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FINAL REPORT
DREDGED MATERIAL SEPARATION TECHNOLOGY AT U.S. COAST GUARD, TRAINING CENTER, CAPE MAY, NEW JERSEY

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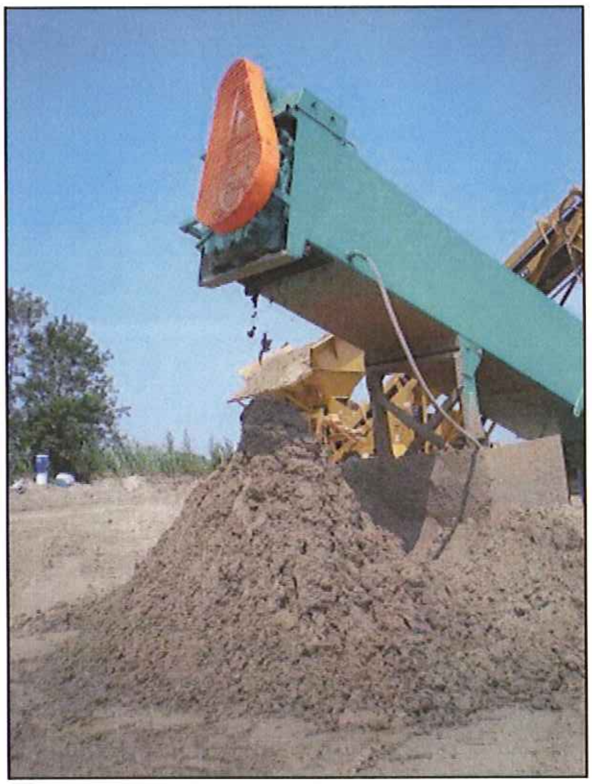
Project 205011.1



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EXECUTIVE SUMMARY

Ocean and Coastal Consultants, Inc. (OCC), partnering with Brice Environmental, Inc. (Brice) has prepared this report of findings for the Phase II Dredged Material Separation Technology Demonstration Project. Funding for this study was provided through an I-Boat NJ Program grant from the New Jersey Department of Transportation – Office of Maritime Resources (NJDOT – OMR). The purpose of the study was to investigate the feasibility of separating sand from silts and clays in a Confined Disposal Facility (CDF), beneficially using that material, and designing a mobile system to cost-effectively excavate material from coastal New Jersey's CDFs. The project was initially planned to be carried out at Nummy Island (Site #103), but changed to Site #3 at the U.S. Coast Guard Training Center (TRACEN) in Cape May, NJ due to planning and logistic issues at Nummy Island. In-kind services for the Dredged Material (DM) Separation Project were provided by the Cape May County Municipal Utilities Authority in the form of supplying recycled mixed colored glass cullet and delivering it to USCG TRACEN, Cape May, NJ, at no charge.

A wet separation system was designed for this demonstration project. The specifications for wet separation included: (1) separating the sand fraction from the silt and clay (fine) fraction of the DM to a degree sufficient for meeting several NJDOT Standard Soil Aggregate Gradations, (2) dewatering the fine fraction following separation from the sand and leaving the fines within the CDF, and (3) minimizing process water use and retaining the water in the CDF. In this project, sand was defined as material greater than 0.074 mm (No. 200 sieve). Material smaller than this comprised the silt and clay (fine) fractions of the DM. Fines are typically difficult to dewater and have little use due to having poor hydraulic and geotechnical properties.

An analytical testing plan for water and dredged material was established in accordance with the Acceptable Use Determination issued by the New Jersey Department of Environmental Protection (NJDEP) to the USCG in July 2006. Sediment and water samples were collected from various areas within the CDF and at various times during the separation process. Only the separated fine portion of the DM contained analytes at concentrations above regulatory standards (New Jersey Soil Cleanup Criteria, both Residential and Non-residential). These were arsenic at 22.5 mg/Kg and Berylium at 1.1 mg/Kg.

Several analytes were detected in both the decant water (supernatant) and supplemental site water from Cape May Inlet that were above NJ Ground Water Quality Standards. In fact, the water taken from Cape May Inlet may be directly responsible for the addition of trace quantities of Aluminum, Iron, Manganese, Sodium, Lead and Selenium into the separation process.

Site #3 at the USCG Training Center in Cape May contains several hundred thousand cubic yards of DM. Approximately 1,066 cubic yards of clean sand were produced during a field demonstration that began on June 28, and ended on July 30, 2006 with completion of processing and mixing. A quantity of 1,000 cubic yards of clean, processed sand was mixed with 1,600 cubic yards of crushed glass to create a total of 2,000 cubic yards of material that met a NJDOT specification for construction aggregate. The crushed glass has a much higher void ratio than the sand, and this accounts for the apparent discrepancy in yardage.

On July 17, a site visit was conducted by the NJDOT for the U.S. Army Corps of Engineers, the NJDEP, Cape May County, the Borough of Stone Harbor, Stockton State College and the USCG to observe the separation process.

In December 2006, the 2,000 cubic yards of sand/ glass blend material was used as structural fill in the NJDOT's Route 52 causeway reconstruction project between Somers Point and Ocean City. The blended material was tested and gradation results show this material can be classified as I-13 material according to the NJDOT's Standard Soil Aggregate Gradations. Additionally, the sandy portion of the separated material (not blended with glass) was tested and meets the NJDOT specification for Zone 3 material.

Clean sand, separated from the DM at Site #3, was also combined with Recycled Concrete Aggregate (RCA) and tested. RCA tends to have very low permeability and the addition of sand improved water flow through the material. Testing of the RCA/ separated sand mix showed increased permeability with an acceptable decrease in the California Bearing Ratio (CBR). A coarser grain size sand would improve permeability even more.

A cost analysis including mobilization, setup and support, material processing, material mixing, site restoration and demobilization was conducted based on the demonstration project. Costs for separating approximately 1,066 cubic yards during the demonstration project were $90.92 per cubic yard. However, as the scale of future projects increase, the estimated cost per cubic yard will decrease. Based on the costs of the demonstration project, and using an implementation cost model similar to a mining operation, the estimated cost for separating 500,000 cubic yards of material is $17.67 per cubic yard.

While this cost per cubic yard is higher than the market value of the product, there are certain benefits that accrue to society through the excavation of material from CDFs and the beneficial use of the material. An initial analysis of these benefits was conducted as part of this study. Economic benefits include local taxes related to property value, state sales taxes, expenditures by boaters, willingness to pay for boating days, and economic impacts resulting from changes in quarry activities. More economic research needs to be done, but it is clear that dredged material management decisions can not be made solely on the price of substitute aggregate materials alone.

Successful completion of the demonstration project suggests that large scale CDF mining to separate sandy material from fines is a viable method for reclaiming CDF capacity. Additionally, amending the sandy fraction with other recycled materials (e.g. crushed glass or recycled concrete aggregate) can provide a resource for various industries including construction and aggregate production.

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1. INTRODUCTION

In July, 2006, OCC (Ocean and Coastal Consultants) and Brice (Brice Environmental Services Corporation) conducted a demonstration project to recover clean sand from the Site #3 Confined Disposal Facility (CDF) at the USCG Training Center (TRACEN), Cape May, NJ for beneficial reuse. Funding for this study was provided through an I-BOAT NJ Program grant from the New Jersey Department of Transportation – Office of Maritime Resources (NJDOT – OMR). The main purpose of the study was to investigate the feasibility of separating sand from silts and clays in a Confined Disposal Facility (CDF) and designing a mobile system to cost-effectively excavate material from other coastal New Jersey CDFs. The project was initially to be carried out at Nummy Island (Site #103) near Stone Harbor, but changed to Site #3 at the U.S. Coast Guard Training Center (TRACEN) in Cape May, NJ due to planning and logistic issues (see Figure 1).

Figure 1. Aerial Photo of USCG TRACEN, Cape May, NJ.

Cost-sharing of this project was provided by the Borough of Stone Harbor and the U.S. Coast Guard. In kind services were provided by the Cape May County Municipal Utilities Authority (CMCMUA) in the form of supplying recycled mixed colored glass cullet and delivering it to USCG TRACEN, Cape May, NJ, at no charge.

A total quantity of 1,066 cubic yards of clean sand were produced during a 32-day field demonstration that began on June 28, 2006 with setup and support, and ended on July 30 with the completion of processing and blending DM with crushed glass. A quantity of 1,000 cubic yards of clean, processed sand from Site #3 (see Figure 2) was mixed with 1,600 cubic yards of crushed glass from the Cape May County Municipal Utilities Authority to create a total of 2,000 cubic yards of construction aggregate.

In December 2006, 2,000 cubic yards of the sand/ glass blend material was used as structural fill in the NJDOT's Route 52 causeway reconstruction project between Somers Point and Ocean City, NJ. The blended material was tested and gradation results show this material to be classified as I-13 material according to the NJDOT's Standard Soil Aggregate Gradations. Additionally, the sandy portion of the separated material (not blended with glass) was tested and meets the NJDOT specification for Zone 3 material.

Figure 2. CDF Site #3 at USCG TRACEN Cape May, NJ

2. BACKGROUND

The pilot demonstration was originally scheduled at a CDF located on Nummy Island (Site #103), near the Borough of Stone Harbor, New Jersey. However, ongoing dredging and placement operations in summer of 2006 prevented the use of that facility. The location for the pilot demonstration was subsequently moved to one of three CDFs at the USCG TRACEN facility (Site #3), Cape May, New Jersey.

During the design phase of the Dredged Material Separation Technology Project, bench scale tests (separation and dewatering) were performed on DM from Nummy Island. Bench scale test results were presented in the Phase I final report dated January 23, 2006. Based on the results of the bench scale testing on the Nummy Island sediments, and the relative similarities between Nummy Island and USCG Site #3 material, it was concluded that the bench scale testing of Nummy Island is fairly representative of back-bay CDF's and performing the demonstration project at USCG Site #3 would be feasible.

The USCG Site #3, as seen in the configuration shown in Figure 2, is a 220,000 square foot diked facility containing approximately 100,000 cubic yards of dredged material. A majority of the material are fine-grained sands (61.3%) with the remainder (38.7%) being silt and clay sized particles. Much of the material came from early dredging of the Cape May Inlet and Harbor. Discrete dredging events are responsible for layers and areas of sediment types within the CDF (see Figure 3).

An Acceptable Use Determination (AUD) for the unrestricted beneficial use of material within the USCG Site #3 was received from the NJDEP Office of Dredging and Sediment Technology (ODST) in November 2000. An amended AUD was issued to the USCG in July 2006 based on the project goals of the Demonstration Project to use material from the CDF in the Route 52 roadway construction project (see Appendix A). The amended AUD stipulated testing of water and sediments during the demonstration project and was used to develop the project testing plan.

Figure 3. Layers of sand and silt/clay material can be observed in Site #3 after excavation.

2.1. CONFINED DISPOSAL FACILITY DREDGED MATERIAL

2.1.1. NUMMY ISLAND

Sediment coring and subsequent analyses were performed by both OCC and HDR/LMS at Nummy Island (Site #103) prior to the demonstration project site being changed to USCG TRACEN. HDR/LMS collected sediments from 6 core holes spread across the CDF. They sampled at 2-foot depth intervals using a split-spoon sampler with a cased hole, which reduces the problems associated with cave-ins, and performed a suite of chemical and textural tests. The sediments were composited based on vertical location in the CDF. The samples were then broken into upper, middle, and lower categories. The upper, middle, and lower composited samples were analyzed for texture (grain size), total organic carbon, and percent moisture. The upper and lower composted samples were also analyzed for chemical composition.

Based on the average of all samples in the center of the CDF, 67% is sand and 33% is clay or silt based on particle size. If the CDF is sliced into 3 layers, the upper 1/3 is by far the finest grained with only 30% sand by weight. The sediments in the lower two-thirds are almost completely (85%) sand sized (HDR/LMS, 2006). These percentages were confirmed by OCC (2006). When the sandy portion of the dike walls is included, the percentage of sand within the entire CDF is estimated to be 75%. It was also determined that the marsh foundation under the CDF consolidated over time due to the overburden placed on it, or was excavated prior to the CDF being constructed and filled, or a combination of the two. The resulting effect is that dredged material is found at deeper levels than the surrounding marsh would suggest.

Sediment samples at Nummy Island were also tested for chemical composition. There were no contaminants in the sediment that exceeded New Jersey Residential Direct Contact Soil Cleanup Criteria (NJRDCSCC), low levels of phthalates (plastics) and petroleum (PAHs), and only trace amounts of metal. Leachate samples from Nummy Island had low levels of bis (2-Ethyltexyl)phthalate and five metals detected over New Jersey Standard Ground Water Quality Criteria (NJSGWQC), manganese, selenium, aluminum, sodium and iron (HDR/LMS, 2006).

2.1.2. USCG TRACEN SITE #3

Dredged material contained in the Site #3 CDF was previously sampled and tested in 2000 by Target Environmental Co., Inc. in support of obtaining an Acceptable Use Determination (AUD) for the material. At that time, six sediment sample cores were obtained to a depth of ten feet below grade at various locations in the CDF as determined by the NJDEP. Individual cores were tested for Total Organic Carbon (TOC), Percent Solids, and grain size. Samples one through three, and four through six were composited into COMP A and COMP B, respectively. The composite samples were tested for bulk sediment chemistry, which includes: base/neutral and acid extractable semi-volatile organic compounds, pesticides, PCBs, target analyte metals, and cyanide.

For individual sediment cores and composite samples, the TOC ranged from 440 to 21,000 mg/kg and averaged 6605 mg/kg, and the Percent Solids ranged from 74 – 95% and averaged 85.25%. Additionally, grain size testing of the individual cores and composite samples resulted in size characteristics similar to Nummy Island as shown in Table 1.

Results of the bulk sediment chemistry on the composite samples showed that no analytes were detected in quantities above NJ Residential Direct Contact Soil Cleanup Criteria (NJRDCSCC) standards. Based on these results, the NJDEP Site Remediation Program granted the USCG TRACEN an Acceptable Use Determination (AUD) for the unrestricted beneficial use of the material contained in the CDF Site #3.

A sample of raw (unprocessed) sediment from the CDF was also analyzed for physical and chemical characteristics prior to the commencement of the dredge separation project. This sample was used as a representative sample for the CDF. The gradation curve shows that 17 percent of the sample is finer than a no. 200 sieve (clay or silt) and 83 percent of the sample is retained by the no. 200 sieve (sand). Approximately 80% of the entire sample is fine grained sand between the no. 60 and no. 200 sieve (see Appendix B).

The chemical composition of raw CDF sediments was analyzed during different parts of the separation process and also different horizontal locations in the CDF. Results indicated that several inorganics and one semivolatile compound (Di-n-butylphthalate) were detected in the dredged material, but in very low levels. The testing plan as defined in the Amended AUD and results are described in greater detail in section 4.2.

Table 1. Comparison of Dredged Material in Site 103 (Nummy Island) and Site 3 (USCG Cape May)

	NUMMY ISLAND Site 103	USCG CAPE MAY Site #3
Percent Sand (size: > 0.0625 in)	Range: 8.00 – 98.00% **Avg: 67.00%**	Range: 31.95 – 89.10% **Avg: 61.30%**
Percent Silt (size: 0.0039 – 0.0625 in)	Range: 0.00 – 45.40% **Avg: 15.22%**	Range: 2.75 – 61.72% **Avg: 26.21%**
Percent Clay (size: < 0.0039 in)	Range: 2.00 – 47.10% **Avg: 17.81%**	Range: 1.90 – 45.47% **Avg: 12.48%**

2.2. GLASS CULLET

The Cape May County Municipal Utilities Authority (CMCMUA) supplied recycled glass cullet (see Figure 4) and delivered it to USCG TRACEN, Cape May, NJ, at no charge. The cullet consisted of mixed color glass, crushed and screened to a material size of less than 0.5 inch (12 mm) or less, and was certified by the NJDOT as a coarse aggregate (see Appendix G). Most of the material is 0.375 inches (9 mm) or less (see grain size curve in Appendix B). The glass cullet contained less than 2% contaminants (non glass materials, including paper, plastic, rubber, metal, etc.) and less than 2% non conforming materials. The contaminants are responsible for the presence of phthalates detected in the amended material (see Appendix A). Weigh tickets were collected for each glass cullet delivery to the site. There were 76 truckloads at an average of

44,000 pounds each. A total of approximately 1,600 cubic yards of glass cullet was delivered to USCG TRACEN for the DM Separation Project.

Figure 4. Crushed glass cullet

2.3. DREDGED MATERIAL SEPARATION UNIT

Dry and wet separation techniques were evaluated during the initial design phase (OCC, 2006). The wet separation process was chosen due to cost, complexity and environmental issues. The specifications for wet separation process included: (1) separating the sand fraction from the silt and clay (fine) fraction of the DM to a degree sufficient for meeting several NJDOT Standard Soil Aggregate Gradations, (2) dewatering the fine fraction following separation from the sand and leaving the fines within the CDF, and (3) minimizing process water use and retaining the water in the CDF. Sand is generally defined as material greater than 0.074 mm (No. 200 sieve). Material smaller than this comprised the silt and clay (fine) fractions of the DM.

For dewatering the fine fraction of the separated material in slurry form, OCC evaluated the use of geotextile dewatering tubes. Hanging bag testing was accomplished with fines from Site 103. The results of the evaluation were presented in the Phase 1 report and indicate that geotextile tubes with flocculent would be a low cost and reliable approach to dewatering fine-grained slurry. One issue raised from the hanging bag tests was slightly elevated contaminants of concern (COC's) in the water draining from the material.

Part of the design was to evaluate an approach to water conservation and reuse. It was observed during site inspections that CDFs often contain ponded water. This water within the CDF can be used for process water. It was also noted that field operations could be established completely within the confines of the CDF. Following sand separation, the slurry containing fines can be pumped to a geotextile dewatering tube. The water drained from the geotextile tube would then be collected within the CDF and reused for sand separation. A design approach of using existing water and performing all processing within the CDF reduces intake water consumption and eliminates any concern of free water leaving the site that may contain slightly elevated COC's. This also avoids the regulatory impact of discharge from a CDF into shellfish waters.

As discussed previously, once it was determined that the Nummy Island CDF could not be used for the pilot demonstration, arrangements were made to utilize Site #3 at the USCG TRACEN, Cape May. In May, 2006, representatives from Brice and OCC visited the Cape May CDF to evaluate site conditions and collect samples for testing. The following determinations were made:

- Site #3 is accessible by land and no barge support was required,
- Vegetation removal (Phragmites) would be an additional requirement at Site #3 to facilitate sand separation,
- Seawater from Cape May Inlet may have to be used for process water should ponded rain water within the CDF prove insufficient,
- The original technical approach for separating sand and dewatering/storing soil fines proposed for the Nummy Island CDF would be applied to Site #3, and
- Sufficient area existed next to the CDF for stockpiling crushed glass and for mixing with the separated sand from Site #3.

3. PROCESSING OF DREDGED MATERIAL

3.1. WET SEPARATION PROCESS

The wet separation process utilizes equipment found in the mining industry. The process uses water to agitate and wash the dredged material, and then uses gravity to separate the heavier particles from the lighter ones. The process has the following steps. An excavator removes material from within the CDF and brings it to a stockpile at the processing unit. A front end loader dumps the DM through a grate onto a conveyor belt. The first grate removes any large debris (see Figure 5). The conveyor drops its load onto a Grizzly vibrating screen (see Figure 6) which has two screens with smaller openings than the first grate. Silt/clay balls and pieces of vegetation are removed during this step. Sandy material then passes through the screen into the feed box of the Eagle sand screw. The sand screw is a fine material washer classifier, and is the primary separation component (see Figure 7). At the same time, water is pumped into the hopper from below causing an upward flow. The water flow rate passing through the sand screw and over the weir provides the mechanism for determining the minimum grain size that is passed up the screw and offloaded into a stockpile. The fine grained material and any remaining vegetation are washed from the hopper over the weir into a basin. The basin is drained by a pump that sends the fine-grained slurry into a geotextile tube for final dewatering.

Figure 5. Dredged material separation plant

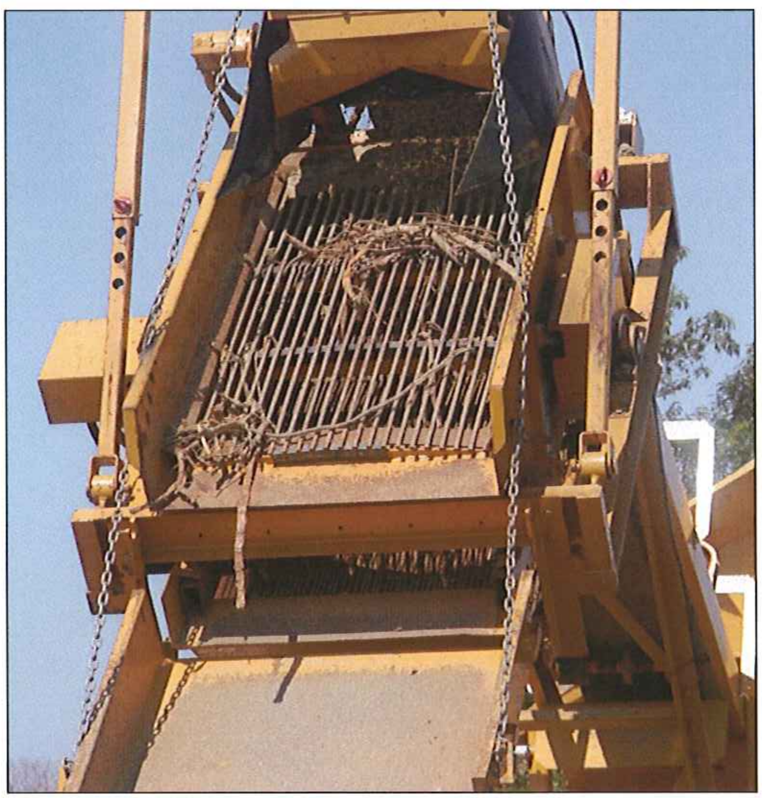


Figure 6. Grizzly vibrating screen.

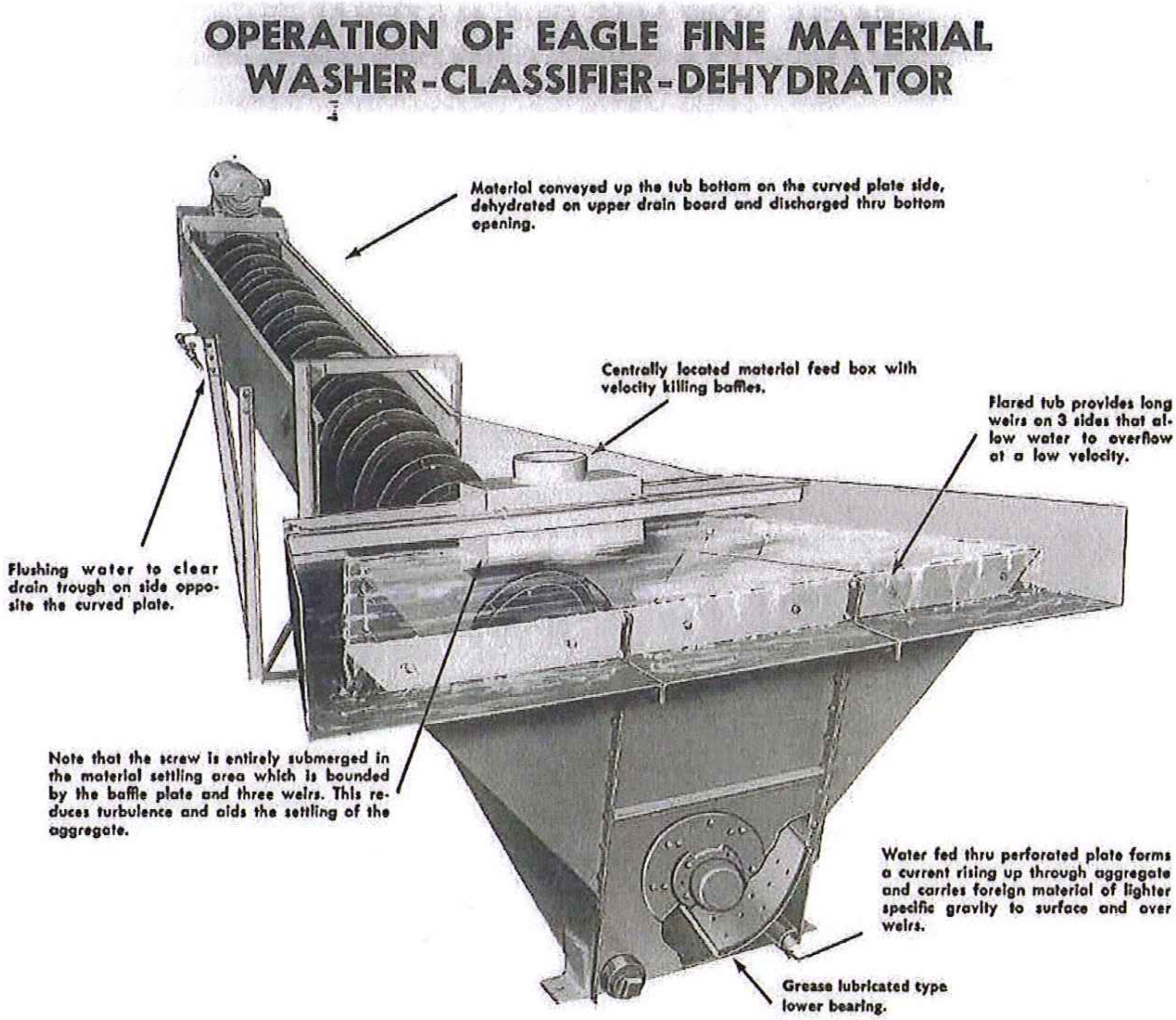


Figure 7. Eagle Sand Screw

3.2. DM PROCESSING AND MIXING - SITE SET UP AND PLANT OPERATION

The demonstration project at USCG TRACEN, Cape May, NJ, Site #3, began with equipment and material mobilization to the site. Brice Environmental began shipping equipment to the site on June 19, 2006. Equipment included the excavation vehicles and wet separation process components described earlier, as well as ancillary components such as a power supply and control panel. The first delivery (255 cubic yards) of crushed glass cullet was received and stockpiled on-site on June 21. The official project kick-off meeting was held on June 29 with the U.S. Coast Guard, Brice Environmental, OCC and the NJDOT prior to processing any dredged material.

Site alternations were made to facilitate the demonstration project. Two access ramps were constructed from the road to the interior of the CDF. The top of the dike was then modified to serve as a roadway for hauling DM for processing within the site. Once the excavators had access to the CDF, Brice began to remove vegetation and strip away the top silt/clay layer to access the sandy material for processing. Figure 9 presents the actual location of various work areas at the USCG Training Center.

A self-priming/self-starting pump was delivered for pumping site water to the separation plant. This pump was located within the CDF (beyond and to the right of the photograph in Figure 9). A second pump was located outside the CDF to pump water from Cape May Harbor to the CDF to supply additional process water as necessary (see Figure 10). The geotextile tube for retaining fines was delivered, rolled out, and installed. The material processing area was established and the separation plant assembled. Flexible piping from the pump that drains the sand screw basin was connected to the geotextile tube.

On July 8, 2007, the polymer injection pump was connected to the overflow weir (see Figure 8). A trial separation process began with ten (10) cubic yards of sand being washed, dewatered and stockpiled. With this initial processing, the polymer dosage rate for the slurry discharge leading to the geotextile tube was refined from initial projections. Far less polymer was required during the processing than originally estimated. The polymer used for chemically conditioning the decant water was Aquamark AQ 200; a high molecular weight, high charge, cationic polyamine coagulant (see Appendix C). The next day, the plant was moved slightly within the site due to settlement and consolidation of the underlying dredged material.

