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Revision 0

# Borehole Summary Report for Well 299-W11- 45 (C4948), ZP-1 Operable Unit

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Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the  
U.S. Department of Energy under Contract DE-AC06-96RL13200

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# Borehole Summary Report for Well 299-W11-45 (C4948), ZP-1 Operable Unit

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GRAAM, Inc.

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ACRONYMS

bgs	below ground surface
btoc	below top of casing
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CFR	<i>Code of Federal Regulations</i>
DOE-RL	U.S. Department of Energy-Richland
DOW	Description of Work
DQO	Data Quality Objectives
EPA	U.S. Environmental Protection Agency
FFS	Fluor Federal Services
FH	Fluor Hanford, Inc.
gpm	gallons per minute
GPS	Global Positioning System
HWIS	Hanford Well Information System
ID	inside diameter
NAD83 (91)	North American Datum of 1983 (1991)
NAVD88	North American Vertical Datum of 1988
NMLS	Neutron Moisture Logging System
NTU	Nephelometric Turbidity Unit
OD	outside diameter
OU	Operable Unit
PNNL	Pacific Northwest National Laboratory
psi	pound per square inch
SAP	Sampling and Analysis Plan
SGLS	Spectral Gamma Logging System
toc	top of casing
RCW	<i>Revised Code of Washington</i>
RLM	Ringold Lower Mud
WAC	<i>Washington Administrative Code</i>

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## METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>	<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>
<b>Length</b>			<b>Length</b>		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
<b>Area</b>			<b>Area</b>		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
<b>Mass (weight)</b>			<b>Mass (weight)</b>		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	tonne	tonne	1.102	ton
<b>Volume</b>			<b>Volume</b>		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
<b>Temperature</b>			<b>Temperature</b>		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
<b>Radioactivity</b>			<b>Radioactivity</b>		
picocuries	37	millibecquerel	millibecquerel	0.027	picocuries

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## 1.0 INTRODUCTION

This report describes the 2005/2006 fiscal year field activities associated with the installation of a single monitoring well drilled down-gradient of Waste Management Area (WMA) T in the 200 West Area to support the WMA T groundwater assessment. This groundwater monitoring well was installed for Fluor Hanford, Inc. (FH) in accordance with in the *Tri-Party Agreement* (Ecology et al. 1989) Milestone M-024-57, the Sampling and Analysis Plan (SAP) (DOE-RL 2005), and the Description of Work (DOW) (FH 2005). Drilling data for this well are summarized in Table 1-1. Documents supporting field activities as well as procedures followed during borehole characterization and well construction are listed in Section 7.0 of this document.

### 1.1 BACKGROUND

WMA T is located in the central part of the 200 West Area. Single-shell tanks (SSTs) located within WMA T still contain fairly large amounts of radioactive and hazardous chemical waste in both liquid and solid form that was generated from T-Plant processes during the production and separation of plutonium between 1948 and 1956. WMA T is still holding approximately 241,000 gallons of liquid waste and 1,825,000 gallons of solids in the form of sludge and salt cake (HNF-EP-0182, *Waste Tank Summary Report for Month Ending January 31, 2006*).

The SSTs located within WMA T are hazardous waste management units regulated under the *Resource Conservation and Recovery Act* of 1976 (RCRA), the Washington State "Hazardous Waste Management" (*Revised Code of Washington* [RCW] 70.105) and it's implementing requirements (*Washington Administrative Code* [WAC] 173-303, "Dangerous Waste Regulations"). Groundwater monitoring at the WMA T is regulated under RCRA interim-status regulations (40 *Code of Federal Regulations* (CFR) 265, Subpart F, by reference of *Washington Administrative Code* WAC 173-303-400[3]). Assessment groundwater monitoring was initiated because of elevated specific conductance values detected in down-gradient wells (BHI-01518, *Description of Work for Calendar Year 2001 RCRA Drilling*).

In 2000, four wells were installed outside the T tank farm (PNNL-13590, *Borehole Data Package for Calendar Year 2000-2001 RCRA Wells at Single-Shell Tank Waste Management Area T*). In 2001, one well was installed outside the T tank farm (PNNL-13830, *Borehole Data Package for Calendar Year 2000-2001 RCRA Wells at Single-Shell Tank Waste Management Area T*). In 2005, well 299-W11-25B (C4669) was drilled and later decommissioned due to complications encountered during well completion. Also in 2005, well 299-W11-46 (C4950) was drilled and completed as a replacement well for 299-W11-25B (C4669) (WMP-20073).

### 1.2 PURPOSE AND SCOPE

The primary purpose of this field effort was to install a single monitoring well East of WMA T in the 200 West Area. This well will provide down-gradient groundwater monitoring coverage and input data for groundwater flow models. The scope of activities described in this report includes the technical data that encompasses the drilling of a single borehole and related well construction. Additional scope of work described in this report includes waste management and subsurface descriptions. All drilling data in this report are presented in the units in which they were measured in the field, with the exception of survey data where applicable which are

reported in metric units. A summary of the new monitoring well is provided in Table 1-1 and the location of the well is shown in Figure 1-1.

Table 1-1. Drilling Summary of Borehole and Well

Well Name/Well ID	Area	Drilling Date		Northing (m)	Easting (m)	Ground Surface Elevation <sup>a</sup> (Brass Cap) (m)	Total Depth (feet bgs)
		Start	Finish				
299-W11-45/C4948	ZP-1 OU	9/2/05	3/9/06	136775.64	566992.84	212.884	438

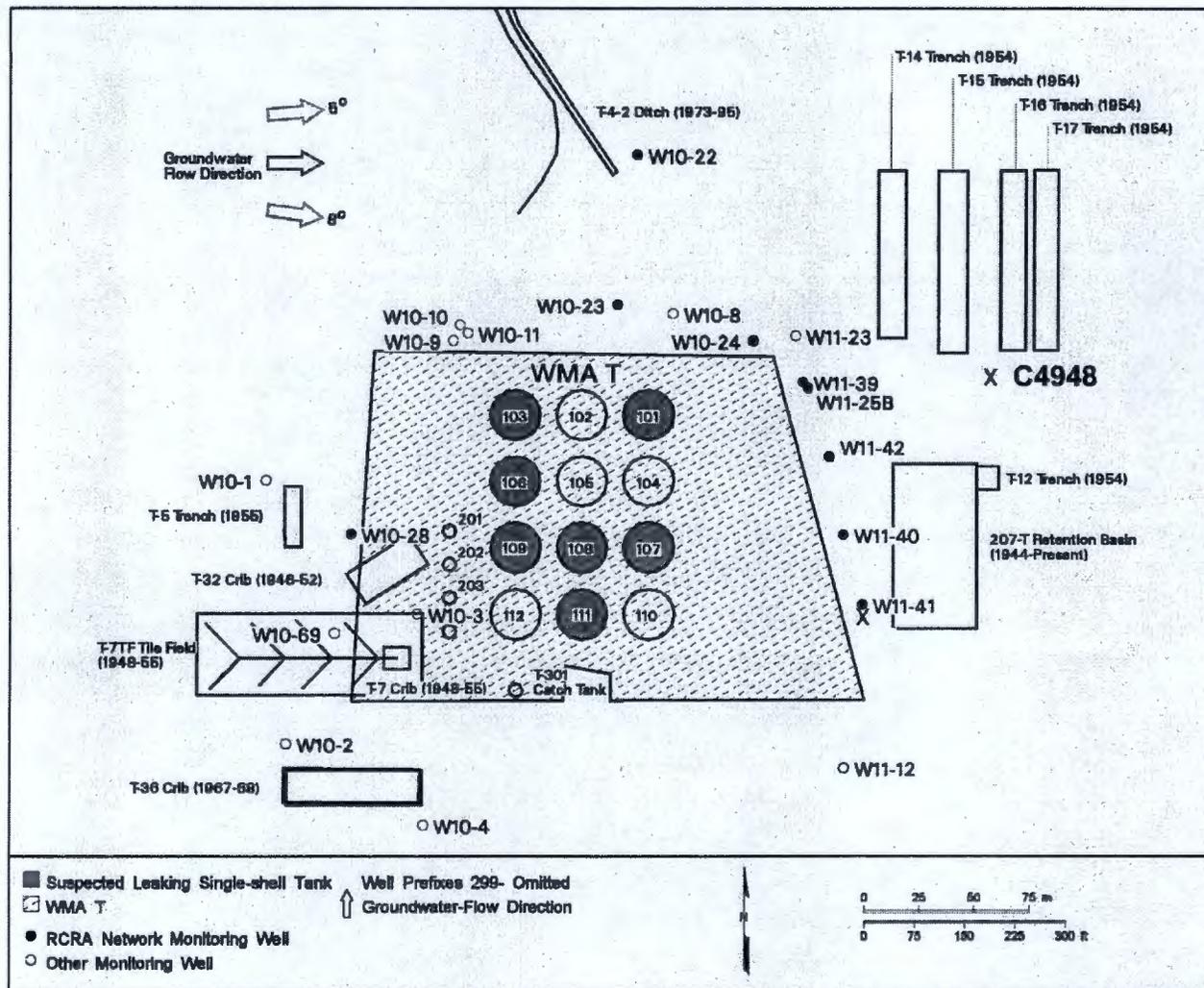
Notes:

Northing and easting coordinates are based on Washington State Plane Coordinates North American Datum of 1983 (NAD83[91]) rounded to 1 m.

