Soil Gas Investigation and Human Health Risk Assessment Work Plan for Parcels C, D, F, G, and H

Nevada Environmental Response Trust Site
Henderson, Nevada

Prepared for:
Nevada Environmental Response Trust
Henderson, Nevada

Prepared by:
ENVIRON International Corporation
Emeryville, California

Date:
March 18, 2013

Project Number:
21-32100GA

Soil Gas Investigation and Human Health Risk Assessment Work Plan for Parcels C, D, F, G, and H

Nevada Environmental Response Trust Site
(Former Tronox LLC Site)
Henderson, Nevada

Nevada Environmental Response Trust (NERT) Representative Certification

I certify that this document and all attachments submitted to the Division were prepared at the request of, or under the direction or supervision of the Trust. Based on my own involvement and/or my inquiry of the person or persons who manage the system(s) or those directly responsible for gathering the information or preparing the document, or the immediate supervisor of such person(s), the information submitted and provided herein is, to the best of my knowledge and belief, true, accurate, and complete in all material respects.

Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Signature: Jay A Steinberg, President, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Name: Jay A. Steinberg, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Title: Solely as President and not individually

Company: Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Date: 3/15/13

Soil Gas Investigation and Human Health Risk Assessment Work Plan for Parcels C, D, F, G, and H

Nevada Environmental Response Trust
(Former Tronox LLC Site)
Henderson, Nevada

Responsible Certified Environmental Manager (CEM) for this project

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.

_____________________________	___March 18, 2013______________
John M. Pekala, PG **Senior Manager**	Date

Certified Environmental Manager
ENVIRON International Corporation
CEM Certificate Number: 2347
CEM Expiration Date: September 20, 2014

The following individuals provided input to this document:

John M. Pekala, PG
Allan J. DeLorme, PE
Lynne Haroun, MPH
Christopher J. Ritchie, PE
Christopher M. Stubbs, PhD, PE
Kimberly Souder
Emily Lisker
James Hiller
Ruben So

Contents

List of Tables

List of Figures

List of Appendices

Acronyms

AST	aboveground storage tank
BCL	Basic Comparison Level
BEC	Basic Environmental Company
bgs	below ground surface
BMI	Black Mountain Industrial
CEM	Certified Environmental Manager
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Converse	Converse Consultants
COPC	chemical of potential concern
CSM	conceptual site model
DVSR	Data Validation Summary Report
EC	exposure concentration
ENSR	ENSR Corporation
ENVIRON	ENVIRON International Corporation
EPC	exposure point concentration
ERM-West	ERM-West, Inc.
ESA	Environmental Site Assessment
FOD	frequency of detection
ft	feet
HI	hazard index
HQ	hazard quotient
HRA	Health Risk Assessment[1]
HHRA	Human Health Risk Assessment[1]
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
IWF	Interceptor Well Field

---

[1] The term HRA was used for risk assessments conducted at the Nevada Environmental Response Trust Site prior to its transfer to the Nevada Environmental Response Trust. For the Trust, environmental investigations are being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The term HHRA is consistent with terminology under CERCLA and is adopted for all risk assessments conducted on behalf of the Trust.

LOU	Letter of Understanding
µg/kg	microgram per kilogram
µg/m^3	microgram per cubic meter
µg/L	microgram per liter
m	meters
ml	milliliters
mph	miles per hour
NCEA	National Center for Environmental Assessment
NDEP	Nevada Division of Environmental Protection
NERT	Nevada Environmental Response Trust (the Trust)
Northgate	Northgate Environmental Management, Inc.
NV	Nevada
OSHA	Occupational Safety and Health Administration
OSSM	Olin Chlor-Alkali/Stauffer/Syngenta/Montrose (formerly POSSM)
POSSM	Pioneer/Olin Chlor-Alkali/Stauffer/Syngenta/ Montrose
PPE	personal protection equipment
PPRTV	Provisional Peer Reviewed Toxicity Values
Qal	Quaternary alluvial deposits
QC	quality control
Site	Nevada Environmental Response Trust Site
TCE	trichloroethylene
Tronox	Tronox LLC
Trust	Nevada Environmental Response Trust
UMCf	Upper Muddy Creek Formation
UR	unit risk
USEPA	US Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound

1.0 Introduction

This Soil Gas Investigation and Human Health Risk Assessment (HHRA) Work Plan (the work plan) has been prepared by ENVIRON International Corporation (ENVIRON) on behalf of the Nevada Environmental Response Trust (the Trust) for Parcels C, D, F, G, and H at the Nevada Environmental Response Trust Site (the Site) located in Henderson, Nevada. For purposes of this work plan, Parcels C, D, F, G, and H are collectively referred to as the Study Area.

This work plan presents the HHRA methodology for evaluating the vapor intrusion pathway[2]. The work plan also incorporates the revised *Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H*, dated October 2012 (ENVIRON 2012c) and addresses comments received from the Nevada Division of Environmental Protection (NDEP) on the October 2012 work plan. In the January 29, 2013 comments, NDEP approved the field work described in the October 2012 work plan. The field work was also discussed in a February 21, 2013 teleconference (NDEP 2013c). The approved field work was implemented the week of March 4, 2013.

1.1 Overview

In a letter to the Trust dated August 7, 2012 (NDEP 2012c), NDEP commented on the May 18, 2012, *Revised Closure and Post-Remediation Screening HRA Report for Parcels C, D, F, G, and H*, prepared by Northgate Environmental Management, Inc. (Northgate)[3]. In comment #12, NDEP stated that the soil gas sampling data collected for the *Site-Wide Soil Gas Human Health Risk Assessment* (Northgate 2010d) were not adequate to characterize risk when the parcels were evaluated individually. In addition, based on a review of figures showing the chloroform plume in shallow groundwater, NDEP noted that soil gas samples from the Phase B investigation were collected from locations where results for volatile organic compounds (VOCs) would likely be biased low. Finally, NDEP commented that it may be reasonable to use site-wide soil gas data in conjunction with groundwater data to evaluate potential risks for the vapor intrusion pathway. This work plan has been prepared in response to NDEP comment #12, comments provided in an August 30, 2012 call between ENVIRON and NDEP, and in response to NDEP's January 29, 2013 comments (NDEP 2013b) on the October 2012 *Soil Gas Investigation Work Plan*.

The following elements are included in this work plan:

1. The field sampling and analysis plan, to address the NDEP-identified data gaps in the available soil gas data for the Study Area with the objective of providing additional analytical data for the characterization of potential risk to human health.
2. The risk assessment approach for evaluating potential human health risks for the vapor intrusion pathway.

---

[2] The vapor intrusion pathway (also referred to as the indoor air pathway in this report) refers to the migration of volatile chemicals from contaminated groundwater or soil into an overlying building.

[3] The term HRA was used for risk assessments conducted at the Site prior to its transfer to the Nevada Environmental Response Trust. For the Trust, environmental investigations are being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The term HHRA is consistent with terminology under CERCLA and is adopted for all risk assessments conducted on behalf of the Trust.

3. The approach for characterizing cumulative risk from exposures to both indoor air (through the vapor intrusion pathway) and soil.[4]

Following completion of soil gas sampling and data validation activities, a Data Validation Summary Report (DVSR) will be prepared and submitted to NDEP. The Study Area will be evaluated either as a single exposure unit, using the maximum detected concentrations across all Study Area parcels for analytes identified as chemicals of potential concern (COPCs) in the soil gas HHRA, or as individual parcels, using maximum detected concentrations within each individual parcel. The specific approach will be determined following a review of the results of the additional soil gas sampling. Because potential risks associated with exposures to indoor air are higher than risks associated with inhalation of ambient (outdoor) air, the need to evaluate the outdoor air pathway will be made in consultation with NDEP following review of the risk results for the indoor air pathway.

The proposed HHRA approach is consistent with risk assessment guidance from the US Environmental Protection Agency (USEPA). Additionally, NDEP guidance and NDEP correspondence applicable to risk assessment, as provided at NDEP's Technical Topics web site (http://ndep.nv.gov/bmi/technical.htm) will be followed. Documents that will guide the preparation of the DVSR and HHRA include, but are not limited to, the following:

- *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part A)* (USEPA 1989);
- *Guidance for Data Usability in Risk Assessment (Parts A and B)* (USEPA 1992a,b);
- *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (USEPA 2002a);
- *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA 2004);
- *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline* (Interstate Technology & Regulatory Council 2007);
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)* (USEPA 2009);
- *Statistical Analysis Recommendations for Field Duplicates and Field Splits, BMI Plant Sites and Common Areas Projects, Henderson, Nevada* (NDEP 2008a);
- *Guidance on the Development of Summary Statistic Tables, BMI Plant Sites and Common Area Projects, Henderson, Nevada* (NDEP 2008c);
- *Supplemental Guidance on Data Validation, BMI Plant Sites and Common Areas Projects, Henderson, Nevada* (NDEP 2009);

---

[4] Potential risks associated with soils within the Study Area are currently being evaluated. The current draft of the soil HRA was submitted to NDEP on May 18, 2012 (Northgate 2012) and NDEP provided comments on the draft HRA on August 7, 2012. Responses to NDEP comments and revisions to the draft HRA are in preparation. Results from the final (NDEP-approved) HRA will be combined with the risk results for the vapor intrusion pathway to evaluate cumulative risk.

- *Soil Physical and Chemical Property Measurement and Calculation Guidance, BMI Plant Sites and Common Areas Projects, Henderson, Nevada* (NDEP 2010b);
- *Supplemental Guidance for Assessing Data Usability for Environmental Investigations at the BMI Complex and Common Areas in Henderson, Nevada* (NDEP 2010c);
- *Revised Guidance on Qualifying Data due to Blank Contamination for the BMI Complex and Common Areas, Henderson, Nevada* (NDEP 2012a); *and*
- *Guidance* on *Unified Chemical Electronic Data Deliverable Format, BMI Plant Sites and Common Areas Projects, Henderson, Nevada* (NDEP 2012b).

1.2 Work Plan Organization

The overall format of the work plan follows:

- The remainder of Section 1 presents background information on the Site and Study Area, including a brief summary of the ownership and operational history, physical setting, climate, geology, and hydrogeology of the area;
- Section 2 describes the features and historical uses of the Study Area and summarizes the results of previous soil and groundwater investigations;
- Section 3 presents the field sampling plan, including a description of pre-sampling activities, health and safety requirements, and soil gas sampling locations; analytical methods, equipment decontamination, and management of investigation-derived waste are described;
- Section 4 describes the approach for data evaluation and data analysis;
- Section 5 presents the conceptual site model (CSM) and the HHRA methodology, including (1) identification of COPCs, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization;
- Section 6 provides the schedule for field work and document preparation; and
- Section 7 lists the references cited in this work plan.

1.3 Site Background

The approximately 410-acre Site is located within Sections 1, 12, and 13 of Township 22 S, Range 62 E within the Black Mountain Industrial (BMI) Complex in unincorporated Clark County, Nevada (Figure 1). The area comprising the BMI Complex (including the Site) is surrounded by the City of Henderson. Parcels C, D, F, G, and H (comprising the Study Area) are generally located towards the Site perimeter, to the north, west, and south (Figure 2). Also within the Site boundaries are Parcels A, B, and E[5]. Parcels A and B have generally been investigated on a timeline separate from environmental investigations of the Study Area (see ENVIRON 2012d). Only limited investigations of Parcel E have been conducted due to the continued operation of the Olin (also referred to as the Olin Chlor-Alkali/Stauffer/-Syngenta/Montrose [OSSM]) groundwater treatment system (NDEP 2010a).

---

[5] Former Parcels I and J (and a portion of Parcel B) were sold and are no longer a part of the Site.

Tronox LLC (Tronox) currently leases a portion of the Site from the Trust (Figure 2), on which it operates a chemical manufacturing business. The Site is surrounded by several facilities owned and operated by a number of chemical companies (Figure 3).

The Site has been the subject of extensive environmental investigations since the 1970s. In 1994, NDEP identified 69 Letter of Understanding (LOU) Potential Source Areas (NDEP 1994), and in 2005 identified an additional potential source area (NDEP 2005) that was further evaluated during the Phase B 2008 investigation (NDEP 2011). These areas are referred to in this and other reports as LOUs. LOUs within the Study Area are identified in Section 2.

1.4 Climate

The climate of Las Vegas Valley is arid, consisting of mild winters and dry, hot summers. Average annual precipitation as measured in Las Vegas from 1971 to 2000 was 4.49 inches. Precipitation generally occurs during two periods, December through March and July through September. Winter storms generally produce low intensity rainfall over a large area. Summer storms generally produce high intensity rainfall over a smaller area for a short duration. The violent summer thunderstorms account for most of the documented floods in Las Vegas area. Winds frequently blow from the south or northwest at a mean velocity of approximately 9 miles per hour (mph); however, velocities in excess of 50 mph are not atypical when weather fronts move through the area. During these windy events, dust, sand, and soil at the ground surface can become airborne and may travel several miles. Temperatures can rise to 120°F in the summer, and the average relative humidity is approximately 20%. The mean annual evaporation rate from lake and reservoir surfaces ranges from 60 to 82 inches per year (summarized from Kleinfelder [1993]).

1.5 Geologic and Hydrogeological Setting

The Site is located within Las Vegas Valley, which occupies a topographic and structural basin trending northwest-southeast and extending approximately 55 miles from near Indian Springs on the north to Railroad Pass on the south. The valley is bounded by the Las Vegas Range, Sheep Range, and Desert Range to the north, by Frenchman and Sunrise Mountains to the east, by the McCullough Range and River Mountains to the south and southeast, and the Spring Mountains to the west. The mountain ranges bounding the east, north, and west sides of the valley consist primarily of Paleozoic and Mesozoic sedimentary rocks (limestones, sandstones, siltstones, and fanglomerates), whereas the mountains on the south and southeast consist primarily of Tertiary volcanic rocks (basalts, rhyolites, andesites, and related rocks) that overlie Precambrian metamorphic and granitic rocks (ENSR Corporation [ENSR] 2007). The Study Area is located on Quaternary alluvial deposits (Qal) that slope north toward Las Vegas Wash. The thickness of the alluvial deposits ranges from less than 1 foot (ft) to more than 50 ft beneath the Site. Soil types identified in on-site soil borings include poorly sorted gravel, silty gravel, poorly sorted sand, well sorted sand, and silty sand (ENSR 2005). The Upper Muddy Creek Formation (UMCf) of Pleistocene age occurs in Las Vegas Valley as valley-fill deposits that are coarse-grained near mountain fronts and become progressively finer-grained toward the center of the valley. Where encountered beneath the Site, the UMCf is composed of at least two thicker units of fine-grained sediments of clay and silt (the first and second fine-grained facies, respectively) interbedded with at least two thinner units of coarse-grained sediments of sand, silt, and gravel (the first and second coarse-grained facies, respectively) (ENSR 2005).

Depth to groundwater ranges from about 27 to 80 feet below ground surface (bgs) and is generally deepest in the southernmost portion of the Site (where Parcel H is located), becoming shallower as it approaches the Las Vegas Wash to the north. The groundwater flow direction at the Site is generally north to north-northwesterly, whereas north of the Site, the direction changes slightly to the north-northeast (ENSR 2005).

A major feature of the alluvial deposits is the stream-deposited sands and gravels that were laid down within paleochannels that were eroded into the surface of the UMCf during infrequent flood runoff periods. These deposits are thickest within the paleochannel boundaries, which are narrow and linear and trend northeastward. The paleochannels (shown on Figure 4) act as preferential pathways for groundwater flow, which may significantly influence the chemical distribution in the alluvium (ENSR 2005). Additional details on the regional and local geology and hydrogeology, including information on the water-bearing zones, are provided in the *Remedial Investigation and Feasibility Study Work Plan* (ENVIRON 2012d) submitted to NDEP on December 17, 2012.

An on-site Interceptor Well Field (IWF) and groundwater barrier wall are shown on Figure 2. The groundwater barrier wall was constructed in 2001 as a physical barrier across the higher concentration portion of an existing perchlorate/chromium plume. The IWF captures the highest concentrations of the groundwater plume located downgradient of on-site source areas. The interceptor wells and barrier wall have significantly decreased chemical concentrations in the alluvium downgradient of the IWF.

2.0 Study Area Description, Historical Uses, and Previous Investigations

This section describes features and historical uses of the Study Area. In addition, results from previous soil and groundwater investigations for VOCs are summarized to support source-area identification for the vapor intrusion pathway CSM. Specifically, as described in Section 2.6, available information and investigation results suggest that groundwater is the primary source of VOCs in soil gas beneath the Study Area.

The following listing identifies Phase I Environmental Site Assessments (ESAs) and soil investigations completed for the Study Area.

- Phase 1 ESAs: In March 2007, Converse Consultants (Converse) completed a Phase 1 ESA that included the areas occupied by Parcels C, D, F, and H (Converse 2007) and a May 21, 2007 addendum to the Phase 1 ESA that included the area occupied by Parcel G (as reported by Tronox [2007]). As part of the Phase 1 ESA, Converse conducted a site visit and reviewed historical aerial photographs dating from 1950 through 2006. In addition, an earlier Phase 1 was completed in 2005 by Tetra Tech EM Inc. for Parcel F (as reported by Converse [2007]).

- Phase 2 soil investigations: Phase 2 soil sampling plans were prepared for Parcels C and D (Basic Environmental Company [BEC] 2007a), Parcel F (BEC 2007b), Parcel G (BEC 2007c), and Parcel H (BEC 2007d,e) to identify and characterize the distribution of Site-related chemicals based on the findings of the Phase A Investigation (ENSR 2007) in the vicinity of future land-use features (e.g., warehouses, commercial office buildings) and historical site features (e.g., identified for further investigation based on information presented in the Phase 1 ESAs). At most locations, samples were collected at both the ground surface and approximately 10 ft bgs and analyzed for 82 VOCs by USEPA Method SW8260B. At some locations, samples were collected at approximately 5 ft bgs instead of 10 ft bgs.

- Phase 2 supplemental soil investigation: Based on the results of the Phase 2 soil investigations, a supplemental soil investigation was conducted in 2008 to address potential data gaps and to define the aerial extent of detected compounds (BEC 2008a). At most locations, samples were collected at the ground surface and approximately 10, 20, 30, and 40 ft bgs and analyzed for 82 VOCs by USEPA Method SW8260B.

NDEP reviewed and approved the soil sampling work plans identified above (approval dates are provided in Section 7, References) and the resulting DVSRs (ERM-West, Inc [ERM-West] 2008a,b; 2009). It is noted that VOC soil contamination was not the subject of any of the interim soil removals completed within the Study Area following the investigations described above. Specifically, the removals addressed contaminants exceeding remediation goals, i.e., primarily asbestos contamination, as well as elevated levels of dioxins/furans at one location in Parcel C and elevated levels of benzo(a)pyrene at one location in Parcel G (BEC 2008b). Confirmation sampling results indicated that all detected analytes or analyte groups (i.e., asbestos, dioxins, SVOCs, PCBs, and arsenic) were below their respective NDEP Basic Comparison Levels (BCLs) and met the NDEP target goals for asbestos (Northgate 2012).

LOUs within and upgradient of the Study Area parcels are listed in Table 1. As shown, NDEP has not specifically identified VOCs as potential contaminants for most LOUs within or immediately upgradient of the Study Area (NDEP 2011). However, it is noted that the initial identification of potential LOU contaminants was based on a review of historical operations and the limited sampling data available at the time of the LOU designations in 1994 (NDEP 1994). Given that the Study Area parcels are situated within the NERT property, as well as in the vicinity of other BMI companies, it is possible that environmental media within one or more of the parcels could have been indirectly impacted. Further, operational histories that included former use of VOCs do not necessarily mean that environmental media has been impacted. While information on operational history was used to inform the soil sampling plans developed for the Study Area, the soil sampling results provide confirmatory evidence for the presence or absence of contamination.

Chloroform concentrations in shallow groundwater wells sampled within or near the Study Area are provided in Table 2. As shown, 17 shallow wells[6] within the Study Area were identified with VOC results (3 in Parcel C, 7 in Parcel D, 3 in Parcel F, 1 in Parcel G, and 3 in Parcel H). Well locations are shown on Figure 4. Chloroform results were selected for presentation as chloroform has been detected at the highest frequencies and concentrations in groundwater and previously collected soil gas samples.

2.1 Parcel C

Parcel C is a 20.4-acre parcel located directly north and adjacent to the former Trade Effluent Settling Ponds (LOU 1). The parcel is entirely vacant land. The Phase 1 ESA reported that sometime prior to 1950, multiple ditches (lined with French drains) oriented north-south were installed across Parcel C, perpendicular to and leading from a main French drain that traversed east-west along the northern berm of the former Trade Effluent Ponds (LOU 1), which were located immediately to the south of Parcel C. The drains were constructed because infiltration from the former, unlined Trade Effluent Ponds resurfaced in Parcel C (Converse 2007). At some point, these ditches were disturbed and possibly graded over (Northgate 2012). Stained soil and gravel and a number of debris piles (reportedly not associated with industrial waste or disposal) were identified based on the review of historical aerial photographs (Converse 2007). No LOUs are located within Parcel C; however, a number of LOUs, including LOUs 1, 2,10, 22, 23, 32, 55, and 58, are located upgradient of Parcel C (Figure 4).

Fifteen soil samples were collected in Parcel C at the surface and at a depth of 10 ft bgs during the Phase 2 soil investigation. With the exception of acetone, a common laboratory contaminant, the following VOCs were detected at low concentrations: chloroform; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; ethylbenzene; isopropylbenzene; methyl ethyl ketone; n-propyl benzene; tetrachloroethylene; toluene; 1,2,3-trichlorobenzene; 1,2,4-trichlorobenzene; 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene; and xylenes. During

---

[6] Shallow groundwater is defined by NDEP as groundwater at depths of up to 90 ft bgs.

the Phase 2 supplemental soil investigation, acetone and methyl ethyl ketone were detected in the single surface sample collected in Parcel C; VOCs were not detected in the 10 ft bgs sample from this same location (ERM-West 2009).

2.2 Parcel D

Parcel D is a 24.6-acre parcel located directly north of Parcel C. The entire parcel is vacant land, although the Phase 1 ESA reported that a number of debris piles (reportedly not associated with industrial waste or disposal) were present. A small debris pile from a homeless encampment near Warm Springs Road on the western portion of Parcel D was noted during a site visit conducted by ENVIRON on March 8, 2013. ENVIRON is in the planning process of removing the debris pile. Southern Nevada Auto Parts (a former Kerr-McGee tenant) operated an auto impound yard where wrecked, police-impounded, and repossessed vehicles were stored. NDEP identified this area as LOU 68. The southern portion of the lease area appeared to have minor soil staining (Kleinfelder 1993). The ditches (French drains) described above for Parcel C extended into and terminated in the eastern two-thirds of Parcel D (Northgate 2012). LOU 6 (the Unnamed Drainage Ditch Segment, also referred to as the Northwest Ditch) extends across Parcel D. The Northwest Ditch, which originated near the Beta Ditch (LOU 5) and crossed the northern portion of the Site (Kleinfelder 1993), conveyed process waste streams from the BMI Complex facilities to the BMI Common Area and was identified under the Phases I and II BMI Common Area Consent Agreement as a BMI Common Areas issue (ENSR 2005; Broadbent & Associates, Inc. 2011).

Seven samples were collected in Parcel D at the surface and at a depth of 10 ft bgs during the Phase 2 soil investigation. Two VOCs (acetone and 1,3-dichlorobenzene) were detected in the same sample at 10 ft bgs, and seven VOCs (acetone; ethylbenzene; n-propyl benzene; toluene; 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene;,and xylenes) were detected in three surface samples. Of note, VOCs were not detected in samples collected in the Northwest Ditch (LOU 6) (ERM-West 2008a). No additional samples for VOC analysis were collected in Parcel D during the 2008 Phase 2 supplemental soil investigation (ERM-West 2009).

2.3 Parcel F

Parcel F is a 7.2-acre parcel on the western boundary of the Site. Most of the parcel is vacant land, although portions of a building foundation are located within the parcel. In October 2005, Tetra Tech EM Inc. completed a Phase I ESA for Parcel F (as reported by Converse [2007] and Northgate [2012]) that identified an empty steel tank, three 55-gallon drums (no longer present on March 8, 2013), soil and gravel staining, a subsurface storm sewer system (LOU 59), and a painted surface on the interior of a building. The Phase 1 ESA review of historical aerial photographs identified a building present on Parcel F in 1950 that was no longer visible in 2006 (Converse 2007).

LOUs 63, 65c, and a portion of LOU 59 are located in Parcel F. Parcel F was leased from 1980 to 1986 by W.S. Hatch Company, a trucking operation. The area within Parcel F that now comprises LOU 63 was leased by J.B. Kelley (also a trucking operation) from 1986 through at least 1993 (Kleinfelder 1993). The company hauled commodities such as lime and soda ash. The specific areas of interest within LOU 63 included a 10,000-gallon fiberglass diesel underground storage tank (UST), a ceramic-lined 600-gallon waste-oil UST, and a truck washing area with eight open concrete vaults that served as foundations for peat storage buildings during World War II. Rinsate from truck washing was reportedly discharged to the former vault floors, metal containment tanks, a storm sewer, and/or the ground surface. Chemicals identified as being in the rinsate included lime, soda ash, barite, and magnesium chloride brine. VOCs were not specifically identified as being present in the rinsate. On-site wash activities ceased in 1991. Additional fluids from truck maintenance activities, such as oil changes, were reportedly discharged to the storm sewer, which conveyed the wash water and other fluids northward to the Beta Ditch (Kleinfelder 1993). Field investigations of the diesel waste-oil USTs were conducted, and both tanks, which were found to have leaked, were removed in 1991. Contaminated soil in the tank pits was reportedly excavated at the time of the tank removal (Kleinfelder 1993).

