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COMPLETION OF WORK REPORT
TIME-CRITICAL REMOVAL ACTION

Administrative Order on Consent For Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

November 2004

Prepared for

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Comm. No. 15RP301

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APPENDICES

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ACRONYMS

CFR	Code of Federal Regulations
CQAP	Construction Quality Assurance Plan
CWR	Completion of Work Report
EPA	Environmental Protection Agency
G&H	Guerriere & Halnon, Inc.
HASP	Health and Safety Plan
LEA	Loureiro Engineering Associates, Inc.
LCI	LEA-Cianci, Inc.
NCP	National Contingency Plan
NPL	National Priorities List
OSC	On-Scene Coordinator
OSWER	Office of Solid Waste and Emergency Response
PCBs	Polychlorinated biphenyls
PPE	Personal Protective Equipment
PRPs	Potentially Responsible Parties
PRSCP	Post-Removal Site Control Plan
RIDEM	Rhode Island Department of Environmental Management
RIDOT	Rhode Island Department of Transportation
SOW	Statement of Work
TCRA	Time Critical Removal Action
UAO	Unilateral Administrative Order

USACE	United States Army Corps of Engineers
VOCs	Volatile Organic Compounds
WP	Work Plan

1. INTRODUCTION

1.1 Terms of Reference

This Completion of Work Report (CWR) has been prepared for the Centredale Manor Performing Parties Group at their request, and as required by Paragraph 60 of the Third Administrative Order on Consent for Removal Action (Order). The Order outlines a Time-Critical Removal Action (TCRA) at the former tailrace portion of the "Centredale Manor Restoration Project Superfund Site" located in North Providence, Rhode Island (Site). This CWR has been prepared in accordance with the Statement of Work (SOW) provided as Appendix D to the Order.

1.2 Site Description

As described by the United States Environmental Protection Agency (EPA), the Site includes two parcels, 2072 and 2074 Smith Street (Plat 14, Lots 200 and 250), encompassing approximately 9.7 acres, as well as certain sediments and floodplain areas of the Woonasquatucket River from Route 44 southerly to Allendale Dam and further to an area just below Lyman Mill Dam. EPA defines the Site to include certain contaminated areas within this area as well as any other location to which contamination from that area has come to be located, or from which that contamination came.

The 2072 Smith Street parcel is occupied by Brook Village Apartments. This parcel is registered as Plat 14, Lot 200 in the Land Evidence Records of North Providence, Rhode Island. Brook Village Apartments consists of an eleven-story apartment building that houses approximately 130 elderly residents. A series of three paved parking lots extend to the south of this building. The area of the parcel surrounding the building and parking lots includes landscaped areas and a paved driveway accessing Smith Street (Route 44), located along the eastern property line. The parcel also includes an interim soil cap located adjacent to the Woonasquatucket River. The parcel is bordered to the north by Smith Street, to the west by the Woonasquatucket River, to the east by a drainage ditch (former tailrace), and to the south by the 2074 Smith Street parcel.

Centredale Manor Apartments occupies the 2074 Smith Street parcel and consists of an eight-story apartment building that houses approximately 130 elderly residents. This parcel is registered as Plat 14, Lot 250 in the Land Evidence Records of North Providence, Rhode Island. Two paved parking lots are located on this parcel to the north and west of the building. The apartment building and parking lots are located on the northern end of the parcel. The remaining area of the parcel includes landscaped areas. The parcel also includes an interim soil cap on the

southern end of the parcel, which is bordered by the Woonasquatucket River to the west and south. The parcel is bordered to the east by the former tailrace. The property is bordered to the north by the Brooks Village Apartments property.

The Site is bordered to the north by Smith Street and to the east and southeast by a perennial drainage channel that is the location of the former tailrace. It is bordered to the west by the Woonasquatucket River. The drainage channel (former tailrace) and the Woonasquatucket River converge at the peninsula located immediately south of the Centredale Manor property.

1.3 Previous Removal Actions

Following several preliminary studies and initial removal actions conducted by EPA and its contractors, the Site was placed on the National Priorities List (NPL) in February 2000. Initial removal actions included clearing and grubbing of approximately six acres of the Site, collecting of over six hundred soil and sediment samples, installing over a mile of cedar and chain-link fencing, and installing an interim soil cap over areas of contaminated soil and sediment. Beginning in April 2000, a TCRA was implemented by certain potentially responsible parties (PRPs) pursuant to a First Unilateral Administrative Order for Removal Action (UAO 1) for the Site. During this TCRA, the PRPs completed the installation of a second interim soil cap. This second interim soil cap was installed on the Brook Village parcel adjacent to the Woonasquatucket River.

In 2001, a Non-Time Critical Removal Action was implemented pursuant to a Second Unilateral Administrative Order for Removal Action (UAO 2) for the Site. The Non-Time Critical Removal Action included the restoration of Allendale Dam, the delineation of dioxin-impacted soil and sediment in residential-use areas along the eastern embankments of Allendale Pond and Lyman Mill Pond, and the excavation and off-Site disposal of certain dioxin-impacted soil and sediment.

1.4 Time-Critical Removal Action Objectives

The TCRA objective, as described in the Order, is to prevent or reduce the potential for the migration of, and direct contact with, surface soils, sub-surface soils and exposed sediments that may be impacted with dioxin, metals, volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and other hazardous substances in the area of the former tailrace. To meet this objective, a permeable protective cap was constructed over such soil and sediment within the former tailrace, as described in this report. A drainage swale was incorporated as part of the permeable protective cap thereby moderating the impact of flood conditions and managing the stormwater runoff that discharges into this area of the Site.

1.5 Organization of this Report

As prepared, this CWR is consistent with the National Contingency Plan (NCP) found in Title 40 of the Code of Federal Regulations Part 300 (40 CFR 300). Specifically, this report meets the requirements set forth in Section 300.165 of the NCP entitled "OSC Reports." This report summarizes the activities performed to meet the requirements and objectives of the removal action. In general, this report describes the activities completed for the: (i) management of stormwater runoff and sedimentation entering the former tailrace along the eastern boundary of the Centredale Manor property; and (ii) construction of a permeable protective cap over the tailrace area.

As organized, this report provides a chronology of the work performed. The report includes a summary description of the methods and procedures that were used in implementing the TCRA. This report also includes a description of the "as-built" conditions of the permeable protective cap and the associated stormwater runoff controls. A photodocumentation log, including pre-construction and post-construction photographs, is also provided to document the sequence of events in implementing the removal action. The remainder of this report is presented as follows:

- A description of the general approach to satisfying the objectives of the TCRA is provided in Section 2;
- A summary of the pre-construction activities that were performed in fulfillment of the SOW is provided in Section 3;
- A summary of the construction activities including a description of the methods, materials, and procedures that were used in implementing the removal action is provided in Section 4;
- A description of the Site inspections performed subsequent to completing the construction activities is provided in Section 5;
- A general description of the plan developed to protect the measures taken pursuant to the TCRA is provided in Section 6;
- A detailed breakdown of the cost to implement the TCRA activities is provided in Section 7; and
- A statement certifying that the information provided in this CWR is true, accurate, and complete is provided in Section 8.

2. GENERAL APPROACH

To satisfy the objectives of the TCRA, a cap that incorporates a drainage swale was constructed over potentially impacted soils and sediments within the former tailrace located along the eastern boundary of the Site. A plan view, profile, and sections of the designed permeable protective cap are provided as Drawing 1. As shown in this drawing, a drainage swale was placed at the downstream side of a sediment trap, which was installed at the northern extent of the former tailrace. From this end of the tailrace, the drainage swale was placed along the western edge of the area to be capped, and with the permeable protective cap extends over all of the potentially impacted materials to the southern extent of the former tailrace. The area to be covered by the permeable protective cap was established by EPA.

As designed, the drainage swale portion of the permeable protective cap consists of 12 inches of clean material placed over the potentially impacted soils and sediments. The permeable protective cap materials consist of approximately 6 inches of sand placed directly over the potentially impacted soils and sediments. This sand layer functions as a filter and separation layer between the potentially impacted material and the overlying cap material. A geotextile fabric placed upon the sand layer provides a definitive separation layer and an additional filtering layer between the potentially impacted material and the overlying cap material. The design incorporates the use of a polyethylene cellular confinement system, having a height of six inches, placed upon the geotextile fabric. The polyethylene cells are filled and covered with approximately 6 inches of 1.5-inch washed stone. A cross-section of this part of the permeable protective cap is illustrated on Drawing 1.

The remaining area of the former tailrace is capped with 24 inches of clean material placed over the potentially impacted soils and sediments. For this area of the permeable protective cap, a geotextile fabric was placed directly upon the potentially impacted soils and sediments to provide a separation layer between the potentially impacted material and the overlying cap materials. A 20-inch layer of clean gravel was placed upon this geotextile layer. The cap cover in this area consists of a four-inch layer of topsoil (loam). A hydroseed was applied to the topsoil areas to protect the cap components from erosion. A cross-section of this part of the permeable protective cap is illustrated on Drawing 1.

3. PRE-CONSTRUCTION ACTIVITIES

3.1 Introduction

The activities completed prior to the commencement of the construction activities included obtaining access agreements from abutting property owners and preparing a Work Plan (WP). The components of the WP included a Site-Specific Health and Safety Plan (HASP), Construction Quality Assurance Plan (CQAP), and Community Relations Support Plan. The WP also included construction specifications. In addition to these pre-construction activities a Physical Alteration Permit Application was prepared and submitted to the Rhode Island Department of Transportation (RIDOT) at the on-set of construction activities. A description of each of these pre-construction deliverables is provided in the sections that follow.

3.2 Off-Site Access Agreements

As provided by the design drawings, the limit of the cap does not extend onto private properties bordering the east side of the project. However, the design included limited clearing activities and the placement of loam/seed adjacent to the edge of the cap on some of these properties. To complete the TCRA field activities, consent to access these private properties was obtained from the property owners.

3.3 Work Plan

As required by Paragraph 54 of the Order, a WP was prepared and submitted to EPA. The WP was prepared in accordance with the SOW provided as Appendix D to the Order. The Plan described all of the activities necessary to meet the requirements and objectives of the removal action as described in the SOW. The WP included a Site-specific HASP, CQAP, and a Community Relations Support Plan.

3.4 Health and Safety Plan

As required by the Order, a Site-specific HASP was prepared for the on-Site activities implemented in completing the TCRA. The HASP identified the procedures, personnel responsibilities, and training necessary to protect on-Site personnel and the general public during the completion of the removal action. The HASP also identified potential hazards that could be encountered at the Site, and provided an assessment of each hazard. The HASP also described procedures and measures, including personal protective equipment (PPE) measures to be employed in minimizing the potential harm that could result from Site hazards.

3.5 Construction Quality Assurance Plan

A CQAP was included as part of the WP. The Plan described the measures to be implemented to ensure that the purchase and installation of the specified materials were in conformance with the WP and the associated construction specifications.

3.6 Community Relations Support Plan

A Community Relations Support Plan was prepared for the on-Site activities to be implemented in completing the TCRA. The Plan specifies the activities to be taken to support the community involvement efforts of EPA.

