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| Soil and Groundwater Remediation

| Regulatory Compliance

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REMEDIAL ACTION PLAN (RAP)

FORMER DODD/DEAL FIRE ACADEMY UPPER SITE STEAD, NEVADA

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September 26, 2002

TABLE OF CONTENTS

1.	INTRODUCTION.....	1
1.1	Site Background.....	1
1.2	Previous Site Investigations.....	1
	1.2.1 Environmental Assessment Activities and Corrective Action Plan for Remediation of Petroleum Contaminated Soil and Groundwater – Part 1 Initial Environmental Assessment Activities.....	2
	1.2.2 Environmental Assessment Activities and Corrective Action Plan for Remediation of Petroleum Contaminated Soil and Groundwater – Part 2 Additional Environmental Assessment Activities.....	3
2.	PROJECT OBJECTIVES	4
3.	SCOPE OF SERVICES.....	5
4.	ADDITIONAL SITE SOIL CHARACTERIZATION.....	6
4.1	Field Data Collection.....	6
	4.1.1 Sample Location and Frequency	6
	4.1.2 Sample Designation.....	6
	4.1.3 Sampling Procedures.....	7
	4.1.4 Sample Custody.....	7
4.2	Sample Chemical Analysis	7
	4.2.1 Analytical Methods.....	8
	4.2.2 Data Quality Level.....	8
4.3	Data Validation.....	8
	4.3.1 Field Quality Control Samples	8
	4.3.2 Comparison with Previous Data.....	9
4.4	Data Summary	9
4.5	Soil Media Properties.....	10
5.	CONCEPTUAL SITE MODEL	11
5.1	Site Description.....	11
	5.1.1 Topography.....	11
	5.1.2 Climate.....	11
	5.1.3 Soil Conditions.....	11
	5.1.4 Groundwater Conditions.....	12
5.2	Chemicals of Potential Concern	12
5.3	Source Characterization	12
5.4	Transport Mechanisms	13
	5.4.1 Volatilization and Atmospheric Dispersion/Enclosed Space Accumulation.....	13
	5.4.2 Leaching and Groundwater Transport.....	13
5.5	Exposure Pathways	13
5.6	Receptor Description	13
	5.6.1 Adjacent Land Use.....	13
	5.6.2 Wells.....	14
	5.6.3 Wetlands	14
6.	RISK-BASED CLEANUP STANDARDS	15
6.1	Tier 1 RBSLs.....	15

6.2	Tier 2 SSTLs	15
6.2.1	Upper Site – Comparison of Data with Tier 2 SSTLs	15
7.	EVALUATION OF GROUNDWATER REMEDIAL ALTERNATIVES	19
7.1	Monitored Natural Attenuation	19
7.2	Excavation and GPT	20
7.3	AS and VE	20
8.	RECOMMENDED REMEDIAL APPROACH.....	22
8.1	Soil Remediation.....	22
8.2	Groundwater Remediation	22
8.2.1	Field Pilot Testing.....	22
8.3	Remediation System Design.....	24
8.4	VOC Abatement.....	24
9.	LIMITATIONS	25
10.	CLOSING	26
11.	REFERENCES.....	27

TABLES

- Table 1 – Laboratory Results for Previously Collected Groundwater Samples
Table 2 – Sample Location Key, Sample Number and Field Observations
Table 3 – Data Quality Levels for Accelerated Site Characterization (ASTM E1912-98)
Table 4 – Samples Selected for EPA 8260B Review
Table 5 – Summary of Compounds Not Detected in Soil
Table 6 – Summary of detections in Soil by Location and Depth for PAHs and VOCs
Table 7 – Tier 1 RBSL Evaluation for Soils
Table 8 – Tier 2 SSTL Evaluation for Soils
Table 9 – Summary of Current Soil Sampling Data with TPH Greater than 1,000 mg/Kg
Table 10 – Summary of Previous Soil Sampling Data with TPH Greater than 1,000 mg/Kg
Table 11 – Summary of Current Soil Sampling Data with TPH Greater than 1,000 mg/Kg and PAH/VOC Detections
Table 12 – Cost Estimate for Excavation and GPT
Table 13 – Cost Estimate for In-Situ Remediation using AS and VE

FIGURES

- Figure 1 – Project Location Map
Figure 2 – Site Plan Showing Previous Exploratory Test Trenches
Figure 3 – Site Plan Showing New Test Pit Locations
Figure 4 – Conceptual Site Model for Upper Site
Figure 5 – Wind Rose
Figure 6 – Typical Air Sparge Point
Figure 7 – Typical Dual Completion Well

APPENDICES

- Appendix A – Summary of Analytical Data from Previous Investigations
Appendix B – Laboratory Results, Initial Soil Screening
Appendix C – Laboratory Results, Extended List of VOCs
Appendix D – Laboratory Results, Quality Control Samples
Appendix E – Laboratory Results, TPH Soil Data
Appendix F – Laboratory Results, Soil Physical Parameters
Appendix G – Well Log for Existing Supply Well – Upper Site
Appendix H – Tier 1 Input Parameter Summary and Model Results
Appendix I – Tier 2 Input Parameter Summary and SSTL's

1. INTRODUCTION

On behalf of the University of Nevada Reno (UNR), McGinley & Associates Inc. (MGA) is pleased to submit this Remedial Action Plan (RAP) for the Former Dodd/Deal Fire Fighting Academy located in Stead, Nevada (Figure 1). This RAP addresses impacts to both soils and groundwater at the site by historic facility usage. The former fire fighting academy, previously operated by UNR encompasses a total of approximately 77 acres, of which approximately 42 acres were used for administrative buildings and fire fighting training. Within the 42 acres, only certain portions of the land were used for active fire fighting training facilities. The 42 acre portion consists of an Upper Site and a Lower Site as shown on Figure 2. This Remedial Action Plan (RAP) addresses only the portion of the facility known as “The Upper Site”, which is located north of Echo Avenue at the Military Road intersection. The upper site encompasses about 14 acres. The Lower Site located at the southeast corner of Military Road and Echo Avenue encompasses about 28 acres, and is addressed under separate cover in the MGA document “Remedial Action Plan, Former UNR Fire Training Academy, Lower Site, Stead, Nevada”.

UNR, the current property owner, has decommissioned the facility and removed all buildings and structures. Both soils and groundwater have been impacted by petroleum hydrocarbons and chlorinated solvents. UNR intends to sell the property. Alternative land use planning includes potential development for commercial and/or light industrial purposes.

The RAP for the site includes a Risk Based Corrective Action (RBCA) evaluation utilizing risk-based screening levels (RBSLs) ASTM Tier 1 and site-specific target levels (SSTLs) ASTM Tier 2 to determine areas that require soil remediation. The Tier 1 and Tier 2 evaluation presented in this report focuses solely on petroleum hydrocarbons and chlorinated solvents in soil at the site. The RAP also includes a recommendation for the installation of an air sparging and vapor extraction for the remediation of petroleum product impacts to deeper (subsurface) soil and groundwater.

Following corrective action, post remediation confirmation samples will be collected and analyzed with full laboratory QA/QC procedures to confirm that the remediation goals were met. In addition, the screening level samples will be compared to the post remediation soil samples to determine usability for a post remediation forward baseline risk assessment. The combined data sets from pre- and post-remediation sampling will be used to conduct a forward risk assessment for site closure.

1.1 Site Background

Fire fighting training was conducted at mock facilities that were set afire using diesel fuel with some gasoline as an igniter. The fires were extinguished with water and foam. The upper site was used historically for fire training activities and consisted of burn areas and unlined waste ponds. Fire training activities were relocated to the Lower Site, leaving only the administrative buildings at the Upper Site. The administrative buildings have been razed, and no structures currently exist on the site.

1.2 Previous Site Investigations

Two previous site investigations were completed for the assessment of petroleum product impacts to soils and groundwater. The site assessment activities are summarized in the following paragraphs.

Selected data from the soil and groundwater assessments have been incorporated in the RBCA evaluation and are summarized in Appendix A.

1.2.1 Environmental Assessment Activities and Corrective Action Plan for Remediation of Petroleum Contaminated Soil and Groundwater – Part 1 Initial Environmental Assessment Activities

Fifty-two (52) exploratory test trenches (TT-1 through TT-52) were excavated at the facility for exploratory and soil sampling activities. Of the 52 test trenches, 30 were installed at the upper site at the approximate locations indicated on Figure 2. In general, the locations of the test trenches were selected based upon proximity to areas of known petroleum product usage. These include former pond areas, underground fuel conveyance piping and mock areas. A total of 81 soil samples were collected at discrete depths from ground surface to five to eight feet below ground surface. At two locations the test trenches were advanced to a depth of approximately 12 feet below ground surface.

Three soil borings were installed at the Upper Site for the collection of representative soil samples and for conversion to groundwater monitoring wells. The approximate locations of the soil borings installed at the site are indicated on Figure 2. Soil samples were collected from each borehole at various depths by driving a split spoon sampling device into undisturbed soils. Soil samples were classified using the Unified Soil Classification System (USCS) in accordance with ASTM D2487. Three monitoring wells (MW-1, MW-2, and MW-3) were constructed and installed to a depth of 57 to 64 feet below ground surface (bgs).

The wells were checked for the presence of free phase product using a Solinst oil/water interface probe. No free phase product was detected in any of the monitoring wells. Water levels were measured and recorded with the interface probe as well. During the sampling activities, neither free phase product nor a petroleum product sheen were noted in the wells. Groundwater samples were collected from each monitoring well using disposable bailers.

The results of several groundwater sampling events are summarized in Table 1. As indicated, a benzene concentration of 1020 µg/L was originally reported (1-21-00) for well MW-2. The most recent sampling event (6-4-02) reported a benzene concentration of 450 µg/L. Benzene was originally reported (1-21-00) at a concentration of 13.3 µg/L for well MW-1, and most recently (6-24-02) at a concentration of 330 µg/L. Reported MTBE concentrations have been relatively minimal, ranging from non-detect to 2.9 µg/L.

