intervals that are more or less susceptible to erosion within a particular core, and may indicate layering within a core. Intervals for which the coefficient of determination of the power law regression fit, r^2, was less than 0.80 were omitted from the comparison and the corresponding bar plots and tables.

Inter-core Erosion Rate Ratios

Two additional ratios were computed to evaluate large-scale spatial erosion susceptibility. An <u>inter-core</u> erosion rate ratio was computed by comparing the individual *core-average* erosion rate with a *site-wide average* erosion rate. The *site-wide average* erosion rate was computed by:

1) Log-averaging the *core-average A* coefficient values from each core to arrive at an average *A* coefficient for the entire site.
2) Arithmetically averaging the *core-average n* coefficient values in each core to arrive at an average *n* coefficient for the entire site.
3) Solving for the *site-wide average* erosion rate following Equation 3 and using the log-average of the range of shear stresses (1.13 Pa).

[4]The shear stress values averaged were: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4 and 12.8 Pa. The logarithmic average of these, used to compute erosion rate ratios, was 1.13 Pa.

The *inter-core* erosion rate ratio computed in this manner provided a qualitative estimate of the erosion susceptibility of each core (as a whole) relative to other cores in the site, potentially indicating spatial locations that are more or less susceptible to erosion than other locations.

Section 2
Results

This section of the report contains both qualitative and quantitative findings from the Sedflume analysis. Results will be presented on a core-by-core basis. Although median particle size data are presented here, Appendix A contains additional grain size statistics and distribution plots.

2.1 NEC01

Core NEC01 was collected in 1.22 m of water from the northeastern part of Upper Union Lake. The core comprised brown silt mixed with organic material. Although the sediment was predominantly brown throughout, the shade changed with depth. The top 0.5 to 1.0 mm of the core contained a low density flocculation layer that was rustic brown in color. Below this surface layer, the core was lighter in color and more compact but still low in density. These characteristics extended to roughly 4 cm, where the color turned to dark brown. The sediment was mottled with sticks and leaves throughout. Several small void spaces were observed at depths between 15 and 20 cm.

A photograph of core NEC01 aligned vertically with the corresponding erosion rate data is presented in Figure 6. An erosion rate of 10^{-5} cm/s is considered incapable of mobilizing sediment (this holds in all erosion rate plots). The sediment surface (depth = 0) is plotted at the top of all graphs, with depth into the sediments increasing down the Y-axis. Shear stresses ranging between 0.1 Pa and 1.6 Pa were applied to the core. Vertical profiles of bulk density and median particle size (d_{50}) are presented in Figure 7. Only two intervals (instead of five) were analyzed in core NEC01 because, upon processing, the core was fractured and leaked water from its bottom during the analysis. However, after the second interval, a sediment grab was taken to determine bulk density and grain size, leading to the three data points seen in Figure 7.

Erosion rates slightly decreased with depth in core NEC01 (Figure 6). In general however, the core contained very soft, relatively unconsolidated sediment. The organic material present in the core made processing difficult at times; the sediment would resist erosion until a threshold value, then fracture and mobilize as organic material pulled from the surface. Layers (2 to 3 cm) of sediment sucked into the flume during the analysis at depths of roughly 8 and 15 cm. As mentioned, testing was stopped prematurely because water leaked from the core's bottom. The core contained a low average critical shear stress of 0.12 Pa (Table 4). Bulk densities, medium particles sizes, organic fractions, and relevant shear stress values (τ_{power}, τ_{no}, τ_{first}, and τ_{crit}) are presented in Table 4, and power law fit parameters are presented in Table 3.

The median particle sizes in NEC01 remained between 21.85 and 24.95 μm (Figure 7), which is within the medium silt range according to the Wentworth Size Classification

(Wentworth Size Classification was used in all grain size determination). Bulk densities were low for NEC01, never exceeding 1.05 g/cm^3.

Intra-core erosion rate ratios of tested intervals in NEC01 are shown in Figure 8. The numbers plotted on the y-axis of all erosion rates plots represent interval (shear stress cycles) starting depths. The vertical dashed line denotes an erosion rate ratio of 1.0. Ratios to the right of the line indicate intervals that are more susceptible to erosion than ratios to the left, relative to the vertically averaged erosion rate of the entire core. Core NEC01 became more resistant to erosion with depth.

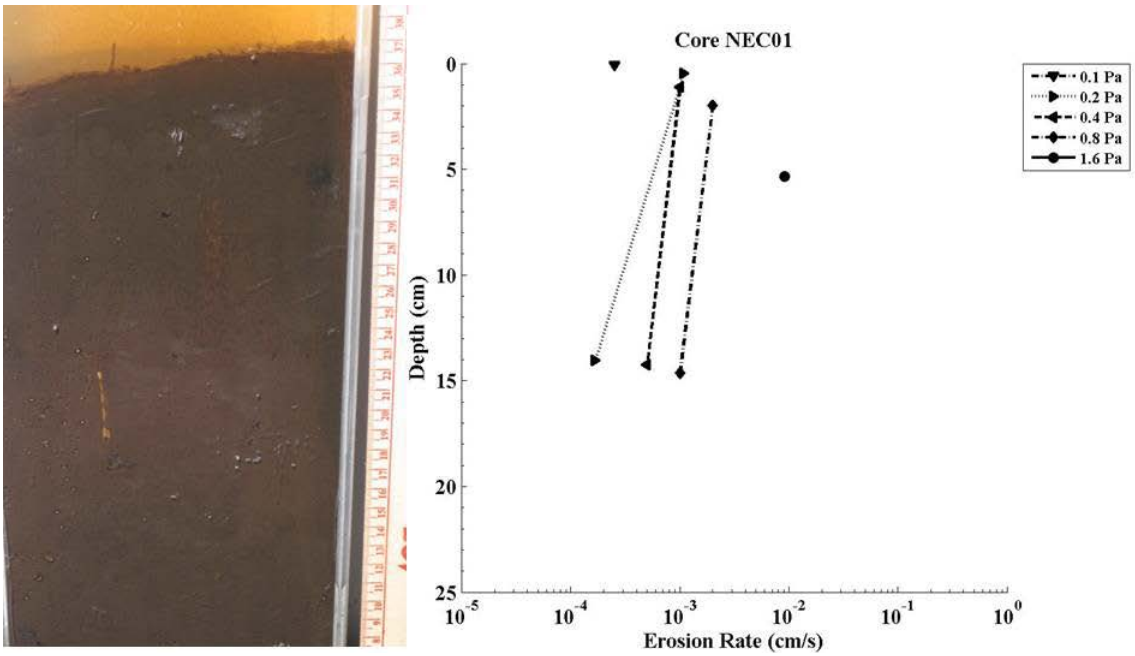

Figure 6. Photo of core NEC01 aligned vertically with the corresponding erosion rates.

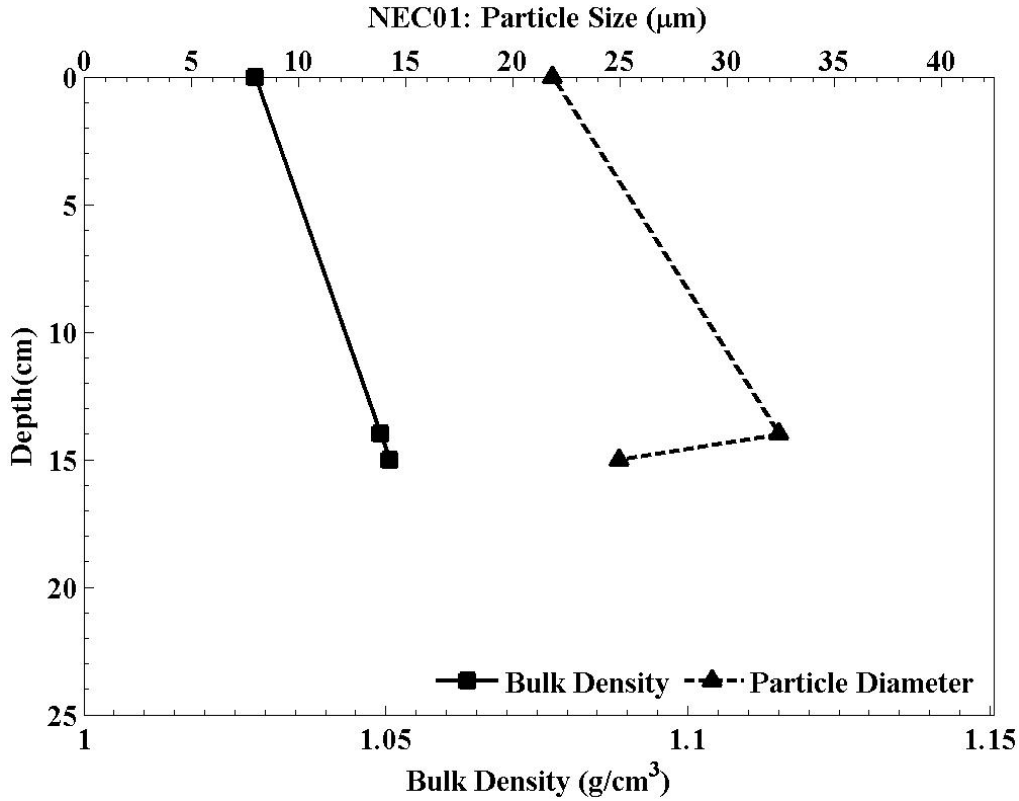

Figure 7. Bulk density and median particle size (d_{50}) with depth for core NEC01.

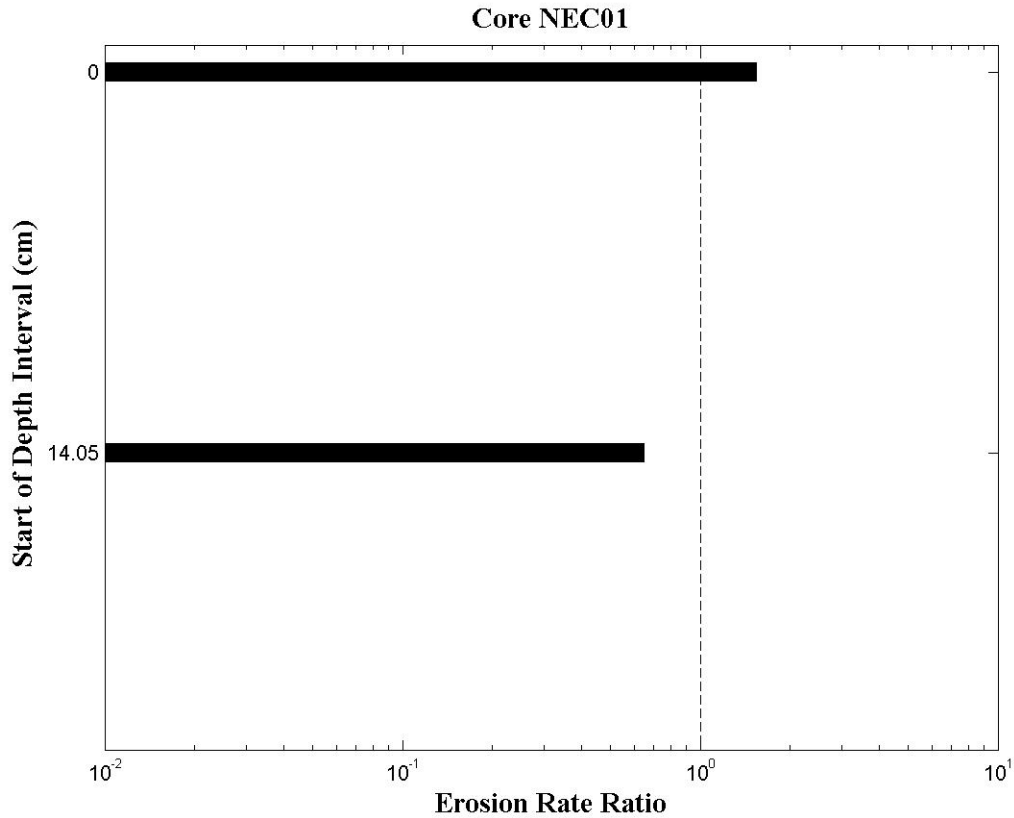

Figure 8. Intra-core erosion rate ratios for core NEC01. The dashed line indicts conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).

Table 3. Power law best-fit variables for specified depth intervals in core NEC01.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.1	5.4	0.00387	1.1	0.90
2	14.1	14.7	0.00143	1.3	0.98

Table 4. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core NEC01.

Depth (cm)	d_{50} (µm)	ρ_b(g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.0	21.85	1.03	0.04	0.04	n/a	0.1	0.10
14.0	32.44	1.05	0.02	0.13	0.1	0.2	0.13
15.0	24.95	1.05	0.02	n/a	n/a	n/a	n/a
Mean	**26.41**	**1.04**	**0.03**	**0.09**	**0.10**	**0.15**	**0.12**

2.2 NEC02

Core NEC02 was collected in 1.22 m of water in the northeastern corner of Upper Union Lake. The core contained a 1 cm low density flocculation layer that was grayish-green in color (color of flocculation layer does not show well in Figure 9). Below the flocculation layer was a sediment horizon of brown and tan silt that extended 9 to 10 cm deep. The second layer streaked vertically into a third sediment horizon that was distinguishable by a color change; the sediment darkened in color. Beneath the third layer was yet another change in sediment color, from dark brown to a reddish brown, which occurred at a depth of roughly 23 cm. Organic material was found mixed with the sediment throughout the core.

A photograph of core NEC02 is shown aligned vertically with its corresponding erosion rate data in Figure 9. Shear stresses ranging between 0.1 Pa and 1.6 Pa were applied to the core. No apparent depth trends can be deduced from the erosion rate data (Figure 9). Erosion throughout the core was uneven and patchy. Some regions on the test section would erode in clumps, while others held tight. Organic material appeared to influence erosion; when organic material was present it lifted from the test section and took chunks of sediment with it. The core's average *LOI* was 0.37. Intra-core erosion rates for core NEC02 are presented in Figure 11. The power law fit for the third interval had an r^2 value less than 0.8, so no intra-core erosion rate ratio was calculated for it, and no A and n values are presented for the third interval in Table 5. The cores average critical shear stress was 0.22 Pa.

Median particle sizes increased between the first and second interval from16.84 μm at the surface to 32.51 μm (Figure 10). The grain sizes then fluctuated with depth, leading to an average particle size of 29.17 μm. Bulk densities followed a similar trend, increasing over the first interval, and then fluctuating with depth.

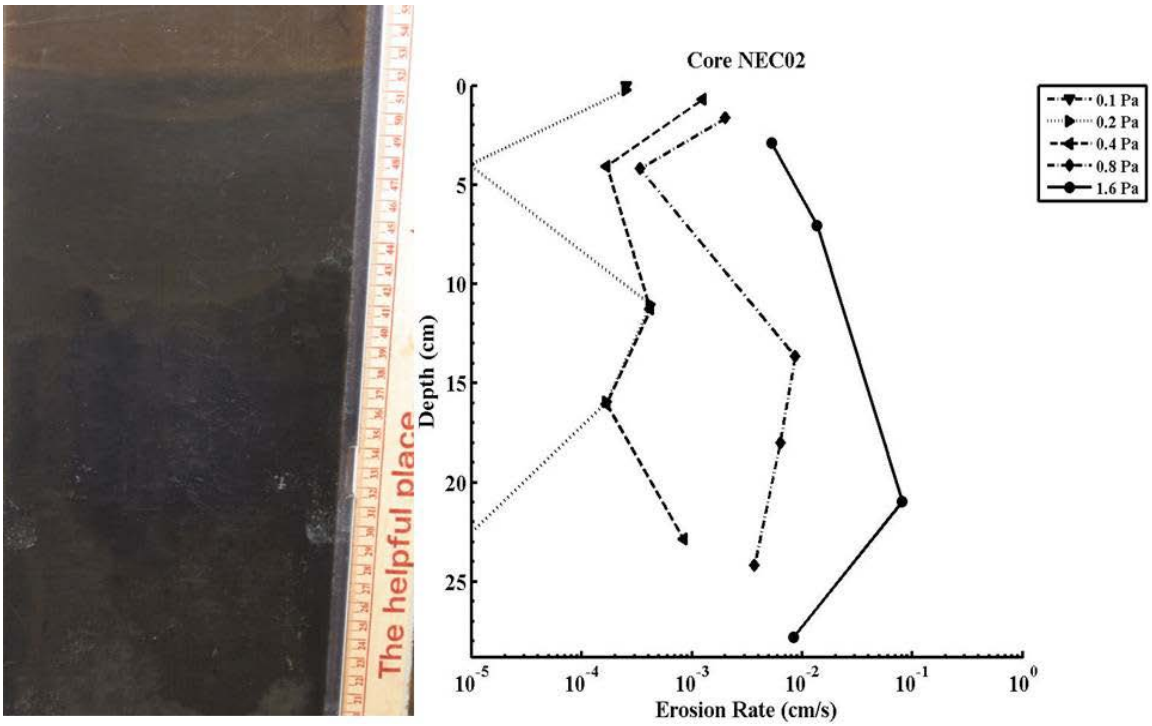

Figure 9. Photo of core NEC02 aligned vertically with the corresponding erosion rates.

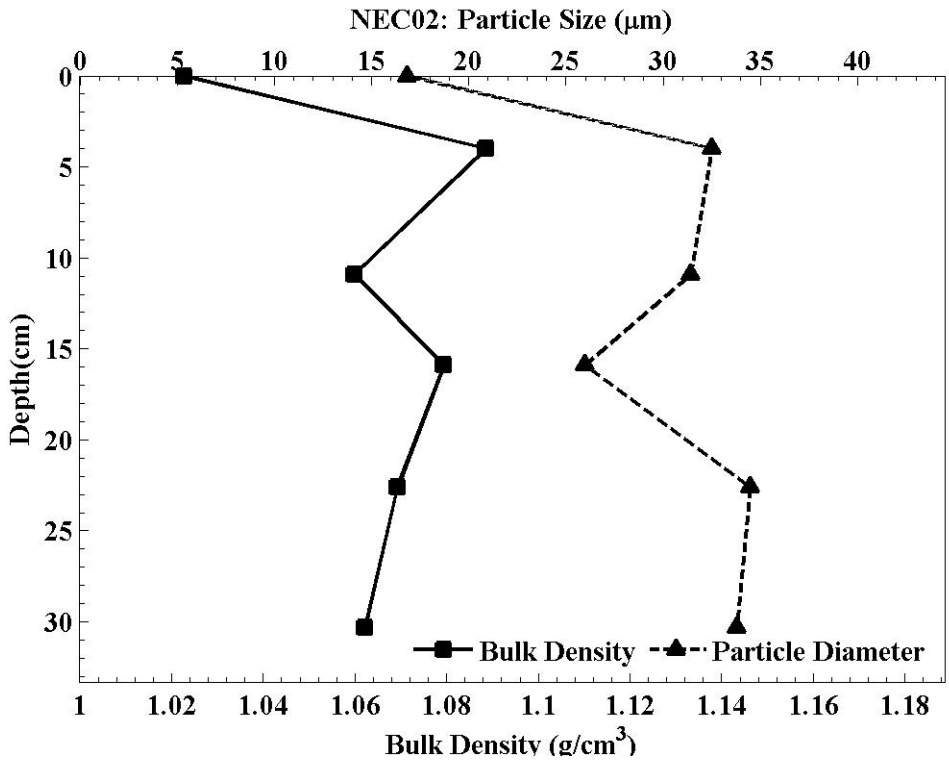

Figure 10. Bulk density and median particle size (d_{50}) with depth for core NEC02.

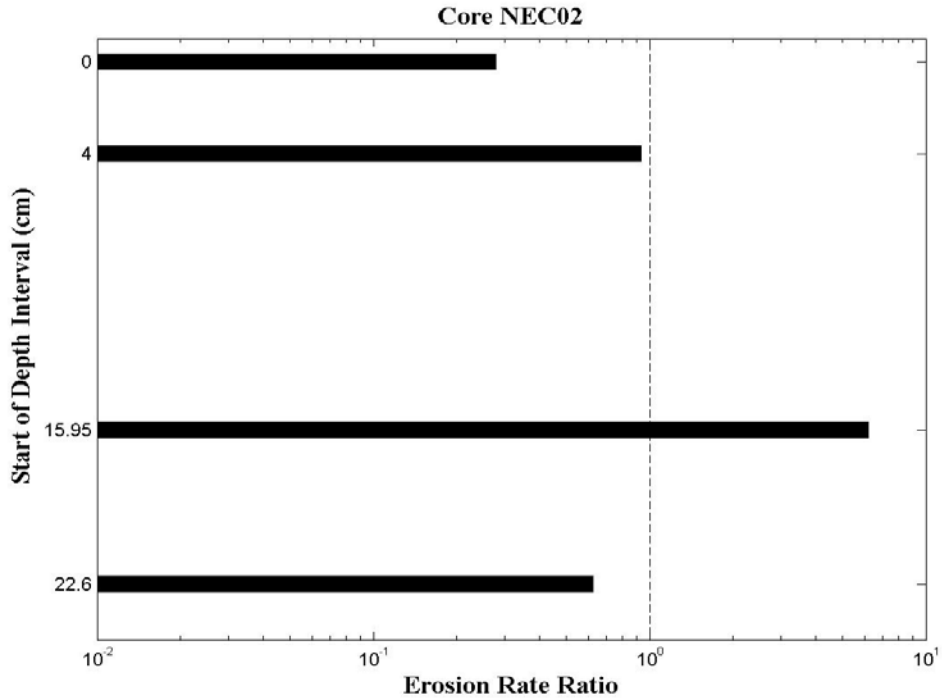

Figure 11. **Intra-core erosion rate ratios for core NEC02. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 5. Power law best-fit variables for specified depth intervals in core NEC02.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.1	2.9	0.00283	1.2	0.94
2	4.0	7.0	0.00185	3.2	0.86
3	11.0	13.7	n/a	n/a	0.75
4	16.0	21.0	0.01203	3.2	0.90
5	22.6	27.8	0.00426	1.7	0.97

Table 6. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core NEC02.

Depth (cm)	d_{50} (µm)	ρ_b(g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.0	16.84	1.02	0.38	0.06	n/a	0.10	0.10
4.0	32.51	1.09	0.36	0.40	0.20	0.40	0.40
10.9	31.43	1.06	0.37	n/a	n/a	0.20	0.20
15.9	25.96	1.08	0.37	0.22	n/a	0.20	0.20
22.6	34.48	1.07	0.36	0.10	0.20	0.40	0.20
Mean	**28.244**	**1.07**	**0.37**	**0.20**	**0.20**	**0.26**	**0.22**

2.3 SCC03

Core SCC03 was collected in 0.91 m of water in the center cove of Upper Union Lake. The first 3 cm of the core comprised silt mixed with organic material and some sand. A low density flocculation layer rested on the core's surface (roughly 5 mm), with sticks and vegetation protruding from the surface. Down core, the organic fraction increased. By a depth of 5 cm, sediment was bound by tightly packed roots. Roots were encountered throughout the remainder of the analysis, requiring removal by hand several times.

A photograph of core SCC03 aligned vertically with the corresponding erosion rate data is presented in Figure 12. Shear stresses ranging between 0.1 Pa and 12.8 Pa were applied to the core. Erosion was highly effected by the presence of roots; sediment slowly mobilized from matted roots, while the roots themselves held tight. At the end of each interval, roots were carefully removed from the cores test section so processing could proceed. Between depths of roughly 18 cm and 24 cm, roots were so tightly packed that processing was impossible. The roots and sediment they bound would hold in place until the shear stress became large enough to lift the entire root system into the flume. Assigned critical shear stress values remained between 0.17 Pa and 0.26 Pa for all intervals except the last, which had a critical shear stress of 1.78 Pa. The core's average critical shear stress was 0.48 Pa. Erosion rate ratios decreased with depth as the sediment became trapped by matted roots.

Median particle sizes generally decreased with depth, averaging in the median silt range at 22.91 μm (Figure 13 and Table 8). Bulk density followed an opposite pattern and decreased with depth, averaging to 1.12 g/cm^3 (Table 15 and Table 8). The decrease in bulk density was likely caused by an increase in organic material. *LOI* increased from 0.22 at the surface, to 0.89 at a depth of 17.5 cm. Because of the high density of roots, the *LOI* was high.

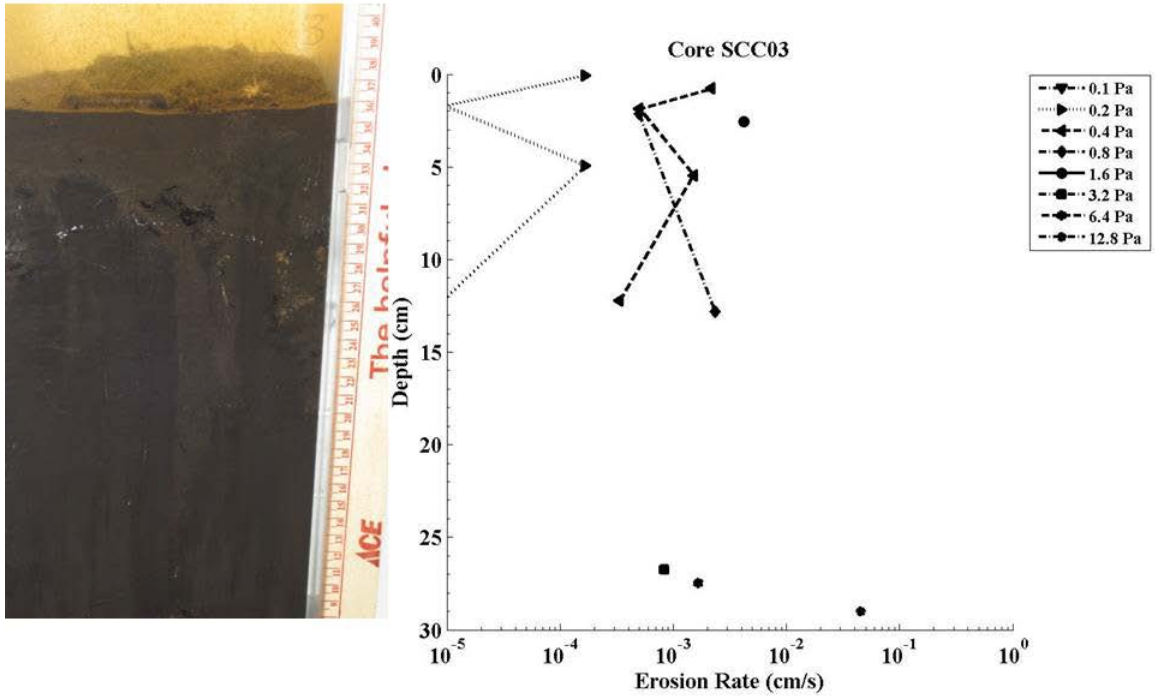

Figure 12. Photo of core SCC03 aligned vertically with the corresponding erosion rates.

