Addendum to the Cave Creek Landfill Groundwater Characterization Work Plan ADEQ Consent Order No. S-102-05

Prepared for:

Maricopa County Solid Waste Management Department
2901 West Durango
Phoenix, Arizona 85009

Submitted by:

AMEC Earth & Environmental, Inc.
Tempe, Arizona

May 11, 2009

AMEC Job No. 09-114-03000

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND TERMS

Acronym/Term	Definition
μg/L	micrograms per liter
AAC	Arizona Administrative Code
amsl	above mean sea level
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
AMEC	AMEC Earth & Environmental
AOC	Administrative Order of Consent
AWQS	Aquifer Water Quality Standards
BAS	Brian A. Stirrat & Associates
bgs	below ground surface
CCL	Cave Creek Landfill
COCs	Constituents of Concern
COP	City of Phoenix
COS	City of Scottsdale
CSM	Conceptual Site Model
DCE	1,1-Dichloroethene
EPA	Environmental Protection Agency
IDW	Investigative Derived Waste
LCS	Low Carbon Steel
MCRM	Maricopa County Risk Management
MCSWMD	Maricopa County Solid Waste Management Department
MDL	Method Detection Limit
PCE	tetrachloroethene
PDB	Passive Diffusion Bag
SRV	Salt River Valley
TCE	trichloroethene
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds
Work Plan	Groundwater Characterization Work Plan, August 26, 2005

1.0 INTRODUCTION

The 2005 Groundwater Characterization Work Plan (*Work Plan*) for Cave Creek Landfill (CCL) was prepared for Maricopa County by Brian A. Stirrat & Associates (BAS), dated August 26, 2005 (2005). On August 31, 2006, ADEQ issued a letter to Maricopa County Solid Waste Management Department (MCSWMD), accepting the *Work Plan* with the provision that additional monitoring wells would need to be installed if the proposed new monitoring well (MW-3) "…fails its intended purposes of assessment and characterization of the nature and extent of releases." (ADEQ, 2006). In addition, recent meetings with ADEQ CCL project personnel on March 24, 2008 and April 8, 2008, resulted in a general consensus that additional groundwater characterization and the installation of additional monitoring wells is necessary to adequately delineate the extent of groundwater contamination at the site. This document has therefore been prepared as an Addendum to the existing *Work Plan* (BAS, 2005) for the CCL, and identifies the approach for the additional groundwater characterization activities.

1.1 Site Information

The CCL is owned and operated by the MCSWMD and is located at 3955 East Carefree Highway, in the City of Phoenix, in Maricopa County, Arizona (Figure 1). Information regarding parcel information and the legal description of the property are included in the *Work Plan* (BAS, 2005).

1.2 Involved Parties

AMEC Earth & Environmental, Inc. (AMEC) has been contracted by MCSWMD and Maricopa County Risk Management (MCRM) to conduct additional groundwater characterization at CCL. Contact information for AMEC is provided below:

MCRM Environmental Programs Manager:	Rita Neill, P.E.
Address:	222 North Central Ave., #1110 Phoenix, Arizona 85004
Phone:	(602) 506-5063
Facsimile	(602) 506-5939
MCSWMD Director:	William (Bill) Thornton
Address:	2901 West Durango Phoenix, Arizona 85009
Phone:	(602) 506-7336
Facsimile	(602) 506-8396
AMEC Project Manager:	Misael Cabrera, P.E.
Address:	1405 West Auto Drive Tempe, Arizona 85284
Phone:	(480) 940-2320
Facsimile	(480) 785-0970

1.3 Landfill History and Permits

Refer to the *Work Plan* (BAS, 2005) for the operational and permitting history of CCL.

1.4 Project Background

The following is a summary of groundwater characterization activities (listed in order of occurrence) as documented in the *Work Plan* (BAS, 2005):

- Installation of a groundwater production well (PW-1) in October 1982.
- Installation of monitoring wells, MW-1 and MW-2 in 1993.
- MCSWMD entered into a Consent Order with ADEQ requiring the characterization of the nature and extent of site (CCL) groundwater contamination in 1999.
- Soil and landfill gas sampling at the CCL in 1999.
- Additional soil gas and landfill gas sampling at the CCL in 2004.
- Geophysical logging of CCL wells PW-1, MW-1, and MW-2, and a gyroscopic survey of MW-2 during the period December 1-3, 2004.
- Extension of PW-1 perforations from 680 to 760 feet below ground surface (bgs) on January 20, 2005.
- Deepening of CCL monitoring wells MW-1 and MW-2 to 820 and 805 feet bgs, respectively, during the period January 21 through February 8, 2005.
- ADEQ revision of the original Consent Order for the CCL on June 29, 2005.

