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Treatability Study on the Bear Creek Valley Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee

Phase II Work Plan for S-3 Site Contaminated Groundwater Interception—In-Field Media Evaluation and Groundwater Capture Methods

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MANAGED BY
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Science Applications International Corporation

contributed to the preparation of this document and should not be considered an eligible contractor for its review.

Y/ER-278

Energy Systems Environmental Restoration Program

Treatability Study on the Bear Creek Valley Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee

Phase II Work Plan for S-3 Site Contaminated Groundwater Interception—In-Field Media Evaluation and Groundwater Capture Methods

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Environmental Management Activities at the
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Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
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PREFACE

This document is a work plan for Phase II of the Bear Creek Valley Characterization Area treabibility study being conducted at the Oak Ridge Y-12 Plant. This work was performed under Work Breakdown Structure 1.4.12.1.1.02.41 (Activity Data Sheet 2302 "Bear Creek Valley"). This document provides the Environmental Restoration Program with a work plan for conducting Phase II of the three-phase treatability study. This plan incorporates conclusions and recommendations of the report on Phase I of this study and coordinates with action being proposed in the Feasibility Study/Environmental Assessment Report for Bear Creek Valley.

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ABBREVIATIONS

1,1,1-TCA	1,1,1-trichloroethane
3-D	three-dimensional
BCV	Bear Creek Valley
BMP	Best Management Practices Plan
BYBY	Boneyard/Burnyard
CA	Characterization Area
COC	contaminant of concern
DOE	U.S. Department of Energy
IP	integration plane
NT	North Tributary
OREIS	Oak Ridge Environmental Information System
PCE	tetrachloroethene
RGO	remedial goal objective
RI	remedial investigation
TDS	total dissolved solids
VOC	volatile organic compound
ZVI	zero valent iron

EXECUTIVE SUMMARY

A treatability study is being conducted to support implementation of early actions at the S-3 Site in the Bear Creek Valley (BCV) Characterization Area (CA). The objectives of the early actions will be (1) to reduce concentrations of uranium and nitrate in Bear Creek and (2) to reduce concentration of contaminants of concern in North Tributary (NT)-1 and NT-2.

The BCV CA is located within the U.S. Department of Energy's Oak Ridge Reservation in east Tennessee. Hazardous and radioactive materials from Oak Ridge Y-12 Plant operations were disposed of at various sites within BCV beginning in the 1940s. Groundwater and surface water in the BCV CA have been contaminated by activities at these waste sites. The remedial investigation (RI) for the BCV CA identified that the greatest mass flux of contaminants from the various sources migrates via groundwater at the source and discharges to surface water in Bear Creek and its tributaries. In the RI, the combined discharge from the S-3 Site and the Boneyard/Burnyard (BYBY) was identified as accounting for 75% of the cancer risk and more than 80% of the chemical toxicity to potential downgradient human receptors. In addition, the S-3 Site has caused degradation of surface water quality in upper Bear Creek and two of its tributaries (NT-1 and NT-2).

The BCV CA treatability study focuses on capture and treatment of shallow groundwater before it discharges to tributary waters. The objectives of treatment of this groundwater are (1) to reduce the concentrations of uranium and nitrate in NT-1 and Bear Creek such that, in concert with actions taken at BYBY, the concentrations of these chemicals in surface water and groundwater are reduced to acceptable levels; (2) to reduce the concentrations of nitrate and metals, and reduce the overall concentration of total dissolved solids to meet ecological remedial goal objectives in NT-1 and upper Bear Creek; and (3) to hydraulically contain the plume of contaminated groundwater that is moving west in bedrock in the Nolichucky Shale along strike from the S-3 Site, such that the rate of contaminant discharge to NT-2 will be reduced in the long term.

The treatability study is being conducted in the following three phases:

- Phase I: Site Characterization and Preliminary Investigation of Treatment Technologies, which was completed in 1996;
- Phase II: In-Field Evaluation of Treatment Technologies and Trench Hydraulics, which is the subject of this work plan; and
- Phase III: Implementation of Integrated Treatment Systems as Early Actions.

Phase I was successful in identifying effective treatment media for further testing. Phase I also successfully identified three pathways for migration of contaminants to surface water at the S-3 Site: GW-835, GW-837, and NT-1.

The objective of Phase II work is to produce conceptual designs for treatment system configurations (specific media and trench types) at the GW-835, GW-837, and NT-1 sites. Based on these results and on the results of Phase I, primary treatment system configurations have been developed for each site. The objectives of Phase II will focus on specific uncertainties associated with deployment of these primary treatment systems for which there are both media- and site-specific uncertainties. These are grouped into two broad categories: (1) those associated with the long-term efficiency of the media in the field and (2) those associated with the hydraulics of groundwater capture. The objectives of Phase II work address the uncertainties by targeting activities to resolve issues in each of those broad groupings of uncertainties. These objectives and activities are:

Objective 1: Define and resolve the issues that the impact long-term treatment efficiency of the selected media or combinations thereof. The activities are as follows:

1. Evaluate existing systems that have been installed in the United States and Canada.
2. Conduct long-term (2–3 months) column test on field panels with water from the GW-835 and GW-837 sites.
3. Identify and develop solutions for engineering issues related to implementation of media and algal mats in the subsurface or surface.

Objective 2: Evaluate groundwater and media deployment systems for the GW-835, GW-837, and NT-1 sites. The activities are as follows:

1. Prepare conceptual designs for media deployment configurations.
2. Evaluate existing systems that have been installed in the United States and Canada.
3. Evaluate modeling of trench and horizontal/inclined well hydraulics for the S-3/NT-1 area.
4. Install and monitor a test trench at GW-835 and a horizontal/inclined test well at NT-1.

Objective 3: Recommend treatment systems for the GW-835, GW-837, and NT-1 sites. The activities are as follows:

1. Define the performance monitoring goals for an early action and address impacts of effluent discharge issues on trench design and medium selection.
2. Establish baseline conditions at the S-3 Site against which performance monitoring goals can be measured during implementation of the early action.
3. Combine a review of data from Phase I, available data from the column panel study, and the hydraulic evaluation of the groundwater capture system, and recommend treatment system configurations and operating parameters for early actions at the GW-835, GW-837, and NT-1 sites.
4. Write a technical report for Phase II that evaluates results of the work and provides recommendations for the early action.

This document is the work plan for Phase II of the treatability study. Chapter 1 is an introduction, Chap. 2 contains a summary of the conclusions and recommendations of the Phase I study, and in Chap. 3 Phase II activities are described, including the rationale for the activities, the objectives, and the approach. The project schedule is presented in Chap. 4, roles and responsibilities of the project team are provided in Chap. 5, and supporting documentation for the Phase II field effort is listed in Chap. 6.

1. INTRODUCTION

A treatability study is being conducted to support implementation of early actions at the S-3 Site in the Bear Creek Valley (BCV) Characterization Area (CA). The objectives of the early actions are (1) to reduce concentrations of uranium and nitrate in Bear Creek to meet downstream concentration goals and (2) to reduce concentration of nitrate, total dissolved solids (TDS), and selected metals in North Tributary (NT)-1 to reduce the risk to the ecology of NT-1 and upper Bear Creek. In addition, a secondary objective of the early actions will be to hydraulically contain a plume of contaminated groundwater in the bedrock of the Nolichucky Shale that is currently migrating west along geological strike from the S-3 Site. This plume discharges contaminants into NT-1 and NT-2; the long-term effect of containment will be to reduce contaminant discharges to these two tributaries.

The S-3 Contaminated Groundwater Interception Project has two objectives: (1) to design and implement early actions for treatment of contaminated groundwater discharge at the S-3 Site, and (2) to support future decision making for the BCV CA where similar technologies may be utilized at other sites in BCV.

The S-3 Contaminated Groundwater Interception Project is being conducted in three phases [*BCV CA Technology Demonstration Action Plan* (SAIC 1996)]. Phase I has been completed, providing sufficient results to determine the activities to be completed in Phase II. The following is a brief description of the objectives of each phase of the treatability study:

Phase I: Site Characterization and Preliminary Investigation of Treatment Technologies. The objectives of Phase I were to (1) identify and characterize possible demonstration sites near Bear Creek, NT-1, and NT-2; (2) test and select effective treatment media; and (3) conduct initial evaluation of bioremediation technologies.

Phase II: In-Field Evaluation of Treatment Technologies and Trench Hydraulics. The objectives of Phase II are to (1) determine efficient treatment trains for S-3 Site–specific water by conducting long-term testing of select media using water from piezometers or test trenches; (2) evaluate hydraulics and flow rate control for treatment trenches and horizontal/inclined wells; (3) determine the most effective design for the treatment train/groundwater capture configurations at each site; and (4) develop optimization data for pilot-scale bioremediation technology designs.

Phase III: Implementation of Integrated Treatment System as an Early Action. The objective of Phase III is to implement groundwater capture trenches and horizontal/inclined wells coupled with in situ or ex situ treatments at the S-3 Site and, if appropriate, operate them in conjunction with bioremediation technologies.

This document is a work plan for Phase II of the treatability study. In Chap. 2 of this document, the conclusions and recommendations of Phase I of this study are briefly summarized (SAIC 1996). In Chap. 3, Phase II activities are described, including the rationale for the activities, the objectives, and the approach. The project schedule is provided in Chap. 4, roles and responsibilities of the project team are presented in Chap. 5, and supporting documentation for the Phase II field effort is listed in Chap. 6.

1.1 BACKGROUND

The BCV CA is located within the U.S. Department of Energy's (DOE's) Oak Ridge Reservation in east Tennessee, about 32 km (20 miles) northwest of Knoxville. About 16.7 km (10.4 miles) long, BCV CA extends from the east end of DOE's Oak Ridge Y-12 Plant westward to the Clinch River.

Hazardous and radioactive materials from Y-12 Plant operations were disposed of at various sites within BCV beginning in the 1940s (Energy Systems 1996). Trenches located at the Bear Creek Burial Grounds and at the Boneyard/Burnyard (BYBY) received large volumes of hazardous and radioactively contaminated solid waste. The S-3 Site, Oil Landfarm, Hazardous Chemicals Disposal Area, and Bear Creek Burial Grounds received hazardous liquid waste.

Groundwater and surface water in the BCV CA have been contaminated by activities at these waste sites. The remedial investigation (RI) for the BCV CA identified that the greatest mass flux of contaminants from the various sources migrates via groundwater at the source and discharges to surface water in Bear Creek and its tributaries (Energy Systems 1996). As part of the RI, contributions of individual wastes sources to the total contaminant mass flux at a downstream location in BCV, called the integration plane (IP), were calculated (Fig. 1.1).

The combined mass flux of contaminants from two sites — the S-3 Site and BYBY — accounts for 75% of the cancer risk and more than 80% of the chemical toxicity to potential human receptors at the IP, with uranium and nitrate contamination accounting for more than 90% of the risk and toxicity. In addition, discharge of contaminated groundwater to surface water from a plume moving west along strike from the S-3 Site has caused degradation of surface water quality in upper Bear Creek and two of its tributaries (NT-1 and NT-2). Water and sediments in these tributaries pose risks to the ecology of these streams due to high concentrations of nitrate, TDS, and metals.

A feasibility study for BCV is currently underway. Three of the five remedial alternatives that will be considered in the feasibility study focus on in situ treatment of surface water or shallow groundwater to prevent migration of contaminants beyond the Bear Creek tributary streams. This emphasis on in situ water treatments is dictated by the nature of the contaminant pathways within BCV (i.e., passive water treatment at those points at which contaminated groundwater funnels into exit pathways before or after upwelling into the Bear Creek tributaries is a reasonable remedial strategy). Thus, to support the remedial action decision-making and design process, a technology demonstration is being conducted within the BCV CA to evaluate the implementability and cost-effectiveness of passive in situ systems that integrate multiple water treatment technologies.

