REMEDIAL ACTION PLAN

UNC Chapel Hill

Airport Road Waste Disposal Area,
Chapel Hill, North Carolina

April 2005

Remedial Action Plan

UNC Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina

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Date:

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Remediating Party Certification Statement (.0306(b)(2)):

"I certify under penalty of law that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this certification, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, the material and information contained herein is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for willfully submitting false, inaccurate or incomplete information."

Peter A. Reinhardt – Director, Environment, Health & Safety
(Name of Remediating Party Official)

(Signature of Remediating Party Official)   4/21/05
Date

North Carolina

ORANGE COUNTY

I, Shelley L. Kutia, a Notary Public of said County and State, do hereby certify that Peter Reinhardt did personally appear and sign before me this the 21 day of April, 2005.

Notary Public (signature)   (OFFICIAL SEAL)

My commission expires: May 29, 2008

Registered Site Manager Certification Statement (.0306(b)(1)):

"I certify under penalty of law that I am personally familiar with the information contained in this submittal, including any and all supporting documents accompanying this certification, and that the material and information contained herein is, to the best of my knowledge and belief, true, accurate and complete and complies with the Inactive Hazardous Sites Response Act G.S. 130A-3 10, et seq, and the voluntary remedial action program Rules 1 5A NCAC 1 3C .0300. I am aware that there are significant penalties for willfully submitting false, inaccurate or incomplete information."

James E. Shilliday III, L.G.,RSM
(Name of Registered Site Manager)

(Signature of Registered Site Manager)   4/21/05
Date

North Carolina

ORANGE COUNTY

I, Shelley L. Kutia, a Notary Public of said County and State, do hereby certify that James E. Shilliday III did personally appear and sign before me this the 21 day of April, 2005.

Notary Public (signature)   (OFFICIAL SEAL)

My commission expires: May 29, 2008

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1. Introduction

ARCADIS has prepared this Remedial Action Plan (RAP) on behalf of The University of North Carolina at Chapel Hill (the University) to address the Airport Road Waste Disposal Area. The site is located near North Carolina Highway 86 (Airport Road) in northern Chapel Hill, Orange County, North Carolina. The location of the site is shown on Figure 1-1. The contents of this document were prepared following the requirements outlined in the August 2004 Implementation Guidelines of the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Waste Management, Superfund Section, Inactive Hazardous Sites Branch, Registered Environmental Consultant (REC) Program. The objective of this RAP is to identify, evaluate, and compare various remedial alternatives to control/remediate buried material, impacted soils, and groundwater at the site and to propose remedial alternatives to address source material and impacted groundwater based on this evaluation.

This introductory section presents a summary of the site conditions, site investigation activities, and the nature and extent of contamination.

1.1 Site Description

1.1.1 Location

The Airport Road Waste Disposal Area is located near Airport Road in northern Chapel Hill, Orange County, North Carolina. The site latitude is 35^{o} 56’ 18.0” N, and the longitude is 79^{o} 03’ 22.0” W (NCDEHNR 1993). The site consists of a 0.489 acre wooded parcel of University property that is located adjacent to the entrance road for the Airport Road Inactive Sanitary Landfill (Figure 1-2). Photographs of the site, surrounding fence, and posted signage are presented in Appendix A.

An approximately 0.2 acre area of this tract was used from 1973 through 1978, with the approval of the State of North Carolina, to dispose of chemical waste from the University’s facilities in 16 separate burial trenches. An additional 0.289 acres adjacent to the 0.2-acre area was proposed for use when the original area was full. However, only two burials were conducted in this expanded area, both in 1979. All references to “site” or “waste disposal area” in this report include the original 0.2-acre area (16 burials) and that portion of the expanded area used for two burials in 1979. Access to the site is restricted by an 8-foot-high locked fence erected by the University in early 1994. Several warning signs surround the site.

Municipal facilities for the Town of Chapel Hill are to the east and south of the site on a parcel leased from the University since 1979. The municipal facilities include but are not limited to paved roadways, parking lots, a street and bus maintenance facility, and an animal shelter. The Horace Williams Airport is south of the site, and the Airport Road Inactive Sanitary Landfill, formerly used by the Town of Chapel Hill, is to the west. The area north of the site is heavily wooded. Crow Branch Creek is located north/northwest of the site in the wooded area. A small residential area accessible from Airport Road is located approximately 1,200 feet north of the site. Most of the property east of Airport Road is also developed for residential use (NCDEHNR 1993).

1.1.2 Site History

The University used the site from 1973 to 1979 to dispose of wastes from the University's teaching, research, and hospital laboratories. A total of 18 burials in trenches were made at the site between 1973 and 1979 (NCDEHNR 1993). Each burial trench had a size of approximately 10 feet (ft) wide, 20 ft long, and 10 ft deep. The burial pits are located adjacent to one another with approximately 4 to 8 ft of native soil separating each pit. Sketches showing the approximate locations of the burials are included in Appendix B. Buried wastes consisted of a variety of constituents, including halogenated and non-halogenated solvents and other organic compounds, pesticides, metals, acids, bases, and PCBs, based on a Notification of Hazardous Waste Site (EPA Form 8900-1) completed in 1981. A list of laboratory chemical wastes disposed of at the site (North Carolina Department of Human Resources ([NCDHR] 1984) is included in Appendix B. No records or indications that pesticides or PCBs have been disposed of at the site were available.

1.1.3 Topography

The site and surrounding property are relatively flat, sloping gently to the north-northwest in the general direction of Crow Branch Creek. Surface elevations in the vicinity of the site are approximately 485 feet above mean sea level (ft msl) and slope to approximately 460 ft msl in the vicinity of Crow Branch Creek. The site location is depicted on a portion of the Chapel Hill 1967 (photorevised 1988) 7.5-minute United States Geologic Survey topographic map which is included as Figure 1-1. A more detailed site map that illustrates various site features, including topography, is presented in Figure 1-3.

1.1.4 Geology

Intrusive investigative activities (bedrock core holes and soil borings) conducted at the site have revealed a relatively thin layer of residual soils and weathered rock (saprolite) overlying competent bedrock. The saprolite layer, which contains the surficial aquifer, varies in lithology from sandy clay to clayey sand, and extends from land surface to approximately 5 to 25 feet below land surface (ft bls). Competent granodiorite bedrock underlies the saprolite. Lithologic information gathered at the site indicated that the competent granodiorite unit occurs at depths ranging from 5 to 25 ft bls and extends to a depth of at least 195 ft bls. The equigranular granodiorite contains abundant high-angle fractures commonly filled with pyrite, calcium carbonate, and chlorite. Occasional brecciated zones were noted at various depths during coring, and no evidence of diabase dikes was observed (Geraghty & Miller 1996).

The subsurface site geology is depicted on north to south and east to west geologic cross sections, which are included as Figures 1-5 and 1-6, respectively. The north to south cross section begins at monitor well MW-29, passes beneath the waste disposal area and crosses Crow Branch Creek before terminating at monitor well MW-34. The east to west cross section begins at monitor well MW-18 and terminates at monitor well MW-36. This cross section roughly parallels Crow Branch Creek.

1.1.5 Hydrogeology

1.1.5.1 Regional Hydrogeology

The hydrogeologic systems of the Piedmont province, in which the subject site is located, possess unique features in comparison to most other groundwater regions. According to LeGrand (2004), these unique characteristics control the principal groundwater flow directions, flow volumes, and the location of system boundaries including recharge and discharge areas. The unique features of the Piedmont system are as follows:

(1) The gneissic metamorphic rocks have been folded, faulted and interstratified with granite or diorite intrusions, resulting in little or no lateral or vertical continuity of hydraulic properties for the igneous rock units.

(2) The active groundwater flow within these rocks is limited to fracture flow. The aerial and vertical distribution and interconnection of these fractures is limited. For instance, fractures in crystalline rocks typically decrease both in width of opening and in frequency with depth. As a result, active groundwater circulation

or flow within fractured igneous rocks is relatively shallow, primarily limited to the upper 250 feet of bedrock. In addition, the igneous rocks have very low storage capacity for groundwater.

(3) Most of the water flowing in these fractures is derived from vertical leakage from the saprolitic soils and the “unfractured” matrix rock. The regolith or saprolite overlying the bedrock forms a shallow aquifer system which is the principal storage reservoir and provides a very local source for domestic drinking water. Groundwater movement within this shallow aquifer reservoir is predominantly vertical, intergranular flow.

(4) The groundwater basins developed in this Piedmont system exhibit shallow flow paths and are not aerially extensive. These basins mimic surface water basins. That is, topographic high points such as ridges and hilltops form drainage basin boundaries and divides which groundwater does not typically flow across. The topographic highs, located on upland ridges, act as the principal area of groundwater recharge. Perennial stream beds represent another basin boundary, as they represent discharge areas where groundwater flows to the surface as diffuse seepage or springs. Shallow, local groundwater flow paths develop, efficiently moving recharge from hilltops to close-by permanent streams, marshes, and wetlands.

The interaction of these unique features within the Piedmont develops a series of shallow, aerially small, flow systems which are almost congruent with the surface-water drainage basins. Each groundwater basin, like the surface-water drainage basin, is separated from adjacent basins. The water table develops in the saprolite in response to precipitation recharge and forms a subdued expression of the local topography (LeGrand, 2004).

1.1.5.2 Site Specific Hydrogeology

The surficial and shallow bedrock aquifer units are the primary areas of concern for groundwater at the site. The surficial aquifer at the site is encountered in the saprolitic soils above bedrock, and extends to depths ranging from 5 to 25 ft bls. Vertical leakage from the surficial aquifer supplies the groundwater present in the fractures within the shallow bedrock layer. Bedrock at the site is generally encountered at depths ranging from 5 to 25 ft bls.

Potentiometric surface maps of the surficial and bedrock aquifer units are presented in Figures 1-7 and 1-8, respectively. These maps were based on water-level data collected in July 2004. The information presented in Figure 1-7 indicates that groundwater flow in the shallow aquifer, south of Crow Branch Creek, is generally to the north, towards Crow Branch Creek. The groundwater flow direction for the shallow aquifer on the north side of Crow Branch Creek is generally toward the east/southeast convergent on Crow Branch Creek. The information presented in Figure 1-8 indicates that the groundwater flow direction in the bedrock aquifer is similar to that of the shallow aquifer, and trends to the north/northeast.

In-situ hydraulic conductivity of the saturated aquifer material has been calculated from slug-test data obtained from selected monitor wells (Geraghty & Miller 1996). The slug tests typically were performed using a 5-foot long cylindrical stainless steel tube to displace the water in the wells while recording the water-level response with a pressure transducer and data logger. Hydraulic conductivities were calculated using AQTESOLV software, which utilizes the Bouwer and Rice Method. Calculated hydraulic conductivity (K) values for the surficial aquifer range from 4.52 x 10^{-6} to 2.31 x 10^{-3} centimeters per second (cm/sec), with an average K of 5.32 x 10^{-4}cm/sec. Similarly calculated K values for the bedrock aquifer range from 3.44 x 10^{-4} to 1.45 x 10^{-2} cm/sec, with an average K of 4.26 x 10^{-3} cm/sec.

A full scale aquifer test was performed on May 6 and 7, 1998 (ARCADIS Geraghty & Miller 1998). Newly installed bedrock aquifer recovery well RW-1, which has an open borehole from 20 to 80 ft bls, was pumped for a total of 24 hours, followed by a 17.5 hour recovery period. Water levels were recorded at a total of 17 observation wells. Approximately 42 ft of drawdown was observed in recovery well RW-1 and observation wells MW-15, OW-5 and OW-6, which are located 20 ft from RW-1. The large amount of drawdown observed in observation wells MW-15, OW-5, and OW-6 indicates that the boreholes for these wells and the borehole for recovery well RW-1 are highly interconnected possibly through northwest-southeast trending fracture zones in the bedrock aquifer. In addition, the drawdown data indicated that pumping RW-1 at 5 gallons per minute created a drawdown of 8.46 ft in well MW-14 located approximately 270 feet upgradient and a drawdown of 1.35 ft in well MW-23 located approximately 350 feet downgradient of the pumping well. The elliptical cone of depression created by pumping recovery well RW-1 provides additional evidence to support the existence of a northwest-southeast trending fracture zone in the bedrock aquifer. The Recovery Well Installation and Aquifer Test Report was transmitted to NCDENR by the University on May 27, 1998.

1.2 Summary of Site Investigation Activities

Multiple investigations have been performed at the Airport Road Waste Disposal Area to characterize and delineate potential impacts associated with the site. The following sections briefly discuss the activities performed during each phase of investigation and the associated results. The groundwater and surface water sample locations discussed in these sections are depicted in Figure 1-3. Soil Sample locations are shown in Figure 1-4. The construction details for the groundwater monitor wells are summarized in Table 1-1.

1.2.1 Initial Environmental Investigations

The University installed five monitor wells (MW-1 through MW-5) in the vicinity of the site after waste disposal activities ceased in 1979. The NCDEHNR Superfund Section completed a Preliminary Assessment (PA) on March 19, 1984, and a Site Inspection (SI) on June 19, 1984. The SI revealed that volatile organic compounds (VOCs), including benzene, chloroform, and methylene chloride, were detected in groundwater samples collected from monitor wells MW-1 and MW-2.

In June 1991, Greenhorne & O'Mara, Inc., at the request of the NCDENR, completed a Phase II Screening Site Investigation (SSI) for the UNC Old Sanitary Landfill (Greenhorne & O'Mara, 1991). The SSI focused primarily on the Airport Road Old Sanitary Landfill and not the chemical waste disposal site. Groundwater, surface soil, surface water, and sediment samples were collected during the SSI. Groundwater samples collected from monitor wells MW-1, MW-2, and MW-3 contained benzene, chloroform, trimethylhydrazine, trichlorofluoromethane, phenol, dimethylphthalate, and isophorone. Some metals and inorganic compounds also were sporadically detected in these groundwater samples. Details of the sampling activities and results can be found in the SSI report (Greenhorne & O'Mara, 1991).

