LONG TERM MONITORING PROGRAM
YEAR 1 IMPLEMENTATION REPORT
STUDY AREA 7 SEDIMENT REMEDY
JERSEY CITY, NEW JERSEY

Submitted to:

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1.0 INTRODUCTION

As required by the Consent Order on Sediment Remediation and Financial Assurances (Consent Order) entered by the U.S. District Court (District of New Jersey) on May 28, 2008 in the matter of *Interfaith Community Organization et al vs. Honeywell International et al, and Riverkeeper, Inc., et al vs. Honeywell International et al* (Civil Action Nos. 95-2097 and 06-0022), Honeywell conducted sediment remediation in the Hackensack River in the vicinity of Study Area (SA) 7 (Site) along Route 440 in Jersey City, New Jersey. The Consent Order, as amended in September 2013, set forth the following specific components of dredging, capping, and monitored natural recovery (MNR) for the Sediment Remedy and the requirements for a long-term monitoring program (LTMP):

- Dredging and subsequent capping in a 0.5-acre area adjacent to the SA-7 bulkhead. Sediments were dredged to a depth of 2 feet (ft) and then capped with 18 inches of sand and armoring.
- Capping of surface sediments (i.e., between depths of 0 to 1 ft) with total chromium concentrations greater than 370 parts per million (ppm) to achieve a 1 ft layer of natural sediments and/or cap material with a concentration of less than 370 ppm total chromium.
    - A six-inch cap placed over a total of 19 acres
    - A twelve-inch cap placed over a total of 18 acres
- MNR over 33 acres where sediments less than 1 ft below the sediment surface are below 370 ppm total chromium but sediments deeper than 1 ft exceed 370 ppm.
- Long-term monitoring to assess the on-going effectiveness of the sediment remedy. Long-term monitoring will be performed in accordance with a Long-Term Monitoring Plan (LTMP; Cornerstone/ENVIRON 2012) for a period of approximately 15 to 25 years following implementation of the remedy.

Capping of three areas (Areas 16, 22, and 28) has been deferred to a future date pending work to be performed adjacent to these areas which could result in disturbance to the cap integrity. These areas will be added to the monitoring program once they are completed.

The LTMP was developed as part of the *100% Design for Study Area 7* (Cornerstone/ENVIRON 2012). The LTMP defined the scope and methods to be implemented to satisfy the requirements of the Consent Order. The monitoring tasks and events outlined in the LTMP are based on the following objectives, as specified in Paragraph 29 of the Consent Order:

- Provide monitoring to ensure that the integrity of the caps is maintained.
- In areas of MNR, confirm either that i) deposition of additional sediments is continuing, or ii) the contemporaneous bathymetry of the river bottom shows an increase or less than a four-inch decrease in the measured elevation of the river bottom.

- Collect data regarding the nature of the benthic community in remediated sediments after the implementation of the remedy.

The LTMP provides for the following monitoring events:

a. "First-Five Year Monitoring Activities" will take place in Years 1, 2, and 5.

b. "Post-High Energy Event Monitoring Activities" will take place promptly following High Energy Events. The Consent Order defines "High Energy Events" as follows:

    i. "A 50-year rainfall event defined by the National Weather Service as a 24-hour period of rainfall exceeding the maximum 50-year/24-hour accumulation, as recorded at Newark Airport;

    ii. A 10-year storm surge event defined as a hurricane event (not a "nor'easter") resulting in an increase in ocean level of either 0.64 meters above normal tidal cycling at the Battery Park tide gauge or 1.40 meters above mean sea level (MSL); or

    iii. A wind event achieving 34 to 40 knots, coming from the south through the west, averaged over 6 hours, as recorded at Newark Airport."

c. "Five-Year Interval Monitoring Activities" will take place at 5-year intervals after Year 5 until either the objectives of the particular monitoring activity have been achieved and maintained for a period of 15 years and through at least two High Energy Events or the remedy has been in place for 25 years and met the objectives, whichever is shorter. According to the Consent Order, if after 25 years any of the objectives has not been met or if any of the objectives is close to being violated, monitoring will continue in 5-year intervals until it is clear that the objectives have been met.

The elements of the long term monitoring program are summarized on **Tables 1** and **2**.

The specific monitoring scope and methods to be performed for the first five years of the monitoring program are defined in the *First Five Year Implementation Plan* ("Implementation Plan"; ENVIRON 2014b). The scope and methods defined in the Implementation Plan account for the post-remediation "as-built" conditions as reported in the *SA-7 Sediment Remedy Documentation and Remedial Action Summary Report* (ENVIRON 2014a) and clarification of objectives of certain monitoring elements. However, the tools and the schedule may be modified in the future to reflect new information or to adjust to changed field conditions.

The monitoring activities for **Year 1** of the long-term monitoring program were conducted from September to November 2014, and included the following:

- Hydraulic and Hydrodynamic Evaluation
- Bathymetric Survey
- Thickness Verification
- Pore Water Sampling
- Sediment Profile Imaging (SPI)
- Biological Sampling

The approach and results for each of these tasks is summarized in Section 2.0 of this report. The results of the Year 1 monitoring characterize the baseline conditions from which results of future monitoring events will be compared to assess the significance of any changed conditions within the Study Area.

Table 1: Summary of Long Term Monitoring of the Capped Areas

Monitoring Elements for Capped Areas	YEAR							LTMP Section Reference
	1	2	5	6 to 15	20	25	HEV	
Hydraulic and Hydrodynamic Evaluation								
Routine Monitoring and Analysis	X	X	X					4.1.1
Severe Event Monitoring and Analysis	X	X	X	X			Note 1	4.1.1
Bathymetry	X	X	X	X	X	X	Note 2	4.1.2
Cap Integrity	X	X	X				Note 3	4.1.3
Pore Water Sampling	X	X	X	Note 4, 5				4.2.1
Surface Sediment Sampling			X	Note 5				4.2.2
Sediment Trap Sampling	Note 6							4.2.3
Biological Monitoring	X	X	X	Note 5				4.3

HEV: Following all High Energy Events

Note 1: After 15 years, high-event assessments will be discontinued if the monitoring objectives have been achieved and maintained for 15 years and through at least two high energy events.

Note 2: Bathymetric surveys will be conducted following up to two high-energy events (if not encountered in the first five years). No additional surveys will be performed if bathymetric surveys show no negative impacts on overall cap integrity (i.e., cap maintains coverage of target areas) for a period of 15 years and through two high-energy events, or a total period of 25 years, whichever is shorter.

Note 3: After Year 5, routine sediment cap thickness monitoring will be discontinued unless data collected during the first five years of monitoring indicate that additional monitoring is warranted. Monitoring will still be conducted following a high-energy event if two such events did not occur within the first five years. Monitoring may also be performed after Year 5 if the bathymetry survey identifies an area of potential erosion warranting further assessment (see Section 4.1.2)

Note 4: Pore water sampling is limited to those areas of potential intermediate groundwater plume upwelling identified in the 2007 *Final Groundwater Investigation Report, Honeywell Study Area 7 Site* ; this corresponds to portions of Cap Areas 1, 6, 8, 13, and 18.

Note 5: After Year 5, sampling will be discontinued, unless the data collected during the first five years of monitoring indicate further monitoring is warranted.

Note 6: If surface sediment sampling of capped areas results in the detection of total chromium concentrations greater than 370 ppm, sediment trap sampling units may be deployed in those areas to further assess site conditions and to evaluate potential contaminant sources.

Table 2: Summary of Long Term Monitoring of the MNR Areas

Monitoring Elements for MNR Areas	YEAR							LTMP Section Reference
	1	2	5	6 to 15	20	25	HEV	
Hydraulic and Hydrodynamic Evaluation								
Routine Monitoring and Analysis	X	X	X					5.1
Severe Event Monitoring and Analysis	X	X	X	X			Note 1	5.1
Bathymetry	X	X	X	X	X	X	Note 2	5.2
Sediment Profile Imaging	X	X	X				Note 3	5.3
Sediment Core Sampling	Note 4							5.2, 7.2

HEV: Following all High Energy Events

Note 1: After 15 years, severe event assessments will be discontinued if the monitoring objectives have been achieved and maintained for 15 years and through at least two high energy events.

Note 2: Bathymetric surveys will be conducted following up to two high-energy events (if not encountered in the first five years). Following at least two high energy events, bathymetry surveys will be conducted only in MNR areas where erosion may have resulted in more than a 4-inch decrease in the elevation of the sediment surface, based on the results of the hydrodynamic evaluation.

Note 3: Following high energy events, SPI surveys will be performed in MNR areas where erosion may have resulted in more than a four-inch decrease in surface sediment elevations based on the hydrodynamic evaluation and measured observations

Note 4: In the event that a bathymetric survey identifies an Erosional Area as defined in the LTMP, sampling of top 12-inches sediment for total chromium in Erosion Areas is required to confirm that concentrations in top 12-inches remain below 370 ppm.

2.0 SCOPE OF WORK AND YEAR 1 RESULTS

The scope of work for Year 1 of the long-term monitoring program included the following tasks:

- Hydraulic and Hydrodynamic Evaluation
- Bathymetric Survey
- Cap Thickness Verification
- Pore Water Sampling
- Sediment Profile Imaging (SPI)
- Biological Sampling

The approach and results for each of these tasks is summarized in the following sections. Photographs of the monitoring implementation are provided in **Appendix A.**

2.1 Hydraulic and Hydrodynamic Evaluation

Records of river stage elevations and weather events during the implementation of the baseline LTMP event in October 2014 were obtained to identify "high energy events" that would warrant additional inspection of the cap and MNR areas. Monitoring of hydraulic conditions near SA-7 included review of surface water elevations from the Battery Park gauge and wind and precipitation records from Newark Airport weather station as reported by the following sources:

- Rainfall recorded at Newark Airport: http://www.wunderground.com/history/
- Tide levels at Battery Park: http://tidesandcurrents.noaa.gov/waterlevels.html?id=8518750
- Wind conditions as recorded at Newark Airport: http://www.wunderground.com/history/

The monitoring data for October 2014 indicate that no high energy events occurred during this monitoring event.

2.2 Bathymetric Survey

A high-resolution multibeam bathymetric survey was conducted by Aqua Survey, Inc. on September 29, 2014. The survey was conducted over the 70-acre remedy area (refer to **Figures 1** and **2**) using a survey boat, R2 Sonic 2022 multibeam sonar, and RTK-DGPS precision positioning equipment. The bathymetry for the remedy area is provided on **Plate 1;** the limits of capping are included on Plate 1 for reference. This survey will be used as the baseline for the long-term cap integrity assessments to identify evidence of erosion of cap materials or native sediments in the MNR areas.

2.3 Cap Thickness Verification

Cap thickness verification was conducted from October 15 to November 3, 2014 to determine if there is any observable loss of cap material. This task was performed around 20 of the 38 long-term monitoring plates that were installed within capped areas during remedy implementation (refer to **Figures 1** and **2** for the “odd” year designated monitoring points). Fourteen of the inspected plate locations were within subtidal areas and six plate locations were within intertidal areas. The as-built cap thicknesses and the estimated exposed length of the monitoring plate stickup posts are listed on **Table 3**. The approach and results of the inspections are summarized below.

<u>Subtidal Areas:</u>

A vessel equipped with a Trimble SPS855 unit was used to navigate to the as-built GPS coordinates of the subtidal long-term monitoring plates within the SA-7 remedy area. Upon arrival at each long-term monitoring plate location, a buoy with proper length of rope and weights were deployed as a visual marker at the GPS located plate location. A diver then followed the weighted rope down to the surface of the cap and inspected an area of at least 10-ft by 10-ft around the GPS-defined plate location. The diver documented the inspection using an underwater video camera and determined whether the long-term monitoring plate posts were exposed. The diver also made general observations of cap conditions including thickness of silt layer formed on the armor stone. Diver observations were recorded on cap thickness verification forms; these observations are summarized on **Table 4**.

Inspections of the 14 plate locations within subtidal areas (plates 1A, 2A, 3A, 7A, 7C, 9A, 11A, 11C, 15A, 17C, 18B, 27A, 29A, and 29C) determined that at all but one plate location (plate 11A in Cap Area 11) the posts of the long-term monitoring plates were not observed and armor stone was present, indicating that the plates have remained buried and no observable loss of cap material has occurred. At location 11A, the long-term monitoring plate was found displaced and resting on top of the cap. Following manual inspection of the cap coverage at this location, Plate 11A was reset by removing the armor layer, setting the plate, and backfilling over the plate with the 6-inch armor layer.

Videos taken of plate locations also revealed the presence of biological growth, crabs, and crab eggs on some cap areas. A summary of video observations is included on **Table 4**.

<u>Intertidal Areas:</u>

A Trimble SPS855 unit was used at low tide when the intertidal cap areas were exposed to navigate to the as-built GPS coordinates of the intertidal long-term monitoring plate locations. Upon arrival at each long-term monitoring plate locations, a white-board displaying the plate location ID was placed at the as-built GPS coordinates as a visual marker, and an inspection of an area at least 10-ft by 10-ft around the GPS-defined plate location was conducted. The field inspector documented the inspection using a video camera and determined whether the long-term monitoring plate was exposed. The field inspector also made general observations about cap conditions including thickness of silt layer formed around the armor stone. Field inspector observations were recorded on cap thickness verification forms which are summarized on **Table 4**.

Inspections of the 6 plate locations within intertidal areas (i.e., plates 6A, 11D, 13A, 13B, 26A, and 30A) revealed that for all but one GPS-defined plate location (i.e., plate 11D in Cap Area 11) the posts of the long-term monitoring plates were not observed and armor stone was present. This indicates that the plates are buried and no observable loss of cap material has occurred. At the GPS installation location of plate 11D, the plate was found to be covered by the armor layer, but the very top of the plate posts was observed, indicating at least 7-inches of cap coverage at this location. However, no signs of erosion of the cap were observed.

Table 3: As-Built Cap Construction and Monitoring Plate Details

	CAP DETAILS					MONITORING PLATES			
Cap Area	Average Sand Layer Thickness (inches)	Average Filter Layer Thickness (inches)	Average Armor Layer Thickness (inches)	Armor Size (inches)	Average Total Thickness (inches)	Plate ID	Interdidal or Subtidal	Stickup length (inches)	Expected Exposed Length* (inches)
1	4.7	NA	6.6	0.75	11.2	1A	Subtidal	12	1
2	7.2	NA	6.7	0.75	13.9	2A	Subtidal	12	0
3	4.6	NA	6.4	0.75	11.0	3A	Subtidal	15	0
4	5.2	NA	6.3	0.75	11.5	NA	Subtidal	NA	NA
5	6.0	6.6	6.2	2.5	18.8	5A	Intertidal	8	0
6A	6.4	6.2	6.0	1	18.6	NA	Intertidal	NA	NA
6B	6.1	5.8	6.3	2.5	18.2	6A	Subtidal	8	0
7A	7.6	NA	5.6	0.75	13.3	7A	Subtidal	12	3
						7C	Subtidal	8	0
7B	6.1	8.4	10.4	2.5	24.9	7B	Subtidal	8	0
7C	5.7	6.7	11.9	3.5	24.3	NA	Subtidal	NA	NA
8A	7.6	NA	5.5	0.75	13.0	NA	Subtidal	NA	NA
8B	8.5	5.7	5.3	1	19.5	8A	Subtidal	18	5
9	6.2	4.4	6.1	1	16.7	9A	Subtidal	18	5
10	9.3	NA	4.4	0.75	13.7	10A	Subtidal	12	0
11A	6.1	8.7	9.9	2.5	24.7	NA	Subtidal	NA	NA
11B	6.8	6.6	5.9	1	19.3	11A	Subtidal	18	0
						11B	Subtidal	18	0
						11C	Subtidal	18	1
						11E	Subtidal	18	0
11C	5.4	5.9	6.7	2.5	18.0	11D	Subtidal	8	0
						11F	Intertidal	8	0
12	NA	NA	24.2	10	24.2	NA	Subtidal	NA	NA
13A	7.5	5.2	6.2	1.0	19.0	13B	Intertidal	15	0
						13D	Intertidal	15	0
13B	6.7	5.9	6.5	2.5	19.1	13A	Intertidal	15	0
						13C	Intertidal	15	0
14	10.3	NA	7.1	0.75	17.4	14A	Subtidal	15	0
15	8.6	NA	7.2	0.75	15.8	15A	Subtidal	15	0
17	9.4	7.2	7.8	2.5	24.3	17A	Subtidal	24	3
						17B	Subtidal	24	2
						17C	Subtidal	24	2
18A	8.9	NA	7.1	0.75	16	18A	Subtidal	15	0
						18B	Subtidal	15	0
18B	8.6	6.7	7.8	2.5	23.1	NA	Subtidal	NA	NA
19A	9.9	6.0	7.4	1	23.3	NA	Subtidal	NA	NA
19B	11.1	NA	7.2	0.75	18.4	19A	Subtidal	15	0
20	10.7	NA	8.0	0.75	18.6	20A	Subtidal	15	0
21	9.5	NA	7.8	0.75	17.3	21A	Subtidal	15	0
23	10.8	NA	10.3	0.75	21.1	NA	Subtidal	NA	NA
24	5.7	7.1	7.5	2.5	20.3	NA	Subtidal	NA	NA
25	6.5	NA	5.4	0.75	11.9	25A	Subtidal	12	0
26	7.0	7.1	8.0	2.5	22.1	26A	Intertidal	8	0
27	6.1	NA	7.1	0.75	13.3	27A	Subtidal	12	3
29A	8.1	8.0	8.0	2.5	24.1	29B	Subtidal	24	1
29B	7.7	6.9	6.9	1	21.5	29A	Subtidal	24	5
						29C	Subtidal	24	4
30A	3.5	7.2	5.6	1	16.3	NA	Subtidal	NA	NA
30B	6.7	6.7	7.6	2.5	20.9	30A	Intertidal	8	0

* = Expected exposed length was determined based on plate stickup length and average cap thickness measurement around the plate location.

An approximately 2-inch layer of very soft silt was also observed to have accumulated on the armor layer to the south, north, and west of the plate location. A summary of video observations is presented on **Table 4.**

2.4 Sediment Profile Imaging (SPI)

The Sediment Profile Imaging (SPI) survey was completed on October 29, 2014 by NewFields Sediment Management and Marine Sciences, LLC, Edmonds, WA to evaluate surface sediment deposition and sediment bed stability in MNR areas. The SPI survey was conducted at 10 designated locations distributed across the SA7 MNR areas, as shown on **Figures 1** and **2**. A minimum of three replicate SPI images were collected at each station.

Sediment profile images were collected using a digital sediment-profile imaging camera system (Ocean Imaging Systems, North Falmouth, MA) deployed from the research vessel (R/V) Tesla. The camera prism was mounted on an assembly that moves up and down within a stainless steel frame by allowing tension or slack on the winch wire. As the camera was lowered, tension on the winch wire kept the prism in the up position. Once the camera frame touched the bottom, slack on the winch wire allowed the prism to vertically intersect the seafloor. The rate of fall of the prism (6 cm/second) was controlled by an adjustable passive hydraulic piston, which minimized the disturbance of the sediment-water interface. The camera was able to obtain images of up to 20 cm (approximately 8 inches) in the upper sediment column.

The SPI study collected the following data used to characterize surface sediment conditions in the MNR area:

1. Camera prism penetration depth (cm)
2. Sediment grain size (major mode and range in phi sizes)
3. Surface boundary roughness
4. Presence of methane
5. Apparent Redox Potential Discontinuity (RPD) Depth (cm)
6. Infaunal successional stage;
7. Benthic habitat categories (Diaz 1995)
8. Organism Sediment Index (OSI) calculation

The survey results are reported in **Appendix B** (note – the location numbering used in the SPI Report provided in Appendix B corresponds to the locations shown on Figures 1 and 2; i.e., HSR-01 is the same as SPI-1, HSR-02 is the same as SPI-2, etc.). The findings of the SPI are similar to the SPI results reported in the *Sediment Remedial Alternatives Analysis Report* (ENVIRON 2006). As described in **Appendix B**, the SPI data indicate a prevalence of Stage III taxa at the majority of stations, and the relatively well-developed benthic communities present in the monitoring sites have not been significantly disturbed. The findings support a conclusion that the sediments within the monitoring area show the presence of an established sediment dwelling benthic community that is typical of the estuarine environment, and not indicative of locations subject to surface sediment erosion.

2.5 Pore Water Sampling

Pore water sampling from the capped areas was conducted in those areas of potential intermediate groundwater plume upwelling identified in the 2007 *Final Groundwater Investigation Report Honeywell Study Area 7 Site*; this corresponds to portions of Cap Areas 1, 6, 8, 13, and 18. As planned, a total of 8 pore water samples were collected between October 16 and October 20, 2014 at the locations shown on **Figures 1** and **2**. A Trimble SPS855 unit was used to navigate to and record pore water sampling locations in the intertidal areas. A vessel equipped with a Trimble SPS855 unit was used to navigate to and record pore water sampling locations in the subtidal areas. A Solinist® Drive Point Profiler was then pushed through the cap armor and filter layers (if present) and used to collect the pore water samples from the underlying sand layer of the cap. Samples were submitted to Accutest (a New Jersey certified laboratory) for hexavalent chromium analysis.

As presented on **Table 5**, hexavalent chromium was not detected in any of the pore water samples. In addition, the MDLs were reviewed and confirmed to be below both the acute and chronic saline water quality criteria.

2.6 Biological Sampling

Biological monitoring was conducted in Year 1 within capped areas and at background reference locations to evaluate the recolonization of benthic species within the remediated areas. Benthic community sampling and analysis was conducted on October 24, 2014 at locations proximate to 20 of the 38 long-term monitoring plates that were installed within capped areas and at three (3) designated off-site reference locations (see **Figure 3**).

A Trimble SPS855 unit was used to navigate to and record biological sampling locations in both intertidal and subtidal areas. Samples were collected using either a Petit Ponar or a Dredge sampler and transported to AquaSurvey's laboratory in Flemington, New Jersey for taxonomic identification. At the laboratory, samples were rinsed with tap water and sieved through a 500-µm sieve to remove the formalin and debris prior to picking. AquaSurvey collected all invertebrate specimens from each grab sample and identified them to the lowest genus and species levels possible. The number of specimens from each grab sample was recorded, taxa diversity was counted, and the percent of each genus and species that comprised each sample was estimated. Each grab sample represented approximately 0.023 square meters (sq. m.) and AquaSurvey used the total number of specimens to estimate the benthic community density reported in number per square meter (No./sq. m.). The results of the benthic survey are presented in **Appendix C.**

The results for density and diversity are presented in **Figures 4** and **5**, based on the summary of data presented in **Appendix C** and **Table 6.** The results indicate that the diversity and density within the cap areas is generally similar to or greater than at the background locations. Diversity ranged from 6 to 32 in the capped areas and from 7 to 14 in the three reference areas. The lowest diversity of 6 was seen at Location 26A in the Northern Area. There was a considerable range of taxa density values within the sediment cap areas, with values ranging from 739 to 67,174 No./sq.m., with an average of 15,354 No./sq.m. The density values at the three background areas were 609, 3,000, and 9,304 No./sq.m; the lowest density of 609 was seen at Location RF1. Overall, these findings show very diverse and abundant sediment dwelling organisms are developing on the cap areas.

2.7 Summary

This monitoring report presents the results of the first long-term monitoring event conducted for the SA7 sediment remediation program, and includes assessment of capped, MNR, and reference areas. As documented in this report:

- During the period of monitoring activities, no high energy events were observed. Monitoring will continue to be performed on a continuous basis to identify any high energy events that would trigger additional assessment. The results of this monitoring will be included in the Year 2 monitoring report.
- The baseline bathymetric survey has been completed. The bathymetric survey will be repeated in Year 2 and the results compared to this baseline survey to identify areas of potential erosion in both capped and MNR areas.
- The cap thickness inspections confirmed that the armoring of the caps remains in-place with no evidence of erosion of cap materials. Cap thickness verification will be performed in Year 2 at the “even” numbered monitoring plates.
- The SPI survey in MNR areas indicates an established sediment dwelling benthic community that is typical of the estuarine environment, and not indicative of locations subject to surface sediment erosion. The SPI survey will be repeated at the same locations in Year 2 to assess changes that may be indicative of erosion of native sediments.
- Hexavalent chromium was not detected in any of the pore water samples. Pore water sampling will be repeated at the same locations in Year 2 to assess changes that may be indicative of upwelling of hexavalent chromium through the cap.
- The benthic community survey indicates diverse and abundant sediment dwelling communities are developing on the cap areas. The benthic community survey will be repeated at the same locations in Year 2 to assess changes from these first year conditions.

In summary, the first year monitoring program demonstrated that the remediation area remains stable relative to constructed conditions. In addition, the planned methods of verification were successfully implemented such that no changes in procedures are necessary.

3.0 REFERENCES

Cornerstone Engineering Group, LLC and ENVIRON International Corporation. 2012. *100% Design Report, Study Area 7 Sediment Remediation, Jersey City, New Jersey*.

ENVIRON International Corporation (ENVIRON). 2006. *Sediment Remedial Alternatives Analysis Report, Study Area 7, Jersey City, New Jersey*.

ENVIRON International Corporation (ENVIRON). 2014a. *SA-7 Sediment Remedy Documentation and Remedial Action Summary Report, Study Area 7 Sediment Remedy, Jersey City, New Jersey*.

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TABLES

Table 4
Cap Inspection Summary
Study Area 7 Sediment Remedy
Jersey City, NJ

Plate ID	Year	Cap Location (Subtidal/Intertidal)	Date	Video Length (min)	Observations (Time Markers)	Northing	Easting	Plate Length Exposed (inches)	Video Completed? (Y/N)	Notes
1A	2014	Subtidal	10/23/2014	12:54	None	686762.67	602446.08	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, siltation (0 to 4 inches) and some biological growth observed on cap material.
2A	2014	Subtidal	10/21/2014	11:23	None	686396.33	602216.12	0	Y	Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, significant siltation (3 to 18 inches) and biological growth observed on cap material.
3A	2014	Subtidal	10/21/2014	11:33	(3:30, 8:05) Crabs	685253.00	600986.4	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, significant siltation (up to 6") and a crab observed on cap material.
6A	2014	Intertidal	10/15/2014	1:20	None	687153.21	603425.76	0	Y	Inspection conducted at low tide, when cap area was exposed. Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, some siltation observed on cap material.
7A	2014	Subtidal	10/21/2014	15:07	(4:50, 5:20, 7:50, 8:20) Crabs	684614.09	600829.93	0	Y	Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, siltation (about 2 inches), biological growth, and crabs observed on cap material.
7C	2014	Subtidal	10/22/2014	12:02	(2:31 to 9:48) Crab eggs (5:25, 9:17, 11:28, 11:34) Crabs	684761.80	601176.29	0	Y	Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, siltation (0 to 5 inches), biological growth, and crabs and crab eggs observed on cap material.
9A	2014	Subtidal	10/21/2014	11:16	(4:25, 6:25, 6:50, 9:30) Crabs	687539.64	602798.81	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, significant siltation (8 to 12 inches) observed on cap material.

