Section 6
Monitoring Plan

The FPA addresses monitoring of the bioreactor in multiple sections. On pages 11-15 the various types of instrumentation and location of placement are discussed. On pages 21–22, the FPA discusses how the proposed monitoring methods will demonstrate the effectiveness of the operation in meeting the goals established for the project. Finally, on pages 25-27, the monitoring parameters and frequency are discussed and outlined in Table 2 of the FPA.

This section of the PDR presents the proposed monitoring plan intended to fulfill the requirements of the FPA sections stated above. Modifications to certain monitoring methods were made at the recommendation of Dr. Reinhart and Dr. Barlaz during the meeting held on June 26, 2002. The modifications are stated in Section 1.6 of this report.

Monitoring the bioreactor will be necessary for proper operation of the system and to determine the performance of the alternate liner system as compared to the standard Subtitle D composite liner system. The information gathered from the instrumentation will be analyzed on a regularly scheduled basis to allow the operators to make adjustments to the operation as necessary and to assess the impact on the alternate liner. This will be particularly important during the early stages of decomposition (i.e.; aerobic and transitional stages) when improper operation can hinder progress. Additional monitoring is proposed to measure the benefits of the system such as measuring the capacity gained through settlement and the increased levels of gas production. The following monitoring parameters are proposed for the Buncombe County bioreactor:

Parameter	Frequency of Monitoring	Instrumentation and Purpose
Leachate Quality	Monthly (until stable) Annually (thereafter)	Sampling from each cell. Identification of waste degradation phase and leachate strength.
Leachate Quantity	Ongoing	Injection pump flowmeter and leachate collection system flowmeter. Determine impact of bioreactor on leachate collection system capacity. Determine amount of leachate and water added to the landfill.
Gas Composition	Monthly (CH_4, CO_2, O_2, N_2, P, and T) Quarterly (Surface Sweeps for methane) At startup if LFG is not	Gem 2000. Identification of gas quality for combustion and energy conversion. Indication of bioreactor process stage and air intrusion. Safeguard against excessive release of methane and NMOCs.

Parameter	Frequency of Monitoring	Instrumentation and Purpose
	treated(NMOCs)	
Gas Volume and Flow Rates	Ongoing for Volume Monthly for Flow Rates	Meter at flare station or energy production device to measure volume. Gem 2000 at the wellheads to measure flow rate. Identification of gas flow rates for combustion and energy conversion. Determine impact of bioreactor on gas production rates.
Waste Temperature	Monthly	MTG gauge (Thermocouple Wire in PVC Tubing). Monitor cooling or overheating of the anaerobic process.
Waste Moisture Content	Monthly	MTG gauge (Electrical resistance using electrodes in a granular insoluble media) Determine effectiveness of the distribution system and avoidance of saturation or dry pockets
Hydraulic Head on the Liner System	Monthly	8 Pressure Transducers and 1 Gas Pressure Transducer in Cell 6. Maintain less than 12-inches of head on the liner system.
Settlement	Quarterly (survey plates) Annually (aerial topo survey)	Settlement Plates, GPS instrument and Aerial Topographic Survey. Quantify additional capacity gained by accelerated settlement using AutoCad software. Monitor decomposition process and rate of settlement graphically.
Leak Detection	Monthly	Sample leak detection zones for liquid to determine liner effectiveness.

6.1 Leachate and Gas Monitoring

6.1.1 Leachate Quality

Table 2 of the FPA states that leachate quality will be tested:

- monthly during the first six months of bioreactor operation of a cell,
- quarterly during the second six months of operation, and
- semi-annually thereafter.

Dr. Reinhart and Dr. Barlaz recommend that the frequency be revised to monthly sampling and testing until such time the leachate quality stabilizes since leachate quality is one of the most critical parameters for monitoring the bioreactor. Once the bioreactor process for a given cell is firmly established in the methane producing stage and the leachate quality is not changing significantly, then the sampling frequency can be reduced to annually.

Dr. Reinhart and Dr. Barlaz also recommended that the number of leachate parameters listed in Table 2 of the FPA be pared down to eliminate unnecessary parameters. The leachate parameters recommended by the professors are:

- pH
- Biological Oxygen Demand
- Chemical Oxygen Demand
- Ammonia

Leachate testing as required by NCDENR (composite samples tested semi-annually for appendix 2 parameters) will be performed in addition to the monthly testing stated above.

The leachate will be sampled separately from each cell. For the cells without sampling ports in the pumping system valve vaults a 2-inch diameter PVC will be installed in the riser section to allow a bailer to be used for sampling.

