CONTAMINANT DELINEATION PLAN
FOR THE
ACTIVE PHASE I LANDFILL

HIGHWAY 49 C&D LANDFILL
2105 SPEEDRAIL COURT
HARRISBURG, NORTH CAROLINA

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1.0 PURPOSE

On behalf of Greenway Waste Solutions of Harrisburg, LLC (GWS), Civil & Environmental Consultants, Inc. (CEC) has prepared this Contaminant Delineation Plan for the Active Phase I Landfill at the Highway 49 C&D Landfill facility. The North Carolina Department of Environmental Quality (NCDEQ) - Solid Waste Section has requested a characterization of the nature and extent of the groundwater contamination at the Active Phase I Landfill. This Plan is submitted in response to the detection of volatile organic compounds (VOCs) at concentrations above the 15A NCAC 02L groundwater quality standards (2L Standards) in detection/assessment monitoring wells at the subject landfill. This Plan proposes:

1) Evaluation of the potential for landfill gas migration along the northern perimeter of the Active Phase I Landfill, its potential to impact groundwater quality, and assess the need for gas extraction;

2) Groundwater quality monitoring, including the evaluation of additional leachate/landfill gas "indicator" parameters to assess the need for gas extraction as a groundwater remedy; and

3) Should an anticipated fate and transport model for another GWS landfill facility prove useful as a predictive tool, GWS will consider a similar modeling effort for the subject Phase I Landfill, or it may elect to collect additional hydrogeology/groundwater quality data, provided that either action is deemed warranted at that time.

2.0 BACKGROUND

GWS operates the Greenway Waste Solutions of Harrisburg, LLC Landfill and Recycling Center at 2105 Speedrail Court in Harrisburg, NC (Cabarrus County). A site vicinity map is provided in Figure 1. The landfill facility was permitted to operate in 2000. As a part of the landfill permit, routine semi-annual groundwater detection monitoring is performed for one background (MW-21) and three down-gradient monitoring wells (MW-55, MW-56 and MW-57) with reports submitted to the NCDEQ Solid Waste Section. The landfill facility and approximate landfill monitoring well locations are depicted in Figure 2.

For the first time and during the April 2013 sampling event conducted by Enviro-Pro, P.C. (EP), benzene and/or vinyl chloride were detected in groundwater samples collected from detection monitoring wells MW-56 and MW-57. These analytes were detected at low concentrations that exceeded their respective 15A NCAC 2L .0200 Standards of 1.0 and 0.03 parts per billion (ppb). EP conducted a confirmation resampling event on May 31, 2013 that verified the presence of these volatile organic compounds (VOCs) at similar concentrations in the same monitoring wells.

At the request of the Solid Waste Section, EP prepared a Proposed Assessment Monitoring Work Plan dated August 5, 2013 to further assess groundwater impacts at the Phase I Landfill. Additional assessment monitoring wells (MW-56A, MW-56D, and MW-57D) were installed hydraulically down-gradient of the landfill and were sampled on October 21, 2013 and November 19, 2013 as part of this initial groundwater assessment. These sampling events confirmed the presence of vinyl chloride in the saprolite and upper bedrock aquifer horizons down-gradient of the landfill.

Subsequently, the Solid Waste Section requested that GWS submit a second phase Groundwater Assessment Work Plan (or Contaminant Delineation Plan) to further characterize the nature and extent of the site groundwater contamination in accordance with 15A NCAC 13B .0545. In response, a Contaminant Delineation Plan (Plan) is presented herein to address the Section's request for additional site characterization. The basis for this Plan is 1) to better understand the

mechanism for groundwater contamination beneath the landfill; 2) to identify and assess pathways for contaminant migration; and 3) to evaluate the risks associated with the identified contaminant migration pathways.

3.0 CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) is a framework that provides the basis for site characterization and ultimately an appropriate remedy to address contaminated media. This section describes a CSM that includes: 1) identification of possible primary and secondary sources of contamination; 2) characterization of the local geology/hydrogeology; 3) a description of the impacted environmental media; 4) assessment of potential exposure risk from detected constituent concentrations via identified exposure pathways; and 5) identification of potential receptors.

3.1 AREA OF CONCERN

As shown in Figure 1, the immediate area of concern (AOC) at the subject site includes: 1) the Active Phase I Landfill; 2) the northern portion of the subject property between the landfill boundary and Coddle Creek; and 3) Coddle Creek. Groundwater flow from the Phase I Landfill is to the north-northeast towards Coddle Creek (Figure 2), which makes the creek a potential receptor of impacted groundwater. There is a residential development located approximately 400 feet from the northern landfill boundary across Coddle Creek, which is supplied by municipal water. Several residential water supply wells are situated hydraulically upgradient and south-southeast and southeast of the active landfill. The nearest water supply well in this area is located approximately 650 feet from the southeastern-most edge of the active landfill.

3.2 REGIONAL GEOLOGY AND HYDROGEOLOGY

The subject landfill is located in the Piedmont Physiographic Province of NC. This zone lies between the Coastal Plain Province (defined by marine deposition) to the east and Blue Ridge Province (mountainous) to the west. Rocks in the Piedmont zone have undergone intense metamorphism, folding, faulting, and igneous intrusion. The region is a fault-bounded composite stack of thrust sheets containing a variety of gneisses, schists, amphibolites, sparse ultramafic bodies, and intrusive granitoids (Horton and McConnell 1991; Nelson and others 1998). The general structure within the zone is characterized by irregular foliation of low dip

and folds transverse to the northeast regional trend. The stratified rocks consist of thinly layered mica schist and biotite gneiss that are interlayered with lesser amounts of amphibolite, calc-silicate rocks, hornblende gneiss, and quartzite. Large and small masses of intruded granite and granodiorite are present throughout the belt and form concordant to semi-concordant bodies in the country rock. Some of these granitoid bodies are gneissic and are probably older than the poorly foliated to non-foliated facies.

The topography of the NC Piedmont region is characterized by low, rounded hills and long, rolling, northeast-southwest trending ridges (Heath 1980). The relief from stream valley to ridge in most areas ranges from 75 to 200 feet. Along the Coastal Plain boundary, the Piedmont region rises from an elevation of 300 feet above mean sea level, to the base of the Blue Ridge Mountains at an elevation of 1,500 feet.

The groundwater system in the Piedmont Province is typically comprised of two interconnected zones comprised by residual soil/saprolite/weathered fractured rock (regolith) overlying fractured crystalline bedrock (Heath 1980; Harned and Daniel 1992). The regolith layer is vertically stratified by degree of weathering. A highly weathered and structure-less residual soil occurs near the ground surface. The residual soil grades into saprolite, a coarser grained material that retains the structure of the parent bedrock. Beneath the saprolite, partially weathered/fractured bedrock occurs with depth until sound bedrock is encountered. A transition zone at the base of the regolith has been interpreted to be present in many areas of the Piedmont. The zone consists of partially weathered/fractured bedrock and lesser amounts of saprolite that grades into bedrock and has been described as “being the most permeable part of the system, even slightly more permeable than the soil zone” (Harned and Daniel 1992). The transition zone thins and thickens within short distances and its boundaries may be difficult to distinguish. It has been suggested that the zone may serve as a conduit of rapid flow and transmission of contaminated water (Harned and Daniel 1992). The regolith layer serves as the principal storage reservoir and provides an inter-granular medium through which the recharge and discharge of water from the underlying fractured rock occurs. Daniel (1990) reported that the porosity of the regolith ranges from 35 to 55 percent near land surface but decreases with depth as the degree of weathering decreases.

Within the fractured crystalline bedrock layer, the fractures control both the hydraulic conductivity and storage capacity of the rock mass. The igneous and metamorphic rocks in the Piedmont are formed as a dense lattice of interlocking crystals; thus, primary porosity is very low, generally less than three percent. Secondary porosity of crystalline bedrock due to weathering and fractures ranges from one to ten percent (Freeze and Cherry 1979) but, porosity values of from one to three percent are more typical (Daniel and Sharpless 1983).

LeGrand developed a conceptual hydrogeologic model of the aforementioned composite regolith-fractured crystalline rock aquifer system in the Piedmont that is useful for the description of groundwater conditions (LeGrand 1988; 1989). The basic hydrologic entity in this conceptual model is the surface drainage basin that contains a perennial stream. Each Piedmont drainage basin is similar to adjacent basins and the conditions are generally repetitive from basin to basin. Within a basin, movement of groundwater is generally restricted to the area extending from the drainage divides to a perennial stream. This hydrogeologic system is referred to as a "slope aquifer system" (LeGrand 1988; 1989). Rarely does groundwater move beneath a perennial stream to another more distant stream or across drainage divides. Therefore, in most cases in the Piedmont, the groundwater system is a two-medium system restricted to the local drainage basin (LeGrand 1988). Groundwater flow paths in the Piedmont are almost invariably restricted to the zone underlying the topographic slope extending from a topographic divide to an adjacent stream. Under natural conditions, the general direction of groundwater flow can be approximated from the surface topography (LeGrand 2004).

3.3 SITE HYDROGEOLOGY

The hydrogeologic unit underlying the site is a composite regolith-fractured crystalline rock (likely diorite and/or granite composition) aquifer system that is typical of the NC Piedmont. Locally, the regolith is characterized by residual sandy silt soils from the surface to approximately 10 feet below grade, and then silty sand saprolite and partially weathered rock (PWR) to depths of 25 to 40 feet below grade. Unweathered fractured bedrock generally occurs at depths ranging from 25 to 40 below grade. The local water table is unconfined and is encountered in the bedrock in the more elevated site areas and in the regolith in lower site areas.

