Technical Memorandum
Residual Phase LNAPL Investigation

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Wausau, Wisconsin

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Section 1
Executive Summary

Remediation of the Wauleco Site has primarily consisted of pumping groundwater and recovery of light non-aqueous phase liquid (LNAPL). This remedial phase has been quite effective, in recovering approximately 147,000 gallons of LNAPL containing pentachlorophenol (PCP), satisfying the Wisconsin Department of Natural Resources (WDNR) that removal of mobile phase LNAPL from the Site has been completed. With the completion of source control of the mobile phase LNAPL, the focus has shifted in recent years to the remaining residual phase LNAPL. Additional data was needed to further evaluate the characteristics and behavior of the residual phase LNAPL that is a continuing source of dissolved phase PCP in groundwater. The additional data was needed to evaluate the applicability of potential additional remedial technologies and alternatives beyond the current groundwater pump and treatment system and to otherwise update the Conceptual Site Model (CSM) for the Site, given the remedial measures conducted over nearly 30 years.

In particular, with respect to the immobile residual phase LNAPL, the primary unknowns were:

- What is the current volume of LNAPL present in the residual phase LNAPL zone, and is there horizontal or spatial variability?
- What is the PCP concentration in this volume of LNAPL, and is there horizontal or spatial variability?

The April 2019 Residual Phase LNAPL Soil Site Investigation Work Plan (TRC, 2019) proposed cryogenic coring and high throughput analyses to be completed, using Dr. Tom Sale's (Colorado State University) approach to collecting detailed information on the characteristics of the residual phase LNAPL. Seven cryogenic coring boreholes were completed throughout the residual phase LNAPL footprint with 127 samples cut and evaluated from the frozen cores collected from these seven borings. This Technical Memorandum presents the results of the data collected in that effort.

The data demonstrate that:

- The residual phase LNAPL has declined from the original saturation of 17% of porosity to a current saturation of 1.6%, or a reduction of 90.6%.
- The PCP concentration in residual phase LNAPL is shown to have reduced from the original 5% to the current average concentration of 0.27%, or a reduction of 94.6%.

- Combining the reduction in the volume of residual phase LNAPL and the PCP concentration in this LNAPL, results in a 99.5% reduction in PCP mass (currently estimated at 5,097 lbs.) from the original estimated PCP mass in residual phase LNAPL.

These results demonstrate that significant source control of the residual phase LNAPL has occurred.

Soil samples were also collected and analyzed for total oxidant demand (TOD) and the potential effectiveness of an in-situ chemical oxidation (ISCO) remedial option to destroy PCP contained in the remaining residual phase LNAPL. These tests indicate that ISCO with persulfate will likely be ineffective for remediating the mineral spirits, and may or may not be effective in remediating PCP in all locations. Further evaluation of the effect of ISCO on PCP would require a small-scale field pilot test to determine whether the application of persulfate will be useful in remediating PCP at this site.

Additional updates to the LNAPL CSM based on the results of the residual phase LNAPL investigation include the following:

- The distribution of PCP mass shows that the majority of the estimated PCP mass is in the vicinity of boring M01 (5,003 lbs. of PCP in LNAPL) with very low concentrations and mass of PCP in the rest of the residual phase LNAPL area (with only 94 lbs. of PCP in LNAPL).
- The mass of PCP in LNAPL is somewhat geologically controlled in the boring M01 area, in that residual phase LNAPL present in fine grained soils contains the bulk of the PCP in LNAPL.

Section 2
Introduction

2.1 Key Terms

Key terms used in this Technical Memorandum include the following:

- **LNAPL:** This is the acronym for light non-aqueous phase liquid.
- **Mobile Phase LNAPL:** This is the former surface coating wood preservative solution that originally consisted of 5% pentachlorophenol (PCP), 85% mineral spirits, and 10% inerts. This is referred to as mobile phase because of its potential to migrate through the unsaturated vadose zone to the water table, and potentially migrate down the groundwater gradient.
- **Residual Phase LNAPL:** This is the former mobile phase LNAPL that based on fluctuations in groundwater elevation, is now present below the water table and is immobile, in terms of its ability to migrate down the groundwater gradient. The residual phase LNAPL is a source of dissolved phase PCP to groundwater.
- **Dissolved Phase PCP in Groundwater:** This is PCP present in the LNAPL that, when in contact with groundwater, becomes dissolved in groundwater through dissolution.

2.2 Site History and Background

The Wauleco, Inc. (Wauleco) facility is located at 125 Rosecrans Street, Wausau, Wisconsin (Figure 1). The property is located in an area of mixed industrial and residential land use. The property is the location of a former window and patio door manufacturer.

As was common in the wood window manufacturing industry, surface coating on the exterior portions of wood windows manufactured at the site was performed using a wood preservative solution of PCP and mineral spirits. Over time, releases of the solution occurred, and LNAPL migrated to the water table and migrated down the groundwater gradient. The LNAPL occurred initially as a mobile phase of LNAPL. However, as the water table fluctuated due to natural or induced changes in groundwater elevation, some of the mobile phase of LNAPL became smeared into the zone of the water table fluctuation. This “smear zone” consists of immobile residual phase LNAPL trapped within the soil. When remediation began in about 1991, LNAPL was present as mobile phase LNAPL, in a saturated layer of LNAPL on the water table and as residual phase LNAPL. Figure 2 illustrates the overall Wauleco Conceptual Site Model (CSM) as a cross section through the center of the property, and extending downgradient.

Much of the remedial focus between 1991 and 2011 was on recovery of the mobile phase LNAPL present on and adjacent to the Wauleco property through groundwater depression and LNAPL recovery. The groundwater extracted through pumping to depress the water table was treated in an above-ground treatment system. The LNAPL recovered was taken off-site and incinerated. In 1999, an enhanced LNAPL recovery system was selected and implemented, to increase LNAPL recovery. This system consisted of installing addition groundwater and LNAPL recovery wells with an increase in groundwater extraction from approximately 22 gallons per minute (gpm) to approximately 42 to 44 gpm. Several operational practices were also used to maximize LNAPL recovery as well.

As shown in the Annual Groundwater Monitoring Reports since that time, the enhanced recovery system was effective in converting residual phase LNAPL to mobile phase LNAPL and recovering the mobile phase LNAPL. The system recovered a total of approximately 147,000 gallons of LNAPL. In 2011, the WDNR agreed that mobile phase LNAPL recovery was complete, and the groundwater extraction system returned to lower pumping rates for containment of the on-site groundwater. The reduction in groundwater extraction was implemented in two steps, from approximately 44 gpm to approximately 29 gpm in March 2011 and then to approximately 22 gpm in June 2012. The system is continuing to be operated at approximately 22 gpm to contain and treat groundwater on the property.

In order to refine the CSM of the site, the horizontal and vertical distribution of residual phase LNAPL was investigated with laser induced fluorescence surveys (LIF) and reported in the Extent of Residual Phase Product/2015 LIF Survey Memo (TRC, 2015). Figure 3 illustrates the results of the LIF survey as a thickness map of residual phase LNAPL[1].

2.3 Purpose

The purposes of this Technical Memorandum are:

- To describe the CSM for the Wauleco project site, including (see Section 3):
  - The groundwater CSM
  - The LNAPL CSM (LCSM)
- To summarize the methods used in performing the residual phase LNAPL investigation (see Section 4).
- To summarize the results of the residual phase LNAPL investigation (see Section 5).
- To summarize the primary updates to the LCSM based on new data from the residual phase LNAPL investigation (see Section 6).

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[1] Figure 3 is modified from the original 2015 memo due to a correction in the LNAPL thickness at point L06.

Section 3
Conceptual Site Model (CSM)

3.1 Wauleco LNAPL Conceptual Site Model

A key component of any environmental remediation project is development of the CSM that is used to develop remedial action objectives and then to select remedial methods to achieve these remedial action objectives. At Wauleco, the presence of LNAPL requires development of a LNAPL CSM, as described in the ITRC LNAPL Guidance (ITRC, 2018) as the LCSM. Numerous reports have been submitted describing the history of LNAPL recovery, LNAPL measurements, and residual phase LNAPL characterization for the Wauleco Site. This section summarizes these data into a LCSM. A figure of the overall historical LNAPL CSM is shown in Figure 2, which is described in the following summary:

- Releases of the surface coating wood preservative solution (i.e., an LNAPL) included spills from the following sources:
    - After the wood window frames were immersed in a dip tank containing the solution, the window frames were removed and allowed to dry at locations in the area of the dip tank. During the drying process, solution dripped off the window frames, and for some of the solution, onto the soil beneath the drying areas.
    - From overfills of underground storage tanks used to store the solution.
- The released solution migrated through the unsaturated vadose zone to the water table.
- Over time, LNAPL that reached the water table migrated down the groundwater gradient.
- The LNAPL occurred initially as a mobile or migrating phase of LNAPL. However, as the water table fluctuated due to natural or induced changes in groundwater elevation, some of the mobile phase of LNAPL became smeared into the zone of the water table fluctuation. This "smear zone" consists of the immobile residual phase LNAPL.
- LNAPL in contact with groundwater is the source of dissolved phase PCP and mineral spirits groundwater. The current status of LNAPL as a source to groundwater is as follows:
    - The mobile phase LNAPL has been addressed to the extent practicable. The small amount of remaining mobile phase LNAPL is not a significant ongoing source to groundwater.
    - The residual phase LNAPL is an ongoing source to groundwater. If sufficient source control of residual phase LNAPL is achieved, then dissolved phase PCP concentrations in groundwater will decrease. Therefore, remedial technologies/actions that are focused on addressing the residual phase LNAPL, either by direct or indirect methods, will be effective in improving groundwater quality.

The ITRC (2018) LNAPL Guidance provides detailed descriptions of the occurrence and migration of LNAPL as background for developing an LCSM. A summary graphic from ITRC (2018), shown in Figure 4, provides a general overview of the history and typical conditions for LNAPL near the water table. Annotations on Figure 4 show how this applies to Wauleco, including the following:

- Figure 4a shows the conditions near the water table during the initial LNAPL release at Wauleco, where the LNAPL was present primarily as mobile phase LNAPL around the water table elevation.
- Subsequent groundwater elevation fluctuations, as shown in Figure 4b and 4c, resulted in the LNAPL being smeared throughout the zone of the water table fluctuations.
- As shown on Figure 4c, the mobile phase LNAPL has been reduced (due to LNAPL recovery at Wauleco), while some residual phase LNAPL remains below the water table.
- As shown in Figure 4d, after a water table rise, the residual phase LNAPL remains below the water table. At Wauleco, this rise in water table can be considered to be the reduction in pumping when discontinuing LNAPL recovery in 2011 and 2012. This resulted in a small rise in the groundwater elevation, with no significant extent of mobile phase LNAPL remaining at the water table (as illustrated in Figure 4d), but with immobile residual phase LNAPL present below the water table.
- Figure 4e presents the hypothetical condition that if the water table falls in the future, that additional mobile phase LNAPL could accumulate around the lower water table surface. At Wauleco, an actual significant drop in groundwater elevation occurred in 2016, during repairs on the Rothschild dam that required an approximate 5 ft. drop in the Lake Wausau pool elevation. As presented in the 2017 Annual Groundwater Monitoring Report (TRC, 2018), the groundwater elevation dropped 2.56 ft. (at well W10A) near the river and 1.9 ft. (at well W45) on the Wauleco property, with the only LNAPL occurrence of 0.2 ft. at well W40. As described in more detail by TRC (2018), this 2016 event demonstrated that there was insufficient residual phase LNAPL present below the water table to accumulate as mobile phase LNAPL during a significant drop in the water table elevation.

The principal components of the LCSM are described in the following subsections.

3.1.1 Horizontal and Vertical Extent of Residual Phase LNAPL

The horizontal and vertical extent of residual phase LNAPL on and around the Wauleco property was assessed via LIF surveys and reported in a 2015 technical memorandum (TRC, 2015). Figure 3 shows the areal distribution and vertical thickness of residual phase LNAPL remaining based on the LIF survey.

As shown in the Annual Groundwater Monitoring Reports (e.g., TRC, 2019), the extent of remaining mobile phase LNAPL is limited to the area of only 3 or 4 wells.

3.1.2 PCP Concentration in LNAPL

The original PCP concentration in the product used for coating window frames is well known from the literature and the product information. The product consisted of 85% mineral spirits, 5% PCP, and 10% inerts.

Analysis of PCP concentration in the LNAPL was required for disposal of collected LNAPL, using the toxic characteristics leaching procedure (TCLP). For liquids, the TCLP analysis consists of analyzing the liquid directly, rather than leaching the liquid as would be done with a solid material. Therefore, these analyses provide information on the PCP concentration present in the recovered LNAPL through time. In addition, there was an analysis of PCP in LNAPL collected from several wells and reported in Keystone (1986[2]). Table 1 provides the data and a graph of PCP concentrations in LNAPL collected through time. The data from 1996 through 2018 represent data from LNAPL collected from the LNAPL recovery system and represent the mobile phase LNAPL. As shown in Table 1, PCP concentrations in mobile phase LNAPL have dropped from:

- An initial concentration of 5%
- To approximately 3.2% in 1986
- To a range of 0.05% to 0.96% in samples collected in 2018.

These data can be used as estimates of PCP concentrations in residual phase LNAPL. Mobile phase LNAPL was in direct contact with the residual phase LNAPL at Wauleco. In addition, LNAPL frequently transitioned between mobile phase and residual phase as the water table fluctuated during LNAPL recovery operations. Therefore, the PCP concentration in the mobile phase and residual phase LNAPL are expected to be very similar. However, direct measurements of PCP concentrations in the residual phase LNAPL were not made prior to this investigation.

3.1.3 Residual Phase LNAPL Saturation

The volume of residual phase LNAPL and the PCP concentration in the residual phase LNAPL determines the mass of PCP remaining in the LNAPL. Therefore, the volume of residual phase LNAPL is an important component of Wauleco's LCSM.

Estimating the volume of residual phase LNAPL requires knowing the residual saturation of LNAPL in the soils. Residual oil saturation can be thought of as how much oil would a sponge retain, submerged in water. This is a critical property for the oil

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[2] Keystone, 1986 Site Characterization Report, September 5, 1986, Appendix D, Table 2.

industry's management of oil reservoirs. Therefore, this property has been studied in detail by the oil industry and transferred to the environmental field.

The residual LNAPL saturation was estimated by Keystone (1992) through soil and LNAPL testing conducted by the University of Texas at Austin, using testing methods developed for the oil industry. These test results (see Appendix A for details) showed that the residual phase LNAPL saturation for the Wauleco LNAPL was approximately 17%. This value indicates that 17% of the pore volume would contain immobile residual phase LNAPL after draining the mobile LNAPL from a water saturated soil sample.

3.1.4 LCSM Data Gaps

Additional information for the LCSM was needed regarding the physical and chemical characteristics of the residual phase LNAPL that will control the release of PCP to groundwater. In particular, the primary unknowns were:

- What is the current volume of LNAPL present in the residual phase LNAPL zone, and is there horizontal or spatial variability?
- What is the PCP concentration in this volume of LNAPL, and is there horizontal or spatial variability?

Ancillary properties for evaluating a chemical oxidation remedial action includes:

- The total oxidant demand (TOD) of the soil containing residual phase LNAPL.
- The ability to reduce the PCP concentration within the residual phase LNAPL zone.

These data were needed to evaluate the applicability of potential additional remedial technologies and alternatives beyond the current groundwater pump and treatment system to address the immobile residual phase LNAPL as a continuing source to groundwater.

In the Residual Phase LNAPL-Soil Investigation Work Plan (TRC, April 2019), TRC proposed to use cryogenic coring using the methods described in Sale (2016) and Kiaalhosseini, et. al. (2016) to collect additional data in support of the LCSM. The advantage of cryogenic coring is the ability to collect the soils and fluids throughout the residual phase LNAPL, by freezing the water and LNAPL, retaining the fluids in the coarse sand soils. In addition, cryogenic coring improves core recovery, retaining more of the soil structure. The cryogenic coring methods are described in the following section.

Section 4
Residual Phase LNAPL Investigation Methods

4.1 Methods

The methods for this investigation included:

- Cryogenic coring
- Core sample handling
- Analyses of the core samples for LNAPL, PCP, and other properties,
- Total Oxidant Demand.

The cryogenic coring, core sample handling, and analyses of core samples are described in detail in Sale (2016) and Kiaalhosseini et al. (2016). A copy of Kiaalhosseini et al. (2016) is included in Appendix B for a detailed description. These methods were implemented at Wauleco according to and consistent with these publications.

TRC contracted with Drilling Engineers, Inc., to complete the cryogenic coring and Dr. Tom Sale of Colorado State University (CSU) to complete the analyses of the collected cores. CSU and Drilling Engineers, Inc., have worked together on several cryogenic coring projects, having developed the methods described in Sale (2016) and Kiaalhosseini et al. (2016). TRC, CSU, and Drilling Engineers coordinated the plans prior to mobilization, providing the equipment, forms, and methods to collect the frozen core, package it, and ship it to CSU for analysis.

Prior to performing the field work, a permit was obtained from the City of Wausau to conduct the borings within the City's right-of-way. Seven cryogenic cores (M01 through M07) were conducted between June 3 and June 8, 2019, at the locations shown on Figure 3. These borings included the following locations:

1. **M01:** On-site in the area of the former dip tank and drying areas, near LIF L03.
2. **M02:** On-site in the area of the thickest residual phase LNAPL and near LIF L06.
3. **M03:** On-site, in the area of thick residual phase LNAPL and near LIF L07.
4. **M04:** Off-site, in the area of residual phase LNAPL extending to the southeast, towards monitoring wells W41 and W27, and in the vicinity of LIF L09.
5. **M05:** Off-site in the northern, central portion of the residual phase LNAPL and near LIF L36.

6. **M06:** Off-site in the southeastern portion of the residual phase LNAPL and near LIF L34.
7. **M07:** Off-site in the furthest extent of the residual phase LNAPL and near well W10A and LIF L39.

In general, the cryogenic coring consisted of using a CME 75 drill rig and CME coring operation (as described in Sale (2016) and Kiaalhosseini et al. (2016)). Borings were advanced using hollow stem augers (without cryogenic coring), to near the top of the LNAPL residual phase interval. The top of the LNAPL residual phase was determined at each cryogenic coring location using data from the nearest LIF borings (TRC, 2015). Upon reaching the targeted interval, the specialized cryogenic soil core barrel was installed and advanced through the LNAPL residual phase interval. This specialized core barrel is fitted with tubing to circulate liquid nitrogen around the soil core barrel, to freeze the sample in the core barrel. The liquid nitrogen is circulated for several minutes, based on the driller's experience and monitoring, to sufficiently freeze the sample, but to allow separation of the inner PVC core tube from the outer steel core barrel after extracting of the core barrel from the borehole.

Upon removal of the core barrel, the inner PVC core tube is extracted from the steel core barrel. Upon removal of each core tube, the tube was inspected and found to be frozen solid, with no free liquids within the core. Each core was immediately labeled, with depth of the top, bottom, and which ends were the top and bottom of the core. End caps were placed on the PVC core barrel, taped onto the frozen PVC core barrel with electrical tape, and covered with duct tape, with a summary sheet in a Ziploc bag wrapped on the core barrel and taped with both electrical tape and wrapped around the core barrel. Multiple labeling was completed as a conservative approach due to the potential challenges of attaching tape to the frozen core. Within 5 minutes of extraction, each frozen core was labeled and placed in a cooler with approximately 50 lbs of dry ice in each cooler.

After each day of sample collection, the coolers of dry ice and cores were shipped overnight to CSU. The next day, contact with CSU confirmed receipt and the coolers were placed in CSU's freezer that is maintained at -80° C (i.e., -112° F).

In addition to the cryogenic cores, samples for TOD analysis were also collected during the June 2019 drilling event. TOD analyses were completed using the methods described by Haselow (2003). TRC contracted with Dr. Haselow at Redox Tech, Inc. to complete these analyses. Dr. Haselow stated that analyses for TOD did not require undisturbed samples, because the TOD would be based on pre-oxidation and post-oxidation samples and that the results would then be scaled to the concentrations of LNAPL and PCP obtained through the cryogenic coring and analysis program. Therefore, disturbed samples were sufficient for TOD analyses. Large volume samples were collected from the auger flights after retracting the augers. A PID meter was used to clearly identify contaminated zones, and bag samples were collected from the auger and sent on ice to Redox Tech, Inc. for their use. The samples subjected to TOD analyses consisted of 50% samples from the bulk soil samples and 50% frozen samples from the cryogenic cores that were sent, frozen, from CSU to Redox Tech.

As described in Kiaalhosseini et al. (2016), the core samples were subjected to High Throughput Soil Analyses. In general, the methods include:

- Cutting the frozen core into 1-inch thick slabs. The cores from the seven cryogenic coring locations were cut into 127 slabs.
- The soil types of each 1-inch slab are described and classified. This was completed by Dr. Tom Sale.
- Each slab is cut into four quarters and used for analyses.
- One quarter is inspected under visible light and ultraviolet (UV) light. Mineral spirits fluoresce under UV light, so that the presence of LNAPL in the sample is visually apparent.
- Laboratory analyses for diesel range organics (DRO) and gasoline range organics (GRO), which are summed for total petroleum hydrocarbons (TPH).
- Laboratory analyses of methane, and porosity.

In addition to these typical analyses, Wauleco samples were also analyzed for PCP.

The LNAPL saturation concentration is calculated using the methods described in Kiaalhosseini et al. (2016). This method starts with determining the TPH concentration where no LNAPL is observed in UV light (TPH_{cutoff}). This is used with the observed TPH, porosity, the mass of the sample, and the density of the LNAPL to calculate the LNAPL saturation. A density of 0.8 g/cm^3 was used for the density of the Wauleco LNAPL, as used throughout the Wauleco project.

Analytical results from CSU are included in Appendix C and TOD analytical results from Redox Tech are included in Appendix D.

4.2 Management of Soil Cuttings from Borings

Soil cuttings from above and below the water table were segregated and containerized in 55-gallon drums and staged on-site. Sixteen 55-gallon drums were generated consisting of the following as shown below in Table A.

Table A
Summary of Drums of Soil Cuttings

NO.	BORING LOCATION	TOTAL NUMBER OF DRUMS	NUMBER OF DRUMS OF SOIL CUTTINGS ABOVE THE WATER TABLE	NUMBER OF DRUMS OF SOIL CUTTINGS BELOW THE WATER TABLE
1	M01	3	2	1
2	M02	2	1	1
3	M03	2	1	1
4	M04	2	1	1
5	M05	2	1	1
6	M06	2	1	1
7	M07	3	2	1
8	TOTAL	16	9	7

As discussed in Section 5, boring M01 contained the highest concentrations of PCP. Therefore, representative samples were collected from the drums containing M01 soil cuttings, and analyzed for Protocol B parameters for waste characterization, see attached Tables 2 and 3 and Appendix E for the laboratory report. Based on the waste characterization results, the soil cuttings are classified as a solid waste, and will be disposed accordingly.

Section 5
Residual Phase LNAPL Investigation Results

5.1 Residual Phase LNAPL Saturation and PCP Concentrations in LNAPL

The cores from the seven cryogenic borings were cut into 127 separate samples of approximately 1-inch thickness. Analytical results and calculations from these analyses are shown in Table 4, and the analytical report in Appendix C. These 127 samples were used to complete:

- 126 analyses for TPH through GRO and DRO.
- 125 analyses for PCP.
- 125 analyses for methane.
- 123 samples for LNAPL saturation.
- 122 samples for porosity.

These analyses were used to calculate the PCP concentration in LNAPL, which is presented in Table 4 as PCP in LNAPL (%). The PCP concentration in LNAPL was calculated for each sample with LNAPL. This was completed using methods described in Appendix F.

5.2 Comparison of LIF and Cryogenic Results

The LIF survey characterized the presence and thickness of the residual phase LNAPL interval through measurement of NAPL fluorescence while pushing a Geoprobe with a laser light and fluorescence detector in its tip. The LIF survey results are described in the Extent of Residual Phase Product/2015 LIF Survey Memo (TRC, 2015). Table 4 illustrates the interval in which a nearby LIF probe detected residual phase LNAPL, as a yellow highlighted interval for each cryogenic boring. These intervals are referred to, herein, as the LIF LNAPL intervals, to distinguish this estimated LNAPL interval from the Cryo LNAPL intervals where the CSU analyses detected LNAPL saturation greater than zero. Comparison of the LIF LNAPL intervals to the Cryo LNAPL intervals indicates that they are generally in good agreement. These comparisons are also illustrated in Figures 5 to 11 for the seven cryogenic borings.

In general, the LIF probes showed a continuous thickness of residual phase LNAPL from when first detected to the bottom of the LIF LNAPL interval. The cryogenic data at on-site borings M01, M02, and M03 indicate the LNAPL is somewhat more sparse through a somewhat greater interval, but roughly, the same thickness. This is shown in attached Table 4 and summarized below in Table B. For example, at boring M01 and nearby LIF03, the LIF LNAPL is continuous from 28.89 ft. to 31.05 ft. bgs., whereas the Cryo LNAPL is discontinuous from 29.083 ft. to 32.167 ft. bgs.

Table B
Cryo LNAPL and LIF LNAPL Thicknesses

CRYO BORING	NEARBY LIF	LNAPL THICKNESS	
		LIF	CRYO
M01	L03	2.16	2.33
M02	L06	5.97	4.12
M03	L07	4.17	4.96
M04	L09	0.75	1.45
M05	L36	1.03	1.32
M06	L34	0.79(a)	3.33
M07	L39	1.45	1.54

Footnote:

(a) LIF interpretation of L34 indicated the interval of residual phase LNAPL was from 21.78 ft. to 22.57 ft. bgs.

The cryogenic data for off-site borings (M04 through M07) show the Cryo LNAPL is continuous, like the LIF LNAPL, but is somewhat greater in thickness. The thickness of the Cryo LNAPL at M06 is significantly thicker than expected for this area based on the 2015 interpretation of nearby LIF L34 and the contours shown on Figure 3 based on surrounding LIFs. However, as shown on Figure 10, LIF L34 does not appear to be inconsistent with the data from cryogenic boring M06, and the 2015 interpretation of LIF L34 appears to have underestimated the thickness of LNAPL in this area.

5.3 Summary of Cryogenic Results

Out of these analyses the following statistics are important for characterization of the residual phase LNAPL at Wauleco:

- Where LNAPL was not present based on laboratory analysis (i.e., 72 of 118 samples), these samples were not used in the statistics. Rather, these samples were used to assess the vertical extent of residual phase LNAPL.
- Where LNAPL is present (i.e., 46 of 118 samples) the average LNAPL saturation is 1.6% and ranges from 0 % to 7.3% (samples with LNAPL saturation of 0% were not used in calculating the average saturation).
- Where LNAPL is present OR where the LIF detected LNAPL (i.e., 75 of 118 samples), the average saturation is 1.0% and ranges from 0% to 7.3%. This average includes zero values where the LIF detected LNAPL and where the cryogenic testing did not detect LNAPL.

- The estimated PCP concentration in LNAPL, as described in Appendix F, ranged from 0% to 2.3%, with an average of 0.27%.

5.4 Comparisons to Original Residual Phase LNAPL

As presented in Section 3, previous data have been collected to estimate the residual phase LNAPL saturation and PCP concentration within the LNAPL. Table C below compares these previous values with updated estimates obtained through the cryogenic coring analyses, and presents the percent reduction in LNAPL saturation and PCP concentration in LNAPL based on these new results.

Table C
Reductions in LNAPL Saturation and PCP Concentration

PERIOD	LNAPL RESIDUAL SATURATION (%)	PCP CONCENTRATION IN LNAPL (%)
Original	17%	5%
2019 Cryogenic Analyses: All samples with detected LNAPL saturation	1.6%	0.27%
Percent Reduction	90.6%	94.6%
2019 Cryogenic Analyses: All samples with detected LNAPL saturation PLUS samples in LIF LNAPL zone	1.0%	Not Applicable (where LNAPL volume = 0, PCP concentration in LNAPL is not defined)
Percent Reduction	94.3%	Not Applicable

The LNAPL residual saturation has reduced 90.6% when considering just the zones with remaining LNAPL, or 94.3% when including samples within the LIF LNAPL interval with zero Cryo LNAPL saturation. The PCP concentration within this LNAPL has been reduced by approximately 94.6%. In combination, this represents a reduction of 99.5%[3] in the mass of PCP present in zones with LNAPL.

These results demonstrate that significant source control of the residual phase LNAPL has occurred.

5.5 LNAPL and PCP Mass Remaining

As described in Section 3, the residual phase LNAPL can act as a source of PCP to groundwater. Therefore, the mass of PCP remaining in LNAPL is a factor in estimating the restoration time frame when evaluating remedial action technologies and alternatives. Therefore, this is an important component of the LCSM at Wauleco.

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[3] The combined reduction is estimated as: 99.5% = 1-((1-90.6%)*(1-94.6%))

The estimated mass of PCP in LNAPL and the estimated mass of LNAPL is presented in Table 4 for each soil sample that contains some LNAPL saturation. For the mass of PCP see the column labeled Mass of PCP in LNAPL (g/M^2). For the mass of LNAPL see the column labeled Mass of LNAPL (g/boring/M^2). These are summed by boring, to provide an estimated mass of PCP in LNAPL and an estimated mass of LNAPL per unit area at each boring. Methods used to calculate these values are described in Appendix F.

As shown in attached Table 5 and summarized below in Table D, the vast majority of the mass of PCP in LNAPL is present at boring M01. For example, the mass of PCP in LNAPL at boring M01 is approximately 125 grams/M^2 compared to 0.76 to 1.7 grams/M^2 at each of the other cryogenic borings. The data were further evaluated to assess why the mass of PCP at boring M01 is so much greater than at the other borings. Figure 5 illustrates the difference. The high concentrations of PCP occur within fine grained soil units present within the residual phase LNAPL at this location.

Table D
Estimated PCP Mass in LNAPL per Boring

CRYO BORING	ESTIMATED MASS OF PCP IN LNAPL PER BORING (grams/boring/M^2)
M01	212
M02	1.54
M03	2.10
M04	0.25
M05	0.36
M06	1.40
M07	0.76

As shown in Table 4, the majority of the mass of PCP in boring M01 originated from Sample ID 706 (PCP concentration of 344 mg/kg) contributing 149 g/M^2 and Sample ID 720 (PCP concentration of 141 mg/kg) contributing 41.8 g/M^2 of the total 212 g/M^2 for boring M01. The soil units for these two samples, as shown on Figure 5 are silt and sandy silt, respectively, whereas all of the other 1-inch thick samples in boring M01 are variations of poorly graded[4] sand and poorly graded gravelly sand.

These samples demonstrate that there is some geologic control on the mass of PCP remaining in the residual phase LNAPL in the vicinity of boring M01. If there are fine grained units within the residual phase LNAPL, these soils may contribute to retaining PCP within the residual

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[4] Poorly graded means well sorted, which also means a uniform grain size with only a trace of silt and clay.

phase LNAPL. Therefore, previous soil boring logs were reviewed within the vicinity of the M01 boring to assess if silt, sandy silt, or clays were present within the residual phase LNAPL interval. The details of this assessment are included in Appendix G, including a table of borings reviewed and where fine grained soil units were encountered in the residual phase LNAPL intervals. Few fine grained units were found throughout the soil column and only one boring, in addition to boring M01, of the 84 borings reviewed in the vicinity of boring M01 identified similar fine grained units within the residual phase LNAPL (for a total of 2 of 85 borings). However, there was a significant difference in the level of detailed soil sampling and description between the cryogenic borings (i.e., M01 through M07) and the historical boring logs at the site. The frozen core from the cryogenic borings preserve even the very thin silt seams that may not be preserved as well in a traditional split spoon sample. Therefore, the frequency of finding silt or clay units is based on the number of cryogenic borings conducted, finding silt or clay within the residual phase LNAPL zone at one of seven locations, or about 14%.

Calculating the estimated mass of PCP in LNAPL, presented in Table 5, uses the area around each of the cryogenic borings. The area represented by boring M01 is divided, with 14% of the area using the PCP mass/area calculated with the fine grained soil PCP concentrations and the remaining 86%) using the mass of PCP in LNAPL calculated without the contribution from the fine grained soils.

As shown in attached Table 5, and summarized below in Table E, the estimated mass of PCP in LNAPL shows most of the remaining mass of PCP in LNAPL is present within the area represented by boring M01.

Table E
Estimated PCP Mass in LNAPL

CRYO BORING	ESTIMATED MASS OF PCP IN LNAPL AREA REPRESENTED BY EACH BORING (lbs)
M01	5,003
M02	16
M03	20
M04	6
M05	11
M06	35
M07	7
Total	5,097

5.6 Total Oxidant Demand Results

Proper design of a field-scale implementation of an in-situ chemical oxidation (ISCO) remedial option requires data on target contaminant levels as well as quantitative estimates of other oxidant sinks. If all of the reactions that consume oxidant are not properly estimated, the amount of oxidant that needs to be injected will be underestimated, and it is likely that the ISCO effort will fail. Additionally, the demand for the oxidant exerted by subsurface materials may make ISCO economically infeasible for particular sites. Therefore, samples collected during the drilling operation for the cryogenic coring were subjected to total oxidant demand (TOD) analyses. Results are summarized in Table 6 and analytical data provided in Appendix D.

There are a number of chemical and physical factors that contribute to the total oxidant demand (TOD) of a subsurface environment. These include: 1) dissolved phase contaminant, 2) sorbed phase contaminant, 3) non-aqueous phase liquids, 4) dissolved phase reduced minerals, 4) solid phase (or sorbed phase) reduced minerals, 5) dissolved and sorbed phase natural organic matter (NOM), and 6) thermal and chemical decomposition. Obviously, the mass of oxidant cannot be reliably estimated from the target contaminant levels alone.

TOD is reported in grams of oxidant per kilogram of groundwater sample. TOD testing for sodium persulfate was completed per Haselow et al. (2003). Based on the analytical comparison between Pre- and Post-TOD analyses (see Table 6), it appears that persulfate had little to no remedial effect on TPH in both M01 and M07. The increase of TPH in the M01 post-treatment sample is likely a result of small-scale heterogeneity in the collected sample that emerges in the analyses of split sub samples. The Pre-TOD M01 subsample may have had no residual NAPL in contrast with the remaining M01 subsample used for the TOD test. It appears that approximately 40% of the PCP was successfully degraded in the M04 test and 90% to 100% in the other tests. However, in the two tests with less than 100% destruction, a larger dose of persulfate had little effect on the amount of destruction. This counter intuitive result may be an artifact of the limited reaction time of this test. The TPH treatment results indicate that persulfate will probably not be effective for remediating the mineral spirits and may or may not be effective in remediating PCP in all locations. The reason for this opinion is that the testing is more aggressive than field implementation and that if the chemical oxidation won't destroy all the mineral spirits, some PCP may not be destroyed by the oxidant because the PCP is dissolved in the mineral spirits. Further evaluation of the effect of ISCO on PCP would require a small-scale field pilot test to see if the application of persulfate will be useful in remediating PCP at this site.

Section 6
LNAPL CSM Update

Based on the data presented herein, the primary updates to the LCSM presented in Section 3 are summarized as follows:

- The amount of LNAPL within the immobile residual phase LNAPL zone has declined substantially from the original estimated volume. The original residual saturation, estimated as 17% based on testing in 1992, has reduced to an average of approximately 1.6%, or a reduction of 90.6% from the original residual saturation.
- The concentration of PCP within this immobile residual phase LNAPL has reduced from the original product of 5% to an average of 0.27%, or a reduction of 94.6% from the original concentration.
- The distribution of PCP mass shows that the majority of the estimated PCP mass is in the vicinity of boring M01 (5,003 lbs. of PCP in LNAPL) with very low concentrations and mass of PCP in the rest of the residual phase LNAPL area (with only 94 lbs. of PCP in LNAPL).
- The mass of PCP in LNAPL is somewhat geologically controlled in the boring M01 area, in that residual phase LNAPL present in fine grained soils contains the bulk of the PCP in LNAPL.

Figure 12 presents this updated LCSM.

Section 7
Findings and Conclusions

7.1 Findings

In summary, the findings from the cryogenic coring sampling were shown to be in general agreement with the LIF characterization of the residual phase LNAPL, but provides quantitative data not available from the LIF surveys. These quantitative data are used to update the LCSM as follows:

- The average LNAPL saturation remaining is estimated to range from 0% to 7.3% of porosity, with an average of 1.6%, which is a 90.6% reduction from the original 17% of LNAPL saturation. Including samples with zero LNAPL saturation that are within the LNAPL interval identified by the LIF survey, the average saturation is 1.0%, or 94.3% reduction.
- The average concentration of PCP in the LNAPL ranged from 0% to 2.3%, with an average of 0.27%, which is a 94.6% reduction in PCP concentration from the original 5% PCP in the product.
- Combining the reduction in the volume of LNAPL (i.e., 90.6%) and the reduction of the PCP concentration in this remaining LNAPL (94.6%), the total reduction in PCP mass is 99.5%.
- The mass of PCP in LNAPL is somewhat geologically controlled in the M01 area, with higher concentrations present in fine grained soils (silt or clay). It is estimated that up to 14% of the residual phase LNAPL in the M01 area may contain fine grained soils.
- The estimated mass of PCP present in residual phase LNAPL is predominantly present in the M01 boring area, with an estimated 5,003 lbs of PCP in LNAPL, compared to a total of 94 lbs of PCP in LNAPL in the remaining residual phase LNAPL area.

7.2 Conclusions

These results demonstrate that significant source control of the residual phase LNAPL has occurred. The data presented in this Technical Memorandum and the updated LCSM will be used in further evaluating groundwater remedial technologies and alternatives.

Section 8
References

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TRC. 2019. 2018 Annual Groundwater Monitoring Report. April 4, 2019

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Table 1
Historical PCP Concentration in LNAPL

SAMPLE DATE	DATE OF ANALYSIS	METHOD	ANALYSIS RESULT	
			mg/L	% w/w
Jun-86	Jun-86	Total[1]		3.23%
26-Aug-96	26-Aug-96	TCLP[2]	11,700	1.46%
16-Feb-98	16-Feb-98	TCLP[2]	25,000	3.13%
2-Sep-99	2-Sep-99	TCLP[2]	11,000	1.38%
23-Oct-00	23-Oct-00	TCLP[2]	5,400	0.68%
12-Oct-01	12-Oct-01	TCLP[2]	5,000	0.63%
19-Sep-02	19-Sep-02	TCLP[2]	4,200	0.53%
23-Jul-03	23-Jul-03	TCLP[2]	10,000	1.25%
7-Mar-05	7-Mar-05	TCLP[2]	1,400	0.18%
18-Jul-05	18-Jul-05	TCLP[2]	1,572	0.20%
22-Oct-06	22-Oct-06	TCLP[2]	6,200	0.78%
10-Nov-08	10-Nov-08	TCLP[2]	790	0.10%
8-Jul-09	8-Jul-09	TCLP[2]	530	0.07%
3-Sep-10	3-Sep-10	TCLP[2]	<1,000	<0.13%
Samples collected over time in 2017 and 2018	18-Apr-18	Total[3]	7700	0.96%
	5/11/2018	TCLP[4]	430	0.05%

Footnotes:

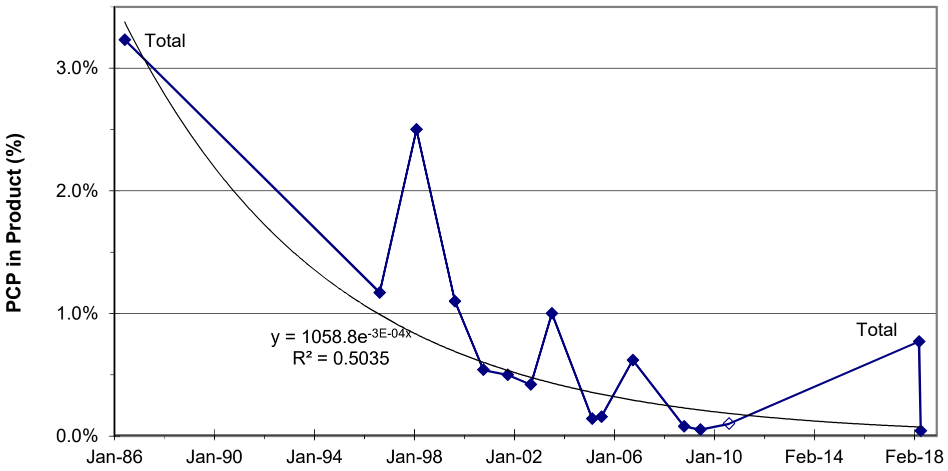
[1] Analysis presented in Keystone, 1986 Site Characterization Report, September 5, 1986, Appendix D, Table 2

[2] Rader Environmental samples of recovered product prior to destruction analyzed by TCLP methods.

