CLOSURE AND
POST CLOSURE CARE PLAN
FOR
WASTE UNITS 1, 2, 3, 5, 7, 9, 10, 11, 12, 13, 16, AND 17
PROTECCION TECNICA ECOLOGICA, INC.

Submitted to:

Proteccion Tecnica Ecologica, Inc.
Carr. 385 KM 3.5
Penuelas, PR 00624

Submitted by:

OHM Remediation Services Corp.
5335 Triangle Parkway, Suite 450
Norcross, GA 30092

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Project No. 16139

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LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
cm/sec	centimeters/second
CQA	Construction Quality Assurance
HDPE	High density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
lbs	Pounds
LCS	Leachate Collection System
msl	Mean sea level
MSW	Municipal solid waste
MW	Monitoring well
NA	Not applicable
NI	Not inspected
NSAT	Not satisfactory
OHM	OHM Remediation Services Corp
oz/sy	Ounces/square yard
ppb	Parts per billion
ppi	Pounds per inch
ppm	Parts per million
Proteco	Proteccion Tecnica Ecologica, Inc.
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
SAT	Satisfactory
SDR	Standard dimension ratio
sec	Second
sf	Square feet
TCLP	Toxicity Characteristic Leachate Procedure
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

Proteccion Tecnica Ecologica, Inc. (Proteco) owns and operates a waste disposal facility in Penuelas, Puerto Rico and is permanently closing Waste Units 1, 2, 3, 5, 7, 9, 10, 11, 12, 13, 16, and 17. This document describes the Closure and Post Closure Plan for those waste units. Preparation of this plan is directed by the United States Environmental Protection Agency (USEPA) and has been developed in accordance with 40 Code of Federal Regulations (CFR) 264 and the Commonwealth of Puerto Rico's Regulation for the Control of Hazardous and Nonhazardous Solid Wastes, Rule 816.

1.1 SITE DESCRIPTION

Proteco's facility is located on the southern side of Puerto Rico approximately 2.5 miles southeast of Penuelas, 2 miles north of Tallaboa Bay of the Caribbean Sea, and 1.5 miles east of the Lower Tallaboa River Valley. The closest community which is approximately 1.5 miles away is Sebouruco. The site occupies approximately 35 acres and is situated in a small valley ranging in elevation from approximately 260 ft msl to 400 feet msl. The rugged upland terrain of the valley is steep and supports little vegetation. The steep hills which surround the site are covered year round with xerophilous vegetation and are inhospitable to residential, commercial, or agricultural development.

Typical climatic conditions are semiarid with 43 inches of annual precipitation, 88 inches of annual evaporation, 79 degrees Fahrenheit annual average temperature, and predominantly easterly winds off the Caribbean Sea. Most precipitation is lost to run-off due to the hard, impermeable surface soil conditions and steep slopes.

The geology beneath the Proteco facility consists of brown/yellow silty clay from land surface with depths ranging from 25 to 115 feet below land surface; gray silty clay occurs beneath the yellow silty clay and is 90 to 130 feet chick; limestone underlies the gray silty clay and is approximately 60 feet thick.

There are three water-bearing zones beneath the site; 1) Alluvial deposits, 2) Principal water-bearing zone, and 3) Reef limestone. There is little evidence to support the idea that the alluvial deposits are prevalent across the Proteco facility. The occurrence of the alluvial deposits is best classified as sporadic with limited extent. The water-bearing strata that is consistently present both vertically and horizontally beneath the Proteco facility is that of the principal water-bearing zone and the Reef limestone.

The Principal water-bearing zone is present in brown/yellow silty clay and gray silty clay lithologic sequences. Depth to groundwater in the Principal water-bearing zone is estimated to be within 50 feet of land surface.

Under optimum natural conditions, the Principal water-bearing zone contains saline water that is non-potable and unsuitable for livestock or irrigation purposes. In addition, the low permeability of the Principal water-bearing zone is insufficient to yield an appreciable amount of water for any purpose.

The Reef limestone water-bearing zone occurs beneath the gray silty clay sequence and the associated Principal water-bearing zone. Depth to groundwater in the Reef limestone water-bearing zone is estimated to be 100 to 200 feet below land surface. The Reef limestone water-bearing zone is less saline than the Principal water-bearing zone and may be acceptable for salt-tolerant livestock and irrigation.

A vicinity map of the area surrounding the site and topographic map of the facility is included in the Project Drawings.

1.2 MAXIMUM WASTE INVENTORY

Various waste disposal activities were conducted at the Proteco disposal facility and in different areas of the site. There are twelve waste units at the site addressed by this Closure and Post Closure Plan. The waste units that will be closed are listed below with the activity that was performed at each unit.

- Waste Unit 1 — Drum burial
- Waste Unit 2 — Drum burial
- Waste Unit 3 — Drum burial
- Waste Unit 5 — Drum burial
- Waste Unit 7 — Neutralization impoundment
- Waste Unit 9 — Oil lagoon
- Waste Unit 10 — Immobilization facility
- Waste Unit 11 — Immobilization facility
- Waste Unit 12 — Land treatment area
- Waste Unit 13 — Rainwater lagoon
- Waste Unit 16 — Immobilization facility
- Waste Unit 17 — Neutralization impoundment

1.2.1 Waste Unit 1

Waste Unit 1 is one of four drum burial pits that is being closed in this action and contains various waste streams. There are approximately 5,800 drums believed to contain

approximately 317,000 US gallons of the United States Environmental Protection Agency (USEPA) Waste Code designations D-001, D-002, D-008, D-009, D-054, F-001, F-003, F-005, F-006, K-046, P-012, U-002, U-044, U-108, U-112, U-113, U-117, U-122, U-134, U-144, U-154, U-162, U-188, U-210, U-211, U-220, U-225, and U-226.

1.2.2 Waste Unit 2

Waste Unit 2 was used to bury drums containing various waste streams. There are approximately 450 drums believed to contain approximately 22,900 US gallons of waste having the same waste code as listed above.

1.2.3 Waste Unit 3

Waste Unit 3 was used to bury drums containing various waste streams. There are approximately 1700 drums believed to contain approximately 92,600 US gallons of waste having the same waste codes as listed above.

1.2.4 Waste Unit 5

Waste Unit 5 was used to bury drums containing various waste streams. The quantity of drums, the volume of waste, and the waste code designations for the material contained in the burial pit is unknown at this time.

1.2.5 Waste Unit 7

Waste Unit 7 was used as a neutralization impoundment. Records indicate that the pit received characteristic corrosive wastes and no listed wastes. The latest sampling activities at the site indicate that the contents of the unit do not exhibit the characteristic of corrosivity.

1.2.6 Waste Unit 9

Waste Unit 9 was an oil lagoon used to collect waste oil. The waste believed to be contained in the unit was approximately 477,700 gallons of water and approximately 300,000 gallons of sludge. During the fall of 1994, soil was added and mixed with the liquid in the lagoon to produce a solid matrix. The substance was then covered with clean soil to the grades of the surrounding area. The primary waste is believed to be waste code designation D-001, but D-002, D-005, D-007, D-008, D-009, D-010, D-013, D-106, D-108, F-001, F-002, F-154, F-188, F-196, F-210, F-220, F-226, F-230, and F-239 are may also be present.

1.2.7 Waste Unit 10

Waste Unit 10 is one of three immobilization facilities which is believed to contain approximately 950 cubic yards of waste. The constituents are not know.

1.2.8 Waste Unit 11

Waste Unit 11 is the second of three immobilization facilities that is being closed at the site. The unit is believed to contain approximately 5,800 cubic yards of waste consisting of the following waste code designations; D-001, D-002, D-008, D-009, D-013, F-002, F-009, U-044, U-138, U-140, U-144, U-154, U-156, U-188, U-201, U-210, U-226, and U-239.

1.2.9 Waste Unit 12

Waste Unit 12 was used as a land treatment area and contains approximately 17,800 cubic yards of waste that is designated with the waste codes of D-002, D-013, and F-003.

1.2.10 Waste Unit 13

Waste Unit 13 was used as a rainwater collection lagoon for the site. Information on constituents contained in the rainwater are unknown. The volume of water varies during the year due to the volume of run-off and the rate of evaporation from 0 up to approximately 80,000 gallons.

