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Collection of Undisturbed Surface Sediments: Sampler Design and Initial Evaluation Testing

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Collection of Undisturbed Surface Sediments: Sampler Design and Initial Evaluation Testing

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NOTICE

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ABSTRACT

In 2001, the National Resource Council (NRC), in a report titled *A Risk-Management Strategy for PCB-Contaminated Sediments*, identified the need for a capability to collect undisturbed surface sediments. Surface sediments are an important source for most exposure of fish to polychlorinated biphenyls via direct uptake from water in contact with sediments. These sediments also are an important source of exposure for fish that feed on prey contaminated by interactions with the sediment and interstitial and overlying water. Thus, contaminant concentrations in surface layer sediment have become a focus of monitoring and assessments. The objective of this project was to develop a sediment sampler that is capable of collecting the upper 15 centimeters (cm) (6 inches) of undisturbed surface sediment. Furthermore, the sediments must be maintained undisturbed inside of the sampling system when the sampler is retrieved so that layers as fine as 1 cm can be removed.

Tetra Tech EM Inc., with design and testing support from AScI Corporation, developed and fabricated an innovative sediment sampler (the Undisturbed Surface Sediment [USS] sampler) that is capable of collecting undisturbed samples of surface sediment. The sampler consists of a core tube housed within a stand that provides isolated, mechanical support in a sediment bed. The sampler is hung from a tower or crane and slowly lowered through the water column. When it makes contact with the bottom, the “feet” and stand legs of the device penetrate the sediment and form a stable platform. The tension on the deployment line is slowly released so that the core tube gently descends into the sediment through the stand hub. The weight spindle then descends and pushes the core tube farther into the sediment, collecting the sample. The sampler is retrieved by pulling on the deployment line attached to the weight spindle to withdraw the core tube from the sediment and water column. The sample is maintained undisturbed inside of the tube until it is removed for subsampling. An extractor piston at the bottom of the core tube pushes the sediment up to the top of the core tube. A slicer block is set over the top of the core tube, the sediment is pushed up into the slicer block until the desired sample thickness is obtained, and the slicer block cuts the sediment column into increments as thin as 1 cm.

The USS sampler was compared with representative core, grab, and dredge sampling devices in a tank test under controlled laboratory conditions. Evaluation of video and turbidity measurements collected during test operations in the tank demonstrated that disturbance of surface sediment was reduced during collection events with the USS sampler when compared with the other devices tested.

The USS sampler was then tested in a field demonstration at Sylvan Lake in Pontiac, Michigan. The USS sampler was tested and compared with a Ponar sampler, a typical commercially available grab sampler

used to collect samples of surface sediment. Video data collected during collocated sampling of sediment at Sylvan Lake demonstrated that the USS sampler offered significantly improved sample collection with minimal disturbance to the surface sediment. Sample material collected and evaluated for particle size did not definitively corroborate the results demonstrated by the video data; however, because the sediment sampled in the lake was uncharacteristically coarse with insufficient fine newly-deposited materials to collect and measure. The lake bed appeared to have been altered by unknown anthropogenic activities. Additional testing, after sampler modification, is recommended in sediment with a greater percentage of fine materials and with the presence of a known contaminant.

Overall, the samples collected with the Ponar sampler tended to contain higher percentages of fine-grained particles than samples collected with the USS sampler. Samples collected with the USS sampler, although coarser in particle size, exhibited significantly less variability from location to location indicating that a consistent depth of sampling was obtained using the USS sampler (i.e., the USS sampler consistently collected only the top 3 cm of surface sediment without incorporation of the finer underlying sediments).

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Trip Report: Field Evaluation of Prototype Sediment Sampler at Sylvan Lake, Michigan

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1.0 INTRODUCTION

In 2001, the National Academy of Sciences (NAS), in a report titled *A Risk-Management Strategy for PCB-Contaminated Sediments*, identified the need to collect undisturbed surface sediments. Surface sediments are an important source for most exposure of fish to polychlorinated biphenyls (PCBs) via direct uptake from water in contact with contaminated sediments. These sediments also are an important source of exposure for fish that feed on prey contaminated by their interactions with the sediment and interstitial and overlying water. Thus, contaminant concentrations in surface layer sediments have become a focus of monitoring and assessment.

In response to this priority, Tetra Tech EM Inc. ([Tetra Tech] 2003) conducted a literature search for the U.S. Environmental Protection Agency (EPA) to identify available technologies for sampling surface sediment that can collect undisturbed sediments up to 1 meter below the interface of the water and sediment. In reviewing the literature, 40 styles of samplers corresponding to three different types of devices — core, grab, and dredge (bed) material — were evaluated against project requirements. Of the three types, the grab samplers are best designed to collect surface sediments distributed horizontally. However, surface sediment collected from these samplers can be perturbed during the sampling process by the bow wave induced by descent and action of the sampling device. As a result of this perturbation, fine-grained particulates in the surface sediment can be washed out from the collected sample. The review concluded that a new sampling technology must be developed to achieve the requirements for sample collection set forth in response to the NRC report.

Therefore, a new approach in sampling design is required to meet this capability in a cost-effective manner. This new design must encompass the entire process of collecting the undisturbed surface sediment sample in a sealable container, transferring it intact from the bottom to the vessel and then to the shore, and sub-sampling it in the laboratory, if necessary. Other desirable features include adaptability of the design to a variety of construction materials and deployment options. Furthermore, the cost for construction and use must not be prohibitive.

The objective of this project was to develop a sediment sampler that is capable of collecting the upper 15 centimeters (cm) (6 inches) of undisturbed surface sediment. Furthermore, the sediments must be maintained undisturbed inside of the sampling system when the sampler is retrieved so that layers as fine as 1 cm can be removed and collected for laboratory analysis. The strategy of adding chemical stabilizers to immobilize a fluid surface sediment interface in a sample core was investigated to assess the approach of solidifying the sample medium for processing in a manner that will not interfere with chemical or biological analysis.

This report summarizes the design, laboratory tank testing, and field demonstration testing of an innovative new sediment sampling device called the Undisturbed Surface Sediment (USS) sampler. Tetra Tech, with design support from AScI Corporation (AScI), developed and fabricated this innovative sediment sampler, which is capable of collecting undisturbed samples of surface sediment. The sampler consists of a core tube housed in a stand that provides a stable platform for proper placement on the sediment surface. The core tube is lowered from this platform in an isolated movement into the sediment bed to collect a specified length of sediment core. Once the sample is collected, the sediment is maintained undisturbed inside of the core tube until removed using a piston and sub-sampled with a slicer block which cuts the sediment core into thin layers.

The USS prototype sampler was fabricated from corrosion-resistant materials using common dimensions of metal stock, wherever possible, to economize on material and labor costs. In the first phase of design verification testing, the performance of the prototype sampler was evaluated in a comparison with commercially available core, grab, and dredge sampling devices under controlled conditions in a specially designed tank that was loaded with harvested sediments. Turbidity data was collected and a video camera was used to record each sampling event to evaluate the efficiency of surface sediment collection.

After the bench-scale evaluation had been successfully completed, the USS sampler was evaluated in a field demonstration at Sylvan Lake in Pontiac, Michigan. The USS sampler and the Ponar sampler, a commercially available grab sampling device, were used in this demonstration to collect collocated sediment samples in a comparison to validate the prototype design. Sampler performance was investigated by reviewing video camera data collected from sampling operations and from the analysis of chemical and physical characteristics of the sediments that were collected from each device.

2.0 CONCLUSION

The USS sampler was specially designed for the collection of the upper 15 cm (6 inches) of sediment in an undisturbed state and to enable the collection of subdivided sediment layers as fine as 1 cm thick. This objective was effectively achieved in the design and fabrication of the USS device, a core-type sampler specially modified to allow removal of collected material from the top of the core tube. The core tube is housed on a platform so that it can be properly placed on the sediment surface. This platform also enables a delayed and isolated entry of the core tube into the sediment bed for sampling. As the device reaches the sediment surface, the core tube is lowered and pushed into the sediment by gentle tapping from the action of the deployment line. The USS sampler is retrieved by lifting on the deployment line. After the sampler is removed from the bed, the core catcher is activated to maintain the sediment undisturbed inside of the tube. Collected sediment is stored inside of the tube until it is sub-sampled. As field personnel take care to ensure that the sampler remains upright, the material collected is pushed up to the top of the core tube, where a slicer block assembly is installed to sub-sample the sediment into layers as fine as 1 cm thick.

The design of the sampler was first evaluated in a tank test, where it demonstrated the ability to collect sediment with less disturbance when compared with three representative types of commercially available samplers. Evaluation of videos and averaged turbidity measurements collected during sampling events in the tank demonstrated that disturbance of the surface sediment was reduced during operation of the USS sampler when compared with the other sediment sampling devices.

Similarly, the performance of the USS sampler was demonstrated in a field sampling event at Sylvan Lake, Michigan. The USS sampler was compared against the Ponar sampler, which is a typical sampler of choice for investigations of surface sediment. The samplers were used to collect collocated sediment samples for comparison analysis. Sampling events were video-documented and the sediment collected was sent to a laboratory for analysis of total organic carbon (TOC) and particle size distribution. Video collected during collocated sampling of sediment with the two devices at Sylvan Lake demonstrated that the USS sampler significantly improved sample collection and minimized disturbance of the sediment surface. The TOC data, in general, showed that the sediment beds sampled were relatively uniform. Samples collected and evaluated for particle size distribution did not conclusively demonstrate the effectiveness of the USS sampler in retaining fine particulates. The sediment was uncharacteristically coarse, suggesting that the lake bottom was likely amended with sand or other coarse material by anthropogenic activities. The surface amendment is suggested by the sharp change in sediment characteristics on visual inspection of sample cores collected and the percentage of fine sediment mass increasing with increasing depth interval.

Contrary to expectations, the sediment collected with the Ponar sampler contained a higher percentage of fine-grained particles than did the sediment collected with the USS sampler. These particle size distribution results were confirmed by both video and laboratory data. The finer particle size distribution in the sediments collected by the Ponar sampler might have been due to the blending or mixing of the surface sediments with the finer sediments that occurred at depth at each site. It was very difficult to accurately and precisely determine and collect only the upper 3 cm of surface sediment once the sediment had been released from the Ponar sampler and the sediment mass spread out in the collection pan. Samples collected with the USS sampler were observed to exhibit less variability in particle size distribution at collocated sampling locations than the Ponar sampler because the USS sampler employs a standardized and precise sub-sampling procedure whereas the Ponar sampler collects sediment in an imprecise manner.

3.0 RECOMMENDATIONS

Although the USS sampler demonstrated its effectiveness at retrieving sediment cores with minimal disturbance, recommendations to improve its design can be offered based on the results of the laboratory and field tests.

It became apparent during field testing that the core catcher device (an eggshell-type catcher mounted in a sliding nosepiece or collar) did not reliably deploy and contain the sediment inside the core during sub-sampling. The leaf-type core catcher used to maintain the collected sample inside of the 6-inch core tube was barely strong enough to resist the suction force on the sediment column when the tube was withdrawn (Fig. 1). Furthermore, rocks and debris in the sediment tended to jam the nosepiece, preventing it from sliding down and releasing the catcher. The rocks and debris ultimately damaged the catcher, further reducing its effectiveness. As a result, it became increasing difficult to retain sediment cores in the tube as sampling progressed. Consequently, the next version of the USS sampler will use a simpler catcher configuration that has been proven in vibracore sampler applications. Essentially, the catcher will be riveted directly into the end of the tube and will be held open position as the tube enters the sediment by a thin disposable plastic ring. This new configuration will require a smaller, 4-inch-diameter core tube to operate effectively.

Figure 1. Core Catcher

The USS sampler demonstrated its ability to collect surface sediments in an undisturbed manner through video documentation of collocated events during tank testing and field studies. Unfortunately, the sediment in Sylvan Lake proved uncharacteristically coarse, suggesting that the surface of the lake bottom may have been altered by anthropogenic activities. Hence, field performance of the sampler in collecting fine sediments could not be verified from the particle size analysis for samples collected during the demonstration, even though video data collected from the sampling events showed otherwise. Lake surface sediment samples tend to be relatively fine grained, in the fine sand to silt and clay range (10 to 1,000 microns). The sediment samples from Sylvan Lake, conversely, appeared uncharacteristic in that the mean size for all samples was typically in the range of coarse sand to gravel (100 to greater than 2,000 microns). Additionally, the samples averaged 30 percent gravel (larger than 2,000 microns), which most likely is the consequence of anthropogenic activities. A follow-on demonstration of the USS sampler should consider locations where the contaminated sediment is unaltered by surface amendment and consisting of fine particulates in order to demonstrate USS sampler effectiveness by means of a particle size investigation.

In addition to TOC analyses, testing for the presence of a known contaminant, such as PCBs, polyaromatic hydrocarbons (PAHs), or petroleum hydrocarbons, may be a better predictor of local conditions at collocated positions in a sediment bed than with the use of a TOC measurement alone. TOC analysis measures an array of compounds that contain organic carbon and is; therefore, a potential predictor for surface conditions. However, the TOC measurements alone may not be as sensitive an indicator as could be provided by addition of contaminant-specific measurement. The follow-on demonstration should be conducted at a site that has surface sediment chemical contamination that can be analyzed in conjunction with the TOC analysis to verify the effectiveness of the USS sampler in collecting undisturbed surface sediments and removing uniform thin layers of the collected surface sediment.

Sylvan Lake was chosen for this field test because the water was exceptionally clear and; therefore, offered excellent conditions for diver-assisted underwater video recording of the sampling events. The exceptionally clear water was likely the result of the presence of coarse, granular material over naturally occurring fine-grained material, possibly because the lake bed was altered by anthropogenic activities. The coarse, granular bottom sediment was not ideal for testing the ability of a sampling device to recover fine-grained, newly-deposited material through particle size analysis. Therefore, a site with a finer-grained layer of surface sediment that also possesses a known level and type of contamination would provide a better opportunity for testing the samplers through laboratory analysis of collected samples, even though these conditions may impair the quality of the test video. In summary, the follow-up sampling round should evaluate the performance of the USS sampler in comparison with a Ponar sampler at a site where chemical and physical characteristics of the sediment have been extensively studied and documented.

4.0 METHODS AND MATERIALS

This section discusses the methods and materials used in sampler fabrication, tank testing, and field testing.

4.1 DESIGN APPROACH AND FEATURES OF USS SAMPLER

A new approach in sampling design was required to achieve the sampling capability identified by NAS in a cost-effective manner. The sampler was designed to encompass the entire process of collecting the undisturbed sediment sample in a sealable container, transferring it intact from the bottom to the ship and then to shore, and sub-sampling it on a boat or in the laboratory if necessary. The design concept also sought adaptability to a variety of construction materials and deployment options and a sampler that was not prohibitively expensive to construct and use.

4.1.1 USS Sampler Design Features

The USS sampler was designed to collect a relatively undisturbed sample of surface sediments by means of slow, controlled insertion and removal of a core tube (Fig. 2). It consists of three main systems with the following functions: a tetrapod stand, a core sampling device, and a ballast system. The features of the systems are described below.

> **Tetrapod support stand.** The weighted four-legged stand provides stable support for the sampler that is independent of boat motion when the USS sampler is lowered to the bottom. This stand contacts the bottom first and supports and stabilizes the sampler so that the rate of entry for the core tube can be controlled. Four support rods penetrate the sediment away from the actual sampling area to minimize interference. Baffles may be installed on the rods, if necessary, to hold the frame a fixed distance off the bottom, even in very soft sediments.
>
> **Core sampler device.** A top block and clamp unit for the core tube rests on the stand and holds the tube as it slides down or up through the hub for sample collection and storage. The core tube consists of a clear cellulose acetate butyrate (CAB) or Lexan® core tube 6 inches in diameter. A core catcher is fastened inside a collar that is mounted at the lower end of the core tube. The tube slowly penetrates into the sediment by operating the ballast system (described below). After it penetrates the sediment, the collar slips down and the catcher releases and closes as the tube is withdrawn. The flap valve at the top of the tube also seals at this time. Once the core is retrieved and capped, it becomes a convenient chamber to hold the immobilized core so that it can be extruded and sub-sampled by slicing it at 1-cm intervals.
>
> **Ballast system**. The lift shaft and weight spindle, as well as other combinations of weights, to be can applied for the desired depth of tube penetration. The flexible design permits the user to change the performance features of the sampler to suit a wide range of sediment conditions.

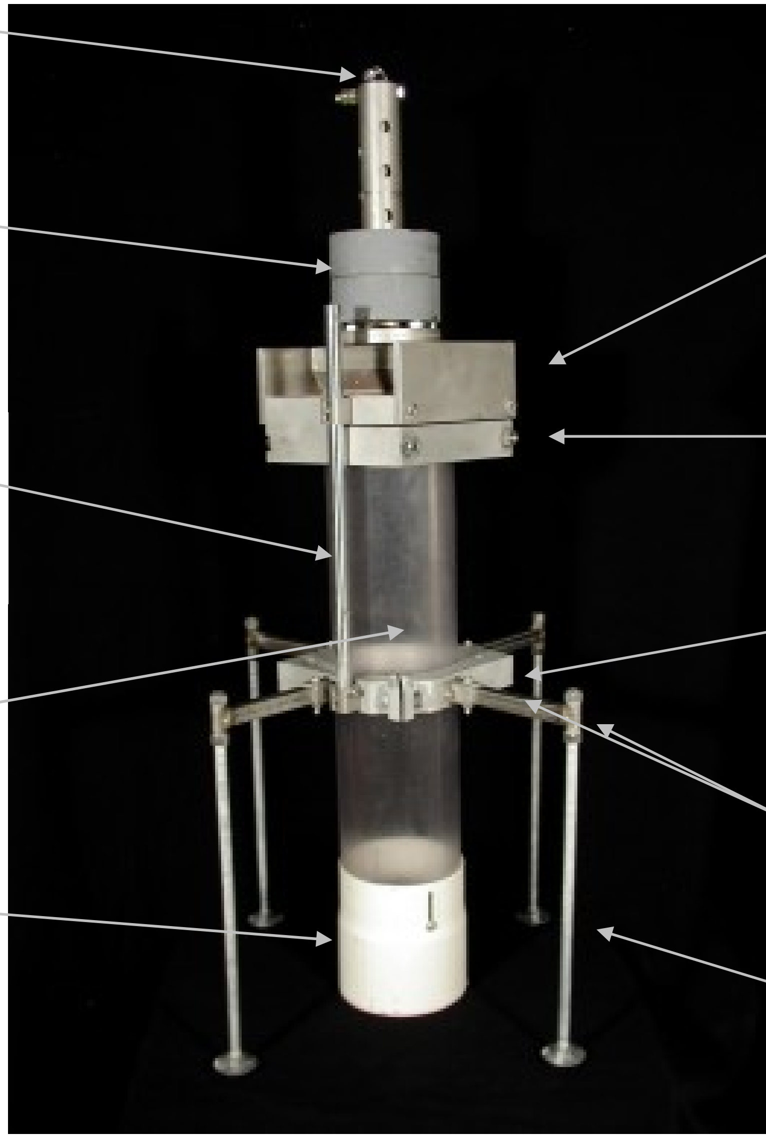


Figure 2. Undisturbed Surface Sediment (USS) Sampler

The most ideal diameter for the core tube was evaluated for the USS sampler. The diameter was selected on the basis of maximizing the volume of sediment collected for laboratory analysis (Table 1). This diameter would also enable the core catcher to effectively retain the material collected inside the tube when it is retrieved from the water. A core tube diameter of 6 inches was selected for the prototype device that could yield 125 grams of sediment, assumed to be about 50 grams of material on a dry-weight basis for analysis. Larger diameters for the core tube are not likely to be effective in retaining sediment

Table 1. Sample Collection Volumes and Weight

Core Tube Diameter (inner diameter) (inches)	Core Tube Collection Diameter (centimeters)	Sample Volume (centimeters^3)	Sample Mass 1-cm Slice[1] (grams)	Sediment Mass Dry-weight Basis[2] (grams)
4 (3.875)	9.8	70	55	20
6 (5.875)	14.9	170	125	50
8 (7.75)	19.8	300	225	90
10 (9.75)	24.8	480	360	140
12 (11.75)	29.8	700	525	210
16 (15.5)	39.4	1200	900	360

Notes:
1. Sample mass assumes that the specific density of the sediment-water mixture is 0.75.
2. Dry weight basis determination assumes a 40 percent solids loading in the sediment mass.

inside the tube using a core catcher device while smaller sizes may require additional sampler deployments to obtain the required sample size.

4.1.2 Sampler Fabrication

The USS sampler consists of six main components, with these functions (Fig. 2):

1. Weight Spindle – The spindle provides an attachment for the lift line and a hammering device (with optional weights added); the lift shaft of the spindle screws into the crossbar of the top block.
2. Top Block – The block provides an anvil (hammering surface) and holds the rubber flap valve in place; it bolts onto the sides of the clamp block.
3. Clamp Block – This block is a movable clamp to hold the core tube and the valve support screen; it is supplied with channels to hold the guide tubes (or rods).
4. Stand Hub – The hub contains spoke sockets for mounting the supporting legs, mounting brackets for the guide tubes, and a ring clamp for the core tube to slide through (or be gripped by).
5. Core Tube and Catcher – This component collects and retains the sediment core sample; the upper end of the tube is held by the clamp block. The core catcher is shown in Figure 1.
6. Slicer Block and Piston – This assembly is an accessory device for pushing the retrieved core sample up the tube (with the piston) and collecting sample increments (with the slicer) in the slicer block chamber. The piston and slicer block are shown in Figures 3 and 4, respectively.

Assembly drawings for the USS sampler are provided in Appendix A.

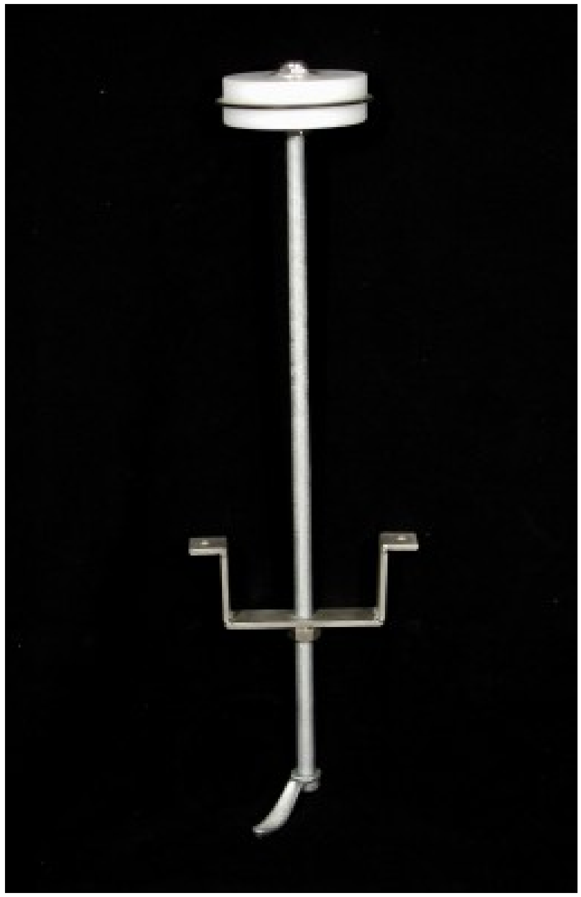


Figure 3. Piston

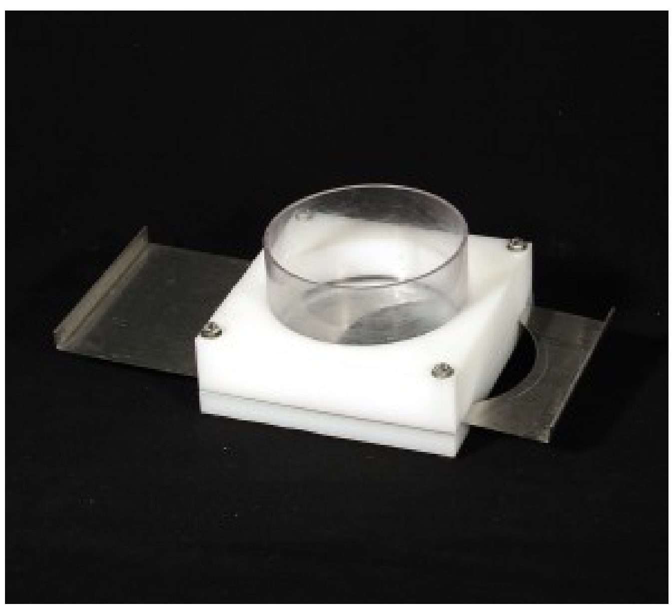


Figure 4. Slicer Block

Table 2. Construction Materials for Sampler Components

Component	Construction Material
Weight Spindle and top block	Type 304 stainless steel*
Piston Rod, mounting bracket, slicer blade, and fasteners	Type 304 stainless steel*
Clamp block and stand hub	6060-t6511 extruded aluminum**
Flap valve and piston gasket	Red silicone rubber (40 duro)
Clamp block O-rings	Black silicone rubber
Slicer block	White nylon
Core tube and slicer block collection chambers	Cellulose acetate butryate (CAB) plastic
Sampler stand legs (threaded rods) and feet (nuts and washers)	Galvanized steel
Core tube and core catcher	CAB plastic
Core tube nose piece (drain pipe collar)	Polyvinyl chloride (PVC)

* Stainless steel was selected to provide strength and durability.

** Extruded aluminum was selected to provide adequate strength and is lighter, cheaper, and easier to machine than stainless steel.

All parts of the USS sampler, including accessories, were constructed from corrosion-resistant materials as summarized in Table 2.

Stainless steel and aluminum components, such as the spindle, top block, clamp block, and stand hub, were all machined from metal stocks that can be obtained in small quantities. These materials were purchased from Metal Express, a materials supply store in Livonia, Michigan. The design makes use of common dimensions of metal stocks wherever possible to economize on material and labor costs. All parts were machined at the Oakland University Machine Shop in Rochester Hills, Michigan.

Certain aspects of the USS sampler design were modified during construction and tank testing. For example, the fabricators experimented with various styles of metal grid to support the rubber flap valve in the clamp block. Ideally, the open area of the material should be maximized to avoid backpressure during core penetration into the sediment, yet the material should still be rigid and strong enough to resist the suction of core withdrawal. Although a honeycomb mesh (1/4-inch cell diameter with 1/4-inch-thick stainless steel) would be an ideal choice since it maximized open area, it was not available in small quantities. Therefore, perforated stainless steel sheet metal (1/8 inch thick with ¼-inch holes on 3/8-inch centers) was used. Sheet metal is readily available and provided rigid and durable construction; however, the reduced open surface area could result in a small increase in the backpressure on the core tube during sampling. These compromises in design or materials were not considered likely to affect the performance of the USS sampler to any significant degree.

4.1.3 Sampler Deployment and Operation

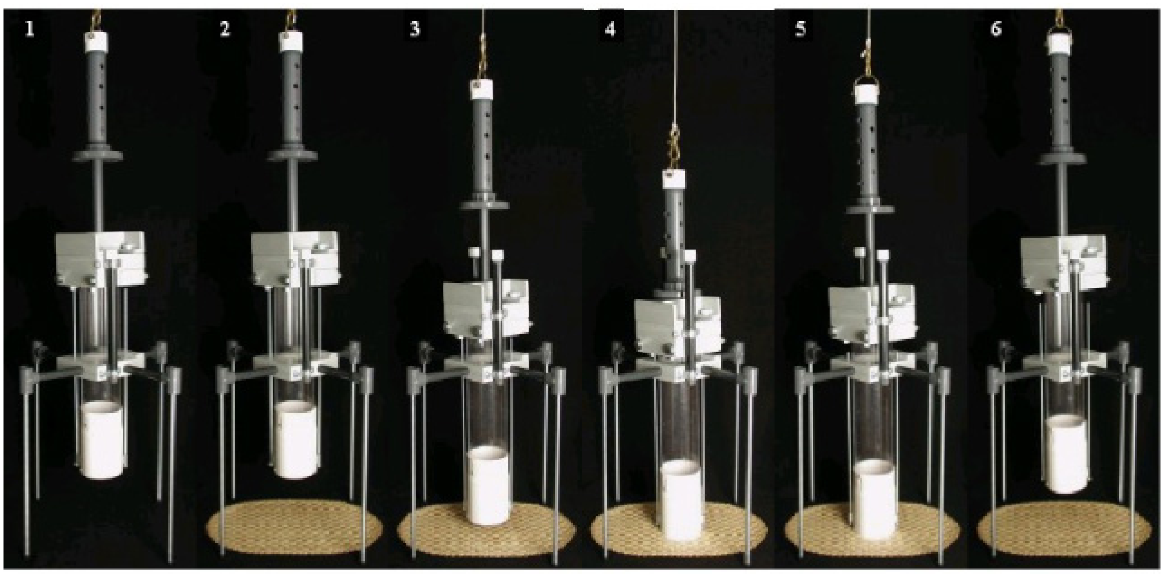
The sampler was designed to operate in the following procedure:

1. As the sampler descends through the water column, the clamp block with the core tube and the weight spindle above it are fully retracted from the stand. The core tube is raised into a position that is well above the stand legs (Fig. 5-1).
2. When it contacts the bottom, the stand legs penetrate the sediment, forming a stable platform for the sampling device. The length or penetration ability of the legs can be adjusted to ensure that the sampler is at rest on the bottom before the tube is allowed to penetrate the sediment (Fig. 5-2).
3. As line tension is slowly released, the core tube descends to the sediment through the opening in the stand hub. In this important step, the user should make every effort to ensure gentle insertion of the core tube into the sediment (Fig. 5-3).
4. As the line tension is further released, the weight spindle (with 10 to 50 pound or more of extra weight, as required by site-specific conditions) descends slowly and pushes the core tube farther into the sediment, collecting the sample. If the sediment is especially firm, the weight spindle may be raised and lowered gently onto the top block for more penetration. A test core may indicate whether the top block can be tapped without unduly disturbing the water-sediment interface zone (Fig. 5-4).
5. The sampler is retrieved from the sediment bed by pulling up on the weight spindle. An increase in line tension while the line is pulled indicates that the spindle has reached the top of the lift rod and that the core tube is beginning to withdraw (Fig. 5-5).
6. The core tube is slowly withdrawn from the sediment. As the tube begins to rise, the nose piece releases and the internal core catcher closes, trapping the sediment inside. A flap valve also closes at the upper tube end to ensure the core is retained (Fig. 5-6).
7. The sampler ascends through the water column. It is essential to retrieve the sampler smoothly and to avoid any shocks that might disturb the water-sediment interface inside the tube.
8. When the sampler is removed from the water and brought on board the sampling platform or boat and is still hanging vertically, the water-sediment interface should be inspected through the clear tube wall to verify that it remains intact.
9. With minimal delay, the extractor piston is carefully inserted into the bottom of the core tube (past the catcher) to seal it. A special U-bracket (with a threaded hole) is bolted to the bottom of the stand hub so that the threaded piston rod can be screwed in through the bracket, forcing the piston gradually up the tube. Excess water collected over the sediment layer is allowed to spill out through the flap valve at the top.
10. The user carefully rests the sampler on its stand legs, loosens the tube clamp, and removes the clamp top block and weight spindle completely to retrieve the surface sediment collected from the device.

11. The sample slicer block (placed in the open position) is slipped over the top of the tube for a water-tight fit. The piston is then forced up slowly until the first layer to be collected is positioned at the proper level inside of the slicer block.
12. The sample layer (such as a 1-cm slice of sediment) is collected by pushing the slicer blade horizontally through the block until it is closed and the sample is isolated in the upper chamber of the block.
13. The sample is spooned or suctioned out of the upper chamber of the block by some convenient means and is transferred to the sample container.
14. The operation is repeated until all the desired sample layers have been collected.

Sampler handling technique is critical throughout the entire operation, since the water-sediment interface zone is fragile and is easily disturbed. It is also important that a trial coring be obtained at a new site before sampling begins to optimize the sampler features (such as weight, leg length, and tube length) and to test procedures for site-specific conditions. Since characteristics of sediment can vary greatly from place to place, the optimum technique can be learned only through trial and error.

It may be desirable for trace contaminant studies to use new core tubes and catcher units at each location to avoid any cross-contamination of samples.



As the sampler descends through the water column (1), the core tube (lower) and weight spindle (upper) are retracted. On contacting the bottom (2), the stand legs penetrate, forming a stable platform. As line tension is released (3), the core tube descends to the sediment through the hole in the stand hub. With further line release (4), the weight spindle (*no weights shown*) descends and pushes the core tube in, collecting the sample. If necessary, the weights may be raised and lowered repeatedly for more penetration. During sampler retrieval, the weight spindle is pulled up first (5), then the core tube is withdrawn (6). As the tube begins to rise, the nose piece releases and the internal core catcher closes, trapping the sediment inside. A flap valve also closes at the upper tube end. The sampler ascends through the water column (1).

Figure 5. Idealized USS Sampler Deployment

4.2 LABORATORY TANK TESTING

Once the prototype USS sampler was fabricated, the sampling device was initially evaluated in a controlled laboratory setting in a comparison with traditional sediment collection devices, including a grab, core, and dredge sampler (Tetra Tech, 2004a). Additional testing was designed to evaluate the ability to stiffen or solidify the water-sediment interface using chemical additives to yield an undisturbed matrix for sub-sampling and analysis.

4.2.1 Tank Facility Design and Setup

A custom-fabricated, 450-gallon fiberglass tank, 48 inches in diameter and 60 inches in height, with an open-top configuration was installed on a steel tank stand in the laboratory (Fig. 6). The three view ports on the sidewalls of the custom fiberglass tank were used to collect video data. A hoist frame was constructed over the tank to lower and raised the samplers for testing in the tank.

A sub-bottom pump and filter system was installed in the tank to help establish and maintain water clarity during testing by drawing water down through the sediment bed to be filtered for removing particulates suspended by sampler testing. Filtered water was recirculated back into the top of the tank. The sub-bottom filter system consists of a coil of 6-inch-diameter perforated plastic drain tile encased in drain sleeve (a polyester fabric "sock" similar to cheesecloth), and sealed at one end (Fig. 7). A series of weights were set over the drain tile to keep it in place so that the assembly could easily be covered in sediment.

Figure 6. Test Tank Facility

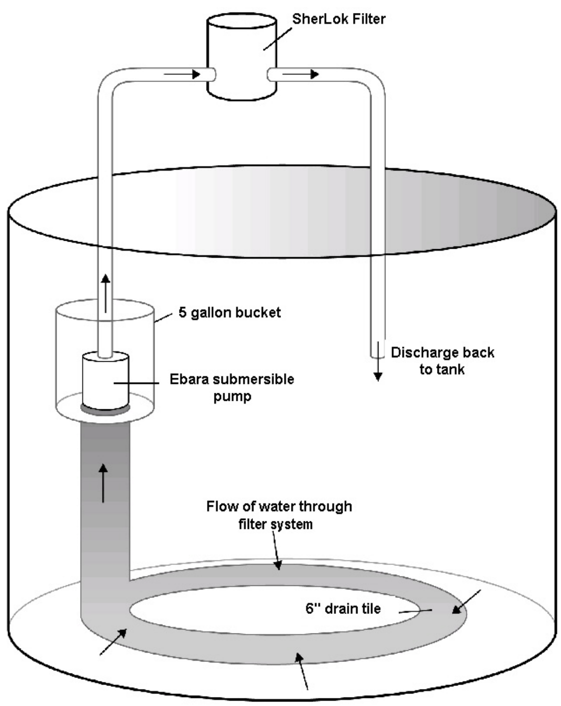


Figure 7. Tank Filtration System

A 5-gallon bucket assembly was attached by a connector pipe on top of the open end of the drain tile coil on the inside wall of the tank. The bucket assembly consists of an open chamber where an Ebara Model EPPD-3MS1 submersible pump was installed just beneath the influent water layer (Fig. 8). This bucket chamber was pumped out and recharged with the water that was drawn downward through the sediment and collected into the underlying drain tile.

Water from the bucket chamber was circulated through the filter system and was controlled by a ball valve to synchronize operation of the pump with the rate of chamber recharge, resulting in a flow rate of about 10 gallons per minute. This rate allowed adequate filtration of particulates for discharge into the top of the tank.

Figure 8. Filter Pump Assembly Bucket

A final filtration step was implemented by passing the water that was pumped from the bucket chamber through a Jacuzzi brand element filter, SherLok Model SL80, which was installed at the top of the tank. The flow from the submersible pump was forced into the filter element, and the resultant clear effluent from this final filtration step was recirculated back into the top of the tank.

A total of 24 5-gallon buckets of sediment were harvested from the Black River in Port Huron, Michigan for the tank test. Sediment in the Black River has the consistency of a fine particulate, highly organic lake silt that contains 20 to 40 percent fine sand and is typical of harbor sediments. Sediment was poured from the buckets into the bottom of the tank directly over the sub-bottom filter system to a depth

Figure 9. Black River Sediment in Test Tank

of approximately 15 inches (Fig. 9), and then the tank was then filled with city tap water. The plastic-lined drain tile and black connector pipe are shown running up the side of the wall, between the observation ports. The tank was filled with approximately 400 gallons of water until it reached a level 8 inches from the top.

The water and sediment in the tank were allowed to settle and equilibrate for 3 days. The water was not clear enough to film the test samplers after this settling time; therefore, the water was further clarified with a liquid polymeric coagulant treatment. "Drop n' Vac" clarifier, manufactured by GLB Pool Care, was added to enhance coagulation and settling of particulates to produce clarity suitable for photography. This chemical coagulant is used commonly for swimming pools. Approximately 20 ounces of the coagulant was first diluted into 5 gallons of tap water to optimize dissolving and mixing of the chemical; then, this treatment was poured into the tank to mix the treatment solution into the 400 gallons of water in the tank. After sufficient mixing, the sump pump was returned to the bucket chamber to promote filtration and recirculation in the tank. The tank system was allowed to rest for at least 24 hours in between each sampler operation to allow for particulates to settle. The coagulant yielded excellent clarity for filming.

This clarifying treatment was added after each sampling trial to promote particulate settling and provide clear water for viewing the sampler test operations. With the increased number of chemical treatments, the pH and alkalinity levels of the tank water were reduced below the normal ranges for river water and the effectiveness of the coagulant was diminished. These levels were; therefore, adjusted upward by adding “On Guard Alkalinity Plus,” a liquid treatment chemical mixture that includes sodium hydrogen carbonate manufactured by N. Jonas & Company. This mixture was added at a quantity of 8 ounces per 400 gallons. Unfortunately, a white precipitate began to accumulate on the sediment surface after two alkalinity treatments. At this point the tank water was drained and the contents were replaced with fresh tap water, followed with another treatment with coagulant to clarify the water. This maintenance cycle of chemical coagulant treatment, neutralization, and replacement of the water after each series of four sampler tests was repeated to maintain water quality for testing.

4.2.2 Tank Test Operations

To conduct the test, a sampler device was lifted with a block and tackle from the overhead boom, swung over the tank, and gently lowered into the water until the lowest part of the sampler was suspended 6 to 8 inches above the sediment. A calibrated Troll 9000 water quality measurement instrument was also suspended in the tank. Two 500-watt photoflood lights were illuminated near opposite sides of the tank, and all other lighting in the room was minimized. The video camera was focused through the porthole on the sampler inside to film operation of the test sampler while sediment was collected from the bottom of the tank (Fig. 10). The sampler was dropped into the sediment, and a cloud of disturbed surface sediment was released into the water column as a result. Turbidity, dissolved oxygen (DO), oxidation reduction potential (ORP), and pH were then recorded for 2 minutes. The test was ended when the sampler was raised above the sediment, at which time filming was stopped.

After each sampling event was complete, the tank system was allowed to rest undisturbed for about an hour to permit a large mass of particulates to settle. After this time, the chemical treatments were implemented to clear the water. When the chemical treatment was complete, the sub-bottom filtration system was operated for 28 to 32 hours between each trial to provide the level of clarity needed for viewing the events. The filtration system was turned off prior to initiating the next sampler trial began.

Figure 10. Test Tank Video Camera

The USS sampler (Fig. 11), a standard Ponar sampler (Fig. 12), a gravity core sampler (Fig. 13), and a US-BMH-60 sampler (Fig. 14) were evaluated in the laboratory tank. A video was collected for four successful sample collection runs for each device using a Sony TRV950 or Sony VX1000 digital video camera. Each filmed segment demonstrated the descent, impact, and retrieval of the sediment sample. When the run was complete, the video segments were processed into a final titled formatted disk submitted to EPA to document the successful performance of the USS sampler (provided in Appendix B).

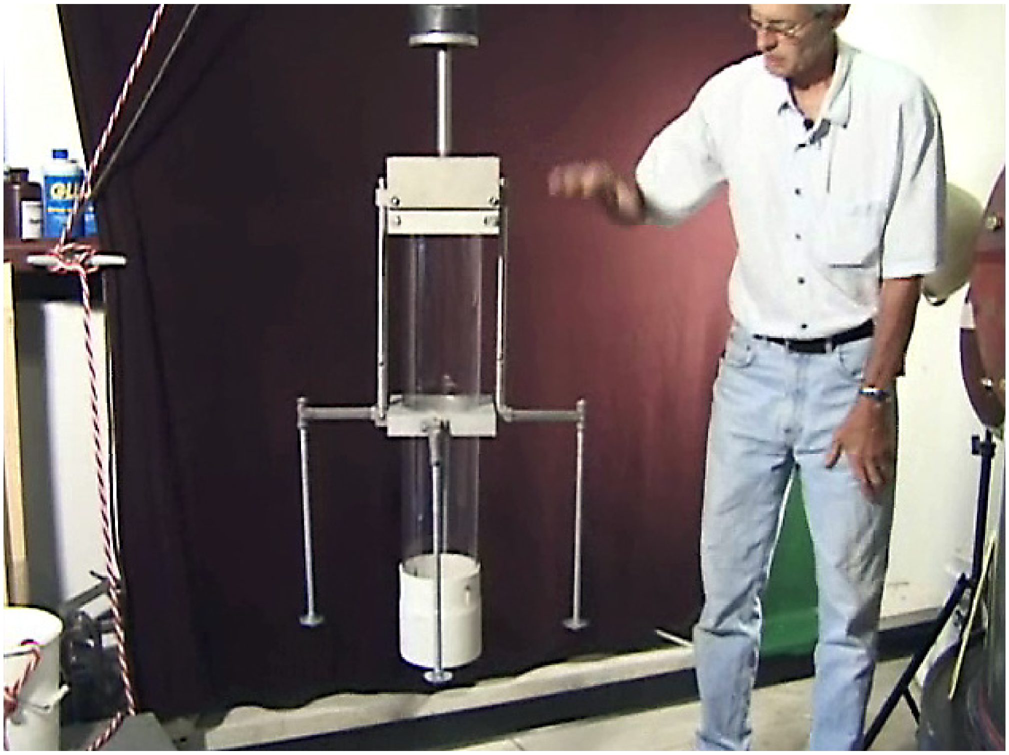


Figure 11. Undisturbed Surface Sediment Sampler

Figure 12. Ponar Sampler

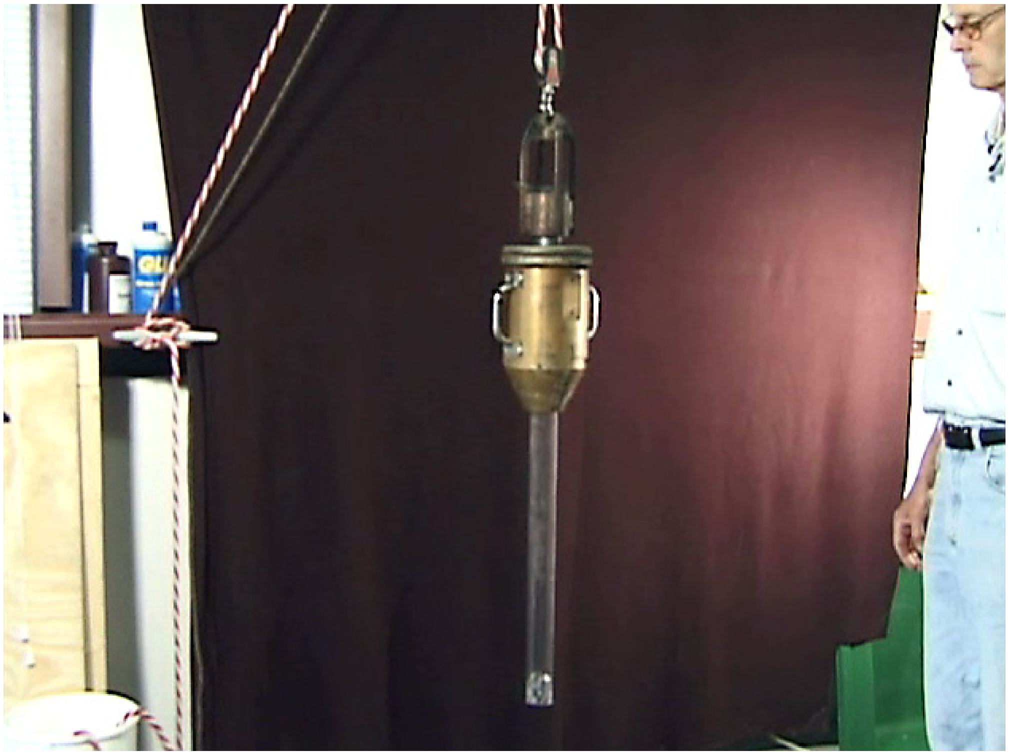


Figure 13. Gravity Core Sampler

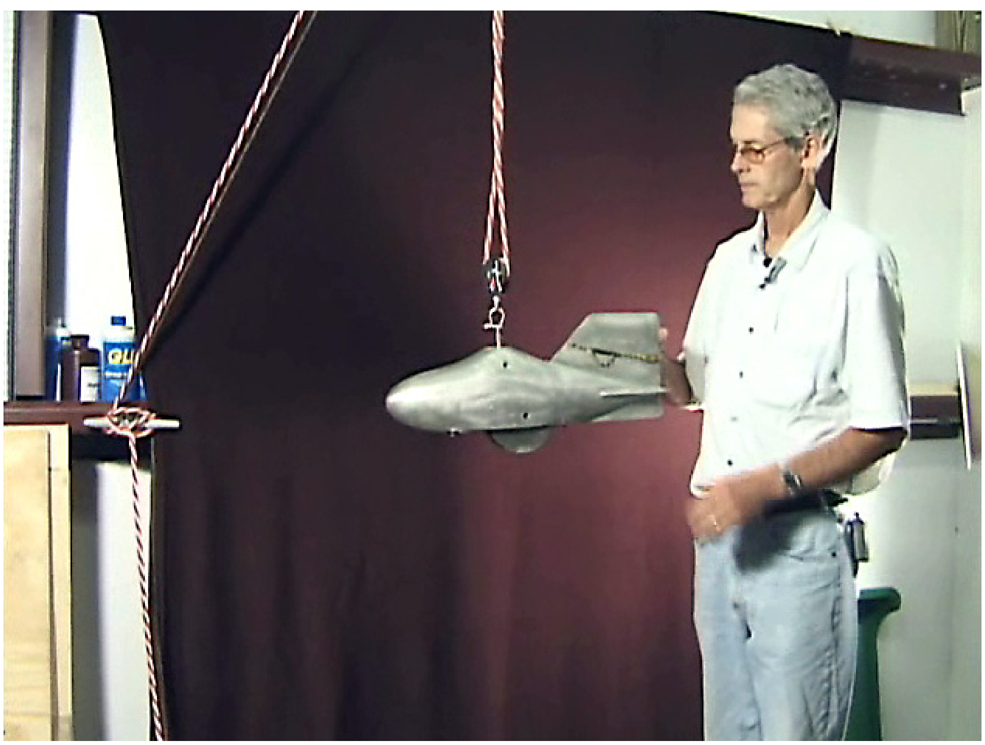


Figure 14. US-BMH-60 sampler

4.2.3 Evaluation of Chemical Additives for Solidifying Water-Sediment Interface

The sediment–water interface in silty sediment environments often occurs not as a sharp boundary, but as a gradient of suspended solids with concentrations that range between the low-solids water column and the high-solids sediment. The boundary between sediments and the water column is often difficult to delineate in high-turbidity environments and moves or changes in response to physical stresses above and below it. This interface is difficult to study in situ without altering it dramatically. As a result, a strategy for collecting samples within this fluid transition involved stiffening the medium and immobilizing contaminant-bearing particles within it, so that incremental layers of the medium could be collected.

Various methods could be used to achieve this end; however, the purpose of this study is to demonstrate the basic utility of this approach. It is desirable that this dynamic zone would be immobilized *in situ* during sample collection and not afterward. Stabilizing the core sample through use of a hydrocolloid or by another means would preserve the integrity of the fluid interface zone. Xanthan gum, propylene glycol alginate, and carrageenan are examples of hydrocolloids that are used widely in food and cosmetic products to thicken and stabilize aqueous mixtures. Chemically, they are high-molecular-weight, branched-chain cellulose compounds that are stable over a range of pH, temperatures, and salt concentrations, are soluble in hot or cold water, and are effective at low concentrations. They have little influence on the behavior of hydrophobic substances, such as PCBs and pesticides. When they are agitated, they change reversibly from gel to liquid, and thus do not interfere with organic solvent extractions. A potential drawback with the use of a hydrocolloid is that this cellulose substance may interfere with collected sediment sample analysis for organic carbon content.

The demonstration crew experimented to identify the optimum mixtures for hydrocolloid with sediment and water to immobilize core samples in tubes. The ability to stiffen the water-sediment interface using a colloid gel or other means would permit incremental slicing of silty sediment sample cores that exhibit a fine consistency at the water-sediment interface.

4.3 FIELD DEMONSTRATION TESTING

The next stage in the evaluating the prototype USS sampler was a field demonstration of performance in comparison with a representative, traditional method for collecting surface sediment (Tetra Tech, 2004b). Grab samplers are typically used to collect surficial sediments to study the horizontal distribution of sediment characteristics; therefore, a Ponar sampling device was used for this comparison.

4.3.1 Field Test Operations

The original test site proposed was located in the Detroit River, Michigan, but an alternative location was selected for field testing as a result of heavy rainfall and turbid conditions affecting the visual clarity of the Detroit River necessary for video documentation. Samples were; therefore, collected at two sites at Sylvan Lake in Pontiac, Michigan. This site is a large urban lake surrounded by residential communities. Sediment samples collected were analyzed for organic carbon content and particle size distribution to assess the impact of the sampler on the quality of the material collected. The USS and Ponar samplers were videotaped while they were sampling surface sediment to evaluate any resulting disturbances to the surface layer. The field testing occurred at Sylvan Lake on September 8 through 10, 2004.

The field demonstration consisted of comparing the operation of the prototype USS sampler with a Ponar sampler. These sampling devices collected collocated sediment samples in the lake to support a comparative analysis. The representative samples were collected and sub-sampled for laboratory analysis to determine the effectiveness of the devices in retaining fine-grained particulates from the sampling process.

The sediment collected with the USS device was sub-sampled into three depth interval layers: 0 to 3 cm, 3 to 6 cm, and 6 to 9 cm. The core was sub-sampled by installing the slicer block on top of the core tube and extruding the core into the slicer block until the core reached the appropriate thickness. The slicer block was then closed; the sub-sample was stirred in the slicer block with a large stainless steel spoon, scooped out, and placed in sample jars for shipment to the laboratory for analysis.

The sediment collected with the Ponar sampler was sub-sampled from the mass of material that was released from the sampler into a stainless steel collection pan. The sub-sample was collected by gently scraping the surface of the sediment mass in the collection pan using a stainless steel spoon. The material collected was placed in a metal bowl, stirred and spooned into sample jars for shipment to the laboratory for analysis. Because the method used to collect the surface sediment from the pan was imprecise, sampling technicians were able to collect only a single sub-sample of the surface layer from the collection pan.

Thirty sediment samples were collected at Sylvan Lake. At Site 1, the USS sampler was used to collect five replicate samples, which were then sub-sampled at each of three successive layers in the cores. Also at Site 1, the Ponar sampler was used to collect five replicate samples into a single surface layer sample. In all, 20 samples were collected from Site 1. Care was taken to collect each sample of undisturbed sediment as close together as possible to minimize local variations in sediment quality. At Site 2, five replicate samples of a top layer of sediment (0 to 3 cm) were collected with each of the two sampling devices. Overall, 10 samples were collected from Site 2.

