2014 YEAR END PROGRESS REPORT

USEPA PROJECT XL

Buncombe County Bioreactor Project

Buncombe County
Solid Waste Management Facility

Alexander, North Carolina

March 2015

Project XL
Environmental Excellence and Leadership

BUNCOMBE COUNTY
PEOPLE TO MATCH OUR MOUNTAINS
NORTH CAROLINA

CDM Smith

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2014 Year-End Bioreactor Progress Report

Executive Summary

Introduction

The Buncombe County Solid Waste Management Facility is located in the mountains of western North Carolina, approximately nine miles north of the city of Asheville. The 557-acre solid waste management facility opened in 1997 with a Subtitle D landfill disposal area that comprises approximately 100 acres. Under the United States Environmental Protection Agency's Project XL, Buncombe County is operating a combined leachate recirculation and gas recovery system at its Subtitle D landfill. The purpose of the project is to determine if liquid addition has any adverse effects on alternative liner systems. The County is also monitoring the effects of liquids addition on waste density and settlement to determine if it is increasing the life of the landfill. This project differs from other Project XL projects in that it is a full-scale project that is being operated over an extended period of time. This project was granted regulatory flexibility to apply water sources other than leachate to the waste, and to apply water sources to the waste in landfill cells with alternative liners. To date, only leachate has been used since there has been adequate leachate available onsite to meet the needs of the project. Although application at the working face is allowed it has not been employed in the bioreactor operation and there are no plans to use it going forward. Additional water sources may be required after the build-as-you-go system is in full operation due to the additional capacity for receiving leachate.

System Designs: Retrofit vs. Build-As-You-Go

The retrofit system, which refers to the shallow, wetting/gas collection trenches that were installed in Cells 1-5 after the cells were filled to capacity has been in operation since April 2007. A Build-As-You-Go wetting system, which means that the infrastructure is installed in phases as the waste is being placed, provides better wetting of the waste and earlier capture of landfill gas. The first stage of the Build-As-You-Go system was installed in Cell 6 in July 2012, and began operation in June 2014 after the trenches were completely covered by a 10-ft minimum layer of waste.

The first stage included installation of five trenches ranging in length from 700 to 950-ft. Six temperature sensors were installed in various locations between the trenches to monitor the extent of wetting and the impact of cold weather wetting on the biological processes. Readings from the sensors are recorded by a datalogger installed at the Cell 6 pump station control panel. If decomposition is determined to be unaffected by cold weather recirculation, then the operators will move to a year-round wetting program that will further reduce the amount of leachate hauled to the WWTP.

Stakeholder Meetings

Stakeholder meetings are held periodically to discuss project status and issues. The project stakeholders include: Buncombe County, NCDENR, USEPA, WNCRAQA, CDM Smith and the University of Florida. The last stakeholder meeting, held in September 2012, established new criteria for determining liner performance. Leachate levels in the sump of Cell 6 are being recorded in 15-minute intervals to see if head on the liner every increases due to leachate recirculation. Rapid increases in leachate levels in the sump would indicate head build-up on the liner system which could lead to higher rates of leakage. Preliminary results show no impact on head on the liner due to the recirculation of leachate. Further data collection is being performed to confirm the preliminary findings.

Operation of Cell 6 HITs

Based on the discussions held at the last stakeholders' meeting, a combination of dedicated recirculation and gas collection horizontal injection trenches (HITs) is desirable for determining the effectiveness of the wetting operation and maximizing early gas capture in Cell 6.

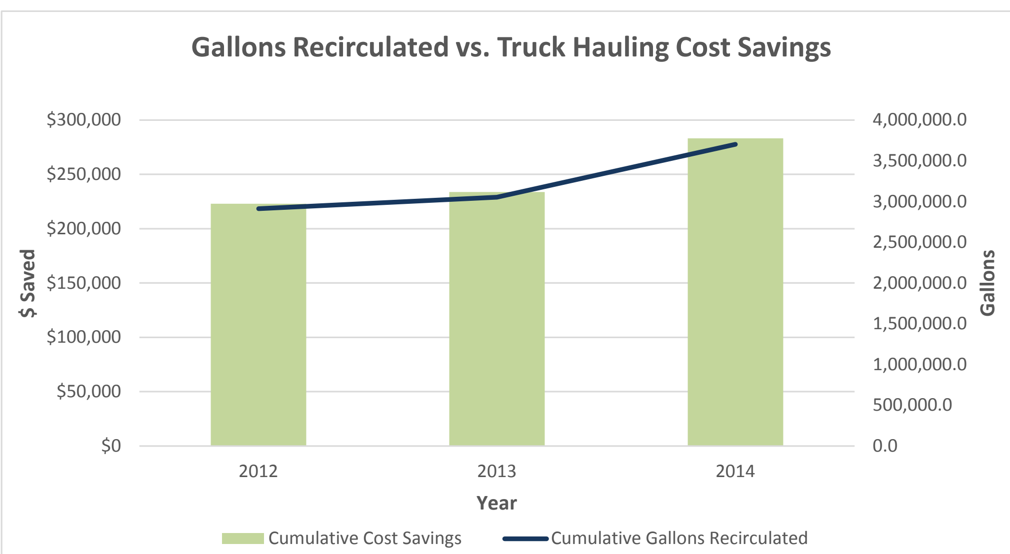
The strategy to date has been to recirculate in HITs 6B and 6C. It is recommended that landfill gas be collected from HITs 6A, 6D, and 6E and that landfill gas quality and flow be measured to determine their effectiveness.

Liner System Performance

To date, the cells equipped with alternative liner systems are functioning at a comparable level to those with prescriptive Subtitle D liner systems. While liquids have been observed in the leak detection zones in nearly all of the landfill cells, testing of the liquids indicate it is groundwater. For Cells 7-10, it is recommended that the design of the leak detection zone (LDZ) be revised to eliminate the 3-foot separation between the LDZ and the bottom of the base liner system, as this will greatly reduce the potential for groundwater infiltration.

Benefits of the Bioreactor Program

Approximately 3.7 million gallons of leachate has been recirculated since the program began, resulting in 741 less truck trips to the wastewater treatment plant (WWTP). That has provided a savings of $283,248.95 in avoided hauling costs as shown in the figure below. With the expansion of the leachate recirculation system into Cell 6, the largest cell of the landfill, the amount of leachate that can be recirculated is significantly increased. The July-December 2014 period was the first period that leachate hauling was not required.



Settlement plates installed in Cells 1 through 5 show an average settlement of 1.16 ft. from October 2005 to April 2014. Comparison of topographic surveys of Cells 1-5 taken in 2010 and 2014, show 0-1 ft. settlement on the slopes and 1-3 ft. settlement over the waste plateau. The prominent settlement areas correspond with the locations of the recirculation trenches but also benefit from stormwater that is captured on the waste plateau.

Landfill gas generation is enhanced by the bioreactor operation and is used to produce electrical power. The power generation facility is registered on the Climate Action Reserve to receive carbon credits for the voluntary capture and destruction of methane. Carbon credits and equivalent passenger vehicle gas emissions offset are shown below:

Year	Carbon Credits	Equivalent Passenger Vehicle Emissions Offset
2012	28,784	5,997 vehicles
2013	29,490	6,208 vehicles
Total	**58,274**	**12,205 vehicles**

This text report provides an update of the Buncombe County Bioreactor Program for second half of 2014. To view the report in its entirety please visit the project website at: http://buncombebioreactor.com/.

Section 1

Introduction

The Buncombe County (County) Solid Waste Management Facility is a host site for a research project being conducted under the USEPA Project XL Program. The purpose of this Year-End report is to present the data collected in 2014. This report was prepared by Kristy Smith - Buncombe County Bioreactor Manager, Christopher Gabel – CDM Smith Inc. and Amy Baricevich – CDM Smith Inc.

1.1 Site Description

The Buncombe County Solid Waste Management Facility is located in the mountains of western North Carolina, approximately nine miles north of the City of Asheville. The 557-acre solid waste management facility (refer to **Figure 1-1**) opened in 1997 and comprises a Subtitle D landfill, construction and demolition (C&D) landfill, wood waste mulching facility, convenience center for residential drop-off, a household hazardous waste (HHW) facility, and a white goods and tires holding facility.

The Subtitle D landfill is 95 acres and consists of 10 disposal cells that are being constructed sequentially over the estimated 30+ year life of the facility. Cells 1 and 2 were constructed with a prescriptive RCRA Subtitle D liner system consisting of a 24" soil barrier layer with a maximum permeability of $1x10^{-7}$cm/sec, a 60-mil high density polyethylene (HDPE) liner and a 24-inch rock drainage layer. Cells 3-6 were constructed with an alternative liner system that uses an 18-inch soil barrier layer with a maximum permeability of $1x10^{-5}$cm/sec, a geosynthetic clay liner (GCL), a 60-mil HDPE liner and a 24" rock drainage layer.

Cells 1-5 are filled to capacity and Cell 6 has been the active disposal cell since 2006. Based on current waste flows, Cell 7 is expected to begin operation in 2021.

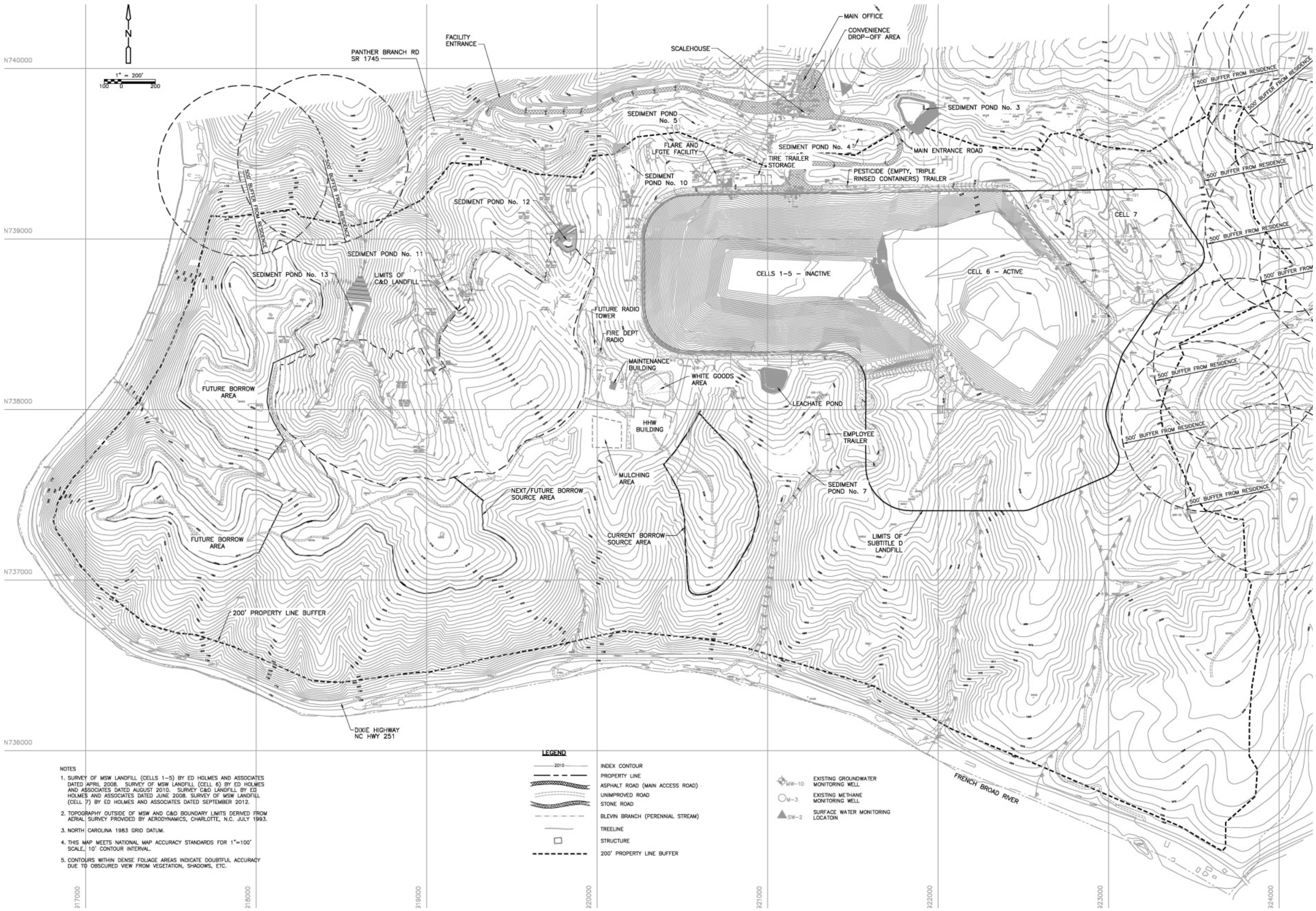


Figure 1-1 Buncombe County Solid Waste Management Facility

1.2 Project Goals

In spite of increasing rates of recycling, landfills remain the primary means of managing solid waste in the US, receiving 54% of the waste generated in 2008 (EPA-530-F-009-021). Municipal solid waste (MSW) landfills in the United States are designed in accordance with the technical guidelines provided in Subtitle D of the Resource Conservation and Recovery Act (RCRA), which requires that landfills be equipped with impermeable base liners and caps. While this requirement has been very successful in preventing groundwater contamination, it has also led to the dry entombment of waste at many landfill sites. Some concern has been raised regarding the long term containment of undecomposed waste and the potential for leachate releases after the post-monitoring period ends (typically 30-years) and the liner systems failure.

One proposed solution is to operate MSW landfills as bioreactors. A bioreactor landfill uses controlled methods of liquids addition to increase waste moisture content as a means for promoting decomposition of waste. The goal of a bioreactor operation is to achieve a stabilized condition while the landfill is still being monitored. Liquids addition has been applied at numerous landfill sites in the US with favorable results.

Federal regulations governing solid waste management restrict liquids addition to only those landfills equipped with prescriptive Subtitle D liner systems. The Buncombe County Bioreactor Project seeks to determine what impact, if any; liquids addition has on alternative liner systems by comparing the performance of the prescriptive Subtitle D liner system in Cells 1 and 2 to the alternative liner systems in Cells 3-10. The data obtained from this project may provide support for modifying federal regulations to allow liquids addition in MSW landfills equipped with alternative liner systems. A Final Project Agreement (FPA) was issued by the USEPA under the Project Excellence and Leadership Program (Project XL) approving Buncombe County's proposal to incorporate a liquids addition process as an integral part of their landfill operation and providing the design, execution, and monitoring framework developed for the project.

1.3 Public Awareness

Public awareness has been an important part of the County's solid waste program since the siting of the facility in the early 1990's. To increase public awareness of the bioreactor project, the County staff have given presentations to various groups, led tours for local area colleges and high schools, and performed a live interview at the bioreactor site for Buncombe County Television. The County also has a website that is available to the public to learn about the project. The website is updated semi-annually with new monitoring data and other information and is accessible at: http://www.buncombebioreactor.com/index.html.

Buncombe County convenes periodic meetings of stakeholders to obtain comments on the Project as well as to report on the progress during the duration of the XL Agreement. Stakeholders include any individuals, government organizations, neighborhood organizations, academic centers, and companies with an interest in the progress of the Buncombe County Solid Waste Management Facility Bioreactor Project. The first stakeholders meeting was held in August 2008 and the second stakeholders meeting was held on September 20th, 2012. The stakeholder meeting was attended by Western North Carolina Regional Air Quality Agency, EPA by teleconference, NCDENR, University of Florida, Buncombe County management, and CDM Smith engineers.

Section 2

Project Description

This project was granted regulator flexibility under Project XL to add liquids to cells with alternative liner systems and to apply liquids other than leachate to the waste mass. To date, only leachate has been used since there has been adequate leachate available onsite to meet the needs of the project. This may change when the build-as-you-go portion of the project is operational since the quantities of liquids addition will increase significantly. Leachate recirculation is not performed during the winter months due to concern of the adverse impacts of cold leachate on decomposition. The project team, in consultation with the project academic advisors, Dr. Morton Barlaz of North Carolina State University, Dr. Timothy Townsend of University of Florida, and Dr. Debra Reinhart of University of Central Florida, established a minimum temperature of 50 degrees F for the recirculation operation as measured at the leachate pond.

2.1 Retrofit Bioreactor System

2.1.1 Leachate Recirculation

Cells 1-5 had nearly reached capacity when the project began, prompting the need to install a retrofit system. The retrofit system is equipped to recirculate leachate using a combination of horizontal injection trenches (HIT) and surficial gravity trenches (SGT) as shown in **Figure 2-1**.

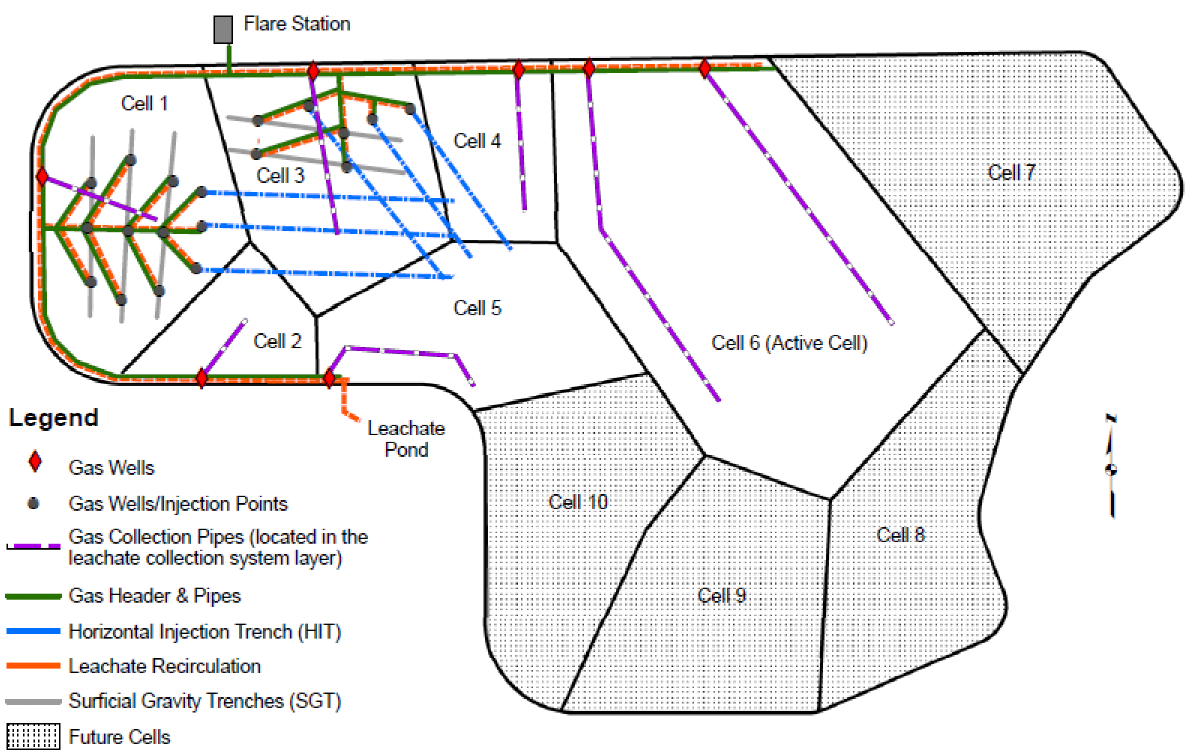


Figure 2-1 Retrofit Bioreactor System

Six horizontal injection trenches (HIT) were installed in the retrofit area. The first three HITs were installed in anticipation of the project being approved when the top of waste was at Elevation 2040. They extend approximately 400 ft. south into the waste mass and are spaced 100 ft. apart. Three more HITs were installed at Elevation 2080 using the same spacing and extend approximately 800 ft. east in the waste. Due to the longer length of these HITs, two pipes were used in each of the trenches to provide more uniform distribution of leachate. This is achieved by using a short pipe that wets the first 400 ft. of the trench and a long pipe that wets the latter half of the trench.

Five surficial gravity trenches (SGT) ranging in length from 450 to 600 ft. were installed on the side slopes at Elevations 2030 (SGT 1), 2050 (SGT 2 and 4) and 2070 (SGT 3 and 5). The trenches were excavated 11 ft. into the waste and capped with a clayey soil to provide containment of the recirculated leachate and allow gas collection without air intrusion. Due to their shallowness, the SGTs are operated differently than the HITs. The HITs are allowed to be pressurized up to 10 psi while recirculating leachate to provide greater lateral distribution while the SGT are operated as a gravity-feed system to avoid leachate seeps.

Construction details of the HIT and SGT are shown in **Figures 2-2** and **2-3**.

All future trenches will be installed during the operational phase of the cells to provide earlier implementation and more thorough wetting.

