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Annual Performance Report for In Situ Bioremediation Operations November 2002 to October 2003, Test Area North, Operable Unit 1-07B

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Idaho Completion Project

Bechtel BWXT Idaho, LLC

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ABSTRACT

This report presents the activities performed and data collected during the operation of the enhanced in situ bioremediation (ISB) remedy component at the Operable Unit 1-07B source area at Test Area North at the Idaho National Engineering and Environmental Laboratory for the reporting period November 2002 through October 2003. In general, activities consisted of sodium lactate injection and groundwater monitoring. Two sodium lactate injection strategies were tested to achieve the desired electron donor distribution and dechlorination activity within the source area. Additional activities, including construction of a second injection well and construction of the new ISB injection facility, were also performed during this period.

The results of the groundwater monitoring indicate that the ISB remedy is operating effectively, stimulating complete dechlorination throughout most of the secondary source. Trichloroethene and cis-DCE concentrations remained low, and ethene was the dominant compound at several source area wells. However, results from downgradient wells indicated that the injection strategies used during this period, including large volume injections, did not distribute electron donor or stimulate dechlorination activity through the entire secondary source in the downgradient direction. Because of this observation, a second injection well was constructed during this reporting period to further distribute electron donor in the downgradient direction. Towards the end of this reporting period, injections were switched from high volume, low concentration injections to low volume, high concentration injections, which were found to create more efficient anaerobic reductive dechlorination conditions in the source area.

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ACRONYMS

AED	alternate electron donor
ARD	anaerobic reductive dechlorination
ASTU	Air Stripper Treatment Unit
Bls	below land surface
COD	chemical oxygen demand
DCE	dichloroethene
DOE	U.S. Department of Energy
GWMP	Groundwater Monitoring Plan
INEEL	Idaho National Engineering and Environmental Laboratory
IRC	INEEL Research Center
ISB	in situ bioremediation
MCL	maximum contaminant level
MS/MSD	matrix spike/matrix spike duplicate
ORP	oxygen reduction potential
OU	operable unit
PCE	tetrachloroethene
PDO	predesign operations
PDP	predesign phase
PE	performance evaluation
QA	quality assurance
RAWP	Remedial Action Work Plan
RPD	relative percent difference
SPME	solid-phase microextraction
TAN	Test Area North
TCE	trichloroethene
TPR	technical procedure
TSF	Technical Support Facility
VC	vinyl chloride
VOC	volatile organic compound

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1. INTRODUCTION

The purpose of this report is to document the ongoing evaluation of the in situ bioremediation (ISB) component of the Test Area North (TAN) Operable Unit (OU) 1-07B remedial action, as measured against the project objectives presented in the governing documents. This annual report provides a summary of ISB activities for the reporting period November 2002 to October 2003.

1.1 Background

A nearly 2-mile long plume of trichloroethene (TCE) in groundwater is located at the TAN facility of the Idaho National Engineering and Environmental Laboratory (INEEL). Due to the size and varying TCE concentrations of the plume, a multicomponent remedy was designed to achieve effective clean up. Enhanced ISB was selected for remediation of the source area portion of the plume. These bioremediation activities have been ongoing since 1998.

1.2 Organization

Included herein are seven sections and five appendixes. Section 1 presents an overview of the ISB remedy component and remedial action objectives, the governing documents, and the requirements for data collection and evaluation during this reporting period. Section 2 describes the activities performed. Section 3 presents the results of these activities, while Section 4 discusses the results in the context of the project objectives. Sections 5 and 6 present conclusions of this year's work and recommendations for additional activities. References are included in Section 7. The five appendixes contain supporting information, as indicated throughout the main text. A CD-ROM is attached (Appendix D), which contains all ISB data collected during the approximately 5 years of ISB operations.

1.3 Overview of the In Situ Bioremediation Remedy

Operable Unit 1-07B consists of a contaminated groundwater plume emanating from the Technical Support Facility (TSF) -05 injection well. Due to the large scale and the varying contaminant concentrations within the plume, the plume has been divided into three zones (Figure 1-1): the hot spot, medial zone, and distal zone. A multicomponent remedy was designed to address each of these three zones, as described 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):

- Hot spot—ISB (anaerobic reductive dechlorination [ARD])
- Medial Zone—Groundwater pump and treat
- Distal Zone—Monitored natural attenuation.