<sup>a</sup>North American Vertical Datum of 1988 (NAVD88) values rounded to 0.001 m.

bgs = below ground surface.

Figure 1-1 Location Map for Monitoring Well 299-W11-45 (C4948) in the ZP-1 Operable Unit



## 2.0 TECHNICAL DATA

This section provides technical details of the drilling methods, well completion, well development, and pump installation activities performed during construction of the groundwater monitoring well in the ZP-1 OU (see Figure 1-1). Drilling data are presented in Table 1-1 and well summary information is located in Appendices A through D.

### 2.1 ZP-1 OPERABLE UNIT

### 2.2 WELL 299-W11-45 (C4948)

This section summarizes activities related to the construction of groundwater compliance monitoring well 299-W11-45 (C4948).

#### 2.2.1 Drilling Summary

Drilling of Well 299-W11-45 (C4948) began on September 2, 2005 using a cable tool drill rig, driving single wall carbon steel temporary casing with a 13 3/8 inch outside diameter (OD) and 12 1/8 inch inside diameter (ID) to a depth of 196.5 ft below ground surface (bgs). Below 196.5 bgs the casing was downsized to single wall carbon steel temporary casing with a 10 3/4 inch OD and 9 1/4 inch ID that was driven to a depth of 436.2 ft bgs. The borehole was advanced using both core barrel and hard tool drilling methods to a total depth (TD) of 438 ft bgs on November 15, 2005. The water table was initially encountered at approximately 253.2 feet bgs on September 23, 2005.

#### 2.2.2 Sample Summary

Multiple water samples were collected from 259.5 – 438 feet bgs and tested for various chemical properties by Pacific Northwest National Laboratory (PNNL) and FH. Archive samples (1-pint glass jars) were collected for FH and PNNL, at five-foot intervals, but were not analyzed in the field. In addition to the archive samples, lithologic changes were recorded and collected in plastic chip trays for future characterization use by both FH and PNNL. Table 2-1 summarizes the water sampling for Well 299-W11-45 (C4948).

Table 2-1. Water Sample Summary for Well 299-W11-45 (C4948)

Sample Number	Sample Date	Sample Method	Kabis Depth (ft bgs)	Pump Intake (ft bgs)	Sample Depth (ft bwt)	Borehole Depth (ft bgs)	Casing Depth (ft bgs)	Open Interval (ft)
B1DN10	26-Sep	Kabis	259.5	N/A	6.5	260	260	0
B1DWX8	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DWY0	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DWY2	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DWY4	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DN05	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DN06	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DWY2	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DWY4	29-Sep	Bail/Kabis	263	N/A	10	263	263	0
B1DN08	29-Sep	Kabis	268	N/A	15	268	268	0
B1DN12	29-Sep	Kabis	268	N/A	15	268	268	0
B1F5P9	4-Oct	Bailer	N/A	N/A	20	274	263	11
B1DN13	4-Oct	Bailer	N/A	N/A	20	274	263	11
B1DN45	4-Oct	Bailer	N/A	N/A	20	274	263	11
B1DN56	4-Oct	Bailer	N/A	N/A	20	274	263	11
B1DN67	4-Oct	Bailer	N/A	N/A	20	274	263	11
B1DN78	4-Oct	Bailer	N/A	N/A	20	274	263	11
B1DN03	6-Oct	Pump	N/A	272	25	279	273	6
B1DN04	6-Oct	Pump	N/A	272	25	279	273	6
B1DN05	6-Oct	Pump	N/A	272	25	279	273	6
B1DN06	6-Oct	Pump	N/A	272	25	279	273	6
B1DN11	6-Oct	Kabis	278	N/A	25	279	273	6
B1DN14	6-Oct	Kabis	278	N/A	25	279	273	6
B1DN46	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DN 57	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DN68	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DN79	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DWX9	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DWY1	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DWY3	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DWY5	7-Oct	Pump	N/A	281.6	30	283.6	279.5	4.1
B1DN16	11-Oct	Kabis	288	N/A	35	288	288	0
B1F856	11-Oct	Kabis	293	N/A	40	294	293	1
B1DN17	11-Oct	Kabis	293	N/A	40	294	293	1
B1DN47	11-Oct	Pump	N/A	291.5	40	294	293	1
B1DN57	11-Oct	Pump	N/A	291.5	40	294	293	1
B1DN69	11-Oct	Pump	N/A	291.5	40	294	293	1
B1DN80	11-Oct	Pump	N/A	291.5	40	294	293	1
B1DN18	12-Oct	Kabis	297	N/A	45	298	298	0

Table 2-1. Water Sample Summary for Well 299-W11-45 (C4948)

Sample Number	Sample Date	Sample Method	Kabis Depth (ft bgs)	Pump Intake (ft bgs)	Sample Depth (ft bwt)	Borehole Depth (ft bgs)	Casing Depth (ft bgs)	Open Interval (ft)
B1DN19	12-Oct	Kabis	297	N/A	45	298	298	0
B1DN48	13-Oct	Pump	N/A	300	50	302.7	302.5	0.2
B1DN59	13-Oct	Pump	N/A	300	50	302.7	302.5	0.2
B1DN70	13-Oct	Pump	N/A	300	50	302.7	302.5	0.2
B1DN81	13-Oct	Pump	N/A	300	50	302.7	302.5	0.2
B1DN20	17-Oct	Kabis	308	N/A	55	308.6	308	0.6
B1DN21	17-Oct	Kabis	313	N/A	60	314	312.5	1.5
B1DN49	17-Oct	Pump	N/A	311.5	60	314	312.5	1.5
B1DN60	17-Oct	Pump	N/A	311.5	60	314	312.5	1.5
B1DN71	17-Oct	Pump	N/A	311.5	60	314	312.5	1.5
B1DN82	17-Oct	Pump	N/A	311.5	60	314	312.5	1.5
B1DN15	18-Oct	Kabis	317	N/A	65	318.5	318	0.5
B1DN22	18-Oct	Kabis	317	N/A	65	318.5	318	0.5
B1DN23	18-Oct	Pump	N/A	305	70	323	322.5	0.5
B1DN24	19-Oct	Kabis	327	N/A	75	327.8	327.8	0
B1FCX1	20-Oct	Pump	N/A	311.5	80	333	332.5	0.5
B1DN50	20-Oct	Pump	N/A	311.5	80	333	332.5	0.5
B1DN61	20-Oct	Pump	N/A	311.5	80	333	332.5	0.5
B1DN50	20-Oct	Pump	N/A	311.5	80	333	332.5	0.5
B1DN50	20-Oct	Pump	N/A	311.5	80	333	332.5	0.5
B1DN72	20-Oct	Pump	N/A	311.5	80	333	332.5	0.5
B1DN83	20-Oct	Pump	N/A	311.5	80	333	332.5	0.5
B1DN26	20-Oct	Kabis	337.4	N/A	85	338.4	338	0.4
B1DN27	21-Oct	Pump	N/A	323	90	343	342.5	0.5
B1DN28	25-Oct	Kabis	348	N/A	95	348	342.5	5.5
B1FJL6	26-Oct	Pump	N/A	339	100	352.5	352.5	0
B1FJL7	26-Oct	Pump	N/A	339	100	352.5	352.5	0
B1DN51	26-Oct	Pump	N/A	339	100	352.5	352.5	0
B1DN62	26-Oct	Pump	N/A	339	100	352.5	352.5	0
B1DN73	26-Oct	Pump	N/A	339	100	352.5	352.5	0
B1DN84	26-Oct	Pump	N/A	339	100	352.5	352.5	0
B1DN30	26-Oct	Kabis	358	N/A	105	358	358	0
B1DN31	27-Oct	Pump	N/A	339	110	363	362.5	0.5
B1DN32	27-Oct	Kabis	368	N/A	115	369	369	0
B1FRC2	28-Oct	Pump	N/A	355	120	373	372.5	0.5
B1DN52	28-Oct	Pump	N/A	355	120	373	372.5	0.5
B1DN63	28-Oct	Pump	N/A	355	120	373	372.5	0.5
B1DN74	28-Oct	Pump	N/A	355	120	373	372.5	0.5
B1DN85	28-Oct	Pump	N/A	355	120	373	372.5	0.5
B1DN34	31-Oct	Kabis	377	N/A	125	378	378	0
B1DN35	31-Oct	Pump	N/A	370	130	383	382.5	0.5
B1DN36	1-Nov	Kabis	388	N/A	135	388	388	0

Table 2-1. Water Sample Summary for Well 299-W11-45 (C4948)

