INEEL/EXT-03-01180

Well Completion Report Test Area North, Well Construction 2003 Operable Unit 1-07B

Idaho Completion Project

Bechtel BWXT Idaho, LLC

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Idaho Completion Project
Idaho Falls, Idaho 83415

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Assistant Secretary for Environmental Management
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Approved by

Lee Nelson
OU 1-07B Project Manager,
Ground Water Cleanup

4/12/04
Date

Doug Vandel
OU 1-07B Project Engineer

4/12/04
Date

ABSTRACT

This report describes activities associated with the installation and completion of three wells drilled in support of the in situ bioremediation remedial action at Test Area North (TAN), Operable Unit 1-07B. TAN-1859 was drilled to 302 ft below land surface (bls) and installed as a new nutrient injection well. TAN-1860 (drilled to 413 ft bls) and TAN-1861 (drilled to 414 ft bls) are to be used as plume extraction and monitoring wells. Both monitoring wells were drilled to the top of the Q-R interbed. Work on this drilling project began in May 2003 and was completed in September 2003.

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ACRONYMS

AEC	Atomic Energy Commission
bls	below land surface
CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act
COC	contaminant of concern
DCE	cis- and trans- 1, 2-dichloroethene
DOE	Department of Energy
ID	inside diameter
INEEL	Idaho National Engineering and Environmental Laboratory
ISB	in situ bioremediation
MCL	maximum contaminant level
NRTS	National Reactor Testing Station
OD	outside diameter
OU	operable unit
PCE	tetrachloroethene
PPE	personal protective equipment
RCIMS	Radiological Control and Information Management Systems
RCT	radiological control technician
TAN	Test Area North
TCE	trichloroethene
TD	total depth
TSF	Technical Support Facility
USGS	United States Geological Survey
VC	vinyl chloride
VOC	volatile organic compound
WAG	waste area group

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1. INTRODUCTION

This report summarizes the drilling, installation, and re-entry activities that were conducted at Test Area North (TAN) at the Idaho National Engineering and Environmental Laboratory (INEEL) between May 21, 2003, and September 2003. The work described in this well completion report supports remedial design/remedial action activities for Waste Area Group (WAG) 1, Operable Unit (OU) 1-07B at TAN. Well construction consisted of drilling one new injection well (TAN-1859) and two monitoring wells (TAN-1860 and TAN-1861); TAN-1861 required re-entry and conditioning of an unstable open well bore annulus. These wells will be applicable to TAN groundwater remedial action efforts and will serve to better define the extent of the groundwater contaminant plume.

2. BACKGROUND

2.1 Site Background

The INEEL (formerly the National Reactor Testing Station [NRTS]) encompasses 2,302 km² (889 mi²) and is located approximately 55 km (34 mi) west of Idaho Falls, Idaho. The Department of Energy (DOE) Idaho Operations Office has responsibility for the INEEL and designates authority to operate the INEEL to government management and operating contractors.

The Atomic Energy Commission (AEC), now the Department of Energy, established the NRTS (now the INEEL) in 1949 as a site for building and testing a variety of nuclear facilities. The INEEL has also been the storage facility for transuranic radionuclides and radioactive low-level waste since 1952. At present, the INEEL supports the engineering and operations efforts of the DOE and other federal agencies in areas of nuclear safety research, reactor development, energy technology and conservation programs, and DOE long-term stewardship programs.

The TAN complex, located in the northeast portion of the INEEL (see Figure 1), covers an area of about 30 km² (12 mi²). It is located approximately 80 km (50 mi) northwest of Idaho Falls and 28 km (15 miles) west of Terreton, Idaho. Test Area North consists of four major facilities that were used to develop a nuclear-powered aircraft and to conduct tests that simulated accidents involving the loss of coolant from nuclear reactors. Industrial activities at the Technical Support Facility (TSF), centrally located at TAN, generated wastewater that was introduced into the groundwater via the TSF-05 injection well.

From approximately 1953 to 1972, the TSF-05 injection well disposed of the liquid waste into the underlying Snake River Plain Aquifer. In 1997, the groundwater beneath TAN was classified as F001-listed waste. The contaminants of concern (COCs) in the groundwater at this site include the volatile organic compounds (VOCs) trichloroethene (TCE), cis- and trans-1,2-dichloroethene (DCE), tetrachloroethene (PCE), and vinyl chloride (VC); and the radionuclides tritium, Sr-90, Cs-137, and U-234. Detailed descriptions of the historical background of this injection well can be found in the *Remedial Investigation Final Report with Addenda for the Test Area North Groundwater Operable Unit 1-07B at the Idaho National Engineering Laboratory* (Kaminski et al. 1994), and in the *Record of Decision Amendment for the Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action* (DOE-ID 2001).

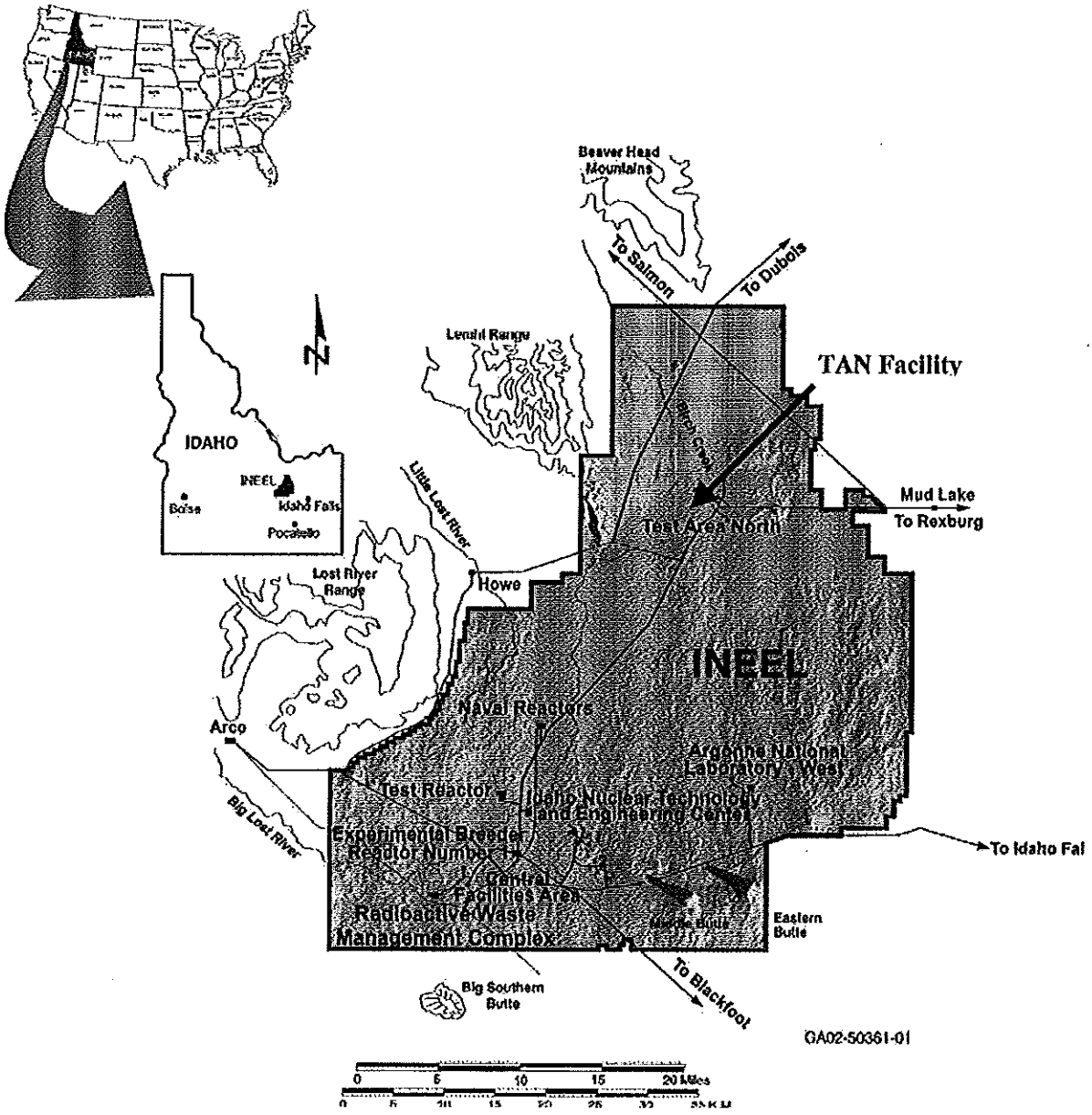

Figure 1. Map of the Idaho National Engineering and Environmental Laboratory showing the location of Test Area North and other Site facilities.