The area identified as LOU 65c was formerly occupied by Nevada Pre-Cast Concrete, which used office space near the J.B. Kelley Site operations from January 1973 to May 1978. As reported by Kleinfelder (1993), Nevada Pre-Cast Concrete used the area only for offices. No waste streams or chemical uses were reported for LOU 65c.

Segments of LOU 59 (the Storm Sewer System) are located in Parcel F. NDEP has not specifically identified VOC contamination as an issue of concern for this LOU (NDEP 2011).

LOUs 4, 25, 26, 27, 28, 41, 60, 65a, 65c, and 65d are upgradient of Parcel F. Historically, VOC use was associated with six of these LOUs (LOUs 4, 28, 41, 65a, 65c, and 65d), while VOC use was not reported for the remaining LOUs (LOUs 25, 26, 27, and 60) (NDEP 2011). In addition, several empty aboveground storage tanks (ASTs) are located upgradient of Parcel F that historically stored sodium chlorate; however, there is no reported history of the tanks leaking. Although the ASTs are at a higher elevation than that of Parcel F, the ASTs are within a bermed and lined containment area designed to hold 110 percent of the contents of the largest tank.

Fifteen soil samples were collected in Parcel F at the surface and at a depth of 10 ft bgs during the 2007 Phase 2 investigation. Of the seven sample locations in LOU 63 (J.B. Kelley Trucking Inc.), acetone was detected at low levels at one sample location at depths of 0 and 10 ft bgs, and methyl ethyl ketone, methyl n-butyl ketone, and 1,2,4-trimethylbenzene were detected at low levels in one surface sample. VOCs were not detected in the one sample location in LOU 65c (Nevada Precast Concrete Products). With the exception of common laboratory contaminants (acetone, methylene chloride, and methyl ethyl ketone), ethylbenzene, 1-nonanal, n-propyl benzene, toluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and xylenes were detected at low levels in six other samples in Parcel F, outside of the LOUs (ERM-West 2008a). During the 2008 Phase 2 supplemental investigation, only two VOCs (carbon tetrachloride and chloroform) were detected at 20 and 30 feet bgs, and three VOCs (acetone, methylene chloride, and 1,2,4-trimethylbenzene) were detected at the surface at all three sample locations. All VOCs were detected at low concentrations, except for chloroform which was detected at concentrations of 200 µg/kg, 300 µg/kg, and 410 µg/kg at one location. Samples were collected at two of the same sample locations in LOU 63 during the Phase 2 supplemental investigation as in the Phase 2 investigation; acetone, chloroform, and methylene chloride were detected at low concentrations in two samples (ERM-West 2009). No samples were collected in LOU 65c (ERM-West 2009).

2.4 Parcel G

Parcel G is a 2.8-acre parcel on the western side of the Site. The parcel is comprised primarily of vacant land, although a building is located on the northern portion of the parcel, and a utility vault, portions of a rail line, and several drain inlets are also present. The Phase 1 ESA identified staining and some debris, indicating the presence of stormwater evaporative residue as reported by BEC (2007c).

LOUs 59, 60, and 65d are located within Parcel G. Segments of LOUs 59 (the Storm Sewer System) and 60 (the Acid Drain System) are located in the parcel. No waste streams or chemical uses have been identified for LOU 65d. Green Ventures International (LOU 65d) leased a building ("S3 Changehouse") from August 1980 to September 1981 for use as a marketing office by a green farming operation. Only office activities were conducted by Green Ventures International (Kleinfelder 1993). NDEP has not specifically identified VOC contamination as an issue of concern for LOUs 59 and 60, while NDEP identified VOCs as potential contaminants for LOU 65d based on historical operations and limited sampling data (NDEP 2011). Further, no LOUs are located immediately upgradient of Parcel G.

Five soil samples were collected at the surface and a depth of 5 ft bgs in Parcel G during the Phase 2 soil investigation. Acetone, methyl ethyl ketone, toluene, and 1,2,4-trimethylbenzene were detected at low levels in 11 samples at all five sample locations. During the 2008 Phase 2 supplemental investigation, soil samples were collected at the surface and at approximately 10, 20, 30, and 40 ft bgs. Of the 82 VOCs analyzed, three VOCs (carbon tetrachloride, chloroform, and trichloroethylene [TCE]) were detected at a depth of 40 feet bgs, and acetone and methylene chloride were detected at low levels at the surface. Chloroform was detected in two samples at two locations at concentrations of 1.5 µg/kg and 110 µg/kg. In the same location of the high chloroform detection, carbon tetrachloride and TCE were also detected. These samples were collected from sample locations within 50 ft to the east and west of LOU 65d (Nevada Precast Concrete Products) (ERM-West 2009).

2.5 Parcel H

Parcel H is a 26-acre parcel in the southern portion of the Site. The parcel is comprised primarily of vacant land that is crossed by dirt roads and drainage channels (Converse 2007). BEC (2007e) and Converse (2007) reported that a pad-mounted transformer (no longer present on March 8, 2013), three debris piles (two of which were no longer present on March 8, 2013), and an abandoned water supply line that served the landscaping area along Lake Mead Parkway are also located within the parcel. BEC (2007e) reported that based on the age of the transformer, it is unlikely that the transformer contained PCBs. (The age of the transformer was not provided by BEC [2007e].) No LOUs were identified within Parcel H.

Nineteen samples were collected at the surface and at a depth of 10 ft bgs in Parcel H during the Phase 2 soil investigation. Acetone, acetonitrile, dichloromethane, toluene, and 1,2,4-trimethylbenzene were detected at low levels in 28 samples at 12 sample locations. Soil samples from Parcel H were not analyzed for VOCs during the Phase 2 supplemental investigation (ERM-West 2009).

2.6 Study Area CSM: Discussion of the Source of VOCs in Soil Gas

Available information and investigation results indicate that the apparent source of VOCs in soil gas beneath the Study Area is groundwater that was historically impacted by on-site and/or off-site releases of VOCs. While VOCs were detected in soil during the Phase 2 investigations described in Sections 2.1 through 2.5, with the exception of common laboratory contaminants (i.e., acetone, methylene chloride, and methyl n-butyl ketone), VOCs were detected at concentrations of less than approximately 25 µg/kg in the surface and 10 ft bgs samples. Similarly, during the Phase 2 supplemental investigation, VOCs (other than chloroform and common laboratory contaminants) were detected at concentrations of less than approximately 5 µg/kg at all depths sampled. At one location in Parcel F, chloroform was detected at relatively high concentrations (i.e., between 200 and 410 µg/kg) at depths of 20 and 30 ft bgs; however, chloroform was not detected in the surface and 10 ft bgs samples from the same location. Chloroform was also detected at a relatively high concentration of 110 µg/kg in another sample at 40 ft bgs in Parcel G, but was not detected in the 0, 10, 20, or 30 ft bgs samples from the same location. These results are consistent with groundwater as the source of chloroform (and other VOCs) in soil gas samples. In reviewing soil, soil gas, and groundwater data for Parcels A and B, Northgate (2010c) also concluded that the apparent source of chloroform and other VOCs detected in soil gas was impacted groundwater migrating beneath Parcels A and B from the south and west (i.e., upgradient from the parcels).

As discussed in the *Remedial Investigation and Feasibility Study Work Plan* (ENVIRON 2012d), the Olin property to the west of the Site (Figure 3) occupies the location of the former BMI Complex chloralkali production facility. In 1947, manufacturing facilities were constructed to produce pesticides and chlorinated organic compounds. Over time, extensive volumes of process effluents and solid wastes were disposed of in unlined ponds and buried on the Olin property. These wastes contained high levels of TDS, chlorinated VOCs, and extensive amounts of phosphoric acid. Prior to 1976, certain process effluents were routed to the Upper and Lower BMI Ponds. Due to the direction of groundwater flow in the region (generally north to northeasterly), a groundwater contaminant plume has migrated onto the Site from the Olin property. Contaminants include VOCs, NAPL, and pesticides. The responsible parties for this plume are currently operating a groundwater treatment system and performing groundwater monitoring under NDEP oversight (ENVIRON 2011b).

Further characterization of the VOCs in groundwater and evaluation of potential on-site and off-site sources of groundwater impacts was in the *Remedial Investigation and Feasibility Study Work Plan* (ENVIRON 2012d).

3.0 Field Sampling Plan

This section identifies pre-sampling activities and the proposed locations and analytical suite for proposed soil gas samples. As described in Section 1.0, the field sampling plan was approved on January 29, 2013 (NDEP 2013b) and further discussed during the February 21, 2013 teleconference (NDEP 2013c). This section is included in the work plan for completeness and to address NDEP's comments in the January 29, 2013 comment letter (NDEP 2013b).

3.1 Pre-Sampling Activities

Prior to initiating the field work, a health and safety plan will be prepared and utility locating, drilling, and analytical laboratory subcontractors will be retained. Sample locations will be cleared by an independent utility locator under the supervision of an ENVIRON engineer or geologist and notification will be made to Underground Service Alert at least three business days prior to starting drilling activities.

3.2 Health and Safety

All personnel performing work at the Site with the potential for exposure to hazardous substances or health hazards are required to be 40-hour Occupational Safety Health Administration (OSHA) trained in accordance with Code of Federal Regulations (CFR) 1910.120 and will meet the personnel training requirements in accordance with 29 CFR 1910.120(e). It is required that Level D personal protection equipment (PPE) be worn by all personnel working at the Site. It is not anticipated that an upgrade to Level C or higher PPE will be necessary, however, all on-site ENVIRON personnel and drillers working at the Site will be trained in the use and limitations of, and be qualitatively fit tested, for half-face respirators in accordance with 29 CFR 1910.134. Prior to conducting sampling activities, a health and safety meeting will be directed by an ENVIRON representative and attended by the sampling team.

3.3 Sampling Locations

A total of 9 soil gas samples will be collected from a depth of 5 ft bgs in the Study Area (2 in Parcel C, 2 in Parcel D, 3 in Parcel F, 2 in Parcel G, and none in Parcel H), as listed in Table 3 and shown on Figure 4. Figure 4 also shows the locations of shallow groundwater wells sampled for VOCs; the wells were identified using NDEP's regional database[7], the Phase A Investigation (ENSR 2007), and the Phase B Groundwater Investigation (Northgate 2010a), as well as soil gas locations within and near the Study Area that were sampled as part of the 2008 soil gas investigation (ENSR 2008). Additionally, Figure 4 shows the concentrations of chloroform in shallow groundwater based on results from the Phase A and B Groundwater Investigations and data obtained from NDEP's regional database. The chloroform plume map was developed by Northgate, as presented in Northgate 2010d. The ENSR (2008) soil gas sampling locations and shallow groundwater wells sampled for VOCs shown on Figure 4 will be evaluated for use in the HHRA. Following the data usability evaluation discussed in Section 4.0, the specific soil gas and shallow groundwater data suitable for use in the HHRA will be selected. Therefore, not all of the soil gas sampling locations and shallow groundwater wells located

---

[7] The NDEP regional database is available at: http://ndep.neptuneinc.org/ndep_gisdt/home/index.xml.

nearby the Study Area (and displayed on Figure 4 and Table 2) are specifically mentioned in Sections 3.3.1 through 3.3.5 below.

The following factors were considered in identifying the proposed sampling locations: (1) chloroform concentrations in shallow groundwater beneath and upgradient of the Study Area parcels, (2) direction of groundwater flow, (3) LOUs at which VOCs may have been used, and (4) VOC results for soil samples collected within the Study Area parcels. The locations of paleochannels, the Olin extraction well field, and the IWF (shown on Figure 2) were also considered. Additionally, several proposed soil gas samples were located near groundwater wells analyzed for VOCs during the Phase B investigation. The purpose of locating proposed soil gas samples near groundwater monitoring wells is to investigate the correlation between soil gas and underlying groundwater concentrations, as recommended by NDEP (NDEP 2012c, 2013b).

The following sections discuss the existing and proposed soil gas sampling locations and identify existing shallow groundwater wells within the Study Area parcels. In NDEP's comment letter on the October 2012 work plan (NDEP 2013b), NDEP approved the soil gas sampling locations. One sampling location, E-SG-8, was moved slightly north to correspond with the revised boundary of Parcel G. This new sampling location is still in a location of higher predicted chloroform concentrations in shallow groundwater and is closer to a shallow groundwater well as discussed further in Section 3.3.4.

3.3.1 Parcel C

Five soil gas samples (SG18, SG19, SG24, SG90, and SG91) were collected within or on the border of Parcel C as part of the 2008 sampling (ENSR 2008) and eight shallow groundwater samples (AA-BW-04A, H-28, M-6A, M-7B, M-98, M-99, M-100, and MC-3) from wells within or on the border of Parcel C were analyzed for VOCs as part of the Phase B sampling (Northgate 2010a). Additional soil gas samples and groundwater samples were collected near Parcel C and will be used to provide additional information about chemical distributions in the vicinity of Parcel C and will be considered for use in the HHRA (Tables 2 and 3).

Two additional samples (E-SG-2 and E-SG-3) will be collected within Parcel C and two additional samples (E-SG-1 and E-SG-9, as discussed below) will be collected in Parcel D near the border of Parcel C (Figure 4). Sample E-SG-2 is in an area of elevated benzene concentrations in shallow groundwater, near groundwater well MC-3, and near the paleochannel extending from the chloroform and benzene groundwater plumes into Parcel C. E-SG-3 is in a region of elevated chloroform concentrations in shallow groundwater and near groundwater well AA-BW-04A. With these additional samples, there will be thirteen paired soil gas and groundwater samples in and near Parcels C and D, one sample located near paleochannels, and two samples collected near predicted maximum concentrations of chloroform and benzene as measured and interpolated in shallow groundwater.

3.3.2 Parcel D

Two soil gas samples (SG16 and SG18) were collected within or on the border of Parcel D as part of the 2008 sampling (ENSR 2008) and seven shallow groundwater samples (M-23, MC-09R, MC-45, MC-53, MC-94, MC-MW-29, MC-MW-32) were collected within Parcel D as part of the Phase B sampling (Northgate 2010a) near the neighboring Olin property. Additional soil gas samples and groundwater samples collected near Parcel D will be used to provide additional information about chemical distributions in the vicinity of Parcel D and will be considered for use in the HHRA (Tables 2 and 3).

Two additional samples (E-SG-1 and E-SG-9) are proposed for Parcel D. Sample E-SG-1 will be collected in Parcel D, near the border of Parcel C; this additional sample can be used to better characterize contaminant distributions along the southern portion of Parcel D and the northern portion of Parcel C. For both Parcels, this location is in a region without nearby soil gas samples. Sample E-SG-9 is located at the southern edge of LOU 68, Southern Nevada Auto Parts Site (formerly Pick-A-Part), and near LOU 6, the Unnamed Drainage Ditch Segment, which crosses Parcel D. The remaining area of Parcel D has adequate soil gas sampling either within the Parcel, or nearby and upgradient of the Parcel. With these additional samples, there will be thirteen paired soil gas and groundwater samples in and near Parcels C and D, and one proposed sample collected near the maximum interpolated concentration of chloroform in shallow groundwater.

3.3.3 Parcel F

One soil gas sample (SG34) was collected in Parcel F in 2008 (ENSR 2008) and three shallow groundwater samples (TR-6, M-92, MC-MW-17) were collected as part of the Phase B sampling (Northgate 2010a) or on the neighboring Olin property. Additional soil gas samples and groundwater samples collected near Parcel F will be used to provide additional information about chemical distributions in the vicinity of Parcel F and will be considered for use in the HHRA (Tables 2 and 3).

Three additional samples (E-SG-4, E-SG-5, and E-SG-6) will be collected within Parcel F, as shown on Figure 4. Samples E-SG-4 and E-SG-6 are in the western portion of the site, near higher predicted chloroform concentrations in shallow groundwater; the two samples should adequately characterize the southwestern and the northwestern portions of Parcel F. Sample E-SG-5 will be collected to better characterize the northern portion of Parcel F as sampling north of Parcel F indicates there may be rapid changes in chloroform concentrations over relatively small distances in this region. With these additional samples, there will be five paired soil gas and groundwater samples in and near Parcel F, and two samples collected near predicted maximum concentrations of chloroform as interpolated in shallow groundwater.

3.3.4 Parcel G

No soil gas samples were collected in Parcel G as part of the 2008 sampling (ENSR 2008). One soil gas sample (SG45) was collected in the former southern portion of Parcel G that is no longer considered part of the Study Area. One shallow groundwater sample (TR-8)[8] was collected as part of the Phase B sampling (Northgate 2010a). Additional soil gas samples and groundwater samples collected near Parcel G will be used to provide additional information

---

[8] This well was not included in the previously submitted October 2012 *Draft Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H* (ENVIRON 2012c).

about chemical distributions in the vicinity of Parcel G and will be considered for use in the HHRA (Tables 2 and 3).

Two additional samples (E-SG-7 and E-SG-8) will be collected inside Parcel G, as shown on Figure 4. E-SG-7 and E-SG-8 were selected to be in the western portion of Parcel G, near higher predicted chloroform concentrations in shallow groundwater. The two samples are required to adequately characterize both the southwestern and the northwestern portions of Parcel G. Parcel G is relatively small, and its eastern portion is well characterized by soil gas samples in or near Parcel G. With these additional samples, there will be one paired soil gas and groundwater sample and two samples collected near predicted maximum concentrations of chloroform as interpolated in shallow groundwater.

3.3.5 Parcel H

Two soil gas samples (SG49 and SG50) were collected in Parcel H as part of the 2008 sampling (ENSR 2008), and four shallow groundwater samples (M-103, M-120, M-121, and TR-10) were collected within or on the border of Parcel H as part of the Phase B sampling (Northgate 2010a). Additional soil gas samples and groundwater samples collected near Parcel H will be used to provide additional information about chemical distributions in the vicinity of Parcel H and will be considered for use in the HHRA (Tables 2 and 3). Parcel H appears to be upgradient of potential chemical plumes and is characterized by soil gas samples on its southwestern, northern, and eastern portions. Additionally, there are three paired soil gas and groundwater samples in and near Parcel H. As such, adequate soil gas and groundwater samples exist to characterize the contaminant distribution in Parcel H, and no additional samples are recommended.

3.4 Sampling Methodology

Nine soil gas samples (E-SG-1 through E-SG-9) will be collected at the locations shown on Figure 4. Based on utility clearing, access limitations, and other field observations, the actual soil gas sample locations and depths may deviate from those proposed herein. In general, the planned depth for the temporary probes is five feet bgs.

To install the soil gas probes, borings will be advanced using direct-push tooling consisting of 2.25-inch outer diameter Macrocore MC5 sampler with new PVC sleeves. All borings will be continuously cored to avoid compressing the surrounding formation. The soil cores will be collected in PVC sleeves to observe the soil conditions and adjust the soil gas probe depth as necessary.

Each temporary soil gas probe will be constructed by placing a new half-inch sintered stainless steel filter at the target depth of five feet. New 0.25-inch outside diameter (0.187-inch inside diameter) Teflon® tubing will be attached to the filter, and will extend in one piece to above the ground surface. The filter will be emplaced within approximately one foot of a sand pack comprised of clean, kiln-dried Monterrey 30-mesh sand. Approximately two inches of dry granular bentonite will be emplaced on top of the sand pack to ensure that the sand pack will not be plugged when the remaining borehole is sealed with hydrated granular bentonite. The tubing will be labeled at the surface for the location and depth. A gas-tight Swagelok® fitting will cap the sampling tube and allow the direct attachment of the sampling train.

Soil gas probes installed using direct-push tooling will be allowed to equilibrate a minimum of 30 minutes before sampling. Soil gas probes installed using hand auger methods will be allowed to equilibrate a minimum of 48 hours. Equilibration times are measured from the time the probe is sealed, including the annular seal as well as the tubing cap, to when the purging and sampling begins. Following equilibration, a laboratory-supplied 1-liter Summa™ canister will be attached to the tubing via quarter-inch Swagelok fittings. A laboratory-supplied critical orifice flow controller (calibrated to 100-200 milliliters per minute [ml/min]) with integral particulate filter will be installed immediately upstream of the Summa™ canister. The sample connections will then be tested using a shut-in test to confirm the integrity of the sample connections.

Once connections are checked, soil gas will be withdrawn from the Teflon® tubing using an evacuated purge Summa™ canister connected via a shut-off valve. The first three dead volumes of soil gas will be discarded to purge the sample tubing, sand pack, and void space of the dry bentonite in the annular space. To calculate the void space of the sand pack and dry bentonite, a porosity of 30% will be assumed.

After purging, the soil gas sample will be collected in a 1-liter Summa™ canister while monitoring the fill time and the in-line vacuum gauge. The sample fill time and initial and final vacuums will be recorded in the field notes. Following sampling, or at a later date, the tubing will be pulled from the ground and the surface patched to match surroundings. During sampling, a tracer gas atmosphere will be generated, maintained, and monitored around the top of the soil vapor probe where the tubing exits the ground and around sample connections. As discussed in the February 21, 2013 teleconference with NDEP (NDEP 2013c), ENVIRON will use helium as a tracer gas for this scope of work as it has significant advantages over liquid tracers, but other leak check options, such as liquid tracers, will be on standby if problems are encountered with using helium.

ENVIRON will be present during drilling to maintain a log of the borings, make observations of the work area conditions, conduct health and safety monitoring of possible organic vapors encountered during drilling, screen and log soil cores, direct the installation of the soil probes, perform leak testing, and collect and maintain custody of soil gas and field quality control (QC) samples. Field QC samples for this investigation will consist of one duplicate soil gas sample and one trip blank sample per sample shipment. Duplicate samples will be collected at a rate of 5% (one duplicate for every 20 primary samples) and will be collected at the same time as primary samples using a T-fitting. Replicate sampling is not planned.

3.5 Sample Handling and Chain-of-Custody

Each lot of sampling containers will be certified as contaminant-free by the laboratory. Samples will be collected, handled, and stored in such a manner that they are representative of their original condition and chemical composition. For soil gas samples collected in Summa™ canisters, this generally means that the containers are free of leaks before, during, and after sampling. The occurrence of leaks will be mitigated through the use of proper tools and tightening canister fittings according to manufacture specifications. Leaks will be identified through the use of vacuum checks before and after sampling as well as before and after transport to the laboratory.

Identification of samples and maintenance of custody are important elements that will be utilized to ensure samples characterize site conditions. All samples will be properly identified and maintained under chain-of-custody protocol to protect sample integrity. Sample chain-of-custody procedures will be used to maintain and document sample integrity during collection, transportation, storage, and analysis. A sample is considered to be under the control of, and in the custody of, the responsible person if the samples are in their physical possession, locked or sealed in a tamper-proof container, or stored in a secure area.

The chain-of-custody form provides an accurate written record that traces the possession of individual samples from the time of collection in the field until they are accepted at the analytical laboratory. The chain-of-custody form also documents the samples collected and the analyses requested. The field sampler will sign the chain-of-custody form and will record the time and date at the time of transfer to the laboratory or an intermediate person. A set of signatures is required for each relinquished/received transfer, including internal transfer. The original imprint of the chain-of-custody will accompany the sample containers and a duplicate copy will be kept in the project file.

If the samples are to be shipped to the laboratory, the original chain-of-custody relinquishing the samples will be sealed inside a plastic bag within the shipping box and the box will be sealed with custody tape that has been signed and dated by the last person listed on the chain-of-custody. US Department of Transportation shipping requirements will be followed and the sample shipping receipt will be retained in the project files as part of the permanent chain-of-custody document. The shipping company (e.g., Federal Express, UPS) will not sign the chain-of-custody forms as a receiver; instead the laboratory will sign as a receiver when the samples are received.

3.6 Analytical Testing

Soil gas samples and QC samples will be submitted to a qualified licensed analytical laboratory under chain-of-custody protocol for analysis of VOCs by USEPA Method TO-15 and helium on a standard 5-day turn-around time. The laboratory's ability to achieve practical quantitation limits that are below concentrations corresponding to either a cancer risk level of 1×10^{-6} for carcinogens or a hazard quotient (HQ) of 1 for non-carcinogens was confirmed.

3.7 Equipment Decontamination

Prior to mobilizing the sampling rigs to the Site, the rig and all associated equipment will be cleaned with a high-pressure, steam washer to remove any oil, grease, mud, tar, and other foreign matter. In order to minimize the potential for cross-contamination, equipment used during the field investigation (including all non-dedicated sampling equipment) will be decontaminated between uses at each sampling location. Decontamination will consist of a detergent wash (Alconox or equivalent) followed by a clean water wash, and finally a clean water rinse; or alternatively, using high pressure steam washer.

Sample containers, soil gas manifolds, and critical orifice flow controllers with integral particulate filters are dedicated sampling equipment and will be received as certified-clean from the laboratory. Materials used for probe construction (tubing, filters, and fittings) will be purchased new and not reused.

3.8 Management of Investigation-Derived Waste

Investigation-derived waste (IDW) will be collected in 5-gallon buckets or 55-gallon drums that will be labeled and sealed following completion of field activities. Each container will be marked with water-proof labels and water-proof markers. Each container will receive a unique identification number and will be cataloged for waste containment documentation purposes. Following characterization, each container of material will be disposed of as appropriate per federal, state and local requirements.

3.9 Evaluation and Reporting of Results

Upon receipt of all field and analytical data, a DVSR will be prepared in accordance with NDEP Guidance (NDEP 2008b, 2009, 2012a,c). The reporting of results of the field work and analytical results will include the following:

- A description of the field methods employed, analytical methods, analytical results, data evaluation methods, and data validation results;
- Laboratory analysis results presented in tabulated form;
- A scale map(s) depicting locations of the soil gas borings;
- A scale map(s) presenting the concentrations of contaminants of concern at each investigative location; and
- Laboratory-certified analytical reports provided in Adobe Acrobat (.PDF) electronic form on a compact disc (CD) in an appendix.

4.0 Data Evaluation

This section describes the sources and types of data that will be considered in the HHRA as well as the data evaluation process.