Sample Number	Sample Date	Sample Method	Kabis Depth (ft bgs)	Pump Intake (ft bgs)	Sample Depth (ft bwt)	Borehole Depth (ft bgs)	Casing Depth (ft bgs)	Open Interval (ft)
B1FRV0	1-Nov	Pump	N/A	370	140	393	392.5	0.5
B1DN53	1-Nov	Pump	N/A	370	140	393	392.5	0.5
B1DN64	1-Nov	Pump	N/A	370	140	393	392.5	0.5
B1DN75	1-Nov	Pump	N/A	370	140	393	392.5	0.5
B1DN86	1-Nov	Pump	N/A	370	140	393	392.5	0.5
B1DN38	2-Nov	Kabis	398	N/A	145	398	398	0
B1DN39	3-Nov	Pump	N/A	379	150	403	402	1
B1DN40	3-Nov	Kabis	408	N/A	155	408	408	0
B1FRY1	7-Nov	Pump	N/A	389	160	414	412.5	1.5
B1DN54	7-Nov	Pump	N/A	389	160	414	412.5	1.5
B1DN65	7-Nov	Pump	N/A	389	160	414	412.5	1.5
B1DN76	7-Nov	Pump	N/A	389	160	414	412.5	1.5
B1DN87	7-Nov	Pump	N/A	389	160	414	412.5	1.5
B1DN42	8-Nov	Kabis	418	N/A	165	418	418	0
B1DN43	9-Nov	Pump	N/A	400	170	423	417.5	5.5
B1FTR4	9-Nov	Kabis	428	N/A	175	428	428	0
B1FV68	10-Nov	Pump	N/A	400	180	433	426	7
B1FTV4	10-Nov	Pump	N/A	400	180	433	426	7
B1FTW4	10-Nov	Pump	N/A	400	180	433	426	7
B1FTX4	10-Nov	Pump	N/A	400	180	433	426	7
B1FTY4	10-Nov	Pump	N/A	400	180	433	426	7
B1FTR5	11-Nov	Kabis	438	N/A	185	438	436	2
B1FV05	11-Nov	Kabis	438	N/A	185	438	436	2

## Notes:

bgs = below ground surface

bwt = below water table

ft = feet

Sep = September

Oct = October

Nov = November

N/A = not applicable

ND = no data

Kabis = Kabis discrete point-interval groundwater sampler

### 2.2.3 Well Completion Summary

Well construction materials, filter pack installation, initial well development, and annular seal for well 299-W11-45 (C4948) are discussed below. A straightness test was performed using an 8 5/8-inch OD, 20.9 ft long tool prior to well completion activities. Construction and completion of this well was carried out from November 21, 2005 to March 9, 2006. Well completion summary data are provided in Table 2-2 and well construction summary sheets are presented in Appendix C.

- **Screen, Riser Casing, and Filter Pack.** 6-inch ID, Schedule 10S, Type 304L stainless steel screen and riser materials were chosen for this well, consisting of 283.28 feet of permanent well casing, a 14.59 foot 20-slot (0.020-in) continuous v-wire wrap screen and a 3.00 foot sump. Filter pack material consists of 10-20 mesh filter pack sand. These selections were based on hydrogeology encountered during drilling, as well as information from nearby wells. The bottom of the stainless steel sump was placed at 298.87 feet bgs and the bottom of the stainless steel screen was set at 295.87 feet bgs while the top of the screen was set at 281.28 feet bgs. The top of the stainless steel riser casing was set 2.0 feet above ground surface. The annular space between the stainless steel casing and the sediments in the borehole was filled with 10-20 mesh filter pack sand from 426.5 feet bgs to 308.1 feet bgs and 303 ft bgs to 271.9 ft bgs, as well as 266 ft bgs to 243.8 ft bgs. An approximate 5-foot bentonite pellet seal separated each of the filter pack intervals. The filter pack is approximately 10 ft above the top of the screen and 10 ft above the current static water level.
- **Filter Pack Installation and Initial Well Development.** The filter pack installation and initial well development process consisted of introducing silica sand into the annular space around the screen and settling the filter pack to eliminate void spaces. Development of the well removed fines in the newly constructed well and reconditioned the borehole walls to minimize effects of drilling, primarily due to caving. A dual-flange surge block was used to develop and settle the sand filter pack in the annular space between the screen and the borehole walls. Surging was carried out in 8 stages, developing the screen in 2 ft interval (approximately 296 feet bgs to 280 feet bgs). Overlap between the filter sand and temporary casing was maintained throughout so that unconsolidated formation sediments would not cave and come in direct contact with the well screen. The level of the filter pack was measured periodically with a weighted tape to monitor overlap and determine when the settling rate within the filter pack had decreased to less than 0.1 feet over a period of 15 minutes. The sand filter pack was surged for combined total of 445 minutes before stability was achieved.
- **Annular Seal.** An annular seal was constructed above and below the filter pack using 3/8-inch coated bentonite pellets, extending from 436.9 ft bgs to 426.5 ft bgs, 308.1 to 303 ft bgs, 271.9 to 266 ft bgs, and 243.8 to 238.2 ft bgs. Bentonite crumbles were placed inside the borehole from 238.2 ft bgs to 11.45 ft bgs and a grout seal was installed from 11.45 feet bgs to ground surface, consisting of Portland Type I/II cement and 5% bentonite powder by volume per WAC 173-160.

#### **2.2.4 Final Well Development Summary**

Final well development for 299-W11-45 (C4948), was performed in accordance with FH procedure GRP-EE-01-6.3, "*Well Development and Testing*" on March 8<sup>th</sup> and 9<sup>th</sup> of 2006. A 3-HP Grundfos electric submersible pump was used to develop the well in a one stage interval until turbidity was less than 5 Nephelometric Turbidity Units (NTU) and other water parameters including temperature and conductivity had stabilized. Water level drawdown during development was monitored continuously using a 20 psi pressure transducer and was recorded with an In-Situ Hermit 3000 datalogger. During development, the pump was operated with the intake located 291 ft from the top of the permanent protective casing (TOC) or 288 ft bgs. The flow rate was maintained at approximately 13 gpm for 8 minutes, 17.6 gpm for 205 minutes and 6.6 gpm for 147 minutes until the turbidity value reached 4.33 NTU. Drawdown observed while the flow rate was at 13 gpm averaged at 22.55 ft, while the flow rate was 17.6 gpm, drawdown averaged out at 23.72 ft and while the flow rate was 6.6 gpm, drawdown averaged at 7.84 ft. Final groundwater parameters are presented in Table 2-3 and well development data are found in Appendix D. Drawdown and recovery curves for the final well development of well 299-W11-45 (C4948) are also presented in Appendix D.

#### **2.1.1e Sampling Pump Installation Summary**

Pump installation was completed on March 10, 2006. A 1.5-horsepower (HP), 8-stage, electric submersible pump (Grundfos™ Model- A P1-0527 10SQE340NE) was installed with the pump intake set at 286 ft TOC (283 ft bgs), which is 1.72 feet below the top of the screen and approximately 29.5 feet below the static water table).

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™ Grundfos is a trademark of Grundfos Pumps Corporation of Clovis, California.

Table 2-2. Well Completion Summary for Well 299-W11-45 (C4948).

Well Name	Well ID	Operable Unit (OU)	Water Level (ft bgs)	Screen <sup>a</sup>					Sandpack <sup>b</sup> Interval (ft bgs)	Seal <sup>c</sup> (ft bgs)	Grout <sup>d</sup> Depth (ft bgs)	Riser		Pump Intake Depth <sup>e</sup> (ft bwt)
				Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Screen Length (ft)	Sump (ft)	Material				Top (ft)	Material	
299-W11-45	C4948	ZP-1	253.5	281.28	295.87	14.59	3.00	ss304L	243.8 - 266 271.9 - 303 308.1 - 426.5	238.2 - 243.8 266 - 271.9 303 - 308.1 426.5 - 438	0.0 - 11.45	+2.0	ss304L	~29.5

Notes:

<sup>a</sup>Screen slot size is 0.020 inch.

<sup>b</sup>Sandpack consists of Colorado silica sand (10-20 mesh).

<sup>c</sup>Bentonite seal consists of 3/8-inch bentonite pellets.

<sup>d</sup>Grout consists of Portland Type I/II cement.

<sup>e</sup> Pump intake depth is determined from groundwater readings taken on day pump was installed and piping used in pump installation. Water level readings recorded at pump installation may vary somewhat from data collected during drilling (column 4).

bgs = below ground surface

bwt = below water table

ft = feet

N/A = not applicable

OU = operable unit

ss = stainless steel

~ = approximate value given

Table 2-3. Well Development Data for Well 299-W11-45.

