Scanned by Zinith Barbee | Date 10/9/09 | Doc ID # 8742

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

RECEIVED OCT - 8 2009 SOLID WASTE SECTION

October 7, 2009

Zinith Barbee
Project Manager
NC Department of Environment and Natural Resources
Division of Waste Management – Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

Received OCT 2009 Waste Management

RE: CAP Resubmittal October 7, 2009 (By Email)
Dunn-Erwin Landfill Facility
SWS Permit No. 43-02
Harnett County, NC

Mr. Barbee,

Attached you will find an updated Corrective Action Plan (CAP) submittal for the Dunn-Erwin Landfill facility for your review. Per our letter dated October 1, 2009, the enhanced bioremediation technology has been replaced with a groundwater extraction trench in conjunction with a leachate management system to form a complete "pump and treat" system for source control and treatment. The existing plume area will continue to be treated with hybrid poplars via phytoremediation as previously documented. A hard copy of this report will be delivered to your office tomorrow morning.

The entire CAP has been revised to reflect the changes mentioned above and to address as many of your comments made in your June 11, 2009 review letter as remained applicable after the revisions. Appendix C of the report contains the Engineers Cost Opinion for the completion of the CAP. This amount is what is being used for the financial assurance form which the County is currently filling out at this time. We hope to have it completed and submitted to your office by the end of the week.

Should you have any questions regarding this re-submittal please do not hesitate to call or email me at the office numbers below.

Sincerely,

C. Tyrus Clayton Jr., P.E.

/attachment

cc: Ryan Sadler, CTC
C. T. Clayton, Sr., PE, CTC
Ed Mussler, SWS (Email copy)
Mark Poindexter, SWS (Email copy)
Shawn McKee, SWS (Email copy)
Geof Little, SWS (Email copy)
Jerry Blanchard, General Services Manager, Harnett County (Email copy)
CJ Poran, PE, ENSOL (Email copy)

P.O. Box 578
46 W. Washington St.
Coats, NC 27521
Phone: 910-897-7070
Fax: 910-897-6767

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

October 7, 2009 **PN:** 3002B

Zinith Barbee
Project Manager
NC Department of Environment and Natural Resources
Division of Waste Management – Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

RE: CAP Resubmittal October 7, 2009 (By Email)
Dunn-Erwin Landfill Facility
SWS Permit No. 43-02
Harnett County, NC

Mr. Barbee,

Attached you will find an updated Corrective Action Plan (CAP) submittal for the Dunn-Erwin Landfill facility for your review. Per our letter dated October 1, 2009, the enhanced bioremediation technology has been replaced with a groundwater extraction trench in conjunction with a leachate management system to form a complete "pump and treat" system for source control and treatment. The existing plume area will continue to be treated with hybrid poplars via phytoremediation as previously documented. A hard copy of this report will be delivered to your office tomorrow morning.

The entire CAP has been revised to reflect the changes mentioned above and to address as many of your comments made in your June 11, 2009 review letter as remained applicable after the revisions. Appendix C of the report contains the Engineers Cost Opinion for the completion of the CAP. This amount is what is being used for the financial assurance form which the County is currently filling out at this time. We hope to have it completed and submitted to your office by the end of the week.

Should you have any questions regarding this re-submittal please do not hesitate to call or email me at the office numbers below.

Sincerely,

C. Tyrus Clayton Jr., P.E.

/attachment

cc: Ryan Sadler, CTC
C. T. Clayton, Sr., PE, CTC
Ed Mussler, SWS (Email copy)
Mark Poindexter, SWS (Email copy)
Shawn McKee, SWS (Email copy)
Geof Little, SWS (Email copy)
Jerry Blanchard, General Services Manager, Harnett County (Email copy)
CJ Poran, PE, ENSOL (Email copy)

P.O. Box 578
46 W. Washington St.
Coats, NC 27521
Phone: 910-897-7070
Fax: 910-897-6767

CORRECTIVE ACTION PLAN
HARNETT COUNTY DUNN-ERWIN LANDFILL
HARNETT COUNTY, N.C.

SWS PERMIT NO. 43-02

PREPARED FOR
HARNETT COUNTY

December 2008
Revised February 2009
Revised October 2009

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

PO Box 578 – 46 West Washington Street - Coats, North Carolina 27521
Phone: 910-897-7070 - Fax: 252 672-8577
Offices located in Coats and New Bern, North Carolina
www.ctclayton.com

CTC PN: 3002B

CORRECTIVE ACTION PLAN

December 2008
Revised February 2009
Revised October 2009

Prepared for:

HARNETT COUNTY, NORTH CAROLINA

Prepared by:

C.T. CLAYTON SR., P.E., Inc.
CTC PN# 03002B

The following Corrective Action Plan was prepared in accordance with NC Solid Waste Management Rules (NCSWMR) 15A NCAC 13 B .1636.

NORTH CAROLINA PROFESSIONAL SEAL 028909 ENGINEER C. TYRUS CLAYTON, JR.

10/07/09

Ryan Sadler
Project Manager

C. Tyrus Clayton, Jr., P.E.
Vice President

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 Background Information 1
1.2 Previous Investigations 1
1.3 Site Characteristics 2
2.0 CONTAMINANT CHARACTERIZATION 2
2.1 April 2008 Statistical Analysis Results 3
2.2 Contaminants of Concern (COC) 5
2.3 Exposure Pathways 5
2.3.1 Methlylene Chloride 5
2.3.2 Trichloroethylene 6
2.3.3 Tetrachloroethlyene 7
2.3.4 1,1-Dichloroethane 8
2.3.5 1,4-Dichlorobenzene 10
2.3.6 Vinyl Chloride 11
2.3.7 Benzene 13
2.3.8 Lead 14
2.3.9 Mercury 17
2.4 Aquifer Use 19
2.5 Risk Assessment 20
3.0 ASSESSMENT OF CORRECTIVE MEASURES (ACM) REVIEW 20
4.0 REMEDIAL APPROACH (History of the remedial approach) 21
4.1 Existing Controls 22
4.2 Leachate Management 23
4.2.1 Leachate Management Overview 23
4.2.2 Leachate Management Evaluation 23
4.3 Phytoremediation (Downgradient Plume Treatment) 25
4.3.1 Phytoremediation Overview 25
4.3.2 Phytoremediation Evaluation 27
4.4 Groundwater Extraction – Pump-and-Treat (Source Release Area Treatment) 28
4.4.1 GE Overview 28
4.4.2GE Evaluation 29
5.0 CORRECTIVE ACTION PLAN IMPLEMENTATION 31
5.1 ***~~Pre-Implementation Activities~~**** 31
5.2 CAP- The Three-Fold Approach 31
5.3 Leachate Management – Source Control 33
5.4 GE – Source Release Area Treatment and Barrier 33
5.5 Phytoremediation – Downgradient Plume Treatment 33
5.5.1Plant Selection 34
5.5.2Planting Techniques 34
5.5.3Fertilization / Soil Amendments 35
5.5.4 Phytoremediation – Stage 1 36
5.5.5 Phytoremediation – Stage 2 36
6.0 MONITORING AND SAMPLING PLAN (GROUNDWATER & REMEDIATION SYSTEMS) 37
6.1 Groundwater Extraction Sampling and Monitoring Frequency (Set 1-GE) 38

6.2 Phytoremediation Stage 1 and Stage 2 Sampling and Monitoring Frequency (Set 1-P1 & Set 1-P2) 38
6.3 Annual Reporting Requirements 41
7.0 EVALUATION OF EFFECTIVENESS OF CAP SYSTEMS and REPORTING REQUIREMENTS 41
8.0 CAP CONTINGENCY PLAN 42
9.0 SCHEDULE AND MAINTENANCE 42
9.1 Schedule 43
9.2 GE and LM Maintenance Plan 43
9.3 Phytoremediation Maintenance Plan 43
9.4 Site Security 43
9.5 Maintenance Contact 44
10.0 COMPLETION OF CORRECTIVE ACTION 44
11.0 REFERENCES 45

TABLES

Table 1 – CAP Monitoring Summary 40

FIGURES

Figure 1 – CAP Tasks and Schedule 32

Corrective Action Plan and Permit Modification Drawings (12 Sheets) ..... (Appendix B)

APPENDICES

Appendix A ..... February 2009 CAP Selected Remedies Letter
Appendix B ..... Drawings (12 sheets)
Appendix C ..... Engineers Cost Estimate of Corrective Action Activities
Appendix D ..... Copy of CAP Application Form
Appendix E ..... Letter of Enhanced Bioremediation Pilot Study Results
Appendix F ..... Minutes of March 31, 2008 Public Meeting on ACM
Appendix G ..... 2003 Assessment of Groundwater Contamination Report on CD

1.0 INTRODUCTION

On behalf of Harnett County, C.T. Clayton, Sr., P.E., Inc. (CTC) has prepared this Corrective Action Plan Report (CAP) for the Dunn-Erwin Landfill and Transfer Station Facility. The CAP was prepared in accordance with NC Solid Waste Management Rules (NCSWMR) 15A NCAC 13 B .1636. This CAP was developed as a result of the confirmed exceedance of permitted Ground Water Protection Standards (GPS) in samples collected from the monitoring wells at the Dunn-Erwin Landfill as detailed in the "Assessment of Groundwater Contamination Plume" report dated August 25, 2003 and the semi-annual statistical analysis and groundwater sampling report issued after the April and October sampling events each year.

Upon approval of the CAP by NCDENR-Solid Waste Section (SWS), Harnett County will implement the approved corrective measure(s) in accordance with 15A NCAC 13 B .1637 and the included schedule.

1.1 Background Information

The existing Dunn-Erwin landfill has been in the same location since opening in 1978. It is located just north of NCSR 1725 in an area surrounded by farmland, forest, wetlands, and scattered houses and farms. The closest town to its boundary is the Town of Erwin, approximately two miles south of the landfill.

The facility currently accepts construction and demolition (C&D) materials under Permit 43-02 and is a transfer station for municipal solid waste generated in the county. The former MSW portion of the Dunn-Erwin Landfill was closed December, 1998, and capped to comply with regulations outlined under the guidance document 15A, NCAC 13B, Section .1627(c)(10). A mechanical gas venting system was installed in the area of the final cap overlying the emplaced municipal solid waste. The closed portion of the landfill consists of approximately 21 acres. C&D waste is currently being placed on the capped area, as per SWS approval. (See drawing Sheet 1.1 – Overall Facility Plan)

1.2 Previous Investigations

2003

Ground water sampling at the Dunn-Erwin MSWLF has been performed by Environment 1, Inc since October 1994. Semi-annual sampling at the Dunn-Erwin MSWLF was initiated in April 1997 and has continued through the present. Each semi-annual event is followed by a Statistical Analysis/Evaluation report interpreting and summarizing the results.

Prior to this ACM, an extensive study was completed in order to better understand the ground water contamination plume at the site, as described in the report dated August 25, 2003, including the field investigation performed in October 2002 in conjunction with the scheduled October 2002 semi-annual sampling event. Also, 12 new observation wells were installed in the general area of the ground water contamination plume during this field investigation. The field investigation was followed by additional laboratory testing, and an extensive analysis and computer modeling.

See the attached Drawing Sheet 1.1 for the 2003 extent of the contamination plume (a copy of the 2003 report is on file with the SWS).

2008

In early January 2008, in order to update and better define the extent of the contaminant plume, the following wells not included in the semi-annual sampling set were sampled and analyzed for Appendix I Organics scan (EPA Method 8260B), as follows:

Three (3) piezometers:	PZ-50, PZ-48S, PZ-47S
Two (2) observation wells:	GP-33-W, GP-27-W

Based on the results of this analysis, the plume boundary was adjusted. This adjusted boundary is shown on the attached Drawing Sheet 1.1. In order to better define the plume boundary, additional observation wells are planned for installation are shown on Drawing Sheet 2.1.

1.3 Site Characteristics

A detailed description of the site topography, geological, and geotechnical properties and characteristics can be found in the August 25, 2003 report noted above. The site's hydrogeology including permeability, ground water levels and gradients, flow rates, and vertical flow analysis is also discussed at length in the August 25, 2003 report. (A hard copy and scanned copy of this report was re-issued to the SWS in June 2009. A scanned copy of the 2003 is found on CD in Appendix G. Additional copies can be obtained from the office of C.T. Clayton, Sr, PE, Inc.)

2.0 CONTAMINANT CHARACTERIZATION

The Dunn-Erwin Landfill (MSWLF) conducts semi-annual ground water sampling and analyses in accordance with North Carolina Solid Waste Management Rules 15A N.C.A.C. 13 B, .1633 and .1634. Sampling events are coordinated and performed in the months of April and October of each year. Statistical analysis is then performed to evaluate whether the ground water and surface water monitoring results of the ground water and surface water monitoring results from the sampling events demonstrate compliance with North Carolina

Groundwater Standards (NCGS) with respect to Appendix I and Appendix II constituents of the North Carolina Solid Waste Management Rules 15A N.C.A.C. 13 B, .1633(a) and .1634(a).

2.1 April 2008 Statistical Analysis Results

Statistical Analysis for the 2008 ground water sampling event was performed and documented in the *Statistical Analysis/Evaluation: April 2008* report dated September 16, 2008. The following information was taken from the Executive Summary of this report:

> Data from the April 2008 semi-annual sampling were evaluated in sets. Set 1 consists of wells monitoring the previously closed (December 1998) solid waste landfill portion of the site where active construction and demolition debris (C&D) placement is ongoing, including monitoring wells (MWs) MW1, MW2, MW3R, MW4, MW5, MW6, MW7B, MW8, and MW31. Monitoring well MW3, which was previously damaged during site operations prior to April 2005 sampling event has been replaced by MW3R as of June 2005. Monitoring wells MW9 and MW10 were installed in March 2001 and have been added to Data Set 1 as of April 2001. These wells have been incorporated into the statistical analysis as their background sampling was completed in October 2002.
>
> In 2006, five (5) new MWs (MW11 - MW15) have been installed in conjunction with the proposed C&D landfill. Theoretically, these new wells belong to Set 1 since they are downgradient of the active C&D and closed MSWLF. These wells will be incorporated into the statistical analysis of Set 1 as Subset 1N after their background sampling is completed in October 2008. Within this Subset 1N, subject to the final proposed C&D landfill design and groundwater monitoring plan, one of these monitoring wells may be designated as an upgradient well to the new landfill. Additionally, one or more of the related four new piezometers (PZ-50 through PZ-53) could also be converted into monitoring wells for the new landfill, as needed.
>
> Set 2 consists of wells monitoring the older closed portion of the landfill site, including MW16, MW23B, MW32, MW33, and the newer MW34 and MW35 installed in June 1996. Monitoring well MW23B is statistically compared with Set 1 as it appears to be located downgradient of these wells.
>
> Set 3 consists of surface water monitoring points (SWPTs) along the wetlands between the active and the closed areas, including SWPT1, SWPT2, and SWPT3.
>
> ….
>
> The statistical analysis results indicate that compliance wells MW6, MW7B, MW8, MW9, and MW10 in Set 1 have statistically significant levels of one or more organics over background levels when compared with the background wells. (cis-1,2-dichloroethylene now qualifies for the TOP and has resulted in SSIOBL for a number

of wells.) In addition, the April 2008 results show that there were less organics detected in concentrations greater than NCGS or GPS when compared to the number of above NCGS or GPS organics detected in October 2007. The April 2008 above NCGS organics include: benzene, 1,4-dichlorobenzene, 1,2-dichloroethane (estimated value), tetrachloroethylene, trichloroethylene, and vinyl chloride in MW6; benzene, tetrachloroethylene, trichloroethylene, and vinyl chloride in MW7B; benzene, methylene chloride, tetrachloroethylene, trichloroethylene, and vinyl chloride in MW8; benzene, 1,4-dichlorobenzene, 1,2-dichloroethane (estimated value), tetrachloroethylene, trichloroethylene, and vinyl chloride in MW9; and benzene, methylene chloride, and vinyl chloride in MW10.

As part of this event's statistical analysis, the prediction interval intra-well comparison was incorporated to verify certain Test of Proportions (TOP) results. In select cases the compliance-to-background well analyses are not accurate because natural, statistically significant variations existed prior to the facility operation commencement. If the TOP indicates a result of Statistically Significant Increase Over Background Level (SSIOBL) for such a constituent, the prediction interval intra-well comparison is used to verify the result. If the average post-operational concentrations of the constituent are within the prediction interval analysis calculated based on background concentrations, the result is not considered SSIOBL.

Using this methodology, beryllium is not SSIOBL for MW2, MW3, and MW4 and cobalt and lead are not SSIOBL for MW7B, which would have resulted as SSIOBL using just the TOP. Cobalt and mercury in MW6 and mercury in MW7B also show statistically significant levels through the TOP. However, cobalt was not detected during MW6's background sampling, and mercury was not included in either well's background sampling. Consequently, these constituents do not qualify for an intra-well comparison. The following inorganics exceeded NCGS or GPS during this sampling event, representing a decrease in the number of inorganics exceeding NCGS compared to the October 2007 results: vanadium in MW31, thallium in MW7B; and vanadium in MW10. The vanadium detections appear to be background, as vanadium was not SSIOBL for any well. The thallium detection is also likely trace background, and its concentration was above the 13B GPS but well below the SWSL. The thallium and vanadium exceedances were estimated concentration values.

In Set 2, no organics or inorganics are statistically significant. No organics were detected in April 2008, consistent with the results from October 2007. For inorganics, barium, cadmium, and lead were detected in Set 2. Of these results, lead was detected over the NCGS in MW32, representing and increase compared to the result from October 2007.

In Set 3, only zinc was detected. These locations were unavailable for sampling due to dry conditions in October 2007. However, zinc has been detected at these locations in the past. No organics or inorganics are statistically significant for Set 3.

2.2 Contaminants of Concern (COC)

Based on the October 2008 statistical analysis report and the August 2003 detailed plume investigation report, the following conclusions regarding ground water contamination at the Dunn-Erwin MSWLF are presented:

- Based on updated groundwater analytical data accumulated since October 1994 from the scheduled semi-annual sampling events, the top six organic contaminants most frequently detected in downgradient monitoring wells at concentrations that consistently have exceeded NCGS include benzene, 1,1-dichloroethane, methylene chloride, vinyle chloride, tetrachloroethylene, and trichloroethylene. Since April of 2007 1,4-dichlorobenzene has also been detected above NCGS.

- Metals mercury and lead have been detected above NCGS in the last two October sampling events (2007 & 2008). Therefore, they have been updated to this report for analysis and treatment

2.3 Exposure Pathways

2.3.1 Methlylene Chloride

Introduction

Methylene chloride, also known as dichloromethane, is a colorless liquid that has a mild sweet odor, evaporates very quickly, and will not easily burn. It is widely used as an industrial solvent and as a paint stripper. It can also be found in certain aerosol and pesticide products and is used in the manufacture of photographic film. Methylene chloride does not appear to occur naturally in the environment. It is made from methane gas or wood alcohol. Most of the methylene chloride released to the environment results from its use as an end product by various industries and the use of aerosol products and paint removers in the home.

Fate & Transport

Methylene chloride is mainly released to the environment in air and to a lesser extent in water and soil, due to industrial and consumer uses. Because methylene chloride evaporates readily, most of it is released into the air. In air, it is broken down by sunlight and by reaction with other chemicals present in the air. About half of the methylene chloride disappears from air in 53-127 days. Although methylene chloride does not dissolve easily in water, small amounts may be found in some drinking water. Methylene chloride that is present in water is broken down slowly by reactions with other chemicals or by bacteria. Over 90 percent of the methylene chloride in the environment changes to carbon dioxide, which is non-toxic. It takes from 1 to 6 days for half the methylene chloride to break down in water. When methylene chloride is spilled on land, it attaches loosely to nearby surface soil particles. It moves from the soil into the air. Some may also move into ground water. We do not know how long it remains in soil. It is not expected that methylene chloride builds up in plants or animals.

Exposure Pathways

Exposure to methylene chloride may occur in air, water, food, or from consumer products. Since methylene chloride evaporates easily, the greatest potential for exposure is breathing in vapors of contaminated air.

2.3.2 Trichloroethylene

Introduction

Trichloroethylene (TCE) is also known as Triclene, Vitran and by other trade names in industry. It is a nonflammable, colorless liquid at room temperature with a somewhat sweet odor and a sweet, burning taste. This man-made chemical does not occur naturally in the environment. Trichloroethylene is now mainly used as a solvent to remove grease from metal parts. It is also used as a solvent in other ways and is used to make other chemicals. Trichloroethylene can also be found in some household products, including typewriter correction fluid, paint removers, adhesives, and spot removers.

Wastewater or municipal water supply treatment systems that rely on coagulation, sedimentation, precipitative softening, filtration, and chlorination are ineffective for reducing concentrations of TCE to nonhazardous levels. Other methods are required for remediation of water contaminated with TCE if the water is to be used for human consumption. TCE usually is remediated through pump and treat, using either air stripping or granular activated carbon, but there are many innovative cleanup methods—physical, chemical, thermal,

and biological—that have been applied successfully to remove TCE from soil and ground water or to convert it into nonhazardous compounds.

Fate & Transport

By far, the biggest source of trichloroethylene in the environment is evaporation from factories that use it to remove grease from metals. It can also enter the air and water when it is disposed of at chemical waste sites. It evaporates easily but can stay in the soil and in ground water. Once it is in the air, about half will be broken down within a week. When trichloroethylene is broken down in the air, phosgene, a lung irritant, can be formed. Under certain conditions found in the workplace, trichloroethylene can break down into chemicals such as dichloroacetylene and phosgene. In the body, trichloroethylene may break down into dichloroacetic acid (DCA), trichloroacetic acid (TCA), chloral hydrate, and 2-chloroacetaldehyde. These chemical products have been shown to be toxic to animals and are probably toxic to humans. Once trichloroethylene is in water, much will evaporate into the air; again, about half will break down within a week. It will take days to weeks to break down in surface water; in ground water the breakdown is much slower because of the much slower evaporation rate. Very little trichloroethylene breaks down in the soil, and it can pass through the soil into underground water. It is found in some foods; the trichloroethylene found in foods is believed to come from contamination of the water used in food processing, or from the food processing equipment cleaned with trichloroethylene. It does not build up in fish, but it has been found at low levels in them. It is not likely to build up in the human body.

Exposure Pathways

Trichloroethylene enters the body when breathing air or drinking water containing it. It can also enter the body if you get it on the skin. When breathing the chemical, about half the amount will get into the bloodstream and organs; the rest will be exhaled. If trichloroethylene is swallowed, most of it will be absorbed into the blood. If trichloroethylene comes in contact with the skin, some of it can enter the body, although not as easily as when it is breathed or swallowed.

2.3.3 Tetrachloroethlyene

Introduction

Tetrachloroethylene (PCE) is a man-made substance widely used for dry cleaning fabrics and textiles and for metal-degreasing operations. It is also used as a starting material (building block) for the production of other man-

made chemicals. Other names that may be used for tetrachloroethylene include perchloroethylene, perc, PCE, perclene, and perchlor. Although tetrachloroethylene is a liquid at room temperature, some of the liquid can be expected to evaporate into the air producing an ether-like odor; evaporation increases as temperature increases.

Exposure Pathways

Because tetrachloroethylene evaporates quickly, the most common exposure to tetrachloroethylene comes from breathing air containing it. This is certainly true for individuals who work with the chemical, but it is probably also true for those who live in industrial and commercial areas where large amounts of the compound is disposed of or utilized. Tetrachloroethylene may also enter the body through drinking contaminated water or eating contaminated food. Because tetrachloroethylene does not pass through the skin to any significant extent, entry into the body by this path is of minimal concern, although skin irritation may result from repeated or prolonged contact with the undiluted liquid.

2.3.4 1,1-Dichloroethane

Introduction

Benzene (C_6H_6) is the first member of a series of aromatic hydrocarbons recovered from refinery streams during catalytic reformation and other petroleum processes. It is a clear, colorless, highly flammable liquid at room temperature. Its vapor is heavier than air and can travel to a source of ignition and flash back.

Benzene is one of the world's major commodity chemicals. Its primary use (85% of production) is as an intermediate in the production of other chemicals, predominantly styrene (for styrofoam and other plastics), cumene (for various resins), and cyclohexane (for nylon and other synthetic fibers). Benzene is an important raw material for the manufacture of synthetic rubbers, gums, lubricants, dyes, pharmaceuticals, and agricultural chemicals. Because of its lipophilic nature, benzene is an excellent solvent. Its use in paints, thinners, inks, adhesives, and rubbers, however, is decreasing and now accounts for less than 2% of current benzene production. Benzene was also an important component of many industrial cleaning and degreasing formulations, but now has been replaced mostly by toluene, chlorinated solvents, or mineral spirits. Although benzene is no longer added in significant quantities to most commercial products, traces of it may still be present as a contaminant.

Fate & Transport

Benzene is rapidly and extensively absorbed by inhalation and ingestion. Absorption through the skin is rapid but not extensive, as most of it evaporates quickly. In humans, approximately 50% of inhaled benzene is absorbed after a 4-hour exposure to approximately 50 ppm benzene in air. An *in vivo* study on human volunteers indicated that approximately 0.05% of a benzene dose applied to the skin was absorbed, whereas in an *in vitro* study of human skin, the absorption of benzene was consistently 0.2% after exposure to doses ranging from 0.01 to 520 microliters per square centimeter. Oral absorption has not been studied in humans. In animals, at least 90% of benzene was absorbed following oral ingestion of a dose of 340 to 500 milligrams per kilogram per day (mg/kg/day).

After exposure, benzene is found throughout the body, but it preferentially distributes into the bone marrow and tissues with either high perfusion rates or high lipid content. Thus, autopsies of people who died after acute exposure showed that lipid-rich tissues, such as the brain and fat, and well-perfused tissues, such as the kidney and the liver, have higher levels of benzene than other tissues.

Once absorbed, benzene is initially metabolized in the liver and later in the bone marrow. Although the total quantity of metabolites is greater in blood than marrow, the concentrations of those metabolites in the marrow can be 400 times greater than in blood. Benzene metabolism in the liver involves oxidation, with phenol as the major metabolite. Bone marrow is the main target organ of chronic benzene toxicity. One or more benzene metabolite is suspected to be responsible for the hematogenous toxicity, although the identity of the ultimate toxicant is unknown. In the marrow, the metabolites may bind covalently to cellular macromolecules (*e.g.*, proteins, DNA, and RNA), causing disruption of cell growth and replication.

Exposure Pathways

Benzene is widespread in the environment. Airborne benzene is usually produced by processes associated with chemical manufacturing or the gasoline industry, including gasoline bulk-loading and discharging facilities and combustion engines (*e.g.*, automobiles, lawn mowers, and snow blowers). Benzene is a component of both indoor and outdoor air pollution. Benzene levels measured in ambient outdoor air have a global average of 6 micrograms per cubic meter ($\mu g/m^3$) (range 2-9 $\mu g/m^3$). In almost all cases, benzene levels inside residences or offices are higher than levels outside and still higher in homes with attached garages and those occupied by smokers. Seasonal variations also affect benzene levels, with higher levels found in the fall and winter when buildings are less well ventilated. People living around

hazardous waste sites, petroleum-refining operations, petrochemical manufacturing sites, or gas stations may be exposed to higher levels of benzene in air. In addition to being inhaled, airborne benzene is absorbed across intact skin in experimental animals. For most people, the level of exposure to benzene through food, beverages, or drinking water is not as high as their exposure through air.

Leakage from underground storage tanks and seepage from landfills or Improper disposal of hazardous wastes has resulted in benzene contamination of groundwater used for drinking. Effluent from industries is also a source of groundwater contamination. In addition to being ingested, benzene in water can also be absorbed through wet skin and inhaled as it volatilizes during showering, laundering, or cooking. Typical drinking water contains less than 0.1 parts per billion (ppb) benzene. Benzene has been detected in bottled water, liquor, and food.

Cigarette smoke is another common source of personal and environmental benzene exposure, representing about half of the benzene to which the general population is exposed. Persons who smoke one pack of cigarettes a day inhale a daily dose of approximately 1 milligram (mg) of benzene, about 3 to 4% of the amount inhaled daily by a worker exposed at the current occupational PEL. Nonsmokers who live with smokers and who are passively exposed to environmental tobacco smoke typically experience 50% greater exposure to benzene than do nonsmokers who live in a smoke-free environment.

2.3.5 1,4-Dichlorobenzene

Introduction

1,4-Dichlorobenzene is a chemical used to control moths, molds, and mildew, and to deodorize restrooms and waste containers. It is also called para-DCB or p-DCB. Other names include Paramoth, para crystals, and paracide reflecting its widespread use to kill moths.

At room temperature, p-DCB is a white or colorless solid with a strong, pungent odor. When exposed to air, it slowly changes from a solid to a vapor. It is the vapor that acts as a deodorizer or insect killer.

Most people recognize the odor as the smell of mothballs, and can smell p-DCB in the air at very low levels. Most p-DCB in our environment comes from its use in moth repellent products and in toilet deodorizer blocks.

Fate & Transport

- In air, it breaks down to harmless products in about a month.
- It does not dissolve easily in water.
- It evaporates easily from water and soil, so most is found in the air.
- It is not easily broken down by soil organisms.
- It is taken up and retained by plants and fish.

