June 2012

Dewatering Monitoring Plan

Lockwood Water and Sewer District Sewer Installation

Lockwood Solvents Groundwater Plume Site

Yellowstone County, Montana

Revision 0

Prepared by:

United States Environmental Protection Agency, Region 8

Signature Page
Dewatering Monitoring Plan

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Document Revision Log

Revision	Date	Primary Changes
0		EPA Final Document

Table of Contents

Acronyms and Abbreviations

cis-DCE	cis-1,2-dichloroethene
COC	contaminant of concern
DEQ	Montana Department of Environmental Quality
EPA	Environmental Protection Agency
gpm	gallons per minute
LSGPS	Lockwood Solvents Groundwater Plume Site
LWSD	Lockwood Water and Sewer District
MCL	EPA's Maximum Contaminant Level
PCE	tetrachloroethene
QAPP	Quality Assurance Project Plan
ROD	Record of Decision
Soco	Soco West
SVE	soil vapor extraction
TCE	trichloroethene
ug/L	micrograms per liter
VC	vinyl chloride
VOC	volatile organic compounds

Distribution List

Dewatering Monitoring Plan

The following is a distribution list of personnel who will receive an electronic copy of the Dewatering Monitoring Plan for the sampling events initially scheduled for 2012 at the Lockwood Solvents Groundwater Plume Superfund Site. The Dewatering Monitoring Plan with original signatures will be placed in the Superfund administrative record. Agency and/or contractor affiliations are also listed for each individual. A hard copy of the signed monitoring plan will be available with the field sampling lead during the events and an electronic copy will be stored on Environmental Protection Agency's (EPA) shared drive. A copy will also be placed in EPA's record center and at the site repository located at Montana State University-Billings.

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1.0 Project Management

1.1 Introduction

The Lockwood Solvents Groundwater Plume Site (LSGPS) is located to the east of Billings, Montana (Figure 1) and consists of chlorinated solvent contamination in soil and groundwater. There are four main contaminants of concern (COCs): tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-DCE), and vinyl chloride (VC). Two primary source areas for chlorinated solvent groundwater contamination have been identified at the LSGPS: Soco West (Soco) and Beall Trailers, Inc.

The *Record of Decision, Lockwood Solvent Groundwater Plume Site* (ROD) (DEQ/EPA 2005) details the selected remedy for the LSGPS. The preferred alternatives identified in the ROD for remediation at the LSGPS are a combination of technologies to clean up the source areas; prevent migration of contaminated groundwater from the source areas; and accelerate cleanup of the contaminated groundwater that has already migrated downgradient of the source areas. The remedial components for Beall include soil vapor extraction (SVE) and enhanced bioremediation. The remedial components for Soco include a permeable reactive barrier, enhanced bioremediation, excavation with low temperature thermal treatment, SVE, and in-situ chemical oxidation. Monitored natural attenuation is also identified for the site-wide groundwater.

In 2010, the Lockwood Water and Sewer District (LWSD) issued a contract to install a sewer system within the Superfund boundaries as part of the Phase 1 Sewer Subdistrict, 2009-02 project. Monitoring of previous dewatering activities associated with sewer installation along Lockwood Road indicated that the radius of influence extended approximately 900 feet from the nearest pumping well (Tetra Tech 2010). This radius of influence occurred during a discharge rate of approximately 300 gallons per minute (gpm) along Lockwood Road. Sample results from the dewatering associated with sewer installation identified low levels (< 5 ug/L) of TCE and the source of this volatile organic compound likely originated from the Beall Trailers facility.

1.2 Plan Objective

The LWSD plans to install the next portion of the Phase 1 Sewer Subdistrict sewer line in 2012, as part of the 2011-01 Project. This phase includes the placement of a sewer line along Taylor Place, Lockwood Road and Lomond Lane. The proposed dewatering will not only transect the leading edge of the Beall Trailers TCE north plume but has the potential to impact the Soco source area which contains PCE and is located approximately 600 feet north of Taylor Place. Figure 2 illustrates the approximate locations of the proposed pumping wells to be installed by LWSD's Construction Contractor, Western Municipal Construction, the linear extent of this phase of the sewer line project, and the locations of the existing monitoring wells to be sampled for this Dewatering Monitoring Plan.

The EPA, through its contractors and an enforcement order with Soco West, will monitor changes in the groundwater flow and contaminant concentrations to minimize the negative effects that dewatering activities may potentially have on the existing source contamination at the Soco facility or the associated dissolved phase plumes emanating from the Beall and Soco facilities. This Dewatering Monitoring Plan is prepared to direct the collection of field parameters, water elevations and analytical data during dewatering operations associated with the installation of a

sewer line along Taylor Place, Lockwood Roadand Lomond Lane that result in a drawdown of 0.5 feet or more in select monitoring wells.

This Dewatering Monitoring Plan includes the relevant components of a Sampling and Analysis Plan, along with a Field Sampling Plan and Quality Assurance Project Plan. This plan is concise and the other documents referenced herein govern the data collection process.

1.3 Project Organization

Table 1 identifies the stakeholders for this program and briefly describes their roles and responsibilities. The project Organization Chart can be found on Figure 3. Further details of the responsibilities and training requirements of the project roles can be found in Section 2.5 of the EPA-approved *Supplemental Sampling Program Quality Assurance Project Plan Remedial Design, Lockwood Solvent Groundwater Plume Site, Beall Source Area Operable Unit 1* (PWT 2012) and Section 1.1 of the EPA-approved *Groundwater Monitoring Quality Assurance Project Plan, Operable Unit 2, Lockwood Solvent Groundwater Plume Site* (ATC 2012). The EPA Remedial Project Manager is responsible for the maintenance and distribution of this Dewatering Monitoring Plan.

It is imperative to the success of this monitoring program that the construction schedule is relayed to the EPA and DEQ constantly and accurately. Open and frequent communication will be facilitated through weekly correspondence to include the EPA, DEQ, LWSD, City of Billings, and their contractors (as appropriate).

1.4 Project Schedule

Per correspondence from the LWSD's contractor dated June 26, the LWSD intends to begin dewatering of Taylor Place on approximately July 1, 2012. The work will proceed from west to east along Taylor Place and then to Lockwood Road. Work will be completed on Lomond Lane in order to allowgroundwater levels to drop and because the dewatering wells are located in the main drive approach of a major trucking company. The work is scheduled to be completed in mid September 2012.

- June 25 through July 8, 2012 – North Frontage Road (no dewatering anticipated)
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- July 9 through July 31, 2012 – Taylor Place
- August 1 through August 20, 2012 – Lockwood Road
- August 21 through August 31, 2012 – Lomond Lane

As discussed below, the EPA intends to collect baseline static water level measurements within one week of the start of dewatering activities. The baseline levels will be collected the week of June 18, 2012. The North Frontage Road portion of the project does not require dewatering and thus does not require monitoring.

1.5 Project Constraints

Practical constraints may include the progression of the LWSD's contractor, Western Municipal Construction, through the dewatering and installation process. The EPA's contractor will provide field support as needed for the duration of the project. A laboratory has been secured to provide quick turnaround analysis as noted below.

2.0 Quality Objectives and Criteria

2.1 Data Quality Objectives

The objective of the data collection for this Dewatering Monitoring Plan is to minimize the potential impact of the dewatering on the Soco source area contaminants and the dissolved phase plumes emanating from both the Soco and Beall source areas by monitoring groundwater water drawdown and contaminant concentrations, thereby managing the dewatering activities. The data collected will be field-based depth to water level measurements, drawdown calculations, and subsequent analytical results if necessary.

Step 1 – *State the Problem*: The LWSD expansion project requires dewatering of the groundwater within the LSGPS. The potential negative impact, primarily movement of contaminated groundwater into areas currently not impacted, shall be prevented or at least minimized, through continuous monitoring of wells that may be potentially affected during dewatering.

Step 2 – *Identify the Goal of the Study*: The overall ogoal of this workplan is to monitor wells during dewatering activities to ensure dewatering does not negatively impact the movement of contamination at the Site.

Step 3 – *Identify Information Inputs*: The EPA and their contractor have evaluated the potential impacts of the proposed dewatering activities to develop the monitoring program detailed in this Dewatering Monitoring Plan. Field-based depth to groundwater measurements will be collected during the dewatering activities. Results of drawdown measurements in certain wells may prompt the collection of analytical samples.

Step 4 – *Define the Study Boundaries*: The lateral boundary is the area of potential influence of the pumping wells as shown on Figure 2. The vertical boundary is the depth of dewatering in the aquifer. The temporal boundary is the summer and early fall of 2012.

Step 5 – *Develop the Analytical Approach*: The EPA will monitor depth to water levels in select existing monitoring wells identified on Figure 2. If the drawdown at a well reaches a certain level identified in Table 2, groundwater samples will be collected for laboratory analysis. If the analytical results and the confirmation sample demonstrate an exceedance of the trigger values noted in Table 2, the stakeholders will determine the appropriate response for the dewatering activities (e.g., termination of dewatering, continuation for a short period, etc.).

Step 6 – *Specify Performance or Acceptance Criteria*: The EPA will utilize field measurements and analytical results to determine if the dewatering activities are or have the potential to influence either the Soco source area or the contaminated groundwater plume(s). A false acceptance error would result in the discontinuation of the dewatering activities when in fact the dewatering is not impacting the contamination. A false rejection error would result in the continuation of the dewatering program when in fact it is impacting the contamination. A goal of this Dewatering Monitoring Plan is to provide sufficient planning and methodologies to prevent against either error.

Step 7 – *Develop the Plan for Obtaining Data*: The monitoring and data collection program is described in subsequent sections of this Dewatering Monitoring Plan.

2.2 Performance Criteria

Data collected under this monitoring plan will be used to appropriately manage the dewatering activities of the LWSD sewer line expansion project, primarily immediate decisions to the continuation of the dewatering activities. The EPA has determined screening level data is sufficient for this purpose and quality assurance and quality control measures beyond the steps described in this Dewatering Monitoring Plan are not necessary.

The EPA will not include in the site database nor validate any data collected as part of this monitoring plan. The data will not be used for making decisions other than as identified in this Dewatering Monitoring Plan. While quality control samples will not be collected, confirmation samples will be collected if a concentration trigger value identified in Table 2 is exceeded. However, standard laboratory quality assurance and quality control measures will not be altered for this sampling program.

Table 3 identifies the COCs, anticipated concentration ranges, analytical method, and other analysis-specific information. The chosen analytical method will result in a method detection limit lower than the trigger values established for this program.

The Precision, Accuracy, Representativeness, Completeness and Comparability parameters are discussed in Section 4.0 of the EPA-approved PWT Quality Assurance Project Plan (QAPP) (PWT 2012) and Section 2.7 of the EPA-approved ATC QAPP; however, they are not applicable to the data evaluation efforts of this monitoring program.

3.0 Data Generation and Acquisition

3.1 Sampling Design

Ten existing monitoring wells have been selected to monitor and evaluate the effects of dewatering. The wells selected are MW001, MW002, MW100, MW103, MW108, MW109, MW110, MW216, MW217, and PT001.

The sample design discussion is supported by the following:

- Figure 2 illustrates the approximate locations of the pumping wells to be installed by the LWSD, the linear extent of this phase of the sewer line project, and the locations of the monitoring wells.
- Attachment A contains the well logs for the wells.
- Attachment B includes the results of the Mann Kendall Trend Evaluations for each of the wells and each of the COCs where sufficient data has been collected to perform this statistical test.
- Attachment C is a Technical Memorandum describing the calculations and assumptions used to evaluate groundwater velocity rates based on existing site information and from the previous dewatering effort (Tetra Tech 2010). Based on these calculations predicted drawdown levels have been established at each well to act as a trigger to invoke sampling.
- Table 4 includes the historical concentrations of the COCs for these wells.
- Table 2 explains the monitoring well locations, rationale, and both drawdown and contaminant concentration trigger values for the dewatering monitoring program.

The EPA's drinking water standard (MCL) and the remedial action level established in the ROD for each of the COCs are as follows:

- PCE – 5 ug/L
- TCE – 5 ug/L
- cis-DCE – 70 ug/L
- VC – 2 ug/L

The following text includes a discussion of each of the wells, including water level changes that would require sampling and the decisions to be made based on the specific analytical results for each well.

For each monitoring location and sample collected, the following guidelines apply:

- Depth to groundwater measurements will be recorded and if drawdown exceeds the trigger value of 0.5 feet in MW002, MW100, MW103, MW109, MW110, or MW217 and 2.0 feet in MW001, MW216 or MW108, groundwater sampling will commence.
- Depth to groundwater measurements will be recorded and if drawdown exceeds the trigger value of 1.0 feet in PT001, the EPA and Soco/ATC will discuss an appropriate course of action. No sampling trigger has been established for this well.
- Any contaminant concentration result that exceeds the well-specific trigger value will require an immediate resampling to confirm the exceedance.
- If the confirmation sample concentration exceeds the well-specific trigger value, the stakeholders will discuss the dewatering program based on the level of the exceedance and the time frame of the pumping program. All possible scenarios, including analytical results, cannot be anticipated at this time. At a minimum, the City of Billings, the LWSD, the EPA and the DEQ will be involved with any decisions made for the dewatering program.
- If the confirmation sample does not exceed the well-specific trigger value, depth to groundwater measurements and the frequency of sampling will revert to the baseline approach.
- The parties listed in Table 5 lists shall be contacted with the groundwater level and analytical results related to sampling activities performed pursuant to this plan; immediately upon receipt of the data by the contractor.

Specific frequency schedules and data collection protocols are discussed in Sections 3.2 and 3.3. If a well is inaccessible during any given activity, the EPA RPM will be notified. Depending on the reason for the inability to sample, potential options will be discussed to ensure the integrity of the monitoring program.

MW001 is located on the south side of the Soco property and upgradient of the Soco impacts. Since MW001 is located immediately adjacent to Taylor Place it is likely that dewatering activities of LWSD pumping wells 8 and 9 will result in the lowering of 4 feet in the groundwater elevation. This well has been sampled semi-annually since 2003 and has never had detections above the MCL for any of the COCs. The Mann Kendall Trend Evaluation of TCE results from this well show an increasing trend at this well which is likely the result of the leading edge of the Beall north plume reaching Taylor Place. This well is being monitored to determine the effects dewatering have on dissolved phase plumes.

If a dewatering related drawdown of 2.0 feet is measured at MW001, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 2.0 feet.

Since only low levels of TCE have been detected in this well and the location is southeast of Soco source contamination, TCE and PCE will be the trigger COCs. Concentration trigger values of > 4 ug/L for TCE and > 1 ug/L for PCE have been selected.

If the results of the confirmation sample from MW001 confirm the exceedance of a trigger value, at a minimum the City of Billings will be notified and the EPA will suggest a sample to be taken directly from the construction dewatering discharge to evaluate potential impact on the city's effluent limits established for this project.

MW002 is located on Ankrum Trucking property approximately 450 feet north of Taylor Place. This well is also located 200 feet southwest of the Soco dissolved phase plume. The LWSD pumping wells 11 and 12 on Lomond Lane are cross gradient from MW002 about 1021 feet and 692 feet respectively from MW002. There have been several MCL exceedances of TCE early on while the other three COCs have been non-detect. The Mann Kendall Trend Evaluation of COCs results from this well show stable/no trend to decreasing trends. This well is being monitored because it is located southwest of the dissolved phase PCE plume to determine if dewatering pulls the dissolved phase plume cross gradient.

If a dewatering related drawdown of 0.5 feet is measured at MW002, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 0.5 feet.

Since this well is located cross gradient southwest of the PCE plume and only low levels of PCE have been detected in this well, PCE and TCE will be the trigger COCs. Concentration trigger values of > 1 ug/L for PCE and > 10 ug/L for TCE have been selected.

If the results of the confirmation sample from MW002 confirm the exceedance of a trigger value, the results will be evaluated within the duration of the dewatering activity. For example, if the exceedance occurs one week after dewatering begins, this indicates that dewatering is having an immediate effect on the plume and source area and discussion needs to commence on whether dewatering needs to be stopped or modified to minimize the impact.

MW100 is approximately 315 feet north of Taylor Place and is also located near the southern boundary of the former tank farm source area. The LWSD pumping wells 8 and 9 are upgradient of MW100 about 387 feet and 414 feet respectively. There have been four MCL exceedances of VC since 2003 and the other three COCs have been mostly non-detect or at very low levels. The Mann Kendall Trend Evaluation of COCs results from this well show stable/no trend to increasing trends. This well is located southwest of the former tank farm source area. It is being monitored to determine if dewatering pulls either the Soco source contamination or the dissolved phase plume cross gradient.

If a dewatering related drawdown of 0.5 feet is measured at MW100, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 0.5 feet.

As this well is located in close proximity to the Soco tank farm source area, PCE and TCE will be the trigger COCs. Concentration trigger values of > 1 ug/L for PCE and > 3 ug/L for TCE have been selected.

If the results of the confirmation sample from MW100 confirm the exceedance of a trigger value, the results will be evaluated within the duration of the dewatering activity. For example, if the

exceedance occurs one week after dewatering begins, this indicates that dewatering is having an immediate effect on the plume and source area and discussion needs to commence on whether dewatering needs to be stopped or modified to minimize the impact.

MW103 is approximately 315 feet north of Taylor Place and is located near the southern boundary of the former tank farm source area. The LWSD pumping well 8 is located about 443 upgradient of MW103 while pumping well 9 is 404 feet. There have been sporadic MCL exceedances of PCE (October 2006 & October 2007), TCE (October 2007), cis-DCE (October 2007 & April 2010), and VC (April 2005, October 2006, October 2008, April 2009, and April 2009). The Mann Kendall Trend Evaluation of COCs results from this well show a stable/no trend to a decreasing trend. This well is being monitored because it is located southeast of the former tank farm source area to determine if dewatering pulls either the source contamination or the dissolved phase plume cross gradient.

If a dewatering related drawdown of 0.5 feet is measured at MW103, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 0.5 feet.

As this well is located in close proximity to the Soco tank farm source area, the trigger concentrations will be > 1 ug/L for PC, > 2 ug/L for TCE, > 20 ug/L for cis-DCE, and > 2 ug/L for VC.

If the results of the confirmation sample from MW0103 confirm the exceedance of a trigger value, the results will be evaluated within the duration of the dewatering activity. For example, if the exceedance occurs one week after dewatering begins, this indicates that dewatering is having an immediate effect on the plume and source area and discussion needs to commence on whether dewatering needs to be stopped or modified to minimize the impact.

MW108 is located on Corcoran Trucking property approximately 100 feet east of Lomond Lane and 250 feet north of Taylor Place. The LWSD pumping wells 11 and 12 are cross gradient about 460 feet and 170 feet respectively and well 5 is located 448 feet upgradient of MW108. Historically this well has had detections of TCE but there has never been an MCL exceedance. The other three COCs have been mostly non-detect or at very low levels. The Mann Kendall Trend Evaluation of TCE results from this well indicate a stable/ no trend to a decreasing trend. Because of its proximity to the proposed work on Lomond Lane and because it is on the fringes of the Beall TCE plume, this well is being monitored.

If a dewatering related drawdown of 2.0 feet is measured at MW108, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 2.0 feet.

Since only low levels of TCE have been detected in this well and the location is southwest of Beall, TCE and PCE will be the trigger COCs. Concentration trigger values of > 4 ug/L for TCE and > 1 ug/L for PCE have been selected.

If the results of the confirmation sample from MW108 confirm the exceedance of a trigger value, at a minimum the City of Billings will be notified and the EPA will suggest a sample to be taken directly from the construction dewatering discharge to evaluate potential impact on the city's effluent limits established for this project.

MW109 is located on Ankrum Trucking property approximately 250 feet northwest of Taylor place and 500 feet southeast of the Soco PCE plume. The LWSD pumping wells 6 and 7 are upgradient of MW109 about 344 feet and 440 feet respectively. Sample results have consistently been above the MCL for TCE although the Mann Kendall Trend Evaluation indicates a decreasing trend for TCE. The other three COCs have been mostly non-detect or at very low levels. This well is being monitored because it is located within the TCE dissolved phase plume.

If a dewatering related drawdown of 0.5 feet is measured at MW109, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 0.5 feet..

Since MW109 is in the TCE plume, TCE will be the trigger COC. A concentration trigger values of > 10 ug/L for TCE has been selected.

If the results of the confirmation sample from MW109 confirm the exceedance of the trigger value, the results will be evaluated within the duration of the dewatering activity. For example, if the exceedance occurs one week after dewatering begins, this indicates that dewatering is having an immediate effect on the plume and source area and discussion needs to commence on whether dewatering needs to be stopped or modified to minimize the impact.