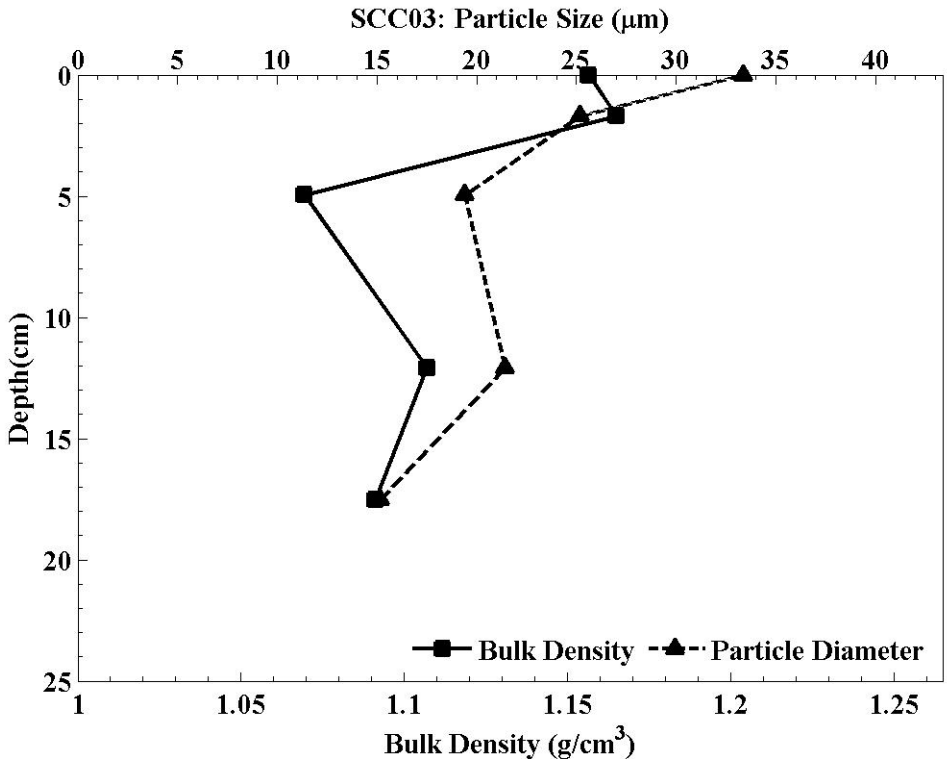

Figure 13. Bulk density and median particle size (d_{50}) with depth for core SCC03.

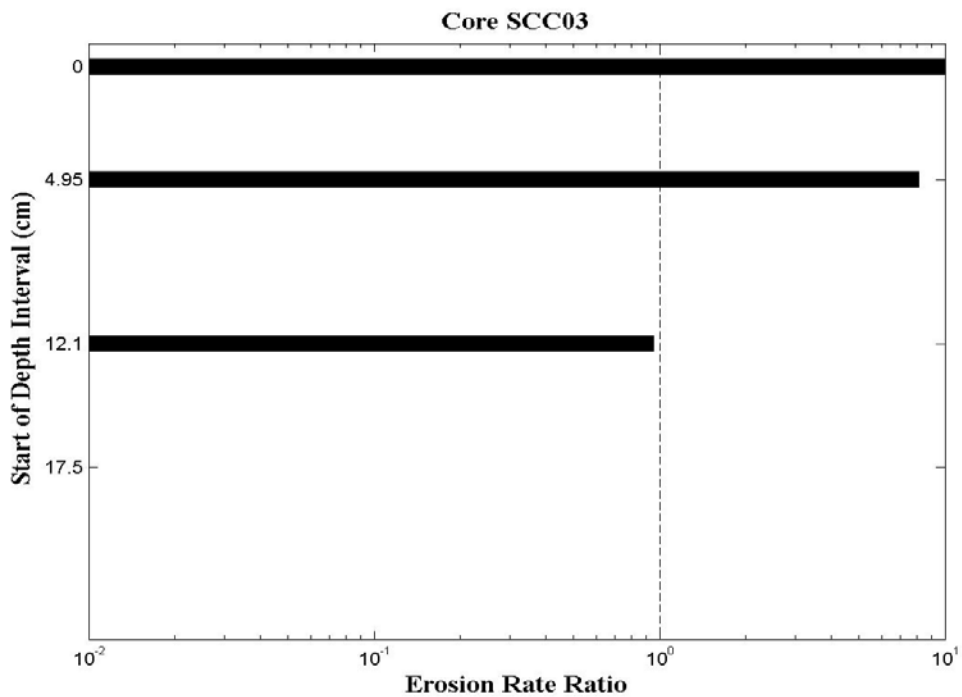

Figure 14. **Intra-core erosion rate ratios for core SCC03. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 7. Power law best-fit variables for specified depth intervals in core SCC03.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.0	0.8	0.06432	3.7	1.00
2	1.7	2.6	n/a	n/a	0.75
3	4.9	5.4	0.02739	3.2	1.00
4	12.1	12.9	0.00436	2.8	1.00
5	17.5	29.0	0.00002	2.9	0.88

Table 8. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core SCC03.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.0	33.37	1.16	0.22	0.17	0.10	0.20	0.17
1.7	25.17	1.16	0.24	n/a	0.20	0.40	0.20
5.0	19.42	1.07	0.83	0.17	n/a	0.20	0.17
12.1	21.44	1.11	0.90	0.26	0.20	0.40	0.26
17.5	15.17	1.09	0.89	1.78	1.60	3.20	1.78
Mean	**22.91**	**1.12**	**0.62**	**0.60**	**0.53**	**0.88**	**0.48**

2.4 NCC04

Core NCC04 was collected in 0.91 m of water in the center cove of Upper Union Lake. A 0.5 cm reddish brown flocculation layer rested on the cores surface. Below the surface layer was dark to medium brown silt. A horizon of brown silt mixed with a high fraction of tan colored sand was observed between roughly 5 and 10 cm. At depths greater than 10 cm, the sand content decreased and the silt colored darkened. At roughly 24 cm, a second sandy silt horizon was observed. Organic material was found interspersed in the sediment throughout the core. Several void (1 to 2 cm in diameter pockets) spaces in the sediment were also encountered between depths of roughly 14 and 16 cm.

A photograph of core NCC04 aligned vertically with the corresponding erosion rate data is presented in Figure 15. Shear stresses ranging between 0.1 Pa and 6.4 Pa were applied to the core. Erosion rates decreased with depth to roughly 20 cm; below this depth a more easily erodible horizon was encountered. The organic material that was interspersed in the sediment often caused clumps of sediment to mobilize while erosion was occurring. When clump erosion did occur, it often left pits or scour holes on the cores surface. The cores average critical shear stress was 0.29 Pa.

Median particle sizes and bulk densities followed a very similar trend with depth in core NCC04; both increased significantly over the first 5 cm as the silty sand horizon was encountered (Figure 16).The average median particle size and bulk density were 91.28 μm (fine to medium sand), and 1.25 g/cm^3 (Table 9). The sand encountered throughout the core appeared to be light colored siliceous sand. The loss on ignition fluctuated between 0.14 and 0.48.

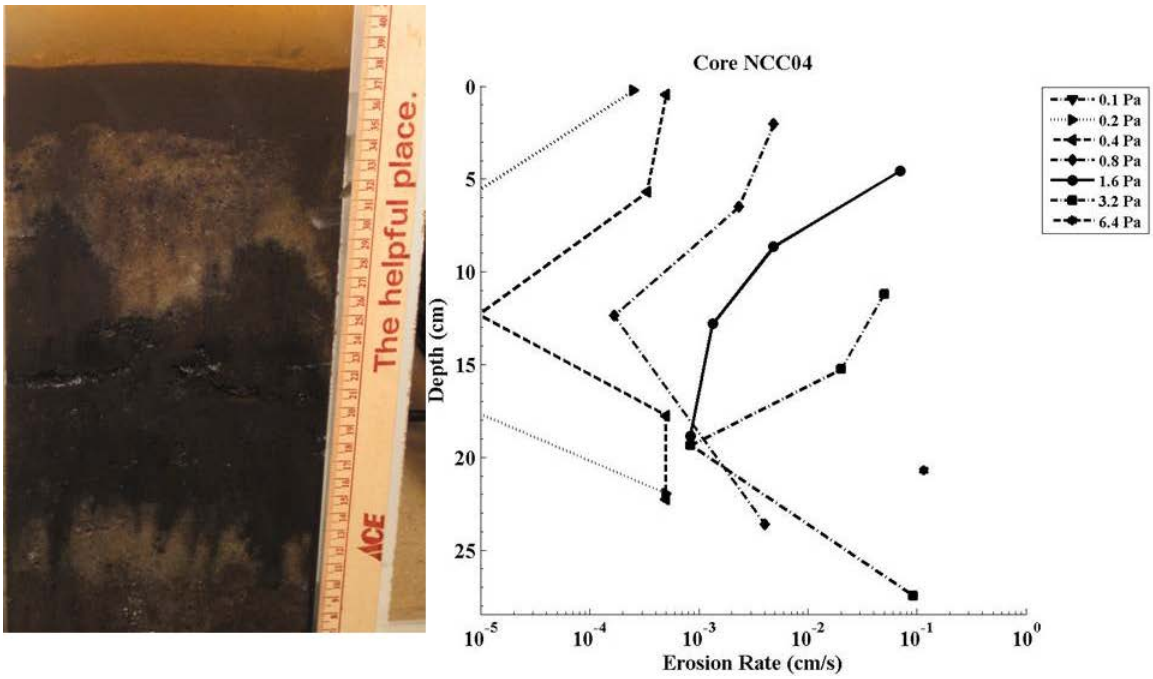

Figure 15. Photo of core NCC04 aligned vertically with the corresponding erosion rates.

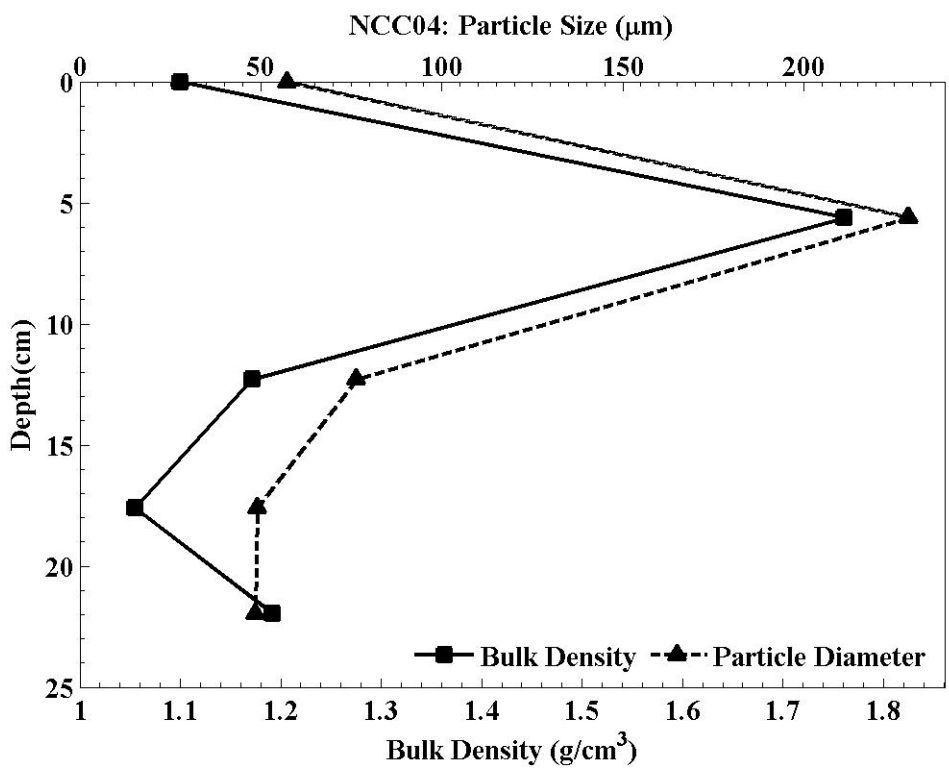

Figure 16. Bulk density and median particle size (d_{50}) with depth for core NCC04.

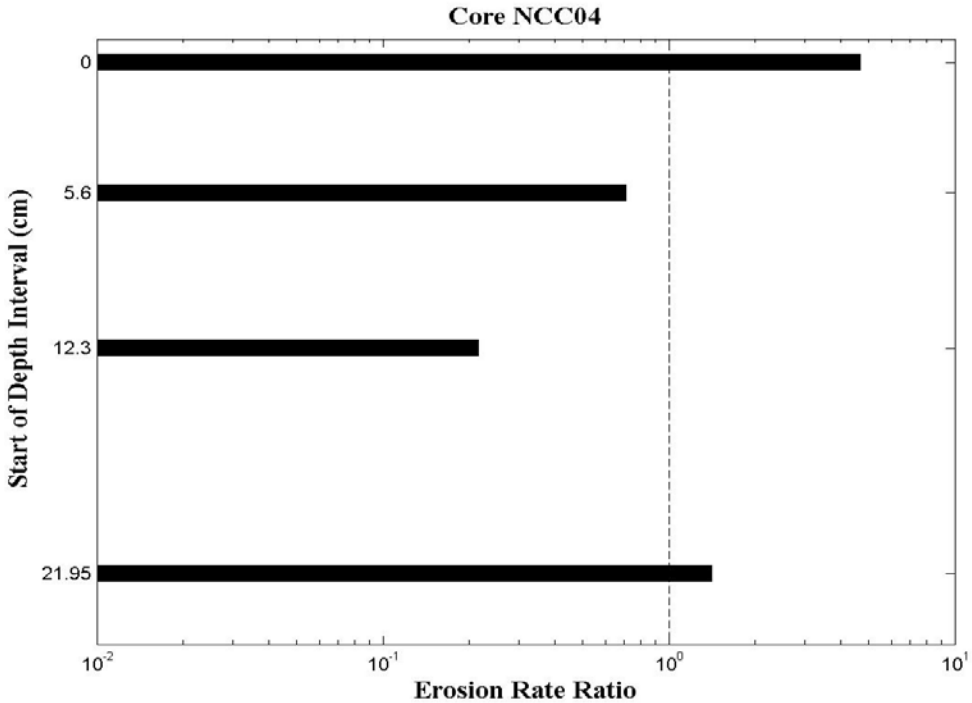

Figure 17. Intra-core erosion rate ratios for core NCC04. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).

Table 9. Power law best-fit variables for specified depth intervals in core NCC04.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.0	4.60	0.01233	2.80	0.95
2	5.6	11.2	0.00280	2.30	0.97
3	12.3	15.3	0.00032	3.50	0.99
4	17.6	20.7	n/a	n/a	0.55
5	22.0	27.5	0.00689	2.00	0.94

Table 10. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core NCC04.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	57.1	1.1	0.26	0.18	0.10	0.20	0.18
5.60	228.9	1.76	0.18	0.23	0.20	0.40	0.23
12.3	76.38	1.17	0.17	0.71	0.40	0.80	0.71
17.6	49.03	1.05	0.48	n/a	0.20	0.40	0.20
22.0	48.51	1.19	0.14	0.12	n/a	0.20	0.12
Mean	**91.98**	**1.25**	**0.24**	**0.31**	**0.23**	**0.40**	**0.29**

2.5 SWC05

Core SWC05 was collected in the southwest cove of Lower Union Lake in 4.47 m of water. The core consisted of silt and fine sand with a very thin flocculation layer on the surface that was tan and light gray. Dark gray striations were observed on the cores edge. Small-in-diameter organic stalks protruded from the surface. No horizons were observed in the core below the flocculation layer.

A photograph of core SWC05 is presented in Figure 18 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 3.2 Pa were applied to the core. Erosion rates generally decreased with depth into the core (Table 21). This trend is further illustrated in Figure 20, where all erosion rates ratios decreased with depth, a common characteristic of cohesive sediments. Organic material in the core played a role in sediment erosion; chunks of organic matter often lifted from the test section pulling sediment along with them. The core's average critical shear stress was 0.13Pa.

Median particle sizes ranged from medium to coarse silt, with a core average of 27.88 µm. Bulk densities increased from 1.05 g/cm^3 at the surface to 1.17 g/cm^3 at a depth of 26.3 cm (Figure 19 and Table 12). The average bulk density was 1.11 g/cm^3. Core SWC05 had a core average *LOI* of 0.21.

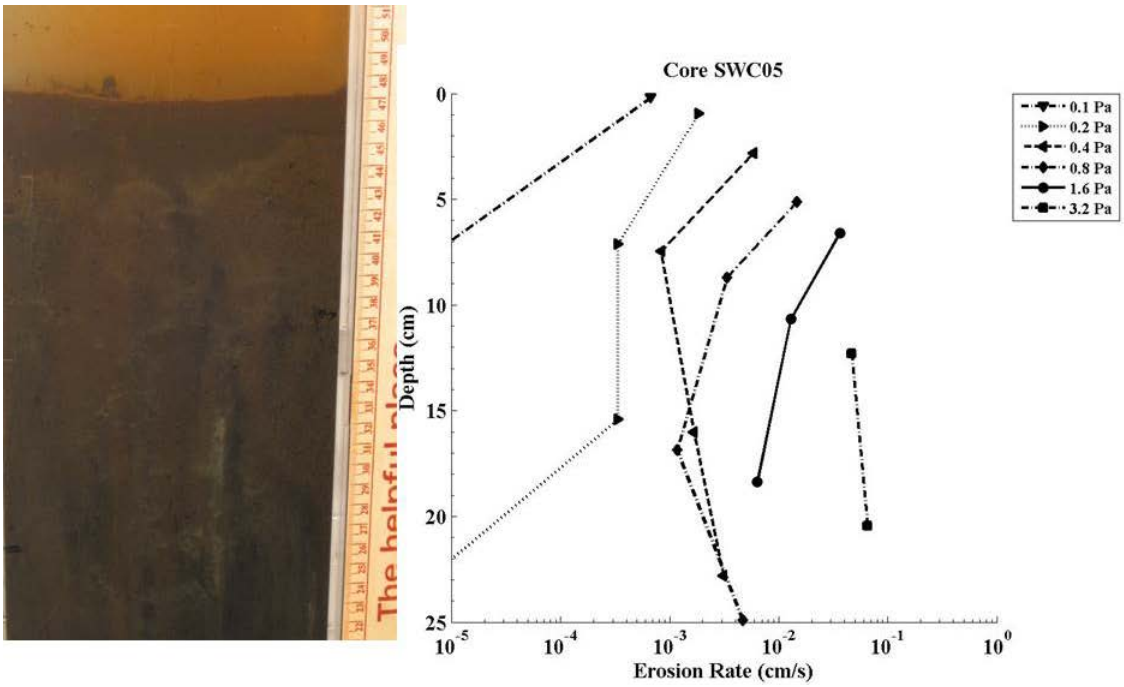

Figure 18 Photo of core SWC05 aligned vertically with the corresponding erosion rates.

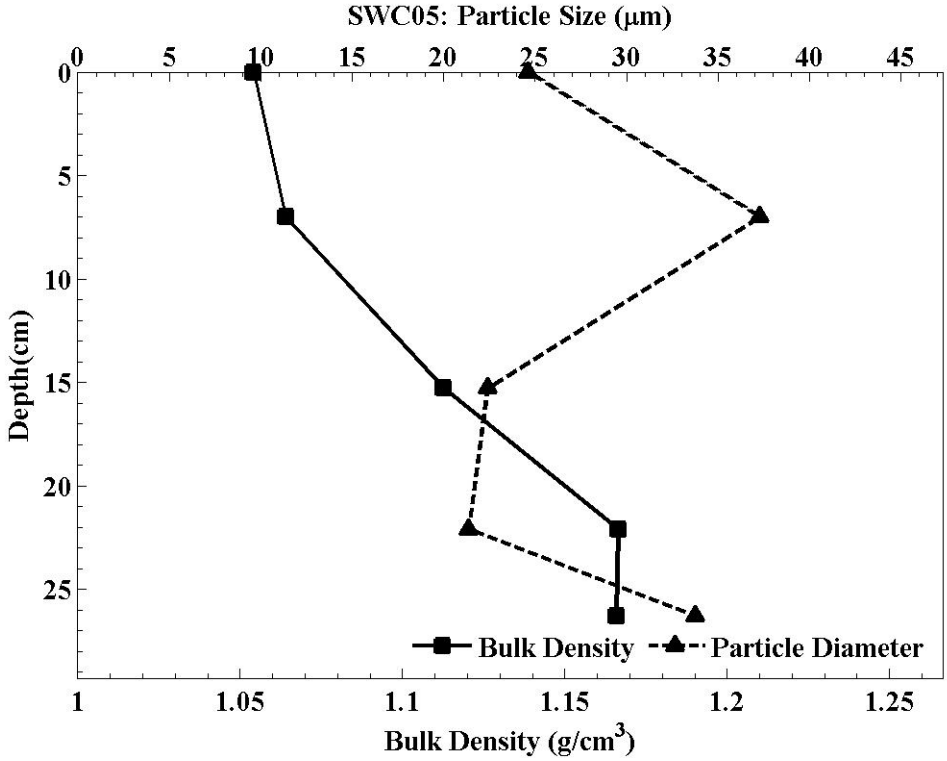

Figure 19. Bulk density and median particle size (d_{50}) with depth for core SWC05.

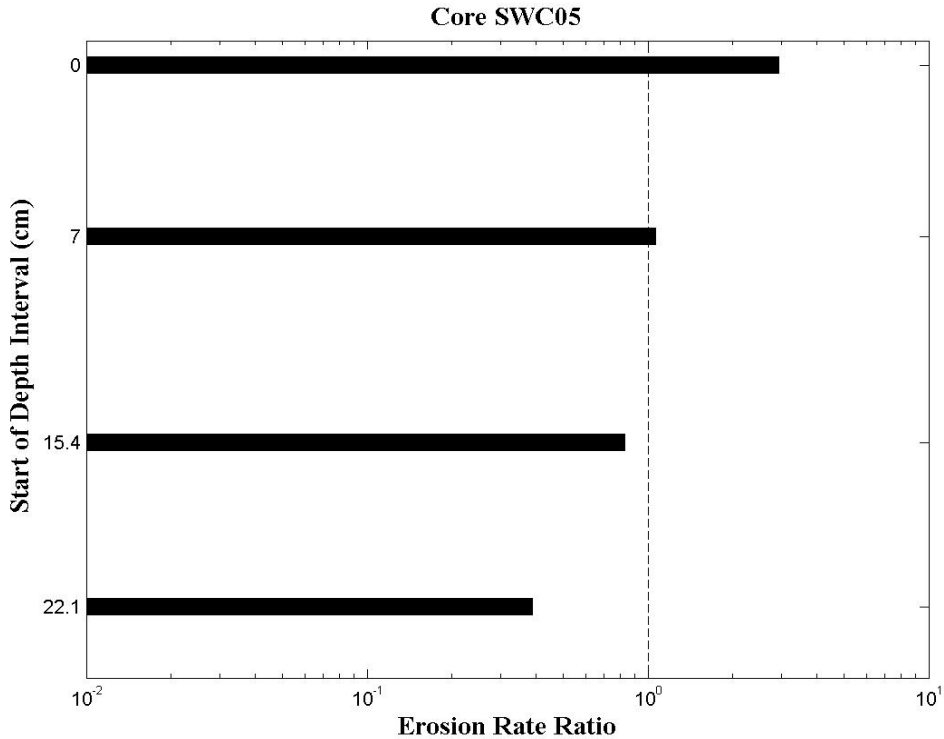

Figure 20. **Intra-core erosion rate ratios for core SWC05. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 11 Power law best-fit variables for specified depth intervals in core SWC05.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.2	6.6	0.01967	1.50	1.00
2	7.0	12.3	0.00532	1.80	1.00
3	15.4	20.5	0.00449	1.70	0.88
4	22.1	24.9	0.00532	0.60	1.00

Table 12 Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core SWC05.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	24.63	1.05	0.27	0.03	n/a	0.10	0.10
7.00	37.27	1.06	0.24	0.11	0.10	0.20	0.11
15.3	22.39	1.11	0.21	0.11	0.10	0.20	0.11
22.1	21.36	1.17	0.17	0.00	0.20	0.40	0.20
26.3	33.73	1.17	0.17	n/a	n/a	n/a	n/a
Mean	**27.88**	**1.11**	**0.21**	**0.06**	**0.15**	**0.23**	**0.13**

2.6 NWC06

Core NWC06 was collected in the northwest cove of Upper Union Lake in 0.91 m of water. The core had a top 0.7 cm low-density floc layer was rust, tan, and brown in color. The subsequent 0.3 to 0.9 cm was fine sand that was tan and light brown colored. The remainder of the core was tan, brown, and black with mottled streaks. Coarse pebble-like material was found throughout the core. During the fourth interval, the core began to leak from its bottom, so the analysis was stopped; only four intervals were processed.