1.2 TREATMENT OBJECTIVE OF THE TREATABILITY STUDY

The BCV CA treatability study focuses on capture and treatment of shallow groundwater before it discharges to tributary waters. The objectives of treatment of this groundwater are (1) to reduce the concentrations of uranium and nitrate in NT-1 and Bear Creek such that, in concert with actions taken at BYBY, the concentrations of these chemicals in surface water and groundwater at the IP are reduced to acceptable levels; (2) to reduce the concentrations of nitrate and metals, and reduce the overall concentration of TDS to meet ecological remedial goal objectives (RGOs) in NT-1 and upper Bear Creek [RGOs for the BCV CA are presented in the BCV CA RI Report (Energy Systems 1996)]; and (3) hydraulically contain the plume of contaminated groundwater that is moving west

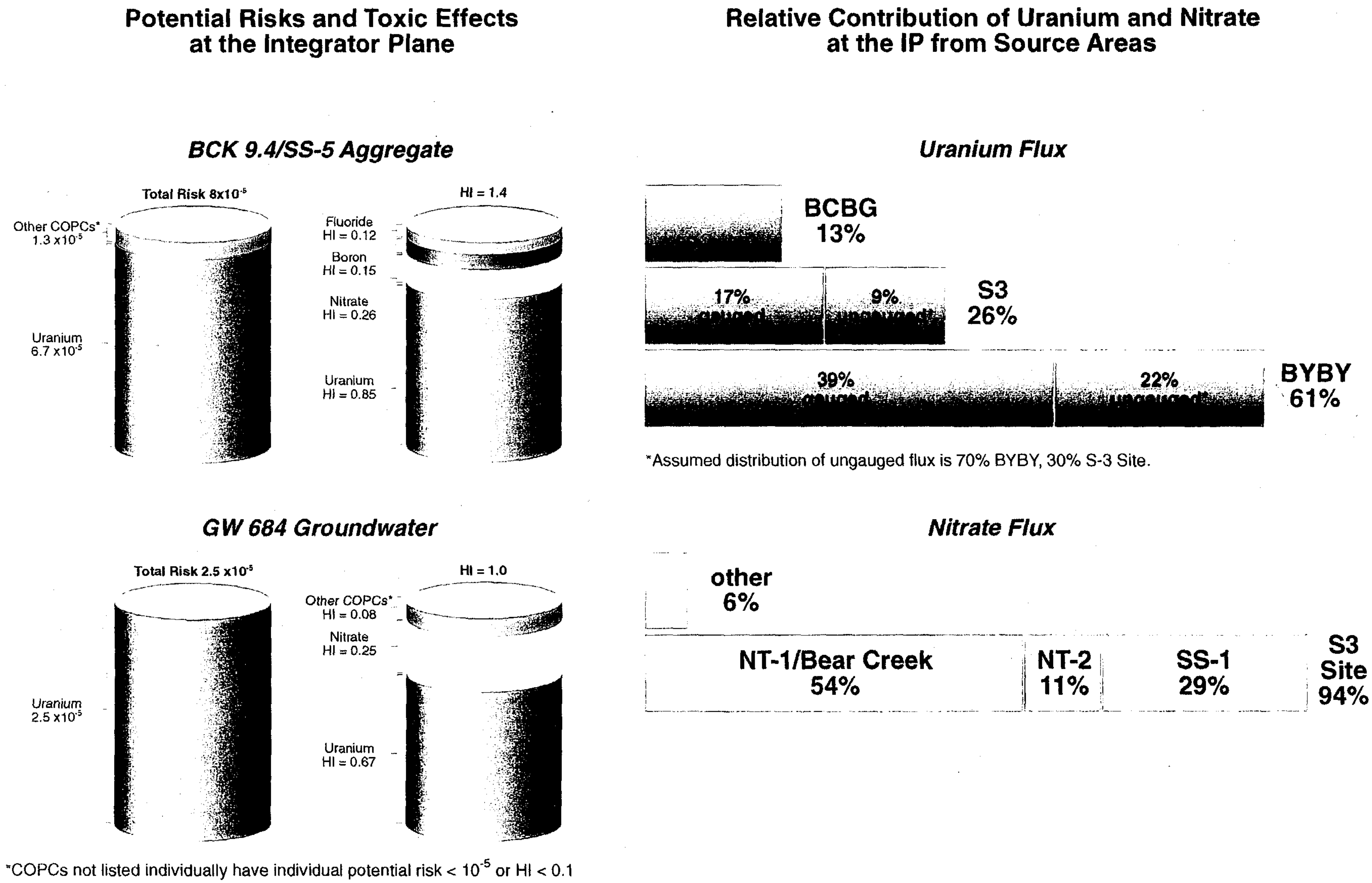


Fig. 1.1. Potential risks and hazards at the integrator point/plane and the relative magnitude of the sources for nitrate and uranium.

in bedrock in the Nolichucky Shale along strike from the S-3 Site such that the rate of contaminant discharge to NT-2 will be reduced in the long term.

In defining these objectives it is realized that it may not be technically feasible to fully achieve objectives 2 and 3; however, technologies used in this treatability study will be considered viable if significant reductions of in-stream contaminant concentrations can be made.

2. SUMMARY OF PHASE I FINDINGS AND RECOMMENDATIONS

2.1 INTRODUCTION

The scope of Phase I included the following activities:

- collect hydraulic and geochemical information on potential S-3 trench installation locations (i.e., adjacent to tributaries NT-1, NT-2, and upper Bear Creek);
- test ability of sorbents (e.g., zeolites, peat moss, activated carbon, Dowex resin) to remove uranium and other metals from two Y-12 groundwater types;
- test ability of zero valent iron (ZVI) to reduce the concentration of uranium and other metals, technetium, nitrate, and volatile organic compounds (VOCs) in three Y-12 groundwater types;
- assess effectiveness of wetlands, MATs, and phytoremediation technology to remove nitrate, uranium, and other metals from contaminated surface water;
- conduct preliminary evaluations to determine if there are forms of the media (e.g., Cercona iron foam) that increase contaminant removal efficiency or reduce the potential for unwanted byproducts (e.g., mix iron with peat moss to reduce ferrous iron in effluent); and
- select trench installation target locations and media to carry into Phases II and III.

The advice of nationally recognized treatment experts was sought to select the technologies and media tested and to understand potential site-specific issues. The testing conducted during Phase I was primarily laboratory batch and column testing. Wetlands testing was conducted at a spring (SS-4) in three small flow-through plots, but most of the MATs and phytoremediation testing was conducted in a greenhouse in batch mode. Further description of the field characterization activities and testing of water types and media is provided below.

Field Characterization Activities. The purpose of the field characterization was to identify the major flowpaths for groundwater contaminants to discharge to the tributaries around S-3, and select the target sites for trench installation. The following activities were conducted as part of the field characterization:

- conducted creek walk-overs to collect field data from surface water and identify seeps;
- based on creek walk-over data, installed 25 temporary 1-in.-diameter pushprobes using geoprobe technology, and conducted chemical analyses; and
- installed four 4-in.-diameter piezometers in primary seepage pathways to collect more complete chemical analyses, conduct pumping tests, and use as a source of water for long-term column tests in Phase II.

Water Types and Media Testing. Four types of Y-12 Plant water were collected and used for testing the different technologies/media. The water types, characteristics, and primary media tested are listed in Table 2.1.

Table 2.1. Y-12 water types and technology/media tested

Water type	Characteristics	Technology/media tested
East End (VOCs[a] only)	carbon tetrachloride dominated	ZVI[b] and activated carbon
Boneyard/Burnyard (BYBY water)	uranium and VOCs (PCE[c], 1,1,1-TCA[d] and daughter products) with low TDS[e] (<1,000 mg/L)	sorbents, ZVI
S-3 Ponds (NT-1)	high TDS, nitrate, metals, uranium, technetium, low pH (4-6) and PCE	sorbents, ZVI, MATs, and phytoremediation
Spring SS-4	low TDS, uranium, and nitrate	wetlands and MATs

[a]volatile organic compounds [b]zero valent iron [c]tetrachloroethene [d]1,1,1-trichloroethane
[e]total dissolved solids

Calcium and bicarbonate are the dominant ions in all but the S-3 (NT-1) water. Calcium and nitrate are the dominant ions in the S-3 water type although many other ions are also elevated. Typical concentrations at trench locations are expected to be uranium (1–4 mg/L), VOCs (0.5–1 mg/L), nitrate (50 mg/L at SS-4 and 2500 mg/L at NT-1), technetium (22,000 pCi/L). Maximum concentrations of some other inorganics at the S-3 Site are barium (380 mg/L), cadmium (4 mg/L), calcium (>10,000 mg/L), strontium (340 mg/L), zinc and nickel (20 mg/L), and copper (3.1 mg/L).

For some testing, the natural waters were spiked with higher levels of VOCs and uranium to represent possible worst-case conditions.

2.2 PHASE I RESULTS

Phase I was successful in identifying effective treatment media for further testing. Phase I also successfully identified key site characteristics that influence treatment efficiency for numerous approaches. Specific findings follow.

2.2.1 Field Characterization

Field characterization efforts have delineated three primary pathways for contaminated groundwater at the S-3 Site to discharge to surface water (Fig. 2.1). The three pathways are as follows:

- Two pathways (pathways 1 and 2 on Fig. 2.1) for uranium-contaminated groundwater to the main stem of Bear Creek adjacent to the former S-3 Ponds. These two pathways were characterized using 4-in. piezometers and are named the GW-835 and GW-837 sites. Groundwater in the shallow pathway to Bear Creek closest to the S-3 Ponds (GW-837) is also contaminated with high TDS, nitrate, technetium, and elevated levels of some metals; groundwater in GW-835 is primarily contaminated with uranium and has lower TDS content (Table 2.2).

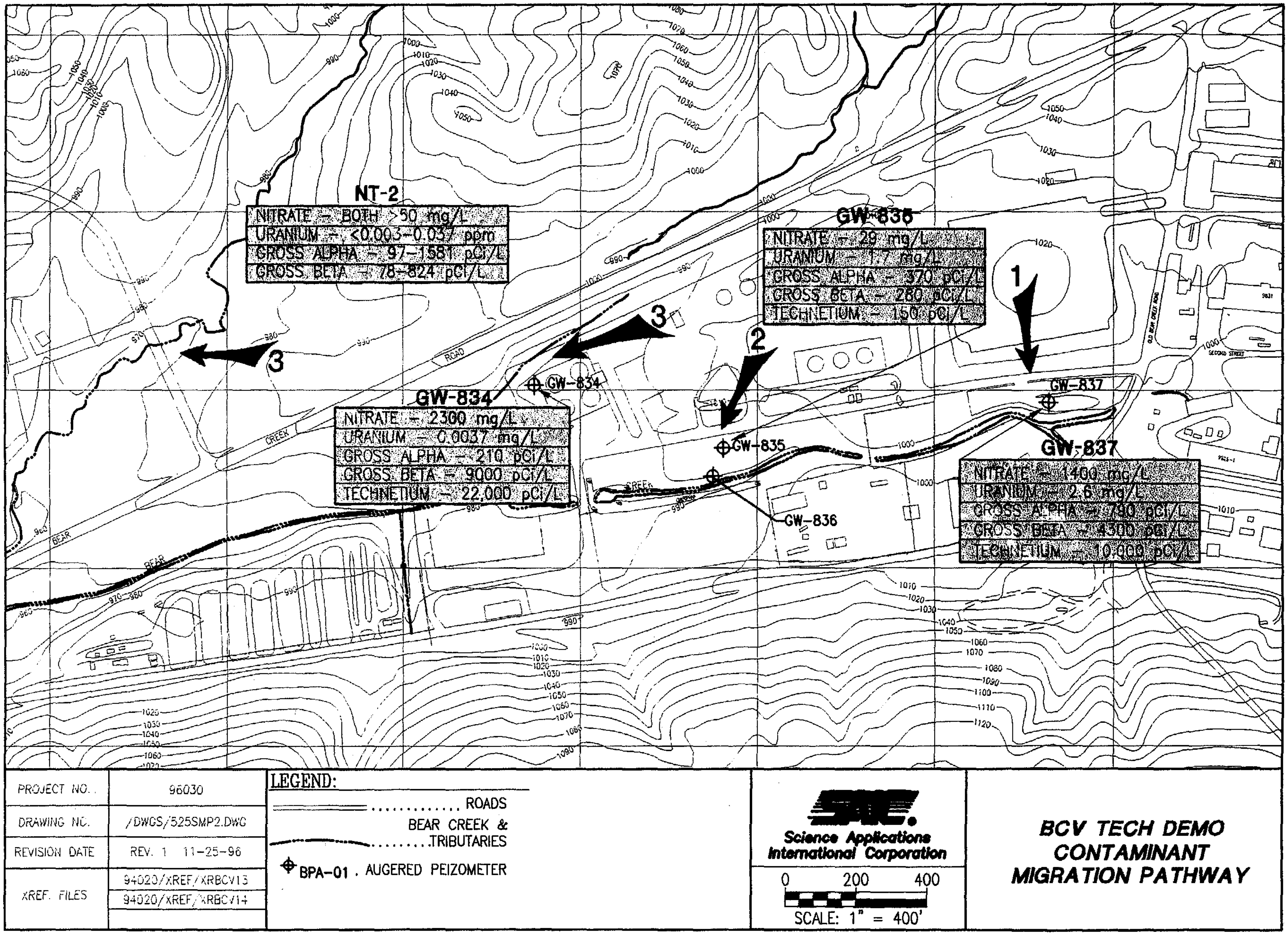


Fig. 2.1. BCV technical demonstration contaminant migration pathway.

