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January 8, 2009

Mr. Ming-Tai Chao, P.E.
Environmental Engineer II
North Carolina Department of Environmental and Natural Resources
Division of Waste Management
Permitting Branch, Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

Subject: Dare County
Dare County Construction and Demolition Landfill (C&DLF)
Permit Modification
Response to Comments

Dear Mr. Chao:

On behalf of Dare County, CDM is pleased to submit revisions to the Dare County Construction and Demolition Landfill Permit Modification per your review comments received on November 19, 2008. For your convenience, CDM has formatted this letter correspondence to present your comment followed immediately by our response in *italics*.

Closure Plan

1. Please provide the Construction Quality Control and Quality Assurance (CQA) Plan for the construction of final cap system appended to the Closure Plan.

   A CQA Plan for the final cap system, in accordance with Rule 0.0541 is provided as ***Attachment 1.***

2. (Section 1.1.1) The Rule .0543 (c)(1) requires the cap has " a permeability less than or equal soils underlying the landfill, or the permeability specified for the final cover in the effective permit, or a permeability no greater than 1.0×10^{-5} cm/sec, **whichever is less**." What is the permeability of the foundation soil (approximate 5-ft man-made compacted fill base) underlying the Cell 1 through Cell 3 of the C&DLF? Please provide the permeability testing results and sample locations relative to the landfill footprint. If the above-requested data are not

available, the alternative soil cap system consisting geosynthetic material and earthen material may be warranted and proposed in the Closure Plan.

The material used for Cell 3, which is representative of on-site material is non-plastic sand, with a unified soil classification that ranged from SP to SM. No hydraulic conductivity testing was required or performed on this material during construction; but based on the material testing and classification, it is reasonable to conclude that the hydraulic conductivity for the construction materials used for the landfill subgrade is greater than 1 x 10^{-5} cm/sec. Therefore, the low permeability soil liner material is being specified as having a hydraulic conductivity of 1 x 10^{-5} cm/sec or less.

3. (Section 1.1.1) The Closure Plan proposes to add bentonite to the on-site soil at a rate of 2% to achieve the required permeability of the low permeability layer. Are there laboratory testing results to support the proposed 2% soil/bentonite ratio being able to achieve the required permeability? What are the provisions (such as a type and quality of bentonite, equipment for mixing and placement processes, and in-place QC testing) to confirm the constructed low permeability layer having a permeability less than or equal to the required permeability?

   There are no laboratory testing results to support the proposed 2% soil/bentonite ratio. This ratio was used based upon previous project experience. As provided in the CQA plan, the appropriate soil/bentonite mix will be established by the Contractor during construction.

4. (Section 1.1.1) To ensure that the earthen material proposed for constructing a final cap can meet the safety factors obtained from the slope stability analysis indicated in Appendix A, the minimum acceptable values of soil density, shear strength, and internal frication angle of the proposed earthen material must be specified in the CQA plan. Additionally, to verify and confirm the in-place material meeting the criteria, the QA/QC testing frequency and methods need to be specified in the CQA Plan.

   The CQA Plan includes the information requested above.

5. (Section 1.1.2) The Permittee may need to explain why the installation and monitoring of perimeter landfill gas wells/probes are not required for the landfill units during their active life and post-closure periods.

   A gas monitoring plan was not previously required, but will be implemented as part of the next cell construction (Cell 4), per the current C&D rules. ***Attachment 2*** *provides the proposed gas monitoring plan for Cells 1-4.*

6. (Section 1.2) The Closure Plan needs to provide scaled drawings to show, but not limited to, the final grades of each closed cells – Cell 1 through Cell 3 (topographic and profile details), erosion and sediment control devices (or BMP), monitoring points (groundwater, surface water, methane gas). Please provide the drawings to the Closure Plan.

   The information requested above was provided in the Dare County Cell 3 Permit to Construct, Permit No. 28-03, which was received by the Division of Waste Management Solid Waste Section on June 7, 2005 and approved on July 22, 2005. This information will also be provided as part of the Cell 4 Permit to Construct. .

7. (Section 1.4.8) In addition to the submittal of certification of closure construction, the Permittee must submit the CQA Report to the Division for review and approval. The CQA report is required by Rule .0540(8) and must be prepared in accordance with Rule .0541.

   This requirement has been addressed in the attached CQA Plan.

8. (Table 1-1) Was there a "shrinkage factor" used to calculate the quantity of soil cap system components? What is the assumption of the soil sources - from the on-site or off-site borrow sources? Please clarify.

   The material quantity and cost provided in Table 1-1 is as measured in-place. A revised Table 1-1 is provided in ***Attachment 3****, which notes this assumption.*

9. (Table 1-1) Have the costs associated with bidding, contracting, closure certification, record notation to deed been considered in the cost estimate for closure? Please clarify.

   A note has been added to the attached Table 1-1 describing the services included as part of the estimate.

10. (Table 1-1) What are the temporary and permanent erosion controls to be constructed during the period of site closure? Please provide an Erosion and Sediment Control Plan and detailed drawings related to the closure activities.

    The construction activities will utilize in-place devices as identified and approved in the Cell 3 Permit to Construct.

Post-Closure Plan

11. (Section 2.1) Please provide the typical examples (with the standardized format) of post-closure inspection forms which will be placed in the post-closure log book. Additionally, the post-closure inspection items must include access road, site security (fencing, signs, gates, etc.) which are listed in Table 2-1. The Post-Closure Plan needs to propose how the inspection and maintenance tasks of above-mentioned items are implemented during the post-closure care periods.

    Attachment 4 *provides a typical example of a post-closure inspection form. In addition, Section 2.1 has been revised to include access road, site security (fencing, signs, gates, etc.). The revised Section 2 is provided as* ***Attachment 5.***

12. (Section 2.1.2) The Permittee should detail the groundwater and surface water monitoring requirements and corrective action requirements, if deem necessary, during the post-closure period [Rules .0543(e)(1)(B)].

    The information requested above was provided and approved in the Dare County Cell 3 Permit to Construct.

13. (Section 2.1.3) The Permittee should detail the methane gas control plan during the post-closure period [Rules .0543(e)(1)(C)].

    Please reference the response to Comment 5.

14. (Section 2.2) The Permittee should provide an Erosion and Sediment Control Plan and detailed drawings related to the closure and post-closure activities of Cells 1 through 3 [Rule .0540(7).]

    The closure and post closure activities will utilize in-place devices as identified and approved in the Cell 3 Permit to Construct.

15. The Post Closure Plan needs to describe what kinds of tasks involve two cost items - "Administration" and "Engineering" listed in Table 2-1 during the post closure care period. Please clarify.

    *A revised Table 2-1 is provided in **Attachment 6**. The revised Table 2-1 includes a description of the Administration and Engineering costs.*

16. (Table 2-1) Cost items under "Maintenance" need add tasks of maintaining surface water monitoring points and landfill gas wells/probes. Please make necessary corrections.

    *This information has been included in the revised Table 2-1 provided in **Attachment 6**.*

If you have any questions or need additional information, please do not hesitate to call me at (919) 787-5620.

Very truly yours,

W. Michael Brinchek, P.E.
Project Manager
Camp Dresser & McKee

Enclosures
cc: Ed Mussler, DWM
Edward Mann, Dare County
Kenton Yang, CDM

Attachment 1
Final Cap System CQA Plan

Construction Quality Assurance Plan
Closure Cap
Contents

Section 1
Introduction

1.1 Purpose

The Construction Quality Assurance (CQA) Plan is intended to fulfill Rule .0541, which requires that a CQA Plan be developed to ensure that the design materials meet the design specifications and the construction and certification requirements set forth in Rule.0540 for the closure of C&D landfills. This plan describes the observations and tests that will be used before, during, and upon completion of closure construction to ensure that the construction materials and workmanship meet the design specifications and the requirements set forth in Rule .0543.

1.2 Quality Assurance and Quality Control

In the context of this CQA Plan, quality assurance and quality control are defined as follows:

- ***Quality Assurance:*** A program of tests and observations, executed by a party independent of the contractor, performed in order to confirm that completed work meets contractual and regulatory requirements and will perform satisfactorily in service.

- ***Quality Control:*** Those actions performed by the contractor or an agent of the contractor which provide a means to monitor the quality of the work being performed.

1.3 Units

In this CQA Plan, all properties and dimensions are expressed in U.S. units, with "equivalent" SI units in parentheses. It should be noted that the conversion is typically only accurate within ten percent. In cases of conflict or clarification, the U.S. units shall be deemed to govern.

1.4 References

The CQA Manual includes references to test procedures of the American Society for Testing Materials (ASTM).

1.5 Overview of Manual

Per .0541(b)(1) through (5) this CQA Plan addresses:

1. Responsibilities and authorities. The plan establishes responsibilities and authorities for the construction management organization. This includes a pre-construction meeting conducted prior to beginning construction of the closure cap. The meeting shall include a discussion of the construction management organization, respective duties during construction, and periodic reporting requirements for test results and construction activities. This information is presented in subsequent sections.

