DRAFT

24 AUGUST 2017

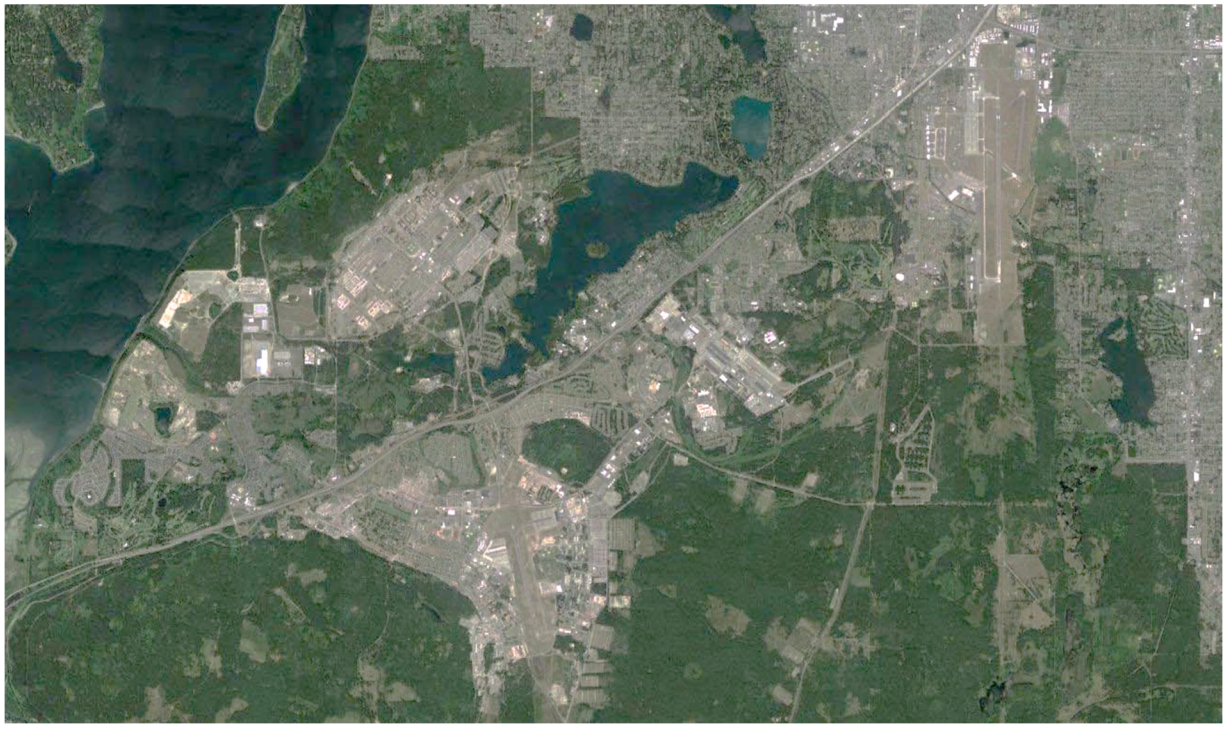
2017 Groundwater Monitoring Plan

Artillery Impact and Central Impact Areas

Joint Base Lewis-McChord

Pierce County, Washington

Joint Base Lewis-McChord Public Works – Environmental Division
IMLM-PWE
MS 17 Box 339500
Joint Base Lewis-McChord, Washington 98433



DEPARTMENT OF THE ARMY
HEADQUARTERS, JOINT BASE LEWIS-MCCHORD
1010 LIGGETT AVENUE, BOX 339500, MAIL STOP 14A
JOINT BASE LEWIS-MCCHORD, WA 98433-9500

REPLY TO ATTENTION OF

August 24, 2017

Public Works

Mr. Charles Hoffman, PE
Department of Ecology
Southwest Regional Office
PO Box 47775
Olympia, Washington 98504-7775

Dear Mr. Hoffman:

Enclosed for your review is one paper copy and one CD of the Draft 2017 Draft Groundwater Monitoring Plan, Artillery and Central Impact Areas, Joint Base Lewis-McChord. This document updates changes made to the Groundwater Monitoring Plan, Artillery and Central Impact Areas, Joint Base Lewis-McChord, Pierce County, Washington dated February 2017.

This document includes sampling procedures following guidance from WAC 173-340-820 and other applicable Ecology guidance. A Sampling and Analysis Plan, Quality Assurance Project Plan and a Site Specific Health and Safety Plan per 29 CFR 1910.120 are also included in this document.

If you have any questions or need clarification, please contact me at (253) 477-3742.

Sincerely,

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Digitally signed by GHEBRESLLASSIE.MESERET.C.1015675159
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Meseret C. Ghebresllassie
Installation Restoration Program Manager
Public Works Department

CF: Greg Caron, Ecology

DRAFT

2017 GROUNDWATER MONITORING PLAN

ARTILLERY IMPACT AND CENTRAL IMPACT AREAS
CONTRACT NO. W912DW-11-D-1031, TASK ORDER 0001

AUGUST 24, 2017

JOINT BASE LEWIS-MCCHORD
PIERCE COUNTY, WASHINGTON

SEALASKA ENVIRONMENTAL SERVICES, LLC
POULSBO, WASHINGTON

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Approved by: _____
Scott Elkind, PE
Project Manager
(360-626-3991)

CONTENTS

CONTENTS (continued)

APPENDICES

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

AIA	Artillery Impact Area
BRAC	Base Realignment and Closure
CFR	Code of Federal Regulations
CIA	Central Impact Area
CLARC	Cleanup Level and Risk Calculation
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
HAZWOPER	Hazardous Waste Operations and Emergency Response
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (also known as octogen)
IDW	investigation-derived waste
IRP	Installation Restoration Program
JBLM	Joint Base Lewis-McChord
µg/L	micrograms per liter
MTCA	Model Toxics Control Act
MW	monitoring well
Plan	Groundwater Monitoring Plan
PPE	personal protective equipment
PQL	practical quantification limit
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RDX	1,3,5-Trinitroperhydro-1,3,5-triazine (also known as Research Department eXplosive)
RPD	relative percent difference
SAP	Sampling and Analysis Plan
Sealaska	Sealaska Environmental Services, LLC
SSHP	Site Safety and Health Plan
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Command
WAC	Washington Administrative Code

1 INTRODUCTION

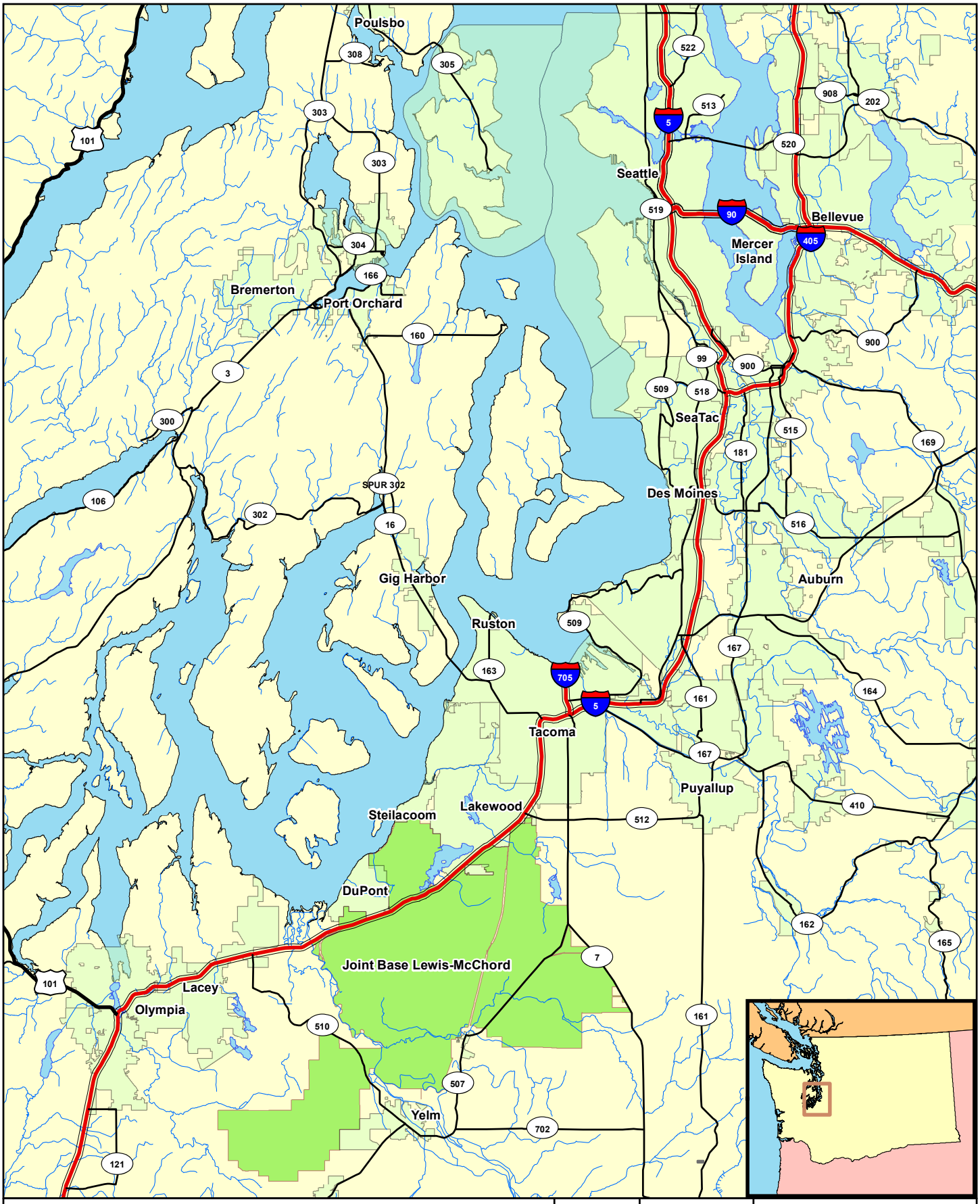
This Groundwater Monitoring Plan (Plan) describes groundwater sampling activities at the Artillery Impact (AIA) and Central Impact Areas (CIA), henceforth called the Impact Areas, Joint Base Lewis-McChord (JBLM) near Tacoma, Washington (Figure 1-1). This Plan updates the current groundwater monitoring plan: 2016 Groundwater Monitoring Plan (Sealaska 2017). Semiannual sampling has been performed since September 2005. The AIA and CIA are shown in Figure 1-2.

1.1 PROJECT BACKGROUND

JBLM Public Works has been conducting groundwater monitoring activities in the JBLM Impact Areas since 1999. The project includes a total of 17 monitoring sites around the Impact Areas (Figure 1-3).

Monitoring locations currently include: 11 monitoring wells (MW); five springs; and a kitchen sink at the Clear Creek Fish Hatchery, located west of the Impact Areas (Figure 1-3). Nine Upper Vashon aquifer wells (98-IA-MW01 through 98-IA-MW04 and 98-IA-MW06 through 98-IA-MW10) and one Lower Vashon aquifer well (98-IA-MW05) were installed during a URS preliminary investigation conducted between 1998 and 1999 (URS 2000). Four Upper Vashon aquifer monitoring wells (01-IA-MW11 through 01-IA-MW14) and one Sea Level aquifer well (01-IA-MW15) were installed in 2001. In addition, three existing Upper Vashon aquifer wells installed at other sites (MW-3-3138, PA-384, and MW-1-9700) were used for groundwater monitoring in the impact areas. Only wells 98-IA-MW01 through 98-IA-MW05, all five seeps and the hatchery sink are currently sampled. The remaining six wells are only monitored for depth to water to assist in the generation of water table contours. Monitoring well construction details are presented in Table 1-1. The five springs (AIA-SP01 through AIA-SP05) are discharges of Vashon Aquifer groundwater at the Nisqually River bluff located along the west extent of the AIA.

URS conducted groundwater monitoring events in June 1999, November 1999, and April 2000. The Fort Lewis Water Program conducted quarterly groundwater monitoring events between August 2000 and April 2005. The Fort Lewis Compliance Cleanup Program now the Installation Restoration Program (IRP) began conducting semiannual groundwater sampling events for select monitoring locations and analytes in September 2005. At that time, groundwater samples were collected from the 18 monitoring wells and five springs and analyzed for nitroaromatics/nitramines, metals, and various inorganic parameters.



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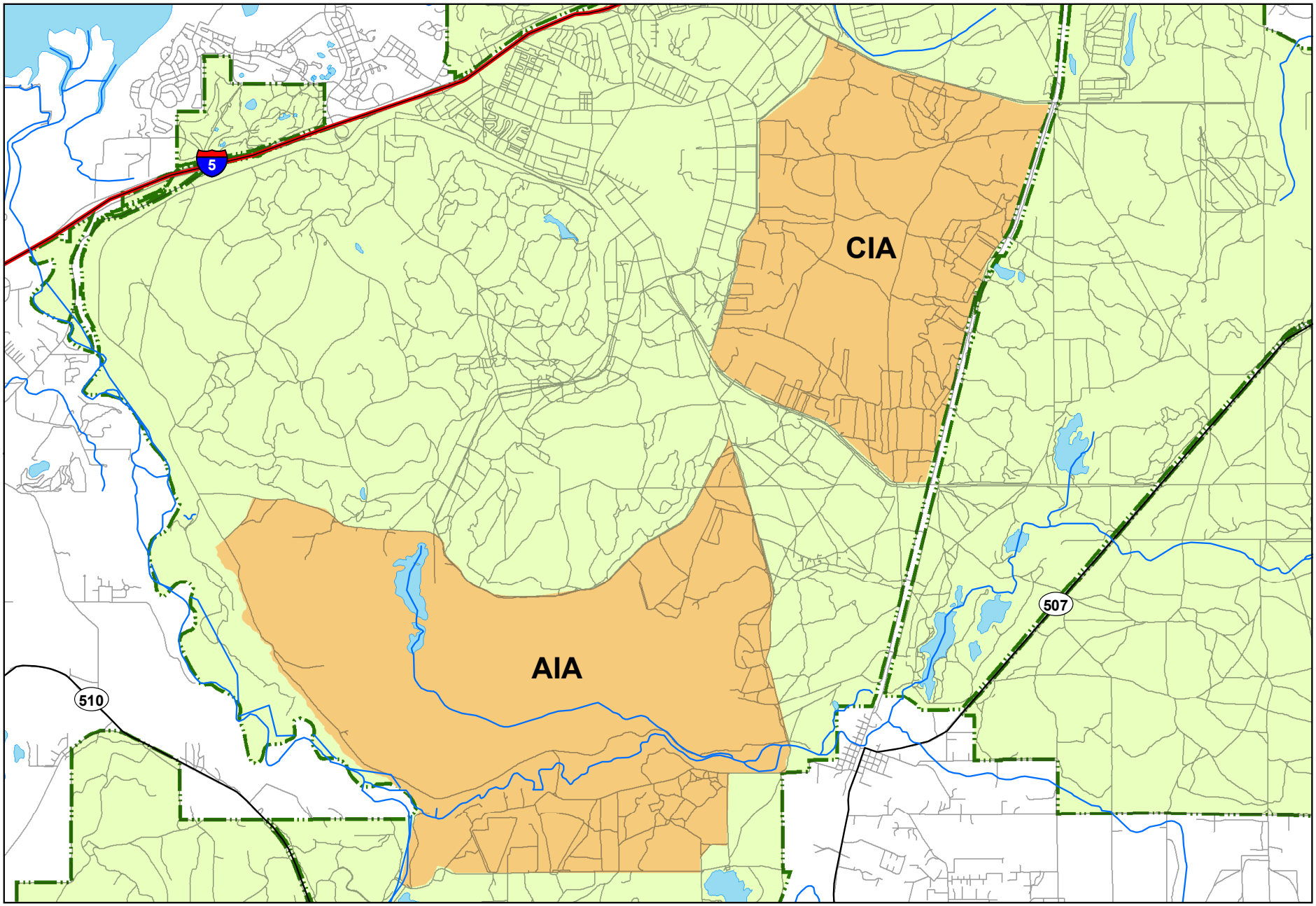

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Miles

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Coordinate System: UTM, Zone 10
Horizontal Datum: WGS 84

USACE

SEALASKA

Figure 1-2
Impact Areas

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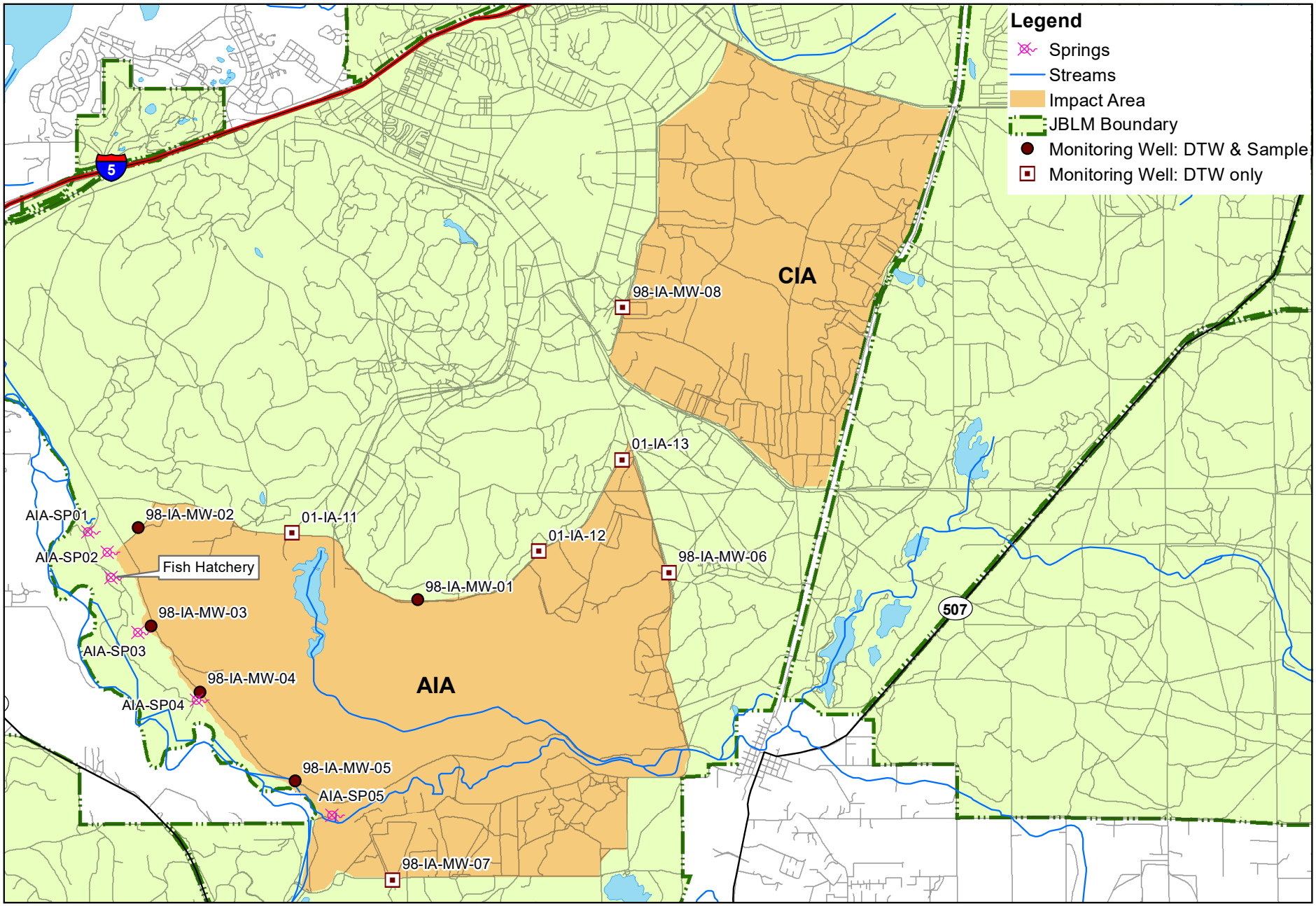

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Figure 1-3
Impact Areas
Well Locations

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Date: 5/30/2017

Table 1-1. Monitoring Well Construction Details

Location ID	Area ID	Easting UTM NAD 83	Northing UTM NAD 83	Elevation (ft AMSL)	Well Depth (ft bgs)	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Completion Date
98-IA-MW01	AIA - Central	529745.99	5208145.64	286.7	46	41	46	18-Dec-98
98-IA-MW02	AIA Downgradient	525635.10	5209346.77	235.4	40	35	40	10-Dec-98
98-IA-MW03	AIA Downgradient	525720.70	5208062.81	244.2	78	73	78	12-Feb-99
98-IA-MW04	AIA Downgradient	526747.86	5206522.07	246.9	63	58	63	18-May-99
98-IA-MW05	AIA Downgradient	527552.17	5205614.88	257.1	122	117	122	31-Mar-99
98-IA-MW06	AIA Upgradient	533338.82	5208747.59	321.9	45	39.5	44.5	20-Dec-98
98-IA-MW07	AIA Downgradient	529258.70	5203982.70	291.0	55	50	55	27-Feb-99
98-IA-MW08	CIA Downgradient	532768.17	5212371.19	322.8	43	38	43	7-Jan-99
01-IA-MW11	AIA Downgradient	527746.49	5209147.04	266.78	65.5	59	64	18-Oct-01
01-IA-MW12	AIA Upgradient	531313.03	5208918.78	289.43	53.7	47	52	19-Oct-01
01-IA-MW13	AIA Upgradient	532539.91	5209774.75	315.43	69.6	62	67	22-Oct-01
AIA-SP01	AIA Downgradient	524892	5208975	220	-	-	-	-
AIA-SP02	AIA Downgradient	525558	5208127	200	-	-	-	-
AIA-SP03	AIA Downgradient	526012	5207310	148.3	-	-	-	-
AIA-SP04	AIA Downgradient	526769	5206221	163.4	-	-	-	-
AIA-SP05	AIA Downgradient	528463	5205071	240	-	-	-	-
Hatchery	AIA Downgradient	-	-	-	-	-	-	-

Notes:
UTM – Universal Transverse Mercator
ft AMSL – Feet above mean sea level
ft bgs – Feet below ground surface
- – No data, not applicable
Area ID – Monitoring wells are located along the perimeter of either the Artillery Impact Area (AIA) or Central Impact Area (CIA). Downgradient or upgradient is the relative position of the monitoring well to either the AIA or CIA depending on groundwater flow.

Location ID:
AIA-SP01 – Artillery Impact Area spring 01
Hatchery – Tap water sample taken from fish hatchery kitchen sink.

Other important monitoring activities include: perchlorate sampling during the November 2000 and November 2002 groundwater monitoring events, surface water sampling during the first five monitoring events, sediment sampling, and comprehensive groundwater level surveys by URS. Based on results of monitoring activities it was determined that the only contaminant of concern present in groundwater at the AIA is RDX (1,3,5-Trinitroperhydro-1,3,5-triazine, also known as the Research Department eXplosive).

Historically, samples were analyzed every 2 years during the wet season sampling events for dissolved metals. Between seven and 15 samples have been collected from most monitoring wells since 1999. However, dissolved barium is the only RCRA 8 metal that has been consistently detected in groundwater samples. Currently there is no MTCA Method A cleanup level for barium and the Method B cleanup level (3,200 micrograms per liter [µg/L]) is much higher than historical sample concentrations. Consequently, analyzing groundwater samples for dissolved metals was discontinued starting with the April 2011 sampling event.

In October 2010, as part of a Base Realignment and Closure (BRAC) action, Fort Lewis and neighboring McChord Air Force Base merged to create Joint Base Lewis-McChord. All base services including the IRP are provided by the Army-led Joint Base.

Currently, there are no Model Toxics Control Act (MTCA) Method A, B, or C groundwater cleanup levels for RDX. Thus, RDX concentrations detected in groundwater samples collected from monitoring wells, springs, and the Clear Creek Fish Hatchery kitchen sink are compared to Washington State Department of Ecology's (Ecology) Cleanup Level and Risk Calculation (CLARC) Method B standard formula value for RDX in groundwater of 0.8 µg/L.

1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The Joint Base Lewis-McChord Public Works Environmental and Natural Resources Division IRP, with assistance from the United States Army Corps of Engineers (USACE) subcontractor Sealaska Environmental Services, LLC (Sealaska), is responsible for the long-term groundwater monitoring at the AIA and CIA. The JBLM IRP Program Manager will ensure that the overall goals of the program meet the Defense Environmental Restoration Program objectives. The Department of Defense is the lead agency for this project but will have assistance from the Hazardous Waste and Toxics Reduction Program with Ecology. The Nisqually Indian Tribe tribal lead will provide Tribal overview. The Sealaska Project Manager will oversee the long-term groundwater monitoring. Samples will be analyzed by ALS Environmental of Kelso, Washington. Project personnel and roles are provided in Table 1-2.

Table 1-2. Proposed Personnel Roles and Responsibilities

Organization	Name	Title	Responsibilities
Washington Department of Ecology	Charles Hoffman	Hazardous Waste and Toxics Reduction Program	Regulatory overview
Nisqually Indian Tribe	David Troutt	Director, Natural Resources	Tribal overview
Joint Base Lewis-McChord Public Works	Meseret Ghebresllassie	Installation Restoration Program Manager	Final review, report signatory
Sealaska Environmental Services	Scott Elkind	Project Manager	Overall project lead, plan and reports review
	Aaron Vernik	Task Manager	Assist project manager, field planning, plan and reports review
	V. Sunrise Patterson	Long-Term Monitoring Field Lead	Field lead, Site Safety and Health Officer; report preparation
	Will Kaage, Tom Malamakal	Field Technicians	Collect field samples, report preparation
Tetra Tech	Keir Craigie	Project Chemist/Quality Control Manager	Data quality review. Oversee data quality control.
ALS Environmental Labs	Kurt Clarkson	Laboratory Project Manager	Lab contact, quality control, final analytical report signatory

2 FIELD SAMPLING AND ANALYSIS PLAN

This Sampling and Analysis Plan (SAP) is designed to present the procedures and documentation required to support groundwater monitoring at the Impact Areas sites in accordance with Washington Administrative Code (WAC) 173-340-820 and applicable Ecology guidance. Descriptions of all of the monitoring wells currently being used to measure depth to water or sample are presented in Table 1-1. Boring logs and well completion diagrams for all of the current wells at the AIA and CIA are presented in Appendix A.

2.1 GROUNDWATER MEASUREMENT, SAMPLING, AND ANALYSIS

Sealaska personnel will conduct groundwater measurement and sampling events semiannually. A summary of the planned monitoring frequency and contaminant of concern is presented in Table 2-1. Monitoring locations are presented on Figure 1-3.

During each event, Sealaska personnel will use an electronic water level indicator to measure the static water level in each monitoring well. All measurements will be recorded to the nearest 0.01-foot from the top of the PVC casing.

Standard low-flow purging procedures will be used to purge water prior to sampling from each of the monitoring wells. These procedures are outlined in Appendix B. Submersible Grundfos Redi-Flo2 pumps with dedicated tubing will be used (except for 98-IA-MW05, in which a bailer will be used). During purging, relative water levels will be monitored with an electronic water level indicator and water quality parameters such as pH, specific conductivity, temperature, dissolved oxygen, and turbidity are measured with a pre-calibrated Horiba U-22 meter or similar to verify stabilization. Acceptable stabilization criteria (EPA 2002) are listed on the Groundwater Monitoring Form included in Appendix C. Groundwater samples will be collected immediately after the field measurements have stabilized without turning off the pumping system. In the event that drawdown is excessive or that water quality parameters do not stabilize, then the monitoring well will be purged until three well volumes have been removed or the pump is covered by less than 2 feet of water, whichever occurs first.

Groundwater samples collected from the Impact Areas sample sites will be analyzed for nitroaromatics and nitramines by United States Environmental Protection Agency (EPA) Method 8330B.

Table 2-2 presents appropriate sample container type, sample preservation, and holding times. Sample containers will be supplied by the laboratory prior to the start of sampling activities.

Table 2-1. Groundwater Sampling Schedule and Analysis Plan Summary

	1st Quarter Sampling Event (Wet Season)		3rd Quarter Sampling Event (Dry Season)	
Location ID	**DTW[1/]**	**RDX[2/, 3/]**	**DTW[1/]**	**RDX[2/, 3/]**
98-IA-MW01	X	X	X	X
98-IA-MW02	X	X	X	X
98-IA-MW03	X	X	X	X
98-IA-MW04	X	X	X	X
98-IA-MW05	X	X	X	X
98-IA-MW06	X	-	X	-
98-IA-MW07	X	-	X	-
98-IA-MW08	X	-	X	-
01-IA-MW11	X	-	X	-
01-IA-MW12	X	-	X	-
01-IA-MW13	X	-	X	-
AIA-SP01	-	X	-	X
AIA-SP02	-	X	-	X
AIA-SP03	-	X	-	X
AIA-SP04	-	X	-	X
AIA-SP05	-	X	-	X
Fish Hatchery	-	X[4/]	-	X[4/]
Duplicate	-	X	-	X
Total # per event	11	12	11	12

Notes:
[1/] DTW – Depth to Water
[2/] RDX – Research Department eXplosive
[3/] Analysis by EPA Method 8330B
[4/] Samples should be collected in triplicate so that laboratory can run matrix spikes/matrix spike duplicates.

Table 2-2. Sample Containers, Preservation, and Holding Times

Analytical Method	Container Type	Preservation	Holding Time
EPA Method 8330B	Two 1 L amber glass with Teflon™ lined lids	Cool to 4°C ±2°C	7 days to extraction, 40 days to analysis

2.2 FIELD RECORDKEEPING

Field data and other related information will be recorded in the field logbook and on the Groundwater Monitoring Forms. Copies of field forms are included in Appendix C. Once completed, the original signed forms will be maintained in the project files for a minimum of 3 years.

2.3 EQUIPMENT DECONTAMINATION PROCEDURES

All non-dedicated monitoring and sampling equipment will be cleaned before use. Non-dedicated equipment will include an electronic water level indicator and submersible pump (with cable).

Following use at each monitoring location, the affected portions of the water level indicator will be scrubbed with potable water containing phosphate-free diluted detergent (i.e., Liquinox) before being sufficiently rinsed with potable water. Likewise, the outside of the pump and affected portions of the cable will be scrubbed with potable water containing diluted detergent. Then, the inside of the pump will be flushed with potable water containing diluted detergent followed by flushing with potable water.

Finally, the pump and cable will be sufficiently rinsed with potable water. Disposable nitrile gloves will be changed before working at the next monitoring location.

Dedicated tubing will be stored in the monitoring well to prevent cross-contamination.

Personal decontamination is discussed in the Site Safety and Health Plan (Section 4).

2.4 INVESTIGATION-DERIVED WASTE

Investigation-derived waste (IDW) generated during sampling events will consist of purge water, decontamination water, and personal protective equipment (PPE) [e.g., nitrile gloves]. IDW will be handled and disposed of as follows:

- Purge water and decontamination water from all monitoring locations will be collected in appropriate containers. This water from the impact areas will be sampled for characterization, transported and staged at Landfill 2. If the results are below cleanup levels, the water will be discharged through the treatment system. If the results are above the cleanup levels, the water will be disposed of at an offsite facility.
- Disposable PPE and equipment will be disposed of in a Sealaska dumpster as part of the normal solid waste stream.

2.5 SAMPLE LABELING, HANDLING AND SHIPMENT

Sample labels will clearly indicate the site location, sample name, date, time, sampler's initials, parameters to be analyzed, preservative added (if any), and any pertinent comments. Sample nomenclature will consist of the monitoring well name (e.g., 98-IA-MW05).

Sample packaging and shipping procedures are based on EPA specifications and United States Department of Transportation regulations as specified in 49 Code of Federal Regulations (CFR) 173.6 and 49 CFR 173.24. All samples will be shipped as non-hazardous material. Samples will be transported directly to ALS laboratory by Sealaska personnel after they have been collected from all four sites. The following are general packaging procedures:

1. Attach sample labels securely to each sample container.
2. Use plastic bubble-wrap bags, sheets, or Styrofoam packing material to protect sample containers.
3. Use insulated plastic or metal-clad plastic coolers as shipping containers.
4. Chill all samples at or below 4ºC with ice.
5. Place the original chain of custody form in the cooler in a sealed plastic bag.
6. Place a signed custody seal on the lid of the cooler and cover with clear plastic tape.
7. Cover and seal the cooler drain with plastic tape.
8. Use strapping tape to shut the cooler.
9. Send by courier or hand-deliver the cooler to ALS for analysis.

2.6 CHAIN OF CUSTODY DOCUMENTATION

Chain of custody procedures are employed to maintain and document sample possession. A sample is considered under a person's custody if it is in that person's physical possession, within visual sight of that person after taking physical possession, secured by that person so that the sample cannot be tampered with, or secured by that person in an area that is restricted to authorized personnel only.

The responsible person will fill in all requested information on the custody record, then they will sign and date the record in the first “relinquished by” box. Original signed custody records listing the samples in the cooler will accompany all shipments of samples. (Note: it is possible that more than one custody form will be needed per cooler to list all the samples

contained in the cooler.) The originator of the custody record will keep the bottom copy (usually pink).

2.7 PROJECT REPORTING

After completion of the semiannual events described in this plan, an annual report will be prepared that includes:

- Investigation chronology
- Discussion of sampling methodology including any deviations from this plan
- A site map for each site showing relevant surface features, sampling locations, groundwater elevations measured during each event, and contaminant concentrations detected during each event
- Summary table of groundwater elevations and contaminant concentrations from all sampling events along with comparison to applicable cleanup levels
- Brief discussion of quality assurance (QA)/quality control (QC) review and verification process including implications for project data as described in the Quality Assurance Project Plan (QAPP)
- Copies of original field forms
- Laboratory certificates of analysis with chain of custody records

An internal draft report will be submitted to USACE, JBLM IRP Program Manager, and United States Army Environmental Command (USAEC) for review and comment. Once revisions have been addressed to reviewer's satisfaction, a draft copy of the report will be submitted to Ecology. Comments provided by Ecology will be addressed and a draft final report will be produced. The report will be finalized once Ecology comment responses have been approved. If no comments are received from Ecology within 3 months following submittal of the draft report, the draft report will be considered "Final." A copy of the final report will also be sent to the Nisqually Indian Tribe for their files.

2.8 ANALYSIS OF DATA

Analysis of RDX data will be performed to help support interpretation and evaluation of RDX concentrations detected in groundwater. Summary statistics will be calculated on all of the monitoring wells, springs, and the fish hatchery using Microsoft Excel's Descriptive Statistics tool. Further statistical analysis will be performed on data from monitoring wells and springs with datasets that do not have half or over half of their data points as non-detect. These currently include monitoring wells 98-IA-MW01 through 98-IA-MW04 and springs

AIA-SP01 through AIA-SP04. Shapiro-Wilk test for normality and linear regression analysis will be performed on the data using ChemStat or similar software. The Mann-Kendall correlation test will be performed on non-parametric RDX data using ChemStat or similar software.

All concentration measurements not known to be in error are considered valid; suspect "outliers" are not removed from the dataset and will be included in the analyses. Unusually high or low concentrations will be determined by professional judgment and may include graphing the data, statistical analysis, and/or visual comparison. Non-detect data, which represent concentration measurements below the practical quantification limits (PQL) but above the minimum detection limit for each constituent, will be evaluated at the reporting limit value (i.e., if the reporting limit was 0.5 µg/L then the concentration value was set at 0.5 µg/L). Non-detect data will be labeled with a "U" qualifier in the data table.

2.8.1 Shapiro-Wilk Test for Normality

Prior to analyzing data for trends, the data will be tested for normal distribution. The null and alternate hypotheses are a summary of a test's objectives, which, in this case, is to test for the data's distribution. The null hypothesis, or what is assumed to be true before given evidence that it may be false, for all tests for normality is that a dataset is normally distributed. The alternate hypothesis, then, is that a dataset is not normally distributed (Helsel and Hirsch 2002). A significance level, or alpha level, of 0.05 will be used when determining whether historical data from monitoring wells was normally distributed or not. P values, generated using the Shapiro-Wilk test for normality, will then be compared to the alpha level. The alpha level is the "cutoff" point for the test statistic in making a decision whether the data were normally distributed or not. P values show the strength of the test in determining whether the data were normally distributed or not. P values range from 0 to 1: The closer a P value is to 1 the better the dataset is normally distributed. P values equal to or below 0.05 (alpha level) are not considered normally distributed.

Datasets that are not considered normally distributed will then be transformed by taking the natural log of the original values. This is generally the most common transformation of water resources data. The Shapiro-Wilk test for normality will be run on the transformed data with the same criteria as the datasets above.

2.8.2 Linear Regression and Mann-Kendall Correlation Analyses

Linear regression trend analyses will be conducted on all concentration data that are found to be normally or log normally distributed using the Shapiro-Wilk test. In this instance, the

null hypothesis for the test is that there is no trend in the data (Helsel and Hirsch 2002). The alpha level for the linear regression analysis will be set at 0.05. P values generated by the analysis are then compared to the alpha level. P values less than the alpha value suggested a trend in the data.

The Mann-Kendall test for correlation will be performed on data that are not normally or log-normally distributed. No assumptions need to be made about the distribution of the data in order to perform the Mann-Kendall test (Helsel and Hirsch 2002). The null hypothesis is the same as the linear regression test above in that there is no trend in the data. The alpha level will be kept the same at 0.05, although the Mann-Kendall test computes a P value for a two-tailed prediction interval. As such, the alpha levels are actually 0.025 or 0.975. A P value that is smaller than 0.025 or larger than 0.975 suggests a correlation between the change in constituent concentration and time.

