Tracer Test Workplan - Pathway 2
S-3 Ponds, Permeable Reactive Barrier Trench Project

1.0 Introduction

The purpose of this workplan is to describe the objectives and procedures for conducting a tracer injection test at the S-3 Ponds, pathway 2, permeable reactive barriers trench site located at the Y-12 Plant. A 225 foot long trench has been excavated at pathway 2 and backfilled with gravel and iron filings. The zero valent iron was installed in a 26 foot long section in the middle of the trench (Figure 1). The trench was constructed to demonstrate the hydraulic capture and treatment of uranium, nitrate, and technetium in a permeable reactive trench configuration. The trench was designed so that contaminated groundwater is collected on the upgradient end of the trench, treated as it passes through the iron filings, and discharges on the downgradient end of the trench. Under certain hydraulic conditions contaminated groundwater may migrate across the trench instead of down the trench. A bromide tracer will be injected in TMW-11 and rhodamine WT dye tracer will be injected in DP-13 to assess flow paths and transport rates through the iron.

2.0 Objectives

The primary objectives of the tracer testing include the following:

1) Determine the groundwater velocity, treatment volume, and groundwater residence time in the iron.

2) Determine the predominant flow paths through the iron. Tracers will be injected in 2 locations to determine if the predominant groundwater flow direction through the iron is parallel to the trench or across the trench.

3.0 Scope

Bromide and a flourescent dye tracer will be injected simultaneously in wells TMW-11 and DP-13, respectively. TMW-11 is located in the gravel portion of the trench just upgradient and east of the iron. DP-13 is located upgradient but north of the iron and out of the trench. Sixteen piezometers and 4 seeps (seeps 1, 2, 3, and 4) suspected to be in the flow path of the iron will be monitored approximately 12 times over a 1 to 2 week period for break through of the tracers. Samples will be collected at a frequency of approximately 2 times a day for the first 2 days to determine the approximate rate of tracer movement. The subsequent monitoring schedule will be adjusted if the tracer is migrating faster or slower than anticipated. Up to 42 piezometers and 4 seeps will be monitored twice during the tracer test to obtain a snap shot of tracer distribution. One snap shot will be conducted after initial breakthrough has occurred at the seeps and a second snap shot sampling round will be conducted several days later. The target date for injection is the week of May 18th. If possible one of the snap shot sampling rounds will take place at the same time as the analytical sampling round planned for the first week of June.

The 16 piezometers that will be monitored on a more frequent basis include:

Routine Sampling Locations - TMW-06, TMW-07, TMW-09, TMW-11, DP-07, DP-08, DP-09, DP-10, DP-11, DP-13, DP-14D, DP-15D, DP-16D, DP-17D, DP-22D, and DP-23D

Additional piezometers besides the ones listed above that will be sampled as part of the 2 snap shot sampling rounds include the following piezometers:

Snap Shot Sampling Locations - DP-14S, DP-15S, DP-16S, DP-17S, DP-18S, I and D, DP-19S, I and D, DP-20S, I and D, DP-21S, I and D, DP-22S and I, DP-23S and I, EW-01, GW-836, TMW-07, TMW-12, TMW-13, TMW-14, TPB-07, and TPB-08

Tasks that will be completed as part of the tracer testing include the following.

Task 1: *Workplan Preparation* - The workplan, NEPA documentation, voluntary TDEC Dye Trace Registration form will be completed prior to tracer injection.

Task 2: *Conduct Background Screen* - At least 1 set of background samples will be collected from the 16 piezometers and 4 seeps listed above. This information will be used to determine background concentrations of bromide and potential dye tracers and finalize the tracer selection and injection concentration. The background samples will be collected during the May 11th analytical sampling round.

Task 3: *Finalize Tracer Selection and Equipment Preparation* - Based on the results of task 2 the selection of tracers will be finalized and any equipment modifications made.

Task 4: *Conduct Tracer Test* - The tracers will be injected the week of May 18th.

Task 5: *Sampling and Analysis* - Sampling and analytical methods that will be used to analyze for individual tracers are discussed in greater detail below. At least 1 in 15 of all samples will have duplicate analyses performed to ensure repeatability. A blank sample will be included in each sampling round.

Task 6: *Data Management* - Analytical results and field notes will be recorded in project logbooks and digital data will be kept on diskettes. Information described in the field notebooks will include project name, date and time, weather conditions, sample location, sample identification number, sample type, if a duplicate or blank sample was collected, and special conditions or changes in procedures.

