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Draft
Focused Feasibility Study for Site 10 Soil and Groundwater at Allegany Ballistics Laboratory Superfund Site

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Norfolk, Virginia

Contract No. N62470-95-D-6007
CTO-0002

November 1996

Prepared by

CH2MHILL

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

SIGNATURE PAGE

Draft

Focused Feasibility Study for
Site 10 Soil and Groundwater at the
Allegany Ballistics Laboratory Superfund Site

Contract Task Order Number - 0002
Contract Number N62470-95-D-6007
Navy CLEAN II Program

Prepared by

CH2M HILL

November 22, 1996

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Acronyms and Abbreviations

ABL	Allegany Ballistics Laboratory
AMC	average monthly concentration
ARAR	applicable or relevant and appropriate requirements
As	arsenic
Ba	barium
BAT	best available technology
BCF	bioconcentration factor
bgs	below ground surface
CAMU	Corrective Action Management Unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	chemicals of potential concern
CS	Confirmation Study
CWA	Clean Water Act
DCE	dichloroethene
DNAPL	Dense nonacqueous phase liquid
EEQ	environmental effects quotient
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentrations
ERA	ecological risk assessment
FAWQC	federal ambient water quality criteria
FFS	focused feasibility study
foc	fraction of organic carbon
ft/day	foot per day
ft/yr	feet per year
GAC	granular activated carbon
gpm	gallons per minute
HI	hazard index
H_2O_2	hydrogen peroxide
Interim RI	Interim Remedial Investigation
IRP	Installation Restoration Program
K_d	distribution coefficient
K_{oc}	carbon water partition coefficient
kW	kilowatt

MCL	maximum contaminant level
MDE	Maryland Department of the Environment
mg/kg	milligrams per kilogram
mmo	methane monooxygenase
msl	mean sea level
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
Na	sodium
NACIP	Navy Assessment and Control of Installation Pollutants Program
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbons
PCE	perchloroethylene
PRG	preliminary remediation goal
RAC	remedial action contractor
RAO	remedial action objectives
RBC	risk-based concentrations
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SVOC	semivolatile organic compounds
ft^2/min	square foot per minute
TCA	trichloroethane
TCE	trichloroethene
TOC	total organic carbon
VOC	volatile organic compound
WVDEP	West Virginia Department of Environmental Protection

Executive Summary

CH2M HILL was contracted by the Atlantic Division of the Naval Facilities Engineering Command (NAVY) to perform RI/FS activities at the Allegany Ballistics Laboratory Superfund Site (ABL). ABL is a government-owned (Navy), contractor-operated (Alliant Techsystems), research, development, testing, and production facility for solid rocket motor propellant. ABL includes multiple sites. A remedial investigation was conducted, which included Site 10, because previous investigations indicated that Site 10 presents a potential threat to human health and the environment. The results of the remedial investigation and previous investigations which included Site 10 are presented and discussed in the *Phase II Remedial Investigation at Allegany Ballistics Laboratory Superfund Site Report* (CH2M HILL, August 1996) (Phase II RI Report) and in the *Draft Phase I Aquifer Testing Report* (CH2M HILL, October 1996). This Focused Feasibility Study (FFS) was performed to evaluate remedial alternatives to address risks associated with contaminated soil and groundwater at Site 10. The FFS summarizes the previous investigations, identifies remedial action objectives (RAOs) and applicable or relevant and appropriate requirements (ARARs), and develops and evaluates remedial alternatives for Site 10 soil and groundwater.

Site 10 is defined as the area around Building 157 on the ABL facility. A trichloroethene (TCE) still was reportedly operated adjacent to the building from 1959 until the early 1960s. Contaminants have been detected in soil and groundwater. The primary contaminants detected in these media are volatile organic compounds (VOCs), with TCE being the most prevalent and detected at the highest concentrations. The TCE still is the probable source of soil and groundwater contamination. Contaminated groundwater has migrated approximately 1,000 feet hydraulically downgradient of Building 157 in the alluvial aquifer and approximately 400 feet in the bedrock aquifer.

The baseline human health risk assessment evaluated a number of exposure scenarios for potentially exposed receptor populations. The potentially exposed receptor populations are current onsite (industrial) workers, potential future residential children and adults, and potential future workers. Under current conditions, the cumulative noncancer risk due to surface soil exposure by industrial workers is almost two orders of magnitude below the threshold value of 1. The total excess lifetime cancer risk to the current industrial worker is $5x10^{-6}$, which is well within the EPA risk range.