A photograph of core NWC06 is presented in Figure 21 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 3.2 Pa were applied to the core. Erosion rates generally decreased with depth into the core with the exception of the final depth interval (Figure 21). The core's average critical shear stress was 0.25 Pa. The power law regression analysis lead to an r^2 value less than 0.8. As a result, the erosion rate ratio for the top interval was not plotted in Figure 23.

Median particle sizes ranged from medium silt to very fine sand, with a core average of 39.88 μm. Bulk densities increased from 1.05 g/cm^3 at the surface to 1.11 g/cm^3 at a depth of 23.5 cm (Figure 22 and Table 14). The average bulk density was 1.09 g/cm^3, and the core average *LOI* was 0.37.

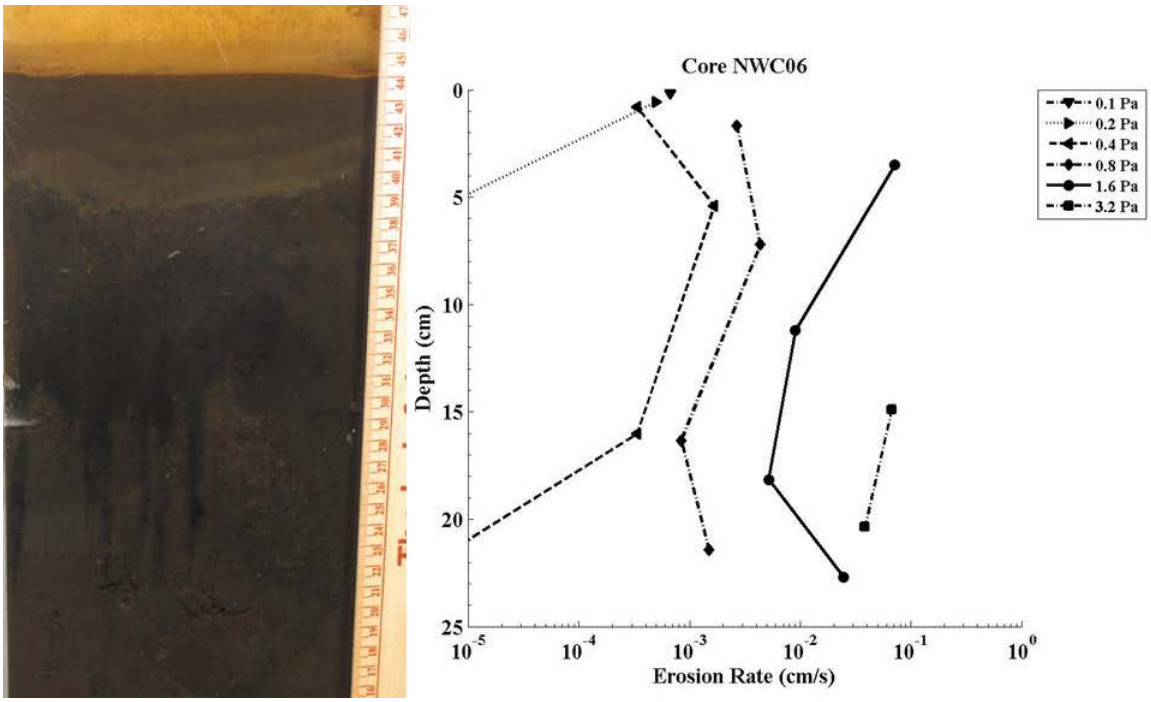

Figure 21. Photo of core NWC06 aligned vertically with the corresponding erosion rates.

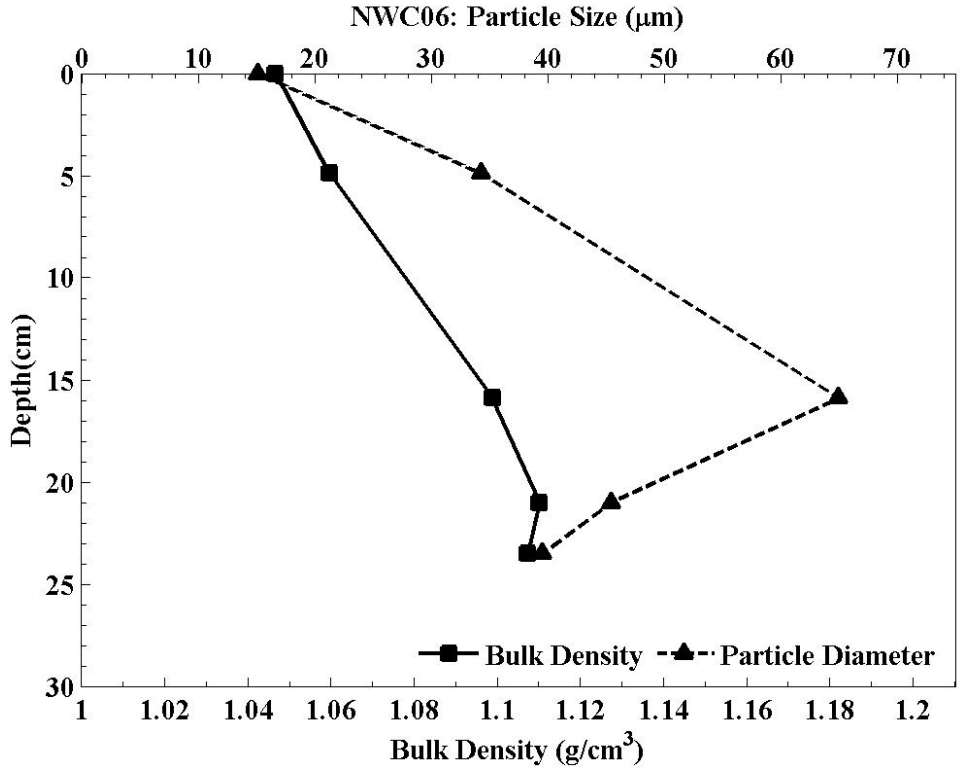

Figure 22. **Bulk density and median particle size (d_{50}) with depth for core NWC06.**

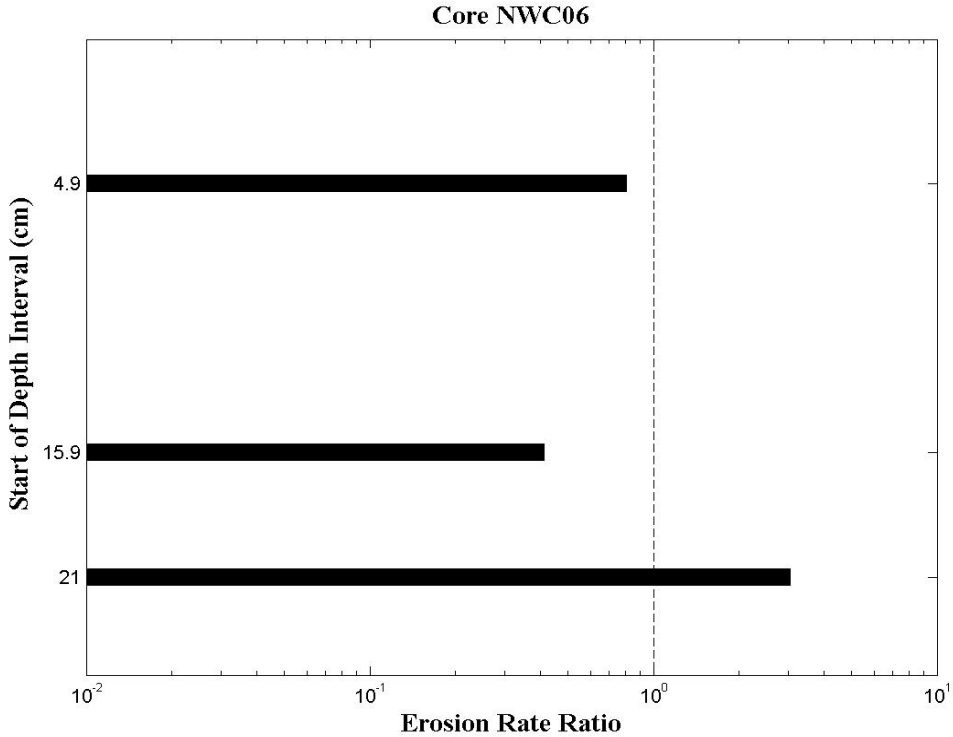

Figure 23. **Intra-core erosion rate ratios for core NWC06. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 13. Power law best-fit variables for specified depth intervals in core NWC06.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.2	3.50	n/a	n/a	0.63
2	4.9	14.9	0.00658	1.70	0.95
3	15.9	20.4	0.00205	2.30	0.98
4	21.0	22.7	0.00369	4.00	1.00

Table 14. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core NWC06.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	15.14	1.05	0.38	n/a	n/a	0.10	0.10
4.90	34.31	1.06	0.38	0.09	0.20	0.40	0.20
15.9	64.99	1.10	0.34	0.27	0.20	0.40	0.27
21.0	45.43	1.11	0.36	0.41	0.40	0.80	0.41
23.5	39.52	1.11	0.40	n/a	n/a	n/a	n/a
Mean	**39.88**	**1.09**	**0.37**	**0.26**	**0.27**	**0.43**	**0.25**

2.7 NWC07

Core NWC07 was collected at northwest cove in Upper Union Lake in 0.91 m of water. The top 2-mm of the core contained a flocculation layer that was orange in color and low in density. The next 1 cm of the core was gelatinous feeling medium brown fine silt, followed by 3 to 4 cm of more compact material that was visually the same as the overlying sediment. The next 2 to 6 cm of the core comprised lighter tan fine silt. Below this depth to 15 cm was tan, brown, and black mottled sediment, followed by uniformly brown material.

A photograph of core NWC07 is presented in Figure 24 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 6.4 Pa were applied to the core. Erosion rates decreased with depth into the core. This trend is also evident in Figure 26, where all erosion rates ratios decreased with depth. Sediment mobilization was dominated by bed load movement and chunk erosion throughout core NWC07. The core's average critical shear stress was 0.34 Pa.

Median particle sizes ranged from medium silt to coarse silt, with a core average of 30.44 μm. Bulk densities increased from 1.04 g/cm^3 at the surface to 1.10 g/cm^3 at a depth of 35.6 cm (Figure 25 and Table 16), averaging to 1.07 g/cm^3. Core NWC07 had a core average *LOI* of 0.40.

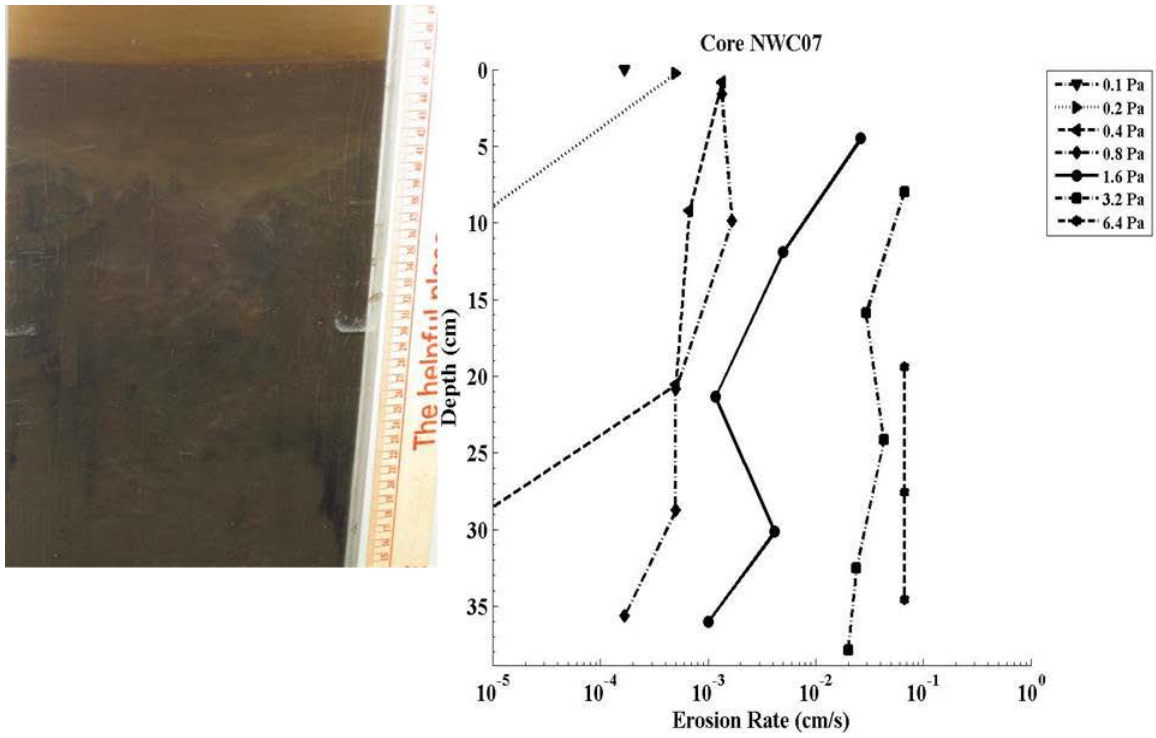

Figure 24. Photo of core NWC07 aligned vertically with the corresponding erosion rates.

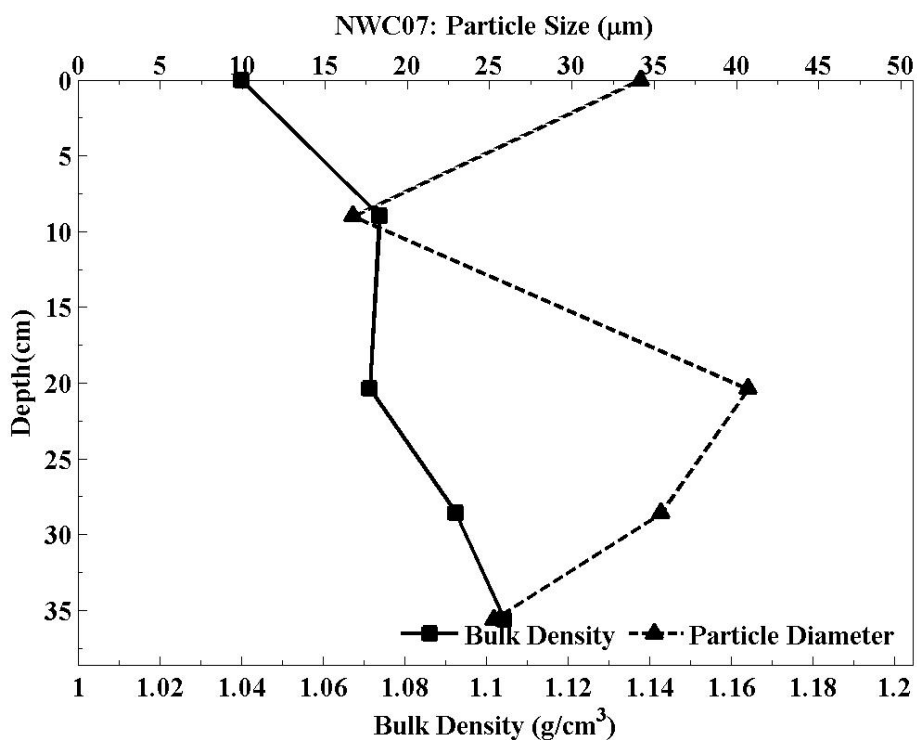

Figure 25. Bulk density and median particle size (d_{50}) with depth for core NWC07.

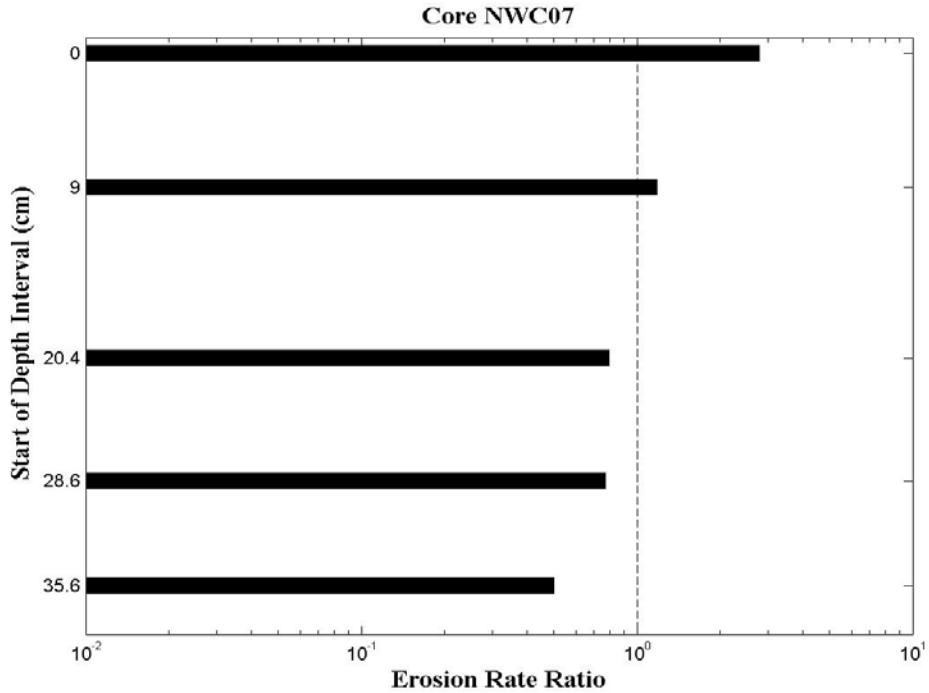

Figure 26. **Intra-core erosion rate ratios for core NWC07. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 15. Power law best-fit variables for specified depth intervals in core NWC07.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.00	8.00	0.00674	1.70	0.93
2	9.00	19.40	0.00283	1.70	0.99
3	20.4	27.6	0.00146	2.10	0.86
4	28.6	34.6	0.0011	2.40	0.98
5	35.6	37.9	0.00029	3.50	0.98

Table 16. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core NWC07.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	34.15	1.04	0.41	0.09	n/a	0.10	0.10
9.00	16.71	1.07	0.39	0.15	0.20	0.40	0.20
20.4	40.69	1.07	0.40	0.27	0.20	0.40	0.27
28.6	35.42	1.09	0.39	0.36	0.40	0.80	0.40
35.6	25.24	1.10	0.38	0.73	0.40	0.80	0.73
Mean	**30.44**	**1.07**	**0.40**	**0.32**	**0.30**	**0.50**	**0.34**

2.8 DAM08

Core DAM08 was collected near Union Lake Dam in 6.1 m of water. The first 5 to 6 cm of the core was tan and grey colored, well-sorted fine grain sediment. A15 to 22 cm horizon followed that was tan to dark brown in color with vertical striations. Beneath the second layer was 12 cm of brown silt and mottled light gray clay, below which rested fine black and brown silt.

A photograph of core DAM08 is presented in Figure 27 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 3.2 Pa were applied to the core. With the exception of the last interval, erosion rates generally decreased with depth into the core. The core's average critical shear stress was 0.25 Pa. Erosion was dominated by the mobilization 0.5 to 1.5 cm chunks of sediment.

Median particle sizes varied from medium to semi-coarse silt, with a core average of 17.65 μm. Bulk densities increased from 1.03 g/cm^3 at the surface to 1.44 g/cm^3 at a depth of 14.4 cm, and then decreased to 1.08 g/cm^3 at a depth of 26.8 cm (Figure 28 and Table 18). The average bulk density was 1.15 g/cm^3. Because sediment mobilized in chunks, the core's test section was pitted. Core DAM08 had a core average *LOI* of 0.25.

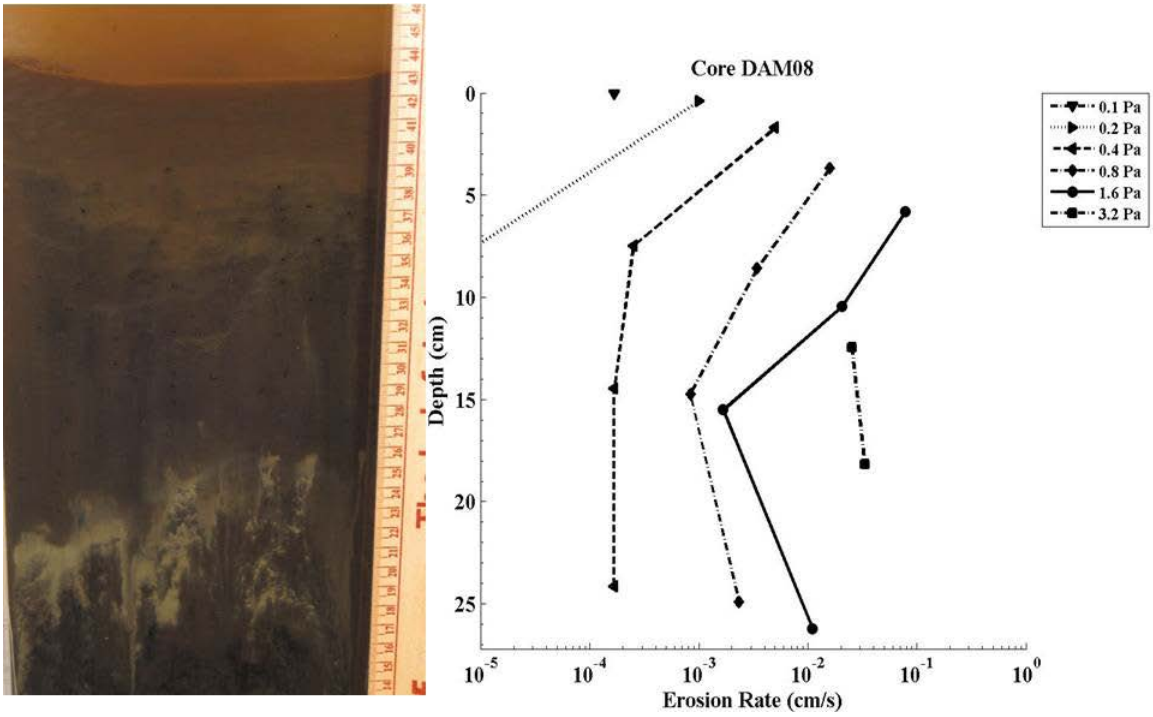

Figure 27. Photo of core DAM08 aligned vertically with the corresponding erosion rates.

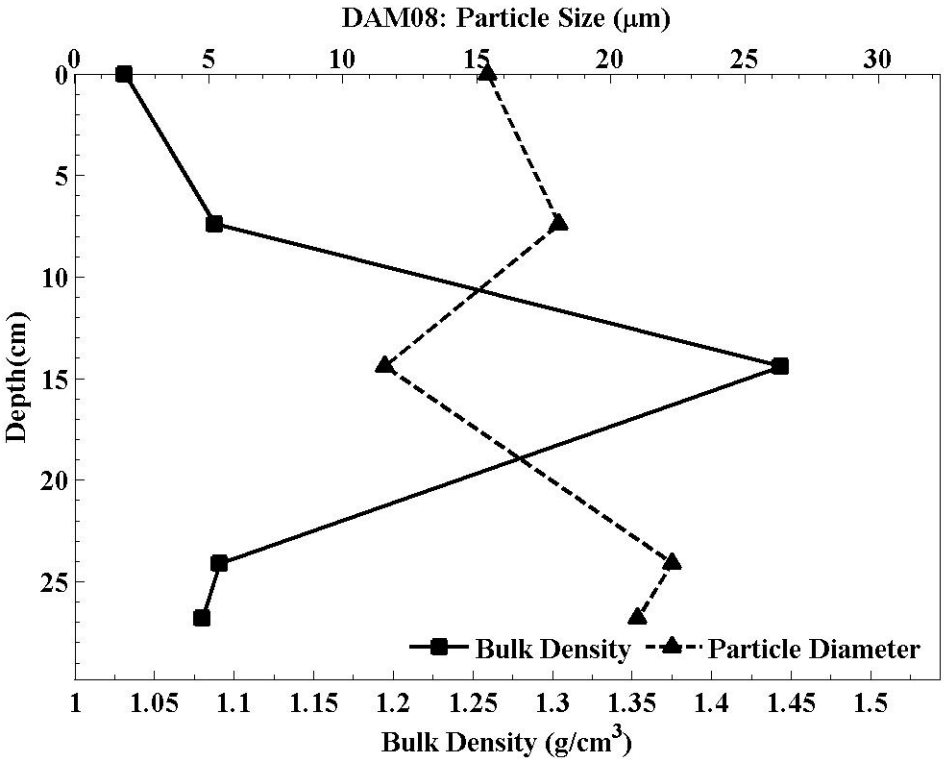

Figure 28. Bulk density and median particle size (d_{50}) with depth for core DAM08.