2.9 PROJECT SCHEDULE

The wet season or high water level sampling event will be conducted between February 1 and April 30 of each year. The dry season or low water level sampling event will be conducted between July 15 and October 31.

2.10 SITE ACCESS

An access permit is required for access to the range to allow sampling of wells 98-IA-MW-04 and 98-IA-MW-05 and springs AIA-SP04 and AIA-SP05, which are located inside the range area. The permit must be scheduled through Range Scheduling on a HFL Form 473 (training resource request) or through the Range Facility Management Support System at least one month prior to the planned sampling date. As part of the request, a map of the required area along with a DD Form 2977, deliberate risk assessment worksheet, will be included within the packet. Explosive Ordnance Disposal personnel are required to clear the trails used to access the wells and springs once per year although they may accompany field staff during each sampling event as well. Additionally, a range escort is required and IRP personnel with a General Services Administration vehicle must accompany sampling personnel. No personally owned vehicles are allowed onto the range. The IRP point of contact is required to call in and out of the area and monitor the range safety net at all times while downrange. All civilians requiring access to these areas will receive an unexploded ordnance hazard awareness and safety class, which will include the 3 R's (Recognize, Retreat, Report). All participants must wear full PPE including a combat helmet, Kevlar vest, eye/ear protection and full-fingered gloves.

3 QUALITY ASSURANCE PROJECT PLAN

3.1 PURPOSE

The following QAPP is designed to show plans for compliance with QA/QC portions of a SAP per WAC 173-340-820. It should be noted that some elements of a typical QAPP are not repeated if included elsewhere in this Plan.

The purpose of QA/QC procedures for this site is to provide assurance that field and analytical procedures produce data of acceptable quality to evaluate long-term trends of contaminant concentrations at the site.

3.2 DATA QUALITY OBJECTIVES

DQOs define the type, quantity, and quality of data that are needed to answer specific environmental questions, and support environmental decisions. DQOs are developed using a systematic planning process described in the Guidance for the Data Quality Objectives Process (EPA 2006). The DQOs consist of the following seven iterative steps:

1. State the problem.
2. Identify the goals of the study.
3. Identify information inputs.
4. Define the boundaries of the study.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

Step 1: State the problem.

- RDX contamination is present in groundwater at the Impact Areas. Monitoring is required to assess concentration trends in groundwater at the site.

Step 2: Identify the goals of the study.

- Continue monitoring of RDX levels in groundwater at specific locations surrounding the Impact Areas.
- Determine the presence, concentration, and potential migration of RDX within the areas sampled.
- Determine if RDX contaminated groundwater is exceeding Ecology Cleanup Level and Risk Calculation Method B standard formula value for RDX.

Step 3: Identify information inputs.

- Groundwater data collected semiannually.
- Established project clean up levels listed in Table 3-1.
- Historical data collected since 1999.

Step 4: Define the boundaries of the study.

- Groundwater sampling locations for the study area are shown in Figure 1-3.

Step 5: Develop the analytic approach.

- If ordnance concentrations in portions of the aquifer have been reduced below cleanup levels, then monitoring for that area may be recommended to be reduced or eliminated.
- If ordnance concentrations demonstrate decreasing trends approaching cleanup levels listed in Table 3-1, in either area, then analysis may be reduced or eliminated.

Step 6: Specify performance or acceptance criteria.

- Overall data quality will be reviewed and verified to determine if the data is useable as described in Section 3.6. Only data that is determined to be useable will be applied for assessing if goals are met.
- To minimize sampling error, samples will be collected by Sealaska personnel who are trained in the collection of groundwater samples and who will use the standard operating procedures described in Appendix B.
- Groundwater samples for laboratory testing will be analyzed by an accredited laboratory. The primary laboratory for this project is ALS Environmental located in Kelso, Washington. The laboratory is accredited by the U.S. Department of Defense Environmental Laboratory Accreditation Program and Ecology.

Step 7: Develop the plan for obtaining data.

- Depth to water measurements will be collected semiannually from eleven existing monitoring wells.
- Samples will be collected from all five springs at the site and the fish hatchery semiannually.

Table 3-1. Practical Quantitation Limits

Analytical Method	Analyte	MTCA Standard Method B Cleanup Level (µg/L)	Typical PQL[1/] (µg/L)
EPA Method 8330B (nitroaromatics and nitramines)	HMX	N/A	0.2
	RDX	0.8	0.2
	1,3,5-Trinitrobenzene	40,000	0.2
	1,3-Dinitrobenzene	2	0.2
	Methyl-2,4,6-trinitrophenylnitramine	N/A	0.2
	Nitrobenzene	8	0.2
	2,4,6-Trinitrotoluene	3	0.4
	4-Amino-2,6-dinitrotoluene	N/A	0.4
	2-Amino-2,4-dinitrotoluene	N/A	0.4
	2,6-Dinitrotoluene	16	0.4
	2,4-Dinitrotoluene	30	0.2
	2-Nitrotoluene (ortho)	80	0.6
	4-Nitrotoluene (para)	80	0.6
	3-Nitrotoluene (meta)	80	0.4

Notes:
[1/] It may not be possible to achieve these quantification limits (e.g., samples that require dilution before analysis).
RDX – Research Department eXplosive
HMX - Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (also known as octogen)
N/A – Not applicable
µg/L – micrograms per liter

3.3 FIELD QUALITY CONTROL SAMPLES

As shown in Table 2-1, it is expected that the following field QC samples will be submitted with the primary samples collected during each sampling event:

- One field duplicate sample will be collected. Field duplicate samples will be given a unique sample ID and sample time independent of the primary sample to "disguise" the duplicate sample from the analytical lab. An example of a typical field duplicate sample ID would be: 98-IA-MW33.
- One primary sample will be collected in triplicate for matrix spike/matrix spike duplicate analysis.

Standard operating procedures for sampling are located in Appendix B.

3.4 LABORATORY QUALITY CONTROL

The project laboratory will be responsible for conducting laboratory QC procedures and reporting laboratory QC results in accordance with laboratory standard operating procedures. It is expected that the project laboratory will perform and report the following laboratory QC once per batch: method blank, laboratory control spike, matrix spike, and matrix spike duplicate. The current project laboratory's control limits for acceptable spike

recoveries and the relative percent difference (RPD) on spike duplicates are shown in Table 3-2. The laboratory will also follow Method 8330B quality control requirement guidelines (DoD/DoE 2017). Tables containing analytical method QC and corrective action tables have been included in Appendix D.

Also, it is expected that the laboratory will perform and report results for surrogate recovery for every sample. The acceptable range of surrogate percent recovery for EPA Method 8330B is 50-150%.

Table 3-2. Spike Recovery and Spike Duplicate Control Limits

Analytical Method	Analyte	Range of Acceptable Laboratory Control Spike Recoveries (%)	Range of Acceptable Matrix Spike/Matrix Spike Duplicate Recoveries (%)	Acceptable Spike Duplicate RPD (%)
EPA Method 8330B (nitroaromatics and nitramines)	HMX	65 - 135	65 - 135	<20
	RDX	68 - 130	68 - 130	<20
	1,3,5-Trinitrobenzene	73 - 125	73 - 125	<20
	1,3-Dinitrobenzene	78 - 120	78 - 120	<20
	Methyl-2,4,6-trinitrophenylnitramine	64 - 128	64 - 128	<20
	Nitrobenzene	65 - 134	65 - 134	<20
	2,4,6-Trinitrotoluene	71 - 123	71 - 123	<20
	4-Amino-2,6-dinitrotoluene	76 - 125	76 - 125	<20
	2-Amino-2,4-dinitrotoluene	79 - 120	79 - 120	<20
	2,6-Dinitrotoluene	77 - 127	77 - 127	<20
	2,4-Dinitrotoluene	78 - 120	78 - 120	<20
	2-Nitrotoluene (ortho)	70 - 127	70 - 127	<20
	4-Nitrotoluene (para)	71 - 127	71 - 127	<20
	3-Nitrotoluene (meta)	73 - 125	73 - 125	<20

Notes:
RDX – Research Department eXplosive
HMX - Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (also known as octogen)
N/A – Not applicable
RPD - relative percent difference

3.5 PRACTICAL QUANTITATION LIMITS

Table 3-1 presents analyte-by-analyte expectations for PQLs relative to MTCA Standard Method B groundwater cleanup levels. It is expected that the current project laboratory will achieve PQLs of appropriate sensitivity for comparisons with regulatory standards.

3.6 QA/QC REVIEW AND VERIFICATION

Overall data quality will be reviewed and verified to determine if the data is suitable for use. Data verification checks will be performed on 100% of project data. The following checks will be performed (as relevant) on the laboratory analytical data package received:

- Documentation identifies the laboratory receiving and conducting analyses, and includes documentation for all samples submitted by the project or requester for analyses.
- Requested analytical methods were performed and the analysis dates are present.
- Requested target analyte results are reported along with the original laboratory data qualifiers and data qualifier definitions for each reported result (and the uncertainty of each result and clear indication of the type of uncertainty reported if required).
- Requested target analyte result units are reported.
- Requested reporting limits for all samples are present and results at and below the requested (required) reporting limits are clearly identified (including sample detection limits if required).
- Sampling dates (including times if needed), date and time of laboratory receipt of samples, and sample conditions upon receipt at the laboratory are documented.
- Sample results are evaluated by comparing sample conditions upon receipt at the laboratory and sample characteristics to the requirements and guidelines present in national or regional data validation documents, analytical method(s), or contract.
- Requested methods (handling, preparation, cleanup, and analytical) are performed.
- Method dates (including dates, times, and duration of analysis for radiation counting measurements and other methods, if needed) for handling, preparation, cleanup, and analysis are present, as appropriate.
- Sample-related QC data and QC acceptance criteria (e.g., method blanks, surrogate recoveries, laboratory control sample (LCS) recoveries, duplicate analyses, MS/MSD recoveries, serial dilutions, post digestion spikes, standard reference materials) are provided and linked to the reported field samples (including the field quality control samples such as trip and equipment blanks).
- Requested spike analytes or compounds (e.g., surrogate, LCS spikes, post-digestion spikes) have been added, as appropriate.
- Sample holding times (from sampling date to preparation and preparation to analysis) are evaluated.
- Frequency of QC samples is checked for appropriateness (e.g., one LCS per 20 samples in a preparation batch).
- Sample results are evaluated by comparing holding times and sample-related QC

data to the requirements and guidelines present in national or regional data validation documents, analytical method(s), or contract.

Results of this evaluation will be presented in a data review report to the project team and summarized in the project report. After evaluation, data will be flagged as necessary in order to maintain data usability. If in the data verification check significant issues are identified, a Stage 2A data validation of the data package will be completed to fully evaluate the potential impact on data usability for project purposes. Corrective action for field or laboratory procedures will be taken as needed in consultation with Ecology.

4 SITE SAFETY AND HEALTH PLAN

The following Site Safety and Health Plan (SSHP) is a short summary of the full Accident Prevention Plan/SSHP included in the Project Management Plan (Sealaska 2016). The SSHP is designed to show plans for compliance with 29 CFR 1910.120, WAC 173-340-810, WAC 296-62-300 (Part R), and USACE Safety and Health Requirements Manual (EM 385-1-1). A copy of the SSHP will be maintained on-site during all field activities.

4.1 SITE SAFETY AND HEALTH OFFICER

Key personnel for the project, including the Site Safety and Health Officer, are included in Table 1-2. Two field professionals will conduct each sampling event due to the steepness of the bluff, the planned field activities, and the nature of impact area operations. Subcontractors and site visitors are not expected at the site. However, if subcontractors or visitors are needed in the future, they will be briefed on health and safety concerns by reading this SSHP before entering the site.

4.2 HAZARD ANALYSIS

The overall hazard level associated with activities described in this Plan is low. The portion of the work conducted in the range area is medium due to the potential munitions in the area. An analysis of the potential physical and chemical hazards associated with field tasks described or implied in the Plan is presented in Table 4-1.

4.3 TRAINING

All site workers are appropriately trained in accordance with 29 CFR 1910.120(e), and WAC 296-62-3040 through 296-62-30465. The work described in the SAP above entails 40-hour initial Hazardous Waste Operations and Emergency Response (HAZWOPER) training, three days of supervised fieldwork, 8-hour annual HAZWOPER refreshers, OPSEC Awareness for Military Members, DoD Employees, and Contract, JS US007 Level 1 Antiterrorism Awareness Training, and UXO Hazard Awareness and Safety training including the 3 R's (for fieldworkers entering the AIA or CIA).

4.4 PERSONAL PROTECTIVE EQUIPMENT

All fieldwork described in the SAP will be completed with Level D PPE to include a safety vest, steel-toe boots, safety glasses, face-shield, or goggles, PVC or nitrile gloves, hard hat (as necessary), hearing protection (as necessary), and a high-visibility, reflective safety vest. Level D PPE has been selected for this fieldwork on the basis of previous investigations (Table 4-2). Modified Level D PPE to include safety toed boots, combat helmet, Kevlar

vest, eye protection, and full fingered gloves is required while entering and sampling in the range area of the AIA and CIA (Table 4-2).

Table 4-1. Groundwater Monitoring and Sampling Task Safety Analysis

Task	Potential Hazard	Actions
Mobilize to work site	Traffic accident	Vehicle Operation - valid driver's license, seat belt use, routine vehicle inspections, no cell phone use while driving. Slow to 10 mph when passing troops on foot on road. Yield to pedestrians in crosswalks.
Groundwater monitoring and sampling	Worker requirements	Medical clearance for hazardous waste work. HAZWOPER (40 hrs.), 3 days of supervised fieldwork, and current refresher for workers. Additional (8 hrs.) supervisor training for the field lead, SSHO, and all other on-site supervisors.
	Struck by vehicles	Sampling vehicle(s) placed between workers and oncoming traffic. High visibility safety vests in traffic areas. No work will be done after twilight or before sun up. Gate will be closed upon entry and exit to the landfill limiting access to other motorists and pedestrians.
	Temperature stress	If temperature is above 80°F or below 40°F, administrative controls will be implemented (cooled or warmed drinks, routine breaks in heated or shaded area, and provisions for emergency heating or cooling).
	Lifting (musculoskeletal injuries)	If equipment is to be moved, an evaluation of potential pinch points and/or weight strain will be conducted. Clear area of all unnecessary equipment and slip/trip hazards. Additional help will be obtained by workers or mechanical assistance used on-site if equipment to be moved is unwieldy, has a weight >50 lbs., or has to be moved by maneuvering through awkward positioning. The portable generator will not be moved out of the back of the sampling truck until all work has been completed for the day. Electric chord from Grundfos pump is long enough to reach from the truck to all wells if needed.
	Electric shock	Portable electrical tools and all portable electrical equipment that poses a shock hazard must be connected through ground fault circuit interrupters.
	Battery Fire/Explosion	Use only batteries that are not installed in vehicles and are not being charged during use for powering equipment.
	Fire	Fire extinguisher rated 2A and 5B (serviced annually and inspected monthly) located in back of cab of sampling vehicle. Fire extinguisher maintenance office is located in Bldg. 02014 on Pendleton Ave. and N. 3rd St. in back of the old fire station at JBLM.
	Chemical exposure	Wash hands before eating or drinking. Nitrile gloves for chemical/contaminant contact. Chemical containers labeled with identity and hazard. Safety Data Sheets (SDSs) on site for all chemicals in use. Site-specific training must address chemicals, hazards, and proper handling.
	IDW Control	No IDW will be stored onsite. Purge water and decontamination water from all monitoring locations will be collected in appropriate containers. The water from the impact areas will be sampled then transported and staged at Landfill 2 pending the analysis. If the results are below cleanup levels, the water will be discharged through the Landfill 2 pump and treat system. If the results are above the cleanup levels, the water will be disposed of at an offsite facility. All disposable PPE and field equipment (bailers, tubing) will be containerized in a Sealaska dumpster.

Table 4-2. Groundwater Monitoring and Sampling PPE Requirements

Level D Personal Protective Equipment (PPE)	**Comments**
Safety Shoes	Mandatory
Hard Hat	If overhead hazards are present
Safety Glasses With Side Shields, Face Shield, or Goggles	Mandatory
Hearing Protection	As necessary (not needed during routine sampling)
Gloves	Nitrile, PVC, or similar during groundwater sampling. Heavy-duty work gloves for material handling.
Other	NA
Safety Cones/Barricades	As needed when working in areas with traffic or other similar potential hazards.
Safety Vest	Mandatory
Knee Pads	Optional
Caution Tape	As needed, to exclude unauthorized personnel
Modified Level D Personal Protective Equipment (PPE)	**Comments**
Safety Shoes	Mandatory
Combat Helmet	Mandatory while working in the AIA or CIA
Kevlar Vest	Mandatory while working in the AIA or CIA
Safety Glasses With Side Shields, Face Shield, or Goggles	Mandatory
Full fingered gloves	Mandatory while working in the AIA or CIA

4.5 MEDICAL SURVEILLANCE

Sealaska personnel participate in the Sealaska Medical Surveillance program that meets the requirements of 29 CFR 1910.120(f). Sealaska site personnel to whom this requirement applies must pass this examination and have a copy of their medical clearance on file before they are allowed to perform any work.

4.6 EXPOSURE MONITORING

Because it was determined that the site contaminants occur at low concentrations in groundwater at the site, it is not likely that personnel exposures to these materials will exceed permissible exposure limits. For this reason, personal exposure monitoring will not be required for this project.

4.7 SITE CONTROL

Due to the nature and scope of fieldwork described in this Plan, establishment of a formal site control program that includes delineated work zones is not warranted. However, as needed, safety cones or barricades will be placed alongside of the sampling truck creating a

temporary safety zone to control hazards such as vehicular traffic. These zones will be established around each work area and safe distances will be maintained between workers and traffic. All site workers will also wear reflective safety vests to increase their visibility to those outside the work zone.

4.7.1 Working in the AIA or CIA

Entry within the AIA or CIA must be scheduled through the Range Scheduling on an HFL Form 473 through RFMSS. Risk assessment DD Form 2977 will be completed prior to entry. Digging or any type is ground penetration will not be permitted, including driving of pickets or marking flags. Elements may utilize surface laid marking instruments.

Field workers must be escorted by an EOD qualified person/team and call in and out of the area and monitor the range safety net at all times while downrange.

While walking to the sample locations within the range, personnel shall follow established EOD cleared pathways and maintain personnel separation as a safety precaution. Only those staff members needed for the sampling should mobilize to the sample site.

4.8 PERSONAL DECONTAMINATION PROCEDURES

Non-disposable PPE or clothing that becomes contaminated during site work will be appropriately cleaned before being put back in service or else replaced. In the event of skin contact with contaminated media, the affected skin will be washed immediately as appropriate.

4.9 CONFINED SPACES

The scope of work described in this Plan above does not include confined space entry. Confined space entry is not anticipated or allowed as part of this Plan.

4.10 SPILL CONTAINMENT

Due to the nature and quantity of drummed liquid waste being generated during sampling events, a site-specific spill containment program is not warranted.

4.11 EMERGENCY CONTACTS

All Emergencies	**Dial 911**
Hospital Saint Clare Hospital 11315 Bridgeport Way SW Lakewood, Washington 98499	(253) 985-1711
U.S. Coast Guard	(206) 217-6000 or VHF Ch. 16
Washington State Poison Center	(800) 222-1222
Agency for Toxic Substances and Disease Registry	(888) 422-8737
Range Support Operations Officer	(253) 967-1555
JBLM IRP Program Manager, Meseret Ghebresllassie	(253) 477-3742 (office)
Sealaska PM, Scott Elkind	(360) 930-3187 (office) (360) 626-3991 (cellular)
Sealaska SSHO, V. Sunrise Patterson	(206) 499-9896 (cellular)
Sealaska Alternate SSHO, Will Kaage	(360) 367-9318 (cellular)
Sealaska Certified Industrial Hygienist (CIH), Steve Frost	(206) 214-8990 (cellular)

The route to the nearest hospital with written directions is shown as Figure 4-1.

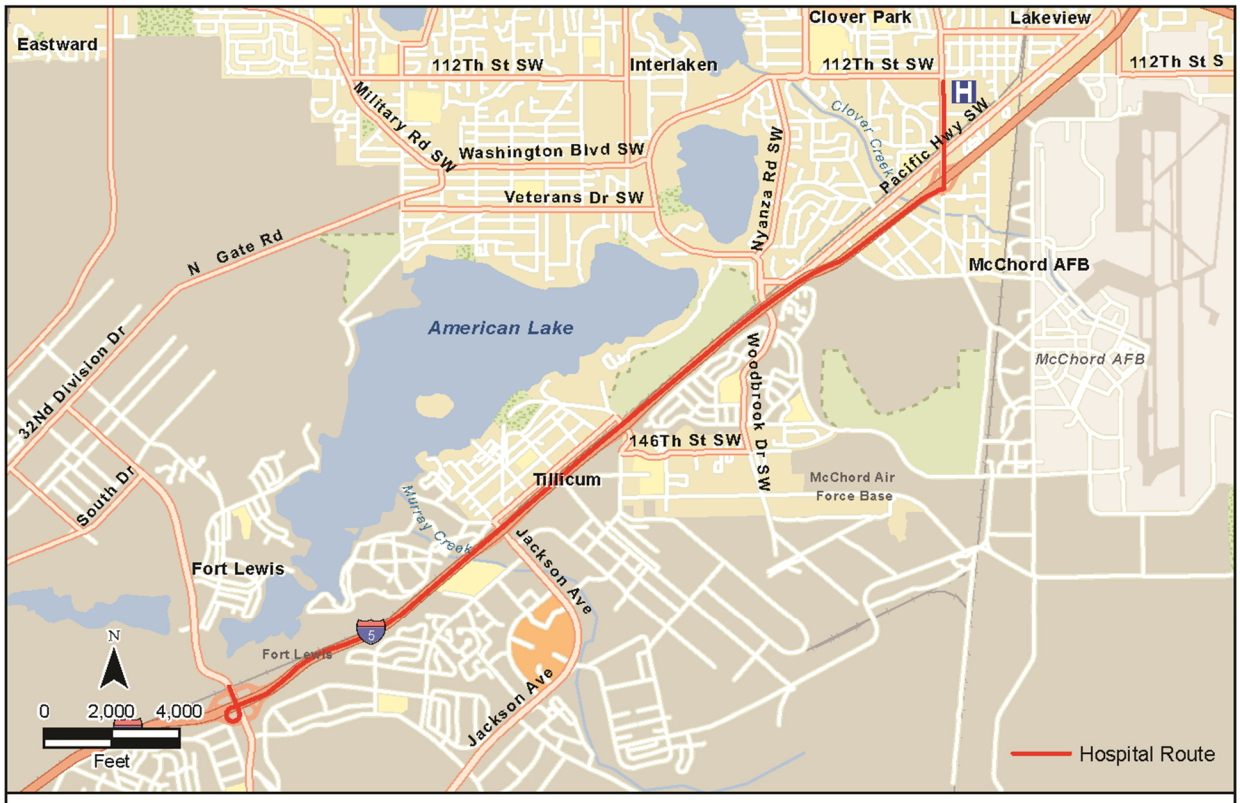


Figure 4-1
Hospital Route

Driving directions from Fort Lewis Gate to St. Clare Hospital, 11315 Bridgeport Way SW, Lakewood, WA.

- Start out going northwest on 41st Division Drive S. for 0.01 mile
- Merge onto I-5 North toward Tacoma / Seattle and travel for 4.8 miles
- Take Exit 125 Lakewood/Joint Base Lewis-McChord, turn left at the end of the off-ramp at the light onto Bridgeport Way SW.
- Go about 3/10 of a mile. St. Clare Hospital is on the right.

Hospital Phone Numbers:

Main: 253-588-1711

Emergency: 253-985-6700

5 REFERENCES

DoD/DoE (Department of Defense/Department of Energy). 2017. Consolidated Quality Systems Manual for Environmental Laboratories, DoD Quality Systems Manual version 5.1/DoE Quality Systems for Analytical Services Version 3.1. January 2017

EPA (United States Environmental Protection Agency). 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA Publication No. 542-S-02-001. May 2002.

EPA. 2006. Guidance on Systematic Planning using the Data Quality Objectives Process, EPA QA/G-4, QAMS. February.

Helsel, D.R. and R. M. Hirsch. 2002. Chapter A3 Statistical Methods in Water Resources. Book 4 - Hydrologic Analysis and Interpretation. Techniques of Water – Resources Investigations of the United States Geological Survey.

Sealaska (Sealaska Environmental Services, LLC). 2017. Final Groundwater Monitoring Plan, Artillery Impact and Central Impact Areas, Joint Base Lewis-McChord, Pierce County, Washington. Prepared by Sealaska for US Army Corps of Engineers, under Contract No. W912DW-11-D-1031. Poulsbo, Washington. February 3.

Sealaska. 2016. Final Project Management Plan (Updated October 17, 2016), Environmental Remediation Program Services, for Joint Base Lewis-McChord and Yakima Training Center, Washington. Prepared by Sealaska for US Army Corps of Engineers, under Contract No. W912DW-11-D-1031. Poulsbo, Washington. October 17.

URS. 2000. Preliminary Investigation Report of Groundwater Monitoring for Munitions Contamination, Artillery Impact Area and Central Impact Area, Joint Base Lewis McChord, Washington. June 2000.

APPENDIX A

BORING LOGS AND WELL COMPLETION DIAGRAMS

WELL COMPLETION REPORT

Project FT LEWIS AIA MONITORING WELL INSTALLATION Well No. 01-1A-11
Completion date 18 OCT 01
Contractor HOLT DRILLING
Rig GEFCO SD300 AIR ROTARY
Operator TOM CRANEY
Inspector L. ADAMO
Depth 63.75 Datum GROUND SURFACE

HOLE DATA
Size: 24 in. to 2 ft.
8 in. to 63.75 ft.
____ in. to ____ ft.

CASING
Type ROPE THREAD
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: 8 in. to 63 ft.
____ in. to ____ ft.
____ in. to ____ ft.

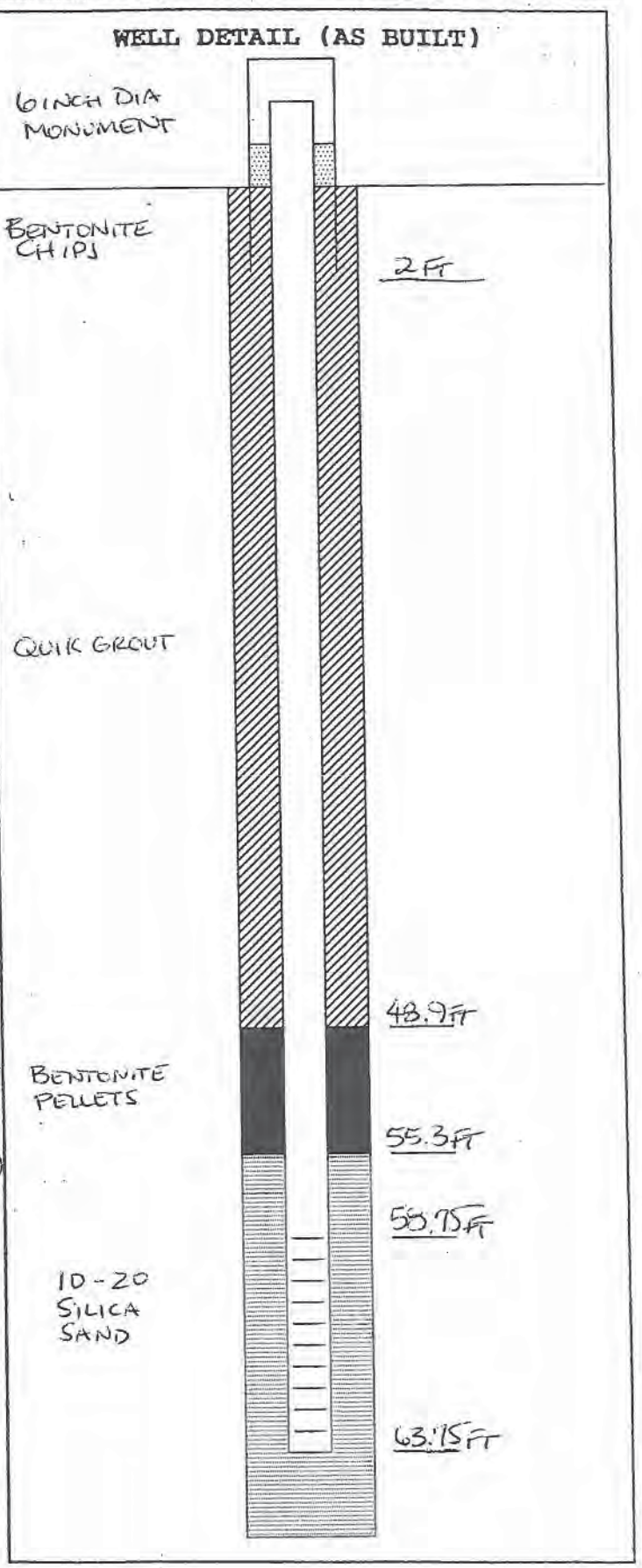
SCREEN
Type PVC PRE-PACK 0.1 SLOT
Mfr. JOHNSON
Composition PVC Dia. 4 INCH O.D 2 INCH I.D.

Fittings:	Length	Dia.
Packer	____	____
Riser	58	2
Tailpipe	____	____

FILTER
Source CSSI
Composition SILICA
Gradation 10-20
Inst. method POURED
Volume used 6-50lbs BAGS
Depth 63.75 to 55.3 ft.

GROUT
Composition QUIK-GROUT
Volume used 200 GAL & 4-50lbs BAGS (CHIPS)
Inst. method PUMPED W/TREMIE
Depth 48.9 to 2 ft.
2 to 0 ft.

REMARKS:
CENTRALIZERS: 2



WELL COMPLETION REPORT

Project FT LENIS AIA MONITORING WELL INSTALLATION Well No. 01-1A-12
Completion date 19 OCT 01
Contractor HOLT DRILLING
Rig GEFCO SD300 AIR ROTARY
Operator TOM CRANEY
Inspector L. ADAMO
Depth 51.67 FT Datum GROUND SURFACE

HOLE DATA
Size: 24 in. to 3 ft.
8 in. to 52.6 ft.
____ in. to ____ ft.

CASING
Type ROPE THREAD
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: 8 in. to 53 ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type PVC PRE-PACK 0.1 SLOT
Mfr. JOHNSON
Composition PVC Dia. 4 INCH O.D 2 INCH I.D.

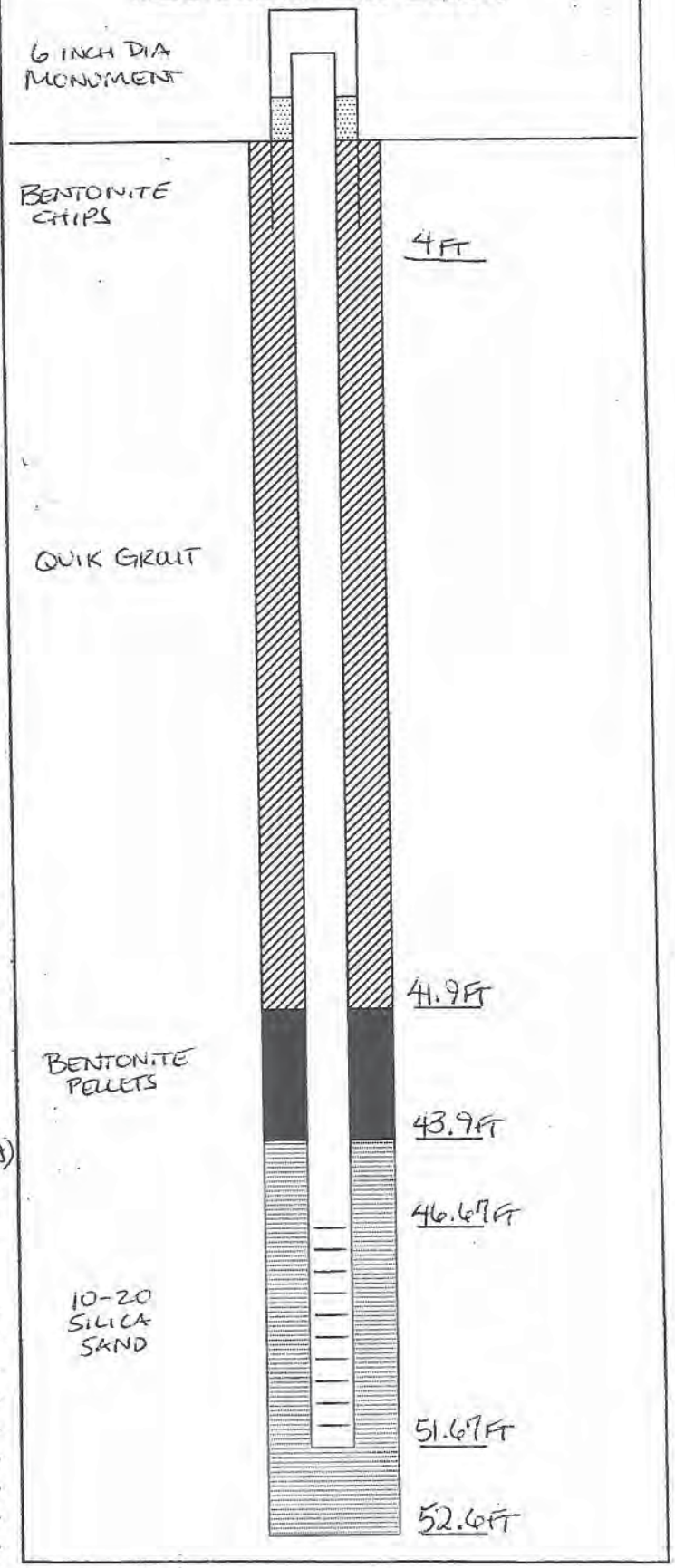
Fittings:	Length	Dia.
Packer		
Riser	50	2
Tailpipe		

FILTER
Source CCSI
Composition SILICA
Gradation 10-20
Inst. method POURED
Volume used 7-50lbs BAGS
Depth 52.6 to 43.9 ft.

GROUT
Composition QUIK-GROUT
Volume used 200 GAL & 8-50lbs BAG (CHIP)
Inst. method PUMPED W/TREMIE
Depth 41.9 to 4 ft.
4 to 0 ft.

REMARKS:
CENTRALIZERS: 2

WELL DETAIL (AS BUILT)



WELL COMPLETION REPORT

Project FT LENIS AIA MONITORING WELL INSTALLATION Well No. 01-1A-13
Completion date 22 OCT 01
Contractor HOLT DRILLING
Rig GEFCO SD300 AIR ROTARY
Operator TOM CRANEY
Inspector L. ADAMO
Depth 67 FT Datum GROUND SURFACE

HOLE DATA
Size: 24 in. to 5 ft.
5 in. to 68.67 ft.
____ in. to ____ ft.

CASING
Type ROPE THREAD
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: 8 in. to 68 ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type PVC PRE-PACK 0.1 SLOT
Mfr. JOHNSON
Composition PVC Dia. 4 INCH O.D 2 INCH I.D.

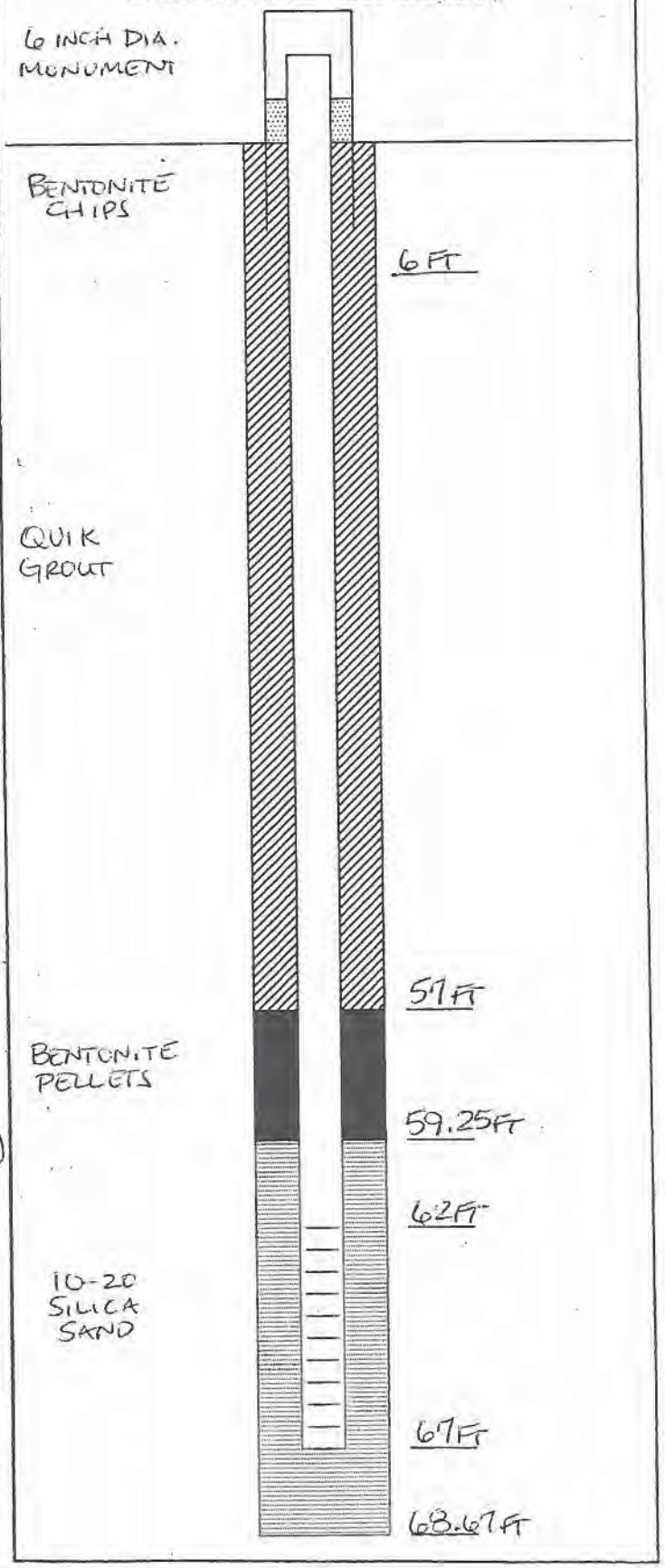
Fittings:	Length	Dia.
Packer	____	____
Riser	65	2
Tailpipe	____	____

FILTER
Source CSSI
Composition SILICA
Gradation 10 - 20
Inst. method POURED
Volume used 8 - 50 lbs BAGS
Depth 68.67 to 59.25 ft.

