EXECUTIVE SUMMARY:

This report documents the first semi-annual monitoring event of 2013 for the Environmental Waste Solutions, LLC (EWS) Class II Landfill. The Class II landfill is registered with the Tennessee Division of Solid Waste Management (TDSWM) with permit number IDL 03-0212. The EWS Camden Class II Landfill is located in Benton County at 200 Omar Circle, Camden, Tennessee (latitude 36°03'16" N/ longitude 88°05'16" W).

The following table presents the wells that were used to develop this report.

Upgradient Monitoring Point	Downgradient Monitoring Points
MW-1	MW-3, MW-4

Groundwater samples were collected on March 27, 2013 and April 11, 2013. ESC Lab Sciences performed the analysis and reported the results on April 5, and April 25, 2013, respectively. All monitoring wells were sampled during the event, with the exception of MW-2, which was recently replaced by MW-4. MW-2 has subsequently been removed from the monitoring network due to the continued lack of a sufficient volume of water required for representative sampling. MW-2 remains in place, and will continue to be monitored for field parameters and water level data. The collected groundwater samples were analyzed for Appendix I inorganics as well as parameters which are present in the landfill leachate which include Chloride, Nitrate, Sulfate, Ammonia (NH3), Boron, and a short list of ions.

Since additional waste streams have been approved for disposal in the EWS Class II Landfill, the TDSWM requested that EWS add the volatile organic compounds (VOCs) included in the Appendix I *Constituents For Groundwater Monitoring* presented in Rule 0400-11-01-.04 (9.) d of the Rules and Regulations Governing Solid Waste Disposal in Tennessee to the existing groundwater constituents. The groundwater was sampled by House Engineering LLC (HE) on July 2, 2013 and taken to the Environmental Science Laboratory in Mt. Juliet, Tennessee for analysis and were reported to HE on July 9, 2013.

In addition to the VOCs several Bromide and Coliform Bacteria were added to the list of parameters to assist in the determination of increases in specific inorganic parameters such as Chloride and Nitrate.

Bromide was selected because of its' excellent performance as a tracer in fate and transport studies. (See attached paper by Flury and Papritz) Furthermore, the Chloride content of soils usually is much larger than the Bromide content, since there is much more Chloride in crustal rock (Bowen, 1979) and since large quantities of Chloride enter the soil in manures, fertilizers, and defrosting agents. Because Bromide occurs in much smaller background concentrations, it often is preferred as a tracer in transport studies (e.g., Owens et al., 1985; Gish et al., 1986; Butters et al., 1989)

The proximity of the Camden sanitary sewer pipe system (**See Figure 2**) was also considered as a potential source of chloride and nitrate detected in groundwater samples.

Since chloride and nitrate are present in the landfill leachate and the sanitary sewer effluent, it was necessary to add yet another parameter to the list which is generally present only in the sanitary sewer effluent. Coliform bacteria were selected for laboratory testing since its presence indicates contamination with human or animal wastes. The EWS Landfill leachate, Camden sanitary sewer effluent and EWS groundwater well samples were tested for Coliform bacteria to assist in the determination in the source of the chloride and nitrate detected in the groundwater.

The results of the laboratory analytical testing of sewer effluent, groundwater and leachate samples taken since 2011 is presented in Table 2 of this report.

Inter-well prediction interval analysis was used to identify statistically significant increases (SSIs) over background concentrations for the analyzed water quality parameters. The percentage of inter-well background non-detects for each parameter determines the primary statistical method utilized for each parameter. If the percentage of non-detects in the background samples is less than 50%, Shewart-CUSUM control charts are utilized. If more than 50% background non-detects exist for the given parameter, non-parametric inter-well prediction limit analysis is conducted on the data. Only parameters reported above the detection limits of the laboratory were evaluated. The results of the analysis are summarized as follows:

- One SSI over background was identified for chloride and barium at MW-3 as a result of the analysis. This is consistent with historical data.

The next semi-annual monitoring event is tentatively scheduled for October, 2013.