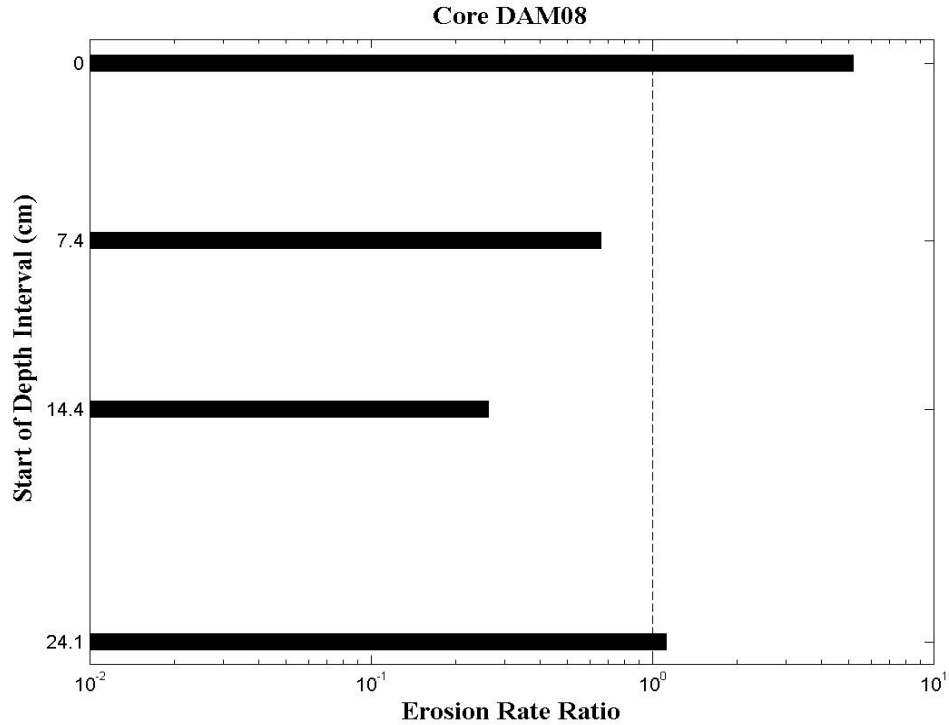

Figure 29. **Intra-core erosion rate ratios for core DAM08. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 17. Power law best-fit variables for specified depth intervals in core DAM08.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.00	5.80	0.02944	2.2	1.00
2	7.40	12.5	0.00347	2.3	0.89
3	14.4	18.2	0.00124	2.4	0.93
4	24.1	26.2	0.00319	3.0	0.98

Table 18. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core DAM08.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	15.40	1.03	0.29	0.07	n/a	0.10	0.10
7.40	18.06	1.09	0.25	0.21	0.20	0.40	0.21
14.4	11.55	1.44	0.10	0.35	0.20	0.40	0.35
24.1	22.26	1.09	0.31	0.32	0.20	0.40	0.32
26.8	20.98	1.08	0.29	n/a	n/a	n/a	n/a
Mean	**17.65**	**1.15**	**0.25**	**0.24**	**0.20**	**0.33**	**0.25**

2.9 DAM09

Core DAM09 was collected at near Union Lake Dam in 6.1 m of water. The first 0.5 to 0.8 mm of the core was a rusty reddish brown color with a very loose flocculation layer. Eight to 12 cm down was sediment of medium brown color with several black anoxic areas and voids (less than 2 cm in diameter). Following that was 1-3 cm of tan buff streaks; 6-12 cm of dark brown and black mottled undulating sediment; 3-10 cm tan and cream sediment with a well-defined horizon; then a brown, tan, and black layer with vertical streaking. By the end of the fourth interval, little sediment was remaining in the core and the fifth interval could not be processed.

A photograph of core DAM09 is presented in Figure 30 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 6.4 Pa were applied to the core. Erosion rates decreased with depth into the core. This trend is evident in Figure 32, where all erosion rate ratios decreased with depth. Because of an r^2 value less than 0.8, an erosion rate ratio was not calculated for the second interval. The core's average critical shear stress was 0.38 Pa.

Median particle sizes were in the coarse silt range, peaking at a depth of roughly 19 cm at a value of 42.48 µm. Bulk densities increased from 1.05 g/cm^3 at the surface to 1.78 g/cm^3 at a depth of 18.5 cm, and then decreased back to 1.10 g/cm^3 at a depth of 34.2 cm (Figure 31 and Table 20). The average bulk density was 1.23 g/cm^3. Core DAM09 had a core average *LOI* of 0.23.

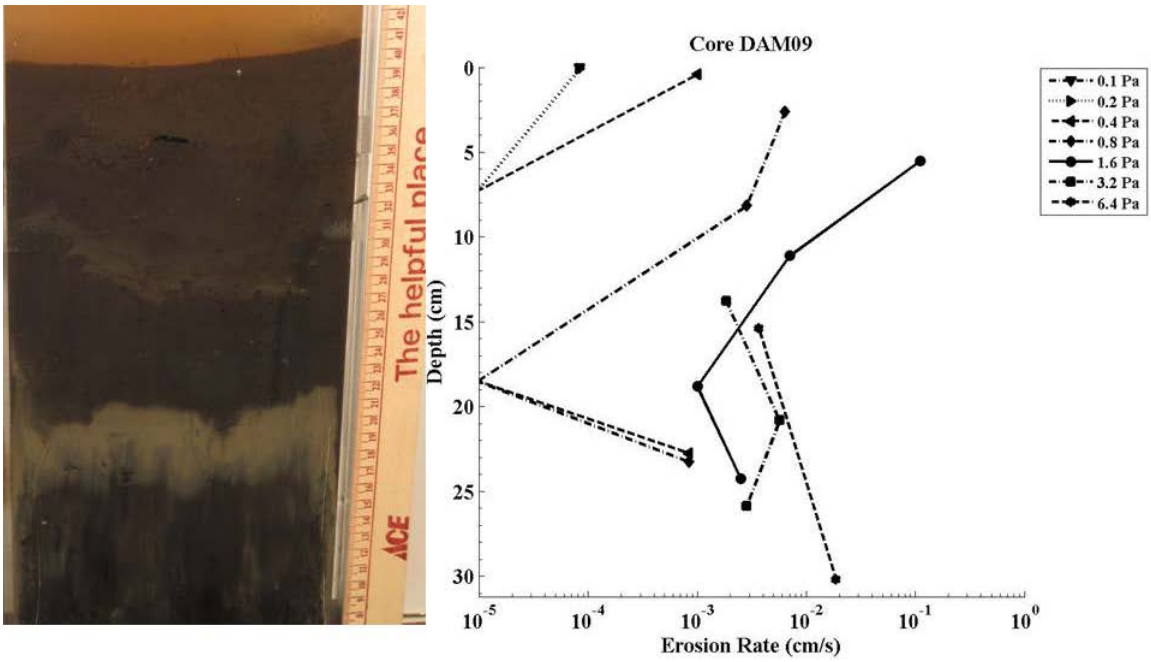

Figure 30. Photo of core DAM09 aligned vertically with the corresponding erosion rates.

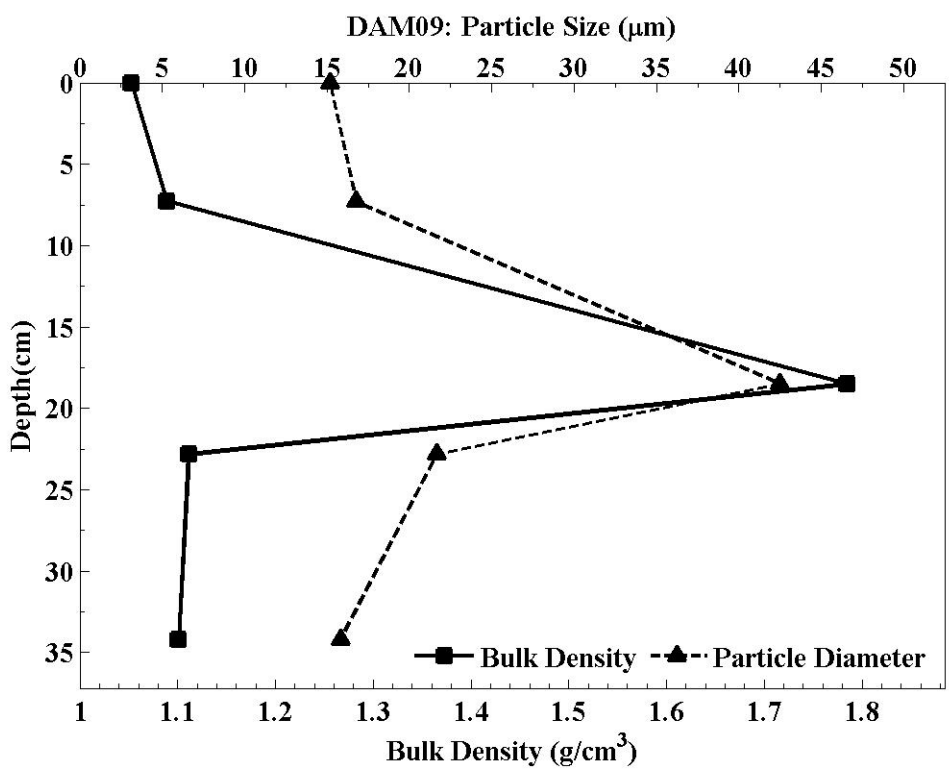

Figure 31. Bulk density and median particle size (d_{50}) with depth for core DAM09.

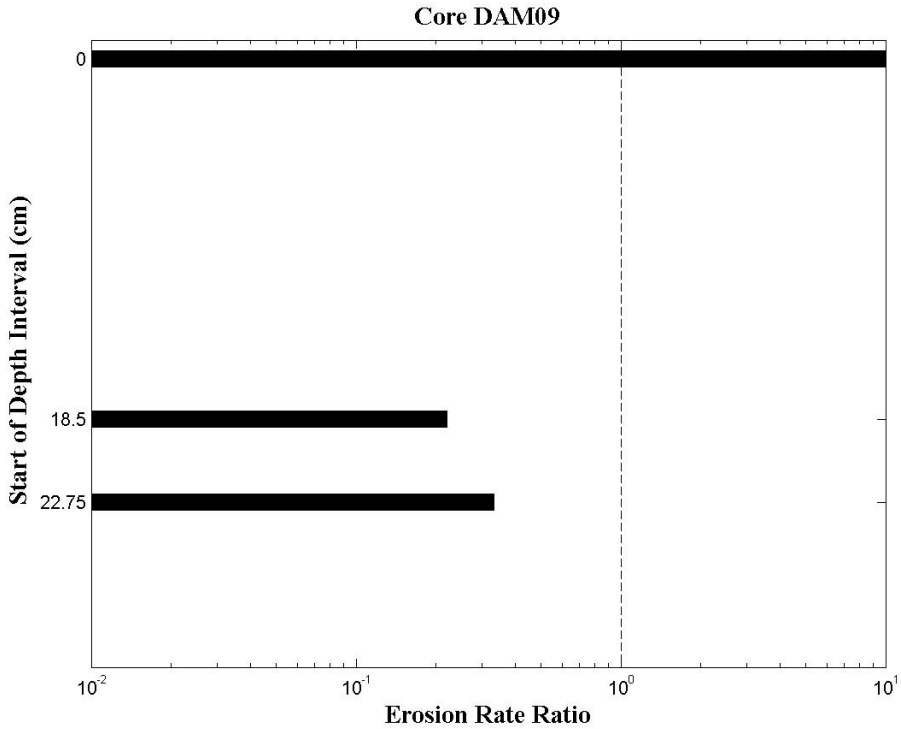

Figure 32. Intra-core erosion rate ratios for core DAM09. The dashed line indicates conditions for the core's average erosion rate (i.e., erosion rate ratio equals 1).

Table 19 Power law best-fit variables for specified depth intervals in core DAM09.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0	5.5	0.01632	2.7	0.94
2	7.3	15.4	n/a	n/a	0.02
3	18.5	20.8	0.00031	2.5	0.99
4	22.8	30.2	0.00149	1.1	0.86

Table 20. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core DAM09.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	15.17	1.05	0.30	0.15	n/a	0.10	0.10
7.30	16.77	1.09	0.25	n/a	0.40	0.80	0.40
18.5	42.48	1.78	0.02	0.64	0.80	1.60	0.80
22.8	21.66	1.11	0.26	0.08	0.20	0.40	0.20
34.2	15.82	1.10	0.32	n/a	n/a	n/a	n/a
Mean	**22.38**	**1.23**	**0.23**	**0.29**	**0.60**	**0.73**	**0.38**

2.10 UBW10

Core UBW10 was collected from the backwater of the Upper Union Lake in 0.61 m of water. The first 2 mm of sediment was low-density and red, orange, and tan in color; followed by 10 mm of brown and tan sediment. The rest of the core was brown, continuous in color, and stratified with 5 to 10 visible accumulations of organic material and scattered voids. The sediment was otherwise uniform in appearance until reaching the base where there was a black lump of organic material.

A photograph of core UBW10 is presented in Figure 33 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 6.4 Pa were applied to the core. Erosion rates generally decreased with depth, increasing only over the last 7 cm of the core processed (depths greater than roughly 28 cm). This trend is also evident in Figure 35, where all erosion rates ratios decreased with depth besides that last interval. The core's average critical shear stress was 0.31Pa.

Median particle sizes remained in the coarse silt range, with a core average of 35.94 μm. Bulk densities fluctuated between 1.06 g/cm^3 and 1.14 g/cm^3, with an average value of 1.10 g/cm^3 (Figure 34 and Table 22). Core UBW10 had a core average *LOI* of 0.44.

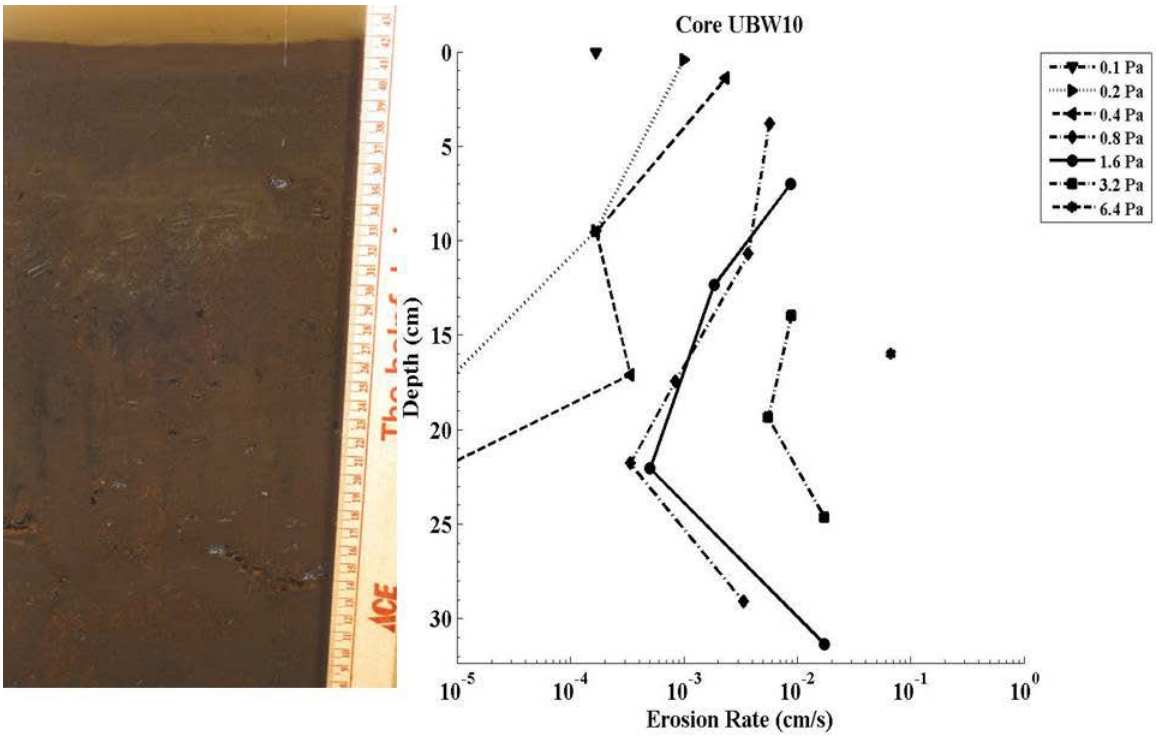

Figure 33. Photo of core UBW10 aligned vertically with the corresponding erosion rates.

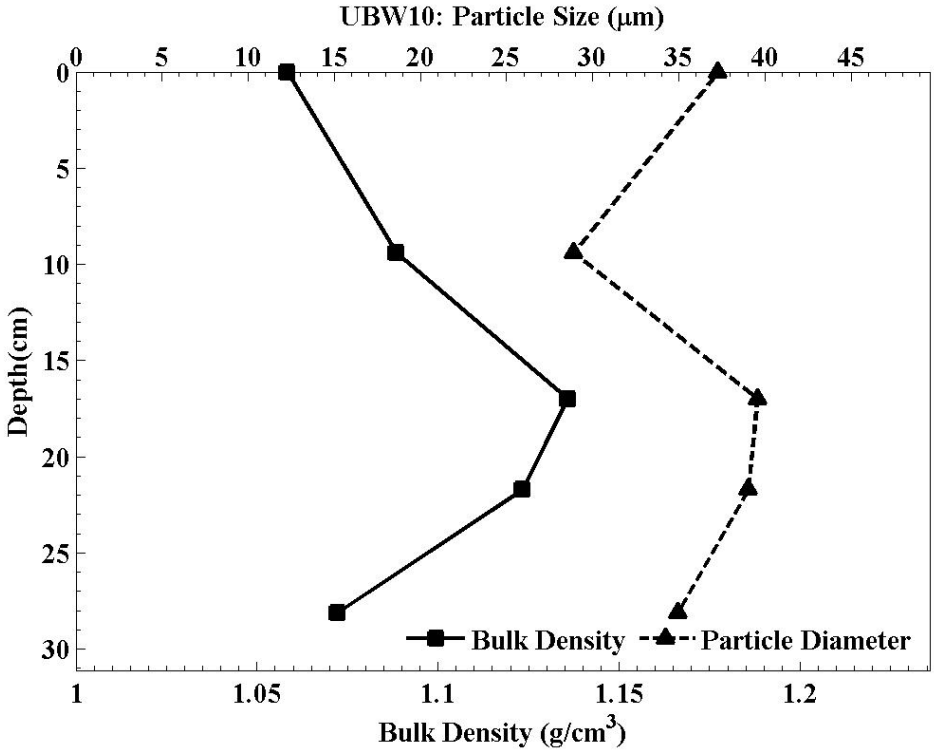

Figure 34. **Bulk density and median particle size (d_{50}) with depth for core UBW10.**

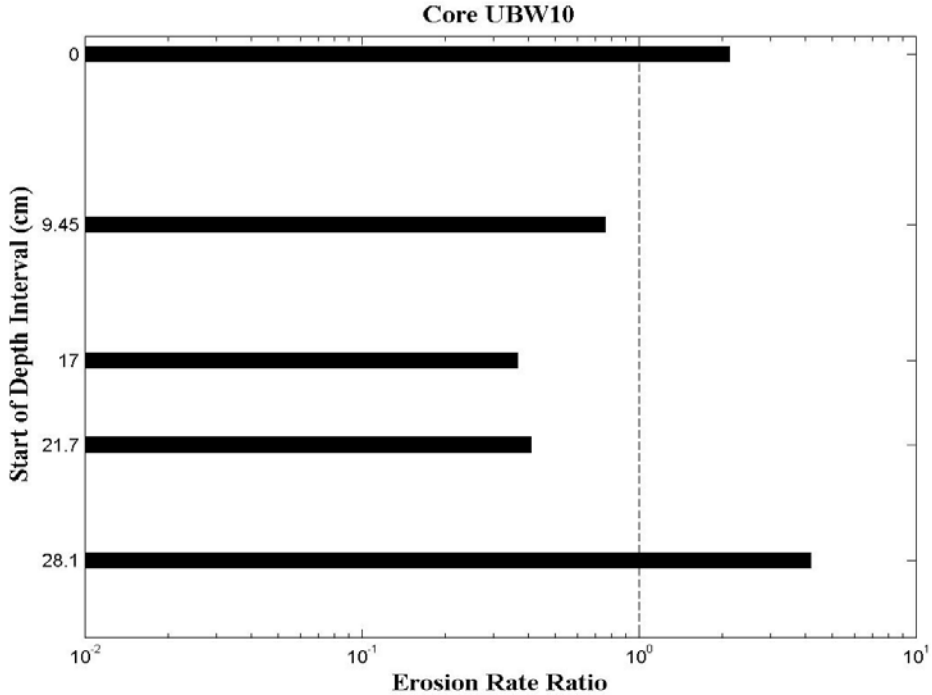

Figure 35. Intra-core erosion rate ratios for core UBW10. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).

Table 21. Power law best-fit variables for specified depth intervals in core UBW10.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.00	7.00	0.00645	1.40	0.94
2	9.50	16.0	0.00178	1.70	0.89
3	17.0	19.4	0.00114	1.40	1.00
4	21.7	24.7	0.00037	2.90	0.83
5	28.1	31.4	0.00566	2.40	1.00

Table 22. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core UBW10.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	37.27	1.06	0.48	0.05	n/a	0.10	0.10
9.40	28.89	1.09	0.40	0.18	n/a	0.20	0.20
17.0	39.57	1.14	0.43	0.16	0.20	0.40	0.20
21.7	39.03	1.12	0.43	0.63	0.40	0.80	0.63
28.1	34.94	1.07	0.47	0.18	0.40	0.80	0.40
Mean	**35.94**	**1.10**	**0.44**	**0.24**	**0.33**	**0.46**	**0.31**

2.11ALM11

Core ALM11 was collected from Almond Beach in the Maurice River in 0.76 m of water. The core's surface was opaque brown silt that was fluidic in texture. The next 2 to 6 cm of sediment was medium brown-colored fine silt. Between depths of roughly 10 and 20 cm, several void spaces were observed as well as pockets of gray sand. Roots were encountered during processing over the top 20 cm of the core; organic material had to be removed from the test section several times during the analysis.

A photograph of core ALM11 is presented in Figure 36 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 6.4 Pa were applied to the core. Applied shear stresses above 0.8 Pa resulted in relatively even erosion rates with depth. The core did appear to stiffen however over the first 5 cm for lower applied shear stresses. The core's average critical shear stress was 0.19 Pa.

Median particle sizes varied from medium to coarse silt, with a core average of 40.40 µm. Bulk densities increased from 1.04 g/cm^3 at the surface to 1.22 g/cm^3 at a depth of 19.8 cm, and then decreased back to 1.14 g/cm^{3}at a depth of 25.4 cm (Figure 37 and Table 24). The average bulk density was 1.11 g/cm^3. Core ALM11 had a core average *LOI* of 0.32.

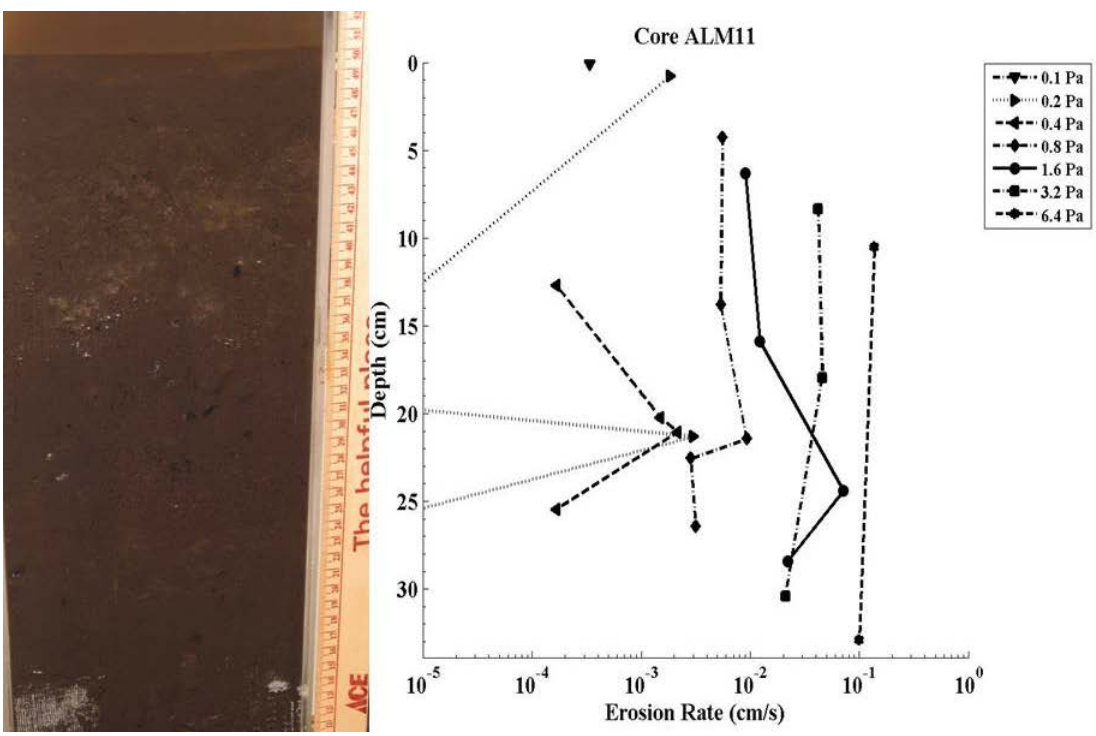

Figure 36. Photo of core ALM11 aligned vertically with the corresponding erosion rates.