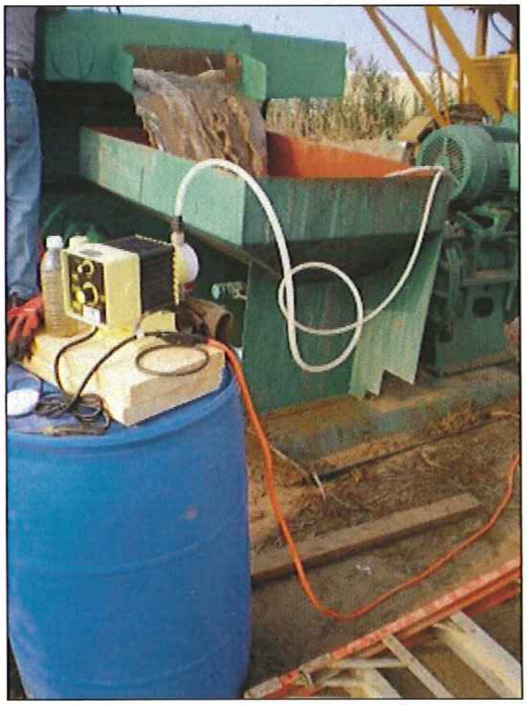


Figure 8. Polymer (blue drum), chemical feed pump, overflow basin and basin drainage pump

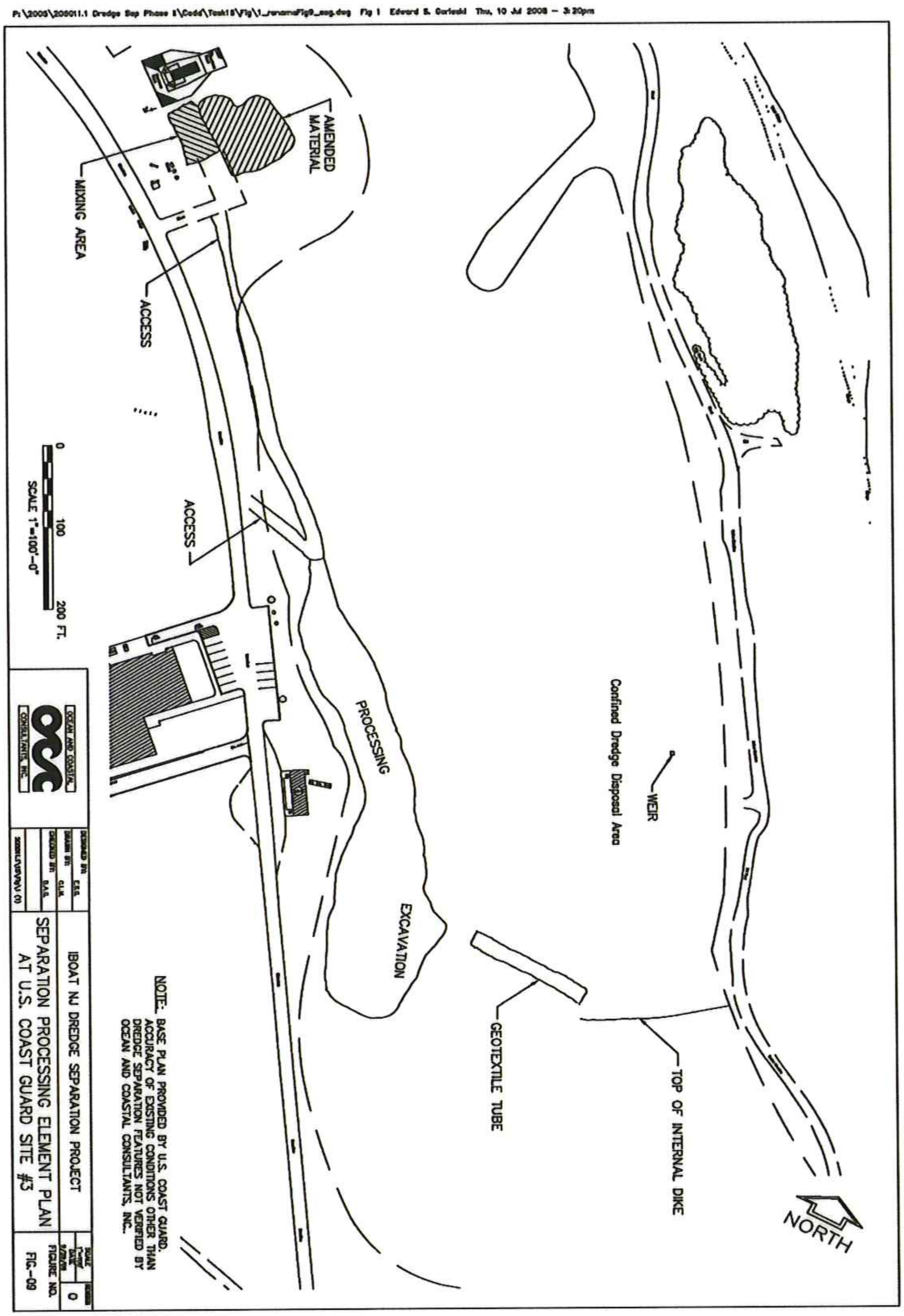


Figure 9. Dredge Separation Demonstration Project Layout - Site #3.

With set-up and initial testing complete, the separation process was able to begin normal production operation by July 10. Selective excavation identified silty pockets and layers which were removed to access sandy material for processing. When necessary, water was pumped from the ocean into the pond within the CDF for use as process water. Shipments of crushed glass cullet continued to arrive and additional processed sand was stockpiled. Stockpiles are shown in Figure 11. Gradation testing was conducted on-site for both the incoming glass cullet and the processed sand. Additionally, samples of the sand, glass and mix were collected for independent testing. Test results are included in Appendix B.

Figure 10. Site #3 after demobilization. North is toward the top of the photograph.

Figure 11. Stockpiled separated sand (left) and stockpiled recycled glass (right).

Large concrete blocks were delivered to establish a sand/glass mixing area. A Bobcat equipped with a rotor tiller (see Figure 12) was utilized for mixing the glass and sand in the correct proportions. On-site gradation testing indicated that the mixed material met NJDOT I-7 specifications. Independent testing, however, showed a discrepancy in the sand fraction passing the No. 100 sieve (0.150 mm). The specification for I-7 is for 0-8% passing the No. 100 sieve while independent test results ranged from 21.6 (Rutgers) to 22.9 (George Harms) (see Appendix B). This discrepancy was due to a very subtle difference in the washing sequence in the gradation test procedure. The sand/glass mix was reclassified to NJDOT I-13 material.

By July 25, the separation plant had produced the amount of sand required for the project and material processing was completed. Additional sand had been produced for further testing and/or experimental use. On July 26th plant disassembly started and rental equipment was demobilized from the site. Restoration began on the CDF perimeter dike to ensure that an outer dike top width of at least 8 feet was left for the USCG. Crushed glass delivery and sand/glass mixing with the Bobcat (see Figure 12) continued.

Dredged material and crushed glass mixing was completed by August 3, 2006. In total, 1,000 cubic yards of sand was mixed with 1,600 cubic yards of crushed glass cullet to produce 2,000 cubic yards of NJDOT I-13 material. The reason a simple summation of volumes does not produce and equivalent volume of mixture is that sand fills the interstitial spaces of the glass, allowing the final mixed material to occupy less space than the total of the input materials. The mixed sand and glass were left stockpiled at the site awaiting removal for beneficial reuse. The small quantity of additional sand (approximately 66 cubic yards) was stockpiled for use by the USCG for various small projects around the base and further testing. All disturbed sites were restored by grading, seeding and fertilizing.

Figure 12. Bobcat used to mix separated sandy material with recycled glass.

3.3. EQUIPMENT

There were three primary operations requiring equipment at the CDF. These operations included site work, dredged material separation, and sand/glass mixing.

Work was conducted around the site to build ramp access for construction vehicles, transform the top of the dike to a construction roadway, clear vegetation, transport dredged material and restore the site by grading, seeding and fertilizing when finished. Traditional site equipment such as a WA 380 Komatsu Wheel Loader, John Deere 550 Dozer, John Deere 120C Excavator and a 50 kW Whisperwatt generator were used on this demonstration project.

There are three materials produced by the separation process. The first, a waste product of vegetation, silt/clay balls and debris, was removed by the screening process and segregated. The second material is the fine-grained material resulting from the wet separation process which is pumped into geotextile tube for dewatering. This material, predominantly silt and clay, is pumped as a slurry at less than 15% by weight into the geotextile tube. A polymer, used to flocculate the fines and improve drainage through the geotextile tube, was added at a prescribed rate at the hopper and pumped through a flexible pipeline to the tube shown in Figures 14 and 15. The geotextile tube is fabricated from woven, high strength polypropylene yarns and is permeable. The water leaving the tube is free of solids and can be used for additional washing operations, yielding a closed water system.

The final material is the clean processed sand. This sand was stockpiled after exiting the sand screw (see Figure 13) and was later mixed with the crushed glass.

Figure 13. Processed sand being discharged from sand screw.

Figure 14. Dewatering Geotextile Tube

The concluding operation was the mixing of the crushed glass cullet with the separated sand. Concrete blocks were arranged to create an enclosed area for this mixing to take place. The two materials were then placed in prescribed lift heights. The relative lift heights determine the percentage each material occupies in the final mixture. A bobcat with a rotary tilling attachment made sufficient passes to mix the material. After the material was mixed, it was then stockpiled to await transport to its final destination.

Figure 15. Site 3 after processing. The geotextile tube can be seen along the interior perimeter of the CDF.

4. MATERIALS TESTING

4.1. TESTING PLAN

A testing and analysis plan was developed in accordance with conditions set forth in the Acceptable Use Determination (AUD) as received from the NJDEP Office of Dredging and Sediment Technology (ODST) in July, 2006. Bulk sediment chemistry was performed on a sample of the recycled glass cullet, as well as three representative samples from each of the following materials:

- Raw Dredged Material from the CDF,
- Sandy portion of material after separation,
- Material amended with crushed glass,
- Fines before the addition of polymer, and
- Fines after the addition of polymer.

Representative samples of the above mentioned materials were taken at various times to best represent the materials throughout the separation process (i.e. the beginning, middle, and end stages of the process).

Additionally, samples of site water and decant water (see Figure 16) from the dewatering process were collected and analyzed. All samples were analyzed for target analytes as found in Appendix B of the New Jersey Dredging Manual.

Physical and hydraulic testing of separated sand material was also performed. The California Bearing Ratio (CBR) was determined for (1) sand mixed with recycled glass to the I-13 specification and (2) several mixtures of separated sand with Recycled Concrete Aggregate (RCA). Developed by the California Department of Transportation, the CBR is a penetration test for evaluation of the mechanical strength of road subgrades. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The CBR test is described in ASTM Standards D1883 and D4429, and AASHTO T193.

The constant head permeability (AASHTO T215) test, also known as a rigid wall permeability test (ASTM D2434), is used to determine the rate of flow of water through a granular soil. The test is run under the assumptions that the sample is saturated (no air voids), is under constant hydraulic conditions, and laminar flow travels in one direction (limited by the rigid cylindrical wall). The primary purpose of a permeability test is to determine how well a geo-material will drain. The procedure is to establish representative values of the coefficient of permeability of granular soils that may occur in natural deposits or as placed in embankments, or when used as base courses under pavements.

4.2. RESULTS

During the demonstration project, approximately 1,600 cubic yards of crushed recycled glass was mixed with approximately 1,000 cubic yards of separated sand to produce 2,000 cubic yards of blended material. Due to the relatively large size of glass particles compared to the grain size of the fine sand, the sand portion of the mix was able to fill interstitial spaces between pieces of glass. For this reason, more than 1,000 cubic yards of the glass cullet had to be added to the 1,000 cubic yards of fine sand to produce a final volume of 2,000 cubic yards of blended material. Chemical and physical testing was performed on the blended material.

4.2.1. CHEMICAL TESTING

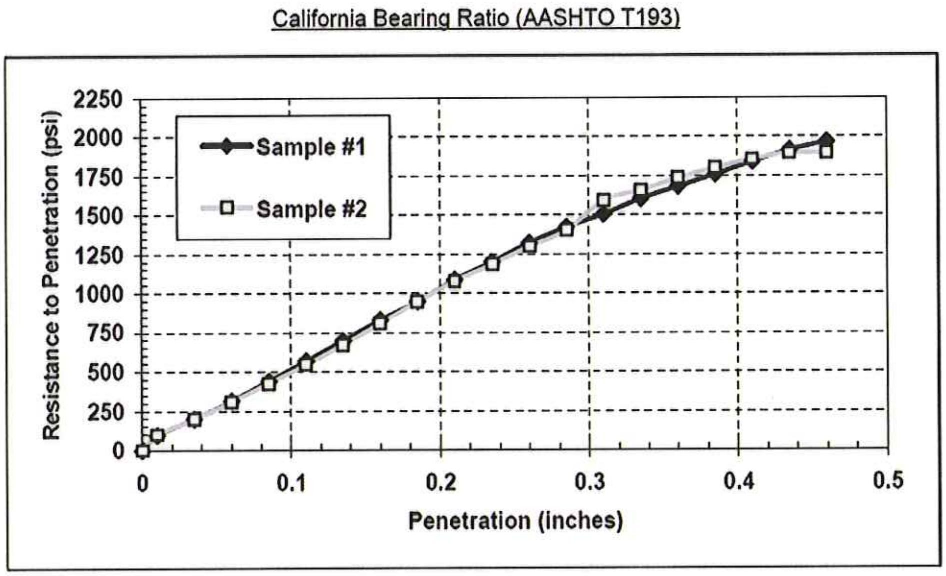
Chemical testing was performed in accordance with the AUD (see Appendix A). Only the fine-grained silts and clays, separated from the sand and retained within the geotextile tube, were found to have target analytes present above published standards. Namely, Arsenic (22.5 mg/Kg) and Beryllium (1.1 mg/Kg) were detected slightly above residential and non-residential NJ soil cleanup criteria. These analytes were detected in the initial stages of the separation process.

Several analytes were detected in both the decant water (see Figure 16) and supplemental site water from Cape May Inlet. In fact, the water taken from Cape May Inlet may be directly responsible for the addition of trace quantities of Aluminum, Iron, Manganese, Sodium, Lead and Selenium. The analytes were detected above NJ Ground Water Quality Standards (NJGWQS). A summary of the analytical results is attached in Appendix A.

Figure 16. Decant water draining from geotextile tube.

4.2.2. PHYSICAL TESTING

Separated sand from the USCG Site 3 CDF was mixed with recycled glass to meet an NJDOT I-13 specification. Moisture density relationship, constant head permeability (AASHTO T215), grain size distribution, and CBR tests were performed on this material. The maximum dry density of the I-13 material is 126.1 pounds per cubic foot (pcf) and the permeability was measured to be 11.3 feet per day (3.9 X 10^{-5} m/sec). The grain size of the material was 93% sand with 5.5% fine gravel and 1.5% silt/clay. The CBR results for the I-13 material averaged 51 and 69 at 0.1 inch and 0.2 inch penetration, respectively. Results are shown below in Figure 17 and in Appendix D.



Sample	γ_d (pcf)	ω% (%)	CBR Value @ 0.1 In.	CBR Value @ 0.2 In.
#1	125.9	4.8	51	69
#2	125.7	4.9	50	68
Average	*125.8*	*4.9*	*51*	*69*

Figure 17. CBR test results for I-13 (sand/glass) material.

4.2.3. TESTING OF RCA/SAND MIX

In addition to mixing the clean processed sand with glass cullet, sand was also mixed with Recycled Concrete Aggregate (RCA) to measure its effect. RCA is a common recycled material, particularly in southern New Jersey where natural forms of aggregate are in short supply. One recurring problem with RCA is its very low permeability. Tests of RCA mixed with 0%, 25% and 50% processed sand were performed for the same parameters as the I-13. In general, as the percentage of sand increases, the CBR value decreases, maximum density decreases, and permeability increases. Based on the CBR results, the addition of 25% to 50% dredged sand with RCA still provides a suitable base course material (CBR values 79 and 67, respectively). However, even at the 50:50 blend, the permeability is still quite low (1.9 feet per day (6.703 X 10^{-6} m/sec)), although an improvement over the RCA. The sand from Site 3 is considered a fine sand. A coarser grain size sand would increase the permeability in the RCA mix. A comparison of CBR and permeability is shown in Figure 18. Complete results are provided in Appendix D.

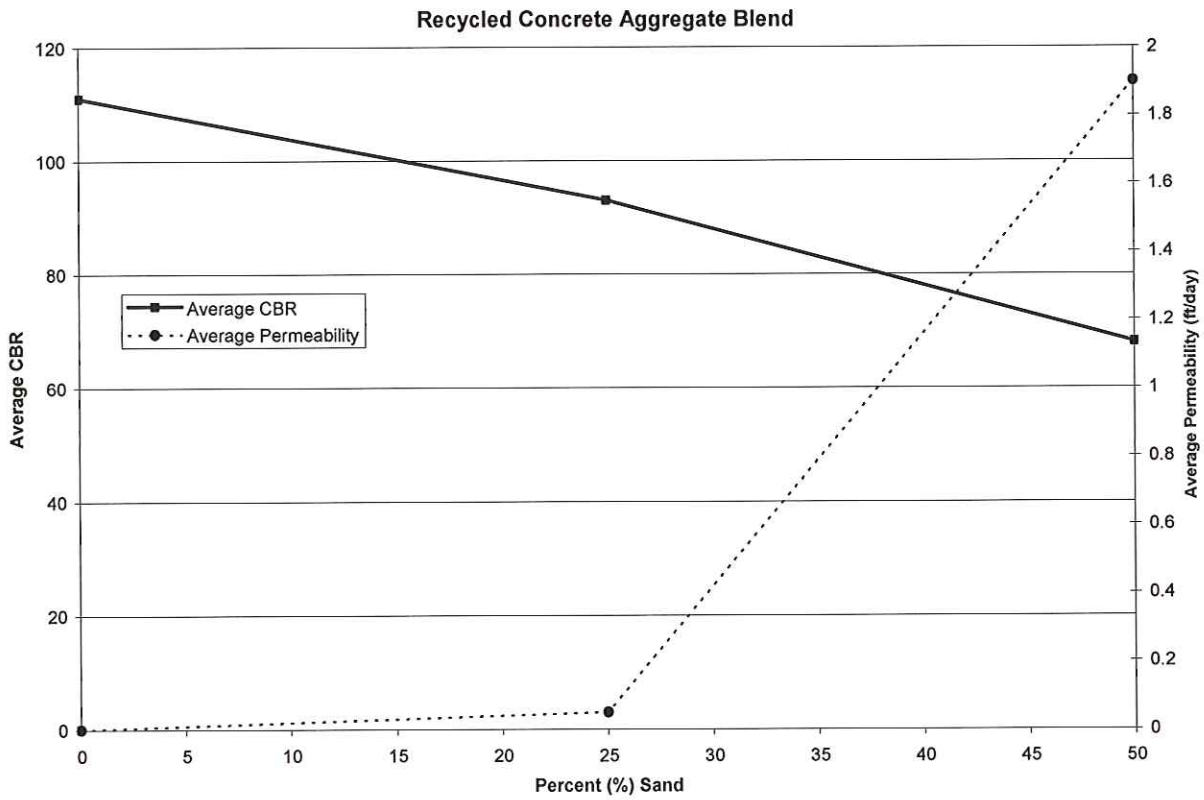


Figure 18. CBR results for separated sand mixed with recycled concrete aggregate.

5. BENEFICIAL USE OF DREDGED MATERIAL

A major focus of this demonstration project was to evaluate beneficial use of separated sand from a coastal New Jersey CDF. The clean sand fraction of separated dredged material can be used for a multitude of beneficial purposes, each with specific grain size or geotechnical requirements. For example, beach nourishment would require clean sand having a similar grain size to the native material while the subbase for a road would have strength and permeability requirements. Potential beneficial uses have been studied by a wide variety of researchers for Delaware River sediments including Maher (2005) and Grubb (2005). In contrast to Delaware River sediments, DM in the southern, coastal portion of New Jersey tends to have a salt content and is finer grained. This makes it more difficult to use in concrete mixes, and has lower permeability.

The beneficial use option chosen for this demonstration project was to provide approximately 2,000 cubic yards of the sand/ glass blend material as structural fill in the NJDOT's Route 52 causeway reconstruction project between Sommer's Point and Ocean City (see Figure 19). The blended material was tested and gradation results show this material can be classified as I-13 material according to the NJDOT's Standard Soil Aggregate Gradations. Additionally, the sandy portion of the separated material (not blended with glass) was tested and meets the NJDOT specification for Zone 3 material.

In order to be accepted for use in Ramp 2 of the causeway project, the material was also tested for Angle of Internal Friction (39°), resistivity (0.2 Kilo-Ohm/cm) and pH (7.8) (see Appendix B-4). The I-13 material was trucked from the USCG Training Center in December 2006 to the Rt. 52 project site.

Figure 19. Ramp construction at the Route 52 causeway reconstruction project.

Difficulties encountered during the final stages of this project are worth mentioning because they highlight impediments to beneficial use of dredged material. In general, when a large construction project is designed, the design engineer specifies a material that will perform as required. Within the geotechnical engineering community, different types of aggregate have generally accepted physical and hydraulic properties. Further, the aggregate types (e.g. I-7) are defined based on virgin geo-materials, not processed or manufactured materials. Because of this, simply meeting a NJDOT specification based on gradation does not guarantee that the processed material can be substituted.

During the bidding process, general contractors identify the source and quantities of material they will need to construct the project. This often means obtaining pricing from the quarry and consideration for transportation distance. Transportation costs often dwarf the cost per cubic yard of the material and are therefore very critical components.

Dredged materials need to be available in sufficient quantities (stockpiled), with known properties (tested), close to the project site, and accepted by the design/construction community before their use will be widespread. The main problem with the present system of beneficial use is that each project is one of a kind. That means that for each use, the design engineer must account for 1) excavation and transportation from the CDF, 2) dewatering and 3) processing (including testing and permitting) before being considered a viable construction material. History shows that this is a major hurdle, and clearly demonstrates that to capture the benefits to society of beneficial use of dredged material, government must play a role.

5.1. OTHER BENEFICIAL USES

Other beneficial uses investigated during this study include the use of the fine fraction in Lightweight Aggregate (LWA) production, and the use of sand - separated and processed, with or without amendments. The creation of LWA not only produces a highly sought after end-product, but can remove all or nearly all of the contaminants present in the parent material. LWA are used in structural applications where relatively high compressive strengths and light weight are important, such as in masonry or structural concrete. It also allows more material (volume) to be shipped for the same amount of weight, such as with pre-cast concrete units, which reduces costs and is consistent with Green Building certification.

The major drawback to LWA production is the use of high temperatures, which require significant energy. Additionally, there are limits to the chemical compositions that can be used in LWA production. Only very fine grained material can be used and the size must also be kept within a fairly tight constraint. Each CDF would have to be tested for chemical composition before being used in the LWA process.

Similar to LWA is a product known as Controlled Low Strength Material (CLSM) or "flowable fill." This product is used in applications where high compressive strength is not required, or in restricted access applications to fill voids. CLSM can be used in embankments, or to fill trenches above pipelines. Due to CLSM's low strength, it can be easily excavated if necessary.

Another common beneficial use for dredged material is as daily cover for landfills, fill for landfill closure or as fill for mine restoration. Material for daily cover needs to be dry enough to work easily and not prone to creating dust. Additionally, the daily cover must not impact the leachate quality of the landfill. Dredged material has also been used in New Jersey for capping of contaminated and brownfield sites. Fine-grained dredged material (silt and clay sized particles) tends to have low permeability. Low permeability is a desirable attribute for landfill caps or liners. Amending the fine fraction of DM with clay may produce a low permeability product suitable for this purpose. An investigation in Ireland (Sheehan, et. al., 2008) found that the average cost of construction of the mineral layer of landfill liner systems was 115 Euros per square meter (approximately $145/SY) in 2006. In Ireland, disposal costs related to offshore disposal are high. Taking these two factors into account, the authors conclude that beneficial use of DM is economically justified, as long as the material is clean.

This dredged material separation demonstration project targeted economically and environmentally sustainable approaches to dredged material amendment. The sandy fraction of separated dredged material from any CDF will likely need to be amended to meet certain use requirements for various types of projects. There are several viable methods for amending the material, including amending materials such as Portland cement or lime. Based on the moisture content of the dredged material, and its physical composition, addition of these materials can increase the strength of dredged material and render it useful in applications such as parking lot subbases (Gaffney and Gorleski, 2005).

Clean, separated sand can also be used to augment the production of sand used in block manufacturing. Present methods of block manufacturing require a very specific sand gradation. Blocks are made by pouring the wet mix into a mold, vibrating/compacting the mix and removing the mold while still wet. The block must retain its shape during the curing period. Additionally, the presence of chlorides is detrimental to concrete mixes. For smaller, designer applications, wet concrete mix is poured into molds and allowed to cure in the mold. This approach is more labor intensive and not conducive to mass production.

This project amended the sand fraction of separated dredged material by mixing the material with crushed glass (for the Rt. 52 project) and crushed recycled concrete aggregate (for testing). Both of these materials are available locally in large quantities and, as testing results show, are capable of resulting in a final product that meets NJDOT Standard Soil Aggregate Gradations. Specific results for material produced during the demonstration project are described above in the Materials Testing section. As stated earlier, however, simply meeting the gradation requirements (defined by virgin geo-materials) does not guarantee successful application for a particular project.

5.2. BENEFICIAL USE POLICY EXAMPLE

In Denmark, the local shortage of virgin sand and gravel has increased the focus on recycling dredged materials. Previously, dredged materials have been used in projects such as motorway construction, feeding of beaches at locations with erosion problems and coastal land fillings etc. An interesting feature associated with dredged materials is the taxation scheme. In order to reduce the use of natural resources and encourage reuse of materials, a tax of DKK 5/m³ is imposed on natural raw materials. Excavation of sand offshore is included. However, dredged materials are not taxed if they are beneficial to either on-land, such as highway construction or offshore purposes. As such, there is an indirect subsidy for use of dredged materials in Denmark. Figure 20 below shows a DM processing facility on the northeast coast of Denmark.

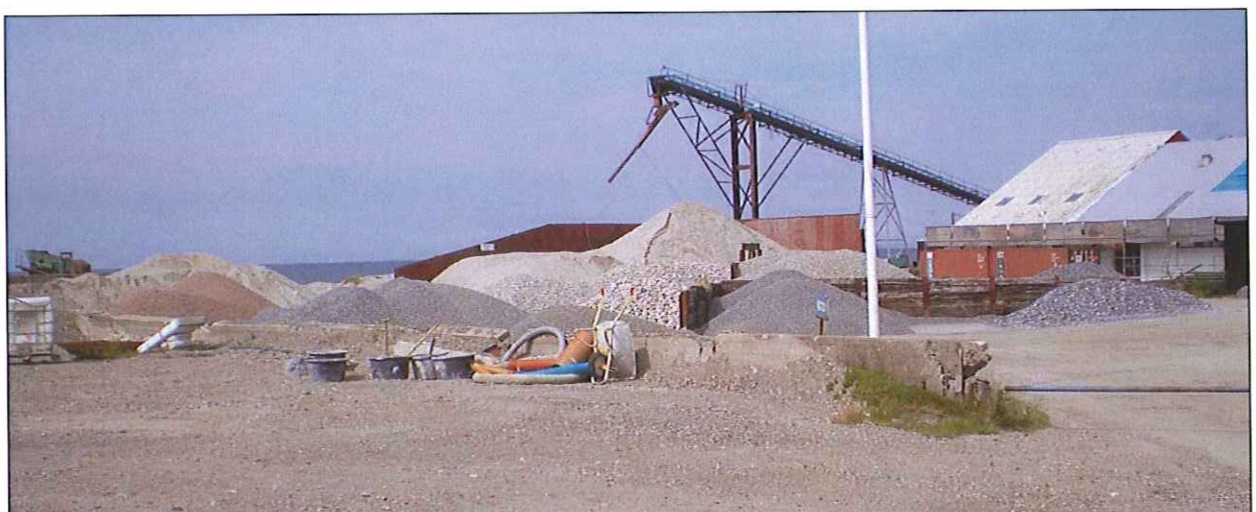


Figure 20. Dredged Material Processing Facility in Denmark.

6. COST ANALYSIS AND ESTIMATES

One of the goals of the demonstration project was to examine costs for producing sand from dredged material contained within a CDF. Actual costs from the demonstration project at Site 3 were broken into the following tasks:

- Mobilization,
- Setup, Support, and Site Restoration,
- Material Processing,
- Sand/Glass Cullet Mixing & Disposition, and
- Demobilization.

Mobilization and Demobilization costs have not been included, nor has sand/glass cullet mixing and disposition. The intent of this cost analysis is to examine costs associated directly with actual site operations.

Costs associated with setting up the separation process onsite, constructing and maintaining an access ramp and road into the CDF, removing Phragmites, silt, and muck to access sand, and site restoration are shown in the table below under *"Setup, Support & Restoration."*

Costs associated with hauling sand to the separation process, operating the separation process, and removing washed sand and placing in a stockpile are shown below under *"Processing."*

The costs shown in the table below are actual costs paid out and do not include markups such as G&A, overhead, and profit.

Task	Fuel	Room & Board	Labor	Outside Equipment	Owned Equipment	Total
Setup, Support & Restoration	$2,121.52	$6,315.15	$13,363.80	$9,543.65	$0.00	$30,344.12
$ Per CY	$1.05	$5.92	$12.54	$8.95	$0.00	$28.47
Processing	$3,982.80	$6,930.62	$17,273.27	$15,400.90	$21,984.34	$66,571.93
$ Per CY	$4.67	$6.50	$16.20	$14.45	$20.62	$62.45
					Total	**$96,916.05**
					Per CY (1,066 CY Total)	**$ 90.92**

Table 2. Total costs for producing 1,066 cubic yards of sand.

Cost items for the two tasks listed in the above table are defined as follows:

- *Fuel* – This item is the cost for diesel fuel delivered to the jobsite for support and process equipment.

- *Room & Board* – Those costs for housing and meals for a crew of (4) four from June 28, 2006 until July 30th, 2006, or approximately (33) thirty-three total days.
- *Labor* – Costs paid out in wages for a crew of (4) four. Typically, the crew worked a (12) twelve hour day; as such, wages were for (8) eight hours of straight time and (4) four hours of overtime. For this project the crew generally worked (7) seven days a week so weekends were paid at an overtime rate of 1.5 times the straight time rate. July 4th was paid at a double time rate.
- *Outside Equipment* – Local equipment used for the project included a WA 380 Komatsu Wheel Loader, John Deere 550 Dozer, John Deere 120C Excavator, Pump, 2 pickup trucks for crew transport, as well as a 50 kW Whisperwatt generator. Rental rates used were quoted monthly rental rates. The rate for the Whisperwatt generator was a monthly rate plus additional charges for extended use based on actual hour meter readings.
- *Owned Equipment* – Equipment owned by Brice included a mechanic truck, a fine material washer, slurry pumps, hoses and screens. Rental rates were derived by taking the purchase prices divided by a (5) five year depreciation rate, adding a (10) ten percent yearly interest expense, adding a (1.5) one point five percent cost for repair and maintenance, and dividing by the expected hours of use per year.

Costs for Tasks 1 (Setup, Support and Restoration) and 2 (Processing) were strongly influenced by (1) site conditions and (2) production rate.

The timeline for Task 1 began (8) eight days prior to commencing Task 2, thus some costs are a reflection of the longer period time; however, the biggest cost was due to site conditions. Site conditions at the CDF consisted of a dense cover of Phragmites that required removal to access sand for processing. In addition, material within the CDF consisted of large areas of moist silt that required removal to access sand for processing. Then sand had to be excavated and transported over to the treatment process. Approximately 10,000 cubic yard of muck required removal just to access the required quantity of sand. As such, approximately half of all fuel, room and board, and labor costs (two out of four total personnel) were incurred in Task 1 mainly to clear, find, and retrieve sand for processing on a daily basis.