3.7 Physical Alteration Permit Application

On October 20, 2003 a Physical Alteration Permit Application was submitted to RIDOT. This application was submitted for approval of the use of the sediment trap at the northern extent of the drainage swale. Upon review of the permit application, which included a Drainage Report, construction specifications, computations, and drawings, RIDOT provided approval to install the sediment trap at the terminus of the RIDOT drainage system.

4. SUMMARY OF CONSTRUCTION ACTIVITIES

4.1 Overview

Loureiro Engineering Associates, Inc. (LEA), through its wholly-owned subsidiary LEA-Cianci, Inc. (LCI), performed the construction activities to satisfy the requirements of the TCRA. The construction was completed primarily with heavy equipment consisting of an excavator, loader and long-stick excavator. Tri-axle dump trucks were used to deliver the earthen material components of the cap to the Site. The sequence and scheme of construction is depicted in the photographs presented in Appendix A. A summary description of the construction techniques and procedures used is presented in this section.

4.2 Photographic Survey

The photographs presented in Appendix A provide a photographic survey of the Site. The survey includes photographs of the former tailrace that document the Site conditions prior to the initiation of construction activities. In addition, a record of the landscape features within and immediately surrounding the former tailrace is captured as part of this survey. The survey also includes photographs taken during construction activities to document the work completed. Photographs of the constructed cap are included in the photographic survey to document the as-built conditions of the permeable protective cap, as well as the adjacent areas that were disturbed during the removal action. Written descriptions of all photographs are provided in the survey provided in Appendix A.

The photographic survey provides a record of the major construction phases and components of the TCRA. Specifically, the photographs document the sequence of construction activities including: cutting and clearing trees; de-watering; shaping of the drainage swale and permeable protective soil cap; and placement of the cap materials. The post-construction photographs document the as-built condition of permeable protective cap. Reference to the photographs presented in Appendix A is made at this time to facilitate an understanding of the TCRA activities performed, as presented in the following sections.

4.3 Site Security

Security was established during the construction activities by maintaining, to the extent practicable, the current chain-link fence and the signs that are in place to limit access to the Site. Sections of the fence along the west side of the former tailrace were removed at the commencement of the construction activities to allow for the mobilization of equipment, the

delivery of materials, and the safe and efficient operation of the construction activities. Signs were posted along the opening in the fence identifying the construction area to be restricted (the exclusion zone). To further prevent entry by unauthorized individuals, on-Site workers monitored the exclusion zone. At the conclusion of each work day, the Site was secured by erecting a temporary fence lined with caution tape across the area where the chain-link fence had been removed. Upon the completion of construction activities, the sections of the chain-link fence that were removed were replaced.

4.4 Layout and Control

Guerriere & Halnon, Inc. (G&H), a professional land surveyor licensed by the State of Rhode Island provided survey layout and grade stakes identifying the locations of the planned permeable protective cap and drainage swale. The layout was performed given the planned components identified in the design drawings. G&H also confirmed the Site property boundaries and existing conditions in the field prior to initiating construction activities. Upon construction of the permeable protective cap and drainage swale, G&H surveyed the final grade contours and the limits of the permeable protective cap and drainage swale. The survey data were used to document the as-built conditions at the Site, as illustrated in Drawing 2.

4.5 Erosion and Sedimentation Controls

A significant component of controlling erosion and sedimentation during the implementation of the removal action included lowering the elevation of Allendale Pond. Prior to the onset of the construction activities, the stop logs at Allendale Dam were removed and the associated sluice gate was opened to allow the pond backwater and surface water runoff present within the former tailrace to drain. The elevation of Allendale Pond was lowered by approximately four feet to an elevation of approximately 89.5 feet.

A check dam was then constructed at the southern end of the former tailrace to minimize the potential for the downstream transport of suspended sediments at the onset of construction. The check dam consisted of 3/4-inch washed stone. To de-water the southern extent of the former tailrace, a temporary drainage ditch was excavated using the long-stick excavator. To enhance the de-watering efforts, water was pumped from areas downstream of the utility crossing to areas within the former tailrace located further downstream. Temporary coffer dams constructed of 3/4-inch washed stone were placed in succession across the former tailrace to minimize the transport of sediment downstream. The water within the former tailrace was directed through the check dam constructed at the southern end of the former tailrace.

4.6 Clearing and Grubbing

Once the proposed limits of the permeable protective cap were staked in the field and the former tailrace was sufficiently drained, clearing activities were initiated by YardStick, Inc. of Johnston, Rhode Island. As a first step, shrubs and brush were cleared from the area within and immediately adjacent to the former tailrace. Once cleared of shrubs and brush, trees that required removal to allow construction activities to take place were cleared from the work area. To the extent possible, steps were taken to allow trees to remain. Trees that were felled were cleared and were chipped along with the shrubs and brush using traditional clearing and chipping machinery. The removed trees and shrubs were chipped on-Site, and the chipped material was used to construct a pathway for heavy equipment within the footprint of the soil cap during the initial construction activities. Because no large trees were present within the limits of the drainage swale, grubbing activities were not necessary to construct the permeable protective cap. Trees present within the limits of the soil cap were cleared to within approximately six inches from the ground surface.

4.7 Decontamination Methods

Construction activities were sequenced such that, to the extent practicable, heavy equipment was operated from a clean work area, outside the low-lying area of the former tailrace. To provide a clean work area throughout the entire length of the tailrace, a temporary road was first constructed using the sand to be placed over the potentially impacted sediments. This temporary road comprised a working face of the cap and was constructed using the long-stick excavator. The sand was placed over sediments along the eastern portion of the former tailrace between Station 4+50 and Station 7+50 (Drawing 1). With the construction of the temporary road, a clean work area was established for the entire length of the swale.

Where it was not possible to construct the cap from a clean work area, and construction equipment and tools were used within the areas of potentially impacted soils and sediments, decontamination procedures were followed to minimize the potential for cross-Site tracking of soils and sediments. A combination of both dry and wet decontamination procedures were used before heavy equipment, hand tools and other hand-held equipment were removed from these areas. For the decontamination process, a temporary equipment decontamination pad was constructed within the area of the drainage swale. This pad was constructed from 20-mil polyethylene sheeting placed upon the temporary sand road at its northern extent. This section of the temporary road was sloped toward the center of the swale such that any water generated during the decontamination process drained into the swale.

Dry decontamination procedures involved scraping and brushing wet and moist soil and sediment from the equipment over the decontamination pad. As needed, wet decontamination procedures were used to clean the heavy equipment and tools. Wet decontamination procedures involved the use of brushes and tap water. The soil and sediment collected on the decontamination pad as a result of the decontamination procedures was temporarily isolated until it could be placed under the cap material.

To further minimize the potential for cross-Site tracking of soils, a temporary tracking pad was installed at the entrance of the existing cap located at the southern portion of the Site property. The temporary tracking pad consisted of a layer of 1½ inch stone placed to a depth of approximately four inches over an area of 12 feet wide by 40 feet long. Thus, equipment could be moved from the material and stockpile staging area on the southern cap, over the tracking pad, and to other work areas without tracking soils across the Site.

4.8 Chronology of Construction Activities

In general, potentially impacted soils and sediments were graded from the western portion of the former tailrace and was placed within the footprint of the permeable protective soil cap to be constructed on the northeastern portion of the former tailrace. The construction of the permeable protective cap generally proceeded from upstream to downstream. Stormwater runoff emanating from Smith Street and discharging into the northern end of the former tailrace was managed by installing the sediment trap at the terminus of the drain pipe. Stormwater from this structure flows into the constructed drainage swale.

Following the construction of the temporary road, the northern extent of the drainage swale was graded and shaped. Excess material in the area of the drainage swale was relocated to within the limits of the permeable protective soil cap. Coincident with establishing the necessary grades for the swale, material was moved for the placement of the sediment trap. This material was also relocated to within the area of the soil cap.

During the grading activities, buried brick, concrete, and debris were encountered in the area of the northern part of the drainage swale. The brick, concrete, and debris buried in this area of the Site is believed to have been part of a building foundation. The foundation debris could not be removed with the heavy machinery dedicated to the project. A Komatsu PC138 excavator equipped with a breaker was used to remove this debris in establishing the necessary design grades. The brick and concrete rubble and other debris were placed within the area of the permeable protective soil cap. During the TCRA, approximately 1,200 cubic yards (cy) of soil, sediment, and debris were placed into the area of the soil cap.

Once the necessary grades were established, the area of the soil cap was shaped, and the sediment trap was installed, the material components of the permeable protective cap and drainage swale were placed. Working from the terminus of the RIDOT drainage pipe and proceeding in a downstream direction, approximately 6 inches of sand were placed directly over the potentially impacted soils and sediments. The typical progression of construction activities was such that the geotextile fabric and overlying stone-filled polyethylene cellular confinement system of the drainage swale were placed to cover the sand layer to prevent erosion of the sand from stormwater runoff. At the northern extent of the work area, this system also covered the exposed face of the materials placed within the footprint of the soil cap. Copies of the material specification sheets for the geotextile fabric and the cellular confinement system are provided in Appendix B. Progressing with construction activities in this manner enabled laborers and heavy equipment to cap the potentially impacted soils and sediments from a clean work area.

The materials placed within the footprint of the permeable protective soil cap were covered with geotextile fabric. The fabric was placed directly upon these materials to provide a separation layer between the potentially impacted material and the overlying cap materials. The cap materials consisted of a 20-inch layer of clean gravel placed upon the fabric. A four-inch layer of topsoil (loam) was placed upon the gravel layer. With the on-set of winter conditions a winterization mat was placed over these cap materials until final Site restoration, including hydroseeding, could occur in the spring.

In the spring of 2004, Site restoration activities were conducted upon the placement of final cap materials at the southern extent of the former tailrace. The Site restoration activities included hydroseeding the topsoil areas of the permeable protective soil cap to protect the cap components from erosion. Site restoration also included grading the areas adjacent to the western extent of the cap that were disturbed during construction activities. These areas were covered with topsoil, and hydroseed was applied to the soil to re-establish vegetation.

5. SITE INSPECTIONS

Following the completion of construction activities, a pre-final inspection was performed by the EPA, the United States Army Corps of Engineers (USACE), the Rhode Island Department of Environmental Management (RIDEM), and the LCI project personnel. This inspection was performed on May 6, 2004 to identify final actions that may be necessary in closing out the field work performed pursuant to the Order. The inspection included an inspection of the permeable protective cap and drainage swale, and the adjacent areas disturbed during the construction activities. Based on this inspection, a "punch-list" of final tasks needed to be completed was developed. This "punch-list" of tasks included the following items:

- At the outlet of the sediment trap, re-grade existing stone such that it fills the cells of the confinement system, and place riprap to dissipate the energies exiting the structure.
- Clean up the ends of the winterization mat on the soil cap.
- Re-grade the stone in the area of the northernmost monitoring well adjacent to the soil cap so it completely fills the cells of the confinement system.
- Clean up soil and place stone in the area of the leak-off adjacent to the northern parking lot to dissipate the flow energies.
- Extend a section of chain-link fence across the drainage swale at the northernmost point of the existing fence line so that unauthorized access is restricted.
- Repair the existing chain-link fence at the locations that were utilized to access the former tailrace.
- Clean up soil and re-seed the area between eastern edge of the northern parking lot and the chain-link fence placed along the western edge of the drainage swale and place a soil erosion control mat to limit erosion due to rainfall until turf is established.
- Re-grade and re-seed the area of the southern cap to remove ruts that developed from the construction activities.