1.2.2 1996 Remedial Investigation

Three phases of field activities conducted at the site by Geraghty & Miller, Inc., were described in a Remedial Investigation (RI) Report dated November 1996 (Geraghty & Miller, 1996). The 1996 RI Report was transmitted to the NCDENR by the University with a letter dated March 3, 1997; however it was not completed in accordance with the requirements of the REC Program. Phase I of the 1995/1996 RI consisted of the installation and sampling of six monitor wells (MW-6, MW-7, MW-9, MW-11, MW-12, and MW-13). These wells, in addition to existing monitor wells MW-1, MW-2, and MW-3, were sampled for VOCs, semi-volatile organic compounds (SVOCs), and inorganic parameters.

Phase II of the 1995/1996 RI consisted of bedrock coring (core holes CH-1, CH-2, and CH-3) and installation of 10 monitor wells (MW-14, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-21, MW-22, and MW-23). Monitor wells MW-14 and MW-23 were installed in core holes CH-1 and CH-3, respectively. The new wells were sampled for VOCs, SVOCs, and inorganic parameters. Surface-water samples also were collected and analyzed for VOCs (including tentatively identified compounds) and some inorganic compounds.

Phase III of the 1995/1996 RI consisted of the installation of four monitor wells (MW-24, MW-25, MW-26, and MW-28), groundwater sampling, four shallow geotechnical soil borings, and five direct push technology (DPT) borings at the site. Surface emission flux samples were also collected. Groundwater samples from the Phase III monitor wells and surface emission flux samples were analyzed for VOCs. Soil samples from DPT borings were analyzed for VOCs, SVOCs, and inorganic parameters.

The 1996 RI Report included a detailed discussion of the investigation procedures and results of the soil and groundwater assessment activities, geotechnical assessment, and surface emission flux sampling. The 1996 RI indicated that groundwater was impacted with both VOCs and SVOCs, but the primary constituents of concern (COCs) in groundwater were volatile organics (i.e., benzene, chloroform, diethyl ether and methylene chloride). The soil data collected during the RI assessment indicated very limited impacts outside the fenced disposal area. Surface water data also indicated very limited impacts to Crow Branch Creek, as only one of six surface water samples collected contained detectable levels of target constituents. The detected constituents in the surface water sample were tetrachloroethene and diethyl ether, both of which were at very low levels.

1.2.3 1996 through 2003 Groundwater Monitoring

To further evaluate the horizontal and vertical extent of impacted groundwater at the site, five additional monitor wells (MW-29, MW-30, MW-31, MW-32, and MW-33) were installed in November 1996. Groundwater from these wells was sampled and analyzed for VOCs. In addition, shallow monitor wells MW-1, MW-3, MW-12, MW-22, MW-25, and bedrock aquifer monitor wells MW-14, MW-15, MW-23, MW-31, and MW-32 were sampled in December 1996, and a complete round of water levels was measured. The groundwater samples from the December 1996 sampling event were analyzed for VOCs, SVOCs, and eight regulated metals. Details of well installation and sampling can be found in the Well Installation and Sampling Report (Geraghty & Miller 1997a) and Groundwater Sampling Report (Geraghty & Miller 1997b). The Well Installation and Sampling Report and the results of the 1996 sampling activities were transmitted to the NCDENR by the University on May 27, 2004.

Additional groundwater monitoring events were conducted at the site in May 1998 (ARCADIS Geraghty & Miller 1999), November 2000 (ARCADIS Geraghty & Miller 2001), and October 2002 (ARCADIS 2003). These three events consisted of a site-wide collection of groundwater elevation data and groundwater sampling for volatile organics to evaluate the primary COCs. Results of the 1998, 2000, and 2002 groundwater monitoring events were transmitted to the NCDENR by the University on May 27, 2004.

In December 2003, re-sampling of select monitor wells MW-12, MW-15, MW-24, MW-32 and MW-33 was conducted. Monitor wells MW-12, MW-15 and MW-24 were sampled to create a vertical profile of groundwater conditions downgradient of the source area. Monitor wells MW-32 and MW-33 were sampled to confirm the presence of diethyl ether reported in these wells in the October 2002 sampling event.

1.2.4 2004 Remedial Investigation

A second RI Report was finalized for the Airport Road Waste Disposal Area in October, 2004 (ARCADIS, 2004b). This RI Report, which was prepared in accordance with the requirements outlined in the REC Program Guidelines, was transmitted to the NCDENR by the University with a letter dated November 1, 2004. The purpose of the 2004 RI Report was to summarize the findings of the multiple phases of investigations previously conducted at the site and to present the findings of additional RI activities conducted in July 2004.

The July 2004 RI activities were conducted in accordance with the May 28, 2004, RI Workplan (ARCADIS 2004a). The field activities performed in this phase of the investigation were designed to complete the delineation of the horizontal and vertical extent of the impacted groundwater plume and included installation of four competent bedrock monitor wells, collection of groundwater samples from all site groundwater monitor wells, collection of surface water samples from Crow Branch Creek, and a complete water level gauging event for the site.

The principal findings of the 2004 RI activities are listed below:

- The calculated vertical gradients for the July 2004 water-level measurement event were upward in five well clusters located downgradient of the disposal area (MW-6/MW-7, MW-12/MW-15, MW-25/MW-26, MW-30/MW-31, and MW-32/MW-33). Well clusters located near the ridge line (MW-2/MW-14 and MW-28/MW-29) exhibited a downward vertical gradient. The vertical gradients indicate that groundwater is moving vertically downward in the area of the ridge (a recharge area) and upward in the general area of Crow Branch Creek (a discharge area), suggesting that the creek is recharged from the shallow and deeper aquifers.

- VOC constituents were detected in the shallow aquifer at concentrations above the established groundwater standards in 5 of the 11 shallow site monitor wells (MW-1, MW-2, MW-6, MW-12, and MW-22). Ten compounds (acetone, benzene, chloroform, 1,2-dichloroethane [1,2-DCA]; diethyl ether, ethylbenzene, methylene chloride, 1,1,2,2-tetrachloroethane [1,1,2,2-TCA], trichloroethene [TCE], and total xylenes) exceeded their respective groundwater standards in shallow wells. Diethyl ether was the most laterally extensive of the constituents. The analytical data indicated that the impacts within the surficial aquifer were confined to wells located on the south side Crow Branch Creek.

- The extent of the dissolved phase plumes observed in July 2004 for most VOC compounds (i.e. benzene, chloroform, and methylene chloride) in the shallow aquifer appear to be relatively consistent with previous sampling events conducted in May 1998, November 2000, and October 2002. In comparison with previous events, the diethyl ether concentrations observed in July 2004 increased in some downgradient shallow wells and new detections were reported in shallow monitor wells MW-5, MW-18, and MW-25. Historical groundwater analytical results are summarized in Table 1-2.

- VOC constituents were detected in the bedrock aquifer at concentrations above the established standards in groundwater samples collected from 8 of the 22 bedrock aquifer monitor wells (MW-7, MW-9, MW-11, MW-13, MW-14, MW-15, MW-17, and MW-31). Seven compounds (acetone, benzene, chloroform, 1,2-DCA, diethyl ether, TCE, and vinyl chloride) exceeded their respective established groundwater standards in bedrock wells. Diethyl ether was the most laterally extensive constituent and was the only VOC compound detected on the north side of the creek.

- Four competent bedrock monitor wells (MW-34, MW-35, MW-36 and MW-37) were installed to further delineate the extent of site-related constituents in the groundwater in the northern portion of the site. Monitor wells MW-34, MW-35 and MW-36 were installed with screen elevations comparable to MW-33 to provide downgradient (east/northeast) delineation. Monitor well MW-37 was installed adjacent to existing monitor wells MW-32 and MW-33 for the purposes of vertical delineation. Diethyl ether was not detected in the new monitor wells MW-34, MW-35, MW-36 or MW-37.

- The analytical data from the July 2004 shallow aquifer and bedrock aquifer monitor well sampling event confirms that the horizontal and vertical extent of the VOC impacted groundwater plume is defined by the existing monitor well network.

- Diethyl ether was detected in three of the six surface water samples collected in July 2004 (SW-3, SW-4, and SW-5). The detection of diethyl ether in Crow Branch Creek likely represents the discharge to the creek of the VOC impacted groundwater plume originating from the waste disposal area. It should be noted that no VOCs were detected in surface water sample SW-6 which is the furthest downgradient surface water sampling point.

1.3 Nature and Extent of Contamination

1.3.1 Soils

A limited number of soil samples were collected during the various phases of the site investigation. During the RI activities conducted in 1996, soil samples were collected from five sample locations immediately outside the fence surrounding the waste burial pits (Figure 1-4). The analytical results from the 1996 soil samples are summarized in Table 1-3. As the data indicates, trace concentrations of volatile organics were detected in two borings located within 5 feet of the fence surrounding the waste burial area. Low concentrations of metals, attributed to background concentrations, were reported in all soil samples. The data suggest that impacted soils do not extend outside the source area.

No soil samples have been collected from the waste burial pits or within the fenced area of the site, due to safety concerns. However, it is presumed that impacted soils are present within, beneath, and adjacent to the individual waste burial pits as a result of direct contact with chemicals leaching from ruptured laboratory containers. The impacted soils are considered a secondary source due to the potential to leach contaminants to the groundwater.

1.3.2 Groundwater

A comprehensive groundwater sampling event was conducted during the July 2004 RI activities to provide horizontal and vertical delineation of the contaminant plume associated with the site. During this event groundwater samples were collected from 11 shallow aquifer monitor wells and 22 bedrock aquifer wells. The laboratory analytical data from this event, summarized in Table 1-2, indicated that volatile organic compounds were present at concentrations exceeding the NCAC 2L Groundwater Standards in samples from both the shallow and bedrock aquifer zones.

1.3.2.1 Shallow Aquifer

Analytical data from the July 2004 RI activities indicated that the horizontal extent of the VOC plume within the shallow aquifer has been delineated. VOCs were detected at concentrations exceeding established groundwater standards at 5 of the 11 shallow monitor wells sampled during this event. Ten compounds (acetone, benzene, chloroform, 1,2-DCA, diethyl ether, ethylbenzene, methylene chloride, 1,1,2,2-TCA, TCE, and total xylenes) were detected within the plume at levels in excess of their respective standards. The highest concentrations of site constituents typically and historically have been detected immediately downgradient of the source area (MW-1 and MW-2).

Contaminant isoconcentration maps for benzene, chloroform, methylene chloride, and diethyl ether, which are the most widely distributed constituents at the site, are provided for the shallow unconsolidated aquifer (Figures 1-9, 1-10, 1-11, and 1-12, respectively). These maps were generated using the analytical data from the 11 shallow aquifer monitor wells sampled during the July 2004 sampling event (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-12, MW-18, MW-20, MW-22, and MW-25) and knowledge of the analytical results from previous groundwater sampling events. The diethyl ether, benzene, chloroform and methylene chloride isoconcentration contour maps indicate that the most laterally extensive groundwater plume in the shallow aquifer is diethyl ether, followed by benzene. Methylene chloride and chloroform groundwater plumes are similar in lateral extent.

Based on the analytical data from the July 2004 sampling event, and the data presented in the isoconcentration maps, the portion of the VOC contaminant plume that exceeds groundwater standards in the shallow unconsolidated aquifer extends from the waste disposal area approximately 600 ft downgradient and terminates in the vicinity of Crow Branch Creek. At its widest point, the VOC contaminant plume is approximately 500 feet wide. The plume geometry in the shallow aquifer is consistent with previously described site hydrogeology and groundwater flow conditions, in that the plume appears to converge on Crow Branch Creek.

The relative lateral extent of site constituents in groundwater can be explained by an evaluation of the water solubility and density of each compound. Compounds with high water solubilities will have greater potential for dispersion and generally spread out through an aquifer more readily than compounds with low water solubilities. Compounds with densities greater than water (greater than 1.0) will have a tendency to sink in the aquifer which may reduce the extent of lateral migration for that compound within the aquifer. Compounds that have densities less than water (less than 1.0) will have a tendency to float in the upper portions of an aquifer which will likely enhance that compound's ability to migrate laterally within the aquifer. The most soluble and least dense of the four compounds is diethyl ether, and as such, this compound is expected to be the most laterally extensive constituent of concern. Diethyl ether has a water solubility of 60,400 milligrams per liter (mg/L) and a density of 0.7134. By comparison, benzene has a water solubility of 1,790 mg/L and a density of 0.8787. Methylene chloride has a higher water solubility than benzene at 13,000 mg/L, but also a higher density at 1.3255. Chloroform has a water solubility of 7,710 mg/L with a density of 1.4835. As a result, methylene chloride and chloroform may be more soluble than benzene, but due to the higher density, may not travel quite as readily in the subsurface. Water solubility and density values were obtained from the Hazardous Substances Databank (HSDB) of the National Library of Medicine TOXNET System (HSDB, 2004).

1.3.2.2 Bedrock Aquifer

Bedrock zone monitor wells were utilized to delineate the horizontal and vertical extent of VOCs in the bedrock aquifer. The analytical results from the July 2004 RI activities indicated that VOCs were detected at concentrations above established groundwater standards in 8 of the 22 bedrock site monitor wells (MW-7, MW-9, MW-11, MW-13, MW-14, MW-15, MW-17, and MW-31) (see Table 1-2). Seven compounds (acetone, benzene, chloroform, 1,2-DCA, diethyl ether, TCE, and vinyl chloride) were determined to be present in the bedrock zone wells above their respective standards. It should be noted that the VOC concentrations in the most impacted bedrock aquifer monitor well (MW-15) are orders of magnitude lower than the VOC concentrations detected in the most impacted shallow aquifer monitor wells (MW-1 and MW-2).