Material processing for generating 1,066 cubic yards of sand began on July 8th and ended on July 25th for a total of (17) seventeen days of production (minus 1 day to adjust the plant) for an average production rate of 63 cubic yards per day. Typical of most pilot demonstrations, the relatively small volume of sand to be produced (1,066 cubic yards) required that a separation process with a low production rate be used. All costs consequently on a per-cubic-yard basis for the project are considerably more than a full-scale process.

Processing utilizing this technology fits a mining-type economic model based on mass production. The volume of soil and production rate is the driving force behind reduced processing costs on a per-cubic yard basis. Typical of a mass production model, the combination of all cost elements (such as mobilization/demobilization, labor, and capital outlay) decrease in a nonlinear fashion, on a per-ton basis, with increased quantity.

6.1 FUTURE CONSIDERATIONS AND COST VARIABLES

Per-cubic yard processing costs are based on site-specific variables. These variables are listed below, with a discussion of their particular impact to costs.

Mass of soil to be processed: Processing costs are tied directly to elements of production rate (or capital outlay) and labor. Labor is one of the biggest cost elements and, typical of a mining process, labor does not increase proportionally with plant scale. Hence, as the production rate increases, the cost of labor on a per-cubic yard basis decreases. Capital outlay is a major cost element. Capital costs for a larger plant with a higher production rate are offset by large quantities of material and reduction in total project labor costs.

Site location & conditions: Conditions can vary greatly between CDFs in terms of accessibility as well as debris and vegetation present. One CDF may be accessible by land while another is only accessible by barge. One CDF may contain dense vegetation that requires removal and disposition while another contains none or sparse vegetation. Yet another CDF may have steep side walls and require excavation for access ramps while another CDF does not. Actual site location and conditions influence logistical and treatment costs on a cubic yard basis.

Product (COC) contaminants of concern: Allowable residual contaminant concentrations in the product destined for beneficial reuse can be site specific. The cleanup level established is important because it affects whether or not physical separation will be consistently effective at a particular CDF and, subsequently, processing costs associated with the risk of batch failure.

Soil characterization (grain size distribution and chemistry, including contamination): Variations in soil structure, particle size, gradation, chemistry, and contaminant concentrations result in processing plants that are site-specific and cannot be universally applied. Plastic clays require highly specialized attrition equipment, while the percentage of clay affects the scale of dewatering equipment. Soil at one site may contain gravel, requiring washing and separation, while soil at another site may contain sands, silts, and clays.

Although sand, silt, and clay are the predominant soil matrices found in CDFs, the examples above show that one processing plant cannot be applied to all CDFs. The ideal processing plant approach is to utilize components predetermined by the bench-scale treatability study as required for use in the overall processing plant.

Site assessment risks: The locale chosen for processing operations influences costs. Locating near offices or other populated areas may affect operational hours (schedule) due to noise associated with processing operations (i.e., loaders, trucks). Locations near rivers or the ocean may result in additional environmental protection measures as well. At Cape May, the "closed-loop" water system precluded the need for discharge into receiving waters.

A highly visual project may result in additional processing costs due to the need for maintaining an appearance beyond that normally required. Site security is another important aspect in evaluating site costs. Although operations may be secured within a fence and locked gate, security personnel may be required.

Split- or single-operations site: Locating processing operations in close proximity, or within a CDF is ideal because the complete process of excavation, haulage, processing, and replacement can be readily scrutinized and performed more efficiently as compared to split operations.

Hauling soil is invariably more expensive than on-site processing. Timing for hauling feed soil and processing soil becomes critical as well. Most importantly, additional regulations and their associated cost impacts may come into play when processing operations are performed outside of the CDF.

Throughput rate required: High production operations require increased attention to logistics for timely delivery of soil for processing, adequate storage space for processed soils, analytical turnaround, and disposition of processed soils.

Hours per day to operate (8 to 24 hrs/day), as well as number of days per week: Mining processes are nearly universally operated 24 hours per day, largely due to the expense associated with start-up and shutdown. As much as 10 percent of total project labor costs can be attributed to time required to start up and shut down the processing plant on a daily basis. Continuous operation is the best use of labor for this type of processing plant at large sites.

On-site or off-site analytical laboratory support: On-site analytical support offers faster turnaround times than an off-site laboratory. Rapid results for feed gradation and/or product contaminants of concern facilitates process optimization. Daily processed soils require stockpiling as discreet batches to confirm processing success. Shipping samples off site for verification analyses can add several days to the turnaround time. Also, additional storage for processed soil is required, which results in larger, more expensive pad requirements and a larger pad area.

Weather conditions/time of year to operate: Operations must be scheduled with local weather conditions in mind. Operations performed during months that are extremely hot impact processing costs because the duration personnel can work in direct sunlight is limited. Scheduling operations for rainy months can potentially impact processing costs with project delays if no provisions are made to handle and dispose of accumulated rainwater. In addition, personnel have to cease operations during periods of severe thunderstorms. Cold weather is invariably difficult to work in and can halt production altogether.

Level of PPE required: PPE requirements are based on the health and safety requirements for the contaminants and hazards associated with the soil processing plant. As the level of worker protection increases, more time is spent suiting up and less time is available to conduct soil processing.

Availability and cost of utilities: Utilizing existing utilities is less costly than having to provide them. Tying into a fire hydrant is a very convenient means of providing water to fill plant components and supply make-up water. 460-volt 3-phase power is typically the type of electricity required for the processing plant.

Generators can be provided for plant power, and water can be hauled in via tanker truck, or taken directly from the ocean. Depending on the plant scale, costs for these will typically add several dollars per ton to the processing costs.

6.1.1 IMPLEMENTATION COST ESTIMATES

As discussed, the biggest impacts to cost on a per-cubic yard basis are quantity of material to process and production rate. Several implementation cost models were developed based on Site

#3 pilot demonstration costs. The cost models reflect Site #3 conditions and the approach used for the pilot demonstration. The below cost projections do not include dewatering tubes and coagulant.

6.1.2 ESTIMATED COSTS FOR 10,000 CUBIC YARD PROJECT

Task	Fuel	Room & Board	Labor	Outside Equipment	Owned Equipment	Total Cost for 10,000 CY
Setup, Support & Restoration	$21,215.20	$18,945.45	$40,091.40	$38,174.60	$0.00	$118,426.65
$ Per CY	$2.12	$1.89	$4.01	$3.82	$0.00	$11.84
Processing	$39,828.00	$20,791.86	$51,819.81	$61,603.60	$219,843.40	$393,886.67
$ Per CY	$3.98	$2.08	$5.18	$6.16	$21.98	$39.39
					Total	**$ 512,313.32**
					Per CY	**$ 51.23**

Table 3. Cost model for producing 10,000 cubic yards.

The following factors were used for the above cost model:

- Field duration of 2 months.
- Fuel costs for both tasks derived by taking the fuel cost for the pilot demonstration and multiplying by 5 to cover costs for larger equipment and adding one additional piece of equipment , such as an excavator and extending for 2 months field direction (pilot costs x 5 x 2 months).
- Room and Board costs derived by taking those for the pilot demonstration and adding an extra individual to each task and extending the field duration to 2 months (pilot costs x 1.5 x 2 months).
- Labor costs derived by taking those costs for the pilot demonstration and adding an extra individual to each task and extending those costs for 2 months field duration (pilot costs x 1.5 x 2 months).
- Outside Equipment costs derived by taking those costs for the pilot demonstration and doubling the cost to cover renting larger equipment and adding one additional piece of equipment and extending those costs for 2 months field duration (pilot costs x 2 x 2 months).
- Owned Equipment costs derived by taking the cost for the pilot demonstration and multiplying by 5 to cover costs for larger equipment to increase the daily production rate and extending the field duration to 2 months (pilot costs x 5 x 2 months).

6.1.3 ESTIMATED COSTS FOR 50,000 CUBIC YARD PROJECT

Task	Fuel	Room & Board	Labor	Outside Equipment	Owned Equipment	Total Cost for 50,000 CY
Setup, Support & Restoration	$42,430.40	$50,521.20	$106,910.40	$76,349.20	$0.00	$276,211.20
$ Per CY	$0.85	$1.01	$2.14	$1.53	$0.00	$5.52
Processing	$79,656.00	$55,444.96	$138,186.16	$123,207.20	$615,561.52	$1,012,055.84
$ Per CY	$1.59	$1.11	$2.76	$2.46	$12.31	$20.24
					Total	**$1,288,267.04**
					Per CY	**$ 25.77**

Table 4. Cost model for producing 50,000 cubic yards.

The following factors were used for the above cost model:

- Field duration of 4 months.
- Fuel costs for both tasks derived by taking the monthly fuel cost for the pilot demonstration, multiplying by 5 to cover larger or additional equipment, and extending it for 4 months (pilot costs x 5 x 4 months).
- Room and Board costs derived by taking the monthly costs for the pilot demonstration and adding 2 additional personnel to each task (for a total of 4 individuals per task), and extending it for 4 months (pilot costs x 2 x 4 months).
- Labor costs derived by taking those costs for the pilot demonstration and adding 2 additional personnel to each task (4 individuals per task) and extending it for 4 months (pilot costs x 2 x 4 months).
- Outside Equipment costs derived by taking those costs for the pilot demonstration, multiplying by 5 for larger or additional equipment and extending it for 4 months (pilot costs x 5 x 2 months).
- Owned Equipment costs derived by taking those costs for the pilot demonstration and multiplying by 7 to cover costs for larger equipment and extending it for 4 months (pilot cost x 7 x 4 months).

6.1.4 ESTIMATED COSTS FOR 500,000 CUBIC YARD PROJECT

Task	Fuel	Room & Board	Labor	Outside Equipment	Owned Equipment	Total Cost for 500,000 CY
Setup, Support & Restoration	$180,329.20	$429,430.20	$908,738.40	$324,484.10	$0.00	$1,842,981.90
$ Per CY	$0.36	$0.86	$1.82	$0.65	$0.00	$3.69
Processing	$338,538.00	$471,282.16	$1,174,582.36	$523,630.60	$4,484,805.36	$6,992,838.48
$ Per CY	$0.68	$0.94	$2.35	$1.05	$8.97	$13.99
					Total	**$ 8,835,820.38**
					Per CY	**$ 17.67**

Table 5. Cost model for producing 500,000 cubic yards.

The following factors were used for the above cost model:

- Field duration of 17 months.
- Fuel costs for both tasks derived by taking the monthly fuel cost for the demonstration and multiplying by 5 for larger or more equipment and extending it for 17 months (pilot costs x 5 x 17 months).
- Room and Board costs derived by taking the monthly costs for the pilot demonstration and adding 4 additional personnel per task (for a total of 8 per task) and extending it for 17 months (pilot costs x 4 x 17 months).
- Labor costs derived by taking the monthly costs for the demonstration and adding 4 additional personnel per task and extending it for 17 months (pilot costs x 4 x 17 months).
- Outside Equipment costs derived by taking those costs for the demonstration, doubling it, to cover larger or additional equipment and extending it for 17 months (pilot costs x 2 x 17 months).
- Owned Equipment costs derived by taking the cost for the pilot demonstration and multiplying by 12 to cover costs for larger equipment and extending it for 17 months (pilot cost x 12 x 17 months).

Production rate is the key with regard to per-cubic yard costs. Additional fuel, room and board, labor, and equipment costs associated with increasing soil volumes are offset by increased production rate over the course of the project.

It is important to note that cost modeling may not translate precisely to actual implementation costs at the volumes shown in the tables and caution should be observed when taking costs modeled for one CDF and applying them to another. Site specific variables discussed previously will affect costs from one CDF to the next.

6.2 COMPARISON TO OTHER COST ESTIMATES

Maher (2005) provides a dredged material evaluation plan which includes a method to estimate the costs associated with stockpiling, grubbing (the removal of vegetation, shrubs, etc.), providing access roads if none exist, and transportation costs. Many of these costs are dependant on distance to final use, and the size of vehicles used to transport the materials. It is also apparent that the first time a CDF is mined for the usable sand will be the most expensive. Future uses of the site, such as in the case of a perpetual use, or Regional Processing Facility (RPF), should be less on a cubic yard basis.

7. BENEFITS STUDY

This project demonstrates the ability to use processed dredged material as a substitute for virgin geo-materials, and the ability to selectively remove material from a CDF thus freeing valuable capacity. However, the cost estimates indicate that processed DM can not compete with the selling price of aggregates from a quarry. It is understood, however, that there are benefits to society of using DM, and the selling cost of virgin quarry material does not capture the full economic impact. In economics, a benefit or a cost not included in the market price of the goods and services being produced, i.e., costs not borne by those who create them and benefits not paid for by those who receive them, are called externalities. Using dredged material introduces externalities that, at present, can not be directly quantified. As New Jersey's CDFs are rapidly filling, it is becoming increasingly difficult to find suitable places to store dredge material. Alternatives for upland disposal of dredged material are often cost prohibitive. One unintended result is the suspension of dredging of certain New Jersey navigable waterways. During this study, the benefits of dredging and recycling dredged materials were examined. Results of this work can be found in Appendix E. This study begins to quantify the negative impacts upon the regional and local economy that would be and is being caused by the discontinuation of dredging. Additionally, this study discusses positive benefits of recycling dredged material, operating regional processing facilities (RPFs) and delaying the closure/opening new quarries versus the conventional storage of DM indefinitely in a CDF.

The benefits of maintaining New Jersey's navigable waterways are numerous. Recreational boating is a large industry in the state, both from tourism dollars and boat building. The Marine Trades Association (2008) reports that in-state recreational boating contributed $1.8 billion to the NJ economy in 2006. Impediments to navigation will restrict boating in ways such as reducing the number of voyages taken by boaters, limiting waterways to shallow draft vessels and eventually closing a waterway to boaters completely. Boaters will begin to turn away from New Jersey and seek waters in other states. The NJ Intracoastal Waterway (NJICW) is a major thoroughfare for boaters traveling up and down the East Coast. To many deeper draft vessels, waterways such as these are only as useful as the shallowest channel.

In addition to the direct value a boater will place on his or her recreational time, varied boater service industries depend on the recreating public. Fuel docks, marinas, restaurants, service centers, fishing tackle stores, and many more of these establishments survive from business brought by boats able to travel within their vicinity. As navigable waterways decrease and boaters take fewer trips within the state, new boat sales fall, hurting boat manufacturers, many of which are located within the state.

The study reiterates the impact that water and waterfront access have on property values. Though the study was unable to find an effective model to quantify the value, there is no doubt that as the percentage of navigable waterways decrease, so does the property value in those areas. The loss of tax revenue will be of direct impact to state and municipal budgets. The number of recreational boats registered in New Jersey has decreased as much as 27% in the past five years, in contrast to increases in boating nationwide (Marine Trades Association, 2006).

There are positive externalities associated with the use of recycled dredged material. Although a cubic yard of virgin quarried geo-material costs less than processed DM, there are additional benefits to using dredged material. New Jersey's CDFs are rapidly reaching capacity. Dredged material not only provides an alternative to virgin material, but its removal from a CDF allows new, needed dredging to occur. The use of recycled Dredged Material reduces the demand on aging local quarries and thus increasing their effective life.

By using recycled dredged material with other products such as crushed glass and recycled concrete aggregate, both of which are available readily in New Jersey, an environmental benefit is obtained. These mixed recycled materials are suitable for roadway subbase, base course, and structural fill depending on their amendment content and resulting geotechnical and hydraulic properties. Recreational boating is tied so intrinsically to New Jersey's economy that allowing channels to silt in could seriously injure local economies, not to mention presenting a safety hazard. In 2006, 11% of New Jersey boat trips were in boats larger than 26 feet in length (Marine Trades Association, 2006). These boats tend to have the deeper drafts.

Additionally, beneficially recycling dredged material from CDFs across the state can reduce the pressure on quarries to provide continued large quantities of aggregates, possibly providing relief from increased raw material costs in the future. As material is removed from a CDF, the CDF is then able to accept additional material, facilitating continued dredging and increasing the safety of the future of New Jersey recreational boaters.

7.1 COMPARING THE COST OF DM SEPARATION WITH THE BENEFITS

Based on the cost analysis presented in Section 6, clean sand, separated and removed from a CDF, has an estimated cost of $17.67 per cubic yard when processed during a large project. The value of that sand is approximately $9 per cubic yard ($6 per ton). That leaves a deficit of $8.67 per cubic yard which must be accounted for by benefits to society, otherwise the process is not viable. The benefits study presented in Appendix E identifies the potential methods to determine externalities, however the actual value of benefits to society, both economically and environmentally, are not presently known. For example, we do not know the exact economic consequences of a dredging stop or the potential substitution level of virgin materials with dredged materials. If these economic impacts were quantified, (loss in boating days, property price reductions, etc.) the benefit could then be estimated.

The question of how much should government pay for beneficially using a cubic yard of dredged material is not simple. An approach could be to determine the value of all positive economic impacts resulting in an annual Total Benefit Measure of Dredging (TBMD). The TBMD could then be divided by the volumetric space requirements (in cubic yards) for new dredged materials per year to give an estimate of $/cubic yard.

Based on the British study referred to in Appendix E, we have an estimate of the social values of virgin materials (sand and gravel). Assuming that the proposed Regional Processing Facilities (RPFs) do not have social costs, the cost of using virgin materials would be a benefit for the portion of the annual dredged materials that can be reused. This volume can be called "X_{reuse}". Additionally, the premature closure of quarries might influence the future costs of materials. This value (a function X_{reuse} and the extent of the closure) should be added to TBMD, which would give the Total Value of Reusing Dredged Materials (TVRDM).

The total value of a cubic yard of beneficially used DM would then be the sale price of the aggregate + TVRDM. This value may be applicable only to a region having a shortage of dredged material placement capacity.

8. CONCLUSIONS / RECOMMENDATIONS

The prospects for cost effectively excavating dredged material from New Jersey back-bay CDFs are good. The project received positive press both locally and nationally (see Appendix F). It is hoped that the demonstration of this technology may result in a Beneficial Use Determination (BUD) from the State such that the DM separation process can be used anywhere in coastal New Jersey. One of the factors hindering wide-scale use of dredged material is that each project must undergo site specific testing and permitting. This adds greatly to the cost of excavation, especially since material contained within the CDF was tested prior to placement. The time associated with testing and permitting the DM impacts the ability of other State and Federal resource agencies to manage and/or use the material. Additionally, access to the CDFs (from a regulatory perspective) due to their location in coastal marshes is an unresolved issue at many CDFs.

The wet separation demonstration showed that the technology is effective for separating sand from fines under a wide range of soil characteristics. This project also demonstrated the ability to design a separation plant that is mobile and can be used in a wide variety of locales. Additionally, this project laid the foundation for estimating cost for separating dredged material on a larger scale. As expected, cost modeling for dredged material separation projects shows the per cubic yard cost of projects reducing as the size of the project and amount of material separated increased. Cost analysis estimates the cost of separating 500,000 cubic yards of dredged material to be approximately \$17.67 per cubic yard, compared to \$90.92 per cubic yard for separating 1,066 cubic yards of the sand during the demonstration project. This cost reduction is a result of the costs of economy of scale and sunk costs such as mobilization and demobilization.

Once the sandy fraction has been separated from the fines, the fines can be dewatered and contained within geotextile dewatering tubes. Using a low dosage rate of polymer (AQ-200), the material dewatered quickly without the fine material clogging the tube's pores. Using the correct polymer dosage, dewatering can be completed in a manner of weeks as opposed to open air settling and mechanical dewatering which are less feasible options given the time it would require for this amount of material to dewater. Geotextile tubes with dewatered material can serve a structural purpose. The berm confining the dredged material can be reconstructed as material is separated. This can also provide easier future material recovery since the material will be dewatered and well contained.

One of the most important lessons to be learned from the Phase II Dredged Material Separation Technology demonstration project is the ability to beneficially use multiple recyclable materials. In this case, the sandy fraction of separated dredged material was mixed with crushed, recycled glass to meet NJDOT specifications and was utilized in a roadway construction project. Tests were also performed on the separated sand with recycled concrete aggregate. Results indicate that both the crushed, recycled glass and recycled concrete aggregate are suitable materials to amend separated dredged material with for utilization in a sustainable manner.

Based on the results of the demonstration project, there are several important steps to be taken to continue the process of establishing dredged material as a resource. Recommendations include:

- Continue to research sediments contained within New Jersey back-bay CDFs and develop a classification system for dredged materials. By establishing a common naming/ characterization method for CDF material, an inventory of available material can be started, possible amendment and usage methods for various materials can be developed, and a dialog can be opened between resource providers and industries/projects needing the material.
- Market the use of separated dredged material, specifically to the aggregate producers and block manufacturers. The use of recycled materials such as dredged material is consistent with LEEDS certification and principals of sustainable development.
- Advocate for the benficial use of dredged material by continued public outreach and education. Work performed to date and in the future will need to be conveyed to the general public, boating world and construction industry to make all aware of the potential benefits and sustainability of recycling sandy dredged material and applying to common usages.
- Embark on the economic research necessary to quantify the benefits of dredged material usage, and dredging New Jersey's waterways.
- Identify NJDOT and other construction projects early to facilitate the use of clean DM in the design. Once the design has specified a virgin geo-material it is difficult to substitute a DM or amended DM.

9. REFERENCES

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Appendix A

Acceptable Use Determination

OCEAN AND COASTAL
CONSULTANTS, INC.

OCEAN AND COASTAL CONSULTANTS, INC.
20 E. CLEMENTON ROAD, SUITE 201N
GIBBSBORO, NJ 08026
PH 856-248-1200 FX 856-248-1206
www.ocean-coastal.com

August 28, 2006

Office of Dredging and Sediment Technology
New Jersey Department of Environmental Protection
401 E. State Street, 6th Floor
P.O. Box 028
Trenton, NJ 08625

Attention: Mr. Dave Risillia

Reference: Dredged Material Separation Technology Project – Analytical Testing Results

Dear Mr. Risillia:

Per the conditions set forth in the Acceptable Use Determination (AUD) as received from the New Jersey Department of Environmental Protection (NJDEP) Office of Dredging and Sediment Technology (ODST) on July 14, 2006, OCC has completed the bulk sediment testing for the Dredged Material Separation Technology Project. Per the AUD, three representative samples of the following materials were tested for target analytes found in Appendix B of the New Jersey Dredging Manual:

1. Raw sediment from the CDF,
2. Sand material after separation,
3. Recycled glass,
4. Amended material,
5. Fines before the addition of polymer, and
6. Fines after the addition of polymer.

In addition, samples of the Site Water (from Cape May Inlet) and Supernatant Water (from the geotextile tubes) were also sampled and tested for target analytes in found in Appendix B of the Dredging Manual.

Representative samples of the above mentioned materials were taken at various times to best represent the materials throughout the entire separation process (i.e. the beginning, middle and end stages of separation). Analytical results are summarized in the attached table. Please feel free to contact me at 856-248-1200 ext. 103 or dgaffney@ocean-coastal.com with any questions or comments you may have.

Sincerely yours,

OCEAN AND COASTAL CONSULTANTS, INC.

Douglas A. Gaffney

Douglas A. Gaffney, P.E.
Regional Director

CC: Kathleen Shilling - USCG

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OCEAN AND COASTAL CONSULTANTS, INC.

I-Boat New Jersey
Dredged Material Separation Demonstration Project
USCG TRACEN
Cape May, NJ
Analytical Testing Data

Parameter	Raw Material			Recycled Glass	Sand			Fines (Pre-Polymer Addition)			Fines (Post-Polymer Addition)			Amended Material			NJSCC (res)	NJSCC (non-res)	Supe
	Beginning	Middle	End		Beginning	Middle	End	Beginning	Middle	End	Beginning	Middle	End	Beginning	Middle	End			Beginnin
Inorganics	*mg/kg*			*mg/kg*	*mg/kg*			*mg/kg*			*mg/kg*			*mg/kg*			*mg/kg*		*m*
Aluminum	3240	2250	2390	44.4	2540	2260	1900	13900	17500	19500	29500	7910	8170	637	1530	939	NA	NA	1.54
Arsenic	1.47	1.64	ND	ND	ND	ND	ND	10.2	12.7	16	22.5	5.32	5.97	ND	ND	ND	20	20	ND
Barium	8.31	5.64	5.47	3.6	6	4.96	3.81	38.5	41.5	50.3	78.3	19.2	20.3	5.72	5.1	4.72	700	47000	0.024
Beryllium	ND	ND	ND	ND	ND	ND	ND	0.499	0.678	0.644	1.1	ND	0.352	ND	ND	ND	1	1	ND
Calcium	997	716	1230	385	974	777	874	2490	2470	2770	4640	1820	1900	438	851	519	NA	NA	271
Cobalt	3.26	3.22	2.32	ND	1.94	1.96	1.87	8.94	9.17	11.7	19.8	5.99	6.61	ND	1.42	ND	NA	NA	ND
Chromium	9.17	6.08	6.87	ND	9.95	6.36	5.09	45.7	51.5	65.1	90.6	24.1	25.1	2.27	4.81	3.58	NA	NA	0.0093
Copper	3.63	1.53	2.19	2.15	3.3	1.91	1.37	20.4	35.1	30.4	54.4	10.1	10.2	1.88	2.24	2.16	600	600	0.0123
Iron	5440	3640	4040	114	4050	3730	3130	23700	28000	31300	46100	13800	14000	1070	2510	1610	NA	NA	1.04
Potassium	634	426	488	30.5	665	510	539	3270	3610	4460	7930	2210	2400	150	346	216	NA	NA	456
Magnesium	1250	911	982	30.3	1290	1020	1190	5080	5260	6380	12700	3850	4100	308	724	438	NA	NA	1070
Manganese	104	80.2	61.9	14	54.2	45.6	43.6	311	197	296	775	164	191	20.9	35.9	34.5	NA	NA	0.377
Sodium	176	ND	253	175	3310	966	3390	2710	2390	2050	17700	5820	7200	533	977	679	NA	NA	9660
Nickel	4.76	3.67	3.74	ND	3.19	3.02	2.67	17.1	18	22.6	37.8	11.2	11.9	ND	2.13	1.42	250	2400	ND
Lead	8.09	3.08	3.62	ND	5.43	3.72	ND	38.5	56.9	60.6	78.8	15.6	14.9	2.33	3.16	2.84	400	600	0.0068
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	63	3100	ND
Vanadium	10	6.53	6.99	ND	7.63	6.63	5.58	48.5	55.8	70.1	94.6	24.9	26.5	1.97	4.5	3.31	370	7100	ND
Zinc	27.6	19.5	18.4	29.9	20.2	14.4	12.1	100	101	137	241	66	70.6	43.8	37.2	35.8	1500	1500	0.0053
Mercury	ND	ND	ND	ND	ND	ND	ND	0.367	ND	0.469	0.633	ND	ND	ND	ND	ND	14	270	ND
Volatiles	*ug/kg*			*ug/kg*	*ug/kg*			*ug/kg*			*ug/kg*			*ug/kg*			*ug/kg*		
Acetone	ND	ND	ND	14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1000000	1000000	14.4
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	0.92
Methyl Chloride	ND	ND	ND	0.691 J	1.08 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	49000	210000	ND
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1000000	1000000	1.66 J
Semivolatiles	*ug/kg*			*ug/kg*	*ug/kg*			*ug/kg*			*ug/kg*			*ug/kg*			*ug/kg*		
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	206 J	ND	ND	126 J	ND	NA	NA	ND
Di-n-butylphthalate	ND	95.2 J	ND	88.6 J	ND	ND	ND	85.3 J	ND	ND	ND	ND	159 J	ND	ND	ND	5700000	10000000	ND
Flouranthene	ND	ND	ND	ND	ND	ND	ND	99.8 J	74.5 J	104 J	ND	233 J	ND	ND	217 J	ND	2300000	10000000	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	227 J	ND	ND	146 J	ND	1700000	10000000	ND
Butylbenzylphthalate	ND	ND	ND	64.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1100000	10000000	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	83.1 J	ND	900	4000	ND
Chrysene	ND	ND	ND	ND	218 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	78.8 J	ND	9000	40000	ND
Bis(2-ethylhexyl)phthalate	ND	ND	ND	451 B	ND	ND	ND	ND	ND	ND	ND	ND	ND	371	182 J	698	49000	210000	ND
Cyanide, Total (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1100	21000	ND
Total Organic Carbons (mg/kg)	8350	ND	ND	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Percent Solids	81.06%	91.94%	90.94%	99.91%	75.14%	92.13%	77.96%	69.13%	73.17%	68.16%	37.31%	59.81%	62.18%	95.11%	93.88%	95.10%	N/A	N/A	N/A
Total Suspended Solids (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	65
pH	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.11
Density (g/mL)	N/A	N/A	N/A	2.51	2.8	2.73	2.55	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes

ND- Not Detected

N/A Not Applicable, not tested for

State of New Jersey
Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

Site Remediation Program
Office of Dredging and Sediment Technology
P.O. Box 028
Trenton, NJ 08625
(609) 292-1250
FAX (609) 777-1914

November 6, 2000

Commander Robert J. Legier, P.E
Facilities Engineer
U.S. Coast Guard Training Center
1 Munro Avenue
Cape May, New Jersey 08204-5092

RE: Acceptable Use Determination
Material in Confined Disposal Facility #3
U.S. Coast Guard Training Facility, Cape May, New Jersey

Dear Commander Legier:

On October 23, 2000 the Office of Dredging and Sediment Technology received your request concerning any use restrictions for the material existing in Confined Disposal Facility #3 at the Cape May Training Center. Your request was accompanied by analytical data performed by Target Environmental Co., Inc. dated October 11, 2000.