GROUT
Composition QUIK-GROUT
Volume used 250 GAL. & 12 - 50 lbs BAG (CHIPS)
Inst. method PUMPED W/TREMIE
Depth 57 to 6 ft.
6 to 2 ft.

REMARKS:
CENTRALIZERS: 2

WELL DETAIL (AS BUILT)



WELL COMPLETION REPORT

Project FT LEWIS AIA MONITORING WELL INSTALLATION Well No. 01-1A-14
Completion date 23 Oct 01
Contractor HOLT DRILLING
Rig GEFCO SD300 AIR ROTARY
Operator TOM CRANEY
Inspector L. ADAMO
Depth 47.5 FT Datum GROUND SURFACE

HOLE DATA
Size: 8 in. to 48.5 ft.
24 in. to 3 ft.
____ in. to ____ ft.

CASING
Type ROPE THREAD
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: 8 in. to 48.5 ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type PVC PRE-PACK 0.1 SLOT
Mfr. JOHNSON
Composition PVC Dia. 4 INCH O.D 2 INCH I.D.

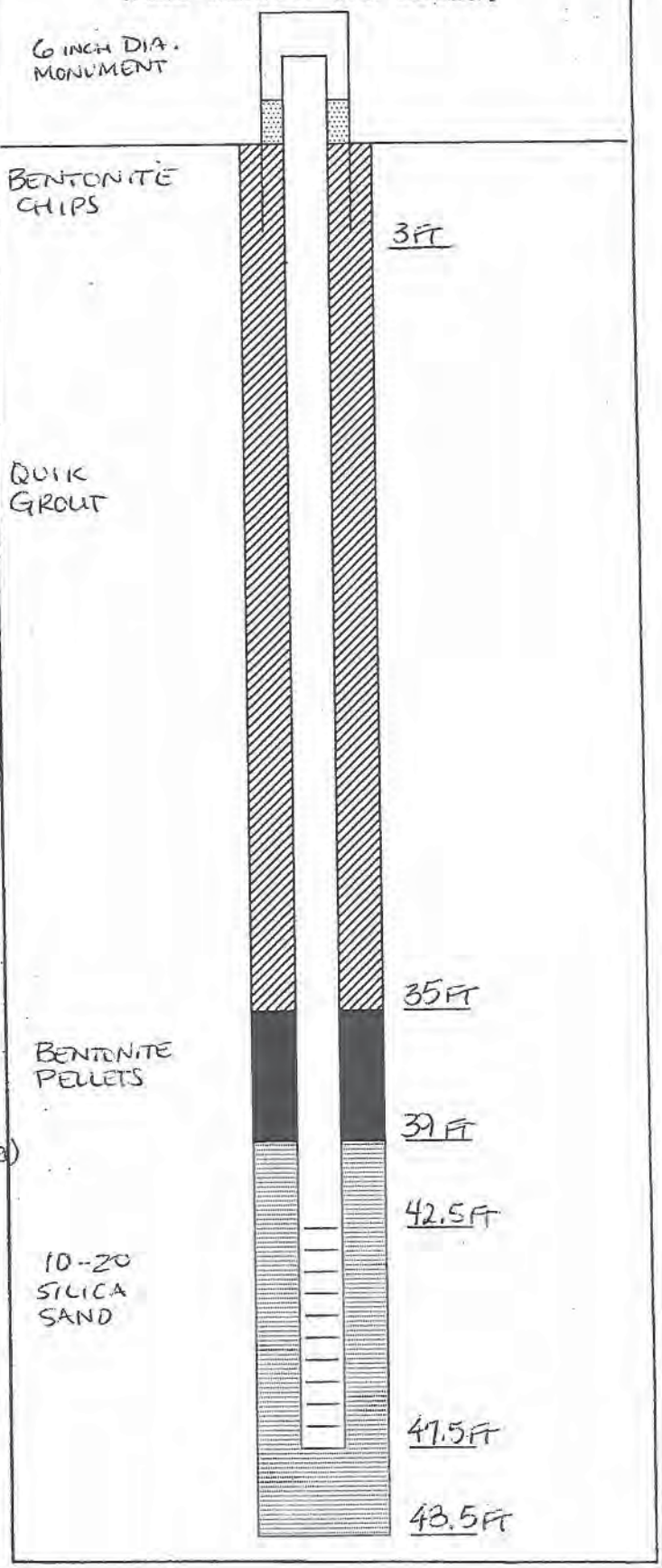
Fittings:	Length	Dia.
Packer		
Riser	49.5	2
Tailpipe		

FILTER
Source CSSI
Composition SILICA
Gradation 10-20
Inst. method POURED
Volume used 8 - 50lbs BAGS
Depth 48.5 to 39 ft.

GROUT
Composition QUIK-GROUT
Volume used 250 GAL & 8--50lbs BAG (CHIPS)
Inst. method PUMPED W/TREMIE
Depth 35 to 3 ft.
3 to 0 ft.

REMARKS:
CENTRALIZERS: 2

WELL DETAIL (AS BUILT)



WELL COMPLETION REPORT

Project FT LEWIS AIA MONITORING WELL INSTALLATION Well No. 01-1A-15
Completion date 17 OCT 01
Contractor HOLT DRILLING
Rig GEFCO SD300 AIR ROTARY
Operator TOM CRANEY
Inspector L. ADAMO
Depth 208 FT Datum GROUND SURFACE

HOLE DATA
Size: 24 in. to 5 ft.
8 in. to 209 ft.
____ in. to ____ ft.

CASING
Type ROPE THREAD AND STANDARD 6"
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: 6 in. to 30 ft.
8 in. to 207 ft.
____ in. to ____ ft.

SCREEN
Type PVC PRE-PACK 0.1 SLOT
Mfr. JOHNSON
Composition PVC Dia. 4 INCH O.D 2 INCH I.D.

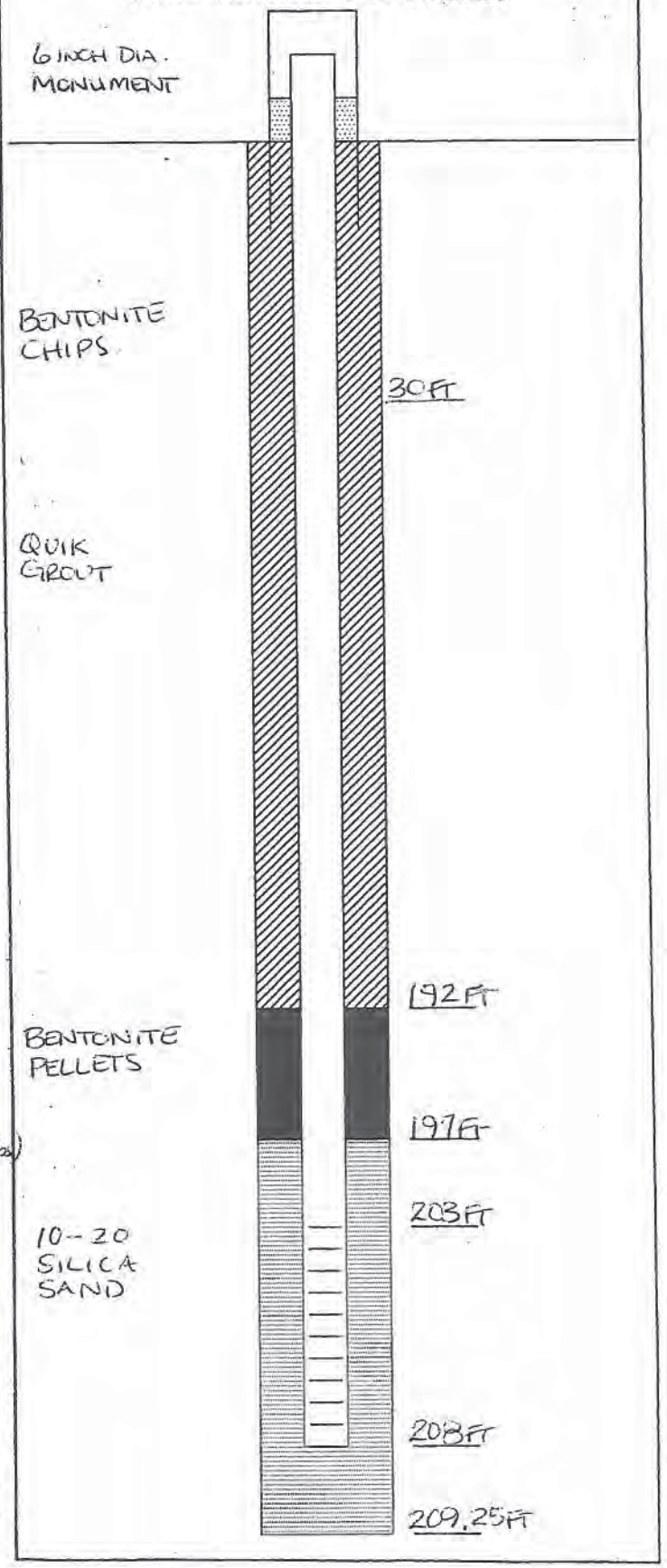
Fittings:	Length	Dia.
Packer		
Riser	205	2
Tailpipe		

FILTER
Source CSSI
Composition SILICA
Gradation 10-20
Inst. method POURED
Volume used 7 - 50 lbs BAGS.
Depth 209.25 to 197 ft.

GROUT
Composition QUIK-GROUT
Volume used 1100 GAL & 10 bgs of CHIPS(50lbs)
Inst. method PUMPED W/ TREMIE
Depth 192 to 30 ft.
30 to 0 ft.

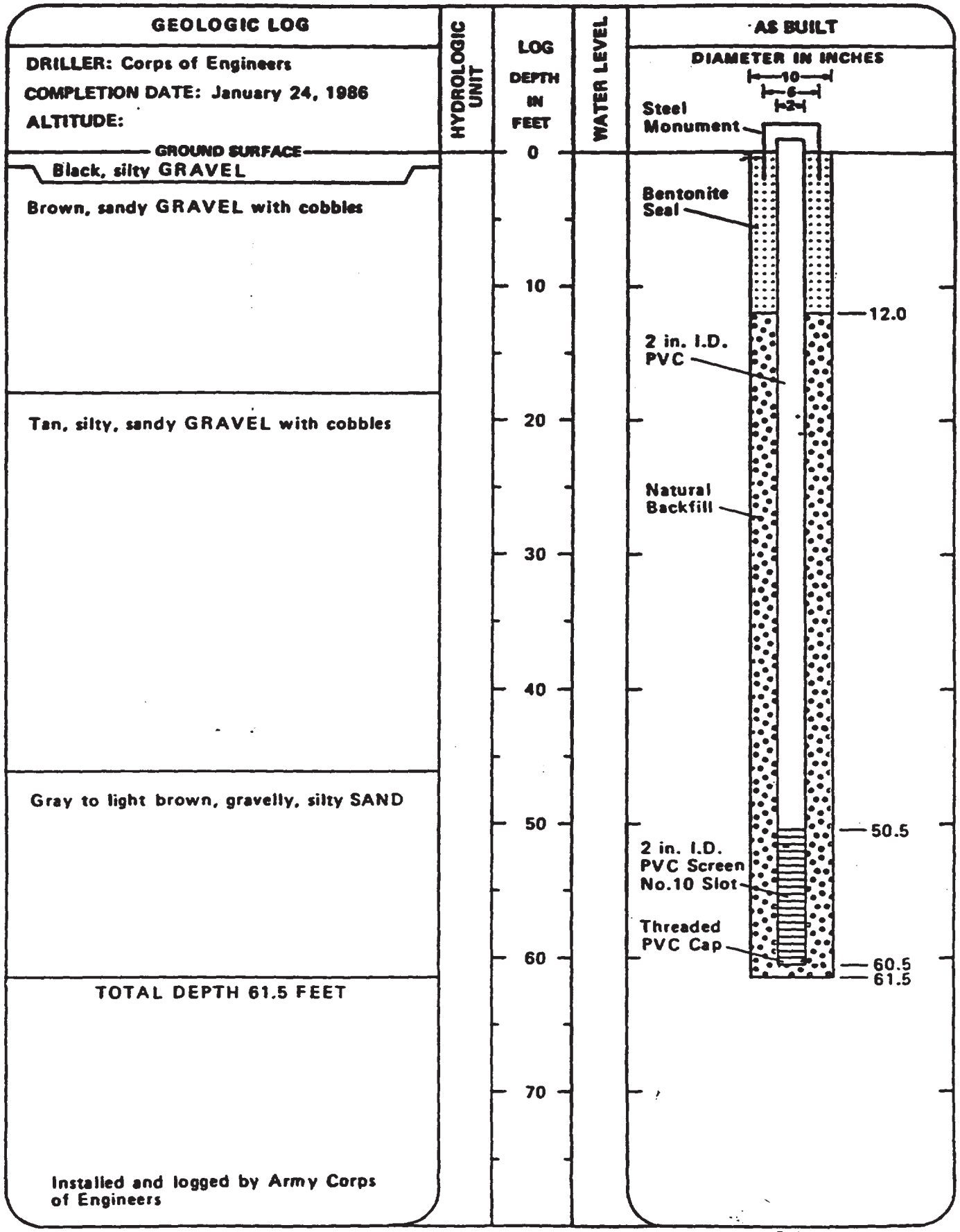
REMARKS:
CENTRALIZERS: 7

WELL DETAIL (AS BUILT)



LOG & AS-BUILT DIAGRAM

FIGURE 84



SHANNON & WILSON, INC.
WASTE MANAGEMENT SERVICES
SEATTLE, WASHINGTON
(206)632-8020

FT. LEWIS LOGISTICS CENTER
PIERCE COUNTY, WASHINGTON

MONITORING WELL
85-PA-384

MAY 1986
W-4487-03

RESOURCE PROTECTION WELL REPORT

START CARD NO. R16884

PROJECT NAME: Installation of Water Monitoring Wells

WELL IDENTIFICATION NO. 98-IA-MW1/Tag #AEP 011

DRILLING METHOD: Auger

DRILLER: Craig S. DeYoung

FIRM: Andrew Well Drilling Services

SIGNATURE:

CONSULTING FIRM: US Army, Corps of Engineers

REPRESENTATIVE: Matt Brookshier

COUNTY: Pierce

LOCATION: SW 1/4 SW 1/4 Sec 19 Twn 18N R 2E

STREET ADDRESS OF WELL: Central Impact Area/Artillery Impact Area, Ft. Lewis, Washington

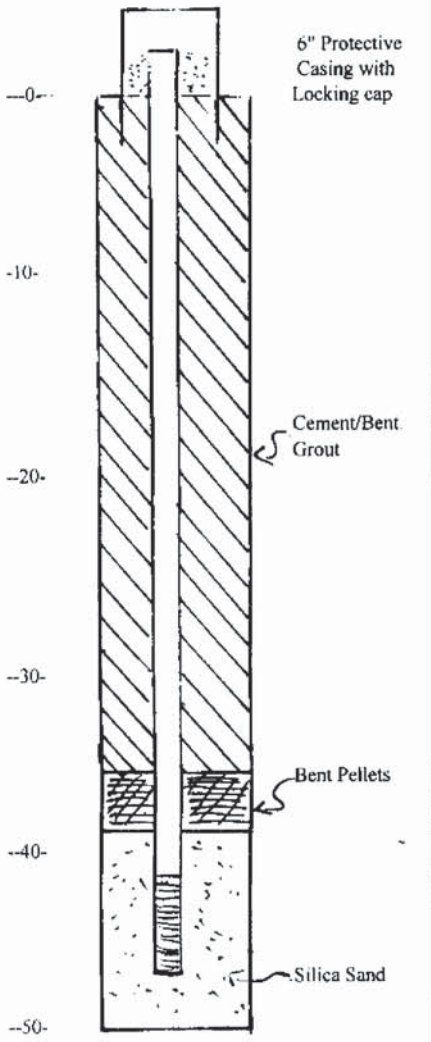
WATER LEVEL ELEVATION: 34.45ft

GROUND SURFACE ELEVATION: Unknown

INSTALLED: December 18, 1998

DEVELOPED: December 18, 1998

As-Built



Well Data

SIZE:	8" to 50.0ft
CASING:	
Ht above Surface:	2ft
	2" Sch 80 PVC
Drive Shoe:	None
SCREEN:	
Type:	2"Sch 80 .010 Slotted PVC
Location:	41.0 to 46.0 ft
MFG:	Boart Longyear
FILTER:	
Composition:	Silica Sand 10/20 and 20/40
Installation:	Poured from surface in cased hole
Depth:	50.0 to 38.0 ft
GROUT:	
Composition:	Bentonite Pellets
Installation:	Poured from surface in cased hole
Depth:	38.0 to 35.0ft
Composition:	Bentonite/cement grout
Installation:	Tremie Pipe
Depth:	35.0 to surface
SURFACE COMPLETION:	Vault Cover

FORMATION DESCRIPTION

0.0- 05.0	Silty Gravel w/cobbles & Sand
05.0-19.0	Gravel & Sand w/occasional cobbles
19.0-50.0	Sand w/gravel & Cobbles

SCALE: 1" = 10ft

PAGE: 1 OF 1

HTRW DRILLING LOG

DISTRICT: CE NWS		HOLE NUMBER: 98-IA-MW1
1 COMPANY NAME: USACE	2 DRILL SUBCONTRACTOR: Andrew Well Drilling Service	SHEET 1 OF 7 SHEETS
3 PROJECT: Ft. Lewis Impact Area	4 LOCATION: Ft. Lewis, WA	
5 NAME OF DRILLER: Matt Gilbert	6 MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61	
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4" ID HSA w 8" OD; 3" OD split spoon drive samplers x 12" long driven by 300lb hammer	8 HOLE LOCATION: T18N; R2E; Sec. 19; SE SW SW	
	9 SURFACE ELEVATION: ~280 FT; 75' grnd	
	10 DATE STARTED: 17 DEC 98	11 DATE COMPLETED: 18 DEC 98
12 OVERBURDEN THICKNESS: 50 FT	15 DEPTH GROUNDWATER ENCOUNTERED: 37.55 FT	
13 DEPTH DRILLED INTO ROCK: 0 FT	16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14 TOTAL DEPTH OF HOLE: 50 FT	17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
DRIVE		9	

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY
						%

22 DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR
		X		M. H. Banks, Jr.

LOCATION SKETCH/COMMENTS — SCALE:

PROJECT: Ft. Lewis Impact Area — HOLE NO: 98-IA-MW1

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW1

PROJECT: Ft. Lewis Impact Area

INSPECTOR: Matt Brookshier

SHEET 2 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	GW - Well graded gravel with cobbles (↑5"). Well rounded mostly volcanic origin gravel and cobbles; few granitic gravels, silt/fine sand (<5%) adhering to surface of gravels; moist, dark brown to black (silt).		Grab			Mobile B-61 turning 4" ID HSA sampling w/ 3" OD x 12" spoon driven by 300lb hammer w/ 36" stroke. Begin drilling - 17 DEC 98 @ 852 finish 0-5FT 852/ Fairly rough drilling, rig bucking cobbley
	2						
	3	transition from reworked root zone					
	4	GW as above, but less silt, more medium sand (10%), moist, grey.					
	5						Drill 5-10FT 902-904
	6	GP-~~SP~~: poorly graded fine gravel and coarse to medium ~~sand~~ gravel, gravel is rounded to subrounded sand is more subangular 65% gravel; 35% sand, minor silt present, no cobbles from auger flights, but probably few, moist grey.		Cuttings			Easier drilling than before, occasional cobbles, smoother past 7FT
	7						
	8						
	9						guide bit is ? very moist clay and coarse sand

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: ~~SB-ID~~-MW1
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 3 OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	GP ~~SW~~: Poorly graded gravel and sand, Gravel (1½" max) sub rounded, some broken, Sand (coarse) sub-angular, All grains have minute coating of fines. damp, brown.		A: 10-11 60% recovery		N: 20 21	Drill 10-15 FT 934-937 Instruct helper to replace sample retainer in spoon rougher drilling Large cobble or rolder at 13FT -Cobbles from 11-13FT easier drilling after 13FT gravel & cobbles to 5" coming up guide bit came up with a lot of clay and coarse sand stuck in it
	15	GP-~~SW~~: Clayey gravel, (poor sample recovery) Gravel with coarse sand and 10% ? clay (based on guide bit) with cobbles (andesite) gravels are broken, sand is subangular, all grains are lightly covered with clay.		B: 15-16 40% recovery		N: 31 40	~~Drill 15-20FT~~ driven through cobble, poor sample recovery Drill 15-20FT 957-959 fairly easy drilling, steady
	19	SP see drive C					

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW1
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 SHEETS of 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	SP: Poorly graded medium sand, trace fines, 10% coarse sand on bottom of drive, 1/16"-1/32" nominal, sub-angular sand, pretty clean, very moist, brown		C: 20-21 100% recovery		N: 17 38	Much resistance on drive sample Drill 20-25FT 10 15-1017 easy drilling, smooth, steady some resistance at 24FT
	22						
	23						
	24						
	25	SP: as above with occasional gravel and cobble. ~~fine~~ coarse sand as above dryer: ~~semi~~ damp, brown.		D: 25-26 80% recovery		N: 17 43	Drill 25-30FT 1038-1039 smooth drill action through run, sounds like occasional gravel or cobble some other material making it up flights now: coarse sand and clay versus gravel & cobbles
	26						
	27						
	28						
	29						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW01
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 5 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	SP: Poorly graded medium sand; very uniform and clean 1/32" nominal grain size sub rounded to sub angular occasional fine gravel (1%) nothing coarser encountered no fines; damp, brown		E: 30-31 90% recovery		N: 19 40	same difficulty driving sample Drill 30-35FT 1101-1107 Easy drilling Possible gravel, cobble at 35FT Guide bit came out clean, no clay, no water
	35	SP: poorly graded coarse sand, clean, medium to coarse sand with occasional gravel (rounded 1") sand is sub rounded to sub angular and much coarser than above		F: 35-36 60% recovery		N: 16 50/5"	Drill 35-40FT 1127-1128 smooth drilling as above bit is wet 1034 WL @ 37.55FT

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: FS-IA-MW1
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 6 OF 7 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	41	SP-~~SP~~: sand and gravel. Sand (60%) is primarily coarse, but all grain sizes are represented. Gravel is fine (1") nominal up to 2", ~~some~~ minute fines present, suspended in water; wet, brown.		G: 40-41 60% recovery		N: 28 50/4"	Drill 40-45FT 1159-1200 smooth drill action, no hang ups
	42						
	43						
	44						WL before sample 1204 @ 39.30FT Formation has heaved 3FT into stem will not exit with drill stem guide bit. Try sample (no recovery must replace bucket. Instead, use 2" spoon x 18" w/ 300 lb hammer 1410 WL @ 39.3FT Drill 45-50FT 1435-1436 easy drilling definitely some gravel.
	45	SP: poorly sorted medium to fine sand, gravel (5%), minute fines (2%), wet, brown, positive reaction to dilatancy test. Gravel is up to 2" size 1" smallest		H: 45~~46~~5		N: 14 missed missed	
	46			100% recovery			
	47						
	48						
	49						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW1

PROJECT: Ft Lewis Import Area

INSPECTOR: Matt Brookshier

SHEET 7 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	51	SP: sand as above wet, brown. From 46 to 51.5 FT there appears to be interbedded zones of sand with more fines than clean sand mixin with (<5%) gravel occasionally.		I: 50 to 51.5 80% recovery		N: 6 21 34	1504 WL at 37.9 FT Bottom of hole at 50 FT
	52						
	53						
	54						
	55						
	56						
	57						
	58						
	59						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW1
Completion date 18 DEC 98
Contractor Andrew Well Drilling
Rig Mobile B-61
Operator Matt Gilbert
Inspector Matt Brookshier
Depth 46.5 FT Datum ground surface

HOLE DATA
Size: 8 in. to 50 ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type .01" slot x 5 FT
Mfr. Board Longyear
Composition PVC Dia. 2"

Fittings:	Length	Dia.
Packer		
Riser	43 FT	2"
Tailpipe		

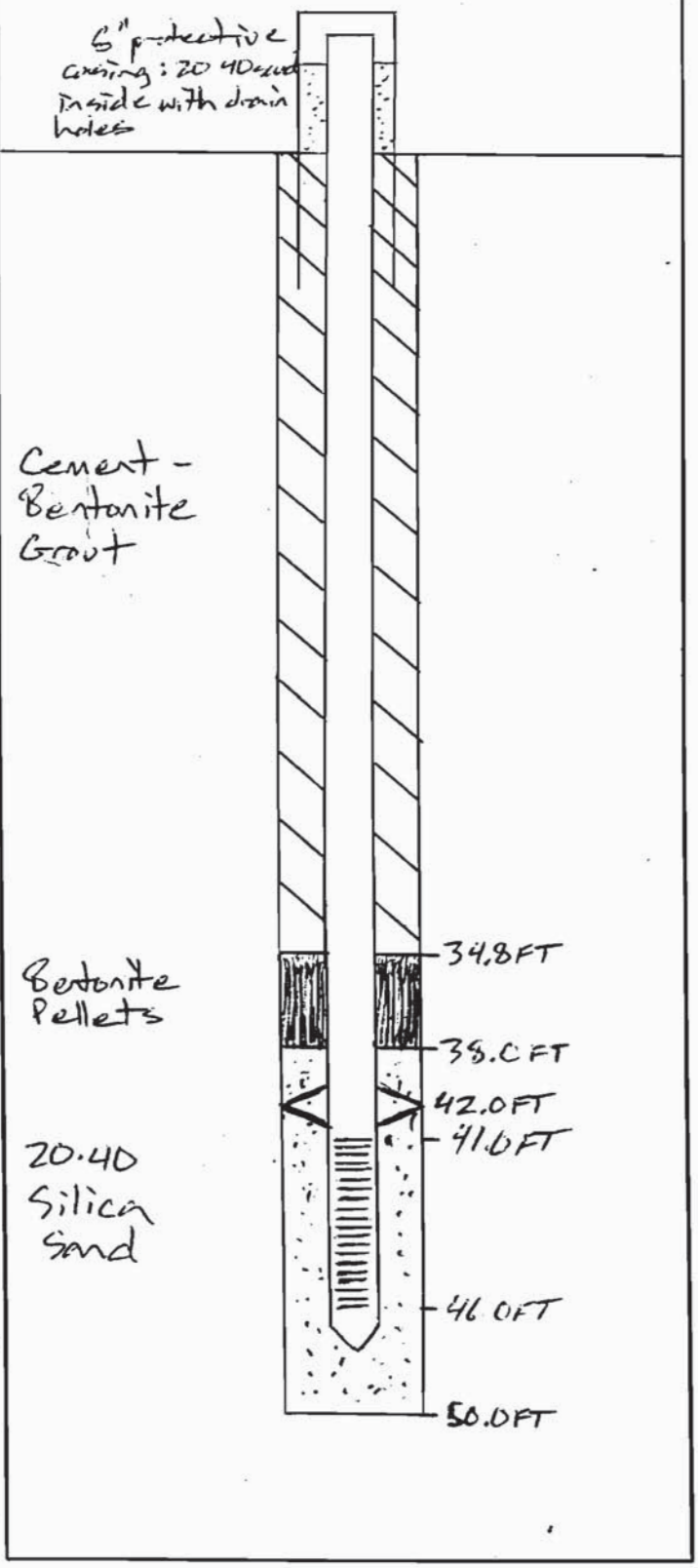
FILTER
Source CSSI
Composition silica sand
Gradation 20-40
Inst. method poured through HSA
Volume used ~2 cuft
Depth 50 to 38.0 ft.

GROUT
Composition Cement-bentonite (3%)
Volume used 17 ft³
Inst. method Tremie
Depth 34.8 to 0 ft.
____ to ____ ft.

REMARKS: Bentonite pellets used for plug (poured) hydrated with 15 gallons of water during mixing of grout (about 70 minutes). PVC was pulled up 1 FT after pellets were poured, drillers were able to tap back down to 46 FT.

WELL DETAIL (AS BUILT)

AEP-011



RESOURCE PROTECTION WELL REPORT

START CARD NO. R16885

PROJECT NAME: Installation of Water Monitoring Wells

WELL IDENTIFICATION NO. 98-IA-MW2/Tag #AEP 010

DRILLING METHOD: Auger

DRILLER: Craig S. DeYoung

FIRM: Andrew Well Drilling Services

SIGNATURE:

CONSULTING FIRM: US Army, Corps of Engineers

REPRESENTATIVE: Matt Brookshier

COUNTY: Pierce

LOCATION: SW 1/4 SE 1/4 Sec 22 Twn 18N R 1E

STREET ADDRESS OF WELL: Central Impact Area/Artillery Impact Area, Ft. Lewis, Washington

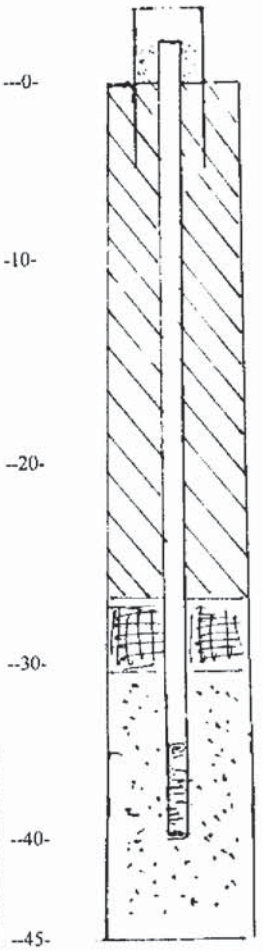
WATER LEVEL ELEVATION: 33ft

GROUND SURFACE ELEVATION: Unknown

INSTALLED: December 18, 1998

DEVELOPED: December 18, 1998

As-Built



Well Data

SIZE:	8" to 45.0ft
CASING:	2" Sch 80PVC
Ht above Surface:	3ft
Drive Shoe:	None
SCREEN:	
Type:	2"Sch 80 .010 Slotted PVC
Location:	40.0 to 35.0 ft
MFG:	Boart Longyear
FILTER:	
Composition:	Silica Sand 10/20 and 20/40
Installation:	Poured from surface in cased hole
Depth:	50.0 to 31.0 ft
GROUT:	
Composition:	Bentonite Pellets
Installation:	Poured from surface in cased hole
Depth:	31.0 to 27.0ft
Composition:	Bentonite/cement grout
Installation:	Tremie Pipe
Depth:	27.0 to surface

SURFACE COMPLETION: Vault Cover

FORMATION DESCRIPTION

0.0- 02.0	Gravel & silty gravel w/cobbles
02.0-13.0	Gravel & Sand w/occasional cobbles
13.0-26.0	Sand & Gravel w/cobbles
26.0-39.0	Medium clean sand
39.0-45.0	Medium Sand w/Clay

SCALE: 1" = 10ft

PAGE: 1 OF 1

HTRW DRILLING LOG

DISTRICT: CENWS		HOLE NUMBER: 98-IA-MW2
1 COMPANY NAME: USACE	2. DRILL SUBCONTRACTOR: Andrew Well Drilling Service	SHEET | SHEETS: of 6
3 PROJECT: Ft. Lewis Impact Area	4 LOCATION: Ft. Lewis, WA	
5 NAME OF DRILLER: Matt Gilbert	6 MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61	
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4" ID HSA; ~8" OD; 3" OD split spoon drive samples X 12" long; 300 lb hammer with 36" stroke	8 HOLE LOCATION: T18N; R1E; Sec. 22; NWSWNE	
	9 SURFACE ELEVATION: ~235 FT; 7.5' quad	
	10. DATE STARTED: 8 DEC 98	11 DATE COMPLETED: 10 DEC 98
12 OVERBURDEN THICKNESS: 45 FT	15 DEPTH GROUNDWATER ENCOUNTERED: 31.0 FT	
13 DEPTH DRILLED INTO ROCK: 0 FT	16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14 TOTAL DEPTH OF HOLE: 45 FT	17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
Drive Samples	8		

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
complete well		X		Matt Brookshier

LOCATION SKETCH/COMMENTS

SCALE:

PROJECT: Ft. Lewis Impact Area

HOLE NO: 98-IA-MW2

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: FB-IA-MW2
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 2 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	GW-GM: Well graded gravel with silt; some cobbles present up to 5", moist dark brown to black (silt). Some medium angular sand in silt. Root Zone		Open hole observation			Mobile B-61 drill turning 4"ID HSA. 0-5 FT drilled as test boring for UXO avoidance. Begin drilling MW2 8DEC98 1503
	2	GW: well graded gravel with sub angular sand (medium to coarse) few fines. Gravel is well rounded, mostly volcanic origin; few granitic pebbles. Grey to olive-brown, damp.					
	3						
	4						
	5						
	6	GW: Well graded gravel, rounded, ½"-2", with coarse sand, angular-subangular, 25%, trace silt. Dark grey to olive brown, moist.		Grab			Drill 5-10 FT 1505-1507 Rig bucking from time to time a few cobbles coming up auger
	7						
	8	Cobbles present, up to 5" size coming up auger flights					
	9						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW2
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 3 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	GW: Well graded coarse gravel with medium sand coating. Gravel from 1"-3", rounded Sand (~15%) 1/16"-1/8" subangular minor silt present, no cobbles noted from cuttings. dark grey, Moist.		Grab			Drill 10-15FT 1513-1514 Very easy drilling, no bucking observed No cobbles up auger flights, coarse gravel
	12						
	13	Finer gravel and coarser sand probably not making it up augers					
	14						
	15	SP: Poorly graded medium sand, sub angular, with fine gravel, 3/4" nominal 3/8-1 1/4" (20%), trace of fines < 1%. Brown-grey, damp. No cobbles, gravel is sub rounded		A: 15-16 80% recovery		N= 24 50	Drill 15-20FT 1537-1539 Smooth drilling through 18FT Cobbles? through 20FT rig working harder
	16						
	17						
	18						
	19						Guide bit has moist sand and clay stuck to it

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW2
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 SHEETS of 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	SP: Poorly graded, coarse to medium sand with gravel ($\frac{1}{2}$"-1") and clay, gravel and sand roundness as before, olive grey to brown; very moist,		B: 20-21 85% recovery		N= 16 31	Drill 20-25FT 1557-1559 Rough drilling as 18-20FT was through 25FT no bucking, but markedly harder drilling than 13-15FT.
	22	One broken up large gravel or cobble in sample					
	23						
	24						
	25						
	26	GP-SF: Poorly graded gravel and sand with clay. Gravel from ¼" to 2" mostly some broken cobbles in span. Sand is medium $\frac{1}{2}$-$\frac{1}{3}$" rounded 35-40%, clay ~5-7% MATERIAL CHANGE		C: 25-26 65% recovery		N= 17 32	Drill 25-30FT 1622-1624 Attempt water level; none
	27	Gravel is more sub-rounded in this sample sand as before, dark brown to olive grey,					Same sand w/ no clay present mostly material change at 26FT? dryer at bottom of sample
	28	wet to moist.					Harder drilling at 27FT rig bucking same
		Material change at 26FT					
	29	see drive D description					

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW2
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 5 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
		SP: Poorly graded medium sand, subangular, 10 fines, <5% fine gravel.		D: 30-31		N= 31	Quit for day 1645
				100% recovery		40	Drill 30-35FT 9DEC98
	31	dark brown, damp, very clean sand, compact					739 - 741
	32						Very smooth drilling
	33						Guide Bit is wet
	34						
	35	SP: Clean poorly graded sand as above,		F: 35-36		N= 9	747: WL @ 31.0FT 805 After drive F
		± ¼" nominal grain size				44	WL @ 31.75FT
	36	dark brown, wet,		100% Rec.			811 WL @ 31.52FT
	37						Drill 35-40 813 - 814 Guide bit is dripping
	38						Smooth drilling as above, possible cobble here and there driller agrees - material heaved redrill 37-40FT with drill rod and guide bit
	39						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: ~~FT~~ 18-IA-MW2
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 6 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (g)	GEOTECH SAMPLE OR CORE BOX NO (h)	ANALYTICAL SAMPLE NO (i)	BLOW COUNT (j)	REMARKS (k)
	41	~~Poor~~ SP: Poorly graded medium sand with minute gravel <5% and trace clay, grey brown wet. much of sample is loose, clay and gravel may be more abundant than appears.		G: 40-41 60% recovery		N= 5 25	930 WL @ 34.75FT after redrilling Material heaved abt. 3FT into stem ~~940 WL @~~ after drive sample Drill 40-45FT 957-1001 A little harder drilling than before Maybe gravelly again Guide bit is very wet
	45	SP: Poorly graded sand as above, much denser, slightly more clay and fine gravel. Cobbles present occasionally wet, ~~dark~~ brown to grey.		H: 45-46 90% recovery		N= 5 16	Driller reports about 5FT material in auger stem Water Level after sample drive 1020 WL @ 41.15 Bottom of Boring at 45FT
	49						

PROJECT
HOLE NO.