Exposure Pathways

- Breathing indoor air in public restrooms and homes that use p-DCB as a deodorizer
- Breathing air around some mothballs (check the label)
- Breathing workplace air where p-DCB is manufactured
- Drinking contaminated water around hazardous waste sites
- Eating foods such as pork, chicken, and eggs that are contaminated with p-DCB from its use as an odor control product in animal stalls
- Eating fish from contaminated waters
- Infants can be exposed by drinking human breast milk from mothers exposed to p-DCB

2.3.6 Vinyl Chloride

Introduction

Vinyl chloride is known also as chloroethene, chloroethylene, ethylene monochloride, or monochloroethylene. At room temperature, it is a colorless gas, it burns easily, and it is not stable at high temperatures. Vinyl chloride exists in liquid form if kept under high pressure or at low temperatures. Vinyl chloride has a mild, sweet odor, which may become noticeable at 3,000 parts vinyl chloride per million parts (ppm) of air. However, the odor is of little value in preventing excess exposure. Most people begin to taste vinyl chloride in water at 3.4 ppm.

Vinyl chloride is a manufactured substance that does not occur naturally; however, it can be formed in the environment when other manufactured substances, such as trichloroethylene, trichloroethane, and tetrachloroethylene, are broken down by certain microorganisms. Production of vinyl chloride in the United States grew at an average rate of about 7% from the early 1980s to the early 1990s, with current growth at about 3% annually. Most of the vinyl chloride produced in the United States is used to make a polymer called polyvinyl chloride (PVC), which consists of long repeating units of vinyl chloride. PVC is used to make a variety of plastic products including pipes, wire and cable coatings, and packaging materials. Other uses include furniture and automobile upholstery, wall coverings, housewares, and automotive parts.

At one time, vinyl chloride was used as a coolant, as a propellant in spray cans, and in some cosmetics. However, since the mid-1970s, vinyl chloride mostly has been used in the manufacture of PVC.

Fate & Transport

Most of the vinyl chloride that enters the environment comes from vinyl chloride manufacturing or processing plants, which release it into the air or into waste water. EPA limits the amount that industries can release. Vinyl chloride also is a breakdown product of other synthetic chemicals. Vinyl chloride has entered the environment at hazardous waste sites as a result of improper disposal or leakage from storage containers or spills, but some may result from the breakdown of other chemicals. In addition, vinyl chloride has been found in tobacco smoke at very low levels.

Liquid vinyl chloride evaporates easily. Vinyl chloride in water or soil evaporates rapidly if it is near the surface. Vinyl chloride in the air breaks down in a few days, resulting in the formation of several other chemicals including hydrochloric acid, formaldehyde, and carbon dioxide.

Some vinyl chloride can dissolve in water. Vinyl chloride can migrate to groundwater and can be in groundwater due to the breakdown of other chemicals. Vinyl chloride is unlikely to build up in plants or animals that you might eat.

Exposure Pathways

Because vinyl chloride usually exists in a gaseous state, you are most likely to be exposed to it by breathing it. Vinyl chloride is not normally found in urban, suburban, or rural air in amounts that are detectable by the usual methods of analysis. However, vinyl chloride has been found in the air near vinyl chloride manufacturing and processing plants, hazardous waste sites, and landfills. The amount of vinyl chloride in the air near these places ranges from trace amounts to over 1 ppm. Levels as high as 44 ppm were found in the air at some landfills. You can also be exposed to vinyl chloride in the air through tobacco smoke from cigarettes or cigars (both active smoking and second-hand smoke). Levels of vinyl chloride in tobacco smoke are very low, usually around 5–30 nanograms per cigarette (a nanogram is 0.000000001 gram).

You can be exposed to vinyl chloride by drinking water from contaminated wells. Most drinking water supplies do not contain vinyl chloride. In a 1982 survey, vinyl chloride was found in fewer than 1% of the 945 groundwater supplies tested in the United States.

People who work at facilities that make vinyl chloride or PVC usually are

exposed to higher levels than the general population. Work exposure occurs primarily from breathing air that contains vinyl chloride, but workers also are exposed when vinyl chloride contacts the skin or eyes. Based on studies using animals, it is possible that if vinyl chloride comes into contact with your skin or eyes, extremely small amounts could enter your body.

2.3.7 Benzene

Introduction

Benzene, also known as benzol, is a colorless liquid with a sweet odor. Benzene evaporates into air very quickly and dissolves slightly in water. Benzene is highly flammable. Most people can begin to smell benzene in air at 1.5-4.7 parts of benzene per million parts of air (ppm) and smell benzene in water at 2 ppm. Most people can begin to taste benzene in water at 0.5-4.5 ppm. One part per million is approximately equal to one drop in 40 gallons. Benzene is found in air, water, and soil. Benzene comes from both industrial and natural sources.

Industrial Sources and Uses. Benzene was first discovered and isolated from coal tar in the 1800s. Today, benzene is made mostly from petroleum. Because of its wide use, benzene ranks in the top 20 in production volume for chemicals produced in the United States. Various industries use benzene to make other chemicals, such as styrene (for Styrofoam® and other plastics), cumene (for various resins), and cyclohexane (for nylon and synthetic fibers). Benzene is also used in the manufacturing of some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides.

Natural Sources. Natural sources of benzene, which include gas emissions from volcanoes and forest fires, also contribute to the presence of benzene in the environment. Benzene is also present in crude oil and gasoline and cigarette smoke.

Fate & Transport

Benzene is commonly found in the environment. Industrial processes are the main sources of benzene in the environment. Benzene levels in the air can be elevated by emissions from burning coal and oil, benzene waste and storage operations, motor vehicle exhaust, and evaporation from gasoline service stations. Tobacco smoke is another source of benzene in air, particularly indoors. Industrial discharge, disposal of products containing benzene, and gasoline leaks from underground storage tanks release benzene into water and soil.

Benzene can pass into air from water and soil surfaces. Once in the air,

benzene reacts with other chemicals and breaks down within a few days. Benzene in the air can also be deposited on the ground by rain or snow.

Benzene in water and soil breaks down more slowly. Benzene is slightly soluble in water and can pass through the soil into underground water. Benzene in the environment does not build up in plants or animals.

Exposure Pathways

Everyone is exposed to a small amount of benzene every day. You are exposed to benzene in the outdoor environment, in the workplace, and in the home. Exposure of the general population to benzene mainly occurs through breathing air that contains benzene. The major sources of benzene exposure are tobacco smoke, automobile service stations, exhaust from motor vehicles, and industrial emissions. Vapors (or gases) from products that contain benzene, such as glues, paints, furniture wax, and detergents, can also be a source of exposure. Auto exhaust and industrial emissions account for about 20% of the total national exposure to benzene. About half of the exposure to benzene in the United States results from smoking tobacco or from exposure to tobacco smoke. People may be exposed to higher levels of benzene in air by living near hazardous waste sites, petroleum refining operations, petrochemical manufacturing sites, or gas stations.

For most people, the level of exposure to benzene through food, beverages, or drinking water is not as high as through air. Drinking water typically contains less than 0.1 ppb benzene. Benzene has been detected in some bottled water, liquor, and food. Leakage from underground gasoline storage tanks or from landfills and hazardous waste sites that contain benzene can result in benzene contamination of well water. People with benzene-contaminated tap water can be exposed from drinking the water or eating foods prepared with the water. In addition, exposure can result from breathing in benzene while showering, bathing, or cooking with contaminated water.

2.3.8 Lead

Introduction

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. It has no characteristic taste or smell. Metallic lead does not dissolve in water and does not burn. Lead can combine with other chemicals to form what are usually known as lead compounds or lead salts.

Lead has many different uses. Its most important use is in the production of

some types of batteries. It is also used in the production of ammunition, in some kinds of metal products (such as sheet lead, solder, some brass and bronze products, and pipes) and in ceramic glazes. Some chemicals containing lead, such as tetraethyl lead and tetramethyl lead, were once used as gasoline additives to increase octane rating. However, their use was phased out in the 1980s, and lead was banned for use in gasoline for transportation beginning January 1, 1996. Other chemicals containing lead are used in paint. The amount of lead added to paints and ceramic products, caulking, gasoline, and solder has also been reduced in recent years to minimize lead's harmful effects on people and animals. Lead used in ammunition, which is the largest non-battery end-use, has remained fairly constant in recent years. Lead is used in a large variety of medical equipment (radiation shields for protection against X-rays, electronic ceramic parts of ultrasound machines, intravenous pumps, fetal monitors, and surgical equipment). Lead is also used in scientific equipment (circuit boards for computers and other electronic circuitry) and military equipment (jet turbine engine blades, military tracking systems).

Most lead used by industry comes from mined ores ("primary") or from recycled scrap metal or batteries ("secondary"). Human activities (such as use of "leaded" gasoline) have spread lead and substances that contain lead to all parts of the environment. For example, lead is in air, drinking water, rivers, lakes, oceans, dust, and soil. Lead is also in plants and animals that people may eat.

Fate & Transport

Lead occurs naturally in the environment. However, most of the high levels found throughout the environment comes from human activities. Sources of lead released to the air include burning fuel, such as coal or oil, industrial processes, and burning solid waste. Once lead goes into the atmosphere, it may travel thousands of miles if the lead particles are small or if the lead compounds easily evaporate. Lead is removed from the air by rain and by particles falling to the ground or into surface water.

The release of lead to air is now less than the release of lead to land. Most of the lead in inner city soils comes from old houses painted with paint containing lead and previous automotive exhaust emitted when gasoline contained lead. Landfills may contain waste from lead ore mining, ammunition manufacturing, or other industrial activities such as battery production.

Sources of lead in dust and soil include lead that falls to the ground from the air, and weathering and chipping of lead-based paint from buildings and other structures. Lead in dust may also come from windblown soil. Disposal of lead in municipal and hazardous waste dump sites may also add lead to soil.

Mining wastes that have been used for sandlots, driveways, and roadbeds can also be sources of lead.

Once lead falls onto soil, it usually sticks to soil particles. Small amounts of lead may enter rivers, lakes, and streams when soil particles are moved by rainwater. Lead may remain stuck to soil particles in water for many years. Movement of lead from soil particles into underground water or drinking water is unlikely unless the water is acidic or "soft". Movement of lead from soil will also depend on the type of lead salt or compound and on the physical and chemical characteristics of the soil.

Sources of lead in surface water or sediment include deposits of lead-containing dust from the atmosphere, waste water from industries that handle lead (primarily iron and steel industries and lead producers), urban runoff, and mining piles.

Some of the chemicals that contain lead are broken down by sunlight, air, and water to other forms of lead. Lead compounds in water may combine with different chemicals depending on the acidity and temperature of the water. Lead itself cannot be broken down.

The levels of lead may build up in plants and animals from areas where air, water, or soil are contaminated with lead. If animals eat contaminated plants or animals, most of the lead that they eat will pass through their bodies.

Exposure Pathways

People living near hazardous waste sites may be exposed to lead and chemicals that contain lead by breathing air, drinking water, eating foods, or swallowing or touching dust or dirt that contains lead. For people who do not live near hazardous waste sites, most exposure to lead may occur in several ways: (1) by eating foods or drinking water that contain lead, (2) by spending time in areas where leaded paints have been used and are deteriorating, (3) by working in jobs where lead is used, (4) by using health-care products or folk remedies that contain lead, and (5) by having hobbies in which lead may be used such as sculpting (lead solder) and staining glass.

Foods such as fruits, vegetables, meats, grains, seafood, soft drinks, and wine may have lead in them. Cigarette smoke also contains small amounts of lead. Lead gets into food from water during cooking and into foods and beverages from dust that contains lead falling onto crops, from plants absorbing lead that is in the soil, and from dust that contains lead falling onto food during processing.

In general, very little lead is found in lakes, rivers, or groundwater used to

supply the public with drinking water. More than 99 percent of all publicly supplied drinking water contains less than 0.005 part of lead per million parts of water (ppm). However, the amount of lead taken into your body through drinking water can be higher in communities with acidic water supplies. Acidic water makes it easier for the lead found in pipes, leaded solder, and brass faucets to enter water. Public water treatment systems are now required to used control measures to make water less acidic. Sources of lead in drinking water include lead that can come out of lead pipes, faucets, and leaded solder used in plumbing. Plumbing that contains lead may be found in public drinking water systems, and in houses, apartment buildings, and public buildings that are more than twenty years old.

Breathing in or swallowing airborne dust and dirt that have lead in them is another way you can be exposed. Skin contact with dust and dirt containing lead occurs every day. Some cosmetics and hair dyes contain lead compounds. However, not much lead can get into your body through your skin.

2.3.9 Mercury

Introduction

Mercury is a chemical (element) that occurs naturally in the environment in several forms. In the metallic or elemental form, mercury is a shiny, silver-white, odorless liquid with a metallic taste. Mercury can also combine with other elements, such as chlorine, carbon, or oxygen, to form mercury compounds. These compounds are called "organic mercury" if they contain carbon, and "inorganic mercury" if they do not. In pure form, these mercury compounds are usually white powders or crystals. All forms of mercury are considered poisonous.

There are many different uses for and sources of mercury. Metallic mercury is mined and is also a waste product of gold mining. Chemical factories that make chlorine use mercury and may release metallic mercury into the air. Thermometers, barometers, batteries, and tooth fillings all contain metallic mercury. Inorganic mercury compounds are commonly used in electrical equipment (for example, batteries, lamps) and skin care and medicinal products. Some inorganic mercury compounds are used in fungicides. Methylmercury is generally produced in the environment, rather than made by human activity. Fungicides and paints may contain other organic mercury compounds. Mercury compounds may be found in the air, soil, and water near hazardous waste sites.

Fate & Transport

Mercury is a naturally occurring metal found throughout the environment as a result of normal breakdown of the earth's crust by wind and water. The total amount of mercury in the environment caused by natural processes throughout the world is far greater than the total amount caused by human activities. However, the amount of mercury that exists in any one place through natural processes is usually very low. In contrast, the amount of mercury that may be at a particular waste site because of human activity can be very high. Air, water, and soil can contain mercury from both natural sources and human activity.

Metallic mercury is a liquid at room temperature. It can evaporate easily into the air and be carried a long distance before returning to water or soil in rain or snow. As mentioned before, some microorganisms in the water or soil can change inorganic forms of mercury to organic forms. Organic forms of mercury can enter the water and remain there for a long time, particularly if there are particles in the water to which they can attach. If mercury enters the water in any form, it is likely to settle to the bottom where it can remain a long time. Mercury also remains in soil for a long time. Mercury usually stays on the surface of the sediments or soil and does not move through the soil to underground water.

Small fish and other organisms living in the water can take up the organic forms of mercury. When larger fish eat these small fish or other organisms that contain organic mercury, their bodies will store most of it. In this way, large fish living in contaminated waters can collect a relatively large amount of organic mercury. Plants may also have a greater concentration of mercury in them if they are grown in soil that contains higher than normal amounts of mercury.

Exposure Pathways

Because mercury occurs naturally in the environment, everyone is exposed to very low levels of mercury in air, water, and food. Sources of higher exposure to metallic mercury include breathing air containing mercury in the workplace or any place where mercury might have been spilled. Also, since amalgam dental fillings are about half metallic mercury, if you them you can be exposed to mercury levels that are higher than the levels normally found in the environment. People with dental fillings containing mercury generally have more mercury in their breath than those who do not have these fillings. However, there is not enough evidence to prove that the mercury in amalgam fillings is causing health effects in humans.

Sources of exposure to inorganic mercury include swallowing or inhaling dust

that contains mercury particles in the workplace and using skin care and medicinal products with small amounts of mercury in them. You can also be exposed to inorganic mercury by drinking water that is contaminated with mercury. For most people, eating contaminated fish is the major source of organic mercury exposure. Some fish contain such high levels of mercury that eating them has been prohibited. Other foods typically contain very little mercury. A greater risk of mercury exposure may occur in fetuses exposed to mercury in their mother's blood and in nursing children who may be exposed to mercury in their mother's milk. Exposure near hazardous waste sites is likely to occur by breathing contaminated air, having contact with contaminated soil, or drinking contaminated water.

2.4 Aquifer Use

In North Carolina, the "beneficial" or end use of the ground water is a source of drinking water according to the regulations under 15A NCAC Subchapter 2L, Section .0103. The ground water on-site is not currently used as a source of drinking water.

There are no public water supply wells within the two mile perimeter of the landfill. All public water is supplied by a county wide water system maintained by Harnett County. The main water line originates in the Town of Lillington, NC. There are no surface water intakes within a two mile perimeter of the landfill.

According to the Harnett County Health Department, there may be individual water wells within a two mile radius but if present, these wells were installed prior to well permits being required and therefore the locations of such wells are unknown.

Monitoring well data and observed base flow conditions suggest that Stewart Creek to the south and an un-named tributary of Stewart Creek to the west are groundwater discharge zones. The aquifer is not used for drinking or recreational purposes between the waste boundary and the discharge zones. Harnett County controls the property between the waste boundary and the downgradient discharge zones.

No ground water withdrawal is occurring or will be allowed to occur within the vicinity of the dissolved contaminant plume, which still resides within the facility boundary. This area is unlikely to be developed in any way in the foreseeable future.

The future plan for the area downgradient of the contaminant plume is a new C&D disposal site.

2.5 Risk Assessment

After reviewing the exposure pathways of the contaminants of concern, the risk to human receptors appears to be low. The low rate of transport and migration of impacted ground water does not pose an immediate threat of migration outside the facility boundaries. All known water consumption near the Site is from a municipal (treated) water supply.

The main pathways for human contact with the contaminants of concern are inhalation and dermal contact. The facility employees and/or visitors (truck drivers and County residents) do not come into contact with the impacted ground water at the facility. Human contact by means of inhalation or skin contact is a cause of concern for personnel sampling ground water at the site. However, all sampling personnel are trained in procedures and the use of personal protective equipment to avoid contact with any potentially impacted water. The potential for inhalation or dermal contact during ground water sampling events is considered to be minimal. Under normal operation conditions at the facility, the possibility of human contact with ground water is very low.

The potential risk to the environment is to downgradient flora or fauna, and microorganisms in the impacted aquifer. Flora and fauna on or above the ground surface are at minimal risk, because there have been no confirmed detections of the contaminants of concern in the downstream surface water samples. Organisms suspected to be living in the subsurface at the site are at potential risk. However, soil micro-organisms are known to use the organic acids and byproducts of the degradation process of the ground water plumes as a food source. Therefore, the potential risk to the environment from the impacted ground water is considered to be low.

3.0 ASSESSMENT OF CORRECTIVE MEASURES (ACM) REVIEW

In our August 2007 Assessment of Corrective Measures Report (ACM) CTC documented corrective measures technologies that appeared relevant as potential corrective measures. Those measures were identified and subjected to preliminary screening for feasibility. Those corrective measures technologies, which obviously were not appropriate for this application (such as excavation and disposal, incineration, etc.) were not considered relevant, and therefore, were not subject to preliminary screening.

The purpose of the report was to identify technologies or combination of technologies that would be realistic, potential remedies for contaminant release at the DELF facility. Selection of realistic remedies is driven by site conditions and characteristics of the COCs reported at the facility. Based on the findings presented in the 2003 *Assessment of Groundwater Contamination Plume* and the subsequent semi-annual monitoring results of the contaminant release at the landfill consist primarily of VOCs. In addition, data presented in the *April 2009 Statistical Analyses/Evaluation* indicated that within the contaminant plume, multiple contaminants have been frequently detected at concentrations that consistently have exceeded

NCGS standards and are considered statistically significant. These COCs were found in a dissolved phase, within the upper most aquifer underlying the facility, and are limited in distribution to within the facility boundary.

4.0 REMEDIAL APPROACH (HISTORY OF THE REMEDIAL APPROACH)

The selection of a potentially successful remedy was based on the geologic and hydrogeologic conditions of the uppermost aquifer at the facility, and the potential risks associated with the contaminant plume. Additionally, the type and size of the source (one that can be removed versus one that cannot be removed) and the urgency of the remedial effort, or aggressiveness, are considered when selecting a remedy. The need for an aggressive or non-aggressive remedy is usually controlled by the risk(s) associated with the release (i.e., a high risk may dictate an aggressive remedy while a low risk may dictate a less aggressive, more cost effective remedy). Additionally, the use of more than one remedy may be required to meet regulatory standards.

Due to the above considerations, as well as the remedy selection criteria set forth in Rule .1636(b), the remedy implementation criteria presented in Rule .1637(d), and the public comment session held March 31, 2008, **Phytoremediation** was chosen by Harnett County as an effective and cost efficient technology for the corrective action.

After a November 26, 2008 meeting with the Solid Waste Section, it was determined that a second remedial method would be required to be installed within the 250-foot compliance boundary of the limits of waste. Within this area, **Enhanced In-situ Bioremediation** (EB) is proposed. A letter from Harnett County Manager Scott Sauer, dated February 12, 2009, is attached indicating the addition of enhanced in-situ bioremediation to the selected CAP technologies (Refer to Appendix A).

On February 16, 2009, Harnett County submitted a revised Corrective Action Plan to the SWS that included both EB and Phytoremediation as remedial technologies to address the contaminant plume. In late May 2009, the SWS contacted the County to review this revised CAP. On June 3, 2009, the SWS and C. T. Clayton, Sr., PE, Inc. (Consultant to Harnett County) met at the SWS Central Office to review and discuss comments concerning the revised CAP.

Based on the June 3rd review meeting and subsequent review letter (dated June 11, 2009), CTC began implementation of a pilot study of the EB process. Soil and water samples were taken in July 2009 for pH and oil retention testing. In addition, “bio-trap” samplers (Process by Microbial Insight, Inc.) were installed in wells within the contaminant plume to determine if the required microbial growth can occur for adequate bioremediation of the contaminant plume. Results from this testing was received from the laboratory on September 22, 2009.

The pH testing of the groundwater was observed to be between 4.55 and 4.91. According to the Microbial Insights, Inc. report, the pH for optimal growth of Dehalococcoides

thenogenes strain 195, the only known bacterium capable of complete reductive dechlorination of PCE to ethane, is between 6.8 and 7.5. This was verified when the Dehalococcoides spp. biomass results came in extremely low. Therefore it was determined that the EB technology would not be a successful remedial technology at the DELF site. (A copy of the letter dated October 1, 2009 and the Microbial Insights, Inc. results are attached in Appendix D.)

Based on the Microbial Insights, Inc. results, **Groundwater Extraction** (GE) and offsite treatment was chosen to replace the previously selected EB as the remedial method to be implored within the 250-foot compliance boundary of the limits of waste.

Over the previous year, the County has been actively conducting inspections to identify leachate "pop-outs" on the side of the active C&D/closed MSW cell. During these inspections several "pop-outs" have been identified and properly repaired by redirecting the leachate back within the disposed waste. However, one such location has been so problematic, that futher action was required. Thus, the County has installed a leachate collection trench, sump, and temporary hauling station to haul the leachate from the facility to the County owned Waste Water Treatment facilty. This activity was documented to the SWS in a letter and plan dated, July 16, 2009.

Based on the leachate "pop-out" issue at this location and another location that has had multiple "pop-outs" in the recent past, the County has chosen to include a **Leachate Management System** (LM) as an additional selected remedial method to be incorporated in the CAP.

4.1 Existing Controls

Before proceeding with the chosen technology it is important to acknowledge the following protective measures which are already in place at the facility:

- Institutional controls are in place that restricts access to the facility and to the contaminated ground water. Site access is controlled by fencing, restricted traffic lanes, and on-site personnel to monitor and direct traffic during daytime operations and locked security gates after hours. All ground water monitoring wells have padlocked steel protective outer casings at the surface.

- County ownership of property downgradient to contaminant plume.

- A final cap covering the disposal area of the closed MSW cell that meets the closure/post closure requirements set forth in Rule .1627.

- Mechanical gas extraction system including flare station with ongoing gas quality monitoring program.

- Semi-annual ground water and surface water quality monitoring that meets the requirements set forth in Rule .1633 and Rule .1634.

4.2 Leachate Management

Leachate Management (LM) is proposed in the CAP design for use in managing the leachate within the active C&D/closed MSW cell and to prevent further realease of contaminantes from this landfill cell.

4.2.1 Leachate Management Overview

The leachate management system proposed will include the construction of a shallow subsurface trench or drain to facilitate the collection of leachate from within the existing landfill cell. The leachate will be pumped to an existing gravity sanitary sewer system owned by Harnett County and transported to the County owned waste water treatment plant for final treatment.

There are no major remediation related impacts associated with leachate extraction (pump-and-treat technology), since leachate extraction results in the physical removal of a possible contamination source. Minor impacts would include the generation of contaminated purge water during sampling events and spill containment at the transport/pumping facility which can be controlled easily enough with portable containment kits.

4.2.2 Leachate Management Evaluation

Rule .1636(b) states that potentially effective remedies for the ground water contamination at the Dunn-Erwin MSWLF shall:

- Be protective to human health and the environment.

  Extraction or Pump-and-Treat is a proven natural technology which is protective to human and environmental health. (Refer to articles referenced in Section 9.0)

- Attain the approved ground water protection standards.

  Leachate extraction and management has the potential to assist in attaining the approved NCGS standards

- Control the source(s) of release so as to eliminate, to the maximum extent practicable, further releases of Appendix II constituents into the environment.

  The source of the contaminant plume is more than likely leachate that has escaped the existing Active C&D/Closed MSW landfill cell. The proposed

leachate management and extraction system will not only provide a means to control but possibly eliminate further release of contamination

- Comply with standards for management of wastes as specified in Rule .1637(d).

  Leachate extraction complies with the standards of Rule .1637(d).

Under Rule .1636(c) the selected corrective measures must be evaluated by the following:

- The long and short-term effectiveness and protectiveness of the remedy, along with the degree of certainty that the remedy will prove successful;

  and

- The effectiveness of the potential remedy in controlling the source to reduce further releases.

  By immediately removing a potential source of the contamination, this technology should have both a short term effect as well as a long term effect on the contaminant plume. The proposed leachate management and extraction system will not only provide a means to control but possibly eliminate further release of contamination.

- The ease or difficulty of implementing the potential remedy.

  The proposed LM system is fairly easily implemented with the use of a temporary hauler to transport the leachate from the facility to the waste water treatment facility (already occurring since July 2009). The long term plan is to install a permanent pumping system to transport the leachate and the contaminanted groundwater (see section 4.2 and 5.0) to the treatment facility. This permanent system will be more difficult to implement.

- Practicable capability of the owner or operator, including a consideration of the technical and economic capability.

  The County owns and operates the multiple comparible sanitary sewer lift stations. The County already has trained technicians capable of operating and maintaining the proposed type of pump system necessary for the leachate extraction.

- The degree to which community concerns are addressed by the potential remedy.

  There were no public comments during the required Public Meeting held on March 31, 2008. (Minutes of meeting attached in Appendix F)

4.3 Phytoremediation (Downgradient Plume Treatment)

Phytoremediation is proposed in the CAP design for use in treating the area of the existing contaminant plume downgradient of the 250 foot compliance buffer not currently covered in mature growth trees nor the paved area around the waste transfer station. The existing forested area of the plume to the west will not be disturbed. It is anticipated that the existing forest and downgradient wetlands will naturally treat that portion of the plume.

4.3.1 Phytoremediation Overview

Phytoremediation is the use of certain plants to clean up soil, sediment, and water contaminated with metals and/or organic contaminants such as crude oil, solvents, and polyaromatic hydrocarbons (PAHs). It is a name for the expansion of an old process that occurs naturally in ecosystems as both inorganic and organic constituents cycle through plants. Plant physiology, agronomy, microbiology, hydrogeology, and engineering are combined to select the proper plant conditions for a specific site. Phytoremediation is an aesthetically pleasing mechanism that can reduce remedial costs, restore habitat, and clean up contamination in place rather than entombing it in place or transporting the problem to another site.

Phytoremediation can be used to clean up contamination in several ways:

- **Phytovolatiliaztion**: Plants take up water and organic contaminants through the roots, transport them to the leaves, and release the contaminants as a reduced of detoxified vapor into the atmosphere.

- **Micro-organism stimulation**: Plants excrete and provide enzymes and organic substances from their roots that stimulate growth of microorganisms such as fungi and bacteria. The micro-organisms in the root zone then metabolize the organic contaminants.

- **Phytostabilization**: Plants prevent contaminants from migrating by reducing runoff, surface erosion, and ground-water flow rates. "Hydraulic pumping" can occur when tree roots reach ground water, take up large amounts of water, control the hydraulic gradient, and prevent lateral migration of contaminants within a ground water zone.

- **Phytoaccumulation/extraction**: Plant roots can remove metals from contaminated sites and transport them to leaves and stems for harvesting and disposal.

- **Phytodegradation by plants**: Organic contaminants are absorbed inside the plant and metabolized to non-toxic molecules by natural chemical processes within the plant.

