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Implementation of Construction Quality Assurance (CQA) Measures for Harbor Sediments and Processed Dredged Material (at Encap Golf Site Meadowlands, New Jersey)

FINAL REPORT
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16. Abstract

On behalf of the New Jersey Department of Transportation Office of Maritime Resources (NJDOT OMR) the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University performed Quality Assurance (QA) inspections for placement of PDM at the Site. The QA inspections provided information to the agencies on whether or not the utilization of PDM as construction fill at the upland sites is practical.

NJDEP approved the beneficial use of processed dredged material (PDM) as a grading and barrier layer fill. Approximately 1.2 million cubic yards of PDM was placed at the Site from October 2004 to September 2006. Dredged sediments from New York/New Jersey Harbor were mixed with Portland cement (8% on wet weight basis) in processing facilities at Port Newark and Jersey City. Processed PDM was allowed to cure for 48 hours at the processing facilities and then transported to the Site for beneficial use.

A summary of PDM placement activities over a two year period is provided in this Report. Recommendations are provided on potential improvements with respect to PDA handling and field placement operations.

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EXECUTIVE SUMMARY

Remediation and closure of 4 landfills approximately 700 acres in total size located in the Meadowlands, New Jersey, is currently ongoing. The Site is referred to as the Encap Golf Site (the Site hereafter). Once remediated, the Site will be developed into golf courses, hotels, conference centers, and residential, commercial and recreational areas. As part of Site remediation, the landfills will receive 2 feet of clayey/silty soil or a synthetic liner as a low permeability barrier layer. Placement of the barrier layer is required by the New Jersey Department of Environmental Protection (NJDEP) to ensure that the exposure of humans and biota to the contaminated materials previously placed is minimized.

NJDEP approved the beneficial use of processed dredged material (PDM) as a grading and barrier layer fill. Approximately 1.2 million cubic yards of PDM was placed at the Site from October 2004 to September 2006. Dredged sediments from New York/New Jersey Harbor were mixed with Portland cement (8% on wet weight basis) in processing facilities at Port Newark and Jersey City. Processed PDM was allowed to cure for 48 hours at the processing facilities and then transported to the Site for beneficial use.

On behalf of the New Jersey Department of Transportation Office of Maritime Resources (NJDOT OMR) the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University performed Quality Assurance (QA) inspections for placement of PDM at the Site. The QA inspections provided information to the agencies on whether or not the utilization of PDM as construction fill at the upland sites is practical.

From the 1.2 million cubic yards of PDM received at the Site as of September 2006, 1/2 was spread and compacted over the Site as grading fill and low permeability barrier layer fill and the rest was stockpiled within or adjacent to a 12-acre area referred to as the Interim Stockpile Area (ISP). A 5- to 6-acre area on the Lyndhurst Landfill and the entire Rutherford East Landfill received 2 feet of PDM as a barrier layer. Based on the limited number of permeability tests performed, the PDM met the NJDEP required permeability criterion of 10^{-5} cm/sec. More permeability tests will be performed to confirm that the PDM cap meets the criterion. Past experience with PDM used as barrier layer fill indicated that PDM has a high potential for meeting the 10^{-5} cm/sec permeability criterion within a wide range of moisture content and density. In addition to permeability, NJDEP required the PDM used as barrier layer fill to meet the NJDEP Non-Residential Direct Contact Soil Cleanup Criteria (NRDCSCC) while the PDM used as grading fill had to meet the Site Specific Alternate Soil Cleanup Criteria.

The PDM received at the Site during the summers of 2005 and 2006 were immediately spread and compacted, while PDM received during cold months were stockpiled within and adjacent to the ISP. The PDM placement contractor, MACTEC Development Corporation (a company based in Golden, Colorado), chose to stockpile PDM during cold weather since during this period the PDM following three days of curing did not meet the trafficability test requirement (Test Method TM 5-530/NAVFAC MO-330/AFM) as agreed to by MACTEC and the Site Operator, Encap Golf LLC. Trafficability is the capacity of soils to support vehicular loads and is measured by a cone penetrometer. MACTEC had stipulated that PDM following three days of curing must be capable of sustaining truck traffic. Trafficability tests were performed by MACTEC field staff and the results were not provided to QA inspector.

Dredged sediments are saturated and difficult to handle. Addition of Portland cement reduces moisture content, resulting in increased workability. Proper placement and compaction requires further moisture reduction or moisture conditioning. Moisture reduction is accomplished by spreading PDM in thin layers (during favorable weather conditions), exposing it to sun and air. Continuous displacement using bulldozer blades or harrowing disks further accelerates the drying process (Figure 5). Two to 3 days of moisture conditioning results in significant moisture reduction, making PDM ready for final compaction. In cold seasons (once ambient temperature falls below 40°F), however, cement hydration and PDM solidification slows down (Maher et al., 2000). As a result of the varying weather conditions, in this project only 1/2 of the 1.2 million cubic yards of PDM received was placed and the rest was stockpiled within or adjacent to the ISP. In response to an enforcement action by the DEP, Encap Golf is seeking approval from the DEP as to how stockpiled PDM could be moved to the final designated locations.

Stockpiling of PDM is not the preferred method of PDM handling. Double handling of PDM results in breaking of soil-cement bonds, thus reducing the strength (Maher et al., 2000). The PDM should have been placed in layers, sloped to allow drainage, moisture conditioned, and compacted. Trafficability requirements should have been waived to allow placement of PDM.

In general, the PDM strength requirement should be designed for the intended end use. PDM used as golf course grading fill does not need to be as strong as PDM supporting paved parking areas or roadways. With respect to handling and placement, PDM should preferably be placed at the final designated location within 2-3 days of mixing and not be

disturbed. Additional costs of handling, placement, or extra cement should be considered if PDM is placed during cold seasons.

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DEFINITIONS

Workability: Possibility of handling, spreading in thin layers and compacting of fine-grained soils.

Trafficability: Capacity of soils to support vehicular loads, as measured by a cone penetrometer.

Stockpiling: Placement of soils in a cone-shaped mound to facilitate surface drainage and to minimize moisture loss due to surface evaporation.

Moisture Conditioning: Aeration and reduction of soils' moisture content by spreading soils in thin layers with continuous displacement, accelerating moisture evaporation.

Site Operator: Encap Golf LLC, currently responsible for development of the Site.