I have reviewed the analytical data submitted with your request. Based on my review, all analytes are reported below the Residential Direct Contact Soil Cleanup Criteria (RDCSCC). These are the most restrictive criteria developed based on a human health risk assessment. Consequently, the levels of contaminants in the dredged material are below regulatory concern, and there are no restrictions on the use of this material. Further, **this letter shall serve as the Department's Acceptable Use Determination for the unrestricted beneficial use of the material contained in Confined Disposal Facility #3.**

Should you have any questions concerning this determination, please do not hesitate to contact me at (609) 292-8838.

Sincerely,

Lawrence J. Baier
Chief
Office of Dredging and Sediment Technology

(4)

TARGET ENVIRONMENTAL CO., INC.
1-800-428-6017 • NJ (609) 804-9100 • Fax: (609) 804-1834
Concern for our Client • Respect for the Environment

October 11, 2000

Ms. Kathleen Shilling
USCG Training Center
Cape May, NJ 08204-5095

RE: Sediment Sampling for Dredge Material CDF #3
USCG Cape May, NJ

Dear Ms. Shilling,

Target Environmental Co., Inc. (TEC) is submitting this letter report documenting the sediment sampling activities performed at the United States Coast Guard (USCG) training facility located in Cape May, New Jersey (see Figure #1).

Sediment Sampling

On September 14, 2000, TEC mobilized to the USCG training facility's Cape May, NJ for the performance of six (6) sediment sampling cores from the stockpiled dredge spoils material. Sediment sampling locations were predetermined by New Jersey Department of Environmental Protection (NJDEP) representatives. Sediment sampling cores were completed with the usage of Geoprobe discrete sampling equipment.

Sediment sampling procedures consisted of determining the sample location, based on the map supplied by NJDEP representatives. Table 1 shows the sediment depths for all sampling locations. Figure #2 shows the location of all sediments samples.

TABLE ONE
SAMPLE DEPTH

Sample No.	Sediment Depth
S-1	10'
S-2	10'
S-3	10'
S-4	10'
S-5	10'
S-6	10'

Sediment sampling consisted of driving a one-inch discreet sampling device for the collection of sediments. All sediment samples were collected in acetate liners, as to avoid possible metals contamination from the steel casing. All sediment samples were

(5)

collected from zero (0) to ten (10) feet below the dredge pile surface. All individual sediment samples were analyzed for total organic carbon, percent moisture and grain size. Sediment sample locations S-1, S-2, and S-3 were composited (COMP-A) and laboratory analyzed for bulk sediment chemistry, which includes: base/neutral & acid extractable semi-volatile organic compounds, pesticides, PCBs, target analyte metals, and cyanide. Sediment sample locations S-4, S-5, and S-6 were composited (COMP-B) and laboratory analyzed for bulk sediment chemistry, which includes: base/neutral & acid extractable semi-volatile organic compounds, pesticides, pcb, target analyte metals, and cyanide.

Sediment Collection and Analysis

Sediment sample location S-1 consisted of dark gray silty sand (field determination). Appendix A contains the soil boring logs for all sampling locations. All soil sampling intervals were homogenous and were therefore composited into one sample. S-1 was laboratory analyzed for total organic carbon, percent moisture and grain size. Table 2 contains the summary of the total organic carbon and percent moisture analysis. Table 3 contains the grain size analysis.

Sediment sample location S-2 consisted of dark gray silty sand (field determination). Appendix A contains the soil boring logs for all sampling locations. All soil sampling intervals were homogenous and were therefore composited into one sample. S-2 was laboratory analyzed for total organic carbon, percent moisture and grain size. Table 2 contains the summary of the total organic carbon and percent moisture analysis. Table 3 contains the grain size analysis.

Sediment sample location S-3 consisted of dark gray silty sand (field determination). Appendix A contains the soil boring logs for all sampling locations. All soil sampling intervals were homogenous and were therefore composited into one sample. S-2 was laboratory analyzed for total organic carbon, percent moisture and grain size. Table 2 contains the summary of the total organic carbon and percent moisture analysis. Table 3 contains the grain size analysis.

Sediment sample location S-4 consisted of dark gray silty sand (field determination). Appendix A contains the soil boring logs for all sampling locations. All soil sampling intervals were homogenous and were therefore composited into one sample. S-2 was laboratory analyzed for total organic carbon, percent moisture and grain size. Table 2 contains the summary of the total organic carbon and percent moisture analysis. Table 3 contains the grain size analysis.

Sediment sample location S-5 consisted of dark gray silty sand (field determination). Appendix A contains the soil boring logs for all sampling locations. All soil sampling intervals were homogenous and were therefore composited into one sample. S-2 was laboratory analyzed for total organic carbon, percent moisture and grain size. Table 2 contains the summary of the total organic carbon and percent moisture analysis. Table 3 contains the grain size analysis.

Sediment sample location S-6 consisted of dark gray silty sand (field determination). Appendix A contains the soil boring logs for all sampling locations. All soil sampling intervals were homogenous and were therefore composited into one sample. S-2 was laboratory analyzed for total organic carbon, percent moisture and grain size. Table 2 contains the summary of the total organic carbon and percent moisture analysis. Table 3 contains the grain size analysis.

Appendix B contains the total organic carbon, percent solids, base/neutral & acid extractable semivolatile compounds, pesticides, PCBs, target analyte metals and cyanide laboratory analytical results. Appendix C contains the grain size analysis results.

Sediment samples S-1, S-2 and S-3 were composited into one sample (COMP-A). Composite sample COMP-A was laboratory analyzed for base/neutral & acid extractable semivolatile compounds, pesticides, PCB's, target analyte metals and cyanide. Table 4 contains the laboratory results for these analysis.

Sediment samples S-4, S-5 and S-6 were composited into one sample (COMP-B). Composite sample COMP-B was laboratory analyzed for base/neutral & acid extractable semivolatile compounds, pesticides, PCB's, target analyte metals and cyanide. Table 4 contains the laboratory results for these analysis.

Conclusions and Recommendations

Laboratory results for both composite sediment samples revealed no exceedances of the NJDEP Residential Soil Cleanup Criteria for target analyte list metals, base/neutral & acid extractable semivolatile compounds, pesticides, PCBs and cyanide.

If you have any questions or concerns about this report, please feel free to contact my Egg Harbor City office at (609) 804-9100.

Sincerely,
Target Environmental Co., Inc

Thomas P. Schultz
Environmental Specialist I

TABLE TWO
SUMMARY OF PERCENT ~~MOISTURE~~ SOLID & TOTAL ORGANIC CARBON RESULTS

Sample Identification	Analytical Parameters	
	Total Organic Carbon (mg/kg)	Percent ~~Moisture~~ Solid
Field ID: S-1 Lab ID: AB14860	3200	90
Field ID: S-2 Lab ID: AB14861	440	95
Field ID: S-3 Lab ID: AB14862	5000	83
Field ID: S-4 Lab ID: AB14863	8100	74
Field ID: S-5 Lab ID: AB14864	3100	91
Field ID: S-6 Lab ID: AB14865	21000	76
Field ID: Comp-A Lab ID: AB14866	4500	89
Field ID: Comp-B Lab ID: AB14867	7500	84

TABLE THREE
SUMMARY OF GRAIN SIZE ANALYSIS RESULTS

Sample Identification	Analytical Parameters		
	Percent Sand Size: > 0.0625 mm	Percent Silt Size: 0.0039 to 0.0625 mm	Percent Clay Size: < 0.0039 mm
Field ID: S-1 Lab ID: AB14860	51.77	2.75	45.47
Field ID: S-2 Lab ID: AB14861	89.10	8.96	1.90
Field ID: S-3 Lab ID: AB14862	31.95	61.72	6.31
Field ID: S-4 Lab ID: AB14863	59.00	34.32	6.64
Field ID: S-5 Lab ID: AB14864	81.76	13.27	4.97
Field ID: S-6 Lab ID: AB14865	46.71	30.94	22.35
Field ID: Comp-A Lab ID: AB14866	66.81	28.12	5.07
Field ID: Comp-B Lab ID: AB14867	63.27	29.62	7.11

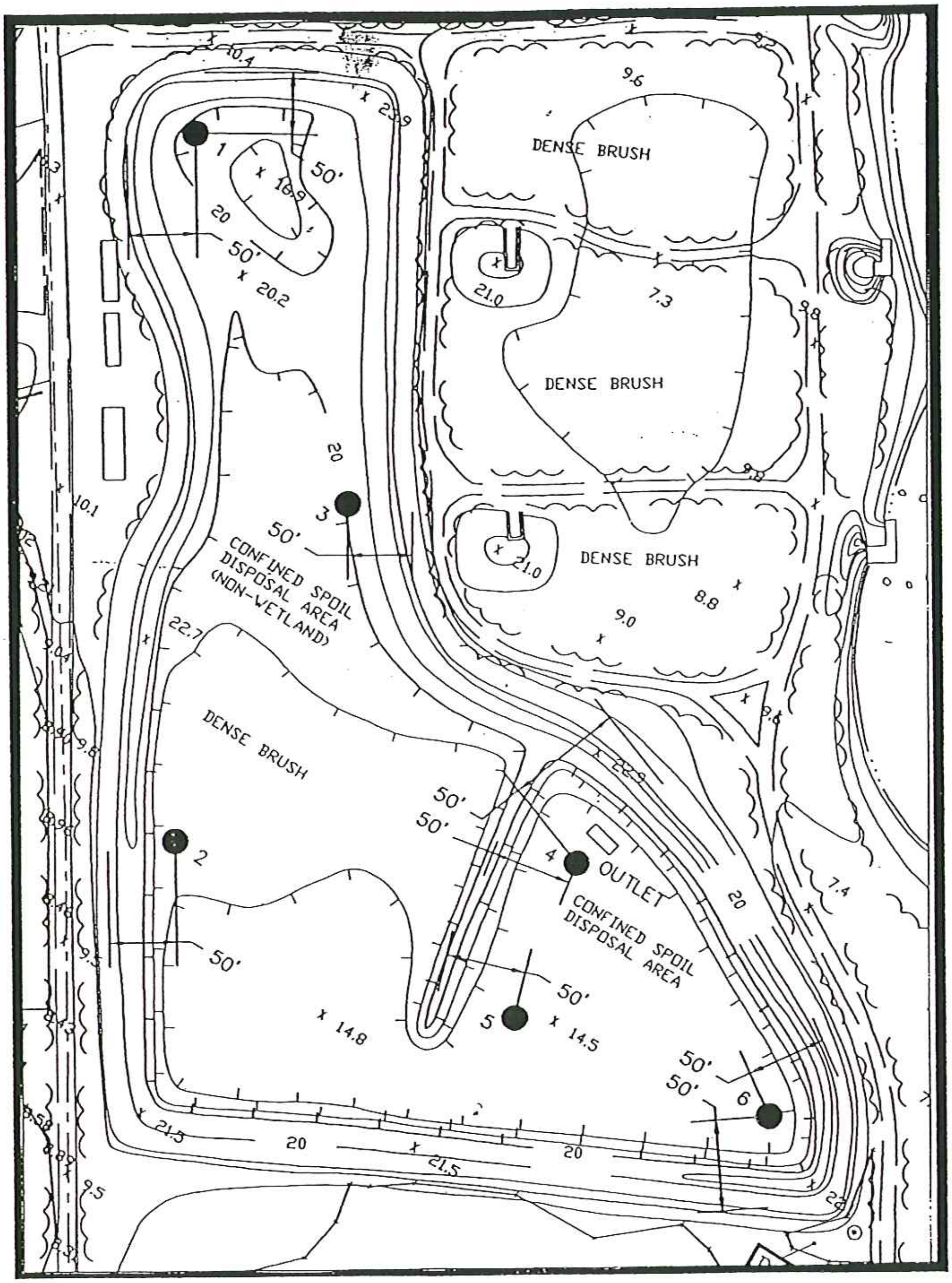


Figure 2: Sediment Sampling Plan Map
Confined Disposal Facility No. 3
USCG Training Facility
Cape May, New Jersey

TABLE FOUR
SUMMARY OF BULK SEDIMENT CHEMISTRY ANALYTICAL RESULTS

Fraction	Analytical Parameters	Sample Identification		Residential Direct Contact Soil Cleanup Criteria
		Field ID: Comp-A Lab ID: AB14866	Field ID: Comp-B Lab ID: AB14867	
Base/Neutral & Acid Extractable Semivolatile Organics	1,2,4-Trichlorobenzene	0.19 U	0.20 U	68
	1,2-Dichlorobenzene	0.19 U	0.20 U	5100
	1,2-Diphenylhydrazine	0.037 U	0.040 U	NP
	1,3-Dichlorobenzene	0.19 U	0.20 U	5100
	1,4-Dichlorobenzene	0.19 U	0.20 U	570
	2,4,5-Trichlorophenol	0.19 U	0.20 U	5600
	2,4,6-Trichlorophenol	0.19 U	0.20 U	62
	2,4-Dichlorophenol	0.19 U	0.20 U	170
	2,4-Dimethylphenol	0.19 U	0.20 U	1100
	2,4-Dinitrophenol	0.37 U	0.40 U	110
	2,4-Dinitrotoluene	0.19 U	0.20 U	1
	2,6-Dinitrotoluene	0.19 U	0.20 U	1
	2-Chloronaphthalene	0.19 U	0.20 U	NP
	2-Chlorophemol	0.19 U	0.20 U	280
	2-Methylnaphthalene	0.19 U	0.20 U	NP
	2-Methylphenol	0.19 U	0.20 U	2800
	2-Nitroaniline	0.19 U	0.20 U	NP
	2-Nitrophenol	0.19 U	0.20 U	NP
	3 & 4-Methylphenol	0.19 U	0.20 U	2800
	3,3'-Dichlorobenzidine	0.19 U	0.20 U	2
	3-Nitroaniline	0.19 U	0.20 U	NP
	4,6-Dinitro-2-methylphenol	0.19 U	0.20 U	NP
	4-Bromophenyl-phenylether	0.19 U	0.20 U	NP
	4-Chloro-3-methylphenol	0.19 U	0.20 U	10000
	4-Chloroaniline	0.19 U	0.20 U	230
	4-Chlorophenyl-phenylether	0.19 U	0.20 U	NP
	4-Nitroaniline	0.19 U	0.20 U	NP
	4-Nitrophenol	0.19 U	0.20 U	NP
	Acenaphthene	0.19 U	0.20 U	3400
	Acenaphthylene	0.19 U	0.20 U	NP
	Anthracene	0.19 U	0.20 U	10000
	Bezidine	0.37 U	0.40 U	NP
	Benzo[a]anthracene	0.042 J	0.20 U	0.9
	Benzo[a]pyrene	0.039 J	0.20 U	0.66
	Benzo[b]fluoranthene	0.049 J	0.047 J	0.9
	Benzo[g,h,i]perylene	0.19 U	0.20 U	NP
	Benzo[k]fluoranthene	0.19 U	0.042 J	0.9

TABLE FOUR (continued)
SUMMARY OF BULK SEDIMENT CHEMISTRY ANALYTICAL RESULTS

Base/Neutral & Acid Extractable Semivolatile Organics	Bis(2-chlorethoxy)methane	0.19 U	0.20 U	NP
	Bis(2-Chloroethyl)ether	0.19 U	0.20 U	0.66
	Bis(2-chloroisopropyl)ether	0.19 U	0.20 U	2300
	Bis(2-ethyhexyl)phthalate	0.054 J	0.056 J	49
	Butylbenzylphthalate	0.019 U	0.20 U	1100
	Carbazole	0.19 U	0.20 U	NP
	Chrysene	0.055 J	0.054 J	9
	Di-n-butylphthalate	0.047 J	0.044 J	5700
	Di-n-octylphthalate	0.071 JB	0.063 JB	1100
	Dibenzo[a,h]anthracene	0.19 U	0.20 U	0.66
	Dibenzofuran	0.19 U	0.20 U	NP
	Diethylphthalate	0.19 U	0.20 U	10000
	Dimethylphthalate	0.19 U	0.20 U	10000
	Fluoranthene	0.075 J	0.075 J	2300
	Fluorene	0.19 U	0.20 U	2300
	Hexachlorobenzene	0.19 U	0.20 U	0.66
	Hexachlorobutadiene	0.19 U	0.20 U	1
	Hexachlorocyclopentadiene	0.56	0.60 U	400
	Hexachloroethane	0.19 U	0.20 U	6
	Indeno[1,2,3-cd]pyrene	0.19 U	0.20 U	0.9
	Isophorone	0.19 U	0.20 U	1100
	N-nitroso-di-n-propylamine	0.19 U	0.20 U	0.66
	N-nitrosodidimethylamine	0.19 U	0.20 U	NP
	N-nitrosodiphenylamine	0.19 U	0.20 U	140
	Naphthalene	0.19 U	0.20 U	230
	Nitrobenzene	0.19 U	0.20 U	26
	Pentachlorophenol	0.19 U	0.20 U	6
	Phenanthrene	0.19 U	0.20 U	NP
	Phenol	0.19 U	0.20 U	10000
	Pyrene	0.060 J	0.064 J	1700
Pesticides	Aldrin	0.0037 U	0.004 U	0.04
	Alpha-BHC	0.0037 U	0.004 U	NP
	Beta-BHC	0.0037 U	0.004 U	NP
	Chlordane	0.0075 U	0.0079 U	NP
	Delta-BHC	0.0037 U	0.004 U	NP
	Dieldrin	0.0037 U	0.004 U	0.042
	Endosulfan I	0.0037 U	0.004 U	NP
	Endosulfan II	0.0037 U	0.004 U	NP
	Endosulfan Sulfate	0.0037 U	0.004 U	NP
	Endrin	0.0037 U	0.004 U	17
	Endrin Aldehyde	0.0037 U	0.004 U	NP

TABLE FOUR (continued)
SUMMARY OF BULK SEDIMENT CHEMISTRY ANALYTICAL RESULTS

Pesticides	Endrin Ketone	0.0037 U	0.004 U	NP
	Gamma-BHC	0.0037 U	0.004 U	0.52
	Heptachlor	0.0037 U	0.004 U	0.15
	Heptachlor Epoxide	0.0037 U	0.004 U	NP
	Methoxychlor	0.0037 U	0.004 U	NP
	P,P'-DDD	0.0037 U	0.004 U	3
	P,P'-DDE	0.0037 U	0.0043	2
	P,P'-DDT	0.0037 U	0.004 U	2
	Toxaphene	0.037	0.04 U	0.10
PCBs	Arochlor-1016	0.019 U	0.02 U	0.49
	Arochlor-1221	0.019 U	0.02 U	0.49
	Arochlor-1232	0.019 U	0.02 U	0.49
	Arochlor-1242	0.019 U	0.02 U	0.49
	Arochlor-1248	0.019 U	0.02 U	0.49
	Arochlor-1254	0.019 U	0.02 U	0.49
	Arochlor-1260	0.019 U	0.02 U	0.49
Target Analyte Metals	Aluminum	4700	9400	NP
	Antimony	1.6 U	1.7 U	14
	Arsenic	2.2 U	11	20
	Barium	18	29	700
	Beryllium	0.68	0.6	1
	Cadmium	0.34 U	0.36 U	1
	Calcium	3200	2300	NP
	Chromium	5.9	34	NP
	Cobalt	4.5	6	NP
	Copper	9.3	20	600
	Iron	1300	18000	NP
	Lead	9.5	38	400
	Magnesium	2800	3600	NP
	Manganese	300	300U	NP
	Mercury	0.19	0.098 U	14
	Nickel	12	14	250
	Potassium	1300	2000	NP
	Selenium	2.8 U	3 U	63
	Silver	0.56 U	0.79	110
	Sodium	500	480 U	NP
	Thallium	1.3 U	1.4 U	2
	Vanadium	11 U	39	370
	Zinc	70	84	1500
	Cyanide	0.28 U	0.30 U	1100

All results reported in mg/kg (ppm).
All results reported in **bold type** exceed Residential Direct Contact Soil Cleanup Criteria.

chlorides ?

Post-it® Fax Note 7671 | Date | # of pages ▶ 3
To D Gaffney | From D Risilia
Co./Dept | Co.
Phone # | Phone #
Fax # 856 248-1200 | Fax #

[...]w Jersey
[...]NMENTAL PROTECTION
[...]ediment Technology
[...]; 028
Trenton, NJ 08625
(609) 292-1250
FAX (609) 777-1914

LISA P. JACKSON
Commissioner

July 14, 2006

Mr. Robert J. Legier
Commander, U.S. Coast Guard
Cape May Facility
1 Munro Avenue
Cape May, NJ 08204-5092

RE: Acceptable Use Determination (AUD) for
I-Boat NJ Dredged Material Separation Technology
Demonstration Project for Transfer and Reuse of
Cape May Harbor Training Facility Maintenance Dredge Materials
DEP File: 0502-05-0008.1

Dear Mr. Legier:

The Office of Dredging and Sediment Technology (ODST) has reviewed your request for a modified AUD received June 14, 2006. In addition, ODST is in receipt of the supplemental information package received from Ocean and Coastal Consultants Inc. entitled "Phase II Proposal Dredged Material Separation Technology On Nummy Island (Site 103), Stone Harbor, New Jersey Demonstration Project", dated January 25, 2006.

The subject AUD modification request seeks to remove approximately 1,000 cubic yards of previously dredged and dewatered material from CDF # 3 of the USCG Cape May Facility. The material will be fluidized and separated via a material separation technology. A slurry of fine fraction particles from the separation process will be mixed with a polymer and pumped into geotubes for dewatering within the CDF. The coarse grain-sandy fraction materials will subsequently be blended onsite with approximately 1,000 cubic yards of recycled glass to produce approximately 2,000 cubic yards of product meeting NJDOT I-7 gradation specifications. The final product will be trucked off-site for use in the NJDOT Route 52 project as fill.

The initial proposal was for materials originating from the Nummy Island CDF and provided chemical sampling of the subject materials. Due to logistical and timing issues, this separation technology is now being proposed at the USCG Cape May facility.

Based upon the information provided including analytical data provided by Target Environmental Co. Inc dated October 11, 2000, the subject Acceptable Use

3. If the permittee elects to dispose/use the dredged material from this project at an alternate location, written authorization must be obtained from the Office of Dredging and Sediment Technology prior to the transport of any dredged material to said alternate disposal location. Any alternate disposal/use location must obtain all required state, local and federal permits before the ODST would grant a modification of this permit to transport dredged material to the alternate location.

Should you have any questions concerning this determination, please do not hesitate to contact David Q. Risilia at (609) 292-9342.

Sincerely,

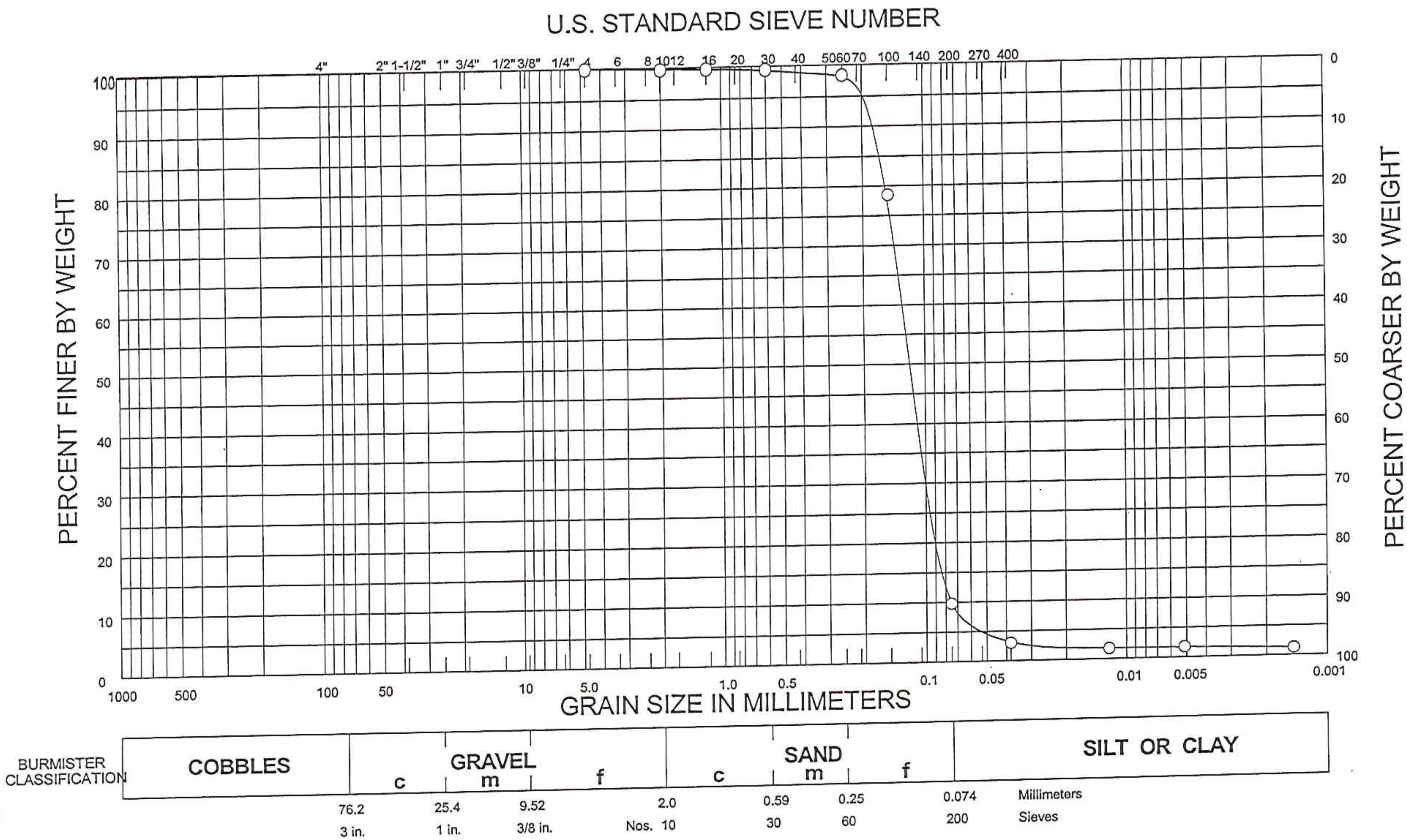
Suzanne Dietrick

Suzanne U. Dietrick, Chief
Office of Dredging and Sediment Technology

Dr/c/aud/Cape May Coast Guard AUD Modification

Appendix B1

Raw Dredged Material

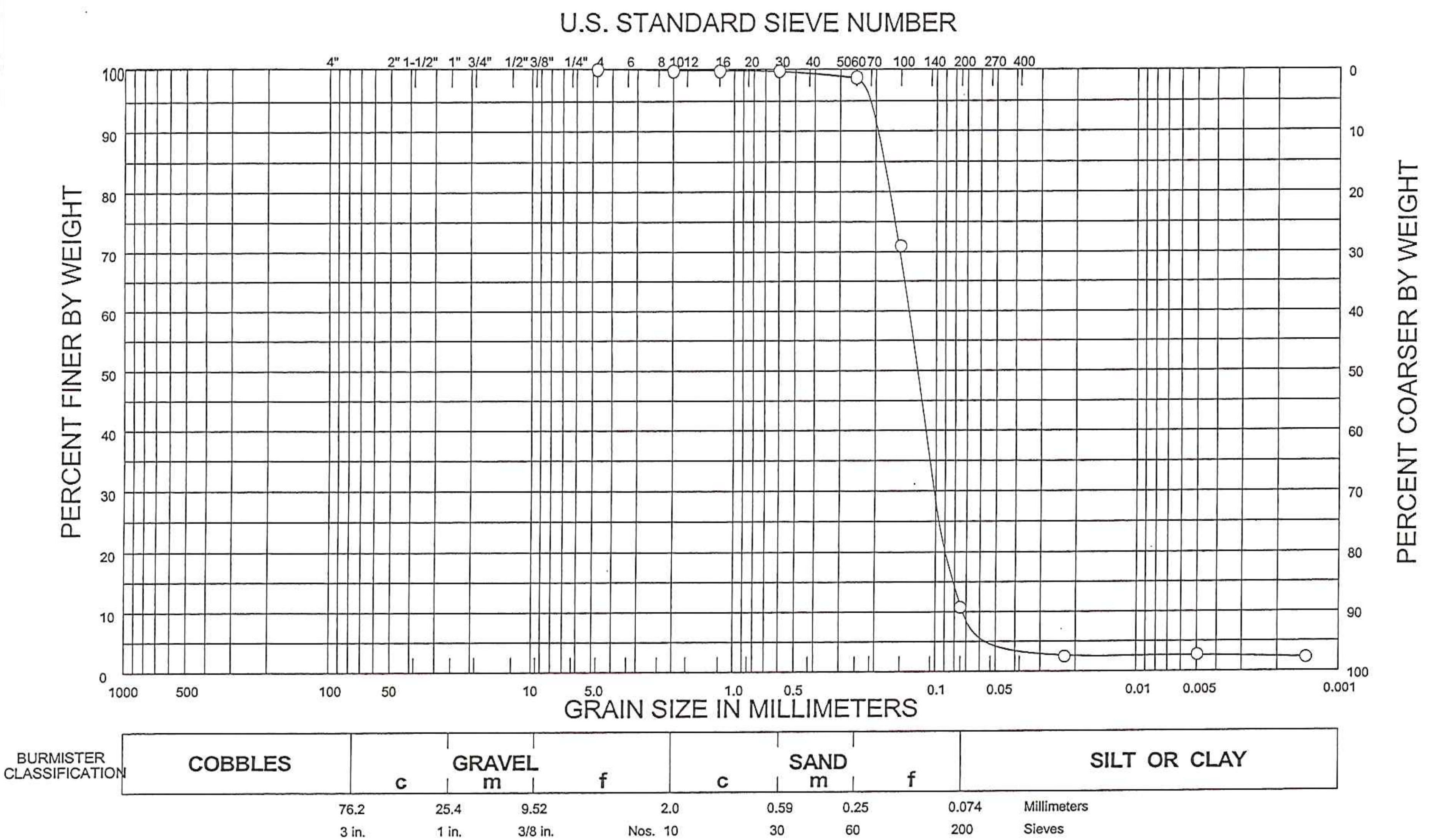


06L014A	QC Labs
L2053351-1	7/27/06
Brown f SAND, trace+ Silt	

GRADATION CURVE

FPA

FRENCH & PARRELLO ASSOCIATES, P.A. CONSULTING ENGINEERS



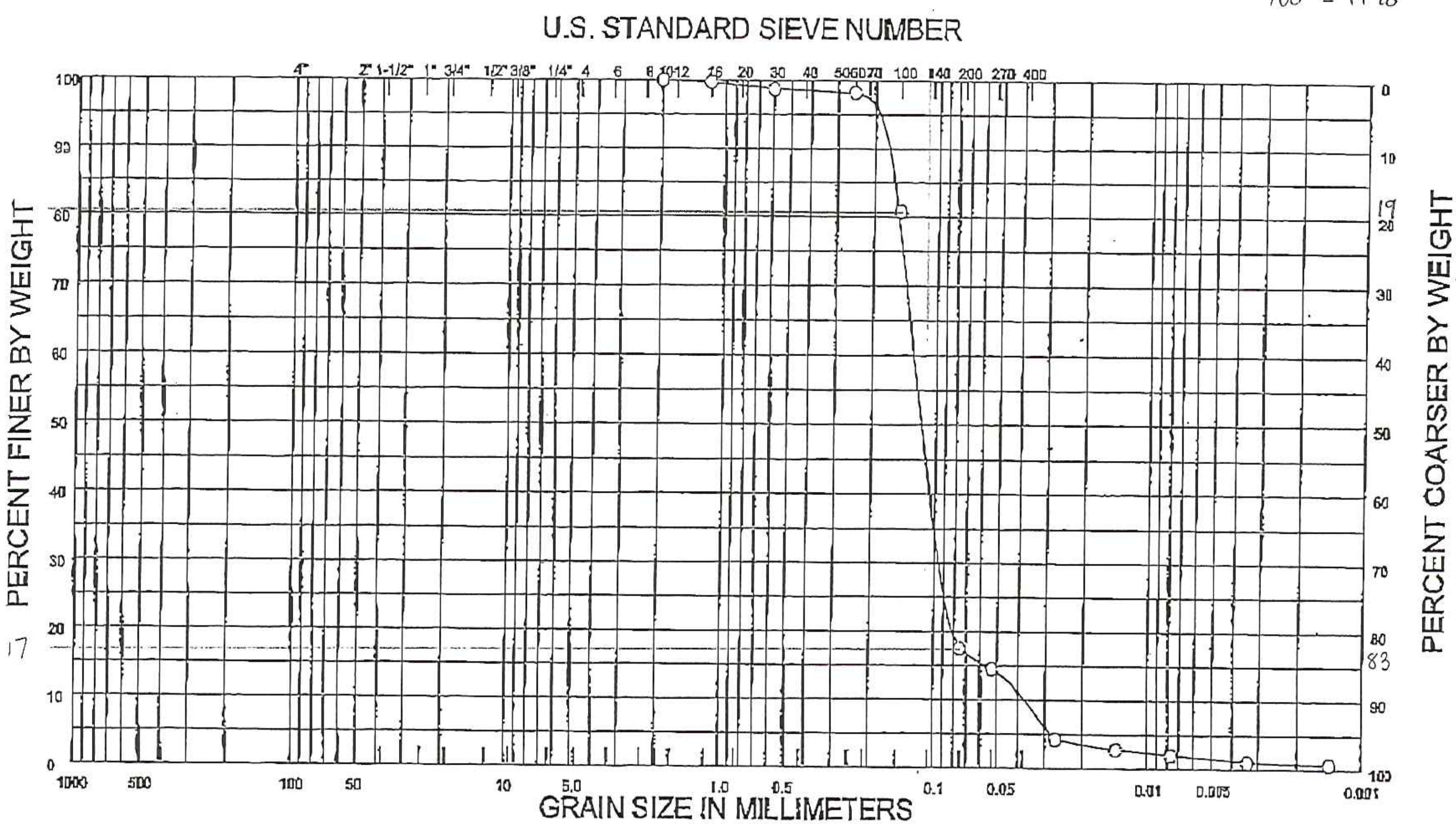
06L014A QC Labs
L2053351-2 7/27/06
Brown f SAND, little- Silt

