Chevron Environmental Management Company

SUPPLEMENTAL REMEDIAL INVESTIGATION WORKPLAN – PHASE 5

Chevron Service Station 9-6590

232 East Woodin Avenue

Chelan, Washington

FSID: 77751227

CSID: 6660

June 16, 2020

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232 East Woodin Avenue
Chelan, Washington
FSID: 77751227
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Prepared for:

Chevron Environmental Management Company

Prepared by:

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CONTENTS

FIGURES

ATTACHMENT

ACRONYMS AND ABBREVIATIONS

Arcadis	Arcadis U.S., Inc.
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and total xylenes
CEMC	Chevron Environmental Management Company
CSID	Cleanup Site Identification Number
CUL	Cleanup level
Ecology	Washington State Department of Ecology
FSID	Facility Site Identification Number
Liedos	Liedos, Inc.
LIF	Laser-induced fluorescence
LNAPL	Light non-aqueous phase liquid
MNR	Nuclear magnetic resonance
MTBE	Methyl *tert*-butyl ether
MTCA	Model Toxics Control Act
PAH	Polycyclic aromatic hydrocarbon
PID	Photoionization detector
site	Chevron Service Station 9-6590
SRI	Supplemental Remedial Investigation
USEPA	United States Environmental Protection Agency
USTs	Underground storage tanks
UVOST – HP	Ultra-Violet Optical Screening Tool – Hydraulic Profiling
VOCs	Volatile organic compounds
work plan	Phase 5 Work Plan

1 INTRODUCTION

On behalf of Chevron Environmental Management Company (CEMC), Arcadis U.S., Inc. (Arcadis) has prepared this Supplemental Remedial Investigation (SRI) – Phase 5 Work Plan (work plan) for Chevron Service Station No. 9-6590 located at 232 East Woodin Avenue, Chelan, Washington (site). A site location map and aerial map are included as Figure 1 and Figure 2, respectively. This work plan has been prepared pursuant to the terms of Agreed Order No. DE 10629, which was entered into by CEMC and the Washington State Department of Ecology (Ecology) in June 2014.

The objective of this work plan is to address additional soil and groundwater data gaps regarding petroleum hydrocarbon contamination that were identified at the site. The results of previous data gap investigations are summarized in the SRI Report – Phase 1 (Leidos 2015), SRI Report – Phase 2 (Leidos 2017), and SRI Report – Phase 4 (Leidos 2019).

2 PROPOSED ACTIVITIES

The proposed activities described in this work plan were discussed during a meeting between Arcadis and Ecology on March 5, 2020. The proposed SRI – Phase 5 activities are as follows:

1. Evaluation of hydraulic conductivity of subsurface hydrogeological units at the site using Ultra-Violet Optical Screening Tool (UVOST) – Hydraulic Profiling (HP) technology.
2. Installation of groundwater elevation transducers in select downgradient groundwater monitoring wells to monitor potential perched groundwater discharge to Lake Chelan.
3. Collect representative Light non-aqueous phase liquid (LNAPL) samples from select monitoring wells to be analyzed for physical parameters.
4. Investigation of shallow soil impacts relating to a suspected underground storage tank (UST) in the vicinity of 221 E. Woodin Avenue.
5. Installation and sampling of external (i.e., outdoor) soil vapor probes in the vicinity of MW-21 and MW-44.

These activities are intended to address the following questions identified during previous discussion of the conceptual site model:

- How does hydraulic conductivity vary with depth, and are significant migration pathways present that could support transport of LNAPL?
- What is the degree of hydraulic communication between the multiple observed hydrostratigraphic units, and what is the relationship between regional hydrology (including lake level and precipitation) and the potentiometric surface in those hydrostratigraphic units?
- Is a source area separate from the site present in the vicinity of MW-21 or MW-27, and is there distinct separation between site impacts and impacts in that area?
- Are there risks relative to vapor intrusion or potential indoor inhalation exposures that warrant further evaluation or mitigation measures?

Additional details regarding the background and methodology for each of these proposed investigation activities are included in the sections below.

3 UTILITY LOCATE

Prior to all intrusive subsurface activities, Arcadis will contact the Northwest Utility Location Center serving Chelan County, Washington a minimum of 48 hours prior to initiating the field activities. A private utility locating company will be subcontracted by Arcadis to conduct a utility scan that will include the use of ground-penetrating radar to confirm that the proposed investigation locations are clear of underground utilities or other obstructions. A third-line of evidence to clear the location of utilities prior to drilling will include clearing the borehole a minimum of 110% of the diameter of the intrusive device (e.g., hollow-stem auger) or an additional 2-inches of overall diameter, whichever is greater, to a minimum depth of 5-feet below ground surface.

4 EVALUATION OF HYDRAULIC CONDUCTIVITY USING UVOST-HP TECHNOLOGY

4.1 Background

In order to investigate the nature and extent of LNAPL impacts, an initial laser-induced fluorescence (LIF) investigation was conducted in November 2016 and reported in the 2017 Phase 2 SRI Report. A total of six (6) LIF borings were completed from Nov 3-5, 2016. The locations are shown on Figure 4.

At the request of Ecology, nuclear magnetic resonance (NMR) logging was considered as a potential investigation technology for mapping vertical hydraulic conductivity using existing site well infrastructure. The number of existing monitoring wells conducive to NMR logging was limited to a total of thirteen (13) wells, based on required well construction (i.e., borehole diameter and well casing diameter). The existing well network only consists of ten (10) 2-inch diameter wells conducive to NMR logging with Vista Clara's Javelin NMR probe, which has a coarse vertical resolution ranging from approximately 20 to 40 inches. None of the existing site wells are conducive to logging with Vista Clara's higher resolution Dart NMR probe, which has a vertical resolution of approximately 9 inches. Similarly, only three (3) existing 4-inch diameter wells are conducive with logging with a larger diameter NMR probe provided by Mt. Sopris, which has an approximately 8-inch vertical resolution. Therefore, the limited scope of a possible NMR investigation would not meet the investigation objectives for mapping continuous hydraulic conductivity at a meaningful vertical resolution at an adequate number of well locations distributed across the site.

The efficacy of miniaturized well profiling (aka. dynamic well profiling) was also considered at the request of Ecology. While this method can provide both depth-dependent water quality sampling and a velocity profile, there are several drawbacks for use with a LNAPL investigation aimed at mapping permeability, specifically: 1) measurements are limited to within the saturated portion of the well screen interval, 2) application is limited to existing well infrastructure and 3) a direct measurement of permeability is not provided.

Ultimately, the UVOST® - HP tool was selected for the proposed investigations, in order to map continuous permeability and further characterize formation LNAPL thickness and migration pathways along the entire length of the boring. The combination of two high-resolution site characterization technologies for detecting in-situ LNAPL and permeability into a single tool provide a number of significant advantages, such as reduced mobilizations and disruptions on daily operations for the City of Chelan. In addition, a direct-push approach is not limited to the existing well infrastructure and provides more flexibility for investigation planning.

4.2 Methodology

Ultra-Violet Optical Screening Tool (UVOST®) Description

The UVOST® probe is a subsurface LNAPL identification technology provided by Dakota Technologies. As the UVOST® probe is advanced into the subsurface, it emits an ultraviolet excitation light and captures returning fluorescence. Polycyclic aromatic hydrocarbon (PAH) compounds, which are a component of common petroleum fuels, readily fluoresce when exposed to ultraviolet light. The magnitude of fluorescence is directly impacted and generally proportional to the LNAPL saturation within the soil, but can also be influenced by soil type, porosity, non-hydrocarbon organic material in the soil, as well as other Facility-specific factors. The fluorescence observed is quantified by comparison to the response of a standard reference solution, known as the reference emitter. The results are expressed as a percentage of reference emitter response. Instrument response is expected in areas with no LNAPL impacts due to the fluorescent properties of native soil materials. However, background fluorescence is typically weak compared to LNAPL fluorescence and does not greatly diminish instrument sensitivity.

The UVOST® probe detects four distinct fluorescent light wavelengths; the relative returns of each wavelength at a given depth are collectively referred to as a waveform. Differences in waveform patterns may indicate differences in the subsurface environment or in LNAPL composition. Waveform changes are indicated by color shifts in the LIF boring log, and snapshots of waveforms at selected depths are presented as callouts on each log.

The return (fluorescent) light signal is analyzed in real time by on-site equipment. As the probe is advanced downward, the fluorescence data form a vertical profile of LNAPL present at the soil boring location. Results are reviewed during and after completing each LIF boring and are considered when selecting subsequent locations.

Site LNAPL samples will be submitted to the chosen vendor prior to field implementation for site-specific calibration.

Hydraulic Profiling (HP) System Description

The UVOST®-Hydraulic Profile (HP) tool is a modification of the standard UVOST® tool to enable simultaneous mapping of both NAPL and soil permeability. The UVOST®-HP probe measures permeability by injecting clean water through a port a few inches ahead of the LIF window and measuring the flow rate and relative pressure response. A vertical profile of pressure is produced that is inversely proportional to permeability – low pressure indicates high permeability and high pressure indicates low permeability soils. Permeability measurements are generally considered relative or semi-quantitative.

The static water elevation can also be estimated by performing a pressure dissipation test in a permeable zone. A dissipation test consists of pausing probe advancement and water flow. The time required for the pressure to stabilize is then observed. This stabilized pressure is the absolute hydrostatic pressure at the given depth. The elevation of the water table can then be calculated after accounting for the atmospheric pressure measured in the field. Dissipation tests are typically not performed in low permeability zones where the time required for the pressure to equilibrate is overly time consuming. The depth of a pressure dissipation test is noted as a blue ring on the pressure logs.

Figure 5 shows the 12 prescribed and 2 contingency boring locations for the proposed UVOST®-HP investigation. Four proposed boring locations are located in the vicinity of 128 East Johnson Avenue to investigate permeability and LNAPL distribution following recent increases in measured in-well LNAPL thicknesses at MW-21 and MW-27 and to better understand LNAPL migration in this portion of the site. Two proposed borings are located adjacent to MW-39 and MW-40 to confirm potentially reduced permeability within Unit B in this portion of the site, as previously noted in soil descriptions. Two proposed borings are located adjacent to MW-15 and MW-16 to investigate permeability and LNAPL distribution in a portion of the site with historically measured in-well LNAPL thicknesses. Three proposed borings are located between MW-38 and the site to further investigation potential LNAPL migration pathways immediately downgradient of the site. A single proposed boring is located at 232 East Woodin Avenue to investigate permeability and LNAPL distribution near the source zone. Two contingent boring locations are proposed to be utilized in the event of access issues or utility conflicts: one location in the vicinity of MW-15 and MW-16 and one location near the source area. Each boring will be advanced through Unit B (glacial lacustrine deposits) with the possible exception to investigate deeper into Unit C (till and outwash deposits) near MW-39. Based on the results of the 2016 LNAPL investigation, improved instrument calibration will be required to provide better certainty for high quality data collection.

Raw data files generated during the UVOST®-HP investigation will be included in the Phase 5 SRI Report as an appendix. Dakota Technologies will provide UVOST®-HP services during the Phase 5 Investigation.

5 LNAPL SAMPLING

5.1 Background

Field observations indicate that in-well LNAPL thickness measurements may be up to several feet at select existing monitoring wells at the site. However, detailed analysis of the LNAPL physical properties has not previously been conducted and compositional analysis is generally limited to wells in the eastern portion of the study area.

5.2 Methodology

ARCADIS will collect LNAPL samples for analysis of physical characteristics and composition. These analyses will include density, viscosity, oil-air interfacial tension, oil-water interfacial tension, and gas chromatogram/flame ionization detector “fingerprinting.” LNAPL samples will also be chemically analyzed to determine speciation, in order to validate the speciation differences observed during the UVOST-HP investigation event and demonstrate what LNAPL types are present.

LNAPL samples will be collected from monitoring wells with sufficient thicknesses of LNAPL using a disposable bailer. Sampling locations may be adjusted or expanded based on site conditions and LNAPL thicknesses.

Further information on LNAPL sampling methodology can be found in the SAP/QAPP and Technical Guidance Instructions (TGI) included in Attachment A.

6 INSTALLATION OF PRESSURE TRANSDUCERS

6.1 Background

Significant uncertainty exists in the current conceptual model regarding the degree of hydraulic connection between water-bearing zones intersected by the well network. Traditional water-level measurements, consisting of a set of single-point observations collected manually across a period of several hours, have generally not been sufficient to resolve questions regarding hydraulic interaction between different water-bearing zones and locations.

Datalogging pressure transducers will be deployed in selected existing monitoring wells to collect a higher-resolution data set more conducive to evaluating hydraulic connectivity. The repeated observations recorded by the dataloggers, collected simultaneously across multiple wells, will allow better insight into the way precipitation, lake level fluctuations, and other regional phenomena affect potentiometric surfaces in the water-bearing zones. Publicly available third-party data, such as lake level and weather observations, will be used in conjunction with the pressure transducer data as part of this evaluation. Note that some proposed transducer deployment locations are monitoring wells which are expected to contain LNAPL. The goal of transducer deployment is not to monitor LNAPL thickness or individual fluid interfaces, but rather to track the overall hydraulic head or potentiometric surface elevation at a given location and depth. As such, the presence or absence of LNAPL will not significantly complicate data interpretation. If warranted based on field observations, an additional transducer can be deployed in LNAPL-containing wells at a depth expected to consistently remain within the in-well LNAPL layer; this will allow tracking of air-LNAPL and LNAPL-water interfaces via comparison of transducer readings and knowledge of LNAPL density.

Previous field observations had also noted the accumulation of methane in some well casings, potentially leading to pressurization. A barometric pressure logger will be deployed just below the well cap at locations susceptible to methanogenesis and will track the gas-phase pressure within the casing, supporting evaluation of the effects of this phenomenon on hydraulic gradients and overall potentiometric surface elevation.

6.2 Methodology

The transducer deployment will be conducted as follows:

- Datalogging pressure transducers with appropriate measurement ranges for the maximum anticipated immersion depth will be procured. Absolute (or sealed) transducers will be used, along with a barometric pressure datalogger, to avoid the need to leave monitoring wells open or uncovered as would be necessary with vented transducers.
- Transducers will be set to record water levels at 60-minute intervals, with internal clocks and start times synchronized.

- Transducers will be deployed in monitoring wells MW-21, MW-27, MW-38, and MW-40. If access to one of the wells in the southwestern portion of the study area is not feasible, a transducer will also be installed in MW-39 as a replacement location. These locations were selected in order to (1) support comparison of groundwater elevations near Lake Chelan relative to recorded lake levels; (2) confirm the expected groundwater flow direction in the area of the lake; and (3) support comparison of seasonal and precipitation-driven fluctuations in different portions of the overall site area, including evaluation of the previously discussed concept that infiltration or stormwater influence may be greater in some areas relative to others.
- Transducers will be suspended from the well cap via a Kevlar cord or similar device.
- The barometric datalogger will be set up onsite in a shaded, covered aboveground location.
- Transducers will be periodically retrieved and replaced in order to download data and confirm proper operation. The schedule for these downloads will be determined based on the timing of other planned site activities.
- Each time a transducer is retrieved/replaced, manual fluid level measurements will be collected to support verification of automated measurements.
- The expected deployment period for the transducers will be 1 year.

Further information on the transducer methodology can be found in the TGI included in Appendix A.

7 SHALLOW SOIL INVESTIGATION

7.1 Background

As discussed in the Supplemental Remedial Investigation Report – Phase 4 (Leidos 2019), Leidos, Inc. (Leidos) conducted a subsurface geophysical survey in the area of 221 East Woodin Avenue on October 23, 2018. The results of this survey indicated the presence of a suspected petroleum UST in the parking area directly south of the building located at 221 East Woodin Avenue. As part of the SRI Phase 4 scope of work, Leidos advanced two shallow soil borings (UST-2 and UST-3) in the sidewalk to the south of the adjacent suspected UST. Additionally, Leidos advanced seven soil borings (SRI4B-1 through SRI4B-7) along both the north and south side of East Woodin Avenue to further characterize soil in the area. Historical soil sample locations are presented in Figure 4.

Analytical results for soil samples collected from borings UST-2 and UST-3 did not contain concentrations of analytes above the Model Toxics Control Act (MTCA) Method A cleanup levels (CULs). However, soil analytical results collected from borings SRI4B-1 through SRI4B-7 indicated the presence of elevated levels of petroleum hydrocarbons above MTCA Method A CULs in subsurface soil on the north side of East Woodin Avenue, specifically in borings SRI4B-1, SRI4B-2, and SRI4B-5. Soil impacts identified in boring SRI4B-5, the boring closest to the suspect UST basin, were encountered at approximately 14.5 ft. below ground surface (bgs). These findings suggest soil impacts on the north side of the 200 block of East Woodin Avenue are the result of a different petroleum source release than the source release at the 232 East Woodin Avenue, where soil impacts are generally observed to begin at 20 feet bgs (Leidos 2019).

Further shallow soil investigation is recommended in the parking area directly south of the building located at 221 East Woodin Avenue in order to confirm the presence of a subsurface UST that may be acting as a primary source of soil impacts beneath the 200 Block of East Woodin Avenue. Proposed shallow soil investigation locations are presented on Figure 5.

7.2 Methodology

Contingent on access to the property located at 221 East Woodin Avenue and prior to advancing soil borings, an air knife and/or vacuum truck will be used to advance exploratory “pothole” excavations to confirm the presence of the suspected UST in the parking area directly south of the building located at 221 East Woodin Avenue. If the presence of the UST is confirmed, Arcadis will plan to use a disposal bailer to collect a sample of any liquid present within the UST. Liquid samples will be sent to an Ecology-accredited laboratory under standard chain-of-custody procedures and analyzed for:

- Gasoline-range organics analyzed by Ecology Northwest Method NWTPH-Gx
- Diesel-range organics and Heavy-oil range organics analyzed by Ecology Northwest Method NWTPH-Dx
- Benzene, toluene, ethylbenzene, and total xylenes (BTEX), methyl tert-butyl ether (MTBE), ethylene dibromide, and ethylene dichloride analyzed by United States Environmental Protection Agency (USEPA) Method 8260
- Total Lead analyzed by USEPA Method 6010

Three soil borings will be pre-cleared by air knife, vacuum truck, and/or hand auger to a minimum depth of 5 feet bgs. After preclearance, boreholes will be advanced to a target depth of approximately 20 feet bgs. Soil borings may be advanced beyond the target depth if visible staining and/or elevated volatile organic compound (VOC) screening impacts are observed. Additional soil borings may be advanced in the area of the suspected UST based on field observations.

During preclearance, soil samples will be collected by hand auger at approximately 2.5 feet bgs for lithologic logging and screened for VOCs using a photo ionization detector. During drilling, soil samples will be collected from 2.5-foot intervals for VOC screening using a photo ionization detector. Soil samples will be collected for laboratory analysis at 5-foot intervals and at the total depth of the boring. Additional soil samples may be collected for laboratory analysis based on field observations.

Soil samples will be sent to an Ecology-accredited laboratory under standard chain-of-custody procedures and analyzed for:

- Gasoline-range organics analyzed by Ecology Northwest Method NWTPH-Gx
- Diesel-range organics and Heavy-oil range organics analyzed by Ecology Northwest Method NWTPH-Dx
- Benzene, toluene, ethylbenzene, and total xylenes (BTEX), methyl tert-butyl ether (MTBE), ethylene dibromide, and ethylene dichloride analyzed by United States Environmental Protection Agency (USEPA) Method 8260
- Total Lead analyzed by USEPA Method 6010

Further information on soil sampling methodology can be found in the SAP/QAPP and associated TGIs included in Appendix A.

8 SOIL VAPOR INVESTIGATION

8.1 Background

As discussed in the Phase 1 Supplemental Remedial Investigation Report and Summary of February 2016 Tier 2 Vapor Intrusion Assessment Sampling Event (Leidos 2015 and 2016), Leidos previously conducted two rounds of Tier 2 vapor intrusion assessment sampling at the site. Soil vapor analytical data collected during these sampling events indicated that the vapor intrusion exposure pathway was incomplete beneath properties located on the southern portion of East Woodin Avenue as determined by sub-slab and indoor air sampling.

Since 2016, in well LNAPL accumulations of up to 16.19 feet have been observed in monitoring well MW-21, potentially reducing the vertical separation distance between the top of the LNAPL and the bottom of the basements identified by Liedos during a site survey in 131, 133, and 135 East Wooding Avenue to less than 15 feet (Liedos 2015). Additionally, as discussed in the Supplemental Remedial Investigation Report – Phase 4 (Leidos 2019), Leidos conducted a subsurface investigation along the northern edge of East Woodin Avenue and encountered shallow soil impacts above MTCA Method A CULs at 14.5 feet bgs in SRI4B-5. Previous vapor intrusion assessment activities completed by Leidos did not evaluate the areas near MW-21 and SRI4B-5.

In order to investigate identified data gaps near MW-21 and SRIB-5, and in lieu of sub-slab and indoor air sampling, Arcadis proposes to install exterior soil vapor probes in the City of Chelan right-of-way in order to collect representative soil vapor samples from a depth roughly equivalent to the bottom of an average business basement. If soil vapor samples collected from exterior soil vapor probes contain concentrations of constituents of concern above MTCA Method B Sub-Slab Soil Gas screening levels, additional evaluation of the soil vapor intrusion pathway may be required. Proposed soil vapor investigations locations are presented on Figure 5.

8.2 Methodology

8.2.1 Soil Vapor Probe Installation

Two soil vapor probes will be advanced to an approximate final borehole depth of 10 feet bgs. The final probe depth will be determined in the field based on observed soil properties and water table depth at the time of installation.

Soil samples will be collected during borehole advancement and visually inspected using visual and manual methods. Additionally, soil from each boring will be screened in the field for VOCs using a calibrated photo-ionization detector (PID). PID readings, soil types, and other pertinent geologic data will be recorded on soil boring logs.

Once the target depth is reached, the borehole will be left open for approximately 2-hours prior to installation to monitor for soil moisture or groundwater infiltration. If moisture conditions are not conducive for soil vapor probe installation the borehole will be backfilled with bentonite to a shallower depth or the borehole will be abandoned.

Soil vapor probes will contain a single, soil vapor screen centered at a depth of 9.5 feet bgs. Soil vapor probe depth may be adjusted in the field based on observation of soil properties, the presence of groundwater in the soil boring, PID field screening results, and moisture content in soil at the time of construction.

Once the soil vapor probe borings have been advanced to their final depth, a 6-inch long, 0.375-inch outer diameter stainless steel soil vapor screen will be set in a one-foot interval of standard sand pack, allowing approximately three-inches of sand above and below the screen. Sand pack is used around the screened interval of the sample probe to allow soil vapor from the surrounding soil to reach the probes. Teflon tubing (or equivalent) will be connected to the soil vapor screen and capped with a vapor-tight two-way valve or Swagelok cap at the surface to eliminate the potential for barometric pressure fluctuations to induce vapor transport between the subsurface and the atmosphere. The two-way valve, if used, will be installed in the closed position to allow equilibration to commence immediately after installation.