The regolith aquifer zone is interconnected by fractures with the underlying crystalline rock aquifer zone. Groundwater recharge occurs in the elevated site areas, and then flows in the direction of Coddle Creek to the north. Calculated vertical hydraulic gradients based on the October 2014 data for monitoring well clusters MW-56A/56D and MW-57/57D, which are located adjacent to Coddle Creek, are upward at 0.022 and 0.052 feet/foot, respectively, indicating local groundwater discharge to Coddle Creek. Monitoring well and water level elevation data are summarized in Table 1.

Porosities of the weathered residuum are estimated to range from 20 to 35 percent. Porosity of the fractured bedrock is estimated to range from 1 to 10 percent. Hydraulic conductivities calculated by EnviroPro, PC for saprolite and partially weathered rock (PWR) ranged from 1.91 x 10^{-4} cm/sec to 3.67 x 10^{-6} cm/sec, with an average of 6.4 x 10^{-5} cm/sec (66 ft/yr). Hydraulic conductivities estimated for the fracture bedrock ranged from 1.64 x 10^{-4} cm/sec to 4.63 x 10^{-5} cm/sec; an average of 6.3 x 10^{-5} cm/sec (65 ft/yr). Based upon the average hydraulic conductivity of 66 ft/yr, an estimated average porosity of 0.30, and a calculated horizontal hydraulic gradient of 0.045, the estimated average site groundwater velocity for the lower regolith zone is approximately 10 ft/year.

3.4 SITE CONCEPTUAL HYDROGEOLOGY MODEL

Local groundwater flow is primarily in the regolith zone with flow also occurring in the fractured or weathered zones in bedrock. Groundwater recharge and discharge at the landfill site is anticipated to follow the local slope aquifer system as described by LeGrand (2004). The general direction of groundwater flow can be approximated from the surface topography. The topography at the site generally slopes toward Coddle Creek to the north. Based on the previously discussed upward vertical hydraulic gradients measured in well clusters near the creek, Coddle Creek functions as a groundwater discharge divide between the site and the properties on the north side of the stream.

3.5 PRIMARY AND SECONDARY SOURCES OF CONTAMINATION

Solid waste that has been disposed by permit in the Phase I Landfill since approximately 2004 is believed to be the primary source of contaminants of concern (COCs) in groundwater. Secondary sources of the groundwater contamination are landfill leachate and/or migrating landfill gas (LFG), which are the media that typically come into contact with the underlying groundwater. The mechanism(s) causing the groundwater impacts at the site are not clearly understood. To propose an appropriate groundwater remedy, it is important to ascertain whether the impacts are caused by leachate or migrating LFG because the remedial approaches to address these sources are significantly different.

Analytical data show parts per billion (ppb) levels of volatile organic compounds (VOCs) in the groundwater. These VOCs primarily include chlorinated aliphatics (i.e., 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, and vinyl chloride) and aromatic hydrocarbons (benzene, toluene, and xylenes). Vinyl chloride, which can be recalcitrant to decay under anaerobic conditions, is the primary VOC in groundwater. The most elevated vinyl chloride levels in site groundwater have been detected in perimeter water table wells MW-56 (8.2 to 27 ppb) and MW-57 (3.9 to 16 ppb) situated northeast of and adjacent to the Active Phase I C&D Landfill. Also, low levels of vinyl chloride have been detected in water table well MW-55 (0.66 to 2.1 ppb) and deeper bedrock well MW-57D (1.1 to 4.5 ppb). The recent April and October 2015 groundwater data show a significant decrease in vinyl chloride concentrations in all landfill monitoring wells when compared with 2013 and 2014 monitoring data. Vinyl chloride levels were shown to recently decrease in spite of a rising water table. Recent VOC data trends are summarized in Section 3.7.

VOCs are dissolved in the groundwater as a result of the contaminated leachate and/or LFG occurring in contact with the water table. Leachate is not collected at the landfill; thus, direct analytical data is not available for its evaluation as a potential source of groundwater impact. LFG (i.e. methane) is routinely monitored on a quarterly schedule in seven existing gas monitoring wells along the perimeter of the Phase I Landfill, as shown in Figure 3. No methane monitoring wells were initially sited along the northern perimeter of the Phase I Landfill as

Coddle Creek serves as a natural control. As documented in the attached field data sheets in Appendix A, methane has been detected in methane monitors MMW-2, MMW-3, and MMW-6 during the second, third and fourth quarterly monitoring events for 2015. These methane concentrations did not exceed allowable regulatory limits.

3.6 POSSIBLE CONTAMINANT TRANSPORT MECHANISMS

3.6.1 Landfill Leachate

Leachate is the resultant liquid created when rainfall percolates into the landfill waste mass and then slowly drains through the waste under gravity. During this process, the leachate picks up soluble contaminants from the waste itself. Xenobiotic organic compounds in leachate may include aromatic hydrocarbons, phenols, chlorinated aliphatics, pesticides, and plastizers. With the exception of phenols, all these organic groups have been observed in the site groundwater. Inorganic compounds in leachate may include arsenate, barium, borate, cobalt, lithium, mercury, selenate and sulfide.

If not controlled or collected, leachate can migrate through permeable material that exists under the landfill. Although geologic materials below the landfill can filter some of the leachate constituents, the more mobile constituents in the migrating leachate can enter the underlying groundwater. Where leachate seeps into groundwater, a plume of groundwater contamination will occur.

3.6.2 Landfill Gas (LFG)

Landfill gas (LFG) is the product of microbiological decomposition of buried organic matter. Certain microorganisms turn complex organic compounds in landfill waste into methane, carbon dioxide, and trace amounts of other compounds. LFG is composed of about 50-55% methane and about 40-45% carbon dioxide. A small percentage of LFG is composed of hydrogen sulfide and other sulfur compounds. The remainder is made up of hundreds of other compounds, including nitrogen and oxygen. About 0.2 to 0.5% of LFG is composed of complex organic

compounds that are not biodegraded. The exact composition of landfill gas is unique to each location. Monitoring is important if specific trace compounds are to be identified.

Appreciable volumes of LFG are generated in landfills in approximately one to three years, depending on the waste types, amount of moisture or other factors. Peak production of LFG is typically five to seven years after waste is disposed in the landfill.

The mechanisms for LFG transport are advection and diffusion. Advection transport is a function of barometric pressure variations and landfill pressure gradients, and it is the primary transport mechanism with regard to emissions and migration control strategies. LFG will migrate vertically or laterally within subsurface materials along the path of least resistance. Highly impermeable landfill covers will likely promote lateral LFG migration. Diffusion transport is minor compared to advection; however, this mechanism is associated with the ultimate transfer of compounds into air, soil, and liquid media. Diffusion transport is compound-specific and is affected by solubility and vapor pressure (i.e. Henry's Law), soil moisture, concentration gradients, organic carbon fraction, and water table fluctuations.

Summary of Published Research on LFG as a Source of VOCs in Groundwater

Some consultants and researchers have recently theorized that landfill gas may be a source of low-level VOC contamination of groundwater. Low-level VOCs found in LFG and in LFG condensate are sometimes found in off-site gas and groundwater monitoring wells. Detection levels range from the low ppb to low parts per million (ppm) levels. The more commonly identified VOCs reported in LFG are chlorinated aliphatics and aromatic hydrocarbons.

LFG may be the source of contamination where:

- The presence of migrating LFG is confirmed in landfill gas monitoring wells;
- A significant increase in leachate "indicator" parameters is not associated with the VOCs;
- VOCs are in some cases detected in upgradient monitoring wells;
- Carbon, oxygen, and hydrogen isotopes indicate the lack of relationship between landfill leachate and the groundwater samples from the impacted well;

- There is a direct relationship between the LFG and gases observed in the headspace of monitoring wells;
- The VOC detected in groundwater was either the same compound or a degradation product of the VOC found in the LFG;
- Typical detected VOC parameters are associated with vapor-phase migration in landfills;
- Low levels of VOCs are detected above background values; and
- VOC concentrations in groundwater are reduced during LFG mitigation.

Site-Specific Evidence for LFG Impact to Groundwater

A significant increase in leachate indicator parameters including alkalinity, chloride, sulfate, and total dissolved solids was not observed concurrent with the initial vinyl chloride detections in wells MW-55 and MW-56. Yet, a significant increase in these indicator parameter concentrations was observed concurrent with the initial vinyl chloride detections in MW-57. These data may indicate that both leachate and landfill gas are secondary sources of the observed groundwater impacts.

Toluene, xylenes, and naphthalene have been detected in background well MW-21 situated upgradient of the landfill. The presence of VOCs in the background monitoring well are evidence suggesting that migrating LFG may be a significant source of groundwater contamination.

Benzene, toluene, and xylenes (commonly referred to as BTEX compounds), naphthalene, 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, and vinyl chloride have been detected in groundwater monitoring wells at the perimeter of the landfill. These detected VOC parameters in site groundwater are commonly associated with vapor-phase migration in landfills.

VOCs have been detected in groundwater monitoring wells at levels ranging from 0.16 to 27 ppb. These low-level VOC detections in site groundwater monitoring wells are typical of the VOC concentrations associated with vapor-phase migration in landfills.

It is our opinion that sufficient data is not available to evaluate the potential for LFG impact to site groundwater. Our recommendation for a preliminary LFG assessment is discussed in Section 4.0.

3.7 SUMMARY OF OCTOBER 2015 GROUNDWATER MONITORING DATA

A summary of findings is presented in this section to update the Solid Waste Section with additional site data obtained during the October 2015 semi-annual groundwater monitoring event conducted at the Phase I Landfill. The monitoring report has been submitted to the Solid Waste Section under a separate cover. A tabulated summary of the groundwater monitoring data is provided below.