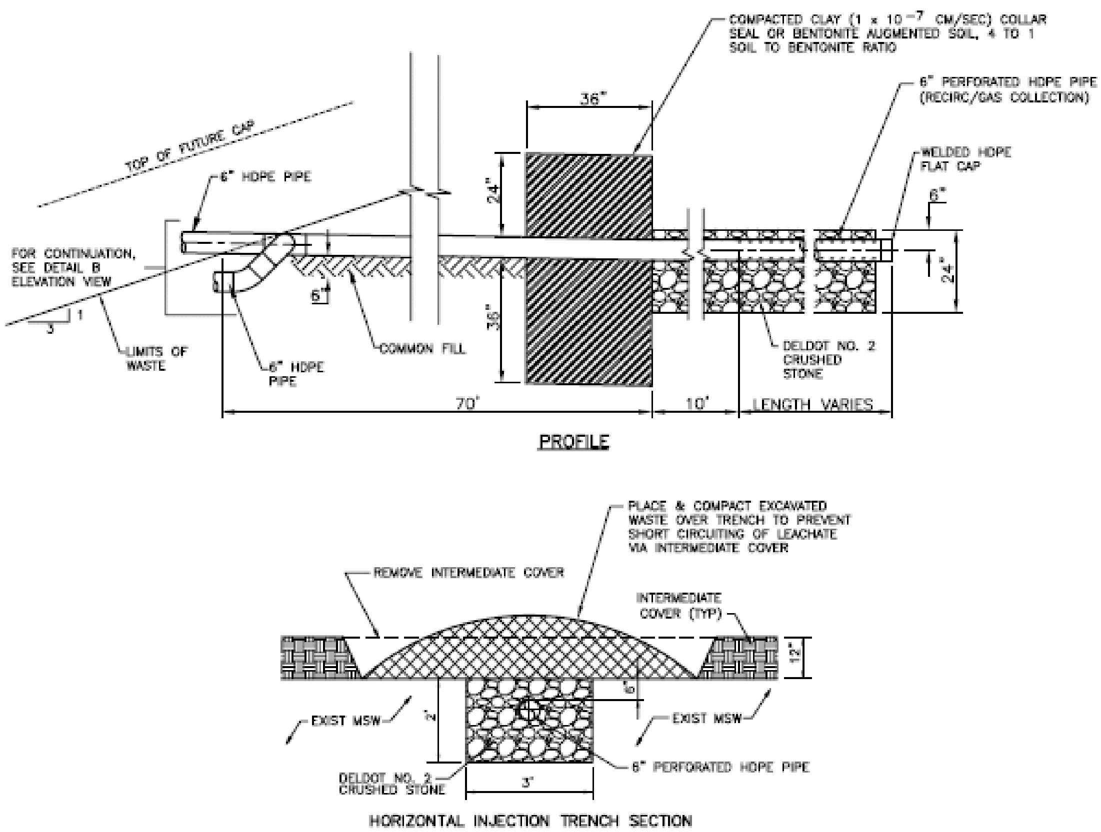


Figure 2-2 Horizontal Injection Trench Detail

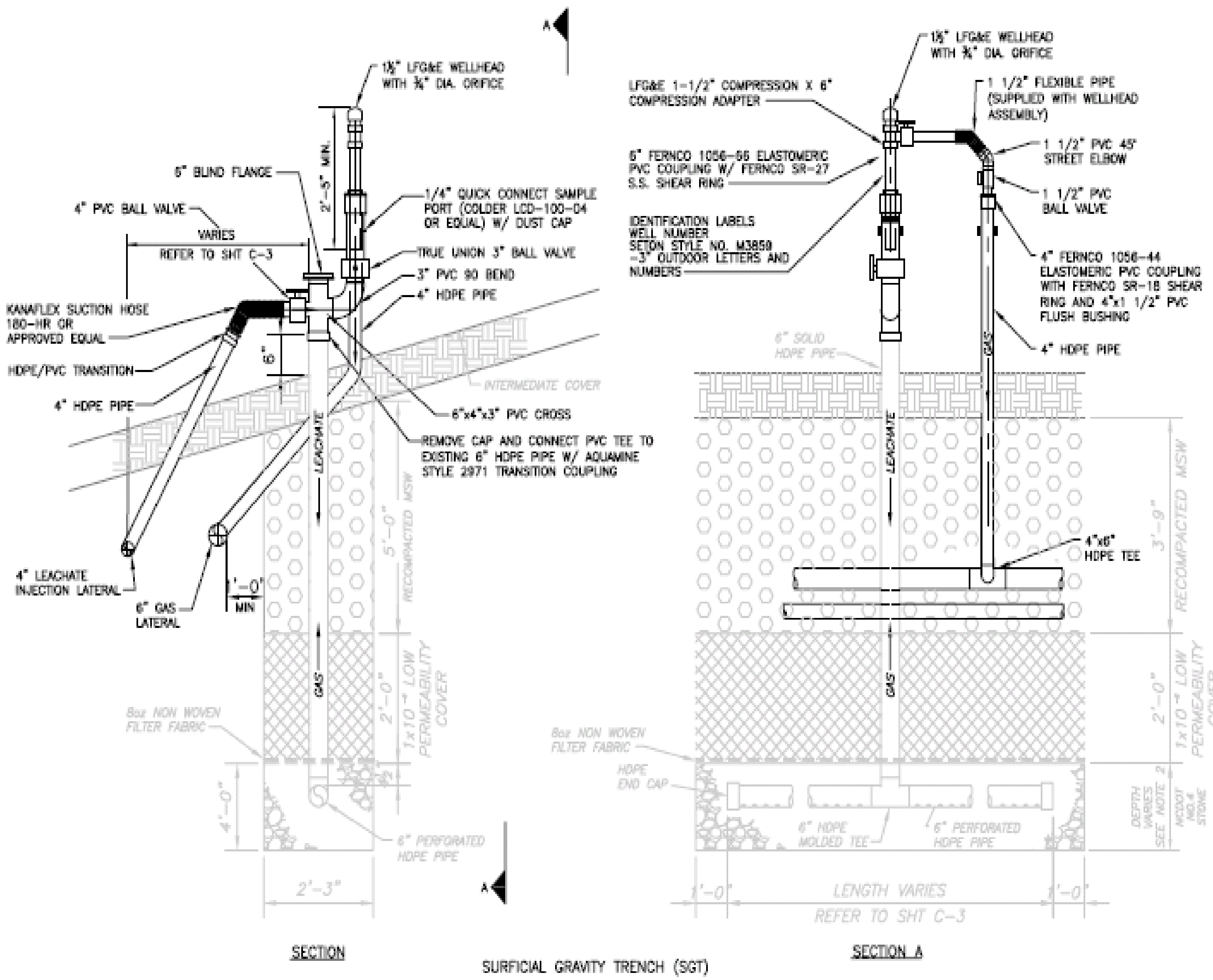


Figure 2-3 Surficial Gravity Trench Detail

2.1.2 Gas Collection

Twenty five (25) vertical gas collection wells were installed in Cells 1-5 as shown in **Figure 2-4**. At the time of the new well field installation the gas collection component of the HITs and SGTs was de-activated. Landfill gas is also collected from the cleanouts of the leachate collection system of each cell.

Based on the LandGEM model, the peak flow rate for the site is estimated to be 1,500 scfm in 2030 as shown in **Figure 2-5**. Gas flow to the landfill gas-to-energy (LFGTE) facility will increase over time and will experience an incremental increase once all the HITs in Cell 6 go online. A second generator may be added to the LFGTE facility when the flow rate exceeds 900 scfm.

2.2 Build-As-You-Go Bioreactor

Phase 2 is a build-as-you-go bioreactor system – meaning that the infrastructure is installed in stages as the waste is being placed. The build-as-you-go approach will allow for more extensive wetting of the waste and earlier capture of landfill gas. The first stage of the Phase 2 system was installed in Cell 6 in 2012 and began operation in June 2014.

2.2.1 Leachate Recirculation and Gas Collection

The first phase in Cell 6 includes five HITs for leachate recirculation and gas collection as shown in **Figures 2-6 and 2-7**. A 100-ft. solid section of pipe is used for the front end of the HITs to maintain the injection process an adequate distance from outer slope to minimize seeps. The solid pipe sections are sloped 3% to drain towards the outer slope of the landfill. P-traps were installed at the head of each HIT and drain down the slope to the leachate sump riser pipe to allow excess recirculated leachate to be removed from the HIT after injection events. This is intended to prolong gas collection capability of the system.

The liquids addition process typically takes between 2 to 6 hours per event and is continuously supervised by the Bioreactor Manager. A rotation schedule is used to allow time between injection events for leachate to drain from the trenches. The rotation schedule is adjusted as needed to account for the varying rates of drainage of the HIT and SGT. Leachate recirculation is reduced or suspended during periods of rainfall until the area dries out sufficiently. The landfill side slopes are carefully inspected during and after each injection event for leachate seeps. Further discussion of the leachate recirculation and gas collection strategy is provided in Section 6.

2.2.2 Temperature Probes

Thermocouples were installed in six (6) locations around the Cell 6 Phase 1 HITs in July 2012 as shown in **Figure 2-8**. The thermocouples consist of a stainless steel temperature sensor with a lead cable as shown in **Figure 2-9**. These thermocouples were placed in 4-inch perforated PVC pipe packed with concrete sand. The cable end of the pipe was left open to allow cable movement during settlement. The sensors transmit temperature data to a datalogger installed adjacent to the Cell 6 pump station control panel that will be downloaded periodically. Temperature readings will be used to monitor decomposition as mesophilic bacteria typically range between 80 and 115°F. The sensors will be helpful in assessing the impacts of leachate temperature during injection. As ambient air temperatures drop in the winter, the leachate in the pond will get colder.