2. Inspection activities: A description of all field observations, tests, and equipment that will be used to ensure that the construction meets or exceeds all design criteria established in accordance with Rule .0543(c) is presented in Sections 4 through 6 of the CQA Plan.

3. Sampling strategies. A description of all sampling protocols, sample size, methods for determining sample locations and frequency of sampling is presented in Sections 4 and 5.

4. Documentation. Reporting requirements for CQA activities are described in detail in Sections 3 through 6

5. Progress and troubleshooting meetings. A plan will be prepared for holding periodic troubleshooting meetings. The proceedings of the meetings will be documented. Meeting information is included in Section 3 of the Plan.

Section 2
Definitions, Responsibilities, and Qualifications of Parties

The parties discussed in this section are associated with the ownership, design, construction, and quality assurance of the landfill closure cap. The definitions, responsibilities, and qualifications of these parties are summarized in Table 2-1 and outlined in the following subsections.

2.1 Contractor

2.1.1 Definition

The Contractor is the company with which the Owner has entered into agreement to construct the project.

2.1.2 Responsibilities

The Contractor is ultimately responsible for meeting the requirements of the Contract Documents and the successful completion of the landfill closure cap construction. Some of the Contractor's specific responsibilities include: providing qualified personnel to perform quality control, providing submittals for the various materials as required by the specifications, scheduling and coordinating the work with suppliers and subcontractors, providing a representative at all times during construction activity, provide surveying services, furnish progress and record drawings, attending progress meetings, and notifying the Engineer of design discrepancies.

2.1.3 Qualifications

The Contractor shall be experienced in all aspects of the work required to successfully construct the project. The Contractor shall be registered in the State of North Carolina and shall provide references from previous projects.

2.2 Contractor's Representative

2.2.1 Definition

The Contractor's Representative (CR) is a qualified individual assigned by the Contractor to represent him/her onsite during construction activities.

2.2.2 Responsibilities

The CR is responsible for: communication with the Engineer and Owner, coordinating and supervising his crew, subcontractors, and quality control personnel, ensuring that construction activities are conducted in accordance with the plans and specifications, immediately notifying the Engineer's Field Representative (EFR) of any discrepancies between the plans and specifications and the field conditions, attending all meetings held on the project, and keeping a daily log of all construction activities onsite.

Table 2-1
Project Personnel Responsibilities

PARTY	DEFINITION	RESPONSIBILITIES	QUALIFICATIONS	REPORT TO
Contractor	Company contracted by Owner to construct project in accordance with plans and specifications	Page 2-1	Licensed in North Carolina and similar project experience	Owner, Engineer, and EFR
Contractor's Representative (CR)	Person assigned by the Contractor to act as the CR onsite	Pages 2-1 and 2-3	Similar project experience	Contractor and EFR
Engineer	Company contracted by Owner for design of the project and to provide services during construction	Page 2-3	Registered professional engineer in North Carolina	Owner
Engineer's Field Representative (EFR)	Person assigned by the Engineer to perform QA inspection and document construction activities	Pages 2-3 and 2-4	Similar project experience	Engineer and Owner
Quality Assurance Laboratory (QAL)	Lab assigned by Owner or Engineer to conduct materials testing	Page 2-4	Experience in testing in accordance with ASTM.	EFR and Owner

2.2.3 Qualifications

The CR shall be an individual who demonstrates the capability to direct all tasks required for landfill closure cap construction. The CR shall demonstrate experience similar to the nature of the project and be knowledgeable of all aspects of the work.

2.3 Engineer

2.3.1 Definition

The Engineer is the party with which the Owner has entered into agreement with to provide project design and construction oversight.

2.3.2 Responsibilities

The Engineer is responsible for performing the engineering design and preparing the associated construction drawings and specifications. The Engineer is responsible for approving all design and specification changes, clarifying the design, reviewing and approving shop drawings, and other tasks as required during construction. The Engineer conducts the pre-construction meeting and progress meetings outlined in this plan. The Engineer will certify that the construction was completed in accordance with this CQA plan and the conditions of the closure plan in accordance with the requirements of Rule .0543 (c)(7), and acceptable engineering practices.

2.3.3 Qualifications

The Engineer shall be a professional engineer registered by the State of North Carolina. The Engineer shall have a working knowledge of landfill closure cap design and construction and all applicable regulatory requirements.

2.4 Engineer's Field Representative

2.4.1 Definition

The EFR is a qualified individual assigned by the Engineer to observe and document activities requiring quality assurance.

2.4.2 Responsibilities

The EFR is responsible for observing and documenting activities related to the quality assurance of the construction of the landfill closure cap. The EFR is responsible for implementation of this CQA Plan and coordination of the Quality Assurance Laboratory (QAL).

The specific duties of the EFR are as follows:

a. Review all construction drawings and specifications.

b. Review other site-specific documentation, including permits.

c. Review all changes to design drawings and specifications as issued by the Engineer.

d. Act as the Owner's representative.

e. Attend all quality assurance related meetings, e.g., resolution, pre-construction, progress, trouble-shooting, etc.

f. Review Contractor's Daily Reports, logs, and photographs.

g. Report to the Engineer, and log any relevant observations.

h. Review the results of laboratory testing.

i. Report any unapproved deviations from the CQA Manual.

j. Prepare the final certification report.

2.4.3 Qualifications

The EFR shall be experienced with the implementation and preparation of quality assurance documentation including: quality assurance forms, reports, certifications, and manuals; and shall have prior experience with soil liner installation.

2.5 Quality Assurance Laboratory

2.5.1 Definition

The QAL is a firm, independent from the Contractor and Owner, responsible for conducting tests on samples of materials for the closure cap construction.

2.5.2 Responsibilities

The QAL shall be responsible for conducting the appropriate laboratory tests as directed by the Engineer and in accordance with the project plans and specifications. The test procedures shall be done in accordance with the test methods outlined in this CQA Plan.

2.5.3 Qualifications

The QAL shall have experience in soil testing and be familiar with American Society for Testing and Materials (ASTM).

2.5.4 Submittals

The QAL shall deliver all test results to the Engineer in written form. Written test results shall be in an easily readable format and include references to the standard test methods used.

Section 3
Communication Between Involved Parties

Communication is essential to achieve a high level of quality during construction and to assure the final product that meets all project requirements. This section discusses the necessary lines of communication.

3.1 Lines of Communication

All communication between parties shall go through the Engineer's Field Representative (EFR), who, in turn, will direct the communication through the proper channels.

3.2 Pre-Construction Meeting

A pre-construction meeting shall be held before construction activity begins. The meeting shall be conducted by the Engineer and attended by the Owner, EFR, Contractor, CR, and a Solid Waste Section representative.

Per Rule .0541(b)(1), the meeting will include a discussion of the construction management organization, the responsibilities and duties of each party during construction, and periodic reporting requirements for testing results and construction activities.

3.3 Progress and Troubleshooting Meetings

Per Rule .0541(b)(5) progress and troubleshooting meetings shall be conducted by the Engineer and attended by the Owner, EFR, and CR. Progress meetings shall be held as deemed necessary, but at a minimum frequency of one per month. These meetings shall discuss current progress, planned activities to be accomplished prior to the next progress meeting, issues requiring resolution, and any new business or revisions to the work. The EFR shall log any problems, decisions, or questions arising at this meeting. If any matter remains unresolved at the end of this meeting, the EFR will be responsible for obtaining a resolution of the matter and for forwarding communication of the decision to the appropriate parties.

Section 4
Low Permeability Soil Liner

The materials, construction and certification requirements in this Section are intended to comply with Rule .0543 (c)(1)(A) and (B).

4.1 Materials

A. Low permeability soil liner materials shall conform to the following properties:

■ Passing the 1-inch Sieve	ASTM D422	100 percent
■ Passing the 200 Sieve	ASTM D1140	45 percent minimum*
■ Liquid Limit	ASTM D4318	30 minimum*
■ Plasticity Index	ASTM D4318	7 minimum*
■ Soil Classification	ASTM D2488	SC, CH, CL, CH, ML, MH
■ Hydraulic Conductivity	ASTM D5084	1.0×10^{-5} cm/s maximum
■ Internal Friction Angle	ASTM D4767	19° minimum
■ Organic Content	ASTM D2974	5% maximum

* The Engineer may modify these conformance test properties based on the results of initial conformance testing, provided modification of these results does not compromise the hydraulic conductivity or internal friction angle test results.

B. A soil-bentonite mixture can be used for the low permeability soil liner provided it achieves the specified hydraulic conductivity and internal friction angles as presented in Paragraph 4.1 A. Both onsite and offsite soils may by used for soil-bentonite mix. Soil to be used for the soil-bentonite mix shall conform to the following properties:

■ Passing the 1-inch Sieve	ASTM D422	100 percent
■ Soil Classification	ASTM D2488	SC, SM, CL, CH, ML, MH

- Soils with organic materials of any kind, particularly leaves and roots, shall not be used in the mixture.