Monitoring Area	VOC Trend Analysis
MW-21	MW-21 is located upgradient and on the south perimeter of the landfill. Toluene and xylenes were detected in the upgradient well at concentration well below their 2L Standards and at lower concentrations than detected in May 2015.
MW-55	MW-55 is located on the north side of the landfill between the disposal area and Coddle Creek. VC was detected in MW-55 at 1.1 µg/L. The recent VC concentration trend for MW-55 is decreasing. Toluene and xylenes were detected in MW-55 at levels below their 2L Standards, and their recent concentration trends are also decreasing. Leachate indicators were not elevated in the MW-55 sample, which is evidence for LFG impact to site ground-water.
MW-56 Cluster	The well cluster in the area of MW-56 is located on the northeast side of the landfill between the disposal area and Coddle Creek. MW-56 – VC has decreased from 27 to 6.3 µg/L; cis-DCE decreased from 4.9 to 3.8 µg/L; previously detected 1,1-DCA, 1,1-DCE, PCE, TCE, methylene chloride, naphthalene, toluene, xylenes, and bis (2-ethylhexyl) phthalate were not detected in the October 2015 event. Leachate indicators were not elevated in the MW-56 sample. CO_2 was elevated and may be evidence for migrating LFG. MW-56A – VC has not been detected in MW-56A. Toluene, xylenes, and bis (2-ethylhexyl) phthalate have decreased to non-detect. Leachate indicators were not elevated in the MW-56A sample. MW-56D - VC has not been detected in MW-56D. Toluene, tetrahydrofuran, and naphthalene have decreased to non-detect. Xylenes decreased from 1.6 to 1.0 µg/L. Leachate indicators were not elevated in the MW-56D sample.
MW-57 Cluster	The well cluster in the area of MW-57 is located on the northeast corner of the landfill between the disposal area and Coddle Creek. MW-57 – VC has decreased from a high of 16 to 3.2 µg/L. Benzene, cis-DCE, and methylene chloride have decreased to non-detect. Elevated alkalinity, CO_2, and Mn suggest landfill gas impact to groundwater. Yet, elevated TDS and Cl may suggest leachate impact to groundwater. Both contaminant sources may be impacting area groundwater. MW-57D - VC has decreased from a high of 4.5 to 1.5 µg/L. Benzene, toluene, xylenes, tetrahydrofuran, and naphthalene have decreased to non-detect. Elevated alkalinity, CO_2, and Mn suggest landfill gas impact to groundwater. Yet, elevated TDS and Cl suggest leachate impact to groundwater. Both contaminant sources may be impacting area groundwater.

Table Notes:
Cl = chloride; CO_2 = carbon dioxide; DCA = dichloroethane; DCE = dichloroethene;
LFG = landfill gas; Mn = manganese; PCE = tetrachloroethene; TCE = trichloroethene;
TDS = total dissolved solids; VC = vinyl chloride;
2L Standards = 15A NCAC 2L .0202 Groundwater Quality Standards; µg/L = microgram per liter.

General Observations

Recent vinyl chloride concentrations are significantly lower than the historical high vinyl chloride levels detected in all site monitoring wells in which VC has been detected.

Evidence suggests that LFG may be impacting groundwater in the vicinity of MW-21, MW-55, MW-56, and well cluster MW-56A/56D. This evidence includes 1) the presence of VOCs in an upgradient monitoring well (i.e. MW-21); and 2) the absence of elevated leachate indicator parameters concurrent with detected VOCs (i.e. MW-55, MW-56, and MW-56A/MW-56D).

LGF would not be expected to raise total dissolved solids or chloride levels; so these parameters may be the most reliable to predict leachate impact on groundwater. Elevated total dissolved solids and chloride were observed in the MW-57 and MW-57D samples. Elevated alkalinity, carbon dioxide, and manganese would suggest landfill gas impact on groundwater. These conditions were also observed in the MW-57 and MW-57D samples.

3.8 EVALUATION OF POTENTIAL EXPOSURE RISK

3.8.1 Potential Exposure Pathways via Impacted Groundwater

Groundwater Supply Wells

One potential exposure pathway for groundwater is by ingestion and dermal contact with impacted groundwater extracted from a water supply well. A residential subdivision is situated approximately 450 feet to the north of the Phase I Landfill beyond Coddle Creek; however, the residences within the subdivision are connected to a public water supply. No private groundwater wells are known to exist within 1,500 feet hydraulically down-gradient of the Active Phase 1 C&D Landfill. A number of residential water supply wells are located hydraulically upgradient to the south-southeast and southeast; the nearest supply well at a distance of approximately 650 feet from the southeastern-most edge of the active landfill. Given the upgradient locations, considerable separation distances, and typically low yields of residential supply wells, the potential to impact the identified surrounding area residential supply wells is low.

Groundwater Discharge to Surface Water

Local slope aquifer system discharge is to Coddle Creek situated north of the subject landfill waste boundary. The surface water classification for Coddle Creek is Class C. Two surface water samples (SW-1 and SW-2) are collected from Coddle Creek as a part of the routine landfill monitoring program. The approximate locations where these surface water samples are collected are shown on Figure 2. Vinyl chloride was detected at a concentration of 1.0 ppb in creek sample SW-2 during the April 2014 monitoring event. Vinyl chloride was not detected in SW-2 before the April 2014, and was not detected in SW-2 during the October 2014 and April 2015 sampling events. The 15A NCAC 2B .0200 surface water human health standard for vinyl chloride is 2.4 ppb. These data indicate that local groundwater discharge to Coddle Creek does not present a significant exposure risk.

Vapors from Shallow VOC-Impacted Groundwater

Structural vapor intrusion may occur where VOC-impacted groundwater migrates near or beneath a building, hazardous VOC vapors partition from the groundwater, and then enter the building. One or more of the identified contaminants in site groundwater present a potential risk due to vapor intrusion. The nearest potential receptors for vapor intrusion potentially resulting from VOC-impacted groundwater are the residences located north of Coddle Creek. Potential hazardous vapors partitioning from impacted groundwater would migrate in the vadose zone above the local water table. Because the local water table intersects with Coddle Creek, potential hazardous vapors that may partition from groundwater moving away from the landfill cannot migrate northward beyond Coddle Creek. Thus, a potential migration pathway does not exist for groundwater-related vapor intrusion to occur in a nearby potential receptor.

3.8.2 Potential Exposure Pathway via Migrating Landfill Gas

Fire and Explosion Hazards

Routine quarterly methane monitoring data is available to evaluate the potential presence of migrating LFG that could result in a fire and/or explosion hazard. Methane measurements have not identified a potential fire or explosion hazard to date. Coddle Creek would serve as a natural

barrier to potential LFG migrating to the north. CEC recommends that routine quarterly methane monitoring be continued to obtain and evaluate potential LFG migration for the assessment of the potential risk due to fire and explosion hazards.

Vapor Inhalation of LFG via Structural Vapor Intrusion

In addition to the primary components – methane and carbon dioxide - landfill gas may contain low levels of VOCs. Due to the presence of Coddle Creek between the landfill and potential residential receptors situated north of the creek, LFG cannot migrate beyond the creek to reach a neighboring structure. Elsewhere, no residential structures exist within 650 feet of the landfill perimeter. Several commercial structures are located to the west of the landfill; the nearest structure over 300 feet from the landfill perimeter.

3.8.3 Summary of Potential Exposure Risk

The exposure pathways are incomplete for VOCs detected in groundwater down-gradient of the Active Phase I Landfill. In a hydraulically upgradient direction of the landfill, private water supply wells have not been identified within 650 feet of the southeastern-most edge of the subject landfill. As such, potential for exposure to groundwater contaminants via drinking or dermal contact is minimal. Also, groundwater moving beneath the landfill discharges to Coddle Creek, which has been shown by routine monitoring to not be significantly impacted. GWS will continue to routinely monitor surface water conditions as part of the landfill permit requirements.

Because groundwater moving beneath the landfill discharges to Coddle Creek, and there are no structures between the landfill perimeter and Coddle Creek, the exposure pathway is not complete for structural vapor intrusion.

To date, methane monitoring data routinely collected at the facility on a quarterly basis do not indicate methane concentrations that would suggest a potential risk for fire and explosion hazards related to migrating LFG. Routine quarterly methane monitoring data collected from the Phase I and Phase I Expansion Landfills should be evaluated with regard to potential vapor-

phase migration to further assess the potential risk due to structural vapor intrusion to inhabitable commercial and residential structures to the west, south, and southeast.

4.0 PROPOSED CHARACTERIZATION OF THE IMPACT SOURCE

As presented in Table 2 and the accompanying vinyl chloride trend charts, a summary of recent VOC data for groundwater assessment monitoring wells at the downgradient margin of the landfill indicates the presence of vinyl chloride at low levels that exceed its 2L Standard of 0.03 ppb. The most recent 2015 groundwater data show a significant decrease in vinyl chloride concentrations in all the landfill monitoring wells. Well gauging data from nested well pairs situated north of the landfill near Coddle Creek show that vertical hydraulic gradients are upward demonstrating that locally groundwater is discharging into Coddle Creek. VOC analyses of surface water samples obtained from Coddle Creek have not typically detected vinyl chloride; although, VC was detected in one surface water sample during the April 2014 monitoring event at 1.0 ppb. Detected VC levels in Coddle Creek are below the human health standard of 2.4 ppb for surface water.

Since October 2013, more recently installed groundwater assessment monitoring wells MW-56A, MW-56D, and MW-57D have been routinely sampled for laboratory analyses. These wells have been sampled over five groundwater monitoring events. VOCs have not been detected in the nested well pair MW-56A/MW-56D installed down-gradient of existing perimeter monitoring well MW-56. Data obtained from the nested well pair MW-57/MW-57D demonstrate that vinyl chloride concentrations in this area are decreasing with depth. Given the upward vertical hydraulic gradient that indicates site groundwater is locally discharging to Coddle Creek and no significant impact to the surface water, it is CEC's opinion that additional delineation of groundwater impacts is not warranted at this time.