1.2.11 Waste Unit 16

Waste Unit 16 is the last of the three immobilization facilities that will be closed at the site. It contains approximately 29,700 cubic yards of waste. The waste codes believed to be represented within the unit are D-001, D-002, D-007, D-008, D-009, D-013, F-001, F-002, F-003, F-005, F-006, F-007, F-018, K-050, K-051, K-052, P-030, P-098, U-002, U-019, U-044, U-151, U-154, U-159, U-188, U-196, U-210, U-220, U-223, and U-226.

1.2.12 Waste Unit 17

Waste Unit 17 was used as a neutralization impoundment and is believed to contain 30,200 gallons of waste designation D-002 with small quantities of D-001 and D-003.

2.0 CLOSURE

2.1 CLOSURE PERFORMANCE STANDARDS

The waste units will be closed with the construction of a geosynthetic and soil closure cover system in compliance with the USEPA guidance documents. At final closure, Proteco will close the waste units in a manner that:

- Minimizes the need for further maintenance, and

- Controls, minimizes, or eliminates, to the extent necessary, to prevent (1) threats to human health and the environment, (2) post closure escape of hazardous waste, (3) hazardous waste constituents, leachate, (4) contaminated rainfall, and (5) migration of waste decomposition products to the ground water, surface water, or to the atmosphere.

This final closure cover system is a Resource Conservation and Recovery Act (RCRA) closure cover that minimizes threats to human health and the environment by physically separating buried wastes or contaminated materials from humans, animals, and plant roots. The closure cover reduces the leaching of contaminants from buried wastes or contaminated soil by reducing water infiltration, thus lessening the risk of groundwater and surface water contamination. The cover design promotes surface drainage and run-off and channels gas emissions. By establishing groundwater monitoring wells, gas vents, and erosion control measures this closure cover effectively reduces the need for continuing maintenance.

2.2 SPECIFICATIONS AND PLANS

To perform the work that is described in this Closure and Post Closure Plan other ancillary documents were prepared that describe and depict different aspects of the closure process. The construction specifications for this Closure and Post Closure Plan are provided in the document, "*Construction Specifications for the Proteccion Tecnica Ecologica, Inc. Closure of Waste Units 1, 2, 3, 5, 9, 10, 11, 12, 13, 16, and 17*" dated November, 1995. A construction quality assurance plan for the geosynthetic and soil components of the closure cover entitled "*Construction Quality Assurance Plan for the Proteccion Tecnica Ecologica, Inc. Closure of Waste Units 1, 2, 3, 5, 9, 10, 11, 12, 13, 16, and 17*" dated November 1995 provides methods for ensuring that the work is constructed and documented in accord with the Construction Specifications. Plans that depict the work to be performed are provided in the document, "*Construction Drawings for the Proteccion Tecnica Ecologica, Inc Closure of Waste Units 1, 2, 3, 5, 9, 10, 11, 12, 13, 16, and 17*" dated November 1995. Other documents that were prepared

for the execution of the closure are an Erosion Control Plan and a Spill Prevention, Countermeasure, and Control Plan. All documents were prepared by OHM Remediation Services Corp. In the case of conflicting information between the Construction Specifications, the CQA Plan, the Construction Drawings, and the Closure Plan, the Construction Specifications will take precedence.

The Construction Specifications include the following sections:

SECTION	TITLE
00200	Instructions to Bidders
00300	Proposal
00410	Bid Bond
00500	Contract
00610	Performance Bond
00620	Payment Bond
00650	Certificate of Insurance
00700	General Conditions
01000	Special Conditions
01010	Summary of the Work
01085	Applicable Standards
01300	Submittals and Substitutions
01310	Construction Schedule
02110	Site Preparation
02210	Grading
02220	Sub-Base Preparation
02221	Low Permeability Layer
02223	Cover Layer
02224	Trenching and Backfilling for Gas Vent Systems
02225	Surface Armor Layer
02270	Rock Excavation
02271	Riprap
02272	Erosion and Sediment Control
02281	Geomembrane
02282	Geotextile
02670	Monitoring Well Installation
02730	High Density Polyethylene (HDPE) Pipe
02930	Seeding, Sodding, and Mulching

The following sheets constitute the Project Drawings:

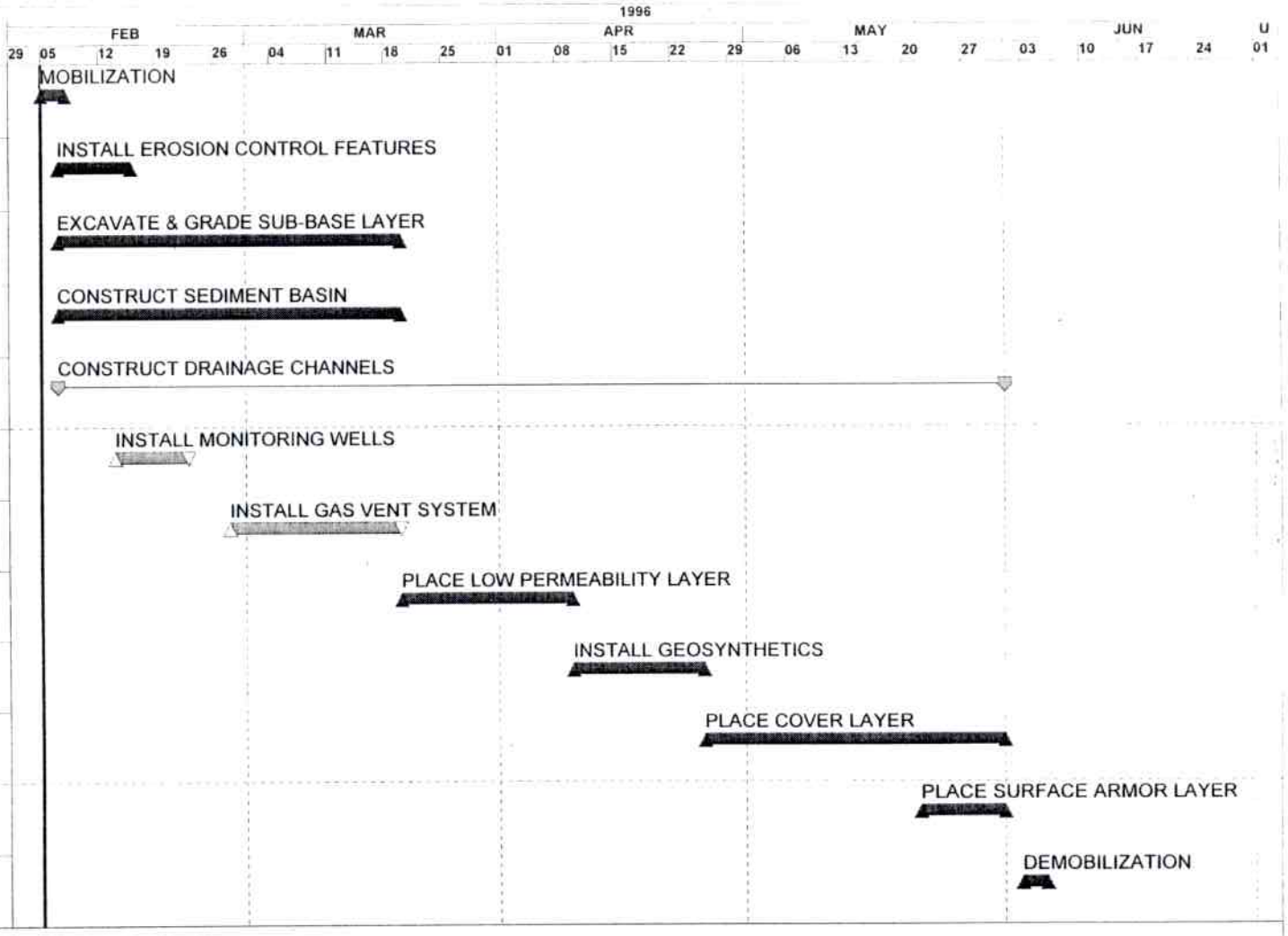
SHEET	TITLE
1	Cover Sheet
2	Vicinity Map, Site Location Map, Legend, and Notes
3	Overall Site Plan and Existing Topography
4	Existing Topography, Units 1, 2, 3, & 5
5	Existing Topography, Units 9, 10, 11, 12, 13, 16, & 17