4.3.2 Sediment Sample Analysis

Sediment samples were collected and analyzed in the laboratory for TOC by SW-846 Method 9060 (EPA, 1997) and particle size (Yamate et al., 1984). Five of the 30 samples collected were also analyzed for concentrations of total PCBs following SW-846 Methods 3550 and 8080 (EPA, 1997). No PCBs were detected in these samples, so it was determined based on the lack of PCBs detected that the levels of this contaminant in Sylvan Lake were not adequate for comparative analysis.

TOC results of collocated sample sets were reviewed to establish the homogeneity of the sediment bed. Substantial differences in the TOC content of collocated samples might suggest the presence of lake current or other interfering underwater influences that may change the consistency of sediment in the sampling region. These influences may; therefore, interfere with the opportunity to demonstrate the effectiveness of the USS sampler in comparison with the reference sampling device. Substantial differences in the TOC content, represented by a difference of 25 percent or greater between collocated samples, indicate that the sediments are sufficiently different and are; therefore, not comparable for evaluating performance of the sampler.

Particle Size Analysis of Sediment Collected by Samplers

Sediment collected in an undisturbed manner will likely show a difference in particle size distribution in a comparison with sediment obtained using traditional sampling devices that alter that sediment being collected. The fine particulates on the surface layer that are disturbed during sampling may not be captured in the collected sediment. Therefore, the particle size of sediment samples collected from each of the comparison devices was evaluated, and a statistical analysis performed to evaluate the device's ability to retain fine particulates in the sample.

The particle-size analysis and statistical parameters calculated describe each sediment sample in terms of the range of particle sizes, the amount of grains within a specific size range, sorting, and symmetry of the particle-size distribution curve. These data were used as follows:

- A direct comparison of collocated samples to investigate the differences between individual samples.
- A comparison of samples collected by a specific sampler to investigate the potential for natural variability to be responsible for differences identified in the collocated samples. This intra-sample group was compared for each sampler.
- A comparison of the total sediment collected with one sampler with the amount collected by the other sampler to investigate overall differences between the sediment samples recovered by the samplers.

A conclusion was drawn from the results of the statistical analysis on the effectiveness of the prototype USS sampler in comparison with the Ponar sampler for collecting undisturbed sediment from the surface layer.

Laboratory Analysis for Particle Size

The samples were dried overnight in an oven at 65°C and then sieved into three size fractions by shaking the sediment sample:

- Larger than 2,000 microns (coarse grains)
- Between 2,000 and 100 microns (medium grains)
- Less than 100 microns (fine grains)

Each size fraction was weighed and reported as a percentage of the total weight.

Particle size of the collected sediment material was analyzed using SEM with the Yamate EPA level 2 method of indirect sample preparation to minimize the impact of handling and analysis on the particulates (Yamate et al., 1984). The portion of the sample smaller than 100 microns (i.e., the fine grains) was mounted on an aluminum stub with carbon tape and further examined using an ISI DS-130 scanning electron microscope (SEM) and an attached calibrated integrated X-ray fluorescence (IXRF) digital imaging system. The fine-grained portion was further divided into the following size fractions:

- Larger than 50 microns
- Fifty to 10 microns
- Ten to 5 microns
- Five to 1 micron
- One to 0.5 microns
- Less than 0.5 microns

Laboratory results were analyzed to evaluate whether the sampling devices differ in their in ability to collect the fine particulates at the surface interface. From these results a trend analysis was conducted using the particle size number density in sediment samples as a means to validate the ability of the USS sampler to retain these particulates during the sampling process.

Each size fraction was assigned based on the number of individual particles where the average size was within the specified ranges. The results were reported as a percentage of the total fine-particulate portion.

As discussed in the preceding paragraphs, two different methods were used to measure the distribution of grain sizes in each sample. No single method is available for the particle size range of interest in the data analysis that can provide size distribution coverage; hence, two methods are required for the investigation. Assimilating data on particle size obtained using different methods can be problematic; however, the particle-size distribution for each sample for this project was calculated using the same two methods in the same manner. Thus, the laboratory analysis methodology will not affect the comparison of statistical parameters of the samples for this analysis.

Statistical Analysis of Particle Size Data

Fully characterized sediment samples were evaluated by calculating the descriptive statistics using the method of moments described in Krumbein and Pettijohn (1938) and Friedman and Johnson (1982). This accurate statistical method is affected by outliers in the fine and coarse fractions. A common problem with particle-size analyses and statistical evaluation is that a portion of the fine sediment may not be fully measured. This portion of fine sediment is generally designated as "less than" the lowest measured value and is considered lost since the range of sizes within this portion is unknown. If the lost sediment is in the 1 to 5 percent range, the descriptive statistics were calculated using the methods described Folk and Ward (1957).

The software program "Gradistat," developed by Blott and Pye (2001), was used to conduct the statistical calculations. Gradistat is a free software program written in Microsoft Visual Basic and integrated into a Microsoft Excel spreadsheet. The program is available at http://scape.brandonu.ca/download/gradistat.zip.

The particle size analysis of the sediment was evaluated for the collocated samples collected from each sampling device using standard descriptive statistics. The parameters used to describe a grain-size distribution are mean, sorting, skewness, and kurtosis. The “mean” represents the median or average particle size. Sorting is also considered as the standard deviation or variance of particle sizes. “Skewness” is the unsymmetrical distribution around a mean value. “Kurtosis” is the curvature in the data that results when classification ranges are abnormally compressed or more spread out than for a true distribution. The formulae for calculating the parameters are provided below. P_x in the formulae is the particle size diameter in microns at the cumulative percentile value of X.

The mean (X_{avg}) - average particle size:

$$X_{avg} = \exp\left[\frac{\ln P_{16} + \ln P_{50} + \ln P_{84}}{3}\right]$$

Sorting (σ) can also be described as the standard deviation. Small values of sorting indicate a well-sorted sample or that the particle sizes do not vary greatly. Large values of sorting indicate a wide variation in grain sizes. Sorting is calculated as:

$$\sigma = \exp\left(\frac{\ln P_{16} - \ln P_{84}}{4} + \frac{\ln P_{5} - \ln P_{95}}{6.6}\right)$$

Skewness (S) is a measure of the symmetry or preferential spread of the particle sizes relative to the average. Negative values of skewness indicate that the distribution is skewed toward the fine-particulate side of the curve, positive values toward the coarse side.

$$S = \frac{\ln P_{16} + \ln P_{84} - 2(\ln P_{50})}{2(\ln P_{16} - \ln P_{84})} + \frac{\ln P_{5} + P_{95} - 2(\ln P_{50})}{2(\ln P_{5} - \ln P_{95})}$$

Kurtosis (K) is the degree of concentration of the particulates relative to the average. Smaller values indicate a greater concentration around the average than do larger values.

$$K = \frac{\ln P_{5} - \ln P_{95}}{2.44(\ln P_{25} - \ln P_{75})}$$

5.0 RESULTS AND DISCUSSION

This section presents the results of the tank and field testing of the USS sampler.

5.1 LABORATORY TANK TESTING

The bench-scale test was designed to evaluate the prototype USS sampler in a controlled laboratory setting that would simulate a field deployment and compare it with representative, traditional sample collection devices for sediments. The simulated deployment was conducted in a test tank to evaluate the impact of the samplers on the integrity of the interface. Additionally, the ability of the USS sampler to collect a 1-cm-thick layer of the sediment column that has been treated with stabilizing agent also was evaluated. A preliminary standard operating procedure (SOP) for USS sampling was developed from this demonstration.

Tank testing was conducted over an 8-week period at Oakland University. Each of the four samplers was tested in the specially designed tank for the performance evaluation. A minimum of four sampling rounds of video and water quality data were collected for each of the samplers evaluated.

Each sampling device was lifted with a block and tackle from the overhead boom, swung over the tank, and gently lowered into the water until the lowest part of the sampler was suspended 6 to 8 inches above the sediment to conduct the test. Video footage was obtained and water quality measurements of turbidity, dissolved oxygen (DO), oxidation reduction potential, and pH were recorded for each round of sampling. Filming and measurements commenced when the sampler was lowered onto the sediment surface. After approximately 2 minutes, the sampler was retrieved from the sediment, the test was concluded, and the filming and measurements were stopped.

The tank system was allowed to sit undisturbed for about 1 hour to permit a large mass of particulates to settle after each sampling event was complete. After this time, the chemical treatments were implemented to clear the water. When chemical treatment was complete, the sub-bottom filtration system was operated for 24 to 32 hours between each sampler trial to provide the level of clarity needed to view the sampler events. The filtration system was turned off before the next sampler trial began.

5.1.1 Video Data Analysis

Videographic data collected from sampling runs of the test devices are presented in Figures 15 though 20. Each of the pictures demonstrates the immediate results of the impact of the sampler on the sediment surface. Figure 15 shows a still shot of a Ponar sampler as the device contacts the surface and its jaws are actuated to close and grab a sediment sample. Figure 16 shows disturbance of the sediment collected inside the clear CAB tube of the gravity corer. Figure 17 demonstrates the disturbance to the surrounding sediment from the action of the gravity corer. Figure 18 shows a lack of sediment disturbance from the USS sampling stand as it rests on the surface. Figure 19 demonstrates the minimal disturbance of the surrounding sediment that resulted when the core tube was pushed into the sediment bed. Figure 20 shows the disturbance of sediment from the BMH-60 sampler. Complete tank test video data are provided in Appendix B – Undisturbed Surface Sediment Sampler Design Validation Laboratory Testing with Visualization.

Figure 15. Ponar Sampling in Test Tank

Figure 16. Gravity Corer Immersion into Sediment Bed

Figure 17. Gravity Corer Sampling in Test Tank

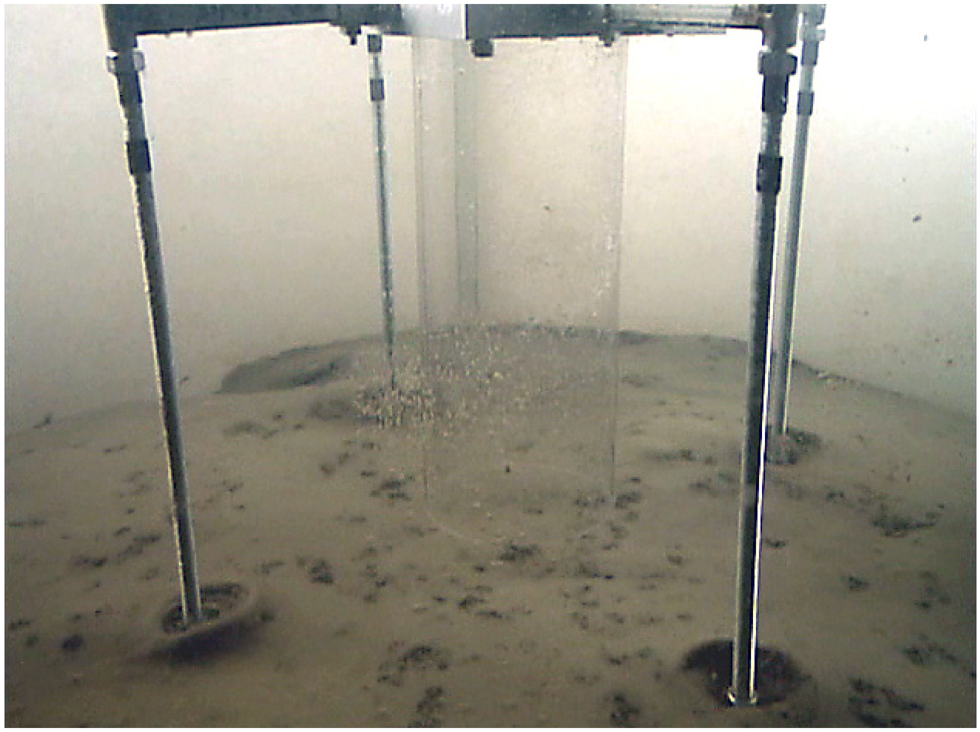


Figure 18. USS Sampler Stand in Test Tank

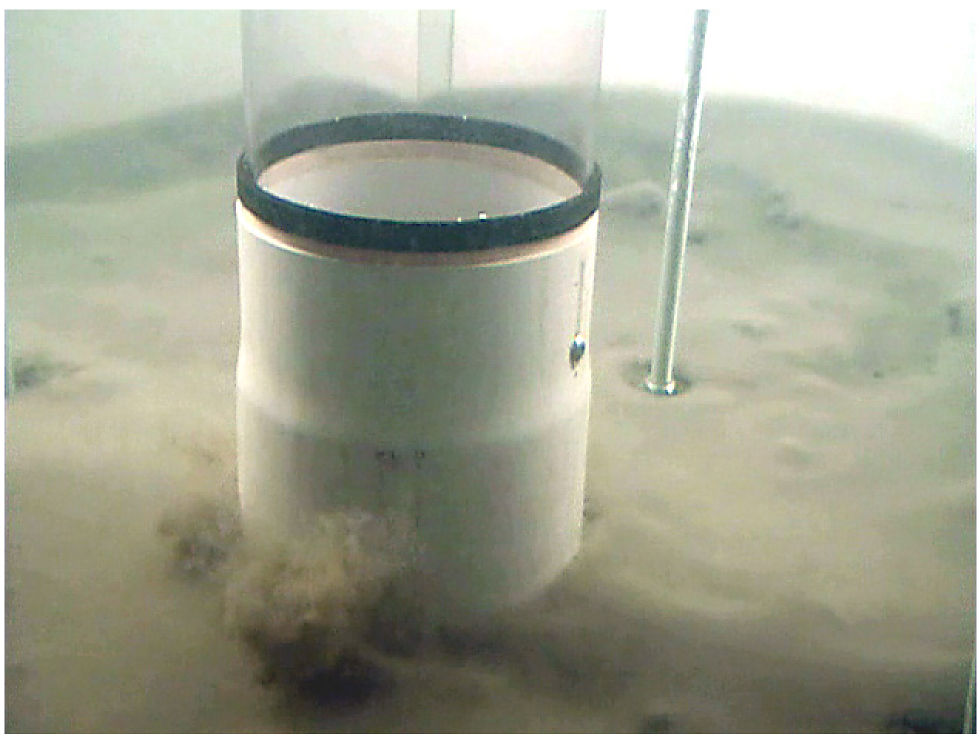


Figure 19. USS Sampler in Test Tank

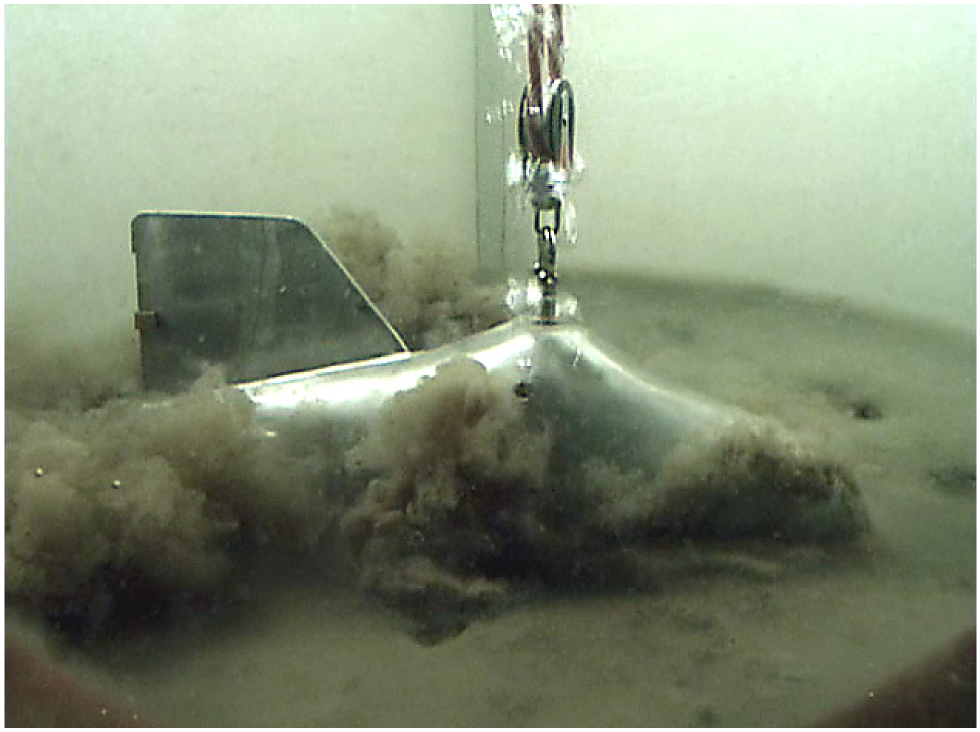


Figure 20. BMH-60 Sampler in Test Tank

5.1.2 Water Quality Analysis

The Troll 9000 Profiler XP was used to measure water quality during sampling events. The pH, oxidation reduction potential (ORP), and DO were measured to monitor the conditions of the water and sediment in the tank. The turbidity of water in the tank was measured during each sampling event to assess the disturbance caused by sampling on the sediment surface. A Win-Situ 2000 data-logging interface was used to collect and manage the process data stream from the Troll 9000 Profiler XP. Water quality data obtained during tank testing are presented in Appendix C.

DO measurements during tank test operations ranged from 6,245 to 8,672 micrograms per liter (µg/L). Generally, the DO of the tank water measured 8,500 µg/L or higher when fresh water was added in the tank. The DO of the tank water decreased over time with the sampling events until the water was replaced to restore clarity for video operations. ORP measured in the tank water ranged from 148 to 226 millivolts (mV), and conductivity ranged from 250 to 500 microsiemens per centimeter (µS/cm). These parameters fluctuated only slightly during the sampling events and did not correlate with water or sediment conditions in the tank.

Turbidity was measured to provide a semi-quantitative evaluation of the amount of sediment suspended as a result of the disturbance caused during the sampling process. Sampler-generated turbidity was evaluated for each sampler during sampling. In a comparison analysis, both the turbidity maxima and sampling time interval averaged values were evaluated to assess performance of the sampler (Table 3).

Table 3. Tank Test Turbidity Data

Sampler	Sampling Event Date	Sampling Time	Turbidity maxima (NTU)	Turbidity time average (NTU)
Ponar	6/8/2004	10:13:14	39.3	15.36
Ponar	6/11/2004	8:28:22	11.1	4.62
Ponar	6/15/2004	11:47:36	20.9	10.86
Gravity	6/21/2004	15:15:48	34.2	24.22
Gravity	6/22/2004	16:04:54	96.3 *	79.16
Gravity	7/1/2004	9:49:28	32.6	21.88
Gravity	7/2/2004	7:21:29	38.7	21.56
USS	7/6/2004	16:05:31	7.7	4.08
USS	7/7/2004	7:31:54	43.0 *	26.84
USS	7/8/2004	10:10:11	3.9	2.24
USS	7/9/2004	7:54:38	6.7	2.00
BMH-60	7/9/2004	17:04:41	388.1	184.46
BMH-60	7/10/2004	19:48:24	54.0 **	22.72
BMH-60	7/11/2004	11:26:31	157.5	103.82
BMH-60	7/12/2004	9:32:42	190.2	105.60

Notes:

NTU Nephelometric turbidity units

* Data qualified as an outlier because the treatment chemical addition prior to testing caused milky conditions

** Data qualified as an outlier because overtreatment of the water from chemical addition caused the fine surface sediment to clump.

The evaluation of both turbidity maxima and time average values demonstrate that the USS sampler generated substantially less particle suspension during tank sampling events, with maximum turbidity levels from 3.9 to 7.7 nephelometric turbidity units (NTU). This low NTU reading indicates that the fine particulates in the surface sediment are substantially less disturbed during the USS sampling than with the other sampling devices. The Ponar sampler generated the next-lowest turbidity levels during sampling events, with maximum levels in the range of 11.1 to 39.3 NTU. The gravity core sampler generated maximum turbidity levels in the range of 32.6 to 38.7 NTU. Finally, the BMH-60 sampler generated the highest maximum turbidity levels, in the range of 157 to 388 NTU.

5.1.3 Evaluation of Water-Sediment Interface Immobilization by Chemical Additives

Chemical additives were evaluated during laboratory tank testing to determine their effectiveness in stiffening a water-sediment interface for sample processing and analytical testing. Solidification of the water-sediment interface inside of a core tube would allow a silty surface sediment sample to be transported in an undisturbed manner and permit the sub-sampling of this stabilized fluid core into small fractions.

Carrageenan, propylene glycol alginate, and xanthum gun hydrocolloid additives were evaluated to determine their effectiveness in stiffening the fluid sediment sample inside of a core tube. These additives were tested in the form of a 100 – 150 mesh fine powder and as an aqueous solution with concentrations ranging from 0.5 percent up to 10 percent hydrocolloid. The results of each addition were observed to determine their impact on stabilizing the fluid sediment sample.

The hydrocolloids added to the sample core in powdered form floated on top of the water column, unable to break through the surface tension and dissolve into the sample in the concentration range of interest. The fine powdered mesh size of the additives, selected to optimize dissolution into the water column above the sediment core, did not possess sufficient mass to sink into the water column. Similarly, hydrocolloid solutions were not appreciably miscible with the fluid due to differences in density and temperature with the sample matrix. Instead of mixing into the water column, these solutions formed a layer on the top of the water column (Fig. 21).

In future testing of this approach, granular or liquid hydrocolloid candidates should be selected that possess a solubility that is less dependant on water temperature than the additives that were available for this study.

5.1.4 Tank Test Summary and Conclusions

The video results from the tank test demonstrate that the USS sampler generated the least amount of disturbance during surface sediment sampling. This low disturbance was achieved through the ability to isolate the sampling event from the descent of the sampler through the water column and the resulting energy forces and bow-wake effect on the sampling medium. The USS sampler core tube was pushed into the sediment bed by mechanical means which limited the impact on the surrounding sediment. When the core tube was retrieved from the sediment bed, the core catcher was released to retain the sample inside of the tube until it was removed for sub-sampling.

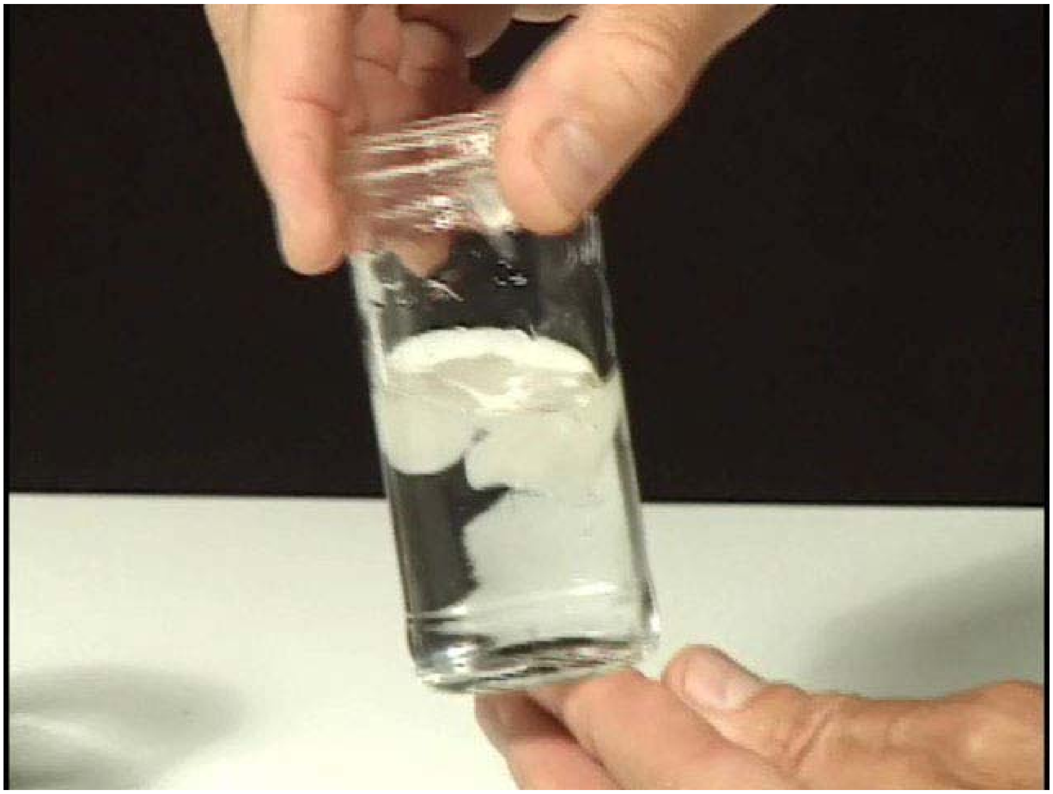


Figure 21. Immiscible Hydrocolloid Solution in Sediment Sample Water.

The water quality analysis results similarly demonstrated that the USS sampler generated the least amount of turbidity and disturbance to the surface sediment during sample collection in comparison with the commercially available samplers. Of the commercially available samplers, the Ponar device collected samples with the least amount of turbidity and disturbance to the surface sediment.

5.2 FIELD DEMONSTRATION TESTING

The performance of the USS sampler was compared with a Ponar sampler. This evaluation was conducted in September 2004 at Sylvan Lake in Pontiac Michigan. Representative sampling rounds were video documented using diver-assisted photography, and sediment samples were collected for laboratory analysis to assess performance of the sampler. In all, a total of 30 samples were collected at two different locations in the lake.

A total of 20 samples were collected at Site 1. The USS sampler was used to collect five replicate sediment cores, which were then sub-sampled at each of three successive layers from the sediment cores.

The Ponar sampler was used to collect five replicate samples which were subsequently sub-sampled to collect the upper 3 cm of sediment. Care was taken to collect each sample of undisturbed sediment as close together as possible to minimize local variations in sediment quality. At Site 2, 10 samples were collected that included five replicate samples of a top layer of sediment (0 to 3 cm) with each of the two sampling devices. Sediment samples were collected and evaluated in the laboratory for TOC and particle size.

5.2.1 Video Data Analysis

Example photographs of the sample collection process using the Ponar sampler that were video documented at Sylvan Lake are presented in Figures 22 through 27. The general sampling process using the Ponar sampler was: (a) the Ponar sampler was deployed from the boat deck and into the lake (Fig. 22), (b) the Ponar sampler was lowered until it came into contact with the sediment surface (Fig. 23 (c) the jaws of the Ponar sampler were closed and the sampler was removed from the sediment (Fig. 24), (d) the Ponar sampler was retrieved back on board the boat (Fig. 25), (e) the Ponar sampler is placed in the collection pan (Fig. 26), and (f) the sampled sediment remained in the collection pan ready for sub-sampling (Fig. 27).

Figure 22. Ponar Sampler Deployment

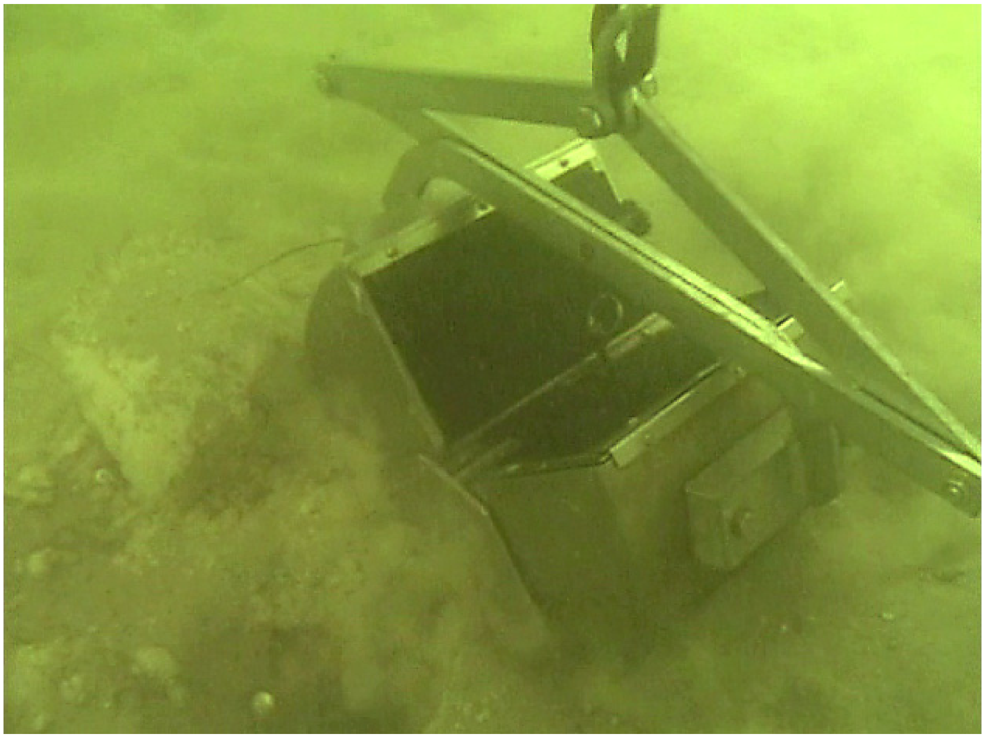


Figure 23. Ponar Sampler in Contact with Sediment Surface

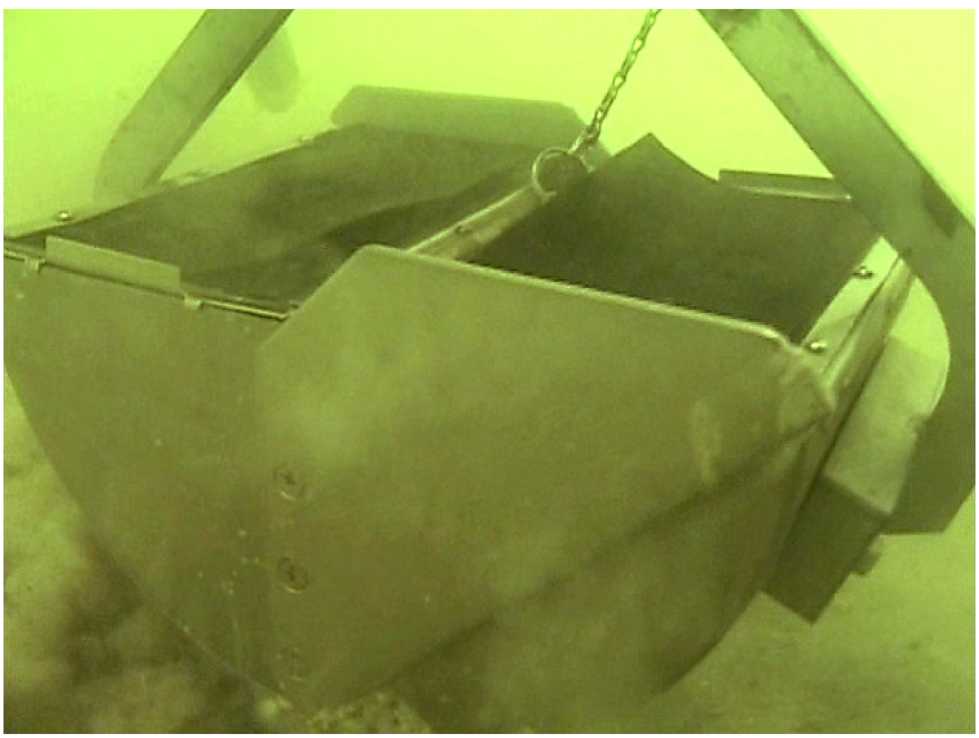


Figure 24. Ponar Sampler Lifting out of Sediment Bed

Figure 25. Ponar Sampler Retrieval

Figure 26. Removal of Sediment from Ponar Sampler

Figure 27. Sediment Collected by Ponar Ready for Sub-sampling

The highlights in the collection process using the USS sampler documented at Sylvan Lake are presented in Figures 28 through 31. The general collection process using the USS sampler was: (a) the USS sampler is launched from the deck into the lake (Fig. 28), (b) the USS sampler core tube comes in contact with the sediment surface (Fig. 29) and was pushed into the sediment, (c) the USS sampler was retrieved and the slicer block assembly installed on the core tube for sub-sampling (Fig. 30), and (d) after the sediment layer was collected, the slicer block with the sediment layer was removed and the rest of the sediment core remains in the core tube (Fig. 31) ready for sampling of the next layer.

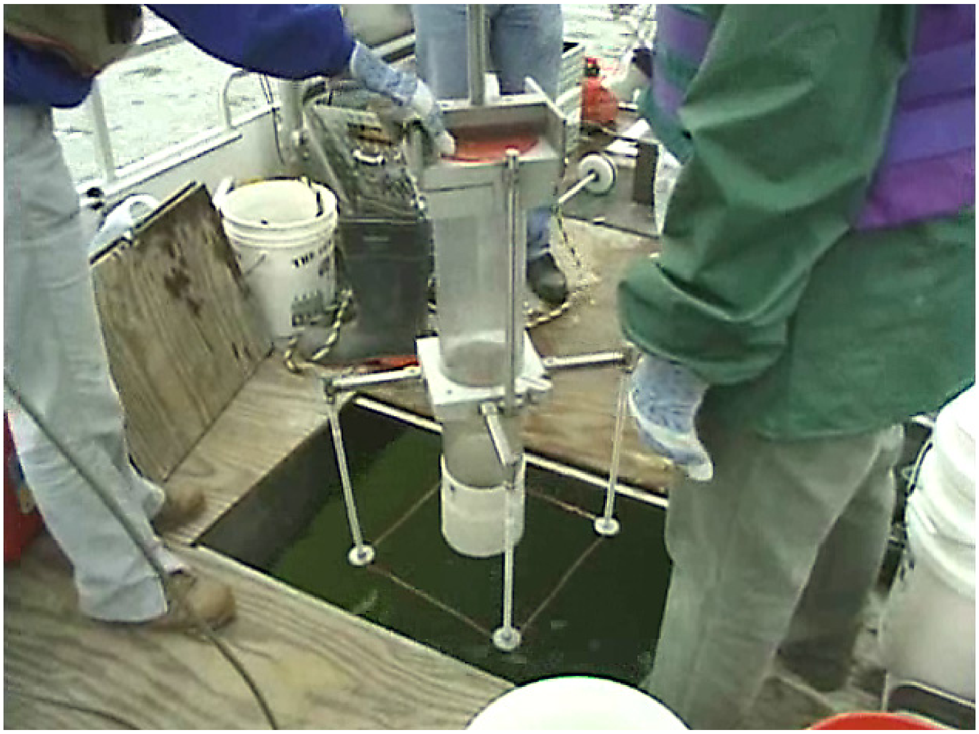


Figure 28. USS Sampler Deployment

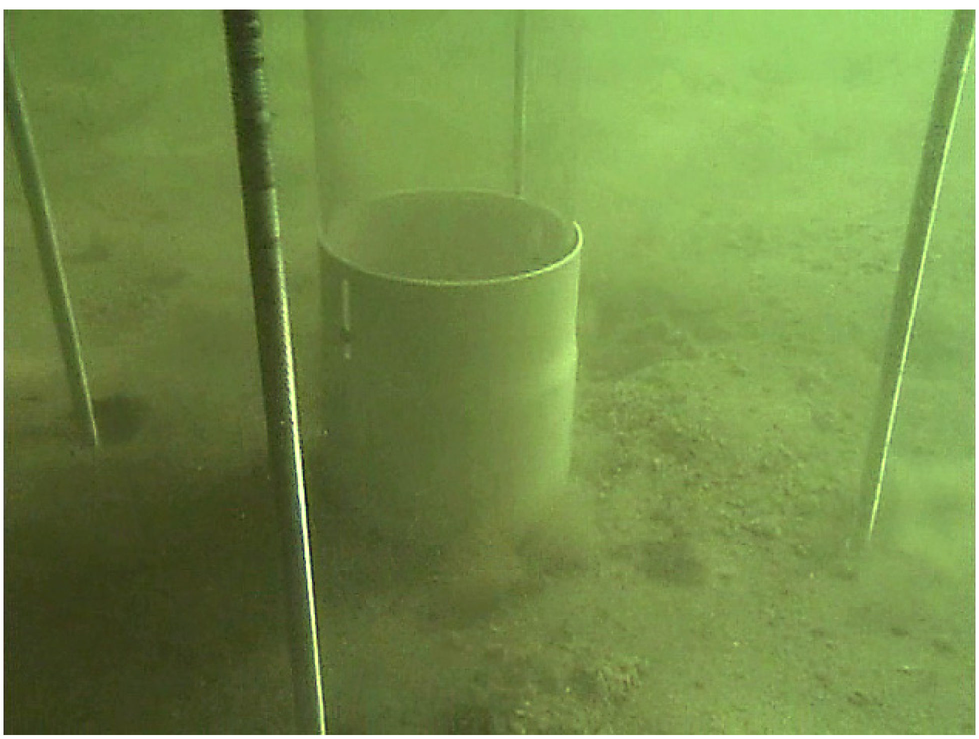


Figure 29. USS Sampler in Contact with the Sediment Surface

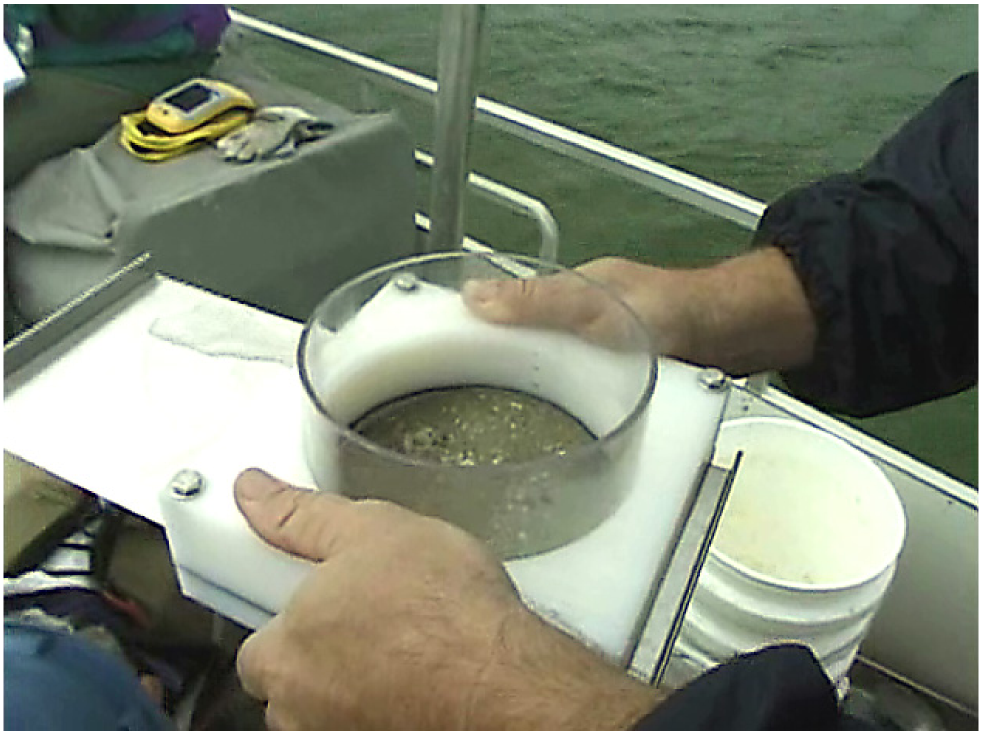


Figure 30. Slicer Block Assembly on Core Tube for Sub-sampling

Figure 31. Sediment in Tube after Sub-sampling Surface Layer.

Video data collected during the sampling events with the Ponar and USS devices were reviewed to evaluate performance of the sampler in minimizing disturbance of the sediment sampled. The Ponar sampler moderately disturbed the surface sediment during sampling where puffs of fine particulates are noticeable around the base and sides of the sampler as it dug into the sediment (Fig. 23). Another cloud of fine particulates was observed in the background as the jaws are closed and the Ponar sampler is lifted out from the sediment (Fig. 24). In contrast, only a minimal cloud of fine particulates was noticeable around the base of the core tube of the USS sampler (Fig. 29). The USS sampler demonstrated, by visual observation, the ability to collect surface sediment in a manner that significantly reduced disturbance of fine surface layer particulates as compared with the typical Ponar sampling device. Complete video documentation of sampler performance is provided in Appendix B, Prototype Undisturbed Surface Sediment (USS) Sampler Field Demonstration CD.

Once the sample was retrieved, a controlled means for sub-sampling the sediment collected for laboratory analysis was developed for use in conjunction with the USS sampler. A slicer block was developed to sub-sample sediment into layers as fine as 1 cm (Fig. 30). Once the sediment sample was collected in the USS sampler, the slicer block was placed over the open upper end of the core tube. The sample was then gently pushed upward through the core tube and into the slicer block using the piston. When enough sediment passed through the opening of the slicer block to reach the desired layer thickness, the blade of the slicer block was slid closed and the sample collected. In contrast, the sediment collected with the Ponar sampler does not provide an effective means for sub-sampling the material for laboratory analysis. Instead, the sediment was drained and dumped into a stainless steel box (Fig. 27), where the sampling technician sub-sampled the surface sediment by scraping the surface of the mass of material resting in the pan with a stainless steel spoon. Even if the Ponar sampler were disassembled by removing the screens and plastic flaps from the top of the chamber so that sub-sampling could be collected directly out of the top of the sampler after the material was sufficiently drained, the sub-samples would still be significantly altered by the effect of bow wake on the sediment surface, the effect of the jaws on the sediment, and the uncontrolled sample collection and water draining processes.

5.2.2 Sediment Sample Analysis

Collocated samples collected from both the Ponar and USS sampling devices were submitted for analysis of TOC and particle size distribution in the laboratory. Samples were analyzed for TOC to verify the uniformity in the collocated samples, and for particle size analysis to establish the relative effectiveness of each sampler at retaining the fine particulates in the sample material collected.

Evaluation of Uniformity of Collocated Samples

Before the particle size distribution data were evaluated, TOC results for collocated sample sets were reviewed to establish the uniformity of the sediment bed. Substantial differences in the TOC content of collocated samples suggest that the presence of lake current or other interfering underwater influences may change the consistency of sediment in the sampling region. This change would; therefore, interfere with the opportunity to demonstrate the effectiveness of the USS sampler in comparison with the reference sampling device. Substantial changes in the TOC content, represented by a difference of 25 percent or more between collocated samples, would indicate that the sediments were significantly different and so were disqualified from further particle size evaluations.

The TOC values for the Ponar sample and collocated USS sample (0 to 3 cm interval) were compared by calculating the percent difference (%Δ) between samplers at a given location (Table 4). Analytical results for sub-samples collected with the USS sampler from 3- to 6- and 6- to 9-cm depth intervals are provided for reference only, even though these data were not considered in the variability analysis between the collocated samples.

In comparing TOC levels in the collocated samples collected by the Ponar and USS samplers, the initial sampling events (sediment 01, 02, and 03) had the distinctly higher %Δ in TOC contents. The % differences ranged from 22 percent to 50 percent in collocated samples. The increased variability suggests that the sediment collected during sampling events 1, 2, and 3 was not particularly homogenous or that the sediment sample was somehow disturbed during sampling. Additionally, field demonstration staff reported difficulties during the first several USS sampler collection events while the crew learned how to use the prototype sampler suggesting an operational impact on these samples.

Table 4. Total Organic Carbon Results of Co-located Sediment Samples

Sample ID	PONAR Sample ID	USS Sampler Sample ID	% Δ*	USS Sampler Sample ID	USS Sampler Sample ID
sediment 01	SL-PONAR-01	SL-USS-01 0-3 cm.		SL-USS-01 3-6 cm.	SL-USS-01 6-9 cm.
TOC	8,600 mg/kg	17,000 mg/kg	50	21,000 mg/kg	22,000 mg/kg
sediment 02	SL-PONAR-02	SL-USS-02 0-3 cm.		SL-USS-02 3-6 cm.	SL-USS-02 6-9 cm.
TOC	16,000 mg/kg	18,000 mg/kg	22	19,000 mg/kg	20,000 mg/kg
sediment 03	SL-PONAR-03	SL-USS-03 0-3 cm.		SL-USS-03 3-6 cm.	SL-USS-03 6-9 cm.
TOC	21,000 mg/kg	14,000 mg/kg	34	20,000 mg/kg	21,000 mg/kg
sediment 04	SL-PONAR-04	SL-USS-04 0-3 cm.		SL-USS-04 3-6 cm.	SL-USS-04 6-9 cm.
TOC	14,000 mg/kg	15,000 mg/kg	<10	19,000 mg/kg	20,000 mg/kg
sediment 05	SL-PONAR-05	SL-USS-05 0-3 cm.		SL-USS-05 3-6 cm.	SL-USS-05 6-9 cm.
TOC	16,000 mg/kg	15,000 mg/kg	<10	22,000 mg/kg	22,000 mg/kg
sediment 06	SL-PONAR-06	SL-USS-06 0-3 cm.		Not collected	Not collected
TOC	21,000 mg/kg	22,000 mg/kg	<10		
sediment 07	SL-PONAR-07	SL-USS-07 0-3 cm.		Not collected	Not collected
TOC	21,000 mg/kg	21,000 mg/kg	<10		
sediment 08	SL-PONAR-08	SL-USS-08 0-3 cm.		Not collected	Not collected
TOC	21,000 mg/kg	22,000 mg/kg	<10		
sediment 09	SL-PONAR-09	SL-USS-09 0-3 cm.		Not collected	Not collected
TOC	21,000 mg/kg	20,000 mg/kg	<10		
sediment 10	SL-PONAR-10	SL-USS-10 0-3 cm.		Not collected	Not collected
TOC	21,000 mg/kg	20,000 mg/kg	<10		

Notes:

cm Centimeter
mg/kg Milligrams per kilogram
* Represents the percent difference in total organic carbon in the collocated samples in the sediment bed.

Particle Size Analysis

Particle size distribution was analyzed in the sediment samples collected during the field demonstration. Sediment particulates were segregated using mechanical means or were measured and counted using microscopic techniques to establish the percentage of particulates classified within specific size intervals of the measurement range from less than 0.5 to greater than 2,000 microns in diameter (Table 5). A statistical analysis was performed on these results to evaluate the effectiveness of the prototype USS sampler in comparison with the Ponar sampler for collecting sediment from the surface layer in an undisturbed manner.

Overall, the results of the particle analysis indicate that the surface sediment at Sylvan Lake consists largely of coarse sand to fine gravel, with the predominant amount of particulates in the size range of 100 to greater than 2,000 microns diameter. An increase in the quantity of fine particulates with increasing depth was found and verified by visual evaluation of the collected sediment. The optimum particle size for the performance analysis would have consisted of 50 percent particulates in the range of 0.5 to 100 microns; however, the majority of samples contained less than 10 percent of the fine particulates. Hence, limited sediment particulates were available for counting to arrive at a conclusion on the effectiveness of capturing the fine particulates by either sampler.

Statistical Analysis of Particle Size

A statistical analysis of sediment distribution was conducted to validate the effectiveness of the USS sampler when compared with the traditional methodology represented by the Ponar sampler in retaining fine particulate sediment. The project objective was to evaluate the fine-grained portion of the sediment sample. The USS sampler was expected to be more effective at collecting this sediment fraction as opposed to the Ponar sampler because of the following factors inherent in the use of the Ponar sampler:

- The Ponar sampler generates a large bow wave as it descends to the sediment surface.
- The jaws of the Ponar sampler disturb the sample as they close to seal the collected sample.
- The Ponar sampler does not provide a means for draining water from the sediment without sufficiently affecting the sediment inside of the sampler jaws.
- The screens and plastic flaps that cover over the top of the jaws hinder collection of the sub-sampled surface layer sediments while housed in the sampling device.
- The Ponar sampler does not provide a system for controlled and measured sub-sampling that is capable of retrieving finely divided depth intervals.

Table 5. Sediment Sample Particle Size Summary

Sample ID	SEM ENERGY DISPERSIVE SPECTROSCOPY						MECHANICAL SIEVE		
	<0.5 (µm)	0.5-1 (µm)	1-5 (µm)	5-10 (µm)	10-50 (µm)	>50 (µm)	<100 (µm)	100-2000 (µm)	>2000 (µm)
SL-PONAR-01	1.43%	0.71%	0.90%	0.31%	0.27%	0.09%	3.70%	87.80%	8.40%
SL-USS-01(0-3 cm)	2.21%	1.14%	2.04%	0.52%	0.34%	0.04%	6.30%	71.80%	21.90%
SL-USS-01(3-6 cm)	2.97%	2.23%	3.81%	0.65%	0.49%	0.05%	10.20%	51.10%	38.70%
SL-USS-01(6-9 cm)	3.12%	2.77%	5.91%	0.95%	1.05%	0.20%	14.00%	42.60%	43.40%
SL-PONAR-02	3.35%	2.05%	4.03%	0.71%	0.51%	0.05%	10.70%	67.70%	21.60%
SL-USS-02(0-3 cm)	1.94%	1.55%	2.48%	0.37%	0.41%	0.14%	6.90%	63.80%	29.40%
SL-USS-02(3-6 cm)	2.84%	2.24%	4.06%	0.71%	0.51%	0.15%	10.50%	38.40%	51.10%
SL-USS-02(6-9 cm)	3.35%	1.93%	3.81%	0.76%	0.70%	0.16%	10.70%	25.20%	64.10%
SL-PONAR-03	3.47%	2.65%	5.06%	0.92%	0.75%	0.14%	13.00%	27.20%	59.80%
SL-USS-03(0-3 cm)	2.58%	1.70%	3.29%	0.55%	0.31%	0.06%	8.50%	77.50%	14.00%
SL-USS-03(3-6 cm)	3.60%	2.18%	3.35%	0.54%	0.40%	0.12%	10.20%	34.00%	55.80%
SL-USS-03(6-9 cm)	5.30%	4.09%	5.33%	0.85%	0.54%	0.20%	16.30%	32.00%	51.70%
SL-PONAR-04	3.16%	2.27%	3.13%	0.68%	0.77%	0.09%	10.10%	79.30%	10.60%
SL-USS-04(0-3 cm)	1.52%	1.17%	2.15%	0.55%	0.41%	0.08%	5.90%	80.50%	13.60%
SL-USS-04(3-6 cm)	5.28%	4.06%	5.12%	0.85%	0.59%	0.10%	16.00%	39.40%	44.60%
SL-USS-04(6-9 cm)	8.23%	3.80%	5.67%	0.86%	0.46%	0.08%	19.10%	38.00%	42.90%
SL-PONAR-05	3.51%	2.63%	4.15%	1.16%	1.27%	0.29%	13.00%	61.70%	25.30%
SL-USS-05(0-3 cm)	2.62%	1.76%	2.95%	0.49%	0.50%	0.08%	8.40%	69.60%	22.00%
SL-USS-05(3-6 cm)	2.49%	1.85%	3.71%	0.58%	0.46%	0.12%	9.20%	31.50%	59.30%
SL-USS-05(6-9 cm)	2.02%	1.60%	3.35%	0.94%	0.63%	0.17%	8.70%	29.40%	61.90%
SL-PONAR-06	2.13%	0.91%	1.10%	0.17%	0.17%	0.10%	4.60%	85.20%	10.20%
SL-USS-06(0-3 cm)	1.79%	0.79%	1.18%	0.20%	0.35%	0.08%	4.40%	82.10%	13.40%
SL-PONAR-07	2.02%	1.04%	1.68%	0.23%	0.28%	0.05%	5.30%	90.00%	4.70%
SL-USS-07(0-3 cm)	1.79%	1.10%	1.21%	0.27%	0.27%	0.08%	4.70%	79.80%	15.50%
SL-PONAR-08	2.00%	1.18%	1.49%	0.17%	0.15%	0.03%	5.00%	77.10%	17.80%
SL-USS-08(0-3 cm)	2.22%	1.43%	1.95%	0.34%	0.33%	0.13%	6.40%	72.50%	21.10%
SL-PONAR-09	2.44%	1.58%	1.42%	0.30%	0.32%	0.14%	6.20%	86.40%	7.50%
SL-USS-09(0-3 cm)	2.45%	0.86%	1.47%	0.18%	0.13%	0.10%	5.20%	82.70%	12.10%
SL-PONAR-10	3.06%	1.47%	2.04%	0.35%	0.37%	0.11%	7.40%	64.40%	28.20%
SL-USS-10(0-3 cm)	2.32%	1.41%	1.59%	0.26%	0.40%	0.12%	6.10%	62.60%	31.30%
Total % of particulates	Total % of Particulates SEM (fine particle size) / σ						Total % Particulates Sieve		
USS Sampler (0-3 cm)	6.28			σ =	1.38		93.72		
Ponar Sampler	7.90			σ =	3.52		92.10		

Notes:

µm Micron
cm Centimeters
SEM Scanning Electron Microscope.