Table 2.2. Analysis of groundwater in the three pathways at the S-3 Site

Analysis	GW-834 (NT-1) Filtered Rep 1	GW-834 (NT-1) Filtered Rep 2	GW-834 (NT-1) Unfiltered Rep 1	GW-834 (NT-1) Unfiltered Unc +/-	GW-834 (NT-1) Unfiltered Rep 2	GW-835 Filtered	GW-835 Unfiltered	GW-835 Unfiltered Unc +/-	GW-837 Filtered Rep 1	GW-837 Filtered Rep 2	GW-837 Unfiltered Rep 1	GW-837 Unfiltered Unc +/-	GW-837 Unfiltered Rep 2
Inorganics													
Aluminum, ug/L	2760	2670	9860		8210	1220	4550		4690	4630	27900		25500
Antimony, ug/L	<100	<500	100		<500	<100	<100		<100	<500	<100		<500
Arsenic, ug/L	<100	<500	<100		<500	<100	<100		<100	<500	<100		<500
Barium, ug/L	>23200	23800	23700		24300	83.5	95.2		483	489	578		587
Beryllium, ug/L	2	<5.0	2.5		<5.0	<1.0	<1.0		2.9	<5.0	4.5		<5
Boron, ug/L	102	<100	114		<100	108	108		23.1	<100	39.9		<100
Cadmium, ug/L	411	391	427		404	<20	<20		199	184	204		196
Calcium, ug/L	> 1000000	2629000	>1000000		2662000	163000	163000		>1000000	1647000	>1000000		1681000
Chromium, ug/L	<20	<100	<20		<100	<20	<20		<20	<100	<20		<100
Cobalt, ug/L	216	212	222		211	<20	<20		257	250	265		265
Copper, ug/L	65.2	<200	70.5		<200	<30	<30		58.6	<200	77.2		<200
Iron, ug/L	362	<800	5810		5700	712	4580		207	<800	14300		14300
Lead, ug/L	<200	<800	<200		<800	<200	<200		<200	<800	<200		<800
Lithium, ug/L	41.8	<50	50.5		<50	30.6	32.4		119	93.8	143		124
Magnesium, ug/L	335000	322000	343000		327000	26000	26400		152000	146000	158000		151000
Manganese, ug/L	>100000	145000	>100000		147000	1120	1160		100000	157000	>100000		159000
Mercury, mg/L	0.0002		<0.0002				0.00049		0.00039		0.0012		
Molybdenum, ug/L	<40	<200	<40		<200	<40	<40		<40	<200	<40		<200
Nickel, ug/L	1660	1710	1710		1750	<40	<40		2130	2130	2140		2210
Phosphorous, ug/L	547	<2000	668		<2000	<300	<300		562	<2000	724		<2000
Potassium, ug/L	29000	26500	32000		28200	6380	7300		43200	38800	47900		42400
Selenium, ug/L	<500	<3000	<500		<3000	<500	<500		<500	<3000	<500		<3000
Silver, ug/L	<20	<80	<20		<80	<20	<20		<20	<80	<20		<80
Sodium, ug/L	506000	494000	516000		500000	17400	17300		695000	677000	705000		688000
Strontium, ug/L	660	6770	6670		6850	488	490		2390	2440	2450		2500
Thallium, ug/L	136	<500	139		<500	<100	<100		143	<500	169		<500
Titanium, ug/L	<20	<80	189		96.2	<20	124		<20	<80	244		161
Uranium, ug/g			0.0037				1.7				2.6		
Vanadium, ug/L	<10	<50	<10		<50	<10	<10		<10	<50	<10		<50
Zinc, ug/L	33.5	<100	44.8		<100	<20	<20		97.6	<100	119		105
Anions													
Alkalinity, mg/L			420				310.1				410		
Bicarbonate, mg/L			443				426				434		
Bromide, mg/L			NA				NA				NA		
Chloride, mg/L			260				28				320		
Fluoride, mg/L			4.8				0.4				4.9		
Nitrite as Nitrogen, mg/L			8.3				0.2				7.3		
Nitrate as Nitrogen, mg/L			2300				29				1400		
Ortho-Phosphate as Phosphorus, mg/L			<5.0				<0.12				<5.0		
Sulfate, mg/L			14				150				390		

Table 2.2 (cont.)

Analysis	GW-834 (NT-1) Filtered Rep 1	GW-834 (NT-1) Filtered Rep 2	GW-834 (NT-1) Unfiltered Rep 1	GW-834 (NT-1) Unfiltered Unc +/-	GW-834 (NT-1) Unfiltered Rep 2	GW-835 Filtered	GW-835 Unfiltered	GW-835 Unfiltered Unc +/-	GW-837 Filtered Rep 1	GW-837 Filtered Rep 2	GW-837 Unfiltered Rep 1	GW-837 Unfiltered Unc +/-	GW-837 Unfiltered Rep 2
Miscellaneous													
Total Dissolved Solids, mg/L							690				11000		
Total Suspended Solids, mg/L			190				9						
Organics													
1,1,1-Trichloroethane, ug/L			10 U				10 U				1 J		
1,1,2,2-Tetrachloroethane, ug/L			10 U				10 U				10 U		
1,1,2-Trichloro-1,2,2-trifluoroethane, ug/L			10 U				5 J				3 J		
1,1,2-Trichloroethane, ug/L			10 U				10 U				10 U		
1,1-Dichloroethane, ug/L			10 U				10 U				10 U		
1,1-Dichloroethene, ug/L			10 U				10 U				10 U		
1,2-Dichloroethane, ug/L			10 U				10 U				10 U		
1,2-Dichloropropane, ug/L			10 U				10 U				10 U		
1,2-Ethanediol, Dinitrate, ug/L			16										
1,5-Pentanediol, Dinitrate, ug/L			10										
2-Butanone, ug/L			4 BJ				3 BJ				8 BJ		
2-Hexanone, ug/L			10 U				10 U				10 U		
4-Methyl-2-pentanone, ug/L			10 U				10 U				2 J		
Acetaldoxime, ug/L			6										
Acetone, ug/L			12				9 BJ				43		
Benzene, ug/L			10 U				10 U				10 U		
Bromodichloromethane, ug/L			10 U				10 U				10 U		
Bromoform, ug/L			10 U				10 U				10 U		
Bromomethane, ug/L			4 J				10 U				2 J		
Carbon tetrachloride, ug/L			10 U				10 U				10 U		
Chlorobenzene, ug/L			10 U				10 U				10 U		
Chloroethane, ug/L			10 U				10 U				10 U		
Chloroform, ug/L			9 J				10 U				7 J		
Chloromethane, ug/L			10 U				10 U				3 J		
cis-1,2-Dichloroethene, ug/L			6 J				10 U				3 J		
cis-1,3-Dichloropropene, ug/L			10 U				10 U				10 U		
Dibromochloromethane, ug/L			10 U				10 U				10 U		
Ethane 1,2-Dichloro-1,1,2-tr							4.03						
Ethylbenzene, ug/L			10 U				10 U				10 U		
Methylene chloride, ug/L			14				10 U				18		
Styrene, ug/L			10 U				10 U				10 U		
Tetrachloroethene, ug/L			2 J				4 J				14		
Toluene, ug/L			10 U				10 U				10 U		
tran-1,2-Dichloroethene, ug/L			10 U				10 U				10 U		
trans-1,3-Dichloropropene, ug/L			10 U				10 U				10 U		
Trichloroethene, ug/L			10 U				10 U				10 U		

Table 2.2 (cont.)

Analysis	GW-834 (NT-1) Filtered Rep 1	GW-834 (NT-1) Filtered Rep 2	GW-834 (NT-1) Unfiltered Rep 1	GW-834 (NT-1) Unfiltered Unc +/-	GW-834 (NT-1) Unfiltered Rep 2	GW-835 Filtered	GW-835 Unfiltered	GW-835 Unfiltered Unc +/-	GW-837 Filtered Rep 1	GW-837 Filtered Rep 2	GW-837 Unfiltered Rep 1	GW-837 Unfiltered Unc +/-	GW-837 Unfiltered Rep 2
Trichlorofluoromethane, ug/L			10 U				10 U				10 U		
Vinyl chloride, ug/L			10 U				10 U				10 U		
Xylene, ug/L			10 U				10 U				10 U		
Radionuclides													
Alpha activity, pC/L			210	56			370	45			790	120	
Beta activity, pC/L			9000	1000			280	34			4300	500	
125-Antimony, pC/L			-0.78	5.1			-2.9	5.6			2.4	5.2	
212-Bismuth, pC/L			13	14			13	16			1.8	16	
134-Cesium, pC/L			-1.2	2			-0.52	2.4			1.2	2.2	
137-Cesium, pC/L			-0.77	2.2			-0.064	3.8			-2.4	3.6	
144-Cerium, pC/L			1.3	12			-3.5	12			-2.1	10	
51-Chromium, pC/L			-1.2	15			8.1	19			9.7	15	
57-Cobalt, pC/L			-0.57	1.5			0.84	1.5			0.31	1.3	
58-Cobalt, pC/L			-1.2	1.8			-1.4	2.1			0.49	2	
60-Cobalt, pC/L			2.3	2			-1.7	3.8			2.9	3.6	
59-Iron, pC/L			0.9	3.3			-0.7	4.8			3	4.2	
212-Lead, pC/L			18	5.6			6.4	5.7			12	5	
54-Manganese, pC/L			0.85	1.9			1.6	2.2			-0.095	2	
95-Niobium, pC/L			3.6	2.1			-0.5	2.3			2.7	2.3	
40-Potassium, pC/L			52	47			50	52			42	49	
106-Ruthenium, pC/L			-2.2	16			13	18			3.9	17	
22-Sodium, pC/L			1.1	1.9			1.5	2.1			-1.5	2.5	
Total Strontium, pC/L			-2.4				0.4				360		
99-Technetium, pC/L			22000	2200			150	16			10000	1000	
208-Thallium, pC/L			4.5	4.4			3.4	4			3.1	3.6	
Tritium, pC/L			1500	280			-46	150			1100	250	
235 Uranium, pC/L			7.8	5			5	18			20	5	
65-Zinc, pC/L			-0.63	4.5			-0.55	4.4			1	5.2	
95-Zirconium, pC/L			-1.9	4			-3.3	4.7			-1.6	4.4	

- One deeper-along-strike flow path (pathway 3 on Fig. 2.1) for nitrate, tetrachloroethene (PCE), technetium, metals, and high TDS-contaminated groundwater to NT-1 (Table 2.2). This deeper-along-strike flow path extends to NT-2 although some of the metals and VOCs are not present at NT-2.

Permeability and groundwater flow rates in these pathways have not been defined; however, piezometers located in the two pathways for uranium to Bear Creek showed lower than expected draw down during well development, indicating that these zones may have relatively higher permeability than the surrounding formation. Single well pumping tests have shown that GW-835 can sustain a pumping rate of up to 6 L/min, whereas GW-837 can only sustain 60 mL/min, and GW-834 has a 100 mL/min pumping rate. Preliminary results from a 12-h pumping test conducted in GW-835 indicated that significant drawdown was not observed in piezometers close to GW-835 and, after switching off the pump, the water level recovered to pretest levels in GW-835 within 10 min. This indicates that GW-835 intersects a groundwater pathway with relatively high hydraulic conductivity and of limited extent.

2.2.2 Treatment Technologies

During Phase I, treatment media were screened to determine applicability for removal of site-specific contaminants of concern (COCs): uranium, metals, VOCs, and nitrate. The goal of screening was to examine test material performance for removal of these COCs under high and low TDS groundwater conditions that are encountered in BCV. (Note that media testing was conducted before the groundwater pathways at the S-3 Site had been identified and the piezometers installed; thus, the water types used were from existing wells). Most of the media were tested using two types of contaminated water that are likely to be encountered at this site. These are NT-1-type water, with characteristics of high TDS (>20,000 ppm), elevated nitrate, calcium, trace metals, and VOCs, and BYBY-type water, with characteristics of lower TDS (<1,000 ppm), uranium, and VOCs. To represent NT-1-type, high-TDS water contaminated with uranium, experimental work was conducted using NT-1 water spiked with 1 ppm uranium. The discussion that follows focuses on the media that worked best.

Uranium Removal. Most of the technologies/media from all categories showed positive results for uranium removal in low TDS (BYBY) water. In some cases (Dowex 21K resin), the agent's loading capacity under equilibrium conditions could not be determined because the media achieved maximum uranium removal at all concentrations tested. For this water type, the best sorbent performers were Dowex 21K resin (>18 mg/g), peat moss (4 mg/g), and iron oxides (powdered form only). ZVI also efficiently removed uranium through reduction and precipitation and possibly some sorption. MATs (70–100% removal) and the constructed wetlands (30–46% removal) were able to remove uranium from surface water containing lower concentrations of uranium (<200 μg/L).

Very few media were able to provide uranium removal under the high TDS conditions provided by NT-1 water. The principle interference in NT-1 appears to be nitrate although high calcium and aluminum also contributed to low scoring of several sorbents. Peat moss had lower removal efficiencies in this water but still provided 0.9 mg uranium removed per gram of peat moss used. ZVI is also a candidate for treatment of S-3 type water. For this media batch, studies showed that the mechanism for uranium removal appears to be primarily the corrosion of the iron and subsequent adsorption to the corrosion products. The importance of reduction and precipitation of uranium to insoluble forms is unclear. Results of column testing indicate reduction and precipitation may be important. The two methods of testing provide different residence times and pH conditions.

Metals Removal. The sorbents tested were relatively ineffective in removing other metals from the test water from S-3 (NT-1). Amberlite IRC-718 and MATs recovered some metals from the NT-1 type water but not enough to carry as a primary treatment mechanism for the more concentrated groundwater. MATs showed promising results for removing aluminum, barium, calcium, cadmium, magnesium, manganese, nickel, and strontium from low-concentration surface water (e.g., SS-4). ZVI removed metals during batch experiments but not during preliminary column experiments. This is attributed to pH changes and more rapid corrosion of ZVI in batch tests and the longer residence time for metals to be exposed to the iron (compared to the column).

Nitrate Removal. Nitrate removal is an important consideration based on the noted interference on removal of other COCs caused by nitrate in NT-1 water. Some nitrate reduction in the lower concentration surface (50 mg/L) was observed in the wetlands and algal mats systems although more testing is required to establish the maximum potential rate of removal. In addition, the effect of biomass grown in a peat moss/ZVI environment should also be considered as a potential medium for nitrate removal. This combination of components appears to provide the reducing environment, a support matrix, and a small amount of degradable carbon to support accelerated nitrate removal. This is the only subsurface treatment option identified at this time for nitrate removal.