Table 4
Cap Inspection Summary
Study Area 7 Sediment Remedy
Jersey City, NJ

Plate ID	Year	Cap Location (Subtidal/Intertidal)	Date	Video Length (min)	Observations (Time Markers)	Northing	Easting	Plate Length Exposed (inches)	Video Completed? (Y/N)	Notes
11A	2014	Subtidal	10/21/2014	7:36	(4:05) Plate	687960.47	603120.3	Whole Plate	Y	Plate was found at the as-built coordinates, sitting on top of the cap area completely exposed. 6 inches of armor material observed around and underneath the plate. No signs of erosion were observed; rather, siltation (0 to 2 inches) observed on cap material. Plate was reinstalled and new as-built coordinates were recorded. 11 inches of the plate legs were left exposed above the armor layer upon backfilling the plate with armor stone.
11C	2014	Subtidal	10/22/2014	16:23	(4:57, 9:20, 10:18) Crabs	688232.95	603393.27	0	Y	Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, siltation (1 to 4 inches), significant biological growth, and crabs observed on cap material.
11D	2014	Intertidal	10/15/2014	0:29	Top of plate posts	688103.13	603577.23	0	Y	Inspection conducted at low tide, when cap area was exposed. The very top of the plate legs were observed at the as-built coordinates. No signs of erosion were observed; rather; siltation (2 to 4 inches) observed on cap material around the plate location.
13A	2014	Intertidal	10/15/2014	1:23	None	686834.71	602965.79	0	Y	Inspection conducted at low tide; at the time of inspection, there were approximately 8 to 12 inches of water above cap materials. Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, some siltation and biological growth observed on cap material.
13B	2014	Intertidal	10/15/2014	0:41	None	687090.08	603046.37	0	Y	Inspection conducted at low tide, when cap area was exposed. Plate was not observed at the as-built coordinates. No signs of erosion were observed.
15A	2014	Subtidal	10/21/2014	11:02	(2:23) Crab eggs (2:12, 5:29) Crabs	685753.88	601541.97	0	Y	Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, siltation (0 to 3 inches) and significant biological growth, crabs and crab eggs observed on cap material.
17C	2014	Subtidal	10/23/2014	11:13	(6:55, 7:29, 7:40) Crabs	688393.41	603041.21	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, siltation (1 to 4 inches), some biological growth, and a crab observed on cap material.
18B	2014	Subtidal	10/23/2014	10:25	(2:27) Crab	686887.64	602516.03	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, siltation (1 to 2 inches), some biological growth, and a crab observed on cap material.

Table 4
Cap Inspection Summary
Study Area 7 Sediment Remedy
Jersey City, NJ

Plate ID	Year	Cap Location (Subtidal/Intertidal)	Date	Video Length (min)	Observations (Time Markers)	Northing	Easting	Plate Length Exposed (inches)	Video Completed? (Y/N)	Notes
26A	2014	Intertidal	10/15/2014	0:52	None	688732.41	603856.06	0	Y	Inspection conducted at low tide, when cap area was exposed. Plate was not observed at the as-built coordinates. No signs of erosion were observed.
27A	2014	Subtidal	10/23/2014	10:08	None	689049.74	603606.53	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, siltation (0 to 4 inches) and significant biological growth observed on cap material.
29A	2014	Subtidal	10/22/2014	9:58	(4:16) Crab	688449.22	603326.8	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, siltation (< 1 inch), some biological growth, and a crab observed on cap material.
29C	2014	Subtidal	10/23/2014	10:14	(3:14, 6:53, 8:54) Crabs	688926.31	603379.45	0	Y	Plate was not observed at the as-built coordinates. Very low visibility. No signs of erosion were observed; rather, siltation (0 to 2 inches), biological growth, and a crab observed on cap material.
30A	2014	Intertidal	10/24/2014	1:10	None	688432.30	603598.31	0	Y	Inspection conducted at low tide, when cap area was exposed. Plate was not observed at the as-built coordinates. No signs of erosion were observed; rather, some siltation and biological growth observed on cap material.

Table 5
Summary of Porewater Sampling Results
Study Area 7 Sediment Remedy
Jersey City, NJ

Location / ENVIRON Sample ID / Sample Date / Comments	NJDEP Acute Saline Water Quality Criteria (SWQC) (d)(s)	NJDEP Chronic Saline Water Quality Criteria (SWQC) (d)(s)	1A	6A	6A	8A	13A	13B	13C	13D	18B
ENVIRON Sample ID			Porewater 1A-20141020	Porewater 6A-20141017	DUP-20141017	Porewater 8A-20141020	Porewater 13A-20141016	Porewater 13B-20141016	Porewater 13C-20141016	Porewater 13D-20141017	Porewater 18B-20141020
Sample Date			10/20/2014	10/17/2014	10/17/2014	10/20/2014	10/16/2014	10/16/2014	10/16/2014	10/17/2014	10/20/2014
Comments					Duplicate						
INORG											
Chromium VI	1100	50	U (5.5)	U (5.5)	U (5.5)	U (5.5)	U (5.5)	U (5.5)	U (5.5)	U (5.5)	U (5.5)

Notes:

1 All concentrations are presented in ug/L (ppb).

2 None of the concentrations exceed the published critieria.

Abbreviations:

U -- Not Detected.

( ) -- Detection Limit.

(d) -- Criterion is expressed as a function of the Water Effect Ratio (WER) using default value of 1.0.

(s) -- Dissolved criterion.

Table 6
Taxa Diversity and Taxa Density Summary for Benthic Community Assessment Grab Samples
Study Area 7 Sediment Remedy
Jersey City, NJ

Station	General Location	Diversity [a]	Density [b] (No./sq.m.)	Total Specimins [c]	Taxon Common Name
7A	Droyers Cove	27	7,826	180	Sea anemone, hydra worms: ribbon, tube, threat, blood, clam, paddle, mud, fan, orbiniid, trumpet bladder clam, soft-shell clam, slipper snail, nudibranch snail, side swimmer, tube maker, skeleton shrimp, mud crab, crab barnacle, acorn barnacle, sea squirt
7C		14	32,261	176	worms: tube, threat, clam, paddle, mud macoma clam, side swimmer, hooded shrimp, acorn barnacle, sea squirt
3A		27	15,435	163	Sea anemone worms: threat, blood, clam, mud, fan, ampharetid, fringed, orbiniid, trumpet bladder clam, surf clam, macoma clam, soft-shell clam, side swimmer, bubble snail, two-groove snail, tube maker, hooded shrimp, sea pill bug, seed shrimp, acorn barnacle, sea squirt
15A	SA-7	32	4,304	99	Sea anemone worms: ribbon, tube, threat, blood, clam, paddle, scale, mud, fan, ampharetid, fringed, orbiniid, trumpet wentletrap snail, slipper snail, side swimmer, skeleton shrimp, shore prawn, mud crab, sea pill bug, acorn barnacle, sea squirt
2A	SA-6	15	2,652	61	worms: ribbon, tube, threat, blood, paddle, mud, fan, orbiniid macoma clam, side swimmer, hooded shrimp, slender isopod
1A	CSO	21	4,783	110	worms: ribbon, tube, threat, clam, paddle, mud, fan, orbiniid, trumpet soft-shell-clam, side swimmer, fish louse, hooded shrimp, acorn barnacle, see squirt
6A	Northern Cove / Northern Area	15	26,304	194	worms: ribbon, tube, threat, clam, paddle, mud, ampharetid macoma clam, bubble snail, side swimmer, slender isopod, sea pill bug, tanaid shrimp
9A		17	23,304	184	worms: tube, threat, blood, mud, fan, orbiniid, trumpet bladder clam, surf clam, soft-shell clam, bubble snail, two-groove snail, side swimmer, fish louse, sea squirt
11A		24	67,174	172	worms: threat, blood, clam, mud, fan, orbiniid, trumpet surf clam, soft-shell clam, wentletrap snail, bubble snail, two-groove snail, side swimmer, tube maker, hooded shrimp, mud crab, sea pill bug, sea squirt
11C		23	28,609	149	worms: ribbon, tube, threat, blood, clam, paddle, mud, orbiniid, trumpet surf clam, macoma clam, soft-shell clam, slipper snail, two-groove snail, side swimmer, hooded shrimp, sand shrimp, acorn barnacle
11D		23	5,174	119	worms: ribbon, tube, earth, threat, clam, paddle, syllid, mud soft-shell clam, ribbed mussel, bubble snail, side swimmer, fish louse, hooded shrimp, shore prawn, sea pill bug, acorn barnacle, tanaid shrimp, sea squirt, two-winged fly, water strider
13A		10	2,435	56	worms: tube, mud, ampharetid soft-shell clam, ribbed mussel, side swimmer, sea pill bug, tanaid shrimp, sea squirt
13B		19	7,348	169	moss animalcule worms: ribbon, tube, clam, paddle, mud, fan, ampharetid soft-shell clam, ribbed mussel, nudibranch snail, side swimmer, fish louse, sand shrimp, sea pill bug, tanaid shrimp, sea squirt
17C		22	19,435	187	worms: tube, thread, blood, clam, paddle, mud, fan, orbiniid, trumpet soft-shell clam, blue mussel, side swimmer, fish louse, hooded shrimp, acorn barnacle, sea squirt
18B		28	20,565	126	Sea anemone worms: tube, threat, blood, clam, paddle, mud, fan, orbiniid, trumpet bladder clam, surf clam, soft-shell clam, bubble snail, slipper snail, side swimmer, fish louse, hooded shrimp, mud crab, sea pill bug, seed shrimp, crab barnacle, acorn barnacle, sea squirt
26A		6	739	17	mud worm, side swimmer, sea pill bug, tanaid shrimp
27A		19	8,826	203	worms: ribbon, tube, threat, blood, clam, paddle, mud, orbiniid tellin clam, macoma clam, soft-shell clam, bubble snail, side swimmer, hooded shrimp, slender isopod, sea pill bug
29A		9	3,348	77	worms: thread, blood, clam, mud, orbiniid soft-shell clam, side swimmer, acorn barnacle
29C		22	4,174	96	moss animalcule, sea anemone worms: thread, clam, paddle, syllid, mud, fan, fringed, orbiniid surf clam, slipper snail, nudibranch snail, side swimmer, tube maker, sand shrimp, sea pill bug, acorn barnacle, sea squirt
30A		18	22,391	163	worms: ribbon, tube, threat, clam, paddle, mud, ampharetid macoma clam, side swimmer, shore prawn, slender isopod, sea pill bug, tanaid shrimp, marsh treader
RF1	Background	7	609	14	worms: blood, clam, paddle, mud bladder clam, soft-shell clam, side swimmer
RF2		9	3,000	69	worms: tube, blood, mud, orbiniid soft-shell clam, slipper snail, side swimmer
RF3		14	9,304	214	worms: threat, blood, mud, orbiniid bladder clam, surf clam, tellin clam, soft-shell clam, bubble snail, side swimmer, sea pill bug, seed shrimp

Notes
(a) Diversity is the total number of taxa seen at each location.
(b) Desnity is an estimated value based on the total number of specimines in the grab sample.
(c) Total number of specimines is the number of indiviudal organims collected in each grab sample.

FIGURES

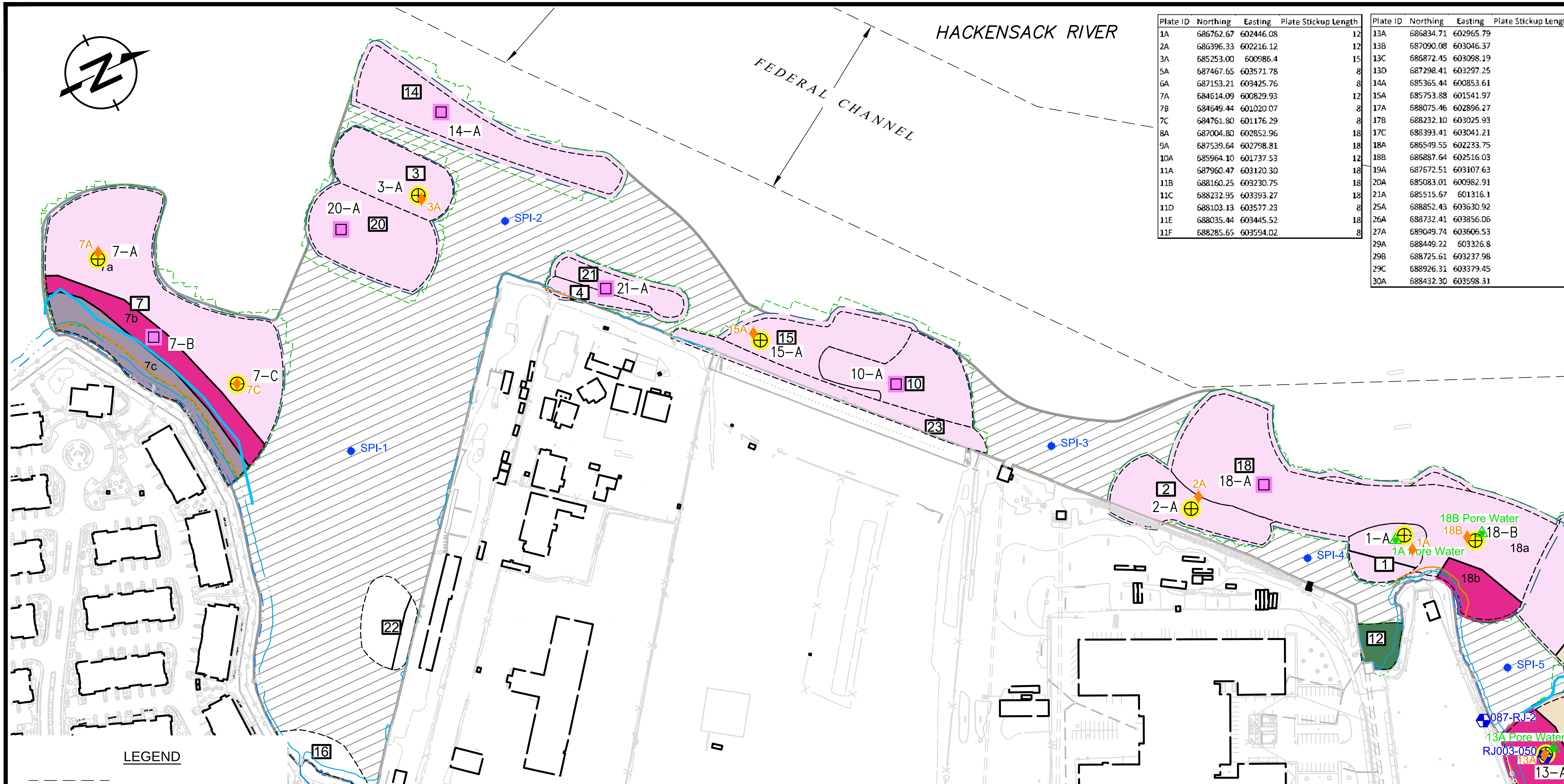


Plate ID	Northing	Easting	Plate Stickup Length
1A	686762.67	602446.08	12
2A	686396.33	602216.12	12
3A	685253.00	600986.4	15
5A	687467.65	603571.78	8
6A	687153.21	603425.76	8
7A	684614.09	600829.93	12
7B	684649.44	601020.07	8
7C	684761.80	601176.29	8
8A	687004.80	602852.96	18
9A	687539.64	602798.81	18
10A	685964.10	601737.53	12
11A	687960.47	603120.30	18
11B	688160.25	603230.75	18
11C	688232.95	603393.27	18
11D	688103.13	603577.23	8
11E	688035.44	603445.52	18
11F	688285.65	603594.02	8

Plate ID	Northing	Easting	Plate Stickup Length
13A	686834.71	602965.79	15
13B	687090.08	603046.37	15
13C	686872.45	603098.19	15
13D	687298.41	603297.25	15
14A	685365.44	600853.61	15
15A	685753.88	601541.97	15
17A	688075.46	602896.27	24
17B	688232.10	603025.93	24
17C	688393.41	603041.21	24
18A	686549.55	602233.75	15
18B	686887.64	602516.03	15
19A	687672.51	603107.63	15
20A	685083.01	600982.91	15
21A	685515.67	601316.1	15
25A	688852.43	603630.92	12
26A	688732.41	603856.06	8
27A	689049.74	603606.53	12
29A	688449.22	603326.8	24
29B	688725.61	603237.98	24
29C	688926.31	603379.45	24
30A	688432.30	603598.31	8

LEGEND

FEDERAL CHANNEL

MEAN HIGH WATER LINE (3.52 FT NGVD29)

EXISTING SHORELINE PROTECTION LIMITS (AS SURVEYED BY SEVENSON ENVIRONMENTAL SERVICES, INC. ON 11/30/2012)

LOW WATER LINE (APPROXIMATE)

7–A AS-BUILT LONG TERM MONITORING PLATE - ODD YEARS

7–B AS-BUILT LONG TERM MONITORING PLATE - EVEN YEARS

GROUNDWATER SAMPLE LOCATION

BIOLOGICAL SAMPLE LOCATION

0.75" ARMOR PLACEMENT

1.0" ARMOR PLACEMENT

2.5" ARMOR PLACEMENT

3.5" ARMOR PLACEMENT

10.0" ARMOR PLACEMENT

MONITORED NATURAL RECOVERY AREA

PROPOSED SPI INVESTIGATION LOCATIONS - YEARS 1, 2, & 5

7 CAP AREA

7a SUB CAP AREAS

PORE WATER SAMPLING LOCATION

0 200
SCALE IN FEET

ENVIRON

DRAFTED BY: BJK/MSB/KPM | DATE: 11/11/2014

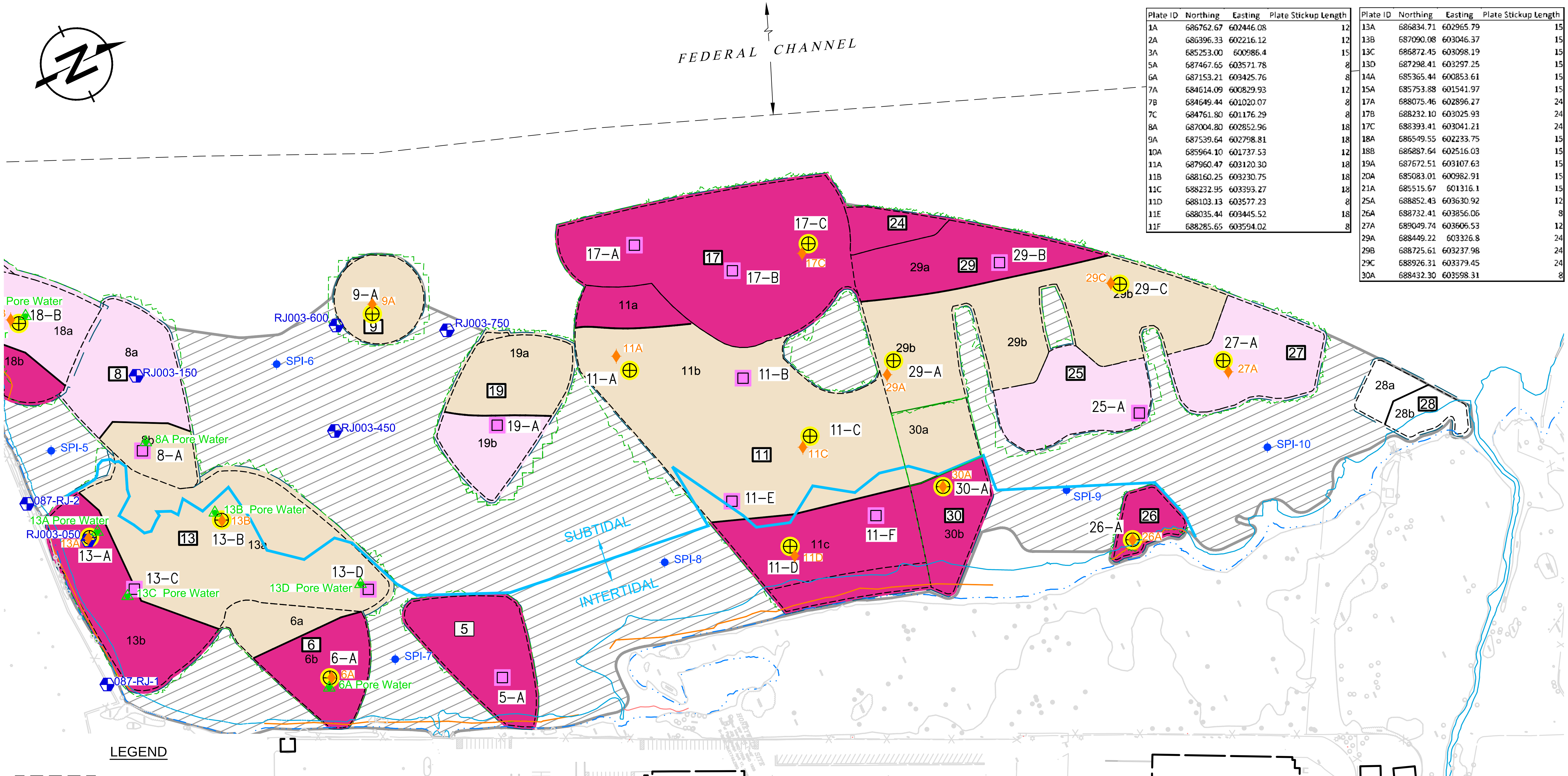
LONG TERM MONITORING PLAN - SOUTHERN AREA

STUDY AREA 7
JERSEY CITY, NEW JERSEY

FIGURE
1

0220255F3

MBLEI 2/5/15 [0220255_AS-BUILT-PLATES -SMPL PROP (PORE WATER)]
F:\0220255\DESIGN 100 PERCENT



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9A	687539.64	602798.81	18
10A	685964.10	601737.53	12
11A	687960.47	603120.30	18
11B	688160.25	603230.75	18
11C	688232.95	603393.27	18
11D	688103.13	603577.23	8
11E	688035.44	603445.52	18
11F	688285.65	603594.02	8

Plate ID	Northing	Easting	Plate Stickup Length
13A	686834.71	602965.79	15
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17C	688393.41	603041.21	24
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18B	686887.64	602516.03	15
19A	687672.51	603107.63	15
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26A	688732.41	603856.06	8
27A	689049.74	603606.53	12
29A	688449.22	603326.8	24
29B	688725.61	603237.98	24
29C	688926.31	603379.45	24
30A	688432.30	603598.31	8

LEGEND

FEDERAL CHANNEL

MEAN HIGH WATER LINE (3.52 FT NGVD29)

EXISTING SHORELINE PROTECTION LIMITS (AS SURVEYED BY SEVENSON ENVIRONMENTAL SERVICES, INC. ON 11/30/2012)

LOW WATER LINE (APPROXIMATE)

7–A AS-BUILT LONG TERM MONITORING PLATE - ODD YEARS

7–B AS-BUILT LONG TERM MONITORING PLATE - EVEN YEARS

GROUNDWATER SAMPLE LOCATION

BIOLOGICAL SAMPLE LOCATION

0.75" ARMOR PLACEMENT

1.0" ARMOR PLACEMENT

2.5" ARMOR PLACEMENT

3.5" ARMOR PLACEMENT

10.0" ARMOR PLACEMENT

MONITORED NATURAL RECOVERY AREA

PROPOSED SPI INVESTIGATION LOCATIONS - YEARS 1, 2, & 5

7 CAP AREA

7a SUB CAP AREAS

PORE WATER SAMPLING LOCATION

0 ###

SCALE IN FEET

ENVIRON

DRAFTED BY: BJK/MSB

DATE: 11/18/2014

LONG TERM MONITORING PLAN - NORTHERN AREA

STUDY AREA 7

JERSEY CITY, NEW JERSEY

FIGURE

2

0220255F3

MBLEI 2/5/15 [0220255_AS-BUILT-PLATES -SMPL PROP (PORE WATER)]
F:\0220255\DESIGN 100 PERCENT

\\environcorp.int\dfs-shares\NCSA\Princeton\DB1(T)\Nielsen\02-20255 Honeywell SA7 Remediation\GIS\Projects\Bio_Samples.mxd

ENVIRON

DRAFTED BY: HN

DATE: 11/17/2014

BIOLOGICAL SAMPLE LOCATIONS

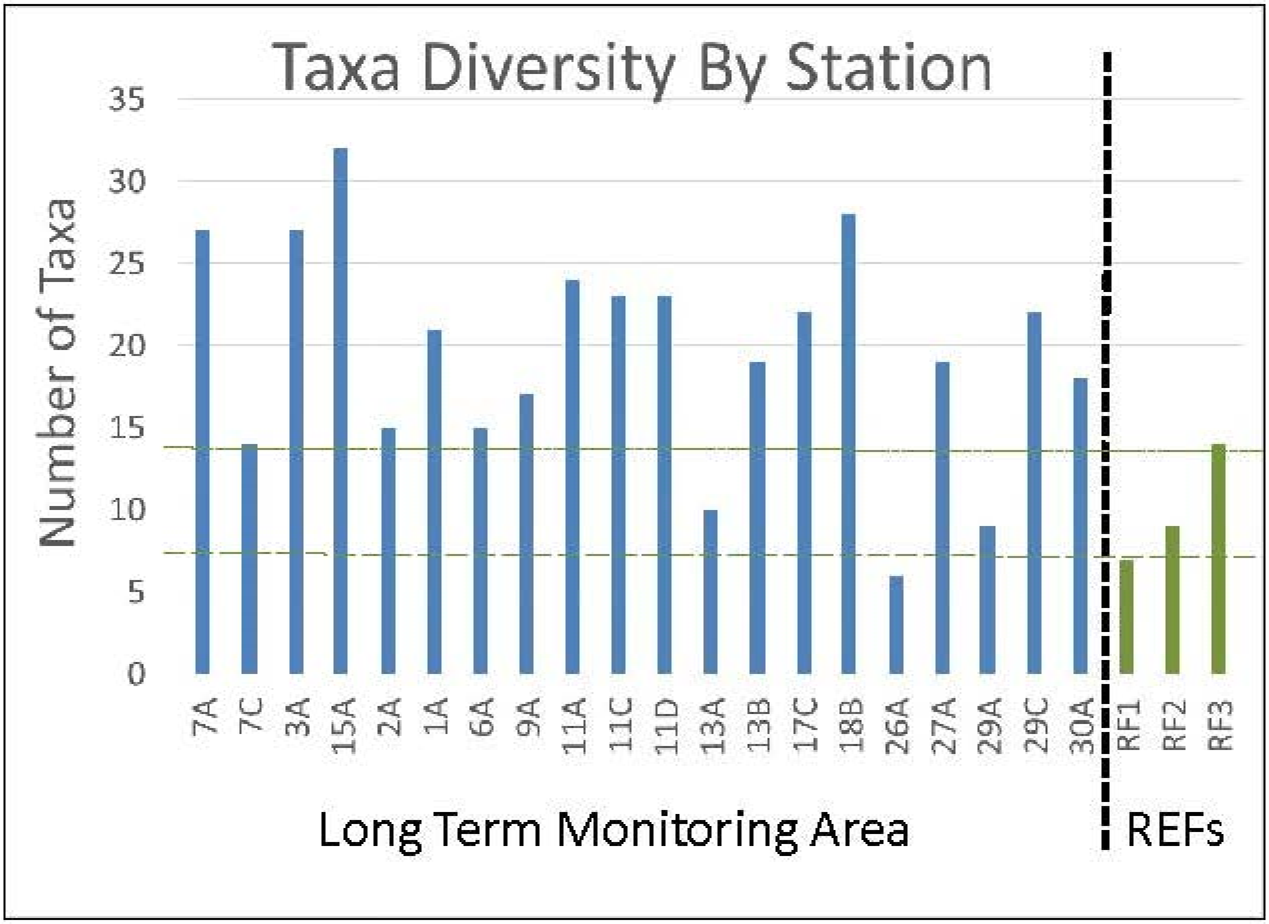
STUDY AREA 7

JERSEY CITY, NEW JERSEY

FIGURE

3

0220255F3



Upper end of diversity measurements from the reference area monitored.

Lower end of diversity measurements from the reference area monitored.

