ONONDAGA LAKE SEDIMENT MANAGEMENT UNIT 8 MICROBEAD MARKER PLACEMENT REPORT

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ATL	Atlantic Testing Laboratories, Ltd. (Canton, New York)
cm	centimeter
ft.	feet
ETS	Environmental Tracing Systems, Ltd. (Helensburgh, Scotland, UK)
gpm	gallons per minute
GPS	global positioning system
hypolimnion	The lower portion of the water column in the middle of a lake during summer stratification where water temperatures are cooler than upper waters (typically in the portion of Onondaga Lake where water depths exceed 30 feet). There is less mixing in the hypolimnion than in the upper portion of the water column.
m	meters
mg/Kg	milligrams per kilogram
NYSDEC	New York State Department of Environmental Conservation
ppm	parts per million (1 ppm is the same as 1 mg/Kg)
ROD	Record of Decision
RTK	real time kinematic (a type of GPS unit capable of better accuracy than non-RTK units)
SBES	single beam echo sounder
SMU	sediment management unit
SOP	standard operating procedure
USEPA	United States Environmental Protection Agency

Note**:** One centimeter is approximately equivalent to 0.4 inch, and one inch is approximately equivalent to 2.5 centimeters.

EXECUTIVE SUMMARY

This report describes the manufacturing, placement and confirmation (in 2009), and post-placement evaluation (in 2010 and 2012) of two different microbead markers now in place in Onondaga Lake Sediment Management Unit (SMU) 8 which is the two-thirds of the Onondaga Lake surface area where water depths exceed 30 feet (ft.)

During June and July 2009, two different microbead markers were placed on top of lake bed sediment at nine different plots within Onondaga Lake SMU 8 in accordance with an agency-approved work plan (Parsons, et al., 2008). One microbead marker, comprised of a silt-sized particle (too small to see with the naked eye), was placed to mimic the actual lake bed sediment and to quantify whether vertical mixing of surface lake sediment is taking place to a measurable extent. A second microbead marker, comprised of a sand-sized particle (visible to the naked eye), was placed to act as a visual marker to quantify future, ongoing sedimentation within SMU 8. Sedimentation has been shown to be taking place in SMU 8 based on cores collected and analyzed previously for cesium-137 and lead-210 radioisotopes. Both sedimentation and vertical mixing affect the pace at which SMU 8 is recovering naturally and thereby meeting remedial goals for SMU 8 established in the 2005 Record of Decision for the lake bottom.

Evaluation of the microbead markers was conducted in several phases in 2010 and 2012 over several areas of SMU 8 and employed various different sampling techniques as summarized below:

Sampling Date	Study Area	Sampling Technique
July 2010	Plots 80093, 80094, 90096, 80099	High resolution sectioning
November 2010	Plots 80094, 80099	High resolution sectioning (after drying the cores)
November 2010	Plots 80094, 80099	High resolution sectioning (after freezing the cores)
October 2012	Plots 80095, 80099	Visual identification through vertically slicing frozen cores

Parsons and Environmental Tracing Systems (ETS) from Helensburgh, Scotland identified, oversaw manufacturing, and coordinated marker placement and evaluation, while Atlantic Testing Laboratories (ATL) from Canton, New York assisted with placing and evaluations following placement of the microbead markers. The two different marker materials were placed simultaneously in a 1- to 2-millimeter thick layer on top of the lake bed sediment at nine SMU 8 locations. Marker placement success was assessed post placement by coring and analyzing the surface sediments within each plot. Future coring and segmentation of sediment within these areas will determine how much sediment has deposited over the sand-sized microbead layer. As discussed in Section 3.3, sub-sampling techniques used prior to 2012 may not have suitably measured the depth of microbeads within the sediment column. Visible varves (also called striations) observed in frozen cores document without question the extent of vertical mixing within sediment whereas laboratory analyses of SMU 8 sediment sub-samples extracted with a syringe or other device introduce more variables and can lead to inconsistent results as presented herein. As a result, a more controllable technique for evaluating microbead marker depth has been developed based on slicing frozen cores. In addition, future monitoring of the microbead marker plots will focus on monitoring the depth of the sand marker as a measure of ongoing natural recovery. Future monitoring of the silt marker is not warranted given frozen cores have demonstrated the presence of horizontal varves that visually document the extent of vertical mixing without subsampling or laboratory analyses.

SECTION 1

INTRODUCTION

1.1 BACKGROUND

Onondaga Lake is a 4.6-square mile (2,900-acre) lake located northwest of the City of Syracuse in central New York State. The lake bottom, its tributaries, and the upland hazardous waste sites related to the lake have been identified as a federal Superfund site on the United States Environmental Protection Agency's (USEPA) National Priorities List. Additional information on the site can be found in the Feasibility Study which assesses remedy alternatives for the lake bottom (Parsons, 2004). A Record of Decision (ROD) issued by the New York State Department of Environmental Conservation (NYSDEC) and the USEPA in July 2005 (NYSDEC and USEPA, 2005) identified the remedy being implemented for the lake bottom which, for SMU 8, includes monitored natural recovery to achieve a mercury probable effects concentration of 2.2 milligrams per kilogram (mg/kg or part per million) in surface sediment at every location and to achieve a bioaccumulation-based sediment quality value for mercury of 0.8 mg/kg on an area-wide basis, within 10 years following the remediation of upland sources, dredging and/or isolation capping of littoral sediment, and initial thin-layer capping. SMU 8 is the deep-water portion of the lake where water depths exceed 30 ft. (9 meters[m]) and where waters vertically stratify annually typically from May to October.

During late 2008, high-resolution radioisotope and mercury cores were collected and subsequently analyzed to determine recent sedimentation history in SMU 8 and to update surface sediment mercury concentrations. These findings were also used to help establish parameter input ranges for a one-dimensional natural recovery model to predict future surface sediment mercury concentrations based on mercury fate and transport.

Sand-sized non-toxic fluorescent microbeads within SMU 8 are a tool to quantify sedimentation rates during implementation of the lake bottom remedy. Given the annual sedimentation rate generally observed in SMU 8 from the 2008 high-resolution cores is typically 0.5 centimeters (cm), and that typically a 1 cm (0.4 inch) segment is the minimum vertical sampling of cores that can be achieved accurately and reproducibly, approximately two to three years are anticipated to be needed following microbead placement, to establish a preliminary ongoing sedimentation rate. Over 20 years of monitoring at a sedimentation rate of 0.5 cm per year, it is anticipated that approximately 10 cm of new sediment will accumulate on top of the stationary sand-sized microbead marker.

The second silt-sized microbead marker provides a way to measure vertical mixing of sediment resulting from bioturbation or other processes in SMU 8. Anoxic conditions in the hypolimnion of SMU 8 during summer stratification significantly limit biological activity. Nonetheless, two sediment cores collected in 2012 at an outer (shallower) portion of SMU 8 off the lake's western shoreline adjacent to Wastebeds 1-8 showed thicker layering of sediment near the sediment-water interface that was not typical of the layering (also called fine striations) found in cores from deeper portions of SMU 8. In addition, more benthic macroinvertebrates may have been present in SMU 8 during 2012 compared to 2008. These 2012 observations in SMU 8 will be investigated further in 2015. Wherever fine striations are observed in historical SMU 8 high-resolution cores, vertical mixing is not taking place.

Four different field tests were conducted during October and November 2008 (Parsons and Environmental Tracing Systems, 2009) which resulted in determining that microbead markers could be used to assess natural recovery in SMU 8:

1. Settling test. Results from this test showed that microbead markers can position themselves on top of SMU 8 sediment.
2. Background fluorescence test. Results from this test showed no significant effect from local sediment characteristics that would hamper the ability to analyze for marker presence.
3. Placement test. This test showed markers could be placed within SMU 8 with some modifications to the equipment.
4. Sampling test: This test provided representative surface sediment samples needed to document sedimentation rates over the marker and/or surface sediment mixing depth.

1.2 PROJECT AND REPORT OBJECTIVES

This Microbead Marker Placement Report describes the manufacturing, placement, and placement confirmation of the two types of microbeads completed in SMU 8 during 2009 in accordance with a work plan approved in advance by NYSDEC (Parsons et al., 2008). This report also describes microbead marker monitoring conducted during 2010 and 2012. Microbead marker monitoring will be conducted again in October 2014 and every three years thereafter in accordance with the approved work plan and in accordance with the Agency-approved monitoring and contingency approach (explained in Parsons, 2008b).

During early 2009, the two different microbead markers to be placed within SMU 8 were manufactured in the United Kingdom for Honeywell. During June and July 2009, both microbead markers were successfully placed onto the sediment surface at nine different plots in SMU 8. One of the microbead markers (Marker A) mimics SMU 8 surface in size and behavior. It is a fine (silt-clay) and can migrate vertically to the extent SMU 8 sediment migrates vertically. Given its size, Marker A particles are not visible to the naked eye and must be detected by a laboratory method analysis described in the work plan approved for microbead-related work (Parsons et al., 2008). The second microbead marker (Marker B) has a larger (sand) grain size and a higher erosion shear stress than Marker A. Marker B is, therefore, less prone to vertical mixing than Marker A. Marker B was placed to quantify future rates of sedimentation on top of the marker (i.e., the mudline or top of sediment at the time the marker is placed). Marker B can be seen at the project site by collecting a sediment sample for visual observation.

The characteristics of these two microbead markers placed in SMU 8 are as follows.

- Marker A consists of silt-sized microbeads each with a particle diameter distributed relatively evenly between 2 to 60 microns (silt-clay) and a dry density of 2.6 grams per cubic centimeter (i.e., 160 pounds per cubic foot) based on the results from particle size and specific gravity analyses completed on 11 surface sediment samples collected throughout SMU 8 during November 2007 (Parsons, 2008a). The purpose of this marker is to monitor vertical mixing of SMU 8 sediment to the extent feasible and necessary.
- Marker B consists of sand-sized microbeads with a particle diameter of 200 to 300 microns (or 0.2 to 0.3 millimeters). The purpose of this marker is to measure ongoing burial of SMU 8 surface sediment given Marker B provides visual evidence of the sediment surface when the marker was placed in 2009.

Remaining sections of this report describe marker manufacturing and placement (Section 2), marker placement confirmation (Section 3). Appendix A presents photos of equipment used to place the markers. Appendix B provides standard operating procedures to be used for future microbead marker sampling efforts based on results reported herein. Appendix C presents photos of the marker quality control check setup. Appendix D presents water velocity results for lower waters measured during 2009 in the vicinity of some of the microbead plots. Appendices E and F present results from the microbead marker checks completed in 2010 and 2012, respectively.

SECTION 2

MICROBEAD MARKER MANUFACTURING AND PLACEMENT

2.1 MICROBEAD MANUFACTURING

Both microbead markers were manufactured in the United Kingdom under the supervision of ETS, using non-toxic polyester-based polymers that are known to be highly resistant to photodegradation and biochemical breakdown even when exposed to the natural elements. The markers include a naturally-occurring mineral (such as barium sulfate) to adjust physical properties of the marker (such as dry density) as needed to meet project objectives. The two markers were manufactured with the same fluorescent pigment label. This pigment comprises approximately 3 percent by weight of the final microbead marker composition. The fluorescent chemical signature was thermoset into the pigment polymer and represents less than 5 percent by weight of the overall pigment. If the microbead does unexpectedly break down gradually over time, the pigment would still retain its fluorescent property.

ETS manufactured enough of both microbead markers based on the amount needed to cover the areas of the lake that will be sampled periodically for up to 20 years into the future and based on a marker placement thickness of 2 millimeters needed to meet project objectives.

2.2 MICROBEAD PLACEMENT

The actual thickness of the combined markers once placed was established to be 2 millimeters. It was determined that from marker placement work at other locations and from the pre-mobilization field team work completed at Onondaga Lake in 2008, that Marker B is visible at a thickness of 1 millimeter or more. Additionally, it was determined that a thickness of approximately 1 millimeter for Marker A would be sufficient to be measured using analytical techniques, described in the approved work plan.

Prior to marker placement, representative samples from each of the nine SMU 8 placement areas were collected and analyzed for particle size. Results from these analyses are summarized in Table 1.

An experienced land surveyor used a single beam echo sounder (SBES) bathymetric survey system with Hypak navigation software to locate and survey each microbead plot. This survey system used real-time kinematic (RTK) global positioning with an on-shore base station.

The two microbead markers were placed in a controlled manner and distributed uniformly over a pre-determined bottom area at each of nine plot locations. Appendix A shows the microbead placement equipment. A self-propelled barge 16.5 ft. wide by 28.5 ft. long was used as the platform for microbead placement. To achieve effective, uniform distribution, each microbead slurry (Marker A [silt], and Marker B [sand]) was pumped down a hose to its own horizontal bar 5 m in length. This horizontal bar—the dosing bar—was towed 2 to 3 m above the

SMU 8 sediment. The dosing bar has multiple discharge slots along the length of the bar, ensuring that the microbeads were discharged over the bar width in a uniform manner.

In order to ensure that the microbeads absorbed any available organic material and had the same surface charge as the SMU 8 sediment, the microbeads were mixed with SMU 8 sediment prior to dosing. Fluidization of the marker and sediment mixture helped to achieve an even marker distribution at the lake bottom.

Fluidization was accomplished by mixing the marker and sediment mixture in a large barrel on board the workboat with lake water pumped from below the thermocline so the temperature of the fluidized microbead slurry matched the temperature of the water into which the microbeads were being discharged. A circulation pump was used to keep everything in suspension and well mixed in the barrel prior to release. Another pump with variable speed was used to pump the marker sediment slurry down the hose which was split into eight slots cut along the dosing bar. The slots were adjusted (length and width) to ensure that each slot discharged the same volume of marker and sediment; this was tested on land by pumping natural sand as a surrogate marker.

The dosing bar was fixed to the deck of the barge with vertical steel rods so the bar remained at a consistently suitable height above the sediment. To ensure the barge did not significantly yaw or pitch while microbeads were being placed, a four anchor system was used. Prior to placement, anchor locations were identified relative to each designated plot area with AutoCAD. At each designated placement plot, four concrete block anchors were placed at 45 degree angles from each corner of the plot area and approximately 300 ft. from the center of the plot. Once deployed, the anchors were attached to the barge with steel cable. Tests were conducted in the lake to show that with this spatial configuration on the bar, sand dropped from 2 m (7 ft.) above the mudline, and silt dropped from 1 m (3 ft.) above the mudline dispersed to successfully cover the entire intended placement area at each plot. The dosing vessel proceeded along a pre-determined path very slowly at a pace of approximately 10 ft. per minute.

Marker A and Marker B were placed simultaneously at each plot in June 2009. The sand (Marker B) was placed at approximately 25 gallons per minute (gpm) approximately 2 m (7 ft.) above the bed to allow the microbeads to settle. The microbeads took a few seconds to settle once the particles reach terminal velocity, as the fall 2008 settling tests showed. The silt (Marker A) was placed approximately 1 m (3 ft.) above the top of sediment, at a slower release rate (12 gpm), because Marker A takes longer to settle than Marker B. The Marker B dosing bar was positioned approximately 1 m above the Marker A dosing bar and offset horizontally 1 m. This offset placement controlled the dispersion of the silt-clay marker and allowed for more dispersion of the sand (being dropped from a higher position).

Once the markers were placed, all equipment was brought on deck and stowed. Anchors were then retrieved with the use of support vessels and reset at the next area. An additional marker was brought to the barge by support vessels and the slurries were created using the same techniques as prior dosing events. By measuring water depths of the slurry mixture, pump rates, and vessel speed, both markers were verified to have been placed consistently within each plot. Duplicating the process ensured consistency from one plot to the next.

The size of each of the 9 marker placement plots (Figure 1) is approximately 125 square meters (140 square yards) as placed (Figures 2 through 10). An area of 125 square meters allows a sub-area of 3 m by 3 m (i.e., 10 ft. by 10 ft.) to be available at each plot for up to 14 future marker sampling efforts, without sampling the same sub-area twice. Depending on the extent the microbead markers become compacted, this density of microbead placement would result in an approximate microbead layer thickness of 0.75 to 2.5 millimeters based on a marker particle size of 0.25 millimeter (i.e., Marker B). This density of placement is equivalent to approximately 200 microbead particles (Marker B) per square millimeter (or 130,000 particles per square inch). Given the large marker volume that was applied, the biggest challenge was keeping the sand in suspension. In order to achieve this, the placement of microbeads at each plot needed to be split in half, because the entire batch of sand marker could not be kept in suspension in one container long enough to apply microbeads over each entire plot at once. Any break in the plot is simply the time gap where the global positioning system (GPS) recorder was stopped while the container of sand marker was refilled and then restarted. Each actual plot is continuous. The barge was held stationary while the second half of the microbeads was prepared for dosing. Checks on the RTK positioning equipment confirmed the barge did not move during this placement, or if there was movement the barge was put back into position.

SECTION 3

MARKER PLACEMENT CONFIRMATION

3.1 CORING PROCEDURE

Consistent with the approved work plan, one core was collected from each of the marker placement plots during early October 2009 to confirm the homogeneity of the microbeads and compaction or mixing during placement. In addition, core samples were collected during early October 2009 from locations immediately surrounding two of the marker placement plots to confirm that minimum spread of the microbeads had occurred beyond the microbead locations as a result of placement. Plot locations 80099 and 80100 were selected for safety reasons due to their proximity to the shore support area and the unpredictable weather in October. In addition, video footage obtained during early October 2009 shows sediment to have settled since the application in June 2009 over the plot area making Marker B not visible from above the sediment surface throughout the 80099 and 80100 placement areas. Video footage was also obtained of a sample core penetrating SMU 8 surface sediment.

To further confirm placement effectiveness and assess the effects of fall turnover on surface sediments in SMU 8, core samples were also collected during November 2009 from each of the nine marker placement plots. In order to assess variability and sampling error, duplicate samples were collected at four of the nine plots. In order to assess uniformity of the plot area, additional samples were collected at two of the nine locations. Each of the placement confirmation samples was collected and processed in accordance with the SOP presented in Appendix B. A 2.5-inch inside diameter gravity corer manufactured in the Netherlands by Eijkelkamp and pre-tested extensively in SMU 8, was used to collect sediment cores from inside and outside 2009 microbead plot areas. A profile view of the corer that has been and will continue to be used for microbead confirmation sampling work can be seen in Appendix A. The gravity corer consists of a frame with strengthening ribs, falling weight and sampler. Using a hoisting unit on board a boat, the sampler is lowered in free fall form approximately 20 ft. above the sediment surface. By its own weight and velocity, the apparatus penetrates the submerged sediment. The depth of penetration is in part determined by sediment composition. In SMU 8 sediment, penetration of the corer will reach to depths of approximately 80 cm (31 in.), if needed. This corer was used with transparent tubing to allow for the visual descriptions of lithology without opening core tube.

The procedure below has been applied for sampling inside and outside each microbead placement plot area:

a. For sampling inside the plot area, a small sampling barge was navigated directly over the plot area. For sampling outside each plot area, the sampling barge was hovered 25 to 100 ft. outside the plot area.

b. RTK GPS was used to ensure the sampling barge was on the target location and little to no movement of the vessel was occurring. Location accuracy for these samples was to within 1 ft. of the intended location.

c. Water depth was measured with an on board depth sounder.

d. The gravity corer was lowered to within 20 ft. of the top of the sediment.

e. The corer was manually lowered slowly to a depth of 2 to 3 ft. into the sediment

f. The corer was then raised to the water surface, capped, and kept upright while transported to shore to avoid mixing, with any observations and measurements made before settling took place.

Locations where placement confirmation samples were collected during October and November 2009 within and outside each of the nine microbead marker plots are included in Figures 2 through 12.

In accordance with the approved work plan, marker sampling was repeated during the summer of 2010 at four of the marker placement locations approximately 12 months following marker placement to establish the effects of one year of lake stratification. Subsequently, marker sampling was conducted during 2012 and will be conducted in 2014 and every three years thereafter (Parsons et al., 2008b).

3.2 CONTROL CHECK IMPLEMENTATION

A control check was initiated for both of the microbead markers following marker placement. The purpose of this control check was to confirm marker longevity over time. Twenty sediment cores were collected from SMU 8. The control checks were set up as follows: (1) a 1- to 2-millimeter thick layer of microbeads was combined with SMU 8 sediments; (2) the slurry was placed on top of each sediment core that had been collected from SMU 8; (3) a small additional quantity of SMU 8 surface sediment was added to each core to represent sediment that is settling in SMU 8 over time; and (4) the cores were then stored in a cool, dark area at the lakeshore away from light that could breakdown the marker over time. For each of these control check cores, SMU 8 sediment was mixed with both the sand marker and the silt marker at the same concentration (by mass). Each core was then dosed with 30 milliliters of sediment/sand/silt solution. Each core was allowed to settled and then evaluated visually for the presence of sand marker. All 20 cores were then capped, labeled, and placed in a refrigerator unit located at the lake shoreline support area.

During each year following marker placement until the natural recovery time period in SMU 8 is complete, a sediment-marker sample will be collected from one of the cores, and a visual determination will be made of the extent the sand microbead marker (Marker B) remains intact and detectable with unchanged properties. During 2010 and 2012, the sand marker was clearly visible in sliced, frozen cores which served as a control check. During 2011 and 2013, control checks were completed to confirm the sand marker remains visible.

3.3 SAMPLE ANALYSIS FOR MARKER PRESENCE

Results from the October 2009 coring show that sand (Marker B) was generally confined to the top one centimeter of sediment. Consistent placement of the sand microbead marker at the top of SMU 8 sediment was confirmed for each plot in October 2009 approximately four months following placement. The sand marker was visible within the top 1 cm in eight of the nine October 2009 cores (Table 1A).

Analyses of the placement confirmation samples for the presence of silt marker were conducted at the ETS Laboratory in Scotland. Table 2 summarizes results from laboratory analyses of the October 2009 confirmation samples, while Table 3 summarizes results from laboratory analyses of the November 2009 confirmation samples. Each sample was weighed, dried, and reweighed to determine the moisture content. A series of dilutions of the dried samples was prepared so that the optimum sediment concentration for microbead marker determination could be assessed. Results in Tables 2 and 3 are expressed as percent silt marker particles.

For the October 2009 confirmation samples, seven 1 cm layers from core OL-MB-80094, six 1 cm layers from core OL-MB-80093, and the top four 1 cm layers in one core from each of the other seven plots were analysed at ETS for the presence of Marker A (silt microbeads) based on fluorescence. In seven of the nine October 2009 cores (all except the core from plots 80093 and 80099), the silt marker was shown to be primarily contained within the surface 1 cm layer of sediment (Table 2).

One core from each of the nine microbead marker plots was also collected in November 2009 and analyzed at ETS for the presence of the silt microbead marker. For the cores from five of the nine microbead marker plots (excluding both cores from microbead marker plots 80093 and 80096, the single core from plot 80101 and one of the two cores from plot 80094), the silt marker was shown to be contained within the top 1 cm of sediment (Table 3). Differences in results from duplicate samples of the core from plot 80094 could also be due to the sample processing technique used at that time that has since been replaced for this work by freezing sediment cores.

Given subsequent examinations of frozen cores beginning in 2012 from microbead plots consistently showed tight layering of sediment near the top of the cores, the percentages of silt marker shown in Table 2 for cores from plots 80093 and 80099 and shown in Table 3 for cores from plots 80093, 80094, 80096 and 80101 were likely an artifact of the core processing technique used at that time which for vertical intervals of sediment as thin as 1 cm has as of 2012 not been used in favor of visually observing sediment layering after freezing and slicing the cores.

Five microbead marker plots were sampled in July 2010. Coring and sub-sampling procedures for the July 2010 sampling effort were identical to those of the 2009 sampling effort documented in Section 3. Sampling at four of these plots in 2009 (plots 80093, 80094, 90096, 80099) showed both the sand and silt marker materials below the top centimeter at these plots.

Marker found below 1 cm in these cores was likely a result of the sub-sampling procedure used at that time. Results from the July 2010 sampling are presented in Appendix E.

It is unclear based on the data collected prior to 2012 to what extent the sub-sampling procedure used at that time affected microbead observations. Contamination of the lower sections likely occurred as the syringe was withdrawn from the core and the fluid-like surface sediment collapsed around the bottom of the syringe. As a result, Parsons/Honeywell has completed an assessment of an alternative sample processing (also called sub-sampling) procedure in 2012. Parsons/Honeywell has concluded that freezing and slicing cores is the most reliable methodology for measuring marker presence going forward.

The presence of any silt marker below the top 2 cm of sample during October 2009 and again during late 2010 is most likely an artefact of the core processing technique as the syringe was withdrawn from the core and the fluid-like surface sediment collapses around the bottom of the syringe. On withdrawing the syringe, the sand marker was visibly smeared on the outside of the syringe. The visibility of the sand marker as a narrow band within the processed cores and the silt tracer analysis appearing as a very high concentration in a single layer in a number of the cores confirms that, in general, the sand and silt markers have been deployed and are behaving as desired. In five of the eight cores, the location of the silt marker is clear.

Results from subsequent sub-sampling in late 2010 show that microbead particles found at depths greater than one centimeter are most likely a result of sub-sampling very non-cohesive, low solids content sediment which may cause smearing of surface sediments into the lower units (see Appendix E).

Additional samples were collected during October 2009 from locations OL-MB-80099 and OL-MB-80100 to assess the extent of any spreading of the markers during placement. There were no visible signs of marker present within these additional samples. Laboratory results for these samples are included on Figure 11 and Figure 12. Results from these samples indicate that some spreading may have occurred to the northwest of location OL-MB-80099. However the western edge of this plot was the finish edge and marker material in sediment to the northwest may have been a result of post placement deck or equipment washing. Results from location OL-MB-80100 indicate very little spread occurred outside of 25 ft. from the plot area.