Since the submittal of the *Work Plan* (BAS, 2005) to the ADEQ in August 2005, the following activities related to groundwater characterization at the CCL have occurred (listed in order of occurrence):

- In August 2007, MCSWMD attempted to raise the dedicated electrical submersible pump in MW-1 for servicing. During the attempted removal, the pump became firmly lodged inside of the well casing thus rendering it inoperable. Additional attempts to remove the pump were unsuccessful and as a result, MW-1 continues to be inoperable.
- MW-3 (Arizona Department of Water Resources (ADWR) Registration No. 55-216293) was drilled and installed between September and December 2007 by Yellow Jacket Drilling Services, LLC., approximately 500 feet east of the CCL property boundary (see Figure 1) on Maricopa County parcel number 211-60-025 which is owned by the Dove Valley Ranch Community Association. MW-3 was completed to a depth of 820 feet bgs, with blank steel casing from land surface to approximately 679 feet bgs, and 0.125 inch wide factory slotted steel screen from approximately 679 to 799 feet bgs (BAS, 2005). The lower part of the borehole from approximately 799 to 830 bgs was filled with hydrated bentonite pellets. Groundwater was reported at a depth of 684 feet bgs during the borehole drilling for MW-3. No Constituents of Concern (COCs) per the Consent Order for the CCL have been detected in MW-3 to date.

Monthly groundwater monitoring and sampling has been conducted at the CLL since 1999 from the four existing site wells. Monthly status reports have been submitted to ADEQ per the Consent Order since that time.

1.5 Adjacent Land Uses

As indicated in the *Work Plan* (BAS, 2005), undeveloped land is currently located in portions of land north, south, and west of CCL. The northeastern boundary of CCL is bounded by a golf course. Since the *Work Plan* was approved by the ADEQ, a residential housing development has been built adjacent to CCL along North Black Mountain Parkway at the southeastern facility boundary (see Figure 1). Additional residential housing is present east of the golf course. As indicated in the *Work Plan*, Carefree Highway is located approximately 0.5 miles north of CCL.

2.0 HYDROGEOLOGIC FRAMEWORK

The hydrogeologic framework for the site is outlined in the *Work Plan* (BAS, 2005). This Addendum to the *Work Plan* contains a summary of the most recent stratigraphic interpretation by ADWR in their update to the Salt River Valley (SRV) groundwater model (ADWR, 2006). This incorporates additional regional drilling data, related to the hydrogeologic units present within and immediately adjacent to the CCL.

2.1 Subsurface Geology

The CCL lies within the Basin and Range Physiographic Province in Central Arizona. In this area, the mountains are generally comprised of crystalline rock separated by broad alluvial valleys. Mountains represent upthrown fault blocks from which sediments have been eroded and deposited in the basins below. In the centers of these basins, depth to bedrock can exceed 10,000 feet bgs. The CCL is located in the East SRV sub-basin of the Phoenix Active Management Area, a groundwater basin established by the ADWR.

Subsurface geology beneath CCL is typical for the East SRV and for the Phoenix area. In the subsurface, sedimentary units that overlie the bedrock in the area of CCL are identified by the ADWR (2006) as the Upper Alluvial Unit (UAU), the Middle Alluvial Unit (MAU), and the Lower Alluvial Unit (LAU). These units are comprised of alluvial deposits associated with surface fluvial/alluvial depositional processes. The UAU is comprised mainly of unconsolidated gravel, sand, and silt deposited in alluvial channel, terrace, and floodplain deposits (Corell and Corkhill, 1994). The MAU is comprised mainly of clay, silt, mudstone and gypsiferous mudstone with some interbedded sand and gravel. Near the margins of the alluvial basins, and the area of CCL, the MAU consists mainly of sand and gravel and is reported as difficult or impossible to distinguish from other units (ADWR, 2006). The LAU is subdivided into two parts in the area of the CCL: The lower part is composed of evaporite deposits (gypsum and anhydrite) interbedded with sand, gravel, and basaltic rocks. The upper part is composed of semi-consolidated sand, gravel and silt.

Geology has been interpolated in the area near CCL due to the large amount of undeveloped land in the region and the lack of deep well drilling logs or other lithologic interpretative data. ADWR (2006) estimates that across the CCL property boundaries, the bottom elevation of the UAU ranges from approximately 1,600 to 1,500 feet above mean sea level (amsl), the bottom of the MAU ranges from approximately 1,200 to 1,000 feet amsl, and the bottom of the LAU ranges from approximately 1000 to 800 feet amsl. The bottom elevation of the MAU at the site is depicted in Figure 2. Based on the lithologic logs for CCL wells MW-1 through MW-3 (as filed with the ADWR), the MAU within and immediately adjacent to the CCL ranges from approximately 1,234 to 1,049 feet amsl. The groundwater elevation at the CCL ranges from approximately 1,163 to 1,205 feet amsl indicating that the UAU is predominantly unsaturated at CCL.

2.2 Surface Water

As presented in the *Work Plan* (BAS, 2005), Cave Creek is located approximately 400 feet northwest of the site and is the only natural surface water body located within a one-mile radius of the CCL (see Figure 1). Cave Creek is generally dry and flows only in response to local rain events. A gauging station, U.S. Geological Survey (USGS) station number 09512280, that monitors the rate is flow and elevation of Cave Creek is located approximately 7 miles north of the CCL property as shown in Figure 3.

Three retention basins are present on the CCL property (See Figure 1). In addition, a pond (construction unknown) is present at the golf course located to the east of CCL.