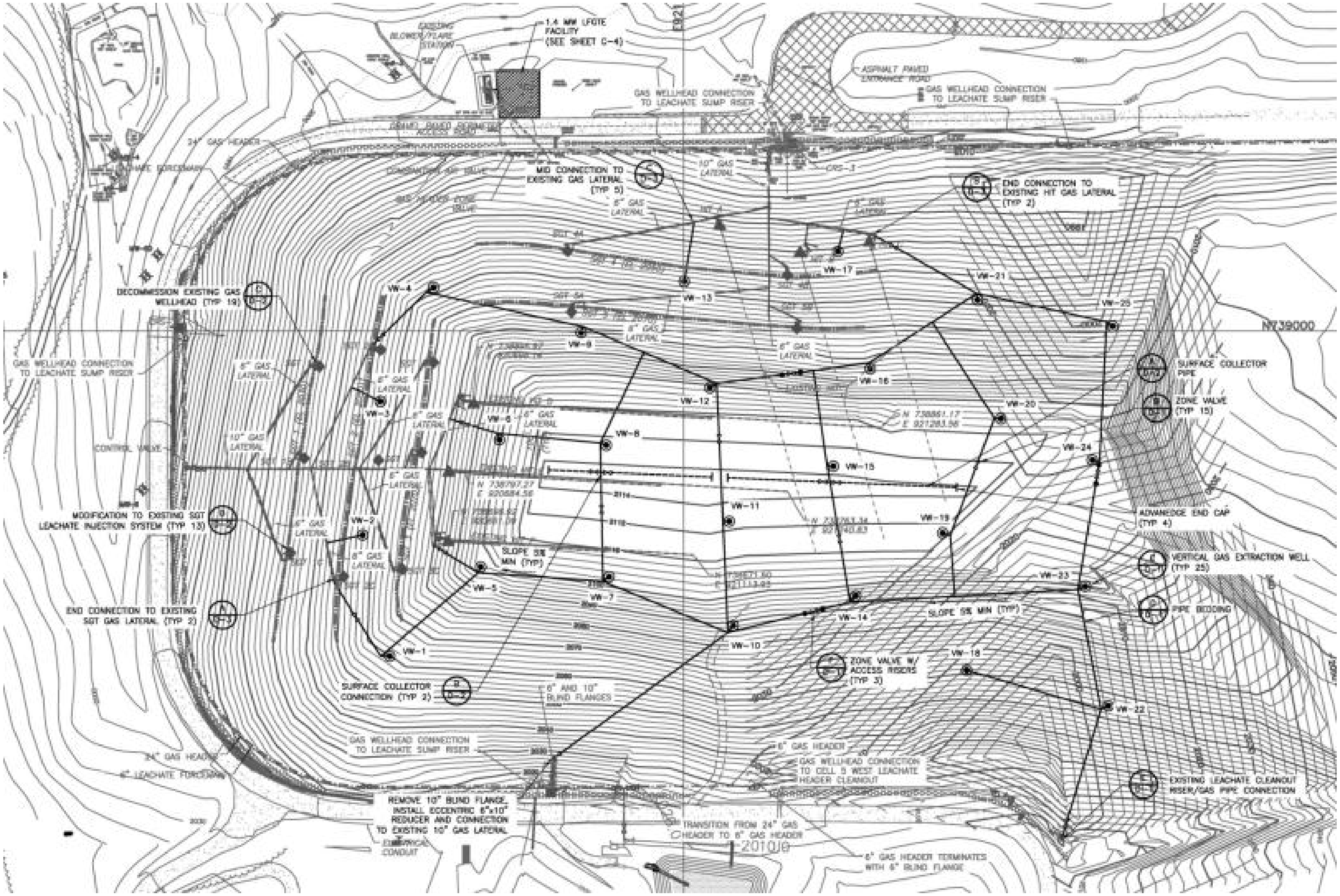


Figure 2-4 Vertical Gas Well Collection System in the Retrofit Area

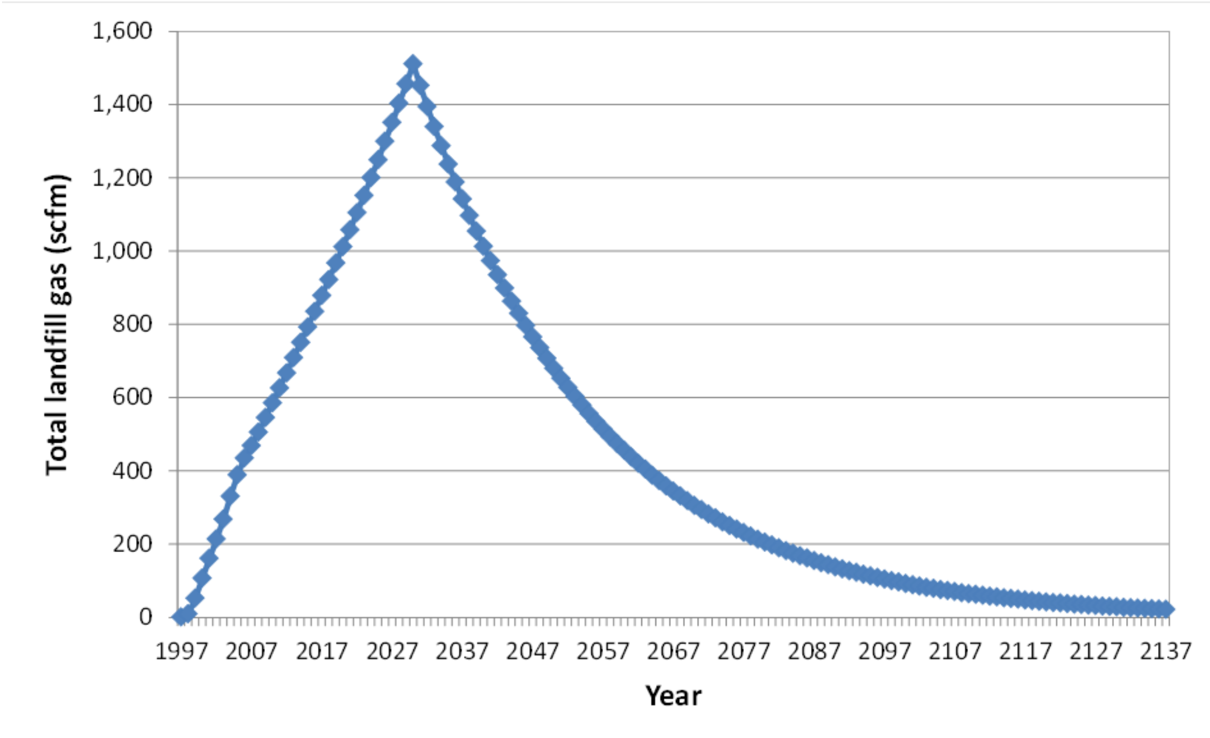


Figure 2-5 Landfill Gas Projections Using LandGEM Model

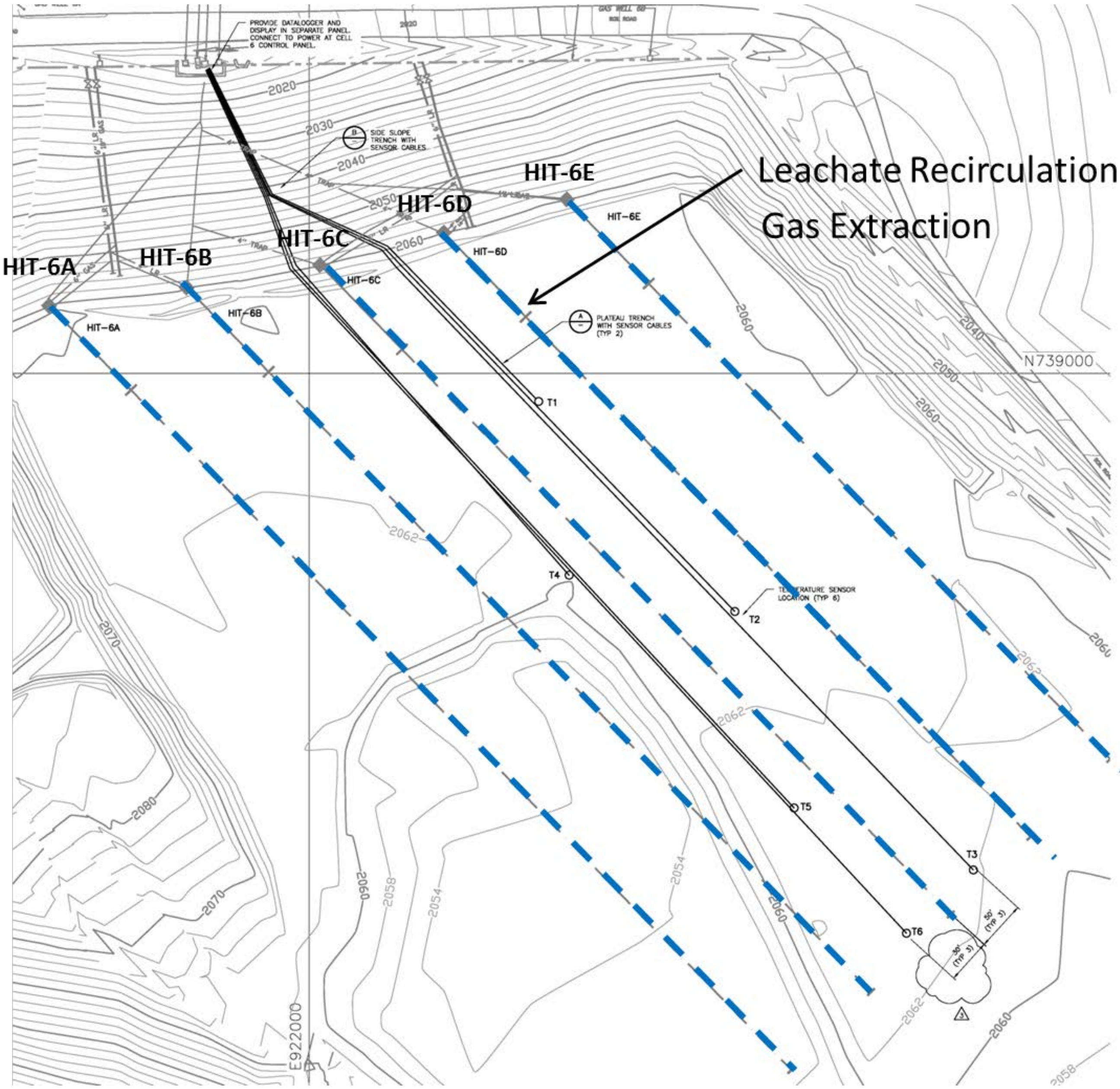


Figure 2-6 Build-As-You-Go Bioreactor System

Figure 2-7 Horizontal Injection Trench Installation in Cell 6

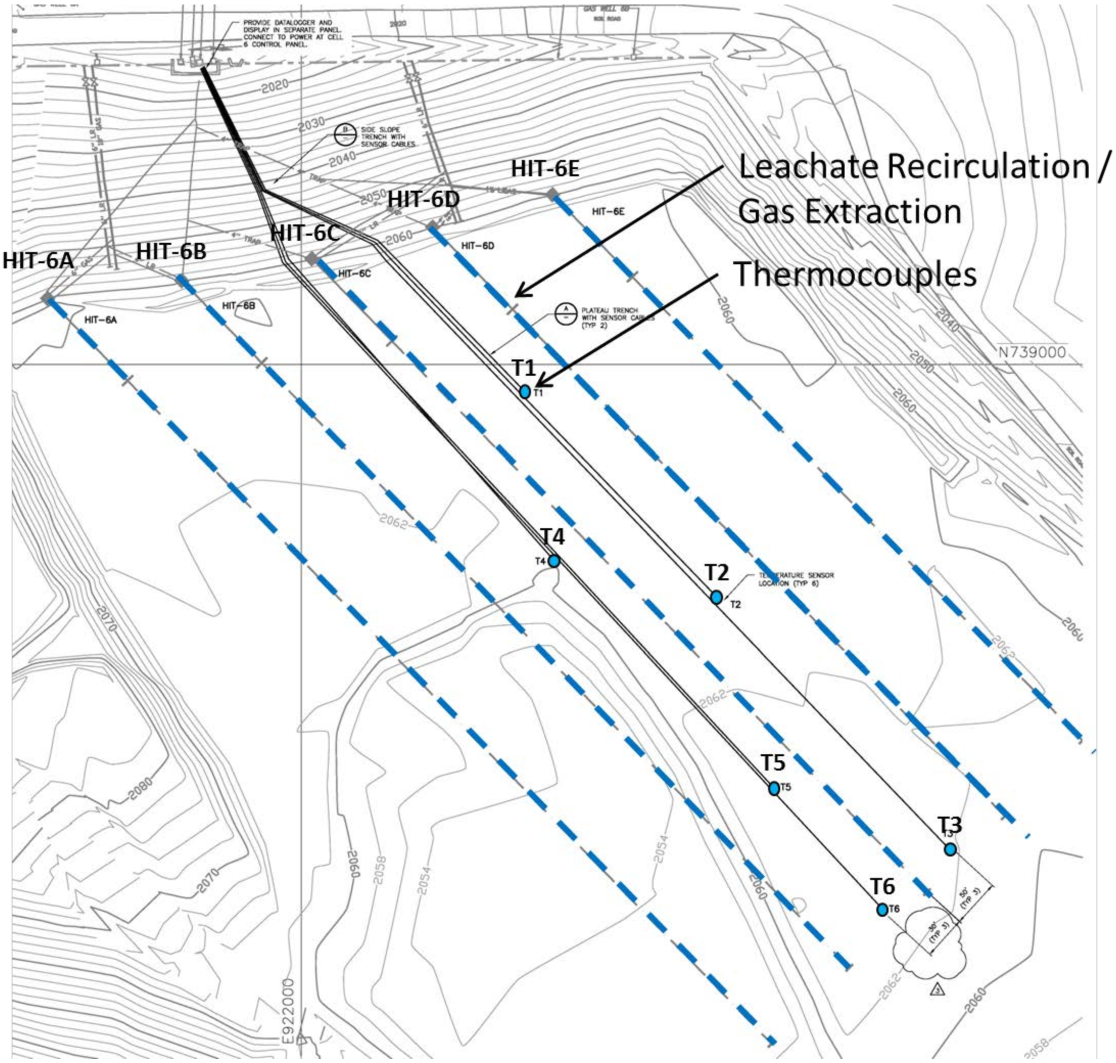


Figure 2-8 Temperature Sensors in Cell 6


Figure 2-9 Installation of Thermocouples in Cell 6

2.3 Landfill-Gas-To-Energy

Buncombe County built a LFGTE facility at its bioreactor landfill to take advantage of the accelerated gas generation. A request for proposals (RFP) was advertised to evaluate private sector interest. At the same time, CDM Smith developed project cost and revenue estimates under a scenario where the County would self-finance the project.

Comparison of nine energy developer proposals to the self-financing option showed that the net revenue would be substantially more if the County self-financed the project. The County elected to proceed without a developer. CDM Smith designed and permitted the LFGTE facility which includes a 1.4-MW generator set, gas conditioning system, and a well field consisting of 25 vertical wells. CDM Smith completed design and permitting of the facility under a fast track approach to reach “shovel-ready” status for ARRA funding. After successfully demonstrating the project’s merits, the County was awarded a $3 million grant. The County completed construction of the LFGTE facility in November 2011. The inaugural ribbon cutting ceremony in May 2012 is shown in **Figure 2-10.**

Figure 2-10 Inaugural Ribbon Cutting Ceremony

Section 3

Monitoring Program

3.1 Program Overview

The monitoring program was developed with assistance from the project academic advisors, Dr. Debra Reinhart and Dr. Morton Barlaz. **Table 3-1** shows the monitoring parameters and frequency of data collection for the project.

As part of facility operation, Buncombe County performs semi-annual testing of the leak detection zones (LDZ), groundwater monitoring wells, leachate pond, and stormwater collection points for the 2L groundwater standards established by North Carolina Department of Environment and Natural Resources. This data is also being used in assessment of the alternative liner system performance.

Table 3-1 Monitoring Parameters and Frequencies

Parameter	Frequency
Leak Detection Quantity	Quarterly
Leak Detection Quality	Quarterly
Leachate Quality	Quarterly
Leachate Quantity	Weekly
Leachate Recirculation Quantity	Ongoing
Gas Composition	Ongoing
Gas Volume and Flow Rates	Ongoing
Settlement Plates	Quarterly
Settlement Survey	Bi-annually
Waste Density	Quarterly
Waste Temperature	Ongoing

3.2 Leak Detection

The landfill cells and leachate pond are equipped with a leak detection zone (LDZ) located beneath the leachate collection system sumps. The LDZ, as shown in **Figure 5-1**, is approximately 1 acre in size and consists of a 60 mil HDPE geomembrane and a 24-inch rock drainage layer located 3-ft below the bottom of the liner system. The geomembrane is sloped to direct liquid to a collection pipe located directly below the leachate sumps. For Cells 3-6, liquid captured in the LDZ is pumped out through vertical stand pipes located along the perimeter berm. Cells 1 and 2 drain liquid through gravity pipes that protrude from the outer slope of the landfill perimeter access road. The drain pipes are equipped with gate valves that the operator opens to check for liquid. Quantity data is not recorded for Cell 1 as it appears to be impacted by a steady supply of groundwater from an underground spring. Further investigation of flow from the Cell 1 LDZ was discussed at the stakeholders meeting held on September 20th, 2012 and is presented in Section 6.

If liquid is present in the LDZ, samples are tested onsite using a Horiba U-22 water quality meter for:

- ORP (oxidation reduction potential)

In addition, liquid samples are collected in sample bottles and sent to Pace Analytical for analysis of:

- BOD5 (Biological Oxygen Demand)
- pH
- COD (Chemical Oxygen Demand)
- Ammonia
- Specific Conductance

The sampling process is dated and recorded in a monitoring log by the Bioreactor Manager.

3.3 Leachate

The quantity of leachate collected is also tracked separately for each cell on a weekly basis. Each cell has a dedicated leachate pump system equipped with a flowmeter that allows the Bioreactor Manager to monitor the number of operating hours for the pumps, the quantity of leachate pumped, and the leachate level in the sumps at the time of monitoring. This data is recorded onto a field form by the Bioreactor Manager.

Leachate quality sampling occurs every quarter. Samples are collected from the leachate pond and from Cells 1-6. The samples are taken from sampling ports located in the valve vaults of the leachate pump stations. Leachate samples are collected in sample bottles and sent to Pace Analytical for analysis of:

- BOD5
- pH
- COD
- Ammonia
- Specific Conductance

On-site analysis of the leachate is also performed using a Horiba U-22 water quality meter. The Horiba unit tests for:

- ORP
- TDS

The sampling process is dated and recorded in a monitoring log by the Bioreactor Manager.

3.4 Leachate Recirculation

The quantity of leachate recirculated is recorded for each injection event using the magnetic flow meter installed at the leachate pond pump station. The Bioreactor Manager records the quantity of leachate injected and identifies the specific HIT/SGT used for the injection event.

3.5 Landfill Gas

The gas collection component of the Retrofit System has been replaced with a gas to energy system and has been in operation since November 2011. Gas composition and flow data is being continually monitored and recorded.

3.6 Landfill Settlement

Settlement plates were installed in 10 locations within the retrofit area. The plates are surveyed quarterly to monitor the rate of waste settlement. In addition to the settlement plates, bi-annual survey of the landfill cells 1 through 5 is being carried out using a 50-foot grid.

3.7 Landfill Temperature

To date, no leachate below 50°F has been allowed to be recirculated for fear of impacting decomposition. Some colder leachate will be injected into Cell 6 HIT to see if it causes any significant drop in temperature. If the results are favorable then the project team will consider allowing leachate colder than 50°F to be used on a regularly basis. Temperature has been monitored in Cell 6 since July 2012 to a get background data prior to leachate recirculation.

3.8 Effective Waste Density

Since settlement plates are difficult to maintain in active cells, effective waste density is being added to the monitoring program for Cell 6 to assess the impact of wetting on landfill capacity. A topographic survey of Cell 6 is used to compute the volume of waste and cover soil in Cell 6 on a quarterly basis. Waste tonnage records are used to calculate the effective density of the waste, which is defined as: the weight of disposed waste/the combined volume of waste and cover soil. Effective density is not the actual density since cover soils are not weighed prior to placement.

Section 4
Collected Data

The monitoring data collected from 2007 through 2014 is presented below in summary graphs and tables. A complete compilation of all data collected to date can be found on the website: http://buncombebioreactor.com/.

4.1 Leak Detection

Table 4-1 shows the annual quantity of liquid collected from the leak detection zone (LDZ). Liquids have been observed in the Cell 1LDZ but the project team is unable to measure the quantity due to the remote location of the discharge. A method to measure quantity from Cell 1 was discussed during the second stakeholders meeting and is presented in Section 6.

Table 4-1 Liquid Collected from LDZ

Sample Year	Cell 1 (gallons)	Cell 2 (gallons)	Cell 3 (gallons)	Cell 4 (gallons)	Cell 5 (gallons)	Cell 6 (gallons)	Leachate Pond (gallons)
	Subtitle D Liner		Alternative Liner				Subtitle D Liner
2007	NA	NA	427	0	0	340	0
2008	NA	NA	3,105	25	2,925	10,475	0
2009	NA	NA	1,375	0	3,300	5,500	0
2010	NA	NA	1,040	0	6,465	3,835	0
2011	NA	93	555	0	3,800	2,015	0
2012	NA	115	530	0	1,850	1,220	3
2013	NA	80	500	0	850	1,150	9
2014	NA	80	450	0	1,150	1,775	65
Cumulative	NA	368	7,982	26	20,340	26,310	77

NA – Unable to measure quantity.

Figure 4-1 shows the monthly quantities of liquid collected from the LDZ. **Figures 4-2** through **4-7** show qualitative data from testing of the liquid. The parameters are pH, conductance, ORP, BOD5, COD and ammonia.

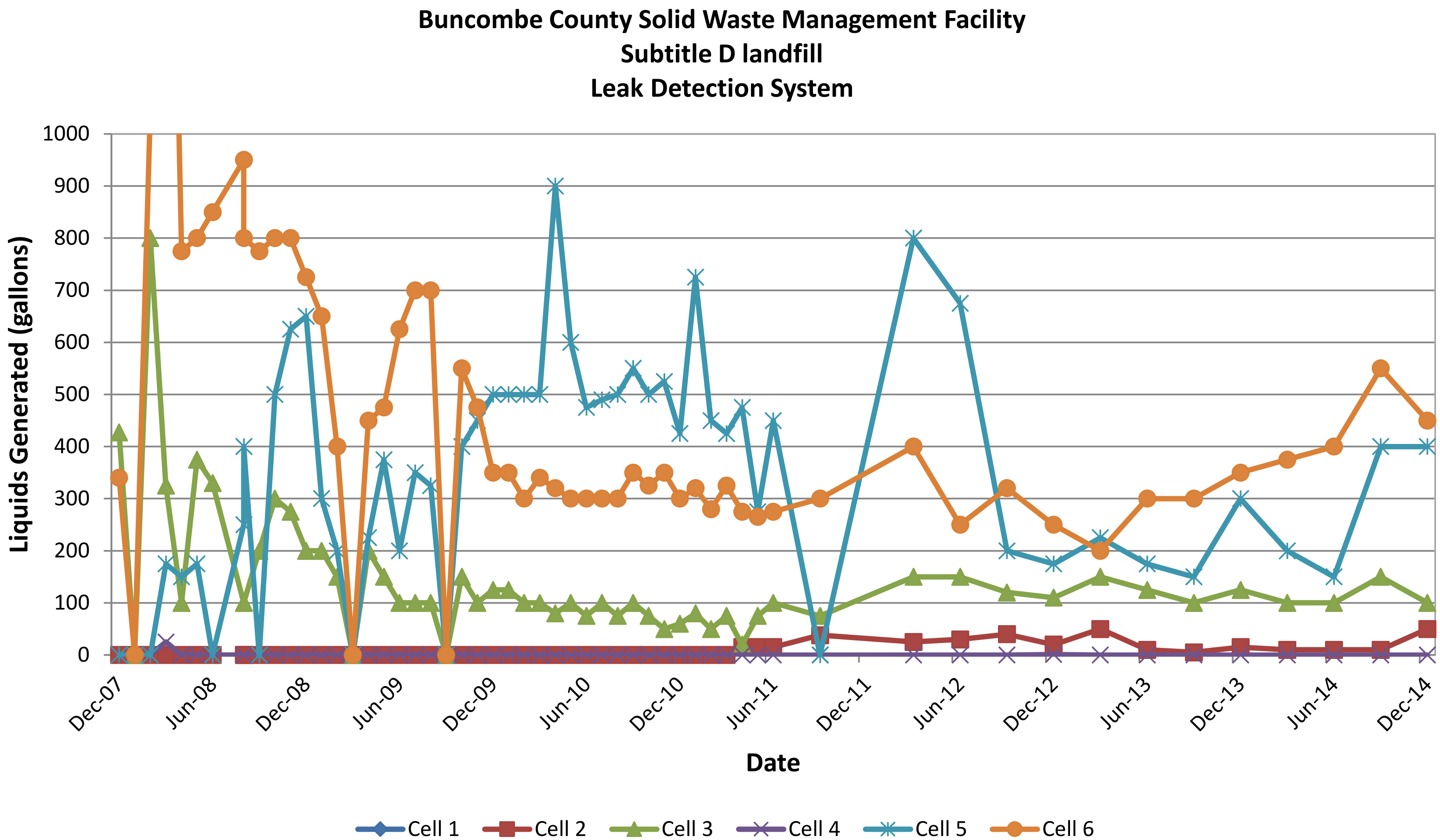
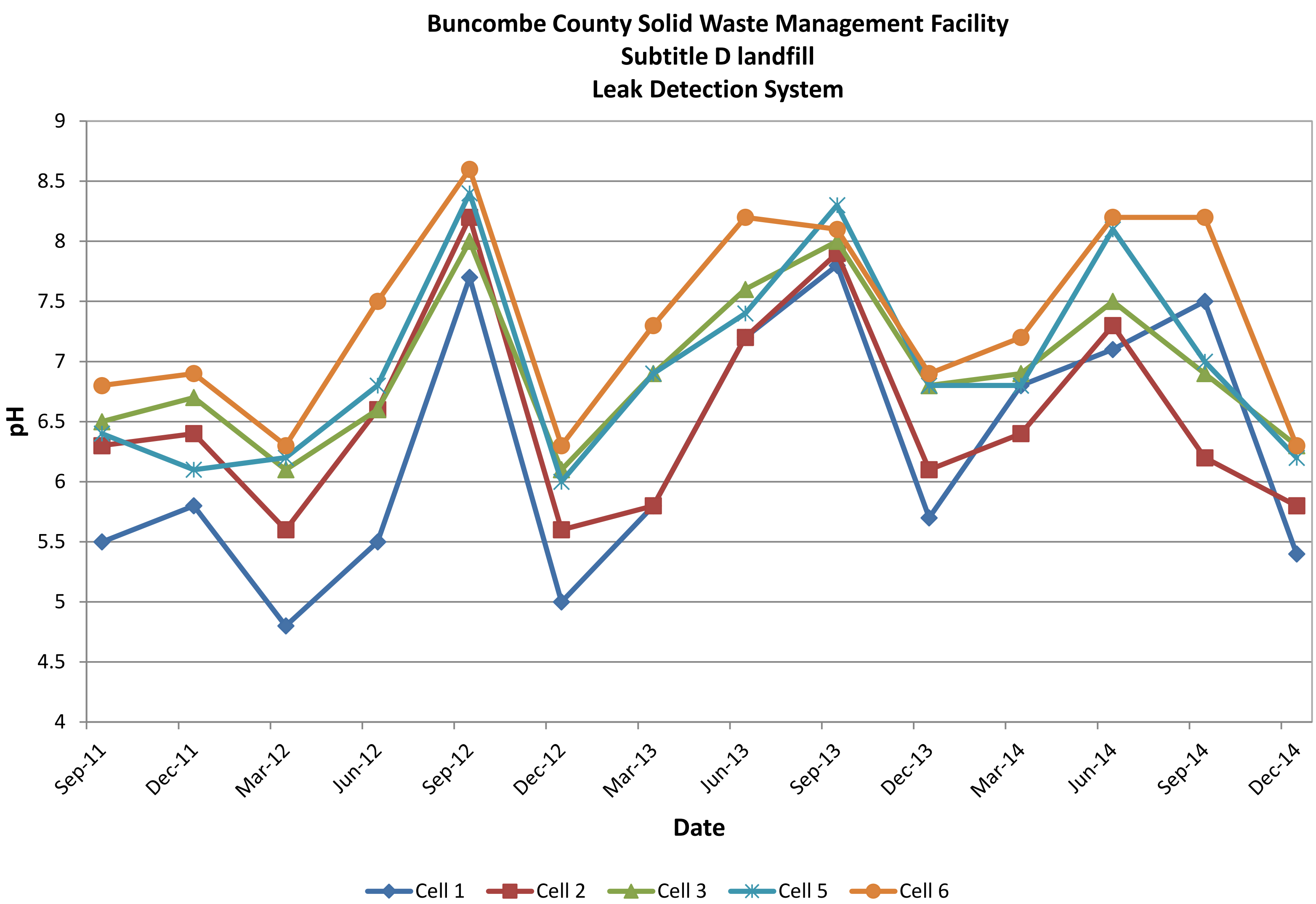


Figure 4-1 Monthly Leak Detection Volumes



Buncombe County Solid Waste Management Facility
Subtitle D landfill
Leak Detection System
pH
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Date
Cell 1
Cell 2
Cell 3
Cell 5
Cell 6