6	Overall Sub-Base Grading Plan
7	Sub-Base Grading Plan, Units 1, 2, 3, & 5
8	Sub-Base Grading Plan, Units 9, 10, 11, 12, 13, 16, & 17
9	Overall Final Grading and Site Plan
10	Final Grading Plan, Units 1, 2, 3, & 5
11	Final Grading Plan, Units 9, 10, 11, 12, 13, 16, & 17
12	Sediment Basin
13	Drainage Plan
14	Erosion/Siltation Control Plan, Units 1, 2, 3, & 5
15	Erosion/Siltation Control Plan, Units 9, 10, 11, 12, 13, 16, &17
16	Cross-Section Cutting Planes, Units 1, 2, 3, & 5
17	Cross-Section Cutting Planes, Units 9, 10, 11, 12, 13, 16, &17
18	Sub-Base Cross-Sections, Units 1, 2, 3, & 5 Cross-Sections A-A', B-B', C-C', D-D', E-E', and F-F'
19	Sub-Base Cross-Sections, Units 9, 10, 11, 12, 13, 16, &17 Cross-Sections G-G' and H-H'
20	Sub-Base Cross-Sections, Units 9, 10, 11, 12, 13, 16, &17 Cross-Sections I-I', J-J', and K-K'
21	Final Grade Cross-Sections, Units 1, 2, 3, & 5 Cross-Sections A-A', B-B', C-C', D-D', E-E', and F-F'
22	Final Grade Cross-Sections, Units 9, 10, 11, 12, 13, 16, &17 Cross-Sections G-G' and H-H'
23	Final Grade Cross-Sections, Units 9, 10, 11, 12, 13, 16, &17 Cross-Sections I-I', J-J', and K-K'
24	Construction Details
25	Construction Details

2.3 SCHEDULE OF CLOSURE

Proteco will begin closure activities upon its receipt of approval of the Closure and Post Closure Plan by the USEPA. The anticipated closure schedule is presented in Figure 2.1. The area of the waste units is approximately 5 acres and work required to construct the RCRA closure includes clearing and grubbing, backfilling, placement of the low permeability layer, installation of geosynthetics, placement of a minimum 2 feet thick cover layer, erosion and sediment controls, and a gas management system.

Act ID	Orig Dur	Rem Dur	Early Start	Early Finish
1000	3	3	05FEB96	07FEB96
2000	7	7	07FEB96	15FEB96
2010	30	30	07FEB96	19MAR96
2060	30	30	07FEB96	19MAR96
2050	82 *	82 *	07FEB96	31MAY96
2090	7	7	14FEB96	22FEB96
2040	15	15	28FEB96	19MAR96
2020	15	15	20MAR96	09APR96
2030	12	12	10APR96	25APR96
2070	25	25	26APR96	31MAY96
2080	7	7	22MAY96	31MAY96
3000	3	3	03JUN96	05JUN96



Start date	05FEB96
Finish date	05JUN96
Run date	13NOV95
Project name	PROTECO

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* Indicates activity continues as needed through project

OHM Remediation Services Corp.
Schedule for Construction of
Close Covers for Waste Units

3.0 CLOSURE COVER DESIGN

Closure will be initiated by grading the waste units to the proposed sub-base elevations which vary between 3 and 8 percent over the closure cover and 50 percent on side slopes. Subsequently a RCRA closure cover will be constructed over all areas where waste has been disposed. The waste unit closure covers will consist of a low permeability layer, a 40 mil high density polyethylene (HDPE) geomembrane, a nonwoven geotextile, an 18 inch cover layer, and a 6 inch surface armor layer.

3.1 CLOSURE COVER FOUNDATION

The site will be cleared of existing vegetation or debris in preparation for placement of the RCRA closure cover. It will be graded to provide a slope between 3 and 8 percent over the actual waste units and up to 50 percent on the surrounding slopes. Common fill will be obtained from off site and/or on site borrow areas to establish the sub-base for the closure cover.

3.1.1 Settlement Potential

Settlement tests were conducted on Waste Units 1 and 16. Waste Unit 1, a drum burial unit, was chosen as a unit where maximum settlement would likely occur because of the nature of deteriorating drums. A test fill approximately 50 feet by 50 feet and 6 feet high was placed over a 3 feet by 3 feet x 1/6 inch steel plate. A steel rod attached to the plate was periodically surveyed to monitor the settlement. Settlement data shown in Appendix I of the Design Report indicates that settlement of 0.017 feet in 2 months occurred at Waste Unit 1. Since Waste Units 2, 3, and 5 are also drum burial units, the anticipated settlement is expected to be similar to Waste Unit 1. A conservative linear extrapolation of this data would be 0.102 feet of settlement in a year.

To generate information that would be representative of settlement throughout the remaining waste units, Waste Unit 16 was identified for testing. Waste filling operations that were conducted in Waste Unit 16 are similar to those conducted in Waste units 9, 10, 11, 12, 13, and 17. The settlement test results for Waste Unit 16 indicate 0.023 feet of settlement occurred. A conservative linear extrapolation for this data indicates 0.138 feet would occur in a year.

To prevent grade reversals and ponding of water on the closure cover the slopes for the closure have been chosen to account for settlement indicated in the load tests. As part of the waste unit closure, heavy equipment will be used to perform clearing and grading operations and to place and compact the sub-base and low permeability layer. This equipment will further compact the waste units prior to placement of the final geosynthetic

and soil closure system. In addition, the surcharge load on the waste has been reduced by replacing a 12 inch thick layer of sand in the drainage layer with a 16 ounce per square yard nonwoven geotextile.

3.1.2 Bearing Capacity and Stability

Additional compaction of the site will occur with the placement of the sub-base and low permeability layer. For the reasons discussed in Section 3.1, the existing landfill is judged to have sufficient bearing capacity for the closure cover. The HDPE geomembrane material was selected for its flexibility and durability in the event settlement does occur. Preparation and placement of a low permeability layer is required to cushion and support the geomembrane. The compacted sub-base and low permeability layer will support the geomembrane and protect it from irregularities during the post closure period.

The nonwoven geotextile and cover layer will be placed soon after installation of the geomembrane. No vehicles will be allowed to drive directly on the geomembrane. The cover layer will be used as a bridge for equipment movement on the installed geosynthetics. The cover layer will be placed at the base of the slopes and pushed up the slopes to prevent damage to the underlying geosynthetics. Equipment used in construction of the closure cover will be limited to 6 pounds per square inch (psi) or less ground contact pressure. As sections of the cover layer are completed, the surface armor will be placed. The CQA Plan discusses inspections, monitoring, and testing to be performed to ensure the low permeability layer is properly installed to support the geomembrane.

3.2 CLOSURE COVER SYSTEM

The closure cover will be constructed and closure will proceed as follows:

- The site will be cleared and grubbed to ensure adhesion between the existing soil and the closure cover. Common fill will be placed to establish the sub-base for the closure cover.

- A soil low permeability layer having a hydraulic conductivity no greater than 1×10^{-7} cm/s will be placed on top of the sub-base.

- Gas vents will extend into the waste and protrude through the closure cover to intercept and discharge gas generated from the waste.

- A 40-mil thick geomembrane consisting of a HDPE smooth surfaced geomembrane will be placed on the sub-base to prevent infiltration of precipitation through the cover and into the underlying waste. The geomembrane will provide maximum flexibility to conform with any settlement which may occur. The liner will have

enough tensile strength and durability to withstand the applied weight of the cover and surface armor layers for the duration of the closure and post closure periods without breakdown or reduced ability to perform as designed.

- A 16 ounce per square yard nonwoven geotextile will be placed on top of the HDPE geomembrane to protect the geomembrane and provide drainage.