2.3 Groundwater

2.3.1 Regional Wells

As presented in Section 2.1, groundwater elevations at the CCL ranges from approximately 1,163 to 1,205 feet amsl (or 675 to 690 feet bgs). Groundwater in the CCL area has continued to be developed as potable and non-potable water sources since the mid to late 1980s. Prior to the development of City of Scottsdale (COS) and City of Phoenix (COP) groundwater well fields (circa 1978) the predominant direction of groundwater flow in the CCL vicinity was to the southwest (Littin, 1979). An evaluation of the changes in groundwater flow directions between 1985 and January 2009 was performed using regional groundwater elevation data obtained from the most recent ADWR Groundwater Site Inventory database (ADWR, 2009), historical CCL vicinity reports, and CCL site and CCL vicinity monitoring and production well data. Of the available data, the following information was used to interpret the predominant direction of groundwater flow:

Time Period	Predominant Groundwater Flow Direction
January 1985	Southwest (Figure 4)
July through August 1993	Southeast (Figure 5) (Dames & Moore, 1993)
January 2006	Southeast (Figure 6)
December 2007	South/Southeast (Figure 7)
January 2009	Southwest (Figure 8)

Hydrographs were generated using the aforementioned water level data to further evaluate and graphically illustrate groundwater level trends within a 3-mile radius of the CCL. The time periods used to depict regional flow directions in Figures 4 through 8 were selected based on the availability of at least four (4) measurements from regional and/or site wells. The hydrographs display an overall decline in groundwater elevations since circa 1983 (Figure 9). A map showing the locations of the wells used to generate the hydrographs is presented as Figure 10. A list of all ADWR-registered wells located within a 3-mile radius of CCL is provided in Table 2. Specifically, the following was noted:

- A groundwater elevation decline of 86.6 feet from 1983 to 2009 occurred in COP Well 55-603807 (Figure 11).
- A groundwater elevation decline of 64.8 feet from 1991 to 2009 occurred in COS Well 55-518789 (a.k.a. COP Well #65) (Figure 12).
- A groundwater elevation decline of 6.92 feet from 2000 to 2009 occurred in COP Well 55-600030 (Figure 13).
- A groundwater elevation decline of 117.1 feet from 1983 to 2007 occurred in COP Well 55-800785 (Figure 14).

Groundwater elevations from these four regional wells were also compared to changes in surface water elevations in Cave Creek using stream gauge data obtained from the USGS (2009) using available data for the time period January 1980 through December 2008. The comparison was conducted to evaluate whether or not there is a direct correlation between changes in surface water elevations in Cave Creek and changes in water level elevations in the regional aquifer within the CCL area. Although no significant responses were noted between the two, and the data suggests that surface water flow along Cave Creek has limited impacts to regional water elevations in the CCL area (see Figure 9), further study is required due to the following:

- The impact to water levels from flow in Cave Creek may be less than the impact of ongoing pumping at the regional wells.
- There is limited water level data for the regional wells before and after measurable flow events in Cave Creek.
- The distance between the regional production wells and Cave Creek is relatively large.

The COP and COS water departments were contacted by AMEC to gather information regarding their long-term pumping plans, as their operations appear to be attributing to the observed decline in groundwater elevations at the CCL. The COS hydrogeologist (COS, 2009) informed AMEC that due to the construction of their water delivery system, their wells in the area (i.e., ADWR Well No. 55-518789 (or COS Well #65)) will continue to pump into the future at rates consistent with those currently reported (see Appendix A).

The COP hydrogeologist (COP, 2009) indicated that the COP will be installing and/or replacing groundwater production wells in the area of CCL to act as Aquifer Storage and Recovery (ASR) wells within the next two years to help mitigate groundwater level declines in their service area. The use of ASR wells is anticipated to further influence groundwater flow directions and groundwater elevations at the CCL, and thus may impact future trichloroethene (TCE) transport mechanisms. Therefore, any future remedial activities recommended for the CCL should be dynamic and adaptable to such influences. The Characterization Plan as presented in Section 3.0 of this Addendum has been created with this in mind. Historical pumping records for select COP wells located within a 3-mile radius of the CCL is included in Appendix A.

2.3.2 CCL Wells

The direction of groundwater flow at the CCL was further evaluated through a three-point problem analysis using groundwater elevation data obtained form CCL wells PW-1, MW-1, MW-2, and MW-3 for the period March 2005 through February 2009 (Table 1). From these data, flow azimuths were calculated for a total of 59 time periods. Based on these calculations, groundwater flow azimuths were greater than 180 degrees from due north in a clockwise direction (corresponding to a groundwater flow direction of southwest) 64 percent of the time. The calculated hydraulic gradient for the same time period evaluated ranged from 0.003 to 0.01 feet/feet, with an average of 0.004 feet/feet. While this analysis indicates that CCL area groundwater flow occurs with a higher frequency to the southwest (from March 2005 through February 2009), groundwater flow direction at the CCL is variable from southwest, to south, and to the southeast as indicated by the groundwater gradient direction frequency diagram presented as Figure 15.

Hydrographs were generated using the aforementioned water level data to further evaluate and graphically illustrate groundwater level trends at CCL. The hydrographs display an overall decline in groundwater elevations since circa 2001 (Figure 16). A map showing the locations of the wells used to generate the hydrographs is presented in Figure 1. Specifically, the following was noted:

- PW-1: The groundwater elevation declined 33 feet from 2001 to 2009.
- MW-1: The groundwater elevation declined 6.72 feet from 2005 to 2007.
- MW-2: The groundwater elevation declined 10.2 feet from 2001 to 2009.
- MW-3: The groundwater elevation declined 2.5 feet from 2008 to 2009.