Figure 4-2 pH

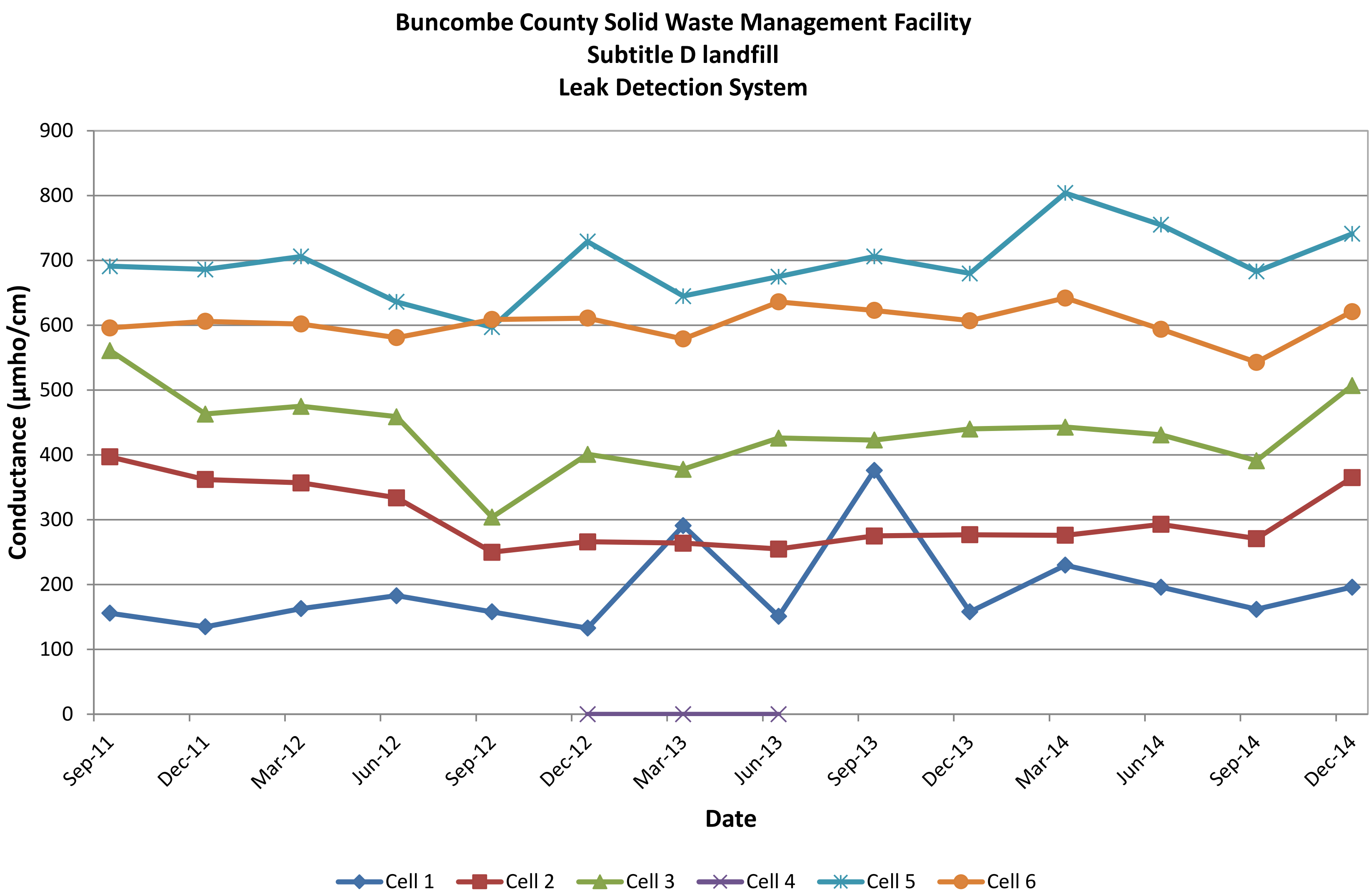


Figure 4-3 Specific Conductance

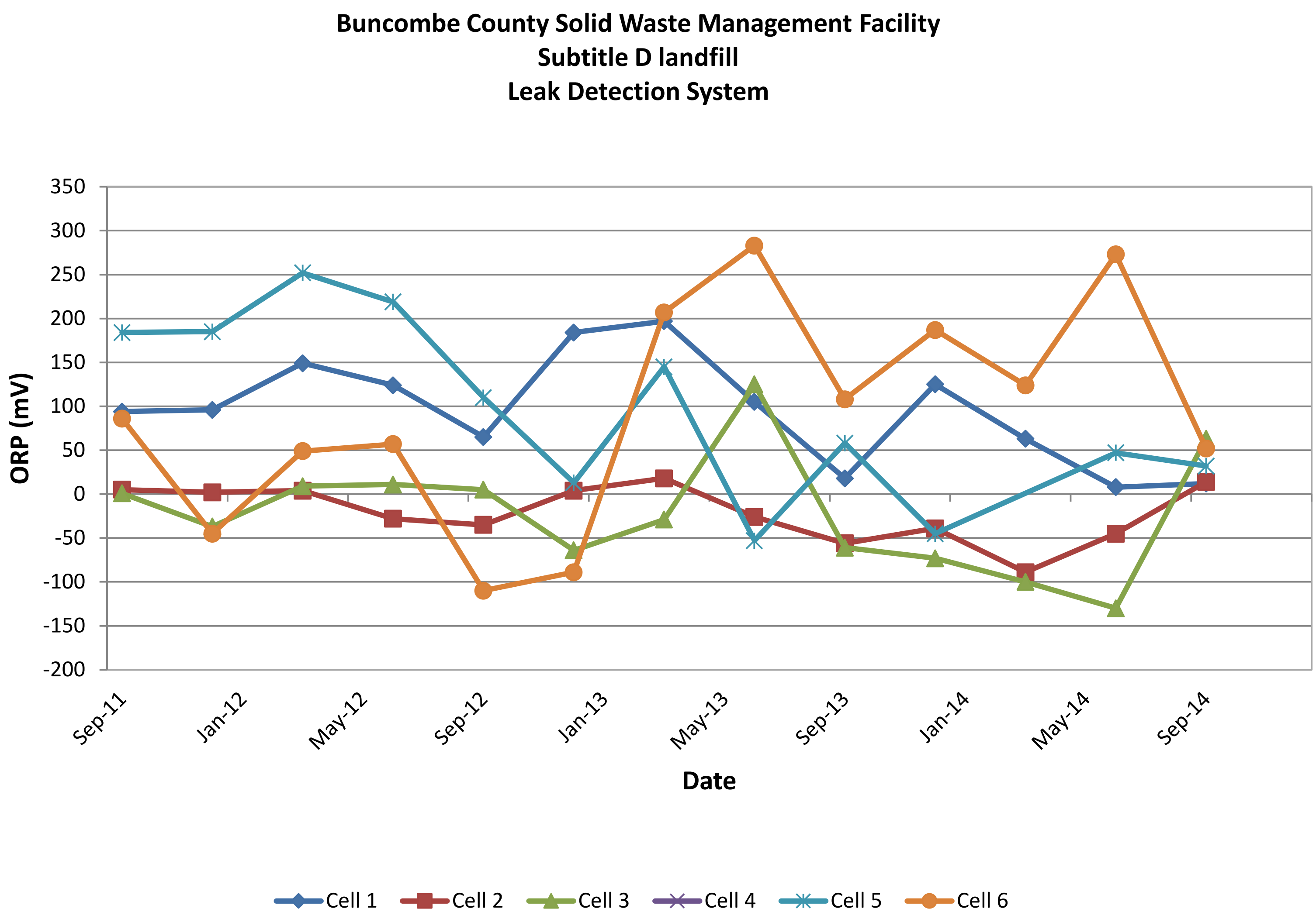


Figure 4-4 Oxidation Reduction Potential

***Note: Data not available after September 2014 due to equipment repairs.**

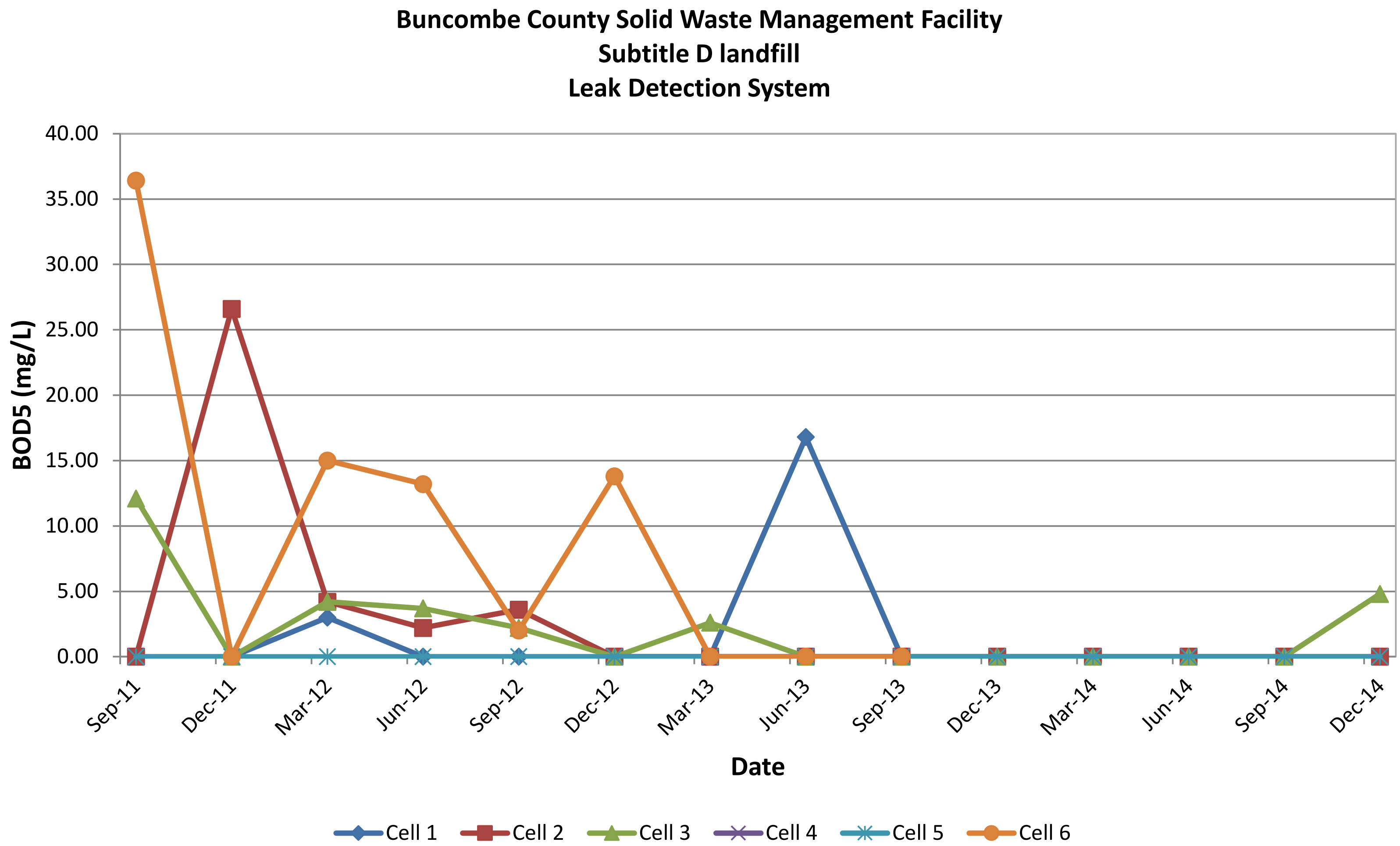


Figure 4-5 BOD5

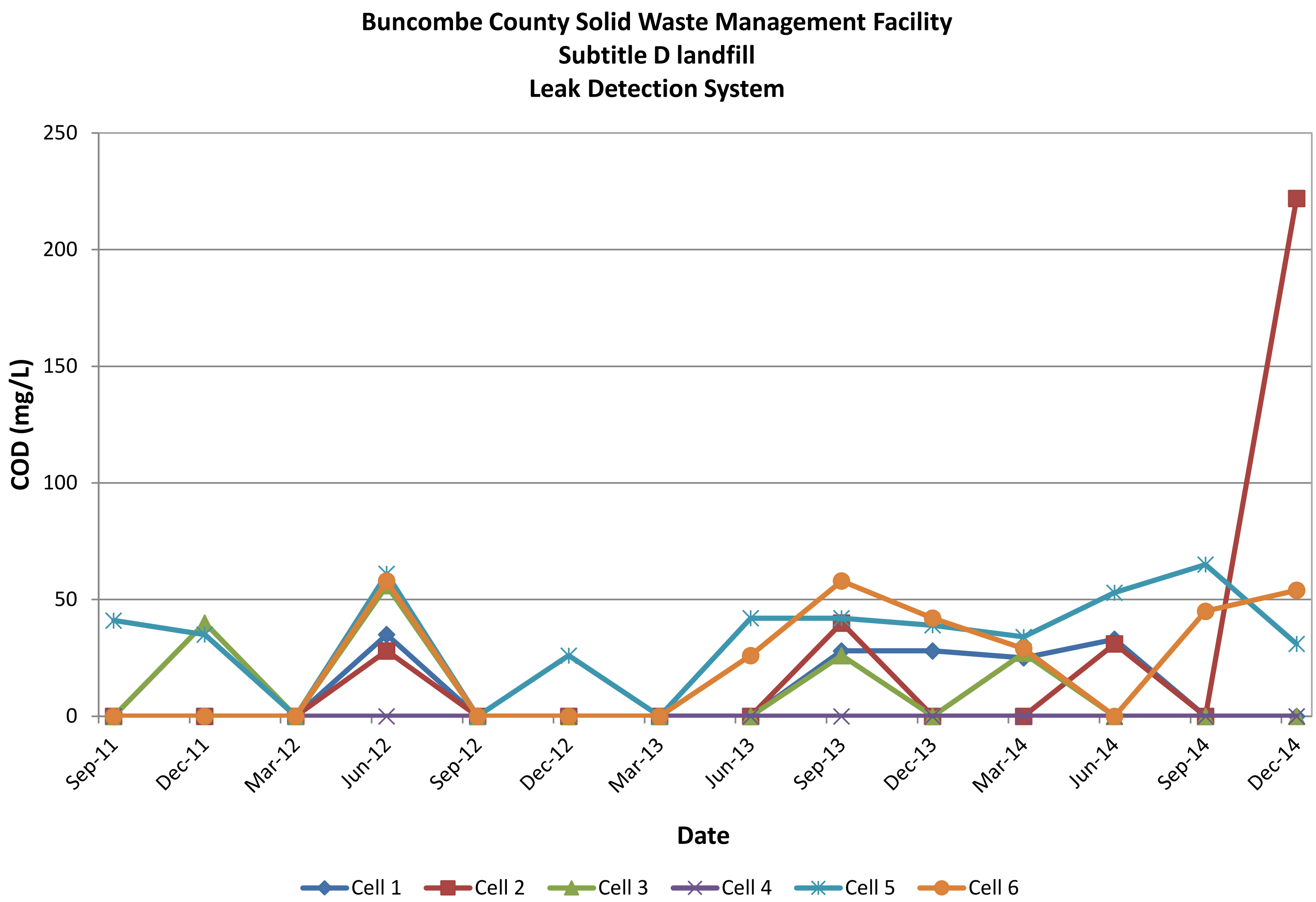


Figure 4-6 COD

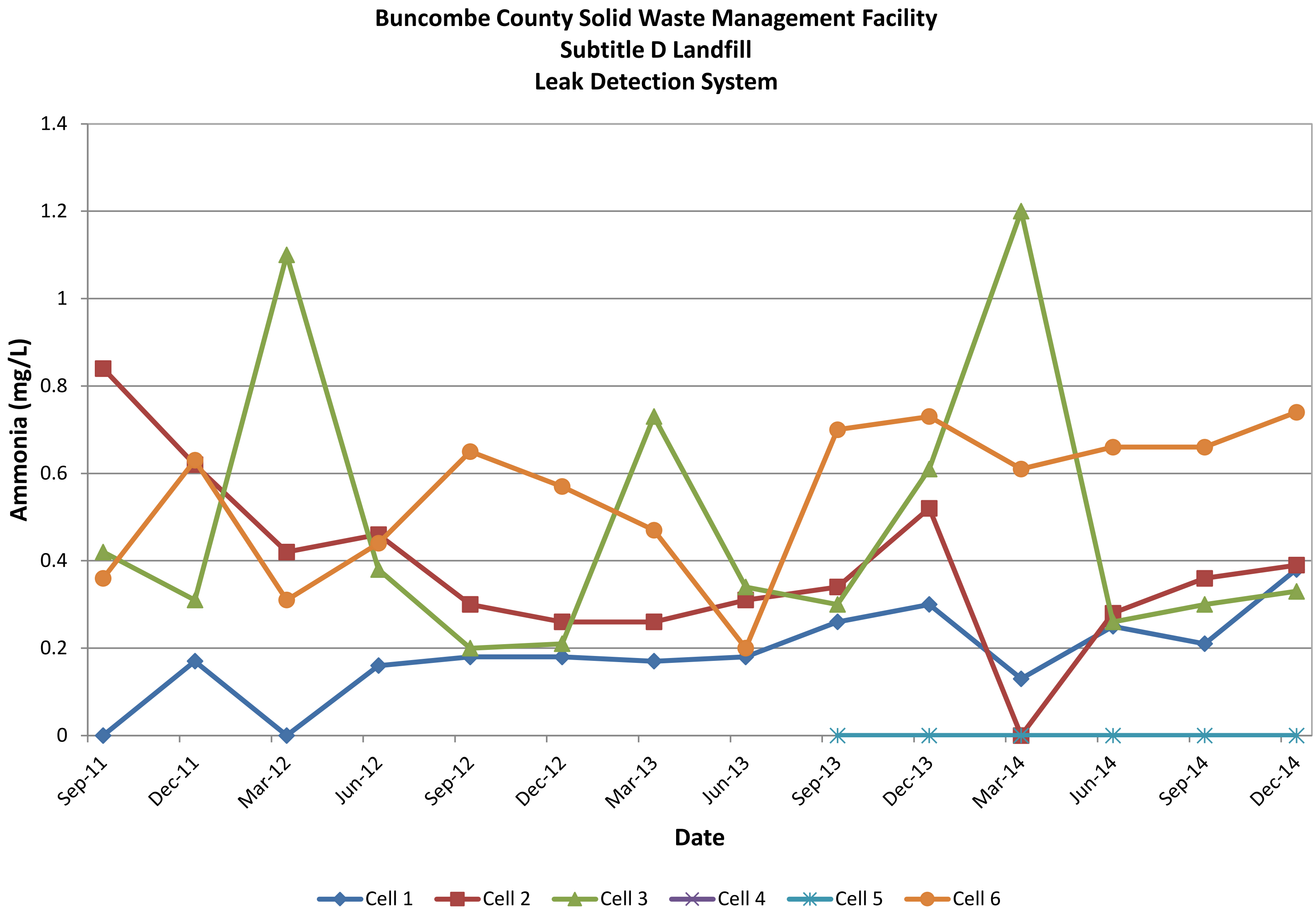


Figure 4-7 Ammonia

jj1658_Figures 4-1 to 4-7.docx

4.2 Leachate Collection System

Table 4-2 shows the quantity of leachate collected from the leachate collection system (LCS) of each cell. **Figure 4-8** shows the quantity of leachate generated in comparison to the rainfall. Leachate samples from Cells 1-6 and the leachate pond were analyzed for BOD5, conductance, COD, ammonia, pH, temperature, ORP, and TDS as shown in **Figures 4-9** through **4-15**.