2.2 Environmental Setting

The surface of the INEEL is relatively flat with the predominant relief manifested either as volcanic buttes jutting from the desert floor or as unevenly surfaced basalt flows, flow vents, and fissures. With the exception of the buttes on the southern border of the INEEL, elevation levels on the INEEL range from 1,460 m (4,790 ft) in the south to 1,802 m (5,913 ft) in the northeast with an average of 1,524 m (5,000 ft) above sea level (Irving 1993). With precipitation ranging from 9 to 13 in. per year, the area is classified as a semiarid sagebrush desert. Yearly temperatures are consistent with western mountain valleys. The average annual temperature is roughly 42°F, with warm dry summers followed by

cold winters. The relatively flat topography and constant temperature variances help to develop frequent gusty winds during all times of the year.

2.3 Geological Setting

The surface of the TAN area is characterized by wind-deposited soils (loess) varying in thickness from 9.1 to 18.9 m (30 to 65 ft). The geology beneath is characterized by basalt flows intercalated with sedimentary interbeds. Basalt flows are highly variable ranging from dense to highly vesicular and from massive to highly fractured. Sedimentary interbeds vary in thickness but are generally thinner than interbeds found elsewhere at the INEEL. Two main interbeds, P-Q and Q-R, consist primarily of silt and clay. At TAN, the P-Q interbed is laterally extensive, but not continuous, and is encountered in about half the wells that are drilled to a depth where it would be expected. The P-Q interbed has an average thickness of about 1.8 m (6 ft). Near the new in situ bioremediation (ISB) injection facility, the P-Q interbed, as observed in the nearby wells, is discontinuous and varies in thickness from approximately .3 to 2.4 m (1 to 8 ft) where present and at a depth of approximately 60.4 m (198 ft) below land surface (bls).

The Q-R interbed appears to be laterally continuous in the area surrounding TAN and ranges from about 125.6 to 143.3 m (412 to 470 ft) bls. The average thickness is about 5.2 m (17 ft), which effectively confines contamination within the aquifer. A more complete description of the geology, hydrogeology, and groundwater contamination at TAN is found in the TAN site conceptual model reports (Sorenson et al. 1996; Bukowski and Sorenson 1998; Bukowski, Bullock, and Sorenson 1998; and Wymore et al. 2000).

3. REMEDIAL ACTION

The objective of the OU 1-07B remedial action is to contain and remove the identified secondary source contaminates and remediate the downgradient contaminated groundwater (plume). The contaminated groundwater was divided into three zones to facilitate remediation of the plume. The boundaries of each zone of the plume were based on TCE concentrations. The three zones (INEEL 1997) were defined as follows:

1. **Hot Spot Zone (TCE concentrations exceeding 20,000 µg/L)**—In situ bioremediation promotes bacterial growth by supplying essential nutrients to bacteria that naturally occur in the aquifer and are able to break down contaminants. An amendment (such as sodium lactate or molasses) is injected into the secondary source area through the TSF-05 injection well or other wells in the immediate vicinity. Amendment injections increase the rate at which the VOCs break down into harmless compounds. The amendment supply is distributed as needed and the treatment system operates year-round. TAN-1859 is a new injection well that will support this system. TAN-1860 and TAN-1861 will be used to monitor the progress and performance of the ISB remedy.

2. **Medial Zone (TCE concentrations between 1,000 and 20,000 µg/L)**—Pump-and-treat involves extraction of contaminated groundwater, treatment through air strippers, and reinjection of treated groundwater. Air stripping is a process that brings clean air into close contact with contaminated liquid, allowing the VOC contaminants to pass from the liquid into the air.

3. **Distal Zone (TCE concentrations between 5 and 1,000 µg/L)**—Natural attenuation is the sum of the physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Monitored natural attenuation includes groundwater monitoring with annual performance reviews for the first 5 years to compare actual natural degradation rates to predicted degradation rates, followed by

additional periodic reviews thereafter at a frequency to be decided by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Idaho Department of Environmental Quality, referred to as the Agencies.

Engineering and administrative controls will be put in place to protect current and future users from health risks associated with groundwater contamination. During the early part of the restoration timeframe, the contaminant plume continues to increase slowly in size until the natural attenuation process overtakes it.

4. WORK PERFORMED

One injection well (TAN-1859) and two monitoring wells (TAN-1860 and TAN-1861) were drilled and completed by a subcontract drilling company between May 27, 2003, and September 2003. The installation and completion of these wells support the ISB remedial action at TAN, OU 1-07B, at the INEEL. The wells are located within the existing boundaries of the OU 1-07B Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) area. TAN-1859 will be connected to the new ISB injection facility and used as a nutrient injection well. TAN-1860 and TAN-1861 will be used as ISB system monitoring wells. TAN-1859 was drilled to a total depth (TD) of 92 m (302 ft) bls. TAN-1860 and TAN-1861 were drilled just into the top of the Q-R interbed to 125.9 m (413 ft) and 126.2 m (414 ft) bls, respectively. Open borehole conditions in TAN-1861 required that reentry and conditioning be conducted twice. The installation of an open-ended screen through a basalt rubble zone interval from 63.7 to 78.9 m (209 to 259 ft) bls stabilized caving of the fractured annulus wall.

Drill cuttings were analyzed at 5-ft intervals for the purpose of describing the subsurface lithology at each well site. A detailed description of lithology and field activity is recorded in the "Environmental Restoration Department Record of Rotary Drillhole" (ER-054-2003) and the "Environmental Restoration Department Field Team Leader's Daily Logbook" (ER-056-2003). Geophysical logging data and downhole video loggings were collected by the United States Geological Survey (USGS). Hard copies of the geophysical logs and video logs are available in the OU 1-07B project file. Appendix A shows the well completion diagrams, lithologic descriptions, and geophysical logs.

All of the wells were constructed in accordance with the most recent versions of the following documents and well drilling specifications:

- "In Situ Bioremediation Well Drilling Specification" (INEEL 2003a)
- "In Situ Bioremediation Well Drilling Plan" (INEEL 2003b)
- *Special Conditions for INEEL FY-03 Well Drilling at TAN* (Edelmayer 2003)
- *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan* (INEEL 2002).

Table 1. provides a well construction summary for the new injection well and monitoring wells. Figure 2 illustrates the location of the new wells. The following sections give detailed end of well reports for each well drilled.

Table 1. Well construction summary for TAN-1859, TAN-1860, and TAN-1861.

Well Name	Hole Diameter (in.)	Hole Depth (ft bls)	Casing Interval (ft)	Screen Interval (ft)	Casing/Screen Diameter (in. OD)	Water Level (ft bls)
TAN-1859	20	58	-3 to 58 csc		16 (sch 40)	
	15	195	-2 to 195 csc		10-3/4 (sch 40)	
	9-7/8	302 TD	-2 to 210 ssp Open Hole 270 to 302	210 to 270 sss (slot 0.02 in., w-0.06)	1-1/4	207
TAN-1860	20	37	-3 to 35.5 csc		16 (sch 40)	
	15	195.5	-.5 to 195.5 csc		10-3/4 (sch 40)	
	9-7/8	414 TD	Open Hole 195.5 to 414			209
TAN-1861	20	65	-3 to 65 csc		16 (sch 40)	
	15	195.5	-2 to 195.5 csc		10-3/4 (sch 40)	
	9-7/8	413 TD	-1.5 to 217.1 ssc Open Hole 277.1 to 413	217.1 to 277.1 ssc (Slot 0.05 in.)	6-5/8 (sch 10)	209

csc-Carbon steel casing
ssc-stainless steel casing
ssp-stainless steel pipe
sss-stainless steel screen
OD-outside diameter
TD-total depth