Groundwater elevations from these four site wells were also compared to changes in surface water elevations in Cave Creek using stream gauge data obtained from the USGS (2009) using available data for the time period April 2001 through February 2009. The comparison was conducted to evaluate whether or not there is a direct correlation between changes in surface water elevations in Cave Creek and changes in water level elevations in the regional aquifer within the CCL area. Large increases in the volume of flow in Cave Creek at the gauging station corresponded to increases in water levels in CCL monitoring wells. The data suggests that surface water flow in Cave Creek at the gauging station has direct impacts to water elevations at the CCL (see Figure 16). However, further study is required to determine if flow in Cave Creek impacts the flow direction at the site.

2.4 Groundwater Contamination

As presented in the *Work Plan (BAS, 2005)*, TCE is the primary COC in groundwater at the CCL, and has been historically detected near or above the ADEQ Aquifer Water Quality Standards (AWQS) for TCE of 5 micrograms per Liter (µg/L). Tetrachloroethene (PCE), 1,1-dichloroethene (1,1-DCE), and toluene have also been historically detected at CCL wells PW-1 and MW-2, but have remained below their respective ADEQ AQWS.

A summary of TCE concentrations reported at the four CCL wells, and the most current TCE concentrations (March 2009), are presented in the table below. The historical monthly concentrations of TCE for the four CCL wells are provided in Table 1, and plotted separately for each CCL well on Figures 17 through 20. Laboratory results for the March 2009 groundwater sampling event are included in Appendix B.

Well ID	Maximum TCE Concentration (µg/L)	Minimum TCE Concentration (µg/L)	Average TCE Concentration (µg/L)	March 2009 Reported TCE Concentration (µg/L)
PW-1	110	ND	18.2	86
MW-1	66	3	25.3	NS
MW-2	320	2.5	108.7	280
MW-3	ND	ND	ND	ND

Notes:
ND – Not detected above the laboratory reported method detection limit (MDL)
NS – Not sampled (inaccessible for sampling because pump is stuck in the well)
AWQS for TCE = 5 µg/L

Of note are the following observations with regards to changes in TCE concentrations from the four existing CCL wells:

- Concentrations of TCE in PW-1 have increased by 86 percent from February 2007 to March 2009 (increasing from 12 to 86 µg/L) (see Figure 17).
- Concentrations of TCE in MW-1 have increased by 95 percent from February 2007 to March 2009 (increasing from less than 3 µg/L to 66 µg/L) (see Figure 18).
- Concentrations of TCE in MW-2 have increased by over 100 percent from February 2007 to March 2009 (increasing from less than 5 µg/L to 280 µg/L) (see Figure 19).
- Concentrations of TCE in MW-3 have been below the laboratory's reported MDL since the well has been sampled (see Figure 20).

3.0 CHARACTERIZATION PLAN

The proposed work includes the following four activities (listed in order of occurrence):

- Vertical Groundwater Profiling at MW-2.
- Optional – Adjust Pump Setting in MW-3 and Collect Groundwater Sample.
- Lateral Plume Definition (Test Boreholes and Monitoring Wells).
- Downgradient Plume Definition (Test Boreholes and Monitoring Wells).

This proposed characterization approach has been designed to leverage data that is collected during one activity before proceeding to the next. The approach also reduces the uncertainty associated with defining the extent of contamination while maintaining an accelerated schedule. The vertical profiling data collected at MW-2 will help select the target depths for groundwater sampling from the test boreholes. Data collected from the test boreholes, in turn, will help identify appropriate locations for the monitoring wells. The objective of the approach is to install a monitoring well network that adequately defines the lateral and downgradient extent of contamination associated with the CCL.

3.1 Vertical Groundwater Profiling at MW-2

AMEC will conduct vertical groundwater profiling at MW-2. The vertical profiling will consist of collecting up to five (5) water quality samples at 20-foot intervals within the well's screen, and submitting them to an Arizona Department of Health Services (ADHS) certified analytical laboratory for the analysis of VOCs using Environmental Protection Agency (EPA) method 8260B. The objective of the vertical profiling is to identify whether or not the concentrations of TCE (and other CCL COCs) vary with depth in the underlying aquifer at MW-2. Data collected from this task will enable us to select the optimal depths for collecting groundwater quality samples from the test boreholes and will aid in the selection of screened depths for the new proposed CCL monitoring wells. The vertical profiling will be conducted using passive diffusion bag (PDB) samplers using the sampling protocols developed by the USGS (Vroblesky, 2001).

Each PDB sampler will consist of a 2-inch diameter low-density polyethylene tube containing high purity, laboratory grade water and heat-sealed at both ends. PDB samplers will be attached to a weighted line by plastic cable ties. The samplers will be deployed and allowed to equilibrate for a minimum of 15 days. Recovery of the PDB samplers will consist of removing them from the wells and decanting the water into 40-milliliter volatile organic analysis (VOA) vials using the straws that are supplied with the PDB samplers, and transferring the samples to a commercial laboratory for analysis using EPA Method 8260B.

3.2 Optional – Adjust Pump Setting in MW-3 and Collect Groundwater Sample

This task is proposed as an optional activity pending the assessment of the concentration profile of TCE (and other VOCs) in MW-2. As presented in Section 2.4, there have been no detections of TCE or other VOCs above their respective laboratory reported MDL in MW-3 since the well has been sampled. It is possible that this may be due to the depth of the permanent pump in MW-3, which is set at approximately 75 feet deeper than the pump intake setting in MW-2. This optional task is intended to evaluate potential variations in TCE concentrations (and other VOCs) with depth below the local (CCL area) groundwater table.