MW110 is located on Keller Trucking property approximately 300 feet northwest of Taylor place. This well is also located 300 feet southwest of the Soco dissolved phase plume. The LWSD pumping wells 7 and 8 are upgradient of MW110 about 416 and 466 feet respectively. There have been seven MCL exceedances for TCE; most recently during the past three October sampling events. The other three COCs have been mostly non-detect or at very low levels. While there have been exceedances, the Mann Kendall Trend Evaluation of TCE results from this well indicate a stable/ no trend. This well is being monitored because it is located within the leading edge of the TCE plume and southwest of the dissolved phase PCE plume to determine if dewatering pulls the dissolved phase plume cross gradient.

If a dewatering related drawdown of 0.5 feet is measured at MW110, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 0.5 feet.

As this well is located within the TCE plume and cross gradient of the PCE plume, PCE and TCE will be the trigger COCs. Concentration trigger values of > 1 ug/L for PCE and > 10 ug/L for TCE have been selected.

If the results of the confirmation sample from MW110 confirm the exceedance of a trigger value, the results will be evaluated within the duration of the dewatering activity. For example, if the exceedance occurs one week after dewatering begins, this indicates that dewatering is having an immediate effect on the plume and source area and discussion needs to commence on whether dewatering needs to be stopped or modified to minimize the impact.

MW216 is located on Drinkwalter and Sons property approximately 46 feet southwest of Lockwood Road and downgradient of the Beall source area. The LWSD pumping wells 1 and 2 are downgradient of MW216 about 99 feet and 288 feet respectively. This well has never had detections above the MCL for any of the COCs. The Mann Kendall Trend Evaluation of COCs results from this well indicate a stable/ no trend to a decreasing trend. This well is being monitored because it is located cross gradient of the dissolved phase TCE plume emanating from Beall to determine if dewatering pulls the dissolved phase plume cross gradient.

If a dewatering related drawdown of 2.0 feet is measured at MW216, then a groundwater sample will be collected immediately and will be sampled weekly as long as the water level measurements are observed to be below 2.0 feet.

As this well is located cross gradient of the TCE plume and only low levels of TCE have been detected in this well, TCE will be the trigger COC. A concentration trigger value of > 4 ug/L for TCE has been selected.

If the results of the confirmation sample from MW108 confirm the exceedance of a trigger value, at a minimum the City of Billings will be notified and the EPA will suggest a sample to be taken directly from the construction dewatering discharge to evaluate potential impact on the city's effluent limits established for this project

MW217 is located on Lumberyard Supply Company property approximately 58 feet southwest of Lockwood Road and downgradient of the Beall source area. The LWSD pumping wells 5 and 6 are downgradient of MW217 about 459 feet and 315 feet respectively. Sample results have consistently been above the MCL for TCE while the other three COCs have been mostly non-detect or at very low levels. The Mann Kendall Trend Evaluation of TCE results from this well indicate a stable/ no trend to a decreasing trend. This well is being monitored because it is a part of the dissolved phase TCE plume emanating from Beall to determine if dewatering pulls the dissolved phase TCE plume down or cross gradient.

If a dewatering related drawdown of 0.5 feet is measured at MW217, then a groundwater sample will be collected immediately.

As this well is part of the TCE plume and only low levels of TCE have been detected in this well, TCE will be the trigger COC. A concentration trigger value of > 10 ug/L for TCE has been selected.

If the results of the confirmation sample from MW217 confirm the exceedance of the trigger value, the results will be evaluated within the duration of the dewatering activity. For example, if the exceedance occurs one week after dewatering begins, this indicates that dewatering is having an immediate effect on the plume and source area and discussion needs to commence on whether dewatering needs to be stopped.

PT001 is located on Soco property immediately on the western fringe of the northwest source area. The LWSD pumping wells 11 and 12 are cross gradient and 7 and 8 are upgradient from PT001. Sample results have consistently been non-detect or at very low levels for the COCs. In sufficient data has been collected from this well to perform a Mann Kendall Trend Evaluation. This well is initially being monitored for drawdown only.

If a dewatering related drawdown of 1.0 feet is measured at PT001, then the EPA and Soco/ATC will discuss an appropriate course of action. At this time, the EPA has not identified a sampling trigger value.

3.2 Sampling Methods

Appropriate protocols for collecting depth to groundwater measurements, field parameters, and groundwater samples; sample documentation (including log books and photographs), labeling, handling, and, shipping; laboratory procedures; decontamination; equipment maintenance and testing; supplies management; and problem resolution are discussed in the EPA-approved

Groundwater Monitoring Quality Assurance Project Plan, Operable Unit 2, Lockwood Solvent Groundwater Plume Site (ATC 2012) and the EPA-approved *Supplemental Sampling Program Quality Assurance Project Plan Remedial Design, Lockwood Solvent Groundwater Plume Site, Beall Source Area Operable Unit 1* (PWT 2012). As two consulting firms will be performing the work under this Dewatering Monitoring Plan (ATC on behalf of Soco and PWT on behalf of the EPA), each firm's activities will be consistent with the provisions of their individual QAPPs and this plan. The two QAPPs are also not inconsistent with each other; therefore providing comparable data from the different wells. This Dewatering Monitoring Plan will only briefly discuss these procedures. Please refer to these documents for additional procedure details.

3.2.1 Depth to Groundwater Measurements

On June 21, 2012 static water levels at monitoring wells MW001, MW100, MW103, MW002, MW108, MW109, MW110, MW216, MW217, and PT001 were measured. These measurements are included in Table 6 and are considered baseline conditions to compare subsequent water elevations against. Water level measurements will also be collected again the week of July 1 prior to dewatering activities. Water level measurements will be collected following the appropriate SOPs and recorded on the Water Level Measurement Record form (Attachment D). Since the water level measurements are relative to the measurements collected during this program only, conversion of the water level measurements to feet above sea level is not necessary.

Water levels in all ten monitoring wells will be monitored on a daily basis, at a minimum, once pumping is initiated. Depth to groundwater in select wells (e.g., MW110) may be continuously recorded with a transducer and downloaded weekly. Water levels will be compared to the drawdown trigger values in Table 2 immediately upon collection. On the first day of any new pumping well start-up, water level measurements will be collected twice a day until the water level stabilizes. At that time, frequency of the water level measurements may be reduced based on discussions between the stakeholders. If a dewatering related drawdown exceeding the well-specific trigger value identified on Table 2 is measured at any of these wells, groundwater sampling will begin in the affected well(s). Continuous monitoring ensures that any changes to the existing dissolved phase groundwater plumes are detected to ensure dewatering does not negatively impact the movement of contamination at the Site.

3.2.2 Groundwater Sampling

If dewatering results in a drawdown that triggers groundwater sampling, samples will be collected immediately and then weekly thereafter from the monitoring wells that reach the trigger drawdown level until groundwater returns to above the trigger groundwater elevation as compared against . Field parameters will also be collected from each well during the collection of each groundwater sample. Field parameters will be measured and recorded in accordance with appropriate SOPs, using a low volume flow-through cell (ATC 2012, PWT 2012). Groundwater samples will be collected from the existing monitoring wells using low flow sampling techniques in accordance with the appropriate groundwater sampling SOPs (ATC 2012, PWT 2012).

At any time, the EPA, in consultation with the other stakeholders, may alter the trigger values or the frequency of water level measurements or sample collection based on field observations, analytical results, changes in the construction schedule, or any other condition as appropriate.

3.3 Sample Handling and Custody

3.3.1 Sample Identification

The sample naming convention that has been used on previous semi-annual groundwater sampling events will be used for this monitoring event. However, a DW for dewatering will be added to end of each sample to discern it from other sample events. The letter C will be added after DW if the sample is a confirmation sample.

3.3.2 Sample Management

After collection, samples will be managed in accordance with appropriate SOPs for Sample Handling (ATC 2012, PWT 2012). Samples will be packaged and hand delivered to a local laboratory once sample collection is completed. Appropriate chain of custody procedures will be followed to ensure samples are accounted for from the field to the laboratory.

3.4 Sample Analysis

Samples will be submitted to Energy Laboratories, Inc., located on 1120 South 27th Street in Billings, Montana, for laboratory analysis of volatile organic compounds (VOCs) by EPA Method 524.2 and appropriate laboratory procedures will be followed. A one-day turnaround will be requested for the analyses. Laboratory data will be compared to historic data and the trigger concentration identified for the monitoring well(s) to determine if dewatering is having any effect on the Soco source contaminants or the dissolved phase plumes. Because of the immediate use of this data for making decisions, data evaluation or validation is not anticipated or required.

3.5 Data Review and Management

All field parameters collected and any laboratory analytical results will be shared with the EPA and DEQ as it becomes available to assist in decision-making. The EPA, in consultation with other stakeholders, will review the data for usability for its intended purpose of evaluating the dewatering activities.

Hard copies of the field forms, sampling forms, and analytical data will be scanned for electronic archive. In addition, any electronic deliverables or documents will be archived. It is not necessary for the analytical data generated from this sampling effort to be validated or entered into Scribe at this time.

4.0 References

ATC. 2012. *Groundwater Monitoring Quality Assurance Project Plan, Operable Unit 2, Lockwood Solvent Groundwater Plume Site.* April.

MDEQ/USEPA. 2005. *Record of Decision, Lockwood Solvent Groundwater Plume Site Billings, Montana.* August.

PWT. 2012. *Supplemental Sampling Program, Quality Assurance Project Plan, Lockwood Solvent Groundwater Plume Site, Beall Source Area Operable Unit 1, Yellowstone County, Montana.* March.

Tetra Tech. 2010. *Groundwater Drawdown Monitoring Report: January 4, 2010, Phase One Sewer Subdistrict – Lockwood Water and Sewer District Construction Dewatering System.* January.

Tables

Table 1
Project Organization and Responsibilities
Dewatering Monitoring Plan
Lockwood Solvents Groundwater Plume Superfund Site

Managers	Organization	Responsibilities
Roger Hoogerheide	EPA	Project oversight/management and decision making authority for discontinuing dewatering if effects of dewatering are impacting the plume or source area
John Podolinsky	DEQ	Project oversight/management and decision making authority for discontinuing dewatering if effects of dewatering are impacting the plume or source area
Andrew Schmidt	EPA	Project oversight/management and decision making authority for discontinuing dewatering if effects of dewatering are impacting the plume or source area
Boris Krizek	City of Billings	Decision making authority for discontinuing dewatering at any time
James Sullivan	ATC Associates (Soco contractor)	Responsible for monitoring/sampling of MW100, MW103, and PT001; provides input on dewatering decisions; provides field data and analytical results to EPA/DEQ
Catherine LeCours	PWT (EPA contractor)	Responsible for monitoring/sampling MW001, MW002, MW108, MW109, MW110, MW216, and MW217; provides input on dewatering decisions; provides field data and analytical results to EPA/DEQ
Woody Woods	LWSD	Decision making authority for discontinuing dewatering at any time
Jock Clause	Western Municipal Construction (LWSD Construction Contractor)	Permittee to LWSD for Industrial Discharge to LWSD sewer collection system. Responsible for all dewatering means, methods and techniques. Responsible for design and operation of construction dewatering system and conducting all required sampling per the permit and per the construction contract with LWSD. Submits sampling results to Owner and Engineer.
Dave Mosser	Morrison - Maierle, Inc. (LWSD Engineering contractor)	Act as the Owner's representative in coordination with the construction contractor, Western Municipal Construction, as well as with EPA and DEQ.
Jill Cook	Morrison - Maierle, Inc. (LWSD Engineering contractor)	Act as the Owner's representative in coordination with the Construction Contractor, Western Municipal Construction, as well as with EPA and DEQ.
Wynn Pippin	Energy Laboratories, Inc.	Provide analytical support for groundwater samples

Table 2
Monitoring Well Locations, Rationale, and Trigger Values
Dewatering Monitoring Plan
Lockwood Solvents Groundwater Plume Superfund Site

Monitoring Well	Location	Rationale	Drawdown Value (feet)	Concentration Trigger Value (ug/L)
MW001	Along Taylor Place, south of the Soco property, upgradient of the Soco source and groundwater plume and side gradient of the Beall TCE plume	Closest monitoring well to Taylor Place	2.0	> 1.0 PCE > 4.0 TCE
MW002	Approximately 450 feet north of Taylor Place, 200 feet southwest of the Soco PCE plume, and 200 feet northeast of the Beall TCE plume	Cross gradient effects of dewatering on the Soco PCE and Beall TCE plumes	0.5	> 1.0 PCE > 10.0 TCE
MW100	Approximately 315 feet north of Taylor Place and near the southern boundary of the former tank farm source area	Upgradient of the Soco source areas and dissolved phase plume	0.5	> 1.0 PCE > 3.0 TCE
MW103	Approximately 315 feet north of Taylor Place and near the southern boundary of the former tank farm source area	Upgradient of the Soco source areas and dissolved phase plume	0.5	> 5.0 PCE > 5.0 TCE > 70.0 cis-DCE > 2.0 VC
MW108	Approximately 100 feet east of Lomond Lane and 250 feet north of Taylor Place	Close proximity to the pumping wells – will monitor field parameters initially	2.0	> 3.0 TCE
MW109	Approximately 250 feet northwest of Taylor place and 500 feet southeast of the Soco PCE plume	Cross gradient effects of dewatering on the Soco PCE plume and effects on the Beall TCE plume	0.5	> 1.0 PCE > 10.0 TCE
MW110	Approximately 300 feet northwest of Taylor Place and 300 feet southwest of the Soco PCE plume	Cross gradient effects of dewatering on the Soco PCE plume and effects on the Beall TCE plume	0.5	> 1.0 PCE > 10.0 TCE
MW216	Approximately 46 feet southwest of Lockwood Road and cross gradient of the Beall TCE plume	Cross gradient effects of dewatering on the Beall TCE plume	2.0	> 4.0 TCE
MW217	Approximately 58 feet southwest of Lockwood Road and within the Beall TCE plume	Downgradient effects of dewatering on the Beall TCE plume	0.5	> 10.0 TCE
PT001	Immediately west of the Soco northwestern source area	Cross gradient effects of dewatering on the Soco source area	1.0	none established at this time

Table 3
Sample Analysis
Dewatering Monitoring Plan
Lockwood Solvents Groundwater Plume Superfund Site

Matrix	Analysis	Anticipated Concentration Range	Action Limit (VOC's only) [1]	Reporting Limits	Analytical Method	Laboratory Identification/ Field	Sample Type	Sample Number [2]	Duplicates / MS/MSD [3]	Holding time	Lab Turnaround Time	Sample volume	Container Size/Type	Preservative	Total Analyses [1]
Groundwater	Tetrachloroethene	0.5 to 15 ug/L	vary for each well monitored	0.5 ug/L	524.2	Energy	Grab	159	N/A	14 days	1 day	120 ml	3 - 40 mL glass	HCl and 4 °C (±2°C)	159
	Trichloroethene	0.5 to 17 ug/L		0.5 ug/L											
	Cis-1,2-Dichloroethene	0.5 to 40 ug/L		0.5 ug/L											
	Vinyl Chloride	0.5 to 18 ug/L		0.5 ug/L											

Notes:

1 Action limits for this dewatering monitoring program are well-specific and are included on Table 2 of this Dewatering Monitoring Plan.

2 Groundwater samples are estimated based on "worst case scenario" of a sample collected every three days (starting three days after initial pumping) for the duration of the project from each well.

3 Data quality objectives for this sampling program does not require QA/QC samples collected in the field.

Table 4

LWSD DEWATERING MONITORING PLAN

LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

Monitoring Wells within the Area of Interest for Dewatering Southern Lomond Lane, Taylor Place, and Lockwood Road

QA/QC samples not included

units - ug/L

STATION	COLLECTIONDATE	CIS-1,2-DICHLOROETHENE	TETRACHLOROETHENE	TRICHLOROETHENE	VINYL CHLORIDE
MW001	4/22/2003	0.5U	0.5U	0.5U	0.5U
MW001	10/21/2003	0.5U	0.5U	0.5U	0.5U
MW001	4/22/2004	0.5U	0.5U	0.5U	0.5U
MW001	10/12/2004	0.5U	0.5U	0.5U	0.5U
MW001	4/27/2005	0.5U	0.5U	0.2J	0.5U
MW001	10/27/2005	0.5U	0.5U	0.5U	0.5U
MW001	4/5/2006	0.5U	0.5U	0.5U	0.5U
MW001	10/24/2006	0.5U	0.5U	0.34J	0.5U
MW001	4/4/2007	0.5U	0.5U	0.35J	0.5U
MW001	10/3/2007	0.5U	0.5U	0.5U	0.5U
MW001	4/16/2008	0.5U	0.5U	0.44J	0.5U
MW001	10/13/2008	0.5U	0.5U	0.68	0.5U
MW001	4/14/2009	0.5U	0.5U	0.58	0.5U
MW001	10/6/2009	0.5U	0.5U	0.76	0.5U
MW001	4/14/2010	0.5U	0.5U	0.26	0.5U
MW001	10/12/2010	0.5U	0.5U	0.19	0.5U
MW001	4/12/2011	0.5U	0.5U	0.81	0.5U
MW001	4/26/2012	0.5U	0.5U	2.1	0.4U
STATION	**COLLECTIONDATE**	**CIS-1,2-DICHLOROETHENE**	**TETRACHLOROETHENE**	**TRICHLOROETHENE**	**VINYL CHLORIDE**
MW002	6/1/2000	0.5	0.2U	4.56	0.2U
MW002	11/16/2000	2150D	536	72	0.5U
MW002	11/16/2000	0.35J	.21J	3.8	731
MW002	7/25/2001	0.68	0.5U	7.1	0.5U
MW002	7/25/2001	0.64	0.5U	6.2	0.5U
MW002	10/23/2001	0.65	0.5U	7.3	0.5U
MW002	2/6/2002	0.78	0.5U	6.5	0.5U
MW002	4/30/2002	0.98	0.5U	6.7	0.5U
MW002	7/24/2002	0.6	0.5U	7.3	0.5U
MW002	10/28/2002	0.99	0.5U	10	0.5U
MW002	4/23/2003	0.76	0.5U	6.6	0.5U
MW002	10/21/2003	1	0.5U	9.1	0.5U
MW002	4/22/2004	0.86	0.5U	6	0.5U
MW002	10/12/2004	0.84	0.5U	7.7	0.5U
MW002	4/27/2005	0.74	0.5U	6	0.5U
MW002	10/26/2005	0.81	0.5U	7	0.5U
MW002	4/4/2006	0.77	0.5U	5.5	0.5U
MW002	10/24/2006	0.5U	0.5U	0.5U	0.5U
MW002	10/24/2006	0.67	0.5U	5.4	0.5U
MW002	4/4/2007	0.58	0.5U	4.1	0.5U
MW002	10/3/2007	0.6U	0.5U	5.2	0.5U
MW002	4/17/2008	0.47J	0.5U	3.6	0.5U
MW002	10/15/2008	0.56	0.5U	4.8	0.5U
MW002	4/15/2009	0.57	0.5U	3.7	0.5U
MW002	10/8/2009	0.64	0.5U	4.5	0.5U
MW002	4/12/2010	0.51	0.5U	3.9	0.5U
MW002	10/13/2010	0.52	0.5U	4.6	0.5U
MW002	4/12/2011	0.42	0.5U	3.1	0.5U
MW002	10/13/2011	0.45	0.5U	4.2	0.5U
MW002	4/16/2012	0.5U	0.5U	3.5	0.4U
STATION	**COLLECTIONDATE**	**CIS-1,2-DICHLOROETHENE**	**TETRACHLOROETHENE**	**TRICHLOROETHENE**	**VINYL CHLORIDE**
MW100	4/23/2003	18	0.23	0.5	3.4
MW100	10/22/2003	0.5U	0.5U	0.3J	0.5U
MW100	4/20/2004	5.8	0.21J	0.7	3
MW100	10/13/2004	0.23J	0.5U	0.39J	0.5U
MW100	4/27/2005	1.7	0.84	1.1	1.2
MW100	10/26/2005	0.52	0.5U	0.6	0.32J
MW100	4/5/2006	2	0.62	1	1.4
MW100	4/4/2007	0.82	1.1	2	0.5U
MW100	10/2/2007	0.48J	0.48J	1.5	0.5U
MW100	4/16/2008	6.9	0.6	1.8	8.3
MW100	10/15/2008	0.65J	0.66J	1.8J	0.3J
MW100	4/15/2009	9.3	1.7	2.3	2.3