A final inspection of the cap was conducted by EPA, USACE, RIDEM, and LCI on August 19, 2004, at which time the work to address the "punch-list" of tasks identified during the May 6, 2004 pre-final inspection were reviewed. Specifically, the inspection was performed to verify that the "punch-list" items had been performed and that the TCRA requirements had been met. During the final inspection the following tasks were identified as tasks remaining to be completed:

- Re-grade the stone in the area of the northernmost monitoring well adjacent to the soil cap so it completely fills the cells of the confinement system.
- Extend a section of chain-link fence across the drainage swale at the northernmost point of the existing fence line so that unauthorized access is restricted.

- Re-grade and re-seed the area of the southern cap to remove ruts that developed from the construction activities

In addition, EPA identified other concerns during this inspection. Specifically, EPA identified that the following tasks should be completed as part of the remaining "punch list" tasks to be performed:

- Place additional stone in the area of the utility crossing.
- Extend a section of chain-link fence across the drainage swale and up the slope of the Site so that it connects the northernmost point of the existing fence line and the existing chain-link fence along the eastern Site property boundary.

During a Site visit conducted on October 21, 2004, EPA acknowledged that these final "punch list" tasks were complete, and that the field requirements of the TCRA had been attained.

6. POST-REMOVAL SITE CONTROLS

As required by the Order, a Post-Removal Site Control Plan (PRSCP), consistent with Section 300.451(l) of the NCP and OSWER Directive No. 9360.2-02, was submitted to EPA. The PRSCP was prepared to ensure the effectiveness and integrity of the TCRA. The PRSCP was submitted under letter of transmittal dated November 15, 2004. EPA approval of the PRSCP is pending.

In general, the PRSCP includes provisions for inspection of the permeable protective cap, and inspection and maintenance of the sediment trap. In addition, the PRSCP includes provisions for documentation and reporting. The Plan also specifies a schedule for inspections as well as any maintenance that may be required.

The sediment trap is an improvement to the RIDOT Smith Street stormwater management system. In accordance with the Permanent Drainage Easement acquired by RIDOT and the PRSCP, inspection of the RIDOT sediment trap is to be performed by RIDOT – Highway & Bridge Maintenance Division. Likewise, any maintenance measures that are required to be taken and/or any repairs that are required to be made to the RIDOT sediment trap are to be made by RIDOT.

7. COSTS FOR THE TIME CRITICAL REMOVAL ACTION

7.1 Overview

As of November 16, 2004, the total cost of implementing the measures to satisfy the requirements of the TCRA is approximately $478,000. This cost includes the cost to prepare this document, but does not include the cost to implement post-removal Site controls. The costs for the engineering design and construction components of the TCRA are provided in this section.

7.2 Engineering Design

The engineering design associated with the implementation of the TCRA included several deliverables. As presented in Section 3, these deliverables included securing authorization to access properties that abut the Site, preparing the WP and associated documents, and filing the RIDOT Physical Alteration Permit Application. The total cost for the engineering design deliverables is approximately $47,000.

7.3 Construction Activities

The cost for construction activities includes the cost for mobilizing/demobilizing, implementing Site controls, constructing the permeable protective cap and drainage swale, and restoring the Site. The total cost associated with these items is approximately $431,000.

7.4 Summary

In summary, the cost incurred in satisfying the requirements of the TCRA include costs for engineering design, construction of the permeable protective cap and associated drainage swale, and Site restoration. Through November 16, 2004, the total cost of implementing the TCRA is approximately $478,000. This cost does not include the cost to implement post-removal Site controls. An itemization of this cost is summarized as follows:

TCRA Activity	Approximate Cost
Engineering Design	$47,000
Construction Activities	$431,000
Implementation of Post-Removal Site Controls	To Be Determined
Approximate Total Through November 15, 2004	$478,000

8. CERTIFICATION STATEMENT

"Under penalty of law, I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of the report, the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

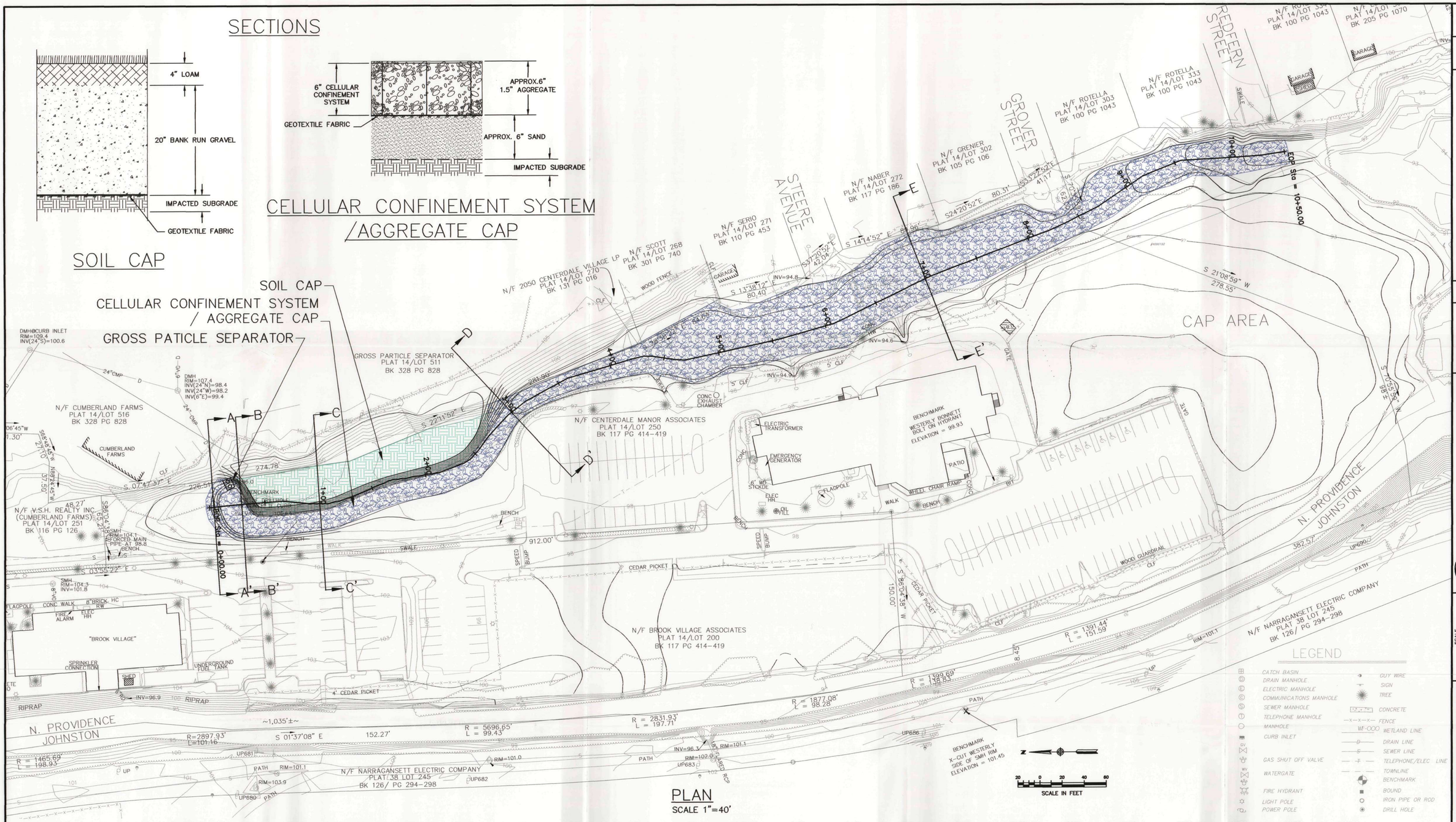
Jeffrey J. Loureiro, P.E., LEP
Project Coordinator

DRAWINGS

SECTIONS

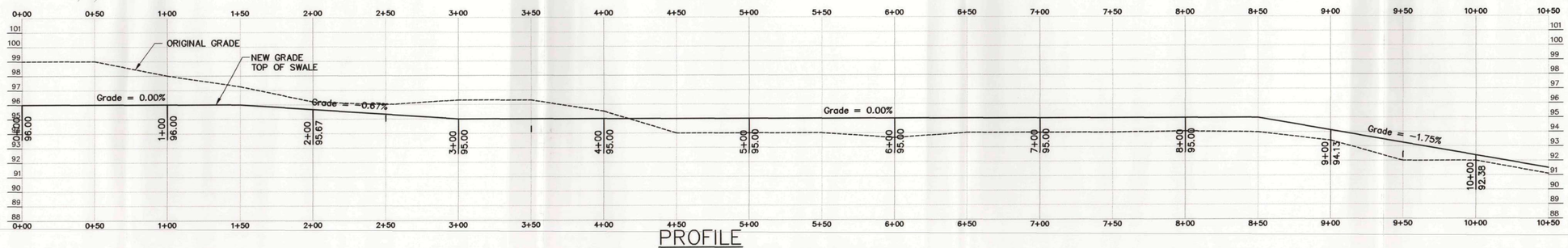
SOIL CAP

CELLULAR CONFINEMENT SYSTEM /AGGREGATE CAP



PLAN

SCALE 1"=40'



PROFILE

HORIZ. SCALE 1"=40' VERT. SCALE 1" =4'

REV.	DESCRIPTION OF REVISION	DATE	APPR.
2	ADDED GROSS PARTICLE SEPARATOR & REGRADED	11/30/03	D.S.
1	ADDED CROSS SECTIONS A-A THRU E-E	10/13/03	D.S.