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APPENDICES

Glossary of Terms

Appendix I – Refers to the required regulatory sample list of groundwater parameters
CEC – Civil & Environmental Consultants, Inc.
Class I Landfill – Municipal Solid Waste Landfill accepts household waste
Class II Landfill – Industrial Waste Landfill
Class IV Landfill – Construction/Demolition Waste Landfill
Class III/IV Landfill – Landscaping and Construction/Demolition Waste Landfill
DML – Construction Demolition Landfill
EPA – Environmental Protection Agency
ESC – ESC Lab Sciences
EWS – Environmental Waste Solutions
GW – Groundwater
HDPE – High Density Polyethylene
HE – House Engineering LLC
HI – Hydrogeologic Investigation
MCL – Maximum Contaminant Level
$\mu S \cdot cm^{-1}$ - micro-Siemens per centimeter
mg/L – milligrams per Liter
MW – Monitor Well
NPPL - Non-parametric prediction limit analysis
ORP – Oxidation Reduction Potential
POTW – Publically Operated Treatment Works
ppm – parts per million*
PQL – Practical Quantitation Limit
QC – Quality Control
SNL – Sanitary Landfill
TDEC – Tennessee Department of Environment and Conservation
TDOG – Tennessee Division of Geology
TDSWM – Tennessee Division of Solid Waste Management
TOC – Top of Casing
VOC – Volatile Organic Compound

* ppm – parts per million* is equivalent to mg/L – milligrams per Liter

I Introduction

A. Site Location

EWS, LLC. owns and operates the Camden Class II landfill located just off highway US 70 at 200 Omar Circle, Camden, Tennessee. The site can be located on the Camden, Tennessee USGS quadrangle at north latitude 36° 3' 16" and west longitude 88° 05' 16" at an average elevation of 400 feet above mean sea level datum (MSL). The location of the facility is indicated in **Figure 1- Site location Map**. The landfill footprint can be viewed in **Figure 2 - Potentiometric Surface Map.**

B. Current Activities

The EWS Camden Class II Landfill currently receives secondary aluminum smelter waste for disposal including aluminum dross and salt cakes and other industrial wastes approved by the TDSWM.

II Aquifer Characteristics

A. Geologic and Aquifer Characteristics

The extensive reworking of the site as a result of the excavation of chert for local road and fill projects has significantly impacted the original site geology. However, the large cuts within the site boundaries have exposed the underlying geologic formations. Based upon a review of the Tennessee Division of Geology (TDOG) Geologic Map and site observations it appears that the site is within the Camden and Harriman Formations. It is reported by the TDOG that the Camden and Harriman Formations are lithologically identical, and not enough fossils are present to form a convenient basis for subdivision.

Camden and Harriman Formations

The Camden and Harriman Formations are described as follows:
Chert, gray with specks and mottlings of very light-gray and yellowish-gray (surfaces stained pale to dark yellowish-orange), bedded and blocky (beds 2 to 8 inches thick), dense, conchoidal fracture, contains pods of white to light gray tripolitic clay, locally stained yellow and brown, fossiliferous. Locally, especially near the top, fragments of chert are cemented into large masses and beds of breccia by dark-brown to moderate-red limonite.

Groundwater potentiometric data collected from the uppermost water bearing zone across the entire proposed waste area footprint during the 1999 and 2006 hydrogeological investigations indicate that the uppermost aquifer is sloped to the southwest. Comparisons of the water bearing zone elevations to static groundwater elevations for both indicate an unconfined aquifer.

B. Monitor Well Integrity & Static Water Levels

The groundwater monitoring network for the Class II Landfill consists of monitor wells MW-1, MW-3, and MW-4. Monitor well MW-1 serves as an up-gradient monitoring point while monitor wells MW-3 and MW-4 serve as down-gradient monitoring points.