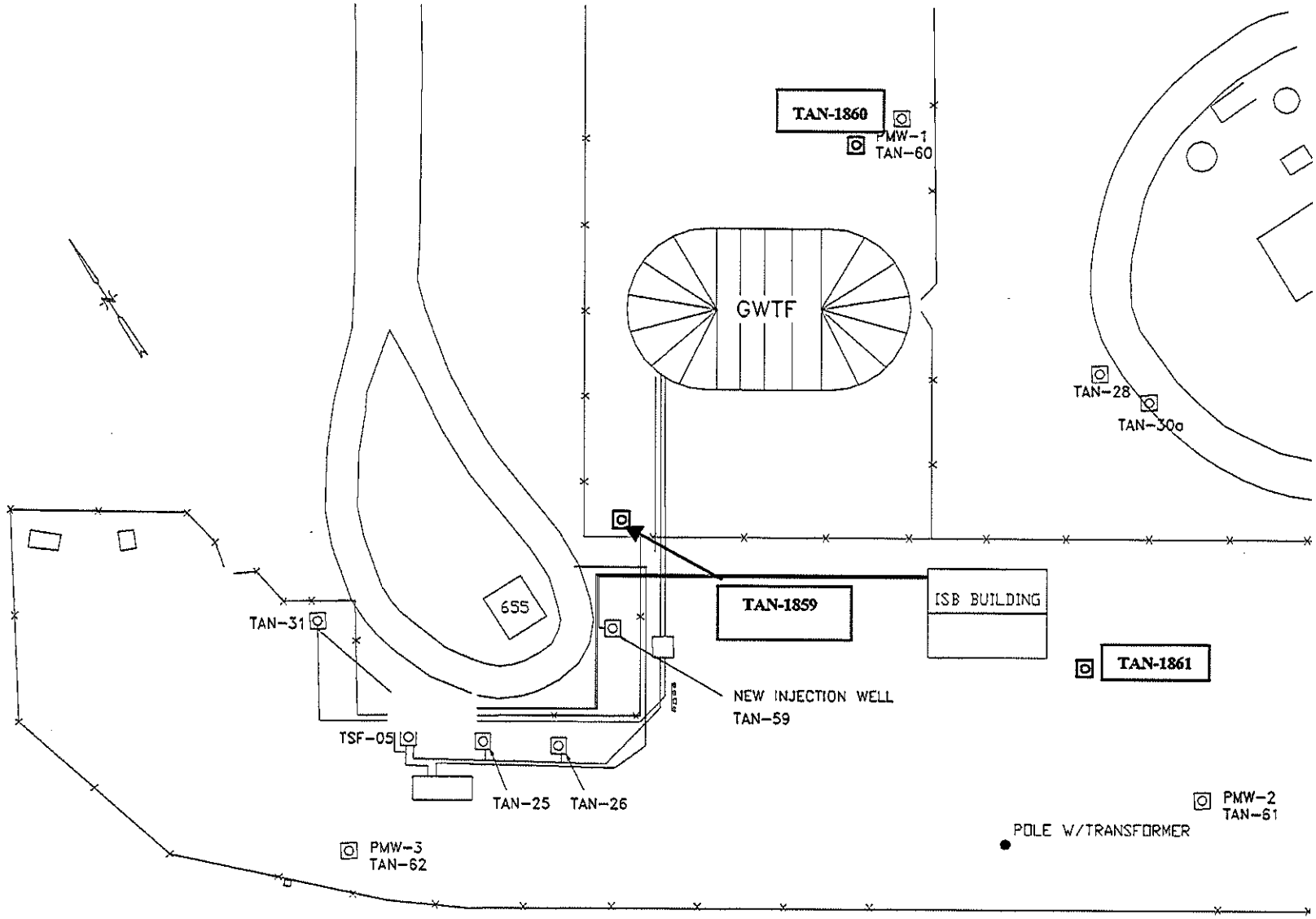

Figure 2. Well location map including TAN-1859, TAN-1860, and TAN-1861.

4.1 TAN-1859 End of Well Report

4.1.1 General

A. Project name:

Test Area North ISB OU 1-07B Injection and Extraction Well Installations.

B. Well number:

TAN-1859.

C. Hole location:

- TAN-GWTF (16.5 m [54 ft] W-SW of TAN-37)
- NORTHING: Not Available
- EASTING: Not Available
- ELEVATION: (29 BC) 4,785.23 ft.

D. Implementation Plans:

i. "In Situ Bioremediation Well Drilling Plan," Rev. C, February 2003.

ii. *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan*, INEEL/EXT-99-00020, Rev. 2, November 2002.

iii. *Special Conditions for INEEL FY-03 Well Drilling at TAN*, Subcontract No. TBD, Special Conditions Issue 0, 1-20-03, Rev. 2, March 3, 2003.

iv. *In Situ Bioremediation Remedial Action Groundwater Monitoring Plan for Test Area North, Operable Unit 1-07B*, INEEL/EXT-2002-00779, Rev. 1, January 2003.

E. Logbooks:

i. ER-054-2003, "Environmental Restoration Department Record of Rotary Drillhole," Pg. 1-14, 186-190, 216.

ii. ER-056-2003, "Environmental Restoration Department Field Team Leader's Daily Logbook," Pg. 2-12, 20-40, 50-51, 61-63.

4.1.2 Drilling and Completion Observations

A. Drilling Company: Dynatec Drilling Incorporated, Salt Lake City, Utah.

B. Field Superintendent: Frank Hight.

C. Drillers: Steve Tawater (driller); Danny Waddoups, Ivan Perks, and Mike Becker (driller's helpers).

D. Geologists: Gary Oberhansley
North Wind, Inc.

E. Field Team Leader: Kory Edelmayer
(BBWI).

F. Drill Rig Type:

Reverse circulation air-rotary Foremost DR-24 with auxiliary Sullair 350 psi/900 cfm air compressor.

G. Drill Bit Type:

20-in. carbide button bit with 10-in. hammer to 58 ft bls; 15-in. carbide button bit with 10-in. hammer to 195 ft bls; and 9-7/8-in. carbide button bit with a 6-1/2-in. hammer to 302 ft bls.

H. Drilling Activity:

A crew of one driller and three helpers worked 10-hour shifts, from 0700 to 1730, four days a week. A geologist oversaw the drilling, logging, and completion of this well. Members of the drilling crew, including the geologist, logged onto Radiological Control Information Management System (RCIMS) each day. A radiological control technician (RCT) surveyed the cuttings and tools used to drill and complete the borehole. A safety person was also assigned to oversee all health and safety aspects of the drilling program. A sampling crew collected water samples for laboratory analysis, and representatives from the WAG observed the handling of wastewater and saturated cuttings.

Drilling of TAN-1859 began at 10:46 on May 27, 2003, using a 20-in. bit and 10-in. hammer, with 7-in. dual-walled drill rods in 6.1-m- (20-ft-) long sections. Drill cuttings were discharged through diverter hoses into a cyclone and then to the ground surface. The borehole was drilled to 1.8 m (6 ft) bls through excavated soil and crushed gravel, then through surface soil of silt and sand (loess) to 10.4 m (34 ft) bls. At that depth, the borehole began to slough and cave in, sticking the hammer/bit and drill rods downhole. The driller back-reamed for over 3 hours to free the hammer/bit and drill rods. The next day, the top of the caving soil was measured at 3.7 m (12 ft) bls. Back-reaming continued until the drill rods and hammer/bit were removed from the borehole annulus. Drilling then continued in the same borehole to the previous depth of 10.4 m (34 ft) bls, and then through more surface soils to the top of basalt bedrock at 14 m (46 ft) bls. Drilling continued to 17.7 m (58 ft) bls in competent basalt, which included an additional .6 m (2 ft) of rat hole because of the sloughing fines above. The drill rods, hammer, and bit were then removed from the well bore and 16-in. outside diameter (OD) (15-3/8-in. inside diameter [ID]) carbon steel casing (Schedule 40) was set at 16.8 m (55 ft) bls on May 29, 2003.

Drilling continued on June 4, 2003, using a 15-in. bit and 10-in. hammer through basalt and several small interbeds to a depth of 59.4 m (195 ft) bls the following day. At that depth, the drill string was tripped out of the borehole and 10-3/4-in. OD carbon steel casing was installed at a total depth of 59.4 m (195 ft) bls.

On June 9, 2003, a Frac tank was moved onto the geomembrane-lined drilling pad, and the exclusion zone surrounding the drill site was posted as a CERCLA site. Upon further

drilling, the drillers used rubber gloves along with the appropriate personal protective equipment (PPE). Drilling continued using a 9-7/8-in. bit and a 6.5-in. hammer to a total depth of 92 m (302 ft) bls in competent basalt. The drill string was then tripped out of the well bore and the drill rig and equipment were moved off location.

After the 10-3/4-in OD casing was set at 59.4 m (195 ft) bls, and in anticipation of the drilling into the aquifer and groundwater COCs, which included TCE and PCE, the cyclone used for discharging drill cuttings to the ground surface was moved on top of the Frac tank to collect both cuttings and produced water. Drill cuttings became saturated with water at approximately 68.6 m (225 ft) bls. During a drill rod connection at 74.9 m (246 ft) bls, water began to be produced. Before drilling continued, water was blown to the surface through the cyclone into the Frac tank until it became mostly clear. Approximately 9 L of produced water was then collected for laboratory analysis by the sampling team.

The Frac tank began to be pumped down into trailer-mounted poly tanks and hauled to the New Pump and Treat Facility (NPTF) for treatment and discharge. On the following day, June 10, 2003, the remaining water was pumped from the Frac tank into the trailer-mounted poly tanks for a total of approximately 2,600 gal of produced water from this well. The USGS video-logged the well bore to 63.1 m (207 ft) bls where standing water was encountered. Because the water was too muddy, the video logging ended at 63.4 m (208 ft) bls. The natural gamma and caliper log was then run from the surface to the bottom of the well bore, at 92 m (302 ft) bls.