Although further contaminant delineation is not proposed, additional groundwater and vapor-phase assessment is required to characterize the landfill source of the groundwater impacts in order to determine an appropriate groundwater remedy. Researchers have identified several "indicator" parameters that not only detect landfill impacts due to leachate and gas migration, but can also distinguish between impacts related to leachate versus those associated with LFG. These analytical parameters, along with routinely monitored field analytical measurements, methane, and groundwater VOC data, will be evaluated to ascertain the most probable source for

the observed groundwater impact. The specific indicator parameters along with their associated indicator characteristics are as follows:

- Chloride - If values elevated above background, the probable source is landfill leachate.
- Ammonia (as Nitrogen) - If values are elevated above background, the most probable source is leachate.
- Total Dissolved Solids - If values elevated above background, the probable source is landfill leachate.
- Alkalinity (as Bicarbonate) - If values are elevated above background, the most probable source is LFG.
- Carbon Dioxide - If values are elevated above background, the most probable source is LFG.
- Calcium - If values are elevated above background, it is an indication of gas impact if other strong leachate indicators are not significantly noted.
- Manganese - If values are elevated above background, it is an indication of gas impact if other strong leachate indicators are not significantly noted.
- Arsenic - If values are elevated above background, it is an indication of gas impact if other strong leachate indicators are not significantly noted.

Also, CEC recommends that vapor-phase data be obtained and evaluated with regard to the potential for migrating LFG to impact groundwater, and to assess the potential risk due to structural vapor intrusion to inhabitable commercial and residential structures nearby the landfill. Specifically, CEC recommends that headspace vapor samples be collected from up to three methane monitoring wells and up to four groundwater shallow monitoring wells to provide a preliminary assessment of whether LFG migration may be occurring at the landfill, and, if so, to determine the vapor-phase constituents contained in the LFG. We propose that well headspace samples will be collected from methane monitors MMW-2, MMW-3, and MMW-6, and from downgradient groundwater monitoring wells MW-55, MW-56, and MW-57 and upgradient well MW-21. These samples will be analyzed by Enthalpy Analytical, Inc. for VOCs via Method TO-15, and for H_2, CO, O_2, N_2, CH_4, and CO_2 via ASTM D 1946-90. The analytical data

obtained from the headspace in each groundwater well will also be compared to the data from the corresponding aqueous sample from that well to evaluate the potential for LFG to contaminate groundwater and to assess the potential for structural vapor intrusion.

GWS has been performing semi-annual groundwater sampling of seven groundwater monitoring wells for Appendix II analyses since VOCs were first detected in site groundwater above 2L standards that triggered assessment monitoring in April 2013. The detected VOCs include vinyl chloride and benzene. Also, other constituents that have been detected at concentrations exceeding the 2L standards include chromium and nickel for which each have a single occurrence, and bis(2-ethylhexyl)phthalate, which had a single occurrence in the background well MW-21 and MW-56A. For six semi-annual groundwater monitoring events, the historical data show that Appendix II semi-VOCs, herbicides, pesticides, and PCBs are not of significant concern at the site. Consequently, GWS is petitioning the Solid Waste Section to amend the assessment monitoring requirements for the Active Phase I Landfill by discontinuing routine groundwater sampling and analyses for Appendix II semi-VOCs, herbicides, pesticides, and PCBs.

NCDEQ – Solid Waste Section has suggested the use of a groundwater flow and solute transport model to predict contaminant migration and evaluate exposure risk at the Phase I Landfill. GWS is anticipating such a modeling effort for another NC landfill facility, so they are requesting that such modeling for the subject Phase I Landfill be postponed until they have an opportunity to evaluate the anticipated other model's usefulness as a predictive tool. Further, GWS reserves the option of either developing a fate and transport model or collecting additional hydrogeology/groundwater quality data to adequately assess exposure risk to groundwater contaminants detected at the subject landfill, provided that either action is deemed warranted at that time.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The most recent 2015 groundwater data show a significant decrease in vinyl chloride concentrations in all the landfill monitoring wells. VOCs have not been detected in the nested well pair MW-56A/MW-56D recently installed down-gradient of existing perimeter monitoring well MW-56. Data obtained from the nested well pair MW-57/MW-57D demonstrate that vinyl chloride concentrations in this area are decreasing with depth. Well gauging data from nested well pairs situated north of the landfill near Coddle Creek show that vertical hydraulic gradients are upward demonstrating that locally groundwater is discharging into Coddle Creek. VOC analyses of surface water samples obtained from Coddle Creek have not typically detected vinyl chloride; although, VC was detected in one surface water sample during the April 2014 monitoring event at 1.0 ppb. Detected VC levels in Coddle Creek are below the human health standard of 2.4 ppb for surface water. Given the 1) recently decreasing VC trends; 2) upward vertical hydraulic gradients that indicate site groundwater is locally discharging to Coddle Creek; and 3) and no significant impact to the surface water, additional delineation of groundwater impacts is not warranted at this time.

Site-specific groundwater data were evaluated with regard to several lines of evidence established by other researchers to assess the possibility that landfill gas (LFG) may be present and impacting groundwater. Such vapor phase contaminant migration may occur through the vadose zone followed by dissolution from the gas phase into the groundwater. As discussed in Section 3.6.2, our evaluation suggests that LFG may be the predominant source for the observed groundwater impacts. The following observed site conditions suggest that migrating LFG may be impacting site groundwater.

- Methane has been detected in methane monitors MMW-2, MMW-3, and MMW-6 during the second, third and fourth quarterly monitoring events for 2015. Thus, the presence of migrating LFG is confirmed in on-site landfill gas monitoring wells.

- A significant increase in leachate "indicator" parameters including alkalinity, chloride, sulfate, and total dissolved solids (TDS) was not observed concurrent with the initial

vinyl chloride detections in wells MW-55 and MW-56. Yet, a significant increase in these indicator parameter concentrations was observed concurrent with the initial vinyl chloride detections in MW-57. These data may indicate that both leachate and landfill gas are secondary sources of the observed groundwater impacts.

- Toluene, xylenes, and naphthalene have been detected in background well MW-21 situated upgradient of the landfill. The presence of VOCs in the background monitoring well are evidence suggesting that migrating LFG may be a significant source of groundwater contamination.

- Benzene, toluene, and xylenes (commonly referred to as BTEX compounds), naphthalene, 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, and vinyl chloride have been detected in groundwater monitoring wells at the perimeter of the landfill. These detected VOC parameters in site groundwater are commonly associated with vapor-phase migration in landfills.

- VOCs have been detected in groundwater monitoring wells at levels ranging from 0.16 to 27 ppb. These low-level VOC detections in site groundwater monitoring wells are typical of the VOC concentrations associated with vapor-phase migration in landfills.

Because migrating LFG can impact groundwater, a site-specific assessment of potential LFG migration is needed as outlined in Section 4.0.

For six semi-annual groundwater assessment monitoring events, the historical data show that Appendix II semi-VOCs, herbicides, pesticides, and PCBs are not of significant concern at the site. Consequently, GWS is petitioning the Solid Waste Section to amend the assessment monitoring requirements for the Active Phase I Landfill by discontinuing routine groundwater sampling and analyses for Appendix II semi-VOCs, herbicides, pesticides, and PCBs.

Should an anticipated fate and transport model for another GWS landfill facility prove useful as a predictive tool to evaluate contaminant migration and exposure risk, GWS will consider a similar modeling effort for the subject Phase I Landfill. Yet, GWS reserves the option of either developing a fate and transport model or collecting additional hydrogeology/groundwater quality data to adequately assess exposure risk to groundwater contaminants detected at the subject landfill, provided that either action is deemed warranted at that time.

On behalf of GWS, CEC is requesting that the Division approve this Contaminant Delineation Plan to evaluate additional LFG and groundwater monitoring data to ascertain the most probable source (leachate or LFG) for the observed groundwater impacts, and to determine whether LFG extraction may be an effective groundwater remedy.

6.0 REFERENCES

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FIGURES

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GREENWAY WASTE SOLUTIONS
OF HARRISBURG, LLC
HIGHWAY 49 C&D LANDFILL
HARRISBURG, NC