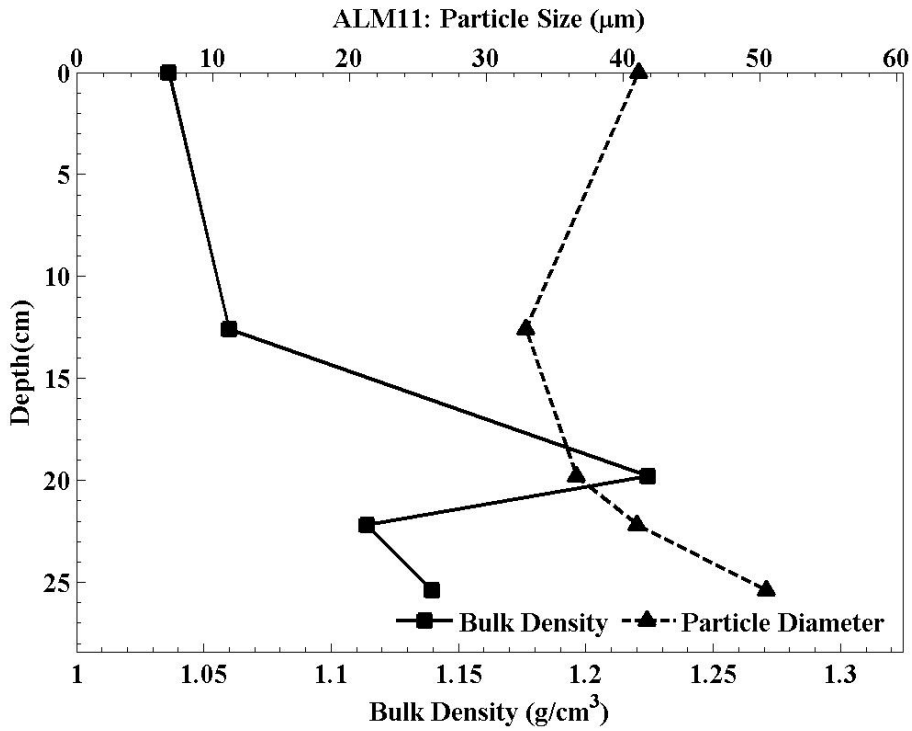

Figure 37. **Bulk density and median particle size (d_{50}) with depth for core ALM11.**

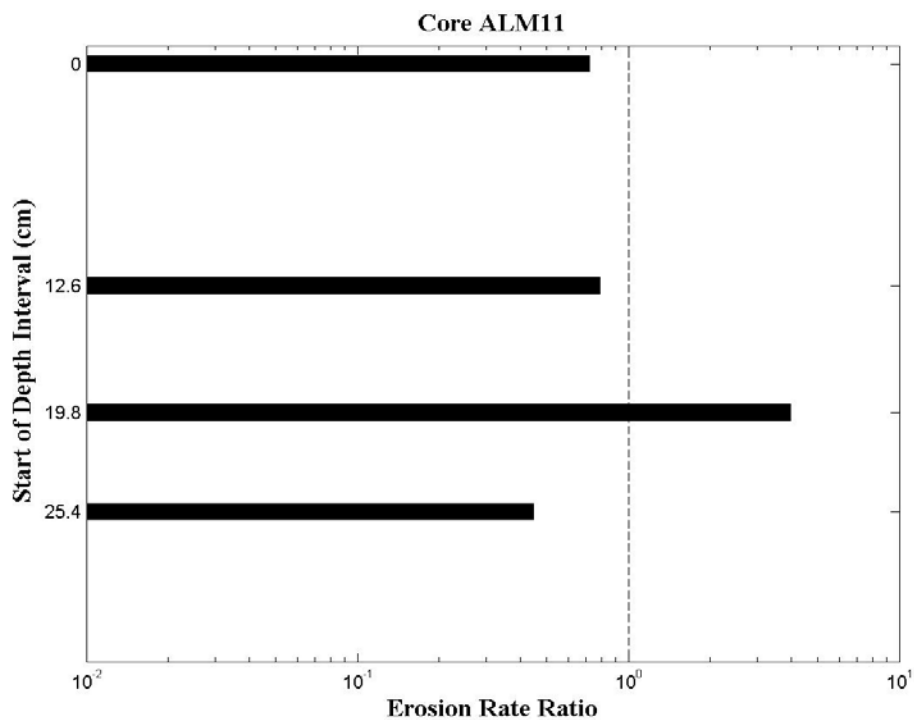

Figure 38. **Intra-core erosion rate ratios for core ALM11. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 23. Power law best-fit variables for specified depth intervals in core ALM11.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.10	10.5	0.00864	1.30	0.96
2	12.6	18.0	0.00345	2.50	0.91
3	19.8	21.5	0.01650	2.60	1.00
4	21.3	24.4	n/a	n/a	0.58
5	25.4	32.9	0.00279	2.10	0.89

Table 24. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core ALM11.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.0	41.11	1.04	0.50	0.03	n/a	0.10	0.10
12.6	32.86	1.06	0.41	0.25	0.20	0.40	0.25
19.8	36.58	1.22	0.13	0.14	0.20	0.40	0.20
22.2	41.03	1.11	0.29	n/a	n/a	0.20	0.20
25.4	50.44	1.14	0.28	0.21	0.20	0.40	0.21
Mean	**40.40**	**1.11**	**0.32**	**0.16**	**0.20**	**0.30**	**0.19**

2.12ALM12

Core ALM12 was collected from Almond Beach in Maurice River in 0.76 m of water. The first 3 mm of the core consisted of a low-density floc layer that was a reddish brown in color and covered with organic material. The next 0.5 to 2.0 cm of the core was composed of a distinct uniform layer of brown sediment followed by 3 to 10 cm of a light cream, and tan colored poorly sorted silt and sand mixture. Numerous black and brown inclusions gradually transitioned into a brown to medium dark brown finer sediment that extended to the base of the core.

A photograph of core ALM12 is presented in Figure 39 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 1.6 Pa were applied to the core. Erosion rates were relatively uniform with depth. The core's average critical shear stress was 0.16 Pa. When sand was encountered during the processing, it often mobilized as individual particles. Otherwise erosion was dominated by the movement of 0.5 to 1.0 cm clumps.

Median particle sizes varied from coarse silt to very fine sand, with a core average of 55.05 μm. Bulk densities decreased from 1.37 g/cm^3 at the surface to 1.11 g/cm^3 at a depth of 19.1 cm (Figure 40 and Table 26). The average bulk density was 1.18 g/cm^3. Core ALM12 had a core average *LOI* of 0.20.

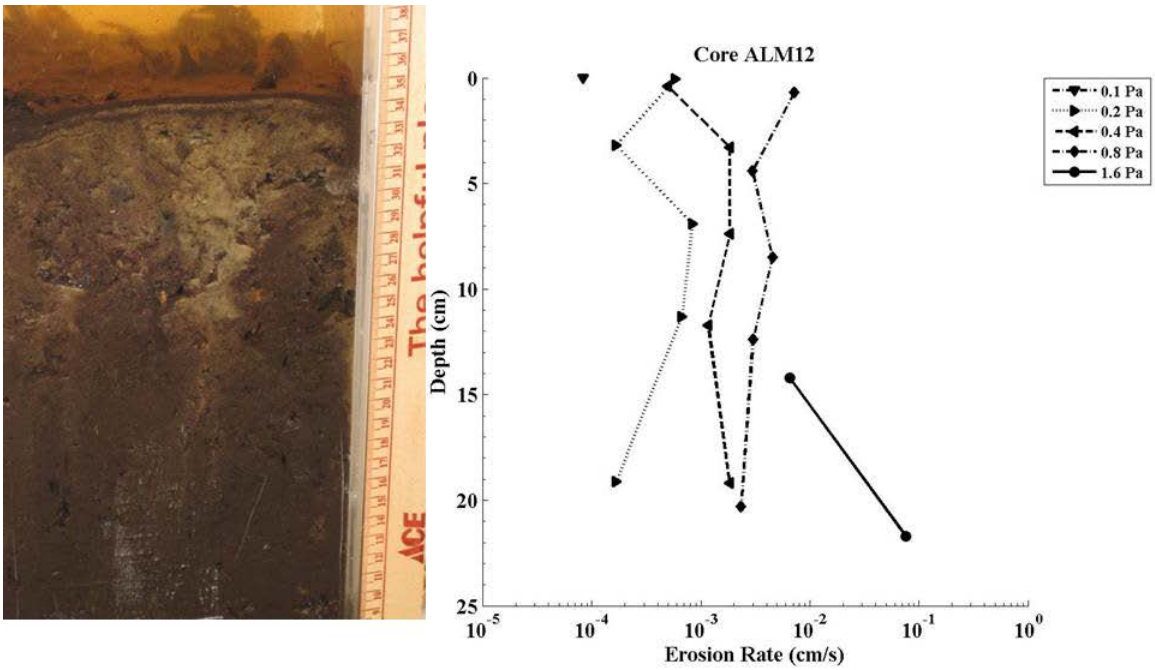

Figure 39. Photo of core ALM12 aligned vertically with the corresponding erosion rates.

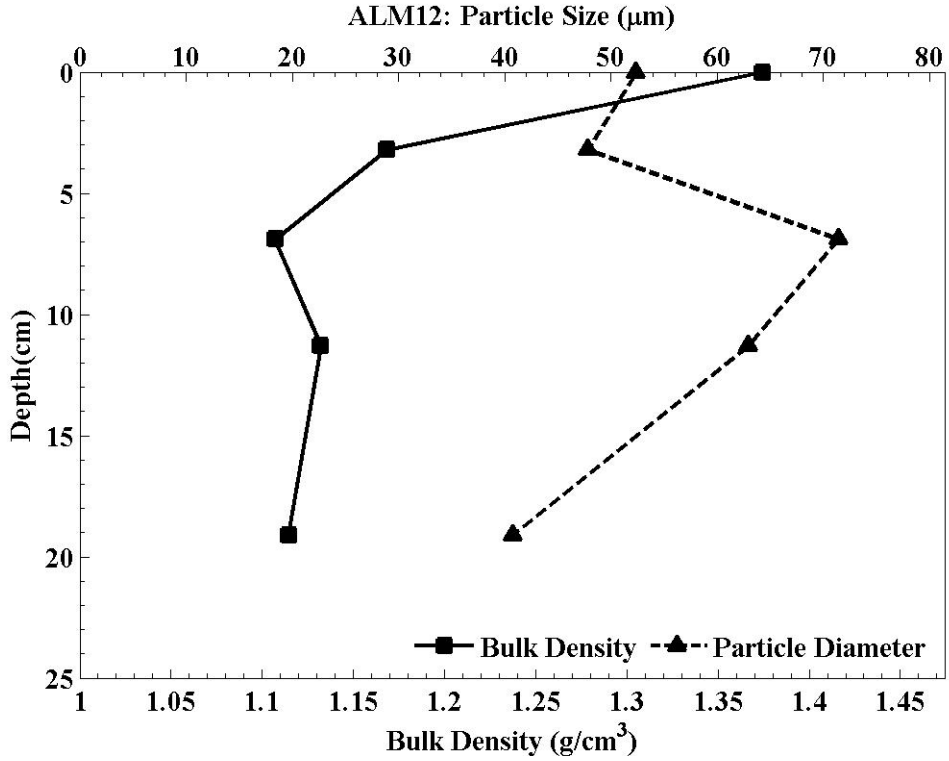

Figure 40. **Bulk density and median particle size (d_{50}) with depth for core ALM12.**

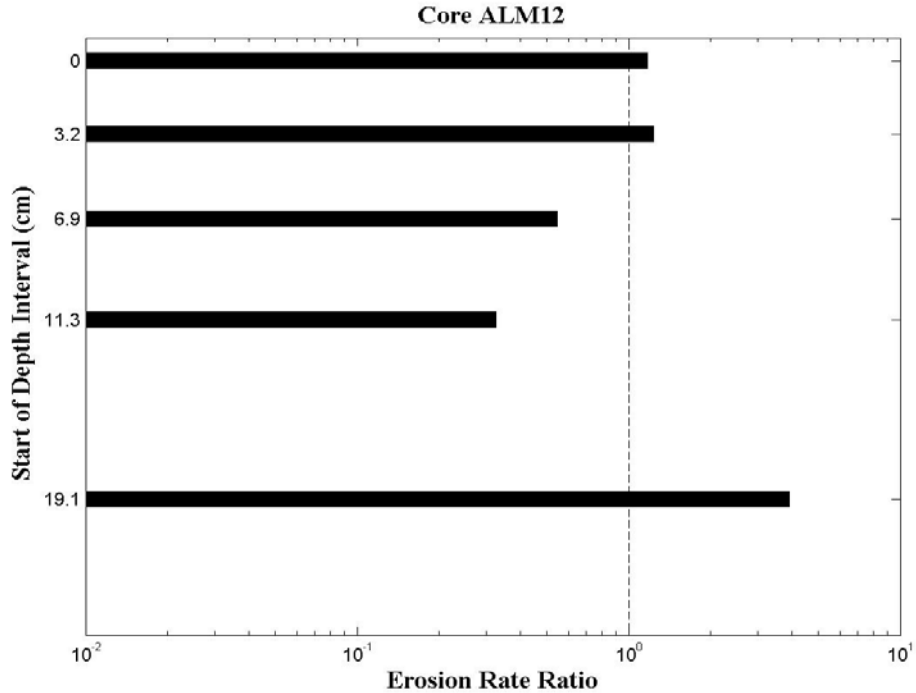

Figure 41. **Intra-core erosion rate ratios for core ALM12. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 25. Power law best-fit variables for specified depth intervals in core ALM12.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.00	0.70	0.00715	1.90	0.87
2	3.20	4.40	0.00650	2.10	0.87
3	6.90	8.50	0.00580	1.20	1.00
4	11.3	14.2	0.00374	1.10	0.99
5	19.1	21.7	0.01251	2.70	0.91

Table 26. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core ALM12.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	52.37	1.37	0.07	0.11	n/a	0.10	0.10
3.20	47.80	1.17	0.16	0.13	0.10	0.20	0.13
6.90	71.42	1.11	0.31	0.04	0.10	0.20	0.20
11.3	62.91	1.13	0.20	0.04	0.10	0.20	0.20
19.1	40.74	1.11	0.26	0.17	0.10	0.20	0.17
Mean	**55.05**	**1.18**	**0.20**	**0.10**	**0.1**	**0.18**	**0.16**

2.13ALM13

Core ALM13 was collected from Almond Beach in Maurice River in 0.3 m of water. The first 1 cm of the core comprised a flocculation layer that was orange, gray, and tan in color with a scattering of leafy organic debris and thin organic strips on the surface. The next 3 to 4 cm was dark gray and black silty sand followed by brown, homogeneous, well sorted silt. Bioturbation was present along one side of the core; evident by worm tubes outlined by lighter colored silt (presumably oxic).

A photograph of core ALM13 is presented in Figure 42 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 3.2 Pa were applied to the core. Erosion rates changed little with depth, with a slight increase towards the bottom of the core. This trend is also evident in Figure 43, where all erosion rates ratios increased with depth. Because of the small size of core ALM13, only three intervals were run. The core's average critical shear stress was 0.20 Pa.

Median particle sizes varied little, remaining in the coarse silt range throughout, with a core average of 35.81 μm. Computed bulk densities were also relatively constant, starting at 1.05 g/cm^3 at the surface and increasing to 1.08 g/cm^3 at a depth of 15.4 cm (Figure 43 and Table 28). The average bulk density was 1.06 g/cm^3. Core ALM13 had a core average *LOI* of 0.40.

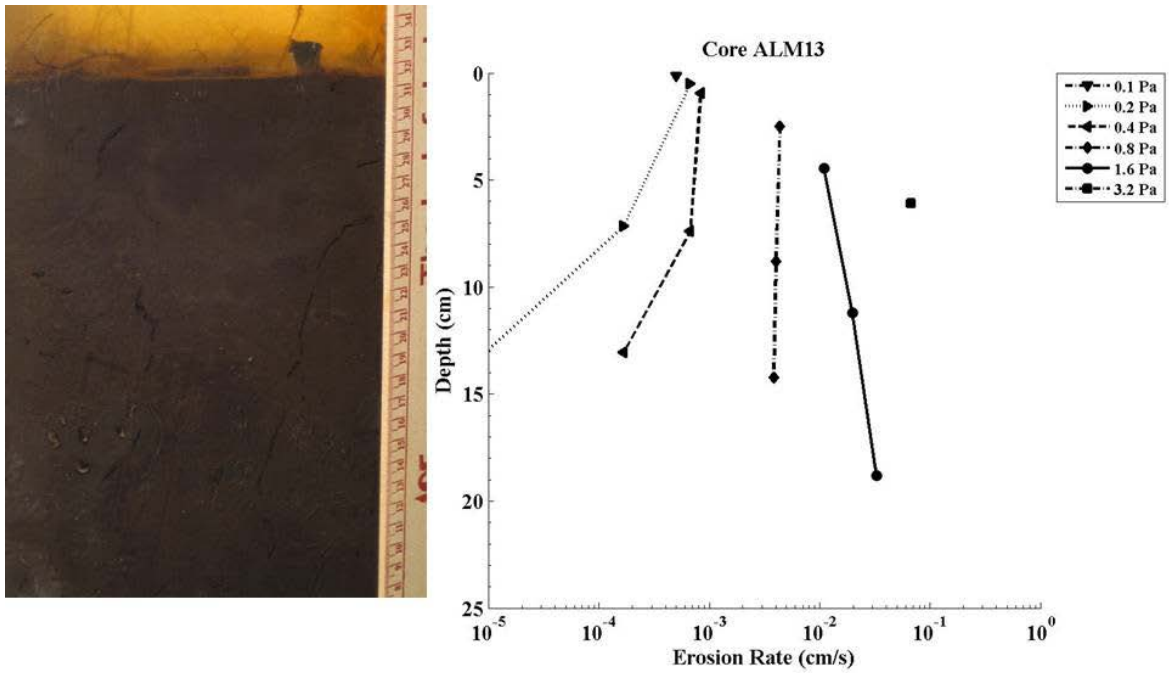

Figure 42. Photo of core ALM13 aligned vertically with the corresponding erosion rates.

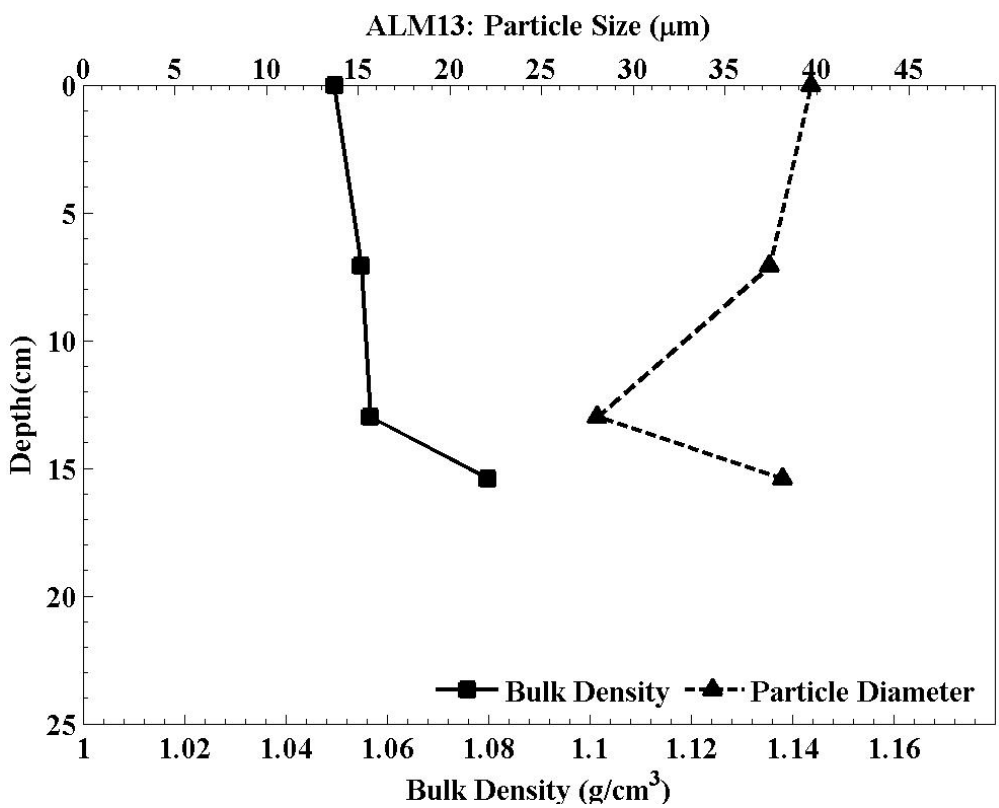

Figure 43. Bulk density and median particle size (d_{50}) with depth for core ALM13.

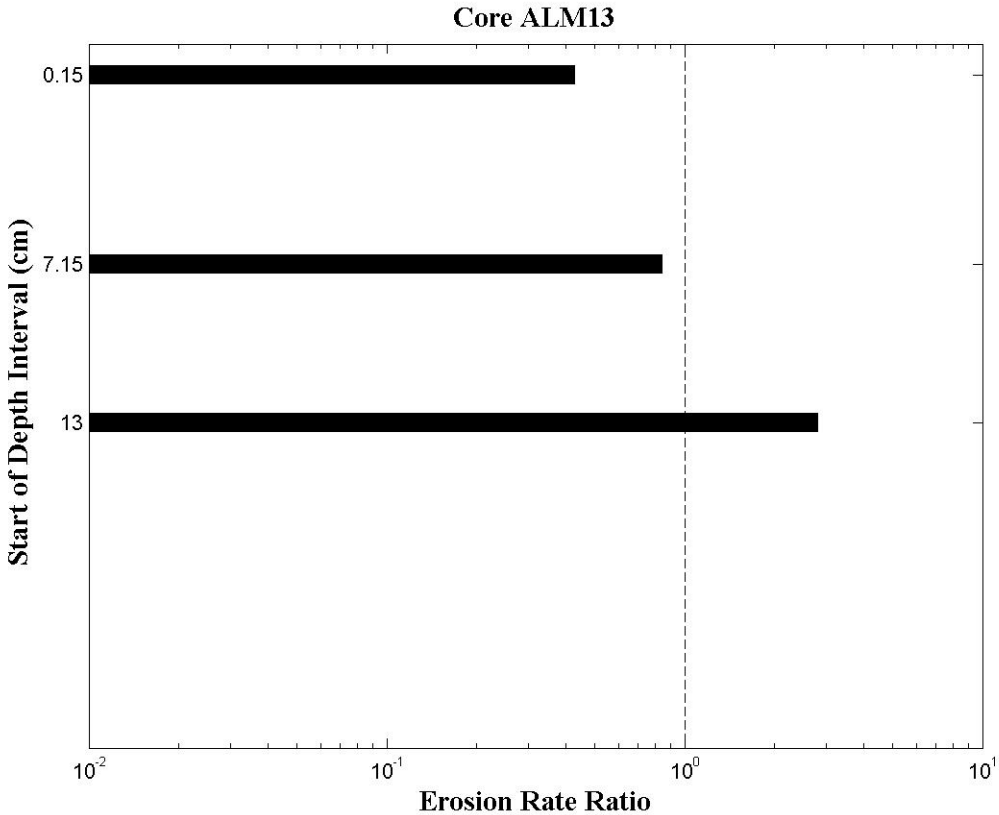

Figure 44. **Intra-core erosion rate ratios for core ALM13. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 27. Power law best-fit variables for specified depth intervals in core ALM13.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.1	6.10	0.00696	1.40	0.92
2	7.1	11.2	0.00649	2.30	1.00
3	13.0	18.8	0.00644	3.80	0.99

Table 28. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core ALM13.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	39.69	1.05	0.39	0.05	n/a	0.10	0.10
7.10	37.42	1.05	0.40	0.17	0.10	0.20	0.17
13.0	28.02	1.06	0.39	0.33	0.20	0.40	0.33
15.4	38.10	1.08	0.39	n/a	n/a	n/a	n/a
Mean	**35.81**	**1.06**	**0.40**	**0.18**	**0.20**	**0.23**	**0.20**

2.14ALL14

Core ALL14 was collected from Alliance Beach in the Maurice River in 0.3 m of water. Roughly 75 percent of the core's surface was covered with woody detritus. The next 3 cm consisted of a low-density dark brown loose layer of silt and sand on top of a very uneven sand layer that spanned down 2 to 6 cm. Below the sand, from roughly 7 to 10 cm, was a medium brown silt with several vertical, sand striations flecked with voids throughout. Organic material was found mixed with the core's sediment at all depths.

A photograph of core ALL14 is presented in Figure 45 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 12.8 Pa were applied to the core. Erosion rates generally decreased with depth into the core. This trend is also evident in Figure 47, where all erosion rate ratios decreased down core. The core's average critical shear stress was 0.24 Pa. Organic matter appeared to armor the bed from erosion. When present, organic material held nearby sediment in place.

Median particle sizes varied from coarse silt to fine sand, with a core average medium particle size of 69.85 μm. Bulk densities decreased from 1.53 g/cm^3 at the surface to 1.26 g/cm^3 at a depth of 25.2 cm (Figure 46 and Table 30). The average bulk density was 1.25 g/cm^3. Core ALL14 had a relatively low organic fraction, with a core average *LOI* of 0.20.

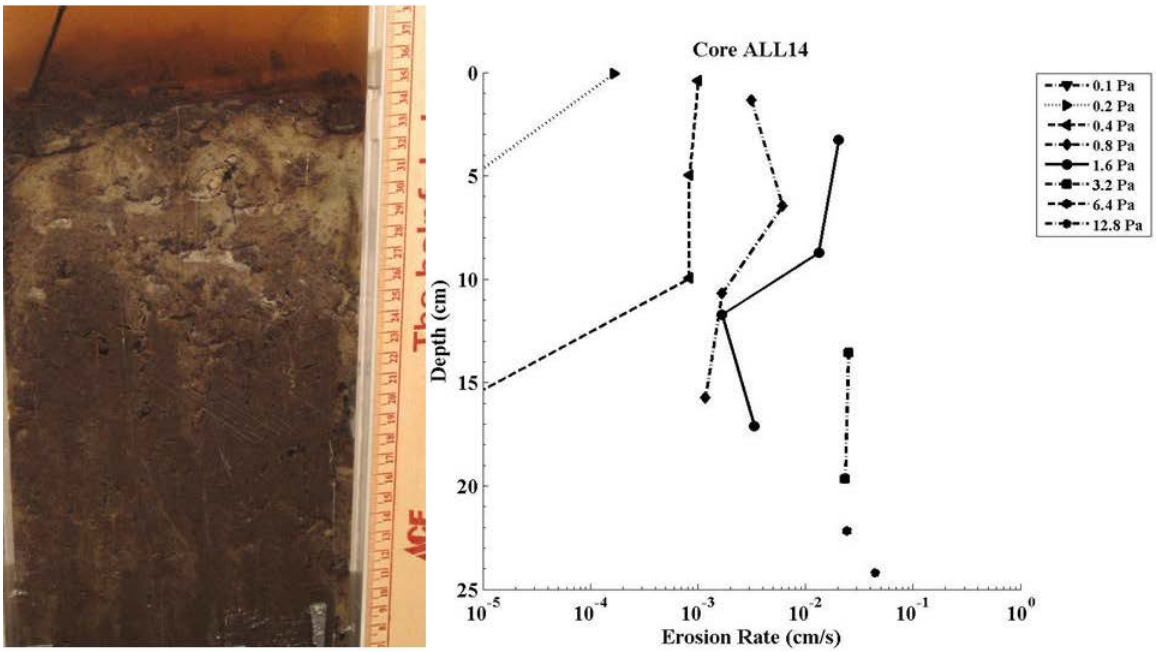

Figure 45. Photo of core ALL14 aligned vertically with the corresponding erosion rates.