[3] Alpha Analytical total analysis using GC/MS-SIM 8270-SIM

[4] CT Labs TCLP Analysis

PCP Concentration in LNAPL



All analyses by TCLP, except as noted as total.
Open symbol indicates non-detect, plotted at detection limit.

Details on 1986 Keystone Sample Analyses and Average for PCP Concentrations in Product

WELL	PCP CONCENTRATION IN PRODUCT (%)	AREA OF SITE
W-7	3.10%	Central portion of product extent
W-4	3.30%	Central portion of product extent
W-5	3.30%	Central portion of product extent
Average of wells W-7, W-4, and W-5	3.23%	Representative of product being recovered
W-15	1.10%	Upgradient extent of product, in the SE lobe of product
W-6	0.30%	Upgradient extent of product

Table 2
PCB and Wet Chemistry Analytical Data
Investigative Derived Waste Analyses

CONSTITUENT	ACCEPTANCE LIMITS	M01-ABOVE WATER RESULT	M01-BELOW WATER RESULT
		10/22/2019	10/22/2019
GC Semivolatiles (mg/Kg)			
PCB-1016		< 0.0060	< 0.0061
PCB-1221		< 0.0075	< 0.0076
PCB-1232		< 0.0074	< 0.0075
PCB-1242		< 0.0056	< 0.0057
PCB-1248		< 0.0067	< 0.0068
PCB-1254		< 0.0037	< 0.0037
PCB-1260		< 0.0084	< 0.0085
Polychlorinated biphenyls, Total	<50	< 0.0033	< 0.0033
Wet Chemistry (%)			
Total Chlorine	<1%	< 0.020	2.0
Wet Chemistry (Degrees F)			
Flashpoint	>140	>176	>176
Wet Chemistry (mg/Kg)			
Cyanide, Total	<200	< 0.25	< 0.21
Sulfide	<200	11	< 4.5
Wet Chemistry (No Unit)			
Free Liquid	0%	Pass	Pass
Wet Chemistry (NONE)			
Specific Gravity	no limit	2.2423	2.2521
Wet Chemistry (SU)			
pH	2.0 - 12.5	6.1	6.6

Notes:

< = Less than the detection limit.

Table 3
TCLP Analytical Data
Investigative Derived Waste

CONSTITUENT	ACCEPTANCE LIMITS	M01-ABOVE WATER RESULT	M01-BELOW WATER RESULT
		10/22/2019	10/22/2019
Volatiles (mg/L)			
Benzene	<0.5	0.023	< 0.010
Carbon tetrachloride	<0.5	< 0.010	< 0.010
Chlorobenzene	<100	< 0.010	< 0.010
Chloroform	<6	< 0.020	< 0.020
1,2-Dichloroethane	<0.5	< 0.010	< 0.010
1,1-Dichloroethene	<0.7	< 0.010	< 0.010
Methyl Ethyl Ketone	<200	< 0.050	< 0.050
Tetrachloroethene	<0.7	< 0.010	< 0.010
Trichloroethene	<0.5	< 0.010	< 0.010
Vinyl chloride	<0.2	< 0.010	< 0.010
Semivolatiles (mg/L)			
1,4-Dichlorobenzene	<7.5	< 0.020	< 0.020
2,4-Dinitrotoluene	<0.13	< 0.010	< 0.010
Hexachlorobenzene	<0.13	< 0.0050	< 0.0050
Hexachlorobutadiene	<0.5	< 0.050	< 0.050
Hexachloroethane	<3	< 0.050	< 0.050
2-Methylphenol	<200	< 0.020	< 0.020
3 & 4 Methylphenol	<200	< 0.020	< 0.020
Nitrobenzene	<2	< 0.010	< 0.010
Pentachlorophenol	<100	< 0.20	< 0.20
Pyridine	<5	< 0.20	< 0.20
2,4,5-Trichlorophenol	<400	< 0.10	< 0.10
2,4,6-Trichlorophenol	<2	< 0.050	< 0.050
Metals (mg/L)			
Arsenic	<5	< 0.010	< 0.010
Mercury	<0.2	< 0.00020	< 0.00020
Barium	<100	0.39 J	0.28 J
Cadmium	<1	< 0.0020	< 0.0020
Chromium	<5	< 0.010	< 0.010
Copper	<100	0.014 J	0.011 J
Lead	<5	< 0.0075	< 0.0075
Nickel	<35	< 0.010	< 0.010
Selenium	<1	< 0.020	< 0.020
Silver	<5	< 0.010	< 0.010
Zinc	<200	0.63 B	0.27 B

Notes:

< = Less than the detection limit.

Table 4
Cryogenic Coring Data and PCP in LNAPL Concentrations

NUMBER OF SAMPLES ANALYZED	CORE ID	SAMPLE ID NUMBER	DEPTH (ft)	THICKNESS (ft)	TPH (mg/kg)	GRO (mg/kg)	DRO (mg/kg)	PCP (mg/kg)	METHANE (mg/kg)	LIF DETECTED LNAPL TOP & BOTTOM DEPTHS (ft.)	POSITIVE LNAPL SAT. THICKNESS (ft)	LIF & CRYO MEASURED LNAPL THICKNESS (ft)	LNAPL (% Sat.)	SAMPLES WITH POSITIVE LNAPL SATURATION	GAS (% Sat.)	WATER (% Sat.)	POROSITY (%)	VALUES EXCLUDED/NOT COLLECTED FROM DATA SET FOR SPECIFIED REASONS	MASS OF PCP (g)/M^2	TOTAL MASS OF PCP (g)/boring/M^2	MASS OF PCP IN LNAPL (g/M^2)	TOTAL MASS OF PCP IN LNAPL ZONES (g/boring/M^2)	MASS OF LNAPL (g/M^2)	MASS OF LNAPL (g/boring/M^2)	VOLUME OF LNAPL (L/M^2)	VOLUME OF LNAPL (L/boring/M^2)	PCP IN LNAPL (mg/L)	PCP IN LNAPL (%)	GEOLOGIC DESCRIPTION
1	M01	700	24.0831	0.25	105	0	105	0	0.008				0.0		91.3	8.7	32.5						0.0		0.0				Poorly Graded Gravelly Sand
2		701	24.5831	0.5	22	0	22	0	🟥				🟥		🟥	🟥	🟥	Rocks likely; excluded					0.0		0.0				Poorly Graded Gravelly Sand
3		702	25.0831	0.5835	0	0	0	0	0.008				0.0		83.9	16.1	22.2						0.0		0.0				Poorly Graded Gravelly Sand
4		703	25.7501	1	0			0	🟥				🟥		🟥	🟥	🟥	ran out of cutable core for water jar, not collected					0.0		0.0				Poorly Graded Gravelly Sand
5		704	27.0831	0.96	0	0	0	24	0.011				0.0		53.9	46.1	36.5		12.65		0.0		0.0		0.0				
6		705	27.6701	1	2	0	2	7	0.007				0.0		62.0	38.0	24.4		3.62		0.0		0.0		0.0				
7		706	29.0831	0.79	4,062	2,458	1,604	344	0.119	28.89	0.79		0.79	0.79	🟥	🟥	🟥		149.21		149.2		0.0		0.0		See Note 1	10% not used in statistics	Silt
8		707	29.2501	0.1685	850	501	349	71	0.014		0.1685		0.17	0.17	28.8	71.0	48.7		6.52		6.5		33.7		4.21E-02		See Note 1	10% not used in statistics	Poorly Graded Sand
9		708	29.4201	0.1665	0	0	0	10	0.006				0.0		35.7	64.3	40.6		0.88		0.0		0.0		0.0				Poorly Graded Sand
10		709	29.5831	0.165	3	3	0	3	0.011			LIF	0.0		39.6	60.4	37.7		0.30		0.0		0.0		0.0				Poorly Graded Gravelly Sand
11		710	29.7501	0.1685	115	99	16	2	0.011	LIF Detected		2.16	0.0		45.5	54.5	35.9		0.22		0.0		0.0		0.0				Poorly Graded Gravelly Sand
12		711	29.9201	0.1665	134	112	22	2	0.011	LNAPL		Cryo	0.0		48.2	51.8	39.4		0.15		0.0		0.0		0.0				Poorly Graded Gravelly Sand
13		712	30.0831	0.165	2,814	1,688	1,127	5	0.013	at	0.165	2.33	1.51	1.51	53.7	44.8	33.7		0.46		0.461		204.6		0.26		1,805	0.2	Poorly Graded Gravelly Sand
14		713	30.2501	0.1685	3,903	2,374	1,529	12	0.015	LIF03	0.3335		2.63	2.63	49.8	47.5	30.0		1.09		1.094		324.1		0.41		2,700	0.3	Poorly Graded Sand
15		714	30.4201	0.165	3,716	1,744	1,972	4	0.005				🟥		🟥	🟥	🟥	Rocks likely; excluded	0.40		0.0		0.0		0.0				Poorly Graded Gravelly Sand
16		715	30.5801	0.165	229	165	64	2	0.014				0.0		62.1	37.9	29.2		0.22		0.0		0.0		0.0				Poorly Graded Gravelly Sand
17		716	30.7501	0.17	7,001	4,439	2,562	60	0.008		0.17		6.88	6.88	38.3	54.8	23.8		5.62		5.62		680.1		0.85		6,613	0.8	Poorly Graded Gravelly Sand
18		717	30.9201	0.165	7,377	4,743	2,634	77	0.018		0.165		7.31	7.31	48.3	44.4	23.8		6.94		6.94		698.9		0.87		7,940	1.0	Poorly Graded Gravelly Sand
19		718	31.0801	0.2485	100	91	8	12	0.014	31.05			0.0		63.5	36.5	26.2		1.61		0.0		0.0		0.0				
20		719	31.4171	0.5435	60	56	5	4	0.009				0.0		62.4	37.6	31.7		1.32		0.0		0.0		0.0				
21		720	32.1671	0.5415	4,743	3,305	1,437	141	0.054		0.5415		0.41	0.41	22.9	76.7	77.4		41.78		41.8		418.6		0.52		79,842	9.98% not used in statistics	Sandy Silt
22		721	32.5001	0.375	0	0	0		0.013				0.0		31.8	68.2	44.9		0.00		0.0		0.0		0.0				Sandy Silt
23		722	32.9171	0.4	48	43	5	4.7	0.013				0.0		40.2	59.8	28.8		1.03		0.0		0.0		0.0				Poorly Graded Sand
24		723	33.3001	0.1915	5.3	5	0	2.4	0.013				0.0		34.7	65.3	27.1		0.25	234.3	0.0	211.6	0.0	2360.0	0.0	3.0			Poorly Graded Gravelly Sand
25	M02	724	21.501	0.7915	0	0	0	1.9	0.000				🟥		🟥	🟥	🟥	Rocks likely; excluded	0.80		0.0		0.0		0.0				
26		725	23.084	0.9585	0	0	0	0	0.0071				🟥		🟥	🟥	🟥		0.00		0.0		0.0		0.0				
27		726	23.418	0.4585	0	0	0	0.0000	0.0056				0.0					Rocks likely; excluded	0.00		0.0		0.0		0.0				
28		727	24.001	0.583	130	107	23	0.0000	0.0257				0.0		36.5	63.5	39.3		0.00		0.0		0.0		0.0				
29		728	24.584	0.4585	213	186	27	0.0000	0.0421				0.0		38.6	61.4	38.4		0.00		0.0		0.0		0.0				
30		729	24.918	0.25	340	255	85	0.0000	0.0000	24.9			0.0		53.3	46.7	32.5		0.00		0.0		0.0		0.0				
31		730	25.084	0.1665	621	431	190	0.0000	0.0493		0.25		0.07	0.07	39.7	60.3	37.3		0.00		0.0		10.2		0.0		0	0.000	
32		731	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	Rocks likely; excluded	0.08		0.08		0.0		0.0				
33		732	25.418	0.1665	7,103	4,222	2,880	0.9640	0.0166		0.25		5.36	5.36	53.8	40.9	29.0		0.09		0.088		630.8		0.79		112	0.014	
34		733	25.584	0.5415	2,270	1,409	861	0.9226	0.0513		0.83325		1.04	1.04	64.9	34.0	36.1		0.27		0.274		494.4		0.62		444	0.055	
35		734	26.501	0.5835	0	0	0	0	0.1404				0.0		30.6	69.4	53.9		0.00		0.0		0.0		0.0				
36		735	26.751	0.208	205	188	18	0.8550	0.0767				0.0		31.9	68.1	43.9		0.10		0.0		0.0		0.0				
37		736	26.917	0.1665	257	206	51	0.8311	0.0753	LIF Detected		LIF	0.0		25.7	74.3	42.7		0.08		0.0		0.0		0.0				
38		737	27.084	0.167	196	178	18	0.8318	0.0770	LNAPL		5.97	0.0		24.4	75.6	45.1		0.08		0.0		0.0		0.0				
39		738	27.251	0.167	209	186	23	0.8401	0.0842	at		Cryo	0.0		39.5	60.5	45.0		0.08		0.0		0.0		0.0				
40		739	27.418	0.1665	795	576	218	0.8386	0.0603	LIF06	0.1665	4.12	0.13	0.13	34.5	65.4	43.3		0.08		0.077		22.5		0.028		2,729	0.341	
41		740	27.584	0.1665	538	443	95	0.8421	0.0485		0.1665		0.02	0.02	51.9	48.1	35.2		0.08		0.077		3.3		0.004		18,571	2.321	
42		741	27.751	0.167	419	352	67	0.9262	0.0570				0.0		35.1	64.9	25.1		0.08		0.0		0.0		0.0				
43		742	27.918	0.1665	2,128	1,432	696	1.0611	0.0575		0.1665		1.54	1.54	46.7	51.7	25.9		0.10		0.097		162.2		0.20		478	0.060	
44		743	28.084	0.5415	2,460	1,705	755	1.0268	0.1217		0.5415		1.14	1.14	42.7	56.1	36.2		0.31		0.305		547.2		0.68		446	0.056	
45		744	29.001	0.5835	2,542	1,721	821	0.5348	0.1509		0.5835		0.44	0.44	24.8	74.7	60.6		0.17		0.171		379.6		0.47		361	0.045	

Table 4
Cryogenic Coring Data and PCP in LNAPL Concentrations

NUMBER OF SAMPLES ANALYZED	CORE ID	SAMPLE ID NUMBER	DEPTH (ft)	THICKNESS (ft)	TPH (mg/kg)	GRO (mg/kg)	DRO (mg/kg)	PCP (mg/kg)	METHANE (mg/kg)	LIF DETECTED LNAPL TOP & BOTTOM DEPTHS (ft.)	POSITIVE LNAPL SAT. THICKNESS (ft)	LIF & CRYO MEASURED LNAPL THICKNESS (ft)	LNAPL (% Sat.)	SAMPLES WITH POSITIVE LNAPL SATURATION	GAS (% Sat.)	WATER (% Sat.)	POROSITY (%)	VALUES EXCLUDED/NOT COLLECTED FROM DATA SET FOR SPECIFIED REASONS	MASS OF PCP (g)/M^2	TOTAL MASS OF PCP (g)/boring/M^2	MASS OF PCP IN LNAPL (g/M^2)	TOTAL MASS OF PCP IN LNAPL ZONES (g/boring/M^2)	MASS OF LNAPL (g/M^2)	MASS OF LNAPL (g/boring/M^2)	VOLUME OF LNAPL (L/M^2)	VOLUME OF LNAPL (L/boring/M^2)	PCP IN LNAPL (mg/L)	PCP IN LNAPL (%)	GEOLOGIC DESCRIPTION
46	M02	745	29.251	0.2915	427	343	85	0.8218	0.0731				0.0		42.3	57.7	47.6		0.13		0.0		0.0		0.0				
47	(cont.)	746	29.584	0.25	373	317	56	0.8964	0.0533				0.0		42.7	57.3	32.9		0.12		0.0		0.0		0.0				
48		747	29.751	0.25	2,416	1,642	774	0.9554	0.0396		0.25		1.47	1.47	38.2	60.3	30.1		0.13		0.131		270.5		0.34		388	0.048	
49		748	30.084	0.25	7.48	7.48	0.00	0.9779	0.0293				0.0		45.6	54.4	25.6		0.13		0.0		0.0		0.0				
50		749	30.251	0.7085	0	0	0	0.9586	0.0133				0.0		63.6	36.4	27.2		0.37		0.0		0.0		0.0				
51		750	31.501	0.9165	1,258	934	324	0.4752	0.1680	30.87	0.9165		0.10	0.10	30.9	69.0	71.2		0.24		0.239		161.6		0.20		1,183	0.148	
52		751	32.084	0.5415	189	156	32	0.7646	0.0234				0.0		36.4	63.6	52.4		0.23		0.0		0.0		0.0				
53		752	32.584	0.5435	108	96	11.3	0.8231	0.1386				0.0		31.3	68.7	48.0		0.25		0.0		0.0		0.0				
54		753	33.171	0.2935	0	0	0	0.8937	0.0292				0.0		52.6	47.4	27.8		0.14	4.1	0.0	1.54	0.0	2682.4	0.0	3.4			
55	M03	754	21.501	0.7915	0	0	0	0.9706	0.0122				0.0		91.4	8.6	39.2		0.42		0.0		0.0		0.0				
56		755	23.084	1.25	0	0	0	1.0721	0.0126				0.0		70.5	29.5	29.8		0.74		0.0		0.0		0.0				
57		756	24.001	1.0085	0	0	0	0.9097	0.0034				0.0		53.3	46.7	43.4		0.50		0.0		0.0		0.0				
58		757	25.101	0.75	0	0	0	0.9071	0.0126				0.0		53.7	46.3	47.9		0.37		0.0		0.0		0.0				
59		758	25.501	0.2835	10,478	5,636	4,842	0.8650	0.0118	25.58	0.2835		3.43	3.43	57.0	39.6	49.1		0.13		0.135		1163.2		1.45		93	0.012	
60		759	25.668	0.5	3,109	1,760	1,349	0.8397	0.0105		0.5		0.81	0.81	48.7	50.5	51.5		0.23		0.230		510.6		0.64		361	0.045	
61		760	26.501	0.5415	8,870	5,612	3,258	0.8793	0.0422		0.5415	LIF	3.27	3.27	39.8	56.9	45.9		0.26		0.261		1981.4		2.48		105	0.013	
62		761	26.751	0.2085	10,058	7,108	2,950	0.3043	0.0508		0.2085	4.17	2.19	2.19	26.8	71.0	59.1		0.03		0.035		658.2		0.82		42	0.005	
63		762	26.918	0.1665	659	517	142	0.8316	0.0094	LIF Detected	0.1665	Cryo	0.06	0.06	31.7	68.3	45.0		0.08		0.076		11.8		0.0		5,168	0.646	
64		763	27.084	0.1665	2,374	1,809	565	0.8291	0.0693	LNAPL	0.1665	4.96	0.99	0.99	44.4	54.6	38.5		0.08		0.076		155.2		0.19		391	0.049	
65		764	27.251	0.1685	4,081	2,828	1,253	0.9301	0.0508	at	0.1685		2.40	2.40	49.6	48.0	33.0		0.09		0.086		326.4		0.41		211	0.026	
66		765	27.421	0.875	3,369	2,403	965	0.8979		LIF07	0.875							ran out of cutable core for water jar, not collected	0.43		0.4		0.0		0.0				
67		766	29.001	0.915	2,351	1,801	550	0.5132	0.0194		0.915		0.42	0.42	28.6	71.0	59.4		0.26		0.258		555.2		0.69		371	0.046	
68		767	29.251	0.2085	559	452	108	0.8030	0.0156		0.2085		0.02	0.02	34.3	65.6	47.1		0.09		0.092		5.3		0.0		13,909	1.739	
69		768	29.418	0.1665	306	255	51	0.8143	0.0171				0.0		32.7	67.3	46.6		0.07		0.0		0.0		0.0				
70		769	29.584	0.1665	363	296	67	0.8334	0.0131	29.75			0.0		31.5	68.5	44.7		0.08		0.0		0.0		0.0				
71		770	29.751	0.25	507	414	93	0.8424	0.0165		0.25		0.003	0.003	33.2	66.7	44.9		0.12		0.116		0.8		0.0		121,860	15.3 not used in statistics	
72		771	30.084	0.675	3,435	2,397	1,038	0.9457	0.0135		0.675		2.44	2.44	41.7	55.9	28.5		0.35		0.350		1144.1		1.43		245	0.031	
73		772	31.101	0.5085	36	33	3.43	0.8699	0.0106				0.0		38.8	61.2	32.4		0.24	4.6	0.0	2.1	0.0	6512.0	0.0	8.1			
74	M04	773	24.001	0.55	0	0	0	0.4414	0.0138				0.0		46.5	53.5	52.6		0.13		0.0		0.0		0.0				
75		774	25.101	1.25	0	0	0	0.9301	0.0368				0.0		43.6	56.4	29.9		0.64		0.0		0.0		0.0				
76		775	26.501	0.8665	61,371	33,632	27,740	0.1356	0.6186		0.8665	LIF	1.67	1.67	22.2	76.1	92.3		0.06		0.064		3264.7		4.08		16	0.002	
77		776	26.834	0.25	1,257	732	525	0.8091	0.0450	26.91	0.25	0.75	0.33	0.33	33.4	66.3	42.9		0.11		0.111		87.3		0.11		1,017	0.127	
78		777	27.001	0.167	860	548	312	0.8374	0.0450	LIF	0.167	Cryo	0.15	0.15	33.4	66.4	43.5		0.08		0.077		27.4		0.0		2,237	0.280	
79		778	27.168	0.1665	1,841	1,081	761	0.8721	0.0145	Detected LNAPL	0.1665	1.45						Rocks likely; excluded	0.08		0.000		0.0		0.0				
80		779	27.334	0.208	497	312	185	0.9042	0.0238	at LIF09			0.0		40.4	59.6	32.4		0.10		0.0		0.0		0.0				
81		780	27.584	0.25	16.3	13.1	3.25	0.9198	0.0389	27.66			0.0		37.9	62.1	29.6		0.13		0.0		0.0		0.0				
82		781	27.834	0.7085	0	0	0	0.9702	0.0162				0.0		49.8	50.2	22.8		0.38		0.0		0.0		0.0				
83		782	29.001	1.3335	407	301	107	0.3828	0.0801				0.0		22.1	77.9	73.3		0.28		0.0		0.0		0.0				
84		783	30.501	0.75	0	0	0	0.9337	0.0185				0.0		66.5	33.5	35.5		0.38	2.4	0.0	0.252	0.0	3379.5	0.0	4.2			
85	M05	784	21.501	0.5415	0	0	0	0.4003	0.0172				0.0		33.7	66.3	45.3		0.12		0.0		0.0		0.0				
86		785	22.584	0.75	0	0	0	0.9038	0.0167				0.0		49.7	50.3	26.7		0.37		0.0		0.0		0.0				
87		786	23.001	0.7085	0	0	0	0.9194	0.0140				0.0		45.6	54.4	33.7		0.36		0.0		0.0		0.0				
88		787	24.001	1.0415	0	0	0	0.1268	0.6173				0.0		23.4	76.6	81.0		0.07		0.0		0.0		0.0				
89		788	25.084	0.71	0	0	0	0.9698	0.5808				0.0		52.1	47.9	34.9		0.38		0.0		0.0		0.0				
90		789	25.421	0.25	380	243	137	0.9802	1.0580	25.41			0.0		45.9	54.1	29.4		0.13		0.0		0.0		0.0				
91		790	25.584	0.165	2,274	1,263	1,011	0.9477	0.8122	at LIF36	0.0925	LIF	1.63	1.63	44.6	53.8	26.5		0.09		0.086		173.9		0.22		395	0.049	
92		791	25.751	0.4585	1,800	1,012	787	0.9824	1.4079	26.44	0.4585	1.03	0.86	0.86	41.3	57.9	33.3		0.25		0.247		321.3		0.40		616	0.077	
93		792	26.501	0.875	3,438	2,717	721	0.0624	3.1789		0.7725	Cryo	0.05	0.05	22.4	77.5	95.2		0.03		0.030		99.3		0.12		242	0.030	
94		793	27.501	1.25	70	61	9.5	0.8361	0.3801			1.32	0.0		47.2	52.8	46.5		0.57		0.0		0.0		0.0				
95		794	29.001	1.0415	3	3	0	0.7120	0.0538				0.0		31.1	68.9	46.7		0.41		0.0		0.0		0.0				
96		795	29.584	0.5415	0	0	0	0.8316	0.0381				0.0		32.5	67.5	44.5		0.25		0.0		0.0		0.0				
97		796	30.084	0.5	2	2	0	0.8189	0.0591				0.0		31.1	68.9	44.5		0.22		0.0		0.0		0.0				
98		797	30.584	0.375	0	0	0	0.8368	0.0446				0.0		38.6	61.4	37.7		0.17		0.0		0.0		0.0				
99		798	30.834	0.125	0	0	0	0.8582	0.0318				0.0		38.2	61.8	43.9		0.06	3.5	0.0	0.363	0.0	594.5	0.0	0.7			

Table 4
Cryogenic Coring Data and PCP in LNAPL Concentrations

NUMBER OF SAMPLES ANALYZED	CORE ID	SAMPLE ID NUMBER	DEPTH (ft)	THICKNESS (ft)	TPH (mg/kg)	GRO (mg/kg)	DRO (mg/kg)	PCP (mg/kg)	METHANE (mg/kg)	LIF DETECTED LNAPL TOP & BOTTOM DEPTHS (ft.)	POSITIVE LNAPL SAT. THICKNESS (ft)	LIF & CRYO MEASURED LNAPL THICKNESS (ft)	LNAPL (% Sat.)	SAMPLES WITH POSITIVE LNAPL SATURATION	GAS (% Sat.)	WATER (% Sat.)	POROSITY (%)	VALUES EXCLUDED/NOT COLLECTED FROM DATA SET FOR SPECIFIED REASONS	MASS OF PCP (g)/M^2	TOTAL MASS OF PCP (g)/boring/M^2	MASS OF PCP IN LNAPL (g/M^2)	TOTAL MASS OF PCP IN LNAPL ZONES (g/boring/M^2)	MASS OF LNAPL (g/M^2)	MASS OF LNAPL (g/boring/M^2)	VOLUME OF LNAPL (L/M^2)	VOLUME OF LNAPL (L/boring/M^2)	PCP IN LNAPL (mg/L)	PCP IN LNAPL (%)	GEOLOGIC DESCRIPTION
100	M06	799	17.501	0.2915	0	0	0	0.8629	0.0090				0.0		41.5	58.5	33.0		0.14		0.0		0.0		0.0				
101		800	18.084	0.5415	276	220	55	0.8945	0.0094				0.0		46.3	53.7	31.2		0.27		0.0		0.0		0.0				
102		801	18.584	0.375	8,073	5,034	3,039	0.8843	0.0071		0.375		3.23	3.23	37.1	59.7	43.7		0.18		0.182		1292.0		1.61		113	0.014	
103		802	18.834	0.2085	5,208	3,272	1,936	0.9016	0.0091		0.2085	LIF	3.87	3.87	48.4	47.7	28.7		0.10		0.103		565.3		0.71		146	0.018	
104		803	19.001	0.417	2,795	1,815	980	0.8706	0.0141		0.417	0.79	1.40	1.40	31.7	67.0	35.3		0.20		0.199		500.5		0.63		318	0.040	
105		804	19.668	0.5	3,090	2,009	1,081	0.9276	0.0224		0.5	Cryo	2.43	2.43	33.2	64.4	26.1		0.25		0.255		773.4		0.97		263	0.033	
106		805	20.001	0.333	3,219	2,076	1,144	0.9342	0.0558		0.333	3.3335	2.68	2.68	41.2	56.1	25.1		0.17		0.171		547.8		0.68		249	0.031	
107		806	20.334	0.25	7,421	4,646	2,775	0.9153	0.1981		0.25		4.37	4.37	63.2	32.4	34.4		0.13		0.126		916.9		1.15		110	0.014	
108		807	20.501	0.5835	1,078	779	299	0.8890	0.1799		0.5835		0.34	0.34	32.3	67.4	36.1		0.28		0.285		174.3		0.22		1,307	0.163	
109		808	21.501	0.6665	1,136	988	148	0.2725	0.7143		0.6665		0.11	0.11	23.5	76.3	66.0		0.10		0.100		116.5		0.15		684	0.086	
110		809	21.834	0.25	63	59	4.7	0.8438	0.1075	21.78			0.0		37.6	62.4	34.4		0.12		0.0		0.0		0.0				
111		810	22.001	0.167	0	0	0	0.9310	0.1505	LIF Detected			0.0		44.0	56.0	29.7		0.09		0.0		0.0		0.0				
112		811	22.168	0.15	2.97	2.97	0	0.9082	0.1835	LNAPL			0.0		38.6	61.4	30.1		0.07		0.0		0.0		0.0				
113		812	22.301	0.0665	3.10	3.10	0	0.9373	0.1112	22.57			0.0		41.6	58.4	27.2		0.03	2.13	0.0	1.42	0.0	4887	0.0	6.11			
114	M07	813	14.501	0.4585	0	0	0	0.9777	0.0121				0.0		84.6	15.4	37.6		0.25		0.0		0.0		0.0				
115		814	15.418	0.5835	0	0	0	1.0153	0.0102				0.0		75.2	24.8	21.2		0.33		0.0		0.0		0.0				
116		815	15.668	0.375	0	0	0	0.9936	0.0059				0.0		66.3	33.7	31.0		0.20		0.0		0.0		0.0				
117		816	16.168	1.1665	0	0	0	0.9696	0.0128				0.0		76.5	23.5	32.5		0.62		0.0		0.0		0.0				
118		824	18.001	1.208	1.78	1.78	0	0.9126	0.0115				0.0		49.4	50.6	39.3		0.60		0.0		0.0		0.0				
119		825	18.584	0.375	681	404	277	0.9301	0.0173	18.56	0.375	LIF	0.17	0.17	52.8	47.0	26.3		0.19		0.191		40.4		0.05		3,789	0.474	
120		826	18.751	0.4585	544	316	228	0.9954	0.0082	LIF Detected	0.4585	1.45	0.13	0.13			9.7	Rocks likely; excluded	0.25		0.250		14.6		0.0		13,742	1.718	
121		817	19.501	0.5	1,878	1,037	841	0.7784	0.0189	LNAPL	0.5	Cryo	0.64	0.64	34.6	64.8	41.7		0.21		0.214		324.7		0.41		526	0.066	
122		818	19.751	0.2085	2,844	1,567	1,277	0.8913	0.0253	at LIF39	0.2085	1.542	1.41	1.41	71.8	26.8	35.5		0.10		0.102		254.8		0.32		320	0.040	
123		819	19.918	0.1665	194	169	26	0.3545	0.0236				0.0		51.2	48.8	25.4		0.03		0.0		0.0		0.0				
124		820	20.084	0.2915	202	154	48	0.9224	0.0361	20.01			0.0		43.6	56.4	24.9		0.15		0.0		0.0		0.0				
125		821	20.501	0.375	16	13	2.58	0.9374	0.0369				0.0		38.5	61.5	26.1		0.19		0.0		0.0		0.0				
126		822	20.834	0.25	3.53	3.53	0	0.9171	0.0439				0.0		53.0	47.0	29.2		0.13		0.0		0.0		0.0				
127		823	21.001	0.0835	0	0	0	0.9395	0.0280				🟥		🟥	🟥	🟥		0.04	3.30	0.0	0.76	0.0	634.5	0.0	0.79			
Statistics across all samples in respective columns				Avg	1778	1110	700	6.9	0.1				0.6	1.6	44.3	55.1	38.8								Avg		3,967	0.27	
				Min	0.0	0.0	0.0	0.0	0.0				0.0	0.0	22.1	8.6	9.7								Minimum		0.0	0.0	
				Max	61,371	33,632	27,740	344	3.2				7.3	7.3	91.4	77.9	95.2								Maximum		79,842	2.3	
				Median	207	186	50	0.90	0.02				0.0	1.01	41.54	57.32	35.92								Median			0.049	
Statistics within the LIF LNAPL Zones				Avg	2,851	1,762	1,112	10	0.1				1.0	1.6	41.6	57.4	39.2												
				Min	0.0	0.0	0.0	0.0	0.0				0.0	0.0	22.2	8.7	9.7												
				Max	61,371	33,632	27,740	344.2	3.2				7.3	7.3	91.3	77.5	95.2												
				Median	969.1	654.1	311.9	0.9	0.0				0.1	1.0	39.8	58.4	35.9												

Legend:

18.56 Denotes LIF detected LNAPL interval with top and bottom depths in
20.01 ft. below ground surface.
🟥 Samples not analyzed.

Notes:

1. PCP concentration in LNAPL set at 10% in samples 706, 707, 720, and 770 and are not used in the statistics because the PCP concentration in LNAPL is uncertain. Samples 706, 707, and 720 have high PCP concentrations and low % saturation, such that the PCP in LNAPL concentration is very sensitive to small changes in the analytical Sample 770 has very low LNAPL % saturation. So, for Samples 706, 707, and 720 the PCP adsorbed to soil is > than assumption that all PCP is in NAPL. Sample 770's LNAPL saturation is so low that any uncertainty leads to an erroneous PCP concentration in LNAPL.
2. Input values used for calculations: soil bulk density - 1,800 kg/M3 LNAPL density - 800 g/L
3. Sample analyses performed by Colorado State University
4. Cells with no data indicate analyses not performed.

Prepared by K. Quinn 8/29/2019
Checked by: S. Sellwood 8/30/2019; 9/11/2019; 10/16/2019

Table 5

Mass of PCP in LNAPL Summary

BORING	AREA AROUND BORING (ft^2)	AREA AROUND BORING (M^2)	TOTAL MASS OF PCP (g/boring/M^2)	MASS OF PCP IN BORING AREA (g)	TOTAL MASS OF PCP IN LNAPL ZONES ONLY (g/boring/M^2)	MASS OF PCP IN LNAPL (g)	MASS OF PCP IN LNAPL (lb)	MASS OF LNAPL (g/boring/M^2)	MASS OF LNAPL IN BORING AREA (g)
M01a	41,121	3,822	234.3	895,417	212	808,862	1,779	2,360	9,020,364
M01b	252,597	23,479	43.3	1,016,195	62.4	1,465,376	3,224	2,360	55,410,810
M02	50,027	4,650	4.1	19,233	1.54	7,169	16	2,682	12,473,110
M03	45,348	4,215	4.6	19,274	2.15	9,044	20	6,512	27,448,875
M04	109,429	10,171	2.4	24,149	0.25	2,565	6	3,379	34,374,344
M05	152,586	14,183	3.5	49,352	0.36	5,148	11	594	8,431,279
M06	119,001	11,061	2.1	23,598	1.42	15,702	35	4,887	54,051,469
M07	45,762	4,254	3.3	14,039	0.76	3,222	7	634	2,698,811
Total (M^2)		75,836	Total (g)	2,061,257	Total (g)	2,317,088		Total (g)	203,909,063
Total (ft^2)	815,871		Total (kg)	2,061	Total (kg)	2,317		Total (kg)	203,909
Total (Ac)	18.7		Total (lb)	4,535	Total (lb)		5,097	Total (lb)	448,600
					Total M01 (lb)		5,003	M01 (lb)	141,749
					Total M02-M07 (lb)		94	M02-M07 (lb)	306,851

Notes:

1. Areas around each boring as shown on Figure 3.
2. Area around M01 subdivided into M01a and M01b based on estimated area with fine grained soil (2% of the area for M01a) and coarse grained soil (98% of area for M01b) within residual phase LNAPL zon

Prepared by: K. Quinn 11/18/2019
Checked by: S. Sellwood 11/21/2019

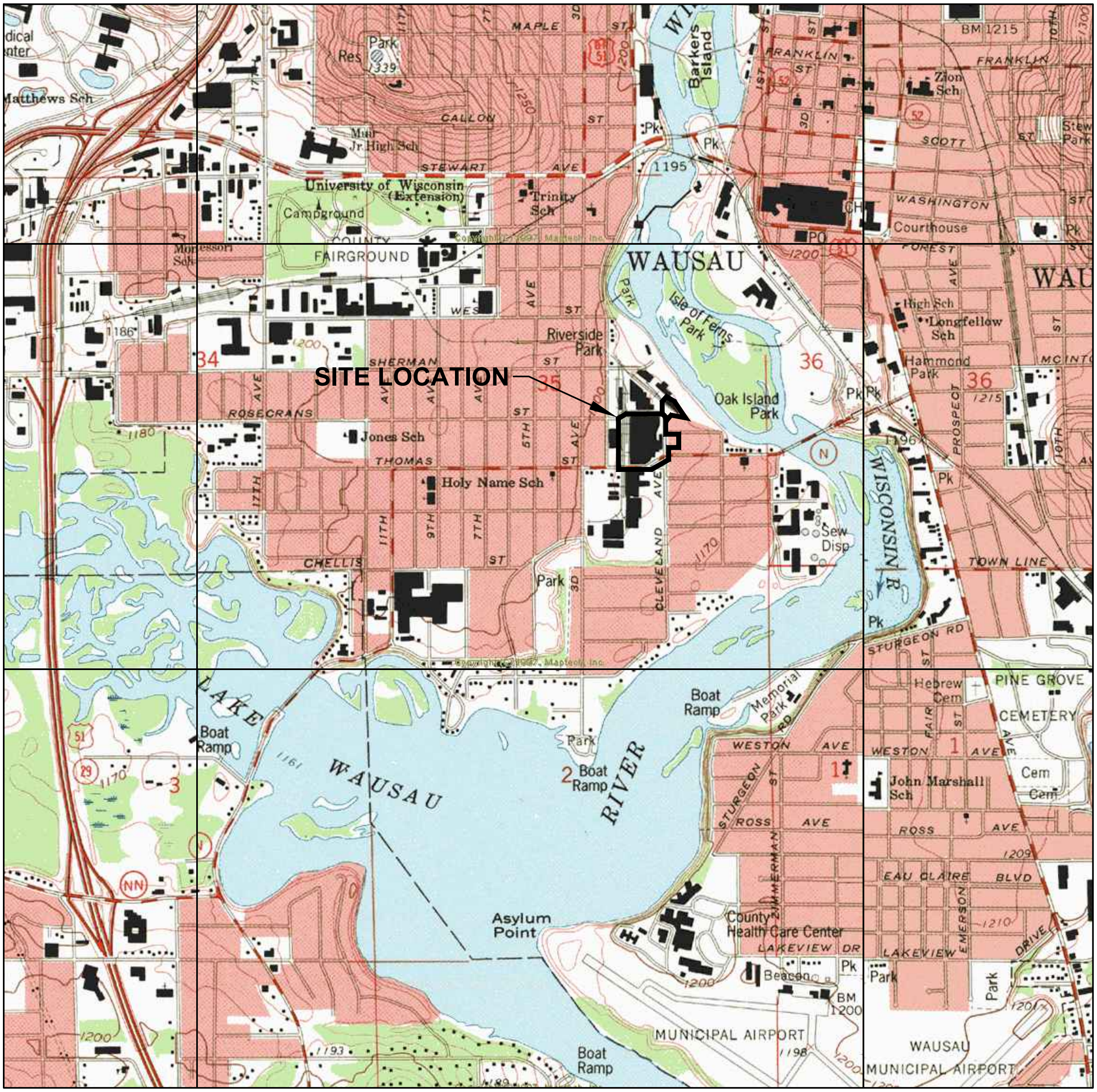
Table 6
Total Oxidant Demand Analytical Results

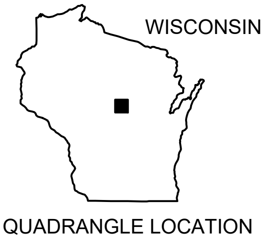
	SAMPLE									
Analysis	M04-775E	M04-775E	M05-792	M05-792	M06-806	M06-806	M01	M01	M07	M07
Dose (g/Kg)	30	60	30	60	30	60	30	60	30	60
Total Oxidant Demand (g/kg Soil)	16.9	25.5	10.6	18.7	14.3	19.2	6.8	12.3	6.3	13.4
Pre-Oxidant Analyses										
TPH as Min. Spirits (mg/kg)	752		<7.4		859		15.6		232	
PCP (mg/kg)	10.3		0.552		17.5		0.55		4.31	
Post Oxidant Analyses	M0430	M0460	M0530	M0560	M0630	M0660	M0130	M0160	M0730	M0760
TPH as Min. Spirits (mg/kg)	220	590	70.8	47.6	103	124	66.1	75.3	85.3	92.3
PCP (mg/kg)	6.63	6.1	<0.069	<0.058	1.3	1.27	<0.06	<0.059	<0.58	<0.57
% Reduction										
TPH as Min. Spirits	70.7%	21.5%	Increase	Increase	88.0%	85.6%	Increase	Increase	63.2%	60.2%
PCP	35.6%	40.8%	100.0%	100.0%	92.6%	92.7%	100%	100%	100%	100%

Notes:

1. Dose - Sodium persulfate applied as two doses (e.g., 30 g/Kg and 50 g/Kg)
2. Percent reductions calculated using 0.0 for non-detect samples.