VOC Destruction. Both Fisher iron and Masterbuilder iron removed VOCs from test water. Masterbuilder iron produced a shorter half-life than Fisher iron. For example, the half-lives of Masterbuilder and Fisher iron were <1.0 h and >11 h, respectively, for batch studies conducted on BYBY water containing PCE and trichloroethylene. For 1,1,1-trichloroethane, they were 1.21 and 4.18, respectively. Palladium coating enhanced the effectiveness of both iron forms, but the gain may be too small to compensate for the added cost of palladium treatment. For example, the calculated batch study half-life for the palladium-coated Masterbuilder was 0.21 h and 0.25 h for uncoated. It is unclear why Masterbuilder has a shorter half-life than Fisher iron, but it appears to be related to impurities present in the iron. By-products were observed, indicating that sorption was not the sole mechanism for removal. The rate of reaction of some of the daughter products of carbon tetrachloride (chloroform and methylene chloride) were too slow for Fisher iron to be a viable candidate for treatment of carbon tetrachloride–contaminated groundwater.

Each of these media either destroys the primary COC (as is the case for nitrate removal in algal mats and VOC removal in ZVI) or adsorbs/precipitates the COC (as is the case for metal and uranium removal in each media).

2.3 PHASE I CONCLUSIONS

Phase I testing provided the following major conclusions:

- The site-specific testing was valuable because water types greatly impacted the performance of most of the media. The results showed that different media are suited to the different water characteristics, and, in addition, mixtures of media may provide the best performance.
- Significantly different conclusions may be obtained when using batch versus column testing, especially for the ZVI. The differences in the production of corrosion products and pH differences can greatly impact the results of the batch versus column testing.
- It was possible to develop conceptual treatment systems for each of the contaminant flow paths by combining chemical, hydraulic, and waste management/discharge issues.

Some of the more promising media include the following:

- Of the "sorbents" tested, the Dowex 21K resin provided the best uranium removal capacity for the low TDS BYBY water. Peat moss was one of the few commercially available sorbent media that worked well for uranium on both the high TDS (S-3 water) and the low TDS water. Peat moss also appears to be a promising media that could be mixed with ZVI to mitigate by-products and perhaps enhance biological nitrate destruction.
- ZVI provides the geochemical conditions to reduce and precipitate uranium and dechlorinate VOCs under the conditions tested. However, the long-term effectiveness and limitations/life span of ZVI—due to clogging, reduced reactivity, and potential for mobilization of uranium and other precipitates—must be understood prior to deploying the media in the subsurface. The residence time needed for destruction of VOCs may be a problem at some higher-flow seepage areas.
- It may be possible to remove uranium and some other metals from the tributaries by installing in-stream MATs systems. The size and engineering considerations for installing this type of system have not been determined.

3. PHASE II OBJECTIVES AND ACTIVITIES

In this chapter of the work plan, the objectives and approaches for individual activities to be conducted under Phase II of this treatability study are described. Where possible, the logic-supporting criteria to be used to select media and trench design parameters are discussed. Refer to Fig. 3.1 for a summary of the overall decision process for the treatability study.

All data developed during the Phase II study will be integrated into a database compatible with the Bechtel Environmental Integrated Management System and the Oak Ridge Environmental Information System (OREIS) systems. This will include surface water and groundwater monitoring results, laboratory results, results of the column panel studies, and any other analytical or physical data collected during the Phase II work. On completion of Phase II, these data will be submitted to OREIS.

For Phase II activities outlined in this chapter, detailed plans will be developed before implementation. Best management, quality assurance, health and safety, and waste management plans will be included. Best management practices (BMP) plans will include details of operations and sampling schedules for the column panel study and the trench/well tests.

3.1 PHASE II OBJECTIVES

The objective of Phase II work is to produce conceptual designs for treatment system configurations (specific media, groundwater capture, and effluent discharge systems) at the GW-835, GW-837, and NT-1 sites.

The results of Phase I of the technology demonstration project have provided a short list of media that are most likely to remove site-specific contaminants from water at the S-3 Site and BYBY. These media are Dowex Resin, for uranium removal in low-TDS water only; ZVI, for uranium and metal removal in low- and high-TDS water; peat moss, for uranium removal in low- and high-TDS water; iron oxides, for removal of uranium and metals from low-TDS water; and algal mats and wetlands, for metals and nitrate removal in surface applications. In addition, preliminary results indicate that a combination of ZVI, peat moss, and biomass may be able to remove nitrate from groundwater.

Based on these results and on the results of Phase I site characterization, primary treatment system configurations have been developed for each site. In selecting primary treatment configurations at this early stage in the treatability study, i.e., prior to completing evaluation of treatment media capabilities and site-specific groundwater capture method, the objectives of Phase II will focus on specific uncertainties associated with deployment of these treatment systems. For each system configuration there are both media- and site-specific uncertainties. Table 3.1 lists the primary treatment configurations for each site, the main uncertainties associated with them, and changes or improvement that may be made to the primary configurations based on resolution of the uncertainties.

The uncertainties associated with each site can be grouped into three broad categories: (1) those associated with the long-term efficiency of the media in the field, (2) those associated with the hydraulics of groundwater capture, and (3) those associated with media deployment.

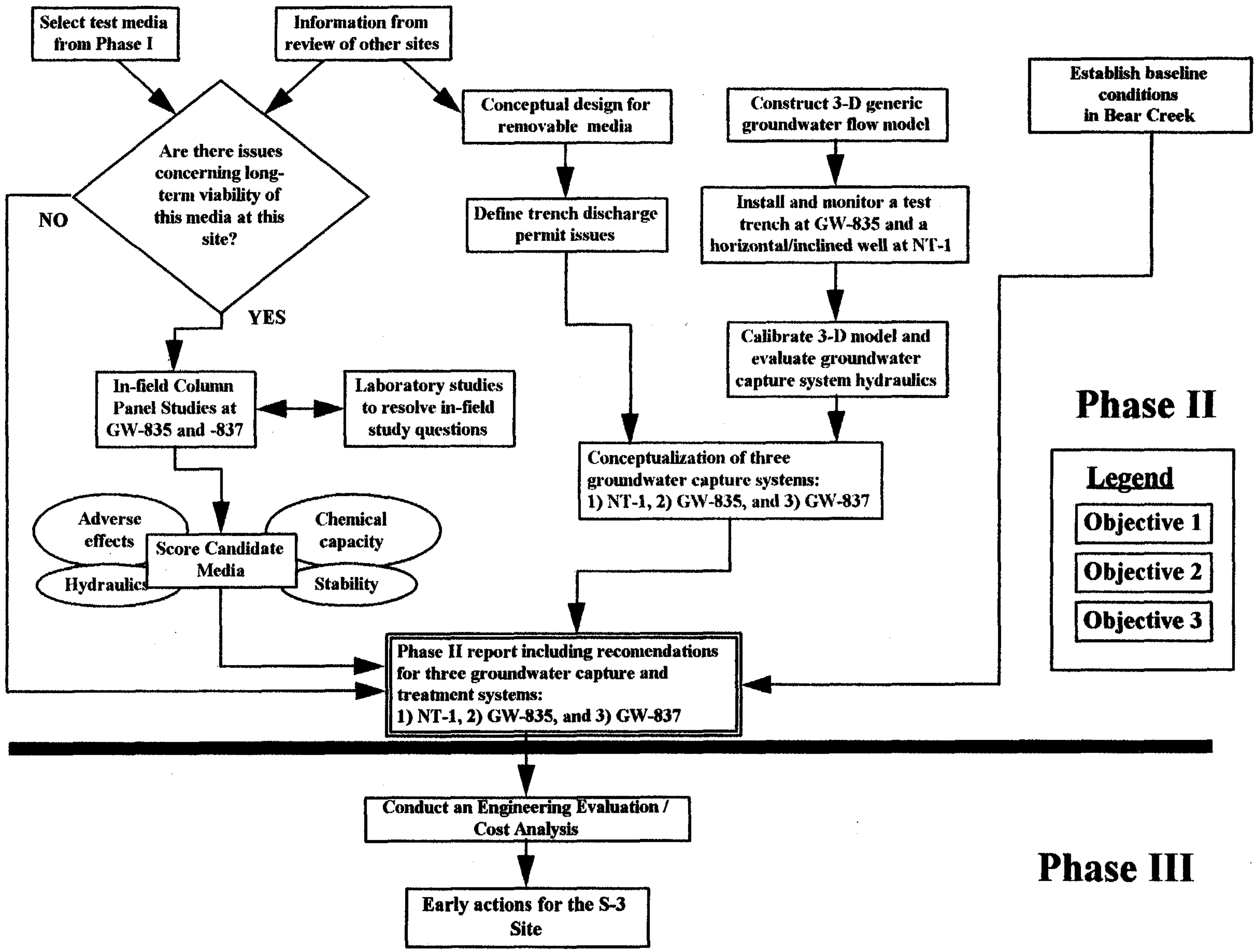


Fig. 3.1. Decision flow chart for Phase II treatability study.

Table 3.1. Primary treatment configurations for the pathways at the S-3 Site and associated uncertainties

Pathway location	Primary treatment configuration	Uncertainties/potential improvements	Possible changes or enhancements
NT-1	Groundwater will be captured in horizontal/inclined wells. Water will be sent directly to the West End Treatment Facility for treatment.	• The best mechanism for groundwater capture is not known. An alternative could be a trench.	• Groundwater will be captured using a trench if a horizontal well is not feasible for groundwater containment.
		• ZVI in conjunction with peat moss and bacteria may enhance removal of nitrate.	• ZVI/peat will be deployed in situ (if a trench is used) or on the surface (if wells are used) to enhance nitrate breakdown in effluent before sending to West End Treatment Facility or discharging to NT-1.
		• Algal mats may be a cost-effective method to remove nitrate and selected metals from NT-1.	• Algal mats will be deployed on the surface to remove critical metals and enhance nitrate breakdown in effluent before sending to West End Treatment Facility or discharging to NT-1.
GW-835	Groundwater will be captured in a pumped trench. Water will be treated using Dowex resin above ground.	• The hydraulics of this site may make a passive trench feasible for use with a granular material such as Dowex.	• The trench will be passive.
		• Dowex resin may not be an efficient treatment media over long time periods due to interferences or other problems.	• ZVI, peat moss, or iron oxides will be used in place of Dowex. Using these media in a passive trench will also be evaluated.
		• If in situ treatment is used, then the treatment media may be deployed by filling the trench or in a removable cassette.	• The design of the trench will include a funnel-and-gate concept with the Dowex deployed in a removable cassette.

Table 3.1 (continued)

Pathway location	Primary treatment configuration	Uncertainties/potential improvements	Possible changes or enhancements
GW-837	Groundwater will be captured and treated in a passive trench filled with ZVI.	• Ferric iron colloidal material may slough off ZVI and carry uranium precipitates with it.	• If native soil is not able to filter the colloidal material, either peat moss will be included with the ZVI to capture sloughing off, or a cassette design will be implemented.
		• Peat moss used in conjunction with ZVI and bacteria may enhance in situ removal of nitrate.	• Peat moss will be included with the ZVI to induce bacterial breakdown of nitrate.
		• If in situ treatment is used, then the treatment media may be deployed by filling the trench or in a removable cassette.	• The passive trench will be designed on a funnel-and-gate concept, and the ZVI will be deployed in a removable cassette.
		• A passive trench design may not be feasible at this site.	• The trench will be pumped. Water will be treated using on-surface ZVI and algal mats to remove uranium, metals, and nitrate.

The objectives of Phase II work are to address the uncertainties by targeting activities to resolve issues in each of those broad groupings of uncertainties. The objectives are as follows:

1. define and resolve the issues that impact long-term viability of treatment efficiency of the selected media or combinations thereof;
2. conduct in-field testing and conceptual design of groundwater capture and media deployment methods for the GW-835, GW-837, and NT-1 sites; and
3. design treatment system configurations (specific media, groundwater capture, and media deployment configurations) for the GW-835, GW-837, and NT-1 sites.

3.2 PHASE II ACTIVITIES

Activities for Phase II work have been identified to address each of the main uncertainties associated with deploying the primary treatment configurations (Table 3.1). Table 3.2 lists the activities to be carried out in addressing the uncertainties listed in Table 3.1. Figure 3.1 is a flow chart showing the relationship between the main objectives and activities of Phase II. The following is a summary of the Phase II activities that will be conducted to meet the objectives outlined above:

Objective 1: Define and resolve the issues that impact the long-term treatment efficiency of the selected media or combinations thereof

1. Evaluate existing systems that have been installed in the United States and Canada, including media effectiveness and by-product issues related to these sites.
2. Conduct long-term (2–3 months) column test on field panels with water from the GW-835 and GW-837 piezometers or test trenches to obtain data concerning long-term effectiveness under field conditions and media capacity for removal of contaminants in field conditions:
   - At GW-835, column testing will be conducted on Dowex resin — the primary treatment media—and on ZVI, iron oxide, peat moss, ZVI/peat moss mix, and ZVI/native soil mix—potential backup media if Dowex does not meet the performance objectives for this site. In addition, combinations of ZVI and peat moss and ZVI and native soil will be tested as potential improvements if ZVI becomes the primary media selection for this site.
   - At GW-837, column testing will be conducted on ZVI — the primary treatment media—and on peat moss and algal mats as potential backup media if ZVI does not meet the performance objectives for this site. In addition, a ZVI/peat moss bioreactor and combinations of ZVI and peat moss and ZVI and native soil will be tested as potential improvements to the primary media selection.