On June 11, 2003, the drillers used a backhoe to remove the drill cuttings from the Frac tank into plastic-lined plywood soil boxes approximately 64 ft^3 in size. The soil boxes were filled to about three-quarters full and SP-400 Water Works Crystals were added to the saturated cuttings as an absorbent. A total of three soil boxes were used with 16 lb of absorbent. These soil boxes were stored nearby in a designated CERCLA storage site. No radiological contamination was detected at this drill site. On June 24, 2003, the drill rig, along with the downhole string and support equipment, was washed down inside a decontamination containment pad using a portable steam cleaner. The RCT surveyed all equipment clean and ready for demobilization.

I. Summary of Well Construction Procedures:

On May 29, 2003, the 16-in. OD carbon steel casing was set at 16.8 m (55 ft) bls, on top of .9 m (3 ft) of cavings, in the 20-in. well bore (drilled to 17.7 m [58 ft] bls). Eight yards of neat cement, with 2% bentonite, were poured between the borehole and the casing. The 10-3/4-in. OD carbon steel casing was set at 59.4 m (195 ft) bls on June 5, 2003, and neat cement, with 3% bentonite, was mixed and poured between the 10-3/4-in. OD casing and borehole from 59.4 to 55.8 m (195 to 183.5 ft) bls (total of 3.5 m [11.5 ft] annular capacity). Granular bentonite was then poured between the two casings from the top of the cement to the surface for the annular seal. The 9-7/8-in. borehole, drilled from 59.4 to 92 m (195 to 302 ft) bls, was finished on June 9, 2003. This interval was left open for later injection development. On June 11, 2003, a .6-m (2-ft) stickup of 10-3/4-in. casing and a .9-m (3-ft) stickup of 16-in. casing was welded to the casings at the surface.

An injection line was installed on June 24, 2003, which included 18.3 m (60 ft) of 1-1/4-in. OD stainless steel screen set at an interval of 64 to 82.3 m (210 to 270 ft) bls. The screen was attached to 1-1/4-in. OD stainless steel injection pipe. The pipe and screen were hung from the well cap on the .6-m (2-ft) stickup of the 10-3/4-in. OD carbon steel casing. The

injection pipe also was extended through the .9-m (3-ft) stickup of the 16-in. OD carbon steel casing and out of the well cap. A cement foundation pad had been poured around the well bore and surface casing as a wellhouse foundation. This is for the wellhouse to be built around the wellhead.

J. Problems Encountered and Lessons Learned:

While drilling through to upper surface soils at 10.4 m (34 ft) bls, the sediments increased in loose sands and the well bore began to cave in behind the bit. This resulted in the collaring off of the bit and air hammer. After back-reaming until the downhole drill string became free and out of the borehole, an additional auxiliary air compressor was added to help lift the caving soil cuttings from the well bore. With the additional air compression, it became easier to clean out the well bore. This appeared to solve the problem.

On June 17, 2003, a second attempt to video-log the well bore was made. At the depth of 73.5 m (241ft) bls, an obstruction prevented the logging of the lower portion of the well bore. To prevent any further caving of the well bore, it was decided not to attempt to run any other logs.

K. Instrumentation Added to Borehole:

None.

4.1.3 Drawings

A. Location maps: See Figure 2.

B. As-built drawings: See Appendix A.

4.2 TAN-1860 End of Well Report

4.2.1 General

A. Project Name:

Test Area North ISB OU 1-07B Injection and Extraction Well Installations.

B. Well Number:

TAN-1860.

C. Hole location:

- TAN-GWTF (24.3 m [80 ft] NW of TAN-28)
- NORTHING: Not Available
- EASTING: Not Available
- ELEVATION: (29 BC) 4,784.99 ft.

D. Implementation Plans:

i. "In Situ Bioremediation Well Drilling Plan," Rev. C, February 2003.

ii. *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan*, INEEL/EXT-99-00020, Rev. 2, November 2002.

iii. *Special Conditions for INEEL FY-03 Well Drilling at TAN*, Subcontract No. TBD, Special Conditions Issue 0, 1-20-03, Rev. 2, March 3, 2003.

iv. *In Situ Bioremediation Remedial Action Groundwater Monitoring Plan for Test Area North, Operable Unit 1-07B*, INEEL/EXT-2002-00779, Rev. 1, January 2003.

E. Logbooks:

i. ER-054-2003, "Environmental Restoration Department Record of Rotary Drillhole," Pg. 17-34, 192-196, 218.

ii. ER-056-2003, "Environmental Restoration Department Field Team Leader's Daily Logbook," Pg. 2-12, 20-40, 50-51, 61-63.

4.2.2 Drilling and Completion Observations

A. Drilling Company: Dynatec Drilling Incorporated, Salt Lake City, Utah.

B. Field Superintendent: Frank Hight.

C. Drillers: Steve Tawater (driller); Danny Waddoups, Ivan Perks, and Mike Becker (driller's helpers).

D. Geologists: Gary Oberhansley (North Wind, Inc.).

E. Field Team Leader: Kory Edelmayer (BBWI).

F. Drill Rig Type:

Reverse circulation air-rotary Foremost DR-24 with auxiliary Sullair 350 psi/900 cfm air compressor.

G. Drill Bit Type:

20-in. carbide button bit with 10-in. hammer to 11.3 m (37 ft) bls; 15-in. carbide button bit with 10-in. hammer to 59.6 m (195.5 ft) bls; and 9-7/8-in. carbide button bit with a 6-1/2-in. hammer to 125.9 m (413 ft) bls.

H. Drilling Activity:

A crew of one driller and three helpers worked 10-hour shifts, from 0700 to 1730, four days a week. A geologist oversaw the drilling, logging, and completion of this well. Members of the drilling crew, including the geologist, logged onto RCIMS each day. An RCT surveyed

the cuttings and tools used to drill and complete the borehole. A safety person was also assigned to oversee all health and safety aspects of the drilling program. A sampling crew collected water samples for laboratory analysis, and representatives from the WAG observed the handling of wastewater and saturated cuttings.

Drilling of TAN-1860 began at 13:15 on May 29, 2003, using a 20-in. bit and 10-in. hammer, with 7-in. dual-walled drill rods in 6.1-m- (20-ft-) long sections. Drill cuttings were discharged through diverter hoses into a cyclone and then to the ground surface. Two auxiliary compressors were used along with the drill rig's own compressor to blow the drill cuttings to the surface to keep the borehole clean. The borehole was drilled to .9 m (3 ft) bls through excavated soil and crushed gravel, then through surface soils of silt and sand (loess) to the top of basalt bedrock at 9.1 m (30 ft) bls. Drilling continued to 11.3 m (37 ft) bls in competent basalt where drilling stopped and the borehole was blown clean. The drill rods, hammer, and bit were then removed from the well bore and 16-in. OD (15-3/8-in. ID) carbon steel casing (Schedule 40) was set at 10.8 m (35.5 ft) bls on June 2, 2003.

Two Frac tanks were moved onto the geomembrane-lined drill pad, and drilling continued on June 16, 2003, using a 15-in. bit and 10-in. hammer. Basalt and one small interbed were drilled to a depth of 59.6 m (195.5 ft) bls 2 days later. At that depth, the drill string was tripped out of the borehole and 10-3/4-in. OD carbon steel casing was installed at a total depth of 59.6 m (195.5 ft) bls. The discharge cyclone was then positioned on top of one Frac tank, and one auxiliary compressor was moved off location.

On June 19, 2003, the exclusion zone surrounding the drill site was posted as a CERCLA site. Upon further drilling, the drillers used rubber gloves along with the appropriate PPE. Drilling continued using a 9-7/8-in. bit and a 6.5-in. hammer to a total depth of 125.9 m (413 ft) bls 1 ft into the Q-R interbed. The drill string then began to be tripped out of the well bore. On June 23, 2003, the tripping of the drill string out of the well bore continued and the drill rig and equipment were moved off location.

After the 10-3/4-in. OD casing was set at 59.6 m (195.5 ft) bls, and in anticipation of the drilling into the aquifer and groundwater COCs, which include TCE and PCE, the cyclone used for discharging drill cuttings to the ground surface was moved on top of the Frac tank to collect both cuttings and produced water. Drill cuttings became saturated with water at approximately 68.9 m (226 ft) bls. During a drill rod connection at 75 m (246 ft) bls, water began to be produced. Drilling continued in fractured and rubble basalt to 87 m (286 ft) bls. At that depth, a drill rod connection was made and water was blown to the surface through the cyclone into the Frac tank until it became mostly clear. Approximately 8 L of produced water was then collected for laboratory analysis by the sampling team.

The water being produced in the Frac tank with the drill cuttings was pumped into the second Frac tank while drilling. The produced water was stored in both Frac tanks until it was pumped into the trailer-mounted poly tanks and sent to the NPTF for treatment and discharge. The total water produced was approximately 16,000 gal.