The November 2009 samples were collected following fall turnover within SMU 8. Visual results from November 2009 show that when sub-sampling the center of the gravity core, sand (Marker B) was found in the top 2 cm of sediment but not any deeper. The presence of the sand marker only in top 2 cm layers indicates that resuspension of lake sediment from lake turnover did not have a significant impact on the placement of Marker B. In general the top four to five 1 cm layers were analyzed for the presence of Marker A (silt microbeads). At locations OL-MB-80093 and OL-MB-80094, the top four 1 cm layers were analyzed. The depth of sampling was dependant on the consistency of the material within each core tube. Observations made at six of the nine November 2009 plot locations (plots 80094, 80095, 80097, 80098, 80099, and 80100) indicates the presence of sand marker almost exclusively in the top 2 cm illustrating that the microbeads continued to remain in place after lake turnover. Additional investigations for the presence of marker material in years 2010 and 2012 are described in detail in Appendix E and Appendix F, respectively. Based on these results, future investigations of SMU 8 sediment cores for the presence of microbead marker will rely on techniques that involve freezing the cores and cutting them open. These techniques are described in Appendix F.

3.4 VELOCITY DATA SUMMARY

Velocity measurements were collected adjacent to each microbead marker plot at the time of microbead marker placement. Typically two to three hours of velocity measurements were collected at each microbead marker plot. Two acoustic doppler velocimeters manufactured by Nortek AS were deployed approximately 50 m from the plot area prior to placement and were collected after placement was finished. One velocimeter was deployed at 0.5 m above the sediment bed and one velocimeter at 1.0 m above the sediment bed at each of the nine microbead marker plots. At each location the variation between the top and bottom meter could be attributable to the bottom meter interacting with SMU 8 sediments. A summary of current velocity data from these velocimeters is located in Appendix D.

SECTION 4

REFERENCES

NYSDEC and USEPA Region 2. 2005. *Record of Decision. Onondaga Lake Bottom Subsite of the Onondaga Lake Superfund Site*. July 2005.

Parsons. 2004. *Onondaga Lake Feasibility Study Report*, Onondaga County, New York. Prepared for Honeywell, in association with Anchor Environmental and Exponent. (The Monitored Natural Recovery Analysis for Onondaga Lake SMU 8 is described in detail in Appendix N of this report.)

Parsons, 2005a. *Onondaga Lake Pre-Design Investigation: Standard Operating Procedures.* Prepared for Honeywell, November 2005.

Parsons, 2008a. *Onondaga Lake Pre-Design Investigation: Phase III Addendum 6 Data Summary Report.* Prepared for Honeywell. Prepared in association with Exponent and Anchor Environmental. June 2008.

Parsons, 2008b. *Onondaga Lake Pre-Design Investigation: Phase III Work Plan – Addendum 6. SMU 8 Sampling to Monitor Natural Recovery*. Prepared for Honeywell. Prepared in association with Exponent and Anchor Environmental. Revised January 2008.

Parsons et al., 2008. *Microbead Marker Work Plan for Monitoring Natural Recovery in SMU 8.* Prepared for Honeywell, East Syracuse, New York. Prepared by Parsons, Anchor Environmental, and Environmental Tracing Systems. September 2008.

Parsons and Environmental Tracing Systems, 2009. M*icrobead Marker 2008 Pre-Mobilization Field Test Data Summary Report.* Prepared for Honeywell, East Syracuse, NY. August 2009.

TABLES

TABLE 1

SUMMARY OF SEDIMENT PHYSICAL CHARACTERIZATION AT MARKER PLACEMENT PLOTS

Location ID	Field Sample ID	Core Depth (cm)	Grain Size (ASTM D422-63) Percent Gravel (%)	Percent Sand (%)	Percent Fines (clay & silt) (%)	Percent Smaller than 0.005 mm (5 microns)	Moisture Content (ASTM D2216) (%)	Specific Gravity (ASTM D854-06)	Sample Description[1]	Field Description
OL-MB-80093	OL-0833-01	0-20	0.2	1.8	98.0	43	272	2.21	Wet, black silt	Wet, very soft, black and brown SILT, trace fine sand, trace organics (leaves), organic peat odor
OL-MB-80094	OL-0833-02	0-20	0.3	1.0	98.7	56	258	2.43	Wet, black silt	Wet, very soft, black SILT, little fine sand, organic peat odor
OL-MB-80095	OL-0833-03	0-20	0.2	1.0	98.8	49	215	2.37	Wet, very dark gray silt	Wet, very soft, black SILT, trace fine sand, trace roots/organics, organic peat odor
OL-MB-80096	OL-0833-04	0-20	0.3	1.1	98.6	45	205	2.57	Wet, very dark grayish brown silt	Wet, very soft, brown SILT, black mottling throughout
OL-MB-80097	OL-0833-05	0-20	0.3	0.8	98.9	41	228	2.65	Wet, black silt	Wet, very soft, black SILT, trace fine sand, trace organics (leaves), organic peat odor
OL-MB-80098	OL-0833-06	0-20	0.3	0.8	98.9	48	248	2.56	Wet, very dark gray silt	Wet, very soft, dark brown and black SILT, little fine sand, organic peat odor
OL-MB-80099	OL-0833-07	0-20	0.4	0.8	98.8	54	258	2.35	Wet, very dark gray silt	Wet, very soft, black SILT, trace fine sand, organic peat odor
OL-MB-80100	OL-0833-08	0-20	0.3	1.3	98.4	53	266	2.55	Wet, black silt	Wet, very soft, black SILT, trace fine sand, organic peat odor
OL-MB-80101	OL-0833-09	0-20	0.2	1.0	98.8	44	240	2.55	Wet, very dark grayish-brown silt	Wet, very soft, dark brown and black SILT, trace fine sand, organic peat odor

Table 1A
Visual Assessment of Microbead Cores Collected in October 2009

Microbead Placement Plot	Date	Initial visual description core	Depth of Sand Tracer Layer (mm)	Remarks of Sub-Sampled Layers	Photo
OL-MB-80093	10/8/2009	Sand tracer visual in top 1 cm of core ~ 1/2 cm very wet, loose, sediment overlaying Sand tracer	2	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80094	10/8/2009	Sand tracer visual in top 1 cm of core Evidence of smearing by core walls on outside of core on one side	2	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80095	10/8/2009	Sand tracer visual in top 1/2 cm of core	2	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80096	10/8/2009	Sand tracer visual in top 1 cm of core Evidence of smearing by core walls on outside of core	2	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80097	10/8/2009	Sand tracer visual in top 1 cm of core Evidence of smearing by core walls on outside of core	2	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80098	10/8/2009	Sand tracer visual in top 1 cm of core Evidence of smearing by core walls to 5 cm on outside of core	3	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80099	10/8/2009	Sand tracer visual in top 1/2 cm of core	2	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80100	10/8/2009	Sand tracer visual in top 1/2 cm of core	2	No visual evidence of sand marker below 1 cm	Yes
OL-MB-80101	10/8/2009	Sand tracer visual in top 1 cm of core Sediment column is mounded in center	2	No visual evidence of sand marker below 1 cm	Yes

TABLE 2

SUMMARY OF MICROBEAD FLUORESCENCE ANALYSES FOR SILT MARKER FROM THE OCTOBER 2009 MICROBEAD PLACEMENT CONFIRMATION "A" LOCATION SAMPLES

	Plot								
Sediment Depth	80093	80094	80095	80096	80097	80098	80099	80100	80101
0-1 cm	13	98	87	98	100	99	37	93	99
1-2 cm	12	1	10	2	0	1	37	4	1
2-3 cm	75	0	3	1	0	1	26	3	0
3-4 cm	0	0	0	0	0	0	0	0	0
4-5 cm	0	0	NA	NA	NA	NA	NA	NA	NA
5-6 cm	0	0	NA	NA	NA	NA	NS	NS	NA
6-7 cm	NS	0	NS	NS	NA	NA	NS	NS	NA

Notes:
1. Results presented as a percent of total material within the depth interval.
2. All samples suitable for use in assessing marker presence
3. NA = Not Analyzed
4. NS = Not Sampled

NOTE:

The silt marker sub-sampling procedure used in 2009 was replaced in 2012 with a core freezing method described in Appendix E. Frozen cores visually show varves or layers in sediment that preclude the value of analyzing subsamples in a laboratory for silt marker extent based on fluorescence.

TABLE 3

SUMMARY OF MICROBEAD FLUORESCENCE ANALYSES FOR SILT MARKER FROM THE NOVEMBER 2009 MICROBEAD SAMPLES

	Plot												
Depth	80093	80093*	80094	80094*	80095	80095*	80096	80096*	80097	80098	80099	80100	80101
0-1 cm	51	56	68	100	100	100	17	69	100	100	100	100	51
1-2 cm	4	44	32	0	0	0	13	13	0	0	0	0	49
2-3 cm	30	0	0	0	0	0	68	18	0	0	0	0	0
3-4 cm	16	0	0	0	0	0	2	0	NS	0	0	0	0
4-5 cm	NS	NS	NS	NS	NS	NS	0	NS	NS	0	0	0	0

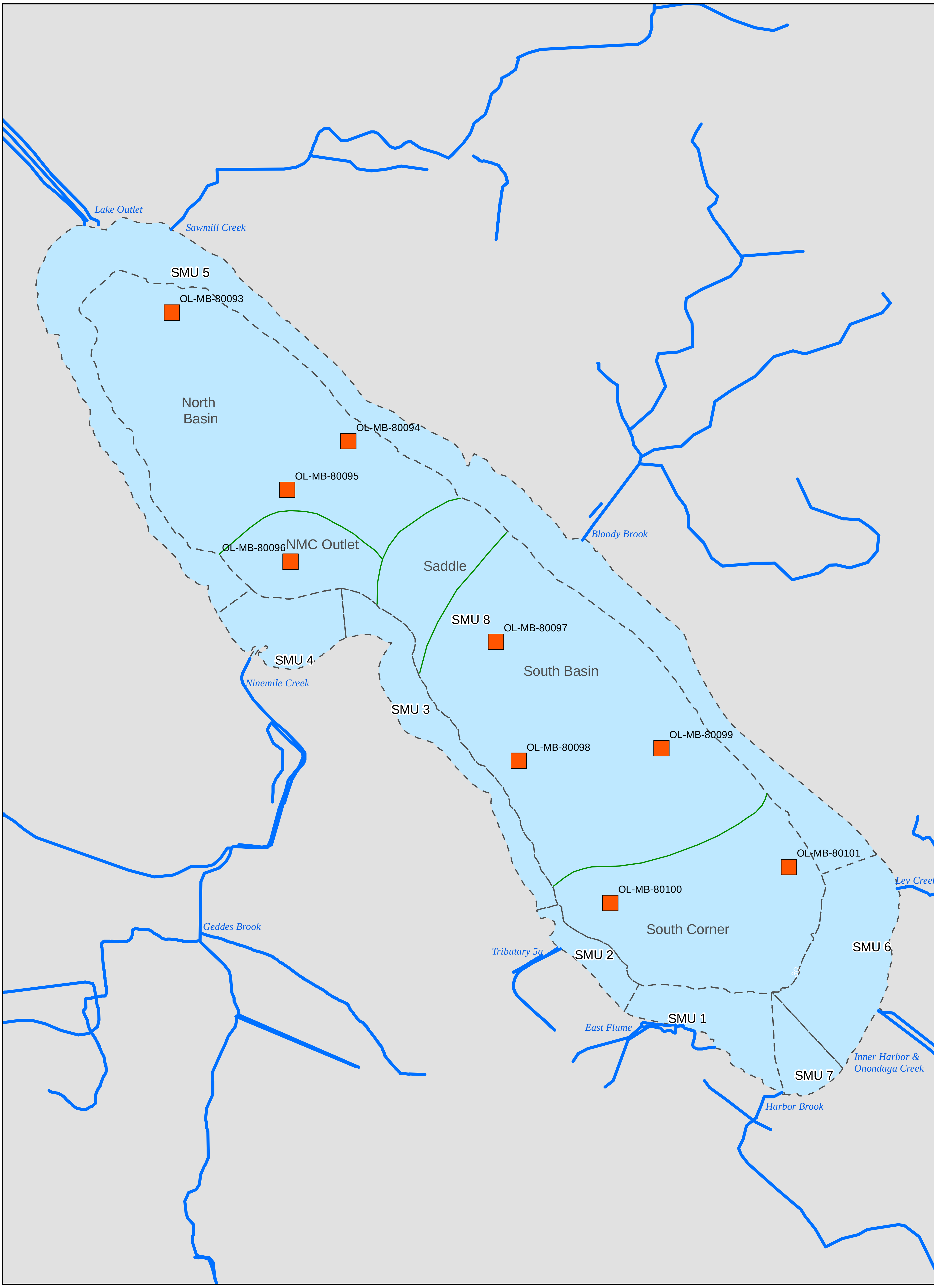
Notes:
1. Results presented as a percent of total material within the interval.
2. All samples suitable for use in assesing marker presence
4. NS = Not Sampled
5. * denotes duplicate sample

NOTE:

The silt marker subsampling procedure used in 2009 was replaced in 2012 with a core freezing method described in Appendix E. Frozen cores visually show varves or layers in sediment that preclude the value of analyzing subsamples in a laboratory for silt marker extent based on fluorescence.

Marker material carried into lower sections as a result of sub-sampling, if counted, would indicate more vertical mixing than is shown when implementing the frozen core method (see Appendix F).

FIGURES



Q:\GIS\GIS_Lake\SMU8\microbeads\microbeads_overview_sample_map.mxd

LOCATIONS

Microbead Plot Locations

NYSDEC Demarcation for SMU 8

0 750 1,500 3,000 4,500 6,000
Feet

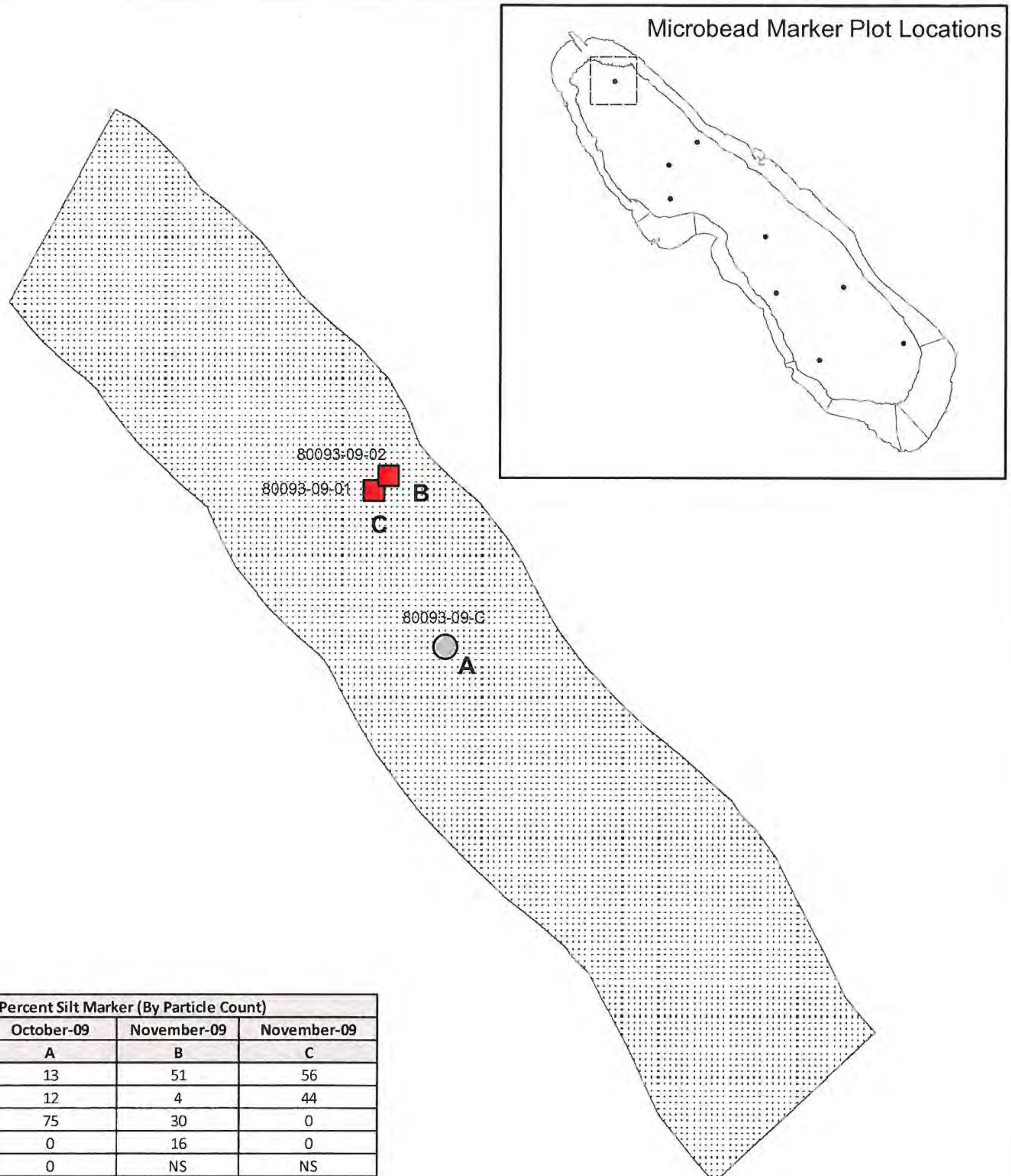
FIGURE 1

Honeywell

Onondaga Lake
Syracuse, New York

Tracer Placement
Plot Locations

PARSONS



Percent Silt Marker (By Particle Count)			
	October-09	November-09	November-09
Depth (cm)	A	B	C
0-1	13	51	56
1-2	12	4	44
2-3	75	30	0
3-4	0	16	0
4-5	0	NS	NS
5-6	0	NS	NS

Notes:
1- Tracer results presented as a percent of total silt marker within the interval.
2- NS = Not Sampled

User: 40189
Date Revised: 9/24/2014 11:37:31 AM
Path: Q:\GIS\GIS_Lake\SMU8\MXDs\2014\microbeads-80093.mxd

Post Placement Sample Locations

- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

N

1 inch = 10 feet

0 2.5 5 10

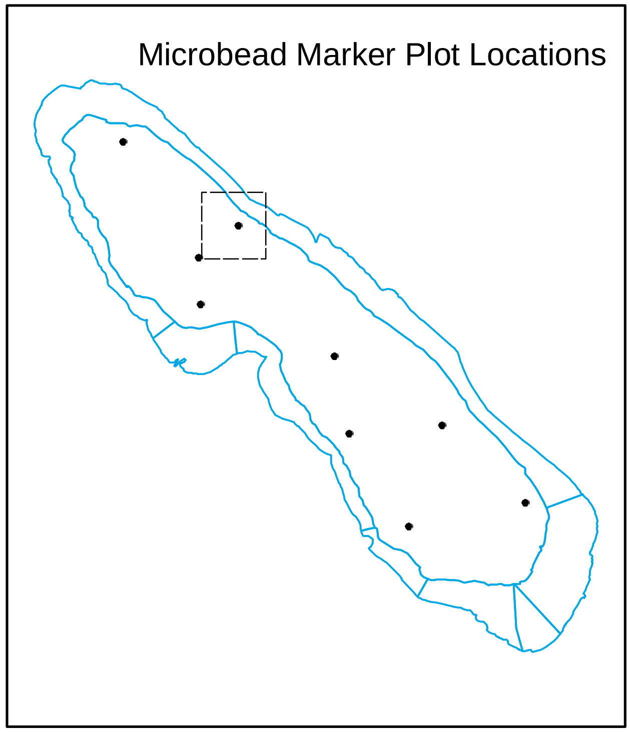
Feet

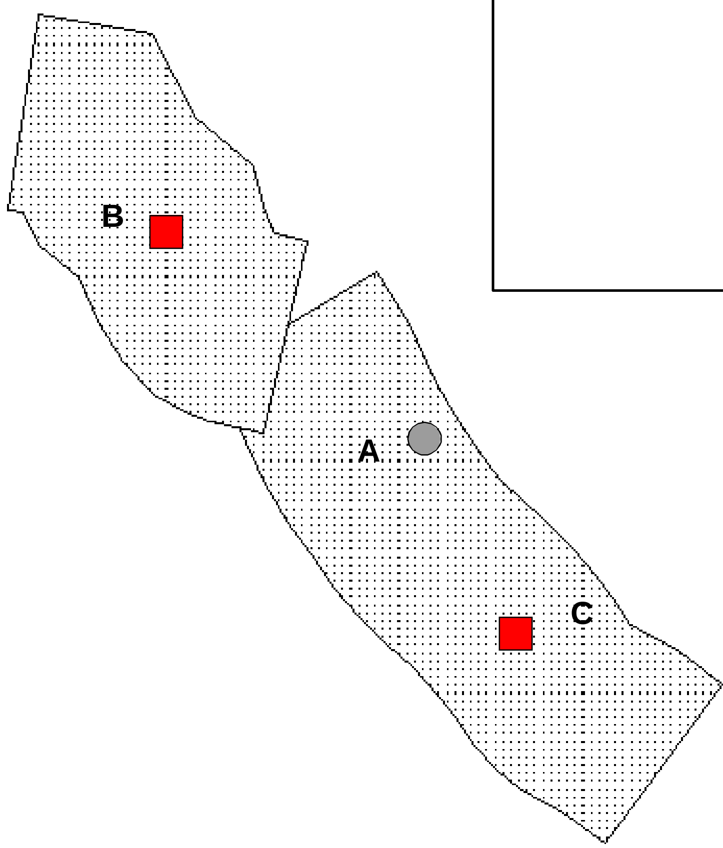
FIGURE 2

MICROBEAD PLOT 80093

Honeywell
Onondaga Lake
Syracuse, New York

PARSONS
301 Plainfield Road, Suite 350; Syracuse, NY 13212





Percent Silt Marker (By Particle Count)			
Depth (cm)	October 2009	November 2009	November 2009
	A	B	C
0-1	98	68	100
1-2	1	32	0
2-3	0	0	0
3-4	0	0	0
4-5	0	NS	NS
5-6	0	NS	NS
6-7	0	NS	NS

POST PLACEMENT 2009 SAMPLE LOCATIONS

- October 2009 Sample Location
- November 2009 Sample Location
- Microbead Placement Area

NOTES

1. Tracer results presented as a percent of total silt marker within the interval.
2. NS = not sampled.

0 5 10 20

Feet

1 inch = 15 feet

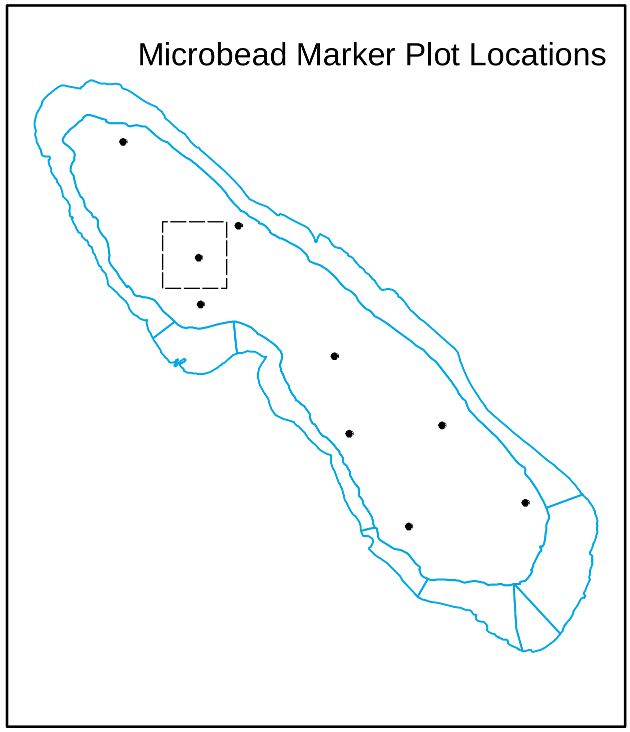
FIGURE 3

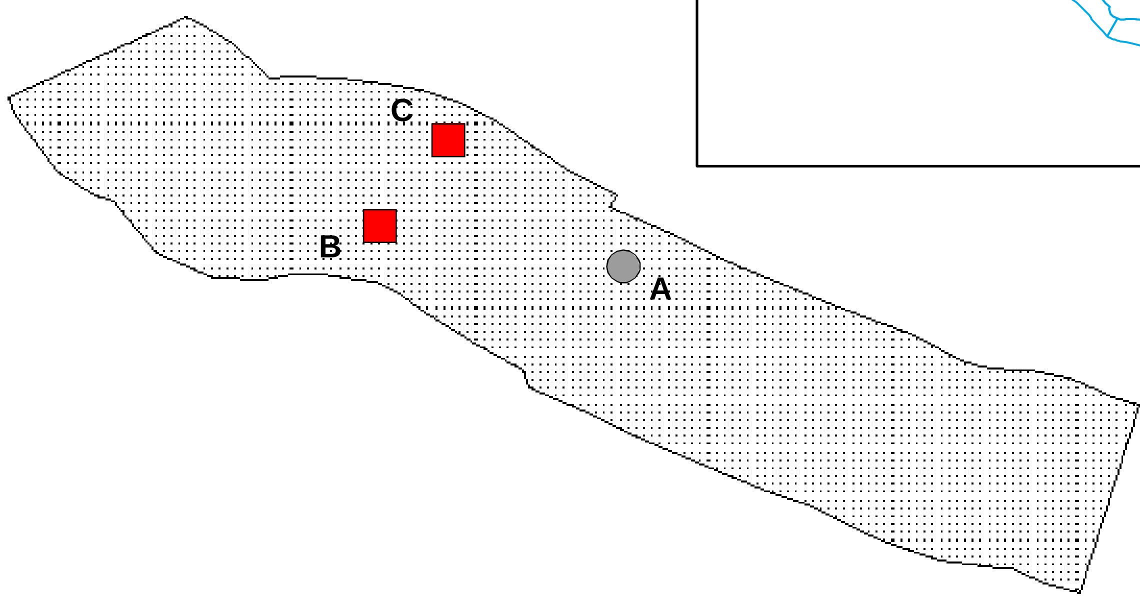
MICROBEAD PLOT 80094

Honeywell

PARSONS

Onondaga Lake
Syracuse, New York





Percent Silt Marker (By Particle Count)			
Depth (cm)	October 2009 A	November 2009 B	November 2009 C
0-1	87	100	100
1-2	10	0	0
2-3	3	0	0
3-4	0	0	0