In addition, the wetlands constructed for Phase I will be maintained during Phase II to evaluate the long-term effectiveness of wetlands as an accompanying treatment technology.

3. Identify and develop solutions for engineering issues related to implementation of media and algal mats in the subsurface or surface, such as pH buffering capacity, clogging, contaminant remobilization, undesirable by-products, storm flow surge control, and site-specific media deployment methods.

Table 3.2. Uncertainties for primary treatment configurations for the pathways at the S-3 Site and Phase II activities

Pathway Location	Uncertainties/potential improvements	Phase II activities
NT-1	• The best mechanism for groundwater capture is not known. An alternative could be a trench.	• 3-D hydraulic model for the S-3 area to evaluate generic trench/well hydraulics. • Installation and monitoring of a horizontal test well at the NT-1 site.
	• ZVI[a] in conjunction with peat moss may enhance removal of nitrate.	• Column panel study at GW-837 (high TDS[b] with nitrate) using a ZVI/peat moss bioreactor. • Laboratory study focused on optimizing bioreactor parameters.
	• Algal mats may be a cost-effective method to remove nitrate and selected metals.	• Algal mat field testing at GW-837 (high TDS with nitrate). • Evaluation of in-stream deployment of algal mats.
GW-835	• The hydraulics of this site may make a passive trench feasible for use with a granular material, such as Dowex.	• 3-D hydraulic model for the S-3 area to evaluate generic trench hydraulics. • Installation and monitoring of a test trench at the GW-835 site. • Evaluation of media deployment configurations.
	• Dowex resin may not be an efficient treatment media over long time periods due to interferences or other problems. • If in situ treatment is used, then the treatment media may be deployed by filling the trench or in a removable cassette.	• Column panel study at GW-835 using Dowex Resin and potential back-up media (ZVI, peat moss, and iron oxides). • Laboratory study focused on evaluating precipitates that may occur in Dowex resin. • Laboratory study focused on optimizing the physical form and treatment efficiency of iron oxide and peat moss as backup media for deployment in situ.
GW-837	• Ferric iron colloidal material may slough off ZVI and carry uranium precipitates with it.	• Column panel study at GW-837 using ZVI/peat moss and ZVI/native soil combinations. • Laboratory study focused on evaluating precipitates that occur in each media. • Laboratory study focused on optimizing the physical form and treatment efficiency of iron oxide and peat moss as backup media for deployment in situ.
	• Peat moss used in conjunction with ZVI may enhance in situ removal of nitrate.	• Column panel study at GW-837 using a ZVI/peat moss bioreactor. • Laboratory study focused on optimizing bioreactor parameters.
	• If in situ treatment is used, then the treatment media may be deployed by filling the trench or in a removable cassette.	• 3-D hydraulic model for the S-3 area to evaluate generic trench hydraulics. • Evaluation of media deployment configurations.
	• A passive trench design may not be feasible at this site.	• Generic 3-D hydraulic model for trench/groundwater interaction. • Installation and monitoring of a test trench at the GW-835 site.

[a]zero valent iron [b]total dissolved solids

Objective 2: Evaluate groundwater and media deployment systems for the GW-835, GW-837, and NT-1 sites

1. Prepare conceptual designs for media deployment configurations. This will include evaluating the limitations of deployment options for the media being tested in Objective 1.
2. Evaluate existing systems that have been installed in the United States and Canada. Assess innovative deployment options that have worked elsewhere.
3. Evaluate trench and horizontal/inclined well hydraulics for the S-3/NT-1 area. This will include determining possible trench hydraulic configurations (e.g., totally passive, passive with hydraulic controls, pumped, impermeable barrier walls, funnel, and gate) and constructing a three-dimensional (3-D) hydraulic model for the S-3 Site area.
4. Install a test trench at GW-835 and a horizontal/inclined test well at NT-1. This will include installing temporary monitoring wells and piezometers at each site, monitoring the effectiveness of the groundwater capture systems, hydraulic testing of the captive systems, and determining effective flow rates for each groundwater capture system.
5. Define the performance monitoring goals for an early action and address impacts of effluent discharge issues on trench design and medium selection. This will include permitting, possible re-injection of water, and evaluating the advantages of a passive system.

Objective 3: Recommend treatment systems for the GW-835, GW-837, and NT-3 sites

1. Establish baseline conditions at the S-3 Site against which performance monitoring goals can be measured during implementation of the early action. This will include establishing monitoring locations and sampling of surface water and shallow groundwater.
2. Combine a review of data from Phase I, data from the column panel study, and the hydraulic evaluation of the groundwater capture system, and select media or media combinations for each site and deployment options.
3. Recommend treatment system configurations and operating parameters for early actions at the GW-835, GW-837, and NT-1 sites.

3.2.1 Objective 1: Define and Resolve the Issues that Impact the Long-Term Treatment Efficiency of the Selected Media or Combinations Thereof

As discussed in Chap. 2, Phase I of this treatability study has identified media, or combinations thereof, that are capable of removing COCs from groundwater found at the S-3 Site. These media are ZVI, iron oxides, peat moss, Dowex resin (only for groundwater with low to moderate TDS), and algal mats. However, for each medium there are specific questions that remain to be answered before they can be applied in an early action. Most of the issues that remain to be resolved are related to the long-term viability of these media. The specific questions that need resolution are as follows:

Dowex Resin

(This medium was selected only for low- to moderate-TDS groundwater, i.e., GW-835.)

- What is the long-term capacity for uranium sorption of this media?
- What loading rates could this media sustain over long periods of time when exposed to groundwater?
- What are the long-term effects of exposure to groundwater on the porosity, permeability, and overall structure of this resin?

Zero Valent Iron

- Does continued exposure to oxidizing groundwater (both high- and low-TDS types) result in iron oxide colloidal material and/or uranium precipitates sloughing from the ZVI? It is likely that this iron oxide colloid could also adsorb COCs, such as uranium, providing another mechanism for remobilization of COCs.
- Over long periods of exposure to groundwater, precipitates will reduce the porosity, permeability, and reactivity of the ZVI. For each water type, the time period over which ZVI can remain effective before its reactiveness and/or permeability is reduced to critical levels needs to be evaluated.
- Do high concentrations of nitrate (a weak oxidizer) cause accelerated consumption of ZVI? This problem is mainly relevant to the GW-837 and NT-1 sites.
- Can ZVI be used in conjunction with peat moss to act as a bioreactor to reduce nitrate concentration in groundwater? In addition, does this configuration enhance the removal of other metals?
- What is the effect of ZVI on other metals over a long treatment period?

Peat Moss

- What is the long-term capacity for uranium sorption of this media?
- What loading rates could this media sustain over long periods of time when exposed to groundwater?
- Does long-term exposure to groundwater cause breakdown of peat moss?
- How does long-term exposure to groundwater effect the porosity and permeability of peat moss? Could compaction or breakdown over time significantly reduce permeability or result in creation of preferential paths through the media?

Iron Oxides

The powder form of some iron oxides that were tested in Phase I, although chemically efficient, are not suitable for deployment in a treatment system due to the fine-grained nature of the material. Pellets of iron oxide foam provide a suitable form for this media in a treatment system; however, this media's ability to remove uranium is significantly reduced when in this form. The following questions need to be resolved for iron oxide foam:

- Can an iron oxide foam be produced that is able to remove uranium from water to sufficiently meet the treatment goals?
- What loading rates could this medium sustain over long periods of time when exposed to groundwater?

Algal Mats

- Can the rate of regeneration of algal mats match the requirement for sorptive sites under high TDS conditions?
- What is the long-term nitrate reduction ability and metal and uranium removal capacity of algal mats, and how often will mats need to be replaced?
- What are the impacts on efficiency and capacity of seasonal variations?
- How can algal mats be implemented in in-stream conditions where flow is highly variable?

Wetlands

- Can a constructed wetland develop the capability to remove uranium and nitrate without the need for carbon supplements like those used to enhance activity during Phase I?
- What impact does seasonal variation have on efficiency and capacity?
- How can wetlands be implemented in conditions where flow is highly variable?

In addition, in the cases where COCs are not destroyed but simply immobilized in the media, there will be an issue of disposing of the contaminated media. For each media evaluated, the form of contaminated media that will need to be removed and disposed and the frequency at which this will occur are needed to evaluate cost-effectiveness of the treatment technology.

Activities in Phase II of the treatability study will resolve these questions using two approaches: (1) a long-term (2–3 month) in-field evaluation of each media in the form of column studies for chemical media and constructed reactors for biological media and (2) focused laboratory studies to resolve specific questions in a more cost-effective way.

To the extent possible, activities in Phase II will be designed to be representative of Phase III to reduce the uncertainty associated with scaling up from the pilot scale used in Phase II to the implementation of an early action in Phase III.

The following sections are detailed descriptions of the proposed activities.

3.2.1.1 Review of existing United States and Canada systems

There are independent efforts evaluating the effectiveness of various media and treatment technologies underway in both the United States and Canada. It is important for the treatability study at the Y-12 Plant to keep abreast of the progress of these other treatment studies. Table 3.3 lists seven existing studies that will be included in this review. Additional locations whose similar treatment technologies are being used will be identified and included in this review. With the focus on looking at media deployment methods and actual operating systems, the following activities will be carried out:

- a matrix of site characteristics will be developed, which will be used to document and compare performance: flow rates, discharge, clogging, residence time, media deployment methods, and treatment byproducts;

- key personnel will be interviewed and sites visited to determine technical and regulatory barriers that have occurred and methods used to resolve these issues; and
- project status will be tracked and copies of key documents will be obtained and reviewed.

Table 3.3. Evaluations of lessons learned information for in situ treatment of groundwater

Site	Description
WAG[a] 5 at ORNL[b]	Seep capture and in situ treatment system for removal of radioactive strontium from seep discharge
Portsmouth	Column studies for removal of VOCs[c] from contaminated groundwater using iron filings
Waterloo	Trench using iron filings for in situ removal of VOCs from groundwater
Sunnyvale	Trench using iron filings for in situ removal of VOCs from groundwater
Mountain City	Trench using iron filings for in situ removal of VOCs from groundwater
Elizabeth City	Trench using iron filings for in situ removal of chromium from groundwater
Colorado Springs	In situ removal of uranium from mine tailings runoff using iron filings

[a]waste area grouping [b]Oak Ridge National Laboratory [c]volatile organic compounds

Product. Results of the review of existing North American treatment systems will be summarized in a technical memorandum. The memorandum will identify characteristics of each site that are similar to those at the S-3 Site and will identify problems that have occurred at this site that could potentially occur at the S-3 Site, therefore providing lessons learned in resolving problems. Where problems have been successfully resolved at a study site, these will be used to develop recommendations for design of the S-3 Site treatment systems.

3.2.1.2 Column panel study

Purpose and Scope. The purpose of the Phase II column study is to observe the performance of the treatment media under field conditions and over a prolonged period of time (2–3 months continuous flow). This will provide a measure of media breakthrough and/or exhaustion and a better indication of potential problems that result from exposing these media to groundwater over long periods of time. This study will be conducted in the field at the source borehole locations at the S-3 Site. This will present the most cost-effective and least problematical means (in terms of waste handling and transportation of materials) to conduct this study.