The statistical parameters for the trend analysis of collocated samples collected from USS and Ponar sampling devices provide a useful indication about the differences in the sediment samples obtained using different sampling equipment and sampling methods. The parameters used in the analysis to describe the particle-size distribution are kurtosis, skewness, sorting, and the mean. Table 6 provides the range of values for each statistical parameter and the evaluation terminology.

Kurtosis is the measure of curvature in the data that results when classification ranges are abnormally compressed or more spread out than for a true distribution. The kurtosis number should be a high positive value under optimum conditions for a trend analysis to validate performance of the sampler in retaining fine particulates, represented by sediment of consistent fine particulate composition to demonstrate that the fines are retained during sampling. Sediments that are similar in nature and grain size are especially important in comparing collocated samples in the sediment bed.

Skewness is the measure of the unsymmetrical distribution of data around a mean value. For the trend analysis, it is desirable to yield a skewness value at 0 to examine consistent, homogenous sediment material.

Sorting is also considered as the standard deviation or variance of particle sizes. It is desirable that the sampled sediment sorting values be low to demonstrate the effectiveness at retaining the fines during collection.

Table 6. Statistical Parameter Values and Terminology

Sorting		**Skewness**		**Kurtosis**	
Very Well Sorted	<1.27	Very Fine Skewed	-1.0 to -0.3	Very Platykurtic	<0.67
Well Sorted	1.27 to 1.41	Fine Skewed	-0.3 to -0.1	Platykurtic	0.67 to 0.90
Moderately Well Sorted	1.41 to 1.62	Symmetrical	-0.1 to 0.1	Mesokurtic	0.90 to 1.11
Moderately Sorted	1.62 to 2.00	Coarse Skewed	0.1 to 0.3	Leptokurtic	1.11 to 1.50
Poorly sorted	2.00 to 4.00	Very Coarse Skewed	0.3 to 1.0	Very Leptokurtic	1.50 to 3.00
Very Poorly Sorted	4.00 to 16.00			Extremely Leptokurtic	>3.00
Extremely Poorly Sorted	>16.00				

Statistical Analysis Results

Overall, the sediment that was collected at Sylvan Lake could not provide the data to properly evaluate the factors and establish a trend to be able to argue that the prototype sampler is more effective than the traditional methodology in maintaining the integrity of the surface sediment. As previously discussed, the sediment needed a number density that equaled or exceeded 50 percent of fine particulates less than 100 microns, instead of the 10 percent sediment that was obtained in this size regime (Table 5). There was an insufficient mass of fine particulate material for proper segregation and measurement; therefore, the trend analysis was not conclusive.

The USS sampler collected a lower percentage of fine-grained particles (less than 100 microns) than the Ponar sampler from the 0- to 3-cm interval at eight of the 10 locations (Table 5). The average percentage of fines collected by the USS sampler was 6.28 percent compared with 7.90 percent by the Ponar sampler. However, the standard deviation for the percentage of fines collected by the USS sampler was only 1.38 percent, compared with 3.52 percent for the Ponar sampler. Thus, the USS sampler obtained samples that were more consistent in the amount of fine-grained material from location to location.

The USS sampler also collected samples from 3 to 6 cm and 6 to 9 cm. An increase was noted in the percent of fine-grained sediment (less than 100 microns) with depth (Table 5). This finding is consistent with photographs and videos of the sampling event. The video data clearly show that the surface sediment consists of granular material that appears to be in the sand- and gravel-size range overlying what appears to be significantly finer-grained material. This documentation supports the conclusion that the sediment surface was altered by anthropogenic activities.

The mean particle diameter for the USS sampler sediment ranged from 522.9 to 755.4 microns (Fig. 32) in the top 3 cm of sediment. The average mean particle diameter of sediment collected by the USS sampler was 604.2 microns, with a standard deviation of 80.9 microns (Table 7). By comparison, the mean particle diameter for the 10 samples collected by the Ponar sampler ranged from 457.9 to 1,136.5 microns. The average mean particle diameter for all 10 samples collected by the Ponar sampler was 607.6 microns with a standard deviation of 202.1 microns. Although the average grain size collected by the Ponar sampler was smaller than for the USS sampler, the variability in the Ponar samples indicates that the USS sampler provided more consistent results.

Table 7. Folk and Ward Geometric Statistical Parameters

Sample Identity	Mean	Sorting	Skewness	Kurtosis
USS-01(0-3 cm)	635.1	3.347	-0.036	0.703
USS-01(3-6 cm)	821.4	6.091	-0.495	1.29
USS-01(6-9 cm)	846.4	6.948	-0.616	1.327
Ponar-01	496.4	2.872	0.026	0.779
USS-02 (0-3 cm)	713.5	3.595	-0.162	0.711
USS-02 (3-6 cm)	1074.2	6.082	-0.761	1.429
USS-02 (6-9 cm)	1281.3	5.487	-0.794	2.011
Ponar-02	597.9	5.890	-0.268	1.347
USS-03 (0-3 cm)	522.9	5.080	-0.224	1.415
USS-03 (3-6 cm)	1164.9	5.670	-0.773	1.546
USS-03 (6-9 cm)	1006.6	7.330	-0.790	1.507
Ponar-03	1136.5	6.409	-0.800	1.718
USS-04 (0-3 cm)	531.1	3.129	0.017	0.764
USS-04 (3-6 cm)	895.6	7.332	-0.682	1.405
USS-04 (6-9 cm)	876.6	7.384	-0.674	1.385
Ponar-04	479.2	5.105	-0.229	1.491
USS-05 (0-3 cm)	618.5	5.204	-0.246	1.233
USS-05 (3-6 cm)	1206.2	5.554	-0.780	1.646
USS-05 (6-9 cm)	1246.8	5.246	-0.782	1.704
Ponar-05	612.2	6.373	-0.306	1.293
Ponar-06	512.5	2.946	0.027	0.779
USS-06 (0-3 cm)	544.6	3.053	0.019	0.767
Ponar-07	457.9	2.716	0.000	0.738
USS-07 (0-3 cm)	566.2	3.131	0.011	0.755
Ponar-08	596.0	3.209	0.000	0.738
USS-08 (0-3 cm)	624.7	3.338	-0.028	0.710
Ponar-09	477.2	2.887	0.024	0.774
USS-09 (0-3 cm)	529.8	3.021	0.023	0.773
Ponar-10	710.0	3.436	-0.122	0.670
USS-10 (0-3 cm)	755.4	3.416	-0.169	0.669

Notes:
cm Centimeter
Mean diameter data are presented in microns.

Eight of the 10 USS samples were characterized as poorly sorted, with two samples being very poorly sorted (Tables 7 and 8; Fig. 32). Six of the 10 Ponar samples were characterized as poorly sorted and the remaining four samplers were very poorly sorted.

The skewness of the USS samples was characterized as symmetrical at six locations while four locations were identified as fine skewed (Tables 7 and 8; Fig. 33). The skewness of the Ponar samples was symmetrical at five locations, with three samples being fine skewed and two samples being very fine skewed.

The kurtosis values for the USS samples fall within the range of platykurtic at seven locations (Tables 7 and 8; Fig. 34). One location exhibited very platykurtic characteristics and two locations were characterized as leptokurtic. The Ponar samples fell within the range of platykurtic at six locations, leptokurtic at three locations, and very leptokurtic at one location.

While in most cases, the means, sorting, skewness, and kurtosis values were equivalent between samples collected by the USS sampler and the Ponar sampler, distinctly greater extremes were identified for the Ponar sampler at the first sampling site location. These extreme values could be the result of the inaccuracy associated with obtaining just the surface layer after the sample was dumped in the collection pan from the Ponar sampler. For example, at sampling location 3, the Ponar sampler data were very fine skewed (Fig. 34; Table 8) while the USS sampler sediment were fine skewed. At sampling location 3, the percent fines increased with depth in all size classes determined by the SEM energy dispersive spectroscopy (Table 5). If during the sub-sample collection process, the sampler was unable to clearly and consistently delineate the top 3 cm of sediment and collected some fraction of the finer sediments underlying the surface layer into the sample, the results would be a skewing of the particle size distribution towards the finer side as was identified at this sampling location.

FIGURE 32
SYLVAN LAKE SEDIMENT CHARACTERISTICS-MEAN

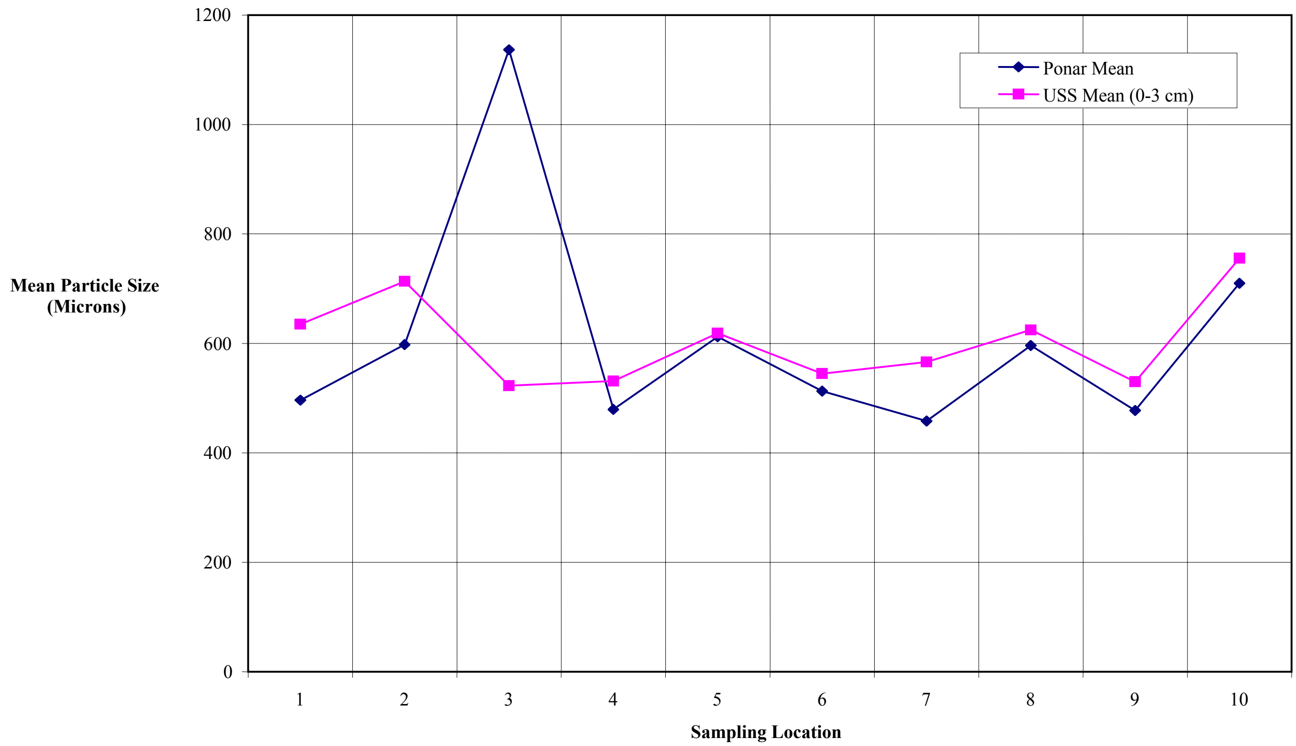


FIGURE 33
SYLVAN LAKE SEDIMENT CHARACTERISTICS-SORTING

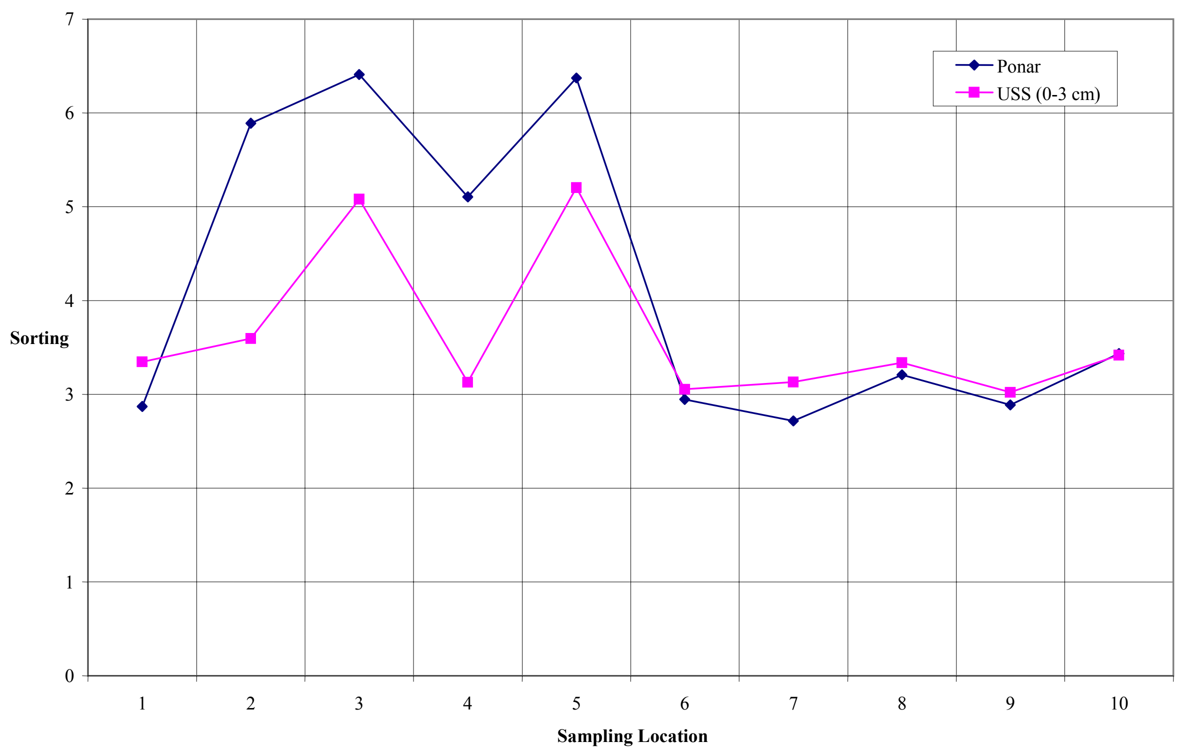


Table 8. Characteristics of Sediment in Sylvan Lake Samples

Sample Identity	Mean	Sorting	Skewness	Kurtosis
Ponar-01	496.4	Poorly Sorted	Symmetrical	Platykurtic
Ponar-02	597.9	Very Poorly Sorted	Fine Skewed	Leptokurtic
Ponar-03	1136.5	Very Poorly Sorted	Very Fine Skewed	Very Leptokurtic
Ponar-04	479.2	Very Poorly Sorted	Fine Skewed	Leptokurtic
Ponar-05	612.2	Very Poorly Sorted	Very Fine Skewed	Leptokurtic
Ponar-06	512.5	Poorly Sorted	Symmetrical	Platykurtic
Ponar-07	457.9	Poorly Sorted	Symmetrical	Platykurtic
Ponar-08	596.0	Poorly Sorted	Symmetrical	Platykurtic
Ponar-09	477.2	Poorly Sorted	Symmetrical	Platykurtic
Ponar-10	710.0	Poorly Sorted	Fine Skewed	Platykurtic
USS-01(0-3 cm)	635.1	Poorly Sorted	Symmetrical	Platykurtic
USS-02 (0-3 cm)	713.5	Poorly Sorted	Fine Skewed	Platykurtic
USS-03 (0-3 cm)	522.9	Very Poorly Sorted	Fine Skewed	Leptokurtic
USS-04 (0-3 cm)	531.1	Poorly Sorted	Symmetrical	Platykurtic
USS-05 (0-3 cm)	618.5	Very Poorly Sorted	Fine Skewed	Leptokurtic
USS-06 (0-3 cm)	544.6	Poorly Sorted	Symmetrical	Platykurtic
USS-07 (0-3 cm)	566.2	Poorly Sorted	Symmetrical	Platykurtic
USS-08 (0-3 cm)	624.7	Poorly Sorted	Symmetrical	Platykurtic
USS-09 (0-3 cm)	529.8	Poorly Sorted	Symmetrical	Platykurtic
USS-10 (0-3 cm)	755.4	Poorly Sorted	Fine Skewed	Very Platykurtic

FIGURE 34
SYLVAN LAKE SEDIMENT SAMPLE CHARACTERISTICS-SKEWNESS

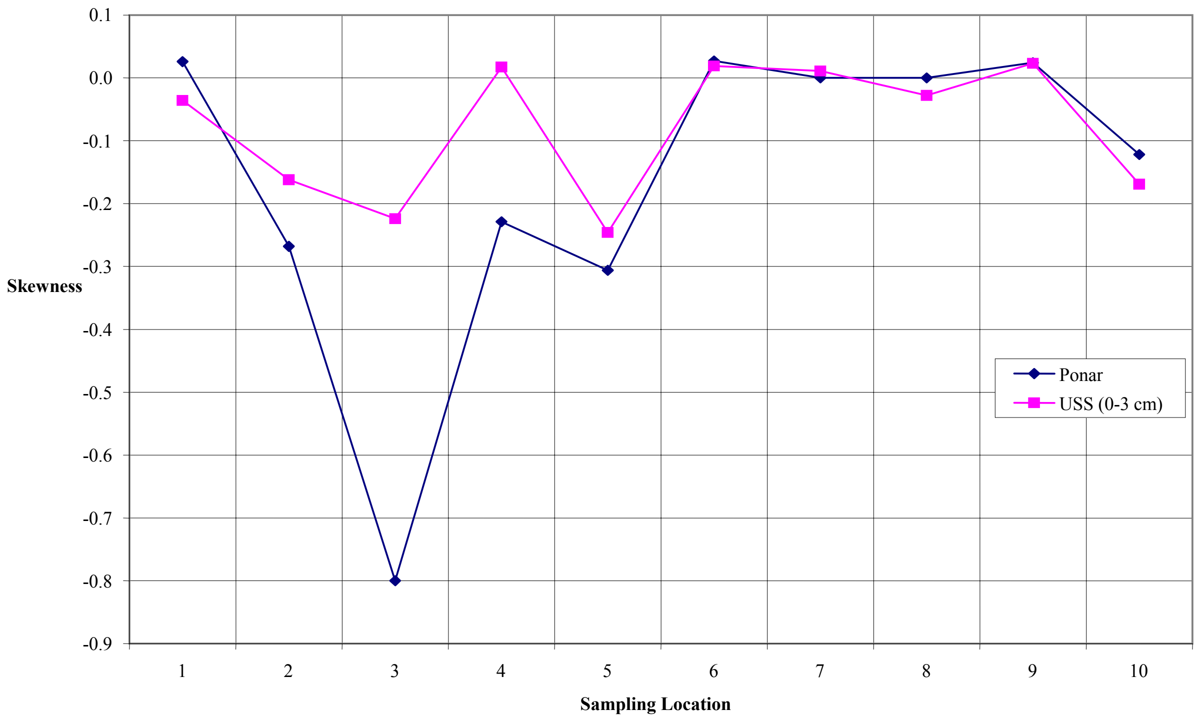
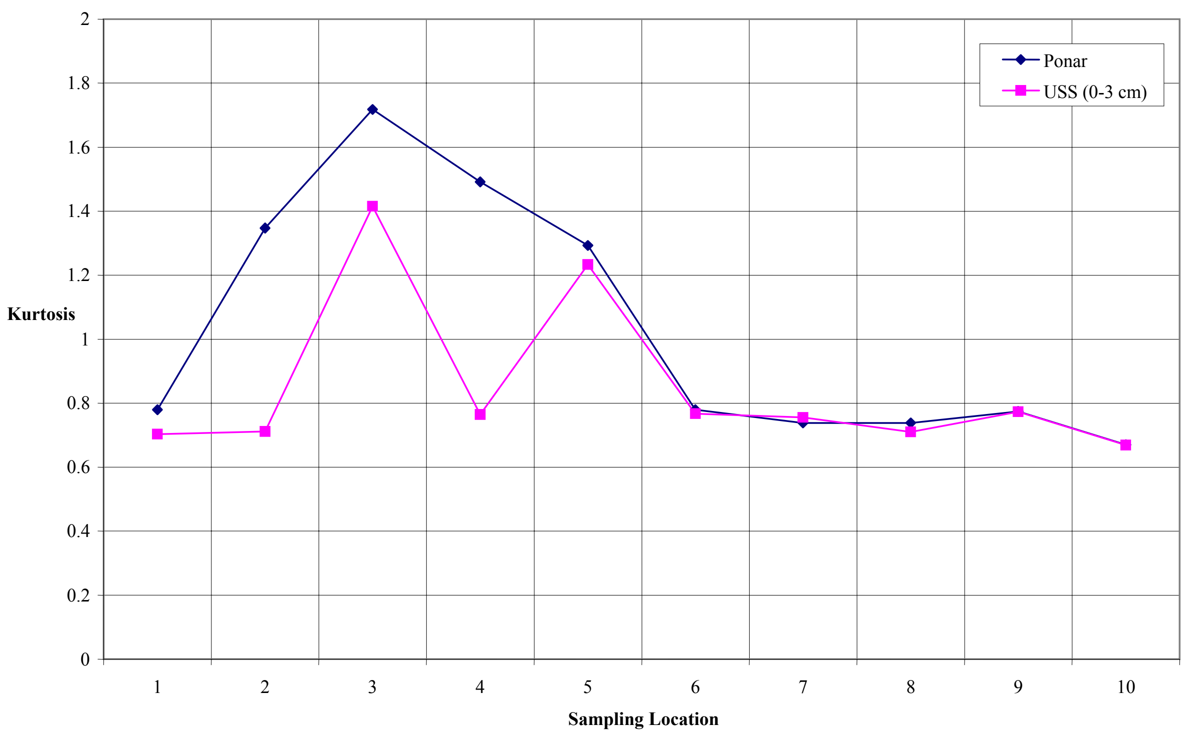


FIGURE 35
SYLVAN LAKE SEDIMENT SAMPLE CHARACTERISTICS-KURTOSIS



5.2.3 Field Demonstration Summary and Conclusions

Overall, the samples collected with the Ponar sampler tended to contain higher percentages of fine-grained particles than samples collected with the USS sampler. One possible explanation for this finding was that during the sub-sampling of sediments collected by the Ponar sampler, the exact area and depth of surface layer sediment collected during sub-sampling was not consistent. The inability of the sampler to precisely delineate the top 3 cm of surface sediment led to the collection and blending in of some of the finer subsurface sediments into the collected sample. This blending resulted in an overall particle size distribution that was finer in samples collected by the Ponar sampler than by the USS sampler. Samples collected with the USS sampler, although coarser in particle size, exhibited significantly less variability from location to location indicating that a consistent depth of sampling was obtained using the USS sampler (i.e., the USS sampler consistently collected only the top 3 cm of surface sediment without incorporation of the finer underlying sediments).

The greatest variability in particle size distribution for both samplers was found in sediment samples collected at the first sampling site which included sampling locations 1 through 5. There was much less variability among samples and between sampling devices at the second sampling site containing locations 6 through 10. This result was likely caused by the field workers' unfamiliarity with the equipment and procedures during the early stages of the sampling event and/or the presence of more uniform sediment at sampling site 2. A more uniform sediment (i.e., a sediment with less textural differences through depth) would lessen the effect of sediment layer blending that may have occurred at the first sampling location where a stark contrast was observed between the surface and subsurface sediments.

The coarse-granular bottom sediment was not ideal for testing the ability of a sampling device to recover newly deposited, fine-grained material. As a result, a lake should be chosen for follow on testing with a better representation of a finer-grained layer of sediment although this layer may affect the quality of the test video for future studies.

Observations of sampler performance from the field demonstration event were used to optimize and revise the SOP for the USS sampler. As the USS sampling device was used for the first time in the field, it was modified to improve efficiency and collection. A complete summary of field sampling is provided in the Sylvan Lake trip report prepared by Dr. Brian Schumacher. This report is found in the Attachment. The video taken during field testing is presented on compact disc, which may be found in Appendix B.

5.3 PROPOSED IMPROVEMENTS TO THE USS SAMPLER DESIGN

As a result of the tank and field testing, the overall design and performance of the USS sampler will be modified. In general, the original design of the USS sampler proved feasible to collect relatively undisturbed cores of soft sediments. The sampler performed essentially as designed in both the tank and field testing, but changes are recommended to improve its reliability.

1. The USS sampler was designed for a 6-inch diameter core tube, which is at the upper extreme of the size for effective use of a flexible “eggshell” or leaf-type core catcher to maximize the volume of sample material collected. Two leaf-type core catchers were placed in staggered positions inside of the nosepiece to increase the area supported by the core catcher and to reinforce the capability to retain the sediments inside of the core tube until it is removed during sub-sampling operations. Unfortunately, the suction and weight of sediment tended to collapse the catcher leaves downward when the sample was withdrawn from the core tube. Once the catcher inverted, the sample was lost as a result. The 6-inch catcher proved unreliable in the 2004 field tests, even though a 4-inch version of the same catcher has long been used successfully in vibracore sampling for cores up to 20 feet long. A proposed new version of the sampler that would use a 4-inch-diameter core tube would likely work better with the leaf type of catcher. Other advantages of a 4-inch core tube for the USS sampler would be greater ease of handling in the field, lower construction cost, and wider availability and lower cost of core tubes. One disadvantage of the 4-inch tube is the smaller volume of sample collected (about half that of the 6-inch tube).

2. The USS sampler was designed with the catcher mounted in a sliding collar or “nose piece.” The collar holds the catcher open when the tube is inserted. When it is withdrawn from the bottom, the collar is designed to slide downward and release the catcher leaves, which then retain the sample. However, the collar was frequently jammed by sediment forced between the collar and the core tube in the tank and field trials. As a result, it failed to slide down and release the catcher. In the field, several remedies were attempted to cover the gap between the tube and collar that included rubber bands, sleeves of polyethylene film, and various kinds of tape. None of these remedies was completely successful in keeping out sediment. Moreover, they sometimes prevented the collar from sliding and releasing the catcher properly when the tube was withdrawn. Consequently, a proposed new version of the sampler will not use an external sliding collar to release the catcher. Instead, the catcher will be mounted directly in the tube (as in vibracore tubes) and will be held open by an internal plastic slip ring to avoid disrupting the sediment-water interface. The ring will be dislodged when the tube is inserted, and the sediment will be disturbed only around the margins of the sample.

3. The USS sampler was designed with a bracket and screw-mounted piston used to push the core sample up from the bottom to collect sediment fractions at the top. Although the mechanism worked well in principle, it was slow and awkward to set up in the field. It required a great deal of manipulation to insert the piston in the tube, fasten the clamp onto the bottom of the stand hub, and thread the piston rod up through it. In a proposed new version of the sampler, the piston would be pushed up in stages using a mechanical jack while segments are added to the piston rod. The piston head may be modified slightly to pass more easily through the catcher. The sampler will rest on its own support frame during the extrusion process (see item 4 below).

4. The USS sampler was designed with a four-legged stand of threaded rods with 2-inch diameter feet. This design provided inadequate support in soft sediments and often failed to hold the

sampler in a stable, upright position while the tube penetrated the sediment. The stability was improved only somewhat by joining the feet together with a skirt of wire. Therefore, the proposed redesigned sampler will use a rigid, four-sided support frame instead of the four separate legs of the current configuration. This redesign will provide a more stable platform in soft sediments, as well as on deck. The structure of the USS sampler with the stand will be simpler and easier to assemble.

The USS sampler was suitable for collecting intact sediment cores in terms of the other design features and materials used. However, all procedures for handling the retrieved sampler and collecting the sub-sample fractions on deck should be streamlined as much as possible to minimize any disturbance of the sediment-water interface in the tube. The design improvements will help achieve the goal of streamlining. Additional refinements in the design of the proposed redesigned version, as well as better techniques for deploying it, will be possible after further experience is gained with different sediments and conditions in the field.

6.0 REFERENCES

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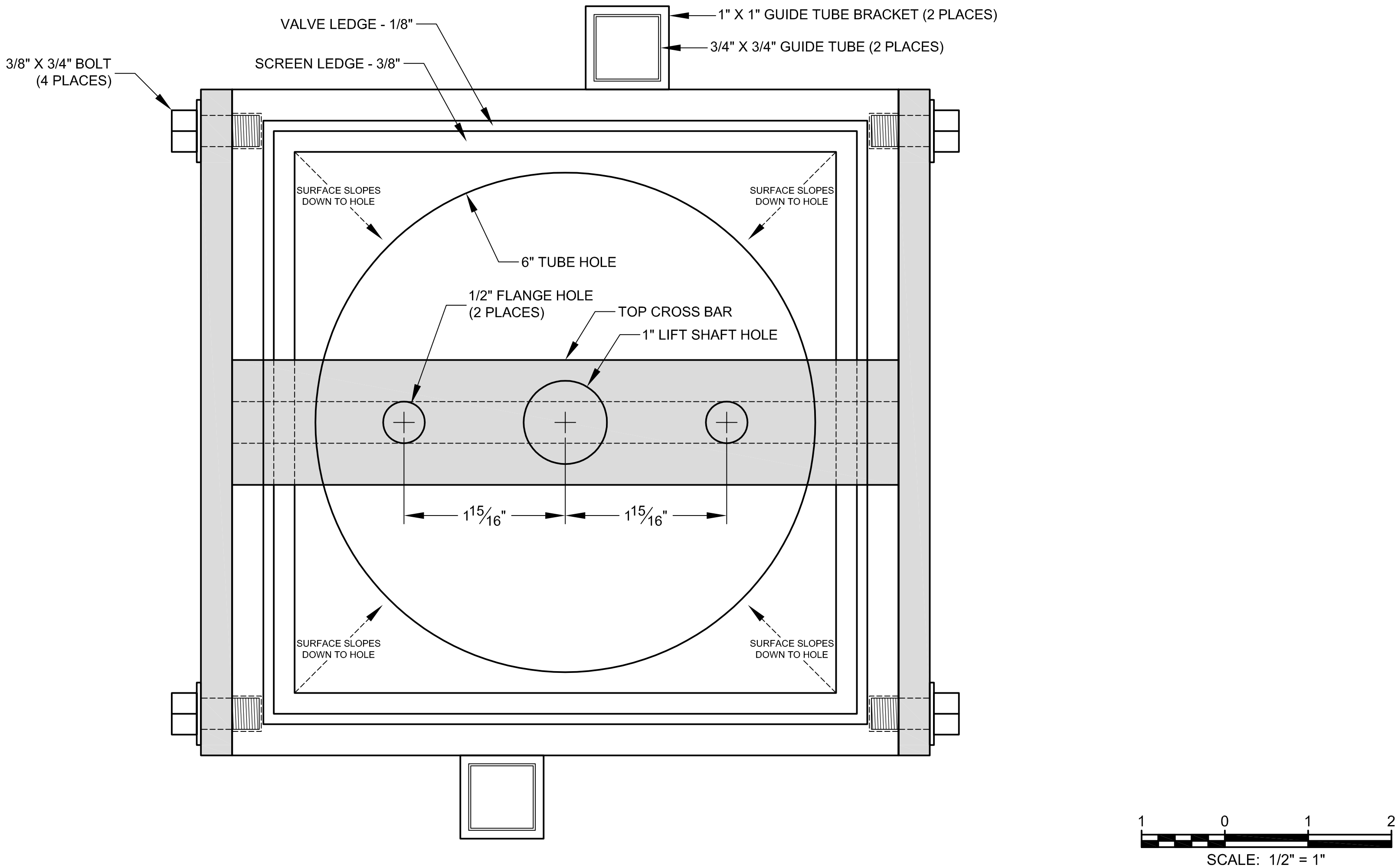
APPENDIX A

USS SAMPLER ASSEMBLY DRAWINGS



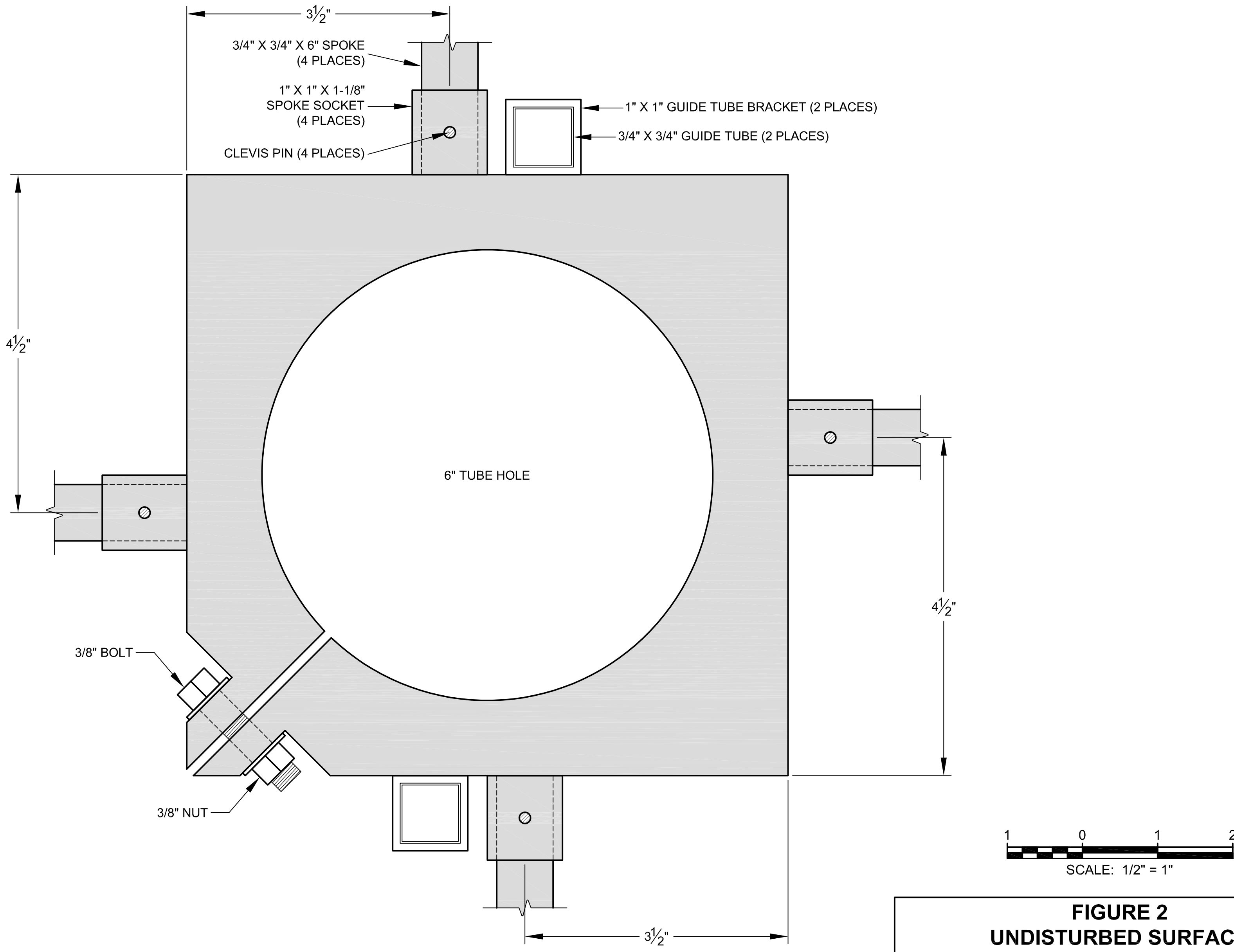
TOP BLOCK ASSEMBLY - TOP VIEW
AS OF 12/01/2004

FIGURE 1
UNDISTURBED SURFACE SEDIMENT SAMPLER
TOP BLOCK ASSEMBLY

PREPARED FOR: EPA
BY: Tetra Tech EM Inc.

WORK ORDER NO.:	CONTRACT NO.:	SHEET:
4D-5753-NBLX	GS-10F-0076K	1 OF 6

FIG1-TOP BLOCK ASSY.dwg - DWH - 12/16/2004



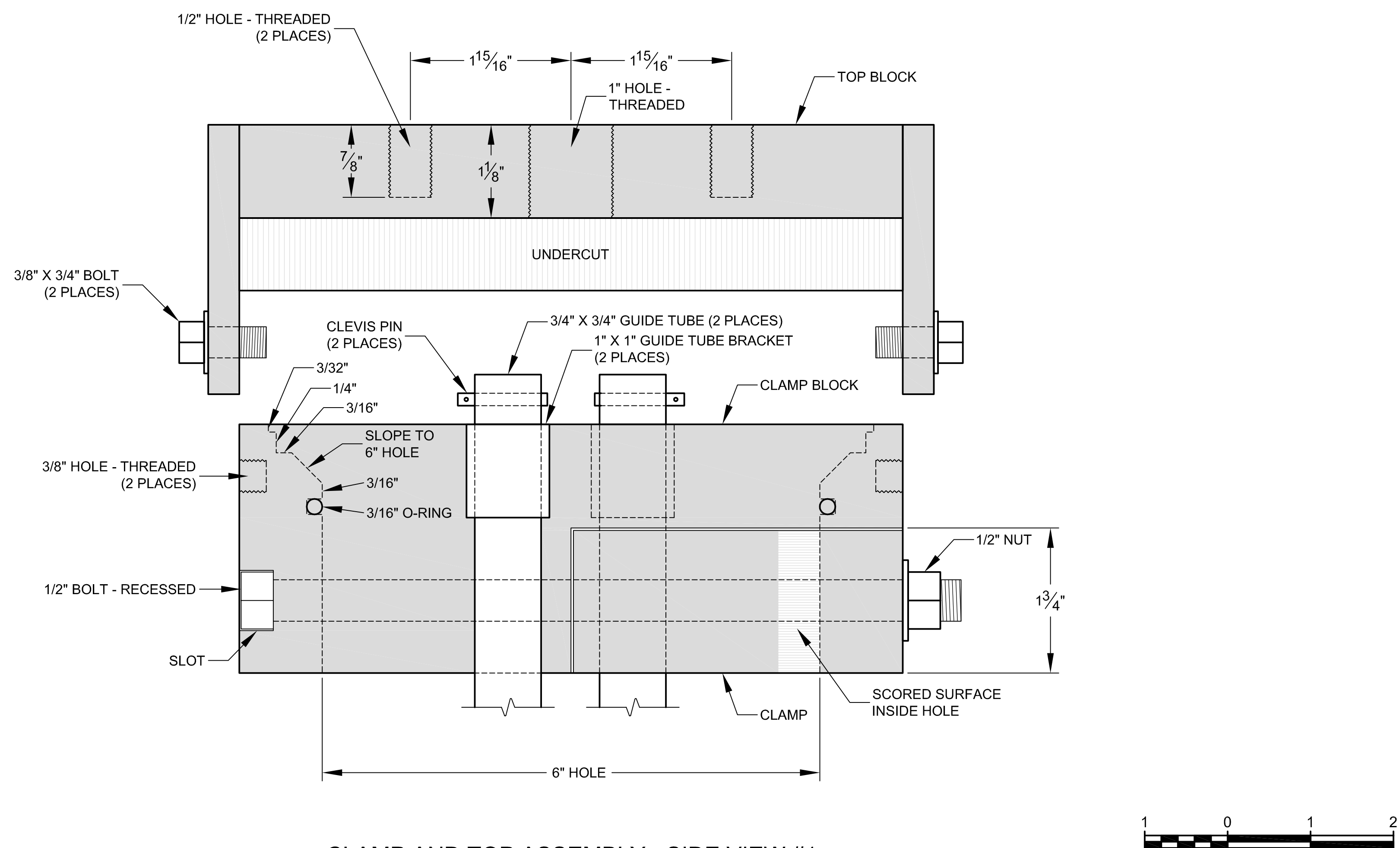
STAND HUB ASSEMBLY - TOP VIEW

AS OF 12/01/2004

FIGURE 2
UNDISTURBED SURFACE SEDIMENT SAMPLER
STAND HUB ASSEMBLY

PREPARED FOR: EPA		BY: Tetra Tech EM Inc.
WORK ORDER NO.: 4D-5753-NBLX	CONTRACT NO.: GS-10F-0076K	SHEET: 2 OF 6

FIG2-STAND HUB ASSY.dwg - DWH - 12/16/2004



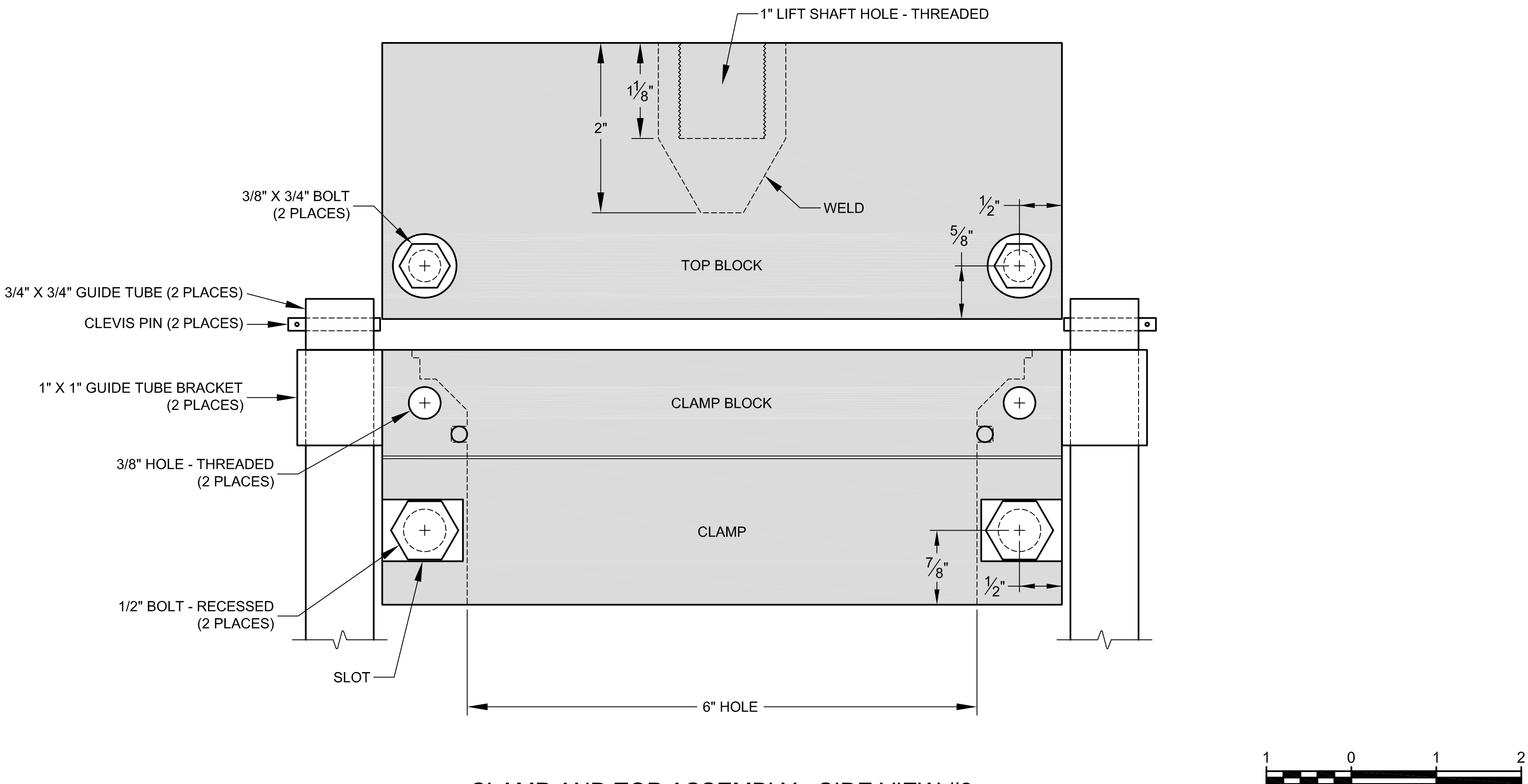
CLAMP AND TOP ASSEMBLY - SIDE VIEW #1

AS OF 12/01/2004

FIGURE 3
UNDISTURBED SURFACE SEDIMENT SAMPLER
CLAMP AND TOP ASSEMBLY

PREPARED FOR: EPA		BY: Tetra Tech EM Inc.
WORK ORDER NO.: 4D-5753-NBLX	CONTRACT NO.: GS-10F-0076K	SHEET: 3 OF 6

FIG3-CLAMP-TOP ASSY.dwg - DWH - 12/16/2004

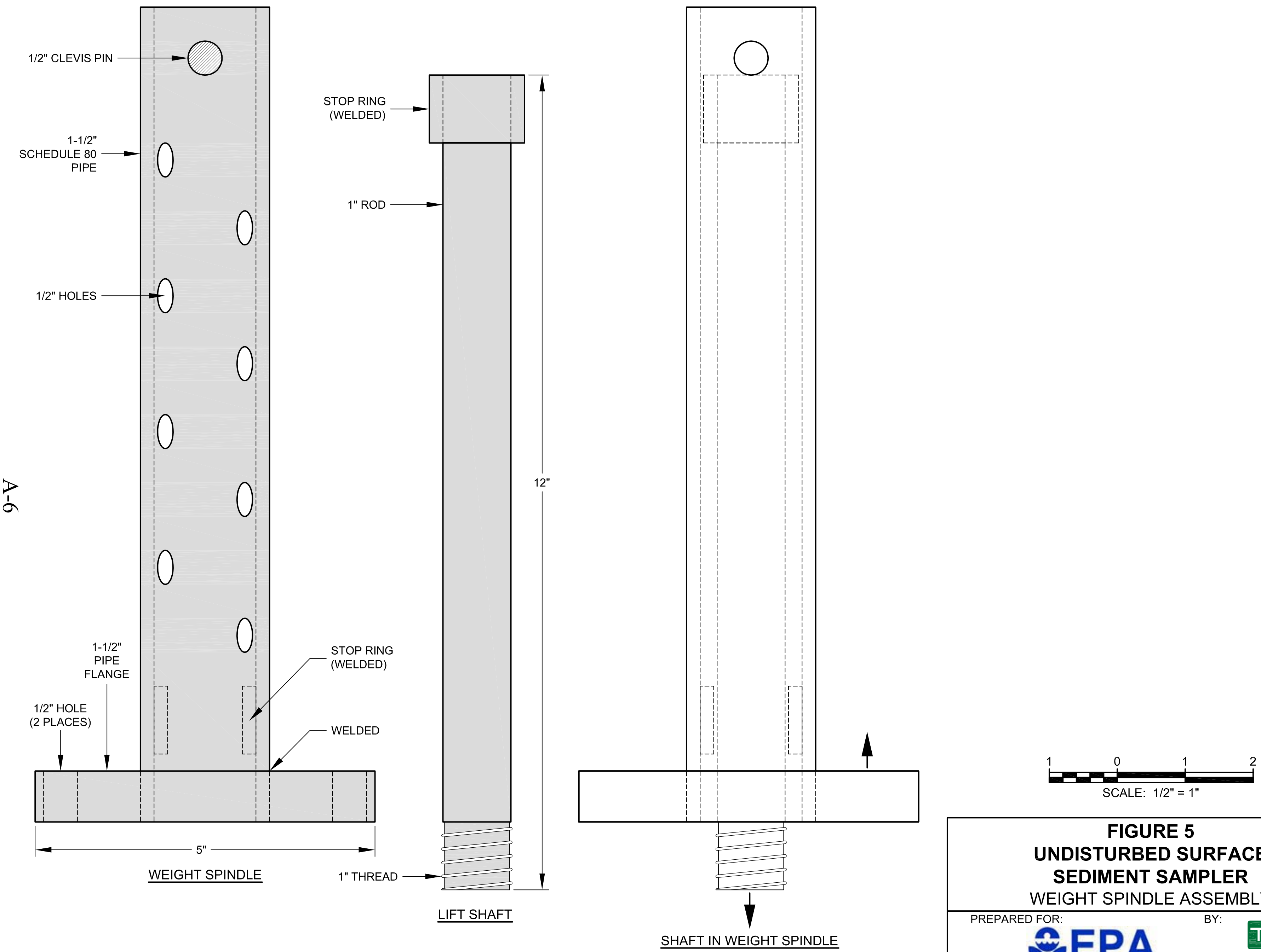


CLAMP AND TOP ASSEMBLY - SIDE VIEW #2

AS OF 12/01/2004

FIGURE 4 UNDISTURBED SURFACE SEDIMENT SAMPLER CLAMP AND TOP ASSEMBLY		
PREPARED FOR: EPA		BY: Tetra Tech EM Inc.
WORK ORDER NO.: 4D-5753-NBLX	CONTRACT NO.: GS-10F-0076K	SHEET: 4 OF 6

FIG4-CLAMP-TOP ASSY.dwg - DWH - 12/16/2004



WEIGHT SPINDLE ASSEMBLY - SIDE VIEW

AS OF 12/01/2004

FIGURE 5

UNDISTURBED SURFACE SEDIMENT SAMPLER

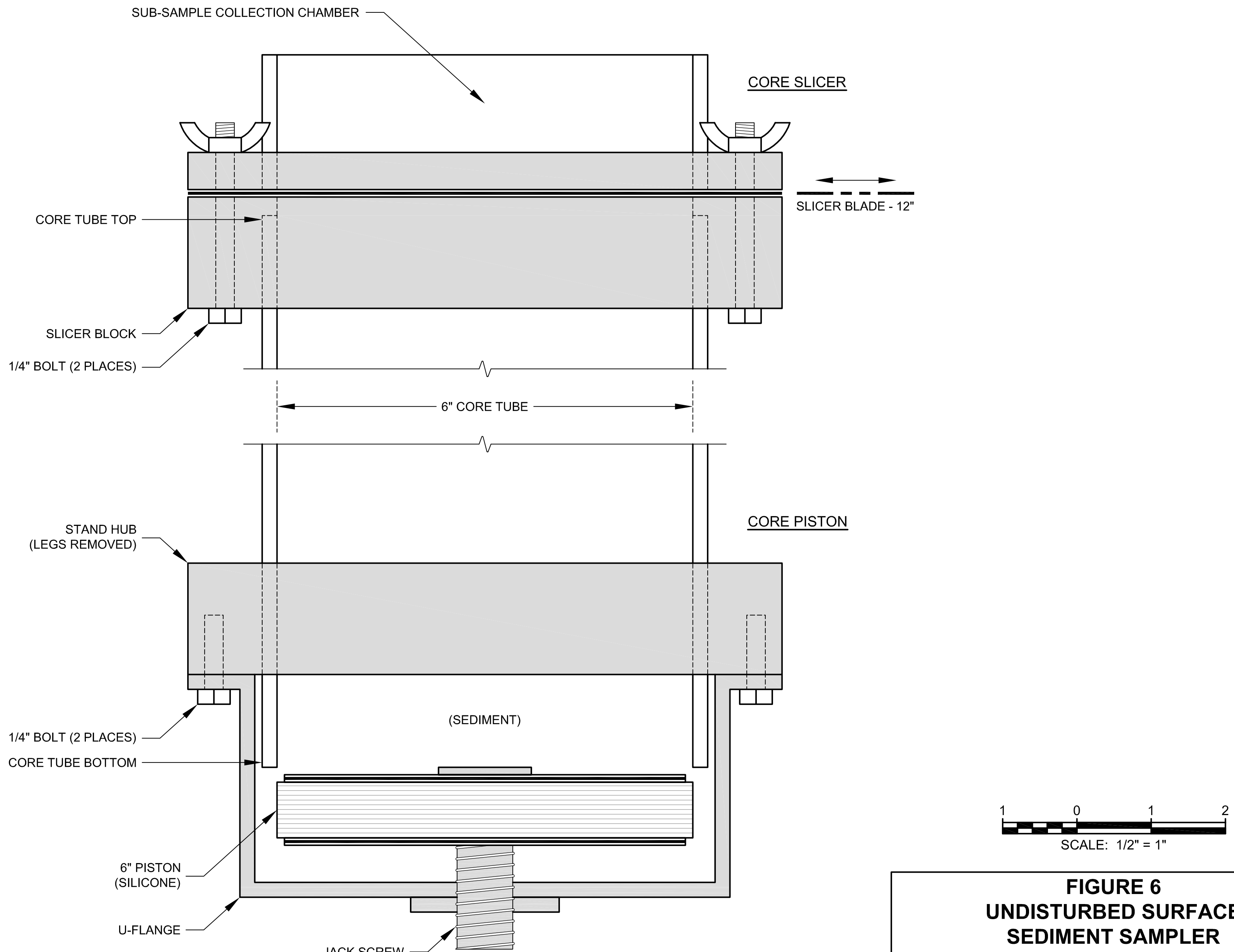
WEIGHT SPINDLE ASSEMBLY

PREPARED FOR: EPA

BY: Tetra Tech EM Inc.