A six-inch layer of dry granular bentonite will be placed above the sand pack followed by hydrated granular bentonite slurry. Dry granular bentonite is used to ensure that the hydrated bentonite slurry does not seal the vapor probe screen and inhibit the collection of soil vapor. The probe locations will be completed with a concrete cap and a flush-mounted, traffic-rated well box with sufficient room to store the tubing and valves or caps. Vapor probes will be sampled a minimum of 48 hours after installation to allow for equilibration.

8.2.2 Soil Vapor Sampling

Purge volume calculation, field conditions, including ambient humidity and temperature, flow rate, pump specifics, and other applicable information will be recorded by field personnel on soil vapor sample collection logs. Purged vapor from the probes will be field screened for methane (as the lower explosive limit) with a MultiRAE Plus portable 4-gas meter or equivalent.

Sampling trains will be assembled using ¼-inch Teflon tubing (or equivalent) with stainless steel compression fittings and connected to the soil vapor probes. Prior to sampling, 3 volumes of stagnant air will be purged from the soil vapor probe and sample train to ensure samples are representative of subsurface conditions. Additionally, a vacuum hold test and helium leak tracer test will be completed to verify the integrity of the soil vapor sampling train. Soil vapor samples will be collected using 1-liter stainless steel evacuated canisters individually cleaned and certified by an Ecology-accredited laboratory. Canisters will be connected to soil vapor sampling regulators set 200 milliliters per minute or less. Canisters will be allowed to collect for up to 10-minutes or when the remaining vacuum reaches 5 inches of mercury, whichever is first.

Soil vapor samples will be submitted to a Washington State certified laboratory under standard chain-of-custody procedures for analysis of the following analytes:

- Total petroleum hydrocarbons with carbon chain specific results: EC5-8 (aliphatics), EC9-12 (aliphatics), and EC9-10 (aromatics) by TPH Massachusetts Air Phase Hydrocarbons
- Benzene, toluene, ethylbenzene, total xylenes, naphthalene, MTBE, and ethylene dibromide by USEPA method TO-15; and

- Oxygen, carbon dioxide, helium, and methane by American Standard for Testing and Materials method D1946.
- Analytical results from the soil vapor samples will be compared to their respective MTCA Method B Sub-Slab Soil Gas Screening Level.

Further information on soil vapor point installation and sampling can be found in the SAP/QAPP and associated TGIs included in Attachment A.

9 MANAGEMENT OF INVESTIGATION DERIVED WASTE

Soil cuttings and purge water generated during the field activities will be containerized in Department of Transportation-approved, 55-gallon steel drums. The drums will be appropriately labeled and temporarily stored on-site pending waste profiling and off-site transportation and disposal.

10 SCHEDULE

Arcadis estimates that planning for the activities described in this work plan can begin immediately upon receiving Ecology approval of this work plan or agreed upon revisions of this work plan. Planning activities are expected to take four to six weeks. However, the schedule of field work is contingent upon property access, street-use or other permits, subcontractor availability, and weather conditions. Expected time frame for field implementation is October- November 2020.

Arcadis will provide Ecology a minimum of 10 days' notice prior to starting field activities.

11 REFERENCES

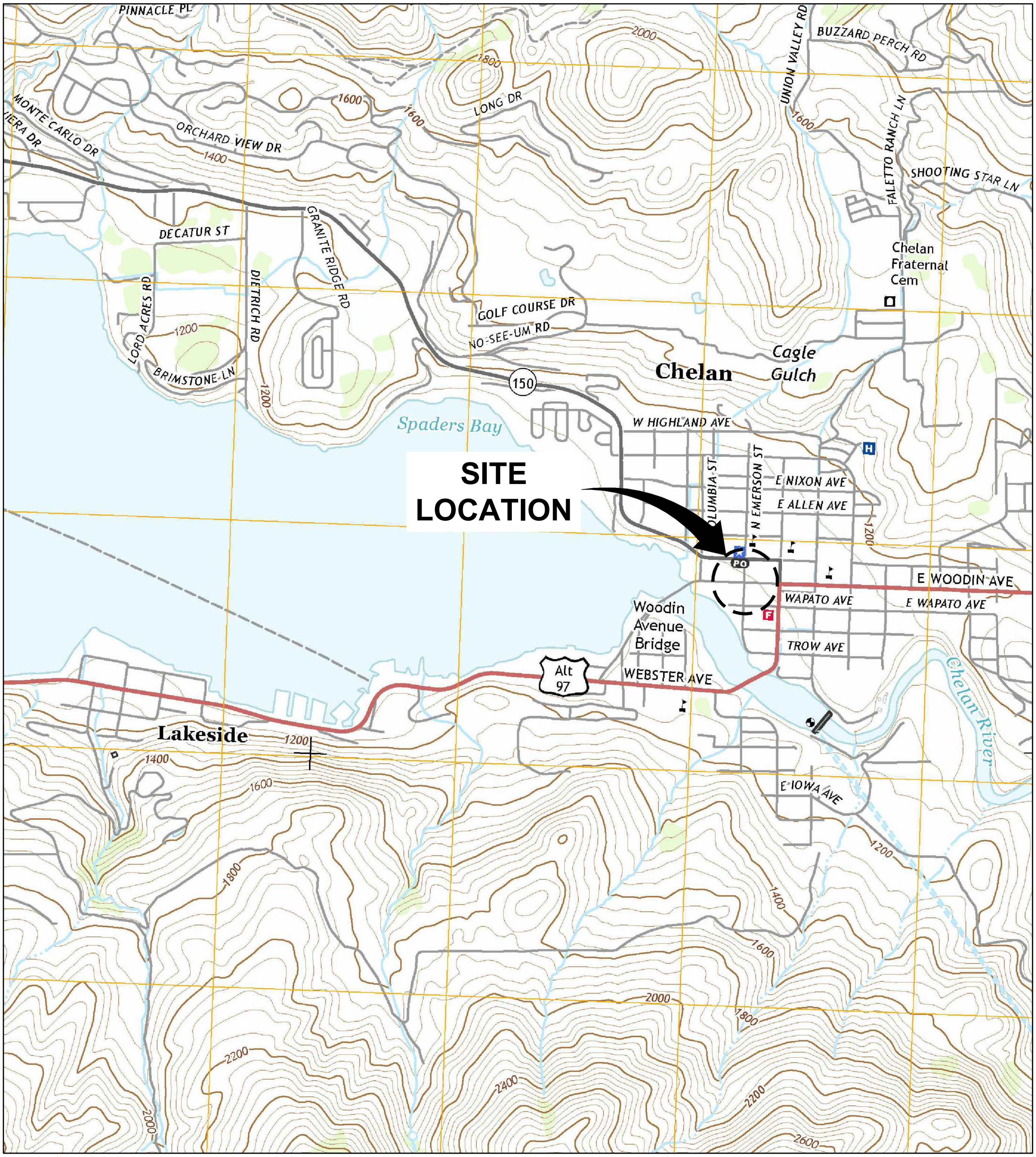
Leidos. 2015. Supplemental Remedial Investigation Report – Phase 1, Chevron Service Station No. 9-6590. December 14.

Leidos. 2016. Summary of February 2016 Tier 2 Vapor Intrusion Assessment Sampling Event. Chevron Service Station No. 9-6590. June 6.

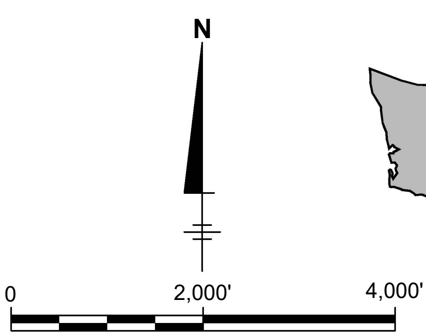
Leidos. 2017. Agency Review Draft Supplemental Remedial Investigation Report – Phase 2, Chelan Chevron. May 31.

Leidos. 2019. Agency Review Draft Supplemental Remedial Investigation Report – Phase 4, Chelan Chevron. July 8.

FIGURES



SOURCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD., CHELAN, WA 2017.



APPROXIMATE SCALE : 1 in. = 2,000 ft.

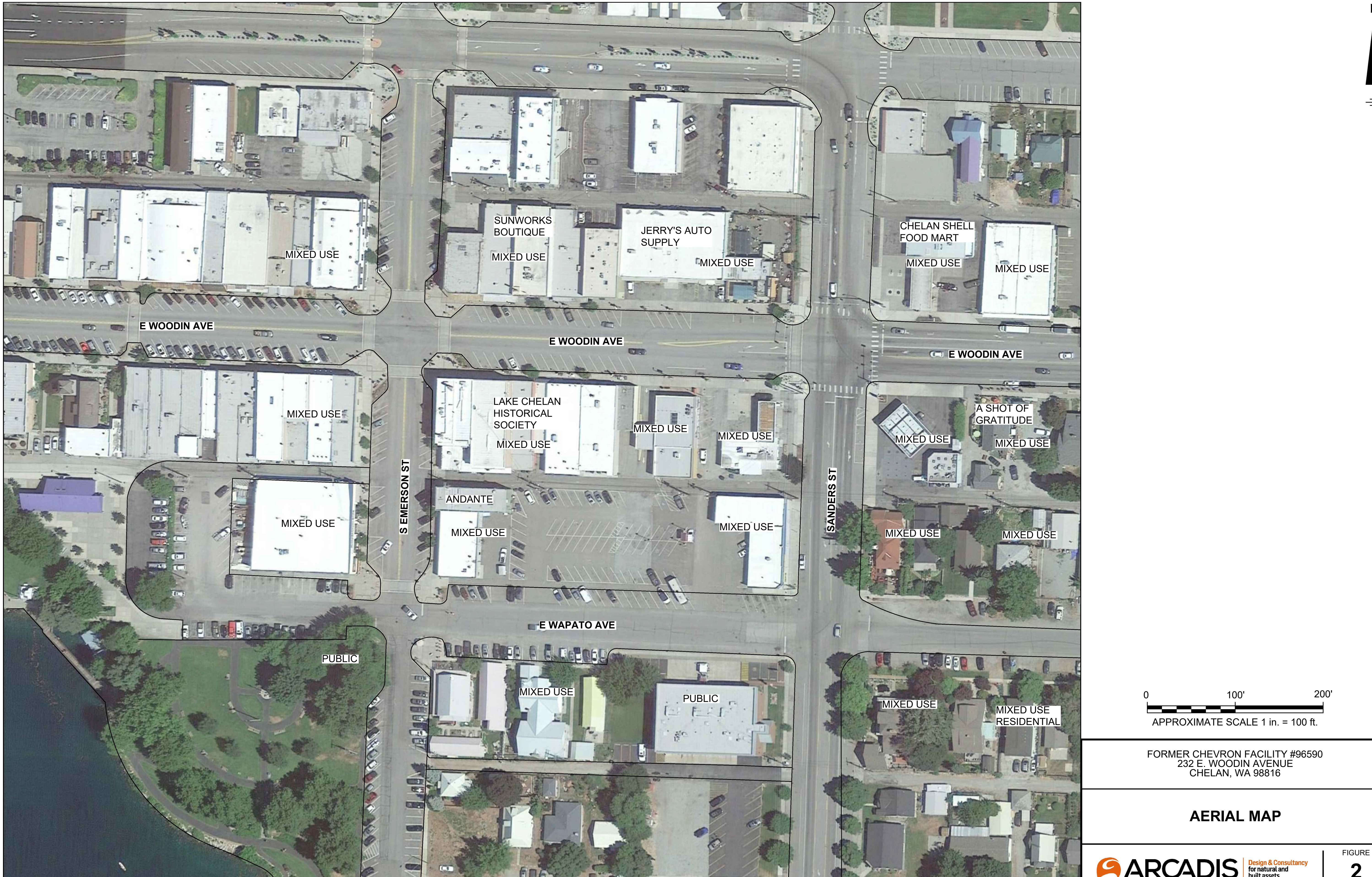
FORMER CHEVRON FACILITY #96590
232 E. WOODIN AVENUE
CHELAN, WA 98816

SITE LOCATION MAP

ARCADIS Design & Consultancy for natural and built assets

FIGURE 1

CITY:EMERYVILLE, CA DIV/GROUP:ENVCAD DB:A.REYES
C:\Users\PAI01041\BIM 360\Arcadis\ANA - CHEVRON CORPORATION\Project Files\ASR 96590 Chelan\2019\30012528.W020101-DWG\96590 FIG 1 SITE MAP.dwg LAYOUT: 1 SAVED: 10/9/2019 11:04 AM ACADVER: 23.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 10/9/2019 11:14 AM BY: ANJANEYAKUMAR, PAVAN KUMAR



FORMER CHEVRON FACILITY #96590
232 E. WOODIN AVENUE
CHELAN, WA 98816

AERIAL MAP

ARCADIS Design & Consultancy for natural and built assets

FIGURE 2

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
C:\Users\PAI01041\BIM 360\Arcadis\ANA - CHEVRON CORPORATION\Project Files\ASR 96590 Chelan\2019\30012528.W0201\01-DWG\96590 FIG 2 AERIAL MAP.dwg LAYOUT: 2 SAVED: 10/9/2019 11:04 AM ACADVER: 23.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 10/9/2019
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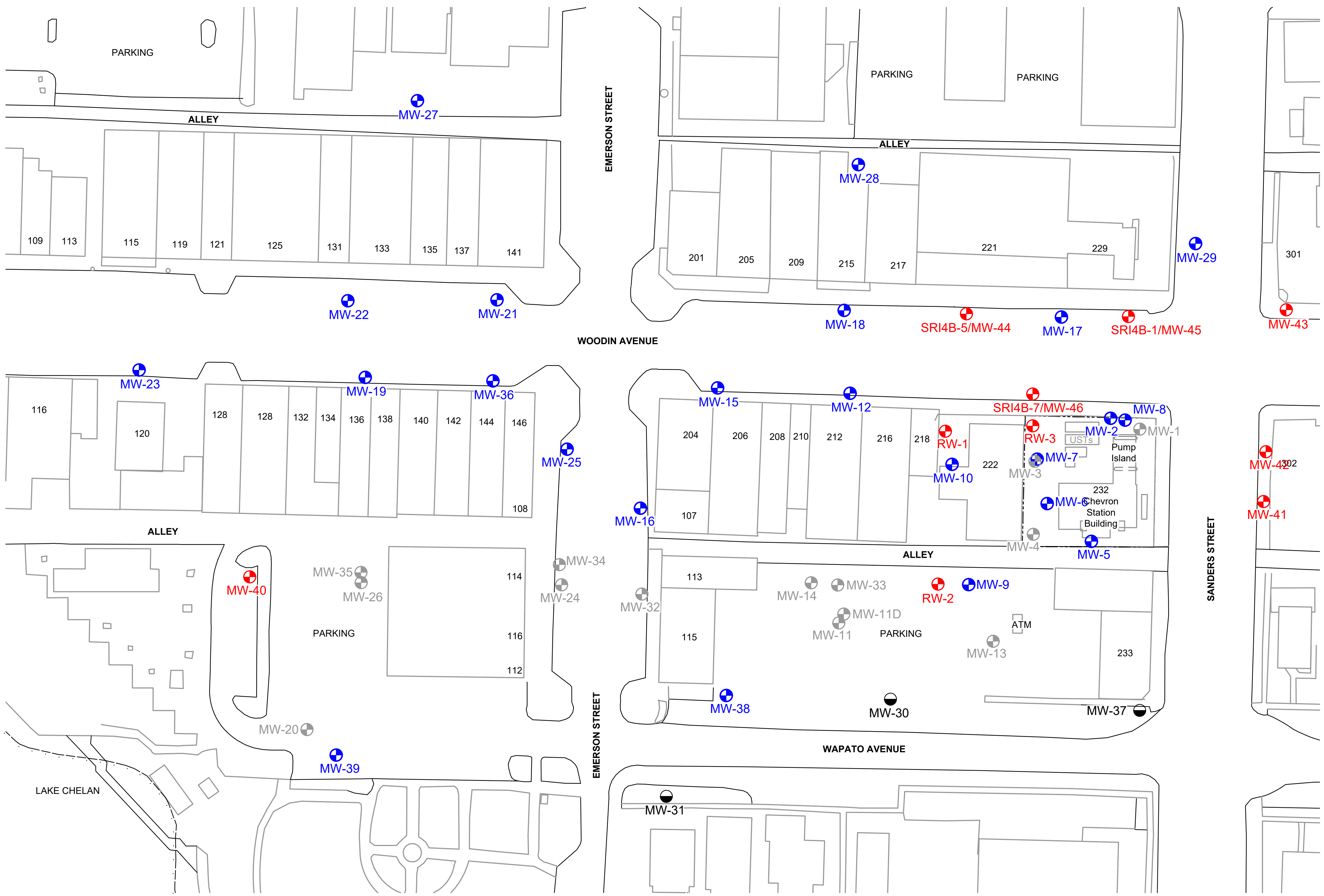


N

LEGEND:

- MW-2 EXISTING PERCHED GROUNDWATER MONITORING OR RECOVERY WELL
- MW-30 EXISTING DEEP GROUNDWATER MONITORING WELL
- MW-1 EXISTING ABANDONED DRY MONITORING WELL
- MW-43 SRI 4 SOIL BORING/MONITORING WELL LOCATION

0 90' 180'

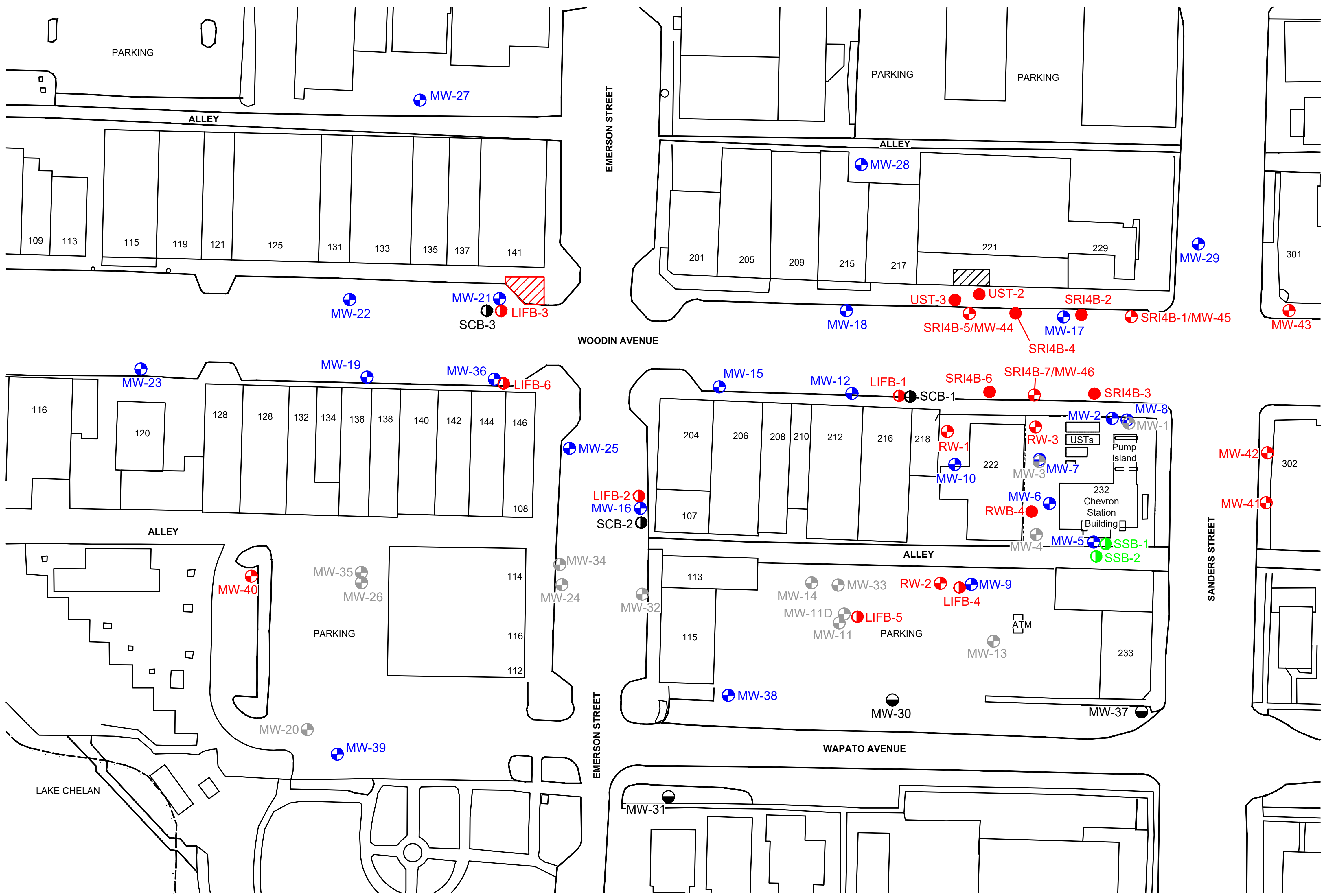
APPROXIMATE SCALE 1 in. = 90 ft.

FORMER CHEVRON FACILITY #96590
232 E. WOODIN AVENUE
CHELAN, WA 98816

MONITORING WELL LOCATIONS

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3



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LEGEND:

MW-2	EXISTING PERCHED GROUNDWATER MONITORING OR RECOVERY WELL
MW-30	EXISTING DEEP GROUNDWATER MONITORING WELL
MW-1	EXISTING ABANDONED DRY MONITORING WELL
MW-43	SRI 4 SOIL BORING/MONITORING WELL LOCATION
SRI4B-2	SRI 4 SOIL BORING LOCATION
LFB-1	SRI PHASE 2 LIF BORING LOCATION
SCB-1	SRI PHASE 2 SOIL CORE AND SOIL CONFIRMATION SAMPLING LOCATION
SSB-1	SRI PHASE 2 SHALLOW SOIL SAMPLING LOCATION
TD	TOTAL DEPTH
	APPROXIMATE AREA OF SOIL BORING INVESTIGATION AT UNDOCUMENTED UST BASIN
	APPROXIMATE AREA OF SUSPECTED UST BASIN

0 90' 180'

APPROXIMATE SCALE 1 in. = 90 ft.