Table 4-2 Leachate Collected from Cells 1-6

	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Total	Rainfall
	(gallons)	(gallons)	(gallons)	(gallons)	(gallons)	(gallons)	(gallons)	(inches)
	Subtitle D Liner		Alternative Liner					
Nov.-Dec. 2007	9,723	487	20,898	11,382	11,675	981,305	1,035,470	
2008	288,526	8,860	94,705	173,647	164,467	8,904,461	9,634,666	33
2009	101,777	35,102	103,371	333,067	356,580	14,610,720	15,540,617	43
2010	173,878	34,813	283,867	419,454	124,089	7,097,590	8,133,691	33
2011	156,900	36,027	44,096	124,478	402,831	6,589,437	7,353,769	37
2012	191,608	71,821	92,225	355,101	332,049	5,441,508	6,484,312	40
2013	351,389	225,251	403,484	652,494	905,800	4,563,843	7,102,261	51
2014	184,767	329,346	111,053	82,890	481,695	1,458,189	2,647,940	31
TOTAL	1,481,260	755,784	1,163,283	2,159,857	2,861,360	49,874,549	58,296,093	271

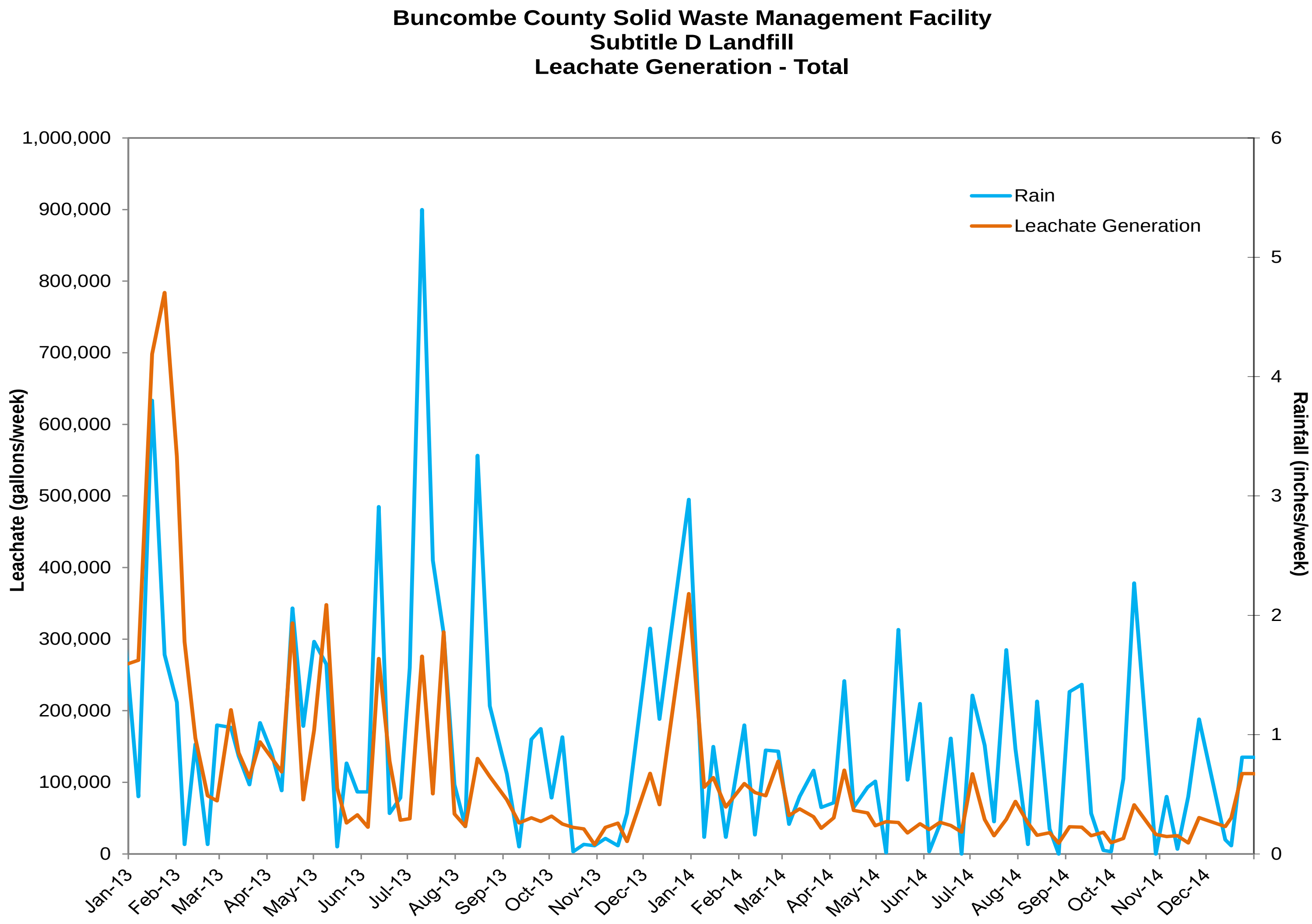


Figure 4-8 Leachate Generation vs. Rainfall

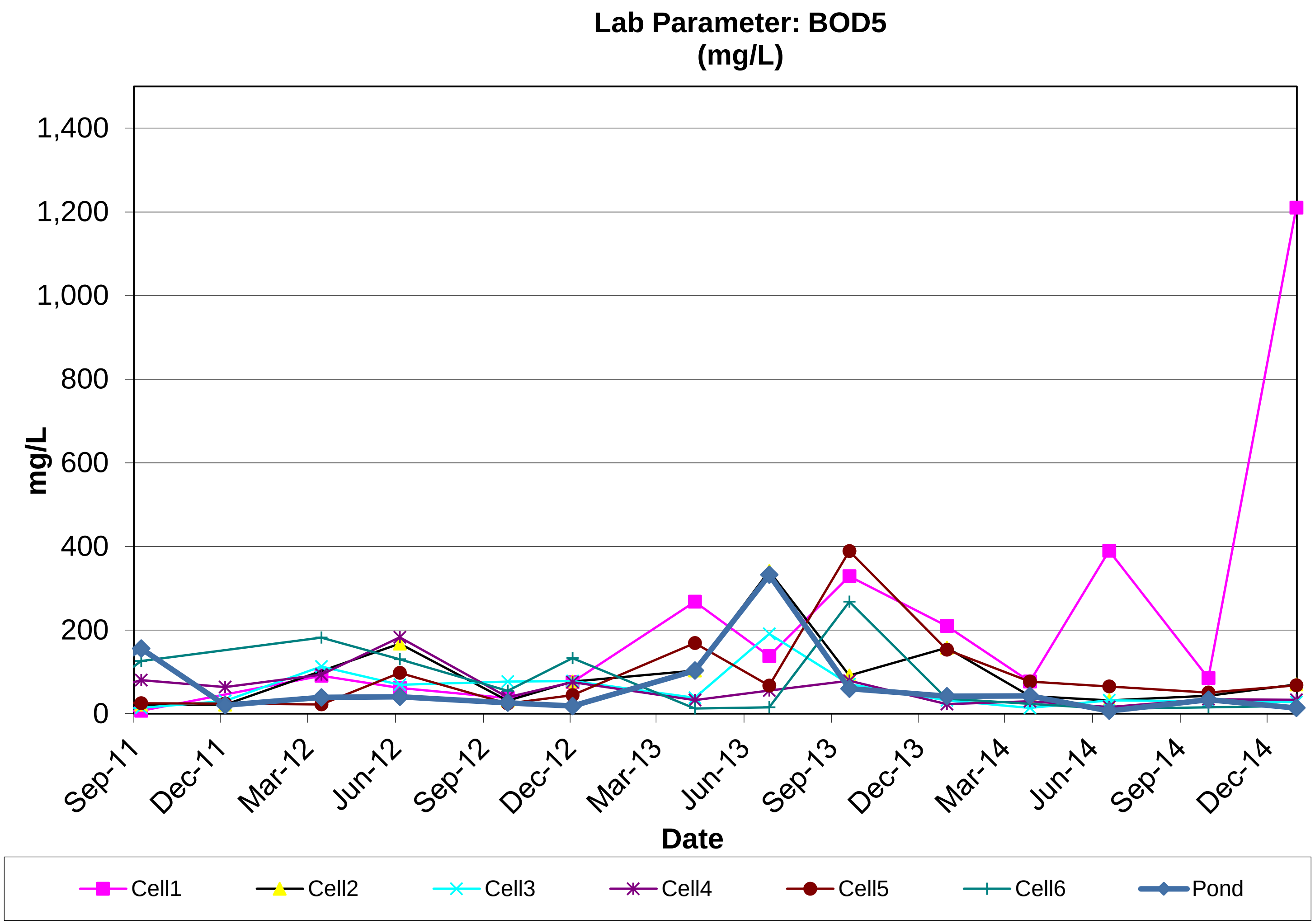


Figure 4-9 BOD5 of Leachate

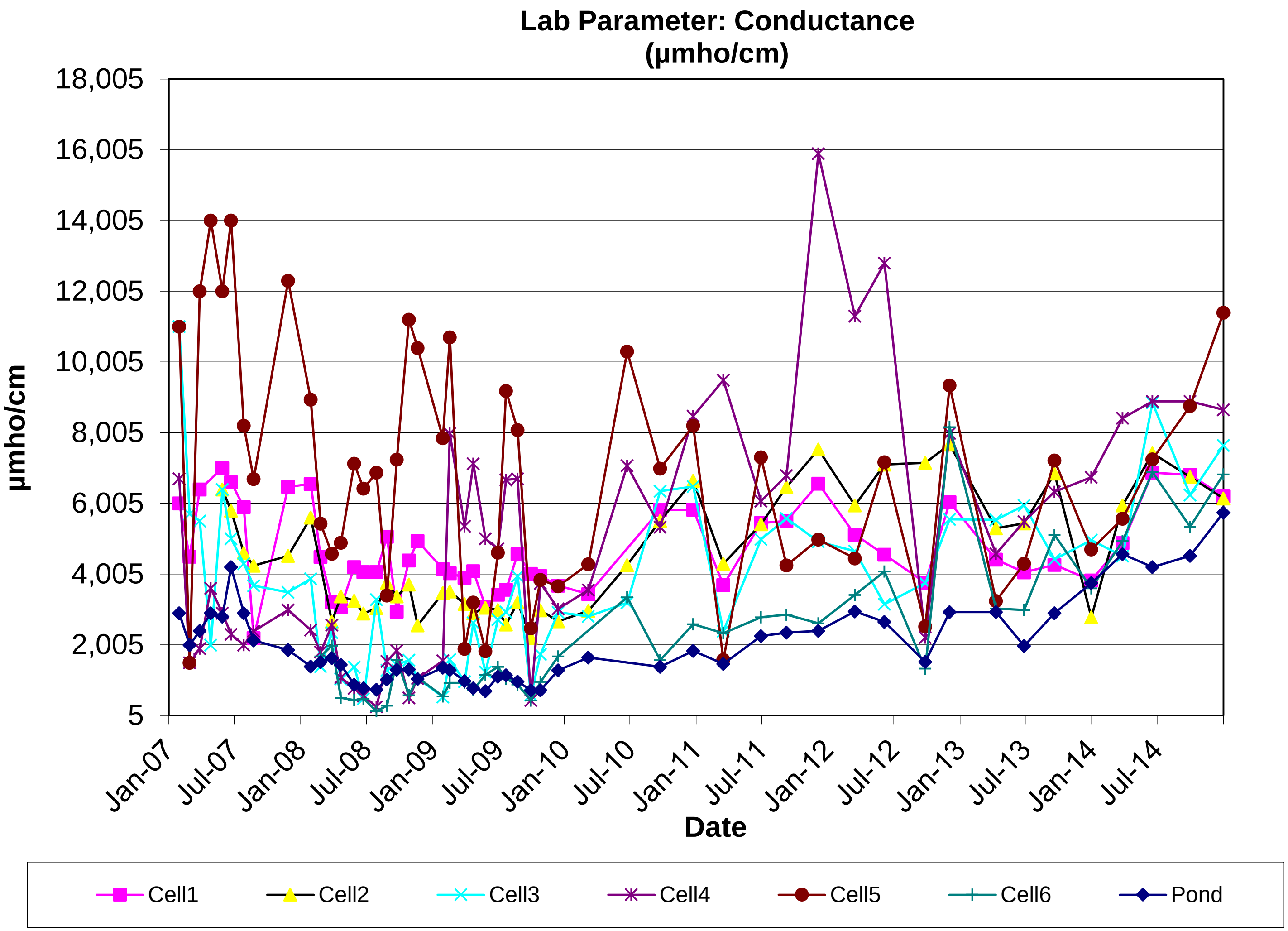


Figure 4-10 Specific Conductance of Leachate

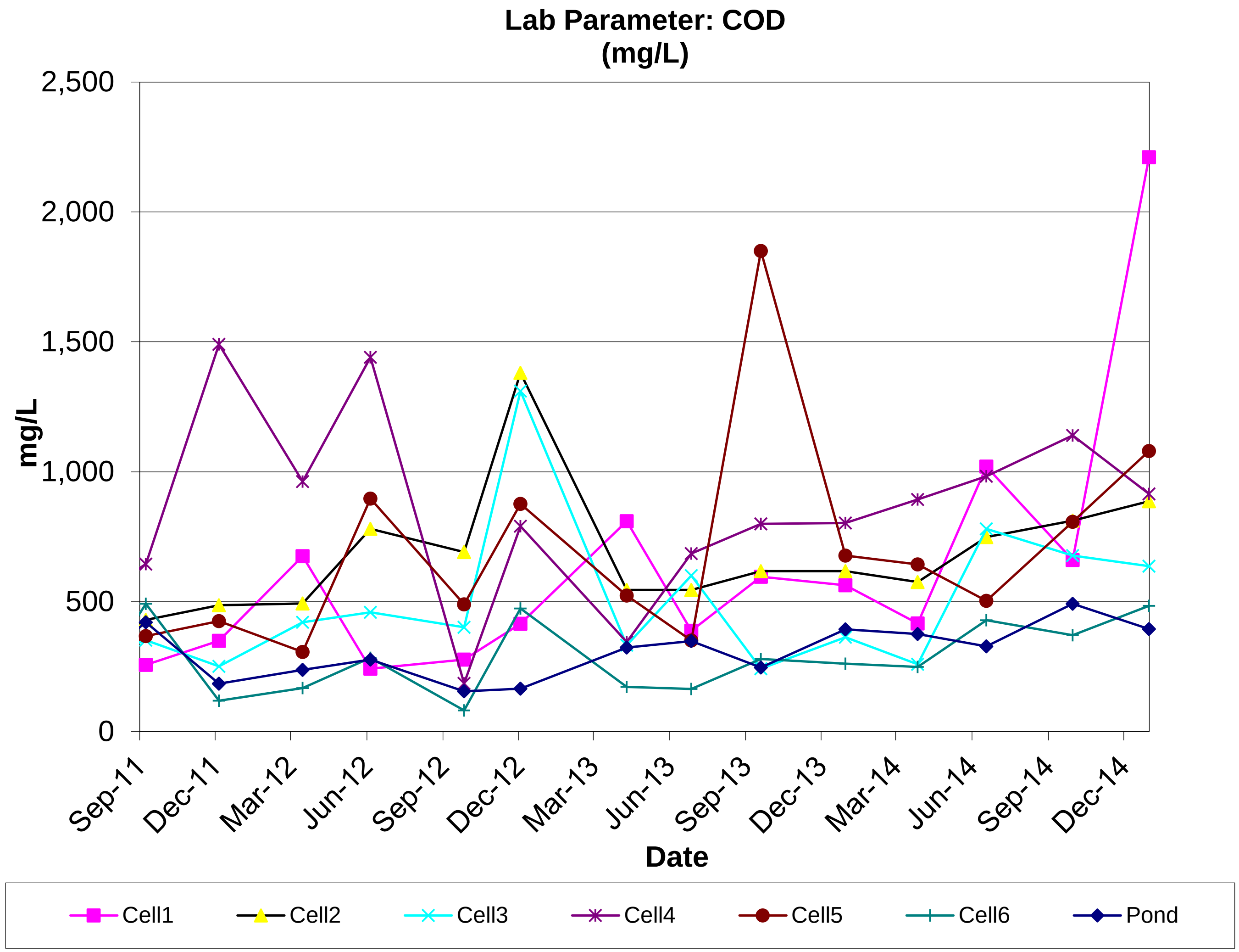


Figure 4-11 COD of Leachate

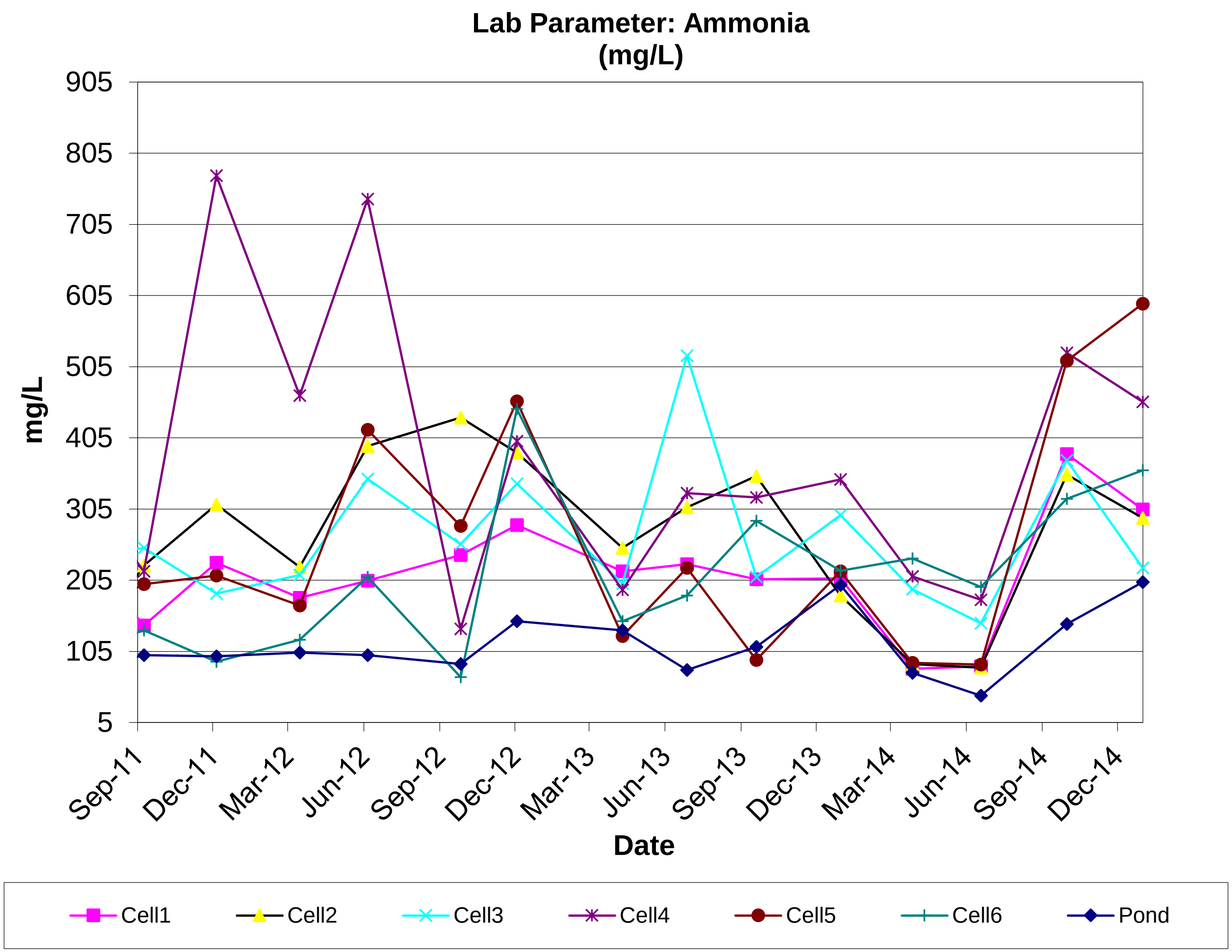


Figure 4-12 Ammonia of Leachate

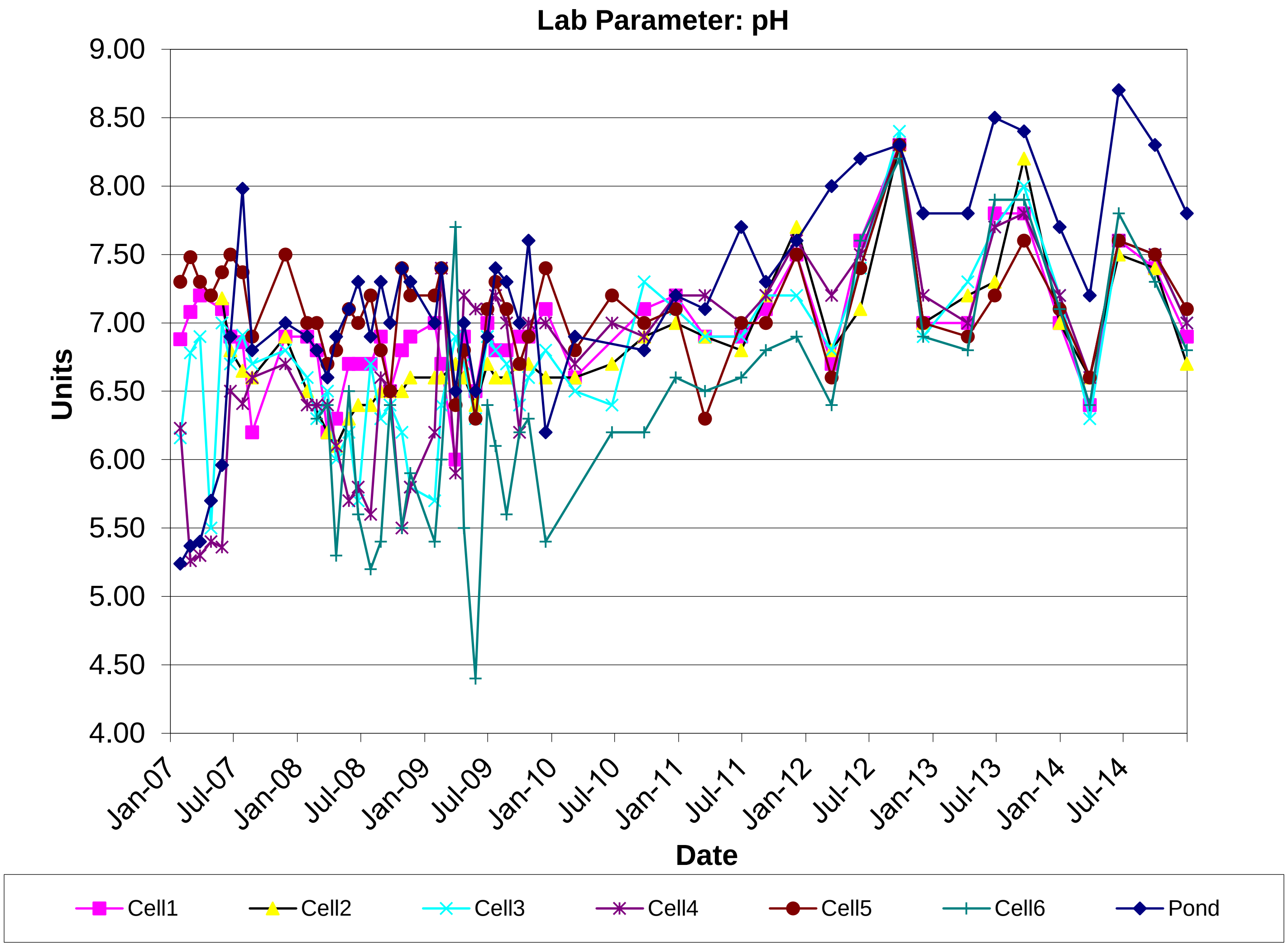


Figure 4-13 pH of Leachate

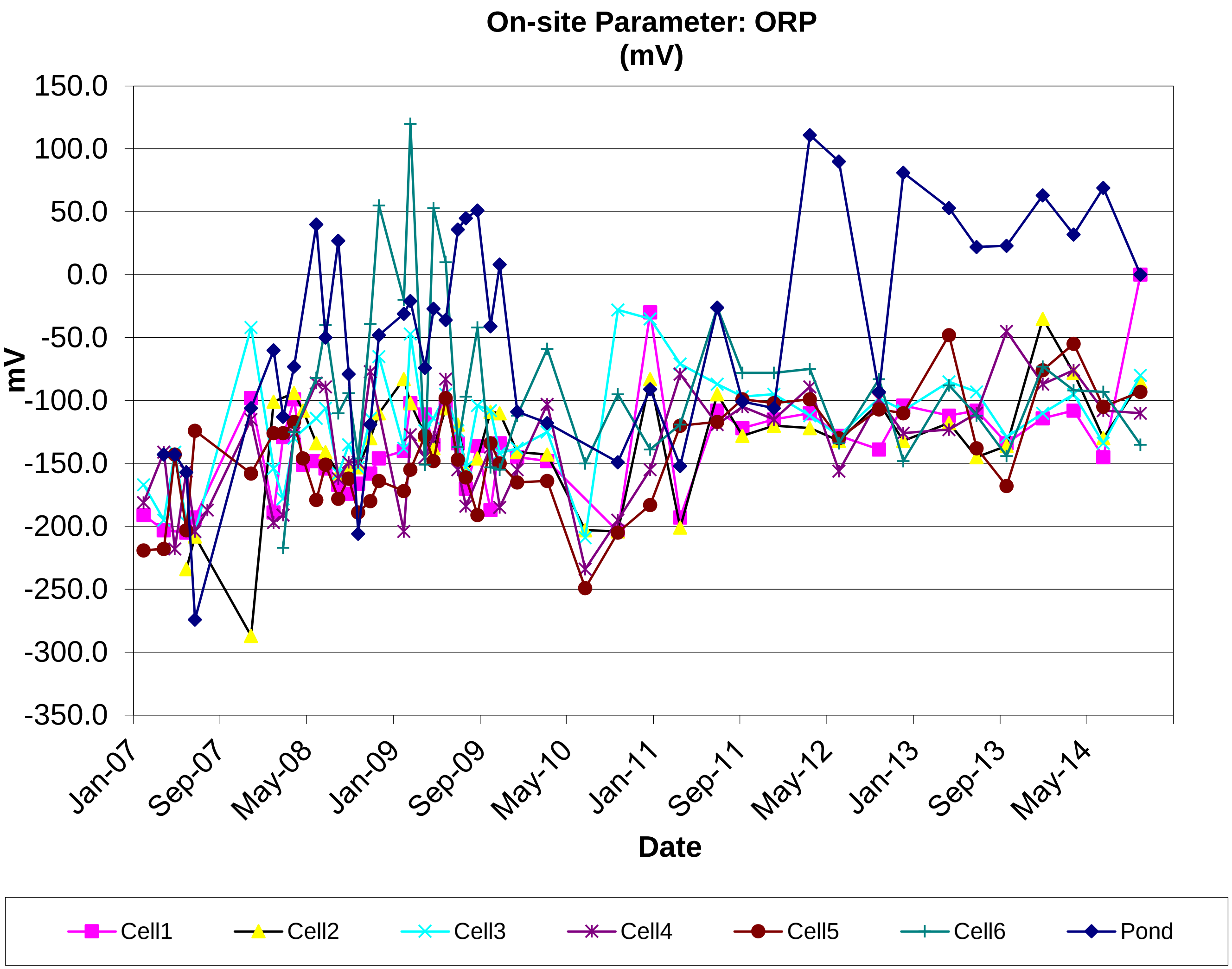


Figure 4-14 ORP of Leachate

***Note: Data not available after September 2014 due to equipment repairs.**

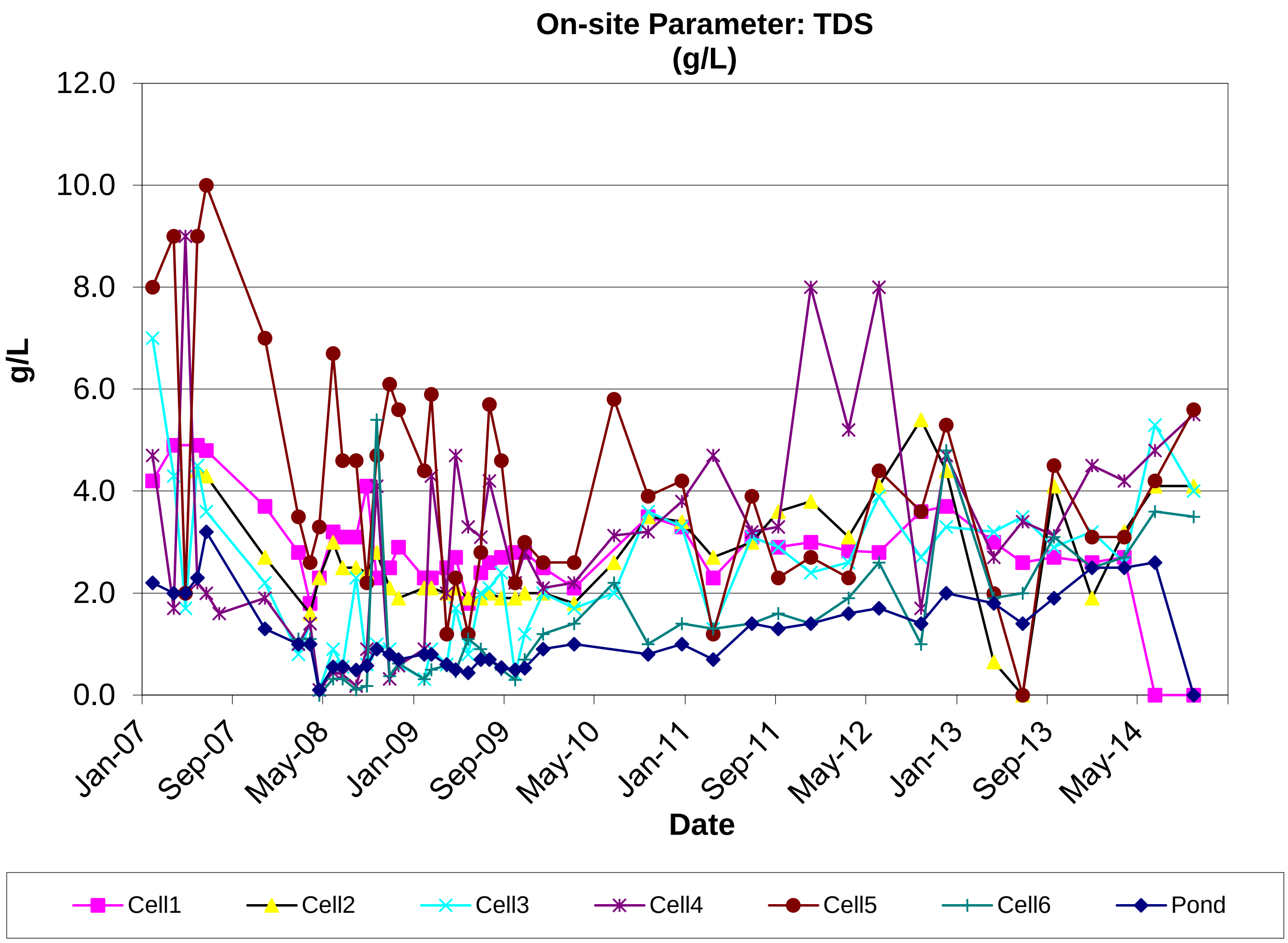


Figure 4-15 TDS of Leachate

***Note: Data not available after September 2014 due to equipment repairs.**

4.3 Leachate Recirculation

Figure 4-16 shows the cumulative quantity of leachate recirculated from 2006 through 2014. Approximately 3.7 million gallons of leachate has been recirculated. The annual leachate recirculated is presented in **Table 4-3**.

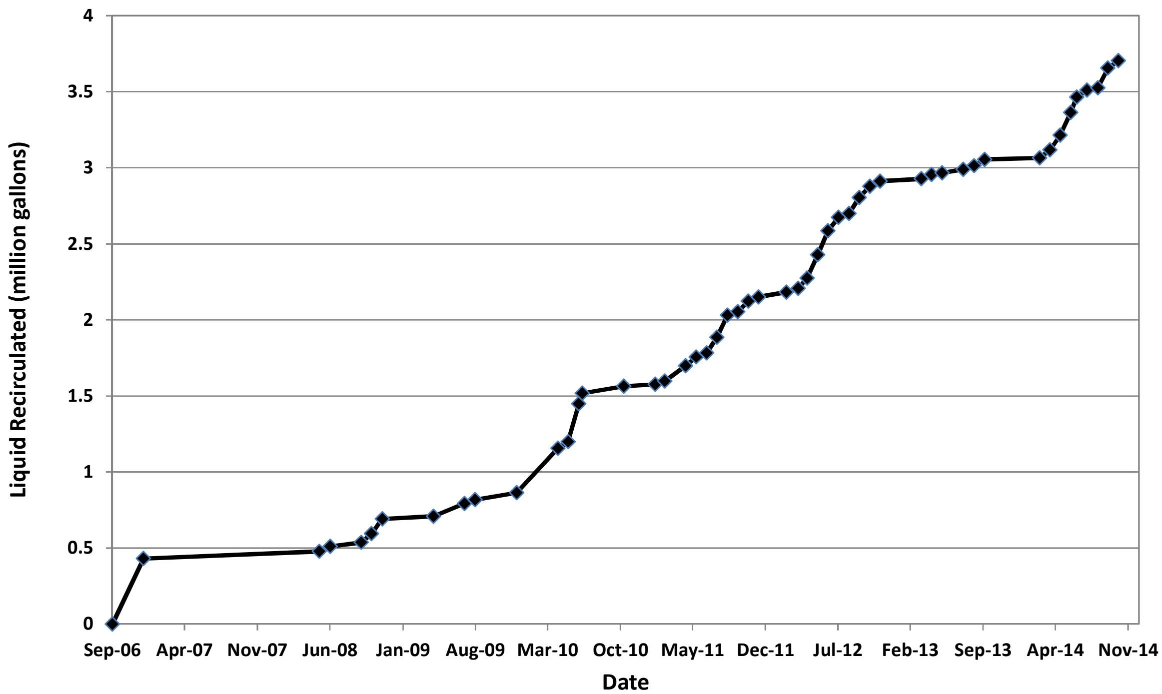