If TCE concentrations in MW-2 decrease with depth (as determined from the PDB sampling as presented in Section 3.1) the pump intake setting in MW-3 will be adjusted upward to approximately the same elevation as the pump intake setting in MW-1 and MW-2 (between 1052 to 1054 feet amsl). Following the pump intake adjustment, AMEC will collect a groundwater sample from MW-3 and submit it to an ADHS Certified analytical laboratory for the analysis of VOCs using EPA Method 8260B. The sampling protocol for collecting the groundwater sample from MW-3 shall be identical to that used by MCSWD to date for the four existing CCL wells. If TCE concentrations in MW-2 do not decrease with depth, then this task shall not be completed.

3.3 Lateral Plume Definition

Up to four (4) test boreholes and two (2) new monitoring wells will be completed (to approximately the same depth as MW-2) to help define the lateral extent (or width) of the TCE plume. More specifically, this will include the following:

- Up to two (2) test boreholes and one (1) new monitoring well located to the east/southeast of MW-2 in one of the two test borings or depending on the results of sampling in the first two test borings and in consultation with MCSWM and ADEQ.
- Up to two (2) test boreholes and one (1) new monitoring well located to the west/southwest of MW-2 in one of the two test borings or depending on the results of sampling in the first two test borings and in consultation with MCSWM and ADEQ.

The proposed locations of the initial test boreholes are based upon the projected 5 µg/L TCE concentration extent using a combination of Darcy's Law (Freeze and Cherry, 1979) and a one dimensional (1-D) dispersion equation (Ogata and Banks 1961, Ogata, 1970), and TCE plume dispersion calculations provided to AMEC by ADEQ developed using the latest version (Version 1.43) of BIOSCREEN-AT (Newell and others, 1996). The final proposed test borehole (see Section 3.5.1) and new monitoring well locations (see Section 3.5.2) will be a combined function of the aforementioned projections and the TCE concentration data collected from groundwater sampling at the proposed test boreholes. Land ownership issues may also play a role in selecting the final test borehole and monitoring well locations, and will be considered (as needed) in the decision making process with MCSWD and ADEQ.

Following ADEQ's approval of the initial test borehole locations, AMEC will coordinate with the selected driller to complete the test boreholes. AMEC will collect groundwater samples during test borehole drilling for analysis of TCE (and other VOCs). The groundwater samples will be submitted to an ADHS Certified analytical laboratory for the analysis of VOCs using EPA Method 8260B. To expedite field activities, the laboratory analyses will be requested on a

24-hour turnaround basis. As further detailed in Section 3.5.1, the sampling depths in the proposed test boreholes will be based on data collected during the vertical profiling of MW-2.

3.4 Downgradient Plume Definition

In addition to defining the lateral extent (or width) of the TCE plume, another objective of this groundwater investigation is to help define the downgradient extent of the TCE plume. Based upon our review of historical groundwater elevation data at the CCL, the direction of groundwater flow varies from south/southwest to south/southeast. The downgradient plume definition will include:

- Up to two (2) test boreholes completed at some distance south of MW-2.
- One (1) new monitoring well completed in one of the test borings or at some distance south of MW-2, or depending on the results of sampling in the first two test borings and in consultation with MCSWM and ADEQ.

The exact locations of the test boreholes and new monitoring well will be based upon the same criteria as presented for lateral plume definition (see Section 3.3).

3.5 Groundwater Characterization Field Work

The following sections describe how this Addendum to the *Work Plan* (BAS, 2005) will be executed in the field.

3.5.1 Test Borehole Drilling and Sampling

Up to two (2) test boreholes (TB-1 and TB-2) will be completed to the east/southeast of MW-2 to help define the eastern lateral extent of the TCE plume. Up to two (2) test boreholes (TB-3 and TB-4) will be completed to the west/southwest of MW-2 to help define the western lateral extent of the TCE plume. Also, up to two (2) test boreholes (TB-5 and TB-6) will be completed to the south of MW-2 to help define the downgradient extent of the TCE plume. A proposed test borehole location map showing the first three test boring locations is provided as Figure 21. During test borehole drilling, AMEC will visually log representative drill cuttings every 10 feet in borehole depth. The proposed drilling method is dual tube air rotary. Each test boring will be approximately 6-inches in diameter and drilled to a total depth that will equal the depth of the highest detected concentrations in MW-2 (as determined from the vertical profiling activities presented in Task 3.1). Use of drilling mud or other drilling additives will be avoided, if possible. However, should the desired drilling depths be unattainable by the dual tube air rotary method, drilling will be converted to a mud rotary method. All groundwater and soil generated during drilling activities will be properly contained for later Investigative Derived Waste (IDW) profiling and disposal purposes per the protocols presented in Section 4.0.