- A 2 feet thick soil layer consisting of an 18 inch cover layer of compacted common fill and a 6 inch surface armor layer will be placed over the geotextile. These soil layers will protect the underlying geosynthetic layers from mechanical damage.

3.3 GEOMEMBRANE LINER

3.3.1 Materials Specification

The 40 mil thick smooth geomembrane will be constructed of high density polyethylene (HDPE). Raw polymer specifications and manufactured sheet specifications for the HDPE geomembrane are as follows:

• Thickness (ASTM D-751)	≥40 mil
• Density (ASTM D-1505 Method A)	≥0.935 g/cc
• Carbon black content (ASTM D-1603)	≥2%
• Tensile properties (ASTM D-638)	
Stress at yield	≥160 lbs/in width
Strain at yield	≥13%
• Tear resistance (ASTM D-1004)	≥30 lbs/in width
• Puncture Resistance (FTMS 101B)	≥52 lbs
• Dimensional Stability (ASTM D-1204)	+/-2.0%
• Melt Index (ASTM D-1238)	0.1 to 1.0 g/10 min
• Stress crack resistance (ASTM D-1693)	≥1200 hours
• Seam Shear Strength (ASTM D-4437)	≥80 lbs/in width

- Seam Peel Adhesion (minimum peel)
  (ASTM D-4437) ≥57 lbs/in width (hot weld)
  ≥48 lbs/in width (extrusion weld)

Further details on these material requirements are provided in the Construction Specification and the CQA Plan.

3.3.2 Physical Stresses

The geosynthetic materials used to construct the closure cover will provide liner integrity under a variety of mechanical stresses. The required calculations of physical stresses and friction factors are included in Appendix J of the Design Report.

These calculations include:

- Ability of the geomembrane to survive differential settlement
- Ability of geomembrane to survive settlement of underlying soil and waste layers
- Ability of soil cover to remain on geosynthetics

3.3.3 Differential Settlement in the Sub-base

Visual inspection of the site indicated no major depressions and satisfactory compaction of the waste at the time of filling. During clearing and grubbing operations and placement of soil fill to establish the sub-base and low permeability layer for the closure cover, further compaction will occur. For these reasons, further settlement resulting in foundation compression and soil liner compression is expected to be minimal. Problems with long term and differential settlement resulting in depressions which can strain the geomembrane are addressed in Appendix I of the Design Report. The Circular Trough Model (Knipschield 1985) which encompasses biaxial and uniaxial settlement was used to determine the required strength of the closure cover. An estimate of 10% settlement was assumed for the calculation. The selected geomembrane will be constructed of HDPE which allows large values of elongation and strain without breaking and provides a flexibility allowing the geomembrane to conform to depressions caused by waste settlement. The calculation shows that the design ratio for the closure cover to be 107 for settlement resulting from long term waste compression. This is much larger than the design ratio at rupture, which was shown by Knipschield (1985) to be 5.0. The factor of safety for differential settlement was determined to be 21.4 which indicates that the geomembrane will be able to survive differential settlement in the waste units.

3.3.4 Strain Requirements at the Anchor Trench

The geomembrane will be anchored in a trench at the toe of the closure cover. A detail drawing of the anchor trench is shown on the Project Drawings. Strain on the geomembrane is of concern in design of liners for the bottom of a landfill because anchoring prevents

sliding of the liner downhill. In the case of the geomembrane closure cover, the anchor trench does not affect the potential for sliding because it is at the toe rather than at the top of the slope. For these reasons, calculation of strain requirements of the anchor trench is not applicable.

3.3.5 Strain Requirements Over Long Side Slopes

The geomembrane must be strong enough to resist tensile forces acting on the geomembrane from the weight of the soil above. The selection of geomembrane provides high strength during installation. The steepest slope of the closed area will be 8 percent with areas beyond the geomembrane having a maximum slope of 50 percent, which will allow safe operation of maintenance equipment over the entire site. At an 8 percent slope, the frictional resistance of 14° plus adhesion available from the geomembrane is adequate to resist the driving forces on the hill and will not slide, as shown in Appendix J of the Design Report.

3.3.6 Chemical Compatibility

Typically, HDPE geomembranes and geotextiles are nonreactive with most leachate constituents (Koerner, 1986). The HDPE geomembrane and geotextile will be placed at least 24 inches above the top of the buried waste in the waste units and, therefore, will not contact chemicals in the waste units. The geomembrane will be in direct contact with the low permeability layer and the geotextile. The only liquid contacting the HDPE geomembrane and geotextile will be precipitation that percolates through the cover layer.

3.3.7 Liner Strength Requirements and Integrity Under Mechanical Stresses

The geomembrane must be capable of withstanding both the stresses of installation and stresses after placement. The 40 mil thick HDPE geomembrane is suitable for both conditions. The thickness and flexibility of the HDPE will provide sufficient strength to withstand installation stresses such as wind, temperature and seaming. As previously discussed, the geomembrane will be placed on the low permeability layer, free of rocks, clods, and other debris that might puncture the geomembrane. No vehicles will be driven on the geosynthetics until the cover layer is placed.

Prior to installation, the geomembrane will be protected from sunlight and the weather by a cover or a temporary shelter. After placement, the geomembrane will be covered with the geotextile and cover layer as quickly as possible after approval of seaming. The 2 feet thick cover layer will provide long term protection from mechanical and thermal stresses. Except during installation, the geomembrane will not be exposed to wind, sunlight, or direct precipitation.

3.3.8 Friction Factor

Smooth surfaced geomembrane will be used to cover the waste units. The maximum slope of the waste unit sub-base for all the waste units is 8 percent. The edges of the waste units have slopes as steep as 50 percent where the geomembrane will cover short distances before it is terminated in an anchor trench. It is shown in the calculations in Appendix J of the Design Report that the frictional resistance of 14 degrees that is available from the geomembrane is adequate to prevent sliding of the geomembrane on the average 5 percent slopes and the anchor trenches. The resistance available on the 5 percent slopes is also adequate to prevent sliding on the steeper 50 percent slopes around the edge of the waste units.

In the final design of the closure cover for the waste units, an HDPE geomembrane has been substituted for the PVC geomembrane liner that was proposed in the first draft of the closure cover design. During the design phase, pullout testing was performed on PVC geomembrane and the site soil by GeoSyntec Consultants of Atlanta, Georgia. The geomembrane tested was a 20 mil thick PVC smooth surfaced geomembrane liner supplied by Staff Industries. The site soil for construction of the waste units closure covers tested is clay (CL) as described in the geotechnical report from Caribbean Soil Testing Co. Inc. that is included in Appendix F of the Design Report. The results of the pullout testing program, reported in a letter report dated September 28, 1994 from GeoSyntec Consultants included in Appendix E of the Design Report, indicates that there is a peak friction angle of 14 degrees and peak adhesion of 99 pounds per square foot between the PVC geomembrane and the site soil.

With the change in geomembrane material from PVC to HDPE to be used in the closure cover there is a question as to the applicability of the pullout testing that was performed on the PVC geomembrane and the site soil. Koerner (1990) reports results of pullout testing that was performed on geomembrane consisting of various substances including HDPE and PVC. The results listed in Table 3.1 indicate that clay soils such as CL-ML and CL provide pullout results for friction angle and adhesion that are virtually the same for HDPE and PVC.

3.3.9 Best Anchorage Configuration for the Geomembrane

As discussed in 3.3.4 the anchorage of the geomembrane is not a design issue. The geomembrane will be anchored in a 2 feet wide, 2 feet deep trench located at the edge of the closure cover around the perimeter of the waste units. This is a typical anchoring method shown in the guidance document and is used primarily to protect against wind damage to the geomembrane.

3.3.10 Cover Layer Stability on Top of Geomembrane

Stability of the cover layer is an important concern in designing a landfill cap. Sliding stability was evaluated for smooth HDPE on the waste units where it will be placed at slopes up to 8 percent. Approximately 70 percent of the cover layer that will overlay the geomembrane is at an average slope of 5 percent, the factor of safety against a sliding block failure is greater than 1 at 1.8. The approximately 30 percent of the cover layer that is at an 8 percent slope has a factor of safety of 1.1 which also greater than 1. The areas where the cover layer will be at a 50 percent slope are short and the soil is keyed into the underlying so that the soil is preventing from sliding. Because all the sections will be connected, an overall factor of safety can be considered as appropriate. Calculations are included in Appendix J of the Design Report.