The integrity of each monitor well is checked during each sampling event prior to groundwater collection. The physical condition of each wellhead is observed and noted along with the condition and ability of any and all locking mechanisms for each monitor well. Once the watertight seal is removed from the top of each monitor well's casing, the well is allowed to de-pressurize. A decontaminated electronic probe is slowly lowered into the monitor well to establish the distance between the established top of casing and the elevation of free groundwater. The distance is then re-checked to ensure that the measurement is of actual static water level and the groundwater is not rising or falling in the monitor well. The electronic probe is capable of determining this distance to within one, one-hundredth of one foot (0.01 foot). This distance is written in the site-specific field book as depth-to-water. Upon collection of this data, the electronic water level probe is removed from the monitor well and decontaminated from contact with the well casing / screen and groundwater.

The following equation is used to determine the elevation of groundwater at each well:

Established Top of Casing Elevation – Depth to Water = Groundwater Elevation

Top of casing elevation has been determined by a licensed land surveyor and is referenced to Mean Sea Level Datum of the World Geodetic Survey of 1984. Groundwater elevations are listed in **Table 1 - Field Parameters & Potentiometric Data, Appendix A**.

C. Groundwater Flow Direction

Groundwater flow at the landfill appears to flow in a southwesterly direction towards Charlie Creek. Groundwater flow in the vicinity of the Class II Landfill appears to flow from a topographic high north, northeast of the landfill toward the southwest where monitor wells MW-3 and MW-4 are positioned to intercept any possible groundwater contaminants leaching from the landfill.

D. Potentiometric Gradient

The Potentiometric surface of the first aquifer occurring beneath the Class II Landfill occurs at approximately twenty-two (23) feet below ground surface at the up-gradient monitor well MW-1 to approximately six (8) feet below ground surface at monitor well MW-2. The groundwater potentiometric data interpreted from the 1999 and 2006 hydrogeological investigations conducted at the site for the uppermost aquifer indicate that the uppermost water bearing zone is sloped to the southwest. Comparisons of water bearing zone elevations to static groundwater elevations for both investigations indicate an unconfined aquifer. The potentiometric gradient calculated from groundwater elevation data collected in March and July of 2013 ranged from 3.56% to approximately 2.2 % slope.

The potentiometric gradient from measurements taken on March 27, 2013 has been calculated according to the following formula:

$$\frac{\text{Highest GW. Elev.} - \text{Lowest GW. Elev.}}{\text{Horizontal Distance between the Potentiometric Contours}} * 100 = \text{Pot. Grad.}$$

$$\frac{(394.05' \text{ at MW-1}) - (358.4' \text{ at MW-2})}{1{,}000'} * 100 = 3.56\%$$

The above calculation assumes a perpendicular gradient between the potentiometric contours drawn between MW-1 to MW-4. These assumptions may provide an artificially higher potentiometric gradient than is likely occurring at the site.

E. Hydraulic Conductivity

Hydraulic conductivity estimations within the first aquifer occurring beneath either landfill have not been determined at this time.

III Groundwater Sampling Procedures

A. Instrumentation

Depth to groundwater measurements were collected by CEC using a Solinst® electronic water level indicator, model # 122. CEC also employed a YSI 556 Multi-parameter probe is used to record pH, specific conductance, temperature, dissolved oxygen and ORP during groundwater sampling events at the landfill. A LaMotte model 2020 turbidity meter or equivalent is used to collect turbidity readings. Each instrument is either checked against known standards or calibrated as per manufacturers' specifications prior to the commencement of sampling activities.

HE utilized a Keck Water Level Meter with 100 feet of tape to check groundwater levels in the monitor wells. HE also utilized a Horiba U22X Multi-parameter probe to record pH, specific conductivity, temperature, dissolved oxygen, ORP and turbidity of the groundwater within each groundwater well prior to and at the time of sampling.

B. Purging and Collection of Field Parameter Values

The total volume of groundwater residing in each monitor well is calculated by subtracting the depth to water from the total depth of each well. This linear distance is next multiplied by 0.163 gallons per foot in a 2 inch (I.D.) monitor well. For purging, a disposable polyethylene bailer with sufficient nylon twine is slowly lowered into the water column. The bailer is allowed to completely submerse into the water column prior to extracting the bailer from the monitor well. The first bailer of purged groundwater is collected in a clean, high-density polyethylene (HDPE) reservoir where it is observed for Temperature, pH, specific conductance, dissolved oxygen, oxidation-reduction potential (ORP) and turbidity. These values are noted in the site specific field book as V_0 and then the collected groundwater is discarded onto the ground, away from the monitor well. Groundwater shall be purged using either a decontaminated down-well pump using new tubing or using new tubing connected to a peristaltic pump or in the case of a pump malfunction, a new disposable bailer.