1.2.2 Environmental Assessment Activities and Corrective Action Plan for Remediation of Petroleum Contaminated Soil and Groundwater – Part 2 Additional Environmental Assessment Activities

Three groundwater monitoring wells (MW-7, MW-8 and MW-9) were installed at the Upper site on April 18 and 19, 2000, and monitor well MW-14 was installed in September, 2000. The well boreholes were advanced to approximately ten feet below the groundwater table. Groundwater was encountered at 60 to 70 feet below ground surface. Groundwater samples were collected and analyzed for concentrations of volatile organic compounds by EPA Method 8260B. The results of several groundwater sampling events are summarized in Table 1. As indicated, benzene concentrations of 150.8 µg/L and 113.5 µg/L were reported in the initial groundwater samples collected from MW-7 and MW-9, respectively. For the June 2002 sampling event, benzene concentrations were reported at 39 µg/L, 600 µg/L, 100 µg/L and non-detect for wells MW-7, MW-8, MW-9 and MW-14, respectively. MTBE has been reported at non-detectable concentrations for each well for every sampling event. Groundwater samples collected from MW-14 (upgradient well) were reported to contain non-detectable BTEX and MTBE concentrations for all sampling events.

In addition to the petroleum product constituents discussed above, tetrachloroethylene was reported in groundwater collected from MW-1 at a concentration of 8.5 µg/L and, 1,2,4 trimethylbenzene and 1,3,5 trimethylbenzene were detected in MW-2 at concentrations of 27 µg/L and 21 µg/L, respectively.

The estimated lateral extent of petroleum product impacts to groundwater, as based upon the results of these previous investigations is presented on Figure 4.

2. PROJECT OBJECTIVES

The objectives of this RAP were to develop a remedial strategy to: 1) mitigate risks to human health and environmental receptors from the identified petroleum hydrocarbon soil contamination at the subject site, and 2) reduce the dissolved petroleum product constituents in groundwater to at, or below, the federal USEPA Maximum Contaminant Levels (MCLs).

With respect to soil contamination, our objective included identification of areas the site that require remediation based on a Tier 1 RBSL and Tier 2 SSTL screening level evaluation. Data from previous investigations and new soil samples were used for the screening evaluation. Previous analytical methods included TPH by EPA Method 8015 Modified and volatile organic compounds (VOCs) by EPA 8260B. However, additional analyses were required to fully characterize the chemicals of potential concern (COPCs) for the site (USEPA, 1992a, ASTM, E 1739-95^{E1}). In addition to VOCs, the new soil samples were analyzed for polycyclic aromatic hydrocarbons (PAHs) and carbon fractions.

Carbon fractions were utilized to facilitate incorporation of previously collected site characterization data for TPH. The TPH Criteria Working Group developed a method to calculate RBSLs and SSTLs for TPH based on transport properties of fractions of the petroleum compounds. The fractions were delineated by the equivalent carbon (EC) number, because these values are related to the compound's mobility in the environment (TPH Criteria Working Group, 1999). Petroleum mixture and individual compound toxicity data were used to develop conservative Reference Doses (RfDs) and Reference Concentrations (RfCs) most representative of each fraction's toxicity (TPH Criteria Working Group, 1999). The petroleum fractions and toxicity criteria were incorporated into the RBCA framework enabling risk evaluation based on TPH. Utilizing a modification to the TPH Criteria Working Group, risk based cleanup standards were developed for TPH fractions.

With respect to groundwater contamination, our objective was to evaluate several remedial alternatives from both a technical and cost perspective and develop a remedial strategy as appropriate. Factors considered included: the nature of contamination, extent of contamination, contaminant concentrations, geologic and hydrogeologic conditions, regulatory remedial objectives, distance to sensitive receptors, site constraints, estimated capital and operating costs and, other site specific factors.

3. SCOPE OF SERVICES

To achieve the project objectives, the following scope of services were performed:

- Advancement of 31 test trenches at selected areas of the site;
- Representative soil sampling;
- Analytical testing of sampled soils;
- Data validation;
- Development of a site conceptual model;
- Development of risk based clean-up standards;
- Evaluation of groundwater remedial alternatives; and,
- Preparation of this Remedial Action Plan, complete with all findings and recommendations.

Each of these services is discussed in detail in the following sections.

4. ADDITIONAL SITE SOIL CHARACTERIZATION

4.1 Field Data Collection

Additional soil data was collected to identify COPCs, delineate the lateral extent of surficial and subsurface soil contamination, and measure physical and chemical properties of the soil. Soil sampling activities followed the ASTM Guide for Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases (ASC) (ASTM, E 1912-98), the Triad Approach to Site Characterization (US EPA, 2001), and Standard Operating Procedures (SOPs) (McGinley Associates, 2001).

Sampling uncertainty increases when fewer samples are collected for higher quality analytical results. The ASC (ASTM, E 1912-98) approach to site characterization defines four levels of data quality that adapts to field screening or equivalent analytical methods for sample analysis. The Triad Approach to Site Characterization allows analytical uncertainty to increase, thus achieving a higher sampling density to characterize a site (Crumbling, et. al, 2001). The result is that sampling uncertainty decreases thereby lowering the overall uncertainty in site characterization. Using these combined approaches 82 soil samples were collected at 31 locations at the Upper Site. Sample locations are shown in Figure 3.

4.1.1 Sample Location and Frequency

The Upper Site was subdivided into two strata each requiring different levels of investigation. Based on previous site characterization data, knowledge of site activities, and visual inspection, the two strata are: 1) areas unlikely to be contaminated and 2) areas known to be contaminated (US EPA, 1996). At the Upper Site, strata one was planned for 11 sample sites or one site per 0.5 acre; strata two was planned for 20 sample sites or one site per 0.4 acre. Areas unlikely to be contaminated were sampled at depths of 2 and 4 feet. Areas known to contain contaminated soils were sampled at depths of 2, 4, and 8 feet.

For the each of the strata, specific sample locations were planned based on a random-start triangular grid (systematic sample). The triangular grid was selected because the probability of hitting a hot spot is typically greater with a triangular grid than with a square grid of the same sample density (US EPA, 1992b). In the areas known to be contaminated, the systematic sampling was supplemented by judgmental sampling for locating hot spots. Hot spots as used here refer to proximity to either above ground or known below ground facility appurtenances. These include former pond areas, underground piping, and/or mock areas. Systematic sampling supplemented by judgmental sampling is the best strategy for the location of potential hot spots (US EPA, 1992a).

Individual sample locations were located on a base map of the site using the methodology outlined above. The locations were then digitized from the map and located in the field using a differential correction GPS survey (real time kinematic survey).

4.1.2 Sample Designation

Soil sampling was conducted during previous investigations, thus it was necessary to develop a sample designation system that enabled the distinction of samples from previous sampling efforts.

Each sample received an alpha designation as “US” to indicate Upper Site. Two additional alpha characters were used to designate the type of sample. These were the same for all samples, but were different from all previous sampling efforts. This designation was “TP” for test pit. Based on the survey for sample locations, each sample point at the site was given a numeric designation, and then designated by the sample depth. For example, the designation for a sample collected at the site is as follows:

- USTP - 15 @ 4' (Upper Site Test Pit -15 Sampled at 4 Feet)

Sample designations are listed in Table 2 for all locations.

4.1.3 Sampling Procedures

Samples were collected from backhoe dug test trenches at depths of 2, 4, and 8 feet as indicated in Table 2. Soil samples were collected using SOPs (McGinley Associates, 2001). The test trenches were dug to 4 feet and samples were collected from the side wall of the excavations at 2 and 4 feet. Care was taken to remove any loose soil to expose fresh soil for sampling. The soil samples were collected by scraping the face of the pit sidewall at the desired depth interval with a stainless steel trowel and placed directly into clean 4 ounce glass jars.

Samples from the 8-foot depth were scraped from soil in the backhoe bucket directly into the glass sample jars. If backhoe refusal was encountered before the 8-foot sample interval, then a sample was collected at the refusal depth and marked as such on the field sample forms and sample container.

Sample jars were properly sealed and labeled with sample number, site location, date, and time. The samples were stored in a cooler at approximately 4⁰C until delivered to the laboratory for analyses.

4.1.4 Sample Custody

Field document control procedures were implemented to ensure that documents and samples were traceable at project completion. Information relevant to field operations was recorded in field sample data sheets and chain-of-custody records. Chain-of-custody procedures were followed during field sample collection, handling, and transfer to Alpha Analytical, Inc. for organic chemical analysis and T N and Associates, Inc. for physical property and chemical analysis. Field document control and sample custody procedures followed SOPs (McGinley & Associates, 2001).

4.2 Sample Chemical Analysis

The soil samples from the Upper Site were initially screened to determine the presence of petroleum hydrocarbons by carbon fraction, PAH, and BTEX. Samples with detects in the initial screening were further evaluated for an extended list of VOCs related to petroleum hydrocarbons and chlorinated solvents. Laboratory reported results from the initial and extended analytical screening are included in Appendix B for the initial screening results and in Appendix C for the extended list of VOCs.

4.2.1 Analytical Methods

BTEX was determined by a slightly modified EPA Method 8260B. Matrix spikes and matrix spike duplicates (MS/MSDs) and laboratory control samples (LCSs) were not prepared with these samples, although periodic Standards and Method Blanks were analyzed. The samples did not undergo the normal multiple analyses necessary to place limiting analytes within, but as near as possible to the upper end of an instrument's calibration. All normal extraction procedures, internal and surrogate standards, and the instrument's normal calibration were used.

The PAHs were determined by a modified EPA Method 8270. MS/MSDs and LCSs were not prepared with these samples, although periodic Standards and Method Blanks were analyzed. The samples did not undergo the normal multiple analyses necessary to place limiting analytes within, but as near as possible to the upper end of an instrument's calibration. A 20-gram aliquot of soil was extracted with 20 ml of methylene chloride in order to achieve the reporting limit of 250 µg/Kg for most of the PAHs. Surrogates were not added, but normal internal standards were used. A special low-level calibration of the PAHs was used to quantitate the data.

The TPH-E was determined using a slightly modified EPA Method 8015B and the same extract that was prepared for the PAHs. The TPHs that were detected were divided into carbon (C) ranges from C8-C9 to C38-C39, all quantified with diesel calibration and each with a reporting limit of 3 mg/Kg.

4.2.2 Data Quality Level

The ASTM Standard Guide for Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases (ASTM, E 1912-98) employs a four tiered data quality system as described in Table 3. The data quality level employed for the field investigation reported herein would be classified Level 2. Laboratory methods were used employing the same instruments that are used for Level 3 EPA Method procedures. Quality control (QC) procedures such as initial multi-point calibration curves, continuing calibration checks and background/blank samples were performed. All results were reported as estimated concentrations from modified-method screen procedures. The data quality was deemed sufficient to screen the data for comparison to RBSLs and SSTLs to determine areas where soils require remediation.

Post remediation confirmation samples will be collected and analyzed with full laboratory QA/QC procedures to confirm the initial site samples and that the remediation goals were met. The screening level samples will be compared to the post remediation soil samples to determine usability for a post remediation forward baseline risk assessment.