C. The soil-bentonite mixture shall consist of an acceptable soil described in Paragraph 4.1 B containing a sealant consisting of free flowing, high swelling sodium-based Wyoming type bentonite. The bentonite sealant shall conform to all items of this specification with all supporting test data certified, submitted to, and approved by the Engineer, prior to bid, as follows:

- The bentonite shall be covered by the Manufacturer's warranty against defects in material and workmanship and shall have a useful life of 30 years under normal weathering and normal use conditions.

D. The low permeability soil liner or soil-bentonite mixture material used for cap construction shall be uniform in character, and after compaction, shall have an in-place saturated hydraulic conductivity of 1.0×10^{-5} cm/s or less.

E. The Contractor shall use adequate construction quality control (CQC) to verify the conformance of materials according to this section. The Contractor shall submit to the Engineer, within 30 days of the effective date of the Agreement, representative samples from the soil source(s). In the case that the submitted samples fail to conform to the required criteria, the Contractor may locate another source, and upon approval of that source by the Engineer, submit samples from the new source for conformance testing at the cost of the Contractor.

F. If the Contractor plans to use any blending of soils as low permeability soil liner material, the Contractor shall submit the blended soil for the Engineer's approval in accordance with the requirements.

4.2 Conformance Testing

A. Initial conformance testing shall be performed by the quality assurance laboratory (QAL) on samples from the soil source to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be dug by the Contractor under the direction of the QAL. The following tests shall be performed on the samples. For soil to be used in a soil-bentonite mix, test 8 will not be performed.

1. Soil Classification (ASTM D2487)
2. Sieve Analysis (ASTM D422) (including hydrometer analysis)
3. Atterberg Limits (ASTM 4318)
4. Moisture-Density Curves (ASTM D698)
5. Specific Gravity (ASTM D854)
6. Laboratory Hydraulic Conductivity (ASTM D5084 except as modified in Paragraph 4.3.1.G)
7. Natural Moisture (ASTM D2216)
8. Shear Tests (ASTM D4767 or as approved by the Engineer)

B. For natural low permeability soil sources, the QAL shall determine an acceptable zone of moisture contents, dry unit weights and compaction for which hydraulic conductivities are less than or equal to 1.0×10^{-5} cm/s by performing the following testing and analysis procedures:

   1. Using the samples extracted from the proposed source, perform Modified and Standard Proctor compaction tests to develop at least two moisture-density curves. For each of the compaction tests use up to five specimens at incremental moisture contents to develop a compaction curve showing dry density for each molding water content.

   2. Permeate each compacted specimen to determine its hydraulic conductivity in accordance with ASTM D5084.

   3. On the graph of dry density vs. moisture content, identify the samples which have hydraulic conductivities less than or equal to 1×10^{-5} cm/s.

   4. Draw an "acceptable zone" of water content and dry density around the passing samples.

   5. Perform Internal Shear Tests on one specimen from the high and low ends of the acceptable zone and plot the friction angles as a function of molding water content.

   6. Based on the shear test results and other pertinent factors such as constructibility, shrink/swell potential, dessication cracks, and consolidation, the QAL shall modify the acceptable zone as required.

C. For soil-bentonite mixes, prior to constructing the test pad, the QAL shall determine an acceptable zone of moisture contents and dry unit weights in which the hydraulic conductivity is less than or equal to 1.0×10^{-5} cm/sec by following the procedures described above in Paragraph 4.2.B (with the exception that samples will be extracted from the pug mill operation). The samples will be taken from a soil-bentonite mix once the bentonite percentage for production has been firmly established. The Contractor shall be responsible for performing preliminary hydraulic conductivity tests on initial mix ratios (based on manufacturer's recommendation and adjusted based on Contractor's experience) in order to establish the percentage of bentonite to be used in production.

D. For each delivery of material from the borrow source, the quality control laboratory (QCL) personnel of the Contractor shall note, on an approved form, the color of the material, date, time, and approximate quantity of material brought onsite and submit copies of completed forms to the Engineer . The soil source shall be conformance tested by the QCL during the excavation and stockpiling operation at the following frequency.

Test	Method	Frequency
Grain Size w/hydrometer	(ASTM D422)	Every 2,000 cy
Atterberg Limits	(ASTM D4318)	Every 2,000 cy
Moisture/Density	(ASTM D698)	Every 5,000 cy
Natural Moisture	(ASTM D2216)	Every 2,000 cy

Results of the tests will be submitted to the Engineer within 24 hours of test completion. The Engineer reserves the right to reject material based on the results of the conformance tests.

4.3 Construction

4.3.1 Test Pad

A. A test pad of a dimension of no less than 40-ft by 60-ft and 18-inch thickness shall be constructed onsite using the same equipment, processing and installation procedures that will be used during full-scale liner construction. The low permeability soil or the soil-bentonite mixture to be used for the test pad shall be the same material that the Contractor proposes to use for construction of the base liner. If approved by the Engineer, the test pad may be installed within the cap limits and incorporated in the work, provided the pad passes all testing requirements.

B. The construction of the pad shall be directed by the QCL. The QCL shall use the acceptable zone established by the QAL to set moisture contents and percent compaction. The QCL may perform tests as needed to assist in the construction of the test pad. However, only the results of the QAL's test will be recognized for determining the performance of the pad.

C. For each lift, the QAL shall perform testing of moisture content and density at a minimum of three test locations. The QAL shall record moisture content, compaction procedures, and density throughout the construction of the test pad. Two Shelby Tube Samples shall be obtained per lift by the QAL. One tube will be used to perform a hydraulic conductivity test. The second tube will be kept as a backup in case of damage to the first sample or dispute of test results.

D. For soil-bentonite mixtures, the bentonite content used for the test pad shall be set by the Contractor and written notification of the mix ratio will be submitted to the Engineer prior to constructing the test pad.

E. One triaxial type hydraulic conductivity test (ASTM D5084) will be performed on each test pad per lift.

H. The cap thickness shall be determined from four locations selected by the QAL per test pad using a method that is approved by the Engineer, which will be determined prior to test pad construction.

4.3.2 Soil Liner Installation

A. The QCL shall supervise the soil liner installation. Work shall not be performed by the Contractor without the QCL onsite. The QCL shall perform field tests (ie. moisture content, densities, etc.) as required to ensure proper installation. The QAL shall perform tests as described in Section 4.4 to determine acceptance of the soil liner.

B. The placement moisture content shall be within the acceptable zone of moisture content as determined by the QAL during the conformance testing of the low permeability soil described in Paragraph 4.2 The acceptable zone may be modified by the Engineer based on results and observations of the test pad.

C. Water for Compaction

1. The Contractor shall provide water as required to guarantee constructability and proper condition of the inplace and stockpiled material.

2. The water shall be of potable quality.

3. Prior to installing the soil liner, the Contractor shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the material be stockpiled for any length of time the Contractor shall slope and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the Contractor shall spread and dry the material as needed to adjust the moisture to the proper level.

D. The materials shall be uniformly compacted to no less than the minimum dry density of the acceptable zone that corresponds to the placement moisture content. The acceptable zone shall be as specified by the QAL in accordance with the procedures outlined in Section 4.3.1?. This minimum density shall be uniformly obtained throughout the entire thickness of the liner. The cap shall be constructed in lifts with a maximum compacted thickness of 6 inches per lift to assure achievement of the specified compaction in the lower part of the cap. However, the initial lift may be placed at 8 inches to prevent mixing with the existing operational cover during compaction.

E. Soil liner material which has been contaminated with clusters of rock or gravel, sand lenses, organic debris or other deleterious material shall be removed and replaced with uncontaminated low permeability soil materials.

F. The Contractor shall use a pugmill to produce the soil-bentonite mix at the required moisture content to achieve an in-place compacted minimum 18-inch thick layer of material with a hydraulic conductivity less than or equal 1×10^{-5} cm/sec. Based on the soil material to be used, the Engineer may direct the Contractor to screen the soils prior to placement in the pugmill. The pugmill must be approved by the Engineer prior to its arrival on site.

G. No low permeability soil liner material shall be placed, spread, or compacted while the existing operational cover or soil liner material is frozen/thawing, saturated, desiccated, nor during unfavorable weather conditions or periods of precipitation. The cap surface must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation of the soil liner material. Any regrading due to the above conditions or final preparation should be retested at those locations for liner thickness prior to placement of the next lift or erosion control layer. Thickness measurements should be performed as indicated in Section 4.4.1.

H. Work shall be limited to an area where a lift can be completed in one working day and shall continue in that area until three lifts have been placed. Completion of an area shall be defined as the construction of a cap of a minimum 18-inches that is homogenously installed at a moisture content and density within the acceptable zone, free rocks larger than 1-inch diameter, and possessing a smooth rolled surface.