Placement Contractor: MACTEC Development Corporation, a Golden, Colorado, company engaged by the Site operator to handle and place processed dredged material (PDM).

INTRODUCTION

Remediation and closure of 4 landfills approximately 700 acres in total size located in the Meadowlands, New Jersey, is currently ongoing. The end use of the Site includes golf courses, hotels, conference centers, and residential and recreational areas. The Site has/will receive various types of fill for grading and either 2 feet of clayey/silty soil or a synthetic liner as a low permeability barrier layer. Placement of the barrier layer is required to ensure that the exposure of humans and biota to the contaminated materials previously placed in those landfills is minimized.

The New Jersey Department of Environmental Protection (NJDEP) approved the beneficial use of processed dredged material (PDM) as grading and barrier layer fill. Silt sediments are dredged from New York and New Jersey Harbors annually, some of which do not meet the ocean disposal criteria but could be used beneficially at confined upland sites in need of grading material and low permeability cap layer. PDM beneficial use is permitted by NJDEP on a case by case basis. If used as barrier layer, the PDM must exhibit permeability value of 10^{-5} cm/sec or less. For this project, the PDM used as

barrier layer must also conform to the NJDEP Non-Residential Direct Contact Soil Cleanup Criteria (NRDCSCC).

The current estimate for the volume of PDM to be placed at the Site is in the order of 2-3 million cubic yards. Approximately 1.5 million cubic yards of PDM is required for the 2-foot-thick low permeability barrier layer. Some of the PDM received to date exceeded the NRDCSCC limits, but meets the Site Specific Alternative Soil Cleanup Criteria thus used as below barrier grading fill.

The NJDEP Office of Dredging and Sediment Technology (ODST) and the New Jersey Department of Transportation Office of Maritime Resources (NJDOT OMR) have a vested interest in the success of the beneficial use of PDM at upland sites. The agencies therefore engaged the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University to provide quality assurance (QA) inspection on their behalf during the placement of PDM. The QA inspection started in October 2004 and continued until September 2006.

The QA inspector responsibilities were to ensure that the PDM was placed in such a way as to provide adequate support as foundation soil for the proposed development and to satisfy the requirements of a low permeability barrier layer. Additionally, the inspector would be able to determine if the engineering specifications were appropriate for the proposed development, based on actual field observations, and could evaluate handling and placement methods adapted by the placement contractor and review PDM laboratory test results conducted by others.

1.0 Site Description

The Site is located in the Borough of North Arlington, Township of Lyndhurst and Borough of Rutherford (Figure 1). The boundaries of the Project Site are generally: Berry's Creek and the northern limits of the Lyndhurst Landfill on the north, the NJ Transit Bergen County Line railroad on the east, the Hackensack River and the New Jersey Turnpike Western Spur on the southeast, and western limits of the Kingsland Park Sanitary Landfill and the Avon Landfill on the southwest and west. The Site is comprised of 4 Landfills: Lyndhurst, Avon, Rutherford (east and west), and Kingsland. Waste material was deposited in those landfills from 1950s to 1980s. Waste originated from municipal, industrial, commercial and demolition waste sources. Institutional

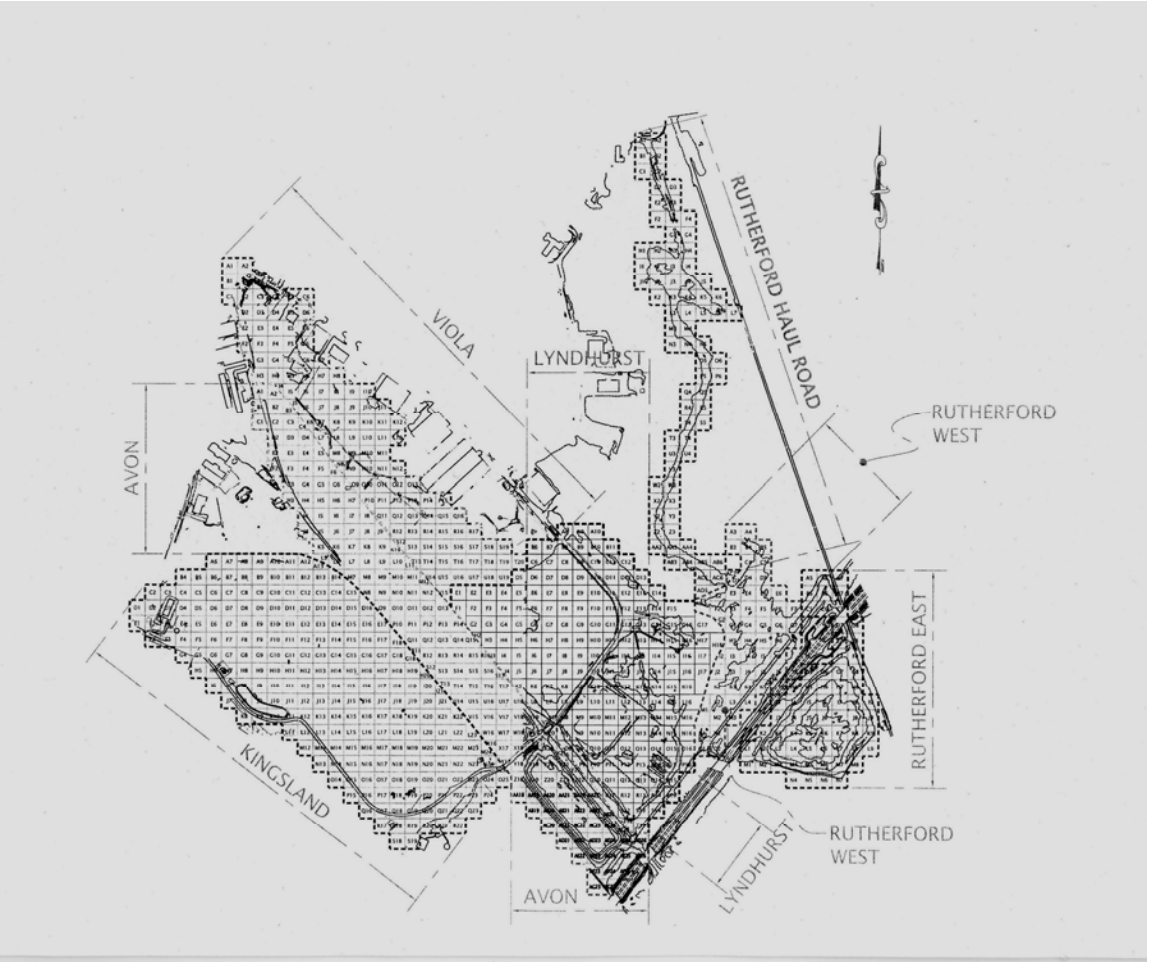


Figure 1. Site Plan

controls prior to implementation of the recent Remedial Action workplan were installed at the NJDEP permitted Kingsland Landfill which included Landfill Cover System, Landfill gas Venting System, Leachate Collection and Control System in board of a soil-bentonite cut-off-wall.

