CAPPING FIELD DEMONSTRATION SUMMARY REPORT

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CQA	construction quality assurance
CQAP	Construction Quality Assurance Plan
CQC	construction quality control
CY	cubic yards
ft	feet
GAC	granular activated carbon
GPS	global positioning system
HDPE	high density polyethylene
LOI	loss of weight by ignition
NYSDEC	New York State Department of Environmental Conservation
QA	Quality Assurance
ROD	Record of Decision
RTK	realtime kinematic
SES	Sevenson Environmental Services
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

Honeywell continues the progress toward achieving the goals of the Onondaga Lake Record of Decision (ROD) and the community's vision for a restored lake with completion of the Capping Field Demonstration. The lake remediation plan, which was selected by the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (USEPA), includes dredging of up to an estimated 2.65 million cubic yards (CY) of contaminated sediments and capping of over 400 acres of lake bottom. Consistent with ongoing design evaluations, the chemical isolation layer of the cap in portions of the lake will include addition of granular activate carbon (GAC) in order to promote long-term chemical isolation. The capping field demonstration described herein was completed to provide additional design- and construction-related information pertaining to placement of the GAC-amended chemical isolation layer. Information gained from this demonstration was provided to NYSDEC prior to issuance of this final report and was utilized in construction planning and implementation.

The capping field demonstration started with an equipment shakedown period. The capping barge used for the demonstration was specifically constructed for the Onondaga Lake project and had not been used before. The system and operating methods were field adjusted during the shakedown period in order to improve the ability to place sand and GAC uniformly during the demonstration. Additional system modifications will be implemented prior to the start of full scale operations to provide further enhancements and provide an even greater uniformity of GAC and sand placement.

The capping field demonstration confirmed that the hydraulic placement equipment proposed for the Onondaga Lake cap can consistently place GAC throughout a sand layer at the specific water depths required for the Onondaga Lake project. The land based feed system demonstrated a slurry of water and GAC could be kept at a constant concentration and metered into a constant sand feed volume that was mixed with water to make a sand/GAC slurry of known concentration. This sand/GAC slurry was pumped out to the capping barge for hydraulic placement.

The water based hydraulic cap placement and GAC testing demonstrated that the *in situ* sand/GAC material placed during the demonstration had a GAC mass balance that correlated with the slurry that was pumped from land. This demonstrated that the GAC metered from shore was remaining with the sand during placement through the water column and no GAC loss to the water column was evident. GAC verification was performed with materials removed from *in situ* catch pans, 12 inch square by 18 inches tall, that were placed on the sediment surface prior to capping. The catch pans were pulled and analyzed after a capping run to determine the GAC content in the pan. It was demonstrated that GAC was horizontally uniform throughout the extents of the runs as determined by the GAC content of the catch pans tested during the demonstration. The GAC particles were visually observed and the particles were vertically distributed in the pans. Additionally, push cores were taken in a capping lane for comparison to the pans, and showed similar vertical GAC distribution.

The data collected from the demonstration indicates that a known concentration of sand/GAC input from shore correlates well with the *in situ* sand/GAC concentration. Full-scale efforts will increase the accuracy and measurements of all the input variables, including GAC concentration, GAC flow, and sand feed rate. With very controlled and measured inputs, and a uniform sand placement, the GAC quantity in the cap required for the design will be ensured. During the startup and commencement of the capping system, an increase testing frequency for layer thickness quality control and GAC verification quality assurance (QA) is proposed. As the capping contractor demonstrates consistency and uniformity of placement, the proposed testing frequency is reduced as proposed measurement metrics have been met.

During the demonstration, the water quality was measured at fixed locations as well as discrete locations throughout the capping area. Water quality impacts were visually minimal and localized to the direct area of the active capping operation. The sand for the majority of the demonstration was a washed sand, from a local distributor. One run was done with a bank run sand that was not washed. There was no measurable or visible difference in the turbidity between the two sand types. No water quality impacts were noted during the demonstration at the fixed monitoring locations. Visible turbidity had generally subsided within 20 minutes after the capping operation had completed placement.

SECTION 1

INTRODUCTION

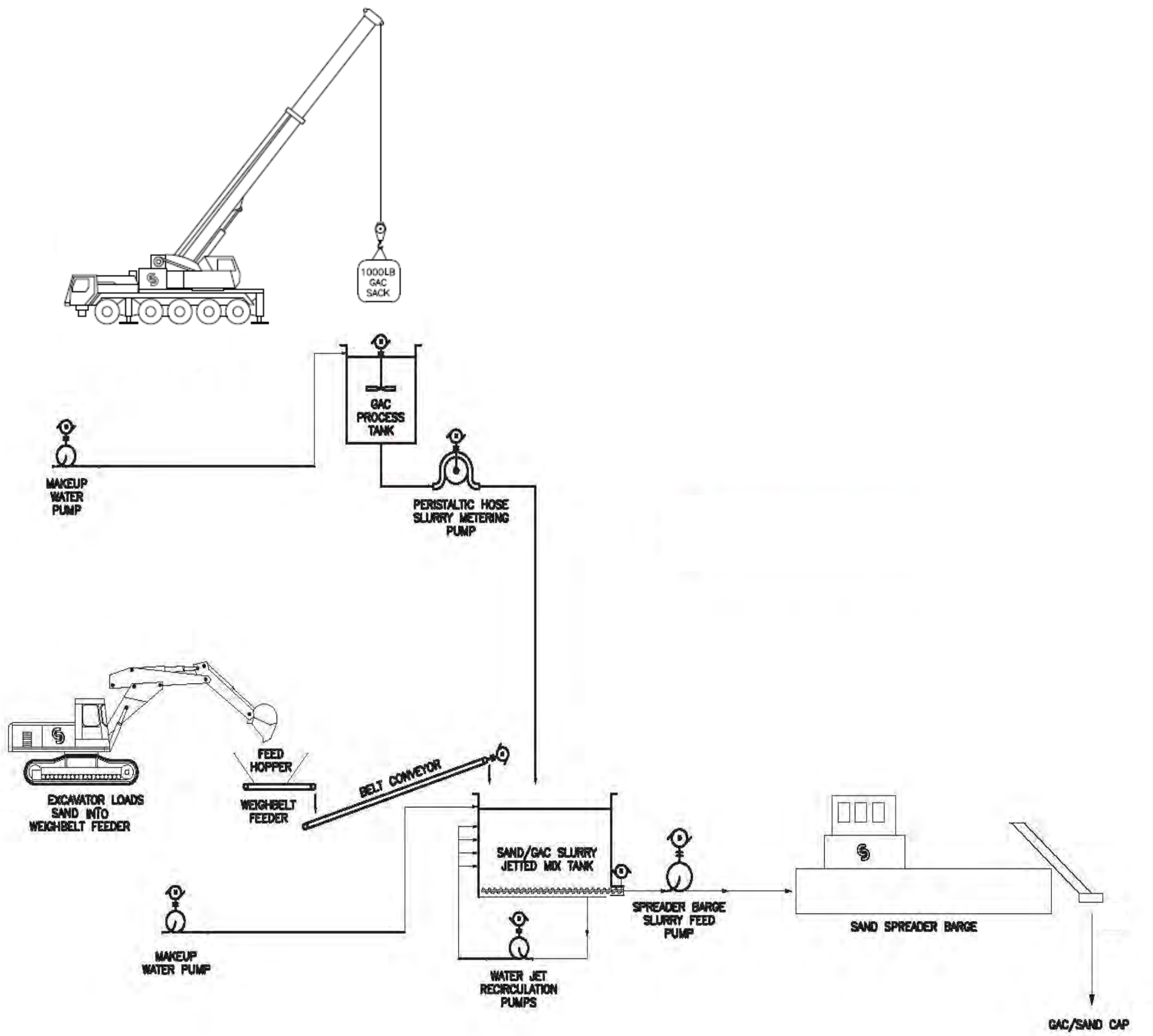
The primary purpose of the work as described in the Onondaga Lake Capping Field Demonstration Work Plan (Work Plan; October 2011) was to demonstrate the ability to effectively place sand and GAC through the water column, resulting in a chemical isolation layer with GAC distributed throughout. The demonstration was completed consistent with the Work Plan approved by the NYSDEC. The capping field demonstration proved the implementability of mixing/slurrying GAC and sand on-shore and placing the material over a pre-defined depth and area within the lake. Information gained from this demonstration and contained in this report was provided to NYSDEC prior to issuance of this final report and was utilized in construction planning and implementation. The placement equipment and techniques demonstrated as part of this study were subsequently optimized as part of the capping start-up and full-scale implementation, They have been effective in meeting the capping requirements specified in the Final Design and Construction Quality Assurance Plan (CQAP, Anchor QEA 2012). Capping operations are in their second year of full-scale implementation, and any questions or uncertainties remaining following completion of this field demonstration have been addressed as part of this implementation.

This summary report describes the field demonstration equipment and materials used for on-shore material management and placement of the material within the lake, the procedures that were followed during the demonstration, and the results and conclusions from the demonstration.

The location for the capping field demonstration was approximately a 1-acre area of Remediation Area D. The cap material staging and slurry equipment location for the demonstration were located on the Wastebed B site adjacent to the in-lake demonstration area. This support location is in proximity to the proposed full-scale capping support area.

The demonstration area covered water depths ranging from approximately 5 to 30 feet (ft). The capping field demonstration took place in a portion of the lake slated for capping only (i.e., no initial dredging), and the full-scale cap for this area will be placed over the demonstration cap during final construction. The process flow diagram for the capping field demonstration is shown in Figure 1.