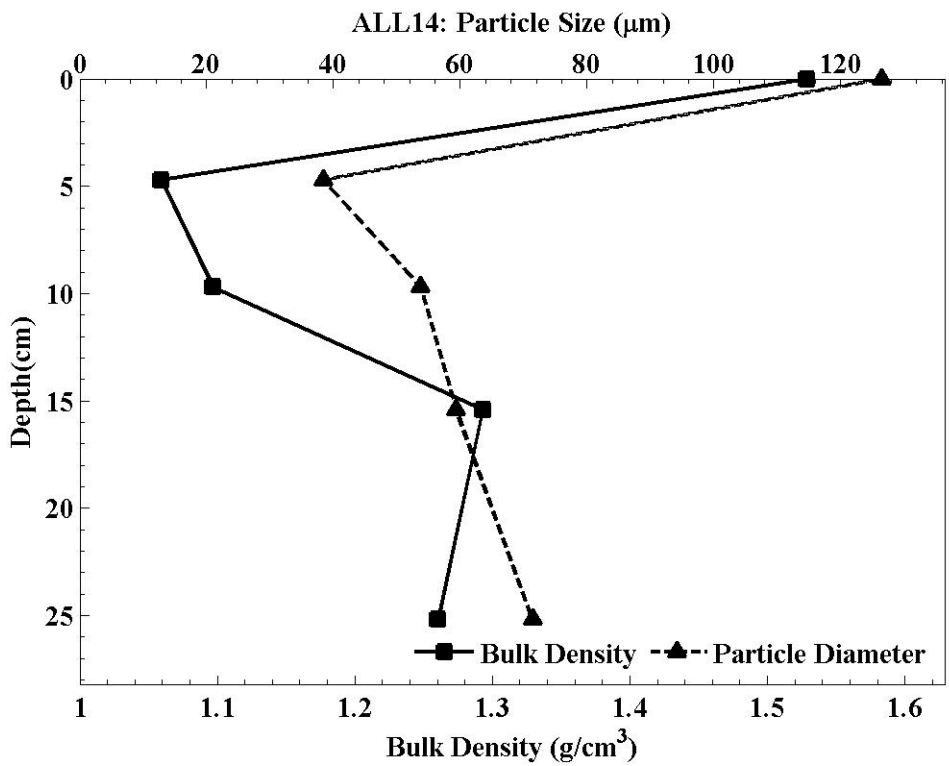

Figure 46. Bulk density and median particle size (d_{50}) with depth for core ALL14.

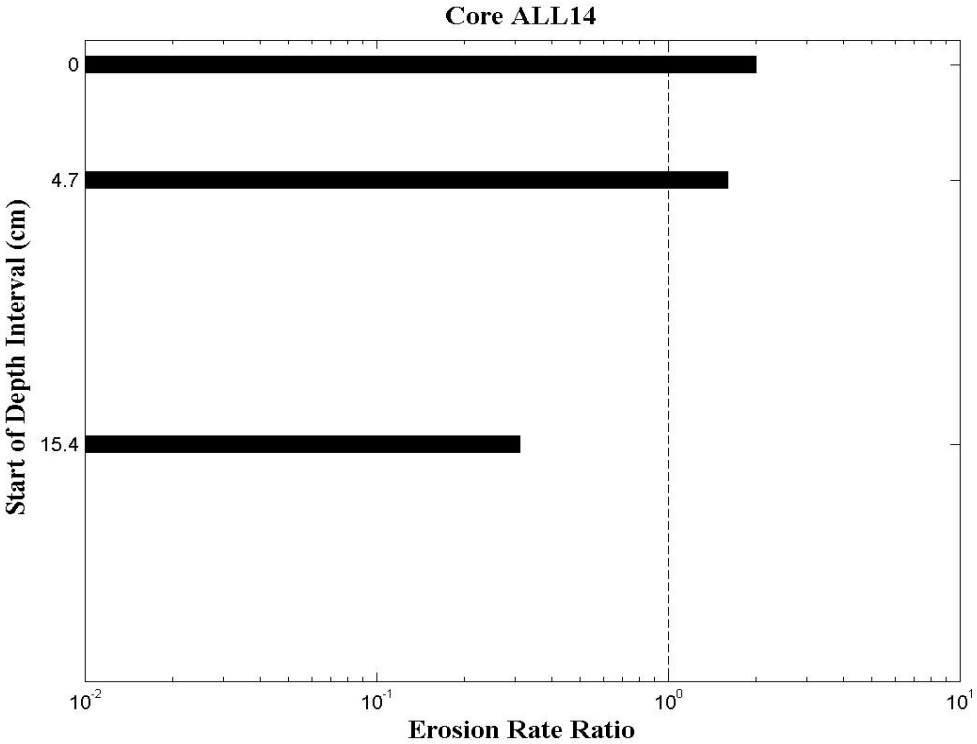

Figure 47. **Intra-core erosion rate ratios for core ALL14. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 29. Power law best-fit variables for specified depth intervals in core ALL14.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.00	3.30	0.00646	2.20	0.99
2	4.70	8.70	0.00634	2.00	0.94
3	9.70	13.6	n/a	n/a	0.77
4	15.4	24.2	0.00210	1.30	0.90

Table 30. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core ALL14.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	126.4	1.53	0.04	0.16	0.1	0.20	0.16
4.70	38.37	1.06	0.43	0.12	0.2	0.40	0.20
9.70	53.75	1.10	0.24	n/a	0.2	0.40	0.20
15.4	59.32	1.29	0.13	0.10	0.4	0.80	0.40
25.2	71.39	1.26	0.18	n/a	n/a	n/a	n/a
Mean	**69.85**	**1.25**	**0.20**	**0.13**	**0.23**	**0.45**	**0.24**

2.15ALL15

Core ALL15 was collected from Alliance Beach in Maurice River in 0.41 m of water. The core contain contained a 1.0 cm flocculated surface-layer that was dark brown in color. Loose pieces (not held in sediment) of organic material were observed resting on the core's surface. Small tubes (less than 1 mm in diameter) extended from the surface, likely worm tubes or some form of plant matter. White sand mixed with brown silt followed the surface layer and extended to a depth of roughly 9 cm. The sand content was higher towards the surface of the core. Below 9 cm, the core contained well mixed sandy silt that was uniformly brown in color. Several small sediment voids were encountered during the analysis between depths of roughly 14.0 and 20.0 cm.

A photograph of core ALL15 is presented in Figure 48 along with its corresponding erosion rate data. Shear stresses ranging from 0.1 Pa to 3.2 Pa were applied to the core. Erosion rates generally decreased with depth into the core (Figure 48). This trend is also evident in Figure 50, where all erosion rates ratios decreased with depth. The core's average critical shear stress was 0.16 Pa.

Median particle sizes varied from coarse silt to very fine sand, with a core average of 56.77 μm. Bulk densities increased from 1.05 g/cm^3 at the surface to 1.49 g/cm^3 at a depth of 0.80 cm, and then decreased again to 1.09 g/cm^3 at a depth of 17.1 cm (Figure 49 and Table 32). The averaged bulk density and *LOI* were 1.23 g/cm^3 and 0.20.

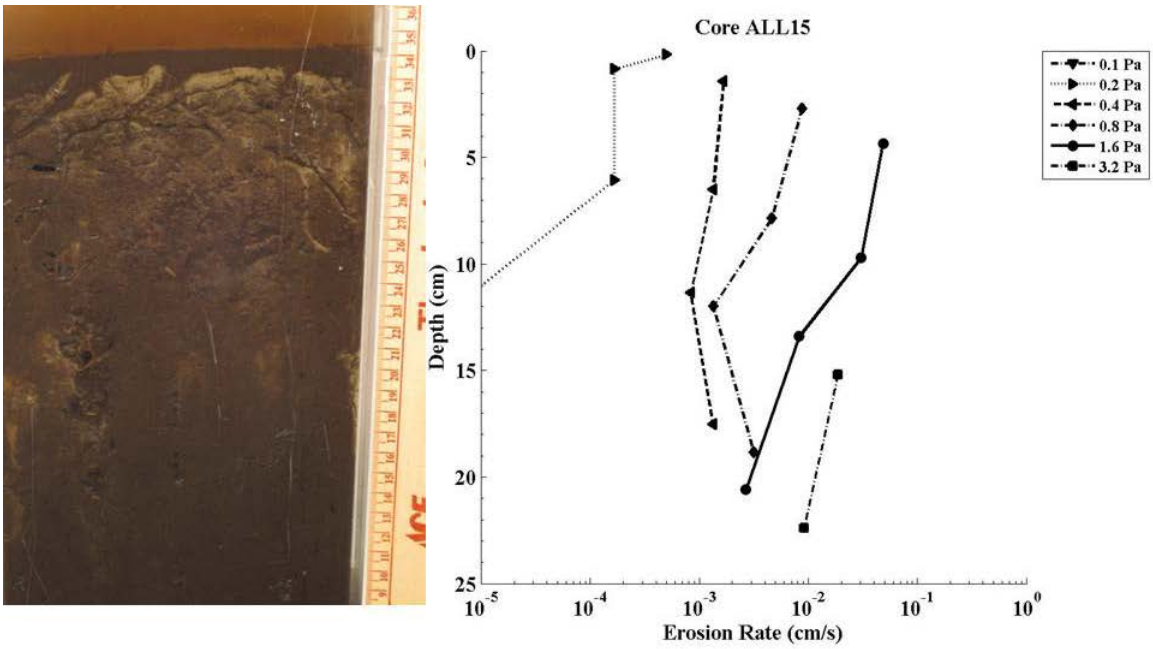

Figure 48. Photo of core ALL15 aligned vertically with the corresponding erosion rates.

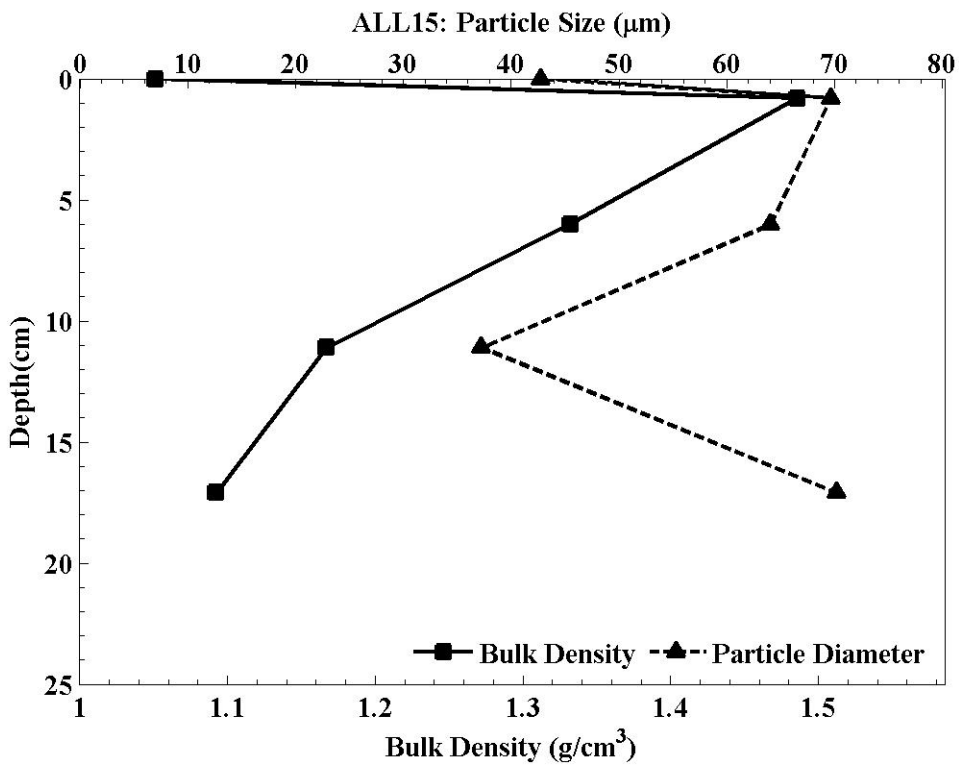

Figure 49. Bulk density and median particle size (d_{50}) with depth for core ALL15.

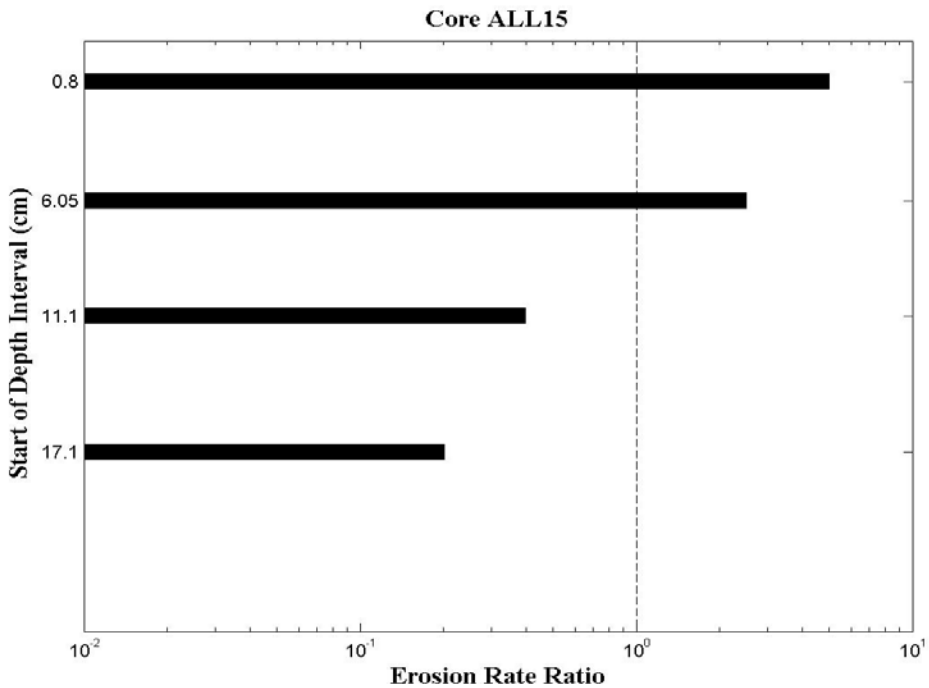

Figure 50. **Intra-core erosion rate ratios for core ALL15. The dashed line indicates conditions for the core's average erosion rate (i.e. erosion rate ratio equals 1).**

Table 31. Power law best-fit variables for specified depth intervals in core ALL15.

Interval	Depth Start (cm)	Depth Finish (cm)	A	n	r^2
1	0.00	0.10	n/a	n/a	0.50
2	0.80	4.40	0.01528	2.70	0.99
3	6.10	9.70	0.00947	2.40	0.99
4	11.1	15.2	0.00296	1.60	0.95
5	17.1	22.4	0.00288	0.80	0.83

Table 32. Median particle size, bulk density, loss on ignition, and critical shear stress with depth for core ALL15.

Depth (cm)	d_{50} (µm)	ρ_b (g/cm^3)	*LOI*	Power Law τ_{cr} (Pa)	τ_{no} (Pa)	τ_{first} (Pa)	τ_{crit} (Pa)
0.00	42.75	1.05	0.40	n/a	0.10	0.20	0.10
0.80	69.63	1.49	0.04	0.15	0.10	0.20	0.15
6.00	64.05	1.33	0.09	0.15	0.10	0.20	0.15
11.1	37.22	1.17	0.18	0.12	0.20	0.40	0.20
17.1	70.20	1.09	0.28	0.02	0.20	0.40	0.20
Mean	**56.77**	**1.23**	**0.20**	**0.11**	**0.15**	**0.28**	**0.16**

Section 3
Summary

Sea Engineering, Inc. (SEI) conducted a Sedflume analysis on 15 sediment cores obtained from Union Lake and Maurice River in Millville, NJ. The cores were collected in water depths ranging between 0.30m to 6.1 m. The primary goal of this work was to characterize the erosion properties and physical characteristics of the lake and rivers sediments. The cores were eroded to determine erosion rates as a function of shear stress and depth into core. In addition, cores were sub-sampled during the analysis to determine sediment bulk density, loss on ignition fraction and particle size distributions at specific depths within the core. Critical shear stresses were calculated from the erosion rate data for five intervals in each core, ranging from 0.1 Pa to 1.78 Pa.

The presence of organic material such as detritus, woody debris, and leafs had a noticeable effect on erosion. The Sedflume analysis provided a quantification of the overall effect of the organic material on sediment erosion characteristics. When high concentrations of organic material were present in a core, erosion was often dominated by the mobilization of large chunks of material as organic pieces lifted from the test section taking sediment along with them. In cores SCC03 and ALL14 however, organic material acted to stiffen the cores. Roots in SCC03 made the core relatively stiff by binding sediment in the root system.

Even though organic material effected erosion, most cores stiffened with depth. This trend is common for sites with cohesive sediments. Cohesive sediments will often self-compact due to overlying material. Compaction reduces the potential for sediment mobility. However, Sedflume results must be analyzed in conjunction with other system characteristics, such as hydrodynamic forcing, to assess overall site stability and sediment transport trends.

To better visualize the relative erodibility of the sediment at the locations where cores were recovered, the ratio of the mean erosion rate of each core (core vertically averaged erosion rate) to the average mean erosion rate of all cores at the site was calculated and plotted (Figure 51). The dashed line in Figure 51 denotes a site-wide average erosion rate ratio of 1.0. A ratio above this line generally means the core is more susceptible to erosion than those below. It is important to note that this does not take into account the hydrodynamic forces or sediment coarsening processes that are responsible for net in-situ transport. Overall, there is no easily discernable spatial pattern in the erosion potential of the sites sediments.

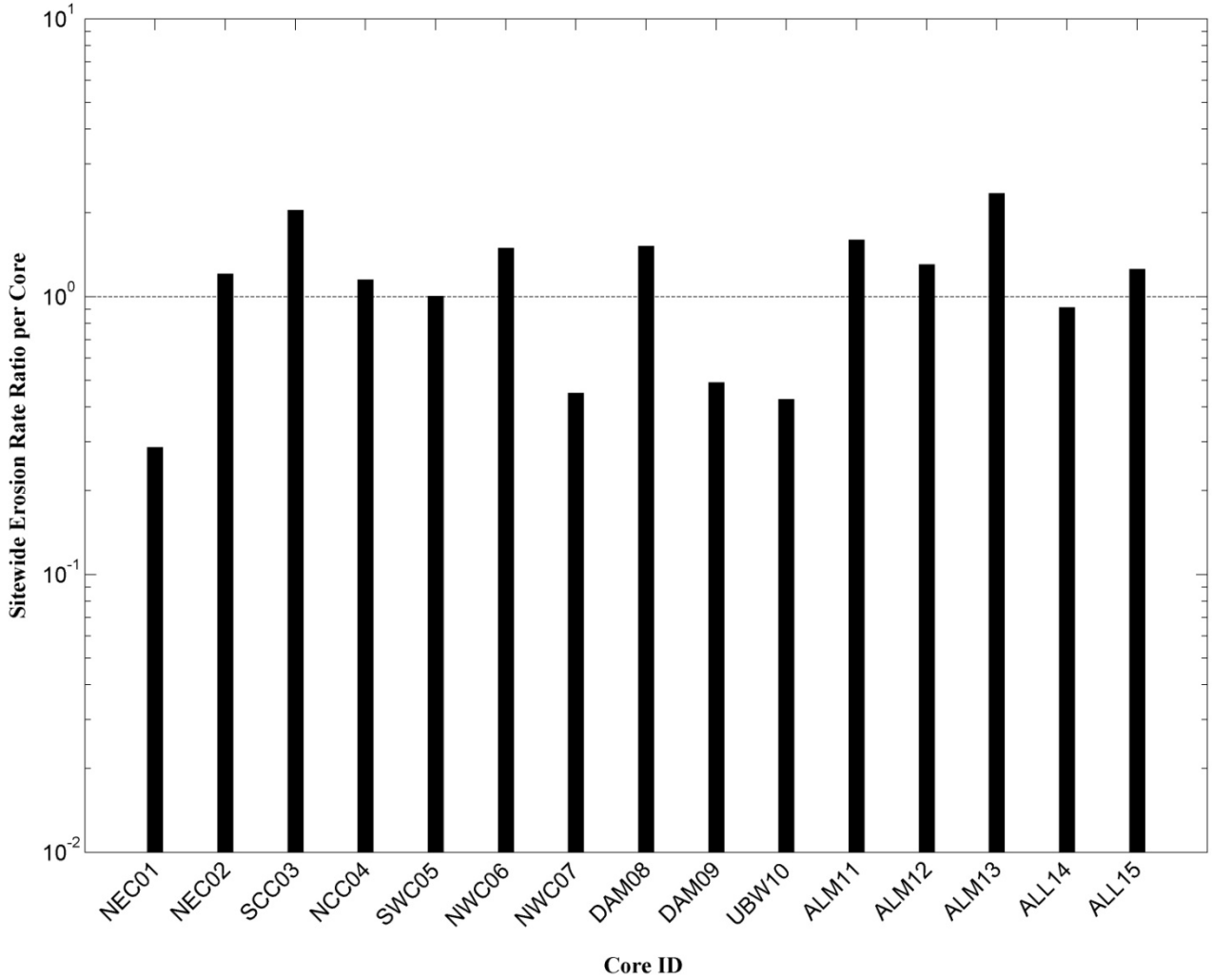

Figure 51. Inter-core erosion rate ratios. Depth-averaged core erosion rates compared to the site-wide average erosion rates.

Section 4
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Appendix A – Particle Size Distributions

Appendix D

Description of LTFATE Surface Water Modeling System

APPENDIX B

Description of LTFATE Surface Water Modeling System

The numerical modeling simulations for the hydrodynamic, sediment transport and contaminant transport modeling components of this study were performed with the LTFATE model, which is a three-dimensional (3D) surface water modeling system supported by ERDC-EL. The hydrodynamic, sediment transport and contaminant transport components of LTFATE are described next.

Hydrodynamic Model

The hydrodynamic model in LTFATE is the Environmental Fluid Dynamics Code (EFDC) model (Hamrick 2007a, 2007b, and 2007c). EFDC is a 3D finite difference model that contains dynamically linked hydrodynamic, sediment transport and contaminant transport modules. EFDC can simulate barotropic and baroclinic flow in a water body due to astronomical tides, wind, density gradients, and river inflow. It solves the 3D, vertically hydrostatic, free surface, turbulence averaged equations of motion. EFDC is extremely versatile, and can be used for 1D, 2D-laterally averaged (2DV), 2D-vertically averaged (2DH), or 3D simulations of rivers, lakes, reservoirs, estuaries, coastal seas, and wetlands. For realistic representation of horizontal boundaries, the governing equations in EFDC are formulated such that the horizontal coordinates, x and y, are curvilinear. To provide uniform resolution in the vertical direction, the sigma (stretching) transformation is used.

The equations of motion and transport solved in EFDC are turbulence-averaged, because prior to averaging, although they represent a closed set of instantaneous velocities and concentrations, they cannot be solved for turbulent flows. A statistical approach is applied, where the instantaneous values are decomposed into mean and fluctuating values to enable the solution. Additional terms that represent turbulence are introduced to the equations for the mean flow. Turbulent equations of motion are formulated to utilize the Boussinesq approximation for variable density. The Boussinesq approximation accounts for variations in density only in the gravity term. This assumption simplifies the governing equations significantly, but may introduce large errors when density gradients are large. The resulting governing equations, presented in the next chapter, include parameterized, Reynolds-averaged stress and flux terms that account for the turbulent diffusion of momentum, heat and salt. The turbulence parameterization in EFDC is based on the Mellor and Yamada (1982) level 2.5 turbulence closure scheme as modified by Galperin *et al*. (1988) that relates turbulent correlation terms to the mean state variables.

The EFDC model also solves several transport and transformation equations for different dissolved and suspended constituents, including suspended sediments, contaminants, and water quality state variables. An overview of the governing equations is given below; detailed descriptions of the model formulation and numerical solution technique used in EFDC are provided by Hamrick (2007b). Additional capabilities of EFDC include: 1) simulation of wetting and drying of flood plains, mud flats, and tidal marshes; 2) integrated, near-field mixing zone model; 3) simulation of hydraulic control structures such as dams and culverts; and 4) simulation of wave boundary layers and wave-induced mean currents.