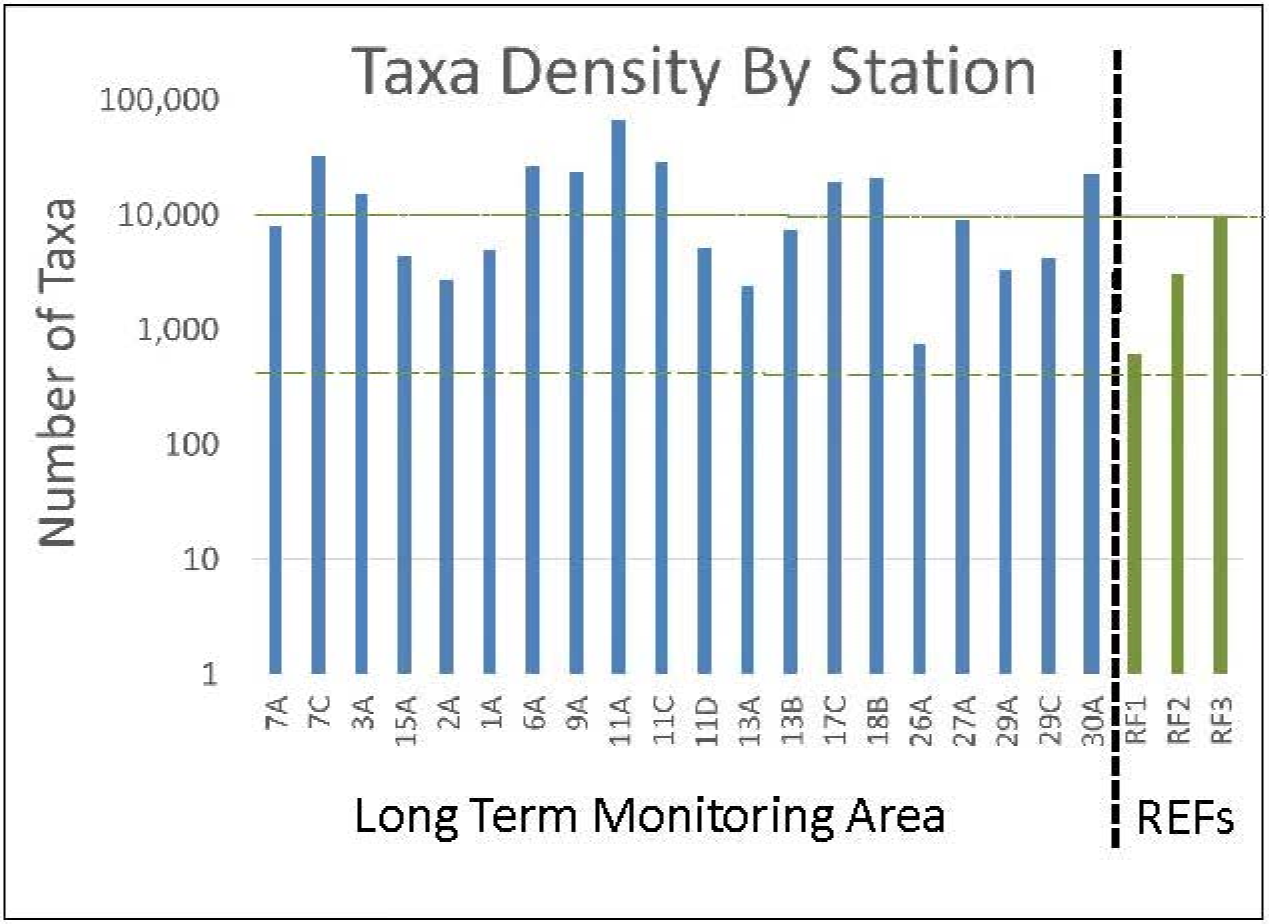
ENVIRON

Benthic Community Grab Sample Diversity Results

Study Area 7 Sediment Remedy

Jersey City, NJ

FIGURE 4



Upper end of density measurements from the reference area monitored.

Lower end of density measurements from the reference area monitored.

ENVIRON

Benthic Community Grab Sample Density Results

Study Area 7 Sediment Remedy

Jersey City, NJ

FIGURE 5

PLATE

NOTES:

1. TOPOGRAPHY: TOPOGRAPHIC ELEVATIONS ARE IN FEET AND ARE REFERENCED TO NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD 29) BASED ON BENCHMARK "PK-NAIL" WHICH HAS AN ELEVATION OF 6.94 FEET NORTH AMERICAN VERTICAL DATUM 1988 (NAVD 88) AS PROVIDED BY HONEYWELL. THE PLANE OF NGVD 29 IS 1.14 FEET BELOW THE PLANE OF NAVD 88 AT KEARNEY POINT, NEW JERSEY BASED ON NATIONAL GEODETIC SURVEY FIRST ORDER TIDAL BENCHMARK "W 16" WHICH HAS A PUBLISHED ELEVATION OF 17.00 FEET NAVD 88 AND 18.14 FEET NGVD 29.

2. BATHYMETRY: FOR THE BATHYMETRIC SURVEY, VERTICAL DATA WERE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29), AND HORIZONTAL COORDINATES WERE REFERENCED TO THE NORTH AMERICAN DATUM OF 1983 (NAD 83) USING THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NJ STATE PLANE). HORIZONTAL POSITIONING WAS PERFORMED WITH RTK-DGPS USING CORRECTIONS FROM KEYNET VRS. THE ACCURACY OF THE RTK-DGPS ROVER USING THE VRS CORRECTIONS WAS VERIFIED BY OCCUPYING CONTROL POINT ASI-PA AVE, LOCATED NEAR THE WESTERN END OF PENNSYLVANIA AVENUE IN KEARNY, NEW JERSEY.

3. SURVEYED BATHYMETRIC CONTOURS WERE PROVIDED IN MLLW DATUM AND CONVERTED TO NGVD 29 DATUM BY PERFORMING AN ELEVATION ADJUSTMENT OF -1.94 FEET. THE ELEVATION ADJUSTMENT IS BASED ON THE DIFFERENCE IN ELEVATION DATUM BETWEEN MLLW AND NGVD 29 AS DOCUMENTED AT TIDAL BENCHMARK "W16".

4. NEAR SHORE CONDITIONS (BETWEEN ELEVATION -1 FT AND +1 FT) ARE DEFINED BASED ON SURVEY DATA POINTS PROVIDED BY AQUA SURVEY INC. FOR THE 2010 BATHYMETRY.

SOURCES:

SITE LAYOUT BASED ON RIVERBED ELEVATIONS NORTHERN SITE, HONEYWELL SA7, SITE INVESTIGATION BY OCEAN SURVEYS, INC. HACKENSACK RIVER, JERSEY CITY, NJ OCTOBER 2007

LOTS BASED ON A MAP SHOWING REMAINING STATE TIDELANDS CLAIMS, BLOCK 1290.1, LOT A1 & A2, BLOCK 1751, LOTS 10K1, 10K2, 11 & 12, CMX, 8/6/09.

2014 BATHYMETRIC CONTOURS BASED ON A BATHYMETRIC SURVEY FOR HONEYWELL BY AQUA SURVEY INC., CONDUCTED ON 9/29/2014 AND DIGITALLY PROVIDED ON 12/18/2014.

TOPOGRAPHIC CONTOURS BASED ON A SURVEY MAP FOR HONEYWELL ENTITLED "ALTA / ACSM LAND TITLE SURVEY BLOCK 1290.1 ~ LOTS 2D, 2E, & 16A.99", BY CMX, DATED 5/23/08 & REVISED THROUGH 11/07/08

BATHYMETRIC BASE MAP	ENVIRON		
HONEYWELL INTERNATIONAL, INC. SA7 SEDIMENT REMEDIATION PROJECT JERSEY CITY, HUDSON COUNTY, NJ	PREPARED BY: EC/PRM DRAFTED BY: PRM APPROVED BY: JS/JMN	DATE: 01/13/2015 SCALE: AS SHOWN PROJECT: 0220255G	PLATE 1

APPENDICES

APPENDIX A
Photographs

Photo 1: Visual inspection of intertidal cap areas at low tide

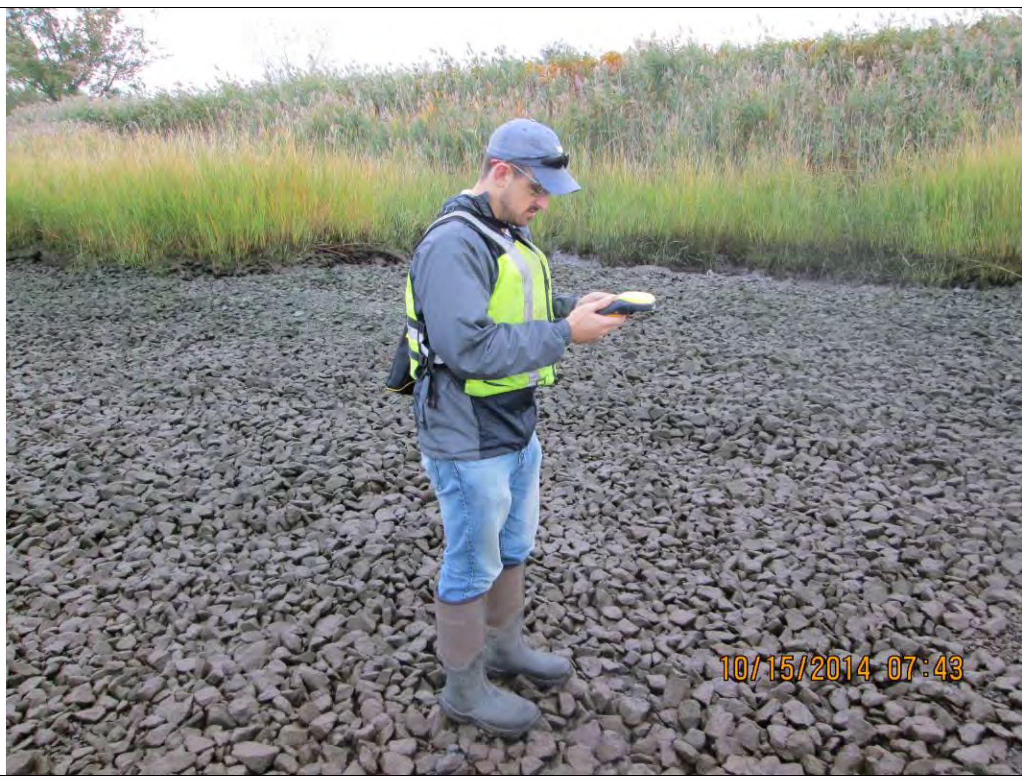


Photo 2: Navigation to intertidal long-term monitoring plate location using Trimble SPS855 GPS unit

Title:	Long-Term Monitoring Program – Year 1	**Date:**	Sept. – Nov. 2014
Site:	SA-7 Sediment Remedy	**Project No.:**	02-20255G
Client:	Honeywell		ENVIRON

Photo 3: Inspection of intertidal plate 11D in Cap Area 11C

Photo 4: Crab eggs observed on sediment cap armor layer in intertidal area

Title:	Long-Term Monitoring Program – Year 1	**Date:** Sept. – Nov. 2014
Site:	SA-7 Sediment Remedy	**Project No.:** 02-20255G
Client:	Honeywell	ENVIRON

Photo 5: Buoy-marked plate location for cap thickness verification in subtidal area

Photo 6: Cap thickness verification by AquaSurvey diver in subtidal area

Photo 7: Solinist® Drive Point Profiler – pore water sampling device

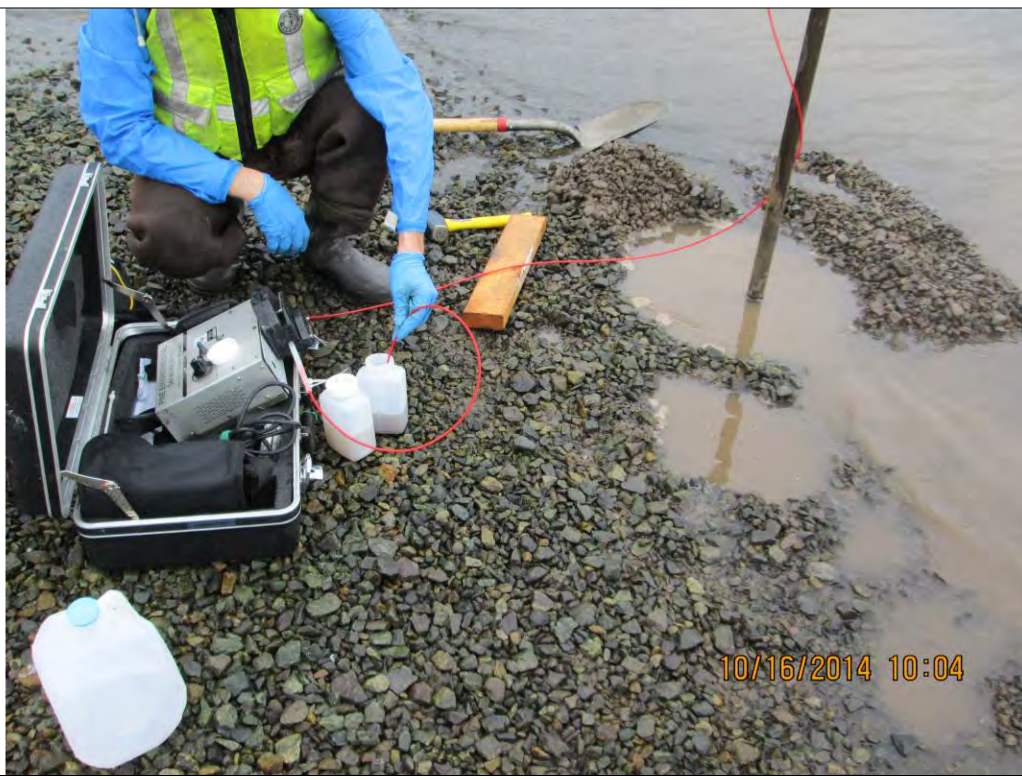


Photo 8: Collecting pore water samples from intertidal areas

Title:	Long-Term Monitoring Program – Year 1	**Date:**	Sept. – Nov. 2014
Site:	SA-7 Sediment Remedy	**Project No.:**	02-20255G
Client:	Honeywell		ENVIRON

Photo 9: Biological sampling in intertidal area

Photo 10: 500-micron sieve used for biological sample collection

Title:	Long-Term Monitoring Program – Year 1	**Date:** Sept. – Nov. 2014
Site:	SA-7 Sediment Remedy	**Project No.:** 02-20255G
Client:	Honeywell	ENVIRON

Photo 11: Biological sampler used in subtidal areas

Photo 12: Preservation of biological samples for laboratory analysis

Photo 13: SPI Camera staged on deck of vessel

Photo 14: Deploying the SPI Camera in subtidal MNR area

Photo 15: View of deployed SPI camera in subtidal MNR area

APPENDIX B
Sediment Profile Imaging Report

NewFields

Sediment Profile Imaging Monitoring Survey in the Lower Hackensack River

Data Report

Prepared for:
Aqua Survey, Inc.
469 Point Breeze Rd.
Flemington, NJ 08822

Prepared by:
NewFields
115 2nd Ave N, Suite 100
Edmonds, WA 98020

November 24, 2014

Table of Contents

List of Figures

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1.0 Introduction

This report presents the results of a sediment profile imaging (SPI) survey conducted at a restoration site along the eastern shore of the Lower Hackensack River, just north of Newark Bay. The purpose of the study was to provide an evaluation of benthic habitat conditions of sediments in proximity to a shoreline restoration site on the Lower Hackensack River, which included capping of sediments in some areas of the near shore. The survey was conducted as part of a Year 1 monitoring program. Benthic habitat conditions were evaluated through the analysis of triplicate SPI images at 10 locations surrounding the restoration site (Figure 1). The SPI survey was conducted on October 29, 2014, by NewFields Sediment Management and Marine Sciences, LLC, Edmonds, WA, under contract to Aqua Survey, Inc., Flemington, NJ.

2.0 Methods

2.1 Field Survey

Sediment profile images were collected by NewFields scientists using a digital sediment-profile imaging camera system (Ocean Imaging Systems, North Falmouth, MA) deployed from the research vessel (R/V) *Tesla*. The R/V *Tesla* is owned and operated by Aqua Survey, Inc. A total of 10 SPI stations were sampled in sediments near the Lower Hackensack River restoration site, and a minimum of three replicate SPI images were collected at each station. Geographic coordinates were recorded for each replicate SPI image collected using a Trimble differential global position system (DGPS) with a horizontal accuracy of ± 3 meters (Appendix A).

2.2 Sediment Profile Imaging Overview

The SPI camera consisted of a wedge-shaped prism with a Plexiglas faceplate; light was provided by an internal strobe. The back of the prism had a mirror mounted at a 45-degree angle to reflect the profile of the sediment-water interface toward the camera, which was mounted horizontally on the top of the prism. The prism was filled with distilled water, through which the photographs were obtained. Because the sediment to be photographed was directly against the clear window (faceplate) comprising the front of the prism, turbidity of the ambient seawater was not a limiting factor. The camera was able to obtain images of up to 20 cm of the upper sediment column in profile.

The camera prism was mounted on an assembly that moves up and down within a stainless steel frame by allowing tension or slack on the winch wire (Figure 2). As the camera was lowered, tension on the winch wire kept the prism in the up position. Once the camera frame touched the bottom, slack on the winch wire allowed the prism to vertically intersect the seafloor. The rate of fall of the prism (6 cm/second) was controlled by an adjustable passive hydraulic piston, which minimized the disturbance of the sediment-water interface.

A trigger was tripped on impact with the bottom, activating a 13 second time-delay on the digital camera; this gave the prism a chance to obtain maximum penetration before an image was collected. After image collection, the camera was raised from the bottom, a wiper blade automatically cleaned off any sediment adhering to the prism faceplate, and the strobes were recharged. The camera was then lowered again to collect a total of three replicate images.

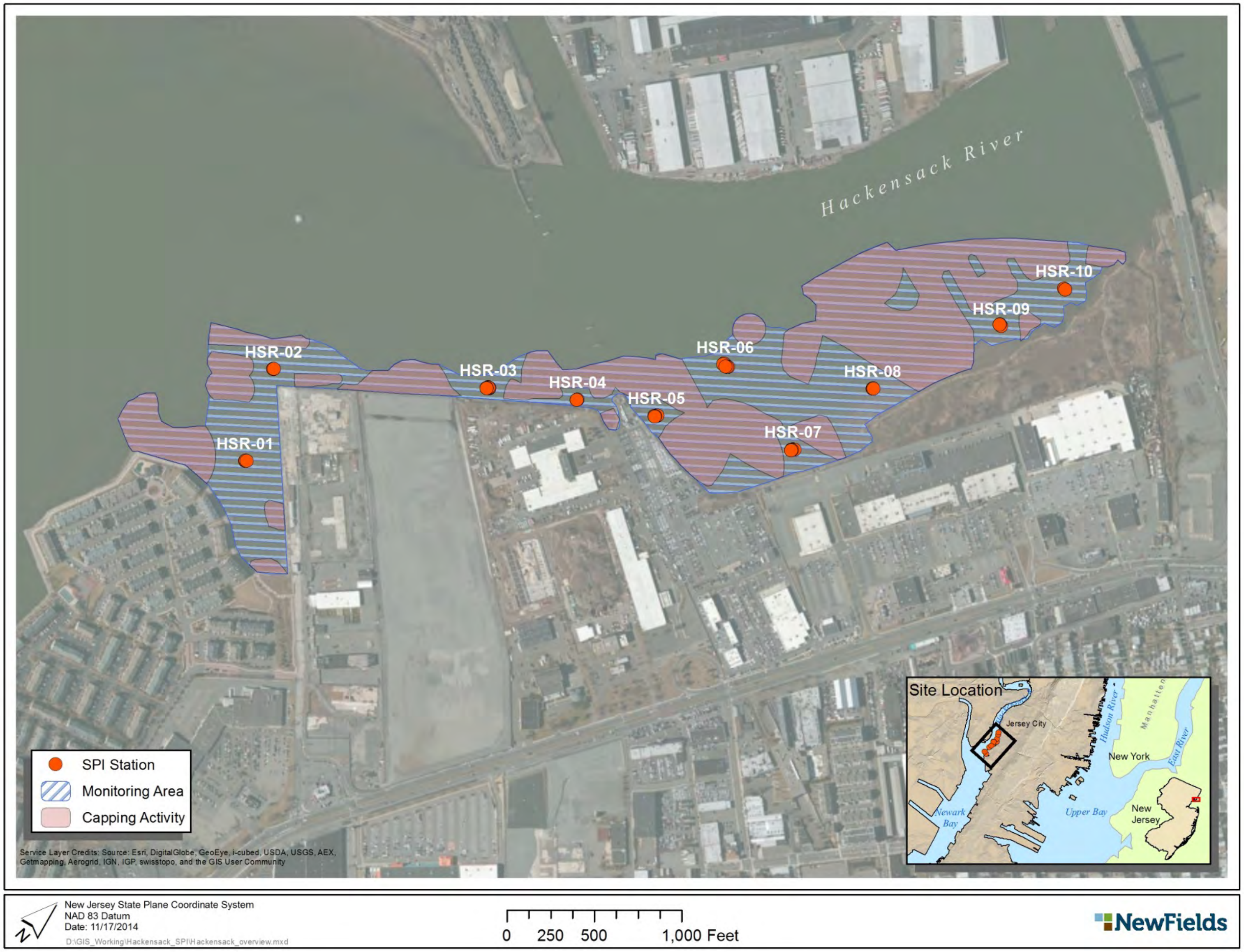


Figure 1. Lower Hackensack River SPI Sampling Locations.

Two weight racks, each capable of holding 125 lb. of lead (in 25 lb. increments) were used to increase penetration. If penetration was too great, weights were removed, or adjustable stops, which control the distance the prism can descend, were lowered.

2.3 SPI Image Analysis

Computer image analysis of SPI images followed a formal and standardized technique developed by Rhoads and Germano (1982, 1986). Physical and biological parameters were measured directly from the digital SPI images by an analyst using computer image analysis software. The image analysis parameters for this project included:

- Camera prism penetration depth (cm)
- Sediment grain size (major mode and range in phi sizes)
- Surface boundary roughness
- Mud clasts
- Presence of methane
- Depth of the apparent RPD (cm)
- Infaunal successional stage
- Benthic habitat categories (Diaz 1995)
- Organism Sediment Index (OSI) calculation

All data were edited and verified by a senior-level scientist before final data synthesis, statistical analysis, and interpretation. Specific measurement techniques and interpretive criteria for each parameter are presented below.

2.3.1 Prism Penetration Depth

The prism penetration depth was determined by measuring both the largest and smallest linear distance between the sediment-water interface and the bottom of the image. Observations regarding the nature and condition of the sediment-water interface were also recorded. Comparative penetration depths from stations of similar grain-size provided an indication of relative sediment water content and shear strength.

2.3.2 Grain Size Major Mode

The sediment grain-size major mode and range, in phi units, were visually determined from the SPI images by overlaying a grain-size comparator at the same scale. This comparator was prepared by photographing a series of Udden-Wentworth size classes (equal to or less than coarse silt up to granule and larger sizes) through the SPI optical system. Seven grain-size classes are on this comparator: ≥ 4 phi (silt/clay), 4 to 3 phi (very fine sand), 3 to 2 phi (fine sand), 2 to 1 phi (medium sand), 1 to 0 phi (coarse sand), 0 to -1 phi (very coarse sand), and < -1 phi (gravels). The lower limit of optical resolution was approximately 62 μm, allowing recognition of grain sizes equal to or greater than coarse silt.

2.3.3 Surface Boundary Roughness

Surface boundary roughness was determined by measuring the vertical distance (parallel to the image border) between the highest and lowest points of the sediment-water interface. In addition, the origin (physical or biogenic) of this small-scale topographic relief was sometimes evident and could be recorded. In sandy sediments, boundary roughness can be a measure of sand-wave height. On silt-clay bottoms, boundary roughness values often reflect biogenic features such as fecal mounds or surface burrows. These features are abundant only in areas where boundary shear stresses are low enough that such delicate features are preserved. Recently placed capping material or disposed dredged material often introduces high surface relief on an otherwise "smooth" bottom. Other surface features were noted when evident, including shell fragments/lag deposits, mud clasts, and wood debris.

2.3.4 Sedimentary Methane

Gas-filled voids in sediment are readily discernible in SPI images because of their irregular, generally circular shape and glassy appearance (due to the reflection of the camera strobe off the gas). The presence of sedimentary methane indicates high organic matter loading to a system as methanogenesis predominates where sulfate is depleted by organic overloading.

2.3.5 Apparent Redox Potential Discontinuity (RPD) Depth

The apparent RPD depth estimates the depth of oxygenation in the upper sediment column and can be considered the depth to which biological mixing by organisms and/or physical mixing are most prevalent. The upper surface of aerobic sediments has a higher light reflectance value than underlying anaerobic sediments. This is apparent in SPI images and is due to oxidized surface sediment that contains minerals in an oxidized state (typically a tan, reddish-brown, or olive color), while the reduced sediments below this oxygenated layer are generally gray or black. The boundary between these layers is called the apparent RPD.

The apparent RPD depth provides an estimate of the biogenic sediment mixing depth because bioturbating organisms mix the oxidized sediment particles downward into the sediment column. Bioturbation also vertically transports buried reduced compounds to the sediment surface and exposes them to an oxidized water column (Aller 1982). The determination of the apparent RPD in well-sorted, sandy sediments can be less clear due to the lack of silt or organic content. A visual determination of the apparent RPD requires an optical contrast between oxidized surface sediments and reduced sediment particles at depth. This contrast may not be apparent in sandy sediments lacking silt content or organic material and may suggest fairly deep oxygen penetration in these sediment habitat types.

Another important characteristic of the apparent RPD is the contrast in reflectance values at this boundary. This contrast is related to the interactions among the degree of organic-loading in the sediment, bioturbation, and bottom-water dissolved oxygen levels. High inputs of labile organic material increase sediment oxygen demand, stimulate sulfate reduction rates, and result in sulfitic products. This results in more highly reduced (lower-reflectance) sediments at depth and higher RPD contrasts. In a region where generally low RPD contrasts exist, images with high RPD contrasts indicate localized sites of relatively high inputs of organic-rich material from natural or anthropogenic sources.

2.3.6 Infaunal Successional Stage

Following a disturbance of the sediment habitat, marine benthic infaunal communities generally follow the succession pattern described by Pearson and Rosenberg (1978) and Rhoads and Germano (1986) (Figure 3). Stage I infauna are typically the first organisms to colonize the sediment surface. In marine and estuarine systems these opportunistic organisms may consist of small, tubicolous, surface-dwelling polychaetes. Stage II organisms are typically shallow-dwelling bivalves or tube-dwelling amphipods. Stage II communities are considered a transitional community before reaching Stage III, the high-order successional stage consisting of long-lived, infaunal deposit-feeding organisms. Stage III invertebrates may feed at depth in a head-down orientation and create distinctive feeding voids visible in SPI images.

This successional dynamic of invertebrate communities in fine-grained, organic-rich marine sediments has been well documented. However, these dynamics are not as well understood in sandy and coarse-grained sediment habitats. In this type of environment, benthic communities comprised of small-bodied, surface-dwelling suspension feeders (e.g., tube-dwelling polychaetes) may remain dominant over the long-term, and the high-order successional Stage III of large, subsurface deposit-feeders may not be achieved.

2.3.7 Benthic Habitat Categories

A benthic habitat classification scheme similar to the approach used in Diaz (1995) was used to classify benthic habitat types (Table 1). The categories are first organized by sediment type then by biological features. The benthic habitat categories determined from SPI images are based on the physical substrate type, the infaunal successional stage present, and the presence or absence of epifauna.

2.3.8 Organism-Sediment Index

The Organism-Sediment Index (OSI) provides a measure of general benthic habitat quality in shallow water environments based on dissolved oxygen conditions, depth of the apparent RPD, infaunal successional stage, and presence or absence of sedimentary methane measured from SPI images (Rhoads and Germano 1986). The OSI is a numerical index ranging from -10 to +11. The lowest value is given to bottom sediments with low or no dissolved oxygen in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment. The OSI for such a condition is –10 (highly disturbed or degraded benthic habitat quality). High OSI values are given to aerobic bottom sediments with a deep apparent RPD, mature macrofaunal community, and no methane gas (unstressed or undisturbed benthic habitat quality). The numerical values and ranges used in calculating the OSI are provided in Table 2.

Previous SPI surveys conducted in various marine and coastal regions have shown that OSI values between +7 and +11 are typical of natural, undisturbed, fine grained sediments. OSI values less than or equal to +6 can provide an indication of a stressed or disturbed benthic environment, and values less than 0 indicate degraded benthic habitat (Valente et al. 1992).