Prepared by: K. Quinn 11/1/2019
Checked by: S. Sellwood 11/11/2019





NOTE

BASE MAP DEVELOPED FROM THE WAUSAU WEST AND WAUSAU EAST, WISCONSIN 7.5 MINUTE U.S.G.S. TOPOGRAPHIC QUADRANGLE MAPS, DATED 1993. PART OF SECTION 35, T29N, R8E

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PROJECT:

WAULECO, INC.
WAUSAU, WISCONSIN

TITLE:

SITE LOCATION MAP

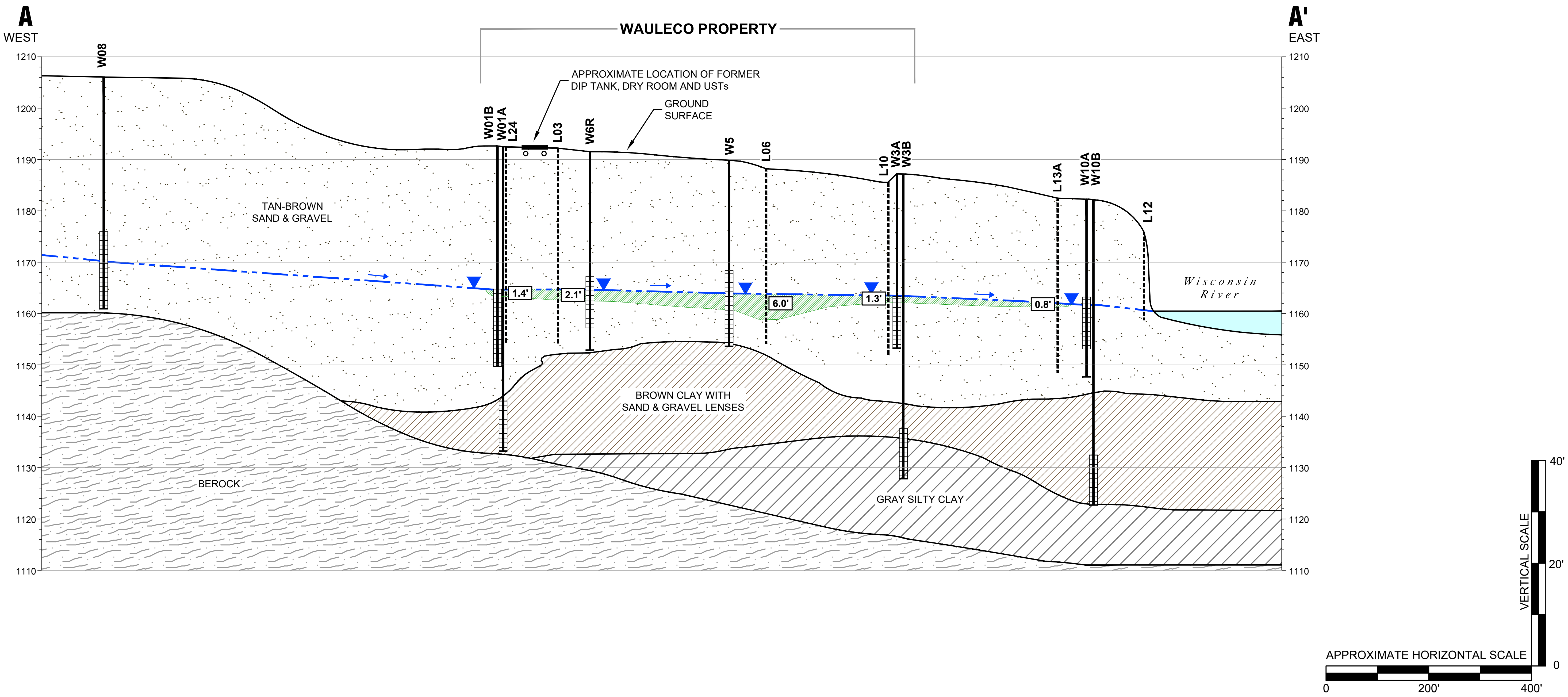
DRAWN BY: B. YUNUSOV
CHECKED BY: K. QUINN
APPROVED BY: B. IVERSON
DATE: DECEMBER 2019
PROJ. NO.: 189597 - ANNUAL REPORT
FILE: 189597.0008.01.dwg

FIGURE 1

DRAWING NAME: J:\Wauleco\189597 - Annual 2019\0008\Phase3Task2\Version2\ 189597.0008.01.dwg --- PLOT DATE: December 10, 2019 - 11:45AM --- LAYOUT: DRAWING 1 SITE LOCATION MAP
8.5x11 --- USER: BYunusov --- ATTACHED XREFS: --- ATTACHED IMAGES: 0-EC; 0-EN; 0-ES; 0-WC; 0-WN; 0-WS; 00-EC; 00-EN; 00-ES;

Version: 2017-10-21

GENERALIZED GEOLOGIC CROSS-SECTION A-A'



LEGEND

▨ SAND & GRAVEL

▨ BROWN CLAY

▨ GREY CLAY

W5

WELL / BORING

WELL SCREEN

END OF BORING

L24

LASER-INDUCED FLUORESCENCE (LIF) PROBE LOCATION AND NUMBER

WATER TABLE ELEVATION (JUNE 13, 2013)

WATER TABLE FLOW DIRECTION

WATER TABLE

0.8'

ZONE OF RESIDUAL PHASE LIGHT NON-AQUEOUS PHASE LIQUIDS (LNAPL)

RESIDUAL PHASE PRODUCT THICKNESS

NOTES

1. LIF SURVEY PERFORMED IN 2013 AND 2015.
2. GENERALIZED GEOLOGIC CROSS-SECTION BASED ON 1985 EDER ASSOCIATES CROSS-SECTION.

PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNAPL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

HISTORICAL LNAPL CONCEPTUAL SITE MODEL

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.0000
CHECKED BY:	K. QUINN	**FIGURE 2**	
APPROVED BY:	B. IVERSON		
DATE:	NOVEMBER 2019		

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FILE NO.: 189597.0008.Ph3T2 FIG1.dwg

LEGEND

W17 ●	MONITORING WELL LOCATION AND NUMBER
PW12 ✲	EXTRACTION WELL LOCATION AND NUMBER
DFOMW-5 ▲	3M GROUNDWATER MONITORING WELL
— - - —	APPROXIMATE PROPERTY LINE
— — — —	FORMER BUILDING OUTLINE
— 50 —	PCP ISOCONCENTRATION CONTOUR INTERVAL VARIES (DASHED WHERE INFERRED)
⬢	-2003 & 2005 LIF LOCATIONS (LIF001-LIF017 SHOWN BUT NOT LABELED)
◈ L22 0'	- 2013 LIF LOCATION - THICKNESS OF LIF RESPONSE
⊕ L24 1.4'	-2015 LIF PROBE LOCATION -THICKNESS OF LIF RESPONSE
M06	CRYOGENIC RESIDUAL PHASE LNAPL INVESTIGATION BORING LOCATIONS
🟩	AREAS REPRESENTED BY CRYOGENIC BORINGS M01 THROUGH MO7
— 0 —	ESTIMATED THICKNESS OF RESIDUAL PHASE PRODUCT

NOTES

1. BASE MAP DEVELOPED FROM DRAWING A107250-1 OF THE SEPTEMBER 1992 SEMI- ANNUAL GROUNDWATER MONITORING REPORT BY KEYSTONE ENVIRONMENTAL, MWH DRAWING 2082658.302160101-B1, AND 3M WELLS LOCATION BASED ON 3M MAPS.
2. LASER INDUCED FLUORESCENCE (LIF) SURVEY COMPLETED JUNE 2-13, 2015 AND JUNE 11-13, 2013 BY TRC AND COLUMBIA TECHNOLOGIES, INC.
3. LIF RESULTS FROM 2003 AND 2005 WERE ALSO USED TO ESTIMATE THE THICKNESS OF RESIDUAL PHASE PRODUCT.
4. THICKNESS OF LIF RESPONSE AT L06 WAS CORRECTED FROM AUGUST 25, 2015 MEMORANDUM, WAULECO: EXTENT OF RESIDUAL PHASE PRODUCT/2015 LIF SURVEY, FIGURE 1, LIF SURVEY RESULTS.

PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNAPL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

RESIDUAL PHASE LNAPL AND LOCATION OF CRYOGENIC BORINGS

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.0000
CHECKED BY:	K. QUINN	**FIGURE 3**	
APPROVED BY:	B. IVERSON		
DATE:	NOVEMBER 2019		

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FILE NO.: 189597.0008.Ph3T2 FIG3.dwg

PLOT DATE: December 10, 2019 - 11:56AM — LAYOUT: FIGURE 3 RESIDUAL PHASE LNAPL AND LOCATION OF CRYOGENIC BORINGS

Version: 2017-10-21

Wauleco LNAPL History and Hypothetical Current Conditions

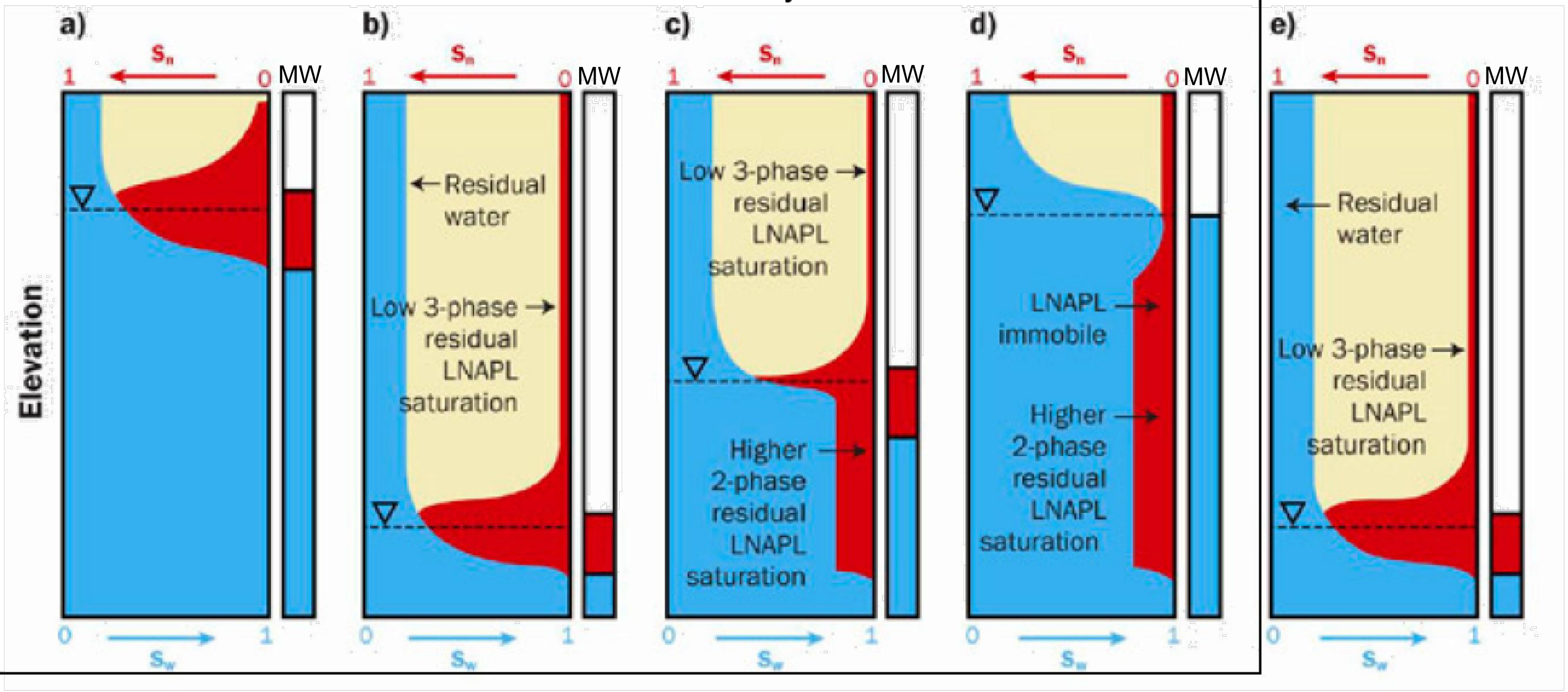
a) Initial Release and Migration

b) Lowest Water Table Elevation

c) During LNAPL Recovery

d) Post LNAPL Recovery

e) Hypothetical Future, but Not at Wauleco



NOTES:

1. FIGURE 4 IS ADAPTED FROM THE ITRC, 2018 LNAPL GUIDANCE FIGURES 3.6 TO ILLUSTRATE LNAPL WITHIN THE FORMATION AND WITHIN MONITORING WELLS AND A TYPICAL HISTORY OF MOBILE PHASE LNAPL AND IMMOBILE RESIDUAL PHASE LNAPL.

2. MW = THIS PORTION OF THE FIGURE ILLUSTRATES LNAPL WITHIN A MONITORING WELL.

PROJECT:
WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:
WAULECO LNAPL HISTORY AND HYPOTHETICAL CURRENT CONDITIONS

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.000
CHECKED BY:	K. QUINN		**FIGURE 4**
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

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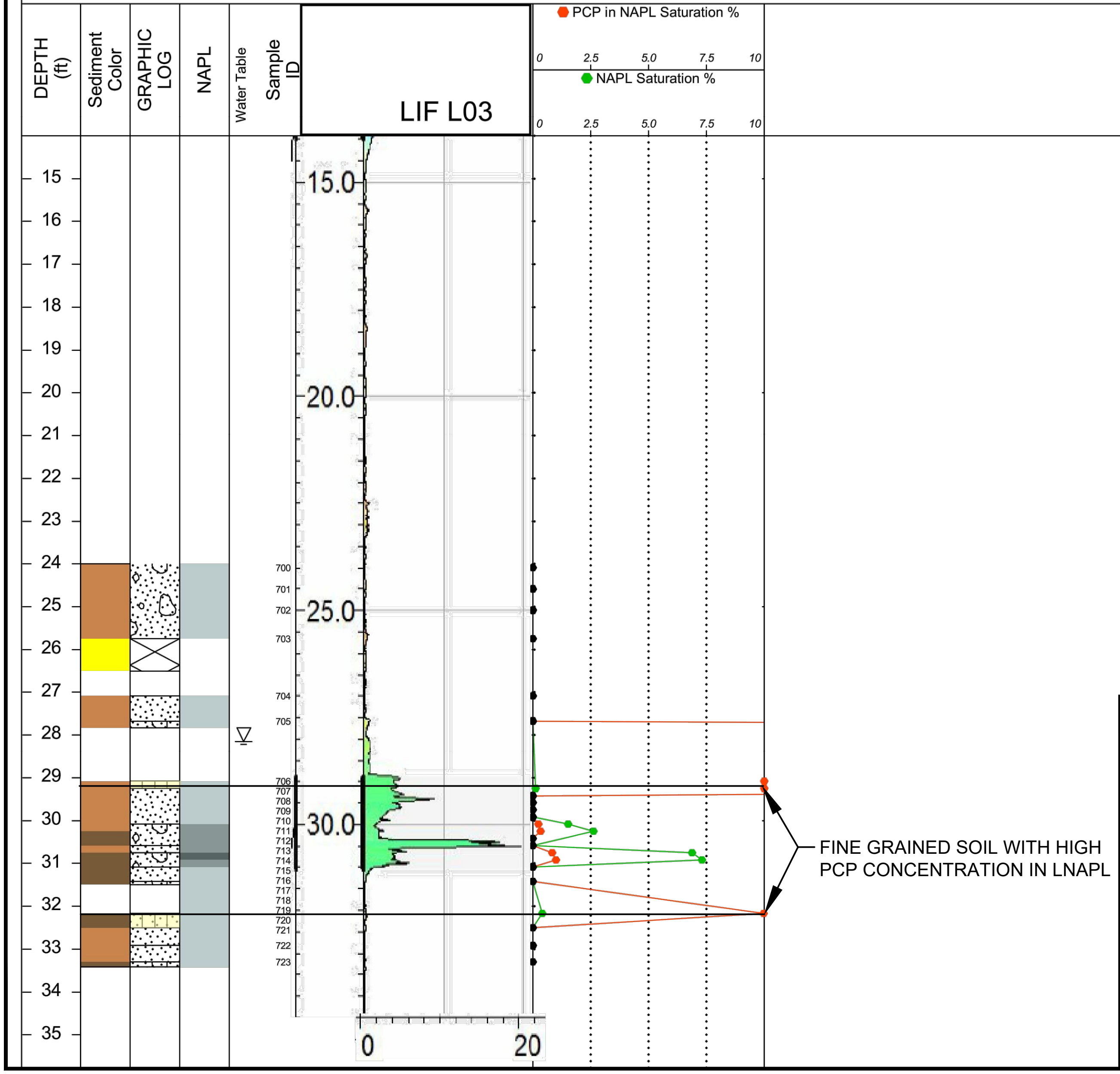
FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

Version: 2017-10-21

- ▨ USCS Poorly-graded Gravelly Sand
- ▨ USCS Poorly-graded Sand
- ☒ Not Sampled
- ▥ USCS Silt
- ☐ Core Not Recovered
- ▥ USCS Sandy Silt

Well Name: 2019TWCM01

Recovery: 73.4%



FINE GRAINED SOIL WITH HIGH PCP CONCENTRATION IN LNAPL

PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

BORING M01 AND LIF L03

DRAWN BY: B. YUNUSOV
CHECKED BY: K. QUINN
APPROVED BY: B. IVERSON
DATE: DECEMBER 2019
PROJ NO.: 189597.0008.000

FIGURE 5

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FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

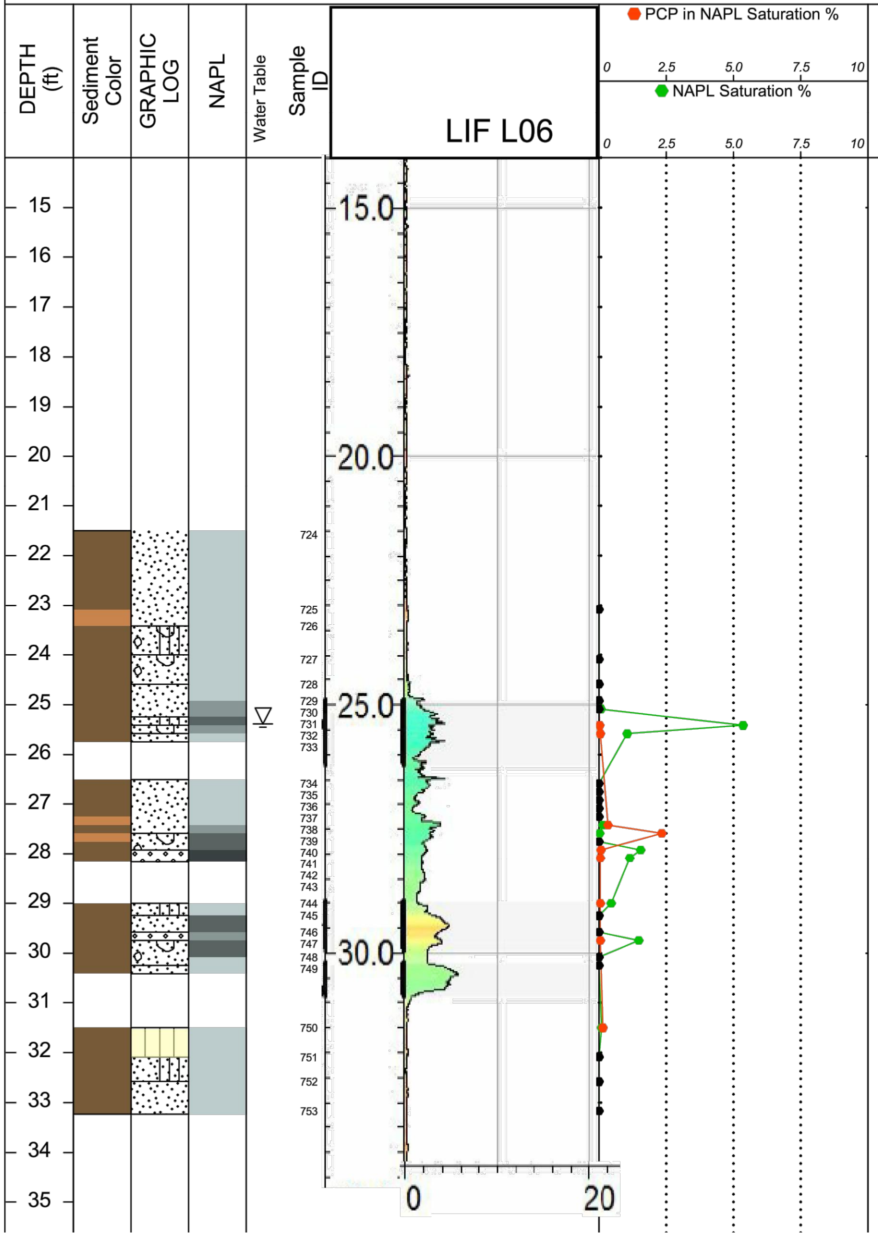
8.5x11 --- USER: BYunusov --- ATTACHED XREF'S: --- ATTACHED IMAGES:
DRAWING NAME: J:\Wauleco\189597 - Annual 2019\0008\Phase3Task2\ 189597.0008.Ph3T2 FIGS4-11.dwg --- PLOT DATE: December 10, 2019 - 11:46AM --- LAYOUT: BORING MO2 AND LIF LO6

Version: 2017-10-21

▨ USCS Poorly-graded Sand
▨ USCS Poorly-graded Sand with Silt
▥ USCS Silt
▨ USCS Poorly-graded Sand with Silt and Gravel
☐ Core Not Recovered
▨ USCS Poorly-graded Gravelly Sand
▨ USCS Well-graded Sand

Well Name: 2019TWCM02

Recovery: 77.3%



PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

BORING MO2 AND LIF LO6

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.000
CHECKED BY:	K. QUINN	**FIGURE 6**	
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

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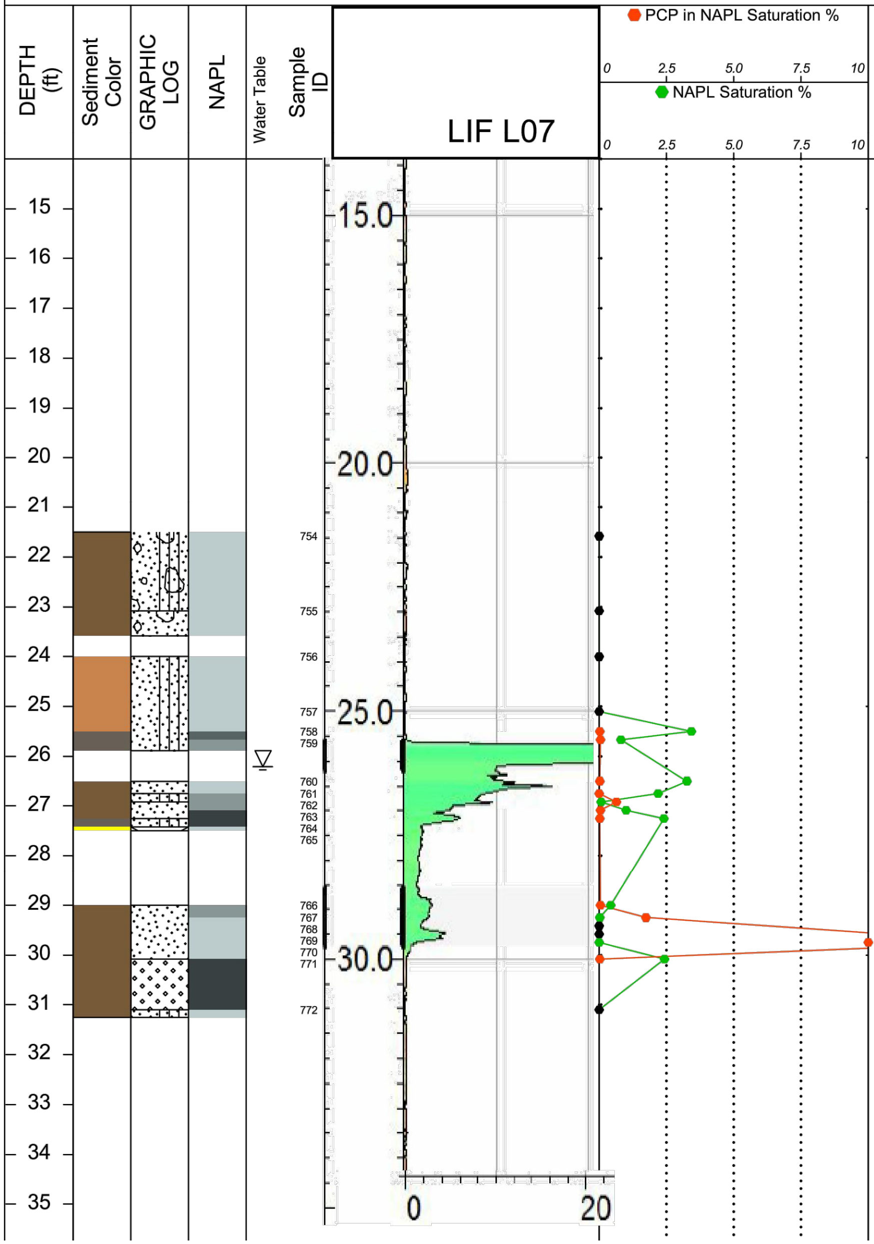
FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

▨	USCS Poorly-graded Sand with Silt and Gravel	▨	USCS Poorly-graded Gravelly Sand
▨	USCS Poorly-graded Sand with Silt	▨	USCS Poorly-graded Sand
▨	USCS Well-graded Sand	☐	Core Not Recovered
		☒	Not Sampled

Well Name: 2019TWCM03

Recovery: 74%



PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

BORING M03 AND LIF L07

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.000
CHECKED BY:	K. QUINN	**FIGURE 7**	
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

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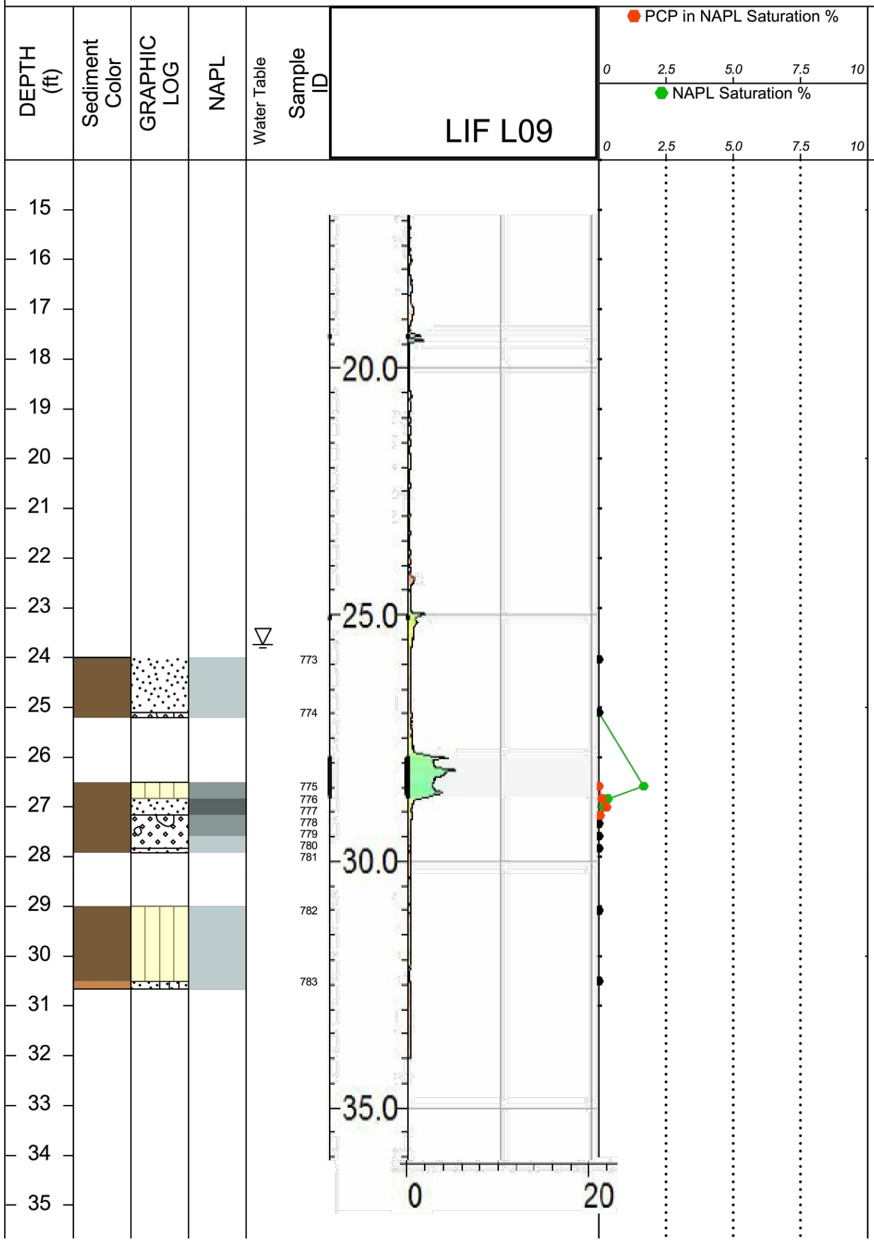
FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

▨	USCS Poorly-graded Sand	▨	USCS Well-graded Gravelly Sand	☐	Core Not Recovered
▥	USCS Silt	▨	USCS Poorly-graded Sand with Silt		

Well Name: 2019TWCM04

Recovery: 64.3%



NOTE:
THE SURFACE ELEVATION OF LIF L09 WAS SHIFTED APPROXIMATELY 2 FT TO MATCH THE LNAPL ZONE IN BORING M04.

PROJECT:
WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:
BORING MO4 AND LIF L09

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.000
CHECKED BY:	K. QUINN	**FIGURE 8**	
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

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FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

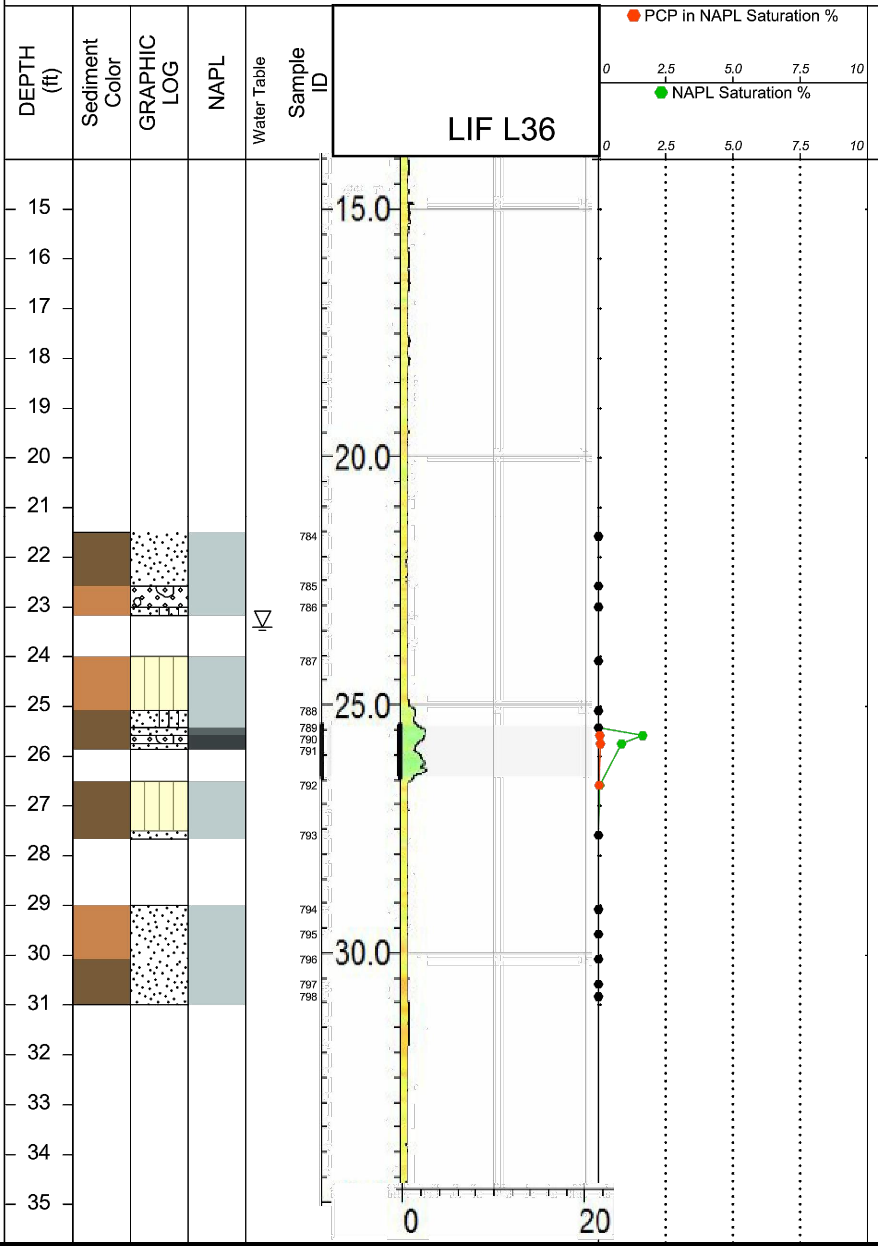
8.5x11 --- USER: BYunusov --- ATTACHED XREF'S: --- ATTACHED IMAGES:
DRAWING NAME: J:\Wauleco\189597 - Annual 2019\0008\Phase3Task2\ 189597.0008.Ph3T2 FIGS4-11.dwg --- PLOT DATE: December 10, 2019 - 11:46AM --- LAYOUT: BORING MO5 AND LIF L36

Version: 2017-10-21

▨ USCS Poorly-graded Sand
▨ USCS Well-graded Gravelly Sand
▨ USCS Poorly-graded Sand with Silt
☐ Core Not Recovered
▥ USCS Silt

Well Name: 2019TWCM05

Recovery: 70.5%



PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

BORING MO5 AND LIF L36

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.000
CHECKED BY:	K. QUINN	**FIGURE 9**	
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

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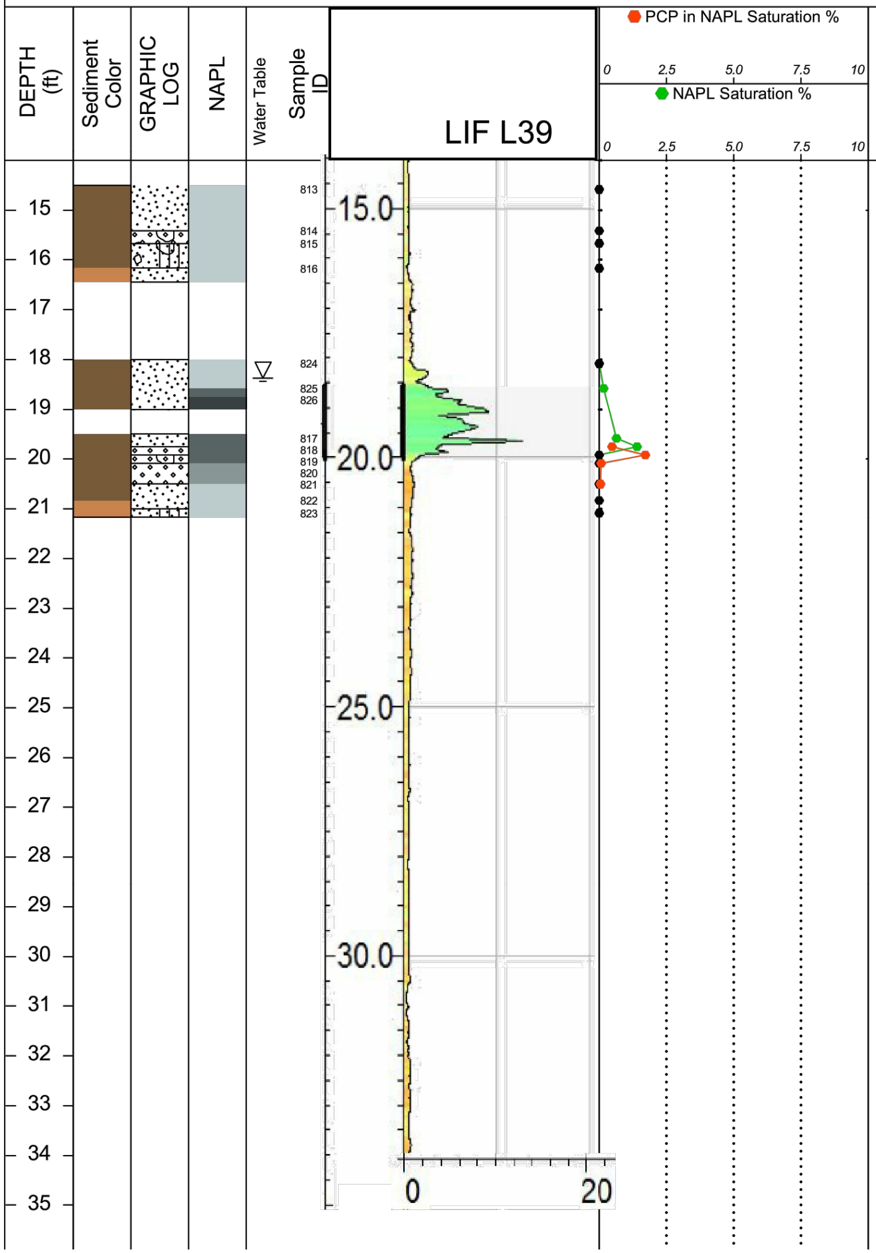
FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

- ▨ USCS Poorly-graded Sand
- ☐ Core Not Recovered
- ▨ USCS Well-graded Gravelly Sand
- ▨ USCS Well-graded Sand
- ▨ USCS Poorly-graded Sand with Silt and Gravel
- ▨ USCS Poorly-graded Sand with Silt

Well Name: 2019TWCM07

Recovery: 69.1%



PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

BORING MO7 AND LIF L39

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.000
CHECKED BY:	K. QUINN		**FIGURE 11**
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

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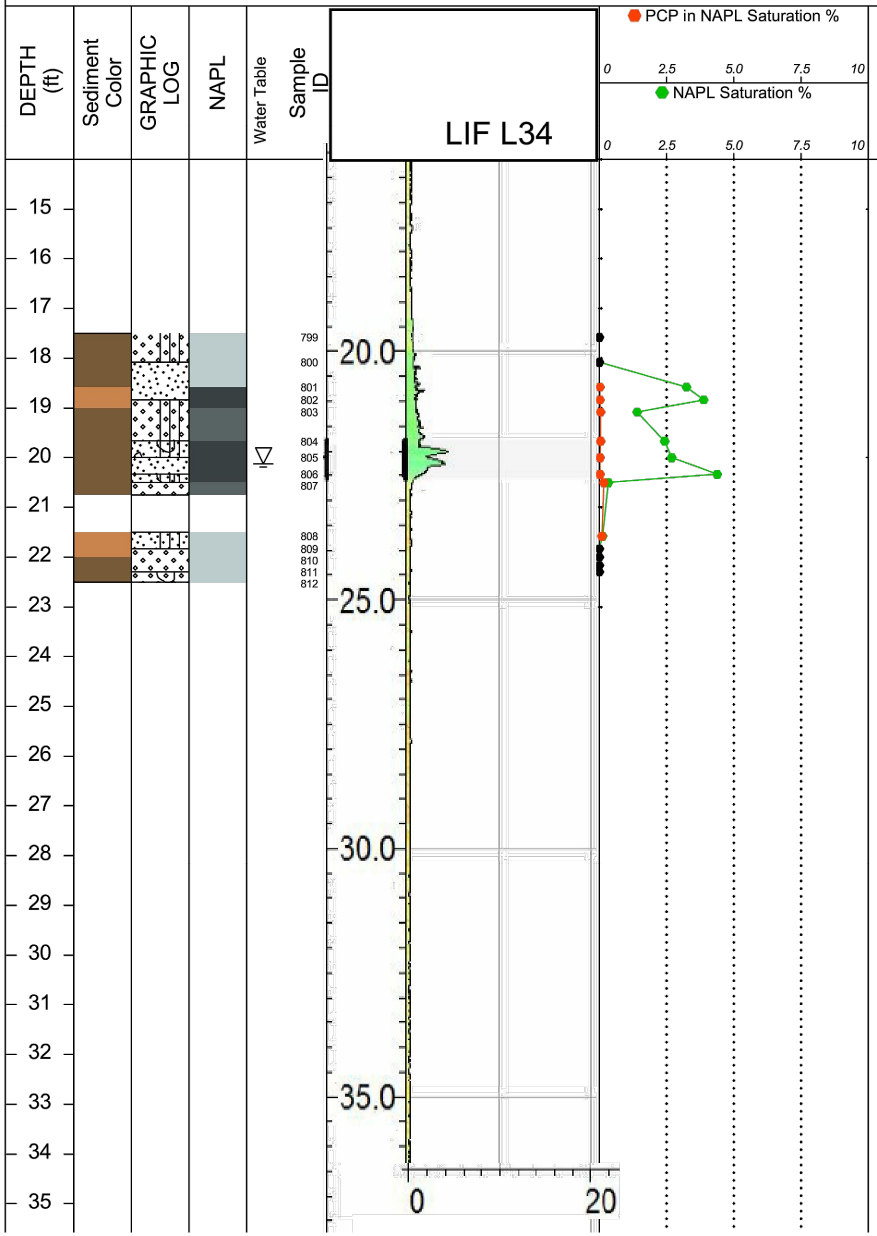
FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

▨ USCS Well-graded Sand with Silt
▨ USCS Well-graded Sand
▨ USCS Well-graded Gravelly Sand
▨ USCS Poorly-graded Sand
☐ Core Not Recovered
▨ USCS Poorly-graded Sand with Silt and Gravel
▨ USCS Poorly-graded Sand with Silt

Well Name: 2019TWCM06

Recovery: 85%



NOTE:
THE SURFACE ELEVATION OF LIFL34 WAS SHIFTED APPROXIMATELY 2 FT TO MATCH THE LNAPL ZONE IN BORING M06.