Figure 4-16 Cumulative Volume of Leachate Recirculated

Table 4-3 Leachate Recirculation Volumes

Date	HITs D, E, and F (gal)	SGTs 1A, B, and C (gal)	SGTs 2A, B, and C (gal)	SGTs 3A, B, and C (gal)	HITs A, B, and C (gal)	SGTs 4A and 4B (gal)	SGTs 5A and 5B (gal)	HITs 6B and 6C (gal)	Annual Total (Gallons)
2006	32,093	48,140	48,140	48,140	32,093	10,698	10,698		230,000
2007	27,907	41,860	41,860	41,860	27,907	9,302	9,302		200,000
2008	116,108	51,914	42,883	35,985	14,720	0	0		261,610
2009	48,210	3,670	1,720	3,590	105,330	8,510	0		171,030
2010	296,600	20,000	24,100	21,300	307,733	21,667	10,000		701,400
2011	298,490	14,129	27,654	21,867	161,068	32,922	29,690		585,820
2012	425,620	24,867	33,968	25,765	213,010	19,955	18,235		761,420
2013	87,820	5,730	12,485	12,195	20,420	2,180	2,050		142,880
2014	420,470	0	11,600	5,290	116,630	6,200	3,680	85,520	649,390
Total	1,753,318	210,310	244,410	215,992	998,911	111,434	83,655	85,520	3,703,550

4.4 Landfill Gas

The total gas flow and methane percentage of the gas collected from the landfill is monitored continuously at the LFGTE facility as presented in **Figure 4-17**.

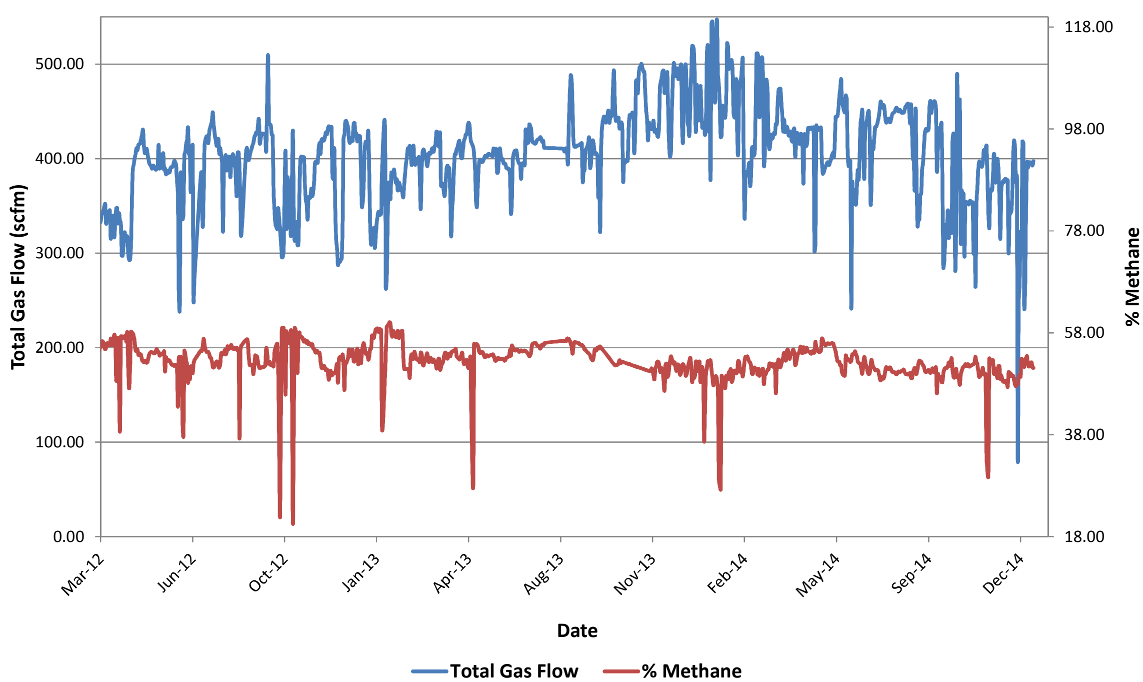


Figure 4-17 Total Gas Flow and Percent Methane at the LFGTE Facility

4.5 Settlement

The location of the ten (10) settlement plates installed within the retrofit area is shown in **Figure 4-18**.

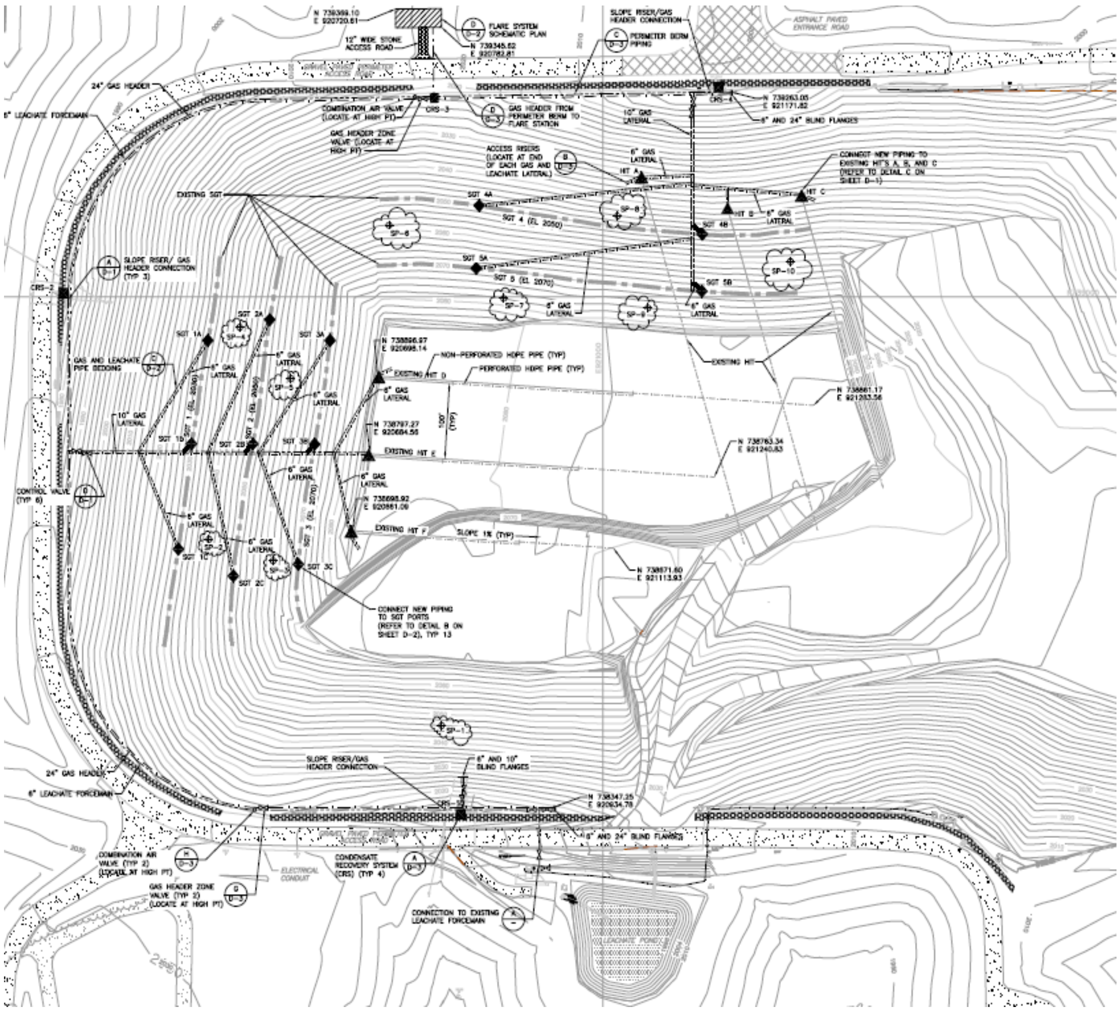


Figure 4-18 Settlement Plates in Cells 1-5
(Plate locations are shown circled with cloud outline.)

Figure 4-19 compares the measured settlement in the settlement plates from July 2006 through June 2014 to the quantity of leachate recirculated in Cells 1-6.

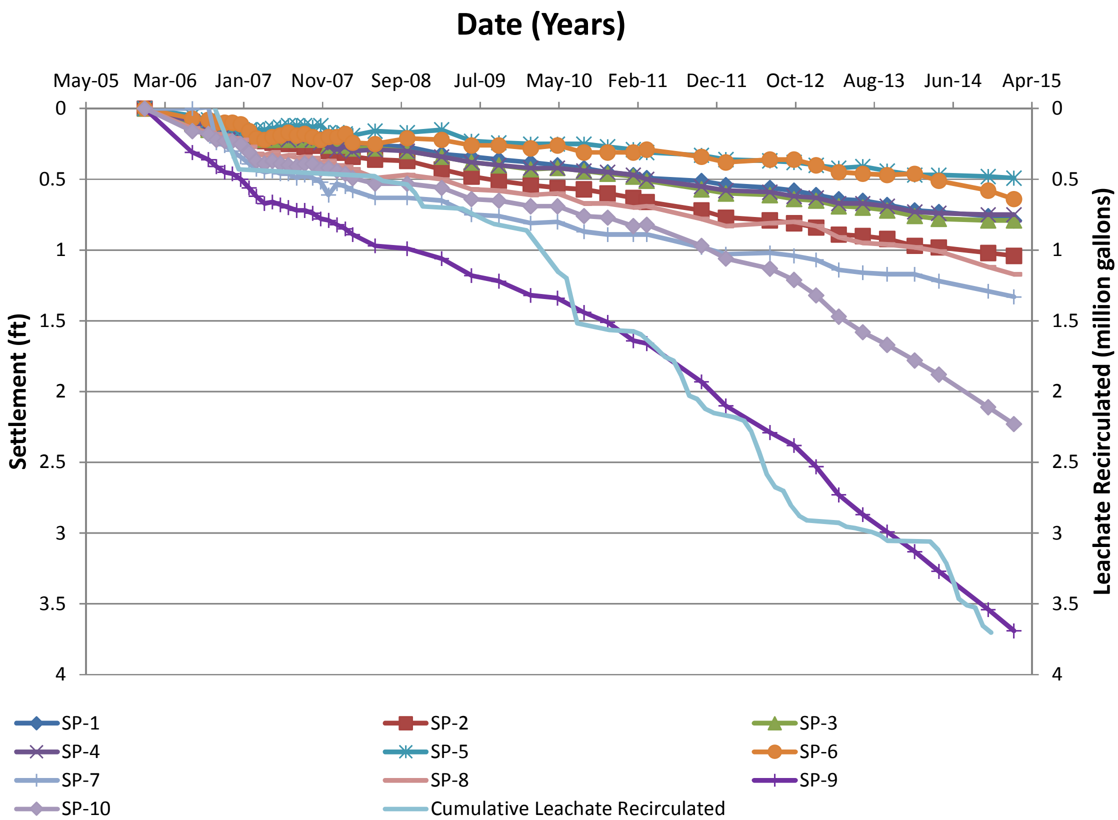


Figure 4-19 Cumulative Settlement

The latest survey of Cells 1 through 5 was done in January 2015. These cells were previously surveyed in November 2010. **Figure 4-20** compares the settlement in Cells 1 through 5 since November 2010.