MW100	10/6/2009	0.9	0.55	1.5	0.5U
MW100	4/13/2010	37	14	3.3	12
MW100	10/13/2010	4.9	0.5	1.4	0.15
MW100	10/24/2006	0.34J	0.89	1.4	0.5U
MW100	4/13/2011	1.6	0.95	1.4	0.31
MW100	10/4/2011	0.67	0.27	1.3	0.16
MW100	4/26/2012	1.8	0.5U	1.8	0.4U
STATION	**COLLECTIONDATE**	**CIS-1,2-DICHLOROETHENE**	**TETRACHLOROETHENE**	**TRICHLOROETHENE**	**VINYL CHLORIDE**
MW103	4/23/2003	14	0.35	0.49	0.83
MW103	10/22/2003	0.53	0.5U	0.27J	0.5U
MW103	4/20/2004	3.8	0.5U	0.29J	0.38J
MW103	10/13/2004	17	0.5U	0.28J	1.1
MW103	4/27/2005	18	0.5U	0.31J	2.1
MW103	10/26/2005	0.43J	0.5U	0.5U	0.5U
MW103	4/5/2006	7.2	0.5U	0.29J	0.89
MW103	10/24/2006	9.8	9	3	2.5
MW103	4/4/2007	8	1.5	0.67	1.3
MW103	10/2/2007	101	11	6.3	10
MW103	4/16/2008	17	0.5U	0.52	0.5
MW103	10/15/2008	16J	3.2J	1.8J	3.4J
MW103	4/15/2009	22	2.7	1.1	3.9
MW103	10/6/2009	0.66	1.4	0.98	0.5U
MW103	4/13/2010	101	0.53	0.78	18
MW103	10/13/2010	0.88	0.5U	0.3	0.5U
MW103	4/13/2011	8.6	0.5U	0.32	0.5U
MW103	10/12/2011	0.93	1.4	1.1	0.5U
MW103	4/26/2012	9.4	0.5U	0.5U	0.4U
STATION	**COLLECTIONDATE**	**CIS-1,2-DICHLOROETHENE**	**TETRACHLOROETHENE**	**TRICHLOROETHENE**	**VINYL CHLORIDE**
MW108	6/18/2002	0.2U	0.2U	0.2U	0.2U
MW108	8/8/2002	0.5	0.5U	2.4	0.5U
MW108	11/1/2002	0.61	0.5U	2.9	0.5U
MW108	4/23/2003	0.56	0.5U	2.5	0.5U
MW108	10/21/2003	0.47J	0.5U	2.9	0.5U
MW108	4/22/2004	0.4J	0.5U	2.5	0.5U
MW108	10/12/2004	0.4J	0.5U	2.7	0.5U
MW108	4/27/2005	0.37J	0.5U	2.6	0.5U
MW108	10/27/2005	0.44J	0.5U	2.6	0.5U
MW108	4/4/2006	0.33J	0.5U	2.3	0.5U
MW108	4/4/2006	0.36J	0.5U	2.6	0.5U
MW108	10/26/2006	0.28	0.5U	2.1	0.5U
MW108	4/4/2007	0.5U	0.5U	2.3	0.5U
MW108	10/3/2007	0.5U	0.5U	2.1	0.5U
MW108	4/15/2008	0.5U	0.5U	1.8	0.5U
MW108	10/13/2008	0.2U	0.5U	1.8	0.5U
MW108	4/15/2009	0.22J	0.5U	1.9	0.5U
MW108	10/7/2009	0.5U	0.5U	2	0.5U
MW108	4/12/2010	0.22	0.5U	1.7	0.5U
MW108	4/12/2010	0.2	0.5U	1.7	0.5U
MW108	10/13/2010	0.28	0.5U	2	0.5U
MW108	4/12/2011	0.2	0.5U	1.7	0.5U
MW108	10/13/2011	0.17	0.5U	2	0.5U
MW108	4/30/2012	0.5U	0.5U	1.8	0.4U
STATION	**COLLECTIONDATE**	**CIS-1,2-DICHLOROETHENE**	**TETRACHLOROETHENE**	**TRICHLOROETHENE**	**VINYL CHLORIDE**
MW109	6/18/2002	0.2U	0.2U	0.2U	0.2U
MW109	8/8/2002	0.86	0.5U	11	0.5U
MW109	11/1/2002	1.3	0.5U	10	0.5U
MW109	4/23/2003	0.92	0.5U	9.3	0.5U
MW109	10/21/2003	1	0.5U	12	0.5U
MW109	4/22/2004	0.88	0.5U	7.9	0.5U
MW109	10/12/2004	0.85	0.5U	10	0.5U
MW109	4/27/2005	0.8	0.5U	9	0.5U
MW109	10/27/2005	0.79	0.5U	9	0.5U
MW109	4/4/2006	0.67	0.5U	8.3	0.5U
MW109	10/23/2006	0.63	0.5U	7	0.5U
MW109	4/4/2007	0.64	0.27J	6.3	0.5U
MW109	10/2/2007	0.69	0.5U	6.4	0.5U
MW109	10/3/2007	0.68U	0.5U	7.9	0.5U
MW109	4/17/2008	0.5	0.2J	5.7	0.5U

MW109	10/13/2008	0.52	0.18J	6.2	0.5U
MW109	10/13/2008	0.54	0.17J	6.5	0.5U
MW109	4/15/2009	0.6	0.22J	5.6	0.5U
MW109	10/7/2009	0.63	0.52	6.2	0.5U
MW109	4/12/2010	0.6	0.23	5.8	0.5U
MW109	10/14/2010	0.47	0.28	5.5	0.5U
MW109	4/12/2011	0.44	U	4.5	0.5U
MW109	10/13/2011	0.42	0.33	6.8	0.5U
MW109	4/30/2012	0.5U	0.5U	5.5	0.4U
MW110	4/23/2003	0.59	0.5U	7	0.5U
MW110	10/21/2003	0.92	0.5U	10	0.5U
MW110	4/22/2004	0.77	0.5U	7.5	0.5U
MW110	10/12/2004	0.66	0.5U	8.2	0.5U
MW110	4/27/2005	0.5U	0.5U	0.82	0.5U
MW110	10/27/2005	0.53	0.5U	4.8	0.5U
MW110	4/4/2006	0.5U	0.5U	2	0.5U
MW110	10/24/2006	0.5U	0.5U	1.4	0.5U
MW110	4/4/2007	0.5U	0.5U	1.4	0.5U
MW110	4/17/2008	0.22J	0.5U	1.7	0.5U
MW110	10/13/2008	0.41J	0.21J	4.5	0.5U
MW110	4/15/2009	0.23J	0.5U	1.8	0.5U
MW110	10/7/2009	0.8	0.82	7.2	0.5U
MW110	4/12/2010	0.34	0.5U	2.5	0.5U
MW110	10/13/2010	0.57	0.4	6.4	0.5U
MW110	4/12/2011	0.33	0.32	4.1	0.5U
MW110	10/13/2011	0.35	0.52	5.7	0.5U
MW110	5/1/2012	3.2J	0.8	3.5	0.5U
STATION	**COLLECTIONDATE**	**CIS-1,2-DICHLOROETHENE**	**TETRACHLOROETHENE**	**TRICHLOROETHENE**	**VINYL CHLORIDE**
MW216	4/22/2003	0.58	0.55	4.6	0.5U
MW216	10/23/2003	0.48J	0.5	3.9	0.5U
MW216	4/19/2004	0.35J	0.39J	3.5	0.5U
MW216	10/12/2004	0.24J	0.46J	3.2	0.5U
MW216	4/28/2005	0.3J	0.49J	3	0.5U
MW216	10/26/2005	0.5U	0.5U	2.5	0.5U
MW216	4/5/2006	0.5U	0.44J	2.6	0.5U
MW216	10/26/2006	0.18J	0.48J	2.5	0.5U
MW216	4/5/2007	0.5U	0.54	2.7	0.5U
MW216	10/3/2007	0.5U	0.46J	2.6	0.5U
MW216	10/16/2008	0.5U	0.55	2.7	0.5U
MW216	4/16/2008	0.2J	0.42J	2.4	0.5U
MW216	4/15/2009	0.23J	0.54	2.5	0.5U
MW216	10/7/2009	0.5U	0.48J	2.4	0.5U
MW216	4/14/2010	0.5U	0.4	2.1	0.5U
MW216	10/14/2010	0.32	0.3	1.9	0.5U
MW216	4/13/2011	0.26	0.3	2.7	0.5U
MW216	10/13/2011	0.19J	0.4J	3.3U	0.5U
MW216	5/1/2012	0.19J	0.5U	3.1	0.5U
STATION	**COLLECTIONDATE**	**CIS-1,2-DICHLOROETHENE**	**TETRACHLOROETHENE**	**TRICHLOROETHENE**	**VINYL CHLORIDE**
MW217	4/22/2003	1.5	1.6	16	0.5U
MW217	10/23/2003	1.2	1.4	15	0.5U
MW217	4/19/2004	0.94	1.2	12	0.5U
MW217	10/12/2004	0.84	1.3	12	0.5U
MW217	4/27/2005	0.86	1.5	12	0.5U
MW217	10/27/2005	0.88	1.3	10	0.5U
MW217	4/5/2006	0.74	1.4	9.4	0.5U
MW217	10/23/2006	0.75	1.4	9.4	0.5U
MW217	4/5/2007	2.5U	1.7	10	2.5U
MW217	10/4/2007	0.77U	1.4	9	0.5U
MW217	4/16/2008	0.72	1.3	8.9	0.5U
MW217	10/16/2008	0.69	1.5	8.6	0.5U
MW217	4/16/2009	0.68	1.3	9	0.5U
MW217	10/7/2009	0.78	1.4	8.4	0.5U
MW217	4/14/2010	0.7	1.6	10	0.5U
MW217	10/14/2010	0.48	1.6	8.9	0.5U
MW217	4/13/2011	0.44	1.5	6.8	0.5U
MW217	10/13/2011	0.37J	1.5	6.8	0.5U
MW217	5/1/2012	0.5U	1.7	7.5	0.5U

Table 5
Analytical Results Distribution List
Dewatering Monitoring Plan
Lockwood Solvents Groundwater Plume Superfund Site

Name	Affiliation	Telephone	Email
Roger Hoogerheide	EPA Project Manager	406-457-5031	Hoogerheide.roger@epa.gov
John Podolinsky	DEQ Project Officer	406-841-5040	jpodolinsky@mt.gov
Woody Woods	Director, Lockwood Water and Sewer District	406-259-4120	woodyw@lockwoodwater.com
Boris Krizek	City of Billings POTW	406-247-8517	KrizekB@ci.billings.mt.us
Jim Sullivan	ATC Associates, Inc. (Soco consultant)	406-259-1033	James.sullivan@atcassociates.com
Catherine LeCours	PWT, Ltd. (EPA consultant)	406-457-5495	clecours@pwt.com

Table 6

Lockwood Dewatering Monitoring Plan

Water Level Measurements June 21

feet below top of casing

Well ID	Date			
	6/21/2012			
MW001 *	17.81			
MW002	8.37			
MW100	10.16			
MW103	10.15			
MW108 *	6.58			
MW109	7.02			
MW110	5.72			
MW216 *	NC			
MW217	11.2			
PT02	6.29			

NC = not collected

* transducer present

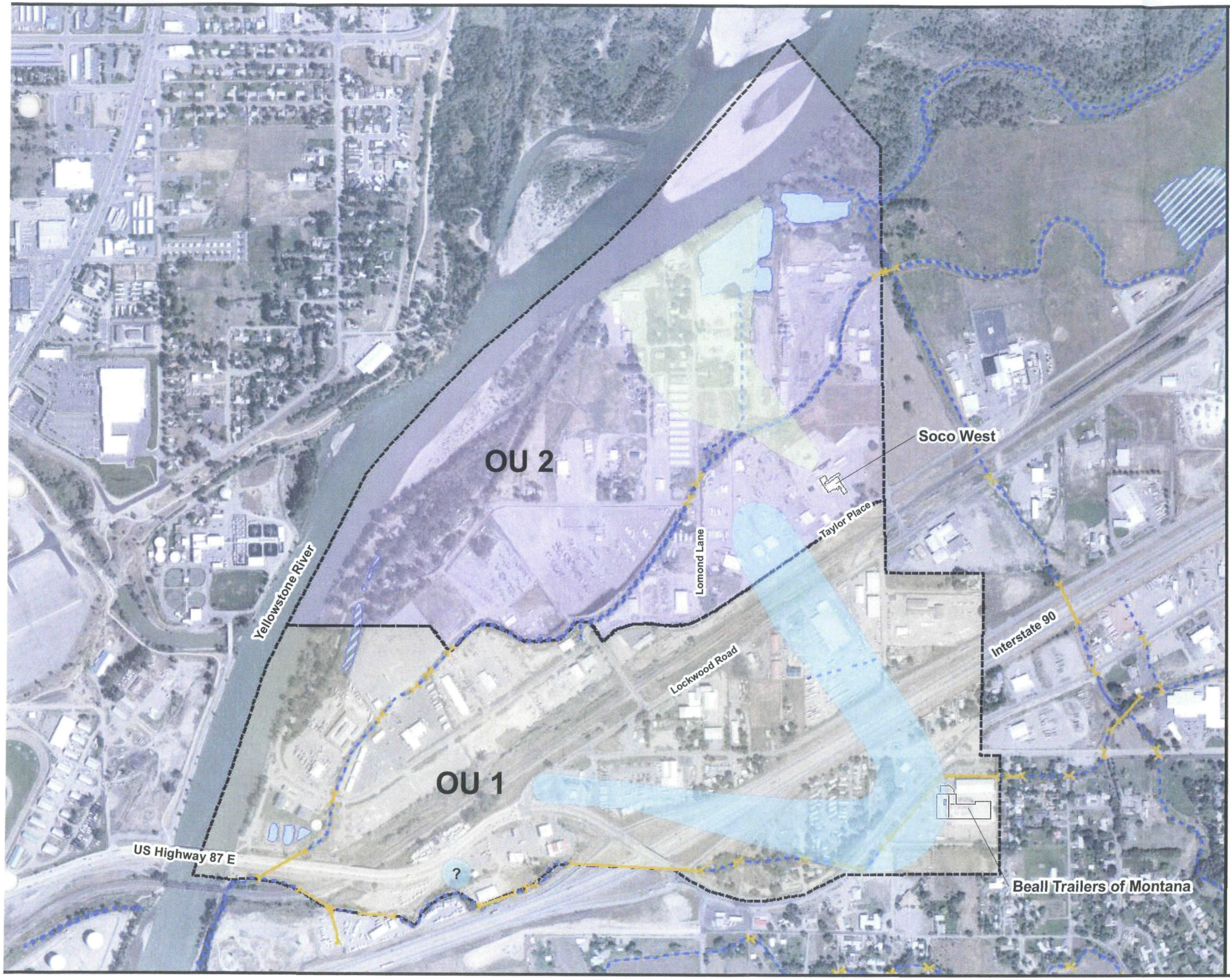
Figures

Figure 1

Site Location and Layout

Dewatering Monitoring Plan
Quality Assurance Project Plan
Lockwood Water and Sewer District Sewer Installation
Lockwood Solvent Groundwater Plume Site

June 2012



- OU 1
- OU 2
- Beall Plume (TCE > 5 µg/L)
- Soco Plume (PCE > 5 µg/L)
- Buildings
- Pond
- Wetlands
- Rail road
- Drainage ditch
- Culvert

Notes: April/May 2012 sampling.
ND - not detected above the method detection limit of 0.5 µg/L.
Locations and plume boundaries are approximate.

N
W E
S

0 200 400 800 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

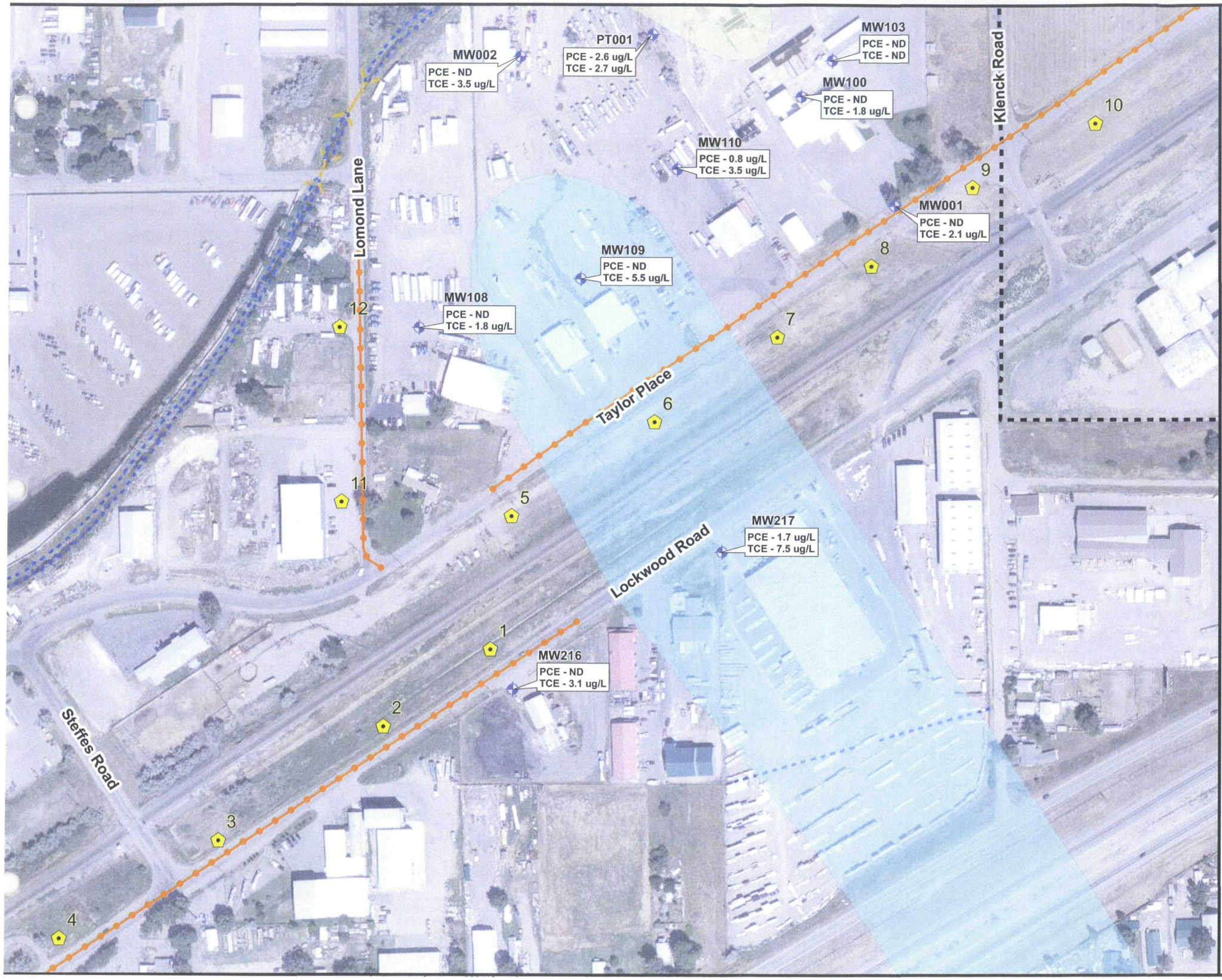
PWT
PACIFIC WESTERN TECHNOLOGIES, LTD.

Figure 2

Pertinent Features

Dewatering Monitoring Plan
Quality Assurance Project Plan
Lockwood Water and Sewer District Sewer Installation
Lockwood Solvent Groundwater Plume Site

June 2012



LWSD Pumping Well

Existing Monitoring Well

Beall Plume (TCE > 5 µg/L)

Soco Plume (PCE > 5 µg/L)

Site Boundary

Culvert

Sewer Expansion

Drainage ditch

Notes: April/May 2012 sampling.
ND - not detected above the method detection limit of 0.5 µg/L.
Locations and plume boundaries are approximate.