Loureiro Engineering Associates, Inc.
100 Northwest Drive • Plainville, Connecticut 06062
An Employee Owned Company

SCALE 1" = 40'
COMM. NO. 15RP102
DATE 09/30/03
DRAWN BY A.C.L.
DATE 09/30/03
APP. BY J.J.L.
DATE 09/30/03

CENTREDALE MANOR RESTORATION PROJECT SUPERFUND SITE
NORTH PROVIDENCE, RHODE ISLAND

SITE PLAN, PROFILE AND TYPICAL CAP SECTION VIEWS

An Employee Owned Company

DRAWING 1

SHEET NO. 1 NO. OF SHEETS 1

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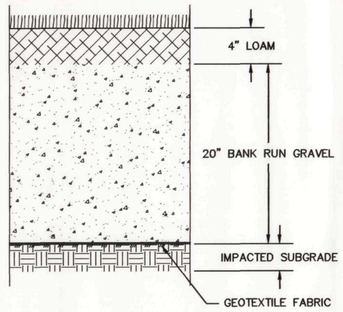
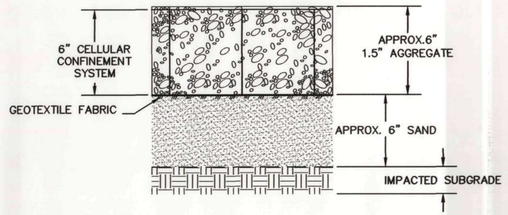
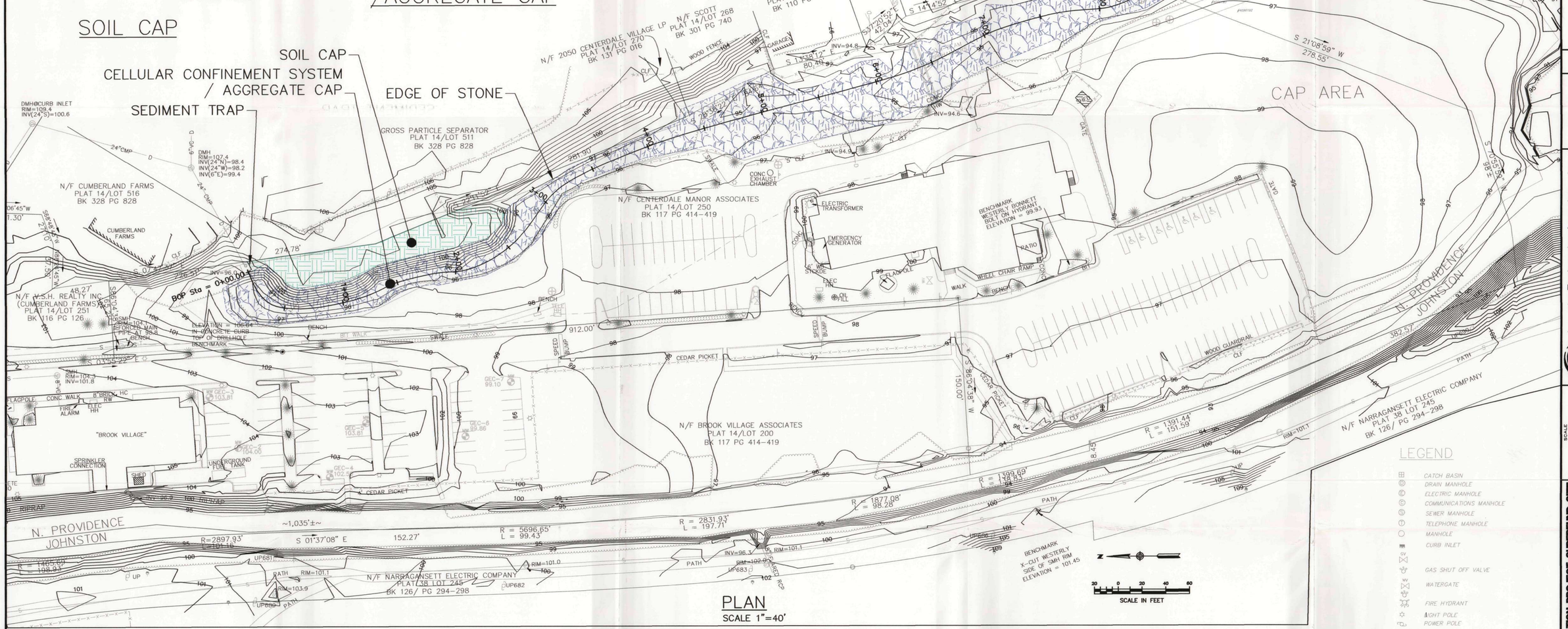
SECTIONS



SOIL CAP

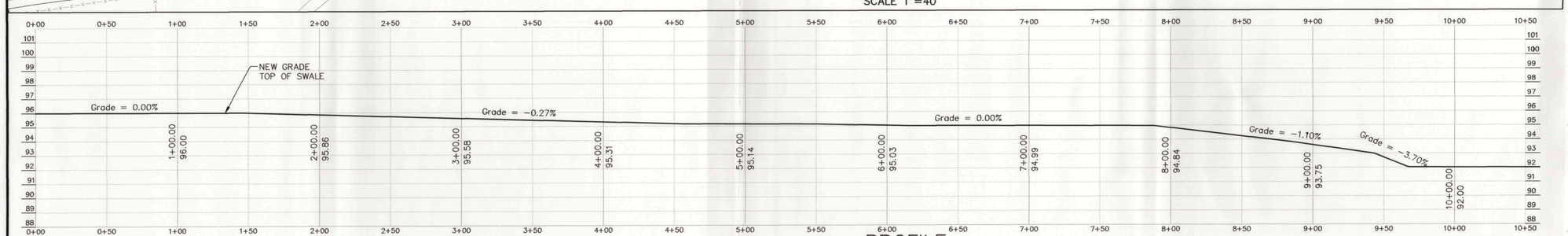


CELLULAR CONFINEMENT SYSTEM /AGGREGATE CAP



PLAN

SCALE 1"=40'



PROFILE

HORIZ. SCALE 1"=40' VERT. SCALE 1" =4'

LEGEND

- CATCH BASIN
- DRAIN MANHOLE
- ELECTRIC MANHOLE
- COMMUNICATIONS MANHOLE
- SEWER MANHOLE
- TELEPHONE MANHOLE
- MANHOLE
- CURB INLET
- GAS SHUT OFF VALVE
- WATERGATE
- FIRE HYDRANT
- LIGHT POLE
- POWER POLE
- GUY WIRE
- SIGN
- TREE
- CONCRETE
- FENCE
- WETLAND LINE
- DRAIN LINE
- SEWER LINE
- TELEPHONE/ELEC LINE
- TOWNLINE
- BOUND
- IRON PIPE OR ROD
- DRILL HOLE
- MONITORING WELL/ PIEZOMETER(STICK-UP)
- MONITORING WELL (FLUSH MOUNT)

REV.	DESCRIPTION OF REVISION	DATE	APPR.

Loureiro Engineering Associates, Inc.
100 Northwest Drive • Plainville, Connecticut 06062
An Employee Owned Company

SCALE 1" = 40'
COMM. NO. 15RP102
DRAWN BY A.C.L. DATE 10-28-04
APP. BY J.J.L. DATE 10-28-04

CENTREDALE MANOR RESTORATION PROJECT SUPERFUND SITE
NORTH PROVIDENCE, RHODE ISLAND

AS-BUILT CONDITIONS PERMEABLE PROTECTIVE CAP AND DRAINAGE SWALE

An Employee Owned Company

DRAWING 2

SHEET NO. 1 NO. OF SHEETS 1

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APPENDIX A

PHOTODOCUMENTATION LOG

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Area of the former tailrace east of the existing chain-link fence, prior to clearing activities (looking south).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Area of the former tailrace, prior to clearing activities (looking north).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Area of the former tailrace at the terminus of the RIDOT stormwater management system, prior to clearing activities (looking south).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Clearing and chipping activities (looking southeast).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Clearing and chipping activities in the area of the former tailrace (looking east).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Check dam installed at the southern extent of the drainage swale prior to implementing construction activities.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Chipped material from clearing operations placed within the footprint of the cap to provide a pathway for heavy equipment.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Chipped material from clearing operations placed within the footprint of the cap to provide a pathway for heavy equipment. Long-stick excavator in background, beginning to shape edge of cap.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Water present within southern extent of drainage swale prior to draining.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Water within Allendale Pond lowered to drain the area of the swale.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Water pumped from areas downstream of the utility crossing to areas between temporary cofferdams set within the swale further downstream.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Placement of the temporary road along the western portion of the former tailrace, south of the utility crossing (looking north).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Long-stick excavator being used along the temporary road to shape the drainage swale.

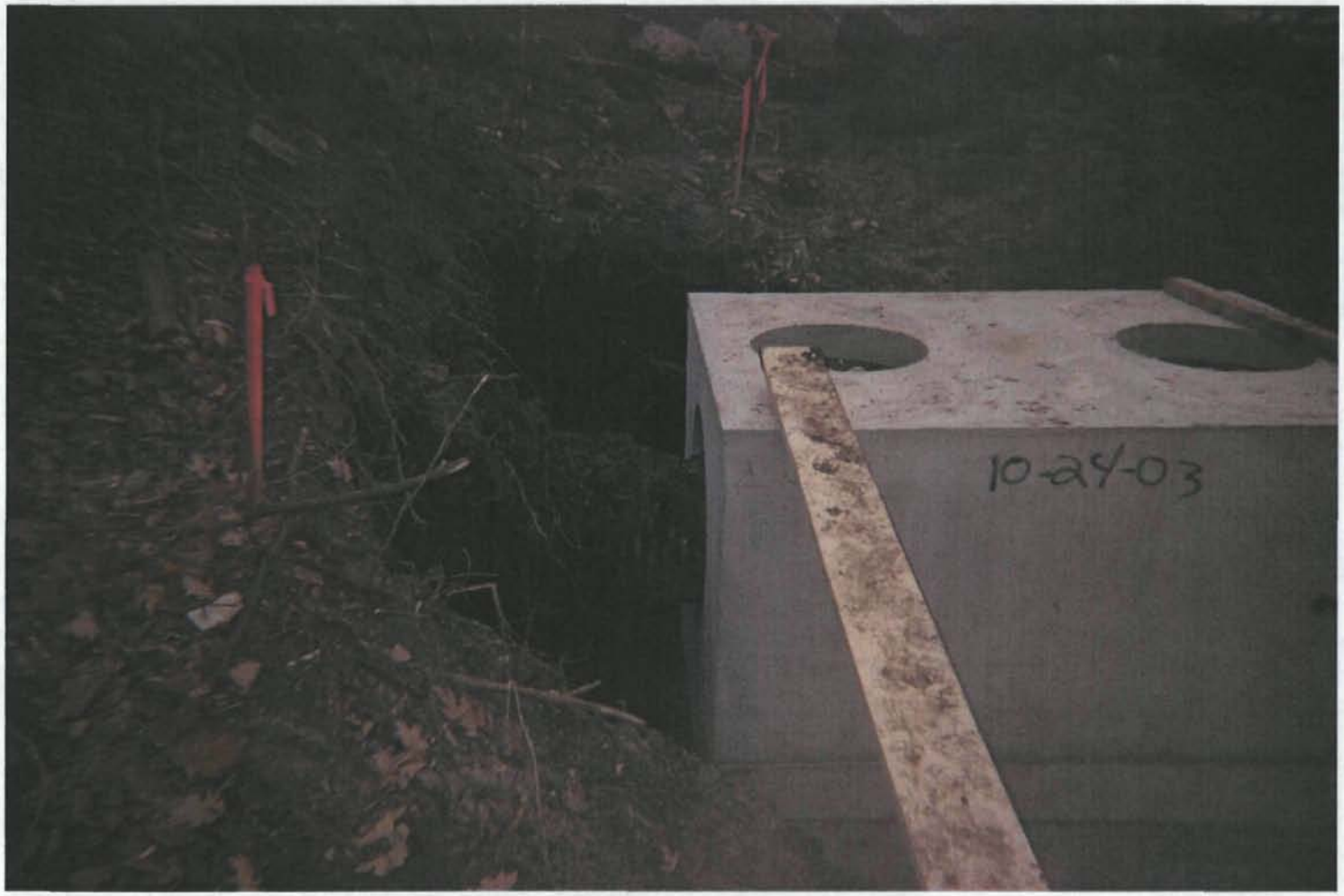
PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Clearing soil and debris from the terminus of the RIDOT stormwater management system.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Clearing soil and debris from the terminus of the RIDOT stormwater management system for the placement of the sediment trap.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island



Placement of the sediment trap at the terminus of the RIDOT stormwater management system.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Placement of the sediment trap at the terminus of the RIDOT stormwater management system.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Placement of the sediment trap at the terminus of the RIDOT stormwater management system.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Excavator being used to shape the edge of the soil cap. Note the brick, concrete, and debris believed to have been part of a building foundation.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Excavator being used to place stone within the cellular confinement system along the bank of the soil cap.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Placement of stone within the cellular confinement system at the utility crossing.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Capping former tailrace soils and sediments below the utility crossing.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Stormwater discharge pipe extending from sediment trap into the area of the drainage swale.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Construction of soil cap adjacent to drainage swale.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Setting the geotextile fabric and the geosynthetic cellular confinement system within the drainage swale.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Construction of the cap over the former tailrace soils and sediments. Note dewatering discharge lines downstream of the work area and temporary coffer dam.