Well Name	Well ID	Operable Unit (OU)	Static Water Level (ft bgs)	Development Date(s)	Pump Intake Depth (ft TOC)	Development Pumping Duration (minutes)	Final Turbidity (NTU)	Final Conductivity ( $\mu\text{S}/\text{cm}$ )	Final Temp ( $^{\circ}\text{C}$ )	Final Flow Rate (gpm)	Final Drawdown (ft)	Total Gallons Pumped
299-W11-45	C4948	ZP-1	253.5	3/8/06 – 3/9/06	291	494	4.33	1564	12.3	6.6	7.84	6,400

Notes:

TOC = top of casing

gpm = gallon per minute

ft = feet

NTU = Nephelometric Turbidity Units

$\mu\text{S}/\text{cm}$  = micro seimen per centimeter

$^{\circ}\text{C}$  = degrees Centigrade

### 3.0 WASTE MANAGEMENT

The ZP-1 OU has specific requirements regarding waste generation as outlined in the supporting documentation. Waste generated from the installation of the well was handled according to the *Data Quality Objective (DQO) Summary Report for the Installation of One Groundwater Monitoring Well West [East] of WMA-T, WMP-26959 (FH 2005)*, with additional details provided below.

#### 3.1 ZP-1 OPERABLE UNIT

Cutting spoils for the ZP-1 OU were handled as described in the following sections.

##### 3.1.1 Vadose Zone Cuttings

Vadose zone cuttings from ZP-1 OU groundwater monitoring well (C4948) were designated low risk from chemical or radiological contamination and were collected in stockpiles near the point of generation until released back into the ground based on field surveys by radiological control technicians (RCT). Drill cuttings were surveyed in accordance with *Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063)*. Vadose zone cuttings were returned to the environment prior to the final well acceptance walkdown.

All wastes generated from drilling and sampling operations were handled as CERCLA waste and were managed in accordance with the *DQO Summary Report for the Installation of One Groundwater Monitoring Well West [East] of WMA-T, WMP-26959 (FH 2005)*.

##### 3.1.2 Saturated Zone Cuttings

All drill cuttings below the highest recorded water table (approximately 202 feet bgs) were containerized in 55-gallon drums lined with a 10-mil plastic liner. Drums were stored on site for final disposition.

##### 3.1.3 Purgewater

Purgewater was collected and contained at the well until transported to the Purgewater Storage and Treatment Facility or the Effluent Treatment Facility. Purgewater, groundwater samples, and decontamination fluids generated during well drilling and sample screening were managed as purgewater in accordance with FH procedure GRP-EE-01-1.11, "*Purge Water Management*", and 90-ERB-040, *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Izatt 1990).

#### 4.0 GEOPHYSICAL SURVEY

Borehole geophysical surveys were performed in well 299-W11-45 (C4948) on September 16 and 19, 2005 and November 17 and 18, 2005. Spectral Gamma Logging System (SGLS) surveys were carried out by S.M. Stoller Corporation from ground surface (0 feet) to 427 feet bgs. Results of the SGLS indicate that Cs<sup>137</sup> was the only man-made radionuclide within the borehole, though it was detected at its minimum detection limit (MDL) of 0.4 pCi/g at sporadic locations. It is S.M. Stoller's interpretation that these detections are merely statistical fluctuations and should not be considered valid. A separate report will provide specific details of these geophysical surveys.

## 5.0 CIVIL SURVEY

The civil survey of well 299-W11-45 (C4948) was performed on April 4, 2006 by a Fluor Federal Services (FFS) Land Surveyor using a Global Positioning System (GPS) under the NAD83 (91) datum. Well 299-W11-45 (C4948) is located at 136775.64 meters North, 566992.84 meters East. Elevation was measured using a leveling technique, from the top of the brass survey marker placed within the surface monument at the time of well completion, under NAVD88 datum. The elevation for the well is 213.614 meters. The civil survey data is available in the Hanford Well Information System (HWIS) database.

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## 6.0 WELL ACCEPTANCE

The ZP-1 groundwater monitoring well, 299-W11-45 (C4948), was transferred from Blue Star Enterprises and accepted by FH. A site acceptance walk down for the well was performed on March 14, 2006 and included representatives from Blue Star Enterprises, GRAM, Inc., and FH, including FH representatives from Geosciences, Environmental Compliance and Quality Assurance (QA).

QA surveillance was performed during the final acceptance walk down. Aspects of well drilling such as functionality of the well, selection of well construction materials, surface protection features, sampling pumps, well identification and site clean-up were observed. The surveillance was deemed satisfactory.

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## 7.0 SUBSURFACE DESCRIPTION

### 7.1 ZP-1 OPERABLE UNIT

This section provides the generalized stratigraphy in the ZP-1 OU, as well as summaries of field observations

#### 7.1.1 Geology/hydrogeology

Generalized stratigraphy in the ZP-1 OU of the Hanford Site includes surficial sediments that primarily consist of Holocene aeolian sands and silts, generally less than 5 m in thickness. The aeolian sediments overlie unconsolidated sediments of the Hanford formation, consisting of sandy gravels and gravelly sands with minor interbedded silt and sand layers. The Hanford formation overlies unconsolidated silts and sands of the Cold Creek Unit, consisting of carbonate-rich silt and sand, interfingering with carbonate-poor silt and sand and occasional caliche. The Cold Creek Unit disconformably overlies sands and gravels of Unit E of the Ringold Formation. Ringold Formation Unit E sediments conformably overlie the Ringold Lower Mud (RLM), an overbank flood deposit that consists primarily of a sandy to clayey silt with minor sand lenses. The RLM conformably overlies coarse basaltic gravels of Unit A of the Ringold Formation. Ringold Formation Unit A sediment disconformably overlies basalt of the Columbia River Basalt Group.

#### 7.1.2 Well 299-W11-45 (C4948)

At this location, in-situ sediments are overlain by a backfill layer of intermixed aeolian sands and crushed gravels, which extend from ground surface to a depth of about 0.2 ft bgs. Sediment below the gravel fill, from 0.2 – 2 feet bgs consists of aeolian sand and silt. The interval from 2 - 24 feet bgs contains a gravel-dominated facies belonging to the Hanford formation. The gravel dominated facies consists of mafic-rich sandy gravels and silty sandy gravels. These sediment consist primarily of poorly-sorted, well-rounded pebbles and cobbles up to 6 inches (15 cm) in diameter with very fine- to coarse-grained sand and silt.

Sand-dominated fluvial deposits of the Hanford formation were encountered from 24 – 98 ft bgs. These deposits consist of medium to very coarse heterolithic sands and interbedded gravelly sands consisting of medium- to very coarse-sand and less than 30% fine- to medium-grained mafic-dominated pebbles.

The Hanford formation overlies sediments of the Cold Creek Unit, encountered in the borehole from 98 ft bgs to 138 ft bgs. The upper portion of the Cold Creek Unit, between 98 ft bgs and 110 ft bgs consists of very-well sorted carbonate-rich silts and calcium carbonate-cemented gravelly sands (caliche). The lower portion of the Cold Creek Unit, between 110 ft bgs and 138 ft bgs consists of carbonate-rich silty sands with intermittent caliche nodules, gravelly sands with less than 15% mafic-rich pebbles, and caliche-encrusted massive silt layers that contain less than 10% sand.

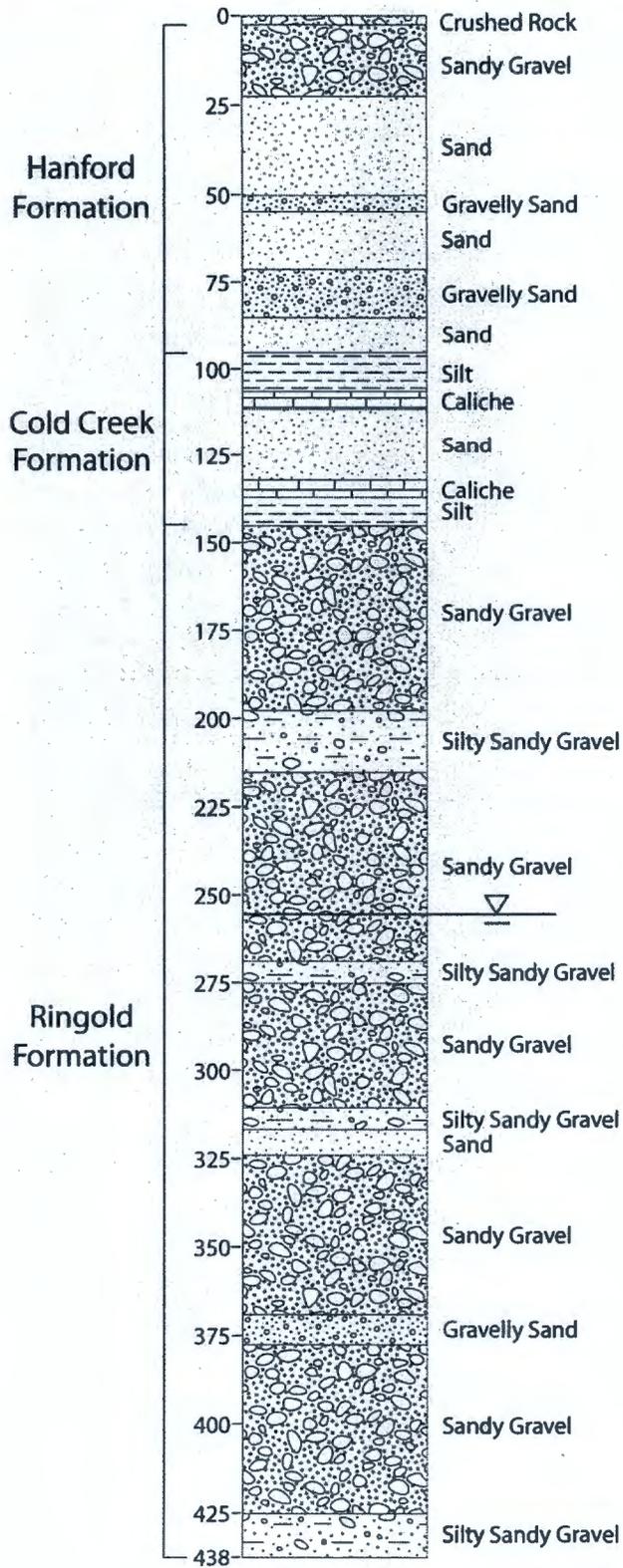
The Ringold Formation, Unit E was encountered between 138 ft bgs to 433 ft bgs. At this location, the Ringold Unit E consists of gravelly sands, sandy gravels and silty sandy gravels.