PROJECT:
WAULECO, INC.
RESIDUAL PHASE LNPAL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:
BORING MO6 AND LIF L34

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.000
CHECKED BY:	K. QUINN		**FIGURE 10**
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

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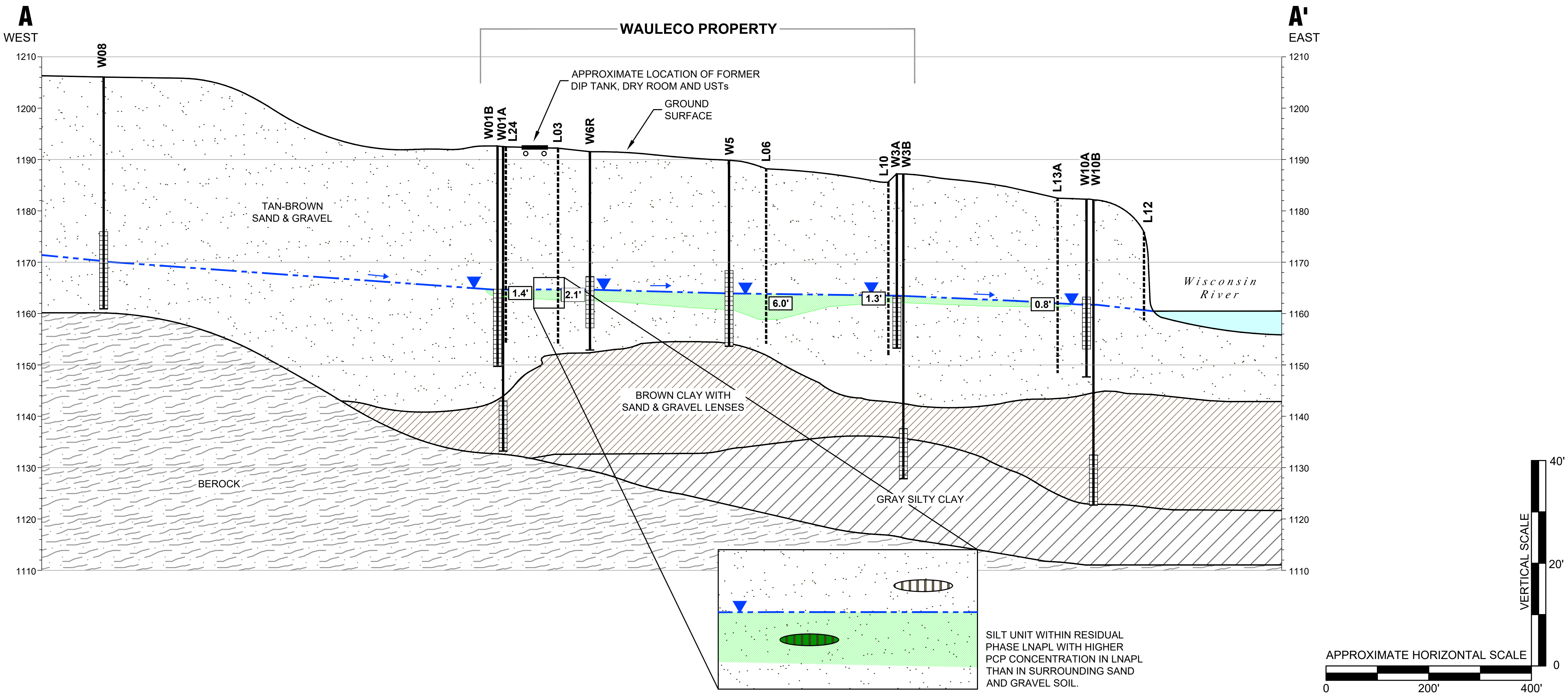
Phone: 608.826.3600

FILE NO.: 189597.0008.Ph3T2 FIGS4-11.dwg

GENERALIZED GEOLOGIC CROSS-SECTION A-A'



LEGEND

- ▨ SAND & GRAVEL
- ▨ BROWN CLAY
- ▨ GREY CLAY
- ▥ SILT OR SANDY SILT

W5
WELL / BORING
WELL SCREEN
END OF BORING

L24
LASER-INDUCED FLUORESCENCE (LIF) PROBE LOCATION AND NUMBER
WATER TABLE ELEVATION (JUNE 13, 2013)
WATER TABLE FLOW DIRECTION
WATER TABLE
0.8'
ZONE OF RESIDUAL PHASE PRODUCT
RESIDUAL PHASE PRODUCT THICKNESS

NOTES

1. LIF SURVEY PERFORMED IN 2013 AND 2015.
2. GENERALIZED GEOLOGIC CROSS-SECTION BASED ON 1985 EDER ASSOCIATES CROSS-SECTION.

PROJECT:
WAULECO, INC.
RESIDUAL PHASE LNAPL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:
CURRENT LNAPL CONCEPTUAL SITE MODEL

DRAWN BY:	B. YUNUSOV	PROJ NO.:	189597.0008.0000
CHECKED BY:	K. QUINN	FIGURE 12	
APPROVED BY:	B. IVERSON		
DATE:	NOVEMBER 2019		

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Phone: 608.826.3600

FILE NO.: 189597.0008.Ph3T2 FIG12.dwg

11x17 --- ATTACHED XREFS: --- ATTACHED IMAGES:
DRAWING NAME: J:\Wauleco\189597 - Annual 2019\0008\Phase3Task2\189597.0008.Ph3T2 FIG12.dwg --- PLOT DATE: December 10, 2019 - 11:48AM --- LAYOUT: FIGURE 12 CURRENT LNAPL CONCEPTUAL SITE MODEL
Version: 2017-03-03

Appendix A
1992 Keystone LNAPL Soil Properties

TABLE 3-3

RESULTS OF CAPILLARY PRESSURE - SATURATION TESTS
WAULECO, INC.
WAUSAU FACILITY

Sample	Depth	Dry Density	Saturated Hydraulic Conductivity	Porosity	Alpha	n	Sm
B-901(A)	9'-17'	109 Pcf	40 Ft/day	0.29	0.91 Ft^{-1}	2.46	12%
B-901(B)	9'-17'	124 Pcf	2 Ft/day	0.28	0.76 Ft^{-1}	2.13	12%
B-905(A)	9'-15'	109 Pcf	12 Ft/day	0.31	0.91 Ft^{-1}	2.01	18%
B-905(B)	9'-15'	124 Pcf	0.2 Ft/day	0.26	0.62 Ft^{-1}	1.66	23%

TABLE 3-4

DESIGN VALUES USED IN SPILLVOL MODEL
WAULECO, INC.
WAUSAU FACILITY

Property	Value	Source
Porosity	0.3	S&A
Van Genuchten alpha	0.9 ft^{-1}	S&A
Van Genuchten n	2.2	S&A
Van Genuchten Sm	0.15	S&A
Sor	0.15	UT
Sog	0.10	UT
G	0.82	Z
Bao	3.20	E
Bow	1.45	E

Notes:

S&A = Stephens and Associates
UT = University of Texas
Z = Zimpro
E = Estimate

TRC Notes:

Sor is the maximum residual saturation in saturated soils as a fraction of porosity.

Sog is the maximum residual saturation in vadose zone soils as a fraction of porosity.

TABLE 3-5

RESULTS OF SOIL CORE FLOOD TESTS
WAULECO, INC.
WAUSAU FACILITY

Sample	Saturated Hydraulic Conductivity	Porosity	Residual Oil Saturation in Water	Residual Oil Saturation in Air	Hydraulic Conductivity At S_{or}
SP-1	27 Ft/day	0.37	0.17	NA	3.3 Ft/Day
SP-2	NA	0.45	NA	0.10	NA
SP-3	43 Ft/day	0.37	0.14	NA	11 Ft/day
SP-4	43 Ft/day	0.39	0.17	NA	12 Ft/day

Note: All soil samples collected from the vicinity of monitoring well W-1A, at a depth of 2 ft. to 3 ft.

NA = Value not available from specific core flood.

TRC Notes:

Residual oil saturation in water is equivalent to Sor in Table 3-4.

Residual oil saturation in air is equivalent to Sog in Table 3-4.

J

ADDENDUM REPORT TO EVALUATION OF TREATMENT SYSTEM ALTERNATIVES FOR PRODUCT REMOVAL

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PROJECT NO. 351950

DECEMBER 1992

KEYSTONE
ENVIRONMENTAL RESOURCES, INC.

Appendix B
Cryogenic Core Collection (C3) from Unconsolidated Subsurface Media

Groundwater
Monitoring&Remediation

Cryogenic Core Collection (C_3) from Unconsolidated Subsurface Media

by Saeed Kiaalhosseini, Richard L. Johnson, Richard C. Rogers, Maria Irianni Renno, Mark Lyverse, and Thomas C. Sale

Abstract

We evaluated tools and methods for in situ freezing of cores in unconsolidated subsurface media. Our approach, referred to as cryogenic core collection (C_3), has key aspects that include downhole circulation of liquid nitrogen (LN) via a cooling system, strategic use of thermal insulation to focus cooling into the core, and controlling LN back pressure to optimize cooling. Two cooling systems (copper coil and dual-wall cylinder) are described. For both systems, the time to freeze a single 2.5-foot (76-cm) long by 2.5-inch (63-mm) diameter core is 5 to 7 min. Frozen core collection rates of about 30 feet/day (10 m/day) were achieved at two field sites, one impacted by petroleum-based light nonaqueous phase liquids (LNAPLs) and the other by chlorinated solvents. Merits of C_3 include (1) improved core recovery, (2) potential control of flowing sand, and (3) improved preservation of critical sediment attributes. Development of the C_3 method creates novel opportunities to characterize sediment with respect to physical, chemical, and biological properties. For example, we were able to resolve water, LNAPL, and gas saturations above and below the water table. By eliminating drainage of water, gas and LNAPL saturations in the range of 6 to 23% and 1 to 3% of pore space, respectively, were measured in LNAPL-impacted intervals below the water table.

Introduction

Collection of cores from unconsolidated subsurface media is common to many disciplines, including geotechnical engineering, mining, and subsurface remediation. Common approaches include hollow-stem auger (HSA) and direct push (DP) drilling techniques. Rotosonic drilling, a promising option in many ways, is not considered here due to concerns with sample vibration and heating. Successful core collection requires effective recovery of sediment core from the targeted interval and preservation of the critical core attributes, including contaminant concentrations, fluid saturations, hydraulic conductivity, and biogeochemical conditions. This paper explores in situ freezing of HSA-collected sediment cores as a means to improve sample recovery as well as preserving critical attributes of the recovered samples. Collectively, steps for collecting in situ frozen cores are referred to as cryogenic core collection (C_3).

Collection of high-quality sediment cores can be challenging. This is particularly true for saturated, cohesionless sediments (e.g., sands and gravels). First, cohesionless sediments commonly fall out of coring systems during withdrawal of the core from the borehole (Figure 1a and 1b). Losses can result from gravity acting on the core, downward movement of pore fluids through the coring system, and/or a vacuum beneath the coring system during withdrawal. A common remedy for losses during core withdrawal is to place a “catcher” at the base of the coring system. Unfortunately, catchers can be ineffective in preventing losses due to sediment flow through catchers, and catchers can compromise core recovery by limiting sediment movement into the collection system.

A second challenge in saturated cohesionless sediments (i.e., below the water table) is “flowing sand.” During withdrawal of coring tools to the surface, the effective stress in the borehole space is reduced with respect to the effective stress in the adjacent formation at the same depth. These unbalanced stresses can lead to flow of sediments and fluids into the HSAs (Figure 1c), which can compromise the quality of cores from deeper intervals. Fluids (e.g., drilling mud) can be added to coring systems to control flowing sediments; however, addition of fluids can be complicated and may compromise critical attributes of cores.

Lastly, during core withdrawal and post recovery, pore fluids commonly drain from cores and are replaced by atmospheric gases (Figure 1d and 1e). The issue of water drainage from core is addressed in McCall et al. (2014). Loss of pore fluids and invasion of atmospheric gases can bias (1) estimates of fluid saturations (i.e., water, nonaqueous phase liquid [NAPL], and gas), (2) estimates of contaminant concentrations (due to losses of pore fluids and volatile compounds), (3) analyses of reactive minerals, and (4) evaluations of microbial ecology.

The limitations of core collection using conventional HSA and DP drilling techniques have led to the exploration of alternatives. However, work to date has not produced a widely adopted solution for the aforementioned challenges.

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doi: 10.1111/gwmr.12186

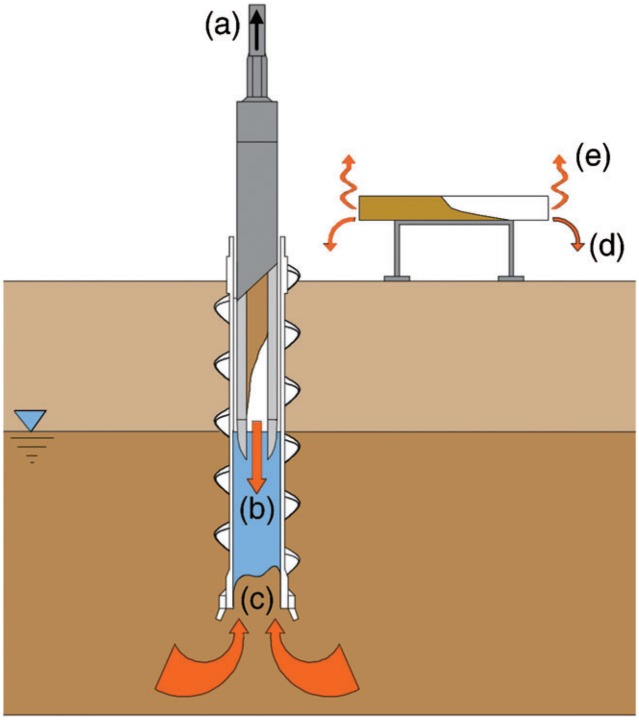

Figure 1. Challenges with conventional collection of cores from unconsolidated subsurface media (a) withdrawal of the coring system, (b) cohesionless sediments drop out of the coring system, (c) flowing sand into the borehole due to unbalanced stresses at drilling front, (d) drainage of pore fluids, and (e) volatilization of compounds and invasion of atmospheric gases.

Early work on collecting undisturbed samples from unconsolidated sediments using freezing techniques was conducted for liquefaction analysis at Fort Peck Dam, Montana. Forty hours of injecting liquid nitrogen (LN) through a pipe with a diameter of 2.5 inches (63 mm), froze the formation radially to diameter of about 2-feet (60 cm) and depth of about 30 feet (10 m) below ground surface (bgs). Subsequent coring of the frozen formation required a giant core barrel and heavy crane (Yoshimi et al. 1984).

Durnford et al. (1991) employed a drive sampler with a gas expansion chamber located in the bottom 3 inches (76-mm) of the drive shoe of the system. Liquid CO_2 was allowed to expand in the gas expansion chamber sampler (−79 °C), ultimately freezing the core sample at the base of the drive sampler (i.e., drive shoe). Freezing at the drive shoe limited the losses of sediment and fluids during sample extraction. However, the Durnford et al. (1991) methods included the following limitations: (1) discharging CO_2 gas downhole at the drive shoe, which may bias fluid saturations and the pH of the pore fluid), (2) the CO_2 supply line was located on the outside of the drive sampler; therefore, it was vulnerable to damage during driving, (3) only the lower portion of the core was frozen, (4) rates of sample freezing were slow in saturated media due to losses of cooling capacity to saturated formation, and (5) issues with flowing sand remained. Murphy and Herkelrath (1996) combined the piston core barrel approach of Zapico et al. (1987) and the liquid CO_2-cooled drive shoe of Durnford et al. (1991). The piston and freezing provided complementary solutions for losses of sediment during withdrawal. Results, both positive and negative, were similar to those of Durnford et al. (1991).

Johnson et al. (2013) wrapped a copper coil around an aluminum core liner in a GeoProbe Dual Tube sampler (GeoProbe 2011) and used LN as the coolant. Importantly, the gas lines were on the inside of the drive sampler to protect them from mechanical damage. Three-foot (90 cm) core sections were frozen in situ prior to withdrawal. Many of the issues related to recovery and sample preservation were addressed by this method. However, the Johnson et al. (2013) work (1) did not address the flowing-sand issue, (2) precluded direct field inspection of core due to the aluminum core liner, and (3) was limited to sample collection in media where DP was applicable.

The objective of this study is to describe a refined set of tools and operational procedures that address the limitations of core collection methods developed to date and enable practical in situ collection of frozen cores from unconsolidated subsurface media. In this study, critical elements associated with the C_3 method include the use of (1) HSA drilling techniques that rely on removal of cuttings via rotation of the auger while pushing the sample system into the targeted sediments, (2) LN as the cryogenic coolant, (3) insulation to focus cooling into the core, and (4) core collection systems that can freeze sediments below the auger cutting head, thereby reducing the likelihood of flowing sand.

The effectiveness of the C_3 method in preserving the distribution of pore contents (i.e., water, LNAPL, and gases) both above and below the water table has been tested and evaluated on frozen cores collected from two contaminated field sites (1) the Francis E. Warren (FEW) AFB in Cheyenne, Wyoming and (2) a former refinery in the western U.S., as further described below and in Sale et al. (2016).

The FEW AFB is an approximately 7000-acre (2850-ha) facility that is underlain by shallow eolian and fluvial deposits. Eolian deposits include local beds of caliche. The Eolian and fluvial deposits are underlain by the Ogallala Formation, which locally consists of interbedded gravel, sand, and silt beds with varying clay content. Through historical maintenance and disposal activities, chlorinated solvents (primarily trichloroethene) were inadvertently released to the subsurface.

The former refinery covers approximately 200 acres (81 ha) and is underlain by North Platte River alluvium. Sediments grade from fine-grained over bank deposits (sand and silts) at ground surface into point bar sands and channel gravels with depth. Beds of gravels and cobbles are also present within the over bank and point bar deposits. The site is impacted by historical releases of petroleum associated with petroleum refining operations between 1923 and 1982.

Methods

Advancement of the C_3 method involved sequential testing and refinement of tools and operational procedures. Initial development was conducted at Drilling Engineers, Inc. and the Colorado State University (CSU) facility in Fort Collins, Colorado. Subsequently, tools and operational procedures were tested and refined at the two aforementioned contaminated field sites. Samples were first collected at

FEW AFB on September 22 and 23, 2014. Two different field mobilizations were carried out at the former refinery site on September 30, 2014 and August 11 and 12, 2015.

C_3 Tools and Operational Procedures

A Central Mining Equipment (CME) 75 HSA drilling system was employed in this study. All work were conducted using 4.25-inch (108-mm) inner-diameter (ID) auger flights. The C_3 core barrel consisted of a modified 4-inch (101-mm) outer-diameter (OD), 5-foot (1.52-m) CME continuous sample tube system with a cryogenic cooling system fit inside the core barrel. Modifications were made to two components of the CME continuous sample tube system. First, two 0.75-inch (19-mm) holes were drilled in the top of the drive head to allow coolant delivery and exhaust lines to enter and exit the top of the core barrel, as shown in Figure S1(a), Supporting Information. Second, a custom-designed drive shoe with 2.5-inch (68-mm) ID was developed to provide clearance for the cooling system and insulation, as shown in Figure S1(b). Two cryogenic cooling systems were ultimately developed: a copper cooling coil and a stainless steel dual-wall cooling cylinder.

Cooling Coil

The configuration of the cooling coil is shown in Figures 2 and S2. The cooling coil consisted of 50 feet (15.24 m) of 0.375-inch (9-mm) OD copper tube wrapped over a length of 2.5 feet (76 cm). The coil was in direct contact with the PVC sample liner. A “U-turn” loop was located at the bottom of the coil to return the cooling coil again around the sampler and back up to the surface. The outside of the coils was covered in 0.25-inch (6.4-mm) closed-cell neoprene insulation which was covered with PVC tape. Five-foot (152-cm) long, 2.5-inch (63-mm) OD clear PVC liners were placed inside the cooling coil within the C_3 barrel for sample collection.

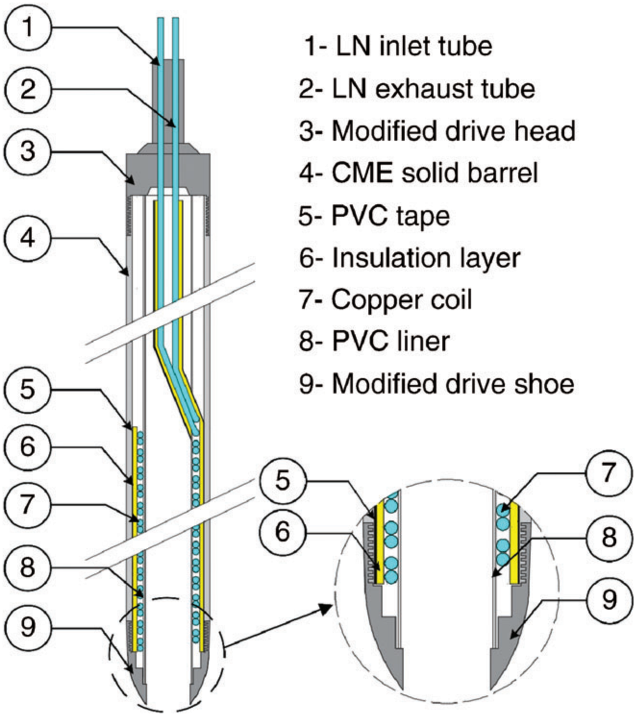

Figure 2. Cross-section of cooling coil system and components placed inside a 5-foot CME continuous sample tube system.

Dual-Wall Cooling Cylinder

The dual-wall cooling cylinder is shown in Figures 3 and S3. This system consists of two concentric stainless-steel tubes, 2.5 foot (76 cm) in length, which were enclosed at the top and the bottom. The dual-wall cooling cylinder was equipped with 0.25-inch (6.4-mm) OD stainless-steel inlet and exhaust tubes at the top of the cylinder. The inlet line carried the LN to the base of the cylinder to focus delivery of the coolant into the base of the sample and the drive shoe. The exhaust line collected LN (liquid and vapor) at the top of the cooling cylinder for delivery back to ground surface. As with the cooling coil system, the outside of the dual-wall cooling cylinder was covered in $^{0.25}$-inch (6.4-mm) closed-cell neoprene insulation and PVC tape. A 2.5-inch (63-mm) OD clear PVC liner was placed inside the cooling cylinder for core collection.

LN Coolant, Delivery, and Exhaust

LN, which provides temperatures as low as −196 °C at atmospheric pressure, was used as the coolant. 160-L LN Dewars with 230-psi (15.8-bar) internal pressure were employed. A 0.75-inch (19-mm) vacuum jacket tube was used to connect the LN Dewar to the downhole delivery line. The delivery and exhaust lines consisted of 5-foot (152-cm) long, 0.375-inch (10-mm) OD sections of stainless-steel tubes, insulated with 0.25-inch (6.4-mm) closed-cell neoprene insulation and covered with heat-shrink PVC tubing. The 5-foot (152-cm) sections were connected with stainless-steel Swagelok™ (Solon, Ohio) unions. Handling of

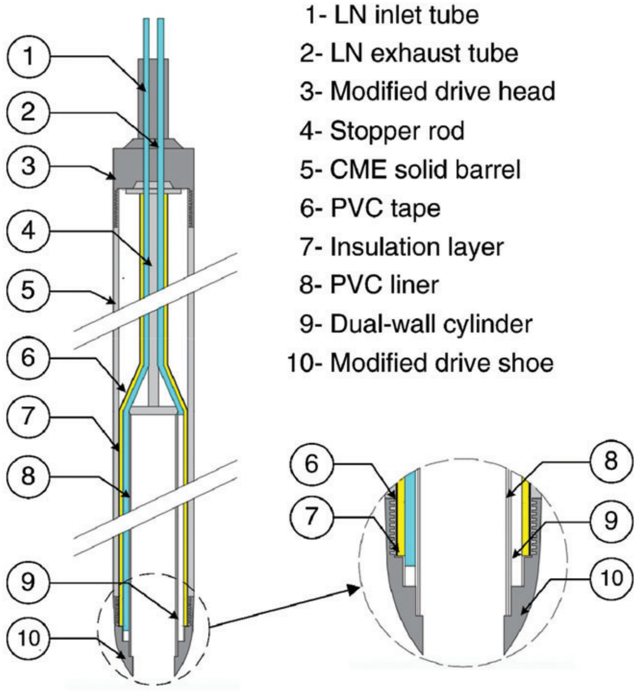

Figure 3. Cross-section of the dual-wall cooling cylinder and components placed inside a 5-foot CME continuous sample tube system.

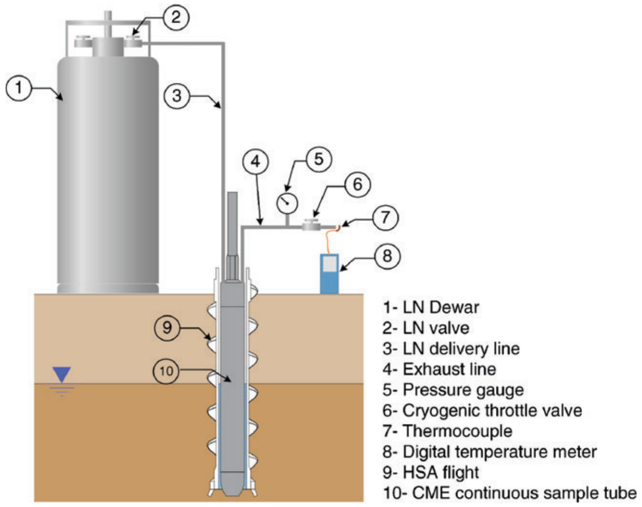

Figure 4. Schematic of the LN cooling delivery and back pressure control system on exhaust line.

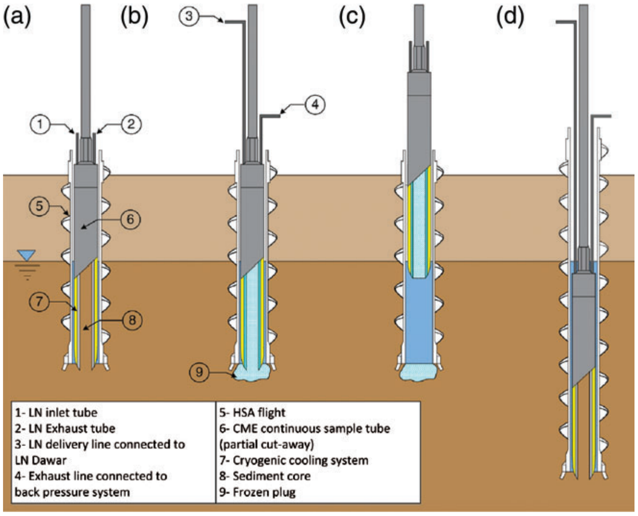

Figure 5. C_3 operational procedure. (a) Advancement of the HSA and the C_3 barrel, (b) injection of LN through the C_3 system to freeze the core and the formation immediately below the drive shoe, (c) withdrawal of the C_3 barrel to the surface and recovery of core, and (d) the HSAs and the C_3 barrel are advanced for the next interval.

LN followed manufacturer's recommendations provided in material safety data sheets. No major safety concerns arose with the use of LN in this study.

A cryogenic throttle valve and pressure gage were placed on the exhaust line above ground surface to control back pressure in the cooling systems, as shown in Figures 4 and S4. Optimal cooling was achieved by (1) maintaining about 200 psi (13.8 bar) at the Dewar, (2) initially imposing zero back pressure at the exhaust in order to maximize flow, and (3) after 0 °C was observed at the exhaust, closing the throttle valve to achieve a back pressure of approximately 100 psi (6.9 bar) in the exhaust line to maintain the nitrogen in a liquid state adjacent to the core.

Controlled Experiments to Determine Freezing Time

Prior to field mobilization, a series of controlled experiments were conducted at the Drilling Engineers, Inc. facility to evaluate the time required to freeze sediment cores in situ. To accomplish these experiments, PVC liners were packed with a silty sand mixture (moderately sorted silt to fine sand) and saturated with tap water. The pre-packed cores were equipped with Type T thermocouples located at the top, middle, and bottom. The thermocouples were connected to a four-channel temperature logger (Omega HH378 temperature meter). The pre-packed cores were placed inside the C_3 barrel and lowered into 10 feet (3 m), as well as 20 feet (6 m), of 4.25-inch (108-mm) ID HSA flights that had been drilled into the ground. Freezing of the pre-packed cores was then carried out as described above (with 200 psi [13.8 bar] at the LN Dewar and, in this case, with no back pressure at the exhaust), and the temperatures were recorded as a function of time.

Operational Procedure

Figure 5a through 5d illustrates the steps involved in the collection of frozen core. First, the HSA and the C_3 barrel were advanced 2.5 feet (76 cm) into the ground, as shown in Figure 5a. Second, LN was delivered to freeze the core, as shown in Figure 4. Ideally, a frozen zone of sediment also formed around the exterior of the drive shoe (Figure 5b). Third, the C_3 barrel was withdrawn from the HSA flights and the core was retrieved to ground surface (Figure 5c). Between Figure 5c and 5d, the core was removed from the barrel, and a new PVC liner was installed in preparation for subsequent sampling (Figure 5d). The collected core was inspected to verify freezing, measured to determine the percent of recovery, capped on the ends, labeled, and immediately placed horizontally on dry ice in a cooler for preservation purposes. A notable complication was that, for some cores, the core liners froze to the cooling coil or dual-wall cooling cylinder. This challenge was eliminated by briefly (less than 20 seconds) running hot water from a pressure washer through the cooling systems to thaw the film of ice holding the core in the system. All frozen cores were shipped to CSU and stored in a walk-in −20 °C refrigeration room.

Core Analysis

The primary objective of the C_3 method is to improve the preservation and analysis of critical core attributes. A three-step process of sub-dividing a sample (i.e., subsampling), preserving the "sub-samples," and subsequent sample analyses is referred to here as "high-throughput analysis" (HTA). The methods of HTA are documented in Sale et al. (2016) and will be briefly discussed here. The combined processes of C_3 and HTA allow all core processing to be conducted in the laboratory, versus in the field, and on a timeframe that is flexible (because the cores are kept frozen). Other advantages of laboratory processing include (1) elimination of weather-related sample biases, (2) access to better environmental control devices (e.g., hoods, gloves, etc.), (3) improved accuracy of measurements (e.g., weights and volumes), and (4) enhanced safety because staff are not deployed to field sites.

As discussed above, frozen core can be used to examine a broad set of physical, chemical, and biological characteristics of sediments. As an example, the distribution of fluid saturations (i.e., water, NAPL, and gases) in frozen cores collected from the former refinery is reported. Other parameters for which preservation analysis can be improved by in situ freezing of sediment cores include: (1) volatile organic compounds, (2) redox-sensitive inorganic water-quality indicators (e.g., Fe(II), H_2, H_2S, O_2) and minerals (e.g., FeS), and (3) microbial ecology and activity, as further explained in Sale et al. (2016).

Frozen cores were collected from four locations (E1D, B2D, B3D, and D4D) in a 0.02-acre (0.008-ha) test area at the former refinery in August 2015. Frozen cores were cut into 1-inch (25.4-mm) sub-sections, referred to as "hockey pucks," at 4-inch (101-mm) intervals using a circular chop saw. Cuts were completed in 5 to 10 s, and the hockey pucks remained frozen at the surface of the cut and through the body of the sample.

Subsequently, hockey pucks were quartered into "subsamples" and preserved. One of the sub-samples was placed in high purity (ACS/HPLC certified) methanol (Honeywell Burdick & Jackson, Muskegon, Michigan). The concentration of total petroleum hydrocarbons (C_{TPH}) in the methanol extract were resolved by gas chromatography. Details of the analytical methods are provided in the Appendix S1, and are well described in Sale et al. 2016. The minimum concentration of total petroleum hydrocarbons in which LNAPL is observed in subsamples under UV light is referred to as the "cut-off concentration" ($\mathrm{C}_{\text{cut-off}}$). Consequently, concentrations of LNAPL (C_{LNAPL}) in subsamples were determined by subtracting $C_{\text{cut-off}}$ from C_{TPH}.

A second subsample was weighed, placed in deionized (DI) water, and the volume of displaced water was weighted. The displaced water mass was used to estimate the total volume of the sample, V_{t}

$$V_t = M_w/\rho_w \tag{1}$$

where M_{w} is the mass of water instantaneously displaced by the sample and ρ_{w} is the density of water (assumed to be 1 gm/cm^3). Subsequently, the second sample was dried and reweighed. Collectively, the initial sample weight, displaced water volume, TPH concentration, and final sample weight were used to resolve physical parameters, including porosity, fluids saturation, and fluids content using Equations 2 through 6:

$$\phi = 1 - (M_d/V_t \cdot \rho_p) \tag{2}$$

$$C_{\mathrm{LNAPL}} = C_{\mathrm{TPH}} - C_{\text{Cut-Off}} \tag{3}$$

$$S_{\mathrm{LNAPL}} = (C_{\mathrm{LNAPL}} \cdot M_d/\rho_{\mathrm{LNAPL}})/(V_t - (M_d/\rho_p)) \tag{4}$$

$$S_{\mathrm{w}} = (\mathrm{V}_{\mathrm{l}} - (C_{\mathrm{LNAPL}} \cdot M_d/\rho_{\mathrm{LNAPL}}))/(V_t - (M_d/\rho_p)) \tag{5}$$

$$S_{\mathrm{g}} = 1 - (S_{\mathrm{LNAPL}} + S_{\mathrm{w}}) \tag{6}$$

$$\theta = S\phi \tag{7}$$

where ϕ is porosity, M_{d} is the mass of dry soil, S_{LNAPL}, S_{W}, and S_{G} are the LNAPL, water and gas saturations, respectively. θ is the volumetric fluid content, calculated for each fluid phase. V_{l} is the liquid (water + LNAPL) volume in the sample. Determination of M_{d}, V_{t}, and V_{l} is described in detail in Sale et al. 2016. In this study the particle density, ρ_p, was assumed to be 2.65 g/cm^3 (value for quartz, Dana and Ford 1929) and ρ_{LNAPL} was assumed to be 0.8 g/cm^3 (value for diesel, Mercer and Cohen 1990).

The two remaining sample quarters were archived for potential future studies. The 3-inch (76-mm) core section from between the hockey pucks was also stored in a freezer for subsequent analyses. Additional information regarding subsampling is presented in Sale et al. 2016.

Sediment subsamples in methanol and DI water were visually logged under visible and ultra-violet (UV) light by a professional geologist. Descriptions of the sediments follow the guidelines for hydrogeological logging of samples presented in Sterrett (2007). Recorded attributes include sediment type, sorting, grain-size distribution, color, and presence of NAPL. Florescence induced by UV light was used to identify the presence of LNAPL (Cohen et al. 1992).

Results

Rate of Cooling Experiments

An example of temperature and the rate of cooling vs. time data, collected during development of the C_3 method, is shown in Figure 6. In this case, approximately 6.5 min is required to completely freeze a pre-packed core. The data were collected from a controlled experiment at 20 feet below the water table (water table at 10 feet bgs).

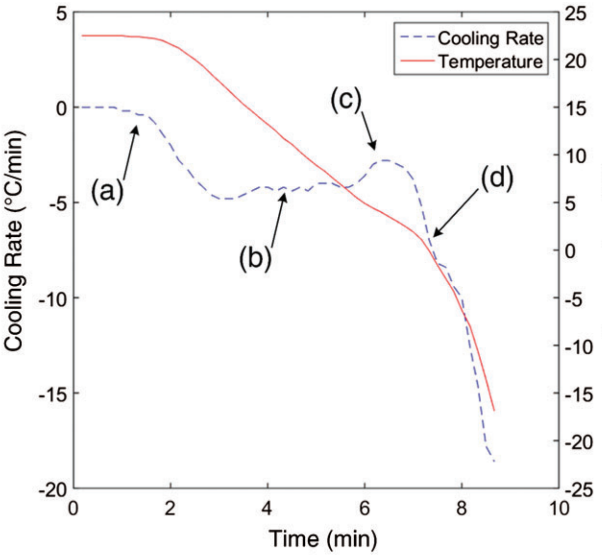

Figure 6. Example data for the cooling experiment: (a) thermal diffusion front reaches thermocouple at the center of the core, (b) cooling rate controlled by water's heat of fusion, (c) cooling rate slows slightly as the freezing front approaches the thermocouple, and (d) the cooling rate increases rapidly after the core is completely frozen.

The experiment was performed using the copper cooling coil system. In Figure 6, the cooling rate curve shows the four phases of freezing the pre-packed soil cores. First, the thermal diffusion front reaches the thermocouple at the center of the core. Second, the cooling rate is controlled by water's heat of fusion. Third, the cooling rate slightly decreases as the freezing front approaches the thermocouple. Last, the cooling rate increases rapidly after the core is completely frozen.

Core Production and Recovery

Table 1 summarizes frozen core production data at FEW AFB and the former refinery using the C_3 method. Through three field efforts and 5 days of drilling, 146 feet (44.5 m) of frozen core were collected. Of the 146 feet of core, all but 10 feet (3.05 m) were collected using coil cooling systems. In more recent projects, a version of the dual-wall cooling cylinder system with larger (0.375-inch [9.5-mm]) inlet and discharge has become the preferred system. The primary advantage of the dual-wall cooling cylinder system is better cooling at the base of the sample and in the formation below the drive shoe interval.

The average cryogenic core production rate was about 30 feet/day (10 m/day). Based on prior HSA coring at both sites, C_3 required approximately 50% more time than conventional sampling using HSA drilling techniques. However, as further described in the following sections, recovery from targeted intervals was improved using the C_3 method, and key attributes, including fluid saturations, were preserved.

Core sample recoveries from field work at FEW AFB and the former refinery site are shown in Figure 7. At FEW AFB, recovery was close to 100%, except for intervals encountering caliche beds that required a center head in lieu of the continuous sample tube system. At the former refinery site, recovery varied between 16 and 100%, with a median of 80%. The primary factor limiting recovery at the former refinery was cobbles larger than the 2.5-inch (63-mm) ID drive shoe, which blocked sediment entry into the sample system. As a basis of comparison, attempts to collect 2.5-foot (760-mm) sediment cores at the former refinery site, using the 2.5-inch (63-mm) ID CME continuous sample tube system without the cryogenic cooling system consistently yielded extremely poor recovery (less than 15%).