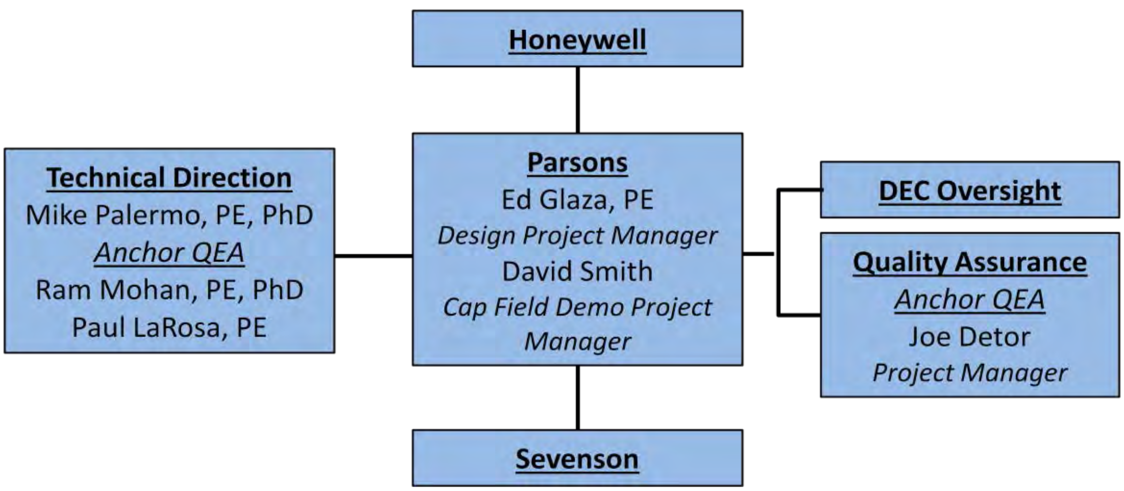
Figure 1. Process Flow Diagram



SECTION 2

FIELD ACTIVITIES

With oversight by Parsons, Sevenson Environmental Services (SES) performed the activities of the capping field demonstration. On-site support was provided by Anchor QEA, including collection of cores and water quality monitoring. On-site technical guidance was provided by Michael Palermo, P.E., Ph.D., (Environmental Dredging and Capping Consultant, and former USACE ERDC Sediment Expert), and Paul LaRosa, P.E., and Ram Mohan, P.E., Ph.D., of Anchor QEA. The NYSDEC provided oversight throughout completion of the demonstration. SES mobilized water-based and shore support equipment, installed and assembled the systems, performed cap material placement for the demonstration, and removed selective equipment throughout October and November 2011.



2.1 SITE PREPARATION AND INITIALIZATION OF SYSTEM

Site preparation activities included installation of storm water/erosion control measures, site clearing, establishing a shore support area, mobilization of equipment, construction of a GAC saturation tank, and construction of the cap material mixing and delivery system. Site prep was initiated by SES on September 30th and continued through October 30th.

2.2 FIELD DEMONSTRATION MATERIALS

The sand used for the capping field demonstration was primarily a washed sand consistent with the materials anticipated for full-scale construction. Sieve analyses for material used can be found in Appendix A. Starting October 20th, approximately 1,500 CY of sand were brought to the site and stockpiled for the demonstration. Additional washed sand was brought on-site as required throughout the demonstration. As discussed with the NYSDEC, unwashed sand was brought to the site for use on November 16th and was used for a single run to evaluate potential differences in turbidity generation during the demonstration. Trucks delivering sand to the site used transport routes consistent with the Work Plan.

GAC was delivered to the site in prepackaged 1,000 pound supersacks prior to the demonstration. The GAC used for the demonstration was Calgon F400, with a specified grain size of 12 by 40 (at least 95 percent passing 12 mesh (1.4mm), maximum of 4 percent passing the 40 mesh (355 µm)). The supersacks of GAC were introduced into a known volume of water in the GAC slurry tank. The GAC/water slurry was kept uniformly mixed with a vertical mixer that extended from the top of the tank to the bottom. Additional considerations will be made for full scale operations to adjust the impeller heights of the vertical mixer in the GAC mix tank. This will further improve consistency of GAC slurry concentration.

2.3 CAP MATERIAL MIXING AND DELIVERY SYSTEM CONSTRUCTION

A hydraulic capping system was used for the placement of capping materials during the demonstration. System components were comprised of the same equipment planned for the full-scale capping construction. A process flow diagram for the demonstration is shown on Figure 1. The land based portion of the system was comprised of an upland hopper, loaded by an excavator, that fed sand from a stockpile to a slurry mix tank. The slurry mix tank mixed the sand with water from the lake. GAC was separately pumped to the discharge of the sand slurry mix tank and introduced into the discharge pipe of sand slurry, creating a sand and GAC slurry mix. The mixed sand/GAC slurry was pumped by a booster pump through a HDPE pipeline to the spreader barge at the demonstration location. The hydraulic cap placement system consisted of a spreader barge equipped with a diffuser plate that reduced the energy of the hydraulic slurry of the capping materials. Each of these components is discussed below.

2.3.1 Sand Feed System

The sand slurry system consisted of a feed hopper, belt conveyor with weigh scale, and a slurry mix tank. A hydraulic excavator loaded the sand material into the hopper. An adjustable door (set to one location once the demonstration started), metered the material exiting the bin on the feed hopper conveyor. At the discharge of the hopper conveyor, the sand was then dropped to the belt conveyor and transported to the sand/ slurry mix tank at a constant rate. The weigh scale on the conveyor was not operational during the demonstration.

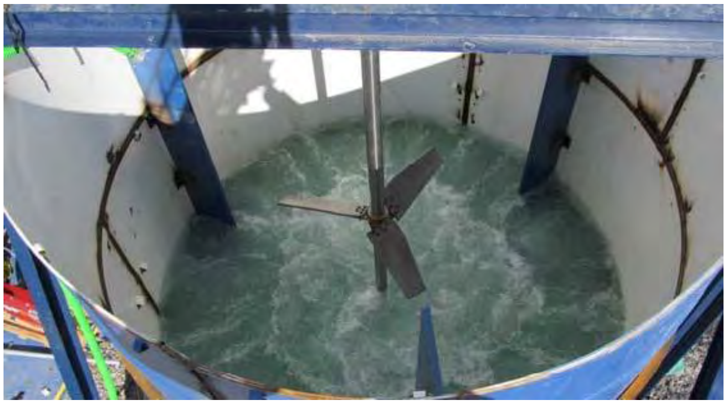
Sand Feed System

2.3.2 Granular Activated Carbon (GAC) Feed System

The GAC was mixed with water prior to placement in order to saturate the void space of the GAC (i.e. removing entrained air) to promote more rapid settling through the water column during placement. All of the GAC required for the demonstration was loaded into the GAC process tank prior to the start of operations.

The GAC slurry system consisted of a process mix tank, a vertical shaft mixer, and a slurry metering pump. A crane loaded the 1000-pound supersacks into the GAC process tank where it was combined with make-up water. The GAC was mixed with water to create a known concentration of GAC in the water solution. The agitation in the process mix tank homogenized the wetted GAC and maintained a uniform concentration. The GAC slurry was then pumped from the tank through a peristaltic metering pump and flow meter, and delivered to the sand/GAC slurry line at the desired rate, based on the planned GAC dose in the demonstration test chemical isolation layer.

GAC Process Tank Side View



GAC Process Tank Top View

GAC Loading

GAC Metering Peristaltic Pump

2.3.3 Sand Slurry Mix Tank

Sand was introduced into the slurry mix tank as makeup water was pumped through the tank. The sand was mixed into the water to form a slurry. The tank was fitted with water jet recirculation pumps to keep the slurry in suspension and homogenized. The slurry was drawn from the tank through a booster pump and pumped out to the spreader barge for placement. GAC was injected into the slurry line after the exit of the slurry mix tank.

Sand Slurry Mix Tank

2.3.4 Slurry Line

A high density polyethylene (HDPE) pipeline was used to transport the sand/GAC slurry to the spreader barge. The HDPE pipe and fittings were brought to the site and fused together to produce the required length of pipe and appurtances for the demonstration test. Sections of HDPE pipe capped on both ends were attached to the slurry pipeline to keep the pipeline floating. The slurry pipeline was marked by buoys and lights to warn recreational boats of the work area.

2.3.5 Spreader Barge

The HDPE slurry pipe was connected to an energy diffuser plate located on the spreader barge. The diffuser system was attached to the front of the barge. The barge had a waterfall type discharge apparatus (steel plate angled towards the water) positioned on the deck of the barge. The angled discharge plate acted to dissipate the energy in the capping material slurry delivered to the placement barge via the floating line, thus allowing the slurry to enter the water in a controlled and uniform manner. The spreader barge had a hydraulic cable winch system and anchors to facilitate the movement of the barge for placement of the material. Using the arrangement of winches and anchors, the spreader barge was operated in a series of parallel "lanes" equal to the width of the diffuser plate.

Spreader Barge

2.4 SYSTEM SHAKEDOWN

The land-based cap material mixing and delivery system was started up on October 31, 2011. The complete hydraulic capping system shakedown was conducted over a three-week period prior to the demonstration and consisted of operation and adjustments of the land and water based equipment. These adjustments were completed in order for the hydraulic capping system to perform as required to produce a uniform sand gradation layer that included GAC. During the equipment shakedown process, capping "runs" (placement within a single capping lane) were conducted to evaluate the consistency of the equipment and material placement and allow for any modifications. Operational considerations during this time were aimed at ensuring the following components:

- A constant sand feed rate from the feed hopper to the slurry tank
- A controllable and consistent GAC feed rate
- A constant sand /GAC slurry pump rate
- Demonstration of proper positioning of the barge

Each of these components of the system was fine tuned during this time to provide consistent operations for the demonstration.

2.4.1 System Modifications

During the equipment shakedown period, modifications were made to the system for placement and retrieval of the cap material. Catch pans were be used to collect samples of the placed capping materials. A catch pan is a steel pan placed on the sediment bottom that collects a sample that is deposited as the cap material is placed. The field demonstration used two sizes of pans, one of which was constructed with two clear sides to view the material prior to emptying the pan. To start the shakedown, the pans had ropes with buoys attached for retrieval of the pan. Early shakedown runs caught the buoys with the capping barge and tipped the pans over. The system of rope and buoys was redesigned using floatable rope in place of buoys. Floatable rope prevented the buoys from catching on the barge during sand placement and tipping over the pans.

Data was collected to assess the effects of the directional movement of the barge as well as the effects of wind and water current direction on the slurry during the placement of the cap. The accuracy of the capping barge Global Positioning System (GPS) was also evaluated. During the capping demonstration, the capping barge GPS was used only for horizontal location and not operated in realtime kinematic (RTK) mode. It was checked periodically during the demonstration with a RTK GPS rover and found to have an accuracy of approximately 6 to 10 ft. During full-scale operations, the capping barge GPS system will be operated with RTK accuracy of less than 1 cm.

Physical modifications to the energy diffuser plate were made throughout the demonstration in an effort to optimize the hydraulic placement performance. Initially the capping barge diffuser plate had baffles bolted across the face. The baffles could be angled to increase the horizontal uniformity of the flow across the diffuser plate. During the equipment shakedown process, the baffle angles were adjusted to try to create a more uniform discharge across the entire width of the plate. Following this effort, the baffles were removed for the remainder of the testing. It was noted that the visual uniformity of flow across the diffuser plate was not impacted when the baffles were removed.