I. If a lift is not to receive a subsequent lift within 16 hours of its completion, the lift shall be sealed with a smooth wheel compactor at the end of each day's work to protect the material from desiccation. Should desiccation cracks develop, soil liner material shall be scarified, disked, rewetted, rehomogenized and recompacted in accordance with the Specifications to the depth of any such cracks or as instructed by the Engineer. If desiccation extends below half of the lift thickness, the lift shall be removed and replaced.

J. During construction, the Contractor shall make all necessary provisions to deal with inclement weather conditions. The Contractor shall be fully responsible for control of stormwater during installation of the cap system and for moisture control and protection of the low permeability soil liner.

M. After final grading and smooth rolling is completed, the compacted soil liner thickness shall not be less than 18-inches. Soil liner will be tested by the QAL on the final lift at a frequency as specified in Section 4.4.1 using a method of hand augering or push tube sampling (minimum 3/4" sample). Each test shall penetrate all underlying lifts to disposed waste. The thickness shall be measured from top of waste to top of low permeability soil liner. Areas not meeting the thickness requirements shall be augmented with additional low permeability soil

material at the expense of the Contractor. Any additional testing or CQA services associated with corrective action for achieving the 18-inch cap thickness requirement will be at the cost of the Contractor. The added material shall be worked into the in-place liner to ensure homogeneity and proper bonding. This shall be done by scarification of the surface prior to addition of the new material. As a minimum, the top 4-in of the soil liner shall be wetted, kneaded, compacted and reworked with the additional material to obtain the required thickness.

4.4 Certification

4.4.1 Field Quality Control

A. The QAL shall conduct the following tests during installation of the low permeability soil or soil-bentonite liner at the specified frequencies.

Test	Method	Frequency
Atterberg Limits	(ASTM D4318)	2/acre/lift
Moisture of Undisturbed Hydraulic Conductivity Sample	(ASTM D2216)	1/two acres/lift
Undisturbed Hydraulic Conductivity	(ASTM D5084)	1/two acres/lift
Density	(ASTM D2937 or ASTM D2992)	4/acre/lift
Moisture	(ASTM D2216 or ASTM D3017)	4/acre/lift
Liner thickness	(Hand Auger or push tube)	4/acre
Grain Size	(Sieve Only)	2/acre/lift

B. All holes made as a result of depth measurements, hydraulic conductivity samples, density tests, grade stakes or other means shall be completely filled by the Contractor with bentonite or soil-bentonite mix, as instructed by the Engineer.

C. The Engineer shall have the authority to request additional hydraulic conductivity tests in areas that, in the Engineer's judgement, may be suspect or deficient. Hydraulic conductivity tests shall be conducted in accordance with ASTM D5084 except as modified in Paragraph 4.3.1.E. For each sample tested, one back-up sample will be extracted in the proximity of the sample location. These samples will be held in a controlled environment at the QAL laboratory as a precautionary measure. If adequate demonstration is presented that a sample was not

representative of the low permeability soil liner or that an error in testing occurred, the backup samples will be tested and the original test will be disregarded.

D. Any sample or area tested shall be rejected, removed and replaced if it does not meet the requirements of the technical specifications. Reconstructed areas shall have feathered, overlapping edges that tie into adjacent liner areas.

E. Grade stakes for soil liner construction shall be numbered by the Contractor and located on an inventory map. The inventory map shall be submitted to the Engineer. Upon completion of an area, the removed stakes will be compared to the inventory map to ensure that none were left inplace.

F. The Contractor shall submit a survey plan with final elevation of top of low permeability soil liner for Engineer's approval.

4.4.2 Corrective Action

If soil has been desiccated to a depth less than or equal to the thickness of a single lift, the desiccated lift may be disked, moistened, and recompacted. However, disking may produce large, hard clods that will require pulverization. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods and hydration to take place uniformly. For this reason it may be necessary to remove the desiccated soil from the construction area, process the lift in a separate processing area, and replace the soil accordingly.

Section 5
Vegetative Cover Materials

The materials, construction and certification requirements in this Section are intended to comply with Rule .0543 (c)(1)(C).

5.1 Materials

A. Vegetative Cover Material

1. Vegetative cover material shall be capable of sustaining native plant growth. Vegetative cover soil shall not be compacted except by tracking during spreading operations.

B. Erosion Control Blanket

1. If needed, erosion control blankets shall consist of wood excelsior with 80% 6-inch fibers or greater fiber length with the top of the blanket covered with photo-degradable or biodegradable netting. Blanket shall be of consistent thickness with fibers evenly distributed throughout the entire area of the blanket. Blanket shall be recommended by manufacturer for use on slopes up to 1.5:1, stormwater channel velocities up to 5 fps, and flow shear stresses up to 2 lbs/sf.

5.2 Conformance Testing

A. Vegetative cover material shall be tested for nutrient fertilizer requirements and pH requirements at a frequency of once per 5,000 cubic yards.

1. The pH value shall be between pH 6.0 and 7.0.

2. Fertilizer and lime shall be spread and incorporated as per soil test recommendations after the vegetative cover material is spread but prior to fine grading.

5.3 Construction

A. The Contractor shall be responsible for identifying earthen material to be used for vegetative cover material and adding amendments to create suitable vegetative cover material. Stockpiled material may be used in areas disturbed by Contractor's activities as approved by the Engineer.

B. Commercial fertilizer, lime, peat, humus, sand or other additives shall be used to counter act soil deficiencies as recommended by the soil analysis and as directed by the Engineer.

5.4 Certification

A. Vegetative cover material thickness will be tested by the QAL on the final lift at a frequency four per acre using a method approved by the Engineer prior to construction of the vegetative cover construction. Each test shall penetrate to the low permeability soil liner material. The thickness shall be measured from top of vegetative cover to top of low permeability soil liner. Areas not meeting the thickness requirements shall be augmented with additional vegetative cover material.

Section 6
Documentation

This Section is intended to comply with Rules .0540(8) and .0541(b)(4) and .0543(c)(7).

Upon completion of construction activities, a Construction Quality Assurance Certification Report will be submitted to the Solid Waste Section in accordance with Rules .0541 and .0543. The report will summarize all quality assurance services performed during construction of the C&D landfill cap and will include, at a minimum the following:

- Field observation inspection reports;
- The results of all construction quality assurance and construction quality control testing required by this Plan;
- Documentation of any failed test results, descriptions of procedures used to correct the improperly installed material and results of all retesting performed;
- Record drawings documenting the completed project and noting any deviation from the approved engineering plans; and
- A comprehensive narrative including, but not limited to, daily reports from the project engineer and a series of color photographs of major project features.

The CQA Certification report shall bear the seal of a North Carolina Professional Engineer who was involved during the construction and a certification that construction was completed in accordance with:

1. This CQA Plan;
2. The conditions of the Permit to Construct;
3. The requirements of Rules .0541 and .0543; and
4. Good engineering practices.

Attachment 2
Gas Monitoring Plan

Appendix B – Contents
Gas Control Plan – C&D Landfill

Section 1
Introduction

Landfill gas (LFG) is a natural by-product of the anaerobic decomposition of landfilled bio-degradable waste. LFG can present a danger to human health and the environment and therefore must be monitored. For these reasons, LFG is regulated by Federal and North Carolina state legislation. This Plan describes the systems and programs needed to fulfill federal and state regulations concerning LFG. In addition, this Plan describes the characteristics of LFG and its migration patterns; and provides alternative methods to control and destroy its harmful components. This additional background information is presented in the Plan to insure it is readily available should a situation occur that requires information and action beyond that described in this Plan. Since this plan is for the C&D landfill, it is noted that LFG generation is expected to be minimal based on the lack of organic matter in the waste stream.

1.1 Purpose

This Plan fulfills the requirements set forth in Rule .0544(d) for monitoring and controlling LFG. This Plan:

- describes the necessary LFG monitoring systems,
- sets forth the monitoring procedures and programs, and
- identifies the actions needed if levels of methane exceed regulatory limits.

1.2 General Characteristics of LFG and Methane Generation

LFG can be an energy resource as well as a source of environmental pollution. The methane content is what makes LFG valuable as an energy resource. LFG is composed of approximately 50 percent methane in contrast to natural gas which consists of approximately 95 percent methane. LFG programs which focus on recovering gas as an energy resource include collection and extraction systems used to maximize its recovery. What makes LFG a source of environmental pollution is its odor, its potentially explosive properties, and its contribution to global warming. LFG programs which focus on the environmental hazards of landfill gas include collection systems to monitor the migration of gas and control or neutralize its environmental impacts.

LFG is composed of 50 to 55 percent methane (CH4); 45 to 50 percent carbon dioxide (CO2); and, less than one percent non-methane organic compounds. These individual gases remain co-mingled and do not naturally separate.

1.2.1 Decomposition Rate and Volume

The decomposition of bio-degradable waste begins with aerobic decomposition that typically lasts three to 18 months until the oxygen in the municipal solid waste (MSW)

landfill is depleted. Following this, the anaerobic phase begins which results in LFG production. This anaerobic phase continues until all of the carbon-based materials are broken down or oxygen is reintroduced.