4.6 Effective Waste Density

The County tracks the effective waste density of the active cell as part of the landfilling operation to assess impacts of liquids addition on compaction. Pre-wetting density values for Cell 6 include:

- 2014: 0.76 tons/cy
- 2013: 0.77 tons/cy
- 2012: 0.86 tons/cy
- 2011: 0.63 tons/cy

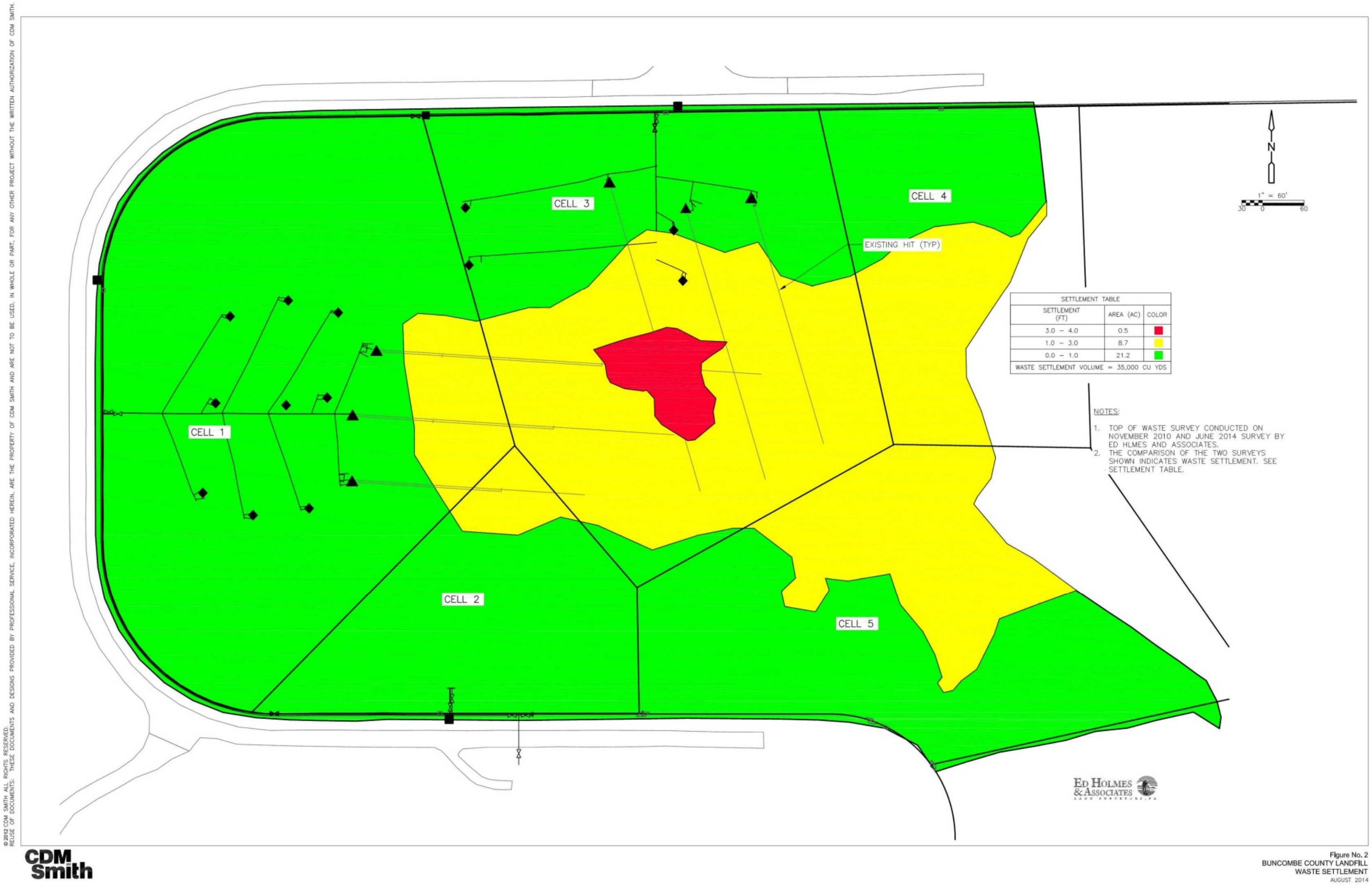


Figure 4-20 Settlement in Cells 1-5 since November 2010

4.7 Temperature of Waste in Cell 6

Thermocouples were installed in six (6) locations around Cell 6 HIT in assessing the impacts of leachate temperature during injection as shown in **Figure 4-21**.

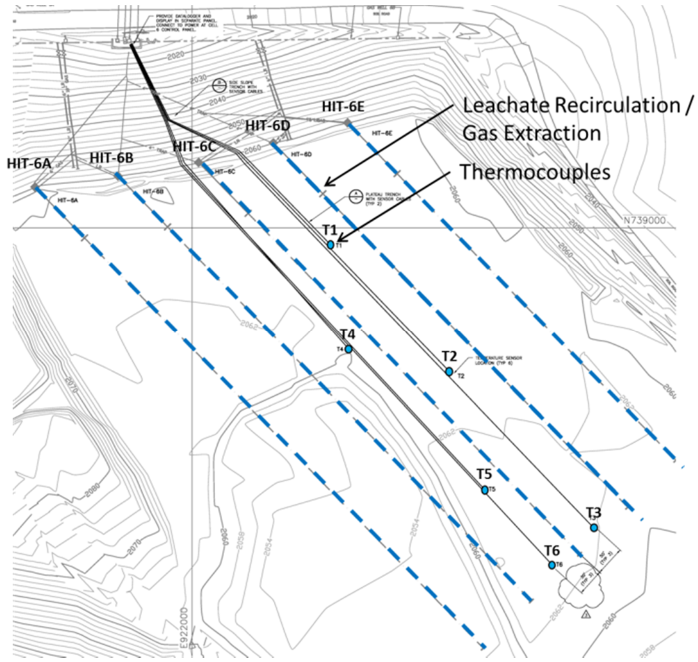


Figure 4-21 Temperature Sensors in Cell 6

The temperature of waste in Cell 6 is shown in **Figure 4-22**. Leachate recirculation in this cell began in June 2014.

The temperature of waste in Cell 6 compared with the depth of waste is shown in **Figure 4-23**.

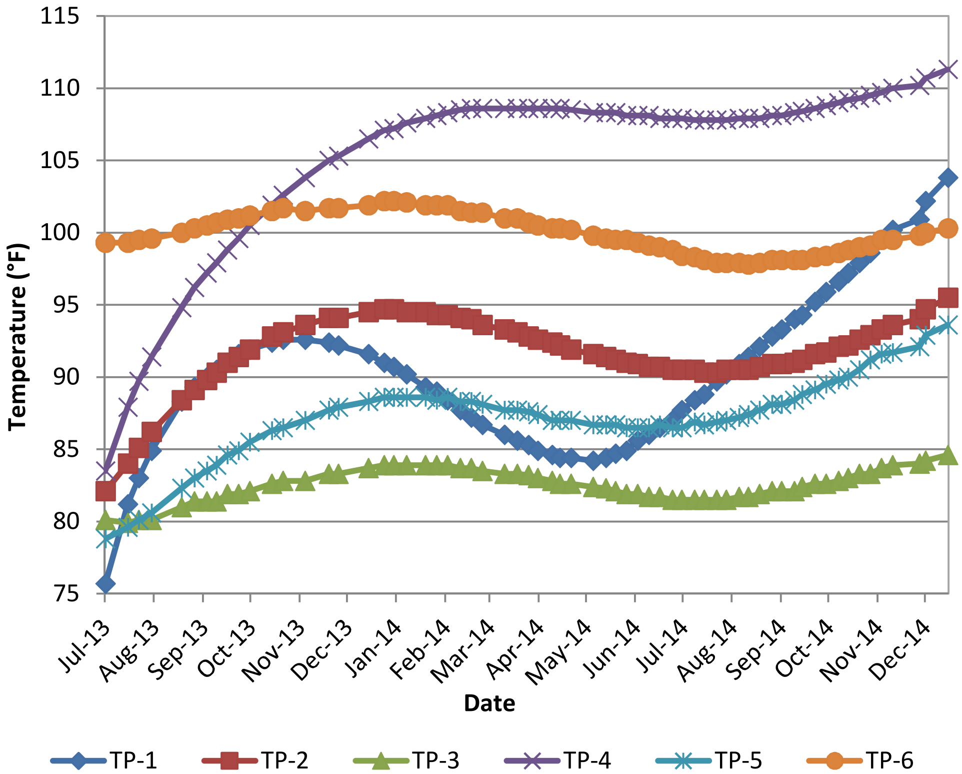


Figure 4-22 Waste Temperature Readings in Cell 6

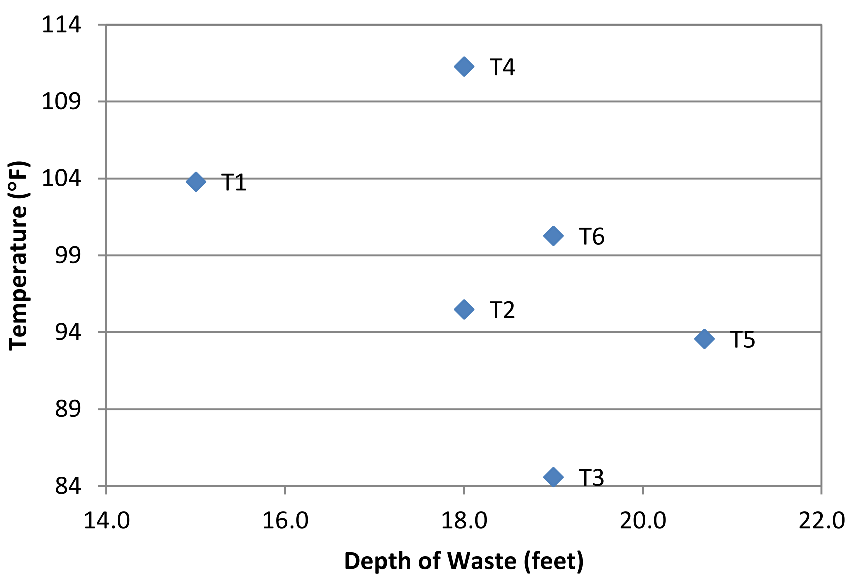


Figure 4-23 Temperature of Waste at Various Depths in Cell 6
(Note: Waste Depths from January 28, 2015 Topographic Survey)

Section 5

Project Assessment

5.1 Leachate Detection and Collection Systems Analysis

5.1.1 Determination of Liquid Source in the LDZ

Liquid present in the LDZ could be leachate that has leaked through the base liner system, groundwater or a combination of both. As shown in **Figure 5-1**, the LDZ are open on the sides and therefore are subject to potential groundwater infiltration. This is particularly evident in Cell 1 where it appears that the LDZ is being impacted by an underground spring based on the amount of flow witnessed during sampling events and the high quality of the water. Comparison of test data between the LDZ, leachate and groundwater was made in an effort to determine the source of the liquid.

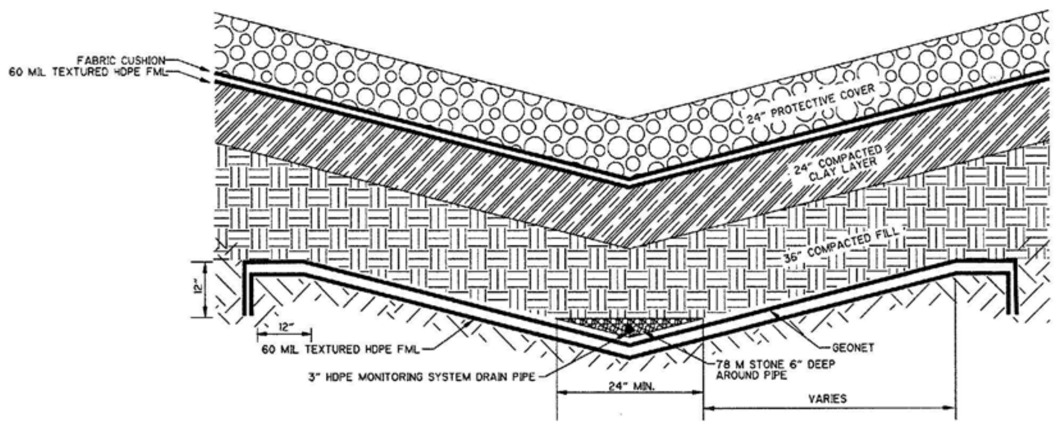


Figure 5-1 Leak Detection Zone in Cells 1-6 and Leachate Pond

The conductance levels of leachate are much higher than the samples tested for the Cell 1 LDZ. The conductance of leachate is in the range of 800-15,000 µmho/cm compared to 200-800 µmho/cm for the LDZ. The LDZ conductance is similar to the levels tested from groundwater well samples in the area as shown in **Figure 5-2**.

Toluene, which is often present in leachate, was found to be much lower in the LDZ samples, which correlate closely with groundwater testing results as shown in **Figure 5-3**.

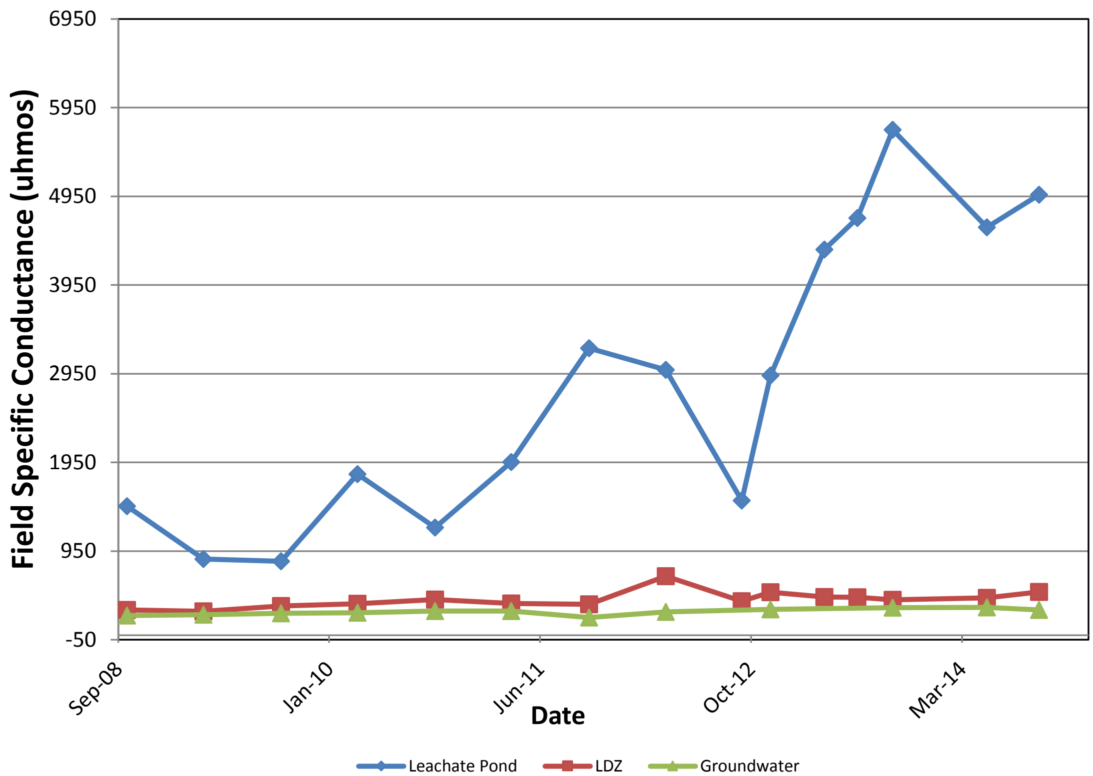


Figure 5-2 Conductance of Leachate, LDZ, and GW Samples
(Values are averages of testing results for the six cells and all GW monitoring wells)

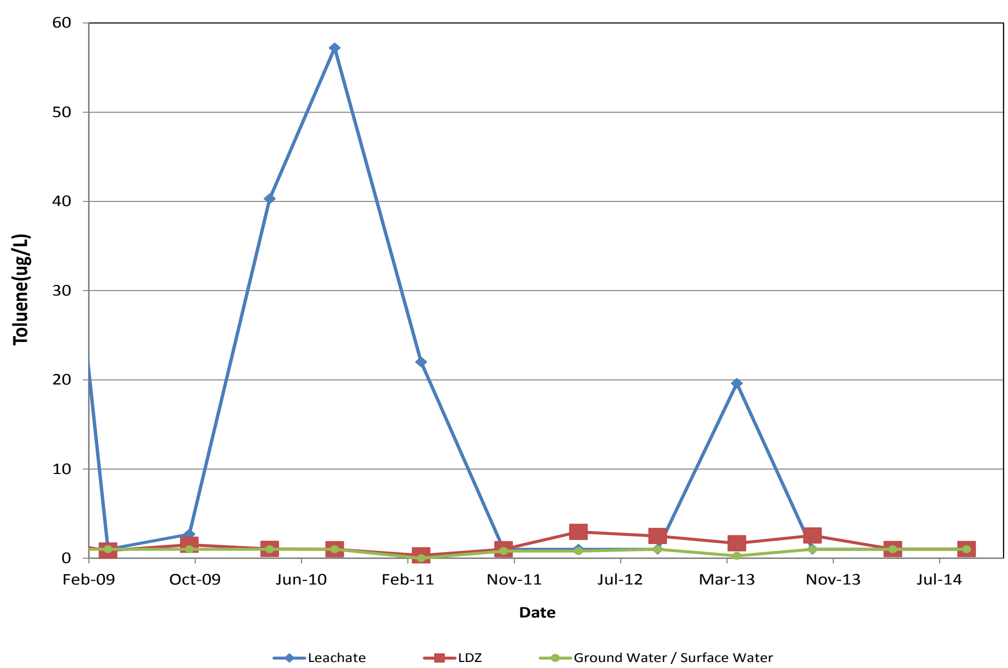


Figure 5-3 Toluene of Leachate, LDZ and GW/SW Samples
(Values are averages of testing results for the six cells and all GW/SW monitoring wells)

Figure 5-4 shows the ORP values for the leachate and LDZ samples for all cells. Comparison of ORP values also shows a strong distinction between leachate and the liquid sampled from the LDZ. The ORP values for leachate are all negative while all but two of the LDZ samples produced positive values. A negative value is indicative of anaerobic conditions as would be expected for landfill leachate. Thus, the positive readings for the LDZ samples support the conclusion that the leachate is not a significant component of the LDZ liquid.