N
W E
S

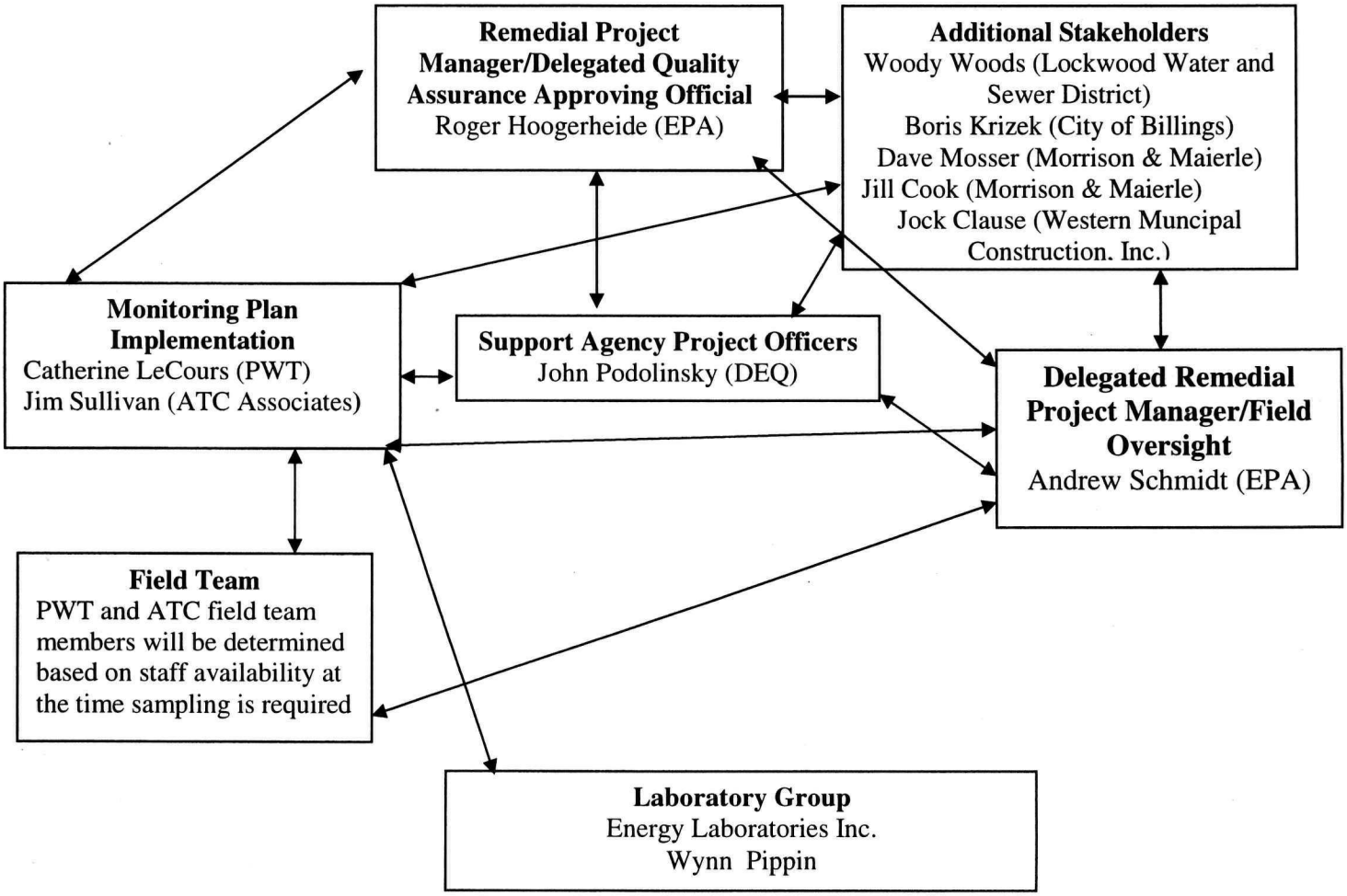
0 100 200 400 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

PWT
PACIFIC WESTERN TECHNOLOGIES, LTD.

Figure 3
Organization Chart
Dewatering Monitoring Plan
Lockwood Solvent Groundwater Plume Superfund Site



Attachment A
Well Logs

LOCKWOOD SOLVENT GROUNDWATER PLUME SITE
YELLOWSTONE COUNTY
MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW216

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3110.5	0		Ground Surface			
	0		***No Samples***			
3109.0	1					
	2					
3108.0	3					
3107.0	4			2.6		
	4		***Silt*** Brown silt with some fine-graded sand, no staining and no odors, damp			
3106.0	5					
3105.0	6		***No Samples***			
3104.0	7					
3103.0	8					
3102.0	9			4.6		
	9		***Silt*** Brown silt with clay, moist, no staining and no odors			
3101.0	10					
3100.0	11					
3099.0	12		***Sand*** Fine-graded sand, moist, no staining and no odors			
3098.0	13		***Silt*** Brown silt with clay, very moist to wet, soft, no staining and no odors	5.0	MW216SB001	
3097.0	14		***No Samples*** Note: Driller indicates gravel starting at 18.75 ft			
3096.0	15					
3095.0	16					
3094.0	17					
3093.0	18					
3092.0	19					
3091.0	20			3.1		

DRILLING DATE: 7/11/02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 34
TOTAL WELL DEPTH (ft btoc): 34
LOGGED BY: Randy Laskowski
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2
TOC ELEVATION (ft AMSL): 3109.99
GROUND ELEVATION (ft AMSL): 3110.53
DRILLING CO.: Maxim
WATER LEVEL (ft btoc): 10.10 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3100.09

Tetra Tech EM Inc.
7 West 6th Avenue, Suite 612
Helena, Montana
(406)442-5588

LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW216

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3090.0	21		***Sandy Gravel*** Brown fine to medium-graded gravel with medium to coarse sand, wet, no staining and no odors			
3089.0	22		***No Samples***			
3088.0	23					
3087.0	24					
3086.0	25					
3085.0	26					
3084.0	27					
3083.0	28					
3082.0	29					
3081.0	30					
3080.0	31					
3079.0	32					
3078.0	33		***Bedrock***			
3077.0	34		End of Log			
3076.0	35					
3075.0	36					
3074.0	37					
3073.0	38					
3072.0	39					
3071.0	40					

DRILLING DATE: 7/11/02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 34
TOTAL WELL DEPTH (ft btoc): 34
LOGGED BY: Randy Laskowski
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2
TOC ELEVATION (ft AMSL): 3109.99
GROUND ELEVATION (ft AMSL): 3110.53
DRILLING CO.: Maxim
WATER LEVEL (ft btoc): 10.10 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3100.09

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW217

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3108.3	0		Ground Surface			
			No Samples			
3107.0	1					
3106.0	2					
3105.0	3					
3104.0	4					
	5		***Clay*** Brown moist soft clay with moderate silt, no staining and no odors	0.5		
3103.0	6					
3102.0	7		***No Samples***			
3101.0	8					
3100.0	9					
3099.0	10		***Silt*** Grey to brown saturated silt with clay grading to silt and fine-graded sand	0.3	MW217SB001	
3098.0	11					
3097.0	12		***Sand*** Fine-graded sand with silt			
3096.0	13		***No Samples***			
3095.0	14					
3094.0	15					
3093.0	16		***Sandy Gravel***			
3092.0	17					
3091.0	18					
3090.0	19					
3089.0	20					

DRILLING DATE: 7/23/02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 32.2
TOTAL WELL DEPTH (ft btoc): 31.1
LOGGED BY: Randy Laskowski
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2
TOC ELEVATION (ft AMSL): 3107.92
GROUND ELEVATION (ft AMSL): 3108.26
DRILLING CO.: O'Keefe
WATER LEVEL (ft btoc): 9.21 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3098.82

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW217

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3087.0	21					
3086.0	22					
3085.0	23					
3084.0	24					
3083.0	25					
3082.0	26					
3081.0	27					
3080.0	28					
3079.0	29					
3078.0	30					
3077.0	31		***Bedrock***			
3076.0	32		End of Log			
3075.0	33					
3074.0	34					
3073.0	35					
3072.0	36					
3071.0	37					
3070.0	38					
3069.0	39					
	40					

DRILLING DATE: 7/23/02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 32.2
TOTAL WELL DEPTH (ft btoc): 31.1
LOGGED BY: Randy Laskowski
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2
TOC ELEVATION (ft AMSL): 3107.92
GROUND ELEVATION (ft AMSL): 3108.26
DRILLING CO.: O'Keefe
WATER LEVEL (ft btoc): 9.21 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3098.82

Tetra Tech EM Inc.
7 West 6th Avenue, Suite 612
Helena, Montana
(406)442-5588

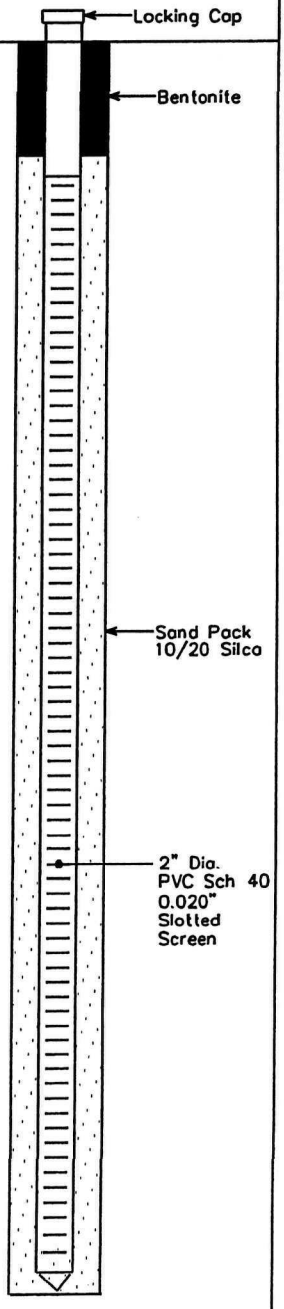
Monitoring Well PT–1

PROJECT: AS/SVE Pilot Study
LOCATION: Brenntag West, Lockwood, MT.
DRILL RIG.: Mobile B–61, Okeefe Drilling Co.

DATE: 12/13/01
HOLE DIA.: 8 in.

LOGGED BY: H. Kaiser
SAMPLER: 2" Dia. Split Spoon
GROUND ELEV.: 3101.5

DESCRIPTION	USCS CLASS	GRAPHIC LOG	DEPTH	BLOWS/6"	SAMPLE	PID (ppm)	RECOVERY
CLAY: With minor medium sand, light grey to brown at depth dry medium stiff no odor or stain.	CL		1	42		0	16"/24"
CLAY: With minor sand, moist light grey, medium stiff to soft, no odor or stain.	CL		2 3 4	3 3 3 2		0	16"/24"
BACKFILL: Encountered 8" of bentonite. (moved location 2 feet North and continued drilling)			5	2 2 2 2		0	14"/24"
CLAY: Moist, grey, medium soft, slight odor, no stain, minor fine sand, (laboratory sample PT–1 6–8 FT.)	CL		6 7	2 3 5	X	0	22"/24"
Top 7", CLAY: As above. Bottom 17", SAND: Wet, brown and grey, minor clay and silt, no odor, medium sand, well sorted.	CL/ SP		8 9	7 6 8 9 12	X	738 107	24"/24"
SAND: Fine grained, wet, grey, minor silt and clay, no odor or stain.	SP		10 11	3 3 3 4		0	12"/24"
Top 12", SAND: As above, medium coarse, wet, grey. Bottom 8", GRAVEL: Fine to coarse, rounded, with sand, wet, grey, no odor.	SP/ GP		12 13	4 29 26 29		0	18"/24"
GRAVEL: With sand, wet, fine to coarse, rounded gravel with medium to coarse sand, no odor or stain.	GP		14 15	45 40 41 29		0	12"/24"
GRAVEL: With sand and minor clay, fine to medium gravel, coarse sand, wet, no odor.	GP		16 17	29 23 40 46		0	10"/24"
Same as Above: Poorly sorted, clay increasing slightly, wet, no odor or stain.	GP		18 19	32 72 80 52		0	20"/24"
SAND and GRAVEL: Coarse sand, fine to medium gravel, wet, no odor. (Laboratory sample PT–1 20–22 FT)	GP		20 21	21 70 67 103	X	0	12"/24"
SAND: With fine gravel in bottom 8", well sorted medium coarse sand, grey, wet. DO: Sand heaving into augers.	GP		22 23	34 50–4"		0	24"/10"
Same as Above: bottom 8" with fine gravel and sand; *heaving sands.*	GP		24 25	30 50–5"		0	24"/11"
SANDSTONE (BEDROCK) Grey medium grained. TD = 28'	SS		26 27	50–3"		0	2"/3"
			28 29 30				



SECOR
International Incorporated
Billings, Montana

Notes:
DO = Drillers observation TD = total depth
Lab samples submitted to Energy Lab for VOC (EPA Method 8260) and TOC analysis.

Project No.
032.60001.004
LOG–0763

MONTANA WELL LOG REPORT

Form No. 603 R2-99

Well ID# EPA-1

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with DNRC within 60 days of completion of the work.** **Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.**

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name U.S. EPA c/o Pete Stevenson
Mailing address U.S. EPA Region 8, 999 18th Street, Suite 500, Denver Co. 80202-2405

2. WELL LOCATION: List ¼ from smallest to largest
____ ¼ ____ ¼ NW ¼ SE ¼, Section 26
Township 1 (N)/S Range 26 (E)W County Yellowstone
Lot ____, Tract/Blk____ Subdivision Name ____
Well Address 1353 Taylor, Billings MT Lockwood MT
GPS ☐ Yes ☐ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☐ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☒ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☒ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: HSA

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 8½ in. from 0' ft. to 25' ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

Casing:
Steel: Wall thickness NA ☐ Threaded ☐ Welded
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

Plastic: Pressure Rating 230 lbs. ☒ Threaded ☐ Welded
Dia. 2" in. from [redacted] 0 ft. to 24' ft.

Perforations/Slotted Pipe:
Type of perforator used NA
Size of perforations/slots ____ in. by ____ in.
____ no. of perforations/slots from ____ ft. to ____ ft.
____ no. of perforations/slots from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No
Material PVC Sch 40
Dia. 2" Slot size 0.010 from 24 ft. to 14 ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel Packed: ☒ Yes ☐ No
Size of gravel 10/20 Silica Sand
Gravel placed from 24' ft. to 12' ft.

Packer: ☐ Yes ☒ No
Type ____ Depth(s) ____

Grout: Material used Bentonite Chips + Neat Cement
Depth from 2' ft. to 2' ft. OR ☐ Continuous feed

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☒ Static water level 12.5' ft. below top of casing **or**
☐ Closed-in artesian pressure ____ psi.
How was test flow measured: bucket/stopwatch, weir, flume, flowmeter, etc ____
Yellowstone groundwater closure area only - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
____ gpm with drill stem set at ____ ft. for ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test ____ ft.
____ gpm pump rate with ____ ft. of drawdown after ____ hrs pumping
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
0	9	Silty clay - Med Brown
9	21	Silty clay - Light Brown
21	25	Sandy gravel - Med Brown

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: 9/23/99

9. REMARKS: ____

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Maxim Technologies
Address Box 30615 Billings MT. 59107
Signature Paul Brand
Date 10/25/99 License no. MMWC #344

MBMG ID#

Montana DNRC P.O. BOX 201601 HELENA, MT 59620-1601 444-6610
DEPARTMENT COPY
DRILLER: Please give this copy to the well owner to complete reverse side.

MONTANA WELL LOG REPORT

Form No. 603 R2-99

Well ID# EPA-2

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describ the amount of water encountered. **This form is to be completed by the driller and filed with DNRC within 60 days of completion of the work.** **Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.**

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name U.S. EPA C/o Pete Stevenson
Mailing address U.S. EPA Region 8
999 18th Suite 500 Denver Col 80202-2405

2. WELL LOCATION: List ¼ from smallest to largest
____ ¼ ____ ¼ NW ¼ SE ¼, Section 26
Township 1 (N) S Range 26 (E) W County Yellowstone
Lot ____, Tract/Blk____ Subdivision Name ____
Well Address 1305 Taylor Lockwood MT
GPS ☐ Yes ☐ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☐ WGS84

3. PROPOSED USE: ☐ Domestic ☐ Stock ☐ Irrigation
☐ Public water supply ☒ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☒ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☐ Rotary ☒ Other: HSA

5. WELL CONSTRUCTION DETAILS:
Borehole:
Dia. 8 1/2 in. from 0 ft. to 23 ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

Casing:
Steel: Wall thickness NA ☐ Threaded ☐ Welded
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

Plastic: Pressure Rating 280 lbs. ☒ Threaded ☐ Welded
Dia. 2" in. from 0 ft. to 23 ft.

Perforations/Slotted Pipe:
Type of perforator used NA
Size of perforations/slots ____ in. by ____ in.
____ no. of perforations/slots from ____ ft. to ____ ft.
____ no. of perforations/slots from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No
Material Sch 40 PVC
Dia. 2" Slot size 0.010 from 13 1/2 ft. to 22 1/2 ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel Packed: ☒ Yes ☐ No
Size of gravel 10/20 Silica Sand + Native Sand
Gravel placed from 10 ft. to 23 ft.

Packer: ☐ Yes ☒ No
Type ____ Depth(s) ____

Grout: Material used Bentonite chips & Neat Cement
Depth from 2 ft. to 10 ft. OR ☐ Continuous feed

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☒ Static water level 5.4 ft. below top of casing or
☐ Closed-in artesian pressure ____ psi.
How was test flow measured:
bucket/stopwatch, weir, flume, flowmeter, etc ____
Yellowstone groundwater closure area only - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
____ gpm with drill stem set at ____ ft, for ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test ____ ft.
____ gpm pump rate with ____ ft. of drawdown after ____ hrs pumping
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

**During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the resevoir of the well casing.*

7. WELL LOG:

Depth, Feet From	Depth, Feet To	Material: color/rock and type/descriptor (example: blue/shale/hard or brown/gravel/water, or brown/sand/heaving)
0	4	Sandy gravel - med Brown
4	8	Clay - med Brown
8	23	Sandy gravel Med Brown
23		Sandstone - Grey
		Bedrock encountered

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: 10/1/99

9. REMARKS:

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.
Name, firm, or corporation (print) Maxim Technologies
Address P.O. Box 30615 Billings MT. 59107
Signature Paul Blas
Date 10/26/99 License no. MMWC #341

MBMG ID#

Montana DNRC P.O. BOX 201601 HELENA, MT 59620-1601 444-6610

DEPARTMENT COPY

DRILLER: Please give this copy to the well owner to complete reverse side.

LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW100

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3103.6	0		Ground Surface			
	1		***No Samples***			
3102.0	2					
3101.0	3					
3100.0	4					
	5		***Silty Clay*** Dark green to black stained	17.6		
3099.0						
3098.0	6			301		
	7		***Clay*** Dark green with black stained		MW100SB001	
3097.0						
3096.0	8			21		
	9		***Clay*** As above, saturated at 8.5 feet	82		
3095.0						
3094.0	10		***Silty Clay*** Dark gray to greenish, trace fine-grained sands			
3093.0	11			28	MW100SB002	
			Silty Clay Olive-green, water table at 11.2			
3092.0	12			42		
3091.0	13		***Sand*** Silty, as above to 13.2 feet			
3090.0	14		***Sandy-Clay*** Fine, no stain or odor	32		
3089.0	15		***Silty/Sandy Clay***			
3088.0	16			27		
3087.0			***Silty Sand*** Olive green to brown, sand is micaceaous, well-sorted, fine-grained			
3086.0	17			5		
	18		***Sand*** Medium well-sorted			
3085.0	19		***Sandy Gravel***	8.1		
3084.0	20					

DRILLING DATE: 6-21-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 33
TOTAL WELL DEPTH (ft btoc): 30.77
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3103.29
GROUND ELEVATION (ft AMSL): 3103.59
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 9.48 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3093.81

Tetra Tech EM Inc.
7 West 6th Avenue, Suite 612
Helena, Montana
(406)442-5588

LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW100

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3083.0	21		***Sand*** Fine to medium, well-sorted			
3082.0	22		***Sandy Gravel***	3		
3081.0	23		***No Samples*** Augering in gravels	4		
3080.0	24			10		
3079.0	25		***Sandy Gravel*** Mediumwith pea gravel, sub-rounded to sub-angular			
3078.0	26			10		
3077.0	27		***Sandy Gravel*** Well-sorted, coarse with mediumsand	64		
3076.0	28		***Sand*** Fine to medium, well-sorted, saturated			
3075.0	29		***Gravels with sand*** Coarse, angular with sand	68		
3074.0	30		***Gravels with sand***		MW100SB003	
3073.0	31					
3072.0	32		***Bedrock*** Sandstone			
3071.0	33		End of Log			
3070.0	34					
3069.0	35					
3068.0	36					
3067.0	37					
3066.0	38					
3065.0	39					
3064.0	40					

DRILLING DATE: 6-21-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 33
TOTAL WELL DEPTH (ft btoc): 30.77
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3103.29
GROUND ELEVATION (ft AMSL): 3103.59
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 9.48 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3093.81

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW103

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3103.6	0		Ground Surface			
			No Samples			
3102.0	2					
3101.0	3					
3100.0	4					
			Silty Clay Olive green, no stain or odor	11		
3099.0	5					
3098.0	6		***No Samples***	5		
3097.0	7					
3096.0	8		***Silty Clay*** Olive-green, trace fine sands			
3095.0	9		***No Samples***	3		
3094.0	10		***Clayey Sand*** Olive-green, very fine sand approximately 15% clay			
3093.0	11		***No Samples***	10		
3092.0	12		***Silty Clay*** Olive-green, very fine well-sorted sands	8		
3091.0	13		***Sand*** Olive-green, well-sorted, no stain or odor			
3090.0	14		***No Samples***	6.3		
3089.0	15		***Sand*** Silica sand, medium, well-sorted			
3088.0	16		***Sandy Gravel*** Fine sand and coarse gravel	10		
3087.0	17		***Sand*** Fine	14.5		
3086.0	18					
3085.0	19		***Gravel*** Coarse-grained	12.8	MW103SB001	
3084.0	20					