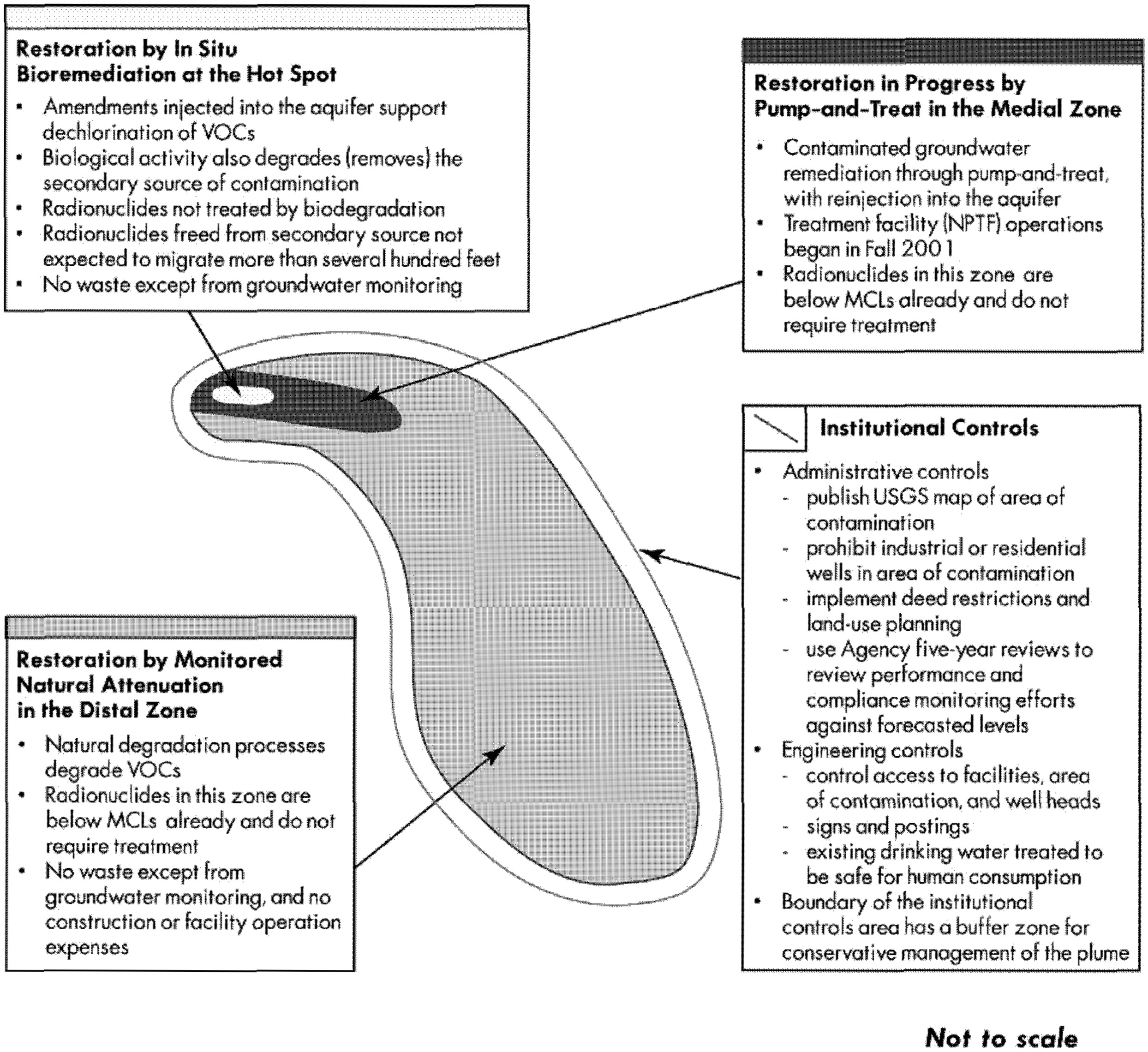

Figure 1-1. Conceptual illustration of the three zones of the TCE plume.

The ISB component of the remedy was divided into a number of operational phases designed to measure the effectiveness of the remedy over time. Sections 1.2.1, 1.2.2, and 1.2.3 provide a summary of ISB activities conducted up through the last annual report (October 2002), the activities covered by this report (November 2002 through October 2003), and future activities (November 2003 and beyond). Table 1-1 presents an overview of the phases used for the implementation of ISB in the hot spot.

Table 1-1. Overview of the phases used for in situ bioremediation implementation in the hot spot.

	1999		2000	2001 2002	2003	2004 - TBD
Phase I	Field Evaluation	PDP-I	PDP-II	Pre-Design Ops	Interim Ops	Initial, Optimization, and Long-Term Ops
Overall Objective	Determine whether TCE dechlorination could be enhanced though the addition of an electron donor.	Monitor ARD reactions under propionate fermentation conditions in the absence of regular lactate injections.	Recreate the conditions for efficient ARD observed during PDP-I.	Continue to operate ISB system while performing construction and setup of ISB injection system.		Continue system operation, while reducing and eventually eliminating downgradient and crossgradient flux of VOCs from the hot spot.
Operations	Small, frequent (weekly/biweekly) lactate injections; groundwater monitoring.	No lactate injections; groundwater monitoring.	Relatively large volume, infrequent (bimonthly) lactate injections; groundwater monitoring; lab studies.	Relatively large volume, infrequent (bimonthly) lactate injections; groundwater monitoring; lab studies.		Implement injection strategy to achieve maximum cost effectiveness; continue groundwater monitoring.
Results	Complete ARD to ethene observed; ISB selected as hot spot remedy.	ARD efficiency increased under propionate utilization conditions in the absence of lactate fermentation.	In general, good conditions for ARD maintained. However, distribution of lactate downgradient was problematic.	In general, good conditions for ARD maintained. However, complete distribution of lactate downgradient was not achieved.		TBD
Controlling Document	Field Evaluation Work Plan[a]	Field Evaluation Work Plan[a]	Field Evaluation Work Plan[a]	PDO Work Plan	RAWP	RAWP

Table 1-1. (continued).