Based on visual observations of the material distribution during the early runs, Sevenson determined that the diffuser plate should be retrofitted with a large rubber belting extending across its entire height and width. With the modification, as the slurry exited the risers onto the diffuser plate, it was forced between the plate and belting prior to discharge into the water. This belting aided in the uniformity of *in situ* sand gradation and did not affect the GAC recovery. In addition to the belting across the diffuser plate, a horizontal platform of expanded metal was fabricated and welded onto the bottom of the diffuser plate in close proximity to the point of entry of the slurry into the lake (see Spreader with Energy Dissipating Belt Addition below). The horizontal expanded metal platform was also covered with belting across its entirety. The belting forced the slurry through the expanded metal and prevented a portion of the slurry from exiting the back of the platform. All demonstration runs on and after November 14th utilized this modified energy diffuser plate setup.

Spreader with Energy Dissipating Belt Addition

2.5 FIELD DEMONSTRATION CAP PLACEMENT

2.5.1 Barge Operations

The cap placement runs for the field demonstration started on November 9th and proceeded through November 18th. During this period, a total of 10 runs were completed. At least one run was accomplished each day, except for November 15. Multiple runs were completed on November 16th and 17th.

The capping materials were placed in a series of parallel “lanes” that were 22-ft wide (corresponding to the width of the angle plate diffuser on the spreader barge). The cap placement operation started at one end of a capping lane, and the sand spreader barge progressed along that lane at a constant rate that provided the target lift thickness of the capping material.

In runs that consisted of passes in one direction (uni-directional), the capping slurry materials were stopped at the end of a pass, the barge was relocated back to the beginning of the first pass, and the slurry was started again. Each additional pass was sequenced the same way. During one direction passes, the spreader plate, mounted on the front of the barge, faced shallower water and the barge was pulled backward from shallow to deeper water. In runs that were done with passes in two directions (bi-directional), the first pass was completed, and as the slurry continued to flow, the barge stopped, reversed directions, and progressed back over the first lane with the same speed in the opposite direction.

2.5.2 Verification Sampling and Analysis

Field Procedure

Post-placement verification samples were collected as part of the capping demonstration project to measure the thickness of capping materials placed and the concentration of GAC within the sand layer. Cap placement samples were collected using “catch pans”, which consisted of open-top containers placed on the sediment prior to cap placement, and were retrieved after placement to observe and measure the applied thickness. The catch pan contents were also sent to the lab for GAC analysis. Catch pans for GAC verification were 12 inches square by 18 inches tall with two clear sides. A secondary set of shallow (1 ft deep) pans were also used to confirm layer uniformity and thickness. Multiple catch pans were deployed for each capping lane of the demonstration. Catch pans to be sent for GAC verification had the material in the pan removed and placed in pre-labeled 5-gallon pails. Once all the samples had been collected, they were transferred to shore for delivery to the lab for GAC verification.

In later runs, in addition to the catch pans, attempts were made to collect cores to aid in the visual observation of sand and GAC vertical uniformity. When collected successfully, cores demonstrated uniform placement of sand and GAC and were a good visual confirmatory tool. However, cores were not successfully retrieved in some locations due to subsurface conditions or core retrieval methodology employed. The core methods employed for the demonstration included push cores and gravity cores. Use of vibracore sampling was considered to overcome the limitations of the push and gravity cores. However, the sampling motion of taking vibracores may have altered the *in situ* sand/GAC layer and therefore were not used

GAC Verification Laboratory Procedure

Collected samples were transferred to shore for measurement of GAC content. GAC was removed from the sample matrix by thermal destruction and quantified by comparing the weight of the sample prior and subsequent to burning. The thermal method developed for the GAC removal relies on exposing the sample to heat that will burn off the GAC without burning off the sand. Full capping catch pan samples taken from a capping run were sieved to remove particle sizes larger and smaller than the expected GAC particles. The sample was segregated using a #10 sieve and a #50 sieve resulting in a weight of materials larger than a #10 sieve, between a #10 and a #50 sieve, and smaller than a #50 sieve. Only material between a #10 and a #50 sieve was processed for GAC verification. This sieve step reduces the sample size to be dried and heated.

Prior the sieve step, the samples were placed in an oven and heated to 110°C to remove the water from the sample. After the sieve step, the sample was weighed and placed in an oven and heated to approximately 600°C to burn off the GAC. The sample was reweighed to determine the quantity of GAC in the sample. The work plan specified that each day's operations would include a control sample of a known weight of carbon in a sand matrix to verify recovery of GAC within the matrix, and that if more than 20 samples were taken per day, a control sample would be taken for each 20 field demonstration samples. Receiving field sample results for the previous day’s runs was paramount to access the operational variable for the next day’s operations. In order to get the field data as soon as possible, rather than analyzing a matrix spike daily, a total of seven spikes were analyzed between November 8th and November 17th when the ovens were available. Matrix spikes analyzed between November 8th and November 16th showed an average recovery of +/- 2.8% of the spiked GAC. Spikes analyzed on the 17th (after the unwashed sand arrived on site) showed recoveries of 17% and 22%. The matrix spikes analyzed on the 17th may have been a blend of washed and unwashed material and may not be representative.

During the burn process, a small portion of the sand is also lost, referred to a background loss of ignition (LOI). The GAC quantification corrects for this background LOI. During the field demonstration, LOI from the sand brought to the site showed background values between 0.61 and 0.83 percent and averaged 0.69 percent of the total weight of the screened sample, based on 9 samples (results provided in Appendix A). For the purposes of this report, the average background loss on ignition of 0.69 percent was used to account for background conditions. The GAC quantification also accounted for the ash content of the GAC. The GAC used for the demonstration had an ash content of 9 percent. This value was provided by the GAC supplier (Calgon) and was verified at the laboratory.

2.6 WATER QUALITY SAMPLING

Turbidity monitoring was performed during the Capping Field Demonstration to assess water quality during capping operations. The monitoring included four full-time turbidity monitoring locations, as well as a single discrete monitoring location. During the demonstration, the work zone for the demonstration test was bordered by a demarcation curtain. Turbidity was monitored both inside and outside the work zone. Three full-time monitors were located approximately 300 ft outside the demarcation curtain in a radial pattern, and the fourth was located approximately 500 ft outside the demarcation curtain. The discrete sampling location varied throughout the work zone during the demonstration to define the water quality impacts localized around and within the capping barge lanes during operations.

Overall, the capping activities performed during the demonstration project had minimal impacts to water quality both outside and within the demarcation curtain. Turbidity generated within the demarcation quickly dissipated following completion of cap placement operations (generally within 20 minutes of completion of operations). Results from the water quality monitoring during the capping field demonstration can be found in Appendix D.

2.7 CURRENT VELOCITY AND WAVE HEIGHT MEASUREMENT

During the Capping Field Demonstration, current velocity was measured to assess the water current conditions during capping demonstration. The water velocities were measured in 16 ft of water at the middle of the water column. The monitor was located approximately 200 ft east of the demonstration area as to not interfere with boat traffic to and from the shore and the demonstration area. Wind and water current plots are presented in Appendix C.

SECTION 3

DISCUSSION OF RESULTS

During the capping field demonstration, operational criteria was used to assess the sand/GAC placement. In general, the operational criteria for the subsequent runs were developed based on observed performance from the previous runs. Operational criteria included, targeted water depth, nominal targeted thickness of each pass, direction of barge movement, and GAC targeted dosage. Additionally, the hydraulic capping equipment was modified at times throughout the demonstration to help improve the uniformity of sand placement by the capping equipment. These criteria and equipment modifications were evaluated to determine the ideal combination that would result in a well mixed, uniform cap, with the desired GAC dosage. Each run was evaluated for desired GAC dose and uniformity of cap materials. A summary of key information from each run is provided in Table 1. Key results and conclusions are discussed below.

3.1 UNIFORMITY OF GAC APPLICATION RATE

Prior to the application of GAC, the sand feed rate exiting the feed hopper was calculated. The feed rate was set by placing a known amount of material in the hopper (bucket count from the excavator) and timing the sand as it was removed from the hopper. The sand feed hopper was operated with a constant feed conveyor belt utilizing a strike off door at the exit of the conveyor from the feed hopper. The door for the hopper was adjusted during the shakedown to provide the required feed rate for the demonstration. During the demonstration, the feed hopper door remained at a fixed height in order to maintain a constant sand feed rate.

For the analysis of the results, the sand/GAC slurry concentration was based on the sand feed rate and the average GAC concentration feed rate for the run. The constant sand feed during each run, as discussed above, was determined to be 180 loose cubic yards per hour. Physical property testing determined the unit weight for the sand 90 pounds per cubic feet. The GAC calculation was based on the average GAC in the water slurry (pounds per gallon) multiplied by the flow rate for the slurry (gallons per minute). The feed concentration was based on the sand feed rate (pounds/minute) divided by the GAC feed rate (pounds/minute). The measurement of the feed variables were based on the equipment and feed system used for the demonstration. For full scale operations, the measurement equipment for the sand and GAC feed systems will be much more robust, to provide additional control and measurement of the feed components.

Figure 2 illustrates the GAC concentration in pounds of GAC per gallon of water within the GAC feedline for each capping run. In general, there is little fluctuation throughout a run indicating that the GAC concentration within the feedline was consistent throughout the duration of each capping run. As discussed above, the sand feed rate was also constant throughout a run, therefore the resulting GAC/sand slurry concentration was consistent throughout each run.