POST PLACEMENT 2009 SAMPLE LOCATIONS

- October 2009 Sample Location
- November 2009 Sample Location
- Microbead Placement Area

NOTES

1. Tracer results presented as a percent of total silt marker within the interval.
2. NS = not sampled.

0 5 10 20
Feet
1 inch = 15 feet

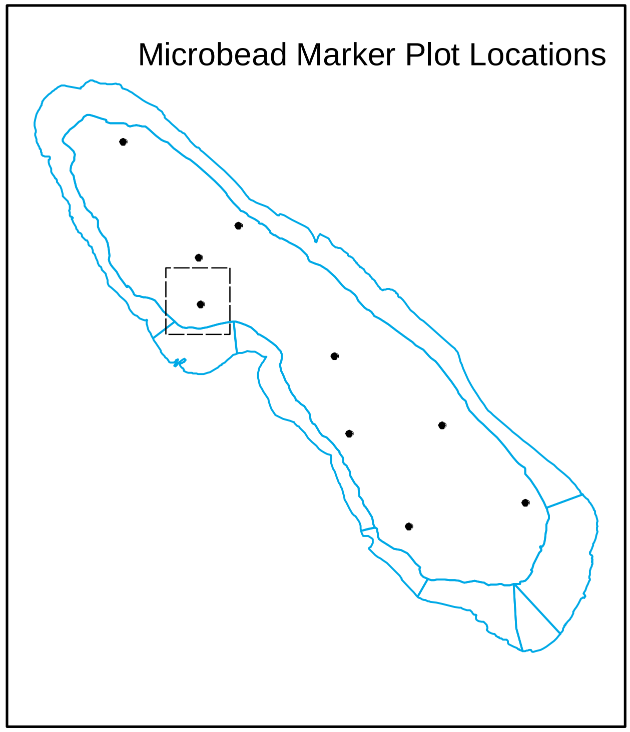
FIGURE 4

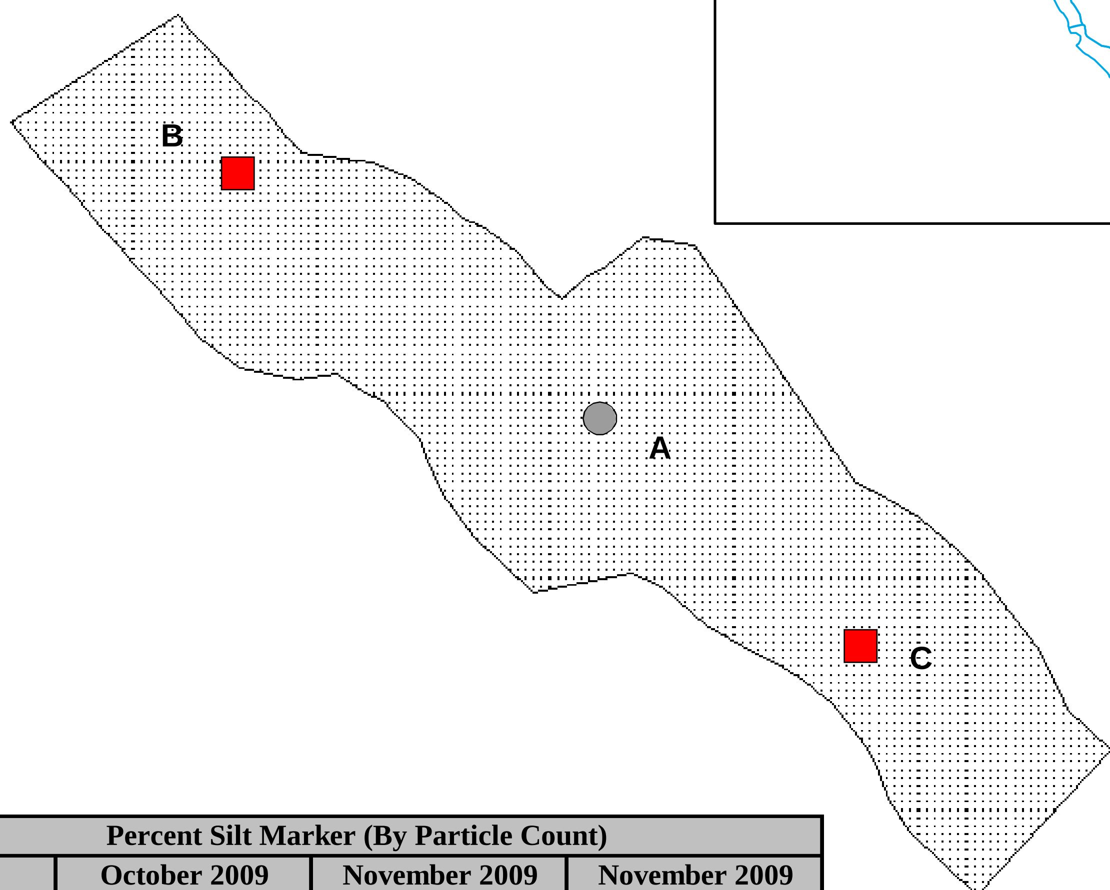
MICROBEAD PLOT 80095

Honeywell

PARSONS

Onondaga Lake
Syracuse, New York





Percent Silt Marker (By Particle Count)			
Depth (cm)	October 2009	November 2009	November 2009
	A	B	C
0-1	98	17	69
1-2	2	13	13
2-3	1	68	18
3-4	0	2	0
4-5	NS	0	NS

POST PLACEMENT 2009 SAMPLE LOCATIONS

- October 2009 Sample Location
- November 2009 Sample Location
- Microbead Placement Area

NOTES

1. Tracer results presented as a percent of total silt marker within the interval.
2. NS = not sampled.

0 5 10 20

Feet

1 inch = 15 feet

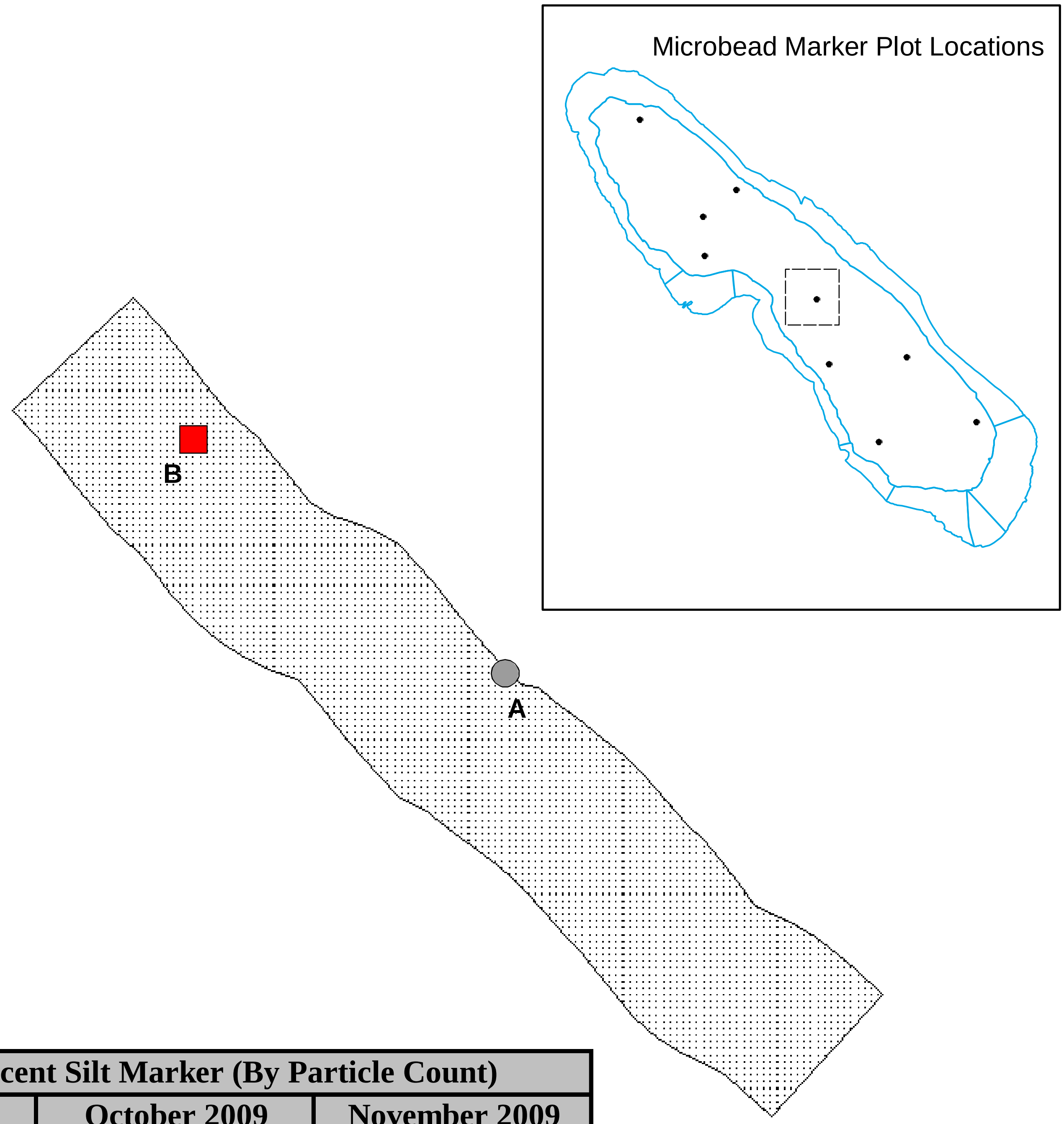
FIGURE 5

MICROBEAD PLOT 80096

Honeywell

PARSONS

Onondaga Lake
Syracuse, New York



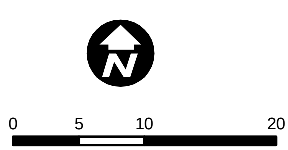
Percent Silt Marker (By Particle Count)		
Depth (cm)	October 2009	November 2009
	A	B
0-1	100	100
1-2	0	0
2-3	0	0
3-4	0	NS

POST PLACEMENT 2009 SAMPLE LOCATIONS

- October 2009 Sample Location
- November 2009 Sample Location
- Microbead Placement Area

NOTES

1. Tracer results presented as a percent of total silt marker within the interval.
2. NS = not sampled.



1 inch = 15 feet

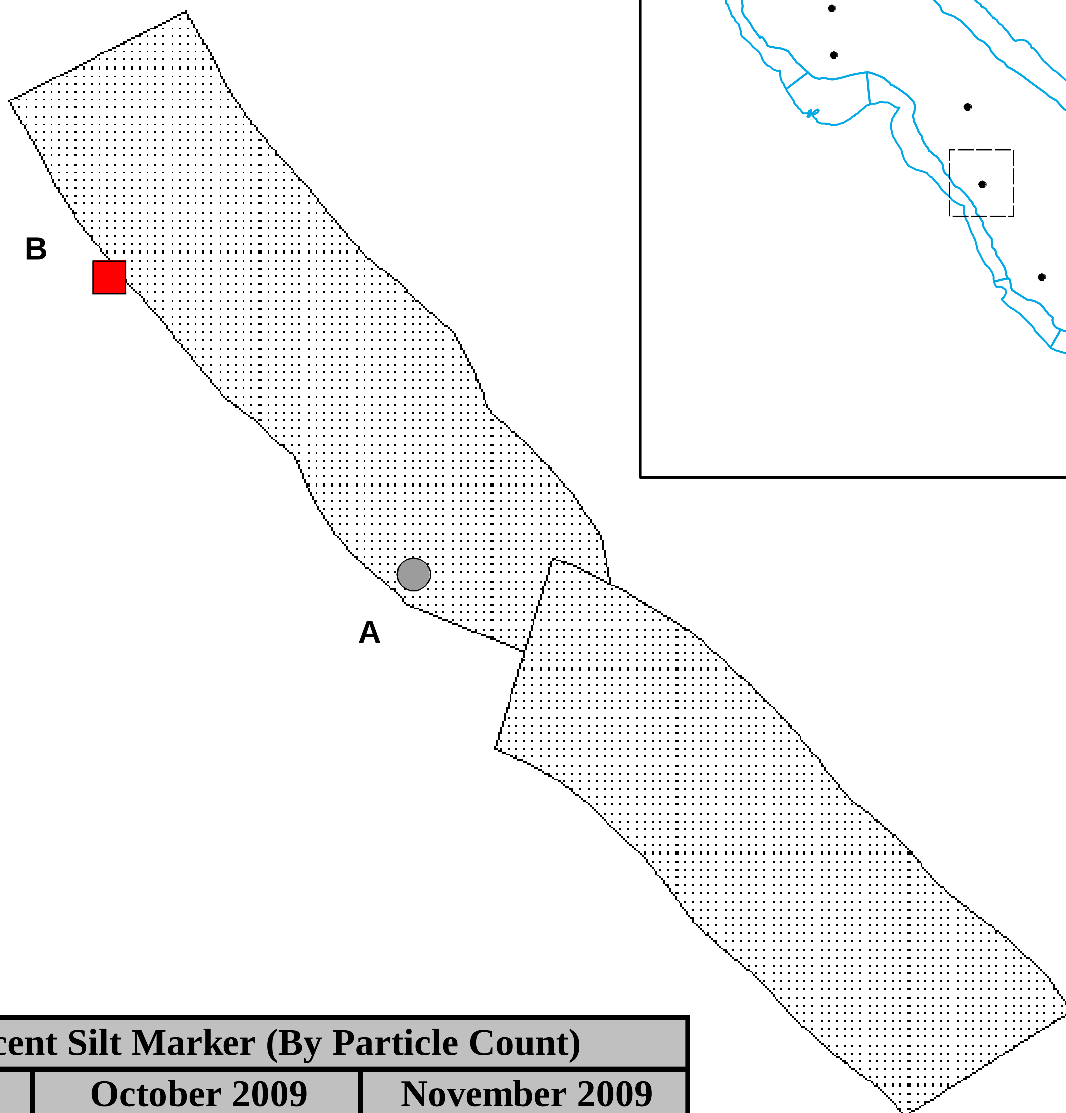
FIGURE 6

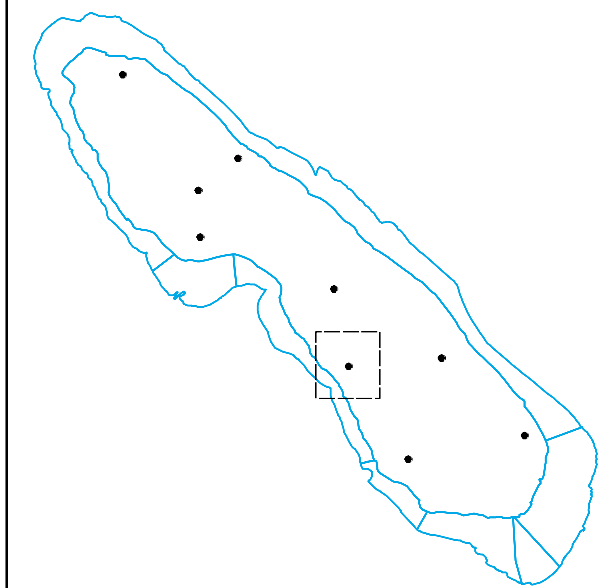
MICROBEAD PLOT 80097

Honeywell

PARSONS

Onondaga Lake
Syracuse, New York





Percent Silt Marker (By Particle Count)		
Depth (cm)	October 2009	November 2009
	A	B
0-1	99	100
1-2	1	0
2-3	1	0
3-4	0	0
4-5	NS	0

POST PLACEMENT 2009 SAMPLE LOCATIONS

- October 2009 Sample Location
- November 2009 Sample Location
- Microbead Placement Area

NOTES

1. Tracer results presented as a percent of total silt marker within the interval.
2. NS = not sampled.

N

0 5 10 20

Feet

1 inch = 15 feet

FIGURE 7

MICROBEAD PLOT 80098

Honeywell

PARSONS

Onondaga Lake
Syracuse, New York

Path: Q:\GIS\GIS_Lake\SMU8\MXDs\2014\microbeads-80099.mxd Date Revised: 9/24/2014 2:51:04 PM User: 40189

Percent Silt Marker (By Particle Count)		
	October-09	November-09
Depth (cm)	A	B
0-1	37	100
1-2	37	0
2-3	26	0
3-4	0	0
4-5	NS	0

Notes:
1- Tracer results presented as a percent of total silt marker within the interval.
2- NS = Not Sampled

Post Placement Sample Locations

- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

N

1 inch = 10 feet

0 2.5 5 10

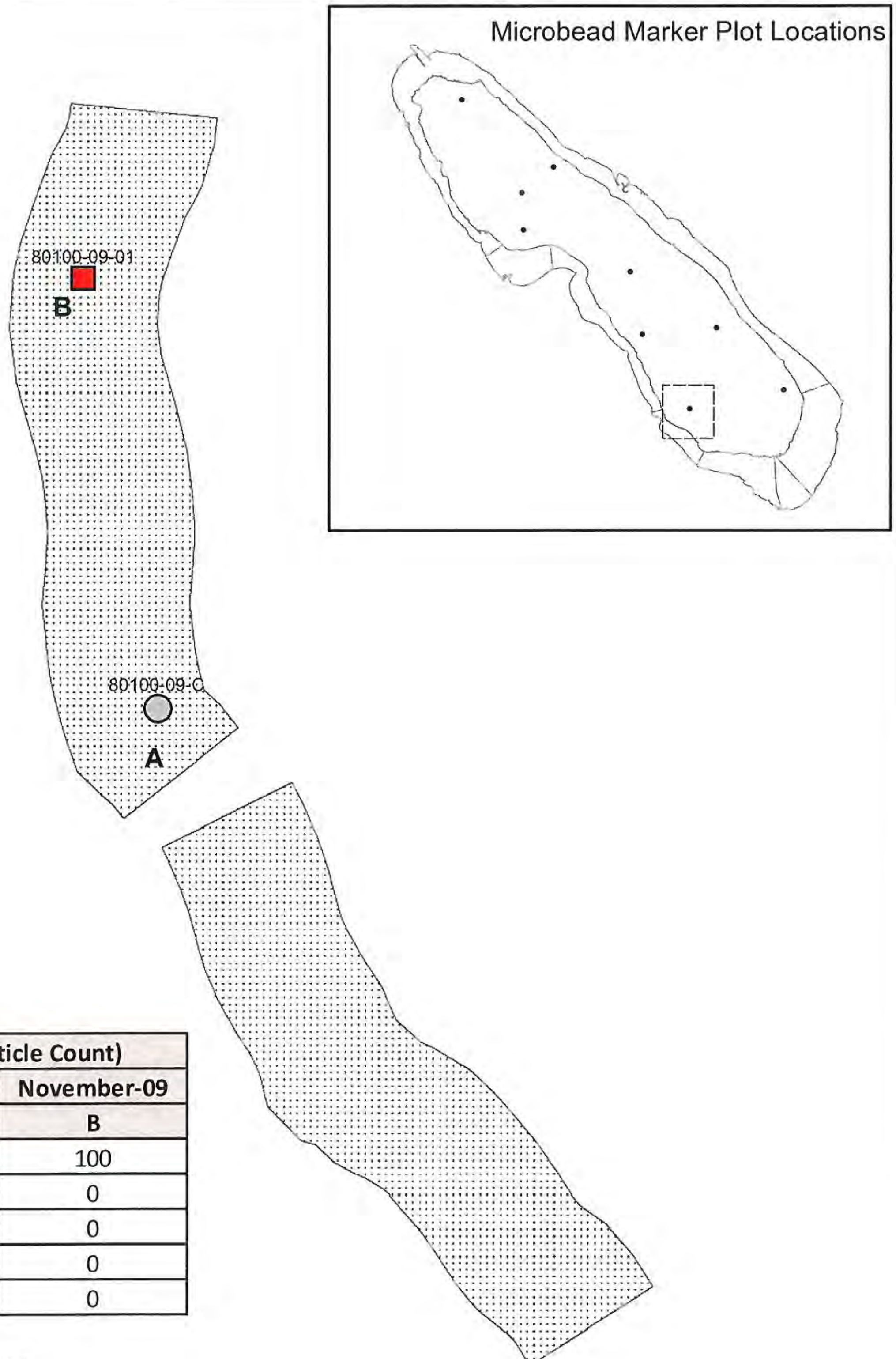
Feet

FIGURE 8

MICROBEAD PLOT 80099

Honeywell Onondaga Lake Syracuse, New York

PARSONS
301 Plainfield Road, Suite 350; Syracuse, NY 13212



Percent Silt Marker (By Particle Count)		
	October-09	November-09
Depth (cm)	A	B
0-1	93	100
1-2	4	0
2-3	3	0
3-4	0	0
4-5	NS	0

Notes:
1- Tracer results presented as a percent of total silt marker within the interval.
2- NS = Not Sampled

Path: Q:\GIS\GIS_Lake\SMU8\MXDs\2014\microbeads-80100.mxd   Date Revised: 9/25/2014 10:32:40 AM   User: 40189

Post Placement Sample Locations

- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

N

1 inch = 17 feet

0 4.25 8.5 17
Feet

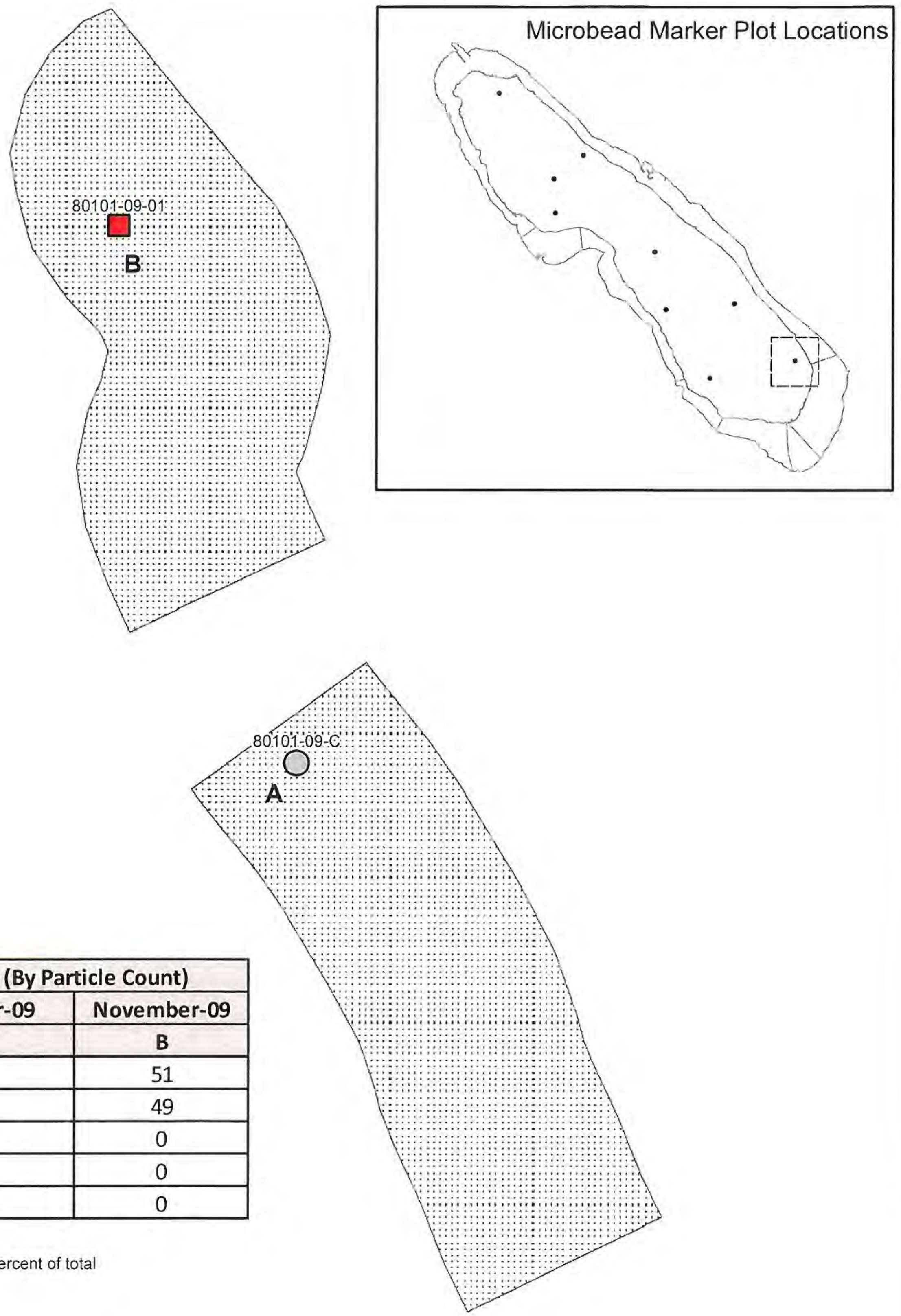
FIGURE 9

MICROBEAD PLOT 80100

Honeywell Onondaga Lake Syracuse, New York

PARSONS
301 Plainfield Road, Suite 350; Syracuse, NY 13212

Path: Q:\GIS\GIS_Lake\SMU8\MXDs\2014\microbeads-80101.mxd Date Revised: 9/24/2014 11:33:58 AM User: 40189



Percent Silt Marker (By Particle Count)		
	October-09	November-09
Depth (cm)	A	B
0-1	99	51
1-2	1	49
2-3	0	0
3-4	0	0
4-5	NS	0

Notes:
1- Tracer results presented as a percent of total silt marker within the interval.
2- NS = Not Sampled