4.1 Data Sources

The following sources and types of data will be evaluated for use in the soil gas HHRA:

- Historical soil gas samples collected in or near the Study Area and analyzed for VOCs from the Phase B Site-Wide Soil Gas Survey (previously summarized in the 2010 Soil Gas HRA [Northgate 2010d]);
- Additional soil gas samples collected in the Study Area and analyzed for VOCs, as identified in this work plan; and
- Groundwater samples collected in or near the Study Area from shallow groundwater wells and analyzed for VOCs.

The data will be used for two primary purposes: (1) to evaluate groundwater and soil gas results relative to the CSM that has been developed for the Site and Study Area (Figure 5) and (2) to characterize potential risks to human health associated with the vapor intrusion pathway. Only data of appropriate quality to meet the specific objectives of the evaluations will be used. Data usability for risk assessment purposes is discussed in Section 4.2 below.

4.2 Data Usability

The primary objective of the data usability evaluation is to identify appropriate data for use in the HHRA. All relevant site characterization data will be evaluated in accordance with the NDEP *Supplemental Guidance for Assessing Data Usability for Environmental Investigations at the BMI Facility in Henderson, NV* (NDEP 2010c), which is based on USEPA's *Guidance for Data Usability in Risk Assessment* (Parts A and B) (USEPA 1992a,b).

The USEPA data usability evaluation framework provides the basis for identifying and evaluating uncertainties in HHRAs with regard to site characterization data. USEPA (1992a) states that "data usability is the process of assuring or determining that the quality of data generated meets the intended use," and that when risk assessment is the intended use, USEPA's guidance "provide[s] direction for planning and assessing analytical data collection activities for the HHRA…" USEPA has established a specific guidance framework to provide risk assessors with a consistent basis for making decisions about the minimum quality and quantity of environmental analytical data sufficient to support risk assessment decisions (USEPA 1992a,b; NDEP 2010c). The USEPA data usability guidance provides an explicit set of data quality criteria that are used to evaluate the usability of site characterization data in the risk assessment process:

- Reports to Risk Assessor;
- Documentation;
- Data Sources;
- Analytical Methods and Detection Limits;

- Data Review; and
- Data Quality Indicators (i.e., precision, accuracy, representativeness, comparability, and completeness).

The data identified for the HHRA will be evaluated relative to the above criteria.

4.3 Data Analysis

As described by NDEP (2010c), the purpose of the data analysis step is to "use simple exploratory data analysis to compare data to the expectations of the CSM, to determine if the data adequately represent the source terms and exposure areas or evaluation areas." Consistent with the NDEP guidance, summary statistics, simple data plots, and spatial plots of the data will be included in the HHRA. All data evaluations will incorporate the soil gas data used in the 2010 Soil Gas HRA (Northgate 2010d) and the data from the new soil gas samples. The results will be discussed in the appropriate section of the HHRA, including in the Uncertainty Analysis section. Additionally, as requested by NDEP, the following types of analyses will be prepared in the HHRA:

- Cross plots for collocated soil gas and groundwater samples collected in or near the Study Area;
- VOC concentrations presented in the 2010 Soil Gas HRA (Northgate 2010d) will be compared with the most recent groundwater sample results for the same wells to evaluate any temporal changes to VOC concentrations in groundwater;
- Risk calculations for the new soil gas samples will be compared to the risk results presented in the Northgate (2010d) Soil Gas HRA; and
- Risks estimated using VOC concentrations for groundwater and the associated soil gas samples will be compared.

Data adequacy will be discussed in the context of: (1) the results of the analytical program to ensure that the analytical program adequately identified all relevant chemicals that have the potential to affect risk calculations; and (2) review of the sampling points and results to ensure that the Study Area has been sufficiently characterized and that areas that may require remediation have not been missed.

5.0 Human Health Risk Assessment Work Plan

This section describes the methodology for the HHRA. The methodology is generally consistent with, but supersedes that presented previously in the 2010 *Health Risk Assessment Work Plan* (Northgate 2010b, approved by NDEP on March 16, 2010). As noted In Section 1, following review of the results of the additional soil gas sampling, a determination will be made as to whether the Study Area will be evaluated as a single exposure unit (using the maximum detected COPC concentrations across all Study Area parcels), or as individual parcels, using maximum detected concentrations within each individual parcel.

Given the complexity of the Site, risk assessments have been completed or are currently in progress or proposed for the different Site areas and/or contaminated media. Figure 6 depicts the HHRAs completed or in progress for the Site, Parcels A and B, and the Study Area for each contaminated medium.

The following sections describe the risk assessment methodology, following USEPA's (1989) four-step process: selection of COPCs, exposure assessment, toxicity assessment, and risk characterization.

5.1 Selection of Chemicals of Potential Concern

A preliminary list of COPCs will be identified that includes all analytes detected in soil gas. This list will be reviewed to determine if frequency of detection (FOD) will be used as a metric to potentially reduce the number of COPCs carried through the HHRA. As suggested by USEPA (1989), chemicals with a FOD less than or equal to 5 percent may be considered for elimination. The rationale for eliminating any detected analytes as COPCs will be fully documented.

5.2 Exposure Assessment

This section presents the exposure assessment methodology, including the CSM, exposure assumptions, fate and transport modeling to predict indoor air concentrations, and determination of exposure concentrations[9] (ECs).

5.2.1 Conceptual Site Model

A CSM depicts the relationships between a chemical source, exposure pathway, and potential receptor at a site. It also identifies the potential exposure routes (e.g., inhalation of air) for contacting impacted media. These source-pathway-receptor relationships provide the basis for the quantitative exposure assessment. Only "complete" source-pathway-receptor relationships are included in the quantitative risk evaluation. The "working" CSM for the Site (including the Study Area) was presented in the *Remedial Investigation/Feasibility Study Work Plan* submitted to NDEP on December 17, 2012. For this HHRA, the potentially exposed population and exposure pathways for the Study Area are highlighted in the CSM presented in Figure 5. The elements of the CSM for the evaluation of the vapor intrusion pathway are summarized below.

---

[9] The term exposure concentration (EC) is used for the inhalation pathway, consistent with current USEPA guidance (2009) for evaluating inhalation exposures. As used in this work plan, the term EC is synonymous with the more familiar term, exposure point concentration (EPC), used for evaluating other (non-inhalation) pathways.

Surrounding land use is predominantly industrial. The nearest residential developments are located north and south of the Site, with residential developments to the east and west located at a greater distance. Given the highly industrialized nature of the 5,000-acre BMI complex (which includes the Study Area, the overall Site, and adjacent facilities), and the long-term lease with Tronox, future use of the Site and parcels is expected to remain industrial/commercial.

For this HHRA, inhalation of vapors released from soil and groundwater to indoor air for long-term indoor commercial/industrial workers is the only pathway evaluated (Figure 5). Other potential receptors include visitors and trespassers. However, as discussed in USEPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002b), evaluation of exposures to members of the public entering an operating facility is generally not warranted for two reasons: (1) public access is restricted or controlled at industrial sites and (2) while the public may have access to a property, exposures of an on-site worker would be much higher than those of a visitor because workers spend substantially more time at a site. Accordingly, on-site visitors and trespassers will not be quantitatively evaluated in the risk assessment.

5.2.2 Exposure Assumptions

Exposure parameters common to all inhalation pathways are the exposure time, exposure frequency, exposure duration, and averaging time. The values used for these parameters are presented in Table 4.

5.2.3 Exposure Concentrations

The following sections describe the fate and transport modeling and approach for calculating ECs.

5.2.3.1 Fate and Transport Modeling

Chemicals detected in soil gas and groundwater can potentially migrate through the unsaturated zone to ambient or indoor air. This migration is quantified for the purposes of this assessment through an intermedia transfer factor. When the transfer factor is multiplied by the source concentration of a chemical in groundwater (in micrograms per liter [µg/L]) or soil gas (in micrograms per cubic meter [$\mu g/m^3$]), the product is the predicted steady-state concentration in indoor or ambient air (in $\mu g/m^3$).

Intermedia transfer factors will be estimated using the screening-level model described by Johnson and Ettinger (1991). Specifically, Version 3.1 of the spreadsheet implementation developed by the USEPA will be used (USEPA 2004). The Johnson and Ettinger model was developed to predict vapor migration into buildings using a combination of diffusion and advection.

For exposure of current/future on-site workers, transfer factors for soil gas to indoor air and for groundwater to indoor air will be derived as follows:

- Soil gas: transport of soil gas from 5 ft bgs into a commercial slab-on-grade building; and
- Groundwater: transport of VOCs released from groundwater at 25-40 feet bgs into a commercial slab-on-grade building.

The Study Area and parcel-specific input parameters for use in the Johnson and Ettinger model are listed in Tables 5 and 6, respectively.

Soil samples were collected to determine site-specific soil properties representative of the unsaturated zone as part of the 2010 Soil Gas HRA (Northgate 2010d). Soil samples were analyzed in accordance with NDEP guidance (NDEP 2010b) at 16 locations at depths of 9 to 15 ft bgs (mostly at 10 ft) across the Site to determine volumetric water content, soil total porosity, dry bulk density, and grain density. The results of the soil testing are shown in Table 7. Since the available data is considered sufficiently representative of the soil properties in the Study Area to be used for modeling purposes, additional soil samples for evaluation of soil properties will not be collected.

Reviews of boring logs (provided in Appendix A) and cross-sections indicated that the Site has a layer of alluvium, comprised of loamy sand approximately 20-50 feet thick. The soil samples shown in Table 7 were all collected in the alluvium. Below the alluvium lies the UMCf, with a higher percentage of clay and silt than the alluvium. Across most of the Site, the unsaturated zone is composed entirely of alluvium. However, in some areas of the Site, the lower portion of the unsaturated zone includes a few feet of the finer-grained UMCf, located just above the groundwater table. The soil properties for the Johnson and Ettinger model were conservatively selected assuming that the entire unsaturated zone is alluvium with site-specific soil properties based on the average of measured values shown in Table 7. It is a conservative assumption to neglect the presence of the UMCf in areas where it is part of the unsaturated zone because the finer-grained UMCf would act to reduce vapor transport. Following review of the analytical data, the impact of this assumption may be evaluated by conducting a sensitivity analysis of the model results.

As there are no buildings present in Parcels C, D, F, and H, a conservative default building, as shown in Table 5, is proposed. The default building size of 100 meters (m) by 100 m (USEPA 2004) was selected. While many commercial buildings are larger, often such a building is partitioned into smaller areas or offices which may represent smaller isolated breathing zones. This building size would have a default vapor flow rate of 5 liters/minute into the building (USEPA 2004). California's default air exchange rate of 1 air change per hour (Cal/EPA 2011) is proposed in the absence of a default rate from USEPA. As there is no default value for the height of a commercial building, a conservative height of 10 feet is proposed, although many commercial buildings have higher first floor ceilings. As shown in Table 6, a parcel-specific depth to groundwater will be used.

5.2.3.2 Exposure Concentrations

The specific soil gas results for use in the HHRA will be identified based on the results of the data evaluation step. Using these results as model input, indoor air concentrations will be modeled using the Johnson and Ettinger (J&E) model. The contaminant concentration in air, rather than contaminant intake, is used as the basis for estimating chemical inhalation risks based on guidance described in *Part F, Supplemental Guidance for Inhalation Risk Assessment* (USEPA 2009). The ECs for noncarcinogens and carcinogens are estimated as follows:

$$EC = \frac{C \times TF \ \times ET \ \times EF \ \times ED}{AT}$$

where:

EC = exposure concentration (μg/m^3)
C = COPC concentration in soil gas or groundwater (μg/m^3or μg/L)
TF = transfer factor (μg/m^3 per μg/m^3 or μg/m^3 per μg/L)
ET = exposure time (hr/d)
EF = exposure frequency (d/yr)
ED = exposure duration (yr)
AT = averaging time (hr); based on ED (yr) × 365 d/yr × 24 hr/d for non-carcinogens (AT_{nc}) and based on 70 yr (average lifetime) for carcinogens (AT_c)

5.3 Toxicity Assessment

Consistent with the NDEP hierarchy for selecting toxicity values to derive BCLs (NDEP 2013a), cancer and noncancer toxicity values will be identified based on the following sources, listed in general order of preference:

- USEPA's Integrated Risk Information System (IRIS). IRIS is an on-line database of USEPA-approved oral and inhalation toxicity values (USEPA 2013).
- USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs). PPRTVs are interim toxicity values developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center. PPRTV values are listed in NDEP's table of BCLs.
- National Center for Environmental Assessment (NCEA, or other current USEPA sources).
- USEPA's Health Effects Assessment Summary Tables (HEAST) (USEPA 1997). HEAST provides an older listing of provisional toxicity values.
- California Environmental Protection Agency (Cal/EPA) toxicity criteria.
- ATSDR toxicological profiles, which list MRLs for evaluating noncarcinogens.
- USEPA's Environmental Criteria and Assessment Office (ECAO).
- NDEP-identified toxicological surrogates.
- Peer-reviewed scientific literature.

5.4 Risk Characterization

This section describes the approach for conducting the final step of the HHRA, the risk characterization step. In this final step, quantitative information on human exposure and chemical toxicity are combined to calculate corresponding receptor-specific cancer risk and hazard levels.

5.4.1 Assessment of Cancer Risks

Carcinogenic risk will be estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to COPCs. The following equations will be used to calculate chemical-specific risk and total risk:

$$Risk_{inhalation} = EC \ \times UR$$

where:

EC = exposure concentration ($\mu g/m^3$)
UR = unit risk ($(\mu g/m^3)^{-1}$)

and

$$Total\ Risk = \sum Individual\ Chemical\ Risk$$

5.4.2 Assessment of Non-Cancer Health Effects

The potential for non-cancer adverse health effects will be estimated as follows:

$$Hazard\ Quotient_{inhalation} = \frac{EC \times CF}{RfC}$$

where:

EC = exposure concentration ($\mu g/m^3$)
CF = conversion factor (10^{-3} mg/µg)
RfC = reference concentration (mg/m^3)

If more than one COPC is evaluated, the HQs for each COPC will be summed to obtain the hazard index (HI).

$$Hazard\ Index = \sum Hazard\ Quotients$$

If an HI exceeds 1.0, the potential for adverse health effects will be further evaluated by considering the “critical effect” or target organ of each COPC, following a process referred to as “segregation of HI.” The segregation of HI by target organ is consistent with USEPA guidance for non-carcinogens (USEPA 1989). This approach, if applied, will be discussed with NDEP.

5.4.3 Cumulative Cancer Risk and Hazard Index

The cumulative cancer risk and non-cancer hazard will be estimated for the soil and vapor intrusion pathways for an indoor commercial/industrial worker. The cumulative risk will be based on the combined results for the vapor intrusion pathway as estimated in the vapor intrusion HHRA and for the soil-ingestion pathway, as reported in the *Revised Post-Remediation Screening Human Health Risk Assessment Report for Parcels C, D, F, G, and H*. As noted previously, the soil HHRA is currently in preparation; the final evaluation of cumulative risks will be based on the NDEP-approved soil HHRA.

To estimate cumulative risk and HI for the indoor commercial/industrial worker, it is assumed that the worker is exposed to COPCs in soil (via incidental ingestion) and soil gas (via inhalation of vapors in indoor air of a commercial building), as represented by the following equations:

$$Cumulative\ Risk = Risk_{inhalation} + Risk_{soil\ ingestion}$$

$$Cumulative\ Hazard\ Index = Hazard\ Index_{inhalation} + Hazard\ Index_{soil\ ingestion}$$

5.5 Uncertainty Analysis

The process of estimating risk has inherent uncertainties associated with the calculations and assumptions used. The approach that is used in the HHRA will be health protective and will tend to overestimate potential exposure. This results in estimated risk and hazard levels that are likely to be higher than the actual risks or hazards experienced by exposed populations. A discussion of key uncertainties associated with the available data and the methodology used to estimate potential risks and hazards will be included in the HHRA.

6.0 Schedule

NDEP approved the field work proposed in the *Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H*, dated October 2012 (ENVIRON 2012c). Field work was completed on March 13, 2013. The DVSR will be submitted to the Trust within approximately six weeks of receiving the validated analytical data from the laboratory. Within approximately four weeks of receipt of the validated soil gas sampling analytical results, the soil gas sampling results and vapor intrusion HHRA report will be submitted to NDEP for review.

7.0 References

Basic Environmental Company (BEC), 2007a. Phase 2 Sampling and Analysis Plan to Conduct Soil Characterization, Tronox Parcels "C" and “D” Site, Henderson, Nevada. September 19. NDEP approved October 29, 2007.

BEC, 2007b. Phase 2 Sampling and Analysis Plan to Conduct Soil Characterization, Tronox Parcel "F" Site, Henderson, Nevada. September 19. NDEP approved October 9, 2007.

BEC, 2007c. Phase 2 Sampling and Analysis Plan to Conduct Soil Characterization, Tronox Parcel "G" Site, Henderson, Nevada. September 27. NDEP approved October 29, 2007.

BEC, 2007d. Phase 2 Sampling and Analysis Plan to Conduct Soil Characterization, Tronox Parcel "H" Site and Errata Pages for Phase 2 Sampling and Analysis Plans to Conduct Soil Characterization, Tronox Parcels "C", "D" and "F" Sites, Henderson, Nevada. November 8. NDEP approved November 20, 2007.

BEC, 2007e. Phase 2 Sampling and Analysis Plan to Conduct Soil Characterization, Tronox Parcel "H" Site, Henderson, Nevada. December 12. NDEP approved December 17, 2007.

BEC, 2007f. Technical Memorandum — Data Review for 2007 Tronox Parcels A/B Investigation, BMI Industrial Complex, Clark County, Nevada. December 6. NDEP found NFA January 17, 2008.

BEC, 2008a. Sampling and Analysis Plan to Conduct Supplemental Soil Characterization, Tronox Parcels "C", "D", "F", "G", and "H", Henderson, Nevada. May 28. NDEP approved June 5, 2008.

BEC, 2008b. Removal Action Workplan for Soil, Tronox Parcels “C”, “D”, “F”, “G” and “H” Sites, Henderson, Nevada. July 1. NDEP approved July 2, 2008.

Broadbent & Associates, Inc., 2011. Quarterly Status Report for the 1st Quarter of 2011. Titanium Metals Corporation, Henderson, Nevada Facility, Facility ID #H000537. April 15.

California Environmental Protection Agency (Cal/EPA), 2011. Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance). Final. Department of Toxic Substances Control. October.

Converse Consultants, 2007. Phase I Environmental Site Assessment [ESA], Approximately 182 Acres, APNs 178-13-601-002,-002, 178-12-101-002, -003, 178-12-201-005, 178-12-601-005, 178-01-401-001, 178-11-501-007, and Portions of 178-12-401-009 & 178-13-101-002, Henderson, Nevada. March 5. NDEP commented May 11, 2007.

ENSR Corporation (ENSR), 2005. Conceptual Site Model, Kerr-McGee Facility, Henderson, Nevada, February. NDEP requested response to comments during the next monthly meeting October 22, 2005.

ENSR, 2007. Phase A Source Area Investigation Results Report, Tronox LLC Facility, Henderson, Nevada, September. NDEP approved the Report November 30, 2007 and Appendix G – Data Validation Summary Report (DVSR) December 17, 2007.

ENSR, 2008. Phase B Source Area Investigation Work Plan, Soil Gas Survey, Tronox LLC Facility, Henderson, Nevada, March. NDEP approved March 26, 2008.

ENVIRON International Corporation (ENVIRON), 2012a. Scope of Work for Response to NDEP Comments on the May 18, 2012 Sale Parcels Risk Assessment, Nevada Environmental Response Trust Site, Henderson, NV. September 11.

ENVIRON, 2012b. Interim Soil Removal Action Completion Report, Nevada Environmental Response Trust Site, Henderson, Nevada, August 2010 – November 2011. Revised September.

ENVIRON, 2012c. Draft Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H, Nevada Environmental Response Trust Site, Henderson, Nevada. October.

ENVIRON, 2012d. Remedial Investigation and Feasibility Study Work Plan, Nevada Environmental Response Trust Site, Henderson, Nevada. December 17. Under NDEP review.

ERM-West, Inc. (ERM-West), 2008a. Data Validation Summary Report, Tronox Parcels C, D, F, and G Investigation, November 2007, BMI Industrial Complex, Clark County, Nevada. February. NDEP approved April 3, 2008.

ERM-West, 2008b. Data Validation Summary Report, Tronox Parcel H Investigation, January 2008, BMI Industrial Complex, Clark County, Nevada. April. NDEP approved May 5, 2008.

ERM-West, 2009. Data Validation Summary Report, Tronox Parcels C, D, F, G and H Supplemental Investigations-June-July 2008, BMI Industrial Complex, Clark County, Nevada. January 2009. NDEP approved July 28, 2010.

Interstate Technology & Regulatory Council (ITRC), 2007. Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline. January.

Johnson, P.C. and R.A. Ettinger, 1991. Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings. Environmental Science and Technology, 25, 1445-1452.

Kleinfelder, 1993. Environmental Conditions Assessment, Kerr-McGee Chemical Corporation, Henderson, Nevada. April.

Nevada Division of Environmental Protection (NDEP), 1994. Phase II Letter of Understanding between NDEP and Kerr-McGee. August 15.

NDEP, 2005. NDEP Response to Conceptual Site Model, dated February 28, 2005. May 6.

NDEP, 2008a. Statistical Analysis Recommendations for Field Duplicates and Field Splits, BMI Plant Sites and Common Areas Projects, Henderson, Nevada. November 14.

NDEP, 2008b. Detection Limits and Data Reporting, BMI Plant Sites and Common Areas Projects, Henderson, Nevada. December 3.

NDEP, 2008c. Guidance on the Development of Summary Statistics Tables, BMI Plant Sites and Common Areas Projects, Henderson, Nevada. December 10.

NDEP, 2009. Supplemental Guidance on Data Validation, BMI Plant Sites and Common Areas Projects, Henderson, Nevada. April 13.

NDEP, 2010a. Letter to Tronox LLC re: TRX Sale Parcels A through K, Tronox LLC. January 7.

NDEP, 2010b. Soil Physical and Chemical Property Measurement and Calculation Guidance, BMI Plant Sites and Common Areas Projects, Henderson, Nevada. March 11.

NDEP, 2010c. Supplemental Guidance for Assessing Data Usability for Environmental Investigations at the BMI Complex and Common Areas in Henderson, Nevada. September 1.

NDEP, 2011. Action Memorandum: Removal Actions, Nevada Environmental Response Trust Site, Clark County, Nevada, July 21.

NDEP, 2012a. Revised Guidance on Qualifying Data due to Blank Contamination for the BMI Complex and Common Areas, BMI Plant Sites and Common Areas Projects, Henderson, Nevada. January 5.

NDEP, 2012b. Guidance on Unified Chemical Electronic Data Deliverable Format, BMI Plant Sites and Common Areas Projects, Henderson, Nevada. March 5.

NDEP, 2012c. NDEP Response to: Revised Closure and Post-Remediation Screening Health Risk Assessment Report for Parcels C, D, F, G, and H. Nevada Environmental Response Trust Site, Henderson, Nevada, Dated: May 18, 2012. August 7.

NDEP, 2013a. User’s Guide and Background Technical Document for the Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas. December 2008. Revision 10. January 2013.

NDEP, 2013b. NDEP Response to: Soil Gas Investigation Work Plan for Parcels C, D, F, G, and H, Nevada Environmental Response Trust Site, Henderson, Nevada, Dated: October 2012. January 29.

NDEP, 2013c. Meeting Minutes regarding NERT’s Questions on the Parcels Soil Gas Issues. February 21.

Northgate Environmental Management, Inc. (Northgate), 2010a. Revised Data Validation Summary Report, Phase B Investigation Groundwater, Tronox LLC, Henderson, Nevada. April 7. NDEP approved April 14, 2010.

Northgate, 2010b. Health Risk Assessment Work Plan, Tronox LLC, Henderson, Nevada, March 9. NDEP approved March 16, 2010.

Northgate, 2010c. Revised Technical Memorandum: Screening-Level Indoor Air Health Risk Assessment for the 2008 Tronox Parcels A/B Soil Gas Investigation, BMI Industrial Complex, Clark County, Nevada. November 12. NDEP commented May 23, 2011.

Northgate, 2010d. Site-Wide Soil Gas Human Health Risk Assessment, Tronox LLC, Henderson, Nevada. November 22. Not reviewed by NDEP.

Northgate, 2010e. Capture Zone Evaluation Report, Tronox LLC. Henderson, Nevada. December 10. NDEP commented April 5, 2011; ENVIRON to submit a Response to Comments and resubmit the 2010 Model.

Northgate, 2012. Revised Closure and Post-Remediation Screening Health Risk Assessment Report for Parcels C, D, F, G, and H. Nevada Environmental Response Trust Site, Henderson, Nevada. May 18. NDEP provided comments on August 7, 2012.

Tronox LLC (Tronox), 2007. Draft Tronox Response to NDEP Comments Regarding Converse Phase I For Various Tronox Parcels. May 29.

US Environmental Protection Agency (USEPA), 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/540/1-89/002:Office of Emergency and Remedial Response. Washington, DC

USEPA, 1990. National Oil and Hazardous Substances Pollution Contingency Plan. US Environmental Protection Agency, Federal Register 55:8666.

USEPA, 1992a. Guidance for Data Usability in Risk Assessment (Part A), Final. April. http://www.epa.gov/oswer/riskassessment/datause/parta.htm

USEPA, 1992b. Guidance for Data Usability in Risk Assessment (Part B), Final. May. http://www.epa.gov/oswer/riskassessment/datause/partb.htm

USEPA, 1997. Health Effects Assessment Summary Tables (HEAST), FY 1997 Update. EPA-540-R-97-036. July.

USEPA, 2002a. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). November.

USEPA, 2002b. Supplemental Guidance for Developing Soil Screening Levels for Superfun Sites. OSWER 9355.4-24. December.

USEPA, 2004. User’s Guide for Evaluating Subsurface Vapor Intrusion into Buildings. February.