	1999	2000	2001	2002	2003	2004 - TBD
Phase I	Field Evaluation	PDP-I	PDP-II	Pre-Design Ops	Interim Ops	Initial, Optimization, and Long-Term Ops
Reports	FDR/FER	2001 Annual Report	2001 Annual Report	2002 Annual Report	2003 Annual Report	Annual Performance/Compliance Reports

a. DOE-ID, 1998, *Enhanced In Situ Bioremediation Field Evaluation Work Plan, Test Area North, Operable Unit 1-07B*, DOE/ID-10639, Revision 0, U.S. Department of Energy Idaho Operations Office, September 1998.
ARD = anaerobic reductive dechlorination
FDR/FER = Field Demonstration Report/Field Evaluation Report
ISB = in situ bioremediation
PDO = predesign operations
PDP = predesign phase
RAWP = Remedial Action Work Plan
TBD = to be determined
TCE = trichloroethene
VOC = volatile organic chemical

1.3.1 Summary of In Situ Bioremediation Activities through the Previous Annual Report (October 2002)

In situ bioremediation activities began in November 1998 with the field evaluation. The overall objective of the field evaluation was to determine whether ARD of TCE could be enhanced through the addition of an electron donor (lactate). Nine months of sodium lactate injection in well TSF-05 and groundwater monitoring throughout the treatment cell produced sufficient data to conclude that ARD was significantly enhanced, and ISB was officially selected as the hot spot remedy. A complete discussion of the results of the field evaluation is presented in the *Field Demonstration Report, Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2000). Following this initial testing phase, activities shifted toward optimization of the ISB remedy. This began in October 1999 with Predesign Phase (PDP) -I activities, which consisted of no sodium lactate injections and continued groundwater monitoring throughout the hot spot. The objective of PDP-I was to see how the system would respond to the absence of regular sodium lactate injections, while only the electron donor (mainly propionate) already present from the field evaluation injections, was utilized. The results indicated an increase in the efficiency of ARD reactions during this time of propionate utilization. PDP-I ended when most of the electron donor present from the field evaluation was depleted and additional lactate injections were needed.

Based on the PDP-I results, an injection strategy that maximized the time of propionate utilization and minimized the time for lactate fermentation was designed for PDP-II. It was the objective of PDP-II to recreate the favorable conditions for efficient ARD observed during PDP-I and to determine the best injection strategy for later phases. PDP-II, beginning in February 2000, consisted of the injection of relatively large volumes of electron donor relatively infrequently (every 8 weeks) compared to the smaller volume, more frequent injections (weekly/semiweekly) that were used during the field evaluation. The results of PDP-II indicated that in general, favorable conditions for ARD were created with this injection strategy; however, the distribution of electron donor to the downgradient area of the source remained problematic. A complete discussion of the results of PDP-I and PDP-II is presented in the *OU 1-07B ISB Annual Performance Report for October 1999 to July 2001* (INEEL 2002a). Shortly after the onset of PDP-II, laboratory studies were initiated to evaluate alternative, potentially less expensive electron donors for their ability to support efficient ARD and to enhance degradation of the secondary source, with the objective of designing the most cost-effective remedy.

The implementation of the next phase of activities, predesign operations (PDO), was initiated in May 2001 with the completion of the *In Situ Bioremediation Predesign Operations Work Plan Test Area North, Operable Unit 1-07B* (INEEL 2002b). In general, the objectives of PDO were to continue the optimization of the ISB remedy through continued operations (i.e., sodium lactate injection and groundwater monitoring) and experimentation with various injection strategies. The results of PDO through July 2001 were presented in the Fiscal Year 2001 ISB Annual Report (INEEL 2002a). Predesign Operations activities continued through Fiscal Year 2002 with continued injection of electron donor to achieve the desired distribution and create the conditions for efficient ARD throughout the source zone. The evaluation of alternate electron donors (AEDs) in laboratory studies continued from the previous reporting period. Details of PDO activities were presented in the *Annual Performance Report for In Situ Bioremediation Operations August 2001 to October 2002, Test Area North Operable Unit 1-07B* (INEEL 2003a).

1.3.2 Activities for the Current Reporting Period (November 2002–October 2003)

The PDO phase ended in October 2002 and was followed by the Interim Operations Phase. The Interim Operations Phase extended from November 2002 through October 2003. This phase was essentially a continuation of the PDO objectives and included activities designed to support a better understanding of AEDs, development of injection strategies to support the initial operations phase, ISB model refinement, and continued ISB sodium lactate addition. The results and activities conducted during the Interim Operations Phase are the focus of this report.

1.3.3 Future Activities (November 2003 and Beyond)

The Initial Operations Phase commenced with the completion of the prefinal inspection for the remedial action (October 2003) and will be followed by a series of phases, as described in the *In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2002a). A summary of these phases and their objectives is presented below, while a complete description is presented in the Remedial Action Work Plan (RAWP):

- Initial Operations Phase—This phase will focus on reducing the flux of volatile organic compounds (VOCs) from the hot spot in the downgradient direction, as measured at TAN-28 and TAN-30A. During this phase, data will also be gathered and analyzed relating to achievement of long-term performance objectives.

- Optimization Operations Phase—This phase will focus on reducing the flux of VOCs from the hot spot in the crossgradient direction, as measured at TAN-1860 and TAN-1861, while maintaining VOC flux reduction in the downgradient direction.

- Long-Term Operations Phase—During this phase, data will continue to be gathered and analyzed relating to achievement of long-term performance objectives. This phase will focus on achievement of hot spot source degradation while maintaining the reduction of VOC flux from the hot spot in the crossgradient and downgradient directions. The RAWP presents the criteria for completion of each phase, as well as performance monitoring and compliance monitoring requirements for each phase. Progress of ISB activities against these requirements will be the focus of future reports.

1.4 Remedial Action Objectives

The ultimate goal of OU 1-07B remedial activities is to achieve the remedial action objectives specified in the Record of Decision Amendment (DOE-ID 2001), as follows:

- Restore the contaminated aquifer groundwater by 2095 (100 years from the signature of the *Record of Decision Declaration 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 1995) by reducing all contaminants of concern to below maximum contaminant levels (MCLs) and a 1×10^{-4} total cumulative carcinogenic risk-based level for future residential groundwater use, and for noncarcinogens, until the cumulative hazard index is less than 1.