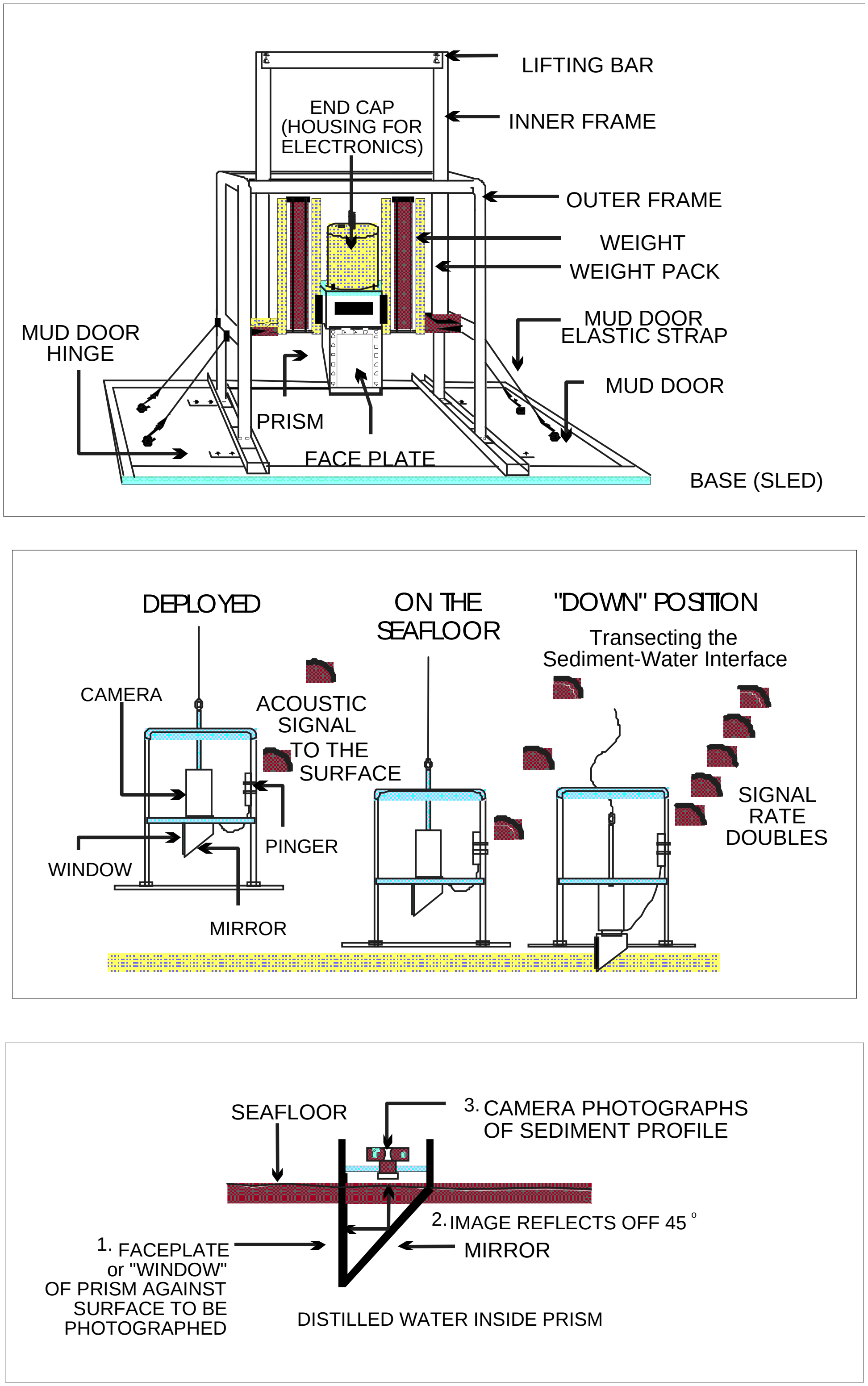
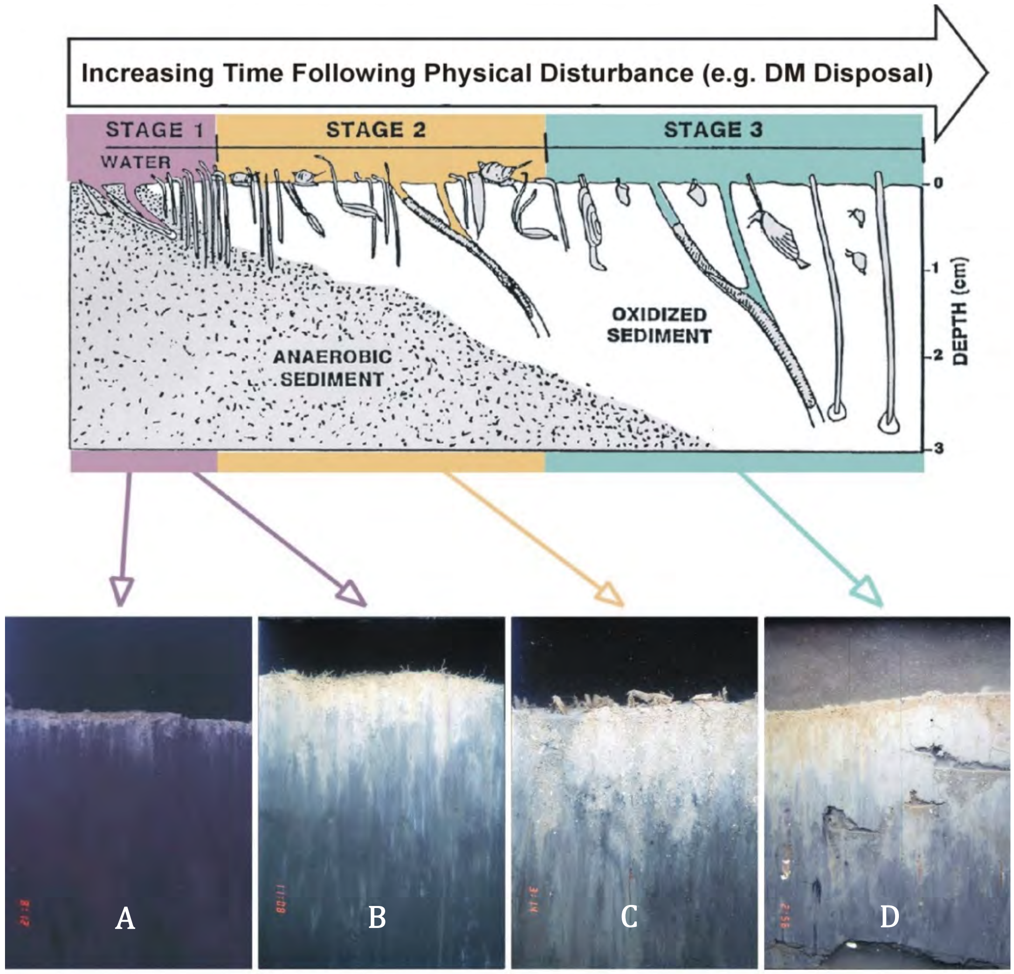


Figure 2. Schematic diagram of the sediment profile camera and sequence of operation.



The development of infaunal successional stages over time following a physical disturbance or with distance from an organic loading source (from Rhoads and Germano 1986). The SPI images below the drawing provide examples of the different successional stages.

<u>Image A</u>: Image A shows highly reduced sediment with a very shallow redox layer (contrast between light colored surface sediments and dark underlying sediments) and little evidence of infauna.

<u>Image B</u>: Numerous small polychaete tubes are visible at the sediment surface in image B (Stage I), and the redox depth is deeper than in image A.

<u>Image C</u>: A mixture of polychaete and amphipod tubes occurs at the sediment surface in image C (Stage II).

<u>Image D</u>: Image D shows numerous burrow openings and feeding pockets (voids) at depth within the sediment; these are evidence of deposit-feeding, Stage III infauna. Note the RPD is relatively deep in this image, as bioturbation by the Stage III organisms has resulted in increased sediment aeration and causing the redox horizon to be located several centimeters below the sediment-water interface.

Figure 3. Successional stage assemblages and relationship to SPI.

Table 1. Description of Benthic Habitat Types (Based on Diaz 1995)

Habitat AM: *Ampelisca* Mat Uniformly fine-grained (i.e., silty) sediments having well-formed amphipod (*Ampelisca* spp.) tube mats at the sediment-water interface. Other species of benthic infauna may also create mats similar to those of *Ampelisca*.
Habitat SH: Shell Bed A layer of dead shells and shell fragments at the sediment surface overlying sediment ranging from hard sand to silts. Epifauna (e.g., bryozoans, tube-building polychaetes) commonly found attached to or living among the shells. Two distinct shell bed habitats: **SH.SI: Shell Bed over silty sediment** - shell layer overlying sediments ranging from fine sands to silts to silt-clay. **SH.SA: Shell Bed over sandy sediment** - shell layer overlying sediments ranging from fine to coarse sand.
Habitat SA: Hard Sand Bottom Homogeneous hard sandy sediments do not appear to be bioturbated, bed forms common, successional stage mostly indeterminate because of low prism penetration. **SA.F: Fine sand** - uniform very fine sand (4 to 3 phi) or fine sand sediments (3 to 2 phi). **SA.M: Medium sand** - uniform medium sand sediments (grain size: 2 to 1 phi). **SA.G: Medium sand with gravel –** predominately medium to coarse sand with a gravel fraction.
Habitat HR: Hard Rock/Gravel Bottom Hard bottom consisting of pebbles, cobbles and/or boulders, resulting in no or minimal penetration of the SPI camera prism. Some images showed pebbles overlying silty-sediments. The hard rock surfaces typically were covered with epifauna (e.g., bryozoans, sponges, tunicates).
Habitat UN: Unconsolidated Soft Bottom Fine-grained sediments ranging from very fine sand to silt-clay, with a complete range of successional stages (I, II and III). Biogenic features may be common (e.g., amphipod and polychaete tubes at the sediment surface, small surface pits and mounds, large borrow openings, and feeding voids at depth). Several sub-categories: **UN.SS: Fine Sand/Silty** - very fine sand mixed with silt (grain size range from 4 to 2 phi), with little or no shell hash. **UN.SI: Silty** - homogeneous soft silty sediments (grain size range from >4 to 3 phi), with little or no shell hash. Generally deep prism penetration. **UN.SF: Very Soft Mud** - very soft muddy sediments (>4 phi) of high apparent water content and deep prism penetration.

Table 2. Calculation of the Organism-Sediment Index

Choose One Value:		
	Mean RPD Depth Classes	Index Value
	0.00 cm	0
	> 0 - 0.75 cm	1
	0.76 - 1.50 cm	2
	1.51 - 2.25 cm	3
	2.26 - 3.00 cm	4
	3.01 - 3.75 cm	5
	> 3.75 cm	6
Choose One Value:		
	Successional Stage	Index Value
	Azoic	- 4
	Stage I	1
	Stage I - II	2
	Stage II	3
	Stage II - III	4
	Stage III	5
	Stage I on III	5
	Stage II on III	5
Choose One or Both if Appropriate:		
	Chemical Parameters	Index Value
	Methane Present	- 2
	No/Low Dissolved Oxygen	- 4
SPI Organism-Sediment Index =		Range: - 10 + 11

3.0 SPI Survey Results

This section presents the results of the 2014 SPI survey as part of the Year 1 monitoring program on the Lower Hackensack River restoration site. A summary of the results is provided in Section 4.0. The SPI survey at the Lower Hackensack River restoration site was conducted on October 29, 2014 and consisted of triplicate images collected at a total of 10 stations. All 10 stations were located within areas approved for monitoring only (outside the capping zones). A summary of the image analysis results (median and average values for each station) is provided in Table 3, and the full image analysis results are provided in Appendix A. Example SPI images showing representative features described below are provided in Figures 4 through 8.

3.1 Prism Penetration Depth

Comparative penetration depths from stations of similar grain size give an indication of relative sediment water content and shear strength. The average prism penetration depths measured from the SPI images during the 2014 survey are presented in Table 3 and Figure 9. The average prism penetration measured from all 10 stations was 12.38 cm (± 5.18 cm; n=30). Deepest prism penetration (20.50 cm) was measured at station HSR-06, where unconsolidated very soft muds (> 4 phi) were present. Shallowest prism penetration (3.79 cm) was measured at station HSR-08, where compact silts and very fine sands were present. Shallower prism penetration was also observed at stations HSR-02 and HSR-09 due to the presence of compact sands or silts.

The maximum number of lead weights (10 weights; 250 pounds) was used at the majority of stations to maximum SPI camera prism penetration, particularly in areas with compact silts and fine sands. At stations HSR-05, 06, and 07, the number of lead weights was reduced to eight (200 pounds) due to over-penetration in unconsolidated, fine-grained sediments at these sites (see Appendix A).

3.2 Grain Size Major Mode

Sediment grain size major mode measured from the SPI images at the monitoring stations are presented in Figure 10. The grain size major mode generally consisted of silt/clay (≥ 4 phi) throughout much of the site (8 of 10 stations). Sediment grain size at stations HSR-02 and HSR-07 was slightly coarser and consisted of very fine sands (4 to 3 phi) with low to moderate amounts of silt.

3.3 Surface Boundary Roughness

The surface boundary roughness measurements for the 2014 SPI survey are presented in Figure 11. Twenty-nine of the 30 replicate images (97%) collected within the site exhibited biogenic roughness, primarily due to the prevalence of tubicolous, surface-dwelling polychaetes or presence of surface burrow structures or biogenic aggregates (see Figures 4 and 5). A single replicate image at station HSR-07 exhibited physical roughness due to the presence of possible sand ripples on the sediment surface. Station HSR-07 is located in very shallow water in the near-shore and the possible sand ripple structures may be due to intertidal wave activity. Mean boundary roughness for the monitoring sites was 1.05 cm (± 0.73 cm; n=30).

3.4 Sedimentary Methane

Sedimentary methane was present in four replicate images from 3 stations (HSR-01, 03, and 06). The presence of methane at these locations can likely be attributed to localized areas of high organic matter loading where methanogenesis predominates in the absence of oxygen.

Methaneogenesis is the final step in the decomposition of organic material. Although methane gas presence results in a negative input value to the OSI index (refer to Table 2), methanogenesis is a common and natural process in estuarine environments, such as the Lower Hackensack River, where organic matter input can be high. In general, the presence of deeper apparent RPD depths and advanced infaunal successional stages (Stage III) in many of the monitoring areas (see Sections 3.5 and 3.6) suggested that the localized presence of methane gas did not provide a significant impact to benthic habitat quality. For example, SPI images collected at HSR-03 and HSR-06 showed the presence of methane bubbles in the sediment column, but both images showed relatively well-developed apparent RPD depths and benthic communities evidenced by Stage III feeding voids (see Figures 5 and 6).

3.5 Apparent RPD Depth

The average apparent RPD depths measured during the 2014 survey varied across the site (Table 3 and Figure 12). Apparent RPD depths (by replicate) ranged from 0.72 to 5.77 cm with an average of 2.67 cm (±1.30; n=30). The shallowest RPD depth (0.72 cm) during the 2014 survey was measured at station HSR-01 (replicate A) where a thin surface layer of tan very soft muds was present overlying dark gray reduced soft muds (Figure 4). However, the average apparent RPD depth for HSR-01 for all three SPI replicates was 1.52 cm. The deepest RPD depth (5.77 cm) was measured at station HSR-03 where unconsolidated water-rich, very soft muds were present with polychaetes and feeding voids visible at depth (Figure 5).

On average, the apparent RPD depths measured in the monitoring areas of the restoration site were comparable or slightly deeper than measurements taken in other estuarine areas. An SPI survey conducted in the Lower Passaic River found apparent RPD depths in brackish and estuarine areas ranged from 0.1 to 4.0 cm with an average of 1.6 cm (Germano and Associates 2005). Apparent RPD depths in the Hudson River Estuary ranged from 0.2 to 5.3 cm in muddy sediments, with an average of 1.6 cm (Iocco et al. 2000).

At stations HSR-01, 04 and 07, the reflectance contrast at the apparent RPD boundaries was generally higher in comparison to the other stations (see Figures 4, 5, and 7). This contrast (difference between light colored surface sediments versus dark reduced sediments at depth) is related to the amount of organic loading to the sediments, bioturbation rates, and concentrations of dissolved oxygen in bottom-waters. The higher reflectance contrast at these stations suggest a higher input of organic-rich material from man-made (e.g., dredged material or stormwater outfalls) or naturally-occurring organic sources (e.g., phytoplankton). High inputs of labile organic matter increase the sediment oxygen demand and increase the amount of sulfide products in the sediment. This results in lower-reflectance, highly reduced sediments at depth and higher RPD contrasts.

3.6 Infaunal Successional Stage

The distribution of infaunal successional stage at the monitoring sites is presented in Figure 13. All of the 10 monitoring stations exhibited Stage I succession in at least a single replicate SPI image. Stage I succession, the pioneering stage, was characterized by tubicolous, surface dwelling polychaetes as well as polychaetes present near-surface. Stage I succession was observed in all three replicate SPI images at station HSR-02; sediments at this station consisted of denser fine sands resulting in lower prism penetration. Stage I succession may be the dominant successional stage for this sediment habitat type (Figure 4). Stage II succession, the transitional stage between Stage I and III, was observed at five of ten stations and was characterized by the presence of small to medium sized polychaetes within the sediment column and moderate apparent RPD depths (see Figure 5). Stage I on III succession was observed at seven of the ten stations and was characterized by surface dwelling polychaetes as well as feeding voids and polychaete worms at depth (see Figures 4 and 6). Station HSR-06 exhibited Stage III taxa in the absence of Stage I in all three replicate images. Azoic conditions (absence of any biological activity) were not observed at any station.

The prevalence of Stage III taxa at the majority of stations and relatively well-developed apparent RPD depths suggests that the benthic communities present in the monitoring sites have not been greatly impacted by capping activities, or enough time has passed to allow for recolonization by Stage III deposit feeding organisms. The depths to which infaunal organism activities were observed in the sediment column are presented in Figure 14. Maximum depths (by replicate) ranged from 0 to 16.67 cm with an average of 8.83 cm (±5.06; n=30). The relatively deep presence of infauna provides further indication of the advanced infaunal successional stages (Stage III) at the majority of the monitoring sites. One exception was station HSR-02, where infaunal organism activity was not observed in two of three replicate SPI images. This is likely due to the presence of more compact sandy sediments at this site.

3.7 Benthic Habitat Classification

Benthic habitat categories similar to Diaz (1995) provide a habitat classification scheme based on sediment type and biological features (see Table 1). The benthic habitat categories observed during the 2014 survey are presented in Figure 15 and consisted of three categories:

1. Unconsolidated Soft Bottom – Very Soft Mud – (UN.SF)
2. Unconsolidated Soft Bottom – Fine Sand/Silty – (UN.SS)
3. Hard Sand Bottom – Fine Sand – (SA.F)

Eighteen of 30 replicate images (60%) collected within the monitoring sites were classified as unconsolidated soft bottom (UN.SF or UN.SS). Hard sand bottom (SA.F) was observed in all three replicates at HSR-02 and 07. Lower camera prism penetration at stations HSR-08 and 09 suggested that the observed silty sediments were dense and consolidated in nature, or underlain by more compact sandy sediments. Therefore, stations HSR-08 and 09 were also classified as SA.F (Figures 4, 7 and 8).

3.8 Organism-Sediment Index

Median OSI values calculated for the 2014 SPI survey are presented in Figure 16. Median OSI values ranged from +3 to +11 at the monitoring sites with a site-wide median OSI of +7. The relatively high OSI values were driven primarily by the relatively deep apparent RPD depths as well as the presence of Stage III deposit feeding organisms at depth. As discussed in Section 2.3.8, OSI values from +7 to +11 are generally considered indicative of unimpacted benthic habitat. The lowest median OSI value of +4 was measured at station HSR-08. This location showed the presence of a hard sand bottom with a relatively shallow RPD and was limited to Stage I succession (surface dwelling polychaetes) in two of three replicate SPI images.

Median OSI values less than or equal to +6 were also measured at stations HSR-01, 02, 04, and 07. The lower OSI values at station HSR-02 (median OSI of +5) was also due to the presence of more compact, sandy sediments. Deposit feeding organisms are less prevalent in compact sandy sediments, resulting in a successional stage leaning toward the pioneering (Stage I) succession rather than Stage III. Future monitoring will confirm whether compact coarse grained sediments are the normal benthic habitat type at these sites.

At station HSR-07, OSI values also ranged from +3 to +5 for the three replicate SPI images. Apparent RPD depths were in the shallower range (average of 1.17 cm) and showed a higher RPD contrast in comparison to the underlying reduced sediments, which suggests a higher input of organic matter from anthropogenic (e.g., capping disturbances, storm water input) or natural sources. Stage II succession was observed in two of three replicate images at HSR-07, and future monitoring may determine whether the benthic habitat at the site may transition to Stage III. At stations HSR-01 and 04, relatively shallow apparent RPD depths (averages of 1.52 and 1.60 cm, respectively) also resulted in median OSI values below +7. However, Stage III succession was observed in SPI replicate images for both stations, which suggests that the OSI values should improve over time as bioturbation activities from Stage III deposit feeders increase at these sites.

3.9 Sedimentary Layering

At stations HSR-01 and HSR-06, secondary reflectance layers were visible at depth within the SPI images (see Figures 4 and 6). These reflectance layers may represent relict apparent RPD depths overlain by more recent sediment depositional layers. Similar to observations during the Lower Passaic River SPI survey (Germano & Associates 2005), seasonal cycles of erosional or depositional events along the Lower Hackensack River would be expected. Future monitoring of the restoration site will help evaluate the effects of seasonal depositional events on the benthic habitat in the monitoring areas.

Table 3. SPI image analysis results (median and average values).

Station	Uncorrected Water Depth* (ft)	Avg. Prism Penetration (cm)	Grain Size Major Mode (phi)	Avg. Boundary Roughness (cm)	Avg. RPD Depth (cm)	Avg. No. of Mud Clasts	Methane Present	Benthic Habitat Type	Avg. Depth of Infaunal Activity (cm)	Highest Successional Stage Present	Median OSI
HSR-01	6.6	16.54	> 4 phi	0.80	1.52	0.66	TRUE	UN.SF	14.28	Stage I on III	6
HSR-02	18.1	6.65	4 to 3 phi	0.55	2.78	0.66	FALSE	SA.F	0.70	Stage I	5
HSR-03	10.4	19.03	> 4 phi	1.30	4.79	0.33	TRUE	UN.SF	12.72	Stage I on III	11
HSR-04	7.0	12.75	> 4 phi	2.36	1.60	0	FALSE	UN.SS	7.52	Stage I on III	5
HSR-05	6.0	13.35	> 4 phi	0.79	3.45	0	FALSE	UN.SF	10.80	Stage III	10
HSR-06	19.1	19.92	> 4 phi	0.62	3.33	2	TRUE	UN.SF	14.15	Stage III	7
HSR-07	3.9	10.03	4 to 3 phi	1.04	1.17	0.66	FALSE	SA.F	7.72	Stage II	5
HSR-08	4.8	4.22	> 4 phi	0.86	1.73	0.33	FALSE	SA.F	3.70	Stage I on III	4
HSR-09	5.5	7.08	> 4 phi	1.20	2.63	0	FALSE	SA.F	5.54	Stage II	7
HSR-10	5.9	14.26	> 4 phi	0.98	3.71	0	FALSE	UN.SF	11.14	Stage I on III	10

*water depth not tide corrected to MLLW

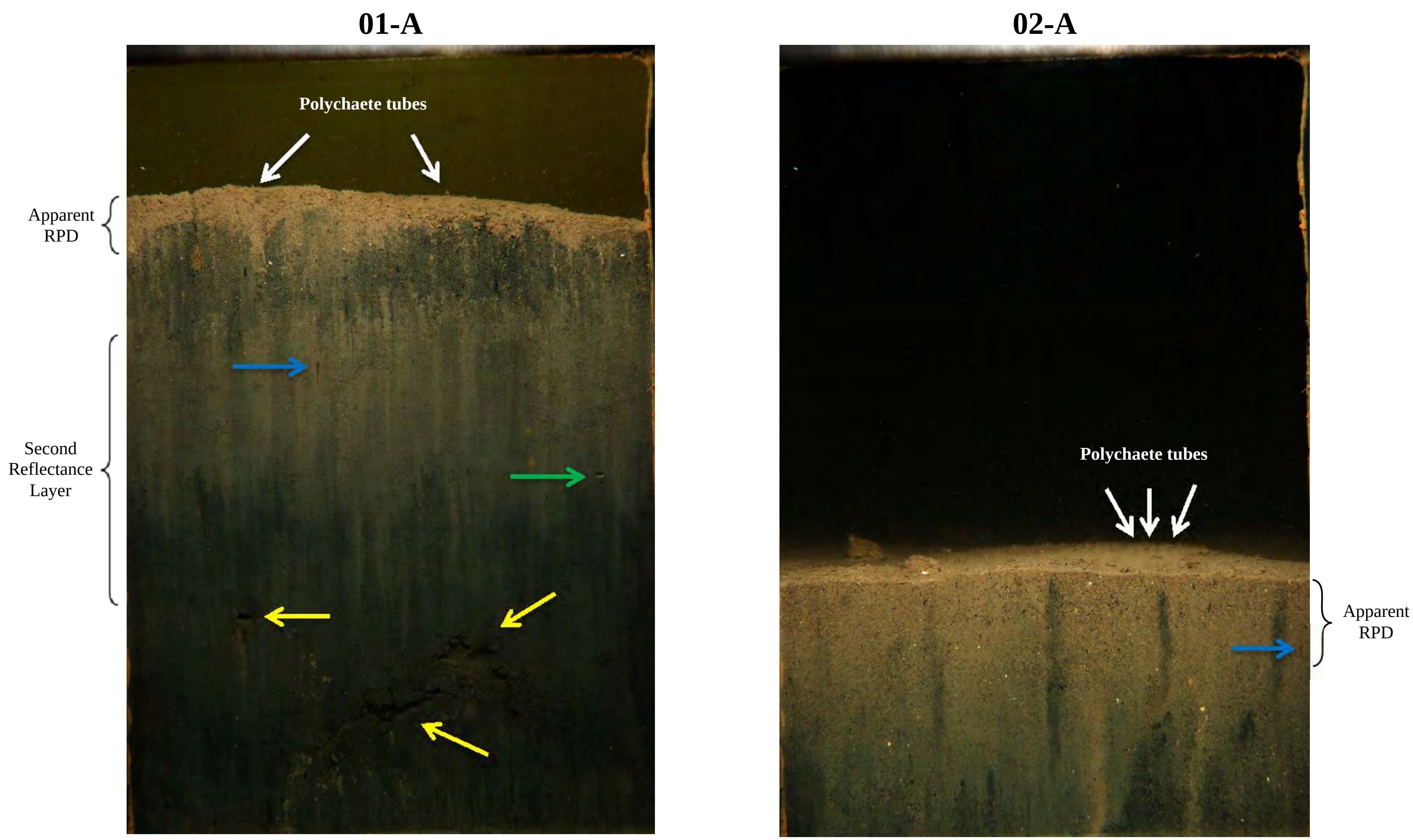


Figure 4. SPI images from stations 01-A and 02-A.

Station HSR-01 replicate A showed unconsolidated very soft muds (> 4 phi) throughout. A surface layer of light tan soft muds was evident overlying gray silts with some fine sands. A second reflectance layer was visible (light gray layers) underlying dark gray silts indicating a possible depositional layer or relict RPD. Polychaete tubes were visible on the surface (white arrows). A polychaete was present at depth (blue arrow) as were feeding voids (yellow arrows). A single methane gas vesicle was present at depth (green arrow). Station HSR-02 replicate A showed tan very fine sands (4 to 3 phi) grading to dark gray very fine sands with some silt. Polychaete tubes were present on surface (white arrows). A single polychaete was present at depth right (blue arrow). Trace shell fragments as well as fine organics were scattered throughout. Image width is 14.7 cm.