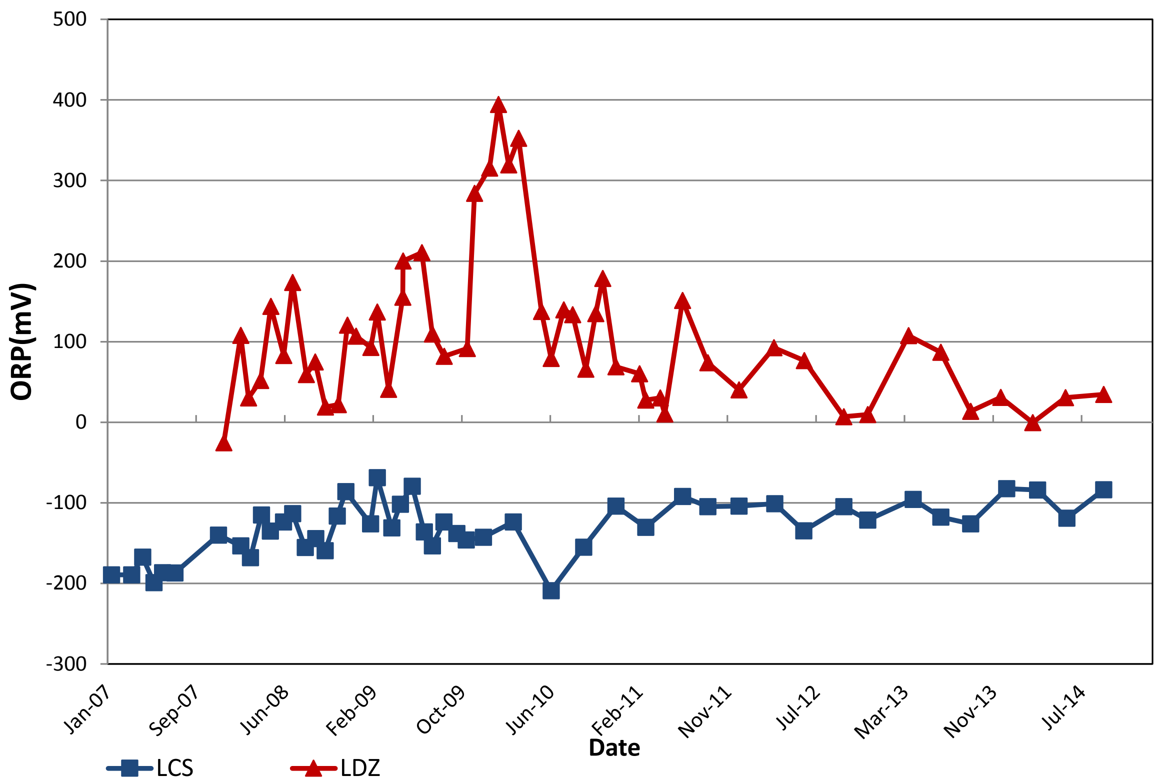


Figure 5-4 ORP of LCS and LDZ
(Values are averages of testing results for the six Cells)

Based on these comparisons it was concluded that the liquid in the LDZ is all or mostly groundwater. As no appreciable amount of leachate appears to be in any of the LDZ it can be concluded that both types of liner systems are performing as designed and are not experiencing adverse impacts from the liquids addition program.

5.1.2 LDZ Quality

The COD reading in Cell 2 in December 2014 was 222 mg/L. Except for in June 2012, COD has been not detected in the Cell 2 LDZ. The cause of this high reading is unknown.

The BOD and COD of the Cell 1 LDZ are higher than the other cells. The cause for this is unknown, and the data will be monitored for the 2015 sampling events.

5.1.3 Leachate Pond

It was observed in 2014, that the quantity of leachate in the LDZ for the pond was significantly higher than in past years. This could be the result of the pond being kept half-full for a major part of the year.

It was also observed that the pH of the leachate in the pond was higher than the leachate in the cells as shown in Figure 4-13. However, the pH trend for the pond follows the leachate pH trend for the cells. It is thought that the concrete liner could possibly contribute to the higher pH in the pond.

5.2 Gas Collection System

The average gas flow for July through December 2014 was 393 scfm, and the average methane concentration of the gas was 50%.

An active gas collection trench was installed in the North Slope of Cells 1 and 3 in September 2014. This trench is a perforated pipe embedded in rock trench surrounded by an air tight tarp. The purpose of the trench is to mitigate landfill gas migration, and it has been working effectively.

5.3 Reduction of Leachate Hauling to the Wastewater Treatment Facility

As of November 1, 2014, a total of 3.7 million gallons of leachate has been recirculated, resulting in 741 avoided truck trips to the wastewater treatment plant and a savings of $283,248.95 in hauling costs. The savings attributed to July through December 2014 is $25,875.72. With the expansion of the wetting system into Cell 6 in June 2014, the largest cell of the landfill, the amount of leachate that can be recirculated is expected to significantly increase.

5.4 Settlement of Waste in Cells 1 through 5

Settlement plates in Cells 1 through 5 indicate that the landfill has settled an average of 1.29 ft. since October 2005 as shown in Figure 4-19. Approximately 3.7 million gallons of leachate has been recirculated from 2006 through December 2014.

The survey using a 50ft foot grid system indicates that the Cells 1 through 5 has settled 0-1 ft. in 21.2 acres, 1-3 ft. in 8.7 acres and 3-4 ft. in 0.5 acres since November 2010 as shown in Figure 4-19. Most of the settlement has occurred in the areas where leachate has been periodically recirculated.

5.5 Relocation of Condensate Discharge Line in Cell 4

The condensate discharge line from the gas wells around Cell 4 was constructed incorrectly and connected to the Leak Detection Zone Riser. All condensate discharge lines connect directly to the leachate sump riser; the condensate line for Cell 4 was disconnected from the leak detection zone and reinstalled correctly into the leachate sump riser at Cell 4.

5.6 Operations in Cell 6 Build-As-You-Go Bioreactor

There is approximately 15 to 20 feet of waste on top the HITs of Cell 6. Leachate recirculation started in HITs 6B and 6C in June 2014. Through the end of 2014, 85,520 gallons of leachate have been injected in these two lines. It is recommended that landfill gas be temporarily collected from HITs 6A, 6D, and 6E. The landfill gas quality and flow should be evaluated from these HITs to determine whether collection should continue or if the HITs should be used for recirculation instead.

Temperature sensors have been installed in these areas to access the impact of leachate temperature during injection.

5.7 Waste Stabilization

Twenty-five vertical wells were installed in Cells 1-5 in November 2010 for the landfill gas-to-energy project. Photographs were taken of the exhumed waste to observe the degree of stabilization as shown in **Figure 5-5** and **5-6**. Waste temperatures were taken immediately after waste was extracted from the boreholes with an infrared thermometer. Most locations showed waste temperatures in the mid-90s with the exception of the following five wells, which showed elevated temperatures:

- VW-6: 100 deg F
- VW-24: 110 -130 deg F
- VW-10: 104 -108 deg F
- VW-18: 110 deg F
- VW-11: 105 -108 deg F

The waste from these five boreholes was observed to be noticeably wetter than the waste for the other boreholes. Steam emanating from the waste of VW-24 was indicative of the elevated temperatures. The waste from this borehole appeared to be well decomposed.

Figure 5-5 Exhumed Waste from Drilling of Vertical Well 24

Figure 5-6 Exhumed Waste from Drilling of Vertical Well 13

The BOD5/COD ratio of the landfill leachate has dropped steadily since 2007 indicating that stabilization of the organic waste fraction is occurring as shown in **Figure 5-7**.

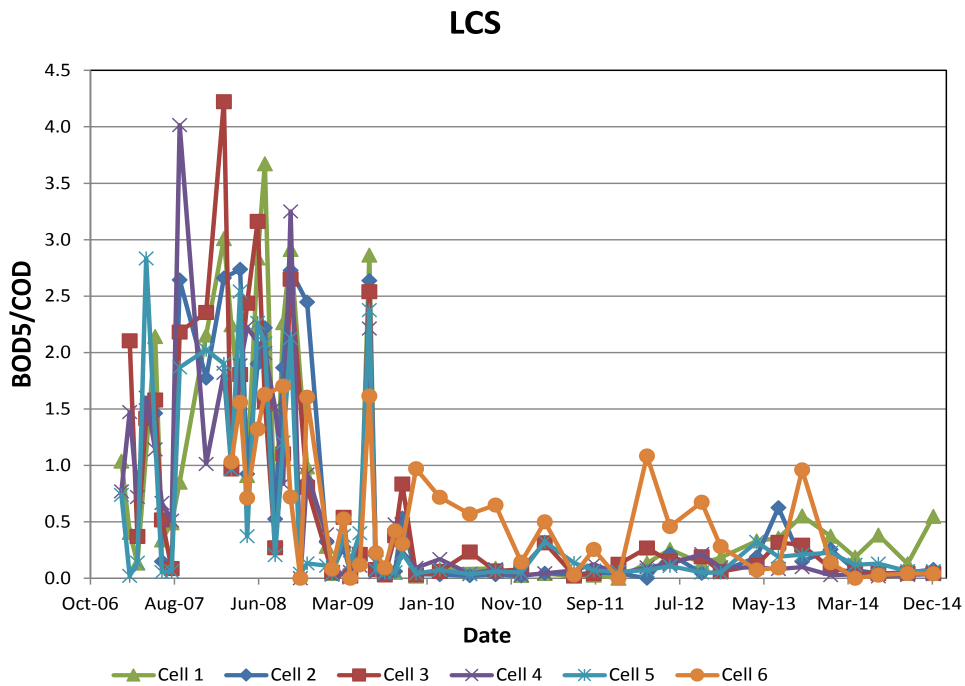


Figure 5-7 BOD5/COD Ratio of LCS in Cells 1-6

5.8 Greenhouse Gas Reductions

The HIT installed in the active disposal cell will provide early capture of LFG that would normally be released to the atmosphere until final grades are obtained and wells are installed. Collected gas from the active area will be measured to determine the amount of greenhouse gas reduction directly attributable to the project. Combustion of LFG also produces carbon credits for the County as the site is registered with the Climate Action Reserve. The County registered the carbon credits and equivalent passenger vehicles gas emissions shown in **Table 5-1** below:

Table 5-1: Carbon Credits Registered

Year	Carbon Credits	Equivalent Passenger Vehicle Emissions Offset
2012	28,784	5,997 vehicles
2013	29,490	6,208 vehicles
Total	**58,274**	**12,205 vehicles**

5.9 Alternative Cover Material

Posi-shell has been approved by the North Carolina Department of Environment and Natural Resources for use at the Buncombe County landfill and is being used as an alternative daily cover since the last progress report. The use of alternative daily cover improves distribution of wetting from the HIT; uses less airspace than soil, and allows the onsite borrow soils to be saved for new cell and capping construction. It may also be contributing to improved compaction of waste. It is recommended that alternative cover material be used to the largest extent possible in the ongoing landfill operation.

Section 6

Stakeholders Meeting

A project stakeholders meeting was held on September 20, 2012 at Buncombe County solid waste management facility to provide an update and discuss project issues. The meeting was attended by the following persons:

NCDENR:	Ed Mussler, Allen Gaither, Andrea Keller
USEPA:	Craig Dufficy, on conference call
WNCRAQA:	David Brigman, Ashley Featherstone
Buncombe County:	Jerry Mears, Jon Creighton, Kristy Smith, Aaron McKinzie, Donna Cottrell
CDM Smith:	Chris Gabel, Ravi Kadambala
University of Florida:	Dr. Timothy Townsend

The following are the various topics discussed during the meeting along with follow-up activities performed.

6.1 Monitoring of the Alternative Liner System

Ed Mussler inquired if the project has sufficient data to reach a conclusion regarding the performance of the alternate liner system and, if so, should we consider revising the project goals of Project XL and writing a final report addressing the performance of the alternative liner system.

Chris Gabel stated that further data is required to reach a conclusion and that Cell 6 will provide a means of tracking an accurate water balance. This will allow us to determine if the liner system is being subjected to higher leachate flows as a result of the newly installed build-as-you-go leachate recirculation system. The retrofit system applies leachate at elevations that are 100+ feet above the leachate sump. The Phase 1 trenches installed in Cell 6 are 20 to 40-feet from the drainage layer.

Ed Mussler inquired if the leachate level at the sump is being monitored as it could be used to determine if leachate recirculation is over-capacitating the collection system. Kristy Smith responded that leachate levels are monitored daily but are not recorded. This prompted the idea of using the existing temperature sensor data logger to record leachate level data in Cell 6.

Follow-up Activities: The level sensors were installed in the sump of Cell 6, and connected to the datalogger to record the head on the liner over time. Preliminary results showed negligible change in the level after one day of adding 13,170 gallons of leachate. The level sensor will be closely monitored with time as more leachate is recirculated.

6.2 Discharge Liquids from Cell 1 LDZ

The Cell 1 LDZ has a large quantity of liquid in it that has been tested numerous times. The test results indicate that it is groundwater. The meeting attendees discussed options for draining the LDZ to determine if groundwater is still recharging this area. The proposed plan is to test the liquid to ensure it is not leachate and then drain into the adjacent stormwater channel. Onsite staff would monitor the process to see how long it takes to drain the accumulated volume. NCDENR representatives suggested submitting a letter describing how the process will be performed and the safeguards to be used to ensure protection of the environment.

Follow-up Activities: A large tank will be used to collect liquids from Cell 1 LDZ, and disposed at the leachate pond.

6.3 Landfill Settlement

Settlement plates are used to track settlement resulting from wetting. We could consider using topographic surveys to supplement the plate information. The surveys could be performed on a 25-ft grid over the final slope areas for comparison from year to year to see where settlement is occurring. The cost is estimated at $3,500 per survey. Graphic representation could include color coded areas based on the amount of the settlement.

Settlement measurements can be taken internally by installing a level sensor into the HIT. The device, known as a settlement profiler consists of a pressure transducer which is connected to a liquid reservoir. The transducer is inserted into the HIT pipe using a push rod allowing measurements to be taken at various points of the trench. The transducer gives a measure of the elevation profile of the pipe relative to the reservoir located on stable ground. The liquid tube is stored on a reel.

Follow-up Activities: Cells 1 through 5 were surveyed on a 50-ft grid in December 2013 and April 2014. The results of this survey are presented in Section 4.5. These Cells will be surveyed again in April 2016 on a bi-annually basis.

6.4 Liquid Addition in Cell 6

Kristy Smith suggested dedicating HIT 6E to gas collection to reduce the likelihood of side seeps of leachate. Dr. Townsend suggested using only HITs 6B and 6D for leachate recirculation to determine the lateral extent of wetting using the temperature probes (refer to **Figure 6-1**). HITs 6A, 6C and 6E will be used for collecting gas. Temperature data and gas flow rates will be measured prior to leachate recirculation to get a background reading. The change in gas flow and temperature data will indicate the impact of leachate recirculation on gas generation.

Potential design changes for the next phase of lines in Cell 6:

1. Consider adding a vertical gas well intersecting the HITs.
2. Consider installing temperature probes inside the HITs.
3. Consider utilizing waste heat from the LFGTE system to heat leachate for year-long leachate recirculation.

Follow-up Activities: Refer to section 5.6 for details on liquid addition in Cell 6.

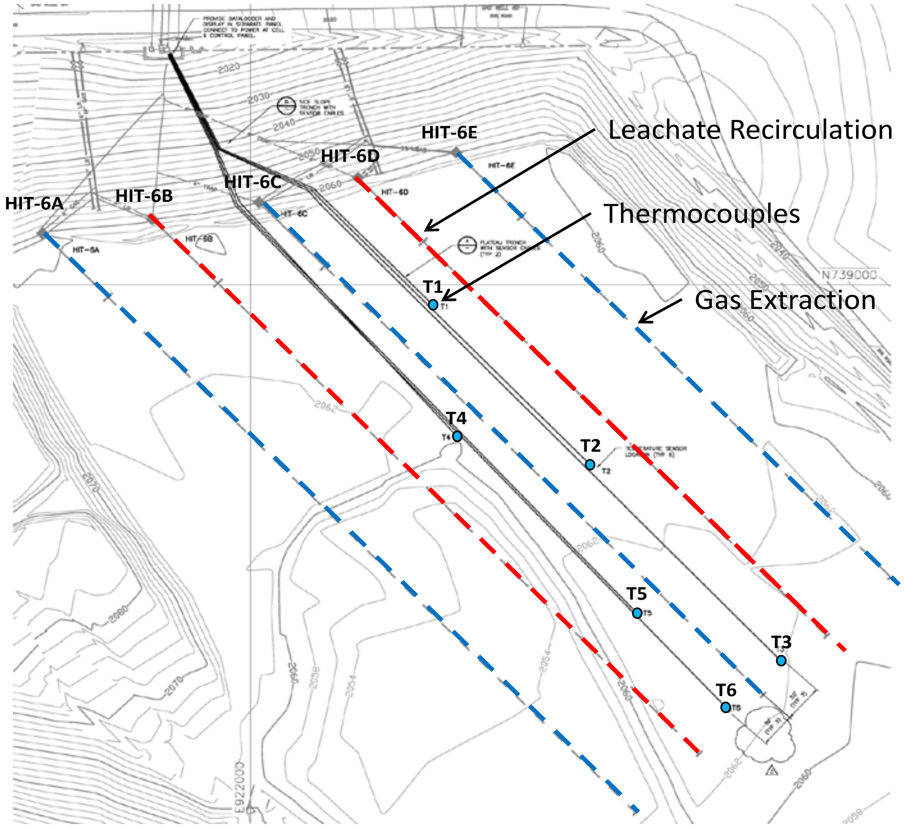


Figure 6-1 An Option Discussed at the Stakeholders' Meeting for Cell 6 HIT Operation

6.5 Gas Collection System

Aaron stated that operation of the small flare was problematic as it keeps going out. Further investigation of the flare revealed that the orifice plate needs to be re-welded.

CDM Smith to perform wellfield adjustments with Buncombe County periodically to optimize gas extraction. Well 6A in the Cell 6 drainage layer is functioning now that leachate sump levels were re-set to provide a lower elevation for Pump ON.

Follow-up Activities: Small flare has been fixed and is currently operational. Refer to section 5.2 for details on the gas collection system.

Section 7

Recommendations

7.1 Modifications to the Monitoring Program

7.1.1 Measuring Settlement

Cells 1 through 5 were surveyed on a 50-ft grid in April 2014. The results of this survey are presented in Section 4.5. The next survey will be performed in April 2015.

7.1.2 Water Balance Monitoring

Water balance monitoring should be added to more accurately track the effects of moisture addition in Cell 6. Leachate, precipitation, and leachate recirculation data are being collected and will be used in a water balance calculation.

7.1.3 Leachate Recirculation Impacts to Head on Liner

Based on discussions with the North Carolina Department of Environment and Natural Resources (NC DENR), it was recommended to monitor and record levels of leachate in the Cell 6 sump during recirculation events. This monitoring will help determine any impacts to the leachate collection system from the recirculation. The pump level sensors in the sump of Cell 6 are connected to a datalogger, which continuously records the head on the liner every 15 minutes. Fluctuations are monitored to indicate changes in the head on the liner. Preliminary results are discussed in Section 6.1. Detailed sump monitoring data will be reflected in the next progress report.

7.2 Recommended Modifications to Design and Operation

7.2.1 Leak Detection Zones

For Cells 7-10, it is recommended that the design of the LDZ be revised to eliminate the 3-foot separation between the LDZ and the bottom of the base liner system, as this will greatly reduce the potential for groundwater infiltration. This is shown in **Figure 7-1**.

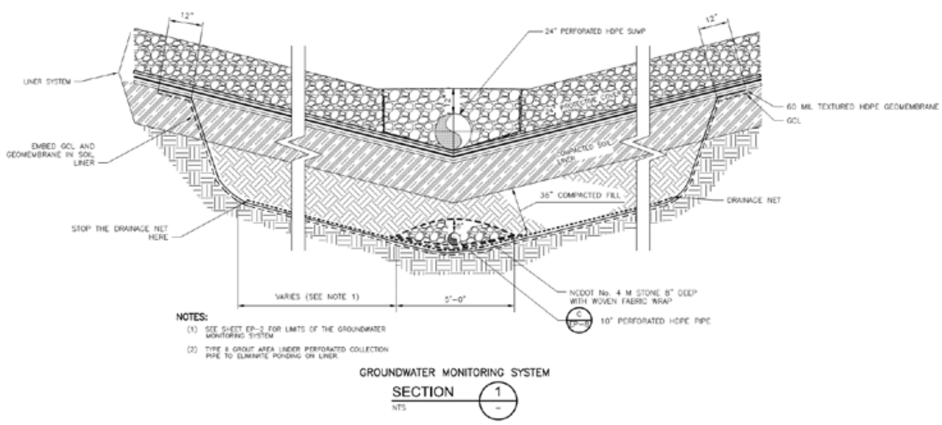


Figure 7-1: Revised LDZ Design

7.2.2 Strategy for Operation of Cell 6 HITs

Based on the discussions held at the stakeholders meeting, a combination of dedicated recirculation and gas collection HIT is desirable for determining the effectiveness of the wetting operation and maximizing early gas capture.

The strategy to date has been to recirculate in HITs 6B and 6C. It is recommended that landfill gas be temporarily collected from HITs 6A, 6D, and 6E. The landfill gas quality and flow should be evaluated from these HITs to determine whether collection should continue or if the HITs should be used for recirculation instead.

7.2.3 Cells 1-5 HITs Maintenance

In order for continued optimal operation, it is recommended that HITs A, B and C be cleaned using high-pressure water jetting to remove clogging.