- Reduce the concentrations of VOCs to below MCLs and a 1×10^{-5} total risk-based level for aboveground treatment processes in which treated effluent will be reinjected into the aquifer.

- Implement institutional controls to protect current and future users from health risks associated with (1) ingestion or inhalation of, or dermal contact with, contaminants in concentrations greater than the MCLs; (2) contaminants with greater than a 1×10^{-4} cumulative carcinogenic risk-based concentration; or (3) a cumulative hazard index of greater than 1, whichever is more restrictive. The institutional controls shall be maintained until concentrations of all contaminants of concern are below MCLs and until the cumulative carcinogenic risk-based level is less than 1×10^{-4}, and for noncarcinogens, until the cumulative hazard index is less than 1. Institutional controls shall include access restrictions and warning signs.

1.5 Governing Documents

The RAWP (DOE-ID 2002a) and supporting documents, specifically the *In Situ Bioremediation Remedial Action Groundwater Monitoring Plan for Test Area North, Operable Unit 1-07B* (INEEL 2002c) and the *ISB Operations and Maintenance Plan for Test Area North, Operable Unit 1-07B* (DOE-ID 2002b), are the governing documents for the Interim Operations Phase reported in this document.

1.6 Reporting Period Requirements

The current reporting period encompasses the Interim Operations Phase, which is the period between the approval of the RAWP (DOE-ID 2002a) and the start of Initial Operations. As specified in the RAWP, the requirements during the Interim Operations Phase are to:

- Continue system operations to reduce contaminant flux from the hot spot

- Routinely monitor performance of the ISB system with respect to indicator parameters, including VOCs, tritium, ethene/ethane/methane, redox parameters, electron donor, bioactivity, and nutrients, and determine whether operational changes are required

- Initiate startup of the final remedy treatment system.

As discussed in the subsequent sections of this document, each of the above requirements was met during this reporting period and the remedy has successfully moved into the Initial Operations Phase.

2. ACTIVITIES PERFORMED

This section provides a description of the activities conducted during Interim Operations of the ISB remedy component for the reporting period. These activities included electron donor injection operations (Section 2.1), groundwater sampling and analysis (Section 2.2), well drilling activities (Section 2.3), construction activities (Section 2.4), groundwater modeling (Section 2.5), waste management (Section 2.6), microcosm studies (Section 2.7), and AED laboratory studies (Section 2.8).

2.1 Electron Donor Injection Operations

This section describes operations pertaining to electron donor injection. Sodium lactate injection operations were performed in accordance with Technical Procedure (TPR) -163, "Nutrient Injection System Operating Procedure," which details the equipment and procedures used to perform injections with the drum pump and manual injection trailer setup. Sodium lactate was brought onsite as a 60% solution (by weight) in 55-gal drums. Injections were performed by pumping directly from the drums into a flowing, potable water line, which allowed for in-line mixing and injecting into TSF-05. Sodium lactate injection dates, volumes, and concentrations during the reporting period are shown in Table 2-1. The "Injection Type" column refers to the approximate volume of sodium lactate plus potable water that was injected, as well as the intended nominal sodium lactate concentration. The actual concentrations, calculated based on actual volumes injected, are presented in the "Resultant Sodium Lactate Concentration" column. A 1X injection was defined as approximately 12,000 gal total volume, and a 4X injection as 48,000 gal total volume. JRW Technologies was the only sodium lactate vendor used during this reporting period. All of the stock products were 60% by weight (w/w) solutions of sodium lactate.

Sodium lactate injection concentrations were modified between 3.0 and 6.0% (nominal concentrations) during the reporting period. These modifications were made in an effort to experiment with different electron donor concentrations to improve ARD efficiency while avoiding density differences that would cause the injected sodium lactate solution to sink to the base of the aquifer before being utilized.

Table 2-1. Sodium lactate injections during the reporting period.

Injection Date	Volume 60% (w/w) Sodium Lactate Injected (gal)	Injection Type	Total Volume Sodium Lactate Solution Injected (gal)	Resultant Sodium Lactate Concentration (%)	Combined Injection Flow Rate (gpm)	Potable Water Flush Volume (gal)
November 19–21, 2002	2,640	4X 3%a	47,716	3.3	40.2	6,840
January 6–8, 2003	2,640	4X 3%	46,747	3.4	38.2	6,480
February 26–28, 2003	2,640	4X 3%	54,016	2.9	40.0	6,840
April 9–10, 2003	2,640	4X 3%	51,166	3.1	40.1	4,560
June 2–4, 2003	2,640	4X 3%	52,724	3.0	40.0	6,840
July 21, 2003	1,320	1X 6%b	11,321	7.0	40.8	2,160
September 8, 2003	1,320	1X 6%	12,185	6.5	40.5	2,160

a. 4X 3% = an injection volume of approximately 48,000 gal and a 3% concentration of sodium lactate.
b. 1X 6% = an injection volume of approximately 12,000 gal and a 6% concentration of sodium lactate.

2.2 Groundwater Sampling and Analysis

This section summarizes groundwater sampling and analysis activities for the reporting period, including an overview of the monitoring procedures and network, sampling schedule and deviations, on-Site and off-Site analyses, multiparameter water quality instrument monitoring, and water level monitoring. Summaries of the analytical methods are provided in Appendix A; Sampling and Analysis Plan tables used during this reporting period are provided in Appendix B; and additional equipment operational details for the multiparameter water quality instruments are provided in Appendix C.