USEPA, 2009. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). Final. EPA-540-R-070-002: Office of Emergency and Remedial Response. Washington, D.C.

USEPA, 2013. Integrated Risk Information System (IRIS). USEPA on-line database: http://www.epa.gov/iris/index.html.

Tables

TABLE 1
LOUs Within and Upgradient of the Study Area Parcels

Parcel	LOUs[a]			Potential Contaminants[b]
	#	Name	Location	
Parcel C	1	Trade Effluent Settling Ponds	upgradient	VOCs (benzene derivatives)
	10	On-Site Hazardous Waste Landfill	upgradient	no VOCs
	22	Pond WC-West and Associated Piping	upgradient	no VOCs
	23	Pond WC-East and Associated Piping	upgradient	no VOCs
	32	Groundwater Remediation Unit	upgradient	no VOCs
	55	Area Affected by July 1990 Fire	upgradient	no VOCs
	58	AP Plant Area New D-1 Building Washdown	upgradient	no VOCs
Parcel D	6	Unnamed Drainage Ditch Segment (BMI Landfill)	within	no VOCs
	68	Southern Nevada Auto Parts Site (Kerr-McGee tenant)	within	no VOCs
Parcel F	4	Former Hardesty Chemical Company Site	upgradient	VOCs (benzene derivatives)
	25	Process Hardware Storage Area	upgradient	no VOCs
	26	Trash Storage Area	upgradient	no VOCs
	27	PCB Storage Area	upgradient	no VOCs
	28	Hazardous Waste Storage Area	upgradient	VOCs
	41	Unit 1 Tenants - Stains	upgradient	VOCs
	59	Storm Sewer System	within	no VOCs
	60	Acid Drain System	upgradient	no VOCs
	63	J.B. Kelley Trucking Inc. Site (Kerr-McGee tenant)	within	VOCs
	65a-d	Nevada Precast Concrete Products (Kerr-McGee tenant)	65c within; 65a,b and d upgradient	VOCs
Parcel G	59	Storm Sewer System	within	no VOCs
	60	Acid Drain System	within	no VOCs
	65d	Green Ventures International (Kerr-McGee tenant)	within	VOCs
Parcel H	--	--	--	--

Notes:

-- = no LOUs are within or upgradient of the Parcel
LOU = Letter of Understanding
VOC = volatile organic compound

[a] Gray highlighted LOUs indicated that NDEP identified them for no further action (ENSR 2007).

[b] The contaminants listed for each parcel were identified in NDEP (2011).

Reference:

ENSR Corporation (ENSR), 2007. Phase A Source Area Investigation Results Report, Tronox LLC Facility, Henderson, Nevada. September. NDEP approved November 30, 2007.

Nevada Division of Environmental Protection (NDEP), 2011. Action Memorandum: Removal Actions, Nevada Environmental Response Trust Site, Clark County, Nevada. July 21.

TABLE 2
Shallow Groundwater Locations with VOC Sampling Data[a]

Parcel	Well ID	Date Sampled	Chloroform (ug/L)
Parcel C	AA-BW-04A	1/26/2009	1300
		1/26/2009	940
		1/26/2009	1400
		1/26/2009	1200
		4/20/2009	3400
		4/20/2009	3100
		4/20/2009	4000
		4/20/2009	4000
		4/20/2009	900
		4/20/2009	910
		7/21/2009	1100
		10/21/2009	480
		10/21/2009	490
		10/21/2009	800
		10/21/2009	740
		5/12/2010	480
		5/12/2010	410
		10/28/2010	400
		10/28/2010	330
		3/24/2011	380
		3/24/2011	500
		10/20/2011	320
		10/20/2011	330
	H-28	3/18/1981	200
		7/1/1981	ND
		10/13/1981	ND
		2/9/1982	ND
		6/23/1982	ND
		12/7/1982	ND
		3/3/1998	ND
		4/29/1998	<5.0
		8/20/1998	<5.0
		11/18/1998	<5.0
		3/18/1999	<5.0
		12/13/2007	<0.66
		12/13/2007	0.66
		4/22/2009	0.90
		7/22/2009	1.2
		7/22/2009	1.1
		10/20/2009	0.70
		4/21/2010	0.32
		10/26/2010	0.64
		3/24/2011	<0.80
		10/20/2011	<0.64
	M-6A	6/27/2008	2.2
Parcel D	M-23	6/25/2008	130
	MC-09R	7/24/2009	7.9
		5/19/2010	4.3
		4/22/2011	6.5
	MC-45	1/17/1986	ND
		2/19/1986	ND
		7/15/1986	ND
		12/6/2006	3.0
		6/25/2008	3.0
	MC-53	4/1/2004	9.0
		6/29/2004	31
		9/28/2004	220
		1/26/2005	30
		4/20/2005	15
		10/26/2005	17

TABLE 2
Shallow Groundwater Locations with VOC Sampling Data[a]

Parcel	Well ID	Date Sampled	Chloroform (ug/L)
Parcel D (Continued)	MC-53 (Continued)	2/1/2006	2.7
		4/26/2006	300
		7/26/2006	25
		12/4/2006	4.0
		1/17/2007	6.6
		4/18/2007	9.6
		7/16/2007	8.1
		12/21/2007	5.1
		1/29/2008	10
		4/9/2008	36
		6/25/2008	13
		7/10/2008	11
		11/6/2008	7.3
		1/21/2009	9.3
		4/14/2009	7.1
		4/21/2010	5.0
	MC-94	10/7/2009	5.4
	MC-MW-29	7/20/2009	45
		11/10/2009	4.8
		5/4/2010	6.8
		4/25/2011	4.7
	MC-MW-32	11/16/2010	9.3
		4/27/2011	2.8
Relevant Nearby Locations for Parcels C and D	AA-BW-03A	12/13/2007	2.4
		12/13/2007	<2.6
		1/21/2009	<0.08
		4/28/2009	0.61
		7/23/2009	0.99
		10/27/2009	3.2
		4/26/2010	0.66
		10/28/2010	<2.8
		3/29/2011	4.9
		10/25/2011	3.4
	AA-BW-05A	1/23/2009	70
		1/23/2009	61
		4/21/2009	44
		7/21/2009	41
		10/20/2009	17
		10/20/2009	16
		5/12/2010	29
		10/27/2010	33
		3/24/2011	28
		10/20/2011	<16
	H-21R	8/24/1999	490
		12/8/1999	780
		3/27/2000	ND
		6/15/2000	<300
		9/21/2000	<300
		11/8/2000	<300
		1/18/2001	<300
		5/24/2001	54
		7/26/2001	37
		10/25/2001	<250
		2/14/2002	35
		4/11/2002	69
		8/2/2002	<250
		11/8/2002	<250
		2/27/2003	23
		6/5/2003	24
		8/21/2003	72

TABLE 2
Shallow Groundwater Locations with VOC Sampling Data[a]

Parcel	Well ID	Date Sampled	Chloroform (ug/L)
Relevant Nearby Locations for Parcels C and D (continued)	H-21R (Continued)	12/11/2003	48
		3/11/2004	61
		6/22/2004	11
		9/16/2004	89
		1/11/2005	13
		2/22/2005	19
		5/24/2005	5.5
		9/23/2005	<25
		10/25/2005	20
		2/2/2006	<5.0
		2/2/2006	<5
		4/25/2006	11
		4/25/2006	9.0
		7/26/2006	11
		7/26/2006	12
		12/1/2006	<200
		12/1/2006	<200
		1/23/2007	<200
		4/20/2007	<40
		7/17/2007	<80
		11/15/2007	19
		11/15/2007	21
		1/30/2008	<100
		4/2/2008	<400
		7/11/2008	<800
		7/11/2008	<800
		11/5/2008	<400
		1/19/2009	<200
		1/23/2009	<0.08
		4/16/2009	<200
		4/20/2010	<100
	H-49A	9/16/2004	10
		11/30/2004	6.0
		2/22/2005	<5.0
		5/24/2005	<5.0
		9/23/2005	7.6
		10/25/2005	7.0
		2/2/2006	<5.0
		4/25/2006	<5.0
		7/25/2006	<5.0
		11/30/2006	<2.0
		1/18/2007	3.4
		4/17/2007	2.3
		7/11/2007	2.0
		11/14/2007	3.2
		1/30/2008	<2.0
		4/3/2008	<2.0
		4/3/2008	<2.0
		7/11/2008	<2.0
		11/5/2008	2.0
		1/19/2009	<2.0
		4/15/2009	<2.0
		4/20/2010	1.4

TABLE 2
Shallow Groundwater Locations with VOC Sampling Data[a]

Parcel	Well ID	Date Sampled	Chloroform (ug/L)
Relevant Nearby Locations for Parcels C and D (continued)	H-56A	9/16/2004	ND
		2/22/2005	<5.0
		5/24/2005	<5.0
		9/23/2005	<5.0
		10/25/2005	<5.0
		1/31/2006	<5.0
		4/25/2006	<5.0
		7/19/2006	1.1
		7/25/2006	<5.0
		11/30/2006	<2.0
		1/17/2007	<2.0
		4/18/2007	<2.0
		4/18/2007	<2.0
		7/11/2007	<2.0
		11/14/2007	<2.0
		1/30/2008	<2.0
		4/3/2008	<2.0
		7/11/2008	<2.0
		11/5/2008	<2.0
		1/19/2009	<2.0
		4/15/2009	<2.0
		4/19/2010	2.0
	H-58A	9/16/2004	ND
		2/22/2005	<5.0
		5/24/2005	<5.0
		9/23/2005	9.6
		10/25/2005	17
		2/2/2006	7.7
		4/25/2006	4.9
		7/25/2006	16
		11/30/2006	<2.0
		1/18/2007	4.3
		4/18/2007	4.6
		7/11/2007	6.6
		11/14/2007	5.6
		1/30/2008	9.7
		1/30/2008	9.0
		4/3/2008	8.6
		7/11/2008	4.8
		11/5/2008	2.4
		1/19/2009	2.0
		4/15/2009	<2.0
		4/19/2010	2.2
	M-44	6/24/2008	34
	M-48	12/6/2006	99
		7/9/2008	180
	M-7B	11/30/2006	2.3
		12/18/2007	2.2
		6/26/2008	2.1
		2/3/2009	1.3
		4/23/2009	1.1
		7/28/2009	1.4
		7/28/2009	1.4
		10/28/2009	1.5
		4/22/2010	1.3
		10/28/2010	<1.8
		3/30/2011	1.9
		10/26/2011	1.5
	M-94	6/23/2008	50

TABLE 2
Shallow Groundwater Locations with VOC Sampling Data[a]

Parcel	Well ID	Date Sampled	Chloroform (ug/L)
Relevant Nearby Locations for Parcels C and D (continued)	M-95	12/4/2006	350
		6/27/2008	390
	M-96	7/9/2008	28
	M-98	11/30/2006	810
	M-99	5/6/2010	150
	M-100	12/4/2006	38
		12/4/2006	36
	MC-3	5/27/2009	16
	MC-62	6/23/2008	2.3
	MC-65	6/20/2008	8.3
	MC-66	6/20/2008	5.2
		6/20/2008	5.3
	MC-97	6/25/2008	3.8
	MC-MW-30	7/22/2009	23
		11/10/2009	84
		5/4/2010	64
		10/27/2010	6.0
		3/29/2011	17
		10/25/2011	11
	MC-MW-31	7/23/2009	300
		11/19/2009	31
		5/3/2010	42
		10/27/2010	38
		3/29/2011	26
		10/25/2011	23
	MC-MW-33	11/17/2010	9.5
		11/17/2010	10
		4/28/2011	<0.33
	MC-MW-36	11/15/2010	100
		4/28/2011	140
	MC-MW-37	11/16/2010	46
		4/28/2011	53
	MC-MW-38	11/16/2010	10
		4/29/2011	8.2
	PC-37	6/20/2008	2.0
	PC-40	6/18/2008	1.6
		12/1/2006	4.0
	PC-72	6/23/2008	29
	WELL-M2	10/24/2008	150
		4/23/2010	<80
	WELL-N	4/23/2010	4.0
	WELL-O	4/23/2010	920
Parcel F	M-92	11/29/2006	30
		7/15/2009	30
		5/14/2010	28
	MC-MW-17	5/8/2008	7000
		11/16/2009	4800
		5/7/2010	5100
		4/22/2011	5100
	TR-6	7/17/2009	2700
		7/27/2010	2000
Parcel G	TR-8	3/20/2006	9.4
		3/20/2006	13
		3/20/2006	14
		7/14/2009	9.8
Parcel H	M-103	3/20/2006	<5.0
		3/21/2006	<5.0
		7/8/2009	0.54

TABLE 2
Shallow Groundwater Locations with VOC Sampling Data[a]

Parcel	Well ID	Date Sampled	Chloroform (ug/L)
Parcel H (Continued)	M-120	3/22/2006	<5.0
		11/28/2006	1.1
		7/7/2009	1.5
		7/27/2010	1.1
	M-121	3/23/2006	<5.0
		7/10/2009	2.6
Relevant Nearby Locations for Parcels F, G, and H	AA-MW-23	7/16/2008	24
		7/16/2008	28
		10/29/2008	24
	M-10	9/19/2001	16
		7/10/2009	55
	M-13	12/1/2006	40
		6/25/2009	36
		6/25/2009	35
	M-97	11/29/2006	12
		7/16/2009	10
	M-124	7/11/2008	240
		11/10/2008	200
	M-137	10/29/2009	2.8
	M-138	10/28/2009	5.1
		10/28/2009	5.0
	M-144	10/27/2009	2.3
	TR-10	3/13/2006	<5.0
		3/21/2006	1.6
		7/14/2009	2.6

Notes:

< = sample not detected
ug/L = micrograms per liter
ND = sample not detected and detection limit not available

[a] ENVIRON identified these wells using NDEP's Regional Database available at http://ndep.neptuneinc.org/ndep_gisdt/home/index.xml, the Data Validation Summary Reports for the Phase A Investigation (ENSR 2007b) and the Phase B Groundwater Investigation (Northgate 2010a).

References:

ENSR Corporation (ENSR), 2007. Phase A Source Area Investigation Results Report, Tronox LLC Facility, Henderson, Nevada, September. NDEP approved the Report November 30, 2007 and Appendix G – Data Validation Summary Report (DVSR) December 17, 2007.

Northgate Environmental Management, Inc. (Northgate), 2010a. Revised Data Validation Summary Report, Phase B Investigation Groundwater, Tronox LLC, Henderson, Nevada. April 7. NDEP approved April 14, 2010.

TABLE 3
Proposed and Existing Soil Gas Sampling Locations[a]

Parcel[b]	Sample ID Number	
Parcel C	E-SG-1	ENVIRON (proposed)
	E-SG-2	ENVIRON (proposed)
	E-SG-3	ENVIRON (proposed)
	SG13	Phase B
	SG14	Phase B
	SG17	Phase B
	SG18	Phase B
	SG19	Phase B
	SG24	Phase B
	SG90	Phase B
	SG91	Phase B
Parcel D	E-SG-1	ENVIRON (proposed)
	E-SG-9	ENVIRON (proposed)
	SG05	Phase B
	SG06	Phase B
	SG11	Phase B
	SG12	Phase B
	SG13	Phase B
	SG14	Phase B
	SG16	Phase B
	SG17	Phase B
	SG18	Phase B
Parcel F	E-SG-4	ENVIRON (proposed)
	E-SG-5	ENVIRON (proposed)
	E-SG-6	ENVIRON (proposed)
	SG33	Phase B
	SG34	Phase B
	SG39	Phase B
	SG63	Phase B
	SG72	Phase B
	SG73	Phase B
	SG74	Phase B
	SG88	Phase B
Parcel G	E-SG-7	ENVIRON (proposed)
	E-SG-8	ENVIRON (proposed)
	SG44	Phase B
	SG45	Phase B
	SG64	Phase B
Parcel H[c]	SG47	Phase B
	SG48	Phase B
	SG49	Phase B
	SG50	Phase B
	SG66	Phase B
	SG67	Phase B
	SG68	Phase B

Notes:
bgs = below ground surface

[a] Phase B soil gas samples that will be used in support of the vapor intrusion health risk assessment were collected at a depth of 5 feet bgs. All ENVIRON samples will also be collected at 5 feet bgs.

[b] For each Parcel, listed samples include locations within or near the Parcel. Results for sample locations outside a Parcel will be discussed in the HHRA to understand the extent of contamination and may be used in the quantitative evaluation, as appropriate.

[c] No additional samples will be collected in Parcel H because adequate soil gas and groundwater samples exist to characterize the contaminant distribution.

TABLE 4
Exposure Parameters

Exposure Factors	Units	Symbol	Long-Term Indoor Commercial Worker	
			Value	Source
Receptor-Specific Exposure Factors				
Target Risk	unitless	TR	1E-06	--
Target Hazard Quotient	unitless	THQ	1.0	--
Exposure Assumptions				
Exposure Frequency	days/year	EF	250	USEPA 2002
Exposure Time[a]	hours/24 hours	ET	8	USEPA 2002
Exposure Duration	years	ED	25	USEPA 2002
Averaging Time for Cancinogens	days	AT_c	25,550	USEPA 2002
Averaging Time for Noncarcinogens	days	AT_{nc}	9,125	USEPA 2002

Notes:

-- = not applicable

USEPA = United States Environmental Protection Agency

kg = kilograms

[a] It is assumed that long-term indoor commercial workers work 8 hours per workday.

References:

USEPA, 2002b. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Office of Emergency and Remedial Response. December.

USEPA, 2009. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment, Final). January.

TABLE 5
Johnson and Ettinger Modeling Parameters for the Study Area

Parameter	Value	Units	Reference/Rationale
Vadose Zone Parameters			
Soil gas sampling depth[a]	5	ft	Site-specific
Groundwater depth	Parcel Specific	ft	See Table 6
Average soil temperature	17	Celsius	Site-specific (Figure 8, USEPA 2004, p. 48). The average groundwater temperature in the Henderson, Nevada area.
USDA soil type in layer A	Loamy Sand	--	Based on laboratory-measured grain size distributions of 15 samples collected across the Site in 2009. The normalized weight percent of sand, silt, and clay was plotted on the U.S. Soil Conservation Service Classification Chart provided in the J&E Model User's Guide (USEPA 2004).
Thickness of soil layer (soil gas)	5	ft	Site-specific
Thickness of soil layer (groundwater)	Parcel Specific	ft	See depth to groundwater in Table 6
Dry bulk density	1.703	g/cm^3	Site-specific. The arithmetic mean of 15 soil samples collected across the Site in 2009 and an additional sample collected in 2008.
Grain density	2.686	g/cm^3	Site-specific. The arithmetic mean of 15 soil samples collected across the Site in 2009 and an additional sample collected in 2008.
Total porosity	0.366	unitless	Site-specific. The arithmetic mean of 15 soil samples collected across the Site in 2009.
Water-filled porosity	0.154	unitless	Site-specific. The arithmetic mean of 15 soil samples collected across the Site in 2009 and an additional sample collected in 2008.
USDA soil type above water table (Alluvium)	Loamy Sand	--	Based on laboratory-measured grain size distributions of 15 samples collected across the Site in 2009. The normalized weight percent of sand, silt, and clay was plotted on the U.S. Soil Conservation Service Classification Chart provided in the J&E Model User's Guide (USEPA 2004).
Capillary fringe thickness	18.75	cm	Default value for loamy sand (USEPA 2004)
Capillary fringe total porosity	0.366	unitless	Site-specific. The arithmetic mean of 15 soil samples collected across the Site in 2009.
Capillary fringe water-filled porosity	0.303	unitless	Default value for loamy sand (USEPA 2004)
***Surface Barrier Parameters* - Indoor Air Scenarios**			
Thickness of foundation	10	cm	Model default (USEPA 2004)
Depth below grade to bottom of floor	15	cm	Model default, slab on grade (USEPA 2004)
Foundation crack ratio	0.005	unitless	Model default (CalEPA 2011)
Average vapor flow rate into building (Q_{soil})	5	L/min	Model default (USEPA 2004)
***Air Dispersion Parameters* - Indoor Scenarios**			
Air exchange rate (AER)	1	1/hr	Cal/EPA (2011). Recommended value for general offices within commercial buildings.
Length of building	1000	cm	Model default (USEPA 2004)
Width of building	1000	cm	Model default (USEPA 2004)
Enclosed space height	300	cm	Conservative assumption.
***Air Dispersion Parameters* - Outdoor Scenarios**			
Q/C_{vol}	Parcel Specific	(g/m^2-s per kg/m^3)	See Table 6

Notes:

bgs = below ground surface
Cal/EPA = California Environmental Protection Agency
HHRA = Human Health Risk Assessment
J&E = Johnson & Ettinger
NA = not applicable
Q/C_{vol} = outdoor air dispersion factor
U.S. = United States
USDA = United States Department of Agriculture
USEPA = United States Environmental Protection Agency

cm = centimeter
ft = feet
g = gram
hr = hour
L = liter
m = meter
min = minute
s = second

TABLE 5
Johnson and Ettinger Modeling Parameters for the Study Area

[a] A few soil gas samples were collected at 20 feet below ground surface; however, a soil gas sampling depth of 5 feet was assumed for these samples, which is a health-protective assumption, for expediency.

References:

Cal/EPA, 2011. Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (Vapor Intrusion Guidance). Final. Department of Toxic Substances Control. October.

USEPA, 2002b. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Office of Emergency and Remedial Response. December.

USEPA, 2004. User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings. Office of Emergency and Remedial Response. February 22.

TABLE 6
Parcel-Specific Johnson and Ettinger Modeling Parameters

Parcel	Area (acres)	Q/C_{vol} (g/m^2-s per kg/m^3)[a]	Depth to Groundwater (ft)[b]
Parcel C	20.9	45.3	25
Parcel D	24.3	44.4	30
Parcel F	7.1	53.4	35
Parcel G	2.8	61.9	40
Parcel H	26.3	43.9	40

<u>Notes:</u>

g = gram
ft = feet
kg = kilogram
m = meter
Q/C_{vol} = site-specific dispersion factor
USEPA = United States Environmental Protection Agency

[a] The following equation was used to calculate Q/C_{vol} using the constants for the Las Vegas, Nevada meterological station (USEPA 2002b).

$$Q/C_{vol} = A \times exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$$

A = 13.3093
B = 19.8387
C = 230.1652
A_{site} = Area of parcel in acres

[b] These values also represent the thickness of the soil layer.

<u>Reference:</u>

USEPA, 2002b. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. December.

TABLE 7
Soil Properties Data[a]

Sample ID	Depth (ft)	Volumetric Water Content[b]	Dry Bulk Density[c] (g/cm³)	Grain Density[d] (g/cm³)	Soil Total Porosity[e] (g/cm³)	Soil Type
SA56-10BSPLP	10	0.134	1.689	2.719	0.379	Loamy Sand
RSAM3-10BSPLP	10	0.145	1.593	2.674	0.404	Loamy Sand
SA166-10BSPLP	10	0.100	1.721	2.681	0.358	Loamy Sand
SA182-10BSPLP	10	0.182	1.740	2.601	0.331	Sandy Loam
RSAJ3-10BSPLP	10	0.154	1.770	2.682	0.340	Loamy Sand
RSAI7-10B	10	0.138	1.661	2.682	0.381	Sand
SA34-10BSPLP	10	0.169	1.738	2.696	0.355	Loamy Sand
SA52-15BSPLP	15	0.239	1.405	2.710	0.481	Sand
RSAQ8-10BSPLP	10	0.148	1.697	2.695	0.370	Sand
RSAN8-10BSPLP	10	0.189	1.679	2.683	0.374	Loamy Sand
RSAQ4-10BSPLP	10	0.141	1.841	2.705	0.319	Sand
SA148-10BSPLP	10	0.119	1.762	2.732	0.355	Sand
SA30-9BSPLP	9	0.160	1.805	2.711	0.334	Sand
SA128-10BSPLP	10	0.156	1.654	2.654	0.377	Loamy Sand
SA102-10BSPLP	10	0.135	1.769	2.696	0.344	Sand
SA64-10BSPLP	10	0.148	1.717	2.651	0.352	Sand
Mean	10.25	0.154	1.703	2.686	0.366	Loamy Sand
Min	9	0.100	1.405	2.601	0.319	NA
Max	15	0.239	1.841	2.732	0.481	NA
Median	10	0.148	1.719	2.689	0.357	NA

Notes:

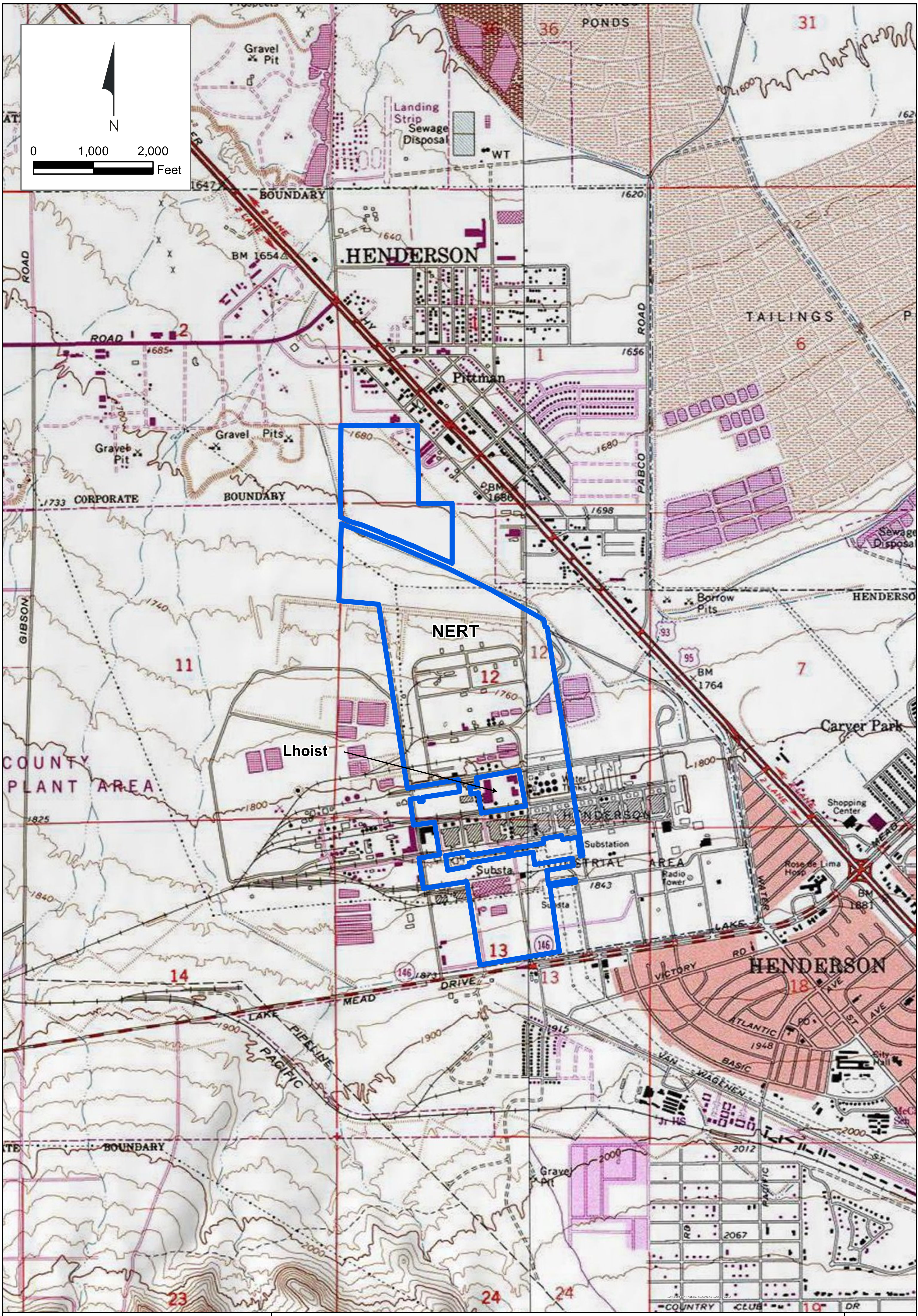
g/cm^3 = grams per cubic centimeter
NA = not applicable

[a] The soil properties were reported in Northgate (2010d).
[b] As measured according to ASTM D 2216.
[c] As measured according to ASTM D 2937.
[d] As measured according to ASTM D 854.
[e] Calculated from dry bulk density and grain density.