Contrary to general assumptions, bioreactors have not been found to produce higher strength leachate than conventional landfills, however the concentrations levels of the various constituents do change more rapidly due to the accelerated process. It is anticipated that a more benign leachate will be produced at a much earlier stage in the life of the landfill than normally occurs in conventional landfills. The ratio of BOD / COD is a reliable indicator for identifying the various degradation phases. The other parameters will be helpful in confirming the ratio indicators and providing information to optimize the system.

Monitoring of these parameters will allow operators to make the proper adjustments such as decreasing the leachate injection quantities and allowing the waste to drain in order to prevent an acid stuck condition from occurring.

6.1.2 Liquid Quantity

As stated in the FPA on pages 11 and 27, liquid quantities will be monitored in terms of gallons added per cell. The leachate quantities will be recorded for each injection event and credited to the appropriate cell according to the location of the injection trench or well. The quantity will be measured by a flowmeter with a totalizer installed on the discharge end of the injection pump. The pump operator will record the flowmeter reading before and after each pumping event to determine the quantity of leachate or water injected.

For the surficial trenches and direct application, the amount of water applied will be measured based on the known capacity of the tanker truck, which is 3,500 gallons. The quantity of water applied will be credited to the appropriate cell according to the surficial trench location and the location of the working face.

Precipitation data will also be recorded onsite and factored into the measurement of water added to the waste. Adjustment will be made to account for evaporation and runoff. Precipitation data will also be compared with the leachate quantity data to better determine the impact of the bioreactor on leachate generation.

6.1.3 Gas Composition, Volume, and Flow Rate

A number of changes to the gas monitoring requirements in Table 2 of the FPA are required to provide consistency with the Federally Enforceable State Operating Permit (FESOP) issued by the Western North Carolina Regional Air Pollution Control Agency. The FESOP requires compliance with the monitoring requirements of NSPS once the bioreactor begins operation. The monitoring requirements of NSPS are sufficient to provide the necessary data for operating the bioreactor and measuring its performance.

The levels of oxygen, nitrogen, methane, carbon dioxide, pressure, and temperature will be measured on a monthly basis at the wellheads to determine the quality of the gas and to check for air intrusion.

Surface emissions of methane will be tested on a quarterly basis.

A performance test for NMOCs will be run within the first 6 months of operation to ensure that the reduction of NMOCs is at least 98% or less than 20 ppm. However, if the collected landfill gas is treated, a performance test for NMOCs will not be performed.

N_2O will not be monitored. This was erroneously included in the FPA.

The volume of gas collected will be measured continuously at the control device (i.e.; flare station or energy conversion unit). The flow rate of gas will be recorded monthly at the wellheads at the same time as when the oxygen, methane, pressure, and temperature are tested.

The combined data from leachate and gas monitoring will ultimately be used to determine when the landfill waste is stabilized. Several thresholds suggested by Townsend and Reinhart include:

- Stabilization occurs when gas production drops to less than 5 percent of the peak value, and
- The leachate BOD / COD ratio is less than 0.1.

6.2 Moisture and Temperature Monitoring

Moisture and temperature data provide useful information for the operation of the bioreactor. Moisture monitoring will determine the effectiveness of the wetting

methods in terms of coverage and uniformity in liquid distribution. In particular, moisture monitoring will be helpful in determining when the waste has reached saturation levels or if dry pockets of waste persist. Temperature will be monitored in conjunction with the moisture to optimize biological activity since anaerobic bacteria are generally more active when the moisture content is above 40 percent and the temperature is between 95^0 F and 130^0 F (The optimum temperature for the anaerobic process is approximately 104 degrees Fahrenheit).

It should be noted that an anaerobic bioreactor such as the system being proposed is not at risk of causing a fire since oxygen and temperature levels are too low for combustion to occur. Some anaerobic bioreactor operators perform a sort of "aerobic jump start" to the system by blowing or pulling air for a short time prior to injection. This method will not be employed for the Buncombe County bioreactor system in order to avoid any potential for combustion.

One concern raised by Dr. Barlaz was the potential cooling of the bioreactor process due to injecting river water during the winter months. The cold river water may lower the temperature of the bioreactor sufficiently to inhibit the process. Monitoring temperature in the landfill during the winter will be important to prevent this from occurring. Temperature is best controlled by adjusting the amount of liquid in the waste. If the cold water is determined to be a problem, the wetting process will be scaled back in the winter or groundwater will be used instead of river water.