On June 24, 2003, the USGS ran the natural gamma and caliper log, along with a deviation log, from the surface to the bottom of the well bore at 125.9 m (413 ft) bls. On the same day after the water from the cuttings in the Frac tank was removed, the drillers used a backhoe to remove the drill cuttings from the Frac tank into plastic-lined plywood soil boxes approximately 128 ft^3 in size. Three soil boxes were filled to about three-quarters full, and approximately 30 lb of SP-400 Water Works Crystals were added to the saturated cuttings as

an absorbent. The drill rig, along with the downhole string and support equipment, was moved off location and washed down inside a decontamination containment pad using a portable steam cleaner. The RCT surveyed all equipment clean and ready for demobilization.

On July 23, 2003, the USGS video-logged the well bore to a depth of approximately 125.6 m (412 ft) bls. The open well bore between 59.6 m (195.5 ft) and125.9 m (413 ft) bls appeared to be in good condition.

I. Summary of Well Construction Procedures:

On June 2, 2003, the 16-in. OD carbon steel casing was set at 10.8 m (35.5 ft) bls (1.7 m [5.5 ft] into competent basalt) on top of .46 m (1.5 ft) of cavings in the 20-in. well bore (drilled to 11.3 m [37 ft] bls). Four yards of neat cement, with 2% bentonite, were poured between the borehole and the 16-in. casing. The 10-3/4-in. OD carbon steel casing was set at 59.6 m (195.5 ft) bls on June 18, 2003, and neat cement, with 3% bentonite, was mixed and poured between the 10-3/4-in OD casing and borehole from 59.6 m (195.5 ft) to 56.4 m (185 ft) bls (total of 3.2 m [10.5 ft] annular capacity). Granular bentonite was then poured between the two casings from the top of the cement to the surface for the annular seal. The 9-7/8-in. borehole, drilled from 59.6 to 125.9 m (195.5 to 413 ft) bls, was finished on June 19, 2003. This interval was left open for later extraction development. On June 24, 2003, a .6 m (2-ft) stickup of 10-3/4-in. casing and a .9 m (3-ft) stickup of 16-in. casing was welded to the casings at the surface.

J. Problems Encountered and Lessons Learned:

While drilling through basalt at 68.9 m (226 ft) bls, the cyclone began to leak water outside of the Frac tank. A metal plate was welded to the cyclone where a hole had worn through by abrasion from the drill cuttings. This stopped the leakage, and drilling was continued.

K. Instrumentation Added to Borehole:

None.

4.2.3 Drawings

A. Location maps: See Figure 2.

B. As-built drawings: See Appendix A.

4.3 TAN-1861 End of Well Report

4.3.1 General

A. Project name:

Test Area North ISB OU 1-07B Injection and Extraction Well Installations.

B. Well Number:

TAN-1861.

C. Hole location:

- TAN-GWTF (34.1 m [112 ft] NW of TAN-27)
- NORTHING: Not Available
- EASTING: Not Available
- ELEVATION: Not (29 BC) 4,785.53 ft.

D. Implementation Plans:

i. "In Situ Bioremediation Well Drilling Plan," Rev. C, February 2003.

ii. *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan*, INEEL/EXT-99-00020, Rev. 2, November 2002.

iii. *Special Conditions for INEEL FY-03 Well Drilling at TAN*, Subcontract No. TBD, Special Conditions Issue 0, 1-20-03, Rev. 2, March 3, 2003.

iv. *In Situ Bioremediation Remedial Action Groundwater Monitoring Plan for Test Area North, Operable Unit 1-07B*, INEEL/EXT-2002-00779, Rev. 1, January 2003.

E. Logbooks:

i. ER-054-2003, "Environmental Restoration Department Record of Rotary Drillhole," Pg. 37-54, 198-202, 220.

ii. ER-056-2003, "Environmental Restoration Department Field Team Leader's Daily Logbook," Pg. 2-4, 16-21, 32-48, 50, 59-70.

4.3.2 Drilling and Completion Observations

A. Drilling Company: Dynatec Drilling Incorporated, Salt Lake City, Utah.

B. Field Superintendent: Frank Hight.

C. Drillers: Steve Tawater and Joe Lambert (drillers); Danny Waddoups, Ivan Perks, Terry Brower, and Mike Becker (drillers' helpers).

D. Geologists: Gary Oberhansley (North Wind, Inc.).

E. Field Team Leader: Kory Edelmayer (BBWI).

F. Drill Rig Type:

Reverse circulation air-rotary Foremost DR-24 with auxiliary Sullair 350 psi/900 cfm air compressor.

G. Drill Bit Type:

20-in. carbide button bit with 10-in. hammer to 19.8 m (65 ft) bls; 15-in. carbide button bit with 10-in. hammer to 59.6 m (195.5 ft) bls; and 9-7/8-in. carbide button bit with a 6-1/2-in. hammer to 126.2 m (414 ft) bls.

H. Drilling Activity:

A crew of two drillers and four helpers worked 10-hour shifts, from 0700 to 1730, four days a week. A geologist oversaw the drilling, logging, and completion of this well. Members of the drilling crew, including the geologist, logged onto RCIMS each day. An RCT surveyed the cuttings and tools used to drill and complete the boreholde. A safety person was also assigned to oversee all health and safety aspects of the drilling program. A sampling crew collected water samples for laboratory analysis, and representatives from the WAG observed the handling of wastewater and saturated cuttings. Because of the closeness of overhead power lines to the well site, a high voltage work permit was required each day of drill rig activity.

Drilling of TAN-1861 began at 10:30 on June 2, 2003, using a 20-in. bit and 10-in. hammer, with 7-in. dual-walled drill rods in 6.1-m- (20-ft-) long sections. Drill cuttings were discharged through diverter hoses into a cyclone and then to the ground surface. Two auxiliary compressors were used along with the drill rig's own compressor to blow the drill cuttings to the surface to keep the borehole clean. The borehole was drilled to .6 m (3 ft) bls through excavated soil and crushed gravel, then through surface soils of silt and sand (loess) to the top of basalt bedrock at 14.3 m (47 ft) bls. At 15.1 m (49.5 ft) bls, an interbed was encountered and drilled to 17.4 m (57 ft) bls where basalt bedrock was again penetrated. Drilling continued to 19.8 m (65 ft) bls in competent basalt where it stopped and the borehole was blown clean. The drill rods, hammer, and bit were then removed from the well bore and 16-in. OD (15-3/8-in. ID) carbon steel casing (Schedule 40) was set at 19.8 m (65 ft) bls on June 3, 2003.

Drilling continued on June 10, 2003, using a 15-in. bit and 10-in. hammer. Basalt and several small interbeds were drilled to a depth of 59.6 m (195.5 ft) bls the following day. At that depth, the drill string was tripped out of the borehole and 10-3/4-in. OD carbon steel casing was installed at a total depth of 59.6 m (195.5 ft) bls. Two Frac tanks were moved onto the geomembrane-lined drill pad, and the discharge cyclone was positioned on top of one Frac tank for cuttings and water containment. In anticipation of the drilling into the aquifer and groundwater COCs (TCE and PCE), the cyclone used for discharging drill cuttings to the ground surface was moved on top of the Frac tank to collect both cuttings and produced water.

On June 12, 2003, the exclusion zone surrounding the drill site was posted as a CERCLA site. Upon further drilling, the drillers used rubber gloves along with the appropriate PPE. Drilling continued using a 9-7/8-in. bit and a 6.5-in. hammer that same day. Drill cuttings became saturated with water at approximately 68.9 m (226 ft) bls. During a drill rod connection at that depth, water began to be produced. Drilling continued in fractured and rubble basalt to 75 m (246 ft) bls. At that depth, the drill string was lifted off the bottom 6.1 m (20 ft) and water was blown to the surface through the cyclone into the Frac tank until it became mostly clear. Approximately 8 L of produced water was then collected at the depth of 68.9 m (226 ft) bls by the sampling team for laboratory analysis. The water being

produced in the Frac tank with the drill cuttings was pumped into the second Frac tank while drilling.

On June 16, 2003, the well bore was drilled to a total depth of 126.2 m (414 ft) bls. The drill string was tripped out of the well bore .6 m (2 ft) into the Q-R interbed. While tripping the drill string out of the well bore, the drill string pulled tight at about 78.6 m (258 ft) bls. To make sure the well bore was still open, a tag line was run to the bottom on the well bore to the depth of 126.2 m (414 ft) bls, total depth. It appeared that the well bore was still open, and the drill rig was released to be moved off location.