GRADATION CURVE

FPA

FRENCH & PARRELLO
ASSOCIATES, P.A.
CONSULTING ENGINEERS

100 = 19%



BURMISTER CLASSIFICATION	COBBLES	GRAVEL c	GRAVEL m	GRAVEL f	SAND c	SAND m	SAND f	SILT OR CLAY

	76.2	25.4	9.52	2.0	0.59	0.25	0.074	Millimeters
	3 in.	1 in.	3/8 in.	Nos. 10	30	60	200	Sieves

06L014A QC Laboratories
L2041522-2 7/18/06
Brown f SAND, little+ Silt Raw B

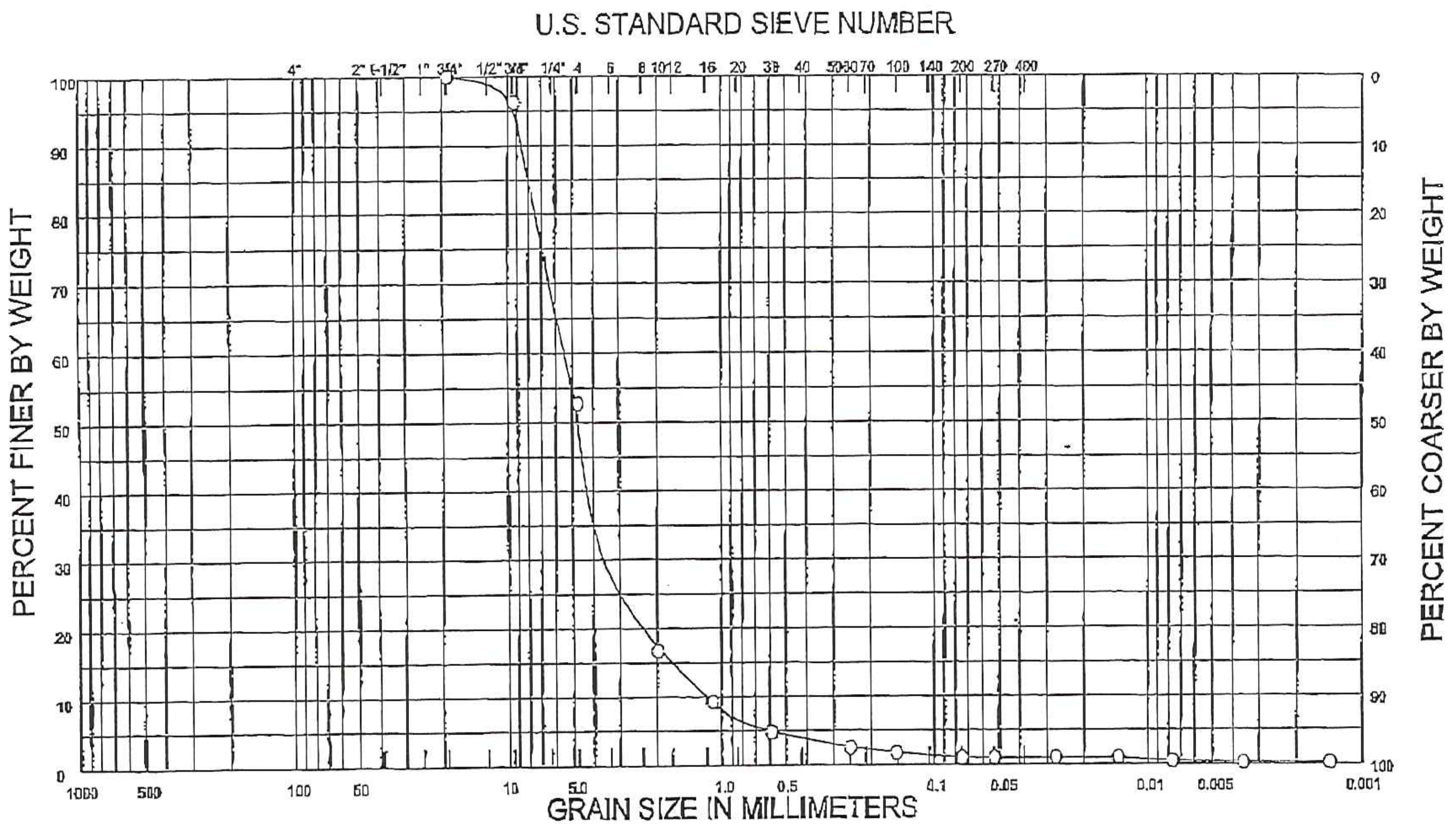
GRADATION CURVE

FPR

FRENCH & PARRELLO ASSOCIATES, P.A. CONSULTING ENGINEERS

Appendix B2

Glass Cullet



BURMISTER CLASSIFICATION	COBBLES	GRAVEL c	GRAVEL m	GRAVEL f	SAND c	SAND m	SAND f	SILT OR CLAY

76.2	25.4	9.52	2.0	0.59	0.25	0.074	Millimeters
3 in.	1 in.	3/8 in.	Nos. 10	30	60	200	Sieves

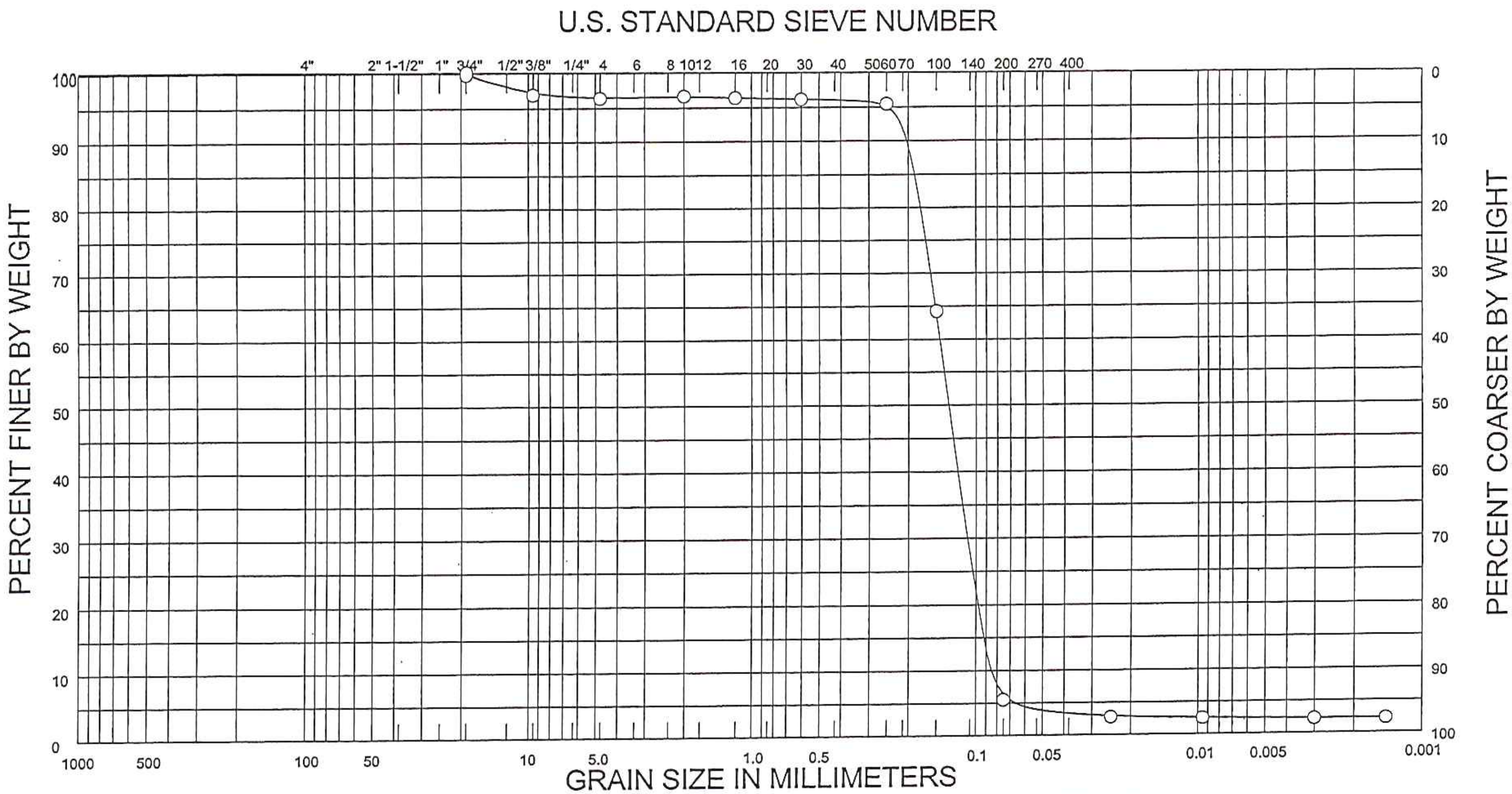
06L014A	QC Laboratories
L2041522-4	7/18/06
Multi-Colored f GRAVEL (Crushed Glass), little cm- Sand, trace- Silt	

GRADATION CURVE

FRENCH & PARRELLO
ASSOCIATES, P.A.
CONSULTING ENGINEERS

Appendix B3

Separated Sand



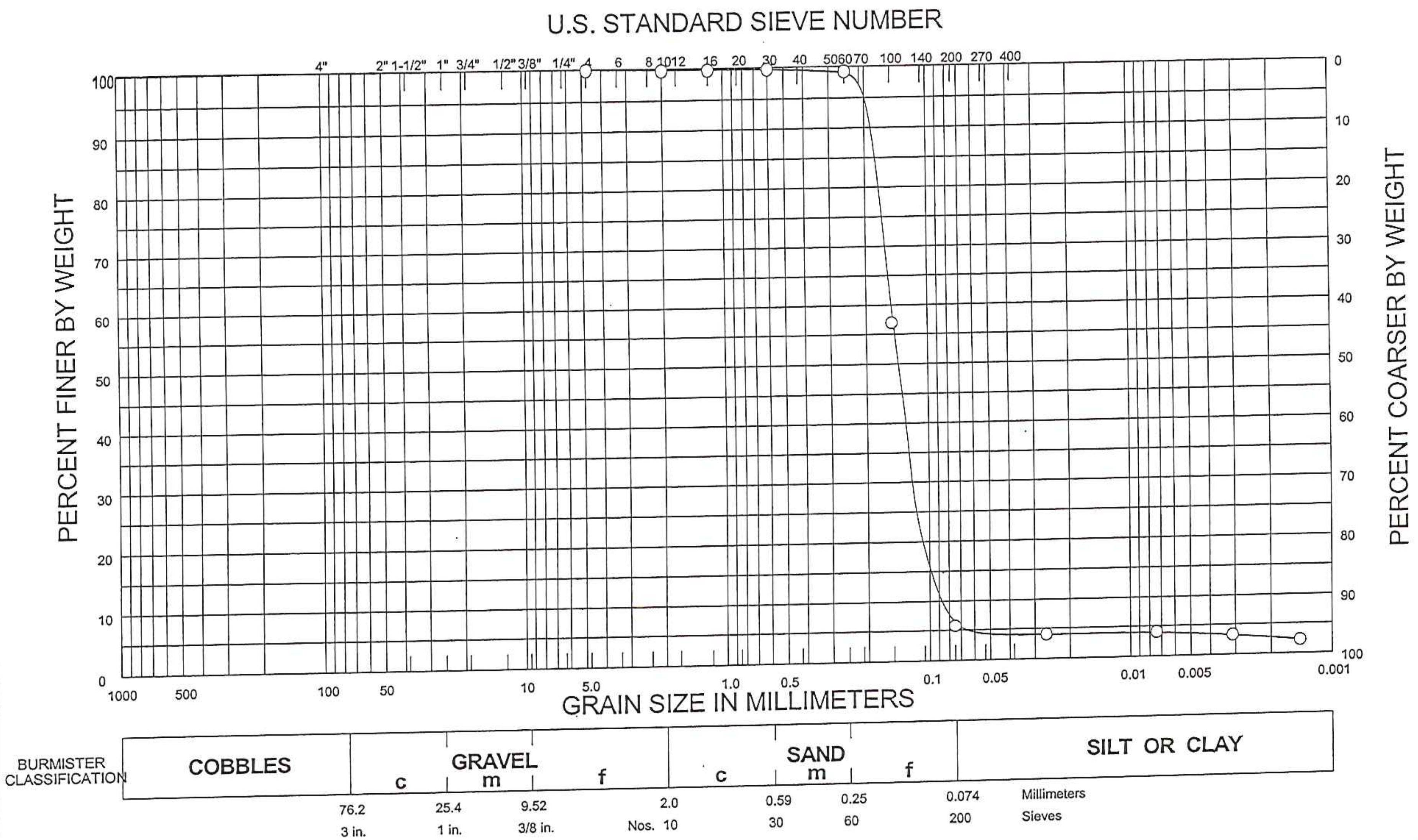
BURMISTER CLASSIFICATION	COBBLES	GRAVEL c	GRAVEL m	GRAVEL f	SAND c	SAND m	SAND f	SILT OR CLAY
Millimeters	76.2	25.4	9.52	2.0	0.59	0.25	0.074	
Sieves	3 in.	1 in.	3/8 in.	Nos. 10	30	60	200	

06L014A	QC Labs
L2053351-3	7/27/06
Brown f SAND, trace- Silt	

GRADATION CURVE

FPA

FRENCH & PARRELLO ASSOCIATES, P.A.
CONSULTING ENGINEERS



06L014A	QC Labs
L2053351-4	7/27/06
Brown f SAND, trace- Silt	

GRADATION CURVE

FPA

FRENCH & PARRELLO ASSOCIATES, P.A. CONSULTING ENGINEERS

Form LB-11a

New Jersey Department of Transportation

Bureau of Materials

Report Analysis
Fine Aggregate

Serial # 955966

Charged to: United States Coast Guard

Proposed Use: For Approval

Kind of Material: Fine Aggregate for bituminous concrete (bank run other than surface course)

Producer: 1) For Approval Location:

Sample taken from	dredge material from off coast Cape May City
Quantity represented	500 tons
Marks on sample	GBC#001
Sampled by	Paul A. Ha[signature]
Date taken	1/23/2007
Date recieved at lab	1/23/2007
Seal number	
Laboratory Serial #	955966

Reported to: 1) For Approval

ATT:

Size of opening square AASHTO T27	Total % Passing	Required % MIN.	Required % MAX.
3/8" (9.5mm)	100	100	
No. 4 (4.75mm)	100	95	100
No. 8 (2.36mm)	100	80	100
No. 16 (1.18mm)	99	50	85
No. 30 (600 µm)	99	25	65
No. 50 (300 µm)	98	10	30
No. 100 (150 µm)	52	1	10
No. 200 (75 µm)	3.4	0	3
Fineness Modulus AASHTO M6		2.3	3.1
Clay (Hydrometer) AASHTO T88			5.0
PERCENT OF STANDARD OTTAWA STRENGTH TEST NJDOT A-1			
7 Day		100	
28 Day			
Light Reflectence NJDOT A-2			
Mica NJDOT A-4			2.0
Soundness, sodium sulfate loss AASHTO T104			5.0
Organic color AASHTO T21			
Plasticity Index AASHTO T89, T90			
Absorption AASHTO T84			2.0
Specific Gravity	Bulk: SSD:	App:	
Densities (lbs/ft³) AASHTO T19	Unit Weight: DRW:	% Voids:	
	Sand Equiv. AASHTO T176 :	Unc. Voids AASHTO T304 :	

Paul A. Hanczaryk

Hydrometer Analysis	
0.001 mm	
0.02 mm	
0.002 mm	
SPECIFIC GRAVITY	

REMARKS: Complies
Chloride % = .206 EO'C 1/25/07

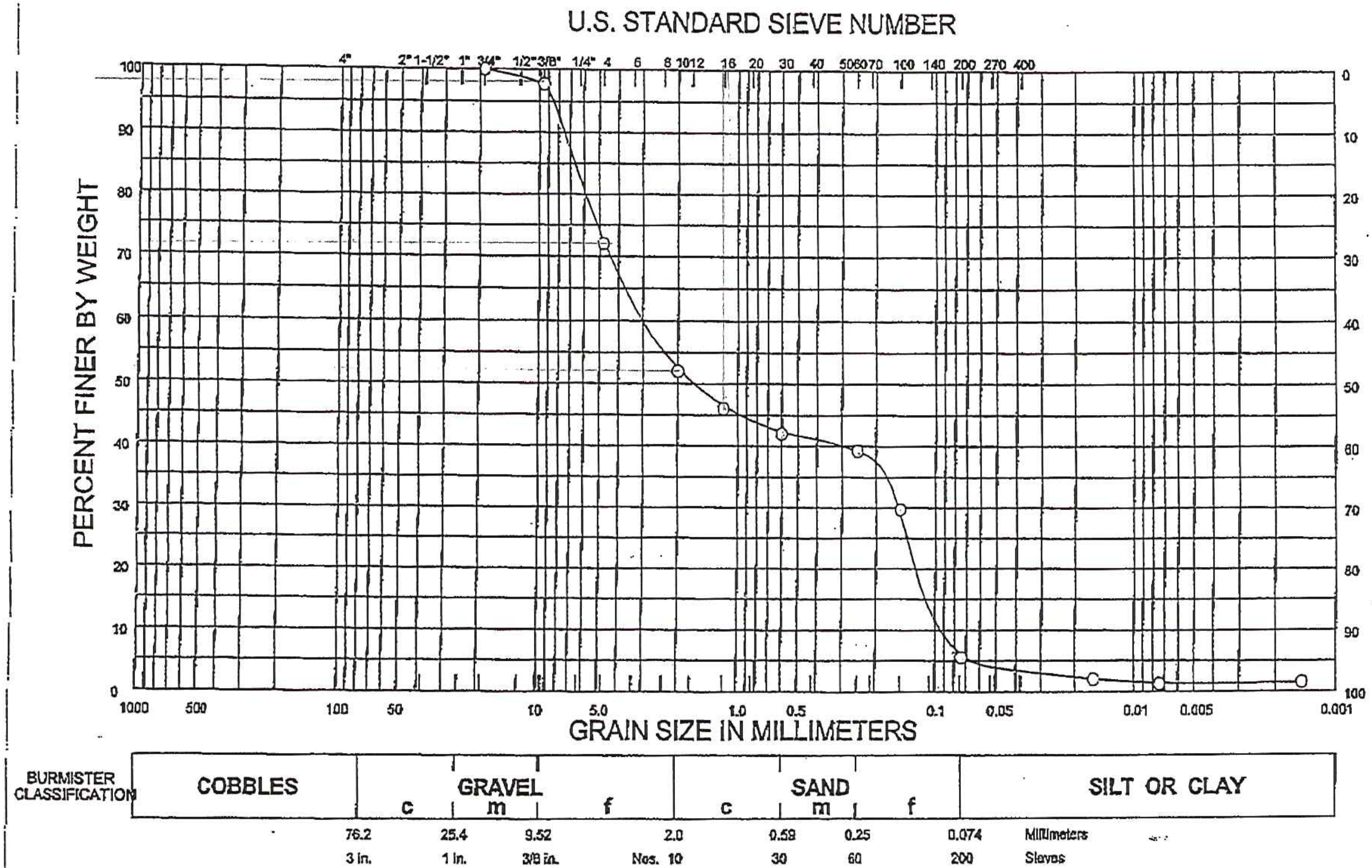
Edmund O'Connor [signature]

Appendix B4

Sand/Glass Mix

L2056832-1

Ocean & Coastal Con.
B00261



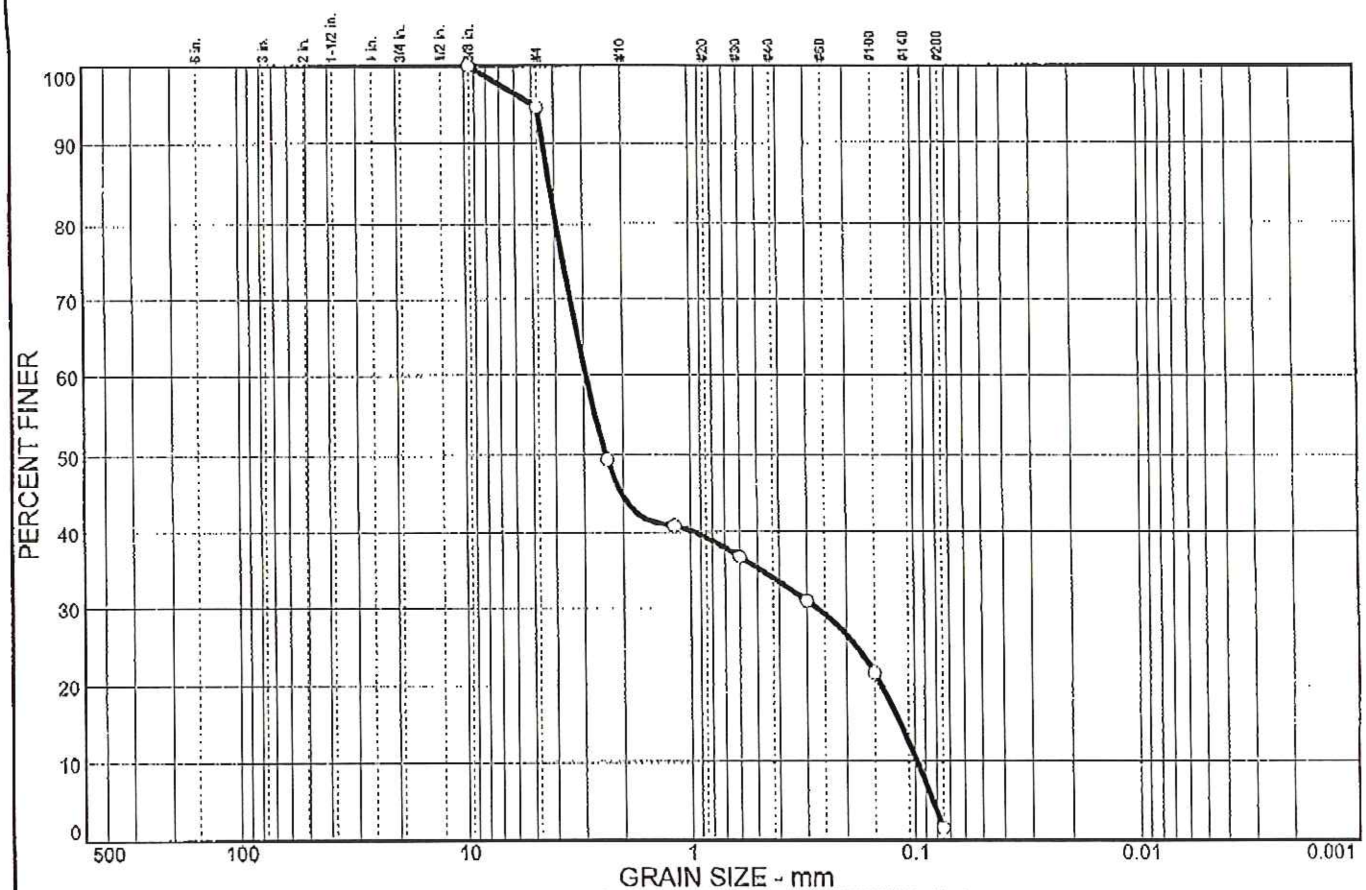
06L014A	QC Laboratories
L2056832	8/1/06
Grey f Gravel, and+cf+ Sand, trace Silt	

GRADATION CURVE

FPA

FRENCH & PARRELLO ASSOCIATES, P.A.
CONSULTING ENGINEERS

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	5.5	49.9	10.7	32.4	1.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	94.5		
#8	49.4		
#16	40.8		
#30	36.7		
#50	30.9		
#100	21.6		
#200	1.5		

* (no specification provided)

Soil Description

Mixed dredge sand and recycled glass to make NJDOT I-7

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 4.20 D_{60}= 2.93 D_{50}= 2.40
D_{30}= 0.272 D_{15}= 0.115 D_{10}= 0.0976
C_u= 30.05 C_c= 0.26

Classification

USCS= AASHTO=

Remarks

F.M.=3.26

Sample No.: #1 **Source of Sample:** **Date:**
Location: **Elev./Depth:**

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY	Client: Ocean and Coastal Consultants Project: I-7 Gradation Project No: Plate

GEORGE HARMS CONSTRUCTION COMPANY INC.
SOIL PARTICLE ANALYSIS

Project: Rt 52	SAMPLE LOCATION: from Tim W. 7-24-06
SOURCE LOCATION:Coast Guard yard Cape May	PROPOSED USE: I-7
DESCRIPTION: **white sand w/ fines and Glass**	ASTM D2487 CLASSIFICATION: N/A
TESTED BY: Bob Garcia	GRADED USING AASHTO T 27 & T11

	POUNDS	MASS OF MATERIAL (GRAMS)	AFTER WASH
WET WEIGHT OF SAMPLE + PAN		3974	
DRY WEIGHT OF SAMPLE + PAN		3746	3676
WEIGHT OF PAN		1556	1556
WEIGHT OF DRY SAMPLE		2190.00	2120
PERCENT OF MOISTURE		5.7	

SIEVE #	CUM. WEIGHT + TARE	CUM. WEIGHT RETAINED	CUM. % RETAINED	% PASSING		I-7 (Zone 1) % PASSING REQUIRED
4"	1556	0	0.0	**100.0**		
2"	1556	0	0.0	**100.0**		
1"	1556	0	0.0	**100.0**		100
3/4"	1556	0	0.0	**100.0**		
1/2"	1556	0	0.0	**100.0**		80-100
#8	2621	1065	48.6	**51.4**		35-100
#16	2790	1234	56.3	**43.7**		25-90
#50	2905	1349	61.6	**38.4**		[redacted]
#100	3244	1688	77.1	**22.9**		[redacted]
#200	3676	2120	96.8	**3.2**		[redacted]

7/26/2006

2006-67 [redacted] zone3 mse-ltp 7-14-06

Borderline
PASSES

CRAIG
TESTING LABORATORIES, INC.
5439 Harding Highway • P.O. Box 427 • Mays Landing, NJ 08330-0427 • (609) 625-1700 • FAX (609) 625-1798

CLIENT:	Ocean and Costal Consultants, Inc.
PROJECT:	Route #52 Ocean City, New Jersey P.O. No. ESG11-14
MATERIAL:	Soil Aggregate Bulk Sample Submitted by Client for Laboratory Analysis
TEST REQUIRED:	Washed Gradation, Laboratory Control Curve, Atterberg Limits, Classification, Angle of Internal Friction, Resistively, pH
DESCRIPTION OF MATERIAL:	Brown Sand with Broken Glass
SOURCE:	Not Indicated
SAMPLE LOCATION:	Not Indicated
SAMPLED BY:	CLIENT
DATE RECEIVED	November 15, 2006
DATE(S) TESTED:	November 18 through December 1, 2006
LAB NUMBER:	44192

LABORATORY ANALYSIS

Washed Gradation Analysis

Sieve Size	Percent Passing
2"	100.0
3/4"	100.0
3/8"	96.9
No. 4	94.9
No. 10	52.0
No. 50	23.0
No. 200	4.8

Laboratory Control Curve Data (ASTM D1557)

Maximum Dry Density:	117.4 lbs./ft.3
Optimum Moisture Content:	7.4 percent

Continued....