Contaminant isoconcentration contour maps for benzene, chloroform, methylene chloride, and diethyl ether depict the horizontal extent of these contaminants within the bedrock aquifer (Figures 1-13, 1-14, 1-15, and 1-16, respectively). The isoconcentration contour maps were generated using analytical data from the 22 bedrock aquifer monitor wells sampled during the July 2004 sampling event (MW-7, MW-9, MW-11, MW-13, MW-14, MW-15, MW-16, MW-17, MW-21, MW-23, MW-24, MW-26, MW-28, MW-29, MW-30, MW-31, MW-32, and MW-33, MW-34, MW-35, MW-36, and MW-37) and knowledge of the analytical results from previous groundwater sampling events.

Based on the results of the July 2004 sampling event, and as depicted in Figures 1-13 through 1-16, the portion of the VOC contaminant plume that exceeds groundwater standards in the bedrock aquifer extends approximately 600 feet downgradient of the waste disposal area and is approximately 900 feet wide at its widest point. While the dissolved phase plume in the shallow aquifer is interpreted to terminate in the vicinity of Crow Branch Creek, the impacted groundwater in the bedrock aquifer extends slightly north of the creek. Diethyl ether was detected in bedrock monitor well MW-33 on the north side of Crow Branch Creek during several groundwater monitoring events; albeit at concentrations far below the standard of 1,200 micrograms per liter (µg/L). No VOC constituents other than diethyl ether were detected in monitor wells located north of the creek during the July 2004 sampling event.

The July 2004 groundwater data were also utilized to examine the vertical extent of impacted groundwater within the bedrock aquifer. Monitor wells have been installed at varying depths within the bedrock aquifer to delineate the vertical extent of impacts. Analytical data from groundwater samples collected at various depths within the impacted groundwater plume indicate that contaminant concentrations generally decrease with depth.

Isoconcentration contour cross sections (Figures 1-17 and 1-18) were created across a profile extending from southeast of the waste burial area to the northwest, extending across Crow Branch Creek. The profile includes shallow aquifer monitor wells MW-1, MW-3 and MW-12 and bedrock aquifer monitor wells MW-14, MW-15, MW-21, MW-24, MW-28 and MW-29. These wells were selected because they are aligned down the axis of the impacted groundwater plume, are directly downgradient of the waste burial area and some of these wells have historically exhibited the greatest concentrations of targeted compounds.

Data from the July 2004 groundwater monitoring event for diethyl ether and benzene are depicted in cross sectional view on Figures 1-17 and 1-18, respectively. These two constituents were selected as they are two of the most laterally and vertically extensive constituents at the site.

The dissolved diethyl ether plume, as depicted on Figure 1-17, has migrated from the waste burial area to the northwest extending slightly beyond Crow Branch Creek. Although present in deep bedrock monitor well MW-14 (1,800 µg/L) and at trace concentrations in deep bedrock monitor well MW-24 (6 µg/L), the predominant mass appears to travel in the shallow aquifer and the upper 50 feet of the bedrock aquifer. This is demonstrated by the concentrations in monitor wells MW-1 (290,000 µg/L), MW-12 (13,000 µg/L) and MW-15 (14,000 µg/L). The concentrations of diethyl ether detected in the shallow aquifer and bedrock aquifer monitor wells are consistent with groundwater flow directions and vertical gradients seen in the shallow and bedrock aquifers.

The dissolved benzene plume, as depicted on Figure 1-18, follows a very similar travel pathway to diethyl ether in the subsurface. The greatest concentrations are seen in the shallow aquifer and upper bedrock aquifer and decrease rapidly to the northwest away from the burial area. Both the diethyl ether and benzene plumes have similar geometry and both appear to terminate in the vicinity of Crow Branch Creek. Based on the isoconcentration contour cross sections presented for benzene and diethyl ether, the groundwater contamination exceeding applicable standards is not believed to extend below 200 ft bls.

1.3.3 Surface Water

Surface water samples have been collected from several locations along Crow Branch Creek during the various phases of the site investigation. The analytical data from three surface water samples collected during the 2004 RI activities indicated the presence of low concentrations of diethyl ether. Low concentrations of diethyl ether have been sporadically detected in surface water samples dating back to 1995. A summary of the diethyl ether concentrations detected throughout the course of monitoring is presented in Table 1-4. As this table indicates, diethyl ether has not been detected in surface water samples at concentrations exceeding the USEPA Region IX Preliminary Remediation Goal (PRG) for tap water (1,200 µg/L). The detection of diethyl ether in Crow Branch Creek likely represents the discharge to the creek of the VOC impacted groundwater plume originating from the waste disposal area. It should be noted that no VOCs have been detected in surface water samples collected at sampling location SW-6 which is the furthest downgradient surface water sampling point.

2. Remedial Action Objectives and Evaluation of Remedies

This section discusses the remedial action objectives (RAOs), general response actions, and available remedial technologies to accomplish RAOs in accordance with Section 5.0 of the August 2004 REC Program Implementation Guidance. Technologies frequently implemented for remedial action at similar sites were considered for remediation at the Airport Road Waste Disposal Area. Screened technologies were combined into alternatives and evaluated using the criteria listed in the REC Program Guidelines.

2.1 Remedial Action Objectives

The RAOs specify site remediation goals and identify COCs, media of concern, and exposure pathways to be addressed by remedial actions. The RAOs are used to screen technologies and evaluate and compare remedial alternatives. The media of concern at the Airport Road Waste Disposal Area include primary source materials (buried chemical containers), secondary source materials (impacted soils), and contaminated groundwater. The major COCs in the groundwater are VOCs including the following: acetone, benzene, chloroform, 1,2-DCA, diethyl ether, ethylbenzene, methylene chloride, 1,1,2,2-TCA, TCE, and total xylenes. Analytical results from soil sampling performed by ARCADIS in 1996 indicate that impacts to soil are generally contained to the source area; therefore, soils outside of the source area are not considered a specific media of concern.

As with any remediation project the primary RAO for the site is to protect human health and the environment. Specific RAOs for the site are based on the media of concern and are listed as follows:

- Minimize further degradation of groundwater quality through source removal/control;
- Reduce further migration of dissolved COCs in groundwater;
- Minimize groundwater impacts to potential receptors;
- Meet clean-up requirements (remedial design goals) for impacted soil and groundwater; and
- Meet the requirements of the Inactive Hazardous Sites Voluntary Cleanup Program as outlined in the Guidelines.

2.2 Compliance with Regulatory Requirements

This section identifies the state and federal (if applicable) laws and regulations which are potentially applicable for the remedial alternatives identified for the site. These regulations/laws are to be complied with during remedial action implementation to meet the cleanup objectives. Table 2-1 identifies the potential regulatory requirements for the remediation of the site. Table 2-2 provides a summary of North Carolina Groundwater Standards, Federal Drinking Water Standard Maximum Contaminant Limits (MCLs), Remediation Goals (adopted from Appendix C-1 of the Guidelines), and maximum observed concentrations of constituents in groundwater at the site. The NCDENR Soil Remediation Goals (SRGs) for the organic compounds at the site are listed in Table 2-3.

2.3 Technology Screening

Remedial technologies for both source remediation and groundwater remediation will be required to meet the RAOs for the Airport Road Waste Disposal Area. While several remedial technologies and process options exist for addressing source materials and groundwater contamination, many are unsuited for the conditions at the project site. Therefore, potential technologies were subjected to an initial screening by which non-viable options were eliminated. The screening process was based on the ability of a given technology and/or process option to satisfy the RAOs and applicable regulatory requirements, as well as technology effectiveness, implementability, and relative cost.

The source control and groundwater remediation technologies under consideration in the following sections were categorized in terms of the following general response actions.

- No Action
- Institutional Controls
- Containment of Source
- Removal of Source
- Ex-situ Treatment of Source
- In-situ Treatment of Source

- Collection/Treatment/Disposal of Groundwater
- Ex-Situ Treatment of Groundwater
- In-Situ Treatment of Groundwater

Although specific technologies were presented for evaluation within each response category, the processes are intended to represent the broader range of process options within a general technology. In general, one or more process options were retained from each general response category for use in formulating remedial alternatives for the site.

2.3.1 Screening of Source Remediation Technologies

Appendix C, Table C-1 identifies various source control/remediation technologies within each general response category and presents a brief discussion of their potential applicability to the site. After screening, viable technologies were retained to form the remedial alternatives discussed in Section 2.4.1. Following is a brief discussion of potential response actions.

No Action

The no action option will be used as a baseline against which other options may be compared. Under no action, source area cleanup would not be undertaken, and the site would be left as it now exists, except for deed/access restriction and monitoring.

Institutional Controls

Institutional controls (fencing and deed restrictions) typically are used for restricting access or exposure to waste material, and may be used in conjunction with other technologies to meet the RAOs. Deed restrictions are required for remedies involving no action and/or no or source control. To streamline the alternatives evaluation/comparison process, institutional controls may be used in conjunction with other technologies but will not be specifically discussed in the remaining sections.

Source Containment

Containment is a source control response category in which physical barriers are used to eliminate further impacts to groundwater and/or other potential receptors. Technologies included in this category prevent infiltration of precipitation and storm water runoff into the contaminated subsurface soils and/or divert groundwater from the contaminated area. Based on available water level information, portions of the primary and secondary source material may be below the groundwater. Therefore, a combination of containment technologies would be required to contain the source material. Implementation of multiple containment technologies would be uneconomical and is also technically ineffective. Therefore, the containment response action was eliminated from further consideration (see Table C-1 in Appendix C).

Source Removal

Excavation and removal of primary and secondary source material for off-site treatment and/or land disposal is technically feasible and is very effective; therefore, this technology was retained for further consideration. Due to the presence of primary source materials (buried chemical containers), treatment of the excavated waste will likely be required to meet Land Disposal Restrictions (LDRs) prior to disposal.

Ex-situ Treatment

Ex-situ treatment options involve the excavation of source material for above ground treatment. Several potential technologies, which include both on-site and off-site treatment options, were identified within this category. However, most technologies were eliminated from further consideration due to the associated costs or because they were not appropriate for the contaminants/waste material at the site. Ex-situ treatment options that were retained for further consideration include macroencapsulation, incineration, and stabilization/solidification. While these technologies were retained, each would necessarily be used in combination with additional technologies in order to meet the RAOs and/or LDRs

In-situ Treatment

In-situ treatment systems for degrading and/or encapsulating waste in place typically reduce the need for soil excavation and transportation to an off-site facility for treatment and disposal. The in-situ technique, in-situ volatilization/solidification, has been retained for further evaluation. This technology can be used to remediate sites with volatile organics by mixing soil with a large-diameter auger/mixer with hot air or steam injection. Following mixing of the source material and volatilization of COCs, solidification occurs by direct injection of reagents and additives into the subsurface soil using specialized machinery with injection augers and rotary-type mixers for blending. This process has the potential to reduce the mobility of inorganic contaminants.

Several other in-situ remediation techniques were considered for the site, but were eliminated as they would be ineffective for the contaminants at the site or because they would not address the potential for future releases from buried containers. Co-solvent flushing is an innovative in-situ technique that was considered for the site. This technology has not been fully demonstrated to be effective at sites similar to the Airport Road Waste Disposal Area; however this and similar methods are retained for further consideration as supplemental technologies for future use.

Technologies Retained for Further Consideration

In summary, source remediation technologies retained for further consideration include:

- No Action
- Institutional Controls: Deed/Land Restriction and Access Restriction
- Excavation
- Off-Site Disposal
- Ex-Situ/In-Situ Stabilization/Solidification
- Ex-situ/In-Situ Volatilization (Mixing)
- Incineration
- Macroencapsulation

2.3.2 Screening of Groundwater Remediation Technologies

Appendix C, Table C-2 identifies several available groundwater remediation technologies and process options within the general response categories. This table also presents a brief evaluation of each technology's viability at the subject site. Technologies retained from this screening process were combined to form remedial alternatives which are then evaluated in section 2.4.2. The following is a brief discussion on the potential response actions.

No Action

The no action option will be used as a baseline against which other options may be compared. Under no action, groundwater cleanup would not be undertaken, and the site would be left as it now exists with minimum monitoring. Institutional actions would be required for this alternative and were also retained for future use and to support other process options.

Natural Attenuation

Natural attenuation is a process option that relies on the natural processes of dispersion and degradation to remediate groundwater contamination. This option is employed at many sites due to its cost effectiveness and innovativeness. However, the current contaminant concentrations at the site are not favorable for natural attenuation to effectively remediate the groundwater plume before impacting the downgradient receptor (Crow Branch Creek). This option does have potential for future use when the groundwater is remediated to lower levels which can be naturally attenuated before reaching the receptor. Therefore, natural attenuation was retained for future implementation.

Extraction Technologies

Groundwater extraction (control) using conventional recovery wells and vacuum enhanced recovery was retained as a representative process option. These technologies are commonly used for the containment and remediation of contaminated groundwater.

Treatment Technologies

Based on the constituents of concern in groundwater, physical/chemical treatment process options such as precipitation/flocculation, filtration, air stripping, carbon adsorption, and ultraviolet treatment were considered. Air stripping was the most preferable alternative for treatment of VOCs (see Table C-2 of Appendix C) and was retained for further evaluation. An activated carbon system may also be required as a polishing step, if the treated effluent is discharged to a surface water body. Process options such as precipitation/flocculation, filtration, and sedimentation (clarification) were retained as support or optional technologies.