A reintroduction of oxygen does not stop the production of LFG, it only inhibits it. The volume of LFG generated over the life of a landfill is a function of the total volume of organic waste in the landfill as influenced by age, moisture, compaction, and pH.

1.2.2 LFG Migration

The production of LFG creates a positive pressure within the landfill that forces the gas to migrate. LFG is lighter than air and moves upward unless there is a barrier. LFG will move laterally along the path of least resistance or lowest pressure. LFG migration is a function of soil conditions, hydrogeologic conditions, and weather conditions. LFG moves through porous soils, along underground pipes, and through trenches. In some cases the LFG migration path can be observed at the surface through observations of stressed vegetation. In these instances LFG replaces the oxygen in root structures and eventually destroys the plants.

If tightly capped, LFG will move downward or laterally. Unless LFG is collected, it may migrate laterally, off the landfill site. If the MSW landfill does not have an impermeable cover cap, LFG may migrate upward, through the MSW landfill surface and cause odor and air quality problems. The lining and capping of an MSW landfill does not effect the production of gas, it improves the potential to collect and control it.

Section 2
Regulatory Background

Because of the real and potential dangers from LFG and the methane in landfill gas, to the public health and safety and to the environment, existing state regulations require owners of C&D landfills to monitor and control it.

2.1 C&D Landfills and North Carolina Regulations

Methane gas is explosive when present within the range of 5 to 15 percent by volume in air. When present in concentrations greater than 15 percent, the mixture will not explode. The 5 percentage mixture is referred to as the Lower Explosive Limit (LEL) while the 15 percentage concentration is referred to as the Upper Explosive Limit (UEL). The State of North Carolina, through its 15A NCAC 13B .0544(d)(1), requires owners or operators of all C&D landfills to ensure that the facility:

A) Does not exceed 25 percent of the LEL for methane in facility structures;

B) Does not exceed the LEL at the facility property boundary; and

C) Does not release methane gas or other explosive gases in any concentration that can be detected in offsite structures.

The LEL means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25 C and atmospheric pressure.

Rule .0544(d)(2) requires that a routine methane monitoring program be implemented to insure that these standards are met. The type of monitoring will be determined based on soil conditions, hydrogeologic conditions under and surrounding the facility, hydraulic conditions on and surrounding the facility, the location of facility structures and property boundaries, and the location of all off-site structures adjacent to property boundaries. Additionally, frequency of monitoring shall be quarterly.

Rule .0544(d)(3) requires that if methane or explosive gas levels exceed the specified limits, the owner or operator must:

A) Immediately take all necessary steps to ensure the protection of human health and notify the Division;

B) Within seven days of detection, place in the operating record the methane or explosive gas levels detected and a description of the steps taken to protect human health;

C) Within 60 days of detection, implement a remediation plan for the methane or explosive gas releases, place a copy of the plan in the operating record, and notify the Division that the plan has been implemented. The plan must describe the nature and extend of the problem and the proposed remedy.

Section 3
LFG Monitoring Program

The LFG monitoring program includes a schedule for reading or monitoring LFG emission levels at designated locations on a regular basis and a system for reporting the concentration levels.

The requirements for regularly reading the emission levels, and the plan for actions if readings exceed safe levels should, at a minimum, be based on compliance with state regulations. The plan that is recommended in this report exceeds the regulatory criteria to further protect the health and safety of nearby residents.

3.1 Frequency of Routine Monitoring

Rule .0544(d)(2) states that a quarterly methane monitoring program be implemented.

3.2 Staffing

Monitoring should consist of having a trained technician use calibrated equipment designed to monitor methane at on-site structures on the landfill property and in locations near the C&D landfill.

The job of monitoring the methane levels will require a trained staff person. Available options include training an existing staff person, hiring a special contractor, or hiring part-time staff to perform this task.

3.3 Monitoring Procedures

Each regular quarterly monitoring procedure shall begin by checking methane levels in the scale-house and any occupied structure on the landfill site. Next, the non-occupied buildings at the landfill shall be checked. Finally, monitoring wells around the C&D landfill shall be checked. Currently there are no methane monitoring wells at the facility. Planned well locations for the facility are provided on Sheet 1.

Proposed wells M-1 through M-12 will be used to monitor for LFG migration.

If the methane levels detected within on-site buildings are greater than 25 percent of the LEL, the technician shall immediately follow the actions presented in Section 4.1 of this report. If methane levels detected at the monitoring wells exceeds the LEL, the technician shall immediately follow the action plan presented in Section 4.2.

3.4 Record Keeping

All readings will be recorded on a standard methane monitoring log form. A sample methane monitoring log is provided at the end of this section. These forms will be reviewed and initialed by the landfill supervisor or the County's environmental consultant and then placed in the landfill operating records. These quarterly methane monitoring logs will remain on file at the landfill with other landfill records. These readings should be available for review by EPA and the State upon request.

METHANE MONITORING LOG FORM
(this report must be completed quarterly)

Dare County C&D Landfill
Dare County, North Carolina

Technician Name: _____

Date: (mo/day/year)_____

General weather conditions: _____

Temperature: _____

Barometric condition pressure: _____

MONITORING INSTRUCTIONS

1. Measure methane levels within structures on the landfill property. The landfill gas reading must not exceed 25% of the methane lower explosive limit (L.E.L). If methane measurements exceed 25% of the L.E.L., contact the landfill supervisor and follow the outlined plan in Appendix B of the operations manual.

2. Measure methane levels at all two groundwater monitoring wells located around the C&D landfill boundaries. The landfill gas reading must not exceed 100% of the methane L.E.L. If methane measurements exceed 100% of the L.E.L., contact the landfill supervisor and follow the outlined plan in Appendix B of the operations manual.

3. Complete the entire data sheet located on the next page.

4. If methane levels exceed the above-mentioned levels at any monitoring location, report the measurements to the County for further action as described in the Gas Control Plan – C&D Landfill.

5. File this methane monitoring log sheet in the landfill office in the appropriate record keeping section with other landfill records.

METHANE MONITORING DATA SHEET

Monitoring Locations	*% L.E.L. Reading*	*Within Compliance*		*Landfill Supervisor Contacted*		*Monitoring Point within Structure*
		Yes	*No*	*Yes*	*No*	
Scale house						
Transfer Station						
M-1						
M-2						
M-3						
M-4						
M-5						
M-6						
M-7						
M-8						
M-9						
M-10						
M-11						
M-12						
Comments and Observations:						
Landfill Supervisor Actions Taken:						

Section 4
Contingency Plan

The North Carolina Solid Waste Management Rules, .0544(d)(3), require a contingency plan for action if methane levels exceed the regulatory concentration limits. The plan for action includes the specific step by step actions needed should regulatory limits be detected.

4.1 Actions if Regulatory Limits Detected in Structures

If any structures on the landfill property measures a methane level equal to or more than 25 percent of the LEL the following actions should be taken:

- the building should be immediately evacuated;
- the landfill supervisor should be immediately contacted;
- all individuals in and around the structure should be ordered to immediately stop smoking;
- all space heaters and similar appliances should be immediately disconnected from their power source;
- all doors and windows in the structure which gave the reading should be opened to permit the methane to escape;
- as a precautionary measure, the landfill operator will open doors and windows in all structures on the landfill property; and
- equipment used to take the readings should be tested immediately to verify it was giving accurate readings.

The technician will then proceed to take readings at all groundwater monitoring wells used for the C&D landfill LFG monitoring. All levels should be verified and recorded in the methane monitoring log book. This information, including the verification that the equipment is providing accurate readings, the current readings, and the levels at all monitoring locations for the previous three quarters should be provided to the County's landfill supervisor. The Dare County landfill supervisor will make the decision to return to business as usual; temporarily evacuate the site; or follow the plan proposed in Section 4.3.

4.2 Actions if Regulatory Limits Detected at Monitoring Wells

If any of the methane monitoring wells measure a level equal to or more than the LEL as defined by in the Rules, the technician should:

- immediately contact the landfill supervisor; and

- recheck the methane levels inside the facility structures. If levels are close to or exceed 25 percent of the LEL the actions in Section 4.1 should be followed.

Once it is verified that levels inside the buildings are safe, the technician should check and record readings at all remaining monitoring wells for the C&D landfill. The equipment used to take the readings should be tested to verify it is giving accurate readings.

This information, the current readings, and the levels for the previous three quarters should be provided to the Dare County landfill supervisor who will make the decision to: return to business as usual; temporarily evacuate the site; or, follow the plan proposed in Section 4.3.

4.3 C&D Compliance Action Plan

If upon verification as described in Sections 4.1 and 4.2, the methane monitoring levels are equal to or exceed the regulatory limits as defined by state regulations, the following actions are proposed to comply with state regulations as well as protect the health and safety of the individuals at or near the C&D landfill.