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Construction of the cap over the former tailrace soils and sediments.

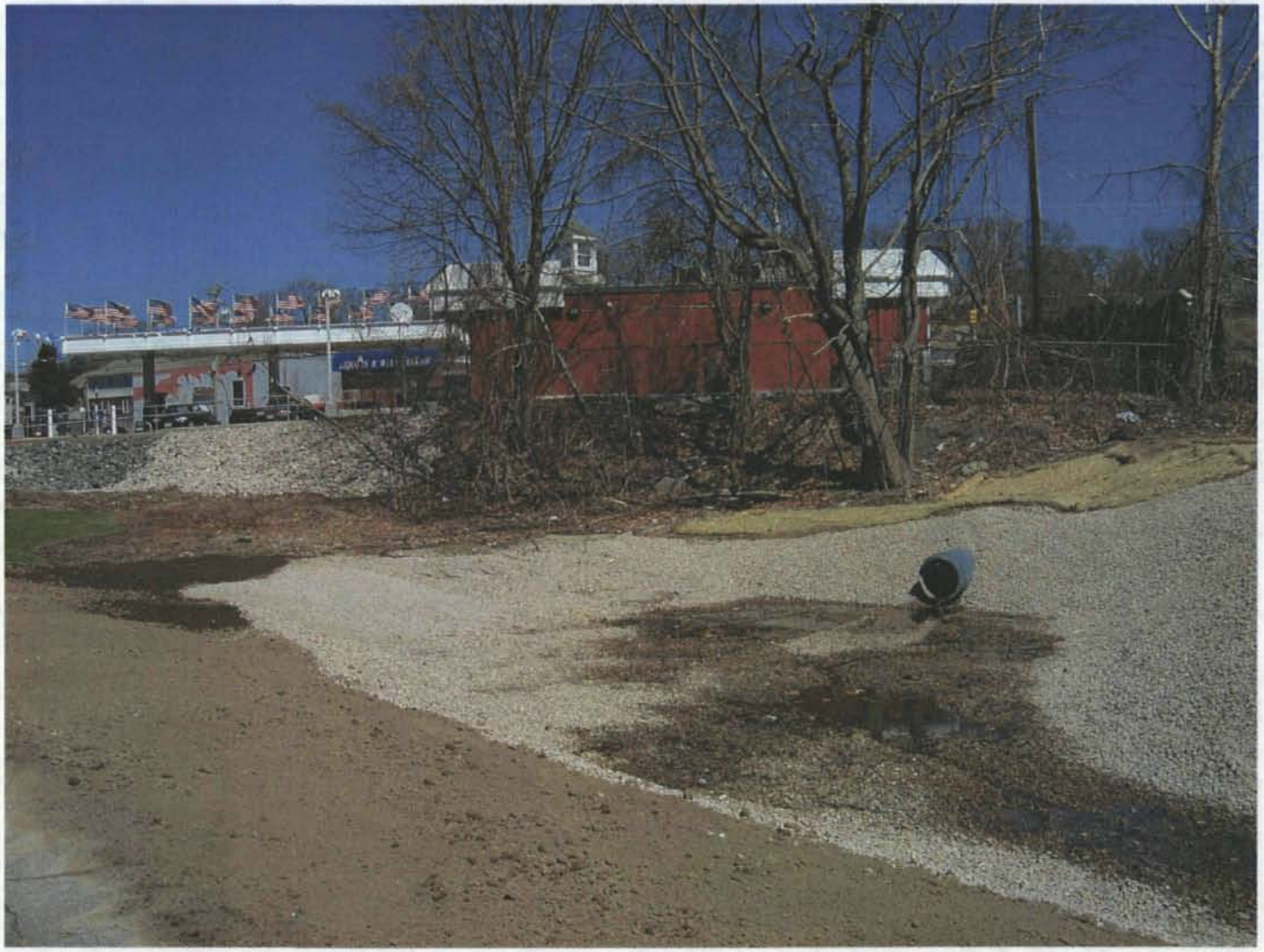
PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Restoration of grass area west of the drainage swale and soil cap (looking north).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Restoration of grass area west of the drainage swale and soil cap (looking north).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island



Restoration of grass area west of the drainage swale (looking northeast).

PHOTODOCUMENTATION
Time-Critical Removal Action
Centredale Manor Restoration Project Superfund Site
North Providence, Rhode Island

Restoration of grass area west of the drainage swale (looking south).

APPENDIX B

MATERIAL SPECIFICATION SHEETS

product

Mirafi® N-Series Nonwoven Polypropylene Geotextiles

for Soil Separation, Filtration, and Protection

Ten Cate Nicolon offers a wide range of nonwoven geotextiles for soil separation, filtration and protection. These geotextiles are cost-effective reinforcement elements which improve and enhance modern construction techniques in a variety of civil engineering applications.

PRODUCT DESCRIPTION

Mirafi® N-Series products are nonwoven geotextiles comprised of polypropylene staple fibers. Mirafi® N-Series Nonwoven Polypropylene Geotextiles provide excellent physical and hydraulic properties in addition to high tensile strengths.

FEATURES AND BENEFITS

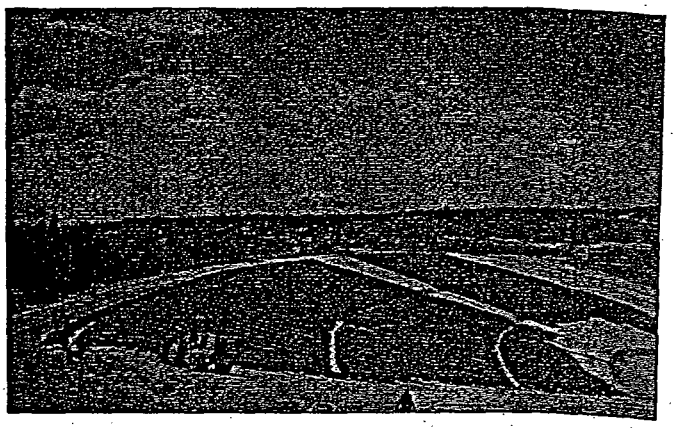
- **Construction.** Mirafi® N-Series geotextiles easily conform to the ground or trench surface for trouble-free installation.
- **Strength.** Mirafi® N-Series geotextiles withstand severe installation stresses with high puncture and burst resistance.
- **Filtration.** High permeability properties provide high water flow rates while providing excellent filtration properties.
- **Environmental.** Mirafi® N-Series geotextiles are chemically stable in a wide range of aggressive environments.
- **Cost effective.** Mirafi® N-Series geotextiles provide economical solutions to many civil engineering applications including a cost-effective alternative to graded-aggregate filters.

APPLICATIONS

Mirafi® N-Series Nonwovens are used in a wide variety of applications including separation, filtration, and protection applications.

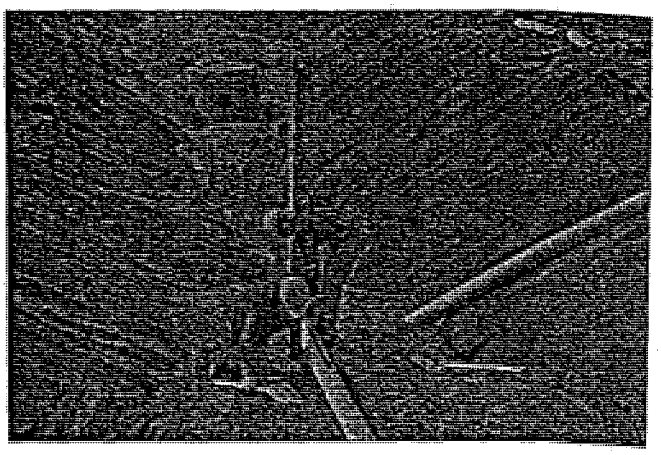
Lightweight nonwovens are predominantly used for subsurface drainage applications along highways, within embankments, under airfields, and athletic fields. For these drainage structures to be effective, they must have a properly designed protective filter. Mirafi® N-Series Nonwoven Geotextiles eliminate the problems of determining the aggregate gradation required to match soil conditions, finding a convenient and economical source of a specific aggregate gradation, transporting and placing graded aggregate, and assuring that the in-place aggregate gradation provides effective filter performance.

Heavyweight nonwovens are use in critical subsurface drainage systems, soil separation, permanent erosion control, and geomembrane liner protection within landfills. These geotextiles provide the required strength and abrasion resistance to withstand installation and application stresses to create an effective, long-term solution.



Mirafi® N-Series heavyweight nonwoven used as a liner protection in landfill application

Mirafi® N-Series lightweight nonwoven used as protective filter in subsurface drainage application.