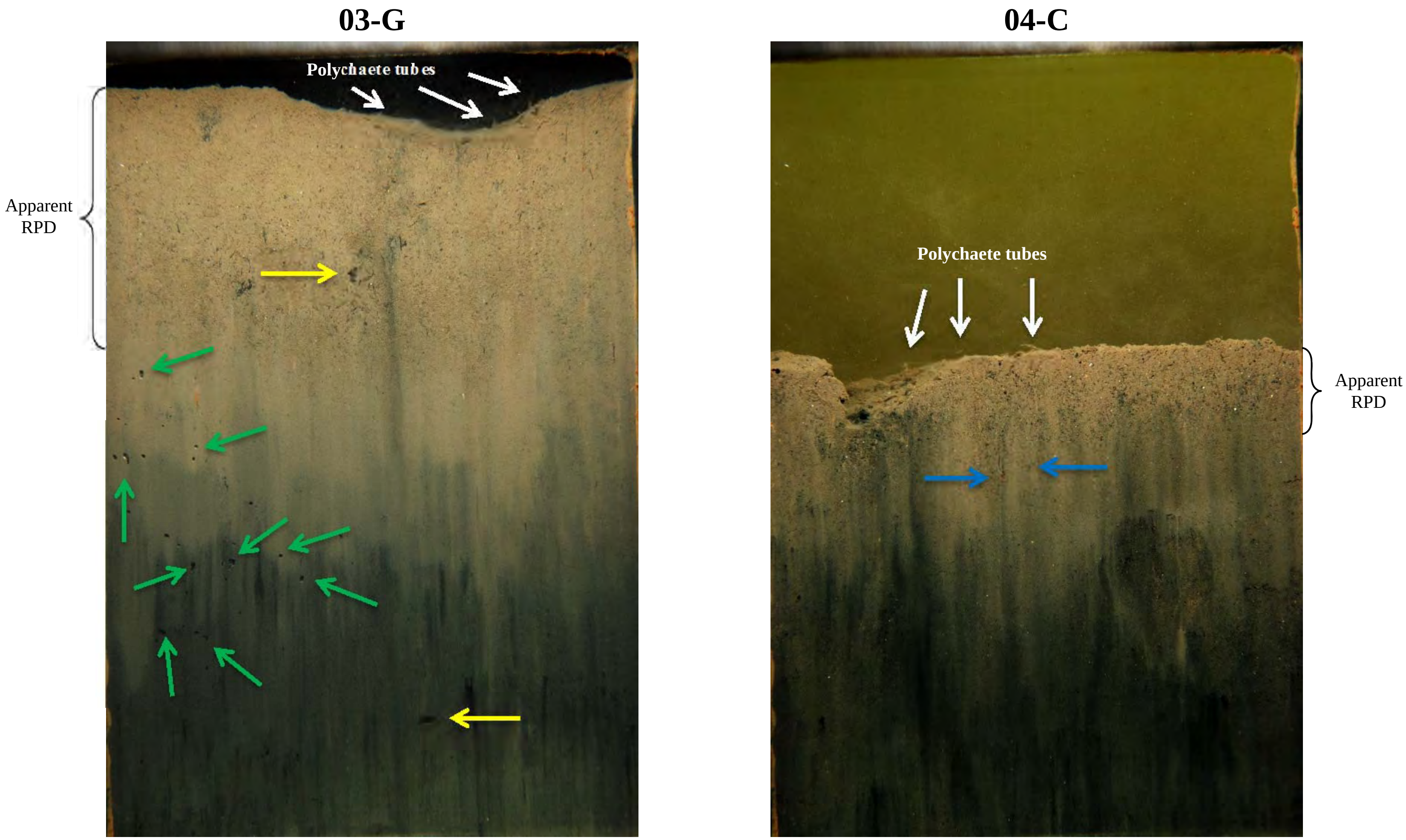


Figure 5. SPI images from stations 03-G and 04-C.

Station HSR-03 replicate G showed unconsolidated very soft muds (>4 phi) throughout grading from a light tan color at the surface to gray at depth. Polychaete tubes were present on the surface (white arrows). Two small feeding voids were evident at depth (yellow arrows) as well as methane gas vesicles (green arrows). Trace organics were intermixed into surface sediments. Successional stage was classified as Stage I on III. Station HSR-04 replicate C showed tan, very fine sands (4 to 3 phi) with some silt grading to light and dark gray very fine sands and silts. Polychaete tubes were evident on the surface (white arrows). Polychaetes were also present near-surface (blue arrows). Successional stage was classified as Stage I - II due to the presence of surface tubes and near-surface dwelling polychaetes. Image width is 14.7 cm.

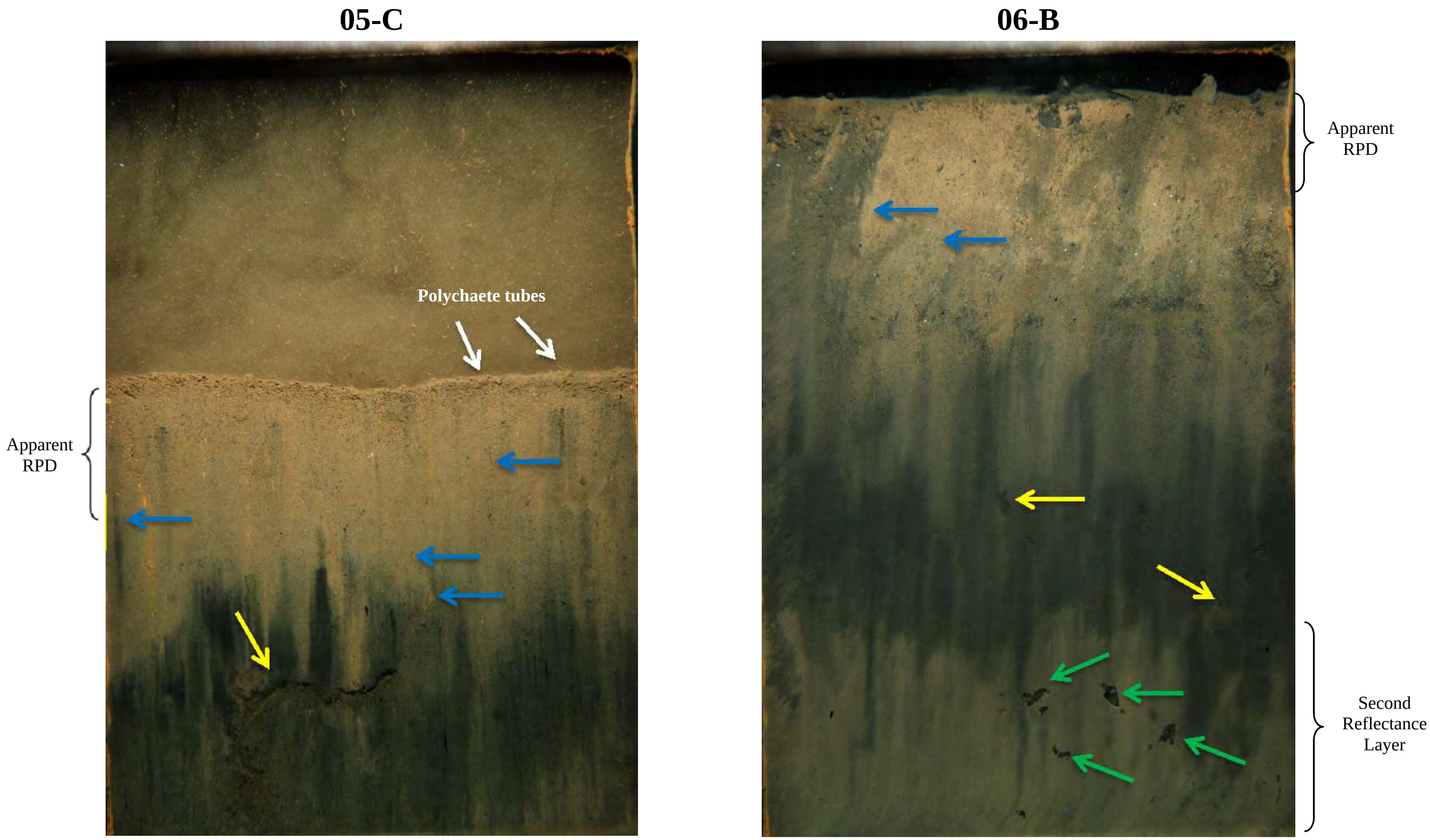


Figure 6. SPI images from station 05-C and 06-B.

Station HSR-05 replicate C showed unconsolidated very soft muds (>4 phi) throughout, grading from tan to dark gray with depth. Polychaete tubes were visible on the surface (white arrows). A feeding void was also present at depth (yellow arrow). Polychaetes were present near-surface (blue arrows). Successional stage was classified as Stage I on III. Station HSR-06 replicate B showed unconsolidated very soft muds (>4 phi) throughout, grading from tan to light and dark gray. A second reflectance layer is evident (alternating light and dark gray muds at depth), indicating a possible depositional layer or relict RPD. Polychaetes were present near-surface (blue arrows). Two collapsed feeding voids were evident at depth (yellow arrows) as well as methane gas vesicles (green arrows). Image width is 14.7 cm.

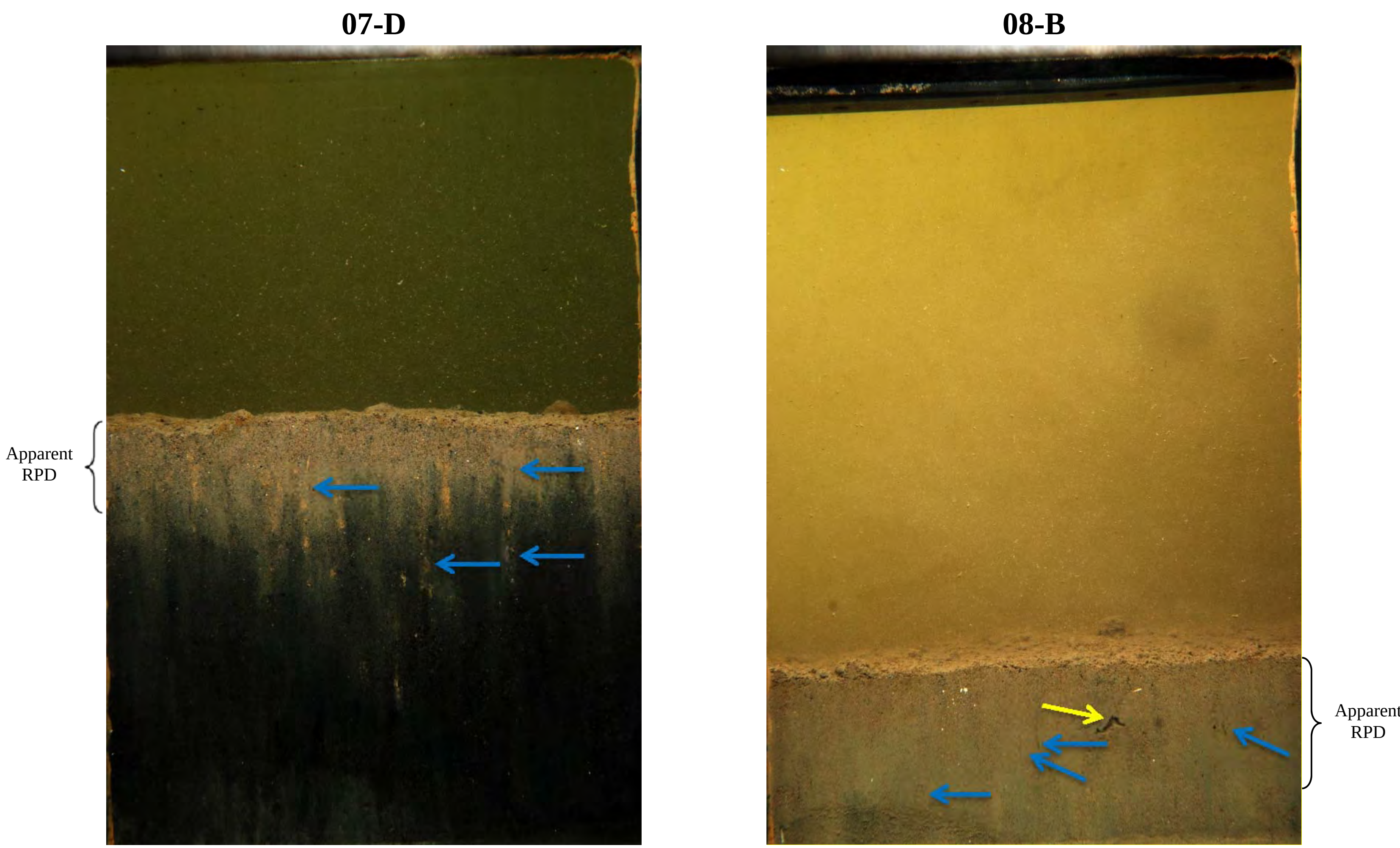


Figure 7. SPI images from stations 07-D and 08-B.

Station HSR-07 replicate D showed tan very fine sands (4 to 3 phi) with some silt overlying dark gray very fine sands and silts. Polychaetes were evident near-surface (blue arrows). Organics were present intermixed into surface sediments. Station HSR-08 replicate B showed homogeneous, compact, tan silt (>4 phi) throughout. Polychaetes were present near-surface (blue arrows). An algal coating was visible on the sediment surface and a small feeding void was present at depth (yellow arrow). Image width is 14.7 cm.

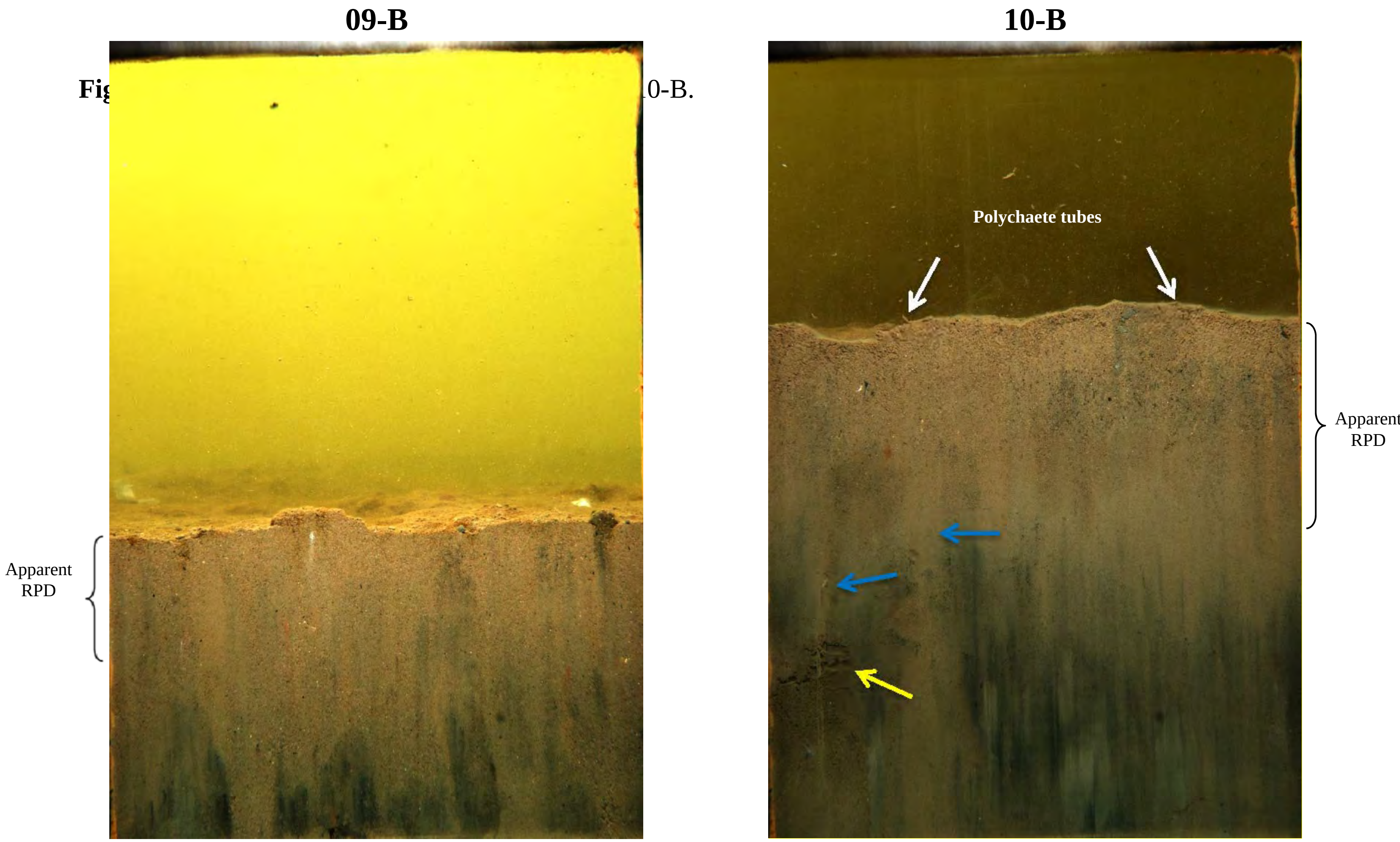


Figure 8. SPI images from stations 09-B and 10-B.

Station HSR-09 replicate B showed tan silts (>4 phi) sands grading to gray very fine sands with some silt at depth. Shell fragments were evident on the sediment surface. Polychaetes were present at depth (blue arrows). Station HSR-10 replicate B showed evidence of Stage I taxa (tube dwelling polychaetes) on the sediment surface (white arrows). Polychaetes were present at depth (blue arrows) as well as a single feeding void (yellow arrow), indicating the presence of Stage III taxa. Image width is 14.7 cm.

Figure 9. 2014 SPI results for camera prism penetration.

Figure 10. 2014 SPI results for grain size major mode.

Figure 11. 2014 SPI results for surface boundary roughness.

Figure 12. 2014 SPI results for mean apparent RPD depth.

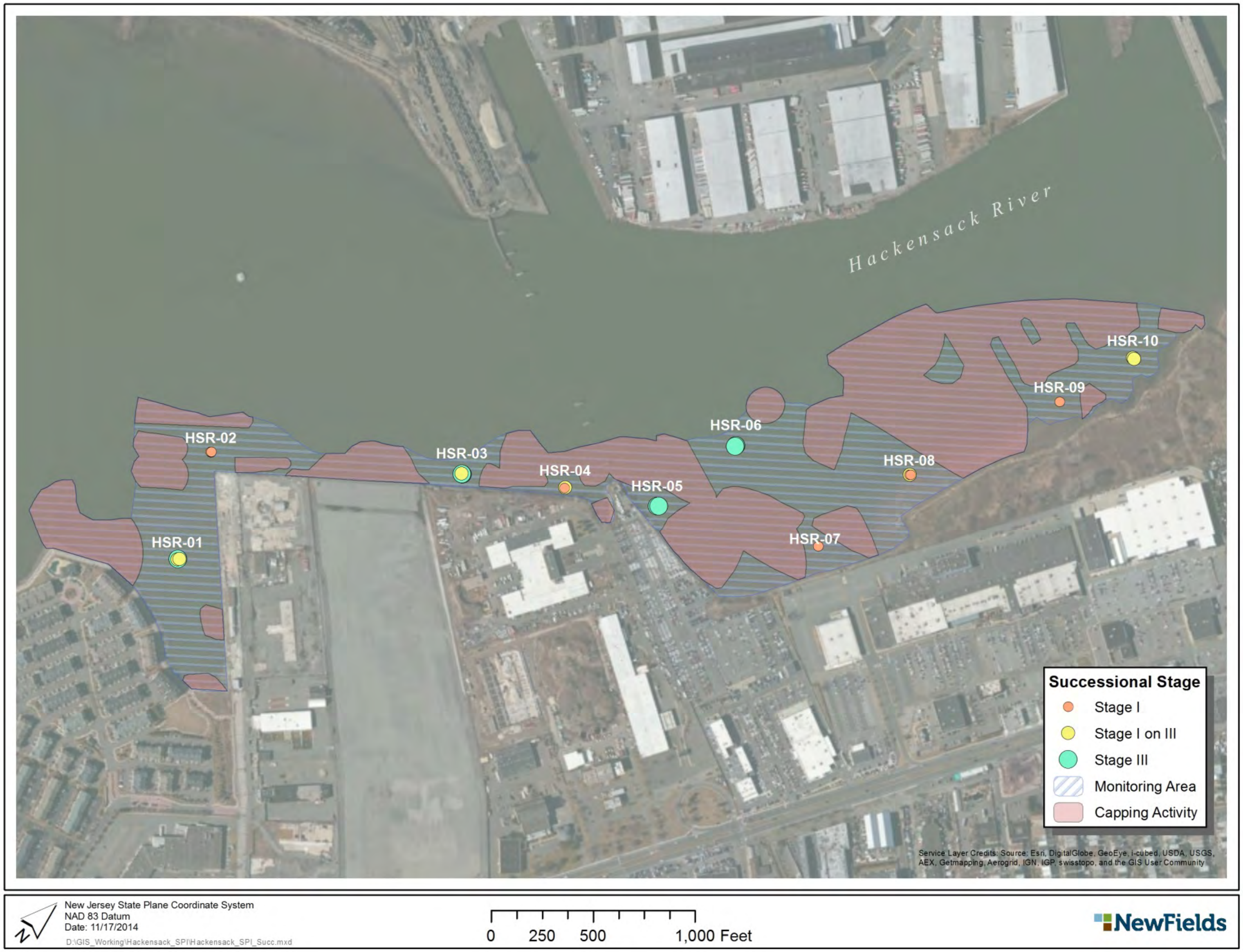


Figure 13. 2014 SPI results for infaunal successional stage.

Figure 14. 2014 SPI results for depth of infaunal activity.

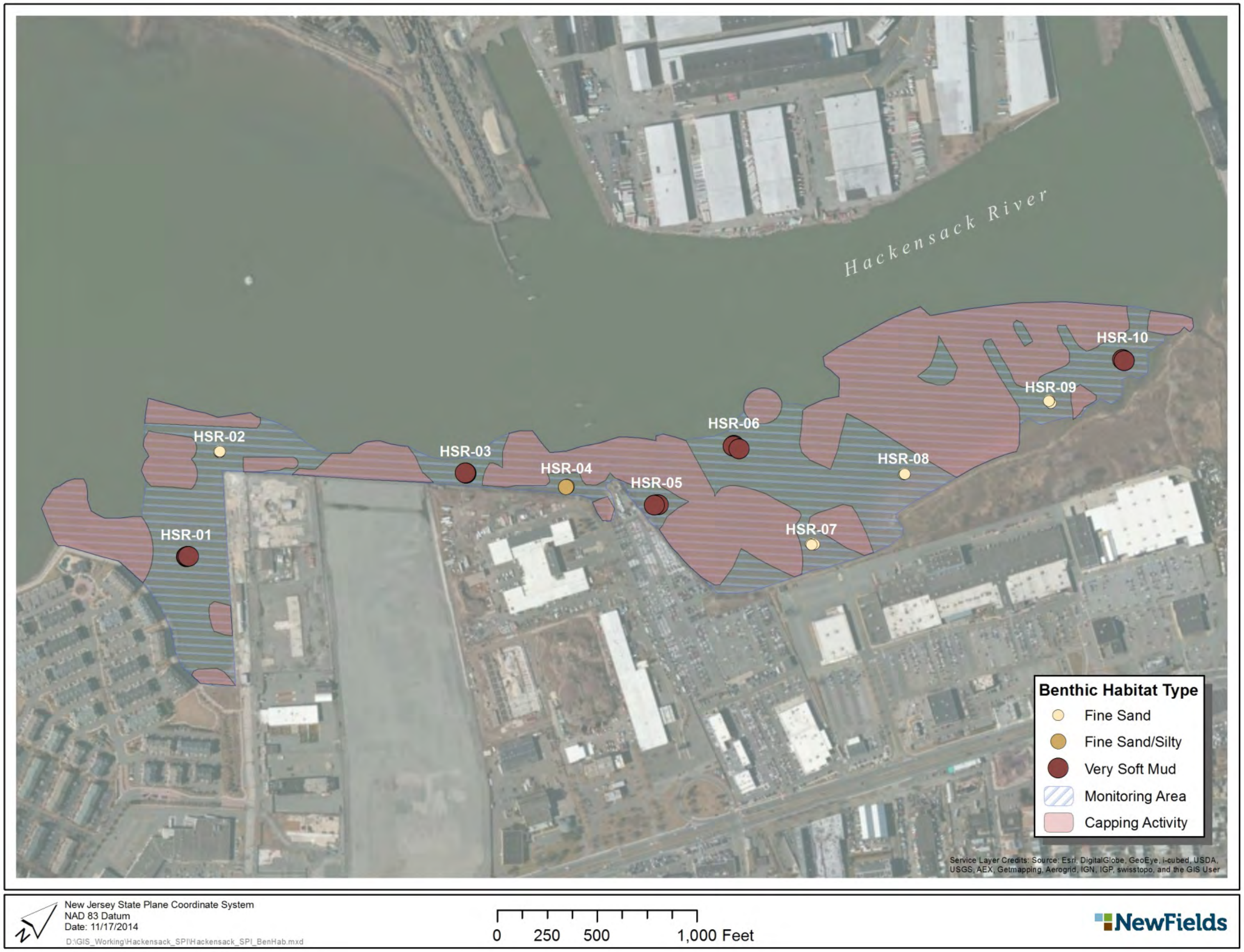


Figure 15. 2014 SPI results for benthic habitat type classification.

Figure 16. 2014 SPI results for the Organism Sediment Index.

4.0 Summary

A sediment profile imaging survey was conducted in the fall of 2014 as part of the Year 1 monitoring program at the Lower Hackensack River restoration site. Triplicate images were collected at a total of 10 stations located within areas approved for monitoring, outside the capping zones. A summary of the results is as follows:

- Unconsolidated, fine-grained sediments (grain size > 4 phi) were observed at six of the ten monitoring stations. The benthic habitat was categorized as unconsolidated soft bottom (UN.SF and UN.SS) (Diaz 1995).
- Sediment grain size at stations HSR-02 and 07 was slightly coarser and the major mode consisted of very fine sands (4 to 3 phi) with low to moderate amounts of silt. Prism penetration was also lower at these stations, reflecting the coarser, more compact nature of these sandy sediments. The benthic habitat was categorized as hard sand bottom with fine sand (SA.F). The benthic habitat was also classified as SA.F at stations HSR-08 and 09 due to the hard compact nature of the silts at these stations.
- Sedimentary methane was present at three monitoring station (HSR-01, 03, and 06) and was likely attributed to localized areas of high organic matter loading. In general, the presence of developed apparent RPD depths and advanced infaunal successional stages (Stage III) in many of the monitoring areas suggested that the localized presence of methane gas did not provide a significant impact to benthic habitat quality.
- On average, the apparent RPD depths measured in the monitoring areas of the restoration site were comparable or slightly deeper than measurements taken in other estuarine areas. Higher reflectance contrast of the apparent RPD and underlying sediments was observed at stations HSR-01, 04, and 07, and suggested higher organic loading from man-made or naturally-occurring sources. Future monitoring will help determine the sources of organic enrichment.
- Stage III infaunal succession observed at the majority of (seven of ten) monitoring stations and relatively deep infaunal depth activity (average of 8.8 cm) suggested that the benthic communities have not been greatly impacted by capping activities, or enough time had passed to allow for recolonization by Stage III deposit feeding organisms.
- Median OSI values ranged from +3 to +11 at the monitoring sites with a site-wide median OSI of +7. The relatively high OSI values were driven primarily by the relatively deep apparent RPD depths as well as the presence of Stage III deposit feeding organisms at depth. Median OSI values equal to +6 or less were measured at five stations (HSR-01, 02, 04, 07, and 08) due to the presence of compact sands, shallow apparent RPD depths, or earlier successional stages. These stations should be monitored in the future for improving OSI values.
- Secondary reflectance layers visible at two stations may represent relict apparent RPDs overlain by more recent sediment depositional layers. Future monitoring of the restoration site will help evaluate the effects of seasonal depositional events on the benthic habitat in the monitoring areas.