2.2.1 Monitoring Procedures

The RAWP (DOE-ID 2002a) and the Groundwater Monitoring Plan (GWMP) (INEEL 2003b) prescribe the requirements for an extensive groundwater monitoring program throughout the ISB treatment cell. In addition to these project specific documents, detailed TPRs have been implemented to provide instructions for all aspects of sample handling, transportation, and recordkeeping. Two project specific TPRs (165 and 166) were developed to govern OU 1-07B monitoring activities. Technical Procedure (TPR) -165, "Low-Flow Groundwater Sampling Procedure" specifies purging and sampling techniques utilizing low-flow sampling principles. This procedure describes the use of variable speed submersible pumps, operated at approximately 3.8 L/min (1 gpm), and custom-built "sample boards" with quick connect fittings, detachable sample ports, and flow-through cells integrated with a multiparameter water quality instrument. This procedure also addresses training, equipment, instrument standardizations, purging, sampling, purge water management, cleaning of equipment, and recordkeeping. Technical Procedure (TPR) -166, "In Situ Bioremediation (ISB) Field Analyses Procedures" provides technical guidance for on-Site analyses of groundwater samples for parameters such as ferrous iron, alkalinity, nitrate, and chemical oxygen demand (COD).

2.2.2 Monitoring Network

Fourteen monitoring wells were sampled routinely during this reporting period. It should be noted that wells TSF-05 and TAN-37 utilized sampling points located at multiple depths within the borehole. In these cases, a letter (e.g., A, B, or C) was used to distinguish between the specific sampling depths. Therefore, a total of 17 locations were sampled in 14 wells. Figure 2-1 provides a map of the ISB treatment area and associated monitoring well locations. Table 2-2 details the 17 monitoring locations, the depth of each sampling point, and the horizontal distance of each point from the TSF-05 injection well.

2.2.3 Sampling Schedule

Sampling events were conducted on a monthly basis throughout this reporting period. The specific sampling dates for this reporting period are shown in Table 2-3. With a few exceptions, all locations identified in Table 2-2 were sampled during each event and a consistent set of analyses was performed. During this reporting period, however, four deviations from the GWMP (INEEL 2002c) were noted. First, only wells TAN-25, TAN-31, TAN-37A, and TAN-37B were sampled on June 16, 2003. The remaining 10 wells were not sampled in order to limit the amount of purge water generated. During this time, well drilling activities had generated large volumes of purge water and the treatment system was temporarily at full capacity. The second deviation was that TAN-31 was not sampled during the July 28-29, 2003, sampling event due to construction activities. The wellhead was in an active construction zone and it was necessary to minimize personnel in the area for safety reasons. The third deviation was related to the installation of the three new monitoring wells (TAN-1859, TAN-1860, and TAN-1861), which were completed in September 2003. These three wells were sampled in August, September, and October. The fourth deviation was related to additional sampling at ANP-8 for the purposes of testing new sample collection equipment.