References:

Northgate Environmental Management, Inc. (Northgate), 2010d. Site-Wide Soil Gas Human Health Risk Assessment, Tronox LLC, Henderson, Nevada. November 22.

Figures



Path: H:\LePetomane\NERT\VI Risk Assessment\GIS\Maps\Fig1_SiteLocationMap.mxd

ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

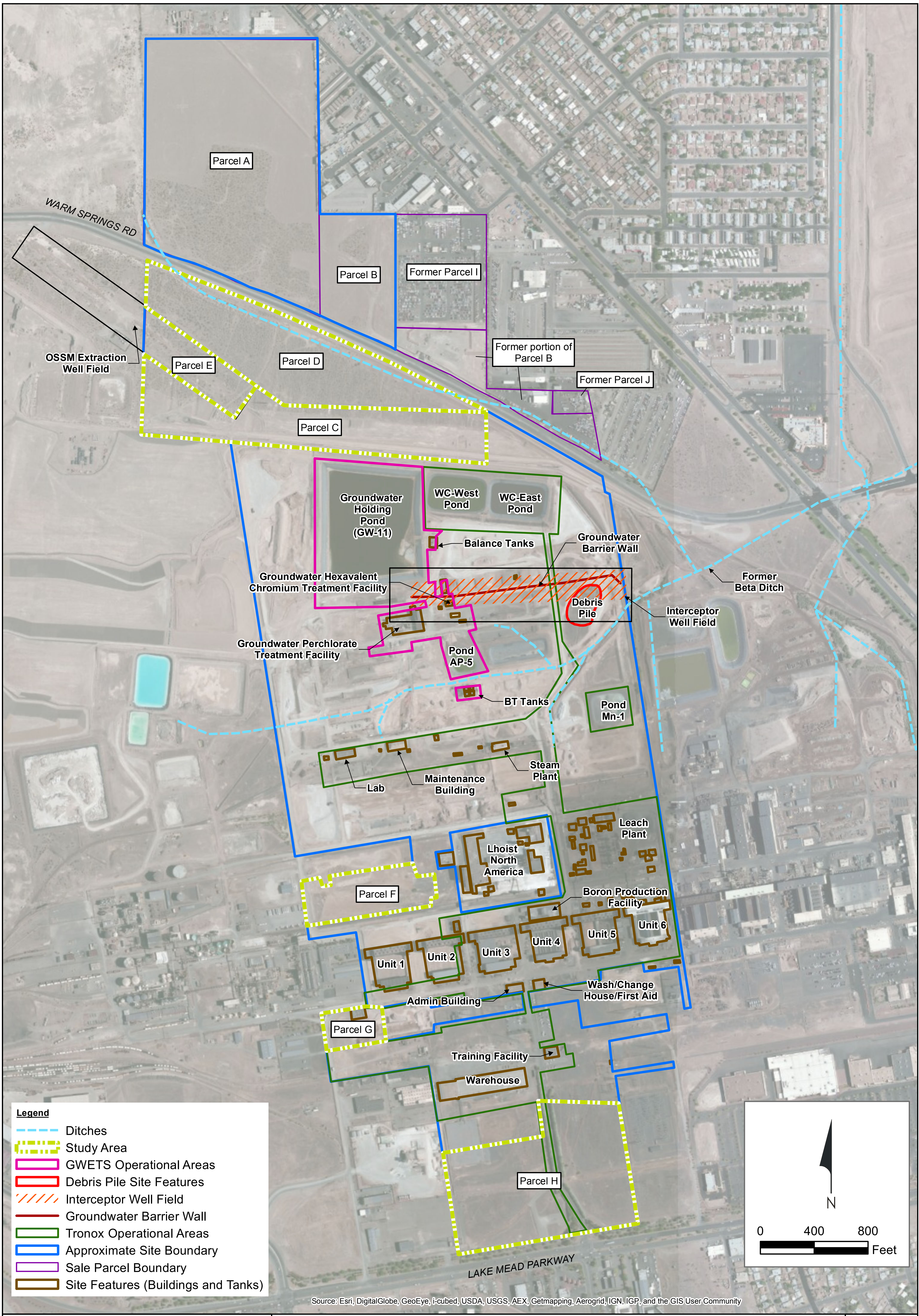
Site Location Map

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure

1

Drafter: RS Date: 3/18/2013 Contract Number: 21-32100GA Approved by: Revised:



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Path: H:\LePetomane\NERT\VI Risk Assessment\GIS\Maps\Fig2_SiteFeatures.mxd

ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

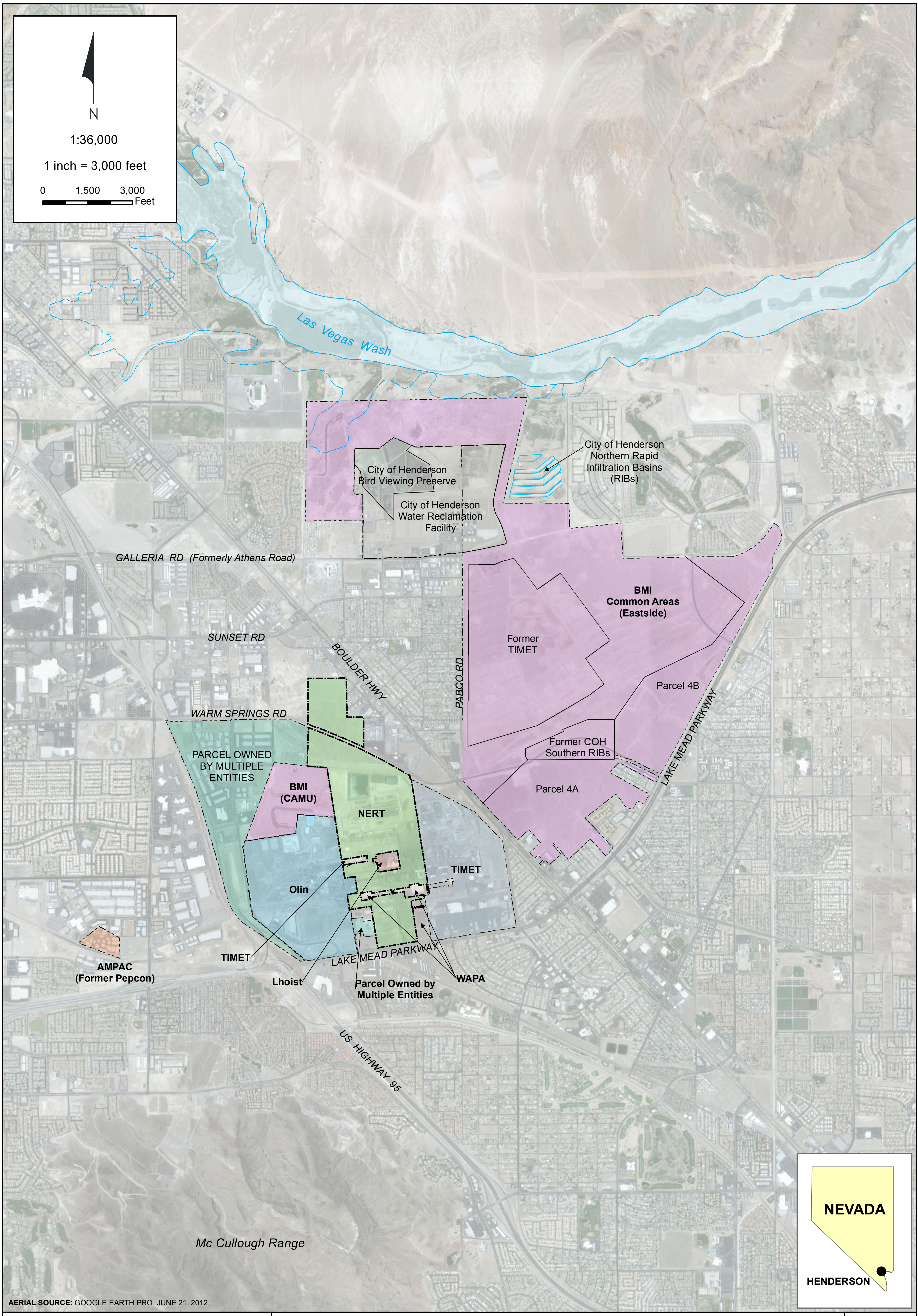
Study Area and Site Features

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure

2

Drafter: EA/RS Date: 3/6/2013 Contract Number: 21-32100GA Approved by: Revised:



AERIAL SOURCE: GOOGLE EARTH PRO. JUNE 21, 2012.

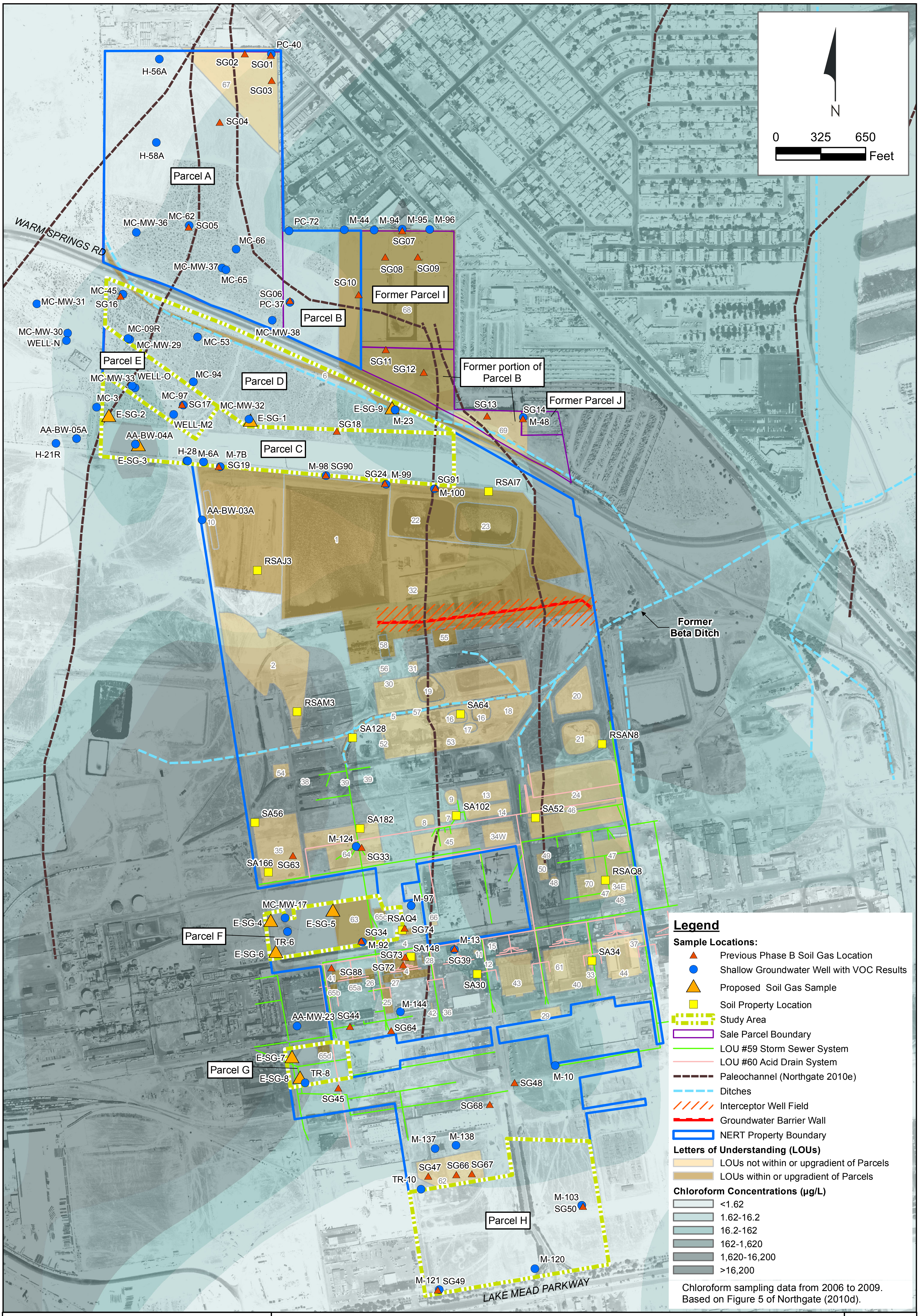
Path: H:\LePetomane\NERT\GWM\Annual Performance Reports\2012 Annual\Figures\StudyAreaMap.mxd

ENVIRON
2200 Powell St., Suite 700, Emeryville, CA 94608

Surrounding Facilities
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
3

Drafter: RS Date: 3/6/2013 Contract Number: 21-32100GA Approved by: Revised:



ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

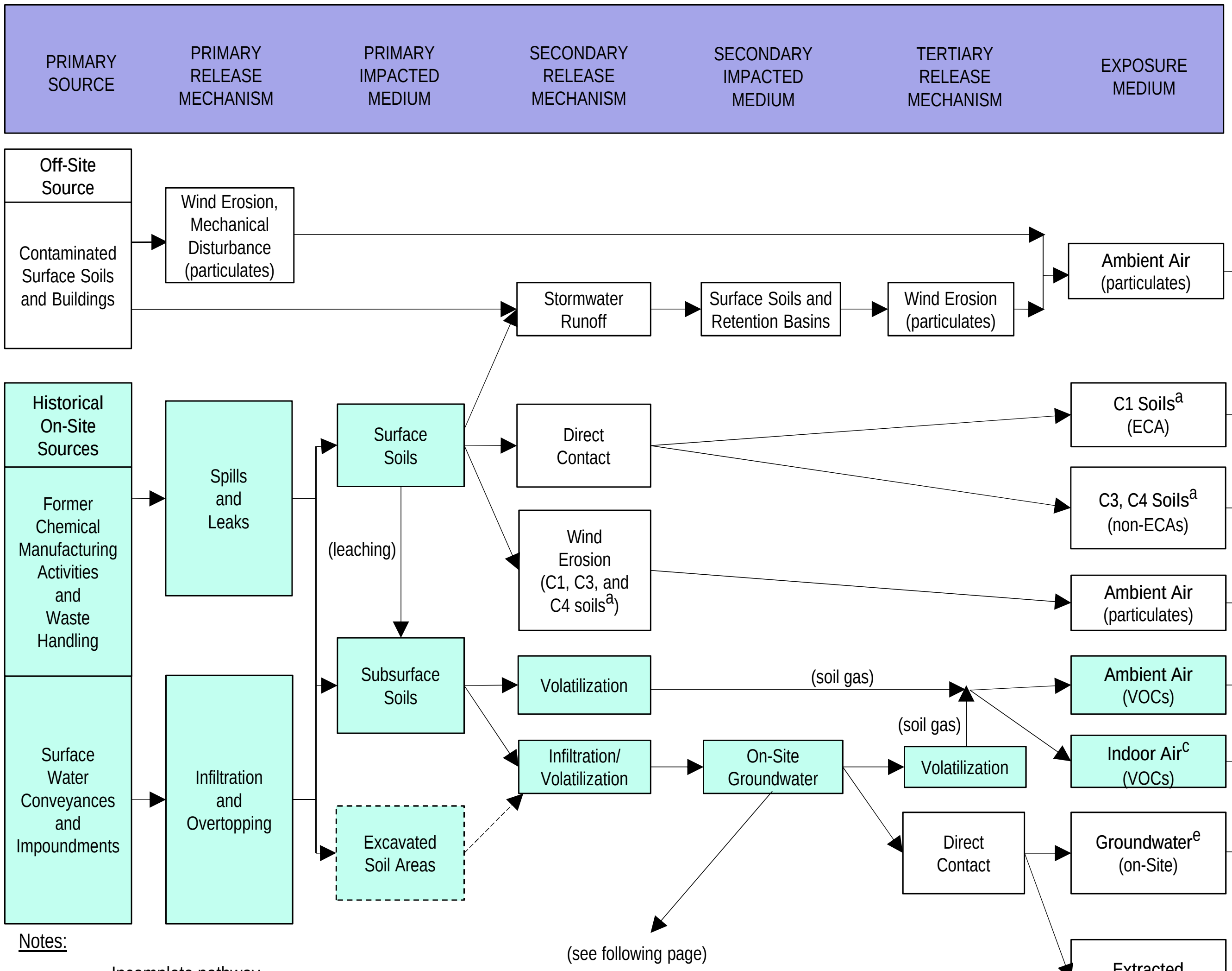
Soil Gas, Groundwater, and Soil Property Sampling Locations

Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
4

Drafter: EA/RS Date: 3/7/2013 Contract Number: 21-32100GA Approved by: Revised:

Path: H:\LePetomane\NERT\VI Risk Assessment\GIS\Maps\Fig4_SG+GW+SoilProps_SampleLocsFINAL.mxd



EXPOSURE MEDIUM	EXPOSURE ROUTE	CURRENT/FUTURE RECEPTOR			
		On-site			Off-site
		Short-term Construction Worker	Outdoor Worker	Indoor Worker	Resident
Ambient Air (particulates)	Inhalation	✓	✓	✓	○
C1 Soils[a] (ECA)	Ingestion Dermal	SMP	SMP	SMP	--
C3, C4 Soils[a] (non-ECAs)	Ingestion	✓	✓	✓	--
	Dermal	✓	✓	○[b]	--
Ambient Air (particulates)	Inhalation	✓	✓	✓	○
Ambient Air (VOCs)	Inhalation	○[d]	○[d]	--	○
Indoor Air[c] (VOCs)	Inhalation	--	--	✓	--
Groundwater[e] (on-Site)	Ingestion	--	--	--	--
	Dermal	--	--	--	--
Extracted Groundwater[f]	Inhalation	--	OSHA[f]	--	--
	Ingestion	--	OSHA[f]	--	--
	Dermal	--	OSHA[f]	--	--

Notes:

--	Incomplete pathway
✓	Complete or potentially complete exposure pathway
○	Complete, but negligible exposure pathway; pathway will be discussed qualitatively.
ECA	Excavation Control Area
SMP	Potential exposures (direct-contact pathways) will be managed through the Site Management Plan (SMP).

ENVIRON

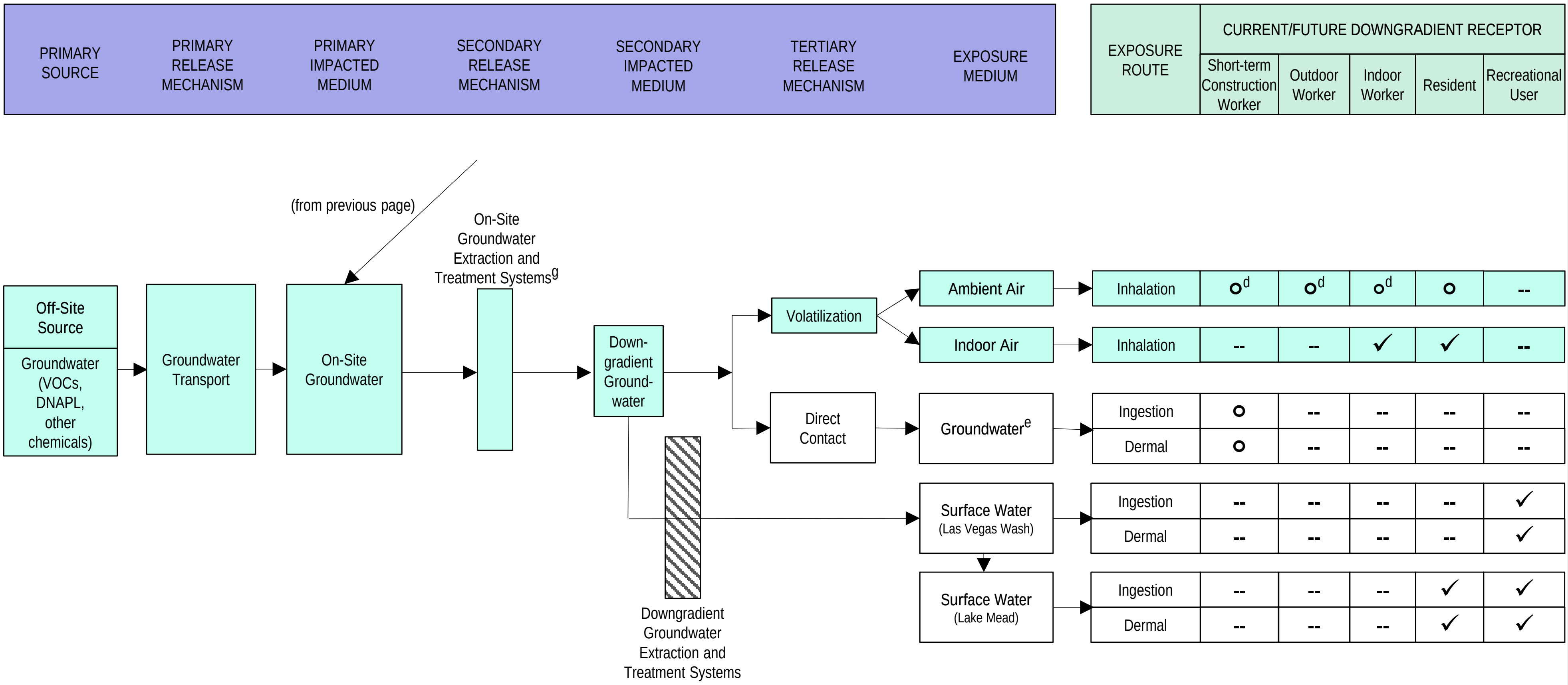
2200 Powell St., Suite 700, Emeryville, CA 94608

Conceptual Site Model for the Site and Study Area (Highlighted Portion)
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5

Drafter: EL Date: 3/18/2013 Contract Number: 21-32100GA Approved by: Revised:

H:\LePetomane\NERT\VI Risk Assessment\HRA Work Plan\Figures\Fig5_ParcelsCSM



EXPOSURE MEDIUM	EXPOSURE ROUTE	CURRENT/FUTURE DOWNGRADIENT RECEPTOR				
		Short-term Construction Worker	Outdoor Worker	Indoor Worker	Resident	Recreational User
Ambient Air	Inhalation	○[d]	○[d]	○[d]	○	--
Indoor Air	Inhalation	--	--	✓	✓	--
Groundwater[e]	Ingestion	○	--	--	--	--
	Dermal	○	--	--	--	--
Surface Water (Las Vegas Wash)	Ingestion	--	--	--	--	✓
	Dermal	--	--	--	--	✓
Surface Water (Lake Mead)	Ingestion	--	--	--	✓	✓
	Dermal	--	--	--	✓	✓

Notes:

--	Incomplete pathway
✓	Complete or potentially complete exposure pathway
○	Complete, but negligible exposure pathway; pathway will be discussed qualitatively.

ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Conceptual Site Model for the Site and Study Area (Highlighted Portion)
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5

Drafter: EL Date: 3/18/2013 Contract Number: 21-32100GA Approved by: Revised:

H:\LePetomane\NERT\VI Risk Assessment\HRA Work Plan\Figures\Fig5_ParcelsCSM

Note:

This CSM, is based off of the preliminary CSM submitted as part of the Remedial Investigation and Feasibility Study (RI/FS) Work Plan (ENVIRON 2012d) for the entire Site. Highlighted portions of this CSM indicate that this component of the CSM applies to Parcels A, B, C, D, F, G, and H, while the portions not highlighted apply to the remainder of the Site. The preliminary CSM, including the identification of sources, release mechanisms, exposure media, exposure routes, and receptors is based on current understanding of on-site and off-site environmental conditions. The CSM will be revised, as appropriate, based on further evaluation of available on-site and off-site characterization data and additional environmental data collected during the RI.