There are several advantages and disadvantages with this technology which are listed below:

Advantages	Disadvantages
Works on a variety of organic and inorganic compounds	May take several years to remediate
Can be either *In Situ/ Ex Situ*	May depend on climatic conditions
Easy to implement and maintain	Restricted to sites with shallow contamination within rooting zone
Low-cost compared to other treatment methods	Harvested biomass from phytoextraction may be classified as a RCRA hazardous waste
Environmentally Friendly and aesthetically pleasing to the public	Consumption of contaminated plant tissue is also a concern
Reduces the amount of wastes to be landfilled	Possible effect on the food chain

Concerning the disadvantages:

- There are no groundwater users within several miles downgradient of this site. If the phytoremediation takes several years to have a positive effect, in conjunction with the planned Groundwater Extraction system, this should not cause any additional exposure to humans.
- The trees will be selectively sampled per the monitoring plan (Section 6 below) to ascertain the plant tissue is contaminated and the eventually harvested material will be properly disposed of.
- The selected plant media, poplar trees, are not a favored food for the local wildlife population. Other species of trees, such as oaks, are in great abundance and mature enough to provide an ample alternative and more appeasing food alternative (acorns) to the most prevalent herbaceous wildlife. As described in the item above, any trees identified to contain harmfull amounts of contaminated plant tissue will be removed upon discovery and properly disposed of.
- Although this site does not necessarily have a shallow contamination, it is proposed that the uncontaminated overburden soils be removed above the contaminated ground water to a depth which would allow the selected plants to root within the aquifer. The proposed grading will excavate approximately 125,000 cubic yards of overburden soil prior to planting of the Phytoremediation plants. The excavated soils will be transported to the onsite borrow area for storage and future use as landfill cover, liner, and/or final cap/cover soils. (See the attached Drawing Sheets 5.1, 5.2, & 5.3)
- The SWS has expressed concern over the plan to not include other technologies downgradient of the planned phytoremediation area (Drawing Sheet 5.1). The current edge of the plume is approximately 690 feet at the closest location to the facility boundary. In the direction of travel of the plume toward that closest boundary line, the plume has moved a maximum of 69 feet from 2003 to 2008 (~14 ft/year). At that rate, the plume will take 49 years to cross the facility boundary. By that time, with

the removal and control of the contaminant source and decrease in groundwater gradient by the three proposed technologies, this remaining portion of contaminant plume should naturally attenuate and/or be treated by the naturally occurring plant and wetland growth.

4.3.2 Phytoremediation Evaluation

Rule .1636(b) states that potentially effective remedies for the ground water contamination at the Dunn-Erwin MSWLF shall:

- Be protective to human health and the environment.

  Phytoremediation is a proven natural technology which is protective to human and environmental health. (Refer to articles referenced in Section 9.0)

- Attain the approved ground water protection standards.

  Phytoremediation has the potential to attain the approved NCGS standards

- Control the source(s) of release so as to eliminate, to the maximum extent practicable, further releases of Appendix II constituents into the environment.

  Two other Pump-and-Treat technologies (Leachate Management:Section 4.1 above and Groundwater Extraction: Section 4.3 below) are included in this plan to control the source of the contamination. Phytoremediation will be used to attempt to remediate what is already present, deter further downgradient transport of the contaminant plume, and the trees will remain onsite to help with any potential future releases.

- Comply with standards for management of wastes as specified in Rule .1637(d).

  Phytoremediation complies with the standards of Rule .1637(d).

Under Rule .1636(c) the selected corrective measures must be evaluated by the following:

- The long and short-term effectiveness and protectiveness of the remedy, along with the degree of certainty that the remedy will prove successful;

and

- The effectiveness of the potential remedy in controlling the source to reduce further releases.

  Two other Pump-and-Treat technologies (Leachate Management:Section 4.1 above and Groundwater Extraction: Section 4.3 below) are included in this plan to control the source of the contamination. Phytoremediation will be used to attempt to remediate what is already present, deter further downgradient

transport of the contaminant plume, and the trees will remain onsite to help with any potential future releases.

- The ease or difficulty of implementing the potential remedy.

  The Dunn-Erwin landfill has a slightly deeper contaminated aquifer than would typically not be acceptable for this remedial technology. Thus the CAP includes a Grading Plan to excavate and remove approximately 125,000 cu yds of overburden soils to allow planting in the appropriate zone for root contact with the aquifer. (Refer to Drawing Sheets 5.1 and 5.2)

  The SWS has indicated concern over if the excavation will be approved by NCDENR-Land Quality Section (LQS). Based on our extensive experience with the LQS review and approval process, we do not foresee any possible reason why this proposed grading plan will not be approved by LQS. Thus, an alternative plan to the grading depicted on the drawings is not being considered at this time.

- Practicable capability of the owner or operator, including a consideration of the technical and economic capability.

  The County owns and operates the heavy equipment necessary to implement the Phytoremediation portion of the CAP. The County plans to utilize their own equipment and operators to minimize costs of construction. The Engineer, CTC, will be on-site to guide the County on proper preparation and planting of the trees. The trees will require minimal operations and maintenance costs. Most of the costs required to operate the system will be in the form of sampling.

- The degree to which community concerns are addressed by the potential remedy.

  There were no public comments during the required Public Meeting held on March 31, 2008. (Minutes of meeting attached in Appendix F)

4.4 Groundwater Extraction – Pump-and-Treat (Source Release Area Treatment)

A Groundwater Extraction System (GE) is proposed in the CAP design for use in treating the source release area and is to be installed within the 250 foot compliance buffer. The GE system should act as a treatment/barrier wall for any future releases if they occur.

4.4.1 GE Overview

Groundwater Extraction is a general term used to describe the removal of contaminated groundwater for treatment. Groundwater Extraction is also known as a Pump-and-Treat technology due to the fact the groundwater is first pumped out and then treated. This method

can be accomplished through various methods such as vertical extraction wells, horizontal extraction wells, and interceptor trenches. Due to the low permeability and low conductivity of the upper aquifer at the DELF site where the contamination is present, the County has chosen to utilize an interceptor trench design to remove the contaminated groundwater and then pump the groundwater to the County owned sanitary sewer system for treatment at the County Waste Water Treatment facility.

4.4.2 GE Evaluation

Rule .1636(b) states that potentially effective remedies for the ground water contamination at the Dunn-Erwin MSWLF shall:

- Be protective to human health and the environment.

  GE is a proven natural technology which is protective to human and environmental health. (Refer to articles referenced in Section 9.0)

- Attain the approved ground water protection standards.

  GE has the potential to attain the approved NCGS standards

- Control the source(s) of release so as to eliminate, to the maximum extent practicable, further releases of Appendix II constituents into the environment.

  The source of the contaminant plume is more than likely leachate that has escaped the existing Active C&D/Closed MSW landfill cell. GE will effectively control source contamination in conjunction with the Leachate Management System (Section 4.2) by acting as a treatment/barrier wall installed perpendicular to the movement of the plume source while the phytoremediation provided by the use of trees will be used to attempt to remediate what is already present.

- Comply with standards for management of wastes as specified in Rule .1637(d).

  GE complies with the standards of Rule .1637(d).

Under Rule .1636(c) the selected corrective measures must be evaluated by the following:

- The long and short-term effectiveness and protectiveness of the remedy, along with the degree of certainty that the remedy will prove successful;

and

- The effectiveness of the potential remedy in controlling the source to reduce further releases.

The source of the contaminant plume is more than likely leachate that has escaped the existing Active C&D/Closed MSW landfill cell. GE will effectively control source contamination in conjunction with the Leachate Management System (Section 4.2) by acting as a treatment/barrier wall installed perpendicular to the movement of the plume source while the phytoremediation provided by the use of trees will be used to attempt to remediate what is already present.

- The ease or difficulty of implementing the potential remedy.

  GE will be reasonably implemented on this site. The depth of the groundwater and confining unit may require the need of specialized excavation equipment and hydraulic stabilization of the excavation during the extraction trench installation.

- Practicable capability of the owner or operator, including a consideration of the technical and economic capability.

  The installation of the groundwater extraction trench may require the rental of specialized equipment. However, the County Solid Waste Department currently have multiple experience heavy equipment operators on staff that are capable of completing the excavation and installation activities of the system. On the other hand, the County may choose to bid the installation to a licensed general contractor so that the staff is not taxed with normal operational duties and construction at the same time.

  Concerning operations: The County owns and operates multiple comparable sanitary sewer lift stations. The County already has trained technicians capable of operating and maintaining the proposed type of pump system necessary for the groundwater extraction.

- The degree to which community concerns are addressed by the potential remedy.

  There were no public comments during the required Public Meeting held on March 31, 2008. (Minutes of meeting attached in Appendix F)

5.0 CORRECTIVE ACTION PLAN IMPLEMENTATION

5.1 ~~Pre-Implementation Activities~~*

***This Section has been deleted due to the completion of pre-implementation activities in July to September 2009 which led to the removal of EB as a potentially viable remedial technology for this site (see February 2009 version of CAP for detailed description and the attached letter in Appendix E).*

5.2 CAP- The Three-Fold Approach

As indicated briefly above, the Dunn-Erwin Landfill CAP will have a three-fold approach:

1. A Leachate Management system has already been implemented with temporary facilities and plans for permanent facilities to treat the source area of the contamination within existing Active C&D/Closed MSW landfill cell.
2. GE will be utilized as a treatment/extraction/barrier wall to the source area of the contamination within the 250-foot compliance buffer to the existing Active C&D /Closed MSW landfill.
3. In addition, a two-stage Phytoremediation plan will be implemented to treat the existing contaminant plume downgradient of the 250 foot compliance buffer. Below is a detailed description of three CAP technologies and design.

The diagram shown on the following page details the schedule and tasks to be completed during the Dunn-Erwin Landfill CAP.

FIGURE 1 – CAP SCHEDULE AND TASKS

Tentative Schedule	DELF CORRECTIVE ACTION PLAN		
	CONTAMINANT SOURCE CONTROL/REMOVAL: Leachate Management System	**CONTAMINANT SOURCE RELEASE AREA CONTROL:** Groundwater Extraction System	**DOWNGRADIENT PLUME TREATMENT:** Phytoremediation
Year 1	Continue temporary Pump&Haul operation until permanent pump sytem installed	Prepare bid package for Groundwater Extraction System, bid, and begin Construction	Grading Implementation area for Stage 1 and Stage 2 as necessary for plantings and proper drainage.
	Prepare bid package for Pump Stations, bid, and begin construction	Install New Monitoring Wells associated with Set 1-GE	Soil Sampling and Augmentation
	Begin operation of Leachate Management System for removal of contaminant source	Begin operation of Groundwater Extraction System for contaminant source control and groundwater gradient decrease.	Plant Trees (Stage 1) & Install Monitoring Set 1-P1
Year 2			Maintain Tree Grove and Irrigate
Year 3	Close existing C&D cell (airspace exhausted) and permanently cap cell with impermeable material	Continue operation of Groundwater Extraction System until contamination is removed and shown to no longer being released from the landfill cell.	Analyze Monitoring Data (constituent and groundwater elevation) from Stage 1, Adjust Stage 2 Plan accordingly, Implement Stage 2
Year 4	Continue operation of Leachate Management sytem until leachate production has significantly decreased in volume		Plant Trees (Stage 2) & Install Monitoring Set 1-P2
Years 5 - 10			Monitor, Maintain, Replace
Years 10 to 15+			As necessary, harvest trees and replace, Monitor, & Maintain

NOTES:

1. The schedule above is assumed to begin after the CAP depicted in this document is approved in full by the NCDENR-SWS.
2. The schedule shown above for Phytoremediation is subject to be shifted so that planting of trees occurs during the period of the year that best facilitates survival of the trees.

5.3 Leachate Management – Source Control

As previously indicated in Section 4 above, the County has already implemented a Leachate Mangement Plan to control the potential source of the contamination in an attempt to correct a re-occuring leachate "pop-out" and direct discharge of leachate from the active C&D/closed MSW landfill cell. The collection portion of the LM system consists of a gravel filled sump area, a deeper gravel collection trench, and a longer shallow gravel filled interceptor trench. The leachate is currently being pumped and hauled from the facility by a permitted septic hauler and disposed of at the County owned waste water treatment facility.

Future plans include the installation of a smaller groundwater extraction and leachate removal suction pump station and a centralized leachate lift station. The smaller pump station will be part of the Groundwater Extraction System (described below) and will take the place of the temporary pump and haul contractor described above. This smaller pump station will discharge into a larger, centralized pump station. This larger lift station will also collect the leachate generated from the onsite MSW transfer station. The centralized lift station will discharge the collected leachate and contaminated groundwater to a County owned gravity sanitary sewer line located on Highway 55. This gravity sewer will transport the leachate/contaminated groundwater to the County owned waste water treatment facility.

Details of this system can be found on included Drawing Sheets 3.1 through 3.4.

5.4 GE – Source Release Area Treatment and Barrier

After completing the EB pilot study sampling (Appendix D), the County chose GE as the replacement technology to treat and control the contaminant plume at the source location within the 250-ft compliance buffer. The GE system will be installed as a linear interceptor trench along the entire width of the plume in order to intercept and create a barrier to further contaminant transport downgradient. The interceptor trench will be excavated approximately 2 feet into the confining unit below the upper aquifer. The 2 foot wide trench will be backfilled with a drainage aggregate (NCDOT #57 Stone) to a depth of 2 feet above the average groundwater elevation. At intervals of approximately 100 feet, groundwater extraction wells will be imbedded in the drainage aggregate. These wells will be pumped by the smaller pump station described above in Section 5.3 to remove the contaminated groundwater and create a linear depression in the groundwater table. This created depression should effectively reverse the naturally occurring groundwater gradient, thus effectively creating a barrier to further contaminant transport away from the source area.

5.5 Phytoremediation – Downgradient Plume Treatment

Harnett County selected Phytoremediation in November 2008 as the technology to implement in a corrective action plan at the Dunn-Erwin Landfill Facility due to several reasons:

- Existing contaminant plume is wide spread with inconsistent concentrations. Phytoremediation offers a method of treatment that does not demand continued mechanical adjustments and monitoring.
- Phytoremediation presents a bioremediation treatment that has a life span of 20+ years with little maintenance costs or efforts as compared to other technologies.
- Phytoremediation provides an aesthetically pleasing landscaping in comparison to other mechanical type remediation systems.

Several tasks were completed in the design of the phytoremediation system. Each are described below. In addition, this section also describes the implementation, both Stage 1 and Stage 2, of the phytoremediation system.

5.5.1 Plant Selection

Important considerations in selecting a plant species for phytoremediation at a site include the following plant characteristics:

- Climatological requirements
- Uptake capabilities
- Tolerance levels to the chemicals found on-site
- Tolerance to pH and salinity of the groundwater and soils on-site
- Depth of the root zone
- Growth rate
- Transpiration rate
- Whether deciduous or evergreen
- Maintenance requirements
- Native vs. Non-native species
- Availability

Many tree suppliers were researched and the County has chosen to purchase 7-9' hybrid poplar poles ("Imperial Carolina", DN-34, Populus Deltoides x Nigra) from Hramor Nursery of Manistee, MI. The poles will be planted almost flush with the ground leaving one bud above the ground surface. The trees are expected to root the entire depth and also form a taproot to seek out the groundwater. Therefore, a root system of over a 17' total depth is expected. (See detail, Drawing Sheet 5.4)

5.5.2 Planting Techniques

The number of trees to plant depends on the size of the space available and the desired plan density. Widely spaced planting has the potential benefit of cost savings if the trees are being installed by augering boreholes, and minimizes or eliminates the cost of thinning. However, greater plant densities will achieve canopy closure more rapidly; therefore, water uptake will also reach a maximum rate more quickly. Greater densities are also appropriate for a tree variety that are more columnar in shape. Very dense plantings should be thinned

when trees are about 3 years old to improve tree vigor and performance. Row spacing will be at least 10 feet wide to allow mowing equipment between rows during establishment. Plantings will be achieved by either the borehole or trenching method with backfill of a mixture of natural soil and amendments.

An investigation into the depth to average water table was performed. As shown on the attached Drawing Sheet 5.1, the average water table contours are roughly 12 to 24 feet deep compared to the existing ground surface for the majority of the CAP phytoremediation implementation area. Since it is expected that the trees will not be able to root much deeper than 10 feet below the bottom of the planted 7-9 foot poles (overall root depth from ground surface will be 17 to 19 feet deep), a grading plan was created to remove the overburden soil from the CAP implementation area. The area will be excavated so that the maximum depth to the water table is approximately 9 feet. A series of swales, berms, and sediment traps have been designed to handle stormwater flow. An E&S Control plan will be submitted under separate cover to NCDENR-LQS for approval prior to any construction activities (the SWS will be provided a courtesy copy of this submittal for file). The SWS has indicated concern over if the excavation will be approved by NCDENR-Land Quality Section (LQS). Based on our extensive experience with the LQS review and approval process, we do not foresee any possible reason why this proposed grading plan will not be approved by LQS. Thus, an alternative plan to the grading depicted on the drawings is not being considered at this time.

The County will also investigate using a Treewell® system or similar design during the Phytoremediation Stage 2 implementation to force the tree roots to channel downward prior to spreading outward in order to reach the aquifer on-site if it is deemed necessary by the results seen from Phytoremediation Stage 1.

5.5.3 Fertilization / Soil Amendments

As part of the tree installation task, soil samples will be sent to a laboratory for agricultural analysis.

Nitrogen is most likely the limiting nutrient in the soil. Nitrogen application rates for rapidly growing hybrid poplars may require up to 200 lb/N/acre/year. Phosphorous and potassium fertilization is also likely to be required. In, addition, hybrid poplars have been known to respond well to the addition of zinc.

If low pH is discovered, lime can be used to adjust soil pH, as needed, based on baseline monitoring data. Aged compost or peat moss can be blended with site soil during planting to improve soil aeration, soil structure, soil density, and more. A formal amendment plan and schedule will be formulated from the lab results and implemented with the Phytoremdiation Stage 1.

5.5.4 Phytoremediation – Stage 1

The Phytoremediation system will be installed in two stages. Stage 1 will be utilized as a large scale pilot study and evaluated so that Stage 2 will be more effective in treatment of the contamination plume.

Stage 1 of the phytoremediation will be implemented by completion of the following activities:

1. Sampling: A Phytoremediation soil investigation will be conducted to produce analytical sampling results to determine the need for amendments and fertilizer rates for the tree planting. Soil samples will be sent to a laboratory for agricultural analysis to evaluate them for nutrients, grain size, and cation exchange capacity. Soil samples will be collected from the entire rooting depth.
2. Grading: The area of the planting will be graded so that the trees can be planted to treat the contaminated groundwater. A full grading plan is depicted on Sheets 5.1 and 5.2 of the attached drawings. Initially, only the area necessary for planting and proper drainage of Stage 1 will be graded and the appropriate drainage structures installed. Upon indication the phytoremediation is positively affecting the groundwater and the groundwater plume, grading will be completed for the entire phytoremediation area.
3. Tree Planting: Trees will be planted on a grid as depicted on Sheets 5.1 and 5.2 of the attached drawings. During the process of installing the trees, the surrounding soils will be amended as necessary based upon the sampling that is to be conducted (See Item 1 above.) Details of the tree planting method(s) to be used are shown on Sheet 5.3 of the attached drawings.
4. Monitoring Point Installation: Multiple piezometers will be installed to determine the effect of the trees on the groundwater contours. These new piezometers are shown on Sheet 2.1 of the attached drawings.
5. Monitoring: These new piezometers and existing piezometers and monitoring wells will be utilized to evaluate the effect of the Stage 1 plantings. The monitoring plan is detailed below in Section 6.

5.5.5 Phytoremediation – Stage 2

If after the 3rd growing season of the Stage 1 phytoremediation system it is found that Stage 1 has shown positive results for remediating the Dunn-Erwin contaminant plume, Stage 2 will be implemented within the plume area. The area for Stage 2 is shown on Sheet 5.2 of the attached drawings. The 5 steps described above will be utilized in this implementation. Currently, unless the results determine a need for revision, the planting density used for Stage 1 will be utilized for Stage 2 (as shown on Sheet 5.2).

As necessary for monitoring, new piezometers and monitoring wells will be installed during the Stage 2 implementation. The proposed locations of these new monitoring points are shown on Sheet 2.1 of the attached drawings. The Stage 2 monitoring plan is detailed below in Section 6.

If the Stage 1 does not show promising remediation results after the 3rd growing season of Stage 1, the County will implement other methods or techniques, as approved by the SWS, that could practicably achieve the compliance requirements as set forth in Rule .1637(b).

6.0 MONITORING AND SAMPLING PLAN (GROUNDWATER & REMEDIATION SYSTEMS)

During each phase and stage of the CAP, groundwater monitoring will be conducted within the GE and Phytoremediation system locations. Monitoring wells will be installed where groundwater sampling will be collected for chemical analysis. Piezometers will be installed in locations where the only data needed are water level measurements for water table contouring and aquifer tests for estimating hydraulic conductivity.

Groundwater samples collected from monitoring wells may be analyzed for CVOCs and their microbial daughter product compounds, nutrients, and field parameters such as temperature, oxidation-reduction potential, and pH. The following additional monitoring shall be added to the current semi-annual monitoring being conducted for the Active C&D /Closed MSW cell at Dunn-Erwin Landfill. Monitoring wells at the facility fall into three sets as follows:

- Set 1 – Wells downgradient to the active C&D /Closed MSW landfill

- Set 2 – Wells associated the older closed portions of the landfill facility across the creek and south of the active C&D landfill

- Set 3 – Surface water monitoring points along the creek/wetland areas to the south and west of the active C&D landfill

(Additional information concerning the current groundwater monitoring plan can be found in the semiannual Statistical Analysis/Evaluation reports for the Dunn-Erwin Facility on file with NCDENR-SWS.)

Based on these previously defined monitoring sets, the new wells and sampling sets associated with CAP phase will be defined as follows:

- Set 1-GE: Groundwater Extraction and General Plume monitoring
- Set 1-P1: Phytoremediation Stage 1
- Set 1-P2: Phytoremediation Stage 2

6.1 Groundwater Extraction Sampling and Monitoring Frequency (Set 1-GE)

In conjunction with or prior to the installation of the GE system, the associated new monitoring wells are to be installed and background sampled. Before and after the installation of the GE System, the following monitoring wells shall be sampled on a semiannual basis to determine the effectiveness of the GE system on both reduction of the groundwater gradient and reduction of the contaminant levels downgradient:

Up-gradient wells to the GE System: MW-6C*, MW 7-B, MW-8B*, GP-38W

Down-gradient wells to the GE System or Plume: MW-6B*, MW-7C*, MW-8, MW-50*, MW-51*, MW-52*, MW-56*, MW-57*, MW-58*, and MW-59*

* Indicates a monitoring well to be installed prior to the start of the GE system operation. These monitoring wells are depicted on Sheet 2.1 of the attached drawings.

MW-6B will replace poorly recharging well MW-6. MW-6 will be abandoned.

The specific sampling parameters and frequency can be seen in Table 1 below.

6.2 Phytoremediation Stage 1 and Stage 2 Sampling and Monitoring Frequency (Set 1-P1 & Set 1-P2)

During the phytoremediation, groundwater sampling will be conducted twice yearly (semi-annually) for CVOC testing. Groundwater measurements will be taken bi-weekly during the growing season (April to October) and monthly during the rest of the year. Groundwater sampling within the test location and in a control area will provide data for rhizosphere effects and hydraulic control. The data will be used to evaluate whether or not the trees are creating a depression in the water table. Two or more transects will be utilized to fully evaluate water levels within the pilot study area and to collect groundwater samples to evaluate the fate of the COCs.

Plant monitoring will include qualitative monitoring (i.e., plant health observations), quantitative monitoring (i.e., growth as indicated by leaf area index, girth, and height), and plant tissue sampling after 6 growing seasons for analysis of the COCs. Randomly selected trees will be used as bench marks for plant monitoring throughout the duration of the phytoremediation project. Monthly qualitative monitoring will be performed until the plot is well established, and tissue sample collection will be performed semi-annually after 6 full growing seasons.

As shown on Sheet 2.1, of the attached drawings, prior to the planting activities, three (3) new proposed monitoring wells (MW53 thru MW55), thirteen (13) new proposed peizometers (P-PZ53 thru P-PZ65) and a new surface water sampling location (SW-4) will

be installed to supplement the existing monitoring well, piezometer, and geoprobe network already in use at the site to assure a thorough evaluation of the effects of the trees within the treatment area.

Those wells associated with Stage 1 (Set 1-P1) will be included as part of the sampling set as well as (Set 1-P2) for Stage 2 of the phytoremediation.

The specific sampling parameters and frequency can be seen in Table 1 below.

TABLE 1 – CAP GROUNDWATER MONITORING PLAN SUMMARY

		PARAMETER						
	Sampling Point	Water Level	Field pH	Metals	Turbidity	Conductivity	Temperature	EPA 8260B (Appendix II)
Set 1-GE	MW-6B	m*	sa	sa	sa	sa	sa	sa
	MW-6C	m*	sa	sa	sa	sa	sa	sa
	MW-7B	m*	sa	sa	sa	sa	sa	sa
	MW-7C	m*	sa	sa	sa	sa	sa	sa
	MW-8	m*	sa	sa	sa	sa	sa	sa
	MW-8B	m*	sa	sa	sa	sa	sa	sa
	GP-38W	m*	sa	sa	sa	sa	sa	sa
	MW-50	m*	sa	sa	sa	sa	sa	sa
	MW-51	m*	sa	sa	sa	sa	sa	sa
	MW-52	m*	sa	sa	sa	sa	sa	sa
	MW-56	m*	sa	sa	sa	sa	sa	sa
	MW-57	m*	sa	sa	sa	sa	sa	sa
	MW-58	m*	sa	sa	sa	sa	sa	sa
	MW-59	m*	sa	sa	sa	sa	sa	sa
Set 1-P1	PZ-41S	bw	sa	sa	sa	sa	sa	--
	PZ-53	bw	sa	sa	sa	sa	sa	--
	PZ-54	bw	sa	sa	sa	sa	sa	--
	PZ-55	bw	sa	sa	sa	sa	sa	--
	PZ-56	bw	sa	sa	sa	sa	sa	--
	PZ-57	bw	sa	sa	sa	sa	sa	--
	PZ-58	bw	sa	sa	sa	sa	sa	--
	PZ-59	bw	sa	sa	sa	sa	sa	--
	MW-9	bw	sa	sa	sa	sa	sa	sa
	MW-10	bw	sa	sa	sa	sa	sa	sa
	MW-15	bw	sa	sa	sa	sa	sa	sa
	MW-53	bw	sa	sa	sa	sa	sa	sa
	GP-34W	bw	sa	sa	sa	sa	sa	sa
	SW-4	bw	sa	sa	sa	sa	sa	sa
Set 1-P2	PZ-47S	bw	sa	sa	sa	sa	sa	sa
	PZ-48S	bw	sa	sa	sa	sa	sa	sa
	PZ-50	bw	sa	sa	sa	sa	sa	--
	PZ-60	bw	sa	sa	sa	sa	sa	--
	PZ-61	bw	sa	sa	sa	sa	sa	--
	PZ-62	bw	sa	sa	sa	sa	sa	--
	PZ-63	bw	sa	sa	sa	sa	sa	--
	PZ-64	bw	sa	sa	sa	sa	sa	--
	PZ-65	bw	sa	sa	sa	sa	sa	--
	GP-25W	bw	sa	sa	sa	sa	sa	sa
	GP-27W	bw	sa	sa	sa	sa	sa	sa
	GP-28W	bw	sa	sa	sa	sa	sa	sa
	GP-30W	bw	sa	sa	sa	sa	sa	sa
	GP-31W	bw	sa	sa	sa	sa	sa	sa
	GP-33W	bw	sa	sa	sa	sa	sa	sa
	GP-34W	bw	sa	sa	sa	sa	sa	sa
	GP-35W	bw	sa	sa	sa	sa	sa	sa
	GP-36W	bw	sa	sa	sa	sa	sa	sa
	GP-37W	bw	sa	sa	sa	sa	sa	sa
	MW-11	bw	sa	sa	sa	sa	sa	sa
	MW-12	bw	sa	sa	sa	sa	sa	sa
	MW-13	bw	sa	sa	sa	sa	sa	sa
	MW-14	bw	sa	sa	sa	sa	sa	sa
	MW-55	bw	sa	sa	sa	sa	sa	sa
	MW-54	bw	sa	sa	sa	sa	sa	sa

bw = biweekly (monthly during November to March)
m = monthly
m* = biweekly during first 6-months, then monthly
SW-4 is a surface water sampling location

sa = seimiannually
a = annually
-- = no reading/sampling

6.3 Annual Reporting Requirements

It is intended for the new sampling events to correspond to the already existing sampling semi-annual sampling schedule of April and October each year. After the completion of the October sampling event a report will be generated to include the results of the Groundwater and Tree Monitoring program. These reports will also include the following:

- Quantitative analysis of the groundwater sampling results
- General conclusion of the health of the Tree grove
- Groundwater contour map of the GE and Phytoremediation areas showing:
    - April, July, & October contours
- Colored isoconcentration maps of the contaminant plume area for the indicator contaminants and their remediated components as the remediation proceeds (these will be similar to those included in the 2003 report)
- The following tables:
    - Historical groundwater level readings for each sampling point including Max, Mean, and Min values
    - Historical analytical results of the sampling events
- Conclusions drawn from the analysis of the results and sampling
- Appendices containing actual lab results, field reports, tree monitoring reports, and facility maps

These reports will be submitted to NCDENR-SWS for review and filing annually after the October sampling event. A copy of the report will be kept on file at the facility, the Harnett County General Service Office in Lillington, NC and at the Coats, NC office of C. T. Clayton, Sr., PE, Inc.