1.1 Remedial Action

Remedial action details were outlined in a document entitled "Revised Remedial Action Workplan/Closure Plan and Major Landfill Disruption Permit Application," which was submitted to NJDEP in April 2002. Landfill remediation activities completed or remaining to be completed on the Site include:

- cap systems placement;
- installation of vertical hydraulic barriers; and

- installation of landfill gas collection systems.

The cap systems approved by NJDEP for the Site includes: PDM, Geosynthetic liner, soil and pavement cover. The landfill cap systems will prevent the exposure of humans and biota to the contaminated materials previously placed. The cap also reduces infiltration and percolation of water through waste thus reducing generation of landfill leachate. A PDM cap is proposed for the Kingsland, Lyndhurst, and Rutherford Landfills. The geosynthetic cover system (consisting of 40-mil low density polyethylene liner and geocomposite drainage layer on top) will be constructed at the Avon Landfill. A two-foot thick soil cover system will be constructed at the Jersey City MUA Aqueduct Property, in areas outside of the pavement areas of the Rutherford Haul Road and at the Lyndhurst Recreation Complex. A pavement cover system is proposed along the Rutherford Haul Road and Valley Brook Avenue and construction haul roads throughout the Site.

As part of Site remediation, a vertical hydraulic barrier system was installed to contain the landfill leachate migrating into surface water bodies. The vertical hydraulic barrier will prevent tidal water migration into and outside of landfill materials. Areas receiving a vertical hydraulic barrier include: Ruther East and west, Lyndhurst Landfill and the Viola Area. Those areas did/will receive PDM and other recycled materials. These actions trigger the need for additional engineering controls such as vertical hydraulic barrier. The vertical hydraulic barrier consists of vinyl sheet pile installed into underlying low permeability soils (i.e. silt or varved clay). The vertical barrier was determined to be unnecessary for Avon Landfill since leachate collection system will reduce the gradient towards the surface water bodies.

A passive gas collection system has been approved has been approved by the NJDEP at the Avon, Lyndhurst and Rutherford Landfills. Specifically, Rutherford Landfill east and west, Rutherford north Node, Lyndhurst Landfill east and west of Viola Ditch will receive the venting system. The gas venting systems consist of a series of perforated collection pipes that direct landfill gas to passive surface vent for discharge. The venting system design for Avon Landfill consists of a network of gas collection trenches installed across the width of the landfill. Vertical HDPE vents will be connected to the piping in each trench and terminated three to six feet above the final surface grade.

With regards to post closure activities, Encap is responsible for operation and maintenance of the constructed engineering controls for a minimum period of 30 years.

1.2 Interim Stockpile Area

A 12-acre area within Lyndhurst Landfill referred to as the Interim Stockpile Area (ISP) (Figure 1) was designated to receive recycled material and PDM while construction of environmental controls such as perimeter containment and a leachate collection system were ongoing. The perimeter containment included installation of vinyl sheetpiles penetrating the waste layer and terminated within the soft organic silt layer immediately beneath the waste layer. The ISP was designated to store recycled materials. Any surface runoff would be drained to drainage swales at the periphery and transferred to a detention pond located at the southeast corner of the ISP. The collected water would then be transferred to the existing leachate collection system. The ISP also had to be lined with 2 feet of compacted low permeability soil or PDM to prevent infiltration of surface water into the waste layer. To comply with the latter requirement, 2 feet of PDM was placed over the 12-acre area following the clearing and grubbing operation in October and November of 2004.

Other than a 2-acre area within the ISP where the PDM was compacted, the rest of the PDM placed within the ISP could not be compacted due to the high moisture content and poor quality of the mix. Pulverized masonry was then placed on top of the PDM to provide access roads for the trucks bringing more PDM to the ISP.

During the winter and early spring months of 2005 and 2006, the ISP received the majority of the PDM delivered to the Site, while small volumes of PDM were spread and compacted outside the ISP. The delivery schedule and sources of the PDM placed within the ISP is described in the following sections.
Other materials, including common fill and sewer treatment plant residuals, were placed within the ISP occasionally. The PDM was continuously stockpiled to create space for additional fill to be imported. No material was removed from the ISP before the last QA inspection in September 2006. Stockpiling of PDM occurred beyond the limits of the ISP and approached Viola Ditch later in the spring of 2005.

From the 1.2 million cubic yards of PDM delivered to the site to date, approximately 0.6 million cubic yards were stockpiled within the ISP and adjacent area. The stockpiled PDM will be used as below barrier layer fill only.

2.0 PDM BENEFICIAL USE

PDM consists of silt and clay sediments removed from NY/NJ Harbor blended with Portland cement and allowed to cure. Dredged sediments are saturated and very soft in consistency, making their handling and placement very difficult. Addition of cement facilitates handling and enhances the engineering properties of the mix, such as shear strength, by decreasing moisture content and bonding of soil particles in the cemented matrix. Due to its silty/clayey nature, PDM is considered a low permeability soil. Past experiences at upland sites where PDM was used as barrier layer indicated that permeability of 10^{-5} cm/sec or less is achievable within a wide range of moisture content and density.

The fill materials used for grading included below barrier, above barrier, and barrier layer fill. NJDEP approved the utilization of PDM as a low permeability barrier layer and below barrier grading fill. The barrier layer fill had to conform to the NJDEP NRDCSCC and meet the NJDEP permeability criterion. The below barrier fill includes common fill, recycled masonry, recycled asphalt, water treatment residuals, and PDM and had to conform to the Site Specific Alternate Soil Cleanup Criteria. The above barrier fill consists of virgin or manufactured soil conforming to the NJDEP RDCSCC and to ground water quality standards. Placement of a 2 foot-thick low permeability cap was required by the NJDEP as part of Site remediation and Landfill closure.