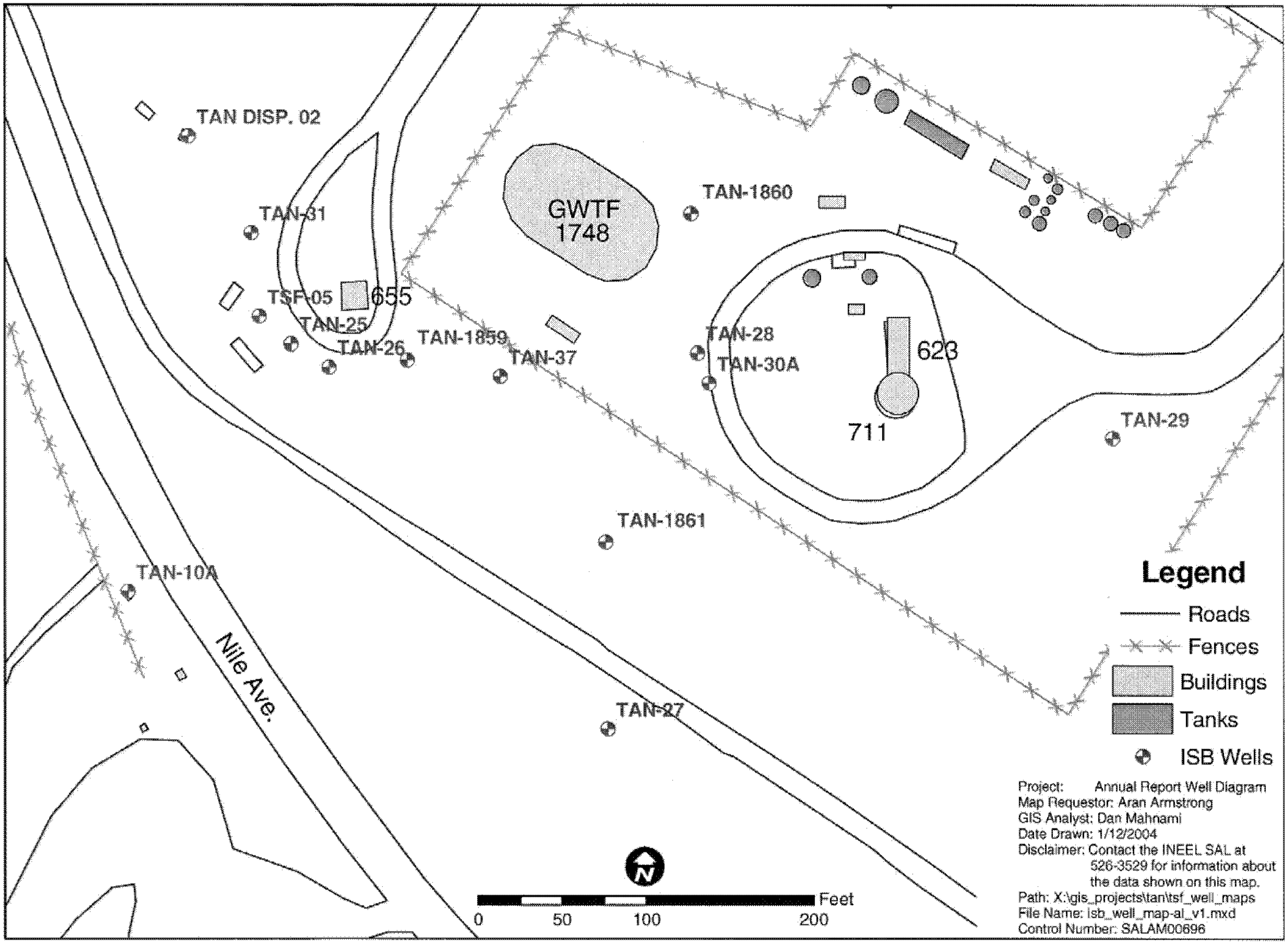

Figure 2-1. Monitoring well network in Operable Unit 1-07B in situ bioremediation treatment cell.

Table 2-2. Wells sampled during in situ bioremediation sampling events.

Well	Depth Sampled (ft)	Distance from TSF-05 (ft)
TSF-05A[a]	235	0
TSF-05B[a]	270	0
TAN-25	218	25
TAN-26	389	50
TAN-27	235	320
TAN-28	240	262
TAN-29	253	513
TAN-30A	313	271
TAN-31	258	50
TAN-37A[a]	240	140
TAN-37B[a]	270	140
TAN-37C[a]	375	140
TAN-10A	233	179
TAN-D2	241	115
TAN-1859	220	92
TAN-1860	269	263
TAN-1861	239	246

a. Wells TSF-05 and TAN-37 are sampled at more than one depth. The letter following the well number is used to represent the sample depth.

Table 2-3. Sampling dates for each sampling event during the current reporting period.

Sampling Event	Sampling Dates	Sampling Event	Sampling Dates
1	November 4–5, 2002	7	May 5-7, 2003
2	December 9–10 and 12, 2002	8	June 16, 2003
3	January 13–14, 2003	9	July 28-29, 2003
4	February 10–11, 2003	10	August 18-20, 2003
5	March 3–4, 2003	11	September 15-18, 2003
6	April 7–9, 2003	12	October 6-8, 2003

2.2.4 Sample Analyses

In general, all monitoring locations were sampled for a standard suite of analytes selected to provide sufficient data to evaluate the progress of the bioremediation remedy. Tables 2-4 and 2-5 summarize the analyte sets by sampling location for each sampling event. The analytical methods, method detection limits, and data quality levels associated with each analyte are summarized in Appendix A. Sampling and Analysis Plan tables (Appendix B) were used to document specific details of each sampling event.

On a monthly basis, samples from each ISB well were analyzed for VOCs, electron donor constituents, tritium, and geochemical parameters. Volatile organic compounds and ethene/ethane/methane were analyzed on a monthly basis using solid phase microextraction (SPME) headspace sampling followed by gas chromatography (Arthur et al. 1992) at the INEEL Research Center (IRC). Volatile organic compound samples were also analyzed on a quarterly basis using U.S. Environmental Protection Agency Method SW-846 8260B, "Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry" (EPA 1996) at an off-site laboratory for comparative purposes. Electron donor constituents were evaluated using ion chromatography and a gas chromatography/flame ionization detector at the IRC. The geochemical parameters were measured using in situ multiparameter water quality instruments and Hach® field test methods.

Gamma spectroscopy and gas flow proportional analyses were run quarterly on samples collected from TAN-29. Gross alpha analysis was also performed on samples collected from the November 2002 sampling event from monitoring wells TSF-05, TAN-25, TAN-26, TAN-28, TAN-29, and TAN-31. Results of these analyses provided data related to concentrations of radionuclide contaminants, as discussed further in Section 3.

Groundwater samples were also collected on several occasions from TAN-25 and TAN-37 to support microbiological research. The samples from TAN-25 provided the media to maintain a microbial culture representative of actual conditions in the source area. Samples from TAN-37C provided media for a second culture to represent areas unaffected by lactate injections. These cultures support ongoing studies related to AEDs, as well as INEEL Laboratory Directed Research and Development projects investigating the response of microbial communities to various injection strategies.

The samples were analyzed at a number of laboratories both at the INEEL and at off-Site commercial laboratories, depending upon holding times, analytical capabilities, and quality level requirements. The IRC provided the majority of the performance-level analytical data for analytes, including VOCs, ethene/ethane/methane, propionate/butyrate/acetate/lactate, and microbiological populations. The ISB Field Laboratory provided performance level data for alkalinity, ferrous iron, sulfate, COD, phosphate, and ammonia. Samples to be sent off-Site were also gamma-screened at the INEEL Radiation Measurements Laboratory to ensure radiological requirements for transportation and laboratory receipt were met. Samples were also sent to commercial laboratories for compliance level VOC data, as well as performance level data for strontium 90, gamma spectroscopy, and gross alpha. The commercial analytical laboratories used during this reporting period are listed in Table 2-6.

Table 2-4. In situ bioremediation sampling and analysis events for the reporting period.