The time required to inject LN through the system to freeze the cores is presented in Figure 7. Using the C_3 method, 5 to 7 min of LN delivery was enough to freeze a 2.5-foot (76 cm) core above and below the water table.

During different core collection runs at the former refinery site, control of flowing sand was evaluated by measuring the solids level in the HSA after removal of the C_3 barrel. This level was compared to prior drilling at the same location when the C_3 method was not used. Preliminary results indicated that the dual-wall cooling system reduced the amount of sediment entering the barrel between core collection runs. Future work will focus on more rigorous evaluation of the potential to control flowing sand via freezing sediments below the drive shoe, including concurrent use of two cryogenic coring tools wherein a second tool is placed in the HSA immediately after withdrawal the first cryogenic coring tool. The second tool will limit movement of sand into the HSA. In the intervening time in which the frozen sample is removed from the first coring tool, frozen sediments below the sampled interval will have a chance to thaw. The concept of allowing time for sediment to thaw addresses the concern that frozen soils below the drive shoe could limit recovery.

Table 1

Core Production and Production Rate at FEW and the Former Refinery

Site	Dates	Core Production (Feet)	Average Core Production Rate (Feet/Day)
FEW AFB	September 22 and 23, 2014	50	25
Former refinery	September 30, 2014	36	36
Former refinery	August 11 and 12, 2015	60	30
	Total	146	29

Core Analysis

Visual Logging of Sediments

Visual logs of the sediments collected from four locations (i.e., E1D, B2D, B3D, and D4D) at the former refinery site (in August 2015) are shown in Figure 8. As is typically seen in stream deposits, sediment generally graded from fine to coarse with depth. Sediment colors graded from reds and browns above 4 feet (1.22 m) bgs to gray and black below 4 feet (1.22 m) bgs. Reds and browns are attributed to oxidized iron minerals. Grays and blacks are attributed to reduced metal sulfides associated with anaerobic degradation of petroleum hydrocarbons (Irianni Renno et al. 2016).

Fluid Saturation, Fluid Content, and Porosity

Figure 8 shows fluid saturation, fluid content, and porosity of frozen cores collected from the former refinery site in August 2015. Most importantly, when doing in situ freezing of cores, the results are not biased by drainage of water from the core during sample collection. Unfortunately, many NAPLs have freezing points well above the temperature achieved during freezing or subsequent storage of core in a −20 °C freezer. Correspondingly, redistribution of NAPL present as a continuous phase is possible during periods when the core is not held in its original vertical orientation. Given the LNAPL saturations less than 2% below the water table, it is likely that the LNAPL below the water table was present as immobile discontinuous blobs, surrounded by frozen water. The limited LNAPL above the water table may have moved during horizontal sample storage. In future work where NAPL saturations are an issue, consideration should be given to storing frozen cores in their original vertical orientation.

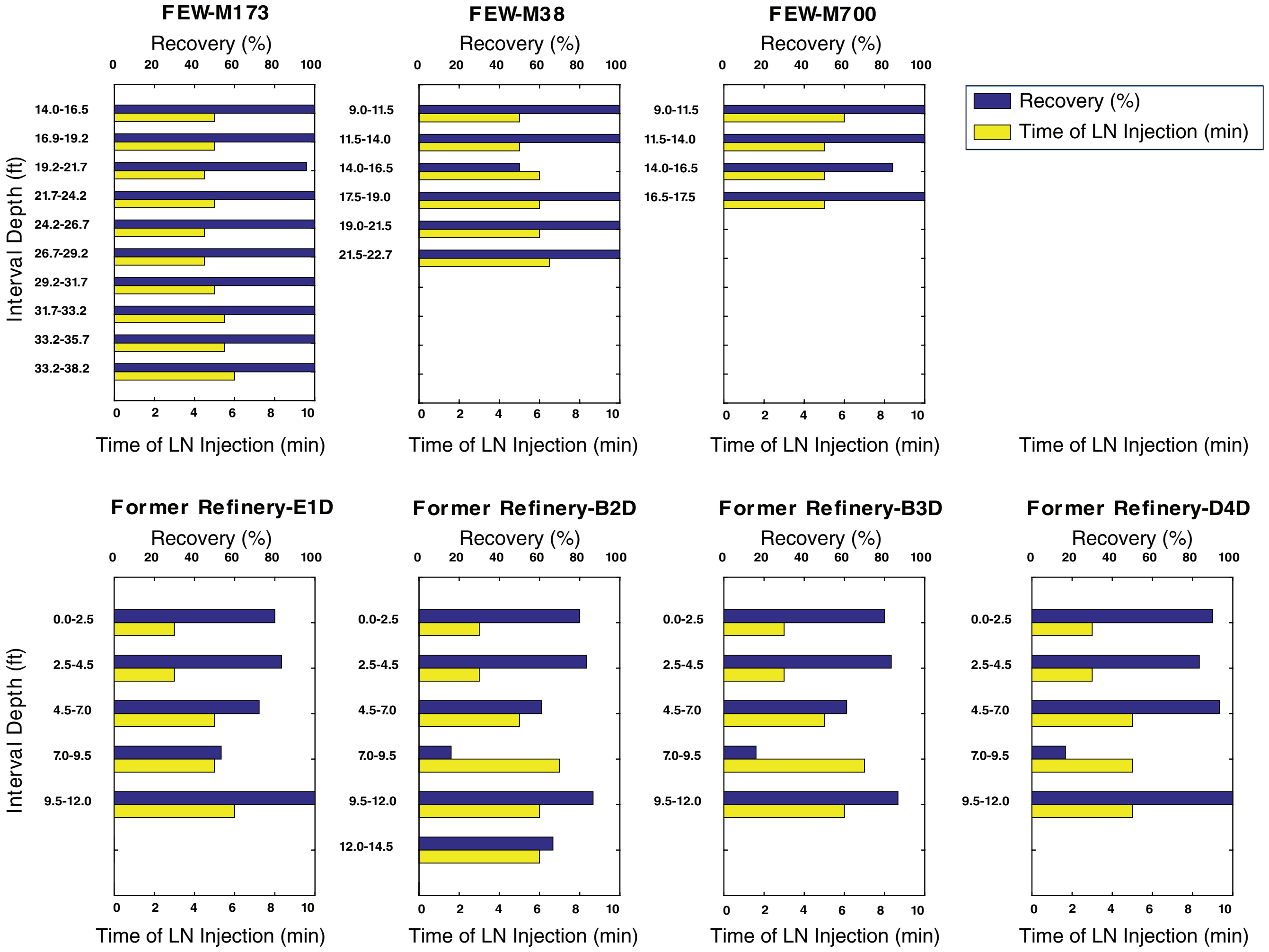

Figure 7. Core recovery and time of LN injection through the C_3 system at: (a) FEW AFB (three locations; M173F, M38C, and M700C) and (b) the former refinery site (four locations; E1D, B2D, B3D, and D4D).

Median fluid content, fluid saturation, and porosities, above and below the water table, are shown in Table 2. Lower porosity values reflect samples where large pieces of solid aggregate comprised a large fraction of the sample. Large gas content/saturations below the water table are attributed to gases being generated by anaerobic natural source zone depletion processes (Amos and Mayer 2006; Irianni Renno et al. 2016). Large gas saturations and small LNAPL content/saturations values below the water table are attributed to natural depletion of LNAPL (natural source zone depletion) via biologically mediated processes (Irianni Renno et al. 2016).

Conclusions

This paper documents a practical approach for collecting in situ frozen cores from unconsolidated subsurface media, referred to as C_3. Key elements of the C_3 method include downhole circulation of LN to copper coil or dual-wall cylinder cooling systems, strategic use of insulation to focus cooling into the core, and back pressure on LN lines to optimize cooling. While the majority of the core described here was collected using coil cooling system, the preferred approach is the dual-wall cooling barrel, due to better freezing at the base of the sampled interval and potentially below the drive shoe. The rate of core collection using the C_3 method was approximately 30 feet/day (10 m/day). Core recoveries in a braided stream deposit and eolian sediments were 80 and nearly 100%, respectively.

Application of the C_3 method has the potential to improve core recovery and preservation of physical, chemical, and biological attributes of sediments. Here we demonstrated the merits of C_3, by examining fluid saturations in the absence of pore fluids drainage that is common with many core-sampling techniques. By preventing drainage of water, we were able to document gas saturations of 6 to 23% in LNAPL impacted media and LNAPL saturations of 1 to 3% of pore space, below the water table. Both high gas and low LNAPL saturations are consistent with natural source zone depletion processes actively depleting LNAPL below the water table.

Cryogenic storage is a standard approach for preserving chemical and biological properties of saturated sediments (e.g., DNA and mRNA [Brow et al. 2010] and redox conditions [U.S. Environmental Protection Agency (U.S. EPA) 2002 and Wilkin 2006]). As a consequence, the ability

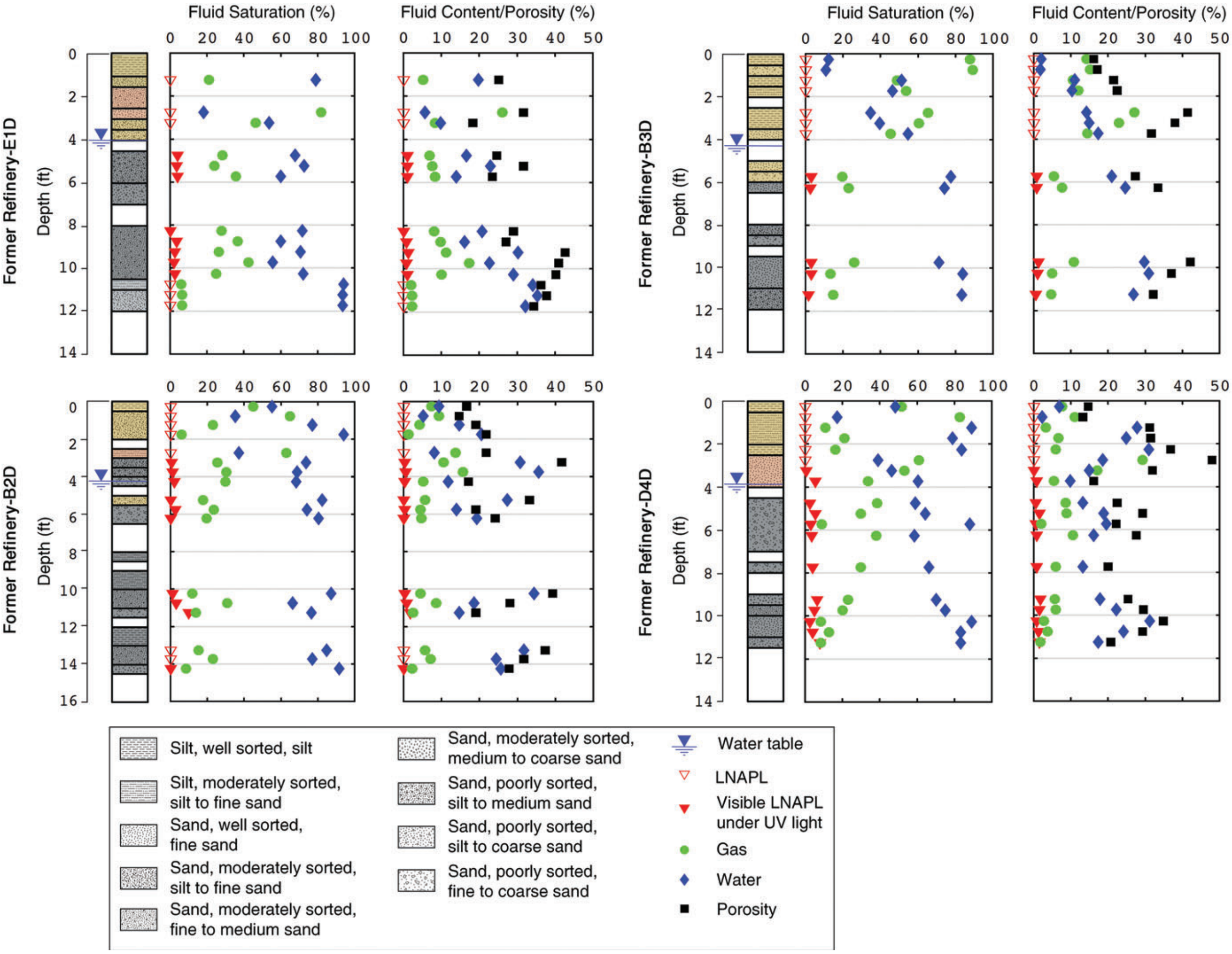

Figure 8. Results of fluid saturation, fluid content, and porosity determined after HTA of frozen cores collected from four locations (E1D, B2D, B3D, and D4D) at the former refinery site (August 2015).

Table 2

Median Porosity, Fluid Content, and Fluid Saturations of Frozen Cores Collected from the Former Refinery Site in August 2015

	Median Results Volume/Volume Porous Media	
	Above the Water Table	Below the Water Table
Porosity	23.7	29.2
Water content/saturation	14.5/49.5	22.1/74.2
Gas content/saturation	10.8/50.5	5.8/22.9
LNAPL content/saturation	0.2/0.6	0.9/2.8

to preserve samples prior to collection using the C_3 is intuitively desirable. However, further work in this area is needed and comparisons of critical parameters with freezing and without freezing are an area of ongoing research. The overarching vision is that C_3 can facilitate better resolution of subsurface conditions, support enhanced site conceptual models, and lead to more frequent selection of successful remedies for subsurface restoration.

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Supporting Information

The following supporting information is available for this article:

Appendix S1. Supplemental Information

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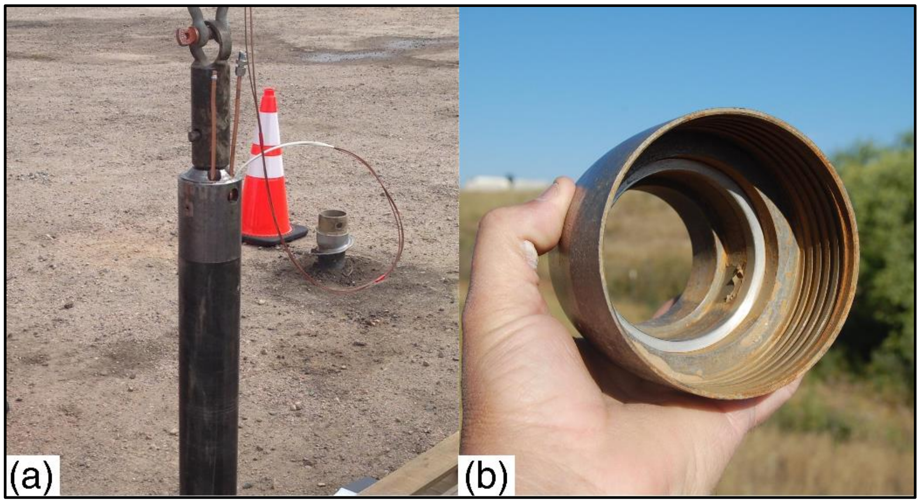

Figure S-1. Modifications on drive head and drive shoe: a) two holes on drive head to pass LN delivery and exhaust lines through the system and b) custom-designed drive shoe to provide clearance for cooling system and insulation.

Figure S-2. Insulated cooling coil being inserted into the core barrel.

Figure S-3. Dual-wall cooling cylinder inserted into the core barrel.

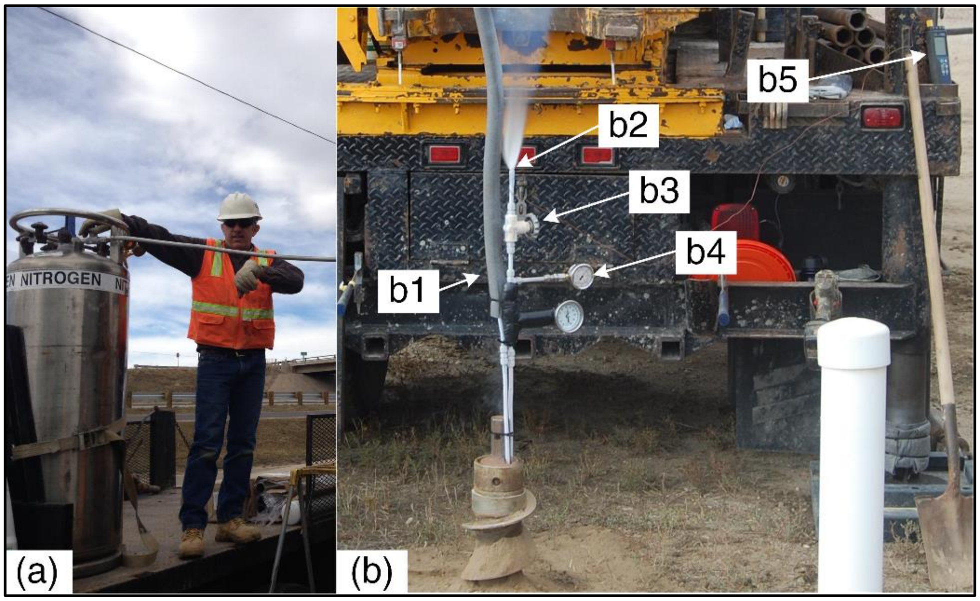

Figure S-4. LN Dewar and back pressure control system: a) LN Dewar with 230 psi (15.8 bar) internal pressure, b1) LN inlet line, b2) exhaust line where the thermocouple was installed, b3) throttle valve, b4) pressure gauge, and b5) digital temperature logger.

TPH Analysis

Concentration of total petroleum hydrocarbons (C_{TPH}) of samples were determined using liquid-solid extraction followed by gas chromatography (GC) method. Sub-samples were agitated in SMI multi-tube vortex, (SMI, Midland, ON, Canada) for one hour. One microliter (µl) of the extract was injected into gas chromatograph (Hewlett Packard, Model 5890 Series II) with a flame ionization detector (FID). The GC was equipped with an automatic sample injector (Hewlett Packard, Model 7673) and a Restek (Bellefonte, PA) RTX-5TM column (30 m length x 0.32 mm ID x 0.25 µm film thickness). The GC temperature was kept at 45 °C for 3 minutes, increased to 120 °C by rate of 12 °C /min, increased to 300 °C by rate of 20 °C /min, and kept at 300 °C for 3 minutes. The injection port and detector temperatures were 250 °C and 300 °C, respectively. The supply rate for the carrier gas (Helium) was 3 ml/minute. A nine-component gasoline range organic (GRO) EPA/Wisconsin mix standard (Restek, Bellefonte, PA) was used for GRO components including BTEX. A ten component diesel range organic (DRO) EPA/Wisconsin mix standard (Restek, Bellefonte, PA) was used for DRO components. All calibration curves were characterized by coefficient of determination greater than 0.99 (R^2>0.99). At least two calibration standards were measured with each GC run. Total petroleum hydrocarbon (TPH) results are reported as the sum of GRO and DRO on a dry weight sediment basis. The dry weight of each sample was determined by removing excess liquids from sub-samples and using microwave oven heating method according to ASTM D4643.

Appendix C
Colorado State University Analytical Results

		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	Saturation %			
Depth	Sample ID	TPH	GRO	DRO	PCP	Methane	NAPL	Gas	Water	Porosity
24.0831	700	104.5269	0	104.5269	0	0.008478	0	91.29362	8.706383	32.5382
24.5831	701	21.6449	0	21.6449	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
25.0831	702	0	0	0	0	0.00756	0	83.92803	16.07197	22.19505
25.7501	703	0			0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
27.0831	704	0	0	0	24.01659	0.010519	0	53.87833	46.12167	36.52604
27.6701	705	2.081893	0	2.081893	6.589255	0.007028	0	62.04196	37.95804	24.44302
29.0831	706	4061.528	2457.875	1603.653	344.1726	0.118586	[redacted]	[redacted]	[redacted]	[redacted]
29.2501	707	850.3968	501.2633	349.1334	70.52928	0.013579	0.12232	28.84018	71.0375	48.68884
29.4201	708	0	0	0	9.627032	0.00594	0	35.71527	64.28473	40.63964
29.5831	709	3.472021	3.472021	0	3.350356	0.010931	0	39.57455	60.42545	37.6608
29.7501	710	115.1296	98.84862	16.28099	2.421725	0.011447	0	45.47793	54.52207	35.92249
29.9201	711	134.0489	111.6165	22.43244	1.616454	0.010566	0	48.1994	51.8006	39.4013
30.0831	712	2814.28	1687.703	1126.577	5.096111	0.013442	1.508883	53.73323	44.75788	33.68971
30.2501	713	3902.902	2374.35	1528.553	11.8289	0.015087	2.626574	49.84905	47.52438	30.02866
30.4201	714	3716.3	1744.243	1972.057	4.40934	0.005076	[redacted]	[redacted]	[redacted]	[redacted]
30.5801	715	228.8181	165.0256	63.79252	2.397588	0.014133	0	62.14771	37.85229	29.19386
30.7501	716	7001.23	4439.412	2561.818	60.26558	0.007512	6.882205	38.29743	54.82037	23.8335
30.9201	717	7376.607	4742.524	2634.083	76.60039	0.018137	7.307642	48.28229	44.41007	23.76373
31.0801	718	99.81641	91.34584	8.470569	11.78269	0.013646	0	63.54677	36.45323	26.17739
31.4171	719	60.07707	55.51948	4.557583	4.430563	0.008974	0	62.39556	37.60444	31.73989
32.1671	720	4742.924	3305.47	1437.454	140.5836	0.053795	0.409222	22.85761	76.73317	77.4495
32.5001	721	0	0	0	0	0.012697	0	31.8333	68.1667	44.92535
32.9171	722	47.81822	42.6701	5.14812	4.690965	0.012607	0	40.17361	59.82639	28.80436
33.3001	723	5.282391	5.282391	0	2.356307	0.01334	0	34.73199	65.26801	27.06684
25.083	724	0	0	0	1.853046	0	[redacted]	[redacted]	[redacted]	[redacted]
23.084	725	0	0	0	0	0.007081	0	52.85994	47.14006	37.9495
23.418	726	0	0	0	0	0.005606	[redacted]	[redacted]	[redacted]	[redacted]
24.083	727	129.8865	106.5381	23.34837	0	0.025697	0	36.47773	63.52227	39.2565
24.584	728	212.7983	185.6041	27.19417	0	0.042066	0	38.60243	61.39757	38.402
24.918	729	340.3988	255.375	85.02381	0	0	0	53.29328	46.70672	32.48443
25.084	730	621.4278	430.9543	190.4735	0	0.049251	0.067732	39.67236	60.2599	37.25915
25.251	731	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
25.418	732	7102.69	4222.417	2880.273	0.964021	0.016581	5.358749	53.7518	40.88945	28.98453
25.584	733	2269.762	1408.68	861.0819	0.92265	0.051286	1.035726	64.91902	34.04525	36.14353
26.583	734	0	0	0	0	0.140363	0	30.56778	69.43222	53.91108
26.751	735	205.4799	187.8932	17.58667	0.854972	0.076747	0	31.92678	68.07322	43.87538
26.917	736	257.4379	206.3137	51.12421	0.831144	0.075251	0	25.72577	74.27423	42.66103
27.084	737	196.1584	177.6628	18.49568	0.831756	0.077017	0	24.44495	75.55505	45.12828
27.251	738	208.7965	185.7211	23.07533	0.840056	0.084152	0	39.45768	60.54232	45.00125
27.418	739	794.6732	576.2608	218.4124	0.838583	0.060305	0.127622	34.50102	65.37136	43.33765
27.584	740	538.018	443.4093	94.60867	0.84207	0.0485	0.023193	51.90616	48.07065	35.19092
27.751	741	418.7373	351.6999	67.03733	0.926156	0.056998	0	35.10282	64.89718	25.11934
27.918	742	2128.325	1432.357	695.9681	1.061111	0.057532	1.5394	46.73548	51.72512	25.94704
28.084	743	2460.357	1705.148	755.2085	1.026777	0.121651	1.144863	42.7421	56.11304	36.19201
29.001	744	2542.204	1721.157	821.047	0.534762	0.150917	0.440402	24.82089	74.73871	60.56863
29.251	745	427.371	342.5362	84.83477	0.82176	0.073132	0	42.32911	57.67089	47.56638
29.584	746	373.2157	316.7348	56.48084	0.89641	0.053283	0	42.6823	57.3177	32.90593
29.751	747	2415.76	1642.221	773.5387	0.955405	0.039564	1.474061	38.23819	60.28775	30.09479
30.084	748	7.480309	7.480309	0	0.977869	0.029308	0	45.60847	54.39153	25.64302
30.251	749	0	0	0	0.958628	0.01333	0	63.59265	36.40735	27.17261
31.501	750	1258.296	934.15	324.1462	0.475248	0.16805	0.101509	30.87325	69.02524	71.21903
32.084	751	188.684	156.4515	32.2325	0.764596	0.023435	0	36.37596	63.62404	52.37091
32.584	752	107.5119	96.21295	11.29899	0.82314	0.13856	0	31.25211	68.74789	47.95852
33.171	753	0	0	0	0.893668	0.029197	0	52.5948	47.4052	27.79814
21.501	754	0	0	0	0.970563	0.012187	0	91.40289	8.597107	39.19648
23.084	755	0	0	0	1.07206	0.012571	0	70.52145	29.47855	29.83919
24.001	756	0	0	0	0.909662	0.003384	0	53.30604	46.69396	43.35764
25.101	757	0	0	0	0.907087	0.01255	0	53.69389	46.30611	47.85617
25.501	758	10477.5	5635.607	4841.897	0.864964	0.011785	3.426285	56.99309	39.58062	49.09946
25.668	759	3108.652	1759.7	1348.952	0.839747	0.01052	0.81227	48.73176	50.45597	51.54637
26.501	760	8870.419	5612.333	3258.086	0.879267	0.042198	3.268813	39.83911	56.89207	45.89414
26.751	761	10057.9	7107.92	2949.983	0.304323	0.050809	2.189152	26.80249	71.00835	59.12107
26.918	762	658.8439	516.8348	142.009	0.831613	0.009414	0.064434	31.66126	68.2743	44.95227
27.084	763	2374.407	1809.087	565.3199	0.829064	0.069317	0.993279	44.37913	54.62759	38.46527
27.251	764	4081.129	2828.365	1252.765	0.930138	0.050775	2.403188	49.58216	48.01465	33.04833
27.421	765	3368.949	2403.457	965.4921	0.89792	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
29.001	766	2350.75	1801.023	549.7272	0.513247	0.01942	0.418666	28.62759	70.95374	59.42088
29.251	767	559.2751	451.7461	107.5291	0.80303	0.015551	0.022078	34.33519	65.64273	47.07101
29.418	768	306.2181	254.7292	51.48896	0.814295	0.017128	0	32.66813	67.33187	46.62073
29.584	769	362.7455	295.8202	66.92531	0.833424	0.01314	0	31.46324	68.53676	44.65668
29.751	770	506.8137	413.8622	92.95147	0.842424	0.016509	0.002773	33.24946	66.74776	44.86754
30.084	771	3435.288	2397.298	1037.99	0.945745	0.013527	2.435747	41.65917	55.90509	28.52983
31.101	772	36.41177	32.98253	3.429243	0.869939	0.010622	0	38.83857	61.16143	32.37771

24.033	773	0	0	0	0.441402	0.013831	0	46.45332	53.54668	52.5829
25.101	774	0	0	0	0.930106	0.036784	0	43.59793	56.40207	29.90356
26.583	775	61371.49	33631.52	27739.97	0.135574	0.618609	1.672925	22.23044	76.09664	92.3389
26.834	776	1257.497	732.014	525.4833	0.809078	0.045038	0.333575	33.37703	66.2894	42.92946
27.001	777	859.7804	547.8606	311.9198	0.837374	0.045031	0.154973	33.40624	66.43879	43.47151
27.168	778	1841.34	1080.582	760.7577	0.872121	0.014524	[redacted]	[redacted]	[redacted]	[redacted]
27.334	779	496.7367	312.1103	184.6264	0.904247	0.023831	0	40.43022	59.56978	32.4377
27.584	780	16.31356	13.06646	3.247102	0.919807	0.038859	0	37.94367	62.05633	29.63477
27.834	781	0	0	0	0.970156	0.016207	0	49.75154	50.24846	22.79506
29.083	782	407.3422	300.8344	106.5078	0.382819	0.080132	0	22.11323	77.88677	73.28405
30.501	783	0	0	0	0.933664	0.018546	0	66.46834	33.53166	35.51258
21.501	784	0	0	0	0.400345	0.01719	0	33.74297	66.25703	45.33691
22.584	785	0	0	0	0.903797	0.016694	0	49.667	50.333	26.71382
23.001	786	0	0	0	0.919418	0.014021	0	45.60375	54.39625	33.68347
24.083	787	0	0	0	0.126751	0.617346	0	23.36031	76.63969	81.02715
25.084	788	0	0	0	0.969772	0.580833	0	52.13056	47.86944	34.87447
25.421	789	380.1667	243.4996	136.6671	0.980188	1.058015	0	45.91183	54.08817	29.38951
25.584	790	2273.62	1262.801	1010.819	0.947738	0.812235	1.632944	44.57765	53.78941	26.45905
25.751	791	1799.524	1012.336	787.1884	0.982421	1.407874	0.86372	41.28203	57.85425	33.26159
26.583	792	3438.138	2716.698	721.44	0.062448	3.178854	0.048873	22.43019	77.52094	95.21848
27.583	793	70.34013	60.86506	9.475074	0.836143	0.38013	0	47.18329	52.81671	46.53067
29.083	794	2.658905	2.658905	0	0.711997	0.053759	0	31.13533	68.86467	46.67922
29.584	795	0	0	0	0.831589	0.038064	0	32.5401	67.4599	44.47287
30.084	796	2.170231	2.170231	0	0.818935	0.059075	0	31.10793	68.89207	44.46144
30.584	797	0	0	0	0.836826	0.044597	0	38.60975	61.39025	37.72243
30.834	798	0	0	0	0.85822	0.031793	0	38.19035	61.80965	43.86665
15.583	799	0	0	0	0.862892	0.009024	0	41.54248	58.45752	33.04783
18.084	800	275.6477	220.4276	55.2201	0.894487	0.009355	0	46.28951	53.71049	31.15811
18.584	801	8072.992	5034	3038.992	0.884316	0.007053	3.233243	37.08523	59.68153	43.68935
18.834	802	5207.708	3271.573	1936.135	0.901602	0.00908	3.870299	48.44232	47.68739	28.7202
19.083	803	2794.784	1814.892	979.8926	0.870618	0.014117	1.395131	31.65011	66.95476	35.2691
19.668	804	3089.685	2009.095	1080.591	0.927566	0.022447	2.432784	33.15063	64.41659	26.06907
20.001	805	3219.242	2075.52	1143.722	0.934197	0.055794	2.684887	41.2124	56.10271	25.12104
20.334	806	7421.351	4646.444	2774.907	0.915342	0.198128	4.368952	63.1993	32.43175	34.41637
20.501	807	1078.364	779.1844	299.1799	0.889035	0.179942	0.339406	32.2603	67.40029	36.08041
21.583	808	1136.174	988.1589	148.0154	0.272457	0.714346	0.108607	23.54318	76.34822	65.99015
21.834	809	63.47576	58.75044	4.725317	0.843761	0.107547	0	37.55878	62.44122	34.39179
22.001	810	0	0	0	0.930991	0.150494	0	44.04193	55.95807	29.71304
22.168	811	2.974668	2.974668	0	0.908179	0.183495	0	38.62412	61.37588	30.08271
22.301	812	3.096084	3.096084	0	0.937342	0.111177	0	41.59863	58.40137	27.22112
14.583	813	0	0	0	0.977692	0.012115	0	84.62252	15.37748	37.5793
15.418	814	0	0	0	1.015302	0.010226	0	75.19644	24.80356	21.19183
15.668	815	0	0	0	0.993608	0.005884	0	66.28868	33.71132	30.95681
16.168	816	0	0	0	0.969649	0.012799	0	76.4587	23.5413	32.5237
19.583	817	1877.99	1036.794	841.1961	0.778374	0.018916	0.639083	34.551	64.80992	41.66514
19.751	818	2843.849	1567.253	1276.595	0.891252	0.025278	1.4121	71.76731	26.82059	35.47636
19.918	819	194.3823	168.6536	25.72867	0.354537	0.023644	0	51.1625	48.8375	25.41203
20.084	820	202.2775	154.252	48.02557	0.922396	0.036097	0	43.58241	56.41759	24.9033
20.501	821	15.79083	13.20978	2.581048	0.937446	0.03686	0	38.46404	61.53596	26.13785
20.834	822	3.526355	3.526355	0	0.917053	0.043916	0	52.95512	47.04488	29.22328
21.083	823	0	0	0	0.939529	0.028045	0	45.03515	54.96485	26.78044
18.001	824	1.784098	1.784098	0	0.912568	0.011467	0	49.42605	50.57395	39.30305
18.584	825	681.0831	403.7702	277.3129	0.93015	0.017299	0.167755	52.82247	47.00978	26.33888
18.751	826	543.5941	316.065	227.5291	0.995381	0.008206	0.134246	[redacted]	[redacted]	[redacted]

Thomas C Sale

Maria Irianni Renno, M. Sc.
Research Associate III, Center for Contaminant Hydrology
Department of Civil and Environmental Engineering
Colorado State University, Fort Collins CO.

Thomas C Sale , PhD.
Professor, Center for contaminant Hydrology
Department of Civil and Environmetal Engineering
Colorado State University, Fort Collins CO.

Appendix D
Total Oxidant Demand Analytical Results

DATA PACKAGE TRC WAUSAU, WI WAULECO

1) TOTAL OXIDANT DEMAND (TOD) SAMPLE ANALYSIS

Samples prepared: August 19, 2019
Samples titrated: September 8, 2019
Oxidant: Sodium Persulfate

Sample	Dose (g/Kg)	Total Oxidant Demand (g/kg Soil)
MO4-775E	30	16.9
MO4-775E	60	25.5
MO5-792	30	10.6
MO5-792	60	18.7
MO6-806	30	14.3
MO6-806	60	19.2
Control	30 g/L	26.3*
Control	60 g/L	47.4*

*Measured control

Pre- and Post-Treatment laboratory analyses for these samples are provided in Appendix A and Appendix B, respectively.

2) TOTAL OXIDANT DEMAND (TOD) SAMPLE ANALYSIS

Samples prepared: September 29, 2019
Samples titrated: October 10, 2019
Oxidant: Sodium Persulfate

Sample	Dose (g/Kg)	Total Oxidant Demand (g/kg Soil)
M0130	30	6.8
M0160	60	12.3
M0730	30	6.3
M0760	60	13.4
Control	30 g/L	29.2*
Control	60 g/L	54.1*

*Measured control

Pre- and Post-Treatment laboratory analyses for these samples are provided in Appendix C and Appendix D, respectively.

For any additional questions on this data package, please contact me.

Sincerely,

Joe Rossabi, Ph.D., P.E.
Redox Tech, LLC
200 Quade Drive
Cary, NC 27513
919-678-0140
919-678-0150 fax

App. A Pre - Treatment Analytical Results 8/23/19

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ANALYTICAL REPORT

TRC ENVIRONMENTAL
KEN QUINN
708 HEARTLAND TRAIL
MADISON, WI 53717

Project Name: WAULECO INC: 2019 REMEDIATION SERVICES
Project Phase:
Contract #: 2399
Project #: 189597.0008.0000
Folder #: 147422
Purchase Order #: 139413

Page 1 of 3
Arrival Temperature: See COC
Report Date: 08/23/2019
Date Received: 08/20/2019
Reprint Date: 08/23/2019

CT LAB Sample#: 317385 Sample Description: M04-PRE Sampled: 08/19/2019 1200

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**14.8**	%	0.1	0.1	1			08/21/2019 14:21	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**752**	mg/kg	7.4	25	1		08/20/2019 13:30	08/22/2019 16:11	AJZ	EPA 8015
Pentachlorophenol	**10.3**	mg/kg	0.29	0.98	5		08/20/2019 13:30	08/22/2019 16:35	JJY	EPA 8270D

CT LAB Sample#: 317386 Sample Description: M05-PRE Sampled: 08/19/2019 1200

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**13.7**	%	0.1	0.1	1			08/21/2019 14:21	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	<7.4	mg/kg	7.4	25	1		08/20/2019 13:30	08/22/2019 15:03	AJZ	EPA 8015
Pentachlorophenol	**0.552**	mg/kg	0.058	0.20	1		08/20/2019 13:30	08/22/2019 15:04	JJY	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

TRC ENVIRONMENTAL
Project Name: WAULECO INC: 2019 REMEDIATION SERVICES
Project #: 189597.0008.0000
Project Phase:

Contract #: 2399
Folder #: 147422

CT LAB Sample#: 317387 Sample Description: M06-PRE Sampled: 08/19/2019 1200

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**12.1**	%	0.1	0.1	1			08/21/2019 14:21	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**859**	mg/kg	7.3	24	1		08/20/2019 13:30	08/22/2019 15:37	AJZ	EPA 8015
Pentachlorophenol	**17.5**	mg/kg	0.28	0.95	5		08/20/2019 13:30	08/22/2019 16:17	JJY	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

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TRC ENVIRONMENTAL
Project Name: WAULECO INC: 2019 REMEDIATION SERVICES
Project #: 189597.0008.0000
Project Phase:

Contract #: 2399
Folder #: 147422

Notes: * Indicates a value in between the LOD (limit of detection) and the LOQ (limit of quantitation). All LOD/LOQs are adjusted to reflect dilution and also any differences in the sample weight / volume as compared to standard amounts.

All samples were received intact and properly preserved unless otherwise noted. The results reported relate only to the samples tested. This report shall not be reproduced, except in full, without written approval of this laboratory. The Chain of Custody is attached.