7.0 EVALUATION OF EFFECTIVENESS OF CAP SYSTEMS AND REPORTING REQUIREMENTS

The Leachate Management and Groundwater Extraction systems will be considered a success if the source area wells within the 250-ft compliance buffer demonstrate a consistent decrease in contaminant levels. In addition depression in the groundwater table surrounding the GE trench will also indicated a successful decrease and control of the groundwater gradient. Continual groundwater level readings will be analyzed during the initial operation of the GE system in the wells surrounding the GE trench and in the GE trench itself to determine the amount of hydraulic control the GE system is exhibiting on the area. Groundwater samples will be analyzed semi-annually to determine the decrease in the contaminants of concern.

The phytoremediation system will be considered a success if the trees exhibit hydraulic control of the test area and uptake the contaminants of concern, thus showing the potential to reduce chemical concentrations below NCGS levels within the Dunn-Erwin Landfill

contaminant plume. Continual water level readings will be analyzed during Stage 1 to determine the amount of hydraulic control the trees have on the test area. Tree corings and/or leaf tissue analysis may be performed to verify uptake of the contaminants of concern.

Most of the chemicals that are taken-up by the trees are expected to be volatized slowly to the atmosphere. A portion will be metabolized by the leaves and woody tissue of the trees.

8.0 CAP CONTINGENCY PLAN

In the event the CAP presented above does not appear to be effectively reducing the groundwater contamination or controlling the horizontal movement of the plume, the contingency plan will need to be implemented. At this time, the contingency plan will be, in this order:

1. In the event of the GE system failing to hydraulically control the area, an additional slurry cutoff wall will be investigated to be installed immediately downgradient of the GE trench.
2. In the event of a phytoremediation failure, install a pump-and–treat or groundwater extraction system along the leading edge of the plume to remove the contaminated groundwater and halt/reduce the downgradient transport of the plume. Groundwater removed will be either treated onsite and discharged or transported to the local wastewater treatment facility.

The triggering events to the implementation of the contingency plan will be if <u>each</u> of the following occurs:

- No statistically significant decrease in the contaminant levels immediately downgradient of the GE injection "wall" within 18 months of the start of operations or no significant change in the hydraulic gradient surrounding the GE system within 12 months of the start of operation. Statistical significant decrease in contaminant levels can be defined as the results of the first 18 months should indicate via a valid statistical prediction model that the CAP System will effectively decrease the levels of contaminantion to below North Carolina groundwater standards within a 10-year operational time.
- Decrease in the contaminant levels within 6 years of the Stage 1 phytoremediation implementation area to below North Carolina groundwater standards.

Otherwise, the current CAP will be deemed effective and at most, adjustments to the current plan may be necessary.

9.0 SCHEDULE AND MAINTENANCE

The following schedule for installation and general maintenance requirements will be adhered to following NCDENR SWS approval.

9.1 Schedule

The implementation schedule for the CAP depicted herein can be found in Figure 1 above in Section 5.2. (Please note: the times given are based upon SWS approval.)

9.2 GE and LM Maintenance Plan

Due to the nature of the GE and LM systems being a fairly simple pump system, a routine mechanical maintenance program will need to be implemented. Pump manufacturer maintenance plans and schedules shall be followed. At a minimum, the onsite piping system(s) shall be inspected for the following:

- leaks or cracking (monthly)
-mechanical operation of all valves or pressure gauges (monthly)
-Clogging or sedimentation of extraction well heads (semi-annually)

The sampling and yearly analysis/reporting will meet the maintenance requirements of the actual GE process and determine if additional maintenance procedures are necessary.

9.3 Phytoremediation Maintenance Plan

Maintenance of the Phytoremediation plot includes routine inspection of groundwater, meteorological and plant monitoring equipment, and the plants themselves. Maintenance of plant and cover vegetation will include:

- Mowing ground cover vegetation on a regular basis (if planting density makes mowing difficult, then mowing may only be completed when herbaceous plant competition becomes detrimental to the trees)
- Monitor trees quarterly for disease or insects
- Fertilizing the area based on the soil monitoring results
- Irrigation during periods of unseasonal dry weather that causes a significant drop in groundwater levels (trees are planted at or in the upper aquifer)
- Animal control to keep out deer, voles, beavers, etc; and
- Pruning and replacing trees as necessary to maintain the health of the grove

9.4 Site Security

The area in which the CAP is to be implemented is secured during non-operating hours of the facility by two (2) locked gates. One is the main entrance gate and the other is the gate immediately to the south of the existing MSW transfer station as depicted on the attached drawings. The second gate is kept locked unless facility personnel need to access the area around the CAP implementation area for maintenance or grounds keeping activities.

During operating hours facility personnel are present at the scale house, the transfer station and the active landfill a majority of time.

9.5 Maintenance Contact

Maintenance of the Phytoremediation plot will be the responsibility of the Owner: Harnett County. The contact information for the maintenance of the CAP will be:

Harnett County
General Services Office
Attn: Jerry Blanchard, General Services Manager/Solid Waste Director
P. O. Box 940
900 S 9th Street
Lillington, 27546
910-893-7536
jblanchard@harnett.org

The onsite facility contact is:

Randy Smith, Solid Waste Operations Manager
910-897-3222

Annual reporting will be the responsibility of the Engineering and Environmental Consultant:

C. T. Clayton, Sr., PE, Inc.
Attn: C. Tyrus Clayton, Jr., PE
P. O. Box 578
46 W. Washington St.
Coats, NC 27521
910-897-7070
tyrus@ctclayton.com

10.0 COMPLETION OF CORRECTIVE ACTION

Completion of the Corrective Action Plan will occur when NCGS standards are met in accordance with 15A NCAC 13 B .1637. It is anticipated to take a minimum of 10 years to fully complete the CAP at this facility. A better estimate of the timeline to completion will be generated at the completion of the Stage 1 of the Phytoremediation.

A detailed cost estimate of the Corrective Action Plan implementation costs and Annual Operation and Maintenance costs are included in Appendix C.

11.0 REFERENCES

The references cited herein may or may not be cited in the text of this report. They are listed here since they were used as references in the creation of the text of this report.

Brady, P. V., M. V. Brady, D. J. Borns. 1998 *Natural Attenuation-CERCLA, RBCA's and the Future of Environmental Remediation.* Lewis Publishers, New York

Chappell, Jonathan. 1997. *Phytoremediation of TCE using 'Populus'*. Status Report prepared for the U.S. EPA Technology Innovation Office

C. T. Clayton, Sr., P. E., Inc. 2008 *Statistical Analysis/Evaluation: April 2008, Dunn Erwin Landfill Facility*

C. T. Clayton, Sr., P. E., Inc. *Assessment of Corrective Measures Harnett County Dunn-Erwin Landfill: August 2007*

Eco-usa.net website, Toxics:Chemicals, accessed October 2009, http://www.eco-usa.net/toxics/chemicals/index.shtml

Ensol, Inc. & C. T. Clayton, Sr., P. E., Inc. 2003 *Assessment of Groundwater Contamination Plume, Dunn Erwin Landfill Facility*

EnviroTools website, *Phytoremediation*, accessed July 2007, *http://www.envirotools.org/factsheets/phytoremediation.shtml*

Environmental Health Perspectives, Volume 103, Number 12, *Absorbing Possibilities: Phytoremediation*, December 1995

Environmental Protection Agency, September 1997, *Design Guidelines for Conventional Pump-and-Treat Systems* EPA 540-S-97-0504

Environmental Protection Agency, December 2002, *Elements for Effective Management of Operating Pump and Treat Systems*, EPA 542-R-02-009

Environmental Protection Agency, July 1996, *Pump-and-Treat Groundwater Remediation: A Guide for Decision Makers and Practitioners*, EPA 625-R-95-005

Environmental Protection Agency, June 1999 *Phytoremediation Resource Guide*, EPA 542-B-99-003

Environmental Protection Agency, February 2000 *Phytoremediation Resource Guide*, EPA 600-R-99-107

Fetter, C. W., 1999. *Contaminant Hydrogeology*, Second Edition, Prentice-Hall, Inc., New York

Fetter, C. W., 1994 *Applied Hydrogeology*, Third Edition, Prentice-Hall, Inc., New York

Hinchee, R.E., A. Leeson, L. Semprini, and S.K. Ong. 1994. *Bioremediation of Chlorinated and Polycyclic Aromatic hydrocarbon Compounds.* Lewis Publishers, Boca Raton

The Interstate Technology and Regulatory Cooperation Work Group Phytoremediation Work Team, November 1999. *Decision Tree Document: Phytoremediation Decision Tree.* accessed http://www.cluin.org/download/partner/phytotree.pdf

Lewis, Amy C. June 2006 *Assessment and Comparison of Two Phytoremediation Systems Treating Slow-Moving Groundwater Plumes of TCE*

Microbial Insights website, *Bio-Trap Samplers*, accessed December 2008, http://www.microbe.com/biotrap.html

North Carolina Department of Environmental and Natural Resources, Solid Waste Rules, 15A NCAC 13B, Division of Waste Management, Raleigh, North Carolina, 1997

North Carolina Department of Environmental and Natural Resources, Classifications and Water Quality, Standards Applicable to the Groundwater of North Carolina, 15A NCAC 2L, Division of Environmental Management, Raleigh, North Carolina

RNAS website, *Remediation & Natural Attenuation Services, Inc.*, accessed February 2009, http://www.rnasinc.com

Jerald L. Schnoor, Ph.D., P.E., DEE, October 1997 *Phytoremediation*, GWRTAC Technology Evaluation Report

United States Public Health Service Agency for Toxic Substances and Disease Registry 1991 *Toxicological Profile for Methylene chloride October 1991 Update*

United States Public Health Service Agency for Toxic Substances and Disease Registry 1990 *Toxicological Profile for Tetrachloroethene January 1990*

United States Public Health Service Agency for Toxic Substances and Disease Registry 1995 *Toxicological Profile for Trichloroethylene August 1995 Draft Update*

APPENDIX A

Harnett
COUNTY
NORTH CAROLINA

Office of the County Manager

www.harnett.org

Scott Sauer
County Manager

William A. (Tony) Wilder
Assistant County Manager

PO Box 759
102 East Front Street
Lillington, NC 27546

ph: 910-893-7555
fax: 910-814-2662

February 12, 2009

Mr. Zinith Barbee, Hydrogeologist II
Division of Waste Management – Solid Waste Section
NC Department of Environment and Natural Resources
1646 Mail Service Center
Raleigh, NC 27699-1646

RE: Selection of Corrective Action Remedy (Revision to October 15, 2008 letter)
Dunn-Erwin Landfill Facility
SWS Permit No. 43-02
Harnett County, NC

Dear Mr. Barbee,

This letter is to serve as the official notification of the revision of the selection of a Corrective Action Remedy and Technology to be utilized for remediation at the Dunn-Erwin Landfill Facility.

Per the meeting with the SWS on November 26, 2008, the previously selected Corrective Action Technology of Phytoremediation has been modified to also include Enhanced In-situ Bioremediation. The Enhanced In-situ Bioremediation will be utilized by injecting a remedial substrate within the 250-ft compliance buffer to the existing landfill to treat the contaminant release that has occurred. The Phytoremediation will be utilized to treat the contaminant groundwater plume that now exists outside the 250 foot compliance buffer and downgradient of the landfill, within the facility boundary.

A more detailed explanation of the Corrective Action Plan and the proposed implementation schedule can be reviewed in the Dunn-Erwin Landfill Corrective Action Plan document being prepared and submitted by our consultant, C. T. Clayton, Sr., PE, Inc.

Please feel free to contact Tyrus Clayton, PE of CTC directly at 910-897-7070 or tyrus@ctclayton.com to discuss this issue further. Also, please copy him on any correspondence concerning solid waste permitting and compliance matters for Harnett County.

Sincerely,

Scott Sauer, Manager
Harnett County

cc: Jerry Blanchard, General Services Manager, Harnett County
C. Tyrus Clayton, Jr., PE, C. T. Clayton, Sr., PE, Inc.
Geoff Little, NCDENR-DWM-SWS
Mark Poindexter, NCDENR-DWM-SWS

APPENDIX B

ABBREVIATIONS

C & D	CONSTRUCTION & DEMOLITION
L.C.I.D.	LAND CLEARING & INERT DEBRIS
M.S.W.	MUNICIPAL SOLID WASTE

GP 23-W — GEOPROBE WELL
PZ 46S — EXISTING PIEZOMETER
MW 9 — EXISTING MONITORING WELL
SURFACE WATER SAMPLING LOCATION
GW-1 — LF GAS EXTRACTION WELL
GM #1 — GAS MONITORING POINT

FACILITY BOUNDARY
FLARE STATION
CLOSED M.S.W. CELL PRE-1994
MAINTENANCE BUILDING
EXISTING BORROW AREA
METAL
WHITE GOODS
RECYCLE BINS
MAIN ENTRANCE GATE
SR 1724
SCALE & SCALE HOUSE
YARD WASTE DISPOSAL
MSW CONVENIENCE & TIRE CENTER
L.C.I.D. CELL
MSW TRANSFER STATION
PERMIT 4307T
ACTIVE C & D CELL
PERMIT 43-02
ASBESTOS, TIRE, AND CLOSED C & D CELLS
FACILITY BOUNDARY
CLOSED M.S.W. CELLS
PZ 40S ESTIMATED (DESTROYED)
PROPOSED C&D LANDFILL
PZ 43 ESTIMATED (DESTROYED)
WETLAND LIMITS (CURRENTLY BEING DELINEATED FOR JURISDICTIONAL DETERMINATION BY THE ARMY CORPS OF ENGINEERS AND NCDENR - DWQ)
FACILITY BOUNDARY
SR 1725
GRAPHIC SCALE
200 100 0 200 400
(IN FEET)

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY: E. TYRUS CLAYTON, JR., PE, No. 10000 ON 10/5/09
THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT
21-00.1103(a) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 53 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

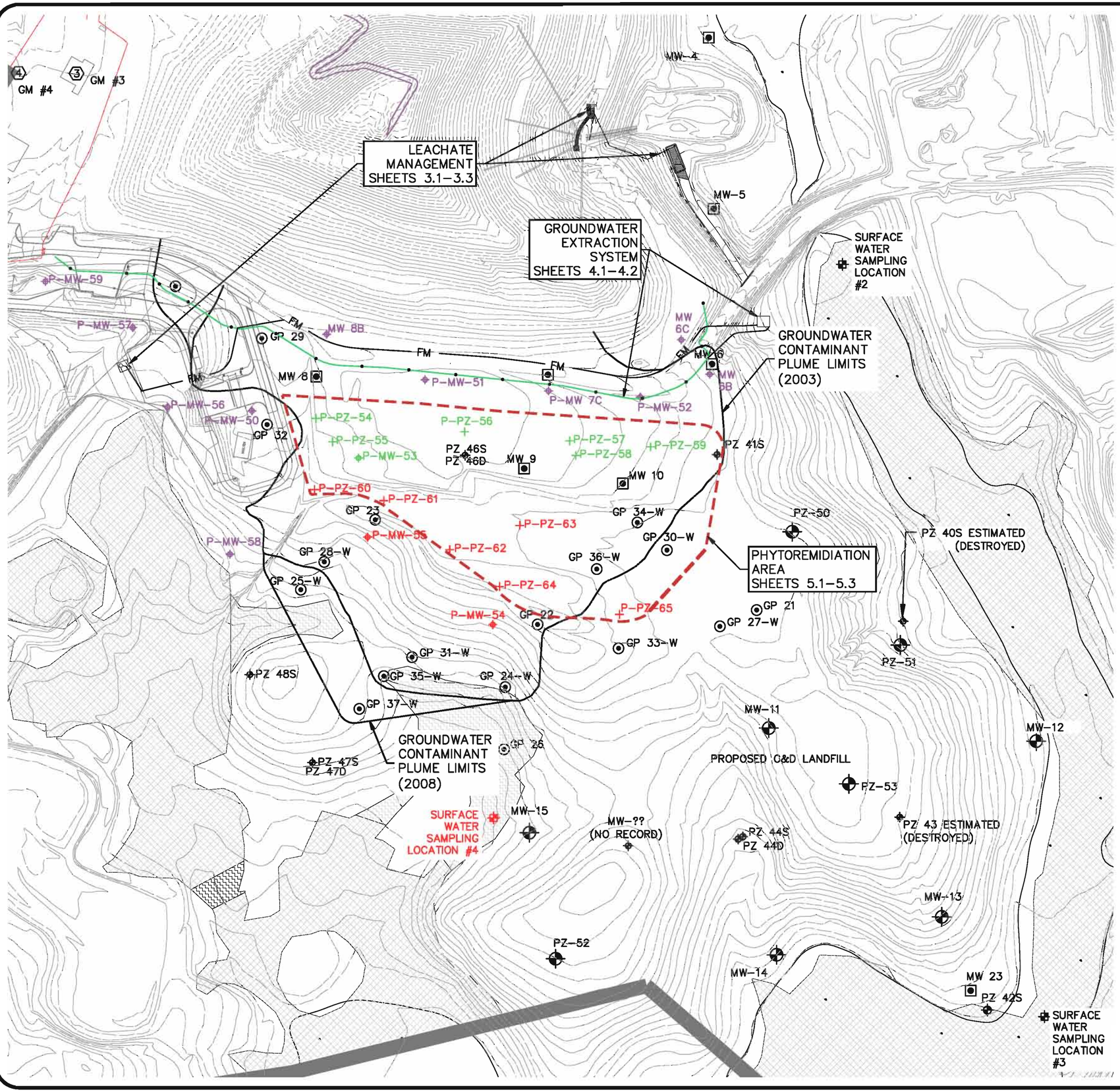
Signature
Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 579
COATS, NORTH CAROLINA 27521
PHONE 910-897-7570 FAX: 910 897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@clayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND PERMIT MODIFICATION REQUEST
SWS PERMIT NO. 43-02
HARNETT COUNTY NORTH CAROLINA

Project No:	03002B	File Name:	030023 MAS
Designed By:	CTC Jr./RS	Drawn By:	JU/WLF
Checked By:	CTC Jr.	Proj. Eng.:	CTC Jr.
Sheet Title	OVERALL FACILITY PLAN		
Date	10/5/09	Sheet	1.1 OF 12
Scale	1" = 200'		

\\SERVER\Projects\03 Harnett County\03002B Corrective Action Plan CAP\Cad\03002B Facility Map and Index Sheet.dwg



GP 23-W	GEOPROBE WELL
PZ 46S	EXISTING PIEZOMETER
MW 9	EXISTING MONITORING WELL
	SURFACE WATER SAMPLING LOCATION
GM #1	GAS MONITORING POINT
P-MW-51	PROPOSED MONITORING SET 1-GE
P-MW-53	PROPOSED MONITORING SET 1-P1
P-MW-55	PROPOSED MONITORING SET 1-P2

ABBREVIATIONS

C & D	CONSTRUCTION & DEMOLITION
L.C.I.D.	LAND CLEARING & INERT DEBRIS
M.S.W.	MUNICIPAL SOLID WASTE

GRAPHIC SCALE
100 50 0 100 200
(IN FEET)

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY C. TYRUS CLAYTON, Jr., PE No. 026905 ON [redacted]
THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.
21-58.1103(d) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 58 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

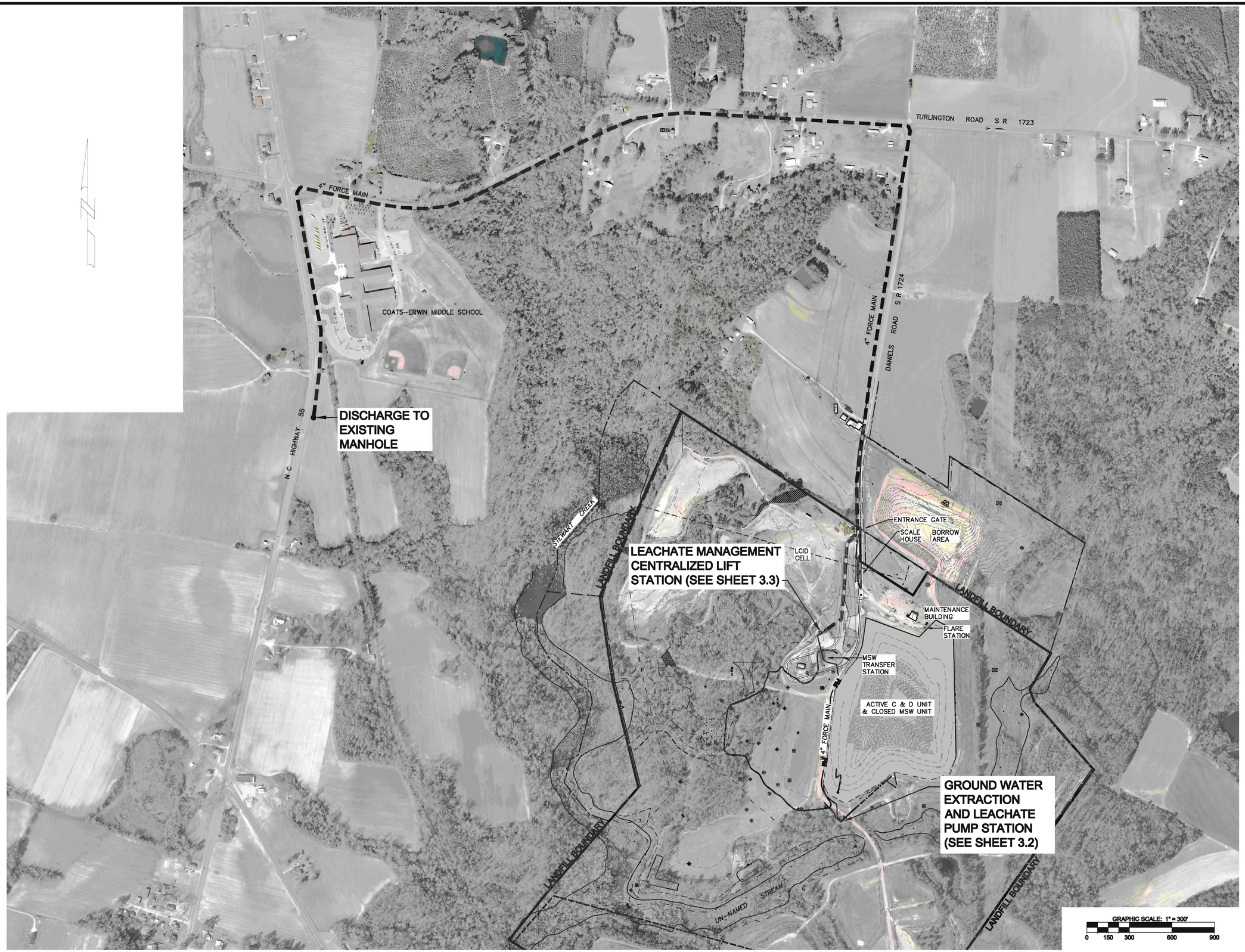
Signature
Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 879
COATS, NORTH CAROLINA 27521
PHONE: 910-897-7070 FAX: 910 897-6767
MOBILE: 919 795-5302 (Tyrus) Email: tjcsr@ctclayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND PERMIT MODIFICATION REQUEST
SWS PERMIT NO. 43-02
HARNETT COUNTY NORTH CAROLINA

Project No: 030028	File Name: 030028 Facility.dwg
Designed By: CTC Jr./RS	Drawn By: JL/WLF
Checked By: CTC Jr.	Proj. Eng.: CTC Jr.
Sheet Title: CAP INDEX AND GROUNDWATER MONITORING PLAN	
Date 10/5/09	Sheet 2.1 OF 12
Scale 1" = 100'	

\\SERVER\Projects\03 Harnett County\030028 Corrective Action Plan CAP\Cad\030028 Facility Map and Index Sheet.dwg



General Notes

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY C. TYRUS CLAYTON, Jr., PE No. 026609 ON OCTOBER 07, 2009. THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.

21-NC.110(b)(i)
BOARD RULES
NORTH CAROLINA
ADMINISTRATIVE CODE
TITLE 21, CHAPTER 56
BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

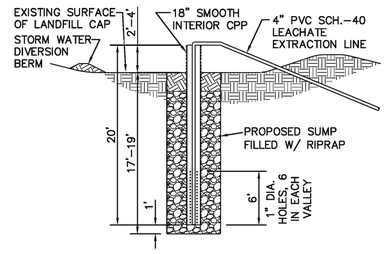
Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE: 910-897-7070 FAX: 910 897-5757
MOBILE: 919 796-8502 (Tyrus) Email: tyrus@ctclayton.com

DUNN-ERWIN LANDFILL CORRECTIVE ACTION PLAN AND PERMIT MODIFICATION REQUEST

HARNETT COUNTY, NORTH CAROLINA

Project No: 03002C	File Name: 03002C MAS.dwg
Designed By: CTC	Drawn By: WLF/AEB
Checked By: CTC	Proj. Eng.: CTC
Sheet Title: LEACHATE MANAGEMENT SYSTEM	
Date: 10/05/09	Sheet: 3.1 OF 12
Scale: 1" = 300'	

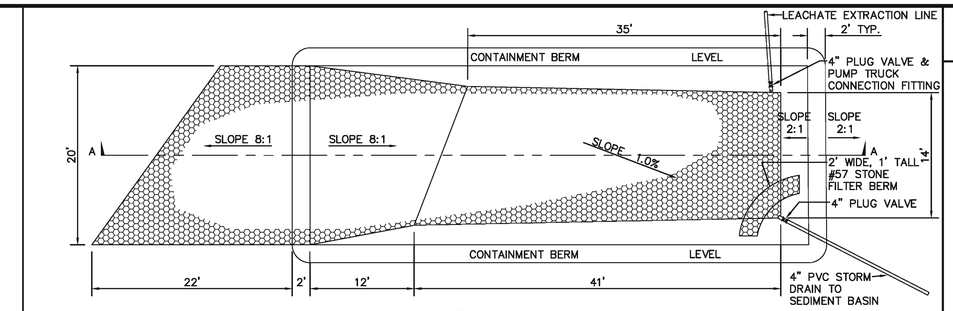
P:\03 Harnett County\03002C DELF Leachate Corrective Action\CAD\03002C MAS.dwg 10/05/09 9:00 PM



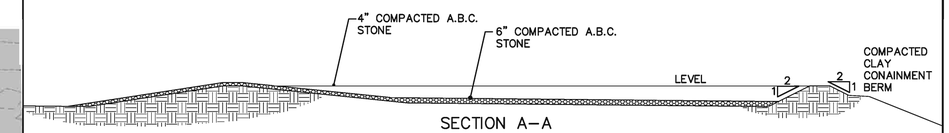
LEACHATE EXTRACTION SUMP DETAIL

NOT TO SCALE

ACTIVE C & D UNIT & CLOSED MSW UNIT



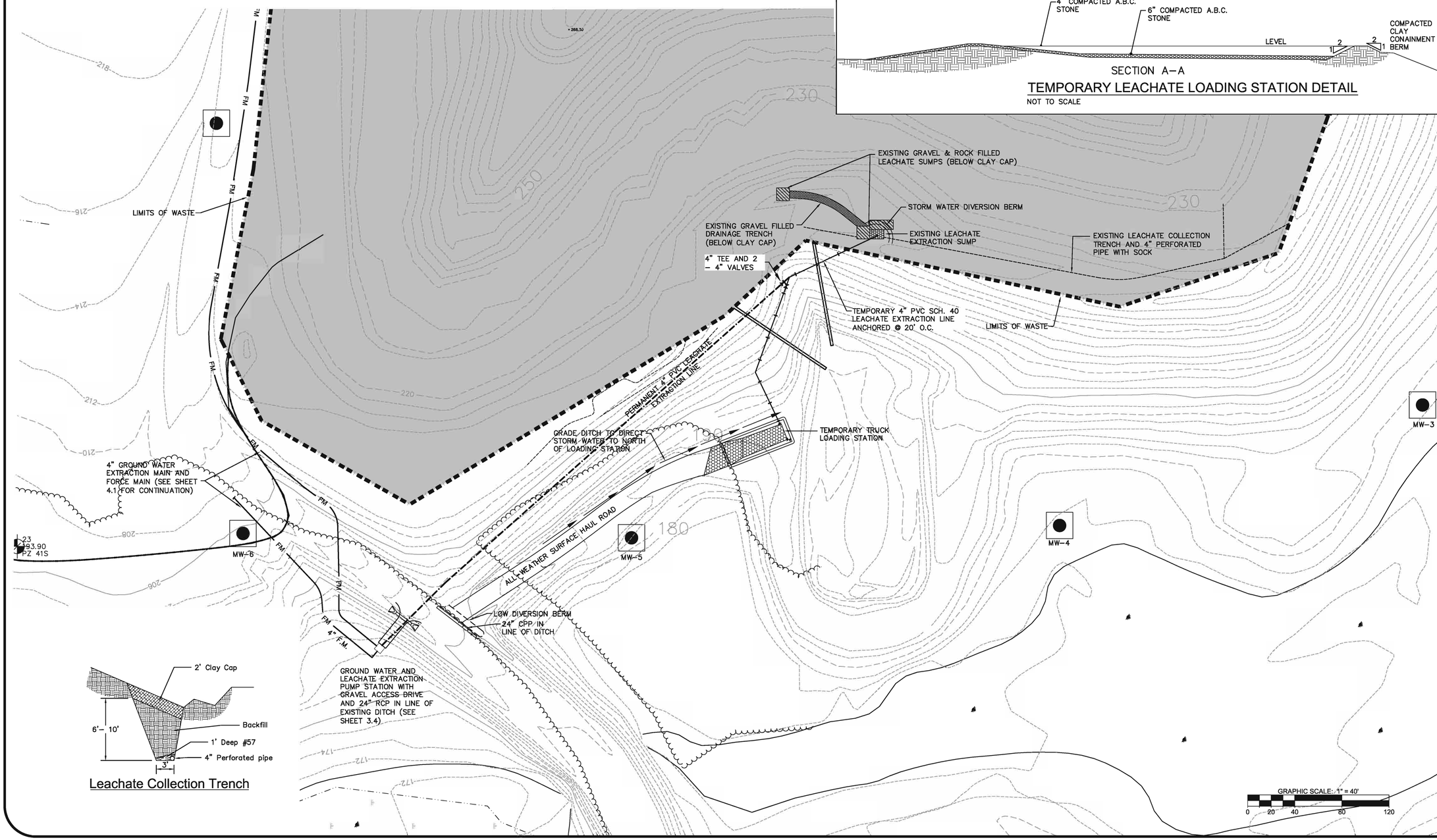
PLAN



SECTION A-A

TEMPORARY LEACHATE LOADING STATION DETAIL

NOT TO SCALE



Leachate Collection Trench

General Notes

LEACHATE COLLECTION SYSTEM AND TEMPORARY LOADING STATION IS INSTALLED AND HAS BEEN IN USE SINCE JULY 2009.