Mirafi® N-Series light weight nonwoven used as protective filter in an athletic field

Ten Cate Nicolon

product

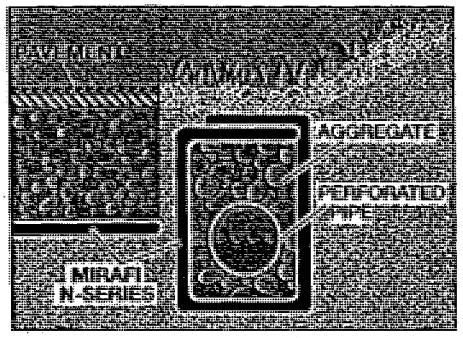
Mirafi® N-Series Nonwoven Polypropylene Geotextiles

for Soil Separation, Filtration, and Protection

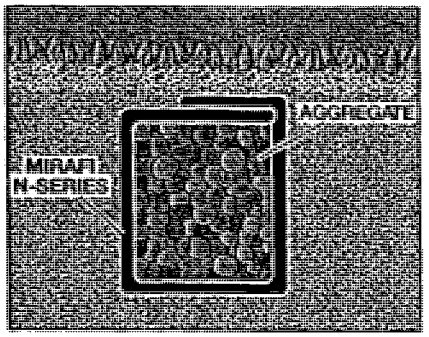
Property / Test Method	Units	140NL	140NC	140N	160N	170N	180N	1100N	1120N	1160N
MECHANICAL PROPERTIES										
Grab Tensile Strength ASTM D 4632										
Strength @ Ultimate	kN (lbs)	0.40 (90)	0.45 (100)	0.53 (120)	0.71 (160)	0.80 (180)	0.9 (205)	1.11(250)	1.34 (300)	1.69 (380)
Elongation @ Ultimate	%	50	50	50	50	50	50	50	50	50
Mullen Burst Strength	kPa	1205	1447	1550	2100	2273	2618	3445	4030	5098
ASTM D 3786	(psi)	(175)	(210)	(225)	(305)	(330)	(380)	(500)	(585)	(740)
Trapezoidal Tear Strength	kN	0.18	0.20	0.22	0.27	0.33	0.36	0.45	0.51	0.62
ASTM D 4355	(lbs)	(40)	(45)	(50)	(60)	(75)	(80)	(100)	(115)	(140)
Puncture Strength	kN	0.24	0.30	0.30	0.42	0.46	0.58	0.69	0.78	1.05
ASTM D 4833	(lbs)	(55)	(65)	(65)	(95)	(105)	(130)	(155)	(175)	(235)
UV Resistance after 500 hrs. ASTM D 4355	% strength	70	70	70	70	70	70	70	70	70
HYDRAULIC PROPERTIES										
Apparent Opening Size (AOS)	US Sieve	60	70	70	70	80	80	100	100	100
ASTM D 4751	mm	0.25	0.212	0.212	0.212	0.180	0.180	0.150	0.150	0.150
Permittivity ASTM D 4491	sec^{-1}	2.0	1.9	1.8	1.4	1.4	1.2	1.0	0.8	0.7
Flow Rate ASTM D 4491	$l/min/m^2$ ($gal/min/ft^2$)	5907 (145)	5698 (140)	5500 (135)	4477 (110)	4278 (105)	3866 (95)	3056 (75)	2648 (65)	2037 (50)
Packaging										
Roll Width	m(ft)	3.8 (12.5) 4.5 (15.0)	3.8 (12.5) 4.5 (15.0)	3.8 (12.5) 4.5 (15.0)	4.5 (15.0)	4.5 (15.0)	4.5 (15.0)	4.5 (15.0)	4.5 (15.0)	4.5 (15.0)
Roll Length	m(ft)	110 (360)	110 (360)	110 (360)	91 (300)	91 (300)	91 (300)	91 (300)	91 (300)	46 (150)
Est. Gross Weight	kg(lbs)	60 (133) 70 (160)	64 (142) 75 (166)	67 (148) 89 (197)	103 (227)	113 (249)	124 (273)	150 (331)	158(348)	114 (251)
Area	$m^2(yd^2)$	418 (500) 502 (600)	418 (500) 502 (600)	418 (500) 502(600)	418 (500)	418 (500)	418 (500)	418 (500)	418 (500)	209 (250)

NOTE: All Mechanical Properties and Hydraulic Properties shown are Minimum Average Roll Values (MARV).

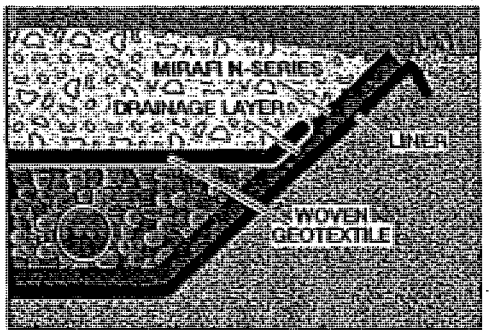
Cut-off/inceptor drain along a roadway or other critical structure



French drain without pipe



Liner protection within a landfill



www.tcnicolon.com

TECHNICAL SERVICES

Complete technical assistance is available from Ten Cate Nicolon and its sales representatives. Service include assistance during design and specification stages as well as initial stages of installation.

WARRANTY

Ten Cate Nicolon warrants that the product that it sells will conform to the specifications published in this literature. For information on limitations to this warranty, contact Ten Cate Nicolon.

CORPORATE OFFICE

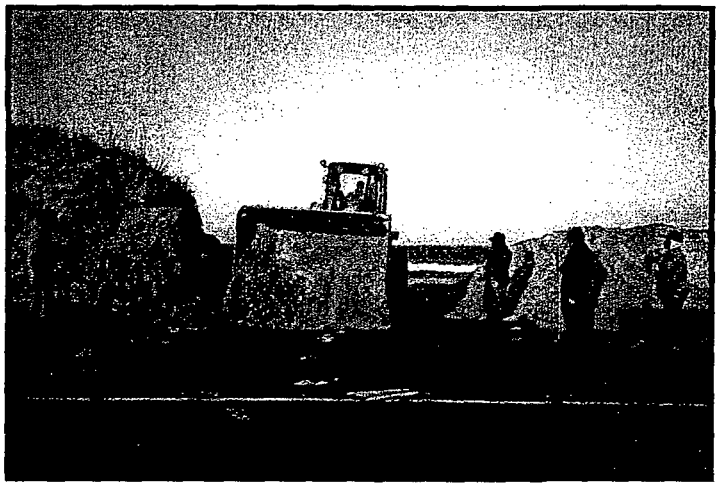
365 South Holland Drive • Pendergrass, GA 30567

(888) 795-0808 • (706) 693-2226 • Fax (706) 693-4400

Ten Cate Nicolon

TERRACELL®

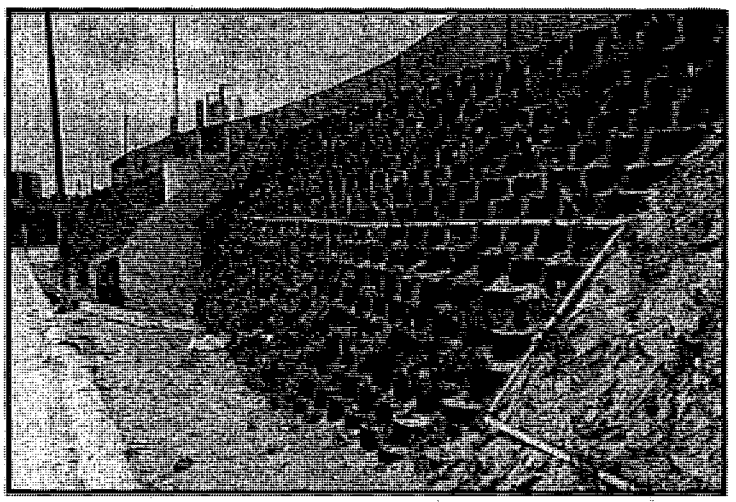
CELLULAR CONFINEMENT SYSTEM



TerraCell is an innovative geosynthetic product made of high density polyethylene strips. These strips are ultrasonically welded to form an extremely strong, honeycomb configuration. A variety of fill materials may be placed within TerraCell: soil, sand, aggregate, concrete, etc. The TerraCell system and the appropriate fill material can solve a variety of engineering and construction challenges.

GROUND STABILIZATION

SLOPE PROTECTION



RETAINING WALLS

The function of the TERRACELL llular confinement system in ground stabilization applications is to spread the loads imposed upon the system. It accomplishes this by confining the aggregate layer.

In many situations, TERRACELL makes it possible to use a reduced quantity of lower quality, locally available granular material. Benefits include savings in aggregate and improved long-term performance. TERRACELL can be used in a variety of stabilization projects including:

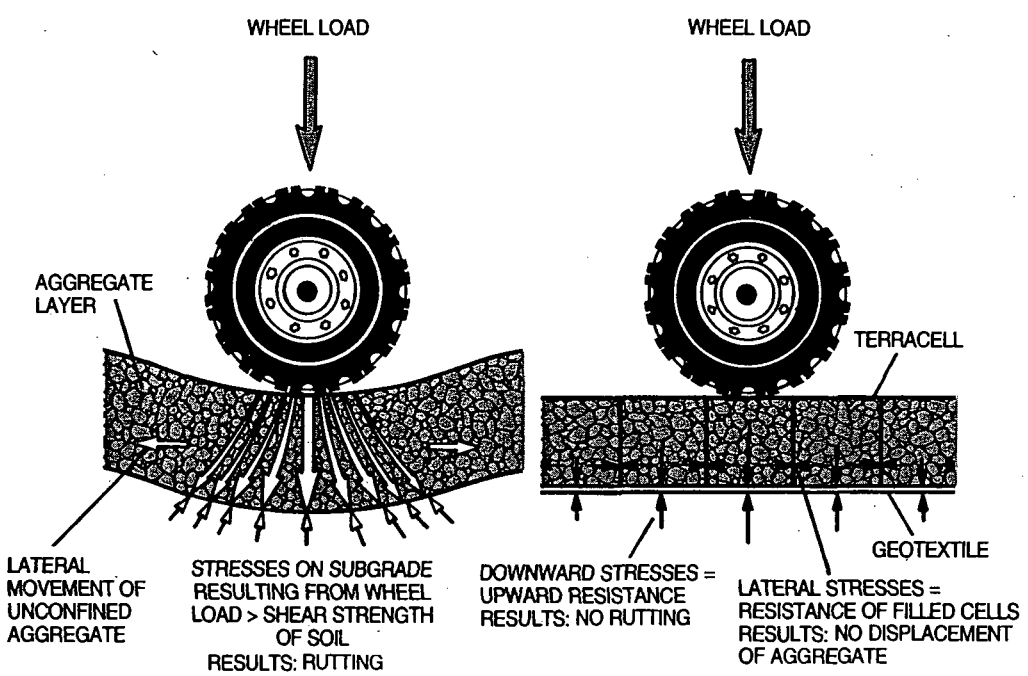
- TREETS, ROADS and HIGHWAYS
- PARKING LOTS, STORAGE AREAS and CONSTRUCTION ENTRANCES
- ACCESS LANES FOR FIRE / EMERGENCY VEHICLES
- RUNWAYS, TAXIWAYS, APRONS, and OVERRUN AREAS
- RAILROAD TRACK BEDS
- TEMPORARY ACCESS ROADS / LOGGING ROADS
- STREAM CROSSINGS / BOAT RAMPS
- WATER and SEWER LINES

Ground Stabilization

MECHANICS

In a ground stabilization application, the function of the aggregate layer is to spread the loads imposed on it so that the pressure, or force per unit area, exerted on the subgrade is reduced below a critical value. The aggregate layer transfers the load outward as well as downward and away from the source. Spreading of loads is accomplished by the interlocking and friction that occur between individual granular particles. The aggregate must be well compacted during construction and remain compacted and free from fines during the life of the project. In other words, for the aggregate layer to perform as designed throughout its intended life, the original quality and degree of compaction must be preserved.