4.3 Data Validation

4.3.1 Field Quality Control Samples

Five samples were collected for quality control. These included three field duplicates, one trip blank, and one field blank. Results of the quality control samples are included in Appendix D.

4.3.1.1 Field Blank

A Field blank was prepared in the field by filling a sample container with clean sand supplied by Alpha Analytical. Field blanks are typically used to evaluate contamination associated with field operations, but may also be used to evaluate contamination associated with laboratory procedures. Field blanks were planned at a rate of one per full day during the sampling activities, and correspondingly one field blank was prepared. The Field blank was below detection limit for all PAH, BTEX, and carbon fractions.

4.3.1.2 Trip Blank

A blank was prepared by the laboratory and transported and analyzed in the same manner as the other samples. Trip blanks are used to evaluate contamination associated with sampling, sample handling and shipment, or laboratory handling and analysis. Trip blanks were planned at a rate of one per full day during the sampling activities, and correspondingly one was prepared. The trip blank was below detection limit for all PAH, BTEX, and carbon fractions.

4.3.1.3 Field Duplicate Samples

Field duplicate samples were prepared by taking a split from the soil sample collected and placing into a separate container. These samples are used to evaluate error associated with sample heterogeneity, sample methodology, and analytical procedures. Three field duplicate samples were collected from a total of 82 soil samples.

The duplicate sample from USTP-21@4 had detections for naphthalene, fluorene, anthracene, fluoranthene, and carbon fractions where as the sample for that location contained no detections for all analytes. The sample and duplicate sample for USTP28@2 were just the reverse pattern. The other five sample and duplicate samples were all below detection limit for all analytes. The differences for samples USTP-21@4 and USTP28@2 were likely due to soil heterogeneity.

4.3.2 Comparison with Previous Data

Summary TPH soil data were compared for the previous investigation (Appendix A, Tables A-1 and A-2) and current soil investigations (Appendix E, Table E-1). The TPH values for the Upper Site ranged from 70 to 10,760 mg/kg for the previous investigation and for the current data from 49 to 19,000 mg/kg. The median values were 1,655 and 1,400 mg/kg, respectively. The two soil investigations sampled some of the same areas around the mocks, underground piping, and ponds. Additionally, the current sampling effort also sampled soils on a more site wide basis using a random-start systematic sampling grid across the Upper Site. These data appear to indicate that the two data sets are comparable on the basis of TPH values.

4.4 Data Summary

The analytical data received from the laboratory (Appendices B and C) were compiled into data sets for the site and is presented in Appendix E, Table E-1. The initial laboratory screening was for PAH, BTEX, and carbon fraction. The compiled data were summarized statistically by number of samples, number of detections, range of detections, percent of samples with detection, range of detection limits. Soil sample data from the initial screening were reviewed for PAH, VOC, and carbon fraction

detections and a subset of 19 samples were selected for additional analytical review by the laboratory, Table 4.

The expanded laboratory review included VOCs by modified EPA Method 8260B. The PAH and VOC data for locations where there were analytical detections are listed by sample location in Appendix E, Table E-2. Table E-2 summarizes the compounds detected for PAHs and VOCs by number of samples, number of detections, range of detections, and range of detection limits. Compounds not detected in the screening process are listed in Table 5. The detection data are summarized by sample location and depth for PAHs and VOCs in Table 6. At the Upper Site there were more detections for PAHs and VOCs at eight feet than shallower samples, and there were more detections for VOCs than for PAHs.

The TPH by carbon fraction laboratory data was also reviewed following the TPH Criteria Working Group methodology (TPH Criteria Working Group, 1998). The TPH Criteria Working Group recommended implementation of a method to determine TPH fractions by solvent extraction of the aliphatic and aromatic compounds by using different solvents for the two groups of compounds. For this investigation the carbon fractions were analyzed as total carbon within a given range. The equivalent carbon number for each of the aromatic compounds (Appendices E and F, Tables E-2 and F-2) was used to assign these compounds to their respective carbon range, (Tables E-4 and F-4). The aliphatic fractions were then separated from the total carbon by subtracting the aromatic fractions from the total carbon. The TPH carbon fraction data are included in Appendix E, Tables E-3, E-4, and E-5.

4.5 Soil Media Properties

Representative soil samples were collected from seven test pits for analysis of the physical and chemical properties. All samples were analyzed for dry bulk density (ASTM D2937), water content (ASTM D2216), specific gravity (ASTM D854), sieve and hydrometer analysis (ASTM D422 and C117), and soil pH (ASTM D4972). Based on the sieve and hydrometer analysis the USCS soil classification was silty sand, with gravel. The geometric mean for the dry bulk density was 1.36 grams/cubic centimeter (g/cm), gravimetric water content was 8.2 percent (11.2 percent volumetric), specific gravity was 2.64 g/cm³, and pH was 7.6. Total organic content (ASTM D2974) was measured on four of the soil samples collected from areas not impacted with petroleum hydrocarbons. One of the test pits sampled contained asphalt material and the result from this sample was eliminated from further evaluation. The total organic content geometric mean of the remaining three samples was 0.4305 percent. This value was divided by 1.724 to account for organic matter other than carbon (e.g., nitrogen, sulfur, phosphorus) bound in the organic molecule. The resulting value for organic carbon was 0.25 percent. The geometric mean for the calculated porosity of the soil from all seven samples was 0.48. The laboratory results for the physical and inorganic chemical soil properties are included in Appendix F.

5. CONCEPTUAL SITE MODEL

Information on historical site use (contaminant sources), contaminant pathways and potential receptors was used to develop a conceptual site model (CSM) as shown in Figure 4 for the Upper Site. The CSM incorporates the interpretation of data developed from previous investigations and the current investigation on contaminant sources, types of contaminants, affected media, and potential routes of migration. The CSM also includes information on the geologic and hydrologic setting. The Upper Site includes an on-site production well for residential use and one off-site receptor (Swan Lake).

5.1 Site Description

5.1.1 Topography

The Upper Site elevation on the west side is about 5040 feet mean sea level (msl) and slopes to the east to about 5020 feet msl. Surface drainage from the site is east toward Swan Lake.

5.1.2 Climate

The area has an arid to semiarid climate with low annual precipitation, low humidity, and wide diurnal temperature fluctuations. The climate in the region is influenced by the presence of the Sierra Nevada Mountains. The area lies in the rain shadow of the Sierra Nevada, receiving approximately 7 inches of precipitation per year. The average annual potential evapotranspiration is approximately 47 to 71 inches per year (Nevada Bureau of Mines and Geology, 1996).

Meteorological data from Reno-Cannon International Airport for the period from 1984 through 1992 was modeled and the results are shown in a wind rose on Figure 5. For the nine year period modeled the predominant wind direction was from the WNW and S with an average wind speed over that same time period of 8.44 miles per hour.

5.1.3 Soil Conditions

Analysis of soil samples from the test trenches indicate that surficial and subsurface soils at the site consist of unconsolidated deposits of silty sand and poorly graded sands of quaternary to recent fluvial and lacustrine origin. These materials typically exhibit moderate to moderately high hydraulic conductivity. During excavation of the test trenches at the Upper Site, dense sandy silt was encountered in most trenches at a depth of approximately five to eight feet below ground surface. Based on the sieve analysis and soil classification the hydraulic conductivity would likely range from less than about 0.03 to 28 feet/day.

Asphalt and concrete construction debris was observed in several of the test trenches at the Upper Site.

5.1.4 Groundwater Conditions

The water table occurs approximately 44 to 53 feet bgs at the Upper Site. Based on groundwater elevation measurements, the groundwater flow direction was calculated to be easterly toward Swan Lake with a hydraulic gradient of 0.0097.

5.2 Chemicals of Potential Concern

During fire fighting training, the mock facilities were set on fire using diesel fuel with some gasoline as an igniter. Based on historical use, petroleum hydrocarbons were identified as chemicals of potential concern (COPCs). Specific compounds include BTEX, PAHs, fuel oxygenate additives, e.g., MTBE, and lead (older gasoline). For this screening level evaluation lead was assumed to be collocated with the petroleum hydrocarbons, and was not analyzed.

Analysis of previous soil and groundwater samples from the Upper Site indicated the presence of benzene, toluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and tetrachloroethylene in monitor well MW-1. Groundwater from MW-2 contained benzene, toluene, ethylbenzene, and xylene. Groundwater from MW-3 contained toluene. Records from site closure activities indicate that heptane, kerosene, isopropanol, and methanol were stored on site. It is our understanding that solvents were not routinely utilized on-site.

The monitoring wells installed on-site as part of the previous investigation have been checked for the presence of free phase product using an oil/water interface probe. No free phase product has been observed in any of the monitoring wells.

5.3 Source Characterization

Primary sources included above ground and underground product storage tanks, distribution lines to the mock areas and surface impoundments. Petroleum hydrocarbon releases to the environment occurred as leaks in fuel distribution lines, seepage from unlined storage ponds, and potentially from over spray from fire fighting activity. Secondary sources include impacted surface and subsurface soils, and dissolved contaminants in groundwater.

Previous site investigations have focused on the areas where fuel was conveyed in underground pipe lines, mock areas, concrete pads, and water storage ponds. The current soil sampling effort was based on a random starting point, systematic grid across the site with a sample frequency of about one sample per one-half acre. The current sampling effort has confirmed that the soil contamination is concentrated around the areas of fuel conveyance pipe lines, mock areas, concrete pads, and water storage ponds.

Analytical testing of soil samples collected during the drilling of MW-1 and MW-2 indicated that petroleum hydrocarbon contamination extends to at least 30 feet and 20 feet in depth, respectively. For these analyses the detection limit for TPH-E was 20 mg/Kg and for TPH-V was 0.5 mg/Kg. Both of these wells are located within or proximal to a former water/sludge retention pond(s). The actual former pond(s) configuration is not known at this time. Based on the detection limit for the volatile compounds for these analyses, volatile contaminants could have migrated to the water table. Groundwater samples from wells MW-1 and MW-2 have reported benzene, toluene, ethylbenzene, xylenes, and tetrachloroethene detections at least once, Appendix A, Table A-3. Thus, for the CSM

at the Upper Site, the soil was assumed impacted to the water table.

5.4 Transport Mechanisms

5.4.1 Volatilization and Atmospheric Dispersion/Enclosed Space Accumulation

Transport mechanisms include volatilization from affected surficial soil, subsurface soil, and groundwater to outdoor air and indoor air. The transport of COPCs by wind was evaluated to locate potential down wind receptors. Soil data from the current and previous investigations indicates that the affected soil zone extends from land surface to the water table in some locations.