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY:
C. TYRUS CLAYTON, Jr., PE No. 028909
ON OCTOBER 07, 2009.
THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.

21-56.1103(d)
BOARD RULES
NORTH CAROLINA
ADMINISTRATIVE CODE
TITLE 21, CHAPTER 56
BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

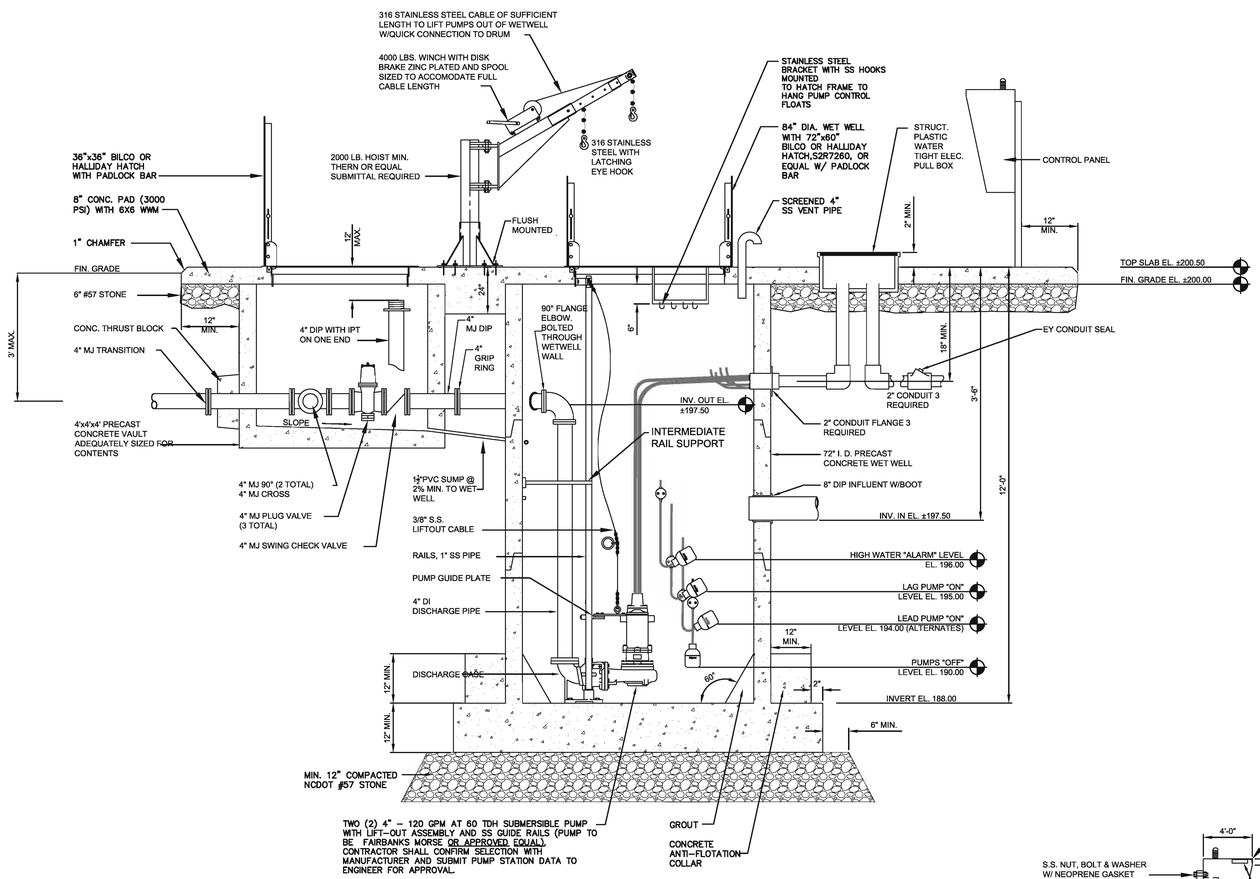
Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE 910-897-7070 FAX: 910 897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

DUNN-ERWIN LANDFILL CORRECTIVE ACTION PLAN AND PERMIT MODIFICATION REQUEST

HARNETT COUNTY, NORTH CAROLINA

Project No: 03002C	File Name: 03002C MAS.dwg
Designed By: CTC	Drawn By: WLF/AEB
Checked By: CTC	Proj. Eng.: CTC
Sheet Title: GROUND WATER EXTRACTION PUMP STATION	
Date: 10/05/09	Sheet: 3.2 OF 12
Scale: AS NOTED	

P:\03 Harnett County\03002C DELF Leachate Corrective Action\CAD\03002C MAS.dwg 10/05/09 3:00 PM



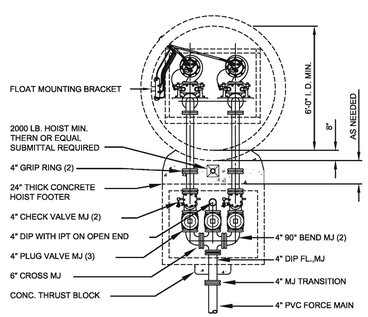
6'-0" I. D. CONCRETE DUPLEX PUMP STATION

SECTION VIEW

NOT TO SCALE

PUMP STATION NOTES

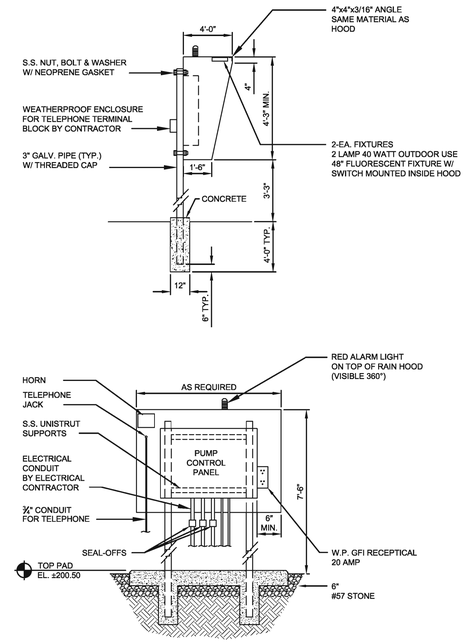
1. MANHOLE AND PRECAST WET WELL SHALL MEET CURRENT REQUIREMENTS OF ASTM C-478.
1. CONCRETE SHALL BE 4000 PSI MINIMUM COMPRESSIVE STRENGTH.
2. ALL REINFORCING STEEL SHALL MEET CURRENT REQUIREMENTS OF ASTM A-615.
3. TAPERED JOINT WITH O-RING GASKET SHALL MEET CURRENT REQUIREMENTS OF ASTM C-361 & C-443.
4. COLD APPLIED JOINT SEALER (SAHOM-98) SHALL BE USED IN ADDITION TO THE JOINT SPECIFIED.
5. FLEXIBLE JOINT (KOR-N-SEAL OR EQUAL) REQUIRED ON ALL PIPE CONNECTIONS TO MANHOLES. VOIDS SHALL BE FILLED FLUSH WITH INSIDE FACE OF MANHOLE WITH NON-SHRINK GROUT.
6. STEM NUT VALVE ONLY. HAND WHEEL OPTIONAL UPON ENGINEER APPROVAL.
7. CONTRACTOR SHALL SUPPLY ONE VALVE WRENCH TO THE TOWN FOR VALVE OPERATION.
8. ALL INTERNAL COMPONENTS SUCH AS RAILS, LIFT OUT CABLE, FLOAT TREE, CHAINS, ETC. SHALL BE STAINLESS STEEL OR EQUIVALENT CORROSION RESISTANT MATERIAL. EXTERNAL HOIST TO BE SS OR HOT DIPPED GALVANIZED.
9. BOTTOM OF BASIN MUST HAVE SMOOTH TROWELED SURFACE FOR MOUNTING SUPPORT CASTING.
10. WET WELL SHALL BE EPOXY COATED W/ 50 mil SURFACE DRY. EPOXY SEALER PRIME COATING AND FINISH COATING SHALL BE NSP 100 AND NSP 120 RESPECTIVELY.
11. AREA LIGHT SHALL BE CONNECTED SUCH THAT IT WILL BE SUPPLIED BY GENERATOR DURING POWER OUTAGE.



6'-0" I. D. CONCRETE DUPLEX PUMP STATION

PLAN VIEW

NOT TO SCALE



RAIN HOOD DETAIL

NOT TO SCALE

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY C. TYRUS CLAYTON, Jr., PE No. 028909 ON OCTOBER 07, 2009. THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.

21-56.1103(d) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 56 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE 910-897-7070 FAX: 910-897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND
PERMIT MODIFICATION REQUEST

HARNETT COUNTY NORTH CAROLINA

Project No:	03002B	File Name:	03002B MAS
Designed By:	CTC Jr./RS	Drawn By:	AEB
Checked By:	CTC Jr.	Proj. Eng.:	CTC Jr.

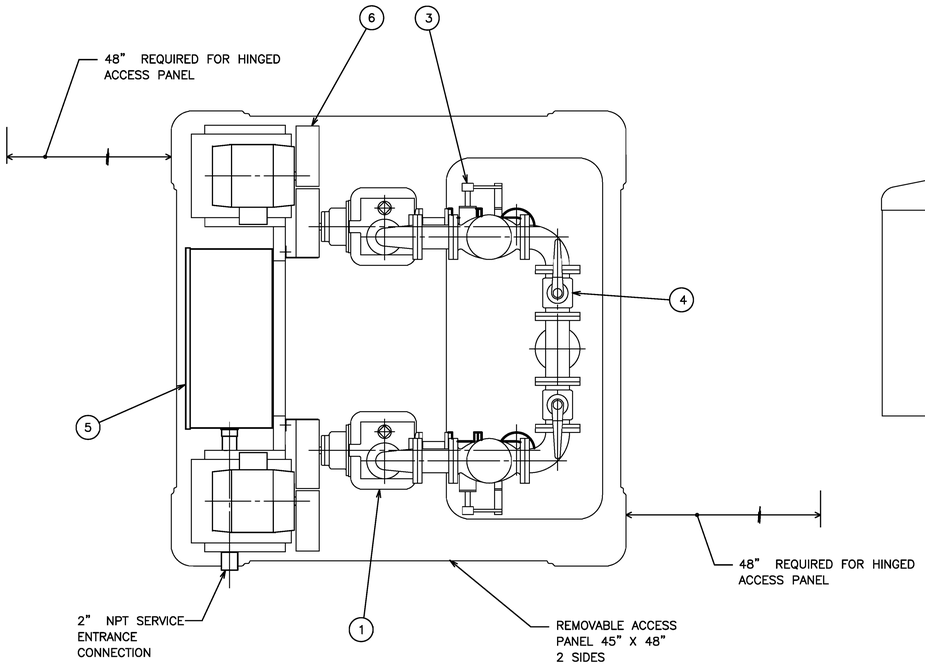
Sheet Title: LEACHATE MANAGEMENT CENTRALIZED LIFT STATION

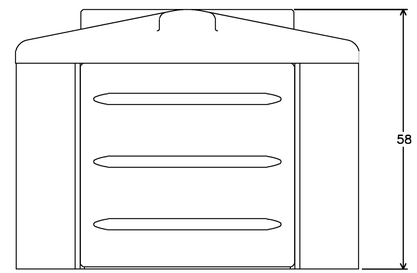
Date: 10/05/09

Scale: NO SCALE

Sheet: 3.3 OF 12

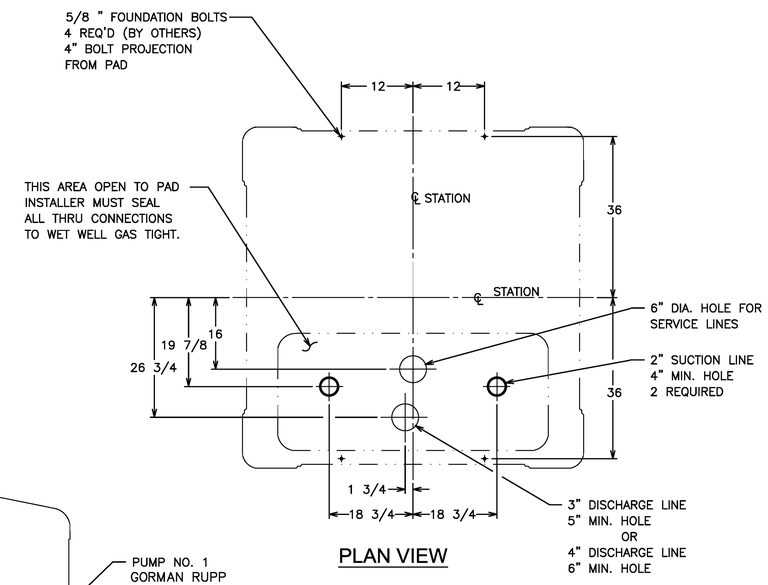
P:\03 Harnett County\03002C DELF Leachate Corrective Action\CAD\03002C MAS.dwg



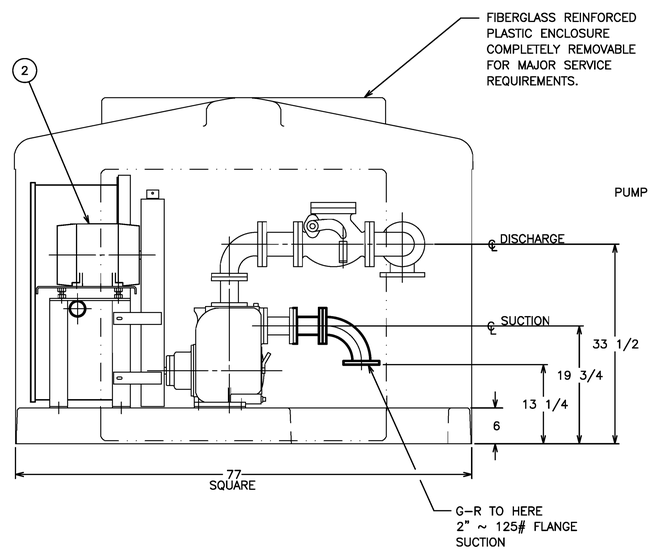


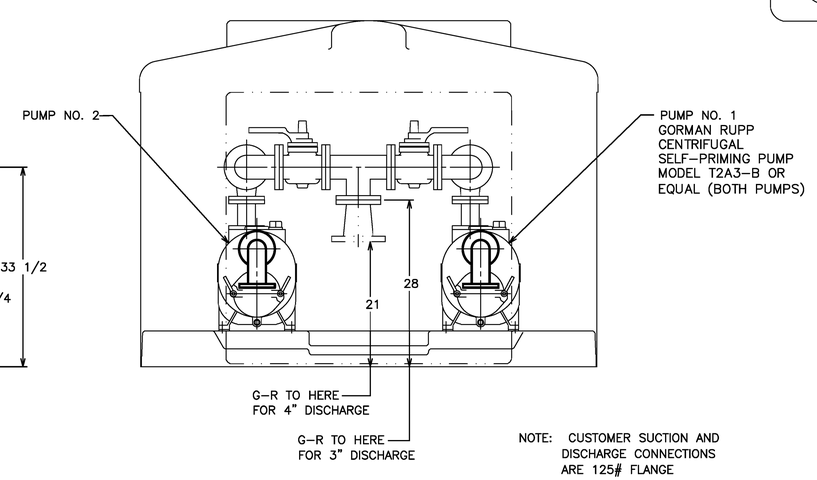
ELEVATION VIEW

ITEM	DESCRIPTION	MAT'L & SIZE	
1	PUMP	CAST IRON	T2A-B
2	MOTOR	CAST IRON	
3	CHECK VALVE	CAST IRON	3"
4	PLUG VALVE	CAST IRON	3"
5	MOTOR CONTROL PANEL	STEEL	
6	BELT GUARD	STEEL	



PLAN VIEW





NOTE: CUSTOMER SUCTION AND DISCHARGE CONNECTIONS ARE 125# FLANGE

2 X 3 X 3 AS SHOWN
2 X 3 X 4 WITH INCREASER

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY:
C. TYRUS CLAYTON, Jr., PE No. 028909
ON OCTOBER 01, 2009.
THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.
21-56.1103(d)
BOARD RULES
NORTH CAROLINA
ADMINISTRATIVE CODE
TITLE 21, CHAPTER 56
BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE 910-897-7070 FAX: 910 897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND
PERMIT MODIFICATION REQUEST

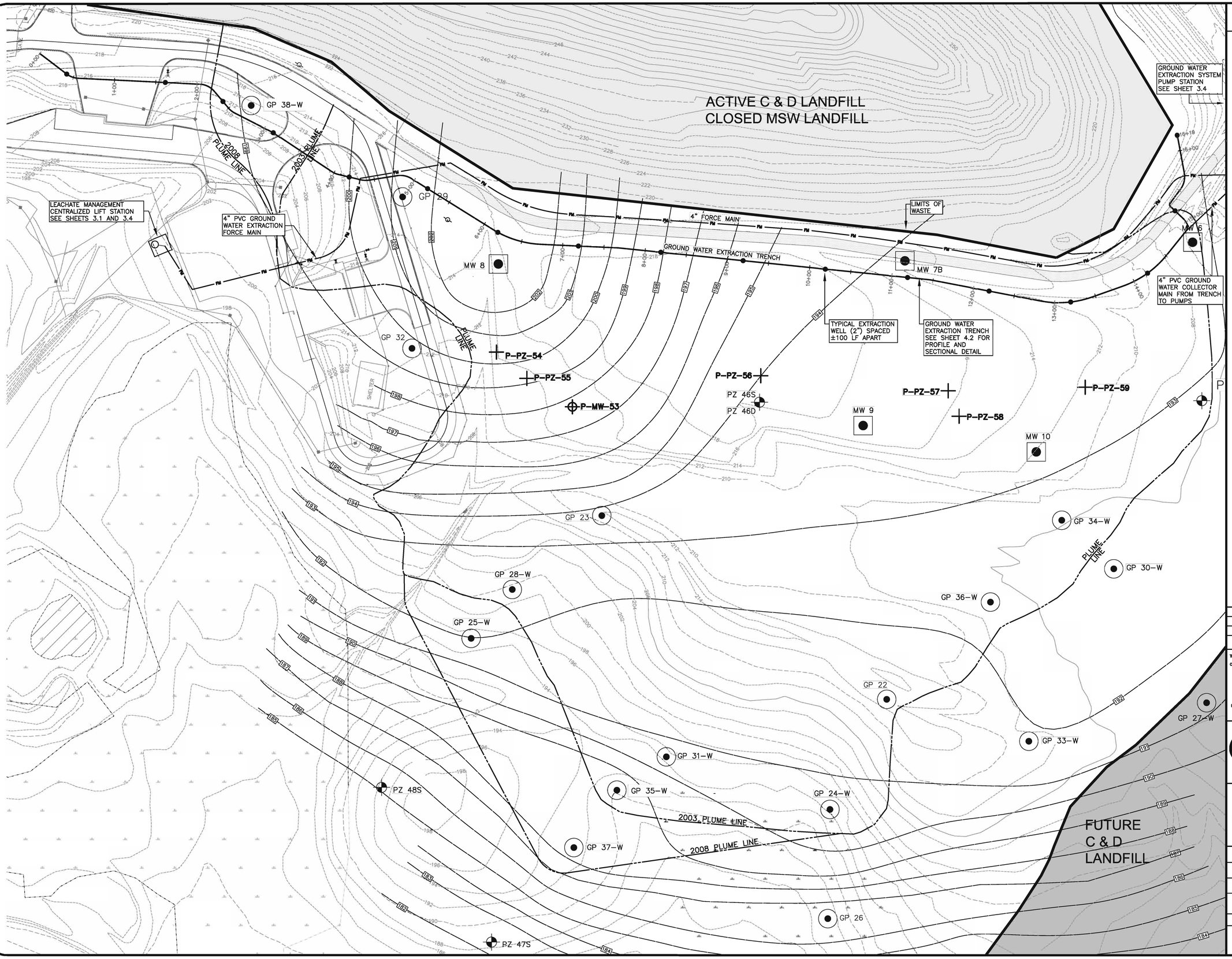
HARNETT COUNTY NORTH CAROLINA

Project No:	03002B	File Name:	03002B MAS
Designed By:	CTC Jr./RS	Drawn By:	WK
Checked By:	CTC Jr.	Proj. Eng.:	CTC Jr.

Sheet Title: GROUND WATER & LEACHATE EXTRACTION PUMP STATION

Date 10/05/09	Sheet 3.4
Scale NO SCALE	OF 12

P:\03 Harnett County\03002C DELF Leachate Corrective Action\CAD\03002C MAS.dwg



EXISTING CONTOURS

EXTENT OF PLUME

AVERAGE GROUND WATER ELEVATION CONTOURS

GP 21 GEOPROBE BORING (NO WELL INSTALLED)

GP 30W GEOPROBE WELL

PZ 46S EXISTING PIEZOMETER

MW 9 EXISTING MONITORING WELL

WETLANDS

GRAPHIC SCALE: 1" = 60'

0 30 60 120 180

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY: C. TYRUS CLAYTON, Jr., PE No. 028909 ON OCTOBER 07, 2002. THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.

21-58.1103(d) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 58 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE 910-897-7070 FAX: 910-897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND
PERMIT MODIFICATION REQUEST

HARNETT COUNTY NORTH CAROLINA

Project No: 03002B	File Name: 03002B MAS
Designed By: CTC Jr./RS	Drawn By: SBK/WLF/aeb
Checked By: CTC Jr.	Proj. Eng.: CTC Jr.

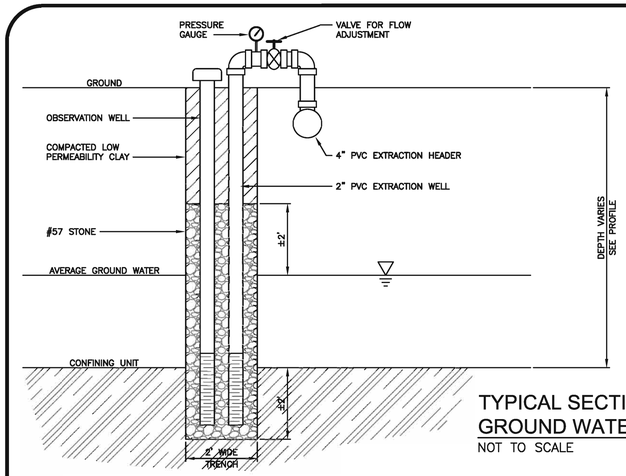
Sheet Title GROUND WATER EXTRACTION SYSTEM PLAN

Date 10/05/09

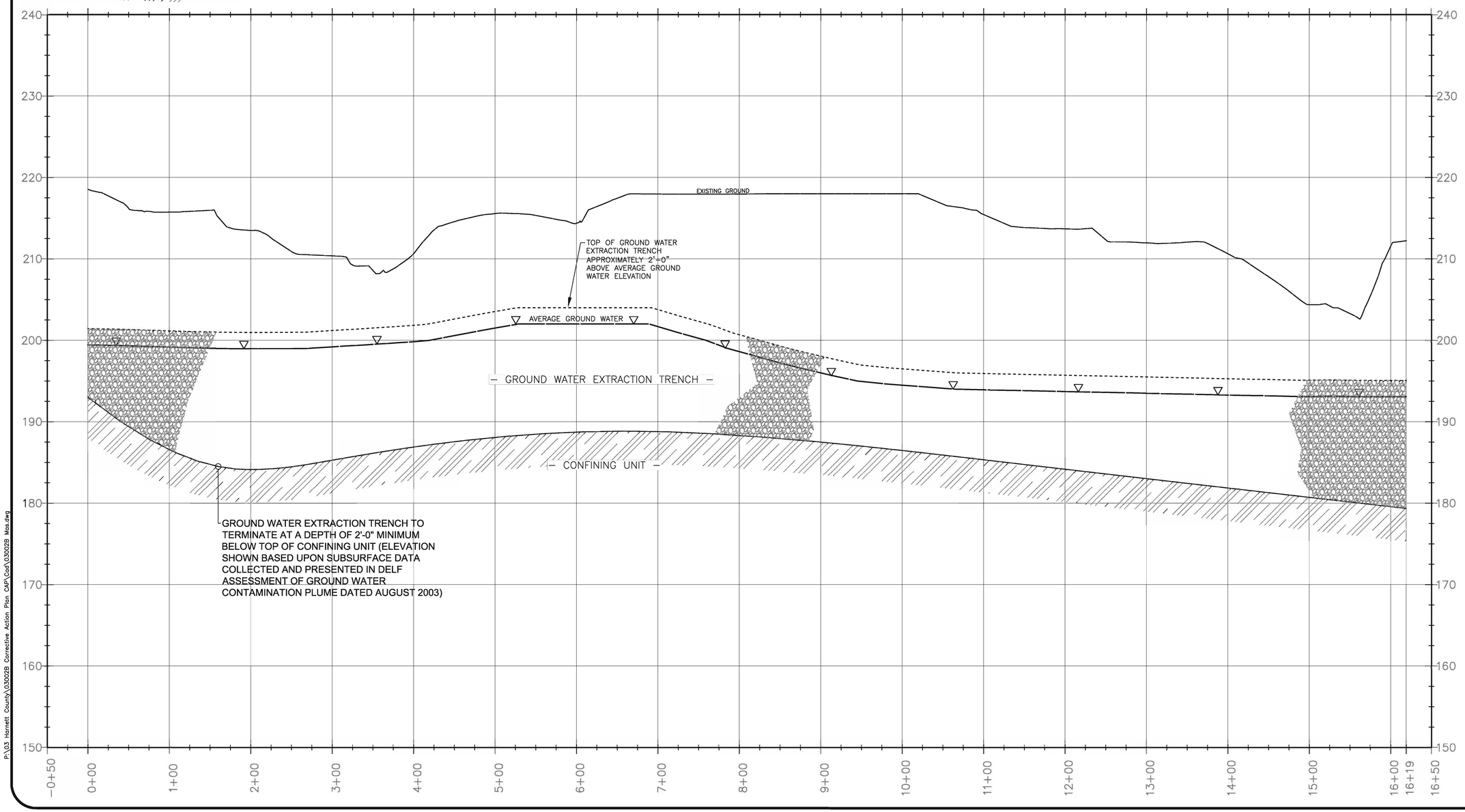
Scale 1" = 60'

Sheet 4.1 OF 12

P:\03 Harnett County\03002B Corrective Action Plan CAP\Cad\03002B Mas.dwg



TYPICAL SECTIONAL VIEW
GROUND WATER EXTRACTION TRENCH
NOT TO SCALE



PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY C. TYRUS CLAYTON, Jr., PE No. 028909 ON OCTOBER 07, 2009. THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.

21-58.1103(d) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 58 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE 910-897-7070 FAX: 910 897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@cclayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND
PERMIT MODIFICATION REQUEST

HARNETT COUNTY NORTH CAROLINA

Project No:	03002B	File Name:	03002B MAS
Designed By:	CTC Jr./RS	Drawn By:	AEB
Checked By:	CTC Jr.	Proj. Eng.:	CTC Jr.

Sheet Title: GROUND WATER EXTRACTION SYSTEM PROFILE

Date: 10/05/09

Scale: 1" = 60' Horz. 1" = 5' Vert.

Sheet 4.2 OF 12

P:\03 Harnett County\03002B Corrective Action Plan CAP\Cad\03002B Mas.dwg

EXISTING C & D LANDFILL

EXISTING LIMITS OF WASTE

HAUL ROAD

HYBRID POPLAR TREES – TYPICAL

10' APART (TYP.)