WORK ORDER NO.:	CONTRACT NO.:	SHEET:
4D-5753-NBLX	GS-10F-0076K	5 OF 6

FIG5-WEIGHT SPINDLE ASSY.dwg - DWH - 12/16/2004



CORE SLICER AND PISTON - SIDE VIEW

AS OF 12/01/2004

FIGURE 6
UNDISTURBED SURFACE SEDIMENT SAMPLER
CORE SLICER AND PISTON

PREPARED FOR: EPA		BY: Tetra Tech EM Inc.
WORK ORDER NO.: 4D-5753-NBLX	CONTRACT NO.: GS-10F-0076K	SHEET: 6 OF 6

APPENDIX B

LABORATORY TESTING VIDEO

FIELD DEMONSTRATION VIDEO

APPENDIX C

LABORATORY TANK TEST

WATER QUALITY DATA

Table XX
Sediment Sampler Design Project
Laboratory Tank Test
BMH-60 Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
7/9/2004	17:04:37	64.12	45.3	226	6.27	7278	257.31
7/9/2004	17:04:39	64.05	13.2	226	6.26	7312	257.57
7/9/2004	17:04:41	64.05	388.1	226	6.28	7332	257.74
7/9/2004	17:04:44	64.03	177.4	226	6.28	7359	258.58
7/9/2004	17:04:46	64.04	298.3	226	6.28	7381	258.75
7/9/2004	17:04:48	64.07	119.3	226	6.28	7398	257.83
7/9/2004	17:04:50	64.08	99.7	226	6.28	7417	257.80
7/9/2004	17:04:52	64.08	98.1	226	6.28	7431	258.01
7/9/2004	17:04:54	64.09	123.6	226	6.28	7443	258.20
7/9/2004	17:04:56	64.10	78.4	226	6.27	7448	257.81
7/9/2004	17:04:58	64.10	82.5	226	6.26	7454	258.06
7/9/2004	17:05:00	64.06	55.9	226	6.28	7468	258.15
7/9/2004	17:05:03	64.04	61.5	226	6.28	7474	257.57
7/9/2004	17:05:05	64.03	60.4	226	6.28	7480	257.81
7/9/2004	17:05:07	64.01	64.6	226	6.28	7487	258.26
7/9/2004	17:05:09	64.01	74.7	226	6.28	7489	258.71
7/9/2004	17:05:11	64.02	76.9	226	6.27	7491	258.85
7/9/2004	17:05:13	64.02	54.6	226	6.27	7491	258.51
7/9/2004	17:05:15	64.02	59.0	226	6.27	7497	258.46
7/9/2004	17:05:17	64.01	60.6	226	6.28	7505	258.52
7/9/2004	17:05:19	64.03	39.2	225	6.28	7501	257.72
7/9/2004	17:05:22	64.03	45.2	225	6.28	7508	258.34
7/9/2004	17:05:24	64.02	81.8	225	6.28	7507	258.34
7/9/2004	17:05:26	64.02	67.8	225	6.28	7507	257.62
7/9/2004	17:05:28	64.01	62.0	225	6.28	7511	258.96
7/9/2004	17:05:30	64.02	69.7	225	6.28	7511	258.63
7/9/2004	17:05:32	64.02	50.8	225	6.28	7507	259.08
7/9/2004	17:05:34	64.02	59.1	225	6.28	7504	258.74
7/9/2004	17:05:36	64.02	61.9	225	6.28	7505	259.13
7/9/2004	17:05:39	64.02	55.6	225	6.29	7505	258.57
7/9/2004	17:05:41	64.02	56.6	225	6.28	7504	258.62
7/9/2004	17:05:43	64.03	50.7	225	6.28	7497	258.97
7/9/2004	17:05:45	64.02	49.2	225	6.28	7497	258.63
7/9/2004	17:05:47	64.02	43.0	225	6.28	7497	258.72
7/9/2004	17:05:49	64.02	46.7	225	6.28	7492	258.63
7/9/2004	17:05:51	64.03	46.4	225	6.28	7491	258.71
7/9/2004	17:05:53	64.03	35.8	225	6.28	7487	258.65
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7/9/2004	17:05:58	64.03	34.7	225	6.28	7481	258.65
7/9/2004	17:06:00	64.03	44.1	224	6.29	7479	258.51
7/9/2004	17:06:02	64.04	26.0	224	6.29	7476	258.58
7/9/2004	17:06:04	64.04	10.7	225	6.29	7474	258.32
7/9/2004	17:06:06	64.07	0.0	224	6.30	7458	259.30
7/10/2004	7:32:12	65.69	8.3	222	5.97	7335	294.51
7/10/2004	7:32:14	65.68	0.6	222	5.97	7348	294.63
7/10/2004	7:32:16	65.68	1.5	222	5.97	7359	294.57
7/10/2004	7:32:18	65.67	0.6	222	5.97	7365	294.59
7/10/2004	7:32:20	65.67	10.1	222	5.97	7370	294.59
7/10/2004	7:32:22	65.69	5.0	222	5.97	7371	294.65
7/10/2004	7:32:25	65.70	2.6	222	5.97	7370	294.47
7/10/2004	7:32:27	65.68	2.4	222	5.97	7370	294.63
7/10/2004	7:32:29	65.69	2.4	222	5.97	7369	294.65
7/10/2004	7:32:31	65.71	1.9	222	5.97	7362	294.65
7/10/2004	7:32:33	65.71	1.6	222	5.97	7362	294.73
7/10/2004	7:32:35	65.71	1.1	222	5.97	7358	294.73
7/10/2004	19:47:50	67.46	6.8	230	6.09	7184	356.13
7/10/2004	19:47:52	67.18	10.3	229	6.09	7265	355.78
7/10/2004	19:47:54	67.10	30.0	229	6.09	7306	356.19
7/10/2004	19:47:56	67.08	9.8	229	6.09	7330	356.39
7/10/2004	19:47:58	67.09	26.9	229	6.09	7345	356.28
7/10/2004	19:48:00	67.10	17.6	229	6.09	7360	356.22
7/10/2004	19:48:02	67.12	21.1	229	6.09	7368	356.45
7/10/2004	19:48:05	67.15	15.1	229	6.09	7371	356.45
7/10/2004	19:48:07	67.15	19.4	229	6.09	7378	356.51
7/10/2004	19:48:09	67.19	14.3	229	6.09	7377	356.57
7/10/2004	19:48:11	67.18	15.4	229	6.09	7379	356.51
7/10/2004	19:48:13	67.17	20.1	229	6.09	7384	356.39
7/10/2004	19:48:15	67.18	20.1	229	6.09	7383	356.60
7/10/2004	19:48:17	67.20	7.8	229	6.09	7380	356.60

Table XX (cont.)
Sediment Sampler Design Project
Laboratory Tank Test
BMH-60 Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
7/10/2004	19:48:19	67.20	10.5	229	6.09	7382	356.57
7/10/2004	19:48:22	67.19	10.7	229	6.09	7385	356.78
7/10/2004	19:48:24	67.20	54.0	229	6.09	7387	356.92
7/10/2004	19:48:26	67.16	25.2	229	6.09	7394	356.72
7/10/2004	19:48:28	67.20	13.2	229	6.09	7389	356.63
7/10/2004	19:48:30	67.18	9.1	229	6.09	7394	356.78
7/10/2004	19:48:32	67.19	14.6	229	6.09	7394	356.75
7/10/2004	19:48:34	67.18	15.6	229	6.09	7399	356.63
7/10/2004	19:48:36	67.17	14.8	229	6.09	7401	356.57
7/10/2004	19:48:38	67.16	22.3	229	6.09	7404	356.66
7/10/2004	19:48:41	67.11	35.9	229	6.09	7412	356.66
7/10/2004	19:48:43	67.10	19.4	229	6.09	7414	356.48
7/10/2004	19:48:45	67.08	23.1	229	6.09	7415	356.72
7/10/2004	19:48:47	67.08	13.6	229	6.09	7418	356.54
7/10/2004	19:48:49	67.09	16.2	229	6.09	7412	356.63
7/10/2004	19:48:51	67.10	11.9	229	6.09	7407	356.72
7/10/2004	19:48:53	67.07	14.7	229	6.10	7410	356.84
7/10/2004	19:48:55	67.05	27.1	229	6.10	7413	356.57
7/10/2004	19:48:57	67.07	25.5	229	6.10	7404	356.81
7/10/2004	19:49:00	67.09	24.7	229	6.10	7395	356.51
7/10/2004	19:49:02	67.10	17.7	229	6.10	7387	356.31
7/10/2004	19:49:04	67.13	19.2	229	6.10	7380	356.39
7/10/2004	19:49:06	67.12	22.2	229	6.10	7381	356.45
7/10/2004	19:49:08	67.13	29.4	229	6.10	7380	356.45
7/10/2004	19:49:10	67.13	23.9	229	6.10	7381	356.69
7/10/2004	19:49:12	67.14	15.9	229	6.10	7379	356.60
7/10/2004	19:49:14	67.13	40.1	228	6.10	7380	356.78
7/10/2004	19:49:17	67.13	18.2	228	6.10	7380	357.07
7/10/2004	19:49:19	67.13	23.2	228	6.10	7379	356.92
7/10/2004	19:49:21	67.13	13.1	228	6.10	7375	356.57
7/10/2004	19:49:23	67.17	1.4	228	6.10	7365	357.04
7/11/2004	11:26:16	68.22	8.1	238	5.92	7387	372.85
7/11/2004	11:26:18	68.21	63.9	238	5.93	7401	373.10
7/11/2004	11:26:20	68.20	83.9	238	5.93	7416	373.33
7/11/2004	11:26:23	68.18	23.9	238	5.93	7431	373.42
7/11/2004	11:26:25	68.17	19.6	238	5.93	7444	373.36
7/11/2004	11:26:27	68.17	35.7	238	5.93	7452	373.36
7/11/2004	11:26:29	68.16	114.2	238	5.93	7460	374.58
7/11/2004	11:26:31	68.14	157.5	237	5.93	7468	375.52
7/11/2004	11:26:33	68.15	135.8	237	5.94	7467	379.36
7/11/2004	11:26:35	68.14	75.9	237	5.94	7469	377.35
7/11/2004	11:26:37	68.15	79.1	237	5.94	7465	377.35
7/11/2004	11:26:40	68.14	62.0	237	5.95	7463	377.61
7/11/2004	11:26:42	68.14	64.3	237	5.95	7457	376.30
7/11/2004	11:26:44	68.14	67.4	236	5.95	7455	375.85
7/11/2004	11:26:46	68.15	71.7	236	5.95	7446	375.72
7/11/2004	11:26:48	68.15	69.3	236	5.95	7439	375.65
7/11/2004	11:26:50	68.17	82.2	236	5.95	7427	375.39
7/11/2004	11:26:52	68.18	73.5	236	5.95	7418	375.62
7/11/2004	11:26:54	68.17	90.9	236	5.95	7413	375.07
7/11/2004	11:26:56	68.17	54.4	236	5.96	7408	375.26
7/11/2004	11:26:59	68.17	74.5	236	5.96	7403	374.78
7/11/2004	11:27:01	68.16	73.7	236	5.96	7396	374.81
7/11/2004	11:27:03	68.18	74.6	236	5.96	7388	374.52
7/11/2004	11:27:05	68.18	82.4	236	5.96	7381	375.00
7/11/2004	11:27:07	68.17	76.6	235	5.97	7376	375.91
7/11/2004	11:27:09	68.16	48.9	235	5.97	7369	376.73
7/11/2004	11:27:11	68.16	73.2	235	5.97	7363	376.63
7/11/2004	11:27:13	68.16	55.5	235	5.97	7354	378.20
7/11/2004	11:27:16	68.16	67.4	235	5.97	7347	379.82
7/11/2004	11:27:18	68.15	79.1	235	5.97	7341	380.29
7/11/2004	11:27:20	68.15	71.8	235	5.98	7332	377.58
7/11/2004	11:27:22	68.14	73.7	235	5.98	7326	379.82
7/11/2004	11:27:24	68.14	86.2	235	5.98	7317	379.39
7/11/2004	11:27:26	68.14	78.2	234	5.98	7312	379.16
7/11/2004	11:27:28	68.13	74.7	234	5.98	7310	378.30
7/11/2004	11:27:30	68.13	68.3	234	5.99	7310	378.70
7/11/2004	11:27:32	68.14	52.1	234	5.99	7303	378.27
7/11/2004	11:27:35	68.14	65.9	234	5.99	7303	378.47

Table XX (cont.)
Sediment Sampler Design Project
Laboratory Tank Test
BMH-60 Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
7/11/2004	11:27:37	68.14	53.9	234	5.99	7303	379.66
7/11/2004	11:27:39	68.14	61.3	234	5.99	7298	379.56
7/11/2004	11:27:41	68.14	53.9	234	5.99	7293	379.89
7/11/2004	11:27:43	68.15	57.8	234	5.99	7285	378.10
7/11/2004	11:27:45	68.16	73.9	234	5.99	7278	378.50
7/11/2004	11:27:47	68.14	58.2	233	5.99	7277	377.55
7/11/2004	11:27:49	68.15	42.5	233	5.99	7271	376.92
7/11/2004	11:27:51	68.16	46.9	233	6.00	7267	377.68
7/11/2004	11:27:54	68.15	52.0	233	6.00	7267	377.45
7/11/2004	11:27:56	68.15	56.9	233	6.00	7262	377.35
7/11/2004	11:27:58	68.16	51.4	233	6.00	7260	377.32
7/11/2004	11:28:00	68.16	47.5	233	6.00	7259	377.12
7/11/2004	11:28:02	68.17	45.2	233	6.00	7255	376.92
7/11/2004	11:28:04	68.17	54.8	233	6.00	7253	376.86
7/11/2004	11:28:06	68.17	57.4	233	6.00	7250	376.96
7/11/2004	11:28:08	68.18	65.0	233	6.00	7244	376.89
7/11/2004	11:28:11	68.18	59.8	233	6.00	7240	377.28
7/11/2004	11:28:13	68.18	75.4	233	6.00	7234	377.35
7/11/2004	11:28:15	68.17	62.4	233	6.00	7231	376.11
7/11/2004	11:28:17	68.17	56.7	233	6.00	7223	376.27
7/11/2004	11:28:19	68.17	7.7	233	6.00	7220	373.26
7/11/2004	11:28:21	68.22	0.0	232	5.99	7209	372.66
7/12/2004	9:31:54	69.66	30.9	221	5.97	7180	380.45
7/12/2004	9:31:56	69.59	5.9	221	5.97	7200	382.09
7/12/2004	9:31:58	69.53	22.5	221	5.97	7384	384.13
7/12/2004	9:32:00	69.47	34.4	221	5.98	7254	383.55
7/12/2004	9:32:02	69.45	29.5	220	5.98	7264	384.20
7/12/2004	9:32:04	69.44	40.0	220	5.98	7277	382.60
7/12/2004	9:32:06	69.44	23.8	220	5.98	7280	383.18
7/12/2004	9:32:08	69.45	29.3	220	5.99	7276	383.07
7/12/2004	9:32:11	69.44	22.6	220	5.99	7275	383.41
7/12/2004	9:32:13	69.43	16.0	220	5.99	7270	382.94
7/12/2004	9:32:15	69.44	12.6	220	5.99	7263	382.80
7/12/2004	9:32:17	69.43	25.5	220	5.99	7260	384.06
7/12/2004	9:32:19	69.44	11.5	220	5.99	7250	383.48
7/12/2004	9:32:21	69.45	11.5	219	5.99	7242	383.65
7/12/2004	9:32:23	69.45	17.5	219	5.99	7237	383.38
7/12/2004	9:32:25	69.45	69.2	219	5.99	7234	384.16
7/12/2004	9:32:28	69.46	16.1	219	5.99	7229	383.72
7/12/2004	9:32:30	69.46	37.1	219	5.99	7223	386.43
7/12/2004	9:32:32	69.46	12.9	219	5.99	7220	383.62
7/12/2004	9:32:34	69.47	47.4	219	5.99	7209	384.74
7/12/2004	9:32:36	69.47	18.5	219	5.99	7203	383.79
7/12/2004	9:32:38	69.44	28.0	219	5.99	7201	382.20
7/12/2004	9:32:40	69.47	66.1	219	5.99	7190	387.81
7/12/2004	9:32:42	69.46	190.2	219	5.99	7190	382.03
7/12/2004	9:32:44	69.45	131.9	219	6.00	7196	388.05
7/12/2004	9:32:47	69.44	111.8	219	6.00	7204	388.47
7/12/2004	9:32:49	69.44	117.9	218	6.01	7209	385.43
7/12/2004	9:32:51	69.47	77.4	218	6.02	7207	387.57
7/12/2004	9:32:53	69.46	52.2	218	6.03	7212	390.19
7/12/2004	9:32:55	69.44	43.6	217	6.04	7219	388.47
7/12/2004	9:32:57	69.43	42.3	217	6.05	7219	388.61
7/12/2004	9:32:59	69.43	29.5	217	6.05	7213	391.03
7/12/2004	9:33:01	69.42	39.6	216	6.06	7204	392.81
7/12/2004	9:33:03	69.43	46.6	216	6.06	7194	390.54
7/12/2004	9:33:06	69.42	35.8	216	6.06	7186	389.34
7/12/2004	9:33:08	69.42	63.4	216	6.06	7175	387.43
7/12/2004	9:33:10	69.41	27.3	216	6.06	7169	388.75
7/12/2004	9:33:12	69.41	43.1	216	6.06	7162	389.69
7/12/2004	9:33:14	69.41	42.0	215	6.06	7158	390.29
7/12/2004	9:33:16	69.41	58.3	215	6.06	7152	390.05
7/12/2004	9:33:18	69.41	35.3	215	6.06	7151	386.80
7/12/2004	9:33:20	69.42	40.9	215	6.06	7146	388.09
7/12/2004	9:33:23	69.42	36.4	215	6.06	7142	386.12
7/12/2004	9:33:25	69.43	31.5	215	6.06	7139	386.87
7/12/2004	9:33:27	69.44	41.8	215	6.06	7134	386.91
7/12/2004	9:33:29	69.43	21.2	215	6.06	7133	387.60
7/12/2004	9:33:31	69.43	28.3	214	6.06	7129	387.15

Table XX (cont.)
Sediment Sampler Design Project
Laboratory Tank Test
BMH-60 Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
7/12/2004	9:33:33	69.42	20.7	214	6.06	7130	387.19
7/12/2004	9:33:35	69.43	20.1	214	6.06	7124	386.18
7/12/2004	9:33:37	69.44	14.5	214	6.06	7119	386.84
7/12/2004	9:33:39	69.43	16.9	214	6.06	7117	386.43
7/12/2004	9:33:42	69.43	13.9	214	6.06	7114	386.01
7/12/2004	9:33:44	69.43	20.0	214	6.05	7110	382.67

Table XX
Sediment Sampler Design Project
Tank Laboratory Test
Gravity Core Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (μg/L)	Conductivity μS/cm
6/21/2004	15:15:08	65.07	1.5	196	6.66	7922	321.62
6/21/2004	15:15:10	65.08	4.9	196	6.66	7928	321.18
6/21/2004	15:15:12	65.06	11.2	196	6.66	7940	320.46
6/21/2004	15:15:14	65.05	14.3	196	6.66	7947	319.79
6/21/2004	15:15:16	65.07	15.4	196	6.66	7951	320.64
6/21/2004	15:15:18	65.08	9.4	196	6.65	7951	321.10
6/21/2004	15:15:20	65.08	12.9	196	6.65	7949	319.05
6/21/2004	15:15:22	65.08	13.0	196	6.65	7953	319.64
6/21/2004	15:15:24	65.07	11.9	196	6.65	7950	322.77
6/21/2004	15:15:27	65.07	11.8	196	6.65	7949	323.84
6/21/2004	15:15:29	65.07	27.8	196	6.65	7942	323.12
6/21/2004	15:15:31	65.07	13.7	196	6.65	7934	322.70
6/21/2004	15:15:33	65.08	19.3	196	6.65	7924	323.04
6/21/2004	15:15:35	65.07	15.1	196	6.65	7918	323.17
6/21/2004	15:15:37	65.08	13.1	196	6.65	7904	321.98
6/21/2004	15:15:39	65.08	19.6	196	6.65	7894	321.18
6/21/2004	15:15:41	65.08	22.3	196	6.65	7882	321.14
6/21/2004	15:15:43	65.09	16.8	196	6.65	7864	322.79
6/21/2004	15:15:46	65.08	17.1	196	6.65	7851	322.22
6/21/2004	15:15:48	65.08	34.2	196	6.65	7830	322.62
6/21/2004	15:15:50	65.09	29.2	196	6.66	7813	323.01
6/21/2004	15:15:52	65.09	23.8	196	6.66	7794	321.07
6/21/2004	15:15:54	65.10	21.0	196	6.66	7775	320.40
6/21/2004	15:15:56	65.09	23.1	196	6.66	7762	321.05
6/21/2004	15:15:58	65.08	25.7	196	6.66	7746	321.01
6/21/2004	15:16:00	65.09	26.6	196	6.66	7730	321.16
6/21/2004	15:16:03	65.11	22.6	196	6.66	7711	321.12
6/21/2004	15:16:05	65.10	17.8	196	6.66	7703	320.88
6/21/2004	15:16:07	65.11	19.9	196	6.66	7689	320.42
6/21/2004	15:16:09	65.10	15.2	196	6.66	7686	317.59
6/21/2004	15:16:11	65.11	15.9	196	6.66	7681	318.27
6/21/2004	15:16:13	65.10	17.0	196	6.66	7680	319.83
6/21/2004	15:16:15	65.10	18.2	196	6.66	7678	319.38
6/21/2004	15:16:17	65.09	13.4	196	6.66	7675	320.90
6/21/2004	15:16:19	65.10	15.9	196	6.66	7672	320.01
6/21/2004	15:16:22	65.10	17.3	196	6.66	7667	320.09
6/21/2004	15:16:24	65.09	12.3	196	6.67	7668	318.53
6/21/2004	15:16:26	65.09	10.0	196	6.67	7664	317.48
6/21/2004	15:16:28	65.09	10.8	196	6.67	7663	316.84
6/21/2004	15:16:30	65.08	15.4	196	6.67	7661	319.77
6/21/2004	15:16:32	65.08	18.1	196	6.67	7665	319.64
6/21/2004	15:16:34	65.07	13.1	195	6.67	7663	319.20
6/21/2004	15:16:36	65.08	10.6	195	6.67	7662	318.88
6/21/2004	15:16:39	65.06	10.3	195	6.67	7663	318.81
6/21/2004	15:16:41	65.05	10.6	195	6.67	7664	318.94
6/21/2004	15:16:43	65.06	11.7	195	6.67	7661	317.91
6/21/2004	15:16:45	65.05	2.0	195	6.67	7659	317.44
6/21/2004	15:16:47	65.06	4.7	195	6.67	7658	318.83
6/21/2004	15:16:49	65.06	4.4	195	6.67	7658	316.65
6/21/2004	15:16:51	65.06	5.9	195	6.67	7659	317.16
6/21/2004	15:16:53	65.08	3.2	195	6.67	7661	319.31
6/21/2004	15:16:55	65.08	4.2	195	6.67	7657	316.75
6/21/2004	15:16:58	65.08	2.8	195	6.67	7660	317.35
6/21/2004	15:17:00	65.08	2.1	195	6.67	7657	317.42
6/21/2004	15:17:02	65.09	4.6	195	6.66	7658	318.45
6/21/2004	15:17:04	65.09	5.2	195	6.66	7658	319.46
6/21/2004	15:17:06	65.09	3.6	195	6.67	7656	318.96
6/21/2004	15:17:08	65.09	5.7	195	6.67	7660	318.99
6/21/2004	15:17:10	65.09	3.0	195	6.67	7661	318.64
6/21/2004	15:17:12	65.10	4.8	195	6.67	7661	318.51
6/21/2004	15:17:15	65.10	4.3	195	6.67	7665	318.06
6/21/2004	15:17:17	65.11	4.0	195	6.67	7665	318.40
6/21/2004	15:17:19	65.13	2.8	195	6.67	7666	317.57
6/21/2004	15:17:21	65.14	0.2	195	6.67	7670	317.29
6/21/2004	15:17:23	65.15	0.3	195	6.67	7678	317.46
6/21/2004	15:17:25	65.16	0.5	195	6.67	7688	316.90
6/21/2004	15:17:27	65.19	0.6	195	6.66	7695	315.82
6/22/2004	16:04:37	65.33	56.6	165	6.57	7978	336.8
6/22/2004	16:04:39	65.31	54.1	164	6.57	7984	337.33

Table XX (cont.)
Sediment Sampler Design Project
Tank Laboratory Test
Gravity Core Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
6/22/2004	16:04:42	65.32	66.6	163	6.57	7983	337.89
6/22/2004	16:04:44	65.32	77.4	163	6.58	7982	338.56
6/22/2004	16:04:46	65.30	63.3	162	6.58	7983	337.55
6/22/2004	16:04:48	65.29	51.6	162	6.57	7982	338.29
6/22/2004	16:04:50	65.29	52.0	162	6.57	7978	338.43
6/22/2004	16:04:52	65.29	87.9	161	6.58	7979	338.14
6/22/2004	16:04:54	65.30	96.3	161	6.57	7978	338.83
6/22/2004	16:04:56	65.30	82.1	161	6.58	7981	337.60
6/22/2004	16:04:58	65.31	77.5	160	6.57	7981	340.24
6/22/2004	16:05:01	65.32	94.0	160	6.58	7984	338.75
6/22/2004	16:05:03	65.32	88.8	160	6.57	7986	339.32
6/22/2004	16:05:05	65.32	74.5	160	6.57	7990	339.12
6/22/2004	16:05:07	65.32	85.7	159	6.57	7995	339.57
6/22/2004	16:05:09	65.32	67.3	159	6.57	8001	338.90
6/22/2004	16:05:11	65.31	71.7	159	6.57	8010	338.51
6/22/2004	16:05:13	65.32	64.4	159	6.57	8015	338.09
6/22/2004	16:05:15	65.31	56.0	159	6.58	8020	338.98
6/22/2004	16:05:18	65.31	38.0	159	6.58	8025	339.49
6/22/2004	16:05:20	65.30	37.4	158	6.58	8029	339.84
6/22/2004	16:05:22	65.31	52.2	158	6.58	8033	340.24
6/22/2004	16:05:24	65.31	45.8	158	6.57	8029	340.21
6/22/2004	16:05:26	65.30	72.3	158	6.57	8029	340.41
6/22/2004	16:05:28	65.31	61.0	158	6.57	8027	337.28
6/22/2004	16:05:30	65.31	8.3	158	6.57	8025	335.39
7/1/2004	9:48:16	67.86	7.9	149	6.48	7030	355.06
7/1/2004	9:48:19	67.83	11.6	149	6.47	7092	354.86
7/1/2004	9:48:21	67.82	14.6	149	6.47	7155	356.02
7/1/2004	9:48:23	67.83	1.1	149	6.47	7214	356.50
7/1/2004	9:48:25	67.83	7.0	150	6.47	7267	355.96
7/1/2004	9:48:27	67.84	5.1	150	6.47	7311	355.93
7/1/2004	9:48:29	67.85	5.8	150	6.46	7352	355.69
7/1/2004	9:48:31	67.84	6.1	150	6.46	7387	355.60
7/1/2004	9:48:33	67.84	4.6	150	6.46	7416	355.24
7/1/2004	9:48:35	67.84	4.8	150	6.46	7441	355.21
7/1/2004	9:48:38	67.84	0.8	150	6.46	7461	355.60
7/1/2004	9:48:40	67.84	7.3	150	6.46	7479	355.48
7/1/2004	9:48:42	67.84	5.3	150	6.46	7493	355.87
7/1/2004	9:48:44	67.85	3.8	150	6.46	7505	355.90
7/1/2004	9:48:46	67.84	2.9	150	6.46	7517	356.08
7/1/2004	9:48:48	67.84	2.2	150	6.46	7526	356.29
7/1/2004	9:48:50	67.84	1.4	150	6.46	7533	356.56
7/1/2004	9:48:52	67.84	1.0	150	6.46	7541	356.11
7/1/2004	9:48:54	67.85	0.9	150	6.46	7546	357.50
7/1/2004	9:48:57	67.85	1.4	150	6.46	7552	356.87
7/1/2004	9:48:59	67.86	2.9	150	6.46	7554	356.53
7/1/2004	9:49:01	67.86	7.2	150	6.46	7552	356.23
7/1/2004	9:49:03	67.86	1.2	150	6.46	7556	355.66
7/1/2004	9:49:05	67.86	2.2	150	6.46	7553	355.48
7/1/2004	9:49:07	67.85	2.9	150	6.46	7557	358.99
7/1/2004	9:49:09	67.86	8.6	150	6.46	7559	361.05
7/1/2004	9:49:11	67.88	4.3	150	6.46	7557	360.16
7/1/2004	9:49:14	67.89	30.9	150	6.46	7557	361.98
7/1/2004	9:49:16	67.89	12.2	150	6.47	7561	365.05
7/1/2004	9:49:18	67.89	15.9	150	6.48	7566	365.08
7/1/2004	9:49:20	67.90	23.1	150	6.48	7565	364.04
7/1/2004	9:49:22	67.89	29.9	150	6.49	7565	363.38
7/1/2004	9:49:24	67.89	26.7	150	6.50	7562	363.35
7/1/2004	9:49:26	67.89	18.7	149	6.51	7552	366.12
7/1/2004	9:49:28	67.91	32.6	149	6.51	7541	364.98
7/1/2004	9:49:31	67.90	15.4	149	6.51	7530	370.37
7/1/2004	9:49:33	67.90	16.0	149	6.51	7516	369.85
7/1/2004	9:49:35	67.89	16.8	149	6.52	7500	370.82
7/1/2004	9:49:37	67.89	15.4	149	6.52	7480	370.27
7/1/2004	9:49:39	67.88	14.1	149	6.53	7464	368.04
7/1/2004	9:49:41	67.89	14.4	148	6.53	7444	365.36
7/1/2004	9:49:43	67.90	16.3	148	6.53	7423	363.44
7/1/2004	9:49:45	67.91	20.9	148	6.53	7402	362.79
7/1/2004	9:49:47	67.91	9.6	148	6.53	7385	367.30
7/1/2004	9:49:50	67.90	6.5	148	6.53	7375	366.44

Table XX (cont.)
Sediment Sampler Design Project
Tank Laboratory Test
Gravity Core Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (μg/L)	Conductivity μS/cm
7/1/2004	9:49:52	67.91	5.9	148	6.52	7362	365.58
7/1/2004	9:49:54	67.91	7.2	148	6.52	7351	365.05
7/1/2004	9:49:56	67.91	2.0	148	6.52	7341	364.92
7/1/2004	9:49:58	67.91	7.1	148	6.52	7333	364.48
7/1/2004	9:50:00	67.91	6.3	148	6.52	7322	363.79
7/1/2004	9:50:02	67.92	16.9	148	6.52	7316	362.91
7/1/2004	9:50:04	67.92	5.3	148	6.52	7308	361.89
7/1/2004	9:50:07	67.93	6.5	148	6.52	7299	364.04
7/1/2004	9:50:09	67.93	5.8	148	6.52	7292	363.63
7/1/2004	9:50:11	67.94	7.3	148	6.52	7288	362.97
7/1/2004	9:50:13	67.93	13.3	148	6.52	7284	362.91
7/1/2004	9:50:15	67.95	11.2	148	6.52	7276	361.98
7/1/2004	9:50:17	67.96	7.6	148	6.52	7274	361.89
7/1/2004	9:50:19	67.97	5.9	148	6.51	7269	361.42
7/1/2004	9:50:21	67.98	6.8	148	6.51	7263	359.27
7/1/2004	9:50:23	67.99	7.8	148	6.51	7263	359.79
7/1/2004	9:50:26	68.00	7.4	148	6.51	7260	359.45
7/1/2004	9:50:28	68.01	13.8	148	6.51	7261	360.03
7/1/2004	9:50:30	67.98	5.0	148	6.51	7272	354.35
7/1/2004	9:50:32	67.94	4.4	148	6.51	7288	355.45
7/1/2004	9:50:34	67.93	0.7	148	6.50	7298	355.21
7/1/2004	9:50:36	67.92	0.0	148	6.49	7309	354.44
7/2/2004	7:20:46	69.03	7.2	204	6.23	7306	380.84
7/2/2004	7:20:49	69.03	8.7	203	6.23	7315	380.74
7/2/2004	7:20:51	69.02	10.6	203	6.23	7329	380.74
7/2/2004	7:20:53	69.02	11.7	203	6.23	7336	380.74
7/2/2004	7:20:55	69.03	14.7	203	6.23	7339	380.94
7/2/2004	7:20:57	69.03	16.9	203	6.23	7342	380.90
7/2/2004	7:20:59	69.04	10.5	203	6.23	7346	381.00
7/2/2004	7:21:01	69.03	18.1	203	6.23	7348	381.24
7/2/2004	7:21:03	69.03	13.5	203	6.23	7346	380.94
7/2/2004	7:21:06	69.04	6.7	203	6.23	7344	380.70
7/2/2004	7:21:08	69.04	9.1	203	6.22	7342	380.67
7/2/2004	7:21:10	69.02	24.8	203	6.23	7341	380.60
7/2/2004	7:21:12	69.02	16.8	203	6.23	7340	380.90
7/2/2004	7:21:14	69.01	14.4	203	6.23	7343	380.87
7/2/2004	7:21:16	69.01	10.3	203	6.23	7350	380.94
7/2/2004	7:21:18	69.00	22.6	203	6.23	7356	380.97
7/2/2004	7:21:20	69.00	11.9	203	6.23	7360	380.94
7/2/2004	7:21:22	68.99	15.9	203	6.23	7367	380.94
7/2/2004	7:21:25	68.99	23.1	203	6.23	7372	380.87
7/2/2004	7:21:27	68.98	11.1	203	6.23	7371	381.31
7/2/2004	7:21:29	68.98	38.7	203	6.23	7366	381.24
7/2/2004	7:21:31	68.97	22.5	203	6.24	7365	381.21
7/2/2004	7:21:33	68.98	12.4	203	6.24	7359	381.98
7/2/2004	7:21:35	68.97	11.7	202	6.24	7358	382.66
7/2/2004	7:21:37	68.97	13.7	202	6.24	7362	382.73
7/2/2004	7:21:39	68.97	20.3	202	6.24	7360	382.80
7/2/2004	7:21:42	68.97	19.8	202	6.25	7358	381.92
7/2/2004	7:21:44	68.97	14.0	202	6.25	7354	381.71
7/2/2004	7:21:46	68.97	24.9	202	6.25	7352	381.58
7/2/2004	7:21:48	68.97	18.9	202	6.25	7359	381.44
7/2/2004	7:21:50	68.96	27.1	202	6.25	7348	381.48
7/2/2004	7:21:52	68.96	19.7	202	6.25	7342	382.12
7/2/2004	7:21:54	68.97	16.5	202	6.25	7342	382.25
7/2/2004	7:21:56	68.96	19.5	202	6.25	7347	382.36
7/2/2004	7:21:58	68.97	10.4	201	6.26	7345	382.19
7/2/2004	7:22:01	68.96	12.0	201	6.26	7352	382.19
7/2/2004	7:22:03	68.95	12.5	201	6.26	7360	382.22
7/2/2004	7:22:05	68.96	12.1	201	6.26	7362	382.25
7/2/2004	7:22:07	68.97	5.8	201	6.26	7360	382.25
7/2/2004	7:22:09	68.97	11.0	201	6.26	7359	382.19
7/2/2004	7:22:11	68.96	9.6	201	6.26	7358	382.29
7/2/2004	7:22:13	68.96	8.4	201	6.26	7353	382.22
7/2/2004	7:22:15	68.97	4.7	201	6.26	7345	382.19
7/2/2004	7:22:17	68.96	5.9	201	6.26	7336	382.12
7/2/2004	7:22:20	68.96	3.1	201	6.26	7329	379.70

Table XX
Sediment Sampler Design Project
Tank Laboratory Test
Ponar Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
6/8/2004	10:12:51	66.77	27.3	252	5.44	8619	361.51
6/8/2004	10:12:53	66.80	14.6	252	5.43	8623	363.49
6/8/2004	10:12:55	66.81	15.0	252	5.42	8627	362.36
6/8/2004	10:12:57	66.87	8.5	251	5.40	8614	361.25
6/8/2004	10:12:59	66.90	10.9	250	5.40	8608	361.65
6/8/2004	10:13:01	66.91	23.5	249	5.43	8604	361.20
6/8/2004	10:13:03	66.87	7.6	249	5.47	8613	362.38
6/8/2004	10:13:05	66.81	1.8	249	5.45	8631	361.65
6/8/2004	10:13:08	66.88	13.2	250	5.44	8611	361.48
6/8/2004	10:13:10	66.88	5.0	251	5.43	8610	362.13
6/8/2004	10:13:12	66.91	8.7	251	5.43	8604	362.02
6/8/2004	10:13:14	66.92	39.3	251	5.45	8600	361.56
6/8/2004	10:13:16	66.88	13.8	251	5.45	8614	363.47
6/8/2004	10:13:18	66.88	10.0	251	5.44	8618	362.72
6/8/2004	10:13:20	66.91	7.7	251	5.44	8609	362.38
6/8/2004	10:13:22	66.94	7.6	251	5.43	8605	362.30
6/8/2004	10:13:24	66.95	15.5	250	5.43	8607	362.41
6/8/2004	10:13:27	66.94	12.4	250	5.43	8609	362.47
6/8/2004	10:13:29	66.92	16.7	250	5.44	8619	362.87
6/8/2004	10:13:31	66.88	11.5	250	5.45	8634	364.50
6/8/2004	10:13:33	66.84	4.1	250	5.43	8645	362.58
6/8/2004	10:13:35	66.89	8.1	249	5.42	8635	362.41
6/8/2004	10:13:37	66.91	9.4	251	5.38	8633	362.72
6/8/2004	10:13:39	66.92	5.2	251	5.39	8658	362.67
6/8/2004	10:13:41	66.90	4.7	251	5.43	8658	362.70
6/8/2004	10:13:43	66.92	3.6	251	5.45	8655	363.35
6/8/2004	10:13:46	66.90	4.0	250	5.46	8660	363.27
6/8/2004	10:13:48	66.90	3.4	250	5.45	8663	364.07
6/8/2004	10:13:50	66.92	5.6	249	5.45	8657	363.52
6/8/2004	10:13:52	66.95	14.7	248	5.45	8649	363.55
6/8/2004	10:13:54	66.92	18.0	248	5.43	8653	367.92
6/8/2004	10:13:56	66.85	13.8	247	5.46	8668	371.01
6/8/2004	10:13:58	66.83	19.5	249	5.48	8672	369.18
6/8/2004	10:14:00	66.83	14.6	250	5.54	8668	366.40
6/8/2004	10:14:03	66.82	13.3	251	5.58	8667	365.16
6/8/2004	10:14:05	66.82	10.2	250	5.55	8664	363.61
6/8/2004	10:14:07	66.84	7.1	250	5.46	8654	362.75
6/8/2004	10:14:09	66.87	2.2	250	5.46	8640	363.35
6/8/2004	10:14:11	66.89	3.5	251	5.46	8629	362.64
6/8/2004	10:14:13	66.97	11.9	251	5.45	8603	362.33
6/8/2004	10:14:15	66.98	4.6	251	5.43	8598	362.58
6/8/2004	10:14:17	66.98	5.0	252	5.43	8600	362.47
6/8/2004	10:14:20	66.96	5.0	252	5.42	8602	362.33
6/8/2004	10:14:22	66.96	3.4	251	5.43	8603	362.41
6/8/2004	10:14:24	66.96	10.1	252	5.43	8601	362.44
6/8/2004	10:14:26	66.97	2.9	252	5.42	8601	362.36
6/8/2004	10:14:28	66.98	2.1	252	5.42	8602	362.38
6/8/2004	10:14:30	66.99	2.4	251	5.42	8599	362.41
6/8/2004	10:14:32	66.98	6.5	252	5.42	8602	362.36
6/8/2004	10:14:34	66.99	3.5	252	5.42	8598	362.36
6/8/2004	10:14:36	66.99	3.9	252	5.42	8596	362.36
6/8/2004	10:14:39	67.00	2.5	252	5.41	8594	362.44
6/8/2004	10:14:41	66.99	3.6	252	5.41	8595	362.53
6/8/2004	10:14:43	66.98	7.4	252	5.40	8597	362.55
6/8/2004	10:14:45	66.98	2.5	252	5.40	8595	362.64
6/8/2004	10:14:47	66.99	1.8	253	5.40	8594	362.64
6/8/2004	10:14:49	67.00	6.8	253	5.40	8591	362.58
6/8/2004	10:14:51	66.99	2.2	253	5.40	8595	362.70
6/8/2004	10:14:53	66.98	4.4	253	5.40	8599	362.58
6/8/2004	10:14:55	66.99	4.8	253	5.40	8597	362.58
6/8/2004	10:14:58	66.99	3.6	253	5.40	8602	362.55
6/8/2004	10:15:00	67.00	8.2	253	5.40	8606	362.50
6/8/2004	10:15:02	66.99	5.9	253	5.40	8613	362.58
6/8/2004	10:15:04	66.99	3.8	253	5.41	8614	362.61
6/8/2004	10:15:06	66.99	4.3	253	5.41	8616	362.50
6/8/2004	10:15:08	67.00	1.5	253	5.40	8623	363.32
6/8/2004	10:15:10	67.17	0.5	253	5.40	8585	363.49
6/8/2004	10:15:12	67.23	1.1	253	5.40	8563	363.49
6/8/2004	10:15:15	67.24	0.3	253	5.41	8562	365.19

Table XX (cont.)
Sediment Sampler Design Project
Tank Laboratory Test
Ponar Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
6/11/2004	8:28:18	67.93	1.4	220	6.16	8076	808.61
6/11/2004	8:28:20	67.93	3.2	220	6.15	8060	808.61
6/11/2004	8:28:22	67.93	11.1	220	6.15	8042	808.61
6/11/2004	8:28:24	67.93	4.2	220	6.15	8026	808.47
6/11/2004	8:28:26	67.91	3.2	219	6.15	8016	808.61
6/11/2004	8:28:28	67.92	0.4	219	6.14	7998	808.61
6/11/2004	8:28:30	67.93	2.3	219	6.16	7982	808.75
6/11/2004	8:28:32	67.92	1.9	219	6.16	7976	808.75
6/11/2004	8:28:35	67.93	7.1	219	6.15	7964	808.33
6/11/2004	8:28:37	67.92	3.0	219	6.15	7967	808.47
6/11/2004	8:28:39	67.92	5.6	218	6.14	7963	808.33
6/11/2004	8:28:41	67.92	7.5	219	6.13	7959	808.19
6/11/2004	8:28:43	67.91	4.1	218	6.13	7956	808.47
6/11/2004	8:28:45	67.91	5.2	218	6.14	7959	808.75
6/11/2004	8:28:47	67.91	3.1	218	6.12	7963	808.47
6/11/2004	8:28:49	67.92	3.9	217	6.12	7959	808.75
6/11/2004	8:28:52	67.93	8.0	217	6.11	7955	808.61
6/11/2004	8:28:54	67.93	2.3	217	6.11	7954	808.61
6/11/2004	8:28:56	67.92	5.6	217	6.11	7956	808.47
6/11/2004	8:28:58	67.93	5.1	217	6.11	7953	808.61
6/11/2004	8:29:00	67.93	2.1	217	6.10	7957	808.61
6/11/2004	8:29:02	67.94	2.1	217	6.09	7957	808.61
6/11/2004	8:29:04	67.95	3.8	217	6.10	7958	808.61
6/11/2004	8:29:06	67.94	1.3	217	6.10	7962	808.61
6/11/2004	8:29:08	67.95	1.8	217	6.10	7960	808.75
6/11/2004	8:29:11	67.95	1.3	217	6.09	7964	808.61
6/11/2004	8:29:13	67.95	4.7	216	6.10	7964	808.75
6/11/2004	8:29:15	67.95	1.6	216	6.11	7967	808.61
6/11/2004	8:29:17	67.94	2.3	216	6.10	7967	808.61
6/11/2004	8:29:19	67.95	3.2	215	6.12	7969	808.61
6/11/2004	8:29:21	67.95	3.5	215	6.11	7970	808.61
6/11/2004	8:29:23	67.95	6.4	216	6.09	7969	808.75
6/11/2004	8:29:25	67.95	1.9	216	6.09	7969	808.61
6/11/2004	8:29:28	67.95	4.0	216	6.09	7971	808.75
6/11/2004	8:29:30	67.95	3.0	215	6.09	7977	808.61
6/11/2004	8:29:32	67.95	3.4	215	6.09	7977	808.61
6/11/2004	8:29:34	67.95	1.6	215	6.10	7985	808.75
6/11/2004	8:29:36	67.95	1.9	215	6.10	7987	808.61
6/11/2004	8:29:38	67.96	6.0	216	6.06	7989	808.61
6/11/2004	8:29:40	67.96	2.7	216	6.03	7991	808.61
6/11/2004	8:29:42	67.96	4.2	215	6.03	7991	808.61
6/11/2004	8:29:44	67.96	2.4	215	6.03	7990	808.61
6/11/2004	8:29:47	67.96	1.1	215	6.02	7989	808.75
6/11/2004	8:29:49	67.97	2.2	215	6.02	7988	808.75
6/11/2004	8:29:51	67.96	1.9	215	6.02	7989	808.61
6/11/2004	8:29:53	67.96	7.4	215	6.02	7989	808.75
6/11/2004	8:29:55	67.96	4.1	215	6.02	7991	808.75
6/11/2004	8:29:57	67.97	5.6	214	6.02	7985	809.02
6/11/2004	8:29:59	67.96	2.5	214	6.02	7988	808.61
6/11/2004	8:30:01	67.95	2.4	214	6.02	7993	808.75
6/11/2004	8:30:04	67.95	5.2	214	6.02	7999	808.61
6/11/2004	8:30:06	67.95	3.6	214	6.02	8002	808.75
6/11/2004	8:30:08	67.96	1.4	214	6.02	8007	808.88
6/15/2004	11:46:36	67.41	11.8	199	6.49	7687	941.31
6/15/2004	11:46:39	67.38	0.3	199	6.50	7692	941.12
6/15/2004	11:46:41	67.43	3.5	199	6.50	7673	941.31
6/15/2004	11:46:43	67.47	5.2	199	6.49	7660	941.31
6/15/2004	11:46:45	67.45	7.6	199	6.49	7660	941.50
6/15/2004	11:46:47	67.45	6.0	199	6.49	7672	941.88
6/15/2004	11:46:49	67.45	3.4	199	6.49	7686	941.69
6/15/2004	11:46:51	67.44	4.4	199	6.49	7710	941.69
6/15/2004	11:46:53	67.45	6.3	199	6.49	7736	942.07
6/15/2004	11:46:55	67.45	6.1	199	6.49	7764	941.88
6/15/2004	11:46:58	67.45	9.2	199	6.49	7792	942.07
6/15/2004	11:47:00	67.45	5.6	199	6.49	7818	942.07
6/15/2004	11:47:02	67.45	9.3	199	6.49	7846	942.26
6/15/2004	11:47:04	67.45	6.4	199	6.49	7873	942.26
6/15/2004	11:47:06	67.46	9.2	199	6.49	7897	942.07
6/15/2004	11:47:08	67.46	9.4	199	6.49	7916	941.88

Table XX (cont.)
Sediment Sampler Design Project
Tank Laboratory Test
Ponar Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
6/15/2004	11:47:10	67.46	10.6	199	6.49	7934	941.88
6/15/2004	11:47:12	67.47	10.7	199	6.49	7948	941.88
6/15/2004	11:47:14	67.47	10.3	199	6.49	7957	942.07
6/15/2004	11:47:17	67.47	10.4	199	6.49	7963	942.07
6/15/2004	11:47:19	67.46	9.1	199	6.49	7973	942.07
6/15/2004	11:47:21	67.47	8.9	199	6.49	7969	942.26
6/15/2004	11:47:23	67.46	6.3	199	6.49	7968	942.07
6/15/2004	11:47:25	67.47	5.3	199	6.49	7962	942.07
6/15/2004	11:47:27	67.46	5.9	199	6.49	7957	942.07
6/15/2004	11:47:29	67.46	5.3	199	6.48	7947	942.07
6/15/2004	11:47:31	67.46	4.9	199	6.49	7941	942.07
6/15/2004	11:47:34	67.47	4.3	199	6.49	7925	942.07
6/15/2004	11:47:36	67.47	20.9	199	6.49	7913	942.07
6/15/2004	11:47:38	67.47	14.0	199	6.49	7903	942.07
6/15/2004	11:47:40	67.46	10.2	199	6.49	7891	942.26
6/15/2004	11:47:42	67.47	9.2	199	6.49	7876	942.26
6/15/2004	11:47:44	67.48	6.8	199	6.49	7861	942.07
6/15/2004	11:47:46	67.47	8.8	199	6.49	7849	942.26
6/15/2004	11:47:48	67.47	9.2	199	6.49	7832	942.07
6/15/2004	11:47:50	67.47	9.1	199	6.49	7818	942.26
6/15/2004	11:47:53	67.47	9.8	199	6.49	7800	942.26
6/15/2004	11:47:55	67.47	5.1	199	6.49	7786	942.26
6/15/2004	11:47:57	67.47	4.3	199	6.49	7768	942.26
6/15/2004	11:47:59	67.47	3.6	199	6.49	7750	942.26
6/15/2004	11:48:01	67.47	3.3	199	6.49	7731	942.26
6/15/2004	11:48:03	67.47	4.1	199	6.49	7715	942.07
6/15/2004	11:48:05	67.46	5.2	199	6.49	7701	942.26
6/15/2004	11:48:07	67.47	19.6	199	6.49	7681	942.07