3.0 PDM VOLUMES/SOURCES

From October 2004 to September 2006, approximately 1.2 million cubic yards of PDM was accepted at the Site. The volumes received from each source and the placement location (temporary or permanent) within the Site is described in detail in the "Meadowlands Golf Redevelopment Project Monthly Construction Reports," prepared by Encap Golf. The following section briefly describes the sources and volumes of PDM received at the Site.

The volumes received were estimated by converting the weight of PDM (measured at the entrance gate) to volumes. A conversion factor of 1.4 between tons and cubic yards was used. In other words, it was assumed that each cubic yard of PDM weighs 1.4 tons or each cubic foot of PDM weighs 104 pounds per cubic foot. This is mostly true for

compacted PDM. Therefore, the estimated 1.2 million cubic yards should be considered as in-situ compacted volume.

3.1 Sources of Dredged Material

Dredged material was generated mostly from NY/NJ Harbor dredging projects. Other sources included private dredging projects in New York or New Jersey. The sources and volumes received from each source as of September 2006 are listed below:

Source	Log Number	AUD* Approved Volume (cyds)	Volume Received (cyds)
Port Jersey Contract 2A, NJ	DE0001-1B-1C-1D-DE0012	600,000	78,500
Darling International, Newark, NJ	DE0003-DE0007	4,000	500
Arthur Kill Contracts 2/3, NJ/NY	DE0004-4A-4B	579,000	455,000
DSDD	DE0008	5,000	1,900
St. George Ferry Terminal, NY	DE0009	10,500	11,400
Port Newark – Port Elizabeth, NJ	DE0010-10A-10B	405,500	98,400
S kill Van Kull-2	DE0011	200,000	200,000
East River Tennis Center, NY	DE0013	21,000	18,300
Brooklyn Naval Yard, NY	DE0014-14A-14B	25,000	28,600
Arthur Kill Maintenance	DE 0016	200,000	200,000
PSE&G Generating Station, Sewaren, NJ	DE0017	40,000	12,500
Conoco Corp., Philips Berth, NJ	DE0018	20,500	6,000
Global Terminal, Jersey City, NJ	DE0019-19A	92,000	11,500
Hugo Neu, Tilcon Reach, Jersey City, NJ	DE0020	68,000	36,100
North Cove Marina, NY	DE0021-21A	25,000	21,400
IMTT of Bayonne Inc., Bayonne, NJ	DE0022-22A-22B	79,000	20,360
Total		**2,803,000**	**1,200,400**

*Acceptable Use Determination

The total volume approved through Acceptable Use Determination (AUD) permits is 2.8 million cyds. An estimated volume of 1.2M cyds was received as of September 2006.

4.0 PDM APPROVAL PROCEDURE

NJDEP ODST issues approvals for acceptance of PDM for the upland sites. The approval is referred to as an Acceptable Use Determination (AUD) certificate. An AUD is issued on a case by case basis. The information to be provided to the ODST as part of a request for approval includes but is not limited to the following:

- Analytical data for each source of dredged material. This includes bulk chemistry on raw and amended sediments and leachate tests on amended sediments
- Geotechnical testing data, including moisture and organic content and gradation,
- Recipe for amending of raw sediments; type and source of additives proposed

5.0 PDM PROCESSING SYSTEMS

Two mixing systems were utilized to amend the PDM received at the Site: the pug mill mixing system and in-scow mixing. Each system is briefly described below.

5.1 Pug Mill System

In a pug mill system, dredged material and an admixture are simultaneously introduced to a pug mill and blended with mixing blades or paddles. A pug mill generally contains a series of rotating shafts and paddles attached to the shafts. Prior to mixing, sediments are dewatered by pumping decanted excess water out into a scow and discharging it at the dredging site. Oversize debris pieces (2-inches or larger) are also screened or raked and collected for off-site disposal.

Raw dredged material and additives are mixed into a pug mill with a retention time of approximately ½ to 1 minute. Pug mill mixing produces a more uniform product than in-scow mixing since the mixing is achieved by a more controlled process. For this project, following mixing, sediments were allowed to cure for 48 hours at the processing facility before being transported by highway trucks to the Site (Figure 3).

Figure 3. Off-loading and Processing of PDM in Pug Mill

5.2 In-scow Mixing

The in-scow mixing method utilizes a rotating mixing head mounted on the arm of a long-reach hydraulic excavator. Similar to the pug mill mixing process, the excess water is decanted into an empty scow to be discharged at the dredging site. Scows are raked to remove large debris, while small debris is left in the mix. Large pieces of debris can severely damage the mixing head so it is crucial to remove them prior to in-scow mixing. Following debris removal, cement in slurry form is injected into the dredged sediments in scow through hoses attached to the excavator arm. Recently modifications have been made to the system to also allow addition of cement in dry form. Concern related to dispersion of cement dust had been the rational for adding cement in slurry form.

The mixing head is then submerged into the dredged material, and its revolutions blend the cement and dredged material (Figure 4). Before the mix is transported to the final destination, enough time is allowed for hydration of the cement (initial curing). Mixed material can be unloaded directly to hauling trucks and transported to the placement site or remain in the scow to be transported in-scow to the placement site. For this project, the PDM was allowed to cure for 48 hours before being transported to the Site.

The additive used in both processes was Portland cement. Portland cement is often preferred because of its availability and predictable quality. Other additives such as cement kiln dust or lime kiln dust have variable quality, which adds uncertainty to the physical properties of the PDM. Fly ash was not also used due to environmental concerns. Dredged material processors were required to add a minimum of 8% (on wet weight basis) Portland cement to the raw dredged material (a condition of the AUD).

Figure 4 - Cement Addition (Right) and In-scow Mixing (Left)

5.3 Evaluation of Processing Systems

Part of the PDM was processed by the Donjon Marine Corporation using the in-scow mixing system and part by the Clean Earth Corporation using the pug mill system. The maximum volume delivered in one day by the two processors together was 5,000 cyds.

Based on visual field observations, dredged material mixed in pug mill was more uniform and contained less moisture than in-scow mixed PDM. On occasion, pockets of raw dredged material, poorly mixed material, or cement pockets were observed in the in-scow mixed PDM, specifically within the first two months of PDM delivery. During the summers of 2005 and 2006, the pug mill mixed PDM required 2-3 days of moisture conditioning prior to rolling, while in-barge mixed PDM required 4-5 days. No data to quantify this difference was produced; the above conclusion is based solely on field observations.