The governing equations that are solved by EFDC are the 3D Reynolds-averaged equations of continuity (Equation A-1), linear momentum (Equations A-2 and A-3), hydrostatic pressure (Equation A-4), equation of state (Equation A-5), and transport equations for salinity and temperature (Equations A-6 and

A-7), written for curvilinear-orthogonal horizontal coordinates and a sigma vertical coordinate, are given by Hamrick (2007b) and repeated below:

$$\frac{\partial(m\varepsilon)}{\partial t}+\frac{\partial(m_y Hu)}{\partial x}+\frac{\partial(m_x Hv)}{\partial y}+\frac{\partial(mw)}{\partial z}=0 \tag{A-1}$$

$$\begin{aligned}&\frac{\partial(mHu)}{\partial t}+\frac{\partial(m_y Huu)}{\partial x}+\frac{\partial(m_x Hvu)}{\partial y}+\frac{\partial(mwu)}{\partial z}-\\&(mf+v\frac{\partial(m_y)}{\partial x}-u\frac{\partial m_x}{\partial y})Hv=m_y H\frac{\partial(g\varepsilon+p)}{\partial x}-\\&m_y(\frac{\partial H}{\partial x}-z\frac{\partial H}{\partial x})\frac{\partial p}{\partial z}+\frac{\partial(mH^{-1}A_v\frac{\partial u}{\partial z})}{\partial z}+Q_u\end{aligned} \tag{A-2}$$

$$\begin{aligned}&\frac{\partial(mHv)}{\partial t}+\frac{\partial(m_y Huv)}{\partial x}+\frac{\partial(m_x Hvv)}{\partial y}+\frac{\partial(mwv)}{\partial z}+\\&(mf+v\frac{\partial(m_y)}{\partial x}+u\frac{\partial m_x}{\partial y})Hu=m_x H\frac{\partial(g\varepsilon+p)}{\partial y}-\\&m_x(\frac{\partial H}{\partial y}-z\frac{\partial H}{\partial y})\frac{\partial p}{\partial z}+\frac{\partial(mH^{-1}A_v\frac{\partial v}{\partial z})}{\partial z}+Q_v\end{aligned} \tag{A-3}$$

$$\frac{\partial p}{\partial z}=\frac{gH(\rho-\rho_o)}{\rho_o}=gHb \tag{A-4}$$

$$\rho=\rho(p,S,T) \tag{A-5}$$

$$\frac{\partial(mHS)}{\partial t}+\frac{\partial(m_y HuS)}{\partial x}+\frac{\partial(m_x HvS)}{\partial y}+\frac{\partial(mwS)}{\partial z}=\frac{\partial(\frac{mA_b}{H}\frac{\partial S}{\partial z})}{\partial z}+Q_s \tag{A-6}$$

$$\frac{\partial(mHT)}{\partial t}+\frac{\partial(m_y HuT)}{\partial x}+\frac{\partial(m_x HvT)}{\partial y}+\frac{\partial(mwT)}{\partial z}=\frac{\partial(\frac{mA_b}{H}\frac{\partial T}{\partial z})}{\partial z}+Q_T \tag{A-7}$$

where u and v are the mean horizontal velocity components in (x,y) coordinates; m_x and m_y are the square roots of the diagonal components of the metric tensor, and $m=m_x m_y$ is the Jacobian or square

root of the metric tensor determinant; p is the pressure in excess of the reference pressure, $\frac{\rho_o gH(1-z)}{\rho_o}$, where ρ_o is the reference density; f is the Coriolis parameter for latitudinal variation; A_v is the vertical turbulent viscosity; and A_b is the vertical turbulent diffusivity. The buoyancy b in Equation A-4 is the normalized deviation of density from the reference value. Equation A-5 is the equation of state that calculates water density (ρ) as functions of p, salinity (S) and temperature (T).

The sigma (stretching) transformation and mapping of the vertical coordinate is given as

$$z = \frac{(z^* + h)}{(\xi + h)} \tag{A-8}$$

where z^* is the physical vertical coordinate, and h and ξ are the depth below and the displacement about the undisturbed physical vertical coordinate origin, $z^* = 0$, respectively, and $H = h + \xi$ is the total depth. The vertical velocity in z coordinates, w, is related to the physical vertical velocity w^* by

$$w = w^* - z\left(\frac{\partial \xi}{\partial t} + \frac{u}{m_x}\frac{\partial \xi}{\partial x} + \frac{v}{m_y}\frac{\partial \xi}{\partial y}\right) + (1-z)\left(\frac{u}{m_x}\frac{\partial h}{\partial x} + \frac{v}{m_y}\frac{\partial h}{\partial y}\right) \tag{A-9}$$

The solutions of Equations A-2, A-3, A-6 and A-7 require the values for the vertical turbulent viscosity and diffusivity and the source and sink terms. The vertical eddy viscosity and diffusivity, A_v and A_b, are parameterized according to the level 2.5 (second-order) turbulence closure model of Mellor and Yamada (1982), as modified by Galperin *et al.* (1988), in which the vertical eddy viscosities are calculated based on the turbulent kinetic energy and the turbulent macroscale equations. The Mellor and Yamada level 2.5 (MY2.5) turbulence closure model is derived starting from the Reynolds stress and turbulent heat flux equations under the assumption of a nearly isotropic environment, where the Reynolds stress is generated due to the exchange of momentum in turbulent mixing. To make the turbulence equations closed, all empirical constants are obtained by assuming that turbulent heat production is primarily balanced by turbulent dissipation.

The vertical turbulent viscosity and diffusivity are related to the turbulent intensity, q^2, turbulent length scale, l and a Richardson number R_q as follows:

$$A_v = \Phi_v ql = 0.4(1+36R_q)^{-1}(1+6R_q)^{-1}(1+8R_q)ql \tag{A-10}$$

$$A_b = \Phi_b ql = 0.5(1+36R_q)^{-1}ql \tag{A-11}$$

where A_v and A_b are stability functions that account for reduced and enhanced vertical mixing or transport in stable and unstable vertical, density-stratified environments, respectively, and the local Richardson number is given as

$$R_q = \frac{gH\frac{\partial b}{\partial z}}{q^2}\frac{l^2}{H^2} \tag{A-12}$$

A critical Richardson number, R_q = 0.20, was found at which turbulence and mixing cease to exist (Mellor and Yamada 1982). Galperin *et al*. (1988) introduced a length scale limitation by imposing an

upper limit for the mixing length to account for the limitation of the vertical turbulent excursions in stably stratified flows. They also introduced stability functions that account for reduced or enhanced vertical mixing for different stratification regimes.

The turbulence intensity (q^2) and the turbulence length scale (l) are computed using the following two transport equations:

$$\frac{\partial(mHq^2)}{\partial t}+\frac{\partial(m_yHuq^2)}{\partial x}+\frac{\partial(m_xHvq^2)}{\partial y}+\frac{\partial(mwq^2)}{\partial z}=\frac{\partial(\frac{mA_q\frac{\partial q^2}{\partial z}}{H})}{\partial z}+Q_q \tag{A-13}$$
$$+2\frac{mA_v}{H}((\frac{\partial^2 u}{\partial z^2})+(\frac{\partial^2 v}{\partial z^2}))+2mgA_b\frac{\partial b}{\partial z}-2mH(\frac{q^3}{(B_1 l)})$$

$$\frac{\partial(mHq^2l)}{\partial t}+\frac{\partial(m_yHuq^2l)}{\partial x}+\frac{\partial(m_xHvq^2l)}{\partial y}+\frac{\partial(mwq^2l)}{\partial z}=\frac{\partial(\frac{mA_q\frac{\partial q^2 l}{\partial z}}{H})}{\partial z}+Q_l$$
$$+2\frac{mE_1lA_v}{H}((\frac{\partial^2 u}{\partial z^2})+(\frac{\partial^2 v}{\partial z^2}))+mgE_1E_3lA_b\frac{\partial b}{\partial z}-H(\frac{q^3}{(B_1)})(1+E_2(\kappa L)^{-2}l^2) \tag{A-14}$$

The above two equations include a wall proximity function, $W=1+E_2l(\kappa L)^{-2}$, that assures a positive value of diffusion coefficient $L^{-1}=(H)^{-1}(z^{-1}+(1-z)^{-1})$). B_1, E_1, E_2, and E_3 are empirical constants with values 16.6, 1.8, 1.33, and 0.53, respectively. All terms with Q's (Q_u, Q_v, Q_q, Q_l, Q_s, Q_T) are sub-grid scale sink-source terms that are modeled as sub-grid scale horizontal diffusion. The vertical diffusivity, A_q, is in general taken to be equal to the vertical turbulent viscosity, A_v (Hamrick 2007b).

The vertical boundary conditions for the solutions of the momentum equations are based on specification of the kinematic shear stresses. At the bottom, the bed shear stresses are computed using the near bed velocity components (u_1, v_1) as:

$$(\tau_{bx},\tau_{by})=c_b\sqrt{u_1^2+v_1^2}\,(u_1,v_1) \tag{A-15}$$

where the bottom drag coefficient $c_b=(\frac{\kappa}{\ln(\Delta_1/2z_o)})^2$, where κ is the von Karman constant, Δ_1 is the dimensionless thickness of the bottom layer, $z_o = z_o^*/H$ is the dimensionless roughness height, and z_o^* is roughness height in meters. At the surface layer, the shear stresses are computed using the u, v components of the wind velocity (u_w, v_w) above the water surface (usually measured at 10 m above the surface) and are given as:

$$(\tau_{sx},\tau_{sy})=c_s\sqrt{u_w^2+v_w^2}\,(u_w,v_w) \tag{A-16}$$

where $c_s=0.001\frac{\rho_a}{\rho_w}(0.8+0.065\sqrt{u_w{}^2+v_w^2})$ and ρ_a and ρ_w are the air and water densities, respectively. Zero flux vertical boundary conditions are used for the transport equations.

The generic transport equation solved in EFDC for a dissolved (*e.g.*, chemical contaminant) or suspended (*e.g.*, sediment) constituent having a mass per unit volume concentration C, is

$$\frac{\partial m_x m_y HC}{\partial t} + \frac{\partial m_y HuC}{\partial_x} + \frac{\partial m_x HvC}{\partial y} + \frac{\partial m_x m_y wC}{\partial z} - \frac{\partial m_x m_y w_{sc} C}{\partial z} =$$
$$\frac{\partial}{\partial_x}\left(\frac{m_y}{m_x} HK_H \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial_y}\left(\frac{m_x}{m_y} HK_H \frac{\partial C}{\partial y}\right) + \frac{\partial}{\partial_z}\left(m_x m_y \frac{K_v}{H}\frac{\partial C}{\partial z}\right) + Q_c \qquad \text{(A-17)}$$

where K_V and K_H are the vertical and horizontal turbulent diffusion coefficients, respectively; w_{sc} is a positive settling velocity when C represents the mass concentration of suspended sediment; and Q_c represents external sources or sinks and reactive internal sources or sinks. For sediment, $C = S_j$, where S_j represents the concentration of the *jth* sediment class. The solution procedure is the same as that for the salinity and heat transport equations, which use a high-order upwind difference solution scheme for the advection terms (Hamrick 2007b). Although the advection scheme is designed to minimize numerical diffusion, a small amount of horizontal diffusion remains inherent in the numerical scheme. As such, the horizontal diffusion terms in Equation A-17 are omitted by setting K_H equal to zero.

Numerically, EFDC is second-order accurate both in space and time. A staggered grid or C grid provides the framework for the second-order accurate spatial finite differencing used to solve the equations of motion. Integration over time involves an internal-external mode splitting procedure separating the internal shear, or baroclinic mode, from the external free surface gravity wave, or barotropic mode. In the external mode, the model uses a semi-implicit scheme that allows the use of relatively large time steps. The internal equations are solved at the same time step as the external equations, and are implicit with respect to vertical diffusion. Details of the finite difference numerical schemes used in the EFDC model are given in Hamrick (2007b), and will not be presented in this report.

Sediment Transport Model

The sediment transport model in LTFATE is the SEDZLJ mixed sediment transport model (Jones and Lick 2001; James *et al*. 2010) that a) includes a three-dimensional representation of the sediment bed, and b) can simulate winnowing and armoring of the surficial layer of the sediment bed. In LTFATE SEDZLJ is dynamically linked to EFDC in that the hydrodynamics and sediment transport modules are run during each model time step.

One of the first steps in performing sediment transport modeling is to use grain size distribution data from sediment samples collected at different locations throughout the model domain to determine how many discrete sediment size classes are needed to adequately represent the full range of sediment sizes. Typically, three to eight size classes are used. For example, two size classes are often used to represent sediment in the cohesive sediment size range, *i.e.*, less than 63 μm, and three to five size classes are often used to represent the noncohesive sediment size range, *i.e.*, greater than 63 μm. Each sediment size class is represented in SEDZLJ using the median or mean diameter within that size range.

Suspended Load Transport of Sediment

EFDC simulates the transport of each of the sediment classes to determine the suspension concentration for each size class in every water column layer in each grid cell. The transport of suspended sediment is determined through the solution of Equation A-17, where $C = S_j$, where S_j represents the concentration of the *jth* sediment class, and Q_{ci} = source/sink term for the *ith* sediment size class that accounts for erosion/deposition.

The settling velocities for noncohesive sediments are calculated in SEDZLJ using the following equation by Cheng (1997).

$$W_s = \frac{\mu}{d}\left(\sqrt{25+1.2d_*^2}-5\right)^{\frac{3}{2}} \tag{A-20}$$

where μ = dynamic viscosity of water; d = sediment diameter; and d_* = non-dimensional particle diameter given by:

$$d_* = d\left[\left(\rho_s/\rho_w - 1\right)g/\nu^2\right]^{1/3} \tag{A-21}$$

where ρ_w = water density, ρ_s = sediment particle density, g = acceleration due to gravity, and ν = kinematic fluid viscosity. Cheng's formula is based on measured settling speeds of real sediments. As such, it produces slower settling speeds than those by Stokes' Law because real sediments have irregular shapes and thus a greater hydrodynamic resistance than perfect spheres as assumed in Stokes' law.

The erosion and deposition of each of the sediment size classes, *i.e.*, the source/sink term in the 3D transport equation given above, and the subsequent change in the composition and thickness of the sediment bed in each grid cell are calculated by SEDZLJ at each time step.

Description of SEDZLJ

SEDZLJ is an advanced sediment bed model that represents the dynamic processes of erosion, bedload transport, bed sorting, armoring, consolidation of fine-grain sediment dominated sediment beds, settling of flocculated cohesive sediment, settling of individual noncohesive sediment particles, and deposition. An active layer formulation is used to describe sediment bed interactions during simultaneous erosion and deposition. The active layer facilitates coarsening during the bed armoring process. The SEDZLJ model was designed to directly use the results obtained from a SEDFLUME study as was performed at the Maurice River - Union Lake (SEI 2013).

Figure A-1 shows the simulated sediment transport processes in SEDZLJ. In this figure, U = near bed flow velocity, δ_{bl} = thickness of layer in which bedload occurs, U_{bl} = average bedload transport velocity, D_{bl} = sediment deposition rate for the sediment being transported as bedload, E_{bl} = sediment erosion rate for the sediment being transported as bedload, E_{sus} = sediment erosion rate for the sediment that is eroded and entrained into suspension, and D_{sus} = sediment deposition rate for suspended sediment. Specific capabilities of SEDZLJ are listed below.

- Whereas a hydrodynamic model is calibrated to account for the total bed shear stress, which is the sum of the form drag due to bed forms and other large-scale physical features (*e.g.*, boulder size particles) and the skin friction (also called the surface friction), the correct component of the bed shear stress to use in predicting sediment resuspension and deposition is the skin friction. The skin friction is calculated in SEDZLJ as a function of the near-bed current velocity and the effective bed roughness. The latter is specified in SEDZLJ as a linear function of the mean particle diameter in the active layer.

- Multiple size classes of both fine-grain (*i.e.*, cohesive) and noncohesive sediments can be represented in the sediment bed. This capability is necessary in order to simulate coarsening and subsequent armoring of the surficial sediment bed surface during high flow events.

To correctly represent the processes of erosion and deposition, the sediment bed in SEDZLJ can be divided into multiple layers, some of which are used to represent the existing sediment bed and others that are used to represent new bed layers that form due to deposition during model simulations. Figure A-2 shows a schematic diagram of this multiple bed layer structure. The graph on the right hand side of this figure shows the variation in the measured gross erosion rate (in units of cm/s) with depth into the sediment bed as a function of the applied skin friction. A SEDFLUME study is normally used to measure these erosion rates.

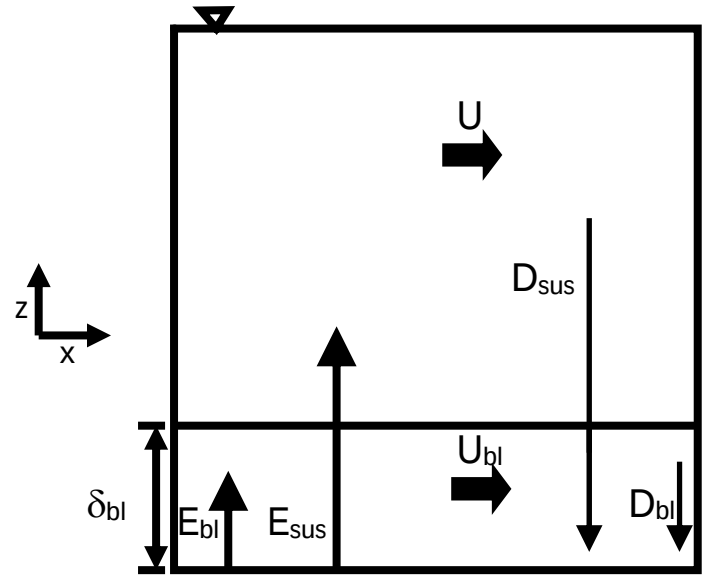

Figure A-1 Sediment Transport Processes Simulated in SEDZLJ

- Erosion from both cohesive and non-cohesive beds is affected by bed armoring, which is a process that limits the amount of bed erosion that occurs during a high-flow event. Bed armoring occurs in a bed that contains a range of particle sizes (*e.g.*, clay, silt, sand). During a high-flow event when erosion is occurring, finer particles (*i.e.*, clay and silt, and fine sand) tend to be eroded at a faster rate than coarser particles (*i.e.*, medium to coarse sand). The differences in erosion rates of the various sediment particle sizes creates a thin layer at the surface of the sediment bed, referred to as the active layer, that is depleted of finer particles and enriched with coarser particles. This depletion-enrichment process can lead to bed armoring, where the active layer is primarily composed of coarse particles that have limited mobility. The multiple bed model in SEDZLJ accounts for the exchange of sediment through and the change in composition of this active layer. The thickness of the active layer is normally calculated as a time varying function of the mean sediment particle diameter in the active layer, the critical shear stress for resuspension corresponding to the mean particle diameter, and the bed shear stress. Figure A-3 shows a schematic of the active layer at the top of the multi-bed layer model used in SEDZLJ.

- SEDZLJ was designed to use the results obtained with SEDFLUME, which is a straight, closed conduit rectangular cross-section flume in which detailed measurements of critical shear stress of erosion and erosion rate as a function of sediment depth are made using sediment cores dominated by cohesive sediment collected at the site to be modeled (McNeil *et al.* 1996). However, when SEDFLUME results are not available, it is possible to use a combination of literature values for these parameters as well as the results of SEDFLUME tests performed at other similar sites. In this case, a

detailed sensitivity analysis should be performed to assist in quantifying the uncertainty that results from the use of these non-site specific erosion parameters.

- SEDZLJ can simulate overburden-induced consolidation of cohesive sediments. An algorithm that simulates the process of primary consolidation, which is caused by the expulsion of pore water from the sediment, of a fine-grained, *i.e.*, cohesive, dominated sediment bed is included in SEDZLJ. The consolidation algorithm in SEDZLJ accounts for the following changes in two important bed parameters: 1) increase in bed bulk density with time due to the expulsion of pore water, and 2)

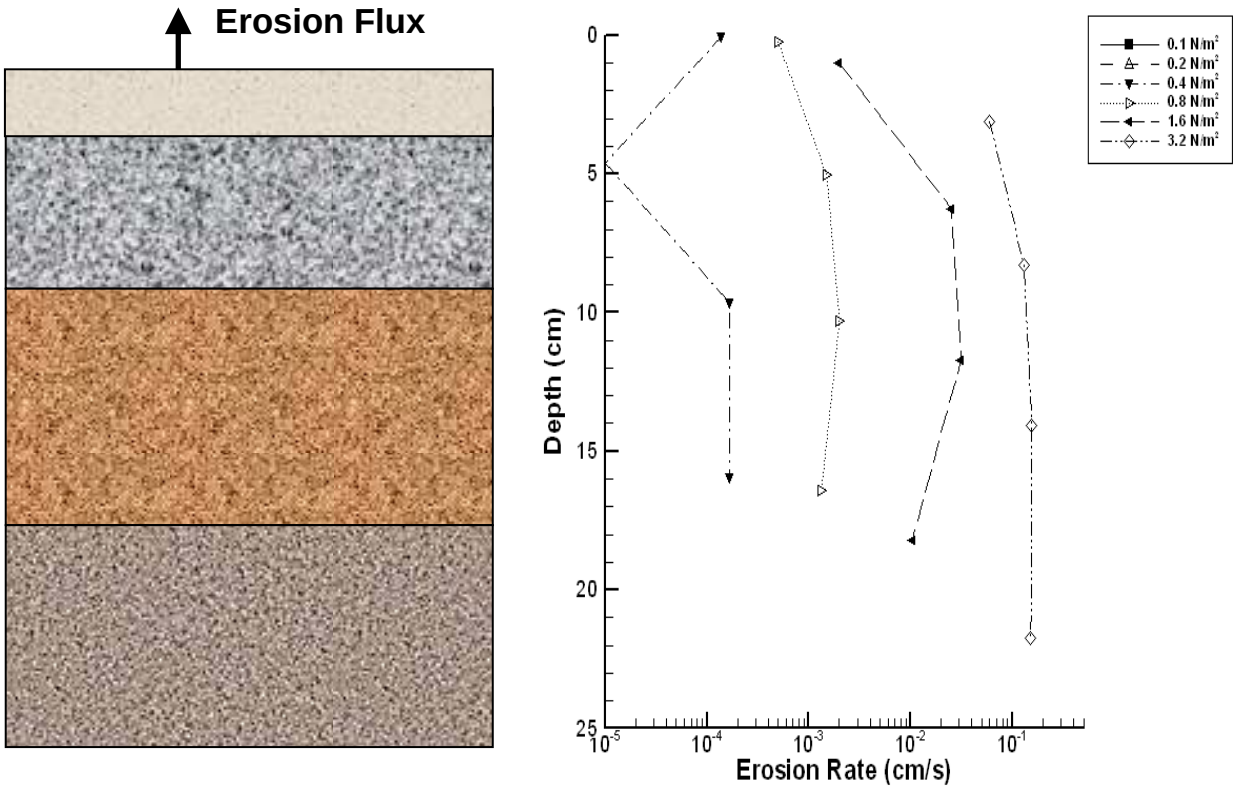

Figure A-2 Multi-Bed Layer Model Used in SEDZLJ

increase in the bed shear strength (also referred to as the critical shear stress for resuspension) with time. The latter parameter is the minimum value of the bed shear stress at which measurable resuspension of cohesive sediment occurs. As such, the process of consolidation typically results in reduced erosion for a given excess bed shear stress (defined as the difference between the bed shear stress and bed shear strength) due to the increase in the bed shear strength. In addition, the increase in bulk density needs to be represented to accurately account for the mass of sediment (per unit bed area) that resuspends when the bed surface is subjected to a flow-induced excess bed shear stress.

Models that represent primary consolidation range from empirical equations that approximate the increases in bed bulk density and critical shear stress for resuspension due to porewater expulsion (Sanford 2008) to finite difference models that solve the non-linear finite strain consolidation equation that governs primary consolidation in saturated porous media (Arega and Hayter 2008). An empirical-based consolidation algorithm is included in SEDZLJ. Simulation of consolidation requires performing specialized consolidation experiments to quantify the rate of consolidation.

- SEDZLJ contains a morphologic algorithm that, when enabled by the model user, will adjust the bed elevation of grid cells to account for erosion and deposition of sediment. Changes in grid cells' bed elevations are used by the hydrodynamic model during the next time step to update the flow field.

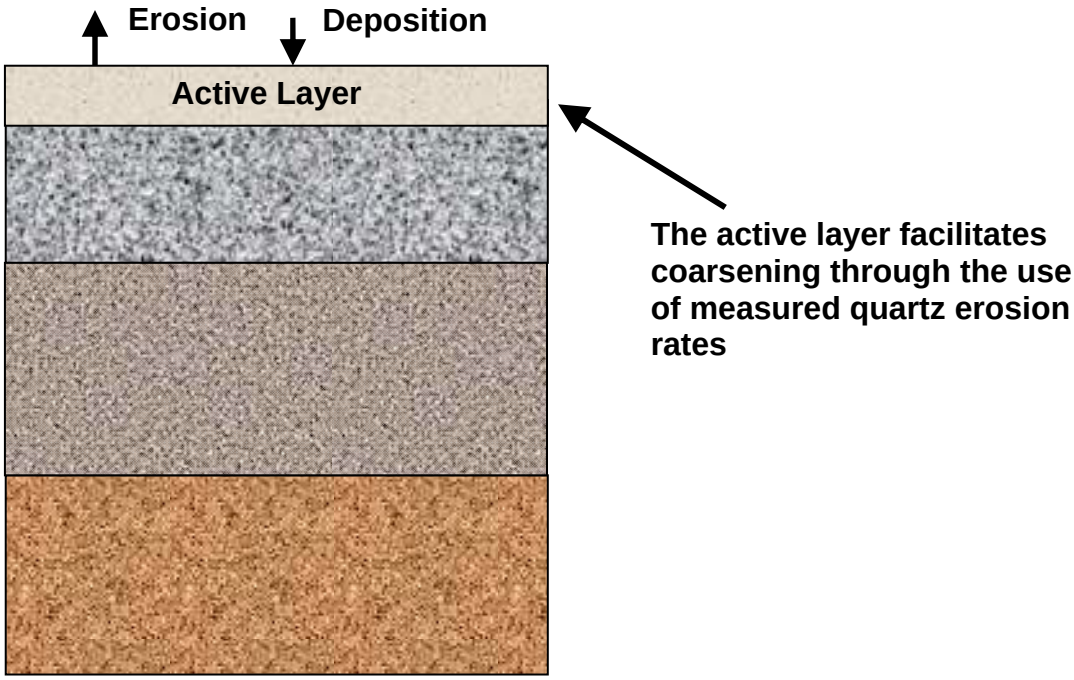

Figure 1-3 Schematic of Active Layer Used in SEDZLJ

- SEDZLJ accounts for the effect of bed slope on erosion rates and bedload transport. The bed slopes in both the x- and y-directions are calculated, and scaling factors are applied to the bed shear stress, erosion rate, and bedload transport equations. A maximum adverse bed slope is specified that prevents bedload transport from occurring up too steep a slope.