4.0 Injection Setup and Tracer Concentrations

Carboys containing the concentrated tracers mixed with distilled water will be used as the reservoir for the injection of the tracers. A peristaltic pump will be used to inject the slug of tracer into the well. A plunger will be used to mix the tracer in the piezometer during injection. Approximately, 10 gallons (37 liters) of bromide tracer will be created by the addition of 135.2 g $MgBr_2\ 6H_2O$ to bring the bromide concentration to 2,000 ppm. Ten gallons is approximately equal to one saturated pore volume in the bromide injection well TMW-11. Approximately, 200 g of a fluorescent dye will be added to 5 gallons (20 liters) of water to produce a concentration of 10,000 ppm dye tracer. Five gallons is equal to approximately 2 pore volumes of the saturated water column in the dye injection piezometer DP-13.

5.0 Field and Analytical Methods

5.1 Bromide Analysis

Bromide is a nonreactive, anionic tracer that is present in natural groundwater at low to undetectable concentrations. It is available as a monovalent or divalent simple salt, and is a commonly used groundwater tracer because of its nonhazardous characteristics and the ease of analysis. Two analytical methods are available for this project: ion-specific probe, and ion chromatography (IC). The ion-specific probe measures a concentration based on electrical conductivity of the solution relative to a reference electrode. The advantages of the probe method are that analytical setup is compact and can be taken to the field for instantaneous measurement, it requires only 5 ml of sample, and the sample is not consumed by the analysis and is, therefore, available for other analyses. The disadvantages are that the detection limit is higher (~ 3-5 ppm) and the accuracy of the measurements is lower than IC.

The second method, ion chromatography (IC), uses chromatographic separation and conductivity to measure concentration compared to a standardized curve. The instrument is highly sensitive, particularly when anion auto-suppression is added, allowing detection at ppb levels. Approximately 20 ml of filtered sample is required and is consumed in the analysis, so that replicate analysis of the same aliquot is not possible. The analyses must be performed in the laboratory and takes somewhat longer than the probe analysis, but numerous samples can be analyzed automatically using an autosampler, thus minimizing technician time.
Because we are interested in capturing the earliest possible arrival, the IC analytical method will be used. If conditions warrant, however, IC measurements may be augmented with probe measurements conducted in the field. Analyses will be conducted in ESD laboratories using a Dionex DX-120 ion chromatograph equipped with a conductivity detector and auto-suppression. The system is computerized for automatic data analysis and digital data recording.

5.5 Fluorescent Dye (rhodamine WT, fluorescein, or acid red #92) Analysis

The dyes under consideration for injection at the S-3 Ponds trench site are commonly used as groundwater tracers and give no indication of significant toxicity in the concentrations used during tracer studies. The final selection criteria for which dye to use will depend on background levels detected in the pre-test screening. The fluorescent dyes can be detected using a spectrofluorophotometer with synchronous scanning. A good description of dye tracing procedures is provided in the Workplan for the K-25 site groundwater tracer test at the K-1070-A Burial Ground for the K-901 Operable Unit.

Dye concentration can be assessed through grab sample analysis or recovered on activated coconut charcoal and unbleached cotton dye receptors commonly referred to as "bugs". Only grab samples will be collected for this project. Approximately 200 g of dye will be used in the the tracer test.