Discharge Options

The preferable discharge option for extracted groundwater is to transfer the treated groundwater to a POTW. Sanitary sewers are present in the vicinity of the site. In order to install a direct connection to the sanitary sewer system the University may negotiate for a discharge permit with Orange County Water and Sewer Authority (OWASA) in accordance with their Sewer Use Ordinance. Another disposal option is to discharge treated water to a surface water body (Crow Branch Creek) under a National Pollutant Discharge Elimination System (NPDES) permit. Both options will require frequent testing of discharged water to ensure that off-site receptors are not impacted.

In-Situ Treatment

In-situ treatment process options for groundwater were considered in the screening process. Reactive walls/zones and air sparging curtains were two treatment technologies considered as potentially applicable options and were retained. In addition, in-situ chemical oxidation is becoming a more popular and powerful remediation tool. Therefore, this option also was retained as a potential groundwater remediation technology. Some of the in-situ processes, such as anaerobic bioremediation, reductive dehalogenation using zero-valent iron metal, etc., have proven effective at other sites. These technologies will be retained for future consideration as supplementary technologies. Phytoremediation also was considered for controlling groundwater. However, this technology is not effective in remediating contaminants at depths below the water table. Therefore, this option was eliminated.

Technologies Retained for Further Consideration

In summary, groundwater remediation technologies retained for further consideration include:

- No Action
- Natural Attenuation
- Institutional Controls: Deed Restriction and Access Restrictions
- Extraction Wells
- Vacuum Enhanced Recovery

- Filtration (Support Technology)
- Precipitation/Flocculation
- Air Stripping
- Activated Carbon
- Sedimentation/Clarification
- In-Situ Chemical Oxidation
- Surface-Water Disposal
- Discharge to a Sanitary Sewer
- Miscellaneous In-Situ Technologies (Reductive Dehalogenation)

2.4 Development and Evaluation of Remedial Alternatives

In the previous section of this report, general response actions and the related remedial technologies and process options were identified. Remedial technologies and process options were screened to narrow the list and develop alternatives for remedial action at the site. These alternatives, which are presented in this section, will be evaluated using a set of criteria listed in the REC Program Guidelines. These criteria are listed below:

- Overall protection of human health and the environment, including attainment of remediation goals;
- Compliance with applicable Federal, State and local regulations;
- Long-term effectiveness and performance;
- Reduction in toxicity, mobility, and volume;
- Short-term effectiveness: effectiveness at minimizing the impact of the site remediation activities on the environment and the local community;
- Implementability: technical and logistical feasibility;

- Cost; and
- Community acceptance.

These criteria are defined further by factors and sub-criteria which are discussed briefly in Appendix D.

2.4.1 Evaluation of Source Remediation Alternatives

Source control alternatives (SCA) developed using technologies retained in the screening process, are listed below:

SCA-1: No Action

SCA-2: In-Situ Volatilization and Stabilization/Solidification of Primary and Secondary Sources

SCA-3: Excavation of Primary and Secondary Sources, Off-Site Treatment, and Off-Site Disposal

SCA-4: Excavation of Primary and Secondary Sources, Ex-Situ Mixing/ Homogenizing and Stabilization, Off-Site Treatment/Disposal

The following sections describe each of the source control alternatives in further detail.

2.4.1.1 SCA-1: No Action

The no action alternative is included to serve as a baseline against which other alternatives are compared. Currently, the waste material has approximately 4 to 5 feet of soil cover. The site is currently covered with mostly pine trees and small bushes, and a locked fence is in place with warning signs. The no action alternative applies to both primary (actual waste/material) and secondary sources (contaminated soils). Since no active source control measures are involved in this option, the potential for continued impacts to the environment are high. This option potentially would require deed restrictions and monitoring to prevent access to, and future development of, the site.

A detailed evaluation of the no action alternative against the eight evaluation criteria is presented in Table 2-4. An opinion of probable costs for the implementation of this alternative is presented as Table 2-5. For the purpose of calculating the cost of this alternative, it is assumed that 10 groundwater wells will be sampled on an annual basis for 30 years. Groundwater samples will be collected to monitor the continued release of contaminants from the source material and the continued downgradient migration of the groundwater contaminant plume. The present worth of opinion of total costs was estimated using a 7 percent discount factor.

2.4.1.2 SCA-2: In-Situ Volatilization and Stabilization/Solidification of Primary and Secondary Sources

The scope of this alternative includes treatment of primary and secondary sources in place using in-situ volatilization/mixing and solidification technology. This process consists of two primary steps: (1) volatilization/mixing of the source materials; and (2) solidification of the source materials in place. Figure 2-1 presents a conceptual process flow schematic of this alternative.

In the first process step, large diameter augers would be used to mix the source materials (soil and waste) in vertical columns. A series of overlapping columns would be necessary to cover the entire source area. The rotary mixing equipment would inject high pressure hot air and steam into the subsurface during the mixing process to volatilize contaminants in the soil/waste matrix. VOCs and some SVOCs that are volatilized during the mixing process would be recovered by applying a vacuum on a shroud covering the ground surface where the soil column is being mixed. The vapors recovered during the mixing process would be treated on-site to reduce contaminant concentrations and then discharged to the atmosphere. According to vendors of this technology, the mixing process could be expected to remediate greater than 90% of contamination in the subsurface.

Upon completion of the volatilization/mixing process, the solidification process would be implemented by injecting a cement-based solidification agent in to the subsurface throughout the mixed area. The solidification process is used to bind/ microencapsulate non-volatile and inorganic compounds in place, including the broken containers. This process would mitigate the potential for further release of contaminants to groundwater. Depending on the volume and depth of treatment, the solidified soil column could vary in diameter from 6 to 18 feet. The injection of the cement based stabilization agent is expected to result in bulking of the solidified material. Typically, stabilization results in the material increasing in volume by 20-50%. Depending on the amount of bulking, the stabilized material would either be transported to an off-site facility for disposal or re-graded on-site. A final soil cover would be installed over the site at the completion of the project. The soil cover would be seeded for erosion control.

Table 2-4 presents a detailed evaluation of the alternative with the eight criteria listed in Section 2.4. An opinion of probable costs for this option is presented in Table 2-6.

2.4.1.3 SCA-3: Excavation of Primary and Secondary Sources, Off-Site Treatment, and Off-Site Disposal

Excavation, treatment, and disposal of primary and secondary sources is expected to address and eliminate the continued release of contamination to groundwater. This alternative includes excavation of buried waste materials and contaminated soil underneath the burial areas to a depth no greater than top of bedrock. The excavation process would initially involve removing the top 4 to 5 feet of soil cover over the waste burial pits. The excavated cover material would be stockpiled on-site and sampled to confirm that it was not impacted with contaminants from the buried waste. If the material was found to contain unacceptable levels of contamination, this soil would be transported off-site for proper treatment and disposal

Once the uncontaminated soil cover is removed, excavation of the burial pits and impacted soils would take place. The excavated materials would be segregated to separate soil and containers. The soils would be transferred to a designated stockpile area for suspect contaminated soils or placed directly in containers for off-site disposal. The excavated chemical containers would be evaluated for chemical compatibility and grouped for proper treatment/disposal. If sufficient quantities of compatible chemicals were found, the chemicals may be bulked in larger storage vessels for transportation and treatment/disposal. Excavated waste materials and impacted soils would be transported to a Resource Conservation and Recovery Act (RCRA)-permitted Subtitle C treatment and disposal facility. The disposal facility would be required to treat the material to Land Disposal Restrictions (LDR) treatment standards.

Excavation activities will be conducted with mechanized excavation equipment as much as practical. Since the excavation should exceed a depth of 5 ft and would likely encounter the shallow water table, shoring/sheetpiling may be required to stabilize the sidewalls of the excavation. Dewatering of the excavation may also be required to remove any groundwater or rainwater that collects in the pit. Groundwater and rainwater extracted from the excavation may be treated with an on-site treatment system prior to appropriate discharge, or the collected water may be containerized for off-site treatment and disposal. All water drained from the roll-off containers would be containerized and transported for off-site treatment and disposal.

Vapors would likely be released to the atmosphere during the excavation process as a result of contaminant volatilization from impacted soils and broken containers. An exclusion zone would be established around the perimeter of the site to control vapor exposure to off-site personnel. Air monitoring would be conducted at the perimeter of the exclusion zone to ensure nearby residential and commercial areas are not negatively impacted. The extent of the exclusion zone would be determined by air modeling conducted prior to beginning the excavation process and utilizing the results of air monitoring activities that would be conducted during the excavation process. Site workers inside the exclusion zone would be required to wear proper protective equipment (i.e., respirators).

As required by the REC program guidelines, soil samples will be collected at the completion of the excavation process to verify that the soil clean-up requirements are achieved. The excavated area will be backfilled with clean soil upon completion of the excavation.

Figure 2-2 presents a conceptual flow schematic for this alternative. Table 2-4 presents a detailed evaluation of the alternative with the eight criteria listed in Section 2.4. An opinion of probable costs for this option is presented in Table 2-7.

2.4.1.4 SCA-4: Excavation of Primary and Secondary Sources, Ex-Situ Mixing/Homogenizing and Stabilization, Off-Site Treatment/Disposal

This alternative is similar in scope to SCA-3 in that it would involve the excavation of primary and secondary sources for off-site disposal. However, this alternative would involve dissimilar treatment of the excavated materials. Excavated materials in this option would be mixed above ground to form a homogenized mixture of soil, containers, and other waste materials. This homogenized mixture would then be placed in roll-off containers and stabilized with fly-ash, concrete, or other stabilizing agent for transportation to a treatment/disposal facility. Contaminants are expected to be volatilized during the mixing/homogenizing process which may reduce contaminant concentrations in the excavated soils. However, these reductions will likely be off-set by increases in contaminant concentrations resulting from the release of contaminants from containers broken during the mixing process.

The excavation process would initially involve removing the top 4 to 5 feet of soil cover over the waste burial pits. The excavated cover material would be stockpiled on-site and sampled to confirm that it was not impacted with contaminants from the buried waste. If the material was found to contain unacceptable levels of contamination, this soil would be transported off-site for proper treatment and disposal.

Once the uncontaminated soil cover was removed, excavation of the burial pits and impacted soils would take place. The excavated materials would be placed on a conveyor system and fed into a hopper that would homogenize the waste stream through mixing/crushing of containers and excavated soils. The homogenized material would be placed directly in roll-off containers to prevent run-off of spilled liquids. A temporary stabilizing agent would likely be added to the homogenized waste for transportation to a treatment facility. Liquids drained from the roll-off containers would be placed in separate containers and transported to a treatment/disposal facility. The homogenized waste and collected liquids would be transported to a RCRA-permitted Subtitle C treatment and disposal facility after the waste streams had been characterized. The disposal facility would be required to treat the material to meet LDR treatment standards.

Excavation activities will be conducted with mechanized excavation equipment as much as practical. As the homogenizing process will result in the mixing of some incompatible chemicals, reactions are expected take place. To reduce the potential for worker exposure to these reactions, workers will not be allowed in the mixing area, unless appropriate PPE is worn. Mechanical excavation equipment will be used to mix materials in the roll-off containers.

Since the excavation will exceed a depth of 5 ft and encounter the shallow water table, shoring/sheetpiling may be required to stabilize the sidewalls of the excavation. Dewatering of the excavation may be required to remove groundwater or rainwater that collects in the pit. Groundwater and rainwater extracted from the excavation would be treated with an on-site treatment system prior to discharge.

Vapors would be released to the atmosphere during the excavation and above ground mixing process as a result of contaminant volatilization from impacted soils and broken containers. Treatment of vapors may be required to reduce contaminant loading to the atmosphere and to reduce the potential for off-site exposure from vapors. An exclusion zone would also be established around the perimeter of the site to control vapor exposure to off-site personnel. Air monitoring would be conducted at the perimeter of the exclusion zone to ensure nearby residential and commercial areas are not impacted. The extent of the exclusion zone would be determined by air modeling conducted prior to beginning the excavation process and based on the results of air monitoring activities conducted during the excavation process. Site workers inside the exclusion zone would be required to wear appropriate protective equipment (i.e., respirators, supplied air, etc.).

As required by the REC program guidelines, soil samples will be collected at the completion of the excavation process to verify that the soil clean-up requirements are achieved. The excavated area will be backfilled with clean soil upon completion of the excavation.

Figure 2-3 presents a conceptual flow process diagram for this alternative. Table 2-4 presents a detailed evaluation of the alternative with the eight criteria listed in Section 2.4. An opinion of probable costs for this option is presented in Table 2-8.

2.4.2 Evaluation of Groundwater Remediation Alternatives

The groundwater remediation alternatives (GWA) selected for the shallow (unconsolidated aquifer) groundwater hot spots and dissolved contamination in the bedrock aquifer at the site are as follows:

GWA-1: No Action

GWA-2: Conventional and Vacuum-Enhanced Recovery of Shallow Groundwater, and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal

GWA-3: Funnel and Gate for Shallow Hot Spot Groundwater Remediation, and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal

GWA-4: In-Situ Chemical Treatment of Shallow and Deep Hot Spot Groundwater, Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal.

The following sections provide a brief description of each of the alternatives.

2.4.2.1 GWA-1: No Action

The no action alternative is included to serve as a baseline by which other groundwater remediation techniques may be evaluated. In the no action scenario, active remediation of contaminated groundwater will not be undertaken. However, groundwater samples from representative monitor wells will be collected and analyzed on an annual basis to evaluate the effectiveness of this alternative and to monitor the downgradient migration of the contaminant plume. These samples will be analyzed for VOCs. The fate and transport of contaminants in the groundwater will depend on natural processes.

A detailed evaluation of this alternative is presented in Table 2-9. Table 2-10 presents the opinion of probable costs for implementation of the no action alternative. For the purpose of calculating the cost of this alternative, it is assumed that 10 groundwater wells will be sampled annually for 30 years. A seven percent discount rate was utilized to calculate the present worth of the alternative.