EXPLANATION:

a	C1, C3, C4 = Category 1, 3, and 4 soils, where C1 = soils 0 – 10 feet bgs in ECAs; C3 = soils 0 – 10 feet bgs with concentrations >BCLs; C4 = soils 0 – 10 feet bgs not previously sampled or available information considered inadequate. C2 soils (not shown in the CSM) are soils 0 – 10 feet bgs with concentrations <BCLs.
b	Not evaluated, consistent with USEPA 2002.
c	--Parcels A and B: For the vapor intrusion (indoor air) pathway, a separate screening-level HRA has been conducted for these Parcels, as presented in the *Revised Technical Memorandum: Screening-Level Indoor Air Health Risk Assessment* (Northgate 2010c; NDEP commented on May 23, 2011). --Parcels C, D, F, G, and H: This Work Plan addresses a sampling data gap noted by NDEP in their comment letter of August 7, 2012. This HRA will be prepared on a timeline separate from that for the Facility Area RI and Baseline HRA (BHRA). --Site-Wide Soil Gas HRA: Volatilization into indoor/ambient air was evaluated in the *Site-Wide Soil Gas Human Health Risk Assessment* (Northgate 2010d, not reviewed by NDEP).
d	Inhalation of VOCs will be higher for the indoor air pathway; inhalation of indoor air serves as an upper-bound estimate of potential exposures to VOCs in ambient air.
e	Groundwater is not and will not be used as a source of drinking water. Incidental ingestion and dermal contact with groundwater by on-site construction workers are not considered complete exposure pathways because depth to groundwater is >20 ft bgs. For off-site workers, depth to groundwater in some areas is <20 ft; however, the intermittent exposures of a construction worker to groundwater would be negligible.
f	Workers at the groundwater extraction and treatment facilities could potentially be exposed to contaminants in extracted groundwater. However, potential exposures of these workers will not be evaluated quantitatively in the BHRA as the workers are regulated by the Occupational Safety and Health Administration (OSHA) and a comprehensive worker health and safety plan (HASP) is in place to mitigate potential exposures.
g	There are two groundwater extraction treatment systems on-site. The groundwater barrier wall and extraction treatment system located north of the former Beta Ditch and upgradient of Parcels C and D treats for perchlorate and hexavalent chromium, and the Olin groundwater treatment system, a portion of which is located in Parcel E, treats for VOCs.
--	Incomplete pathway
✓	Complete or potentially complete exposure pathway and/or exposures evaluated for other receptors serve as an upper-bound estimate.
○	Complete, but negligible exposure pathway; pathway will be discussed qualitatively.
ECA	Excavation Control Area
SMP	Potential exposures (direct-contact pathways) will be managed through the Site Management Plan (SMP).

ENVIRON

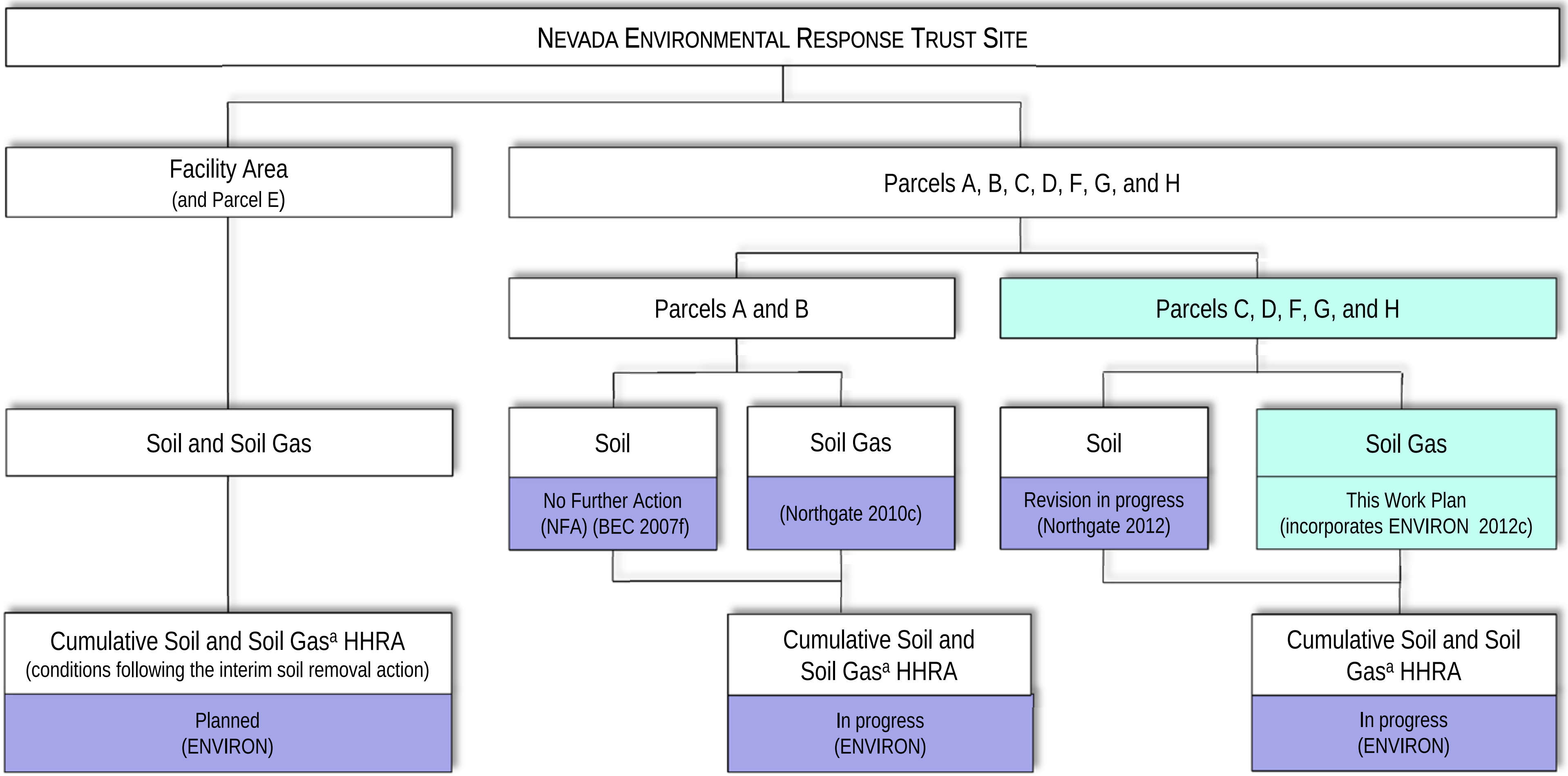
2200 Powell St., Suite 700, Emeryville, CA 94608

Conceptual Site Model for the Site and Study Area (Highlighted Portion)
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
5

Drafter: EL
Date: 3/18/2013
Contract Number: 21-32100GA
Approved by:
Revised:

H:\LePetomane\NERT\VI Risk Assessment\HRA Work Plan\Figures\Fig5_ParcelsCSM



Notes:

Green highlighted boxes are the subject of this Work Plan.

HHRA = Human Health Risk Assessment

[a] Risks for soil gas are being addressed through evaluation of the vapor intrusion pathway.

ENVIRON

2200 Powell St., Suite 700, Emeryville, CA 94608

Road Map of Site Risk Assessments
Nevada Environmental Response Trust Site, Henderson, Nevada

Figure
6

Drafter: EL | Date: 3/18/2013 | Contract Number: 21-32100GA | Approved by: | Revised

H:\LePetomane\NERT\VI Risk Assessment\HHRA Work Plan\Figures\Fig6_Roadmap

Appendix A

Soil Boring Logs

Geraghty & Miller, Inc.

WELL LOG

Well No.: H-23

Project: Stauffer Chemical Company

Date Completed: 1/31/80

Location: Henderson, Nevada

Description	Depth Below Land Surface (feet)
Sand, silty to clayey, grayish-brown very fine to very coarse (poorly sorted), and gravel, pebbles, cobbles and boulders, rounded to subangular; also with layers of caliche and caliche-cemented sand and gravel Notes: layers of cemented sand and gravel 27'-29', 31'-34', 40'-41'; organic odor in mud at 37'	0 - 42½
Clay, silty, to silt, clayey, light brown with traces of sand and gravel in matrix; also, with occasional thin layers of sand, reworked caliche, and caliche (Muddy Creek Formation) Notes: thin layers of white silt and clay (reworked caliche) at 54'-55', 87', 96'.	42½ - 101

LITHOLOGY LOG

FOR HENDERSON

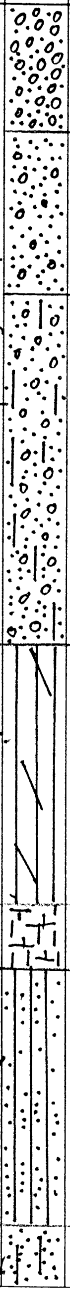
WELL NO. H-28

Description	Depth Below Land Surface (feet)
Sand, silty to clayey, grayish-brown very fine to very coarse (poorly sorted), and gravel, pebbles, cobbles and boulders, rounded to subangular; also with layers of caliche and caliche-cemented sand and gravel	0 - 44½
Clay, silty, to silt, clayey, light brown with traces of sand and gravel in matrix; also, with occasional thin layers of sand, reworked caliche, and caliche (Muddy Creek Formation)	44½ - 51

Data from Geraghty and Miller, Inc., October, 1980.

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMC LLC	LOCATION HENDERSON NV	BORING NUMBER M 106

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
4	0-4 Gravel, sdy, lt brn (5YR5/4). interbeds of sdy gravel and gravelly sd Sd 40-60%, vf-vcg, A-SR, Gravel 40-60, pea size to 1/2", volc, com caliche rinds on clasts. Sl. calcareous		GP							
9	4-9 SAND, gravelly, lt brn, com calichification vf-vc, A-SR, w/ 10-20% volc pea gravel.		SW							
15 20	9'-20' SAND, gravelly & silty, lt brn. 10-20% silt in matrix, sd, vf-vc, A-SR, 25-35% pea gravel, volc, up to 2". Mod-com caliche rinds		GM							DAMP @ 15'
25 28	20-28 SILT, lt brn (5YR5/4) w/ minor lt gry oran (10YR 8/4). Non-calcareous. Tr. vf-fg sd. 5-10% clay in matrix		ML							
30	28-30 SILT, calcareous, lt brn. com. v. thin parallel calcareous laminae		ML							
35 38	30-38 SILT, sdy and SAND, silty, interbedded, lt brn. SLT : SD = 70:30. vfg, A-SA sd, 20%, in SILT 30-40% SILT in sd		ML/SM							WET @ 30'
	38-42 SAND, silty lt brn, vfg w/ 30-40% silt		SM							

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
◧ AUGER
◨ ROCK CORE
■ THIN-WALLED TUBE
◧ CONTINUOUS SAMPLER
⧅ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▧ CLAY
▥ SILT
▒ SAND
⁘ GRAVEL
▧ SILTY CLAY
▧ CLAYEY SILT
▩ DEBRIS FILL
☐ HIGHLY ORGANIC (PEAT)
▧ SANDY CLAY
▧ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED
2-2-01

PAGE
1 of 2

DRILLING METHOD
PERCUSSION

DRILLED BY
LAYNE

LOGGED BY
ED KRISH

EXISTING GRADE ELEVATION (FT. AMSL)

LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMC LLC	LOCATION Henderson NV	BORING NUMBER M-106

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
	sl. calcareous		SM							
42	42-52 SILT, lt brn. w/ 10.% clay and 10% vfg sd 42-47 mod calcareous lt. gry oran (10YR 8/4)		ML				☒	50 - 51.5	100 %	
52	52-55 SILT, sdy, lt brn, 20-30% vfg sd.		ML							
55	55'-64' SAND, slty. lt brn and paleoran (10YR 7/2) where calcareous. vfg, A-SA w/ 30-40% silt & 5-10% clay 58-62 calcareous		SM							
64	64-75 SILT, sdy, lt brn, sl. calcareous. 20-25% vfg sd, 10% clay		ML				☒	70 - 71.5	100%	
75	75-78 SILT, sdy, 20% vfg, mottled v. pale oran (10YR 8/2) & yell gry (5Y 8/1)		ML							
78	Com. calc. nodules, tr. gyp. 10-15% clay in matrix									TD @ 78'

EXPLANATION

▼ Water Table (24 Hour)

▽ Water Table (Time of Boring)

PID Photoionization Detection (ppm)

NO. Identifies Sample by Number

TYPE Sample Collection Method

☒ SPLIT-BARREL	◧ AUGER	◨ ROCK CORE
■ THIN-WALLED TUBE	◧ CONTINUOUS SAMPLER	⧅ NO RECOVERY

DEPTH Depth Top and Bottom of Sample

REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▧ CLAY	▦ DEBRIS FILL
▥ SILT	≈ HIGHLY ORGANIC (PEAT)
▩ SAND	▧ SANDY CLAY
⁙ GRAVEL	▧ CLAYEY SAND
▧ SILTY CLAY	☐ ______
▥ CLAYEY SILT	☐ ______

DATE DRILLED 2-2-01

PAGE 2 of 2

DRILLING METHOD Percussion

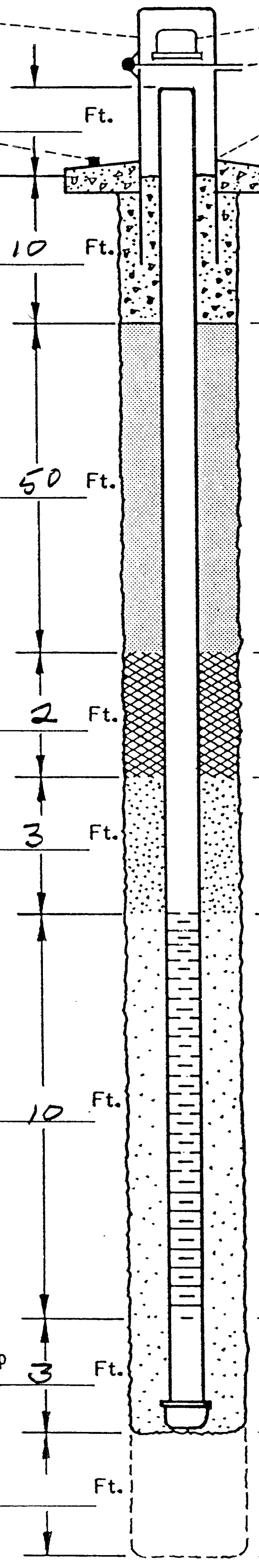
DRILLED BY LAYNE

LOGGED BY Ed Krish

EXISTING GRADE ELEVATION (FT. AMSL)

LOCATION OR GRID COORDINATES

KERR-McGEE CORPORATION
HYDROLOGY DEPARTMENT
MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe
Yes ☒ No ☐
Steel ☒ PVC ☐
____ Ft.

Surveying Pin ?
Yes ☐ No ☒

Concrete 10 Ft.

Cement/Bentonite Grout Mix
Yes ☒ No ☐
5.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder 50 Ft.
Other: ____

Bentonite Seal 2 Ft.
Pellets ☒ Slurry ☐

Filter Pack Above Screen 3 Ft.

FILTER PACK MATERIAL
Silica Sand ☐
Washed Sand ☒ 10 Ft.
Pea Gravel ☐
Other: ____
Sand Size 3-12

Dense Phase Sampling Cup 3 Ft.
Bottom Plug
Yes ☒ No ☐

Overdrilled Material Backfill ____ Ft.
Grout ☐ Sand ☒
Caved Material ☐
Other: ____

DEPTH BELOW GRADE	DEPTH FROM TOP OF CASING
10	
60	
62	
65	
75	
78	

Casing Cap Vent ? Yes ☒ No ☐
Lock ? Yes ☐ No ☒
Weep Hole ? Yes ☐ No ☒
Concrete Pad ____ Ft. x ____ Ft. x ____ Inches

DRILLING INFORMATION:

1. Borehole Diameter= 9 Inches.
2. Were Drilling Additives Used ? Yes ☐ No ☒
   Revert ☐ Bentonite ☐ Water ☐
   Solid Auger ☐ Hollow Stem Auger ☐
3. Was Outer Steel Casing Used ? Yes ☐ No ☒
   Depth= ____ to ____ Feet.
4. Borehole Diameter for Outer Casing ____ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC ☒ Galvanized ☐ Teflon ☐ Stainless ☐ Other ____
2. Type of Casing Joints: Screw-Couple ☒ Glue-Couple ☐ Other ____
3. Type of Well Screen: PVC ☒ Galvanized ☐ Stainless ☐ Teflon ☐ Other ____
4. Diameter of Casing and Well Screen:
   Casing 2 Inches, Screen 2 Inches.
5. Slot Size of Screen: 0.020
6. Type of Screen Perforation: Factory Slotted ☒ Hacksaw ☐ Drilled ☐ Other ____
7. Installed Protector Pipe w/Lock: Yes ☒ No ☐

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing ☐ Pumping ☒
   Air Surging (Air or Nitrogen) ☐ Other ____
2. Time Spent on Well Development ?
   ____/____ Minutes/Hours
3. Approximate Water Volume Removed ? ____ Gallons
4. Water Clarity Before Development ? Clear ☐ Turbid ☐ Opaque ☐
5. Water Clarity After Development ? Clear ☐ Turbid ☐ Opaque ☐
6. Did Water have Odor ? Yes ☐ No ☐
   If Yes, Describe ____
7. Did Water have any Color ? Yes ☐ No ☐
   If Yes, Describe ____

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling 20 Ft. Date 2-2-01
Before Development ____ Ft. Date ____
After Development ____ Ft. Date ____

Driller/Firm LAYNE
Drill Rig Type AP-1000
Date Installed 2-2-01
Drill Crew PERRY
Well No. M-106
Kerr-McGee Hydrologist Ed Krish

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMC LLC	LOCATION HENDERSON, NV	BORING NUMBER M107

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	SOIL SAMPLE TYPE	SOIL SAMPLE DEPTH	SOIL SAMPLE REC.	REMARKS OR FIELD OBSERVATIONS
	TD 57' M107 is 10' S of M106. SEE M106 lith log for description									

EXPLANATION

▼ Water Table (24 Hour)

▽ Water Table (Time of Boring)

PID Photoionization Detection (ppm)

NO. Identifies Sample by Number

TYPE Sample Collection Method

☒ SPLIT-BARREL

▮ AUGER

▮ ROCK CORE

■ THIN-WALLED TUBE

▮ CONTINUOUS SAMPLER

◸ NO RECOVERY

DEPTH Depth Top and Bottom of Sample

REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

- ▨ CLAY
- ▥ SILT
- ░ SAND
- ⁘ GRAVEL
- ▨ SILTY CLAY
- ▨ CLAYEY SILT
- ▩ DEBRIS FILL
- ≈ HIGHLY ORGANIC (PEAT)
- ▨ SANDY CLAY
- ▨ CLAYEY SAND
- ☐ ______
- ☐ ______

DATE DRILLED 2-2-01

PAGE 1 of 1

DRILLING METHOD PERCUSSION

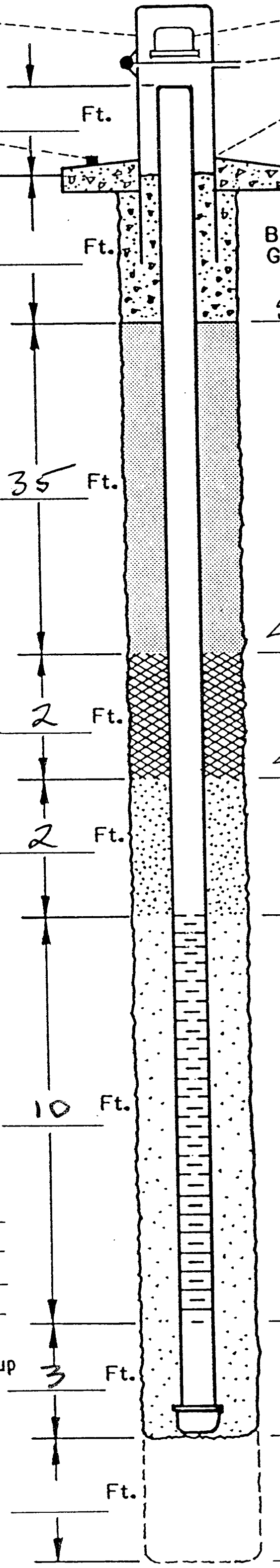
DRILLED BY LAYNE

LOGGED BY Ed Krish

EXISTING GRADE ELEVATION (FT. AMSL)

LOCATION OR GRID COORDINATES

KERR-McGEE CORPORATION
HYDROLOGY DEPARTMENT
MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe
Yes ☒ No ☐
Steel ☒ PVC ☐
____ Ft.
Surveying Pin ?
Yes ☐ No ☒

Casing Cap Vent ? Yes ☒ No ☐
Lock ? Yes ☒ No ☐
Weep Hole ? Yes ☐ No ☒
Concrete Pad ____ Ft. x ____ Ft. x ____ Inches

Concrete ____ Ft.

Cement/Bentonite Grout Mix
Yes ☒ No ☐
5.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder
35 Ft.
Other: ____

Bentonite Seal
2 Ft.
Pellets ☒ Slurry ☐

Filter Pack Above Screen
2 Ft.

FILTER PACK MATERIAL
Silica Sand ☐
Washed Sand ☒
10 Ft.
Pea Gravel ☐
Other: ____
Sand Size 3-12

Dense Phase Sampling Cup
3 Ft.
Bottom Plug
Yes ☒ No ☐

Overdrilled Material Backfill
____ Ft.
Grout ☐ Sand ☒
Caved Material ☐
Other: ____

DEPTH BELOW GRADE	DEPTH FROM TOP OF CASING
5	
40	
42	
44	
54	
57	

DRILLING INFORMATION:

1. Borehole Diameter= 9 Inches.
2. Were Drilling Additives Used ? Yes ☐ No ☒
   Revert ☐ Bentonite ☐ Water ☐
   Solid Auger ☐ Hollow Stem Auger ☐
3. Was Outer Steel Casing Used ? Yes ☐ No ☒
   Depth= ____ to ____ Feet.
4. Borehole Diameter for Outer Casing ____ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC ☒ Galvanized ☐ Teflon ☐
   Stainless ☐ Other ____
2. Type of Casing Joints: Screw-Couple ☒ Glue-Couple ☐ Other ____
3. Type of Well Screen: PVC ☒ Galvanized ☐
   Stainless ☐ Teflon ☐ Other ____
4. Diameter of Casing and Well Screen:
   Casing 2 Inches, Screen 2 Inches.
5. Slot Size of Screen: 0.020
6. Type of Screen Perforation: Factory Slotted ☒
   Hacksaw ☐ Drilled ☐ Other ____
7. Installed Protector Pipe w/Lock: Yes ☒ No ☐

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing ☐ Pumping ☒
   Air Surging (Air or Nitrogen) ☐ Other ____
2. Time Spent on Well Development ?
   ____/____ Minutes/Hours
3. Approximate Water Volume Removed ? ____ Gallons
4. Water Clarity Before Development ? Clear ☐
   Turbid ☐ Opaque ☐
5. Water Clarity After Development ? Clear ☐
   Turbid ☐ Opaque ☐
6. Did Water have Odor ? Yes ☐ No ☐
   If Yes, Describe ____
7. Did Water have any Color ? Yes ☐ No ☐
   If Yes , Describe ____

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)
During Drilling 20 Ft. Date 2-2-01
Before Development 19.47 Ft. Date 2-3-01
After Development ____ Ft. Date ____

Driller/Firm LAYNE
Drill Rig Type AP-1000
Date Installed 2-2-01
Drill Crew Perry
Well No. M-107
Kerr-McGee Hydrologist Ed Krish

ENSR

1220 Avenida Acaso
Camarillo, California 93012
(805) 388-3775

Client:	Tronox LLC
Project Number:	04020-023-151
Site Location:	Henderson, NV
Coordinates:	26715198.289 N , 828917.057 E NAD83
Elevation:	1877.98 ft, msl
Drilling Method:	Sonic - Continuous Core
Sample Type(s):	Split Spoon/Core
Boring Diameter:	7-inch
Weather:	Cold, cloudy, 30s to 40s
Logged By:	Ed Krish
Date/Time Started:	3/11/06 7:30 am
Drilling Contractor:	Prosonic
Ground Elevation:	
Date/Time Finished:	3/11/06

Boring No. M-117

Sheet: 1 of 2
Monitoring Well Installed: Yes
Screened Interval: 130-150 feet
Depth of Boring: 157 feet
Water Level: 79.4 feet

Depth (ft)	Sample ID	Sample Depth (ft)	Blows per 6"	Recovery (feet)	Headspace (ppm)	U.S.C.S	MATERIAL IDENTIFICATION, color, description of fine grained material (silt and clay) description of coarse grained material (sand and gravel), structural or mineralogical features, density or stiffness, moisture content, odors or staining.	Depth (Ft.)
	M-117-0.5	☒		10		SM (GM)	**ALLUVIUM:** SILTY/GRAVELY SAND, with silty gravel lenses present, pale yellow brown (10YR 6/4), 10-20% silt with trace clay, 60 to 80% sand (very fine- to very coarse-grained, angular to subrounded), 10 to 30% gravel to 2" maximum, (commonly 1/8" to 3/4", subangular to angular, volcanic to basaltic, well graded), dry, no unusual odor or staining.	
	M-117-5	☒			0.0			
10	M-117-10	☒		10	0.0			
20	M-117-20 M-117-20D	☒		10	0.0			
							From 27 to 40 ft: brown (5YR 5/4).	
30	M-117-30	☒		10	0.0			
40	M-117-40	☒		10	0.0			40 ft
						GM	**ALLUVIUM:** SANDY SILTY GRAVEL, brown (5YR 5/4), 25% silt with trace clay, 35% sand (very fine- to very coarse-grained, angular to subrounded), 40% gravel to 2 1/2" maximum (commonly 1/8" to 1", angular to subangular), dry, no unusual odor or staining. From 46 to 47 ft: caliche zone at contact with Muddy Creek Fm - First coarse-grained facies at 47'.	47 ft
50	M-117-50	☒		10	0.0	SM (GM)	**MUDDY CREEK FORMATION - FIRST COARSE-GRAINED FACIES:** SILTY SAND and GRAVELLY SAND, with silty gravel lenses present, brown (5YR 5/4 & 5/6), 20 to 45% silt with trace clay, 50 to 70% sand (very fine- to very coarse-grained, angular to subrounded), 0 to 20% gravel to 1" maximum (commonly 1/8" to 3/4", angular to subangular), dry, no unusual odors or staining.	
60	M-117-60	☒		20	0.0			
70	M-117-70	☒			0.0		Damp at 70' From 72 to 74 ft: caliche zone, nodular.	
80	M-117-80 M-117-80D	☒		17	0.0		From 79 to 85 ft: common caliche nodules to 1/2". Wet at 80' From 85 to 100 ft: Sp. (?) caliche nodules to 1/2".	▼
90								
				20				
100								