4.3.1 Immediate Action

If methane levels exceed the specified limits, the landfill operator or the landfill supervisor will take immediate action to ensure the protection of human health and safety. This will include:

- evacuate all buildings on the site;
- open all doors and windows in buildings on the landfill site;
- notify the Dare County Manager Office's about the concentration levels;
- if warranted by the degree of intensity of the methane concentration, check the methane levels in structures near the landfill yet outside the facility boundary;
- if warranted by the degree of intensity of the methane concentration, evacuate the landfill area or evacuate the area adjacent to the landfill;
- notify the Division about the reading;
- begin to identify or narrow down the source of the methane causing the readings exceeding the regulatory limits (i.e. the path that the methane is taking to the monitoring location);
- begin to identify the extent of the methane problem; and
- as appropriate, begin to take corrective action to control the methane levels in building at the landfill site, at the boundaries to the landfill, and at the landfill site.

4.3.2 Actions Within Seven Days

If methane levels exceed the regulatory limits, the County must, within seven days, place in the operating record the gas levels detected and a description of the steps taken to protect human health.

It is also suggested that at this time, the operator begin to develop a plan which:

- describes the nature and extent of the problem and
- proposes a remedy for the problem.

4.3.3 Actions Within Sixty Days

If methane levels exceed the specified limits, the County must take the following actions within 60 days:

- implement a remediation plan for the methane gas release;
- place a copy of the plan in the operating record of the landfill; and
- notify the Division that the plan has been implemented.

4.4 Public Relations and Information

As with any potentially dangerous situation, it is important to keep the public, public service agencies, and the media informed. False information, inaccurate information, or the lack of information concerning potential explosions at a public facility could create panic.

If the County Manager determines that a potentially dangerous situation exists, it is recommended that a one page explanation of the situation be written and distributed to all homes and businesses within a one-half mile radius of the landfill. This should be done within the first two to four hours of making the determination that a potential danger to human health and safety exists.

It is recommended that the County Manager appoint one individual to provide information to: the media; the police authorities with jurisdiction in the area; and area medical facilities. Area hospitals and police departments may receive calls once the local media releases the story. Centralizing the flow of information will avoid conflicting information and inaccurate information. Providing detailed and honest facts about the situation being under control is critical.

Section 5
Options for Controlling LFG

This section presents several options which may be implemented by Dare County should methane readings exceed regulatory levels. It is presented in this Plan to insure that the information is readily available to the County if needed.

If regular LFG monitoring demonstrates levels that exceed the regulatory limits, the state requires actions by the owner to eliminate the problem. Remedial options to eliminate the problem include controlling the migration path or controlling the release of the LFG into the environment.

5.1 Migration Control Techniques

Four techniques which can be used for controlling the migration of LFG include:

- impermeable physical barriers
- passive removal system
- active removal system
- air injection or air dikes

5.1.1 Impermeable Physical Barriers

An impermeable physical barrier, such as a landfill liner or a vertical impermeable barrier, can be installed to impede and ultimately stop the migration of LFG. This type of a barrier also helps to contain the gas thereby facilitating its collection.

5.1.2 Passive Removal System

A passive removal system generally provides a safe path of least resistance for migrating LFG to exit the landfill. Passive removal systems include open air ditches or passive venting wells installed in porous gravel trenches. These systems are designed to rely on the difference between the internal landfill pressure and the atmospheric pressure to control the migration path that the LFG takes.

5.1.3 Active Removal System

An active removal system requires the installation of a connected system of collection pipes, wells, trenches, well heads, collection headers, storage tanks, blowers, or compressors. Active removal systems include the use of a mechanized device (usually a gas compressor) to induce a vacuum in the well or trench to draw-out the LFG. Active systems include both positive and negative pressure extraction. Active systems are similar to a gas removal system for recovery projects. Installation of an active removal system may enable the gas control system to be integrated into a recovery system at a future date.

5.1.4 Air Injection

Air injection, or the creation of "air dikes" was first tried in Monterey Park, California in 1980. In this control technique, air is injected into the ground and distributed through a perforated screen. This technique is used to stop the migration of the methane through very saturated soils when use of a vacuum extraction system would pull in water.

The injection of air into a landfill as a technique for controlling LFG migration is potentially dangerous and not recommended. The introduction of air or oxygen into a landfill may create a number of problems such as subsurface landfill fires. Additionally, it could affect the percentage of methane content in the LFG, making it more explosive. The introduction of air will ultimately result in only temporarily slowing the production of methane by interrupting the anaerobic condition and not provide a long term solution. It could also cause the methane to migrate to a more potentially dangerous location.

5.2 Environmental Control Techniques

In addition to controlling the migration of LFG, it is possible and may be necessary to control its negative environmental effects by controlling its release into the environment. Two methods for accomplishing this control are through its recovery and use as an energy source or by burning the LFG through flares.

5.2.1 Control through LFG Recovery Systems

Recovering LFG for use as an energy source virtually eliminates its release into the atmosphere. A LFG recovery system requires the installation of a collection system and a system to pipe the gas to a user or to a generator which can turn the gas into an energy source.

There are two common types of LFG collection system designs, vertical and horizontal. The appropriate system is based on the way the landfill was constructed to be filled, vertically with lifts, or horizontally. A horizontal collection system is best used for landfills filled in a horizontal pattern. A vertical collection system is best used in landfills designed to be filled vertically or vertically with lifts. Both systems involve installing perforated pipes surrounded by rocks or gravel. Horizontal systems install the pipes in trenches. Vertical systems install the pipes in wells or manholes. A horizontal system does not lend itself to a high vacuum recovery operation. This system is best installed as the horizontal layers are completed, before the landfill is completed. Vertical systems can be installed either when the landfill is operating or after it is closed.

While LFG recovery systems are expensive to install and operate, some income may be generated from the sell of the gas or the energy produced from the system.

5.2.2 Control through Flaring LFG

A second method of controlling the release of LFG into the environment is by destroying it by flaring it as it is released from the MSWLF. Like recovering LFG for use as an energy source, flaring LFG also requires a collection system. However, the collection system need not be as elaborate a system as is needed for gas recovery.

In order for the flares used to destroy the harmful components in LFG, they must burn the LFG for:

- an adequate period of time (.25 to five seconds);
- at an adequate temperature (300 to 500 degrees above its auto ignition temperature) to insure complete destruction of trace elements; and,
- with sufficient turbulence, (i.e. with a uniform mix of gas and air).

Four types of flares are typically used throughout the United States: open flares, enclosed flares, invisible flares, and emission control enclosed flares.

- Open Flares, also called pipe flares, function like candles. They are often used with a passive recovery system and are ignited manually. One problem typically associated with them is that they may blow out with a strong wind.
- Enclosed flares are designed to hide the flame and protect it from blowing out in a strong wind.
- Invisible flares extend 20 to 30 feet above the landfill surface and are designed to create a "flame envelope." This design may not permit an adequate gas and air mix.
- Emission control enclosed flares rise 35 to 50 feet above the landfill surface. They are designed with an air damper to control both LFG and air flow. These are the most effective in the destruction of NMOC.

Section 6
Bibliography

Clinton, Michael and Roquetta, Alex. "The Landfill Technician," Municipal Solid Waste Management Magazine, July/Aug, 1992.

EPA, Air and Energy Engineering Research Laboratory, Research Triangle Park, Landfill Gas Energy Utilization:Technical Options and Case Studies, June 1992.

EPA, Clean Air Act, Section 111, May 30, 1991, proposed new source performance standards.

Energy Tactics, Electric Power for Landfill Gas, N.Y., N.Y., August, 1992.

GRCDA/SWANA, Publication # GR-LG 0301, Landfill Gas Management: Control, Recovery, and Utilization, Volume 2, Selected Papers from 1987 - 1990, 247 pp, published 1991.

Khalil, M.A.K. and R. A. Rasmussen. Constraints on the Global Sources of Methane and an Analysis of Recent Budgets. Tellus, 42 B 229-236, 1990.

O'Leary, Philip, Sanitary Landfill Leachate and Gas Management, Seminar Documents, December 3 - 6, 1991.