PHYTOREMEDIATION AREA STAGE 1

PHYTOREMEDIATION AREA STAGE 2

2003 PLUME BOUNDARY

CAP FULL IMPLEMENTATION BOUNDARY (SEE CAP NOTE, SHEET 5)

DO NOT DISTURB EXISTING MATURE TREES

2008 PLUME BOUNDARY

FUTURE C & D LANDFILL

GP 29 · GP 32 · GP 23 · GP 28–W · GP 25–W · GP 31–W · GP 35–W · GP 37–W · GP 24–W · GP 22 · GP 33–W · GP 36–W · GP 34–W · GP 30–W · GP 27–W · GP 21

MW 8 · MW 7B · MW 6 · MW 9 · MW 10 · MW–11

PZ 46S · PZ 46D · PZ 41S · PZ 48S

SHELTER

EXISTING CONTOURS
PROPOSED CONTOURS
EXTENT OF PLUME
CAP FULL IMPLEMENTATION BOUNDARY
AVERAGE GROUND WATER ELEVATION CONTOURS
GP 21 GEOPROBE BORING (NO WELL INSTALLED)
GP 30W GEOPROBE WELL
PZ 46S EXISTING PIEZOMETER
MW 9 EXISTING MONITORING WELL
HYBRID POPLAR PHYTOREMEDIATION
TREE LINE
WETLANDS

PROPOSED MONITORING WELLS AND PIEZOMETERS SHOWN ON SHEET 2.1

GRAPHIC SCALE: 1" = 40'
0 20 40 80 120

PHYTOREMEDIATION STAGE 1 DATA TABLE

STAGE 1 SIZE	1.86 ACRES
TREES PER ACRE	±806
TREE SPACING	ROWS: 10' APART TREES: 5.7' O.C.
TREE CONFIGURATION	1500 TREES TOTAL

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY C. TYRUS CLAYTON, Jr., PE No. 025909 ON OCTOBER 07, 2009. THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.

21–56.1103(d) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 56 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE 910-897-7070 FAX: 910-897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

PHYTOREMEDIATION GRADING NOTES

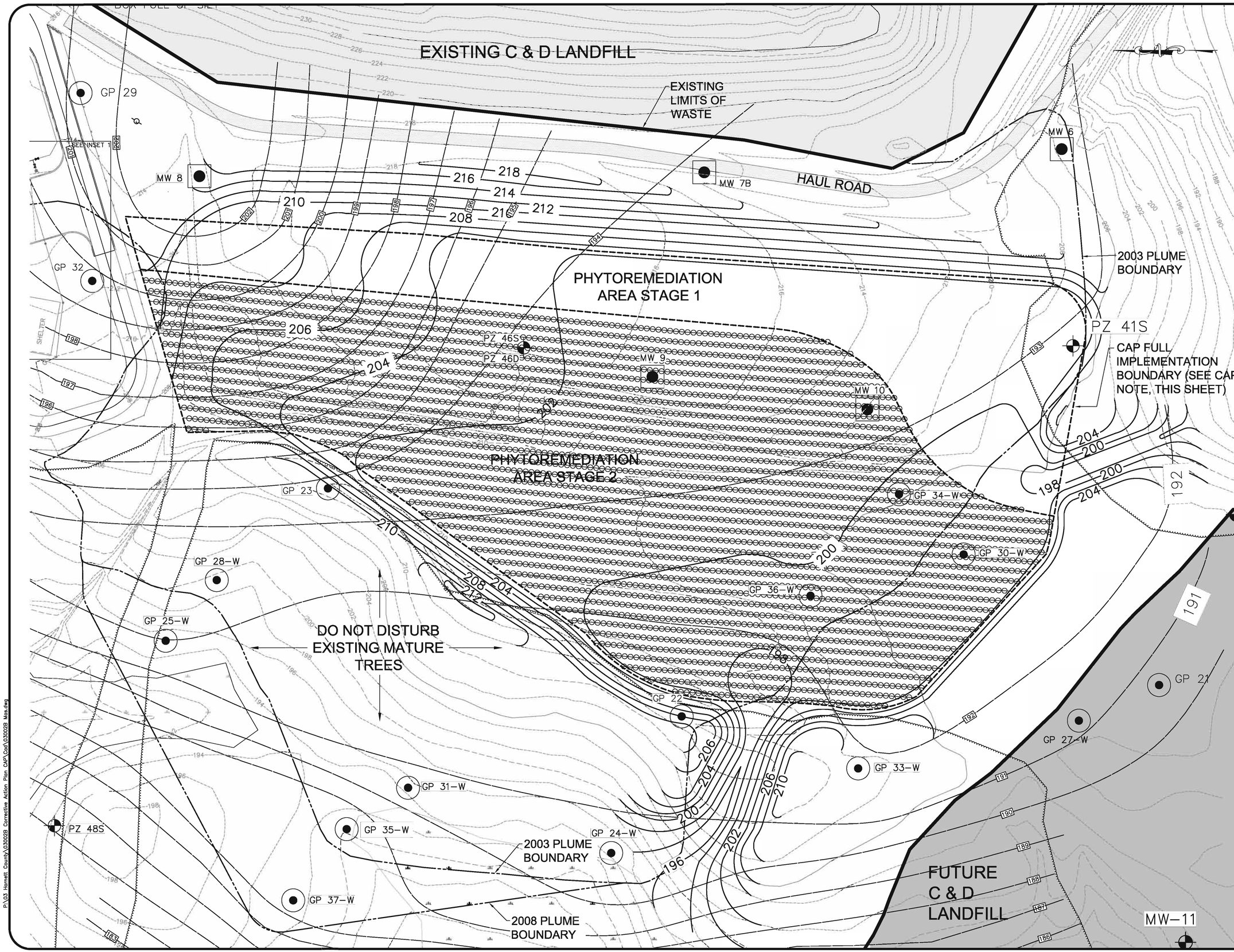
1. GRADING SHOWN IS FOR FULL PHYTOREMEDIATION IMPLEMENTATION (STAGE 1 & 2).
2. SUFFICIENT GRADING FOR STAGE 1 WILL BE COMPLETED PRIOR TO TREE INSTALLATION.
3. UPON DETERMINATION OF EFFECTIVENESS OF STAGE 1, GRADING FOR STAGE 2 WILL BE COMPLETED.

DUNN-ERWIN LANDFILL CORRECTIVE ACTION PLAN AND PERMIT MODIFICATION REQUEST

HARNETT COUNTY NORTH CAROLINA

Project No:	03002B	File Name:	03002B MAS
Designed By:	CTC Jr./RS	Drawn By:	SBK/WLF
Checked By:	CTC Jr.	Proj. Eng.:	CTC Jr.
Sheet Title	PHYTOREMEDIATION STAGE 1 PLAN		
Date	10/05/09	Sheet	5.1 OF 12
Scale	1" = 40'		

P:\03 Harnett County\03002B Corrective Action Plan CAP\Cad\03002B Mas.dwg



EXISTING CONTOURS
PROPOSED CONTOURS
EXTENT OF PLUME
CAP FULL IMPLEMENTATION BOUNDARY
AVERAGE GROUND WATER ELEVATION CONTOURS
GP 21 GEOPROBE BORING (NO WELL INSTALLED)
GP 30W GEOPROBE WELL
PZ 46S EXISTING PIEZOMETER
MW 9 EXISTING MONITORING WELL
HYBRID POPLAR PHYTOREMEDIATION
TREE LINE
WETLANDS

CAP NOTE:
UPON COMPLETION OF THE PHYTO-REMEDIATION STAGE 1, AN ANALYSIS WILL BE COMPLETED TO ADJUST THE IMPLEMENTATION AREA OF STAGE 2 AND DETERMINE ACTUAL PLANTING DENSITIES FOR FULL IMPLEMENTATION. (REFER TO DELF-CAP PLAN AS APPROVED BY NCDENR-SWS)

PROPOSED MONITORING WELLS AND PIEZOMETERS SHOWN ON SHEET 2.1

GRAPHIC SCALE: 1" = 40'
0 20 40 80 120

PHYTOREMEDIATION STAGE 2 DATA TABLE

STAGE 2 SIZE	4.85 ACRES
TREES PER ACRE	±765
TREE SPACING	ROWS: 10' APART TREES: 5.7' O.C.
TREE CONFIGURATION	3711 TREES TOTAL

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY C. TYRUS CLAYTON, Jr., PE No. 028609 ON OCTOBER 07, 2009. THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERIFIED DOCUMENT.
21-58.1103(c) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 58 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature
Date

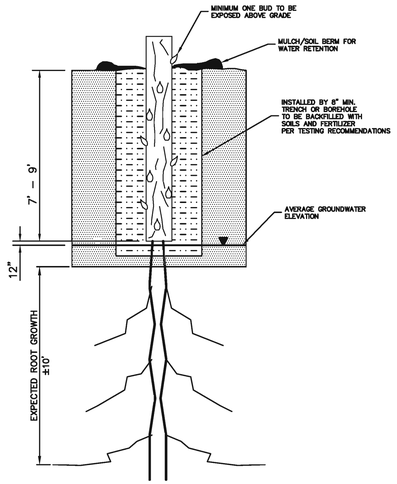
Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE: 910-897-7073 FAX: 910 897-6787
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND PERMIT MODIFICATION REQUEST

HARNETT COUNTY NORTH CAROLINA

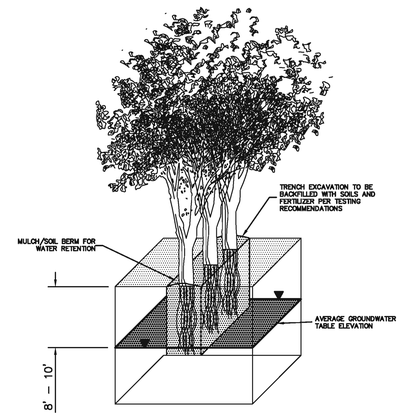
Project No: 03002B	File Name: 03002B MAS
Designed By: CTC Jr./RS	Drawn By: SBK/WLF
Checked By: CTC Jr.	Proj. Eng.: CTC Jr.
Sheet Title: PHYTOREMEDIATION STAGE 2 PLAN	
Date: 10/05/09	Sheet 5.2
Scale: 1" = 40'	OF 12

P:\03 Harnett County\03002B Corrective Action Plan CAP\Cad\03002B Mas.dwg



PHYTOREMEDIATION
PREFERRED METHOD
CUTTING PLANTING DETAIL

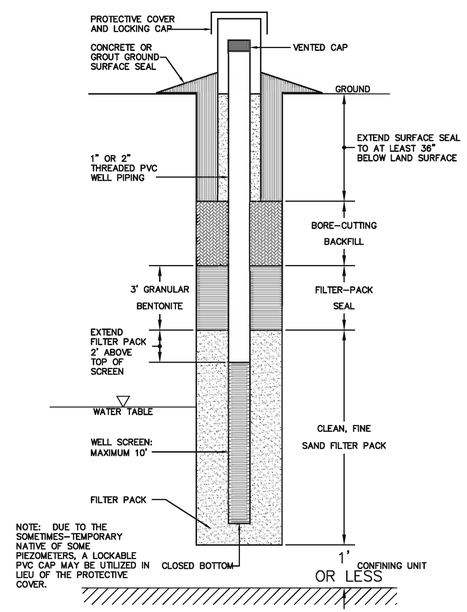
NOT TO SCALE



PHYTOREMEDIATION
ALTERNATE METHOD
TREE TRENCH INSTALLATION

NOT TO SCALE

NOTE: REQUIRES ROOTED TREES



NOTE: DUE TO THE SOMETIMES-TEMPORARY NATIVE OF SOME PIEZOMETERS, A LOCKABLE PVC CAP MAY BE UTILIZED IN LIEU OF THE PROTECTIVE COVER.

TYPICAL MONITORING WELL OR
PIEZOMETER CONSTRUCTION

NOT TO SCALE

General Notes

PERMIT DOCUMENT
FOR REVIEW ONLY
NOT RELEASED FOR CONSTRUCTION

No.	Revision/Issue	Date

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY C. TYRUS CLAYTON, JR., PE No. 028909 ON OCTOBER 07, 2009. THIS ELECTRONIC MEDIUM IS NOT CONSIDERED A CERTIFIED DOCUMENT.

21–58.1103(d) BOARD RULES NORTH CAROLINA ADMINISTRATIVE CODE TITLE 21, CHAPTER 58 BOARD OF EXAMINERS FOR ENGINEERS AND SURVEYORS

Signature

Date

Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING
POST OFFICE BOX 578
COATS, NORTH CAROLINA 27521
PHONE 910-897-7070 FAX: 910-897-6787
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

DUNN-ERWIN LANDFILL
CORRECTIVE ACTION PLAN AND
PERMIT MODIFICATION REQUEST

HARNETT COUNTY NORTH CAROLINA

Project No:	03002B	File Name:	03002B MAS
Designed By:	CTC Jr./RS	Drawn By:	SBK
Checked By:	CTC Jr.	Proj. Eng.:	CTC

Sheet Title: PHYTOREMEDIATION DETAILS

Date: 10/05/09

Scale: AS SHOWN

Sheet 5.3 OF 12

P:\03 Harnett County\03002B Corrective Action Plan CAP\Cad\03002B Mas.dwg

APPENDIX C

DELF CORRECTIVE ACTION PLAN COST OPINION

Groundwater Extraction Trench

Item	Unit	Quantity	Unit Cost	Cost
Mobilization / Demobilization	LS	1	$21,582	$21,582
57 Drainage Stone for collection trench	TON	2600	$85	$221,000
Groundwater Extraction Pump Station	LS	1	$48,000	$48,000
Groundwater Extraction Header 4"	FT	1600	$12	$19,200
Groundwater Extraction PVC Force Main 4"	FT	1500	$12	$18,000
Extraction Wells	EA	16	$1,000	$16,000
Misc. Piping & Valves	LS	1	$10,000	$10,000
Electrical Supply to Wetwell	LS	1	$3,000	$3,000
Asphalt Repair	SY	75	$75	$5,625
Concrete Repair	SY	25	$75	$1,875
Fencing Repair	LS	1	$2,000	$2,000
Erosion Control - Seeding & Mulching	LS	1	$5,000	$5,000
Misc. Site Work	LS	1	$10,000	$10,000

Leachate Management System

Item	Unit	Quantity	Unit Cost	Cost
Mobilization / Demobilization	LS	1	$19,948	$19,948
Gravel Bed & Drain System	LS	1	$20,000	$20,000
Electrical Service to Pumps & Pump Station	LS	1	$6,000	$6,000
4" PVC Leachate Transfer Line	FT	500	$14	$7,000
4hp Grinder Pump Station w/Controls & Generator	LS	1	$115,000	$115,000
4" PVC Force Main to NC 55	FT	9570	$14	$133,980
6" HDPE Stream Crossing	FT	300	$125	$37,500
Air Release Valve & Manhole	EA	1	$4,500	$4,500
Erosion Control - Seeding & Mulching	LS	1	$1,500	$1,500
Misc. Site Work	LS	1	$7,000	$7,000

Phytoremediation (Stage 1 & Stage 2)

Item	Unit	Quantity	Unit Cost	Cost
Mobilization / Demobilization	LS	1	$72,411	$72,411
Grading - 129,000 CY CUT	CY	129000	$8	$1,032,000
Site Preparation - Tilling / Amendments	AC	8.5	$2,100	$17,850
Hybrid Poplar Plantings	EA	5500	$12	$66,000
Irrigation System	LS	1	$25,000	$25,000
Erosion Control - Seeding & Mulching	AC	10	$1,500	$15,000

Monitoring Point Installation

Item	Unit	Quantity	Unit Cost	Cost
Monitoring Wells with Protective Case	EA	11	$850	$9,350
Piezometer	EA	11	$650	$7,150
Subtotal				**$1,978,471**
Permitting, Surveying, Administration, Contingency, Easements and Engineering (30%)				**$593,541**
TOTAL				**$2,572,012**

Environmental / CAP Reporting

Bi-Annual Sampling of MWs	EA	2	$16,000	$32,000
Bi-Annual Sampling Report	EA	2	$15,000	$30,000
			ANNUAL TOTAL	$62,000
			30 YR MONITORING COST (2009 Dollars)	$1,860,000

Operations and Maintenance

Item	Unit	Quantity	Unit Cost	Cost
Monthly Groundwater Extraction System O&M	Month	12	$1,000	$12,000
Monthly Leachate Management System O&M	Month	12	$800	$9,600
Monthly Phytoremediation System O&M	Month	12	$1,000	$12,000
Pump/Piping Replacement	LS	1	$2,000	$5,000
Tree Replacement	LS	1	$1,000	$1,000
Annual Electrical Costs	Month	12	$5,000	$60,000
			ANNUAL TOTAL	$99,600
			10 YR O&M COST (2009 Dollars)	$996,000

APPENDIX D

North Carolina Department of Environment and Natural Resources
Division of Waste Management
Solid Waste Section

North CarolinaSolid Waste Groundwater Corrective Action Permit Modification Application

Pursuant to 15A NCAC 13B .1636, "Within 14 days of selecting a remedy, the permittee shall submit an application to modify the permit describing the selected remedy to the Division for evaluation and approval." The application shall include the demonstrations necessary to comply with the financial assurance requirements set forth in Paragraph (d) of Rule .1628.

Please attach the following: (1) a copy of the minutes from the public meeting discussing the Assessment of Corrective Measures, (2) a signed resolution/proclamation/document adopting the remedy, (3) a site map designating locations of groundwater monitoring wells and surface water monitoring locations that will be impacted by the remedy, (4) any draft conceptual schematics/figures/plans relating to the selected remedy, (5) a list of any required registrations, permits, and approvals, (6) a copy of most recent permit issued by the Solid Waste Section, and (7) an amendment to the Financial Assurance Mechanism, including a break-down of the cost estimates for closure, post-closure and corrective action.

Send the application and attachments to NCDENR-DWM, Solid Waste Section, Compliance Unit, 1646 Mail Service Center, Raleigh, NC 27699-1646. This application and any documents attached to this application are "Public Records" as defined in NC General Statute 132-1. As such, these documents are available for inspection and examination by any person upon request (NC General Statute 132-6).

Please type or print all information legibly.

I. Site Identification

Permit Number: 43-02

Solid Waste Rule Designation (.0500 or .1600): .0500

Facility Name: Dunn-Erwin C&D Landfill

Facility Physical Address: 449 Daniels Road

City: Dunn

Zip: 28334

County: Harnett

Waste Type: Construction and Demolition (C&D)

II. Owner and Operator Information

☑ Check box, if owner and operator are the same.

Owner

Name: Harnett County

Address: PO Box 940 Lillington, NC 27546

Phone Number: 910-893-7536

Operator

Name:

Address:

Phone Number:

III. Groundwater Corrective Action

Selected remedy (include addition lines if needed):

(1) Groundwater Extraction Trench (Pump & Treat)

(2) Phytoremediation

(3)

Contingency Plan A: Pump & Treat (for (2) Phytoremediation)

Contingency Plan B:

IV. Financial Assurance

Financial Assurarance Mechanism: Government Financial Test

Total Cost Estimate for 30 Years (based upon ACM): $ 5,428,012.00

V. Project Schedule (upon Division approval)

Approximate Date of Remedy Construction Completion (if applicable): Approximately 4 years from start.

Approximate Date of Implementation of Remedy: 10/01/10 or approximately one year from approval.

Approximate Date of Baseline Sampling Completion (if applicable): 04/15/10

Approximate Date of First Remedy Performance and Effectiveness Report Submittal: 05/01/11

VI. Environmental Consultant

Consulting Company: C.T. Clayton, Sr., P.E., Inc.

Address: PO Box 578 Coats, NC 27521

Phone Number: 910-897-7070

VII. Signatures

To the best of my knowledge, the information reported and statements made in this North Carolina Solid Waste Groundwater Corrective Action Permit Modification Application are true and correct. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of fine and imprisonment.

If Owner and Operator are the same, please sign for Owner and type or write SAME for Operator.

Owner

Owner Name (Printed or Typed): JERRY T. BLANCHARD

Owner Signature: Jerry T. Blanchard Date: 10/6/09

Operator

Operator Name (Printed or Typed): Same as above

Operator Signature: Date: 10/6/09

NC Professional Geologist or NC Professional Engineer

Name (Printed or Typed): C. Tyrus Clayton, Jr.

Signature: C Tyrus Clayton Jr. Date: 10/6/09

AffixNCProfessional Geologist/Engineer Seal:

NORTH CAROLINA PROFESSIONAL SEAL 028903 ENGINEER C. TYRUS CLAYTON, JR.

APPENDIX E

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

October 1, 2009 **PN:** 3002B

Zinith Barbee
Project Manager
NC Department of Environment and Natural Resources
Division of Waste Management – Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

RE: Follow-up to Letter Dated September 29, 2009 from Mr. Zinith Barbee
Dunn-Erwin Landfill Facility
SWS Permit No. 43-02
Harnett County, NC

Mr. Barbee,

As a follow-up to your letters dated July 9, 2009 & September 29, 2009, CTC would like to provide an update on the recent actions performed pertaining to implementation of a Corrective Action Plan (CAP) at the Dunn Erwin C&D Landfill (DELF) that have occurred since our June meeting.

As detailed in our July 26, 2009 letter, a pilot study was performed to ascertain if the Enhanced Bioremediation (EB) technology proposed in our original CAP submittal would work in a slightly acidic aquifer as present at the DELF site. Soil and groundwater samples were sent to Microbial Insights, Inc. to perform pH testing, soil oil retention testing, and Dehalococcoides spp. biomass testing. The tests results were received on September 22, 2009 and CTC has been in the process of reviewing the findings. The County has also contracted the services of Wetland Solutions to provide wetland delineation of the areas downgradient of the DELF. This portion of work is currently ongoing.

The pH testing of the groundwater was observed to be between 4.55 and 4.91. According to the Microbial Insights, Inc. report, the pH for optimal growth of Dehalococcoides ethenogenes strain 195, the only known bacterium capable of complete reductive dechlorination of PCE to ethane, is between 6.8 and 7.5. This was verified when the Dehalococcoides spp. biomass results came in extremely low. It has therefore been determined that the EB technology will not work at the DELF site. The County must now proceed with another groundwater remediation technology. Testing results are attached.

CTC is currently redesigning the CAP to meet your October 7, 2009 deadline with a Groundwater Extraction (GE) trench to perform as the source treatment and to prevent future releases downgradient. The existing plume will continue to be treated by the proposed use of Phytoremediation. CTC will also be addressing the items noted in your June 11, 2009 review letter in the CAP resubmittal.

In conclusion, CTC and the County are diligently revising the DELF Correction Action Plan and addressing your comments. Hopefully, the response and above timeline will demonstrate that both CTC and the County has put forth much effort in attempting to stay in compliance.

P.O. Box 578
46 W. Washington St.
Coats, NC 27521
Phone: 910-897-7070
Fax: 910-897-6767

Please feel free to contact me to discuss this issue further.

Sincerely,

C. Tyrus Clayton Jr., P.E.

/attachment

cc: Ryan Sadler, CTC
C. T. Clayton, Sr., PE, CTC
Ed Mussler, SWS
Mark Poindexter, SWS
Shawn McKee, SWS
Geof Little, SWS
Jerry Blanchard, General Services Manager, Harnett County
CJ Poran, PE, ENSOL

microbialinsights

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
Web: www.microbe.com

SITE LOGIC Report

Stable Isotope Probing (SIP) Study

Contact: Ryan Sadler
Address: C.T. Clayton, SR. PE. Inc – Coats, NC
P.O. Box 578
Coats, NC 27521

Phone: 910.897.7070

Email: ryan@ctclayton.com

MI Identifier: 029GH

Report Date: September 22, 2009

Project: Dum-Erwin CAP

Comments:

NOTICE: This report is intended only for the addressee shown above and may contain confidential or privileged information. If the recipient of this material is not the intended recipient or if you have received this in error, please notify Microbial Insights, Inc. immediately. The data and other information in this report represent only the sample(s) analyzed and are rendered upon condition that it is not to be reproduced without approval from Microbial Insights, Inc. Thank you for your cooperation.

Executive Summary

Bio-Trap® samplers baited with ^{13}C labeled benzene were deployed in Bio-MW7B and Bio-MW8 for 32 days and then recovered for analysis. A complete summary of the results is provided in Table 1.

- Low levels of biomass (~10^4 cells/g) were detected in both samplers.
- There was not a sufficient level of biomass present to analyze for the ^{13}C enriched biomass.
- Quantification of the ^{13}C dissolved inorganic carbon (DIC) did not indicate that mineralization of any of the ^{13}C labeled benzene was occurring.
- Comparison of pre- and post-deployment concentrations of ^{13}C labeled benzene demonstrated a loss of 19% in Bio-MW7B and a 20% loss in Bio-MW8.
- Census analysis for Dehalococcoides spp. (DHC) indicated a low level of the bacteria to be present.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

Overview of Approach

Stable Isotope Probing (SIP)

Stable isotope probing (SIP) is an innovative method to track the environmental fate of a "labeled" contaminant of concern to unambiguously demonstrate biodegradation. Two stable carbon isotopes exist in nature – carbon 12 (^{12}C) which accounts for 99% of carbon and carbon 13 (^{13}C) which is considerably less abundant (~1%). With the SIP method, the Bio-Trap® sampler is baited with a specially synthesized form of the contaminant containing ^{13}C labeled carbon. Since ^{13}C is rare, the labeled compound can be readily differentiated from the contaminants present at the site. Following deployment, the Bio-Trap® is recovered and three approaches are used to conclusively demonstrate biodegradation of the contaminant of concern.

- The loss of the labeled compound provides an estimate of the degradation rate (% loss of ^{13}C).
- Quantification of ^{13}C enriched phospholipid fatty acids (PLFA) indicates incorporation into microbial biomass.
- Quantification of ^{13}C enriched dissolved inorganic carbon (DIC) indicates contaminant mineralization.

Phospholipid Fatty Acids (PLFA): PLFA are a primary component of the membrane of all living cells including bacteria. PLFA decomposes rapidly upon cell death (1, 2), so the total amount of PLFA present in a sample is indicative of the viable biomass. When combined with stable isotope probing (SIP), incorporation of ^{13}C into PLFA is a conclusive indicator of biodegradation.

Some organisms produce "signature" types of PLFA allowing quantification of important microbial functional groups (e.g. iron reducers, sulfate reducers, or fermenters). The relative proportions of the groups of PLFA provide a "fingerprint" of the microbial community. In addition, *Proteobacteria* modify specific PLFA during periods of slow growth or in response to environmental stress providing an index of their health and metabolic activity.

CENSUS: CENSUS is based on a technique called quantitative polymerase chain reaction (qPCR) whereby many copies of a specific gene are generated. As each gene copy is made, a fluorescent marker is released, measured, and used to quantify the number of target genes present in a sample. The choice of target gene depends on the contaminant of concern. For example, at MTBE impacted sites, CENSUS quantification of *Methylibium petroleiphilum* PM1 (qPM1), a known MTBE-utilizing bacterium, would be used as an index of the MTBE-degrading community.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

microbialinsights

Results

Table 1. Summary of the results obtained from the Bio-Trap® Units. Interpretation guidelines and definitions are found later in the document.

Sample Name	Bio-MW7B	Bio-MW8
^{13}C Contaminant Loss		
Benzene Pre-deployment (mg/bd)	1.29	1.29
Benzene Post-deployment (mg/bd)	1.04	1.04
% Loss	19%	20%
First Order Rate Constant (1/days)	0.007	0.007
Half Life (days)	103	102
Biomass		
Total Biomass (Cells/bd)	7.37E+04	3.85E+04
^{13}C Mineralization		
DIC Del (‰)	-6	-12
% 13C	1.10	1.09
Community Structure (% total PLFA)		
Firmicutes (TerBrSats)	0.0	0.0
Proteobacteria (Monos)	92.6	85.8
Anaerobic metal reducers (BrMonos)	1.1	0.0
Actinomycetes (MidBrSats)	0.0	0.0
General (Nsats)	6.4	14.2
Eukaryotes (Polyenoics)	0.0	0.0
Physiological Status (Proteobacteria only)		
Slowed Growth	0.36	0.82
Decreased Permeability	0.06	0.12
Census		
Dehalococcoides spp. (DHC) (cells/bead)	1.67E+01 (J)	8.40E+00 (J)

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

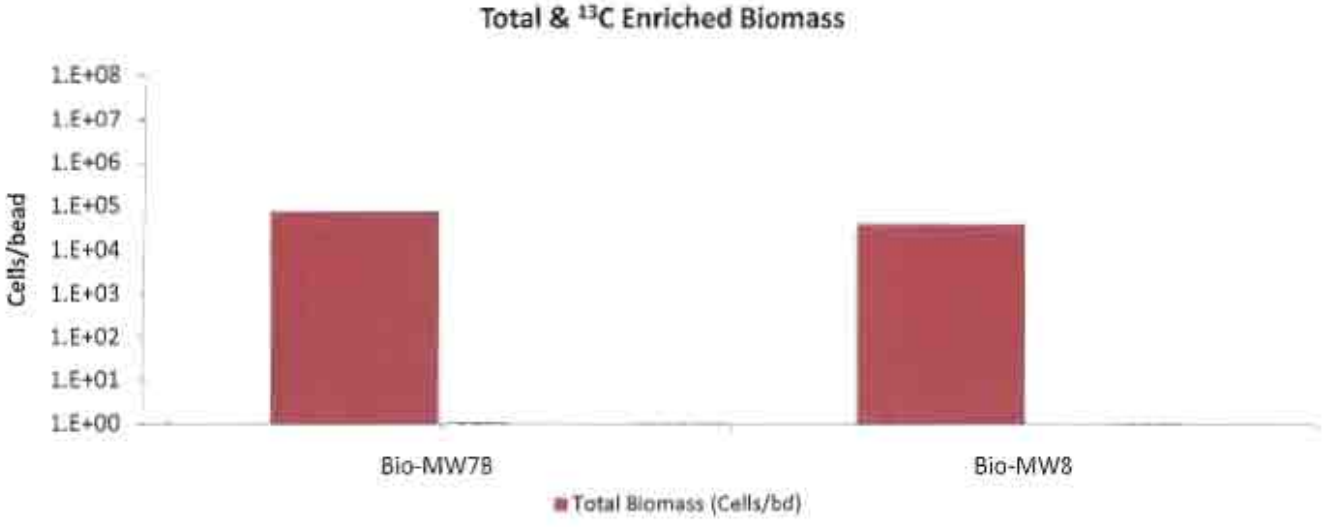


Figure 1. Biomass content is presented as a cell equivalent based on the total amount of phospholipid fatty acids (PLFA) extracted from a given sample. Total biomass is calculated based upon PLFA attributed to bacterial and eukaryotic biomass (associated with higher organisms).