Normally, bailers are not used at the EWS Camden Class II Landfill. However, if bailers are used due to pump malfunction, bailers shall be constructed of either polyethylene or Teflon. Bailers shall be factory decontaminated and sealed as to allow no environmental contaminants to interact with the bailer. New nylon twine shall be fixed to each bailer via a tied knot.

The collected groundwater will be decanted into a flow-through cell where it will be observed for pH, specific conductance, temperature, and turbidity. These values will be noted in the site specific field book as V_0 and then the collected groundwater will be poured onto the ground, down-gradient from the monitor well.

Groundwater shall be purged from the monitor well for a specific period of time that allows for a new volume of water to have passed into the flow-through cell. Once this volume of water has been purged, the field chemistry parameters will again be observed and recorded in the field book as V_1. This procedure for purging groundwater continues for an additional well volume, if sufficient groundwater is available. After the second purged well volume has been observed for field parameter values, the values are checked against values for V_1. If the pH and specific conductance values for each volume purged vary no more than 10% from V_1 to V_2 and the temperature has stabilized to within one degree Celsius, preparations are made to collect a groundwater sample for submittal to an analytical laboratory. If the field parameters have not stabilized, the purging procedure shall continue until either one of the following conditions are met:

1. Field stabilization occurs,
2. Well is purged dry, or
3. Five well volumes have been purged.

If the monitor well is purged dry, then the recharging groundwater shall be collected within twenty-four hours.

Field parameter values are presented in **Table 1 – Groundwater Field Data, Appendix A**. A detailed account of each purge and sample procedure conducted at each monitor well is presented in **Appendix B**.

C. Sample Collection & Preservation

Groundwater samples are collected from monitor wells once field parameter data indicates that stagnant water has been purged from the well. Groundwater is placed in laboratory supplied sample vessels in the following order if analyzed: Appendix I inorganics – one (1), five-hundred (500) ml preserved with nitric (HNO3) acid; Chloride, Nitrate, Sulfate – one (1), two-hundred fifty (250) ml unpreserved HDPE jar; Ammonia – one (1), two-hundred fifty (250) ml HDPE jar preserved with sulfuric (H2SO4) acid.

D. Quality Assurance & Quality Control

Field blanks were collected for each sample collection event performed to date at the EWS Class II Landfill. CEC collected a field blank next to monitoring well MW-3. HE collected a field blank next to MW-4. The field blanks were collected by pouring deionized water into a duplicate set of sample bottles. Thereby, allowing any airborne contaminants a chance to enter the field blank sample. Laboratory analytical testing of the field blanks did not reveal the presence of any of the EWS Class II Landfill site specific target compounds.

In addition, a duplicate sample was collected from MW-3 for laboratory quality control purposes. The reported values for the duplicate sample are similar to the original MW-3 sample with the exception of Aluminum and Iron. Aluminum was detected at a concentration of 0.82 mg/L in the original sample from MW-3 and at a concentration of 0.38 mg/L in the duplicate from MW-3. Iron was detected at a concentration of 0.3 mg/L in the original sample from MW-3 and at a concentration of 0.17 mg/L in the duplicate from MW-3.

E. Sample Chain-of-Custody

A sample Chain-of-Custody (COC) traveled along with each sample kit from ESC to EWS and finally back to ESC for the sampling events. The CEC SOP for Chain of Custody 07-01-01 may be found in **Appendix E**.