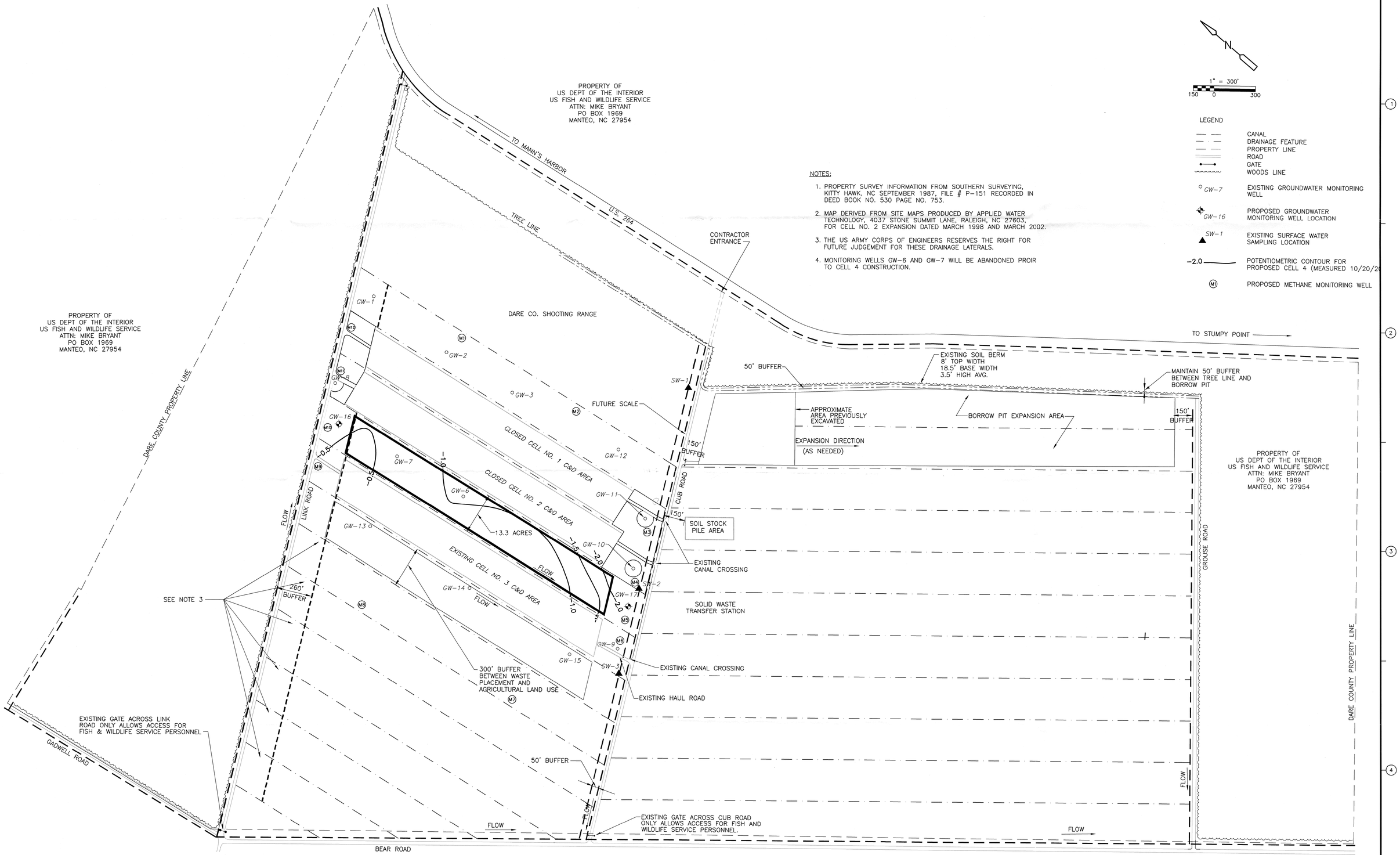
Poland, Ronald, Collection System for Landfill Gas, Recovery and Control, One Size May Not Fit All, Waste Management, Inc, Chicago, Ill. 1991.

Thorneloe, Susan, EPA, Landfill Gas Recovery, Utilization Options and Economics, Presented at the 16th Institute of Gas Technology, March 5, 1992.

Thorneloe, Susan, EPA, Global Emissions and Control, Landfill Gas Utilization, presented at the 2nd U.S. Conference on Municipal Solid Waste Management, June 3 - 5, 1992.

Thorneloe, Susan, EPA, Paper presented at the EPA Symposium on Greenhouse Gas

Emissions and Migration Research, August 18 - 20, 1992.



NOTES:

1. PROPERTY SURVEY INFORMATION FROM SOUTHERN SURVEYING, KITTY HAWK, NC SEPTEMBER 1987, FILE # P-151 RECORDED IN DEED BOOK NO. 530 PAGE NO. 753.
2. MAP DERIVED FROM SITE MAPS PRODUCED BY APPLIED WATER TECHNOLOGY, 4037 STONE SUMMIT LANE, RALEIGH, NC 27603, FOR CELL NO. 2 EXPANSION DATED MARCH 1998 AND MARCH 2002.
3. THE US ARMY CORPS OF ENGINEERS RESERVES THE RIGHT FOR FUTURE JUDGEMENT FOR THESE DRAINAGE LATERALS.
4. MONITORING WELLS GW-6 AND GW-7 WILL BE ABANDONED PROIR TO CELL 4 CONSTRUCTION.

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: M. COLONE
DRAWN BY: J. KILLINGSWORTH
SHEET CHK'D BY: K. YANG
CROSS CHK'D BY:
APPROVED BY:
DATE: DECEMBER 2008

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consulting • engineering • construction • operations

COUNTY OF DARE
NORTH CAROLINA

CONSTRUCTION AND DEMOLITION LANDFILL EXPANSION

LANDFILL GAS MONITORING PLAN

PROJECT NO. 17952-56960
FILE NAME: LFGMP-SHEET1.DWG

SHEET NO. 1

Attachment 3
Closure Cost Estimate

Table 1-1

Closure Cost Estimate
Dare County C&DLF
Dare County, North Carolina
Revised December 2008

	Quantity	Unit	Cost	Total
Final Cover System				
Grade Intermediate Cover/Strip Existing Vegetation	33.9	ac	$1,500.00	$50,850
Cap System Components:				
a. 18" Erosion Layer[1]	82,038	cy	$13.30	$1,091,105
b. 18" Low-Permeability Layer, augmented with 2% bentonite[1]	82,038	cy	$20.00	$1,640,760
Seeding, Fertilizing & Mulching	33.9	ac	$1,850.00	$62,715
Temporary Erosion Control	33.9	ac	$3,000.00	$101,700
Permanent Erosion and Stormwater Control	33.9	ac	$33,300.00	$1,128,870
Landfill Gas Management				
Vertical Gas Vents (34 @ Avg. Depth of 10')	340	vf	$108.50	$36,890
Surveys	33.9	ac	$333.33	$11,300
Final Landscaping				
Seeding, Fertilizing & Mulching	33.9	ac	$1,850.00	$62,715
Indemnification	1	ls	$5,000.00	$5,000
Subtotal				$4,191,905
Bonds and Mobilization/Demobilization (5% of Subtotal)				$209,595
Engineering Services, CQA/CQC (12% of Subtotal)[2]				$503,029
Contingency (15% of Subtotal)				$628,786
			TOTAL	**$5,533,315**
			COST PER ACRE	**$163,225**

1. The material quantity is as measured in-place and compacted.
2. Engineering services include construction document preparation; construction contract administration; construction observation; preparation of the CQA report; closure certification; and record notation to deed.

Attachment 4
Post Closure Inspection Form

Dare County
Construction and Demolition Debris Landfill
Post-Closure Inspection Form

Inspection List	Last Date of Inspection	Frequency of Inspection	Condition GC/MC/NR[1]	Photographs	Map ID's	Corrective Action/Comments
2.2.2 Undercutting and rutting of inlets & outlets		Semi-annually[2]				
2.3 Sedimentation Devices						
2.3.1 Sediment Level		Semi-annually[2]				
2.3.2 Outlet Control Device		Semi-annually[2]				
2.3.3 Berm Stability		Semi-annually[2]				
3. Monitoring						
3.1 Groundwater and Gas Monitoring Wells						
3.1.1 Casing Condition (cracks, corrosion, etc...)		Semi-annually				
3.1.2 Condition of locking system and cover		Semi-annually				
3.1.3 Presence of surface seal damage		Semi-annually				
3.1.4 Debri near cap		Semi-annually				
3.1.5 Sampling performed		Semi-annually				
3.2 Landfill Gas Monitoring System						
3.2.1 Gas vent blockages		Quarterly				
3.2.2 Gas vent condition		Quarterly				
3.2.3 Gas vent air pump test		Annually				

1 Description of Condition
GC = Good condition
MC= Monitor condition to determine course of action
NR = Needs repair

2 Inspection should be conducted after major storm events.

Dare County
Construction and Demolition Debris Landfill
Post-Closure Inspection Form

Inspector: _____ **Weather:** _____
Date/Time: _____

Inspection List	Last Date of Inspection	Frequency of Inspection	Condition GC/MC/NR[1]	Photographs	Map ID's	Corrective Action/Comments
1. Site Maintenance						
1.1 Final Cover System						
1.1.1 Signs of erosion (ruts, sediment deposits, etc.)		Quarterly				
1.1.2 Patches of stressed or dead vegetation		Quarterly				
1.1.3 Animal burrows		Quarterly				
1.1.4 Recessed areas or ponding		Quarterly				
1.1.5 Leachate seepage stains and/or flowing leachate		Quarterly				
1.1.6 Upheaval or Cracks in the cap		Quarterly				
1.1.7 Tree saplings (especially species with tap roots)		Quarterly				
1.1.8 Semi-Annually mowed (Y/N)		Quarterly				
1.2 Site Security and Access						
1.2.1 Access Road		Quarterly				
1.2.2 Security Fencing and Gates		Quarterly				
1.2.3 Signage		Quarterly				
2. Erosion and Sedimentation Control System						
2.1 Drainage Ditches						
2.1.1 Obstructions		Semi-annually[2]				
2.1.2 Erosion of side slopes		Semi-annually[2]				
2.1.3 Loss of vegetative cover		Semi-annually[2]				
2.1.4 Excessive build-up of sediment		Semi-annually[2]				
2.2 Drainage Pipes						
2.2.1 Obstructions		Semi-annually[2]				

Attachment 5
Post Closure Plan

Section 2
Post-Closure Plan

The North Carolina Solid Waste Regulation Section Rule 15A NCAC 13B .0543(a) requires owners/operators of C&DLFs to prepare a post-closure plan. The purpose of the plan is to provide the necessary information for preserving the integrity of the landfill facility in its post-closure life. This post-closure plan specifically addresses maintenance activities for the closure cap, landfill gas monitoring system, groundwater monitoring wells, and erosion and sedimentation control system to be installed at the C&DLF. This plan also addresses certification and financial assurance requirements.