On June 17, 2003, the USGS ran the natural gamma and caliper log from the surface to the bottom of the well bore at 126.2 m (414 ft) bls. When the natural gamma and caliper log was run, the caliper showed a negative spike at the depth of 78.6 m (258 ft) and 79.6 m (261 ft) bls. The tool also pulled slightly tight at 78.6 m (258 ft) bls. The produced water stored in both Frac tanks was pumped into the trailer-mounted poly tanks and sent to the NPTF for treatment and discharge. The total water produced was approximately 10,000 gal. That same day, after the water from the cuttings in the Frac tank was removed, the drillers used a backhoe to remove the drill cuttings from the Frac tank into plastic-lined plywood soil boxes approximately 64 ft^3 in size. Seven soil boxes were filled to about three-quarters full and one soil box at 128 ft^3 in size was filled to one-half full. Approximately 54 lb of SP-400 Water Works Crystals were added to the saturated cuttings as an absorbent. The drill rig, along with the downhole string and support equipment, was moved off location on June 24, 2003, and washed down inside a decontamination containment pad using a portable steam cleaner. The RCT surveyed all equipment clean and ready for demobilization.

On July 23, 2003, the USGS video-logged the well bore to a depth of 79.6 m (261 ft) bls. The open well bore between 63.7 m (209 ft) and 78.9 m (259 ft) bls appeared to be highly fractured with unstable basalt rock rubble along the walls of the borehole. At 79.6 m (261 ft) bls, the well bore was bridged off with fallen rock rubble. The drill rig and equipment was remobilized on July 28, 2003, and the next day the open borehole was reamed and conditioned from 59.6 m (195.5 ft) bls (just below the 10-3/4-in. casing) to 126.2 m (414 ft) bls (the original TD). The produced cuttings and water were contained in a Frac tank on the well pad. The drill string was tripped from the well bore with no indication of drag from a tight hole. The drill rig and equipment were moved off the drill site and decontaminated as before. The RCT again surveyed the equipment clean and it was moved off location. The total amount of water produced during the reentry of the well bore was estimated to be 2,000 gal. This water was also sampled for lab analysis at the depth of 83.8 m (275 ft) bls.

On August 14, 2003, the USGS again videoed the well bore and encountered the water level at 63.7 m (209 ft) bls, as well as an obstruction at 86.6 m (284 ft) bls. While the video camera was being lowered through the fractured rubble zone from 63.7 m (209 ft) to 78.9 m (259 ft) bls, several fractured basalt fragments fell down the annulus making the water muddy with no visibility. To allow the water to clear and to see what the obstruction was, the USGS returned on August 17, 2003, and videoed the open well bore again. A bridge of basalt rubble was clearly seen at 73.5 m (241 ft) bls.

On September 25, 2003, Dynatec set the drill rig back on the well bore to reenter and ream out the bridge at 73.5 m (241 ft) bls. Both the 16-in. and 10-3/4-in. carbon steel casing stickup was cut to about 12 m (39 ft) above land surface. The open borehole was reamed and conditioned from 59.6 m (195.5 ft) to 68.3 m (224 ft) bls. Reaming and conditioning of the borehole continued on September 29, 2003. The bridge at 73.5 m (241 ft) bls easily pushed

through and the borehole was cleaned to the bottom of the borehole at 126.2 m (414 ft) bls with no problems. Approximately 1,000 gal of water was produced with very little drill cuttings. All were contained inside the Frac tank.

The drill string was then removed from the borehole and 6-5/8-in. stainless steel casing was installed to 84.5 m (277.1 ft) bls. The bottom 18.3 m (60 ft) of casing had been slotted to enable water to enter into the casing. After the stainless steel casing was installed, the drill rig and equipment were moved off the well site and decontaminated. The following day the stickup on the 6-5/8-in. stainless steel casing was cut to .5 m (1.5 ft) above land surface and the 16-in carbon steel casing was welded back onto the surface stickup to .9 m (3 ft) above land surface. The drill rig and equipment, which were surveyed by the RCT and found to be clean, were removed from TAN.

I. Summary of Well Construction Procedures:

On June 3, 2003, the 16-in. OD carbon steel casing was set at 19.8 m (65 ft) bls (2.4 m [8 ft] into competent basalt) in the 20-in. well bore (drilled to 19.8 m [65 ft] bls). Seven yards of neat cement, with 2% bentonite, were poured between the borehole and the 16-in. casing. The 10-3/4-in. OD carbon steel casing was set at 59.6 m (195.5 ft) bls on June 11, 2003, and neat cement, with 3% bentonite, was mixed and poured between the 10-3/4-in. OD casing and borehole from 59.6 m (195.5 ft) to 56.1 m (184 ft) bls (total of 3.5 m [11.5 ft] annular capacity). Granular bentonite was poured between the two casings from the top of the cement to the surface for the annular seal on June 12, 2003. The 9-7/8-in. borehole, drilled from 59.6 m (195.5 ft) to 126.2 m (414 ft) bls, was finished on June 16, 2003. This interval was left open for later extraction development. On June 24, 2003, a .6 m (2-ft) stickup of 10-3/4-in. casing and a .9 m (3-ft) stickup of 16-in. casing were welded to the casings at the surface.

On September 29, 2003, 6-5/8-in. OD stainless steel casing, in 6.1-m (20-ft) lengths, was set at 84.5 m (277.1 ft) bls with .5 m (1.5 ft) of stickup. A stainless steel landing ring was welded to the casing, which was hung from the surface on the 10-3/4-in. carbon steel casing. A 1/4-in. rubber gasket was used to separate the carbon steel casing from the stainless steel casing to avoid ionic transfer and corrosion. The bottom 18.3 m (60 ft) of casing was slotted with 3-in.-long, 0.05-in. slots 4 in. apart and in four horizontal rows the full length of each of the three bottom casing sections. The slot positions were staggered on center spacing between each row. The open end was ground and smoothed before being placed downhole.

J. Problems Encountered and Lessons Learned:

As seen on the video logs that were taken after drilling and the reentry of the well bore, it was apparent that the fractured rubble zone between 63.7 m (209 ft) and 78.9 m (259 ft) bls is too unstable to prevent it from caving in and bridging off the well bore annulus. To stabilize the well bore for future extraction development and testing of the well, a 6-5/8-in. OD stainless steel casing, with the bottom 18.3 m (60 ft) slotted at 0.05 in., was installed in August 2003. On October 14, 2003, the USGS again ran a video log to check the stainless steel casing and open borehole. The water level was seen at 64.3 m (211 ft) bls, and the bottom of the stainless steel casing was observed to be 84.7 m (278 ft) bls. The inside of the stainless steel casing that had been slotted showed some residual burrs remaining. The burrs had been checked prior to running the casing downhole and seemed to be easily removable when running a flute inside the casing. The burrs should then fall to the bottom of the borehole. The bottom of the open borehole showed several large basalt fragments that had

been dislodged while running the stainless steel casing into the well. The present TD of the open borehole is now at 125.6 m (412 ft) bls.

K. Instrumentation Added to Borehole:

None.

4.3.3 Drawings

A. Location maps: See Figure 2.

B. As-built drawings: See Appendix A.

5. WATER SAMPLING

The one injection well (TAN-1859) and the two monitoring wells (TAN-1860 and TAN-1861) were drilled within the known, or interpreted, TCE plume. The other VOC COCs consist of PCE, cis-1,2 DCE, and trans-1,2 DCE. These VOCs are also present within the defined plume. Detectable quantities of TCE were expected to be present in water produced from these wells.

Because TCE detection was expected, samples of formation water were collected as soon as enough water was produced to do so for each well drilled. As the wells penetrated the water table and water was produced to the surface, it was containerized in a Frac tank along with the saturated borehole cutting. A sampling team collected produced water samples from each well for VOC analysis, following the information in the *In Situ Bioremediation Action Groundwater Monitoring Plan for the Test Area North* (INEEL 2003c). Concentrations of TCE, PCE, cis-1,2 DCE, and trans-1,2 DCE detected in waters produced from the three wells drilled were below the maximum contaminant level (MCL) in accordance with federal drinking water standards. Drilling with a high volume of compressed air apparently stripped away most of the VOCs. The laboratory results of the samples for all of the above listed compounds in each well showed concentration units to be less than 1 µg/L, except for compound TCE in TAN-1860, which was 2 µg/L. All water produced during well drilling activities was processed through the New Pump and Treatment Facility in accordance with established procedures.