AMEC will collect a representative “grab” sample of groundwater at a similar depth interval where the maximum concentration of TCE is detected from the MW-2 vertical profiling activities. Only one groundwater sample will be retrieved from each test borehole. The groundwater samples will be submitted to an ADHS Certified analytical laboratory for the analysis of VOCs using EPA Method 8260B. To expedite field activities, the laboratory analyses will be requested on a 24-hour turnaround basis. Based upon our initial evaluation of bids obtained from four qualified and licensed Arizona drilling companies, along with our analysis of available sampling methods given the anticipated drilling methods and the objectives of this Addendum, it is anticipated that the groundwater samples will be collected with one of the three following methods:

- Case and Bail
- Hydropunch™.
- SimulProbe™.

Selection of the most appropriate sampling method/sampling tool will be based on numerous factors, including but not limited to: equipment availability; costs; geologic conditions (i.e., hard rock conditions or the presence of cemented formations or large cobbles, preventing the use of a direct-push sampling tool), etc. However, if none of these sampling methods will allow the successful collection of a representative groundwater sample, then other methods may be proposed pending the evaluation of drilling and sampling conditions. A summary of three proposed sampling methods is provided below:

CASE AND BAIL

If a drive casing advance method is used to drill the test boreholes, then the “Case and Bail” method will be the preferred sampling method. In this method, a temporary section of blank drill pipe is advanced to the desired sampling depth (below the groundwater table). Once the desired sampling depth has been reached, drilling is ceased and groundwater is allowed to enter the open end (bottom) of the drive casing, until is has reached the aquifer’s natural potentiometer surface (equivalent to the elevation of the groundwater table). A decontaminated bailer is then lowered into the drive casing and groundwater from the bailer is removed from the drive casing until a representative sample can be collected. Determining when a “representative sample” can be collected will be based upon the stabilization of groundwater quality parameters (i.e., specific conductance, pH, temperature, total dissolved solids, etc.) and the clarity of the sample. Appendix C provides two separate case studies which utilized the Case and Bail sampling technique for VOCs.

HYDROPUNCH™

If a representative groundwater sample can not be collected from the test boreholes using the Case and Bail method, then AMEC will use a HydroPunch™ tool. The HydroPunch™ tool is a direct-push sampling device which allows the sampler to be “pushed into” undisturbed sediments below the groundwater table for the collection of a groundwater sample. Once the desired sampling depth has been reached, drilling is ceased and the HydroPunch™ tool is advanced with a down-hole hammer device (mounted on the drilling rig) to approximately 3 to 4 feet into the undisturbed sediment at the bottom of the test borehole. After the tool has been successfully advanced into the undisturbed sediment, it is lifted approximately 1 foot to expose the internal screen inside of the tool, allowing groundwater to enter the HydroPunch™ tool. A decontaminated bailer specifically designed for the HydroPunch™ tool is then lowered into the screened interval inside of the HydroPunch™ tool to retrieve the groundwater sample. Appendix D provides a case study which utilized the HydroPunch™ tool for sampling VOCs in groundwater and also includes the manufactures specifications for the tool.

SIMULPROBE™

If a representative groundwater sample can not be collected from the test boreholes using the Case and Bail method or with a HydroPunch™ tool, then AMEC will use a SimulProbe™ tool. The SimulProbe™ tool is very similar to the HydroPunch™ tool, except that it is pressurized with an inert gas (typically nitrogen) during sample collection to prevent water from entering the sampler except at the desired sampling depth. After the tool has been successfully advanced into the undisturbed sediment, the groundwater sample is collected by raising the SimulProbe™ tool several inches to expose a one-inch diameter screen which is connected to tool. The inert gas is bled off (at the ground surface), allowing the groundwater sample to enter the SimulProbe™ tool. Following the collection of approximately 1 liter of water, the SimulProbe™ tool is re-pressurized with inert gas (at the ground surface) and brought to the surface for sample retrieval. Appendix E provides the manufactures specifications and operating procedures for the SimulProbe™ tool.

3.5.2 Drill, Test, and Install New Monitoring Wells

Following our evaluation of data collected from the completion of lateral definition test boring activities, one new permanent monitoring well (proposed MW-4) will be drilled and installed to the east/southeast of MW-2, and one new permanent monitoring well (proposed MW-5) will be drilled and installed to the west/southwest of MW-2. The proposed MW-4 will be located either at TB-1 or TB-2, or at a third new drilling location should neither TB-1 or TB-2 be suitable well locations given the project objectives previously defined. The proposed MW-5 will be located either at TB-3 or TB-4, or at a third new drilling location should neither TB-3 or TB-4 be suitable well locations given the project objectives previously defined.

In addition, after the evaluation of data collected from the completion of downgradient test boring activities, one new permanent monitoring well (proposed MW-6) will be drilled and installed to the south of MW-2 (see Figure 21). The proposed MW-6 will be located either at TB-5 or TB-6, or at a third new drilling location should neither TB-5 or TB-6 be suitable well locations given the project objectives previously defined.

Well construction will begin with the over-reaming of the selected test boreholes followed by lithologic and geophysical logging and described below. If a new drilling location is chosen instead of a test borehole location, then over-reaming will not be necessary. Due to the size of the borehole and the depths required to construct the new monitoring wells, it is anticipated that a mud rotary drilling technique will be required.

Before well installation, AMEC will subcontract with a qualified contractor to perform downhole geophysical logging in the over-reamed (or new) borehole. The logging suite shall include the following:

- Electric (SP, short and long normal resistivity).
- Gamma.
- Caliper.