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW2
Completion date 9DEC98
Contractor Andrew Well Drilling
Rig Mobile B-61 w/ 4"ID HSA
Operator Matt Gilbert
Inspector Matt Brookshier
Depth 45FT Datum Ground Surface at ~235FT

HOLE DATA
Size: 8"OD in. to 45FT ft.
_____ in. to _____ ft.
_____ in. to _____ ft.

CASING
Type _____
Mfr. _____
Ht. above gnd. surf. _____
Drive shoe _____
Size: _____ in. to _____ ft.
_____ in. to _____ ft.
_____ in. to _____ ft.

SCREEN
Type .01" slot x 5FT
Mfr. Beart Longyear
Composition PVC Dia. 2"

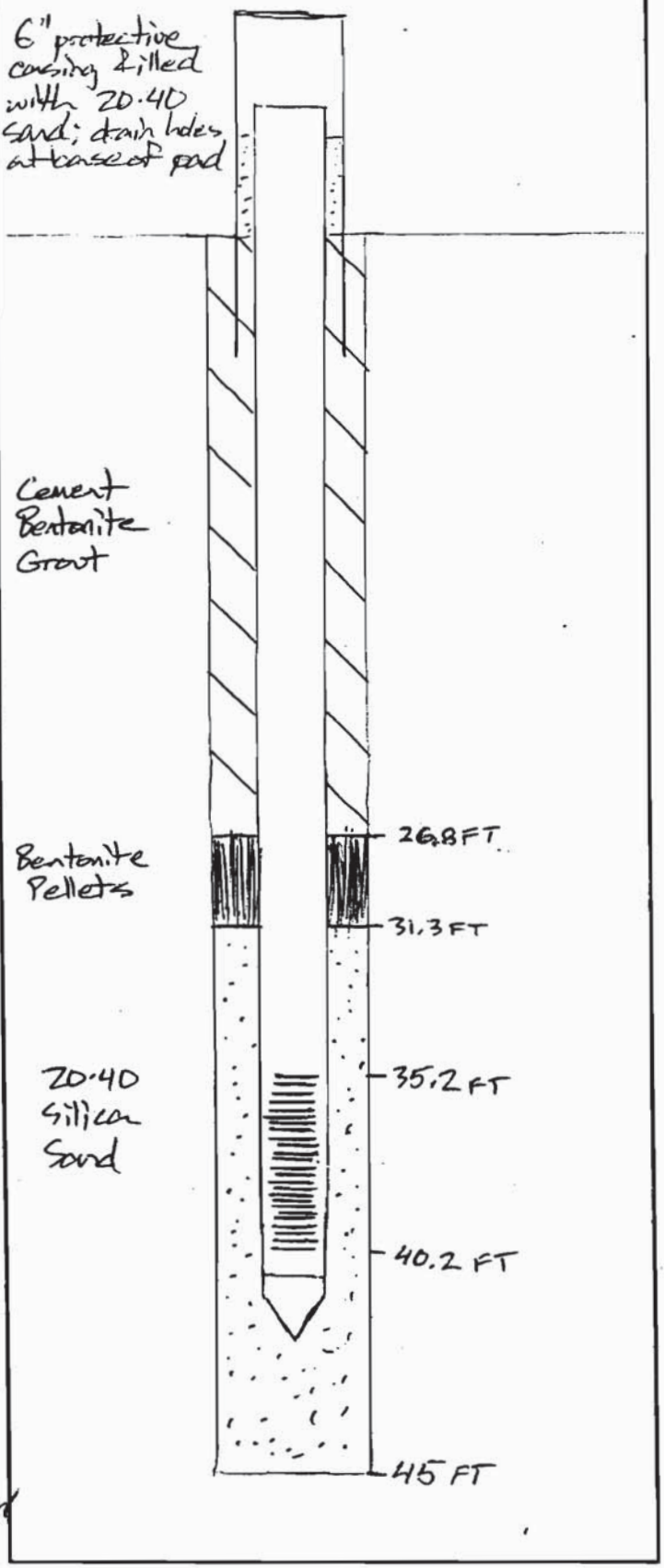
Fittings:	Length	Dia.
Packer		
Riser (PVC)	37FT	2"
Tailpipe		

FILTER
Source CSSI
Composition silica sand
Gradation 20 40
Inst. method Poured down auger stem
Volume used ~2 cubic feet
Depth 45FT to 31.3FT ft.

GROUT
Composition Cement - Bentonite
Volume used ~41 cubic feet
Inst. method Tremie pipe x 1" dia.
Depth 26.8FT to 0FT ft.
_____ to _____ ft.

REMARKS: Drilled until dense material was encountered to ensure water was not perched. Bentonite pellets poured high, formation must have caved sand while pouring pellets; Hole took a lot of grout; sides of boring were probably reamed due to cobbles encountered while drilling.

WELL DETAIL (AS BUILT)



HTRW DRILLING LOG

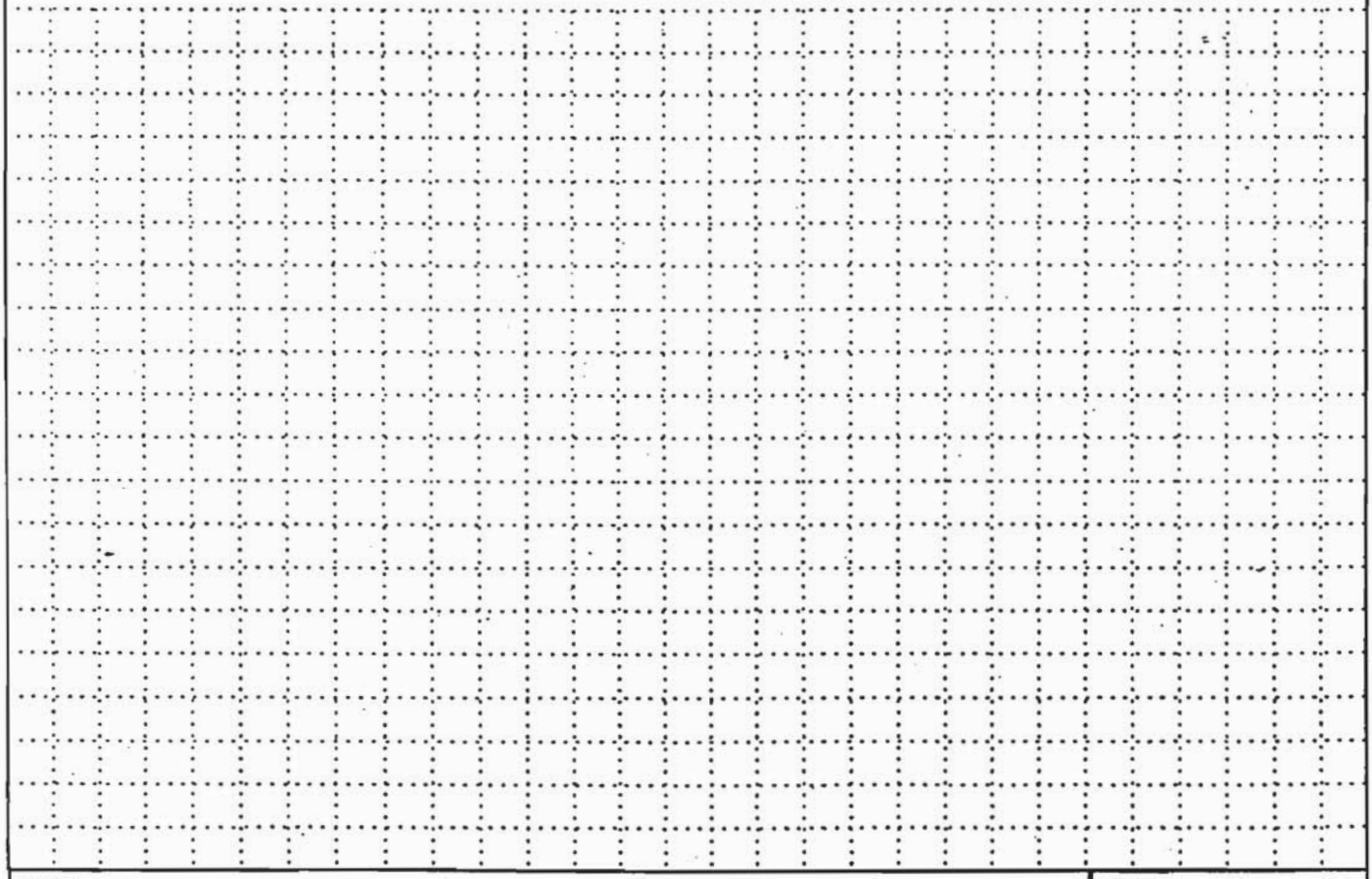
1. COMPANY NAME: USACE	DISTRICT: CENWS	HOLE NUMBER: 98-IA-MW3
2. DRILLING SUBCONTRACTOR: Andrew Well Drilling		SHEET 1 OF 10 SHEETS
3. PROJECT: Ft. Lewis Impact Area	4. LOCATION: Ft. Lewis, WA	
5. NAME OF DRILLER: Matt Gilbert	6. MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61 & Ingersol Rand T-4	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Drilled from 0-60 FT with 4" ID HSA and encountered no water. Continued boring with air rotary using 6" casing driven by down hole casing hammer boring with an eccentric under reamer bit.	8. HOLE LOCATION: T18N, R1E, Sec. 27, SWNWNE	
	9. SURFACE ELEVATION: ~235 FT based on 7.5' Quadrangle	
	10. DATE STARTED: 7DEC98	11. DATE COMPLETED: 12 FEB99
12. OVERBURDEN THICKNESS: 89 FT	15. DEPTH GROUNDWATER ENCOUNTERED: 66 FT	
13. DEPTH DRILLED INTO ROCK: 0 FT	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14. TOTAL DEPTH OF HOLE: 89 FT	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
Drive Samples	10		

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Well Completion		X		Matt Brookshier

LOCATION SKETCH/COMMENTS SCALE:



PROJECT	HOLE NO.
Ft Lewis Impact Area	98-IA-MW3

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW3
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 2 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	GW-GM: Well graded gravel with silt, Cobbles to 6" and coarse sand present less than 5%, mostly volcanic origin, well rounded gravels, few granitic present. black to dark brown (from silt), moist		Visual Inspection Open Hole			Mobile B-61 turning 4" ID Hollow stem Augers Begin drilling 7DEC98@747 First 5FT of boring was drilled for UXO avoidance
	2						
	3						
	4	GW as above with less silt and more fine sand (stuck to gravels. Sand is markedly more angular than gravels, grey, moist					
	5						Drill 5-10FT 752-754
	6	GP: poorly graded gravel, smaller gravel sizes missing, coarse well rounded 2"-3" with medium to fine sand coating grey-olive brown, moist.		Cook from auger flights			Fairly smooth drilling, gravelly no cobbles
	7						
	8						
	9						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW3
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET: 3 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	GW: well graded gravel, some cobbles and medium subangular sand stuck on gravels, grey, moist, Gravel is well rounded sand is medium, but coarser sand may be present, but not coming up augers (based on outcrop on bluffs)		Grab			10-15 FT Drill: 802-810 slower drilling not too rough, Driller suspects fairly large cobbles: none coming up augers
	12						
	13						
	14						
	15	GW: well graded gravel with abundant cobbles. Only smaller fraction coming up auger flights, gravel as above, grey, moist		Grab			Drill 15-20 FT 0825-829 Rough drilling at 15 FT auger is straying from vertical around a boulder? Steam coming up from boring
	16						
	17	Very cobbley 15-20 FT					
	18						
	19						Change in drill action, much smoother driller reports

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

EM 1110-1-4000
31 Aug 94

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW3

PROJECT: Ft. Lewis Impact Area | INSPECTOR: Matt Brookshier | SHEET 4 of SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	GP: Poorly graded gravel, 1-1½" nominal, fine to medium sand adhering to surface of rounded gravel, sand is more angular dark brown to grey, moist.		Grab from augers flights			Drill 20-25FT 840-843 much easier drilling, no bucking.
	22						
	23						
	24						3" OD x 12" split-spoon driven by 300lb hammer with 36" stroke.
	25	GP: poorly graded fine gravel ¼-½" nominal, some gravel to 1½", less rounded than previous to sub-angular, sand present, about 5%, angular, few fines, trace clay, brown to yellow brown, moist.	A: 5% recovery N=100/3"	B: 80% recovery			Drive A was collected from original boring. Refusal was encountered at 29FT and boring was abandoned. Another boring was advanced adjacent to the first and Drive B was taken.
	26				A cobble was stuck in the end of the HSA cutting head.		
	27						
	28						Drill 25-30FT 1123-1125 smooth drill action
	29						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-FA-MW3
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 5 OF 7 SHEETS

ELEV (a)	DEPTH (ft)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	SP: Poorly graded coarse sand, some gravel to 1¼" and less clay than above moist, grey to brown less finer sand than above as well		C 30% recovery		N= 16 50	Probably pushed a cobble down while driving Attempted WL: none Drill 30-35FT 1150 to 1153 fairly smooth drill action
	32						
	33						
	34						
	35	SP: Poorly graded sand with cobbles and some gravels, sand is subangular to angular and finer than above, medium, grey, moist to dry		D 30% recovery		N= 24 38	Broken cobble in spoon Attempted WL driller reports cobbles from 32-35 FT Drill 35-40 FT 1225 to 1235 Drilling is rougher than before, much trouble at 38FT Pulled back augers and rammed with guide bit. made it through
	36						
	37						
	38						
	39						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW3
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 6 OF 7 SHEETS

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO (E)	ANALYTICAL SAMPLE NO (F)	BLOW COUNT (G)	REMARKS (H)
	41	SP-GP: Poorly graded medium clean sand with gravel at 1" nominal. Sand is more rounded than previous: subrounded		E 100% recovery		N= 36 50	1305: WL none. Drill 40-45. 1325-1327.
	42	no fines (<1%) dark brown, moist. Gravel is rounded to subrounded					very smooth drilling no wet material has come up augers through 45 FT
	43						
	44						
	45						
		SP as above, less gravel than before, moist		F 100% recovery		N= 55 55/4"	No free water. Drill 45 to 50 FT. 1403 to 1405. Bit is dry. Drilling was smooth, a few cobbles encountered
	46						
	47						
	48						
	49						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW3
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 7 SHEETS OF 10

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	51	SP: Poorly graded medium sand, more gravel than above, sand is subrounded gravel is well rounded cobbles are present in this zone, very clean, brown-grey, moist.		G 50-51 60% recovery		N: 82 50/2"	Cobble stuck in nose of spoon, Sound for water, none Drill 50-55FT 1426-1546
	52						
	53						Smooth drilling some cobbles much harder drilling at 53-55.
	54						
	55	SP: as above, medium sand with some gravel, no fines, cobbles probably present as indicated by drill action		H 100% recovery		N = 100/6"	Check for WL, none: moist sand stuck in sounder Drill 55-60FT 1527-1530
	56						
	57						rig bucking some
	58						1540: sound hole, moist sand in stinger again no water,
	59						Boring was abandoned at 60FT depth Advancement of boring will be air rotary

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW3
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Broderick
SHEET 8 OF 10 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	61	SP: medium to fine subangular sand, occasional gravel stringers through 64FT rounded, up to 1¼", elongated, damp, brown to yellow brown		samples collected on cuttings returned through cyclone			Continuation of MW3 boring past 60FT with Ingersol 2and T-4 air rotary rig driving 6" casing using an eccentric under reamer bit hammering on shoe, 0-59FT drilled 9 and 10-FEB99 using 20FT casing 11FEB99 825:
	62						begin 59-79FT run Good cuttings from 60-64 FT, driller suspects denser formation
	63						
	64						832 Cuttings return is clogged, all material is blowing out around casing adapter
	65	SP: as above with little or no gravel some ½" clay pods returning at about 69 FT through 70 FT					
	66						
	67						
	68						very few cuttings returning, now very difficult to estimate what zone cuttings are from
	69						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW3
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 9 OF 10 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	71	SP as before, occasional gravels and very thin zones with up to 5% fines damp, brown.		samples basaltic material blowing out of casing top			Cuttings return is only occasional now; come in large slugs.
	72						
	73						
	74						855 Casing adapter blew off again but still very few cuttings returning
	75						
	76	SP: sand (medium to fine) as above with occasional silt up to 10%, moist, brown					900 Tubing cleared? much discharge big slugs of material moving thru. Impossible to tell what some cuttings are from
	77						
	78	fine gravel at 78 FT grading up to 1¼" at end of run.					909 end run
	79	some fine sand in spoon, brown, saturated		I no recovery			Unsit presence of drive sample 950 water blown from case as bit is reinserted.

PROJECT | HOLE NO.

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER 98-IA-MW3
PROJECT Ft. Lewis Impact Area
INSPECTOR Matt Brockshier
SHEET 10 SHEETS OF 10

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	81	SP: Medium to fine sand, wet, brown, reacts positively to dilatency test,		Samples based on cuttings blowing out of casing top.			1141 ready for 79-84 FT run WL @ 66.0 FT Test water zone by blowing all water out then monitor recharge back to 66FT in 15 minutes Drill 79-84 FT 1402 - 1414 All material is blowing out of casing top again, a lot of broken gravel. Fine sand at end of run.
	82	Stringers of gravel from 82-84 FT					
	83						
	84	Inspector not present to observe drilling from 84-89 FT					1425 WL @ 70.35 FT Have to leave for DPW yard job. Drill from 84-89' to explore for till noted at near by outcrop
	85						
	86						
	87						1530 Drillers reports change of material at 87FT
		GC: Clayey fine gravel with sand, damp, brown orange.		Sample based on material stuck in casing adapter			
	88	sample is very ground up but very compact material in formation is very dense.					Drillers are trying to use a down hole air hammer (casing hammer) to drive sample not working, no drop hammer present on site,
	89	Bottom of boring at 89 FT		J no recovery sleeve			

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW3
Completion date 12 FEB 99
Contractor Andrew Well drilling
Rig Ingersol Rand T-4
Operator Matt Gilbert
Inspector Matt Brookshier
Depth 78 FT Datum ground surface

HOLE DATA
Size: 6" in. to 89' ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type .01" slot prepack w/ 20-40 sand
Mfr. Boart Longyear
Composition PVC Dia. 2"ID/4"OD

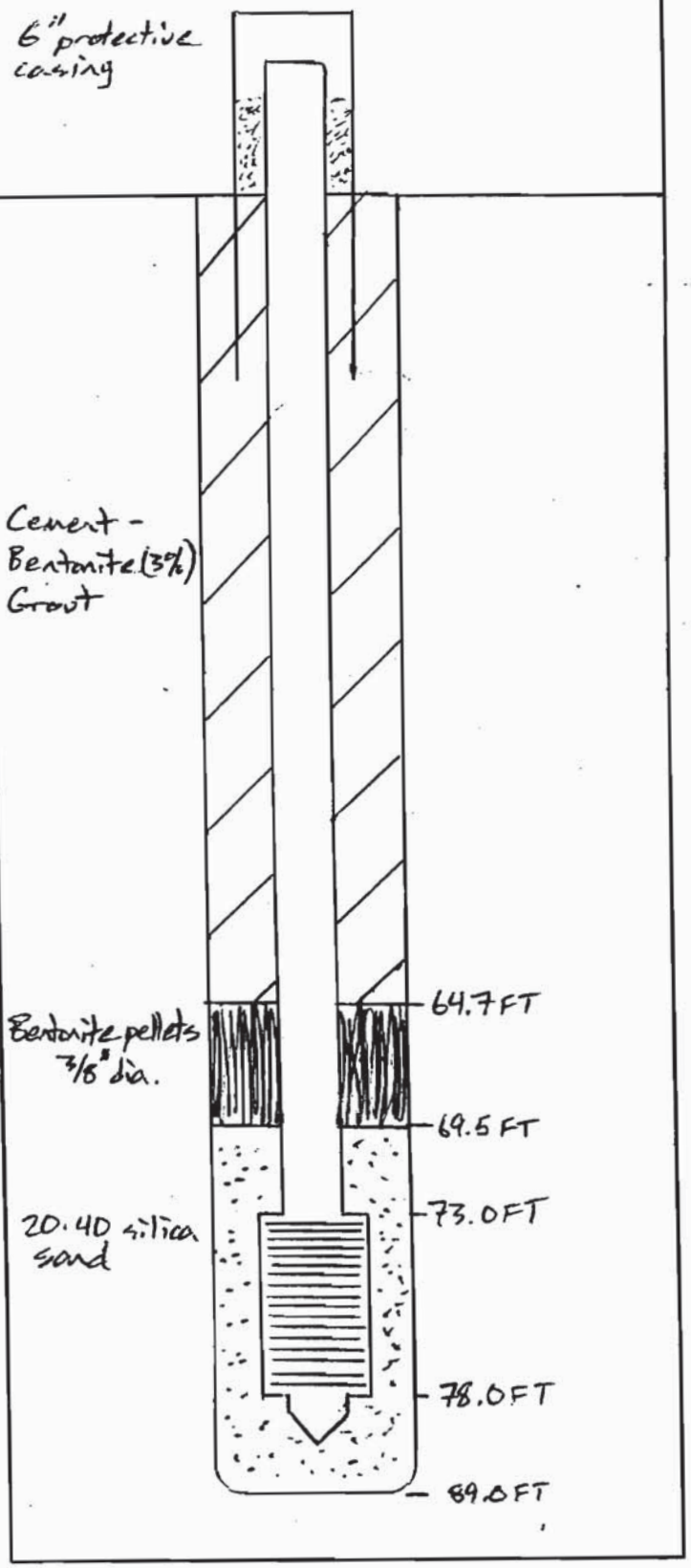
Fittings:	Length	Dia.
Packer		
Riser		
Tailpipe		

FILTER
Source CSSI
Composition silica sand
Gradation 20-40
Inst. method Poured through casing
Volume used 4 cuft (some used for backfill)
Depth 83 to 69.5 ft.

GROUT
Composition Cement/Bentonite (3%)
Volume used 31 cuft
Inst. method Tremied
Depth 64.7 to 0 ft.
____ to ____ ft.

REMARKS: Hole backfilled from 83-78 FT with 20-40 silica sand, 3 pails bentonite pellets used for plug; hydrated for ~3 hours.

WELL DETAIL (AS BUILT)



HTRW DRILLING LOG

DISTRICT: CENWS		HOLE NUMBER: 98-IA-MW4
1 COMPANY NAME: USACE	2. DRILL SUBCONTRACTOR: Andrew Well Drilling	SHEET 1 OF SHEETS 13
3 PROJECT: Ft. Lewis Impact Area	4 LOCATION: Ft. Lewis, WA	
5 NAME OF DRILLER: Matt Gilbert	6 MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61 & Ingersol Rand T-4	
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Drilled from 0-65 FT with 4" ID HSA, guide bit was locked inside auger at 65FT. Boring was completed using 6" casing air rotary eccentric under reamer bit and down hole casing hammer	8 HOLE LOCATION: T18N, R1E, Sec. 26, SWNWSW	
	9 SURFACE ELEVATION: ~240FT from 7.5' Quadrangle	
	10. DATE STARTED: 5 DEC 98	11 DATE COMPLETED: 17 MAY 99
12 OVERBURDEN THICKNESS: 110 FT	15 DEPTH GROUNDWATER ENCOUNTERED: 54.9 FT	
13 DEPTH DRILLED INTO ROCK: 0 FT	16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14 TOTAL DEPTH OF HOLE: 110 FT	17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
Drive Samples	11		

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY %

22 DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
well completion		X		Matt Brookshier

LOCATION SKETCH/COMMENTS — SCALE:

PROJECT: FT. Lewis Impact Area — HOLE NO: 98-IA-MW4

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: ~~98-MIA-MW4~~

PROJECT: Ft. Lewis Impact Area | INSPECTOR: Matt Brookshier | SHEET 2 SHEETS OF 8

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO (E)	ANALYTICAL SAMPLE NO (F)	BLOW COUNT (G)	REMARKS (H)
	1	GW-GM: Well graded gravel with silt. Some coarse sand and cobbles up to 5". Material is mostly volcanic origin with occasional granitic gravel. Appears mostly dark brown to black due to silt content, moist through root zone		Open Hole Observation			Mobile B-61 turning 4" ID HSA. HSA is ~8" OD. Begin drilling MW4 5DEC96 at 1507
	2						First 5 FT was test boring for UXO avoidance
	3						
	4						
	5	GW: Well graded gravels with <5% fine sand and silt. No cobbles coming up flights, grey to brown olive, moist. Gravel is well rounded, sand is more ~~angular~~ sub angular, sharp		Grab			Drill 5-10 FT 1313-1315
	6						Drilling is somewhat rough but progress is good, ~~dust~~ steam coming from HSA
	7						Driller reports that formation is cobbley
	8						
	9						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW4
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 3 SHEETS OF 8

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	GP: Coarse gravel and cobbles, few fines coming up flights. A fine coating of moist sub-angular medium sand on gravels and cobbles. ~~moist~~ grey, damp		Grab from augers flights			Drill 10-15 FT 1522-1534 Drill action is rough, obstruction at 13 FT, steam coming up stem Driller reports that obstruction must be larger than 1 FT; unless it past 3" OD x 12" split spoon sampler driven by 300lb hammer with 36" stroke Trouble getting augers to mate
	12						
	13	Very cobbley (boulder?) zone begins at about 11 FT.					
	14						
	15	GP: Poorly graded gravel 1"-2" and ¼" nominal, many cobbles and medium to coarse sand damp, grey		A: 15-16 60% recovery		N= 55 50/3"	Drill 15-20 FT 1551 - refusal at 15 FT; bit is destroyed, all cutting teeth gone 10DEC98, 1150
	16						
	17						try drilling 5-15 FT in farthest hole south - refusal at 11.5 FT, Try middle hole, drill 5-10 FT: 1243-1245 10-15 FT: 1250-1254 Very rough drilling auger stem pinging a few times, cutting teeth breaking? Very cobbley
	18	SP: see drive B					
	19						Drill 15-20 FT 1332 - rough drilling through 18 FT, smooth action to 20 FT

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-ALW4
SHEET 4 SHEETS OF 8

PROJECT: Ft. Lewis Monitor Well
INSPECTOR: Matt Brookshire

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	SP: Poorly graded medium sand with ~7% rounded gravel 1" nominal. Sand is sub rounded to ~~sub~~angular 1/32" nominal, ~~moist~~ damp, brown grey Occasional Cobble		B: 20-21 80% recovery		N= 21 35	Drill 20-25 FT 1352 to 1354 Easy drilling, gravel/cobble throughout, but sporadic
	22						
	23						
	24						
	25	GP~~SP~~ Poorly graded sandy gravel. 1-2" and 1/4" predominant, all rounded to sub-rounded. Sand, (30%) is coarse to medium, much less round than gravel. Trace clay present (1-2%) moist, brown. Part of a broken cobble in sample 5-6"?		C: 26-30 40% recovery		N= 30 50/5"	Drill 25-30 FT 1416 - Moderate drill action through 29 FT, gravels or cobbles present easier drilling 29-30 FT
	26						
	27						
	28						
	29						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW4
PROJECT: Ft. Lewis #1 Impact Area
INSPECTOR: Matt Brookshier
SHEET 5 SHEETS OF 8

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	GP as above, a little more fine gravel fraction, slightly (trace) more clay, moist brown, some larger broken gravel in sample		D: 30-31 60% recovery		N= 4 50	Drill 30-35FT 1444 to 1445 Fairly smooth drilling, encounter a cobble here and there for length of run. Good amount of clay coated gravel and cobbles coming up auger flights
	32						
	33						
	34						
	35	GP as above		E: 35-36 75% recovery		N= 17 34	Drill 35-40FT 1505-1506 Very smooth drill action, no sign of cobbles
	36	SP: Poorly graded sand medium, fairly dense, mostly sub angular, 1/32" nominal grain size, clean, damp, brown, No gravel mixed in sand					
	37						
	38						
	39						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW4

PROJECT: Ft. Lewis Impact Area

INSPECTOR: Matt Brookshier

SHEET 6 OF 8 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	41	SP: Poorly graded medium sand as above but with few gravels 1-3" (~5%) well rounded, damp brown		F: 40-41 100% recovery		N= 27 43	Drill 40-45FT 1536-1537 Possible cobbles at 42FT; smooth drilling otherwise Guide bit dry
	42						
	43						
	44						
	45	SP as above but with clay lense, 3/4" thick at 45.5FT. No gravel, damp, brown denser than above		G: 45-46 100% recovery		N= 15 52	Drill 45-60FT 1600- smooth drilling cobble at 47FT and 49FT, very smooth through run all together Guide bit is dry
	46						
	47						
	48						
	49						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW4
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 7 SHEETS of 8

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	51	SP-SC: Poorly graded ~~clayey~~ sand with clay and few gravels, Compact, medium sand as before, moist, brown		H: 50-51 70% recovery		N= 14 28	~~Drill 50-55FT~~ 1630 endshift Instruct driller to pull auger up to 48FT, Maybe on top of till? 11DEC98: Drill 50-52.5FT 836-837; medium sand coming up auger some resistance at 52FT Does not look like till from ostrop
	52						
	53	SP/GP: sand and gravel with <5% clay, hard moist brown.		I: 52.5-53 100% recovery		N= 90/6"	Drill 52.5-55FT 907-908 Smooth drilling
	54						
	55	GP/SP: gravel (fine) and sand (medium) with <5% clay. Some coarser gravel present rounded. fine gravel is sub-rounded sand is sub-angular, wet brown		J: 55-56 70% recovery		N= 47 60/4"	After sample 935. WL @ 54.9FT
	56						
	57						Drill 55-60FT 946-946 Smooth drilling slower at 58.5FT
	58	Top of till? dense, no till: compact lense?					
	59						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IAMW4
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 OF 13

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	61	SP: Coarse sand with 10% gravel to 1" clay up to about 5%, very dense, moist, brown		K: 60-61 100% recovery		N=A 50	1013: WL@ 57.5FT 1035 WL@ 57.5FT Some heave in K drill 60-65FT 1045-1048 drill action is smooth
	62						
	63						
	64						
	65	Bottom of boring at 65FT		Attempted sample: all heave			Driller says that sample was taken inside auger stem (1.5FT of heave) Instruct to redo with drill rod: pull up & redrill back down for sample. Heaved again and guide bit locked inside HSA. Have to abandon hole.
	66						
	67	12 DECAB, 920: cutting head and guide bit finally out of hole. Guide bit is locked inside auger					Hole will have to be advanced by air rotary.
	68	by clay, silt & fine sand with coarser material on top. Likely encountered					16MAY99
	69	overcompacted material at 62-63FT. This material, mixed with water, heaved into HSA locking up bit and preventing completion of well.					0-65 FT drilled by air rotary 911-1625

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

EM 1110-1-4000
31 Aug 94

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW 4
PROJECT: I A GW Investigation
INSPECTOR: Richard Smith
SHEET 2 OF 13 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	60						
	61						61'@15:27 16:00 water level @ 53' and rising 5 minutes after clearing the casing of sand w/air + water. restart @ 16:17 some water blew out @ startup making water 65'@16:20
	62	SP: Fine to coarse rounded sand with gravel (35%), minor brown silt, wet. Gravel is fine to coarse (1") and sub-rounded to rounded					
	63						
	64						
	65	cutting s very silty					
	66						
	67	GP: Fine to coarse rounded gravel, volcanics, with 25% fine brown sand and 5-10% brown silt, wet					Formation is making water
	68						
	69						
	70						70'@16:25

61' = 5' on mast

PROJECT: I A GW Investigation
HOLE NO.: MW 4

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

EM 1110-1-4000
31 Aug 94

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW 4
PROJECT: IA GW Investigation
INSPECTOR: Richard Smith
SHEET 2 OF 13 SHEETS

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO (E)	ANALYTICAL SAMPLE NO (F)	BLOW COUNT (G)	REMARKS (H)
	70						
	71						
	72	color change to orange lots of orange silt/clay very fine sand runny.					The color of this unit matches exactly a unit observed downslope a bit 60' below top of cliff. lost formation water. Driller adding water
	73						
	74	color change to brown w/ hint of orange but cuttings still fine sand w/ silt/clay (40%) sand is brown.					
	75						75' @ 16:28
	76						
	77						
	78	color change to tan with some gravel with fine sand (50%) and silt/clay (30%)					
	79						
	80						80' @ 16:33

PROJECT: IA GW Investigation
HOLE NO.: MW 4

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW-4
PROJECT: IA GW Investigation
INSPECTOR: Richard Smith
SHEET: 10-11 OF SHEETS: 13

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	80	GP: Coarse gravel, mixed volcanics (black, gray, green and red) with some fine to coarse sand (20%) and trace silt/clay, brown.					816@1635 stopped for the day 17MAY99
	81						
	82	GP: gravel with sand and clay, light brown to oxidation color, moist (adding water)					855 begin drilling, adding water Check WL @ 825: none
	83						
	84	SM, silty sand with occasional gravel much wetter light brown to grey		Descriptions based on cuttings return			900 @ 85 Ft
	85						
	86	All sand is angular to sub angular dark grey to grey volcanic					
	87						
	88						
	89						
	90						

PROJECT: IA GW Investigation
HOLE NO. MW-4

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW-4

PROJECT: Ft. Lewis Impact Area

INSPECTOR: Matt Brookstrier

SHEET 12 OF 13 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	90	SP-SM - fine to					st. #1 adding
		medium sand with					water
	91	silt 5-10% sand					91 FT 90#
		is dark grey					
		finer material is					
	92	light grey, appears					
		to be moist to wet					
		occaisonal gravel					
	93	to 1"					
		10-15% gravel at					
		93 FT appears to					
		be all volcanic					
	94						
							915 at 95FT
		SP-SM: fine to					
		medium sand as					st. #1 adding
	95	above w/ 10-15%					water
		gravel and a like					
		amount silt.					
	96	tan to light grey					
		wet to moist					
		all gravel is abat					
	97	1" nominal, subrounded					
	98	increasing gravel					
		20-30%?					
		some matrix					
	99	Large volume of water					End run at
		return at 99 FT					100 FT 925
							Sand hole, no
	100						water pull up
							case 3 FT water

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW-4
PROJECT: Ft Lewis Impact Area
INSPECTOR: Matt Broadsheir
SHEET 13 SHEETS OF 13

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	100	SP Gravelly sand (medium to fine) with silt. Gravel is 1" & larger nominal subrounded, sand is subangular, dk grey, silt is lighter grey to tan. tan-olive overall appearance, damp to moist					Pulled up case @ 940 to 96FT to check WL, none drilled back to 100FT no water return Begin 100-110 run 1015 not adding any water
	101						
	102						
	103						
	104	less gravel & coarser sand at 104					
	105	SP as above: gravelly (20-30% sand (fine to coarse) with some silt (less than above (5%) brown, ~~moist~~ damp.					
	106						
	107						
	108						End run @ 1028 no water level attempted, dry formation Bottom of boring at 110 FT
	109						
	110	Bottom of hole 110 FT					

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW4
Completion date 18 MAY 99
Contractor Andrew Well Drilling
Rig Ingersol Rand T-4
Operator Matt Gilbert
Inspector Matt Brookshire
Depth 62.55 Datum BGS

HOLE DATA
Size: 6" in. to 110 ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type .01 slot prepack
Mfr. Grant Lonyear
Composition PVC Dia. 2" (4" OD)

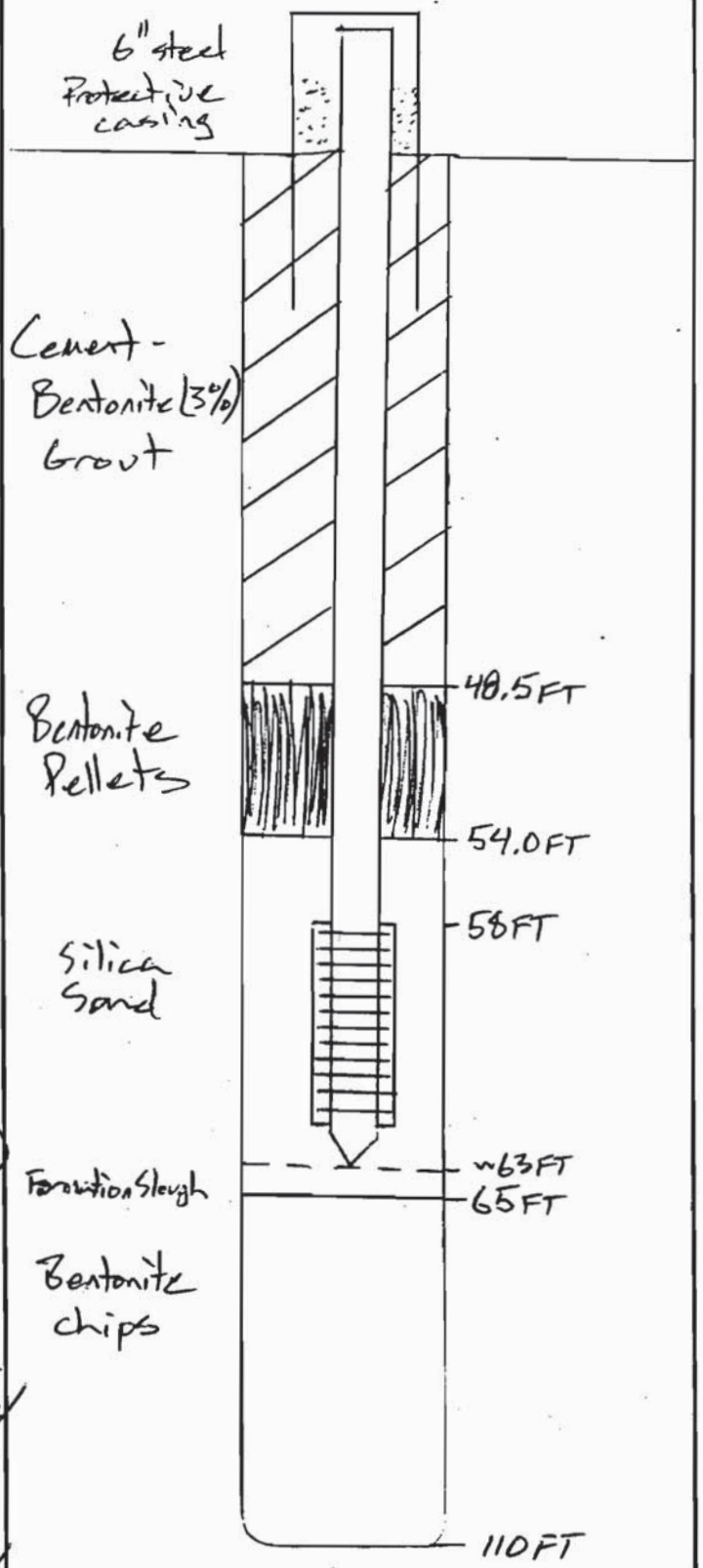
Fittings:	Length	Dia.
Packer		
Riser		
Tailpipe		

FILTER
Source CSSI
Composition silica
Gradation 20-40
Inst. method Poured
Volume used 5 cf
Depth 63 to 54 ft.