Approach. The approach in Phase II will consist of a panel of columns piped to groundwater piezometers at the S-3 Site. Each panel will consist of an arrangement of several columns, each column containing one of the selected treatment media. Media combinations will be studied by placing two columns with different media in line. Field panels will be set up at the GW-835 and GW-837 sites. A column panel study for the NT-1 site is not planned at this time. It is expected that information from the high-nitrate-type water at the GW-837 site will provide sufficient information to determine the optimum treatment configuration for NT-1. Figure 3.2 shows the media that will be used at each site:

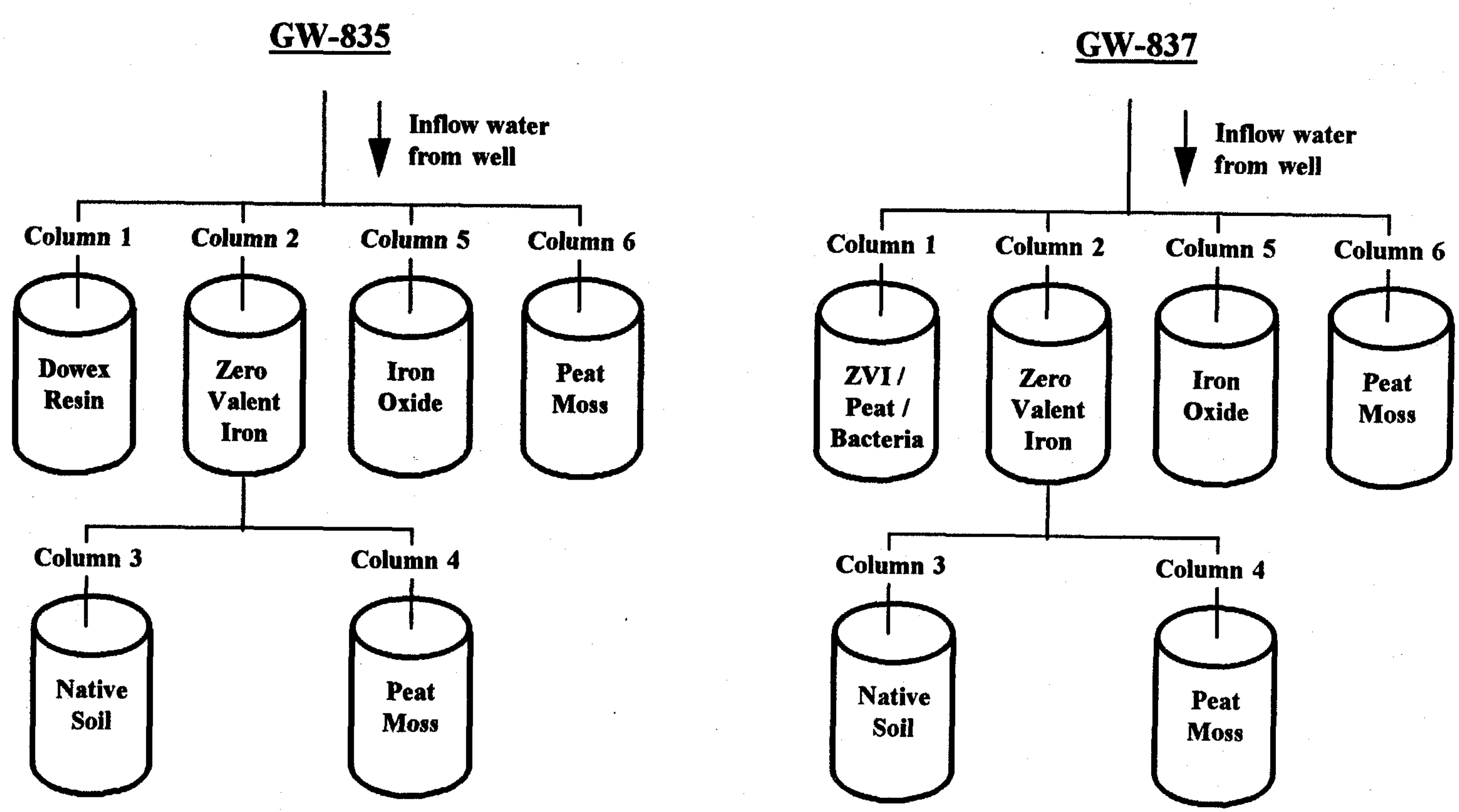


Fig. 3.2. Media to be tested during the Phase II treatability study.

- At GW-835, column testing will be conducted on Dowex resin—the primary treatment media—and on ZVI, iron oxide, peat moss, ZVI/peat moss mix, and ZVI/native soil mix—potential backup media if Dowex does not meet the performance objectives for this site. In addition, combinations of ZVI and peat moss and ZVI and native soil will be tested as potential improvements if ZVI becomes the primary media selection for this site.
- At GW-837, column testing will be conducted on ZVI—the primary treatment media—and on peat moss and algal mats as potential backup media if ZVI does not meet the performance objectives for this site. In addition, a ZVI/peat moss bioreactor and combinations of ZVI and peat moss and ZVI and native soil will be tested as potential improvements to the primary media selection.

At each site, column panels will be located adjacent to the piezometer, and groundwater will be fed directly from the source to the treatment unit. This will avoid significant changes in water chemistry, such as oxygenation or volatilization of contaminants. Since the unit will be processing the water under real-time conditions, it will be subject to fluctuations in water chemistry experienced daily, weekly, and seasonally. To reduce the number of uncontrolled variables, the flow rate will be maintained at a constant rate during the experiments.

The mass of media packed in each column will depend on the media. The aim of the investigation is to pack sufficient media into each column such that breakthrough of significant concentrations of contaminants occurs in the 2- 3-month monitoring period, and the columns can be run for a period of time after breakthrough has occurred. Breakthrough indicates an approach to saturation for the media in the column and will provide a measure of the life span for each media. This will allow for monitoring of the breakthrough curve during the study. Results from Phase I will be used to calculate the mass of media to be packed into each column.

The performance of the treatment media over a 2- to 3-month time period under these conditions will be measured. The response of the media and treatment efficiency to, for example, temperature fluctuations and dilution of source water during precipitation events will be measured. Measurement of efficiency will be conducted by analyzing contaminant concentrations and water parameters such as temperature, pH, and dissolved oxygen in the inflow and outflow streams and from sample ports along the length of the columns. Hydraulics of treatment media will also be evaluated by recording flow rates and pressure drop over each column. Flow rates for each column will be measured continuously so that the total loading of each column can be calculated.

On completion of each column, experiment media from the columns will be sampled and analyzed using visual observations and electron microscopy to evaluate the extent and chemistry of precipitates in the columns.

Product. Results of the column panel study will be summarized in a technical memorandum. The technical memorandum will include a description of the column panel, study results, and conclusions from the study. The technical memorandum will also include description of results from supporting laboratory studies (Sect. 3.2.1.3), algal mat testing (Sect. 3.2.1.4), and wetland testing (Sect. 3.2.1.5). The technical memorandum will recommend treatment media for each site, loading rates for those media, and optimal flow rates.

3.2.1.3 Laboratory studies to support column panel study

Purpose and Scope. The purpose of this task is to provide a mechanism to provide continued laboratory-scale testing support to the project in the development of the most efficient and cost-effective media and media combinations. Much of work under this scope will be performed by a parallel project funded by EM-50. Field testing of media in columns will produce additional issues about specific media that may need resolution prior to implementation in the field. The following are examples of such issues:

- the need to improve efficiency of promising media, and reduce unwanted byproducts;
- the propensity for precipitates to form that could potentially clog pores in the media and reduce their efficiency in the field;
- the propensity for precipitates to form that could provide a vehicle for contaminants to bypass the primary removal mechanism;
- the need for pre- and/or post-treatment methods required to make promising treatment media more viable;
- the need to document performance of a ZVI/peat moss/biomass combination.

Approach. The general approach to this task will be to conduct specific laboratory studies with narrow scope aimed at producing solutions to individual, media-specific problems and/or limitations of promising treatment media. These problems/limitations were either identified during Phase I or may be identified during Phase II field evaluation of treatment media. Figure 3.3 shows the decision flow chart for use of laboratory studies to support the column panel study. Areas of media-specific issues that were identified in Phase I and need resolution by laboratory studies are as follows:

- Mitigation of byproducts from ZVI and other sorbents. Initially, peat moss will be evaluated to determine if it can be used to remove ferrous iron and minor dechlorination daughter products generated during treatment of groundwater with ZVI. Production of these byproducts could potentially discount ZVI as a treatment media if not addressed. This study will be conducted in parallel to the column panel study where in-line use of ZVI and peat moss is also being studied.
- Combination of peat moss and ZVI will be evaluated for its ability to reduce nitrate concentrations by biological reduction.
- Chemical enhancement of treatment efficiency by changing the physical character of the media or mixing media. For example, it will be assessed if certain types of trace contaminants in iron enhance the sorptive and/or dechlorination properties of the media.
- The physical forms (e.g., foam, pellets, size fraction, etc.) of ZVI and peat moss will be investigated to optimize treatment efficiency.

Laboratory studies will be initiated to address the issues listed above. It is anticipated that additional issues will be raised during the course of the investigation and these will be addressed as they arise. The schedule for laboratory support will be restricted to the period of time for the column studies and trench conceptual design (Objective 2). Selection of media for inclusion in the early action design (Objective 3) will be conducted on the schedule indicated in Chap. 4.

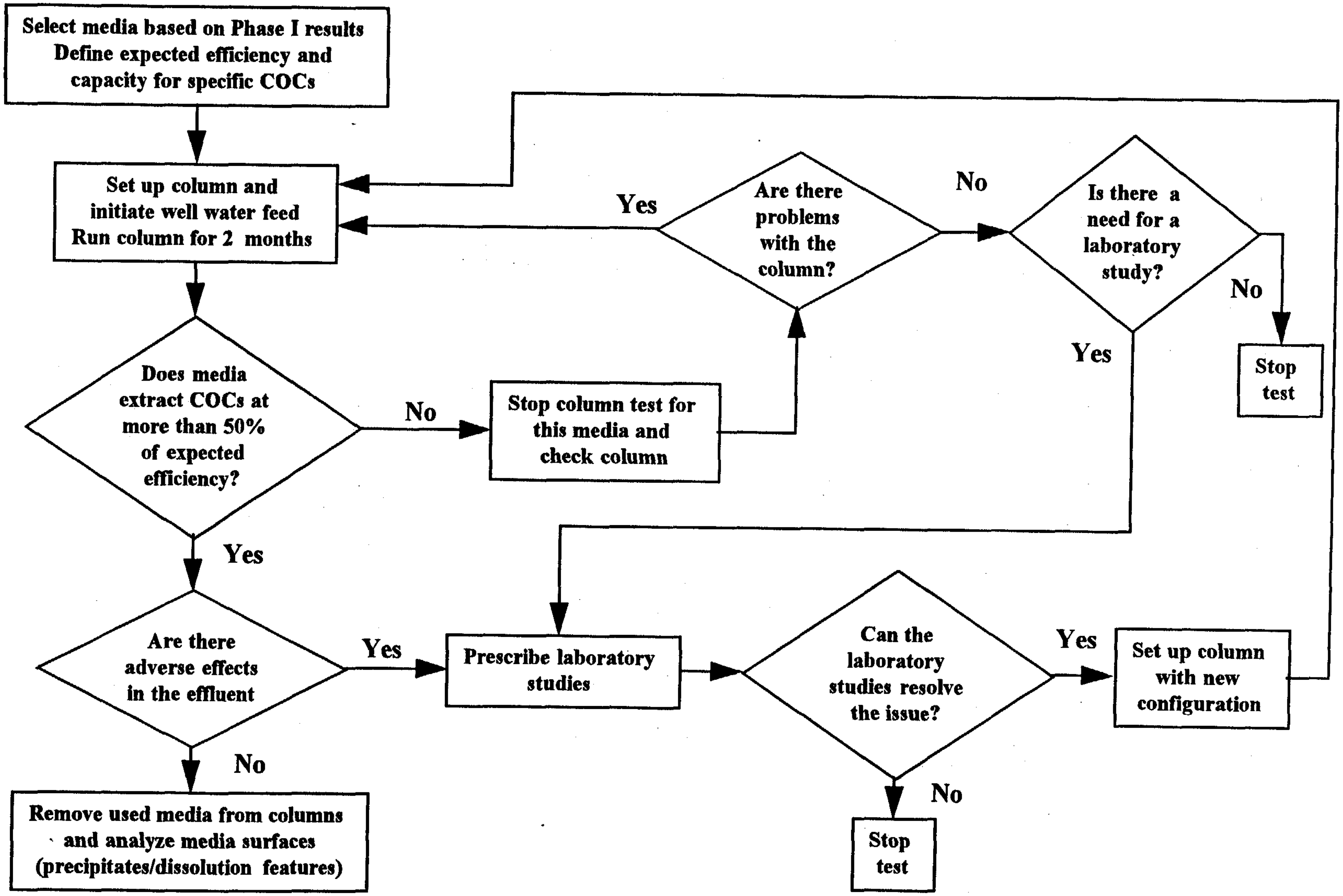


Fig. 3.3. Decision flow chart for use of laboratory studies to support the column panel study.

Product. Results of the laboratory testing will be included in the technical memorandum for the column panel study. In addition, a separate report will be produced by the laboratory studies funded separately through EM-50.

3.2.1.4 Algal mat field testing

Purpose and Scope. Preliminary testing suggested the mat system was effective in removing metals (aluminum, barium, calcium, manganese, cadmium, nickel, and uranium) while reducing nitrate from surface water within the BCV CA. The purpose of this Phase II task is to compare the mats directly with other nonbiological media under in-field conditions (variable temperature, sunlight, and contaminant concentrations) at the high-TDS pathways. The following are key objectives for this test:

- establish a fully acclimated bioreactor at GW-837,
- collect operating data showing the MATs' response to high-TDS water at GW-837,
- determine metal deposition within the mats reactor to assess capacity (to establish size criteria for operating mats),
- demonstrate the capability to sustain denitrification rates, and
- demonstrate that effluent quality and removal capacity can be maintained.

Approach. The algal mat system is not amenable to testing in a column configuration. Therefore, a mats reactor will be used in place of a column to treat water from GW-837 along with the column test operation.

A single algal mat reactor will receive a slipstream similar to the column tests. The test will run for six months to allow adequate acclimation to the water and to allow establishment of a steady denitrification rate. During the test, flow will be measured continuously, and effluent quality will be measured on a weekly basis. At the completion of the study, samples of the mat itself will be analyzed for metals to define the location of metals deposition.

Product. Results of the algal mat testing will be included in the technical memorandum for the column panel study

3.2.1.5 Wetland monitoring

Purpose and Scope. Results from the evaluation of wetlands for use as a final stage treatment technology in Phase I were incomplete. However, the results show that this technology may be successfully implemented at sites where uranium occurs at relatively low concentrations. The purpose of further examining wetlands in Phase II is to evaluate implementation of constructed wetlands as a component of the Phase III early actions. The following four key issues need to be resolved and are the scope of this task:

- **Size of a wetlands needed to treat surface water streams in BCV**. Before a decision can be made to implement a constructed wetland as an early action, the size of the wetland for each designated stream, such as SS-4, needs to be estimated.