Notes:

Checked by SWB Date: 8/10/06

ENSR 1220 Avenida Acaso Camarillo, California 93012 (805) 388-3775	*Client:* Tronox LLC *Project Number:* 04020-023-151 *Site Location:* Henderson, NV	**Boring No. M-118**
	Coordinates: 26715068.012 N , 828036.397 E ; NAD 83 *Elevation:* 1874.53 feet	*Sheet:* 1 of 2
	Drilling Method: Sonic - Continuous Core	*Monitoring Well Installed:* Yes
	Sample Type(s): Split Spoon/Core *Boring Diameter:* 7-inch	*Screened Interval:* 138-158 feet
Weather: Sunny, windy, 50s F	*Logged By:* Ed Krish *Date/Time Started:* 3/8/06 11:45 am	*Depth of Boring:* 163 feet
Drilling Contractor: Prosonic	*Ground Elevation:* *Date/Time Finished:* 3/8/06 5:05 pm	*Water Level:*

Depth (ft)	Sample ID	Sample Depth (ft)	Blows per 6"	Recovery (feet)	Headspace (ppm)	U.S.C.S	MATERIAL IDENTIFICATION, color, description of fine grained material (silt and clay) description of coarse grained material (sand and gravel), structural or mineralogical features, density or stiffness, moisture content, odors or staining.	Depth (Ft.)
	M-118-0.5	☒		10		SM (GM)	**ALLUVIUM:** SILTY SAND and GRAVELY SAND, with silty gravel lenses present, brown (5YR 5/5), 15 to 20% silt, 65 to 70% sand (very fine- to very-coarse-grained, angular to subangular), 10 to 20% volcanic gravel to 4" maximum (commonly granule to pea gravel, 18" to 1/4", angular to subangular), dry, no unusual odor or staining.	
	M-118-5	☒			2.4			
10	M-118-10	☒		10	12.8			
20	M-118-20 M-118-20D	☒		10	5.1			
30	M-118-30	☒		10	2.9			
40	M-118-40	☒		10	4.7		From 40 to 51 ft: very pale orange (10YR 8/2) with common caliche nodules and soft cement in sand matrix, nodules to 2 1/2".	
50	M-118-50	☒		10			From 51 to 52 ft: Silty Sand, very fine- to fine-grained, common caliche nodules, possibly reworked Muddy Creek Fm.	52 ft
						SM (GM)	**MUDDY CREEK FM - FIRST COARSE-GRAINED FACIES:** SILTY SAND and SILTY/GRAVELY SAND, with silty gravel lenses present, brown (5YR 5/5), 10 to 35% silt, 60 to 80% sand (very fine- to very coarse-grained, angular to subrounded), 0 to 15% granules and pea gravel (1/8" to 3/8", angular to subangular), interbedded, dry, no unusual odors or staining. From 52 to 62 ft: Local zones with caliche nodules (1/8" to 1" diameter).	
60	M-118-60	☒		7	0.4			
				13				
70							Damp at 75'	
							From 77 to 80 ft: Local zones with caliche nodules (1/8" to 1" diameter).	
80	M-118-80	☒		7			Wet from 80'	
							From 83 to 87 ft: Local zones with caliche nodules (1/8" to 1" diameter).	
				13				
90							From 92 to 102 ft: Local zones with caliche nodules (1/8" to 1" diameter).	
				13				
100					3.4			

Notes:

Checked by SWB Date: 8/10/06

ENSR

1220 Avenida Acaso
Camarillo, California 93012
(805) 388-3775

Client: Tronox LLC
Project Number: 04020-023-151
Site Location: Henderson, NV
Coordinates: 26715162.900 N, 828387.792 E, NAD 83 *Elevation:* 1875.81 ft, msl
Drilling Method: Sonic - Continuous Core
Sample Type(s): Split Spoon/Core *Boring Diameter:* 7-inch

Boring No. M-120

Sheet: 1 of 2
Monitoring Well Installed: Yes
Screened Interval: 80-100 feet
Weather: Windy, 40s to 58s F
Logged By: Ed Krish
Date/Time Started: 3/8/06 9:00 am
Depth of Boring: 107 feet
Drilling Contractor: Prosonic
Ground Elevation:
Date/Time Finished: 3/8/06
Water Level: 79.47

Depth (ft)	Sample ID	Sample Depth (ft)	Blows per 6"	Recovery (feet)	Headspace (ppm)	U.S.C.S	**MATERIAL IDENTIFICATION, color, description of fine grained material (silt and clay) description of coarse grained material (sand and gravel), structural or mineralogical features, density or stiffness, moisture content, odors or staining.**	Depth (Ft.)
	M-120-0.5	☒		7		SW/SP	**ALLUVIUM:** SAND, brown (5YR 5/4), 20% silt and clay, 60% sand (very fine- to fine-grained with common medium- to very coarse-grained sand, angular to subangular), 20% granules and gravel (fine-grained to 1/2", angular to subangular), gravelly, dry, no unusual odors or staining.	
	M-120-5	☒		3	0.0			
10	M-120-10	☒		12	1.0			
20	M-120-20	☒		10	1.8			21 ft
						GM	**ALLUVIUM:** SANDY GRAVEL, brown (5YR 5/4), 20% silt and clay, 30% sand (very fine- to very coarse-grained, angular to subangular), 50% gravel to 3 1/2" (mostly 1/8" to 1 1/2", angular to subangular, basaltic), dry.	26 ft
				3		SM	**ALLUVIUM:** SILTY SAND, brown (5YR 5/4), 25 to 35% silt, 75% sand (very fine- to fine-grained with minor medium to coarse-grained sand, angular to subangular), 0 to 5% granules and gravel (fine gravel to 1/4"), dry, no unusual odors or staining.	
30	M-120-30	☒		11	0.8		From 31 to 41 ft: moderate calcite cement.	
40	M-120-40 M-120-40D	☒		12	2.2			
							From 48 to 49 ft: caliche zone with nodules to 3 1/2".	
				12	1.6		Contact with Muddy Creek Fm at 49 ft	49 ft
50	M-120-50	☒				SC/SM (GM)	**MUDDY CREEK FM - FIRST COARSE-GRAINED FACIES:** SAND, with silty gravel lenses present, silty gravel lenses present and varying amounts of silt, clay and/or gravel, brown (5YR 5/4), 0 to 20% clay, 10 to 50% silt, 50 to 70% sand (very fine- to fine-grained, with medium- to very coarse-grained sand, angular to subangular), 0 to 15% gravel (granules to fine gravel to 1", angular to subangular), dry.	
60	M-120-60	☒		7	0.8		From 49 to 57 ft: sand, silty or clayey. From 57 to 83 ft: sand, gravelly ± silt.	
				15				
70								
80	M-120-80	☒		7	1.8		Damp at 80' From 83 to 102 ft: sand, silty. Wet at 85'	▼
90				15				
100				8				

Notes:

Checked by SWB Date: 8/10/06

ENSR

1220 Avenida Acaso
Camarillo, California 93012
(805) 388-3775

Client: Tronox LLC
Project Number: 04020-023-151
Site Location: Henderson, NV
Coordinates: 26715001.237 N, 827694.571 E, NAD 83 *Elevation:* 1872.90 ft, msl
Drilling Method: Sonic
Sample Type(s): Split Spoon/Core *Boring Diameter:* 7-inch

Boring No. M-121

Sheet: 1 of 2
Monitoring Well Installed: Yes
Screened Interval: 77-97 feet
Depth of Boring: 107 feet
Water Level: 76.1

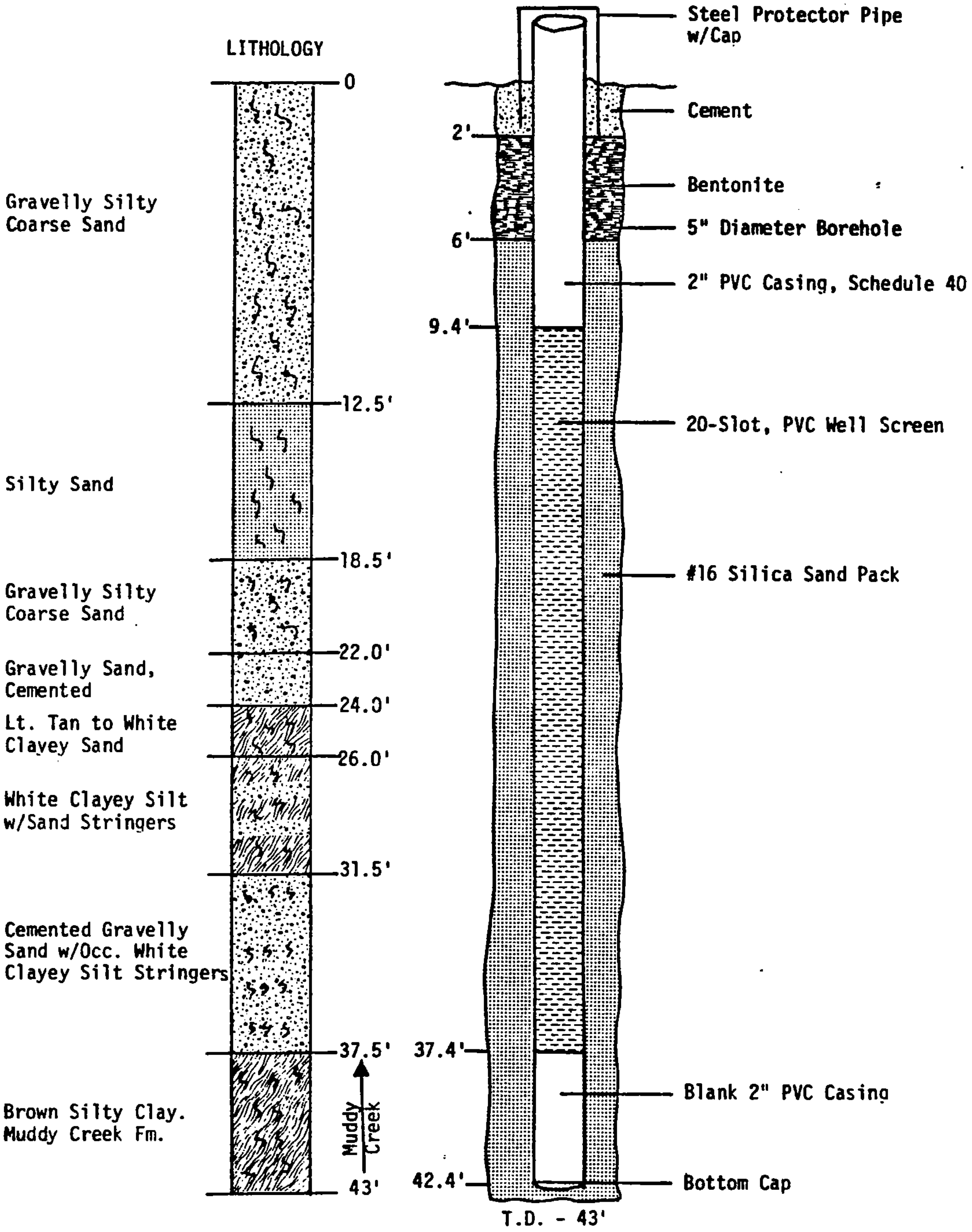
Weather: Windy, cold, 30s F
Logged By: Ed Krish
Date/Time Started: 3/10/06 7:30 am
Drilling Contractor: Prosonic
Ground Elevation:
Date/Time Finished: 3/10/06 1:00 pm

Depth (ft)	Sample ID	Sample Depth (ft)	Blows per 6"	Recovery (feet)	Headspace (ppm)	U.S.C.S	MATERIAL IDENTIFICATION, color, description of fine grained material (silt and clay) description of coarse grained material (sand and gravel), structural or mineralogical features, density or stiffness, moisture content, odors or staining.	Depth (Ft.)
	M-121-0.5	☒		10		SM/GM	**ALLUVIUM:** SILTY/GRAVELLY SAND, brown (5YR 5/4), 15% silt with trace clay, 60% sand (very fine- to fine-grained, angular to subangular), 25% volcanic gravel (commonly 1/8" to 3/4", angular to subangular), dry, no unusual odors or staining.	
	M-121-5	☒			0.0			
	M-121-5D							
10	M-121-10	☒		10	0.0			
20	M-121-20	☒		10	17.2			
30	M-121-30	☒		10	2.0			
40	M-121-40	☒		6	0.8		From 44 to 45ft: Silty Sand, 75% sand (very fine-grained sand with medium- to coarse-grained sand, angular to subangular), caliche zone with nodules to 4 1/2".	45 ft
				4				
				10	3.3	SM (GM)	**MUDDY CREEK FM - FIRST COARSE-GRAINED FACIES:** SILTY SAND and GRAVELLY SAND, with silty gravel lenses present, brown (5YR 5/5), locally very silty to 40% silt with trace clay, gravely zones with 5 to 15% gravel (granules and fine gravel to 1", commonly 1/8" to 1/4", angular to subangular), no unusual odors or staining.	
50	M-121-50	☒					From 45 to 52 ft: with 5% granules to 1/4".	
60	M-121-60	☒		10	89.6			
							From 63 to 67 ft: with 10% granules to 1/4".	
70					104.0			
				13			From 71 to 72 ft: with 5% granules to 1/8". Damp at 71'	
							From 77 to 79 ft: with 5% granules to 1/8".	▼
80	M-121-80	☒		17	0.0		From 80 to 82 ft: with 15% granules, fine gravel to 1". From 82 to 89 ft: with 5% granules to 1/8". Wet at 80'	
90							From 89 to 92 ft: with 10% granules to 1/4".	
				10			From 97 to 102 ft: with 5% granules to 1/8".	
100								

Notes:

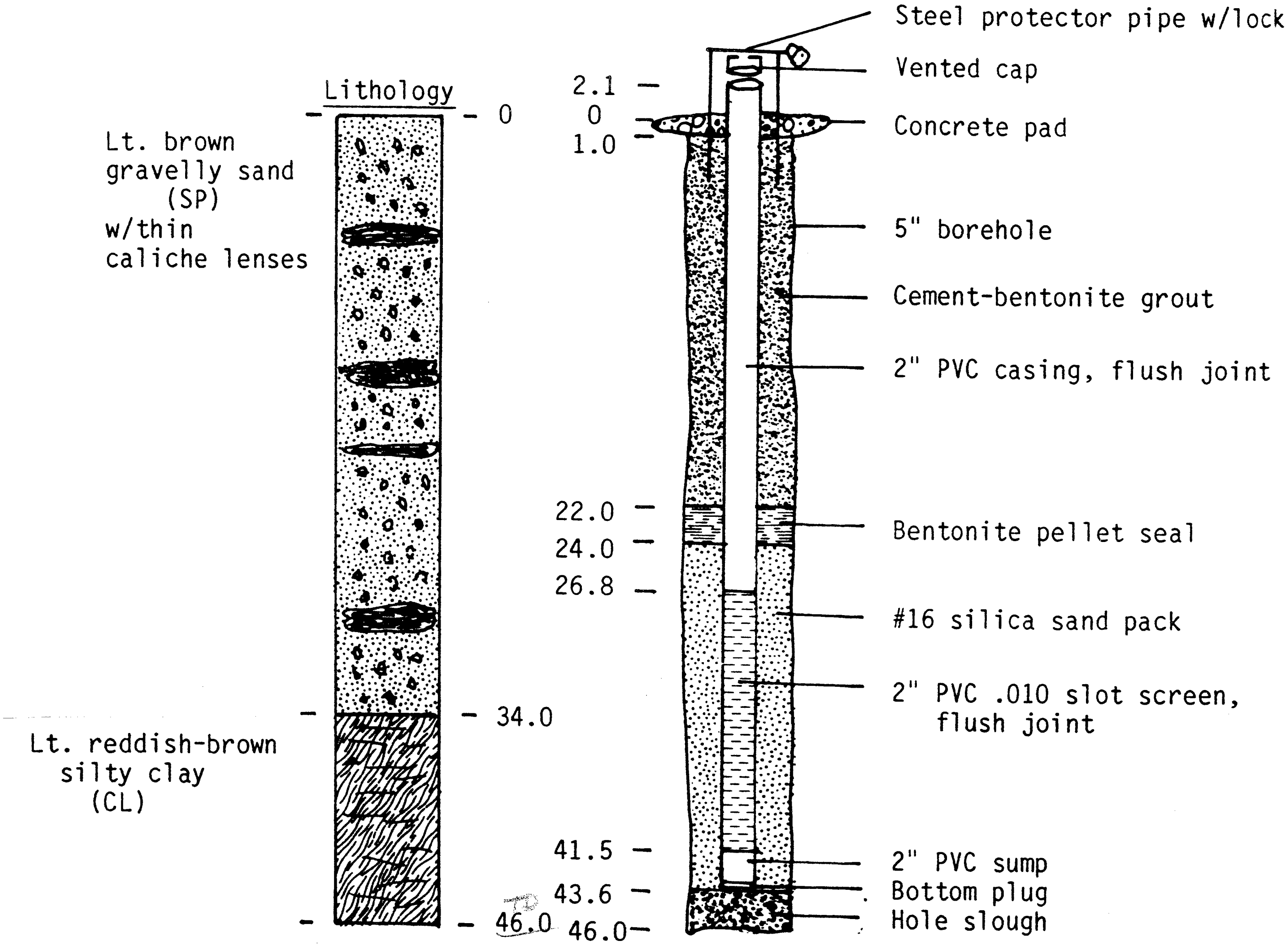
Checked by SWB Date: 8/10/09

WELL CONSTRUCTION DIAGRAM
MONITOR WELL M-23
HENDERSON FACILITY



Note: Drilled 8-11-83

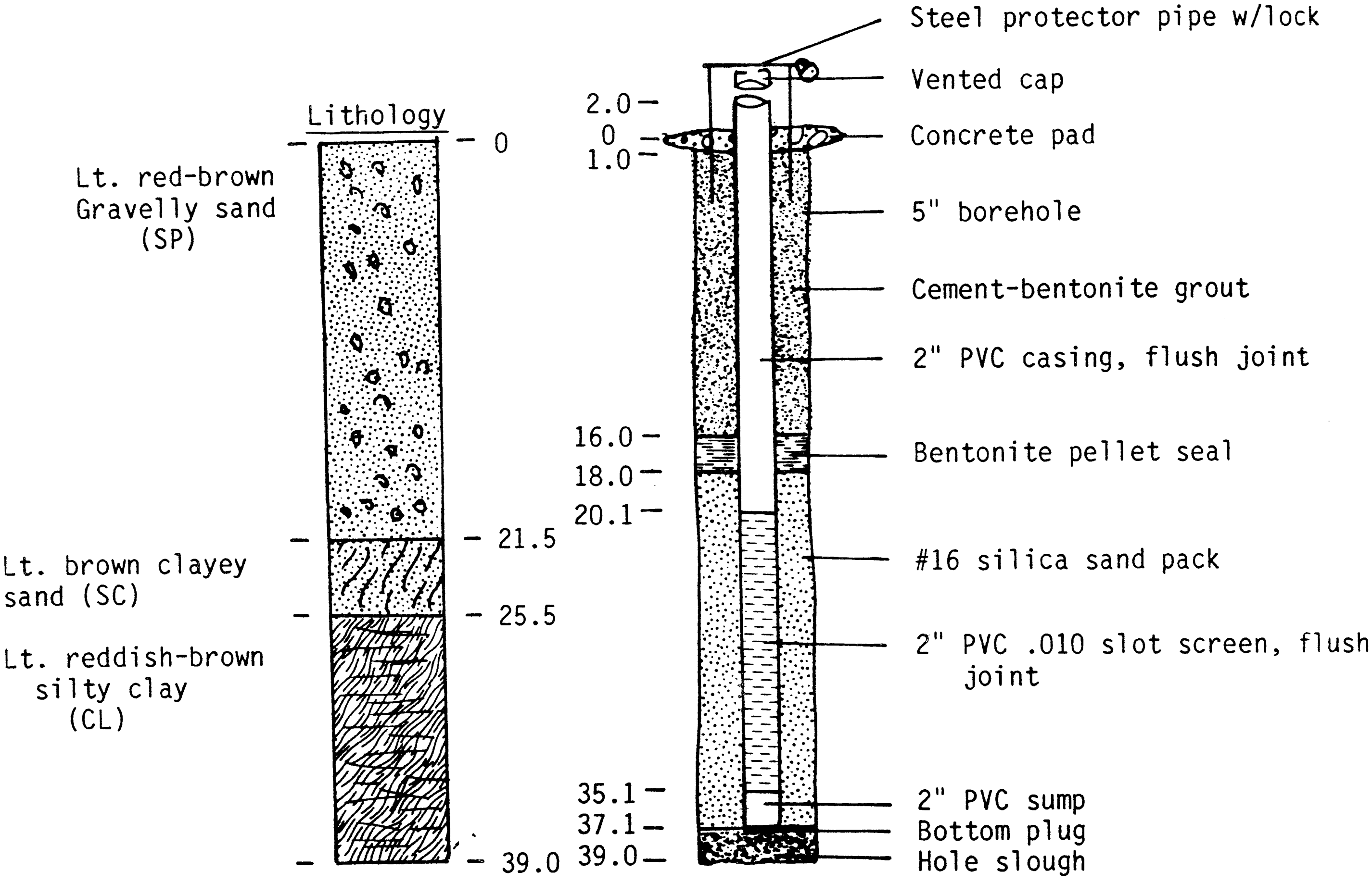
WELL CONSTRUCTION DIAGRAM
WELL M-6A
HENDERSON, NV



Date Drilled: 12-18-86
Drilled By: Mooney Drilling
Drilling Method: Rotary Wash
Logged By: W. M. Goodman, KM

WELL CONSTRUCTION DIAGRAM
WELL M-7A
HENDERSON, NV

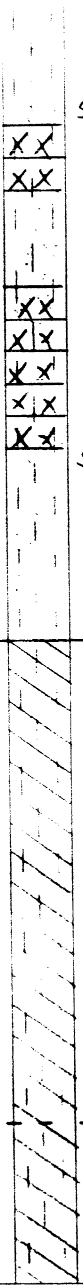
P - A



Date Drilled: 12-18-86
Drilled By: Mooney Drilling
Drilling Method: Rotory Wash,
Bentonite
Logged By: W. M. Goodman, KM

SOIL BORING LOG KM–5655-A

KERR-McGEE CORPORATION Hydrology Dept. Engineering Services	KM SUBSIDIARY CHEMICAL	LOCATION HENDERSON, NV.	BORING NUMBER M-92



DEPTH IN FEET	LITHOLOGIC DESCRIPTION	UNIFIED SOIL FIELD CLASS.	BLOWS PER FOOT	PID (ppm)	SOIL SAMPLE NO	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
	SILTY SAND, LT-MEDIUM BROWN, WELL GRADED, DRY TO SLIGHTLY MOIST	SM				▮			
5	CALICHE-CEMENTED GRAVEL ZONE @ 4-6'					▮			
10	SILTY SAND; FINE-COARSE GRAINED, CALICHE CEMENTED GRAVELLY ZONE @ 9-14'	SM				▮			EARTHY OR MUSTY ODOR NOTED DURING DRILLING
15	SILTY SAND AS ABOVE, BECOMING MODERATELY MOIST @ 18'					▮			
20	SILTY CLAY, LT. BROWN, SLI. TO MODERATELY MOIST, STIFF, OCC. FINE TO MED SAND GRAINS	CL				▮			
25						▮			
30						▮			
35	SILTY CLAY AS ABOVE; SATURATED, MOD. PLASTIC	▽				▮			
40									

EXPLANATION

▼ Water Table (24 Hour)

▽ Water Table (Time of Boring)

PID Photoionization Detection (ppm)

NO. Identifies Sample by Number

TYPE Sample Collection Method

SPLIT-BARREL

AUGER

ROCK CORE

THIN WALLED TUBE

CONTINUOUS SAMPLER

NO RECOVERY

DEPTH Depth Top and Bottom of Sample

REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY

DEBRIS FILL

SILT

HIGHLY ORGANIC PEAT

SAND

SANDY CLAY

GRAVEL

CLAYEY SAND

SILTY CLAY

X CALICHE

CLAYEY SILT

DATE DRILLED 5/4-5/93	PAGE 1 of 2

DRILLING METHOD: HOLLOW STEM AUGER

DRILLED BY: WESTERN TECH.