5.0 References

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Appendix A

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Pixel Cal. Factor: 0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Water Depth	# of Weights	Date	Time	Camera Penetration (cm)				Surface Relief (cm)
										Area	Min	Max	Mean	
JB	JSN	HSR_01	A	40.7130855	-74.1057895	6.6	5	10/29/14	10:20	262.91	17.21	18.13	17.78	0.92
JB	JSN	HSR_01	B	40.71309348	-74.1057859	6.6	5	10/29/14	10:23	256.77	17.19	17.67	17.36	0.48
JB	JSN	HSR_01	C	40.7131067	-74.1057684	6.6	5	10/29/14	10:24	214.08	14.19	15.2	14.48	1.01
JB	JSN	HSR_02	A	40.71438697	-74.1067946	18.1	5	10/29/14	10:36	107.13	7.05	7.45	7.24	0.40
JB	JSN	HSR_02	B	40.714387	-74.1068051	18.1	5	10/29/14	10:38	95.71	5.98	6.87	6.47	0.89
JB	JSN	HSR_02	C	40.71439509	-74.1067955	18.1	5	10/29/14	10:39	92.15	6.03	6.38	6.23	0.35
JB	JSN	HSR_03	D	40.71669736	-74.1035109	10.4	5	10/29/14	11:01	295.77	19.38	20.68	20.00	1.30
JB	JSN	HSR_03	E	40.7166974	-74.103521	10.4	5	10/29/14	11:02	248.44	16.45	17.58	16.80	1.13
JB	JSN	HSR_03	G	40.71669588	-74.1035271	10.4	5	10/29/14	11:10	299.98	19.56	21.02	20.28	1.46
JB	JSN	HSR_04	A	40.71760093	-74.1021118	7	5	10/29/14	13:01	195.76	13.09	13.62	13.24	0.53
JB	JSN	HSR_04	B	40.71759159	-74.1021175	7	5	10/29/14	13:02	174.91	9.35	13.46	11.83	4.11
JB	JSN	HSR_04	C	40.71758818	-74.1021153	7	5	10/29/14	13:02	195.12	11.41	13.85	13.19	2.44
JB	JSN	HSR_05	A	40.7183488	-74.1007743	6	4	10/29/14	11:21	191.55	12.69	13.56	12.95	0.87
JB	JSN	HSR_05	C	40.71836507	-74.1007554	6	4	10/29/14	11:22	186.78	12.39	12.89	12.63	0.50
JB	JSN	HSR_05	D	40.71832503	-74.1007977	6	4	10/29/14	11:30	213.95	14.03	15.04	14.47	1.01
JB	JSN	HSR_06	B	40.71968527	-74.1006314	19.1	5	10/29/14	12:40	303.21	20.34	20.8	20.50	0.46
JB	JSN	HSR_06	C	40.7196708	-74.1006315	19.1	5	10/29/14	12:41	279.75	18.58	19.43	18.92	0.85
JB	JSN	HSR_06	D	40.71970117	-74.1005218	19.1	4	10/29/14	12:48	300.61	20.09	20.64	20.33	0.55
JB	JSN	HSR_07	C	40.71959325	-74.0983344	3.9	4	10/29/14	11:42	104.46	5.99	7.84	7.06	1.85
JB	JSN	HSR_07	D	40.71955937	-74.0983807	3.9	5	10/29/14	11:47	173.58	11.65	11.91	11.74	0.26
JB	JSN	HSR_07	E	40.71955825	-74.0983654	3.9	5	10/29/14	11:48	167.06	10.79	11.8	11.30	1.01
JB	JSN	HSR_08	A	40.7211471	-74.0981864	4.8	5	10/29/14	11:58	55.99	3.22	4.46	3.79	1.24
JB	JSN	HSR_08	B	40.72115559	-74.0981821	4.8	5	10/29/14	11:59	73.42	4.66	5.37	4.96	0.71
JB	JSN	HSR_08	C	40.72115982	-74.0981751	4.8	5	10/29/14	12:00	57.90	3.54	4.18	3.92	0.64
JB	JSN	HSR_09	A	40.72330425	-74.0973552	5.5	5	10/29/14	12:09	93.99	5.71	7.2	6.36	1.49

Note: Water depth in feet; uncorrected

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Pixel Cal. Factor
0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Water Depth	# of Weights	Date	Time	Camera Penetration (cm)				Surface Relief (cm)
										Area	Min	Max	Mean	
JB	JSN	HSR_09	B	40.72331024	-74.0974026	5.5	5	10/29/14	12:10	128.01	8.25	9.05	8.66	0.80
JB	JSN	HSR_09	C	40.72330172	-74.0974013	5.5	5	10/29/14	12:11	92.04	5.64	6.94	6.22	1.30
JB	JSN	HSR_10	A	40.72443424	-74.0970572	5.9	5	10/29/14	12:22	213.94	14.14	15.15	14.47	1.01
JB	JSN	HSR_10	B	40.72443619	-74.0970244	5.9	5	10/29/14	12:23	212.40	13.76	14.92	14.36	1.16
JB	JSN	HSR_10	C	40.7244372	-74.0970248	5.9	5	10/29/14	12:24	206.20	13.69	14.45	13.94	0.76

Note: Water depth in feet; uncorrected

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Pixel Cal. Factor
0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Grain Size (phi)			Surface Roughness	Apparent RPD Thickness (cm)				Low DO
						Min	Max	Maj Mode		Area	Min	Max	Mean	
JB	JSN	HSR_01	A	40.7130855	-74.1057895	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	14.86	0.26	2.34	1.00	FALSE
JB	JSN	HSR_01	B	40.71309348	-74.1057859	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	42.04	0.64	5.58	2.84	FALSE
JB	JSN	HSR_01	C	40.7131067	-74.1057684	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	10.7	0.00	2.48	0.72	FALSE
JB	JSN	HSR_02	A	40.71438697	-74.1067946	> 4 phi	3 to 2 phi	4 to 3 phi	Biogenic	46.43	0.25	6.03	3.14	FALSE
JB	JSN	HSR_02	B	40.714387	-74.1068051	> 4 phi	3 to 2 phi	4 to 3 phi	Biogenic	33.5	0.43	3.33	2.27	FALSE
JB	JSN	HSR_02	C	40.71439509	-74.1067955	> 4 phi	4 to 3 phi	4 to 3 phi	Biogenic	43.25	0.46	3.14	2.92	FALSE
JB	JSN	HSR_03	D	40.71669736	-74.1035109	> 4 phi	> 4 phi	> 4 phi	Biogenic	63.21	1.92	5.67	4.27	FALSE
JB	JSN	HSR_03	E	40.7166974	-74.103521	> 4 phi	> 4 phi	> 4 phi	Biogenic	64	0	5.79	4.33	FALSE
JB	JSN	HSR_03	G	40.71669588	-74.1035271	> 4 phi	> 4 phi	> 4 phi	Biogenic	85.28	3.24	9.14	5.77	FALSE
JB	JSN	HSR_04	A	40.71760093	-74.1021118	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	28.25	0.69	2.66	1.91	FALSE
JB	JSN	HSR_04	B	40.71759159	-74.1021175	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	14.69	0.00	2.30	0.99	FALSE
JB	JSN	HSR_04	C	40.71758818	-74.1021153	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	28.2	0.00	2.97	1.91	FALSE
JB	JSN	HSR_05	A	40.7183488	-74.1007743	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	58.61	0.8	4.86	3.96	FALSE
JB	JSN	HSR_05	C	40.71836507	-74.1007554	> 4 phi	> 4 phi	> 4 phi	Biogenic	52.87	0.58	4.99	3.57	FALSE
JB	JSN	HSR_05	D	40.71832503	-74.1007977	> 4 phi	> 4 phi	> 4 phi	Biogenic	41.69	1.65	3.72	2.82	FALSE
JB	JSN	HSR_06	B	40.71968527	-74.1006314	> 4 phi	> 4 phi	> 4 phi	Biogenic	38.09	0.00	4.04	2.58	FALSE
JB	JSN	HSR_06	C	40.7196708	-74.1006315	> 4 phi	> 4 phi	> 4 phi	Biogenic	30.31	0.25	4.16	2.05	FALSE
JB	JSN	HSR_06	D	40.71970117	-74.1005218	> 4 phi	> 4 phi	> 4 phi	Biogenic	79.34	3.65	4.98	5.36	FALSE
JB	JSN	HSR_07	C	40.71959325	-74.0983344	4 to 3 phi	3 to 2 phi	4 to 3 phi	Physical	16.55	0.44	2.54	1.12	FALSE
JB	JSN	HSR_07	D	40.71955937	-74.0983807	4 to 3 phi	3 to 2 phi	4 to 3 phi	Biogenic	18.92	0.41	2.45	1.28	FALSE
JB	JSN	HSR_07	E	40.71955825	-74.0983654	4 to 3 phi	3 to 2 phi	4 to 3 phi	Biogenic	16.34	0.38	2	1.10	FALSE
JB	JSN	HSR_08	A	40.7211471	-74.0981864	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	28.31	0.44	2.73	1.91	FALSE
JB	JSN	HSR_08	B	40.72115559	-74.0981821	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	27.87	1.13	3.3	1.88	FALSE
JB	JSN	HSR_08	C	40.72115982	-74.0981751	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	20.49	0.68	1.82	1.39	FALSE
JB	JSN	HSR_09	A	40.72330425	-74.0973552	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	40.94	1.55	4.34	2.77	FALSE

NewFields Sediment Profile Image Analysis

Project: Lower Hackensack River

Pixel Cal. Factor
0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Grain Size (phi)			Surface Roughness	Apparent RPD Thickness (cm)				Low DO
						Min	Max	Maj Mode		Area	Min	Max	Mean	
JB	JSN	HSR_09	B	40.72331024	-74.0974026	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	35.04	0.36	3.53	2.37	FALSE
JB	JSN	HSR_09	C	40.72330172	-74.0974013	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	40.73	0.43	3.09	2.75	FALSE
JB	JSN	HSR_10	A	40.72443424	-74.0970572	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	71.76	1.09	5.78	4.85	FALSE
JB	JSN	HSR_10	B	40.72443619	-74.0970244	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	48.72	0.34	5	3.29	FALSE
JB	JSN	HSR_10	C	40.7244372	-74.0970248	> 4 phi	4 to 3 phi	> 4 phi	Biogenic	43.99	1.18	5.07	2.97	FALSE

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Pixel Cal. Factor
0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Mud Clasts				Methane				Benthic Habitat
						Present	Count	Avg. Diam.	Oxidation	Present	Count	Mean Depth	Diameter	
JB	JSN	HSR_01	A	40.7130855	-74.1057895	FALSE				TRUE	3	7.24	0.22	UN.SF
JB	JSN	HSR_01	B	40.71309348	-74.1057859	FALSE				FALSE				UN.SF
JB	JSN	HSR_01	C	40.7131067	-74.1057684	TRUE	2	1.04	Reduced	FALSE				UN.SF
JB	JSN	HSR_02	A	40.71438697	-74.1067946	TRUE	2	0.77	Oxidized	FALSE				SA.F
JB	JSN	HSR_02	B	40.714387	-74.1068051	FALSE				FALSE				SA.F
JB	JSN	HSR_02	C	40.71439509	-74.1067955	FALSE				FALSE				SA.F
JB	JSN	HSR_03	D	40.71669736	-74.1035109	FALSE				FALSE				UN.SF
JB	JSN	HSR_03	E	40.7166974	-74.103521	TRUE	1	1.42	Oxidized	FALSE				UN.SF
JB	JSN	HSR_03	G	40.71669588	-74.1035271	FALSE				TRUE	26	11.87	0.24	UN.SF
JB	JSN	HSR_04	A	40.71760093	-74.1021118	FALSE				FALSE				UN.SS
JB	JSN	HSR_04	B	40.71759159	-74.1021175	FALSE				FALSE				UN.SS
JB	JSN	HSR_04	C	40.71758818	-74.1021153	FALSE				FALSE				UN.SS
JB	JSN	HSR_05	A	40.7183488	-74.1007743	FALSE				FALSE				UN.SF
JB	JSN	HSR_05	C	40.71836507	-74.1007554	FALSE				FALSE				UN.SF
JB	JSN	HSR_05	D	40.71832503	-74.1007977	FALSE				FALSE				UN.SF
JB	JSN	HSR_06	B	40.71968527	-74.1006314	TRUE	1	0.74	Reduced	TRUE	14	17.45	0.50	UN.SF
JB	JSN	HSR_06	C	40.7196708	-74.1006315	TRUE	3	2.63	Reduced	TRUE	15	16.98	0.44	UN.SF
JB	JSN	HSR_06	D	40.71970117	-74.1005218	TRUE	1	1.78	Reduced	FALSE				UN.SF
JB	JSN	HSR_07	C	40.71959325	-74.0983344	FALSE				FALSE				SA.F
JB	JSN	HSR_07	D	40.71955937	-74.0983807	TRUE	2	0.68	Oxidized	FALSE				SA.F
JB	JSN	HSR_07	E	40.71955825	-74.0983654	FALSE				FALSE				SA.F
JB	JSN	HSR_08	A	40.7211471	-74.0981864	FALSE				FALSE				SA.F
JB	JSN	HSR_08	B	40.72115559	-74.0981821	TRUE	1	0.73	Oxidized	FALSE				SA.F
JB	JSN	HSR_08	C	40.72115982	-74.0981751	FALSE				FALSE				SA.F
JB	JSN	HSR_09	A	40.72330425	-74.0973552	FALSE				FALSE				SA.F

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

					Pixel Cal. Factor									
					0.571446									
Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Mud Clasts				Methane				Benthic
						Present	Count	Avg. Diam.	Oxidation	Present	Count	Mean Depth	Diameter	Habitat
JB	JSN	HSR_09	B	40.72331024	-74.0974026	FALSE				FALSE				SA.F
JB	JSN	HSR_09	C	40.72330172	-74.0974013	FALSE				FALSE				SA.F
JB	JSN	HSR_10	A	40.72443424	-74.0970572	FALSE				FALSE				UN.SF
JB	JSN	HSR_10	B	40.72443619	-74.0970244	FALSE				FALSE				UN.SF
JB	JSN	HSR_10	C	40.7244372	-74.0970248	FALSE				FALSE				UN.SF

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Pixel Cal. Factor
0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Biological Indicators	Infaunal Depth of Activity (cm)	Tubes (count)	Burrows (count)	Successional Stage	OSI
JB	JSN	HSR_01	A	40.7130855	-74.1057895	surface tubes; polychaete at depth; feeding voids at depth	15.98	3	1	Stage I on III	5
JB	JSN	HSR_01	B	40.71309348	-74.1057859	polychaete and feeding void at depth	12.82	0	0	Stage III	9
JB	JSN	HSR_01	C	40.7131067	-74.1057684	many polychaetes near-surface; burrow at depth	14.04	0	0	Stage I on III	6
JB	JSN	HSR_02	A	40.71438697	-74.1067946	surface tubes; polychaetes at depth	2.1	40	0	Stage I	6
JB	JSN	HSR_02	B	40.714387	-74.1068051	surface tubes	0	5	0	Stage I	5
JB	JSN	HSR_02	C	40.71439509	-74.1067955	surface tubes	0	1	0	Stage I	5
JB	JSN	HSR_03	D	40.71669736	-74.1035109	polychaetes at depth; feeding voids at depth	16.24	0	0	Stage III	11
JB	JSN	HSR_03	E	40.7166974	-74.103521	small feeding voids at depth	5.17	0	0	Stage III	11
JB	JSN	HSR_03	G	40.71669588	-74.1035271	surface tubes; polychaetes near-surface; void at depth	16.76	5	0	Stage I on III	9
JB	JSN	HSR_04	A	40.71760093	-74.1021118	surface tubes; polychaetes at depth; void at depth	9.44	3	0	Stage I on III	8
JB	JSN	HSR_04	B	40.71759159	-74.1021175	surface tubes; polychaete at depth	6.17	28	0	Stage I	3
JB	JSN	HSR_04	C	40.71758818	-74.1021153	surface tubes; polychaetes at depth; surface burrow?	6.96	3	1	Stage I on II	5
JB	JSN	HSR_05	A	40.7183488	-74.1007743	polychaetes near-surface	8.96	0	0	Stage III	**11**
JB	JSN	HSR_05	C	40.71836507	-74.1007554	polychaetes at depth; feeding void at depth	11.22	0	0	Stage III	10
JB	JSN	HSR_05	D	40.71832503	-74.1007977	polychaetes at depth	12.22	0	0	Stage II	7
JB	JSN	HSR_06	B	40.71968527	-74.1006314	collapsed voids at depth; polychaetes near-surface	14.58	0	0	Stage III	7
JB	JSN	HSR_06	C	40.7196708	-74.1006315	polychaete at depth	14.94	0	0	Stage III	6
JB	JSN	HSR_06	D	40.71970117	-74.1005218	surface tubes; polychaetes near-surface	12.93	3	0	Stage I on II	8
JB	JSN	HSR_07	C	40.71959325	-74.0983344	surface tubes; polychaete near-surface	2.81	2	0	Stage I	3
JB	JSN	HSR_07	D	40.71955937	-74.0983807	polychaetes near-surface	10.9	0	0	Stage II	5
JB	JSN	HSR_07	E	40.71955825	-74.0983654	polychaetes at depth	9.46	0	0	Stage II	5
JB	JSN	HSR_08	A	40.7211471	-74.0981864	polychaetes near-surface	3.29	0	0	Stage I	4
JB	JSN	HSR_08	B	40.72115559	-74.0981821	polychaetes near-surface; feeding void at depth	4.13	0	0	Stage I on III	8
JB	JSN	HSR_08	C	40.72115982	-74.0981751	polychaetes near-surface	3.69	0	0	Stage I	3
JB	JSN	HSR_09	A	40.72330425	-74.0973552	polychaetes near-surface	3.41	0	0	Stage I	5

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Pixel Cal. Factor
0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Biological Indicators	Infaunal Depth of Activity (cm)	Tubes (count)	Burrows (count)	Successional Stage	OSI
JB	JSN	HSR_09	B	40.72331024	-74.0974026	polychaetes at depth	8.73	0	0	Stage II	7
JB	JSN	HSR_09	C	40.72330172	-74.0974013	polychaetes near-surface	4.49	0	0	Stage II	7
JB	JSN	HSR_10	A	40.72443424	-74.0970572	surface tubes; polychaetes near-surface; void at depth	8.54	1	0	Stage I on III	11
JB	JSN	HSR_10	B	40.72443619	-74.0970244	surface tubes; polychaetes near-surface; void at depth	14.11	3	0	Stage I on III	10
JB	JSN	HSR_10	C	40.7244372	-74.0970248	polychaetes near-surface; void at depth	10.76	0	0	Stage I on III	9

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Pixel Cal. Factor
0.571446

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Comments
JB	JSN	HSR_01	A	40.7130855	-74.1057895	unconsolidated very soft mud throughout; light tan soft mud/silts on surface overlying layer of dark gray silts w/ fine sands grading to light gray very soft mud grading to dark gray silts/mud; polycheate tubes on surface as well as at depth; feeding voids at depth; a few small methane gas vesicles as well as trace woody debris at depth
JB	JSN	HSR_01	B	40.71309348	-74.1057859	unconsolidated very soft mud throughout; tan very soft mud/silts on surface, grading to dark gray very soft muds/silts; single polychate at depth as well as feeding void at depth; slight organic debris (wood?) intermixed in near-surface layer
JB	JSN	HSR_01	C	40.7131067	-74.1057684	unconsolidated very soft mud throughout; thin surface layer tan very soft mud/silts grading to dark gray very soft muds/silts; polychaetes near-surface; small burrow at depth; reduced mud clasts on surface likely artifact from prev. drop; slight woody debris/organics intermixed in surface layer
JB	JSN	HSR_02	A	40.71438697	-74.1067946	tan v.f.sands grading to dark gray v.f.sands/silts; trace shell frags throughout; surface tubes; polychaete at depth right; woody debris/organics intermixed into surface layer
JB	JSN	HSR_02	B	40.714387	-74.1068051	tan v.f.sands grading to gray v.f.sands/silts; trace shell fragments near surface; small surface tubes; organics/woodydebris intermixed in surface layer; possible slight rippled surface
JB	JSN	HSR_02	C	40.71439509	-74.1067955	tan v.f.sands grading to gray v.f.sands with some silt at depth; surface tubes; trace organics/woody debris throughout
JB	JSN	HSR_03	D	40.71669736	-74.1035109	unconsolidated very soft muds throughout; tan very soft mud grading to gray very soft mud; polychaetes at depth as well as feeding voids at depth; trace organics mixed throughout
JB	JSN	HSR_03	E	40.7166974	-74.103521	unconsolidated very soft muds throughout; tan very soft muds grading to gray very soft muds; small feeding voids at depth; trace organics/woody debris near-surface
JB	JSN	HSR_03	G	40.71669588	-74.1035271	unconsolidated very soft muds throughout; tan very soft muds grading to gray very soft muds; polychaetes near-surface; surface tubes; single void at depth; methane gas vesicles @ ~11cm depth; organics mixed in surface layer
JB	JSN	HSR_04	A	40.71760093	-74.1021118	tan v.f.sands grading go light and dark gray v.f.sands w/ some silt; surface tubes; polychaetes at depth; voids at depth; organics/woody debris intermixed throughout
JB	JSN	HSR_04	B	40.71759159	-74.1021175	disturbed surface possibly from prev. drop or burrow; tan v.f.sands w/ trace silts grading to dark gray v.f.sands and silts; surface tubes; polychaetes at depth; organic/woody debris in surface sediments on right
JB	JSN	HSR_04	C	40.71758818	-74.1021153	tan v.f.sands and silts grading to dark gray v.f.sads and silts; surface tubes; polychaetes near-surface; possible surface burrow left; organics/woody debris intermixed into surface layer
JB	JSN	HSR_05	A	40.7183488	-74.1007743	tan very soft muds grading to dark gray very soft mud; polychaetes near-surface; possible collapsed burrow at depth center
JB	JSN	HSR_05	C	40.71836507	-74.1007554	tan very soft muds grading to dark gray very soft muds; polychaetes at depth; feeding void at depth
JB	JSN	HSR_05	D	40.71832503	-74.1007977	unconsolidated tan very soft muds grading to dark gray very soft muds; polychaetes near-surface and at depth;
JB	JSN	HSR_06	B	40.71968527	-74.1006314	unconsolidated tan very soft mud overlying gray very soft muds; organics/woody debris intermixed in surface layer; polychaetes near-surface; collapsed voids at depth; methane gas vesicles @ ~ 17cm depth; trace shell fragments throughout
JB	JSN	HSR_06	C	40.7196708	-74.1006315	unconsolidated tan very soft muds overlying gray very soft muds; polychaete at depth within burrow; methane gas vesicles at depth; large reduced clasts on surface = artifact from wiper blade
JB	JSN	HSR_06	D	40.71970117	-74.1005218	unconsolidated tan very soft muds grading to gray very soft muds; polychaetes near-surface; reduced clast on surface + artifact from prev.drop; organics intermixed into surface layer
JB	JSN	HSR_07	C	40.71959325	-74.0983344	lower pen due to sands; tan v.f.sands overlying dark gray v.f.sands; surface tubes; organics on surface; possible ripples on surface
JB	JSN	HSR_07	D	40.71955937	-74.0983807	tan v.f.sands grading to dark gray v.f.sands; polychaetes near-surface; organics on surface
JB	JSN	HSR_07	E	40.71955825	-74.0983654	tan v.f.sands grading to dark gray v.f.sands; polychaetes at depth; organics intermixed into surface seds
JB	JSN	HSR_08	A	40.7211471	-74.0981864	consolidated, homogeneous silts throughout with some v.f. sands; shell fragments near-surface; polychaetes near-surface; possible algal coating on surface
JB	JSN	HSR_08	B	40.72115559	-74.0981821	homogeneous tan v.f.sands and silts throughout; shell fragments near-surface; polychaetes near-surface; single feeding void at depth; possible biogenic clasts on surface
JB	JSN	HSR_08	C	40.72115982	-74.0981751	consolidated, homogeneous tan v.f.sands and silts; polychaetes near-surface
JB	JSN	HSR_09	A	40.72330425	-74.0973552	homogeneous tan v.f.sands and silts; polychaetes near-surface; shell frags at depth; algal coating on surface

NewFields Sediment Profile Image Analysis
Project: Lower Hackensack River

Analyst (Initials)	QA (Initials)	Station	Replicate	Lat	Long	Comments
					Pixel Cal. Factor: 0.571446	
JB	JSN	HSR_09	B	40.72331024	-74.0974026	tan v.f.sands grading to light and dark gray v.f.sands and silts; shell frags on surface; trace organics throughout; polychaetes at depth
JB	JSN	HSR_09	C	40.72330172	-74.0974013	tan v.f.sands and silts grading to light gray v.f.sands and silts; polychaetes near-surface
JB	JSN	HSR_10	A	40.72443424	-74.0970572	tan v.f.sands and solft muds grading to gray soft muds; surface tubes; polychaetes near-surface; two voids at depth
JB	JSN	HSR_10	B	40.72443619	-74.0970244	tan v.f.sands and solft muds grading to gray soft muds; surface tubes; polychaetes near-surface; two voids at depth; possible depositional layer (gray silt) at depth
JB	JSN	HSR_10	C	40.7244372	-74.0970248	tan v.f.sands and solft muds grading to gray soft muds; polychaetes near-surface; void at depth

APPENDIX C
Benthic Survey Report

Aqua Survey, Inc.

Technical Report

Taxonomic Identification of Benthic Macroinvertebrates

Hackensack River, Hudson County, New Jersey

ENVIRON International Corporation
214 Carnegie Center
Princeton, NJ 08540

January 13, 2015

ASI Job No. 34-111

469 Point Breeze Road
Flemington, NJ 08822

Phone: 908-788-8700
Fax: 908-788-9165
mail@aquasurvey.com
www.aquasurvey.com

Table of Contents

Figures and Tables

Signature Page

Taxonomic Identification of Benthic Macroinvertebrates

Hackensack River, Hudson County, New Jersey

The report as well as all records and raw data were audited and found to be an accurate reflection of the study. Copies of the raw data will be maintained by Aqua Survey, Inc., 469 Point Breeze Road, Flemington, New Jersey, 08822.

1/13/15

Robert M. Fristrom
Quality Assurance Officer

Date

1/13/15

Michelle Thomas
Laboratory Manager

Date

1-13-15

Jon Doi, Ph.D.
Executive Vice President

Date

Technical Report

Taxonomic Identification of Benthic Macroinvertebrates

Hackensack River, Hudson County, New Jersey

Study Initiation Date

October 24, 2014

Study Completion Date

January 13, 2015

Performing Laboratory

Aqua Survey, Inc.
469 Point Breeze Road
Flemington, New Jersey 08822

Sponsor

ENVIRON International Corporation
214 Carnegie Center
Princeton, NJ 08540

Laboratory Project ID

ASI Job No. 34-111

I. INTRODUCTION

The objective of this task was to isolate and identify to the family level the organisms in samples of benthic substrate from the Hackensack River, Hudson County, New Jersey.

II. TEST ADMINISTRATION

A. Sponsor

ENVIRON International Corporation
214 Carnegie Center
Princeton, NJ 08540

B. Testing Facilities

Aqua Survey, Inc.
469 Point Breeze Road
Flemington, New Jersey 08822

Normadeau Associates, Inc.
Suite 101, Building A
400 Old Reading Pike
Stowe, PA 19464

C. Dates of Study

Date of Study Initiation: October 24, 2014
Date of Study Completion: January 13, 2015

D. Study Participants

Jon Doi, Ph.D.	Executive Vice-President
Tom Dolce	Field Operations Manager
Robert Fristrom	Quality Assurance Officer
Liz Horn	Scientist
Jim Karwacki	Field Operations
Matt Shappell	Field Operations
Kevin Sondag	Field Operations
Michelle Thomas	Laboratory Manager
Jeff Thomas	Scientist

III. MATERIALS AND METHODS

A. Sampling

Twenty-three (23) grab samples were collected by ASI personnel on October 24, 2014 from the Hackensack River, Hudson County, New Jersey. All samples were received at ASI in Flemington, New Jersey under chain of custody. Upon arrival at ASI, the samples were logged in and assigned unique sample numbers. Sample positioning was performed using a Trimble SPS 855 Differential Global Positioning System. The (DGPS) coordinates and identification numbers are listed in Table 1. Site maps are presented in Figures 1 and 2.