Post Placement Sample Locations

- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

1 inch = 10 feet

0 2.5 5 10

Feet

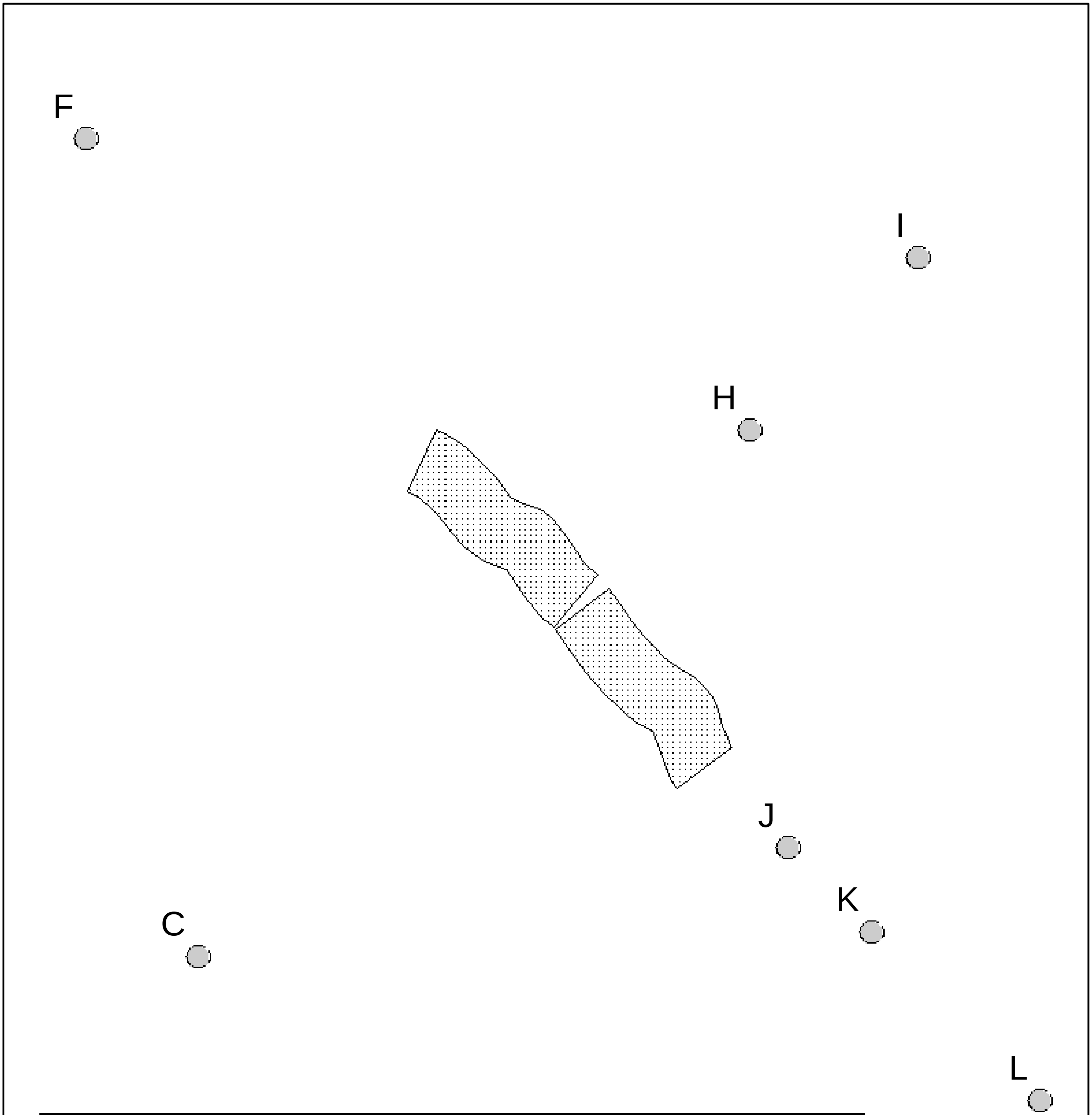
FIGURE 10

MICROBEAD PLOT 80101

Honeywell Onondaga Lake Syracuse, New York

PARSONS

301 Plainfield Road, Suite 350; Syracuse, NY 13212



Counts Silt Marker (Per Top 2 cm)							
Depth (cm) / Location	C	F	H	I	J	K	L
0-2 cm	<1	861	<1	<1	<1	<1	1.9

POST PLACEMENT 2009 SAMPLE LOCATIONS

- October 2009 Sample Location

0 10 20 40
Feet
1 inch = 30 feet

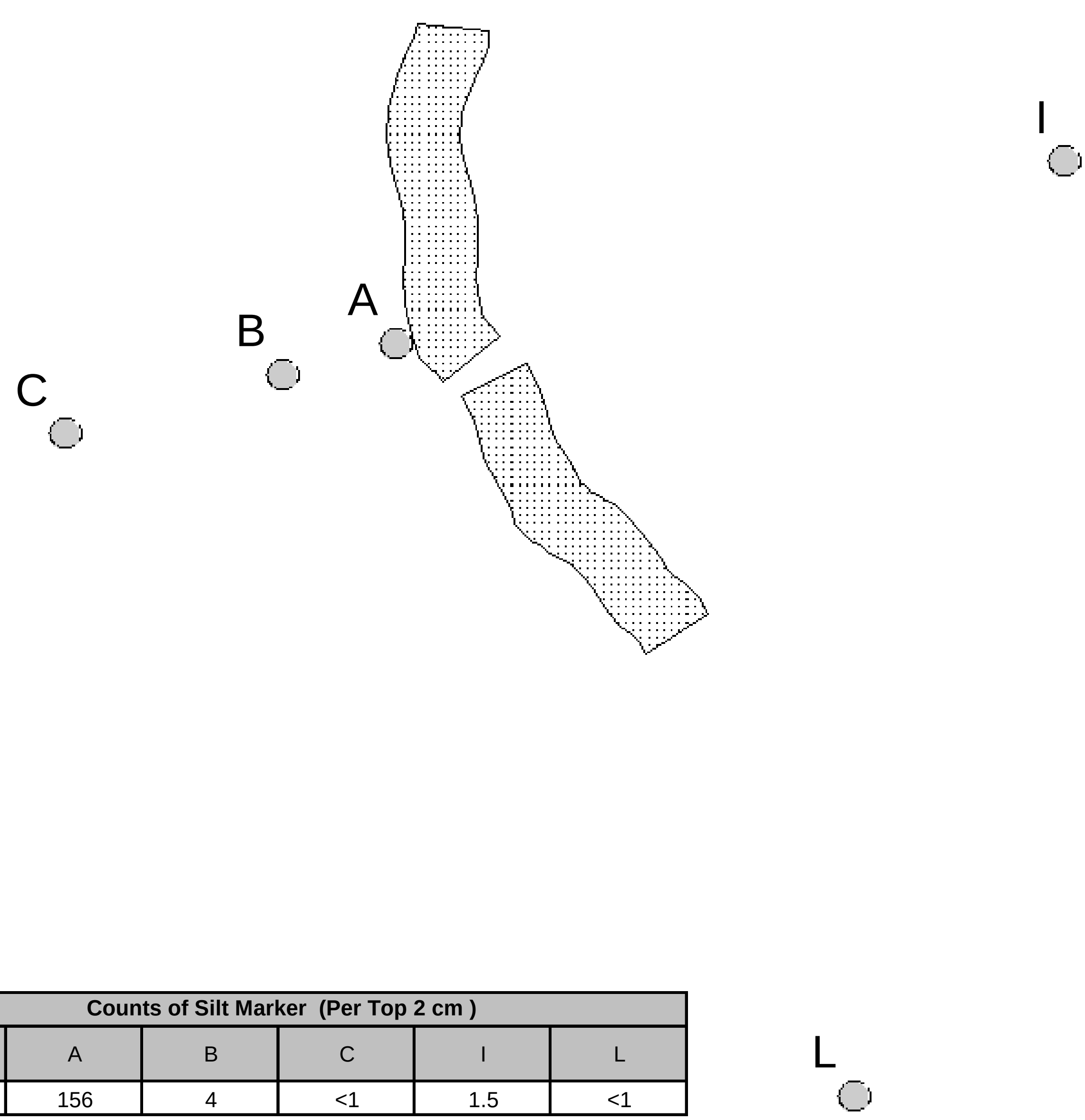
FIGURE 11

PLOT 80099
VICINITY SAMPLE RESULTS

Honeywell

PARSONS

Onondaga Lake
Syracuse, New York



Counts of Silt Marker (Per Top 2 cm)					
Depth (cm) / Location	A	B	C	I	L
0-2 cm	156	4	<1	1.5	<1

POST PLACEMENT 2009 SAMPLE LOCATIONS

● October 2009 Sample Location

NOTES
1. Tracer results presented as a percent of total silt marker within the interval.
2. NS = not sampled.

0 12.5 25 50
Feet
1 inch = 38 feet

FIGURE 12
PLOT 80100
VICINITY SAMPLE RESULTS

Honeywell

PARSONS

Onondaga Lake
Syracuse, New York

APPENDIX A

PHOTOS OF EQUIPPED BARGE AND DOSING BARS

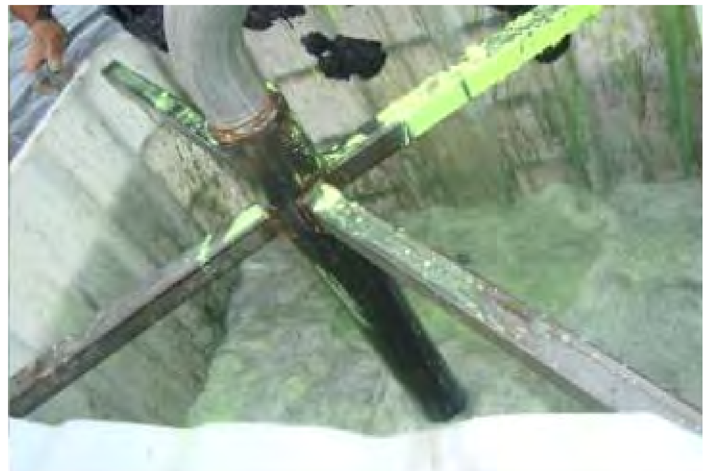
APPENDIX A

PHOTOS OF EQUIPPED BARGE AND DOSING BARS

Barge was positioned using four concrete block anchors that were placed at 45 degree angles from each corner of the plot area and approximately 300 ft. from the center of the plot.

Microbead material and native sediments from SMU 8 were slurried.

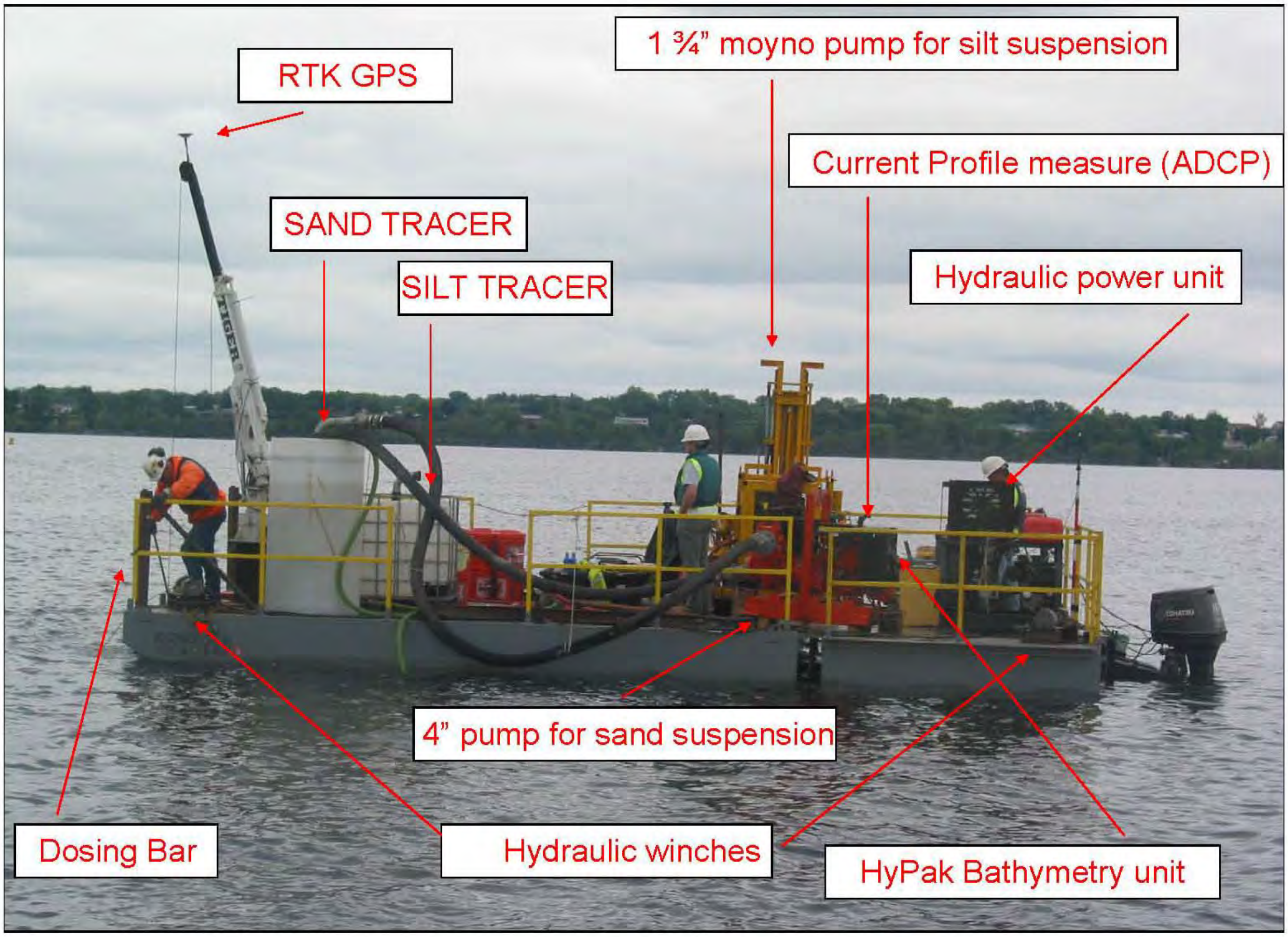
Silt Marker A slurry:



Sand Marker B slurry:

Microbead material was pumped to two horizontal dosing bars.

Final barge configuration



SMU 8 sediments were sampled with a gravity corer.

APPENDIX B

SOPS FOR SEDIMENT SAMPLING AND SEDIMENT PROCESSING FOR MICROBEAD PLACEMENT AREAS

APPENDIX B

STANDARD OPERATING PROCEDURE (SOP) FOR SMU 8 SEDIMENT CORE SAMPLING AND PROCESSING FROZEN CORES

B.1 SMU 8 SEDIMENT SAMPLING PROCEDURE

After assessing numerous types of sediment cores for SMU 8 microbead-related sampling work, a gravity corer was selected and used as the optimum corer to collect sediment samples from the upper few inches of SMU 8 sediment for microbead placement analyses. The selected gravity corer is manufactured by Eijkelkamp Agrisearch Equipment BV (located in The Netherlands), and pre-tested extensively by Parsons in SMU 8 during 2009. The gravity corer consists of a frame with strengthening ribs, falling weight and sampler. This corer was selected due to its ability to collect samples without disturbing the surficial layers.

The gravity corer collects sediment samples approximately 3.0 inches in diameter that are undisturbed. Weights can be placed over the gravity corer as needed to improve penetration into the sediment. Using a hoisting unit on board of a boat the sampler can be lowered in free fall. By its own weight and velocity, the apparatus penetrates the submerged soil. The depth of penetration is in part determined by the composition of the submerged soil.

While handling the corer, the user should wear leather or canvas gloves to minimize the potential for cuts or scrapes.

The step-by-step sampling procedure is as follows:

1. Check corer condition prior to each use.
    a. Check that the corer holds water under suction and that the tubes are threaded properly.
2. Measure water depth.
3. Securely attach the corer to a winch with cable or line of sufficient strength to accommodate the weight of the sampler, any additional weights, the sediment to be sampled and the suction of the sediment.
4. Slowly lower the corer using a winch and A-frame or boom arm through a moon pool or over the side of the vessel. Maintain tension on the corer to keep it vertical.
5. Lower the corer by hand to the sediment bed by releasing the marked corer line (1 foot increments) to the corresponding water depth. The corer is specifically designed and balanced to remain vertical while being lowered.
6. After the corer contacts the sediments on the bottom, relax the tension as needed to allow the corer to penetrate into the sediment while remaining in a vertical position.
7. Place tension on the cable or line and very slowly retrieve the corer and sediment sample to avoid any disturbance of the core sample. Before the core tube breaks the water surface, carefully cap the bottom of the core tube..

8. Discard the sample in board containment (i.e., 5 gallon bucket) if sample recovery is lower than approximately 90 percent of the penetration depth or if there is any sign of sample washout. Rejected samples should not be discarded into the lake at any time.
9. Record observations about the suitability of the sample including penetration depth, sample depth, presence of any debris, bubbles, banding and coloring of sediments, or evidence of agitation due to sample collection. Also, record any evidence that the surface sediment is undisturbed and intact (e.g., any different color or texture and corresponding depth). If the sample is collected within a microbead plot, note any visual band of microbeads or spread down the edges, measure any definite band or layer. Take 2-3 digital photographs of the core.
10. Unthread the core from the corer apparatus.
11. Set the corer into a bracket on the boat deck to hold the corer in a stable vertical position.
12. Carefully siphon off excess water and cap the top of each tube while minimizing head space.
13. Wipe the outside of each tube.
14. While maintaining tubes in a vertical position, record any visual variations in sediment characteristics with depth.
15. Seal the top end with cap.
16. Label the outside of each core tube with the sample identification (ID) and core orientation with an up arrow. Also label the top cap with the sample ID.
17. Maintain core in a vertical position while transporting to a processing facility on shore.
18. Decontaminate the corer as needed and discard any excess sample as non-hazardous waste.

If cap material (clean sand from capping operations) is visible in any of the cores, the core location and cap material encountered will be recorded and the core will subsequently be collected at a different location.

B.2 SMU 8 SEDIMENT SAMPLE PROCESSING

During transport, every effort should be made to ensure that each core is not disturbed. Cores should be placed vertically into a cooler and packed with dry ice to freeze the sediment so it can be cut without disturbing the sediment cross section

Once the cores have been completely frozen (generally after 24 hours on dry ice) they are then laid flat into a crib which prevents the cores from moving. Using a reciprocating saw, the cores are cut lengthwise into two cross sections.

The cores should be frozen to a point where it difficult to scrape excess ice off the surface of the exposed cross-section following cutting. A heat source is then used sparingly to melt the ice slightly along the cut surface to allow excess ice to be scraped from the cores using a standard dry wall tapping knife. Following heating and additional scraping, the exposed cross-surfaces of the frozen cores can be visually inspected.

APPENDIX C

PHOTO OF QC CHECK SET UP

APPENDIX C

PHOTO OF QC CHECK SET UP

Step 1:

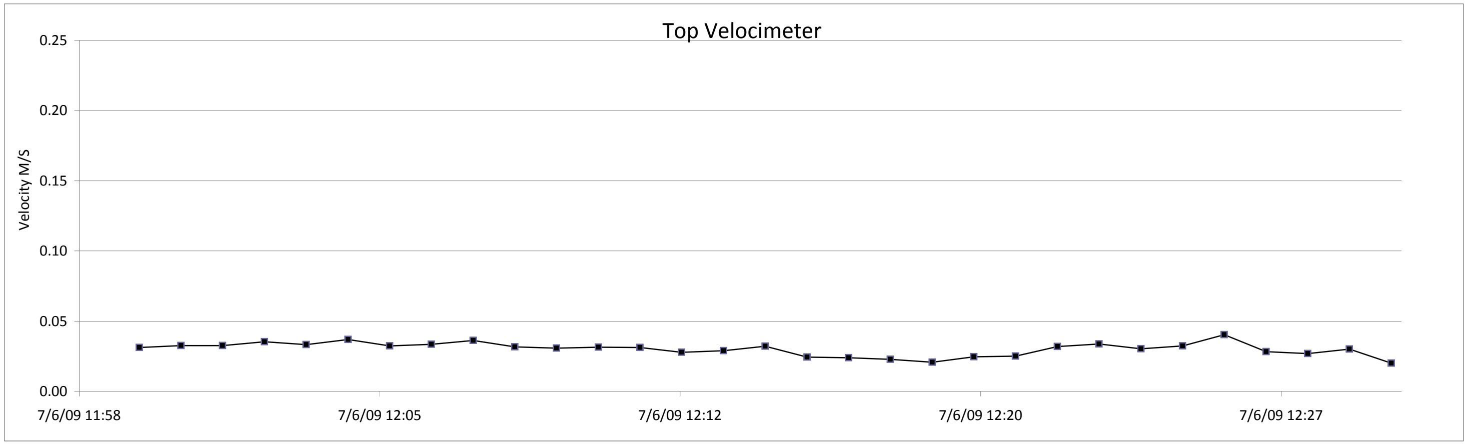
Marker material was mixed with SMU 8 sediment

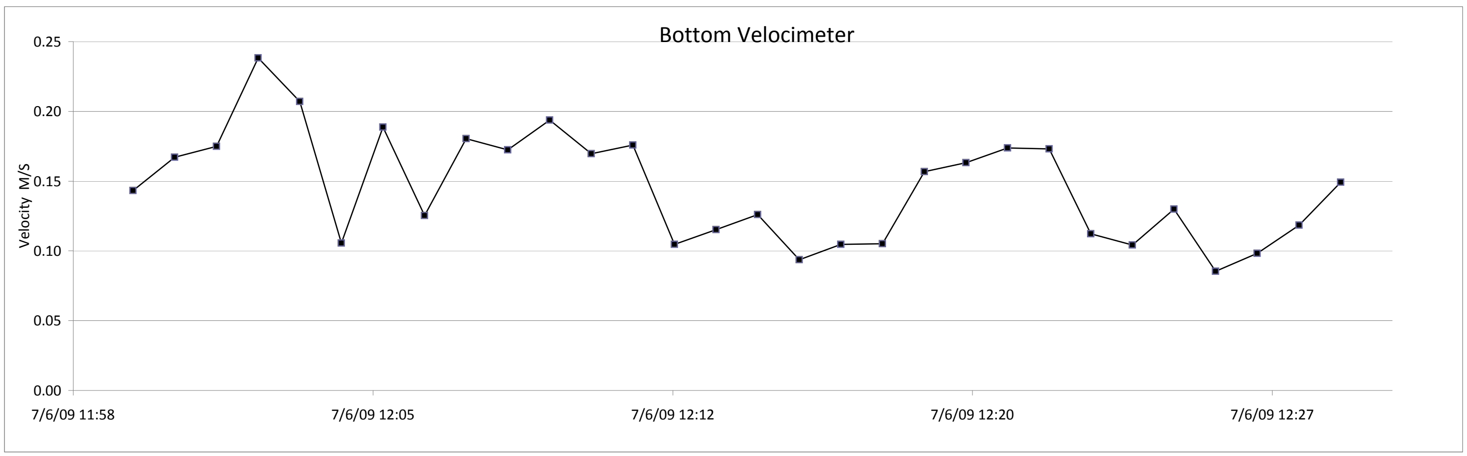
Step 2:

Mixed material was placed in 20 core tubes and allowed to settle.