IV Laboratory Analytical Procedures

A. Analytical Methods

All laboratory testing of groundwater samples taken in 2013 were performed by the Environmental Science Corporation (ESC) located in Mt. Juliet, Tennessee. However, the leachate analytical tests were performed by TEC Lab in Jackson, Tennessee. The analytical methods chosen for this monitoring event are the most appropriate procedures as directed by the Tennessee Division of Solid Waste Management (TDSWM) and the United States Environmental Protection Agency's publication SW-846, entitled *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (3rd Edition)*.

The SW-846 methods used for the analysis of groundwater (if necessary) were as follows:

Method 6010b	Inductively Coupled Plasma (ICP) – Atomic Emission Spectrometry
Method 6020	ICP – Mass Spectrometry
Method 7470A	Mercury in Liquid Waste – Manual Cold Vapor Technique
Method 8011	1,2-dibromoethane & 1,2 dibromo-3-chloropropane by Micro-extraction and Gas Chromatography
Method 8260B	Volatile Organic Compounds by Gas Chromatograph / Mass Spectrometry
Method 9056	Determination of Inorganic Anions by Ion Chromatography (Fluoride)
Method 9222D	Fecal Coliform Membrane Filter Procedure

B. Laboratory Analytical Results

Laboratory reports from the analysis of groundwater samples collected from the EWS Camden Class II Landfill during the semi-annual monitoring event were prepared by ESC and reported to CEC on August 13, 2012. Copies of the laboratory reports are located in **Appendix C –**

Laboratory Analytical Reports. Constituent values from all laboratory analysis along with applicable maximum contaminant levels (MCLs) are presented in **Table 2 – Analytical Results, Appendix A**.

C. Quality Control Qualifier Codes

The EPA Contract Laboratory Program states that sample and result qualifiers should be utilized as part of a total quality control process. ESC complies with this directive and reports all qualifiers along with explanations of QC qualifier codes. One QC qualifier code was indicated during the laboratory analysis of groundwater samples during this monitoring event and can be viewed along with the **Laboratory Analytical Reports, Appendix C**.

V Statistical Analysis

A. Applicable Methods

The Rules of Tennessee Department of Environment and Conservation, Division of Solid Waste Management Chapter 1200-1-7-.04 states, in part, that each landfill must conduct and report statistical analysis as part of the evaluation of groundwater monitoring data. Several methods may be employed for this endeavor. EWS Camden Class II Landfill has chosen to use Inter-well and intra-well non-parametric prediction limit analysis (NPPL) at this time.

First, the distribution of the data was evaluated for normality. For all wells, the data was not normally distributed; therefore, non-parametric statistical methods were chosen. Inter-well and intra-well non-parametric prediction limit analyses (NPPL) were deemed appropriate for this data set. Inter-well analyses compared the concentrations observed at the down-gradient monitoring locations to the concentrations observed at the up-gradient monitoring location during this monitoring event. For the Class II Landfill, monitor well MW-1 was considered as background. Intra-well analysis was also utilized at MW-1 to compare the concentrations observed during the July 2012 groundwater sampling event to the established background data set.

The percentage of inter-well background non-detects for each parameter determines the primary statistical method utilized for each parameter. If the percentage of non-detects in the background samples is less than 50%, Shewart-CUSUM control charts are utilized. If more than 50% background non-detects exist for the given parameter, non-parametric inter-well prediction limit analysis is conducted on the data.

The computer program ChemStat was used for all statistical computations. Worksheets indicating inter-well and intra-well statistical analysis sheets and time versus concentration charts may be viewed in **Appendix D, Statistical and Trend Analysis**.

B. Results

Review of the statistical analysis performed on the available data indicated that there were two statistically significant increases (SSI's) over background data. The SSI's over background data were limited to Barium (MW-3), and Chloride (MW-3). The Barium and Chloride detections at MW-3 are well below their associated MCL's.

Trend analysis utilizing the limited data available from the monitoring events showed no distinct trends for the site monitoring wells.

VI Conclusions and Recommendations

Representative groundwater samples were collected from monitor wells MW-1, MW-3 and MW-4. Groundwater samples have been analyzed for Appendix I inorganics, Bromide, Chloride, Nitrate, Sulfate, Ammonia (NH_3), a short list of ions, and Coliform bacteria.