GROUT
Composition Cement-Bentonite (3%)
Volume used 20 cf
Inst. method tremied
Depth 48.5 to 0 ft.
____ to ____ ft.

REMARKS: Bored through over compacted zone at ~73FT to investigate deeper natural properties. No other water bearing zones encountered. Backfilled boring to ~65FT with 18 bags Pure Gold medium chips. Formation heaved 2FT into casing; well constructed on top of heave material.

WELL DETAIL (AS BUILT)



HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW5
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Richard Smith
SHEET 2 OF 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	50	CL as above					
	51						
	52	SP-SC: Coarse sand with 10% gray clay balls, sand is clean and all dark gray/green subangular to subrounded All volcanics					Easier + faster drilling again @ 52'
	53						
	54	GP: Coarse and fine gravel (to 2") with sand (15%) and minor silt and clay coating gravel (<5%). Silt/clay is brown. Gravel and sand primarily volcanic origin					54' discharge water turning brown again
	55						55' @ 11:03
	56						
	57	GP-GC: Coarse and fine gravel, sub-rounded coated with sticky brown clay (10-15%) and coarse sand (25%), brown					
	58	GP: Fine to coarse sub-rounded gravel (to 1 1/2") with 30% fine brown sand, and <5% brown silt/clay. Gravels primarily black, gray to green volcanics.					stopped to add more casing.
	59						
	60						60' @ 11:13

PROJECT: IA GW Munitions Investigation
HOLE NO: 99-IA-MW-51

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

HTRW DRILLING LOG

DISTRICT: CE NWS

HOLE NUMBER: 98-IA-MW5

SHEET 1 OF 15 SHEETS

1. COMPANY NAME: USACE

2. DRILL SUBCONTRACTOR: Andrew Well Drilling

3. PROJECT: Ft. Lewis Impact Area

4. LOCATION: Ft. Lewis, WA

5. NAME OF DRILLER: Matt Gilbert

6. MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61 & Ingersol Rand T-4

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Drilled from 0-40FT with 4" ID HSA & completed well, found to be in perched zone & was abandoned. Readvanced boring with air rotary using 6" casing and eccentric underreamer bit. Casing was driven with downhole hammer

8. HOLE LOCATION: TBN, R1E, Sec, 35, NENESE

9. SURFACE ELEVATION: ~255 FT from 7.5' Quad

10. DATE STARTED: 2 DEC 98

11. DATE COMPLETED: 31 MAR 99

12. OVERBURDEN THICKNESS: 130FT

15. DEPTH GROUNDWATER ENCOUNTERED: 109.65 FT

13. DEPTH DRILLED INTO ROCK: 0FT

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

14. TOTAL DEPTH OF HOLE: 130FT

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): 27.8FT perched zone

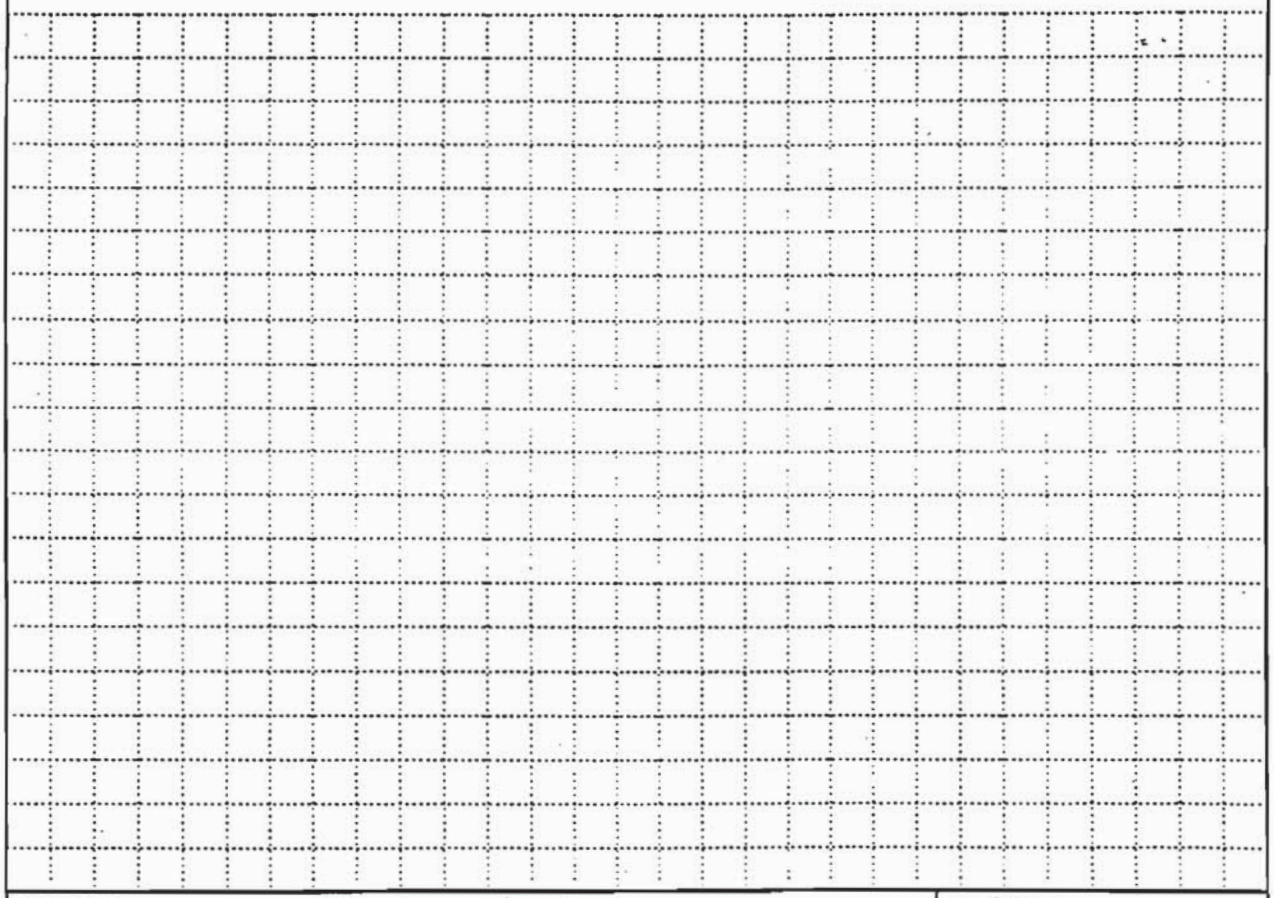
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
Drive Samples	7		

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
well completion		X		Matt Brookshier

LOCATION SKETCH/COMMENTS

SCALE:



PROJECT: Ft. Lewis Impact Area

HOLE NO: 98-IA-MW5

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW5
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Bookshier
SHEET 2 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	GP-GM, Silty gravel, poorly graded 2-3" nominal. Silt is very dark brown to black with fine sand, moist. Sediment has been extensively reworked and burned vegetation is present throughout		Grab			Mobile B-61 turning 4" ID HSA. Begin drilling from 6FT, first five feet was test hole for UXO-avoidance
	2						
	3						
	4	GP-Poorly sorted gravel 2-6" nominal & cobbles with some fine sand and silt (<5% each) grey, moist.		Grab			Harder drilling
	5	Top of undisturbed formation.					Begin drilling 2 DEC 98 @ 1015.
	6	All gravels are well rounded with some subrounded pieces					
	7	90% volcanic 10% granitic					
	8						Hard drilling, rig rocking around obstruction at 8FT
	9						To 10FT at 1023

PROJECT: Ft. Lewis Impact Area
HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW5

PROJECT: Ft. Lewis Impact Area | INSPECTOR: Matt Brookshier | SHEET 3 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	GP - Coarse gravel 3" nominal with some cobbles and clay (≤5% each) gravel is sub rounded yellow-grey (clay) and moist, some broken gravel in sampler due to drive.		A 70% recovery		N= 13 32	3"ID x 12" split spoon w/ 300 lb hammer with 36" stroke Drill 10-15FT 1050-1052 much easier drilling
	12						
	13						
	14						
	15	GP - Coarse gravel and cobbles with some clay, grey, dry. Material is slightly larger nominal size than previous. Poor recovery due to broken cobble in nose of spoon		B 40% recovery		N= missed	Drill 15-20FT Went to East gate to locate Woodward-Clyde for Bill Goss
	16						
	17						Lunch
	18						
	19	Change of materials between 16 and 20FT see sample C					

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-HLW5
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	SP-SC: Coarse sand with clay. Sand is subrounded to sub-angular 3/8" - 1/8" in clay matrix, yellow to grey, moist,		C 70% recovery		N= 41 52	Drill 20-25 FT
	22	Some gravel (1") <5%					Drillers reports very hard drilling
	23	Probably cobbley as well based on drilling action					
	24						Attempt water level: muddy, no free water
	25	SP- Coarse sand with some fine gravel and cobbles, less clay than above.		D 40% recovery		N= 62/6"	
	26	Sand is coarser than above up through 3/4",					Drill 25-30 FT
	27	yellow-brown, moist					1318-1321 smooth drill operation, no bucking, some steam ~~dust~~ from auger flights
	28	Cobble stuck in nose of spoon resulting in poor recovery.					~~Attempt w~~
	29						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: FB-IA-MW5
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brackshier
SHEET 5 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	SP - Poorly sorted ~~coarse~~ medium sand, with minor gravel up to 1½", sand is 1/16" nominal vf to ¼", sub angular, brown grey wet.		E: 30-31 90% recovery		N= 50 50	Blows with 300lb hammer are light piston part of hammer seems to have too much friction WL @ 27.8FT after drive E 1340
	32						Drill 30-35FT 1354-1357 smooth drilling
	33						
	34						Attempt WL before sample: no reading
	35						
		SP as above, a little more gravel, more uniform sand 1/16". Moist, no water level possible		E: 35-36 100% recovery		N= 26 59	WL after drive no water
	36						
	37						Drill 35-40 1432-1435 cutting coming up are very soupy: clayey sand
	38						
	39	Change of materials between 36 and 40FT					WL before drive G: dry

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98TA-MW5
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshire
SHEET 6 SHEETS 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	41	SP-SC: Poorly sorted clayey sand, medium grained with some gravel to 1", wet, brown yellow		G 4041 80% recovery		N= 48 60	WL @ 40.6 FT 1505 Too clayey to complete well at this zone. A well was installed & screened from 33-28 FT but was discovered to be in a perched zone. Well was abandoned.
	42						
	43						
	44						
	45						Continuation of boring was accomplished with air rotary. First deep monitoring well was lost & hole abandoned 13-15 FEB 99 Second deep well was drilled and completed 29-31 MAR 99
	46						
	47						
	48						
	49						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW5 replacement
Completion date 31 MAR 99
Contractor Andrew Well Drilling
Rig Ingersol-Rand T-4
Operator Matt Gilbert
Inspector Matt Brookshier
Depth 122 FT Datum bgs

HOLE DATA
Size: 6 in. to 125 ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type Brown Longyear Prepack 2" ID
Mfr. ____
Composition PVC Dia. 4"

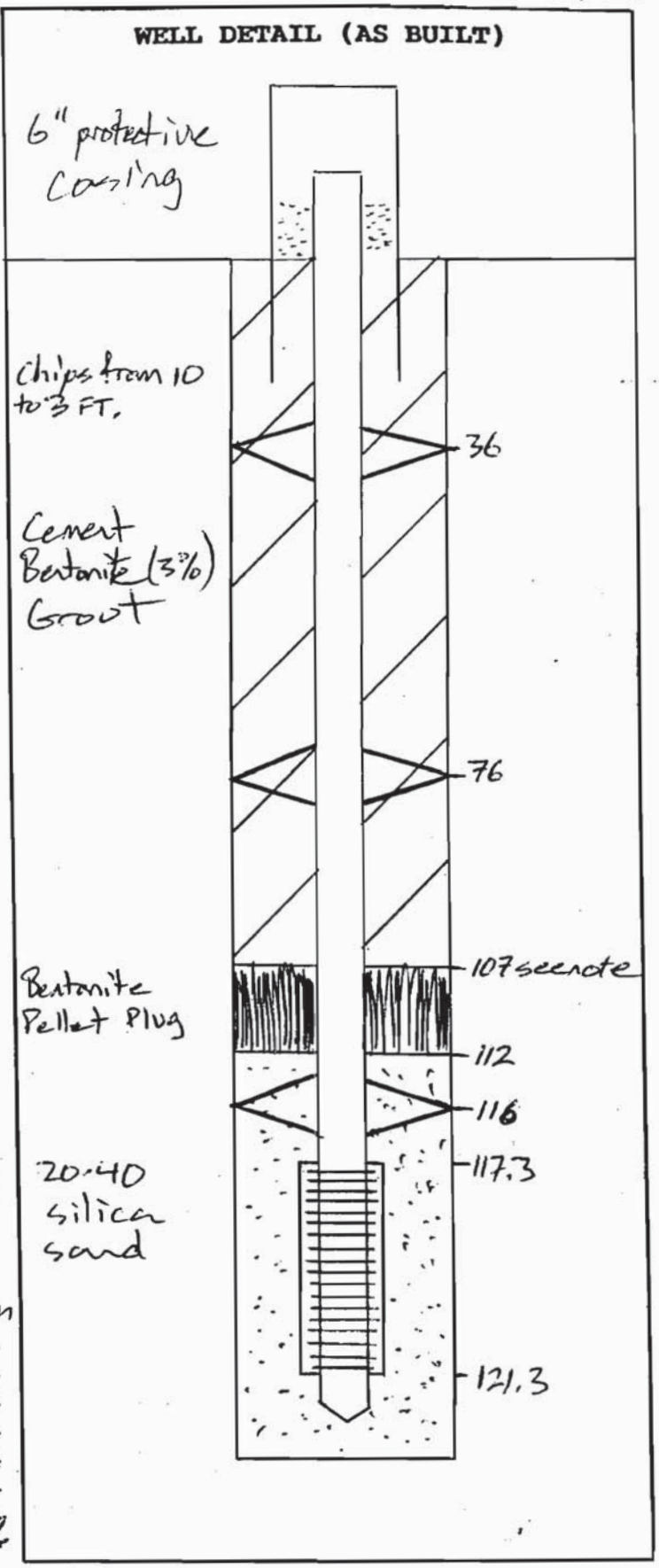
Fittings:	Length	Dia.
Packer		
Riser		
Tailpipe		

FILTER
Source CSSI
Composition silica
Gradation 20-40
Inst. method Poured around prepack
Volume used ~10 cf 500 lbs.
Depth 122 FT to 112 FT ft.

GROUT
Composition Cement bentonite
Volume used ~50 cf
Inst. method Pumped down hole
Depth 107 to 10 ft.
3 to 0 ft.

REMARKS: Casing was pulled up from 125 - 119 FT to open up water bearing zone. Hole caved from 125-122 FT; well was ~~set~~ set on top of native material. Pellets bridged in casing driller reported pellets to 107 FT but w/ only 4.5 gal. Pellets. Plug is likely much thinner. Grout was not tremied. Chips from 10-3 FT.

WELL DETAIL (AS BUILT)



EM 1110-1-4000
31 Aug 94

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER 99-IA-MW-5D

PROJECT IA GW Mun. Inv. | INSPECTOR Richard Smith | SHEET 6 of 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	40	GP as above					Begin @ 09:30 Discharge hose stuff plugged. Cuttings spewing out from casing/hose connector
	41						
	42						42.5' stopped @ 09:40 to clear plug in discharge hose 10:20 restart
	43						
	44						
	45	GP. Fine to coarse (<1.5") sub-rounded gravel with fine to coarse sand (30%) and trace brown silt (<5%)					45' @ 10:32
	46	silt is brown, gravel and sand generally gray, brown + black, altered origins.					46' much harder drilling like cobbles
	47	cuttings @ 46'-48' primarily fragments of basalt cobble or boulder. discharge is grayish					48' a little easier drilling
	48	GP as above but some brown clay coating gravel					
	49	CL: Clay with ~20% fine sand, plastic, dark gray/brown, moist. Discharge water dark gray.					
	50						50' @ 10:55

=40' on mast

PROJECT IA. GW Munitions Inv. | HOLE NO 99-IA-MW-5D

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER 99-IA-MW-5D

PROJECT IA GW Munitions Inv | INSPECTOR Richard Smith | SHEET 8 OF 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	60	SM: Fine silty Sand. Sand is grey, silt is brown (15-20%) Minor clay; brown overall					Restart @ 11:46 Driller reports action indicates clay + sand Driller reports possible perched water on top of SM unit
	61	Very compact material					
	62						
	63						
	64	SP: Medium to coarse sub-rounded sand with fine gravel subrounded (20%), minor brown silt, Gravels and sand dark volcanic blacks to greens + browns					
	65						65' @ 11:57
	66						
	67	SP-SC: Medium to coarse sub-angular to subrounded sand with clay + silt (10%) and rounded fine gravel (15%), brown					
	68						
	69	↓ sand coarse sand clay replaced by silt					
	70	SP-SM					70' @ 12:05

PROJECT IA GW Munitions Investigation | HOLE NO. 99-IA-MW-5D

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW-5D
PROJECT: IA-GW Munitions Inv
INSPECTOR: Richard Smith
SHEET 9 OF 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	70	SP-SM continued					Driller reports gravel
	71	GP. Fine, sub-angular to sub-rounded gravel (¾"), with coarse sub-angular to sub-round sand (40%); primarily black, green and red-brown volcanic clasts. Gravel becoming coarse past 72' and coated w/ brown clay (1" gravel)					Driller turned off water @ 72'. Formation dry to moist. Turned back on again @ 73'.
	72						
	73	and very fine sand.					
	74						
	75	GP. Fine to coarse sub-rounded gravel (to > 1½"), with fine to coarse sand (25%)					75' @ 12:20
	76	All volcanic clasts, minor brown silt colors in matrix. Sand decreasing w/ depth and becoming coarser.					
	77						
	78						
	79						Stopped to add more casing and drill rod
	80	GP as above mostly coarse					80' @ 12:33

PROJECT: IA GW Munitions Investigation
HOLE NO: 19-IA-MW-5D

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW-5D
PROJECT: IA GW Munitions Invest
INSPECTOR: Richard Smith
SHEET 10 OF 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	80	GP as above ↓ Coarsening downward					Restart @ 13:15 Driller reports small amount of water @ startup Driller not adding water 82' somewhat harder drilling possible cobbles
	81						
	82	Returns numerous ~~returns~~ contain ~~them~~ fragments of larger black basalt cobbles. but also coated w/ brown clay. moist					slow drilling
	83	No clay past 83.5'					
	84						
	85	GP: Coarse gravel and cobbles since 82'. Little or no sand, minor clay (brown) gravel is volcanics moist					85' @ 13:38 Driller now adding water
	86						
	87						
	88						
	89						
	90	GP as above					90' @ 13:58

PROJECT: IA GW Munitions Investigation
HOLE NO. 99-IA-MW-5D

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW-5D
PROJECT: IA GW Munitions Invest
INSPECTOR: Richard Smith
SHEET 11 OF 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	90	GP as above					
	91	GP-GC: Coarse sub-rounded gravel (1") with fine to coarse sand (~~35~~ 35%) and clay (10%), brown.					some what faster drilling @ 91'
	92						
	93	GP: Coarse sub-rounded gravel >90% volcanics, gray, black + dark green, minor brown silt					
	94						
	95	GP-as above					95' @ 14:15
	96						
	97						
	98						
		GP-GC as above					
	99	GP: Coarse gravel, sub-rounded, with fine to coarse sand (20%) and 45% brown silt, volcanics					stopped to add more casing + drill rod
	100						100' @ 14:38

PROJECT: IA GW Munitions Investigation
HOLE NO: 99-IA-MW-5D

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW-5D
PROJECT: IA GW
INSPECTOR: Richard Smith
SHEET 12 OF 14 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
~~[illegible]~~	100	GP as above					Restarte 15:10 Driller adding water
	101						
	102	occasional sandy zones					
	103	Based on lithologies observed on nearby cutbank of N. River, probably alternating SP+GP					
	104						
	105	GP as above with sandy (30-40%) zones fine to med. sand. some ~~light~~ brown silt but gravels gray/black volcanics					105' @ 15:45
	106						
	107						
	108	Thin clayey zone (brown) @ 108'.					
	109	another thin SC zone @ 109' then back to GPas above					
	110						Stopped to add more casing and drill rod 110' @ 16:05

PROJECT: IA GW
HOLE NO. 99-IA-MW-5D

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER MW-5D
PROJECT IA GW
INSPECTOR Richard Smith
SHEET 13 OF 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	110	GP: Fine to coarse gravel with sand (20-40%) little or no brown silt mostly volcanics black, dark gray. Possible Cobbles					Raster te 16:42
	111						
	112						112' @ 16:20 stopped for the day 15 Feb 1999 Start @ 08:43 No water in hole @ startup- Driller adding water..
	113						
	114						
	115	GP: Coarse gravel (1" or greater) with sand (15%), little or no brown silt (<1%) Gravel is black, dark gray, green and red volcanics. Possible cobbles					115' @ 09:05
	116						
	117	Past 117 some brown clay and silt on gravel cuttings (silt/clay <10% of total return)					
	118						
	119						No formation water encountered since start, stopped to add more casing and drill rod
	120						120 @ 09:43

PROJECT IA GW Munitions Contamination
HOLE NO. 99-IA-MW-5D

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

EM 1110-1-4000
31 Aug 94

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER 99-IA-MW-5D
PROJECT IA GW
INSPECTOR Richard Smith
SHEET 14 SHEETS 14 OF 14

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	120	GP: sub-rounded gravel fine to coarse with sand medium to coarse (20%) little or no fines, gravels black, dark gray, green + red, wet past 120.5'. volcanics.					Restart @ 10:30 RGS Formation water @ 120.5'
Suspect interlaying zone here	121						
	122						Bit plugged. Must remove from hole stopped @ 11:09 @ 122'. 12:50 w.l. = 109.65' b.g.
	123	Some orange-brown silt w/ GP.					Restart @ 15:42 Making water. Bit and hammer working much better..
	124	Becoming clayey with orange-brown clay + silt (10%)					
	125						125' @ 15:56 No water past 125'
	126	SP: Medium sand with fine to coarse gravel (30%) and <5% silt. Unit is slightly oxidized to orange-brown color. May contain significant clay fraction (10-15%)					
	127						
	128	lost orange-brown color here					128' @ 16:15 stopped to check w.l. w.l. = 121' and very slowly rising after hearing bubbling noise restart @ 17:30 Not making water
	129	GP-GC: Fine to coarse gravel with sand and clay (10-15%), brown, moist.					
	130						130' @ 17:35

PROJECT IA GW
HOLE NO 99-IA-MW-5D

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

Well installation was lost on 15FEB99
Work was re-done 29-31MAR99: well completion

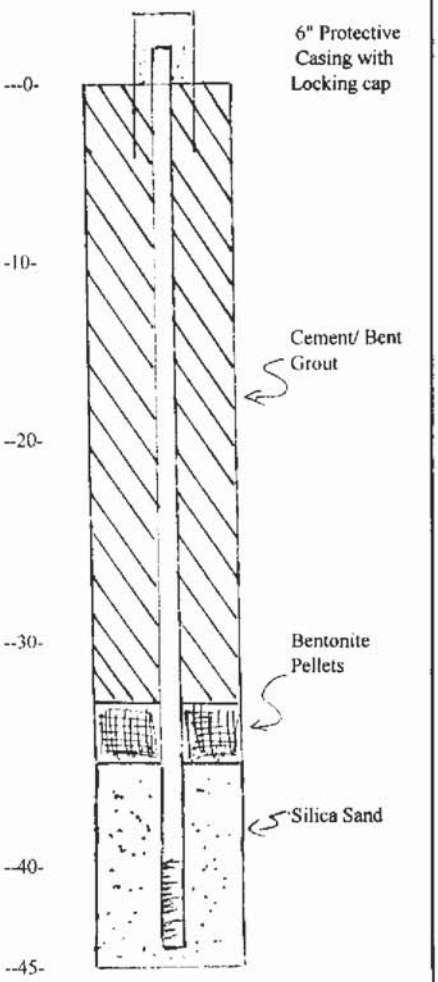
RESOURCE PROTECTION WELL REPORT

START CARD NO. R16889

PROJECT NAME: Installation of Water Monitoring Wells
WELL IDENTIFICATION NO. 98-IA-MW6/Tag #AEP 006
DRILLING METHOD: Auger
DRILLER: Craig S. DeYoung
FIRM: Andrew Well Drilling Services
SIGNATURE:
CONSULTING FIRM: US Army, Corps of Engineers
REPRESENTATIVE: Matt Brookshier

COUNTY: Pierce
LOCATION: SE 1/4 SW1/4 Sec 21 Twn 18N R 2E
STREET ADDRESS OF WELL: Central Impact Area/Artillery Impact Area, Ft. Lewis, Washington
WATER LEVEL ELEVATION: 30ft
GROUND SURFACE ELEVATION: Unknown
INSTALLED: December 18, 1998
DEVELOPED: December 18, 1998

As-Built



Well Data

SIZE:	8" to 45.0ft
CASING:	2" Sch 80PVC
Ht above Surface:	2ft
Drive Shoe:	None
SCREEN:	
Type:	2"Sch 80 .010 Slotted PVC
Location:	39.0 to 44.0 ft
MFG:	Boart Longyear
FILTER:	
Composition:	Silica Sand 10/20 and 20/40
Installation:	Poured from surface in cased hole
Depth:	36.0 to 45.0 ft
GROUT:	
Composition:	Bentonite Pellets
Installation:	Poured from surface in cased hole
Depth:	36.0 to 33.0ft
Composition:	Bentonite/cement grout
Installation:	Tremie Pipe
Depth:	33.0 to surface
SURFACE COMPLETION:	Vault Cover

FORMATION DESCRIPTION

00.0-02.0	Gravel & silty gravel w/cobbles
02.0-08.0	Coarse gravel w/sand
08.0-30.0	Sand & Gravel w/cobbles
30.0-40.0	Fine Gravel
40.0-45.0	Fine sand and gravel

SCALE: 1" = 10ft

PAGE: 1 OF 1

HTRW DRILLING LOG

DISTRICT: CENWS

HOLE NUMBER: 98-IA-MW6

SHEET 1 OF 6 SHEETS

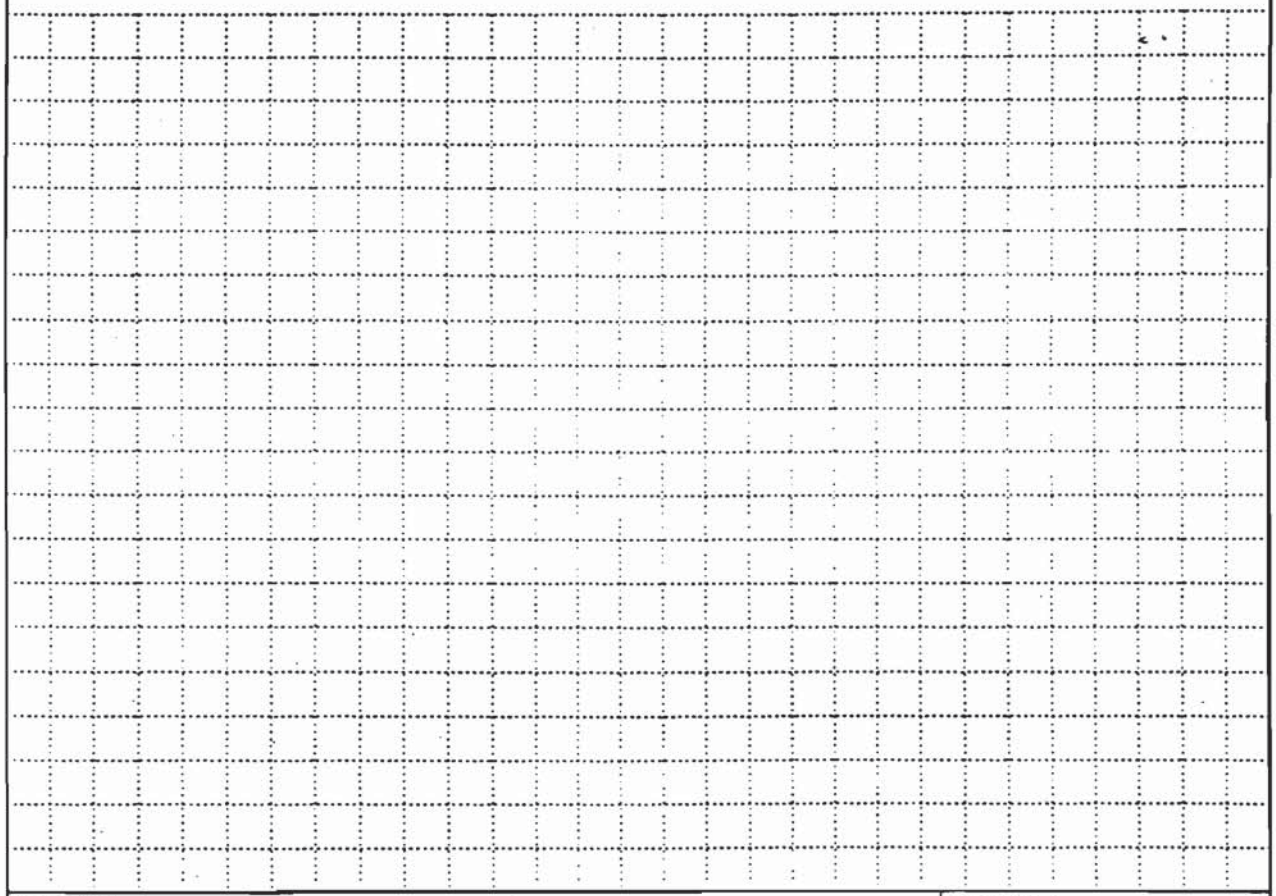
1 COMPANY NAME: USACE	2 DRILL SUBCONTRACTOR: Andrew Well Drilling
3 PROJECT: Ft. Lewis Impact Area	4 LOCATION: Ft. Lewis, WA
5 NAME OF DRILLER: Matt Gilbert	6 MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4" ID HSA; 8" OD; 3" OD x 12" drive sample (split spoon) driven by 300lb hammer with 36" stroke	8 HOLE LOCATION: T18N; R2E; Sec. 21; NESESW
	9 SURFACE ELEVATION: ~ 315 FT; 7.5' quad
	10 DATE STARTED: 19 DEC 98 / 11 DATE COMPLETED: 20 DEC 98
12 OVERBURDEN THICKNESS: 45 FT	15 DEPTH GROUNDWATER ENCOUNTERED: 35.85 FT (approximate due to heaving)
13 DEPTH DRILLED INTO ROCK: 0 FT	16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED
14 TOTAL DEPTH OF HOLE: 45 FT	17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY): 31.85 FT due to 3 FT heave in augers

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
Drive Samples		8	

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY

22 DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR
Well completion		X		Matt Brookshire

LOCATION SKETCH/COMMENTS — SCALE:



PROJECT: Ft. Lewis Impact Area — HOLE NO: 98-IA-MW6

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: GB-IA-MW6
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 2 SHEETS OF 6.

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	GP-~~SP~~: Gravel (coarse) and sand (medium-coarse) with cobbles (6-8" max). Silt (black, 10-15%) in first 2FT of run (root zone). Gravel and cobbles are rand to subrounded, sand is sub-angular, brown to black, damp.		Grab			Mobile B-61 with 4" ID HSA. Begin drilling MW6 MODE at 804. Rough drilling; many cobbles at surface destruction at 3FT Finish run at 810 Cuttings are dry due to heat of bit
	2						
	3	GP: Coarse gravel with 5-7% sand and cobbles 20%, very little fines (light coating) on larger particles; damp, grey					
	4						
	5	GP: Coarse gravel, better graded than before but no fine gravel. Some medium sand clinging to larger gravels, almost no fines. grey to brown, damp.		Cuttings			Drill 5-10 FT 816-818 Somewhat better drilling, rough at 7-8FT, gravelly w/ cobbles
	6						
	7						
	8	GP - see drive A below					
	9						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: FB-IA-MW6
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 3 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	SP: Loose to medium sand, sub-angular, w/ light coating of clay or silt (1-2%), gravel present, maybe up to 15%, moist, brown Gravel is rounded as usual, somewhat elongated.		A: 10-11 50% recovery		N: 8 25	Poor recovery, sample poorly represents materials. Drill 10-15 FT 851-852 Fairly smooth drilling, gravels present
	12						
	13						
	14						
	15	SP/GP: sand and gravel. Sand is coarse to medium, sub-angular; gravel is sub-rounded primarily 3/4-1" with some fines and a few grains to 2½", white fines as coating over larger grains; in this sample no clay appears, moist, brown.		B: 15-16 50% recovery		N: 25 40	Poor recovery again, most fines material is falling out of spoon Drill 15-20 FT 910-911 Smooth drilling some gravels present
	16						
	17						
	18						
	19						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW6
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	SP ~~SP~~: Coarse sand and gravel, gravel is more rounded than sand, clay coating on all grains, moist, brown, 40% gravel, 60% sand		C: 20-21 30% recovery		N: 25 50/4"	Poor recovery again, instruct driller to correct situation. most finer materials have fallen out of sample bucket. Drill 20-25 FT 1009-1011 rough drilling at beginning, then smoothing through run. Formation seems to be less gravelly and moister, will try sample D
	22						
	23						
	24						
	25	SP ~~SP~~ as above Gravel is 1-1½" nominal, sand is coarse to medium, less fines adhering to large grain sizes, moist, brown.		D: 25-26 76% recovery		N: 25 50	5½" cobble broken up in sample otherwise good recovery Drill 25-30 FT 1040-1043 pretty rough drilling, obstruction at 24 FT, possible cobble zone from 26-30 FT coarse gravel is only material coming up auger, all have light coating of fines.
	26						
	27						
	28						
	29						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW6
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET: 5 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	GP: Fine gravel, mostly subangular, some gravel up to 1¼", sand (med, um-coarse) present up to 20%; Thin clay(thes) coating on all grains as before moist, brown.		E: 30-31 80% recovery		N: 23 30	Good recovery, formation is pretty moist
	32						Drill 30-35 FT 1106-1107
	33	Only slightly more on the gravel side than sample D. Similar material					drilling is smoother than last drive some bucking indicating occasional cobbles
	34						
	35	GP as above with cobbles, wet, brown.		F: 35-36 50% recovery		N: 16 38	Sample is wet, attempt WL: none
	36	one broken cobble among sample material					cobble probably impeded good sample recovery
	37						Drill ~~40~~ 35-40 FT 1133-1135
	38						drill action similar to previous runs only coarse gravel from auger mostly 1½-2½" grain all rounded
	39						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW6
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 6 OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	41	~~SP~~ SW: well graded sand, sub angular, much more fine sand in upper part of sample due to settlement from water column. Lower half of sample is coarse to medium with a little fine sand, <5% gravel and minute fines, saturated, brown. Some reworking of formation may have resulted from re-drilling		G: 40-41 60% recovery		N: 17, 38	Bucket came out wet, very clayey WL @ 31.85FT much fine sand & fines in water @ 1133 before drive G is taken 1143: 3FT of material in HSA, must redrill w/ drillstem Previous WL is misleading. 1245: formation at ~~39~~ 40' 10" ready for drive sample 1338 WL @ 35.85 Drill 40-45FT 1405-1408 fairly smooth drilling
	45	GP/SP: fine gravel & coarse sand 5% larger gravel, less coarse than usual to subangular, 5% fine sand (silt?) probably less, sand is primarily sub-angular, saturated, grey-brown		H: 45-46 50% recovery		N: 38, 42	1455 after sample WL @ 35.90 Bottom of boring is at 45FT
	48						
	49						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW6
Completion date 20 DEC 98
Contractor Andrew Well Drilling
Rig Mobile B-61
Operator Matt Gilbert
Inspector Matt Brookshire
Depth 45 FT Datum ground surface

HOLE DATA
Size: 8" in. to 45 FT ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type .01" X 5 FT
Mfr. Bowt Longyear
Composition PVC Dia. 2"

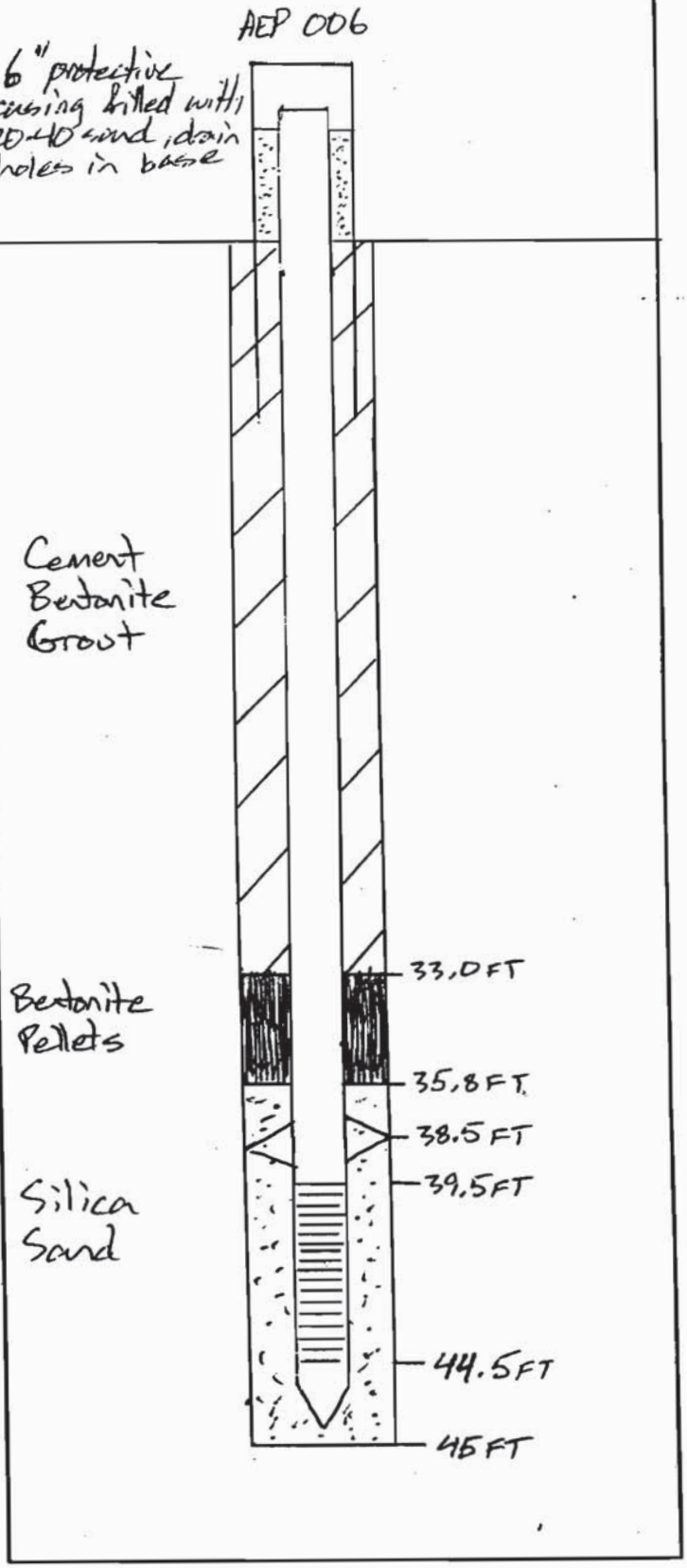
Fittings:	Length	Dia.
Packer		
Riser	42 FT	2"
Tailpipe		

FILTER
Source CSSI
Composition silica sand
Gradation 20-40
Inst. method poured through HSA
Volume used 4 cubic ft (4 sacks)
Depth 45 FT to 35.8 FT ft.