APPENDIX D

VELOCITY DATA

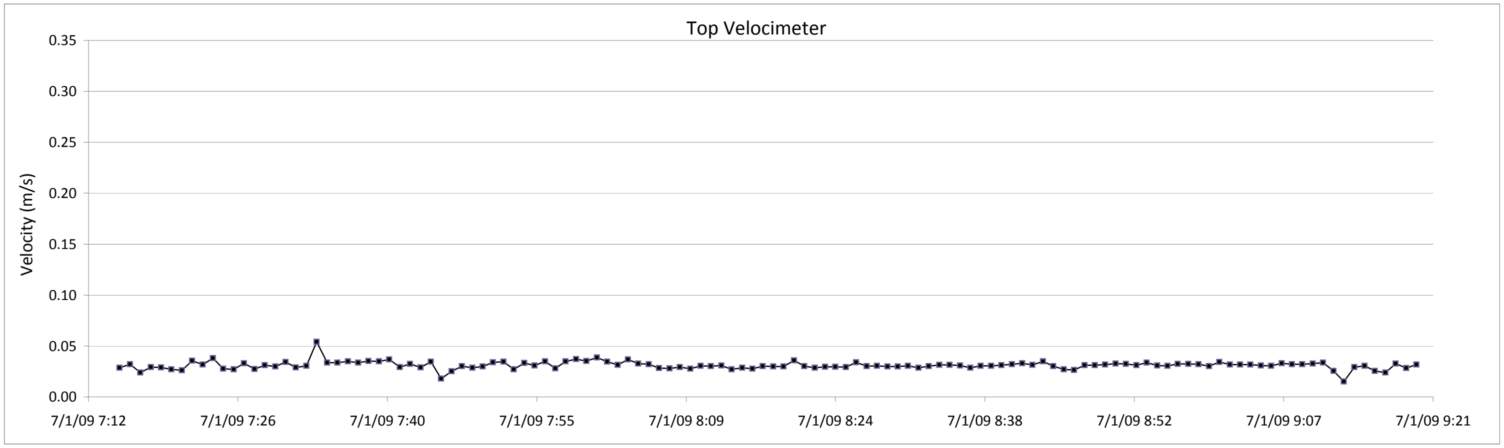


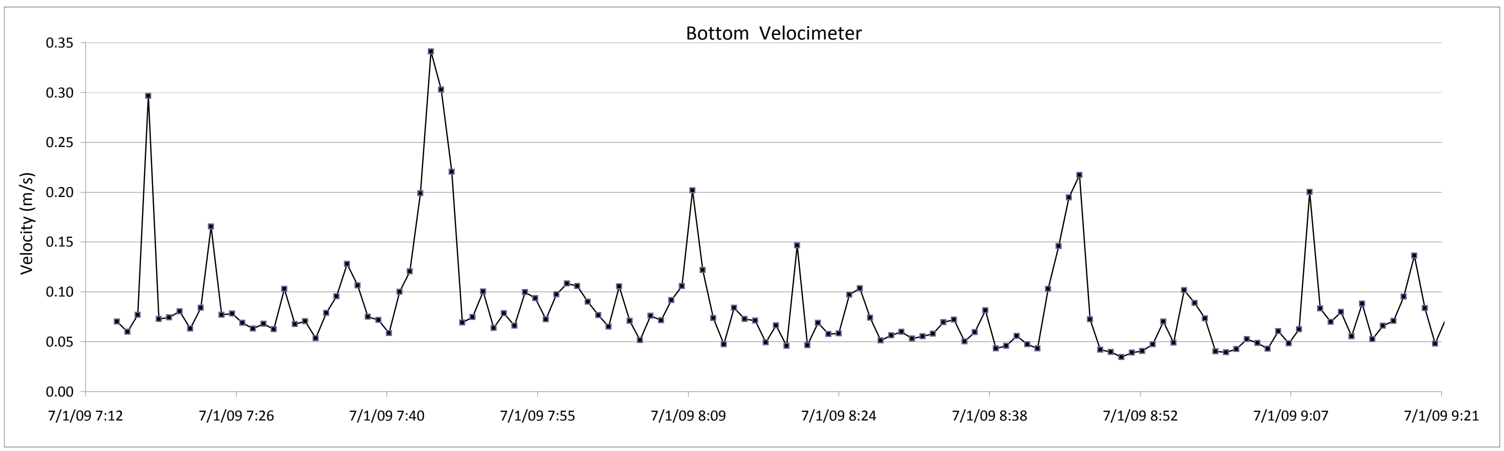


MICROBEAD PLOT 80093

Notes:

1) Data collected using Nortek acoustic doppler velocimeters
2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed
3) Data represents the horizontal components of velocity
4) M/S-meters per second





MICROBEAD PLOT 80094

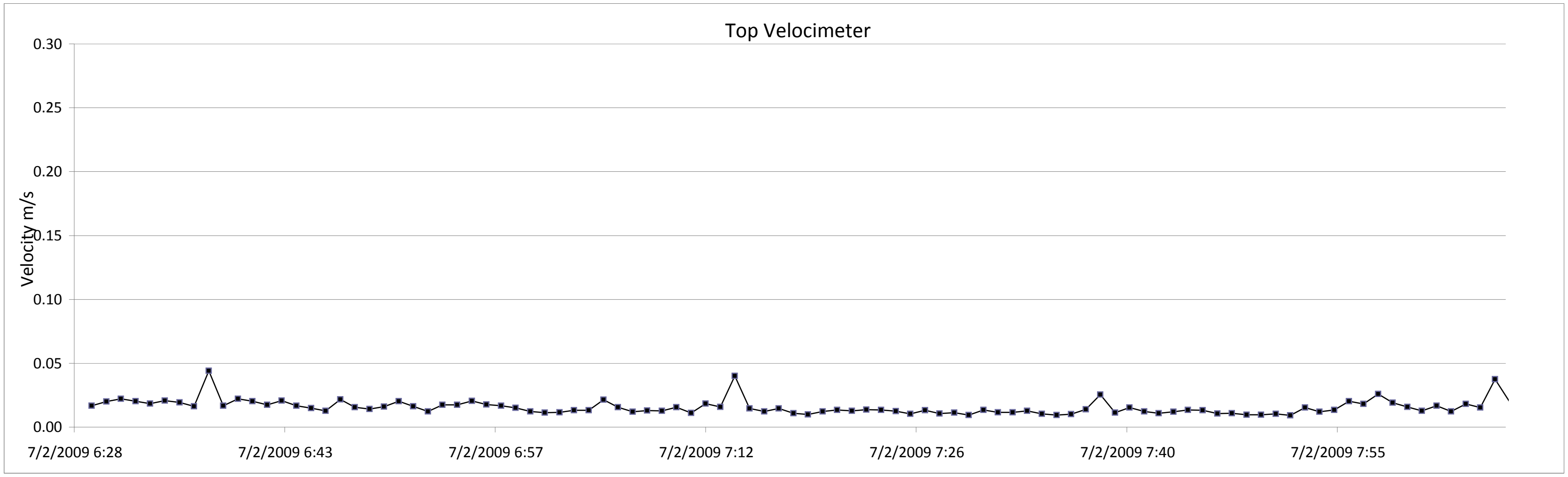
Notes:

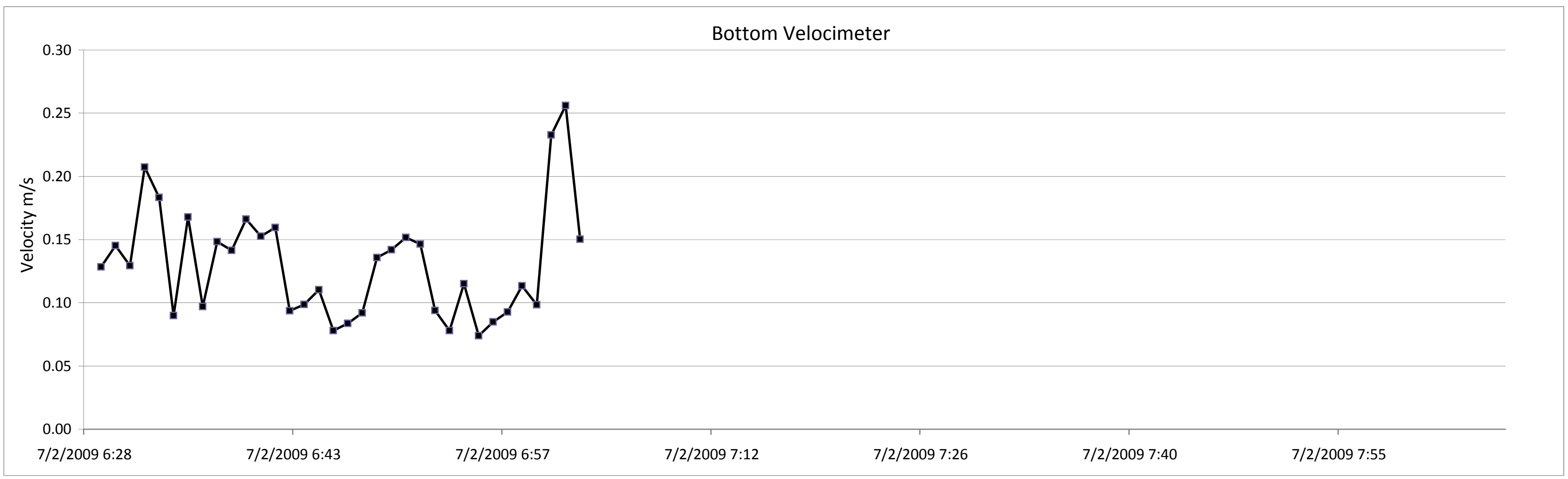
1) Data collected using Nortek acoustic doppler velocimeters

2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed

3) Data represents the horizontal components of velocity

4) M/S-meters per second





MICROBEAD PLOT 80095

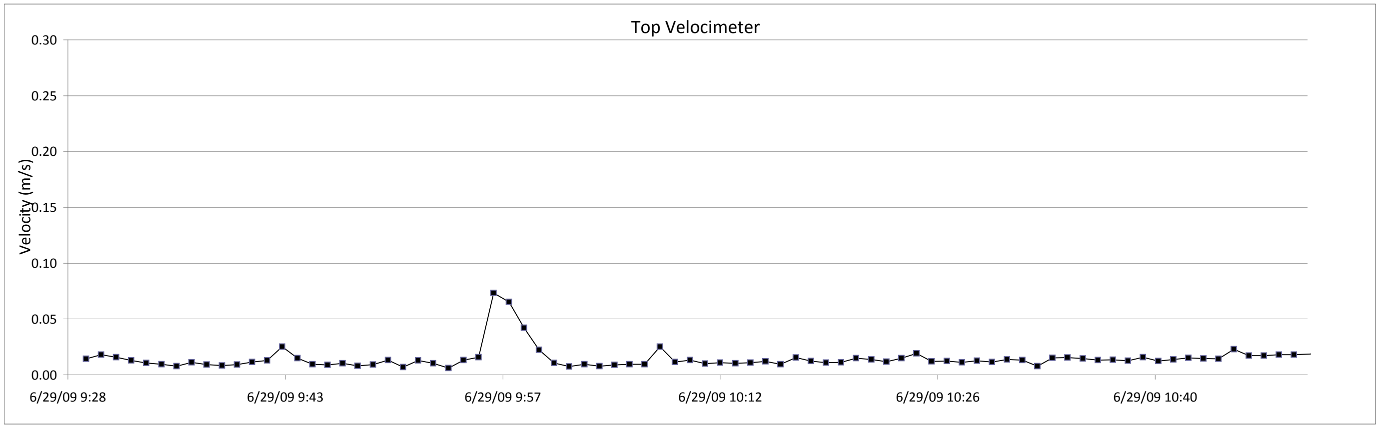
Notes:

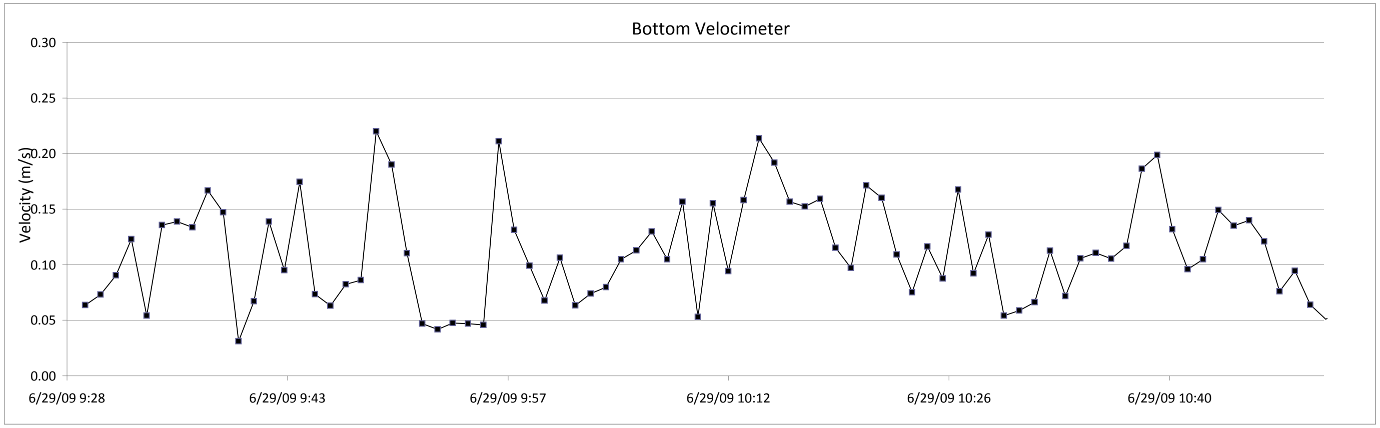
1) Data collected using Nortek acoustic doppler velocimeters

2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed

3) Data represents the horizontal components of velocity

4) M/S-meters per second

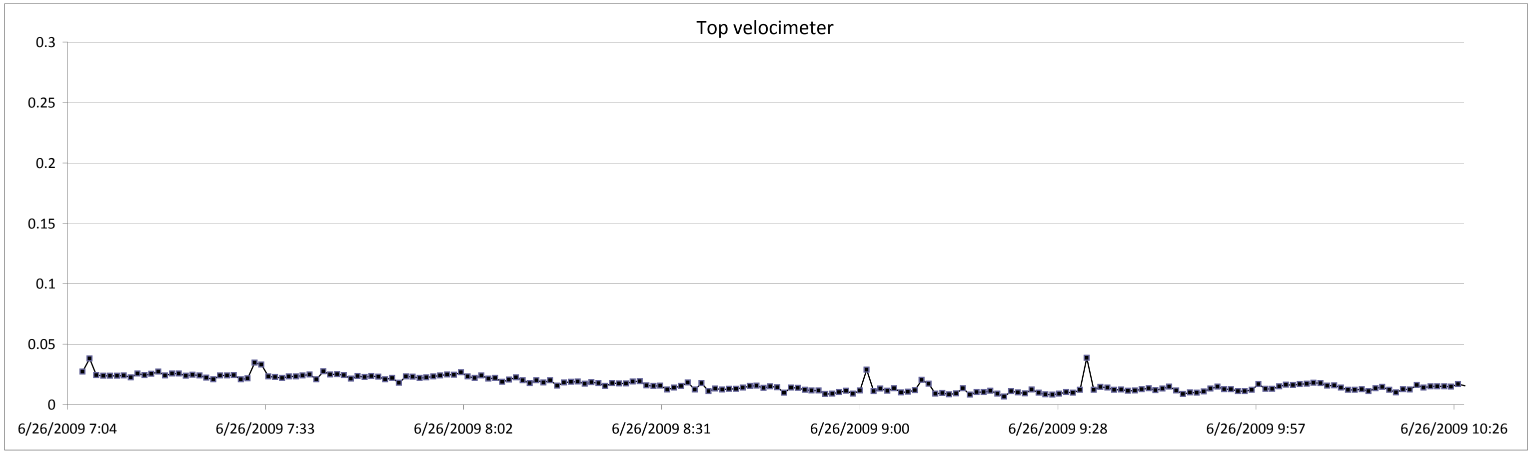


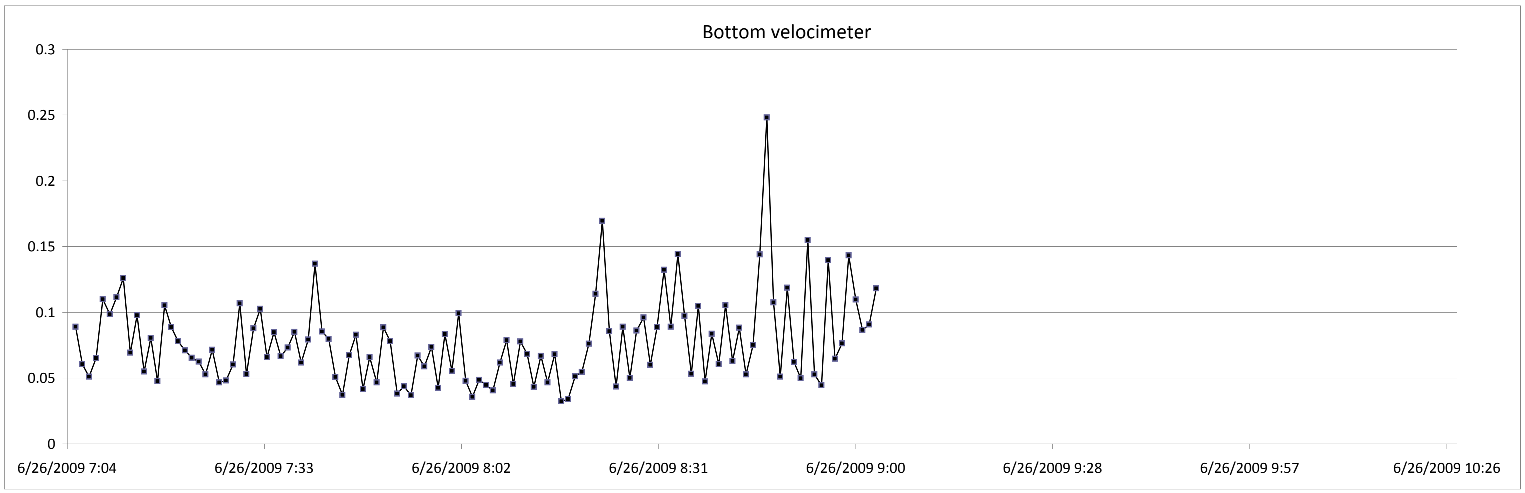


MICROBEAD PLOT 80096

Notes:

1) Data collected using Nortek acoustic doppler velocimeters
2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed
3) Data represents the horizontal components of velocity
4) M/S-meters per second

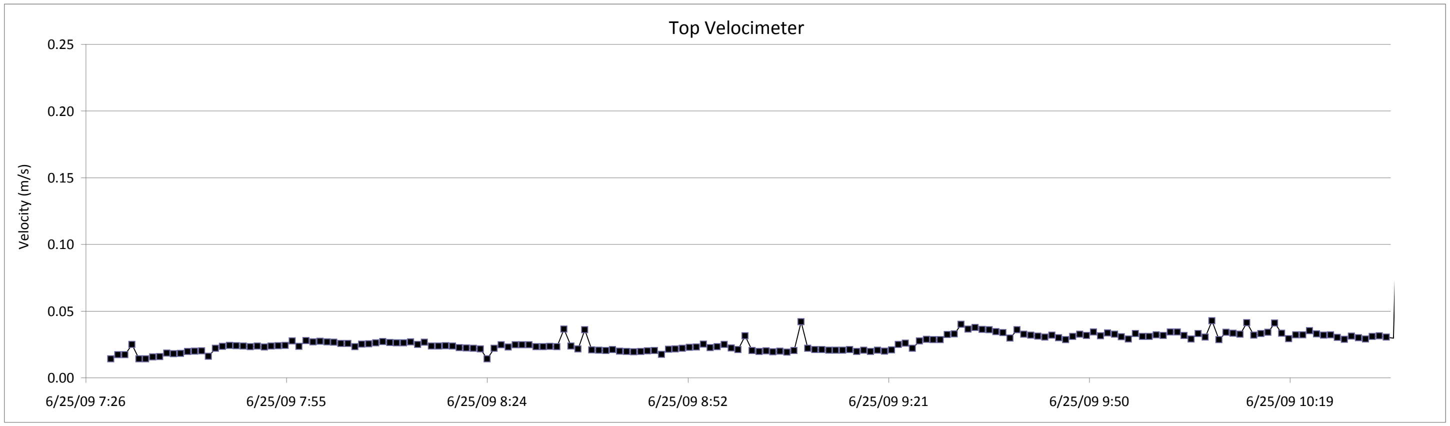


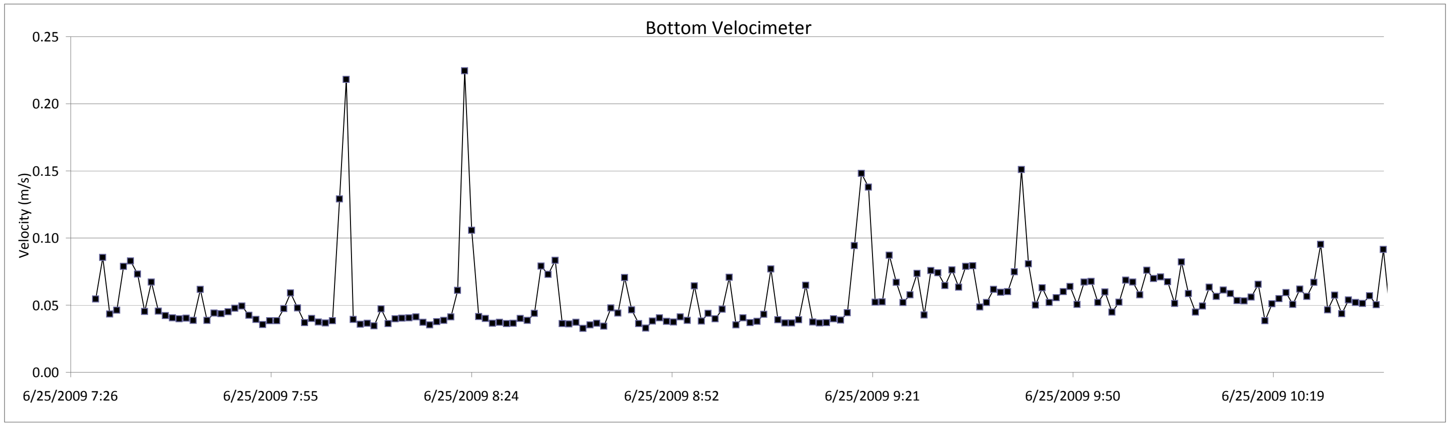


MICROBEAD PLOT 80097

Notes:

1) Data collected using Nortek acoustic doppler velocimeters
2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed
3) Data represents the horizontal components of velocity
4) M/S-meters per second

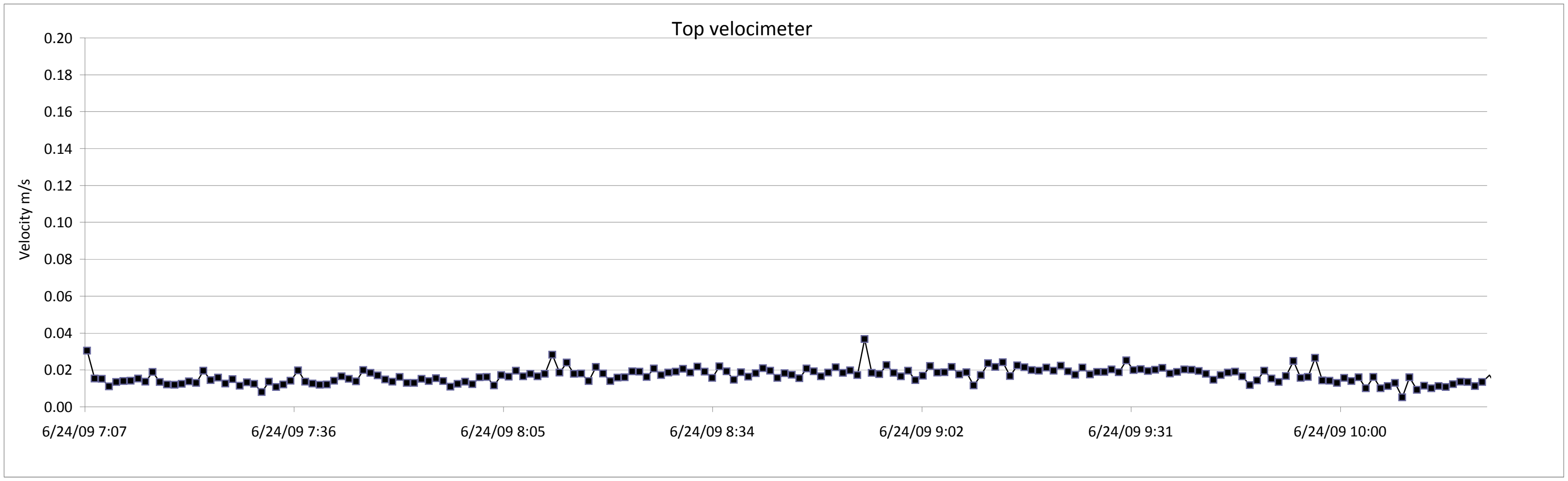


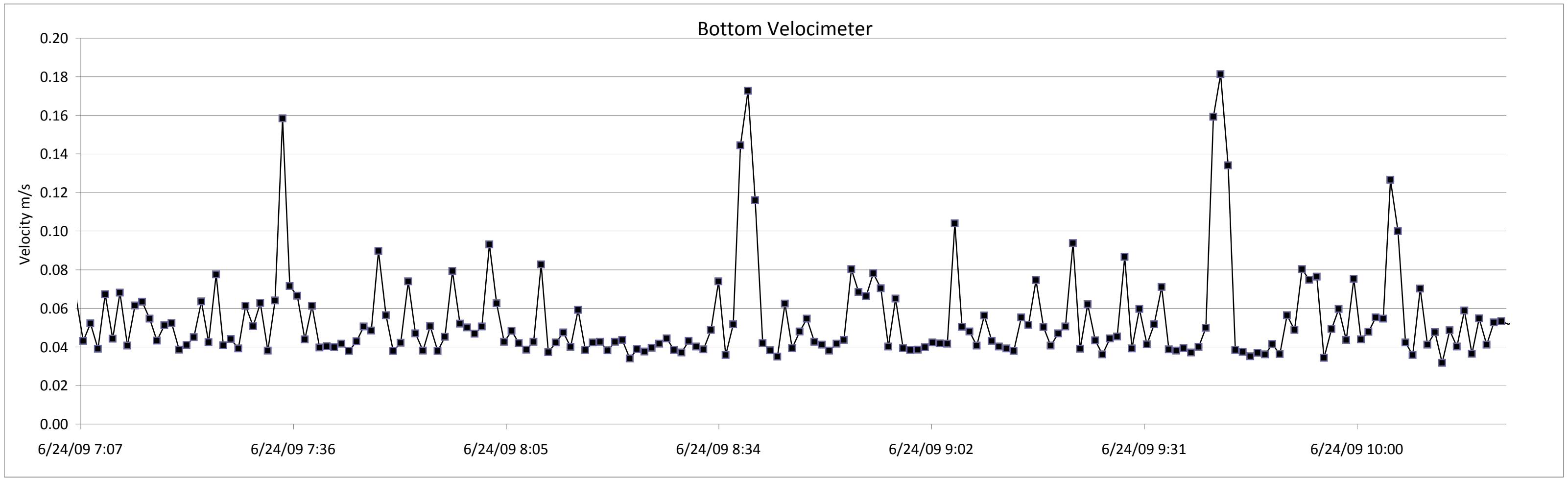


MICROBEAD PLOT 80098

Notes:

1) Data collected using Nortek acoustic doppler velocimeters
2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed
3) Data represents the horizontal components of velocity
4) M/S-meters per second





MICROBEAD PLOT 80099

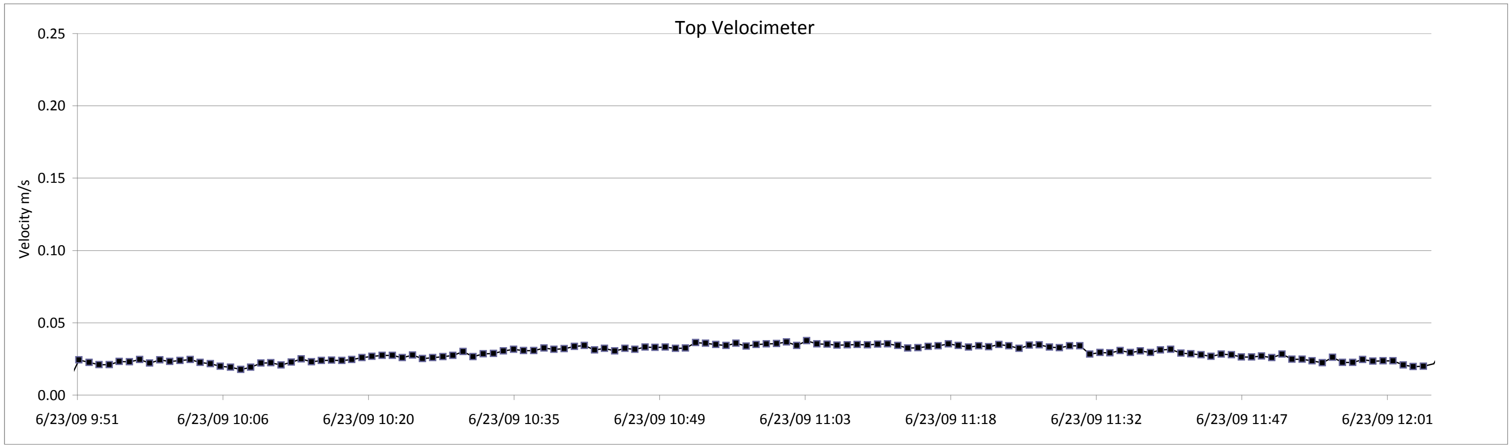
Notes:

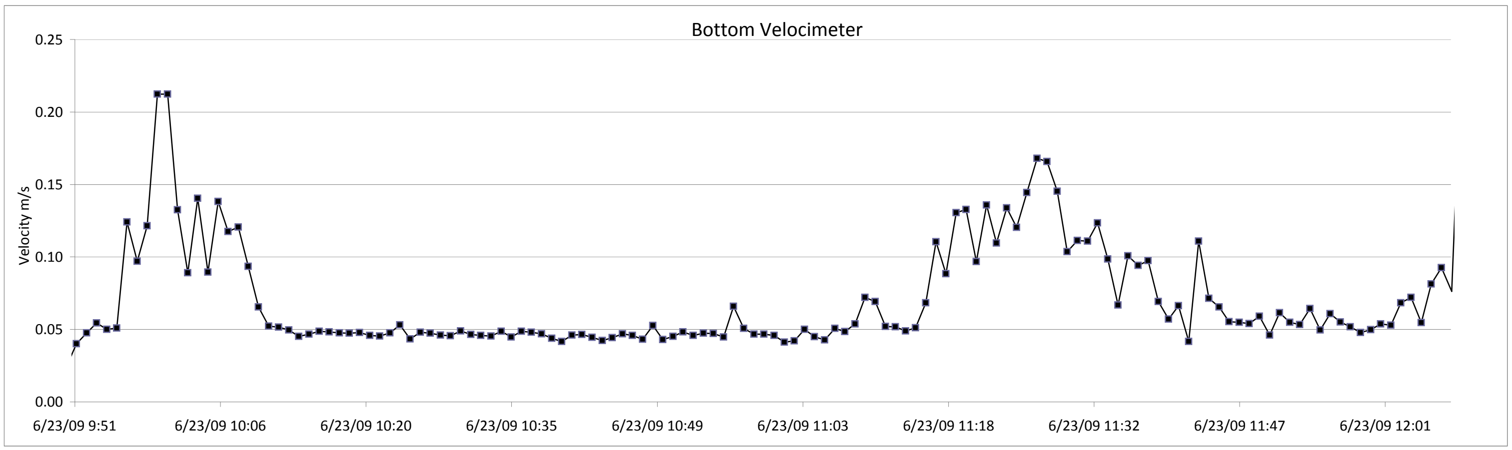
1) Data collected using Nortek acoustic doppler velocimeters

2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed

3) Data represents the horizontal components of velocity

4) M/S-meters per second





MICROBEAD PLOT 80100

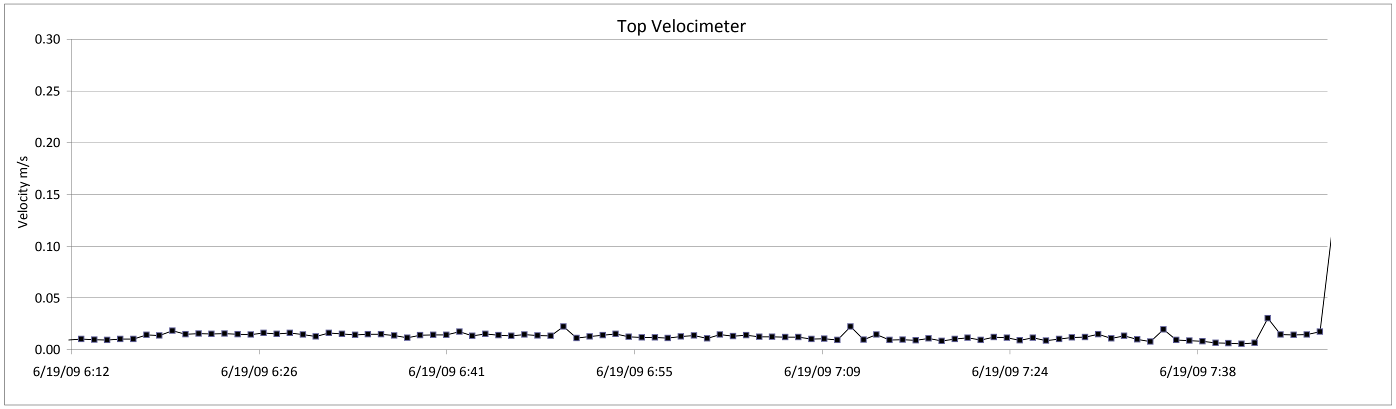
Notes:

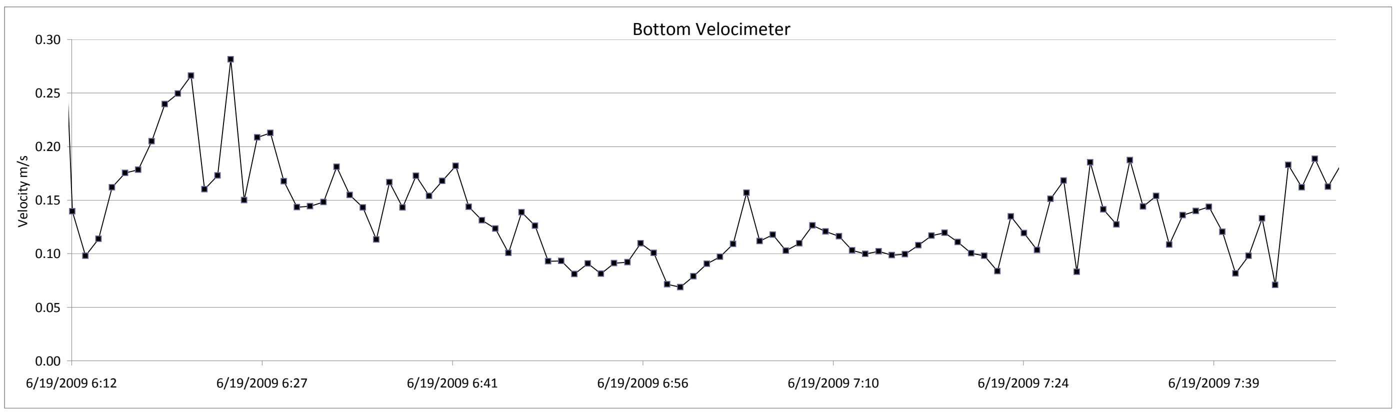
1) Data collected using Nortek acoustic doppler velocimeters

2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed

3) Data represents the horizontal components of velocity

4) M/S-meters per second





MICROBEAD PLOT 80101

Notes:

1) Data collected using Nortek acoustic doppler velocimeters
2) Bottom velocimeter approximately 0.5 meters above sediment bed; top velocimeter approximately 1.0 meter above sediment bed
3) Data represents the horizontal components of velocity
4) M/S-meters per second

APPENDIX E

RESULTS FROM 2010 MICROBEAD MARKER PLOT SAMPLING

APPENDIX E

RESULTS FROM 2010 MICROBEAD MARKER PLOT SAMPLING

The purpose of this appendix is to provide an update of microbead marker sampling work completed on behalf of Honeywell during 2010.

E.1 JULY 2010 MICROBEAD MARKER SAMPLING EFFORTS

Shallow cores from select microbead plots were collected in July 2010 to assess whether compaction or mixing had any effect on the microbead material over the course of approximately 13 months (June 2009 through July 2010). Five microbead marker_plots were sampled in July 2010. Sampling at four of these plots in 2009 (plots 80093, 80094, 90096, 80099) showed both the sand and silt marker materials below the top centimeter at these plots. Sampling these plots in 2010 was done to address two objectives, 1) to assess whether the 2009 data was anomalous, 2) to assess the effect of compaction or mixing on the two types of microbead markers (sand and silt). Cores were also collected from a fifth plot 80100 in 2010, because prior sampling did not include the southern half of the plot. Sampling at the southern portion of plot 80100 in 2010 added additional information about homogeneity of the plot area in addition to assessing what effect compaction or mixing had on the two types of marker material.

Coring and sub-sampling procedures for the July 2010 sampling effort were identical to those of the 2009 sampling effort documented in Section 3 of the *Onondaga Lake Sediment Management Unit 8 Microbead Marker Placement Report*, May 2010. The depth of sampling within each core was dependant on the depth at which the syringe could adequately penetrate the sediment which was related, in turn, to the cohesiveness and consistency of the sediments. For each one centimeter sub-sample, a particle count of marker material was quantified based on fluorescence measurements made at a wavelength selected based on microbead characteristics identified when the beads were manufactured. Results are reported as a percentage of particles within each sub-sample as compared to the total particle count within all subsamples for a given core. Sample results from July 2010 indicate the presence of both sand and silt markers below the top centimeter. Work is continuing to determine if the presence of marker material below the top centimeter is perhaps a product of sampling procedures. Sample results for the July 2010 sampling event are presented in Table E-1, shown on Figures E1 through E5, and summarized in this section.

<u>Microbead Marker Plot 80093</u>

<u>Core 80093-10-01</u>

Lake Location: northern end of the lake, centrally located in the microbead plot.

Collection Date: July 2010

Core Depth into Sediment: 63.5 cm

Core Description:

General: All intervals wet and soft. There appeared to be smearing of brown and green-colored materials downward into black sediment along the edges of the plastic core. Green-colored materials were visible in the core at a depth of 24 cm.

0 to 2 cm: light brown silt

2 to 4 cm: grey/brown silt

Below 4 cm: dark grey silt

Laboratory Results:

The vast majority (97%) of the silt marker was found within the top 3 cm (Table E-1); with counts ranging from 17.3 to 35.9 per mg wet weight. The counts below 3 cm ranged from 0.1 to 1.2 counts per mg wet weight. Silt marker was not detected from 6 to 7 cm.

The sand marker had similar distribution, with 97% of the material in the top 3 cm and counts ranging from 160 to 271 counts per gram wet weight. In the 3 to 4 cm depth interval, the sand marker was detected at 16 counts per gram wet weight. Sand marker was not detected below 4 cm.

Core 80093-10-02

Lake Location: northern end of the lake, located in the northwest of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 74.2 cm

Core Description:

General: From the field observations, the core was collected vertically (i.e., not slanted). Each interval sampled was wet and soft. A line of green-colored material was visible at 2.54 cm. There appears to be smearing of the brown and green-colored materials on the left side of the photo downward into the grey sediment along the contact with the plastic core.

0 to 1 cm: brown silt

Below 1 cm: grey/brown silt

Laboratory Results:

The vast majority (90%) of the silt marker was found within the top 3 cm (Table E-1); with counts ranging from 2.6 to 73.6 counts per mg wet weight. The counts below 3 cm ranged from 0.7 to 15.2 counts per mg wet weight.

The sand marker had similar distribution with 81% of the marker material in the top 3 cm and counts ranging from 71.8 to 94.2 counts per gram wet weight. Below the 3 cm depth, the sand marker counts ranged from 6.7 to 50.7 counts per gram wet weight (3%).

Core 80093-10-03

Lake Location: northern end of the lake, adjacent to the southwest portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 69 cm

Core Description:

General: From the field observations, the core was collected vertically (i.e., not slanted). Intervals sampled were wet and soft. Green-colored material was visible in the core at a depth of 11 cm. Large gaps and air spaces were visible throughout the core.

0 to 1 cm: brown silt

Below 1 cm: grey silt

Laboratory Results:

The vast majority (97%) of the silt marker was found within the top 3 cm (Table E-1); with counts ranging from 0.8 to 45.7 counts per mg wet weight. Silt marker counts below 3 cm ranged from 0.04 to 1.1 counts per mg wet weight.

77% of the sand material was found in the top 3 cm with counts ranging from 40.0 to 81.1 counts per gram wet weight. Below the 3 cm depth, sand marker counts ranged from 1.7 to 22.1 counts per gram wet weight (0 to 10%).

Core 80093-10-04

Lake Location: northern end of the lake, adjacent to the southwest portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 76 cm

Core Description:

General: From the field observations, the core was collected vertically (i.e., not slanted). Green-colored material was visible in the core at a depth of 25.4 cm. The entire core consisted of wet, soft, grey/brown silt, with sediment near top of the core being slightly lighter.

Laboratory Results:

The vast majority (97%) of the silt marker was found within the top 2 cm (Table E-1); with 0.71 counts per mg wet weight in the top cm and 3.93 counts per mg wet weight in the second cm.

The sand marker had similar distribution with 99% of the sand material on the top 2 cm at counts ranging from 171.7 to 277.2 counts per gram wet weight. At the 3 cm depth, the sand marker was detected at 4.6 counts per gram wet weight. Sand was not detected below the 3 cm depth.

Evaluation of Results from Cores at Plot 80093

Results for core 80093 show at least 77% of both markers were found in the top 3 cm.

Microbead Marker Plot 80094

Core 80094-10-01

Lake Location: northwest end of the lake, northwest portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 46 cm

Core Description:

General: From the field observations, the core was collected vertically (i.e., not slanted) and green-colored material was present on the surface sediments. Green-colored material was visible in this core at a depth of 12 cm.

0 to 1 cm: light, brown silt or “fluff” layer

1 to 2 cm: wet, soft, light brown silt

Below 2 cm: wet, soft, dark grey silt

Laboratory Results:

The vast majority (97%) of the silt markers were found in the top 1 cm (Table E-1) with a count of 12.5 counts mg wet weight, The remaining 3% of silt markers are located in at 1 to 3 cm and no silt marker was detect below 3 cm.

The sand marker had similar distribution in terms of percentage; with 90% located in the top 1 cm and a count of 66.7 counts per gram wet weight. The remaining 10% sand marker was detected between 1 and 4 cm with counts that range from 0.46 to 3.9 counts per gram wet weight. Samples were not collected below the 4 cm depth.

Core 80094-10-02

Lake Location: northwest end of the lake, northwest portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 63 cm

Core Description:

General: From the field observations, the core was collected vertically (i.e., not slanted). The top 7 cm of the core consists of wet, soft, grey to grey-brown silt. Green-colored material was present on the surface sediment and visible in the core at a depth of 18 cm.

Laboratory Results:

Silt marker counts were lower than expected and ranged from 0.04 to 2.7 counts mg wet weight. 72% of the silt marker was located in the top 1 cm and no silt was detected below 4 cm.

The sand marker counts were lower than expected as well and were only detected in the top 1.0 cm at 25.7 counts per gram wet weight.(100% of the sand marker detected).

Evaluation of Results for 80094 cores:

Results for core 80094 show at least 72% of both markers was found in the top 1 cm. Cores collected at microbead plot location 80094 showed sand and silt marker counts in the top few centimeters were lower in magnitude than expected. These low silt counts could be attributed to the cores being located near the edge of the marker plot.

Microbead Marker Plot 80096

Core 80096-10-01

Lake Location: northeast end of the lake, adjacent to the northeast portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 82 cm

Core Description:

General: From the field observations, the core was collected vertically (i.e., not slanted).

0 to 2 cm: wet, soft, brown silt

Below 2 cm: wet, soft, dark grey silt

Laboratory Results:

Silt counts ranged from 0.03 to 0.24 counts per mg wet weight with 35 % being in the top 2 cm. The sand marker was also found at lower than expected counts of 2.87 and 0.33 counts per gram wet weight.

90% of the sand marker was found to be within the top 1 cm of the core. The remaining 10% was found at the 8 to 9 cm interval.

Core 80096-10-02

Lake Location: northeast end of the lake, adjacent to the northeast portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 73 cm

Core Description:

General: From the field observations, the core was collected vertically with a slightly uneven surface. Green-colored material was visible to 45 cm.

0 to 3 cm: wet soft, light brown silt

Below 2 cm: wet, soft, gray to gray-black silt

Laboratory Results:

The silt marker was found to be most heavily concentrated in the 1-2 cm and 3-4 cm intervals however silt marker was detected in all 8 cm intervals.

The sand marker was found to be most heavily concentrated in the 2-3 cm and 3-4 cm intervals however sand marker was detected in all 8 cm intervals.

Evaluation of Results for 80096 cores

The sand marker was found primarily in the top 4 cm of both cores. The low counts detected at 80096-10-01 of both makers could be attributed to the location being slightly outside of the defined microbead plot. The silt markers were found to be generally evenly distributed throughout the top 9 cm (Table E-1) on a percentage basis. This distribution of silt marker throughout the top 9 cm could suggest the surface sediment was disturbed during core collection or processing. However, the silt particle counts are much lower than what might consider reliable to evaluate vertical dispersion.

Microbead Marker Plot 80099

Core 80099-10-01

Lake Location: southwestern end of the lake, northern portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 44 cm

Core Description:

General: From the field observations, the core was collected vertically with an even surface. There appears to be smearing of green-colored material downward into the black sediment along the contact with the plastic core. Green-colored material was visible to 23 cm. The entire core consists of wet, soft, black silt.

Laboratory Results:

The majority (88%) of the silt marker was present in the top 3 cm, no silt marker was detected in the 3 to 4 cm unit, and the remaining 12% was present from 4 to 8 cm with the highest counts at 7-8 cm.

The majority (85%) of the sand marker was present in the top 2 cm, no sand marker was detected in the 4 to 8 cm unit, and 9% was detected in the 8-9 cm unit.

Core 80099-10-02

Lake Location: southwestern end of the lake, adjacent to the southeastern portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 32 cm

Core Description:

General: From the field observations, the core was collected vertically with an even surface. Green-colored material was visible to 13 cm. The entire core consists of wet, soft, black silt.

Laboratory Results:

The silt marker was found in the top 4 cm units as well as at 5 to 6 cm and 7 to 8 cm with low counts ranging from 0.02 to 0.8 counts per mg wet weight.

The sand marker was found in the top 2 cm units as well as at 3 to 4 cm with low counts ranging from 0.18 to 0.95 counts per gram wet weight.

Evaluation of Results for 80099 cores

Silt marker detected at depths below 3 cm in core 10-1 cannot be explained. If natural migration had moved the marker downward the marker would be expected to be measured in all depth intervals sampled.

Low counts in both markers in core 10-1 were expected with the core being located outside of the plot area. Gaps in detectable marker (s) vertically within a core cannot be explained. If natural migration had moved the marker downward the markers would be observed in each of the sediment intervals.

Microbead Marker Plot 80100

Core 80100-10-01

Lake Location: southwestern end of the lake, adjacent to the southern portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 32 cm

Core Description:

General: From the field observations, the core was collected vertically with an even surface. Green-colored material was visible to 14 cm. The entire core consists of wet, soft, black silt.

Laboratory Results:

The silt marker was found evenly distributed throughout the top 6 cm at counts ranging from 0.1 to 0.6 counts per mg wet weight. No samples were collected below the 6 cm unit.

Sand marker was only detected in the 0 to 1 cm unit and a count of 2.4 counts per gram wet weight. Low counts in both markers are expected with the core being located outside of the plot area.

Core 80100-10-02

Lake Location: southwestern end of the lake, adjacent to the southern portion of the microbead plot

Collection Date: July 2010

Core Depth into Sediment: 32 cm

Core Description:

General: From the field observations, this core was collected vertically with an even surface. Green-colored material was visible to 14 cm. The entire core consists of wet, soft, black silt.

Laboratory Results:

As a result of the non-cohesiveness of the upper sediments, samples from 0 to 4 cm slipped out of the syringe under their own weight. Both markers were detected in the 4 to 5 cm and the 5 to 6 cm interval; however results from those intervals are not applicable for assessing vertical spread.

<u>Evaluation of Results for 80100 cores</u>

The silt marker was found distributed throughout the top 7 cm (Table E-1) in Core 10-1. This distribution throughout the top 7 cm could suggest the surface sediment was disturbed during core collected or through sample processing. Results for Core 10-2 cannot be evaluated for marker distribution.

E.2 NOVEMBER 2010 SAMPLING EFFORTS

Marker material carried into lower sections as a result of sub-sampling, if counted, would indicate more vertical mixing than is shown based on other methods, such as cutting frozen cores. The data collected in 2009 and in July 2010 does not provide a definitive answer to this question. Additional cores were collected in November 2010 to assess the effect of sub-sampling on the position of the marker material within a core. Coring procedures for the November 2010 sample effort were identical to those of the 2009 and July 2010 sampling efforts (see Section 3 of the *Onondaga Lake Sediment Management Unit 8 Microbead Marker Placement Report*,). Photo documentation of these cores was not compiled, because the cores collected in November 2010 were collected only to evaluate sub-sampling techniques and cores from the same plots had already been collected earlier the same year. Boring logs used to record the visual descriptions of the cores were kept for records.

Two modifications were made to the sub-sampling process in November 2010. One set of cores was allowed to dry some to allow for stiffening of the surface sediments prior to sampling. A second set of cores were frozen prior to sectioning into 1 cm intervals. These modification were implemented to help assess what effect, if any, sub-sampling had on the position of the marker material within a core.

<u>E.2.1 Microbead Marker Sub-Sampling Modification # 1</u>

One core was collected from microbead marker plot 80094 and 80099 in November 2010. Both of these cores were allowed to partially dry within the upper sediment units to allow for stiffening of the material prior to insertion of the syringe. Previous sub-sampling efforts did not allow for the stiffening of sediment prior to the insertion of the syringe which could have led to smearing of materials from upper sediment units into lower sediment units. Once collected in the syringe, sub-sampling procedures were identical to those of the 2009 and July 2010 sampling efforts. Sample results for the November 2010 sampling event are presented in Table E-2, shown on Figures E2 and E4, and summarized below.

Microbead Marker Plot 80094

Core 80094-10-03

Lake Location: southwest end of the lake, adjacent to the southern portion of the microbead plot

Collection Date: November 2010

Core Depth into Sediment: 32 cm

Core Description:

General: From the field observations, the core was collected vertically with an even surface. Green-colored material appeared to be smeared to a depth of 8 cm. The entire core was wet, soft, brown silt.

Laboratory Results:

The majority (93%) of the silt marker was found in the top 3 cm with counts ranging from 58.4 to 78.9 counts per mg wet weight.

Sand maker was found concentrated (96%) in the top 3 cm with counts of 254 to 759 counts per gram wet weight Sand marker was also detected from 3 to 8 cm ranging from 0.5 to 1.9%.

Evaluation of Results for the 80094 Core

Results for core 80094 show at least 93% of both markers were found in the top 3 cm.

Microbead Marker Plot 80099

Core 80099-10-03

Lake Location: southwest end of the lake, adjacent to the northern portion of the microbead plot.

Collection Date: November 2010

Core Depth into Sediment: 32 cm

Core Description:

General: From the field observations, the core was collected vertically with an even surface. The entire core is wet, soft, brown-grey silt.

Laboratory Results:

The majority (98%) of the silt marker was found in the top 1 cm at 104.0 counts per mg wet weight. Counts of silt marker ranged from 0.2 to 0.8 per mg wet weight below the top 1 cm.

The majority of sand marker (98%) was also found in the top 1 cm. Counts of sand marker in the 1 to 2 cm and 2 to 3 cm intervals were 9.0 and 2.3 counts per gram wet weight respectfully.

Evaluation of Results for the 80099 Core

Nearly all of both markers (98%) were found in the top 1 cm. Additional silt maker was found between 1 and 3 cm and at 6 to 7 cm ranging from 0.18 to 0.78%. Additional sand maker was found between 1 and 3 cm ranging from 0.4 to 1.6%.

E.2.2 Microbead Marker Sub-Sampling Modification # 2

A second core was collected from plot 80094 and from plot 80099 during November 2010. Both of these cores were allowed to partially dry within the upper sediment units to allow for stiffening of the material prior to insertion of the syringe. Once sediment was collected within the syringe, the syringe was placed in a cooler with dry-ice and allowed to freeze. Previous sub-sampling efforts did not allow for the stiffening of sediment prior to the insertion of the syringe which could have led to smearing of materials from upper sediment units into lower sediment units or the freezing of sediment after insertion of the syringe. Once frozen in the syringe, sub-sampling procedures were identical to those of the 2009 sampling effort and can be found in Section 3 of the main report. Sample results for the November 2010 sampling event are presented in Table E-2, shown on Figures E2 and E4, and summarized in this sub-section.

Microbead Marker Plot 80094

Core 80094-10-04

Lake Location: northwest end of the lake, adjacent to the southern portion of the microbead plot

Collection Date: November 2010

Core Depth into Sediment: 29.5 cm

Core Description:

General: No boring log or photo is available for this core.

Laboratory Results:

The majority of silt marker (85%) was found in the top 1 cm. Counts of silt marker ranged from 0.1 to 4.9 per mg wet weight.

The majority of sand marker (87%) was also found in the top 1 cm. Counts of sand marker ranged from 0.6 to 191.1 per gram wet weight. Sand maker was found between 1 and 4 cm and at 5 to 7 cm ranging from 0.3 to 10.6 %.

Evaluation of Results for the 80094 Core

At least 85% of both markers were found in the top 1 cm of sediment.

Microbead Marker Plot 80099

Core 80099-10-04

Lake Location: southwest end of the lake, adjacent to the northern portion of the microbead plot

Collection Date: November 2010

Core Depth into Sediment: 29 cm

Core Description:

General: No boring log or photo is available for this core.

Laboratory Results:

Ninety-four percent of the silt maker and 100% of the sand marker were found at the 7 to 8 cm depth interval most likely due to a sample labeling error. As a result, the marker concentrations from this core are not considered to be reliable.

Evaluation of Results for 80099 Core

Results do not appear to be reliable for evaluating vertical distribution of either marker.