FORMER CHEVRON FACILITY #96590
232 E. WOODIN AVENUE
CHELAN, WA 98816

SITE PLAN WITH SOIL BORINGS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
4

LEGEND:

- MW-2 — PERCHED GROUNDWATER MONITORING OR RECOVERY WELL
- MW-30 — DEEP GROUNDWATER MONITORING WELL
- MW-1 — ABANDONED DRY MONITORING WELL
- SRI4B-2 — SRI 4 SOIL BORING LOCATION
- LIFB-4 — SRI PHASE 2 LIF BORING LOCATION
- SCB-1 — SRI PHASE 2 SOIL CORE AND SOIL CONFIRMATION SAMPLING LOCATION
- SCB-2 — SRI PHASE 2 SHALLOW SOIL SAMPLING LOCATION
- PRESCRIBED UVOST-HP LOCATIONS (30-50' TD)
- CONTINGENCY UVOST-HP LOCATIONS (30-50' TD)
- PRESCRIBED TRANSDUCER INSTALLATION
- CONTINGENCY TRANSDUCER INSTALLATION
- PROPOSED SHALLOW SOIL INVESTIGATION
- PROPOSED SOIL VAPOR POINTS
- TD — TOTAL DEPTH
- APPROXIMATE AREA OF SOIL BORING INVESTIGATION AT UNDOCUMENTED UST BASIN
- APPROXIMATE AREA OF SUSPECTED UST BASIN

N

0 90' 180'

APPROXIMATE SCALE 1 in. = 90 ft.

FORMER CHEVRON FACILITY #96590
232 E. WOODIN AVENUE
CHELAN, WA 98816

PROPOSED INVESTIGATION LOCATIONS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5

ATTACHMENT

Appendix A Sampling and Analysis Plan

Chevron Environmental Management Company

SAMPLING AND ANALYSIS PLAN

Chevron Service Station 9-6590

232 East Woodin Avenue

Chelan, Washington

FSID: 77751227

CSID: 6660

June 16, 2020

SAMPLING AND ANALYSIS PLAN

Chevron Service Station 9-6590
232 East Woodin Avenue
Chelan, Washington
FSID: 77751227
CSID: 6660

Prepared for:

Chevron Environmental Management Company

Prepared by:

Arcadis U.S., Inc.
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Tel 206 325 5254

Our Ref:

30045295

Date:

6/16/2020

Andy Pennington for
Matthew Spurlin
Principal Scientist

Steve Mahony
Staff Scientist

Grayson Fish, LG
Project Manager

CONTENTS

TABLES

APPENDICES

1 INTRODUCTION

On behalf of Chevron Environmental Management Company (CEMC), Arcadis U.S., Inc. (Arcadis) has prepared this Sampling and Analysis Plan (SAP) for Chevron Service Station No. 9-6590 located at 232 East Woodin Avenue, Chelan, Washington (site). This SAP is an appendix to the Supplemental Remedial Investigation (SRI) – Phase 5 Work Plan (workplan; Arcadis 2020) which is being prepared pursuant to the terms of Agreed Order No. DE 10629, which was entered into by CEMC and the Washington State Department of Ecology (Ecology) in June 2014.

1.1 Purpose and Objectives

The purpose of this SAP is to outline the specific procedures for the sampling and monitoring activities described in the work plan and to identify the quality assurance requirements for the sampling and laboratory analysis in compliance with the Model Toxics Control Act (MTCA) regulations for sampling and analysis plans (WAC 173-340-820).

1.2 Document Organization

This SAP is organized into the following sections:

- Section 1 – Introduction. Describes the scope and purpose of this SAP.
- Section 2 – Field Sampling Plan (FSP). Describes the sampling methodology for the field sampling and monitoring activities.
- Section 3 – Quality Assurance Project Plan (QAPP). Describes the quality assurance (QA) procedures for the field activities and laboratory analyses.

1.3 Roles and Responsibilities

Chevron Project Manager – Tim Bishop: CEMC's representative for the site.

Arcadis Project Manager – Grayson Fish: Responsible for providing technical oversight and reviewing all activities performed to verify that project objectives are met.

Health and Safety Officer – To be determined (TBD): Responsible for overseeing project health and safety issues and implementing corrective actions as needed.

Arcadis Field Lead – TBD: Responsible for overseeing sampling activities to verify that all field and analytical objectives are in compliance with this SAP.

Arcadis Field Personnel – TBD: Responsible for implementing the activities described in this SAP.

Ecology-Certified Laboratory – Pace Analytical Laboratories, Inc and Eurofins Air Toxics Laboratories, Inc..: Responsible for providing the analytical testing specified in this SAP.

2 FIELD SAMPLING PLAN

2.1 Scope of Work

The proposed activities are described in the work plan and listed below. The proposed SRI – Phase 5 activities are as follows:

1. Evaluation of hydraulic conductivity of subsurface hydrogeological units at the site using Ultra-Violet Optical Screening Tool (UVOST) – Hydraulic Profiling (HP) technology.
2. Installation of groundwater elevation transducers in select downgradient groundwater monitoring wells to monitor potential perched groundwater discharge to Lake Chelan.
3. Collect representative Light non-aqueous phase liquid (LNAPL) samples from select monitoring wells to be analyzed for physical parameters.
4. Investigation of shallow soil impacts relating to a suspected underground storage tank (UST) in the vicinity of 221 E. Woodin Avenue.
5. Installation and sampling of external (i.e., outdoor) soil vapor probes in the vicinity of MW-21 and MW-44.

2.2 Sampling Objectives

The objectives of the soil, LNAPL, and soil vapor sampling activities are presented below:

- Characterize subsurface soil in the vicinity of the suspected UST located near 221 E. Woodin Avenue.
- Characterize LNAPL observed in select monitoring wells.
- Characterize subsurface soil vapor in the vicinity of MW-21 and MW-44.

2.3 Sampling Methodology

The sampling methodology was developed to collect data that are of sufficient quality to meet the objectives presented in Section 2.1. The sample collection techniques and specific sampling procedures will follow the methods presented in the Technical Guidance Instructions (TGIs) provided in Attachment 1.

2.3.1 Utility Locate

Prior to all intrusive subsurface activities, Arcadis will contact the Northwest Utility Location Center serving Chelan County, Washington a minimum of 48 hours prior to initiating the field activities. A private utility locating company will be subcontracted by Arcadis to conduct a utility scan that will include the use of ground-penetrating radar to confirm that the proposed investigation locations are clear of underground utilities or other obstructions. A third-line of evidence to clear the location of utilities prior to drilling will include clearing the borehole a minimum of 110% of the diameter of the intrusive device (e.g., hollow-stem auger) or an additional 2-inches of overall diameter, whichever is greater, to a minimum depth of 5-feet below ground surface.

2.3.1.1 Subsurface Soil Sampling

Arcadis will collect soil samples as described in the workplan. Soil samples will be collected according to the methodology presented in the TGI for Soil Drilling and Sample Collection (Attachment 1).

- Arcadis field staff will conduct field screening which will include visual observation and using a photoionization detector (PID) to measure VOCs according to the TGI for Soil Drilling and Sample Collection (Attachment 1). All sampling field activity and data will be recorded on field sampling logs. Samples will be labeled, handled and shipped using the procedures described in the Arcadis Standard Operating Procedure (SOP) for Sample Chain of Custody (Attachment 1).
- Samples will be submitted to Pace Analytical Laboratories, Inc for the following analysis:
    - Gasoline-range organics analyzed by Ecology Northwest Method NWTPH-Gx
    - Diesel-range organics and Heavy-oil range organics analyzed by Ecology Northwest Method NWTPH-Dx
    - Benzene, toluene, ethylbenzene, and total xylenes (BTEX), methyl tert-butyl ether (MTBE), ethylene dibromide (EDB), and ethylene dichloride (EDC) analyzed by United States Environmental Protection Agency (USEPA) Method 8260
    - Total Lead analyzed by USEPA Method 6010

2.3.1.2 LNAPL Sampling

Arcadis will collect LNAPL samples from select wells for analysis of physical characteristics and composition. These analyses will include density, viscosity, oil-air interfacial tension, oil-water interfacial tension, and gas chromatogram/flame ionization detector “fingerprinting.” LNAPL samples will also be chemically analyzed to determine speciation, in order to validate the speciation differences observed during the Ultra-Violet Optical Screening Tool (UVOST) – Hydraulic Profiling (HP) investigation event and demonstrate what LNAPL types are present. LNAPL samples will be collected using the procedures described in the Arcadis TGI for LNAPL Sample Collection (Attachment 1).

2.3.1.3 Soil Vapor Sampling

Arcadis will collect soil vapor samples as described in the workplan. Soil vapor samples will be collected according to the methodology presented in the TGI for Sub-Slab Soil Vapor or Soil Vapor Sampling Using Whole Air Canisters Analyzed via USEPA Method TO-15 (Attachment 1).

- Samples will be submitted to Eurofins Air Toxics Laboratories, Inc for the following analysis:
    - Total petroleum hydrocarbons with carbon chain specific results: EC5-8 (aliphatics), EC9-12 (aliphatics), and EC9-10 (aromatics) by TPH Massachusetts Air Phase Hydrocarbons
    - Benzene, toluene, ethylbenzene, total xylenes, naphthalene, MTBE, EDC, EDB and ethylene dibromide by USEPA method TO-15 (Select Ion Monitoring); and

- Oxygen, carbon dioxide, helium, and methane by American Standard for Testing and Materials method D1946.

2.3.1.4 Transducer Data Logging

Arcadis will deploy pressure transducers as described in the workplan. Water-level monitoring data will be collected according to the methodology presented in the TGI for Water-Level Monitoring using Data Logging Instruments (Attachment 1).

2.4 Quality Assurance/Quality Control Samples

The following quality assurance samples will be collected during implementation of the sampling program.

- One field duplicate sample collected per medium (e.g., one duplicate collected for soil, one duplicate collected for soil vapor). Field duplicate samples will be sequentially numbered and for the purposes of laboratory analysis and chain-of-custody there will be no identifying markers of duplicate samples.
- One trip blank per cooler containing samples that will be analyzed for volatile compounds.

2.5 Sample Nomenclature

Samples will be identified with a unique alpha-numeric code that will identify the type of sample and the location where the sample was collected.

The following sample codes will be used:

- Soil samples will be labeled with the prefix "B-"and will include the boring identification number and depth. For example, a soil sample collected from boring B-1 at a depth of 5 ft would be labeled B-1-5.
- LNAPL samples will be labeled with the monitoring well designation and date corresponding to the month and year the sample was collected. For example, a sample collected from MW-44 in September 2020 would be labeled MW-44-0920.
- Soil vapor samples will be labeled with the prefix "SV-" and will include the soil vapor well designation and date corresponding to the month and year the sample was collected. For example, a sample collected from SV-1 in September 2020 will be labeled SV-1-0920
- Quality assurance samples will be given the following labels:

    - Field duplicate samples will be given the prefix "DUP-"followed by the matrix, and the date the sample was collected. For example, a field duplicate for a soil sample collected on September 1, 2020 would be labeled DUP-S-090120.

    - Trip blank samples will be given the prefix "TB-" followed by the date the sample was collected. For example, a trip blank sample collected on September 1, 2020 would be labeled TB-090120.

2.6 Sample Labeling, Handling, and Chain of Custody

Sampling handling and packaging will be in accordance with the procedures outlined in the Arcadis SOP for Sample Chain of Custody (Attachment 1). All sample containers labels will be completed will the following information:

- Project name and project number
- Sample designation
- Name or initials of the sampler
- Date and time of sample collection

2.7 Equipment Decontamination

Equipment decontamination will be performed using the procedures outlined in the TGI for Groundwater and Soil Sampling Equipment Decontamination (Attachment 1). Site personnel will perform decontamination of all equipment prior to removal from the site and between sample locations.

2.8 Residuals Management

All soil, water, decontamination liquids, personal protective equipment (PPE), and other waste generated during the field sampling activities will be managed in accordance with applicable local, state, and federal requirements. Residuals will be managed in accordance with the procedures outlined in the TGI for Investigation-Derived Waste Handling and Storage (Attachment 1).

Waste profiles will be generated for each waste stream to be transported off site as required by the selected disposal facility. Disposal characterization samples will be collected as needed to meet facility requirements.

3 QUALITY ASSURANCE PROJECT PLAN

3.1 Objective

The objective of this SAP is to document the planning, implementation, and assessment procedures for the planned compliance monitoring and sampling activities described in the work plan. The SAP also documents the QA/QC activities that will be performed to confirm that the data collected are of known and acceptable quality.

3.2 Analytical Method Requirements

The analytical methods and procedures are summarized in Table F-1. The method detection limits (MDLs) and QA indicators including accuracy, precision, and completeness are also listed.

3.3 Quality Assurance Indicators

QA indicators are generally defined in terms of six parameters, representativeness, comparability, sensitivity, completeness, precision, and accuracy. Representativeness is the degree to which the sampling data accurately and precisely represent the site conditions. Comparability is the degree of confidence with which one data set can be compared to another.

3.3.1 Completeness

Completeness is defined as a measure of the amount of valid data obtained from the sampling event compared to the total amount that was obtained. Completeness of a field or laboratory data set will be calculated by comparing the number of valid sample results generated to the total number of results generated.

$$Completeness = \frac{Number\ of\ Valid\ Results}{Total\ Number\ of\ Results\ Generated} x\ 100$$

The assessment of completeness will require professional judgment to determine data usability for intended purposes.

3.3.2 Precision

Precision is a measure of the reproducibility of sample results. The goal is to maintain a level of precision consistent with the objectives of the action. To maximize precision, sampling and analytical procedures will be followed. Checks for precision will include the analysis of laboratory duplicates and field duplicates. Checks for field measurement precision will include duplicate field measurements. Field precision is difficult to measure because of temporal variations in field parameters. However, precision will be controlled through the use of experienced field personnel, properly calibrated meters, and duplicate field measurements. Field duplicates will be used to assess precision for the entire measurement system, including sampling, handling, shipping, storage, preparation, and analysis.

Laboratory data precision will be monitored through the use of laboratory duplicate sample analyses.

The precision of data will be measured by calculation of the relative percent difference (RPD) by the following equation:

$$RPD = \frac{|\ A - B\ | \times\ 100}{(A + B)/2}$$

Where:

A = Analytical result from one of two duplicate measurements

B = Analytical result from the second measurement

3.3.3 Accuracy

Accuracy is a measure of how close a measured result is to the true value. Both field and analytical accuracy will be monitored through initial and continuing calibration of instruments. In addition, reference standards, matrix spikes, blank spikes, and surrogate standards will be used to assess the accuracy of the analytical data.

The accuracy of field measurements will be controlled by experienced field personnel, properly calibrated field meters, and adherence to established protocols. The accuracy of field meters will be assessed by review of calibration and maintenance logs. Laboratory accuracy will be assessed through the use of MS, surrogate spikes and laboratory control samples. Where available and appropriate, QA performance standards will be analyzed periodically to assess laboratory accuracy. Accuracy will be calculated in terms of percent recovery as follows:

$$Percent\ Recovery = \frac{(A - X) \times\ 100}{B}$$

Where:

A = Value measured in spiked sample or standard

X = Value measured in original sample

B = True value of amount added to sample or true value of standard

This formula is derived under the assumption of constant accuracy between the original and spiked measurements.

3.3.4 Sensitivity

Sensitivity is a quantitative measurement to determine if the analytical laboratory's procedures/methodologies and their associated method detection limits (MDLs) can satisfy the project requirements as they relate to the project action limits.

3.4 Laboratory Quality Control

Internal laboratory QC checks will be used to monitor data integrity. These checks will include method blanks, laboratory control samples, internal standards, surrogate samples and calibration standards. Laboratory control charts will be used to determine long-term instrument trends.

3.4.1 Method Blanks

Sources of contamination in the analytical process, whether specific analyses or interferences, must be identified, isolated, and corrected. The method blank is useful in identifying possible sources of contamination within the analytical process. For this reason, it is necessary that the method blank be initiated at the beginning of the analytical process and encompass all aspects of the analytical work. As such, the method blank would assist in accounting for any potential contamination attributable to glassware, reagents, instrumentation, or other sources that could affect sample analysis. One method blank will be analyzed with each analytical series associated with no more than 20 samples.

3.4.2 Laboratory Control Samples

Laboratory Control Samples (LCS) are standards of known concentration and are independent in origin from the calibration standards. The intent of LCS analysis is to provide insight into the analytical proficiency within an analytical series. This includes preparation of calibration standards, validity of calibration, sample preparation, instrument set-up, and the premises inherent in quantitation. Reference standards will be analyzed at the frequencies specified within the analytical methods.

3.4.3 Surrogate Spikes

Surrogates are compounds that are unlikely to occur under natural conditions but that have properties similar to the analytes of interest. This type of control is primarily used for organic samples analyzed by GC/MS and GC methods and is added to the samples prior to purging or extraction. The surrogate spike is utilized to provide broader insight into the proficiency and efficiency of an analytical method on a sample-specific basis. This control reflects analytical conditions that may not be attributable to sample matrix.

If surrogate spike recoveries exceed specified QC limits, the analytical results must be evaluated thoroughly in conjunction with other control measures. In the absence of other control measures, the integrity of the data may not be verifiable, and reanalysis of the samples with additional control may be necessary.

Surrogate spike compounds will be selected utilizing the guidance provided in the analytical methods.

3.4.4 Laboratory Duplicates

Laboratory duplicates will be analyzed to assess laboratory precision. Laboratory duplicates are defined as a separate aliquot of an individual sample that is analyzed as a separate sample.

3.4.5 Calibration Standards

Calibration check standards analyzed within a particular analytical series provide insight regarding instrument stability. A calibration check standard will be analyzed at the beginning and end of an analytical series, or periodically throughout a series containing a large number of samples.

In general, calibration check standards will be analyzed after every 12 hours or more frequently, as specified in the applicable analytical method. If results of the calibration check standard exceed specified tolerances, samples analyzed since the last acceptable calibration check standard will be reanalyzed.

3.5 Field Instruments and Equipment

Prior to field sampling, each piece of field equipment will be inspected to confirm that it is operational and calibrated in accordance with the manufacturer's instruction manual or the analytical method used. All meters that require charging or batteries will be fully charged or have fresh batteries. If instrument servicing is required, the maintenance arrangements will be made for timely service. Field instruments will be maintained according to the instructions provided by the manufacturer.

Logbooks will be kept for each field instrument. Logbooks will contain records of operation, maintenance, calibration, and any problems and repairs. Logbooks for each piece of equipment will be maintained in project records.

3.6 Laboratory Instruments and Equipment

Laboratory instrument and equipment documentation procedures include details of any observed problems, corrective measure(s), routine maintenance, and instrument repair (including information regarding the repair and the individual who performed the repair). Preventive maintenance of laboratory equipment generally will follow the guidelines recommended by the manufacturer. A malfunctioning instrument will be repaired immediately by in-house staff or through a service call from the manufacturer. Paperwork associated with service calls and preventative maintenance calls will be kept on file by the laboratory.

The laboratory manager will be responsible for the routine maintenance of instruments used in the particular laboratory. Any routine preventative maintenance carried out is logged into the appropriate logbooks. The frequency of routine maintenance is dictated by the nature of samples being analyzed, the requirements of the method used, and/or the judgment of the laboratory manager.

All major instruments are backed up by comparable (if not equivalent) instrument systems in the event of unscheduled downtime. An inventory of spare parts is also available to minimize equipment/instrument downtime.

3.7 Assessment and Response Actions

Performance and systems audits may be completed in the field and laboratory. Field performance audit summaries will contain an evaluation of field activities to verify that the activities are performed according to established protocols. The observations made during field performance audits and any recommended changes/deviations to the field procedures will be recorded and documented. In addition, systems audits comparing scheduled QA/QC activities with actual QA/QC activities completed will be performed. The audits will be performed periodically as required by the task needs and duration.

3.8 Data Management

The purpose of data management is to confirm that the necessary data are accurate and readily accessible to meet the analytical and reporting objectives of the project. The field activities will include a significant number of samples that require a structured, comprehensive, and efficient program for management of data.

Data management procedures will be employed to efficiently process the information collected, such that the data are readily accessible and accurate.

3.8.1 Field Data Management

Field activities require consistent documentation and accurate record keeping. Complete and accurate record keeping will be maintained, including field books, digital field forms and chain of custody forms. Field books or digital field forms will detail observations and measurements made during the site work. Data will be recorded directly into digital field forms or site-dedicated, bound notebooks, with each page dated and signed. To verify, at a future date, that notebook pages are not missing, each page will be sequentially numbered. Erroneous entries will be corrected by a single line strike out of the original entry, initialing, dating and then documenting the proper information.

Chain of custody forms will be used to document and track sample possession from time of collection to the time of disposal. A chain of custody form will accompany each field sample collected, and one copy of the form will be filed in the field office. Field personnel will be briefed on the proper use of the chain of custody procedure.

All field documentation will be scanned and saved to the Arcadis electronic project folder. Hard copies will be stored in the Arcadis Seattle, Washington office.

3.8.2 Analytical Data Management

Analytical data packages received from the laboratory will be reviewed and compared against the information on the chain of custody to confirm that the correct analyses were performed for each sample and that results for all samples submitted for analysis were received. Any discrepancies noted will be promptly corrected in coordination with the laboratory.

All data will be housed in a personal computer-based project database. The project database will include pertinent geographical, field, and analytical data. Information that will be used to populate the database will be derived from the surveying of sampling locations, field observations and analytical results. The project database will be backed up on a weekly basis at minimum or whenever major modifications are made. Access to the database will be limited to authorized project personnel.

3.9 Sample Designation System

A concise and easily understandable sample designation system will be used to facilitate sample tracking and sample management. The sample designation system to be employed during the sampling activities will be consistent, yet flexible enough to accommodate unforeseen sampling events or conditions. A combination of letters and numbers will be used to yield an unique sample number for each field sample collected, as outlined in Section 2.5.

3.10 Corrective Action

Corrective actions are required when field or analytical data are not within the objectives specified in this QAPP. Corrective actions include procedures to promptly investigate, document, evaluate, and correct data collection and/or analytical procedures. All corrective actions for situations including analytical or field equipment malfunctions, nonconformance or noncompliance with the QA requirements, or changes to the sampling procedures will be documented with the project records and maintained in the project file. All corrective action procedures must be initiated prior to continuing with the field or analytical procedure.

3.11 Laboratory Reports

The laboratory will maintain QA records related to analyses, QC, and corrective action. This information will be made available upon request. Routine reporting will include documenting all internal QC checks performed for the project.

3.12 Data Validation and Verification

Data validation entails a review of the QC data and the raw data to verify that the laboratory was operating within required limits; the analytical results were correctly transcribed from the instrument read-outs; and which, if any, environmental samples were related to out-of-control QC samples. The objective of data validation is to identify any questionable or invalid laboratory measurements. Data validation reports will be prepared for each sample batch according to the Laboratory Data Validation Guidelines for Evaluating Inorganic Analyses (EPA, 2004) and Laboratory Data Validation Function Guidelines for Evaluating Organics Analysis (EPA 1999). Resolution of any issues regarding laboratory performance or deliverables will be handled between the laboratory and the data validator. Data validation reports will be kept electronically in the project file on an Arcadis server.