3.3.11 Installation

The earthwork contractor will be responsible for preparing and maintaining the sub-base and low permeability layer in a condition suitable for liner installation. The low permeability layer will be smooth and firm. Sharp stones, gravel, debris, or any other objects which could penetrate the liner will be removed. The low permeability layer will be visually inspected prior to installation of the geomembrane.

The geomembrane will be delivered to the site on rolls, stored off the ground in small stacks, and protected with a covering or a temporary storage shelter. The storage space will be protected from theft, vandalism, and passage of vehicles. Geosynthetics will be handled in a manner to prevent physical damage, contamination, and exposure.

Geomembrane will be installed during dry, moderately warm weather to minimize the effects of thermal expansion and contraction. The manufacturer's instructions will be followed for geomembrane placement and seam overlap. The method used to unroll the panels will not cause scratches or crimps in the geomembrane. Sandbags will be placed along the edges of the geomembrane to prevent uplift pressures and the resulting wind damage. Field panels will be placed one at a time in a manner which minimizes wrinkles.

The panels will be seamed immediately after placement following the manufacturer's recommended thermal sealing procedures. The ambient temperature shall be above 35° F during seaming. Surfaces to be seamed will be clean and dry when the seams are made. Seams will be oriented parallel to the line of maximum slope. All field seams will be nondestructive tested in accordance with ASTM D-4437 seam evaluation using the vacuum box technique. Destructive tests will be performed on test specimens in accordance with ASTM D-413 and ASTM D-638 for peel and shear of geomembrane seams. One sample will be taken for destructive testing a minimum of every 500 linear feet of weld.

The geomembrane will be covered within the time limits specified by the manufacturer. The geotextile and cover layer will be placed on the geomembrane as soon as possible after approval of the geomembrane placement. The cover layer will be placed on the geosynthetics using rubber tired or tracked vehicles. Vehicles will be driven at least 12 inches of the cover layer. Vehicles will not be allowed to drive directly on the geosynthetics.

CQA procedures to be followed for geomembrane and geotextile installation, including inspections, material certifications, and testing are discussed in the project CQA Plan.

3.4 COVERAGE

Records of waste placement are not available for the waste units. Therefore, geophysical studies, aerial photography, employee interviews, site inspections, and test pits have been used to determine the area and boundaries of the waste units. Based on information from these sources, it was determined that the waste units are located as shown on the design drawings. The entire area will be covered by the RCRA closure cover.

Table 3.1 – Friction Values and Efficiencies for Various Clay Soils to Various Geomembranes

	Soil No. 1 ML-CL				*Soil No. 2 CL-ML*			
Description	c	E_c(%)	ϕ	E_ϕ(%)	c	E_c(%)	ϕ	E_ϕ(%)
Soil-to-soil	9.0	100	38	100	12.0	100	34	100
	c_a	E_c(%)	δ	E_ϕ(%)	c_a	E_c(%)	δ	E_ϕ(%)
Geomembrane-to-soil								
PVC	8.5	94	39	100	3.7	31	23	69
CPF	8.0	89	40	100	3.2	27	24	71
EPDM	5.0	55	33	87	5.0	42	23	67
HDPE	5.0	88	26	68	2.0	17	23	67
Embossed HDPE	9.0	100	35	92	11.0	92	29	58
	Soil No. 3 ML-CL				*Soil No. 4 CL-ML*			
Description	c	E_c(%)	ϕ	E_ϕ(%)	c	E_c(%)	ϕ	E_ϕ(%)
Soil-to-soil	20	100	30	100	25	100	24	100
	c_a	E_c(%)	δ	E_ϕ(%)	c_a	E_c(%)	δ	E_ϕ(%)
Geomembrane-to-soil								
PVC	14.0	70	16	53	7.0	28	24	100
CPF	13.0	65	17	57	8.0	32	23	96
EPDM	8.0	40	23	77	7.5	30	20	83
HDPE	14.0	70	15	50	3.0	12	21	88
Embossed HDPE	18.0	90	27	90	15.0	60	26	100
	Soil No. 5 CL-SP							
Description	c		E_c(%)		ϕ		E_ϕ(%)	
Soil-to-soil	28		100		22		100	
	c_a		E_c(%)		δ		E_ϕ(%)	
Geomembrane-to-soil								
PVC	12.0		43		17		77	
CPF	10.0		36		19		86	
EPDM	9.0		32		18		82	
HDPE	14.0		50		15		68	
Embossed HDPE	16.0		57		25		100	

Note: c and ca are in units of kN/m^2, ϕ and δ are in degrees.

4.0 LEACHATE, SUBSURFACE, AND SURFACE WATER

4.1 LEACHATE MONITORING SYSTEM

The existing waste units have no bottom liner or Leachate Collection System (LCS). During various site inspections, no leachate has been detected seeping out of the waste units along the perimeter. Placement of the RCRA closure cover will reduce percolation of surface water into the waste units, thus reducing any leachate production.

The Hydrologic Evaluation of Landfill Performance (HELP) model (Version 2.05) was used to estimate the volume of water that will percolate into the waste. This model estimates the amount of precipitation that will seep through the RCRA cap. HELP model analyses were performed for a conservative situation representing a slope length of 200 feet and a slope of 3 percent. Rainfall and temperature data for the region of Penuelas, Puerto Rico and evaporation data for San Juan, Puerto Rico, was used in the computer model. No compaction was assumed in the 6 inch surface armor layer. However, the 18 inch cover layer was modeled as compacted, reducing infiltration of water through the closure cover. Detailed results of these HELP model analyses are provided in Appendix A of the Design Report.

To monitor the surrounding area for leachate which may emanate from the waste units, three monitoring wells will be installed downgradient of the facility as shown in the Project Drawings. The monitoring program that will be conducted will be a continuation of the existing program. The program which describes the parameters to be analyzed, the frequencies that testing will be conducted, and the criteria for the data are described in Part B Permit for the facility.

4.2 DRAINAGE LAYER DESIGN

To ensure the integrity of the geomembrane, it is necessary to maintain less than 12 inches of head on the geomembrane. This will be accomplished with the installation of a lateral drainage layer, consisting of 16 ounce per square yard nonwoven geotextile with a minimum transmissivity of 14.5×10^{-3} $ft^3/min./ft$. The HELP Model analyses were used to determine the required transmissivity of the geotextile beneath the final cover. At a 5 percent slope, the transmissivity was calculated to be $3.8 \times 10^{-3} ft^3/min./ft$. which yields a factor of safety of 3.8. The HELP model analyses were also used to calculate the maximum head on the geomembrane and the amount of run-off from the closure cover for the longest lengths of the 5 percent slope. These slopes were identified as the worst case scenarios and used for design of all the waste units. The results of these HELP model calculations, presented in Appendix A of the Design Report indicate that the maximum peak daily head of

0.03 inches will occur on the liner. This value is well below the maximum allowable head of 12 inches.

The HELP model calculations indicate the daily peak run-off from the cap will be 25,070.00 cubic feet per acre and the daily peak drainage from the lateral drainage layer will be 105.00 cubic feet per acre.

4.3 RUN-ON CONTROL

Because the waste units are located on ridges and hills, run-on of surface water is not a concern. Extensive permanent drainage channels and sediment basins are part of the closure design as shown in the Project Drawings. These surface water control features will be used to route any stormwater run-on around and through a stormwater retention or diversion system.

4.4 RUN-OFF CONTROL

Run-off from the closure cover will be controlled by several measures. Run-off from the waste units will be controlled through permanent drainage channels constructed along the perimeter of the waste units. Silt fences will be used to control the flow of surface water from the waste unit area to the permanent sediment basins that will be constructed to collect run-off during construction of the closure cover. The control measures, channels, and silt fences will be relocated and reinstalled as necessary to accommodate the waste unit closure cover construction.