6.0 PDM ACCEPTANCE CRITERIA

Prior to the inception of fill placement operations, Encap Golf released a Term Sheet specifying the physical conditions of PDM for acceptance at the Site. The Term Sheet pre-mixing requirements included removal of excess free water and removal of oversize debris pieces (4 inches or larger). PDM had to conform to the following:

- Maximum hydraulic conductivity (permeability) of 10^{-5} cm/sec for the PDM used as low permeability barrier layer
- Minimum unconfined compressive strength of 1,000 pounds per square foot (psf) in 72 hours and 2,000 psf in 28 days
- Maximum particle size of 4 inches

- Trafficable for the highway trucks within 72 hours determined by Test Method TM 5-530/NAVFAC MO-330/AFM (supporting fully loaded highway trucks without excessive rutting or the trucks becoming stuck
- Minimum daily delivery rate of 5,000 cyds

Another requirement not initially included in the Term Sheet but later agreed to by Encap Golf and the processors was for the PDM to be allowed to cure for 48 hours at the processing facility prior to delivery.

6.1 Placement Contractor

MACTEC Development Corporation, a company based in Golden, Colorado, was engaged by Encap Golf to place the imported PDM at the Site. By contractual agreement, Encap Golf agreed to provide MACTEC with PDM conforming to the Term Sheet requirements, while MACTEC agreed to be responsible for placing and compacting of the PDM.

The agreement between Encap Golf and the processors, however, did not include the Term Sheet conditions related to the PDM field performance. The processors maintained that the field performance of PDM was affected by the material handling and placement methodologies employed by MACTEC and was beyond their control. The processors and Encap Golf had only agreed to the processors' performing dewatering, screening of debris, and adding of 8% Portland cement (on wet weight basis) to raw dredged material as required by the AUD. Encap Golf Site and MACTEC did not modify their agreement despite experiencing different field conditions than those envisioned in the Term Sheet. This resulted in MACTEC stockpiling 0.6 million cubic yards of PDM over the ISP. The other factor which contributed to stockpiling of PDM (vs. placement) was that the engineering controls were partially in place limiting the areas within the Site where PDM could be placed.

7.0 PDM PLACEMENT

Delivery and placement of PDM started in October 2004 and is ongoing to date. In this section, placement operations are briefly described during four time periods including:

- October 2004 to June of 2005
- June 2005 to October 2005,
- October 2005 to April 2006
- April 2006 to August 2006

October 2004 – June 2005

Starting in October 2004, sediments from Port Jersey were processed by Donjon Marine dredging company in its Port Newark Facility and transported to the Site. The PDM was initially placed within Lyndhurst Landfill inside the ISP. PDM was also placed on Kingsland and Lyndhurst Landfills in the winter of 2004. The PDM on Kingsland was

periodically pushed and graded to allow for drainage; however, high moisture content and adverse weather conditions did not allow for proper compaction and therefore the 3-day trafficability requirement was not met.

Until June 2005, the imported PDM was stockpiled within the ISP and between the ISP and Viola Ditch. The placement contractor decided to stockpile the PDM since they claimed that the PDM did not meet the trafficability requirement. On occasion, layers of pulverized masonry were placed on top of PDM to construct access roads for trucks bringing more PDM to the ISP and the nearby area. The PDM within the ISP was periodically pushed and stockpiled to provide space for additional PDM.

During the spring of 2005, PDM placed over Kingsland Landfill was graded in layers with varying thicknesses of 2 to 4 feet. The PDM placed over side slopes were graded to allow for drainage. Prior to placement of PDM, sub-grade preparation, usually including grubbing, grading and proof-rolling of native soil, was not performed. Proper sub-grade preparation would have helped achieve better compaction of overlying layers.

June 2005 – October 2005

In June 2005, MACTEC began moisture conditioning of the PDM placed over Kingsland Landfill. Moisture conditioning consisted of periodic displacement of PDM by bulldozers, exposing it to sun and air for moisture reduction (Figure 5). PDM previously placed on Kingsland was graded as per the proposed final grading plan. Significant moisture reduction occurs following 2-3 days of moisture conditioning during favorable weather conditions. The process is significantly slower in cold seasons. PDM from Port Jersey that had been processed by the pug mill system was placed at Kingsland upon delivery, since it met the trafficability requirement (based on MACTEC testing). As stated previously, dredged material processed by the pug mill system was generally more uniformly mixed, contained less moisture, and could be placed faster than in-scow mixed PDM (Figure 6). Also starting in June 2005, PDM delivered to the Site was placed over Rutherford East Landfill. Grubbing and clearing had taken place in April and May 2005 and placement of PDM from Arthur Kill followed in July 2005. The PDM was moisture conditioned for 2-3 days before it could be compacted. PDM layers in the range of 12 to 24 inches were placed and compacted using a smooth wheel roller. Pulverized masonry was placed over some areas on top of PDM for the construction of finger roads to facilitate truck traffic.

Figure 5 - Moisture Conditioning Using Harrowing Disks

Figure 6 – Dredged Material Processed in Pug Mill (left) and In-Scow (Right)

Rutherford West Landfill also received PDM from the same source, and a similar procedure was followed for moisture conditioning and compaction. The majority of the PDM received in the summer of 2005 was placed on Rutherford East, however. Kingsland Landfill received PDM in the late spring and summer of 2005 which was placed at the summit and over the side slopes. PDM layers thickness ranged from 1 to 5 feet. Re-grading of PDM took place once the revised grading plan became available. Limited areas received layers of PDM with the appropriate thickness of 1-1.5 feet which could be properly compacted. Thicker layers (up to 5 feet) of PDM were placed elsewhere on Kingsland and compacted on the surface. No shear tests were performed to determine whether the target shear strength of 1,000 psf was achieved. Nevertheless, no signs of slope failure or significant subsidence were observed within the areas on which PDM was placed. If Kingsland Landfill is going to be developed as a golf course, which exerts nominal structural loads on the foundation soils, achieving the target strength may

not be necessary. If structures are to be built on the existing soils, regardless of PDM strength, a deep foundation system such as piling is required.