4 REFERENCES

Arcadis U.S. Inc. 2020. Supplemental Remedial Investigation Workplan – Phase 5. Chevron Service Station No. 9-6590. June 15.

USEPA 1999. Contract Laboratory Program National Functional Guidelines for Organic Data Review. EPA 540-R-99-008.

USEPA 2004. Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA 540-R-04-004.

TABLE

Table F-1

Analytical Methods, Measurement Criteria, Containers, and Preservation Requirements

Sampling and Analysis Plan
Chevron Station 9-6590
Chelan, Washington

Parameter	Analytical Method	Analytical Procedure	Reporting Units	Laboratory MDL	Bottle Type	Preservation	Holding Time
Soil Analysis							
DRO	NWTPH-Dx (without silica gel cleanup)	GC/FID (Ecology 1997)	mg/kg	1.33	1 x 8-oz glass jar with Teflon®-lined lid	Cool to <6°C	14 days to analysis
RRO			mg/kg	3.33			
GRO [C6 - C12]	NWTPH-Gx	Purge and trap or direct injection and GC/FID (Ecology 1997)	mg/kg	0.84750	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
Benzene	8260D	GC/MS	mg/kg	0.000467	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
Toluene	8260D	GC/MS	mg/kg	0.001300	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
Ethylbenzene	8260D	GC/MS	mg/kg	0.000737	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
Total Xylenes	8260D	GC/MS	mg/kg	0.000880	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
Methyl Tert-Butyl Ether	8260D	GC/MS	mg/kg	0.000350	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
1,2-Dibromoethane	8260D	GC/MS	mg/kg	0.000648	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
1,2-Dichloroethane	8260D	GC/MS	mg/kg	0.000649	40 ML Amber w MEOH	Cool to <6°C	14 days to analysis
Lead	6010D	Inductively Coupled Plasma (ICP)	mg/kg	0.208	1 x 8-oz glass jar with Teflon®-lined lid	Cool to <6°C	6 months
Light Non-Aqueous Phase Liquid Analysis							
[C3-C36] Whole-Oil Molecular Characterization Gas Chromatography "Fingerpint"	ASTM D3328	GC/FID	Area %	N/A	HDPE 40 mL vial	None	None
[C8-C40] Semi-Quantitative Molecular Characterization	EPA8270 Mod	GC/MS - Full Scan Mode	Area %	N/A	HDPE 40 mL vial	None	None
Density	D4052	D4052	g/cm3	N/A	HDPE 40 mL vial	None	None
Viscosity	D7042	D7042	cP	N/A	HDPE 40 mL vial	None	None
Interfacial Tension	D971	D971	Dynes/cm	N/A	HDPE 100 mL vial	None	None
Soil Vapor Analysis							
TPH [EC5-8] (aliphatics), [EC9-12] (aliphatics), [EC9-10] (aromatics)	TPH Massachusetts Air Phase Hydrocarbons	GC/MS	µg/m3	Unknown	1L Summa Canister (100% Certified)	None	6 months
Benzene	USEPA Method TO-15 / TO-15 Selective Ion Monitoring	GC/MS	µg/m3	0.08		None	6 months
Toluene		GC/MS	µg/m3	0.25		None	14 days
Ethylbenzene		GC/MS	µg/m3	0.25		None	14 days
Total Xylenes		GC/MS	µg/m3	0.61		None	14 days
Naphthalene		GC/MS	µg/m3	0.06		None	14 days
Methyl Tert-Butyl Ether		GC/MS	µg/m3	0.15		None	14 days
Ethylene Dibromide		GC/MS	µg/m3	0.025		None	14 days
Oxygen	ASTM D-1946	Field Meter / GC	%	0.23		None	14 days
Carbon Dioxide	ASTM D-1946	Field Meter / GC	%	0.023		None	14 days
Methane	ASTM D-1946	Field Meter / GC	%	0.00024		None	14 days
Helium	ASTM D-1946	GC	%	0.12		None	14 days

Notes:
1. Laboratory method detection limits (MDLs) for soil are reported on a dry weight basis.
2. Accuracy and precision results may differ from the criteria shown as specified by the analytical method reference.
2. Ecology. 1997. Analytical Methods for Petroleum Hydrocarbons. ECY 97-602. June.
3. EPA. 1986. Test Methods for Evaluating Soil Waste, Physical/Chemical Methods. SW-846, Third Edition.

Abbreviations:
DRO = diesel range organics
RRO = residual-range organics
GRO = gasoline-range organics
MS = mass spectrometry
GC = gas chromotography
FID = flame ionization dete(ug = micrograms
PID = photo ionization dete(L = liter
kg = killograms
mg = milligrams
N/A = Not applicable

APPENDIX

Arcadis Technical Guidance Instruction and Standard Operating Procedure

TGI – SOIL DRILLING AND SAMPLE COLLECTION

Rev #: 1

Rev Date: May 12, 2020

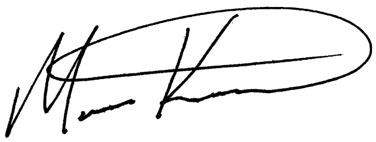
VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 11, 2018	All	Updated and re-written as a TGI	Marc Killingstad
1	May 12, 2020	None	Review – no changes necessary	Marc Killingstad

APPROVAL SIGNATURES

Prepared by:  10/11/2018

Christopher Keen Date:

Technical Expert Reviewed by:  05/12/2020

Marc Killingstad (Technical Expert) Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes general drilling procedures and the methods to be used to field screen and collect soil samples for laboratory analysis in unconsolidated sediments. For soil description procedures, please refer to the *TGI - Soil Description*. For monitoring well installation in granular aquifers, please refer to the *TGI - Monitoring Well Installation*.

Overburden (unconsolidated sediments) drilling is commonly performed using the hollow-stem auger drilling method. Other drilling methods suitable for overburden drilling, which are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and hand tools may also be used. Drilling within consolidated materials such as fractured bedrock is commonly performed using water-rotary (coring or tri-cone roller bit), air rotary or rotasonic methods. For guidance when drilling in consolidated materials (i.e., bedrock), please refer to the *TGI – Bedrock Core Collection and Description*.

The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, types of sampling to be conducted, required sample quality and volume, and cost.

Field screening of soil samples is commonly performed using a photoionization detector (PID) and/or a flame ionization detector (FID). These instruments are used to measure relative concentrations of volatile organic compounds (VOCs) for the selection of samples for further laboratory or field analysis. Field screening for dense non-aqueous phase liquids (DNAPL) may be performed using hydrophobic dye (Oil Red O or Sudan IV), which is pertinent at chlorinated solvent sites.

Collection of soil samples for laboratory analysis may be performed using a variety of techniques including grab samples and composite or homogenized samples. Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample. Samples for VOC analysis will not be homogenized or composited and are collected as discrete grab samples.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools).

3 PERSONNEL QUALIFICATIONS

Arcadis field personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or state/federal regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilizing to the field, Arcadis field personnel will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP), Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Personnel responsible for overseeing drilling operations will have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

Arcadis personnel directing, supervising, or leading soil sampling activities will have a minimum of 1 year of previous environmental soil sampling experience. Field employees with less than 6 months of experience will be accompanied by a supervisor (as described above) to ensure that proper sample collection techniques are employed.

Additionally, the Arcadis field team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

4 EQUIPMENT LIST

The following materials will be available, as required, during soil boring drilling, field screening, and sampling activities:

- Site-specific HASP and health and safety documents identified in the HASP
- Field Implementation Plan (FIP)/work plan that includes site map with proposed boring locations, field sampling plan (with corresponding depths, sample analyses, sample volume required, and sample holding time), and previous boring logs (as available)
- Appropriate personal protective equipment (PPE), as specified in the HASP
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP)
- Photoionization detector (PID), flame ionization detector (FID) or other air monitoring equipment, as needed, in accordance with the HASP
- Drilling equipment required by *ASTM D1586*, when performing split-spoon sampling
- Disposable plastic liners, when drilling with direct-push equipment
- Appropriate soil sampling equipment (e.g., stainless steel spatulas/spoons/bowls, knife)
- Stainless steel hand auger and stainless-steel spade if using manual methods
- Indelible ink pens
- Engineer's ruler or survey rod
- Sealable plastic bags (e.g., Ziploc®)
- Air-tight sample containers and 8-oz. glass Mason jars or driller's jars
- Aluminum foil
- Plastic sheeting (e.g., Weatherall Visqueen)
- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels)
- Appropriate sample blanks (trip blank supplied by the laboratory), as specified in the FSP
- Soil sample containers and labels (supplied by the laboratory) appropriate for the analytical method(s) with preservative, as needed (parameter-specific)
- Appropriate transport containers (coolers) with ice and appropriate labeling, packing, and shipping materials;
- Appropriate soil boring log (**Attachment 1**)
- Chain-of-custody forms
- Field notebook.

- Digital camera (or smart phone with camera)
- Drums or other containers appropriate for soil and decontamination water, as specified by the site investigation-derived waste (IDW) management plan, and appropriate drum labels

5 CAUTIONS

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See appropriate guidance for proper utility clearance protocol. Work will be performed in accordance with the Arcadis *Utility Location and Clearance Health and Safety Standard* and the *Utilities and Structures Checklist* will be completed before beginning any intrusive work.

Prior to beginning field work, the project technical team will ensure that all field logistics (e.g., access issues, health and safety issues, communication network, schedules, etc.) and task objectives are clearly understood by all team members. An internal call with the project technical team to review the FIP/work plan scope and objectives is strongly recommended prior to mobilization to ensure that the field work will be effectively and efficiently executed.

Some regulatory agencies have specific requirements regarding borehole abandonment and grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling plan.

If DNAPL is known or expected to exist at the site, refer to the project specific documents (e.g., DNAPL Contingency Plan) for additional details regarding drilling to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquid (LNAPL) is known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Water used for drilling, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply will be considered.

Specifications of materials used for backfilling the borehole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPL is likely to be present or in groundwater with high salinity. In these situations, neat cement grout is preferred.

Store and/or stage empty and full sample containers and coolers out of direct sunlight. Be careful not to over-tighten lids with Teflon® liners or septa. Over-tightening can impair the integrity of the seal and can cause the glass to shatter and create a risk for hand injuries.

NOTE: *Field logs and some forms are considered to be legal documents. All field logs and forms will therefore be filled out in indelible ink. Do not use permanent marker or felt-tipped pens for labels on* *sample container or sample coolers. Permanent markers could introduce volatile constituents into the samples.*

NOTE: *An Arcadis employee that is appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.*

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Working outside at sites with suspected contamination may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include biological hazards (e.g., stinging insects, ticks in long grass/weeds, etc.), and potentially the use of sharp cutting tools (scissors, knife). Only use non-toxic peppermint oil spray for stinging insect nests. Review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives and use appropriate hand protection.

If thunder or lighting is present, discontinue drilling and sampling until 30 minutes have passed after the last occurrence of thunder or lighting.

7 PROCEDURE

The procedures for drilling and the methods to be used to field screen and collect soil samples for laboratory analysis are presented below:

DRILLING PROCEDURES

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area.
2. Advance boring to designated depth:
    a. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent)
    b. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent)

c. Decontaminate equipment between samples in accordance with the FIP/work plan (or equivalent)

d. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is described in *ASTM D1586 – Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils* (ASTM D1586).

    i. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary

e. Rotasonic drilling produces soil cores that, for the most part, are relatively undisturbed, but note that when drilling in consolidated or finer-grained sediment the vibratory action during core barrel advancement may create secondary fractures or breaks

f. Dual-rotary removes cuttings by compressed air or water/mud and allow only a general assessment of geology

3. Describe each soil sample as outlined in the appropriate project records (refer to the description procedures outlined in the *TGI - Soil Description*)

    a. Record descriptions on the soil boring log (**Attachment 1**) and/or field notebook.

    b. When possible photo document the samples (e.g., soil cores, split-spoons)

    c. During soil boring advancement, document all drilling events in field notebook, including blow counts (i.e., the number of blows from a soil sampling drive weight [140 pounds] required to drive the split-barrel sampler in 6-inch increments) and work stoppages

    d. Blow counts will not be available if rotasonic, dual-rotary, or direct-push methods are used; however, if standard penetration testing is required during rotasonic drilling, an automatic drop hammer may be used in conjunction with the method to switch from core barrel advancement to standard penetration testing

4. The drilling contractor will be responsible for obtaining accurate and representative samples, informing the supervising Arcadis geologist of changes in drilling pressure, and keeping a separate general log of soils encountered, including blow counts

    a. The term “samples” means soil materials from particular depth intervals, whether or not portions of these materials are submitted for laboratory analyses

    b. Records will also be kept of occurrences of premature refusal due to boulders or construction materials that may have been used as fill

    c. Where a boring cannot be advanced to the desired depth, the boring will be abandoned, and an additional boring will be advanced at an adjacent location to obtain the required sample

    d. Where it is desirable to avoid leaving vertical connections between depth intervals (e.g., if DNAPL or perched LNAPL are known or expected to exist at the site), the borehole will be sealed using cement and/or bentonite (see **Section 5** above)

e. Multiple refusals may lead to a decision by the supervising geologist to abandon that sampling location

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings. Examples of this technique include Geoprobe®, Diedrich Environmental Soil Probe (ESP) System, or AMS PowerProbe. Environmental probe systems typically use a hydraulically operated percussion hammer.

Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff to medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual tube liner for sampling soil (dual tube sampling system).

The outside diameter (OD) of the outer casing ranges from 2.25 to 6 inches and the OD of the inner sampling tube diameter ranges from 1.4 to 4.5 inches. The outer casing isolates overlying soil and permits the unit to continue to probe at depth. The dual tube sampling system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, a single rod system may be used that does not provide a cased boring and which does not allow for tremie-grouting from the bottom up.

The known or expected site conditions (e.g., presence of NAPL) will be evaluated when selecting the type of direct-push sampling system to be employed.

Direct-push drilling can generally achieve target depths 100 feet or less and the achievable depth is based on the site geology.

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
2. Advance soil boring to designated depth.
    a. Collect soil samples at appropriate interval as specified in in the FIP/work plan (or equivalent)
    b. Collect, document, and store samples for laboratory analysis as specified in in the FIP/work plan (or equivalent)
    c. Decontaminate equipment between samples in accordance with in the FIP/work plan (or equivalent)
    d. Samples will be collected using dedicated, disposable, plastic liners
3. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

Manual Methods

Manual methods may also be used to complete shallow soil borings. Examples of this technique include using a spade, spoon, scoop, hand auger, or slide hammer. Manual methods are typically used to collect surface soil samples (0 to 6 inches) or to complete soil borings/collect soil samples from a depth of 5 feet or less.

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris
3. Use a spade, spoon, scoop, hand auger, or slide hammer to collect a sample of the required depth interval
4. Use an engineer's ruler or survey rod to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface
5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval
    a. To prevent the hole from collapsing, it may be necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) pipe to maintain the opening
    b. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent)
    c. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent)
    d. Decontaminate equipment between samples in accordance with the FIP/work plan (or equivalent)
6. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

FIELD SCREENING PROCEDURES

PID and FID Screening

Soils are typically field screened with a PID or FID for a relative measure of the total VOCs at sites where VOCs are known or suspected to exist. The PID employs a UV lamp to measure VOCs and the ionization energy (IE) of the site constituents need to be considered when selecting the type of lamp (e.g., 10.6 eV, 11.7 eV) that will be used. In general, any compound with an IE lower than that of the lamp photons can be measured. The FID has a wide linear range and responds to almost all VOCs. Field screening is performed using one (or both) of the following two methods:

1. Upon opening the sampler, the soil is split open and the PID or FID probe is placed in the opening and covered with a gloved hand. Such readings will be obtained at several locations along the length of the sample.
2. A portion of the collected soil is placed in a jar, which is covered with aluminum foil, sealed, and allowed to warm to room temperature. After warming, the cover is removed, the foil is pierced with the PID or FID probe, and a reading is obtained.

Initial PID readings will be recorded on the soil boring log (**Attachment 1**) and/or in the field notebook. The soil sample will be separated from the slough material (if any) by using disposable gloves and a pre-cleaned stainless-steel spoon.

For the second method, a representative portion of the sample will be placed in a pre-cleaned air-tight 8-ounce container (as quickly as possible to avoid loss of VOCs), filling the container half full to allow for the accumulation of vapors above the soil. An aluminum foil seal will be placed between the glass and metal cap and the cap will be screwed on tightly. Unless the screening will be performed immediately after the sample is placed in the container, the sample containers will be stored in a cooler chilled to approximately 4ºC until screening can be performed.

The headspace of the 8-ounce container will be measured using a PID or FID as follows:

1. Samples will be taken to a warm work space and allowed to equilibrate to room temperature for at least one hour.
2. Prior to measuring the soil vapor headspace concentration, the 8-ounce container will be shaken.
3. The headspace of the sample will then be measured directly from the 8-ounce container by piercing the aluminum foil seal with the probe of the PID or FID and measuring the relative concentration of VOCs in the headspace of the soil sample. The initial (peak) reading must be recorded.

The PID or FID must be calibrated according to the manufacturer's specifications at a minimum frequency of once per day prior to collecting PID or FID readings. The PID will be calibrated to a benzene-related compound (isobutylene) while the FID will be calibrated to methane.

The time, date, and calibration procedure must be clearly documented in the field notebook and/or the calibration log book.

If at any time the PID or FID results appear erratic or inconsistent with field observations, then the instrument will be recalibrated.

If calibration is difficult to achieve, then the PID’s lamp will be checked for dirt or moisture and cleaned, or technical assistance will be required. Maintenance and calibration records will be kept as part of the field quality assurance program.

NAPL Screening

To screen for the potential presence of non-aqueous phase liquid (NAPL) in soil, drilling procedures must allow for high-quality porous media samples to be taken. Split-spoon samplers or direct-push samplers will be collected continuously ahead of the auger, drill casing/rods, or probe rods.

Upon opening each split-spoon sampler or direct-push plastic liner sleeve, the soil will immediately be evaluated for the presence of visible NAPL. If NAPL is immediately visible in the sample, its depth will be noted.

Additionally, the soil will be screened for the presence of organic vapors using a PID or FID. During screening, the soil will be split open using a clean spatula or knife and the PID or FID probe will be placed in the opening and covered with a gloved hand (**Method 1** above). Such readings will be obtained along the entire length of the sample. Alternatively, **Method 2** for PID/FID screening (outlined above) may also be performed. If the PID or FID examination reveals the presence of organic vapors above 100 parts per million (ppm), the sample will undergo further detailed evaluation for visible NAPL.

The assessment for NAPL will include the following tests/observations:

- Evaluation for Visible NAPL Sheen or Free-Phase NAPL in Soil Sampler
    - NAPL sheen will be a colorful iridescent appearance on the soil sample
    - NAPL may also appear as droplets or continuous accumulations of liquid with a color typically ranging from yellow to brown to black, depending on the type of NAPL
    - Creosote DNAPL (associated with wood-treating sites) and coal tar DNAPL (associated with manufactured gas plant [MGP] sites) are typically black and have a characteristic, pungent odor
    - Pure chlorinated solvents may be colorless in the absence of hydrophobic dye. Solvents mixed with oils may appear brown
    - Particular care will be taken to fully describe any sheens observed, staining, discoloration, droplets (blebs), or NAPL saturation
- Soil-Water Pan Test
    - A portion of the selected soil interval with the highest PID or FID reading above 100 ppm will be placed in a disposable polyethylene dish along with a small volume of potable or distilled water
    - The dish will be gently tilted back and forth to mix the soil and water, and the surface of the water will be viewed in natural light to observe the development of a sheen, if any
    - A small quantity of Oil Red O or Sudan IV hydrophobic dye powder will be added, and the soil and dye will be manually mixed for approximately 30 to 60 seconds and smeared in the dish to create a paste-like consistency
    - A positive test result will be indicated by a sheen on the surface of the water and/or a bright red color imparted to the soil following mixing with dye
- Soil-Water Shake Test
    - A small quantity of soil (up to 15 cc) will be placed in a clear, colorless, jar containing an equal volume of potable or distilled water (40-mL vials are well suited to this purpose, but not required)
    - After the soil settles into the water, the surface of the water will be evaluated for a visible sheen under natural light
    - The jar will be closed and gently shaken for approximately 10 to 20 seconds
    - Again, the surface of the water will be evaluated for a visible sheen or a temporary layer of foam
    - A small quantity (approximately 0.5 to 1 cc) of Oil Red O or Sudan IV powder will be placed in the jar
    - The sheen layer, if present, will be evaluated for a reaction to the dye (change to bright red color)
    - The jar will be closed and gently shaken for approximately 10 to 20 seconds
    - The contents in the closed jar will be examined under natural light for visible bright red dyed liquid inside the jar

- A positive test result will be indicated by the presence of a visible sheen or foam on the surface of water, a reaction between the dye and the sheen layer upon first addition of the dye powder, a bright red coating on the inside of the vial (particularly above the water line), or red-dyed droplets within the soil

NOTE: *If NAPL is obviously present upon opening the soil sampler or evaluating the soil sample within the split-spoon sampler or direct-push liner sleeve, it is not necessary to perform a soil-water pan test or soil-water shake test. In addition, it is not necessary to perform both a soil-water pan test and a soil-water shake test; either test method is acceptable. The pan test may be preferred in some circumstances because the presence of a sheen may be easier to see on a wider surface.*

NOTE: *When using hydrophobic dye in the tests above, color will be assessed outdoors under natural light during the period between sunrise and sunset, regardless of the degree of cloud cover. The hydrophobic dye Safety Data Sheets (SDS) will be incorporated into the HASP and reviewed prior to use and the dyes will be carefully handled and disposed in accordance with regulations*.

SOIL SAMPLE COLLECTION FOR LABORATORY PROCEDURES

If not specifically identified in the FIP, soil samples will be selected for laboratory analysis based on:

1. Their position in relation to identified source areas
2. The visual presence of source residues (e.g., NAPL)
3. The relative levels of total VOCs based on field screening measurements
4. The judgment of the field coordinator

Samples designated for laboratory analysis will be placed in the appropriate containers.

Sample containers for VOC analysis will be filled first immediately following soil core retrieval to reduce loss of VOCs.

If samples will be collected for other analytical parameters, a sufficient amount of the remaining soil will then be homogenized as described below and sample containers will be filled for other parameters.

VOC samples will be collected as discrete samples using a small diameter core sampler (e.g., En Core® Sampler, Terra Core™ Sampler).

The En Core® Sampler is a disposable volumetric sampling device that collects, stores and delivers soil samples without in-field chemical preservation. The En Core® Sampler requires the use of a reusable T-handle.