Submitted by:

Brett M. Szymanski
Project Manager
608-356-2760

Current CT Laboratories Certifications
Wisconsin (WDNR) Chemistry ID# 157066030
Wisconsin (DATCP) Bacteriology ID# 289
Louisiana NELAP (primary) ID# ACC20190002
Illinois NELAP Lab ID# 200073
Kansas NELAP Lab ID# E-10368
Virginia NELAP Lab ID# 460203
Maryland Lab ID# 344
ISO/IEC 17025-2005 A2LA Cert # 3806.01
DoD-ELAP A2LA 3806.01
GA EPD Stipulation ID ACC20190002

REDOX TECH, LLC

422

"Providing Innovative In Situ Soil and Groundwater Treatment"

CHAIN C

20
C
Phor

****

Folder #: 147422

Company: TRC ENVIRONMENTA

Project: WAULECO

Logged By: JRB PM: BM

****

1

Client/Reporting Information

Company Name Redox Tech LLC
Address 200 Quade Drive
City Cary State NC Zip 27513
Project Contact Jonathan Sawyer
Phone # 9196334964
email address sawyer@Redox-Tech.com
Samplers Name Jonathan Sawyer

Project Information

Project Name Wauleco -TRC
Sampling Location
Turnaround Time
Contaminants of Concern

…uter
WW-Waste Water
SW-Surface Water
SO-Soil

Field ID	Collection Date	Collection Time	Matrix	# of bottles	# of bottles preserved	preservative	PCP - polychlorophenol	TPH - mineral spirits	Moisture Content				Comments
M04-Pre	8/19/19	1200	SO	1	NA	none	x	x	x				317385
M05-Pre	8/19/19	1200	SO	1	NA	none	x	x	x				317386
M06-Pre	8/19/19	1200	SO	2	NA	none	x	x	x				317387

Sample unpacked by:
Sample received in good condition? [✓ Y] or N 1.3°C ice present JRB 8/20/19 940
If no, explain:
Relinquished by: Redox Jonathan Sawyer Date/Time: 12:16 8/19/19
Received by: JRB Date/Time: 8/20/19 947

Comments: Bill to TRC

App. B Post - Treatment Analytical Results 9/25/19

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ANALYTICAL REPORT

REDOX TECH LLC
JONATHAN SAWYER
200 QUADE DR
CARY, NC 27513

Project Name: WAULECO INC: 2019 REMEDIATION SERVICES
Project Phase:
Contract #: 2399
Project #: 189597.0008.0000
Folder #: 147945
Purchase Order #: 139413

Page 1 of 4
Arrival Temperature: 3.1
Report Date: 09/24/2019
Date Received: 09/10/2019
Reprint Date: 09/24/2019

CT LAB Sample#: 325112 Sample Description: M0430 Sampled: 09/08/2019 1400

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Solids, Percent	**74.3**	%	0.1	0.1	1			09/18/2019 14:13	BMM	EPA 8000C
Percent Moisture	**25.7**	%	0.1	0.1	1			09/18/2019 14:13	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**220**	mg/kg	8.6	29	1		09/18/2019 12:30	09/23/2019 13:47	AJZ	EPA 8015
Pentachlorophenol	**6.63**	mg/kg	0.068	0.23	1	Y	09/18/2019 12:30	09/20/2019 01:33	JJY	EPA 8270D

CT LAB Sample#: 325122 Sample Description: M0460 Sampled: 09/08/2019 1400

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Solids, Percent	**63.1**	%	0.1	0.1	1			09/18/2019 14:13	BMM	EPA 8000C
Percent Moisture	**36.9**	%	0.1	0.1	1			09/18/2019 14:13	BMM	ASTM D2974-87
Organic Results										

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

CT LAB Sample#: 325122 Sample Description: M0460 Sampled: 09/08/2019 1400

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
TPH as Mineral Spirits	**590**	mg/kg	9.9	33	1		09/18/2019 12:30	09/23/2019 14:21	AJZ	EPA 8015
Pentachlorophenol	**6.10**	mg/kg	0.077	0.26	1	Y	09/18/2019 12:30	09/20/2019 01:52	JJY	EPA 8270D

CT LAB Sample#: 325123 Sample Description: M0530 Sampled: 09/08/2019 1400

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Solids, Percent	**71.6**	%	0.1	0.1	1			09/18/2019 14:13	BMM	EPA 8000C
Percent Moisture	**28.4**	%	0.1	0.1	1			09/18/2019 14:13	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**70.8**	mg/kg	8.8	29	1		09/18/2019 12:30	09/23/2019 14:55	AJZ	EPA 8015
Pentachlorophenol	<0.069	mg/kg	0.069	0.23	1	Y	09/18/2019 12:30	09/20/2019 02:10	JJY	EPA 8270D

CT LAB Sample#: 325124 Sample Description: M0560 Sampled: 09/08/2019 1400

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Solids, Percent	**84.2**	%	0.1	0.1	1			09/18/2019 14:13	BMM	EPA 8000C
Percent Moisture	**15.8**	%	0.1	0.1	1			09/18/2019 14:13	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**47.6**	mg/kg	7.4	25	1		09/18/2019 12:30	09/23/2019 15:29	AJZ	EPA 8015
Pentachlorophenol	<0.058	mg/kg	0.058	0.20	1	Y	09/18/2019 12:30	09/20/2019 02:29	JJY	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

CT LAB Sample#: 325125 Sample Description: M0630 Sampled: 09/08/2019 1400

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Solids, Percent	**86.2**	%	0.1	0.1	1			09/18/2019 14:13	BMM	EPA 8000C
Percent Moisture	**13.8**	%	0.1	0.1	1			09/18/2019 14:13	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**103**	mg/kg	7.4	25	1		09/18/2019 12:30	09/23/2019 16:02	AJZ	EPA 8015
Pentachlorophenol	**1.30**	mg/kg	0.057	0.19	1	Y	09/18/2019 12:30	09/20/2019 02:47	JJY	EPA 8270D

CT LAB Sample#: 325126 Sample Description: M0660 Sampled: 09/08/2019 1400

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Solids, Percent	**70.2**	%	0.1	0.1	1			09/18/2019 14:13	BMM	EPA 8000C
Percent Moisture	**29.8**	%	0.1	0.1	1			09/18/2019 14:13	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**124**	mg/kg	8.9	30	1		09/18/2019 12:30	09/23/2019 16:37	AJZ	EPA 8015
Pentachlorophenol	**1.27**	mg/kg	0.071	0.24	1	Y	09/18/2019 12:30	09/20/2019 03:06	JJY	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

Notes: * Indicates a value in between the LOD (limit of detection) and the LOQ (limit of quantitation). All LOD/LOQs are adjusted to reflect dilution and also any differences in the sample weight / volume as compared to standard amounts.

All samples were received intact and properly preserved unless otherwise noted. The results reported relate only to the samples tested. This report shall not be reproduced, except in full, without written approval of this laboratory. The Chain of Custody is attached.

Submitted by:
Eric T. Korthals
Project Manager
608-356-2760

QC Qualifiers

Code	Description
B	**Analyte detected in the associated Method Blank.**
C	**Toxicity present in BOD sample.**
D	**Diluted Out.**
E	**Safe, No Total Coliform detected.**
F	**Unsafe, Total Coliform detected, no E. Coli detected.**
G	**Unsafe, Total Coliform detected and E. Coli detected.**
H	**Holding time exceeded.**
I	**Incubator temperature was outside acceptance limits during test period.**
J	**Estimated value.**
L	**Significant peaks were detected outside the chromatographic window.**
M	**Matrix spike and/or Matrix Spike Duplicate recovery outside acceptance limits.**
N	**Insufficient BOD oxygen depletion.**
O	**Complete BOD oxygen depletion.**
P	**Concentration of analyte differs more than 40% between primary and confirmation analysis.**
Q	**Laboratory Control Sample outside acceptance limits.**
R	**See Narrative at end of report.**
S	**Surrogate standard recovery outside acceptance limits due to apparent matrix effects.**
T	**Sample received with improper preservation or temperature.**
U	**Analyte concentration was below detection limit.**
V	**Raised Quantitation or Reporting Limit due to limited sample amount or dilution for matrix background interference.**
W	**Sample amount received was below program minimum.**
X	**Analyte exceeded calibration range.**
Y	**Replicate/Duplicate precision outside acceptance limits.**
Z	**Specified calibration criteria was not met.**

Current CT Laboratories Certifications

Wisconsin (WDNR) Chemistry ID# 157066030
Wisconsin (DATCP) Bacteriology ID# 289
Louisiana NELAP (primary) ID# ACC20190002
Illinois NELAP Lab ID# 200073
Kansas NELAP Lab ID# E-10368
Virginia NELAP Lab ID# 460203
Maryland Lab ID# 344
ISO/IEC 17025-2005 A2LA Cert # 3806.01
DoD-ELAP A2LA 3806.01
GA EPD Stipulation ID ACC20190002

****

Folder #: 147945

Company: TRC ENVIRONMENTA

Project: WAULECO

Logged By: JRB PM: BM

****

****

REDOX TECH, LLC

"Providing Innovative In Situ Soil and Groundwater Treatment"

CHAIN OF CUSTOD

200 Quade Drive
Cary, NC 27513
Phone: 919-678-0140

Page 01 of 01

Client/Reporting Information

Company Name: Redox Tech LLC

Address: 200 Quade Drive

City: CARY State: NC Zip: 27513

Project Contact: SAWYER@Redox-Tech.com

Phone #: 919 633 4964

email address:

Samplers Name:

Project Information

Project Name: Wauleco TRC

Sampling Location:

Turnaround Time:

Contaminants of Concern: VOC-LNARL

Matrices

GW-Groundwater

WW-Waste Water

SW-Surface Water

SO-Soil

							Requested Analysis (include method and bottle type)						
Field ID	Collection Date	Collection Time	Matrix	# of bottles	# of bottles preserved	preservative	Pentachlorophenol PCP	TPH - Mineral Spirits	Moisture Content				Comments
M0430	9/08/19	1400	SO	1		NA	x		x				325112
M0460	9/08/19	1400	SO	1			x		x				325122
M0530	9/08/19	1400	SO	1			x		x				325123
M0560	9/8/19	1400	SO	1			x		x				325124
M0630	9/8/19	1400	SO	1			x		x				325125
M0660	9/8/19	1400	SO	1			x		x				325126

Sample unpacked by:

Sample received in good condition? [✓ Y] or N

If no, explain:

JRB 9/10/19 1115

Relinquished by: Jonathan Sawyer Redox 21 Date/Time:

Received by: Date/Time: 9/10/19 10:45

3.1° #23

Comments:

App. C Pre - Treatment Analytical Results 10/14/19

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ANALYTICAL REPORT

TRC ENVIRONMENTAL
KEN QUINN
708 HEARTLAND TRAIL
MADISON, WI 53717

Project Name: WAULECO INC: 2019 REMEDIATION SERVICES
Project Phase:
Contract #: 2399
Project #: 189597.0008.0000
Folder #: 148473
Purchase Order #: 139413

Page 1 of 2
Arrival Temperature: 5.4
Report Date: 10/11/2019
Date Received: 10/01/2019
Reprint Date: 10/14/2019

CT LAB Sample#: 334831 Sample Description: M01PRE Sampled: 09/26/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**13.4**	%	0.1	0.1	1			10/09/2019 14:38	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**15.6**	mg/kg	7.2 *	24	1		10/04/2019 15:00	10/10/2019 12:54	AJZ	EPA 8015
Pentachlorophenol	**0.550**	mg/kg	0.057	0.19	1		10/04/2019 15:00	10/08/2019 18:55	RPN	EPA 8270D

CT LAB Sample#: 334844 Sample Description: M07PRE Sampled: 09/26/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**14.5**	%	0.1	0.1	1			10/09/2019 14:38	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**232**	mg/kg	7.5	25	1		10/04/2019 15:00	10/10/2019 12:21	AJZ	EPA 8015
Pentachlorophenol	**4.31**	mg/kg	0.059	0.20	1		10/04/2019 15:00	10/08/2019 19:14	RPN	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

Notes: * Indicates a value in between the LOD (limit of detection) and the LOQ (limit of quantitation). All LOD/LOQs are adjusted to reflect dilution and also any differences in the sample weight / volume as compared to standard amounts.

All samples were received intact and properly preserved unless otherwise noted. The results reported relate only to the samples tested. This report shall not be reproduced, except in full, without written approval of this laboratory. The Chain of Custody is attached.

Submitted by:

Brett M. Szymanski
Project Manager
608-356-2760

Current CT Laboratories Certifications
Wisconsin (WDNR) Chemistry ID# 157066030
Wisconsin (DATCP) Bacteriology ID# 289
Louisiana NELAP (primary) ID# ACC20190002
Illinois NELAP Lab ID# 200073
Kansas NELAP Lab ID# E-10368
Virginia NELAP Lab ID# 460203
Maryland Lab ID# 344
ISO/IEC 17025-2005 A2LA Cert # 3806.01
DoD-ELAP A2LA 3806.01
GA EPD Stipulation ID ACC20190002

Folder # 148473
Company: TRC ENVIRONMENTA
Project: WAULECO
Logged By: JRB PM BM

REDOX TECH, LLC

"Providing Innovative In Situ Soil and Groundwater Treatment"

STODY

Cary, NC 27513
Phone: 919-678-0140

Page 1 of 1

Client/Reporting Information

Company Name Redox Tech LLC
Address 200 Quade Drive
City Cary State NC Zip 27513
Project Contact Jonathan Sawyer
Phone # 919.633.4964
email address Sawyer@Redox-Tech.com
Samplers Name Jonathan Sawyer

Project Information

Project Name Wauleco
Sampling Location
Turnaround Time
Contaminants of Concern PCP, LNAPL

Matrices

- GW-Groundwater
- WW-Waste Water
- SW-Surface Water
- SO-Soil

Field ID	Collection Date	Collection Time	Matrix	# of bottles	# of bottles preserved	preservative	Requested Analysis (include method and bottle type) PCP Pentachlorophenol	TPH - as mineral spirits	Moisture content				Comments
MO1Pre	9/26	1500	SO	1			x	x	x				334831
MO7Pre	9/26	1500	SO	1			x	x	x				334844

Sample unpacked by:
Sample received in good condition? Y or N
If no, explain:
Relinquished by: Redox Tech Date/Time: 9/26/19
Received by: JRB Date/Time: 10/1/19 1141

Comments:

meltwater only IR25(probe)
5.4°
10/1/19 1100 jls
xxxx

Post-Treatment Analytical Results 10/30/19
App. D

CT LABORATORIES
delivering more than data from your environmental analyses

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608-356-2760 • www.ctlaboratories.com

ANALYTICAL REPORT

TRC ENVIRONMENTAL
KEN QUINN
708 HEARTLAND TRAIL
MADISON, WI 53717

Project Name: WAULECO
Project Phase: 2019 REMEDIATION SERVICES
Contract #: 2399
Project #: 189597.0008.0000
Folder #: 148672
Purchase Order #: 139413

Page 1 of 4
Arrival Temperature: 2.9
Report Date: 10/30/2019
Date Received: 10/08/2019
Reprint Date: 10/30/2019

CT LAB Sample#: 337661 Sample Description: M0130 Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**19.5**	%	0.1	0.1	1			10/09/2019 14:56	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**66.1**	mg/kg	8.0	26	1		10/14/2019 13:45	10/19/2019 05:35	AJZ	EPA 8015
Pentachlorophenol	<0.060	mg/kg	0.060	0.20	1	M	10/14/2019 13:45	10/17/2019 12:59	RPN	EPA 8270D

CT LAB Sample#: 337662 Sample Description: M0160 Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**19.3**	%	0.1	0.1	1			10/09/2019 14:56	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**75.3**	mg/kg	7.9	26	1		10/14/2019 13:45	10/19/2019 03:55	AJZ	EPA 8015
Pentachlorophenol	<0.059	mg/kg	0.059	0.20	1		10/14/2019 13:45	10/17/2019 13:20	RPN	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

CT LAB Sample#: 337663 Sample Description: M0730 Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**16.5**	%	0.1	0.1	1			10/09/2019 14:56	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**85.3**	mg/kg	7.2	24	1		10/14/2019 13:45	10/19/2019 04:28	AJZ	EPA 8015
Pentachlorophenol	<0.058	mg/kg	0.058	0.20	1		10/14/2019 13:45	10/17/2019 13:40	RPN	EPA 8270D

CT LAB Sample#: 337664 Sample Description: M0760 Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Inorganic Results										
Percent Moisture	**13.7**	%	0.1	0.1	1			10/09/2019 14:56	BMM	ASTM D2974-87
Organic Results										
TPH as Mineral Spirits	**92.3**	mg/kg	7.1	24	1		10/14/2019 13:45	10/19/2019 05:01	AJZ	EPA 8015
Pentachlorophenol	<0.057	mg/kg	0.057	0.20	1		10/14/2019 13:45	10/17/2019 14:00	RPN	EPA 8270D

CT LAB Sample#: 337665 Sample Description: M0130W Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Organic Results										
TPH as Mineral Spirits	<130	ug/L	130	440	1		10/11/2019 13:00	10/18/2019 10:05	AJZ	EPA 8015
Pentachlorophenol	**39**	ug/L	2.1	7.1	1		10/11/2019 14:30	10/15/2019 15:48	RPN	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

CT LAB Sample#: 337666 Sample Description: M0160W Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Organic Results										
TPH as Mineral Spirits	<140	ug/L	140	460	1		10/11/2019 13:00	10/18/2019 10:38	AJZ	EPA 8015
Pentachlorophenol	**44**	ug/L	2.0	6.8	1		10/11/2019 14:30	10/15/2019 16:07	RPN	EPA 8270D

CT LAB Sample#: 337667 Sample Description: M0730W Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Organic Results										
TPH as Mineral Spirits	**90000**	ug/L	1400	4600	10		10/11/2019 13:00	10/18/2019 11:11	AJZ	EPA 8015
Pentachlorophenol	**810**	ug/L	43	150	20		10/11/2019 14:30	10/15/2019 17:20	RPN	EPA 8270D

CT LAB Sample#: 337668 Sample Description: M0760W Sampled: 10/04/2019 1500

Analyte	Result	Units	LOD	LOQ	Dilution	Qualifier	Prep Date/Time	Analysis Date/Time	Analyst	Method
Organic Results										
TPH as Mineral Spirits	**95000**	ug/L	1300	4400	10		10/11/2019 13:00	10/18/2019 11:45	AJZ	EPA 8015
Pentachlorophenol	**830**	ug/L	43	150	20		10/11/2019 14:30	10/15/2019 17:39	RPN	EPA 8270D

Unless specifically stated to the contrary, soil/sediment/sludge sample results/LOD/LOQ/RLs were reported on a Dry Weight Basis

Notes: * Indicates a value in between the LOD (limit of detection) and the LOQ (limit of quantitation). All LOD/LOQs are adjusted to reflect dilution and also any differences in the sample weight / volume as compared to standard amounts.

All samples were received intact and properly preserved unless otherwise noted. The results reported relate only to the samples tested. This report shall not be reproduced, except in full, without written approval of this laboratory. The Chain of Custody is attached.

Submitted by:
Brett M. Szymanski
Project Manager
608-356-2760

QC Qualifiers

Code	Description
B	**Analyte detected in the associated Method Blank.**
C	**Toxicity present in BOD sample.**
D	**Diluted Out.**
E	**Safe, No Total Coliform detected.**
F	**Unsafe, Total Coliform detected, no E. Coli detected.**
G	**Unsafe, Total Coliform detected and E. Coli detected.**
H	**Holding time exceeded.**
I	**Incubator temperature was outside acceptance limits during test period.**
J	**Estimated value.**
L	**Significant peaks were detected outside the chromatographic window.**
M	**Matrix spike and/or Matrix Spike Duplicate recovery outside acceptance limits.**
N	**Insufficient BOD oxygen depletion.**
O	**Complete BOD oxygen depletion.**
P	**Concentration of analyte differs more than 40% between primary and confirmation analysis.**
Q	**Laboratory Control Sample outside acceptance limits.**
R	**See Narrative at end of report.**
S	**Surrogate standard recovery outside acceptance limits due to apparent matrix effects.**
T	**Sample received with improper preservation or temperature.**
U	**Analyte concentration was below detection limit.**
V	**Raised Quantitation or Reporting Limit due to limited sample amount or dilution for matrix background interference.**
W	**Sample amount received was below program minimum.**
X	**Analyte exceeded calibration range.**
Y	**Replicate/Duplicate precision outside acceptance limits.**
Z	**Specified calibration criteria was not met.**

Current CT Laboratories Certifications

Wisconsin (WDNR) Chemistry ID# 157066030
Wisconsin (DATCP) Bacteriology ID# 289
Louisiana NELAP (primary) ID# ACC20190002
Illinois NELAP Lab ID# 200073
Kansas NELAP Lab ID# E-10368
Virginia NELAP Lab ID# 460203
Maryland Lab ID# 344
ISO/IEC 17025-2005 A2LA Cert # 3806.01
DoD-ELAP A2LA 3806.01
GA EPD Stipulation ID ACC20190002

148672

Folder # 148672
Company: TRC ENVIRONMENTA
Project WAULECO
Logged By: JRB PM BM

REDOX TECH, LLC

"Providing Innovative In Situ Soil and Groundwater Treatment"

CHAIN OF CUST

200 Quade Drive
Cary, NC 27513
Phone: 919-678-0140

Page 1 of 1

Client/Reporting Information

Company Name: Redox Tech LLC
Address: 200 Quade Drive
City: Cary State: NC Zip: 27513
Project Contact: Joe Rossabi
Phone #: 919-678-0140
email address: rossabi@Redox-Tech.com
Samplers Name: Jonathan Sawyer

Project Information

Project Name: Wauleco - TRC
Sampling Location:
Turnaround Time: Standard
Contaminants of Concern: LNAPL

Matrices

GW-Groundwater
WW-Waste Water
SW-Surface Water
SO-Soil

Requested Analysis (include method and bottle type)

Field ID	Collection Date	Collection Time	Matrix	# of bottles	# of bottles preserved	preservative	PCP - Pentachlorophenol	TPH - Mineral Spirits	Moisture %				Comments
M0230	10/4/19	1500	SO	1			X	X	X				337661
~~M0130~~ M0160		1500	SO	1			X	X	X				662
M0730		1500	SO	1			X	X	X				663
M0760		1500	SO	1			X	X	X				664
M0130W		1500	GW	2			X	X	X				665
M0160W		1500	GW	2			X	X	X				666
M0730W		1500	GW	2			X	X	X				667
M0760W	10/4/19	1500	GW	2			X	X	X				668

Sample unpacked by:
Sample received in good condition? Y or N
If no, explain:
Relinquished by: Jonathan Sawyer Date/Time: 10/4/19 1600
Received by: Date/Time: 10/8/19 11:05

Comments:
JRB 10/8/19 1108

Appendix E
Investigative Derived Waste Laboratory Report

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eurofins | Environment Testing
TestAmerica

ANALYTICAL REPORT

Eurofins TestAmerica, Chicago
2417 Bond Street
University Park, IL 60484
Tel: (708)534-5200

Laboratory Job ID: 500-172213-1
Client Project/Site: Wauleco - 189597.0008 P3T2

For:
TRC Environmental Corporation.
PO BOX 8923
Madison, Wisconsin 53708-8923

Attn: Mr. Bruce Iverson

Sandie Fredrick

Authorized for release by:
11/11/2019 2:42:35 PM

Sandie Fredrick, Project Manager II
(920)261-1660
sandie.fredrick@testamericainc.com

The test results in this report meet all 2003 NELAC and 2009 TNI requirements for accredited parameters, exceptions are noted in this report. This report may not be reproduced except in full, and with written approval from the laboratory. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

Table of Contents

Case Narrative

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Laboratory: Eurofins TestAmerica, Chicago

Narrative

Job Narrative
500-172213-1

Comments
No additional comments.

Receipt
The samples were received on 10/23/2019 8:30 AM; the samples arrived in good condition, properly preserved and, where required, on ice. The temperature of the cooler at receipt was 2.1° C.

GC/MS VOA
Method 8260B: The matrix spike / matrix spike duplicate (MS/MSD) precision for 512099 were outside control limits for Chloromethane. Sample matrix interference and/or non-homogeneity are suspected because the associated laboratory control sample LCS) recoveries were within acceptance limits.

Method 8260B: The MS/ MSD (matrix spike and matrix spike duplicate) in batch 512099 were analyzed 21 and 49 minutes outside the method specified 12 hour tune time. M01-Above Water (500-172213-1), M01-Below Water (500-172213-2), (500-172213-B-1-A MS) and (500-172213-B-1-A MSD)

Method 8260B: The method blank for 512099 contained Naphthalene, n-Butylbenzene 1,3,5-Trimethylbenzene and 1,2,4-Trimethylbenzene above the method detection limit and below the Reporting limit (RL). These target analytes concentration were non-detectin the associated sample; therefore, re-analysis of sample was not performed: therefore results were reported.

Method 8260B: The extraction blank for 512002 contained 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene and n-Butylbenzene. These was above the method detection limit (MDL) but below the reporting limit (RL). The method blank associated with analytical batch 512099 has detect for Naphthalene,1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene and n-Butylbenzene above the method detection limit (MDL) but below the reporting limit (RL). These analytes were non-detect in the samples; therefore, re-extraction and re-analysis of samples were not performed.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

GC/MS Semi VOA
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

GC Semi VOA
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Metals
Method 6010C: The low-level CCV at line118 in 6010C batch 500-513587 was above the method acceptance limits of 70-130% recovery for Arsenic. The sample M01-Above Water (500-172213-1) and M01-Below Water (500-172213-2) was bracketed. The mid-range bracketing the data were all within the 90-110% recovery limits. The sample is a non-detect, therefore the data has been reported.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

General Chemistry
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Organic Prep
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Detection Summary

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Client Sample ID: M01-Above Water

Lab Sample ID: 500-172213-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Benzene	0.023		0.020	0.010	mg/L	20		8260B	TCLP
Barium	0.39	J	0.50	0.050	mg/L	1		6010C	TCLP
Copper	0.014	J	0.025	0.010	mg/L	1		6010C	TCLP
Zinc	0.63	B	0.10	0.020	mg/L	1		6010C	TCLP
Flashpoint	>176		99.0	99.0	Degrees F	1		1010A	Total/NA
Sulfide	11		9.5	4.5	mg/Kg	1		9034	Total/NA
pH	6.1		0.2	0.2	SU	1		9045D	Total/NA
Free Liquid	Pass				No Unit	1		9095B	Total/NA
Specific Gravity	2.2423				NONE	1		SM 2710F	Total/NA

Client Sample ID: M01-Below Water

Lab Sample ID: 500-172213-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Barium	0.28	J	0.50	0.050	mg/L	1		6010C	TCLP
Copper	0.011	J	0.025	0.010	mg/L	1		6010C	TCLP
Zinc	0.27	B	0.10	0.020	mg/L	1		6010C	TCLP
Flashpoint	>176		99.0	99.0	Degrees F	1		1010A	Total/NA
pH	6.6		0.2	0.2	SU	1		9045D	Total/NA
Free Liquid	Pass				No Unit	1		9095B	Total/NA
Total Chlorine	2.0		0.021	0.021	%	1	☼	9251	Total/NA
Specific Gravity	2.2521				NONE	1		SM 2710F	Total/NA

This Detection Summary does not include radiochemical test results.

Method Summary

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Method	Method Description	Protocol	Laboratory
8260B	Volatile Organic Compounds (GC/MS)	SW846	TAL CHI
8270D	Semivolatile Organic Compounds (GC/MS)	SW846	TAL CHI
8082A	Polychlorinated Biphenyls (PCBs) by Gas Chromatography	SW846	TAL CHI
6010C	Metals (ICP)	SW846	TAL CHI
7470A	Mercury (CVAA)	SW846	TAL CHI
1010A	Ignitability, Pensky-Martens Closed-Cup Method	SW846	TAL CHI
9014	Cyanide	SW846	TAL CHI
9034	Sulfide, Acid soluble and Insoluble (Titrimetric)	SW846	TAL CHI
9045D	pH	SW846	TAL CHI
9095B	Paint Filter	SW846	TAL CHI
9251	Chlorine, Total	SW846	TAL SAV
Moisture	Percent Moisture	EPA	TAL CHI
SM 2710F	Specific Gravity, Density	SM	TAL CHI
1311	TCLP Extraction	SW846	TAL CHI
3010A	Preparation, Total Metals	SW846	TAL CHI
3510C	Liquid-Liquid Extraction (Separatory Funnel)	SW846	TAL CHI
3541	Automated Soxhlet Extraction	SW846	TAL CHI
5030B	Purge and Trap	SW846	TAL CHI
5050	Bomb Preparation Method for Solid Waste	SW846	TAL SAV
7470A	Preparation, Mercury	SW846	TAL CHI
9010B	Cyanide, Distillation	SW846	TAL CHI
9030B	Sulfide, Distillation (Acid Soluble and Insoluble)	SW846	TAL CHI

Protocol References:

EPA = US Environmental Protection Agency
SM = "Standard Methods For The Examination Of Water And Wastewater"
SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL CHI = Eurofins TestAmerica, Chicago, 2417 Bond Street, University Park, IL 60484, TEL (708)534-5200
TAL SAV = Eurofins TestAmerica, Savannah, 5102 LaRoche Avenue, Savannah, GA 31404, TEL (912)354-7858

Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collected	Received	Asset ID
500-172213-1	M01-Above Water	Solid	10/22/19 10:45	10/23/19 08:30	
500-172213-2	M01-Below Water	Solid	10/22/19 11:05	10/23/19 08:30	

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client Sample ID: M01-Above Water

Lab Sample ID: 500-172213-1

Date Collected: 10/22/19 10:45

Matrix: Solid

Date Received: 10/23/19 08:30

Method: 8260B - Volatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Benzene	**0.023**		0.020	0.010	mg/L			11/04/19 15:04	20
Carbon tetrachloride	<0.010		0.020	0.010	mg/L			11/04/19 15:04	20
Chlorobenzene	<0.010		0.020	0.010	mg/L			11/04/19 15:04	20
Chloroform	<0.020		0.040	0.020	mg/L			11/04/19 15:04	20
1,2-Dichloroethane	<0.010		0.020	0.010	mg/L			11/04/19 15:04	20
1,1-Dichloroethene	<0.010		0.020	0.010	mg/L			11/04/19 15:04	20
Methyl Ethyl Ketone	<0.050		0.10	0.050	mg/L			11/04/19 15:04	20
Tetrachloroethene	<0.010		0.020	0.010	mg/L			11/04/19 15:04	20
Trichloroethene	<0.010		0.020	0.010	mg/L			11/04/19 15:04	20
Vinyl chloride	<0.010		0.020	0.010	mg/L			11/04/19 15:04	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene (Surr)	*113*		*72 - 124*		*11/04/19 15:04*	*20*
Dibromofluoromethane (Surr)	*94*		*75 - 120*		*11/04/19 15:04*	*20*
1,2-Dichloroethane-d4 (Surr)	*96*		*75 - 126*		*11/04/19 15:04*	*20*
Toluene-d8 (Surr)	*104*		*75 - 120*		*11/04/19 15:04*	*20*

Method: 8270D - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1,4-Dichlorobenzene	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 16:00	1
2,4-Dinitrotoluene	<0.010		0.010	0.010	mg/L		11/04/19 16:18	11/05/19 16:00	1
Hexachlorobenzene	<0.0050		0.0050	0.0050	mg/L		11/04/19 16:18	11/05/19 16:00	1
Hexachlorobutadiene	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 16:00	1
Hexachloroethane	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 16:00	1
2-Methylphenol	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 16:00	1
3 & 4 Methylphenol	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 16:00	1
Nitrobenzene	<0.010		0.010	0.010	mg/L		11/04/19 16:18	11/05/19 16:00	1
Pentachlorophenol	<0.20		0.20	0.20	mg/L		11/04/19 16:18	11/05/19 16:00	1
Pyridine	<0.20		0.20	0.20	mg/L		11/04/19 16:18	11/05/19 16:00	1
2,4,5-Trichlorophenol	<0.10		0.10	0.10	mg/L		11/04/19 16:18	11/05/19 16:00	1
2,4,6-Trichlorophenol	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 16:00	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2-Fluorobiphenyl (Surr)	*62*		*34 - 110*	*11/04/19 16:18*	*11/05/19 16:00*	*1*
2-Fluorophenol (Surr)	*53*		*27 - 110*	*11/04/19 16:18*	*11/05/19 16:00*	*1*
Nitrobenzene-d5 (Surr)	*75*		*36 - 120*	*11/04/19 16:18*	*11/05/19 16:00*	*1*
Phenol-d5 (Surr)	*36*		*20 - 100*	*11/04/19 16:18*	*11/05/19 16:00*	*1*
Terphenyl-d14 (Surr)	*98*		*40 - 145*	*11/04/19 16:18*	*11/05/19 16:00*	*1*
2,4,6-Tribromophenol (Surr)	*89*		*40 - 145*	*11/04/19 16:18*	*11/05/19 16:00*	*1*

Method: 6010C - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<0.010		0.050	0.010	mg/L		11/01/19 15:45	11/05/19 02:00	1
Barium	**0.39**	**J**	0.50	0.050	mg/L		11/01/19 15:45	11/05/19 02:00	1
Cadmium	<0.0020		0.0050	0.0020	mg/L		11/01/19 15:45	11/05/19 02:00	1
Chromium	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:00	1
Copper	**0.014**	**J**	0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:00	1
Lead	<0.0075	^	0.050	0.0075	mg/L		11/01/19 15:45	11/05/19 02:00	1
Nickel	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:00	1
Selenium	<0.020		0.050	0.020	mg/L		11/01/19 15:45	11/05/19 02:00	1

Client Sample ID: M01-Above Water

Date Collected: 10/22/19 10:45
Date Received: 10/23/19 08:30

Lab Sample ID: 500-172213-1

Matrix: Solid

Method: 6010C - Metals (ICP) - TCLP (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Silver	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:00	1
Zinc	**0.63**	**B**	0.10	0.020	mg/L		11/01/19 15:45	11/05/19 02:00	1

Method: 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	<0.00020		0.00020	0.00020	mg/L		11/04/19 09:15	11/05/19 07:59	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Flashpoint	**>176**		99.0	99.0	Degrees F			11/06/19 14:44	1
Cyanide, Total	<0.25		0.49	0.25	mg/Kg		11/01/19 10:15	11/01/19 15:33	1
Sulfide	**11**		9.5	4.5	mg/Kg		11/07/19 20:27	11/08/19 02:23	1
pH	**6.1**		0.2	0.2	SU			10/25/19 11:54	1
Free Liquid	**Pass**				No Unit			11/06/19 14:48	1
Specific Gravity	**2.2423**				NONE			11/07/19 17:18	1

Client Sample Results

Client Sample ID: M01-Above Water

Lab Sample ID: 500-172213-1

Date Collected: 10/22/19 10:45
Date Received: 10/23/19 08:30
Matrix: Solid
Percent Solids: 97.0

Method: 8082A - Polychlorinated Biphenyls (PCBs) by Gas Chromatography

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
PCB-1016	<6.0		17	6.0	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1
PCB-1221	<7.5		17	7.5	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1
PCB-1232	<7.4		17	7.4	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1
PCB-1242	<5.6		17	5.6	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1
PCB-1248	<6.7		17	6.7	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1
PCB-1254	<3.7		17	3.7	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1
PCB-1260	<8.4		17	8.4	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1
Polychlorinated biphenyls, Total	<3.3		17	3.3	ug/Kg	☼	11/01/19 18:07	11/02/19 08:01	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Tetrachloro-m-xylene	*100*		*49 - 129*	*11/01/19 18:07*	*11/02/19 08:01*	*1*
DCB Decachlorobiphenyl	*107*		*37 - 121*	*11/01/19 18:07*	*11/02/19 08:01*	*1*

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Chlorine	<0.020		0.020	0.020	%	☼	10/29/19 11:59	10/29/19 17:45	1

Client Sample ID: M01-Below Water

Lab Sample ID: 500-172213-2

Date Collected: 10/22/19 11:05

Matrix: Solid

Date Received: 10/23/19 08:30

Method: 8260B - Volatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Benzene	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20
Carbon tetrachloride	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20
Chlorobenzene	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20
Chloroform	<0.020		0.040	0.020	mg/L			11/04/19 15:32	20
1,2-Dichloroethane	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20
1,1-Dichloroethene	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20
Methyl Ethyl Ketone	<0.050		0.10	0.050	mg/L			11/04/19 15:32	20
Tetrachloroethene	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20
Trichloroethene	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20
Vinyl chloride	<0.010		0.020	0.010	mg/L			11/04/19 15:32	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene (Surr)	*114*		*72 - 124*		*11/04/19 15:32*	*20*
Dibromofluoromethane (Surr)	*94*		*75 - 120*		*11/04/19 15:32*	*20*
1,2-Dichloroethane-d4 (Surr)	*98*		*75 - 126*		*11/04/19 15:32*	*20*
Toluene-d8 (Surr)	*105*		*75 - 120*		*11/04/19 15:32*	*20*

Method: 8270D - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1,4-Dichlorobenzene	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 16:24	1
2,4-Dinitrotoluene	<0.010		0.010	0.010	mg/L		11/04/19 16:18	11/05/19 16:24	1
Hexachlorobenzene	<0.0050		0.0050	0.0050	mg/L		11/04/19 16:18	11/05/19 16:24	1
Hexachlorobutadiene	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 16:24	1
Hexachloroethane	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 16:24	1
2-Methylphenol	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 16:24	1
3 & 4 Methylphenol	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 16:24	1
Nitrobenzene	<0.010		0.010	0.010	mg/L		11/04/19 16:18	11/05/19 16:24	1
Pentachlorophenol	<0.20		0.20	0.20	mg/L		11/04/19 16:18	11/05/19 16:24	1
Pyridine	<0.20		0.20	0.20	mg/L		11/04/19 16:18	11/05/19 16:24	1
2,4,5-Trichlorophenol	<0.10		0.10	0.10	mg/L		11/04/19 16:18	11/05/19 16:24	1
2,4,6-Trichlorophenol	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 16:24	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2-Fluorobiphenyl (Surr)	*72*		*34 - 110*	*11/04/19 16:18*	*11/05/19 16:24*	*1*
2-Fluorophenol (Surr)	*51*		*27 - 110*	*11/04/19 16:18*	*11/05/19 16:24*	*1*
Nitrobenzene-d5 (Surr)	*80*		*36 - 120*	*11/04/19 16:18*	*11/05/19 16:24*	*1*
Phenol-d5 (Surr)	*37*		*20 - 100*	*11/04/19 16:18*	*11/05/19 16:24*	*1*
Terphenyl-d14 (Surr)	*103*		*40 - 145*	*11/04/19 16:18*	*11/05/19 16:24*	*1*
2,4,6-Tribromophenol (Surr)	*100*		*40 - 145*	*11/04/19 16:18*	*11/05/19 16:24*	*1*

Method: 6010C - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<0.010		0.050	0.010	mg/L		11/01/19 15:45	11/05/19 02:04	1
Barium	**0.28**	**J**	0.50	0.050	mg/L		11/01/19 15:45	11/05/19 02:04	1
Cadmium	<0.0020		0.0050	0.0020	mg/L		11/01/19 15:45	11/05/19 02:04	1
Chromium	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:04	1
Copper	**0.011**	**J**	0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:04	1
Lead	<0.0075	^	0.050	0.0075	mg/L		11/01/19 15:45	11/05/19 02:04	1
Nickel	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:04	1
Selenium	<0.020		0.050	0.020	mg/L		11/01/19 15:45	11/05/19 02:04	1

Client Sample ID: M01-Below Water

Date Collected: 10/22/19 11:05
Date Received: 10/23/19 08:30

Lab Sample ID: 500-172213-2

Matrix: Solid

Method: 6010C - Metals (ICP) - TCLP (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Silver	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 02:04	1
Zinc	**0.27**	**B**	0.10	0.020	mg/L		11/01/19 15:45	11/05/19 02:04	1

Method: 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	<0.00020		0.00020	0.00020	mg/L		11/04/19 09:15	11/05/19 08:01	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Flashpoint	**>176**		99.0	99.0	Degrees F			11/06/19 16:17	1
Cyanide, Total	<0.21		0.41	0.21	mg/Kg		11/01/19 10:15	11/01/19 15:33	1
Sulfide	<4.5		9.5	4.5	mg/Kg		11/07/19 20:27	11/08/19 02:25	1
pH	**6.6**		0.2	0.2	SU			10/25/19 11:57	1
Free Liquid	**Pass**				No Unit			11/06/19 14:50	1
Specific Gravity	**2.2521**				NONE			11/07/19 17:18	1

Client Sample Results

Client Sample ID: M01-Below Water

Date Collected: 10/22/19 11:05
Date Received: 10/23/19 08:30

Lab Sample ID: 500-172213-2

Matrix: Solid
Percent Solids: 96.3

Method: 8082A - Polychlorinated Biphenyls (PCBs) by Gas Chromatography

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
PCB-1016	<6.1		17	6.1	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1
PCB-1221	<7.6		17	7.6	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1
PCB-1232	<7.5		17	7.5	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1
PCB-1242	<5.7		17	5.7	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1
PCB-1248	<6.8		17	6.8	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1
PCB-1254	<3.7		17	3.7	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1
PCB-1260	<8.5		17	8.5	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1
Polychlorinated biphenyls, Total	<3.3		17	3.3	ug/Kg	☼	11/01/19 18:07	11/02/19 08:16	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Tetrachloro-m-xylene	*90*		*49 - 129*	*11/01/19 18:07*	*11/02/19 08:16*	*1*
DCB Decachlorobiphenyl	*105*		*37 - 121*	*11/01/19 18:07*	*11/02/19 08:16*	*1*

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Chlorine	**2.0**		0.021	0.021	%	☼	10/29/19 11:59	10/29/19 17:45	1

1
2
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12
13
14
15

Definitions/Glossary

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Qualifiers

Metals

Qualifier	Qualifier Description
^	ICV,CCV,ICB,CCB, ISA, ISB, CRI, CRA, DLCK or MRL standard: Instrument related QC is outside acceptance limits.
B	Compound was found in the blank and sample.
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
PQL	Practical Quantitation Limit
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)

QC Association Summary

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

GC/MS VOA

Leach Batch: 513169

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	1311	
500-172213-2	M01-Below Water	TCLP	Solid	1311	
LB 500-513169/1-A	Method Blank	TCLP	Solid	1311	

Analysis Batch: 513331

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	8260B	513169
500-172213-2	M01-Below Water	TCLP	Solid	8260B	513169
LB 500-513169/1-A	Method Blank	TCLP	Solid	8260B	513169
MB 500-513331/7	Method Blank	Total/NA	Solid	8260B	
LCS 500-513331/5	Lab Control Sample	Total/NA	Solid	8260B	

GC/MS Semi VOA

Leach Batch: 512951

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	1311	
500-172213-2	M01-Below Water	TCLP	Solid	1311	
LB 500-512951/1-F	Method Blank	TCLP	Solid	1311	

Prep Batch: 513495

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	3510C	512951
500-172213-2	M01-Below Water	TCLP	Solid	3510C	512951
LB 500-512951/1-F	Method Blank	TCLP	Solid	3510C	512951
MB 500-513495/1-A	Method Blank	Total/NA	Solid	3510C	
LCS 500-513495/2-A	Lab Control Sample	Total/NA	Solid	3510C	