Table XX
Sediment Sampler Design Project
Laboratory Tank Test
USS Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
7/6/2004	16:05:27	69.49	0.1	147	6.13	6245	416.90
7/6/2004	16:05:29	69.53	1.9	147	6.13	6253	416.90
7/6/2004	16:05:31	69.56	7.7	147	6.14	6262	416.94
7/6/2004	16:05:33	69.55	5.3	147	6.14	6268	417.10
7/6/2004	16:05:35	69.57	5.4	147	6.14	6280	417.18
7/6/2004	16:05:37	69.58	1.0	147	6.14	6280	417.06
7/7/2004	7:31:29	70.41	0.4	208	5.60	6801	441.65
7/7/2004	7:31:31	70.40	0.9	208	5.60	6804	441.69
7/7/2004	7:31:33	70.39	1.2	208	5.60	6808	441.65
7/7/2004	7:31:35	70.40	1.5	208	5.60	6809	441.69
7/7/2004	7:31:37	70.39	3.5	208	5.59	6808	441.69
7/7/2004	7:31:39	70.39	20.2	208	5.59	6809	441.69
7/7/2004	7:31:42	70.39	11.5	208	5.59	6806	441.69
7/7/2004	7:31:44	70.38	15.1	208	5.59	6803	441.69
7/7/2004	7:31:46	70.39	27.9	208	5.58	6801	441.74
7/7/2004	7:31:48	70.39	15.4	208	5.58	6800	441.69
7/7/2004	7:31:50	70.39	33.3	208	5.58	6795	441.74
7/7/2004	7:31:52	70.39	40.6	208	5.58	6798	441.69
7/7/2004	7:31:54	70.38	43.0	208	5.58	6802	441.74
7/7/2004	7:31:56	70.39	7.7	208	5.58	6802	441.74
7/7/2004	7:31:59	70.38	9.6	208	5.58	6810	441.78
7/7/2004	7:32:01	70.38	15.1	208	5.57	6813	441.74
7/7/2004	7:32:03	70.38	15.7	208	5.57	6818	441.78
7/7/2004	7:32:05	70.37	15.1	208	5.57	6824	441.74
7/7/2004	7:32:07	70.37	19.6	208	5.57	6830	441.74
7/7/2004	7:32:09	70.38	19.9	208	5.57	6839	441.74
7/7/2004	7:32:11	70.37	8.5	208	5.57	6853	441.78
7/7/2004	7:32:13	70.37	9.6	208	5.57	6863	441.74
7/7/2004	7:32:15	70.36	18.3	208	5.57	6875	441.83
7/7/2004	7:32:18	70.36	19.2	208	5.57	6887	441.83
7/7/2004	7:32:20	70.34	16.4	208	5.57	6896	441.92
7/7/2004	7:32:22	70.35	14.9	208	5.57	6907	441.87
7/7/2004	7:32:24	70.34	18.1	208	5.58	6910	441.92
7/7/2004	7:32:26	70.34	25.7	208	5.58	6919	441.96
7/7/2004	7:32:28	70.34	21.9	208	5.58	6923	442.06
7/7/2004	7:32:30	70.32	21.1	207	5.58	6933	442.06
7/7/2004	7:32:32	70.34	15.6	207	5.58	6932	442.15
7/7/2004	7:32:35	70.33	14.4	208	5.58	6938	442.28
7/7/2004	7:32:37	70.34	9.3	207	5.58	6939	442.42
7/7/2004	7:32:39	70.32	7.2	207	5.58	6944	442.51
7/7/2004	7:32:41	70.34	11.6	207	5.58	6943	442.60
7/7/2004	7:32:43	70.34	15.3	207	5.58	6940	442.73
7/7/2004	7:32:45	70.34	17.4	207	5.58	6940	442.69
7/7/2004	7:32:47	70.35	21.4	207	5.58	6934	442.78
7/7/2004	7:32:49	70.35	19.7	207	5.58	6929	443.00
7/7/2004	7:32:51	70.35	14.9	207	5.58	6926	443.10
7/7/2004	7:32:54	70.35	13.5	207	5.58	6918	443.19
7/7/2004	7:32:56	70.35	10.1	207	5.58	6910	443.23
7/7/2004	7:32:58	70.37	8.1	207	5.58	6900	443.28
7/7/2004	7:33:00	70.35	5.0	207	5.58	6892	443.32
7/7/2004	7:33:02	70.36	1.4	207	5.58	6879	443.41
7/7/2004	7:33:04	70.36	2.0	207	5.58	6869	443.46
7/7/2004	7:33:06	70.37	1.3	207	5.58	6857	443.50
7/7/2004	7:33:08	70.37	1.2	207	5.58	6845	443.55
7/7/2004	7:33:11	70.38	0.8	208	5.58	6830	443.55
7/7/2004	7:33:13	70.37	0.7	208	5.58	6819	443.60
7/7/2004	7:33:15	70.38	1.0	207	5.58	6807	443.64
7/7/2004	7:33:17	70.39	1.4	207	5.58	6794	443.69
7/7/2004	7:33:19	70.38	1.8	207	5.58	6782	443.73
7/7/2004	7:33:21	70.39	3.6	207	5.58	6771	443.82
7/7/2004	7:33:23	70.40	5.1	207	5.58	6755	443.87
7/7/2004	7:33:25	70.39	5.7	207	5.58	6745	443.91
7/7/2004	7:33:27	70.40	5.2	207	5.58	6735	444.00
7/7/2004	7:33:30	70.40	5.6	207	5.58	6723	444.05
7/7/2004	7:33:32	70.40	6.0	207	5.58	6715	444.05
7/7/2004	7:33:34	70.40	5.5	207	5.58	6707	444.05
7/7/2004	7:33:36	70.41	5.4	208	5.58	6699	444.00
7/7/2004	7:33:38	70.40	5.3	207	5.58	6693	443.96
7/7/2004	7:33:40	70.40	5.6	207	5.58	6687	443.91

Table XX (cont.)
Sediment Sampler Design Project
Laboratory Tank
USS Sampler

Date	Time	Temperature (ºF)	Turbidity (NTU)	ORP (mV)	pH	Dissolved Oxygen (µg/L)	Conductivity µS/cm
7/7/2004	7:33:42	70.41	6.3	207	5.58	6681	443.87
7/7/2004	7:33:44	70.41	6.7	207	5.58	6677	443.78
7/7/2004	7:33:47	70.41	5.9	207	5.58	6672	443.69
7/7/2004	7:33:49	70.40	5.8	207	5.58	6669	443.60
7/7/2004	7:33:51	70.41	6.3	207	5.58	6663	443.55
7/7/2004	7:33:53	70.40	6.2	207	5.58	6662	443.46
7/7/2004	7:33:55	70.42	6.2	207	5.58	6655	443.41
7/7/2004	7:33:57	70.41	6.8	207	5.58	6653	443.37
7/7/2004	7:33:59	70.42	6.1	207	5.58	6649	443.28
7/7/2004	7:34:01	70.41	5.7	207	5.58	6647	443.23
7/7/2004	7:34:03	70.41	5.6	207	5.58	6643	443.23
7/7/2004	7:34:06	70.41	5.8	207	5.58	6643	443.19
7/7/2004	7:34:08	70.41	6.3	207	5.58	6640	443.19
7/7/2004	7:34:10	70.41	4.9	207	5.58	6639	443.14
7/7/2004	7:34:12	70.41	3.7	207	5.58	6634	443.10
7/7/2004	7:34:14	70.40	2.7	207	5.58	6633	443.10
7/7/2004	7:34:16	70.40	2.7	207	5.58	6629	443.14
7/7/2004	7:34:18	70.40	3.4	207	5.58	6624	443.14
7/7/2004	7:34:20	70.40	1.9	207	5.58	6619	443.14
7/7/2004	7:34:23	70.40	0.7	207	5.58	6616	443.14
7/7/2004	7:34:25	70.41	0.3	207	5.58	6608	443.14
7/7/2004	7:34:27	70.40	0.0	207	5.58	6603	443.14
7/7/2004	18:52:39	70.67	0.1	256	4.77	6997	464.88
7/7/2004	18:52:41	70.67	0.3	255	4.80	6996	464.93
7/7/2004	18:52:44	70.68	0.2	255	4.80	6993	464.88
7/7/2004	18:52:46	70.68	0.1	255	4.79	6996	465.03
7/7/2004	18:52:48	70.68	1.4	255	4.79	6987	464.93
7/7/2004	18:52:50	70.67	2.8	255	4.79	6997	464.98
7/7/2004	18:52:52	70.68	1.9	255	4.81	6975	464.83
7/7/2004	18:52:54	70.67	0.6	255	4.81	6974	464.93
7/7/2004	18:52:56	70.67	0.7	255	4.80	6985	464.98
7/7/2004	18:52:58	70.68	1.3	255	4.81	6966	464.78
7/7/2004	18:53:00	70.68	0.6	255	4.81	6972	464.78
7/7/2004	18:53:03	70.67	0.9	254	4.82	6973	465.03
7/7/2004	18:53:05	70.68	0.4	255	4.80	6964	465.03
7/7/2004	18:53:07	70.68	0.9	255	4.82	6959	465.08
7/7/2004	18:53:09	70.66	0.6	255	4.82	6964	465.08
7/7/2004	18:53:11	70.66	1.0	255	4.82	6958	465.03
7/7/2004	18:53:13	70.66	2.6	255	4.83	6963	465.03
7/7/2004	18:53:15	70.63	1.2	255	4.82	6961	465.08
7/7/2004	18:53:17	70.66	0.8	255	4.79	6959	465.08
7/8/2004	10:10:02	70.14	1.2	218	5.93	8213	586.32
7/8/2004	10:10:05	70.13	1.3	218	5.93	8224	586.32
7/8/2004	10:10:07	70.13	2.2	218	5.93	8213	586.32
7/8/2004	10:10:09	70.13	1.0	218	5.93	8220	586.32
7/8/2004	10:10:11	70.13	3.9	218	5.93	8220	586.40
7/8/2004	10:10:13	70.12	3.1	217	5.93	8219	586.40
7/8/2004	10:10:15	70.13	1.0	217	5.93	8229	586.40
7/8/2004	10:10:17	70.13	2.1	218	5.93	8227	586.40
7/8/2004	10:10:19	70.13	0.9	217	5.93	8224	586.40
7/8/2004	10:10:22	70.12	2.0	217	5.94	8221	586.32
7/8/2004	10:10:24	70.12	1.2	217	5.93	8219	586.32
7/9/2004	7:54:15	63.12	0.1	224	6.61	7420	244.90
7/9/2004	7:54:17	63.12	0.0	224	6.61	7421	244.95
7/9/2004	7:54:19	63.12	0.2	224	6.61	7419	244.97
7/9/2004	7:54:21	63.12	0.2	224	6.61	7420	244.99
7/9/2004	7:54:23	63.12	0.3	224	6.61	7417	244.86
7/9/2004	7:54:26	63.11	0.7	224	6.62	7420	244.49
7/9/2004	7:54:28	63.11	0.6	224	6.62	7418	244.54
7/9/2004	7:54:30	63.11	0.5	224	6.62	7414	244.81
7/9/2004	7:54:32	63.11	0.6	224	6.62	7415	244.79
7/9/2004	7:54:34	63.11	1.3	224	6.62	7414	244.55
7/9/2004	7:54:36	63.11	0.3	224	6.62	7416	244.59
7/9/2004	7:54:38	63.11	6.7	224	6.62	7419	244.81
7/9/2004	7:54:40	63.11	0.7	225	6.62	7426	244.86
7/9/2004	7:54:43	63.12	1.0	225	6.62	7430	245.26
7/9/2004	7:54:45	63.12	0.2	225	6.62	7436	245.59
7/9/2004	7:54:47	63.11	0.2	225	6.62	7445	245.37
7/9/2004	7:54:49	63.11	0.4	225	6.62	7448	245.44
7/9/2004	7:54:51	63.11	0.3	225	6.62	7459	245.85

APPENDIX D

FIELD DEMONSTRATION TESTING DATA

Sediment Sample TOC Results

Sample ID	Depth (cm)	TOC	Units	Date Collected	Easting	Northing	GPS Comment
SL-USS-01	0-3	17,000	mg/kg	09/08/04	799843.055	4724836.014	sediment 01
SL-USS-01	3-6	21,000	mg/kg	09/08/04			
SL-USS-01	6-9	22,000	mg/kg	09/08/04			
SL-PONAR-01	0-3	8,600	mg/kg	09/08/04			
SL-USS-02	0-3	18,000	mg/kg	09/08/04			
SL-USS-02	3-6	19,000	mg/kg	09/08/04			
SL-USS-02	6-9	20,000	mg/kg	09/08/04			
SL-PONAR-02	0-3	16,000	mg/kg	09/08/04			
SL-USS-03	0-3	14,000	mg/kg	09/08/04	799850.704	4724839.324	sediment 03
SL-USS-03	3-6	20,000	mg/kg	09/09/04			
SL-USS-03	6-9	21,000	mg/kg	09/09/04			
SL-PONAR-03	0-3	21,000	mg/kg	09/09/04			
SL-USS-04	0-3	15,000	mg/kg	09/09/04	799854.879	4724837.507	sediment 04
SL-USS-04	3-6	19,000	mg/kg	09/09/04			
SL-USS-04	6-9	20,000	mg/kg	09/09/04			
SL-PONAR-04	0-3	14,000	mg/kg	09/09/04			
SL-USS-05	0-3	15,000	mg/kg	09/09/04	799850.295	4724837.599	sediment 05
SL-USS-05	3-6	22,000	mg/kg	09/09/04			
SL-USS-05	6-9	22,000	mg/kg	09/09/04			
SL-PONAR-05	0-3	16,000	mg/kg	09/09/04			
SL-USS-06	0-3	22,000	mg/kg	09/09/04	800186.485	4725696.400	sediment 06
SL-PONAR-06	0-3	21,000	mg/kg	09/09/04			
SL-USS-07	0-3	21,000	mg/kg	09/09/04	800185.426	4725717.470	sediment 07
SL-PONAR-07	0-3	21,000	mg/kg	09/09/04			
SL-USS-08	0-3	22,000	mg/kg	09/09/04	800181.725	4725716.986	sediment 08
SL-PONAR-08	0-3	21,000	mg/kg	09/09/04			
SL-USS-09	0-3	20,000	mg/kg	09/09/04	800181.145	4725716.293	sediment 09
SL-PONAR-09	0-3	21,000	mg/kg	09/09/04			
SL-USS-10	0-3	20,000	mg/kg	09/09/04	800189.242	4725724.308	sediment 10
SL-PONAR-10	0-3	21,000	mg/kg	09/09/04			

3380 Chastain Meadows Parkway
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770.499.7500
Fax 770.499.7511

Clayton®
GROUP SERVICES

September 22, 2004

Ms. Julie Capri
TETRA TECH
200 E. Randolph Dr.
Chicago, IL 60601

Client Reference:	USS FIELD TESTING
Clayton Reference:	A0409065

Dear Ms. Capri:

Attached is our analytical laboratory report for the sample received on Sept. 13, 2004 enclosed is a copy of the chain-of-custody record to acknowledge receipt of these samples. The results apply only to the samples analyzed in this project.

Please note that any unused portion of the samples will be discarded on Oct. 13, 2004 unless you have requested otherwise.

We appreciate the opportunity to assist you. If you have any questions concerning this report, please contact me at (770) 499-7500.

Sincerely,

for Alan M. Segrave, P.G.
Director, Laboratory Services
Atlanta Regional Office

AMS/ams
Attachments

PARTICLE SIZING
FOR
TETRA TECH

Clayton GROUP SERVICES

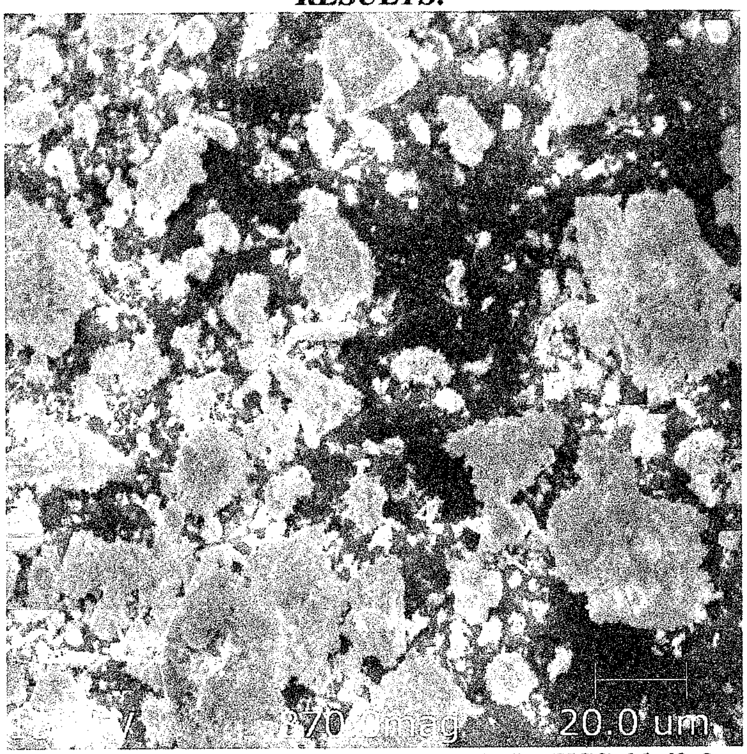
SUMMARY:

The objective of this study was to determine the particle size of soil samples. The samples were received on Sept. 13, 2004. Scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and an IXRF digital image system were utilized to examine the sample.

PREPARATION AND ANALYSIS:

The samples were first dried in an oven then sieved using a 2 mm and 100 µm sieve. Each fraction was weighted and the fine fraction was examined by SEM to determine the particle size of that fraction. The fine fraction was mounted on an aluminum stub with carbon tape. An ISI DS-130 SEM examined the particles and sizing was preformed using an attached IXRF digital imaging system calibrated with magnification standards.

RESULTS:

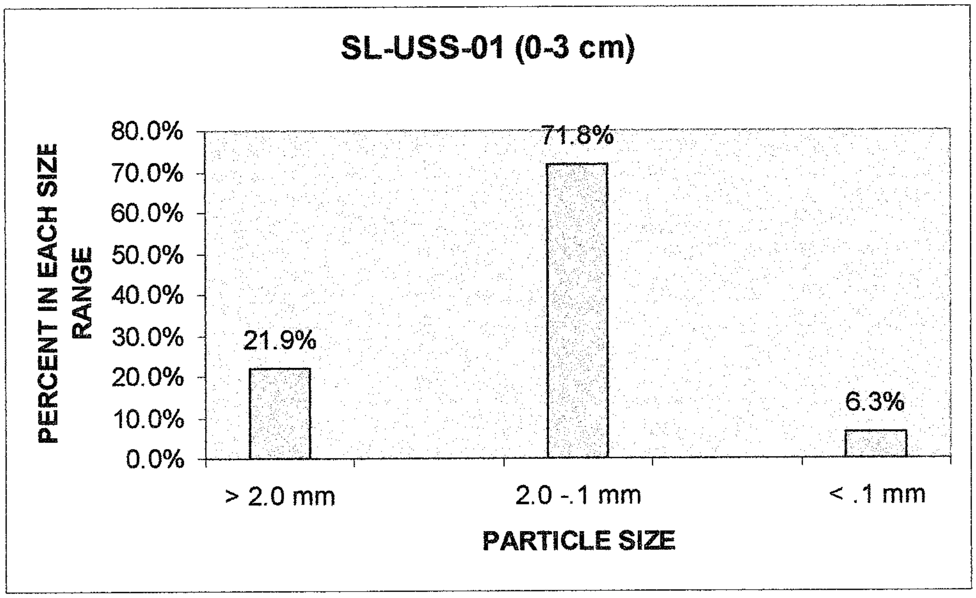


PHOTOMICROGRAPH OF SAMPLE SL-USS-01 (0-3 cm) AT 870X

Results for the sieve analysis for SL-USS-01 (0-3 cm) is as follows:

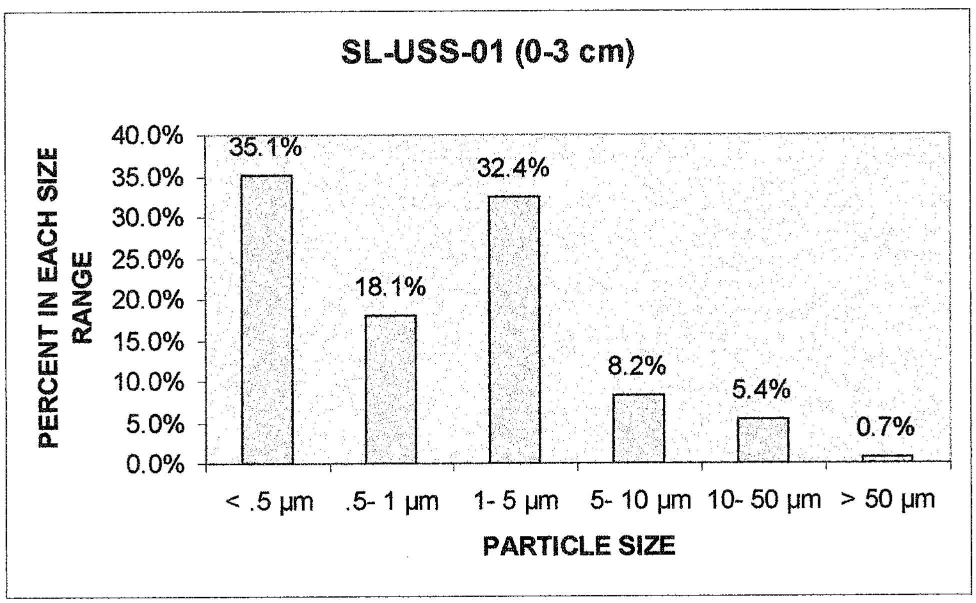
> 2 mm	21.9%
2 mm- 100 µm	71.8%
< 100 µm	6.3%

PARTICLE SIZING FOR TETRA TECH

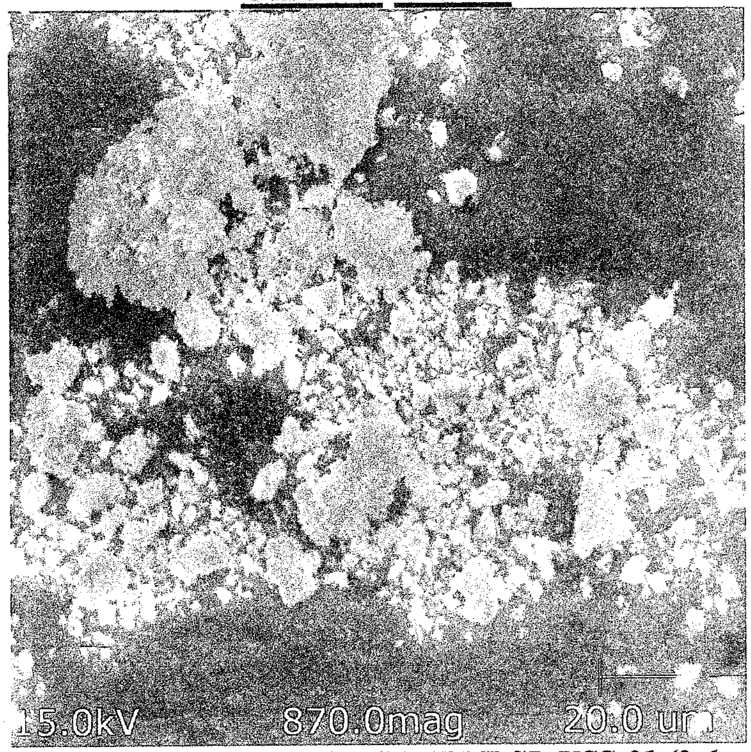


Results of the SEM particle size for SL-USS-01 (0-3 cm) is as follows:

< .5 µm	35.1%
.5- 1 µm	18.1%
1- 5 µm	32.4%
5- 10 µm	8.2%
10- 50 µm	5.4%
> 50 µm	0.7%



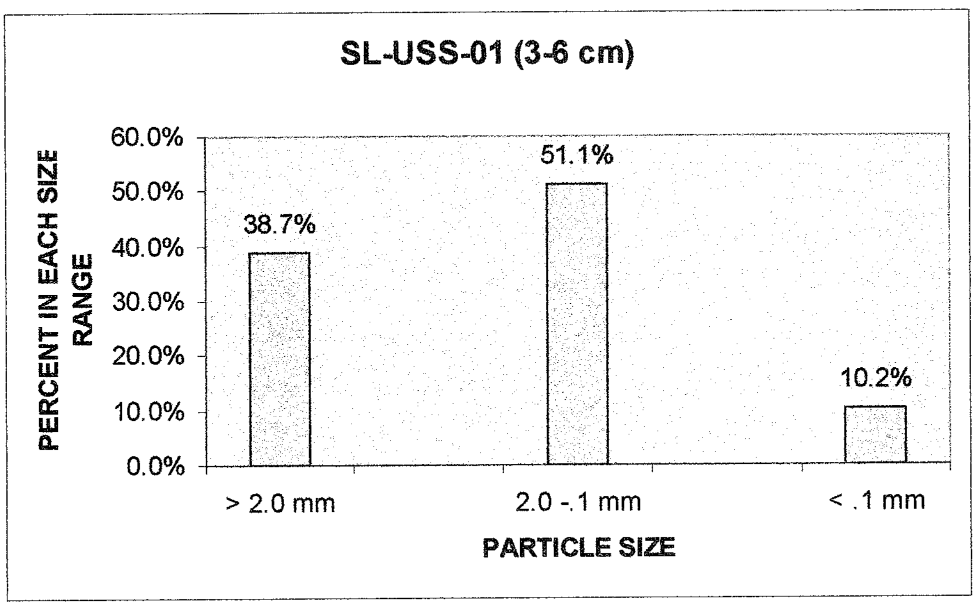
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-01 (3-6 cm) AT 870X

Results of the sieve analysis for SL-USS-01 (3-6 cm) is as follows:

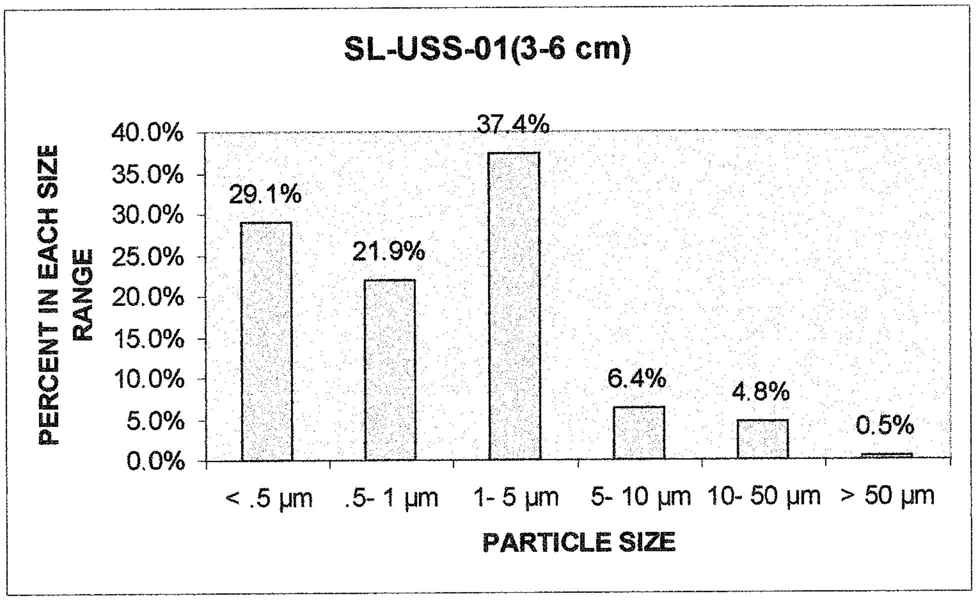
> 2 mm	38.7%
2 mm- 100 µm	51.1%
< 100 µm	10.2%



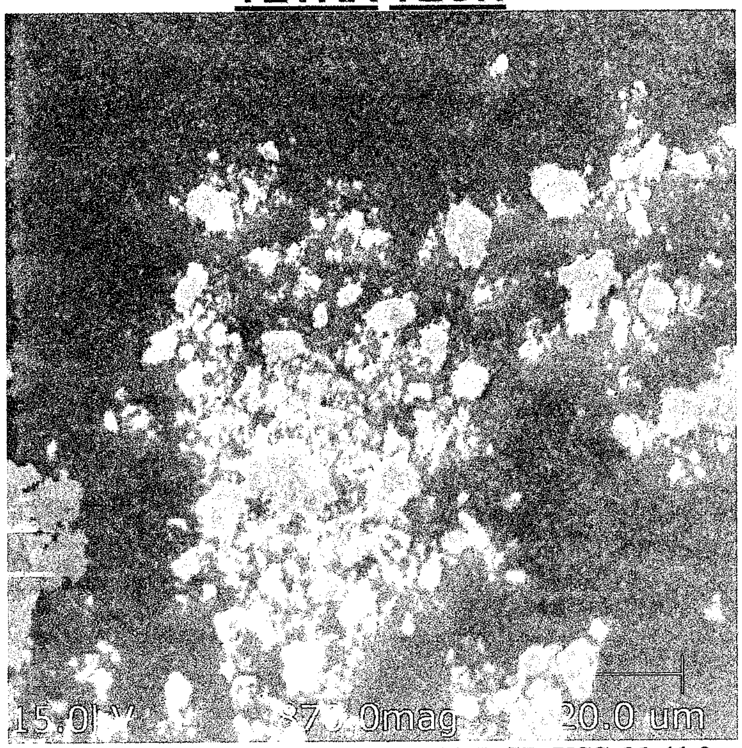
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size for SL-USS-01 (3-6 cm) is as follows:

< .5 µm	29.1%
.5- 1 µm	21.9%
1- 5 µm	37.4%
5- 10 µm	6.4%
10- 50 µm	4.8%
> 50 µm	0.5%



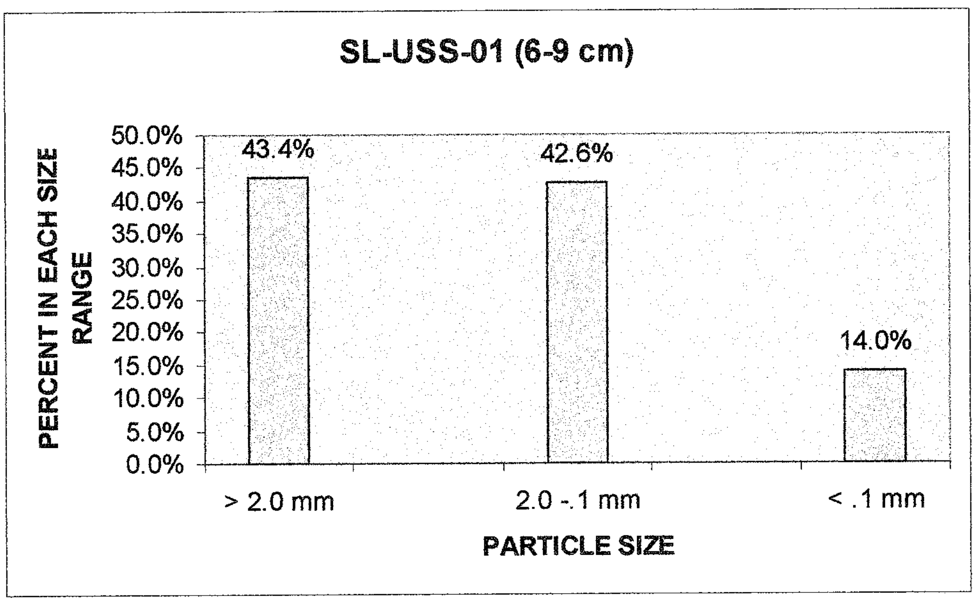
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-01 (6-9 cm) AT 870X

Results of the sieve analysis for SL-USS-01 (6-9 cm) is as follows:

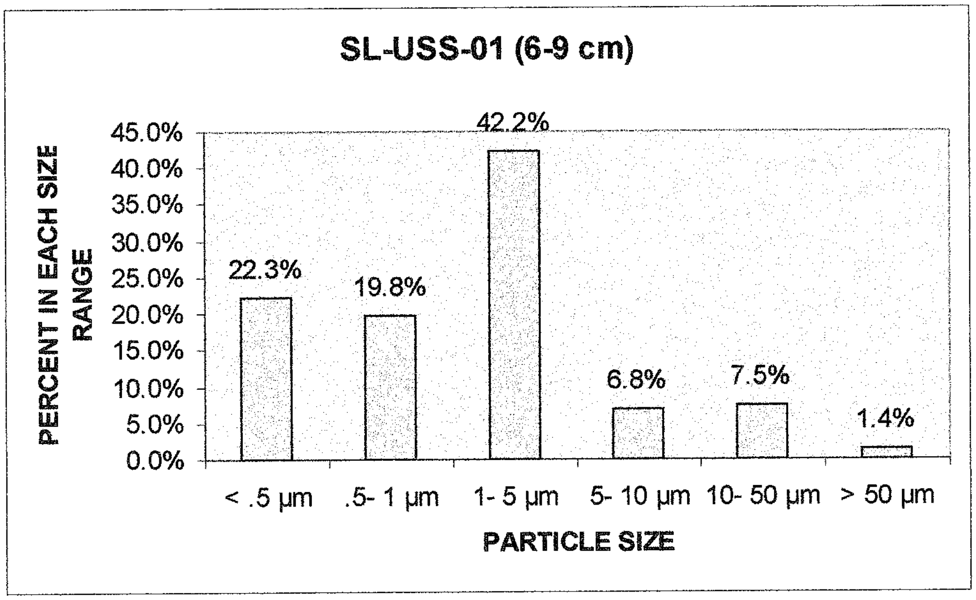
> 2 mm	43.4%
2 mm- 100 µm	42.6%
< 100 µm	14.0%



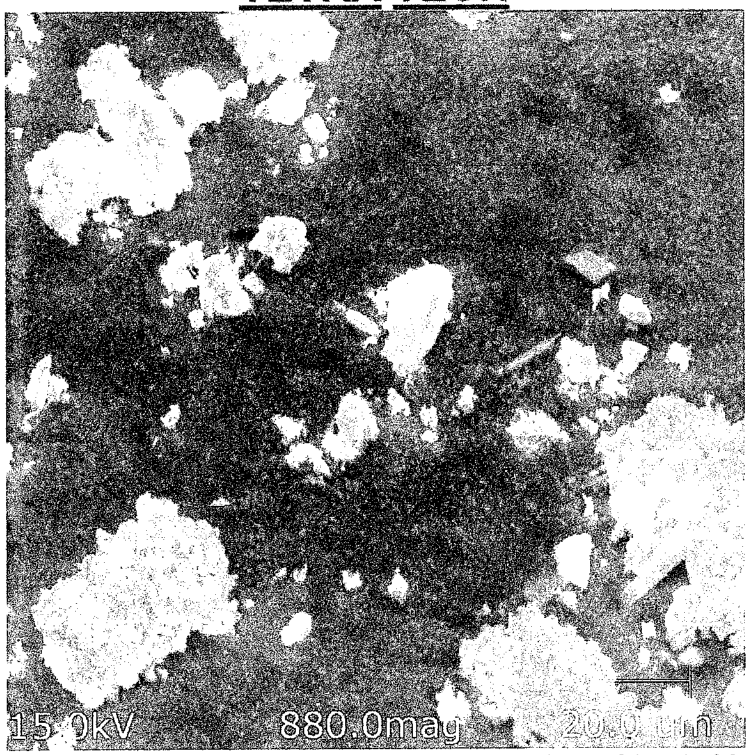
PARTICLE SIZING
FOR
TETRA TECH

Results of the SEM particle size analysis for SL-USS-01 (6-9 cm) is as follows:

< .5 µm	22.3%
.5- 1 µm	19.8%
1- 5 µm	42.2%
5- 10 µm	6.8%
10- 50 µm	7.5%
> 50 µm	1.4%



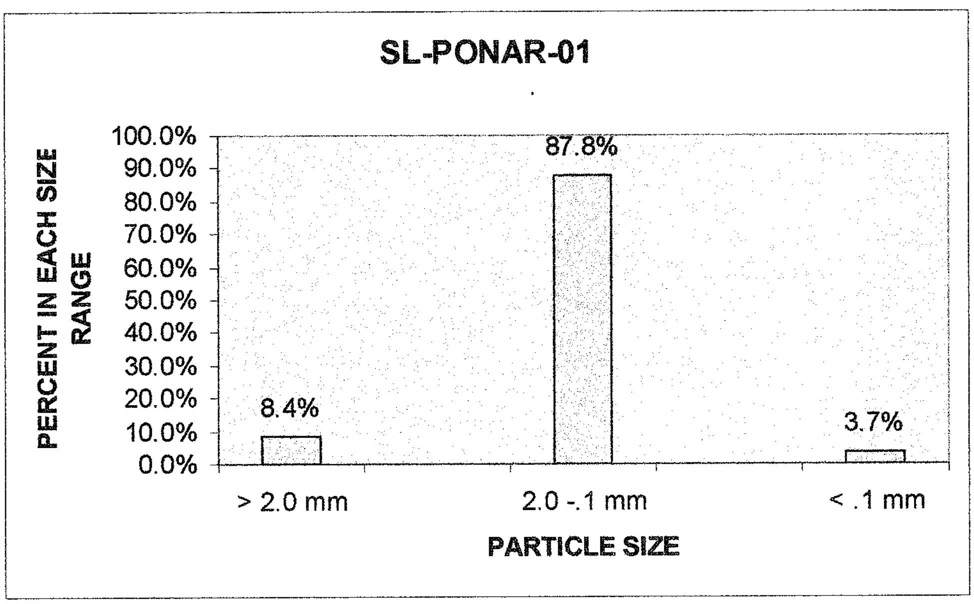
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-PONAR-01
AT 880X

Results of the sieve analysis for sample SL-PONAR-01 is as follows:

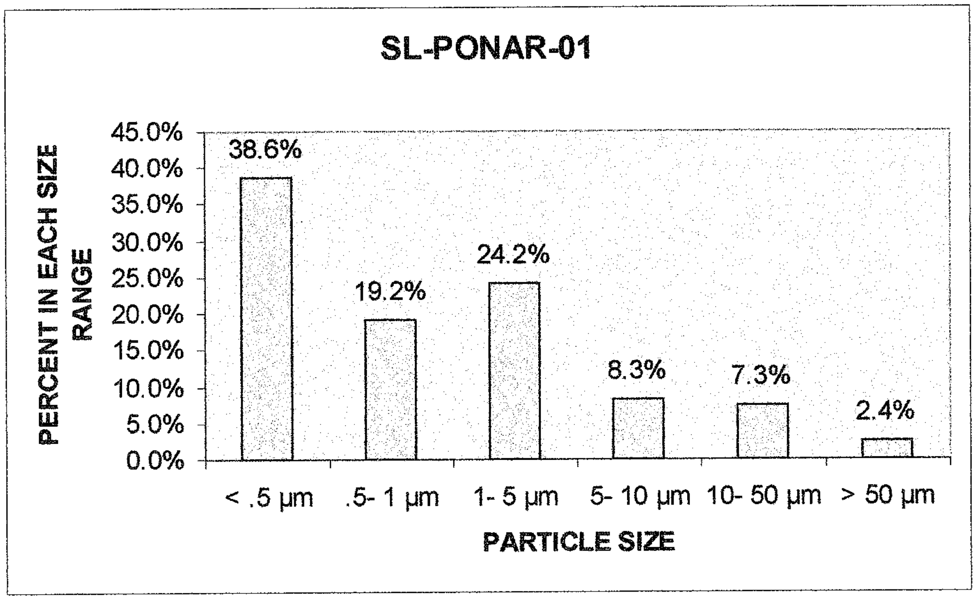
> 2 mm	8.4%
2 mm- 100 µm	87.8%
< 100 µm	3.7%



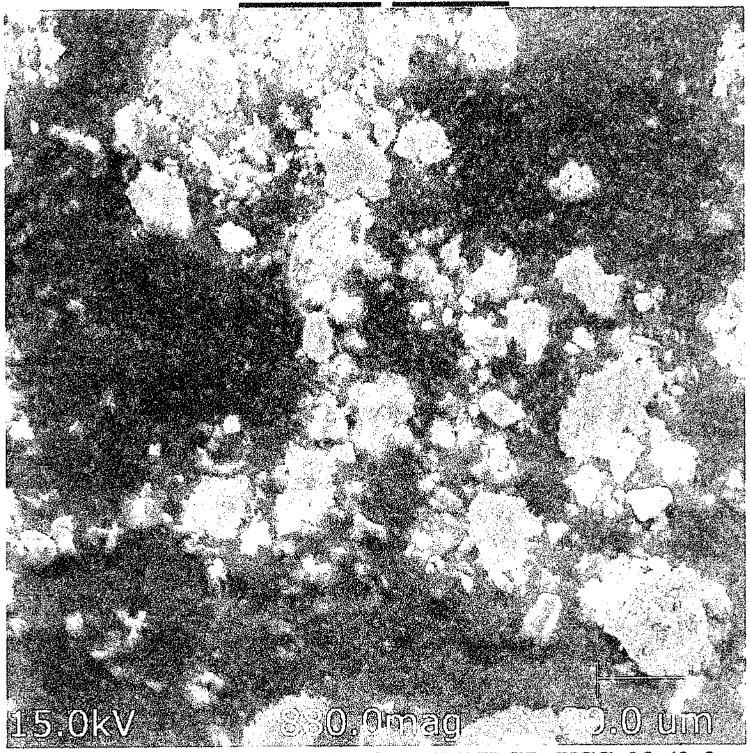
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-01 is as follows:

< .5 µm	38.6%
.5- 1 µm	19.2%
1- 5 µm	24.2%
5- 10 µm	8.3%
10- 50 µm	7.3%
> 50 µm	2.4%



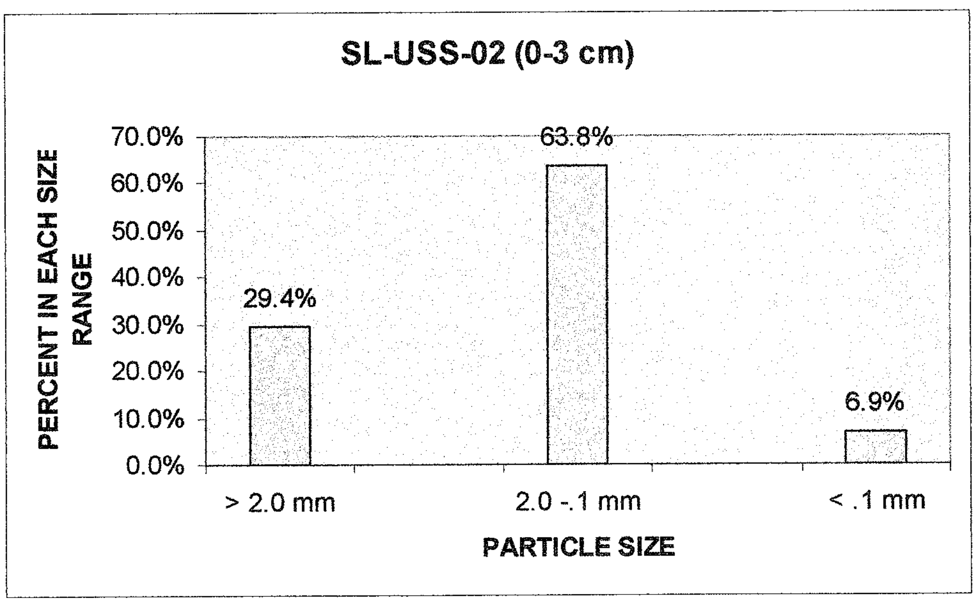
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-02 (0-3 cm)
AT 880X

Results of the sieve analysis for sample SL-USS-02 (0-3 cm) is as follows:

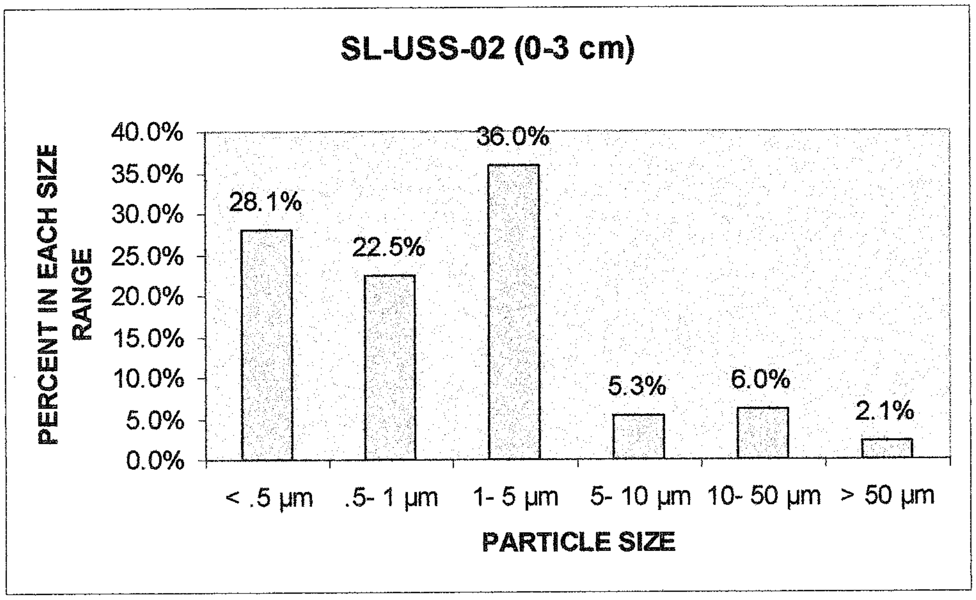
> 2 mm	29.4%
2 mm- 100 µm	63.8%
< 100 µm	6.9%



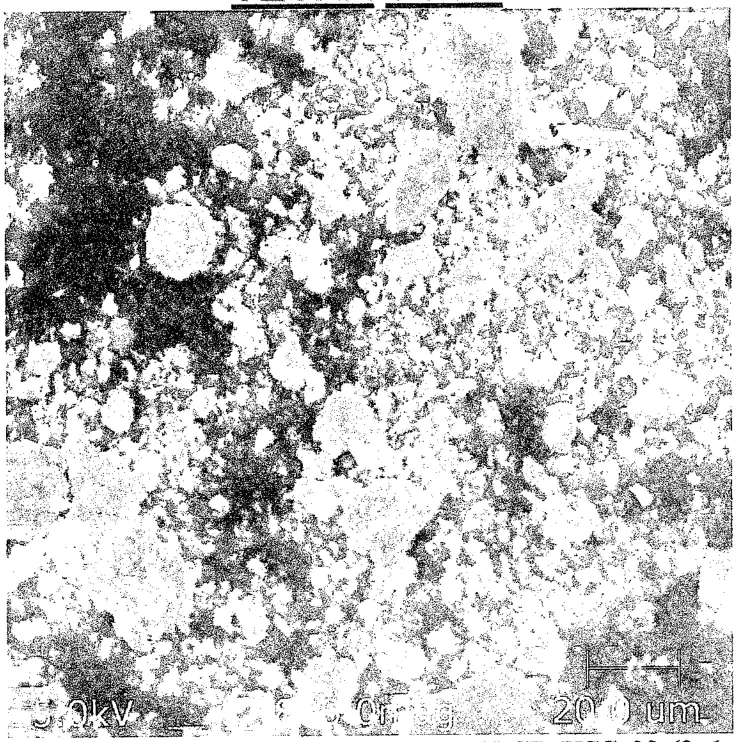
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-02 (0-3 cm) is as follows:

< .5 µm	28.1%
.5- 1 µm	22.5%
1- 5 µm	36.0%
5- 10 µm	5.3%
10- 50 µm	6.0%
> 50 µm	2.1%



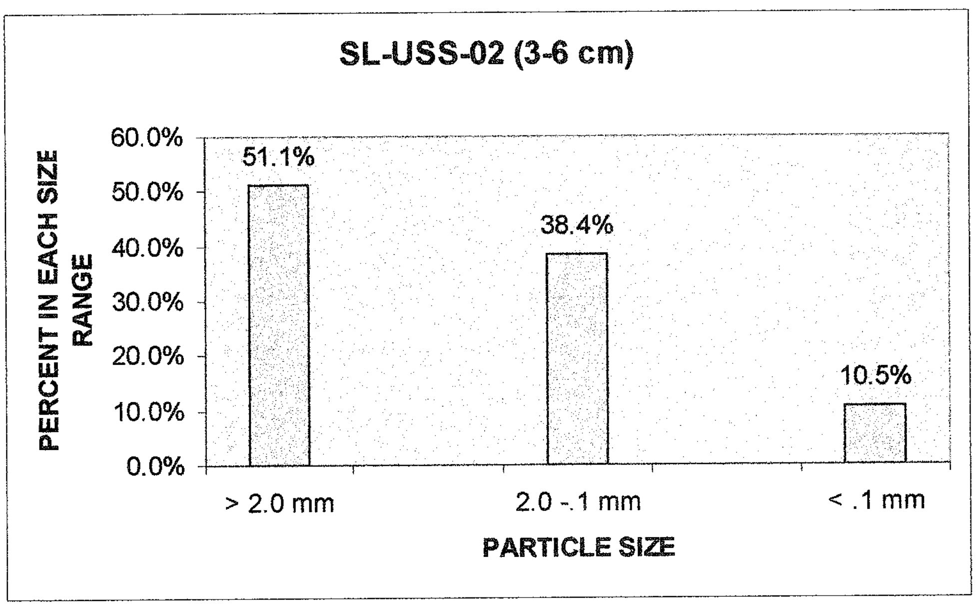
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-USS-02 (3-6 cm)
AT 880X

Results for sieve analysis for SL-USS-02 (3-6 cm) is as follows:

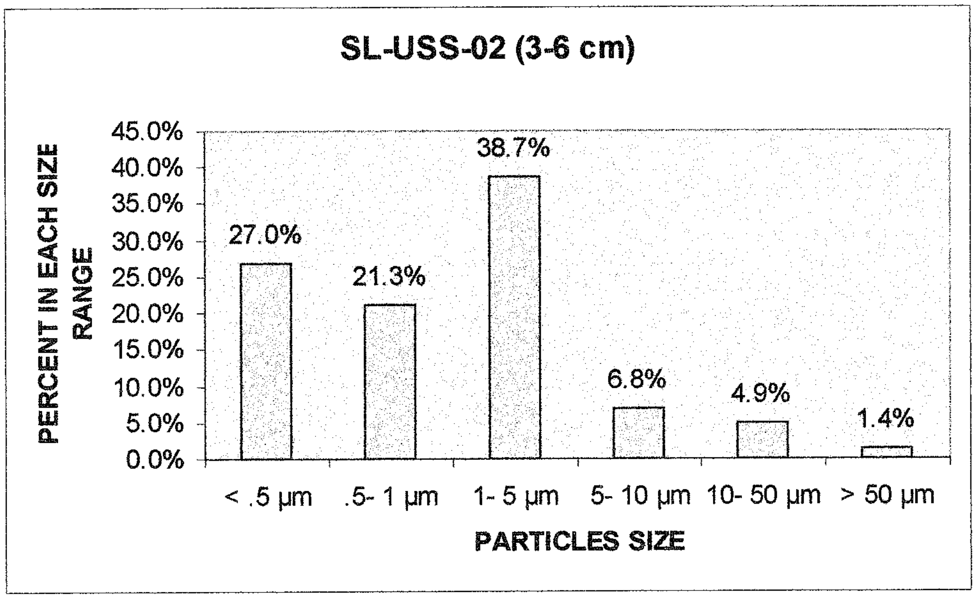
> 2 mm	51.1%
2 mm- 100 µm	38.4%
< 100 µm	10.5%



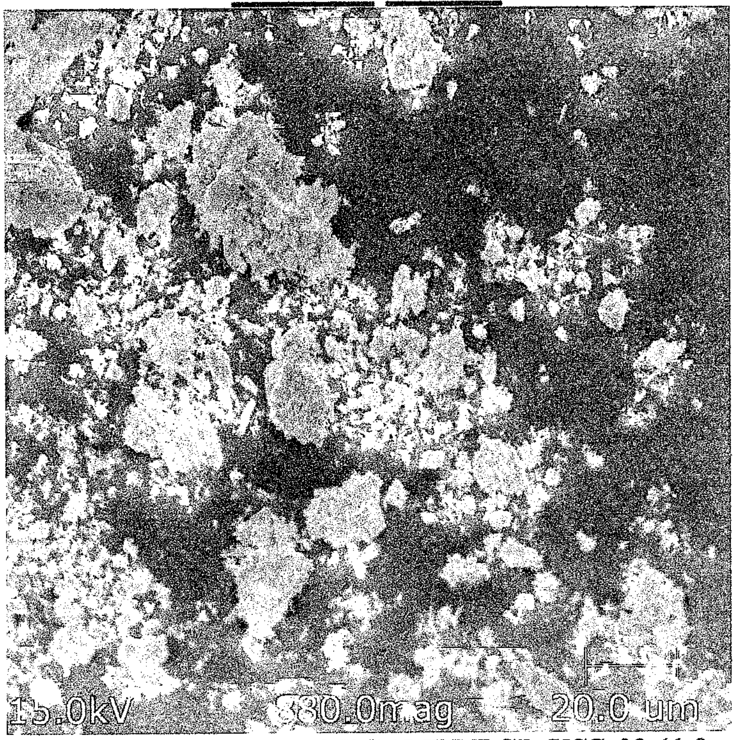
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-02 (3-6 cm) is as follows:

< .5 µm	27.0%
.5- 1 µm	21.3%
1- 5 µm	38.7%
5- 10 µm	6.8%
10- 50 µm	4.9%
> 50 µm	1.4%



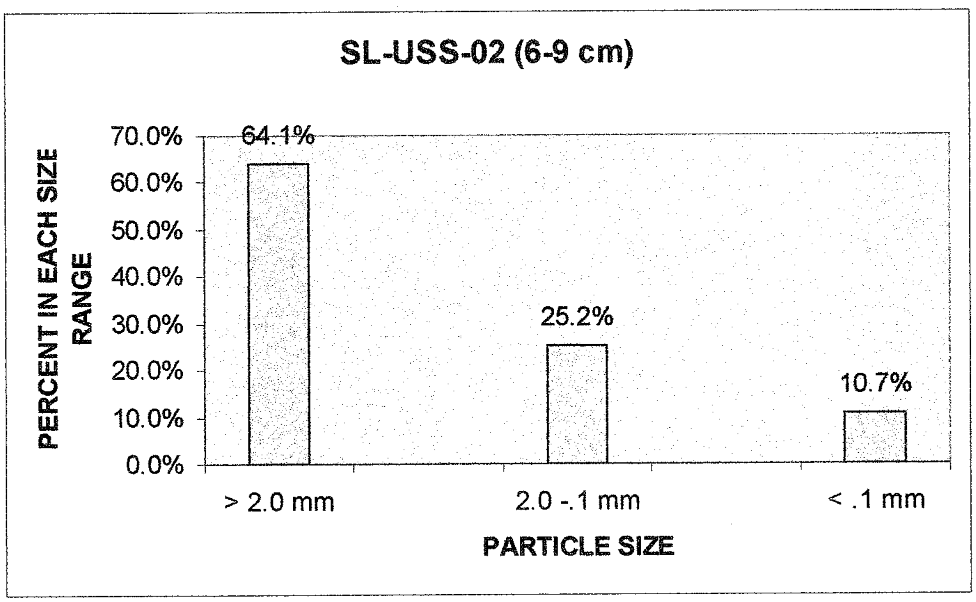
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-02 (6-9 cm) AT 880X