SITE MAP

DRAWN BY:	MTB	CHECKED BY:	EHS	APPROVED BY:	SLB	FIGURE NO.:	1
DATE:	SEPT 2015	DWG SCALE:	1"=250'	PROJECT NO:	111-370.002		

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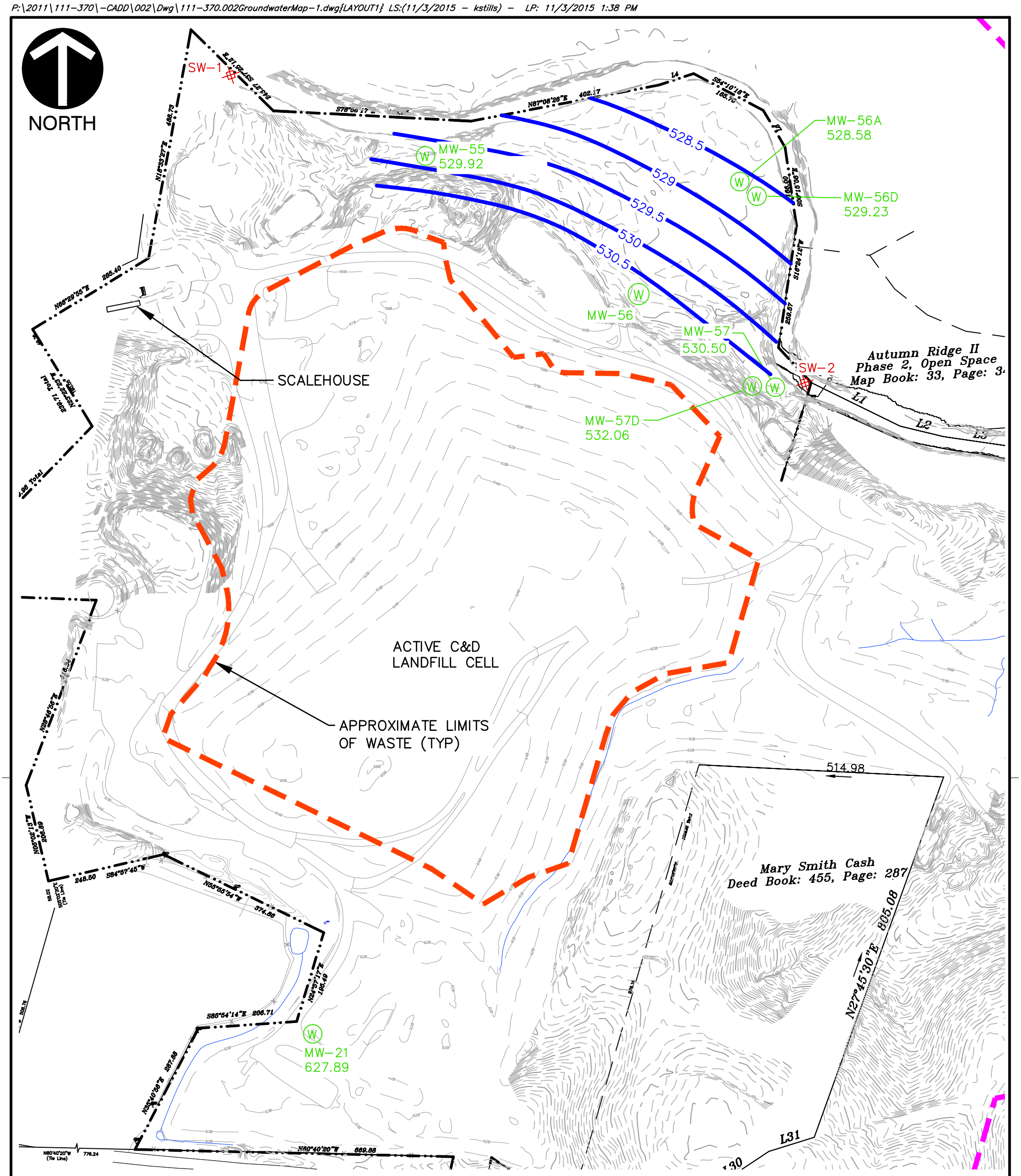

SURVEYORS NOTES:

1) This property may be subject to any easements and/or Rights-of-way of record.

2) Boundary information based on Deed Book 455; Page 281, Book 456; Page 318 Book 853; Page 79, and Book 455; Page 284 as recorded in the Cabarrus County Register of Deeds.

3) This survey is of an existing parcel or parcels of

4) AT&T Right of Way based on Deed Book 118, Page 152.

5) Midway Lighting and Improvement Company based on Deed Book 118, Page 50.

6) Points within Coddle Creek are computed points only.

7) Property is in a special flood zone according to Flood Insurance Rate Map: 37025C0120-D Dated: November 2, 1994.

8) Area by coordinate method.

LEGEND

- APPROXIMATE LIMITS OF WASTE
- BOUNDARY
- EXISTING CREEK
- POTENTIOMETRIC CONTOUR
- APPROXIMATE LOCATION OF MONITORING WELL
- APPROXIMATE LOCATION OF SURFACE WATER SAMPLE COLLECTION

REFERENCE

1. 2013 TOPOGRAPHIC INFORMATION PROVIDED BY PATTERSON LAND SURVEYING, PA – DATE OF AERIAL PHOTOGRAPHY JUNE 1, 2013
2. EXISTING TOPOGRAPHIC CONTOUR INFORMATION PROVIDED BY INDEPENDENT MAPPING CONSULTANTS – FEBRUARY 7, 2008
3. EXISTING AND PROPOSED WELL LOCATIONS PROVIDED BY PATTERSON LAND SURVEYING AND TOM BOLYARD, P.G. FROM ENVIRO-PRO, P.C.

SCALE IN FEET

0 200 400

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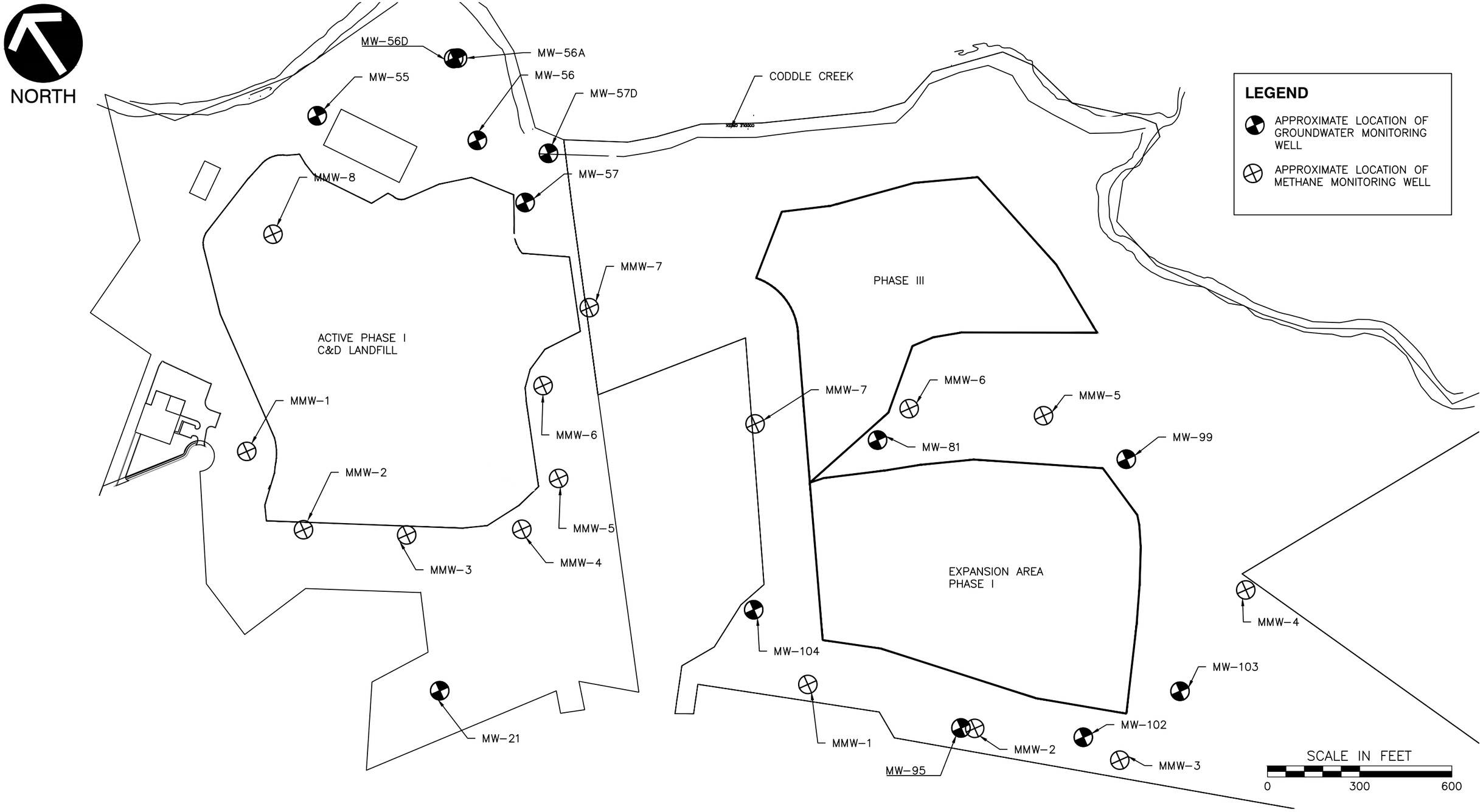
HARRISBURG, NORTH CAROLINA

GROUNDWATER POTENTIOMETRIC MAP

DRAWN BY:	TMG	CHECKED BY:	SLB	APPROVED BY:	SLB	FIGURE NO.:	2
DATE:	AUG. 2013	DWG SCALE:	1"=200'	PROJECT NO:	111-370.002		



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METHANE MONITORING WELL LOCATION MAP

DRAWN BY:	PNP	CHECKED BY:	EHS	APPROVED BY:	EHS	FIGURE NO.:
DATE:	MARCH 2016	DWG SCALE:	1"=300'	PROJECT NO:	111-370.002	3

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TABLES

Table 1
Monitoring Well and Water Level
Elevation Data

MW ID	Well Depth	Screen Interval	TOC Elev.	Depth to Water (TOC)	WT Elev.	Depth to Water (TOC)	WT Elev.	Depth to Water (TOC)	WT Elev.
				10/17/2014		4/15/2015		10/20/2015	
MW-21	50	35 - 50	627.89	40.17	587.72	38.69	589.20	39.14	588.75
MW-55	23	5 - 20	545.28	15.36	529.92	15.14	530.14	14.93	530.35
MW-56	25	10 - 25	NM	7.80	NM	6.86	NM	6.41	NM
MW-56A	20	10 - 20	541.79	13.21	528.58	9.64	532.15	13.02	528.77
MW-56D	50	40 - 50	542.01	12.78	529.23	9.76	532.25	11.70	530.31
MW-57	20	10 - 20	543.11	12.61	530.5	12.35	530.76	11.53	531.58
MW-57D	50	40 - 50	543.69	11.63	532.06	11.31	532.38	12.39	531.30