Aggregate support systems are improved with the use of a geotextile fabric. Fabrics contribute to the long-term performance of aggregate layers because of their ability to separate and confine. Fabric acts as a permeable barrier between the aggregate and the subgrade, keeping the aggregate layer free from the fines that can destroy its load bearing characteristics. Fabric also provides a high friction surface that resists lateral movement by the lowest layer of aggregate, thereby confining those particles in direct contact with the fabric. Quality and state of compaction of the aggregate determine how well this layer can withstand lateral pressures above the lowest level.



HOW TERRACELL WORKS

The TERRACELL cellular confinement system provides confinement throughout the depth of the aggregate layer, not just at the interface between the aggregate and the subgrade. The ability of the aggregate layer to spread surface forces and reduce pressures on the subgrade is no longer dependent solely upon the properties of the aggregate itself. TERRACELL provides the necessary confinement and preservation of compaction. This action allows the use of lower quality and/or quantity of more readily available aggregates thus saving time and money. Studies and actual installations have shown that rounded aggregates, such as sand, confined within the cells, perform better than thicker layers of higher quality aggregates used without a cellular confinement system.

Refer to:
"TerraCell - Design Guidelines for Ground Stabilization"
on our website: www.WEBTECGEOS.com.

ECONOMICS

During construction of roads, parking lots, sewer lines, etc., pockets of soft, poor soils are sometimes encountered. Typically, soil is removed to a significant depth and replaced with expensive fill materials. This procedure can be costly and time consuming. An effective alternative is to use a stabilization fabric with TERRACELL placed directly on the prepared subgrade. Cells are then filled with readily available granular materials and compacted.

INSTALLATION

TERRACELL is installed quickly and easily by semi-skilled labor and without any special equipment. Sections are shipped to the job site in collapsed form.

1. A geotextile is often recommended to separate fill materials from the subgrade. Simply unroll the fabric directly onto the prepared subgrade, overlapping adjacent panels 12 to 24 inches.
2. Determine where the first section of TERRACELL is to be placed and put stakes at the four corners of the area. Stakes can be wooden, metal (#3 or #4 rebar), or any suitable material that will not easily bend or break.
3. Overstretch the section of TERRACELL as much as possible (beyond its proposed length) a few times and then place the four corners over the embedded stakes. Additional stakes may be needed along the perimeter in order to get full expansion of each section. In situations where it is difficult or impractical to use stakes to hold a section open, such as over an impervious liner, an installation frame may be used. Adjacent sections are installed in similar fashion and butted or stapled together to achieve continuous coverage.
4. Fill the first rows of cells with a front end loader or back-dump along the edge of the section and push the fill into the cells using a bulldozer blade. Continue until all cells are filled. Never allow equipment to drive over *unfilled cells*. It is best to overfill slightly to allow for reduction in volume of the granular material as it is compacted.
5. Compact the fill material. Depending on the nature of the aggregate, a vibratory roller and/or water may be required to achieve a desired compaction level. The most common method of compacting the aggregate is through multiple passes by tracked equipment.

Once the cells are filled and the aggregate compacted, the TERRACELL constructed base is ready to withstand heavy traffic loads.

The function of TERRACELL cellular confinement system is:

(A) EROSION CONTROL - to minimize and/or eliminate the erosive actions of wind and water on exposed soils.

(B) SLOPE STABILITY - to prevent sliding or sloughing off by providing sufficient weight at the foot and/or along the face of the slope.

Benefits include cost savings in materials and labor during both installation and subsequent periodic maintenance. TERRACELL can be used in a variety of erosion control or slope protection projects, including:

- SLOPES and CUTS
- SHORELINES
- RIVER BANKS
- CHANNEL BANKS and LININGS
- CULVERT and SEWER PIPE OUTFLOWS

Slope Protection

MECHANICS

(A) EROSION CONTROL: Most unprotected soil surfaces are prone to erosion. It takes place when the forces of the wind or flowing water dislodge and transport soil particles. Although silty soils are most susceptible to erosion, clays and sands are at risk when strong erosive forces exist. Erosion occurs when flowing water or heavy winds form rills in the soil. Over time, these forces are concentrated within the rills. This accelerates the erosive process and makes the rills deeper. For a storm of a given duration and intensity, three principal site parameters determine the amount of erosion likely to take place:

1. steepness of the slope
2. height and length of the slope
3. type of soil on the surface of the slope

On short and gentle slopes, seeding that is protected by excelsior/straw blankets or an erosion control fabric is usually the most cost-effective method of erosion protection. In more severe erosive situations, a geotextile and a layer of stone 12 to 24 inches deep might be required on the face of the slope. Although this arrangement can be effective in preventing erosion, in comparison to the TERRACELL system, it tends to be very costly and highly unattractive. Drawbacks include creating an environment for rodents and insects by allowing vegetation to grow where it is difficult to cut and control. This creates a potential hazard for children and animals.

(B) SLOPE STABILITY: For any given soil at a certain moisture content, there is an angle beyond which the soil will not stand without external support. Whenever the steepness of the slope exceeds this failure angle, gravitational forces act on the soil mass to create shear stresses causing the slope to fail through sliding or sloughing off. The process ends when a new equilibrium is achieved at an angle less steep than the initial one.

In many situations, it is desirable to have a slope steeper than the shear strength of the soil will allow. One method employed to achieve this objective is to provide external weight at the foot and/or along the face of the slope. The resulting counterweight increases the effective failure angle, preserving the stability of the slope. Riprap is commonly used because of its weight and the fact that it also acts as an erosion control material. As discussed previously, riprap has serious drawbacks.

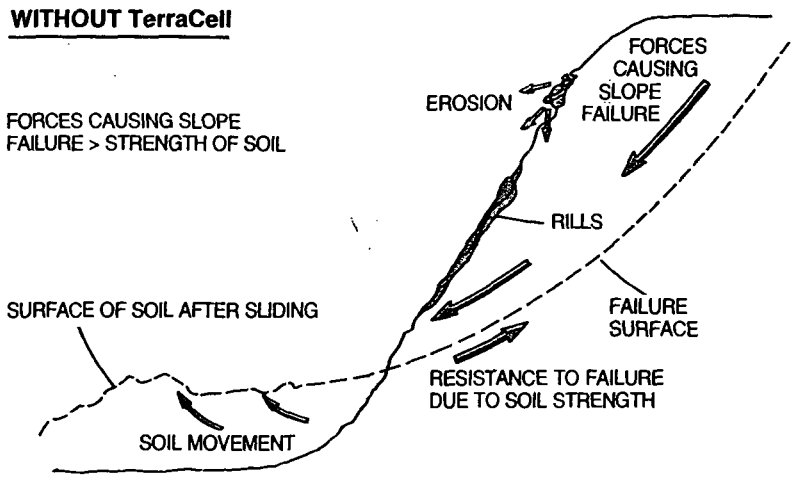
Refer to:
"TerraCell - Design Guidelines for Slope Erosion Control"
on our website: www.WEBTECGEOS.com.

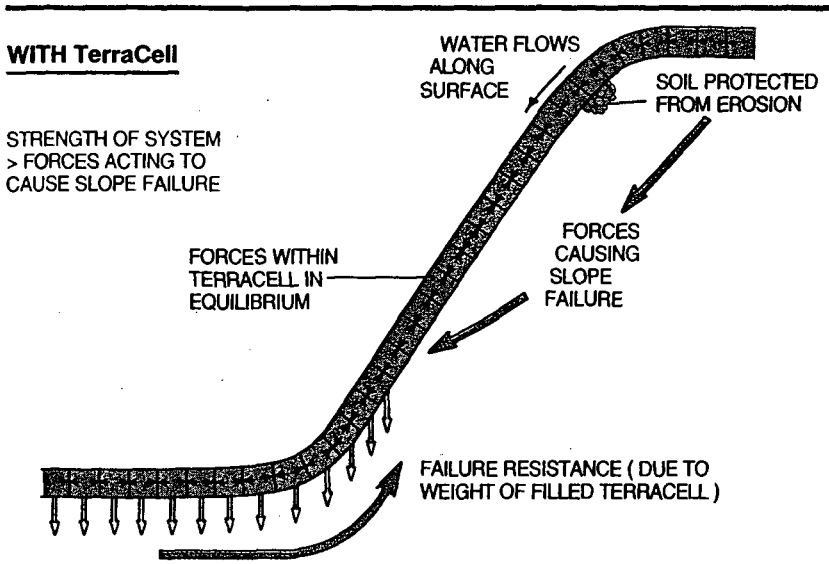
HOW TERRACELL WORKS

For difficult erosion control situations, the TERRACELL cellular confinement system can be substituted for a more conventional "hard" system of expensive, heavy materials such as riprap, armor stone, revetment mats, gabions, etc., depending upon the severity of the erosive forces encountered. TERRACELL can be filled with soil or sand, small rock, concrete, etc. The cells confine the fill material and protect it from being moved by wind or water. Each cell in the system acts as a small dam that allows water or wind to pass over the top while holding the fill in place. The cell walls inhibit formation of rills, thus preventing the erosion process from developing. Lastly, a soil-filled TERRACELL slope can be seeded without worry that the system will interfere with mowing operations.

In areas subjected to substantial erosive forces such as shorelines, bends along river banks, outflow pipes, etc., concrete might be the most effective material selected to prevent erosion. When filled with concrete, TERRACELL becomes an articulated concrete mat that conforms to possible differential settlement while protecting the underlying soil from either wind or water erosion.

In slope stability situations, where external weight on the slope is needed to achieve stability, TERRACELL keeps the fill material in place so that its function as a counterweight is preserved. TERRACELL (8") filled with sand provides an evenly distributed weight of approximately 80 pounds per square foot.





ECONOMICS

Slope protection using heavy armor stone tends to be very costly in terms of materials and the time consumed in installation, especially if the rock must be transported from off site. Slope protection using TERRACELL filled with locally available soils, small rocks, or concrete can be more effective than expensive alternatives and is usually less costly to maintain. The TERRACELL system provides one solution for both erosion control and slope stability problems.

INSTALLATION

TERRACELL used in erosion control and slope protection applications is installed in the same manner as in ground stabilization projects. (Additionally, stakes should be left in place to insure that TERRACELL will remain permanently anchored to subgrade). When using concrete, place the concrete as in any other form, exercising care not to cause the TERRACELL to be displaced during the pouring operation. Whether using fill materials or concrete, it is recommended that the cells be filled from the base of the slope upward.

The TERRACELL cellular confinement system acts as a form for containing the granular materials used to build the structure and provides tensile reinforcement. TERRACELL accomplishes the following:

1. prevents possible erosion and allows compaction of face materials without causing them to be dislodged.
2. provides reinforcement of materials behind the face.

In many situations, TERRACELL makes it possible to build a retaining wall using locally available soils and/or aggregates. In some cases, a combination of the two types of materials is both practical and cost effective. The locally available soil, including material not of the quality normally specified for use in constructing retaining walls, is placed in the cells. A free-draining material would be placed behind and below the TERRACELL to alleviate any potential hydrostatic problems developing at the back of the wall. TERRACELL can also be used in a variety of other vertical or near vertical, structures, including:

- BULKHEADS
- RIVER BANK/ CHANNEL WALLS
- DIKES & COFFERDAMS

Retaining Walls

MECHANICS

Retaining walls are structures built for the purpose of stabilizing very steep slopes using minimal land area. A common example is a cut into the side of a hill to build or widen a road. The slope created is so steep as to be unstable and requires a retaining wall to prevent slope failure.