6. REFERENCES

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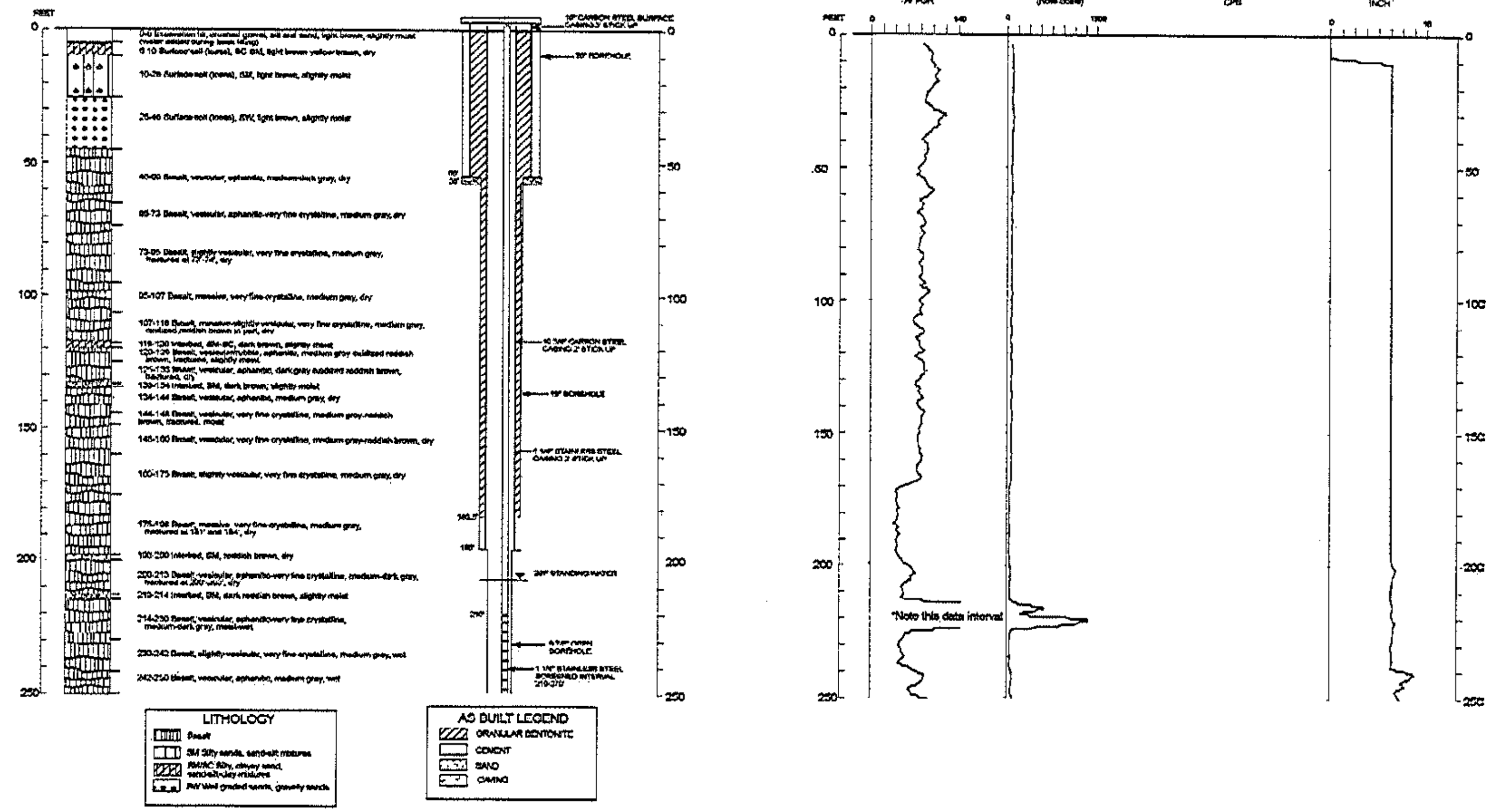
Appendix A

Well Completion Diagrams

WELL NAME: TAN-1859
Facility: TAN-GWTF
Well Type: Injection
Well Status: Active
Year Drilled: 2002-2003
Total Depth: 302'
Start Date: 5/27/03
End Date: 6/9/03
Completion Depth: 302'

Driller: Dynatec
Geologist: G. Oberhansley
Drill Method: Dual Air Rotary
Drill Fluid: Air
Elevation: (29 DC)

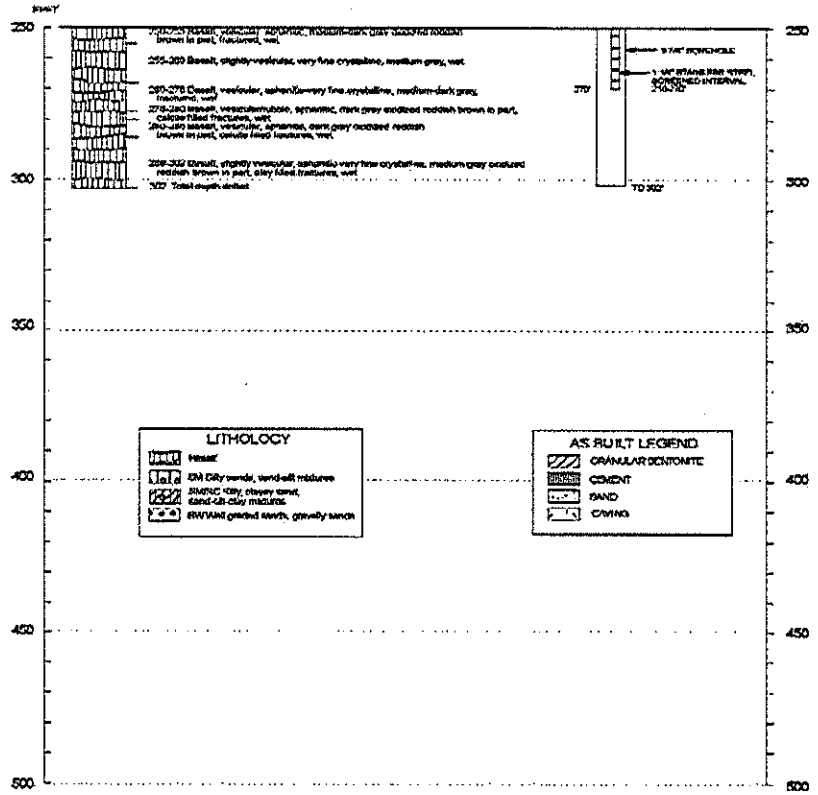
Todays Date: 10/31/03
Water Level: 207'
Water Level Date: 6/10/03
Water Level Access: Casing

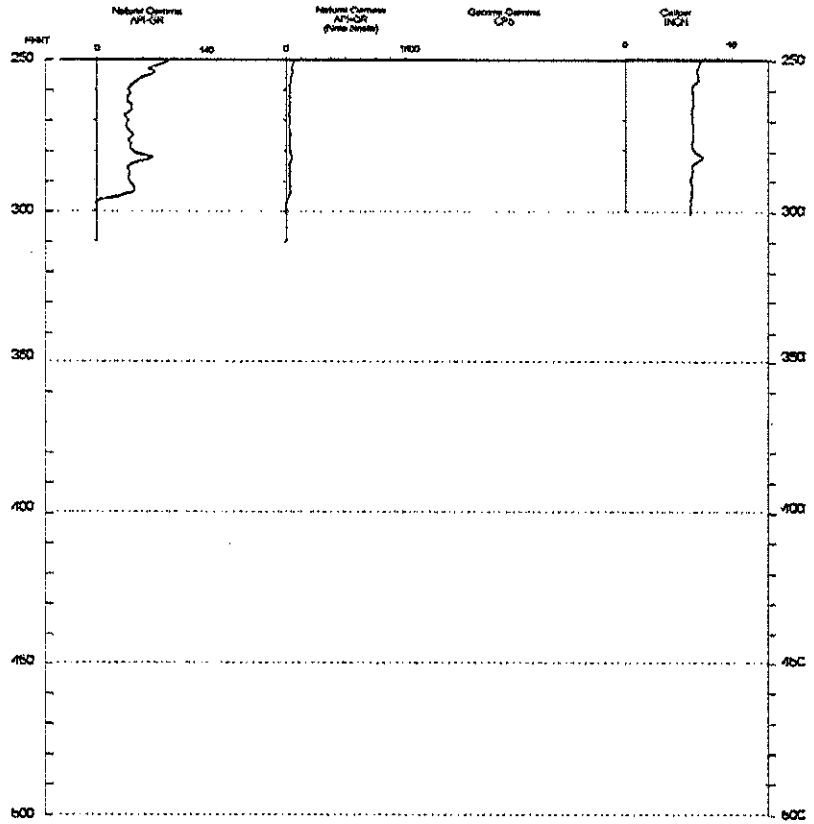


WELL NAME: TAN-1859
Facility: TAN-GWTF
Well Type: Injection
Well Status: Active
Year Drilled: 2002-2003
Total Depth: 302'
Start Date: 5/27/03
End Date: 6/9/03
Completion Depth: 302'

Driller: Dynatec
Geologist: G. Oberhansley
Drill Method: Dual Air Rotary
Drill Fluid: Air
Elevation: (GS PC)

Todays Date: 10/31/03
Water Level: 207'
Water Level Date: 6/10/03
Water Level Access: Casing