5.4.2 Leaching and Groundwater Transport

Several chemicals that were detected in soils during previous investigations were also detected in groundwater at the site. These chemicals include benzene, toluene, ethylbenzene, xylenes, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene (Appendix A, Table A-3). Tetrachloroethene was detected in the groundwater but was not detected in the soils.

5.5 Exposure Pathways

The anticipated future use for the Upper Site is industrial development. Thus the on-site receptors evaluated were commercial/industrial and construction worker exposure. The onsite exposure pathways include:

- Dermal contact with surficial and subsurface soils,
- Inhalation of outdoor air and indoor air,
- Potential potable water use from an existing well at the site, and
- Groundwater migration to Swan Lake.

Two offsite receptors evaluated were commercial outdoor worker and groundwater migration to Swan Lake.

5.6 Receptor Description

5.6.1 Adjacent Land Use

Adjacent parcels of land to the north and southeast are currently developed for commercial purposes. East of the Upper Site is an undeveloped parcel which given current surrounding land use would reasonably be assumed to have the potential for commercial property. Further east of the Upper Site is undeveloped land currently owned by the Nevada National Guard and Swan Lake.

Approximately 1000 feet southwest from the Upper Site is currently developed for residential use. This location is not in the predominately downwind direction from the site, see Wind Rose Figure 5.

5.6.2 Wells

Well log files at the Division of Water Resources, Department of Conservation and Natural Resources in Carson City were reviewed for wells located within one mile of the site. A production well is located on the property is designated on the Well Drillers Report as a “Fire Well” (Appendix G). Based on information from UNR personnel the well has been sold to the Truckee Meadows Water Authority. The “Fire Well” is 8-inches-diameter, 300 feet deep, and the well casing is cemented from land surface to 50 feet deep and gravel packed from 50 to 300 feet. No other drinking water or irrigation wells were found within a one-mile radius of the subject property. However, the records indicate that there are 16 wells located on land owned by UNR in Stead. Based on conversations with UNR personnel, our understanding is that two wells exist on the subject property, both of which are located on the upper site. One well is a monitoring well installed for a different investigation unrelated to the site.

The Truckee Meadows Water Authority (TMWA) currently owns the well that was drilled on site for fire fighting purposes. The intended use for the well is for groundwater supply. The current evaluation assumes that groundwater remediation will be completed prior to use of the well.

The only other wells within a one-mile radius of the subject property are 1) a test well at the Stead Airport, approximately ½-mile to the north, 2) an industrial use well on unimproved private property, 500 feet to the east, and 3) a plugged well on private property, approximately ½-mile to the southeast.

5.6.3 Wetlands

Swan Lake lies about 2000 feet east of the Upper Site. The lake appears as a perennial feature. Shallow groundwater from the site discharges to the lake. About 2000 feet south from the Lower Site, the Reno/Stead Wastewater Treatment plant discharges water to Swan Lake. About 490 AF/year of water is committed for discharge from the treatment plant.

6. RISK-BASED CLEANUP STANDARDS

The development of the risk-based cleanup standards were based on the exposure parameters listed in Appendices H and I, Input Parameter Summary, which are USEPA default values. The target risk values were established at 10^{-6} individual and 10^{-5} cumulative for Class A/B carcinogens and 10^{-5} individual for Class C carcinogens. The target hazard index was 1.0. There are no aquatic standards for PAH and BTEX. Thus for the soil leaching to groundwater and transport to Swan Lake pathway, the standard used was the maximum concentration level (MCL). Development of the risk-based standards herein utilized the software program RBCA Toolkit for Chemical Releases (Groundwater Services, Inc., 2000), which is based on the ASTM RBCA Guidance (ASTM, E 1739-95^{E1}).

6.1 Tier 1 RBSLs

Tier 1 evaluation typically uses a look-up table for generic RBSLs based on default values for exposure factors and estimated site properties. The assumptions to derive the Tier 1 RBSL values were reviewed and determined to be very conservative for some pathways (e.g., precipitation infiltration rate at 11.8 inches/year) and under estimates other site parameters (e.g., source width parallel to groundwater flow and wind velocity). Other site specific parameters that differ from the Tier 1 assumptions include depth of the surface soil zone, depth to the base of the contaminated zone, and depth to the water table. However, Tier 1 results were compared to soil sampling data from the current investigation. The results were weighed against maximum detection, the maximum detection limit, and the exposure media and receptor in Table 7. Tier 1 model results are included in Appendix I. This review aided in the development of the Tier 2 SSTLs for the Upper Site. No COPCs were removed from further Tier evaluation at this level of screening.

6.2 Tier 2 SSTLs

6.2.1 Upper Site – Comparison of Data with Tier 2 SSTLs

The Tier 2 evaluation was developed by using site specific information (explained in Section 4.5) collected during the current investigation and appropriate points of exposure as described in the CSM. Given the target risk levels and exposure factors (Appendix I), SSTLs were back calculated for each COPC at the site. The applicable SSTLs calculated were for the complete exposure pathways for volatilization from soil to indoor air for commercial workers and surface soil vapor inhalation, ingestion and dermal contact for construction workers, Table 8 and Appendix I.

6.2.1.1 Exposure Media and Receptor Evaluation

Alternative land use planning for the Upper Site includes potential development for commercial and/or light industrial purposes. Based on current land use adjacent to the subject property, the most reasonable development of adjacent land would also be for commercial and/or light industrial purposes. The exposure pathways modeled at this site were (1) indoor air inhalation of vapor from impacted soil and groundwater by on-site workers and construction workers, (2) outdoor air inhalation of vapor from impacted soil and groundwater by on-site workers and construction workers, (3) dermal contact and ingestion of the soil by on-site workers and construction workers, and (4) leaching to groundwater and potable water ingestion from the on-site well and transport to

Swan Lake. Figure 4 shows the exposure pathways for the Tier 2 SSTL screening.

6.2.1.2 PAH and VOC Compounds

A summary of soil sampling data from the current investigation was compared with the maximum sample detection and maximum detection limit, and the exposure media and receptor in Table 8. Based on the evaluation, benzene for the sample from USTP18@8 was the only constituent that exceeded the SSTL. The maximum detection limit for benzene also exceeded the SSTL; the detection limits for individual samples listed in Table E-2 were compared to the SSTL. The maximum detection limit for ten soil samples from test pits USTP16, USTP19, USTP21 Duplicate, USTP22, USTP25, USTP26, USTP28, and USTP29 exceeded the SSTL for benzene. Except for the samples from test pits USTP16 and USTP25, these locations are within or proximal to a former water/sludge retention pond(s) at the Upper Site.

6.2.1.3 TPH Fractions

Typically in applying the TPH Criteria Working Group methodology, concentration information for individual PAH and VOC compounds is not established, except for benzene and toluene because of the very limited C range reported, see Appendix E, Table E-4. The method utilizes the risk associated with the compounds within a specified carbon range.

For this assessment the TPH fractions were analyzed as total carbon (aliphatic and aromatic) within a given carbon range, Table E-3, and reported to 3 mg/Kg. Equivalent carbon numbers for the analytes detected by the modified EPA Method 8260B and PAHs by modified EPA Method 8270 were used to develop the aromatic fraction list shown on Table E-4 with reporting limits in the microgram/kilogram range. The aliphatic fraction, Table E-5, was developed by subtracting the aromatic fraction from the total carbon fraction. This methodology for developing the carbon fractions differs from the TPH Criteria Working Group methodology which utilizes a combination of solvent extraction and extract cleanup to separate the sample into aliphatic and aromatic fractions. However, because the methodology used for this assessment utilizes a more sensitive method to determine the aromatic fractions, the results should be as accurate as the Working Group methodology and are suitable for screening level evaluation of site soils.

The lowest carbon fraction analyzed by the modified EPA method 8015B was C-8. Thus, aliphatic compounds lighter than C-8 are not included in the assessment. Findings from both previous site investigations and the current investigation indicate that diesel is the most common fuel hydrocarbon found at the site. For diesel, the lightest aliphatic compound is n-Octane at C-8. The aromatic fractions were developed from the modified EPA 8260B analysis, thus benzene (C-6) the lightest of the aromatic compounds, is included in the assessment.

The SSTL for TPH screening was calculated using the critical fraction method where the minimum value of all the fraction specific SSTLs is divided by their respective mass fractions. On this basis the SSTL for TPH at the upper Site was calculated at 1,100 mg/Kg. Based on the assumptions made in applying the TPH methodology, for soil screening purposes 1,000 mg/Kg was used to compare to the TPH data. Table 9 summarizes the data from the current investigation where TPH exceeded the target SSTL. Samples from test pits at locations USTP-18, -19, -20, -21, -22, -26, -28, and -29 exceeded the TPH SSTL. Table 10 summarizes the data from previous investigations where TPH

exceeded the target SSTL. Samples from test pits at locations TT-1, -4, -6, -7, -40, -41, -42, -43, -44, -45, -46, and -47 exceeded the TPH SSTL. These locations are shown on Figure 2.

6.2.1.4 SSTL Summary

For this screening level evaluation, concentration information was developed for individual PAH and VOC compounds, as well as for TPH. Table 11 summarizes the current soil sampling data with TPH greater than 1,000 mg/Kg and PAH and VOC detections. At USTP-18 TPH exceed 12,000 mg/Kg and benzene exceeded its SSTL. At only one location where TPH was greater than 12,000 mg/kg did a VOC (benzene) concentration exceed its SSTL.

6.2.1.5 Uncertainty Associated with Estimation of SSTLs

Uncertainties associated with the development of the Tier 2 SSTLs include factors relating to the analytical laboratory analysis methodology, selection of COPCs, soil sampling (distribution of contaminants), site physical setting, exposure parameters, and modeling assumptions.

The analytical laboratory methodology was selected to provide screening level data at as many points across the site as possible to lower the overall sampling uncertainty. The data quality level employed for the field investigation reported herein was at Level 2 according to ASTM ASC Guidance (ASTM, E 1912-98). All results were reported as estimated concentrations from modified EPA method screen procedures. The data quality was deemed sufficient to screen the data for comparison to RBSLs and SSTLs to determine areas where soils require remediation. The laboratory procedures enabled a larger number of samples to be collected that reduced the overall sampling uncertainty (Crumbling, et. al, 2001).