DRILLING DATE: 6-24-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs):
TOTAL WELL DEPTH (ft btoc):
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.):
WELL CASING DIAMETER (in.):
TOC ELEVATION (ft AMSL):
GROUND ELEVATION (ft AMSL):
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc):
GROUNDWATER ELEV (ft AMSL).:

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW103

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3083.0	21		***Sand*** Fine	5		
3082.0	22		***Gravel*** Coarse, poorly sorted	13		
3081.0	23		***Sand*** Well-sorted, medium			
3080.0	24		***Sandy Gravel*** Saturated	11		
3079.0	25		***Sandy Gravel*** Rounded to sub-rounded gravels with sand			
3078.0	26		***Sandy Gravel*** Sand is moderately well-sorted silica sand; gravel is sub-angular, no stain or odor	3.8		
3077.0	27		***Sandy Gravel*** Rounded to sub-rounded gravels in medium micaceous sand, wet	15		
3076.0	28		***Gravel*** Fewer sands than above; gravels aresub-rounded alluvial			
3075.0	29		***Sand*** Medium well-sorted silica sand			
3074.0	30		***Gravel*** Rounded alluvial gravels, no stain or odor	6		
3073.0	31		***No Samples***			
3072.0	32		***Sandy Gravel*** Coarse alluvial gravels with sand			
3071.0	33		***Bedrock*** Sandstone light gray			
3070.0	34		End of Log			
3069.0	35					
3068.0	36					
3067.0	37					
3066.0	38					
3065.0	39					
3064.0	40					

DRILLING DATE: 6-24-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs):
TOTAL WELL DEPTH (ft btoc):
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.):
WELL CASING DIAMETER (in.):
TOC ELEVATION (ft AMSL):
GROUND ELEVATION (ft AMSL):
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc):
GROUNDWATER ELEV (ft AMSL).:

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW108

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3099.3	0		Ground Surface			
			No Samples			
3098.0	1					
3097.0	2					
3096.0	3					
3095.0	4		***Silty Clay*** Dark brown, moderate organic content, no odor, saturated at 4.6 ft.	8		
3094.0	5					
3093.0	6		***No Recovery*** ***No Samples***			
3092.0	7					
3091.0	8					
3090.0	9		***Silty Clay*** As above	8.1		
3089.0	10		***Sand*** Well-sorted, fine silica sand			
3088.0	11		***No Recovery*** ***No Samples***			
3087.0	12					
3086.0	13					
3085.0	14		***Sand*** As above	37		
3084.0	15		***Sandy Gravel*** Poorly sorted, coarse, sub-angular to sub-rounded with medium sand and clay			
3083.0	16		***No Recovery***			
3082.0	17		***No Samples***			
3081.0	18					
3080.0	19			21		
	20					

DRILLING DATE: 6-18-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 30.0
TOTAL WELL DEPTH (ft btoc): 26.7
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3098.77
GROUND ELEVATION (ft AMSL): 3099.30
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 6.46 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3092.31

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW108

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3078.0	21		***Sandy Gravel*** Coarse gravel with fine to medium sand; 20% sub-rounded gravel to 1mm, 20% 2-3 mm diameter, no odor			
3077.0	22		***No Recovery***			
3076.0	23		***No Samples***			
3075.0	24		***Sand*** Medium-grained, well-sorted, silica sand.	38	MW108SB001	
3074.0	25		***Gravel*** Coarse, sub-angular to sub-rounded gravels; 0-1 cm 20%, 1-2 cm 70%, 2-4 cm 10%.			
3073.0	26					
3072.0	27		***No Sample***			
3071.0	28					
3070.0	29		***Sand*** Fine-grained, well-sorted, silica sand.	10		
3069.0	30		***Bedrock*** Shale dark marine shale.			
3068.0	31		End of Log			
3067.0	32					
3066.0	33					
3065.0	34					
3064.0	35					
3063.0	36					
3062.0	37					
3061.0	38					
3060.0	39					
	40					

DRILLING DATE: 6-18-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 30.0
TOTAL WELL DEPTH (ft btoc): 26.7
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3098.77
GROUND ELEVATION (ft AMSL): 3099.30
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 6.46 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3092.31

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW109

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3100.2	0		Ground Surface			
	0		***No Samples***			
3099.0	1					
3098.0	2					
3097.0	3					
3096.0	4		***Silty Sand*** Light tan to brown silty sand.	17.5		
3095.0	5					
3094.0	6		***Clay*** Blocky			
3093.0	7		***No Samples***			
3092.0	8					
3091.0	9		***Clay*** Kaolinitic, stiff, silty	40	MW109SB001	
3090.0	10					
3089.0	11		***No Samples***			
3088.0	12					
3087.0	13					
3086.0	14		***Clay*** As above	17		
3085.0	15					
3084.0	16		***Sand*** Medium well-sorted.			
3083.0	17		***Gravel*** Coarse, angular gravel.			
3082.0	18		***No Samples***			
3081.0	19		***Sand*** Medium well-sorted sand.	16.4		
	20					

DRILLING DATE: 6-18-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 32.0
TOTAL WELL DEPTH (ft btoc): 30.1
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3099.94
GROUND ELEVATION (ft AMSL): 3100.21
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 6.57 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3092.31

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW109

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3079.0	21		***Gravel*** Gravel-coarsening downward, sub-angular to sub-rounded.			
3078.0	22		***No Sample***			
3077.0	23					
3076.0	24			34		
3075.0	25		***Sand*** Medium well-sorted, saturated.			
3074.0	26		***Gravel*** Coarse, poorly sorted, sub-rounded to sub-angular gravel, no odor.			
3073.0	27		***No Samples***			
3072.0	28					
3071.0	29			19		
3070.0	30		***Sand*** Medium well-sorted; sharp contact with gravels below.			
3069.0	31		***Gravel*** Poorly sorted, angular.			
3068.0	32		***Bedrock*** Sandy shale dark			
3067.0	33		End of Log			
3066.0	34					
3065.0	35					
3064.0	36					
3063.0	37					
3062.0	38					
3061.0	39					
	40					

DRILLING DATE: 6-18-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 32.0
TOTAL WELL DEPTH (ft btoc): 30.1
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3099.94
GROUND ELEVATION (ft AMSL): 3100.21
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 6.57 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3092.31

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW110

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3098.9	0		Ground Surface			
			No Samples			
3098.0	1					
3097.0	2					
3096.0	3					
3095.0	4					
			Silty Clay	12.7		
3094.0	5		Dark brown silty clay			
3093.0	6		***No Recovery***			
			No Samples			
3092.0	7					
3091.0	8					
3090.0	9			20.6		
			Silty Clay		MW110SB004	
3089.0	10		As above, moist.			
3088.0	11					
			No Samples			
3087.0	12					
3086.0	13					
3085.0	14			23		
			Silty Clay			
3084.0	15		As above.		MW110SB001	
			No Samples			
3083.0	16					
3082.0	17					
3081.0	18					
3080.0	19			25		
			Sand			
3079.0	20		Well-sorted, fine			

DRILLING DATE: 6-19-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 30.5
TOTAL WELL DEPTH (ft btoc): 29.84
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3098.71
GROUND ELEVATION (ft AMSL): 3098.93
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 5.6 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3093.11

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LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

YELLOWSTONE COUNTY

MONTANA

LOG OF BOREHOLE

Borehole/Well ID: MW110

Elevation (+/- AMSL)	Depth (ft bgs)	Lithologic Symbol/ Recovery	Lithologic Description	Headspace PID Reading	Soil Sample ID/ Sample Interval	Monitoring Well Completion
3078.0	21		***Gravel*** Coarse alluvial gravels			
3077.0	22		***No Samples***			
3076.0	23					
3075.0	24		***Sand*** Medium well-sorted.	25		
3074.0	25					
3073.0	26		***Gravel*** Coarse, sub-angular to sub-rounded, slight odor.			
3072.0	27		***No Samples***			
3071.0	28					
3070.0	29		***Sandy Gravel*** Sub-rounded to sub-angular gravels with saturated, medium sands.	48	MW110SB002	
3069.0	30					
3068.0	31		***Bedrock*** Sandstone dark gray, medium			
3067.0	32		End of Log			
3066.0	33					
3065.0	34					
3064.0	35					
3063.0	36					
3062.0	37					
3061.0	38					
3060.0	39					
3059.0	40					

DRILLING DATE: 6-19-02
DRILLING METHOD: HSA
BOREHOLE DEPTH (ft bgs): 30.5
TOTAL WELL DEPTH (ft btoc): 29.84
LOGGED BY: J. Faubion
CLIENT: MDEQ
PROJECT NO.: S1176-10RIRPRT

BOREHOLE DIAMETER (in.): 8.25
WELL CASING DIAMETER (in.): 2.0
TOC ELEVATION (ft AMSL): 3098.71
GROUND ELEVATION (ft AMSL): 3098.93
DRILLING CO.: SK Geotechnical
WATER LEVEL (ft btoc): 5.6 (10/28/02)
GROUNDWATER ELEV (ft AMSL).: 3093.11

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Attachment B
Mann Kendall Trend Evaluations

Mann Kendall Trend Evaluation

Contaminant: CIS-1,2-Dichloroethene

Monitoring Inputs

Quarter	MW001	MW100	MW103	MW110	MW002
	ug/l	ug/l	ug/l	ug/l	ug/l
1	0.25	0.23	17	0.77	0.76
2	0.25	1.7	18	0.66	1
3	0.25	0.52	0.43	0.25	0.86
4	0.25	2	7.2	0.53	0.84
5	0.25	0.34	9.8	0.25	0.74
6	0.25	0.82	8	0.25	0.81
7	0.25	0.48	101	0.25	0.77
8	0.25	6.9	17	0.22	0.67
9	0.25	0.65	16	0.41	0.58
10	0.25	9.3	22	0.23	0.6U
11	0.25	0.9	0.66	0.8	0.47J
12	0.25	37	101	0.34	0.56J
13	0.25	4.9	0.88	0.57	0.57
14	0.25	1.6	8.6	0.33	0.64J
15	0.25	0.67	0.93	0.35	0.51
16	0.25	1.8	9.4	0.32	0.52

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Decreasing
MW002	Decreasing

5-12 Quarter Evaluation

MW001	Stable/No Trend
MW100	Increasing
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

9-16 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

12 Quarter Evaluation

MW001	Stable/No Trend
MW100	Increasing
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

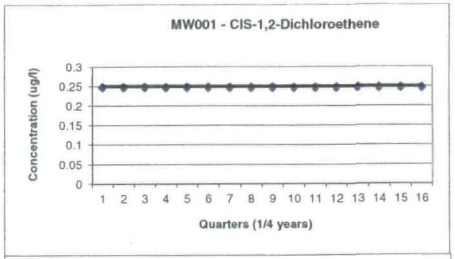
16 Quarter Evaluation

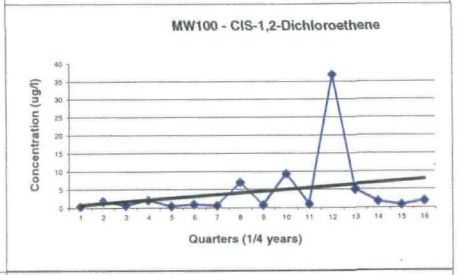
MW001	Stable/No Trend
MW100	Increasing
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Decreasing

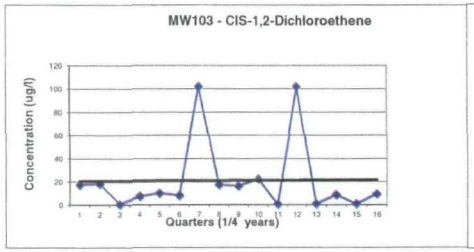
7 Year Evaluation

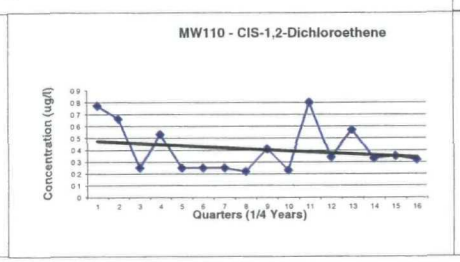
Mess1	Decreasing

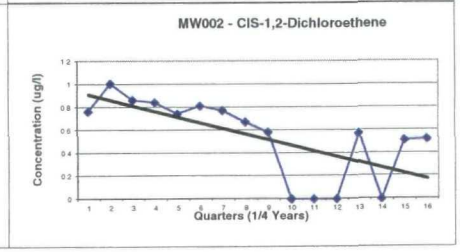
(See 7 year sheet for chart)











Mann Kendall Trend Evaluation

Contaminant: PCE

Monitoring Inputs

Quarter	MW108	MW109	MW216	MW217	
	ug/l	ug/l	ug/l	ug/l	ug/l
1	0.25	0.25	0.46	1.3	
2	0.25	0.25	0.49	1.5	
3	0.25	0.25	0.25	1.3	
4	0.25	0.25	0.44	1.4	
5	0.25	0.25	0.48	1.4	
6	0.25	0.27	0.54	1.7	
7	0.25	0.25	0.46	1.4	
8	0.25	0.2	0.55	1.3	
9	0.25	0.18	0.42	1.5	
10	0.25	0.22	0.54	1.3	
11	0.25	0.52	0.48	1.4	
12	0.25	0.23	0.4	1.6	
13	0.25	0.28	0.3	1.6	
14	0.25	0.25	0.3	1.5	
15	0.25	0.33	0.4	1.5	
16	0.25	0.25	0.25	1.7	

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Increasing
MW217	Stable/No Trend
0	Stable/No Trend

5-12 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

9-16 Quarter Evaluation

MW108	Stable/No Trend
MW109	Increasing
MW216	Decreasing
MW217	Increasing
0	Stable/No Trend

12 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

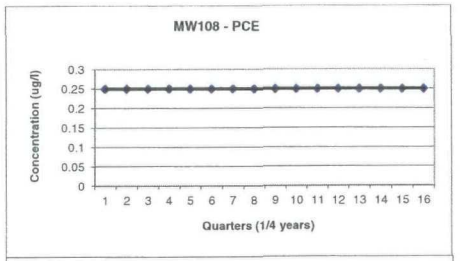
16 Quarter Evaluation

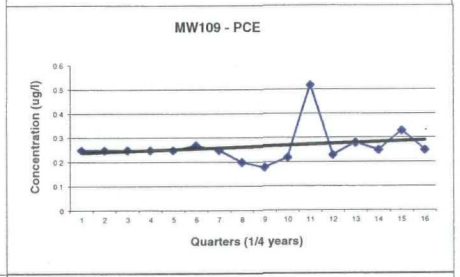
MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Decreasing
MW217	Increasing
0	Stable/No Trend

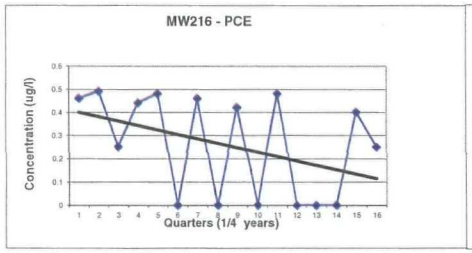
7 Year Evaluation

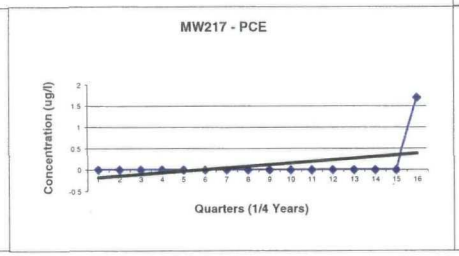
Mess1	Decreasing

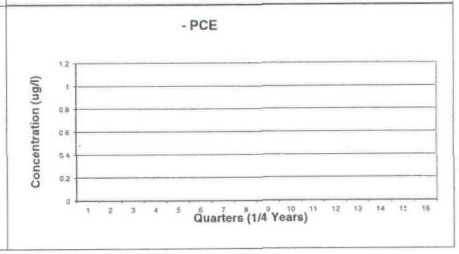
(See 7 year sheet for chart)











Mann Kendall Trend Evaluation

Contaminant: DCE

Monitoring Inputs

Quarter	MW108	MW109	MW216	MW217	
	ug/l	ug/l	ug/l	ug/l	ug/l
1	0.4	0.25	0.24	0.84	
2	0.37	0.25	0.3	0.86	
3	0.44	0.25	0.25	0.88	
4	0.33	0.25	0.25	0.74	
5	0.28	0.25	0.18	0.75	
6	0.25	0.27	0.25	1.25	
7	0.25	0.25	0.25	0.39	
8	0.25	0.2	0.25	0.72	
9	0.1	0.18	0.2	0.69	
10	0.22	0.22	0.23	0.68	
11	0.25	0.52	0.25	0.78	
12	0.2	0.23	0.25	0.7	
13	0.28	0.28	0.32	0.48	
14	0.2	0.25	0.26	0.44	
15	0.17	0.33	0.19	0.37	
16	0.25	0.25	0.19	0.25	

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW108	Decreasing
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

5-12 Quarter Evaluation

MW108	Decreasing
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

9-16 Quarter Evaluation

MW108	Stable/No Trend
MW109	Increasing
MW216	Stable/No Trend
MW217	Decreasing
0	Stable/No Trend

12 Quarter Evaluation

MW108	Decreasing
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Decreasing
0	Stable/No Trend

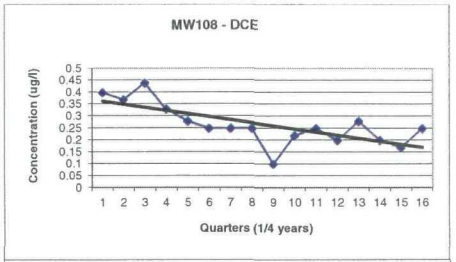
16 Quarter Evaluation

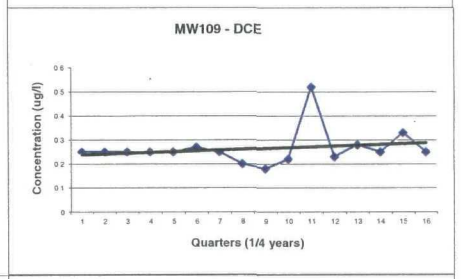
MW108	Decreasing
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Decreasing
0	Stable/No Trend

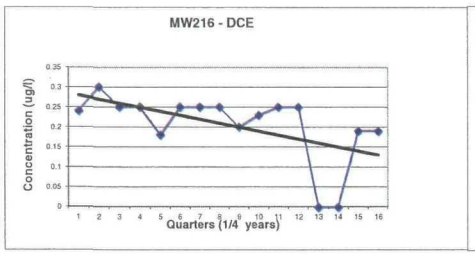
7 Year Evaluation

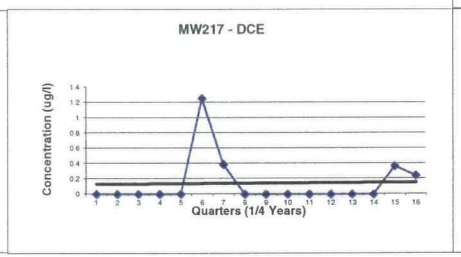
Mess1	Decreasing

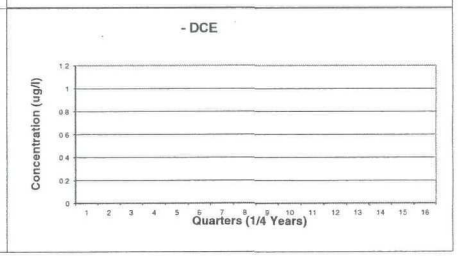
(See 7 year sheet for chart)











Mann Kendall Trend Evaluation

Contaminant: PCE

Monitoring Inputs

Quarter	MW001	MW100	MW103	MW110	MW002
	ug/l	ug/l	ug/l	ug/l	ug/l
1	0.25	0.25	0.25	0.25	0.25
2	0.25	0.84	0.25	0.25	0.25
3	0.25	0.25	0.25	0.25	0.25
4	0.25	0.62	0.25	0.25	0.25
5	0.25	0.89	9	0.25	0.25
6	0.25	1.1	1.5	0.25	0.25
7	0.25	0.48	11	0.25	0.25
8	0.25	0.6	0.25	0.25	0.25
9	0.25	0.66	3.2	0.21	0.25
10	0.25	1.7	2.7	0.25	0.25
11	0.25	0.55	1.4	0.82	0.25
12	0.25	14	0.53	0.25	0.25
13	0.25	0.5	0.25	0.4	0.25
14	0.25	0.95	0.25	0.32	0.25
15	0.25	0.27	1.4	0.52	0.25
16	0.25	0.25	0.25	0.8	0.25

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

5-12 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Decreasing
MW110	Stable/No Trend
MW002	Stable/No Trend