Table 1
Capping Field Demonstration Summary

Run Date	Lane	Run Length (ft)	Water Depth (ft) (ft)	Materials		Pass	Lift Thickness per pass (in.)	Number of Passes	Pass Direction	Sand Feed Rate (cy/hr)	GAC Pump Rate (gpm)	GAC Slurry Concentration (lbs/gal)	GAC/Sand Input Concentration* (lb GAC/lb Sand)	Catch Pans #	Water Depth (ft)	Thickness (in.)	>#10 mesh (%)	Between #10 & #50 (%)	<#50 mesh (%)	Total Sand Weight (lb)	Carbon Weight (lb)	GAC/Sand Concentration (lb GAC/Lb Sand)	Slurry Mix Line >#10 mesh (g)	>#10 mesh (%)	Between #10 & #50 (g)	Between #10 & #50 (%)	<#50 mesh (g)	<#50 mesh (%)	Total Sand Weight (g)	Carbon Weight (g)	Measured GAC/Sand Concentration (lb GAC/lb Sand)
Sand Gradation																	± 47%	± 33%	± 20%												
11/9/2011	2	150	5'-14'	Sand	GAC	1	4.5	2	bi-directional	180	45	0.61	0.38%	1	11'	11.5	50.9%	43.2%	5.9%	91	0.340659341	0.38%	747.6	30.4%	1126.4	45.8%	583.9	23.8%	2457.90	12.6373626	0.51%
												0.70	0.43%	2	8'	3.75	51.8%	26.5%	21.7%	27.2	0.098901099	0.36%	1034.5	29.0%	1691.3	47.4%	842.4	23.6%	3568.20	16.043956	0.45%
						2				180		0.64	0.40%	6	8'	5.75	35.5%	47.1%	17.4%	42	0.197802198	0.47%	959.7	35.2%	1192	43.8%	571.4	21.0%	2723.10	11.6483516	0.43%
												0.62	0.38%	10	6'	12.3	41.9%	42.0%	16.1%	110.7	0.395604396	0.36%	1011.7	38.5%	1077.2	41.0%	540.4	20.6%	2629.30	169.230769	6.44%
Average GAC/sand concentration for the run												**input**	**0.40%**								**Catch Pans**	**0.39%**								**Slurry Mix Line**	**1.96%**
11/10/2011	2A	100'	8'-14'	Sand	GAC	1	4.5	2	uni-directional	180	45	0.48	0.30%	1	13'	9.4	51.5%	39.6%	8.9%	76.7	0.230769231	0.30%	1653.6	43.2%	1496.6	39.1%	673.8	40.7%	3824.00	9.23076923	0.24%
												0.45	0.28%	3	11'	10	49.9%	39.9%	10.2%	80.2	0.263736264	0.33%	1038.6	39.4%	1079.7	41.0%	515	19.6%	2633.30	15.6043956	0.59%
						2				180		0.46	0.28%	4	15'	7.4	66.0%	27.0%	7.0%	58.9	0.131868132	0.22%	1394.1	54.3%	805.8	31.4%	366.3	14.3%	2566.20	8.68131868	0.34%
												0.46	0.28%	8	9'	9	54.9%	33.1%	12.0%	75.9	0.241758242	0.32%	524.1	27.2%	906.9	47.0%	499.2	25.9%	1930.20	8.68131868	0.45%
Average GAC/sand concentration for the run												**input**	**0.29%**								**Catch Pans**	**0.29%**								**Slurry Mix Line**	**0.41%**
11/11/2011	2A	100'	8'-14'	Sand	GAC	1	2.25	4	uni-directional	180	45	0.44	0.27%	2	10'	13	53.2%	37.1%	9.8%	96.3	0.318681319	0.33%	1172.4	40.2%	1175	40.3%	565.7	19.4%	2913.10	12.0879121	0.41%
												0.57	0.35%	5	12'	15.5	58.0%	34.6%	7.3%	134.8	0.373626374	0.28%	902.1	34.7%	1173.2	45.2%	522.9	20.1%	2598.20	12.1978022	0.47%
						2				180		0.48	0.30%	7	15'	7.25	60.0%	31.8%	8.2%	99.8	0.285714286	0.29%	487	23.7%	1000.3	48.8%	563.6	27.5%	2050.90	7.36263736	0.36%
												0.55	0.34%	6	16'	9	70.7%	25.0%	4.3%	66.9	0.10989011	0.16%	1035.6	37.0%	1190.5	42.5%	576.1	20.6%	2802.20	11.4285714	0.41%
Average GAC/sand concentration for the run												**input**	**0.31%**								**Catch Pans**	**0.27%**									**0.41%**
11/14/2011	9	100'	10'-16'	Sand	GAC	1	2.25	4	uni-directional	180	45	0.40	0.25%	6	16'	4.6	56.1%	34.7%	9.3%	59.4	0.153846154	0.26%	1870.3	49.9%	1280.8	34.2%	598.6	16.0%	3749.70	5.93406593	0.16%
												0.49	0.30%	1	12'	8.1	58.4%	30.6%	10.9%	69.5	0.197802198	0.29%	937.1	38.8%	989.3	40.9%	489.7	20.3%	2416.10	3.84615385	0.16%
						2				180		0.36	0.22%	3	11'	12.1	52.7%	36.9%	10.3%	103.7	0.362637363	0.35%	1870.4	55.1%	1015.5	29.9%	509.1	15.0%	3395.00	9.45054945	0.28%
												0.37	0.23%	5	14'	9.4	59.6%	31.1%	9.4%	81.1	0.21978022	0.27%	480.9	26.6%	837.5	46.2%	492.6	27.2%	1811.00	6.59340659	0.36%
Average GAC/sand concentration for the run												**input**	**0.25%**								**Catch Pans**	**0.29%**									**0.24%**
11/16/2011	8	150'	9'-12'	Sand	GAC	1	2.25	4	uni-directional	180	45	0.38	0.23%	6	10'	11.1	57.4%	32.7%	9.8%	96.8	0.274725275	0.28%	2228.4	59.4%	1036.6	27.7%	483.8	12.9%	3748.80	8.24175824	0.22%
												0.47	0.29%	12	11'	7.4	67.3%	23.0%	9.7%	58.8	0.10989011	0.19%	2056.7	52.6%	1289.8	33.0%	560.5	14.3%	3907.00	11.5384615	0.30%
						2				180		0.57	0.35%	10	11'	5.5	54.1%	31.0%	14.9%	40.3	0.10989011	0.27%	2357.2	60.4%	1049.9	26.9%	496.1	12.7%	3903.20	10.5494505	0.27%
												0.43	0.27%	11	12'	11.2	58.8%	33.1%	8.1%	95.5	0.230769231	0.24%	1715.8	53.2%	1005.9	31.2%	501.5	15.6%	3223.20	8.24175824	0.26%
Average GAC/sand concentration for the run												**input**	**0.29%**								**Catch Pans**	**0.25%**								**Slurry Mix Line**	**0.26%**
11/16/2011	8	150'	16'-24'	Sand	GAC	1	2.25	4	uni-directional	180	45	0.38	0.23%	3	16'	7	53.1%	34.6%	12.3%	54.4	0.153846154	0.28%	2228.4	59.4%	1036.6	27.7%	483.8	12.9%	3748.80	8.24175824	0.22%
												0.47	0.29%	4	22'	6.7	53.9%	35.7%	10.4%	55.7	0.142857143	0.26%	2056.7	52.6%	1289.8	33.0%	560.5	14.3%	3907.00	11.5384615	0.30%
						2				180		0.57	0.35%	9	24'	7.9	56.8%	32.4%	10.8%	64.1	0.142857143	0.22%	2357.2	60.4%	1049.9	26.9%	496.1	12.7%	3903.20	10.5494505	0.27%
												0.43	0.27%										1715.8	53.2%	1005.9	31.2%	501.5	15.6%	3223.20	8.24175824	0.26%
Average GAC/sand concentration for the run												**input**	**0.29%**								**Catch Pans**	**0.25%**								**Slurry Mix Line**	**0.26%**
11/16/2011	3	100'	15'-20'	un-washed Sand	GAC	1	4.5	2	bi-directional	180	45	0.30	0.19%	4	*19'*	5.3	47.8%	40.3%	11.9%	41.2	0.120879121	0.29%	914.8	35.3%	1102.5	42.5%	574.9	22.2%	2592.20	9.34065934	0.30%
												0.39	0.24%	10	*17'*	8.8	59.9%	32.9%	7.2%	72.6	0.164835165	0.23%	754.2	32.0%	1076.3	45.6%	527.4	22.4%	2357.90	10	0.36%
						2				180		0.43	0.27%	14	*17'*	7.5	43.1%	45.5%	11.4%	65.9	0.208791209	0.32%	159.2	12.6%	651	51.3%	458	36.1%	1268.20	7.14285714	0.48%
														1	*15'*	3.6	12.3%	58.4%	29.2%	24.3	0.17582418	0.73%									
Average GAC/sand concentration for the run												**input**	**0.23%**								**Catch Pans**	**0.39%**								**Slurry Mix Line**	**0.38%**
11/17/2011	9	100'	9'-18'	Sand	GAC	1	4.5	2	bi-directional	180	45	0.32	0.20%	8	9'	8.1	45.7%	42.4%	11.9%	66.5	0.21978022	0.33%	1023.1	42.9%	899.6	37.7%	463.1	19.4%	2385.80	7.58241758	0.32%
												0.44	0.27%	11	18'	6.3	56.3%	38.8%	4.9%	55.1	0.098901099	0.18%	2732.6	60.4%	1252.2	27.7%	535.8	11.9%	4520.60	9.45054945	0.21%
						2				180				15	13'	9.8	59.1%	33.3%	7.6%	81.7	0.120879121	0.15%									
														3	15'	8.1	58.8%	34.9%	6.3%	68.5	0.098901099	0.14%									
Average GAC/sand concentration for the run												**input**	**0.23%**								**Catch Pans**	**0.20%**								**Slurry Mix Line**	**0.26%**
11/17/2011	9	100'	9'-18'	Sand	GAC	1	4.5	2	bi-directional	180	22.5	0.39	0.12%	5	13'	8.1	55.4%	35.4%	9.2%	70.62	0.065934066	0.09%									
												0.41	0.13%	8	16'	7.1	54.6%	36.6%	8.7%	60.6	0.087912088	0.15%									
						2				180				11	11'	10	54.3%	36.0%	9.8%	90.1	0.098901099	0.11%									
Average GAC/sand concentration for the run												**input**	**0.12%**								**Catch Pans**	**0.12%**								**Slurry Mix Line**	
11/18/2011	10	60'	12'-18'	Sand	GAC	1	4.5	2	bi-directional	180	22.5	0.35	0.11%	2	16'	5	57.9%	36.2%	5.9%	40.6	0.054945055	0.14%	1685	50.8%	1119	33.7%	515.1	15.5%	3319.10	4.06593407	0.12%
														4	15'	7.5	59.1%	33.9%	7.1%	55.2	0.043956044	0.08%									
						2				180				6	12'	9	52.1%	39.3%	8.6%	69.8	0.076923077	0.11%									
Average GAC/sand concentration for the run												**input**	**0.11%**								**Catch Pans**	**0.11%**								**Slurry Mix Line**	**0.03%**