The data collected from the geophysical logging activities will be combined with our visual identifications determined from lithologic logging to better define the geologic setting at the CCL. The borehole will be drilled to a depth based in part on the results of the vertical profiling in monitoring well MW-2 and from our geologic and geophysical interpretations of drilled cuttings. Thus, the new monitoring wells (MW-4 through MW-6) will be ideally screened across the zone of highest TCE concentrations and within the MAU. The screened interval will also be designed to facilitate collection of groundwater samples to account for the historical observed groundwater level declines in the site area.

Based upon the pump intake depth setting in MW-1 and MW-2 (and also to account for anticipated future decreasing water levels at the CCL), AMEC has assumed that the new monitoring wells (MW-4 through MW-6) will be screened from approximately 720 to 800 feet bgs (depending on surface elevation and the depth to groundwater of the new well, these depths may be adjusted), with blank casing from ground surface to 720 feet bgs. MW-4 and MW-5 will be constructed of 6-inch diameter nominal low carbon steel (LCS) and will have an 80-foot long, 0.125 inch/slot screen section with 20 feet above the water table and 60 feet below the water table. The borehole will be at least 12 inches in diameter to accommodate annular material installations.

Filter pack (No. 10 Tacna Gravel) will be installed from the bottom of the borehole to 10 feet above the top of the well screen. The filter pack will be surged to promote settlement, and additional filter pack will be added as needed. A 5-foot thick zone of hydrated bentonite pellets will then be placed on top of the filter pack. Installation of the bentonite pellets will be followed by a cement-bentonite grout installed from the top of the bentonite pellets to the ground surface. To comply with ADWR's minimum well construction standards, the monitoring wells will be installed with a 10-inch diameter LCS conductor casing from land surface to at least 20 feet bgs. All annular materials will be installed with a tremmie pipe.

The monitoring wells will be completed with an above-ground, lockable steel monument case. All IDW generated during over-reaming and construction activities will be properly contained at the drill sites for later IDW profiling and disposal purposes per the protocols presented in Section 4.0. MW-6 (the proposed downgradient well) will be constructed similarly to MW-4 and MW-5 but with an 8-inch diameter casing and a 14-inch diameter borehole. The larger casing will allow thorough aquifer testing and analysis (post-groundwater characterization) as remedial alternatives are evaluated.

The new monitoring wells will be developed using the surge, bail and pump method. This development method is performed by surge blocking (to agitate the fines), bailing (to remove the fines), and pumping (to remove the remaining fines). The development procedure shall be as follows:

- Bail the well to remove fine sediment in the bottom of the well and to determine if water will flow into the well.
- Lower the surge block slowly into the well until it is approximately 10 to 15 feet below the static water level.
- Begin a gentle up and down movement of the surge block to cause water and material to flow into the well.
- Stop surging and bail the well to remove particulate matter.
- Continue surging process while increasing both depth of the surge block and intensity of the surge. Continue until the block is just above the screen interval, pausing frequently to bail.
- Upon completion of surging and bailing, pump the well 10 feet below the top of the groundwater table to clear any remaining fines from the well area. Then lower the pump another 20 feet and pump again. Then lower the pump to the bottom of the screened interval and pump again.
- Continue pump development until the turbidity of the development water is measured at or below five nephalmeteric turbidity units, or best attainable as determined by visual inspections conducted by the field personnel during pump development.

Water produced from the well development activities will be properly contained at the new monitoring well sites for later IDW profiling and disposal purposes per the protocols presented in Section 4.0. It is approximated that well development will take approximately two to four hours per well, and will produce up to 4,000 gallons from each well (depending on the achieved pump development flow rate). Water levels in the other CCL wells (MW-1, MW-2, MW-3, and PW-1) will be measured and recorded by AMEC personnel prior to, during, and after well development activities to monitor for potential drawdown in the aquifer due to groundwater pumping at the new monitoring wells. All IDW (mud, soil and groundwater) generated from this task will be profiled and disposed of in accordance with Section 4.0.

Following well development, each new monitoring well shall be equipped with a dedicated stainless steel electrical submersible pump and PVC sounding tube to allow for collection of a groundwater sample (after well development and for future groundwater monitoring events). The groundwater sample will be submitted to an ADHS Certified analytical laboratory for the analysis of VOCs using EPA Method 8260B. The locations of the test borings will be surveyed, at a minimum, with a hand held GPS unit with sub-meter accuracy. In addition, each monitoring well will be surveyed by a certified Arizona Register Land Surveyor. Elevations (z-direction) will have an accuracy of .01 feet.

AMEC will oversee all pertinent well construction and sampling activities.

4.0 IDW MANAGEMENT

Waste handling shall be dealt with on a location-specific basis. Waste may be classified as non-investigative waste or IDW. Non-investigative waste, such as litter and household garbage, shall be collected on an as-needed basis to maintain the site in a clean and orderly manner. This waste shall be containerized and transported to the designated sanitary landfill or collection bin. Acceptable containers shall be sealed boxes or plastic garbage bags.

During this investigation, cuttings generated during soil boring advancement will be disposed of properly. Cuttings from the vadose zone will be segregated and disposed of separately as non-impacted IDW. Soil cuttings from below the water table will be profiled and disposed of as described below. Mixed solids and water (mud) and mud from the drilling program will be collected in leak-proof containers to settle. Water will then be separated from the solids. The soils will be containerized in lined roll-off bins with lids. The bins will then be transported to a temporary storage area until the completion of the investigation when all cuttings will be disposed of according to the constituents of concern in the containerized soils. The number of containers shall be estimated on an as-needed basis. The containers shall be transported in such a manner to prevent spillage or particulate loss to the atmosphere.