EWS Groundwater Quality Relative to the EPA Primary Drinking Water Standards

Laboratory analytical results for the groundwater samples collected from the facility monitor wells for the EWS Class II Landfill indicated that two compounds were detected at concentrations which exceeded the EPA maximum contaminant levels (MCL). Specifically, the concentration of Arsenic in MW-1 and the concentration of Nitrate in MW-4 were detected above their respective maximum contaminant levels (MCL).

Arsenic was detected in MW-1 at a concentration of (0.049 mg/l). The MCL for Arsenic is (0.01 mg/l). Arsenic has been detected at concentrations exceeding the primary drinking water MCL prior to the disposal of waste in the landfill. More specifically, laboratory analytical testing of groundwater samples taken from MW-1 during background testing of the groundwater prior to waste placement in the landfill revealed concentrations of Arsenic ranging from 0.024 mg/L to 0.072 mg/L. Therefore, the presence of Arsenic in the groundwater is attributable to naturally occurring deposits in the soil overburden since there is no immediate development up-gradient of the well.

Nitrate was detected at MW-4 at a concentration of (29 mg/L) on March 27, 2013 and at (16 mg/L) on April 11, 2013. The MCL for Nitrate is (10 mg/L). A discussion relative to the source of the Nitrate in the groundwater is provided in a later section of this document.

EWS Groundwater Quality Relative to the Tennessee Secondary Drinking Water Standards

Laboratory analytical results for the groundwater samples collected in March and April of 2013 from the EWS Class II Landfill groundwater monitor well network indicated that four of the site specific groundwater monitor list of compounds were detected at concentrations which exceeded the Tennessee Public Water Supply Secondary Drinking Water Standards (2DW). Those parameters included Iron and Manganese in the upgradient groundwater well identified as MW-1, Aluminum and Manganese in MW-3, and Chloride, Nitrate, and Manganese in MW-4.

Aluminum has been detected historically in each of the groundwater monitor wells. A review of the Tennessee Division of Geology (TDOG) publication titled "Geologic Source and Chemical Quality of Public Groundwater Supplies in Western Tennessee" written by C.R. Lanphere reported Aluminum concentrations of 1.3 mg/L and 1.2 mg/L in two wells owned and used by the city of Camden for drinking water. Each of the aforementioned concentrations exceeds the Tennessee Secondary Drinking Water Standard for Public Water Supply sources. The Aluminum which was detected in groundwater samples taken from MW-3 during the March 2013 sample event was present at a concentration of 0.82 mg/L which is under the concentration which has been reported by the TDOG for Camden drinking water supply wells.

Iron was detected at a concentration of 26 mg/L in MW-1 prior to the placement of waste. Therefore, the concentration in the groundwater sample taken during the March 2013 sample event of 16 mg/L is not considered the result of a new offsite source.

Manganese has been detected in at least one of the wells since groundwater sampling was initiated at the site. Therefore, it is believed that the Manganese is occurs naturally in the site soils. The high turbidity of the groundwater during the July 2013 sample event would increase the potential for detection of Manganese.

Chloride has historically been detected in MW-3 at concentrations ranging from 8.2 mg/L to 25 mg/L even prior to waste placement in the landfill. Chloride has also been historically detected in MW-1 at concentrations ranging from 1.9 mg/L to 2.9 mg/L even prior to waste placement.

The Chloride detected in MW-4 was detected in the groundwater samples taken during the March 2013 groundwater sample event at 270 mg/L which exceeds the Tennessee Secondary Drinking Water Standard for Public Water Supply sources. Therefore, EWS requested a second sample event be performed to verify the concentration and determine the potential source of the Tennessee Secondary Drinking Water Standard for Public Water Supply Standard exceedence. The second sample of groundwater was secured in April and the laboratory testing reported the Chloride concentration at 150 mg/L which is below the Tennessee Secondary Drinking Water Standard for Public Water Supply maximum concentration of 250 mg/L.