9-16 Quarter Evaluation

MW001	Stable/No Trend
MW100	Decreasing
MW103	Decreasing
MW110	Increasing
MW002	Stable/No Trend

12 Quarter Evaluation

MW001	Stable/No Trend
MW100	Increasing
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

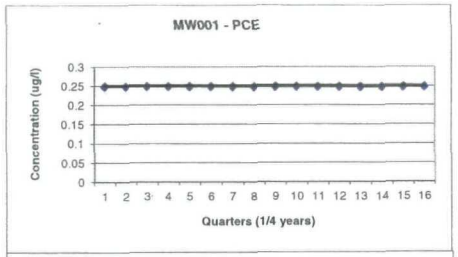
16 Quarter Evaluation

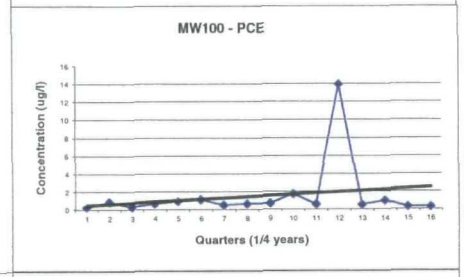
MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Increasing
MW002	Stable/No Trend

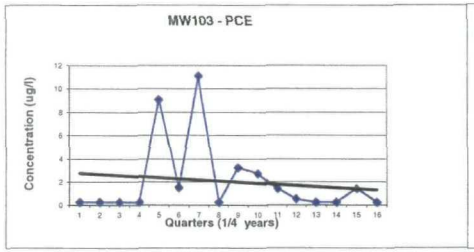
7 Year Evaluation

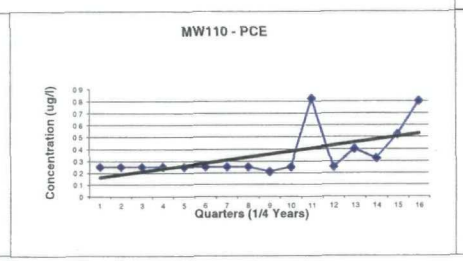
Mess1	Decreasing

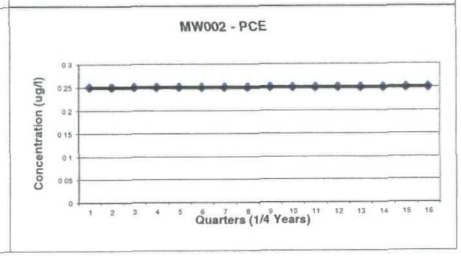
(See 7 year sheet for chart)











Mann Kendall Trend Evaluation

Contaminant: TCE

Monitoring Inputs

Quarter	MW001	MW100	MW103	MW110	MW002
	ug/l	ug/l	ug/l	ug/l	ug/l
1	0.25	0.39	0.28	8.2	6
2	0.25	1.1	0.31	0.82	7.7
3	0.2	0.6	0.25	4.8	6
4	0.25	1	0.29	2	7
5	0.25	1.4	3	1.4	5.5
6	0.34	2	0.67	1.4	5.4
7	0.35	1.5	6.3	1.4	4.1
8	0.25	1.8	0.52	1.7	5.2
9	0.44	1.8	1.8	4.5	3.6
10	0.68	2.3	1.1	1.8	4.8
11	0.58	1.5	0.98	7.2	3.7
12	0.76	3.3	0.78	2.5	4.5
13	0.26	1.4	0.3	6.4	3.9
14	0.19	1.4	0.32	4.1	3.1
15	0.81	1.3	1.1	5.7	4.2
16	2.1	1.8	0.25	3.5	3.5

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW001	Stable/No Trend
MW100	Increasing
MW103	Increasing
MW110	Stable/No Trend
MW002	Decreasing

5-12 Quarter Evaluation

MW001	Increasing
MW100	Increasing
MW103	Stable/No Trend
MW110	Increasing
MW002	Decreasing

9-16 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Decreasing
MW110	Stable/No Trend
MW002	Stable/No Trend

12 Quarter Evaluation

MW001	Increasing
MW100	Increasing
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Decreasing

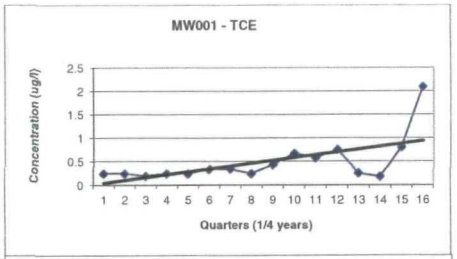
16 Quarter Evaluation

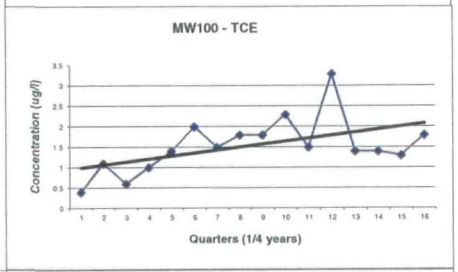
MW001	Increasing
MW100	Increasing
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Decreasing

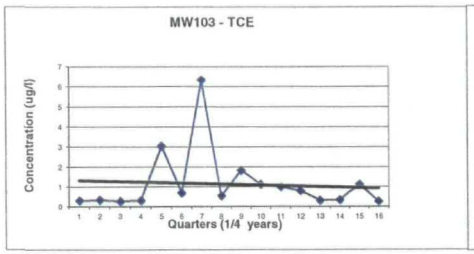
7 Year Evaluation

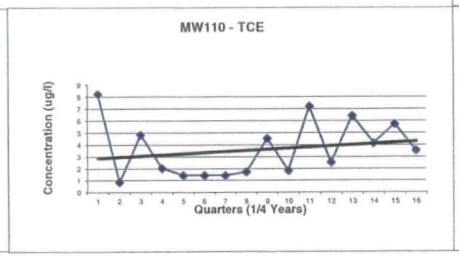
Mess1	Decreasing

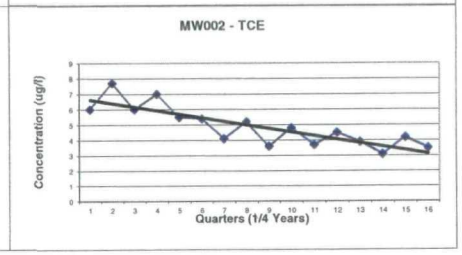
(See 7 year sheet for chart)











Mann Kendall Trend Evaluation

Contaminant: TCE

Monitoring Inputs

Quarter	MW108	MW109	MW216	MW217	
	ug/l	ug/l	ug/l	ug/l	ug/l
1	2.7	10	3.2	12	
2	2.6	9	3	12	
3	2.6	9	2.5	10	
4	2.3	8.3	2.6	9.4	
5	2.1	7	2.5	9.4	
6	2.3	6.3	2.7	10	
7	2.1	7.9	2.6	9	
8	1.8	5.7	2.7	8.9	
9	1.8	6.2	2.4	8.6	
10	1.9	5.6	2.5	9	
11	2	6.2	2.4	8.4	
12	1.7	5.8	2.1	10	
13	2	5.5	1.9	8.9	
14	1.7	4.5	2.7	6.8	
15	2	6.8	1.65	6.8	
16	1.8	5.5	3.1	7.5	

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW108	Decreasing
MW109	Decreasing
MW216	Stable/No Trend
MW217	Decreasing
0	Stable/No Trend

5-12 Quarter Evaluation

MW108	Decreasing
MW109	Decreasing
MW216	Decreasing
MW217	Stable/No Trend
0	Stable/No Trend

9-16 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Decreasing
0	Stable/No Trend

12 Quarter Evaluation

MW108	Decreasing
MW109	Decreasing
MW216	Decreasing
MW217	Decreasing
0	Stable/No Trend

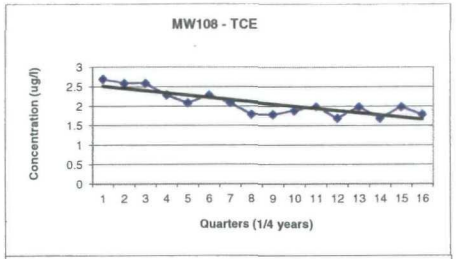
16 Quarter Evaluation

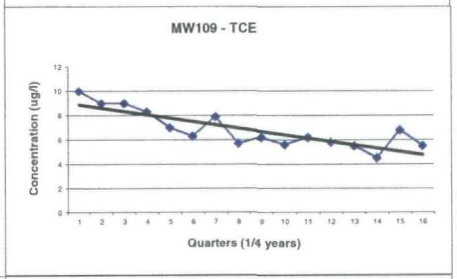
MW108	Decreasing
MW109	Decreasing
MW216	Decreasing
MW217	Decreasing
0	Stable/No Trend

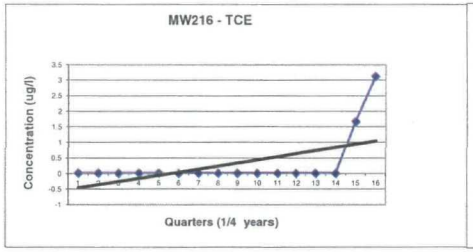
7 Year Evaluation

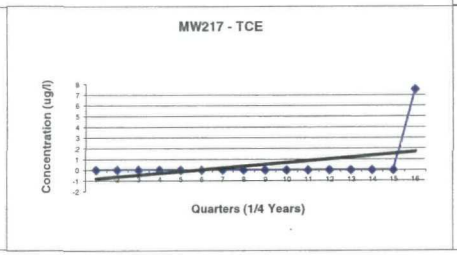
Mess1	Decreasing

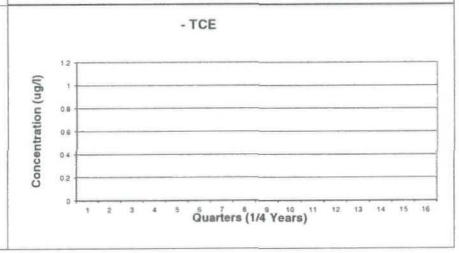
(See 7 year sheet for chart)











Mann Kendall Trend Evaluation

Contaminant: Vinyl Chloride

Monitoring Inputs

Quarter	MW001	MW100	MW103	MW110	MW002
	ug/l	ug/l	ug/l	ug/l	ug/l
1	0.25	0.25	1.1	0.25	0.25
2	0.25	1.2	2.1	0.25	0.25
3	0.25	0.32	0.25	0.25	0.25
4	0.25	1.4	0.89	0.25	0.25
5	0.25	0.25	2.5	0.25	0.25
6	0.25	0.25	1.3	0.25	0.25
7	0.25	8.3	10	0.25	0.25
8	0.25	0.3	0.5	0.25	0.25
9	0.25	2.3	3.4	0.25	0.25
10	0.25	0.25	3.9	0.25	0.25
11	0.25	12	0.25	0.25	0.25
12	0.25	0.15	18	0.25	0.25
13	0.25	0.25	0.25	0.25	0.25
14	0.25	0.31	0.25	0.25	0.25
15	0.25	0.16	0.25	0.25	0.25
16	0.2	0.2	0.2	0.25	0.25

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

5-12 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

9-16 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Decreasing
MW110	Stable/No Trend
MW002	Stable/No Trend

12 Quarter Evaluation

MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

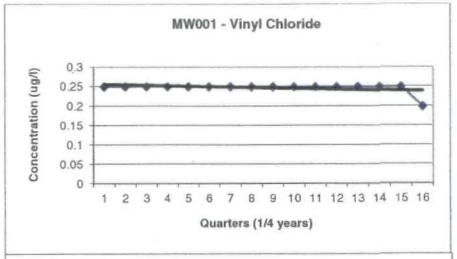
16 Quarter Evaluation

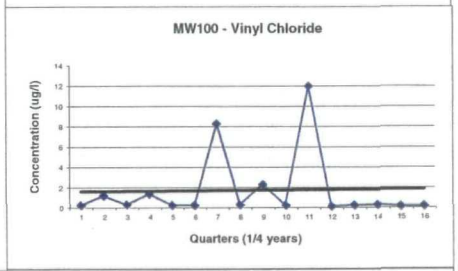
MW001	Stable/No Trend
MW100	Stable/No Trend
MW103	Stable/No Trend
MW110	Stable/No Trend
MW002	Stable/No Trend

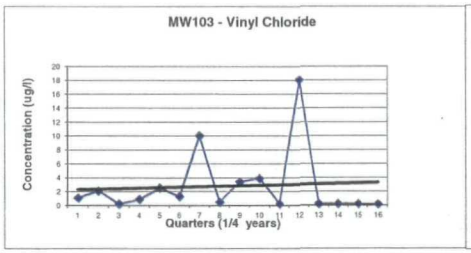
7 Year Evaluation

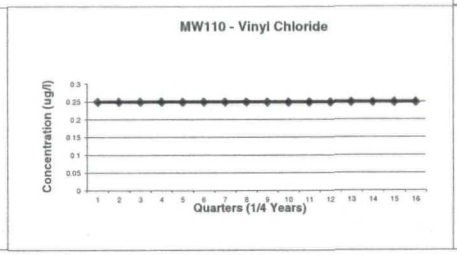
Mess1	Decreasing

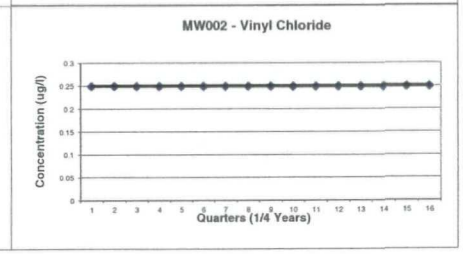
(See 7 year sheet for chart)











Mann Kendall Trend Evaluation

Contaminant: VC

Monitoring Inputs

Quarter	MW108	MW109	MW216	MW217	
	ug/l	ug/l	ug/l	ug/l	ug/l
1	0.25	0.25	0.25	0.25	
2	0.25	0.25	0.25	0.25	
3	0.25	0.25	0.25	0.25	
4	0.25	0.25	0.25	0.25	
5	0.25	0.25	0.25	0.25	
6	0.25	0.25	0.25	0.25	
7	0.25	0.25	0.25	0.25	
8	0.25	0.25	0.25	0.25	
9	0.25	0.25	0.25	0.25	
10	0.25	0.25	0.25	0.25	
11	0.25	0.25	0.25	0.25	
12	0.25	0.25	0.25	0.25	
13	0.25	0.25	0.25	0.25	
14	0.25	0.25	0.25	0.25	
15	0.25	0.25	0.25	0.25	
16	0.25	0.25	0.25	0.25	

Data Entry Cell

Mann-Kendall Results

0-8 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

5-12 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

9-16 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

12 Quarter Evaluation

MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

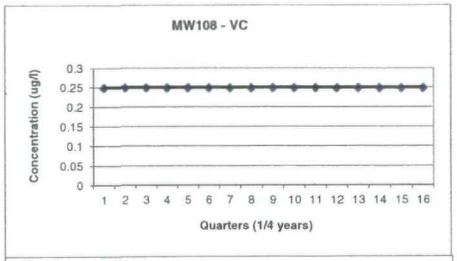
16 Quarter Evaluation

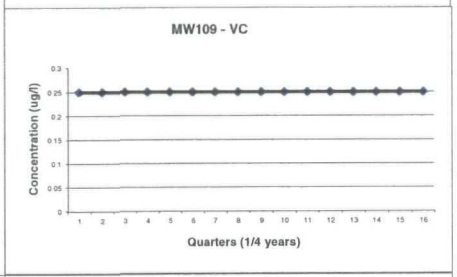
MW108	Stable/No Trend
MW109	Stable/No Trend
MW216	Stable/No Trend
MW217	Stable/No Trend
0	Stable/No Trend

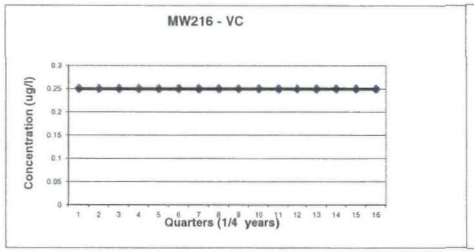
7 Year Evaluation

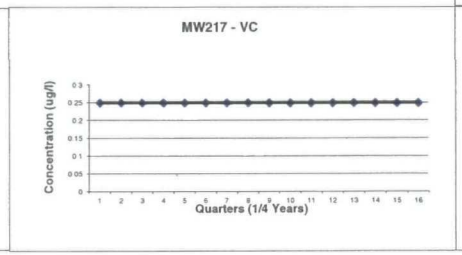
Mess1	Decreasing

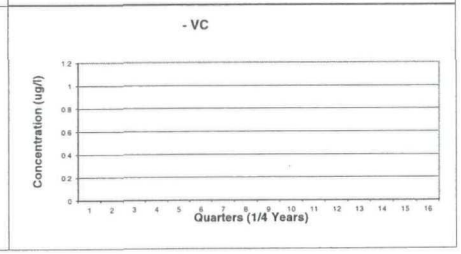
(See 7 year sheet for chart)











Attachment C
Technical Memorandum

PACIFIC WESTERN TECHNOLOGIES, LTD.
11049 W. 44th Avenue, Suite 200, Wheat Ridge, CO 80033 • 303.274.5400 • FAX 303.274.6160

TECHNICAL MEMORANDUM June 22, 2012

Subject: Evaluation of Groundwater Flow Velocity and Prediction of Drawdown Levels due to Dewatering Efforts for Sewer Line Installations

Site: Lockwood Solvent Groundwater Plume Site
Yellowstone, County, Montana

Reference: Dewatering Monitoring Plan, EPA Region 8, June 2012
Lockwood Water and Sewer District (LWSD) Sewer Line Installation

Attachments: Calculation and reference sheets, 20 pgs.

PURPOSE

The purpose of this technical memorandum is to present the calculations supporting an estimate of groundwater flow velocity and predicted drawdown levels of groundwater due to dewatering efforts supporting planned sewer line installations by the LWSD. Dewatering activities are planned for the sewer lines along select roads near the Lockwood Solvent Groundwater Plume Site and potential impacts are being monitored. Previous dewatering efforts were performed in 2009/2010 as reported in the *Groundwater Drawdown Monitoring Report: January 4, 2010, prepared by Tetra Tech, Inc., Billings, MT,* and information gathered from that effort is used to support these calculations along with site specific aquifer characteristic data from the EPA Remedial Investigation efforts.

DATA EVALUATION

Groundwater Travel Distance

Based on the reported aquifer parameters from the *Remedial Investigation Report - Lockwood Solvent Groundwater Plume Site, June 2003* travel distance of groundwater is expected to be limited, if any. However, the hydraulic conductivity (K) values from the site seem very low when compared to representative values of hydraulic conductivity for alluvial aquifers (Rahn 1986, p. 19 and 20 of attached calculations), so calculated impacts can be misleading versus observed drawdown data.

Drawdowns

The K values used were based on slug tests and they are so low that it would suggest this area should not have to be dewatered. However, we know this is not true because dewatering is required and withdrawal rates are not trivial from past efforts. Preliminary use of equations to calculate drawdown provides results that were not realistic compared to drawdown observed from the actual monitoring of groundwater levels during the 2009/2010 sewer dewatering project. Thus, the best predictions of expected drawdowns for the site are to use the reported 2009/2010 drawdowns and area of influence.

CONSIDERATIONS

- If there are MAJOR concerns of impacts to the plumes prior to the beginning of the next phase of dewatering, then a conservative approach is recommended for groundwater level monitoring (either

manual collection or with transducers) and subsequent groundwater sampling based on drawdown trigger levels.

- Further calculations can be performed, but based on existing data and observations they are not expected to be as representative as actual observed efforts from the 2009/2010 dewatering.
- A full pumping test with correct data collection would be the best way to quantify the site aquifer. To our knowledge this has not yet been done at the site.
- Data from the past dewatering effort could be plotted in the appropriate graphs to do a pump test analysis, even though multiple wells were pumped, this would provide a more realistic determination of the aquifer parameters. The evaluation would not be as straight forward as a standard pump test. Additional multi-well assumptions would be required.
- Existing data and parameters may not have been compared to field values in the specific site areas. The K values appear low for expected values for an alluvial aquifer. However, the groundwater gradients are low and likely water is moving slowly.
- Another calculation for groundwater velocity would be to look at the plume itself. What is the observed expansion of the plume and concentrations monitored over time. This is the most general and comprehensive way to calculate a rate of movement which inherently includes the retardation factors of all the contaminants. If that evaluation matches up to the calculations provided so far it is then a good cross check.