The IDW shall be segregated at the site according to matrix (solid or liquid). Each container shall be properly labeled with site identification, sampling location, constituents of concern, and other pertinent information for handling. Upon completion of drilling, composite samples of the waste materials (cuttings from below the water table and all liquids) will be collected and analyzed by EPA Method 8260B for profiling purposes. Groundwater generated during the investigation will be containerized in Department of Transportation-rated drums or rented tanks. Based on the analyses, the soil, mud and groundwater will be transported off-site and disposed of at an appropriate disposal facility for the waste materials.

5.0 SCHEDULE

The following schedule has been developed for the additional groundwater characterization at CCL, and is based upon our knowledge of the CCL site, local geologic conditions, and our experience completing similar projects in scope:

Conduct vertical groundwater profiling at MW-2 during the month of May 2009.

Option 2 – Adjust pump setting at MW-3 & collect composite groundwater sample during the month of June 2009.

Test Borehole Drilling, Vertical Profiling (Lateral Plume Definition), and MW-4 and MW-5 installation during June and July 2009 pending ADEQ approval and subcontractor availability.

Test Borehole Drilling, Vertical Profiling (Downgradient Plume Definition), and MW-6 well installation during June and July 2009, pending ADEQ approval and subcontractor availability.

Three weeks after receipt of the final laboratory analytical results, a draft report will be submitted to ADEQ for review. This report will address all field activities presented herein as they relate to the nature and extent of groundwater contamination at the CCL. The report will also provide recommendations for further delineation, if necessary, and potential remediation solutions.

6.0 REFERENCES

Arizona Department of Environmental Quality, 2006. Letter to the Maricopa County Solid Waste Management Department, Re: New Monitoring Well at the Cave Creek Landfill. August 31, 2006.

Arizona Department of Water Resources, 2006. Salt River Valley Model Geology Update – Provisional Report. Modeling Report No. 16. October 10, 2006.

Arizona Department of Water Resources, 2008. Well Abandonment Handbook. September 2008.

Arizona Department of Water Resources, 2009. Groundwater Site Inventory (GWSI) database. Queried on March 2009.

Brian A. Stirrat & Associates, 2005. Maricopa County Waste Management Department Cave Creek Landfill Groundwater Characterization Work Plan. Prepared for Maricopa County Solid Waste Management Department. August 26, 2005.

Brian A. Stirrat & Associates, 2008. Cave Creek Landfill Groundwater Monitor Well Completion Report. Prepared for Maricopa County Risk Management Department. January 17, 2008.

City of Phoenix, 2009. Verbal Communication on March 19, 2009.

City of Scottsdale, 2009. Written Communication on March 13, 2009.

Corell, S.W., and Corkhill, E.F. 1994. A Regional Groundwater Flow Model of the Salt River Valley – Phase II, Phoenix Active Management Area Numerical Model, Calibration and Recommendations. ADWR Hydrology Division, Modeling Report No. 8. March.

Dames and Moore, 1993. Cave Creek Landfill Hydrologic Report. Prepared for Maricopa County. September 17, 1993.

Freeze, R.A. and Cherry, J.A., 1979. Groundwater, Prentice-Hall Inc. Englewood Cliffs, N.J., 604 p. TIC#3476

Littin, G.R., 1979. Maps showing ground-water conditions in the New Driver-Cave Creek area, Maricopa and Yavapai counties, Arizona; 1977. Water Resources Investigation Report 79-1068.

Newell, C., R. McLeod and J. Gonzales, 1996. BIOSCREEN, Natural Attenuation Decision Support System, User's Manual Version 1.3. EPA/600/R-96-087. This document is available on the U.S. EPA web site at http://www.epa.gov/ada/csmos/models/bioscrn.html.

Ogata, A., and Banks, R.B. (1961). "A solution of the differential equation of longitudinal dispersion in porous media." U.S. Geological Survey, Prof. Pap. No. 411-A.

Ogata, Akio. 1970. Theory of dispersion in a granular medium. U.S. Geological Survey Professional Paper 411-I, p. 134.

United States Geological Survey (USGS), 2009. Stream Flow Measurements for the Nation, USGS Site Number 09512280 (Cave Creek Blw Cottonwood Cr Near Cave Creek, Az.). Internet Site http://waterdata.usgs.gov/nwis/measurements/?site_no=09512280&amp.

Vroblesky, D.A., 2001. User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells. Part 2, Field Tests. U.S. Geological Survey Water-Resources Investigations Report 01–4061.

TABLES

FIGURES

APPENDIX A

COP AND COS PUMPING INFORMATION

APPENDIX B

LABORATORY RESULTS FOR MARCH 2009 SAMPLING EVENT

APPENDIX C

INFORMATION ON CASE AND BAIL SAMPLING METHOD

APPENDIX D

INFORMATION ON HYDROPUNCH™ SAMPLING METHOD

APPENDIX E

INFORMATION ON SIMULPROBE™ SAMPLING METHOD

APPENDIX F

ADEQ COMMENTS AND MCRM/MCSWMD RESPONSES TO COMMENTS