2.4.2.2 GWA-2: Conventional and Vacuum-Enhanced Recovery of Shallow Groundwater (Hot Spot) and Conventional Recovery of Bedrock Groundwater, Treatment and Disposal

The scope of this alternative includes groundwater extraction in the shallow aquifer (overburden) using both the vacuum-enhanced recovery (VER) technique and conventional pumping technique. The VER technology will be employed in the vicinity of the source area while conventional pumping techniques will be employed downgradient near Crow Branch Creek. VER was selected for the source area for two primary reasons: 1) it enhances recovery of contaminated groundwater from low-permeability soils such as those present at the site, and 2) VER will extract air and vapors in the exposed vadose zone promoting volatilization of contaminants from the soil matrix. Downgradient of the source area, contaminated groundwater in the shallow and bedrock aquifer will be recovered using conventional pumping techniques. The extracted groundwater from both the VER and conventional pumping systems will be treated with an on-site air stripper to remove VOCs prior to disposal. An optional carbon polishing system may also be utilized after the air stripper to further reduce VOC concentrations in the discharged water. It is assumed that the treated water will be discharged via an NPDES permit or to the publicly owned treatment works (POTW) system. It is also assumed that the concentrations of dissolved organics in the recovered groundwater will be relatively low; therefore, emissions from the air stripper or vacuum extraction will not require vapor phase treatment.

The recovery system discussed in this alternative will likely consist of four shallow VER wells located immediately downgradient of the source area, in the vicinity of MW-1. There will also be six conventional recovery wells located downgradient of the source area, near Crow Branch Creek, that would function as containment wells. Three of the conventional recovery wells would be in the surficial aquifer, while the other three would pump from the bedrock aquifer. The extraction wells will be piped to a central treatment system located on site. For the purposes of this evaluation, it is estimated that shallow wells will operate for approximately 10 years and deep extraction wells will operate for approximately 30 years. Figure 2-4 presents a conceptual process flow schematic of this alternative.

A detailed evaluation of this alternative is presented in Table 2-9. Table 2-11 presents the opinion of probable costs for implementation of this alternative.

2.4.2.3 GWA-3: Funnel and Gate for Shallow Hot Spot Groundwater Remediation and Conventional Recovery of Bedrock Groundwater, Treatment and Disposal

The scope of this alternative includes a funnel and gate technology to achieve passive remediation of shallow groundwater in the overburden aquifer and conventional extraction of bedrock groundwater. An air stripper with a carbon polishing system will be used to treat extracted groundwater, and the treated effluent will be discharged to Crow Branch Creek. Figure 2-5 presents a process flow schematic of this alternative.

The funnel and gate system will utilize a low permeability wall constructed of sheet piles to convey shallow groundwater towards a central treatment area (gate). The gate will be constructed of permeable backfill with air sparging and vapor extraction points. As groundwater containing VOCs passes through the gate, it is volatilized by the air sparging system and the vapors are removed by a vapor extraction system. The funnel and gate system will be installed downgradient of Monitor Well MW-1 (hot spot) for the treatment of high concentration VOCs in the overburden aquifer. The conventional recovery wells for the bedrock aquifer will be constructed near the creek as in Alternative GWA-2.

A detailed evaluation of this alternative is presented in Table 2-9, and the opinion of probable costs for implementation of this alternative are presented in Table 2-12.

2.4.2.4 GWA-4: In-Situ Chemical Treatment of Shallow and Deep Hot Spot Groundwater and Conventional Recovery of Bedrock Groundwater, Treatment and Disposal

In-situ chemical oxidation of organic compounds can be achieved by injecting chemicals (acetic acid, ferrous sulfate, and hydrogen peroxide) in a sequence into injection/monitor wells. Injection of these chemicals will produce hydroxyl radicals which can oxidize organic compounds in-place. Hydroxyl radicals are very powerful oxidizing agents which will oxidize organic compounds to carbon dioxide and water. Production of hydroxyl radicals will involve conversion from liquid to vapor state with a consequent large volume expansion.

This alternative consists of using the chemical oxidation method for remediation of dissolved contaminants in both shallow (overburden) and deep bedrock hot spots. It is assumed that existing deep monitor wells, in addition to a set of shallow injection wells, will be required to implement this process for groundwater remediation. This scenario involves the use of the chemical oxidation process to remediate in the shallow hot spots (around Monitor Well MW-1) and bedrock hot spots (around MW-14). However, a conventional groundwater recovery, treatment, and disposal system will be required to capture the impacted groundwater plume and eliminate discharge the nearby creek. As indicated in GWA-2, approximately three bedrock recovery wells are assumed to be sufficient to contain the bedrock contamination. Figure 2-6 presents a process flow schematic for this alternative.

A detailed evaluation of this alternative is presented in Table 2-9, and the opinion of probable costs for implementation of this alternative is presented in Table 2-13.

2.5 Comparative Analysis of Alternatives

This section compares the relative performance of the source remediation and groundwater remediation alternatives discussed in the previous sections with respect to the eight REC Program evaluation criteria listed at the beginning of Section 2.4. Alternatives for source remediation and groundwater remediation are compared separately, as the remedial actions will be conducted independently of one another.

2.5.1 Comparison of Source Remediation Alternatives

Four source remediation alternatives have been identified for the site. The alternatives, which are described in Section 2.4.1, include SCA-1: No Action; SCA-2: In-Situ Volatilization and Stabilization/ Solidification of Primary and Secondary Sources; SCA-3: Excavation of Primary and Secondary Sources, Off-Site Treatment, and Off-Site Disposal; and SCA-4: Excavation of Primary and Secondary Sources, Ex-Situ Mixing/Homogenizing and Stabilization, Off-Site Treatment/Disposal. Table 2-4 presents an evaluation of each of the source control alternatives with respect to the eight evaluation criteria. The following sections summarize the results of this evaluation process.

2.5.1.1 Protection of Human Health and the Environment

Groundwater samples collected during the multiple phases of investigation at the site have indicated that groundwater is impacted with contaminants released from the source material and that the contaminant plume is migrating downgradient. Surface water data from Crow Branch Creek indicate that contaminants have been detected in this receptor, albeit at concentrations below surface water standards. The SCA-1 (no action) alternative would involve no source control measures and would not prevent further releases to groundwater from the source material; therefore this alternative would not be protective of human health or the environment. The SCA-2 alternative (in-situ volatilization/solidification) would likely reduce the volume of contaminants in the ground and reduce the risk of further releases or exposure to human beings; therefore this alternative is considered protective of human health and the environment. The SCA-3 (excavation, segregation, and off-site treatment/disposal) alternative would eliminate the potential for future releases and is therefore protective of the environment. However, SCA-3 would pose a slightly greater risk to on-site workers than the other alternatives, because workers would need to handle the waste material. On-site workers would be required to wear protective equipment in all active remediation scenarios, therefore the alternative is still considered protective of human health. Once completed, this alternative would virtually eliminate the risk of further releases or exposure to human beings. SCA-4 (excavation, homogenizing, off-site treatment) would also involve the removal of the source material and is therefore protective of the environment. This alternative would also require less handling of the waste material by on-site workers and is therefore protective of human health. In addition, SCA-4 would also virtually eliminate the risk of further releases or exposure to human beings once it is completed.

2.5.1.2 Compliance with Applicable Regulations

Several remedial action objectives have been established for this site as discussed in Section 2-1. The no action alternative (SCA-1) would not satisfy any of the RAOs for the site. This alternative would also not satisfy the regulatory requirements listed in Table 2-4.

Alternatives SCA-2, SCA-2, and SCA-4 would all assist in meeting the RAOs for the site and would also assist in achieving the applicable soil and groundwater clean-up standards. However, implementation of these alternatives will require that several other regulations are enforced including the following:

- State water quality and air pollution control permits;
- OSHA requirements for PPE and excavation standards;
- Transportation and disposal requirements under DOT and RCRA regulations; and
- Land disposal restrictions (LDRs) for treatment of excavated wastes.

2.5.1.3 Long-Term Effectiveness and Permanence

Alternative SCA-1 would result in continued release of contaminants from primary and secondary sources to groundwater. Furthermore, additional releases could occur from the material that remains in the primary source area. Therefore, the no action alternative (SCA-1) will not be an effective means of improving the condition of the site. SCA-2 involves in-situ mixing and stabilization of contaminants. While this method will result in the removal of a majority of the contamination in the source area, broken containers and some residual soil contamination will be left in place, albeit in a stabilized mass. The stabilization process should immobilize most of the contaminants left in place; however, the potential will exist for source material in the stabilized mass to continue leaching to groundwater. Any untreated soils may also leach contaminants to groundwater. Leaving a stabilized mass in place may also preclude future development of the site. Excavation is a commonly used remedy that is extremely effective at reducing risks from buried source materials; therefore, SCA-3 and SCA-4 are considered the best alternatives for the long term effectiveness and permanence of the remedy.

2.5.1.4 Reduction of Toxicity, Mobility, and Volume

The no action alternative (SCA-1) would not reduce the volume, mobility, or toxicity of the contaminants, with the exception of natural attenuation processes. Natural attenuation is not anticipated to be effective due to the high concentrations observed on-site. The in-situ volatilization and stabilization alternative (SCA-2) is expected to remove significant volumes of contaminants from the subsurface. However, some VOCs and SVOCs will be left in place in this option. The materials left in place would be less mobile as they would be encapsulated in a stabilized mass, although the potential will exist for further leaching of contaminants to groundwater. The SCA-3 and SCA-4 alternatives both involve the removal and treatment of primary and secondary source material and would therefore provide the largest reductions in contaminant mobility, volume, and toxicity.

2.5.1.5 Short-Term Effectiveness

Alternative SCA-1 would not disturb the source material and would not adversely impact workers or the community. The remaining alternatives would have the potential for worker and community exposure during implementation due to the volatilization of contaminants during the excavation process, mixing process, and/or the transportation process. SCA-2 and SCA-4 would likely result in more vapors being generated than the other alternatives due to the mixing process. Vapor control devices would likely be required in these scenarios to reduce contaminant loading to the atmosphere. SCA-3 has a higher potential for direct worker exposure to contaminants due to the necessity of workers to handle the excavated waste containers. Use of proper protective equipment will be required under all three active remediation scenarios to ensure worker safety.

2.5.1.6 Implementability

The no action alternative (SCA-1) would have a minimum of activities and would therefore be easily implemented. The in-situ treatment technology (SCA-2) would require a specialized rig that is available from few vendors. However, once mobilized this treatment technology can be implemented fairly quickly and easily (approximately 3-5 weeks to completion). Another potential benefit of this technology is that the mixing process is conducted below ground which could reduce worker exposure. SCA-4 could be fairly easy to implement as the excavation process could be conducted with conventional construction equipment, however the process will be complicated by the need to homogenize the waste stream. There are some dangers involved in mixing incompatible chemicals, even when conducted remotely. Locating a Subtitle C treatment facility that can effectively treat the homogenized waste stream may also be difficult. Alternative SCA-3 would also utilize conventional construction techniques for excavation, although the process would be slowed considerably due to the labor intensive practices of manually segregating the material. Alternatives SCA-3 and SCA-4 may both require extensive permitting efforts to obtain permission to transport and dispose of the material off-site.

2.5.1.7 Costs

Based on a comparison of the four source control alternatives, SCA-1 has the lowest present worth cost. This alternative will be used as a baseline for comparison purposes only. Among the other three, the probable cost of implementing alternative SCA-2 has the lowest present worth. The costs of implementing SCA-3 and SCA-4 are similar to one another, but are higher than SCA-2.

Costs were estimated based on the conceptual designs of the SCAs outlined in this document. The cost estimation is intended as an opinion only and is based on the prior experience of ARCADIS on similar projects. The costs do not include vendor/contractor quotes as this would require a detailed design. Actual costs may vary as much as –30 to +50 percent. A detailed cost estimate will be prepared as part of the detailed design documents in the Source Remediation Preconstruction Report.

2.5.1.8 Community Acceptance

Community acceptance of the various source remediation technologies is currently unknown.

2.5.2 Comparison of Groundwater Remediation Alternatives

Four groundwater remediation alternatives have been identified for the site. The alternatives, which are described in Section 2.4.2, include GWA-1: No Action; GWA-2: Conventional and Vacuum-Enhanced Recovery of Shallow Groundwater, and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal; GWA-3: Funnel and Gate for Shallow Hot Spot Groundwater Remediation, and Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal; GWA-4: In-Situ Chemical Treatment of Shallow and Deep Hot Spot Groundwater, Conventional Recovery of Bedrock Groundwater, Treatment, and Disposal. Table 2-9 presents an evaluation of each of these groundwater remediation alternatives with respect to the eight evaluation criteria. The following sections summarize the results of this evaluation process.

2.5.2.1 Protection of Human Health and the Environment

Groundwater samples collected during the multiple phases of investigation at the site have indicated that groundwater contamination is present at concentrations in excess of applicable groundwater remediation standards in both the surficial and bedrock aquifers. Groundwater impacts in excess of the standards extend as far downgradient as Crow Branch Creek. Water level data collected at the site indicates that Crow Branch Creek is directly recharged by site groundwater and limited contaminant impacts have been detected in this surface water receptor. Contaminant concentrations are not expected to naturally attenuate in a reasonable time frame; therefore, the no action alternative (GWA-1) is not deemed to be protective of the environment. The no action alternative does not reduce exposure risks and therefore it is not considered protective of human health.

Groundwater remediation alternatives GWA-2, GWA-3, and GWA-4 involve active remediation scenarios that are designed to reduce contaminant concentrations within groundwater and prevent further migration of the contaminant plume. As such, these alternatives are all considered to be protective of human health and the environment.