Pebbles and cobbles in this interval are 30 to 60% mafic-rich and the remainder of the sediments consist of felsic, volcanic, metamorphic and granitoid cobbles; presumably derived from volcanic terranes, unroofed intrusives, and metamorphic terranes in the Cascade Mountain range. Sands in this interval are fine to medium grained; approximately 15 to 40% of the total volume is quartz-dominated. Silt fractions range between 5 and 20%. Within the lower section of this interval (425 ft bgs to 433 ft bgs) sparse clay nodules were observed in the borehole cuttings and could represent a very thin layer of the Ringold Lower Mud unit.

Sediments of the Ringold Formation Unit A were encountered between 433 ft bgs to 438 ft bgs (TD). The Ringold Unit A in this interval consists of silty sandy gravels that are mafic-rich and felsic-poor. A silty-sandy matrix is found in the silty sandy gravels within the interval, and displays very dark gray-green staining and as well as dark colored lenses of silt interbedded with cobbles of weathered basalt.

Lithologic descriptions and geologic borehole logs for this well were prepared in accordance with FH procedure GRP-EE-01-7.0, "*Geologic Logging*," and are included in Appendix B.

Figure 7-1 Subsurface Geology of Well 299-W11-45 (C4948)



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**APPENDIX A:**  
**WELL SUMMARY SHEET**  
**WELL C4948 (3 PAGES)**

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WELL SUMMARY SHEET		Start Date: 9-2-05	Page 1 of 3	
		Finish Date: 3-9-06		
Well ID: C4948	Well Name: 299-W11-45			
Location: East of WMA-T 200W	Project: T-2 Monitoring Well			
Prepared By: Jake Horner	Date: 3-8-06	Reviewed By: L.D. Walker	Date: 3/29/06	
Signature: <i>Jake Horner</i>		Signature: <i>L.D. Walker</i>		
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth In Feet	Lithologic Description	
6" Stainless steel Sch 10 Type 304L riser pipe: 72.0' - 281.28' bgs		0	0'-0.2': Crushed rock	
			0.2'-2': Sandy Silt (SM)	
				2'-5': Silty Sandy Gravel (SG)
				5'-10': Sandy Gravel (SG)
				10'-18': Silty Sandy Gravel (SG)
			25	18'-24': Sandy Gravel (SG)
6" Stainless steel Sch 10 Type 304L 20 slot screen: 281.28' - 295.87' bgs				
				24'-50': Sand (S)
6" Stainless steel Sch 10 Type 304L Sump: 295.87' - 298.87' bgs			50	50'-54': Gravelly Sand (GS)
				54'-63': Sand (S)
Cement Grout: 0' - 11.45' bgs				63'-65.5': Gravelly Sand (GS)
Granular Bentonite: 11.45' - 238.2' bgs			75	65.5'-73': Sand (S)
Protective surface casing is 8" SS set 1.0' above the 6" riser				73'-89.5': Gravelly Sand (GS)
13 3/8" Temp casing: 0' - 196.5' bgs			100	89.5'-98': Sand (S)
			98'-107': Silt (M)	
10 3/4" Temp casing: 196.5' - 436.2' bgs			107'-110': Caliche	
			110'-131.5': Sand (S)	
All temporary casing was removed.		125		
			131.5'-132': Blank	
			132'-138': Silt (M)	
			138'-195': Sandy Gravel (SG)	

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WELL SUMMARY SHEET		Start Date: 9-2-05		Page 2 of 3	
		Finish Date: 3-9-06			
Well ID: C4948			Well Name: 299-W11-45		
Location: East of WMA-T 200W			Project: T-2 Monitoring Well		
Prepared By: Jake Horner		Date: 3-8-06	Reviewed By: L.D. Walker		Date: 3/29/06
Signature: <i>Jake Horner</i>			Signature: <i>L.D. Walker</i>		
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA			
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description	
Bentonite pellets: 238.2' - 243.8' bgs		150		138'-195': Sandy Gravel (SG)	
10-20 mesh silica sand: 243.8' - 266' bgs		175			
Bentonite pellets: 266' - 271.9' bgs		200		195'-220': Silty Sandy Gravel (SSG)	
10-20 mesh silica sand: 271.9' - 303' bgs		225		220'-250': Sandy Gravel (SG)	
Groundwater depth: 253.5' bgs (3-9-06)		250		250'-252': Silty Sandy Gravel (SSG)	
		275		252'-270': Sandy Gravel (SG)	
				270'-275': Silty Sandy Gravel (SSG)	
				275'-315': Sandy Gravel (SG)	

A-6003-643 (03/03)

WELL SUMMARY SHEET		Start Date: 9-2-05	Page 3 of 3
		Finish Date: 3-9-06	
Well ID: C4948	Well Name: 299-W11-45		
Location: East of WMA-T 200W	Project: T-2 Monitoring Well		
Prepared By: Jake Horner	Date: 3-9-06	Reviewed By: L.D. Walker	Date: 3/28/06
Signature: <i>Jake Horner</i>		Signature: <i>L.D. Walker</i>	
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Lithologic Description
Bentonite Pellets: 308.1' - 308.0'		300	275-315': Sandy Gravel (sg)
			315-318': Silty Sandy Gravel (msg)
		325	318-322': Sand (s)
10-20 mesh silica sand: 426.5' - 308.1'			322-370': Sandy Gravel (sg)
		350	
		375	370'-378': Gravelly Sand (gs)
Bentonite Pellets: 436.9' - 426.5'			
Natural Backfill: 438.0' - 436.9'		400	378'-425': Sandy Gravel (sg)
		425	425'-438': Silty Sandy Gravel (msg)
			TD = 438 ft bgs
All depths are in ft. below ground surface.			
All temporary casing has been removed.			

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**APPENDIX B  
BOREHOLE LOG  
WELL C4948 (11 PAGES)**

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BOREHOLE LOG						Page 1 of 11
Well ID: C4948		Well Name: 299-W11-45		Location: ~300' East of WAA-T		
Project: T-2 Groundwater Monitoring well				Reference Measuring Point: Ground surface		
Depth (Ft.)	Sample		Graphic Log	Sample Description	Comments	
	Type No.	Blows Recovery				
0				0-0.2' Crushed rock (drill cut)	Cable tool with temporary casing	
				0.2'-2' Sandy silt (cut)	steel casing & drive barrel	
5	Grab			2'-5' Silty sandy gravel (sG) v. coarse pebbles to small cobbles with med-fine sand & silt.	5' Archive Sample (AS) #1	
10	Grab			5'-10' Sandy gravel (sG) well-rounded, med.-v. coarse pebbles with med.-course sand & ~10% silt.	10' AS #2	
15	Grab			10'-18' Silty sandy gravel (sG) sub-rounded pebble-cobble gravel with coarse to fine sand & ~75% silt.	15' AS #3	
20	Grab			18'-24' Sandy gravel (sG) v.P. sorted - sub-rounded pebbles & cobbles (70% basalt, 30% other) with coarse sub-angular sand (60-70% basalt).	20' AS #4A & 4B	
25	Grab			24'-40' Sand (S) well-sorted, sub-angular, med. grained heterolithic sand with <10% pebbles	25' AS #5A & 5B	
30	Grab			- @ ~35' hrs a 2" layer of sandy silt was encountered	30' AS #6A & 6B	
35	Grab				35' AS #7A & 7B	
Reported By: Jake Horner				Reviewed By: L.D. Walker		
Title: Geologist				Title: Geologist		
Signature: Jake Horner		Date: 9-2-05		Signature: L.D. Walker		
				Date: 12/27/05		