Evaluation of the Source of Chloride and Nitrate Impacts to MW-4 Groundwater

From a review of the laboratory test results performed on the initial groundwater sample taken from MW-4 it was evident that the elevated concentration Chloride, Nitrate and Ammonia Nitrate in the groundwater was attributable to anthropogenic sources. Due to the presence of both Ammonia at concentrations exceeding 3,000 mg/L and Chloride present at concentrations exceeding 30,000 mg/L in the EWS landfill leachate it was necessary to further evaluate if the landfill leachate was the source of the high concentration of inorganic parameters in the groundwater.

Specific Conductivity Measurements

EWS initially measured the **specific conductivity** of the water within the sediment pond below the current waste disposal cell which is upgradient of MW-4 in an attempt to determine if the landfill leachate was leaking from the landfill. Based upon the base elevation of the sediment pond and landfill sump the sediment basin would also be impacted by the high concentration of Chloride and Nitrates within the landfill leachate. Measurements taken by HE with a Horiba U22x Multi-parameter meter determined the conductivity of the pond water at 67 micro-Siemens per centimeter ($\mu S \cdot cm^{-1}$). Measurements taken by CEC with a YSI 556 Multi-parameter probe revealed that the conductivity of the groundwater within MW-4 was as high as 1041 $\mu S \cdot cm^{-1}$ on March 27, 2013 and as high as 977 $\mu S \cdot cm^{-1}$ on April 11, 2013. CEC also measured the effluent within the Camden POTW manhole on April 11, 2013 and the result was 984 $\mu S \cdot cm^{-1}$. HE measured the groundwater from within MW-4 on July 2, 2013 at 690 $\mu S \cdot cm^{-1}$. It should be noted that CEC reported groundwater measurements of specific conductivity on the other downgradient well designated as MW-3 at a concentration of 138 $\mu S \cdot cm^{-1}$ on March 27, 2013. HE reported groundwater measurements of specific conductivity in MW-3 at a concentration of 260 $\mu S \cdot cm^{-1}$ on July 2, 2013. All specific conductivity measurements taken from MW-3 were substantially lower than those taken from MW-4 and the Camden POTW manhole. It should also be noted that MW-3 is closer to the waste footprint than MW-4.

Groundwater Tracer Parameters

Prior to the promulgation of the EPA Subtitle D landfill regulations chloride was a compound routinely used for evaluating impacts to groundwater from landfill leachate due to its mobility in through even low permeability clay soils. However, since large quantities of Chloride enter the soil in manures, fertilizers, and defrosting agents and since there is often a naturally occurring concentration of Chloride in both the soil overburden and crustal rock it has been replaced as the most reliable compound to determine impacts from anthropogenic sources. Chloride has been replaced as a groundwater tracer by Bromide because it occurs in much smaller background concentrations and migrates through the natural environment more rapidly. Thus, it has become the preferred tracer in of many groundwater professionals who perform transport studies (e.g., Owens et al., 1985; Gish et al., 1986; Butters et al., 1989).

Chloride Summary

Historical Evaluation of Elevated Chloride Concentration in MW-2

In 2011 an evaluation was performed to determine the potential source of the Chloride in the EWS groundwater monitor well designated as MW-2. Initially, EWS sampled the landfill leachate and sent the sample to the lab to determine the concentration of Appendix 1 parameters for comparison with the parameters detected in the groundwater from within MW-2. Another potential source of impact to the groundwater in MW-2 was also identified. The sanitary sewer manhole located 45 feet southeast of MW-2 had been observed to overflow on numerous occasions both before and since MW-2 was sampled in 2011. The overflow of the manhole resulted in standing water adjacent to and around MW-2. Therefore, EWS staff sampled the overflow of water from the manhole and delivered the sample to TEC Environmental Laboratories, Inc. in Jackson, Tennessee, for testing. The pH of the sample was also determined along with the concentration of Aluminum and Chloride.