2.5.2.2 Compliance with Applicable Regulations

The no action alternative is not expected to reduce groundwater contaminant concentrations to meet applicable remediation goals; therefore GWA-1 is not expected to comply with the RAOs for the site or applicable state and federal regulations.

The remaining alternatives, GWA-2, GWA-3, and GWA-4, are active remediation scenarios that are expected to lower groundwater contaminant concentrations and to eventually meet the groundwater remediation goals. Therefore, all of the active scenarios would satisfy the groundwater RAOs for the site. However, implementation of these alternatives would also require that other applicable state and federal regulations are complied with, including the following:

- Discharge limitations for treated groundwater will require an NPDES permit for discharge to Crow Branch Creek or a pre-treatment permit for discharge to the sanitary sewer system;
- Air emissions from treatment systems should comply with the requirements of NCAC Title 15A, Chapter 2D and 2H;
- Air emissions from each of the recovery treatment processes may not require control devices, in which case an air permit would not be required. If control devices were necessary, an air permit may be required;
- Installation of recovery wells will require a well construction permit; and
- Alternative GWA-4 will require an injection well permit as required by NCAC Title 15A, Chapter 2C.

2.5.2.3 Long-Term Effectiveness and Permanence

The no action alternative will not reduce groundwater contaminant concentrations and will not prevent further downgradient migration of the contaminant plume towards potential receptors; therefore, GWA-1 is not deemed to be an effective means of controlling impacts from the plume. The remaining alternatives all have the potential to reduce the extent of, and concentrations within, the contaminant plume and are considered suitable alternatives for meeting the RAOs of the site. However, if source control is not implemented these alternatives will only serve as means of controlling the migration of the plume.

While considered an effective means of controlling downgradient migration of shallow groundwater, the funnel and gate technology in GWA-3 would be the slowest alternative for lowering on-site contaminant concentrations. This technology is a passive system that relies on groundwater flow to transport contaminants to the treatment area. A pump and treat system would also be utilized in this option to control contaminant migration in the bedrock aquifer. While pump and treat is an active remediation system that will extract contaminants from the subsurface, this technology will require long term operation to effectively meet the groundwater remediation goals.

Alternative GWA-2 would utilize an active pump and treat system to control the migration of, and concentrations within, the contaminant plume. In order to expedite the remediation process, this method would employ VER technology in the source area extraction wells for the shallow aquifer. VER technology can accelerate mass recovery by providing both groundwater and vapor extraction. By lowering contaminant concentrations in the source area, this technology could reduce contaminant loading to the downgradient shallow and bedrock aquifers. While this alternative is expected to be more efficient than GWA-3, the pump and treat system would require long term operation to meet the remediation goals.

The in-situ remediation technique in alternative GWA-4 has the potential to provide the most rapid decline in contaminant concentrations, provided that the oxidation system can be effectively implemented. Injection of the chemical oxidation materials into the subsurface may be difficult due to the low permeability of the shallow aquifer materials. This method will also require the long term operation of a pump and treat system to effectively meet the RAOs and control contaminant migration within the bedrock aquifer.

2.5.2.4 Reduction of Toxicity, Mobility, and Volume

The no action alternative (GWA-1) is not expected to result in significant reductions in the toxicity, mobility, or volume of contaminated groundwater. Should additional releases occur from the primary source material, the toxicity and volume of the contaminant plume would be expected to increase.

Alternatives GWA-2, GWA-3, and GWA-4 involve active remediation of the groundwater contaminant plume using groundwater extraction and/or in-situ treatment technologies. The net result of these technologies is that the contaminant plume is contained and significant reductions in contaminant concentrations are achieved.

2.5.2.5 Short-Term Effectiveness

The no action alternative (GWA-1) would involve minimal effort and therefore no impacts would be anticipated in its implementation. The remaining alternatives would also result in minimal impacts to the surrounding community. The impacts associated with alternatives GWA-2, GWA-3, and GWA-4 would be confined to the site.

Standard construction techniques would be utilized to perform all recovery well, equipment, building, and recovery system piping installation activities for each alternative. Any impacts to workers during these activities could be minimized through use of proper protective equipment. The trenching activities required for alternative GWA-3 would increase the potential for impacts, as site workers would likely be exposed to higher vapor concentrations. The chemical oxidation process employed in alternative GWA-4 also presents an increased risk of impacts if not carefully implemented. The oxidation process can cause reactions that are uncontrollable and could impact on-site workers.

2.5.2.6 Implementability

The no action alternative (SCA-1) would have a minimum of activities and would therefore be easily implemented. The pump and treat system proposed in alternative (GWA-2) would also be easily implemented. This alternative would require the installation of a minimal number of extraction wells that could be constructed using traditional well drilling techniques. Pump test and VER test results from the site have indicated that recovery wells would be able to extract sufficient volumes of groundwater for the technology to be effective.

Alternative GWA-3, which involves a combination of funnel and gate technology and pump and treat, would be somewhat more difficult to implement than the previous two options. This option would require trenching to install an impermeable barrier wall near the source area which would increase the potential for worker exposure. The air sparge gate used in this method would also be difficult to maintain should any bio-fouling occur. As in GWA-2, the recovery wells would be constructed using traditional well drilling techniques.

Alternative GWA-4 would likely be the most difficult option to implement due to the low permeability of subsurface materials at the site. This method would require a pilot test prior to implementation to determine if the injection technology and/or the chemical oxidation technology would work at this site. In a full scale scenario, it is assumed that existing deep wells and new shallow wells would be used to inject the required solutions. Any new wells would be constructed using traditional well drilling techniques.

2.5.2.7 Costs

Based on a comparison of the four groundwater remediation alternatives, GWA-1 has the lowest present worth cost. This alternative will be used as a baseline for comparison purposes only. Among the other three alternatives, the probable cost of implementing alternative GWA-2 has a lowest present worth. However, the present worth cost of all three alternatives was fairly similar.

Costs were estimated based on the conceptual designs of the GWAs outlined in this document. The cost estimation is intended as an opinion only and is based on the prior experience of ARCADIS on similar projects. The costs do not include vendor/contractor quotes as this would require a detailed design. Actual costs may vary as much as –30 to +50 percent. A detailed cost estimate will be prepared as part of the detailed design documents in the Groundwater Remediation Preconstruction Report.

2.5.2.8 Community Acceptance

Community acceptance of the various groundwater remediation technologies is currently unknown.

2.6 Selection of Remedial Alternatives

The following sections briefly describe the selection of source remediation and groundwater remediation alternatives.

2.6.1 Selection of the Source Remediation Alternative

The results of multiple phases of investigation at the Airport Road Waste Disposal Area have indicated that releases from buried laboratory waste have resulted in the formation of a groundwater contaminant plume that could potentially impact downgradient receptors. Several viable source control alternatives have been developed to prevent further impacts to groundwater. These alternatives are discussed in Section 2.4 and evaluated against a set of pre-defined criteria in Section 2.5.

A no action alternative (SCA-1), in which no source control activities would be implemented, was presented for the purpose of comparing active scenarios. The no action alternative would not meet the RAOs for the site and has been eliminated from further consideration.

The active source control alternatives (SCA-2, SCA-3, and SCA-4) all have the potential to satisfy the RAOs for the site. Source control alternative SCA-2 would involve in-situ mixing and solidification of the primary and secondary waste material. During the mixing process high-pressure air and steam would be injected into the subsurface to volatilize contaminants in the soil matrix and chemicals spilled from broken containers. Vendors estimate that roughly 90% of the contaminants would be removed during the mixing process. The remaining material would be stabilized in place using concrete. The benefits of this technology are that it is easily implemented and reduces the need for direct worker contact with the source material. The primary worker hazards associated with this method would be from vapors generated during the volatilization process. Unfortunately this technology does have its downsides: (1) the mixing process could break containers that are currently intact and potentially liberate significant quantities of chemical materials releasing these materials to the shallow aquifer; (2) it is difficult to confirm that all source have been removed and/or stabilized; (3) contaminants left in place could continue to leach to groundwater; (4) leaving a stabilized mass in place could preclude future development of the site from both the land use and public perception standpoints; (5) a tremendous amount of vapor could be generated that could potentially impact off-site areas; and (6) mounding of the groundsurface that will result from bulking will have visual impacts on the site. While this is the least expensive remedial alternative for the site, the long term implications of leaving the waste in place may preclude implementation of this option.

Source control alternatives SCA-3 and SCA-4 both involve removal of all primary and secondary source material using conventional excavation techniques. These options would both permit the collection of samples from the sides and base of the excavation that could be used to confirm that all source material had been removed. Alternatives SCA-3 and SCA-4 differ in their approach to handling the waste once excavated. In alternative SCA-4, the excavated wastes (buried containers and impacted soils) would be homogenized through a mixing/crushing process and placed in roll-off containers. A temporary stabilizing agent would then be mixed with the homogenized waste for transportation to an off-site treatment/disposal facility. The benefit of handling the waste in this manner is that workers would not have to come into direct contact with the waste and workers would not be exposed to any reactions that would occur due to mixing of incompatible materials. Potential downsides to this technology include the following: (1) a high amount of vapors would be generated during the mixing/homogenizing process which could potentially impact off-site areas if not treated properly; (2) locating a Subtitle-C facility capable of accepting the homogenized waste may be difficult; (3) contaminant concentrations in the excavated soil will increase as containers break during the homogenizing process.

Alternative SCA-3, like SCA-4 involves excavation of primary and secondary source materials using conventional excavation techniques. In this alternative, primary source materials such as full and broken containers would be manually segregated from the soils. The soils would be placed in roll-off containers and chemicals would be packed in laboratory over-packs for transportation to the Subtitle C treatment and disposal facility. This method would minimize the generation of vapors, thus reducing the potential for off-site impacts. Any increased risk resulting from direct worker exposure to the primary and secondary source material would be minimized through use of proper personnel protective equipment and selection of a remediation contractor experienced with this type of work. Segregation of the waste streams into soils and compatible chemicals will also simplify the process of finding a treatment facility to handle the waste. The additional cost associated with this alternative versus SCA-2 is outweighed by the technology’s long term effectiveness; therefore, the best alternative for source area remediation is SCA-3.

2.6.2 Selection of the Groundwater Remediation Alternative

Several groundwater remediation alternatives were presented in Section 2.4 which are capable of satisfying the RAOs that have been established for the site. One of the alternatives was a no action option, in which groundwater remediation would not be undertaken. This option was merely presented as a tool for evaluating the other scenarios and would not meet the RAOs. Therefore the no action alternative has been eliminated from further consideration.

Groundwater remediation alternatives GWA-2, GWA-3, and GWA-4 all include a pump and treat design for remediation of the bedrock aquifer. Remediation of the bedrock aquifer is expected to be a long term process and the alternatives will all produce similar long term results. Therefore, the bedrock remediation design was not a deciding factor in choosing a remedy for the site.

Groundwater remediation alternatives GWA-2, GWA-3, and GWA-4 presented various methods for remediating surficial groundwater contamination. The in-situ chemical oxidation process in alternative GWA-4 is an innovative method and has the potential for rapid reductions in contaminant concentrations; however, its field application at similar sites is fairly limited and the low permeability of the surficial aquifer materials may limit its effectiveness. A thorough pilot test program would need to be conducted prior to implementing this technology. Alternative GWA-3 involves a passive method for containment and treatment (funnel and gate) of shallow hot spots, whereas alternative GWA-2 involves active remediation of shallow hot spots using a VER technique. Both GWA-2 and GWA-3 are easily implementable, but the VER system in Alternative GWA-2 is expected to have a shorter project life compared to that of the reactive wall (sparge curtain) in alternative GWA-3. An initial estimate of the costs associated each remediation technology indicates that GWA-2 will be the least expensive option to implement.

Based on its ease of implementation, effectiveness, and cost the best alternative for groundwater remediation is GWA-2.

3. Proposed Remedial Action

This section presents a description and conceptual design of the proposed source control and groundwater remediation scenarios for the Airport Road Waste Disposal Area in Chapel Hill, North Carolina. In addition, various plans required for implementing the proposed remedies also are identified in this section. It should be noted that the proposed design specifications presented in this document may be modified in the final engineering design for the remedies which will be presented in the context of Preconstruction Reports. Separate Preconstruction Reports will be submitted for the source control and groundwater remedies. Any modifications would be subject to review by the NCDENR.

3.1 Description and Conceptual Design of the Proposed Source Remedial Action

3.1.1 Description of the Proposed Source Remedial Action

The first step in implementing the remedy selected (SCA-3) will be to remove the top 4 to 5 feet of soil that was placed over the burial trenches as a protective cap. The excavated cover material will be stockpiled on-site and sampled to confirm that it is not impacted with contaminants from the buried waste. If the material is found to be impacted at concentrations above the soil remediation goals, this soil will be transported off-site for proper treatment and disposal.

Once the cover soil is removed, excavation of the burial pits and impacted soils will commence. All materials recovered during the excavation process will be screened for separation of soil and containers. The soils will be transferred to roll-off boxes or to a designated stockpile area for suspect contaminated soils. The intact chemical containers will be screened for chemical compatibility using a field Hazardous Category (HAZCAT) Analysis and grouped together for over-packing and proper treatment/disposal. If sufficient quantities of compatible chemicals are found, the chemicals may be bulked in larger storage vessels for transportation and treatment/disposal. Broken containers and other miscellaneous materials would be segregated from the waste stream and placed in designated bins for proper packing and disposal. All excavated waste materials and impacted soils would be transported to a Resource Conservation and Recovery Act (RCRA)-permitted Subtitle C treatment and disposal facility. The disposal facility would be required to treat the material to Land Disposal Restrictions (LDR) Treatment Standards.