Bedload Transport of Noncohesive Sediment

The approach used by Van Rijn (1984) to simulate bedload transport is used in SEDZLJ. The 2D mass balance equation for the concentration of sediment moving as bedload is given by:

$$\frac{\partial\left(\delta_{bl}C_b\right)}{\partial t} = \frac{\partial q_{b,x}}{\partial x} + \frac{\partial q_{b,y}}{\partial y} + Q_b \qquad \text{(A-22)}$$

where δ_{bl} = bedload thickness; C_b = bedload concentration; $q_{b,x}$ and $q_{b,y}$ = x- and y-components of the bedload sediment flux, respectively; and Q_b = sediment flux from the bed. Van Rijn (1984) gives the following equation for the thickness of the layer in which bedload is occurring:

$$\delta_{bl} = 0.3dd_*^{0.7}(\Delta\tau)^{0.5} \qquad \text{(A-23)}$$

where $\Delta\tau = \tau_b - \tau_{ce}$; τ_b = bed shear stress, and τ_{ce} = critical shear stress for erosion. The bedload fluxes in the x- and y-directions are given by:

$$q_{b,x} = \delta_{bl}\, u_{b,x} C_b$$

$$q_{b,y} = \delta_{bl} u_{b,y} C_b$$

where $u_{b,x}$ and $u_{b,y}$ = x- and y-components of the bedload velocity, u_b, which van Rijn (1984) gave as

$$u_b = 1.5\tau_*^{0.6}\left[\left(\frac{\rho_s}{\rho_w} - 1\right) gd\right]^{0.5} \tag{A-24}$$

with the dimensionless parameter τ_* given as

$$\tau_* = \frac{\tau_b - \tau_{ce}}{\tau_{ce}} \tag{A-25}$$

The x- and y-components of u_b are calculated as the ratios of u and v to the total hydrodynamic velocity times u_b, respectively.

The sediment flux from the bed due to bedload, Q_b, is equal to

$$Q_b = E_b - D_b \tag{A-26}$$

where E_b is the erosion of sediment into bedload, and D_b is the deposition of sediment from bedload onto the sediment bed.

Deposition of Sediment

In contrast to previous conceptual models, deposition of suspended noncohesive sediment and cohesive flocs is now believed to occur continually, and not just when the bed shear stress is less than a so-called critical shear stress of deposition (Mehta 2014). The rate of deposition of the *ith* sediment size class, $D_{sus,i}$ is given by:

$$D_{sus,i} = -\frac{W_{s,i} C_i}{d} \tag{A-27}$$

where $W_{s,i}$ is given by Eq. A-20 for noncohesive sediment and by the empirical formulation used for the settling velocities of suspended flocs and bed aggregates, and d = thickness of the bottom water column layer in a three-dimensional model. Because of their high settling velocities, noncohesive sediments deposit relatively quickly (in comparison to the deposition of cohesive sediments) under all flows. Due to the settling velocities of flocs being a lot slower than those of noncohesive sediment, the deposition rate of flocs are usually several orders of magnitude smaller.

Deposited cohesive sediments usually form a thin surface layer that is often called a fluff or benthic nepheloid layer that is often less than 1 cm in thickness. The fluff layer typically forms in estuaries and coastal waters via deposition of suspended flocs during the decelerating phase of tidal flows, in particular immediately before slack water (Krone 1972; and Hayter and Mehta 1986). The fluff layer is usually easily resuspended by the accelerating currents following slack water in tidal bodies of water.
The rate of deposition of the *ith* noncohesive sediment class moving as bedload is given by (James *et al*. 2010):

$$D_{bl,i} = -P_{bl,i} W_{s,i} C_{bl,i} \tag{A-28}$$

where $C_{bl,i}$ = mass concentration of the *ith* noncohesive sediment class being transported as bedload, and $P_{bl,i}$ = probability of deposition from bedload transport. The latter parameter is given by:

$$P_{bl,i} = \frac{E_{bl,i}}{W_{s,i} C_{bl,i}^{eq}} \tag{A-29}$$

where

$$C_{bl,i}^{eq} = \frac{0.18 C_o \tau_b}{d_*} \tag{A-30}$$

which is the steady-state sediment concentration in bedload that results from a dynamic equilibrium between erosion and deposition, d_* is given by Eq. A-21, and $C_o = 0.65$.

Erosion of Sediment

Erosion of a cohesive sediment bed occurs whenever the current and wave-induced bed shear stress is great enough to break the electrochemical interparticle bonds (Partheniades, 1965; Paaswell, 1973). When this happens, erosion takes place by the removal of individual sediment particles or bed aggregates. This type of erosion is time dependent and is defined as surface erosion or resuspension. In contrast, another type of erosion occurs more or less instantaneously by the removal of relatively large pieces of the bed. This process is referred to as mass erosion, and occurs when the bed shear stress exceeds the bed bulk strength along some deep-seated plane that is typically much greater than the bed shear strength of the surficial sediment.

The erosion rate of cohesive sediments, E, is given experimentally by:

$$\begin{aligned} E &= 0; && (\tau < \tau_{cr}) \\ E &= A\tau^n; && (\tau_{cr} < \tau < \tau_m) \\ E &= A\tau_m^n; && (\tau > \tau_m) \end{aligned} \tag{A-31}$$

where the exponent, coefficient, critical shear stress for erosion, and maximum shear stress (above which E is not a function of τ) n, A, and τ_{cr}, respectively, are determined from a SEDFLUME study. The erosion rates of the noncohesive sediment size classes were determined as a function of the difference between the bed shear stress and the critical shear stress for erosion using the results obtained by Roberts *et al.* (1998) who measured the erosion rates of quartz particles in a SEDFLUME.

The erosion rate of the *ith* noncohesive sediment size class that is transported as bedload, $E_{bl,i}$, is calculated by the following equation in which it is assumed there is dynamic equilibrium between erosion and deposition:

$$E_{bl,i} = P_{bl,i} W_{s,i} C_{bl,i} \tag{A-32}$$

Contaminant Transport Model

The contaminant transport model in LTFATE is a three-phase partitioning model that is used to simulate the transport of one or more contaminants during a single model simulation. It can be used to simulate the

transport of organic chemicals (*e.g.*, PCBs), metalloids (*e.g.*, Arsenic), and metals (*e.g.*, Copper, Zinc). Use of a three-phase partitioning model explicitly accounts for the freely dissolved contaminant, the phase (or fraction) that is bioavailable via waterborne exposures, and is a better representation of the bioavailable fraction than a two-phase partitioning model as is used in other contaminant fate models such as HSCTM-2D (Hayter *et al.* 1999). Since the model simulation described in this report is of Arsenic transport in the Blackwater Branch and the Maurice River, NJ, the remainder of this chapter concentrates on the specifics of representing the transport and fate of Arsenic.

Metals and metalloids can be distributed in various phases in aquatic ecosystems. One representation of this distribution is that the chemicals are partitioned among the particulate organic matter (POM), the dissolved organic matter (DOM), and also the freely dissolved form (USEPA 1998). The degree of partitioning, as characterized by the dissolved, *i.e.*, free plus dissolved organic carbon (DOC) complexed, and particulate fractions, f_d and f_p, respectively, is an important parameter that controls the fate of chemicals. This is because the transport of both the dissolved and particulate chemical phases is related to this phase distribution (USEPA 1998).

In LTFATE it is assumed that the total Arsenic (*As*) load is distributed among the three phases, *i.e.*, freely dissolved *As*, DOC-complexed *As*, and sorbed or particulate organic carbon (POC) bound *As*, and that *As* is in equilibrium across all these phases. While the actual time it takes to reach complete equilibrium can be relatively long, it is often assumed that equilibrium between the dissolved and particulate phases occurs over a time scale of only a few hours to a day (Jepsen *et al.* 1997). This is the basis of the equilibrium partitioning assumption that is commonly used in contaminant transport modeling. Transport processes that affect the fate of *As*, and that are represented in LTFATE are discussed next.

Both dissolved and particulate-bound (sorbed) *As* are advected by the predominately river-driven flow in the Maurice River. Sorbed As is transported with sediment particles as the latter are moved as a result of bed load, suspended load, deposition and resuspension as simulated by the sediment transport model. Sorption of contaminants such as *As* onto both inorganic and organic particles generally refers to both adsorption and absorption (Elzerman and Coates 1987). Adsorption of a sorbate to a sorbent occurs at a surface or interface, while absorption continues beyond the interface and involves incorporation of the sorbate into the interior of the sorbent. Distinction between the two processes is usually not precise, thus explaining the use of the collective term.

Sorption of inorganic compounds is a chemical coordination process involving certain reactions between absorbents and the inorganic adsorbate (Dzombak and Morel 1987). Sorption models for inorganic contaminants should simulate these chemical reactions and account for interactions between electrical surface charges and ion adsorption. Sorption models are empirical in nature due to the complex electrochemical interactions, and are generally applicable to a specific sorbent-sorbate pair (Dzombak and Morel 1987). Typically, a geochemical-metals speciation model, such as MINTEQA2 (Brown and Allison 1987), is used to compute metals precipitation and sorption/desorption for the site specific geochemical conditions. As such, sorption (or partitioning) of contaminants onto sediments is usually treated as a process in thermodynamic equilibrium that occurs rapidly compared to transformation processes such as hydrolysis, microbial transformation, photolysis, volatilization, and chemical oxidation. These slower processes are usually simulated using a kinetic approach (Baughman and Burns 1980) and are not represented in LTFATE.

Partition coefficients, P, are used to define the distribution of a contaminant between the particulate and the two dissolved phases. Values for P usually correspond to equilibrium conditions at which rates of desorption and adsorption are equal. Because of typically high values of P, the total mass of contaminants sorbed to suspended sediments is usually higher than that in the dissolved phase.

Sorbed contaminant mass on both suspended sediments and bed sediments must be included in contaminant transport model. Contaminants that are sorbed on bed sediments either sorbed directly onto deposited sediments or sorbed onto suspended sediments that subsequently deposited on the bed. LTFATE includes a one-dimensional (vertical) diffusion model that simulates the molecular diffusive transport of freely dissolved contaminants in the pore water within the sediment bed in each grid cell in the model. The upper boundary condition is the vertical diffusive flux of contaminants that occurs in proportion to the gradient between the dissolved concentration in the overlying water column and that in the pore water in the top bed layer. This diffusive flux is due to molecular diffusion and bioturbation. In addition, the advective transport due to groundwater flow and associated dissolved contaminants can also be simulated. This will probably need to be simulated to represent the flux of dissolved *As* into the Blackwater Branch. Another transport process, volatilization, is also simulated in LTFATE. Volatilization is the loss of freely dissolved chemicals via transfer from the water column to the atmosphere.

The transport equation for the freely dissolved chemical is:

$$\begin{aligned}
&\partial_t\left(m_x m_y H C_w\right)+\partial_x\left(m_y H u C_w\right)+\partial_y\left(m_x H v C_w\right)+\partial_z\left(m_x m_y w C_w\right)\\
&=\partial_z\left(m_x m_y \frac{A_b}{H}\partial_z C_w\right)+m_x m_y H\left(\sum_i\left(K_{dS}^i S^i \chi_S^i\right)+\sum_j\left(K_{dD}^j D^j \chi_D^j\right)\right)\\
&\quad -m_x m_y H\left(\begin{array}{c}\sum_i\left(K_{aS}^i S^i\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_S^i-\chi_S^i\right)\\ +\sum_j\left(K_{aD}^j D^j\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_D^j-\chi_D^j\right)+\gamma C_w\end{array}\right)
\end{aligned} \tag{A-33}$$

where C_w is the mass of freely dissolved contaminant per unit total volume, C_S is the mass of contaminant sorbed to sediment class i per mass of sediment, C_D is the mass of contaminant sorbed to dissolved material j per unit mass of dissolved material, φ is the porosity, ψ_w is the fraction of the freely dissolved contaminant available for sorption, K_a is the adsorption rate, K_d is the desorption rate, and γ is a net linearized decay rate coefficient. Since equilibrium partitioning is assumed, the adsorption and desorption rates are both equal to zero.

The sorption kinetics are based on the Langmuir isotherm (Chapra 1997) with $\hat{\chi}$ denoting the saturation adsorbed mass per carrier mass. The solids and dissolved material (*i.e.*, DOC) concentrations, S and D, respectively, are defined as mass per unit total volume. The index j is the number of contaminants, and the index i is the number of classes of solids, *i.e.*, organic particulate matter and inorganic sediment. The transport equation for the contaminant adsorbed to DOC is:

$$\begin{aligned}
&\partial_t\left(m_x m_y H D^j \chi_D^j\right)+\partial_x\left(m_y H u D^j \chi_D^j\right)+\partial_y\left(m_x H v D^j \chi_D^j\right)+\partial_z\left(m_x m_y w D^j \chi_D^j\right)\\
&\quad=\partial_z\left(m_x m_y \frac{A_b}{H}\partial_z\left(D^j \chi_D^j\right)\right)+m_x m_y H\left(K_{sD}^j D^j\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_D^j-\chi_D^j\right)\\
&\qquad -m_x m_y H\left(K_{dD}^j+\gamma\right)\left(D^j \chi_D^j\right)
\end{aligned} \tag{A-34}$$

The transport equation for the contaminant adsorbed to suspended solids is:

$$\partial_t\left(m_x m_y H S^i \chi_S^i\right)+\partial_x\left(m_y H u S^i \chi_S^i\right)+\partial_y\left(m_x H v S^i \chi_S^i\right)+\partial_z\left(m_x m_y w S^i \chi_S^i\right)$$
$$+\partial_z\left(m_x m_y w_S^i S^i \chi_S^i\right)=\partial_z\left(m_x m_y \frac{A_b}{H}\partial_z\left(S^i \chi_S^i\right)\right) \tag{A-35}$$
$$+m_x m_y H\left(K_{aS}^i S^i\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_S^i-\chi_S^i\right)-m_x m_y H\left(K_{dS}^i+\gamma\right)\left(S^i \chi_S^i\right)$$

The concentrations (in units of sorbed mass per unit total volume) of chemicals adsorbed to DOC and solids, C_D and C_S, respectively, are defined as:

$$C_D^j = D^j \chi_D^j \tag{A-36}$$

$$C_S^i = S^i \chi_S^i \tag{A-37}$$

Introducing Equations A-36 and A-37 into Equations A-33 – A-34 gives:

$$\partial_t\left(m_x m_y H C_w\right)+\partial_x\left(m_y H u C_w\right)+\partial_y\left(m_x H v C_w\right)+\partial_z\left(m_x m_y w C_w\right)$$
$$=\partial_z\left(m_x m_y \frac{A_b}{H}\partial_z C_w\right)+m_x m_y H\left(\sum_i\left(K_{dS}^i C_S^i\right)+\sum_j\left(K_{dD}^j C_D^j\right)\right)$$
$$-m_x m_y H\left(\begin{array}{c}\sum_i\left(K_{aS}^i S^i\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_S^i-\chi_S^i\right)\\ +\sum_j\left(K_{aD}^j D^j\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_D^j-\chi_D^j\right)+\gamma C_w\end{array}\right) \tag{A-38}$$

$$\partial_t\left(m_x m_y H C_D^j\right)+\partial_x\left(m_y H u C_D^j\right)+\partial_y\left(m_x H v C_D^j\right)+\partial_z\left(m_x m_y w C_D^j\right)$$
$$=\partial_z\left(m_x m_y \frac{A_b}{H}\partial_z C_D^j\right)+m_x m_y H\left(K_{sD}^j D^j\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_D^j-\chi_D^j\right) \tag{A-39}$$
$$-m_x m_y H\left(K_{dD}^j+\gamma\right)C_D^j$$

$$\partial_t\left(m_x m_y H C_S^i\right)+\partial_x\left(m_y H u C_S^i\right)+\partial_y\left(m_x H v C_S^i\right)+\partial_z\left(m_x m_y w C_S^i\right)$$
$$+\partial_z\left(m_x m_y w_S^i C_S^i\right)=\partial_z\left(m_x m_y \frac{A_b}{H}\partial_z C_S^i\right) \tag{A-40}$$
$$+m_x m_y H\left(K_{aS}^i S^i\right)\left(\psi_w \frac{C_w}{\phi}\right)\left(\hat{\chi}_S^i-\chi_S^i\right)-m_x m_y H\left(K_{dS}^i+\gamma\right)C_S^i$$

The LTFATE sorbed contaminant transport formulation currently assumes equilibrium partitioning with the adsorption and desorption terms in Equations A-39 and A-40 being equal, such that:

$$\left(K_{sD}^{j}D^{j}\right)\left(\psi_{w}\frac{C_{w}}{\phi}\right)\left(\hat{\chi}_{D}^{j}-\chi_{D}^{j}\right)=K_{dD}^{j}C_{D}^{j} \tag{A-41}$$

$$\left(K_{aS}^{i}S^{i}\right)\left(\psi_{w}\frac{C_{w}}{\phi}\right)\left(\hat{\chi}_{S}^{i}-\chi_{S}^{i}\right)=K_{dS}^{i}C_{S}^{i} \tag{A-42}$$

Solving Equations A-41 and A-42 for the ratio of C_D and C_S to C_w gives

$$\frac{C_{D}^{j}}{C_{w}}=\frac{f_{D}^{j}}{f_{w}}=P_{D}^{j}\frac{D^{j}}{\phi} \tag{A-43}$$

$$\frac{C_{S}^{i}}{C_{w}}=\frac{f_{S}^{i}}{f_{w}}=P_{S}^{i}\frac{S^{i}}{\phi} \tag{A-44}$$

where P is the partition coefficient. With the relationship between the mass fractions expressed as

$$f_{w}+\sum_{i}f_{S}^{i}+\sum_{j}f_{D}^{j}=1 \tag{A-45}$$

the expressions for these three fractions are given by:

$$\begin{aligned}
f_{w}&=\frac{C_{w}}{C}=\frac{\phi}{\phi+\sum_{i}P_{S}^{i}S^{i}+\sum_{j}P_{D}^{j}D^{j}}\\
f_{D}^{j}&=\frac{C_{D}^{j}}{C}=\frac{P_{D}^{j}D^{j}}{\phi+\sum_{i}P_{S}^{i}S^{i}+\sum_{j}P_{D}^{j}D^{j}}\\
f_{S}^{i}&=\frac{C_{S}^{i}}{C}=\frac{P_{S}^{i}S^{i}}{\phi+\sum_{i}P_{S}^{i}S^{i}+\sum_{j}P_{D}^{j}D^{j}}
\end{aligned} \tag{A-46}$$

Adding Equations A-32, A-33, and A-34, and using the equilibrium partitioning relationships given by Equations A-41 and A-42 gives the following transport equation for the total contaminant concentration:

$$\begin{aligned}
&\partial_{t}\left(m_{x}m_{y}HC\right)+\frac{1}{m_{x}m_{y}}\partial_{x}\left(m_{y}HuC\right)+\frac{1}{m_{x}m_{y}}\partial_{y}\left(m_{x}HvC\right)+\partial_{z}\left(m_{x}m_{y}wC\right)\\
&\qquad-\partial_{z}\left(m_{x}m_{y}\sum_{i}w_{s}^{i}f_{s}^{i}C\right)=\partial_{z}\left(m_{x}m_{y}\frac{A_{b}}{H}\partial_{z}C\right)-m_{x}m_{y}H\gamma C
\end{aligned} \tag{A-47}$$

Equation A-47 is solved for C, and then the concentrations for the three phases are solved for using the relationships given by Equation A-46. The bottom boundary condition for Equation A-47 is given by

Hamrick (2007c). In addition, the one-dimensional (vertical) transport equation for C_w in the pore water in the sediment bed that is solved in each grid cell is described by Hamrick (2007c).

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APPENDIX B

Data Requirements for the LTFATE Surface Water Modeling System

The modeling of the Arsenic transport in the Maurice River system using the LTFATE surface water modeling system (see Appendix B for a detailed description of LTFATE) is being performed to evaluate the effectiveness of the planned three-year flushing period for the Maurice River system following remediation of the contaminated sediments and floodplain soils in the contaminated portion of the Blackwater Branch watershed. LTFATE contains dynamically linked 3D hydrodynamic and transport modules. The transport modules used in this modeling study are the mixed sediment transport and contaminant transport modules. This model could also be used to evaluate the relative differences in the rates of decline over a multi-decadal time period of the Arsenic contamination in the Maurice River system between the proposed remedial measures.

One of the primary objectives of all modeling studies at contaminated sediment sites should be to use the requisite site-specific data to constrain model inputs to the greatest extent possible because it reduces the uncertainty in model predictions and increases model reliability (Hayter *et al*. 2014). As such, the data requirements for LTFATE, as for all multi-dimensional transport models, is significant. Table A-1 contains a list of data that are required for performing modeling of Arsenic transport in the Maurice River system. These data were either already measured or are currently being collected.

At present, the LTFATE model is underdevelopment. These tasks include grid development, calibration and validation of the hydrodynamic model, calibration and validation of the mixed sediment transport model, and calibration and validation of the *As* transport model. Final model runs are scheduled to be initiated in early FY 2015. To support the surface water transport modeling being performed with LTFATE, a watershed loading model is also being developed using the USEPA Basins model. Output from the Basins model is being used to provide the fluxes of water and suspended sediment at the open water boundaries of the Maurice River *As* transport model.

Table A-1. Required Data for Modeling Arsenic Transport

Hydrodynamic Data	Measurement Technique
Bathymetric Surveys	*Perform bathymetric surveys at selected transects along Maurice River and in Union Lake*: These surveys would be used to determine the differences in the bathymetry along these transects between the bathymetric survey performed in the early 1990s and that to be performed in 2012 or 2013. These new surveys would also be used to update the existing model grid of the Maurice River system that was developed by Hayter and Gu (1998).
Velocity Measurements	*Measure cross-sectional velocity profiles at two locations along the Maurice River between the Blackwater Branch confluence and Union Lake during the rising limbs of two different high flow events on the Maurice River*: These measurements would be used to perform the essential tasks of calibrating and validating the hydrodynamic model in LTFATE.
Sediment Transport Data	**Measurement Technique**
Composition of the sediment bed	*Collect grab samples of the surface sediment at a minimum of three locations along each river and lake transect that was surveyed in the early 1990s*: The grain size distribution (GSD) of the inorganic sediments and the percentage of organic matter would be determined for each grab sample. These data would allow the existing spatially varying sediment composition to be represented in the sediment transport model in LTFATE.
Suspended Sediment Concentration (SSC) time series	*Measure the SSC time series near the model grid upstream boundary on the Maurice River and at (at least) one of the bridges where velocity measurements are to be made over two high flow events*: These measurements would be used to perform the essential tasks of calibrating and validating the sediment transport model in LTFATE and in constructing the upstream boundary conditions for the sediment transport model for these two high flow events.
Erodibility of the fine-grain and mixed sediments	*Measure the erosion rates, bulk densities, and GSD of fine-grain and mixed sediment at the surface and with depth in sediment cores collected at different locations in the Blackwater Branch, Maurice River and Union Lake*: These site-specific data would be used to specify the erosion rates of both surficial and buried fine-grain and mixed sediments as a function of the applied bed shear stress and sediment bulk densities in the sediment transport model in LTFATE. A SEDFLUME study (see Appendix B) was conducted in 2013 to measure these data.

Arsenic Related Data	Measurement Technique
Particulate and Dissolved *As* concentrations in the bottom sediment and floodplain soils	*Determine particulate and dissolved As concentrations at the surface and with depth in sediment cores collected at different locations in the Blackwater Branch, Maurice River and Union Lake*: These data would be used to initialize the horizontally and vertically varying *As* concentrations in the contaminant transport model in LTFATE.
Particulate and dissolved *As* concentration time series	*Measure these As concentration time series near the model grid upstream boundary on the Maurice River and at (at least) one of the bridges where velocity measurements are to be made over two high flow events*: These measurements would be used to perform the essential tasks of calibrating and validating the contaminant transport model in LTFATE and in constructing the upstream boundary conditions for the contaminant transport model for these two high flow events.
Partition coefficient and desorption rate	*Measure the As partition coefficients on suspended sediments and bed sediments as well as the desorption rates of particulate As from suspended sediments to the water column and from bed sediments to pore water*: These site-specific measurements are needed to reduce the uncertainty in the contaminant transport model in LTFATE that would result if literature values were used for these parameters.
Groundwater Flux of Dissolved *As* along the Blackwater Branch to the Maurice River system	*Measure the average post-remediation flux of dissolved As via groundwater along the Blackwater Branch to the overlying water in Blackwater Branch and the Maurice River*: Determination of this average flux of dissolved *As*, which would be added as a source term in the dissolved contaminant transport equation solved by the contaminant transport model in LTFATE, will help improve the accuracy of the simulations of *As* transport and fate using the LTFATE modeling system.

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