BOREHOLE LOG					Page 2 of 11
Well ID: C4948		Well Name: 299-W11-45		Location: ~300' East of WMA-T	
Project: T-2 (GW) Monitoring Well			Reference Measuring Point: Ground surface		
Depth (Ft.)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
40	Grab		[Graphic Log: 44'-50' interval]	44'-50' Sand (S) Moderately sorted coarse, sub-angular to sub-rounded retrolithic sand with sparse fine pebbles	40' A.S. # 8A & 8B
45	Grab			50'-54' Gravely sand (GS) Med. sorted, med. - coarse sub-angular sand with fine to med. pebbles (75% < 2.5φ)	45' A.S. # 9A & 9B
50	Grab		[Graphic Log: 54'-56' interval]	54'-56' Sand (S) Med. sorted, med. grained, sub-angular sand (retrolithic) with local carbonaceous cement (reacts w/ HCl)	50' A.S. # 10A & 10B
55	Grab			56'-63' Sand (S) Same as above with no cement	55' A.S. # 11A & 11B
60	Grab		[Graphic Log: 63'-65.5' interval]	63'-65.5' Gravely sand (GS) Poorly sorted, fine - coarse, sub angular to sub-rounded sand with fine, sub-angular to sub-rounded pebbles (75% basalt, 30% dia) thin sand grains display minor oxidation & are weakly cemented.	60' A.S. # 12A & 12B
65	Grab			65.5'-73' Sand (S) Well sorted, coarse, sub-angular to sub-rounded retrolithic sand with sparse pebbles	65' A.S. # 13A & 13B
70	Grab		[Graphic Log: 73'-78' interval]	73'-78' Gravely sand (GS) Well sorted, v. coarse, sub-angular to angular retrolithic sand with fine to med. sub-angular pebbles (80% med. 20% dia). Pebbles & sand are slightly oxidized.	70' A.S. # 14A & 14B
75	Grab			75' A.S. # 15A & 15B	

Reported By: Jake Horner

Reviewed By: L.D. Walker

Title: Geologist

Title: Geologist

Signature: [Handwritten Signature]

Date: 9/6/05

Signature: [Handwritten Signature]

Date: 12/27/05

BOREHOLE LOG					Page 3 of 11
Well ID: C4948		Well Name: 299-W11-45		Location: ~300' East of WMA-T	
Project: T-2 GW Monitoring Well			Reference Measuring Point: Ground surface		
Depth (FL)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
80	Grab			78'-80.5' Gravelly sand (GS) Pebbles became smaller (v. fine - fine) & are more sparse - 5% silt is also present.	80' A.S. #16A & 16B
85	Grab			@85' Gravelly sand (GS) v. well-sorted, v. coarse sub-rounded sand (40% or 60% med. & fine - med. sub-rounded pebbles (70% med. 30% silt))	85' A.S. #17A & 17B
90	Grab			Minor CaCO <sub>3</sub> is present forming v. weak clumps of sand	90' A.S. #18A & 18B
95	Grab			89.5'-89.7' Silt (M) Olive brown (2.5% Fe <sub>2</sub> O <sub>3</sub> ) layer of moist silt	96' A.S. #19A & 19B
100	Grab			89.7'-96' Sand (S) Med. sorted, med. to v. coarse sub-rounded to sub-angular sand with sparse, sub-rounded v. fine basalt pebbles, very similar to GS above the silt, but with fewer pebbles, v. coarse sand grains are 70% basalt.	100' A.S. #20A & 20B
105	Grab			@97' grain size decreases to a medium grained sand with very fine v. fine pebbles, very weak CaCO <sub>3</sub> cementation is encountered, forming small clumps of sand.	105' A.S. #21A & 21B
110	Grab			98'-107' Silt (M) v. well sorted, moderately cemented (with CaCO <sub>3</sub> ) silt	110' A.S. #22A & 22B
115	Grab			107'-110' CaCO <sub>3</sub> cemented sand & gravel (caliche)	115' A.S. #24A & 24B

Reported By: John Harris      Reviewed By: L.D. Walker  
 Title: Geologist      Title: Geologist  
 Signature: John Harris      Date: 9-8-05      Signature: L.D. Walker      Date: 12/27/05

BOREHOLE LOG					Page 4 of 11
Well ID: C4948		Well Name: 299-NH-45		Location: ~300' East of WMA-T	
Project: T-2 GW Monitoring Well		Reference Measuring Point: Ground surface			
Depth (FL)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
120	Grab			110-111' Silty sand (s.s.) weakly cemented, poorly sorted silty sand with small calcite nodules	120' A.S. #25A & 25B
125	Grab			111-112' Sandy silt (s.m.) very pale brown (10% 7/8, moist) CaCO <sub>3</sub> has decreased	125' A.S. #26A & 26B
130	Grab			112-113' Slightly silty sand (s.s.) med sorted, med. graded, sub- angular to sub-rounded sand with 15% silt. Pebbles are very sparse. Silt is light tan & roots with HCl	130' A.S. #27 & 28B
135	Grab			113-117' Sand (s) well sorted, med. fine, sub- angular to sub-rounded sand	135' A.S. #28A & 28B *Changed to hand tool drilling method @ 138' depth.
140	Grab			117-121' Silty sand (s.s.) Fine grained sand with ~30% silt & 10-20% coarse basalt sand grains. CaCO <sub>3</sub> laminations are present	140' A.S. #29A & 29B
145	Grab			121-127' Silty sand (s.s.) same as above, but with increase cementation & calcite nodules are present	145' A.S. #30A & 30B
150	Grab			127-130' Sand (s) med sorted, coarse to fine sand with <10% silt. Larger sand grains are mostly basalt. Weak CaCO <sub>3</sub> com. is still present	150' A.S. #31A & 31B
155	Grab			130-131.5' Gravelly sand (g.s.) 90% med sorted, coarse sub-angular sand (50% basalt) & 10% med. sorted sub-round pebbles (80% basalt)	155' A.S. #32A & 32B
Reported By: Jake Horner			Reviewed By: L.D. Walker		
Title: Geologist			Title: Geologist		
Signature: Jake Horner		Date: 9/12/05	Signature: L.D. Walker		Date: 12/27/05

BOREHOLE LOG					Page 5 of 11
Well ID: C4948		Well Name: 229-WH-45		Location: ~300' East of WMA-T	
Project: T-2 SW Monitoring Well			Reference Measuring Point: Ground Surface		
Depth (Ft.)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
160	Grab			136.5' - 132' Caliche layer White (10 yr old, dry) mat. cemented sand & silt	160' A.S. #33A & 33B Cable tool, hand tool drilling
165	Grab			132' - 138' Silt(m) / Sandy silt(m) v. well sorted light olive brown (2.5% silt, slightly damp) with gravel 10% very fine sand - @ 136' silt is very wet, forming a small pocket of mud silt is badly damp above & below 136' zone	165' A.S. #34A & 34B
170	Grab			138' - 195' sandy gravel (s.g.) well sorted well rounded to sub-rounded small cobbles & coarse pebbles with ~15% mat. in fine sand & silt. Cobbles & pebbles are predominantly quartzitic. Gravel are not rounded.	170' A.S. #35A & 35B
175	Grab			@ 165' top cobbles & pebbles are predominantly basalt (~60% / 80' A.S. #37A & 37B with ~20% quartzitic sand fraction is quartz dominated with ~70% quartz & 30% mat. Silt fraction ranges from to 5%.	175' A.S. #36A & 36B
180	Grab			185' - 190' silty sand sub-rounded pebbles & cobbles (predominantly quartzitic) with mat. to fine sand (65% quartz) & 10% silt. Silt fraction was determined by an increased thickness in hand soil cuttings.	180' A.S. #37A & 37B
185	Grab			195' - 220' Silty, sandy gravel sub-rounded pebbles & cobbles (predominantly quartzitic) with mat. to fine sand (65% quartz) & 10% silt. Silt fraction was determined by an increased thickness in hand soil cuttings.	185' A.S. #38A & 38B
190	Grab			190' - 195' Silty sand sub-rounded pebbles & cobbles (predominantly quartzitic) with mat. to fine sand (65% quartz) & 10% silt. Silt fraction was determined by an increased thickness in hand soil cuttings.	190' A.S. #39A & 39B
195	Grab			195' - 220' Silty, sandy gravel sub-rounded pebbles & cobbles (predominantly quartzitic) with mat. to fine sand (65% quartz) & 10% silt. Silt fraction was determined by an increased thickness in hand soil cuttings.	195' A.S. #40A & 40B