Based on historical site use, the COPCs were limited to consideration of petroleum hydrocarbons and solvents. Specific compounds include BTEX, PAHs, fuel oxygenate additives, e.g., MTBE, and lead (older gasoline). For this screening level evaluation lead was assumed to be collocated with the petroleum hydrocarbons, and was not analyzed. Analysis of previous soil samples from the Lower Site indicated the presence of methylene chloride, 1,1,2-trichloroethane, and trichloroethylene. Records from site closure activities indicate that heptane, kerosene, isopropanol, and methanol were stored on site. It is our understanding that solvents were not routinely utilized on-site.

Based on previous site investigations, the distribution of contaminants was conceptualized as being associated with the fuel storage and distribution lines, mock facilities, and ponds. For the current study, soil samples were collected based on a random starting point systematic grid across the site with samples added at suspected hot spots. The current sampling program has confirmed that soil contamination is focused around the former site facilities. Sample locations outside the fuel storage and distribution lines, mock facilities, and ponds did not indicate the presence of TPH, PAHs, and/or VOCs.

The physical setting includes characteristics related land use and exposure pathways. The future land use for the SSTLs assumes that the site is developed solely for commercial/industrial purposes. The Truckee Meadows Water Authority (TMWA) currently owns the well that was drilled on site for fire fighting purposes. The intended use for the well is for groundwater supply. The current evaluation assumes that groundwater remediation will be completed prior to use of the well.

Exposure parameters were based on EPA default values as outlined in the ASTM RBCA guidance. The EPA factors are generally conservative and therefore uncertainty associated with the use of these factors is likely small.

Chemical fate and transport, and exposure modeling require assumptions about the physical and chemical environment. There is uncertainty associated with how well models approximate the relationship between the site environmental conditions, COPCs, and exposure media.

Air source zone modeling is based on wind speed and direction data from Reno Cannon Airport. The wind rose model used data averaged over a period of nine years and should be indicative of long-term conditions for the region.

Subsurface vapor modeling was based on the Johnson and Ettinger model. In general, the model is highly sensitive to soil water-filled porosity, soil vapor permeability, soil-building pressure differential, depth to bottom of soil contamination, and depth to top of soil contamination (Johnson and Ettinger, 1997). Soil physical and chemical parameters (porosity, percent water content, density, grain size distribution, and organic content) were based on samples collected from the site. Soil vapor permeability and soil-building pressure differential were based on default values. The depth to the top and base of the contaminated soil was based on the CSM and assumed that the entire soil column was impacted. At the former pond(s) location the assumption is believed to represent conditions based on observations from on-site data. However, for areas outside the former pond(s), the assumption should be conservative and therefore the model likely would over predict subsurface vapor concentrations in those areas.

7. EVALUATION OF GROUNDWATER REMEDIAL ALTERNATIVES

MGA evaluated several alternatives for remediating the deeper petroleum-contaminated soil and groundwater. Factors considered included: the nature of contamination, extent of contamination, contaminant concentrations in the soil and groundwater, geologic and hydrogeologic conditions, regulatory remedial objectives, distance to sensitive receptors, site constraints, estimated cost and other site specific factors.

The following remedial alternatives were evaluated:

- Monitored natural attenuation (MNA);
- Excavation and groundwater pump and treat (GPT); and
- Air sparging (AS) and vapor extraction (VE).

Each of these remedial alternatives is discussed in detail in the following sections.

7.1 Monitored Natural Attenuation

Natural attenuation consists of a variety of physical, chemical, and/or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume and concentration of contaminants in the soil and groundwater. These processes include: intrinsic biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation or destruction of contaminants (*U.S. Environmental Protection Agency, 1997*). MNA consists of collecting data to assess the rate at which natural attenuation may be occurring and evaluate whether natural attenuation processes will reduce the contaminant concentrations in the soil and/or groundwater to acceptable levels within a reasonable time frame.

Several factors must be considered when evaluating MNA as a sole remedial alternative. These factors include, but are not limited to, the following:

- Proximity of the plume(s) to sensitive receptors or sensitive areas (i.e. drinking water or irrigation wells, surface waters, wetlands, playgrounds, schools, etc.);
- Potential exposure pathways;
- Geologic and hydrogeologic conditions;
- Lateral and vertical extent of contamination;
- Source control;
- Contaminant concentrations in the soil and groundwater;
- Present and future land use;
- Chemical and physical properties of the soil and groundwater (i.e. pH, moisture content of the impacted soil, total organic content, availability of electron acceptors such as nitrate, oxygen, carbon dioxide, sulfate, and iron, temperature of the soil and groundwater, nutrient concentrations, etc.);
- Nature of contaminant(s); and,
- Regulatory remedial objectives.

Each of these factors have been discussed in previous sections.

While natural attenuation processes will likely assist in stabilizing the dissolved contaminant plume at the Upper site, it is unlikely that the contaminant concentrations in the groundwater will be reduced to at or below the regulatory action levels in a reasonable time frame relying solely on natural attenuation processes. The cost of monitoring the groundwater would likely exceed the cost of active remediation.

7.2 Excavation and GPT

It is unlikely that the TPH concentrations reported in site soils (See Appendix A and E) will be reduced significantly as a result of natural attenuation processes. The contaminants that are sorbed onto the soil matrix may serve as a source of additional groundwater contamination. As meteoric water percolates downward through the contaminated soil matrix, contaminants that are sorbed onto the soil matrix may leach into water. These contaminants are transferred into the shallow aquifer if the meteoric water reaches the groundwater table. We recommend that actions be taken to prevent the contamination that is sorbed onto the soil matrix from being transferred into the water. This can be accomplished by one or more of the following: 1) excavating the contaminated soil, 2) *in-situ* remediation of the contaminated soil, or 3) placing a “cap” over the impacted area.

This remedial option would consist of excavation and on-site thermal treatment of the soil with TPH concentrations in excess of the state action level and installation of a GPT system to remediate the contaminated groundwater.

A GPT system would be installed to extract and treat the contaminated groundwater. The GPT system would likely consist of several groundwater extraction wells with submersible pumps, a groundwater treatment system (granular activated carbon) and several underground injection wells. GPT may not reduce the dissolved contaminant concentrations to at or below the MCLs. GPT is effective in substantially reducing the dissolved contaminant concentrations in a relatively short period of time; however, after the initial reduction, the contaminant concentrations reach asymptotic levels, which may be above the MCLs, at which point continued operation of the GPT system does not achieve significant results. This is a result of contaminants sorbing onto the saturated zone soil matrix and slowly leaching into the groundwater over time.

The estimated costs for excavating the contaminated soil and remediating the contaminated groundwater utilizing GPT technology at Upper Site is presented in Table 12. We have based our cost estimate on operating the GPT system for three years.

7.3 AS and VE

This remedial option would consist of installing an *in-situ* AS and VE system at the Upper site to reduce the contaminant concentrations in the soil and groundwater. Air sparging is an *in-situ* groundwater remediation technology where air is injected at low to moderate pressures (0 to 15 psi) below the dissolved contaminant plume through a series of AS points. As air bubbles migrate upward through the saturated zone, contaminants are “stripped” and/or volatilized and are transferred into the unsaturated zone where they can be extracted by a VE system. VE is an *in-situ* soil remediation technology where a vacuum is applied to one or more horizontal and/or vertical VE wells/galleries; thereby creating a pressure gradient in the unsaturated zone which induces the flow

of volatile organic compounds (VOCs) towards the VE wells/galleries. The VOC's that are extracted are either destroyed utilizing thermal oxidation, catalytic oxidation or internal combustion or captured by passing the extracted vapor stream through granular activated carbon (GAC). AS and VE also increase the oxygen content in the soil and groundwater; thereby, enhancing aerobic biodegradation of the hydrocarbons.

The remediation system would consist of approximately 20 AS points and several vertical VE wells placed strategically throughout the contaminated area, associated conveyance piping and appurtenances, equipment and GAC to capture VOC's that are extracted by the VE system. We estimate it may take one to two years to reduce the dissolved contaminant concentrations in the groundwater at the Upper site to at or below the MCLs using AS and VE. The estimated costs to install an AS/VE system and operate the system for 18 months are summarized in Table 13.

8. RECOMMENDED REMEDIAL APPROACH

8.1 Soil Remediation

As discussed in Section 6.2.1.3, results of the ASTM risk assessment indicated that TPH levels below a concentration of 1000 mg/kg should satisfy the soil screening health risk criteria. A substantial portion of soils impacted with petroleum hydrocarbons exceeding this level, are located proximal the former unlined pond are of the facility (See Figure 2). At these locations, TPH levels exceeding 1000 mg/kg extend up to 20 feet below ground surface. Invasive and extensive remedial technologies such as excavation of contaminated soils exceeding this level would be considered cost prohibitive.

Correspondingly it is recommended that the vacuum extraction (VE) system as discussed in the following sections be installed and operated for 12 to 18 months. The purpose of the VE system is twofold, to extract VOCs that are transferred into the unsaturated zone as a result of sparging, and extract VOC's that are sorbed onto the unsaturated zone soil matrix. It is anticipated that the later will result in a substantial reduction of hydrocarbon mass. After operating the VE system for the recommended duration, re-sampling of subsurface soils should be performed in order to assess residual TPH concentrations. Post remediation confirmation samples should be collected and analyzed with full laboratory QA/QC procedures to confirm that the remediation goals were met. Both the post remediation soil samples and the screening level samples will be used for a post remediation forward baseline risk assessment. With the anticipated TPH mass reduction and removal of the volatile fractions, it is expected that the baseline risk will fall within the acceptable range for most of the soil. Thus, the amount of contaminated soils subject to future invasive remediation such as excavation and offsite treatment would be substantially reduced.

It is our understanding that the University may elect to subdivide the subject site such that some portions could be liquidated. Should any subdivided parcels result in smaller isolated areas of surficial hydrocarbon contaminated soils, it is recommended that soils with TPH concentrations exceeding 1,000 mg/kg be excavated and transported offsite for treatment.

8.2 Groundwater Remediation

Based on our evaluation of the remedial alternatives detailed herein and the potential use of the well by TMWA, MGA recommends installing an *in-situ* AS and VE system at the Upper Site for remediation of VOC impacted groundwater. The purpose of the AS system is to reduce the dissolved contaminant concentrations to at, or below, the MCLs and increase the dissolved oxygen content in the groundwater; thereby enhancing aerobic biodegradation of the off-site contamination. MGA estimates the cost to install the AS/VE system and operate the system for 18 months will be approximately \$360,000. Based on the contaminant concentrations at this site and site specific factors, we anticipate that the dissolved contaminant concentrations will be reduced to acceptable levels within 18 months of activating the AS/VE system.

8.2.1 Field Pilot Testing

It is recommended that field pilot tests be performed to gather information to design the AS and VE system. The field pilot testing will be performed concurrently with installation of the AS points and

VE wells. The proposed pilot tests are discussed in detail in the following sections.