Post-closure care will begin immediately following final closure of the landfill. Post-closure care may be decreased from the minimum time period of 30 years specified in the regulations if the County can demonstrate that the reduced period will pose no threat to human health or the environment. However, the SWS reserves the right to increase the post-closure care period if it is deemed necessary to protect human health and the environment.

2.1 Maintenance and Monitoring Activities

Post-closure maintenance and monitoring activities for the C&DLF are described in the following sections.

2.1.1 Final Cover System

Inspection of the final cover system will take place quarterly and encompass the entire landfill. Items of concern to be noted by the inspector include but are not limited to: signs of erosion (ruts, sediment deposits, etc.), patches of stressed or dead vegetation, animal burrows, recessed areas or ponding, upheaving, leachate seepage stains and/or flowing leachate, cracks in the cap, damaged gas vents and tree saplings (especially species with tap roots). Following each inspection, a summary report of the condition of the cover and the items of concern should be recorded in the post-closure log book of the facility. Areas that require further attention should be photographed and delineated on a map of the facility. These items should also be entered in the log book. Since post-closure inspection personnel will most likely change during the post-closure period, the post-closure log book should be kept in a standardized format that allows for new inspection personnel to easily review the results of past post-closure inspections of the site.

Action should be taken immediately to address any items of concern identified during the inspection. Obvious repair items should be performed under the supervision of the post-closure maintenance manager. If an item of concern requires further study to determine a course of action, the engineering firm responsible for closure design should be contacted for consultation.

As part of general maintenance, the vegetative cover should be mowed at least twice a year to suppress weed and brush growth. If vegetative cover is not adequate in any particular area, soil amendments should be applied as necessary and the area re-seeded in order to re-establish vegetation. Insecticides may be used to eliminate insect populations that are detrimental to the vegetation. Animal burrows and eroded or depressed areas should be filled in with compacted soil and reseeded.

2.1.2 Site Access and Security

In addition to the final cover cap, quarterly inspection shall be performed on all site access roads and all security features; including but not limited to fencing, gates, signage, etc.

2.1.2 Groundwater Monitoring Wells

Inspection of the groundwater monitoring wells will take place semi-annually during sampling events. The inspection will consist of verifying the condition of the monitoring wells to ensure that they are providing representative samples of the ground water being collected. The inspector should note the following:

1) The total depth of the well should be recorded every time a water sample is collected or a water level reading is taken to check if sediment has accumulated at the bottom. If sediment build-up has occurred, the sediment should be removed by pumping or bailing.
2) If turbid samples are collected from a well, redevelopment of the well will be necessary.
3) The above-ground protective casing should be inspected for damage. The protective casing should be of good structural integrity and free of any cracks or corrosion. The lockable cover and lock should also be checked at this time.
4) The surface seals should be inspected for settling and cracking. If the seal is damaged in any way, the seal should be replaced.
5) The well casing and cap should be inspected. The casing and cap should be of good structural integrity and free of any cracks or corrosion. Any debris should be removed from around the cap to prevent it from entering the well.

The condition of the groundwater monitoring system should be recorded in the post-closure log book following each sampling event. Monitoring of the groundwater wells shall be conducted as described in the groundwater monitoring plan.

2.1.3 Landfill Gas Monitoring System

Inspection of the landfill gas monitoring system should take place at least quarterly. The inspection should consist of verifying the condition and operation of the passive gas vents and gas monitoring wells. The full depth of all vents and monitoring wells should be checked for blockage that may be caused by settlement or cracks in the

casing. At least once a year, all vents and wells should be tested with an air pump to ensure they are free-flowing. The summary of each inspection of the landfill gas monitoring system should be recorded in the post-closure log book along with photographs of any items of concern.

Testing of the gas monitoring wells shall be conducted quarterly, or as otherwise approved by the SWS.

If any vents or wells are not properly working, they should be flushed and pressure cleaned. If all attempts to repair a vent or well are unsuccessful, a replacement will be installed.

2.2 Erosion and Sedimentation Control System

Inspection of the erosion and sedimentation control system should occur semi-annually and after major storm events. During each inspection, the elements of the system including drainage ditches, drainage pipes, sedimentation devices, and inlet/outlet structures should be checked for obstructions and damage. The drainage ditches should be inspected for obstructions, erosion of side slopes, loss of vegetative cover, shifting of riprap, excessive buildup of sediment, or any other item that may prevent the proper functioning of the ditch. Drainage piping should be checked for blockages and the inlets/outlets should be inspected for undercutting and rutting. The sediment level in the sedimentation devices should be measured to determine if removal is required. The condition of the outfall structure should be checked to ensure proper functioning. The berms should be inspected for stability. Following each inspection, a summary report should be entered in the post-closure log book along with photographs of any items of concern.

Maintenance and/or repairs should be performed immediately as prescribed by the inspectors review.

2.3 Certification of Post-Closure

Following completion of the post-closure care period, a certification verifying that post-closure care was performed in accordance with the post-closure plan and signed by a registered professional engineer licensed in the State of North Carolina will be made part of the operating record. The County will notify the SWS that the certification has been placed in the operating record.

2.4 Name of Individual Responsible for Post-Closure Maintenance of the Site

Mr. Edward Mann of Dare County is currently responsible for operations and maintenance of the site. Mr. Mann can be reached at the following address:

Mr. Edward Mann
Public Works Director, Dare County
P.O. Box 100
Manteo, North Carolina 27954

Mr. Mann most likely will not be employed with Dare County throughout the entire 30 year post-closure period. A new individual will be appointed at the time Mr. Mann's employment with the County ends.

2.5 Planned Use of Landfill after Closure

There are no current planned uses for the landfill site after closure. The property will remain County property, maintained by the County, with public access prohibited.

2.6 Financial Assurance

Dare County will submit a financial assurance package to SWS in accordance with the criteria set forth under Rule .0546. A detailed cost estimate for post-closure care has been prepared and is provided herein (Table 2-1) and a copy has been placed in the operating record. The cost estimate is based on 30 years of post-closure care.

Per Rule .0546(c)(3)(B), the County will annually adjust the post-closure cost estimate for inflation within 60 days prior to the anniversary date of the establishment of the financial instrument. Dare County anticipates using the local financial government test, and therefore will be required to update the post-closure cost estimate for inflation within 30 days after the close of the fiscal year and before submission of updated information to the SWS.

Attachment 6
Post Closure Cost Estimate

Table 2-1

Post-Closure Cost Estimate
Dare County C&DLF
Dare County, North Carolina
Revised December 2008

	Quantity	Unit	Cost	Total
Administration[1]	30	yr	$5,000	$150,000
Engineering[2]	30	yr	$10,000	$300,000
Monitoring				
15 Groundwater Monitoring Well and QA/QC Samples Analyzed Semi-Annually for 30 years	60	events	$2,475	$148,500
3 Surface Water Sample Analyzed Semi-Annually for 30 years	60	events	$325	$19,500
Maintenance				
Fencing, Gates, Signs, etc.	30	yr	$1,000	$30,000
Access Roads	30	yr	$3,000	$90,000
Mowing	30	yr	$12,000	$360,000
Stormwater Structures	30	yr	$9,000	$270,000
Final Cover System Inspection & Repair	30	yr	$25,000	$750,000
Groundwater Monitoring Wells	30	yr	$8,000	$240,000
Surface Water Monitoring Points	30	yr	$2,500	$75,000
Landfill Gas Wells	30	yr	$5,000	$150,000
Subtotal				$2,583,000
Contingency (15%)				$387,450
			TOTAL	**$2,970,450**
			ANNUAL COST	**$99,015**

1. Administration costs include contract selection and procurement of firms to perform inspection, monitoring and repairs.
2. Engineering costs include general site inspection activities.