CRAIG
TESTING LABORATORIES, INC.
5439 Harding Highway • P.O. Box 427 • Mays Landing, NJ 08330-0427 • (609) 625-1700 • FAX (609) 625-1798

Ocean and Costal Consultants, Inc.
Route #52
Ocean City, New Jersey
P.O. No. ESG11-14

Atterberg Limits:	Sample was found to be non-plastic
Classification:	SC
Angle of Internal Friction:	39°
Resistivity:	0.2 Kilo-Ohm/cm
pH	7.8

trp
Reported to:
Mr. Douglas A. Gaffney (3)
WGCC1

Respectfully Submitted,
CRAIG TESTING LABORATORIES, INC
Michael W. Cannan
Michael W. Cannan
President

Appendix C

MSDS Sheet for AQ300

AQM

AQUAMARK, INC.
AQ 200
MATERIAL SAFETY DATA SHEET

AQUAMARK, INC,
P.O. Box 773
Chesterland, OH 44026

Emergency Telephone Numbers
(440) 564-1227 Aquamark (weekdays)
(800)424-9300 Chemtrec (24 hrs.)

Supersedes: 08/19/2005
Date: 01/17/2006

MSDS No.: 03004

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME:	**AQUAMARK 200**
SYNONYMS:	None
CHEMICAL FAMILY:	Cationic Polyamine
MOLECULAR FORMULA:	Mixture
MOLECULAR WGT:	Mixture

2. COMPOSITION/INFORMATION ON INGREDIENTS

OSHA REGULATED COMPONENTS

COMPONENT	CAS. NO.	%	TWA/CEILING	REFERENCE

*No Permissible Exposure Limits (PEL/TLV) have been established by OSHA or ACGIH.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

APPEARANCE AND ODOR: Liquid, slightly viscous, colorless to amber, amine odor.

STATEMENTS OF HAZARD:

CAUTION! MAY CAUSE EYE AND SKIN IRRITATION

POTENTIAL HEALTH EFFECTS

EFFECTS OF OVEREXPOSURE:

The acute oral (rat) and dermal (rabbit) LD50 values are 6.16 ml/kg and greater than 10.0 ml/kg, respectively. The 4-hour LC50 (rat) value is estimated to be greater than 2500ppm. Direct contact with this material may cause mild eye and skin irritation.

4. FIRST AID MEASURES

Material is not expected to be harmful by ingestion. No specific first aid measures are required.
In case of skin contact, wash affected areas of skin with soap and water.
In case of eye contact, immediately irrigate with plenty of water for 15 minutes.
Material is not expected to be harmful if inhaled. If inhaled, remove to fresh air.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

FLASHPOINT:	>200 ^{0}F; 93^0 C
METHOD:	Closed Cup
FLAMMABLE LIMITS(% BY VOL):	Not Available
AUTOIGNITION TEMP:	Not Available
DECOMPOSITION TEMP	Not Available

EXTINGUISHING MEDIA AND FIRE FIGHTING INSTRUCTIONS

Use water spray, carbon dioxide or dry chemical to extinguish fires. Use water to keep containers cool.
Wear self-contained, positive pressure breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Where exposure level is not known, wear NIOSH approved, positive pressure, self-contained respirator. Where exposure level is known, wear NIOSH approved respirator suitable for level of exposure. In addition to the protective clothing/equipment in Section 8 (Exposure Controls/Personal Protection), wear impervious boots. Spills of this product are very slippery. Spilled material should be absorbed onto an inert material and scooped up. The area should be thoroughly flushed with water and scrubbed to remove residue. If slipperiness remains, apply more dry-sweeping compound.

7. HANDLING AND STORAGE

Avoid contact with eyes, skin and clothing. Wash thoroughly after handling.
To avoid product degradation and equipment corrosion, do not use iron, copper or aluminum containers or equipment.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS AND PERSONAL PROTECTIVE EQUIPMENT (PPE)
Engineering controls are not usually necessary if good hygiene practices are followed. Before eating, drinking or smoking, wash face and hands thoroughly with soap and water. Avoid unnecessary skin contact. Impervious gloves and aprons are recommended to prevent skin contact. For operations where eye or face contact can occur, wear eye protection such as chemical splash-proof goggles or face shield. For operations where inhalation exposure can occur, a NIOSH approved respirator recommended by an industrial hygienist may be necessary.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE AND ODOR:	Liquid, slightly viscous, colorless to amber, amine odor.
BOILING POINT:	~212 F; 100 C
MELTING POINT:	-0 F; -18 C
VAPOR PRESSURE:	Not available
SPECIFIC GRAVITY	1.1-1.2
VAPOR DENSITY:	Not available
% VOLATILE (BY WT):	50
pH:	5-7
SATURATION IN AIR (% BY VOL):	Not applicable
EVAPORATION RATE:	Not Applicable
SOLUBILITY IN WATER:	Complete
VOLATILE ORGANIC CONTENT:	Not Available

10. STABILITY AND REACTIVITY

STABILITY:	Stable
CONDITIONS TO AVOID:	None known
POLYMERIZATION:	Will Not Occur
CONDITIONS TO AVOID:	None known
INCOMPATIBLE MATERIALS:	Avoid aluminum, iron and copper. Strong oxidizers, acids.
HAZARDOUS DECOMPOSITION PRODUCTS:	Carbon monoxide, carbon dioxide, ammonia, and oxides of Nitrogen; hydrogen chloride: dimethylamine

11. TOXICOLOGICAL INFORMATION

Toxicological information for the product is found under Section 3 HAZARDS IDENTIFICATION.
Toxicological information on the OSHA regulated components of this product is as follows:
This product contains no OSHA regulated (hazardous) components.
This California Proposition 65 Warning (applicable in California only) – This product contains (a) chemical(s) known to the State of California to cause cancer and birth defects or other reproductive harm.

12. ECOLOGICAL INFORMATION

Juvenile Turbot (Scopthalmus maximus), 96 hr Semi-static LC50: 464 mg/L; Marine Copepod (Acartia tonsa), 48 hr LC50; 23 mg/L; Marine Algae (Skeletonoma costatum), 72 hr EC50: 0.70 mg/L; Seawater BOD 28: 0%.LC50 determinations without added suspended solids overestimate the true toxicity of cationic polymers.
Suspended solids and other dissolved organic materials like humic acid are present in natural waters and reduce the effective concentration of the polymer and there by its toxicity.
The no-observable-effect concentration (NOEC) for both Bluegill and Trout species is 0.32 mg/L.

LC50

BLUEGILL, 96 HOUR:	0.53 mg/L
TROUT 96 HOUR:	0.42 mg/L
DAPHNIA, 48 HOUR	0.29 mg/L
OCTANOL/$H_2$0 PARTITION COEF:	Not Available

13. DISPOSAL CONSIDERATIONS

The information on RCRA waste classification and disposal methodology provided below applies only to the AQUAMARK product, as supplied. If the material has been altered or contaminated, or it has exceeded its recommended shelf life, the guidance may be inapplicable. Hazardous waste classification under federal regulations (40 CFR Part 261 et seq.) is dependent upon whether material is a RCRA "listed hazardous waste" or has any of the four RCRA "hazardous waste characteristics". Refer to 40 CFR Part 261.33 determine if a given material to be disposed of is a RCRA "listed hazardous waste"; information contained in Section 15 of this MSDS is not intended to indicate if the product is a "listed Hazardous waste". RCRA Hazardous Waste Characteristic. There are four characteristics defined in 40 CFR Section 261.21-61.24: Ignitability, Corrosivity, Reactivity, and Toxicity. To determine Ignitability, see Section 5 of this MSDS (flash point). For Corrosivity, see Section 9 and 14 (pH and DOT Corrosivity). For Reactivity, see Section 10 (incompatible materials). For Toxicity, see Section 2 (composition). Federal regulations are subject to change. State and local requirements, which may differ from or be more stringent than the federal regulations, may also apply to the classification of the material if it is to be disposed. AQUAMARK encourages the recycle, recovery and reuse of materials, where permitted, as an alternate to disposal as a waste. AQUAMARK recommends that organic materials classified as RCRA hazardous wastes be disposed of by thermal treatment or incineration at EPA approved facilities. AQUAMARK has provided the foregoing for information only; the person generating the waste is responsible for determining the waste classification and disposal method.

14. TRANSPORT INFORMATION

This section provides basic shipping classification information. Refer to appropriate transportation regulations for specific requirements.

	D.O.T. SHIPPING INFORMATION	IMO SHIPPING INFORMATION
SHIPPING NAME:	NOT APPLICABLE/NOT REGULATED	NOT APPLICABLE/NOT REGULATED
HAZARD CLASS/ PACKING GROUP:	Not Applicable	Not Applicable
UN NUMBER:	Not Applicable	Not Applicable
IMDG PAGE:	Not Applicable	Not Applicable
D.O.T. HAZARDOUS SUBSTANCES:	(PRODUCT REPORTABLE QUANTITY) Not Applicable	Not Applicable
TRANSPORT LABEL REQUIRED:	None Required	None Required

14. TRANSPORT INFORMATION (con.)

	ICAO/IATA		TRANSPORT CANADA
SHIPPING NAME:	NOT APPLICABLE/NOT REGULATED		NOT APPLICABLE/NOT REGULATED
HAZARD CLASS:	Not Applicable		Not Applicable
SUBSIDIARY CLASS:	Not Applicable		Not Applicable
UN/ID NUMBER:	Not Applicable		Not Applicable
PACKING GROUP:	Not Applicable		Not Applicable
TRANSPORT LABEL REQUIRED:	None Required		None Required
PACKING INSTR:	PASSENGER	Not Applicable	Not Applicable
	CARGO	Not Applicable	
MAX NET QTY:	PASSENGER	Not Applicable	Not Applicable
	CARGO	Not Applicable	

ADDITIONAL TRANSPORT INFORMATION

TECHNICAL Name (N.O.S.): Not Applicable

15. REGULATORY INFORMATION

INVENTORY INFORMATION

US TSCA: All components of this product are included on the TSCA inventory in compliance with the Toxic Substance Control Act, 15 U.S.C. 2601 et. Seq.
This product contains a chemical substance that is subject to export notification under Section 12 (b) of the Toxic Substances Control Act, 15 U.S.C. 2601 et. seq. (this requirement applies to exports from the United States only).

CANADA DSL: Components of this product have been reported to Environment Canada in accordance with subsection 25 of the Canadian Environmental Protection Act and are included on the Domestic Substances List.

EEC EINECS: All components of this product are included on the European Inventory of Existing Chemical Substances (EINECS) in compliance with Council Directive 67/548/EEC and its amendments.

OTHER ENVIRONMENTAL INFORMATION The following components of this product may be subject to reporting requirements pursuant to Section 313 of CERCLA (40 CFR 372), Section 12(b) of TSCA, or may be subject to release reporting requirements (40 CFR 307, 40 CFR 311, etc.) See Section 13 for information on waste classification and waste disposal of this product.

COMPONENT	CAS. NO.	%	TPQ(lbs)	RQ(lbs)	S313	TSCA 12B
1,3-Dichloropropanol	000096-23-1	<0.05	NONE	NONE	NO	YES
2,3-Dichloropropanol	000616-23-9	<0.02	NONE	NONE	NO	YES

PRODUCT CLASSIFICATION UNDER SECTION 311 OF SARA
Not Applicable under SARA TITLE III

16. OTHER INFORMATION

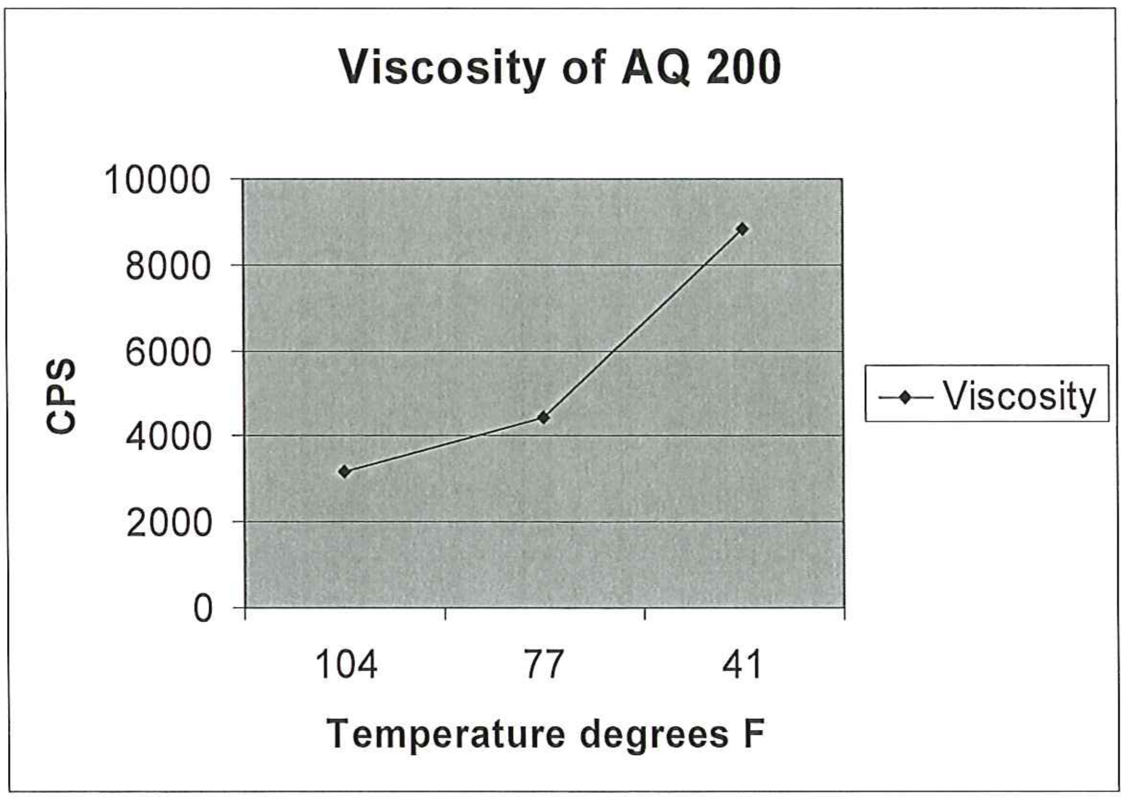
NFPA HAZARD RATING **(National Fire Protection Association)**

Fire	FIRE: Materials that must be preheated before ignition can occur.
1	HEALTH: Materials that, under emergency conditions, can cause significant irritation.
Health 1 0 Reactivity	
-	REACTIVITY: Materials that in themselves are normally stable, even under fire
Special	exposure conditions.

REASON FOR ISSUE:

New format and phone number

This information is given without any warranty or representation. We do not assume any legal responsibility for same, nor do we give permission, inducement or recommendation to practice any patented invention without a license. It is offered solely for your consideration, investigation and verification. Before using any product, read its label.



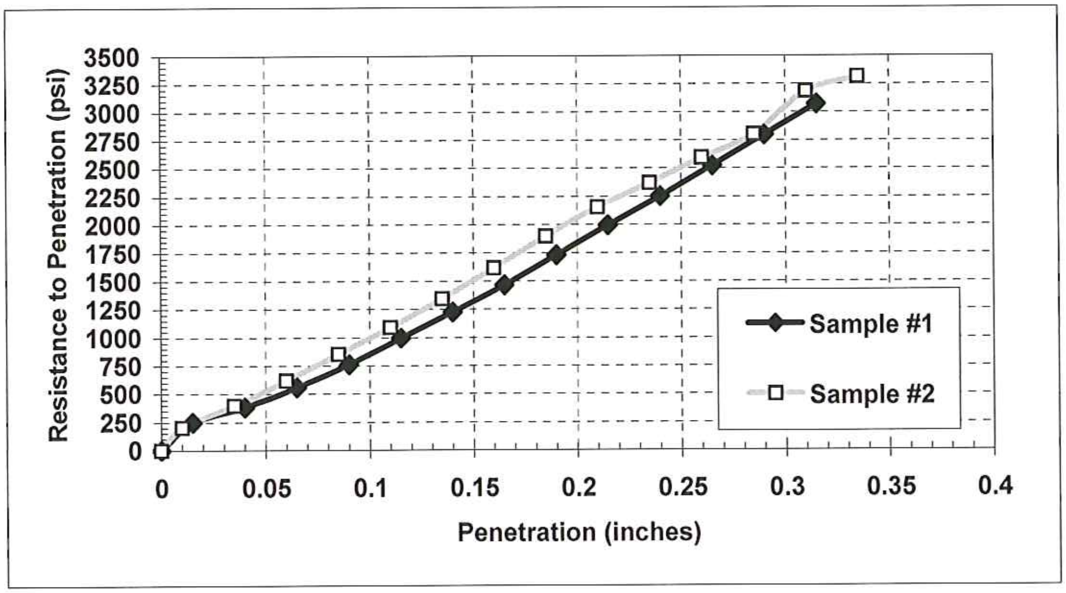
Appendix D

CBR Results
(Sand/Glass Mixture)

Laboratory Evaluation - Test Summary of Recycled Concrete Blends Material

Sample Type: 100% Recycled Concrete

California Bearing Ratio (AASHTO T193)

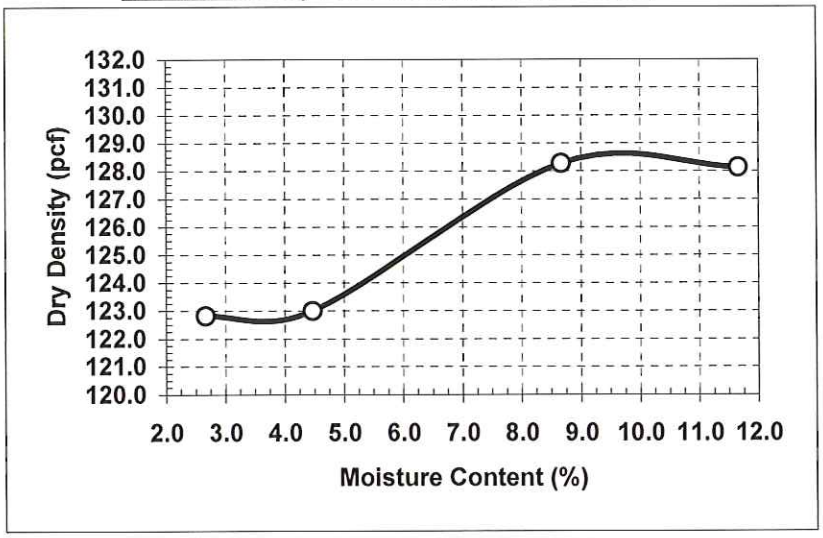


Sample	γ_d (pcf)	ω% (%)	CBR Value @ 0.1 In.	CBR Value @ 0.2 In.
#1	128	9.9	86	123
#2	128.2	9.6	100	137
Average	*128.1*	*9.8*	*93*	*130*

Laboratory Evaluation - Test Summary of Recycled Concrete Blends Material

Sample Type: 100% Recycled Concrete

Moisture-Density Relationship (AASHTO T180)



Optimum Moisture Content = 9.6%

Maximum Dry Density = 128.6 pcf

Constant Head Permeability (AASHTO T215)

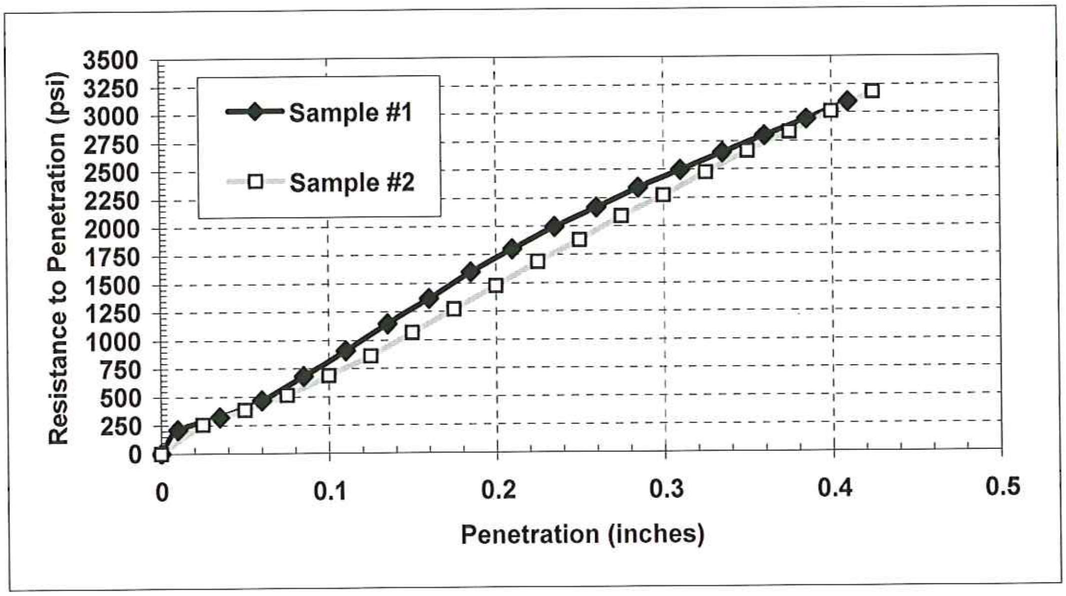
Sample	γ_d (pcf)	ω% (%)	h/L*	Permeability (ft/day)
#1	128.4	9.4	0.4	0
#2	128.3	9.8	5.6	0
Average	***128.4***	***9.6***	***3.00***	***0***

* - Hydraulic Gradient during testing

Laboratory Evaluation - Test Summary of Recycled Concrete Blends Material

Sample Type: RCA Blend (75% RCA: 25% Dredge Sand)

California Bearing Ratio (AASHTO T193)

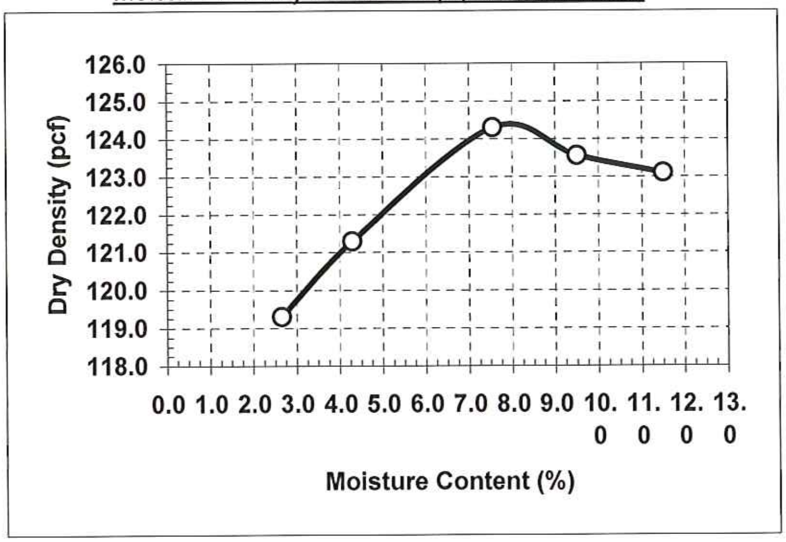


Sample	γ_d (pcf)	ω% (%)	CBR Value @ 0.1 In.	CBR Value @ 0.2 In.
#1	124	7.2	89	115
#2	123.9	7.9	69	98
Average	***123.95***	***7.6***	***79***	***107***

Laboratory Evaluation - Test Summary of Recycled Concrete Blends Material

Sample Type: RCA Blend (75% RCA: 25% Dredge Sand)

Moisture-Density Relationship (AASHTO T180)



Optimum Moisture Content = 7.5%

Maximum Dry Density = 124.3 pcf

Constant Head Permeability (AASHTO T215)

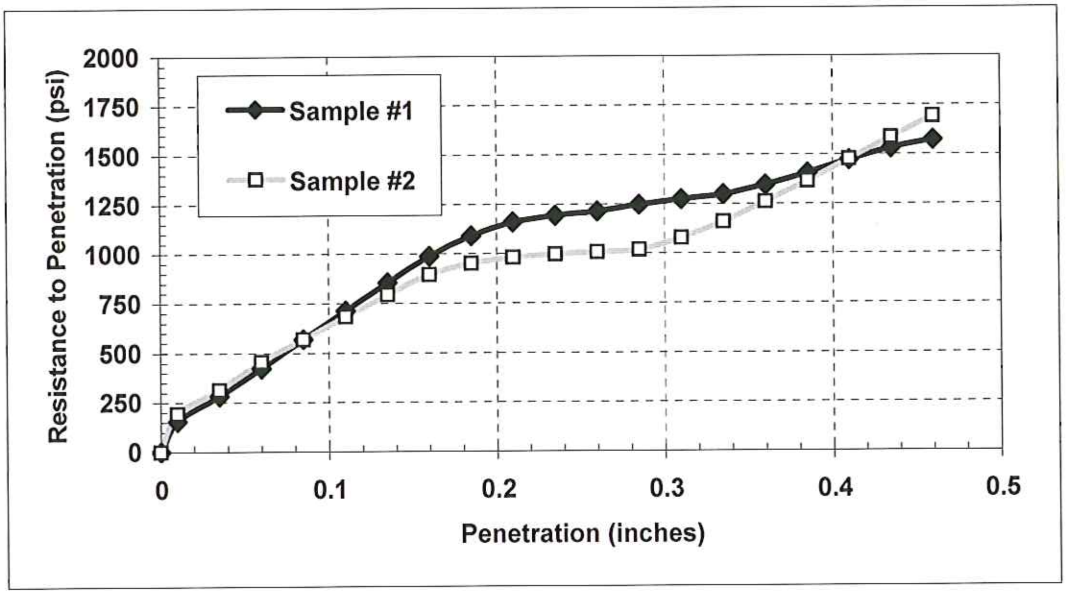
Sample	γ_d (pcf)	ω% (%)	h/L*	Permeability (ft/day)
#1	123.7	8.3	0.44	0
#2	124.4	7.7	5.4	0.1
Average	***124.1***	***8***	***2.92***	***0.05***

* - Hydraulic Gradient during testing

Laboratory Evaluation - Test Summary of Recycled Concrete Blends Material

Sample Type: RCA Blend (50% RCA: 50% Dredge Sand)

California Bearing Ratio (AASHTO T193)

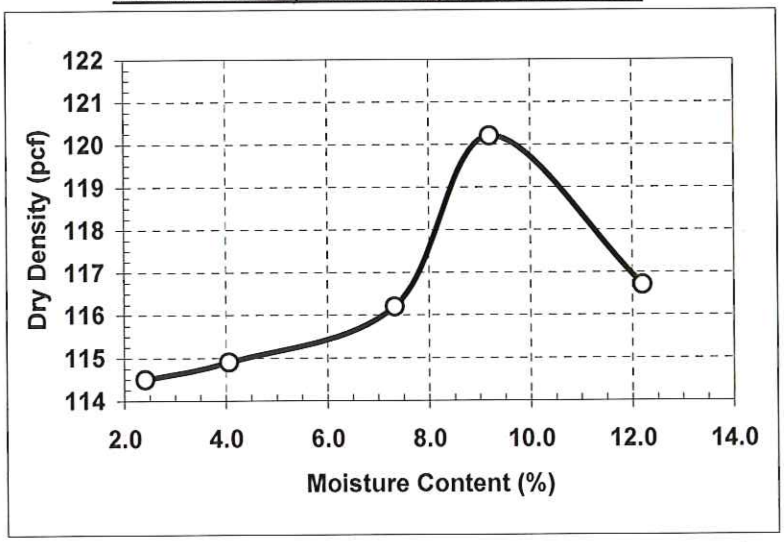


Sample	γ_d (pcf)	ω% (%)	CBR Value @ 0.1 In.	CBR Value @ 0.2 In.
#1	120.2	9.2	69	73
#2	121.3	8.7	64	65
Average	*120.75*	*9.0*	*67*	*69*

Laboratory Evaluation - Test Summary of Recycled Concrete Blends Material

Sample Type: RCA Blend (50% RCA: 50% Dredge Sand)

Moisture-Density Relationship (AASHTO T180)



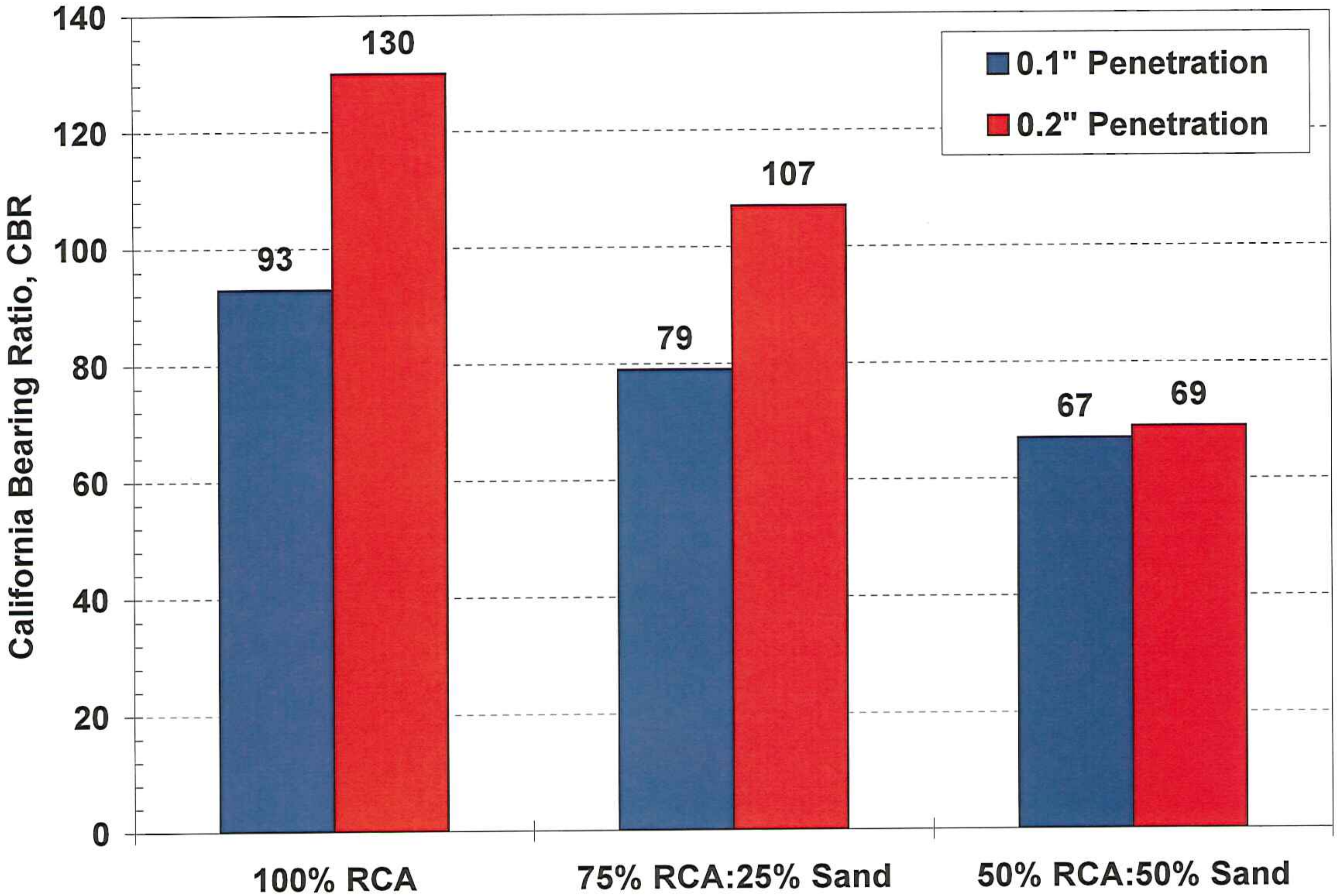
Optimum Moisture Content = 9%

Maximum Dry Density = 120.5 pcf

Constant Head Permeability (AASHTO T215)

Sample	γ_d (pcf)	ω% (%)	h/L*	Permeability (ft/day)
#1	119.6	8.6	0.4	1.7
#2	120.1	8.8	5.6	2.1
Average	***119.9***	***8.7***	***3.00***	***1.9***

* - Hydraulic Gradient during testing


California Bearing Ratio, CBR
140
120
100
80
60
40
20
0
0.1" Penetration
0.2" Penetration
93
130
79
107
67
69
100% RCA
75% RCA:25% Sand
50% RCA:50% Sand

Appendix E

Benefit Study

Appendix E

Benefit Study

Appendix E

Benefit Study

Ocean and Coastal Consultants, Inc.