8.2.1.1 Installation of AS Point and VE Wells

Two AS points (AS-1 and AS-2) and one dual-completion AS point/VE well (AS-3/VE-3) will be installed at the Upper site to facilitate field pilot testing. Air sparge point AS-1 will be installed approximately 20 feet west of MW-2 and AS-3 will be installed approximately 30 feet east MW-2. The dual-completion AS point/VE well will be installed approximately 60 feet southeast of MW-2. The AS points and VE wells will be installed by a Nevada-licensed driller. Drilling will be performed utilizing a truck-mounted, hollow-stem auger. A geologist or engineer will be onsite to oversee field activities. Soil cuttings will be placed in 55-gallon steel drums and stored onsite pending disposal.

The AS point boreholes will be advanced to approximately 25 feet below the groundwater table. The AS point will be constructed of one-inch diameter, schedule 40 PVC. An 18-inch long, one-inch diameter, PVC screen (0.01-inch slot) will be placed at the bottom of the borehole. A threaded cap will be placed on the top and bottom of the casing. Silica sand will be placed in the annulus of the borehole to one foot above the screen. A minimum, ten-foot thick bentonite seal will be placed on top of the filter pack and the remainder of the annulus will be filled with cement slurry. The AS point will be completed inside a traffic-rated well box. The proposed construction details for the AS point are depicted in Figure 6.

The dual completion AS point/VE well borehole will be advanced to approximately 25 feet below the groundwater table. The AS point will be constructed of one-inch diameter, schedule 40 PVC. An 18-inch long, one-inch diameter, PVC screen (0.01-inch slot) will be placed at the bottom of the borehole. A threaded cap will be placed on the top and bottom of the casing. Silica sand will be placed in the annulus of the borehole to one foot above the screen. A bentonite seal will be placed on top of the filter pack to the surface of the groundwater table to prevent short-circuiting of injected air up the borehole.

The VE well will be installed on top of the bentonite seal. The VE well will be constructed of four-inch diameter PVC casing. A 10-foot screen (0.02-inch slots) will be placed on top of the bentonite seal. A threaded cap will be placed on the bottom of the screen and a locking well cap will be placed on top of the casing. Silica sand will be placed in the annulus of the borehole to one foot above the screen. A five-foot thick hydrated bentonite seal will be placed on top of the filter pack and the remainder of the annulus will be filled with cement slurry. The AS point/VE well will be completed inside a flush-mounted, steel well box. The proposed construction details for the dual completion AS point/VE well are depicted in Figure 7.

8.2.1.2 Pilot AS Test

The purpose of the AS pilot test is to determine the radius of influence the AS point. This information will be utilized to determine the optimal spacing of the AS points. We generally define the radius of influence as the distance from the AS point at which “mounding” of the groundwater is observed and/or significant increases in dissolved oxygen (DO) are measured. Localized mounding of the groundwater around the AS point during sparging as a result of air displacing water from the soil matrix in the saturated zone. We anticipate that the radius of influence of the AS points will be approximately 25 to 35 feet.

The first test will be performed using AS-1 as an air injection point. Upon completion of testing in AS-1, a second test will be performed using AS-2 as an air injection point. Air will be injected into each sparge point at a rate of approximately three cubic feet per minute using an oil-less air compressor. The depth to groundwater and DO in MW-2 will be measured and recorded prior to, and during the pilot test using electronic meters. The pilot test will be terminated once these parameters have stabilized.

8.2.1.3 Pilot VE Test

The purpose of the VE pilot test is to determine the effective radius of influence the VE wells. This information will be utilized to determine the optimal spacing of the VE wells. We generally define the radius of influence as the distance from the AS point at which an induced vacuum of at least 0.5 inches of water is measured. Based on the geologic condition, we anticipate that the radius of influence of the VE wells will be approximately 50 to 100 feet.

The pilot VE test will consist of applying a vacuum to VE-3 utilizing a regenerative blower. The induced vacuum in MW-2, MW-8 and MW-9 will be measured during the pilot using a magnahelic gauge. The pilot test will be terminated once the induced vacuum in these wells stabilizes.

8.3 Remediation System Design

We anticipate that the remediation system at the Upper site will consist of 25 to 30 AS points and five to ten dual-completion AS points/VE wells, conveyance piping, and associated equipment. Monitoring wells MW-1, MW-2 and MW-7 will also be used as VE wells. The field pilot test data will be evaluated while the drill rig is onsite to determine the quantity and optimum locations of the AS points and dual-completion AS point/VE wells. The information from the pilot test will also be evaluated to determine the size of the AS and VE equipment.

The remediation equipment will be placed in a central location. The AS points and VE wells will be connected to the remediation equipment via aboveground PVC piping. Following installation of the AS points and dual-completion AS point/VE wells, we will prepare detailed construction drawings and specifications for installing the conveyance piping, remediation equipment and associated appurtenances.

8.4 VOC Abatement

Vapors that are extracted by the VE system will be passed through granular activated carbon (GAC) to capture VOC's in the vapor stream. Representative samples of vapor effluent from the GAC canisters will be collected by MGA personnel on a periodic basis. Carbon change outs will be scheduled once initial break through is detected.

9. LIMITATIONS

The conclusions and recommendations presented herein are based on analytical data, field measurements, survey data and results of previous environmental assessment and/or remediation activities. MGA makes no warranties or guarantees as to the accuracy or completeness of information provided or compiled by others. The results reported herein are applicable to the time the sampling occurred. Changes in site conditions may occur as a result of rainfall, snowmelt, water usage, or other factors.

It should be recognized that definition and evaluation of environmental conditions is a difficult and inexact science. Judgments and opinions leading to conclusions and recommendations are generally made with an incomplete knowledge of the conditions present. More extensive studies, including additional environmental investigations, can tend to reduce the inherent uncertainties associated with such studies. Additional information not found or available to MGA at the time of writing this report may result in a modification to the conclusions and recommendations contained herein.

The presentation of data in plots of contours presented herein is intended for the purpose of the visualization of environmental conditions. A greater degree of spatial and temporal data density may result in a more accurate representation of environmental conditions. Although such data visualization techniques may aid in providing a conceptual understanding of environmental conditions, such presentations are not intended to completely depict environmental conditions.

This report is not a legal opinion. The services performed by MGA have been conducted in a manner consistent with the level of care ordinarily exercised by members of our profession currently practicing under similar conditions. No other warranty, expressed or implied, is made.

10. CLOSING

MGA trusts the information provided herein satisfies the requirements of the NDEP and the University of Nevada Reno at this time. Should you have any questions regarding this report, feel free to contact us (775) 829-2245 at your convenience.

Respectfully submitted,

McGinley & Associates, Inc.

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations, and ordinances.

The use of the word "certify" in this document constitutes an expression of professional opinion regarding those facts or findings which are the subject of the certification and does not constitute a warranty or guarantee, either expressed or implied.

Joseph M. McGinley, PE, RG
Principal, C.E.M. #1036, Exp. 11/02

In association with,
Hackenberry Associates LLC

Paul Hackenberry

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Table 1: Laboratory Analytical Results for Groundwater Samples – Upper Site

ID	DATE	BENZ	TOL	ETH	XYL	MTBE
MW-1	1-21-00	13.3	80.3	ND	ND	ND
	6-22-00	53	ND	ND	ND	ND
	7-16-01	270	ND	ND	ND	2.9
	6-4-02	330	ND	ND	ND	2.7
MW-2	1-21-00	1020	20	15	362	ND
	6-22-00	920	14	ND	362	ND
	7-16-01	610	ND	ND	150	ND
	6-4-02	450	2.4	ND	81.3	ND
MW-3	1-21-00	ND	3.3	ND	ND	ND
	6-22-00	ND	ND	ND	ND	ND
MW-7	4-25-00	150.8	6.5	40.1	67.1	ND
	6-22-00	190	8.0	ND	152	ND
	6-4-02	39	ND	ND	ND	ND
MW-8	4-25-00	ND	ND	ND	ND	ND
	6-22-00	ND	ND	ND	ND	ND
	7-16-01	280	ND	ND	61	ND
	6-4-02	600	ND	ND	2.4	ND
MW-9	4-25-00	113.5	ND	ND	17.5	ND
	6-22-00	83	ND	ND	ND	ND
	7-16-01	48	ND	ND	2.7	ND
	6-4-02	100	ND	ND	3.7	ND
MW-14	9-8-00	ND	ND	ND	ND	ND
	9-20-00	ND	ND	ND	ND	ND
	6-4-02	ND	ND	ND	ND	ND

ID Sample location
BENZ Benzene (µg/L)
ETH Ethylbenzene (µg/L)
TOL Toluene (µg/L)
XYL Xylenes (µg/L)
MTBE Methyl tert-butyl ether (µg/L)
ND Not detected

Table 2. Sample Location Key, Sample Number, and Field Observations, Upper Site

Strata	Map Number	Sample Location Number	Chemical Analysis			Soil Media Physical Properties	Comments/Observations
			Depth (feet) and Last Digit of Sample Number		Strata Total Sample Count	Sample Depth	
1	1	USTP-1	2	4			Hold 4 ft sample pending results of 2 ft sample.
	2	USTP-2	2	4			Hold 4 ft sample pending results of 2 ft sample.
	3	USTP-3	2	4		4	Hold 4 ft sample pending results of 2 ft sample.
	4	USTP-4	2	4			Hold 4 ft sample pending results of 2 ft sample.
	5	USTP-5	2	4			Hold 4 ft sample pending results of 2 ft sample.
	6	USTP-6	2	4			Hold 4 ft sample pending results of 2 ft sample.
	7	USTP-7	2	4			Hold 4 ft sample pending results of 2 ft sample. Duplicate sample collected at 4 ft.
	8	USTP-8	2	4			Hold 4 ft sample pending results of 2 ft sample.
	9	USTP-9	2	4			Hold 4 ft sample pending results of 2 ft sample.
	10	USTP-10	2	4			Hold 4 ft sample pending results of 2 ft sample.
	11	USTP-11	2	4		22	4
2	12	USTP-12	2	4	8		
	13	USTP-13	2	4	8		
	14	USTP-14	2	4	8		Duplicate sample collected at 8 ft.
	15	USTP-15	2	4	8		
	16	USTP-16	2	4	8		
	17	USTP-17	2	4	8		
	18	USTP-18	2	4	8		Asphalt observed as fill material at 2-4 ft. Moderate hydrocarbon odor detected at 8 ft.
	19	USTP-19	2	4	8		
	20	USTP-20	2	4	8		Slight hydrocarbon odor detected in samples collected at 4 and 8 ft.
	21	USTP-21	2	4	8		Duplicate sample collected at 4 ft.
	22	USTP-22	2	4	8		Slight hydrocarbon odor detected at 2 and 4 ft.
	23	USTP-23	2	4	8		
	24	USTP-24	2	4	8		
	25	USTP-25	2	4	8		
	26	USTP-26	2	4	8		4
27	USTP-27	2	4	8			
28	USTP-28	2	4	8		Duplicate sample collected at 2 ft. Moderate hydrocarbon odor detected at 8 ft.	
29	USTP-29	2	4	8		Strong hydrocarbon odor detected at 8 ft.	
30	USTP-30	2	4	8			
31	USTP-31	2	4	8	60		
Total by Depth			31	31	20		
TOTAL NUMBER OF SAMPLES						82	3

Table 3. Data Quality Levels for Accelerated Site Characterization (ASTM E1912-98)		
Data Quality Level	Instruments Used for Quality Level	Comments
1	PID	Initial soil screening, clean samples cannot be determined from these methods.
2	GC/PID; IR; Immunoassay	Laboratory methods that have been adapted for field use. Intended for delineation of COCs.
3	EPA Approved Laboratory Methods (EPA SW846)	EPA SW846 Methods with complete QA/QC
4	“State of the Art” developed specifically for a site or COPC	Methods specifically developed for a particular site or chemical.