All units given in feet
TOC = Top of Casing Elevation
WT = Groundwater Table

Table 2
Summary of Recent Site Groundwater Monitoring Data
Highway 49 C&D Landfill

Well ID		**MW-21 (Background Well)**								
Sampling Date		10/18/11	10/23/12	4/22/13	10/21/13	11/19/13	4/3/14	10/17/14	4/15/15	10/20/15
VOCS (µg/L)	**2L Std.**									
Benzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	3	ND	ND	ND	ND	ND	**25**	ND	2.1 J	ND
Carbon Disulfide	700	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	100	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dinoseb	7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	600	ND	ND	ND	ND	ND	ND	ND	2.5	1
Xylenes	500	ND	ND	ND	ND	ND	ND	ND	2.7	1.1
beta-BHC	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCA	6	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCE	350	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCE	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrahydrofuran	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	6	ND	ND	ND	ND	ND	ND	ND	0.21 J	ND
Acetophenone	NS	ND	ND	ND	ND	ND	ND	ND	ND	2.9
METALS (mg/L)										
Arsenic	0.01	ND	ND	ND	ND	NA	ND	ND	ND	0.01
Barium	0.7	0.0543	0.137	0.14	0.12	NA	0.12	0.043	0.05	0.14
Cadmium	0.002	ND	ND	ND	ND	NA	ND	ND	ND	0.00033
Calcium	NS	NA	NA	NA	NA	NA	NA	NA	NA	31
Chromium	0.01	ND	ND	ND	ND	NA	ND	ND	ND	0.00033
Cobalt	NS	ND	ND	ND	0.0099	NA	0.0066	ND	ND	0.011
Copper	1	ND	NS	0.0056	0.0068	NA	0.0033	0.37	0.05	ND
Lead	0.015	ND	ND	ND	ND	NA	ND	ND	ND	0.0018
Manganese	0.05	NA	NA	NA	NA	NA	NA	NA	NA	**1.8**
Nickel	0.1	ND	0.0154	ND	ND	NA	ND	ND	ND	0.0052
Selenium	0.02	ND	ND	ND	ND	NA	ND	ND	0.0013	ND
Thallium	NS	ND	N	ND	ND	NA	0.00057	ND	ND	ND
Vanadium	NS	ND	ND	ND	ND	NA	ND	ND	ND	0.0081
Zinc	1	0.159	ND	0.05	0.062	NA	0.061	0.048	0.041	0.19
Indicator Parameters (mg/L)										
Alkalinity	NS	125	156	180	NA	NA	NA	NA	NA	160
Ammonia- N		NA	NA	NA	NA	NA	NA	NA	NA	ND
Carbon Dioxide		NA	NA	NA	NA	NA	NA	NA	NA	200
Chloride	250	11.4	14.8	11	NA	NA	NA	NA	NA	10
Sulfate	250	12	30.9	32	NA	NA	NA	NA	NA	1.5
TDS	500	221	242	270	NA	NA	NA	NA	NA	310

2L Std. = 15A NCAC 02L .0202 Groundwater Standards (Eff. April 1, 2013) NA = Not Analyzed ND = Not Detected NS = Not Specified
Bold values exceed the NCDENR Standard

Table 2
Summary of Recent Site Groundwater Monitoring Data
Highway 49 C&D Landfill

Well ID		**MW-55**								
Sampling Date		10/18/11	10/23/12	4/22/13	10/21/13	11/19/13	4/3/14	10/17/14	4/15/15	10/20/15
VOCS (µg/L)	**2L Std.**									
Benzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	700	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	100	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dinoseb	7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	0.03	ND	ND	ND	**1.7**	**1.5**	ND	**2.1**	**0.66**	**1.1**
Toluene	600	ND	ND	ND	ND	ND	ND	ND	2.2	1.3
Xylenes	500	ND	ND	ND	ND	ND	ND	ND	2.1	1.2
beta-BHC	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCA	6	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCE	350	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCE	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrahydrofuran	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	6	ND	ND	ND	ND	ND	ND	ND	0.13 J	ND
Acetophenone	NS	ND	ND	ND	ND	ND	ND	ND	ND	6
METALS (mg/L)										
Arsenic	0.01	ND	ND	ND	0.001	NA	ND	ND	ND	0.0097
Barium	0.7	0.132	0.15	0.19	0.15	NA	0.21	0.13	0.17	0.17
Cadmium	0.002	ND	ND	ND	ND	NA	ND	ND	ND	ND
Calcium	NS	NA	NA	NA	NA	NA	NA	NA	NA	51
Chromium	0.01	ND	ND	ND	ND	NA	ND	ND	ND	ND
Cobalt	NS	0.0082	0.0096	ND	0.013	NA	0.0091	0.0066	0.0061	0.011
Copper	1	ND	0.0261	0.017	0.055	NA	0.01	0.0071	0.017	ND
Lead	0.015	ND	ND	ND	ND	NA	ND	ND	ND	ND
Manganese	0.05	NA	NA	NA	NA	NA	NA	NA	NA	**0.26**
Nickel	0.1	0.0085	0.0212	ND	0.035	NA	0.028	0.018	0.022	0.021
Selenium	0.02	ND	ND	ND	ND	NA	ND	0.0011	0.0018	ND
Thallium	NS	ND	ND	ND	ND	NA	0.00054	ND	ND	ND
Vanadium	NS	ND	0.0155	ND	0.025	NA	0.014	0.013	0.0075	0.013
Zinc	1	ND	0.0105	ND	0.079	NA	0.086	0.055	0.038	0.042
Indicator Parameters (mg/L)										
Alkalinity	NS	216	145	220	NA	NA	NA	NA	NA	180
Ammonia- N		NA	NA	NA	NA	NA	NA	NA	NA	ND
Carbon Dioxide		NA	NA	NA	NA	NA	NA	NA	NA	270
Chloride	250	13.1	14.9	13	NA	NA	NA	NA	NA	23
Sulfate	250	24.7	29.4	55	NA	NA	NA	NA	NA	ND
TDS	500	315	249	350	NA	NA	NA	NA	NA	340

2L Std. = 15A NCAC 02L .0202 Groundwater
Bold values exceed the NCDENR Standard

Table 2
Summary of Recent Site Groundwater Monitoring Data
Highway 49 C&D Landfill

Well ID		**MW-56**								
Sampling Date		10/18/11	10/23/12	4/22/13	10/21/13	11/19/13	4/3/14	10/17/14	4/15/15	10/20/15
VOCS (µg/L)	**2L Std.**									
Benzene	1	ND	ND	**2**	**2**	**1.4**	**2.1**	**1.1**	**0.48 J**	**1.3**
Bis(2-ethylhexyl)phthalate	3	ND	ND	ND	ND	ND	ND	ND	10	ND
Carbon Disulfide	700	ND	ND	ND	ND	ND	ND	ND	ND	1.4
cis-1,2-Dichloroethene	70	ND	ND	12	8.4	5.4	8	3.9	4.9	3.8
2,4-Dimethylphenol	100	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dinoseb	7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	ND	ND	ND	ND	ND	0.94 J	ND
Trichloroethene	3	ND	ND	**1.2**	ND	ND	ND	ND	0.46 J	ND
Vinyl Chloride	0.03	ND	ND	**14**	**24**	**18**	**26**	**27**	**8.2**	**6.3**
Toluene	600	ND	ND	ND	ND	ND	ND	ND	1.4	ND
Xylenes	500	ND	ND	ND	ND	ND	ND	ND	1.7	ND
beta-BHC	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCA	6	ND	ND	ND	ND	ND	ND	ND	0.29 J	ND
1,1-DCE	350	ND	ND	ND	ND	ND	ND	ND	0.31 J	ND
PCE	0.7	ND	ND	ND	ND	ND	ND	ND	0.43 J	ND
Tetrahydrofuran	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	6	ND	ND	ND	ND	ND	ND	ND	0.15 J	ND
Acetophenone	NS	ND	ND	ND	ND	ND	ND	ND	ND	1.5
METALS (mg/L)										
Arsenic	0.01	ND	ND	ND	ND	NA	ND	ND	ND	0.0029
Barium	0.7	0.102	0.145	0.07	0.068	NA	0.13	0.015	0.098	0.045
Cadmium	0.002	ND	ND	ND	ND	NA	ND	ND	ND	ND
Calcium	NS	NA	NA	NA	NA	NA	NA	NA	NA	17
Chromium	0.01	ND	ND	ND	ND	NA	ND	ND	ND	ND
Cobalt	NS	0.0098	0.0072	0.027	0.023	NA	0.033	ND	0.035	0.0091
Copper	1	ND	0.0324	ND	0.0037	NA	0.004	0.0062	0.0011	ND
Lead	0.015	ND	ND	ND	ND	NA	ND	ND	ND	ND
Manganese	0.05	NA	NA	NA	NA	NA	NA	NA	NA	**0.95**
Nickel	0.1	ND	0.0155	ND	ND	NA	ND	ND	0.0098	ND
Selenium	0.02	ND	ND	ND	ND	NA	ND	ND	0.0017	ND
Thallium	NS	ND	ND	ND	ND	NA	0.0013	ND	ND	ND
Vanadium	NS	ND	0.0151	ND	0.0067	NA	0.034	ND	ND	0.012
Zinc	1	0.0124	0.0104	0.062	0.074	NA	0.071	0.018	0.031	0.06
Indicator Parameters (mg/L)										
Alkalinity	NS	224	152	130	NA	NA	NA	NA	NA	190
Ammonia- N		NA	NA	NA	NA	NA	NA	NA	NA	ND
Carbon Dioxide		NA	NA	NA	NA	NA	NA	NA	NA	440
Chloride	250	13.8	14.9	8.2	NA	NA	NA	NA	NA	8.5
Sulfate	250	18.7	32	63	NA	NA	NA	NA	NA	ND
TDS	500	325	284	260	NA	NA	NA	NA	NA	390