Analysis Batch: 513569

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	8270D	513495
500-172213-2	M01-Below Water	TCLP	Solid	8270D	513495
LB 500-512951/1-F	Method Blank	TCLP	Solid	8270D	513495
MB 500-513495/1-A	Method Blank	Total/NA	Solid	8270D	513495
LCS 500-513495/2-A	Lab Control Sample	Total/NA	Solid	8270D	513495

GC Semi VOA

Prep Batch: 513218

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	3541	
500-172213-2	M01-Below Water	Total/NA	Solid	3541	
MB 500-513218/1-A	Method Blank	Total/NA	Solid	3541	
LCS 500-513218/2-A	Lab Control Sample	Total/NA	Solid	3541	

Analysis Batch: 513231

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	8082A	513218
500-172213-2	M01-Below Water	Total/NA	Solid	8082A	513218
MB 500-513218/1-A	Method Blank	Total/NA	Solid	8082A	513218
LCS 500-513218/2-A	Lab Control Sample	Total/NA	Solid	8082A	513218

Metals

Leach Batch: 512951

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	1311	
500-172213-2	M01-Below Water	TCLP	Solid	1311	
LB 500-512951/1-B	Method Blank	TCLP	Solid	1311	
LB 500-512951/1-C	Method Blank	TCLP	Solid	1311	

Prep Batch: 513182

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	3010A	512951
500-172213-2	M01-Below Water	TCLP	Solid	3010A	512951
LB 500-512951/1-B	Method Blank	TCLP	Solid	3010A	512951
LCS 500-513182/2-A	Lab Control Sample	Total/NA	Solid	3010A	

Prep Batch: 513400

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	7470A	512951
500-172213-2	M01-Below Water	TCLP	Solid	7470A	512951
LB 500-512951/1-C	Method Blank	TCLP	Solid	7470A	512951
MB 500-513400/11-A	Method Blank	Total/NA	Solid	7470A	
LCS 500-513400/12-A	Lab Control Sample	Total/NA	Solid	7470A	

Analysis Batch: 513587

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	6010C	513182
500-172213-2	M01-Below Water	TCLP	Solid	6010C	513182
LB 500-512951/1-B	Method Blank	TCLP	Solid	6010C	513182
LCS 500-513182/2-A	Lab Control Sample	Total/NA	Solid	6010C	513182

Analysis Batch: 513622

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	TCLP	Solid	7470A	513400
500-172213-2	M01-Below Water	TCLP	Solid	7470A	513400
LB 500-512951/1-C	Method Blank	TCLP	Solid	7470A	513400
MB 500-513400/11-A	Method Blank	Total/NA	Solid	7470A	513400
LCS 500-513400/12-A	Lab Control Sample	Total/NA	Solid	7470A	513400

General Chemistry

Analysis Batch: 511702

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	Moisture	
500-172213-2	M01-Below Water	Total/NA	Solid	Moisture	
500-172213-1 DU	M01-Above Water	Total/NA	Solid	Moisture	

Analysis Batch: 511852

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	9045D	
500-172213-2	M01-Below Water	Total/NA	Solid	9045D	
LCS 500-511852/5	Lab Control Sample	Total/NA	Solid	9045D	
LCSD 500-511852/6	Lab Control Sample Dup	Total/NA	Solid	9045D	

QC Association Summary

General Chemistry

Prep Batch: 513080

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	9010B	
500-172213-2	M01-Below Water	Total/NA	Solid	9010B	
MB 500-513080/1-A	Method Blank	Total/NA	Solid	9010B	
HLCS 500-513080/2-A	Lab Control Sample	Total/NA	Solid	9010B	
LCS 500-513080/3-A	Lab Control Sample	Total/NA	Solid	9010B	
LLCS 500-513080/4-A	Lab Control Sample	Total/NA	Solid	9010B	

Analysis Batch: 513417

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	9014	513080
500-172213-2	M01-Below Water	Total/NA	Solid	9014	513080
MB 500-513080/1-A	Method Blank	Total/NA	Solid	9014	513080
HLCS 500-513080/2-A	Lab Control Sample	Total/NA	Solid	9014	513080
LCS 500-513080/3-A	Lab Control Sample	Total/NA	Solid	9014	513080
LLCS 500-513080/4-A	Lab Control Sample	Total/NA	Solid	9014	513080

Analysis Batch: 513953

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	9095B	
500-172213-2	M01-Below Water	Total/NA	Solid	9095B	

Analysis Batch: 513974

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	1010A	
500-172213-2	M01-Below Water	Total/NA	Solid	1010A	

Analysis Batch: 514221

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	SM 2710F	
500-172213-2	M01-Below Water	Total/NA	Solid	SM 2710F	
500-172213-2 DU	M01-Below Water	Total/NA	Solid	SM 2710F	

Prep Batch: 514241

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	9030B	
500-172213-2	M01-Below Water	Total/NA	Solid	9030B	
MB 500-514241/1-A	Method Blank	Total/NA	Solid	9030B	
LCS 500-514241/2-A	Lab Control Sample	Total/NA	Solid	9030B	

Analysis Batch: 514257

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	9034	514241
500-172213-2	M01-Below Water	Total/NA	Solid	9034	514241
MB 500-514241/1-A	Method Blank	Total/NA	Solid	9034	514241
LCS 500-514241/2-A	Lab Control Sample	Total/NA	Solid	9034	514241

Prep Batch: 593500

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	5050	
500-172213-2	M01-Below Water	Total/NA	Solid	5050	
MB 680-593500/1-A	Method Blank	Total/NA	Solid	5050	

General Chemistry (Continued)

Prep Batch: 593500 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
LCS 680-593500/2-A	Lab Control Sample	Total/NA	Solid	5050	
500-172213-1 MS	M01-Above Water	Total/NA	Solid	5050	
500-172213-1 MSD	M01-Above Water	Total/NA	Solid	5050	
500-172213-1 DU	M01-Above Water	Total/NA	Solid	5050	

Analysis Batch: 593570

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-172213-1	M01-Above Water	Total/NA	Solid	9251	593500
500-172213-2	M01-Below Water	Total/NA	Solid	9251	593500
MB 680-593500/1-A	Method Blank	Total/NA	Solid	9251	593500
LCS 680-593500/2-A	Lab Control Sample	Total/NA	Solid	9251	593500
500-172213-1 MS	M01-Above Water	Total/NA	Solid	9251	593500
500-172213-1 MSD	M01-Above Water	Total/NA	Solid	9251	593500
500-172213-1 DU	M01-Above Water	Total/NA	Solid	9251	593500

Surrogate Summary

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Method: 8260B - Volatile Organic Compounds (GC/MS)

Matrix: Solid

Prep Type: Total/NA

Percent Surrogate Recovery (Acceptance Limits)

Lab Sample ID	Client Sample ID	BFB (72-124)	DBFM (75-120)	DCA (75-126)	TOL (75-120)
LCS 500-513331/5	Lab Control Sample	108	94	92	107
MB 500-513331/7	Method Blank	114	94	98	104

Surrogate Legend

BFB = 4-Bromofluorobenzene (Surr)
DBFM = Dibromofluoromethane (Surr)
DCA = 1,2-Dichloroethane-d4 (Surr)
TOL = Toluene-d8 (Surr)

Method: 8260B - Volatile Organic Compounds (GC/MS)

Matrix: Solid

Prep Type: TCLP

Percent Surrogate Recovery (Acceptance Limits)

Lab Sample ID	Client Sample ID	BFB (72-124)	DBFM (75-120)	DCA (75-126)	TOL (75-120)
500-172213-1	M01-Above Water	113	94	96	104
500-172213-2	M01-Below Water	114	94	98	105
LB 500-513169/1-A	Method Blank	112	90	91	107

Surrogate Legend

BFB = 4-Bromofluorobenzene (Surr)
DBFM = Dibromofluoromethane (Surr)
DCA = 1,2-Dichloroethane-d4 (Surr)
TOL = Toluene-d8 (Surr)

Method: 8270D - Semivolatile Organic Compounds (GC/MS)

Matrix: Solid

Prep Type: Total/NA

Percent Surrogate Recovery (Acceptance Limits)

Lab Sample ID	Client Sample ID	FBP (34-110)	2FP (27-110)	NBZ (36-120)	PHL (20-100)	TPHL (40-145)	TBP (40-145)
LCS 500-513495/2-A	Lab Control Sample	79	51	86	35	107	106
MB 500-513495/1-A	Method Blank	99	47	89	34	108	101

Surrogate Legend

FBP = 2-Fluorobiphenyl (Surr)
2FP = 2-Fluorophenol (Surr)
NBZ = Nitrobenzene-d5 (Surr)
PHL = Phenol-d5 (Surr)
TPHL = Terphenyl-d14 (Surr)
TBP = 2,4,6-Tribromophenol (Surr)

Method: 8270D - Semivolatile Organic Compounds (GC/MS)

Matrix: Solid

Prep Type: TCLP

Percent Surrogate Recovery (Acceptance Limits)

Lab Sample ID	Client Sample ID	FBP (34-110)	2FP (27-110)	NBZ (36-120)	PHL (20-100)	TPHL (40-145)	TBP (40-145)
500-172213-1	M01-Above Water	62	53	75	36	98	89
500-172213-2	M01-Below Water	72	51	80	37	103	100
LB 500-512951/1-F	Method Blank	72	47	81	37	105	107

Surrogate Legend

FBP = 2-Fluorobiphenyl (Surr)
2FP = 2-Fluorophenol (Surr)
NBZ = Nitrobenzene-d5 (Surr)
PHL = Phenol-d5 (Surr)
TPHL = Terphenyl-d14 (Surr)
TBP = 2,4,6-Tribromophenol (Surr)

Method: 8082A - Polychlorinated Biphenyls (PCBs) by Gas Chromatography

Matrix: Solid **Prep Type: Total/NA**

Percent Surrogate Recovery (Acceptance Limits)

Lab Sample ID	Client Sample ID	TCX1 (49-129)	DCBP1 (37-121)
500-172213-1	M01-Above Water	100	107
500-172213-2	M01-Below Water	90	105
LCS 500-513218/2-A	Lab Control Sample	119	113
MB 500-513218/1-A	Method Blank	102	102

Surrogate Legend

TCX = Tetrachloro-m-xylene
DCBP = DCB Decachlorobiphenyl

QC Sample Results

Method: 8260B - Volatile Organic Compounds (GC/MS)

Lab Sample ID: MB 500-513331/7
Matrix: Solid
Analysis Batch: 513331

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Benzene	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1
Carbon tetrachloride	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1
Chlorobenzene	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1
Chloroform	<0.0010		0.0020	0.0010	mg/L			11/04/19 11:53	1
1,2-Dichloroethane	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1
1,1-Dichloroethene	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1
Methyl Ethyl Ketone	<0.0025		0.0050	0.0025	mg/L			11/04/19 11:53	1
Tetrachloroethene	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1
Trichloroethene	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1
Vinyl chloride	<0.00050		0.0010	0.00050	mg/L			11/04/19 11:53	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene (Surr)	*114*		*72 - 124*		*11/04/19 11:53*	*1*
Dibromofluoromethane (Surr)	*94*		*75 - 120*		*11/04/19 11:53*	*1*
1,2-Dichloroethane-d4 (Surr)	*98*		*75 - 126*		*11/04/19 11:53*	*1*
Toluene-d8 (Surr)	*104*		*75 - 120*		*11/04/19 11:53*	*1*

Lab Sample ID: LCS 500-513331/5
Matrix: Solid
Analysis Batch: 513331

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Benzene	0.0500	0.0548		mg/L		110	70 - 120
Carbon tetrachloride	0.0500	0.0473		mg/L		95	59 - 133
Chlorobenzene	0.0500	0.0509		mg/L		102	70 - 120
Chloroform	0.0500	0.0477		mg/L		95	70 - 120
1,2-Dichloroethane	0.0500	0.0503		mg/L		101	68 - 127
1,1-Dichloroethene	0.0500	0.0506		mg/L		101	67 - 122
Methyl Ethyl Ketone	0.0500	0.0636		mg/L		127	46 - 144
Tetrachloroethene	0.0500	0.0503		mg/L		101	70 - 128
Trichloroethene	0.0500	0.0506		mg/L		101	70 - 125
Vinyl chloride	0.0500	0.0551		mg/L		110	64 - 126

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
4-Bromofluorobenzene (Surr)	*108*		*72 - 124*
Dibromofluoromethane (Surr)	*94*		*75 - 120*
1,2-Dichloroethane-d4 (Surr)	*92*		*75 - 126*
Toluene-d8 (Surr)	*107*		*75 - 120*

Lab Sample ID: LB 500-513169/1-A
Matrix: Solid
Analysis Batch: 513331

Client Sample ID: Method Blank
Prep Type: TCLP

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Benzene	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20
Carbon tetrachloride	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20
Chlorobenzene	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20
Chloroform	<0.020		0.040	0.020	mg/L			11/04/19 12:21	20

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Method: 8260B - Volatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: LB 500-513169/1-A
Matrix: Solid
Analysis Batch: 513331

Client Sample ID: Method Blank
Prep Type: TCLP

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1,2-Dichloroethane	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20
1,1-Dichloroethene	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20
Methyl Ethyl Ketone	<0.050		0.10	0.050	mg/L			11/04/19 12:21	20
Tetrachloroethene	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20
Trichloroethene	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20
Vinyl chloride	<0.010		0.020	0.010	mg/L			11/04/19 12:21	20

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene (Surr)	*112*		*72 - 124*		*11/04/19 12:21*	*20*
Dibromofluoromethane (Surr)	*90*		*75 - 120*		*11/04/19 12:21*	*20*
1,2-Dichloroethane-d4 (Surr)	*91*		*75 - 126*		*11/04/19 12:21*	*20*
Toluene-d8 (Surr)	*107*		*75 - 120*		*11/04/19 12:21*	*20*

Method: 8270D - Semivolatile Organic Compounds (GC/MS)

Lab Sample ID: MB 500-513495/1-A
Matrix: Solid
Analysis Batch: 513569

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 513495

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1,4-Dichlorobenzene	<0.0020		0.0020	0.0020	mg/L		11/04/19 16:18	11/05/19 13:12	1
2,4-Dinitrotoluene	<0.0010		0.0010	0.0010	mg/L		11/04/19 16:18	11/05/19 13:12	1
Hexachlorobenzene	<0.00050		0.00050	0.00050	mg/L		11/04/19 16:18	11/05/19 13:12	1
Hexachlorobutadiene	<0.0050		0.0050	0.0050	mg/L		11/04/19 16:18	11/05/19 13:12	1
Hexachloroethane	<0.0050		0.0050	0.0050	mg/L		11/04/19 16:18	11/05/19 13:12	1
2-Methylphenol	<0.0020		0.0020	0.0020	mg/L		11/04/19 16:18	11/05/19 13:12	1
3 & 4 Methylphenol	<0.0020		0.0020	0.0020	mg/L		11/04/19 16:18	11/05/19 13:12	1
Nitrobenzene	<0.0010		0.0010	0.0010	mg/L		11/04/19 16:18	11/05/19 13:12	1
Pentachlorophenol	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 13:12	1
Pyridine	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 13:12	1
2,4,5-Trichlorophenol	<0.010		0.010	0.010	mg/L		11/04/19 16:18	11/05/19 13:12	1
2,4,6-Trichlorophenol	<0.0050		0.0050	0.0050	mg/L		11/04/19 16:18	11/05/19 13:12	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2-Fluorobiphenyl (Surr)	*99*		*34 - 110*	*11/04/19 16:18*	*11/05/19 13:12*	*1*
2-Fluorophenol (Surr)	*47*		*27 - 110*	*11/04/19 16:18*	*11/05/19 13:12*	*1*
Nitrobenzene-d5 (Surr)	*89*		*36 - 120*	*11/04/19 16:18*	*11/05/19 13:12*	*1*
Phenol-d5 (Surr)	*34*		*20 - 100*	*11/04/19 16:18*	*11/05/19 13:12*	*1*
Terphenyl-d14 (Surr)	*108*		*40 - 145*	*11/04/19 16:18*	*11/05/19 13:12*	*1*
2,4,6-Tribromophenol (Surr)	*101*		*40 - 145*	*11/04/19 16:18*	*11/05/19 13:12*	*1*

Lab Sample ID: LCS 500-513495/2-A
Matrix: Solid
Analysis Batch: 513569

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 513495

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
1,4-Dichlorobenzene	0.0400	0.0230		mg/L		58	23 - 110
2,4-Dinitrotoluene	0.0400	0.0425		mg/L		106	63 - 129

QC Sample Results

Method: 8270D - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: LCS 500-513495/2-A
Matrix: Solid
Analysis Batch: 513569

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 513495

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Hexachlorobenzene	0.0400	0.0406		mg/L		102	61 - 126
Hexachlorobutadiene	0.0400	0.0267		mg/L		67	20 - 100
Hexachloroethane	0.0400	0.0209		mg/L		52	20 - 100
2-Methylphenol	0.0400	0.0298		mg/L		74	53 - 115
3 & 4 Methylphenol	0.0400	0.0288		mg/L		72	50 - 116
Nitrobenzene	0.0400	0.0337		mg/L		84	54 - 121
Pentachlorophenol	0.0800	0.0514		mg/L		64	42 - 148
Pyridine	0.0800	0.0300		mg/L		38	15 - 110
2,4,5-Trichlorophenol	0.0400	0.0400		mg/L		100	63 - 124
2,4,6-Trichlorophenol	0.0400	0.0403		mg/L		101	62 - 121

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
2-Fluorobiphenyl (Surr)	*79*		*34 - 110*
2-Fluorophenol (Surr)	*51*		*27 - 110*
Nitrobenzene-d5 (Surr)	*86*		*36 - 120*
Phenol-d5 (Surr)	*35*		*20 - 100*
Terphenyl-d14 (Surr)	*107*		*40 - 145*
2,4,6-Tribromophenol (Surr)	*106*		*40 - 145*

Lab Sample ID: LB 500-512951/1-F
Matrix: Solid
Analysis Batch: 513569

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 513495

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1,4-Dichlorobenzene	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 14:48	1
2,4-Dinitrotoluene	<0.010		0.010	0.010	mg/L		11/04/19 16:18	11/05/19 14:48	1
Hexachlorobenzene	<0.0050		0.0050	0.0050	mg/L		11/04/19 16:18	11/05/19 14:48	1
Hexachlorobutadiene	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 14:48	1
Hexachloroethane	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 14:48	1
2-Methylphenol	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 14:48	1
3 & 4 Methylphenol	<0.020		0.020	0.020	mg/L		11/04/19 16:18	11/05/19 14:48	1
Nitrobenzene	<0.010		0.010	0.010	mg/L		11/04/19 16:18	11/05/19 14:48	1
Pentachlorophenol	<0.20		0.20	0.20	mg/L		11/04/19 16:18	11/05/19 14:48	1
Pyridine	<0.20		0.20	0.20	mg/L		11/04/19 16:18	11/05/19 14:48	1
2,4,5-Trichlorophenol	<0.10		0.10	0.10	mg/L		11/04/19 16:18	11/05/19 14:48	1
2,4,6-Trichlorophenol	<0.050		0.050	0.050	mg/L		11/04/19 16:18	11/05/19 14:48	1

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2-Fluorobiphenyl (Surr)	*72*		*34 - 110*	*11/04/19 16:18*	*11/05/19 14:48*	*1*
2-Fluorophenol (Surr)	*47*		*27 - 110*	*11/04/19 16:18*	*11/05/19 14:48*	*1*
Nitrobenzene-d5 (Surr)	*81*		*36 - 120*	*11/04/19 16:18*	*11/05/19 14:48*	*1*
Phenol-d5 (Surr)	*37*		*20 - 100*	*11/04/19 16:18*	*11/05/19 14:48*	*1*
Terphenyl-d14 (Surr)	*105*		*40 - 145*	*11/04/19 16:18*	*11/05/19 14:48*	*1*
2,4,6-Tribromophenol (Surr)	*107*		*40 - 145*	*11/04/19 16:18*	*11/05/19 14:48*	*1*

QC Sample Results

Client: TRC Environmental Corporation. Job ID: 500-172213-1
Project/Site: Wauleco - 189597.0008 P3T2

Method: 8082A - Polychlorinated Biphenyls (PCBs) by Gas Chromatography

Lab Sample ID: MB 500-513218/1-A **Client Sample ID: Method Blank**
Matrix: Solid **Prep Type: Total/NA**
Analysis Batch: 513231 **Prep Batch: 513218**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
PCB-1016	<5.9		17	5.9	ug/Kg		11/01/19 18:07	11/02/19 07:30	1
PCB-1221	<7.3		17	7.3	ug/Kg		11/01/19 18:07	11/02/19 07:30	1
PCB-1232	<7.3		17	7.3	ug/Kg		11/01/19 18:07	11/02/19 07:30	1
PCB-1242	<5.5		17	5.5	ug/Kg		11/01/19 18:07	11/02/19 07:30	1
PCB-1248	<6.6		17	6.6	ug/Kg		11/01/19 18:07	11/02/19 07:30	1
PCB-1254	<3.6		17	3.6	ug/Kg		11/01/19 18:07	11/02/19 07:30	1
PCB-1260	<8.2		17	8.2	ug/Kg		11/01/19 18:07	11/02/19 07:30	1
Polychlorinated biphenyls, Total	<3.2		17	3.2	ug/Kg		11/01/19 18:07	11/02/19 07:30	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Tetrachloro-m-xylene	*102*		*49 - 129*	*11/01/19 18:07*	*11/02/19 07:30*	*1*
DCB Decachlorobiphenyl	*102*		*37 - 121*	*11/01/19 18:07*	*11/02/19 07:30*	*1*

Lab Sample ID: LCS 500-513218/2-A **Client Sample ID: Lab Control Sample**
Matrix: Solid **Prep Type: Total/NA**
Analysis Batch: 513231 **Prep Batch: 513218**

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
PCB-1016			167	192		ug/Kg		115	57 - 120		
PCB-1260			167	167		ug/Kg		100	61 - 125		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
Tetrachloro-m-xylene	*119*		*49 - 129*
DCB Decachlorobiphenyl	*113*		*37 - 121*

Method: 6010C - Metals (ICP)

Lab Sample ID: LCS 500-513182/2-A **Client Sample ID: Lab Control Sample**
Matrix: Solid **Prep Type: Total/NA**
Analysis Batch: 513587 **Prep Batch: 513182**

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Arsenic			0.100	0.0975		mg/L		97	80 - 120		
Barium			0.500	0.508		mg/L		102	80 - 120		
Cadmium			0.0500	0.0478		mg/L		96	80 - 120		
Chromium			0.200	0.199		mg/L		100	80 - 120		
Copper			0.250	0.249		mg/L		100	80 - 120		
Lead			0.100	0.0975		mg/L		97	80 - 120		
Nickel			0.500	0.491		mg/L		98	80 - 120		
Selenium			0.100	0.0898		mg/L		90	80 - 120		
Silver			0.0500	0.0485		mg/L		97	80 - 120		
Zinc			0.500	0.490		mg/L		98	80 - 120		

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: LB 500-512951/1-B
Matrix: Solid
Analysis Batch: 513587

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 513182

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<0.010		0.050	0.010	mg/L		11/01/19 15:45	11/05/19 01:31	1
Barium	<0.050		0.50	0.050	mg/L		11/01/19 15:45	11/05/19 01:31	1
Cadmium	<0.0020		0.0050	0.0020	mg/L		11/01/19 15:45	11/05/19 01:31	1
Chromium	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 01:31	1
Copper	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 01:31	1
Lead	<0.0075		0.050	0.0075	mg/L		11/01/19 15:45	11/05/19 01:31	1
Nickel	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 01:31	1
Selenium	<0.020		0.050	0.020	mg/L		11/01/19 15:45	11/05/19 01:31	1
Silver	<0.010		0.025	0.010	mg/L		11/01/19 15:45	11/05/19 01:31	1
Zinc	0.0646	J	0.10	0.020	mg/L		11/01/19 15:45	11/05/19 01:31	1

Method: 7470A - Mercury (CVAA)

Lab Sample ID: MB 500-513400/11-A
Matrix: Solid
Analysis Batch: 513622

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 513400

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	<0.00020		0.00020	0.00020	mg/L		11/04/19 09:15	11/05/19 07:48	1

Lab Sample ID: LCS 500-513400/12-A
Matrix: Solid
Analysis Batch: 513622

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 513400

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Mercury			0.00200	0.00203		mg/L		101	80 - 120		

Lab Sample ID: LB 500-512951/1-C
Matrix: Solid
Analysis Batch: 513622

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 513400

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	<0.00020		0.00020	0.00020	mg/L		11/04/19 09:15	11/05/19 07:53	1

Method: 9014 - Cyanide

Lab Sample ID: MB 500-513080/1-A
Matrix: Solid
Analysis Batch: 513417

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 513080

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Cyanide, Total	<0.25		0.50	0.25	mg/Kg		11/01/19 10:15	11/01/19 15:20	1

Lab Sample ID: HLCS 500-513080/2-A
Matrix: Solid
Analysis Batch: 513417

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 513080

Analyte			Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Cyanide, Total			20.0	20.5		mg/Kg		102	90 - 110		

QC Sample Results

Method: 9014 - Cyanide (Continued)

Lab Sample ID: LCS 500-513080/3-A
Matrix: Solid
Analysis Batch: 513417

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 513080

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Cyanide, Total	5.00	5.34		mg/Kg		107	85 - 115

Lab Sample ID: LLCS 500-513080/4-A
Matrix: Solid
Analysis Batch: 513417

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 513080

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec. Limits
Cyanide, Total	2.00	2.10		mg/Kg		105	75 - 125

Method: 9034 - Sulfide, Acid soluble and Insoluble (Titrimetric)

Lab Sample ID: MB 500-514241/1-A
Matrix: Solid
Analysis Batch: 514257

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 514241

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sulfide	<4.7		10	4.7	mg/Kg		11/07/19 20:27	11/08/19 01:50	1

Lab Sample ID: LCS 500-514241/2-A
Matrix: Solid
Analysis Batch: 514257

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 514241

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Sulfide	207	182		mg/Kg		88	80 - 120

Method: 9251 - Chlorine, Total

Lab Sample ID: MB 680-593500/1-A
Matrix: Solid
Analysis Batch: 593570

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 593500

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Chlorine	<0.020		0.020	0.020	%		10/29/19 11:59	10/29/19 17:45	1

Lab Sample ID: LCS 680-593500/2-A
Matrix: Solid
Analysis Batch: 593570

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 593500

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Total Chlorine	0.990	0.776		%		78	70 - 130

Lab Sample ID: 500-172213-1 MS
Matrix: Solid
Analysis Batch: 593570

Client Sample ID: M01-Above Water
Prep Type: Total/NA
Prep Batch: 593500

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Total Chlorine	<0.020		0.201	0.163		%	☼	81	70 - 130

QC Sample Results

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Method: 9251 - Chlorine, Total (Continued)

Lab Sample ID: 500-172213-1 MSD
Matrix: Solid
Analysis Batch: 593570

Client Sample ID: M01-Above Water
Prep Type: Total/NA
Prep Batch: 593500

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Total Chlorine	<0.020		0.199	0.167		%	☼	84	70 - 130	2	40

Lab Sample ID: 500-172213-1 DU
Matrix: Solid
Analysis Batch: 593570

Client Sample ID: M01-Above Water
Prep Type: Total/NA
Prep Batch: 593500

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Total Chlorine	<0.020		<0.020		%	☼	NC	40

Method: SM 2710F - Specific Gravity, Density

Lab Sample ID: 500-172213-2 DU
Matrix: Solid
Analysis Batch: 514221

Client Sample ID: M01-Below Water
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Specific Gravity	2.2521		2.24		NONE		0.4	

Lab Chronicle

Client Sample ID: M01-Above Water
Lab Sample ID: 500-172213-1
Date Collected: 10/22/19 10:45
Matrix: Solid
Date Received: 10/23/19 08:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
TCLP	Leach	1311			513169	11/01/19 14:13	GCA	TAL CHI
TCLP	Analysis	8260B		20	513331	11/04/19 15:04	STW	TAL CHI
TCLP	Leach	1311			512951	10/31/19 12:15	GCA	TAL CHI
TCLP	Prep	3510C			513495	11/04/19 16:18	CMC	TAL CHI
TCLP	Analysis	8270D		1	513569	11/05/19 16:00	AJD	TAL CHI
TCLP	Leach	1311			512951	10/31/19 12:15	GCA	TAL CHI
TCLP	Prep	3010A			513182	11/01/19 15:45	BDE	TAL CHI
TCLP	Analysis	6010C		1	513587	11/05/19 02:00	EEN	TAL CHI
TCLP	Leach	1311			512951	10/31/19 12:15	GCA	TAL CHI
TCLP	Prep	7470A			513400	11/04/19 09:15	MJG	TAL CHI
TCLP	Analysis	7470A		1	513622	11/05/19 07:59	MJG	TAL CHI
Total/NA	Analysis	1010A		1	513974		MS	TAL CHI
					(Start)	11/06/19 14:44		
					(End)	11/06/19 16:17		
Total/NA	Prep	9010B			513080	11/01/19 10:15	MS	TAL CHI
Total/NA	Analysis	9014		1	513417		MS	TAL CHI
					(Start)	11/01/19 15:33		
					(End)	11/01/19 15:33		
Total/NA	Prep	9030B			514241	11/07/19 20:27	SJP	TAL CHI
Total/NA	Analysis	9034		1	514257	11/08/19 02:23	SJP	TAL CHI
Total/NA	Analysis	9045D		1	511852		TMS	TAL CHI
					(Start)	10/25/19 11:54		
					(End)	10/25/19 11:57		
Total/NA	Analysis	9095B		1	513953		SJP	TAL CHI
					(Start)	11/06/19 14:48		
					(End)	11/06/19 14:53		
Total/NA	Analysis	Moisture		1	511702	10/24/19 08:55	LWN	TAL CHI
Total/NA	Analysis	SM 2710F		1	514221	11/07/19 17:18	PFK	TAL CHI

Client Sample ID: M01-Above Water
Lab Sample ID: 500-172213-1
Date Collected: 10/22/19 10:45
Matrix: Solid
Date Received: 10/23/19 08:30
Percent Solids: 97.0

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3541			513218	11/01/19 18:07	ACK	TAL CHI
Total/NA	Analysis	8082A		1	513231	11/02/19 08:01	BJH	TAL CHI
Total/NA	Prep	5050			593500	10/29/19 11:59	SM	TAL SAV
Total/NA	Analysis	9251		1	593570	10/29/19 17:45	SM	TAL SAV

Client Sample ID: M01-Below Water
Lab Sample ID: 500-172213-2
Date Collected: 10/22/19 11:05
Matrix: Solid
Date Received: 10/23/19 08:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
TCLP	Leach	1311			513169	11/01/19 14:13	GCA	TAL CHI
TCLP	Analysis	8260B		20	513331	11/04/19 15:32	STW	TAL CHI

Lab Chronicle

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Client Sample ID: M01-Below Water

Lab Sample ID: 500-172213-2

Date Collected: 10/22/19 11:05
Date Received: 10/23/19 08:30

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
TCLP	Leach	1311			512951	10/31/19 12:15	GCA	TAL CHI
TCLP	Prep	3510C			513495	11/04/19 16:18	CMC	TAL CHI
TCLP	Analysis	8270D		1	513569	11/05/19 16:24	AJD	TAL CHI
TCLP	Leach	1311			512951	10/31/19 12:15	GCA	TAL CHI
TCLP	Prep	3010A			513182	11/01/19 15:45	BDE	TAL CHI
TCLP	Analysis	6010C		1	513587	11/05/19 02:04	EEN	TAL CHI
TCLP	Leach	1311			512951	10/31/19 12:15	GCA	TAL CHI
TCLP	Prep	7470A			513400	11/04/19 09:15	MJG	TAL CHI
TCLP	Analysis	7470A		1	513622	11/05/19 08:01	MJG	TAL CHI
Total/NA	Analysis	1010A		1	513974		MS	TAL CHI
					(Start)	11/06/19 16:17		
					(End)	11/06/19 17:50		
Total/NA	Prep	9010B			513080	11/01/19 10:15	MS	TAL CHI
Total/NA	Analysis	9014		1	513417		MS	TAL CHI
					(Start)	11/01/19 15:33		
					(End)	11/01/19 15:34		
Total/NA	Prep	9030B			514241	11/07/19 20:27	SJP	TAL CHI
Total/NA	Analysis	9034		1	514257	11/08/19 02:25	SJP	TAL CHI
Total/NA	Analysis	9045D		1	511852		TMS	TAL CHI
					(Start)	10/25/19 11:57		
					(End)	10/25/19 12:01		
Total/NA	Analysis	9095B		1	513953		SJP	TAL CHI
					(Start)	11/06/19 14:50		
					(End)	11/06/19 14:55		
Total/NA	Analysis	Moisture		1	511702	10/24/19 08:55	LWN	TAL CHI
Total/NA	Analysis	SM 2710F		1	514221	11/07/19 17:18	PFK	TAL CHI

Client Sample ID: M01-Below Water

Lab Sample ID: 500-172213-2

Date Collected: 10/22/19 11:05
Date Received: 10/23/19 08:30

Matrix: Solid
Percent Solids: 96.3

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3541			513218	11/01/19 18:07	ACK	TAL CHI
Total/NA	Analysis	8082A		1	513231	11/02/19 08:16	BJH	TAL CHI
Total/NA	Prep	5050			593500	10/29/19 11:59	SM	TAL SAV
Total/NA	Analysis	9251		1	593570	10/29/19 17:45	SM	TAL SAV

Laboratory References:

TAL CHI = Eurofins TestAmerica, Chicago, 2417 Bond Street, University Park, IL 60484, TEL (708)534-5200
TAL SAV = Eurofins TestAmerica, Savannah, 5102 LaRoche Avenue, Savannah, GA 31404, TEL (912)354-7858

Accreditation/Certification Summary

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Laboratory: Eurofins TestAmerica, Chicago

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
Wisconsin	State Program	999580010	08-31-20

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
SM 2710F		Solid	Specific Gravity

Laboratory: Eurofins TestAmerica, Savannah

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
	AFCEE	SAVLAB	
Alabama	State	41450	06-30-20
Alaska	State	GA00006	06-30-20
Alaska (UST)	State	17-016	09-30-20
ANAB	Dept. of Defense ELAP	L2463	09-22-22
ANAB	DoD	L2463	09-22-22
ANAB	ISO/IEC 17025	L2463.01	09-22-22
ANAB	ISO/IEC 17025	L2463.01	09-22-22
Arizona	State	AZ0808	12-14-19
Arkansas DEQ	State	19-015-0	02-01-20
Arkansas DEQ	State Program	88-0692	02-01-20
California	State	2939	06-30-20
Colorado	State	GA00006	12-31-19
Connecticut	State	PH-0161	03-31-21
Florida	NELAP	E87052	06-30-20
GA Dept. of Agriculture	State Program	N/A	06-12-20
Georgia	State	E87052	06-30-20
Georgia	State Program	N/A	06-30-20
Georgia (DW)	State	803	06-30-20
Guam	State	19-007R	04-17-20
Hawaii	State	<cert No.>	06-30-20
Indiana	State	C-GA-02	06-30-20
Iowa	State	353	09-22-20
Kansas	NELAP	E-10322	10-15-20
Kentucky (DW)	State	KY90084	12-31-19
Kentucky (UST)	State	<cert No.>	06-30-20
Kentucky (UST)	State Program	18	06-30-20
Kentucky (WW)	State	KY90084	12-31-19
Kentucky (WW)	State Program	90084	12-31-19
Louisiana	NELAP	02011	06-30-20
Louisiana (DW)	State	LA009	12-31-19
Maine	State	GA00006	09-26-20
Maryland	State	250	12-31-19
Massachusetts	State	M-GA006	06-30-20
Massachusetts	State Program	M-GA006	06-30-20
Michigan	State	9925	06-30-20
Mississippi	State	<cert No.>	06-30-20
Mississippi	State Program	N/A	06-30-20
Nebraska	State	NE-OS-7-04	06-30-20
Nebraska	State Program	TestAmerica-Savannah	06-30-20

Accreditation/Certification Summary

Client: TRC Environmental Corporation.
Project/Site: Wauleco - 189597.0008 P3T2

Job ID: 500-172213-1

Laboratory: Eurofins TestAmerica, Savannah (Continued)

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
New Hampshire	NELAP	2096	05-29-20
New Hampshire	NELAP	2096	05-29-20
New Jersey	NELAP	GA769	06-30-20
New Mexico	State	GA00006	06-30-20
New York	NELAP	10842	04-01-20
North Carolina (DW)	State	13701	07-31-20
North Carolina (DW)	State Program	13701	07-31-20
North Carolina (WW/SW)	State	269	12-31-19
North Carolina (WW/SW)	State Program	269	12-31-19
Oklahoma	State	9984	08-31-20
Pennsylvania	NELAP	68-00474	06-30-20
Puerto Rico	State	GA00006	01-01-20
South Carolina	State	98001	06-30-20
Tennessee	State	02961	06-30-20
Texas	NELAP	T104704185-19-13	11-30-19 *
Texas	NELAP	T1047004185-19-3	11-30-19
Texas	TCEQ Water Supply	T104704185	09-23-20
US Fish & Wildlife	US Federal Programs	LE058448-0	07-31-20
USDA	US Federal Programs	P330-18-00313	10-29-21
Virginia	NELAP	10509	06-14-20
Washington	State	C805	06-10-20
West Virginia (DW)	State	9950C	12-31-19
West Virginia (DW)	State Program	9950C	12-31-19
West Virginia DEP	State	094	11-30-19
Wisconsin	State	999819810	08-31-20
Wyoming	State	8TMS-L	06-30-20 *
Wyoming	State Program	8TMS-L	06-30-16 *

* Accreditation/Certification renewal pending - accreditation/certification considered valid.