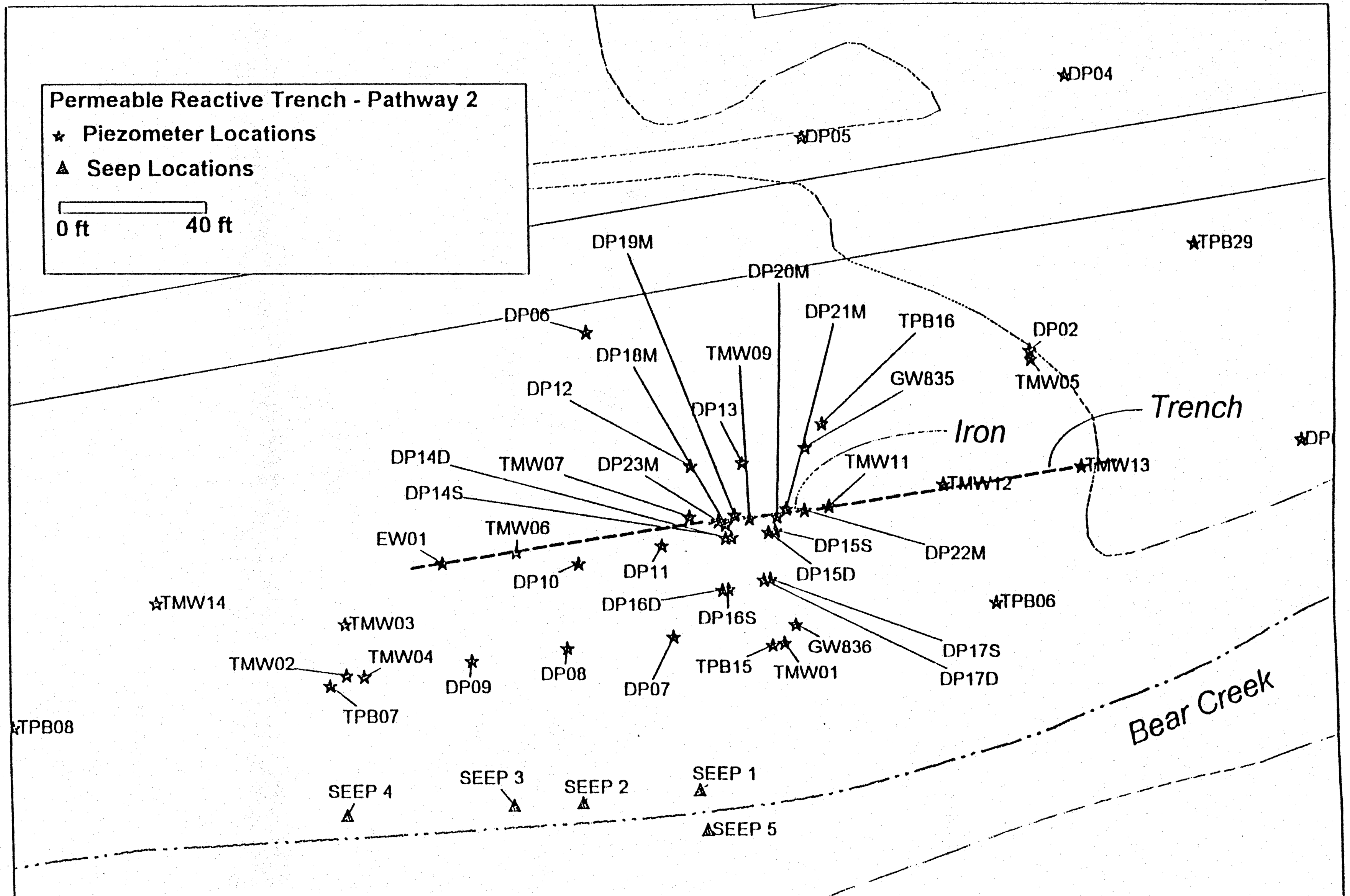
5.3 Sampling Methods

Background samples will be collected and analyzed for bromide and dye tracers prior to the start of the injections. Initially, sampling will be conducted twice a day, however, sampling frequency will be adjusted throughout the tests, depending on analytical results. Once breakthrough has occurred, the sampling frequency can be reduced to capture the main characteristics of the breakthrough curves. Samples can be prepared and stored in a refrigerator until several sampling rounds have been accumulated in order to minimize analytical time. Samples from the piezometers will be collected by pumping with a peristaltic pump. Samples will be filtered with an in-line 40 micron filter prior to collection in 80 ml glass containers. Seep samples will be collected by dipping a glass or stainless steel dipper into the seep, filtering a portion of the sample and collecting the filtered sample in the 80 ml glass containers.