2L Std. = 15A NCAC 02L .0202 Groundwater
Bold values exceed the NCDENR Standard

Table 2
Summary of Recent Site Groundwater Monitoring Data
Highway 49 C&D Landfill

Well ID		**MW-56A**						**MW-56D**					
Sampling Date		10/21/13	11/19/13	4/3/14	10/17/14	4/15/15	10/20/15	10/21/13	11/19/13	4/3/14	10/17/14	4/15/15	10/20/15
VOCS (µg/L)	**2L Std.**												
Benzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	3	ND	ND	ND	**30**	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	700	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
cis-1,2-Dichloroethene	70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dinoseb	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	600	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND	1.7	ND
Xylenes	500	ND	ND	ND	ND	1.5	ND	ND	ND	ND	ND	1.6	1
beta-BHC	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCA	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCE	350	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCE	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrahydrofuran	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.2 J	ND
Naphthalene	6	ND	ND	ND	ND	0.12 J	ND	ND	ND	ND	ND	0.12 J	ND
Acetophenone	NS	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	1.8
METALS (mg/L)													
Arsenic	0.01	ND	NA	0.001	ND	ND	0.0027	ND	NA	ND	ND	ND	ND
Barium	0.7	0.028	NA	0.037	0.04	0.048	0.064	0.019	NA	0.03	0.017	0.03	0.033
Cadmium	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	NS	NA	NA	NA	NA	NA	27	NA	NA	NA	NA	NA	62
Chromium	0.01	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND
Cobalt	NS	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND
Copper	1	0.0018	NA	0.002	0.0014	ND	ND	0.0011	NA	0.0011	0.0019	0.0014	ND
Lead	0.015	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND
Manganese	0.05	NA	NA	NA	NA	NA	**0.083**	NA	NA	NA	NA	NA	**0.073**
Nickel	0.1	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND
Selenium	0.02	ND	NA	ND	0.0013	0.0019	ND	0.0011	NA	0.001	ND	ND	ND
Thallium	NS	ND	NA	0.00052	ND	ND	ND	ND	NA	0.00051	ND	ND	ND
Vanadium	NS	ND	NA	ND	ND	ND	0.0076	ND	NA	ND	ND	ND	ND
Zinc	1	0.013	NA	0.018	0.02	ND	0.022	0.011	NA	0.015	0.014	ND	ND
Indicator Parameters (mg/L)													
Alkalinity	NS	NA	NA	NA	NA	NA	82	NA	NA	NA	NA	NA	150
Ammonia- N		NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND
Carbon Dioxide		NA	NA	NA	NA	NA	120	NA	NA	NA	NA	NA	140
Chloride	250	NA	NA	NA	NA	NA	20	NA	NA	NA	NA	NA	7.5
Sulfate	250	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND
TDS	500	NA	NA	NA	NA	NA	230	NA	NA	NA	NA	NA	320

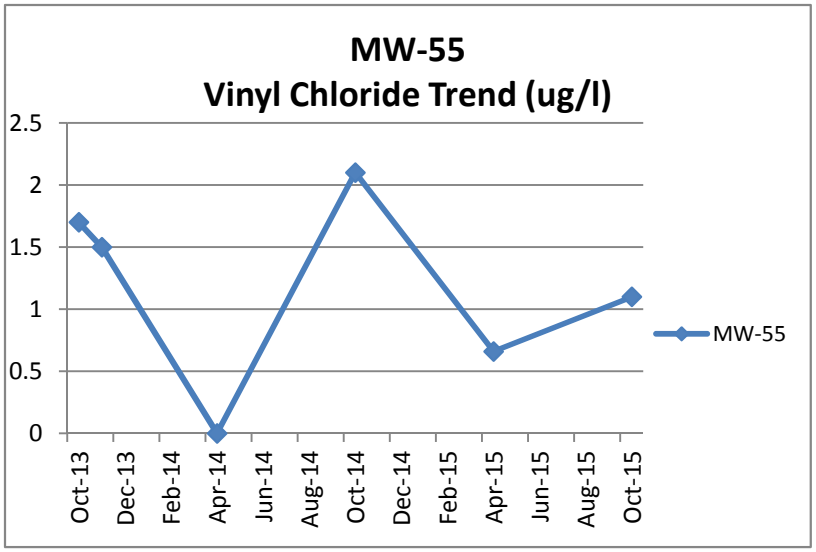
2L Std. = 15A NCAC 02L .0202 Groundwater
Bold values exceed the NCDENR Standard

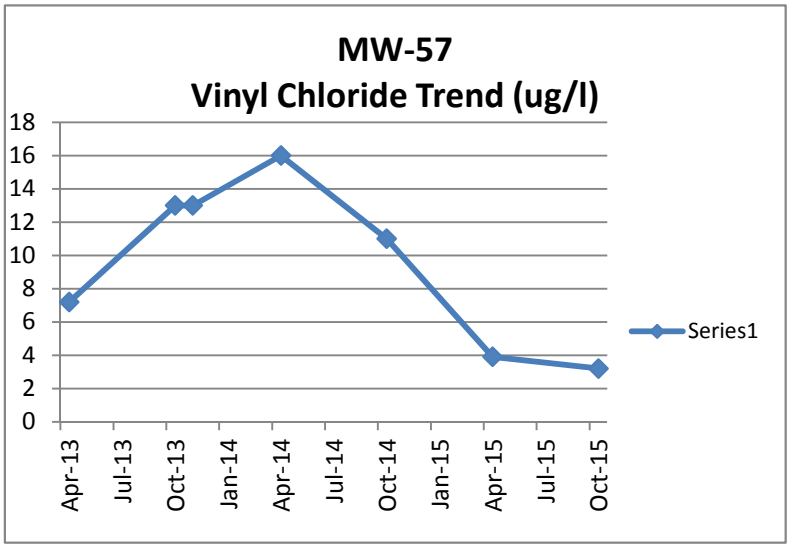
Table 2
Summary of Recent Site Groundwater Monitoring Data
Highway 49 C&D Landfill

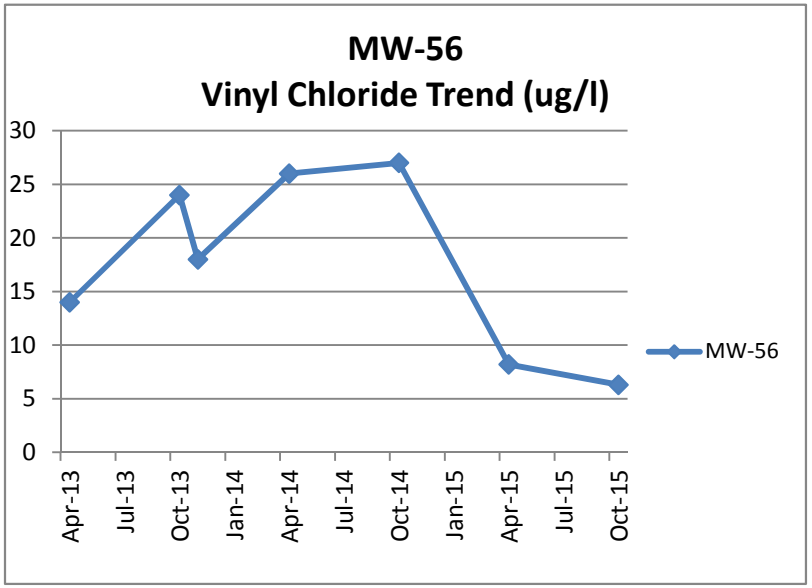
Well ID		**MW-57**								
Sampling Date		10/18/11	10/23/12	4/22/13	10/21/13	11/19/13	4/3/14	10/17/14	4/15/15	10/20/15
VOCS (µg/L)	**2L Std.**									
Benzene	1	ND	ND	ND	ND	ND	ND	ND	0.89 J	ND
Bis(2-ethylhexyl)phthalate	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	700	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	ND	ND	**1.2**	ND	ND	ND	ND	0.61 J	ND
2,4-Dimethylphenol	100	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dinoseb	7	ND	ND	ND	ND	ND	3.2	ND	ND	ND
Methylene Chloride	5	ND	ND	**1.1**	ND	ND	ND	ND	0.71 J	ND
Trichloroethene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	0.03	ND	ND	**7.2**	**13**	**13**	**16**	**11**	**3.9**	**3.2**
Toluene	600	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes	500	ND	ND	ND	ND	ND	ND	ND	ND	ND
beta-BHC	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCA	6	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCE	350	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCE	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrahydrofuran	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	6	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetophenone	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND
METALS (mg/L)										
Arsenic	0.01	ND	ND	ND	0.005	NA	ND	0.0017	ND	0.0018
Barium	0.7	0.0741	0.152	0.079	0.38	NA	0.38	0.41	0.31	0.41
Cadmium	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	NS	NA	NA	NA	NA	NA	NA	NA	NA	130
Chromium	0.01	ND	ND	ND	ND	NA	0.013	ND	ND	ND
Cobalt	NS	ND	ND	ND	0.024	NA	0.023	0.064	0.011	0.047
Copper	1	ND	ND	ND	0.0033	NA	0.016	0.014	ND	ND
Lead	0.015	ND	ND	ND	ND	NA	0.006	ND	ND	ND
Manganese	0.05	NA	NA	NA	NA	NA	NA	NA	NA	**19**
Nickel	0.1	ND	ND	ND	0.013	NA	0.021	0.0072	0.02	0.0089
Selenium	0.02	ND	ND	ND	0.0057	NA	ND	0.0018	ND	0.0025
Thallium	NS	ND	ND	ND	ND	NA	0.00056	ND	ND	ND
Vanadium	NS	ND	0.0062	ND	ND	NA	0.051	ND	ND	ND
Zinc	1	0.117	ND	ND	0.18	NA	0.2	0.17	0.046	0.093
Indicator Parameters (mg/L)										
Alkalinity	NS	153	692	700	NA	NA	NA	NA	NA	500
Ammonia- N		NA	NA	NA	NA	NA	NA	NA	NA	1.7
Carbon Dioxide		NA	NA	NA	NA	NA	NA	NA	NA	700
Chloride	250	13.5	15.4	63	NA	NA	NA	NA	NA	39
Sulfate	250	12.1	31.4	120	NA	NA	NA	NA	NA	ND
TDS	500	230	1020	1100	NA	NA	NA	NA	NA	**890**