All excavation activities will be conducted with mechanized excavation equipment so as to minimize site workers' direct contact with source materials. Since the excavation will exceed a depth of 5 ft and will likely encounter the shallow water table, shoring/sheetpiling may be required. Dewatering will also be required to remove any groundwater or rainwater that collects in the open excavation. All groundwater and rainwater extracted from the excavation would be stored in an on-site fractionalization tank. Depending on the results of a characterization analysis, the water would either be discharged to the sanitary sewer system or transferred to an approved treatment facility.

Vapors will likely be released to the atmosphere during the excavation process as a result of contaminant volatilization from impacted soils and broken containers. An exclusion zone would be established around the perimeter of the site to prevent off-site personnel and public exposure to vapors. Air monitoring would be conducted at the perimeter of the exclusion zone to ensure nearby residential and commercial areas are not impacted. The boundaries of the exclusion zone will be determined by air modeling conducted prior to beginning the excavation process and based on actual air monitoring data collected during excavation. Site workers inside the exclusion zone will be required to wear proper protective equipment (i.e., respirators or supplied air).

Soil samples will be collected from the base and sidewalls of the excavation to verify that the soil clean-up requirements are achieved. The excavated area will be backfilled with clean soil at the completion of the project.

3.1.2 Conceptual Design of Proposed Source Remedial Action

This section presents a conceptual analysis of how the selected source control remedy may be implemented. Information presented in this section is not intended to serve as the final design specification for the remedy.

3.1.2.1 Treatment Area

The source area consists of a 0.5-acre tract of land that is easily accessible from Municipal Drive. A total of 18 laboratory waste burial cells were constructed within an approximately 0.3 acre portion of this tract. Each cell reportedly had an average size of approximately 10 feet wide by 20 feet long by 10 feet deep. A majority of the burial cells were constructed in two parallel trenches with approximately 4 to 8 feet of native soil separating each cell. The laboratory wastes were placed within the lower 4 to 5 feet of each burial cell and covered with fly ash. The upper 4 to 5 feet of each cell (trench line) was backfilled with clean soil as a protective cap. Figure 3-1 illustrates the estimated extent of the source area. Sketches showing the approximate locations of the burials are also included in Appendix B.

The buried laboratory waste containers and soils located within and directly beneath the burial cells have been identified as primary sources and will be removed during implementation of this remedy. Other soils within the footprint of, and immediately adjacent to, the burial area that have been impacted by contaminants at concentrations above applicable remediation goals are identified as secondary sources and will also be removed during implementation of this remedy. Secondary sources are assumed to extend to a depth no greater than groundwater, which is encountered in the waste disposal area at a depth of approximately 15 feet. Figure 3-2 illustrates the approximate boundaries of the area to be excavated. The soil remediation goals are outlined in Table 2-3.

3.1.2.2 Excavation

The excavation process will proceed one burial cell at a time. The first step in the process will be to remove the top 4 to 5 feet of soil that was placed over the burial cell as a protective cap. The excavated cover material will be stockpiled in a designated area and sampled to confirm that it is not impacted with contaminants from the buried waste. If the material is found to contain unacceptable levels of contamination, this soil will be transported off-site for proper treatment and disposal.

Once the cover soil has been removed, excavation of the buried waste material will proceed. The waste will likely consist of a conglomeration of containers (broken and intact), fly ash, and soil. All materials recovered during the excavation process will be screened for separation of soil and containers. The soils will be transferred to roll-off boxes and the waste containers will be transferred to a designated area for segregation and packing. After all containers have been removed from the burial cell an additional 1-foot of the surrounding soils (base and sidewalls) shall be excavated to ensure that all soils that were in direct contact with the waste have been removed. The excavation will then proceed to the next burial cell in the trench line. It may be necessary to install sheet piling if the sidewalls of the excavation are compromised or if groundwater is encountered during the excavation process.

After all burial cells within a trench line have been excavated and all primary source material has been removed, soil samples will be collected from the sidewalls and bottom of the excavated area. The samples will be analyzed for VOCs to determine if contaminants are still present at levels above the soil remediation goals. If necessary, additional soils will be excavated until soil samples confirm that contaminant levels are below the established remediation goals. The depth of excavation is not expected to exceed 13 feet which corresponds with the top of the water table. Sheet piling and proper excavation techniques will be utilized to ensure stability of the sidewalls. Upon removal of all secondary sources, the excavated area will be backfilled with clean material. The remedial activities will then proceed to the next line of burial cells, until all waste has been removed.

Heavy equipment such as a trackhoe or backhoe shall be used for excavation activities, as much as practical. Workers will not enter the excavation unless deemed safe and necessary. To prevent excess mixing of suspect-clean soil with the mixed soil and wastes, the excavator bucket will not contain teeth. A plate may be welded to the teeth to create a flat cutting surface if a toothless bucket is not available. The rate of excavation shall not proceed at a rate that exceeds the capacity of the proposed stockpiles and the waste segregation activities.

3.1.2.3 Waste Segregation

Chemical containers removed during the excavation process will be segregated from the excavated soils for separate handling and packing. The waste segregation process will be conducted in a designated area, either by creating small piles of excavated material that can be sorted by site workers or by placing the material on a conveyor system. A trommel may also be used to screen soils for any small or broken containers.

The chemical containers will be transferred to a secure area, within the fenced portion of the site, for further characterization and segregation. The containers will be separated based on chemical compatibility. A hazardous category (HazCat) analysis will be conducted on all unknown chemicals for proper segregation. Upon receiving the results of the HazCat analysis, compatible chemicals will be packed in laboratory over-packs or in approved bulking containers for transportation to the treatment/disposal facility.

Soil will also be segregated into suspect clean and suspect impacted stockpiles. Suspect clean soils, which will consist of the overburden material from ground surface to a depth of 4 ft bls, will be sampled and analyzed for VOCs. If the analytical results indicate that the material is clean the material may be used as backfill for the excavation. All impacted or saturated soils will be placed directly in roll-off containers. The impacted soils will be transferred to an approved treatment and disposal facility.

3.1.2.4 Stockpile and Waste Segregation Areas

During the excavation process some materials will be temporarily stockpiled outside the site boundaries. A designated clean soil stockpile area will be located west of the site as depicted on Figure 3-3. All impacted soils will be stored in an appropriate waste storage area. Both clean and impacted soils will be sampled to determine treatment and disposal alternatives. Clean soil may be re-used (if suitable) as backfill material for the excavation. All hazardous soils will be transported to an approved facility for treatment and disposal. The soil stockpile area will be maintained in such a manner so as to prevent off site impacts due to wind, rain, flooding, etc. through the use of liners and covers.

Figure 3-3 depicts the area that is proposed for segregation and temporary storage of the excavated chemical containers. This area will be located inside the fenced area and west of the waste burial pits. This area will be maintained in such a manner so as to protect against further impacts to the site. Containment devices used in this area will likely include liners and pre-engineered secondary containment units. The waste containers will be placed in laboratory over-packs, once the material has been identified. Material will be transported off site to an approved facility for treatment and disposal.

3.1.2.5 Dewatering and Storage Operations

During the excavation process water may collect in the excavation area as a result of flooding, groundwater infiltration, and rainwater. All effort will be made to minimize or exclude dewatering to the extent possible, through quick and efficient excavation techniques. If required, water may be pumped from the pit to an on-site fractionalization tank. A characterization analysis will be performed on any collected water to evaluate disposal options. Depending on the results of the characterization analysis, the water may be disposed of to the sanitary sewer system or transferred to an approved treatment facility by a licensed waste hauler. Any transfer to the sewer system will be approved in advance by the POTW.

3.1.2.6 Backfill and Final Grading

At the completion of the remedy, the excavated area will be backfilled with clean material from the site (if suitable) and/or approved off-site fill material. The backfill will be compacted in place by tamping in 1-foot lifts using the bucket of the excavator. Backfill will be completed to the surrounding ground surface.

Once the entire burial area has been excavated and backfilled, a final grade will be completed over all disturbed areas. All disturbed areas shall be evenly graded and a 1-foot layer of on-site topsoil shall be added to the disturbed areas. The final grade of the burial area shall be slightly elevated from surrounding areas to ensure positive drainage from the burial area and eliminate the potential for ponding. Annular rye grass seed, or an approved equal, will be spread over all disturbed areas upon completion of final grade. A thin layer of wheat-straw mulch will be added thereafter to reduce the potential for seed movement due to rain.

3.1.2.7 Waste Treatment and Disposal

All hazardous materials will be transported to a RCRA approved facility for treatment and disposal. Copies of the transport manifests, bills of lading, certified weigh tickets, and certificates of receipt at the RCRA facility will be maintained in the operating record for the site.

3.1.2.8 Emissions Modeling and Vapor Control

There is a high potential for vapors to be generated during the remedy implementation. Therefore, air monitoring will be conducted during all planned field activities to ensure that the workers and the surrounding community are appropriately protected from the potential physical and chemical hazards. This monitoring shall be in accordance with the Site-Specific HASP.

An intrinsically safe PID or FID shall be used to measure trace quantities of VOCs in air and generally have a low ppm sensitivity range. A combination meter (e.g., combustible gas indicator [CGI] and oxygen meter) shall additionally be used to monitor the presence of oxygen, flammable/explosive gases and vapors, and hydrogen sulfide. Dust monitoring shall be required to measure and mitigate any wind-borne dust problems that may occur at the site. A real-time dust monitor or MiniRam (MIIE Model PDM-3, or equivalent) that can monitor dust values of 0.01 to 100 milligram per cubic meter (mg/m^3) as particulates shall be utilized.

All site activities will be conducted in such a manner so as to minimize the generation of vapors. The main source of vapors is assumed to be the volatilization of contaminants from the open burial cells. The cells will be excavated one at a time to minimize the amount exposed material.

A vapor/dust barrier will be installed around the perimeter of the site consisting of plastic sheathing or other suitable material on a 10-foot high chain link fence. The results of dispersion modeling indicate that this should provide sufficient protection against the migration of vapors onto adjacent properties. An exclusion zone will also be established around the perimeter of the site. Within this zone all personnel will be required to wear respiratory protection. The level of respiratory control and the limits of the exclusion zone will be discussed in the site specific HASP.

3.1.2.9 Contractor Selection

The selection of a remediation contractor that has experience with similar remediation projects will be critical factor in the effective and safe implementation of this remedy. The selected contractor will be responsible for implementing all aspects of the corrective action including site setup; construction; excavation; waste segregation and analysis; packing and labeling of collected wastes; coordinating waste treatment disposal; traffic control; air monitoring; sedimentation and erosion control; and any other requirements identified the final design package.

3.2 Description and Conceptual Design of Proposed Groundwater Remedial Action

3.2.1 Description of Proposed Groundwater Remedial Action

The groundwater remediation alternative that has been proposed for this site (GWA-2) involves a combination of conventional pumping and vapor enhanced recovery techniques. As discussed in previous sections, the groundwater remedial alternative will necessarily address contamination in both the surficial and bedrock aquifers.

Two recovery methods will be used to extract groundwater from the surficial aquifer. Four VER wells will be installed in the shallow "hot spot" area located immediately downgradient of the source area. VER was selected for this area because it offers a considerable advantage over conventional pumping by increasing the effective gradient to the well, allowing an increased pumping rate and capture zone beyond that achieved by pumping alone. VER also increases mass recovery rates by extracting vapor from the subsurface, which will assist with reducing any soil impacts resulting from high contaminant concentrations in this area. Three conventional pumping wells will be used to recover shallow groundwater in the vicinity of Crow Branch Creek. The purpose of these wells is to contain groundwater at the downgradient extent of the contaminant plume and minimize impacts to Crow Branch Creek.

Three conventional recovery wells will be utilized to recover groundwater from the bedrock aquifer. These recovery wells will be located at the downgradient extent of the bedrock contaminant plume in the vicinity of Crow Branch Creek. The bedrock aquifer in the vicinity of Crow Branch Creek has an upward vertical gradient and is a likely recharge source for the surficial aquifer and the creek. Pumping from the proposed bedrock wells will contain the downgradient edge of the contaminant plume and prevent further impacts to the creek.

Groundwater collected by the VER and conventional pumping wells will be treated by an on-site system prior to discharge to the OWASA sanitary sewer system. The extracted groundwater from both systems would first enter a settling tank to remove any sediment. The combined streams would then be pumped to a shallow-tray air stripper to remove dissolved phase constituents from the recovered groundwater. The primary contaminants of concern at the site are VOCs, and based on experience at similar sites, air strippers provide an efficient mechanism for removing these contaminants. The treated water would then be discharged to the OWASA sanitary sewer system. The discharged water will be sampled on a regular basis to ensure treatment standards are achieved. If additional treatment is required a granular activated carbon system may be added to the treatment train after the air stripper. Any free product removed from the oil water separator will be containerized and transported off-site for proper treatment and disposal.

This technique is considered to be a long term remedy for the site. It is estimated that shallow wells will operate for approximately 10 years and deep extraction wells will operate for approximately 30 years.

3.2.2 Conceptual Design of Proposed Groundwater Remedial Action

The following sections discuss the conceptual design of the pump and treat system proposed as the groundwater remedy for the site.

3.2.2.1 Aquifer Testing

ARCADIS prepared a Recovery Well Installation and Aquifer Test Report in September 1998 (ARCADIS Geraghty & Miller 1998) that summarized recovery and observation well installation, vacuum enhanced recovery testing, and bedrock aquifer testing activities conducted at the site between March and April 1998. The wells installed during this period included one bedrock recovery well (RW-1), one shallow VER well (VER-1), and several temporary monitoring wells. The construction details for RW-1 and VER-1 are summarized in Table 1-1. The VER pilot test and bedrock aquifer tests were conducted to evaluate the characteristics of the shallow and bedrock aquifers and determine if active recovery would be an effective alternative for controlling groundwater contamination at the site.

The September 1998 Recovery Well Installation and Aquifer Test Report presented the methods used in the VER pilot test and the bedrock aquifer testing. The report also presented the raw data from these tests.