Reported By: John Horner

Reviewed By: L.D. Walker

Title: Geologist

Title: Geologist

Signature: John Horner

Date: 9-20-05

Signature: L.D. Walker

Date: 12/27/05

BOREHOLE LOG					Page 6 of 11
Well ID: C4948		Well Name: 299-WM-45		Location: ~300' East of WMA-T	
Project: T-2 GW Monitoring Well			Reference Measuring Point: Ground Surface		
Depth (Ft.)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
200	Grab		2.0 0.0 0.0 0.0 0.0 0.0	220'-250' Sandy gravel sub-rounded pebbles & cobbles (60% quartzite) with med. sand (60% 70% quartz) & 10% silt. pebbles & cobbles	200' AS # 44A & 44B
205	Grab		0.0 0.0 0.0	are mostly 20 med. sized cobbles with no reaction to HCl	205' AS # 47A & 47B
210	Grab		0.0 0.0 0.0	250'-252' silty sandy gravel med sorted sub-rounded heterolithic silt pebbles to large cobbles quartzite, rounded to med & quartz with sub-rounded to sub-angular medium grained sand (50-60% quartz) & 20% silt. The sandy silt matrix is a dark grayish brown 2.5 y4/2 (damp).	210' AS # 43A & 43B
215	Grab		0.0 0.0 0.0	@ 251' the soil becomes more damp	215 AS # 44A & 44B
220	Grab		0.0 0.0 0.0		220' A.S. # 45A & 45B
225	Grab		0.0 0.0 0.0		225' AS # 46A & 46B
230	Grab		0.0 0.0 0.0		230' A.S. # 47A & 47B
235	Grab		0.0 0.0 0.0		235' A.S. # 48A & 48B
Reported By: Jake Horner			Reviewed By: L.D. Walker		
Title: geologist			Title: geologist		
Signature: <i>Jake Horner</i>		Date: 9-21-05	Signature: <i>L.D. Walker</i>		Date: 12/27/05

BOREHOLE LOG					Page 7 of 11
Well ID: C4948		Well Name: 277 W11 45		Location: ~300' East of WMA-T	
Project: T-2 GW monitoring well			Reference Measuring Point: Ground surface		
Depth (Fl.)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
240	Grab		0.0	252'-270' Sandy gravel (s/s)	
			0.0	Med sorted, sub-rounded to	240 A.S. #49A & 49B
			0.0	well rounded hydroplastic pebbles	
			0.0	& cobbles (60% quartzite) with	
			0.0	sub-angular to sub-rounded	
245	Grab		0.0	med to fine sand (60% quartzite) AS. #50A & 50B	
			0.0	& ~10% silt fraction is	B247 changed back
			0.0	concentrated on cobbles surfaces to drive barrel method	
			0.0	granules are med rounded	Water Table = 253.2' bgs
250	Grab		0.0	@ 265' silt fraction has	
			0.0	noticeably reduced.	250 A.S. #51A & 51B
			0.0		
255	Grab		0.0		255 A.S. #52A & 52B
			0.0		259 bgs Katis sample #6
			0.0		BIDN10
260	Grab		0.0		260 A.S. #53A & 53B
			0.0		263' bgs Barbed sample #6
			0.0		BIDN18B
			0.0		BIDN10 (PRV)
			0.0		BIDN12
265	Grab		0.0		BIDN14
			0.0		265 A.S. #54A & 54B
			0.0		268 bgs Katis sample #7
			0.0		BIDN18 & BIDN12 (PRV)
270	Grab		0.0	270'-275' Silty sandy gravel	
			0.0	Med rounded, well-sorted to	BIDN18 & BIDN12 (PRV)
			0.0	sub-rounded, med sorted	270 A.S. #55A & 55B
			0.0	hydroplastic pebbles & cobbles	274 Barbed sample #5
			0.0	with fine to coarse sand	BIDN13, BIDN16,
			0.0	& ~20% silt. No cohesion	BIDN15, BIDN67 & BIDN78
			0.0	no flk	(PRV)
275	Grab		0.0		275 A.S. #56A & 56B
			0.0		279 pumped sample #6
			0.0		BIDN13, BIDN14
			0.0		BIDN15 & BIDN16

Reported By: Jake Horner

Reviewed By: L.D. Walker

Title: Geologist

Title: Geologist

Signature: *Jake Horner*

Date: 0-6-05

Signature: *L.D. Walker*

Date: 12/27/05

BOREHOLE LOG					Page 8 of 11
Well ID: C494R		Well Name: PN11-45		Location: ~300' East of WMA-T	
Project: T-2 (6) Monitoring Well			Reference Measuring Point: Ground surface		
Depth (Ft.)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
280	W.S.			275' - 280' Silty sand (S.G.)	278' A.S. # 57 @ 280'
	Grab			278' - 280' Poorly sorted, sub-rounded to well-rounded pebbles & cobbles with well-sorted sub-angles to sub-rounded med. to fine silica sand (40%)	279' A.S. # 58 @ 285'
	W.S.			280' - 285' In pockets on weathered surfaces, sand fraction is generally clean, with < 2% fine gravel or moderately rounded	280' A.S. # 59
	Grab			285' - 290' Maximum cobble is ~15cm	283.6' PNAL W.S. # 6
	W.S.			290' - 295' 293' sand fraction is dominantly quartz (~70%)	BIDN46, BIDN51, BIDN68
	Grab			295' - 300' 310' increasing silt content	BIDN79, BIDN89, BIDN91, BIDN93 & BIDN95
	W.S.			300' - 305' 315' - 318' Silty sandy gravel	295' A.S. # 60
	Grab			305' - 310' Med. well sorted, well to sub-rounded pebbles & cobbles with poorly sorted, fine to coarse sand & ~15% silt.	298' Kabis sample # BIDN16
	W.S.			310' - 315' 318' - 322' Sand (S)	293' Kabis # BIDN17
	Grab			315' - 320' Med. well sorted, sub-rounded, med. silica sand (20% matric) with very sparse pebbles & no silt.	293' Pumped # BIDN47, BIDN47, BIDN48 & BIDN48
	W.S.		320' - 325' @ 319.5' pebble/cobble fraction increases (15% pebbles & cobbles, 85% silica sand)	BIDN70, BIDN81, BIDN80, BIDN80	
	Grab			300' A.S. # 61	
	W.S.			298' Kabis # BIDN18	
	Grab			# BIDN19	
	W.S.			302.7' Pumped sample # BIDN48, BIDN59, BIDN70, & BIDN81	
	Grab			305' A.S. # 62	
	W.S.			308.6' Kabis # BIDN80	
	Grab			310' A.S. # 63	
	W.S.			314' Kabis # BIDN21	
	Grab			314' Pumped # BIDN49, BIDN60, BIDN71 & BIDN82 (PNAL) & FH samples BIFR2, BIFR3 & BIFR4.	

Reported By: Jake Horner  
 Title: Geologist  
 Signature: [Signature]  
 Date: 10/18/05

Reviewed By: L.D. Walker  
 Title: Geologist  
 Signature: [Signature]  
 Date: 12/27/05

BOREHOLE LOG					Page 9 of 11
Well ID: C4948		Well Name: 299-A11-45		Location: East of WMA-T (~300')	
Project: T-2 GW Monitoring Well			Reference Measuring Point: Ground Surface		
Depth (Fl.)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
320	Grab			322-327' Sandy gravel (s.G)	326' Kabis #
				Rubble / cobble fraction increased to 50%, max cobble is ~5"	330' A.S. # 66
				min silts now present	325' Pumped #
				sand fraction is med. to fine	BIDN73
325	Grab			with 65% gr. & 35% mths.	325' A.S. # 67
				@ 325' a 9" layer of well-sorted med. grained silica sand with one pebbles was encountered	328' Kabis # BIDN75
					330' A.S. # 68
330	Grab				333' Pumped # BIDN50, BIDN74, BIDN72 & BIDN73 (Pump) & FH
				327'-370' Sandy gravel (s.G) 65% poorly sorted sub-angular to sub-rounded pebbles & cobbles (max cobbles are ~5") with 30% sub-angular med. grained silica sand & 5% silt accumulated on cobble surfaces.	336' Kabis # BIDN76
335	Grab				335' A.S. # 69
					340' A.S. # 70
					343' Pumped # BIDN77
					343' change to hand tool drilling method
340	Grab				345' A.S. # 71
					348' Kabis # BIDN78
					350' A.S. # 72
					3525' Pumped BVAL
345	Grab				354' Pumped # BIDN79, BIDN72, BIDN73 & BIDN74 & FH sample
					355' A.S. # 73
350	Grab				350' same as above
				358' Kabis # BIDN30	
				360' A.S. # 74	
				363' Pumped sample # BIDN31	
355	Grab			365' A.S. # 75	
Reported By: Jake Norner			Reviewed By: L.D. Walker		
Title: Geologist			Title: Geologist		
Signature: <i>Jake Norner</i>		Date: 10/24/05	Signature: <i>L.D. Walker</i>		Date: 12/27/05

A-6003-642 (03/03)