Results for the sieve analysis for sample SL-USS-02 (6-9 cm) is as follows:

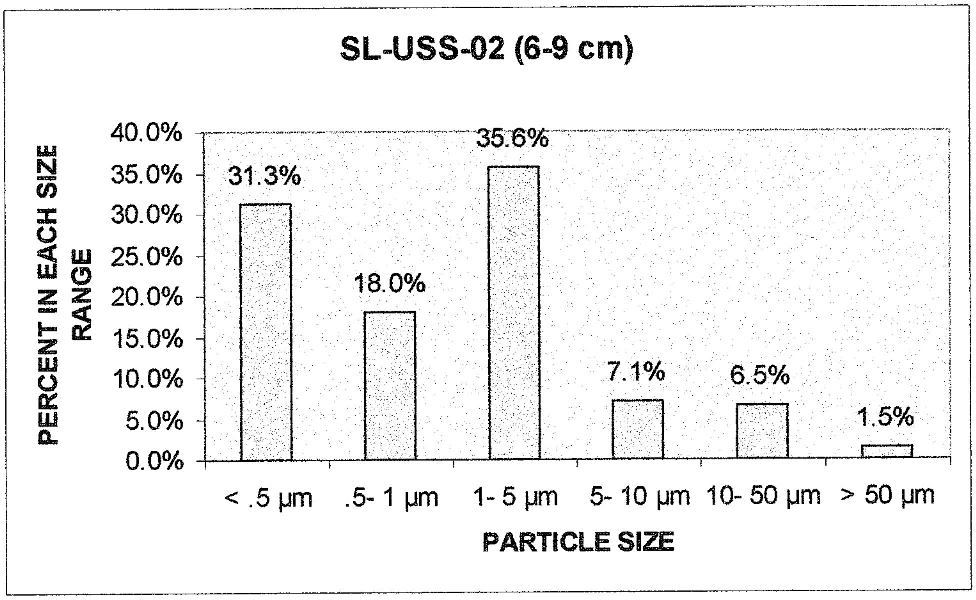
> 2 mm	64.1%
2 mm- 100 µm	25.2%
< 100 µm	10.7%



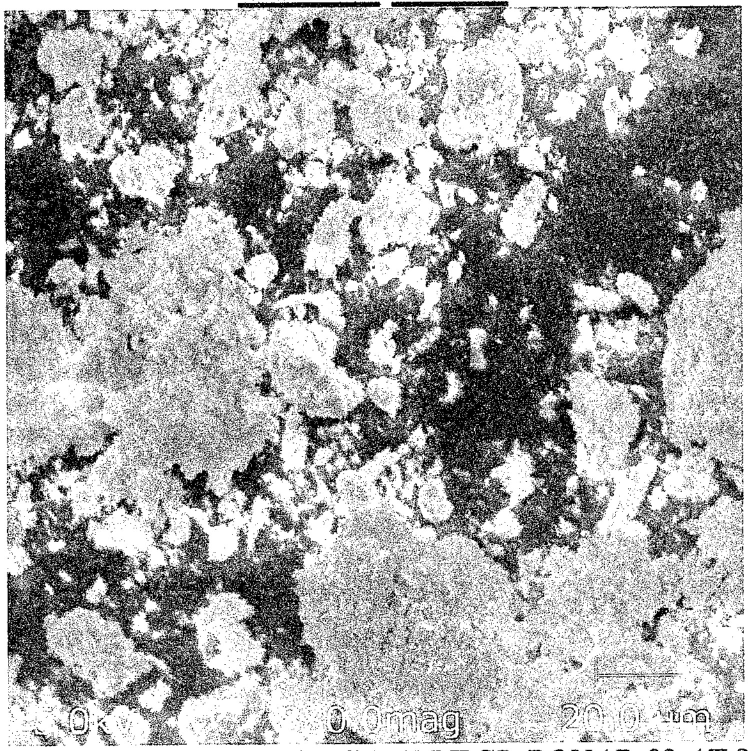
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-02 (6-9 cm) is as follows:

< .5 µm	31.3%
.5- 1 µm	18.0%
1- 5 µm	35.6%
5- 10 µm	7.1%
10- 50 µm	6.5%
> 50 µm	1.5%



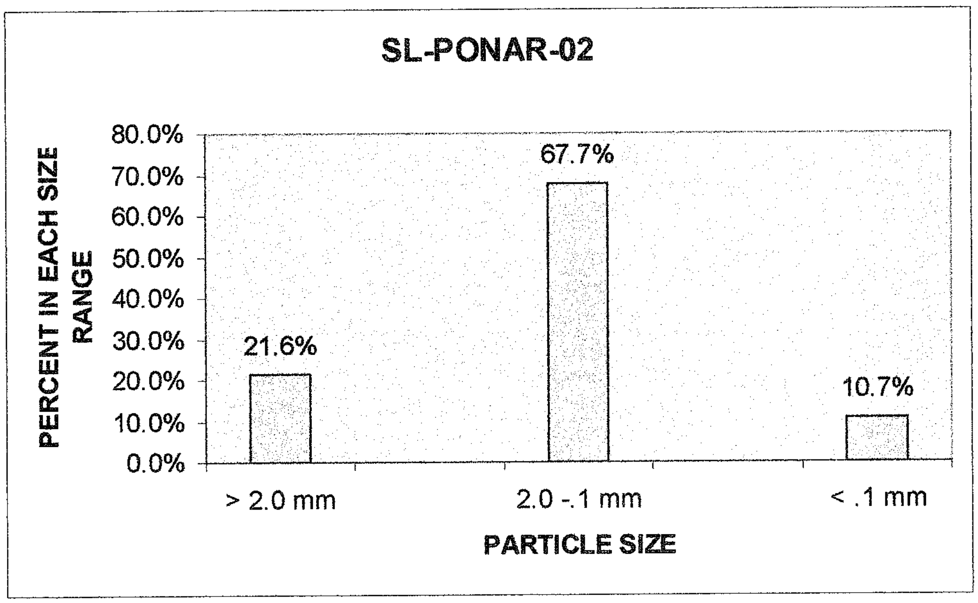
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-PONAR-02 AT 880X

Results of the sieve analysis for sample SL-PONAR-02 is as follows:

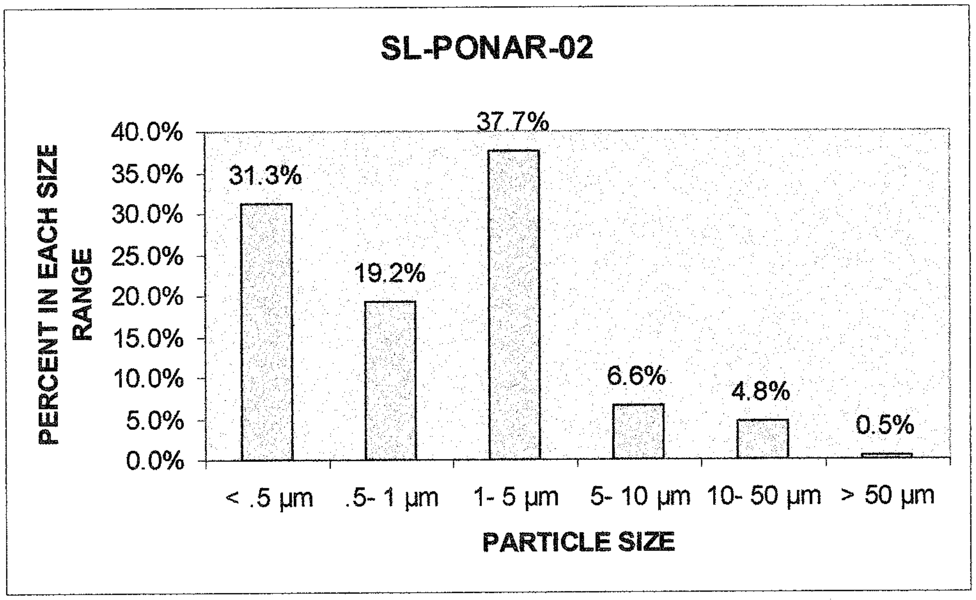
> 2 mm	21.6%
2 mm- 100 µm	67.7%
< 100 µm	10.7%



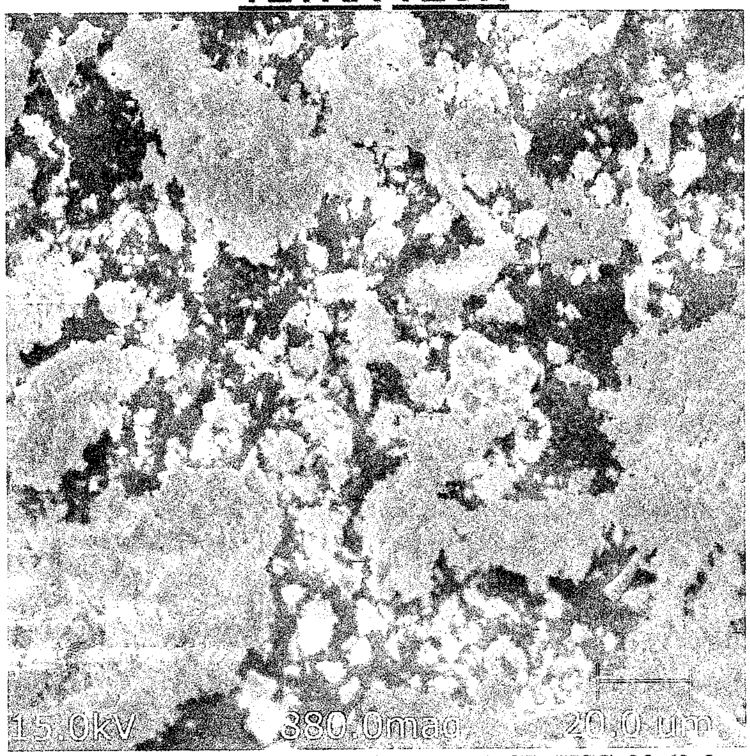
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-02 is as follows:

< .5 µm	31.3%
.5- 1 µm	19.2%
1- 5 µm	37.7%
5- 10 µm	6.6%
10- 50 µm	4.8%
> 50 µm	0.5%



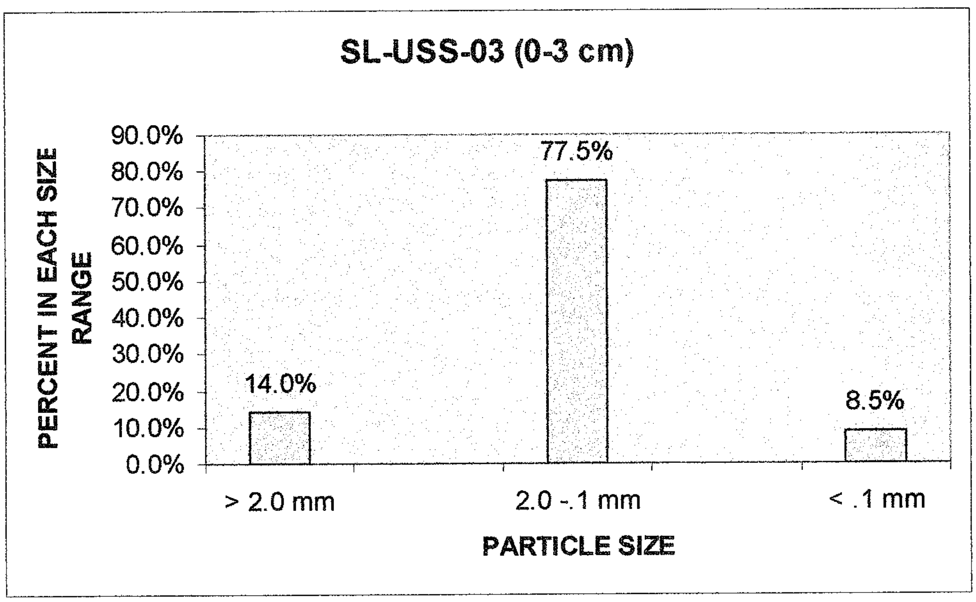
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-03 (0-3 cm)
AT 880X

Results of the sieve analysis for sample SL-USS-03 (0-3 cm) is as follows:

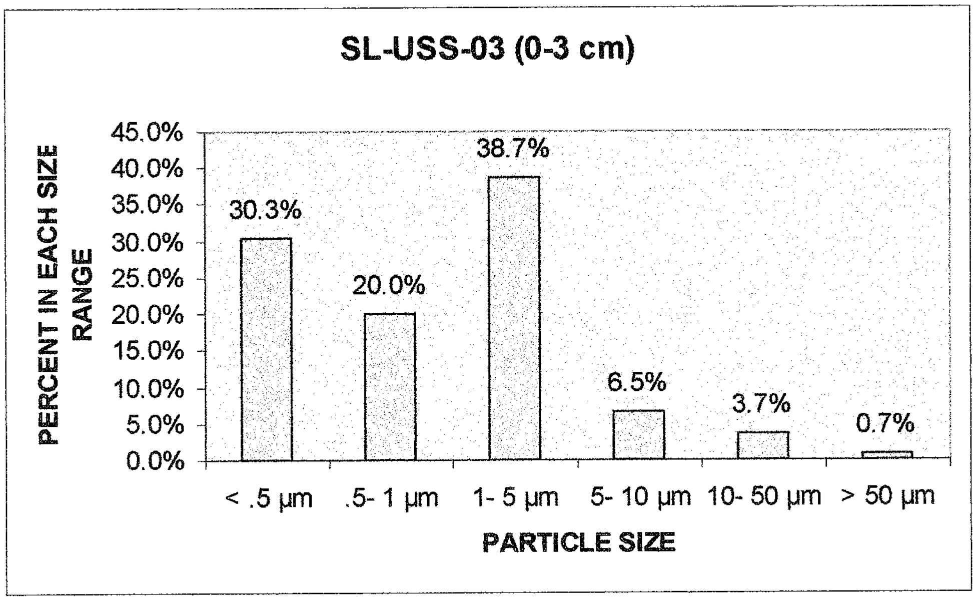
> 2 mm	14.0%
2 mm- 100 µm	77.5%
< 100 µm	8.5%



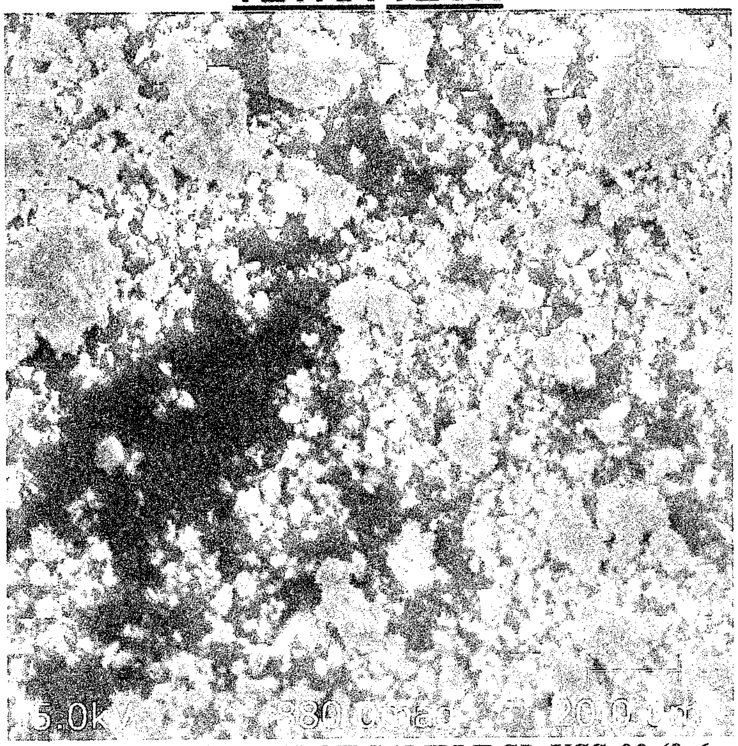
PARTICLE SIZING FOR TETRA TECH

Results for the SEM analysis for SL-USS-03 (0-3 cm) is as follows:

< .5 µm	30.3%
.5- 1 µm	20.0%
1- 5 µm	38.7%
5- 10 µm	6.5%
10- 50 µm	3.7%
> 50 µm	0.7%



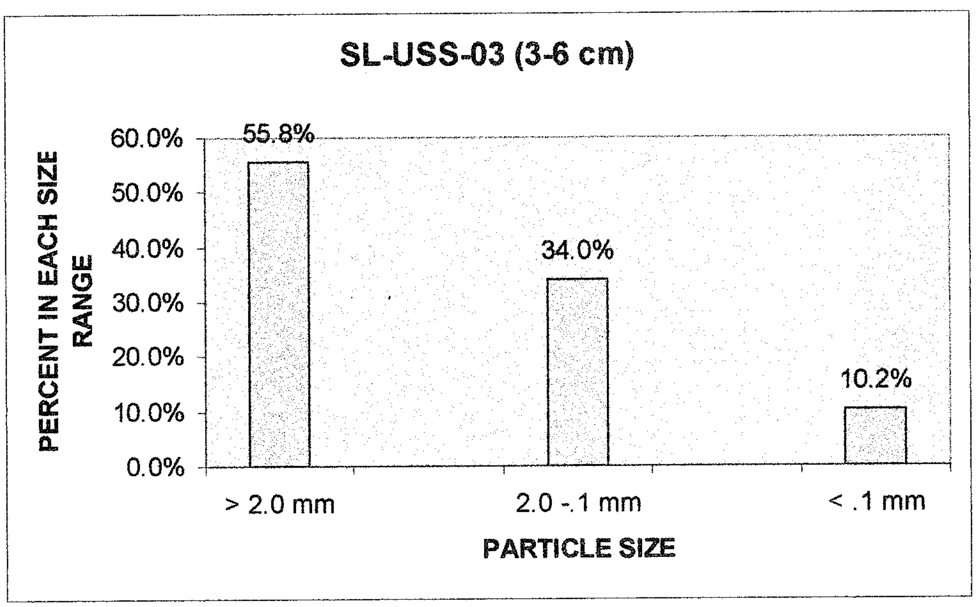
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-03 (3-6 cm)
AT 880X

Results for the sieve analysis for SL-USS-03 (3-6 cm) is as follows:

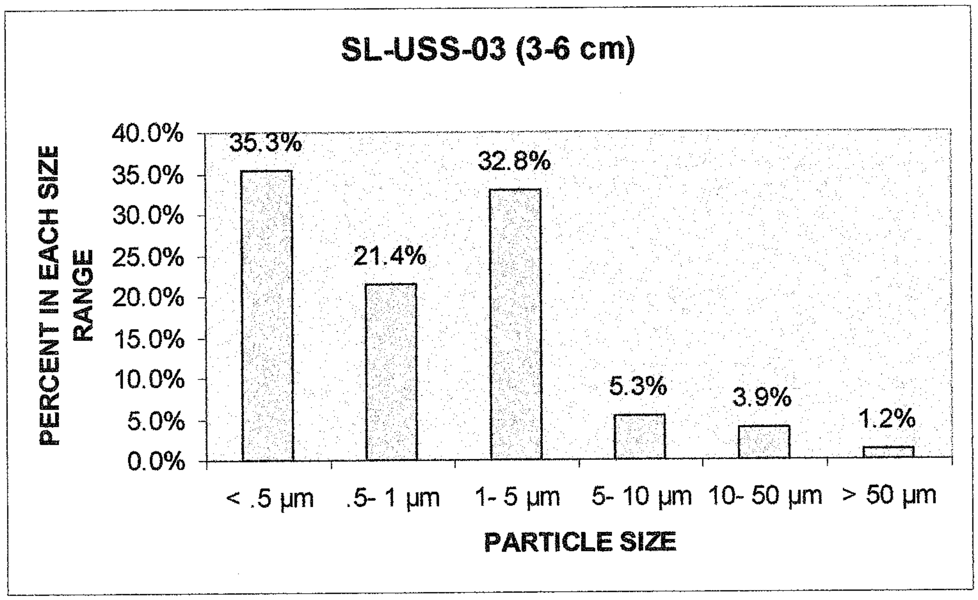
> 2 mm	55.8%
2 mm- 100 µm	34.0%
< 100 µm	10.2%



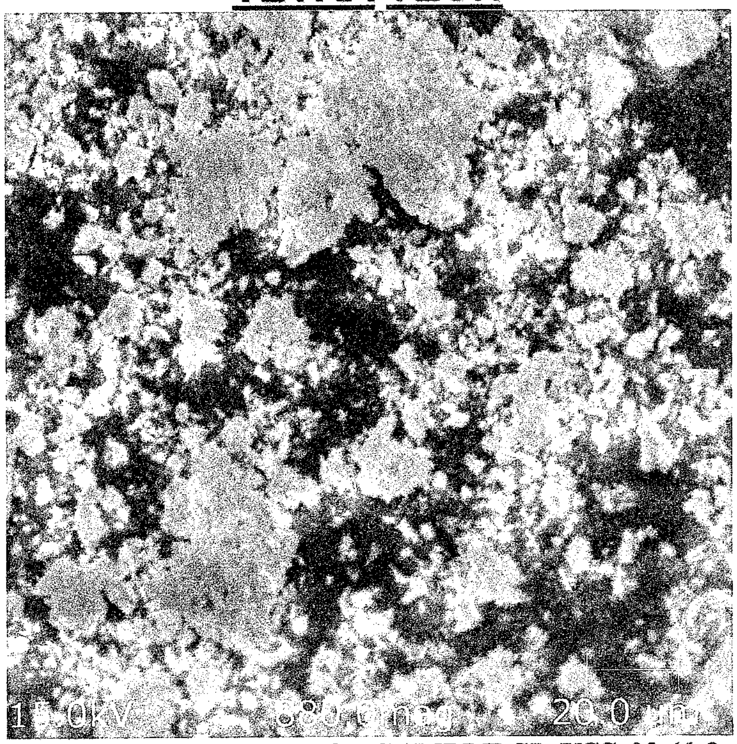
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-USS-03 (3-6 cm) is as follows:

< .5 µm	35.3%
.5- 1 µm	21.4%
1- 5 µm	32.8%
5- 10 µm	5.3%
10- 50 µm	3.9%
> 50 µm	1.2%



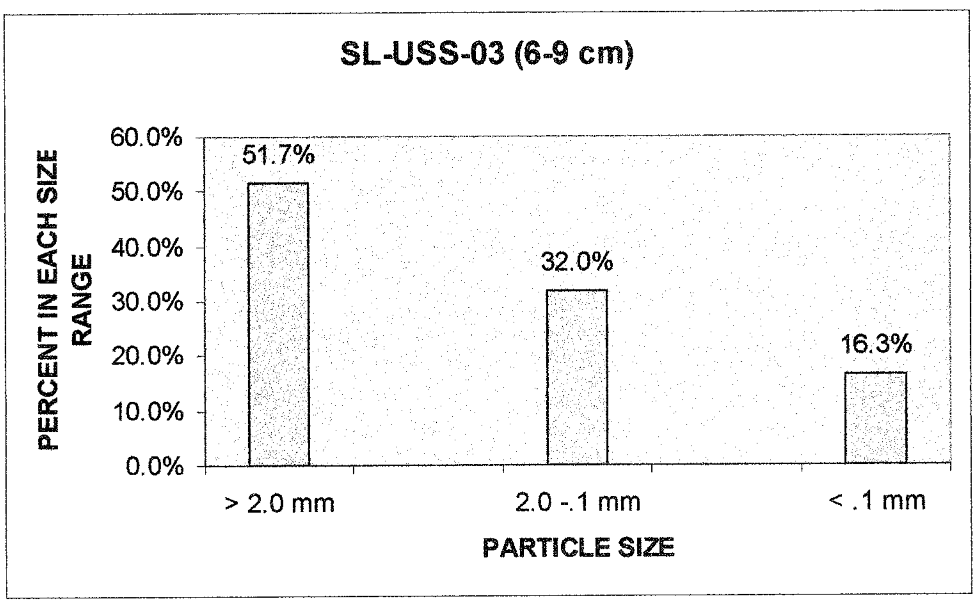
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-USS-03 (6-9 cm) AT 880X

Results for the sieve analysis for SL-USS-03 (6-9 cm) is as follows:

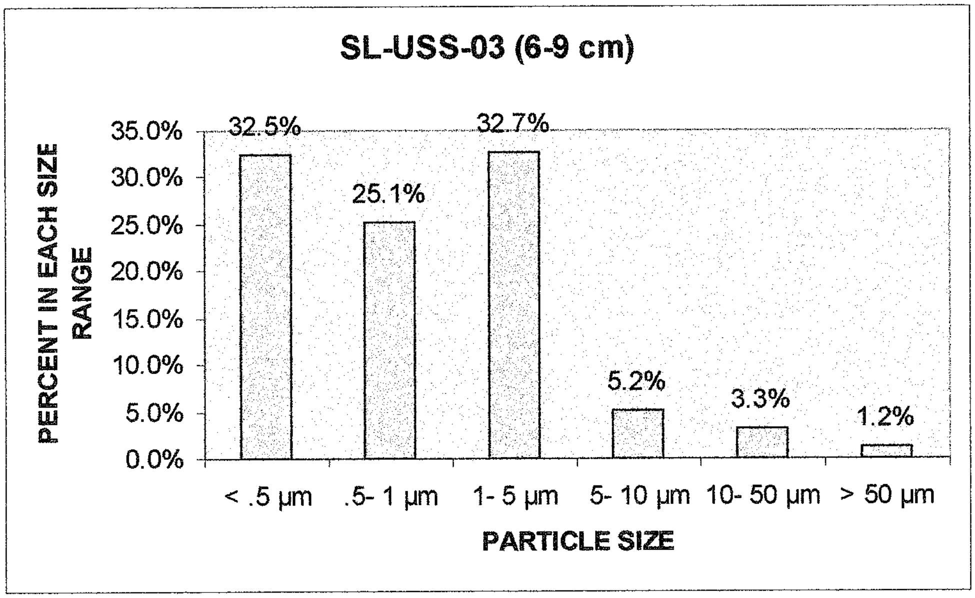
> 2 mm	51.7%
2 mm- 100 µm	32.0%
< 100 µm	16.3%



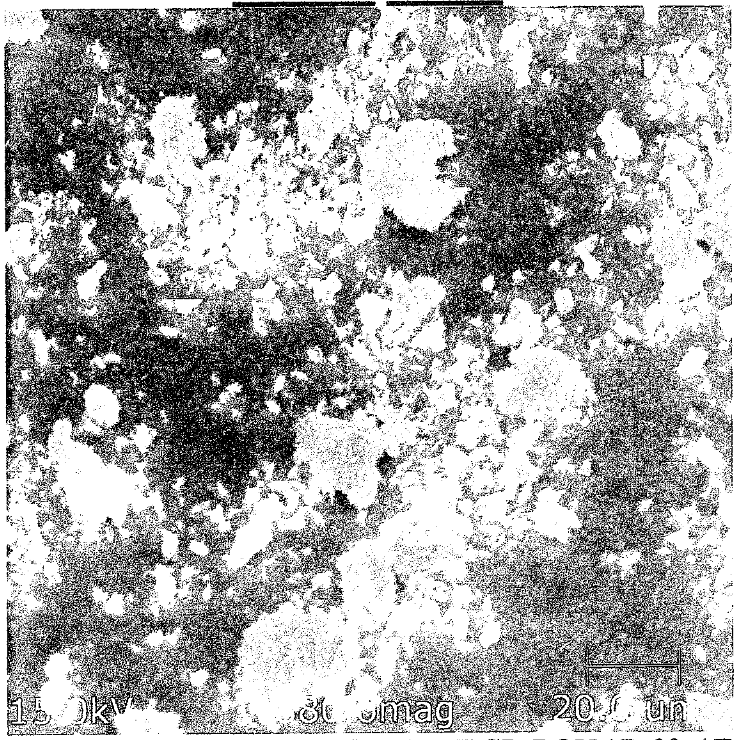
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-03 (6-9 cm) is as follows:

< .5 µm	32.5%
.5- 1 µm	25.1%
1- 5 µm	32.7%
5- 10 µm	5.2%
10- 50 µm	3.3%
> 50 µm	1.2%



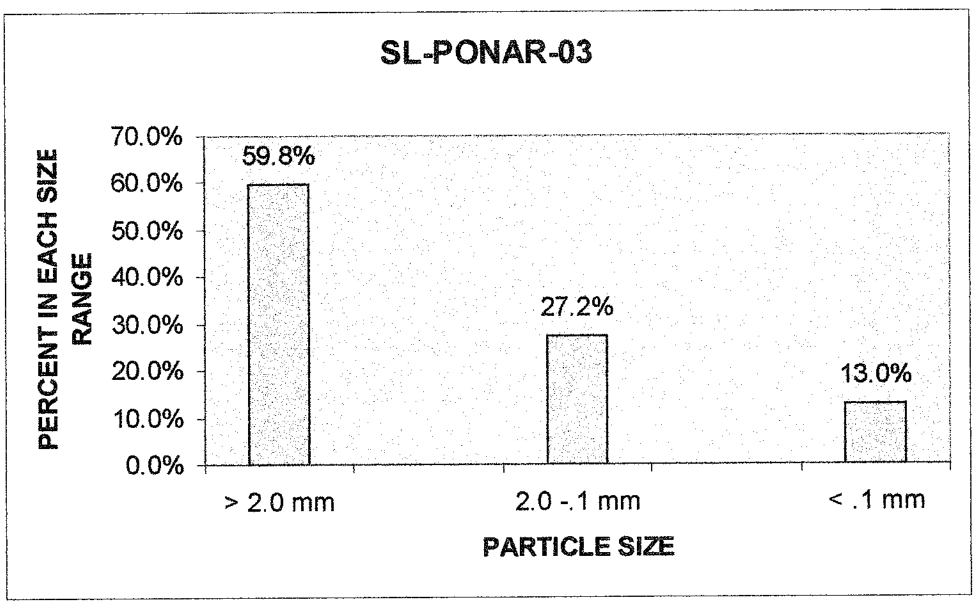
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-PONAR-03 AT 880X

Results for the sieve analysis for SL-PONAR-03 is as follows:

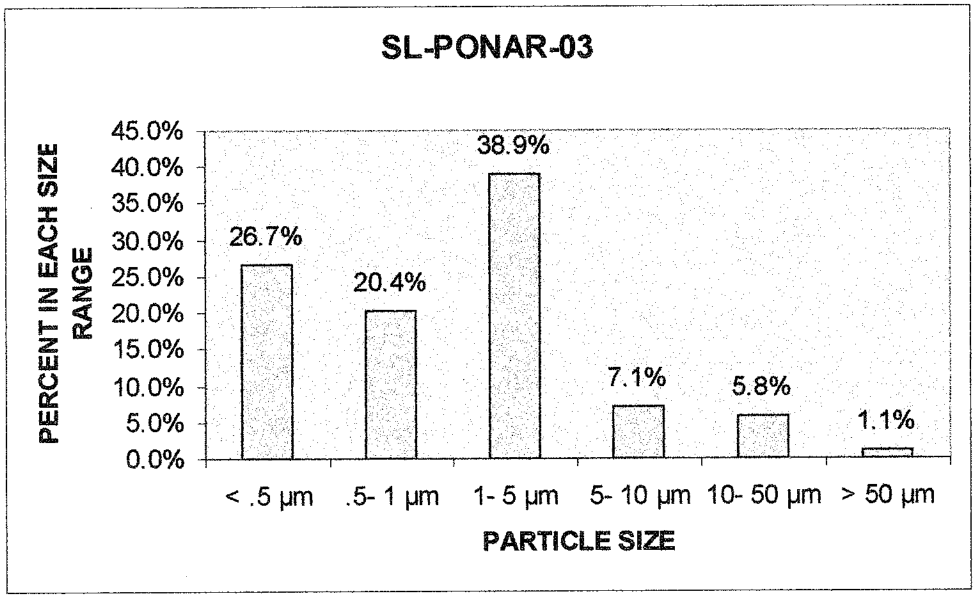
> 2 mm	59.8%
2 mm- 100 µm	27.2%
< 100 µm	13.0%



PARTICLE SIZING
FOR
TETRA TECH

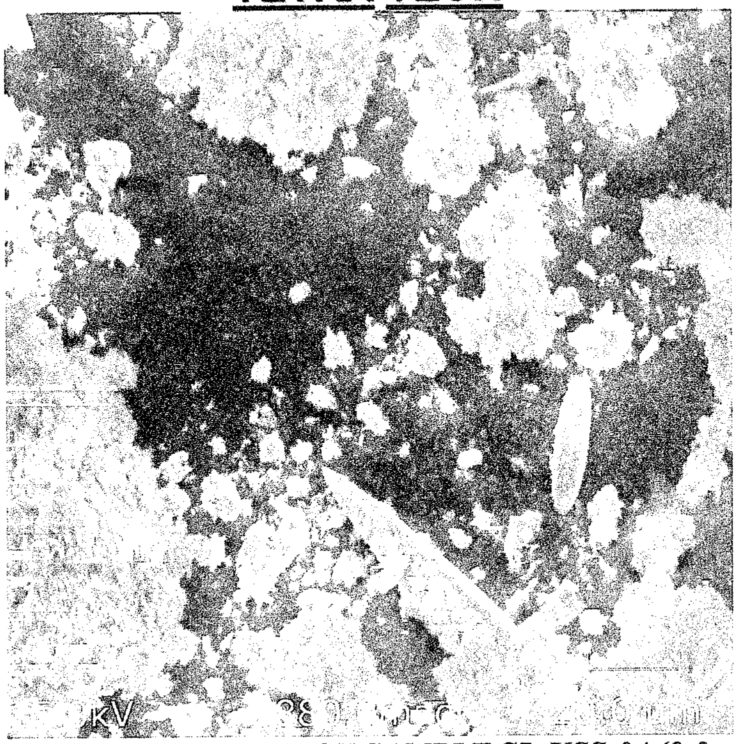
Results for the SEM particle size analysis for SL-PONAR-03 is as follows:

< .5 µm	26.7%
.5- 1 µm	20.4%
1- 5 µm	38.9%
5- 10 µm	7.1%
10- 50 µm	5.8%
> 50 µm	1.1%



PARTICLE SIZING
FOR
TETRA TECH

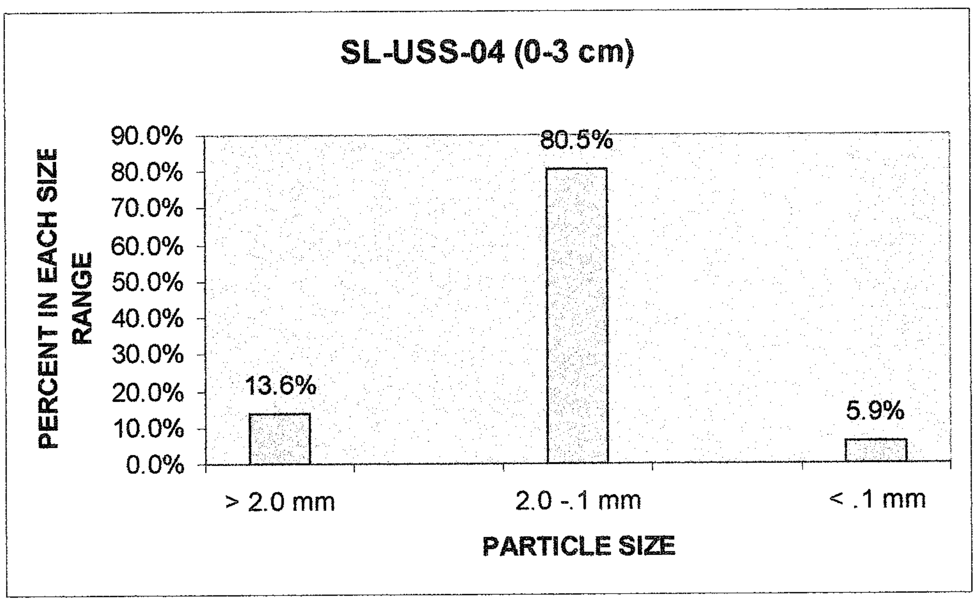
Clayton GROUP SERVICES



PHOTOMICROGRAPH OF SAMPLE SL-USS-04 (0-3 cm)
AT 880X

Results for the sieve analysis for SL-USS-04 (0-3 cm) is as follows:

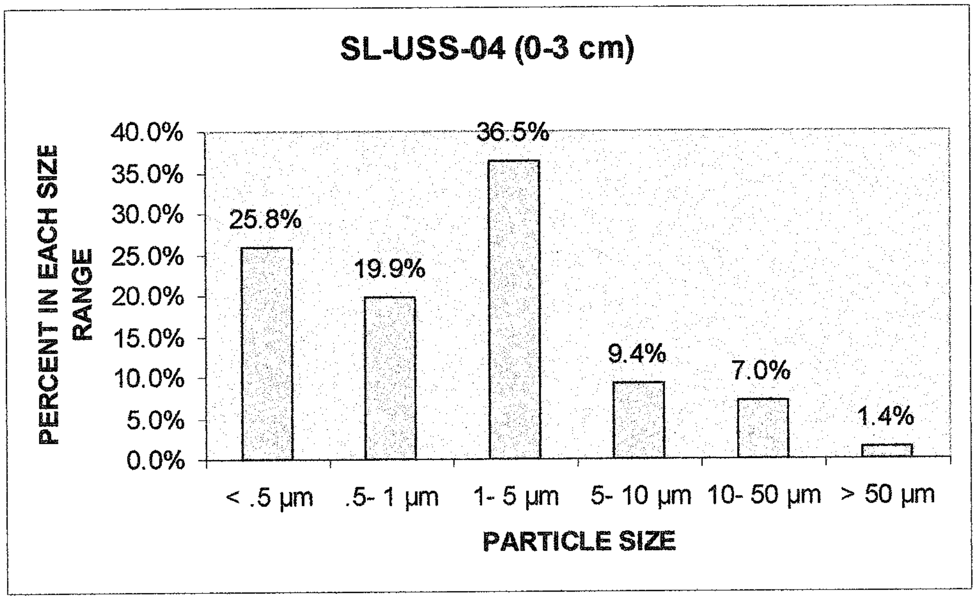
> 2 mm	13.6%
2 mm- 100 µm	80.5%
< 100 µm	5.9%



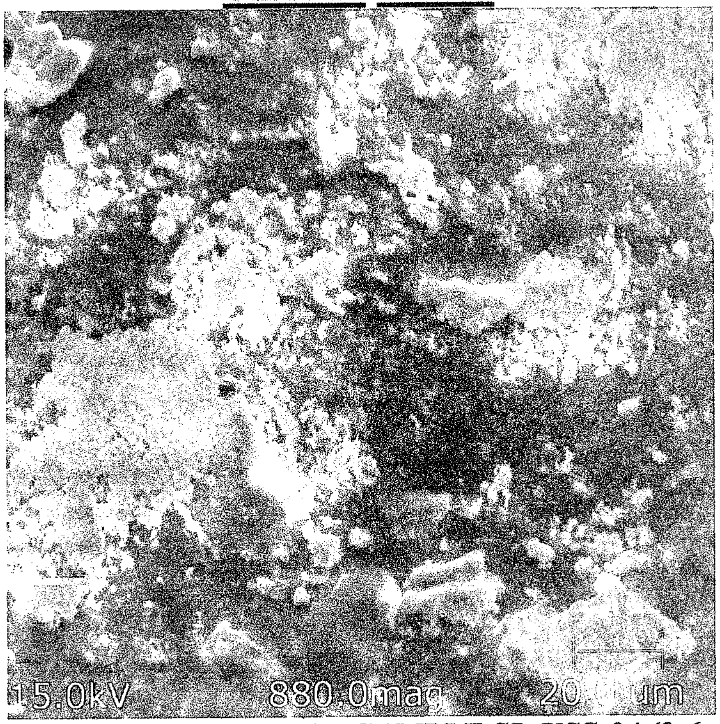
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-04 (0-3 cm) is as follows:

< .5 µm	25.8%
.5- 1 µm	19.9%
1- 5 µm	36.5%
5- 10 µm	9.4%
10- 50 µm	7.0%
> 50 µm	1.4%



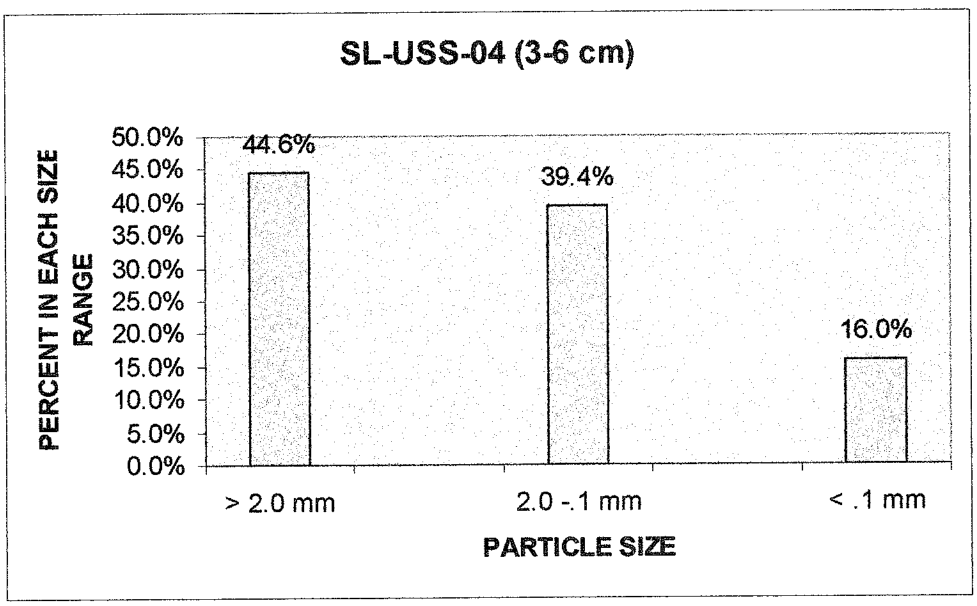
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-04 (3-6 cm) AT 880X

Results for the sieve analysis for SL-USS-04 (3-6 cm) is as follows:

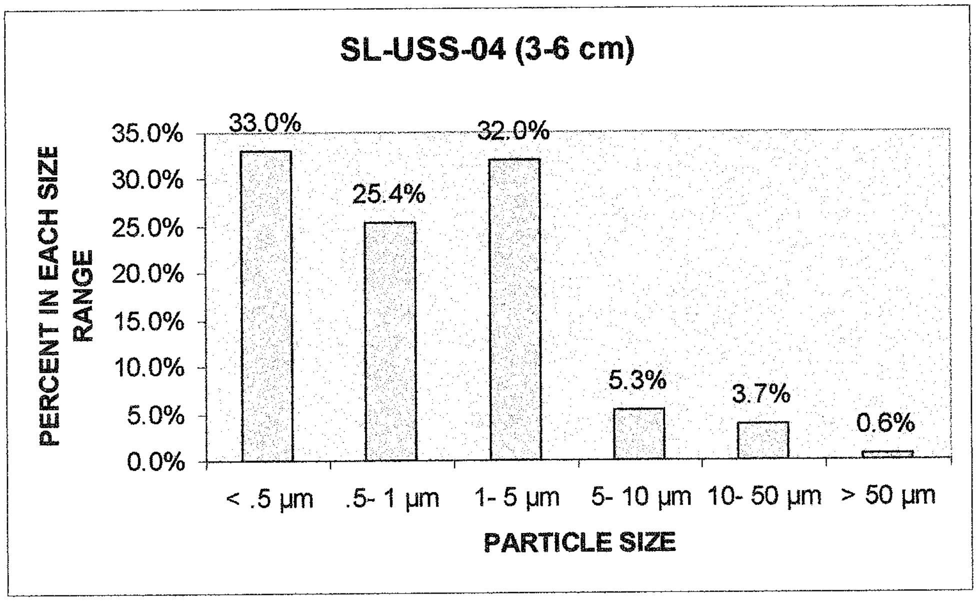
> 2 mm	44.6%
2 mm- 100 µm	39.4%
< 100 µm	16.0%



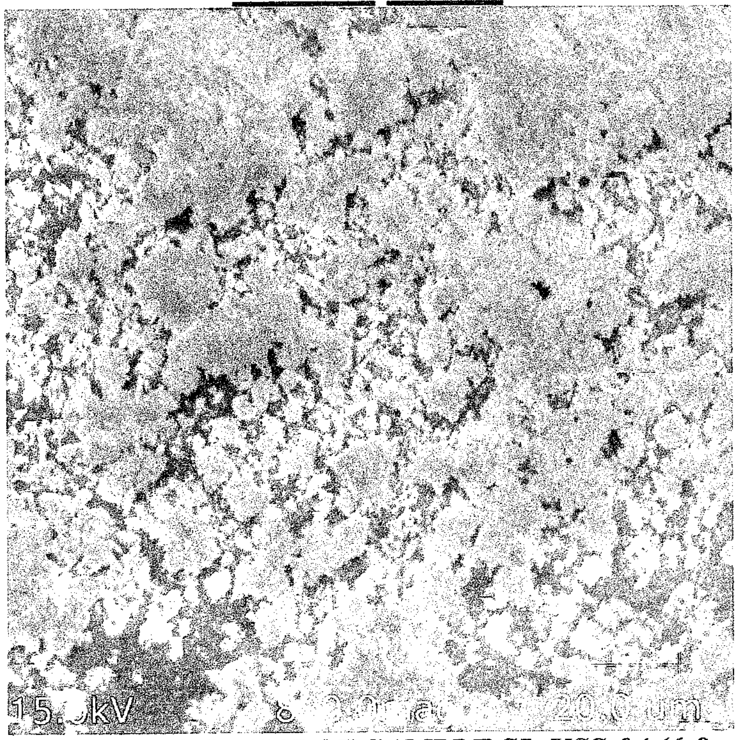
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-USS-04 (3-6 cm) is as follows:

< .5 µm	33.0%
.5- 1 µm	25.4%
1- 5 µm	32.0%
5- 10 µm	5.3%
10- 50 µm	3.7%
> 50 µm	0.6%



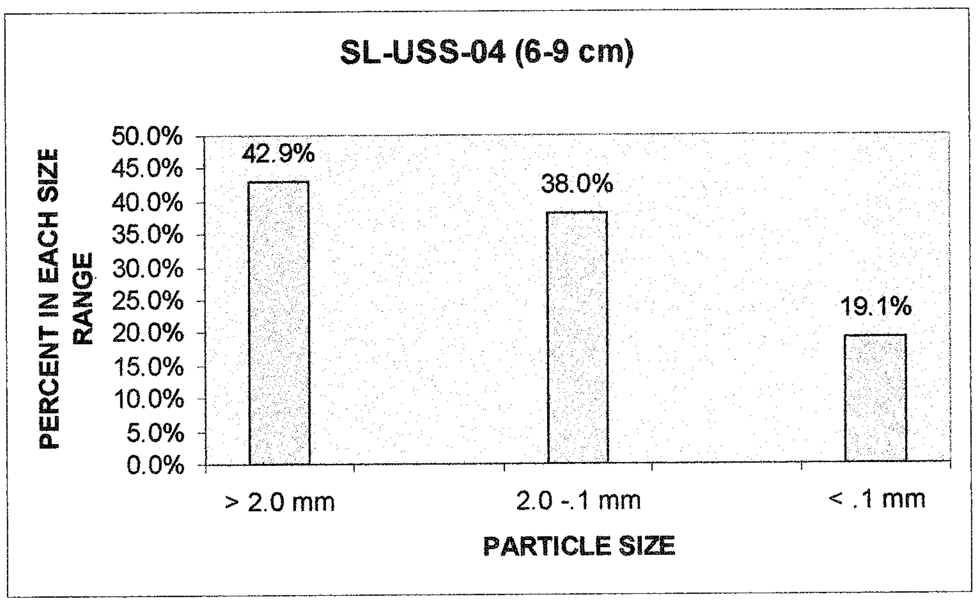
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-04 (6-9 cm) AT 880X

Results for the sieve analysis for SL-USS-04 (6-9 cm) is as follows:

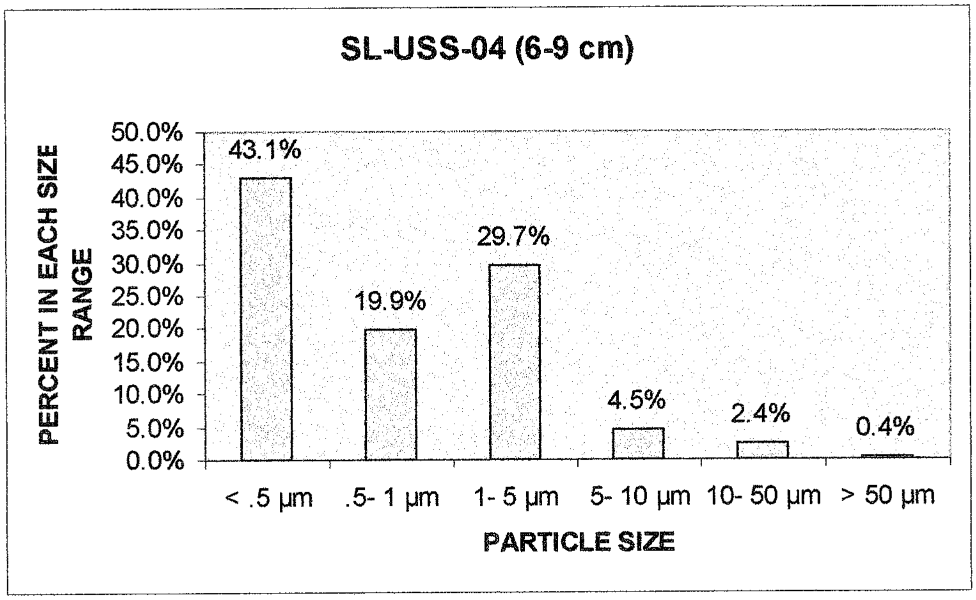
> 2 mm	42.9%
2 mm- 100 µm	38.0%
< 100 µm	19.1%



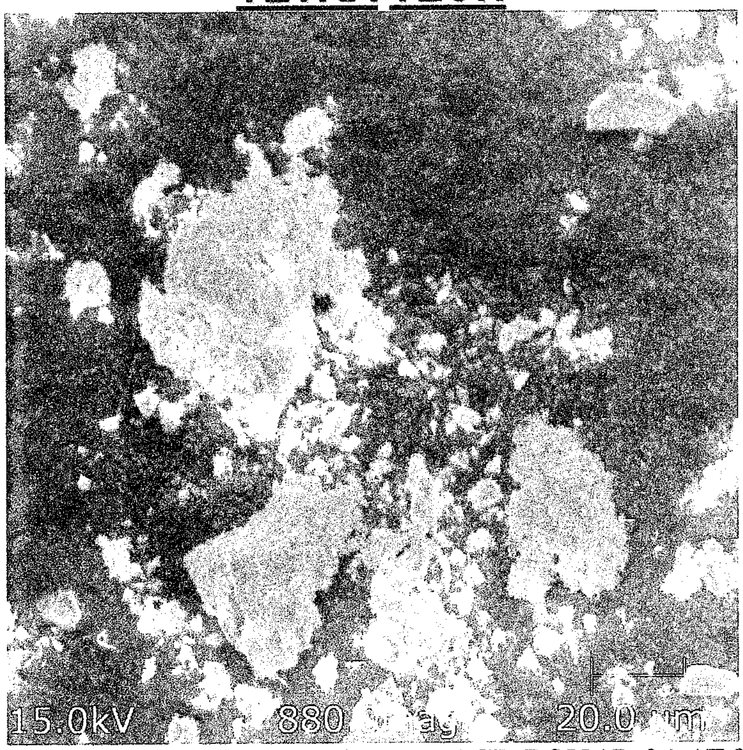
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-USS-04 (6-9 cm) is as follows:

< .5 µm	43.1%
.5- 1 µm	19.9%
1- 5 µm	29.7%
5- 10 µm	4.5%
10- 50 µm	2.4%
> 50 µm	0.4%



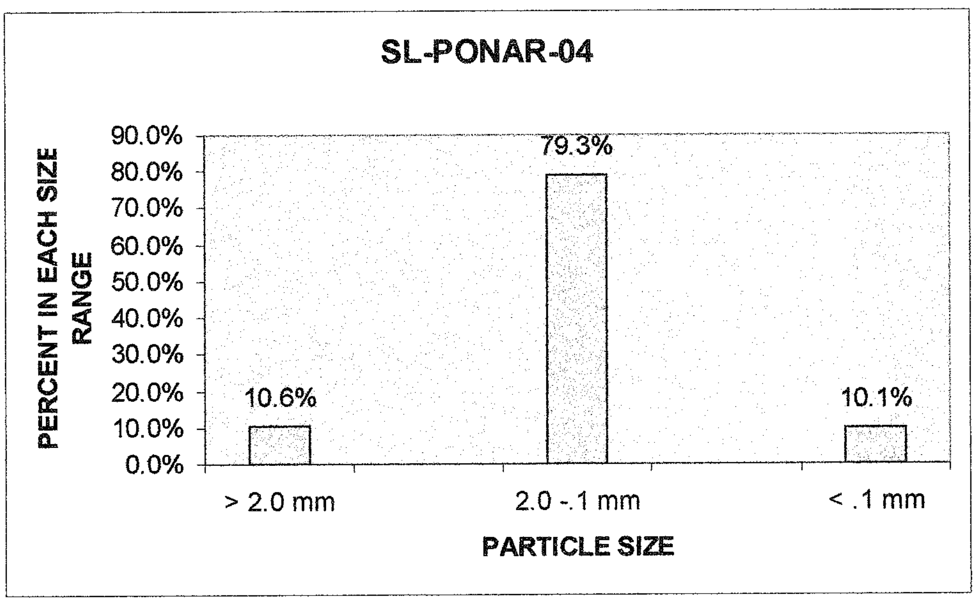
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-PONAR-04 AT 880X

Results for the sieve analysis for SL-PONAR-04 is as follows:

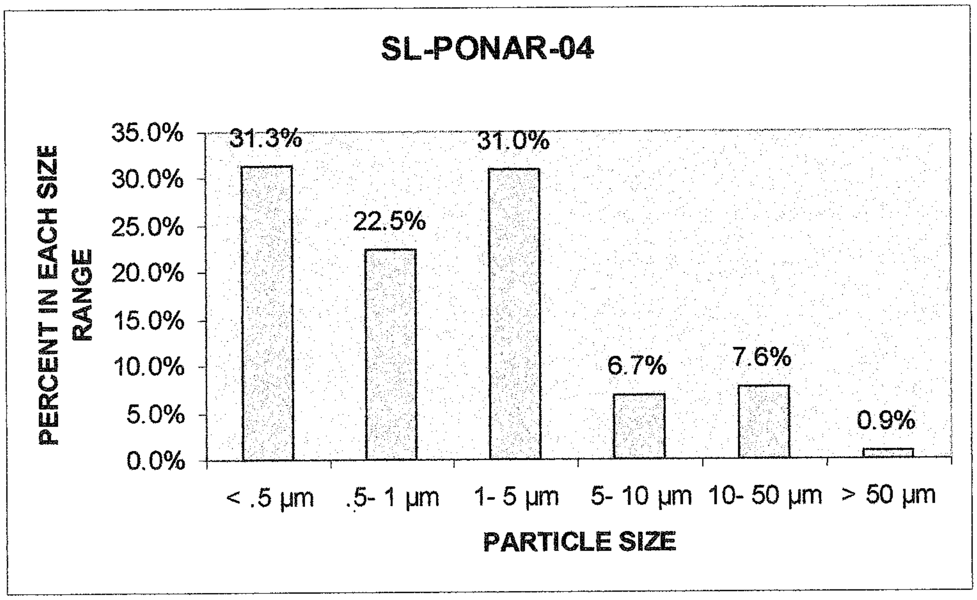
> 2 mm	10.6%
2 mm- 100 µm	79.3%
< 100 µm	10.1%



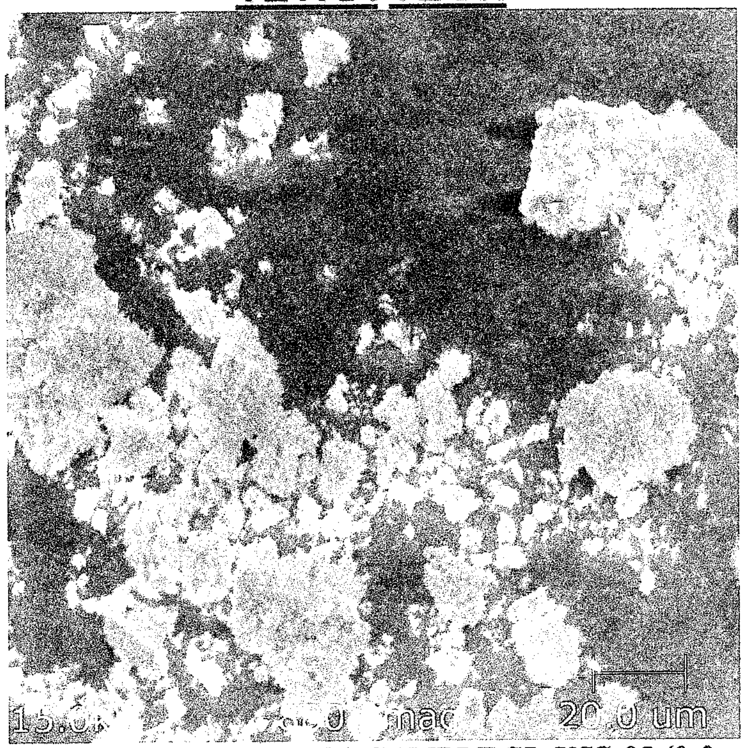
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-04 is as follows:

< .5 µm	31.3%
.5- 1 µm	22.5%
1- 5 µm	31.0%
5- 10 µm	6.7%
10- 50 µm	7.6%
> 50 µm	0.9%



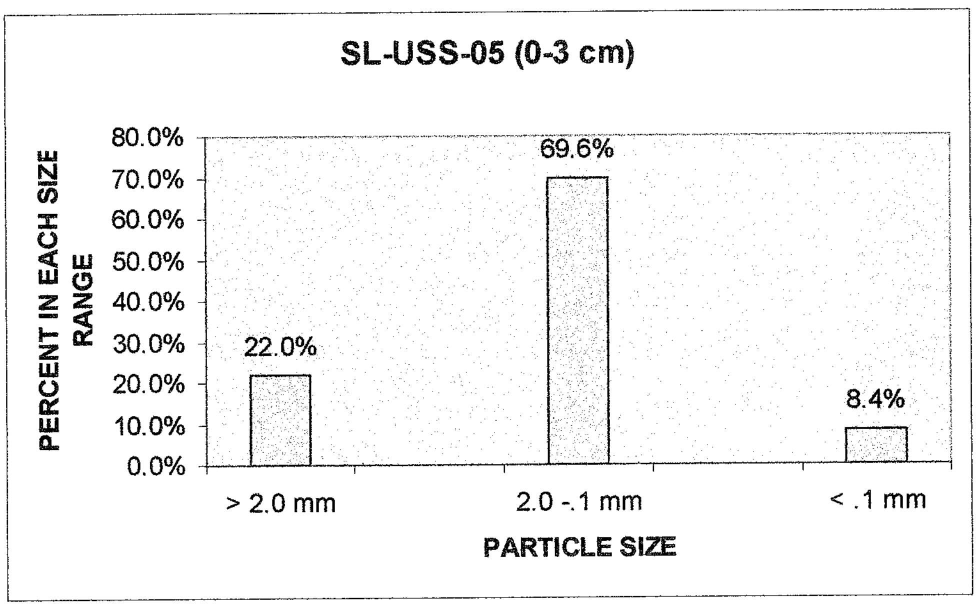
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-05 (0-3 cm)
AT 880X

Results for the sieve analysis for SL-USS-05 (0-3 cm) is as follows:

> 2 mm	22.0%
2 mm- 100 µm	69.6%
< 100 µm	8.4%



PARTICLE SIZING
FOR
TETRA TECH

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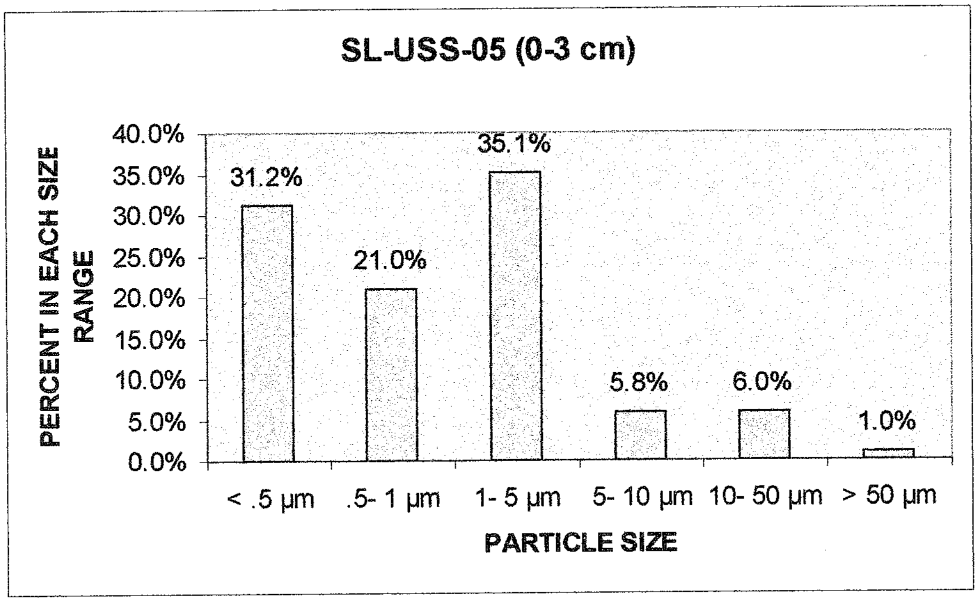
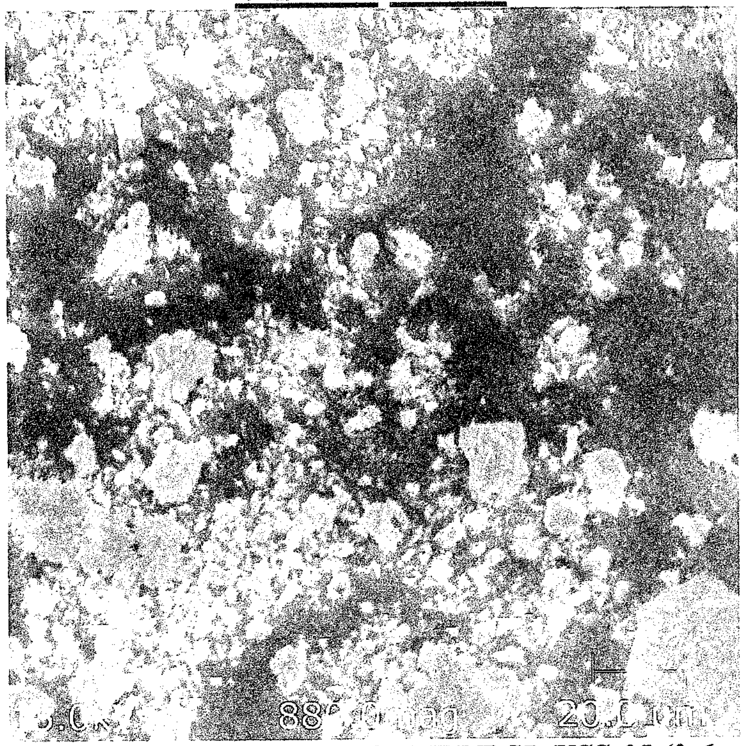
Results for the SEM particle size analysis for SL-USS-05 (0-3 cm) is as follows:

< .5 µm	31.2%
.5- 1 µm	21.0%
1- 5 µm	35.1%
5- 10 µm	5.8%
10- 50 µm	6.0%
> 50 µm	1.0%



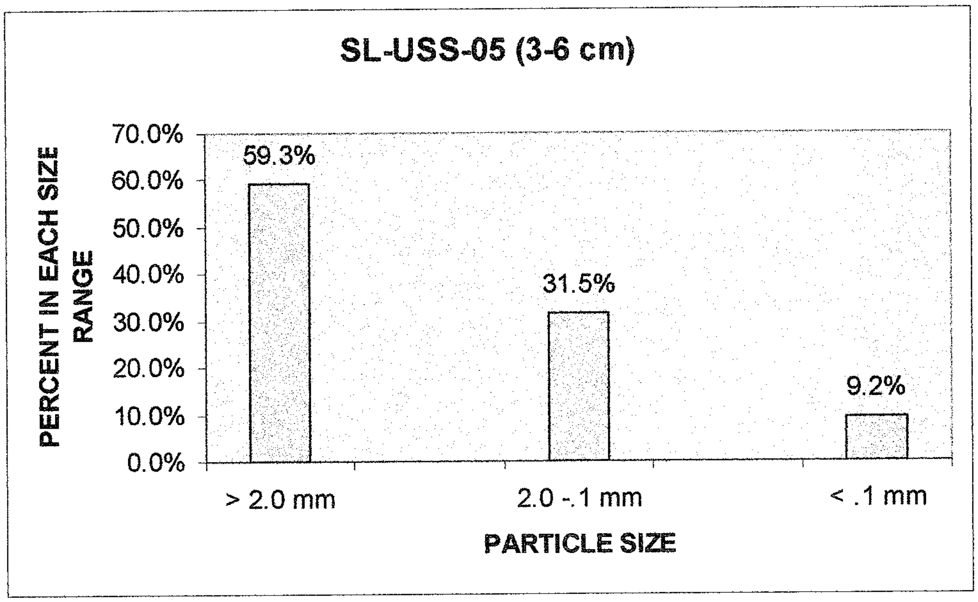
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-05 (3-6 cm) AT 880X

Results for the sieve analysis for SL-USS-05 (3-6 cm) is as follows:

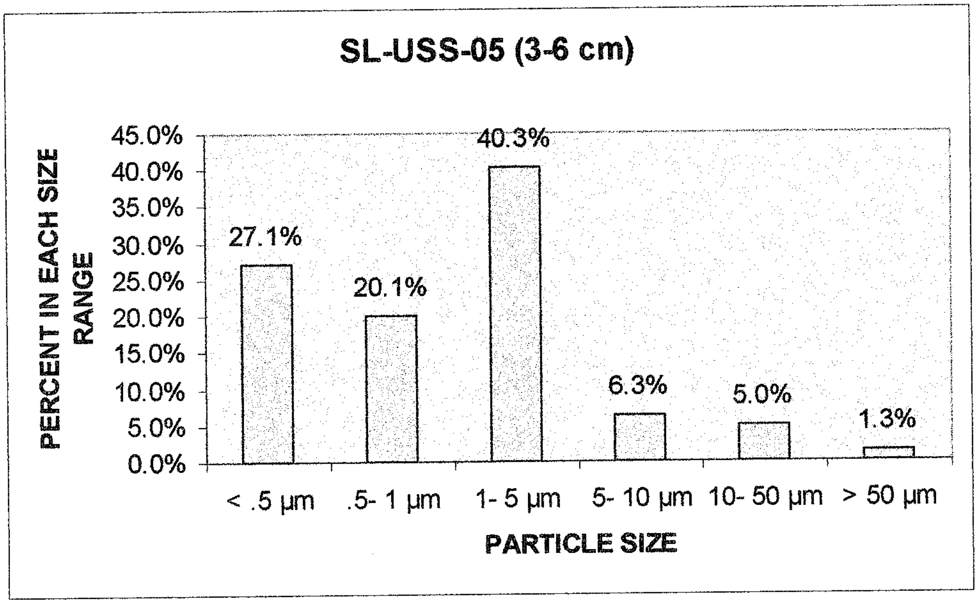
> 2 mm	59.3%
2 mm- 100 µm	31.5%
< 100 µm	9.2%



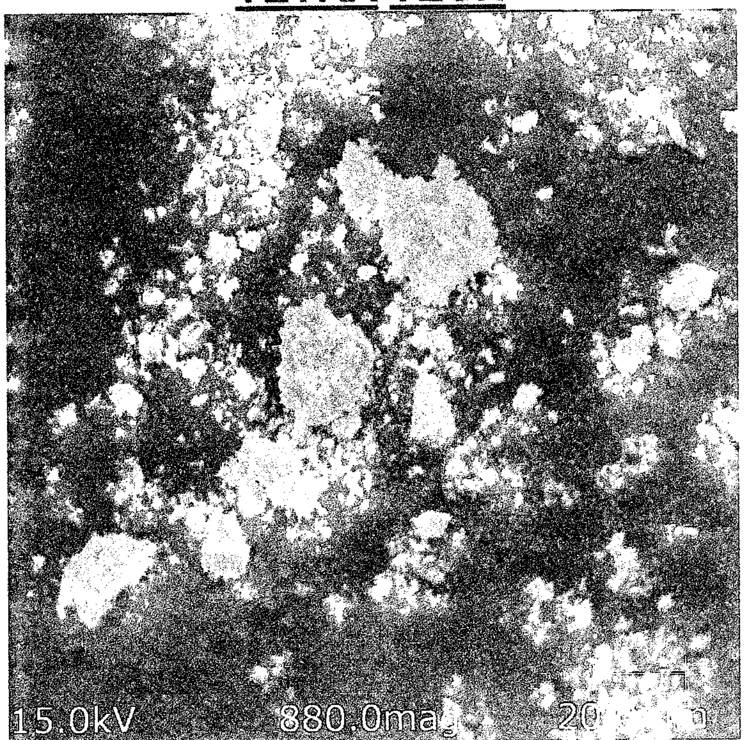
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-05 (3-6 cm) is as follows:

< .5 µm	27.1%
.5- 1 µm	20.1%
1- 5 µm	40.3%
5- 10 µm	6.3%
10- 50 µm	5.0%
> 50 µm	1.3%



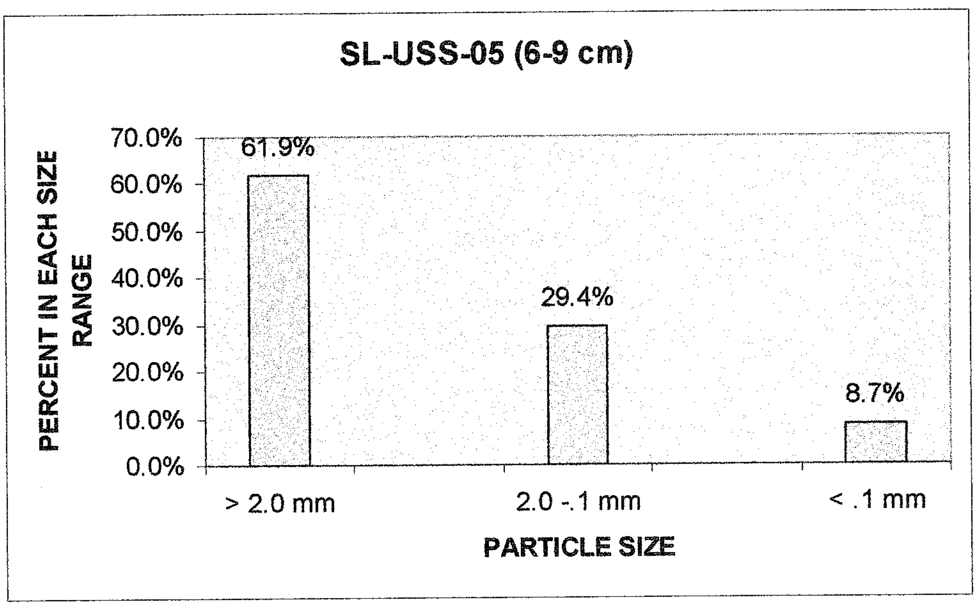
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-05 (6-9 cm) AT 880X

Results for the sieve analysis for SL-USS-05 (6-9 cm) is as follows:

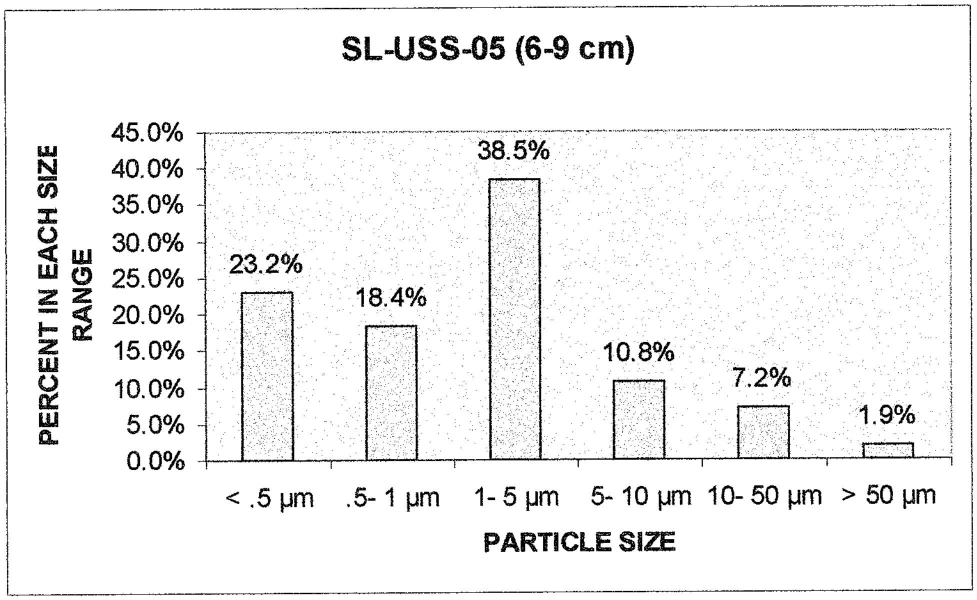
> 2 mm	61.9%
2 mm- 100 µm	29.4%
< 100 µm	8.7%



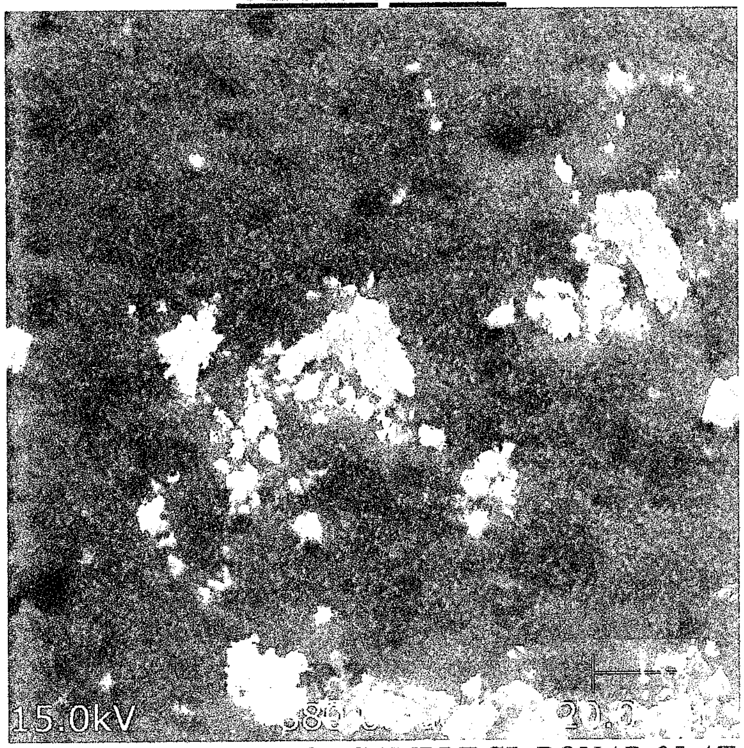
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-05 (6-9 cm) is as follows:

< .5 µm	23.2%
.5- 1 µm	18.4%
1- 5 µm	38.5%
5- 10 µm	10.8%
10- 50 µm	7.2%
> 50 µm	1.9%



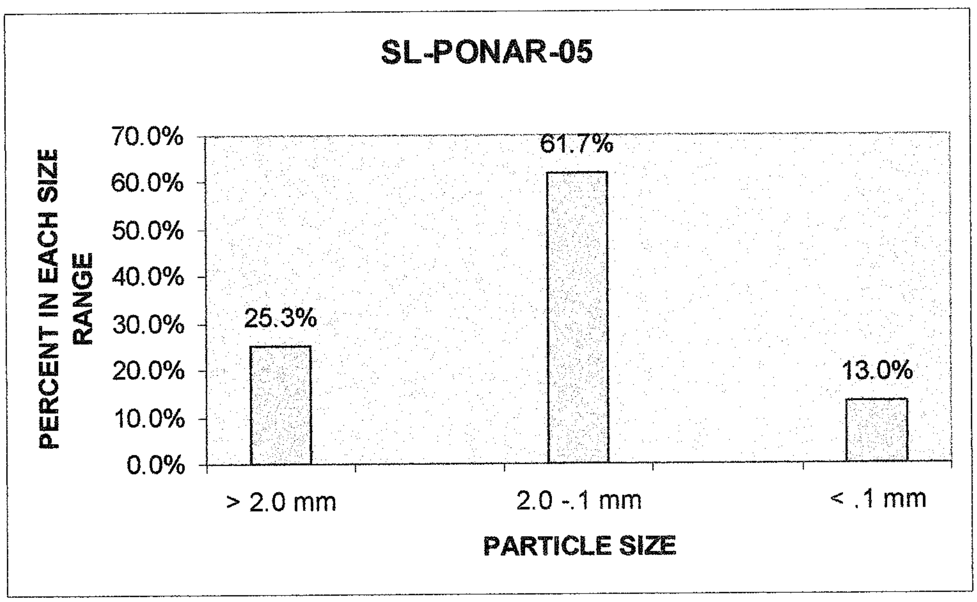
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-PONAR-05 AT 880X

Results for the sieve analysis for SL-PONAR-05 is as follows:

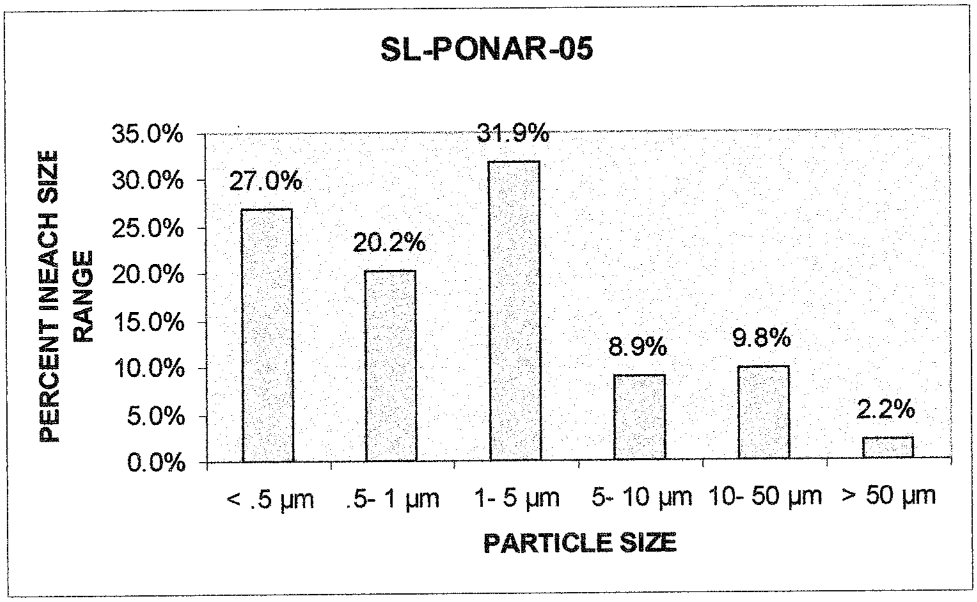
> 2 mm	25.3%
2 mm- 100 µm	61.7%
< 100 µm	13.0%



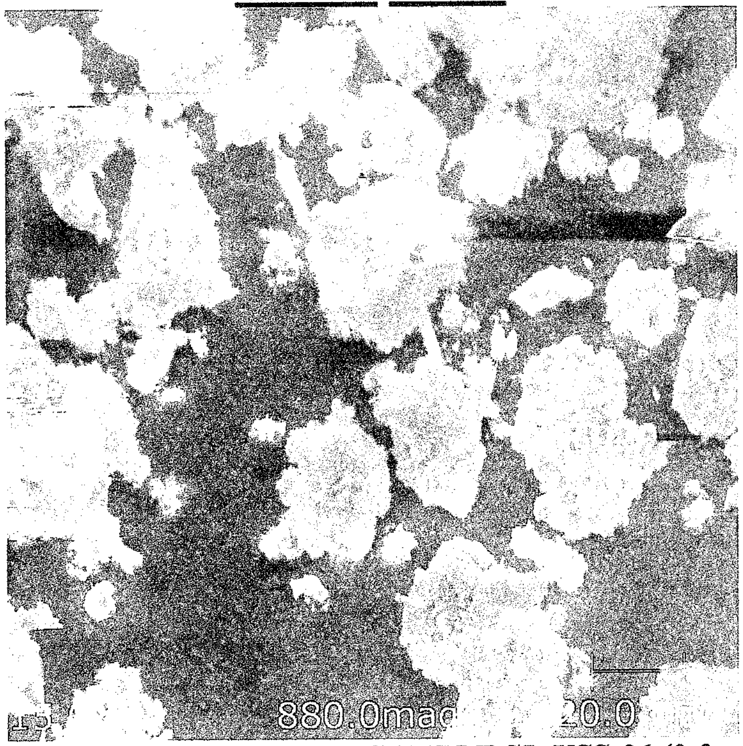
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-05 is as follows:

< .5 µm	27.0%
.5- 1 µm	20.2%
1- 5 µm	31.9%
5- 10 µm	8.9%
10- 50 µm	9.8%
> 50 µm	2.2%



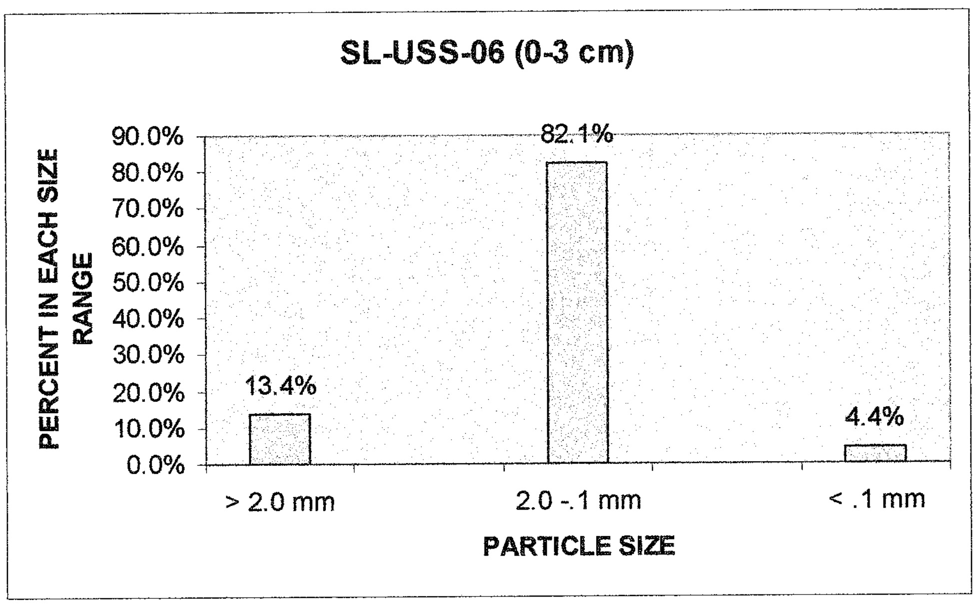
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-06 (0-3 cm)
AT 880X

Results for the sieve analysis for SL-USS-06 (0-3 cm) is as follows:

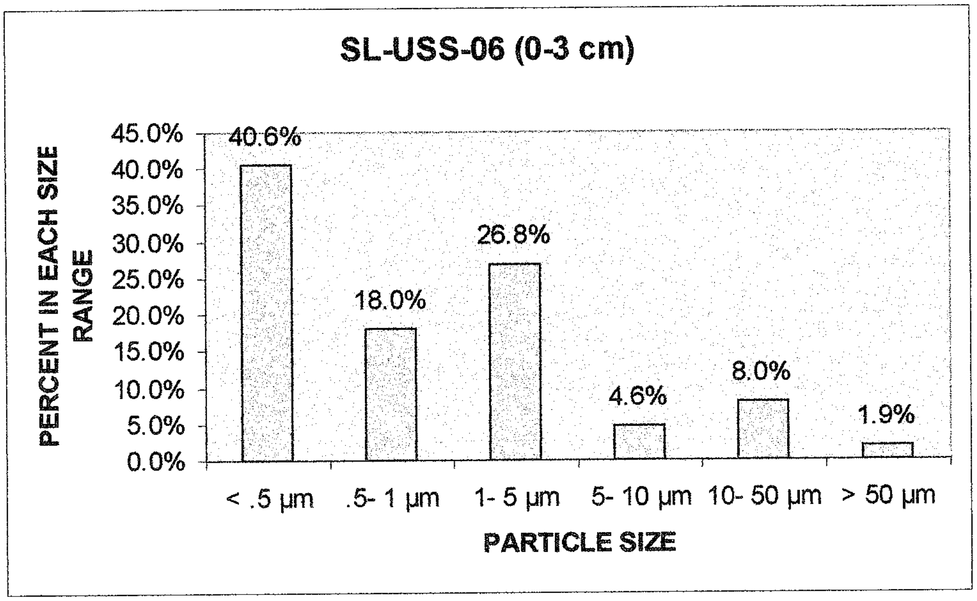
> 2 mm	13.4%
2 mm- 100 µm	82.1%
< 100 µm	4.4%



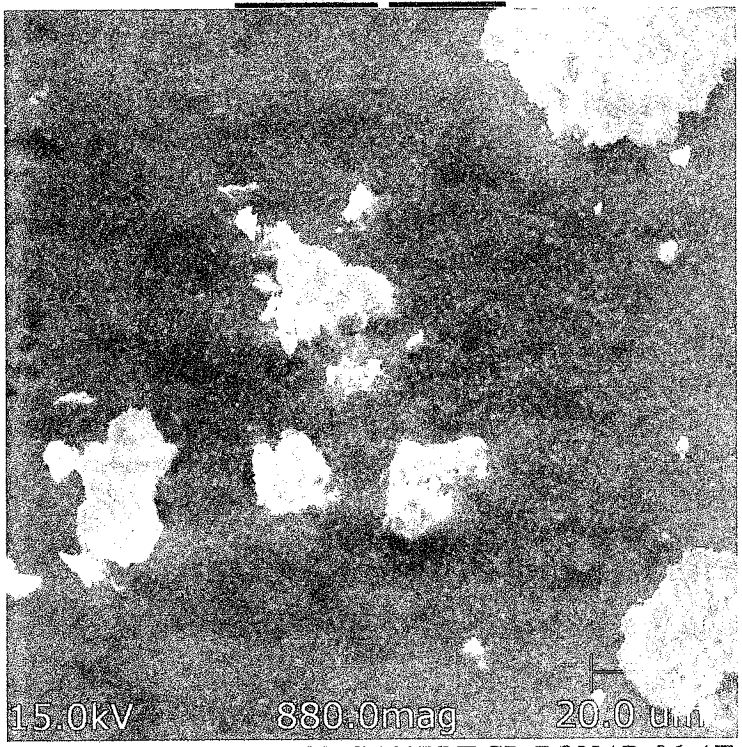
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-06 (0-3 cm) is as follows:

< .5 µm	40.6%
.5- 1 µm	18.0%
1- 5 µm	26.8%
5- 10 µm	4.6%
10- 50 µm	8.0%
> 50 µm	1.9%



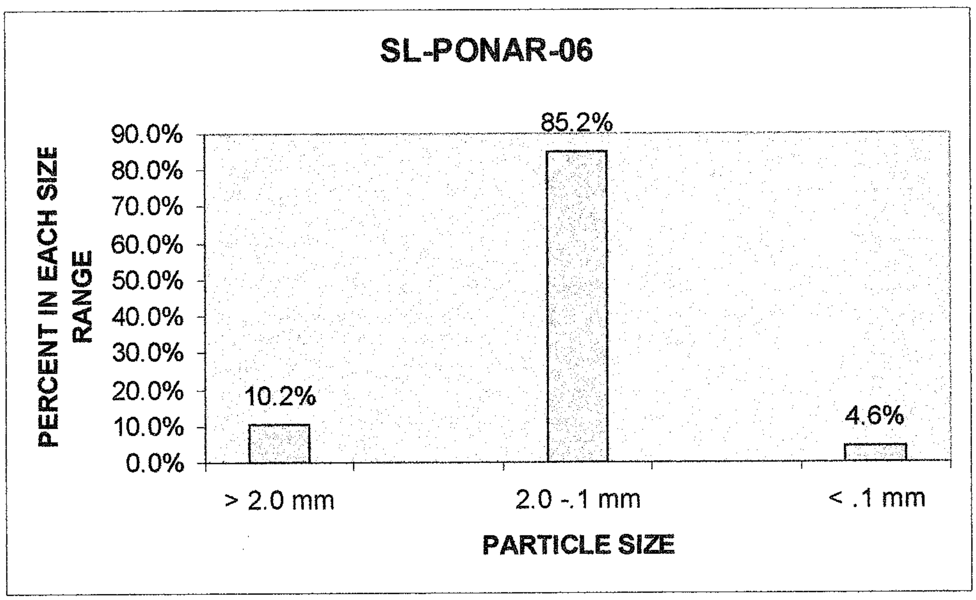
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-PONAR-06 AT 880X

Results for the sieve analysis for SL-PONAR-06 is as follows:

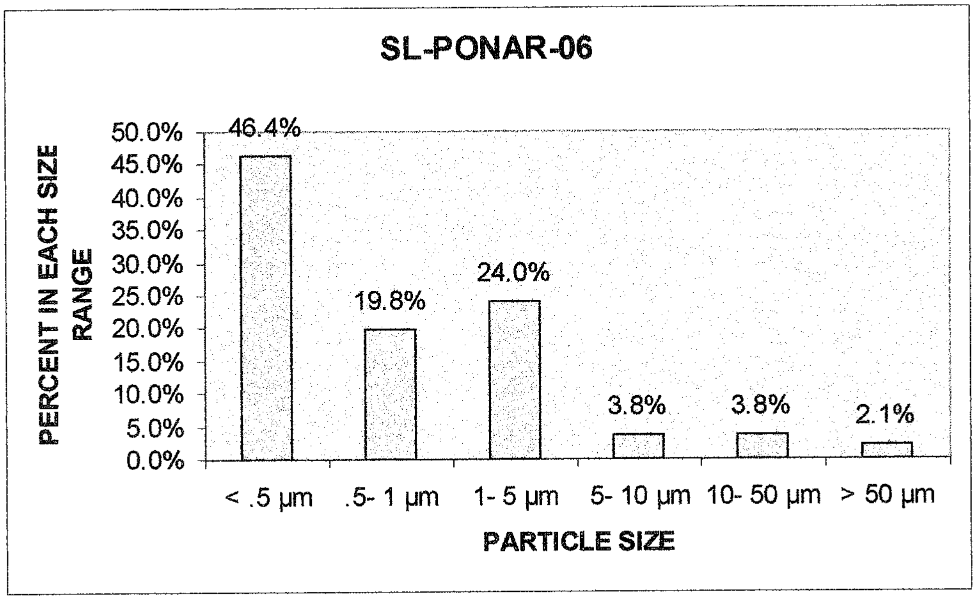
> 2 mm	10.2%
2 mm- 100 µm	85.2%
< 100 µm	4.6%



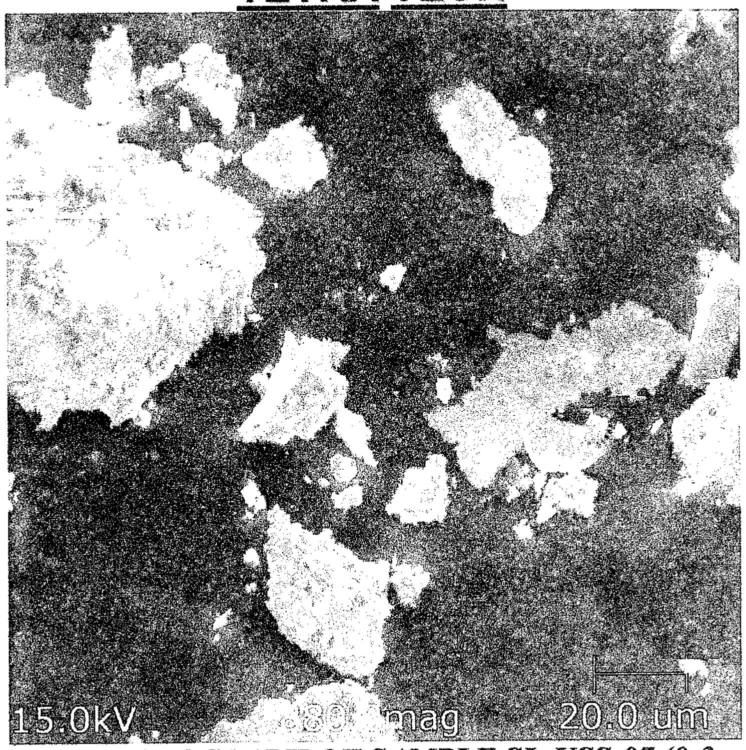
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-06 is as follows:

< .5 µm	46.4%
.5- 1 µm	19.8%
1- 5 µm	24.0%
5- 10 µm	3.8%
10- 50 µm	3.8%
> 50 µm	2.1%



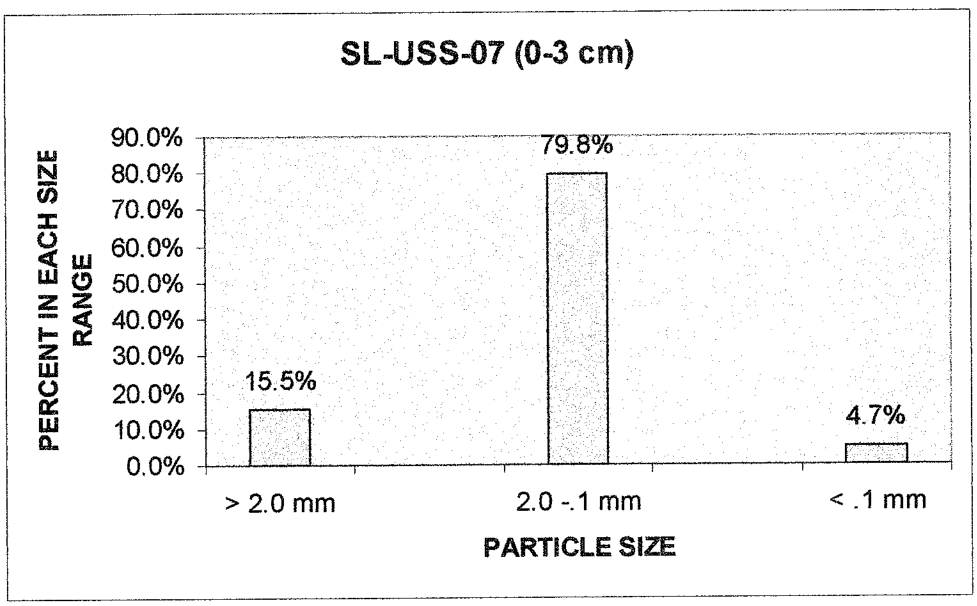
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH OF SAMPLE SL-USS-07 (0-3 cm)
AT 880X

Results for the sieve analysis for SL-USS-07 (0-3 cm) is as follows:

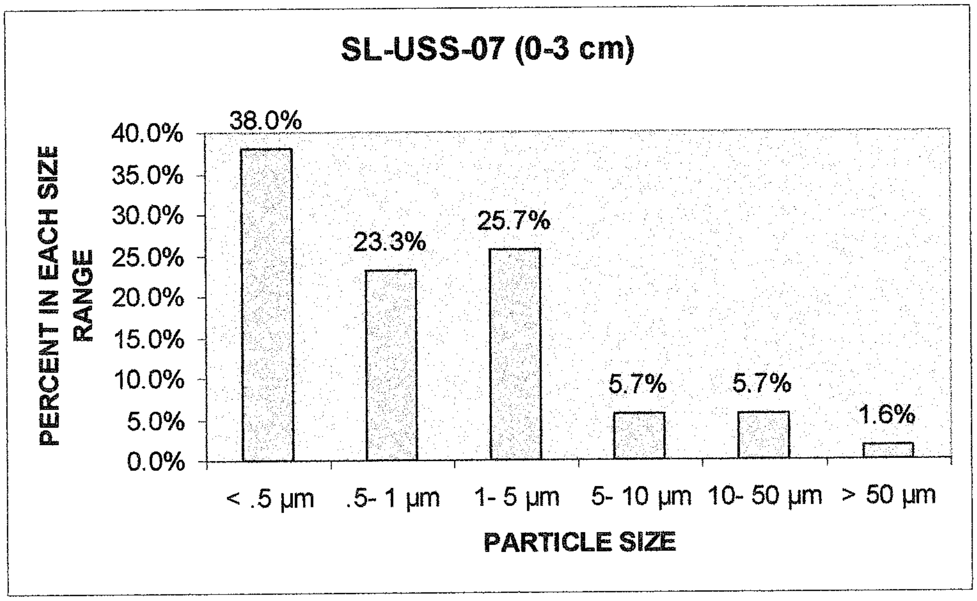
> 2 mm	15.5%
2 mm- 100 µm	79.8%
< 100 µm	4.7%



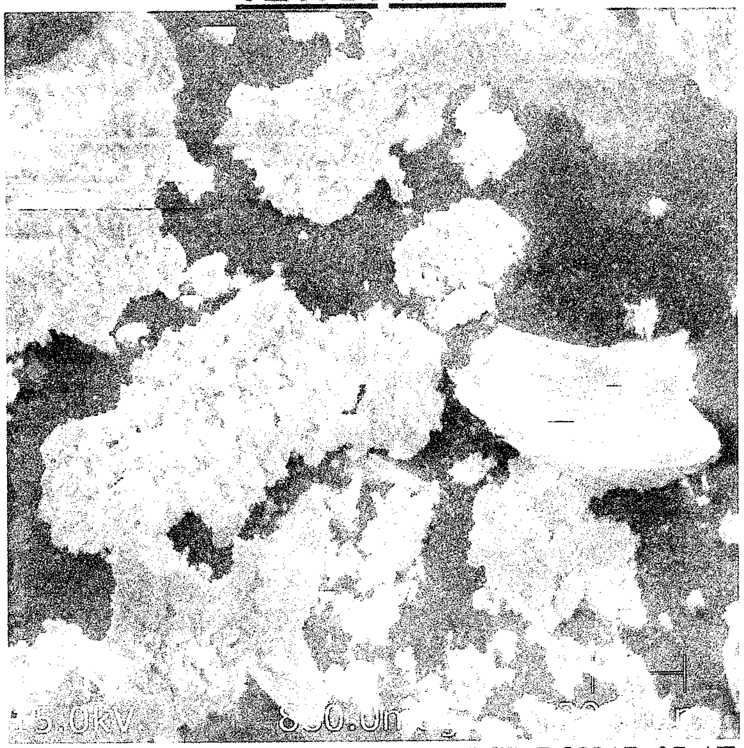
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-USS-07 (0-3 cm) is as follows:

< .5 µm	38.0%
.5- 1 µm	23.3%
1- 5 µm	25.7%
5- 10 µm	5.7%
10- 50 µm	5.7%
> 50 µm	1.6%



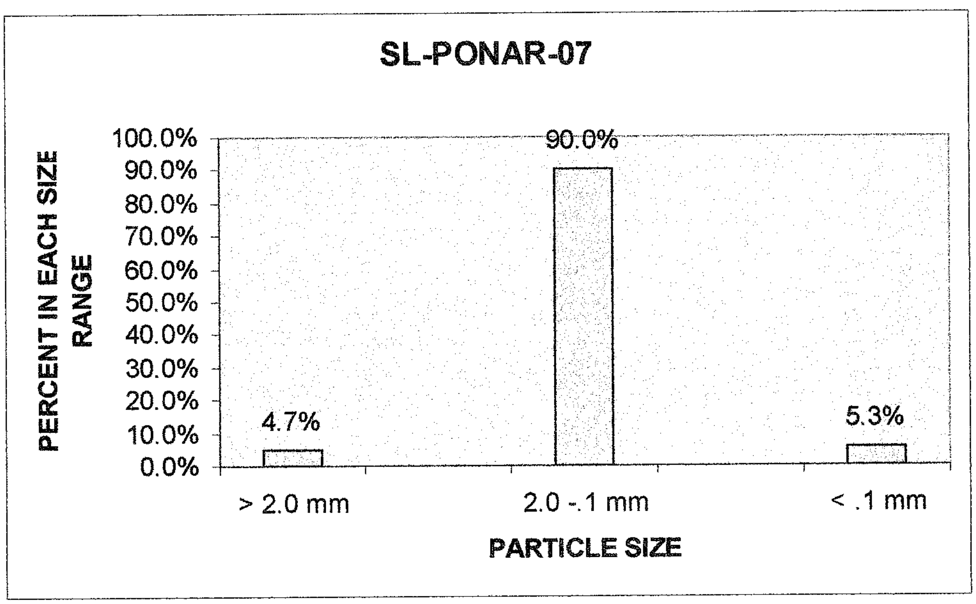
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-PONAR-07 AT 880X

Results for the sieve analysis for SL-PONAR-07 is as follows:

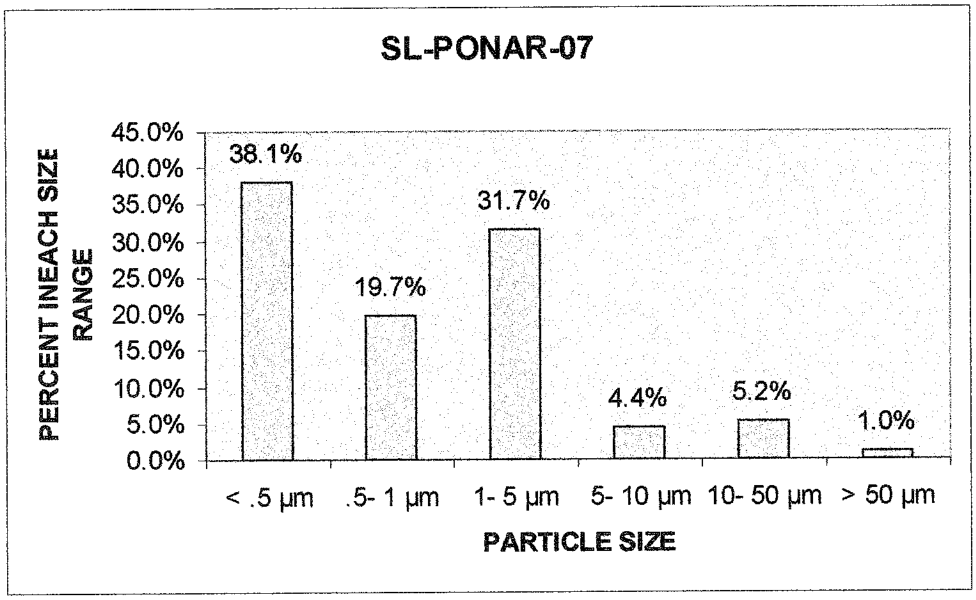
> 2 mm	4.7%
2 mm- 100 µm	90.0%
< 100 µm	5.3%