3.2.2.2 Groundwater Modeling

ARCADIS developed a groundwater flow model for the Airport Road Waste Disposal Area to assist with the design of the remedial scenario for the site. The groundwater flow model was created using the code MODFLOW, a publicly available groundwater flow simulation program developed by the U.S. Geological Survey (McDonald and Harbaugh, 1988). The finite-difference grid used in the model consists of three layers, 180 columns, and 180 rows. The model grid uses 10 foot (ft) horizontal grid spacing in the area of the constituent plumes to provide increased computational detail and grades to 100 ft horizontal spacing at the perimeter of the grid. Boundary conditions and hydraulic property zones were created using geologic, hydrogeologic, and climatic data. The groundwater flow model was calibrated statistically using the general algorithm known as the Gauss-Newton method. The primary criterion for evaluating the calibration of the groundwater flow model was the difference between simulated and observed water levels at a set of calibration targets. The model was calibrated to July, 2004 conditions.

The primary objective of the model was to assist in determining the optimal configuration of pumping wells to ensure: (1) rapid removal of groundwater with the highest constituent concentrations; (2) containment of the surficial and bedrock aquifer contaminant plumes so as to prevent impacts to Crow Branch Creek; (3) containment of the source area groundwater to prevent further downgradient migration of elevated constituent concentrations. Based on the modeling results a configuration of four shallow VER wells, three surficial aquifer conventional pumping wells, and three bedrock aquifer conventional pumping wells were selected for the site. The four VER wells (VER-1 through VER-4) would be located in the vicinity of the source area, while the three conventional pumping shallow wells (SW-1 through SW-3) would be located downgradient, in the vicinity of Crow Branch Creek. The three bedrock aquifer wells (RW-1 through RW-3) would also be located near Crow Branch Creek.

The groundwater flow model was also used to estimate the pumping rates that will be required to provide adequate coverage of the groundwater contaminant plume. The four VER wells will each recover groundwater at a rate of 0.2 gallons per minute (gpm). Shallow recovery wells SW-1 and SW-2 will pump at 0.6 gpm, while SW-3 will pump at 1 gpm. Bedrock recovery wells, RW-1, RW-2, and RW-3 will pump at 5 gpm, 3 gpm, and 10 gpm, respectively. Figures 3-4 and 3-5 illustrate the capture zones that will be generated in the surficial and bedrock aquifer in comparison to the delineated extent of diethyl ether. As these figures illustrate, the recovery well network is anticipated to provide adequate coverage of the contaminant plume.

A detailed discussion of the model design and pumping simulations is presented in the January 2005 Development of a Groundwater Flow Model and Remediation System Design report (ARCADIS, 2005). This report can be found in Appendix E.

3.2.2.3 Recovery System Design

The groundwater recovery system will consist of four shallow VER wells, three shallow conventional pumping wells, and three bedrock conventional pumping wells, as discussed in the previous sections. Groundwater in the conventional pumping wells will be recovered using submersible electric recovery pumps. Groundwater and vapor recovery in the VER wells will be collected with 1-inch diameter drop tubes installed in each well. A liquid ring pump, or similar vacuum pump, will be used to generate the suction required for the VER wells. All pumps will be appropriately sized based on the total design head and flow rates.

Recovery wells RW-1 (bedrock recovery) and VER-1 (shallow VER recovery) have already been installed. The construction details for these wells are summarized in Table 1-1. The remaining recovery wells will be installed during installation of the treatment system. The shallow recovery wells will be constructed of 4-inch-diameter stainless steel screen and casing and will be screened from approximately 5 to 25 ft bls. The deep recovery wells will be constructed using 6-inch-diameter steel surface casing to approximately 25 ft bls. A 6-inch-diameter open borehole will then be drilled to approximately 80 ft bls. Figures 3-6, 3-7, and 3-8 present the construction details of a typical VER, shallow recovery, and bedrock recovery well, respectively. The recovery well screens and gravel pack will be properly sized to prevent the aquifer material (fines) from entering the wells.

The proposed recovery well locations are depicted in Figure 3-9. Recovery piping will be required to convey extracted groundwater from the shallow and bedrock conventional recovery wells and the shallow VER wells to a centralized treatment system. Typically, this piping will be schedule 40 PVC or polyethylene, installed in a trench below the freeze line (approximately 2 feet deep). The trench will be backfilled and compacted after the piping is installed. Figure 3-10 presents a preliminary layout of the proposed recovery well, piping, and treatment system locations.

3.2.2.4 Treatment System Design

Figure 3-11 presents a process flow diagram for the proposed treatment process. As depicted in the figure, the contaminated groundwater from the recovery wells will be conveyed to an on-site treatment system consisting of a knockout pot, oil water separator, and an air stripper. The knockout pot will be used to separate vapor and water collected from the VER system. Groundwater collected in the knockout pot will be pumped to a settling tank, which is the first step in the treatment process. All extracted groundwater will flow through the settling tank to assist in removing sediment. The water will then be pumped from the settling tank to an air stripper unit. Based on past experience at similar sites, low profile air strippers provide the most efficient performance and require the least amount of maintenance. The air stripper size, number of trays, and air-to-water ratio necessary to achieve the required discharge criteria will be specified in the engineering design report, and will be based on the flow rates and influent contaminant concentrations from the recovery well network. The design specifications for the settling tank, knockout pot, and transfer pumps will also be outlined in the engineering design report and will be sized based on flow rates.

A low-profile air stripper process uses forced draft, countercurrent air routed through baffled aeration trays to remove VOCs from the groundwater. Influent groundwater is allowed to flow into the inlet chamber over a distribution weir and along the baffled aeration trays. Clean air is blown up through the perforated aeration tray, forming a froth of bubbles which creates a large mass transfer surface area to volatilize VOCs. The treated water then flows into a sump and is available for discharge or additional treatment, while the contaminated air is discharged directly into the atmosphere.

The treated groundwater from the air stripper sump will be discharged directly to the sanitary sewer system, assuming that the University is able to negotiate a pre-treatment disposal permit with OWASA or to Crow Branch Creek via an NPDES permit. The pre-treatment permit will require samples of the treated groundwater to be collected on a regular basis to ensure contaminant levels in the discharge water do not exceed established criteria. If additional treatment of the extracted groundwater is required prior to discharge, activated carbon vessels could be added to the treatment system after the air stripper. The activated carbon would function as a polishing unit to remove untreated organic contaminants from the air stripper. Any spent carbon will be shipped to an off-site permitted facility for regeneration or disposal, and a fresh carbon vessel will be placed in its location. The treatment system is designed to operate continuously and will be provided with safety features to prevent accidental releases of untreated water.

If discharge is to Crow Branch Creek the University will obtain an NPDES permit prior to treatment system construction.

All treatment system equipment will be enclosed inside an on-site building as protection from vandalism and weather. A concrete pad will be constructed to provide a level surface for this building.

3.3 Permitting

Permits/notifications will be required to implement the remedial action. The following permit applications/notifications will be filed with appropriate regulatory agencies:

- Pre-treatment permit application for disposal of treated effluent to the sanitary sewer system or NPDES permit;
- Recovery well construction permits will be obtained from the DWQ;
- Notification will be provided to the DAQ; and
- Sediment and erosion control plan will be prepared but no permit will be required since the area to be disturbed will be less than 1-acre.

3.4 Construction Plans and Specifications

The initial activities necessary to implement the proposed source control and groundwater remedies will include the preparation of construction plans and technical specifications. The site remediation contract document packages for each remedy will include:

- Construction plans;
- Technical specifications;
- Bidding information; and
- Proposed contract/agreement.

Bid documents will be submitted to qualified contractors. All bidding activities will be coordinated with the UNC Facilities Planning and Construction. After providing an opportunity for the contractors to review the documents, a pre-bid meeting will be held at the site to familiarize contractors with site conditions. Any questions and concerns regarding the remedial system construction will be addressed in this meeting. Any minor changes in the design that may be required to improve the constructability of the remedial system or clarifications recognized during the pre-bid meeting will be addressed as an addendum to the bid-package. This addendum will be submitted to all qualified contractors who received the bid package.

Upon receipt of the bids from the qualified contractors, an appropriate contractor will be selected to construct the remedial systems. Separate contractors will be selected for implementing the excavation and groundwater pump-and-treat systems. Generally, the contractors will be prequalified based on previous similar experience. The prequalified contractors will bid on the project and final award will be based on price. Subsequent to the award of the contracts, the selected contractors will be required to submit site-specific pre-construction work plans which will include, at a minimum, a schedule of activities, equipment/material procurement, a Contractor's Site Safety Plan (CSSP), a commitment regarding the personnel and equipment availability, and a list of all subcontractors and their qualifications.

The selected contractor will be responsible for performing all site work in conformance with the project design plans and specifications as economically and efficiently as possible without disruption to on-site or off-site activities.

3.5 Health and Safety Plan

Comprehensive health and safety plans (HASP) have been prepared for the remedial activities at the Airport Road Waste Disposal Area. Separate HASPs have been prepared for source area and groundwater remedial activities and both are presented in Appendix F. The requirements of the HASP will be strictly enforced during the remedy construction and implementation. A separate health and safety and contingency plan will be required from the construction contractors.

4. Groundwater Remediation System Inspection, Maintenance and Monitoring

An environmental monitoring program is required to monitor the progress of remediation and ensure that remedial efforts meet the design objectives. Based on the monitoring data, the groundwater remediation system can be optimized by making appropriate field alterations.

Regular inspection and maintenance of the groundwater remediation system will be conducted to ensure proper operation of the system. In addition, system performance will be monitored through system sampling activities, and monitor well and recovery well sampling activities. The following sections describe the proposed inspection and maintenance program, the proposed system performance monitoring program, and the proposed groundwater monitoring program.

4.1 System Inspection and Maintenance Program

Inspection and maintenance of the groundwater remediation system will be performed on a periodic basis. Inspection and maintenance tasks will consist of an inspection of the recovery system piping, positive displacement pump, oil water separator, air stripper, and transfer pumps. A system check will also be performed to ensure that the recovery pumps are operating properly. In addition to this inspection, the following tasks will be conducted:

- Inspect air stripper blower flow switch and all tank high-level switches for proper operation;
- Inspect air stripper for fouling;
- Measure and record vapors and groundwater flow rates;
- Measure and record vacuum readings on all VER and nearby monitor wells;
- Measure and record water levels from all site monitor wells;
- Inspect and cleanup totalizers, if fouled; and
- Collect sample of treated groundwater to ensure water meets discharge permit requirements.

4.2 System Performance Monitoring Program

Combined influent to the treatment system (air stripper) will be sampled once weekly during the first month of system operation, quarterly during the first year and semi-annually thereafter. These samples will be analyzed for VOCs using U.S. Environmental Protection Agency (USEPA) Method 8260. In addition, water samples will be collected after the air stripper and after carbon treatment (if carbon treatment is determined necessary) to evaluate the effectiveness of the treatment system at removing the VOCs from the extracted groundwater. The pumping rates for the recovery wells and recovery system operation will be re-evaluated if analytical data indicate that the groundwater recovery system is producing groundwater with higher than anticipated VOC concentrations or if the analytical data indicate that the treatment system is not effectively removing the VOCs from the groundwater.

Effluent samples will be collected from the treatment system and analyzed according to the requirements of the discharge permit with OWASA.

4.3 Groundwater Monitoring Program

Water levels in the site monitor wells and recovery wells will be measured on a quarterly basis during the first year of operation, semi-annually for the next 2 years, and annually thereafter. These data will be used to construct groundwater elevation maps and to evaluate the groundwater recovery system's effectiveness in containing and remediating the dissolved contaminant plume.

The four VER recovery wells, three shallow bedrock recovery wells, and three deep bedrock recovery wells will be sampled prior to system startup, quarterly during the first year of operation and annually thereafter. The measurement frequency may change based on sampling results and reduction of contaminant concentrations.

The proposed monitoring program also will include quarterly sampling of selected monitor wells during the first year of implementation, semi-annually the next 2 years and annually thereafter. These samples will be analyzed for VOCs using USEPA Method 8260. This monitoring plan may be adjusted after the second year. The monitor wells to be sampled will be selected in the design phase.

5. Future Reporting

Throughout implementation of the source remediation and groundwater remediation processes, quarterly progress reports will be prepared and submitted to the NCDENR as per the requirements of the REC Program Guidelines. The progress reports will be in memo form and contain a brief description of the remedial activities conducted to date. In addition, several major reports will be prepared and submitted. The major reports will include the following:

5.1 Preconstruction Reports

Prior to implementation of the source control and groundwater remediation scenarios, Preconstruction Reports will be submitted to the NCDENR. The Preconstruction Reports for source control and groundwater remediation will be submitted independently of one another. These reports will include the following items:

1. Final Engineering Design Report, including a detailed description of the final design, a summary of changes from the conceptual design in the RAP, and final construction plans and specifications. A preliminary list of drawings and specifications that will be included in the report is presented in Appendix H.
2. Copies of any required permits or approvals.
3. An updated project schedule.

5.2 Construction Completion Report/Remedial Action Completion Reports

Within 90 days of construction completion, a Construction Completion Report (CCR) will be submitted to NCDENR. CCR reports for source control and groundwater remediation will be submitted independently of one another. These reports will include “as built” plans and specifications, a summary of any variances from the final RAP, and a summary of any problems encountered during construction.

5.3 Groundwater Monitoring Reports

Within 90 days of the completion of each groundwater monitoring event a groundwater monitoring report will be prepared that will summarize for the previous period, groundwater treatment system activity and performance, groundwater monitoring results, operation and maintenance activities. Discharge reports of the system effluent and flow information will be prepared at the frequency requested by the POTW or as required by the DWQ for the NPDES permit.

6. References

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