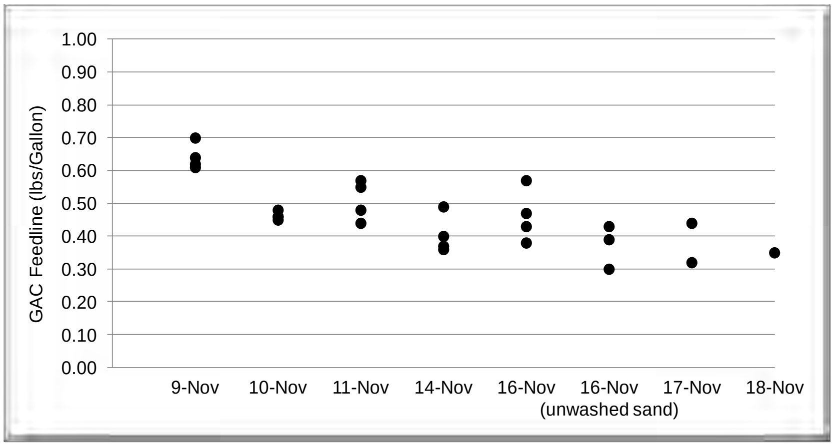


Figure 2. GAC concentration (lbs/gallon) in the feedline by run

3.2 GAC MASS BALANCE

For each capping demonstration run, multiple catch pans were deployed throughout the lane. A subset of pans from each lane, generally representative of the entire lane, were tested for GAC content. The general layout for the four GAC verification pans was; two pans along the centerline of the lane (one near the start and one near the finish of the lane), and two in the approximate center of the length of a lane offset approximately 5 ft from each edge of the lane. A typical pan layout can be seen in Appendix B. A comparison of the average GAC to sand concentration (calculated from the GAC input and sand feed rate) to that of the concentration in the catch pans for each run shows that GAC will settle through the water column to create the required chemical isolation layer and that minimal GAC is lost to the water column. Table 2 shows the variance between the average calculated GAC/sand input concentration and the resulting average GAC concentration in the cap as measured in the individual catch pans. The greatest variability was seen during the testing of the unwashed sand product due to one outlier biased high and during the final two days of the demonstration when a low dose of GAC application was applied.

Table 2. GAC input concentration and *in situ* measurements. [1] single outlier removed

	Average GAC/Sand Concentration (GAC feedline (lbs/min) ÷ Sand feed rate (lbs/min))	**Average Catch Pan Concentration** GAC (lbs.)÷ Sand (lbs.)	**Variance**
Date	Avg.	Avg.	
11/9/2011	0.40%	0.39%	3%
11/10/2011	0.29%	0.29%	0%
11/11/2011	0.31%	0.27%	-13%
11/14/2011	0.25%	0.29%	16%
11/16/2011	0.29%	0.25%	-14%
11/16/2011 (unwashed) [1]	0.23%	0.28%	18%
11/17/2011	0.23%	0.20%	-13%
11/17/2011 (low dose)	0.12%	0.12%	0%
11/18/2011 (low dose)	0.11%	0.11%	0%
			-0.38%

3.3 HORIZONTAL UNIFORMITY OF GAC

For each capping demonstration run, multiple catch pans were deployed throughout the lane. Each pan was retrieved and evaluated for stratigraphy and lift thickness. A subset of pans from each lane was tested for GAC content. In general, four pans per lane were selected for testing. A typical catch pan layout can be seen in lane layout figures in Appendix B. If catch pans slated for GAC verification testing collected less than a representative layer thickness (i.e., less than 4 inches of cap material), a catch pan that was scheduled for thickness verification only replaced the non-representative pan and was used for the GAC verification testing.

The percent recovery of the GAC input dose measured within *in situ* catch pans along the length of a run (north, middle, and south of the capping lanes) is generally consistent within each run (Figure 3).

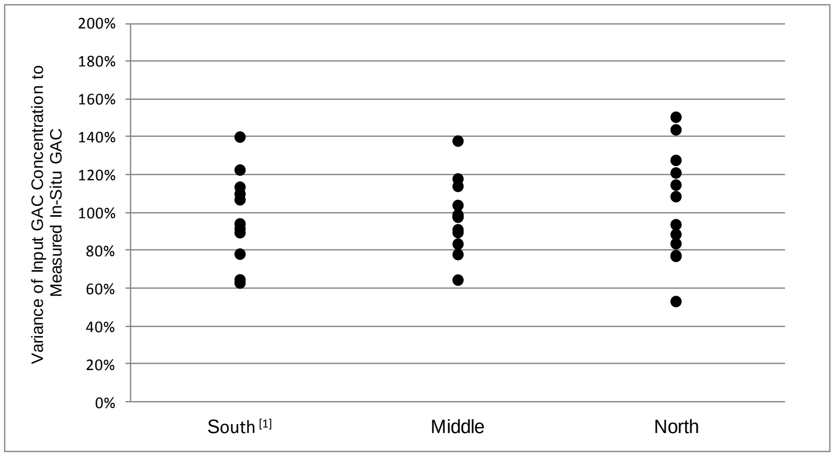


Figure 3. Percent recovery of GAC input dose measured within *in situ* catch pans from south to north. [1] *Outlier of 317% on 11/16 removed*

The percent recovery of the GAC input dose measured within *in situ* catch pans across each lane (i.e. from the eastern, center, and western portions of the capping lanes), is generally higher in the center and eastern portion of the lane (Figure 4). This bias of material toward the eastern side could be attributable drift of the barge, lack of GPS accuracy over the course of the run (i.e., not pulling directly over the pans) or lack of slurry uniformity across the front of the spreader plate. As discussed in Section 4, full-scale operations will include enhancement to address these potential issues.

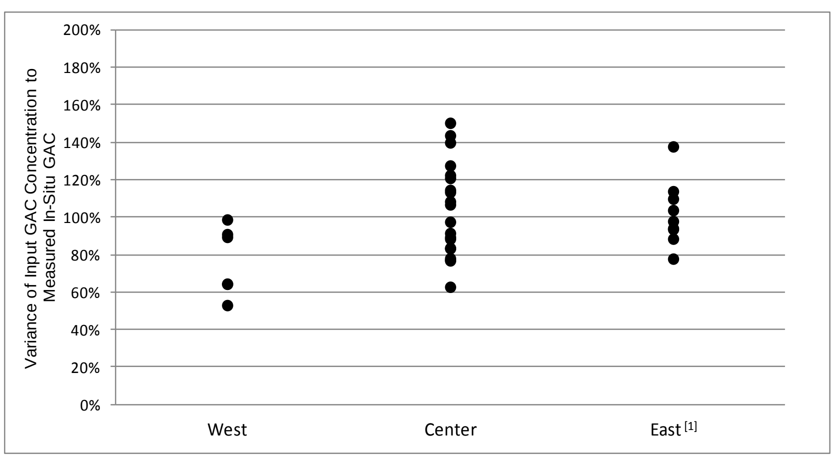


Figure 4. Percentage of GAC input dose measured within *in situ* catch pans from west to east. [1] *Outlier of 317% on 11/16 removed*

Evaluating horizontal uniformity of GAC placement was a primary objective of the field demonstration. The subsections below evaluate horizontal uniformity variables observed during the demonstration.:

3.3.1 GAC Uniformity Relative To Water Depth

An evaluation of GAC uniformity versus water depth for each run indicates that GAC will settle through the water column to create the required chemical isolation layer throughout the water depths required for capping within Onondaga Lake. As shown in Figure 5, there was no significant difference in GAC variability across the various water depths evaluated.

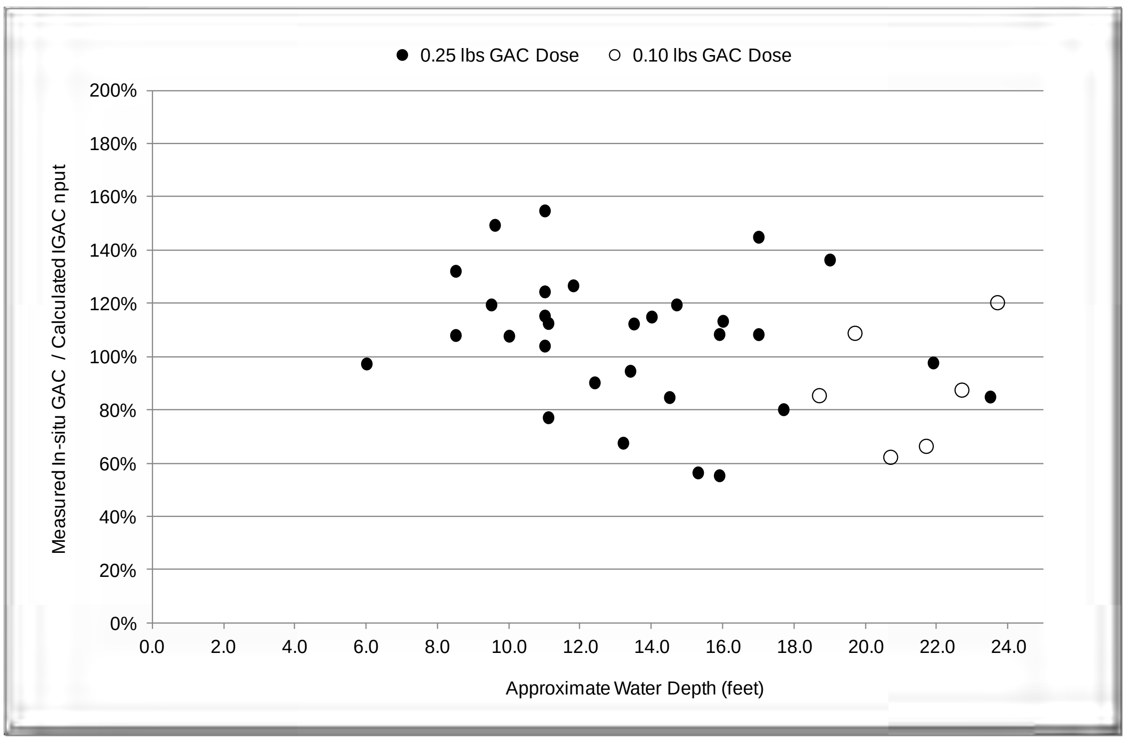


Figure 5. Measured *in situ* GAC percentage of calculated GAC input

3.3.2 GAC Uniformity relative To Grain Size

Each catch pan that was selected for GAC analysis was first sieved to isolate the material containing the majority of the GAC and lower the sample volume (see Section 2.5.2). GAC used throughout the field demonstration was a product with a specification of at least 95 percent passing the # 12 sieve and less than 4 percent passing the # 40 sieve. Therefore, when screening for carbon, the material passing a #10 sieve and being retained on a #50 sieve was used for GAC Verification analysis. Figure 6 shows the grain size (percent by weight of sand and GAC) of each catch pan versus the percent concentration of GAC recovered from each pan. As shown in these figures, there is an apparent correlation between grain size and GAC concentration. The full-scale operations will be implemented to optimize horizontal uniformity of grain size placement, which will help ensure uniform horizontal distribution of GAC.