CONCLUSIONS

The groundwater velocity calculations using the parameters from previous site investigations and recent dewatering efforts indicate that the planned dewatering for 2012 will have minimal impacts to the movement of groundwater. There are no indications that the diversion of existing contaminant plumes will be affected by the dewatering efforts. Total travel distance of groundwater for the full 56 day dewatering is 0.04 feet for static conditions and 0.02 feet for pumping conditions see attached calculations pages 2 and 3, respectively. Based on groundwater velocity calculations it appears most of the water released will be from direct storage from the aquifer. Therefore lateral movement would be limited. Additionally, validation of the groundwater velocity sensitivity to K can be done by increasing the K value by 1000 times the reported site value. Even at that increase of K value, which would then be representative of coarse gravel, the travel distance is only increased to ~40 feet for the duration of dewatering effort. Therefore, the evaluation of potential groundwater plume movement is quite conservative both given the field parameters and from artificially varying the K values to extreme limits but within representative ranges.

Calculations to estimate expected drawdowns in the wells were attempted, but with the aquifer parameters, namely the very low hydraulic conductivity, the calculations presented an unrealistic drawdown as compared to real observed values from the 2009/2010 dewatering effort. Overall, the best approach for evaluation of drawdown is to use the observed drawdown from the 2009/2010 report and apply an overlay of the Cone of Depression as found in Figure 5 to the areas of concern. Compared to the 2009/2010 dewatering effort expect drawdowns in the Lockwood areas of 1-2 feet. This approach was used to prepare the drawdown trigger values for sampling in the EPA Dewatering Monitoring Plan, June 2012.

If there any further questions or comments regarding this technical memorandum please contact Bruce Peterman at 303 274-5400 x45 or Ram Ramaswami at x19.

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Engineering Calculation Sheet

PROJECT LOCKWOOD SOLVENT GW PLUME - DEWATERING PLAN			CLIENT EPA
BY B. PETERMAN	CHKD Ram Ramaswami	APPD	JOB NO. COPA 980 1 22 001 1 006
DATE 6/15/2012	DATE 6/22/2012	DATE	SHEET 1 of 20 REV 0

EVALUATION OF GROUND WATER VELOCITY AT STATIC CONDITIONS
NO DEWATERING ACTIONS.

SOURCE FOR AQUIFER PARAMETERS USED IN CALCS:

REMEDIAL INVEST. REPORT - LOCKWOOD SOLVENT GROUNDWATER PLUME SITE
JUNE 2003, TETRA TECH EM, INC, 249p.

CALCS SELECT POINT PATHS A+B on Fig 3-8 (P10/20)
FROM Oct. 28, 2002 ALLUVIAL AQUIFER WATER LEVELS

PATH A - MW 001 to MW 126; DISTANCE (MAP) = 2330 ft = L ✓

Difference in groundwater elevation = ΔA = 3095 - 3080 = 15ft ✓

PATH B - MW 204 to MW 124; DISTANCE = 4485 ft = L ✓

ΔH = 3110 - 3082 = 28ft ✓
(h_1 h_2)

FORMULA FOR AVERAGE GROUNDWATER VELOCITY FROM
GROUNDWATER and WELLS, 2nd ED, F.G. DRISCOLL, P. 83 EQN 5.18a ✓

$$V_{avg} = \frac{\frac{K(h_1 - h_2)}{L}}{n}$$

K = hydraulic conductivity (ft/d)
h = ground water elev. (ft)
L = FLOW PATH LENGTH (ft)
n = effective porosity of aquifer

GIVEN:

K = Avg of 8 slug tests in TABLE 3.2 - Summary of RI Slug Test Results (P14/20)
used available monitoring wells from Alluvial aquifer
K = 0.34 ft/d ✓

n = Avg. of 4 measured porosities in Table 5-6 - Summary of (P16/20) ✓
Geotechnical Engineering parameters measurements
n = 0.328 ✓

L = from PATH A & B ABOVE

h_1, h_2 = Groundwater elevations from PATH A & B above

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Engineering Calculation Sheet

PROJECT LOCKWOOD SOLVENT GW PLUME-DEWATERING PLAN			CLIENT EPA
BY B. PETERMAN	CHKD Ram Ramaswami	APPD	JOB NO CORA 980 122 001 000
DATE 6/15/2012	DATE 6/22/2012	DATE	SHEET 2 of 20 REV 0

Calc. Avg. Velocity for both Paths A & B

PATH A:

$$V = \frac{0.34\ ft/d\ (3095 - 3080\ ft)}{\frac{2330\ ft}{0.328}} = 0.00667\ ft/d$$

VELOCITY AT NATURAL GRADIENT

$= 0.000718\ ft/day$

PATH B:

VELOCITY AT NATURAL GRADIENT

$$V = \frac{0.34\ ft/d\ (3110 - 3082\ ft)}{\frac{4485\ ft}{0.328}} = 0.00647\ ft/d$$

$= 0.000696\ ft/day$

EXPECTED TRAVEL = Dewatering Schd is for pumping of multiple wells @ various stages

TOTAL PROJECT DURATION ⇒ 56 days

PATH A: $(0.000718 / 0.00667\ ft/d)\ 56\ days = 0.37\ ft$

$0.040\ ft$

PATH B: $(0.000696 / 0.00647\ ft/d)\ 56\ days = 0.36\ ft$

$0.039\ ft$

CONCLUSION GROUND WATER UNDER STATIC CONDITIONS AND NATURAL GRADIENT IS SLOW AND FOR PUMPING DURATION WOULD NOT BE EXPECTED TO MOVE FAR FROM CURRENT CONDITIONS ✓

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Engineering Calculation Sheet

PROJECT LOCKWOOD SOLVENT GW PLUME - DEWATERING			CLIENT EPA
BY B. Peterman	CHKD Ram Ramaswami	APPD	JOB NO. CORA.980.122.001.006
DATE 6/15/2012	DATE 6/22/2012	DATE	SHEET 3 of 20 REV 0

PUMPING CONDITIONS — PAST

EVALUATION OF GROUNDWATER VELOCITY DURING DEWATERING EFFORTS IN SUPPORT OF SEWER LINE INSTALLATIONS in JAN. 2010. RESULTS OF DEWATERING AND MONITORING WERE USED for CALCULATIONS. REFERENCE DOCUMENT: GROUNDWATER DRAWDOWN MONITORING REPORT, JAN. 4, 2010 AS PREPARED FOR COP CONSTRUCTION, LLC by TETRA TECH, BILLINGS, MT. USING SAME EQNs FROM PAGE 1. ✓

FROM FIGURE 5 – Pumping Drawdown Contours Phase One Sewer Substract Lockwood Water and Sewer District 12/1/2009 ✓

SELECT A TRAVEL PATH WITHIN CONE OF DEPRESSION FROM MW-100 to ROUGHLY CENTER OF DRAWDOWN AREA (near COP 28+27) (SEE ATTACHED FIG 5) ✓ P(11/20)

DISTANCE MEASURED = 1170 ft = L

$\Delta h = (h_1 - h_2) = 4.5\text{ ft} - 0\text{ ft} \Rightarrow 4.5\text{ ft}$ ✓

Avg. groundwater velocity during pumping (dewatering)

$$V = \frac{0.34\text{ ft/d}\,(4.5\text{ ft})}{\frac{1170\text{ ft}}{0.328}} = \frac{0.00399\text{ ft}}{\text{d}}$$

0.000429 ft/d

EXPECTED TRAVEL DURING PUMPING

$(0.00399\text{ ft/d})(56\text{ days}) =$ 0.024 ft

0.22 ft

CONCLUSION: Even during pumping from previous dewatering efforts, travel time in cone of depression is very small and also is inherently combined w/ natural travel times, ∴ don't do NOT expect plume movement to be significant.

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Engineering Calculation Sheet

PROJECT Lockwood Solvent Grw Plume – Dewatering Impact			CLIENT EPA
BY B. Peterman	CHKD Ram Ramaswami	APPD	JOB NO. CORA 980 122 001 006
DATE 6/15/2012	DATE 6/22/2012	DATE	SHEET 4 of 20 REV 0

PURPOSE: PROVIDE A SIMPLE DEWATERING CALCULATION FOR GROSS VOLUME AVAILABLE IN LOCAL AREA OF PLUME USING PAST CONE OF DEPRESSION EXTENT

WATER VOLUME REMOVAL CALCULATIONS: ASSUME EACH DEWATERING WELL PUMPS @ 60 gpm

FROM CONSTRUCTION SCHEDULE FOR 2012

		VOLUME TOTAL
COMOND LN – 2 WELLS – 120 GPM RUN AT 13 DAYS	⇒	2,246,400 gal. ✓
TAYLOR PL – 6 WELLS – 360 GPM RUN AT 29 days	⇒	15,033,600 gal ✓
LOCKWOOD RD – 4 wells – 240 GPM RUN AT 25 days	⇒	8,640,000 gal ✓

ESTIMATED Volume of water to be removed over the duration of the dewatering project w/ overlap of pumping days (5 days each) for each segment AT START-up only. ⟶ TOTAL 25,920,000 gal

Overall about 10% of volume removed from aquifer area below

Rough volume calculation of AQUIFER STORAGE in AREA OF planned dewatering.

USE DIAMETER OF CONE OF DEPRESSION; COMOND LN THRU LOCKWOOD RD AS SHOWN IN FIG. 5 FROM TETRA TECH REPORT. (12/1/2009)

MEASURED DIAMETER – 2170 ft; use simple circle

$$\text{Area} = \frac{\pi d^2}{4} = \frac{\pi (2170\,ft)^2}{4} = 3,698,361\,ft^2 \checkmark$$

USE SATURATED THICKNESS OF AQUIFER OF 25 ft

FROM TABLE 5-7 – model input parameter in RI ✓ (P17/20)

Volume = Area x THICKNESS = $3,698,361\,ft^2 \times 25\,ft = 92,459,025\,ft^3$ ✓

using $7.48\,gal/ft^3$ ⇒ 691,593,507 gal NOW apply eff. porosity of 0.328 ⇒ 226,842,670 gal TOTAL VOLUME AVAILABLE

THEORETICALLY TO DEWATER ENTIRE SYSTEM AT RANGE OF 300–600 GPM would take 525 days and 263 day, respectively. ✓

PACIFIC WESTERN TECHNOLOGIES, LTD.

Engineering Calculation Sheet

PROJECT LOCKWOOD SOLVENT GW PLUME - DEWATERING PLAN			CLIENT EPA
BY B. PETERMAN	CHKD Ram Ramaswami	APPD	JOB NO. CORA 980 122 001 006
DATE 6/15/2012	DATE 6/22/2012	DATE	SHEET 5 of 20 REV 0

LOCKWOOD DEWATERING SCHEDULE 2012

WORK AREAS	CONSTRUCTION SCHD	DUR	DEWATER SCHD	LEAD +5	# WELLS
NORTH FRONTAGE RD	6/20 - 7/1	12d	NONE		NONE
LOMOND LN	7/1 - 7/8	8d	6/26 - 7/8	13d	2 ✓
TAYLOR PL	7/9 - 7/31	23d	7/3 - 7/31	29d	6
LOCKWOOD RD	8/1 - 8/20	20d	7/27 - 8/20	25d	4

PUMPING INFLUENCE
TOTAL DAYS 67 days

PUMPING CALENDAR DAYS
OVERLAP ⇒ 56 DAYS

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Engineering Calculation Sheet

PROJECT LOCKWOOD SOLVENT GW PLUME - DEWATERING PLAN			CLIENT EPA
BY B. Peterman	CHKD Ram Ramaswami	APPD	JOB NO. CORA 1980 122 001 006
DATE 6/21/2012	DATE 6/22/2012	DATE	SHEET 6 of 20 REV 0

AQUIFER PARAMETERS USED FOR CALCULATIONS

TABLE 3-2 (RI for Lockwood) (P 14/20)

K_{Avg} = 0.335 ft/d = 1.18×10^{-4} cm/sec = 0.102 m/d

TABLE 5-6

n = effective porosity = 0.328 Avg. ✓

TABLE 5-7

SATURATED THICKNESS = 25 ft ✓

DEWATERING WELL FLOW

Q = 60 gpm per well

FLOW RANGE DURING DEWATERING (Attached)

Q_R = 120 to 600 GPM Depending of pumping well Segment overlap

June 2012

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
22						1 153	2 154
23	3 155	4 156	5 157	6 158	7 159	8 160	9 161
24	10 162	11 163	12 164	13 165	14 166	15 167	16 168
25	17 169	18 170	19 171	20 172	21 173	22 174	23 175
26	24 176	25 177	26 178	27 179	28 180	29 181	30 182

LOMOND LN – 2 WELLS (11 & 12)

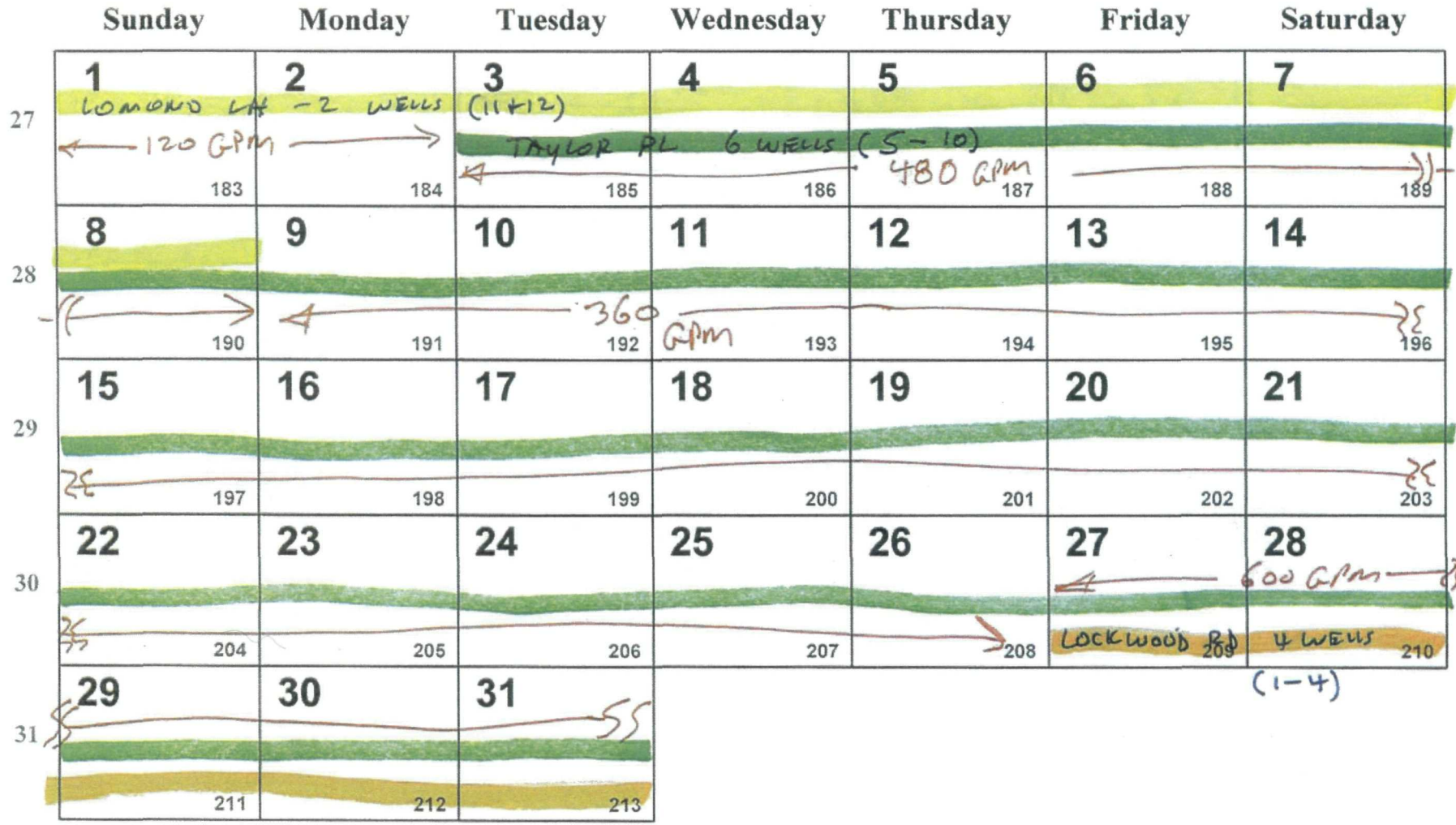
120 GPM

5 d

USE 60 gpm per well

p 7/20

July 2012



314

02/8d

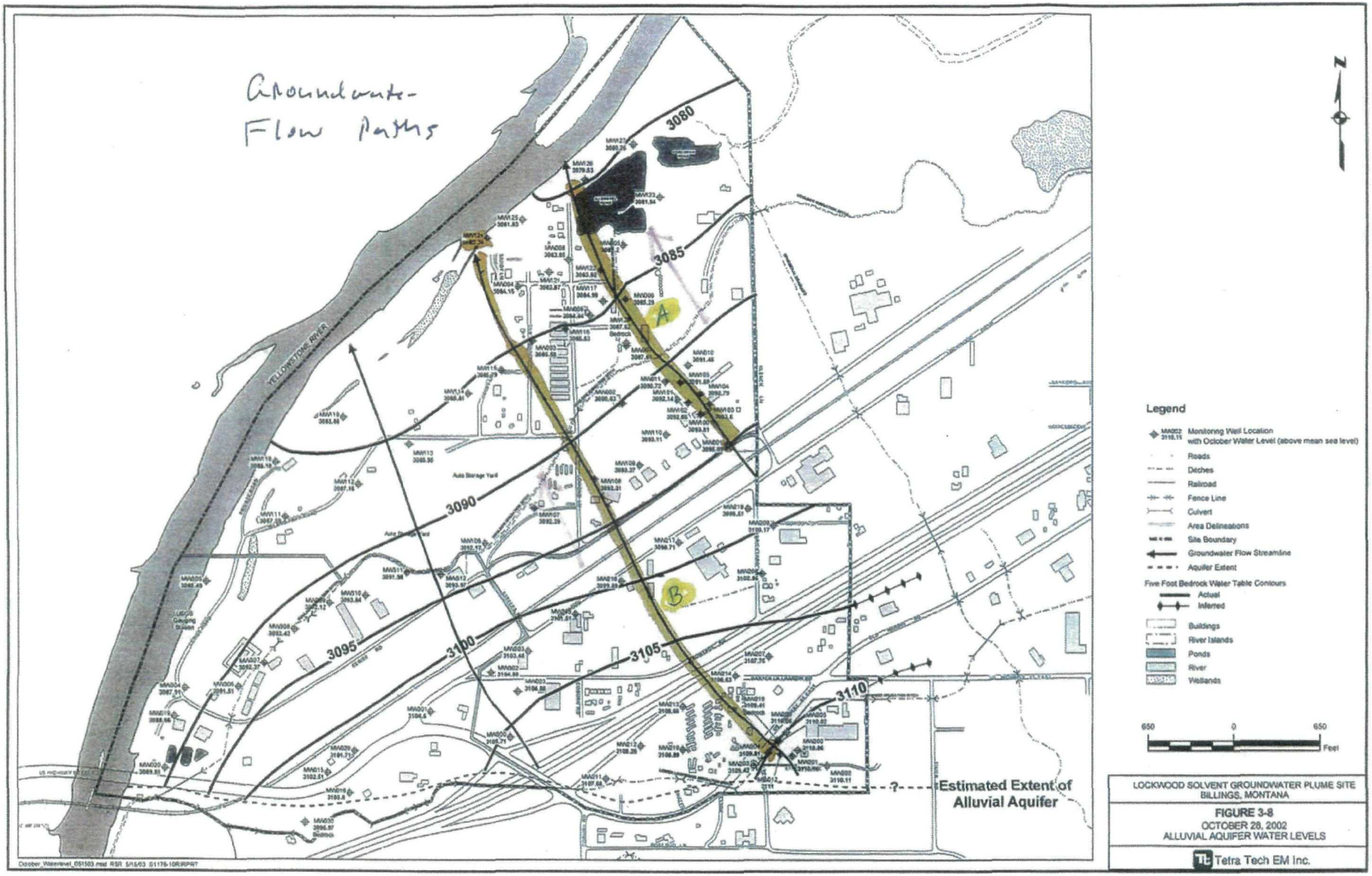
August 2012

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
31				1 214	2 215	3 216	4 217
32	5 218	6 219	7 220	8 221	9 222	10 223	11 224
33	12 225	13 226	14 227	15 228	16 229	17 230	18 231
34	19 232	20 233	21 234	22 235	23 236	24 237	25 238
35	26 239	27 240	28 241	29 242	30 243	31 244	