The Terra Core™ Sampler is a one-time use transfer tool, designed to collect soil samples and transfer them to the appropriate containers for in-field chemical preservation (e.g., methanol).

The small diameter core sampler will be used according to the manufacturer's instructions (e.g., En Novative Technologies). Some regulatory agencies have specific requirements regarding VOC sample collection. Determine whether the oversight agency has specific requirements prior to commencing sampling and collect samples at appropriate interval as specified in the FIP/work plan (or equivalent). Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample.

NOTE: *Samples for VOC analysis will NOT be homogenized or composited and will be collected as discrete samples as described above*.

The procedure for mixing samples is provided below.

1. Mix the materials in a stainless steel (or appropriate non-reactive material) bowl using a stainless-steel spoon (or disposable equivalents)
    a. When dealing with large sample quantities, use disposable plastic sheeting and a shovel or trowel
    b. NOTE: *When preparing samples for metals analyses, do not use disposable aluminum (or metal tools or trays other than stainless steel), as it may influence the analytical results*
2. Flatten the pile by pressing the top without further mixing
3. Divide the circular pile by into equal quarters by dividing out two diameters at right angles
4. Mix each quarter individually using appropriate non-reactive bowls, spoons and/or sheeting
5. Mix two quarters (as described above) to form halves, then mix the two halves to form a composite or homogenized sample
6. Place composite or homogenized sample into specified containers
7. Remaining material will be disposed of in accordance with project requirements and applicable regulations
8. Sample containers will be labeled with sample identification number, date, and time of collection and placed on ice in a cooler (target 4° Celsius)
9. Samples selected for laboratory analysis will be documented (chain-of-custody forms), handled, packed, and shipped in accordance with the procedures outlined in the FIP/work plan (or equivalent).

8 WASTE MANAGEMENT

Investigative-Derived Waste (IDW) generated during drilling activities, including soil and excess drilling fluids (if used), decontamination liquids, and disposable materials (plastic sheeting, PPE, etc.) will be stored on site in appropriately labeled containers (disposable materials will be contained separately) and disposed of properly. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, PPE). Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field log book.

9 DATA RECORDING AND MANAGEMENT

Management of the original documents from the field will be completed in accordance with the site-specific QAPP.

In general, drilling activities will be documented on appropriate field/log forms as well as in a proper field notebook. All field data will be recorded in indelible ink. Field forms, logs/notes (including daily field and calibration logs), digital records, and chain-of-custody records will be maintained by the field team lead.

Initial field logs and chain-of-custody records will be transmitted to the Arcadis Certified Project Manager (CPM) and Technical Lead at the end of each day unless otherwise directed by the CPM. The field team leader retains copies of the field documentation.

Additionally, all documents (and photographs) will be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of drilling activities, soil descriptions, soil boring information, and quantities of materials used.

In addition, the locations of soil borings will be documented photographically and in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

10 QUALITY ASSURANCE

Quality assurance procedures shall be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate TGI.

Field-derived quality assurance blanks will be collected as specified in the FIP/work plan and/or site-specific QAPP, depending on the project quality objectives. Typically, field rinse blanks (equipment blanks) will be collected when non-dedicated equipment (e.g., split-spoon sampler, stainless steel spoon) is used during soil sampling. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Trip blanks for VOCs, which aid in the detection of contaminants from other media, sources, or the container itself, will be kept with the coolers and the sample containers throughout the sampling activities and during transport to the laboratory.

Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook.

11 REFERENCES

ASTM D1586 - *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*. ASTM International. West Conshohocken, Pennsylvania.

12 ATTACHMENTS

Attachment 1. Soil Boring Log Form

ATTACHMENT 1

Soil Boring Log Form

ARCADIS Design & Consultancy for natural and built assets

SOIL BORING LOG

Boring/Well ____________ Project ______________________________ Page ___ of ___

Site Location ______________________________________ Drilling Started ____________________

Total Depth Drilled ________ Feet Hole Diameter __________ inches Drilling Completed ____________________

Type of Sample or Coring Device ______________ Length and Diameter of Coring Device ______________________ Sampling Interval ____________ feet

Drilling Method ______________ Drilling Fluid Used ______________

Drilling Contractor ______________________________ Driller ______________________

Prepared By ______________________________ Helper ______________________

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				**Udden-Wentworth Description:** principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, additional comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

ARCADIS Design & Consultancy for natural and built assets

SOIL BORING LOG (CONT'D)

Boring/Well ______________________ Prepared By ______________________________________ Page ___ of ___

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				Udden-Wentworth Description: principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, addtl. Comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

TGI - LNAPL SAMPLE COLLECTION

Rev #: 0

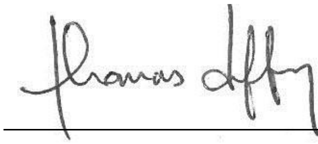
Rev Date: October 16, 2018

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 16, 2018	All	Re-written as a TGI	Andy Pennington

APPROVAL SIGNATURES

Prepared by:

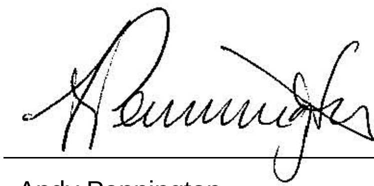


10/16/2018

Thomas Duffy

Date:

Technical Expert Reviewed by:



10/16/2018

Andy Pennington

Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

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2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes the methods to be used to collect light non-aqueous phase liquid (LNAPL) samples for specialized physical testing (e.g. density, viscosity, interfacial tension) and/or chemical speciation testing. It is important to note that the physical testing parameters are temperature sensitive. Therefore, the laboratory should be directed to analyze the samples at representative subsurface fluid temperatures. The fluid data are used to support site-specific LNAPL mobility calculations and development of the LNAPL site conceptual model.

This TGI applies to task orders and projects associated with Arcadis. This TGI may be modified, as required, depending on site-specific conditions, equipment limitations or limitations imposed by the procedure. The ultimate procedure employed will be documented in the appropriate project work plans or reports. If changes to the testing procedures are required due to unanticipated field conditions, the changes will be discussed with the project manager as soon as practicable and documented in the project report.

3 PERSONNEL QUALIFICATIONS

Arcadis personnel directing, supervising, or leading LNAPL sample collection activities should have previous related sampling experience collecting fluids from wells and will be trained in shipping hazardous material. Field employees with less than 6 months of experience will be accompanied by a supervisor (as described above) to ensure that proper sample collection techniques are employed.

Prior to mobilizing to the field, the sampling team must review and be thoroughly familiar with relevant site-specific documents including, but not limited to, the site Work Plan, Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), Health and Safety Plan (HASP), historical information, and site relevant documents.

Additionally, the sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization.

4 EQUIPMENT LIST

The following materials may be helpful during LNAPL sampling:

- Work Plan (or equivalent), site plan of monitoring well locations, site FSP, and site-specific HASP;
- Appropriate health and safety equipment (e.g., personal protective equipment [PPE]), as specified in the HASP;
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP);
- Photoionization detector (PID), flame ionization detector (FID) or other air monitoring equipment, as needed, in accordance with the HASP;
- Monitoring well construction logs or tables, historical water level information, Site map with groundwater elevation contours, and previous groundwater sampling logs, if available;
- Dedicated plastic sheeting or other clean surface to prevent sampling equipment contact with the ground;
- Bailers to be used in sampling:
    - appropriate dedicated bottom-loading, bottom-emptying bailers (i.e., polyvinyl chloride [PVC], polyethylene, Teflon®, or stainless steel);
    - polypropylene or nylon rope;
    - A 1¾-inch-diameter bailer should be used for 2-inch-diameter wells. For 4-inch-diameter wells, a 3-inch-diameter bailer may be used.
- Oil/water interface meter, in accordance with the FSP or Work Plan;
- LNAPL sample containers and labels appropriate for the analytical method(s), as needed (parameter-specific);

- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels);
- Appropriate transport containers (coolers) and appropriate labeling, packing, and shipping materials;
- Chain-of-custody forms;
- Field notebook;
- Digital camera (or phone with camera);
- Keys to wells and contingent bolt cutters for rusted locks and replacement keyed-alike locks; and,
- Drums or other containers for investigation-derived waste (IDW), as specified by the site IDW management plan, and drum labels.

5 CAUTIONS

The sample volume needed for laboratory analysis will vary depending on the analyses to be conducted. The project team should confer with the laboratory before the sampling event to identify the appropriate containers and preservation requirements. Note that using smaller containers and smaller overall volumes may be helpful in complying with hazardous material shipping requirements.

Remember that field logs and some forms are considered to be legal documents. All field logs and forms will therefore be filled out in indelible ink.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

Be careful not to over-tighten lids with Teflon® liners or septa (e.g., 40-mL vials). Over-tightening can impair the integrity of the seal.

An Arcadis employee appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.

6 HEALTH AND SAFETY CONSIDERATIONS

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work. Generators and cord and plug equipment will employ an overcurrent protection device such as an integrated ground fault circuit interrupter (GFCI) cord. If thunder or lighting is present, discontinue sampling until 30 minutes have passed after the last occurrence of thunder or lighting.

7 PROCEDURE

The procedures for sampling monitoring wells are presented below:

1. Don safety equipment, as required in the HASP. Depending on site-specific security and safety considerations, this often must be done prior to entering the work area.
2. Review equipment list (Section 4 above) to confirm that the appropriate equipment has been acquired.
3. Record site and monitoring well identification on the sampling log, along with date, arrival time, and weather conditions. Also identify the personnel present, equipment utilized, and other relevant data requested on the log.
4. Label all sample containers with indelible ink.
5. Place plastic sheeting adjacent to the well for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
6. Remove lock from well and if rusted or broken, replace with a new brass keyed-alike lock.
7. Unlock and open the well cover while standing upwind of the well. Remove well cap and place on the plastic sheeting. Insert the PID probe approximately 4 to 6 inches into the casing or the well headspace and cover it with a gloved hand. Record the PID reading on the field log. Perform air monitoring in the breathing zone according to the HASP and/or JSA.
8. Set the sampling device and other sampling equipment on the plastic sheeting.
9. Measure liquid levels (depth to LNAPL and depth to water) within the well using the oil/water interface meter and record in field notes.
10. Collect the LNAPL sample by slowly lowering the bailer into the LNAPL, but not into the water. Pull the bailer out of the well. If both water and LNAPL are present, allow the liquids to separate. Use a bottom emptying device to decant (drain) the appropriate amount of LNAPL into the appropriate container(s). Drain off remaining, unneeded liquids into a “waste” bucket. Record the amount of LNAPL removed from the well in notes. The required sample volumes and containers are dependent upon the laboratory analyses to be performed.
11. Note the time on the sample label. Secure with packing material in an insulated, durable transport container. Note that use of ice or chilling of samples is typically not necessary for LNAPLs sampling; however, this can be confirmed with the laboratory prior to the sampling event.
12. Record the time sampling procedures were completed on the appropriate field logs
13. Replace the well cap and lock well or install a new lock if needed.
14. Complete the procedures for chain-of-custody, handling, packing, and shipping. Chain-of-custody forms must be filled out and checked against the labels on the sample containers progressively after each sample is collected.

15. Place all disposable sampling materials (such as plastic sheeting, disposable tubing or bailers, and health and safety equipment) in appropriate containers.
16. If new locks were installed, forward copies of the keys to the client Project Manager (PM) and Arcadis PM at the end of the sampling activities.

8 WASTE MANAGEMENT

IDW, including purged LNAPL, decontamination liquids, and disposable materials (plastic sheeting, PPE, etc.) will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan (or equivalent), FSP, and/or IDW management guidance document, and according to state and/or federal requirements. Disposable materials will be contained separately. Containers must be labeled at the time of collection. General guidelines for IDW management are set forth in a separate IDW management TGI.

9 DATA RECORDING AND MANAGEMENT

Sampling activities will be documented on in an appropriate field notebook or in electronic notes. Initial field logs and chain-of-custody records will be transmitted to the Arcadis PM at the end of each day unless otherwise directed by the PM. The sample team leader retains copies of the sampling logs.

Additionally, all documents (and photographs) should be electronically filed in the appropriate project directory for easy access.

10 QUALITY ASSURANCE

- No trip blanks or duplicates are typically required for LNAPL sampling; however, if desired, duplicate samples could be collected on a project-specific basis for either physical or chemical analyses.
- Clean all equipment that will come in contact with LNAPL prior to use in the first well and after each subsequent well following procedure for equipment decontamination.

11 REFERENCES

Not applicable.

TGI - SUB-SLAB SOIL VAPOR OR SOIL VAPOR SAMPLING USING WHOLE AIR CANISTERS ANALYZED VIA USEPA METHOD TO-15

Rev #: 1

Date: September 18, 2016

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
1	9/18/2016	All	Updated Rev0	Mitch Wacksman

APPROVAL SIGNATURES

Prepared by: ______________________ Date: 9/18/2016

Eric Cathcart

Reviewed by: ______________________ Date: 9/18/2016

Mitch Wacksman (Technical Expert)

I. INTRODUCTION

This Technical Guidance Instruction (TGI) document describes the procedures to conduct a building survey prior to indoor air sampling.

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II. SCOPE AND APPLICATION

This document describes the procedures for collecting exterior soil vapor or sub-slab soil vapor (herein referred to as "soil vapor") samples using whole air canisters for the analysis of volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 (TO-15). This document assumes a sample port – either sub-slab or exterior soil vapor – has already been installed. This document covers the above ground assembly and sampling methods.

Method TO-15 uses a 1-liter 3-liter or 6-liter SUMMA® passivated stainless steel canister to collect a whole-air sample. The whole-air sample is then analyzed for VOCs using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GS/MS) system to provide typical compound detection limits of 0.5 parts per billion volume (ppbv).

The following sections list the necessary equipment and detailed instructions for collecting soil vapor samples for VOC analysis.

III. PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. Arcadis field sampling personnel will be well versed in the relevant technical guidance instructions (TGIs) and possess the required skills and experience necessary to successfully complete the desired field work. Arcadis personnel responsible for leading soil vapor sample collection activities must have previous soil vapor sampling experience.

IV. EQUIPMENT LIST

The equipment required for soil vapor sample collection is presented below:

- 1,3, or 6 – liter stainless steel SUMMA® canisters (order at least one extra, if feasible) (batch certified canisters or individual certified canisters as required by the project);
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g.,5-, 10, or 30- minutes) or flow rate (e.g., < 200 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible);
- 1/4-inch OD tubing (Teflon®, or similar);
- Extra 1/4-inch Swagelok front and back compression sleeves
- Decontaminated stainless steel Swagelok or comparable "T" fitting and ball or needle valve for isolation of purge leg of sample train;
- Stainless steel duplicate "T" fitting provided by the laboratory (if collecting duplicate [i.e., split] samples);
- 60-mL syringe equipped with a three-way leur lock valve;
- Appropriate equipment and materials for quality assurance testing as laid out in the respective quality assurance TGIs (i.e., helium leak testing, water dam testing, methane testing);
- Appropriate-sized open-end wrench (typically 9/16-inch and ½");
- Tedlar® bag to collect purge air for venting outside a structure if working inside;
- Portable weather meter, if appropriate;

- Chain-of-custody (COC) form;
- Sample collection log (attached);
- Nitrile gloves;
- Work gloves; and
- Field notebook

V. CAUTIONS

The following cautions and field tips should be reviewed and considered prior to installing or collecting a soil vapor sample.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Ensure that the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory). Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 3 -7 – inches Hg) remains in the canister when sample collection is terminated.

- The integrity of the sample train will be tested in accordance with the project specific requirements. These procedures are contained in their own TGI documents and include helium leak testing, water dam testing, and methane screening.

- It is important to record the canister pressure, start and stop times, and sample identification on a proper field sampling form. You should observe and record the time/pressure at the start, and then again one or two hours after starting the sample collection. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it is not stuck. If the canister is running correctly for a 24-hour period, the vacuum will have decreased slightly after one or two hours (for example from 29 inches to 27 inches). Consult your project manager, risk assessor or air sampling expert by phone if the SUMMA canister does not appear to be working properly.

- Ensure that there is still measurable vacuum in the SUMMA® after sampling. Sometimes the gauges sent from labs have offset errors, or they stick.

- When sampling carefully consider elevation. If your site is over 2,000’ above sea level or the difference in elevation between your site and your lab is more than 2,000’ then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in them. http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped a two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters and flow controllers from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Check the seal around the soil vapor sampling port by using a tracer gas (e.g., helium) or other method established in the appropriate guidance document. See TGI library and project specific instructions for appropriate TGIs.

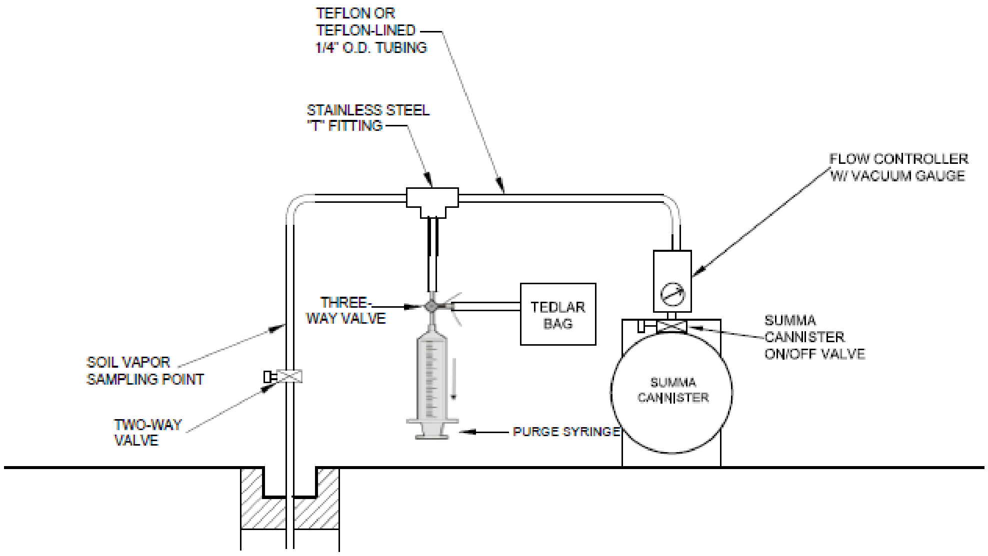
VI. HEALTH AND SAFETY CONSIDERATIONS

All sampling personnel should review the appropriate health and safety plan (HASP) and job safety analysis (JSA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. Field sampling must be carefully performed to minimize the potential for injury and the spread of hazardous substances.

VII. SOIL VAPOR SAMPLE COLLECTION

Sample Train Assembly

The following procedures should be used to collect a soil vapor sample using a whole air canister (i.e., SUMMA canister). These methods can be used for both exterior soil vapor samples and interior sub-slab soil vapor samples collected from both permanent or temporary sample points installations. A schematic of the suggested sample train set up is included below



1. Assemble the sample train by removing the cap from the SUMMA canister and connecting the flow controller with in-line particulate filter and vacuum gauge. The flow controller attaches directly to the canister and dictates the sample duration. This piece will come preset from the laboratory.

2. Attach the canister and flow controller assembly to a stainless steel T-fitting using a short length of 1/4-inch OD Teflon tubing. This T-fitting adds a leg to the sample train that will be used to purge "dead" air from the sample train in order to collect a more representative sample.

3. Connect the purge syringe with three-way valve to one of the free ends of the T-fitting using a length of Teflon sample tubing, Swagelok compression fittings and silicon tubing.

4. Attach the Swagelok two-way valve to the remaining free end of the T-fitting using a short length of ¼-inch OD Teflon tubing. The two-way valve will be immediately adjacent to the sample point in the train assembly. This valve is used to isolate the sample train from the sample point prior to sampling in order to test the sample train's integrity.

5. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two SUMMA canisters using stainless steel Swagelok duplicate sample T-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample T-fitting provided by the laboratory.

6. Attach the terminal end of the two-way Swagelok valve to the sample port as appropriate. This may be done using the options below:

a. Use a section of silicon tube to connect the Teflon sample tubing to the barbed fitting of a Vapor Pin™ port.

b. Use Swagelok compression fittings to connect Teflon tubing to sampling port. Teflon tape should never be used on Swagelok compression fitting connections.

c. Wrap the Teflon tubing with Teflon tape to seal around the slab then use VOC free clay to further seal around the slab if using temporary points.

Sample Documentation

1. Record on the sample log and COC form the flow controller number with the appropriate SUMMA® canister number.

2. Record the following information on the sample log, if appropriate (contact the local airport or other suitable information source [e.g., site-specific measurements, weatherunderground.com] to obtain the information):

   a. wind speed and direction;

   b. ambient temperature;

   c. barometric pressure; and

   d. relative humidity.

3. Take a photograph of the SUMMA® canister and surrounding area.

Sample Collection

1. Perform a leak-down-test by closing the two-way valve to the sample port. Open the three-way valve to the syringe and pull a vacuum. Quickly close the three-way valve and record the pressure indicated on the gauge connected to the canister. If there are no leaks in the system this vacuum should be held. If vacuum holds proceed with sample collection; if not attempt to rectify the situation by tightening fittings.

2. Open the two-way valve and purge the soil vapor sampling port and tubing with the portable sampling pump. Purge approximately three volumes of air from the soil vapor sampling port and sampling line using a flow rate of 200 mL/min. Purge volume is calculated by the following equation “purge volume = 3 x Pi x inner radius of tubing^2 x length of tubing. Purge air will be collected into a Tedlar bag to provide that VOCs are not released into interior spaces. Perform quality control method tests concurrently, as appropriate

3. Close the three-way valve to the syringe in order to isolate this leg of the sample train.

4. Open the SUMMA® canister valve to initiate sample collection. Record on the sample log (attached) the time sampling began and the canister pressure.

   If the initial vacuum pressure registers less than -25 inches of Hg, then the SUMMA® canister is not appropriate for use and another canister should be used.

5. Check the SUMMA canister approximately half way through the sample duration and note progress on sample logs.

Termination of Sample Collection

1. Arrive at the SUMMA® canister prior to the end of sample collection.

2. Record the final vacuum pressure. Stop collecting the sample by closing the SUMMA® canister valves. The canister should have a minimum amount of vacuum (approximately 5 inches of Hg or slightly greater).

3. Record the date and local time (24-hour basis) of valve closing on the sample collection log and COC form.

4. Disconnect sample tubing from the sample port; replace any coverings or abandon as appropriate to mitigate tripping hazards.

5. Remove the particulate filter and flow controller from the SUMMA® canister, re-install the brass plug on the canister fitting, and tighten with the appropriate wrench.

6. Package the canister and flow controller per Department of Transportation regulations for return shipment to the laboratory. These regulations can be found at the Transportation Safety Program's Team Site on the Source. The SUMMA® canister does not require preservation with ice or refrigeration during shipment.

7. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

8. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via overnight carrier (e.g., Federal Express) for analysis.

VIII. WASTE MANAGEMENT

No specific waste management procedures are required.

IX. DATA RECORDING AND MANAGEMENT

Measurements will be recorded on the sample log at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, initial vacuum reading, and final pressure reading. Field sampling logs and COC records will be transmitted to the Project Manager.

X. QUALITY ASSURANCE

Duplicate samples should be collected in the field as a quality assurance step per project requirements. Generally, duplicates are taken from 10% of samples, but project specific requirements should take precedence.

XI. REFERENCES

DiGiulio et. al. 2003. Draft Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA TO-15 to Support Vapor Intrusion Investigations. http://www.cdphe.state.co.us/hm/indoorair.pdf (Attachment C)

Di Giulio et. Al. 2006. Assessment of Vapor intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples. USEPA. EPA/600/R-05/147.

New York State Department of Health (NYSDOH). 2005. DRAFT “Guidance for Evaluating Soil Vapor Intrusion in the State of New York” February 23, 2005.

TGI – GROUNDWATER AND SOIL SAMPLING EQUIPMENT DECONTAMINATION

Rev: 1

Rev Date: May 8, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	February 23, 2017	ALL	Conversion from SOP to TGI	Cassandra McCloud / Pete Frederick
1	May 8, 2020	4-5	Added note regarding use of Liquinox and 1,4-Dioxane	Marc Killingstad

APPROVAL SIGNATURES

Prepared by:		Date:	02/23/2017
	Derrick Maurer		
Technical Expert Reviewed by:		Date:	May 8, 2020
	Marc Killingstad (Technical Expert)		

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2 SCOPE AND APPLICATION

Decontamination is performed on sampling equipment prior to sample collection to ensure that the sampling equipment that contacts a sample, or monitoring equipment that is brought into contact with environmental media to be sampled, is free from analytes of interest and/or constituents that could interfere with laboratory analysis for analytes of interest. Sampling equipment must be appropriately cleaned prior to use for sampling or coming into contact with environmental media to be sampled, and following completion of the sampling event prior to shipment or storage. The effectiveness of the decontamination procedure should be verified by collecting and analyzing equipment blank samples.

The sampling equipment cleaning procedures described herein includes pre-field, in the field, and post-field cleaning of sampling equipment which may be conducted at an established equipment decontamination area (EDA) on site, as appropriate and necessary. Sampling equipment that may require decontamination at a given site includes: soil sampling tools; groundwater, sediment, and surface-water sampling devices; water testing instruments; down-hole instruments; and other activity-specific sampling equipment. Non-disposable equipment will be cleaned before collecting each sample, between each sample collected, and prior to placing sampling equipment in protective cases, or containers for transport. Cleaning procedures for sampling equipment should be monitored by collecting equipment blank samples as required in project work plans, field sampling plans, quality assurance project plans (QAPP), or other pertinent project documents. Dedicated and/or single-use (i.e., not to be re-used) sampling equipment will not require decontamination.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and Technical Guidance Instructions (TGIs) and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The equipment required for equipment decontamination is presented below:

- Health and safety equipment, including appropriate PPE, as required in the site Health and Safety Plan (HASP)
- Deionized water that meets that analytical criteria for deionized water with no detectable constituents above the reporting limits for the methods to be used and analytes being analyzed for. Deionized water is used for inorganics, and organic-free water for VOCs, SVOCs, pesticides, etc.
- Non-phosphate detergent such as Alconox or, if sampling for phosphorus or phosphorus-containing compounds, Liquinox (or equivalent). NOTE: *Liquinox has shown to provide false positives for 1,4-Dioxane and should not be used at sites where that may be a constituent of concern (COC).*
- Tap water
- Rinsate collection plastic containers
- DOT-approved waste shipping container(s), as specified in the work plan, field sampling plan, or regulatory requirements if decontamination waste is to be shipped for disposal
- Brushes
- Large heavy-duty garbage bags
- Spray bottles

- (Optional) – Isopropyl alcohol (free of ketones) or methanol. These can be wipes or diluted with water (usually 1part isopropyl/methanol to 10 parts water) if a spray is needed.
- Airtight, sealable plastic baggies, such as Ziploc-type
- Plastic sheeting

5 CAUTIONS

Rinse equipment thoroughly and allow the equipment to dry before re-use or storage to prevent introducing solvent into sample medium. If manual drying of equipment is required, use clean lint-free material to wipe the equipment dry. Ensure all rinsate materials do not adversely affect sample collection efficiency or analytical results.

Store decontaminated equipment in a clean, dry environment. Do not store near combustion engine exhausts. Properly containerize equipment to ensure cross-contamination doesn't happen from other uncontaminated surfaces or equipment.

If equipment is damaged to the extent that decontamination is uncertain due to cracks, gouges, crevices, or dents, the equipment should not be used and should be discarded or submitted for repair prior to use for sample collection.

A proper shipping determination regarding hazardous materials will be performed by a DOT-trained individual for cleaning materials shipped by Arcadis.

Caution should be exercised to avoid contact with the pump casing and water in the container while the pump is running (do not use metal drums or garbage cans) to avoid electric shock.

6 HEALTH AND SAFETY CONSIDERATIONS

Review the safety data sheets (SDS) for the cleaning agents and materials used in decontamination. If solvent is used during decontamination, use appropriate PPE and work in a well-ventilated area and stand upwind while applying solvent to equipment. Apply solvent in a manner that minimizes potential for exposure to workers and bystanders. Follow health and safety procedures outlined in the HASP.

7 PROCEDURE

A designated area will be established to clean sampling equipment in the field prior to and following sample collection. Equipment cleaning areas will be set up within or adjacent to the specific work area, but not at a location that expose equipment to contamination (i.e. exposed to combustion engine exhaust). Detergent solutions will be prepared in clean containers for use in equipment decontamination. Decontaminated equipment should be handled by workers wearing clean gloves, properly changed to prevent cross-contamination.

Cleaning Sampling Equipment

1. Wash the equipment/pump with potable water.

2. Wash with detergent solution (Alconox, Liquinox or equivalent) to remove all visible particulate matter and any residual oils or grease. NOTE: *Liquinox has shown to provide false positives for 1,4-Dioxane and should not be used at sites where that may be a constituent of concern (COC).*
3. If equipment is very dirty, precleaning gross debris with a brush and tap water may be necessary.
4. If non-aqueous phase liquids are present, the use of isopropyl alcohol (free of ketones) or methanol is recommended. Cloth wipes or diluted solution can be used to remove the non-aqueous phase liquids that are hard to remove with detergent solution in step 2. Consult with project manager if non-aqueous phase liquids are present onsite and design an appropriate decontamination procedure that includes step 4.
5. Rinse with deionized water.

Decontaminating Submersible Pumps

Submersible pumps may be used during well development, groundwater sampling, or other investigative activities. The pumps must be cleaned and flushed before and between uses. This cleaning process will consist of an external detergent solution wash and tap water rinse, a flush of detergent solution through the pump, followed by a flush of potable water through the pump. Flushing will be accomplished by using an appropriate container filled with detergent solution and another container filled with potable water. The pump should be flushed with deionized water as the last step prior to use. The pump will run long enough to effectively flush the pump housing and hose (unless new, disposable hose is used). Disconnect the pump from the power source before handling. The pump and hose should be placed on or in clean polyethylene sheeting to avoid contact with the ground surface.

8 WASTE MANAGEMENT

Equipment decontamination rinsate will be managed in conjunction with all other waste produced during the field sampling effort. Waste management procedures are outlined in the work plan or Waste Management Plan (WMP).

9 DATA RECORDING AND MANAGEMENT

Equipment cleaning and decontamination will be noted in the field notebook for project documentation. Information will include the type of equipment cleaned, the decontamination location, specific procedures utilized, solvents and/or cleaning agents used, source of water, and deviations or omissions from this TGI.

Unusual field conditions should be noted if there is potential to impact the efficacy of the decontamination or subsequent sample collection.

An inventory of the solvents brought on site and used and removed from the site will be maintained in the project documentation. Records will be maintained for solvents used in decontamination, including lot number and expiration date.

Containers with decontamination fluids will be labeled.

10 QUALITY ASSURANCE

Equipment blanks should be collected to verify that the decontamination procedures are effective in minimizing potential for cross contamination. The equipment blank is prepared by pouring deionized water (or organic-free water, for organic analyses) over the clean and dry tools and collecting the water into appropriate sample containers. Equipment blanks should be analyzed for the same set of parameters that are performed on the field samples collected with the equipment that was cleaned as specified in the sampling and analysis plan. Equipment blanks are collected per equipment set, which represents all of the tools needed to collect a specific sample.

11 REFERENCES

USEPA Region 9 - Field Sampling Guidance #1230, Sampling Equipment Decontamination.

USEPA Region 1 - Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

ARCADIS Design & Consultancy for natural and built assets

TGI - INVESTIGATION-DERIVED WASTE HANDLING AND STORAGE

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APPROVAL SIGNATURES

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The objective of this Technical Guidance Instruction (TGI) is to describe the procedures to manage investigation-derived wastes (IDW), both hazardous and nonhazardous, generated during site activities, which may include, but are not limited to: drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. For the purposes of this TGI, IDW is considered to be discarded materials which are defined as solid waste by United States Environmental Protection Agency (EPA) standard 40 CFR § 261.2 (which may include liquids, solids, or sludges). IDW may include soil, groundwater, drilling fluids, decontamination liquids, as well as contaminated personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials. Hazardous or uncharacterized IDW will be collected and staged at the point of generation. Quantities small enough to be containerized in 55-gallon drums will be taken to a designated temporary onsite storage area (discussed in further detail under Drum Storage) pending characterization and disposal. IDW materials will be characterized using process knowledge and appropriate laboratory analyses to determine the waste classification and evaluate proper safe handling and disposal methods.

This TGI describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly transported from the project site and disposed. The procedures included in this TGI for handling and temporary storage of IDW are based on the EPA's guidance document *Guide to Management of Investigation Derived Wastes* (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical evidence indicates otherwise. IDW will be managed to ensure the protection of human health and the environment and will comply with all applicable or relevant and appropriate requirements (ARAR). Although not comprehensive, the following laws and regulations on Hazardous Waste Management should be considered as potential ARAR. It is the Arcadis Certified Project Manager (CPM) and/or designated Technical Expert to determine which laws and regulations, at all levels of government, are applicable to each project site and activity falling under this TGI.

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC § 6901-6987.
- Federal Hazardous Waste Regulations 40 CFR § 260-265

Department of Transportation (DOT) Hazardous Materials Transportation 49 CFR

Occupational Safety and Health Administration (OSHA) Regulations 29 CFR

State Laws and Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Regional, County, Municipal, and Local Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Initial Storage

Pending characterization, IDW will be temporarily stored appropriately within each area of contamination (AOC). Under RCRA, "storage" is defined as the "holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere" (40 CFR § 260.10). The onsite waste staging area will be in a secure and controlled area. Uncharacterized wastes are considered potentially hazardous wastes and must be stored in DOT approved packaging. Liquid wastes must be stored in DOT approved closed head drums or other approved containers (e.g., portable tank containers) that are compatible with the type of material stored therein. Solid materials must be stored in DOT approved open head drums where practicable. Larger quantities of solid IDW can be containerized in bulk containers (such as in a roll-off box). Soil from large excavation projects may be managed in stockpiles with within the AOC and does not need to be containerized until exiting the AOC.

Characterization

Waste characterization can either be based on generator knowledge, such as using historical process knowledge and safety data sheets (SDS), or can be based upon characterization sampling analytical results. IDW typically is not characterized using SDS as it is a mixture of aged chemicals and environmental media. Historical process knowledge should be used to determine if the IDW is a listed hazardous waste (40 CFR § 261.31-33). If the IDW is not a listed hazardous waste, waste characterization can be completed by laboratory analysis of representative samples of the IDW. The laboratory used for waste characterization analysis must have the appropriate state and federal accreditations and may be required to be pre-approved by the Client. IDW will be classified as RCRA hazardous or non-regulated under RCRA based on the waste characterization determination.

If IDW is characterized as RCRA hazardous waste, RCRA and DOT requirements must be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR § 262 and 49 CFR § 171-178. Waste material classified as RCRA nonhazardous may be handled and disposed of as nonhazardous waste in accordance with applicable federal, state, and local regulations.

Storage Time Limitations

Containerized hazardous wastes can be temporarily stored for a maximum of 90 calendar days from the accumulation start date for a large quantity generator or a maximum of 180 calendar days from the accumulation start date for a small quantity generator. Wastes classified as nonhazardous may be handled and disposed of as nonhazardous waste and are not subject to storage time limitations.

This is TGI may be modified by the CPM and/or Technical Expert for a specific project or client program, as required, dependent upon client requirements, site conditions, equipment limitations, or limitations imposed by the procedure. The resulting procedure employed to execute the work will be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with the CPM and/or Technical Expert as soon as practicable, and if approved to be performed, be documented.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have current regulatory- and Arcadis-required health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Personnel handling and packaging hazardous waste and performing hazardous waste characterizations must have RCRA hazardous waste management training per 40 CFR § 264.16. Additional state-specific hazardous waste management training is required in certain states (i.e., California).

Although not common practice, in certain situations Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator. Arcadis personnel who sign waste profiles and/or waste manifests will have both current RCRA hazardous waste management training per 40 CFR § 264.16 and current DOT hazardous materials transportation training per 49 CFR § 172.704. Arcadis field personnel will also comply with client-specific training. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and Technical Guidance Instructions (TGIs) and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The Following Materials, as required, will be available for IDW handling and Storage:

- Appropriate personal protective equipment as specified in the Site Health and Safety Plan (HASP)
- DOT approved containers
- Hammer
- Leather gloves
- Drum dolly
- Appropriate drum labels (outdoor waterproof self-adhesive)
- Portable tank container
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as determined by the CPM and/or Technical Expert.
- Indelible ink and/or permanent marking pens
- Plastic sheeting
- Appropriate sample containers, labels, and forms
- Stainless-steel bucket auger
- Stainless steel spatula or knife
- Stainless steel hand spade
- Stainless steel scoop
- Digital camera
- Field logbook

5 CAUTIONS

Filled drums can be very heavy, become unbalanced, or spill its contents. Therefore, use appropriate moving techniques and equipment for safe handling. Similar media (e.g. soils with other soils; or liquids with other liquids) will be stored in the same drums to aid in sample analysis and disposal. Drum lids must be secured to prevent rainwater from entering the drums and leakage during movement. Drums containing solid material may not contain any free liquids. Waste containers stored for extended periods of time may be subject to deterioration. Drum Over Packs may be used as secondary containment. All drums must be visually inspected for condition to ensure that they are in good condition without visible evidence of rusting, holes, breakage, etc., to prevent potential leakage and facilitate subsequent disposal. All drum lids must be verified as having a properly functioning secured lid prior to use.

6 HEALTH AND SAFETY CONSIDERATIONS

As determined by the site's known and suspected hazards, appropriate PPE must be worn by all field personnel within the designated work area. Exposure air monitoring may be required during certain field activities as required in the Site Health and Safety Plan. If soil excavation in areas with potentially hazardous contaminants is possible, contingency plans will be developed to address the potential for encountering gross contamination or non-aqueous phase liquids. All excavation activities shall be in compliance with OSHA standard 29 CFR 1926.651 Excavations, and any other applicable regulations.

Arcadis field personnel and subcontractors will be trained in and perform their work in compliance with all applicable federal, state, and local health and safety regulations as well as Arcadis' HASP and applicable Client health and safety requirements.

7 PROCEDURE

Specific waste temporary storage and handling procedures to be used are dependent upon the type of generated waste, including type of media (e.g. soils or free liquids) and constituents of concern. For this reason, IDW can be stored in a secure location onsite in separate 55-gallon storage drums, where solids can be stockpiled onsite (if nonhazardous) and purge water may be stored in portable tank containers. Waste materials such as broken sample bottles or equipment containers and wrappings will be stored in 55-gallon drums unless they were not in contact with sample media.

Management of IDW

Minimization of IDW should be considered by the project team during all phases of the project. Site managers may want to consider techniques such as replacing solvent based cleaners with aqueous-based cleaners for decontamination of equipment, reuse of equipment (where it can be properly decontaminated), limitation of traffic between exclusion and support zones, and drilling methods and sampling techniques that minimize the generation of waste. Alternative drilling and subsurface sampling methods may include the use of small diameter boreholes, as well as borehole testing methods such as a core penetrometer or direct push technique instead of coring.

Drum Storage

Drums containing hazardous waste will be stored in accordance with the requirements of 40 CFR 265 Subpart I (for containers) and 265 Subpart DD (for containment buildings). All 55-gallon drums will be stored at a secure, centralized onsite location that is readily accessible for vehicular pick-up. Drums confirmed as, or assumed to contain hazardous waste will be stored over an impervious surface provided with secondary spill containment. The storage location will, for drums containing liquid, have a containment system that can contain at least the larger of 10% of the aggregate volume of staged materials or 100% of the volume of the largest container. Drums will be closed during storage and be in good condition in accordance with the Guide to Management of Investigation-Derived Wastes (USEPA, 1992).

Hazardous Waste Determination

Waste material must be characterized to determine if it meets any of the federal definitions of hazardous waste as required by 40 CFR § 262.11. If the waste does not meet any of the federal definitions, it must then be established if any state-specific or local-specific hazardous waste criteria exist/apply.

Generator Status

Once hazardous waste determination has been made, the generator status will be determined. Large quantity generators (LQG) are generators who generate more than 1,000 kilograms of hazardous waste in a calendar month. Small quantity generators (SQG) of hazardous waste are generators who generate greater than 100 kilograms but less than 1,000 kilograms of hazardous waste in a calendar month. Very small quantity generators (VSQG) are generators who generate less than 100 kilograms of hazardous waste per month. Please note that a generator status may change from month to month and that a notice of this change is usually required by the generator's state agency.

Accumulation Time for Hazardous Waste

A LQG may accumulate hazardous waste on site for 90 calendar days or less without a permit and without having interim status, provided that such accumulation is in compliance with requirements in 40 CFR § 262.17. A SQG may accumulate hazardous waste on site for 180 calendar days or less without a permit or without having interim status, subject to the requirements of 40 CFR § 262.16. VSQG requirements are found in 40 CFR § 262.14. NOTE: The federal VSQG and SQG provisions may not be recognized by some states (e.g., California and Rhode Island). State-specific and local-specific regulations must be reviewed and understood prior to the generation of hazardous waste.

Satellite Accumulation of Hazardous Waste Satellite accumulation (SAA) will mean the accumulation of as much as fifty-five (55) gallons of hazardous waste, or the accumulation of as much as one quart of acutely hazardous waste, in containers at or near any point of generation where the waste initially accumulates, which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of 40 CFR § 262.15 and without any storage time limit, provided that the generator complies with 40 CFR § 262.15.

Once more than 55 gallons of hazardous waste accumulates in SAA, the generator has three days to move this waste into storage.

Storage recommendations for hazardous waste include:

- Ignitable or reactive hazardous wastes must be >50 feet from the property line per 40 CFR § 265.176 (LQG generators only).
- Hazardous waste should be stored on a concrete slab (asphalt is acceptable if there are no free liquids in the waste).
- Drainage must be directed away from the accumulation area.
- Area must be properly vented.
- Area must be secure.

Drum/Container Labeling

Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (e.g., polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or "Testing in Progress" label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Pending Analysis, Hazardous, or Nonhazardous)
- Waste generator's name (e.g., client name)
- Project Name
- Name and telephone number of Arcadis project manager
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%)
- Media (e.g., solid, liquid)
- Accumulation start date

- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

IDW containers will remain closed except when adding or removing waste. Immediately upon beginning to place waste into the drum/container, a “Waste Container” or “Pending Analysis” label will be filled out to include the information specified above, and affixed to the container. Once the contents of the container are identified as either non-hazardous or hazardous, the following additional labels will be applied.

- Containers with waste determined to be non-hazardous will be labeled with a green and white "Nonhazardous Waste" label over the "Waste Container" label.
- Containers with waste determined to be hazardous will be stored in an onsite storage area and will be labeled with the "Hazardous Waste" label and affixed over the "Waste Container" label.

The ACCUMULATION DATE for the hazardous waste is the date the waste is first placed in the container and is the same date as the date on the "Waste Container" label. DOT hazardous class labels must be applied to all hazardous waste containers for shipment offsite to an approved disposal or recycling facility. In addition, a DOT proper shipping name will be included on the hazardous waste label. The transporter should be equipped with the appropriate DOT placards. However, placarding or offering placards to the initial transporter is the responsibility of the generator per 40 CFR § 262.33.

Inspections and Documentation

All IDW will be documented as generated on a Drum Inventory Log maintained in the field log book. The Drum Inventory will record the generation date, type, quantity, matrix and origin (e.g., Boring-1, Test Pit 3, etc.) of materials in every drum, as well as a unique identification number for each drum. The drum inventory will be used during drum pickup to assist with labeling of drums. The drum storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

Emergency Response and Notifications

Specific procedures for responding to site emergencies will be detailed in the HASP. If the generator is designated as a LQG, a Contingency Plan will need to be prepared to include emergency response and notification procedures per 40 CFR § 265 Subpart D. In the event of a fire, explosion, or other release which could threaten human health outside of the site or when Client or Arcadis has knowledge of a spill that has reached surface water, Client or Arcadis must immediately notify the National Response Center (800-424-8802) in accordance with 40 CFR § 262.265. Other notifications to state and/or other local regulatory agencies may also be necessary.

Drilling Soil Cuttings and Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities, subsurface soil sampling, or installation of monitoring wells. Depending on the drilling method, drilling fluids known as "muds" may be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Soil cuttings will be labeled and stored in 55-gallon drums with bolt-sealed lids.

Excavated Solids

Excavated solids may include, but are not limited to: soil, fill, and construction and demolition debris. Prior to permitted treatment or offsite disposal, potentially hazardous excavated solids may be temporarily stockpiled onsite as long as the stockpile remains in the same AOC from where it was excavated. Potentially hazardous excavated solids removed from the AOC must be immediately containerized in labeled drums or closable top roll-offs lined with 9-mil polyvinyl chloride (PVC) sheeting and are subject to LQG storage time limits. Nonhazardous excavated solids can be stockpiled either inside or outside of the AOC, do not have to be containerized and are not subject to hazardous waste regulations. Potentially hazardous excavated solids must not be mixed with nonhazardous excavated solids. All classes of excavated solid stockpiles should be maintained in a secure area onsite. At a minimum, the floor of the stockpile area will be covered with a 20-mil high density polyethylene liner that is supported by a foundation or at least a 60-mil high density polyethylene liner that is not supported by a foundation. The excavated material will not contain free liquids. The owner/operator will provide controls for windblown dispersion, run-on control, and precipitation runoff. The run-on control system will prevent flow onto the active portion of the pile during peak discharge from at least a 25-year storm and the run-off management system will collect and control at least the water volume resulting from a 24-hour, 25-year storm (USEPA, 1992). Additionally, the stockpile area will be inspected on a weekly basis and after storm events. Individual states may require that the stockpile be inspected/certified by a licensed professional engineer. Stockpiled material will be covered with a 6-mil polyvinyl chloride (PVC) liner or sprayed dust control product. The stockpile cover will be secured in place with appropriate material (concrete blocks, weights, etc.) to prevent the movement of the cover.