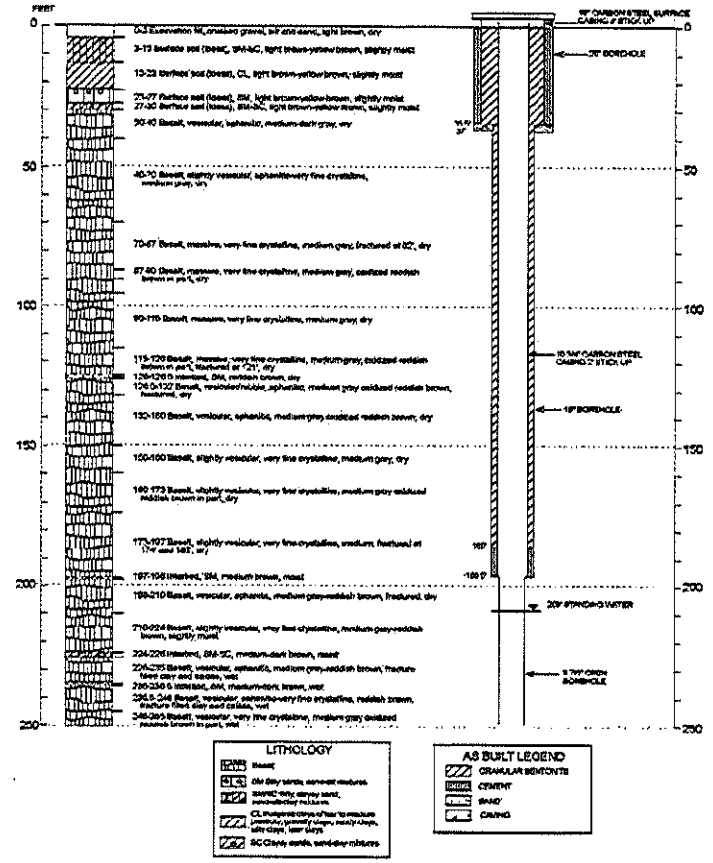


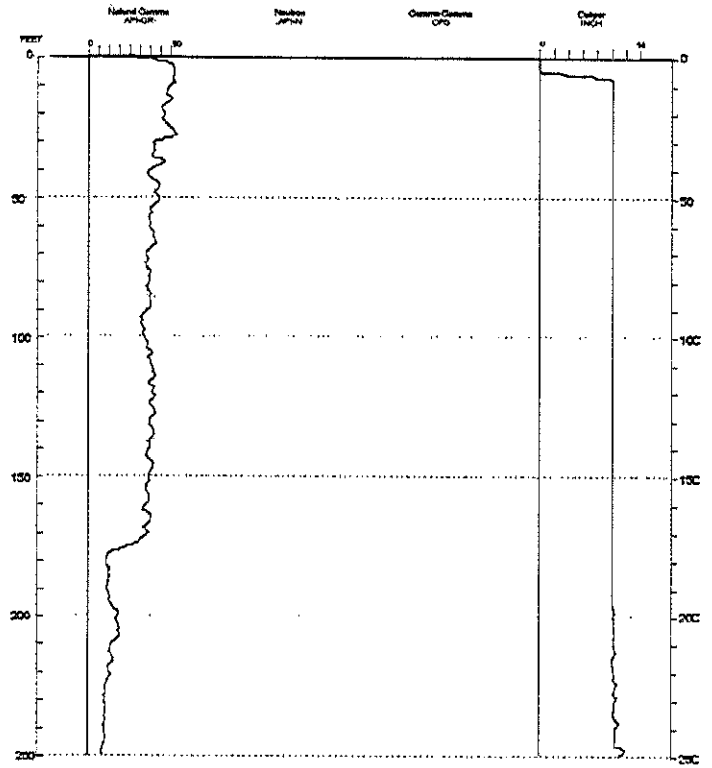


WELL NAME: TAN-1660
Facility: TAN-GWTF
Well Type: Extraction
Well Status: Active
Year Drilled: 2003
Total Depth: 413'
Start Date: 5/29/03, 6/19/03
End Date: 6/19/03
Completion Depth: 413'

Driller: Dynatec
Geologist: G. Oberhansley
Drill Method: Dual Air Rotary
Drill Fluid: Air
Elevation: (GS EL)

Todays Date: 11/03/03
Water Level: 209'
Water Level Date: 7/22/03
Water Level Access: Casing

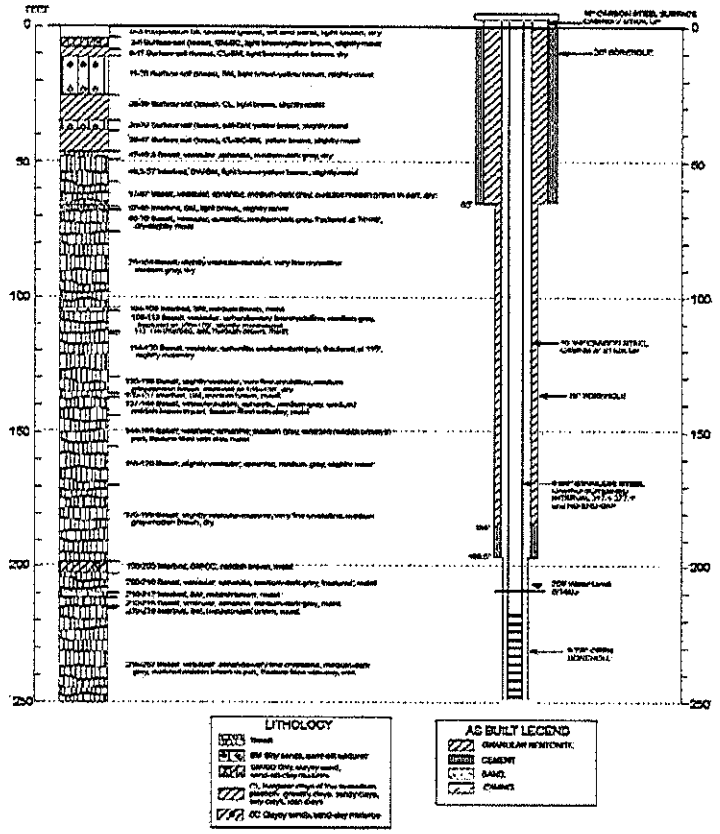


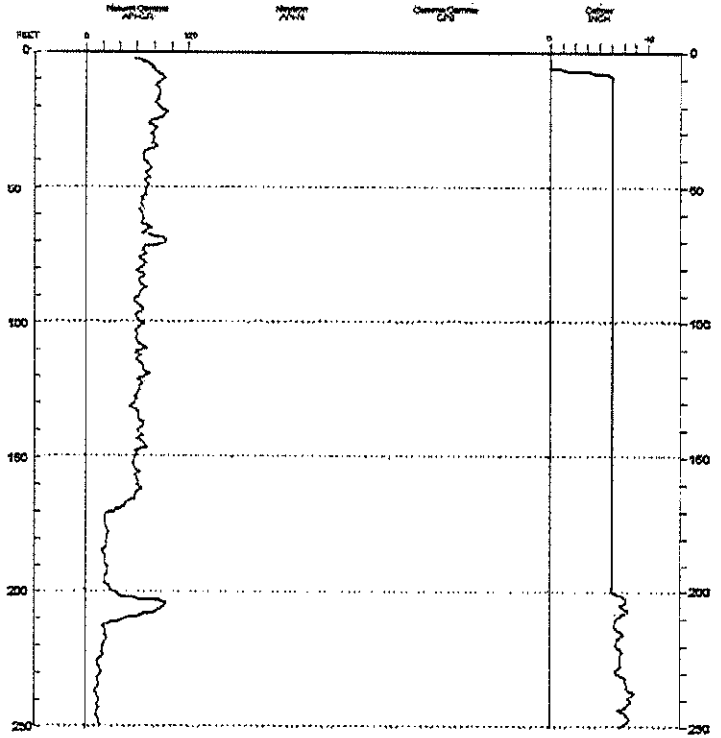


WELL NAME: TAN-1667
Facility: TAN-GWTF
Well Type: Extraction
Well Status: Active
Year Drilled: 2003
Total Depth: 414'
Start Date: 6/2/03
End Date: 6/16/03
Completion Depth: 414'

Driller: Dynatec
Geologist: C. Oberhansley
Drill Method: Dual Air Rotary
Drill Fluid: Air
Elevation:

Todays Date: 11/07/03
Water Level: 203'
Water Level Date: 7/23/03
Water Level Access: Casing





WELL NAME: TAN-1861
Facility: TAN-GWTF
Well Type: Extraction
Well Status: Active
Year Drilled: 2003
Total Depth: 414'
Start Date: 6/2/03
End Date: 6/16/03
Completion Depth: 414'

Driller: Dynatec
Geologist: G. Oberhansley
Drill Method: Dual Air Rotary
Drill Fluid: Air
Elevation: (2 BC)

Todays Date: 11/07/03
Water Level: 209'
Water Level Date: 7/23/03
Water Level Access: Casing