GROUT
Composition Cement-bentonite (3%)
Volume used 23 ft³ (21 cement / 2 bent.)
Inst. method Tremie pipe
Depth 33 to 0 ft.
____ to ____ ft.

REMARKS: Large volume of sand used; bentonite pellets hydrated during grout mixing. Surface protection emplaced on 21 DEC 98.

WELL DETAIL (AS BUILT)



HTRW DRILLING LOG

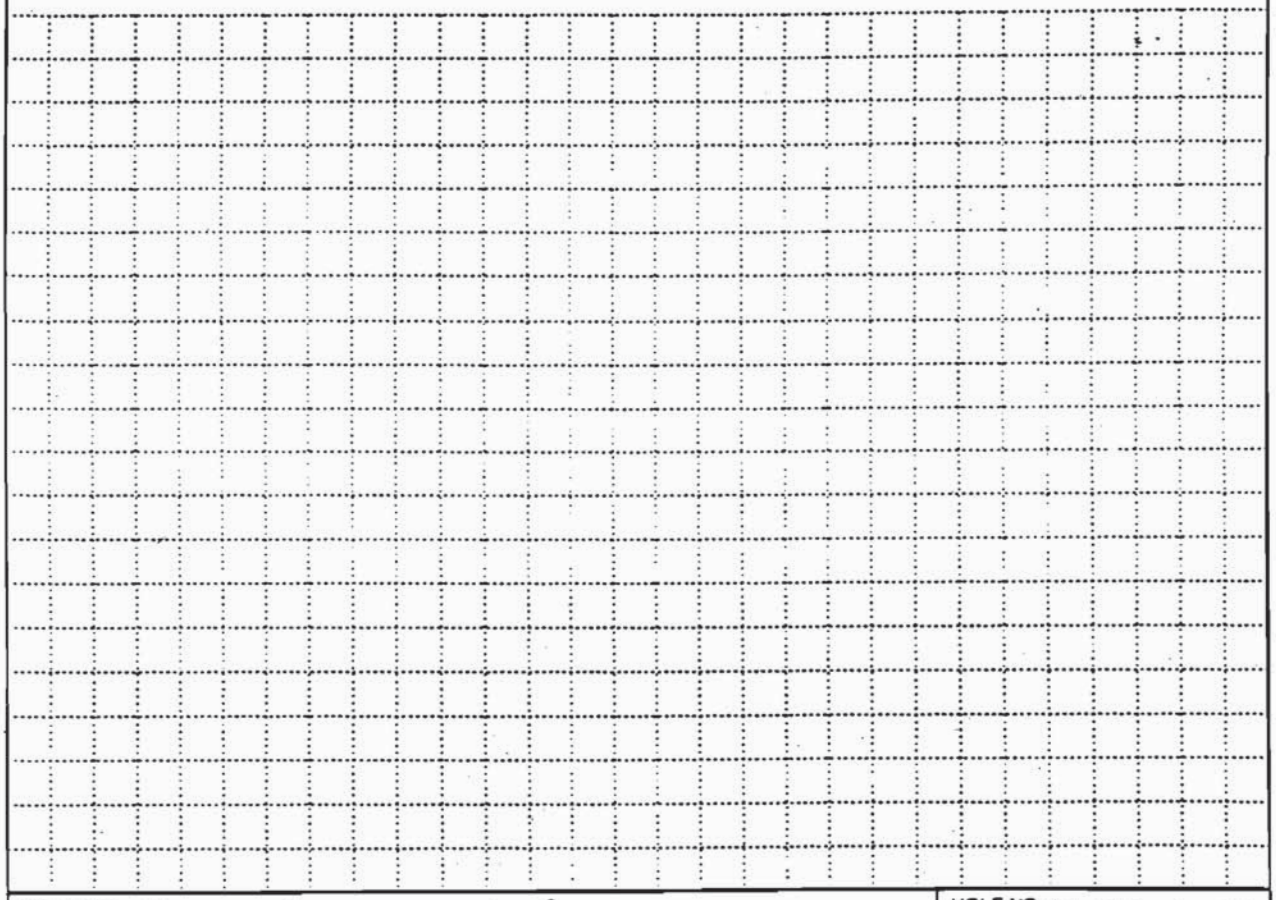
DISTRICT: CENWS		HOLE NUMBER: 98-IA-MW7
1 COMPANY NAME: USACE	2. DRILL SUBCONTRACTOR: Andrew Well Drilling	SHEET 1 OF 6 SHEETS
3 PROJECT: Ft. Lewis Impact Area	4 LOCATION: Ft. Lewis, WA	
5 NAME OF DRILLER: Matt Gilbert	6 MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61 & Ingersol Rand T-4	
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Drilled from 0-40FT to reboard with 4" ID HSA & abandoned hole. Continued with air rotary using eccentric undereamer bit driving 6" casing with down hole hammer. No samples taken during air rotary.	8 HOLE LOCATION: T17N, R1E, Sec. 1, NWNESE	
	9 SURFACE ELEVATION: ~280FT from 7.5' Quadrangle	
	10. DATE STARTED: 11JAN99	11 DATE COMPLETED: 26FEB99
12 OVERBURDEN THICKNESS: 59 FT	15 DEPTH GROUNDWATER ENCOUNTERED: 41.40FT	
13 DEPTH DRILLED INTO ROCK: 0FT	16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14 TOTAL DEPTH OF HOLE: 59 FT	17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
Drive Samples	7		

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
well completion		X		Matt Brookshier

LOCATION SKETCH/COMMENTS SCALE:



PROJECT: Ft. Lewis Impact Area HOLE NO: 98-IA-MW7

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 9B-IA-MW7
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 2 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	SP-SM: fine sand and silt; occasional gravel, damp, black to dark brown; root zone		Grab			Mobile B-61 tomido 4" ID HSA; 3" OD x 18" split spoon driven w/ 300lb x 36" Drill 0-5 FT 835-840
	2	SP-SM: fine sand and silt; sand is sub angular to sub rounded; no gravel noted, damp, brown		Grab			smooth drill action A lot of gravel and cobbles on surface; none in cuttings
	3						
	4						
	5						
	6	SM: silty sand, medium reaction to dilatancy test. sand is very fine, subrounded, material is non plastic, moist brown, ~~to much~~ and few particles no test larger than 1/64"		Grab			Drill 5-10FT 845-847 smooth drill action harder at 9.5FT: cobble?
	7						
	8						
	9	SP (see drive A)					

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW7
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 3 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	SP: Poorly graded medium to fine sand, sub-rounded to sub-angular; about 2% silt; damp, brown, no gravel or cobbles formation is pretty clean below silty layer		A: 10-11.5FT 50% recovery		N= 14, 14, 11	Hydraulic driving at 11 FT Drill 10-15FT 905=908 drill cuttings are clean, medium sand. very smooth drill action, no gravel
	15	SP as above		B: 15-16.5FT 70% recovery		N: 22, 28, 19	
	16	SP: Poorly graded medium sand (1/16-3/32"), with (rounded) gravel to 10%, no fines, damp, brown, Occasional cobble to 5"					Drill 15-20FT 928-930 rougher drilling through 18FT then easy again
	18	gravels are mostly volcanic origin; occasional granitic or gneissic gravel					occasional gravel in cuttings; mostly medium sand with some silt
	19						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: TB-IA-MW7
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 SHEETS of 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	GP: Poorly graded, well rounded gravel (1" nominal up to 3") with medium sand (10%) and occasional cobble, very moist, brown, fines (clay?) up to 5% (sticky coating on larger grain size)		C: 20-21.5FT 30% recovery		N: 5 5 7	Instruct driller to change sample retriever Drill 20-25FT 946-948 fairly smooth operation, gravelly cuttings are still 70-30 mix medium sand to 1" gravel
	25	SP: Poorly graded, coarse to medium, sub angular sand with sub rounded gravel (1-1½") 10% and cobbles occasionally to 5", No fines, moist brown.		D: 25-26.5FT 60% recovery		N: 22 24 20	Drill 25-30FT 1012-1014 bucking at 26.5FT smooth thereafter

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW7
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 5 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	GP: Poorly graded, well rounded gravel (1" nominal to 3") with coarse sand (10-15%) and clay coating on larger grains. Some free clay (yellow) to 5%, very moist, brown		E: 30-31.5FT 50% recovery		N: 4 6 23	Drill 30-35 FT 933-936 Drilling is somewhat rough after 32FT gravelly and occasional large cobble (34.5FT) More gravel returning from hole now, about 30% sand and some silt.
	32						
	33						
	34						
	35	GP: same as above with cobbles, moist brown.		F: 35-36.5FT 10% recovery		N: 50/5"	Gravel and cobbles, spoon is clayey & nose is freshly dented.
	36						
	37			Pulled up drillstring; repaired tooth & drilled back to 38FT			Drill 35-36.5 1055-1100 @ 38FT cutting tooth came up; ~~no progress after 38FT, dwell~~ Cuttings are all gravel now.
	38	? very hard till? GC- see G		Return cuttings are all coarse gravel with dark brown to black fines and very fine sand coat.			Drill 35-40FT 1334-1341; 2nd hole 6FT south very hard drilling constant progress but very slow after 38FT
	39	Bottom of boring at 40.0 FT					

PROJECT
HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: BOIA-MW7
PROJECT: A. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 6 & 6 SHEETS

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO (E)	ANALYTICAL SAMPLE NO (F)	BLOW COUNT (G)	REMARKS (H)
	41	GC: Clayey gravel (7.11) practically all grain size represented; coarse gravel and sand dominant in clayey matrix, ~~very~~ hard to medium, damp green-grey,		G: 40-41.5FT 100% recovery		N: 12 34 70	Samplespoon stuck in Formation hammered out w/ reverse blows from 140lb hammer Abandoned hole at 40FT depth with bentonite chips Continuation of boring with air rotary: redrill from 0-40FT 26 FEB 99. see next page
	42						
	43						
	44						
	45						
	46						
	47						
	48						
	49						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER 98-DP-MW17

PROJECT Ft. Lewis Impact Area | INSPECTOR Matt Brookshire | SHEET ___ SHEETS OF ___

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	51	SP-SM: Gravelly sand with silt; sand is course to medium, subangular with some fines; gravel is sub-rounded 3/4" and larger brown.		cuttings return.			1256 @ 50FT Most fines lost out top of casing
	52						
	53						
	54						
	55	SP-SM as above, slightly more silty, and somewhat less gravel, light brown,		cuttings return			940 @ 55FT
	56						
	57	increasingly silty through end of run to 59FT					
	58						End of run at 59FT 953 1010: WL @ 42.65FT 1024 WL @ 41.4FT
	59	Bottom of Boring at 59.0FT					

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: FB-IP-MW7

PROJECT: Ft. Lewis Impact Area

INSPECTOR: Matt Brookshire

SHEET ___ SHEETS OF

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	41	GC: Sandy clayey gravel; coarse sand and gravel in clay matrix (till) gravel is subrounded, sand is subangular; grey. (Finer sand fraction is being blown out top of casing).		descriptions based on cuttings Most finer material is blowing out top of case			Continuation of auger boring through "till" Using IR T-4 with under-reamer rotary air bit driving 6" casing. Drill 39-59FT 26FEB99; 950 to
	42						-Water added to remove cuttings, a lot of material rom top of casing
	43	color change to brown at 42FT, materials appear to be the same					
	44						
	45	GP-GC: Sandy gravel with clayey; sand is medium to coarse; gravel as above with some fines, brown.					910 @ 45FT
	46						
	47						
	48						
	49						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW7
Completion date 27 FEB 99
Contractor Andrews Well Drilling
Rig Ingersoll-Rand T-4
Operator Matt Gilbert
Inspector Matt Brookshier
Depth 55.0 Datum ground surface

HOLE DATA
Size: 6 in. to 59 ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type Board-Longyear .01" slot
Mfr. Board-Longyear
Composition PVC Dia. 2"

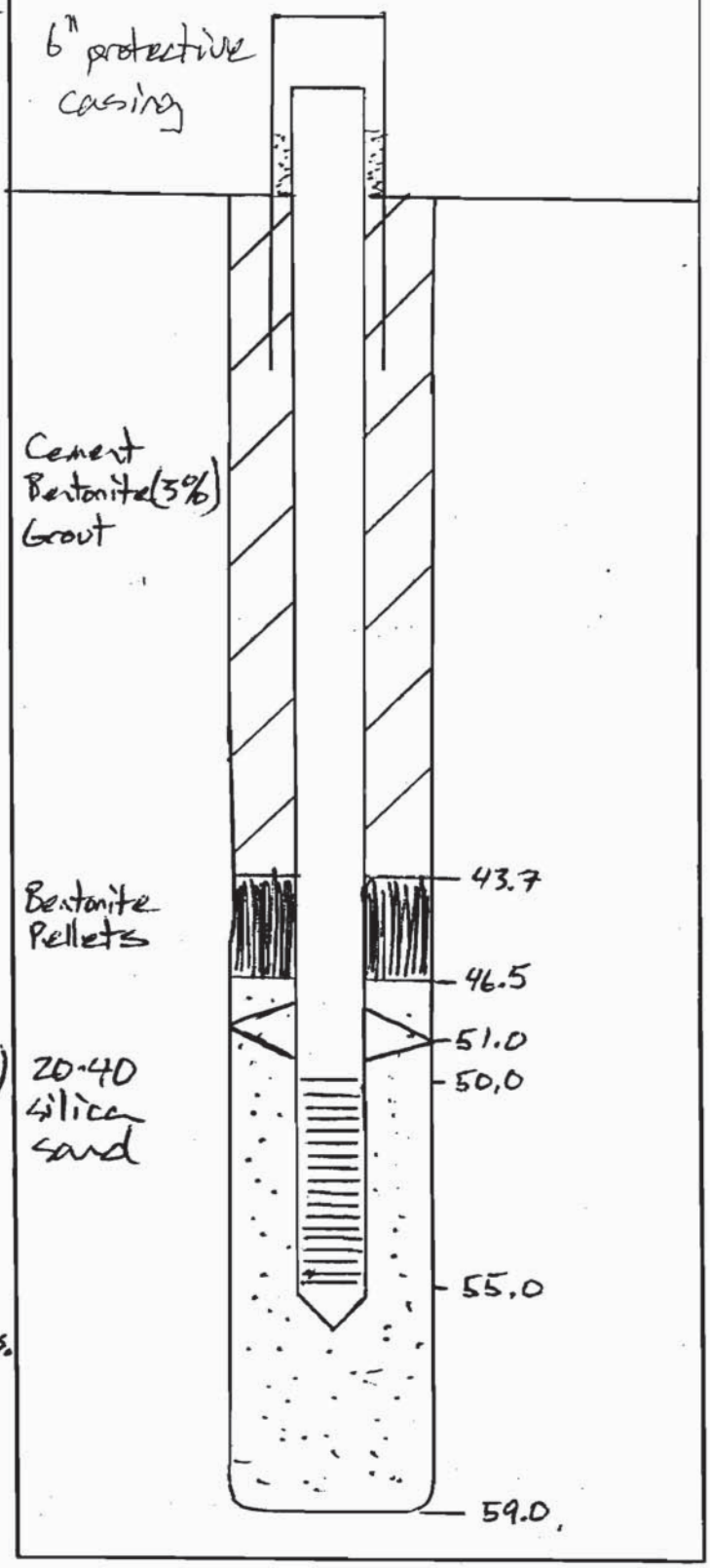
Fittings:	Length	Dia.
Packer		
Riser		
Tailpipe		

FILTER
Source CSSI
Composition silica
Gradation 20-40
Inst. method Poured
Volume used ~8 ft³
Depth 59.0 FT to 46.5 FT ft.

GROUT
Composition Cement-Bentonite (3%)
Volume used 42 ft³
Inst. method Tremie
Depth 43.7 to 20 ft.
18 to 0 ft.

REMARKS: Hole backfilled with 20-40 sand to 55 ft. Bentonite pellets (2 pails) hydrated for 18 hrs. Drillers pumped 30 of grout to 20 ft bgs then used 4 sacks bentonite chips then pumped 12 ft³ to surface.

WELL DETAIL (AS BUILT)



RESOURCE PROTECTION WELL REPORT

START CARD NO. R16880

PROJECT NAME: Installation of Water Monitoring Wells

WELL IDENTIFICATION NO. 98-IA-MW8/Tag #AEP 008

DRILLING METHOD: Auger

DRILLER: Craig S. DeYoung

FIRM: Andrew Well Drilling Services

SIGNATURE:

CONSULTING FIRM: US Army, Corps of Engineers

REPRESENTATIVE: Matt Brookshier

COUNTY: Pierce

LOCATION: SE 1/4 NE1/4 Sec 8 Twn 18N R 2E

STREET ADDRESS OF WELL: Central Impact Area/Artillery Impact Area, Ft. Lewis, Washington

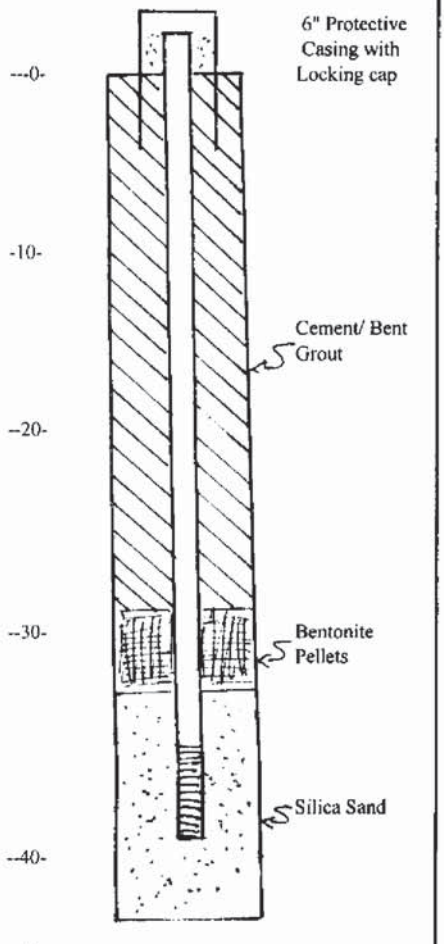
WATER LEVEL ELEVATION: 33.5ft

GROUND SURFACE ELEVATION: Unknown

INSTALLED: December 18, 1998

DEVELOPED: December 18, 1998

As-Built



Well Data

SIZE:	8" to 45.0ft
CASING:	2" Sch 80PVC
Ht above Surface:	2ft
Drive Shoe:	None
SCREEN:	
Type:	2"Sch 80 .010 Slotted PVC
Location:	43.0 to 38.0 ft
MFG:	Boart Longyear
FILTER:	
Composition:	Silica Sand 10/20 and 20/40
Installation:	Poured from surface in cased hole
Depth:	32.0 to 45.0 ft
GROUT:	
Composition:	Bentonite Pellets
Installation:	Poured from surface in cased hole
Depth:	29.0 to 32.0ft
Composition:	Bentonite/cement grout
Installation:	Tremie Pipe
Depth:	29.0 to surface
SURFACE COMPLETION:	Vault Cover

FORMATION DESCRIPTION

00.0-05.0 Gravel w/cobbles
05.0-10.0 Coarse sand
10.0-23.0 Gravels w/Sand
23.0-26.0 Sandy gravel
26.0-45.0 Gravelly & Cobbley Sand

SCALE: 1" = 10ft

PAGE: 1 OF 1

HTRW DRILLING LOG

DISTRICT: CENWS

HOLE NUMBER: 98-JA-MW8

SHEET 1 OF 6 SHEETS

1 COMPANY NAME: U.S. Army Corps of Engineers

2. DRILL SUBCONTRACTOR: Andrew Well Drilling Service Inc.

3 PROJECT: Ft. Lewis Impact Area

4 LOCATION: Ft. Lewis, WA

5 NAME OF DRILLER: Matt Gilbert

6 MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61

7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4" ID HSA; Samples with 3" OD x 17" split spoon sampler with 300 lb hammer

8 HOLE LOCATION: T8N; R2E; Sec. 8; NESENE

9 SURFACE ELEVATION: ~320 FT (from 7.5' quadrangle)

10. DATE STARTED: 7 JAN 98

11 DATE COMPLETED: 7 JAN 98

12 OVERBURDEN THICKNESS: 45 FT

13 DEPTH DRILLED INTO ROCK: 0 FT

14 TOTAL DEPTH OF HOLE: 45 FT

15 DEPTH GROUNDWATER ENCOUNTERED: 31.40 FT (was very muddy)

16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 33.20 FT 14 hrs after drilling

17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

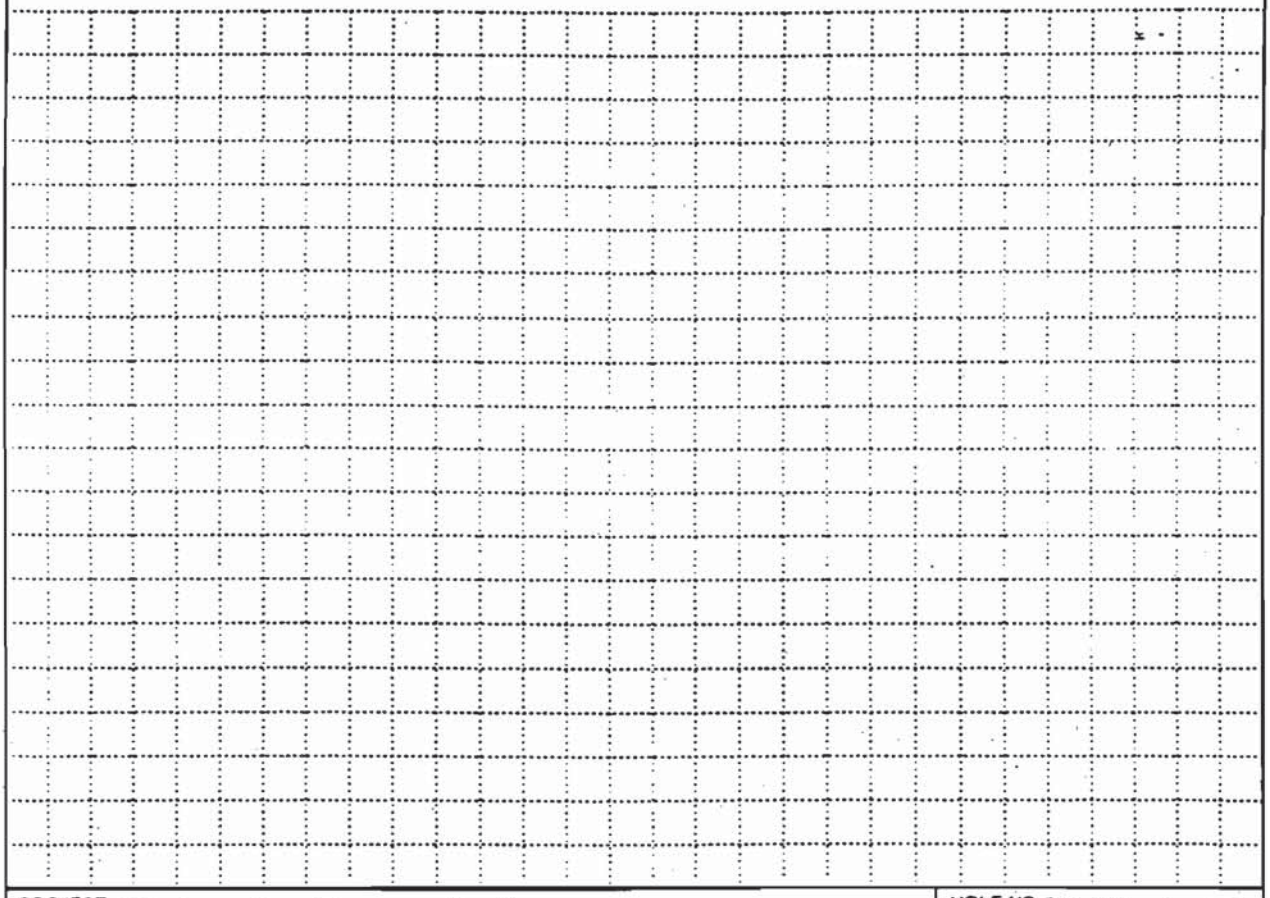
18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
3" spl.t spoon drive	8		

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY
						%

22 DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR
		X		Matt Brookshier

LOCATION SKETCH/COMMENTS

SCALE:



PROJECT: Ft. Lewis Impact Area

HOLE NO: 98-JA-MW8

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: FB-IA-MW8
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshire
SHEET 2 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	GW: Well graded gravel with cobbles, sand, and silt; gravel size particles and larger are well rounded, sand is sub-angular, coarse to medium; silt is black (root zone to 2FT) abundance of silt drops to thin coating on larger particles below 2FT. formation is damp and black to 2FT; damp and grey to brown to 5FT.		Grab			Mob, ¼ 861 tasing 4" ID HSA; Sampling with 3" OD x 12" spoon driven by 300 lb hammer with 36" stroke Begin MW8 boring 7JAN99 Drill 0-5FT 1010-1012 Pretty rough drilling mostly gravel with cobbles up to 5". Mostly volcanic origin particles; granitic gneissic rock 1-2%
	2						
	3						
	4						
	5						Drill 5-10FT 1019-had to leave to talk on phone. Drillers report refusal at 9FT Back on site at 1049: drillers back down to 5FT Drill 5-10FT 1049-1050 some backing not too rough
	6	SW: well graded sand, coarse to medium, sub-rounded to sub angular, 10-20% gravel present well rounded 1½-¾", fine coating of silt and very fine sand on larger particles (1-2%); damp brown		Grab			
	7						
	8						
	9						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER 98-IA-MW26
SHEET 3 SHEETS OF 6

PROJECT Ft. Lewis Impact Area
INSPECTOR Matt Brookshier

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	GP: Poorly graded gravel 1-1/4" and coarse to medium sand. Larger grains have light coating of silt. Gravel 70% sand 30% damp, brown.		A: 10-11 no recovery Grab		N: 17 27	Instruct drillers to go to 15FT for next sample try: must be pushing a large cobble-down. Drill 10-15FT 1109-1110 fairly smooth drilling, rougher from 13-15FT material is slightly coarser than 5-10FT interval
	12						
	13						
	14						
	15	SP: Poorly graded, coarse, subangular sand with gravel. Gravel is sub rounded 2"-1/4". Trace of fines present, much less than cuttings from 0-15FT, material is brown, moist. Probably occasional cobbles		B: 15-16.5 70% recovery		N: 13 18 15	Drillers change to brand new 3" OD X 18" split spoon; still using 300lb hammer with 36" stroke Drill 15-20FT 1137-1138 somewhat rough drilling through 16.5FT smoothes thereafter, gravelly probably cobbley from 13-16.5FT cuttings returning are still primarily gravel, some sand
	16						
	17						
	18						
	19						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: FB-IA-MW8
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 SHEETS 6 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	SP: poorly graded, coarse, sub angular sand, medium sand 10%; gravel 1:½"-1½" sub rounded 10%, trace clay; moist, brown to dark grey.		C: 20-21.5 80% recovery		N: 20 25 30	broken cobble driven into spoon Drill 20-25FT 1200-
	22	A few pea size pods of blue-grey clay. Occasional cobble.					rough from 22 to 23FT occasional rough spot there after.
	23						Cutter head tooth came up auger flights, will drive sample and then pull head up for repairs
	24						
	25	GP: sandy (coarse) poorly graded gravel with 5% fines, gravel is mostly coarse w/ occasional cobble to 5", sub rounded sand is sub angular (40%) some free clay, mostly a film of fines on larger grain sizes. very moist, brown.		D: 25FT to 26.5FT 75% recovery		N: 13 20 18	1225 pulling augers 1345 drilling from surface in same boring with new cutter head
	26						
	27						Drill 25-30FT 1353-1354 drilling is rough from 25-26.5 then very smooth to 30FT
	28						
	29						very moist clay/silt on guidebit

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-TA-MW8
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshire
SHEET: 5 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	SP: gravelly poorly graded coarse sand, sub angular; larger grains coated with fines (some free clay) about 5%; wet, brown. Cobbles occasionally, one andesite cobble in spoon.		E: 30FT -31.5FT 50% recovery		N: 12 40 45/3"	Sampler hit a large rock at 30.6FT 1420 WL @ 31.4 FT Drill 30-35FT 1424-1425 drilling is fairly rough, coarse materials, occasional cobble
	32						
	33	Formation is just barely wet, some free water					
	34						
	35			F: 35FT-36.5FT no recovery		N: 50/2" refusal	Driving on top of a rock Instruct drillers to drill to 40FT and take next sample; formation is too cobbley to get good recovery
	36	SP: cobbley coarse sand and fine gravel, some fines and fine sand, about 5%, wet, brown. Based on a handful of material					WL @ 34.0FT 1444 water rose up to 32FT on drive sampler
	37						
	38						Drill 35-40FT 1449-1450 Rough drilling at first, pretty smooth after 36.5FT
	39						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER 48-IA-MW8

PROJECT Ft. Lewis Impact Area | INSPECTOR Matt Brookshier | SHEET 6 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	41	SP: Coarse to medium sand with gravel and ~1% fines. Sand is subangular, well compacted. Scattered gravel is subrounded to well rounded, occasional cobble, maybe occasional clayey stringer, wet brown		G: 40FT-41.5FT 100% recovery		N: 10 heave 41 48	Formation heaved 2FT material in auger have drillers drill back down with more weight on pipe 1506 WL @ 33.35 1537 WL @ 33.40 Drill 40-45FT 1541 – 1542 rough drilling 41-42, then fairly smooth, gravelly
	42						
	43						
	44						
	45	Bottom of boring 45DFT					
		SP: clayey coarse sand with fine gravel, compact, occasional larger gravel and cobble wet, brown.		H: 45.0-46.5FT		N: 5 heave 21 50/4"	6" heave in stem 1609 WL @ 33.35 Bottom of hole sounds at 45.15 Quit for day 1615 drillers need supplies.
	46						
	47	Clay orfives are uniform throughout sample					
	48						
	49						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW8
Completion date 8JAN98
Contractor Andrew Well Drilling
Rig Mobile B-61
Operator Matt Gilbert
Inspector Matt Brookshier
Depth _____ Datum _____

HOLE DATA
Size: 8 in. to 45 FT ft.
_____ in. to _____ ft.
_____ in. to _____ ft.

CASING
Type _____
Mfr. _____
Ht. above gnd. surf. _____
Drive shoe _____
Size: _____ in. to _____ ft.
_____ in. to _____ ft.
_____ in. to _____ ft.

SCREEN
Type .01" slot
Mfr. Boart Longyear
Composition PVC Dia. 2"

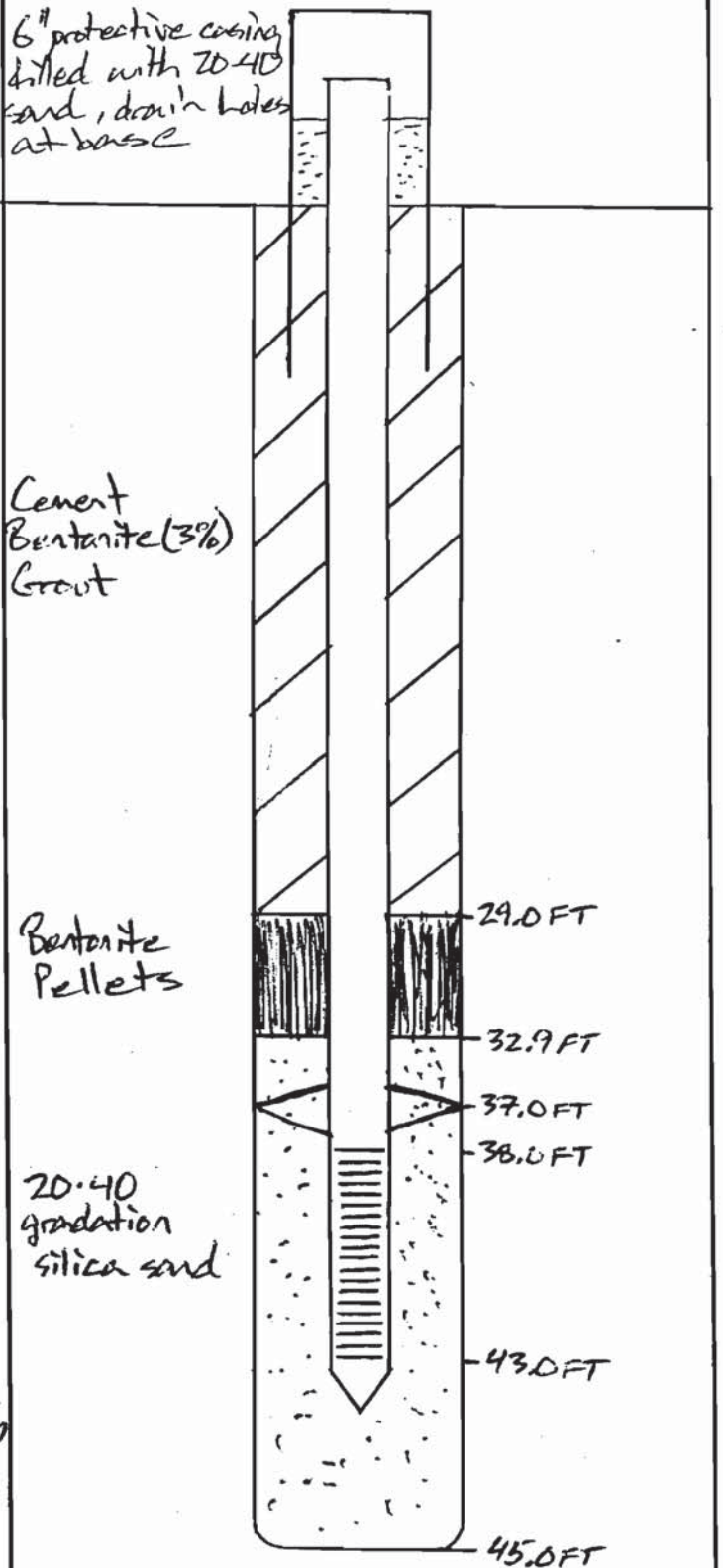
Fittings:	Length	Dia.
Packer		
Riser	40 FT	2"
Tailpipe		

FILTER
Source CSSI
Composition silica
Gradation 20-40
Inst. method poured down HSA
Volume used ~3 cu ft
Depth 45 to 32.9 FT ft.