Decontamination Solutions

Decontamination solutions are generated during the decontamination of personal protective equipment and sampling equipment. Decontamination solutions may range from detergents, organic solvents and acids used to decontaminate small field sampling equipment to steam cleaning rinsate used to wash heavy field equipment. These solutions are to be labeled and stored in closed head drums compatible with the decontamination solution. Decontamination procedures, including personnel and field sampling equipment, must comply with applicable Arcadis procedural documents.

Disposable Equipment

Disposable equipment includes personal protective equipment (e.g., tyvek coveralls, gloves, booties and APR cartridges) and disposable sampling equipment such as trowels or disposable bailers. If the media sampled exhibits hazardous characteristics per results of waste characterization sampling, contaminated disposable equipment will also be disposed of as a hazardous waste. If compatible with the original IDW waste stream (i.e., the IDW is a solid and the disposal equipment is a solid), the disposable equipment can be combined with the IDW. If these materials are not compatible (i.e., the IDW is a liquid and the disposal equipment is a solid), the disposable equipment will be stored onsite in separate labeled 55-gallon drums. Uncontaminated or decontaminated disposable equipment can be considered nonhazardous waste.

Purge Water

Purge water includes groundwater generated during well development, groundwater sampling, or aquifer testing. The volume of groundwater generated will dictate the appropriate storage procedure. Monitoring well development and groundwater sampling may generate three well volumes of groundwater or more. This volume will be stored in labeled 55-gallon drums. Aquifer tests may generate significantly greater volumes of groundwater depending on the well yield and the duration of the test. Therefore, large-volume portable polyethylene tanks will be considered for temporary storage pending groundwater-waste characterization.

Purged Water Storage Tank Decontamination and Removal

The following procedures will be used for inspection, cleaning, and offsite removal of storage tanks used for temporary storage of purge water. These procedures are intended to be used for rented portable tanks such as Baker Tanks or Rain for Rent containers. Storage tanks will be made of inert plastic materials. The major steps for preparing a rented tank for return to a vendor include characterizing the purge water, disposing of the purge water, decontaminating the tank, final tank inspection, and mobilization. Decontamination and inspection procedures are described in further detail below.

- Tank Cleaning: Most vendors require that tanks be free of any visible sediment and water before returning, a professional cleaning service may be required. Each specific vendor should be consulted concerning specific requirements for returning tanks.
- Tank Inspection: After emptying the tank, purged water storage tanks should be inspected for debris, chemical staining, and physical damage. The vendors require that tanks be returned in the original condition (i.e., free of sediment, staining and no physical damage).

8 WASTE MANAGEMENT

Soil/Solids Characterization

Waste characterization will be conducted in accordance with waste hauler, waste handling facility, and local/state/federal requirements. In general, RCRA hazardous wastes are those solid wastes determined by a Toxicity Characteristic Leaching Procedure (TCLP) test or to contain levels of certain toxic metals, pesticides, or other organic chemicals above specific applicable regulatory agency thresholds. If the one or more of 40 toxic compounds listed in Table I of 40 CFR § 261.24 are detected in the sample at levels above the maximum unregulated concentrations, the waste must be characterized as a toxic hazardous waste. Wastes can also be considered “listed” hazardous waste depending on site-specific processes.

Composite soil samples will be collected at a frequency of one sample per 250 cubic yard basis for stockpiled soil or one per 55-gallon drum per different waste stream for containerized. A four-point composite sample will be collected per 250 cubic yards of stockpiled material and for each drum waste stream. Sample and composite frequencies may be adjusted in accordance with the waste handling facility’s requirements and may be reduced for large volumes of waste with consistent properties. Waste characterization samples will be considered valid for consistent waste streams for a period of 1 year. Waste characterization samples may be analyzed for the TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls (PCBs), as well as reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- or local-specific regulations may require a different or additional sampling approaches.

Wastewater Characterization

Waste characterization will be conducted in accordance with the requirements of the waste hauler, waste handling facility, and local/state/federal governments. In general, purge water should be analyzed by methods appropriate for the known contaminants, if any, that have been historically detected in the monitoring wells. Samples will be collected and analyzed in accordance with the requirements of the waste disposal facility. Wastewater characterization samples may be analyzed for TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- and/or local-specific regulations may require different or additional sampling approaches.

Sample Handling and Shipping

All samples will be appropriately labeled, packed, and shipped, and the chain-of-custody will be filled out in accordance with current Arcadis sample chain of custody, handling, packing, and shipping procedures and guidance instructions.

It should be noted that additional training is required for packaging and shipping of hazardous and/or dangerous materials. Please refer to the current Arcadis training requirements related to handling and shipping of samples, shipping determinations, and hazardous materials.

Preparing Waste Shipment Documentation (Hazardous and Nonhazardous)

Waste profiles will be prepared by the Arcadis CPM and forwarded, along with laboratory analytical data to the Client for approval/signature. The Client will then return the profile to Arcadis who will then forward to the waste removal contractor for preparation of a manifest. The manifest will be reviewed by Arcadis prior to forwarding to the Client for approval. Upon approval of the manifest, the Client will return the original signed manifest directly to the waste contractor or to the Arcadis CPM for forwarding to the waste contractor. Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an <u>authorized representative of the generator</u>.

Final drum labeling and pickup will be supervised by an Arcadis representative who is trained and experienced with applicable waste labeling procedures. The Arcadis representative will have a copy of the drum inventory maintained in the field book and will reconcile the drum inventory with the profile numbers on the labels and on the manifest. Different profile numbers will be generated for different matrices or materials in the drums. For example, the profile number for drill cuttings will be different than the profile number for purge water. When there are multiple profiles it is critical that the proper label, with the profile number appropriate to a specific material be affixed to the proper drums. A copy of the Arcadis drum inventory will be provided to the waste transporter during drum pickup and to the facility receiving the waste.

9 DATA RECORDING AND MANAGEMENT

Waste characterization sample handling, packing, and shipping procedures will be documented in accordance with relevant Arcadis procedures and guidance instructions as well as applicable client and/or project requirements, such as a Quality Assurance Project Plan or Sampling and Analysis Plan. Copies of the chain-of-custody forms will be maintained in the project file. Arcadis should photograph or maintain a copy of any hazardous waste manifest signed on behalf of Client in the corresponding office DOT record file.

10 QUALITY ASSURANCE

The CPM or APM will review all field documentation once per week for errors or omissions as compared to applicable project requirements including but not limited to: the proposal/scope of work, QAPP, SAP, HASP, etc. Deficiencies will be noted, tracked, and resolved. Upon correction, they will be noted for project documentation.

11 REFERENCES

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

TGI - WATER-LEVEL MONITORING USING DATA LOGGING INSTRUMENTS

Rev: 0

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

Additional instrumentation that is not covered in this technical guidance include the use of vibrating-wire transducers. Information on these instruments and other technical aspects is covered within United States Geological Survey guidance documents (Freeman, et al., 2004 and Cunningham et al., 2011)

2 SCOPE AND APPLICATION

This TGI describes procedures to measure and record groundwater and surface-water levels with data logging instruments such as pressure transducers that are used for several different applications and durations. The high-resolution data acquisition applications include:

- Hydraulic testing and aquifer characterization
- Horizontal and vertical hydraulic gradients
- Groundwater/surface-water interaction
- Surface-water, ocean tides, and earth tides

- Remediation, mining, or water supply system performance/operations and maintenance.

Thoughtful planning and proper design combine to form the backbone of high-resolution water-level monitoring via data logging instruments because it is important to ensure that data are acquired to meet the project and data quality objectives. A detailed field implementation plan is essential for execution of the work described in this TGI. Therefore, it is strongly recommended that the project hydrogeologist develop a detailed field implementation plan that clearly outlines the objectives, design of the monitoring to be performed, specific steps/procedures to be followed, communication expectations and protocol, and health and safety requirements. This plan will be reviewed with field personnel prior to mobilization to the field.

Design considerations include adequate spatial coverage both laterally (spacing and number of wells or surface points) and vertically (shallow to deep groundwater zones), presence and nature of surface-water and surface-water body sediment point, and collection of background data. The conceptual site model (CSM) drives the design decisions through consideration of key components such as surface topography, changes in geology (i.e., heterogeneity), aquifer characteristics (e.g., confined/unconfined, depth, extent, sources of recharge, discharge points, vertical leakage between hydrostratigraphic units, groundwater flow direction), groundwater to surface water interaction zones, and presence of pumping wells and/or injection wells.

Manual water-level measurements, following the *TGI – Manual Water-Level Monitoring*, involves taking an instantaneous measurement of the water level in a well or surface-water body to a known survey point. Knowledge of the vertical datum of the survey is needed to ensure accuracy and consistency. Manual readings are used initially to understand the water column of the system; if historical measurements are available, the historical fluctuation of water levels will be used to determine pressure transducer installation depths. Or, if the monitoring is for a pumping or injection test, the estimated drawdown or mounding will also be considered. Manual water-level measurements are also used to adjust the pressure transducer measurements to an elevation datum either during post-processing or during programming of the pressure transducer with an offset using the instrument software. Additionally, manual water-levels are used to monitor accuracy and potential drift of the instrument readings.

Understanding the instrument type is also critical when planning and designing a water-level monitoring program. Many brands of data logging instruments are available that have different accuracies, sizes, memory capacity, acquisition rates, depth restrictions, warranties, and life spans. All new instruments come with laboratory calibration certificates or are available upon request. If renting an instrument, the rental company must provide the calibration and age to confirm it is within calibration recommendations per the manufacturer. Standard pressure transducers can also record temperature and specific conductance/conductivity depending on the model. More advanced instruments, such as multiparameter probes (sondes), can be customized to provide multiple data types as well (e.g., pH, dissolved oxygen, fluorescence) and requires multi-point calibration.

Other important considerations when planning/designing for a project include:

- Depth required to account for fluctuations and accuracy;
- Density variation;
- Nonaqueous phase liquid (NAPL) monitoring;

- Matching depth with instrument model;
- Choosing absolute (sealed) or vented (gauge);
- Direct read cable or cord requirements;
- Wellhead or surface-water structure connection;
- Acquisition rate needed;
- Available/required memory (acquisition rate and duration); and
- Communication equipment (e.g., direct read cable with laptop, wireless communication).

In general with most instrument brands, the accuracy of a pressure transducer decreases with increasing head.

Absolute pressure transducers (i.e., non-vented or sealed) do not require a vented tube within the cable or a cable and are cheaper to install; however, a sealed transducer must be coupled with barometric pressure measurements so that compensation of the atmospheric pressure can be subtracted and/or evaluated for characterization (correction, barometric efficiency, or barometric response function). Data-logging barometric pressure transducers are available from most manufacturers.

Gauged pressure transducers (i.e., vented) must have a vented tube within the cable to vent the instrument to the atmosphere, are generally more expensive, and can have complications with the vent tube twisting/bending or collecting moisture. Although vented pressure transducers do not need barometric compensation, barometric pressure measurements are still needed, particularly if aquifer characterization is required for the evaluation (i.e., calculating barometric efficiency). Vented pressure transducers are more frequently used for field programs that require short-term, real-time measurements and evaluation (e.g., slug tests).

Collection and evaluation of weather station data, including rainfall and barometric pressure, will be incorporated into the test design. Precipitation data is necessary to understand and account for recharge response for both surface water and groundwater applications. Site-specific weather station data is preferred; however, the data can also be obtained from local weather stations maintained by third parties (e.g., National Oceanic and Atmospheric Administration or local airport). These third-party datasets, though, should be used with caution; always confirm availability of the data, data resolution, and that the distance from the site is adequate as the distribution of precipitation can be highly variable.

Different brands of pressure transducers may offer different acquisition programming functions and interfaces (e.g., differential, linear, and logarithmic logging of data) and overwriting of memory or slate (i.e., once memory is full, pressure transducers typically stop recording). Additional programming beyond the pressure head of the overlying water column includes setting reference points to measure water level elevation or depth to water. Software is available from the manufacturer (typically free of charge) that provides an interface between a laptop/tablet/mobile device and the particular brand of transducer. Note that the interfacing software is compatible with most laptops and most manufacturers have recently adapted their programs for mobile applications with some brands for use on tablets or smart phones. There are also remote considerations for radio (WiFi or Bluetooth or cellular) telemetry to have direct data feeds to servers or databases. Communication equipment, specific to the brand, are available (e.g., direct connection via cable or by Bluetooth).

Over the last several years, data acquisition rates and memory have been significantly improved by manufacturers with acquisition rates as low as 10 measurements per second and may record in memory more than 350,000 total data points. The selection of a specific brand or model to meet data acquisition needs and data quality objectives (accuracy) is based on the overall project objectives. Compatibility with the geochemistry or contaminant chemistry is also a consideration when selecting an instrument.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the extraction constant rate tests will have the following qualifications:

- Familiarity and competency with
  - quantitative hydrogeology,
  - understanding of the Project Site,
  - this TGI, and
  - the scope of work and objectives (i.e. reviewed the field implementation plan with project hydrogeologist).
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment required for this testing. Project personnel involved must understand the use, installation, and software required, which will be loaded on the communication device and tested before the event.
- Completed current health and safety training in accordance with the project health and safety plan (HASP) (e.g., 40-hour Hazardous Waste Operations and Emergency Response [HAZWOPER] training and/or Occupational Safety and Health Administration HAZWOPER site supervisor training and/or site-specific training, as appropriate).

4 EQUIPMENT LIST

The following items are required for water level measurements:

- HASP
- Personal protective equipment (PPE) as specified in the HASP
- Decontamination equipment
  - Non-phosphate laboratory soap (Alconox or equivalent), brushes, clean five-gallon buckets or clean wash tubs.
  - Distilled or de-ionized (required for sites with metals) water for equipment decontamination
  - Solvent (methanol/acetone) rinse - optional
  - Optional plastic drop cloth (e.g. Weatherall Visqueen) to place beneath the buckets or tubs to reduce potential for contamination of the tape or probe

- Photoionization detector (PID) and/or organic vapor analyzer (optional)
- 150-foot measuring tape (or sufficient length for the maximum site depth requirement)
- Tools and/or keys required for opening wells
- Well construction summary table and/or well construction logs
- Summary table of previous water-level measurements
- Field notebook and appropriate field forms (**Attachment 1**); a pressure transducer field form is also available using FieldNow
- Indelible ink pen
- Digital camera or camera on smart device if photo documentation is necessary
- Electronic water-level indicator, or oil-water level indicator, that is calibrated and graduated in 0.01-foot increments
- Electrical tape
- Pressure transducers, direct-read cables (if applicable), specialized well caps (if necessary), and wire/Kevlar cord to deploy/hang transducers (In-Situ or Solinst® brand equipment is preferred)
- Pressure transducer communication equipment—laptop/tablet/mobile device (smart phone) with associated chargers and loaded with appropriate pressure transducer software
- Barometric pressure transducer, rain logger, tipping bucket, or weather station (if applicable)
- Flash USB memory stick

Site-specific details regarding the equipment required and its use will be described in the field implementation plan and discussed during a kick-off meeting prior to the field work. Photographs of common examples of transducers, specialized well caps, and related equipment is included in **Attachment 2**.

5 CAUTIONS

The notes listed below are intended to provide reminders and information for potential issues, particular application notes, or key points:

- Test all equipment with the interface/communication device (laptop/tablet/mobile device) to be used in the field <u>prior</u> to mobilization to ensure functionality.
- Decontaminate each piece of equipment that will be placed into the well, including the pressure transducer, cable/cord, and electronic water-level indicator.
- Instrument equilibration takes time, especially when temperature changes are highly variable during deployment. Allow at least 5 to 10 minutes for equilibration and verify stability with real time data review.

- Direct-read cables may require time to stretch once transducers are deployed especially if they were shipped in tight coils. Allow 10 to 20 minutes following transducer deployment for the cables to equilibrate as well.
- For manual water-level measurements, please refer to *TGI – Manual Water-Level Monitoring*.
- When taking manual water-level measurements, at least three measurements of the depth to water will be performed to ensure accuracy of measurements and that the pressure transducer will be installed at an appropriate depth.
- When taking total depth measurements, compare the measurements to the well construction log to verify total depth and determine the amount of material accumulation in the well (if any). Evaluate the available water column and depth at which the pressure transducer will be set. This deployment depth will be established in the field implementation plan to understand the fluctuations induced naturally or by hydraulic testing. The depth of deployment will ensure that the water level does not fall below the pressure transducer sensor (dry conditions) or does not rise to a level that exceeds the specified pressure tolerance of the transducer.
- If the presence of a non-aqueous phase liquid (NAPL) is known or suspected at the site or within specific wells, *do not use* an electronic water-level indicator. Use an oil-water interface meter instead.
- Special considerations are also required for installation of pressure transducers if NAPL or other density-driven situations exist (e.g. zones of increased groundwater density due to reagent injections) and if there are concerns regarding the presence of explosive conditions down-well. Density corrections can be made during post-processing or directly programmed into the pressure transducer. Pressure transducers may be installed below or within light NAPL (LNAPL) or dense NAPL (DNAPL) for specialized testing or monitoring.
- The head space in the well requires venting to the atmosphere for (1) proper equilibration and (2) so that pressure does not build up in the head space that could affect the instrument readings.
- When using specialized well caps, ensure a measuring point (survey) point offset is recorded by taking a manual depth to water measurement prior to installation and after installation to the known measurement point. The pressure transducer accuracy is reduced when correlating to a known survey point for the elevation calibration (at the accuracy of the manual water-level meter). However, the actual fluctuations evaluated are at the accuracy of the pressure transducer model.
- Special applications may exist that require sealing of the wellhead space. If this is the case, proper planning and an additional pressure transducer may be needed for the sealed head space.
- Understanding instrument drift (vertical movement of transducer due to a variety of reasons) is primarily required for long-term projects (monitoring over a period of months to years). Drift can be evaluated post-processing and by recording the differences between pressure transducer readings and manual measurements (offsets) through time. If drift is excessive (determined by senior technical staff/project hydrogeologist) by the accuracy or continual increasing/decreasing differences of the water-levels, then instrument recalibration by the manufacturer or replacement may be necessary.

- During installation, data download, or operation verification, a manual depth to water measurement is required (see the *TGI – Manual Water-Level Monitoring*). Manual water levels can be recorded on the form provided in **Attachment 1** or by using FieldNow electronic data collection.
- Limit handling of the pressure transducers to prevent the need for post-processing shift adjustments.
- If freezing conditions may be encountered, refer to manufacturer guidelines that may include installation with a balloon filled with a nontoxic antifreeze solution.
- If multiple water-level meters will be used, calibrate prior to performing field activities by taking a water-level measurement from one well using all water-level meters to be used on site. Record the well ID, water-level meter ID (e.g., A, B), depth to water, and time measured (see form provided in **Attachment 1** or use FieldNow). Water level meters and transducers will be decontaminated as described in the *TGI – Manual Water-Level Monitoring*.
- Ensure that pressure transducer wellhead connections are secured according to manufacturer guidelines and using proper equipment. If the pressure transducers need to be redeployed, do so in such a manner to discourage movement/slippage of the line/cable or pressure transducer.
- Barometric pressure transducers require specific conditions for proper operation. Place the barometric pressure transducer in a cool/shaded location that is protected from precipitation and condensation. Desiccants can be used to help with condensation. Often, barometric pressure transducers are placed in a well casing stickup, between the inner and outer casings.
- Pressure transducers (including barometric loggers) require clock synchronization by one device. Most pressure transducer software does not account for daylight savings time.
- Pressure transducer details (serial number, model, programming, deployment, and retrieval information) must be recorded (see **Attachment 1** or use FieldNow). Also record the date and time of all manual water-level measurements.
- The barometric pressure transducer will always be the first to be deployed. The barometric pressure, rain, or weather station logger/equipment are always last to be downloaded (after all other transducers), following the same protocol as the pressure transducers.
- All time will be recorded in 24-hour format with the time zone indicated. Programming will be required for future start at equal intervals on an even interval (e.g., 14:05:00 start) to facilitate post-processing.
- All data (pressure transducer, barometric pressure, rain, and weather station logger/equipment) will be downloaded and saved as the software raw data file and exported as .csv (comma-separated values) or .xls (Excel spreadsheet) file upon download. Filenames will follow the form specified in the field implementation plan. For example, the format may be Well ID_YYYYMMDD (e.g., GW1_20190405) with an additional numeral if multiple daily downloads occur at one well. In addition, cloud services or other networking can be used to transmit data, and remote telemetry systems can be set up to record data in a specified database.
- Communication protocols will be outlined in the field implementation plan. In general, field staff should communicate with the rest of the project team prior to and at the completion of each field visit/monitoring event (before demobilizing from the site). Communication with the project team is critical so informed decisions can be made to address any complications that arise.

6 HEALTH AND SAFETY CONSIDERATIONS

Field work will be performed in accordance with the HASP, which includes related Job Safety Analyses (JSA) and safety data sheets (SDS) for site hazards and risks. Arcadis field personnel must review and understand the HASP and sign the appropriate acknowledgement page of the HASP prior to the start of work.

Appropriate PPE, as specified in the HASP, will be worn during these activities. At a minimum, Level D PPE, including hard hat, safety glasses, steel-toe boots, and nitrile gloves, is generally required.

Health and safety tailgate meetings will be conducted at least once daily (in the morning) and at the start of each task to discuss the scope of work, hazards associated with the work, and each person's responsibilities.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or oil. Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife). Open well caps slowly and keep face and body away to allow to vent any built-up pressure.

Field personnel will thoroughly review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives.