Likewise, if the temperature sensors indicate a region of the waste is experiencing elevated temperatures, the operators will need to add additional leachate and/or decrease the negative pressure of the gas collection system if air intrusion is evident.

The proposed devise for monitoring moisture and temperature was recommended by Dr. Reinhart and is called an MTG, which stands for Moisture, Temperature, and Gas. It is a handmade instrument developed by a graduate student for use in the Florida Demonstration Bioreactor Project at the New River Landfill. The device incorporates thermocouple wiring and electrical resistance to measure temperature and moisture, respectively. The gas component of the device will not be used for this project.

The MTGs will provide continuous monitoring that will be recorded monthly by the landfill staff using a datalogger.

The FPA states in Table 1 on page 12 that moisture and temperature will be monitored by installing measuring devices near the bottom of the landfill and at three different depths in the waste using 20-foot vertical spacing. Placement of the MTG will be consistent with this general criterion. The issue of trench spacing will also be considered regarding the placement of the MTGs. The proposed trench spacing of 100 feet will be monitored for effectiveness by placing MTGs at various horizontal distances between trenches including the midpoint. Monitoring these devices for

moisture will indicate whether the lateral distribution is sufficient to provide overlap of wetting between trenches. If the lateral distribution is demonstrated to be insufficient then the spacing between trenches will be reduced for future trench installations.

6.3 Other Proposed Monitoring

6.3.1 Hydraulic Head on the Liner System

Build-up of hydraulic head on the liner system is of particular interest since an alternative liner system was constructed in Cells 3, 4, and 5 and will most likely be used for the future cells. Monitoring the head on the liner system in conjunction with monitoring the amount of leachate collected in the secondary collection system will provide an assessment of the liner performance.

As discussed on page 13 of the FPA, the County will install devices that are capable of measuring head levels. In Table 1, the FPA calls for the use of 8 pressure transducers placed on the liner to monitor head build up.

Monitoring for hydraulic head is proposed for Cell 6 using 8 pressure transducers (PTs) installed in the rock drainage layer of the leachate collection system. Electrical wiring will be used to connect the transducers to a datalogger outside the landfill to allow readings to be recorded monthly. A gas pressure transducer will also be installed to allow correction for gas pressure contribution to the overall pressure recorded by the PTs. High readings will indicate to the operators that the leachate injection process should be scaled down or temporarily suspended until the head returns to an acceptable level. Monitoring of hydraulic head for future cells will be considered after data from Cell 6 is collected.

The critical time to monitor hydraulic head will be when the waste depth in a cell is between 30 and 60 feet. During this stage of the filling operation the injection quantities will be reduced to account for the lack of buffer capacity offered by the waste.

6.3.2 Settlement

One of the advantages of a bioreactor operation is that the majority of settlement occurs during the active filling stage thus allowing the operator to utilize the additional capacity. In conventional landfills much of the settlement occurs after the landfill is closed which prevents using the additional capacity and creates problems for the closure cap. It has also been demonstrated that overall settlement of bioreactor landfills is much greater since more of the waste is decomposed.

On page 27 of the FPA, it requires that settlement plates be monitored semi-annually and topographic surveys of the waste grades be performed annually. However, since settlement is expected to occur rapidly during peak stages of decomposition, it was

decided to shorten the timeframe between monitoring the settlement plates. On page 14 of the FPA, it is stated that the settlement plates will be installed as areas of the landfill reach design grade. However, large areas of the landfill will be at intermediate grades for extended periods of time as other areas of the landfill are being filled. In order to monitor the settlement as it is happening, the settlement plates will be placed at intermediate waste grades as well was design grades and surveyed quarterly to determine the amount and rate of settlement occurring in the landfill. Estimates of additional capacity gained due to settlement will be calculated to determine what effect the bioreactor has on the life of the facility. These estimates will be crosschecked by performing annual topographic surveys and volume calculations.

6.3.3 Leak Detection

The leak detection zones beneath each cell will be checked monthly for liquid. If liquid is present it will be tested for conductivity to determine if it is leachate. If the nature of the liquid is still in question further testing will be performed to determine its source. The liquid will be pumped out and the volume will be recorded separately for each cell. Comparison of leakage quantities will be made between Cells 1 and 2, which have a Subtitle D composite liner system, and the other cells, which have an alternate composite liner system.

6.3.4 Degree of Stabilization (Optional)

As stated in Table 2 of the FPA, waste samples may be collected and tested for degree of stabilization (i.e.; biochemical methane potential, cellulose, lignin, and hemi-cellulose), heavy metals, and organic pollutants if funding is available.