- **Effect of winter conditions on uranium removal.** Lower temperatures, sunlight, and plant biomass (i.e., winter conditions) may have a negative impact on the system's ability to remove uranium if the mechanism is directly linked to plant viability. However, if the removal mechanism is primarily chemisorption and bacterial activity, these conditions will have a lesser impact.

- **Uptake of uranium into/onto the solid phases (roots, stems, and soil).** The distribution of uranium in the solid phase of the wetland will be an important parameter in evaluating the capacity of the wetland to remove uranium and in determining disposal criteria for the final waste product.

- **Rate of denitrification in mature wetlands.** In Phase 1, carbon supplements were introduced to the wetland tests to enhance bacterial denitrification activity after it became apparent that the newly planted wetlands were unable to provide sufficient soluble carbon to support bacterial activity. It needs to be determined if, with maturity, a constructed wetland can develop the capability for producing the necessary carbon to promote denitrification.

Approach. The existing constructed wetlands, established in BCV at the SS-4 Site, will be used to conduct this continued evaluation. The wetlands will be maintained for the duration of Phase II activities (January–December 1997) that includes both warm and cold weather periods. This will allow documentation of seasonal changes in treatment efficiency and determination of whether the change is related to physical changes in the system.

To allow determination of size needed to establish capacity of uranium removal, the wetlands currently operated in parallel flow streams will be connected in series. In-flow and out-flow streams from each wetland will be monitored to provide a profile of contaminant removal rates along the flow path through the three wetlands. In addition, it is anticipated that during spring 1997, the existing wetlands will have developed sufficient maturity to test removal rates for uranium and nitrate without the need for soluble carbon supplements.

Evaluation of the distribution of uranium uptake by solid phase materials will be performed by sampling the wetland solid phase material at completion of the monitoring period and analyzing the various solid phase components (roots, stems, soil minerals, and soil organic matter) for uranium.

Product. Results of the wetland monitoring will be included in the technical memorandum for the column panel study. The technical memorandum will also contain a recommendation for deployment of the wetland as part of an early action at the S-3 Site, including the expected efficiency of the technology and a conceptual design for deployment.

3.2.2 Objective 2: Evaluate Groundwater and Media Deployment Systems for the GW-835, GW-837, and NT-1 Sites

The goal of this component of Phase II of the demonstration project is to evaluate trench hydraulics at the S-3 Site, and identify the likely trench types for the GW-835, GW-837, and NT-1 sites.

3.2.2.1 Conceptual design for media deployment configurations

One aspect of in situ media placement is for the media to be easily removable from the trench and replaceable. Replacement operations may need to be conducted on an annual basis or on a less frequent schedule depending on the media and the site-loading rates. The objective of this task in the treatability study will be to develop conceptual designs for treatment media replacement in an in situ deployment. Options currently being considered are:

- using the medium as the granular fill material in the trench;
- installing the medium in a removable device in one portion of the trench with groundwater flow funneled to pass through the medium; and
- for a pumped trench, installing the medium in the well riser so that water pumped from the trench flows through the medium before reaching the ground surface.

For each medium emplacement option, a conceptual design will be produced, and factors affecting the use of each option will be identified.

Product. Results will be reported in a technical memorandum with a preferred conceptual design for in situ deployment of the media tested in Objective 1 at a generic site. If it is not feasible to deploy a media in situ, then a conceptual design for surface deployment will be substituted.

3.2.2.2 S-3 Site groundwater flow modeling

A 3-D groundwater flow model will be constructed for the area at the S-3 Site. The model will initially be calibrated using pumping test data from previous studies and from the Phase I results. Further calibration and "fine tuning" of the model will be carried out after installation of a test trench at GW-835 and a horizontal/inclined test well at NT-1. The objectives of modeling are twofold:

- After initial construction and calibration of the model for a generic BCV setting, the objective of groundwater flow modeling will be to provide input into determination of the design of a hydraulic test trench for the GW-835 site and a horizontal/inclined test well for the NT-1 site by providing generic design criteria.
- With detailed calibration of the model using information from the test trench and horizontal/inclined well, the model will provide input to conceptual design of the trenches for the early action. Using this model as a basis, passive and pumped trenches will be modeled following two or three conceptual generic designs (including passive trenches with funnel- and gate-type systems). The optimum design for groundwater capture at each of the three sites—GW-835, GW-837, and NT-1—will be determined.

Hydraulic data from monitoring the test trench and horizontal/inclined well will be used for detailed calibration of the 3-D groundwater flow model. Although the focus of the model at this time will be the trench at GW-835 and the horizontal/inclined well at NT-1, the model will be calibrated such that it is applicable to other sites located on the Nolichucky Shale in BCV and will negate the need for further test trenches.

Product. The product will be a 3-D groundwater flow model for the S-3 Site that includes submodels for generic trenches and horizontal/inclined wells. The results of modeling evaluation will be presented in a technical memorandum that will include a recommendation for both (1) the test groundwater capture systems at each site and recommended flow rates and monitoring for each system and (2) a preliminary recommendation for full scale groundwater capture systems at

GW-835, GW-837, and NT-1 that will include consideration for method of deployment of the primary treatment media.

3.2.2.3 Hydraulic testing—installation of a test trench and a horizontal/inclined test well

Purpose and Scope. A high degree of uncertainty is associated with groundwater hydraulics in BCV, due mainly to the prevalent phenomena of fracture flow. The hydraulics of a trench or horizontal/inclined well will have a significant impact on the design of the completed treatment system, and, due to the high level of uncertainty, the hydraulics of groundwater capture need to be evaluated before designs can be completed.

The study will focus on determining the effectiveness of a trench and a horizontal/inclined well in selectively capturing contaminated groundwater in the overburden and shallow bedrock intervals and producing a flow regime that causes the captured groundwater to pass through the treatment media. An additional consideration for the NT-1 site is that the horizontal/inclined well alters the flow regime sufficiently to capture the intermediate and deep interval groundwater plume.

There are specific constraints on trench design set by the media selected for treatment when a passive trench design is chosen. For example, the pressure drop over the media needs to be high enough to maintain flow and low enough to promote even flow through the media. For a pumped trench or horizontal/inclined well, there are fewer constraints because the hydraulics of the capture system are somewhat controlled by the rate of pumping. In addition, much of the water contributing to total flow in the Bear Creek tributaries that drain Pine Ridge is not contaminated. In understanding the hydraulics of groundwater capture by a trench in this fractured media, the aim of the study is to avoid capturing (and treating) clean water.

Test capture systems will be constructed at GW-835 and NT-1 with the following objectives:

- measure the hydraulic capture zone of a trench at GW-835;
- measure the hydraulic capture zone of a horizontal/inclined well at NT-1;
- evaluate likely flow-through rates and concentration fluctuations for the treatment system for the variable flow conditions (summer and winter, baseflow, and stormflow) at each site;
- evaluate collection efficiency issues, including contaminated groundwater bypassing the capture system, media siltation, and optimum pumping rates (for nonpassive systems); and
- detail calibration of the groundwater flow model for a trench and horizontal/inclined well groundwater capture system.

Approach. The activities for the hydraulics study will include four tasks: (1) trench installation at GW-835, (2) horizontal/inclined well installation at NT-1, (3) installation and instrumentation of groundwater monitoring network at each site, and (4) monitoring and testing of each system.

Task 1: Trench Installation at GW-835

A hydraulics test trench will be installed at the GW-835 site following the design criteria evaluated above. The trench will be up to 200 ft long and up to 30 ft deep and backfill with an inert, high-conductivity filter pack media. A perforated polyvinyl chloride pipe will be laid along the base of trench, and a sump with pump for controlling head in the polyvinyl chloride pipe will be used.

Task 2: Horizontal/Inclined Well Installation at NT-1

A horizontal/inclined test well will be installed at the NT-1 site following the design criteria evaluated by the modeling task. The horizontal/inclined well will consist of a horizontal well with a horizontal screened section up to 200 ft long and up to 75 ft deep in the Nolichucky Shale bedrock, targeted on the main zones of migration for the along-strike plume. The well will be configured such that water can be pumped from the screened section and the hydraulic bench controlled.

Task 3: Installation and Instrumentation of the Groundwater Monitoring Network

Existing wells and piezometers will be used to the extent possible to monitor the hydraulic impact of the both the trench and the horizontal/inclined well. In addition:

- up to four temporary piezometers will be installed in overburden in the vicinity of the trench at GW-835;
- two temporary piezometers will be installed into the GW-835 trench backfill;
- two bedrock monitoring wells will be installed to monitor the impact of the GW-835 trench on bedrock groundwater; and
- up to two bedrock monitoring wells will be installed to monitor the effects in the Nolichucky Shale bedrock of the horizontal/inclined well at NT-1.

Pressure transducers and conductivity/temperature probes will be installed in those monitoring wells and piezometers and in existing wells GW-526, GW-345, and GW-346.

Task 4: Groundwater Capture System Monitoring and Testing

Each groundwater capture system (trench at GW-835 and horizontal/inclined well at NT-1) will be designed such that the hydraulic head can be controlled by pumping. A series of tests will be designed that will allow prediction of flow rates in each system during varying hydraulic conditions.

The groundwater capture systems will be initially pumped at varying rates for short periods of time (24 h) to determine the optimum pumping rate for capturing contaminated groundwater. A longer-term pumping test (up to 1 month) will then be conducted on each system to assess the hydraulic capture zones and to evaluate likely concentration fluctuations for the treatment system for the variable flow conditions (winter and summer, baseflow, and stormflow).

Prior to testing of the capture systems, nearby wells and piezometers will be monitored continuously for two weeks for water levels, temperature, and conductivity. In addition, samples of groundwater will be taken for analysis for field parameters and selected analytical parameters. After completion of the 2-week period, the trench and horizontal/inclined wells will be tested independently. During testing, nearby wells and piezometers will be monitored for water levels, field parameters, and selected analytical parameters. Pumping rates will also be monitored. Effluent from pumping tests will be treated at the West End Treatment Facility.

Product. The product will be a test trench at the GW-835 site and a horizontal/inclined well at the NT-1 site. Both of these facilities will be operational and available as a component of the early actions if necessary. Each site will also have an instrumented monitoring network that will also be available for monitoring the early action. The results of testing these two groundwater capture systems will be presented in a technical memorandum that will include a recommendation and conceptual design for full scale capture systems at each site. These conceptual designs will also include recommendations for operating procedures and monitoring.

3.2.2.4 Performance objectives and impact of applicable or relevant and appropriate requirements and discharge permitting on treatment system design

Performance objectives will be developed for implementation of the early action and will be an integral component of the design for the treatment system. The performance objectives will be based on measurable criteria that may include the following:

- concentration of COCs in surface water in Bear Creek downstream of the S-3 Site;
- concentrations of COCs in shallow groundwater either in the trench or immediately downgradient of the trench system (passive systems);
- concentrations of COCs in discharged effluent from the treatment system and stability of the chemical efficiency of the system to remove COCs (pumped systems); and
- stability of the media hydraulics, i.e., little change in time of flow rates or pressure drop over the media either in situ in the trench, in removable media, or in above-ground systems.

Concentration-based performance objectives for the early action phase of the treatability study reflect the site-specific RGOs developed in the RI, the overall risk-based goals for BCV as a whole (the IP assessment), and the treatment system effluent discharge permitting issues. The resulting performance objectives will be chemical-specific, medium-specific concentration limits that will address all COCs for groundwater and surface water at the S-3 Site. Where a pumped system is used, performance objectives may also consider applicable or relevant and appropriate requirements for surface water where effluent is discharged to the ground or stream.

Although these performance objectives will be used to develop goals for the treatability study Phase III early action, they are not intended to provide final action levels for BCV and the S-3 Site in particular. Final action levels will be provided in the feasibility study. Therefore, if the technology does not achieve individual chemical-specific concentrations, it should not be judged ineffective solely for that reason. Although the performance objectives may not be achieved, a treatment system may represent the best available technology for treating groundwater discharged at the S-3 Site.

Product: Results of the performance objectives evaluation will be included in the Phase II Report.

3.2.3 Objective 3: Recommend Treatment Systems for the GW-835, GW-837, and NT-1 Sites

Design of the Phase III early action treatment system will combine inputs from the Phase II studies of trench hydraulics and treatment media to derive a conceptual design for treatment systems at the GW-835, GW-837, and NT-1 sites. The selected design will need to meet defined site-specific performance criteria, which may or may not include meeting applicable or relevant and appropriate requirements and site-specific RGOs. The following is a description of the main components of the design of the Phase II treatment system.

3.2.3.1 Establishing the baseline for in-stream contaminant concentrations

To measure performance goals during implementation of the early action, it will be necessary to establish baseline conditions at the S-3 Site. This will include identifying monitoring locations for monitoring surface water and groundwater and sampling these media at these locations in a consistent manner for at least 1 year prior to implementing the early action.