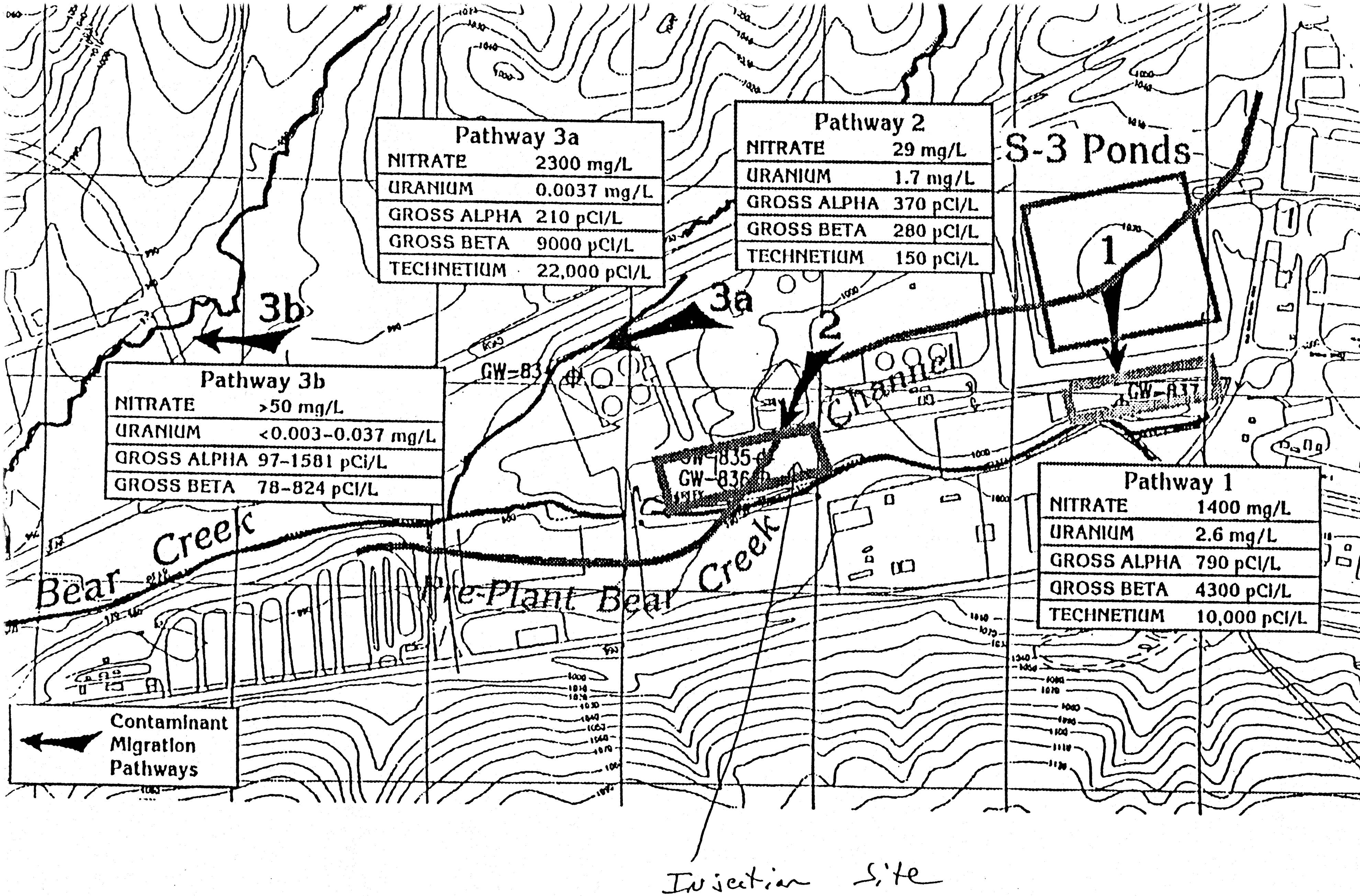
5.4 Quality Control

At least 1 in 15 of all samples will have duplicate analyses performed to ensure repeatability. A blank sample will be included in each sample shipment. In addition, calibration curves will be constructed for each tracer and sample standards will be analyzed periodically during each set of analyses. Sampling teams will protect against the generation of contaminated samples by:

- donning new latex gloves before the start of sample collection at each site;
- working downstream of surface water sample collection points;
- collecting seep samples in order from downstream to upstream;
- refrigerating samples at a temperature of 4 degrees C if stored prior to analysis in the laboratory.



Permeable Reactive Trench - Pathway 2
Piezometer Locations
Seep Locations
0 ft
40 ft
DP04
DP05
TPB29
DP19M
DP20M
DP21M
TPB16
DP02
TMW05
DP06
DP18M
TMW09
GW835
Trench
DP12
DP13
Iron
DP14D
TMW07
DP23M
TMW11
TMW12
TMW13
DP14S
TMW06
EW01
DP15S
DP22M
DP10
DP11
DP15D
TMW14
DP16D
DP16S
TPB06
TMW03
GW836
DP17S
TMW02
TMW04
DP09
DP08
DP07
TPB15
TMW01
DP17D
TPB07
TPB08
Bear Creek
SEEP 4
SEEP 3
SEEP 2
SEEP 1
SEEP 5


S-3 Ponds
Pathway 3a
NITRATE 2300 mg/L
URANIUM 0.0037 mg/L
GROSS ALPHA 210 pCi/L
GROSS BETA 9000 pCi/L
TECHNETIUM 22,000 pCi/L
Pathway 2
NITRATE 29 mg/L
URANIUM 1.7 mg/L
GROSS ALPHA 370 pCi/L
GROSS BETA 280 pCi/L
TECHNETIUM 150 pCi/L
Pathway 3b
NITRATE >50 mg/L
URANIUM <0.003-0.037 mg/L
GROSS ALPHA 97-1581 pCi/L
GROSS BETA 78-824 pCi/L
Pathway 1
NITRATE 1400 mg/L
URANIUM 2.6 mg/L
GROSS ALPHA 790 pCi/L
GROSS BETA 4300 pCi/L
TECHNETIUM 10,000 pCi/L
3b
3a
2
1
GW-835
GW-836
GW-837
Channel
Bear Creek
Pre-Plant Bear Creek
Contaminant Migration Pathways
Injection Site