LOGGED BY: — REED

EXISTING GRADE ELEVATION (FT AMSL): ~ 1800'

LOCATION OR GRID COORDINATES:

SOIL BORING LOG KM–5655-A

KERR-McGEE CORPORATION Hydrology Dept. Engineering Services	KM SUBSIDIARY CHEMICAL	LOCATION HENDERSON, NV.	BORING NUMBER M-93

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER FOOT	PID (ppm)	SOIL SAMPLE NO.	SOIL SAMPLE TYPE	SOIL SAMPLE DEPTH	SOIL SAMPLE REC.	REMARKS OR FIELD OBSERVATIONS
	GRAVEL FILL									
1	SILTY SAND, LT TO MED. BROWN, DRY, AND GRAVEL 1-6'		SM		0 0					
5	SILTY SAND AS ABOVE, GRAVEL AND COBBLES COMMON FROM 6-10'				0 0 0					NO HYDROCARBON ODOR
10	SILTY SAND AS ABOVE. BECOMING SLI. MOIST; CALICHE-CEMENTED GRAVELLY ZONE FROM 14-15'	XX			0 0					
15		XX	SM		0 0 0					
20					0 0					
23.5	SILTY CLAY, LT. BROWN, SLI. MOIST, STIFF, SAND GRAINS COMMON				0 0					
25			CL		0 0 0					
30	SILTY CLAY SATURATED @ 33'				0 0 0					NO HYDROCARBON ODOR
33			∇							
35					0 0 0 0 0					
40										

EXPLANATION

▼ Water Table (24 Hour)
∇ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
▧ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY
▥ SILT
▩ SAND
⁙ GRAVEL
▧ SILTY CLAY
▧ CLAYEY SILT
▩ DEBRIS FILL
☰ HIGHLY ORGANIC (PEAT)
▧ SANDY CLAY
▧ CLAYEY SAND
☒ CALICHE
☐ ______

DATE DRILLED 5/5/93	PAGE 1 of 2
DRILLING METHOD HOLLOW STEM AUGER	
DRILLED BY WESTERN TECH.	
LOGGED BY T. REED	
EXISTING GRADE ELEVATION (FT AMSL) ~1798'	
LOCATION OR GRID COORDINATES	

P-A 6/03

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMC LLC	LOCATION HENDERSON, NV	BORING NUMBER PC 102

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6'	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
	0-8 GRAVEL, gry brn, sl. sdy (10-15) m-vc & sl slty (10%). Grav. up to 4", ave 1/2"		GP							start 11AM. finish 11:30 am wet @ 0' WTR @ 2'
8	8-14 slty SAND & slty sdy GRAVEL, interbedded 8-9 brn, slty (40%) vf-f sd 9-11 brn slty sdy gravel, 30% silt, 20% f-c sd, 50% pea gravel to 1" 11-14 brn, slty vf-f sd		SM/GM							dry 8-9' wet @ 9'
14			ML/SM							
19	14-19 sdy SILT and slty SAND, interbedded, brn to ltgrnish brn. vf-f sd		GW							
22	19-22 sdy GRAVEL, gry brn, 30-40% vf-vc, A-SR sd in gran./pea gravel, SR-R, to 1/2" (volc)		SM							
24	22-24 slty SAND, brn 30% silt in vf-fg sd		GM/SM							
28	24-28 slty sdy GRAVEL, dec silt from 30% @ 24 to 15% @ 28'. brn, f-m w/ cg SR sd in pea grav/gran to 1/2-3/4" 28-36 sdy GRAVEL, gry brn & whtish. Contains abu ls. gravels. 20-30% f-vc; SR sd in gran/pea gravel ave 1" w/ up to 6" locally		GW							
36			GM/SM							
39			GW							

EXPLANATION

▼ Water Table (24 Hour)

▽ Water Table (Time of Boring)

PID Photoionization Detection (ppm)

NO. Identifies Sample by Number

TYPE Sample Collection Method

☒ SPLIT-BARREL

◧ AUGER

◧ ROCK CORE

■ THIN-WALLED TUBE

◧ CONTINUOUS SAMPLER

◪ NO RECOVERY

DEPTH Depth Top and Bottom of Sample

REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY	▩ DEBRIS FILL
▥ SILT	≋ HIGHLY ORGANIC (PEAT)
▒ SAND	▨ SANDY CLAY
⁙ GRAVEL	▨ CLAYEY SAND
▨ SILTY CLAY	☐ ______
▥ CLAYEY SILT	☐ ______

DATE DRILLED 8-17-00

PAGE 1 of 2

DRILLING METHOD PERCUSSION

DRILLED BY LAYNE

LOGGED BY ED KRISH

EXISTING GRADE ELEVATION (FT. AMSL)

LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCC	LOCATION Henderson, NV	BORING NUMBER PC 36

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	SOIL SAMPLE TYPE	SOIL SAMPLE DEPTH	SOIL SAMPLE REC.	REMARKS OR FIELD OBSERVATIONS
5 10	SAND, gravelly, f-m w/c-vc 0-12.5' mod yell brn (10YR5/4) f-m sd (w/minor c-vc) and minor gravel (10-20% of 1/4"-1 1/4"). Dry. Contains 10-15% silt. Minor caliche cement @12.5 damp		SW/ GW							
12.5 15	SAND, silty & gravelly, f-m w/c-vc 12.5'-15' 15-20% 1/4"-1/2" grav and 25-30% silt.		GM							wet @ 15' ▽
20 25	SAND, silty, mod yell brn, SA-SR, 30% silt, no gravel f-m w/c grained		SM							Water sample taken when hole 30' deep
27	SAND, mod yell brn, vf-f w/m, compact, w/20% silt		SP/ SM				☒	29-30	100	
30.5 35	SAND, silty, gravelly, f-m w/c-vc and 10-15% 1/4" gravel. 25-30% silt. Minor caliche cement		SM							

EXPLANATION

▼ Water Table (24 Hour)

▽ Water Table (Time of Boring)

PID Photoionization Detection (ppm)

NO. Identifies Sample by Number

TYPE Sample Collection Method

☒ SPLIT-BARREL

▯ AUGER

▯ ROCK CORE

■ THIN-WALLED TUBE

▯ CONTINUOUS SAMPLER

◿ NO RECOVERY

DEPTH Depth Top and Bottom of Sample

REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY	▩ DEBRIS FILL
▥ SILT	☐ HIGHLY ORGANIC (PEAT)
▦ SAND	▨ SANDY CLAY
⁘ GRAVEL	▨ CLAYEY SAND
▨ SILTY CLAY	☐ ______
▨ CLAYEY SILT	☐ ______

DATE DRILLED 4-27-98	PAGE 1 of 2

DRILLING METHOD
Auger

DRILLED BY
Weber

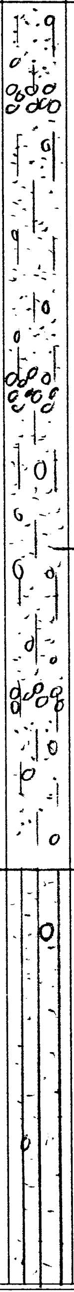
LOGGED BY
E.J. Krish

EXISTING GRADE ELEVATION (FT. AMSL)

LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCLLC	LOCATION HENDERSON, NV.	BORING NUMBER PC-37

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
	SAND / SILTY SAND; OCC. GRAVEL; LT. TAN-BROWN; WELL-GRADED; GRAVEL ZONE @ 3-4'									
5			SM							
10	SAND AS ABOVE; GRAVEL ZONE @ 12-13'									
15										
	— — — — — — —		▽							
	SAND AS ABOVE; GRAY-BROWN; GRAVEL ZONE @ 22'									
20										
25										
27	SANDY SILT; OCC. GRAVEL; LT. GRAY-BROWN; SATURATED									
30			ML							
35										

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
◸ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▧ CLAY
▥ SILT
▩ SAND
⁘ GRAVEL
▧ SILTY CLAY
▧ CLAYEY SILT
▩ DEBRIS FILL
〰 HIGHLY ORGANIC (PEAT)
▧ SANDY CLAY
▧ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED 4/27/98	PAGE 1 of 2

DRILLING METHOD HSA
DRILLED BY WEBER DRLG.
LOGGED BY T. REED
EXISTING GRADE ELEVATION (FT. AMSL)
LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCC	LOCATION Henderson, NV	BORING NUMBER PC38

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
	SAND, gravelly, lt brn								
	0-40', f-m w/ c-vc sd								
	and 30-35% 1/4-3/4" grav.								
5	(Minor 3/4"-2" grav). Slight								
	silty 5-10%. Minor								
	caliche cement throughout	SW							
10									
15									
20	20'-40' 20% silt, lt brn								
	sd and grav as above								
25									
30									DAMP @ 33'
									▽
35									
									MOIST-WET @ 40'

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
AUGER
ROCK CORE
■ THIN-WALLED TUBE
CONTINUOUS SAMPLER
NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY	DEBRIS FILL
SILT	HIGHLY ORGANIC (PEAT)
SAND	SANDY CLAY
GRAVEL	CLAYEY SAND
SILTY CLAY	☐ ______
CLAYEY SILT	☐ ______

DATE DRILLED: 4-27-98
PAGE: 1 of 2
DRILLING METHOD: AUGER
DRILLED BY: WEBER
LOGGED BY: E J Krish
EXISTING GRADE ELEVATION (FT AMSL):
LOCATION OR GRID COORDINATES:

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCLLC	LOCATION HENDERSON, NV	BORING NUMBER PC-39

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	SOIL SAMPLE TYPE	SOIL SAMPLE DEPTH	SOIL SAMPLE REC.	REMARKS OR FIELD OBSERVATIONS
	SAND / SILTY SAND; LT. TAN-BROWN; OCC. GRAVEL; SLI. MOIST; WELL-GRADED								
5									
		SM							
10	SAND AS ABOVE; GRAVEL ZONE @ 10'								
15									
17	— — — — — — — —	▽							
20									
25									
		SM							
30									
	GRAVEL ZONE @ 33-35'								
35									
40									

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▯ AUGER
▯ ROCK CORE
■ THIN-WALLED TUBE
▯ CONTINUOUS SAMPLER
◺ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY
▥ SILT
▩ SAND
⁘ GRAVEL
▨ SILTY CLAY
▨ CLAYEY SILT
▩ DEBRIS FILL
≈ HIGHLY ORGANIC (PEAT)
▨ SANDY CLAY
▨ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED 4/27/98
PAGE 1 of 2
DRILLING METHOD HSA
DRILLED BY WEBER DRLG.
LOGGED BY T. REED
EXISTING GRADE ELEVATION (FT. AMSL)
LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCC	LOCATION HENDERSON, NV	BORING NUMBER PC 40

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
	SAND, gravelly, mod yell brn (10YR 5/4). Contains 20-30% 1/4"-3/4" gravel.						▮			
5	Slightly silty (5%).						▮			
	0'-10' w/ minor cobbles - 3/4"-3"						▮			
10	minor caliche cement throughout						▮			
	0'-43' sand is f-m w/ minor c-vc						▮			
15							▮			
			SW				▮			@ 18' damp
20							▮			
25							▮			
30							▮		▽	@ 30' moist-wet
	32'-35' cobbles w/ caliche cement						▮			
35							▮			

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
⧅ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▧ CLAY
▥ SILT
▩ SAND
⁘ GRAVEL
▧ SILTY CLAY
▥ CLAYEY SILT
▩ DEBRIS FILL
☐ HIGHLY ORGANIC (PEAT)
▧ SANDY CLAY
▧ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED 4-27/28-98
PAGE 1 of 2
DRILLING METHOD AUGER
DRILLED BY WEBER
LOGGED BY E. J. Krish
EXISTING GRADE ELEVATION (FT. AMSL)
LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCC	LOCATION HENDERSON, NV	BORING NUMBER PC 42

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	SOIL SAMPLE TYPE	SOIL SAMPLE DEPTH	SOIL SAMPLE REC.	REMARKS OR FIELD OBSERVATIONS
	SAND, gravelly, lt brn (5YR 6/4). poorly sorted, SA-SR, f-vc w/ 20-30% 1/4"-3/4" gravel. Weak caliche cement throughout									
5										
10	0'-41' sparse silt (5-10%)									
15										
20			SW							
25										
30	31-41' Calichefied sand and gravel, slow drilling, poor returns									31-41' hard drilling - sample off auger flites
35										

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
▧ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY
▥ SILT
▩ SAND
⁘ GRAVEL
▨ SILTY CLAY
▨ CLAYEY SILT
▩ DEBRIS FILL
≋ HIGHLY ORGANIC (PEAT)
▧ SANDY CLAY
▧ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED 4-28/29-98	PAGE 1 of 2

DRILLING METHOD: AUGER

DRILLED BY: WEBER

LOGGED BY: E.J Krish

EXISTING GRADE ELEVATION (FT. AMSL)

LOCATION OR GRID COORDINATES

SOIL BORING LOG KM—5655-A

KERR-McGEE CORPORATION Hydrology Dept. Engineering Services	KM SUBSIDIARY Chemical	LOCATION Henderson, NY	BORING NUMBER PC-71

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER FOOT	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
5 10 15	Tan to reddish brown silty sand with variable small to medium gravel in thin layers. Alluvial Sequence		GM							
	Caliche and Gray Sand		SP				☒	17.5-18	0.5	1035
20	Hard red clay		CL				☒	20-21	1'	1045
25	reddish-brown silty clay		CL				☒	24.5-26	1,5	1055
							☒	27-28	1'	1110
30	Reddish-brown clay, blocky, dry-Muddy Creek TD 33 Ft		CL				☒	30-31	1'	1130
35										

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
◻ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▧ CLAY	▩ DEBRIS FILL
▥ SILT	☐ HIGHLY ORGANIC (PEAT)
▒ SAND	▧ SANDY CLAY
⁘ GRAVEL	▧ CLAYEY SAND
▧ SILTY CLAY	☐ ______
▥ CLAYEY SILT	☐ ______

DATE DRILLED 11-30-98
PAGE 1 of 1
DRILLING METHOD Hollow Stem Auger
DRILLED BY Compliance Drilling
LOGGED BY Steve Lower
EXISTING GRADE ELEVATION (FT. AMSL)
LOCATION OR GRID COORDINATES

SOIL BORING LOG KM–5655-A

KERR-McGEE CORPORATION Hydrology Dept. Engineering Services	KM SUBSIDIARY Chemical	LOCATION Henderson, NV	BORING NUMBER PC-72

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	UNIFIED SOIL FIELD CLASS.	BLOWS PER FOOT	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
0–28	Tan to reddish brown silty sand with variable small to medium gravel Alluvial Sequence	GM							
24.5–25						☒	24.5-25	0.5	1515
28–34.5	Sequence of caliche and gray coarse sand	SP							
34.5–40	Reddish-brown clay, firm, blocky - Muddy Creek	CL							
						☒	34.5-35	0.5	1600
						☒	35-36	1'	0750
						☒	37-38	1'	0810
40	TD 38 ft								

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▌ AUGER
▐ ROCK CORE
■ THIN-WALLED TUBE
▌ CONTINUOUS SAMPLER
▢ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY	▩ DEBRIS FILL
▥ SILT	▤ HIGHLY ORGANIC (PEAT)
▦ SAND	▧ SANDY CLAY
⁘ GRAVEL	▧ CLAYEY SAND
▨ SILTY CLAY	☐ ______
▥ CLAYEY SILT	☐ ______

DATE DRILLED: 12-1-98
PAGE: 1 of 1
DRILLING METHOD: Hollow Stem Auger
DRILLED BY: Compliance Drilling
LOGGED BY: Steve Lower
EXISTING GRADE ELEVATION (FT. AMSL):
LOCATION OR GRID COORDINATES:

SOIL BORING LOG KM—5655-A

KERR-McGEE CORPORATION Hydrology Dept. Engineering Services	KM SUBSIDIARY Chemical	LOCATION Henderson, NV	BORING NUMBER PC-73

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER FOOT	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
	Tan to reddish brown silty sand with variable small to medium gravel in thin layers									
5										
10										
15			GM							
20										
25										
30	Gray silty sand with small gravel									
35			GM							
40										

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▯ AUGER
▯ ROCK CORE
■ THIN-WALLED TUBE
▯ CONTINUOUS SAMPLER
⧄ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY
▥ SILT
▩ SAND
⁘ GRAVEL
▨ SILTY CLAY
▨ CLAYEY SILT
▩ DEBRIS FILL
☐ HIGHLY ORGANIC (PEAT)
▨ SANDY CLAY
▨ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED 12-1-98
PAGE 1 of 2
DRILLING METHOD Hollow Stem Auger
DRILLED BY Compliance Drilling
LOGGED BY Steve Lower
EXISTING GRADE ELEVATION (FT. AMSL)
LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMC LLC	LOCATION HENDERSON, NV	BORING NUMBER TR 11

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
5	0 - 4 GRAVEL, sdy, mod yell brn (10YR 5/4), sd vf-vc, gravel up to 1" diam. A-SR, com caliche cement		GW							
	4-8 sand, vf-vc, A-SA 7-8 hard caliche		SW							
10 15 20	8-28 SAND, gravelly, gry oran (10YR7/4) to mod yell brn (10YR 5/4). vf-vc, A-SA, gravel to to 1" diam Com. caliche cement		SP							
25	24-28 lg cobbles w/ com caliche, hard		GP							
30	28-32 SAND, w/ minor caliche and granules vf-vc		SW							
35	32-50 GRAVEL, hard, cemented, fractured. Com caliche cement. Minor sd interbeds and in matrix Gry oran and dusky yell brn		GW							

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
⧄ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY
▥ SILT
▩ SAND
⁘ GRAVEL
▨ SILTY CLAY
▨ CLAYEY SILT
▩ DEBRIS FILL
≋ HIGHLY ORGANIC (PEAT)
▨ SANDY CLAY
▨ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED 10-10-99
PAGE 1 of 7
DRILLING METHOD ARCH
DRILLED BY BEYLIK
LOGGED BY Ed Krish
EXISTING GRADE ELEVATION (FT AMSL)
LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY: KMC LLC	LOCATION: HENDERSON	BORING NUMBER: TR-12

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
5	0-5 GRAVEL w/ slty sd in matrix. Com caliche coatings. .Sized up to 2', volcanics		GM							
10	5-10 SAND, slty w/ mod cobble-size volc gravel, Com caliche coatings. Sd vf-vc, A-SR		SW							
15 19	10-19 Gravel, boulders, w/com. caliche coatings. Mod vf-vc slty sand matrix dk yell brn (10YR 2/2) and gry oran (10YR 7/4)		GW							
21	19-21 SAND, slty w/mod pea gravel, volc.		SW							
27	21-27 Gravel, boulders w/ mod slty sd matrix. dk yell brn + gry oran. Sd vf-vc. Mod cemented Com caliche coatings		GW							
30 36	27-36 GRAVEL, up to boulder size w/ minor vf-vc sd matrix. HARD well cemented w/ caliche		GP							
38	36-38 SAND, HARD, well cemented (caliche), vf-vc		SP							
39	38-39 SAND + GRAVEL, as above, uncemented		GW SP							

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
◸ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY
▥ SILT
▩ SAND
⁘ GRAVEL
▧ SILTY CLAY
▥ CLAYEY SILT
▩ DEBRIS FILL
≋ HIGHLY ORGANIC (PEAT)
▧ SANDY CLAY
▧ CLAYEY SAND
☐ ______
☐ ______

DATE DRILLED: 10-16-99
PAGE 1 of 8
DRILLING METHOD: ARCH
DRILLED BY: BEYLIK
LOGGED BY: Ed Krish
EXISTING GRADE ELEVATION (FT AMSL):
LOCATION OR GRID COORDINATES:

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY	LOCATION	BORING NUMBER
	KMCLLC	HENDERSON	TR-5

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
0–5	SANDY GRAVEL w/ SILT; SLI. MOIST; GRAYISH-ORANGE PINK 5YR 7/2		GW							
5–10	SAND (VF-MED.) WITH SILT AND GRAVEL; SLI. MOIST; 5YR 7/2		SW							
10–20	SANDY GRAVEL, SLI. MOIST; SOME SILT; GRAYISH-ORANGE PINK 5YR 7/2		GW							
20–25	SAND; VF-F GRAINED; MED-COARSE SAND OCC. TO COMMON; SLI.-MOD. MOIST; LT. BROWN 5YR 6/4		SW							
25–37	GRAVELLY SAND; VF-COARSE; MOD. MOIST; LT. BROWN; 5YR 6/4		SW							Qal
37–40	37-62 SILT w/thin sdy zones, mod yell brn (10YR5/4) calcareous		ML							MC fg

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
◧ AUGER
◨ ROCK CORE
■ THIN-WALLED TUBE
◧ CONTINUOUS SAMPLER
⧄ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY	▩ DEBRIS FILL
▥ SILT	☐ HIGHLY ORGANIC (PEAT)
▦ SAND	▨ SANDY CLAY
⁘ GRAVEL	▨ CLAYEY SAND
▨ SILTY CLAY	☐ ______
▥ CLAYEY SILT	☐ ______

DATE DRILLED: 9/16-9/22/99
PAGE: 1 of 7
DRILLING METHOD: ARCH
DRILLED BY: BEYLIK
LOGGED BY: T. REED
EXISTING GRADE ELEVATION (FT AMSL):
LOCATION OR GRID COORDINATES:

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCC	LOCATION HENDERSON	BORING NUMBER TR 6

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE				REMARKS OR FIELD OBSERVATIONS
						NO.	TYPE	DEPTH	REC.	
	TD 80' 15' North of TR 5 see TR 5 lith log for lithology									

EXPLANATION

▼ Water Table (24 Hour)

▽ Water Table (Time of Boring)

PID Photoionization Detection (ppm)

NO. Identifies Sample by Number

TYPE Sample Collection Method

☒ SPLIT-BARREL

▮ AUGER

▮ ROCK CORE

■ THIN-WALLED TUBE

▮ CONTINUOUS SAMPLER

◻ NO RECOVERY

DEPTH Depth Top and Bottom of Sample

REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY	▩ DEBRIS FILL
▥ SILT	◻ HIGHLY ORGANIC (PEAT)
▦ SAND	▧ SANDY CLAY
⁙ GRAVEL	▧ CLAYEY SAND
▨ SILTY CLAY	☐ ______
▥ CLAYEY SILT	☐ ______

DATE DRILLED 9-24-99	PAGE 1 of 1

DRILLING METHOD ARCH

DRILLED BY BEYLIK

LOGGED BY E. KRISH

EXISTING GRADE ELEVATION (FT AMSL)

LOCATION OR GRID COORDINATES

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCC	LOCATION HENDERSON	BORING NUMBER TR7

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	TYPE	DEPTH	REC.	REMARKS OR FIELD OBSERVATIONS
5 10 12	0-12 GRAVEL, sdy, gry oran (10YR7/4) and mod yell brn (10YR 5/4). 60-70% gravel up to 1" diam in sd (f-vc) matrix. Mod. calcite cement. Mod calichification		GW							
15 20	12-20 SAND, gravelly, as above w/ 30-40% 1" diam volc gravel		SW							
26	20-26 SAND, silty gry oran (10YR 7/4) vf-vc w/ 20% silt in matrix		SM							
30 35	26-43 SAND, gry orange (10YR 7/4) vf-m w/ minor vc, A-SA, calcareous w/ sp-sd-size caliche nodules		SW							damp @ 28'

EXPLANATION

▼ Water Table (24 Hour)

▽ Water Table (Time of Boring)

PID Photoionization Detection (ppm)

NO. Identifies Sample by Number

TYPE Sample Collection Method

☒ SPLIT-BARREL

◨ AUGER

◫ ROCK CORE

■ THIN-WALLED TUBE

◧ CONTINUOUS SAMPLER

⧄ NO RECOVERY

DEPTH Depth Top and Bottom of Sample

REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY

▥ SILT

▩ SAND

⁘ GRAVEL

▧ SILTY CLAY

▥ CLAYEY SILT

▦ DEBRIS FILL

☐ HIGHLY ORGANIC (PEAT)

▨ SANDY CLAY

▧ CLAYEY SAND

☐ ______

☐ ______

DATE DRILLED 9/25-9/26/99	PAGE 1 of 8
DRILLING METHOD ARCH	
DRILLED BY BEYLIK	
LOGGED BY E KRISH	
EXISTING GRADE ELEVATION (FT AMSL)	
LOCATION OR GRID COORDINATES	

SOIL BORING LOG KM-5655-B

KERR-McGEE CORPORATION Hydrology Dept. - S&EA Division	KM SUBSIDIARY KMCC	LOCATION HENDERSON	BORING NUMBER TR8

DEPTH IN FEET	LITHOLOGIC DESCRIPTION	GRAPHIC LOG	UNIFIED SOIL FIELD CLASS.	BLOWS PER 6"	PID (ppm)	SOIL SAMPLE NO.	SOIL SAMPLE TYPE	SOIL SAMPLE DEPTH	SOIL SAMPLE REC.	REMARKS OR FIELD OBSERVATIONS
	Hole Located 12 ft South of TR7 - see TR7 for Lithology TD 98' NOTE: IN TR8 first MC gravel started @ 62' and ended at 93 ft.									

EXPLANATION

▼ Water Table (24 Hour)
▽ Water Table (Time of Boring)
PID Photoionization Detection (ppm)
NO. Identifies Sample by Number
TYPE Sample Collection Method

☒ SPLIT-BARREL
▮ AUGER
▮ ROCK CORE
■ THIN-WALLED TUBE
▮ CONTINUOUS SAMPLER
⧄ NO RECOVERY

DEPTH Depth Top and Bottom of Sample
REC. Actual Length of Recovered Sample in Feet

GRAPHIC LOG LEGEND

▨ CLAY	▩ DEBRIS FILL
▥ SILT	≈ HIGHLY ORGANIC (PEAT)
▒ SAND	▨ SANDY CLAY
⁘ GRAVEL	▨ CLAYEY SAND
▨ SILTY CLAY	☐ ______
▥ CLAYEY SILT	☐ ______

DATE DRILLED 9/30/99	PAGE 1 of 1
DRILLING METHOD ARCH	
DRILLED BY BEYLIK	
LOGGED BY E. KRISH	
EXISTING GRADE ELEVATION (FT AMSL)	
LOCATION OR GRID COORDINATES	