BOREHOLE LOG					Page 10 of 11
Well ID: C4948		Well Name: 299-AH-45		Location: ~300' East of WMA - T	
Project: T2 GW Monitoring Well			Reference Measuring Point: Ground surface		
Depth (FL)	Sample		Graphic Log	Sample Description	Comments
	Type	Blows Recovery			
360	Grab		[Hand-drawn log showing soil texture with circles and dots]	365' Sand & silt fraction have increased (60% sand, 35% pebbles/cobbles & 5% silt)	368' Kabis sample # BIDN32 370' A.S. # 76
365	Grab			370'-375' Gravely sand (s.g.) Sand fraction continued to increase (70% sand, 25% gravel & -5% silt). Pebble cutting one ~1cm. Sand is a medium silica-rich sand.	372.5-373': pumped water samples: BIDN74, BIDN52, BIDN69, BIDN63, BIFRC1, BIFRC2, BIFRC3
370	Grab		[Hand-drawn log showing soil texture]	375' heavy sand - med to coarse, 5-10% pebbles to 1cm	375' A.S. # 77
375	Grab			378-385' Sandy gravel (s.g.) several large pebbles & cobble fragments (70%) with poorly sorted med. to coarse heavy silty sand (28% silt) & ~2% silt.	378' Kabis sample # BIDN34 380' A.S. # 78
380	Grab		[Hand-drawn log showing soil texture]	385' pebble/cobble fragments size decreases to ~.25cm (max size)	383' Pumped sample # BIDN35 385' A.S. # 79
385	Grab				388' Kabis sample # BIDN36
390	Grab		[Hand-drawn log showing soil texture]	390' same as above	390' A.S. # 80
395	Grab				393' Pumped water samples: BIDN53, BIDN64, BIDN75 & BIDN86 (P/N/L) & PH samples: BIFRTR, BIFRVD & BIFRVI.
398	Grab			395' A.S. # 81 398' Kabis sample # BIDN38	

Reported By: Jake Horner  
 Title: Geologist  
 Signature: [Signature] Date: 1-2-05

Reviewed By: L.D. Walker  
 Title: Geologist  
 Signature: [Signature] Date: 12/27/05

BOREHOLE LOG				Page 11 of 11	
Well ID: <u>C4948</u>		Well Name: <u>299A21-45</u>		Location: <u>East of WMA-T</u>	
Project: <u>T-2 Monitoring Well</u>		Reference Measuring Point: <u>Ground Surface</u>			
Depth (Ft.)	Sample		Graphic Log	Sample Description	Comments
	Type No.	Blows Recovery			
400	Grab				Proposed 400' BIDN39 @ 405' by 400' A.S. # 82
405	Grab				405' A.S. # 83
410	Grab			415' - Increasing silt fraction (5-10%) 418' - Ringold E gravel (no mud)	408' Kobs sample # BIDN40 410' A.S. # 84 411' Proposed 415' to
415	Grab			425' - 433' Silty sandy gravel (no) Small pebbles to small pebble fragments (60% max) with 25% silt to coarse, tabular silt sand & -10% silt. Sparse 1cm nodules of clay are present. Nodules of	412' Kobs 415' BIDN42 418' - 419.5' split soon sample to check lithology
420	Grab			changed together with sand & cobble chert. Could be a thin clay lens above the red as the top of the lens did not	418' A.S. # 85 419' A.S. # 86 taken from ss. shoe.
425	Grab			433' - 438' Silty sandy gravel (no) Pebble/cobble fraction has increased to 70%. Some quartzite cobbles are still present. Sand/silt matrix consists of two distinct zones. Silica sand is present with	423' Proposed 425' BIDN43 426' A.S. # 87 428' Kobs 425' # BIFTR4
430	Grab			very dark grayish green (2.5/5.6 GLEYS), similar to very dark pockets of silt are present plus cobbles (weathered boulders?)	430' A.S. # 88 435' A.S. # 89 436' A.S. # 90 433' Proposed 435' BIFTR67, BIFTR68 BIFTR69 BIFTR70, BIFTR71, BIFTR72 & BIFTR73
435	Grab				436' Kobs sample # BIFTR5 & BIFTR6
440	Grab				
445	Grab				
450	Grab				
455	Grab				
460	Grab				
465	Grab				
470	Grab				
475	Grab				
480	Grab				
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795	Grab				
800	Grab				
805	Grab				
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955	Grab				
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965	Grab				
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975	Grab				
980	Grab				
985	Grab				
990	Grab				
995	Grab				
1000	Grab				

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**APPENDIX C**  
**WELL CONSTRUCTION SUMMARY FOR:**  
**WELL C4948 (2 PAGES)**

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WELL CONSTRUCTION SUMMARY REPORT				Start Date: 9-2-05			
				Finish Date: 3-9-06			
				Page 1 of 2			
Well ID: C4948		Well Name: 299-W11-45		Approximate Location: East of WMA-T 200W			
Project: T-2 Monitoring Well		Other Companies: GRAM Inc.		Geologist(s): Jake Horner, Mike Carron, Watson Bowles, Robin Henderson, & Jess Heckings			
Drilling Company: BSE-NW		License #: 1430		Driller: Gary Howell			
TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)			
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger:	Diameter 13 3/8 From 0 to 196.5			
13 3/8"	0 - 196.5	13 3/8 / 12 1/8	Cable Tool ✓	Diameter 10 3/4 From 196.5 to 436.2			
10 3/4"	196.5 - 436.2	10 3/4 / 9 1/4	Air Rotary:	Diameter _____ From _____ to _____			
			A.R. w/Sonic:	Diameter _____ From _____ to _____			
				Diameter _____ From _____ to _____			
				Diameter _____ From _____ to _____			
*Indicate Welded (W) - Flush Joint (F.J.) Coupled (C) & Thread Design							
13 3/8" with rope threads							
10 3/4" with box threads							
Drilling Fluid:							
Total Drilled Depth: 436.5'		Hole Dia @ TD: 10 3/4"		Total Amt. Of Water Added During Drilling: ~300 gallons			
Well Straightness Test Results: Pass		Static Water Level: 253.5'		Date: 3-9-06			
GEOPHYSICAL LOGGING							
Sondes (type)	Interval	Date	Sondes (type)	Interval	Date		
Spectral Gamma	0 - 427	11-15-05					
COMPLETED WELL							
Size/WL/Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
1 3/8" / 6" / SS riser	12.0 - 281.28	box	n/a	Cement Grout	0 - 11.45	8 ft <sup>3</sup>	n/a
6 3/8" / 6" / SS screen	281.28 - 295.87	box	20	Granular Bentonite	11.45 - 238.2	567 ft <sup>3</sup>	n/a
6 3/8" / 6" / SS sump	295.87 - 298.87	box	n/a	Bentonite Pellets	238.2 - 243.8	25 ft <sup>3</sup>	n/a
				Silica Sand	243.8 - 266	105 ft <sup>3</sup>	10-20
				Bentonite Pellets	266 - 271.9	1.9 ft <sup>3</sup>	n/a
OTHER ACTIVITIES							
Aquifer Test:		Date:	Well Decommission:		Yes: No: Date:		
Description:		Description:					
WELL SURVEY DATA (if applicable)							
Washington State Plane Coordinates:			Protective Casing Elevation: Not available at this time				
			Brass Survey Marker Elevation: -LOW 3/29/06				
COMMENTS / REMARKS							
See page 2 for more information on well completion							
Reported By: Jake Horner		Title: Geologist		Signature: <i>Jake Horner</i>			
				Date: 3-24-06			

WELL CONSTRUCTION SUMMARY REPORT				Start Date: 9-2-05			
				Finish Date: 3-9-06			
				Page 2 of 2			
Well ID: C4948		Well Name: 299-W11-45		Approximate Location: East of WMA-T			
Project: T-2 Monitoring WPM			Other Companies: GRAM Inc.				
Drilling Company: BSE-NR			Geologist(s): Jake Horner, Mike Carron Nathan Bowles, Robin Henderson Jess Hocking				
Driller: Gary Howell		License #:					
TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)			
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger	Diameter	From to		
			Cable Tool	Diameter	From to		
			Air Rotary	Diameter	From to		
			A.R. w/Sonic	Diameter	From to		
				Diameter	From to		
				Diameter	From to		
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter	From to		
<del>GR</del>			<del>GR</del>				
Total Drilled Depth:		Hole Dia @ TD:		Drilling Fluid:			
Well Straightness Test Results:			Static Water Level:		Date:		
GEOPHYSICAL LOGGING							
Sondes (type)	Interval	Date	Sondes (type)	Interval	Date		
COMPLETED WELL							
Size/WL/Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
				Silica Sand	271.9 - 303	160ft <sup>3</sup>	10-20
				Bentonite Pellets	303 - 308.1	3.1 ft <sup>3</sup>	N/A
				Silica Sand	308.1 - 426.5	69.5ft <sup>3</sup>	10-20
				Bentonite Pellets	426.5 - 436.9	2.5 ft <sup>3</sup>	N/A
				Natural Backfill	436.9 - 438	N/A	N/A
OTHER ACTIVITIES							
Aquifer Test:		Date:	Well Decommission:		Yes: No: Date:		
Description:			Description:				
WELL SURVEY DATA (If applicable)							
Washington State Plane Coordinates: N/A			Protective Casing Elevation: N/A				
			Brass Survey Marker Elevation: N/A				
COMMENTS / REMARKS							
Reported By: Jake Horner		Title: Geologist		Signature: Jake Horner			
				Date: 3-24-06			

WMP-29683, REV 0

**APPENDIX D**  
**WELL DEVELOPMENT DATA FOR:**  
**WELL C4948 (2 PAGES)**

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