Table 4. Samples Selected for EPA 8260B Review

Sample Identification	ClientSample Identification	Total Carbon Range mg/Kg
02011820-04A	USTP-18 @ 2	6600
02011820-05A	USTP-18 @ 4	280
02011820-06A	USTP-18 @ 8	13000
02011820-07A	USTP-19 @ 2	1200
02011820-10A	USTP-20 @ 2	1100
02011820-11A	USTP-20 @ 4	470
02011820-12A	USTP-20 @ 8	49
02011820-16A	USTP-22 @ 2	12000
02011820-17A	USTP-22 @ 4	1900
02011820-25A	USTP-25 @ 2	300
02011860-02A	USTP-26@2	<4800
02011860-03A	USTP-26@4	1300
02011860-04A	USTP-26@8	3700
02011860-08A	USTP-28@2	14000
02011860-09A	USTP-28@4	490
02011860-10A	USTP-28@8	1500
02011860-11A	USTP-29@2	1700
02011860-12A	USTP-29@4	730
02011860-13A	USTP-29@8	19000
Total Number of Samples		19

Table 5. Summary of Compounds Not Detected in Soil

Acenaphthylene	Ethyl Tertiary Butyl Ether (ETBE)
Acenaphthene	Tertiary Amyl Methyl Ether (TAME)
Fluoranthene	Tertiary Butyl Alcohol (TBA)
Pyrene	Bromobenzene
Chrysene	Bromochloromethane
Benzo(b)fluoranthene	Bromodichloromethane
tert-Butylbenzene	Bromoform
1,1,1,2-Tetrachloroethane	Bromomethane
1,1,1-Trichloroethane	Carbon tetrachloride
1,1,2,2-Tetrachloroethane	Chlorobenzene
1,1,2-Trichloroethane	Chloroethane
1,1-Dichloroethane	Chloroform
1,1-Dichloroethene	Chloromethane
1,1-Dichloropropene	cis-1,2-Dichloroethene
1,2-Dibromo-3-chloropropane (DBCP)	cis-1,3-Dichloropropene
1,2-Dibromoethane (EDB)	Dibromochloromethane
1,2-Dichlorobenzene	Dibromomethane
1,2-Dichloroethane	Dichlorodifluoromethane
1,2-Dichloropropane	Dichloromethane
1,3-Dichlorobenzene	Hexachlorobutadiene
1,3-Dichloropropane	Styrene
1,4-Dichlorobenzene	Tetrachloroethene
2,2-Dichloropropane	trans-1,2-Dichloroethene
2-Chlorotoluene	trans-1,3-Dichloropropene
4-Chlorotoluene	Trichloroethene
Methyl tert-butyl ether (MTBE)	Trichlorofluoromethane
Di-isopropyl Ether (DIPE)	Vinyl chloride

Table 6. Summary of Detections in Soil by Location and Depth for PAH and VOC at the Upper Site

Sample Identification	Client Sample Identification	PAH Summary	VOC Summary
UPPER SITE STRATA - 2			
02011820-06A	USTP-18 @ 8	4	13
02011860-03A	USTP-26@4	3	0
02011860-04A	USTP-26@8	3	14
02011860-08A	USTP-28@2	5	8
02011860-09A	USTP-28@4	1	0
02011860-10A	USTP-28@8	3	9
02011860-13A	USTP-29@8	4	0
Total Number	2 feet	5	8
of Detections	4 feet	4	0
by Depth	8 feet	14	36

Table 7. Tier 1 RBSL Evaluation for Soils at Upper Site, January 2002

	Number of Samples	Number of Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)	Tier 1 RBSL (mg/kg)	Comparison to RBSL	RBSL Comparison to Maximum Detection Limit
Polynuclear Aromatic Hydrocarbons (PAHs)									
Naphthalene	72	5	7.70E-01	6.40E+00	2.50E-01	2.50E-01	3.40E+04	Max. Value < RBSL	Max. DL < RBSL
Fluorene	72	5	5.90E-01	5.90E+00	2.50E-01	2.50E-01	1.20E+02 >C _{sat}		Max. DL < RBSL
Anthracene	72	6	3.80E-01	1.40E+01	2.50E-01	2.50E-01	6.40E+00 >C _{sat}		Max. DL < RBSL
Fluoranthene	72	4	3.50E-01	8.80E-01	2.50E-01	2.50E-01	7.80E+01 >C _{sat}		Max. DL < RBSL
Pyrene	72	2	3.60E-01	6.00E-01	2.50E-01	2.50E-01	6.10E+01 >C _{sat}		Max. DL < RBSL
Aromatic Hydrocarbons									
Benzene	72	1	4.80E+01	4.80E+01	1.00E-02	5.00E-02	9.60E-03	Max. Value > RBSL	Max. DL > RBSL
Toluene	72	2	1.20E-01	1.30E-01	2.50E-02	1.00E-01	5.00E+01	Max. Value < RBSL	Max. DL < RBSL
Ethylbenzene	72	3	3.00E-02	5.90E-01	2.50E-02	1.00E-01	6.40E+01	Max. Value < RBSL	Max. DL < RBSL
Xylenes, Total	72	4	8.50E-02	4.90E+00	2.50E-02	1.00E-01	1.90E+04	Max. Value < RBSL	Max. DL < RBSL
TPH Fractions									
Aliphatic >C08-C10	72	9	5.18E+00	6.25E+02	3.00E+00	3.00E+02	1.80E+03	Max. Value < RBSL	Max. DL < RBSL
Aliphatic >C10-C12	72	16	4.80E+00	7.77E+02	3.00E+00	3.00E+02	1.80E+03	Max. Value < RBSL	Max. DL < RBSL
Aliphatic >C12-C16	72	19	1.04E+01	4.08E+03	3.00E+00	3.00E+02	2.50E+03	Max. Value > RBSL	Max. DL < RBSL
Aliphatic >C16-C21	72	19	3.32E+01	1.08E+04	3.00E+00	3.00E+02	1.60E+01 >C _{sat}		Max. DL > RBSL
Aliphatic >C21-C34	72	19	9.15E+00	5.13E+03	3.00E+00	3.00E+02	1.60E+01 >C _{sat}		Max. DL > RBSL
Aromatic >C05-C07	72	1	4.80E-02	4.80E-02	1.00E-02	5.00E-02	4.60E-01	Max. Value < RBSL	Max. DL < RBSL
Aromatic >C07-C08	72	2	1.20E-01	1.30E-01	2.50E-02	1.00E-01	7.40E+01	Max. Value < RBSL	Max. DL < RBSL
Aromatic >C08-C10	72	4	9.20E-01	1.11E+01	2.50E-01	2.50E-01	1.10E+02	Max. Value < RBSL	Max. DL < RBSL
Aromatic >C10-C12	72	5	1.50E+00	1.04E+01	2.50E-01	2.50E-01	1.70E+02	Max. Value < RBSL	Max. DL < RBSL
Aromatic >C12-C16	72	0	0.00E+00	0.00E+00	2.50E-01	2.50E-01	1.10E+03	Max. Value < RBSL	Max. DL < RBSL
Aromatic >C16-C21	72	5	5.90E-01	5.90E+00	2.50E-01	2.50E-01	1.00E+02 >C _{sat}		Max. DL < RBSL
Aromatic >C21-C35	72	6	1.00E+00	1.49E+01	2.50E-01	2.50E-01	8.30E+00 >C _{sat}		Max. DL < RBSL

Note:

Numbers in dark blue indicate that risk-based target concentration is greater than constituent residual saturation value