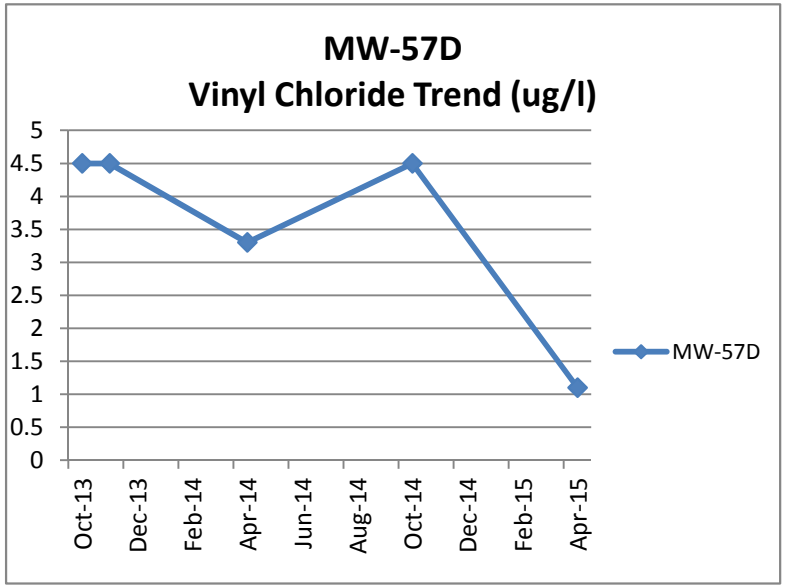
2L Std. = 15A NCAC 02L .0202 Groundwater
Bold values exceed the NCDENR Standard

Charts for Table2
Highway 49 C&D Landfill
CEC Project 111-370.002









APPENDIX A
2015 METHANE MONITORING DATA

ENVIRO-PRO
PROFESSIONAL CORPORATION

January 5, 2016

Mr. Mike Griffin
Greenway Waste Solutions of Harrisburg, LLC
19109 W. Catawba Avenue, Suite 200
Cornelius, North Carolina 28031-5613

RE: Methane Monitoring Report (2nd, 3rd, and 4th Quarters 2015)
Highway 49 C&D Landfill
Harrisburg, North Carolina
Project No. EP-1271

Dear Mr. Griffin:

Attached please find the second, third, and fourth quarter 2015 Methane Monitoring Field Data sheets for the seven methane monitoring wells (MMW-1 through MMW-7) at the subject site. Methane readings were recorded in the field on June 25, September 29, and December 28, 2015 by Enviro-Pro personnel utilizing a Landtec GEM-2000 Gas Extraction Monitor. Methane was detected during these field events in MMW-2, MMW-3, and MMW-6 at levels below NCDENR allowable limits. Low methane concentrations were also observed in the air at ground level at these locations, due to the presence of decomposing wood chips and mulch on the ground from past storage in these areas. The methane detected in these wells is not believed to be related to the landfilling of any buried material within this facility.

Please contact me at (803) 547-4955 if you have any questions concerning this information.

Sincerely,
ENVIRO-PRO, P.C.

Thomas H. Bolyard

Thomas H. Bolyard, P.G.
Senior Hydrogeologist

2646 Farmlake Lane • Fort Mill, SC 29708 • (803) 547-4955 • Fax (803) 548-2233

METHANE MONITORING FIELD DATA

Well Number: MMW-1

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 6/25/15

Personnel: BVB

Time: 10:00 a.m.

Ambient Temperature: 80° F

Barometric Pressure: 30.08

Weather Conditions: Clear & Hot

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane: 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-2

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 6/25/15

Personnel: BVB

Time: 10:15 a.m.

Ambient Temperature: 81° F

Barometric Pressure: 30.08

Weather Conditions: Clear & Hot

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-3

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 6/25/15

Personnel: BVB

Time: 10:25 a.m.

Ambient Temperature: 81° F

Barometric Pressure: 30.08

Weather Conditions: Clear & Hot

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 2.3 % LEL: 13

METHANE MONITORING FIELD DATA

Well Number: MMW-4

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 6/25/15

Personnel: BVB

Time: 10:40 a.m.

Ambient Temperature: 82° F

Barometric Pressure: 30.08

Weather Conditions: Clear & Hot

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-5

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 6/25/15

Personnel: BVB

Time: 10:50 a.m.

Ambient Temperature: 82° F

Barometric Pressure: 30.08

Weather Conditions: Clear & Hot

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-6

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 6/25/15

Personnel: BVB

Time: 11:05 a.m.

Ambient Temperature: 83° F

Barometric Pressure: 30.08

Weather Conditions: Clear & Hot

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 1.1 % LEL: 4.7

METHANE MONITORING FIELD DATA

Well Number: MMW-7

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 6/25/15

Personnel: BVB

Time: 11:20 a.m.

Ambient Temperature: 83° F

Barometric Pressure: 30.08

Weather Conditions: Clear & Hot

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-1

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 9/29/15

Personnel: BVB

Time: 10:15 a.m.

Ambient Temperature: 70° F

Barometric Pressure: 29.93

Weather Conditions: Cloudy & Warm

Soil Moisture Conditions: Sl. Moist

Condition of Well: Good

Methane Reading: % Methane: 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-2

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 9/29/15

Personnel: BVB

Time: 10:30 a.m.

Ambient Temperature: 70° F

Barometric Pressure: 29.93

Weather Conditions: Cloudy & Warm

Soil Moisture Conditions: Sl. Moist

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-3

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 9/29/15

Personnel: BVB

Time: 10:45 a.m.

Ambient Temperature: 71° F

Barometric Pressure: 29.93

Weather Conditions: Cloudy & Warm

Soil Moisture Conditions: Sl. Moist

Condition of Well: Good

Methane Reading: % Methane 1.3 % LEL: 7.3

METHANE MONITORING FIELD DATA

Well Number: MMW-4

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 9/29/15

Personnel: BVB

Time: 11:00 a.m.

Ambient Temperature: 71° F

Barometric Pressure: 29.93

Weather Conditions: Cloudy & Warm

Soil Moisture Conditions: Sl. Moist

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-5

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 9/29/15

Personnel: BVB

Time: 11:15 a.m.

Ambient Temperature: 72° F

Barometric Pressure: 29.93

Weather Conditions: Cloudy & Warm

Soil Moisture Conditions: Sl. Moist

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-6

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 9/29/15

Personnel: BVB

Time: 11:25 a.m.

Ambient Temperature: 72° F

Barometric Pressure: 29.93

Weather Conditions: Cloudy & Warm

Soil Moisture Conditions: Sl. Moist

Condition of Well: Good

Methane Reading: % Methane 0.5 % LEL: 3.2

METHANE MONITORING FIELD DATA

Well Number: MMW-7

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 9/29/15

Personnel: BVB

Time: 11:40 a.m.

Ambient Temperature: 73° F

Barometric Pressure: 29.93

Weather Conditions: Cloudy & Warm

Soil Moisture Conditions: Sl. Moist

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-1

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 12/28/15

Personnel: BVB

Time: 10:20 a.m.

Ambient Temperature: 58° F

Barometric Pressure: 30.10

Weather Conditions: Cloudy & Cool

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane: 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-2

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 12/28/15

Personnel: BVB

Time: 10:30 a.m.

Ambient Temperature: 58° F

Barometric Pressure: 30.10

Weather Conditions: Cloudy & Cool

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 2.3 % LEL: 9.7

METHANE MONITORING FIELD DATA

Well Number: MMW-3

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 12/28/15

Personnel: BVB

Time: 10:45 a.m.

Ambient Temperature: 59° F

Barometric Pressure: 30.10

Weather Conditions: Cloudy & Cool

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0.9 % LEL: 5.8

METHANE MONITORING FIELD DATA

Well Number: MMW-4

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 12/28/15

Personnel: BVB

Time: 10:55 a.m.

Ambient Temperature: 59° F

Barometric Pressure: 30.10

Weather Conditions: Cloudy & Cool

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-5

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 12/28/15

Personnel: BVB

Time: 11:10 a.m.

Ambient Temperature: 59° F

Barometric Pressure: 30.10

Weather Conditions: Cloudy & Cool

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0

METHANE MONITORING FIELD DATA

Well Number: MMW-6

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 12/28/15

Personnel: BVB

Time: 11:20 a.m.

Ambient Temperature: 60° F

Barometric Pressure: 30.10

Weather Conditions: Cloudy & Cool

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 1.7 % LEL: 5.5

METHANE MONITORING FIELD DATA

Well Number: MMW-7

Project Name: Highway 49 C&D Landfill

Location: Harrisburg, NC

Project Number: EP-1271

Date: 12/28/15

Personnel: BVB

Time: 11:35 a.m.

Ambient Temperature: 60° F

Barometric Pressure: 30.10

Weather Conditions: Cloudy & Cool

Soil Moisture Conditions: Dry

Condition of Well: Good

Methane Reading: % Methane 0 % LEL: 0