A review was performed of the results of both the landfill leachate testing and the Camden POTW manhole waste water testing. The results of the testing revealed Chloride concentrations in the water from the manhole at 367 mg/L and Aluminum at 0.284 mg/L. The results of the testing of the leachate revealed Chloride concentrations at 23,100 mg/L while Aluminum was not detected. Based upon this analytical testing it appears that the source of the detected Chloride at a measured concentration of 44 mg/L in MW-2 was most likely not attributable to the migration of leachate from the landfill. This opinion was based upon the fact that the concentration of chloride in the landfill leachate along with the proximity of the landfill limits would potentially result in much higher concentrations of chloride in the groundwater than 44 mg/L. This in combination with the fact that no aluminum was detected in the leachate while the sanitary sewer waste water revealed aluminum concentrations within the range detected in MW-2. Therefore, the impacts of chloride and aluminum in MW-2 could possibly be more attributable to the recent problems with overflows from the Camden sanitary sewer system.

To further substantiate this claim the EPA computer developed fate and transport program referred to as Multi-Med was used to predict the concentration of chloride in MW-2 with a transient condition such as an overflow from the Camden POTW manhole. The results of the modeling resulted in a predicted concentration of 48 mg/L in MW-2 based on the concentration of chloride in the manhole. This predicted concentration of Chloride at 48 mg/l in MW-2 was extremely accurate since the actual concentration of Chloride in MW-2 was determined in the laboratory at 44 mg/L.

Current Evaluation of Elevated Chloride in MW-4

As previously discussed Chlorides were detected in groundwater samples taken from MW-4 at concentrations ranging from 150 mg/L to 270 mg/L. In addition, laboratory testing of leachate samples taken at the site has revealed Chloride concentrations in excess of 30,000 mg/L. Finally, a Camden POTW manhole located within close proximity (less than 50 feet) of MW-4 has been sampled and tested for Chloride in April of 2013. The results indicate the concentration of Chloride in the Camden POTW of 250 mg/L in a waste water sample taken the same day as a groundwater sample was taken from MW-4. The lab tests performed on the groundwater sample taken from MW-4 measured the Chloride concentration at 150 mg/L.

Bromide Summary

Bromide testing was performed on the landfill leachate, the groundwater from MW-4, and on waste water samples secured from the Camden POTW manhole closest to MW-4. The laboratory analytical testing revealed the presence of Bromide in the leachate at a concentration of 19 mg/L. However, Bromide was not detected in the groundwater sample taken from MW-4 or the waste water sample taken from the Camden POTW manhole.

Anthropogenic Indicator Parameters

As previously mentioned the proximity of the Camden POTW to the groundwater monitor network at the EWS Class II Landfill along with observations of overflows from the pipe network manholes warranted an investigation of the POTW as a possible source of groundwater impact. EWS has previously sampled (November 2011) the groundwater from MW-2 and delivered the sample to ESC so they could perform the test for Fecal Coliform. ESC reported Fecal Coliform in the groundwater sample from MW-2 at 99 col/100ml.

A review of the results of the initial testing of groundwater samples from MW-4 also created a suspicion that the Camden POTW may be a potential source of the high levels of chloride particularly since MW-4 is even closer to the Camden POTW pipe network than MW-2. It is estimated that MW-4 is situated within approximately 15 feet of the Camden POTW pipe network. Therefore, samples were collected from MW-4 and taken to ESC to determine if **Coliform** was present in the groundwater from within MW-4. ESC reported a total coliform concentration within the groundwater from MW-4 at 720 MPN/100ml which again would suggest impact from the Camden POTW pipe network which transmits sewer wastes to the treatment lagoons adjacent to the EWS Class II Landfill property. This opinion is also based upon recent laboratory analytical testing of the landfill leachate for the presence of e coli, fecal coliform and total coliform. None of the aforementioned coliform parameters were detected in the landfill leachate.

In conclusion, it is the opinion of HE that MW-4 is not presently impacted from the EWS Class II Landfill disposal operations and should not be placed into the assessment phase of groundwater monitoring. This opinion is based upon the results of the laboratory analytical testing of groundwater, leachate and POTW effluent and the detailed discussions presented in the previous sections of this report.

The next semi-annual groundwater monitoring event for the EWS Class II Landfill is tentatively scheduled for October, 2013.