Attachments: Tables E-1 and E-2 and Figures E1 through E5.

Table E-1
Results of Cores Collected to Evaluate the Presence of Fluorescent Tracer In SMU 8 Sediments
Data Collected July 2010

SILT TRACER : Counts per milligram wet weight — **SILT**

Depth	80093-10-01	80093-10-02	80093-10-03	80093-10-04	80094-10-01	80094-10-02	80096-10-01	80096-10-02	80099-10-01	80099--10-02	80100-10-01	80100-10-02
0-1 cm	19.1	70.4	2.0	0.7	12.5	2.7	0.24	2.0	31.4	0.2	0.1	
1-2 cm	35.9	2.6	45.7	3.9	0.3	0.5	0.04	70.4	16.8	0.8	0.4	
2-3 cm	17.3	73.6	0.8	0	0.1	0.4	0	19.3	0.8	0.3	0.6	
3-4 cm	1.2	0.7	1.1	0	0	0.1	0.15	89.9	0	0.2	0.5	
4-5 cm	0.1	15.2	0.3	0.04		0	0.07	23.6	0.8	0.0	0.4	6.0
5-6 cm	0.3		0.0	0.04		0	0.22	25.6	0.9	0.03	0.1	7.3
6-7 cm	0		0.1	0.03		0	0.03	17.6	0.5	0.0	0	
7-8 cm	1.1		0.1	0.03			0	1.9	4.7	0.0		
8-9 cm			0.1				0.04					
Sum	74.9	163	50.2	4.8	12.9	3.7	0.80	250.2	55.9	1.6	2.2	13.2

SILT TRACER : Percentage (counts per wet weight) — **% SILT**

Depth	80093-10-01	80093-10-02	80093-10-03	80093-10-04	80094-10-01	80094-10-02	80096-10-01	80096-10-02	80099-10-01	80099--10-02	80100-10-01	80100-10-02
0-1 cm	25.46	43.30	3.93	14.80	96.68	72.72	29.93	0.80	56.14	12.09	4.71	
1-2 cm	47.93	1.62	91.11	82.32	2.66	13.39	5.48	28.15	30.03	51.11	20.05	
2-3 cm	23.12	45.27	1.61	0	0.66	10.02	0	7.71	1.42	19.67	28.30	
3-4 cm	1.56	0.46	2.11	0	0	3.87	18.80	35.93	0	14.14	22.44	
4-5 cm	0.13	9.36	0.54	0.78		0	9.09	9.43	1.43	0	18.77	45.15
5-6 cm	0.35		0.09	0.74		0	27.53	10.22	1.69	1.83	5.73	54.85
6-7 cm	0		0.22	0.72		0.00	4.36	7.02	0.84	0	0.00	
7-8 cm	1.45		0.21	0.64			0	0.74	8.46	1.17		
8-9 cm			0.18				4.82					

Note: Marker material carried into lower sections as a result of sub-sampling, if counted, would indicate more vertical mixing than is shown based on other methods.

Table E-1
Results of Cores Collected to Evaluate the Presence of Fluorescent Tracer In SMU 8 Sediments
Data Collected July 2010

SAND TRACER : Counts per gram wet weight — **SAND**

Depth	80093-10-01	80093-10-02	80093-10-03	80093-10-04	80094-10-01	80094-10-02	80096-10-01	80096-10-02	80099-10-01	80099--10-02	80100-10-01	80100-10-02
0-1 cm	163.2	71.8	47.8	171.7	66.7	25.7	2.87	173.5	247.0	0.18	2.4	
1-2 cm	270.9	94.2	81.1	277.2	3.9	0	0	406.0	98.7	0.29	0	
2-3 cm	160.1	74.3	40.0	4.6	2.8	0	0	524.9	7.6	0	0	
3-4 cm	16.0	6.71	22.1	0	0.46	0	0	559.1	6.5	0.95	0	
4-5 cm	0.5	50.7	13.2	0		0	0	323.2	0	0	0	31.1
5-6 cm	0		5.4	0		0	0	287.8	0	0	0	113.1
6-7 cm	0		3.2	0		0	0	202.5	0	0	0	
7-8 cm	0		3.7	0			0	75.6	39.8	0		
8-9 cm			1.7				0.33					
Sum	610.6	297.7	218.2	453.4	73.9	25.7	3.2	2552.5	399.6	1.4	2.4	144.2

SAND TRACER : Percentage (counts per wet weight) — **%SAND**

Depth	80093-10-01	80093-10-02	80093-10-03	80093-10-04	80094-10-01	80094-10-02	80096-10-01	80096-10-02	80099-10-01	80099--10-02	80100-10-01	80100-10-02
0-1 cm	26.72	24.13	21.91	37.86	90.20	100.00	89.76	6.80	61.81	12.55	100.00	
1-2 cm	44.37	31.64	37.16	61.13	5.34	0	0	15.91	24.71	20.51	0	
2-3 cm	26.22	24.95	18.34	1.02	3.84	0	0	20.56	1.90	0	0	
3-4 cm	2.62	2.26	10.11	0	0.62	0	0	21.90	1.62	66.94	0	
4-5 cm	0.08	17.04	6.07	0		0	0	12.66	0	0	0	21.58
5-6 cm	0		2.48	0		0	0	11.28	0	0	0	78.42
6-7 cm	0		1.44	0		0	0	7.93	0	0	0	
7-8 cm	0		1.70	0			0	2.96	9.96	0		
8-9 cm			0.80				10.24					

Note: Marker material carried into lower sections as a result of sub-sampling, if counted, would indicate more vertical mixing than is shown based on other methods.

Table E-2 Results of Cores Collected to Evaluate the presence of Fluorescent Tracer In SMU 8 Sediments
Data Collected November 2010

SILT TRACER : Counts per milligram wet weight

Depth	80094-10-03	80094-10-04	80099-10-03	80099-10-04
0-1 cm	58.4	4.9	104.0	0.4
1-2 cm	74.4	0.3	0.8	0.1
2-3 cm	78.9	0.2	0.3	0
3-4 cm	12.5	0.2	0.0	0
4-5 cm	1.0	0.0	0.0	0.10
5-6 cm	0.0	0.0	0.0	0.43
6-7 cm	0.0	0.1	0.2	0.45
7-8 cm	0.5	0.0	0.0	30.64
Sum	225.6	5.7	105.4	32.4

SILT TRACER : Percentage (counts per wet weight)

Depth	80094-10-03	80094-10-04	80099-10-03	80099-10-04
0-1 cm	25.87	85.11	98.71	1.16
1-2 cm	32.97	6.09	0.78	0.36
2-3 cm	34.96	3.83	0.33	0.00
3-4 cm	5.54	3.32	0.00	1.00
4-5 cm	0.45	0.00	0.00	0.32
5-6 cm	0.00	0.00	0.00	1.33
6-7 cm	0.00	1.64	0.18	1.39
7-8 cm	0.21	0.00	0.00	94.44
Sum	100.0	100.0	100.0	100.0

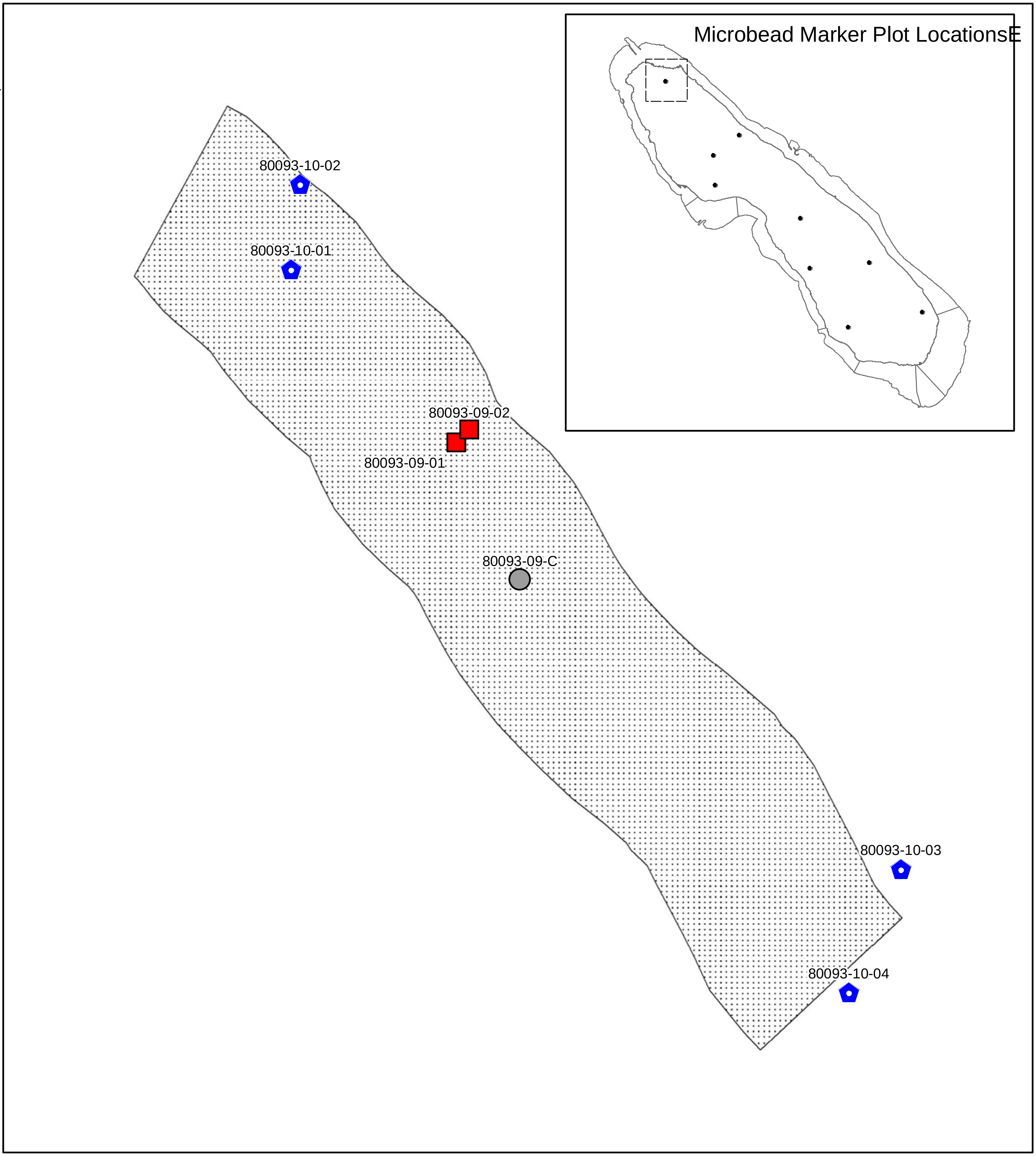
SAND TRACER : Counts per gram wet weight

Depth	80094-10-03	80094-10-04	80099-10-03	80099-10-04
0-1 cm	254.7	191.1	561.6	0
1-2 cm	759.2	23.2	9.0	0
2-3 cm	532.6	0.7	2.3	0
3-4 cm	8.9	1.29	0	0
4-5 cm	30.8	0	0	0
5-6 cm	1	1.6	0	0
6-7 cm	6	0.6	0	0
7-8 cm	2	0	0	556
Sum	1596.1	218.4	572.9	555.8

SAND TRACER : Percentage (counts per wet weight)

Depth	80094-10-03	80094-10-04	80099-10-03	80099-10-04
0-1 cm	15.96	87.46	98.03	0
1-2 cm	47.56	10.63	1.57	0
2-3 cm	33.37	0.33	0.40	0
3-4 cm	0.56	0.59	0	0
4-5 cm	1.93	0	0	0
5-6 cm	0.09	0.71	0	0
6-7 cm	0.39	0.27	0	0
7-8 cm	0.14	0	0	100.00

Notes:
Marker material carried into lower sections as a result of sub-sampling, if counted, would indicate more vertical mixing than is shown based on other methods.



Post Placement Sample Locations

- November 2010 Microbead Core Locations
- July 2010 Microbead Core Locations
- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

1 inch = 10 feet

0 3 6 12

Feet

FIGURE E1

MICROBEAD PLOT 80093

Honeywell

Onondaga Lake
Syracuse, New York

PARSONS

301 Plainfield Road, Suite 350; Syracuse, NY 13212

Path: Q:\GIS\GIS_Lake\SMU8\MXDs\2011\microbeads.mxd

Date Revised: 1/3/2012 10:09:06 AM

User: p0013927

User: p0013927
Date Revised: 1/3/2012 10:09:06 AM
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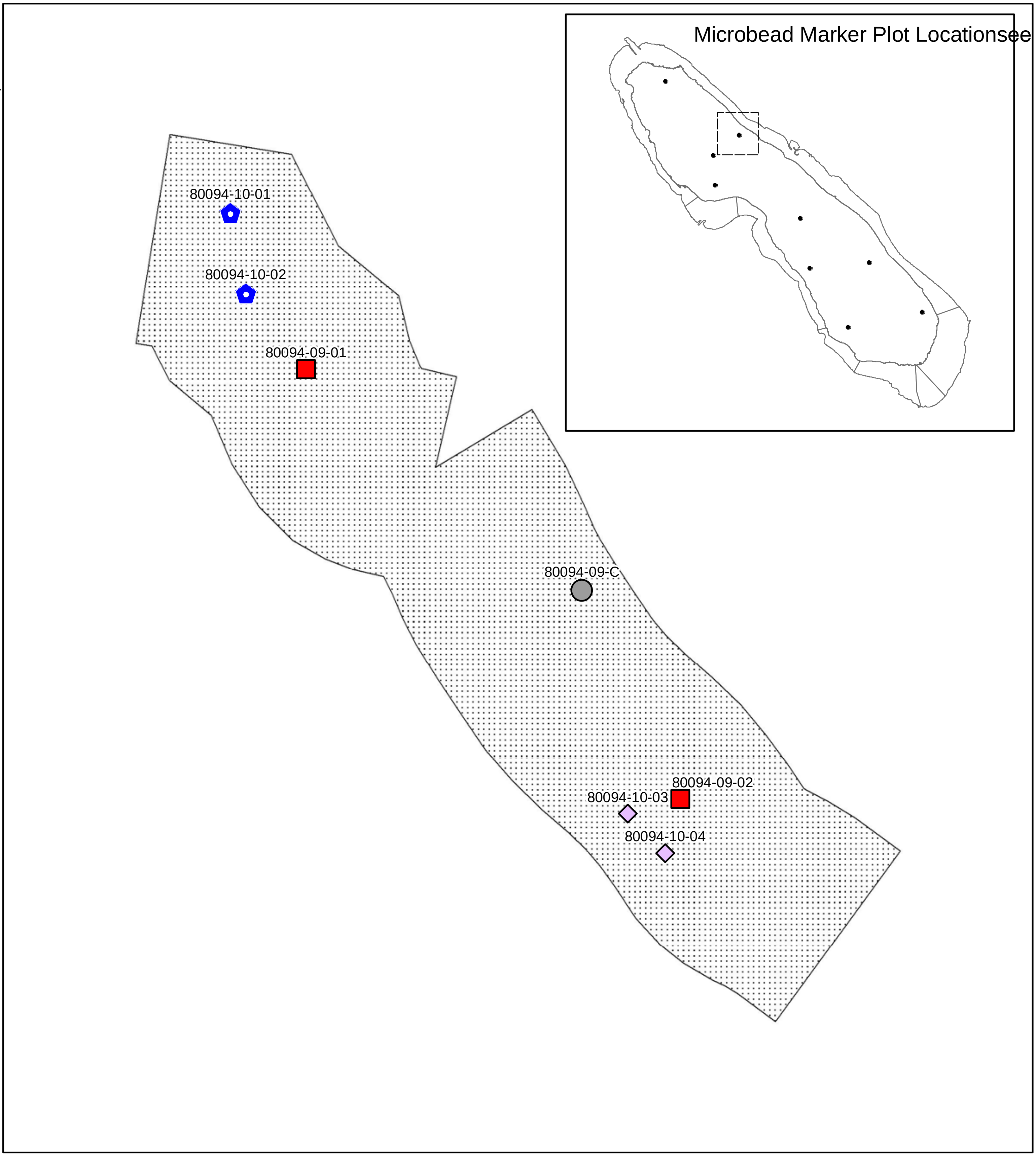


Post Placement Sample Locations

- November 2010 Microbead Core Locations
- July 2010 Microbead Core Locations
- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

1 inch = 9 feet

0 2.75 5.5 11

Feet

FIGURE E2

MICROBEAD PLOT 80094

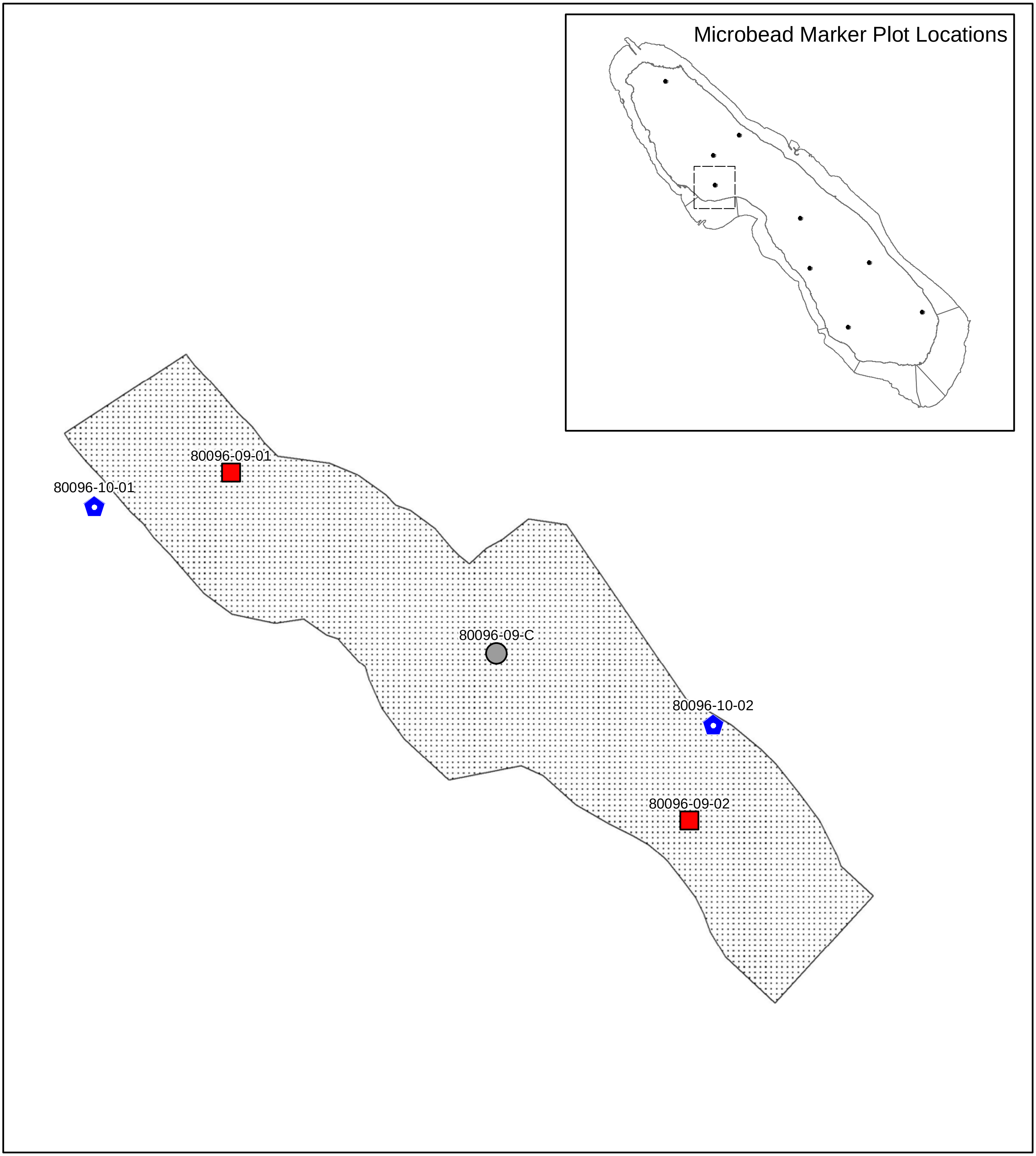
Honeywell

Onondaga Lake
Syracuse, New York

PARSONS

301 Plainfield Road, Suite 350; Syracuse, NY 13212

Path: Q:\GIS\GIS_Lake\SMU8\MXDs\2011\microbeads80096.mxd
Date Saved: 1/3/2012 10:24:22 AM
Author: JDF



Post Placement Sample Locations

- November 2010 Microbead Core Locations
- July 2010 Microbead Core Locations
- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

1 inch = 13 feet

0 3.75 7.5 15

Feet

FIGURE E3

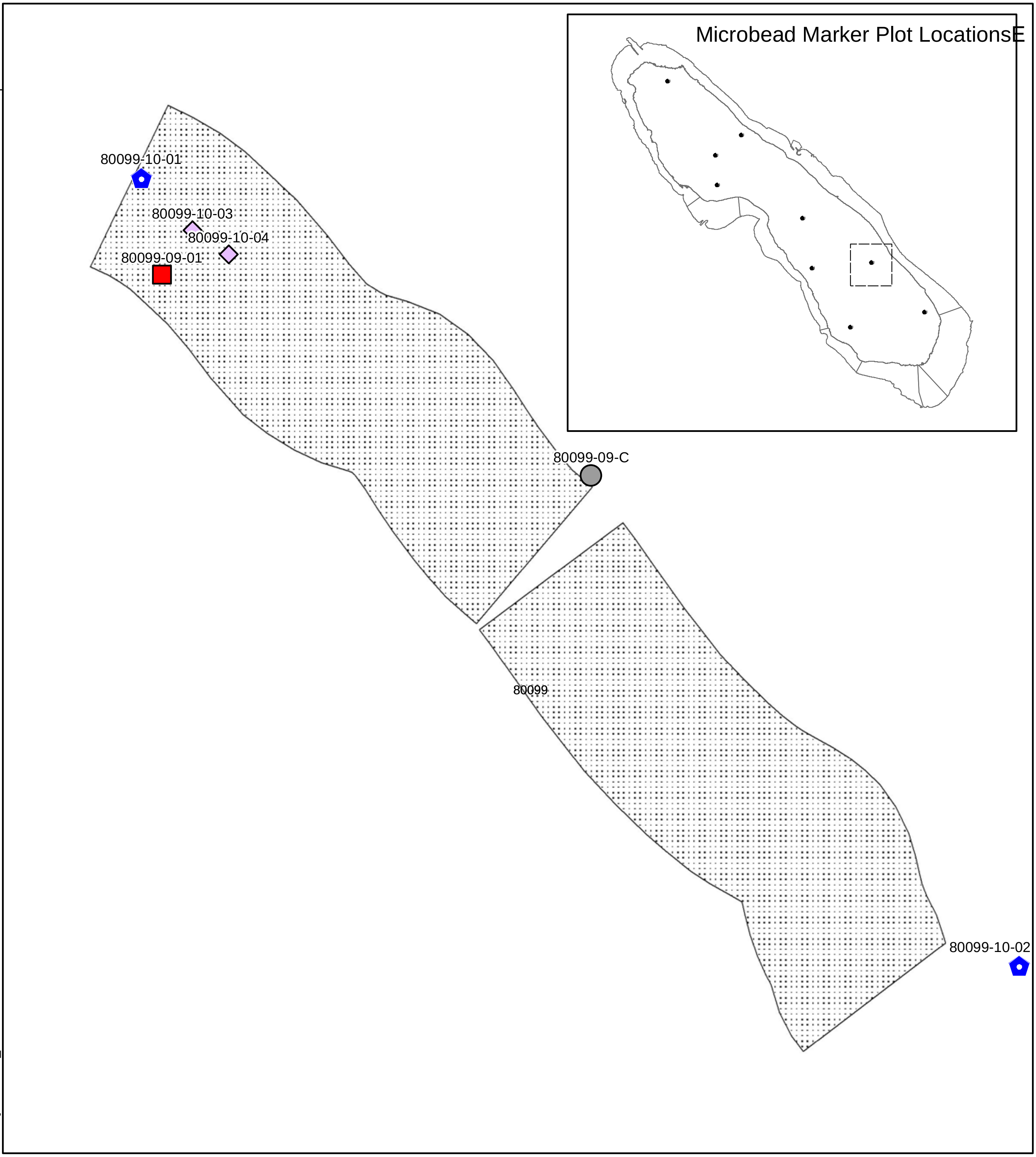
MICROBEAD PLOT 80096

Honeywell

Onondaga Lake
Syracuse, New York

PARSONS

301 Plainfield Road, Suite 350; Syracuse, NY 13212



Post Placement Sample Locations

- November 2010 Microbead Core Locations
- July 2010 Microbead Core Locations
- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