5.0 GAS MANAGEMENT SYSTEM

The following section describes the design and procedures for gas venting and control of decomposition gases within the waste units. The gas management system includes passive gas vents at various locations within the limits of the waste units to discharge gas generated in the waste.

5.1 GAS PRODUCTION AND MIGRATION

The waste units are located in a remote section of the Proteco facility with no structures located within 300 feet. Site inspections found that vegetative growth around the facility was not stressed and there were no indications of gas migration beyond the waste units. Currently, there is no evidence of gas production or release from any of the waste units. Because the waste units have been out of operation for approximately 10 years, gas migration pathways most likely have been established. Underground cracks and fissures between waste lifts and cells caused by settlement and subsidence are probable migration pathways. Any such channels within the waste will provide routes for gas migration to the gas vents that penetrate the closure cover.

The majority of waste gas is produced from the decomposition of the organic fraction of municipal solid waste (MSW). The total gas production (assuming normal conditions) is reported to reach a peak in 6 years or less (Tchobanoglous et al., 1993). Since operations have been terminated for 10 years, there is likely minimal gas production. To estimate the amount of gas produced at the waste units, the following assumptions have been made:

- The source of gas production is the MSW fraction because hazardous waste produces minimal gas.
- The facility is a hazardous waste disposal facility and there is no MSW within the waste units.

A volume estimate of the total amount of gas generated by the waste units is 7.5 cubic feet per minute, based on Bagchi, 1990. The calculation is based on typical gas production rates of landfills in the pseudo-steady-state stage of gas production. Because of the content of the waste units, low methane production rates are expected. The calculations for this estimate are in Appendix K of the Design Report.

5.2 PASSIVE GAS VENTS

Passive gas vents will be placed at high points within the waste units to discharge gas generated in the waste. Details of the vents are shown in the Project Drawings. To construct each passive unit, a 12 inch deep trench will be excavated in the compacted sub-base. Horizontally at the bottom of the trench, a 4 inch diameter, perforated HDPE pipe will be placed on 4 inches of #57 stone. A 4 inch diameter HDPE vent pipe will then be connected to the horizontal 6 inch pipe and routed up for exit above the closure cover. The remainder of the trench will be filled with #57 stone to the surface of the sub-base. The area will be covered with low permeability layer soil, geomembrane, geotextile, cover layer, and surface armor. An HDPE boot will be constructed around the vent pipe to maintain the integrity of the geomembrane. The pipe will extend 4 feet above the final grade of the closure cover to allow gases to discharge into the atmosphere.

6.0 CONSTRUCTION QUALITY ASSURANCE PLAN

The purpose of the Construction Quality Assurance (CQA) Plan is to ensure that design of the RCRA closure cover complies with the hazardous waste regulations and construction of the RCRA closure cover conforms with the Closure and Post Closure Plan and construction documents. The Closure and Post Closure Plan, which was prepared to comply with CFR 264, is the basis for the construction plans and specifications. A copy of the CQA Plan will be kept at the Proteco office at the landfill site during closure activities. The plan will be available for review by regulatory agencies upon request.

The Project Drawings and Construction Specifications, which are separate documents, detail the requirements for placement of the RCRA closure cover on the waste units. A typical section of the RCRA closure cover and cross sections of the waste units are shown in the Project Drawings. The quality assurance activities discussed in this plan summarize the requirements of the CQA Plan and describes the quality assurance activities to be performed by Proteco or its designated representative.

6.1 RESPONSIBILITY AND AUTHORITY

The USEPA is the permitting agency responsible for the review and approval of the Closure and Post Closure Plan, Construction Specifications, and the CQA Plan. The USEPA also will review the construction quality assurance documentation for the RCRA closure cover.

Proteco is the owner of the waste units and is responsible for the design, construction, and post closure care of the RCRA closure cover. Proteco has direct responsibility for implementing the closure plan and providing the post closure care during the 30 year post closure period.

Proteco or their designate will serve as the construction quality assurance officer/inspector during construction of the closure covers of the waste units. Throughout this section reference to Proteco will also mean Proteco's designated CQA consultant. Proteco's responsibilities include being familiar with the Closure and Post Closure Plan, Project Drawings, Construction Specifications, and CQA Plan so that interpretation and clarifications can be made, scheduling and coordinating quality assurance activities, inspecting construction activities to ensure conformance with the construction documents, maintaining communication between the various parties involved, confirming accuracy of data, review and interpretation of data, ensuring the construction contractor is performing quality assurance activities, reporting results of the quality assurance activities, and making recommendations concerning acceptance of the construction contractor's work.

The construction contractor will be retained by Proteco to construct the RCRA closure cover on the waste units in accordance with the approved Closure and Post Closure Plan and construction documents. Requirements for contractor construction quality control are included in the Construction Specifications, CQA Plan, and the contractor's basic contract.

6.2 MEETINGS AND REPORTS

Periodic meetings will be held to monitor the progress of the project and issues arising during construction of the RCRA closure cover. The meetings will be scheduled by Proteco and the attendance will depend on the issues being addressed. Potential attendees will include representatives from the USEPA, the construction contractor, and the design engineer. All meetings will be documented in writing.

A preconstruction meeting to review all project requirements, in particular quality assurance requirements, will be held before work begins on the site. Topics of discussion will include: quality assurance documents, roles and responsibilities of each entity, establishing lines of authority and communication, procedures for inspecting work and reviewing data and other documents, and changes that need to be made before actual construction begins.

The construction contractor will be required to submit a daily report summarizing work accomplished the previous day, work planned for the current day, personnel and equipment to be used, and potential problems. When necessary, meetings will be held to address specific problems or deficiencies and develop resolutions.

6.3 PERSONNEL QUALIFICATIONS

Proteco or its designated CQA consultant will serve as the construction quality control officer for the project. The representative assigned to the project will have adequate formal training and practical field experience to ensure proper quality assurance during the construction of the RCRA closure cover. He will be present during construction and be responsible for inspecting relevant activities to ensure compliance with the construction documents.

As necessary, the design engineer will provide technical assistance and support to Proteco. The design engineer's representative will be familiar with the specifics of the project and will have appropriate experience.

The construction contractor will be required to provide a quality control officer for the project. The contractor's quality control officer will be responsible for review and approval of all submittals required by the Construction Specifications and ensuring the requirements of the CQA Plan are met.

6.4 INSPECTION ACTIVITIES

The quality assurance activities for the project include construction materials quality control and construction quality assurance. Construction materials quality control ensures that the materials used comply with the Construction Specifications. The Construction Specifications and CQA Plan provide a detailed listing of all the quality assurance testing, methodologies, frequencies, etc. that are discussed in the following sections. The purpose of construction quality assurance is to ensure that the RCRA closure cover is constructed in compliance with the construction documents. Upon completion of installation of each component, the component will be inspected to identify any damage that may have occurred during its installation or during construction of another component. Any damage will be repaired and these corrective measures will be documented in quality assurance records.

6.4.1 Sub-Base Layer

Prior to placement of the RCRA closure cover, the waste units will be cleared and grubbed to remove grass, brush, and small trees and prepare the site for the closure cover. The area to be covered will be graded to provide a slope typically between 3 and 8 percent. Grading of the site to establish the sub-base for the RCRA closure cover will be accomplished by addition of backfill obtained from off-site if necessary. The backfill used to establish the sub-base for the closure cover will be common fill as specified in the construction documents. The backfill material will be visually inspected as it is placed to ensure it meets the Construction Specifications and does not contain objects that could damage or adversely affect overlying layers of the closure cover. The site CQA representative will observe placement of the fill in 9 inch loose lifts to achieve a 6 inch thick compacted layer. Proteco will be responsible for performing tests to document achieving 95 percent compaction in accordance with ASTM D 698 (Standard Proctor). This will minimize the potential for settlement and subsidence in the future. The site CQA representative will review and approve test results. Other geotechnical tests will be performed on this layer to ensure that it fulfills the Construction Specifications. Those inspections are detailed in both the Construction Specifications and the CQA Plan.

6.4.2 Gas Management System

The materials used in the construction of the gas vents in the landfill will be inspected by the site CQA representative upon delivery to the site. Certifications, manufacturer's literature/specifications, and other information will be reviewed to ensure conformance with the specifications. Installation of the vents will be observed to assure compliance with the construction plans and specifications.