Table 8. Tier 2 SSTL Evaluation for Soils at Upper Site, January 2002

	Number of Samples	Number of Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)	Tier 2 SSTL (mg/kg)	Comparison to SSTL	SSTL Comparison to Maximum Detection Limit	Exposure Media and Receptor
Polynuclear Aromatic Hydrocarbons (PAHs)										
Naphthalene	72	5	7.70E-01	6.40E+00	2.50E-01	2.50E-01	8.60E+03	Max. Value < SSTL	Max. DL < SSTL	Construction Worker Inhalation, Ingestion, Dermal Contact
Fluorene	72	5	5.90E-01	5.90E+00	2.50E-01	2.50E-01	3.10E+01 >C _{sat}		Max. DL < SSTL	
Anthracene	72	6	3.80E-01	1.40E+01	2.50E-01	2.50E-01	1.60E+00 >C _{sat}		Max. DL < SSTL	
Fluoranthene	72	4	3.50E-01	8.80E-01	2.50E-01	2.50E-01	2.00E+01 >C _{sat}		Max. DL < SSTL	
Pyrene	72	2	3.60E-01	6.00E-01	2.50E-01	2.50E-01	1.50E+01 >C _{sat}		Max. DL < SSTL	
Aromatic Hydrocarbons										
Benzene	72	1	4.80E+01	4.80E+01	1.00E-02	5.00E-02	1.10E-02	Max. Value > SSTL	Max. DL > SSTL	Comercial Indoor Air On-Site
Toluene	72	2	1.20E-01	1.30E-01	2.50E-02	1.00E-01	1.60E+01	Max. Value < SSTL	Max. DL < SSTL	Comercial Indoor Air On-Site
Ethylbenzene	72	3	3.00E-02	5.90E-01	2.50E-02	1.00E-01	8.30E+01	Max. Value < SSTL	Max. DL < SSTL	Comercial Indoor Air On-Site
Xylenes, Total	72	4	8.50E-02	4.90E+00	2.50E-02	1.00E-01	4.00E+03	Max. Value < SSTL	Max. DL < SSTL	Construction Worker Inhalation, Ingestion, Dermal Contact
TPH Fractions										
Aliphatic >C08-C10	72	9	5.18E+00	6.25E+02	3.00E+00	3.00E+02	3.20E+01	Max. Value > SSTL	Max. DL > SSTL	Comercial Indoor Air On-Site
Aliphatic >C10-C12	72	16	4.80E+00	7.77E+02	3.00E+00	3.00E+02	6.10E+02	Max. Value > SSTL	Max. DL < SSTL	Construction Worker Inhalation, Ingestion, Dermal Contact
Aliphatic >C12-C16	72	19	1.04E+01	4.08E+03	3.00E+00	3.00E+02	1.10E+03	Max. Value > SSTL	Max. DL < SSTL	Construction Worker Inhalation, Ingestion, Dermal Contact
Aliphatic >C16-C21	72	19	3.32E+01	1.08E+04	3.00E+00	3.00E+02	3.90E+00 >C _{sat}		Max. DL > SSTL	
Aliphatic >C21-C34	72	19	9.15E+00	5.13E+03	3.00E+00	3.00E+02	3.90E+00 >C _{sat}		Max. DL > SSTL	
Aromatic >C05-C07	72	1	4.80E-02	4.80E-02	1.00E-02	5.00E-02	1.90E-01	Max. Value < SSTL	Max. DL < SSTL	Comercial Indoor Air On-Site
Aromatic >C07-C08	72	2	1.20E-01	1.30E-01	2.50E-02	1.00E-01	2.10E+01	Max. Value < SSTL	Max. DL < SSTL	Comercial Indoor Air On-Site
Aromatic >C08-C10	72	4	9.20E-01	1.11E+01	2.50E-01	2.50E-01	3.30E+01	Max. Value < SSTL	Max. DL < SSTL	Comercial Indoor Air On-Site
Aromatic >C10-C12	72	5	1.50E+00	1.04E+01	2.50E-01	2.50E-01	3.40E+02	Max. Value < SSTL	Max. DL < SSTL	Construction Worker Inhalation, Ingestion, Dermal Contact
Aromatic >C12-C16	72	0	0.00E+00	0.00E+00	2.50E-01	2.50E-01	5.90E+02	Max. Value < SSTL	Max. DL < SSTL	Construction Worker Inhalation, Ingestion, Dermal Contact
Aromatic >C16-C21	72	5	5.90E-01	5.90E+00	2.50E-01	2.50E-01	2.60E+01 >C _{sat}		Max. DL < SSTL	
Aromatic >C21-C35	72	6	1.00E+00	1.49E+01	2.50E-01	2.50E-01	2.10E+00 >C _{sat}		Max. DL < SSTL	

Note:

Numbers in dark blue indicate that risk-based target concentration is greater than constituent residual saturation value

Table 9. Summary of Current Soil Sampling Data with TPH Greater Than 1,000 mg/Kg

ClientSample ID	C8-C9	C10-C11	C12-C13	C14-C15	C16-C17	C18-C19	C20-C21	C22-C23	C24-C25	C26-C27	C28-C29	C30-C31	C32-C33	C34-C35	C36-C37	C38-C39	Total Carbon Range
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
UPPER SITE STRATA - 2																	
USTP-18 @ 2	500	670	630	500	420	410	500	500	420	520	590	630	340	<300	<300	<300	6,630
USTP-18 @ 8	<30	270	1100	2400	2900	2800	2300	850	220	67	<30	<30	<30	<30	<30	<30	12,907
USTP-19 @ 2	<3	<3	22	130	260	330	260	140	53	18	9.2	4.5	<3	<3	<3	<3	1,227
USTP-20 @ 2	<3	<3	17	100	210	260	240	140	67	29	17	9.1	<3	<3	<3	<3	1,089
USTP-22 @ 2	<30	55	290	1200	2300	2800	2700	1700	530	160	44	<30	<30	<30	<30	<30	11,779
USTP-22 @ 4	<3	9.5	120	310	450	490	310	120	35	12	4.2	<3	<3	<3	<3	<3	1,861
USTP-26@2	<300	<300	<300	<300	560	610	390	<300	<300	<300	<300	<300	<300	<300	<300	<300	1,560
USTP-26@4	43	99	110	98	91	93	99	96	93	110	120	130	82	56	<30	<30	1,320
USTP-26@8	<3	110	270	620	870	900	540	260	88	28	9.2	3.5	<3	<3	<3	<3	3,699
USTP-28@2	<3	96	540	1900	2800	3300	2800	1600	480	91	26	13	<3	<3	<3	<3	13,646
USTP-28@8	<3	29	150	310	330	330	200	86	13	5.9	<3	<3	<3	<3	<3	<3	1,454
USTP-29@2	<30	48	49	110	290	450	410	280	110	<30	<30	<30	<30	<30	<30	<30	1,747
USTP-29@8	<3	<3	190	1800	3600	4500	4200	2800	1100	280	14	5.1	<3	<3	<3	<3	18,489

TABLE 10. Summary of Previous Soil Sampling Data with TPH Greater Than 1,000 mg/Kg

Sample ID	TPH- E (mg/Kg)	TPH-V (mg/Kg)	Range
Upper Site			
TT-1 @ 6'	1300	NA	Diesel
TT-4 @ 16"	1335	NA	Diesel
TT-6 @ 1'	1030	NA	Diesel
TT-7 @ 3'	2845	NA	Diesel
TT-40 @ 2"	1075	NA	Diesel
TT-41 @ 2'	3245	NA	Diesel
TT-41 @ 4'	2215	NA	Diesel
TT-41 @ 6'	2590	NA	Diesel
TT-42 @ 2'	1975	NA	Diesel
TT-42 @ 4'	5075	NA	Diesel
TT-42 @ 6'	3805	NA	Diesel
TT-43 @ 2'	5600	NA	Diesel
TT-43 @ 4'	4830	NA	Diesel
TT-44 @ 6'	2080	NA	Diesel
TT-45 @ 6'	3535	NA	Diesel
TT-46 @ 5.5'	5370	NA	Diesel
TT-46 @ 9.5'	10760	NA	Diesel
TT-47 @ 8.5'	1020	NA	Diesel
Monitoring Well Soil Samples			
MW-1 @ 10'	5565	38	Diesel
MW-1 @ 15'	1470	0.84	Diesel
MW-1 @ 20'	2840	3.45	Diesel
MW-2 @ 10'	8235	104	Diesel
MW-2 @ 20'	1190	4.7	Diesel

Table 11. Summary of Current Soil Sampling Data with TPH Greater Than 1,000 mg/Kg and PAH/VOC Detections

ClientSample ID	Total Carbon Range mg/Kg	PAH Summary	VOC Summary	PAH and/or VOC Exceeding Tier 2 SSTLs
UPPER SITE STRATA - 2				
USTP-18 @ 2	6,630			
USTP-18 @ 8	12,907	4	13	Benzene
USTP-19 @ 2	1,227			
USTP-20 @ 2	1,089			
USTP-21 @ 4	16,000	5	1	
USTP-22 @ 2	11,779			
USTP-22 @ 4	1,861			
USTP-26@2	1,560			
USTP-26@4	1,320	3		
USTP-26@8	3,699	3	14	
USTP-28@2	13,646	5	8	
USTP-28@4	<1,000	1		
USTP-28@8	1,454	3	9	
USTP-29@2	1,747			
USTP-29@8	18,489	4		
Total Number of Detections of TPH/PAH/VOC by Depth	2 feet	7	5	8
	4 feet	4	9	1
	8 feet	4	14	36

Table 12: Cost Estimate for Excavation and GPT - Upper Site

Description	Unit	Quantity	Rate	Total
Mobilization/demobilization of excavation equipment	LS	1		\$10,000
Mobilization/demobilization of thermal treatment equipment	LS	1		\$15,000
Excavate contaminated soil	yd ³	55,000	\$2.00	\$110,000
Load and haul contaminated soil to treatment area	yd ³	55,000	\$5.00	\$275,000
Thermal treatment of soil	Ton	75,000	\$30	\$2,250,000
Backfill and compaction (wheel-roll)	yd ³	55,000	\$7.00	\$385,000
Analytical fees	LS	1		\$30,000
CEM costs (coordination, supervision and oversight, reporting)	LS	1		\$60,000
Field pilot testing and design of GPT system	LS	1		\$10,000
Installation of groundwater recovery and underground injection wells (estimate 8 to 10 wells, each well installed to a depth of approximately 70 fbs)	Ft	700	\$45	\$31,500
Conveyance piping, pumps and associated appurtenances	LS	1		\$70,000
Granular activated carbon (treatment of extracted groundwater)	LS	1		\$100,000
Permits	LS	1		\$5,000
Operation and maintenance of GPT system	Month	36	\$3,000	\$108,000
Quarterly sampling/reporting of groundwater monitoring, extraction and underground injection wells	Quarter	12	\$3,000	\$36,000
Decommission system, abandon groundwater recovery and underground injection wells	LS	1		\$15,000
TOTAL ESTIMATED COST				\$3,500,500

Table 13: Cost Estimate for *In-situ* Remediation using AS and VE

Description	Unit	Quantity	Rate	Total
Field pilot testing	LS	1		\$3,000
Install AS points (estimate 25 to 30 AS points, each point installed at approximately 75 fbgs)	Ft.	2,100	\$31	\$65,100
Install dual completion AS points/VE wells (estimate 5 to 10 dual completion AS point/VE wells)	Ft.	750	\$50	\$37,500
Survey AS point/VE well locations	LS	1		\$2,000
Remediation system design	LS	1		\$7,500
Installation of conveyance piping for system	LS	1		\$60,000
Equipment/GAC	LS	1		\$50,000
Hook-up equipment, system start-up	LS	1		\$5,000
Electricity to operate equipment	Month	18	\$1,000	\$18,000
Permits	LS	1		\$2,000
Operation, monitoring and maintenance of system	Month	18	\$3,000	\$54,000
Quarterly sampling/reporting of monitoring wells	Quarter	6	\$2,500	\$15,000
Granular activated carbon (changeout)	LS	1		\$25,000
Decommission system/abandon AS points and VE wells	LS	1		\$15,000
TOTAL ESTIMATED COST				\$359,100