Benefits of dredging and recycling dredged materials

Revised Draft report

June 2008

COWI

Ocean and Coastal Consultants, Inc.

Benefits of Dredging and Recycling Dredged Materials

Revised Draft report

June 2008

Report no.	Study report 01
Issue no.	1
Date of issue	September 11, 2007
	October 22, 2007
	June 30, 2008
Prepared	JALG/JJD
Checked	JJD
Approved	JJD
Revised	DAG

Table of Contents

1 Background

To keep waterways and harbors fully functional, the State of New Jersey has to remove sediment from the waterways on a continual basis. At present, the Confined Disposal Facilities (CDF) along the Jersey shore, in which dredged material is stored, are close to full capacity. Furthermore, it has become increasingly difficult from a permitting perspective and costly due to the value of upland to find new sites for this purpose that are proximal to the waterways that require dredging.

The successful completion of the dredge separation demonstration project suggests that large scale CDF mining in Regional Processing Facilities (RPF) is a viable method for reclaiming CDF capacity. However, the revenue from the recycled material can not balance the costs of mining the clean, sandy material. Therefore, this option does not seem beneficial at first sight (Lawler, et al. 2004).

It may be, however, that there are more benefits related to reusing dredged material than what is reflected in the market price for the raw material or separated sand fraction. Furthermore, benefits from dredging waterways may even be large enough to outweigh additional costs of recycling dredged material.

These additional benefits to society are the subject of this report.

1.1 Framework of the Report

Before moving on to the analysis and assessment of the benefits of dredging navigational waterways and recycling dredged material in New Jersey, the overall framework and scope of the report is described as follows.

Benefit Assessment

This report focuses on two aspects related to dredging navigational waterways in New Jersey.

- Benefits of dredging compared to no dredging[1] of waterways due to lack of placement options, and,

[1] In this report, economic impacts associated with delays in dredging are excluded from the analysis.

- Benefits of recycling dredged material compared to conventional storage and deposition in CDFs.

To keep things clear, benefits and costs associated with the above mentioned aspects will be presented and discussed separately in the remaining part of the report.

1.1.1 Economic Scale of Social Benefits

In the assessment of economic impacts, the scale is set to be the State of New Jersey. Consequently, costs and benefits are only assessed on a state level. This means that net loss incurred in one region/harbor within New Jersey, which is partly/completely substituted by a net gain in another region/harbor within the state is treated as a transfer payment.

In this study, a stop in dredging is expected to cause changes in the tax revenue from property taxes, sales taxes and fuel taxes. These amounts might be substantial and could have a large influence on the budget of the state of New Jersey and the local municipalities. From a budget point of view, these losses count as costs. However, in a welfare (social) economic framework, changes in the tax revenue to the State of New Jersey are also perceived as transfer payments.

Taxes cause distortions/excess burdens in the economy and thus have a marginal cost to society. The distortions appear because the taxed agents may change their economic behavior so that the amount of taxes paid is reduced. The reductions in tax revenues could both count as costs or benefits in the analysis. However, this depends on the level of distortion caused by the alternative taxed good, which is used to replace the loss in taxes caused by a dredging stop[2] (see sections 2.1.3 and 2.3.1).

1.2 Outline of the Report

The paper is outlined as follows. For each of the benefit assessment aspects, benefits of dredging and benefits of recycling dredged materials, the main economic consequences are presented and a framework for estimating the economic impacts is put forward. This is followed by a presentation of estimated potential economic consequences and a discussion of how applicable the identified estimates are with respect to the focus of this report.

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[2] In Denmark, the Ministry of Finance estimates the average distortion effect to be 20% (Finansministeriet 200X)

2 Benefits of Dredging Compared to No Dredging of Waterways

The benefits associated with maintaining the waterways through dredging in New Jersey are related to marina and harbor boating activities as well as the quality of life for homeowners on the water. The value of this "quality of life" can be seen in the increased value of homes and the higher assessed property taxes. Marina and Harbor boating activities are strongly dependent on the navigability and safety of the waterways. If navigability is reduced or becomes hazardous, this will reduce the boating activities and thus result in a negative economic impact. The boating population in New Jersey listed several infrastructure concerns when surveyed, one of which was shallow channels (10.1%) (Marine Trades Association, 2008).

It is also possible that the reduced navigability can influence the assessed property value in the area. However, this requires that the property prices entail a specific price premium for either boating access either from the property or a local marina/harbor[3].

2.1 Framework for estimating economic impacts

Following Herstine et al. (2007) the economic impacts of reduced navigability due to a stop in dredging activities can be assessed by comparing economic activity under a baseline scenario of current navigability with economic activity under an alternative scenario of reduced navigability.

In short, economic impacts mainly occur in three categories:

1. Impacts resulting from changes in the number of recreational and commercial boating trips (including directly associated economic activities such as dock-n-dine restaurants)

2. Impacts resulting from changes in the number of boats purchased/ maintained by recreational and commercial boaters (i.e., some, not all, boaters may choose to stop purchasing/maintaining vessels due to decreased access to coastal waters)

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[3] This price premium is not be confused with a price premium for access to water, aesthetic views etc.

3 Impacts resulting from changes in property price

The principle estimation procedures of the three impacts are presented below.

2.1.1 Estimation of Impacts Resulting from Changes in the Number of Recreational Boating Trips

On a yearly basis, the economic impacts of a dredging stop on boater trips under baseline conditions are a function of:

1 The baseline number of recreational boating trips made per year in the waterways of New Jersey by resident boaters and non-resident boaters, respectively.

2 The average expenditures by spending category (i.e., boat fuel, slip fees, restaurants, etc.) made per trip (for resident boaters and non-resident boaters separately), the portion of expenditures spent in New Jersey and outside New Jersey and the consumer surplus excess these expenditures.

3 Multiplying the baseline trip numbers by the average expenditure numbers to generate *direct impact spending* estimates by expenditure category, geographic region, and boater residency

4 Using an economic input-output model to estimate the employment, labor income (wages and salaries), and taxes supported by the direct spending.

5 Using an economic input-output model to estimate the indirect and induced impacts (i.e., the economic "multiplier effects") of the direct spending on economic output/sales/business activity, employment, labor income (wages and salaries), and taxes.

2.1.2 Estimation of Impacts Resulting from Changes in the Number of Boats Purchased/Maintained by Recreational Boaters

The annual economic impacts of boat purchases/maintenance by boaters in New Jersey under baseline conditions are a function of:

1 The number of resident recreational boaters who are susceptible to changes in the waterway navigability and as a consequences either cease boating altogether or move their boat to a location outside New Jersey (rather than buy a smaller boat and continue boating, etc.) in response to reduced navigability.

2 The average value of the boat owned by boaters with the above characteristics.

3 The depreciation rate.

4 The portion of these purchases made from New Jersey boat builders

5 The employment, wages, and taxes supported by the direct expenditures, as well as the indirect and induced impacts supported by the direct expenditures.

2.1.3 Estimation of Impacts Resulting from Changes in Property Price

The economic impacts of property price by boating facilities under baseline conditions are a function of:

1 The number of properties with a price premium due to either direct access to boating facilities (water front properties with a private slip) or access to boating facilities in the local marina/harbor.

2 The relation between the price premium and the extent of reduction in navigability.

3 Average price premium of the properties with the above characteristics.

In this context it must be emphasized that changes in property prices influence the tax revenue to the state of New Jersey and the local municipality. The exact loss in tax revenues is a function of the abovementioned changes in the appraised property values, but also a function of the type of taxation schedule of private property. However, as previously argued, these direct losses are from a welfare (social) economic point of view to be treated as transfer payments. But seen from a state budget point of view, these losses would naturally be important to have quantified.

To estimate the economic impacts of *changes* in the New Jersey waterway navigability conditions, the above presented relations between impacts and economic activities must be formalized in an economic benefit/cost model. As put forward, the economic impacts depend on a number of parameters such as; the extent of the closure, type of vessels and activities etc. In the following, these parameters are briefly presented and put into an economic assessment context.

2.1.4 The Scope of Waterway Closure

An important parameter in the assessment of the economic impacts caused by a stop in dredging of waterways is the extent of the closure. More specifically, if the stop in dredging does not influence all waterways, substitute boat outing and boating sites may be available (see the discussion in the section below.) This should naturally be taken into account, as the costs of no dredging otherwise would be exaggerated. On the other hand, the New Jersey Intracoastal Waterway is, to some degree, only as viable as its shallowest point. A certain percentage of boaters from other states utilize the waterway as a transit route, and therefore a closure would affect the entire waterway.

2.1.5 Class of Vessel Influenced

The class of vessel influenced by a closure is also important to take into account. Smaller vessels or vessels with shallow draft might not be as strongly influenced as deeper draft vessels by a dredging stop, as they can navigate on more shallow waters. In this relation, the type of vessel might also relate to the type of use of the vessel. Boats used for inland fishing might draw less water than boats used for deep-sea fishing, sailboats, etc. Additionally, boats longer than 26 feet are generally not trailered without a significant cost, therefore boats in this class do not easily move from one region to another. In New Jersey, 11% of recreational boat trips are with powerboats or sailboats greater than 26 feet (Marine Trades Association, 2008).

2.1.6 Substitution between Alternative outing Locations within and across States

The previously mentioned parameters indicate that substitute sites for outings should be taken into account when assessing the costs of a stop in dredging of coastal waterways. From a welfare economic point of view, this potential substitution is of particular interest, as loss in one region which is partial or complete may be substituted by a gain in another region within the state, and would be considered a transfer payment, from region to another. New Jersey's existing marinas are highly regulated, and it is unlikely that there is an overcapacity of available slips. Therefore, capacity may or may not exist to accommodate the shifting of boats from one region to another. Additionally, many transient boaters consider the entire New Jersey Intracoastal Waterway to be one "location" with the result that a dredging stop in one area equally affects the navigability and safety of the entire waterway.

Depending on the extent of the closure and the type of vessels influenced, local boaters will have alternative locations to out from. It is not within the scope of the report to assess these substitution patterns. It is recommended to gather this information before assessing the economic impacts of a dredging stop. To illustrate the issue, a few examples are provided below. To keep things simple, only harbor/marina related economic activities are touched upon. Upland consequences and potential decline in property values are excluded from the examples.

Example 1: Total closure of a local marina

The example takes the point of origin in the closure of a local marina with (a) and without (b) the possibility to increase the number of slips in the adjacent harbors.

In both cases the local marina closes for all types of boating activities, recreational boaters, anglers etc.

1a) In this case the adjacent marinas and harbor have enough available boat slips to cover the loss in slips from the closed marina and have the necessary capacity to handle all activities from the closed marina.

Consequently, the economic activities (primary economic activities such as renting of slips, purchase of fuel etc. and secondary water related economic activities such as lodging, dining, travel etc.) are expected to partly or completely (perfect substitutes) to be moved to the adjacent marinas and harbors.

1b) In this case the adjacent marinas and harbors do not have any available boat slips but have the necessary capacity to handle all other types of activities from the closed marina. The economic impact in this case is larger than in the former (case 1a). There is both a loss in consumer (people renting slips) and producer surplus (primary and secondary income losses associated with renting out boat slips).

Example 2: Partial closure of a regional area

The example is based on an assumption that a larger area will be affected by the stop in dredging. Four sub-cases are presented. (2a) All types of vessels are influenced. Given the higher costs of transportation, small vessel users find it too costly and difficult to trail their boat or drive to another part of the state in order to be able to boat. Substitution between vessel types is not possible. Substitute harbors outside the region have enough available boat slips to cover the loss in slips from the closed region and have the necessary capacity to handle all activities from the closed. (2b) As in case 2a) however, minor vessels are not influenced. (2c) As case 2b) however, substitution between vessel types is possible.(2d) As case 2c) however, only substitute harbors outside the state of New Jersey have enough available boat slips to cover the loss in slips from the closed region and have the necessary capacity to handle all activities from the closed.

2a) In this sub-case, the water related traffic is closed down in an entire region. The economic activities (primary and secondary) are expected to be moved to the marinas and harbors outside the region. As available boating facilities are available within the state, no inter state substitutes are relevant. All primary and secondary economic activities are thus kept within the state. Compared to case 1a), the distance to substitute sites in the state is expected to increase, which will reduce the demand (and economic activities) for boating slips and recreational boating trips in general. It is assumed that small boaters completely stop boating and as substitution between vessel types in assumed to be zero, then all economic activities associated with minor vessels are lost.

2b) Minor vessels are not influenced by the dredging stop, all economic activities related to minor vessel boating activities are therefore unchanged. As substitution between vessel types is assumed to be zero, larger vessel boaters cannot change to smaller boats. The welfare economic impacts are consequently smaller compared to case 2a).

2c) This case is identical to case 2b), except from that large vessel owners might change to a smaller type of vessel, which can navigate in the shallow waters. Economically, this increases the consumer surplus of boaters who choose to substitutes to a smaller vessel and therefore do not have to trail or drive to a harbor outside the region. Compared to case 2b) the welfare economic impacts are smaller in 2c).

2d) This scenario is an extension of 2c). More specifically, large vessel owners, who do not choose to use smaller vessels, have to trail their boat to another state or have the boat located in a harbor in another state. These costs naturally reduce the number of boating trips and overall consumer surplus. Furthermore, the entire producer surplus (primary and secondary) are no longer kept in the state, therefore, from a welfare economic point of view, these surpluses are to be excluded from the overall assessment of costs and benefits. As a consequence everything else being equal, this increases the economic impact of a stop in dredging in New Jersey.

In all, these examples intend to give an idea of the importance of monitoring/tracking potential types of substitutions both between boat outing sites but also between types of boats. This seems particularly important in the case of a partial closure (both geographical and vessel type related) of the waterways in dimensions.

2.2 Review on Values of Lost Boating Days and Secondary Economic Impacts

In the present section a short review of the existing literature is presented. It should be mentioned that only are few studies have been found.

2.2.1 Lost Boating Days

In a recent survey carried out in North Carolina, Herstine et al. (2007)/Whitehead et al. (2007) estimate recreational boaters' willingness to pay (WTP) for an Atlantic Intracoastal Waterway Dredging and Maintenance Program by using the economic valuation method, Contingent Valuation (CVM)[4]. The aim of the survey was to estimate the changes in value of recreational boating associated with a change in dredging of waterways.

In the study, only recreational owners of boats larger than 16 feet were sampled. The study included both local (resident) and transient (non-resident) recreational boaters. In total 902 residents and 104 non-resident useful responses were obtained based on an initial sample size of 1400 respondents. The scenario, defining the change in the dredging maintenance, explained to the respondents that without dredging the Atlantic Intra Coastal Waterways, the

[4] , see Mitchell and Carson (1989) for an introduction to CVM.

inland waters would be about four feet deep. With dredging the depth would be 12 feet[5].

The payment vehicle was an annual boating registration fee for boats larger than or equal to 16 feet. One of five dollar amounts was randomly assigned to the respondents ($10, $25, $50, $75 or $100). Respondents answering no were asked if they would pay $1. Based on the regression models, they estimate that owners of boats larger or equal to 16 feet annually are willing to pay $90.49 (residents) and $98.79 (non-residents), on average. WTP is found to correlate with income (income elasticity of 0.26), additional boat outings and perception of the credibility of the dredging management. WTP did not covariate significantly with regards to whether; respondents trail the boat, if respondents have the boat at a marina or at a private dock (Whitehead, 2007- personal communication).

In Appendix A, the properties of the effective samples are presented and commented on. In the case of transferring the estimated benefits from Herstine et al (2007)/Whitehead et al. (2007) these should be taking into account in order to check for difference in characteristics between North Carolina and New Jersey Boaters.

In the survey the Travel Costs Method (TCM) was used to estimate the associated costs of with boating activities. These are estimated to be $67.40 and $104.47 per boat trip for residents and non-residents, respectively. However, the figures only include terrestrial costs and thus not aquatic costs. Furthermore, the nature of the boat outing is not accounted for. The use of the inland waterway might be a gateway to another water body (i.e. multipurpose trip).

The study is very appealing in the present contexts, as it directly touches upon the issue of loss in boating days associated with a stop in dredging activities. Furthermore, the study is from North Carolina, which geographically makes the study area within relatively short distance from project area (New Jersey). However, referring to the American Boating Industry new instrument to measure economic impact of marinas (Recreational Marine Research Center, 2007), North Carolina is located in the northern part of the South East region and New Jersey in northern part of the Mid Atlantic region. This point towards that the economic impacts of a boat day loss in New Jersey might different compared to a boat day loss in North Carolina.

In a survey on the west coast (Department of Boating and Waterways, 2002), California boaters were asked how much they were willing to pay for a given recreational outing[6]. Based on 1,713 valid responses, the mean boating user day value was estimated to be $4.14. Compared to the Whitehead et al. (2007), the estimated WTP is for all boat types and not just boats larger than or equal to

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[5] As such, the study does directly address the preferences among recreational boaters for avoiding a complete closure of some or all waterways, which potentially could be the scenario in New Jersey.

[6] It is important to put forward that the background data of the respondents participating in the survey are not as well defined as in Whitehead et al. (2007)

16 feet[7]. Multiplying with the average number of person per boat trip (3.7) this is equal to a mean $15.76 and with a median WTP of $5.00 (38% of the respondents stated a zero value). WTP was found to correlate with region, boat owner income group and boat owner age. Multiplying the day use value with the stated number of trips and average number of days per trip[8], the average individual annual WTP is estimated to be $671. The Herstine et al. (2007) and California studies are not directly comparable. The reason is that Herstine et al. elicit the preferences of the boat owners, whereas the California study does not specifically target boat owners. Adjusting the California boating estimate with regard the average number of people per trip reduces the WTP to $181/year.

In the report, two other measures of WTP are also applied to estimate the value of boating recreation. The first is a compensation lump sum measure, based on the stated compensation boaters would accept for having their main access to the "waterway most often used" no longer accessible. By multiplying the stated lump sum value with and appropriate interest rate (5.75%) and dividing with the stated number of annual trips and average number of day/trip, a per boating day compensation measure is estimated. On the entire sample the average compensation measure is $100.71 and with a median of $0.29. The annual compensation value per boat is $2,761.

The second measure of recreational boating values is assessed using a travel costs approach. The travel cost values are estimated on the stated expenditure on auto and truck fuel per day. Including only responses of boaters with boats under 26 feet, the mean expenditure on gas is $26.36 per day. Assuming that this expenditure represents 50% of the operational costs, total costs are $52.72. Dividing the estimate with the typical number of people on a typical boating trip, the value per boating day is $17.89. This value must be perceived as a conservative estimate, as it for example does not include trailer maintenance, lodging, etc. See Department of Boating and Waterways, (2002) for further details.

Compared to the Herstine et al. (2007), these California estimates might relate to a different boating market. More specifically, both the type of boating and the waterway characteristics are perceived to be very different from the New Jersey boating market. Consequently, the obtained figures should be used with some care. This information is provided herein due to the general lack of this type of data.

2.3 Secondary Economic Impacts

2.3.1 Expenditures

The secondary effects of lost boating days relates to the loss in economic activities such as the purchase of new boats made by New Jersey boat builders, em-

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[7] In their analysis, they do not find any significant difference in WTP between people who own a boat smaller or equal to/larger than 26 feet

[8] These are not reported in the survey

ployment, economic output / business activity, labor income (workers' wages, salaries & benefits) and fee revenues. Each of the economic impact measures listed can be categorized with regard to the nature of the economic activity. More specifically, the impacts can be direct, indirect or induced. The sum of these economic activities is the total economic impacts. In short, the direct impact relates to the instantly economic response to an initial change in the economy, such as a reduction in profit in a fishing gear store due to reduction in anglers outings in an area. The indirect impact corresponds to the economic ripple effects on sub contractors supplying the industries directly affected (the fishing gear store). The induced impact is the employees and owners spending response affected by the direct and indirect economic impacts. In the economic literature, the sum of the indirect and induced economic impacts is called "economic multiplier effects. The multiplier effects are commonly estimated using economic input-output model methodology.

In the State of New Jersey, the direct expenditures are approximated by the sales of establishments in the SIC areas. Estimated on county level, the shore area is responsible for \$384.1 m in direct spending and a total of \$509.1m. On the state level, these figures add up to \$543.3 and \$720.1m (total spending), respectively. Adjusting for multiplying effects the total economic impacts on state level are \$946.8.3m and \$1,287.9m in direct and total expenditures, respectively (Perniciaro, 2003).

The Marine Trades Association of New Jersey reports that recreational boaters spent \$2.1 billion in 2006. Of the money spent, \$1.1 billion were in trip related expenditures while the rest was in annual boating purchases such as registration fees, maintenance, etc.

These numbers are both large and substantial. Consequently, from a conservative point of view, only the direct spending could be applied in the analysis of the economic impacts of a stop in dredging of the waterways. Again, it is worth putting forward that the effective impacts might be considerably smaller, if the closure of the waterways does not apply for all types of boating activities and in all regions in the state. Furthermore, it must mentioned that the obtained estimates from the travel cost studies in North Carolina and California most probably should not be used together with the estimates of the secondary economic impacts. The reason is that travel cost expenditures for New Jersey boaters most probably are entailed in the secondary economic impact estimates.

In addition to the obtained estimate from the Perniciaro (2003) study, an online economic assessment tool has been launched. It is an interactive system designed to understand boater spending and provide estimates of the overall economic impact of existing and planned marinas can have on a local, regional and national level. It is possible to estimate the economic losses associated with changes in boater behaviour across different boat types and types of spending areas.

In relation to losses in economic activities assessed in the Perniciaro (2003) study and the Online Boating Economic Impact Tool (http://www.marinaeconomics.com), it is very important to stress that these are the losses for the boating sector and industry. However, in the overall economy, expenditures in boating sector may change to expenditures in a substitute sector and thus would not be entirely "lost" in the economy. If the excess expenditure is kept within the state, the net loss associated with a dredging stop would consequently be considerably smaller than the presented estimates.

Finally, it is worth mentioning, that there could be a loss in net tax revenue (fuel tax etc.) associated with a reduction in both direct and total spending. However, with reference to the section 1.1.1, these are treated as transfer payments and are as such not accounted for in the analysis. But seen from a state or local budget point of view, these losses would naturally be important to have quantified.

2.3.2 Property Price Impacts

In the literature it is well established that proximity or direct access to waterfronts adds a price premium to a property (See Blomquist, 1988, Garrod and Willis, 1999). This price premium covers a number of characteristics of living in close proximity to the coast, such as visual and landscape amenities and recreational values. With reference to the latter, a stop in dredging activities and consequently a closure of navigable waterways could potentially reduce the price premium on properties close to the coast. People simply will not pay as much for the house if the possibilities of outing from the property are limited (waters only navigable by small vessel types) or even impossible.

The loss in benefits might not be limited to properties located at the waterfront and with a private boat slip. As such, properties located in the relatively proximity of small marinas and harbors might also drop in price, if the marinas/ harbors no longer can constitute recreational boating. As mentioned the price premium for boat outing possibilities is most probably entailed in the price premium of living close to the sea. It has not been possible to find any studies focusing on this specific element in the hedonic house price function.[9]

2.4 Summary of Results

From the above presented analyses, it seems evident that a dredging stop in areas of waterways in New Jersey potentially can have a large negative economic impact. These benefits are displayed in table 2-1.

[9] The problem at stake is that the application of the hedonic price method requires variations in environmental quality within a single housing market, such as a waterfront in a specific area. But, in this case boating access may not vary sufficiently and further expansion of the geographic area may be in violation with the assumption of a single housing market.

Table 2-1 Impacts of Dredging Stop

Type of impacts	Study	Value	Method	Study area
Lost boating days				
consumer surplus	Herstine et al (2007)	\$90.49-98.79/year/boat owner \$67.40-104.47/trip	CVM TCM	North Carolina
	Department of Boating and Waterways (2002)	\$671/year/boat \$52.72/trip	CVM TCM	California
Secondary economic impacts	Perniciaro (2003)	\$543-720.1m in direct and total expenditure \$947-1,299m in direct and total expenditure with multiplication effects		New Jersey
Property value		Expected to be negative but no estimates available		

3 Benefits of Recycling Dredged Materials Compared to Conventional Storage and Deposition in Confined Disposal Facilities

Currently the predominant method of dredged material management consists of pumping dredged materials into a Confined Disposal Facility (CDF). In New Jersey, these CDFs are located upland, along the shoreline and on islands. The capacity of many of the existing CDFs has been depleted and few coastal areas are available to construct new CDFs. Consequently, transporting dredged materials to distant upland CDFs may be required in the future. Dredging costs increase dramatically with distance.

There is a diverse range of potential uses of dredged materials, which, if used, could increase capacity in existing CDFs and reduce the demand for new CDF sites. Unfortunately, beneficial use options have proven to involve higher costs (transportation and handling).

Consequently, beneficially using dredged material is seldom cost efficient from the point of view of a marina owner, small municipality, or individual user. However, the use of dredged materials is expected to reduce the demand for virgin materials excavated from existing or new quarries. This is of particular importance seen from a New Jersey point of view, as no new mines or quarries have been opened in previous 20 years.

Accordingly, in the longer run, the construction industry might benefit from the accessibility and predictability of material available from a Regional Processing Facility. Quarries will benefit from extended life of their facility thus postponing the cost of closure and cost of permitting new or expanded facilities. Therefore, society as a whole may benefit from the availability of construction materials that minimize these costs. Furthermore taking into account that no new quarries have been opened in the previous 20 years in New Jersey (USGS, 2004), recycling dredged material might keep the costs for construction down in the future, as existing quarries close either because they are empty or policy related reasons[10]. This is perceived to be particularly evident in the coastal areas, where transportation from upland quarries will increase the costs of construction materials.