1 inch = 11 feet

0 3 6 12

Feet

FIGURE E 4

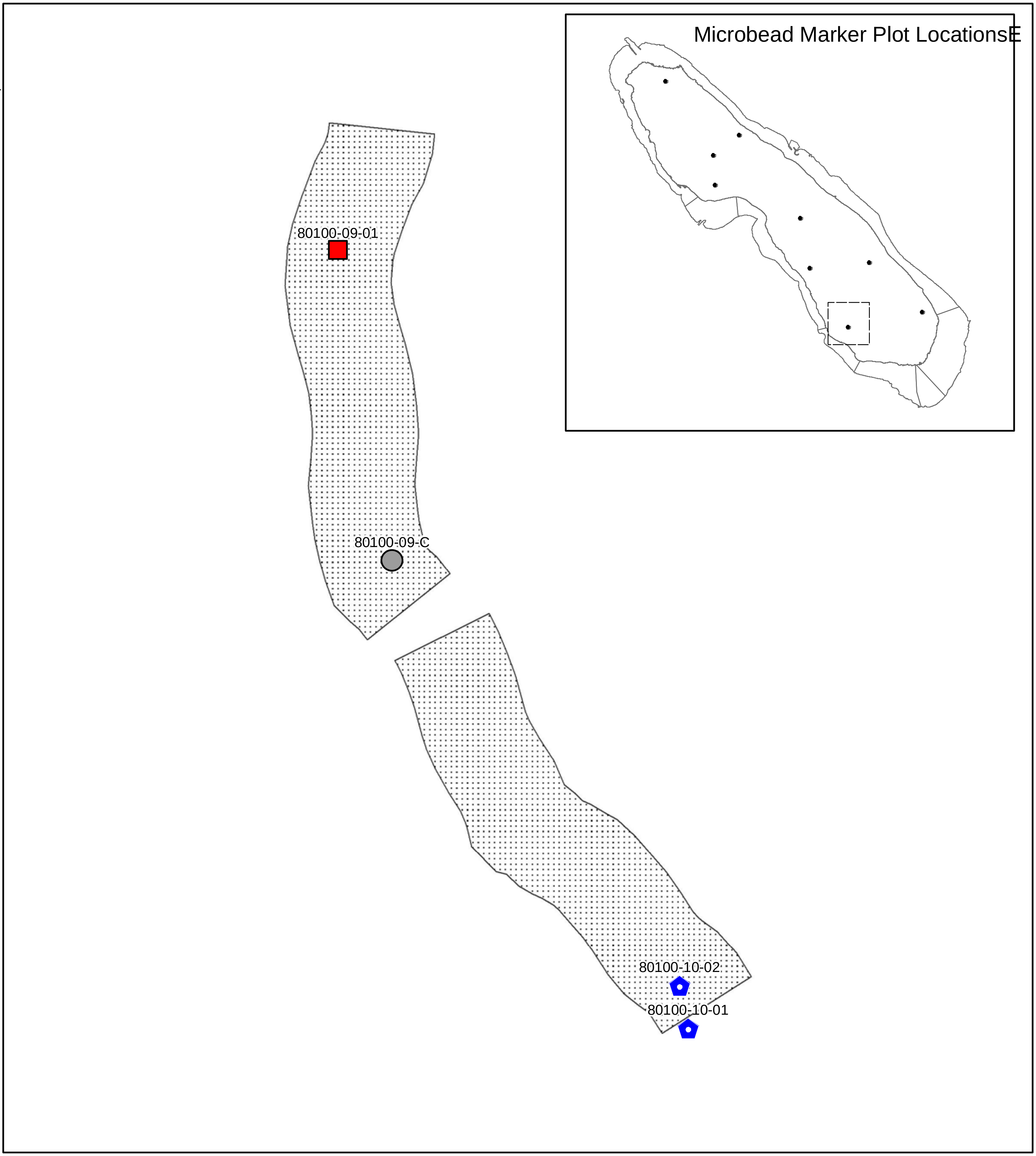
MICROBEAD PLOT 80099

Honeywell

Onondaga Lake
Syracuse, New York

PARSONS

301 Plainfield Road, Suite 350; Syracuse, NY 13212



Post Placement Sample Locations

- November 2010 Microbead Core Locations
- July 2010 Microbead Core Locations
- November 2009 Microbead Core Locations
- October 2009 Microbead Core Locations
- Microbead Placement Area

1 inch = 18 feet

0 5 10 20

Feet

FIGURE E5

MICROBEAD PLOT 80100

Honeywell Onondaga Lake Syracuse, New York

PARSONS

301 Plainfield Road, Suite 350; Syracuse, NY 13212

Path: Q:\GIS\GIS_Lake\SMU8\MXDs\2011\microbeads.mxd Date Revised: 1/3/2012 10:09:06 AM User: p0013927

APPENDIX F

RESULTS FROM 2012 MICROBEAD MARKER PLOT SAMPLING

In an effort to further assess the coring and sample processing method for the microbead cores, five cores were collected from two microbead plots in SMU 8 on October 17, 2012 and subsequently frozen, for visual inspection of the microbead marker in a manner consistent with frozen core collection efforts for observations of banding in 2011. This microbead marker plot sampling effort presented in this appendix is the most recent sampling effort completed in any of the microbead marker plots. The memo from Anchor QEA that follows this introduction presents results from the 2012 sampling effort. The sand microbead marker is shown to be distinctly visible as a line below the sediment-water interface. As a result of this effort, the sub-sampling procedure consisting of freezing and slicing frozen cores will be used in future microbead marker evaluation efforts.

ANCHOR QEA

290 Elwood Davis Road, Suite 340
Liverpool, New York 13088
Phone 315.453.9009
Fax 315.453.9010
www.anchorqea.com

MEMORANDUM

To:	David Babcock, Parsons	**Date:**	November 21, 2012
From:	Deirdre Reidy, Anchor QEA, LLC	**Project:**	120139-01.02
Cc:	Martin Hennessey, Parsons Carl Stivers, Anchor QEA, LLC		
Re:	Evaluation of the SMU 8 Sediment Processing Method Based on Visual Inspection of the Sand Microbead Marker Material in November 2012 SMU 8 Cores		

SUMMARY

To assess sedimentation rates in SMU 8, fluorescent microbead marker material was placed on the surface of SMU 8 sediments at nine locations throughout SMU 8 in June-July 2009 . The sand microbead marker has a grain size similar to sand, making it less likely to vertically mix with the silty SMU 8 sediments upon placement or sampling, thus providing a useful tool to measure the thickness of sediment deposition over the top of the marker layer (post mid-2009 sedimentation rates). Microbead plot sampling efforts prior to this current effort had shown vertical movement of the microbead marker that appears to be an artifact of the sampling method. In an effort to refine the coring and sample processing method for the microbead cores, five cores were collected in October 2012 from two microbead plots in SMU 8, subsequently frozen and then visually inspected. A line of sand marker was observed in sediment cores from the North Basin microbead plot 80095 at depths 0.5 to 1.5 cm below the sediment-water interface. Sand marker was not observed in the cores from the South Basin microbead plot 80099, because the cores were inadvertently collected just outside the plot area. Sediment layering was observed at 0.5 to 2 cm vertical intervals throughout cores from each of the two plots sampled. Based on the observations described in this memorandum, the sampling method of freezing the cores prior to sampling successfully minimizes vertical movement of the microbead marker due to sampling procedures.

METHODS

Sediment cores were collected on October 17, 2012 in a manner consistent with frozen core collection efforts for observations of banding in 2010 (Parsons, 2010), 2011 (Anchor QEA, 2012a), and 2012 (Anchor QEA, 2012b). These microbead cores were placed vertically into a cooler, packed with dry ice for transport, and maintained in a frozen state for splitting. Visual observations were conducted on November 1, 2012.

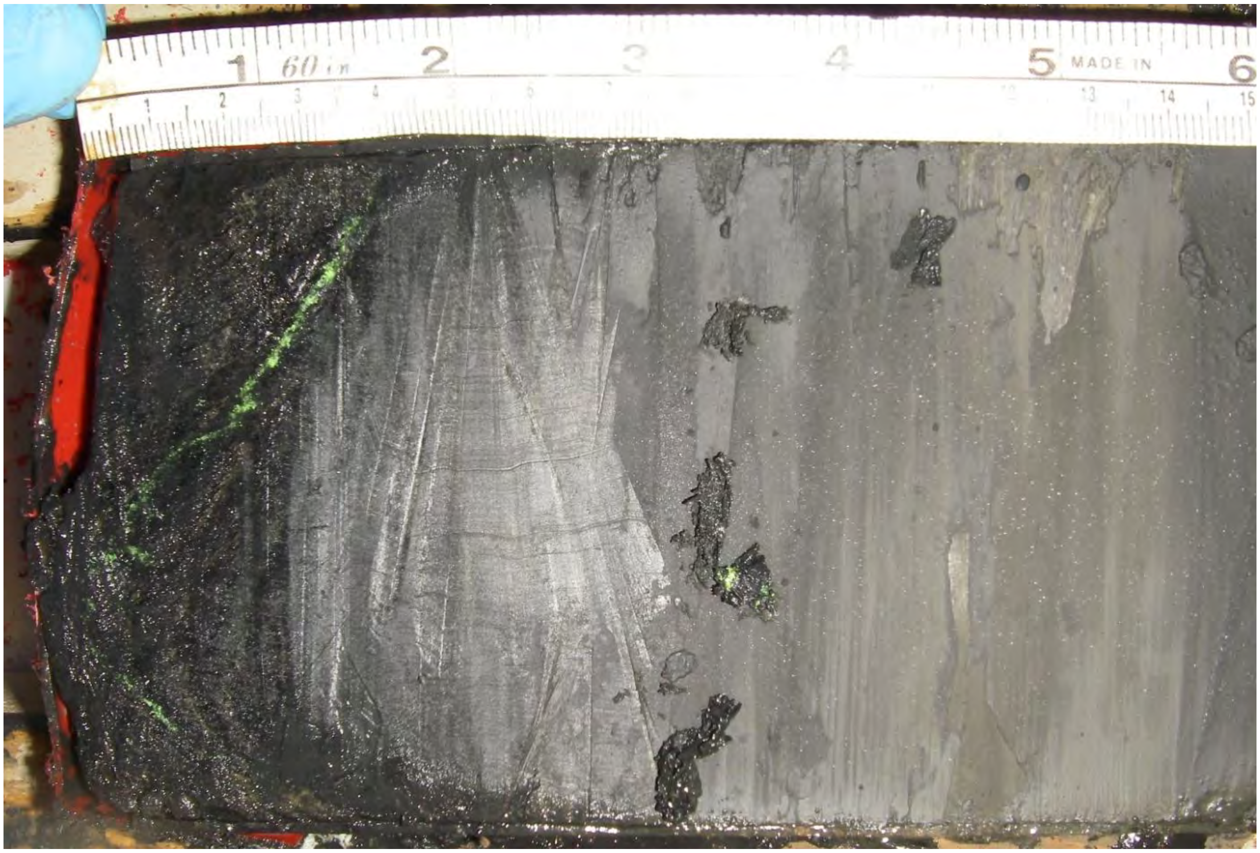
Figure 1 shows the locations of the microbead plots where the five cores were collected in October 2012: two cores were collected from microbead plot OL-MB-80099 in the South Basin, and two cores plus one duplicate core were collected from microbead plot OL-MB-80095 in the North Basin.

Each of the five cores was split open vertically using a saws-all to expose the vertical cross section and allow visual inspection for the sand microbead marker and for sediment varves/layers. To avoid artificially moving the sand microbead marker to the top of sediment, the cores were cut from the surface of the core to the bottom of the core. Photographs were taken and observations were recorded for each core. The vertical cross section of each core was observed for evidence of the sand microbead marker. In addition to recording observations of the microbead marker material in these cores, observations of sediment varves/layers were recorded from one core collected at both microbead plots. Martin Hennessey and Dave Babcock of Parsons, Deirdre Reidy and Jim Ryan of Anchor QEA, and Bob Montione of AECOM were in attendance when the frozen cores were sliced on November 1, 2012. The following sections detail the visual observations of each of the sliced cores.

RESULTS

Core #1 from OL-MB-80095 (North Basin)

Prior to slicing the frozen core vertically, green microbead marker material was observed through the lexan core tube along the sides of the core throughout the core length. This observation is indicative of smearing occurring from the core tube during collection. Once the core was sliced open, visual inspection of the vertical cross section revealed a distinct green marker at a depth of 0.5 cm from the surface of the core. The marker appeared intact and there was no evidence of mixing (see photo below).

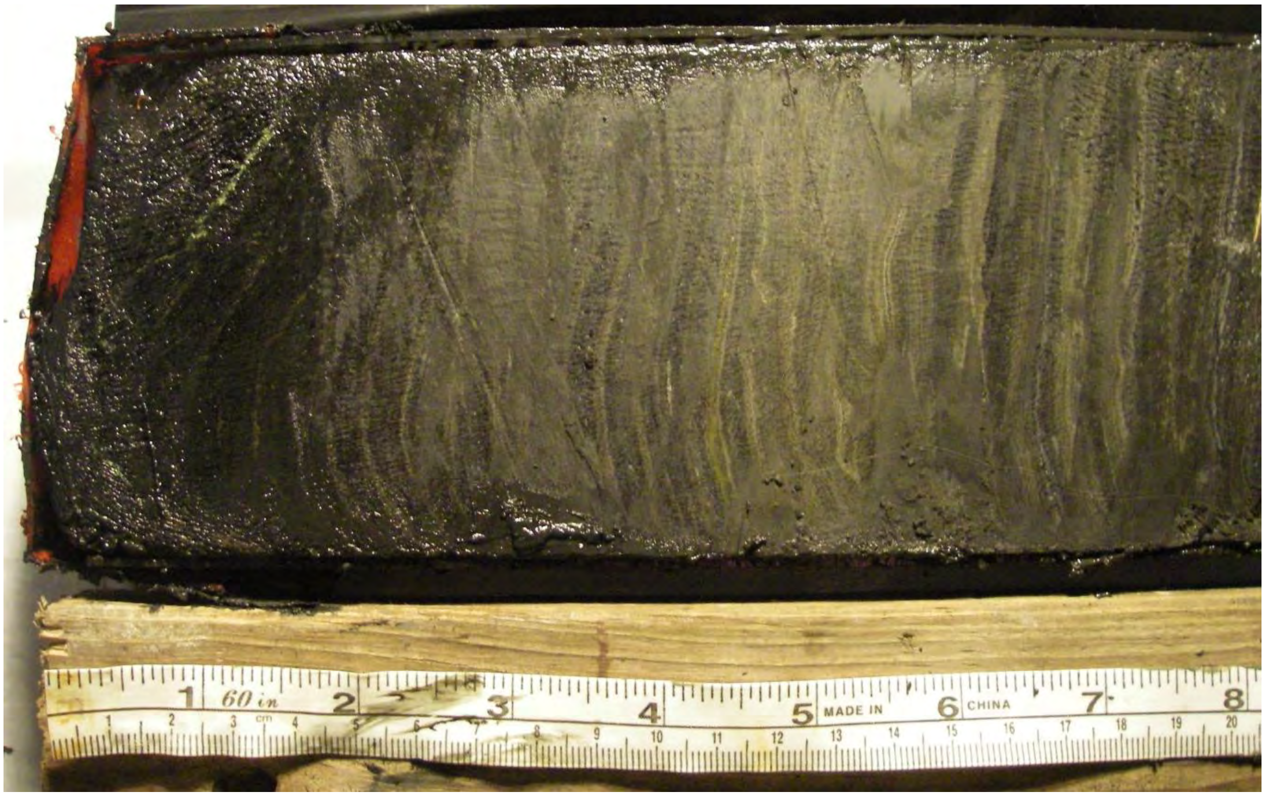


Core #1 from Microbead Plot OL-MB-80095 – Vertical Cross Section Showing Presence of Microbead Marker

Visual inspection of Core #1 from OL-MB-80095 (see photo on page 4) indicated laminations beginning at 0.5 cm from the top of the core. The core was dark brown to tan in color. The detailed descriptions of the laminations present are as follows:

- Dark brown sediment at surface to the depth of the green microbead marker (0.5 cm)
- Gray/tan bands (1 mm thick) observed every 0.5 cm from a depth of 1 cm to a depth of 2 cm
- Bands (1 mm thick) observed every 1 cm from a depth of 2 cm to a depth of 4 cm
- Tan band (2 to 3 mm thick) observed at a depth of 5 cm
- Tan band (1 to 2 mm thick) observed at a depth of 6 cm
- Tan band (1 to 2 mm thick) observed at a depth of 7 cm
- Tan bands (2 mm thick) observed every 0.5 cm from a depth of 7.5 cm to a depth of 10.5 cm

- Greenish-brown band observed at a depth of 11 cm
- Tan bands (3 mm thick) observed every 0.5 cm from a depth of 11 cm to a depth of 14 cm
- Alternating bands of dark brown (0.5 cm thick) to tan (0.5 thick) from 14 cm depth to 19 cm depth



Core #1 from Microbead Plot OL-MB-80095 – Vertical Cross Section Showing Presence of Banding after Thawing

Core #1 (Duplicate) from OL-MB-80095 (North Basin)

No microbead marker material was observed in the duplicate core collected from this location. The core was likely collected outside the boundary of the microbead plot.

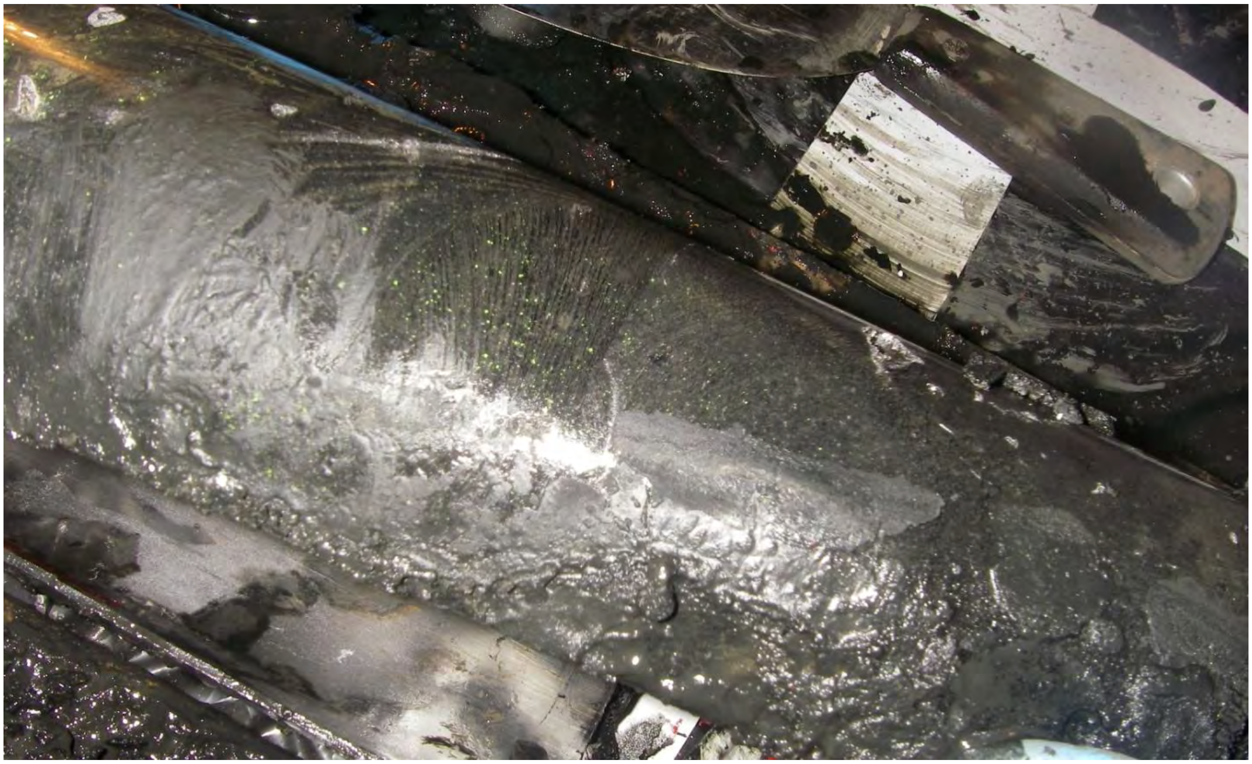
Core #2 from OL-MB-80095 (North Basin)

Visual inspection of the vertical cross section showed a distinct green marker at a depth of approximately 1 to 1.5 cm from the surface of the core. The marker appeared intact and there was no evidence of mixing (see photo below). Observations of banding were not recorded for this second core collected from microbead plot OL-MB-80095.

Core #2 from Microbead Plot OL-MB-80095 – Vertical Cross Section Showing Presence of Microbead Marker

Core #1 from OL-MB-80099 (South Basin)

Prior to slicing the frozen core, green sand marker material was observed through the lexan core tube along the sides of the core throughout the core length, as shown in the photo on page 6. However, the microbead marker material was not observed in the vertical cross section. It is likely that the core was collected on the edge of the microbead plot.



Core #1 from Microbead Plot OL-MB-80099 – Outside of the Core Showing Presence of Microbead Marker

Visual inspection of the vertical cross section of the core indicated banding starting at a depth of 2 cm. The core was black to gray in color. Descriptions of the varves/layers present are as follows (see photo on page 7:

- Black sediment at surface to a depth 2 cm, where a 2 mm thick gray band was observed
- Gray band (3 mm thick) observed at a depth of 3 cm
- Gray band (2 mm thick) observed at a depth of 4.5 cm
- Gray band (3 mm thick) observed at a depth of 5.5 cm
- Gray band (3 mm thick) observed at a depth of 6.5 cm
- Gray band (4 to 5 mm thick) observed at a depth of 7 cm
- Gray band (4 to 5 mm thick) observed at a depth of 7.5 cm
- Gray band (3 to 4 mm thick) observed at a depth of 8.5 cm
- Gray band (3 to 4 mm thick) observed at a depth of 9.5 cm

Figure 6
Core #1 from Microbead Plot OL-MB-80099 – Vertical Cross Section Showing Presence of Banding

Core #2 from OL-MB-80099 (South Basin)

No microbead marker material was observed in the duplicate core collected from this location. The core was likely collected outside the boundary of the microbead plot.

REFERENCES

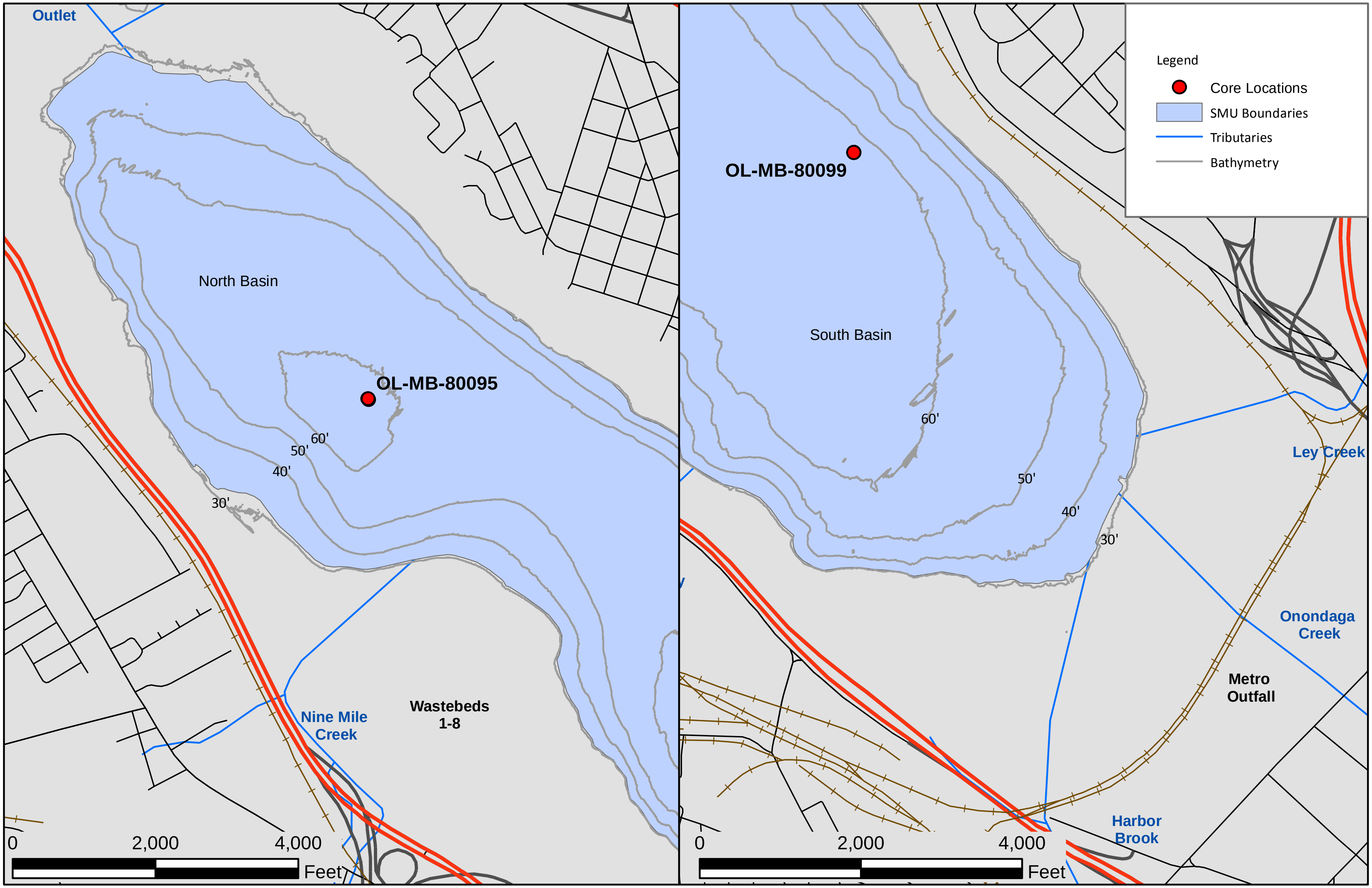
Anchor QEA (Anchor QEA, LLC), 2012a. *Evaluation of Extent of Mixing within Onondaga Lake Profundal Zone Surface Sediments Based on Visual Inspection of Late 2011 SMU 8 Cores*. January 11, 2012.

Anchor QEA, 2012b. Evaluation of Extent of Mixing in Shallow Profundal Surface Sediments of Onondaga Lake Based on Visual Inspection of June 2012 SMU 8 Cores. July 23, 2012.

Parsons, 2010. Evaluation of Onondaga Lake Profundal Surface Sediment Mixing Depths Based on Visual Evidence. December 17, 2010.

Parsons, 2012. Attachment A Results From 2010 Microbead Marker Plot Sampling to the *Onondaga Lake Sediment Management Unit 8 Microbead Marker Placement Report*. Prepared for Honeywell, Syracuse, New York. January 2012.

Parsons and Environmental Tracing Systems, 2010. *Onondaga Lake Sediment Management Unit 8 Microbead Marker Placement Report*. Syracuse, New York. Prepared for Honeywell, Syracuse, New York. May 2010.



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ANCHOR QEA

Honeywell PARSONS

Figure 1
2012 Core Collection for Visual Inspection from Microbead Plots
Evaluation of the SMU 8 Sediment Processing Method
Honeywell-Parsons/Onondaga Lake