6.4.3 Low Permeability Layer

Two feet of a low permeability (hydraulic conductivity $\geq 1 \times 10^{-7}$ cm/sec) clay will be placed on the sub-base to prevent infiltration of surface water into the waste units. The manufacturer will provide certification that the material properties listed in the Construction Specifications have been met before the soil is accepted for placement on the waste units. Placement of the low permeability layer will be in accordance with the Construction Specifications.

A small scale test pad will be constructed to ensure the design permeability can be achieved. The test pad will be a minimum of 40 feet by 40 feet in size and will be constructed on or near the waste units. The test pad will be used to determine the optimum moisture content of the low permeability layer, the number of equipment passes required to achieve the required compaction, and the in-situ permeability of the low permeability layer, and other site specific construction requirements. The experience gained during the test pad construction and testing will be used to finalize the procedures to be used in actual low permeability layer placement.

Prior to placement of the low permeability layer, the surface will be surveyed to obtain data for as-built submittals.

6.4.4 Geomembrane

A 40 mil thick smooth surfaced HDPE geomembrane will be installed above the low permeability layer. The supplier will provide documentation confirming that the raw polymer material and manufactured sheet will comply with the Construction Specifications. The supporting surface of the geomembrane will be inspected prior to seaming to ensure the surface is acceptable. Sandbags will be placed along the edges of the geomembrane to control panel uplift by wind. Surfaces to be seamed will be clean and dry when the seams are made. Field seaming will occur during dry, moderately warm weather at temperatures no lower than 35 degrees Fahrenheit. Manufacturer's instructions will be followed when sealing around gas vents penetrating the geomembrane. The material requirements for the geomembrane, the quality assurance testing methods, and the installation methods for the geomembrane are described in the Construction Specifications and the CQA Plan.

Destructive trial seams will be conducted to determine the integrity of the geomembrane field seams. Destructive tests include peel and shear test performed on fragment portions of geomembrane by an independent laboratory prior to commencing seaming activities and at periodic intervals throughout the day. Additionally, destructive peel and shear field tests are to be performed on destructive samples from the installed seams. These samples may be collected randomly or in areas of suspect quality. Destructive samples of installed seam welds will be cut into several pieces and distributed to:

- The installer to perform construction quality control field testing,
- Proteco to retain and appropriately catalog or archive, and
- An independent laboratory for peel and shear testing.

A quality control technician will monitor each seam crew and perform a visual inspection. This technician will be aware of the effects of weather, temperature, humidity, and cloud cover on the geomembrane.

Nondestructive test methods to be conducted in the field on the in-place geomembrane to determine the integrity of the geomembrane seams are the pressure test, vacuum box test or the air lance technique. The criteria for this testing is listed in the Construction Specifications and the CQA Plan.

The site CQA representative inspection personnel will be aware of the effects that weather conditions may have on the geomembrane and seaming procedures. If the weather becomes unacceptable for geomembrane installation, the CQA representative will recommend stopping installation until conditions are favorable.

6.4.5 Geotextile

To protect the geomembrane and provide drainage, a 16 oz/sy nonwoven geotextile will be placed across the entire geomembrane. Placement of the geotextile will be observed to ensure complete coverage of the geomembrane, proper overlap, and compliance with the manufacturer's instructions. The material requirements for the geotextile are presented in the Construction Specifications and the CQA Plans.

6.4.6 Cover Layer

The 2 feet thick cover layer will consist of 18 inches of common fill and 6 inches of surface armor which will be placed above the geotextile. During construction of the cover soil layer, a site CQA representative will monitor the uniformity of the application process, observe the placement procedure to ensure that the soil is compacted properly, and measure the thickness and slope of the topsoil layer. Inspection personnel will also ensure that care is taken near gas vents to prevent damage by construction equipment.

The common fill will be visually inspected as it is placed to ensure that it meets the Construction Specifications and does not contain objects that could damage underlying layers of the closure cover. The site CQA representative will observe placement of the fill in 9 inch loose lifts. The common fill will be compacted to 95% of the maximum Standard Proctor dry density. The site CQA representative will be responsible for performing tests for moisture content and density on the common fill . The site CQA representative and Proteco will review and approve test results.

7.0 POST CLOSURE ACTIVITIES

7.1 POST CLOSURE CONTACT

During the post closure care period, information about this hazardous waste site and any activities at the site can be obtained from Proteco at the following address and from the following contact points:

Proteccion Tecnica Ecologica, Inc.
Doctor Jorge Fernandez
P.O. Box 71331
San Juan, PR 00936-8431
(809) 272-8411

Proteccion Tecnica Ecologica, Inc.
Rene Rodriguez
Carr. 385 KM 3.5
Penuelas, PR 00624
(809) 836-2058

7.2 POST CLOSURE STANDARDS

Post closure care will be performed in accordance with 40 CFR 264. During final closure activities at the waste units, a copy of the approved Closure and Post Closure Plan shall be furnished to the USEPA regional administrator Director upon request, including request by mail. After final closure has been certified, Proteco will keep the approved Closure and Post Closure Plan on file during the remainder of the post closure period. After final closure, Proteco will:

- Maintain the integrity and effectiveness of the final cover, including making repairs to the closure cover as necessary to correct the effects of settling, subsidence, erosion, or other events.

- Prevent run-on and run-off from eroding or otherwise damaging the final cover, and maintain the surface drainage system including the sediment basins and channels

- Protect and maintain surveyed benchmarks.

Post closure care for the waste units will begin after completion of closure and continue for 30 years. The USEPA Regional Administrator Director may shorten or extend this post closure period if doing so will protect human health and the environment.

Post closure use of the waste units shall never be allowed to disturb the integrity of the final closure cover, unless the USEPA Regional Administrator Director finds that the disturbance is:

- Necessary to the proposed use of the closed waste units, and will not increase the potential hazard to human health or the environment, or

- Necessary to reduce a threat to human health or the environment.

Proteco understands that if any future activities are carried out at the closed waste units , the USEPA Director will be informed in writing. At this time, there are no plans to use the closed waste units. Signs posted along the waste units' boundaries will warn that breaking of the ground surface is prohibited. This notice is designed to ensure the integrity of the closure cover is not disturbed.

7.3 SURVEY PLAT

When the certification of closure of the waste units is submitted, Proteco will submit a survey plat indicating the location and dimensions of the closed waste units with respect to permanently surveyed benchmarks to the local zoning authority with jurisdiction over local land use and the USEPA Regional Administrator Director. The survey plat will be prepared and certified by a professional land surveyor registered in Puerto Rico. The plat will be filed with the local zoning authority, or the authority with jurisdiction over local land use, will contain a note, prominently displayed, which states Proteco's obligation to restrict disturbance of the closed disposal area.

7.4 SECURITY CONTROLS

The area is presently surrounded by a security fence. This fence will be maintained to ensure that access to the site is controlled. Signs which state: "Warning-Disturbing Soil Surface Prohibited" will be posted in locations at the closed disposal area to ensure the area is not disturbed. Signs which state: "Danger - Keep Out Authorized Personnel Only" will be posted at the entrance gates.

7.5 INSPECTION, MONITORING, AND MAINTENANCE

7.5.1 Certification of Closure

Within 60 days of completion of closure, Proteco shall submit to the USEPA, by registered mail, a certification that the waste units were closed in accordance with the construction documents in the approved Closure and Post Closure Plan. The certification will be signed by the owner or operator and by an independent registered professional engineer registered in Puerto Rico. Documentation supporting the independent registered professional engineer's certification will be furnished to the Director upon request.

7.5.1 Inspections

An inspection program shall be established to inspect the surface armor layer, erosion control measures and all other physical aspects of the site. Initially, Proteco will make these inspections on a monthly basis or more frequently, as necessary. In addition, the site will be inspected annually by a professional engineer registered in Puerto Rico for the first two years after completion of closure. For the remainder of the normal post closure period, the site shall be inspected quarterly by Proteco. A log of all inspections and any resulting maintenance work will be kept on file at Proteco. Copies will be sent to the USEPA. If the engineer discovers a deficiency in the closure cover of the waste units, this deficiency will be noted and corrective action will be initiated within 14 days. Table 7.1 presents a sample inspection log.