[10]According to New Jersey Geological Survey (2004), among other reasons, rising real estate prices and environmental concerns has pressured the industry to close quarries/mines.

Reusing dredged materials is thus associated with a number of benefits in relation to the above mentioned properties. These benefits are presented and discussed in the following section.

3.1 Framework for Estimating Economic Impacts

The economic impacts of recycling dredged materials can be assessed by comparing economic activity under a baseline scenario of current dredged material management and economic activity under an alternative scenario of recycling dredged material. In short, economic impacts mainly occur in three categories:

1 Impacts resulting from changes in the number of CDFs

2 Impacts resulting from changes in quarry activities

3 Impacts resulting from the operation of Regional Processing Facilities (RPFs)

As it will be presented in the following subsections, the economic impacts are related to changes in property prices and economic benefits to quarry operators. Assuming a well functioning property market, it is perceived that changes in property prices, to a large extent, will reflect the nuisances associated with close proximity to operating CDFs, quarries and RPFs. Unlike quarries and RPFs, CDFs tend to operate intermittently.

In economic terms, changes in property prices only reflect some of the economic impacts associated with running CDFs, quarries and RPFs. For example, people who work in vicinity of the sites, but live in another area could also experience nuisances from these sites. Furthermore, property prices only relate to use values and thus do not account for non-use values. To take into account the economic impacts, which are not quantified by changes in property prices, studies based on stated preferences, i.e. stated willingness to pay becomes relevant.

3.1.1 Impacts Resulting from Changes in the Number of, and Activities in, CDFs Quarries and RPFs

The annual economic impacts of property price reductions caused by the close proximity to a local CDF, quarry or RPF under baseline conditions are a function of:

1 The number of CDFs, quarries or RPFs, which have a negative influence on the property prices.

2 The number of properties which have a negative price premium associated with having a CDF, quarry or RPF in the proximity.

3 The price premium function, defined by: distance to the site and the types of amenities associated with the CDF, quarry or RPF, such as; odor, seagulls, noise, landscape deterioration (view), perceived risk of soil and water contamination and increased truck traffic.

4 The average negative price premium

5 An appropriate discount rate.

In addition to the potential reduction in property prices, recycling dredged material might also postpone or even remove the costs associated with closing quarries and start-up costs (including permitting) for new quarries. These avoided costs also counts as benefits and should be included in the analysis.

3.2 Review of Economic Impacts Resulting from Changes in the Number of CDFs

As mentioned, reusing dredged materials is expected to significantly reduce demand for new facilities in all three types of areas (upland, coastal and marsh island). This could have a positive effect on property prices several ways. First of all, the activities of existing CDFs might be reduced or even closed down. Secondly, sites identified for future CDFs or RPFs might remain undeveloped.

As mentioned in Lawler et al. (2004) land in the coastal area is a scarce resource. The closure of an existing CDF opens up an alternative nonwater-related use of the previous CDF area while potentially closing the water-related use. In the case of Belmar, NJ, condominiums were built on a CDF with the result that future dredging of the Shark River became extremely costly.

3.3 Review of Economic Impacts Resulting from Changes in Quarry Activities

Using dredged material in construction work, etc. reduces the demand for virgin materials. Potentially, this could reduce activities in existing quarries and a reduced demand for new quarries. As previously mentioned, recycling dredged material might postpone or even eliminate the costs associated with closing quarries and start-up costs for new quarries. These avoided costs are important to take into account as they represent benefits in the analysis.

Besides these direct avoided costs, changes in quarry activities could lead to positive changes in property prices and thus increase in net benefits to society.

However, without detailed information about the gravel or quarry sites from which virgin material are substituted by dredged materials, it is difficult a priori to identify the type of benefits and their marginal value. In the section below, estimates of potential benefits of reusing dredged materials are listed and discussed.

3.3.1 Reduction in Property Prices Associated with New or Expanded Quarries

In relation to estimating the marginal costs of extracting virgin materials from quarries, it would also be appropriate to look into the hedonic literature. Since quarries are characterized by nuisances such as truck traffic, noise and potential dust problems, they might influence neighboring property prices negatively.

3.3.2 Willingness to Pay to close quarries.

In a British study from 1999 (Department for Communities and Local Government) the Willingness to Pay (WTP) for premature closure of quarries is estimated using CVM. Based on 21 local samples in a radius of 5 miles from different quarry sites with different characteristics, the WTP for closing the local quarry is assessed. The characteristics of the quarries vary with regard to the source type (hard rock and sand/gravel) and scale of the output (thousand tones /year). Besides the 21 local samples, a national sample of 1,000 respondents was also applied. Whereas focus in the local samples was on local quarries, the focus in the national surveys was quarries located in two National Parks[11]. The result of the survey is presented in table 3-1 below.

[11] The reports argue that any type of landscape would be worth protecting. In order to give a more realistic and practical frame of the survey it was chosen to focus on quarries in two specific national parks.

Table 3-1 WTP for closure of quarries

Survey	Category		WTP/year in a five years period[12]
Local	Hard rock	Average	£10.23-10.30 ($20.60)
		50,000-200,000 mt	£9.98 ($19.96)
		200,000-500,000 mt	£3.80 ($7.60)
		500,000-1,000,000 mt	£6.68 ($13.36)
		over 1,000,000 mt	£13.37 ($26.74)
	Sand and Gravel	Average	£13.20-15.57 ($31.14)
		50,000-200,000 mt	£12.73 ($25.46)
		200,000-500,000 mt	£10.78 ($21.56)
		500,000-1,000,000 mt	£25.89 ($51.78)
	Wharves	(all output)	£15.05-28.84 ($57.68)
	Recycling sites	(all output)	£8.75-9.18 ($18.36)
National			£5.09-5.15 ($10.30)

The figures in the table display the social marginal costs of excavation of virgin materials perceived by both the people living close to existing quarries (local surveys) and people who do not (national survey).

In this report, it is the sand and gravel estimates that are of particular interest. On average the household in the local samples are willing to pay between £13.20-15.57 ($26.40 - 31.14) per year in a five year period for the closure of the local quarry. Interestingly, these WTPs seem to vary with regard the size of the quarry. Respondents living within 5 miles of a quarry with a production capacity smaller than 500,000 mt/year are willing to pay between £10-78-12.73/year ($21.56 - 25.46). For larger quarries the average annual WTP is £25.89/five year period ($51.78).

It must be kept in mind that these estimates are based on a British sample. Transferring the estimates to the present case in NJ should therefore be done with care. Nevertheless the figures illustrate that people living close to quarries experience social costs of extracting virgin materials from quarries and that these social costs seem to be correlated with the size of the quarry. Opening a new quarry in New Jersey, near a populated area will likely have a social cost.

The results from the national survey are also of interest. The results indicate the overall perceived social costs of excavating virgin materials. More specifically, the respondents are on average willing to pay between £5.09-5.15/year

[12] The estimated WTP is the mean WTP in each distance band with, weighted by the number of households in that band.

($10.18 - 10.30) to close quarries in a national park. In must be put forward that these results are contingent on the survey scenario; closure of quarries in national parks. It would therefore not be correct to use these estimates to assess the social costs for any quarry, as the estimates are perceived to be very site specific. Nevertheless, the result might indicate both a general social benefit of using dredged material (avoiding using virgin geo-materials) and that quarries located in sensitive areas are associated with social costs, which extends beyond the local communities.

A final comment related to the estimated social costs is that there might be potential risk of double counting marginal costs of existing quarries, if the estimates are used together with marginal costs estimates obtained from hedonic studies concerning property prices and the location of quarries in the neighborhood, see below. Furthermore, living close to a recycling facility site also seems to generate social costs. More specifically, respondents living close a recycling site are willing to pay between £8.75-9.18 for a closure of the recycling facility. Seen in relation to recycling dredged materials, these figures indicate a potential social cost of operation RPFs, if located close to population centers.

3.4 Review of Economic Impacts Resulting from the Operation of an RPF

Just as the closure of an existing CDF in an urban area might have a *positive* temporary impact on property prices, the operation of a new RPF or upgrading of a CDF to a RPF might have a *negative* impact on property prices. Most CDFs in the coastal New Jersey region, however, are not near residences. In rare instances, such as the one-time, NJDEP-mandated use of Sedge Island in Stone Harbor, neighbors did complain.

Negative impacts on property prices could occur if the RPF covers a larger geographic area compared to a single CDF. In that case, the noise and transport nuisances could be substantially larger when compared to a small CDF. Again, a RPF might have some of the same negative characteristics of a quarry. Consequently, the displayed estimates for the benefits of closing a CDF also seem as valid estimates (with a negative sign) in relation to the economic impacts of operating an RPF in an urban or residential area. In general, however, closing a CDF would have negative economic impacts if the CDF were required for cost effective DM placement.

3.5 Summary of results

The assessment of benefits associated with recycling dredged materials reveals that these benefits might primarily be associated with changes in property prices.

Type of impact	Study	Value	Method	Study area
	DCLG (1999) Sand and gravel	£13.20-15.57/year ($26.40 - 31.14/year) in five year period	CVM	UK
	Recycling sites	£8.75-9.18/year ($17.50 - 18.36) in five year period		
	National survey	£5.09-5.15/year ($10.18 - 10.30) in a five year period		

4 Experiences from other Countries

In the present chapter, the experiences from other countries with regard to recycling both dredged materials and other classes of waste materials are presented

4.1 Experiences from Denmark

In Denmark it is assessed that approx. 65,000 tonnes/year can be disposed at sea (in addition to large volumes of sand from navigation channels off the West coast of Jutland, which are not included in the estimate). These figure should been seen in comparison to the 740-770,000 tonnes/year that must be located either on land or in disposal facilities at sea or in coastal zone (Miljøstyrelsen 2002).

In Denmark, the local shortage of virgin sand and gravel has increased the focus on recycling dredged materials. Previously, dredged materials have been used in projects such as motorway construction, feeding of beaches at locations with erosion problems and coastal land fillings etc. An interesting feature associated with dredged materials is the taxation scheme. In order to reduce the use of natural resources and encourage reuse of materials, a tax of DKK 5/m^3 is imposed on natural raw materials. Excavation of sand offshore is included. However, dredged materials are not taxed if they are beneficial to either on-land, such as highway construction or offshore purposes. As such, there is an indirect subsidy for use of dredged materials in Denmark.

4.2 Experiences from the Netherlands

Dredging of waterways is of significant importance in the Netherlands. In order to maintain waterways for shipping and water discharges, 30-35 million m^3 of sediments are removed on an annual basis.

To stimulate treatment of dredged materials, the Dutch Government has set aside a budget of at least € 70 million for subsidies for treatment in a four year period. The subsidy is meant to reduce the differences in costs between disposal and treatment. Secondly, some classes of contaminated dredged materials can be treated at reasonable costs and with existing technologies. To motivate the treatment and use, compared to disposal, a disposal tax has been levied on these classes of dredged materials.

4.3 The Danish Waste Management Model

To facilitate innovation in relation to promoting the use of dredged material, the Danish waste management model is briefly presented in this section.

Denmark has a close interplay between EU regulation and national regulations on waste. EU regulations lay down overall frameworks and principles, whereas the Danish Folketing decides on organization and legislation in the area of waste.

Waste from households, the industrial and commercial sectors are managed in comprehensive waste management system. A key element in the Danish Waste model is source separation. Especially, separation of paper, cardboard and glass has a general acceptance and are used extensively by citizens and enterprises.

4.3.1 Policy Instruments

The Danish waste model is based on a combination of traditional non-economic instruments, such as acts, orders, circulars and a number of economic instruments covering taxes, charges, subsidies and packaging deposit-return systems.

Generally, there is a tax on waste In Denmark. The tax is differentiated so that it is most expensive to dispose of waste in a landfill, cheaper to incinerate it and tax exempt to recycle it. Furthermore, "green" taxes are also levied on for example packaging, plastic bags, disposable tableware and nickel-cadmium batteries.

In addition to the present instruments, deposit and return systems have been established for a number of packaging types. For example, packages for beer and carbonated soft drinks are covered by a deposit and return system. The results are that disposal of some 390,000 tons of waste every year are avoided[13].

Furthermore, cleaner technologies are subsidized with the aim toward a reduction of environmental impacts during the entire life cycle of the product. Subsidies can even be granted to specific projects that aim at solving waste problems by, for example, developing new forms of treatment.

Also agreements are used as an instrument to meet environmental targets in the waste area. One example is an agreement with the Danish Contractors' Association on selective demolition of building materials; another example is an agreement with municipal councils on CFC-containing refrigerators.

In New Jersey, a bonus system provided asphalt producers with $1/ton to use recycled glass in their mix. When this incentive was eliminated, asphalt producers stopped using glass. This points to both the value to society of recycling glass, and the cost associated with using a recycled material.

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[13] This corresponds to around 20 per cent of the total amount of domestic waste from households.

5 Conclusions

In the present report the benefits associated with dredging coastal waterways in New Jersey and recycling dredged material have been analyzed. In the analysis the existing literature has been screened for useful information related to the economic impacts related to a stop in dredging of waterways, slips and marinas as well as recycling the dredged materials. In the report, various estimates of the economic impacts have been presented both in relation to loss in boating days, and willingness to pay to close quarries or other facilities. These estimated figures are important in relation to the assessment of economic impacts associated with a dredging stop and reusing dredged materials. However, it must be put forward that the analysis of the economic impacts are strongly limited by information related to the scale of the impacts, such as:

1. How many boating days are lost?
2. How many properties are affected?
3. What are the substitution patterns within and outside New Jersey with regard to boating activities and expenditures?

With more information on these matters, the assessment of economic impacts can be carried out on a more detailed level and make the assessment more complete.

In the following sections, the overall findings are presented.

5.1 Benefits of Dredging Compared to No Dredging of Waterways

A stop in dredging activities is expected to have negative effects on the economy in relation to both boating activities and property prices. More specifically, a stop in dredging will reduce the possibilities in boat outings and a partly/completely closure of marinas and ports. Depending on the number of substitute outing sites in the state, these impacts will vary. Based on a study from North Carolina, the annual WTP for maintaining dredging is estimated $90.49 for North Carolina residents and $98.79 for non residents owning a boat larger or equal to 16 feet. Based on the same sample, the travel costs (exclusive aquatic costs) are estimated to be $67.40 and $104.47 per boat trip for residents and non-residents, respectively. In a California study, the average annual WTP for boating was found to be $671 and $181 respectively. Due to the geographical and aquatic differences between California and New Jersey, the Carolina study is perceived to give the most reliable results.

A stop in boating activities will also have secondary effects in the economy. From Perniciaro (2003), the secondary economic activities associated with boating are estimated to be $1,287.9m in total costs, inclusive of multiplication effects.

In relation to reduction in expenditures in the boating sector, it is important to note that these might be partly substituted by expenditures in another economic sector. A dredging stop might therefore be associated with smaller net economic impacts and large changes in the distribution of expenditures, going from the boating sector to other sectors.

A final economic impact analyzed in the report is reduction in property prices if the coastal waters become impossible to navigate. Unfortunately, it has not been possible to obtain an estimate for these impacts. However, it perceived that these impacts might be considerable and will have effects both on the stated budget (reduction in tax revenues from property tax) and welfare economically (reduction in property values).

5.2 Benefits of Recycling Dredged Materials Compared to Conventional Storage and Deposition in Confined Disposal Facilities

The benefits associated with beneficially using dredged materials relate to changes in activities in existing/new CDFs, quarries and RPFs. More specifically, the economic impacts would be expected in relation to property price adjustments to the changes in activities in the above mentioned activities. The true economic impact will depend on the individual CDF's characteristics. Existing CDFs, particularly in the southern part of NJ, are located in remote areas. Accordingly, it is perceived that the economic impacts in property prices from CDFs are very small, if any at all.

Property prices might not represent the entire economic impacts from changes in activities in CDFs, quarries and RPFs. Property prices relate only to use values and thus do not account for non-use values. In that case, stated preference surveys can be a good approach. Finally, results also indicate that excavating virgin materials compared to reusing dredged materials, overall could cause social costs. In a British survey, respondents were on average willing to pay between £5.09-5.15/year ($10.18 - 10.30) to close quarries in a national park. Though these estimates are perceived to be very site specific, they could indicate both a general social cost of using dredged material and that quarries located in sensitive areas are associated with social costs, which outstretch beyond the local communities.

5.3 Recommendations for Future Research and Information

As presented in the previous sections, estimating the economic impacts of a dredging stop or slowdown of the New Jersey coastal waterways, and of beneficially using dredged material requires substantial information on the economic patterns in society. In the following sections, these will be elaborated on.

5.3.1 Stop in dredging activities

Starting with the stop in dredging, estimates of loss in welfare associated with loss in boating days have been obtained through various sources. Based on these studies, the overall potential economic impacts seem to have been addressed. However, as emphasized, the magnitude of the impacts strongly rely on assumptions related to the extent of the closure of waterways (type of boats, number of marinas etc) and the potential substitute boating sites. More specifically, if substitute boating sites are available in the state of New Jersey, the economic impacts might be smaller than originally perceived or vice versa.

To give a correct estimate of the impacts on boating activities of stop in dredging, it is therefore important to find the information regarding:

1. **The extent of the closure of waterways.**
2. **Potential substitute sites for boat outings, in state and out of the state.**
3. **Potential substitution patterns between classes of boats.**

For each of these categories it is important to categorize with regard to the geographical extent of a potential closure of the waterways and the type of boats affected (size and boating activity).

In the assessment of economic impacts, property prices were argued to drop significantly if the waterways can no longer be navigated. Anecdotal evidence exists, however, it has not been possible to find any studies which have isolated the effect of navigable waterways for properties located close to the coast. As these impacts might be substantial, **a correct quantification of these impacts seems to be important.** This could be done by **applying the hedonic house price method in a relevant case area.** However, as the existing literature has not reported an estimate of water navigability, this might not be a feasible method to obtain an estimate. An alternative method to obtain an economic estimate would be **to use stated preferences method such as Contingent Valuation or Choice Experiments.** With these methods, people living in the relevant policy areas could be directly inquired about the strength of their preferences for keeping the waterway navigable. More specifically, the people could be asked about the willingness to pay either directly (CVM) or through choices among alternative scenarios of waterway closure.

5.3.2 Recycling of Dredged Materials

The assessed impacts associated with recycling dredged materials are broadly reported with respect to potential changes in property prices as a function of the distance to new facilities. It has not been possible to directly give a single point estimate such as a % decrease in price/mile. A stated preference survey might be relevant.

In order to assess the overall economic impact on property prices, information on the potential number of households living close to existing and new CDFs, quarries and RPF sites is also important.

A final recommendation relates to the potential demand among consumers for recycled dredged material compared to virgin materials. In the economic literature, there is an increasing focus on the demand for sustainably produced goods, such as organically farmed produce, Max Harvelar Coffee, etc. Among these products are also recycled materials. In a Danish Study (Ladenburg & Martinsen, 2004) consumers expressed a positive WTP for toilet paper made from recycled paper compared to paper made from new fibers. This indicates that consumers might be willing to trade-off economic losses with the recycling of dredged materials. However, dredged materials might represent a different type of good, as consumers do not get a first hand experience by driving on a highway made from recycled materials. Consequently, **the average WTP might be very small. By summing up the values for all New Jersey consumers, however, these values might be considerable and should potentially be assessed.**

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Appendix A: Sample properties of the Herstine et al. (2007) study

	NC Residents			Non-Residents		
Variable	*Cases*	*Mean*	*Std. Dev.*	*Cases*	*Mean*	*Std. Dev.*
Length	902	28.07	8.98	104	42.36	17.08
Draft	902	3.00	1.36	104	4.11	1.37
Trips1	902	38.43	43.23	104	11.95	16.12
Typical	900	0.83	0.38	104	0.84	0.37
Trips1x	902	41.69	45.13	104	11.00	14.94
Trips2	902	42.33	40.81	104	27.28	58.36
Trips3	902	46.01	45.59	104	33.07	67.60
Trips4	902	23.20	32.99	104	19.23	57.03
Single	902	0.84	0.37	104	0.38	0.49
Perfish	902	0.60	1.28	104	0.19	0.36
Travcost	902	67.40	104.47	104	209.52	542.48
Subcost1	9802	269.58	76.08	104	267.48	15.01
Income	818	85.37	25.16	92	93.23	22.82
Income2	902	77.42	34.50	104	82.48	36.83
Missinc	902	0.09	0.29	104	0.12	0.32
White	900	0.98	0.15	104	1.00	0.00
Male	902	0.87	0.33	104	0.83	0.38
Age	882	46.25	121.26	104	51.61	12.99
House	813	2.73	1.02	90	2.72	1.36
Children	731	0.61	0.89	85	0.53	1.14
Married	896	0.73	0.44	103	0.72	0.45
Educ	896	15.88	2.47	103	15.63	2.49

In the table length and draft are the stated average length and draft of the boats. Without going to much into details, the figure indicates that Non-residents marginally might be more sensitive to reduced navigability in the inland waters. Non-residents' boats have an average draft, which is approximately 1 foot deeper compared to residents. Trips 1 refers to the number of trips in the previous 12 months, Typical is the ratio of respondents for whom this was a normal year and Trip1x is stated normal number of trips for those respondents stating that Trips 1 was not normal. Trips2 is number of expected trips under current conditions. Trips3 is number of expected trips if the average depth was increased to 12 feet. Trips4 is number of expected trips if dredging stopped completely and the average depth would be 4 feet.

Naturally, non-residents generally take fewer trips than residents. Interestingly, the non-residents relatively expects to increase the number of trips in the next 12 month and the average number of trips at 4 feet water depth are also the same for non-residents and residents.

This indicates that the future impact of less navigable waterways might have an increasingly economic impact on non-residents, especially taking into account the estimated travel costs for non-residents (Travcost). Travcost is average estimated costs to access the point to the waterways. Subcost1 is the travel costs to a substitute site outside the state, see below for further comments. Single displays the number of single day trips. Perfish denotes if the primary purpose was fishing. The rest of the variables are the socio demographics characteristics of the respondents in the survey. Income2 and Missinc relate to respondents who did not report their household income level.

Appendix F

Articles

Waste Glass and Dredged Sand Used for Construction Material

In-House Engineer Develops Concept for Beneficial Use

Captain Jeff Bacon of the Corps of Engineers, Philadelphia District photographs piles of sand, left, and crushed recycled glass called cullet that will be combined to create fill material for road construction. Photo by Stanley White, OCC.

Government entities in New Jersey are funding an experiment to mix recycled glass with sand from a dredged material confined disposal facility (CDF) to create fill for road construction.

Earlier this year, the I BOAT NJ Program, administered by the New Jersey Department of Transportation (NJDOT) Office of Maritime Resources, awarded a $600,000 grant to Ocean and Coastal Consultants (OCC) to develop the demonstration project. Recycled glass from the Cape May County Municipal Utilities Authority is being mixed with clean processed sand from the CDF at the U.S. Coast Guard Training Center in Cape May, New Jersey, and is slated for use by the New Jersey Department of Transportation (NJDOT) for reconstruction of County Route 52.

Under the I BOAT NJ grant, OCC developed the concept and designed and carried out the project along with Brice Environmental Services of Fairbanks, Alaska. Brice has worked in New Jersey before, separating lead from artillery range soil at Fort Dix.

Brice used an Eagle fine material washer, classifier and dehydrator, otherwise known as a sand screw, and a Grizzly vibrating screen to separate sand from the dredged material. The overflow slurry with fines was pumped to a geotextile tube for containment and dewatering. A polymer was added to the slurry to coagulate the fines and aid in dewatering.

Mixing the sand and glass with a rotary tiller. Photo by Edward Gorleski, OCC

CDFs dot the Intracoastal Waterway and coastal wetlands of New Jersey, and local authorities have a vested interest in removing material from these sites.

The Borough of Stone Harbor, New Jersey is a cost-sharing partner in the concep-

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Stir, Shake or Mix: Ground Glass-Sand To Subsurface 52

By AL CAMPBELL

CAPE MAY — Crushed bottles once filled with demon rum and ice cold beer will mix with purified sand to form a gritty subsurface for Route 52 causeway's reconstruction that connects wet Somers Point to dry Ocean City.

If the mix, known in engineering parlance as I-7, proves a success in its new use, many mucked-in boaters, constrained by silt, may raise a glass of bubbly to toast a new use for dredge material.

There is such dredge material aplenty in Cape May County drying in government-approved "CDFs" (certified disposal facilities).

There are 150,000 cubic yards reposing on Nummy Island at Site 103 in Middle Township from Stone Harbor's back bays.

That site was originally to be used for this test, but permits did not materialize in time, according to Douglas Gaffney, project engineer, of Ocean and Coastal Consultants, Inc., of

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Al Campbell

Engineer Douglas Gaffney Regards Mound Of Recycled Glass From MUA

Subsurface 52

(From Page 1)

Gibbsboro.

Gaffney took a handful of the ground glass for inspection, and explained that it was more plentiful in this area than other "aggregates," such as pebbles, which must be trucked here, thus adding to costs of road projects.

The county MUA has mountains of the glass, readily available at its Woodbine recycling center.

"We think we are pretty close to giving them all the glass they need," said John Baron, MUA Solid Waste manager.

Like many others, Baron hopes the experiment proves successful, since it would give an added benefit to the tons of recycled glass processed at Woodbine.

A prior test use of ground glass at the MUA mixed it with asphalt for use as road surface. That product, dubbed "glass-phalt," has some drawbacks, since sharp pieces of glass sometimes protruded.

That cannot happen on this project, since the glass is ground finer, and will be under the top surface layer.

Additionally, there are 1 million cubic yards piped onto land that was to become the U.S. Coast Guard Training Center, when Cape May Inlet was created long ago.

Presently, there is a pilot project, funded by a $550,000 grant from the state Department of Transportation under the I Boat Program that will test the feasibility of using that sand mixed, 50-50 or 75-25, with crushed glass provided by the county MUA.

It will be trucked from the Coast Guard Training Center, close to Cape May Inlet where much of the sand originated, to the Route 52 causeway project.

Roadwork on Route 52 is scheduled to begin this year. The two-phase project is scheduled to be completed by late 2012. It includes northbound and southbound lanes of Route 52 and those portions of the bridges and roadway over the islands.

On July 13, Gaffney escorted the Herald on a site tour at the Training Center.

First stop, Gaffney showed a small mountain of MUA crushed glass, which he estimated at 1,000 cubic yards beside a 400 cubic yard mound of purified sand.

On the other side of a dune at the site, several workers using excavation equipment joined Al Brice of Fairbanks, Alaska.

Brice is a principal of Brice Environmental, based in Alaska, which has made a specialty of removing lead from rifle and artillery ranges for the U.S. Department of Defense.

A mechanized separator churned away at the loads of dredge material fed into it. A rough grate removed large items, such as roots, allowing the sand-clay mixture to be slowly moved by a screw-like device.

Washed by recycled water, purified by whale-like geo-tubes about 50 yards away, the clay fell out and looked like gray-brown golf balls.

Pure sand spits out the other end of the machine. It will be carted to that nearby 400-cubic-yard mound to be mixed with the crushed glass.

Funding for the project resulted from the first round of grants in the I Boat Program. The revenues came from increased boat registration fees that began in 2003. Thus boaters, who benefit from deeper, dredged waterways, are paying for the project.

That program provides grant funds to selected eligible applicants to promote, improve and enhance the marine industry in the state for the benefit of the general boating public.

Contact Campbell at (609) 886-8600 Ext 28 or: al.c@cmcherald.com

Appendix G

Glass Acceptance by Department of Transportation

Form LB- 9

New Jersey Department of Transportation OCT 0 4 2005

Bureau of Materials

Report Analysis
Coarse Aggregate

Serial # 942349

Charged to: FCR Inc.

Proposed Use: Quality Control

Kind of Material: glass   Size: *8

Producer: FCR Inc.   Location: Woodbine,NJ

Sample taken from	stockpile under conveyor	Reported to:
Quantity represented	20 tons	
Marks on Sample	FVB#436	FCR Inc.
Sampled by	Frank Brigonde	
Date taken	9/7/2005	
Date taken at lab	SEP 8 2005	2046 Route 610
Seal number		
Laboratory Serial #	942349	Woodbine,NJ

Size of opening square AASHTO T27	Total % Passing	Required % MIN.	Required % MAX.
4" (100 mm)			
3.5" (90 mm)			
3" (75 mm)			
2.5" (63 mm)			
2" (50 mm)			
1.5" (37.5 mm)			
1" (25 mm)			
3/4" (19 mm)			
1/2" (12.5 mm)	⊗ 99	100	
3/8" (9.5 mm)	96	85	100
No. 4 (4.75 mm)	⊗ 43	10	30
No. 8 (2.36 mm)	⊗ 15	0	10
No. 16 (1.18 mm)	⊗ 6	0	5
No. 30 (600 μ m)			
No. 50 (300 μ m)			
No. 100 (150 μ m)			
No. 200 (75 μ m)			
Plasticity Index AASHTO T90			
Absorption AASHTO T85			
Sodium Sulfate AASHTO T104			
L. A. Abrasion AASHTO T96			

08270-2429

ATT: Paul McIntyre

Mat. Reg. S

Specific Gravity, Bulk: SSD: App.:

AASHTO T19 Unit Wt. (pcf): Dry Rodded Wt. (pcf): % Voids:

Reflectance NJDOT A-2 : Scratch/Hard. NJDOT A-8 : Flat/Elongate ASTM D4791 : (10% max.)

NJDOT A-5 Coating, NA Fines: Adherent Fines:

NJDOT A-4 Petrologic Analysis: Acceptable - Other - (5% max.)

Carbonate - Weathered - (5% max.) Crushed Count -

P.C.C. - R.A.P. - Brick/Friable - (4% max.)

wood - (0.1% max.) Glass - 100% Paper - trace Plastic - trace Metal - 0

Paul A. Hanczaryk

REMARKS:

Complies as a coarse aggregate when permitted by the specifications.

Paul A. H[signature]