7 PROCEDURE

The following procedure will be performed at each wellhead or surface-water point during deployment, download, reset, or retrieval of the pressure transducers:

7.1 Pressure Transducer Setup and Deployment

1. Prior to mobilization, pressure transducers and related equipment will be checked and tested to verify working condition. Each pressure transducer will be accessed with the manufacturer software to ensure proper connection capabilities with laptop/tablet/smart or Bluetooth device. Pressure transducers will be submerged in a bucket of water at a known depth to verify accuracy and proper operation.
2. Don appropriate PPE (as required by the HASP).
3. Inspect wellhead for damage. Open the well/remove well cap and allow for atmospheric equilibration. If required in the HASP, measure headspace with PID. Measure the depth to water three times, and record final measurement, well ID, and date and time on the field form (**Attachment 1**) or using FieldNow. Measure total depth of well and confirm well construction against well construction log or summary table. Use appropriate length cable or cord to install the pressure transducer. If surface water monitoring is being completed, follow the same procedures for the stilling well or stream gauge.
4. Deploy pressure transducers:
   a. The barometric pressure transducer will be programmed and installed first. The barometric transducer will be installed in an open atmosphere setting protected from weather (sun or rain),

such as inside an outer well casing which does not pose a risk of flooding. Use desiccants if excessive condensation is expected.

b. Prior to deployment, program the pressure transducer following the manufacturer's instructions and as outlined in the field implementation plan. Information programmed into the transducer will include well identification, parameter to be measured (select Level/Depth, Top-of-Casing, or Elevation, and use appropriate reference elevation, if applicable), recording interval, units, and recording type (e.g., linear, differential, event, logarithmic). Determine start time (following the recommendations stated below) and other options:

   i. All pressure transducers will be synchronized to start after instrumentation is completed at monitoring wells or surface water points. Note that each time a pressure transducer is accessed an option for synchronization to a device can be done. Ensure a consistent device is used or the previous pressure transducer time and new synchronized device differences are recorded.

   ii. Pressure transducers will be programmed for a future start date that is consistent with the time interval selected (start time is at even increments using the future start option, with 00 seconds and recording interval, as applicable [e.g., 08:00:00]).

c. Cables or cords will be pre-measured to match the deployment depth as specified in the field implementation plan Ensure connections are not cross-threaded and sealed. If using a cord, use of a small-diameter Kevlar cord with a bowline knot for connections is recommended. Vented pressure transducers have a top cable connection that will likely have a desiccant connection to inhibit moisture concerns in the vent tube.

d. Slowly lower the pressure transducer to avoid any sudden disturbance of the water surface. Set to the appropriate depth for the project and data quality objectives as specified in the field plan. If setting the transducer at the base of a well or in a shallow stream, ensure there is at least 6 inches of vertical water column below the transducer to prevent the instrument from coming into contact with sediment. Attach the transducer cable or cord to the well cap and ensure that it is secured to prevent potential movement.

e. Record all pressure transducer settings on the field form (**Attachment 1**) or using FieldNow.

f. Check and record the manual depth to water measurement and initial transducer readings to confirm accuracy of test setup and if anomalies are observed (e.g., depth to water measurement does not match the initial reading and/or transducer readings don't match manual measurements), consult with Project Hydrogeologist and/or Project Technical Lead.

g. If required, coil excess pressure transducer cable without damaging it and leave inside the protective well casing.

h. Close wellhead and confirm it is vented (do not fully tighten j-plugs or caps) to the atmosphere and not sealed (use specific manufacturer well cap assembly, as necessary).

i. Scan/photograph all paper notes and forms, back up to an external flash memory stick, and upload to project folder/Sharepoint as specified in the field implementation plan.

7.2 Transducer Retrieval/Download/Reset of Pressure Transducer or Barometric Pressure Logger

1. Follow Steps 1 and 2 in Section 7.1.
2. Retrieve, if applicable, and/or connect to the pressure transducer using appropriate communication equipment and device.
3. Download data following the manufacturer's instructions. Perform an initial qualitative review of the data to identify anomalies and dataset completeness and record the date and time interval.
4. Save data (raw data file and exported .csv or .xls) on communication device (laptop/tablet/mobile device) or using the cloud. Duplicate data on an external flash memory stick. If copied to the cloud, have support staff check for data completeness. Preview saved information to ensure data were saved accurately. Check available memory of the pressure transducer and leave recording or follow the field plan for resetting.
5. Make relevant notes on field form (**Attachment 1**) or FieldNow.
6. Check and assess remaining memory relative to the recording frequency and recording frequency and clear/reset as necessary to avoid data loss. To reset the transducer, follow programming guidelines presented in Section 7.1.
7. Scan/photograph all paper notes and forms back up to an external flash memory stick, and upload to project folder/Sharepoint as specified in the field implementation plan.
8. If the retrieval of a transducer was necessary, reinstall following guidelines outlined in Section 7.1.

Before leaving the site (if possible), confirm that the data are saved on the cloud or server, and communicate the location to the project team.

Additional data download/management is necessary if other site instruments have been deployed (e.g., rain logger, weather station). Follow the same protocol as described above for retrieval/download/reset as needed.

Following final downloading and transducer pull event, decontaminate all transducers and cables as described in the *TGI – Manual Water-Level Monitoring*.

8 WASTE MANAGEMENT

Decontamination fluids, PPE, and other disposable equipment will be properly stored on site in labeled containers and disposed of properly. Waste containers must be properly labeled and documented in the field log book. Review the *TGI – Investigation-Derived Waste Handling and Storage* for additional information and state- or client-specific requirements.

9 DATA RECORDING AND MANAGEMENT

In general, data recording and management will follow the steps outlined above in Section 7.2. Specific data management protocols will be outlined in the field implementation plan.

Data/information uploaded to the Arcadis server or the cloud after each field visit/monitoring event at a minimum will include:

- Pressure transducer and other instrument data which should include:
  - Well IDs/locations
  - Measurement times
  - Depth to water/pressure head readings
  - Additional measurements, as necessary (e.g., temperature)
  - Total well depths
- Field notes
- Calibration information (water-level meters and pressure transducers)
- Photographs of the activities performed (if necessary)
- Any discrepancies or interesting findings/observations.

Once all data/information are collected and recorded, all notes/forms/data will be uploaded to the appropriate project folder/Sharepoint. Project field personnel will send an email to the project Task Manager, Technical Expert, and Data Manager for notification. The work completed that day, significant observations, and copies of the data listed above will be summarized in the email. The appropriate team members will review the data for accuracy and provide feedback.

10 QUALITY ASSURANCE

The quality items listed below are intended to provide information to ensure that data are collected at highest quality possible based on the field conditions:

- Calibrate the electronic water-level meter prior to use, instead of using an engineer's ruler, to ensure accurate length demarcations on the tape or cable. Record the results.
- Measurements will be conducted three times and the final measurement will be recorded.
- Review the field notes once the field data are delivered.
- Ensure all rental instruments are within calibration warranty dates.
- Do not install the transducer closer than 6 inches from the base of the well to eliminate the possibility of fouling the transducer with sediment accumulated at the bottom of the well or surface-water point.
- To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening unless directed by the manufacturer.
- Test functionality using a bucket or barrel filled with water. Submerge the pressure transducer, measure and estimate the water head above the pressure transducer, and compare the measurement to the reading (recall that absolute [sealed] pressure transducers will have compounded barometric pressure).

- Additional testing of the pressure transducers includes checking the pressure transducer response to changing heads by raising the pressure transducer a known distance, observing the change in head, and measuring the distance manually.
- Check and assess memory prior to deployment and after each download to avoid data loss. Use time interval between download events, sampling frequency, and remaining memory capacity of the transducer to determine if sufficient memory is available or the transducer requires resetting. Alternatively, remaining memory and sampling frequency can be used to schedule future downloading events.

11 REFERENCES

Cunningham, W.L., and Schalk, C.W., comps., 2011. *Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p.*

Freeman, L.A., Carpenter, M.C., Rosenberry, D.O., Rousseau, J.P., Unger, R. and McLean, J.S., 2004. Use of submersible pressure transducers in water-resources investigations: US Geological Survey Techniques of Water-Resources Investigations, book 8, chap. *A3*.

USEPA 2013. *SESD Operating Procedure, Groundwater level and Well Depth Measurement*. January 29.

ARCADIS Design & Consultancy for natural and built assets

PRESSURE TRANSDUCER LOG

Personnel: ______________________ Event: ______________________ Weather: ______________________

Pressure Transducers								Manual Depths					
Well or Stilling Point ID	Pressure Transducer Brand/Model	Serial Number	Program Start Date and Time	Initial Recording Interval	Approximate Deployment Depth (ft bTOC)	Transducer Location (above or below pump)	File Name	Water-Level Meter (A,B,C)	Date	Time	DTB (ft bTOC)	DTW (ft bTOC)	Notes

NOTES:

ft bTOC - feet below top of casing.

DTW and DTB - depth-to-water and depth-to-bottom

Solinst Levelogger connected to a PC using an optical reader

Solinst Levelogger and direct read cable connected to a PC using a PC interface cable

In-Situ LevelTrolls and BaroTroll

In-Situ vented cable and desiccant pack

Well cap assemblies for transducer deployment

Deployed transducers to measure barometric pressure and water level

Wireless communication equipment

SOP - SAMPLE CHAIN OF CUSTODY

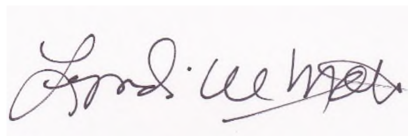
Rev: #2

Rev Date: April 29, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	April 19, 2017	All	Re-write to COC only	Richard Murphy
1	May 23, 2017	4	Add: Guidance on use of previous version of SOP.	Peter Frederick
		9	Add: Info on COCs for multiple shipping containers	
		7	Modify: Move letter i. to letter m. and change to “when appropriate”	
2	April 29, 2020	4	Remove obsolete link	Lyndi Mott
		11	Remove obsolete link	

APPROVAL SIGNATURES

Prepared by:		05/23/2017
	Peter C. Frederick	Date:
Technical Expert Reviewed by:		05/29/2020
	Lyndi Mott (Technical Expert)	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the general Chain of Custody (COC) procedures and guidance instructions for samples collected from project sites that are relinquished from Arcadis' possession.

COC is defined as the maintenance of an unbroken record of possession of an item from the time of its collection through some analytical or testing procedure. COC is typically documented by a written record of the collection, possession, and handling of samples collected from a project location. Each sample will be tracked by a documented record that efficiently documents the individuals who were responsible for the sample during each successive transfer of that sample to various recipients beyond Arcadis' possession. This information can be used to legally establish the integrity of the samples and therefore the analytical results derived from the samples. This information can be used in addition to other records and documentation regarding the samples, such as field forms, field logs, and photographs.

A sample is considered under custody if:

- It is in your possession; or
- It is in your view, after being in your possession; or
- It was in your possession and then you then locked it up to prevent tampering; or
- It is in a designated secure area.

Continued use of previous version of SOP:

Although not recommended, Arcadis program-, project-, and client-teams may be able to use the previous version of this SOP provided that it meets all of the quality expectations of Arcadis and client, and meets applicable regulatory requirements. It is up to the program, project, and/or client-team leader to determine whether it is appropriate to adopt the current SOP or to continue using the previous version.

However, all new work not associated with the previous version of this SOP must be performed with the current version of the SOP.

When adopting this new SOP, users of the previous versions must be aware that specific handling, packing, and shipping procedures and guidance has been removed and that those should be addressed within program or project plans (e.g. QAPPs, Work Plans, SAPs, etc.) or in a more detailed SOP or TGI specific to that sampling activity, whether related to media, constituent/analyte, client, state, etc.

In addition, adopting this new SOP will require users to refer to the Arcadis DOT Safety Program for procedures and guidance on the determination and handling, packing, and shipping of samples that are or may be considered hazardous materials.

3 PERSONNEL QUALIFICATIONS

Arcadis personnel performing work under the purview of this SOP will have received appropriate training and have field experience regarding the collection of samples from project locations. Arcadis personnel will have all other applicable and appropriate training relevant to the sampling work and project site.

4 EQUIPMENT LIST

The following list provides materials that may be required for each COC. Project reporting and documentation requirements must be reviewed with the CPM prior to execution of work. Additional materials, tools, equipment, etc. may be required, and project staff are required to verify with the CPM and/or Technical Expert what specific equipment is required to complete the COC.

- Indelible ink pen (preferably either black or blue ink);
- COC form (**Appendix A**) from either Arcadis, laboratory receiving and analyzing the samples, or other applicable and appropriate entity for the work performed;
- When appropriate, such as for litigation or expert testimony work, custody seals or tape.

5 CAUTIONS

One way in which the law tries to ensure the integrity of evidence is by requiring proof of the chain of custody by the party who is seeking to introduce a particular piece of evidence.

A proper chain of custody requires three types of affirmations: (1) affirmation that a sample is what it purports to be (for example, soil collected from a specified location and depth); (2) affirmation of continuous possession by each individual who has had possession of the sample from the time it is collected until the time it is analyzed or held by a laboratory; and (3) affirmation by each person who has had possession that sample remained in substantially the same condition and not contaminated or affected by outside influences from the moment one person took possession until the moment that person released the evidence into the custody of another (for example, affirmation that the sample was stored in a secure location where no one but the person in custody had access to it).

Proving chain of custody is necessary to "lay a foundation" for the samples in question, by showing the absence of alteration, substitution, or change of condition.

Ensure that appropriate sample containers with applicable preservatives, coolers, and packing material are planned for and provided at the site at the time of sample collection.

Understand the offsite transfer requirements of the samples for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation.

An Arcadis employee appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging, and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.

The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

6 HEALTH AND SAFETY CONSIDERATIONS

Follow the health and safety procedures outlined in the project/site Health and Safety Plan (HASP) as well as other applicable H&S requirements, such as:

- Arcadis Hazardous Material/DOT handling, packaging, and shipping training
- Project site-specific H&S training
- Client-specific H&S training
- Constituent-specific H&S training
- Media-specific H&S training

7 PROCEDURE

Collected samples must be uniquely identified, and properly documented, containerized, labeled with unique identifier, possessed in a secure manner during remainder of sampling event, packaged, and shipped to recipient laboratory.

Sample Identification

The method of sample identification depends on the type of measurement or analyses performed. In some cases, in-situ measurements of existing conditions and/or sample location must be made during sample collection. These data will be recorded directly on field forms, logbooks, or other project record data sheets used to permanently retain this information for the project file. Examples of location identification information includes: latitude/longitudinal measurements, compass directions, well number, building number, floor number, room name, or proximity to a site feature unique to the site. Examples of in-situ measurements are pH, temperature, conductivity, flow measurement, or physical condition of the media being sampled. Physical samples collected are identified by a unique identifying number or code on a sample tag or label. These physical samples are removed from the sample location and transported to a laboratory for analyses.

In some cases, before samples are placed into individual containers and labeled as individual samples, samples may be separated into portions depending upon the analytical methods and required duplicate or triplicate analyses to be performed.

When completing a COC for samples, personnel must complete the following:

1. Written COCs must be completed with indelible ink (preferably either black or blue colored ink).
2. Written COCs must be completed using legible printed writing, and not cursive writing.
3. All entry fields on the COC form must be completed. If information is not applicable for a specific entry field, personnel will either put “N/A” or use a strike-out line or dash like “-----------“ to indicate no applicable information is needed for that field.
4. Use of quotation marks or lines/down arrows to represent repetitive/duplicative text in similar fields.
5. Regardless of the type or specific COC form, the following pertinent information must be provided on the COC form:
    a. Arcadis project number
    b. Arcadis project name
    c. Project location, including street address, city, state, building number, providing as much detail as appropriate
    d. Recipient laboratory contact and sample receiving shipping location information
    e. Entities’/persons’ contact information for who will be receiving analytical results
    f. Name of sampler, i.e. person collecting sample and relinquishing possession of samples to the next entity in the chain of custody
    g. Date of sample collection

h. If appropriate for the sample media, contaminant/constituent of concern, or analytical method, document time of sample collection using standard military time

i. Sample analytical method(s)

j. Turnaround time required for analyses and/or reporting

k. Instructions to laboratory regarding handling, timing, analyses, etc. as applicable and appropriate

l. Printed name and signature of the individual person who collected the samples and relinquishing possession of the samples

m. If appropriate or when documentation of the specific sample collection method will influence how the laboratory handles, prepares, or analyzes the samples, document the sample collection methodology used for collecting the samples (e.g. ASTM D5755)

6. The following additional specific information will be entered on the COC form, regardless of what type of COC is being used:

   a. Unique Sample Identifier – The sample identifier (ID) must be unique to the individual sample it is applied to. The information in which the sample ID conveys is determined by the CPM, Technical Expert, and/or other project team members in advance of sample collection so that sample identification is consistently applied for the project. The sample nomenclature may be dictated by a specific client, program, or project database and require unique identification for each sample collected for the project. Consult with the CPM and/or Technical Expert for additional information regarding sample identification.

      The sample ID could convey specific information regarding the sample to aid personnel in recognizing what the sample represents, or they may be arbitrary so as to facilitate the anonymity of the sample location, media, constituent of concern, project site, etc.

      Examples of unique identifiers include:

      1. Well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be “SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain of custody form. DO NOT use the apostrophe or quotes in the sample ID.

      2. Sample names may also use the abbreviations “FB,” “TB,” and “DUP” as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively.

   b. List the date of sample collection. All indicated dates must be formatted using either mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

   c. When appropriate for the analytical procedure used, list the local time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

d. Samples should be indicated to be either “Grab” or “Composite”. Grab samples are collected from only one unique location at one specific point in time.

e. Composite samples are a group of individual samples that are combined for analysis in their totality. Composite samples need to be documented if they are either collected from a number of different locations over a broader area to be representative of the entire area being sampled, or if they are representative of a single location over an extended period of time.

f. If used, preservatives for the individual sample will be noted.

g. The requested analytical method(s) that the samples are being analyzed for must be indicated. As much detail, as necessary, should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering “EPA Method 8082 – PCBs” or “EPA PLM 600-R93-116.” In cases where multiple analytical methods and/or analytical parameters are required for an individual sample, each method should be indicated for the sample (e.g., EPA 8082/8260/8270 or EPA PLM/400-point count).

h. If there are project-specific sample analytes to be reported, they should be specifically listed for each individual sample (e.g., 40 CFR 264 Appendix IX).

i. The total number of containers for each analytical method requested should be documented. This information may be included under the parameter or as a total for the sample.

j. When necessary, note which samples should be used for site specific matrix spikes.

k. Indicate special project-specific requirements pertinent to the handling, shipping, or analyses. These requirements may be on a per sample basis such as “extract and hold sample until notified,” or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG).

l. Indicate turnaround time (TAT) required for samples on COC. If individual samples have differing TATs, the different TATs for each sample or groups of samples must be clearly indicated.

m. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory. The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

n. If available, attach the Laboratory Task Order or Work Authorization forms.

o. The “Relinquished By” field must contain the signature of the Arcadis person who relinquished custody of the samples to the next entity in the chain of custody, which may be another person, the shipping courier, or the analytical laboratory.

p. Dates and times must be indicated using the following format:

   1) Date: either mm/dd/yy e.g., 01/01/17 OR mm/dd/yyyy e.g., 01/01/2017

   2) Time: use military format, e.g. 9:30 a.m. is 0930 and 9:30 p.m. is 2130

q. The “Received By” section is signed by sample courier or laboratory representative who received the samples from the sampler or it is signed upon laboratory receipt from the overnight courier service.

4. When more than one page of the COC form is required to complete the total number of samples, use as many sheets as necessary to accurately and clearly document the samples and information. Some COCs may have a standard first page/cover page, and subsequent pages may not contain all the detailed fields as the first page/cover page. Ensure that any subsequent pages convey all of the necessary and pertinent information for each individual sample as required in this procedure document.
5. Pages of the COC must retain a page count of the total number of pages; e.g., Page 1 of 3, Page 2 of 3, Page 3 of 3.
6. Upon completing the COC forms, forward the original signed COC with the sample package. Ensure that the original COC form is secured with the sample package so that it remains with the physical samples for the duration of transport and handling to its final destination and ensure that the COC form will not be become damaged or rendered unreadable due to sample breakage/leakage if stored inside the sample shipping container or outside influences if COC is stored in an outside plastic pouch to the container.
7. If you’ve collected enough samples that would require more than one container to ship them all to the same laboratory or location, then each separate/individual container that contains any number of samples must have a separate COC representing only those samples contained within that specific container. For example, if you have 3 total shipping containers for all of your samples, you must have a total of 3 separate, individual COCs for each of the 3 containers representing only those samples in their representative container. Thus, every container holding samples must have its own, individual COC.
8. If electronic chain of custody (eCOC) forms are utilized, ensure that the requirements of this procedure and guidance instructions are followed to the extent possible. Verify that proper signature and COC procedures are maintained with the CPM and/or Technical Expert when using eCOC.

8 WASTE MANAGEMENT

Not Applicable.

9 DATA RECORDING AND MANAGEMENT

The original signed COC shall be submitted with the samples. Copies of COC records will be transmitted to the CPM or designee at the end of each day unless otherwise directed by the CPM. The sampling team leader retains copies of the chain of custody forms for filing in the project file. Record retention shall be in accordance with client- and project-specific requirements and Arcadis policies, the most stringent will apply.

10 QUALITY ASSURANCE

COC forms will be legibly completed in accordance with this procedure and guidance instruction document, as well as other applicable and appropriate project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents.

COC records will be reviewed by the CPM or their appropriate designee for completeness and accuracy to the applicable requirements. Non-conformances will be noted and corrected in a timely manner on the copies retained by Arcadis as well as contacting the ultimate receiving entity for correction to the originally signed COC in their possession.

11 REFERENCES

Arcadis Client Document Retention Guide

Arcadis Transportation Safety Program requirements, procedures, and guidance instructions

EPA Samplers' Guide – Contract Laboratory Program Guidance for Field Samplers, EPA document EPA-540-R014-013 October 2014

EPA Region III – *Sample Submission Procedures for the Office of Analytical Services and Quality Assurance (OASQA) Laboratory Branch* revision 13.0 January 29, 2014

EPA Region I Office Environmental Measurement and Evaluation – *Standard Operating Procedures for Chain of Custody of Samples* revision 1 March 25, 2002

EPA Region IV Science and Ecosystem Support Division *Operating Procedure for Sample and Evidence Management* January 29, 2013

APPENDIX A
Chain of Custody Form

ARCADIS

ID#

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ____ of ____

Lab Work Order #

Send Results to:		
Contact & Company Name:	Telephone:	
Address:	Fax:	
City State Zip	E-mail Address:	
Project Name/Location (City, State):	Project #:	
Sampler's Printed Name:	Sampler's Signature	

Preservative								
Filtered (✓)								
# of Containers								
Container Information								

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ______
G. Other: ______
H. Other: ______

Containment Information Key
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ______
10. Other: _______

Matrix Key:
SO - Soil
W - Water
T - Tissue
SE - Sediment
SL - Sludge
A - Air
NL - NAPL/Oil
SW - Sample Wipe
Other: ________

SAMPLE ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix									REMARKS

Special Instructions/Comments

☐ **Special QA/QC Instructions (✓)**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Last Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt	Firm:	Firm:	Firm:	Firm:
Shipping Tracking #:	Condition/Cooler Temp:_____	Date/Time:	Date/Time:	Date/Time:	Date/Time:

SOP – Sample Chain of Custody Rev1_May 23, 2017

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