240 GPM
12 D 4 WELLS (1-4)
LOCKWOOD

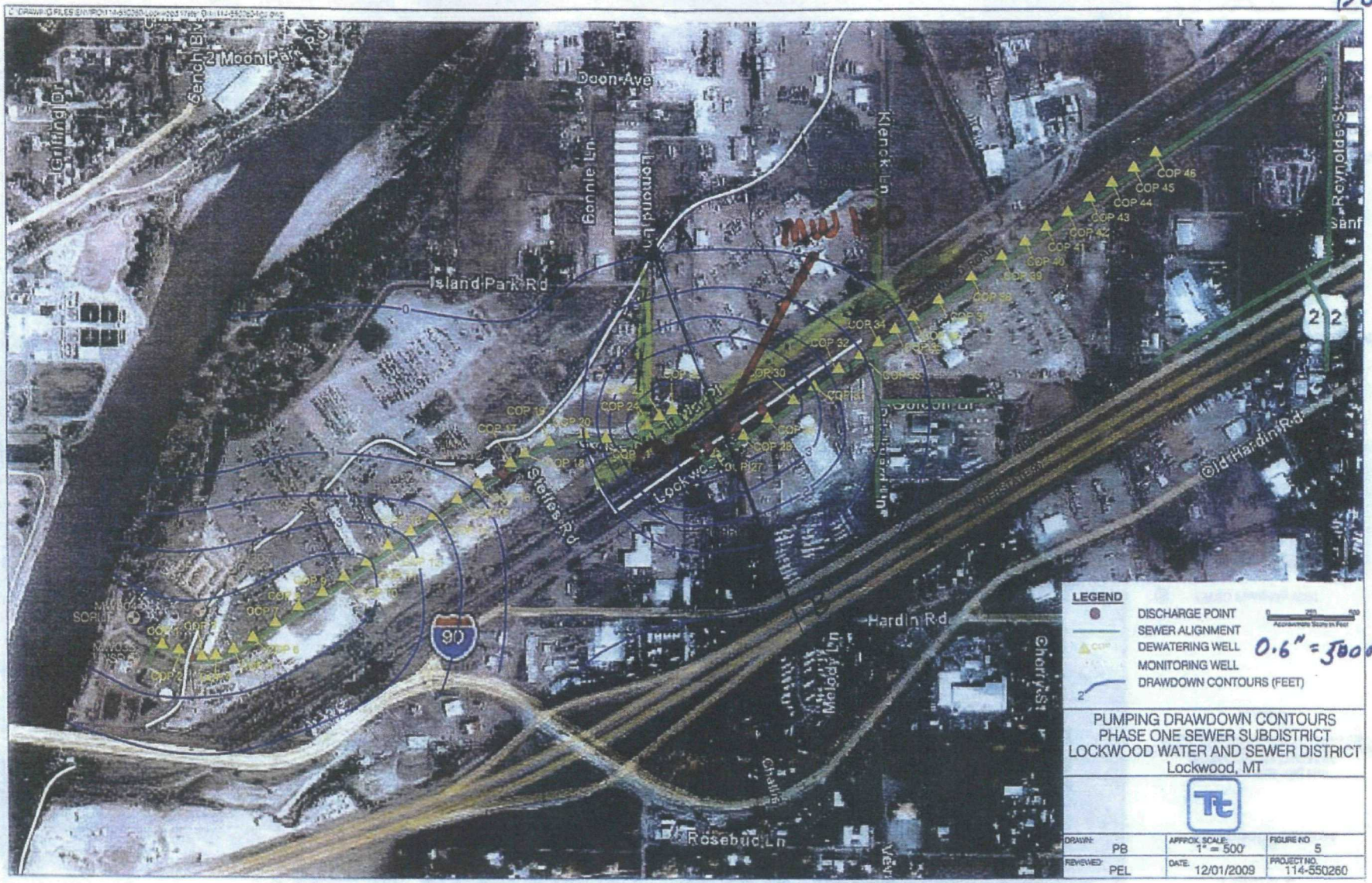
20d

TOTAL PUMPING 56 d


Groundwater-
Flow Paths
3080
3085
3090
3095
3100
3105
3110
A
B
YELLOWSTONE RIVER
Auto Storage Yard
Estimated Extent of
Alluvial Aquifer
?
N
Legend
Monitoring Well Location
with October Water Level (above mean sea level)
Roads
Ditches
Railroad
Fence Line
Culvert
Area Delineations
Site Boundary
Groundwater Flow Streamline
Aquifer Extent
Five Foot Bedrock Water Table Contours
Actual
Inferred
Buildings
River Islands
Ponds
River
Wetlands
650
0
650
Feet
LOCKWOOD SOLVENT GROUNDWATER PLUME SITE
BILLINGS, MONTANA
FIGURE 3-8
OCTOBER 28, 2002
ALLUVIAL AQUIFER WATER LEVELS
Tetra Tech EM Inc.

P10/20

6/15/12 BDP w/ PWT



MW100 – CTR DRAWDOWN = $\frac{1.4" \; 500ft}{0.6"}$ = ~1170 ft ✓

ΔH = ~4.5ft – 0 (MW-100) = 4.5 ft ✓

A – B = dia. of cone of depression

$\frac{2.6" (500 ft)}{0.6"}$ = 2170 ft ✓

P = 20

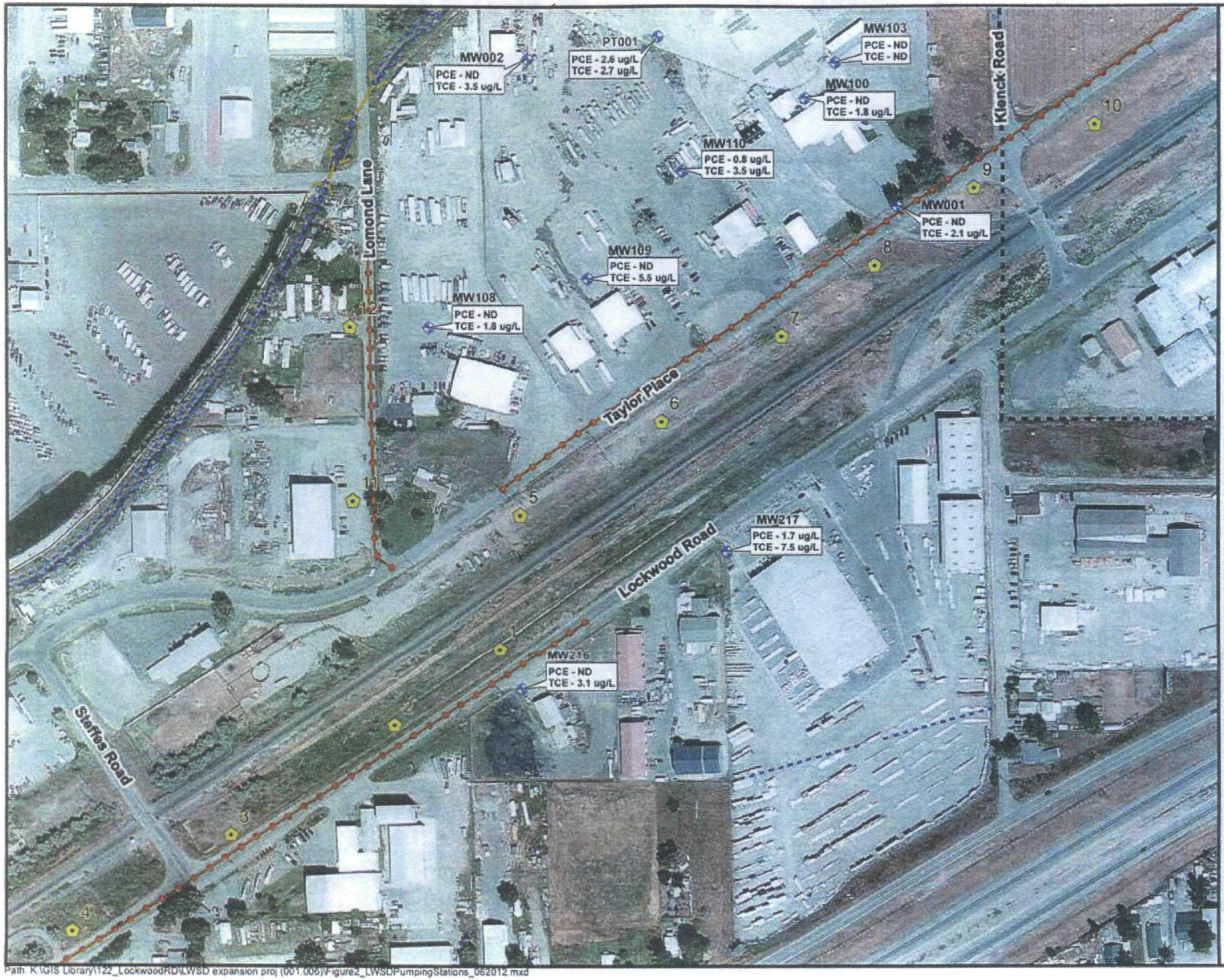


Figure 2

Pertinent Features

Dewatering Monitoring Plan
Quality Assurance Project Plan
Lockwood Water and Sewer District Sewer Installation
Lockwood Solvent Groundwater Plume Site

June 2012

- LWSD Pumping Well
- Existing Monitoring Well
- Soco Plume
- Site Boundary
- Culvert
- Sewer Expansion
- Drainage ditch

Note: April/May 2012 sampling
ND - not detected above the method detection limit of 0.5 ug/L

N
W E
S

0 100 200 400 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photography Provided by Bing Maps
NAIP 2009

PWT
PACIFIC WESTERN TECHNOLOGIES, LTD.

Path: K:\GIS Library\122_LockwoodRD\LWSD expansion proj (001.006)\Figure2_LWSDPumpingStations_062012.mxd

12/12

DEWATERING

		DISTANCE									
LOMOND LANE	WELL	MW001	MW002	MW100	MW103	MW108	MW109	MW110	MW216	MW217	PT001
	Pumping Well 11	1343	1021	1310	1410	406	699	1010	545	823	1196
	Pumping Well 12	1218	692	1105	1198	170	527	798	860	952	914
TAYLOR PLACE	WELL	MW001	MW002	MW100	MW103	MW108	MW109	MW110	MW216	MW217	PT001
	Pumping Well 5	1056	978	1089	1179	448	527	820	371	459	1068
	Pumping Well 6	690	828	759	857	544	344	539	649	315	823
	Pumping Well 7	375	812	512	598	769	440	416	943	477	695
	Pumping Well 8	136	875	387	443	980	625	464	1188	692	680
	Pumping Well 9	154	1010	414	404	1223	864	635	1456	947	760
	Pumping Well 10	465	1242	632	177	1515	1153	902	1737	1216	969
LOCKWOOD ROAD	WELL	MW001	MW002	MW100	MW103	MW108	MW109	MW110	MW216	MW217	PT001
	Pumping Well 1	1284	1264	1354	1453	704	814	1100	99	538	1355
	Pumping Well 2	1560	1456	1613	1714	854	1044	1344	288	814	1582
	Pumping Well 3 Dry	1981	1788	2017	2117	1173	1425	1734	707	1240	1951
	Pumping Well 4 Dry	2374	2119	2394	2497	1511	1794	2106	1105	1639	2305

MEASURED DISTANCES BETWEEN PLANNED DEWATERING WELLS AND LOCKWOOD SITE MONITORING WELLS.

6/20/2012

P13/20

TABLE 3-2

SUMMARY OF RI SLUG TEST RESULTS
LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

Well Number	Aquifer Zone	Test Date	Test Type Conducted	Hydraulic Conductivity (ft/sec)	Hydraulic Conductivity (ft/d)	Hydraulic Conductivity (cm/sec)
MW107	Alluvial	8-13-02	Slug Removal	2.78 E-06	0.24	8.47 E-05
MW110	Alluvial	8-13-02	Slug Removal	4.86 E-06	0.42	1.48 E-04
MW117	Alluvial	8-12-02	Slug Removal	1.97 E-06	0.17	6.01 E-05
MW128	Bedrock	8-12-02	Slug Removal	1.02 E-05	0.88	3.10 E-04
MW203	Alluvial	8-13-02	Slug Removal	2.08 E-06	0.18	6.33 E-05
MW213	Alluvial	8-12-02	Slug Removal	4.28 E-06	0.37	1.31 E-04
MW215	Alluvial	8-13-02	Slug Removal	3.7 E0-06	0.32	1.12 E-04
MW301	Alluvial	8-13-02	Slug Removal	7.29 E-06	0.63	2.22 E-04
MW308	Alluvial	8-13-02	Slug Removal	4.05 E-06	0.35	1.23 E-04

Notes:

Solution Method: Bouwer-Rice (1976)

cm/sec Centimeters per second
ft/sec Feet per second
ft/d Feet per day

Avg 8 Alluvial wells
K values
TOTAL = 2.68
Avg = 0.335 ft/d ✓
H = 0.63
L = 0.17

Avg = 1.18 x E-4 cm/s

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES OF COPCs
LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

COPC	CAS #	Water Solubility (mg/L)	Log K_{ow}	K_{oc} (L/kg)	Vapor Pressure (as mm of Hg)	Henry's Law Constant (atm-m^3/mol)
PCE	127-18-4	150 at 25°C	3.40	426[a]	18.47 at 25°C	0.018 at 25°C
TCE	79-01-6	1,366 at 25°C	2.42	130[a]	74 at 25°C	0.11 at 25°C
Vinyl Chloride	75-01-4	2,763 at 25°C	1.36	30[a]	2,600 at 25°C	1.2 at 10°C
cis-1,2 DCE	156-59-2	3,500 at 25°C	1.86	125[a]	180 at 20°C	0.00408 at 24.8°C
trans-1,2 DCE	156-60-5	6,300 at 25°C	2.09	36	265 at 20°C	0.00938 at 24.8°C

Notes:

Source: Wiedemeier and others 1999, except as noted.

[a] Default value used in BIOCHLOR Model (Aziz and Others 2002)
°C Degree Celsius
atm-m^3/mol Atmospheric cubic meters per mole
COPC Chemical of Potential Concern
DCE Dichloroethene
Hg Mercury
K_{oc} Organic-carbon partition coefficient
K_{ow} Octanol-water partition coefficient
L/kg Liters per kilogram
mg/L Milligrams per liter
PCE Tetrachloroethene
TCE Trichloroethene

Assume $\rho = 1.2515 \frac{g}{cc} \times \frac{1000\ kg}{1000\ L} = 1.2515 \frac{kg}{L}$

$t_r = 1 + \frac{\rho K_p}{\epsilon}$ $\epsilon = 0.328$ Avg ρ from Table 5-6 (p16/20)

@ MW 110 $f_{OC} = 0.28$? (Table 5-6)

$f_{OC} = 0.003$

$K_{p\ TCE} = 0.003 \times 263 = 0.789$

$K_{p\ PCE} = 2512 \times 0.003 = 7.54$

$t_{r\ TCE} = 1 + \frac{1.2515 \times 0.789}{0.328} \approx 4.01$ times

$t_{r\ PCE} = 1 + \frac{1.2515 \wedge 7.54}{0.328} \approx 29$ times

P15/20

TABLE 5-6

SUMMARY OF GEOTECHNICAL ENGINEERING PARAMETER MEASUREMENTS
LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

Sample No.	Sample Date	Well/Boring	Sample Depth (ft bgs)	Moisture Content (weight percent)	Organic Carbon[A] (weight percent)	Dry Bulk Density[B]	Specific Gravity	Effective Porosity
MW110SB001	6/19/2002	MW110	14:0 - 16.0 ft	NA	0.28	NA	NA	NA
MW118SB001	7/22/2002	MW118	14.0 - 16 ft	20	0.08	NA	NA	NA
MW127SB002	7/24/2002	MW127	24.0 - 26.0 ft	20	2.05	NA	NA	NA
MW210SB100	8/13/2002	MW210	9.8 - 11.8 ft	28	0.18	NA	NA	NA
MW300SB001	8/14/2002	MW300	15.0 - 15.9 ft	4.9	0.13	NA	NA	NA
MW305SB002	7/22/2002	MW305	14.0 - 16.0 ft	24	0.05	NA	NA	NA
MW311SB001	7/18/2002	MW311	19.0 - 21.0 ft	18	0.07	NA	NA	NA
PT004-001[C]	12/15/2001	PT004	8.5 - 9.0 ft	43.6	NA	1.12 g/cm^3	NA	NA
PT004-002[C]	12/15/2001	PT004	9.0 - 9.5 ft	45.2	NA	1.11 g/cm^3	NA	NA
PT002-001[C]	12/13/2001	PT002	6.5 - 7.0 ft	34.9	NA	1.26 g/cm^3	NA	NA
PT001-001[C]	12/12/2001	PT001	7.0 - 7.5 ft	31.4	NA	1.37 g/cm^3	NA	NA
SB203SB002	7/09/2002	SB203	19.0 - 21.0 ft	18.6	NA	97.5 pcf	2.7	0.422
SB203SB004	7/09/2002	SB203	44.0 - 45.5 ft	14.3	NA	111.2 pcf	2.68	0.355
MW202SB001	7/17/2002	MW202	19.0 - 21.0 ft	16.1	NA	118.5 pcf	2.7	0.297
MW202SB002	7/17/2002	MW202	21.0 - 22.5 ft	8.8	NA	129.6 pcf	2.72	0.236

n = porosity Avg. 0.328

Notes:
[A] Analyzed by EPA Method EPA 415.2/A5310C
[B] Analyzed by Method ASTM D2850
[C] Samples collected by SECOR International Inc., results reported in SECOR. 2002. Subsurface Investigation Report, Lockwood Solvent Site, Lockwood, Montana.

ft bgs = Feet below ground surface
NA = Not analyzed
g/cm^3 = Grams per cubic centimeter
pcf = Pounds per cubic foot

1.215 g/cc

02/9/d

TABLE 5-7

MODEL INPUT PARAMETERS AND ASSUMPTIONS
LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

Model Parameters	Units	Initial	Calibrated	Initial	Calibrated
		Model Value		Model Value	
		Area B Plume		Area A Plume	
Aquifer	none	Alluvium	nc	Alluvium	nc
Aquifer type	none	unconfined	nc	unconfined	nc
Hydraulic conductivity	ft/d	0.275	1.63	0.295	70
Hydraulic conductivity	cm/sec	9.708E-05	5.754E-04	1.041E-04	2.471E-02
Aquifer thickness	ft	25	nc	22	22
Transmissivity	ft2/d	7	nc	6	1,540
Effective porosity	none	0.27	nc	0.27	nc
Hydraulic gradient	ft/ft	0.0059	nc	0.0066	nc
Gradient direction	degrees	285	nc	320	nc
Seepage velocity	ft/d	0.0060	0.0356	0.0064	1.5296
Seepage velocity	ft/yr	2.2	13.0	2.2	558.3
Longitudinal dispersivity	ft	10	nc	20	nc
Transverse dispersivity	ft	1	nc	2	nc
Vertical dispersivity	ft	0.1	nc	0.2	nc
Retardation - PCE	none	4.18	nc	4.18	nc
Retardation - TCE	none	1.97	nc	1.97	nc
Retardation - DCE	none	1.93	nc	1.93	nc
Retardation - VC	none	1.22	nc	1.22	nc
Fraction of organic carbon	none	0.0018	nc	0.0018	nc
Bulk density	g/cm^3	1.12	nc	1.12	nc
(K_{oc}) - PCE	L/kg	426	nc	426	nc
(K_{oc}) - TCE	L/kg	130	nc	130	nc
(K_{oc}) - DCE	L/kg	125	nc	125	nc
(K_{oc}) - VC	L/kg	30	nc	30	nc

p17/22

TABLE 5-7
(Continued)
MODEL INPUT PARAMETERS AND ASSUMPTIONS
LOCKWOOD SOLVENT GROUNDWATER PLUME SITE

Model Parameters	Units	Initial	Calibrated	Initial	Calibrated
		Model Value		Model Value	
		Area B Plume		Area A Plume	
Decay coefficient -PCE	$years^{-1}$	2.4	0.10	2.40	0.75
Decay coefficient -TCE	$years^{-1}$	2.4	0.01	2.40	3.00
Decay coefficient -DCE	$years^{-1}$	2.2	0.007	2.20	0.70
Decay coefficient -VC	$years^{-1}$	4.9	4.8	4.90	4.80
Source	none	SS	nc	SS	nc
Source Activity	years	24	nc	30	nc

Notes:

cm/sec	Centimeters per second
DCE	cis-1,2,-Dichloroethene
ft	Feet
ft/d	Feet per day
ft/yr	Feet per year
g/cm^3	grams per cubic centimeters
L/kg	Liters per kilogram
nc	No change in model parameter value for calibrated model
PCE	Tetrachloroethene
SS	Steady state
TCE	Trichloroethene
VC	Vinyl chloride

Source Activity — Number of years that a continuing contribution of source has occurred in the subsurface. This is a value assumed for the model; actual time may vary.

P/8/20

Attachment D
Water Level Measurement Record

Attachment D

Water Level Measurement Record

Dewatering Monitoring Plan

Lockwood Solvents Groundwater Plume Superfund Site

MW ____________ **page _____ of _____**

Date	Time	Static Water Level Reading (feet below top of casing)	Change from Previous Measurement	Sampler