Sampling Event	Analyte Set[a]	Sampling Location[b]
1	M, Sp	All ISB wells
	N	All ISB wells
	^{90}Sr, GS	TAN-29
	GA	TSF-05A, TSF-05B, TAN-25, TAN-26, TAN-28, TAN-29, and TAN-31
2	M	All ISB wells
	MB	TAN-37C
3	M	All ISB wells
4	M, Sp	All ISB wells
	^{90}Sr, GS	TAN-29
	MB	TAN-25
5	M	All ISB wells
	MB	TAN-25 and TAN-37C
6	M	All ISB wells (all analytes listed)
	MB	TAN-37C
7	M, Sp	All ISB wells (all analytes listed)
	N	All ISB wells
	^{90}Sr, GS	TAN-29
	MB	TAN-37C
8	M	TAN-25, TAN-31, TAN-37A, and TAN-37B (all analytes listed)
	MB	TAN-25, TAN-37A, and TAN-37B
9	M	All ISB wells (except TAN-31)
	MB	TAN-25 and TAN-37C
10	M, Sp	All ISB wells (all analytes listed), TAN-1859, TAN-1860, and TAN-1861 (all analytes listed except tritium and split samples for VOCs and E/E/M, a gamma screen sample was also collected at TAN-1859)
	^{90}Sr, GS	TAN-29
	MB	TAN-25 and TAN-37C
11	M	All ISB wells and TAN-1859, TAN-1860, and TAN-1861 (a gamma screen sample was also collected at TAN-1859)
	MB	TAN-25 and TAN-37C
12	M	All ISB wells and TAN-1859 and TAN-1860 (a gamma screen sample was also collected at TAN-1859)

a. The analyte set key is provided in Table 2-5.

b. All ISB wells include: TSF-05A, TSF-05B, TAN-25, TAN-26, TAN-27, TAN-28, TAN-29, TAN-30A, TAN-31, TAN-37A, TAN-37B, TAN-37C, TAN-10A, and TAN-D2.

Table 2-5. Key for analyte sets shown in Table 2-4.

Analyte Set Code	Analytes	Analysis Location
M	ISB monthly monitoring analyte list:	IRC (INEEL Research Center)
	Volatile organic compounds (VOCs) trichloroethene (TCE), tetrachloroethene (PCE), cis-1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE), and vinyl chloride (VC)	
	Ethene/Ethane/Methane (E/E/M)	
	Propionate/Butyrate/Acetate/Lactate (P/B/A/L)	
	Tritium	Off-Site laboratory
	Alkalinity, ferrous iron, sulfate, COD (chemical oxygen demand)	ISB Field Laboratory
	Gamma Screens (Wells TSF-05A, TSF-05B, TAN-25, TAN-26, and TAN-31)	Radiation Measurements Laboratory
N	Nutrients:	ISB Field Laboratory
	Phosphate, ammonia	
Sp	Splits:	Off-Site laboratories
	VOCs	
	Ethene/Ethane/Methane	
^{90}Sr	Strontium-90	Off-Site laboratories
GS	Gamma Spectroscopy	
GA	Gross Alpha	
MB	Microbiological research	IRC

2.2.5 Multiparameter Water Quality Instrument Monitoring

During this reporting period, two different multiparameter water quality instruments, both capable of collecting water quality data in situ and during well purging, were used. Results of the multiparameter water quality monitoring are reported in Section 3.1.6 and all the related data are also provided on the attached CD. Two instrument types, the Multi Parameter TROLL® 9000E (manufactured by In Situ, Inc.) and the Hydrolab® (manufactured by the Hach Company) were used to measure temperature, oxygen reduction potential (ORP), pH, dissolved oxygen, and specific conductance during well purging and during in situ deployment in a subset of ISB wells. In situ specific conductance data were used qualitatively to assess distribution of electron donor. In situ temperature, pH, and ORP data were used qualitatively to assess suitability of aquifer conditions for ARD.

Table 2-6. Off-Site analytical laboratories used during this reporting period.

Laboratory	Analyses
Severn Trent Laboratories, St. Louis, Earth City, MO	VOC Splits E/E/M Splits
Southwest Research Institute, San Antonio, TX	E/E/M Splits VOC Splits
General Engineering Laboratories, Inc., Charleston, SC	Tritium Strontium 90 Gamma Spectroscopy Gross Alpha

E/E/M = ethane/ethane/methane
VOC = volatile organic compound

TROLLS® were frequently deployed during this reporting period in wells TAN-28, TAN-30A, and TAN-37 (at both the A and B depth). A TROLL® was deployed in TAN-31 from the beginning of this reporting period through April 2003 when it was removed to prepare for construction activities. All TROLLS® deployed in situ were removed for routine maintenance approximately once per month and usually redeployed the same day. Routine maintenance included field standardization, changing batteries, and downloading and reprogramming tests. Data gaps longer than a few days are the result of operational issues ranging from running out of battery power or malfunctioning of the instrument or the instrument probes. Hydrolabs® were used for purge data collection from November 2002 through January 2003. TROLLS® were used for purge data collection from February 2003 through October 2003. A CTD-Diver, manufactured by Van Essen Instruments, was deployed during this reporting period in TAN-25. The diver only collects depth, specific conductance, and temperature data.

All operational issues for these three types of instruments, including deployment and removal dates, are detailed in Appendix C.