There are two basic types of retaining walls:

- A CANTILEVER retaining wall is usually made of reinforced concrete and acts as a structural member.
- A GRAVITY retaining wall has a vertical or near vertical face and its ability to retain the soil behind it depends on gravity (its own weight). This type of wall is usually composed of unreinforced concrete or soil. If made of soil, the wall generally consists of a facia and one or more layers of reinforcing member (geotextile, grid, metal strips, etc.) extending from the facia back into the soil mass. The functions of the facia are to prevent soil from sloughing off the surface of the wall and to prevent erosion of the face of the wall. The function of the reinforcing member is to increase the effective thickness of the wall which increases its stability.

The wall itself must be built to withstand pressures applied by the retained soil. This force, "lateral earth pressure", is dependent upon several parameters, including the geometry of the wall and the characteristics of the retained soil, such as its unit weight and angle of internal friction. In designing a retaining wall, it is necessary to consider potential forces that could cause wall failure and compare them to the stability calculations of the proposed wall, taking into account generally accepted safety factors.

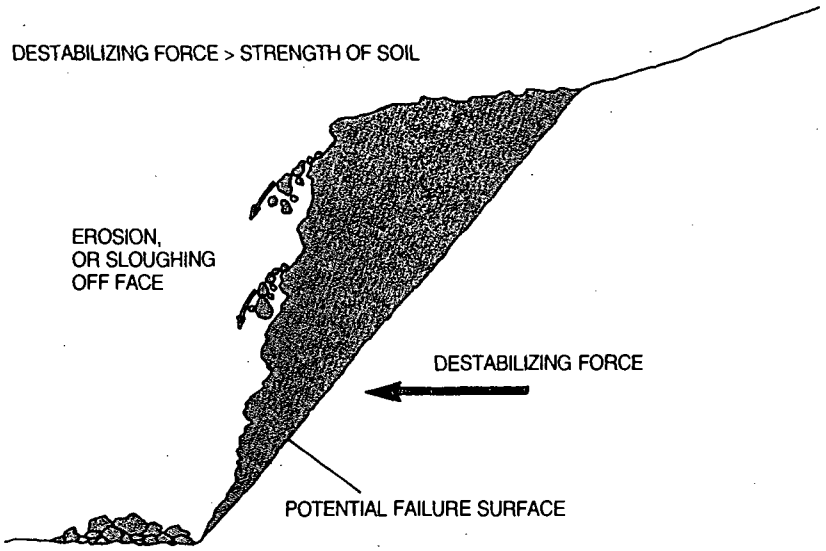
HOW TERRACELL WORKS

When the TERRACELL cellular confinement system is used to construct a retaining wall it functions as both the facia and the reinforcing element. A section of standard dimensions filled with soil or rock acts as a large heavy mattress. These mattresses are the building blocks for a gravity retaining wall. The mattresses can be placed with either dimension along the face of the wall creating a structure with inherent stable characteristics. TERRACELL keeps the soil or rock from falling or being eroded off the face of the wall. Its confining action prevents dislodging of the fill at or near the face during compaction. Lastly, the size of expanded TERRACELL panels significantly increases the effective thickness of a wall. This allows walls of considerable height to be built without the need for additional reinforcing elements, such as grids or metal tie-backs.

Although TERRACELL can make the building of retaining walls simple and straightforward, the design of these structures is crucial to their successful performance. Considerations, such as internal and external drainage in critical portions of the wall, must be addressed. Plans for any vertical structure should always be prepared by an experienced designer.

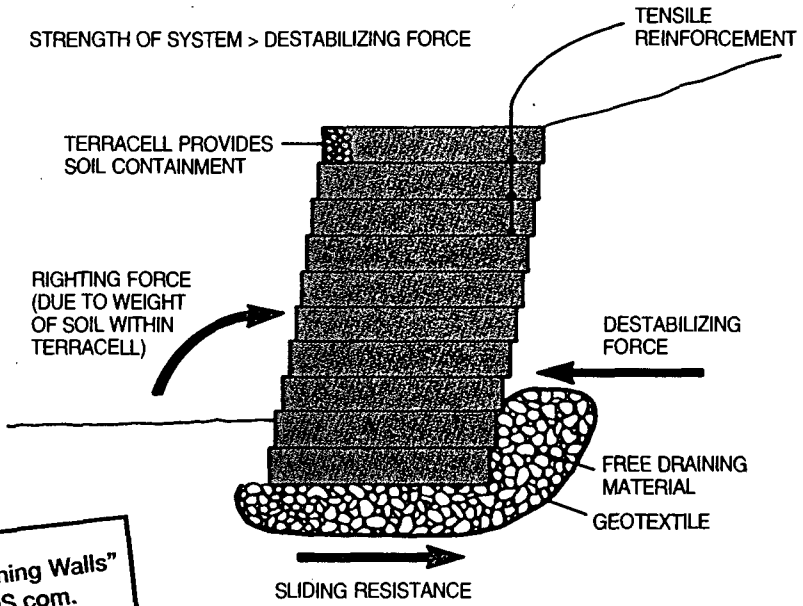
ECONOMICS

A poured-in-place concrete wall or a wall composed of costly materials such as select fills, timbers, steel, concrete block, or gabion baskets, can be very expensive and time consuming to construct. A gravity retaining wall made of TERRACELL and locally available soils and/or aggregates offers an economic alternative to these other systems.



INSTALLATION

Install the bottom section of TERRACELL in much the same manner as described in the stabilization section. In most applications, place the second and subsequent sections such that the front of each panel is slightly offset back from the front of the panel below. Also, stagger the sections in brick laying fashion so that the panels are not directly on top of each other. As the wall increases in height, keep heavy compaction equipment off the face and sides. As always, observe all safety precautions. Insure that any internal or external drainage materials or procedures required are properly installed.



Refer to:
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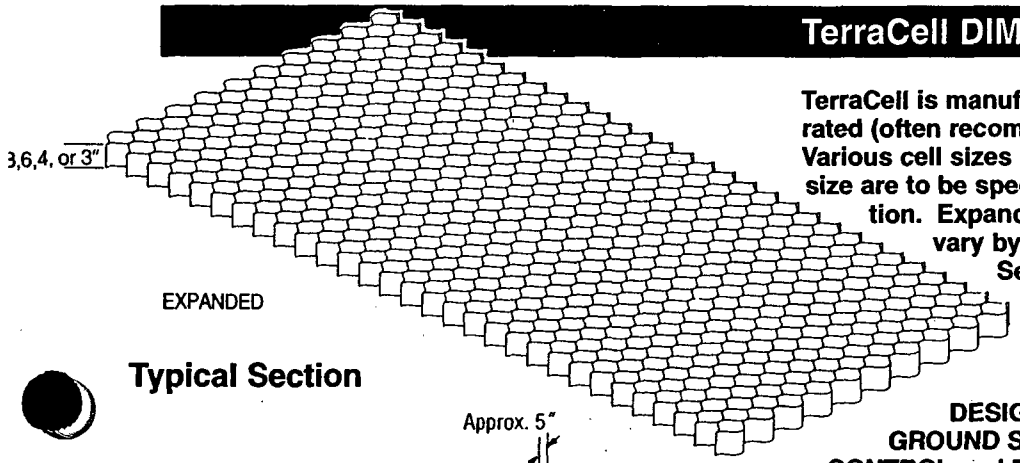
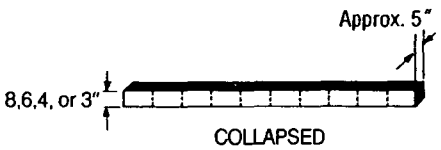
on our website: www.WEBTECGEOS.com.

TerraCell DIMENSIONS



TerraCell is manufactured in several heights in perforated (often recommended) or solid wall versions. Various cell sizes are available. Cell height and cell size are to be specified based on the project application. Expanded TerraCell section dimensions vary by cell size and number of strips used. Sections can often be under-expanded or over-expanded to meet coverage requirements. Refer to TerraCell specifications for details.

Typical Section



DESIGN GUIDELINES are available for GROUND STABILIZATION, SLOPE EROSION CONTROL and RETAINING WALL applications. Please refer to WEBTEC's website, www.webtecgeos.com, or call us toll-free, (800) 438-0027, for this or any other information.

WEBTEC Geosynthetics Include:

TerraTex CONSTRUCTION FABRICS®
TerraTex BARRIER FENCING™
TerraCell® CONFINEMENT SYSTEM
TerraJute™ EROSION CONTROL FABRIC
TerraGuard™ EROSION CONTROL BLANKETS
TerraGuard™ TURF REINFORCING MATS
TerraDrain® DRAINAGE COMPOSITES
EconoFence® SILT FENCES
TerraGrid® GEOGRIDS
TerraTex FILTERBAGS™

TerraCell® and WEBTEC's broad line of geosynthetic products are marketed through a network of local distributors. For further information, contact your local distributor or:

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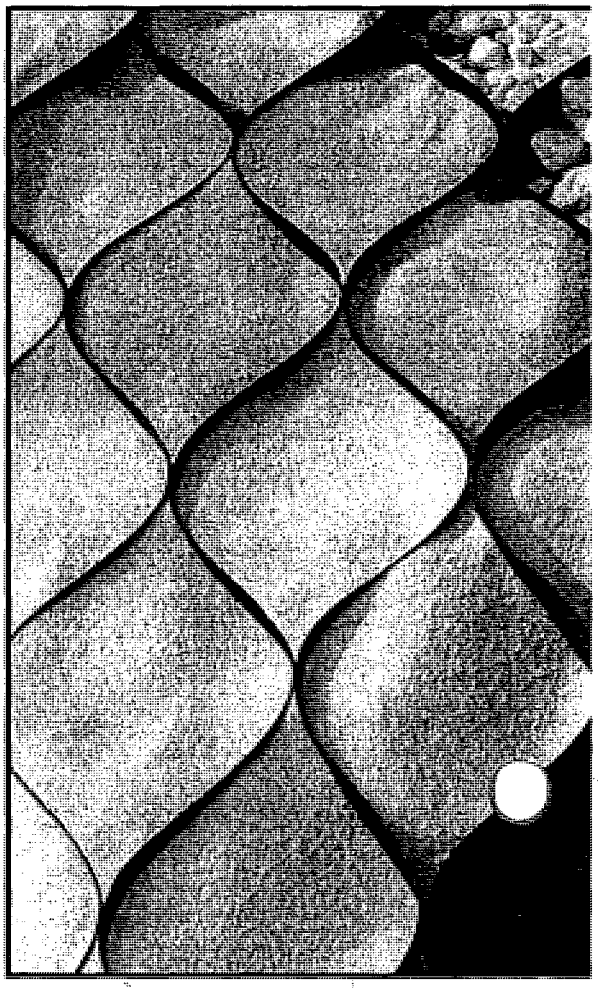

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