October 2005 – April 2006

From October 2005 until April 2006, the imported PDM was stockpiled within the area between the ISP and Viola Ditch. To date, the PDM has not been removed from that area to its final placement location. The same is true for the PDM placed within the ISP. The PDM within the ISP was periodically covered by non-dredged fill material such as sandy soils and water treatment plant residuals. By April 2006, the height of stockpiled PDM within the ISP was about 50 feet above the initial Site grades. Once removed, the stockpiled PDM will be used as a below barrier layer for grading of the Site.

April 2006 – August 2006

In April 2006, PDM received at the site was no longer stockpiled but placed over Kingsland, East Rutherford, Avon, and Lyndhurst Landfills. Also in April 2006, the PDM placed on Lyndhurst Landfill over the proposed recreational area was graded, and two 1-foot layers were placed as a low permeability barrier layer. That area was the first location at the Site receiving the low permeability barrier layer. Samples were collected and tested by MACTEC and met the 10^{-5} cm/sec criterion (test results are provided in Appendix A). The PDM was later covered by 2 feet of clean fill.

During the summer of 2006, the imported PDM was utilized either as below barrier fill or as barrier layer. Avon Landfill is currently the only area where PDM is used as grading material. Since the summer of 2006, Encap Golf Site has accepted only PDM meeting the barrier layer requirement of NJDEP NRDCSCC. Considering the volume of PDM currently stockpiled at the ISP, Encap Golf Site estimated that the Site has received sufficient volumes of PDM as grading fill, but PDM qualifying for barrier layer fill is still needed. Approximately 1.5 million cubic yards of PDM is required to cover the Site with a 2-foot thick low permeability barrier layer.

Rutherford East Landfill received PDM from April to July 2006 as grading material and as barrier layer. Grading material was placed at the summit and over the side slopes and was extended to coincide with the perimeter vertical barrier (vinyl sheet piling). No PDM was placed beyond the vertical barrier. The final two layers of PDM (each 12 inches in

thickness) were considered to be the low permeability barrier. A 2-foot-thick layer of clean fill/growing medium will be placed on top of the PDM.

The PDM placed at Kingsland Landfill was graded. It is our understanding that while more fill material/PDM is needed to achieve the final grades, no additional fill will be placed until the gas extraction system is installed.

PDM placement operation during the QA inspection period is summarized in the Table below:

Dredged Material Source/ Placement Location	**Placement Location**	**Placement Status**	**Barrier Fill/ Below Barrier Fill**
Port Jersey Contract 2A, NJ	ISP	Stockpiled/compacted on a 2-acre area	Below Barrier
	Kingsland, Avon	Spread, with nominal compaction	Below Barrier
		stockpiled, later	Below Barrier
		moved/compacted	Below Barrier
	East Rutherford	Spread, compacted	Barrier Layer
Darling International Berthing Salvage, Newark, NJ	Kingsland	Spread, with nominal compaction	Below Barrier
Arthur Kill Contracts 2/3, NJ/NY	Kingsland,	Spread, with nominal compaction	Below Barrier
		Not spread or compacted	
	ISP	Spread, compacted	Below Barrier
	East Rutherford	Spread, compacted	Below Barrier
	Lyndhurst West		Barrier Layer
St. George Ferry Terminal, NY	ISP	Not spread or compacted	Below Barrier
Port Newark - Port Elizabeth, Channels, NJ	Kingsland,	Spread, compacted	Below Barrier
	ISP	Not spread or compacted	
South Kill Van Kull 2, NJ	West/East Rutherford	Spread, compacted	Below Barrier
	Kingsland	Spread, compacted	Below Barrier
East River Tennis Center, NY	Avon landfill	Spread, compacted	Below Barrier
	Lyndhurst	Spread, compacted	Barrier Layer
Brooklyn Naval Yard, NY	ISP	Not spread or compacted	Below Barrier

Arthur Kill Maintenance, NJ/NY	ISP	Not spread or compacted	Below Barrier
PSE&G Sewaren Generating Station, Sewaren, NJ	ISP	Not spread or compacted	Below Barrier
Conoco Corp., Philips Berth, NJ	ISP	Not spread or compacted	Below Barrier
Global Terminal, Jersey City, NJ	ISP East Rutherford	Not spread or compacted Spread, compacted	Below Barrier Below Barrier
Hugo Neu – Tilcon Reach, Jersey City, NJ	ISP	Not spread or compacted	Below Barrier
North Cove Marina, NY	Kingsland Landfill East Rutherford	Spread, compacted Spread, compacted	Below Barrier Barrier Layer
IMTT of Bayonne, Bayonne, NJ	East Rutherford	Spread, compacted	Barrier Layer
Raritan River, Keasbey Reach	East Rutherford	Spread, compacted	Barrier Layer

8.0 EVALUATION OF PLACEMENT/ACCEPTANCE CRITERIA

As discussed in Section 6.0, the Term Sheet specifying processing requirements and physical conditions of PDM upon delivery included the following terms:

a) Minimum unconfined compressive strength of 1,000 pounds per square foot (psf) in 7 days and 2,000 psf in 28 days
b) Maximum particle size of 4 inches
c) Addition of 8% Portland cement on a wet weight basis to the raw sediments

d) Trafficable for the highway trucks within 72 hours determined by Test Method TM 5-530/NAVFAC MO-330/AFM (supporting fully loaded highway trucks without excessive rutting or the trucks becoming stuck)
e) Minimum daily delivery rate of 5,000 cyd
f) Maximum hydraulic conductivity (permeability) of 10^{-5} cm/sec for the PDM used as low permeability barrier layer

The processing contractors agreed that they would remove large debris, add 8% cement as required by the AUD, and maintain a minimum daily delivery rate. However, they maintained that achieving the target 3-day trafficability and strength requirement should

not be their responsibility. Ultimately, Encap Golf Site withdrew the trafficability and strength requirements from the Term Sheet.

In the agreement between Encap Golf Site and MACTEC, however, Encap Golf Site was responsible for providing MACTEC with PDM meeting the Term Sheet conditions upon delivery. From MACTEC's standpoint, if trafficability in 3 days was not achieved, meaning that trucks hauling PDM could not access and unload at the designated unloading locations, the cost of additional handling should be assessed. As we understand it, since no agreements had been made for bearing the additional cost, MACTEC chose to stockpile PDM that did not meet the trafficability requirement.