GROUT
Composition Cement-Bentonite (3%)
Volume used 33 ft³
Inst. method Tremie pipe
Depth 29.0 to 0 ft.
_____ to _____ ft.

REMARKS: Had trouble with sand bridging in HSA had to knock it down with steel rod; same problem with bentonite pellets, constantly tamped with rod while pouring pellets. Boring took a lot of grout. While drilling, had to pull auger due to damaged bit, and redrilled back down to 25 FT mark.

WELL DETAIL (AS BUILT)
AEP-008



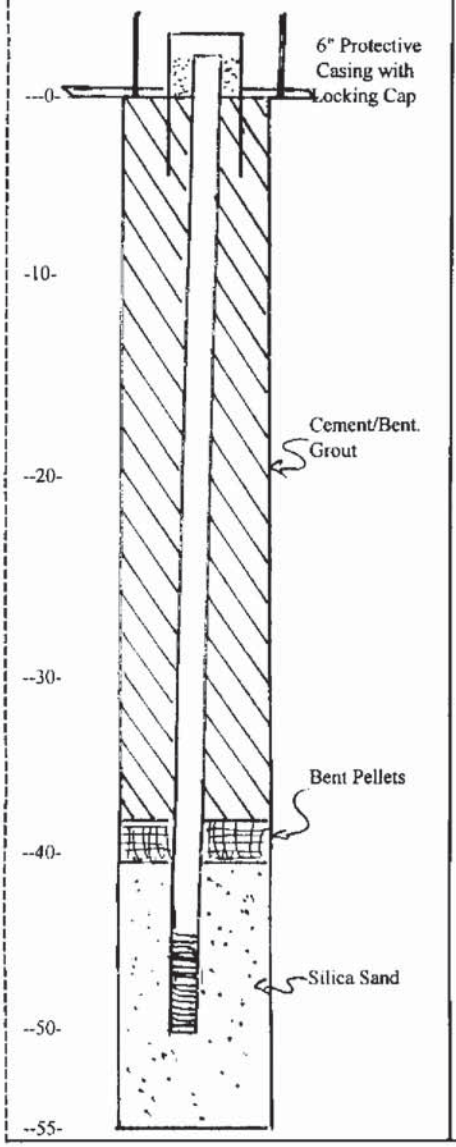
RESOURCE PROTECTION WELL REPORT

START CARD NO. R16881

PROJECT NAME: Installation of Water Monitoring Wells
WELL IDENTIFICATION NO. 98-IA-MW9/Tag #AEP 009
DRILLING METHOD: Auger
DRILLER: Craig S. DeYoung
FIRM: Andrew Well Drilling Services
SIGNATURE:
CONSULTING FIRM: US Army, Corps of Engineers
REPRESENTATIVE: Matt Brookshier

COUNTY: Pierce
LOCATION: SW 1/4 NE 1/4 Sec 16 Twn 18N R 2E
STREET ADDRESS OF WELL: Central Impact Area/Artillery Impact Area, Ft. Lewis, Washington
WATER LEVEL ELEVATION: 33
GROUND SURFACE ELEVATION: Unknown
INSTALLED: December 18, 1998
DEVELOPED: December 18, 1998

As-Built



Well Data

SIZE:	8" to 55.0ft
CASING:	
Ht above Surface:	2ft
	2" Sch 80 PVC
Drive Shoe:	None
SCREEN:	
Type:	2"Sch 80 .010 Slotted PVC
Location:	49.0 to 44.0 ft
MFG:	Boart Longyear
FILTER:	
Composition:	Silica Sand 10/20 and 20/40
Installation:	Poured from surface in cased hole
Depth:	41.0 to 50.0 ft
GROUT:	
Composition:	Bentonite Pellets
Installation:	Poured from surface in cased hole
Depth:	38.0 to 41.0ft
Composition:	Bentonite/cement grout
Installation:	Tremie Pipe
Depth:	38.0 to surface
SURFACE COMPLETION:	Vault Cover

FORMATION DESCRIPTION

00.0- 10.0 Gravel w/silty sand
10.0-25.0 Gravel and Sand
25.0-30.0 Sandy gravel
30.0-55.0 Sand w/gravel

SCALE 1" = 10ft

PAGE: 1 OF 1

HTRW DRILLING LOG

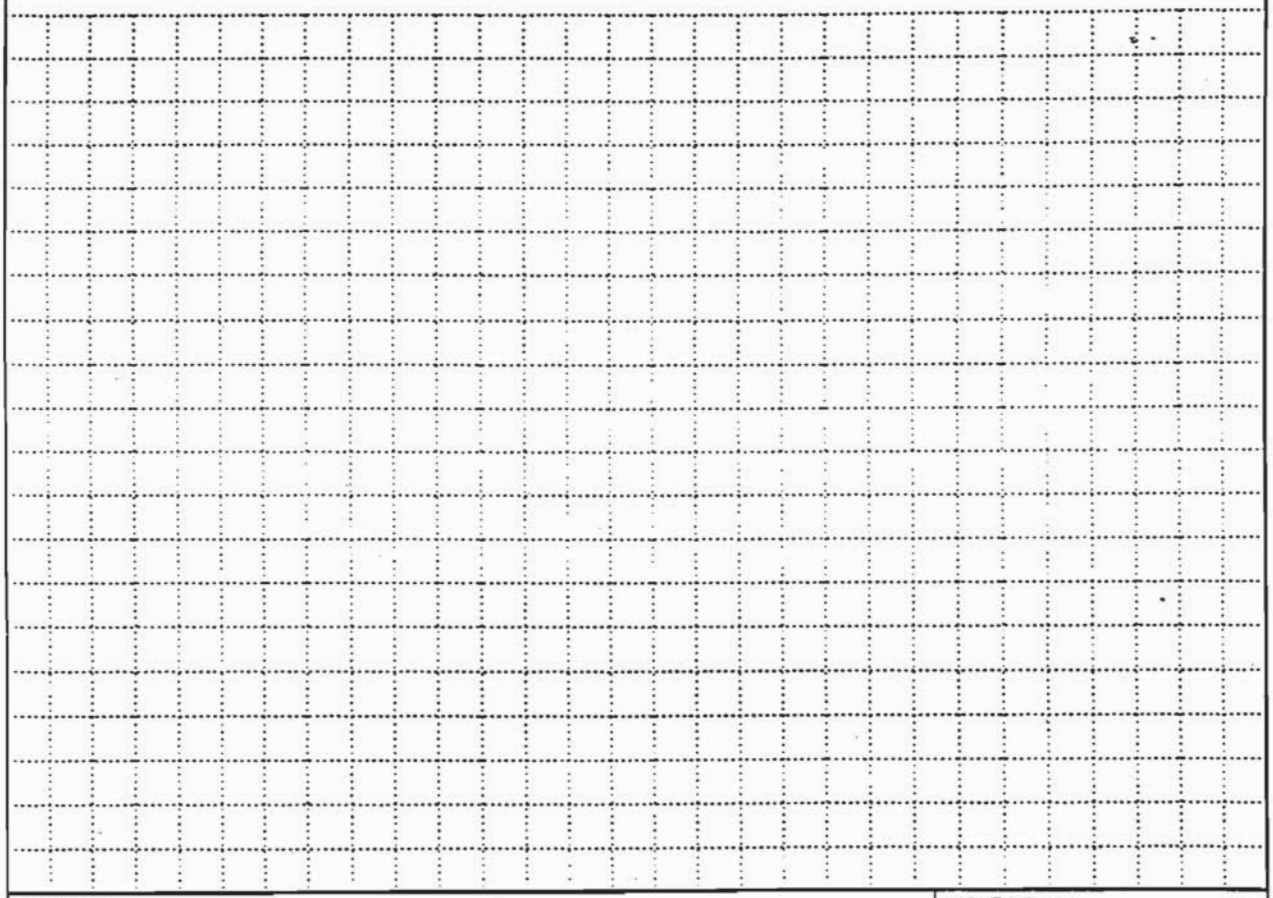
DISTRICT: CENWS

HOLE NUMBER: 98-IA-MW9

SHEET 1 OF 7 SHEETS

1. COMPANY NAME: U.S. Army Corps of Engineers
2. DRILL SUBCONTRACTOR: Andrew Well Drilling Service
3. PROJECT: Impact Area Monitoring Wells
4. LOCATION: Ft. Lewis, WA
5. NAME OF DRILLER: Matt Gilbert
6. MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-61
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4" ID Hollow Stem Auger - 8" OD; 3" OD split spoon drive sampler x 12"; 2" OD split spoon drive sampler x 18"
8. HOLE LOCATION: SE SW NE; Sec. 16; T18N; R2E
9. SURFACE ELEVATION: ~320 FT ; 7.5' quad
10. DATE STARTED: 17NOV98
11. DATE COMPLETED: 18 NOV98
12. OVERBURDEN THICKNESS:
13. DEPTH DRILLED INTO ROCK: 0
14. TOTAL DEPTH OF HOLE: 55 FT
15. DEPTH GROUNDWATER ENCOUNTERED: 42.25 FT
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):
18. GEOTECHNICAL SAMPLES: Drive Samples — DISTURBED: 10 — UNDISTURBED:
19. TOTAL NUMBER OF CORE BOXES:
20. SAMPLES FOR CHEMICAL ANALYSIS — VOC: — METALS: — OTHER (SPECIFY): — OTHER (SPECIFY): — OTHER (SPECIFY):
21. TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE — BACKFILLED: — MONITORING WELL: X — OTHER (SPECIFY):
23. SIGNATURE OF INSPECTOR: Matt Brookshier

LOCATION SKETCH/COMMENTS — SCALE:



PROJECT: Ft. Lewis Impact Area — HOLE NO: 98-IA-MW9

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW9

PROJECT: Ft. Lewis Impact Area

INSPECTOR: Matt Brookshier

SHEET 2 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	1	GW: well graded gravel 1½-2" nominal grading to ½", dry, grey to brown <5% dark brown silt		Grab Sample			17NOV98: begin drilling at 1335 w/ Mobile B-61 driving 4¼" HSA
	2	Mix of granitic and volcanic gravels					
	3						
	4						Drilling paused: 1340-1440 some trouble mating auger flights, have to weed out bad flight joints. Had to pull cutting head out of hole and attach to new flight
	5	cuttings from 5-10 ft brought up auger flights are unchanged from above		Grab Sample			
	6						
	7						Drilling 5-10 ft 1444-1448 wire buckled in cat head, fixing problem 1455-1605 AGAIN at 1615
	8						
	9						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW9
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshire
SHEET 3 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	GW-SW-well graded gravelly sand, gravel 1" nominal grading through medium sand, dry, brown grey (no silt) sand is sub-angular gravel is rounded 50% sand 50% gravel by drive sample		A 10-11		mixed-poor blows	1406 hammer w/ 36" stroke 18NOV98 begin w/ drive sample at 0800 3" OD split spoon 12" long 50% recovery for A
	12						
	13						Drill 10-15 FT 825-827 soft drilling sandy zone
	14						
	15					N= 16	50% recovery
	16	GW-SW-Well graded gravel and sand as above, moist, brown (no silt) very clean gravels more sub-rounded than above		B 15-16		39	Drill 15-20 FT 950-952 very easy drilling
	17						
	18	formation appears to be pretty soft (based on drilling)					blows are pretty weak still
	19						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW9
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshire
SHEET 4 of 7 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	No sample collected		C 20-21		39 50/1	No recovery Advised drillers to put a sample retainer in spoon for next drive
	22	No moisture on spoon					
	23						
	24						
	25	Change in materials somewhere between 16 and 25 FT				N= 100/5"	Drill 20-25 933-935 very easy drilling 10% recovery
		Poor sample recovery GP-GC - GRAVEL with clay and sand, gravel to 3" (broken in spoon) in clay and medium sand matrix, moist, grey/brown		D 25-26			
	26						
	27						Drill 25-30 1001-1004 easy drilling
	28						
	29						
		Change in materials between 26-30 FT gradation changing?					

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW9
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 5 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	SP - Poorly sorted medium sand with gravel (1") 10% and clay (silt?) coating, about 2%, Charcoal present in bottom of		E 30-31.5		N= 37 43 45 100% recovery	140 lb hammer with 18" long 2" OD spoon. Experiment to see if recovery is better
	32	sample, moist, grey brown					Drill 30-35FT
	33	charcoal or coal pieces are up to 3/8"					1040 - very easy drilling
	34						
	35	SP as above, poor sample recovery, Appears to be more		F		N= 37 43 50/5	30% recovery
	36	gravel than E to about 30%, same		35-36.5			Drill 35-40 1108-1112
	37	clay content. moist brown grey No charcoal					harder drilling mast bucking around a bit
	38	gravel up to 1½"					moist cuttings coming up auger flights finally
	39						

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW9

PROJECT: Ft. Lewis Impact Area

INSPECTOR: Matt Brookshier

SHEET 6 OF 7 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	41	SP-SC - coarse to medium sand with some clay 5-7% moist, brown/grey		G		N= 43, 56/6	10% recovery probably pushed a cobble down in front of sample will change back to 3" sampler for H
	42	very poor sample to classify materials by		40-41.X			Drill 40-45
	43						SWL @ 1250 42.25 FT
	44						
	45	SP - poorly sorted medium to coarse		H		N= 28 50/4	140 lb hammer 3" OD x 12" spoon
	46	sand w/ Gravel (1¼") and some clay <5% wet, grey/olive		45-45.9			80% recovery Drill 45-50 1324-1327 fairly easy drilling
	47	sand somewhat gap graded ¼" & ⅛" nominal					
	48						WL @ 41.5 FT 1335
	49						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: ~~98-IA-MW9~~

PROJECT: Ft Lewis Impact Area. INSPECTOR: Matt Brookshier SHEET 7 SHEETS OF 7

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	51	SP as above, poorly sorted sand 3/8" and 1/16" nominal, trace gravel to 1½", some clay, saturated, brown/grey more clay than H- much soupier		I 50-51		N= 29 50/5"	140lb hammer with 3"OD x 12" spoon ~~Drill 50-55~~ WL @ 42.5 FT 1359 Drill 50-55 1406-1409 easy drilling
	52						
	53						
	54						
	55	Bottom of boring @ 55FT					
	56	SP-SC: Poorly ~~sorted~~ coarse sand and clay with some gravel up to 1½". Nominal sand 3/8"-½" with some fine sand in a clayey matrix grey ~~brown~~ olive, wet.		J 55-56		N= 27 48	1420 WL @ 51.5FT 70% recovery 1445 WL @ 51.5
	57						
	58						
	59						

PROJECT HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW9
Completion date 20 NOV 98
Contractor Andrew Well Drilling
Rig Mobile B-61
Operator Matt Gilbert
Inspector Matt Brookshier
Depth 50 FT Datum Ground Surface

HOLE DATA
Size: 8" in. to 55 FT ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type .01 inch slot x 5FT
Mfr. Boart Longyear
Composition PVC Dia. 2"

Fittings:	Length	Dia.
Packer		
Riser		
Tailpipe		

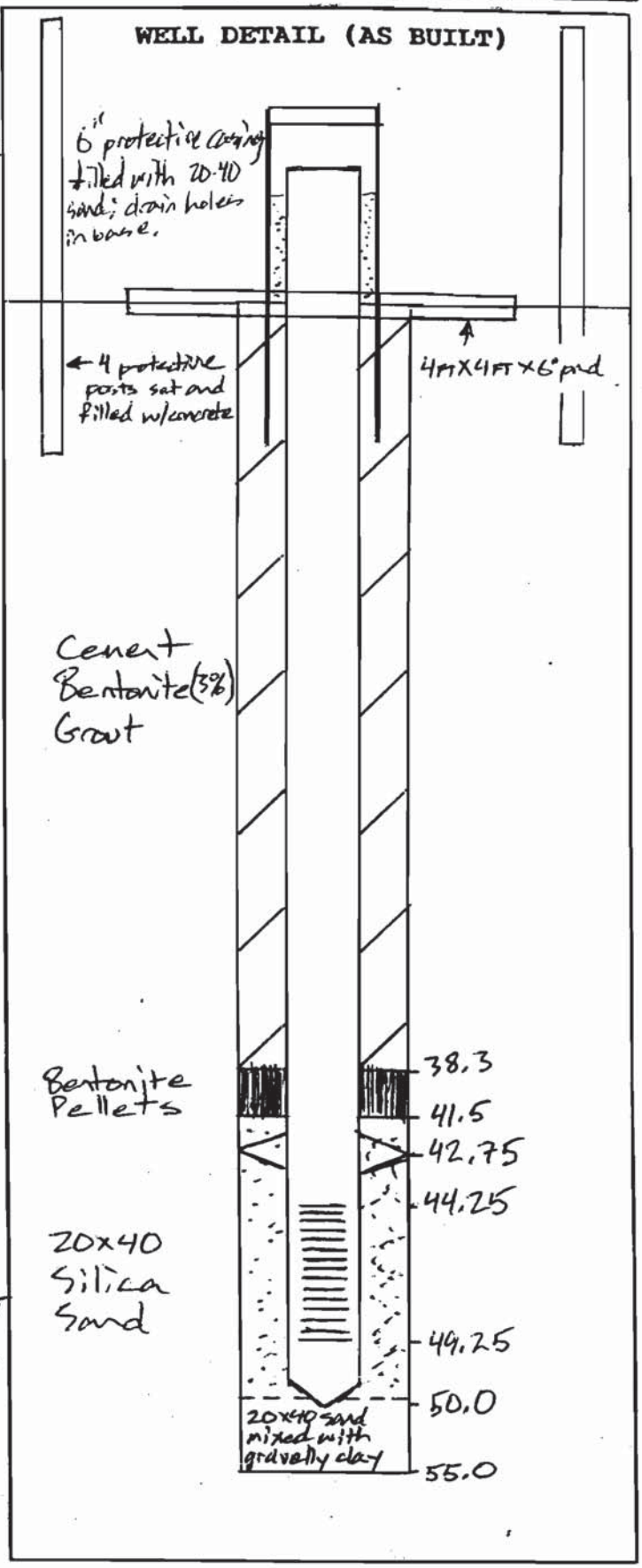
FILTER
Source Colorado Silica Sand
Composition silica
Gradation 20x40
Inst. method poured and surged
Volume used ~2 ft³ (2 sacks)
Depth 50 FT to 41.5 FT ft.

GROUT
Composition cement-bentonite(3%)
Volume used 30 sacks + 1 sack = ~31 ft³
Inst. method tremie
Depth 38.3 FT to 0 FT ft.
____ to ____ ft.

REMARKS: Attempted to fill 55-50 FT with 20x40 sand, but formation heaved filling that area. Bentonite pellet plug hydrated with 20 gallons of water for 18 hours.

20x40 sand placed in casing riser and 2, ⅛" drain holes drilled in base of riser. Cap is locked with 485 series lock.

WELL DETAIL (AS BUILT)



RESOURCE PROTECTION WELL REPORT

START CARD NO. R16882

PROJECT NAME: Installation of Water Monitoring Wells

WELL IDENTIFICATION NO. 98-IA-MW10/Tag #AEP 012

DRILLING METHOD: Auger

DRILLER: Craig S. DeYoung

FIRM: Andrew Well Drilling Services

SIGNATURE:

CONSULTING FIRM: US Army, Corps of Engineers

REPRESENTATIVE: Matt Brookshier

COUNTY: Pierce

LOCATION: SE 1/4 NW1/4 Sec 11 Twn 18N R 2E

STREET ADDRESS OF WELL: Central Impact Area/Artillery Impact Area, Ft. Lewis, Washington

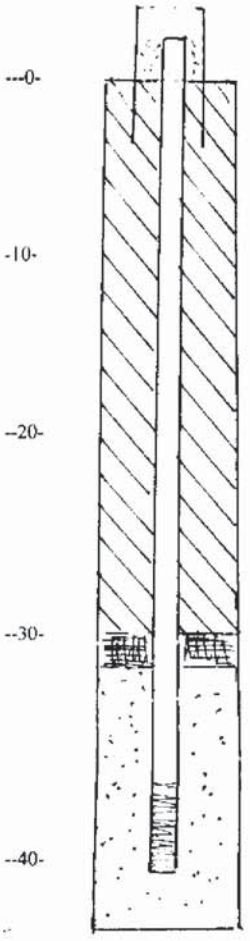
WATER LEVEL ELEVATION: 27ft

GROUND SURFACE ELEVATION: Unknown

INSTALLED: December 18, 1998

DEVELOPED: December 18, 1998

As-Built



Well Data

SIZE:	8" to 43.0ft
CASING:	2" Sch 80PVC
Ht above Surface:	2ft
Drive Shoe:	None
SCREEN:	
Type:	2"Sch 80 .010 Slotted PVC
Location:	39.0 to 34.0 ft
MFG:	Boart Longyear
FILTER:	
Composition:	Silica Sand 10/20 and 20/40
Installation:	Poured from surface in cased hole
Depth:	32.0 to 43.0 ft
GROUT:	
Composition:	Bentonite Pellets
Installation:	Poured from surface in cased hole
Depth:	30.0 to 32.0ft
Composition:	Bentonite/cement grout
Installation:	Tremie Pipe
Depth:	30.0 to surface
SURFACE COMPLETION:	Vault Cover

FORMATION DESCRIPTION

00.0-05.0	Gravel w/cobbles
05.0-09.0	Coarse sand
09.0-43.0	Sandy Gravels

SCALE: 1" = 10ft

PAGE: 1 OF 1

HTRW DRILLING LOG

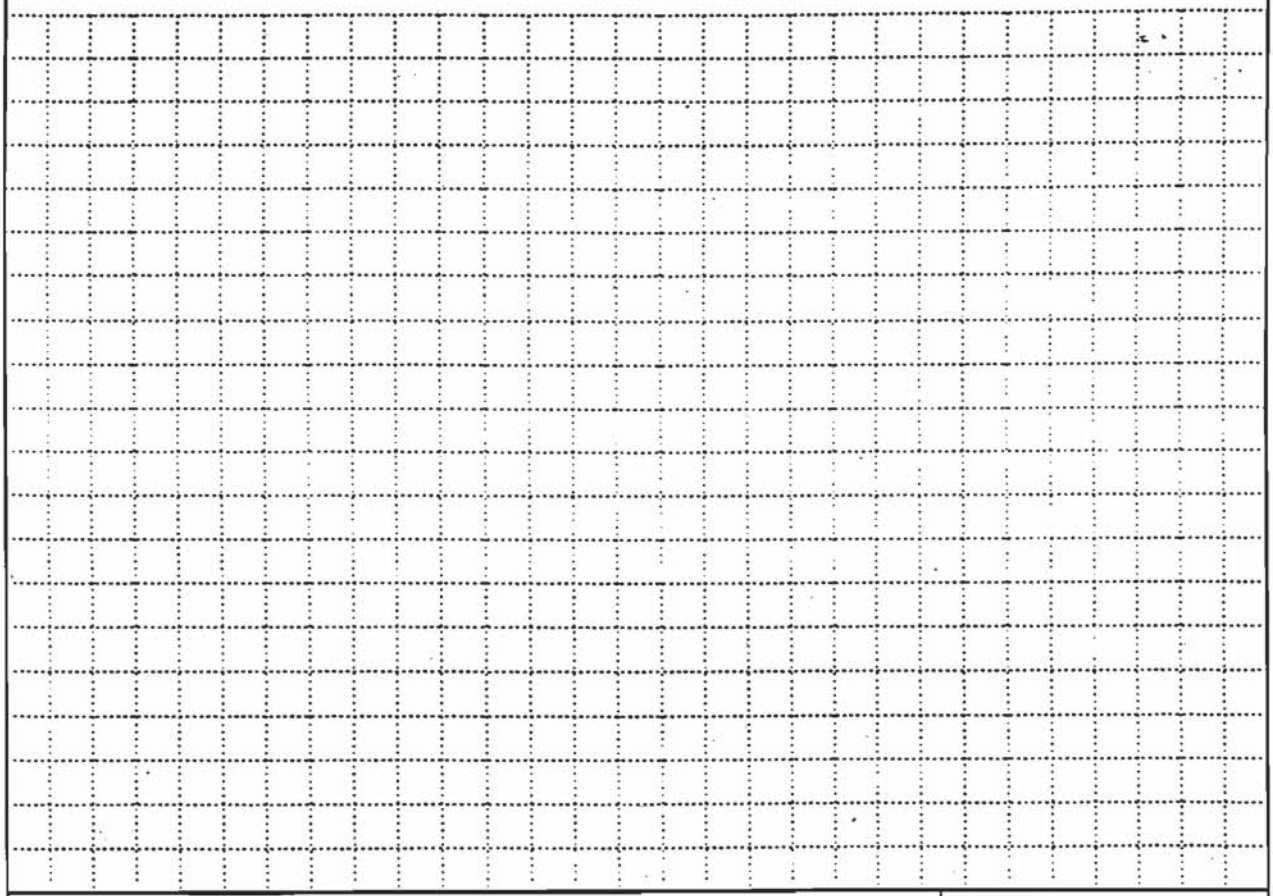
DISTRICT	CENWS
HOLE NUMBER	98-IA-MW10
SHEET	1 OF 6 SHEETS
1 COMPANY NAME	USACE
2. DRILL SUBCONTRACTOR	Andrew Well Drilling Service
3 PROJECT	Ft. Lewis Impact Area
4 LOCATION	Ft. Lewis, WA
5 NAME OF DRILLER	Matt Gilbert
6 MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-61
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	4" ID HSA: 8" OD; 3" OD x 12" split spoon drive sampler; 300lb hammer w/ 36" stroke
8 HOLE LOCATION	T18N; R2E; Sec. 11; SW SE NW
9 SURFACE ELEVATION	~360 FT
10. DATE STARTED	21 NOV 98
11 DATE COMPLETED	5 JAN 99
12 OVERBURDEN THICKNESS	43 FT
13 DEPTH GROUNDWATER ENCOUNTERED	29.55 FT
13 DEPTH DRILLED INTO ROCK	0 FT
16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14 TOTAL DEPTH OF HOLE	43 FT
17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
Drive Samples	8		

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR
well completion		X		Matt Brookshier

LOCATION SKETCH/COMMENTS SCALE:



PROJECT	HOLE NO
Ft. Lewis Impact Area	98-IA-MW10

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW10

PROJECT: Ft. Lewis Impact Area | INSPECTOR: Matt Brookshier | SHEET 2 SHEETS OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
		silty gravel, root zone, 1" gravel, dark brown, moist			Grab		Begin 0825 21NOV98 4" ID HSA turned by Mobile B-61
	1						Has been running for 36 hours
	2						
		GW: well graded gravel with medium sand. Gravel 3" through 3/4", sand 1/32" - 1/8", Gravel is well rounded, sand is subrounded to sub-angular, mostly volcanic rock, a few granitic gravels. grey/brown, moist			Grab		Drill 0 - ~~10 FT~~ 5 FT 0825-0827
	3						Moderately easy drilling, rig bucking from time to time
	4						
	5						Still some trouble with drill transmission
		SW: well graded, coarse to medium sand with some gravels (rounded) up to 1", sand is sub-rounded, brown/olive, moist		Grab			
	6						
	7						0845 Large cobble or boulder at 7FT giving rig problems 0850: down to check on transmission
	8	more granitic and gneissic gravels at this site than AIA borings; Volcanics are still 95% of gravels.		Torque Converter had to be replaced			910 could not pass ~~dog~~ obstruction, moved rig 3 FT east
	9						Transmission is down 4JAN99 resume drilling MW10 at 1343. To 7FT @ 1353 refusal, must be 4-5 FT boulder To 10FT @ 1445 (15FT SW)

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW10
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 3 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	11	SP: Poorly graded medium, subangular sand with gravel (10%) and ~~debris~~ occasional cobble. Fine sand present up to 10%, no fines, dry, dark brown.		A: 10-11 65% recovery		N: 46 27	Finally make it past 7FT, mark hole is 15FT SW of previous 3 attempts (1445) Drove through a 4-5" cobble in 1st 6"
	12	Gravel is rounded to sub rounded and mostly volcanic origin					Drill 10-15FT 1514 to 1515
	13						very smooth drilling, no cobbles encountered
	14						
	15	SP/GP: Poorly graded coarse sand and gravel (3/4"-1 1/2" remind), sand is subangular as above but much coarser. Gravel (up to 45%) is rounded. Trace fines present, just enough to discolor skin. Sample is dry, dark brown to dark grey		B: 15-16 60% Recovery		N: 14 18	Sample is very dry with no cohesion, changed basket for Drive C
	16						
	17						Drill 15-20FT 1531-1532
	18						very smooth drilling as before no resistance noted
	19						Cuttings returning are coarse, rounded gravel with fine coating of fine sand and silt/clay

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: TB-DA-MW10
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 4 SHEETS OF 6

ELEV (a)	DEPTH (ft)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	21	GP-SP: Gravel and sand similar to drive B but more gravel, very loose material, Gravel is rounded to subrounded, ½"-2½", with light coating of fine sand and silt. Sand is mostly coarse (40% of material), subangular with some medium to fine constituent (5-10%); dry, dark brown to grey		~~C: 20-21~~ C: 20.5-21.5 50% recovery		~~N:~~ ~~19~~ ~~25~~ N: 19 32	No recovery in spoon (1 broken cobble) will redo sample; sampler stopped at 20.5 Drill 20-25FT 1557-1559 Drilling is much rougher at 21FT to 23FT then smooth again
	25	SP: Poorly graded coarse sand with some fine to medium gravel, little or no fines; sand is sub angular; gravel is rounded to subrounded (finer gravel) moist, dark brown to dark grey		D: 25-26 50% recovery		N: 25 10/4"	Driving against a large cobble or boulder at 25.5 Drill 25-30FT 1621-1623 rougher drilling cobble zone at 27-28FT guide bit is very moist Cuttings are mostly 1" gravel coated with thin veneer of fine sand and fines.

PROJECT | HOLE NO.

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 98-IA-MW10
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 5 SHEETS OF 6

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
	31	SP: Poorly graded medium to fine sand with occasional gravel, sand is sub angular, some silt present, wet, brown		E: 30-31 100% recovery		N: 13 15	1632 WL at 29.55 FT Drill 30-35 FT 1636-1638 smooth drill action
	35	SP as above but with no gravel, slightly more silt, wet, brown		F: 35-36 100% recovery		N: 6 13	5JAN99, 915 WL at 30.45 FT Drill 35-40 FT 919-921 Very smooth drill operation

PROJECT
HOLE NO.

ENG FORM 5056A-R, AUG 94
(Proponent: CECW-EG)

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: 78-IA-MW10
PROJECT: Ft. Lewis Impact Area
INSPECTOR: Matt Brookshier
SHEET 6 & 6 SHEETS

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO (E)	ANALYTICAL SAMPLE NO (F)	BLOW COUNT (G)	REMARKS (H)
	41	SP: Poorly graded medium to fine sand with minute silt, sand is subangular as before but slightly more fine sand content, wet brown.		G:40-41 100% recovery		N: 7 18	963 WL ② 32.05FT Drill to 43FT to start placing filterpack, form is heaving slightly due to such fine sand. 957-959
	42						
	43	43.0FT bottom of boring					
	44						
	45						
	46						
	47						
	48						
	49						

PROJECT

HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

WELL COMPLETION REPORT

Project Ft. Lewis Impact Area Well No. 98-IA-MW10
Completion date 6JAN99
Contractor Andrew Well Drilling
Rig Mobile B-61
Operator Matt Gilbert
Inspector Matt Brockbier
Depth 43 FT Datum Ground surface

HOLE DATA
Size: 8 in. to 43 FT ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type .01" slot
Mfr. Smart Longyear
Composition PVC Dia. 2"

Fittings:	Length	Dia.
Packer		
Riser	36 FT	2"
Tailpipe		

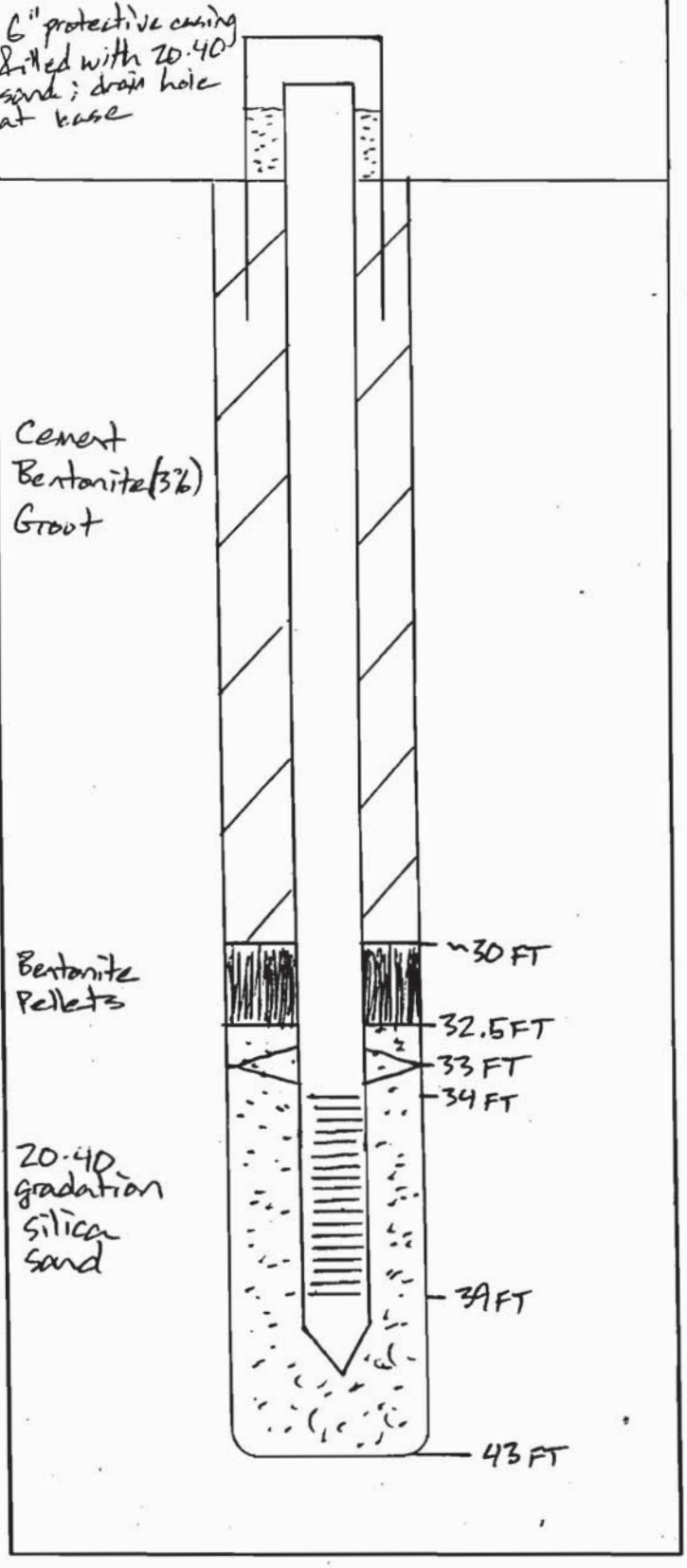
FILTER
Source CSSI
Composition silica
Gradation 20-40
Inst. method pour through HSA
Volume used 2 cuft
Depth ~43 to 32.5 ft.

GROUT
Composition Cement-Bentonite (5%)
Volume used 18 cuft
Inst. method pumped down HSA
Depth ~30 to 0 ft.
____ to ____ ft.

REMARKS: Boring was drilled to 43FT due to heaving formation. Bentonite plug thickness is estimated due to bridge of pellets in HSA. Grout was not tremied due to plug of pellets inside auger; grout was placed through a hole punched through the obstruction. Drillers pulled PVC up 2FT while removing augers. Screened interval was specified to be from 41-36 FT.

WELL DETAIL (AS BUILT)

AEP-012



SUMMARY LOG

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER MW-3

PROJECT Building 3138 | INSPECTOR RICHARD SMITH | SHEET 2 OF 2 SHEETS

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)
		GP-GM: Coarse gravel with silt and sand, brown, moist to wet.					
			PID=0ppm CGI=0%LEL			11/6,18/6,35/6	
	10	GM: Fine and coarse silty gravel with sand, moist, dark brown/ black, wood fragments + roots.	PID=0ppm CGI=0%LEL			5/6,7/6,12/6	
		GP: Fine to coarse gravel with sand, wet, brown.	PID=0ppm CGI=0%LEL			14/6,50/6	
	20		PID=0ppm CGI=0%LEL			10/6,20/6,10/6	
						20/6,50/6	
	30						

PROJECT Building 3138 & 6038 Monitoring Well Installation | HOLE NO. MW-3

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

Figure 4-2. (Concluded) Unique WA DOE # ACS 895

WELL COMPLETION REPORT

Unique WA DOE # ACS 895

Project Building 3138 Monitoring Well Installation Well No. MW-3
Completion date 5/7/97
Contractor R&R Drilling
Rig Mobile B-61
Operator Rick Carmel
Inspector Richard Smith
Depth 24 feet Datum Ground Surface

HOLE DATA
Size: 6 in. to 24 ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type ____
Mfr. ____
Ht. above gnd. surf. ____
Drive shoe ____
Size: ____ in. to ____ ft.
____ in. to ____ ft.
____ in. to ____ ft.