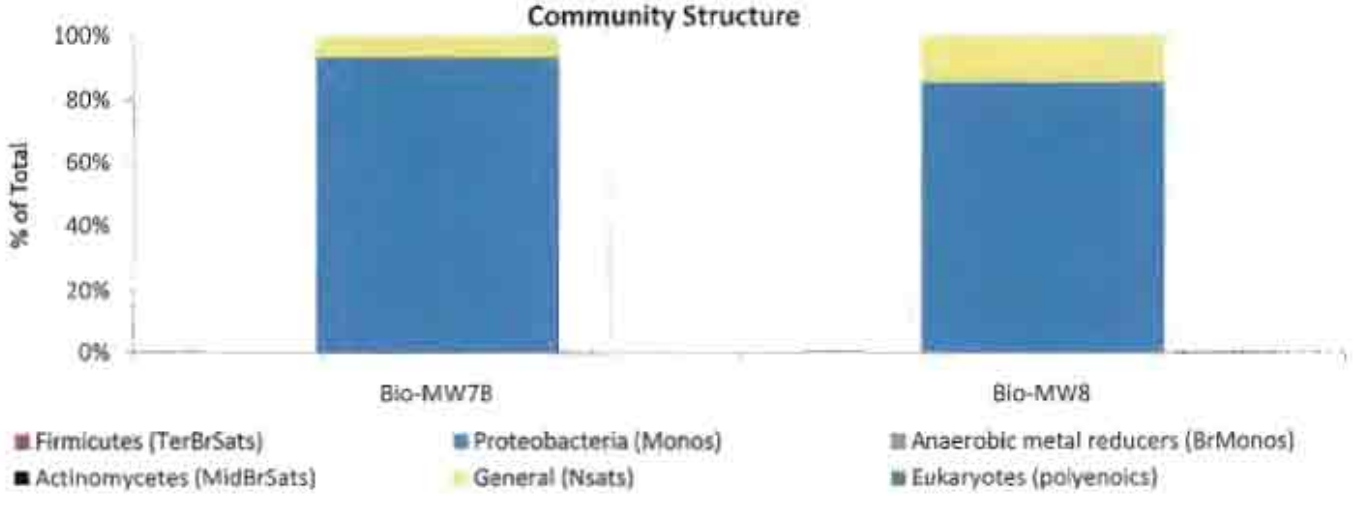


Figure 2. Relative percentages of total PLFA structural groups in the samples analyzed. Structural groups are assigned according to PLFA chemical structure, which is related to fatty acid biosynthesis. See the table in the interpretation section for detailed descriptions of the structural groups.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

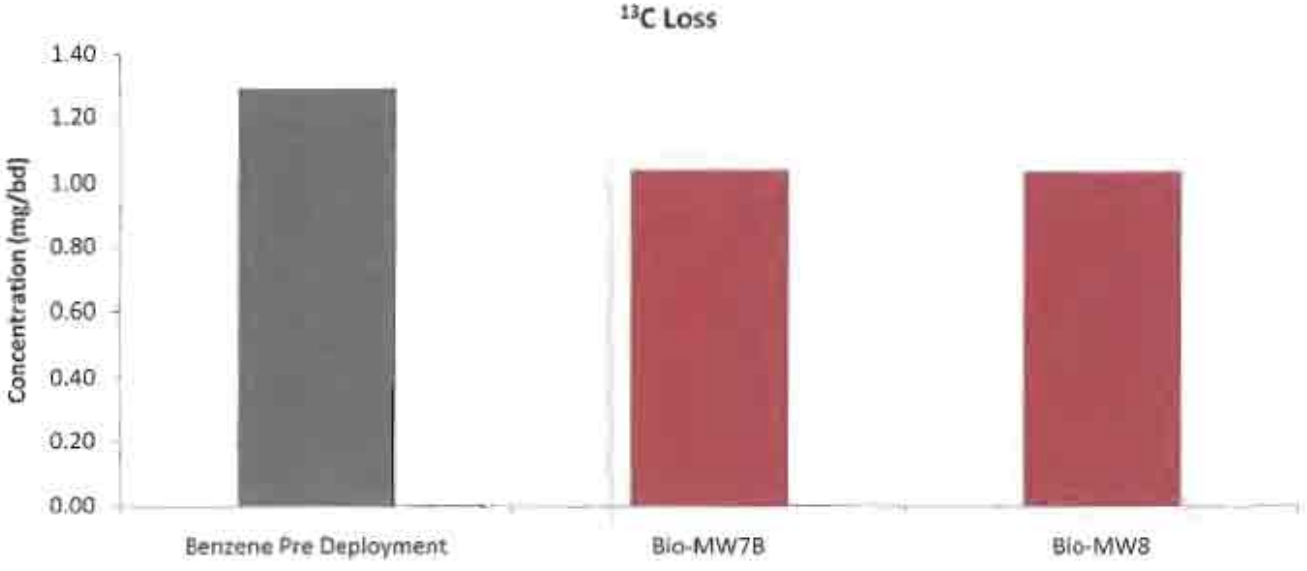


Figure 3. Comparison of Pre-deployment concentrations loaded on Bio-Sep beads to the concentrations detected after incubation.

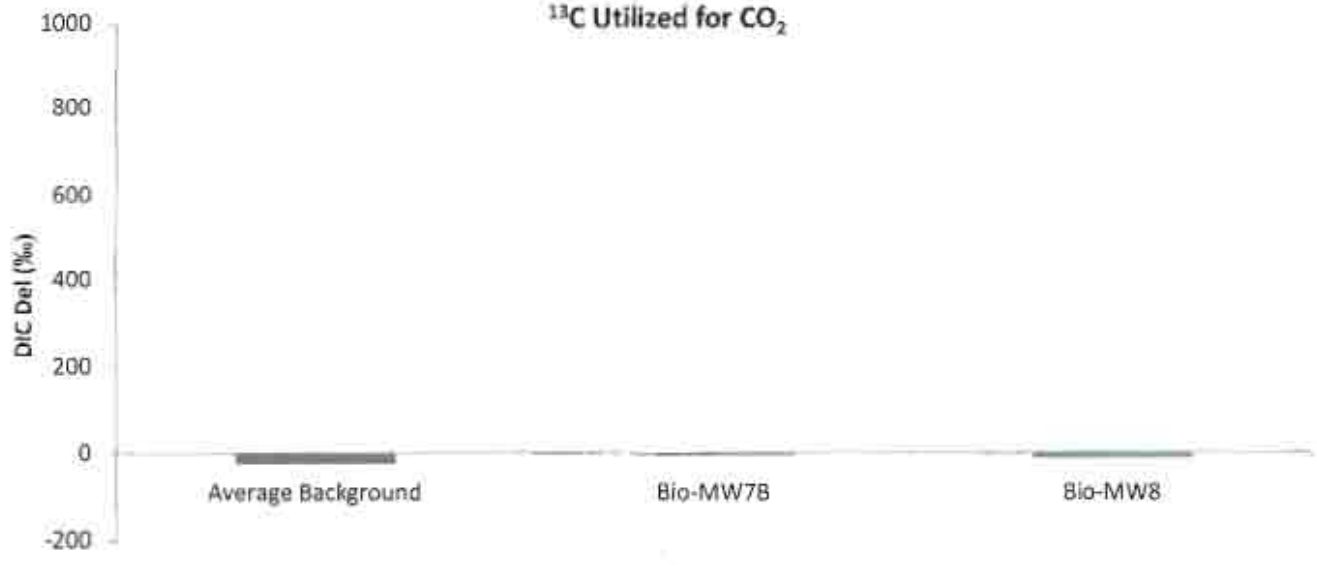


Figure 4. Comparison of the Del value obtained from DIC from each Bio-Trap® unit to the average background Del observed in samples not exposed to ^{13}C enriched compounds.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

Interpretation

Interpretation of the results of the SIP Bio-Trap® study must be performed with due consideration of site conditions, site activities, and the desired treatment mechanism. The following discussion describes interpretation of results in general terms and is meant to serve as a guide.

Contaminant Concentration: Bio-Traps® are baited with a ^{13}C labeled contaminant of concern and a pre-deployment concentration is determined prior to shipping. Following deployment, Bio-Traps® are recovered for analysis including measurement of the concentration of the ^{13}C labeled contaminant remaining. Pre- and post-deployment concentrations are used to calculate percent loss, to estimate the first order degradation rate constant (k), and to estimate the contaminant half life (Results Summary Table). For a description of how the first order rate constant is calculated, please see the glossary at the end of the report. The first order rate constant can be used to compare different wells or treatments depending on the design of the study. A higher value is indicative of a greater biodegradation rate.

Alternatively, the contaminant half life can be used to make the same types of comparisons between wells and treatments. By definition, half life is the amount of time required for the contaminant concentration to equal half of the initial concentration (see glossary for calculation).

Biomass Concentrations: PLFA analysis is one of the most reliable and accurate methods available for the determination of viable (live) biomass. Phospholipids break down rapidly upon cell death, so biomass calculations based on PLFA content do not include "fossil" lipids from dead cells. Total biomass (cells/bead) is calculated from total PLFA using a conversion factor of 20,000 cells/pmole of PLFA. When making comparisons between wells, treatments, or over time, differences of one order of magnitude or more are considered significant.

Total Biomass		
Low	Moderate	High
10^3 to 10^4 cells	10^5 to 10^6 cells	10^7 to 10^8 cells

For SIP studies, the ^{13}C enriched PLFA is also determined to conclusively demonstrate contaminant biodegradation and quantify incorporation into biomass as a result of the ^{13}C being used for cellular growth. The % ^{13}C incorporation (^{13}C enriched biomass/total biomass) is also provided in the data summary table, but the value must be interpreted carefully especially when comparing wells or treatments. Typically, biodegradation of a contaminant of concern is performed by a small subset of the total microbial community. For Bio-Traps® with large total biomass, the % ^{13}C incorporation value could be low despite significant ^{13}C labeled biomass and loss of the compound. The % ^{13}C incorporation should be viewed in light of total biomass, percent loss, and dissolved inorganic carbon (DIC) results.

^{13}C enrichment data is often reported as a del value. The del value is the difference between the isotopic ratio ($^{13}C/^{12}C$) of the sample (R_s) and a standard (R_{std}) normalized to the isotopic ratio of the standard (R_{std}) and multiplied by 1,000 (units are parts per thousand, denoted ‰).

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

R_{std} is the naturally occurring isotopic ratio and is approximately 0.011180 (roughly 1% of naturally occurring carbon is ^{13}C). The isotopic ratio, R_x, of PLFA is typically less than the R_{std} under natural conditions, resulting in a del value between -20 and -30‰. For a SIP Bio-Trap® study, biodegradation and incorporation of the ^{13}C labeled compound into PLFA results in a larger $^{13}C/^{12}C$ ratio (R_x) and thus del values greater than under natural conditions. Typical PLFA del values are provided below.

PLFA Del (‰)		
Low	Moderate	High
0 to 100	100 to 1,000	>1,000

Dissolved Inorganic Carbon (DIC): Often, bacteria can utilize the ^{13}C labeled compound as both a carbon and energy source. The ^{13}C portion used as a carbon source for growth can be incorporated into PLFA as discussed above, while the ^{13}C used for energy is oxidized to $^{13}CO_2$ (mineralized).

^{13}C enriched CO_2 data is often reported as a del value as described above for PLFA. Under natural conditions, the R_x of CO_2 is approximately the same as R_{std} (0.01118 or about 1.1% ^{13}C). For an SIP Bio-Trap® study, mineralization of the ^{13}C labeled contaminant of concern would lead to a greater value of R_x (increased $^{13}CO_2$ production) and thus a positive del value. As with PLFA, del values between 0 and 100‰ are considered low, values between 100 and 1,000‰ are considered moderate, and values greater than 1,000‰ are considered high. Thus DIC %^{13}C are considered low if the value is less than 1.23%, moderate if between 1.23 and 2.24%, and high if greater than 2.24%.

Dissolved Inorganic Carbon (DIC) Del and % ^{13}C		
Low	Moderate	High
0 to 100	100 to 1,000	>1,000
1.11 to 1.23%	1.23 to 2.24 %	>2.24 %

CENSUS: CENSUS analysis provides quantification of an organism or functional genes responsible for biodegradation of the contaminant of interest. CENSUS results can be compared between wells, between treatments, or over time to evaluate degrader populations, depending upon the design of the study. CENSUS analysis is often included in SIP studies to provide an additional line of evidence supporting biodegradation as a treatment mechanism and can be used for long-term monitoring of a degrader population following completion of the SIP study.

Community Structure (% total PLFA): Community structure data is presented as a percentage of PLFA structural groups normalized to the total PLFA biomass. The relative proportions of the PLFA structural groups provide a "fingerprint" of the types of microbial groups (e.g. anaerobes, sulfate reducers, etc.) present and therefore offer insight into the dominant metabolic processes occurring at the sample location. Thorough interpretation of the PLFA structural groups depends in part on an understanding of site conditions and the desired microbial biodegradation pathways. For example, an increase in mid chain branched saturated PLFA (MidBrSats), indicative of sulfate reducing bacteria (SRB) and *Actinomycetes*, may be desirable at a site where anaerobic BTEX biodegradation is the treatment mechanism, but would not be desirable for a corrective action promoting aerobic BTEX or MTBE biodegradation. The following table provides a brief summary of each PLFA structural group and its potential relevance to bioremediation.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

Table 3. Description of PLFA structural groups.

PLFA Structural Group	General classification	Potential Relevance to Bioremediation Studies
Monoenoic (Monos)	Abundant in Proteobacteria (Gram negative bacteria), typically fast growing, utilize many carbon sources, and adapt quickly to a variety of environments.	Proteobacteria is one of the largest groups of bacteria and represents a wide variety of both aerobes and anaerobes. The majority of Hydrocarbon utilizing bacteria fall within the Proteobacteria
Terminally Branched Saturated (TerBrSats)	Characteristic of Firmicutes (Low G+C Gram-positive bacteria), and also found in Bacteriodes, and some Gram-negative bacteria (especially anaerobes).	Firmicutes are indicative of presence of anaerobic fermenting bacteria (mainly *Clostridia/Bacteriodes* like), which produce the H_2 necessary for reductive dechlorination
Branched Monoenoic (BrMonos)	Found in the cell membranes of micro-aerophiles and anaerobes, such as sulfate- or iron-reducing bacteria	In contaminated environments high proportions are often associated with anaerobic sulfate and iron reducing bacteria
Mid-Chain Branched Saturated (MidBrSats)	Common in sulfate reducing bacteria and also Actinobacteria (High G+C Gram-positive bacteria).	In contaminated environments high proportions are often associated with anaerobic sulfate and iron reducing bacteria
Normal Saturated (Nsats)	Found in all organisms.	High proportions often indicate less diverse populations.
Polyenoic	Found in eukaryotes such as fungi, protozoa, algae, higher plants, and animals.	Eukaryotic scavengers will often rise up and prey on contaminant utilizing bacteria.

Physiological Status (*Proteobacteria*): Some *Proteobacteria* modify specific PLFA as a strategy to adapt to stressful environmental conditions (3, 4). For example, *cis* monounsaturated fatty acids may be modified to cyclopropyl fatty acids during periods of slowed growth or modified to *trans* monounsaturated fatty acids to decrease membrane permeability in response to environmental stress. The ratio of product to substrate fatty acid thus provides an index of their health and metabolic activity. In general, status ratios greater than 0.25 indicate a response to unfavorable environmental conditions.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

Glossary

Del: A Del value is the difference between the isotopic ratio ($^{13}C/^{12}C$) of the sample (R_s) and a standard (R_{std}) normalized to the isotopic ratio of the standard (R_{std}) and multiplied by 1,000 (units are parts per thousand denoted ‰).

$$Del = (R_s - R_{std})/R_{std} \times 1000$$

First Order Rate Constant: The first order rate is expression is $C=C_0e^{-kt}$ where C is the post-deployment concentration (mg/bead), C_0 is the pre-deployment concentration (mg/bead), k is the first order rate constant (1/days), and t is the deployment time (days). Upon rearrangement and using pre-and post-deployment concentrations, $k=-\ln(C/C_0)/t$.

Half Life: Half life is the amount of time required for the contaminant concentration to equal half of the initial concentration and is expressed as $C=C_0/2$. Substituting into the rate expression and solving for half life ($t_{1/2}$), $t_{1/2} = \ln(0.5)/-k$. As opposed to the rate constant, a higher half life ($t_{1/2}$) indicates a lower degradation rate.

References

1. White, D.C., W.M. Davis, J.S. Nickels, J.D. King, and R.J. Bobbie. 1979. Determination of the sedimentary microbial biomass by extractable lipid phosphate. Oecologia 40:51-62.
2. White, D.C. and D.B. Ringelberg. 1995. Utility of signature lipid biomarker analysis in determining in situ viable biomass. In P.S. Amy and D.L. Halderman (eds.) The microbiology of the terrestrial surface. CRC Press, Boca Raton.
3. Guckert, J.B., M.A. Hood, and D.C. White. 1986. Phospholipid ester-linked fatty acid profile changes during nutrient deprivation of *Vibrio chloerae*: increases in the trans/cis ratio and proportions of cyclopropyl fatty acids. Applied and Environmental Microbiology. 52:794-801.
4. Tsitko, I.V., G. M. Zaitsev, A. G. Lobanok, and M.S. Salkinoja-Salonen. 1999. Effect of aromatic compounds on cellular fatty acid composition of *Rhodococcus opacus*. Applied and Environmental Microbiology. 65:853-855.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
www.microbe.com

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8133
Web: www.microbe.com

SITE LOGIC Report

Acidity and Oil Retention Report

Contact:	Ryan Sadler	**Phone:**	910.897.7070
Address:	C.T. Clayton PO Box 578 Coats, NC 27521	**Email:**	ryan@ctclayton.com

MI Identifier:	**011GG**	**Report Date:**	7/20/2009

Project: DELF CAP 030028

Comments:

NOTICE: This report is intended only for the addressee shown above and may contain confidential or privileged information. If the recipient of this material is not the intended recipient or if you have received this in error, please notify Microbial Insights, Inc. immediately. The data and other information in this report represent only the sample(s) analyzed and are rendered upon condition that it is not to be reproduced without approval from Microbial Insights, Inc. Thank you for your cooperation.

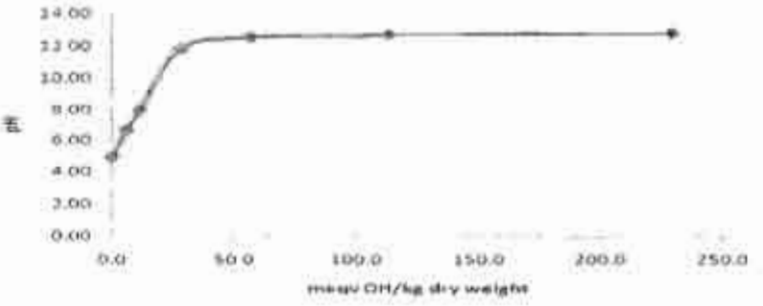
Role of Subsurface pH

Every organism has a pH range within which growth is possible and typically a well-defined optimum pH for maximum growth rates and activity. Although organisms that thrive in low pH (acidophiles) and high pH (alkaliphiles) environments have been isolated, most microorganisms are classified as neutrophiles with pH optimums between pH 6 and 8. Many important bacterial groups responsible for biodegradation of chlorinated solvents belong to this neutrophile category. For example, the pH for optimal growth of *Dehalococcoides ethenogenes* strain 195, the only known bacterium capable of complete reductive dechlorination of PCE to ethene, is between pH 6.8 and 7.5 (Maymo-Gatell, 1997). Likewise, optimal pH ranges for several *Desulfitobacterium* species capable of reductive dechlorination of chlorinated ethenes and ethanes are near neutral (Gerritse et al, 1999; Suyama et al, 2001). Thus maintenance of a circum neutral pH subsurface environment can be an important factor in promoting reductive dechlorination.

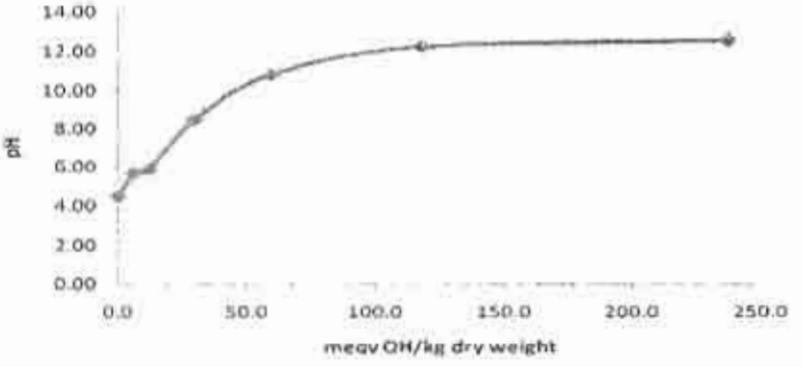
2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8113
E-Mail: dhyde@microbes.com
Web: www.microbes.com

Results—pH Buffering and Acidity Testing

pH 1-1.2	
meqv/kg	pH
0.0	4.91
5.7	6.65
11.4	8.03
28.4	11.88
57.1	12.57
113.2	12.73
228.8	12.85



pH 2-1.2	
meqv/kg	pH
0.0	4.55
5.9	5.75
11.8	5.93
29.5	8.55
59.6	10.89
118.1	12.28
237.2	12.63



2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8131
E-Mail: dogles@microbe.com
Web: www.microbe.com

microbialinsights

Results—pH Buffering and Acidity Testing for Water

Groundwater Acidity Results	meq/L
pH 1-3.4	Not Detected
pH 2-3.4	Not Detected

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8113
E-Mail: dingles@microbe.com
Web: www.microbe.com

microbialinsights

Edible Oil Retention Study

Chlorinated solvents including tetrachloroethene (PCE) and trichloroethene (TCE) have been widely used in a variety of industrial/commercial applications and are now prominent groundwater contaminants. Under anaerobic conditions, PCE and TCE are susceptible to biological reductive dechlorination through the daughter products cis-dichloroethene and vinyl chloride to ethene, an innocuous end product. While monitored natural attenuation (MNA) can be an effective remedial approach, reductive dechlorination can be hindered by a lack of electron donors under MNA conditions. Therefore, biostimulation by subsurface injection of a suitable electron donor such as an edible oil emulsion is often performed to promote biological reductive dechlorination and enhance anaerobic bioremediation.

Although a wide variety of site-specific variables including contaminant area, saturated zone thickness, and injection point spacing must be considered, one of the most fundamental design parameters when evaluating biostimulation as a treatment technology is the amount of emulsified oil required. Simply put, if the injected mass is too low, the oil will be rapidly depleted and long-term performance will be limited. Conversely, overestimation of the edible oil mass required leads to increased costs with little improvement of overall treatment. Thus, the amount of emulsified oil injected should be optimized to permit effective treatment at the lowest possible capital cost.

The amount of emulsified oil required is a function of the maximum amount of oil retained per mass of aquifer material (OR_M) in addition to the treatment zone dimensions. Typically, the OR_M (g oil/g aquifer material) is estimated based on the sediment type. However, reported OR_M values range from as low as 0.0004 g/g for coarse grained sands and gravel to as high as 0.01 g/g for fine, clayey sands containing kaolinite. Considering that underestimation or overestimation of OR_M can dramatically impact treatment efficiency and capital costs, determining a site-specific OR_M is a cost-effective measure to optimize biostimulation as a remedial action.

How is OR_M Determined?

Two 8 oz. jars containing site aquifer material is submitted to Microbial Insights for an OR_M Column Study. A subsample of the aquifer material is obtained for Total Organic Carbon (TOC) analysis prior to the addition of the chosen edible oil emulsion. The remaining aquifer material is loaded into a laboratory column. Three pore volumes of the chosen oil emulsion are pumped through the column followed by three pore volumes of water at a rate of approximately one pore volume per hour. The treated aquifer material is then removed from the column and homogenized for TOC analysis (in triplicate). The OR_M is calculated based on the change in TOC and the carbon content of the oil. Typical OR_M values range between 0.001 and 0.01 g TOC/g aquifer material.

2340 Stock Creek Blvd.
Rockford, TN 37853-3001
Phone: 865.574.8159
Fax: 865.574.8114
E-Mail: dogles@microbe.com
Web: www.microbe.com

microbialinsights

Results-Oil Retention

ORM 1, 1-2				
Mass of Sediment	130.48	g		
Emulsion Volume	78	mL		
Purge Volume (water chase)	78	mL		
Emulsion TOC	0.09	g/g		
Initial Sediment TOC	0.0003	g/g	Std Dev	0.0000
Final Sediment TOC	0.0004	g/g	Std Dev	0.0005
Maximum Oil Retention (OR_M)	**0.0001**	**g/g**		

ORM 2-1,2			
Mass of Sediment	118.76	g	
Emulsion Volume	81	mL	
Purge Volume (water chase)	81	mL	
Emulsion TOC	0.09	g/g	
Initial Sediment TOC	0.0006	g/g	Std Dev
Final Sediment TOC	0.0020	g/g	Std Dev
Maximum Oil Retention (OR_M)	**0.0019**	**g/g**	

2340 Stock Creek Blvd
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8153
E-Mail: dogles@microbe.com
Web: www.microbe.com

Glossary of Terms

Biostimulation: The subsurface injection of an amendment (often an electron donor) to stimulate bioremediation.

OR_M: Maximum oil retention (g oil/g aquifer material)

TOC: Total Organic Carbon

References Cited

Gerritse et al. 1999. Influence of different electron donors and acceptors on dehalorespiration of tetrachloroethene by *Desulfitobacterium frappieri* TCE1. Appl. Environ. Microbiol. 65(12): 5212-5221.

Maymo-Gatell, X. 1997. *Dehalococcoides ethenogenes* Strain 195, A novel eubacterium that reductively dechlorinates tetrachloroethene (PCE) to ethene. Report No. AL/EQ-TR-1997-0029.

Suyama et al. 2001. Isolation and characterization of *Desulfitobacterium* sp. strain Y51 capable of efficient dehalogenation of tetrachlorethene and polychloroethanes. Biosci. Biotechnol. Biochem. 65(7): 1474-1481.

2340 Stock Creek Blvd.
Rockford, TN 37853-3044
Phone: 865.573.8188
Fax: 865.573.8111
E-Mail: doplex@microbe.com
Web: www.microbe.com

microbialinsights

2340 Stock Creek Blvd.
Rockford TN 37853-3044
Phone: (865) 573-8188
Fax: (865) 573-6133
Email: info@microbe.com

Client: Ryan Sadler
C.T. Clayton, SR. PE. Inc.
PO Box 578
Coats, NC 27521

Phone: 910.897.7070

Fax: 910.897.6767

Identifier: 029GH **Date Rec:** 08/13/2009 **Report Date:** 08/18/2009

Client Project #: 03002B **Client Project Name:** Dum- Erwin CAP

Purchase Order #:

Analysis Requested: CENSUS, PLFA, PLFA+SIP

Comments:

Reviewed By:

Lora M Cole

NOTICE: This report is intended only for the addressee shown above and may contain confidential or privileged information. If the recipient of this material is not the intended recipient or if you have received this in error, please notify Microbial Insights, Inc. immediately. The data and other information in this report represent only the sample(s) analyzed and are rendered upon condition that it is not to be reproduced without approval from Microbial Insights, Inc. Thank you for your cooperation.

MICROBIAL INSIGHTS, INC.