Table 1 DGPS Coordinates and Sample Identification

Sample	Northings	Eastings	ASI ID #
1A	686765.4	602479.0	20140784
2A	686420.1	602200.2	20140788
3A	685255.6	600995.9	20140786
6A	687156.5	603426.7	20140792
7A	684620.3	600817.8	20140787
7C	684761.8	601176.3	20140796
9A	687547.9	602781.1	20140789
11A	687948.1	603083.1	20140782
11C	688210.6	603407.4	20140780
11D	688103.5	603598.3	20140793
13A	686831.9	602966.5	20140790
13B	687090.4	603047.9	20140791
15A	685747.0	601523.3	20140785
17C	688373.9	603053.5	20140781
18B	686876.1	602502.7	20140783
26A	688732.4	603856.1	20140795
27A	689049.6	603631.3	20140777
29A	688425.7	603346.9	20140779
29C	688910.9	603370.2	20140778
30A	688432.3	603598.3	20140794
RF 1	693370.8	605235.5	20140776
RF 2	688702.1	597405.4	20140774
RF 3	681303.5	597405.3	20140775

B. Sample Preparation

Upon receipt at the laboratory, the benthic sediment samples were stored prior to sorting. Once sorting commenced, the samples were rinsed with tap water and sieved through a 500-μm sieve to remove the formalin and debris prior to picking. Benthic samples were completely picked to remove all invertebrates from the substrate and the organisms were stored in individual containers with 70% methanol. Since the entire sample could not be subsampled effectively due to volume variation, the organisms were subsampled for identification purposes. The goal was to use a 200 count method (from EPA's Rapid Bioassessment Protocols for Use in Streams and Rivers; Benthic Microinvertebrates). These subsampled organisms were placed into another vial (labeled as above, plus the descriptor "ID'd"). If less than 200 organisms were found the whole sample was keyed.

All organisms were stored in separately labeled vials filled with clean 70% ethanol. The samples will be archived at Aqua Survey, Inc. for a minimum of five years, after which the samples will be returned to the client or properly disposed.

C. Taxonomic Identification

The total and estimated number of organisms present and the number of taxa are presented in the summary tables. Density of each taxon was calculated by dividing the number of organisms by the approximate volume of sediment. Calculations for percent abundance was done for each organism in each sample.

Organisms were sorted by taxon and keyed to the family level or lower using one or more of the following keys:

Abbott, R.T. 1974. American Seashells, The Marine Mollusca of the Atlantic and Pacificc Coasts of North America. Van Norstrand Reinhold Co. New York, NY. 663 pp.

Bousfield, E.L. 1973. Shallow-water Gammaridean Amphpoda of New England. Cornell University Press. Ithaca, NY. 312 pp.

Burch, J. B., 1972. Freshwater Sphaeriacean clams (Mollusca: Pelecypoda) of North America. U. S. Environmental Protection Agency Biota of Freshwater Ecosystems Identification Manual No. 3. 31 pp.

Fauchald, K. 1977. The Polychaete Worms, Definitions and Keys to the Orders, Families, and Genera. Natural History Museum of Los Angeles County, Science Series 28:1-190.

Gosner, K.L. 1971. Guide to identification of marine and estuarine invertebrates: Cape Hatteras to the Bay of Fundy. John Wiley & Sons, Inc. 693 p

Kathman, R.D., and R.O. Brinkhurst. 1998. Guide to the freshwater oligochaetes of North America. Aquatic Resources Center, College Grove, TN. 264 pp.

Merritt, R. W., K. W. Cummins, and M. B. Berg (eds). 2008. An Introduction to the Aquatic Insects of North America (4th ed.). Kendall/Hunt Publ. Co., Dubuque, IA 1158 pp.

NOAA Technical Report. New Polychaeta from Beaufort, with a key to all species recorded from North Carolina. NMFS CIRC. 375: 1-140.

Pettibone, M.H. 1963. Marine Polychaete Worms of the New England Region, Aphroditidae through Trochochaetidae. U.S. Nat. Mus., Bull. 227:1-356.

Rogers, D. C. and M. Hill, 2008. Key to the Freshwater Malacostraca (Crustacea) of the Mid-Atlantic Region. EPA-230-R-08-017. US Environmental Protection Agency, Office of Environmental Information, Environmental Analysis Division, Washington, DC.

Williams, A.B. 1984. Shrimps, Lobsters, and Crabs of the Atlantic Coast of the Eastern United States, Maine to Florida. Smithsonian Institution Press. Washington D.C. 550 pp.

IV. RESULTS

Results of the benthic taxonomic enumeration for the 23 samples are summarized in Tables 2a through 2w.

Figure 1

Environ

Lower Hackensack River

Sample Location Map 1

ASI Project: 34-111

Coordinate System:

State Plane NAD 83
New Jersey US Survey Foot

N
W E
S

0 100200 400 600 800
Feet

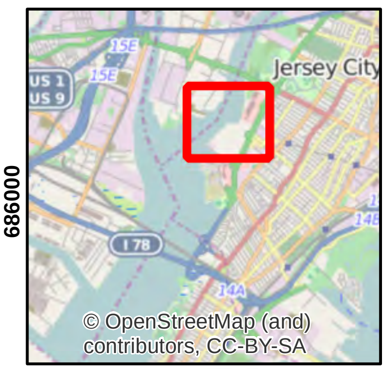

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Figure 2

Environ

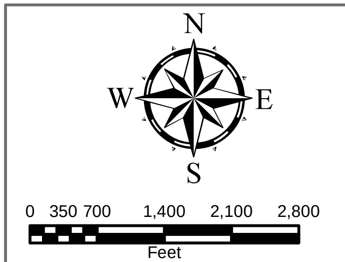
Lower Hackensack River

Reference Location Map

ASI Project: 34-111

Coordinate System:

State Plane NAD 83
New Jersey US Survey Foot



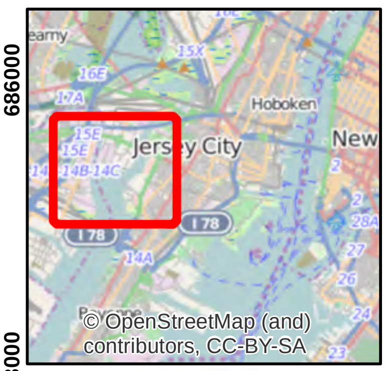


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Table 2a

Sample Location:	**Station 1A**			
Collection Date:	October 24, 2014			
Sample Gear:	Petite Ponar / Dredge (approximate area = 0.023 sq. m.)			

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Paleonemertea				
Carinomidae				
Carinoma tremaphoros	ribbon worm	1	43	0.9%
Tubificida				
immature tubificid w/o hair chaetae	tube worm	3	130	2.7%
Capitellida				
Capitellidae				
Heteromastus filiformis	thread worm	1	43	0.9%
Mediomastus ambiseta	thread worm	1	43	0.9%
Nereidae				
Alitta succinea	clam worm	1	43	0.9%
Laeonereis culveri	clam worm	1	43	0.9%
Phyllodocidae				
Eteone sp.	paddle worm	2	87	1.8%
Hypereteone heteropoda	paddle worm	3	130	2.7%
Spionida				
Spionidae				
Polydora cornuta	mud worm	2	87	1.8%
Streblospio benedicti	mud worm	33	1,435	30.0%
Sabellida				
Sabellariidae				
Sabellaria vulgaris	fan worm	2	87	1.8%
Sabellidae				
Potamilla neglecta	fan worm	1	43	0.9%
Terebellida				
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	37	1,609	33.6%
Pectinaridae				
Pectinaria gouldii	trumpet worm	2	87	1.8%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	3	130	2.7%
Amphipoda				
Ampeliscidae				
Ampelisca abdita	side swimmer	4	174	3.6%
Aoridae				
Grandidierella japonica	side swimmer	3	130	2.7%
Copepoda				
Notodelphyidae	fish louse	1	43	0.9%
Cumacea				
Leuconidae				
Leucon americanus	hooded shrimp	7	304	6.4%
Thoracica				
Balanidae				
Balanus improvisus	acorn barnacle	1	43	0.9%
Ascidiacea				
Molgulidae				
Molgula manhattensis	sea squirt	1	43	0.9%
Total Taxa		**21**		**100.0%**
Total Specimens		**110**		
Community Density			**4,783**	

Table 2b

Sample Location: **Station 2A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Hoplonemertea				
Amphiporidae				
Amphiporus bioculatus	ribbon worm	1	43	1.6%
Tubificida				
immature tubificid w/o hair chaetae	tube worm	2	87	3.3%
Capitellida				
Capitellidae				
Heteromastus filiformis	thread worm	3	130	4.9%
Mediomastus ambiseta	thread worm	1	43	1.6%
Phyllodocida				
Glyceridae				
Glycera americana	blood worm	2	87	3.3%
Phyllodocidae				
Eteone sp.	paddle worm	1	43	1.6%
Hypereteone heteropoda	paddle worm	4	174	6.6%
Spionida				
Spionidae				
Streblospio benedicti	mud worm	19	826	31.1%
Sabellida				
Sabellariidae				
Sabellaria vulgaris	fan worm	1	43	1.6%
Terebellida				
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	17	739	27.9%
Venerioda				
Tellinidae				
Macoma balthica	macoma clam	4	174	6.6%
Amphipoda				
Ampeliscidae				
Ampelisca abdita	side swimmer	1	43	1.6%
Aoridae				
Grandidierella japonica	side swimmer	2	87	3.3%
Cumacea				
Leuconidae				
Leucon americanus	hooded shrimp	2	87	3.3%
Isopoda				
Anthuridae				
Cyathura polita	slender isopod	1	43	1.6%
Total Taxa		**15**		**100.0%**
Total Specimens		**61**		
Community Density			**2,652**	

Table 2c

Sample Location:	**Station 3A**
Collection Date:	October 24, 2014
Sample Gear:	Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub-sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Actiniaria					
Diadumenidae					
Diadumene leucolena	sea anemone	1	2	95	0.6%
Capitellida					
Capitellidae					
Mediomastus ambiseta	thread worm	4	9	379	2.5%
Phyllodocida					
Glyceridae					
Glycera americana	blood worm	3	7	284	1.8%
Nereidae					
Alitta succinea	clam worm	1	2	95	0.6%
Spionida					
Spionidae					
Polydora cornuta	mud worm	3	7	284	1.8%
Streblospio benedicti	mud worm	10	22	947	6.1%
Sabellida					
Sabellariidae					
Sabellaria vulgaris	fan worm	25	54	2,367	15.3%
Sabellidae					
Potamilla neglecta	fan worm	2	4	189	1.2%
Terebellida					
Ampharetidae					
Hobsonia florida	ampharetid worm	1	2	95	0.6%
Cirratulidae	fringed worm	1	2	95	0.6%
Orbiniidae					
Leitoscoloplos robustus	orbiniid worm	7	15	663	4.3%
Pectinaridae					
Pectinaria gouldii	trumpet worm	2	4	189	1.2%
Anomalodesmonata					
Lyonsiidae					
Lyonsia arenosa	bladder clam	5	11	473	3.1%
Venerioda					
Mactridae					
Mulinia lateralis	surf clam	6	13	568	3.7%
Tellinidae					
Macoma balthica	macoma clam	1	2	95	0.6%
Myoida					
Myidae					
Mya arenaria	soft-shell clam	55	120	5,208	33.7%
Cephalaspidea					
Acteonidae					
Japonactaeon punotostriatus	bubble snail	4	9	379	2.5%
Pyramidellacea					
Pyramidellidae					
Boonea bisuturalis	two-groove snail	1	2	95	0.6%
Amphipoda					
Ampeliscidae					
Ampelisca abdita	side swimmer	6	13	568	3.7%

Table 2c (continued)

Sample Location: **Station 3A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub- sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Amphipoda (continued)					
Aoridae					
Grandidierella japonica	side swimmer	5	11	473	3.1%
Unciola serrata	side swimmer	3	7	284	1.8%
Corophiidae					
Monocorophium acherusicum	tube maker	3	7	284	1.8%
Cumacea					
Leuconidae					
Leucon americanus	hooded shrimp	1	2	95	0.6%
Isopoda					
Idoteidae					
Edotea triloba	sea pill bug	1	2	95	0.6%
Ostracoda					
Sarsiellidae	seed shrimp	4	9	379	2.5%
Thoracica					
Balanidae					
Balanus improvisus	acorn barnacle	1	2	95	0.6%
Ascidiacea					
Molgulidae					
Molgula manhattensis	sea squirt	7	15	663	4.3%
Total Taxa		27	**27**		**100.0%**
Total Specimens		163	**355**		
Community Density				**15,435**	

Table 2d

Sample Location: **Station 6A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sub-sample Count**	**Estimated Total**	**Density (no./sq.m.)**	**Percent Abundance**
Hoplonemertea					
Amphiporidae					
Amphiporus ochraceus	ribbon worm	1	3	136	0.5%
Tubificida					
immature tubificid w/o hair chaetae	tube worm	25	78	3,390	12.9%
Capitellida					
Capitellidae					
Capitella capitata	thread worm	2	6	271	1.0%
Phyllodocida					
Nereidae					
Alitta succinea	clam worm	4	12	542	2.1%
Phyllodocidae					
Hypereteone heteropoda	paddle worm	1	3	136	0.5%
Spionida					
Spionidae					
Polydora cornuta	mud worm	21	65	2,847	10.8%
Streblospio benedicti	mud worm	36	112	4,881	18.6%
Terebellida					
Ampharetidae					
Hobsonia florida	ampharetid worm	17	53	2,305	8.8%
Venerioda					
Tellinidae					
Macoma balthica	macoma clam	2	6	271	1.0%
Cephalaspidea					
Haninacidae					
Haminoea solitaria	bubble snail	1	3	136	0.5%
Amphipoda					
Ampithoidae					
Ampithoe valida	side swimmer	5	16	678	2.6%
Aoridae					
Grandidierella japonica	side swimmer	31	97	4,203	16.0%
Isopoda					
Anthuridae					
Cyathura polita	slender isopod	1	3	136	0.5%
Sphaeromidae					
Sphaeroma quadridentatum	sea pill bug	30	94	4,068	15.5%
Tanaidacea					
Tanaidae					
Tanais dulongii	tanaid shrinp	17	53	2,305	8.8%
Total Taxa			**15**		**100.0%**
Total Specimens		194	**605**		
Community Density				**26,304**	

Table 2e

Sample Location: **Station 7A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Hydrozoa				
Sertulariidae				
Sertularia sp.	hydra	-	"colonial"	-
Actiniaria				
Metridiidae				
Metridium senile	sea anemone	14	609	7.8%
Hoplonemertea				
Amphiporidae				
Amphiporus bioculatus	ribbon worm	2	87	1.1%
Tubificida				
immature tubificid w/o hair chaetae	tube worm	1	43	0.6%
Capitellida				
Capitellidae				
Mediomastus ambiseta	thread worm	2	87	1.1%
Phyllodocida				
Glyceridae				
Glycera americana	blood worm	1	43	0.6%
Nereidae				
Alitta succinea	clam worm	24	1,043	13.3%
Phyllodocidae				
Paranaitis speciosa	paddle worm	1	43	0.6%
Spionida				
Spionidae				
Polydora cornuta	mud worm	6	261	3.3%
Streblospio benedicti	mud worm	2	87	1.1%
Sabellida				
Sabellariidae				
Sabellaria vulgaris	fan worm	30	1,304	16.7%
Sabellidae				
Potamilla neglecta	fan worm	34	1,478	18.9%
Terebellida				
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	2	87	1.1%
Pectinaridae				
Pectinaria gouldii	trumpet worm	1	43	0.6%
Anomalodesmonata				
Lyonsiidae				
Lyonsia arenosa	bladder clam	1	43	0.6%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	4	174	2.2%
Littorinimorpha				
Calyptraeidae				
Crepidula plana	slipper snail	10	435	5.6%
Nudibranchia				
Flabellinidae				
Flabellina sp.	nudibranch snail	3	130	1.7%

Table 2e continued

Sample Location:	**Station 7A**
Collection Date:	October 24, 2014
Sample Gear:	Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Amphipoda				
Aoridae				
Grandidierella japonica	side swimmer	6	261	3.3%
Corophiidae				
Monocorophium acherusicum	tube maker	6	261	3.3%
Melitidae				
Melita nitida	side swimmer	12	522	6.7%
Caprellida				
Caprellidae				
Paracaprella tenuis	skeleton shrimp	1	43	0.6%
Xanthidae				
Rithropanopeus harrisii	mud crab	2	87	1.1%
Isopoda				
Idoteidae				
Edotea triloba	sea pill bug	2	87	1.1%
Rhizocephala				
Sacculinidae				
Loxothylacus panopaei	crab barnacle	2	87	1.1%
Thoracica				
Balanidae				
Balanus improvisus	acorn barnacle	2	87	1.1%
Ascidiacea				
Molgulidae				
Molgula manhattensis	sea squirt	9	391	5.0%
Total Taxa		**27**		**100.0%**
Total Specimens		**180**		
Community Density			**7,826**	

Table 2f

Sample Location: **Station 7C**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sub-sample Count**	**Estimated Total**	**Density (no./sq.m.)**	**Percent Abundance**
Tubificida					
immature tubificid w/o hair chaetae	tube worm	33	139	6,049	18.8%
Capitellida					
Capitellidae					
Heteromastus filiformis	thread worm	1	4	183	0.6%
Phyllodocida					
Nereidae					
Alitta succinea	clam worm	5	21	917	2.8%
Phyllodocidae					
Eteone sp.	paddle worm	5	21	917	2.8%
Hypereteone heteropoda	paddle worm	8	34	1,466	4.5%
Spionida					
Spionidae					
Polydora cornuta	mud worm	9	38	1,650	5.1%
Streblospio benedicti	mud worm	64	270	11,731	36.4%
Venerioda					
Tellinidae					
Macoma balthica	macoma clam	2	8	367	1.1%
Amphipoda					
Ampeliscidae					
Ampelisca abdita	side swimmer	2	8	367	1.1%
Aoridae					
Grandidierella japonica	side swimmer	37	156	6,782	21.0%
Photidae					
Leptocheirus plumulosus	side swimmer	7	30	1,283	4.0%
Cumacea					
Leuconidae					
Leucon americanus	hooded shrimp	1	4	183	0.6%
Thoracica					
Balanidae					
Balanus improvisus	acorn barnacle	1	4	183	0.6%
Ascidiacea					
Molgulidae					
Molgula manhattensis	sea squirt	1	4	183	0.6%
Total Taxa			**14**		**100.0%**
Total Specimens		176	**742**		
Community Density				**32,261**	

Table 2g

Sample Location: **Station 9A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub-sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Tubificida					
immature tubificid w/o hair chaetae	tube worm	3	9	380	1.6%
Capitellida					
Capitellidae					
Mediomastus ambiseta	thread worm	15	44	1,900	8.2%
Phyllodocida					
Glyceridae					
Glycera americana	blood worm	3	9	380	1.6%
Goniadidae	blood worm	1	3	127	0.5%
Spionida					
Spionidae					
Polydora cornuta	mud worm	2	6	253	1.1%
Streblospio benedicti	mud worm	26	76	3,293	14.1%
Sabellida					
Sabellariidae					
Sabellaria vulgaris	fan worm	1	3	127	0.5%
Terebellida					
Orbiniidae					
Leitoscoloplos robustus	orbiniid worm	7	20	887	3.8%
Pectinaridae					
Pectinaria gouldii	trumpet worm	2	6	253	1.1%
Anomalodesmonata					
Lyonsiidae					
Lyonsia arenosa	bladder clam	1	3	127	0.5%
Venerioda					
Mactridae					
Mulinia lateralis	surf clam	14	41	1,773	7.6%
Myoida					
Myidae					
Mya arenaria	soft-shell clam	97	283	12,285	52.7%
Cephalaspidea					
Acteonidae					
Japonactaeon punotostriatus	bubble snail	3	9	380	1.6%
Pyramidellacea					
Pyramidellidae					
Boonea bisuturalis	two-groove snail	2	6	253	1.1%
Amphipoda					
Ampeliscidae					
Ampelisca abdita	side swimmer	5	15	633	2.7%
Copepoda					
Notodelphyidae	fish louse	1	3	127	0.5%
Ascidiacea					
Molgulidae					
Molgula manhattensis	sea squirt	1	3	127	0.5%
Total Taxa			**17**		**100.0%**
Total Specimens		184	**536**		
Community Density				**23,304**	

Table 2h

Sample Location: **Station 11A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub-sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Capitellida					
Capitellidae					
Mediomastus ambiseta	thread worm	1	9	391	0.6%
Phyllodocida					
Glyceridae					
Glycera americana	blood worm	4	36	1,562	2.3%
Goniadidae	blood worm	1	9	391	0.6%
Nereidae					
Alitta succinea	clam worm	3	27	1,172	1.7%
Spionida					
Spionidae					
Polydora cornuta	mud worm	2	18	781	1.2%
Streblospio benedicti	mud worm	13	117	5,077	7.6%
Sabellida					
Sabellariidae					
Sabellaria vulgaris	fan worm	18	162	7,030	10.5%
Sabellidae					
Potamilla neglecta	fan worm	8	72	3,124	4.7%
Terebellida					
Orbiniidae					
Leitoscoloplos robustus	orbiniid worm	5	45	1,953	2.9%
Pectinaridae					
Pectinaria gouldii	trumpet worm	1	9	391	0.6%
Venerioda					
Mactridae					
Mulinia lateralis	surf clam	14	126	5,468	8.1%
Myoida					
Myidae					
Mya arenaria	soft-shell clam	80	719	31,244	46.5%
Caenogastropoda					
Epitoniidae					
Epitonium sp.	wentletrap snail	1	9	391	0.6%
Cephalaspidea					
Acteonidae					
Japonactaeon punotostriatus	bubble snail	1	9	391	0.6%
Pyramidellacea					
Pyramidellidae					
Boonea bisuturalis	two-groove snail	1	9	391	0.6%
Amphipoda					
Ampeliscidae					
Ampelisca abdita	side swimmer	5	45	1,953	2.9%
Aoridae					
Grandidierella japonica	side swimmer	3	27	1,172	1.7%
Unciola serrata	side swimmer	1	9	391	0.6%
Corophiidae					
Monocorophium acherusicum	tube maker	2	18	781	1.2%
Melitidae					
Melita nitida	side swimmer	1	9	391	0.6%

Table 2h continued

Sample Location: **Station 11A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub- sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Cumacea					
Leuconidae					
Leucon americanus	hooded shrimp	1	9	391	0.6%
Decapoda					
Xanthidae					
Rithropanopeus harrisii	mud crab	1	9	391	0.6%
Isopoda					
Idoteidae					
Synidotea laevidorsalis	sea pill bug	4	36	1,562	2.3%
Ascidiacea					
Molgulidae					
Molgula manhattensis	sea squirt	1	9	391	0.6%
Total Taxa			**24**		**100.0%**
Total Specimens		172	**1,545**		
Community Density				**67,174**	

Table 2i

Sample Location: **Station 11C**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub-sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Hoplonemertea					
Amphiporidae					
Amphiporus bioculatus	ribbon worm	1	4	192	0.7%
Tubificida					
immature tubificid w/o hair chaetae	tube worm	3	13	576	2.0%
Capitellida					
Capitellidae					
Heteromastus filiformis	thread worm	1	4	192	0.7%
Mediomastus ambiseta	thread worm	1	4	192	0.7%
Phyllodocida					
Glyceridae					
Glycera americana	blood worm	2	9	384	1.3%
Nereidae					
Alitta succinea	clam worm	5	22	960	3.4%
Laeonereis culveri	clam worm	3	13	576	2.0%
Phyllodocidae					
Eteone sp.	paddle worm	4	18	768	2.7%
Hypereteone heteropoda	paddle worm	3	13	576	2.0%
Spionida					
Spionidae					
Polydora cornuta	mud worm	2	9	384	1.3%
Streblospio benedicti	mud worm	80	353	15,360	53.7%
Terebellida					
Orbiniidae					
Leitoscoloplos robustus	orbiniid worm	20	88	3,840	13.4%
Pectinaridae					
Pectinaria gouldii	trumpet worm	2	9	384	1.3%
Venerioda					
Mactridae					
Mulinia lateralis	surf clam	1	4	192	0.7%
Tellinidae					
Macoma balthica	macoma clam	2	9	384	1.3%
Myoida					
Myidae					
Mya arenaria	soft-shell clam	3	13	576	2.0%
Littorinimorpha					
Calyptraeidae					
Crepidula plana	slipper snail	1	4	192	0.7%
Pyramidellacea					
Pyramidellidae					
Boonea bisuturalis	two-groove snail	2	9	384	1.3%
Amphipoda					
Ampeliscidae					
Ampelisca abdita	side swimmer	2	9	384	1.3%
Aoridae					
Grandidierella japonica	side swimmer	2	9	384	1.3%
Cumacea					
Leuconidae					
Leucon americanus	hooded shrimp	4	18	768	2.7%
Decapoda					
Crangonidae					
Crangon septemspinosa	sand shrimp	1	4	192	0.7%
Thoracica					
Balanidae					
Balanus improvisus	acorn barnacle	4	18	768	2.7%
Total Taxa			**23**		**100.0%**
Total Specimens		149	**658**		
Community Density				**28,609**	

Table 2j

Sample Location: **Station 11D**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Hoplonemertea				
Amphiporidae				
Amphiporus ochraceus	ribbon worm	1	43	0.8%
Tubificida				
immature tubificid w/o hair chaetae	tube worm	4	174	3.4%
Enchytraeidae	earth worm	1	43	0.8%
Capitellida				
Capitellidae				
Capitella capitata	thread worm	1	43	0.8%
Phyllodocida				
Nereidae				
Alitta succinea	clam worm	4	174	3.4%
Phyllodocidae				
Hypereteone heteropoda	paddle worm	4	174	3.4%
Syllidae				
Aulolytus sp.	syllid worm	1	43	0.8%
Spionida				
Spionidae				
Polydora cornuta	mud worm	45	1,957	37.8%
Streblospio benedicti	mud worm	10	435	8.4%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	4	174	3.4%
Mytiloida				
Mytilidae				
Geukensia demissa	ribbed mussel	1	43	0.8%
Cephalaspidea				
Haninacidae				
Haminoea solitaria	bubble snail	1	43	0.8%
Amphipoda				
Ampithoidae				
Ampithoe valida	side swimmer	1	43	0.8%
Aoridae				
Grandidierella japonica	side swimmer	31	1,348	26.1%
Copepoda				
Notodelphyidae	fish louse	1	43	0.8%
Cumacea				
Leuconidae				
Leucon americanus	hooded shrimp	1	43	0.8%
Decapoda				
Palaemonidae				
Palaemonetes vulgaris	shore prawn	1	43	0.8%
Idoteidae				
Edotea triloba	sea pill bug	1	43	0.8%
Thoracica				
Balanidae				
Balanus improvisus	acorn barnacle	1	43	0.8%
Tanaidacea				
Tanaidae				
Tanais dulongii	tanaid shrinp	1	43	0.8%

Table 2j continued

Sample Location: **Station 11D**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Ascidiacea				
Molgulidae				
Molgula manhattensis	sea squirt	2	87	1.7%
unknown Diptera	two-winged fly	1	43	0.8%
Hemiptera				
Gerridae	water strider	1	43	0.8%
Total Taxa		**23**		**100.0%**
Total Specimens		**119**		
Community Density			**5,174**	