Approximately 0.6 million cubic yards of PDM currently stockpiled over the ISP will need to be removed. It was demonstrated in a Pilot Study called "Beneficial Use of PDM in Roadway Embankment Application," performed by Rutgers University in 2000, that excavation into stockpiled PDM months after stockpiling will break the soil-cement bonds, reducing the strength of the materials. The lack of trafficability or accessibility of trucks to the designated unloading locations will result in the need for additional material pushing by bulldozers. The costs of stockpiling, re-loading, and on-site transportation of PDM far exceed the costs of extra bulldozer work.

Shear strength of 2,000 psf was initially required to ensure that the PDM will safely support structural loads of proposed buildings near the edge of the slopes. As we understand it, the strength requirement was waived once it was decided to limit the use of PDM to barrier layer fill and grading fill for the golf courses. Although the PDM was placed on the side slopes and not compacted to reach a target density and strength, no evidence of slope failure or excessive movement was observed. This suggests that the strength requirements were excessive.

Laboratory permeability tests performed on two samples of field compacted PDM indicated that the required permeability of 10^{-5} cm/sec. was achieved (Appendix A). Past experience at sites where PDM has been used as barrier layer fill showed that the target permeability is achievable within a wide range of moisture content and density. Additional samples will be collected and tested for permeability to satisfy the NJDEP cap performance requirements. We understand that additional samples will be collected and tested for permeability once PDM cap is placed over the designated areas of the Site.

9.0 SUMMARY/RECOMMENDATION

Remediation and closure of 4 landfills totally approximately 700 acres in size located in Meadowlands, New Jersey, is currently ongoing. As part of Site remediation, the landfills will receive either 2 feet of clayey/silty soil or a synthetic liner as a low permeability barrier layer fill.

NJDEP approved the beneficial use of PDM as grading and low permeability barrier layer fill subject to meeting permeability of 10^{-5} cm/sec and the NJDEP NRDCSCC.

Quality Assurance inspections were conducted from November 2004 through September 2006 to evaluate whether the utilization of PDM as barrier layering material is practical and economically feasible. During this period, 1.2 million cubic yards of processed dredged material was accepted at the Site. Nearly one half of the material was spread and compacted over the Site and the rest was stockpiled within the ISP.

A PDM acceptance Term Sheet specifying physical conditions of PDM was released by Encap Golf LLC, the Site Operator. The Term Sheet required PDM to be trafficable in 3 days to sustain truck traffic and meet shear strength of 2,000 psf in 28 days. Only the PDM delivered during the summers of 2005 and 2006 met those requirements. High ambient temperatures in summer months accelerated the moisture reduction, thus increasing trafficability and strength. PDM not meeting the strength requirements was stockpiled at the ISP.

The initial plan was to use PDM as foundation soil for supporting structures; however, its application was later limited to grading fill for the golf courses and landscaped areas. Experience in similar golf course applications showed that side slopes of 2.5 horizontal to 1 vertical could be constructed with PDM spread in thin layers and left in place to cure over time. A similar approach could have been adapted for this Site. Excavation and spreading of PDM months after stockpiling tend to break the soil-cement bonds, thus reducing its strength. Therefore this procedure is not recommended.

The PDM placement contractor chose to stockpile the PDM that did not meet the trafficability requirement in 3 days. From the contractor's standpoint, additional material handling and placement costs were not included in the agreement should PDM fail to meet the Term Sheet specifications. No modifications to the agreement between the placement contractor and Encap Golf were made to address this issue. Excavation,

transportation, and placement of stockpiled PDM disturbs the cured PDM and will result in strength loss and higher costs.

Ideally, PDM should be placed at its final designated placement location within 2-3 days after mixing to allow for curing and to avoid further disturbance and breaking of the soil-cement bonds. Drainage should have been provided to divert surface flow from infiltrating the spread PDM until final compaction could be accomplished. Remixing PDM with cement once spread in layers and prior to compaction is very effective for enhancing strength. Cement can be blended in dry forms with PDM using shallow mixers; however, the added cost of mixing and the potential for dust dispersion should be addressed.

A limited number of permeability tests performed to date on samples of compacted PDM collected from the field indicated that the 10^{-5} cm/sec or less permeability as required by NJDEP was achieved.