SCREEN
Type Wheelabrator, Sch. 40 .006" slotted
Mfr. Johnson
Composition PVC Dia. 2"

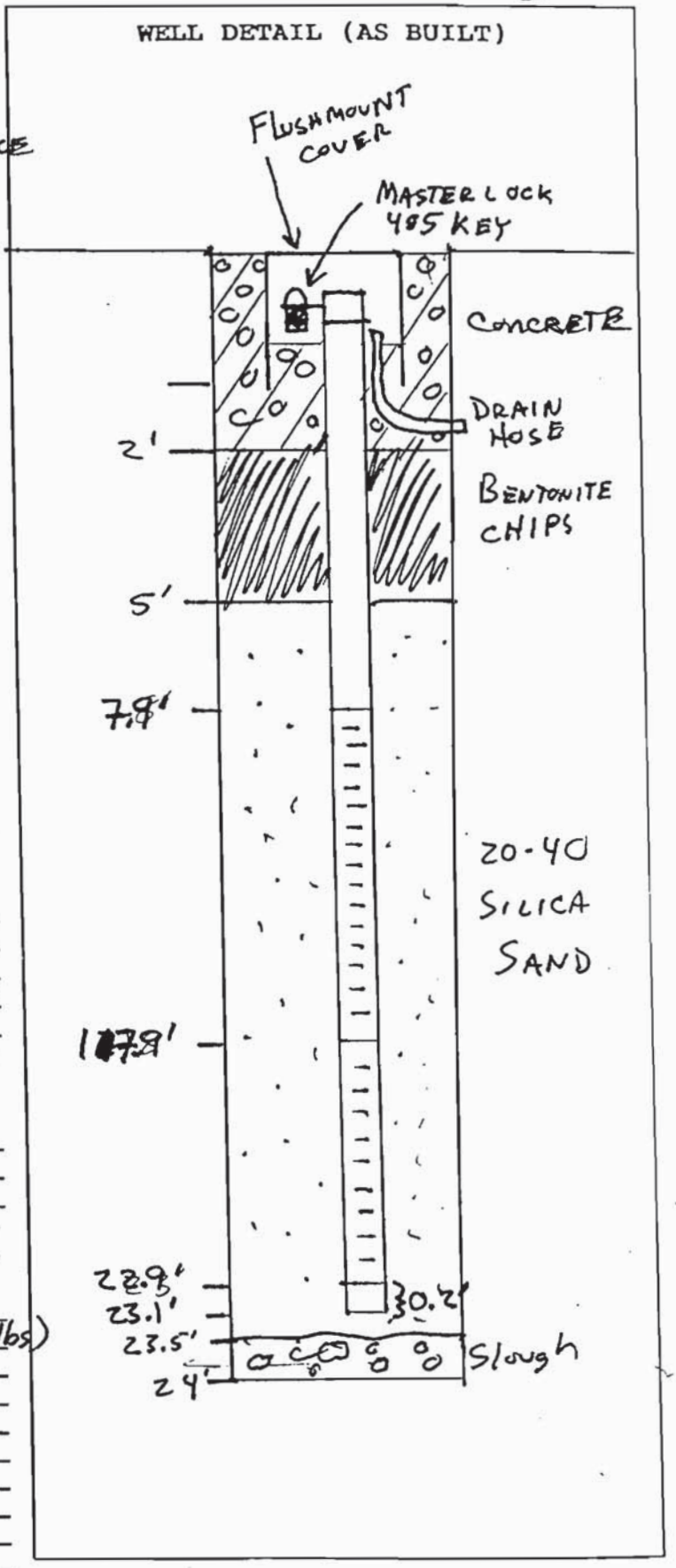
Fittings:	Length	Dia.
Packer		
Riser		
Tailpipe		

FILTER
Source Colorado Silica Sand Inc
Composition Silica Sand
Gradation 20-40
Inst. method Poured Down Hole
Volume used ~~650~~ 700 lbs
Depth 5' to 23.5' ft.

GROUT
Composition ____
Volume used ____
Inst. method ____
Depth ____ to ____ ft.
____ to ____ ft.

REMARKS: Bentonite chips thoroughly hydrated - 2 (50lbs) sacks.

WELL DETAIL (AS BUILT)



ENVIRONMENTAL BOREHOLE LOG 9700-MW1

Date Started 1/8/96	Location N 651372.92/E 1134129.45	Depth Water First Encountered (Ft) 7.0
Date Completed 1/8/96	Drilling Company R&R	Drilling Method 4 1/4" I.D. HSA
Total Depth (Ft) 20.1	Sampling Method Split-spoon sampler	Hammer: Weight (lbs) 300 Drop (In) 18
Borehole Diam. (In) 10	Ground Elev. (ft) 274.84 / Monument Elev. (ft) 278.08	PVC Elev. (ft) 277.68

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol
								Ground Surface	
	1		9-24-25	72	0	1015		Medium dense to dense, dark brown, silty, sandy, fine to coarse GRAVEL; moist; scattered organics; (Fill?).	GM
	2		6-7-7	77	0	1026			
5	96AM01 SL01		20-26-32	44	0	1036	5.0	Very dense, silty, sandy, fine to coarse GRAVEL with cobbles; moist; wet below approximately 7 feet.	GM
	96AM01 SL02A		40-35-24	22	0	1043			
10	96AM01 SL02B		45-50/5"	58	0	1053	10.0	Very dense, grayish-brown, slightly silty, gravelly, fine to coarse SAND; wet.	SW-SM
	96AM01 SL03		20-35-50/2"	64	0	1108	12.0	Very dense, brown, fine to coarse SAND, trace of silt; wet.	SW
15	96AM01 SL04		45-50/3"	100	0	1121	15.0	Very dense, brown, fine to coarse sandy, fine to coarse GRAVEL, trace of silt; wet; not compacted.	GW
	96AM01 SL05		45-50/4"	70	0	1148			
20							20.0	BOTTOM OF BORING 20.08 FEET	

Soil Log / Well Log: 1.0, 3.5, 4.8, 7-11-96, 19.3, 20.1

Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

- 2" O.D. Split-Spoon Sample
- 3" O.D. Split-Spoon Sample
- Water Level and Date Measured
- Water Level at Time of Drilling

9700 Block Site Assessment
Fort Lewis, Washington

LOG OF BORING MW-1

June 1996 T-4108-03

Logged By	Reviewed By	SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	FIG. 7
PVH	KAT		

WQ20398
2.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. _____

UNIQUE WELL I.D. # 301

Water Right Permit No. _____

(1) **OWNER:** Name NISQUALLY INDIAN TRIBE Address _____

(2) **LOCATION OF WELL:** County Pierce SW ¼ AND SW 1/4 NW 1/4 Sec 22 T. 16N N., R 1E W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) Clear Creek

(3) **PROPOSED USE:** ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☒
Fish Production

(4) **TYPE OF WORK:** Owner's number of well (If more than one) #2
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16" inches. Drilled 80 feet. Depth of completed well 80 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 16" Diam. from +3 ft. to 50 ft.
Welded ☒ Liner installed ☐ Threaded ☐
" Diam. from _____ ft. to _____ ft.
" Diam. from _____ ft. to _____ ft.

Perforations: Yes ☐ No ☒
Type of perforator used _____
SIZE of perforations _____ in. by _____ in.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name HOUSTON
Type SS Model No. _____
Diam. 14" Slot size 150 from 55 ft. to 70 ft.
Diam. _____ Slot size 100 from 70 ft. to 75 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel _____
Gravel placed from _____ ft. to _____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 19' ft.
Material used in seal Cement Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? _____ Depth of strata _____
Method of sealing strata off _____

(7) **PUMP:** Manufacturer's Name _____
Type: _____ H.P. _____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level +25 APPROX ft.
Static level 14' ft. below top of well Date 4-1-94
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? AQUA FLO
Yield: 1500 gal./min. with 4' ft. drawdown after 5 hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.
Airtest _____ gal./min. with stem set at _____ ft. for _____ hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
FINE TO COARSE GRAVEL W SAND SILT	0	8
FINE TO MED SAND WITH OCC GRAVEL AND TRACE OF SILT	8	12
	12	22
FINE TO COARSE GRAVEL WITH SAND TRACE SILT		
FINE TO COARSE GRAVEL W COBBLES AND SAND AND TRACE SILT	22	43
	43	48
FINE TO COARSE GRAVEL W SAND OCC COBBLES TRACE OF SILT		
	48	52
FINE TO COARSE GRAVEL W COBBLES AND SAND AND TRACE OF SILT		
	52	62
FINE TO COARSE GRAVEL W SAND OCC. COBBLES AND TRACE SILT		
	62	77
FINE TO COARSE GRAVEL W COBBLES AND SAND, AND A TRACE OF SILT		
	77	80
FINE TO MED SAND OCC GRAVEL AND A TRACE OF SILT		

Work Started 11-93 19. Completed 3 19 94

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME AQUA FLO INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 1413 MERIDIAN E PUYALLUP WA

(Signed) Willy Hillert (WELL DRILLER) License No. 1469

Contractor's Registration No. 601348179 Date 5-3 19 94

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93) * * 1

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Start Card No. 2W020395

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

UNIQUE WELL I.D. # 302

Water Right Permit No. _____

(1) **OWNER:** Name NISQUALLY INDIAN TRIBE Address _____

(2) **LOCATION OF WELL:** County Pierce SW ¼ AND SW 1/4 NW 1/4 Sec 22 T. 18 N., R 1E W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) CLEAR CREEK

(3) **PROPOSED USE:** ☐ Domestic ☐ Industrial ☐ Municipal ☐ ☐ Irrigation ☐ Test Well ☐ Other ☒ ☐ DeWater
FISH PRODUCTION

(4) **TYPE OF WORK:** Owner's number of well (If more than one) #3
Abandoned ☐ New well ☐ Method: Dug ☐ Bored ☐ Deepened ☐ Cable ☑ Driven ☐ Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16" inches. Drilled 80 feet. Depth of completed well 80 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 16 " Diam. from +3 ft. to 50 ft.
Welded ☒
Liner installed ☐
Threaded ☐
_____ " Diam. from _____ ft. to _____ ft.
_____ " Diam. from _____ ft. to _____ ft.

Perforations: Yes ☐ No ☒
Type of perforator used _____
SIZE of perforations _____ in. by _____ in.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name HOUSTON
Type SS Model No. _____
Diam. 14 Slot size 150 from 55 ft. to 70 ft.
Diam. ____ Slot size 100 from 70 ft. to 75 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel _____
Gravel placed from _____ ft. to _____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 19 ft.
Material used in seal BENTONITE CEMENT
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? _____ Depth of strata _____
Method of sealing strata off _____

(7) **PUMP:** Manufacturer's Name _____
Type: _____ H.P. _____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 20 ft.
Static level 4 ft. below top of well Date 4-1-94
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? AQUA FLO
Yield: 1500 gal./min. with 8 ft. drawdown after 5 hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.
Airtest _____ gal./min. with stem set at _____ ft. for _____ hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Grey silty Fine SAND	0	19
BROWN GRAVEL AND SAND W OCC COBBLES + TRACE SILT	19	50
Brown gravel w SAND and COBBLES and TRACE SILT	50	54
BROWN GRAVEL AND SAND AND OCC. COBBLES	54	58
BROWN GRAVEL, SAND AND OCC. COBBLES	58	70
BROWN GRAVEL, SAND AND COBBLES	70	80

Work Started 12 93, 19. Completed 3, 19 94

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME AQUA FLO INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 1413 MERIDIAN E PUYALLUP WA

(Signed) Wally Hallett (WELL DRILLER) License No. 1469

Contractor's Registration No. 601338179 Date 5-3, 19 94

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93) * * f

Start Card No. 34919

UNIQUE WELL I.D. # 303

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Water Right Permit No. _____

(1) **OWNER:** Name NISQUALLY INDIAN TRIBE Address _____

(2) **LOCATION OF WELL:** County Pierce SW¼ AND SW 1/4 NW 1/4 Sec 22 T. 18 N., R. 1E W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) Clear Creek

(3) **PROPOSED USE:** ☐ Domestic ☐ Industrial ☐ Municipal ☐ ☐ Irrigation ☐ Test Well ☐ Other ☑ ☐ DeWater
Fish PRODUCTION

(4) **TYPE OF WORK:** Owner's number of well (If more than one) _____
Abandoned ☐ New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16" inches.
Drilled 85 feet. Depth of completed well _____ ft.

(6) **CONSTRUCTION DETAILS:**
Casing Installed: 16 " Diam. from +3 ft. to 55 ft.
Welded ☐ _____ " Diam. from _____ ft. to _____ ft.
Liner installed ☐
Threaded ☐ _____ " Diam. from _____ ft. to _____ ft.

Perforations: Yes ☐ No ☒
Type of perforator used _____
SIZE of perforations _____ in. by _____ in.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name HOUSTON
Type SS Model No. _____
Diam. 14 Slot size 100 from 60 ft. to 65 ft.
Diam. _____ Slot size 150 from 65 ft. to 80 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel _____
Gravel placed from _____ ft. to _____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 19 ft.
Material used in seal BENTONITE CEMENT
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? _____ Depth of strata _____
Method of sealing strata off _____

(7) **PUMP:** Manufacturer's Name _____
Type: _____ H.P. _____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 20 ft.
Static level 4 ft. below top of well Date 4-1-94
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? AQUA FLO
Yield: 1500 gal./min. with 8 ft. drawdown after 5 hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.
Airtest _____ gal./min. with stem set at _____ ft. for _____ hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
FINE TO COARSE GRAVEL WITH COBBLES AND SAND AND TRACE OF SILT	0	12
FINE TO COARSE GRAVEL W SAND OCC COBBLES AND TRACE OF SILT	12	25
FINE TO COARSE GRAVEL WITH COBBLES AND SAND TRACE SILT	25	48
FINE TO COARSE GRAVEL W COBBLES SAND, TRACE SILT	48	52
FINE TO COARSE GRAVEL W COBBLES, SAND, AND TRACE SILT	52	85

Work Started 1-94 19. Completed 3 19 94

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME AQUA FLO INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 1413 MERIDIAN E PUYALLUP WA

(Signed) _____ (WELL DRILLER) License No. 1469

Contractor's Registration No. 601336179 Date 5-3 19 94

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 20402
UNIQUE WELL I.D. # 304
Water Right Permit No.

(1) OWNER: Name Nisqually Indian Tribe Address

(2) LOCATION OF WELL: County Pierce SW 1/4 and SW 1/4 NW 1/4 Sec 22 T. 18 N., R 1E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Clear Creek

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☒ Fish Production

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16" inches.
Drilled 85 feet. Depth of completed well 85 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from +3 ft. to 58 ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Houston
Type SS Model No.
Diam. 14" Slot size 150 from 63 ft. to 83 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 17 ft.
Material used in seal Bentonite cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 20 ft.
Static level 4' ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom?
Yield: 1500 gal./min. with 8 ft. drawdown after 5 hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown silty fine to med sand with gravel	0	12
Brown gravel with fine to med sand	12	18
Brown fine to med sand occ cobble	18	23
" " "	23	63
Brown well graded gravel and fine to med sand w cobbles	63	68
Brown gravel w sand	68	73
Brown gravel and sand w cobbles	73	79
Brown coarse gravel w sand and cobbles	79	85

Work Started 2 94, 19. Completed 3, 19 94

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Aqua Flo Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 1413 Meridian E Puyallup
(Signed) [signature] (WELL DRILLER) License No. 1469
Contractor's Registration No. 201338179 Date 5-3, 19 94

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

APPENDIX B

STANDARD OPERATING PROCEDURES

SOP 1

GROUNDWATER PURGING & SAMPLING MONITORING WELLS USING A SUBMERSIBLE PUMP

This operating procedure provides general information on groundwater purging and sampling from monitoring wells using a submersible pump.

EQUIPMENT REQUIRED

- Level D personal protective equipment (e.g., nitrile gloves, rain gear, steel-toe boots, safety glasses, and high-visibility safety vest)
- Submersible pump (e.g., Grundfos) with reusable tubing
- Pump controller
- Power source (generator)
- Electric water level measurement meter
- Sample containers with preservative
- Insulated cooler(s), chain of custody seals, appropriate cooler packing supplies (e.g., bubble wrap), and ice or blue ice
- Sample labels and appropriate documentation (e.g., chain of custody forms)
- Field log

PROCEDURES

PREPARATION

1. Record necessary data in field log.
2. Don appropriate personal protection equipment, as specified in the Site Safety and Health Plan.
3. Consult the well log for each well to determine the most productive zone. If at all possible, the pump intake shall not be placed within 2-feet of the well bottom or low-water level.
4. Ensure any downhole equipment (pump, tubing, and water level meter) has been properly decontaminated prior to use.

PURGING

1. Set up power source and pump controller.
2. Discharge all purge water to a temporary container for disposal at the Landfill 2 Pump and Treatment system.
3. Begin purging at a rate of 0.1 to 0.5 liters/minute. The appropriate purge rate will be determined by monitoring groundwater draw down controlled by site specific conditions. The water level should stabilize and ideally the pump rate should be sufficiently low enough to allow an equal or greater amount of water to recharge the well so little or no water level draw down is observed.
4. Measure groundwater levels every 5 minutes to ensure that the groundwater in the well is not being drawn down. If significant draw down occurs, more than 6 inches, lower the speed of the pump or turn the pump entirely off.
5. Repeat until the water level stabilizes to closely match the recharge rate.
6. Purge groundwater for 15 minutes. After 15 minutes, depth to water will be checked and if the level is within 6 inches of the initial depth to water then a sample will be collected. If the water level is 7 inches or lower than the initial depth to water than the well will be given time to recharge.

SAMPLING

1. Collect sample directly from the end of the discharge tubing maintaining the established flow purge rate.
2. Minimize the formation of air bubbles, aeration, and turbulence by using the established flow rate while filling the sample vial for BTEX/TPH-G analysis and pouring the sample water gently down the inside of the bottle.
3. Form a meniscus over the mouth of the vial to eliminate formation of air bubbles and head space prior to capping.
4. Screw the Teflon-lined cap on tightly to prevent the container from leaking.
5. Label, package, and ship sample containers to the analytical laboratory as described in the RI/FS Work Plan.
6. Store and ship the samples at 4°C.

SAMPLE COMPLETION/DECONTAMINATION

1. Extract the pump from the well. Decontaminate all sampling equipment that comes in contact with the well water between the sampling locations**.** To decontaminate equipment:
   - Wash the water level meter using a Liquinox solution.
   - Rinse the water level meter with tap water.
2. Gather and dispose of all non-dedicated supplies and equipment properly.

SOP 2

FIELD PARAMETER MEASUREMENT FOR GROUNDWATER SAMPLING

Field parameters (temperature, pH, turbidity, oxidation-reduction potential, specific conductance, salinity, and dissolved oxygen) will be monitored during purging of the monitoring wells and prior to surface water sampling with a Horiba water quality meter or equivalent. Measurements will be conducted in accordance with the manufacturer's instructions and the following procedures:

- Calibrate or verify calibration of the water quality meter according to SOP 3. For low-flow purging of the monitoring wells:
  - Set up and begin purging well.
  - Determine the flow rate using a graduated cylinder or equivalent.
  - Attach a flow-through cell to the polyethylene tubing. Position the water quality meter probe in the flow-through cell. Begin purging the monitoring well.
  - After the cell has been flushed at least twice, begin monitoring the field parameters, and continue approximately every 3 to 5 minutes during purging. Record water quality measurements the appropriate field logbook or on a well purge data sheet.
  - When the indicator parameters have stabilized for three consecutive readings, the well is considered stabilized and ready for sample collection. Remove the flow-through cell from the tubing.
- For surface water sampling, position the probe directly in the water body. Record water quality measurements in the appropriate field logbook or on a well purge data sheet.

Decontaminate the water quality meter probe between wells by rinsing it with commercially purchased water. If debris or odor is noted, wash with Liquinox and rinse with commercially purchased water as needed.

SOP 3

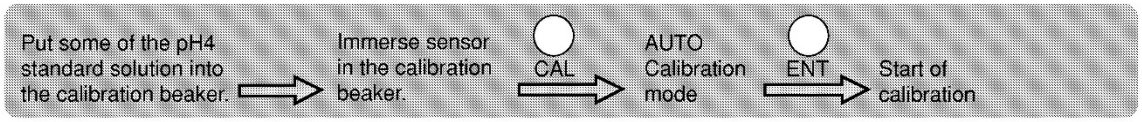
WATER QUALITY METER CALIBRATION

The Horiba® water quality meter or equivalent will be calibrated at the beginning of each day prior to using the instrument to collect field parameters for samples (as detailed below in Steps 1-6). Alternatively, at the discretion of the operator, calibration may be omitted if a calibration check is performed and demonstrates the parameters are within the expected range (as described below in Step 7).

The daily calibration will be performed using the Auto-Calibration function and a standard pH 4 Auto-Calibration solution. The Auto-Calibration function performs a one-point calibration of the pH sensor, conductivity sensor, and turbidity sensor in the standard pH 4 Auto-Calibration solution, while the dissolved oxygen sensor is calibrated in the atmosphere simultaneously. The following procedure is for Horiba® U-20 series, however Horiba® U-50 series follow similar procedures and have similar expected parameter values.

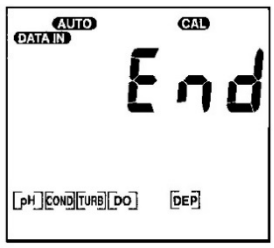
The meter's calibration must be checked at the beginning of the day (immediately following calibration or in lieu of performing a calibration) and at the end of the day to determine if parameter values have drifted from original calibration. Additionally, it is highly recommended that a mid-day calibration check is performed so that any problems can be identified more readily. Calibration checks are not a recalibration of the meter but a check of the calibration to ensure the continued accuracy of the meter. Use of the meter for field samples must be bracketed by calibration checks that are within the expected range.

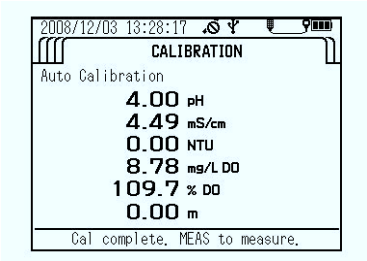
1. Triple-rinse the sensors with commercially available bottled drinking water.
2. Fill the calibration beaker to the marked line with the standard pH 4 Auto-Calibration solution. If using a Horiba® U-50 series, the transparent calibration beaker will need to be inserted into the black calibration beaker upon filling the transparent beaker with the pH 4 Auto-Calibration solution.
3. Immerse the sensors in the beaker.
4. Turn "On" water quality meter.
5. Press **CAL** button, then press **ENT** button to start Auto-Calibration.



6. Upon completion of the calibration of the pH, conductivity, turbidity, and dissolved oxygen sensors the water quality meter screen will display “END” for the U-20 series or “Cal Complete” for the U-50 series.

Note – If an error code is displayed, reference manufacturer’s Operation/Instruction Manual.





Press the **MEAS** button to display measured parameter values. Record, at a minimum, values for pH, turbidity, conductivity, and dissolved oxygen (values for temperature, salinity, and oxygen reduction potential (ORP) may also be recorded to evaluate meter). Expected parameter value ranges are as follows:

a. 4.00 units for pH (± 10%)

b. 4.49 mS/cm for conductivity (± 10%)

c. 0 NTUs for turbidity (+ 10 NTUs)

d. 8.00 mg/L to 12.00 mg/L for dissolved oxygen (± 10%)

*Note – The age of the Auto-Calibration solution and temperature fluctuations can effect expected parameter value ranges. If the recorded parameter value is outside the expected range, consult the manufacturer’s Operations Manual for indicated value tables for parameters at various temperatures. If parameter values are outside of expected ranges, rinse sensors and perform Auto-Calibration again.

REFERENCES

Horiba, Ltd. 2000. Multi Water Quality Monitoring System U-020 Series Operation Manual.

Horiba, Ltd. 2009. Multi Water Quality Checker U-50 Series Instruction Manual.

APPENDIX C

EXAMPLE FIELD FORMS

CHAIN OF CUSTODY

ALS Environmental
1317 South 13th Ave., Kelso, WA 98626 | 360.577.7222 | 800.695.7222 | 360.636.1068 (fax)

SR# _____

PAGE _____ OF _____ COC# _____

PROJECT NAME
PROJECT NUMBER
PROJECT MANAGER
COMPANY NAME
ADDRESS
CITY/STATE/ZIP
E-MAIL ADDRESS
PHONE # FAX #
SAMPLER'S SIGNATURE

SAMPLE I.D.	DATE	TIME	LAB I.D.	MATRIX	NUMBER OF CONTAINERS	Semivolatile Organics by GC/MS 625☐ 8270☐ 8270LL☐ SIM PAH☐	Volatile Organics 624☐ 8260☐ 8021☐ BTEX☐	Hydrocarbons (*see below) Gas☐ Diesel☐ Oil☐	Oil & Grease/TRPH 1664 HEM☐ 1664 SGT☐	PCBs Aroclors☐ Congeners☐	Pesticides/Herbicides 608☐ 8081☐ 8141☐ 8151☐	Chlorophenolics - 8151M Tri☐ Tetra☐ PCP☐	Metals, Total or Dissolved (See List below)	Cyanide☐ Hex-Chrom☐	(circle) pH, Cond., Cl, SO_4, PO_4, F, NO_2, NO_3, BOD, TSS, TDS, Turb.	(circle) NH_3-N, COD, TKN, TOC, DOC, NO_2+NO_3, T-Phos	TOX 9020☐ AOX 1650☐ 506☐	Alkalinity☐ CO_3☐ HCO_3☐	Dioxins/Furans 1613☐ 8290☐	Dissolved Gases CO_2☐ RSK 175☐ Methane☐ Ethane☐ Ethene☐			REMARKS

REPORT REQUIREMENTS

___ I. Routine Report: Method Blank, Surrogate, as required
___ II. Report Dup., MS, MSD as required
___ III. CLP Like Summary (no raw data)
___ IV. Data Validation Report
___ V. EDD

INVOICE INFORMATION

P.O. # _____
Bill To: _____

TURNAROUND REQUIREMENTS

_____ 24 hr. _____ 48 hr.
_____ 5 day
_____ Standard (15 working days)
_____ Provide FAX Results

_____
Requested Report Date

Circle which metals are to be analyzed:

Total Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

***INDICATE STATE HYDROCARBON PROCEDURE: AK CA WI NORTHWEST OTHER: _____ (CIRCLE ONE)**

SPECIAL INSTRUCTIONS/COMMENTS:

☐ Sample Shipment contains USDA regulated soil samples (check box if applicable)

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature / Date/Time	Signature / Date/Time	Signature / Date/Time	Signature / Date/Time
Printed Name / Firm	Printed Name / Firm	Printed Name / Firm	Printed Name / Firm

Sealaska Environmental Services

Marine Science Center, P.O. Box 869
18743 Front Street, NE, Suite 201
Poulsbo, WA 98370

Well Inspection, Purging, and Field Measurement Form

Contract Number: _____ Task Order: _____ Location: _____ Site Name: _____

Well Data

Well ID: _____ Well Head Locked: Y: ___ N: ___ Depth to Water (ft btoc): _____

Total Well Depth (ft btoc): _____ Exterior Seal Good: Y: ___ N: ___ Depth to Product (ft btoc): _____

Mid Screen Depth (ft btoc): _____ Pooled Water in Well Head: Y: ___ N: ___ Product Thickness (ft): _____

Purge Rate (liters/min): _____ Inner Casing Straight and Clear: Y: ___ N: ___ Volume Purged (liters): _____

Purge Method: Peristaltic/Submersible/Bladder/Other: _____ Remarks: _____

Water Sample Data

Sample ID: _____ Type: _____ Date: _____ Time: _____ # Containers: _____

QC Sample ID: _____ Type: _____ Date: _____ Time: _____ # Containers: _____

Sampling Personnel: _____

Remarks (color, odor, etc.): _____

Time	Purge Vol. (liters)	Depth to Water (ft btoc)	pH	Spec. Cond. (ms/cm)	Turbidity (NTU)	DO (mg/L)	Temp. (ºC)	ORP (mv)	Other
Stabilization Requirements			**(± 0.2 units)**	**(± 10%)**	**(± 10% or <20)**	**(± 10%)**	**(± 10%)**	**(± 10)**	
	0		**Initial Depth to Water (Pre-pumping)**						

Well Volume Calculation

Well volume (liters) = [Well casing volume (liters/ft)] x [Length of water column (ft)]

Well casing diameter (in) → Well casing volume (liters/ft)

1.25" → 0.3 1.5" → 0.4 2" → 0.6 2.5" → 1 3" → 1.4 3.5" → 2 4" → 2.5 6" → 5.5

APPENDIX D

ANALYTICAL METHOD QUALITY CONTROL AND CORRECTIVE ACTION TABLES

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Soil drying procedure	Each sample, LCS, and Method Blank. The appropriateness of the drying step is determined by each project.	Laboratory must have a procedure to determine when the sample is dry to constant mass. Entire sample must be air dried at room temperature.	NA.	Flagging is not appropriate.	Commercial PT samples must reflect the grinding, extraction, and analysis steps as a minimum. Record date, time, and ambient temperature on a daily basis while drying samples. If a laboratory utilizes a self-spiked LCS, the fortification must be performed prior to any preparation steps performed (drying, grinding, etc.) Drying may introduce a bias and is not recommended for certain compounds. Drying should be performed in the laboratory, not the field. Commercial PT samples must reflect the grinding, extraction, and analysis steps as a minimum. *(continued next page)*

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Soil drying procedure *(Continued)*					LCS reference material is not required to be air dried if the vendor specifies that drying is not required. LCS and Blank matrix can be Ottawa sand, clean soil, or other vendor provided clean matrix.
Soil sieving procedure	Each sample, LCS, and Method Blank. The appropriateness of the sieving step is determined by each project.	Weigh entire sample. Sieve entire sample with a 10 mesh sieve. Breakup pieces of soil (especially clay) with gloved hands. Collect and weigh any portion unable to pass through the sieve.	NA.	Flagging is not appropriate.	Do not include vegetation or debris in the portion of the sample that passes through the sieve unless that is a project specific requirement. Projects may require an alternate sieve size.
Soil grinding procedure	Initial demonstration at start up and any time major equipment is changed or when a reduction in the number or time of grinding cycles occurs. Each required sample, LCS, Blank, and Matrix Spike sample. The appropriateness of the grinding step is determined by each project.	**Initial demonstration of grinding equipment**: The laboratory must initially demonstrate that the grinding procedure is capable of reducing the particle size to < 75 µm by passing representative portions of ground sample through a 200 mesh sieve (ASTM E11).	NA.	Flagging is not appropriate.	Grinding and sieving is an iterative process, so cycles and duration can be varied to reduce heat if all samples are treated the same. Grinding may introduce a bias and is not recommended for certain compounds. Each sample, LCS, and Method Blank must use the same grinding process (i.e., same time intervals and number of grinding cycles).

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Grinding Blanks	One per batch of samples. The Grinding Blank must be processed: after the LCS (if ground), or after a client identified sample with known contamination, or at the end of the batch.	No reported analytes must be detected > 1/2 LOQ.	Blank results must be reported and the affected samples must be flagged accordingly if blank criteria are not met. If required, reprep and reanalyze Method Blank and all QC samples and field samples processed with the contaminated blank.	If any individual Grinding blank is found to exceed the acceptance criteria, apply B-flag to the samples following that blank.	At least one Grinding Blank per batch must be analyzed. For batch preparation, the Grinding Blank and the Method Blank can be one in the same. A Grinding Blank using clean solid matrix (such as Ottawa sand) must be prepared (e.g., ground and subsampled) and analyzed in the same manner as the sample. If cross-contamination is a concern, then more than one Grinding Blank per batch may be necessary.
Soil subsampling process	Each sample, LCS, blank, and Matrix Spike sample. All sample types must be subsampled, including those that were not initially dried, ground, or sieved.	Entire sample is mixed and spread out evenly on a large flat surface (e.g., baking tray), and 30 or more randomly located increments are removed from the entire depth and breadth to obtain the appropriate subsample size.	NA.	Flagging is not appropriate.	The total subsample weight collected can vary based on the requirements of the extraction process.

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Soil Sample Triplicate	At the subsampling step, performed on one sample per batch. Cannot be performed on any sample identified as a blank (e.g., Field Blank, Method Blank, Grinding Blank).	The RSD for results above the LOQ must not exceed 20%.	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	If reported per the client, apply J-flag to all samples within that batch if acceptance criteria are not met and explain in the Case Narrative.	Sample triplicates are randomly selected unless the project specifies the sample to be used.
Aqueous sample preparation	Each sample and associated batch QC samples.	Solid phase extraction (SPE) using resin-based solid phase disks or cartridges are required.	NA.	Flagging is not appropriate.	The salting-out procedure is not permitted.
Ion Transitions (Parent-> Product)	Prior to method implementation.	The chemical derivation of the ion transitions must be documented.	NA.	Flagging is not appropriate.	NA.
Initial Calibration (ICAL) for all analytes (including surrogates)	At instrument setup and after ICV or CCV failure, prior to sample analysis.	ICAL must meet one of the three options below: Option 1: RSD for each analyte ≤ 15%; Option 2: linear least squares regression for each analyte: $r^2 \geq 0.99$; Option 3: non-linear least squares regression (quadratic) for each analyte: $r^2 \geq 0.99$.	Correct problem, then repeat ICAL.	Flagging is not appropriate.	Minimum 5 levels for linear and 6 levels for quadratic. No samples shall be analyzed until ICAL has passed.

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analyte(s) and surrogates within ± 20% of true value.	Correct problem. Rerun ICV. If that fails, repeat ICAL.	Flagging is not appropriate.	No samples shall be analyzed until calibration has been verified with a second source.
Continuing Calibration Verification (CCV)	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within ± 20% of the true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since the last acceptable calibration verification.	Results may not be reported without valid CCVs. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Internal Standards (IS)	If employed, every field sample, standard and QC sample.	Retention time within ± 30 seconds from retention time of the midpoint standard in the ICAL; Internal standard signal (area or height) within -50% to +100% of ICAL midpoint standard. On days when ICAL is not performed, the daily initial CCV can be used.	Inspect instrumentation for malfunctions and correct problem. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	If corrective action fails in field samples, data must be qualified and explained in the Case Narrative. Apply Q-flag to analytes associated with the non-compliant IS. Flagging is not appropriate for failed standards.	NA.

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Method Blank (MB)	One per preparatory batch.	No analytes detected > 1/2 LOQ or > 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.	Correct problem. If required, reprep and reanalyze Method Blank and all QC samples and field samples processed with the contaminated blank.	If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Results may not be reported without a valid Method Blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed. For batch preparation, the Grinding Blank and the Method Blank can be one in the same.
Laboratory Control Sample (LCS)	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. Use LCS Tables 8330B for HPLC analysis. Use LCS Tables 8321 for LC/MS or LC/MS/MS analysis.	Correct problem. If required, reprep and reanalyze the LCS and all samples in the associated preparatory batch for the failed analytes, from the sub-sampling step on, if sufficient sample material is available.	If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch.	A solid reference material containing all reported analytes must be prepared (e.g., ground and subsampled) and analyzed in exactly the same manner as a field sample. A Standard Reference Material (SRM) that is used for a LCS can be ground as a single batch and subsampled repeatedly as long as the SRM is within expiration date. *(continued next page)*

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Laboratory Control Sample (LCS) *(Continued)*					If a laboratory utilizes a self-spiked LCS, the fortification must be performed prior to any preparation steps performed, such as drying, grinding, and sieving. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Matrix Spike (MS)	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.	Analytes and surrogates are spiked into the MS and MSD after subsampling. For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference (i.e., matrix effect or analytical error).

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Matrix Spike Duplicate (MSD) or Matrix Duplicate (MD)	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. MSD or MD: RPD of all analytes ≤ 20% (between MS and MSD or sample and MD).	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.	Analytes and surrogates are spiked into the MS and MSD after subsampling. For matrix evaluation only. If MSD results are outside the limits, the data shall be evaluated to determine the source(s) of difference. For Sample/MD: %Recovery and RPD criteria only apply to analytes whose concentration in the sample is greater than or equal to the LOQ.
Surrogate Spike	All field and QC samples.	QC acceptance criteria specified by the project if available; otherwise use QSM Appendix C limits or in-house LCS limits if analyte(s) are not listed.	Correct problem, then reprep and reanalyze all failed samples for all surrogates in the associated preparatory batch if sufficient sample material is available. If obvious chromatographic interference is present, reanalysis may not be necessary, but the client must be notified prior to reporting data and the failures must be discussed in the Case Narrative.	Apply Q-flag to all associated analytes if acceptance criteria are not met and explain in the Case Narrative.	Alternative surrogates are recommended when there is obvious chromatographic interference.

Table B-3. Nitroaromatics, Nitramines, and Nitrate Esters Analysis by HPLC, LC/MS, or LC/MS/MS (Method 8330B)					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Comments**
Confirmation of positive results (second column)	All results > the DL must be confirmed.	Calibration and QC criteria are the same for the confirmation analysis as for initial or primary column analysis. Results between primary and second column RPD ≤ 40%.	Report from both columns.	Apply J-flag if RPD > 40%. Discuss in the Case Narrative.	Use of a UV detector with a UV diode array detector or vice versa is not considered a valid confirmation technique. Confirmation analysis is not needed if LC/MS or LC/MS/MS was used for the primary analysis. Secondary column – Must be capable of resolving (separating) all of the analytes of interest and must have a different retention time order relative to the primary column. Use project specific reporting requirements if available; otherwise, report from the primary column.

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