For early action aimed at mitigating groundwater discharge to Bear Creek above its confluence with NT-1, monitoring will be conducted at the National Pollutant Discharge Elimination System monitoring point at Bear Creek Kilometer 12.46 during Phase II activities. This location already has an established baseline of sampling from 1989 to 1992. For discharge to NT-1, the NT-1 sampling location previously used by the Groundwater Protection Program will be sampled. This is also a location with past monitoring data (six samples from between 1990 and 1994) that will reduce the extent of sampling needed to establish the baseline conditions. In addition, the seeps in NT-1 (2 seeps) and Bear Creek (2 seeps) sampled during the Phase I activities will be sampled.

Stream flow will be measured weekly at each stream site and grab samples of surface water will be taken quarterly at baseflow and stormflow (two samples, four times per year) for 1 year. In addition, field parameters — specific conductance, pH, and turbidity — will be measured at the same time as stream flow (weekly).

In addition to in-stream monitoring locations for each location (GW-835, GW-837, and NT-1), a piezometer installed as part of the Phase I or Phase II activities will be selected for sampling to establish a baseline for shallow groundwater at each site. These piezometers will have water levels and field parameters recorded on a weekly basis and will be sampled monthly for COC analysis for 1 year.

Surface water and groundwater samples will be analyzed for metals, major anions, uranium, ^{99}Tc, and VOCs.

Product: The product will consist of a technical memorandum summarizing the results of baseline monitoring and a database of the data compatible with the Bechtel Environmental Integrated Management System and the OREIS system.

3.2.3.2 Phase II report and recommendations for early actions

The Phase II report will summarize the results and conclusions from the technical memoranda produced during Phase II activities. The report will focus on combining the results of the various studies and recommending early actions for the study sites.

Using data from Phase II column studies and technical evaluation of trench hydraulics, preliminary conceptual design for groundwater capture systems will be developed for the GW-835, GW-837, and NT-1 sites and will be included in the recommendations of the Phase II report. Conceptual designs will include the following:

- trench location, orientation, size, and depth;
- additional engineering features, such as impermeable barriers;

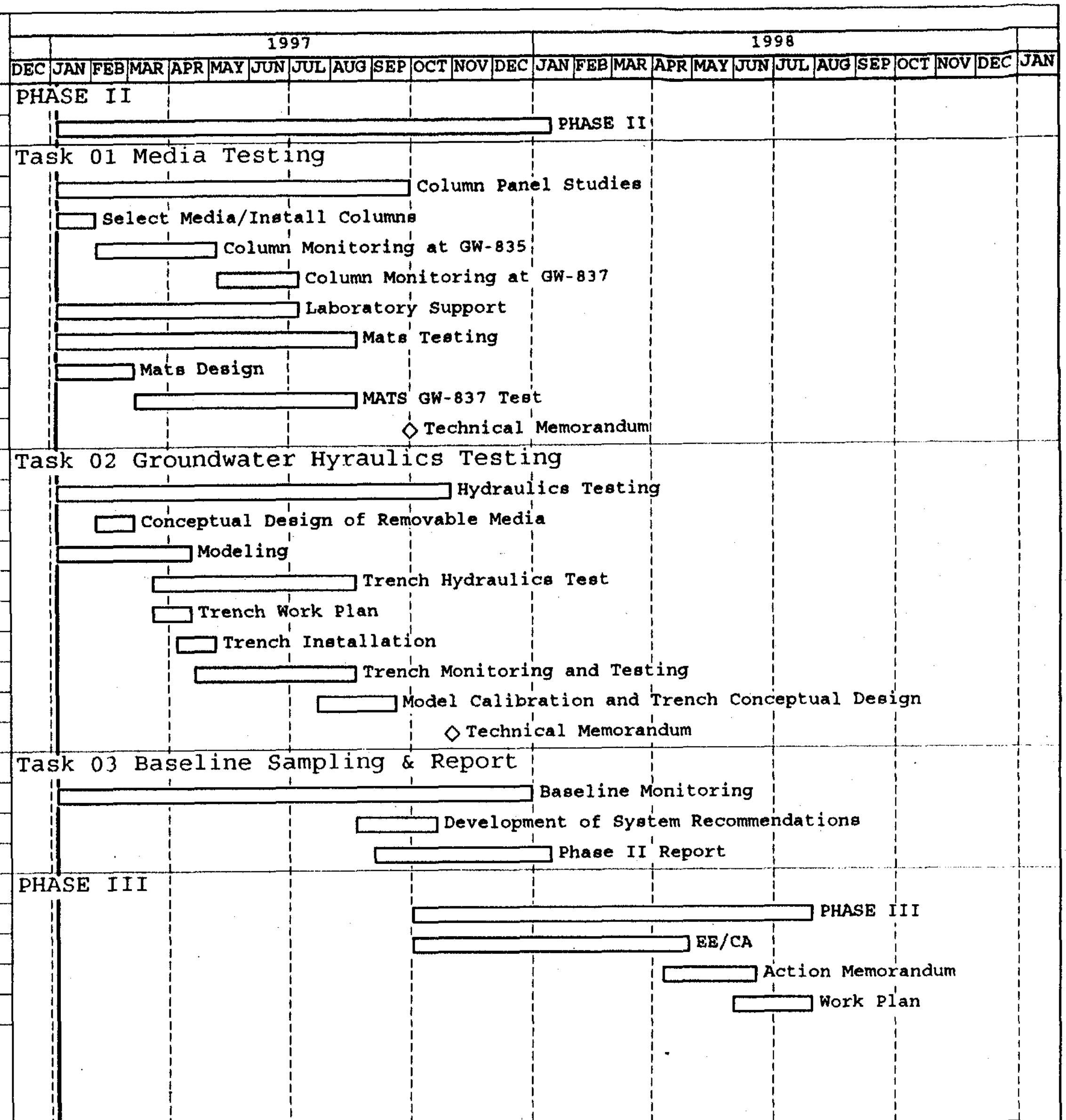
- estimates of flow-through rates and capture zones; and
- likelihood of achieving performance criteria.

Product: The product of this final task will be the Phase II report. This report will incorporate the technical memoranda developed in each task in Phase II into a coherent report. The conclusion for the report will contain the recommendations for early actions at the S-3 Site.

4. PROJECT SCHEDULE

The project schedule is provided in Fig. 4.1. The project schedule assumes completion of Phase II field activities in October 1997 and initiation of Phase III of the treatability study (Engineering Evaluation/Cost Analysis) at that time.

ACTIVITY ID	EARLY START	EARLY FINISH	ORIG DUR	Activity
PHASE II				
000-001	6JAN97	14JAN98	268	PHASE II
Task 01 Media Testing				
100-000	6JAN97	30SEP97	192	Column Panel Studies
100-001	6JAN97	4FEB97	22	Select Media/Install Columns
100-005	5FEB97	7MAY97	66	Column Monitoring at GW-835
100-010	8MAY97	8JUL97	44	Column Monitoring at GW-837
100-015	6JAN97	8JUL97	132	Laboratory Support
100-025	6JAN97	21AUG97	164	Mats Testing
100-030	6JAN97	6MAR97	44	Mats Design
100-040	7MAR97	21AUG97	120	MATS GW-837 Test
100-045		30SEP97	0	Technical Memorandum
Task 02 Groundwater Hyraulics Testing				
200-000	6JAN97	31OCT97	215	Hydraulics Testing
200-001	5FEB97	6MAR97	22	Conceptual Design of Removable Media
200-003	6JAN97	18APR97	75	Modeling
200-004	20MAR97	20AUG97	110	Trench Hydraulics Test
200-005	20MAR97	18APR97	22	Trench Work Plan
200-010	7APR97	6MAY97	22	Trench Installation
200-015	21APR97	20AUG97	88	Trench Monitoring and Testing
200-020	22JUL97	19SEP97	44	Model Calibration and Trench Conceptual Design
200-040		31OCT97	0	Technical Memorandum
Task 03 Baseline Sampling & Report				
300-000	6JAN97	31DEC97	258	Baseline Monitoring
300-010	20AUG97	20OCT97	44	Development of System Recommendations
300-020	3SEP97	14JAN98	96	Phase II Report
PHASE III				
400-000	2OCT97	30JUL98	216	PHASE III
400-005	2OCT97	28APR98	149	EE/CA
400-010	9APR98	18JUN98	51	Action Memorandum
400-020	1JUN98	30JUL98	44	Work Plan



Plot Date 5DEC96
Data Date 6JAN97
Project Start 6NOV96
Project Finish 30JUL98

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

HOBB

BCV S-3 Treatability Study
Phase II and Phase III
Project Schedule

Sheet 1 of 1

Date	Revision	Checked	Approved

Fig. 4.1. BCV S-3 Site treatability study Phase II and Phase III project schedule.

5. TEAM MEMBER ROLES AND RESPONSIBILITIES

Figure 5.1 is the organization chart for the Phase II activities.

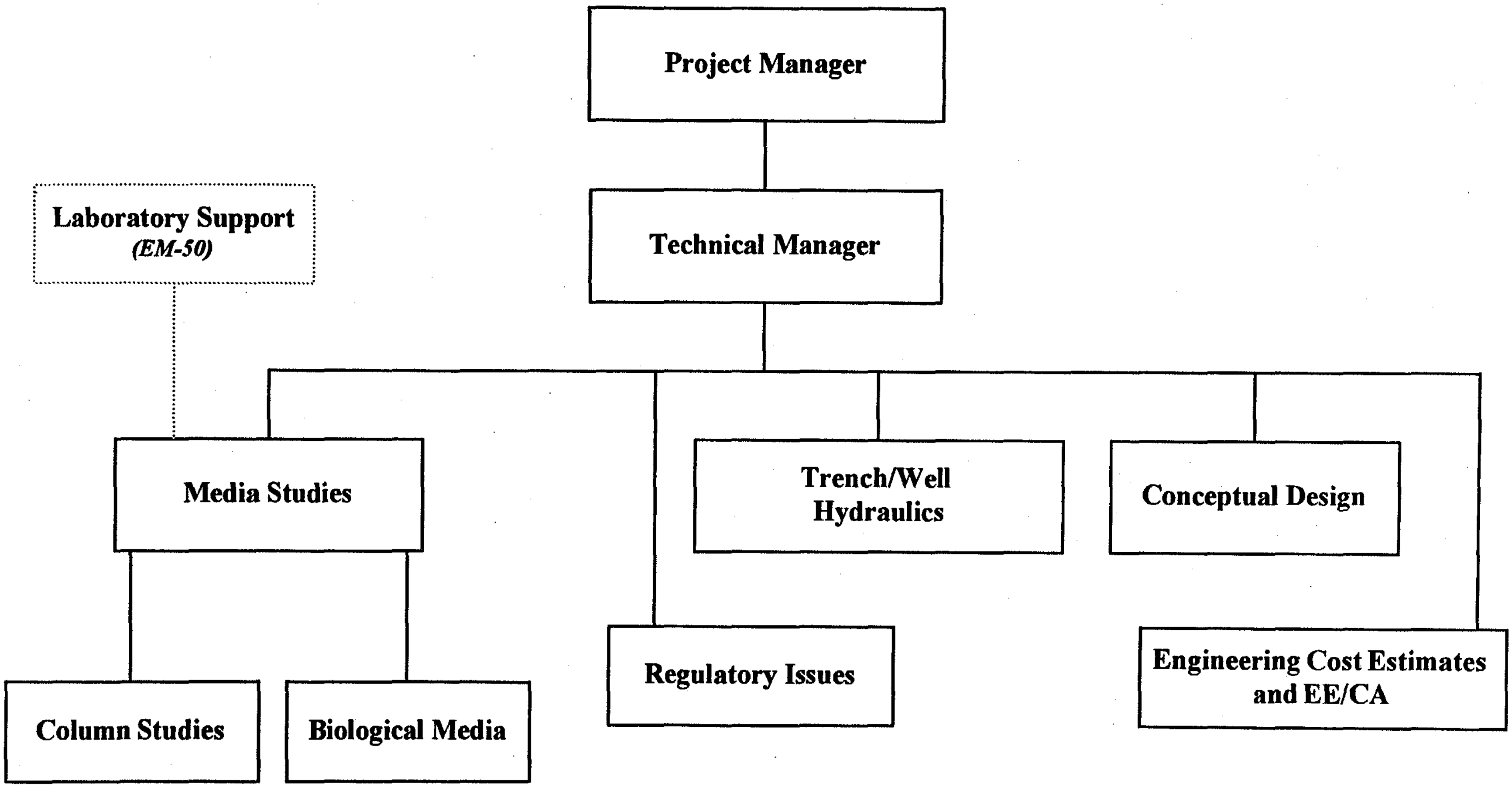


Fig. 5.1. Organization chart for the Phase II treatability study activities.

6. SUPPORTING DOCUMENTATION FOR FIELD WORK

During implementation of Phase II of the treatability study, the following detailed plans will be developed to support the field efforts:

- Detailed design and BMP for the column pond study,
- Detailed design and BMP for trench and horizontal well testing,
- data management plan,
- quality assurance/quality control plan,
- health and safety plan, and
- waste management plan.

BMPs will include operational information, sampling programs, and waste management plans.

7. REFERENCES

Energy Systems (Lockheed Martin Energy Systems, Inc.) 1996. *Report on Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1455/V1–V6/D1, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tenn.

SAIC (Science Applications International Corporation) 1996. *Bear Creek Valley Characterization Area Technology Demonstration Action Plan*, Y/EN-5479, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tenn.

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