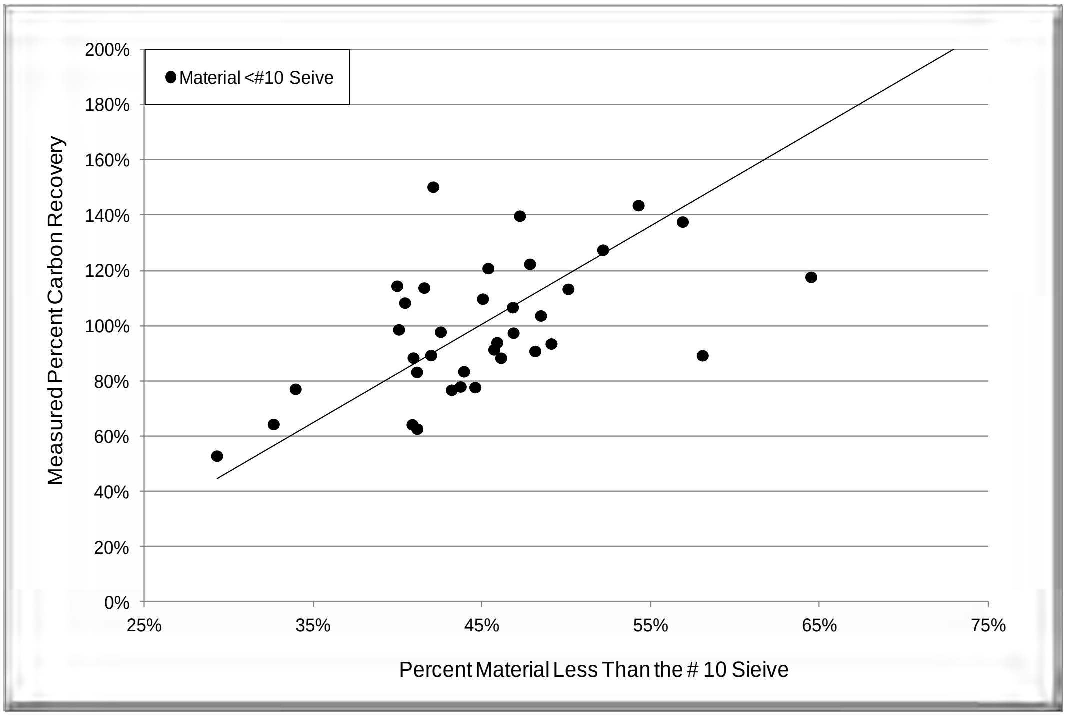


Figure 6. Evaluation of material less than the #10 sieve and percent GAC recovery

3.3.3 GAC Uniformity Relative To Cap Placement Operations

The two cap placement operational procedures that were evaluated relative to horizontal uniformity of GAC distribution were targeted lift thickness and direction of travel of the spreader barge (i.e., one direction versus two directions). As shown in Figure 7, slightly better GAC recovery is seen when operational procedures targeted a nominal 2.25 inch lifts and moving the spreader barge in one direction. However, during the demonstration, the spreader barge was never operated in two directions while targeting a nominal 2.25 inch lift passes. Therefore, it is not possible to determine if lift thickness or travel direction was the controlling factor in the improved performance observed under these operational procedures. Additionally, most of the variability in the performance of the placement of nominal 4.5 inch lifts in multiple directions was observed on one day (November 17th) suggesting an anomaly may have effected GAC placement on this day.

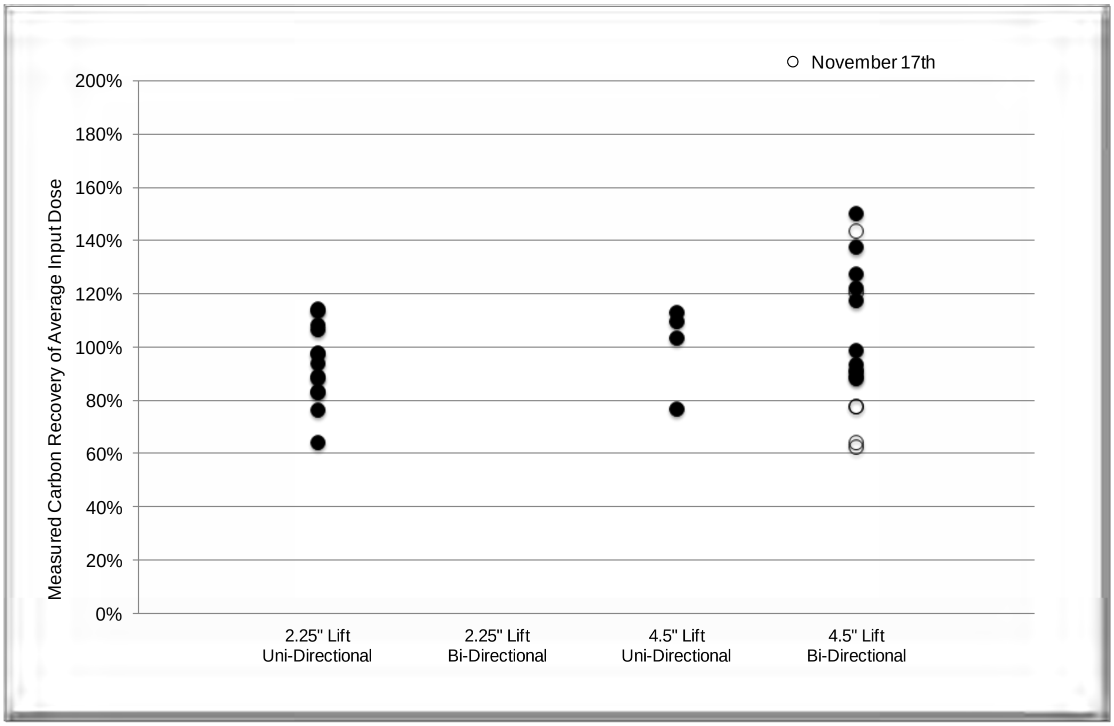
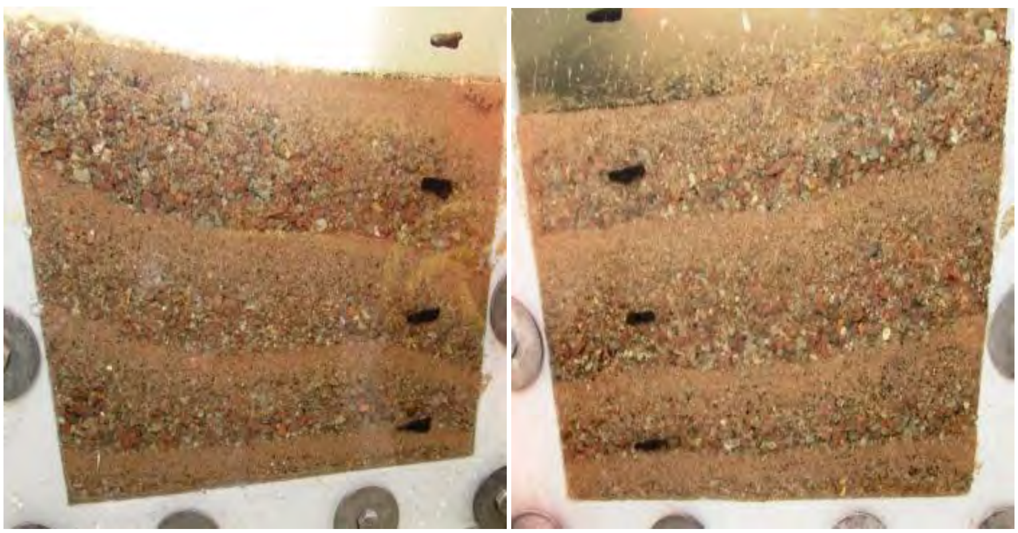


Figure 7. Evaluation of nominal pass thickness and barge movement direction

3.4 VERTICAL UNIFORMITY

During the shakedown period, multiple catch pans with two clear sides were deployed for each run. A complete photo log of all the demonstration catch pans and cores is provided in Appendix B. After a capping lane was completed for the demonstration, each catch pan deployed for the run was retrieved and visually evaluated for stratigraphy and the presence of GAC. During the shakedown, it was observed that the GAC recovery catch pans appeared to not be an accurate representation of how the material would be placed *in situ*. Although the pans may not have represented how the material looked *in situ*, as long as the pans captured all the materials that entered the pan, they remained accurate for the GAC recovery testing. Pans retrieved during the early shakedown period showed the presence of the coarser fraction of the sand cap material on top of the finer fraction. Additionally, the stratigraphy of the catch pans throughout the demonstration was often irregular and differed from one side of the pan to the other. To evaluate other methods to determine an accurate representation of how the sand material and GAC settled onto the bottom of the lake, additional wider shallower catch pans and sediment cores were used. Wider shallower pans were used for all the demonstration runs, and cores were collected from the capping run on November 16th and November 18th to be used as a comparison to the catch pans. These cores, taken from the east, center, and west of the lane depicted similar distribution of material gradation to that observed in the catch pans with coarser sand material, where present, on top of the finer sand material.

To increase the homogeneity of the *in situ* sand material, the barge was rotated 180 degrees to relieve, to the extent possible, any pinching that had been noticed in the slurry line. Additional capping runs were performed on the 9th, 10th, and 11th of November. For these runs, catch pans were the only means used to evaluate the vertical uniformity of the cap. Improvement in the homogeneity of the material distribution was noticeable after this modification (Appendix B – Photo log), and GAC was visually better distributed. After the run on November 11th, belting and grating was added to further improve the placement of sand material as discussed in Section 2.5.1.