2.2.6 Water Level Monitoring

The 2001 ISB Annual Report (INEEL 2002a) recommended maintaining transducers in wells TSF-05, TAN-25, and TAN-31 and reporting data for these wells in future ISB annual reports. Data from these three wells showed discernable mounding resulting from sodium lactate injections in TSF-05. Based on these recommendations, groundwater elevations were measured every 15 minutes using pressure transducers connected to data loggers in wells TSF-05, TAN-25, and TAN-31 for the January 6-8, 2003, and February 26-28, 2003, sodium lactate injections. The transducer network was disabled on April 1, 2003, to prepare for construction activities. The CTD-Diver remained operational in TAN-25 collecting groundwater elevation data every 4 hours for all of the injections during this reporting period. Water level monitoring data were used to determine whether sodium lactate injections have resulted in localized changes in permeability around TSF-05 and to observe localized water level rises (i.e., mounding) resulting from sodium lactate injections in TSF-05. The results of this monitoring are presented in Section 3.1.

2.3 Well Drilling Activities

Three wells were installed during this reporting period. TAN-1859 was drilled to 302 ft below land surface (bls) and installed as a new nutrient injection well to be connected to the ISB injection facility. TAN-1860 (drilled to 413 ft bls) and TAN-1861 (drilled to 414 ft bls) were installed as 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 September 2003. Details of the well construction are provided in the *Well Completion Report Test Area North, Well Construction 2003 Operable Unit 1-07B* (INEEL 2003c).

2.4 Construction Activities

During this reporting period, workers constructed the new ISB Facility. This facility is approximately 1,500 ft^2 and is designed to house the amendment injection system and to provide office and laboratory space for rapid turnaround field testing. After ISB construction was complete, component testing was performed on the injection system to ensure that the equipment was properly installed and operated in accordance with the design specifications. The component testing was followed by a system operability test using potable water to demonstrate proper operation of the total treatment system. Concurrent with the system operability test, a management self-assessment of the facility was used to determine the facility's operational readiness, including a review of procedures, training, and other items necessary to safely operate the system. Afterwards, a final inspection was conducted by the U.S. Department of Energy Idaho Operations Office, Environmental Protection Agency, and Idaho Department of Environmental Quality, which concluded that the facility was ready to begin operations. The *In Situ Bioremediation Final Inspection Report* (ICP 2004) provides a summary of the final inspection, findings, and corrective actions for the facility.

2.5 Groundwater Modeling

Groundwater modeling was used to support the ISB remedy component. During previous reporting periods, investigators developed a predictive tool that can be used to simulate electron donor transport and distribution under various electron donor injection strategies. No substantial model development work was performed during the reporting period. Some initial two-well electron donor injection scenarios (TSF-05 and TAN-1859) were simulated but the output from these was considered preliminary so no results are presented here. These scenarios will be further developed during the next reporting period and the results will be presented in the Fiscal Year 2004 ISB Annual Report.

2.6 Waste Management

As in previous years, hazardous waste was generated as a result of ISB sampling activities and managed in accordance with the requirements of the *Waste Management Plan for Test Area North Final Groundwater Remediation Operable Unit 1-07B* (INEEL 2002d). This waste included potentially contaminated wipes, sample bottles, personal protective equipment (i.e., gloves), sample residue from field analyses, sample rinsate, and purge water. Removal of all solid materials and sample residue from field analyses performed in the ISB Field Laboratory was coordinated with INEEL Waste Generator Services. Unaltered sample rinsate and purge water was transported to the New Pump and Treat Facility for processing following each sampling event, in accordance with TPR-6641, "New Pump and Treat Facility Purge Water Injection Procedure."

2.7 Microcosm Studies

Concentrations of trans-DCE have remained steady or increased in the source area wells since the beginning of ISB operations. Because of this, it was recommended in the 2002 Annual Report (INEEL 2003a) that the rate of ARD of trans-DCE relative to cis-DCE be evaluated in laboratory microcosm studies. Therefore, in 2003, a laboratory test was established to compare observed dechlorination rates of trans-DCE, cis-DCE, and TCE. Three microcosms were initiated to support this investigation. Results are presented in Section 3.6.

An existing laboratory, sodium lactate-fed culture, derived from TAN-25 groundwater undergoing complete ARD of TCE to ethene, was used to inoculate the microcosms. Fresh TAN groundwater from the source area was also used to ensure the recruitment of microbial populations lost as a result of lab conditions. Serum vials (160 mL) were used as microcosms to grow the cultures. Each microcosm was then spiked with trans-DCE (7,000 ppm), cis-DCE (7,000 mg/L), or TCE (7,000 mg/L). All microcosms also received a small dose of TCE (~1,000 mg/L) and cis-DCE (~100 mg/L) as a result of residual concentrations in the water used as the media. The microcosms were monitored after 1 month for TCE, cis-DCE, trans-DCE, vinyl chloride (VC), ethene, ethane, methane, lactate, acetate, propionate, butyrate, and pH. A second sample of the trans-DCE microcosm was taken 3 months after inoculation to determine if any activity had been developed over time. Sampling was conducted identically to the procedure described above.

2.8 Alternate Electron Donor Laboratory Studies

While data from the field evaluation and PDP-I indicated that lactate is an effective electron donor for ARD in the TAN system, it was recognized that other alternative donors might be equally or more effective in terms of stimulating ARD and/or may be more cost-effective. Therefore, laboratory studies of AEDs were designed to assess the beneficial properties of AEDs relative to sodium lactate for achieving cost-effective dechlorination in the TSF-05 source area. The criteria determined to be important in this system were:

- ARD efficiency and cost-effectiveness
- Impact of AED solution on contaminant solubility
- Impact of the AED on the microbial community
- The metals content of the AED injection solution.

Studies were performed to address each of these four issues. Complete descriptions of the molecular studies, including the methods, results, and conclusions, are presented in the "Fiscal Year 2003 Alternate Electron Donor Evaluation, Test Area North Final Remedy, Operable Unit 1-07B" (in preparation).