The following items will be inspected and maintained during the post closure care period:

- Security controls
- Final cover
- Run-off controls
- Benchmarks
- Erosion controls
- Surface armor layer maintenance
- Gas management system

The following post closure inspection schedule is suggested for the site but should be modified as experience dictates:

First two years of closure:

a) After every major storm event, Proteco shall inspect the site to assure that excessive erosion or other damage has not occurred.

b) A complete inspection of the site including all security facilities will be made monthly by Proteco. All repairs made will be noted.

c) A professional engineer registered in Puerto Rico will inspect the site annually. One copy of the inspection report will be submitted to the USEPA.

After the first two years of closure:

a) After every major storm event, Proteco will inspect the site to assure that excessive erosion or damage has not occurred.

b) Quarterly a complete inspection of the site will be conducted by Proteco using the checklist shown in Table 7.1. All repairs will be made as necessary.

7.5.3 Security Control Devices

The signs and fence will be monitored for damage monthly during post closure care. Signs and fencing will be repaired or replaced as needed. The gates will be kept locked at all times. Additional security measures will be implemented if there are signs of intrusion.

7.5.4 Erosion Damage and Cover Settlement, Subsidence, and Displacement

Permanent collection channels around the perimeter of the waste units will direct surface water flow into sediment basins and the sediment trap to control run-off and prevent erosion. After construction is complete and the surface armor is installed, permanent collection channels, sediment basins, and the sediment trap will be maintained. The permanent riprap lined channels will direct surface run-off and subsurface run-off from the lateral drainage layer away from the waste units and into the surface water drainage system surrounding the waste units. The collection channels, sediment basins, and sediment traps will be maintained by Proteco throughout the post closure period.

Cover erosion of 1 ton/acre/year was predicted using the United States Department of Agriculture Universal Soil Loss Equation. This rate of soil loss is less than the maximum allowance of 2 tons/acre/year. Therefore, the slope of the closure cover will minimize erosion of the landfill surface. The calculations are included in Appendix D of the Design Report.

The RCRA closure cover will be inspected monthly and after rainfall events of 2 inches in an 8 hour period or greater throughout the post closure care of 30 years. The inspector will look for evidence of settlement, subsidence, or displacement; drainage and ponding of surface water; damaged vegetation; presence of undesirable vegetation; and erosion.

Areas of minor erosion on the closure cover will be backfilled or regraded as necessary in accordance with this Closure and Post Closure Plan. Areas of significant erosion will be

repaired by replacing appropriate layers of the RCRA closure cover necessary. Repaired areas will be monitored.

7.5.5 Integrity of Run-on and Run-off Control Measures

The topography of the waste units are such that run-on of precipitation is not a concern. The site will be been graded to allow relatively uniform run-off from the waste units' area. Run-off from the closure cover will flow into collection channels, sediment basins, and a sediment trap before exiting into the streams surrounding the facility. The erosion control features will be inspected quarterly. Any erosion problems will be corrected promptly. Existing erosion controls will be repaired or improved as necessary. Additional erosion control measures will be installed if the existing measures prove to be inadequate.

7.5.6 Gas Venting System

The venting system will be inspected quarterly for damage to the vents. During post closure care, vents will be replaced as necessary. If damage is severe, the entire vent may need to be replaced.

7.5.7 Benchmarks

Upon completion of the RCRA closure cover, ten permanent benchmarks will be established at the site. The benchmarks will be inspected monthly for obvious damage, and to determine if they are still present. A certified land surveyor registered in Puerto Rico will verify the elevations of the benchmarks annually. Benchmarks will be monitored throughout post closure care.

7.6 POST CLOSURE NOTICES

Within 60 days after certification of closure of the waste units, Proteco will record a notation in accordance with the local law on the deed or any other instrument that is examined during a title search to the waste units' property that will in perpetuity notify any potential purchaser of the property's condition:

- The land has been used to dispose of hazardous wastes.
- Its use is restricted under 40 CFR 264 Subpart G.
- The survey plat and record of the type, location, and quantity of hazardous wastes disposed of within the waste units have been filed with the local government and with the USEPA Director.

- Submit a signed certification that Proteco recorded the above listed notations including a copy of the document in which the notation has been placed to the USEPA Director.

No later than 60 days after the completion of the established post closure care period for the waste units, Proteco shall submit to the USEPA Director by registered mail a certification that the post closure care period for the closed disposal area was implemented in accordance with the specifications in the approved post closure plan. The certification shall be signed by Proteco and an independent professional engineer registered in Puerto Rico. Documentation supporting the independent Puerto Rico professional engineer's certification shall be furnished to the USEPA Director upon request until he or she releases Proteco from the financial assurance requirements for post closure care under "Cost estimate for post closure care" (40 CFR 264.144).

7.7 POST CLOSURE USES

No other uses are planned for the waste units property during the post closure period.

7.8 TRAINING

Proteco will use experienced personnel for site inspections and maintenance programs. Any major problems arising such as gas migration problems will be immediately referred to a registered professional engineer. In general, materials and equipment needed for various repairs will be dependent upon the nature and extent of the repair. Materials and equipment will be consistent with those considered standard for the construction industry and consistent with the Construction Specifications.

Table 7.1 – Sample Inspection Log						
Inspection Log					**SAT - Satisfactory** **NSAT - Not Satisfactory**	**NA - Not Applicable** **NI - Not Inspected**
DATE:	AREA INSPECTED:		SIGNATURE OF INSPECTOR:			
Physical Property Inspected	SAT	NSAT	NA	NI	LOCATION AND PROBLEMS OBSERVED	DATE CORRECTIVE ACTION TAKEN
Erosion Control						
Warning Signs Present						
Monitoring Well: Integrity of Locks						
Monitoring Well: Integrity of Casing						
Monitoring Well: Integrity of Guard Posts						
Gas Vents						
Benchmarks						
Fence and Gates						

8.0 REFERENCES CITED

Bagchi, A., (1990), *Design, Construction and Monitoring of Sanitary Landfill*, John Wiley and Sons.

Cadwaller, M., (1986), *Landfill Closures Using HDPE Membranes*, Gundle Lining Systems.

Corbit, R. A. (1990), *Standard Handbook of Environmental Engineering*, McGraw-Hill, Inc.

Knipshield, F. W., (1985), "Material Selection and Dimensioning of Geomembranes for Groundwater Protection," *Waste and Refuse*, Vol. 22.

Koerner, Robert M. (1986) *Designing with Geosynthetics* Prentice-Hall, Englewood Cliffs, New Jersey.

Koutsourais, M., (1990), *Proceedings of The 4th GRI Seminar, Geosynthetics, Interface Friction and New Developments*, Geosynthetics Research Institute.

Tchobanoglous, G., Theisen, H., and Samuel Vugul (1993) *Integrated Solid Waste Management*, McGraw-Hill, Hightstown, New Jersey.

USEPA, May (1991) **Seminar Publication** - *Design and Construction of RCRA/CERCLA Final Covers* EPA/625/4-91/025 Office of Research and Development, Washington, D.C.

USEPA, August (1989) **Seminar Publication** - *Requirements for Hazardous Waste Landfill Design, Construction, and Closure* EPA/625/4-89/022 Office of Research and Development, Washington, D.C.

USEPA, July (1989) **Technical Guidance Document:** *Final Covers on Hazardous Waste Landfills and Surface Impoundments* EPA 530-SW-89-047 Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA, October (1986) **Technical Guidance Document:** *Construction Quality Assurance for Hazardous Waste Land Disposal Facilities* EPA 530-SW-86-031 Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA, May (1987) *Design, Construction and Maintenance of Cover Systems For Hazardous Waste* EPA/600/2-87/039 Office of Research and Development, Washington, D.C.

Richardson, G. and Koemer, R., December (1987) *Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments* EPA/600/2-87/097 Office of Research and Development, Washington, D.C.

Wanielista, M., (1990), *Hydrology and Water Quality Control*, John Wiley and Sons.