Catch Pan # 1 on November 14th (front and back of pan)

As seen in Appendix B and in the above photos, the added belting on the diffuser plate further increased the uniformity of the sand cap material for each lift. Some variability was seen between pans, and the cap surface within the pans was sloped (low to high in the direction of barge movement) for the pans collected on November 11th and 14th. When individual lifts were visually evident in the catch pans, GAC was seen to be well distributed vertically though each lift. On occasion, the material in the catch pans showed visual evidence of being mixed in the catch pan (i.e., not layered). The GAC was vertically distributed throughout the material in these pans; however, it is unclear if the settling of this material is representative of the overall layer of material placed.

To further assess whether the catch pans were an accurate representation of the *in situ* cap, sediment cores were collected in the vicinity of pans for the capping run conducted on November 16th. Both pans and cores showed good distribution of GAC vertically throughout the cap. Photos of the GAC distribution in the pans and lexan cores was hampered by reflection from the lexan of the cores, but was evident from the observations. Visual observations of the catch pans showed variability in material from one side of the pan to the other. Attempts were made to collect core samples co-located with the catch pans. The cap thickness was greater in the co-located cores than in the pans at four out of six locations (Figure 8). At two of these locations, cores were retained and evaluated for grain size. Sieve analysis shows that the pans and cores had a similar ratio of coarse, medium, and fine sand; however, the cores visually showed a more uniform *in situ* gradation of the material (Figures 9 and 10).

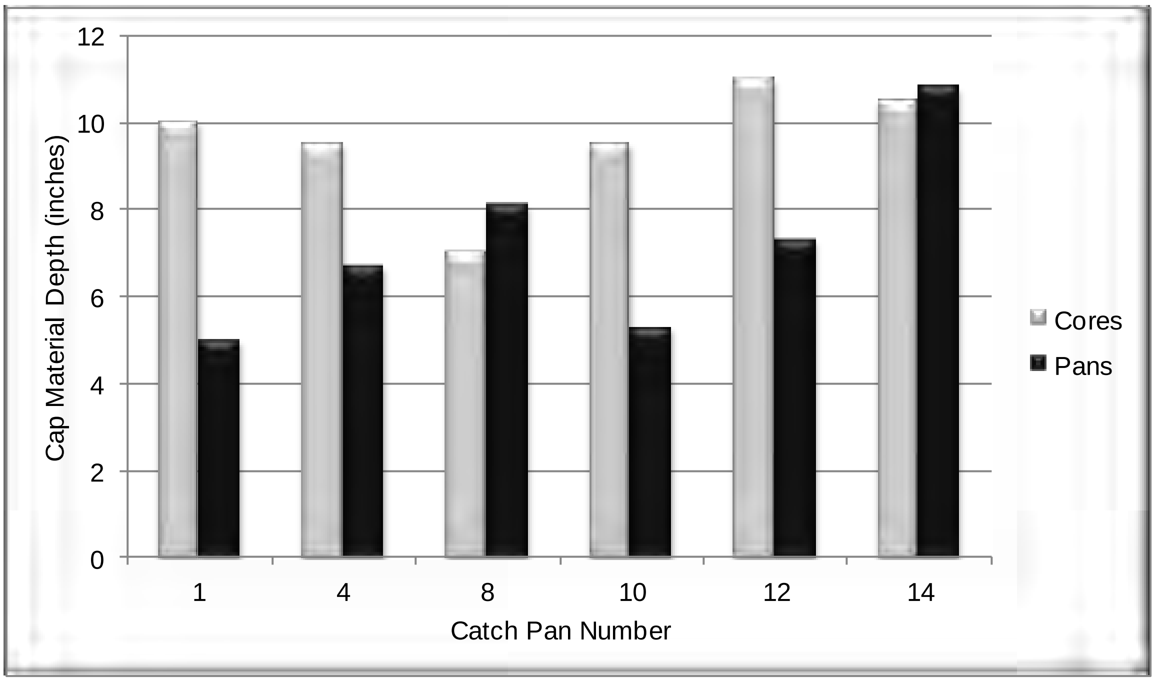


Figure 8. Comparison of cap thickness in sediment cores and catch pans for capping run conducted on November 16th in Lane 8

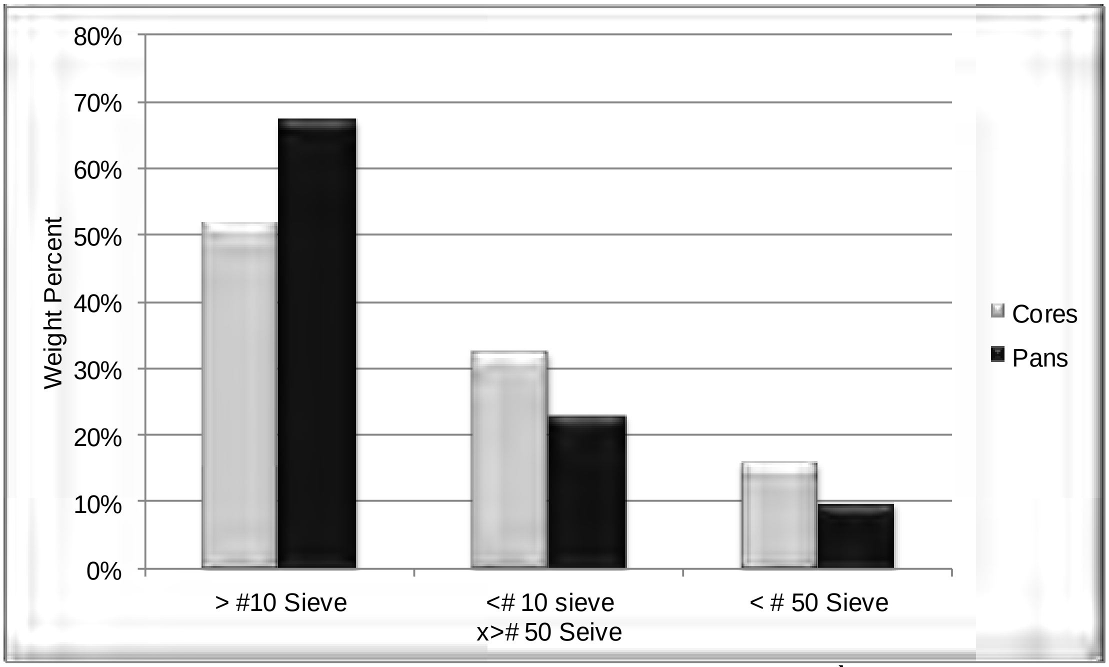


Figure 9. Catch pan location # 12, November 16th 2011

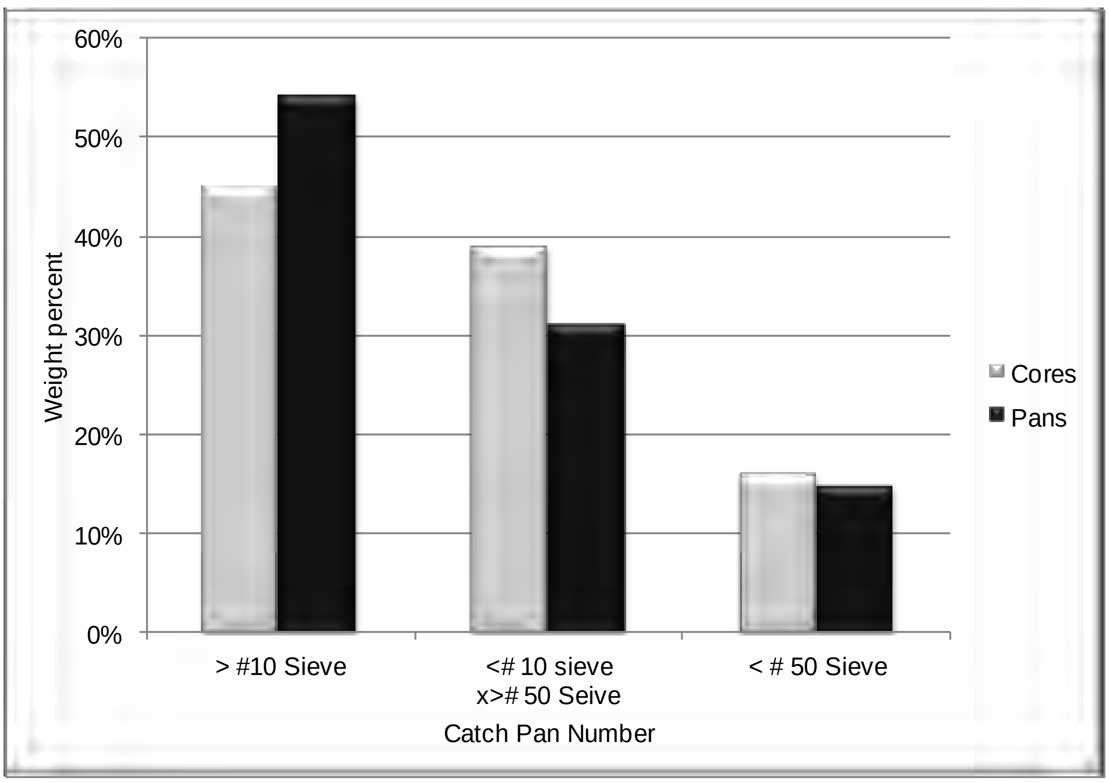


Figure 10. Catch pan location # 10, November 16th 2011

3.5 SUPPLEMENTAL SLURRY SAMPLING

Intermediate process samples were collected at several steps during the cap material mixing and delivery process (i.e., prior to placement on the lake bottom) to measure the GAC concentration. Samples were collected from the GAC slurry line, the discharge of the sand/GAC slurry mix tank, and from the four GAC/sand slurry risers that discharge to the barge spreader plate, as shown in Figure 1. Samples were collected at 10-minute intervals throughout the duration of a run, generally resulting in three to four samples per run at each location.

As shown in Figure 11, the GAC concentration was relatively uniform throughout each run. However, the variability exceeded what would be expected based on the measured uniformity of the GAC and sand feed rate discussed in Section 3.1. This variability may have been a result of collection of a samples that were not representative of the materials within the pipeline. Sampling at this location involved collection of material from a 16-inch pipe using a 2-inch sample port on the outside portion of a mitered HDPE elbow (see picture below). Given the size differential between the sample port and the pipe as well as the velocity of the slurry (~6,000 gpm), sampling from a 2-inch sampling port in this location may not give a representative sample of the slurry in the pipe.