Eurofins TestAmerica, Chicago
2417 Bond Street
University Park, IL 60484
Phone: 708-534-5200 Fax: 708-534-5211

Chain of Custody Record

eurofins
Environment Testing
TestAmerica

Client Information

Sampler: Tom Dushek
Phone: (608) 826-3644
Lab PM: Fredrick, Sandie
E-Mail: sandie.fredrick@testamericainc.com
Carrier Tracking No(s):
COC No: 500-76367-35477.1
Page: Page 1 of 1
Job #: 189597.0008

Client Contact: Mr. Bruce Iverson
Company: TRC Environmental Corporation.
Address: PO BOX 8923
City: Madison
State, Zip: WI, 53708-8923
Phone:
Email: biverson@trccompanies.com
Project Name: Protocol B Wauleco
Site: Wausau, WI

Due Date Requested:
TAT Requested (days): Normal
PO #: Purchase Order Requested – 144885
WO #:
Project #: 50015049
SSOW#:

Analysis Requested

500-172213 COC

Preservation Codes:

A - HCL	M - Hexane
B - NaOH	N - None
C - Zn Acetate	O - AsNaO2
D - Nitric Acid	P - Na2O4S
E - NaHSO4	Q - Na2SO3
F - MeOH	R - Na2S2O3
G - Amchlor	S - H2SO4
H - Ascorbic Acid	T - TSP Dodecahydrate
I - Ice	U - Acetone
J - DI Water	V - MCAA
K - EDTA	W - pH 4-5
L - EDA	Z - other (specify)

Other:

500-172213

	Sample Identification	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	WI Protocol B	Total Number of containers	Special Instructions/Note:
				Preservation Code:						
1	M01 - Above Water	10/22/19	1045	G	Solid	N	N	✓	2	
2	M01 - Below Water	↓	1105	G	Solid	N	N	✓	2	

Possible Hazard Identification
☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown* ☐ *Radiological*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For ________ Months*

Deliverable Requested: I, II, III, IV, Other (specify)
Special Instructions/QC Requirements:

Empty Kit Relinquished by: | Date: | Time: | Method of Shipment:

Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
T.J. Dushek	10/22/19 1600		Paula Buckley	10/23/19 0830	TA
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company

Custody Seals Intact: Δ Yes Δ No
Custody Seal No.:
Cooler Temperature(s) °C and Other Remarks: 1.1→2.1

Ver: 01/16/2019

ORIGIN ID:RRLA (708) 534-5200
SAMPLE RECEIPT
TESTAMERICA LABS
2417 BOND STREET

UNIVERSITY PARK, IL 60484
UNITED STATES US

SHIP DATE: 18OCT19
ACTWGT: 25.00 LB MAN
CAD: 525155/CAFE3211

551C3/2A3C/10AE

TO

TESTAMERICA CHICAGO
2417 BOND STREET

UNIVERSITY PARK IL 60484-3101
(708) 534-5200 REF:
INV:
PO: DEPT:

RMA:

FedEx
Express

E

J521113060501uv

FedEx
TRK# 0221 **7125 4941 1808**

WED - 23 OCT 10:30A
PRIORITY OVERNIGHT

XH JOTA

60484
IL-US
ORD

FID 977656 22OCT19 CWAA 568C3/2A3C/06A2

500-172213 Waybill

Eurofins TestAmerica, Chicago
2417 Bond Street
University Park, IL 60484
Phone: 708-534-5200 Fax: 708-534-5211

Chain of Custody Record

eurofins | Environment Testing TestAmerica

Client Information (Sub Contract Lab)	Sampler:	Lab PM: Fredrick, Sandie	Carrier Tracking No(s):	COC No: 500-127678.1
Client Contact: Shipping/Receiving	Phone:	E-Mail: sandie.fredrick@testamericainc.com	State of Origin: Wisconsin	Page: Page 1 of 1
Company: TestAmerica Laboratories, Inc.		Accreditations Required (See note): State Program - Wisconsin		Job #: 500-172213-1
Address: 5102 LaRoche Avenue, ,	**Due Date Requested:** 11/4/2019	**Analysis Requested**		**Preservation Codes:**
City: Savannah	**TAT Requested (days):**			
State, Zip: GA, 31404				
Phone: 912-354-7858(Tel) 912-352-0165(Fax)	PO #:			
Email:	WO #:			
Project Name: WISDOT MADISON	Project #: 50015049			
Site:	SSOW#:			Other:

Preservation Codes:

A - HCL	M - Hexane
B - NaOH	N - None
C - Zn Acetate	O - AsNaO2
D - Nitric Acid	P - Na2O4S
E - NaHSO4	Q - Na2SO3
F - MeOH	R - Na2S2O3
G - Amchlor	S - H2SO4
H - Ascorbic Acid	T - TSP Dodecahydrate
I - Ice	U - Acetone
J - DI Water	V - MCAA
K - EDTA	W - pH 4-5
L - EDA	Z - other (specify)

Sample Identification - Client ID (Lab ID)	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	9251_Total_Cl/5050	Total Number of containers	Special Instructions/Note:
	☒	☒	Preservation Code:		☒	☒		☒	
M01-Above Water (500-172213-1)	10/22/19	10:45 Central		Solid			X	1	
M01-Below Water (500-172213-2)	10/22/19	11:05 Central		Solid			X	1	

Note: Since laboratory accreditations are subject to change, TestAmerica Laboratories, Inc. places the ownership of method, analyte & accreditation compliance upon out subcontract laboratories. This sample shipment is forwarded under chain-of-custody. If the laboratory does not currently maintain accreditation in the State of Origin listed above for analysis/tests/matrix being analyzed, the samples must be shipped back to the TestAmerica laboratory or other instructions will be provided. Any changes to accreditation status should be brought to TestAmerica Laboratories, Inc. attention immediately. If all requested accreditations are current to date, return the signed Chain of Custody attesting to said complicance to TestAmerica Laboratories, Inc.

Possible Hazard Identification
Unconfirmed

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* ______ *Months*

Deliverable Requested: I, II, III, IV, Other (specify) Primary Deliverable Rank: 2

Special Instructions/QC Requirements:

Empty Kit Relinquished by:	Date:		Time:	Method of Shipment:	
Relinquished by:	Date/Time: 10/23/19 1600	Company TA	Received by:	Date/Time: 10/24/19 900	Company TASA
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Custody Seals Intact: Δ Yes Δ No	Custody Seal No.:		Cooler Temperature(s) °C and Other Remarks: 2.0/2.1		

Ver: 01/16/2019

Login Sample Receipt Checklist

Client: TRC Environmental Corporation.

Job Number: 500-172213-1

Login Number: 172213
List Number: 1
Creator: Buckley, Paula M

List Source: Eurofins TestAmerica, Chicago

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	True	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	2.1
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Login Sample Receipt Checklist

Client: TRC Environmental Corporation. Job Number: 500-172213-1

Login Number: 172213
List Number: 2
Creator: Weston, Pamela

List Source: Eurofins TestAmerica, Savannah
List Creation: 10/24/19 10:30 AM

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	N/A	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	N/A	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Appendix F
PCP Concentration and Mass Calculations

PCP Concentration and Mass Calculations

Table 4 and Appendix C includes the analyses of the cryogenic cores by Colorado State University for several parameters to characterize the LNAPL and PCP concentrations within the cores collected through, and slightly above and below, the residual phase LNAPL zone at Wauleco. This appendix describes the methods to calculate the PCP concentration in LNAPL and the mass of PCP present in the residual phase LNAPL and how the sample results are incorporated into the analysis.

The cores from the seven cryogenic borings were cut into 127 separate samples of approximately 1-inch thickness. Analytical results and calculations from these analyses are shown in Table 4.

These 127 samples were used to complete:

- 126 analyses for TPH through GRO and DRO. Sample 731 in boring M02 was not analyzed because of interference due to the presence of rocks.
- 125 analyses for PCP. Samples 721 in boring M01 and 731 in boring M02 were not analyzed because of interference due to the presence of rocks.
- 123 analyses for methane. Samples 701 and 703 in boring M01, sample 731 in boring M02, and sample 765 in boring M03 were not analyzed due to the presence of rocks.
- 118 samples for LNAPL saturation. Eight samples, in addition to those not analyzed for TPH, were not presented because of the presence of rocks in the sample or running out of sample volume.
- 122 samples for porosity. Samples 703, 706, and 714 in boring M01, 726 in boring M02, and 765 in boring M03 were not estimated due to rocks or other complications in the samples interfering with getting reasonable values.

The results from these analyses were used to calculate the PCP concentration in LNAPL, which is presented on Table 4 as PCP in LNAPL (%). The PCP concentration in LNAPL was calculated for each sample that had LNAPL and detectable PCP. This was completed by dividing the mass of PCP in a sample by the volume of LNAPL in that sample. These two values were calculated using the following methods:

- The mass of PCP in each sample with LNAPL present was calculated by multiplying the PCP concentration by the sample thickness, a unit area, and a soil density of 1,800 kg/M^3.
- The volume of LNAPL present in a sample is calculated by multiplying the LNAPL saturation by the porosity, the sample thickness, and a unit area.

Dividing the mass of PCP in LNAPL in each sample by the volume of LNAPL in each sample results in a concentration of PCP in LNAPL, with the appropriate conversions, in mg/L. Presenting this concentration in percent on a weight by weight basis requires dividing the concentration in mg/L by the density of the LNAPL, which is estimated as 800 g/L (or a specific gravity of 0.8).

The estimated PCP concentration in LNAPL ranged from 0% to 2.3%, with the exception of a few samples. These samples and how the results are handled are as follows:

- Sample IDs 706 and 707 had relatively high PCP concentrations (344 mg/kg and 71 mg/kg, respectively) relative to their LNAPL saturations (0.07% and 0.12%, respectively). Dividing the high PCP concentration by the low LNAPL volume results in a concentration that is unreasonable or impossible. The calculation for Sample 706 would suggest that there is more PCP mass than the mass of LNAPL, so that its PCP concentration is greater than 100% PCP. Similarly, sample ID 707 showed a concentration of 26% PCP. These results show that there is PCP adsorbed into the soil with very little LNAPL present. Therefore, these values are not representative of PCP in LNAPL and, therefore, are not used in the PCP statistics shown on Table 4 and presented in Section 5.
- The PCP concentration in Sample ID 720 was 141 mg/kg, but had substantially more LNAPL saturation (0.41%) than samples 706 and 707. This sample's PCP concentration in LNAPL would be 9.98% PCP. This is the value used in Table 4. However, this is an outlier, compared to the vast majority of the results, and is expected to be an overestimate of the PCP concentration in LNAPL.
- Sample ID 770 resulted in a PCP concentration in LNAPL of 15%, because it had a very low LNAPL saturation (0.003%). A small error in the LNAPL saturation would result in a large change in the PCP concentration in LNAPL. Therefore, the PCP concentration in LNAPL is very uncertain, and is excluded from the statistics for the PCP concentration in LNAPL presented in Table 4.

Appendix G
Fine-grained Soils in the Residual Phase LNAPL Zone

Fine-grained Soils in the Residual Phase LNAPL Zone

Fine-grained soils present significantly different fluid and contaminant retention properties than coarse grained soils. As presented in Section 5 of this report, the fine-grained soils present within the residual phase LNAPL zone are shown to have significantly different LNAPL and PCP characteristics than the sand and gravel soils. Therefore, the distribution of these fine-grained soils within the residual phase LNAPL smear zone in the vicinity of boring M01 are presented in this appendix.

The coarse-grained soil deposits at Wauleco originated from deposition from glacial outwash in the Wisconsin River bedrock valley. Therefore, the bulk of the soils are medium to coarse grained sand and gravel deposits. This is clearly illustrated in the boring logs presented in Appendix G-1. However, fine-grained deposits of silt and sandy silt are expected within the sand and gravel deposits. Typically, the fine-grained material is carried downstream, but some fine-grained material may be deposited as overbank or bar deposits in an outwash deposit. Even when deposited, the high energy outwash environment will generally erode these fine-grained deposits before accumulating more sand and gravel. However, some fine-grained deposits can be retained, and occur typically as isolated lenses of finer grained soils within the sand and gravel matrix.

The boring logs in the vicinity of boring M01 were reviewed to identify fine-grained soils that may occur within the residual phase LNAPL smear zone. Table G-1 summarizes the review of the boring logs shown on Figure G-1. The ground surface elevation and the source is shown on Table G-1. Many of the boring logs did not include their surface elevation, therefore, the surface elevation, at the time of the boring, is estimated based on a 2012 LIDAR topographic survey map. While those surface elevations are approximate, the lack of fine-grained soils in the proximity of the residual phase LNAPL elevation reduces the importance of accurate ground surface elevations for this purpose.

The borings were screened as follows:

- Did the boring extend through the elevation of the residual phase LNAPL (see column Does Borehole Extend Into Smear Zone).
- Reviewed the boring logs for the presence of a fine-grained soil unit on the boring (see Table G-1 column Is Silt Or Clay Present As Primary Soil Component). The soil description for those borings with silt, sandy silt, clay, silty clay, etc. are shown on Table G-1.
- The depths and elevations of these units are presented in Table G-1.
- The final steps of this evaluation were to identify whether any of the fine-grained soil units were present within the LIF peak (i.e., the extent of the LIF detected residual phase LNAPL).

As shown on Table G-1, out of the 84 borings surveyed, only 1 boring, W70B, showed a fine-grained soil unit within the residual phase LNAPL interval. As shown on Figure G-1, boring W70B is surrounded with numerous other borings where no fine-grained soil units were recorded.

Table G-1
Boring Logs Review for Silt or Clay in LIF Residual Phase LNAPL Zone

NUMBER OF BORINGS	LOCATION ID	EASTING	NORTHING	GROUND SURFACE ELEVATION (ft. MSL)	NOTES ON GROUND SURFACE ELEVATION[1]	NOTES ON BORING LOG	BOREHOLE DEPTH (ft bgs)	ELEVATION OF BOREHOLE BOTTOM (ft)	EXTEND INTO SMEAR ZONE? (Generalized as less than Elev. 1165 ft)	IS SILT OR CLAY PRESENT AS PRIMARY SOIL COMPONENT?	DEPTH TO TOP OF SILT/CLAY (ft bgs)	DEPTH TO BOTTOM OF SILT/CLAY (ft bgs)	TOP OF FINES ELEVATION	BOTTOM OF FINES ELEVATION	WITHIN GENERALIZED LIF LNAPL INTERVAL (1157 to 1165)	SILT/CLAY ELEVATION COMPARED TO SPECIFIC LIF PEAK	NOTES ON SOIL TYPE(S) WITHIN GENERALIZED LIF INTERVAL
1	B-100	2062608	406974	1187.38	From topo		44	1143.4	Yes	No							
2	B-101	2062571	406975	1190.00	Est. Pre-Mound		34	1156.0	Yes	silt, some sand (top depth estimated)	33.6	34	1156.4	1156	No		
3	B-102	2062585	406999	1187.71	From topo		35	1152.7	Yes	No							
4	B-103	2062632	407012	1187.39	From topo		50	1137.4	Yes	No							
5	B-104	2062645	407026	1187.36	From topo		36	1151.4	Yes	No							
6	B-105	2062607	406999	1187.52	From topo		35	1152.5	Yes	No							
7	B-106	2062623	406983	1187.30	From topo		36	1151.3	Yes	No							
8	B-200	2062627	407027	1187.51	From topo		39	1148.5	Yes	No							
9	B-201	2062632	407027	1187.47	From topo		36.5	1151.0	Yes	No							
10	B-202	2062637	407026	1187.43	From topo		39	1148.4	Yes	No							
11	B-203	2062642	407026	1187.38	From topo		39	1148.4	Yes	No							
12	B-204	2062627	407022	1187.48	From topo		39	1148.5	Yes	No							
13	B-206	2062637	407022	1187.40	From topo		39	1148.4	Yes	No							
14	B-207	2062642	407021	1187.36	From topo		39	1148.4	Yes	No							
15	B-208	2062627	407017	1187.46	From topo		39	1148.5	Yes	No							
16	B-209	2062632	407017	1187.42	From topo		39	1148.4	Yes	No							
17	B-210	2062637	407017	1187.37	From topo		39	1148.4	Yes	No							
18	B-211	2062641	407016	1187.33	From topo		39	1148.3	Yes	No							
19	B-213	2062631	407012	1187.39	From topo		39	1148.4	Yes	No							
20	B-214	2062636	407012	1187.35	From topo		39	1148.3	Yes	No							
21	B-215	2062641	407012	1187.31	From topo		39	1148.3	Yes	No							
22	B-216	2062616	406999	1187.44	From topo		39	1148.4	Yes	No							
23	B-219	2062568	406973	1187.72	From topo		39	1148.7	Yes	No							
24	B-220	2062609	406975	1187.38	From topo		36.5	1150.9	Yes	No							
25	B-221	2062652	406984	1187.07	From topo		31.5	1155.6	Yes	No							
26	B-222	2062652	407013	1187.23	From topo		36.5	1150.7	Yes	No							
27	B-223	2062654	406983	1187.05	From topo		36.5	1150.6	Yes	No							
28	B-300	2062570	406976	1187.72	From topo		34	1153.7	Yes	No							
29	B-301	2062653	406984	1187.06	From topo		34	1153.1	Yes	No							
30	B-302	2062652	407014	1187.24	From topo		34	1153.2	Yes	No							
31	B-305	2062632	407022	1187.44	From topo		37	1150.4	Yes	No							
32	B-400	2062774	406827	1185.62	From topo		29	1156.6	Yes	No							
33	B-401	2062817	406827	1185.28	From topo		29	1156.3	Yes	No							
34	B-402	2062753	406741	1185.69	From topo		29	1156.7	Yes	No							
35	B-403/W-33	2062821	406809	1185.20	From topo		35.5	1149.7	Yes	No							
36	B-404/W-34	2062878	406850	1184.85	From topo		33	1151.8	Yes	No							
37	B-405	2062936	406871	1184.40	From topo		27	1157.4	Yes	No							
38	B-406	2062984	406952	1184.34	From topo		27	1157.3	Yes	No							
39	B-407	2062984	407021	1184.47	From topo		28.5	1156.0	Yes	No							
40	B-408	2062983	407103	1184.52	From topo		29	1155.5	Yes	No							
41	B-409	2062959	407189	1184.79	From topo		27	1157.8	Yes	No							
42	B-500	2062573	406974	1195.78	Historical Info		34	1161.8	Yes	No							
43	B-501	2062633	406962	1195.97	Historical Info		32	1164.0	Yes	silty clay, some medium sand	21.5	23	1174.4699	1172.9699	No		

Table G-1

Boring Logs Review for Silt or Clay in LIF Residual Phase LNAPL Zone

NUMBER OF BORINGS	LOCATION ID	EASTING	NORTHING	GROUND SURFACE ELEVATION (ft. MSL)	NOTES ON GROUND SURFACE ELEVATION[1]	NOTES ON BORING LOG	BOREHOLE DEPTH (ft bgs)	ELEVATION OF BOREHOLE BOTTOM (ft)	EXTEND INTO SMEAR ZONE? (Generalized as less than Elev. 1165 ft)	IS SILT OR CLAY PRESENT AS PRIMARY SOIL COMPONENT?	DEPTH TO TOP OF SILT/CLAY (ft bgs)	DEPTH TO BOTTOM OF SILT/CLAY (ft bgs)	TOP OF FINES ELEVATION	BOTTOM OF FINES ELEVATION	WITHIN GENERALIZED LIF LNAPL INTERVAL (1157 to 1165)	SILT/CLAY ELEVATION COMPARED TO SPECIFIC LIF PEAK	NOTES ON SOIL TYPE(S) WITHIN GENERALIZED LIF INTERVAL
44	B-502	2062637	407003	1196.54	Historical Info		34	1162.5	Yes	silty clay, some fine sand	21	27	1175.544	1169.544	No	L02 and L03 LIF peaks are in elevation range 1160-1165. This does not overlap with fine grained soils.	
45	B-900	2062903	406992	1185.11	From topo		31	1154.1	Yes	silty clay	30.5	31	1154.6071	1154.1071	No		
46	B-901	2062845	407034	1185.75	From topo		23	1162.7	Yes	No							
47	B-903	2062768	407041	1186.45	From topo		31	1155.4	Yes	silty clay	30.5	31	1155.9452	1155.4452	No		
48	B-904	2062772	406851	1185.69	From topo		31	1154.7	Yes	silty clay	29	31	1156.6889	1154.6889	No		
49	B-1000	2062585	406930	1185.42	Survey		25	1160.4	Yes	No							
50	B-1001	2062675	406908	1185.38	Survey		25	1160.4	Yes	No							
51	B-1002	2062604	406961	1185.38	Survey		25	1160.4	Yes	No							
52	B-1003	2062559	407040	1193.04	Survey		30	1163.0	Yes	No							
53	B-1004	2062561	406997	1192.02	Survey		30	1162.0	Yes	No							
54	B-1005	2062509	406991	1190.87	Survey		32	1158.9	Yes	No							
55	B-1006	2062544	407086	1192.83	Survey		30	1162.8	Yes	No							
56	B-1007	2062547	407147	1191.88	Survey	No day on log	30	1161.9	Yes	No							
57	B-1008	2062509	406792	1193.10	Survey		32	1161.1	Yes	No							
58	B-1009	2062546	406832	1191.26	Survey		30	1161.3	Yes	No							
59	B-1100	2062558	406963	1191.24	Survey	blind drilled to 10 ft	37	1154.2	Yes	No							
60	B-1101	2062650	406984	1195.51	Survey		34	1161.5	Yes	No							
61	B-1104	2062625	407048	1192.59	Survey	blind drilled to 10 ft	31	1161.6	Yes	No							
62	B-1105	2062579	407087	1191.49	Survey		37	1154.5	Yes	No							
63	B-1106	2062584	407062	1192.86	Survey	blind drilled to 10 ft	37	1155.9	Yes	No							
64	B-1106	2062602	407043	1192.86	Survey	blind drilled to 10 ft	37	1155.9	Yes	No							
65	B-1107	2062583	407042	1193.30	Survey		30	1163.3	Yes	sandy SILT, little gravel	21	26	1172.3	1167.3	No		
66	B-1108	2062607	407042	1193.26	Survey		35	1158.3	Yes	No							
67	B-1109	2062622	406997	1196.92	Survey		35	1161.9	Yes	No							
68	PW-04	2062908	407079	1188.00	From topo		47	1141.0	Yes	silt and clay, some sand	34	47	1154	1141	No		sand and gravel, trace silt (25.5-34)
69	PW-05	2062914	406905	1186.93	From topo		52	1134.9	Yes	silt and clay, some sand	34.5	52	1152.43	1134.93	No		sand and gravel, trace silt (25-34.5)
70	PW-13	2062854	407121	1189.70	1189.7 on boring log, 1190.0 on well log		37	1152.7	Yes	silty clay	36	37	1153.7	1152.7	No		sand with some gravel and little silt (25-30), sand/gravel with little silt and clay (30-32.5)
71	PW-18	2062903	407138	1187.64	From topo		35	1152.6	Yes		34	35	1153.64	1152.64			sand with silt/gravel (1-34)
72	PW-19	2062810	407028	1188.62	From topo		36	1152.6	Yes	clay 35-36	35	36	1153.62	1152.62	No		sand with silt/gravel (6-24)
73	PW-21	2062864	406998	1187.69	From topo		37	1150.7	Yes	clay 35.5-37	35.5	37	1152.19	1150.69	No		sand with silt/gravel (6-35.5)
74	PW-22	2062869	406937	1189.80	From topo		38	1151.8	Yes	No							
75	W01A	2062433	407203	1191.61	From topo	log notes to refer to W1B for 50-58	50	1141.6	Yes	No							sand and gravel, trace silt (0-50)
76	W01B	2062431	407204	1192.39	From topo		58	1134.4	Yes	No							sand and gravel, trace silt (0-50) from W01A log

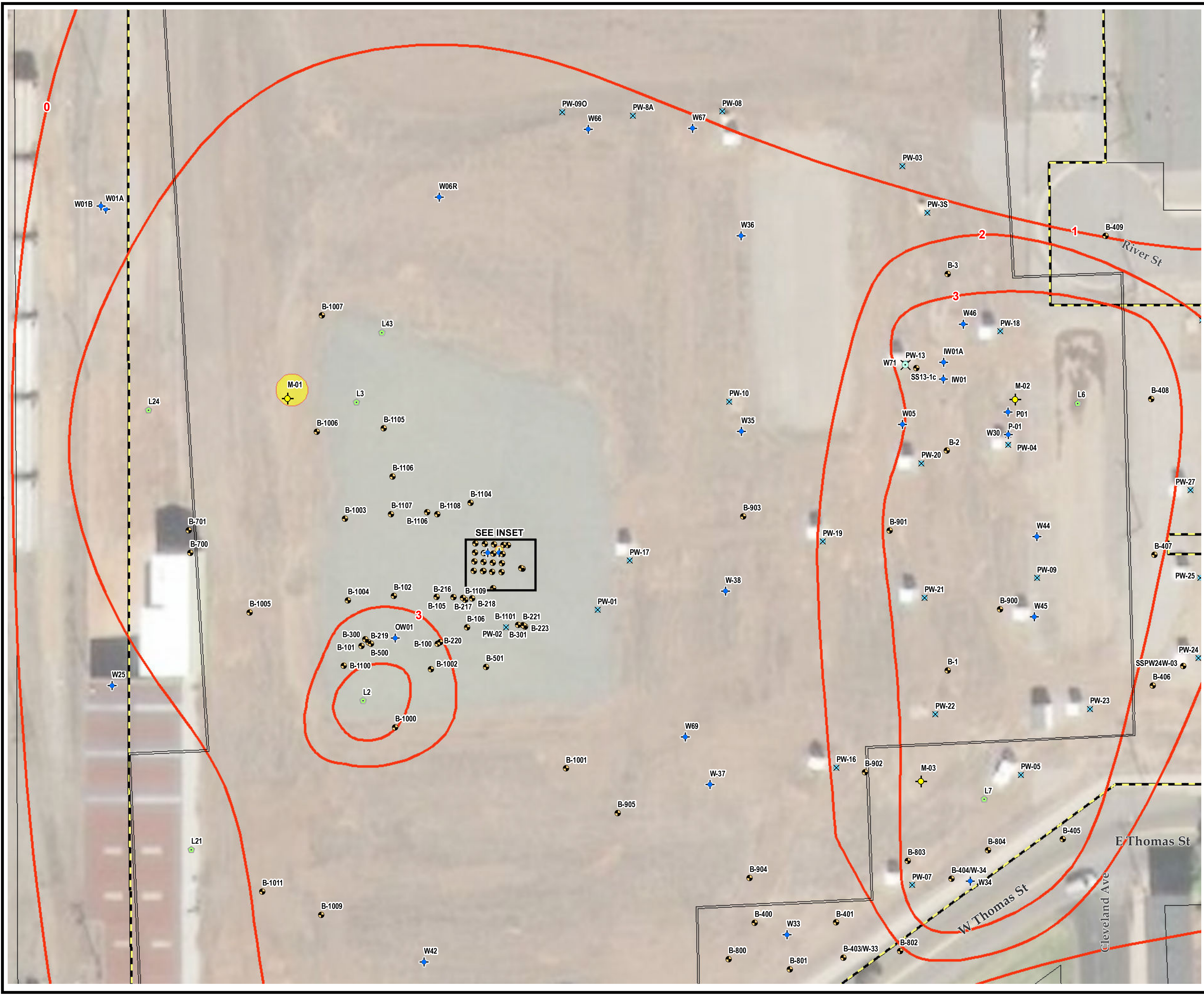
Table G-1
Boring Logs Review for Silt or Clay in LIF Residual Phase LNAPL Zone

NUMBER OF BORINGS	LOCATION ID	EASTING	NORTHING	GROUND SURFACE ELEVATION (ft. MSL)	NOTES ON GROUND SURFACE ELEVATION[1]	NOTES ON BORING LOG	BOREHOLE DEPTH (ft bgs)	ELEVATION OF BOREHOLE BOTTOM (ft)	EXTEND INTO SMEAR ZONE? (Generalized as less than Elev. 1165 ft)	IS SILT OR CLAY PRESENT AS PRIMARY SOIL COMPONENT?	DEPTH TO TOP OF SILT/CLAY (ft bgs)	DEPTH TO BOTTOM OF SILT/CLAY (ft bgs)	TOP OF FINES ELEVATION	BOTTOM OF FINES ELEVATION	WITHIN GENERALIZED LIF LNAPL INTERVAL (1157 to 1165)	SILT/CLAY ELEVATION COMPARED TO SPECIFIC LIF PEAK	NOTES ON SOIL TYPE(S) WITHIN GENERALIZED LIF INTERVAL
77	W05	2062852	407089	1188.08	From topo		41.5	1146.6	Yes	clay (unclear if there may also be sand/silt)	38	41.5	1150.08	1146.58	No		
78	W17	2063192	407155	1185.50	From topo		35.5	1150.0	Yes	clayey silt, some sand	33	35.5	1152.5	1150	No		sand and gravel, trace silt (8-33)
79	W25	2062437	406952	1192.00	From topo		46.5	1145.5	Yes	No							sand, trace/little gravel, trace silt
80	W30	2062908	407084	1188.20	From topo		37	1151.2	Yes		41.5	41.5	1146.7	1146.7			sand and gravel, trace silt (8-33)
81	W34	2062888	406849	1188.54	From topo		33	1155.5	Yes	No							sand, trace gravel (22.5-33)
82	W35	2062767	407086	1189.34	From topo		40	1149.3	Yes	clay 36.5-40	36.5	40	1152.84	1149.34	No		sand with silt/gravel/clay (29-25)
83	W41	2062993	406527	1182.54	From topo		35	1147.5	Yes	No							sand, trace to little gravel
84	W70B	2062640	407022	1197.8	From Boring Log		47	1150.8	Yes	silty clay 35-37.5, sandy silt 40-42.5	35	42.5	1162.8	1155.3	Yes	L02 and L03 LIF peaks are in elevation range 1160-1165, which overlaps with the upper part of the silty clay interval	silty clay with gravel (35-37.5), silty sand (37.5-40), silt (40-42.5)

Notes:

1. Ground surface elevations noted as "From Topo" is based on LIDAR survey data provided by Marathon County, 2012. Elevations noted as "Survey" is from survey information provided in the report with the boring log.

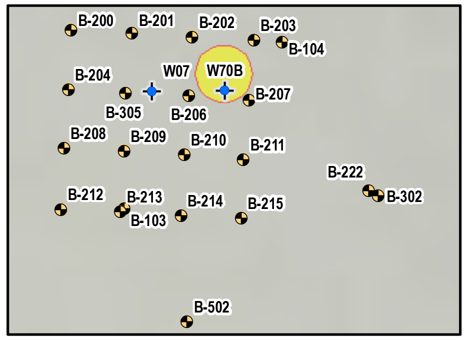
Prepared by: L. Auner
Checked by: S. Sellwood



LEGEND

- ✦ CRYOGENIC SOIL SAMPLE
- ✕ EXTRACTION WELL
- ✦ MONITORING WELL
- ● SOIL BORING
- ✕ TEMPORARY WELL
- ● LIF LOCATION
- LOCATION WITH SILT OR CLAY WITHIN THE RESIDUAL PHASE LNAPL ZONE
- APPROXIMATE WAULECO PROPERTY BOUNDARY
- FORMER HISTORICAL BUILDING FOOTPRINT
- ESTIMATED THICKNESS OF RESIDUAL PHASE LNAPL (FT)

MAP INSET



NOTES

1. BASE MAP IMAGERY FROM ESRI, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER, 2018.

0 50 100 Feet

1 " = 50 '

1:600

PROJECT:

WAULECO, INC.
RESIDUAL PHASE LNAPL INVESTIGATION
WAUSAU, WISCONSIN

TITLE:

FINE GRAINED SOILS
WITHIN RESIDUAL PHASE LNAPL

DRAWN BY:	S. MAJOR	PROJ NO.:	189597.0003-T1
CHECKED BY:	K. QUINN	FIGURE G-1	
APPROVED BY:	B. IVERSON		
DATE:	DECEMBER 2019		

TRC

708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
www.trcsolutions.com

FILE NO.: 189597-036.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin Central FIPS 4802 Feet (Foot US)
Map Rotation: 0

Plot Date: 12/10/2019, 13:47:44 PM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: S:\1-PROJECTS\Wauleco\189597-GeneralGIS\189597-036.mxd

WISCONSIN TEST DRILLING, INC.

SCHOFIELD, WISCONSIN

FIELD BORING LOG

Sheet 1 Of 1

OC

Job No. 1401

Boring No. B-200

FOR Keystone SNE

LOCATION Wausau, WI

Elev.

GROUND WATER
While drilling ____ Time after drilling ____
Before casing removal ____ Depth to water ____
After casing removal ____ Depth to cave-in ____

Start 9-21-88
Unit D-25
Chief CB

Casing/Probe Weight 140#
Drop 30"

Sample No.	Moisture	Blows on Sampler 0/6	Blows on Sampler 6/12	Sample Recovery	Total Blows	VISUAL FIELD CLASSIFICATION AND REMARKS	Unconfined Strength	Boulders	Blows on Casing Size	Blows on Probe Size	Drilling Method
						PEA GRAVEL					2¼" HSA
1	D	7	4								
		5		.1	9	6.5'					
2	D		26								
		12	8	.1	20	Dark Brown SAND, With Gravel					
3	M	13	17								
		23		.5	40						
4	M	41	14								
		21		.8	35	16.5'					
						Dark & Light Brown SAND, With Gravel					
5	M	11	24								
		22		.6	46	21.5'					
						Light Brown SAND, With Gravel					
6	M	20	26								
		33		.8	59						
7	W		31								
		55	39	1.0	94						
8	W	10	13								
		32		.8	45						
9	W		14								
		45	51	1.0	96						
10	W	8	17								
		26		1.0	43	36.5'					
11	W		33			Dark Brown SAND, With Gravel					
		20	16	.4	36						
						E.O.B. @ 39.0'					

WISCONSIN TEST DRILLING, INC.

SCHOFIELD, WISCONSIN

FIELD BORING LOG

Sheet 1 Of 1

Job No. 1401

Boring No. B-201

FOR Keystone SNE

LOCATION Wausau, WI Elev.

GROUND WATER	While drilling		Time after drilling	
	Before casing removal		Depth to water	
	After casing removal		Depth to cave-in	

Start 9-18-88

Unit D-25

Chief CB

Casing/Probe

Weight 140#

Drop 30"

Sample No.	Moisture	Blows on Sampler 0/6	6/12	Sample Recovery	Total Blows	VISUAL FIELD CLASSIFICATION AND REMARKS	Unconfined Strength	Boulders	Blows on Casing Size	Probe Size	Drilling Method
						Dark Brown SAND C-F, With Gravel					3¼" HSA
1	M	6	9								
		10		.1	19						
2	M		10								
		8	10	.5	18						
3	M	5	8								
		11		.1	19						
						14.0'					
4	M	7	16			Brown M-F SAND, Trace Gravel					
		20		1,0	36						
5	M	16	16								
		21		1.3	37						
6	M	20	32								
		33		1.5	65	26.0'					
7	W		15			Brown C-F SAND, With Gravel					
		50	37		87						
8	W	45	50								
		38		1.5	88						
9	W		58								
		70	62	1.4	132						
10	W	65	65								
		69			134	E.O.B. @ 36.5'					

5 10 15 20 25 30 35 40 45

WISCONSIN TEST DRILLING, INC.

SCHOFIELD, WISCONSIN

FIELD BORING LOG

Sheet 1 Of 1

FOR Keystone SNE

LOCATION Wausau, WI Elev.

Job No. 1401

Boring No. B-202

GROUND WATER
While drilling
Before casing removal
After casing removal
Time after drilling
Depth to water
Depth to cave-in

Start 9-16-88
Unit D-25
Chief MP

Casing/Probe
Weight 140#
Drop 30"

Drilling Method: 3¼" HSA

Sample No.	Moisture	Blows on Sampler 0/6	6/12	Sample Recovery	Total Blows
1	D	8	16		
		24		0	40
2	W		24		
		17	15	.6	32
3	W	5	5		
		4		.2	9
4	M	8	19		
		26		1.0	45
5	M	9	14		
		18		1.0	32
6	M	24	41		
		49		.7	90
7	W		83		
		49	38	1.0	87
8	W	54	55		
		29		1.0	84
9	W		24		
		18	35	1.0	53
10	W	103	29		
		28		1.0	57
11	W		63		
		26	46	1.0	72

VISUAL FIELD CLASSIFICATION AND REMARKS

PEA GRAVEL

6.5'

COBBLE, With Gravel

16.5'

Light Brown SAND, With Fine Gravel

26.5'

Light Brown SAND, With Coarse Gravel

31.5'

Light Brown SAND, W/Coarse Gravel, Slight Odor

34.0'

Lt. & Dk. Brown SAND, W/C. Grvl, Odor

36.5'

Strong Odor

E.O.B. @ 39.0'

Unconfined Strength | Boulders | Blows on Casing Size | Probe Size | Drilling Method

WISCONSIN TEST DRILLING, INC.

SCHOFIELD, WISCONSIN

FIELD BORING LOG

Sheet 1 Of 1

Job No. 1401

Boring No. B-203

FOR Keystone SNE

LOCATION Wausau, WI

Elev.

GROUND WATER
While drilling
Before casing removal
After casing removal

Time after drilling
Depth to water
Depth to cave-in

Start 9-12-88
Unit D-25
Chief MP

Casing/Probe
Weight 140#
Drop 30"

Drilling Method 3¼" HSA

Sample No.	Moisture	Blows on Sampler 0/6	Blows on Sampler 6/12	Sample Recovery	Total Blows
1	M	77 23	37	.7	60
2	W	3 3	3	.2	6
3	W	4 29	16	1.1	45
4	W	9 26	21	.6	47
5	M	18 27	21	1.4	48
6	M	63	73 53	1.5	116
7	W	70 41	50	1.1	91
8	W	55	33 58	1.2	113
9	W	26 26	25	1.0	51
10	W	53	46 33	1.0	86

VISUAL FIELD CLASSIFICATION AND REMARKS

GRAVEL

Asphalt (.2') — 2.5'

Brown M-F SAND, With Gravel

E.O.B. @ 39.0'

Unconfined Strength | Boulders | Blows on Casing Size | Probe Size

5 10 15 20 25 30 35 40 45

WISCONSIN TEST DRILLING, INC.

SCHOFIELD, WISCONSIN

FIELD BORING LOG

Sheet 1 Of 1

Job No. 1401

Boring No. B-204

FOR Keystone SNE

LOCATION Wausau, WI Elev. ______

GROUND WATER
While drilling ______
Before casing removal ______
After casing removal ______

Time after drilling ______ ______
Depth to water ______ ______
Depth to cave-in ______ ______

Start 9-22-88
Unit D-25
Chief CB

Casing/Probe ______
Weight 140#
Drop 30"

Sample No.	Moisture	Blows on Sampler 0/6	Blows on Sampler 6/12	Sample Recovery	Total Blows		Visual Field Classification and Remarks	Unconfined Strength	Boulders	Blows on Casing Size	Blows on Probe Size	Drilling Method
							PEA GRAVEL					2¼" HSA
1	D	42	12			5						
		11		0	23							
2	D		16									
		16	9	.1	25							
							9.0'					
3	M	9	8			10	Dark Brown SAND, With Gravel					
		9		.3	17							
4												
4		11	13			15						
		11		0	24							
5	M	11	15			20						
		12		.4	27							
6	M	24	30			25						
		30		.6	60		26.5'					
7	W		32									
		26	32	.8	58		Light & Dark Brown Mixed SAND, W/Gravel					
8	W	15	50			30						
		30		.8	80		31.5'					
9	W		14				Dark Brown SAND, With Coarse Gravel					
		33	31	1.0	64							
10	W	--	50			35						
		42		.5	92							
11	W		21									
		50	43	1.0	93		E.O.B. @ 39.0'					
						40						
						45						

State of Wisconsin
Department of Natural Resources

Route To:
☐ Solid Waste
☒ Emergency Response
☐ Wastewater
☐ Haz. Waste
☐ Underground Tanks
☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION

Form 4400-122 7-91

Page 1 of 2

Facility/Project Name: **Wauleco Inc.** 4113.0020
License/Permit/Monitoring Number:
Boring Number: **W70B**

Boring Drilled By (Firm name and name of crew chief): **WTD Environmental Drilling - J. Weeks**
Date Drilling Started: **6/20/94**
Date Drilling Completed: **6/20/94**
Drilling Method: **4 1/4" I.D. HSA**

DNR Facility Well No. | WI Unique Well No.
Common Well Name: **W70B**
Final Static Water Level: **1161.8** Feet MSL
Surface Elevation: **1197.8** Feet MSL
Borehole Diameter: **6** inches

Boring Location
State Plane ______ N, ______ E S/C/N
NW 1/4 of SE 1/4 of Section 35, T 29 N, R 7 [✓ E]/W
Lat ______
Long ______
Local Grid Location (if applicable): 1271.8 Feet ☒N ☐S 1220.6 Feet ☒E ☐W

County: **Marathon**
DNR County Code: **37**
Civil Town/City/or Village: **Wausau**

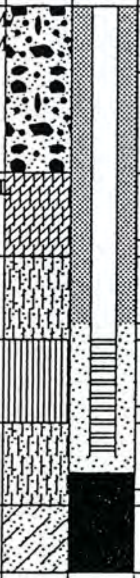
Sample Number	Sample Length Recovered (in.)	Blow Counts	Depth In Ft	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plastic Limit	Soil Properties: P 200	RQD/ Comments
				1" Black Tar and Gravel Cap Loose, Brown SAND and GRAVEL, Some Cobbles	SP/GP									
1	15	7	5	Loose, Brown, Fine to Medium SAND, Some Gravel, Trace Silt	SP					M				SS
2	7	4	10	(Loose, Wood Chips Encountered)						M				SS
3	6	39	15	Very Loose to Dense, Light Brown, Fine to Medium SAND, Trace Gravel	SP					M				SS
4	16	3	20							M				SS
5	18	10	25	Loose, Light Brown, Fine to Medium SAND, Trace Silt	SP					M				SS

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: MEH / TJK
Firm: MONTGOMERY WATSON

This form is authorized by Chapters 144.147 and 162, Wis. Stats. Completion of this report is mandatory. Penalties: Forfeit not less than $10 nor more than $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 144.99 and 162.06, Wis. Stats.

Sample										Soil Properties				
Number	Length Recovered (in.)	Blow Counts	Depth In Ft	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plastic Limit	P 200	RQD/ Comments
6	18	32		Dense, Dark Brown, Fine to Coarse SAND and GRAVEL, Little Silt and Clay	GP-GM SP-SM					M				SS
7	17	27	35 ▽	Very Stiff, Brown, Silty CLAY, Some Gravel	CL-ML					W				SS
8	3	27		Medium Dense, Brown, Silty SAND, Some Gravel	SM					W				SS
9	15	20	40	Very Stiff, Brown, Sandy SILT, Trace Gravel	ML					W				SS
10	12	32		Dense, Brown, Silty, Fine to Medium SAND, Trace Gravel	SM					W				SS
11	18	23	45	Medium Dense, Medium Brown, Clayey SAND, Little Gravel	SC					W				SS
				End of Boring at 47.0 ft										
			50											
			55											
			60											
			65											
			70											
			75											