Table 2k

Sample Location:	**Station 13A**
Collection Date:	October 24, 2014
Sample Gear:	Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Tubificida				
immature tubificid w/o hair chaetae	tube worm	12	522	21.4%
Spionida				
Spionidae				
Polydora cornuta	mud worm	5	217	8.9%
Streblospio benedicti	mud worm	3	130	5.4%
Terebellida				
Ampharetidae				
Hobsonia florida	ampharetid worm	3	130	5.4%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	2	87	3.6%
Mytiloida				
Mytilidae				
Geukensia demissa	ribbed mussel	1	43	1.8%
Amphipoda				
Aoridae				
Grandidierella japonica	side swimmer	11	478	19.6%
Isopoda				
Sphaeromidae				
Sphaeroma quadridentatum	sea pill bug	9	391	16.1%
Tanaidacea				
Tanaidae				
Tanais dulongii	tanaid shrinp	6	261	10.7%
Ascidiacea				
Molgulidae				
Molgula manhattensis	sea squirt	4	174	7.1%
Total Taxa		**10**		**100.0%**
Total Specimens		**56**		
Community Density			**2,435**	

Table 2l

Sample Location: **Station 13B**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Entoprocta				
Pedicellinidae				
Barentsia gracilis	moss animalcule	-	"colonial"	-
Hoplonemertea				
Amphiporidae				
Amphiporus ochraceus	ribbon worm	6	261	3.6%
Tubificida				
immature tubificid w/o hair chaetae	tube worm	23	1,000	13.6%
Phyllodocida				
Nereidae				
Alitta succinea	clam worm	1	43	0.6%
Phyllodocidae				
Hypereteone heteropoda	paddle worm	3	130	1.8%
Spionida				
Spionidae				
Polydora cornuta	mud worm	87	3,783	51.5%
Streblospio benedicti	mud worm	4	174	2.4%
Sabellida				
Sabellidae				
Potamilla neglecta	fan worm	8	348	4.7%
Terebellida				
Ampharetidae				
Hobsonia florida	ampharetid worm	3	130	1.8%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	1	43	0.6%
Mytiloida				
Mytilidae				
Geukensia demissa	ribbed mussel	1	43	0.6%
Nudibranchia				
Flabellinidae				
Flabellina sp.	nudibranch snail	1	43	0.6%
Amphipoda				
Ampithoidae				
Ampithoe valida	side swimmer	1	43	0.6%
Aoridae				
Grandidierella japonica	side swimmer	9	391	5.3%
Copepoda				
Notodelphyidae	fish louse	2	87	1.2%
Decapoda				
Crangonidae				
Crangon septemspinosa	sand shrimp	1	43	0.6%
Isopoda				
Sphaeromidae				
Sphaeroma quadridentatum	sea pill bug	1	43	0.6%
Tanaidacea				
Tanaidae				
Tanais dulongii	tanaid shrinp	1	43	0.6%
Ascidiacea				
Molgulidae				
Molgula manhattensis	sea squirt	16	696	9.5%
Total Taxa		**19**		**100.0%**
Total Specimens		**169**		
Community Density			**7,348**	

Table 2m

Sample Location: **Station 15A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Actiniaria				
Metridiidae				
Metridium senile	sea anemone	1	43	1.0%
Hoplonemertea				
Amphiporidae				
Amphiporus bioculatus	ribbon worm	2	87	2.0%
Tubificida				
immature tubificid w/o hair chaetae	tube worm	1	43	1.0%
Capitellida				
Capitellidae				
Heteromastus filiformis	thread worm	2	87	2.0%
Mediomastus ambiseta	thread worm	1	43	1.0%
Phyllodocida				
Glyceridae				
Glycera americana	blood worm	1	43	1.0%
Nereidae				
Alitta succinea	clam worm	9	391	9.1%
Phyllodocidae				
Hypereteone heteropoda	paddle worm	1	43	1.0%
Paranaitis speciosa	paddle worm	1	43	1.0%
Polynoidae				
Lepidonotus sublevis	scale worm	1	43	1.0%
Spionida				
Spionidae				
Polydora cornuta	mud worm	3	130	3.0%
Streblospio benedicti	mud worm	2	87	2.0%
Sabellida				
Sabellariidae				
Sabellaria vulgaris	fan worm	2	87	2.0%
Sabellidae				
Potamilla neglecta	fan worm	6	261	6.1%
Terebellida				
Ampharetidae				
Hobsonia florida	ampharetid worm	1	43	1.0%
Cirratulidae	fringed worm	1	43	1.0%
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	11	478	11.1%
Pectinaridae				
Pectinaria gouldii	trumpet worm	1	43	1.0%
Caenogastropoda				
Epitoniidae				
Epitonium sp.	wentletrap snail	1	43	1.0%
Littorinimorpha				
Calyptraeidae				
Crepidula plana	slipper snail	8	348	8.1%
Amphipoda				
Aoridae				
Grandidierella japonica	side swimmer	9	391	9.1%
Corophiidae				
Monocorophium acherusicum	tube maker	1	43	1.0%
Gammaridae				
Gammarus daiberi	side swimmer	2	87	2.0%
Melitide				
Melita nitida	side swimmer	2	87	2.0%

Table 2m continued

Sample Location: **Station 15A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Caprellida				
Caprellidae				
Paracaprella tenuis	skeleton shrimp	3	130	3.0%
Decapoda				
Palaemonidae				
Palaemonetes vulgaris	shore prawn	1	43	1.0%
Xanthidae				
Rithropanopeus harrisii	mud crab	1	43	1.0%
Isopoda				
Idoteidae				
Edotea triloba	sea pill bug	2	87	2.0%
Synidotea laevidorsalis	sea pill bug	2	87	2.0%
Ostracoda				
Sarsiellidae	seed shrimp	1	43	1.0%
Thoracica				
Balanidae				
Balanus improvisus	acorn barnacle	12	522	12.1%
Ascidiacea				
Molgulidae				
Molgula manhattensis	sea squirt	7	304	7.1%
Total Taxa		**32**		**100.0%**
Total Specimens		**99**		
Community Density			**4,304**	

Table 2n

Sample Location: **Station 17C**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub-sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Tubificida					
immature tubificid w/o hair chaetae	tube worm	2	5	208	1.1%
Capitellida					
Capitellidae					
Heteromastus filiformis	thread worm	1	2	104	0.5%
Mediomastus ambiseta	thread worm	3	7	312	1.6%
Phyllodocida					
Glyceridae					
Glycera americana	blood worm	5	12	520	2.7%
Nereidae					
Alitta succinea	clam worm	10	24	1,039	5.3%
Laeonereis culveri	clam worm	3	7	312	1.6%
Phyllodocidae					
Hypereteone heteropoda	paddle worm	2	5	208	1.1%
Spionida					
Spionidae					
Streblospio benedicti	mud worm	22	53	2,286	11.8%
Sabellida					
Sabellariidae					
Sabellaria vulgaris	fan worm	56	134	5,820	29.9%
Sabellidae					
Potamilla neglecta	fan worm	3	7	312	1.6%
Terebellida					
Orbiniidae					
Leitoscoloplos robustus	orbiniid worm	12	29	1,247	6.4%
Pectinaridae					
Pectinaria gouldii	trumpet worm	1	2	104	0.5%
Myoida					
Myidae					
Mya arenaria	soft-shell clam	1	2	104	0.5%
Mytiloida					
Mytilidae					
Mytilus edulis	blue mussel	1	2	104	0.5%
Amphipoda					
Ampeliscidae					
Ampelisca abdita	side swimmer	1	2	104	0.5%
Aoridae					
Grandidierella japonica	side swimmer	1	2	104	0.5%
Gammaridae					
Gammarus daiberi	side swimmer	1	2	104	0.5%
Melitidae					
Melita nitida	side swimmer	1	2	104	0.5%
Copepoda					
Notodelphyidae	fish louse	21	50	2,183	11.2%
Cumacea					
Leuconidae					
Leucon americanus	hooded shrimp	1	2	104	0.5%
Thoracica					
Balanidae					
Balanus improvisus	acorn barnacle	3	7	312	1.6%
Ascidiacea					
Molgulidae					
Molgula manhattensis	sea squirt	36	86	3,741	19.3%
Total Taxa			**22**		**100.0%**
Total Specimens		187	**447**		
Community Density				**19,435**	

Table 2o

Sample Location: **Station 18B**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub-sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Actiniaria					
Metridiidae					
Metridium senile	sea anemone	3	11	490	2.4%
Tubificida					
immature tubificid w/o hair chaetae	tube worm	3	11	490	2.4%
Capitellida					
Capitellidae					
Heteromastus filiformis	thread worm	1	4	163	0.8%
Mediomastus ambiseta	thread worm	5	19	816	4.0%
Phyllodocida					
Glyceridae					
Glycera americana	blood worm	2	8	326	1.6%
Nereidae					
Alitta succinea	clam worm	7	26	1,143	5.6%
Phyllodocidae					
Eteone sp.	paddle worm	1	4	163	0.8%
Spionida					
Spionidae					
Streblospio benedicti	mud worm	6	23	979	4.8%
Sabellida					
Sabellariidae					
Sabellaria vulgaris	fan worm	9	34	1,469	7.1%
Sabellidae					
Potamilla neglecta	fan worm	8	30	1,306	6.3%
Terebellida					
Orbiniidae					
Leitoscoloplos robustus	orbiniid worm	6	23	979	4.8%
Pectinaridae					
Pectinaria gouldii	trumpet worm	1	4	163	0.8%
Anomalodesmonata					
Lyonsiidae					
Lyonsia arenosa	bladder clam	2	8	326	1.6%
Venerioda					
Mactridae					
Mulinia lateralis	surf clam	3	11	490	2.4%
Myoida					
Myidae					
Mya arenaria	soft-shell clam	30	113	4,896	23.8%
Cephalaspidea					
Acteonidae					
Japonactaeon punotostriatus	bubble snail	1	4	163	0.8%
Littorinimorpha					
Calyptraeidae					
Crepidula plana	slipper snail	2	8	326	1.6%
Amphipoda					
Ampeliscidae					
Ampelisca abdita	side swimmer	1	4	163	0.8%
Aoridae					
Grandidierella japonica	side swimmer	3	11	490	2.4%
Melitidae					
Melita nitida	side swimmer	2	8	326	1.6%

Table 2o continued

Sample Location: **Station 18B**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sub- sample Count**	**Estimated Total**	**Density (no./sq.m.)**	**Percent Abundance**
Copepoda					
Notodelphyidae	fish louse	1	4	163	0.8%
Cumacea					
Leuconidae					
Leucon americanus	hooded shrimp	1	4	163	0.8%
Decapoda					
Xanthidae					
Rithropanopeus harrisii	mud crab	1	4	163	0.8%
Isopoda					
Idoteidae					
Edotea triloba	sea pill bug	3	11	490	2.4%
Ostracoda					
Sarsiellidae	seed shrimp	1	4	163	0.8%
Rhizocephala					
Sacculinidae					
Loxothylacus panopaei	crab barnacle	1	4	163	0.8%
Thoracica					
Balanidae					
Balanus improvisus	acorn barnacle	7	26	1,143	5.6%
Ascidiacea					
Molgulidae					
Molgula manhattensis	sea squirt	15	56	2,448	11.9%
Total Taxa			**28**		**100.0%**
Total Specimens		126	**473**		
Community Density				**20,565**	

Table 2p

Sample Location:	**Station 26A**
Collection Date:	October 24, 2014
Sample Gear:	Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Spionida				
Spionidae				
Streblospio benedicti	mud worm	1	43	5.9%
Amphipoda				
Aoridae				
Grandidierella japonica	side swimmer	1	43	5.9%
Melitidae				
Melita nitida	side swimmer	4	174	23.5%
Isopoda				
Idoteidae				
Edotea triloba	sea pill bug	1	43	5.9%
Sphaeromidae				
Sphaeroma quadridentatum	sea pill bug	9	391	52.9%
Tanaidacea				
Tanaidae				
Tanais dulongii	tanaid shrinp	1	43	5.9%
Total Taxa		**6**		**100.0%**
Total Specimens		**17**		
Community Density			**739**	

Table 2q

Sample Location: **Station 27A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Hoplonemertea				
Amphiporidae				
Amphiporus bioculatus	ribbon worm	1	43	0.5%
Tubificida				
immature tubificid w/o hair chaetae	tube worm	1	43	0.5%
Capitellida				
Capitellidae				
Heteromastus filiformis	thread worm	7	304	3.4%
Mediomastus ambiseta	thread worm	2	87	1.0%
Phyllodocida				
Glyceridae				
Glycera americana	blood worm	3	130	1.5%
Nereidae				
Laeonereis culveri	clam worm	53	2,304	26.1%
Phyllodocidae				
Eteone sp.	paddle worm	5	217	2.5%
Hypereteone heteropoda	paddle worm	13	565	6.4%
Spionida				
Spionidae				
Polydora cornuta	mud worm	2	87	1.0%
Streblospio benedicti	mud worm	65	2,826	32.0%
Terebellida				
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	24	1,043	11.8%
Venerioda				
Tellinidae				
Angulus agilis	tellin clam	3	130	1.5%
Macoma balthica	macoma clam	2	87	1.0%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	7	304	3.4%
Cephalaspidea				
Haninacidae				
Haminoea solitaria	bubble snail	1	43	0.5%
Amphipoda				
Ampeliscidae				
Ampelisca abdita	side swimmer	10	435	4.9%
Cumacea				
Leuconidae				
Leucon americanus	hooded shrimp	1	43	0.5%
Isopoda				
Anthuridae				
Cyathura polita	slender isopod	2	87	1.0%
Idoteidae				
Edotea triloba	sea pill bug	1	43	0.5%
Total Taxa		**19**		**100.0%**
Total Specimens		**203**		
Community Density			**8,826**	

Table 2r

Sample Location:	**Station 29A**
Collection Date:	October 24, 2014
Sample Gear:	Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Capitellida				
Capitellidae				
Heteromastus filiformis	thread worm	3	130	3.9%
Phyllodocida				
Glyceridae				
Glycera americana	blood worm	3	130	3.9%
Goniadidae	blood worm	1	43	1.3%
Nereidae				
Alitta succinea	clam worm	3	130	3.9%
Spionida				
Spionidae				
Polydora cornuta	mud worm	1	43	1.3%
Terebellida				
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	38	1,652	49.4%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	1	43	1.3%
Amphipoda				
Ampeliscidae				
Ampelisca abdita	side swimmer	1	43	1.3%
Thoracica				
Balanidae				
Balanus improvisus	acorn barnacle	26	1,130	33.8%
Total Taxa		**9**		**100.0%**
Total Specimens		**77**		
Community Density			**3,348**	

Table 2s

Sample Location: **Station 29C**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Entoprocta				
Vesicularidae				
Bowerboakia sp.	moss animalcule	-	"colonial"	-
Actiniaria				
Metridiidae				
Metridium senile	sea anemone	3	130	3.1%
Capitellida				
Capitellidae				
Mediomastus ambiseta	thread worm	2	87	2.1%
Phyllodocida				
Nereidae				
Alitta succinea	clam worm	14	609	14.6%
Phyllodocidae				
Eteone sp.	paddle worm	1	43	1.0%
Hypereteone heteropoda	paddle worm	1	43	1.0%
Syllidae				
Aulolytus sp.	syllid worm	1	43	1.0%
Spionida				
Spionidae				
Polydora cornuta	mud worm	4	174	4.2%
Sabellida				
Sabellariidae				
Sabellaria vulgaris	fan worm	10	435	10.4%
Sabellidae				
Potamilla neglecta	fan worm	20	870	20.8%
Terebellida				
Cirratulidae	fringed worm	1	43	1.0%
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	8	348	8.3%
Venerioda				
Mactridae				
Mulinia lateralis	surf clam	1	43	1.0%
Littorinimorpha				
Calyptraeidae				
Crepidula plana	slipper snail	3	130	3.1%
Nudibranchia				
Flabellinidae				
Flabellina sp.	nudibranch snail	1	43	1.0%
Amphipoda				
Aoridae				
Grandidierella japonica	side swimmer	4	174	4.2%
Corophiidae				
Monocorophium acherusicum	tube maker	3	130	3.1%
Melitidae				
Melita nitida	side swimmer	1	43	1.0%
Decapoda				
Crangonidae				
Crangon septemspinosa	sand shrimp	1	43	1.0%
Isopoda				
Idoteidae				
Edotea triloba	sea pill bug	2	87	2.1%

Table 2s continued

Sample Location: **Station 29C**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Thoracica				
Balanidae				
Balanus improvisus	acorn barnacle	11	478	11.5%
Ascidiacea				
Molgulidae				
Molgula manhattensis	sea squirt	4	174	4.2%
Total Taxa		**22**		**100.0%**
Total Specimens		**96**		
Community Density			**4,174**	

Table 2t

Sample Location: **Station 30A**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sub-sample Count	Estimated Total	Density (no./sq.m.)	Percent Abundance
Hoplonemertea					
Amphiporidae					
Amphiporus ochraceus	ribbon worm	2	6	275	1.2%
Tubificida					
immature tubificid w/o hair chaetae	tube worm	42	133	5,770	25.8%
Capitellida					
Capitellidae					
Capitella capitata	thread worm	1	3	137	0.6%
Phyllodocida					
Nereidae					
Alitta succinea	clam worm	13	41	1,786	8.0%
Laeonereis culveri	clam worm	4	13	549	2.5%
Phyllodocidae					
Hypereteone heteropoda	paddle worm	5	16	687	3.1%
Spionida					
Spionidae					
Polydora cornuta	mud worm	14	44	1,923	8.6%
Streblospio benedicti	mud worm	49	155	6,731	30.1%
Terebellida					
Ampharetidae					
Hobsonia florida	ampharetid worm	5	16	687	3.1%
Venerioda					
Tellinidae					
Macoma balthica	macoma clam	1	3	137	0.6%
Amphipoda					
Ampithoidae					
Ampithoe valida	side swimmer	1	3	137	0.6%
Aoridae					
Grandidierella japonica	side swimmer	16	51	2,198	9.8%
Melitidae					
Melita nitida	side swimmer	1	3	137	0.6%
Decapoda					
Palaemonidae					
Palaemonetes pugio	shore prawn	1	3	137	0.6%
Isopoda					
Anthuridae					
Cyathura polita	slender isopod	1	3	137	0.6%
Idoteidae					
Edotea triloba	sea pill bug	1	3	137	0.6%
Tanaidacea					
Tanaidae					
Tanais dulongii	tanaid shrinp	1	3	137	0.6%
Hemiptera					
Mesoveliidae	marsh treader	5	16	687	3.1%
Total Taxa			**18**		**100.0%**
Total Specimens		163	**515**		
Community Density				**22,391**	

Table 2u

Sample Location: **Station RF1**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	Common Name	Sample Count	Density (no./sq.m.)	Percent Abundance
Phyllodocida				
Goniadidae	blood worm	1	43	7.1%
Nereidae				
Alitta succinea	clam worm	1	43	7.1%
Phyllodocidae				
Hypereteone heteropoda	paddle worm	1	43	7.1%
Spionida				
Spionidae				
Polydora cornuta	mud worm	2	87	14.3%
Anomalodesmonata				
Lyonsiidae				
Lyonsia arenosa	bladder clam	1	43	7.1%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	4	174	28.6%
Amphipoda				
Aoridae				
Grandidierella japonica	side swimmer	4	174	28.6%
Total Taxa		**7**		**100.0%**
Total Specimens		**14**		
Community Density			**609**	

Table 2v

Sample Location: **Station RF2**
Collection Date: October 24, 2014
Sample Gear: Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Tubificida				
immature tubificid w/o hair chaetae	tube worm	25	1,087	36.2%
Phyllodocida				
Glyceridae				
Glycera americana	blood worm	1	43	1.4%
Spionida				
Spionidae				
Marenzelleria viridis	mud worm	1	43	1.4%
Polydora cornuta	mud worm	1	43	1.4%
Streblospio benedicti	mud worm	35	1,522	50.7%
Terebellida				
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	2	87	2.9%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	2	87	2.9%
Littorinimorpha				
Calyptraeidae				
Crepidula plana	slipper snail	1	43	1.4%
Amphipoda				
Aoridae				
Grandidierella japonica	side swimmer	1	43	1.4%
Total Taxa		**9**		**100.0%**
Total Specimens		**69**		
Community Density			**3,000**	

Table 2w

Sample Location:	**Station RF3**
Collection Date:	October 24, 2014
Sample Gear:	Petite Ponar / Dredge (approximate area = 0.023 sq. m.)

Taxon	**Common Name**	**Sample Count**	**Density (no./sq.m.)**	**Percent Abundance**
Capitellida				
Capitellidae				
Mediomastus ambiseta	thread worm	16	696	7.5%
Phyllodocida				
Glyceridae				
Glycera americana	blood worm	7	304	3.3%
Goniadidae	blood worm	2	87	0.9%
Spionida				
Spionidae				
Streblospio benedicti	mud worm	29	1,261	13.6%
Terebellida				
Orbiniidae				
Leitoscoloplos robustus	orbiniid worm	19	826	8.9%
Anomalodesmonata				
Lyonsiidae				
Lyonsia arenosa	bladder clam	1	43	0.5%
Venerioda				
Mactridae				
Mulinia lateralis	surf clam	25	1,087	11.7%
Tellinidae				
Angulus agilis	tellin clam	1	43	0.5%
Myoida				
Myidae				
Mya arenaria	soft-shell clam	97	4,217	45.3%
Cephalaspidea				
Acteonidae				
Japonactaeon punotostriatus	bubble snail	10	435	4.7%
Cylichnidae				
Arcteocina canaliculata	bubble snail	3	130	1.4%
Amphipoda				
Ampeliscidae				
Ampelisca abdita	side swimmer	1	43	0.5%
Isopoda				
Idoteidae				
Edotea triloba	sea pill bug	1	43	0.5%
Ostracoda				
Sarsiellidae	seed shrimp	2	87	0.9%
Total Taxa		**14**		**100.0%**
Total Specimens		**214**		
Community Density			**9,304**	

Appendix A

Chains of Custody

CHAIN OF CUSTODY RECORD

AQUA SURVEY, INC.

469 POINT BREEZE ROAD
FLEMINGTON, NJ 08822
(908) 788-8700 OFFICE
(908) 788-9165 FAX

www.aquasurvey.com

CLIENT: Environ	METHOD OF SHIPMENT: ASI Truck
PROJECT/SITE NAME: Study Area 7	TO: ASI - Flemington, NJ
ASI JOB NUMBER: 34-111	FROM: Elizabeth Marino - Elizabeth, NJ
SAMPLING & ANALYSIS AUTHORIZED BY: Environ	DATE: 10-24-14

SAMPLE NUMBER	SAMPLING LOCATION AND DESCRIPTION	DATE	TIME	SED	WTR	COM	GRB		NO. CNT.	ANALYSES REQUIRED *	SEE WORK ORD.
				SAMPLE TYPE							
20140774	RF2; N: 6887021, E: 597405.4	10-24-14	906				X		1	Taxonomy	
20140775	RF3; N: 681308.5, E: 597405.3		933				X		1		
20140776	RF1; N: 693370.8, E: 605235.5		948				X		1		
20140777	27A; N: 689049.6, E: 603631.3		1013				X		1		
20140778	29C; N: 688910.9; E: 603370.2		1029				X		2		
20140779	29A; N: 688425.7; E: 603346.9		1116				X		2		
20140780	11C; N: 688210.6; E: 603407.4		1154				X		2		
20140781	17C; N: 688373.9; E: 603053.5		1231				X		2		
20140782	11A; N: 687948.1; E: 603083.1		1247				X		1		
20140783	18B; N: 686876.1; E: 602502.7		1317				X		1		
20140784	1A; N: 686765.4; E: 602479.0		1340				X		1		

	DATE	TIME			
SAMPLE COLLECTED BY: Kevin Sowdas, Jim Krewocki			EXACT SAMPLING LOCATION: Study Area 7 - Hackensack River		
SAMPLE RELINQUISHED BY: [signature]	10-24-14	1900	SAMPLE RECEIVED BY: Tom Pohre	DATE 10/27/14	TIME 0800
SAMPLE RELINQUISHED BY:			SAMPLE RECEIVED BY:	DATE	TIME
SAMPLE RELINQUISHED BY:			SAMPLE RECEIVED BY:	DATE	TIME
SPECIAL INSTRUCTIONS:					

* Attach Separate Sheet If Necessary

102412

CHAIN OF CUSTODY RECORD

AQUA SURVEY, INC.

469 POINT BREEZE ROAD
FLEMINGTON, NJ 08822
(908) 788-8700 OFFICE
(908) 788-9165 FAX

www.aquasurvey.com

CLIENT: ENVIRON

PROJECT/SITE NAME: STUDY AREA 7

ASI JOB NUMBER: 34-111

SAMPLING & ANALYSIS AUTHORIZED BY: ENVIRON

METHOD OF SHIPMENT: ASI TRUCK

TO: ASI - FLEMINGTON NJ

FROM: ELIZABETH MARINA - ELIZABETH, NJ

DATE: 10-24-14

SAMPLE NUMBER	SAMPLING LOCATION AND DESCRIPTION	DATE	TIME	SED	WTR	COM	GRB		NO. CNT.	ANALYSES REQUIRED *	SEE WORK ORD.
				SAMPLE TYPE							
20140785	15A; N: 685747.0, E: 601523.3	10-24-14	1422				X		2	Taxonomy	
20140786	3A; N: 685255.6, E: 600995.9	↓	1427				X		1	↓	
20140787	7A; N: 684620.3, E: 600817.8	↓	1442				X		2	↓	
20140788	2A; N: 686420.1, E: 602200.2	↓	1509				X		1	↓	
20140789	9A; N: 687547.9, E: 602781.1	↓	1533				X		1		

SAMPLE COLLECTED BY: KEVIN SONDAG, JIM KAROWICKI

EXACT SAMPLING LOCATION: STUDY AREA 7 - HACKENSACK RIVER

	DATE	TIME		DATE	TIME
SAMPLE RELINQUISHED BY: [signature]	10-24-14	1900	SAMPLE RECEIVED BY: Tom Dilee	10/27/14	0800
SAMPLE RELINQUISHED BY:			SAMPLE RECEIVED BY:		
SAMPLE RELINQUISHED BY:			SAMPLE RECEIVED BY:		

SPECIAL INSTRUCTIONS:

* Attach Separate Sheet If Necessary

102412

CHAIN OF CUSTODY RECORD

AQUA SURVEY, INC.

469 POINT BREEZE ROAD
FLEMINGTON, NJ 08822
(908) 788-8700 OFFICE
(908) 788-9165 FAX

www.aquasurvey.com

CLIENT: Environ	METHOD OF SHIPMENT: AUTO
PROJECT/SITE NAME: SA-7	TO: ASI
ASI JOB NUMBER: 34-111	FROM: Jersey City, NJ
SAMPLING & ANALYSIS AUTHORIZED BY: ENVIRON	DATE: 10-24-14

SAMPLE NUMBER	SAMPLING LOCATION AND DESCRIPTION	DATE	TIME	SAMPLE TYPE SED	WTR	COM	GRB		NO. CNT.	ANALYSES REQUIRED *	SEE WORK ORD.
13A	#20140790 N686831.87 E802966.47 WRG	10-24-14		1					1	Taxonomy	
13B	#20140791 N687090.40 E603047.93	10-24-14		1					1		
6A	#20140792 N687156.47 E603426.70	10-24-14		1					1		
11D	#20140793 N688103.48 E603598.31	10-24-14		1					1		
30-A	#20140794 N688432.30 E603598.31	10-24-14		1					1		
26A	#20140795 N688732.38 E603856.10	10-24-14		1					1		
7C	#20140796 N684761.80 E601176.29	10-24-14		1					1		

	DATE	TIME		DATE	TIME
SAMPLE COLLECTED BY: ASI			EXACT SAMPLING LOCATION: Jersey City, Lower Hackensack River		
SAMPLE RELINQUISHED BY: [signature]	10-24-14	1836	SAMPLE RECEIVED BY: Tom Dolce	10/27/14	0800
SAMPLE RELINQUISHED BY:			SAMPLE RECEIVED BY:		
SAMPLE RELINQUISHED BY:			SAMPLE RECEIVED BY:		
SPECIAL INSTRUCTIONS:					

* Attach Separate Sheet If Necessary

102412