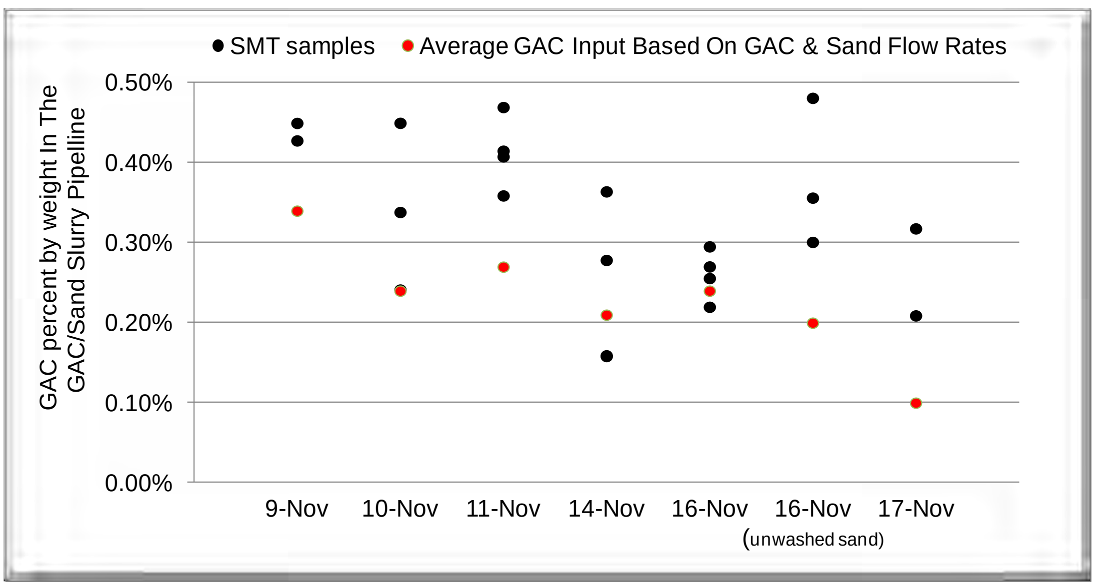
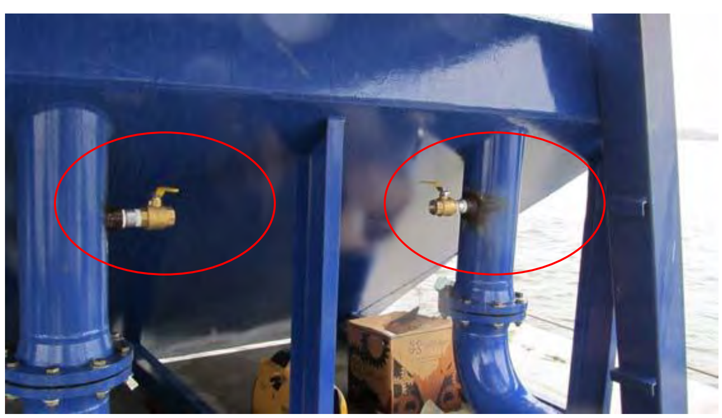


Figure 11. GAC/sand slurry concentration in the slurry pipeline by run

GAC/Sand Slurry Mix Line Sample Port

During the shakedown period prior to runs on November 9th, samples collected from the four risers on the capping barge were analyzed for grain size distribution and GAC verification. Sampling at this location involved collection of material from an 8-inch pipe using a 2-inch sample port perpendicular to the flow. Given the size differential between the sample port and the riser pipe as well as the velocity of the slurry (approximately 6,000 gpm), sampling from a 2-inch sampling port may not give representative sample of the slurry in the pipe. The data showed that risers 3 and 4 were receiving a greater amount of the coarse fraction of sand material. This uneven distribution of materials through the risers may have been in part due to the pinching of the slurry line from shore to the barge causing separation of the material within the pipeline. On November 9th, to relieve pinch points observed in the slurry feed line to the capping barge, to extent possible, the barge was detached from the anchors and roated180 degrees allowing the slurry line to extend from the back of the barge out into the lake before looping back toward shore. Data collected from the riser from November 9th through November 16th is included in Appendix A. The data show variability in total sample weight and GAC across the riser and with time. This variability could be a result of sampling bias. However, the ratio of coarse material to fine material stays relatively even indicating the grain size distribution material is uniform.



Sample Ports on Vertical Riser Before Surry Enters The Diffuser Plate

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The following conclusions are supported based on the results of the capping field demonstration:

- The capping field demonstration confirmed that the hydraulic placement equipment proposed for the Onondaga Lake cap can consistently place GAC throughout a sand layer at the specific water depths required for the Onondaga Lake project. The land based feed system demonstrated a slurry of water and GAC could be kept at a constant concentration and metered into a constant sand feed volume that was mixed with water to make a sand/GAC slurry of known concentration.
- The GAC testing demonstrated that the *in situ* sand/GAC material placed during the demonstration had a GAC mass balance that correlated with the slurry that was pumped from land. This demonstrated that the GAC metered from shore was remaining with the sand during placement through the water column and no GAC loss to the water column was evident.
- The closure of the mass balance discussed above also demonstrated that the catch pans were successful in collecting the GAC that was placed. However, the distribution of material visualized through the clear walls of the catch pans did not appear representative of how the cap materials were actually placed. This may be due to "shadowing" effects or hydrodynamics within the 18 inch tall catch pans as cap material collected within them. Shallower pans and/or cores may provide a preferred method for evaluating vertical distribution and thickness of the cap materials placed.
- The demonstration was completed in water depths from five to thirty feet and there was no noticeable difference in GAC recovery, horizontal uniformity or vertical distribution in pans in shallow or deep water depths. This indicates that water depth is not a significant issue in being able to successful place the GAC/sand cap.
- Horizontal uniformity of GAC distribution was relatively good regardless of whether a 9-inch layer consisted of four nominal 2.25 inch passes or two nominal 4.5 inch passes inches and at a nominal two and one quarter inches, and regardless of whether the capping barge operated in one or two directions. The data indicate that thinner passes and/or operating the barge in one direction may have resulted in slightly better uniformity. However, given the numerous variables involved and relatively limited number of runs, the potential benefits of these operational approaches cannot be determined.
- GAC distribution was correlated with sand grain size distribution, indicating that achieving uniform distribution of grain size will help ensure uniform distribution of GAC.

- During the demonstration the water quality was measured at fixed locations as well as discrete locations throughout the capping area. Water quality impacts were visually minimal and localized to the direct area of the active capping operation. The sand for the majority of the demonstration was a washed sand, from a local distributor. One run was done with a bank run sand that was not washed. There was no measurable or visible difference between the two sand types. No water quality impacts were noted during the demonstration at the fixed monitoring locations. Visible turbidity had generally subsided within 20 minutes after the capping operation had completed placement.

4.2 INCORPORATION OF RESULTS INTO FULL-SCALE CAPPING OPERATIONS

Full-scale capping operations use the capping equipment employed during the demonstration project. The placement equipment and techniques demonstrated as part of this study were optimized as part of the capping start-up and full-scale implementation The start of the 2012 capping operations focused on producing a uniform *in situ* cap thickness and sand material gradation across the path of the capping barge energy diffuser discharge. Prior to starting capping operations, the capping slurry system was modified to include flow dispersion flanges on the capping barge slurry lines to equilibrate flow through the four discharge pipes.

Capping operations in 2012 began in RA C. At the start of capping operations in 2012, an initial “commissioning/startup” period that includes several construction quality control (CQC) and construction quality assurance (CQA) sampling and testing procedures was conducted. The purpose of the initial period was to improve system performance and dosing correlations in areas where cap amendments (i.e., GAC and/or siderite) are required for the chemical isolation layer, and to confirm that the capping methods consistently achieve the *in situ* composition of the amended cap layer consistent with the design requirements. This period consisted of a more intense sampling and testing program of the chemical isolation layer over an area sufficient to prove out the accuracy of the means, methods, and controls employed.

The commissioning/startup period for capping operations began in Model Area C3, which is a deep water area that does not require dredging (i.e., cap-only area) and requires both siderite and GAC. Deep water capping areas have greater tolerance ranges for post-cap water depth requirements than shallow water capping areas. This provided the ability to place additional cap material during the commissioning/startup period, if required, to achieve the designed amendment dosing while staying within the range of designed water depths.

During the capping field demonstration, placement of the cap in multiple thin lifts while operating the spreader barge in a single direction appeared to produce a slightly more consistent sand gradation and GAC placement. Operationally, placing a cap in a single direction would significantly impact the project capping schedule for both GAC amended and non-amended cap placement. Therefore, the initiation of cap placement in 2012 included operation of the capping barge in two directions while placing four targeted nominal 2.25-inch thick layers totaling 0.75 ft. This operational condition was not attempted during the demonstration project. The 2012 cap placement initiation also included operation of the capping barge in two directions while placing two targeted nominal passes of 4.5-inch thick layers totaling 0.75 ft to verify the effectiveness of the barge system modifications to uniform placement of the sand/GAC layer. The objective during the initial stages of the commissioning/startup to full-scale project production was to demonstrate that placing the cap in multiple lifts while operating the spreader barge in both directions would result in a uniform placement of GAC and other cap materials. This approach proved effective during full-scale implementation.

Modified catch pans were be used for thickness and for GAC verification sampling as described in the Construction Quality Assurance Plan (CQAP, Anchor QEA 2012). Due to the potential bias of the intermediate sampling points used during the field demonstration (slurry mix line, vertical risers), only GAC slurry, GAC slurry feed rate, sand feed rate and *in situ* GAC analysis were implemented for commissioning/startup and for full-scale operations.

The GAC for the cap is saturated in water prior to use. The GAC is saturated for a minimum of two hours while being agitated, although it is typically saturated longer during normal operations.

Land based measurement and recording capabilities and instrumentation were significantly increased for the full scale capping operations. The GAC slurry concentration is created in the tanks using calibrated weigh measurement of the GAC and flow of the water. It is pumped to the sand slurry system and measured and recorded using a calibrated density flow meter. The sand feed system use a calibrated weigh scale for control of the sand entering the system. Additional details on the GAC and feed system monitoring and control systems, including accuracies, is provided in the CQAP.

Controls for the full scale capping barge that were not operational during the field demonstration include RTK GPS for location of the equipment, flow and density meters for capping material measurement.