2340 Stock Creek Blvd. Rockford, TN 37853-3044
Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **C.T. Clayton, SR. PE. Inc.**
Project: Dum- Erwin CAP

MI Project Number: **029GH**
Date Received: 08/13/2009

Sample Information

Client Sample ID:		**Bio - MW7B**	**Bio - Mw8**
Sample Date:		08/11/2009	08/11/2009
Units:		cells/bead	cells/bead
Analyst:		ab	ab
Dechlorinating Bacteria			
Dehalococcoides spp.	DHC	**1.67E+01 (J)**	**8.40E+00 (J)**

Legend:
NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

APPENDIX F

Clayton, Sr., P.E., Inc.
C.T. Clayton, Sr., Professional Engineer

MEETING MINUTES

HARNETT COUNTY
Assessment of Corrective Measures

PUBLIC MEETING
March 31, 2008 – 9:00 AM – Public Library – Lillington, NC

CTC Inc. PN# 03002

Attendees:

Name	Company	Phone	Fax
Jerry Blanchard	Harnett County	(910) 893-7536	(910) 814-3967
C. Tyrus Clayton, Jr., P. E.	C. T. Clayton, Sr., P. E., Inc.	(910) 897-7070	(910) 897-6767
Ryan Sadler	C. T. Clayton, Sr., P. E., Inc.	(910) 897-7070	(910) 897-6767

Distribution:

All Attending
C. T. Clayton, Sr., P. E. — C. T. Clayton, Sr., P. E., Inc.
Zenith Barbee — NCDENR
Jaclynne Drummond — NCDENR

Minutes:

1. Mr. Clayton waited until approximately 9:20AM to start the Power Point presentation to await any late arrivals. Although no members of the public showed up to attend the meeting, Mr. Clayton went forward with the presentation.
2. Mr. Clayton went through each slide of the presentation (attached).
3. Mr. Clayton opened the floor for questions and comment. None were received.
4. The meeting adjourned at approximately 10:00AM.

April 1, 2008

Ryan Sadler
Project Manager

This report is the opinion of a C. T. Clayton, Sr., P.E., Inc. representative. Unless written notice disputing the information contained in this report is received within seven (7) days of the report date, it shall be assumed that all parties are in agreement that this information is true and correct.

3100 NC 27 East
Coats, NC 27521
Phone: 910-897-7070
Fax: 910-897-6767

Offices located in Coats and New Bern, North Carolina
www.ctclayton.com

PUBLIC MEETING TO REPORT ON THE ASSESSMENT OF CORRECTIVE MEASURES FOR THE DUNN/ERWIN LANDFILL
PERMIT # 43-02

PRESENTED BY:
C.T. CLAYTON, SR. P.E., INC.

ON BEHALF OF:
HARNETT COUNTY, N.C.

9:00AM, MARCH 31, 2008
PUBLIC LIBRARY, LILLINGTON, N.C.

Introduction ..... Dunn-Erwin Landfill

The existing Dunn-Erwin landfill has been in the same location since opening in 1978. It is located just north of NCSR 1725 in an area surrounded by farmland, forest, wetlands, and scattered houses and farms. The closest town is Erwin approximately two miles south of the landfill.

Dunn-Erwin Landfill continued

Dunn-Erwin Landfill continued

The facility currently accepts construction and demolition (C&D) materials under Permit 43-02 and is a transfer station for municipal solid waste generated by the county. The former MSW portion of the Dunn-Erwin Landfill was closed December, 1998.

The closed portion of the landfill consists of approximately 21 acres. C&D Waste is currently being placed on the closed area, as per North Carolina Solid Waste Section approval.

Groundwater Sampling

Groundwater sampling has occurred at the Dunn-Erwin Landfill since October 1994. Semi-annual sampling events are coordinated and performed in April and October of each year.

Statistical analysis is then performed to evaluate whether the ground water and surface water monitoring results demonstrate compliance with North Carolina Groundwater Standards.

Groundwater Sampling continued

Once groundwater sampling indicated that contaminants were above groundwater protection standards, an Assessment of Corrective Measures (ACM) was undertaken to include analysis of potential corrective measures. This was completed in August, 2007.

Groundwater Sampling continued

In 2002-2003, prior to the Assessment of Corrective Measures, an extensive study and field investigation was completed in order to better understand the ground water contamination plume at the site. 12 new observation wells were installed in the general area of the ground water contamination plume during the study. The field investigation was followed by additional laboratory testing, and an extensive analysis and computer modeling.

A detailed understanding of the site topography, geological, and geotechnical properties and characteristics as well as the site's hydrogeology including permeability, ground water levels and gradients, flow rates, and vertical flow analysis was presented in an August , 2003 report.

Groundwater Sampling continued

Based on the latest statistical analysis reports and the August 2003 detailed plume investigation report, the following contaminants are present and have been detected in concentrations above the allowable North Carolina Groundwater Standards.

- Methylene Chloride
- Tetrachloroethylene
- Trichloroethylene

Methylene Chloride

Methylene Chloride is a colorless liquid widely used as an industrial solvent and as a paint stripper. It can also be found in certain aerosol and pesticide products and is used in the manufacture of photographic film.

Methylene Chloride that is present in water is broken down slowly by reactions with other chemicals or by bacteria. Over 90% of the methylene chloride in the environment changes to carbon dioxide, which is non-toxic. It is not expected that methylene chloride builds up in plants and animals.

Because methylene chloride evaporates easily, the greatest potential for exposure is breathing in vapors of contaminated air.

Tetrachloroethylene (PCE)

Tetrachloroethylene is liquid widely used for dry cleaning fabrics and textiles and for metal-degreasing operations. It is also used as a building block for the production of other man-made chemicals.

Because PCE evaporates so quickly, the most common exposure comes from breathing it in. It may also enter the body through drinking contaminated water or eating contaminated food.

Trichloroethylene

Trichloroethylene is a nonflammable, colorless liquid. It is mainly used as a solvent to remove grease from metal parts. It is also used as a solvent in other ways and is used to make other chemicals. It can be found in some household products such as typewriter correction fluid, paint removers, adhesives, and spot removers.

Exposure can occur by breathing, swallowing, or by skin contact. It is not likely to build up in the human body.

Risk Assessment

After reviewing the exposure pathways of the three contaminants of concern, the risk to human receptors appears to be low. The low rate of transport and migration of impacted ground water does not pose an immediate threat of migration outside the facility.

Risk Assessment continued

The main pathways for human contact are inhalation and dermal contact. Since the contaminants are confined to the ground-water, under normal landfill operating conditions, the possibility of human contact is very low. All water consumption near the site is from a municipal (treated) water supply.

Risk Assessment continued

The potential risk to the environment is to down gradient flora or fauna, and microorganisms in the impacted aquifer. Flora and fauna on or above ground surface are at minimal risk, because there have been no confirmed detections of the contaminants of concern in the downstream surface water samples.

Assessment of Corrective Measures

Per NCAC 13 B.1635 the County completed an Assessment of Corrective Measures to research all potential technologies/remedies for the ground water contamination at the Dunn/Erwin MSWLF.

Assessment of Corrective Measures continued

Strategies identified during the ACM had to meet the following criteria:

- Be protective to human health & the environment.
- Attain the approved ground water protection standards.
- Control the release, so as to eliminate further releases to extent possible.

Assessment of Corrective Measures continued

The ACM had to address the following:

- Cost of the implementation
- State and local permit requirements
- Performance, reliability, ease of implementation.
- Time required to begin and complete remedy.
- Other environmental or public health requirements that may substantially affect implementation

Initial Screening

Corrective measures technologies that were deemed relevant were researched and screened for feasibility.

The remedial technologies evaluated can be classified into two treatment schemes: in-situ treatment (in place) and ex-situ treatment (out of place).

All methods will require continued sampling to monitor progress.

Initial Screening continued

The following technologies were screened:

- Monitored Natural Attenuation
- Vertical Barrier Walls
- Ground Water Extraction System
- Hydraulic Gradient Controls (Injection)
- Enhanced Bioremediation (HRC®)
- Enhanced Bioremediation (Oxidation)
- Enhanced Bioremediation (Nitrate)
- Phytoremediation

Initial Screening continued

The following technologies were screened:

- Air Sparging
- Hot Water or Steam Flushing/Stripping
- Dual Phase Extraction
- Vacuum Vapor Extraction
- Air Stripping with NPDES Disposal
- Carbon Absorption
- Public Owned WWTP
- UV Oxidation

Initial Screening continued

A total of 16 remedial alternatives were evaluated against 17 performance criteria. The 17 performance criteria were grouped into three performance groups:
Feasibility and Effectiveness, Implementation, and Cost.

After Screening, the following five technologies were retained for further review: Monitored Natural Attenuation, Groundwater Extraction System, Air Sparging, Enhanced Bioremediation, and Phytoremediation.

Existing Controls

The following measures are already in place at the facility:

- Site fenced. Monitoring wells padlocked.
- County ownership down gradient.
- Final cap covering the closed MSW.
- Mechanical gas extraction system.
- Semi-annual ground & surface water quality monitoring per State rules.

Monitored Natural Attenuation

With Monitored Natural Attenuation, natural processes work to clean up or attenuate polluted soils and groundwater.

This can include dilution with clean groundwater, evaporation, and microbial ingestion which changes chemicals to harmless byproducts.

Monitored Natural Attenuation continued

Monitored Natural Attenuation (MNA) is generally not favored by regulatory agencies due to the fact that MNA relies on natural processes which may not completely clean up the pollutants or the clean up process may take longer than deemed acceptable; therefore this technology will not be discussed further.

Pump and Treat

- Extraction system is constructed.
- Groundwater is pumped to the surface.
- Groundwater is hauled to a water treatment plant where it is cleaned and released.

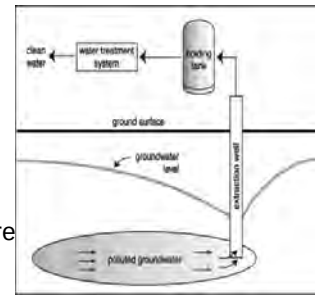


Image Credit: http://www.clu-in.org/download/citizens/pump_and_treat.pdf

Pump and Treat continued

Ease of Implementation

- Extensive construction and fairly substantial equipment costs. (Pumps, Generator, Monitoring Equipment)
- Six months of quantitative monitoring of the system should be adequate to calibrate and detect removal efficiencies.

Pump and Treat continued

Remediation Impacts

Minor impacts may include the generation of contaminated purge water during sampling events and spill containment at the transport/pumping facility.

Pump and Treat continued

Remediation Timeframe

- Will most likely take several years due to low conductivity of the contaminated aquifer at the site.

- Because the plume is not migrating off site at concentrations above NC2L Drinking Water Standards, GE will be used to constrain the plume to its current footprint.

Pump and Treat continued

Institutional Requirements

The SWS will likely require a permit modification for the DELF facility. In addition, GE technologies have the potential to produce liquids that could require and NCDENR-DWQ pump and haul permit in order to transport to the local WWTP.

Pump and Treat continued

Remediation Costs

The costs associated with a GE system would include the System Monitoring Plan, installation of the GE system, sampling and analysis, data evaluation and reporting.

An estimated cost to construct and operate a GE system for five years would be in the range of $682,000.

Soil Vapor Extraction and Air Sparging

- Compressed air is forced into wells
- The air bubbles filter through the plume causing the pollutants to evaporate.
- The soil vapors are collected through additional wells and treated prior to release into the atmosphere

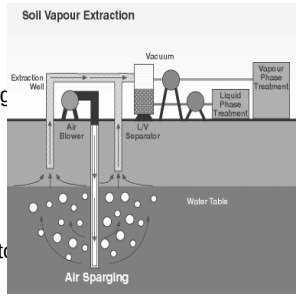


Image Credit: http://www.melltd.com/fs.htm

Air Sparging continued

Ease of Implementation

- Will likely require extensive construction and substantial equipment costs (aerators, pumps, generator, monitoring equipment)
- Six months of quantitative monitoring of the system should be adequate to calibrate and detect removal efficiencies.

Air Sparging continued

Remediation Impacts

Minor impacts may include the generation of contaminated purge water during sampling events and spill containment at the transport/pumping facility.

Air Sparging continued

Remediation Timeframe

- Will most likely take several years due to low conductivity of the contaminated aquifer at the site.
- Because the plume is not migrating off site at concentrations above NC2L Drinking Water Standards, GE will be used to constrain the plume to its current footprint.

Air Sparging continued

Remediation Costs

The costs associated with an AS system would include the System Monitoring Plan, installation of the AS system, sampling and analysis, data evaluation and reporting.

An estimated cost to construct and operate an AS system for five years would be in the range of $587,000.

Phytoremediation

- Specialized trees are planted with deep root systems
- Tree roots uptake water & pollutants
- Pollutants are transformed within the tree and are changed in to gases which are released into the air.

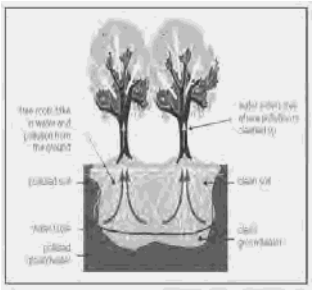


Image Credit: http://oceanworld.tamu.edu/resources/oceanography-book/Images/phytoremediation.gif

Phytoremediation continued

Implementation Requirements

- Hiring of a qualified consultant to provide site applicability analysis, bioavailability and chemical migration analyses, training, and technical consulting.
- Treatability Study
- Pilot Study

Phytoremediation continued

Remediation Impacts

- There are no major remediation related impacts associated with Phytoremediation.

Remediation Timeframe

- Timeframe depends on concentration and length of growing season. Expect to see a decrease in COCs in 5-10 years.

Phytoremediation continued

- Costs associated with Phytoremediation include design costs, permitting costs, and evaluation costs.
- The estimated cost for a full-scale implementation and operation for 5 years is $318,000.

Enhanced Bioremediation

- Chemical injection wells are installed in the vicinity of the plume.
- The chemicals react with pollutants as they flow downgradient.

image credit: http://www.vironex.com/pages/equip_remediation.html

Enhanced Bioremediation continued

Implementation Requirements

- Lab testing / treatability study
- Pilot Study
- Installation of injection wells
- Injection of EB compound
- Monitoring / Re-injections as required

Enhanced Bioremediation continued

Remediation Impacts

- Minor to include the generation of contaminated purge water during sampling.

Remediation Timeframe

- An observable decrease in COCs is estimated to be 12 to 18 months.

Enhanced Bioremediation continued

Remediation Costs

Costs associated with EB include design costs, permitting costs, capital costs to purchase the EB compound, construction and installation cost, and evaluation/monitoring costs.

An estimated cost to construct and operate the system for five years is $490,000.

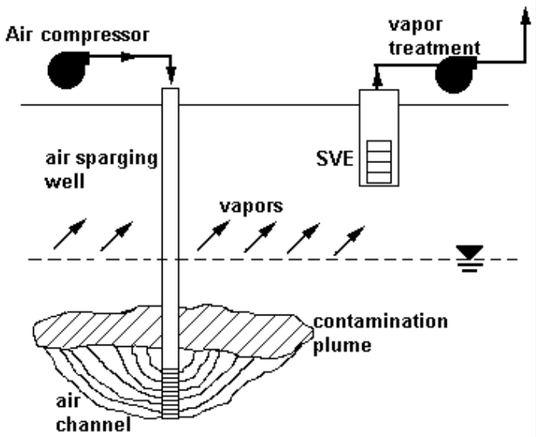
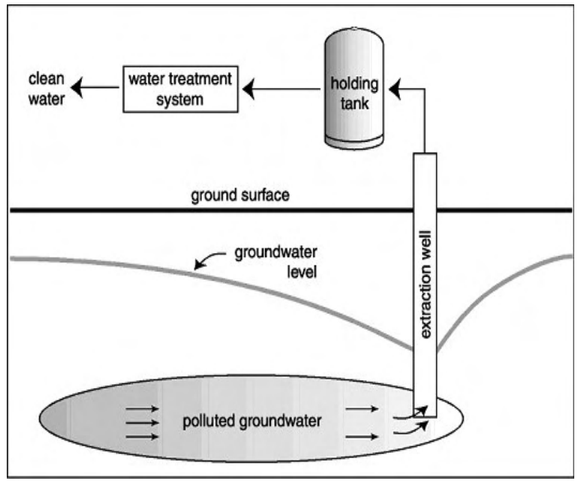
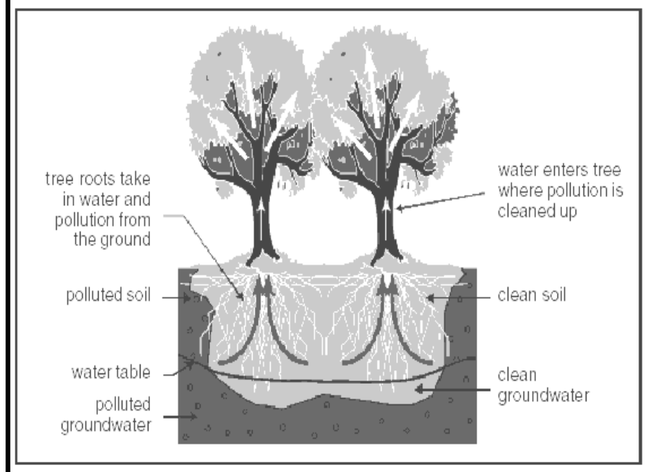
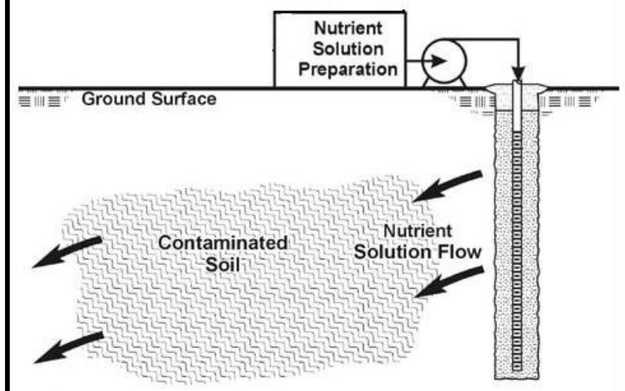
Additional Information

For additional information regarding remediation technologies visit http://www.cluin.org

For additional information on the contaminants listed in this presentation visit http://www.epa.gov or http://daq.state.nc.us/toxics/haps-taps/

For additional information on North Carolina solid waste rules visit http://wastenotnc.org/

DUNN/ERWIN LANDFILL ASSESSMENT OF CORRECTIVE MEASURES SELECTED TECHNOLOGIES

AIR SPARGING W/ SOIL VAPOR EXTRACTION	GROUNDWATER EXTRACTION SYSTEM	PHYTOREMEDIATON	ENHANCED BIOREMEDIATION
			
Description: Wells would be installed connected to an air compressor to pump air through the contamination plume. Other wells would be installed shallower to intercept the vapors which would be treated and then released into the atmosphere.	**Description:** Wells would be installed to pump the contaminated groundwater to an onsite holding tank. It would then be transported to a local waste water treatment plant for cleansing.	**Description:** Phytoremediation involves planting special hybrid fast growing, deep rooting trees in the contamination zone. The trees act as pumps which pull the contaminated ground water into the tree where the pollutants are transformed and released as carbon dioxide into the atmosphere.	**Description:** Enhanced Bioremediation is the use of natural or engineered nutrients which are injected into the contamination plume. Indigenous microorganisms present in the soil feed on the nutrients and by chain reaction and dehalogenation processes, the pollutants are broken down.
Ease of Implementation: Will likely require extensive construction & equipment costs (pumps, wells, generator, monitoring equipment). The SWS will likely require a permit modification	**Ease of Implementation:** Will likely require extensive construction & equipment costs (pumps, wells, generator, monitoring equipment). The SWS will likely require a permit modification and NCDENR-DWQ could require a pump and haul permit in order to transport the liquids to the WWTP.	**Ease of Implementation:** Will require the removal of several feet of soil (which can be done with current equipment on-site) to reach the contaminated zone. An experienced consultant will need to be hired for proper selection of plants and for treatability study. A pilot study would follow.	**Ease of Implementation:** A laboratory treatability study would need to be performed. Field work would include installation of treatment injection wells and the injection of treatment compound. Periodic re-injections could be required to reach acceptable ground water standards. A pilot study would follow.
Remediation Timeframe: Will most likely take several years due to the low conductivity of the soil (the clayey soils make travel of medium difficult)	**Remediation Timeframe:** Will most likely take several years due to the low conductivity of the soil (the clayey soils make travel of medium difficult)	**Remediation Timeframe:** Will most likely take several years due to the low conductivity of the soil (the clayey soils make travel of medium difficult)	**Remediation Timeframe:** An observable decrease in concentration of contaminants could be seen in as little as 12-18 months. However, if further contaminant releases occur, re-injections will be required.
Remediation Costs: Cost of implementation including Startup Costs, Design Costs, Construction Costs & Contingencies is estimated at **$487,000** Operation and Maintenance cost are estimated at **$15,000 to $26,000** per year	**Remediation Costs:** Cost of implementation including Startup Costs, Design Costs, Construction Costs & Contingencies is estimated at **$442,000** Operation and Maintenance cost are estimated at **$15,000 to $26,000** per year	**Remediation Costs:** Cost of implementation including Startup Costs, Design Costs, Construction Costs & Contingencies is estimated at **$218,000** Operation and Maintenance cost are estimated at **$10,000 to $20,000** per year	**Remediation Costs:** Cost of implementation including Startup Costs, Design Costs, Construction Costs & Contingencies is estimated at **$376,000** Operation and Maintenance cost are estimated at **$18,000 to $26,000** per year. Re-injections could range between **$40,000 and $60,000** per event.

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

Fax

To: City of Dunn – Government Channel #7	**From:** Ryan Sadler
FAX: 910-230-3590	**Pages:** 2 including this
Phone: 910-230-3500	**Date:** February 25, 2008
Re: Public Announcement – Dunn/Erwin Landfill	
Cc: File	**PN:** 03025

For Review **Please Comment** **Hard Copy to Follow** **X This is your Original**

- **Comments:**

To Whom It May Concern:,

Attached you will find a public announcement (press release) for a public meeting to satisfy the requirements of Title 15A NCAC 13B .1635(d) of the North Carolina Solid Waste Management Rules.

Thank You,

Ryan Sadler

P. O. Box 578
46 W. Washington Street
Coats, North Carolina 27521
PHONE 910-897-7070 FAX: 910 897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

County Plans Public Meeting to Review Groundwater Findings and Corrective Measures for Dunn/Erwin Landfill

Dunn, NC – (February 29, 2008) – The Harnett County Solid Waste Department has scheduled a public meeting in accordance with Title 15A NCAC 13B.1635(d) to review the findings and to discuss corrective measures related to impacted groundwater associated with the formerly operated municipal solid waste landfill of which accepted waste until 1993 and is now operated as a construction and demolition debris landfill.

The public meeting will be held March 31, 2008 at the Harnett County Public Library, 601 North Main Street, Lillington, North Carolina, at 9:00AM.

After the public meeting, Harnett County will select a remedy(ies) in accordance with the requirements of 15A NCAC 13B.1636 and submit the corrective measure(s) in a Corrective Action Plan for approval by the Solid Waste Section of the NC Department of Environment and Natural Resources.

The Assessment of Corrective Measures which outlines the site study and the remedial options being considered are available for public inspection at the following location during normal business hours: C.T. Clayton, Sr., P.E, Inc., 46 W Washington Street, Coats, NC.

All Harnett County residents are invited to attend.

* * * Communication Result Report (Feb. 25. 2008 10:47AM) * * *

1)
2)

Date/Time: Feb. 25. 2008 10:47AM

File No.	Mode	Destination	Pg(s)	Result	Page Not Sent
3171	Memory TX	2303590	P. 2	OK	

Reason for error
E. 1) Hang up or line fail
E. 2) Busy
E. 3) No answer
E. 4) No facsimile connection
E. 5) Exceeded max. E-mail size

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

Fax

To: City of Dunn – Government Channel #7	**From:** Ryan Sadler
FAX: 910-230-3590	**Pages:** 2 including this
Phone: 910-230-3500	**Date:** February 25, 2008
Re: Public Announcement – Dunn/Erwin Landfill	
Cc: File	**PN:** 03025

For Review **Please Comment** **Hard Copy to Follow** **X This is your Original**

• Comments:

To Whom It May Concern:,

Attached you will find a public announcement (press release) for a public meeting to satisfy the requirements of Title 15A NCAC 13B .1635(d) of the North Carolina Solid Waste Management Rules.

Thank You,

Ryan Sadler

P. O. Box 878
46 W. Washington Street
Coats, North Carolina 27521
PHONE 910-897-7070 FAX: 910 897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

Fax

To: WCKB Radio	**From:** Ryan Sadler
FAX: 910-892-3135	**Pages:** 2 including this
Phone: 910-892-3133	**Date:** February 25, 2008
Re: Public Announcement – Dunn/Erwin Landfill	
Cc: File	**PN:** 03025

For Review **Please Comment** **Hard Copy to Follow** **X This is your Original**

- **Comments:**

To Whom It May Concern:,

Attached you will find a public announcement (press release) for a public meeting to satisfy the requirements of Title 15A NCAC 13B .1635(d) of the North Carolina Solid Waste Management Rules.

Thank You,

Ryan Sadler

P. O. Box 578
46 W. Washington Street
Coats, North Carolina 27521
PHONE 910-897-7070 FAX: 910 897-6767
MOBILE: 919 795-6302 (Tyrus) Email: tyrus@ctclayton.com

County Plans Public Meeting to Review Groundwater Findings and Corrective Measures for Dunn/Erwin Landfill

Dunn, NC – (February 29, 2008) – The Harnett County Solid Waste Department has scheduled a public meeting in accordance with Title 15A NCAC 13B.1635(d) to review the findings and to discuss corrective measures related to impacted groundwater associated with the formerly operated municipal solid waste landfill of which accepted waste until 1993 and is now operated as a construction and demolition debris landfill.

The public meeting will be held March 31, 2008 at the Harnett County Public Library, 601 North Main Street, Lillington, North Carolina, at 9:00AM.

After the public meeting, Harnett County will select a remedy(ies) in accordance with the requirements of 15A NCAC 13B.1636 and submit the corrective measure(s) in a Corrective Action Plan for approval by the Solid Waste Section of the NC Department of Environment and Natural Resources.

The Assessment of Corrective Measures which outlines the site study and the remedial options being considered are available for public inspection at the following location during normal business hours: C.T. Clayton, Sr., P.E, Inc., 46 W Washington Street, Coats, NC.

All Harnett County residents are invited to attend.

* * * Communication Result Report (Feb. 25. 2008 10:48AM) * * *

1)
2)

Date/Time: Feb. 25. 2008 10:47AM

File No.	Mode	Destination	Pg(s)	Result	Page Not Sent
3172	Memory TX	8923135	P. 2	OK	

Reason for error
E. 1) Hang up or line fail
E. 2) Busy
E. 3) No answer
E. 4) No facsimile connection
E. 5) Exceeded max. E-mail size

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

Fax

To: WCKB Radio	**From:** Ryan Sadler
FAX: 910-892-3135	**Pages:** 2 including this
Phone: 910-892-3133	**Date:** February 25, 2008
Re: Public Announcement – Dunn/Erwin Landfill	
Cc: File	**PN:** 03025

For Review **Please Comment** **Hard Copy to Follow** **X This is your Original**

• Comments:

To Whom It May Concern:,

Attached you will find a public announcement (press release) for a public meeting to satisfy the requirements of Title 15A NCAC 13B .1635(d) of the North Carolina Solid Waste Management Rules.

Thank You,

Ryan Sadler

P. O. Box 578
46 W. Washington Street
Coats, North Carolina 27521
PHONE 910-897-7070 FAX: 910 897-5757
MOBILE: 919 796-6302 (Tyrus) Email: tyrus@ctclayton.com

STATE OF NORTH CAROLINA
COUNTY OF HARNETT

In the matter of:

Ref ad #: 156970 CT CLAYTON

I, Suzanne Godwin, being duly sworn, say: that I am CLASSIFIED ADVERTISING CLERK of THE DAILY RECORD, a newspaper published at Dunn, Harnett County, North Carolina, and that the attached clipping is a copy of the Notice Published said newspaper for 1 days, as follows:

02/29/2008

as required by law in the above entitled suit.

This newspaper is qualified for legal advertising in accordance with G.S. 1-597 and 1-598.

Suzanne Godwin

Classified Advertising Clerk, THE DAILY RECORD

Subscribed and sworn to before me, this 29th day of February, 2008

Misty D. Everette

Misty D. Everette, Notary Public

My commission expires My Commission Expires 02-08-2009

County Plans Public Meeting to Review Groundwater Findings and Corrective Measures for Dunn/Erwin Landfill

Dunn, NC - (February 29, 2008) - The Harnett County Solid Waste Department has scheduled a public meeting in accordance with Title 15A NCAC 13B.1635(d) to review the findings and ti discuss corrective measures related to impacted groundwater associated with the formerly operated municipal solid waste landfill of which accepted waste until 1993 and is now operated as a construction and demolition debris landfill.

The public meeting will be held March 31, 2008 at the Harnett County Public Library, 601 North Main Street, Lillington, North Carolina, at 9:00AM.

After the public meeting, Harnett County will select a remedy(ies) in accordance with the requirements of 15A NCAC 13B.1636 and submit the corrective measure(s) in a Corrective Action Plan for approval by the Solid Waste Section of the NC Department of Environment and Natural Resources.

The Assessment of Corrective Measures which outlines the site study and the remedial options being considered are available for public inspection at the following location during normal business hours: C.T. Clayton, Sr., P.E., Inc., 46 W Washington Street, Coats, NC .

All Harnett County residents are invited to attend.
2/29, 2008

APPENDIX G