APPENDIX A

LABORATORY PERMEABILITY TEST RESULTS

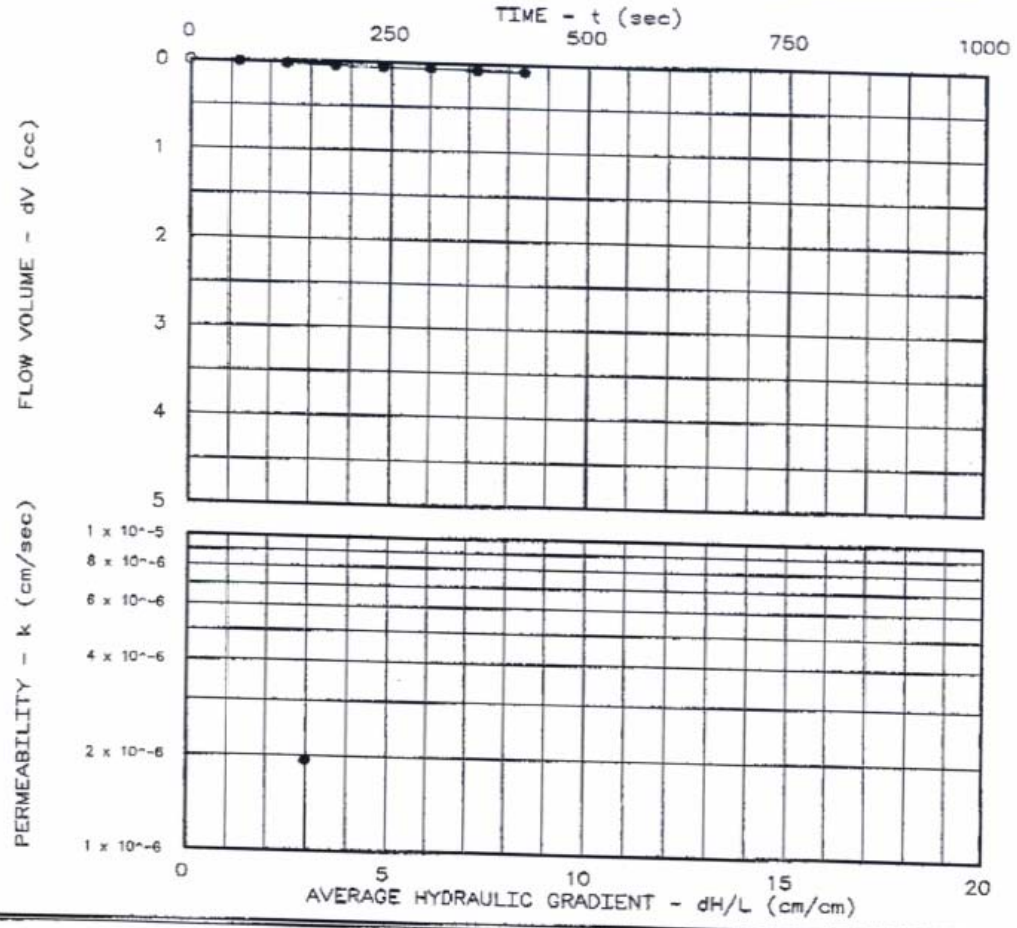
MAILED
To: Farhad
From: Encap
11/17/06

PERMEABILITY TEST REPORT

TEST DATA:
Specimen Height (cm): 11.02
Specimen Diameter (cm): 6.49
Dry Unit Weight (pcf): 78.6
Moisture Before Test (%): 16.6
Moisture After Test (%): 76.9
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 65.0
Test Pressure(psi): 65.0
Back Pressure(psi): 64.5
Diff. Head (psi): 0.5
Flow Rate (cc/sec): 1.90 x 10^-4
Perm. (cm/sec): 1.94 x 10^-6

SAMPLE DATA:
Sample Identification:
Sample #1
Visual Description:
PDM Material
Remarks:

Maximum Dry Density (pcf): 82.4
Optimum Moisture Content (%): 15.7
ASTM(1557)
Percent Compaction: 95.4%
Permeameter type:
Sample type: Shelby



Project: Mactec
Location: Encap
Date: 10-09-06

PERMEABILITY TEST REPORT
MATERIALS TESTING INC.

Project No.:
File No.: 184
Lab No.: S-5467
Tested by: NP
Checked by: FGP
Test: CH - Constant head

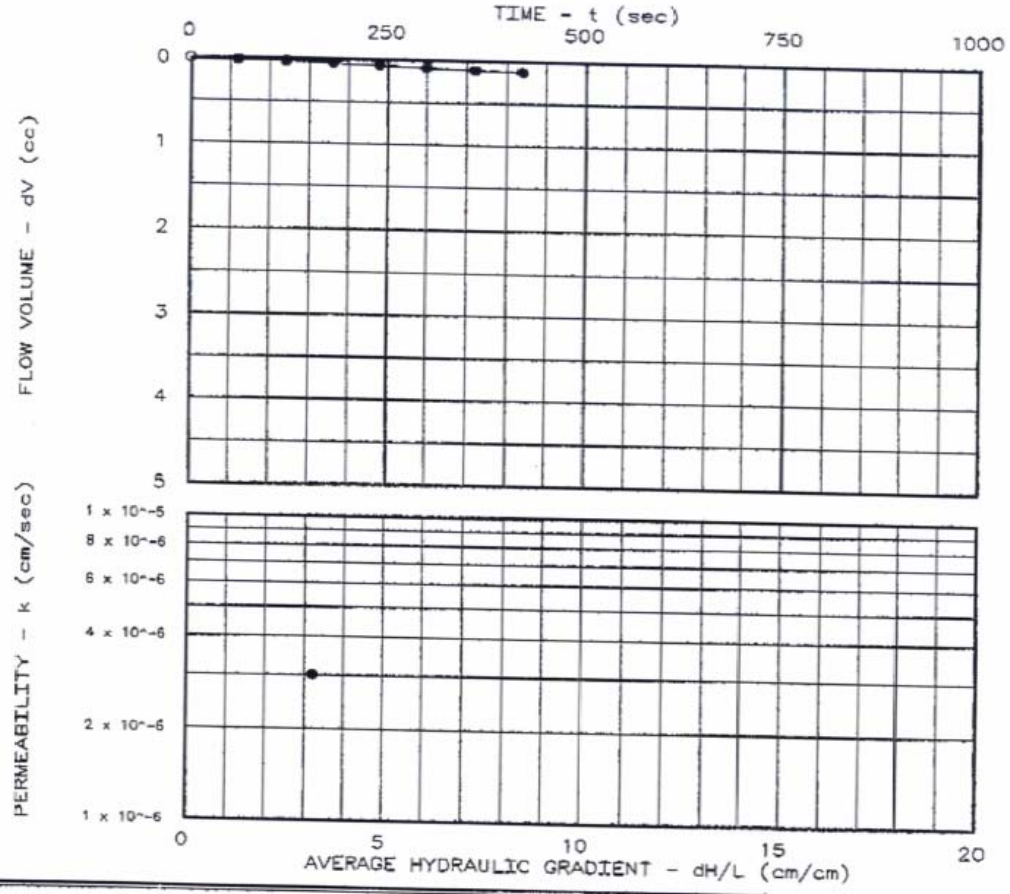
To: Farhad
From: Encap

PERMEABILITY TEST REPORT

TEST DATA:
Specimen Height (cm): 10.21
Specimen Diameter (cm): 6.41
Dry Unit Weight (pcf): 79.8
Moisture Before Test (%): 25.6
Moisture After Test (%): 78.8
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 70.0
Test Pressure(psi): 65.0
Back Pressure(psi): 64.5
Diff. Head (psi): 0.5
Flow Rate (cc/sec): 3.10 x 10^-4
Perm. (cm/sec): 3.00 x 10^-6

SAMPLE DATA:
Sample Identification:
Sample # 2
Visual Description:
PDM Material
Remarks:

Maximum Dry Density (pcf): 82.4
Optimum Moisture Content (%): 15.7
ASTM(1557)
Percent Compaction: 96.8%
Permeameter type:
Sample type: Shelby



Project: Mactec
Location: Encap
Date: 10-10-06

PERMEABILITY TEST REPORT
MATERIALS TESTING INC.

Project No.:
File No.: 183
Lab No.: S-5467
Tested by: NP
Checked by: FGP
Test: CH - Constant head

APPENDIX B

DAILY CONSTRUCTION REPORTS

(Provided in Electronic Format)

APPENDIX C

CONSTRUCTION PHOTOS

(Provided in Electronic Format)