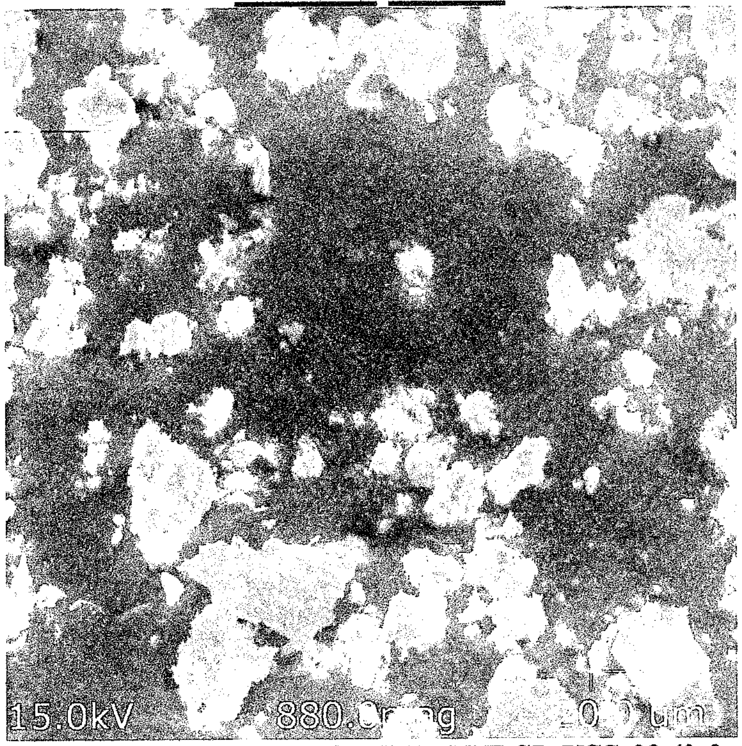
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-07 is as follows:

< .5 µm	38.1%
.5- 1 µm	19.7%
1- 5 µm	31.7%
5- 10 µm	4.4%
10- 50 µm	5.2%
> 50 µm	1.0%



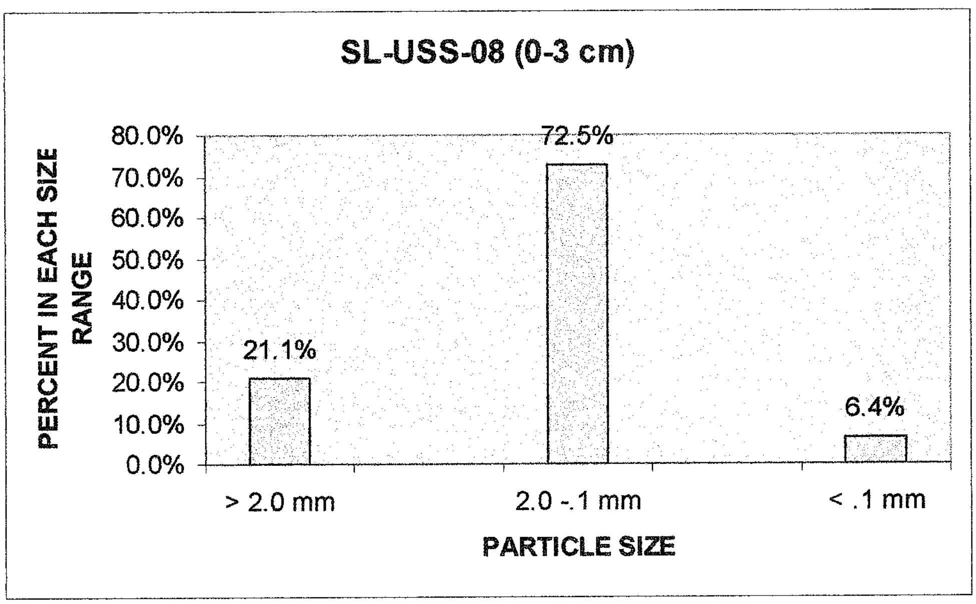
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-USS-08 (0-3 cm) AT 880X

Results for the sieve analysis for SL-USS-08 (0-3 cm) is as follows:

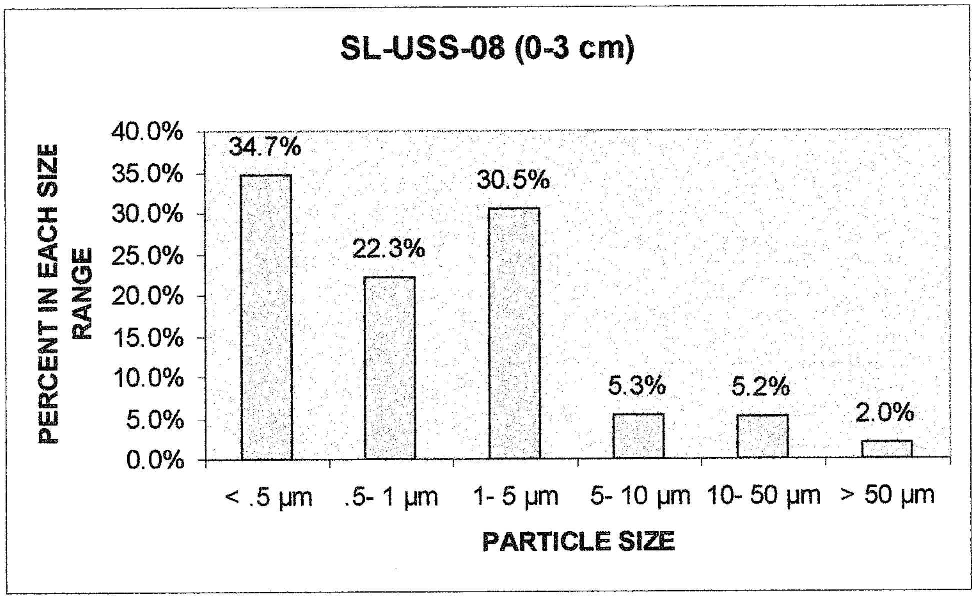
> 2 mm	21.1%
2 mm- 100 µm	72.5%
< 100 µm	6.4%



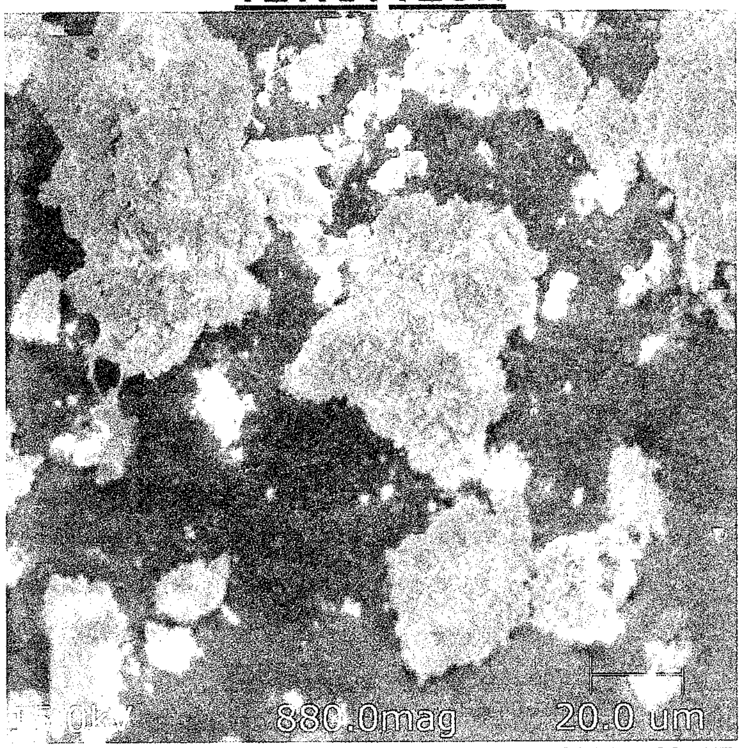
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-08 (0-3 cm) is as follows:

< .5 µm	34.7%
.5- 1 µm	22.3%
1- 5 µm	30.5%
5- 10 µm	5.3%
10- 50 µm	5.2%
> 50 µm	2.0%



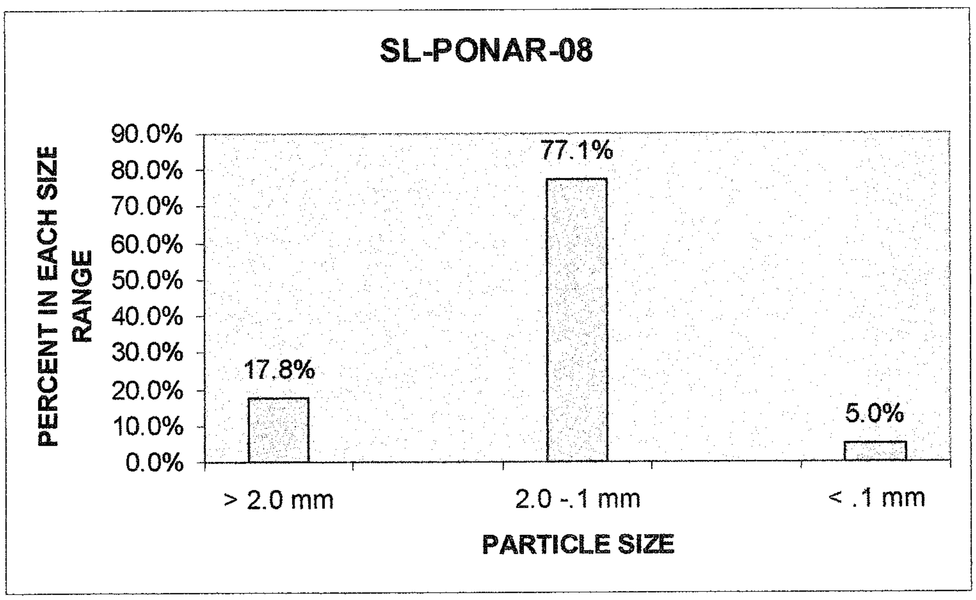
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-PONAR-08 AT 880X

Results for the sieve analysis for SL-PONAR-08 is as follows:

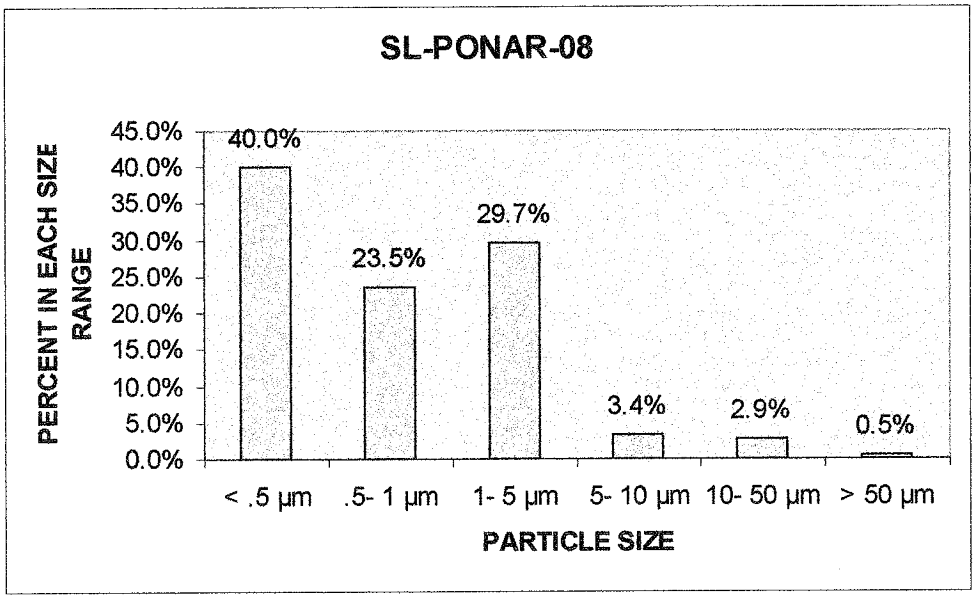
> 2 mm	17.8%
2 mm- 100 µm	77.1%
< 100 µm	5.0%



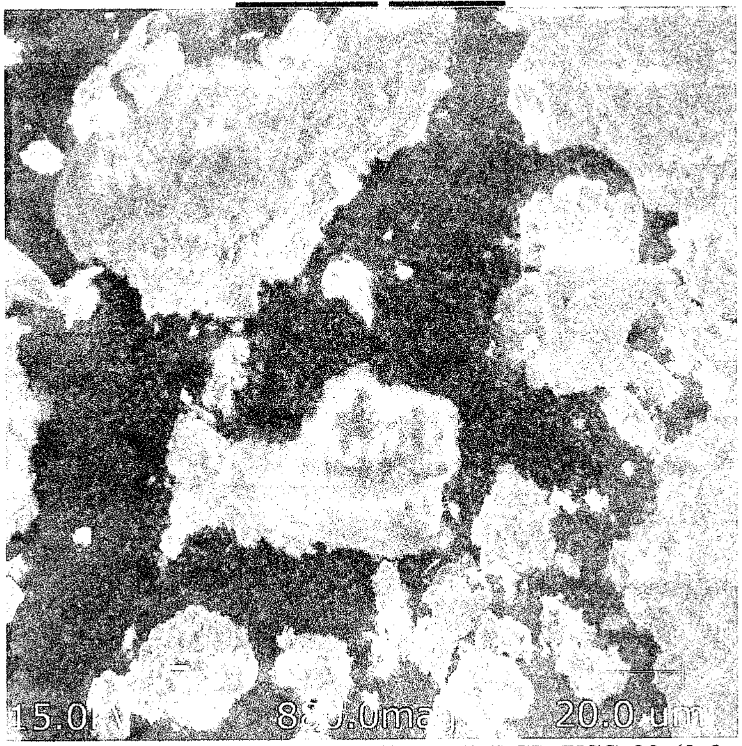
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-08 is as follows:

< .5 µm	40.0%
.5- 1 µm	23.5%
1- 5 µm	29.7%
5- 10 µm	3.4%
10- 50 µm	2.9%
> 50 µm	0.5%



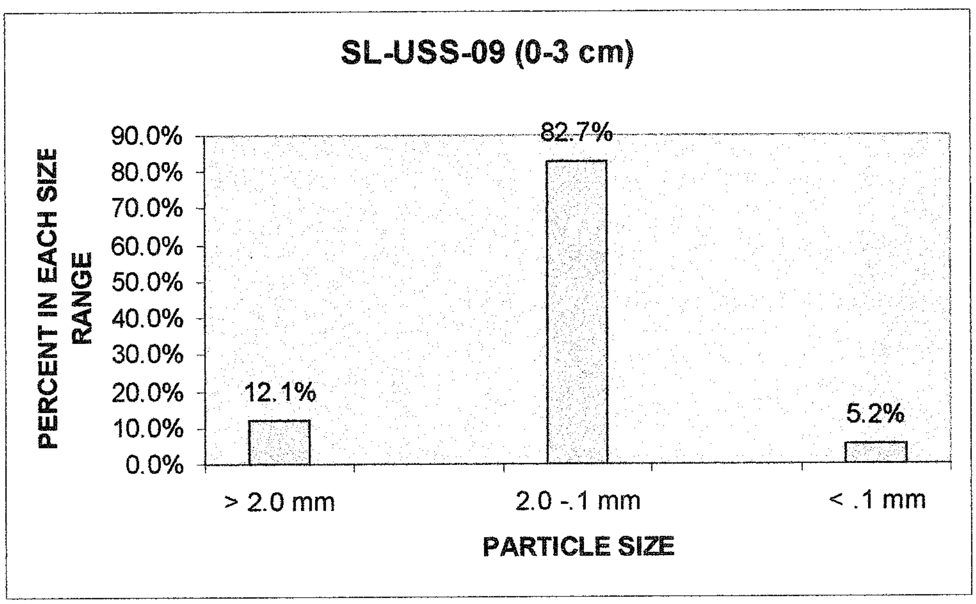
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-USS-09 (0-3 cm) AT 880X

Results for the sieve analysis for SL-USS-09 (0-3 cm) is as follows:

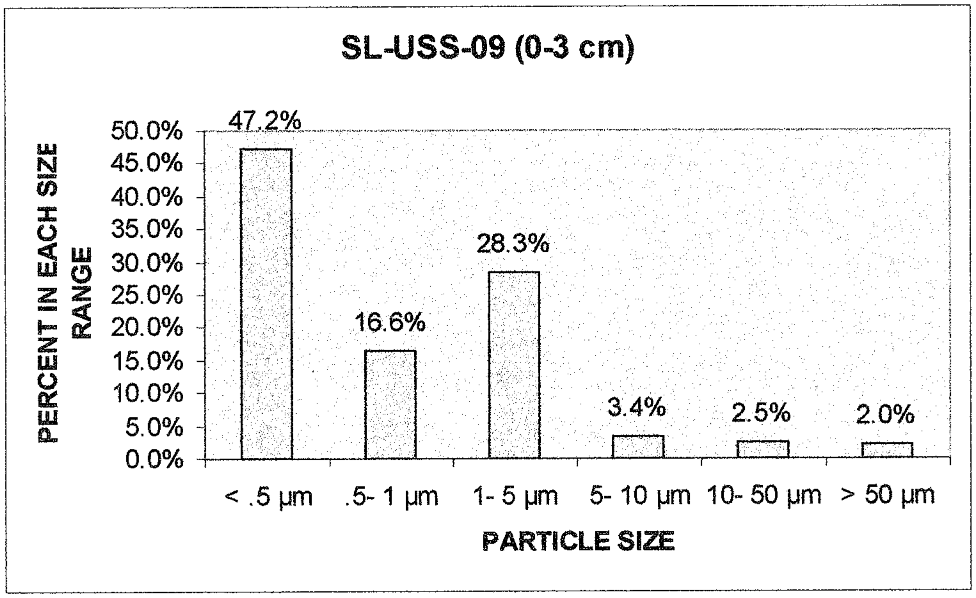
> 2 mm	12.1%
2 mm- 100 µm	82.7%
< 100 µm	5.2%



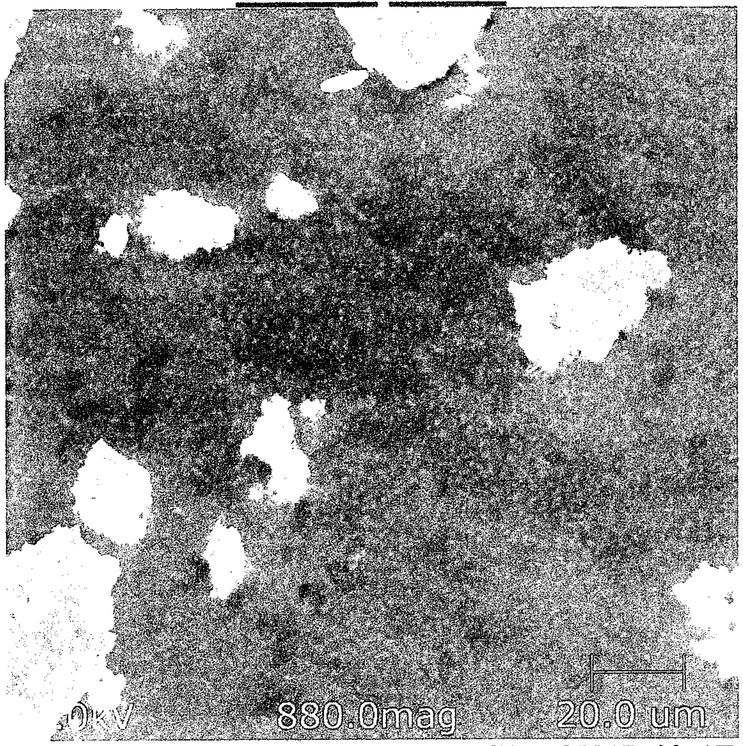
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-09 (0-3 cm) is as follows:

< .5 µm	47.2%
.5- 1 µm	16.6%
1- 5 µm	28.3%
5- 10 µm	3.4%
10- 50 µm	2.5%
> 50 µm	2.0%



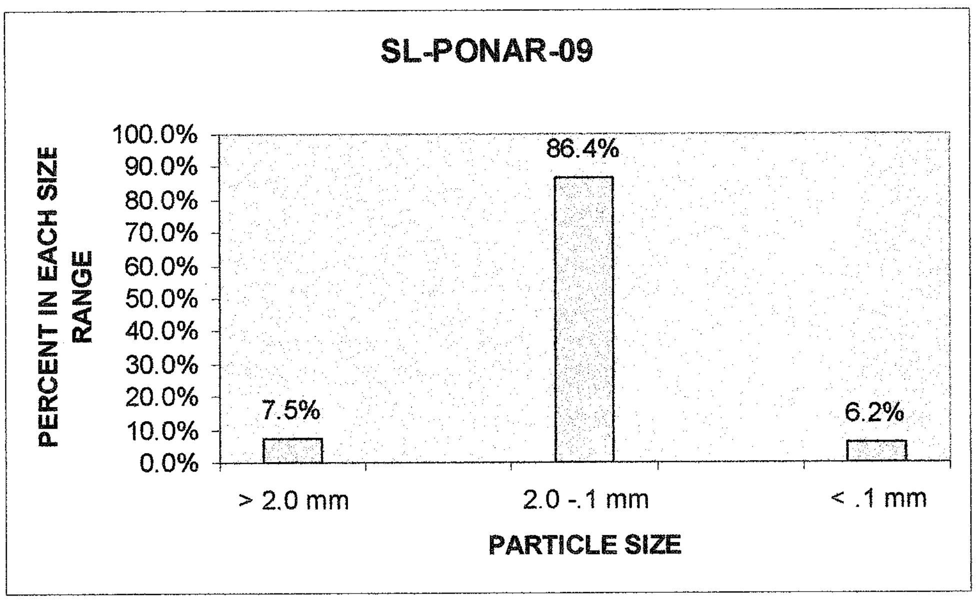
PARTICLE SIZING
FOR
TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-PONAR-09 AT 880X

Results for the sieve analysis for SL-PONAR-09 is as follows:

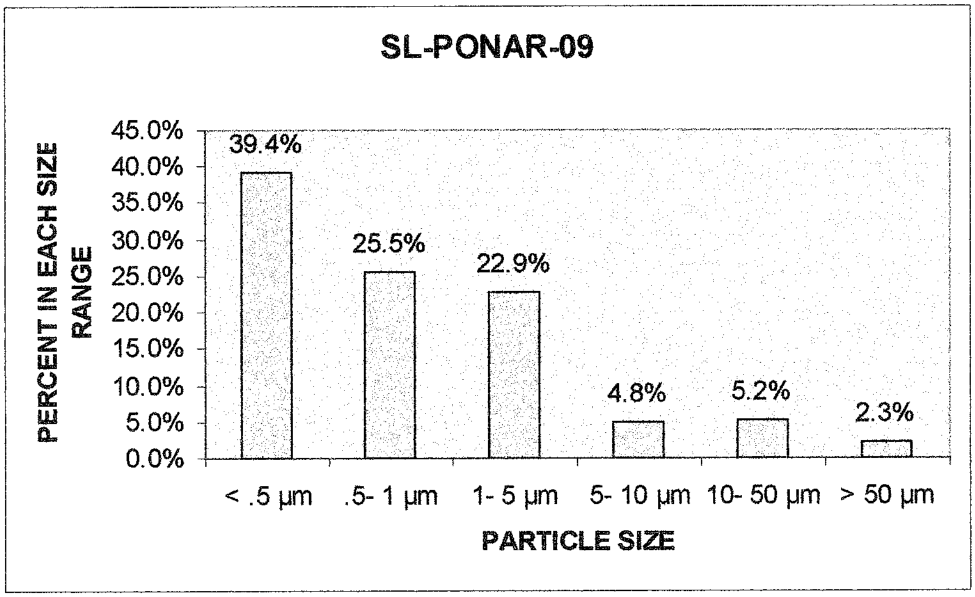
> 2 mm	7.5%
2 mm- 100 µm	86.4%
< 100 µm	6.2%



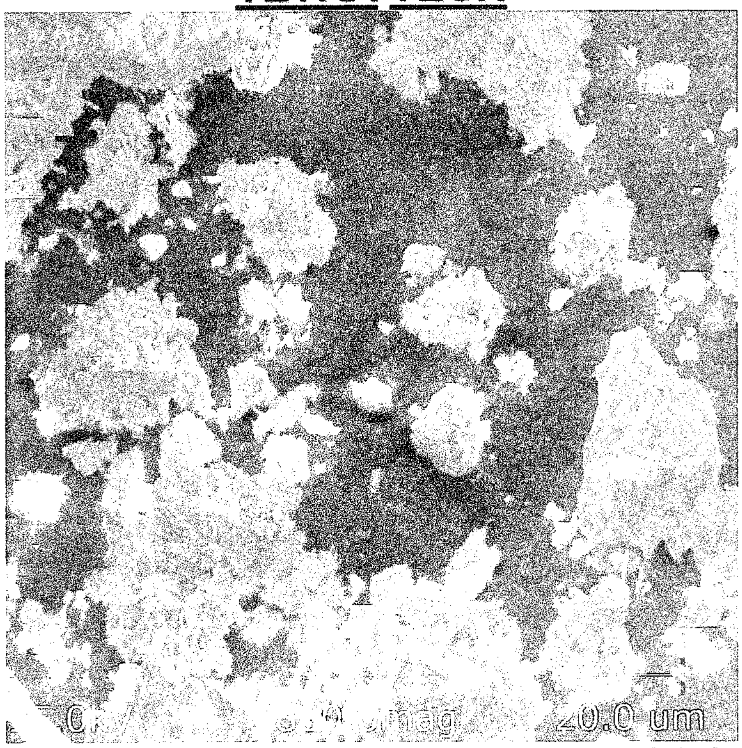
PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-09 is as follows:

< .5 µm	39.4%
.5- 1 µm	25.5%
1- 5 µm	22.9%
5- 10 µm	4.8%
10- 50 µm	5.2%
> 50 µm	2.3%



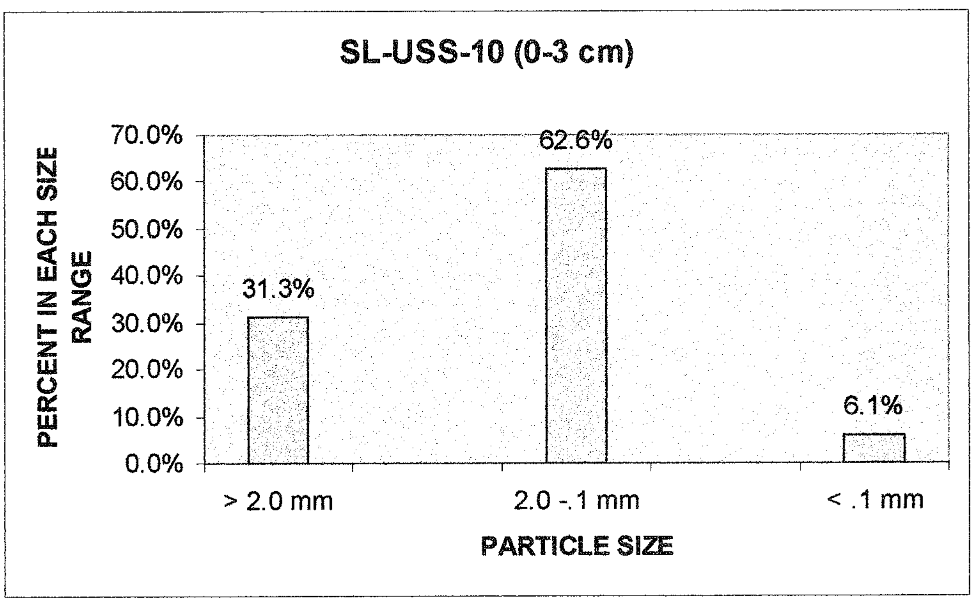
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-USS-10 (0-3 cm)
AT 880X

Results for the sieve analysis for SL-USS-10 (0-3 cm) is as follows:

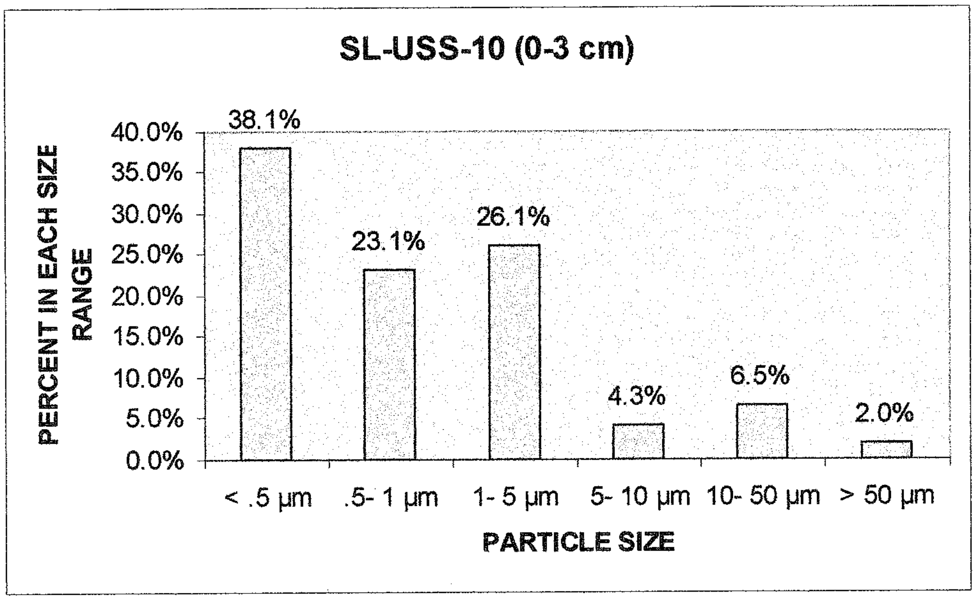
> 2 mm	31.3%
2 mm- 100 µm	62.6%
< 100 µm	6.1%



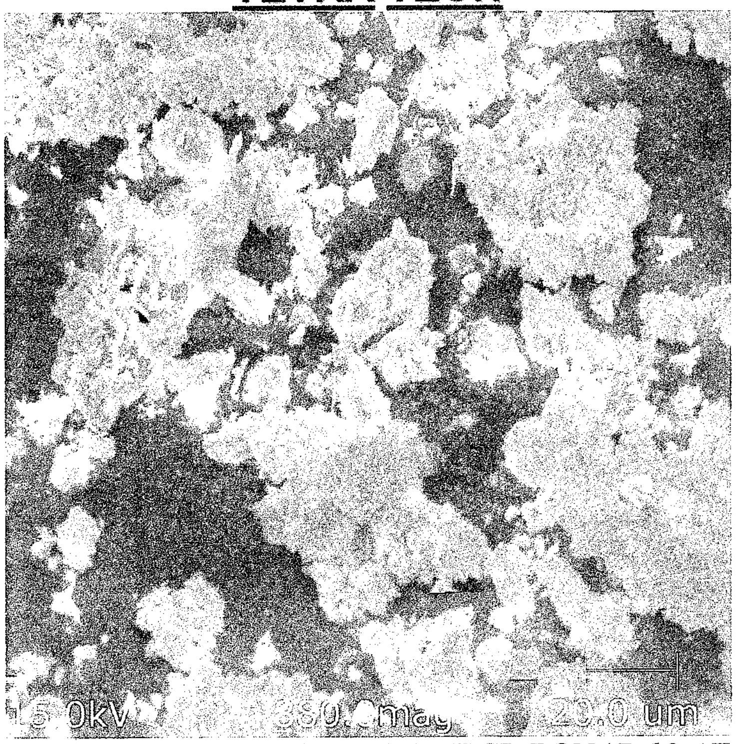
PARTICLE SIZING FOR TETRA TECH

Results for the SEM particle size analysis for SL-USS-10 (0-3 cm) is as follows:

< .5 µm	38.1%
.5- 1 µm	23.1%
1- 5 µm	26.1%
5- 10 µm	4.3%
10- 50 µm	6.5%
> 50 µm	2.0%



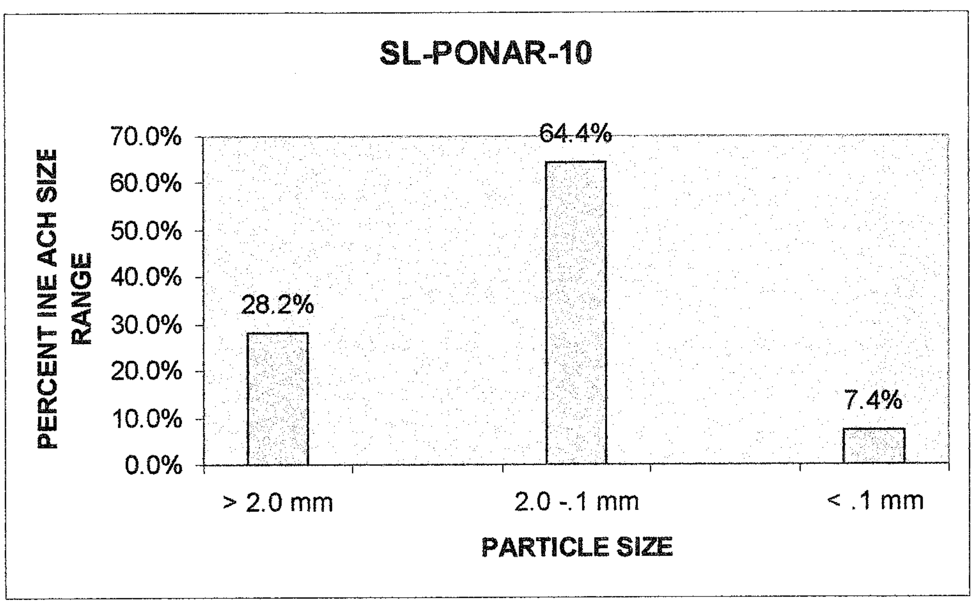
PARTICLE SIZING FOR TETRA TECH



PHOTOMICROGRAPH FOR SAMPLE SL-PONAR-10 AT 880X

Results for the sieve analysis for SL-PONAR-10 is as follows:

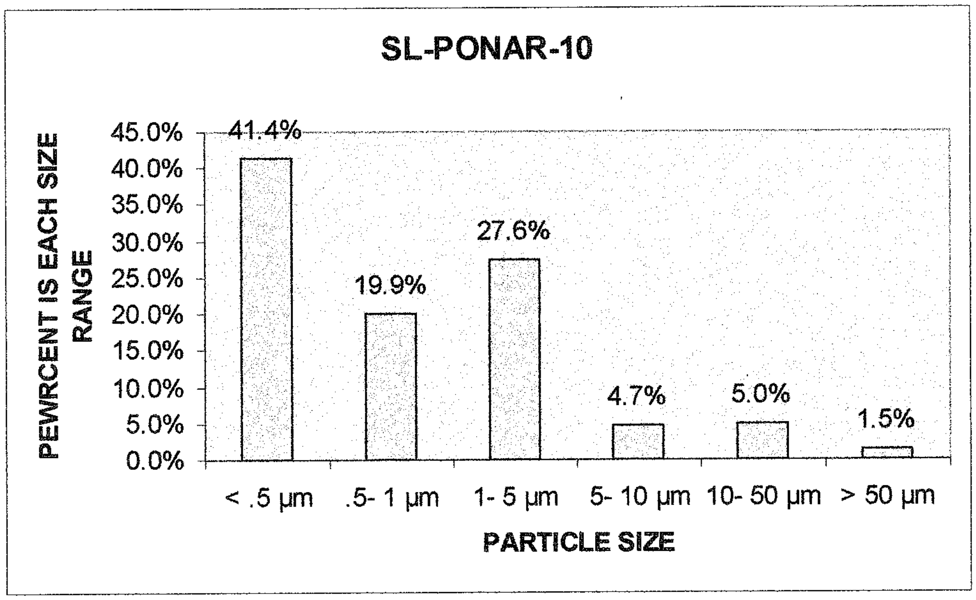
> 2 mm	28.2%
2 mm- 100 µm	64.4%
< 100 µm	7.4%



PARTICLE SIZING
FOR
TETRA TECH

Results for the SEM particle size analysis for SL-PONAR-10 is as follows:

< .5 µm	41.4%
.5- 1 µm	19.9%
1- 5 µm	27.6%
5- 10 µm	4.7%
10- 50 µm	5.0%
> 50 µm	1.5%



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Chicago, IL 60601
312-856-8700
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Chain of Custody Record

No. A0409065 Page 1 of 3

1548

Project name: USS Field Testing	TtEMI technical contact: Stephanie Wenning
Project number: G10534-4011-410302	TtEMI project manager: Julie Capri
Lab PO#:	Lab: Clayton Laboratory
Field samplers: Stephanie Wenning, Heidi Nemeth	Field samplers' signatures: [illegible]

Preservative Added: Ice

Sample ID	Sample Location	Date	Time	Matrix	MS / MSD	40 ml VOA	1 liter Amber	500 ml Poly	Sleeve	Glass Jar	VOA	SVOA	Pest/PCBs	Metals	TPH Purgeables	TPH Extractables	[illegible]
SL-USS-01 (0-3 cm)	Sylvan Lake	9/8/04	1000	Sediment						X							X
SL-USS-01 (3-6 cm)		9/8/04	1000							X							X
SL-USS-01 (6-9 cm)		9/8/04	1000							X							X
~~SL-USS-SW~~ SL-PONAR-01		9/8/04	1010							X							X
SL-USS-02 (0-3 cm)		9/8/04	1515							X							X
SL-USS-02 (3-6 cm)		9/8/04	1515							X							X
SL-USS-02 (6-9 cm)		9/8/04	1515							X							X
SL-PONAR-02		9/8/04	1525							X							X
SL-USS-03 (0-3 cm)		9/9/04	0955							X							X
SL-USS-03 (3-6 cm)		9/9/04	0955							X							X
SL-USS-03 (6-9 cm)		9/9/04	0955							X							X
SL-PONAR-03	Sylvan Lake	9/9/04	1050	Sediment						X							X

	Name (print)	Company Name	Date	Time
Relinquished by: Stephanie Wenning	Stephanie Wenning	TtEMI	9/11/04	1230
Received by:				
Relinquished by:				
Received by:				
Relinquished by:				
Received by: K. Smith	K. Smith	Clayton	9/13/04	11:30 am

Turnaround time/remarks:
Attn: Alan Seagrave

Fed Ex #:

WHITE-Laboratory Copy YELLOW-Sample Tracker PINK-File Copy

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Chain of Custody Record No. ______

Page 2 of 3

1549

Lab PO#:		Lab: Clayton Laboratory
Project name: USS Ball Testing	TtEMI technical contact: Stephanie Wenning	Field samplers: Stephanie Wenning, Keith Nemeth
Project number: G1053144011 4A0302	TtEMI project manager: Julie Capri	Field samplers' signatures: Stephanie Wenning, Keith Nemeth

Preservative Added: FCE

Sample ID	Sample Location	Date	Time	Matrix	MS / MSD	40 ml VOA	1 liter Amber	500 ml Poly	Sleeve	Glass Jar	VOA	SVOA	Pest/PCBs	Metals	TPH Purgeables	TPH Extractables	XL Particle Size
SL-USS-04 (0-3)	Sylvan Lake	9/9/04	1100	Sediment						2							X
SL-USS-04 (3-6)	↓	↓	↓	↓						2							X
SL-USS-04 (6-9)										2							X
SL-PONAR-04			1110							2							X
SL-USS-05 (0-3)			1155							2							X
~~BM~~ SL-USS-05 (3-6)			1155							2							X
SL-USS-05 (6-9			1155							2							X
SL-PONAR-05			1205							2							X
SL-USS-06 (0-3)			1540							2							X
SL-PONAR-06			1550							2							X
SL-USS-07 (0-3)			1605							2							X
SL-PONAR-07	Sylvan Lake	9/9/04	1615	Sediment						2							X

	Name (print)	Company Name	Date	Time
Relinquished by: Stephanie Wenning	Stephanie Wenning	TtEMI	9/10/04	1230
Received by:				
Relinquished by:				
Received by:				
Relinquished by: KB				
Received by:				

Turnaround time/remarks:

Attn: Alan Seagrave

Fed Ex #:

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Chicago, IL 60601
312-856-8700
Fax 312-938-0118

Chain of Custody Record No. 1557

Lab PO#:

Lab: Clayton Laboratory

Project name: USS Field Testing

TtEMI technical contact: Stephanie Wenning

Field samplers: Stephanie Wenning, Heidi Nemeth

Project number: G1053 4401 149 0302

TtEMI project manager: Julie Capri

Field samplers' signatures: [signatures]

Preservative Added: ICE

Sample ID	Sample Location	Date	Time	Matrix	MS / MSD	40 ml VOA	1 liter Amber	500 ml Poly	Sleeve	Glass Jar	VOA	SVOA	Pest/PCBs	Metals	TPH Purgeables	TPH Extractables	Sed. Particle Size
SL-USS-08 (0-3)	Sylvan Lake	9/9/04	1645	Sed.						X							X
SL-PONAR-08	↓	9/9/04	1655	Sed.						X							X
SL-USS-09 (0-3)	↓	9/9/04	1420	Sed.						X							X
SL-PONAR-09	↓	9/9/04	1430	Sed.						X							X
SL-USS-10 (0-3)	↓	9/10/04	1225	Sed.						X							X
SL-PONAR-10	↓	9/10/04	1315	Sed.						X							X

	Name (print)	Company Name	Date	Time
Relinquished by: Stephanie Wenning	Stephanie Wenning	TtEMI	9/10/04	1230
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Received by:				
Relinquished by:				
Received by:				

Turnaround time/remarks:

Attn: Alan Seagrave

Fed Ex #:

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SAMPLE #	COARSE FRACTION	PERCENTAGE	MEDIUM FRACTION	PERCENTAGE	FINE FRACTION	PERCENTAGE	TOTAL
1	22.4	21.9%	73.3	71.8%	6.4	6.3%	102.1
2	36.8	38.7%	48.5	51.1%	9.7	10.2%	95
3	40.1	43.4%	39.3	42.6%	12.9	14.0%	92.3
4	8.8	8.4%	91.6	87.8%	3.9	3.7%	104.3
5	28.2	29.4%	61.2	63.8%	6.6	6.9%	96
6	59.4	51.1%	44.7	38.4%	12.2	10.5%	116.3
7	57.7	64.1%	22.7	25.2%	9.6	10.7%	90
8	22.6	21.6%	70.9	67.7%	11.2	10.7%	104.7
9	15.3	14.0%	84.6	77.5%	9.3	8.5%	109.2
10	52.5	55.8%	32	34.0%	9.6	10.2%	94.1
11	43.2	51.7%	26.7	32.0%	13.6	16.3%	83.5
12	24.8	59.8%	11.3	27.2%	5.4	13.0%	41.5
13	15.9	13.6%	94.1	80.5%	6.9	5.9%	116.9
14	40.7	44.6%	36	39.4%	14.6	16.0%	91.3
15	42.7	42.9%	37.8	38.0%	19	19.1%	99.5
16	7.1	10.6%	53.1	79.3%	6.8	10.1%	67
17	20.7	22.0%	65.6	69.6%	7.9	8.4%	94.2
18	59.8	59.3%	31.8	31.5%	9.3	9.2%	100.9
19	61.8	61.9%	29.3	29.4%	8.7	8.7%	99.8
20	15.9	25.3%	38.8	61.7%	8.2	13.0%	62.9
21	12.4	13.4%	75.7	82.1%	4.1	4.4%	92.2
22	8.3	10.2%	69	85.2%	3.7	4.6%	81
23	14.4	15.5%	74.3	79.8%	4.4	4.7%	93.1
24	4.1	4.7%	78.6	90.0%	4.6	5.3%	87.3
25	19.1	21.1%	65.6	72.5%	5.8	6.4%	90.5
26	19.8	17.8%	85.7	77.1%	5.6	5.0%	111.1
27	9.5	12.1%	65	82.7%	4.1	5.2%	78.6
28	6.4	7.5%	74.1	86.4%	5.3	6.2%	85.8
29	31.2	31.3%	62.4	62.6%	6.1	6.1%	99.7
30	26.8	28.2%	61.2	64.4%	7	7.4%	95

ATTACHMENT

TRIP REPORT: FIELD EVALUATION OF PROTOTYPE SEDIMENT SAMPLER

AT SYLVAN LAKE, MICHIGAN

Trip Report:

Field Evaluation of Prototype Sediment Sampler at Sylvan Lake, Michigan

Dates: September 8-9, 2004

Location: Sylvan Lake, Michigan

Participants: Brian Schumacher, Ph.D., U. S. Environmental Protection Agency
John Zimmerman, U. S. Environmental Protection Agency
Elliott Smith, Ph.D., AScI Corporation
Stephanie Wenning, Tetra Tech EM Incorporated
Heidi Nemeth, Tetra Tech EM Incorporated
Luke Clyburn, Noble Odyssey Foundation

Purpose of Trip:

The primary purpose of the trip to Sylvan Lake, Michigan, was to collect a suite of sediment samples for use in the evaluation of the prototype Undisturbed Surface Sediment (USS) sampler. The sample collection is part of an ongoing research effort being conducted by the U.S. Environmental Protection Agency, National Exposure Research Laboratory, Characterization & Monitoring Branch in Las Vegas, Nevada. The research effort is concerned with assessing differences between standard and innovative sampling procedures for collection of an undisturbed sediment surface.

The following portion of the report presents information for the date and time during which the field team was sampling in Michigan. Included for each day's observations are the identification and description of sampling locations; discussions of safety and logistical issues; weather and other field-related conditions; contacts made; and general descriptions of sampling activities.

Day 1 (September 8, 2004):

On the morning of September 8, sampling equipment and materials were loaded on the sampling boat for transport to the initial sampling area. Dr. Elliot Smith provided a basic health & safety (H&S) briefing, including general H&S procedures for use of life vests, hard hats, and water craft safety. All members of the sampling team signed statements verifying that they had read and understood the H&S plan. Once a check had been made to ensure that all needed equipment was on board, the sampling team set sail to test the sediment samplers.

Weather: At 1000, conditions were partly cloudy and breezy; ~ 65 °F. By 1400, the sky was overcast and the winds picked up with intermittent gusts of ~ 15 mph; ~ 75 °F.

<u>Sampling location #1</u>: Southwest quadrant of Sylvan Lake.

Upon arrival at the first sampling area, the boat was triply anchored and each member of the sampling crew donned their safety gear (steel toe shoes, safety glasses, hard hats and appropriate gloves). Additional personal protective and safety equipment (e.g., hearing protection, first aid kit) was readily available for use, if needed. During this time, Mr. Clyburn suited up to begin the underwater filming of the samplers.

As Dr. Smith assembled the USS sampler, he explained the principles of the sampler operation. Once the diver was in place, the USS sampler was lowered to the lake bottom, inserted, and retrieved.

The operation of the plunger used to advance the sediment up the core barrel for sampling had a few glitches (e.g., ease of assembly, advancement of the sample up the core barrel) but these difficulties were overcome by the sampling team. Once the core had been advanced to the top of the core barrel, the core slicing apparatus was placed on the top of the core barrel, the core advanced the proper distance, the slicing blade passed through the sample, and the three samples specified in the quality assurance project plan (QAPP) were taken. Each time a sampling attempt was made, the boat was moved a few feet to ensure an undisturbed sediment surface. The comparison samples were retrieved with the ponar sampler. Collection of only the top 3 cm of sediment from the ponar sampler was difficult as the sample tended to spread out and mix together upon release from the sampler into the sampling preparation pan.

The USS sampler was then reassembled, the boat moved, and a second sampling event was attempted. This attempt failed to retrieve a sample because the core catcher failed to deploy and hold the sediment sample in the core barrel as the sampler broke the water surface. The core catcher appeared to fail because the cutting shoe did not advance down the core barrel upon removal of the barrel from the bottom of the lake. The design of the cutting shoe was such that the fingers of the core catcher are sandwiched between the cutting shoe and the core barrel until the cutting shoe advances during sample retrieval and the fingers are released.

The USS sampler was then decontaminated, reassembled, and two more attempts were made with no retrieval of a sample. It appeared that as the core barrel was advanced into the sediment, the sediment got into the space between the core barrel and the cutting shoe assembly. The friction caused by this sediment stopped the cutting shoe from advancing upon removal from the lake bottom. One modification was attempted in the field to alleviate this problem. A foam tape was applied to the core barrel just above the top of the cutting shoe during the assembly of the USS sampler in an effort to block the sediment from entering the space. On the third attempt, a sample was retained in the core barrel and samples were collected. The Ponar sampler was then used and a subsample was taken from the top 3 cm.

After lunch, samples from three more areas around sample location 1 were retrieved with each of the two samplers. The USS sampler continued to have problems retaining the samples. This problem was overcome by attaching the cutting shoe in its fully extended position so that the core catcher fingers were already released as the core barrel was inserted into the sediment.

Day 2 (September 9, 2004):

On the morning of September 9, sampling equipment and materials were loaded on the sampling boat for transport to the sampling area. Dr. Elliot Smith provided a basic health & safety (H&S) briefing, including general H&S procedures for use of life vests, hard hats, and water craft safety. Once a check had been made to ensure that all needed equipment was on board, the sampling team traveled back to the first sampling location.

Weather: At 0800, the sky was overcast and the wind breezy with intermittent gusts to ~15 mph; ~65 °F. At 1400, it was clear and breezy with intermittent gusts to ~15 mph; ~78 °F.

Upon arrival at the first sampling location, the boat was triply anchored and each member of the sampling crew donned their safety gear (steel toe shoes, safety glasses, hard hats and appropriate gloves). Additional personal protective and safety equipment (e.g., hearing protection, first aid kit) was readily available for use, if needed. Mr. Clyburn filmed the above water assembly of the samplers and procedures for preparing and collecting the retrieved sediment samples.

The last samples from location 1 were collected with both samplers and the crew returned to the shore for lunch. After lunch, the crew, minus Mr. Clyburn, returned to the boat and headed to the second sampling location.

Sampling location #2: Northwest quadrant of Sylvan Lake.

Upon arrival at the second sampling location, a check of health and safety equipment was made prior to any sampling activities. The second location was in deeper water than the first location. At this location, five samples were taken with each type of sediment sampler. The samples at this location were collected only of the top 3 cm of each core. On one of the cores taken with the USS sampler, a critter (probably a Daphnid) was seen swimming around in the water above the sediment sample and plants.

All but one of the samples needed from this location were taken before the end of the day. The sampling crew, minus Dr. Schumacher and Mr. Zimmerman, was to return the following day to complete the last sample at the second location.

General Discussion:

The ability and consistency of the core catcher to close and maintain the sample in the USS sampler was a major concern throughout the sampling trip. Loss of a sample is costly in terms of time and effort in the field. Discussions among the sampling crew concerning this issue lead to multiple variations/modifications of the original USS sampler design in an effort to improve the core catcher's efficiency. The modifications included using the foam tape or duct tape to prevent sediment from entering between the cutting shoe and core catcher, using electrical tape on the screws used to hold the core catcher and cutting shoe in place to prevent sediment entry into the space between the cutting shoe and core catcher, and screwing the cutting shoe in place with two additional screws. Dr. Smith believed that most of the core catcher problems would be alleviated by using a 4-inch diameter core tube since core catchers can be purchased in the 4-inch size while for the 6-inch core tube, the core catcher had to be made from two core catchers.

The ability of the USS sampler to collect an undisturbed sample was clearly demonstrated (see Fig. 2). The core slicing device worked very well. The plunger mechanism was awkward but once in place worked very well. A coarser thread on the plunger would make the plunger more effective and quicker to use.

Numerous variations on the steps in sampling protocol were used (i.e., rarely did the sampling crew follow the same pattern of events during sample collection with the USS sampler). The variations were mainly due to the learning experience of the crew in the field and due to the adjustments to the USS sampler that were necessary to make it work more efficiently.

The USS sampler was bulky and not very conducive to being used by a 2-person crew and certainly not a 1-person crew.

Mr. Clyburn noted that during his underwater filming of the USS sampler that if the bottom surface was uneven and soft, the USS sampler would sink its feet into the sediments at uneven rates resulting in a tilted USS sampler. While this tilting did not prevent the collection of an undisturbed sample, it did lead to an uneven surface of the collected core and presumably a non-uniform depth cut from the collected core (i.e., on the thinner edge, perhaps only 1st cm was collected leaving the 2nd and 3rd cm to be collected in the second depth sample and not in the original surface sample). A thick wire was wrapped around the legs of the sampler in an effort to increase the sediment surface contact area but this attempted fix was found to be ineffective.

Future Directions:

The USS sampler needs to be modified to better ensure the ability and effectiveness of the core catcher to close and hold the sediment sample once the sampler breaks the water surface during retrieval.

The development of a 4-inch diameter USS sampler is recommended to help alleviate the problem with the core catcher and to make the USS sampler more “user-friendly” in terms of weight, ease of use, and the ability to be used effectively by a 1- or 2-person crew.

An investigation into using larger feet to help prevent the sampler from sinking unevenly into the sediment may improve the USS sampler’s ability to collect an even sediment thickness across the surface layer.

Additional testing of the USS sampler in the field is necessary to establish a fixed sampling protocol and to test any modifications to the USS sampler that resulted from the field sampling effort.

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