The pathways that were combined to get the total noncancer and cancer risks for the future residential scenario were the surface soil and most likely groundwater supply exposures. The bedrock aquifer is the most likely groundwater source for the site. The total noncancer risk from all pathways for a potential future residential child is twice the EPA risk level of 1. The total noncancer risk for a future residential adult is 0.8. The age-adjusted cancer risk is $1.2x10^{-4}$, just above the EPA recommended target risk range of $1x10^{-6}$ to $1x10^{-4}$. TCE is the main driver for this risk.

The goal of the baseline ecological risk assessment (ERA) was to evaluate the ecological risks associated with known or suspected contamination at Site 10. The general conclus0ion of the ERA is that levels of contaminants detected at Site 10 do not appear to represent much of a risk to wildlife. The area undergoes frequent disturbances, which limits the type and abundance of wildlife. Because of the relatively low contaminant concentrations, the consistency of Site 10 data with background concentrations, the disturbed and low quality habitat, and the relatively small area of habitat, Site 10 appears to represent a moderate risk to ecological resources.

Remedial action objectives (RAOs) for Site 10 soil are:

- Prevent or minimize the exposure of future site residents and construction workers to contaminated soil.
- Prevent or minimize migration and leaching of contaminants from the soil that may result in contamination of groundwater above health-based criteria and ARARs.

The RAOs for Site 10 groundwater are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.

- Prevent or minimize offsite migration of contamination originating from Site 10.

The first step in setting cleanup levels is to establish preliminary remediation goals (PRGs) for each chemical of potential concern (COPC) in soil and groundwater.

The surface soil COPCs were compared to EPA Region III RBCs (soil ingestion), applicable or relevant and appropriate requirements (ARARs), and surface soil background concentrations. The background concentrations were developed in a memorandum from the Navy to the USEPA and the West Virginia Department of Environmental Protection (WVDEP) in which a facility-wide statistical analysis of inorganic analytical results was performed to develop inorganic background concentrations specific to the ABL facility. The comparison revealed that the maximum detected concentration of each surface soil COPC is equal to or below the background concentration. In addition, the maximum detected concentrations of aluminum and arsenic are below the EPA Region III residential RBCs (soil ingestion), and the maximum detected concentration of beryllium is below the industrial RBC. Therefore, no surface soil PRGs were established in this FFS, and no remedial alternatives for surface soil were developed.

The subsurface soil COPCs are arsenic and manganese. The maximum detected concentrations of arsenic and manganese are greater than the risk assessment RBCs and the EPA Region III residential RBCs (soil ingestion), but less than the industrial RBCs. In addition, the human health risk assessment concluded that the carcinogenic risks to future construction workers are within and at the lower end of the EPA risk range. The noncarcinogenic risk to future construction workers is below the hazard index of 1. Therefore, no subsurface soil PRGs were established, and no remedial alternatives were developed in this FFS to remediate Site 10 subsurface soil.

The human health risk assessment did not identify any VOC constituents as surface or subsurface soil COPCs. However, the VOCs in Site 10 soil were compared to EPA Region III RBCs, transfer from soil to groundwater, in order to develop soil PRGs which are protective of the underlying aquifers. Based on this comparison, TCE is the only VOC present at a concentration greater than the RBC for transfer from soil to groundwater.

PRGs for VOCs were developed for Site 1 (the ordnance burning ground) soil in a memorandum from the Navy to the USEPA and the WVDEP. The Site 1 soil PRGs were developed using the Summers method (Sumers et. al., 1980) which is an analytical fate and transport model used to estimate the concentration in the aquifer of contaminants leached from unsaturated soil. This model was used to develop PRGs which are based on preventing the leaching of soil contaminants to the aquifers at concentrations which would exceed Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) in the aquifers. Based on the Summers method, the PRG for TCE is 152 µg/kg. The maximum detected TCE concentration above the water table in Site 10 soil is 140 µg/kg. Therefore, the TCE contaminant concentrations in soil are already below the PRGs for protection of the aquifers. No remedial alternatives were developed in this FFS to remediate Site 10 soil because the existing TCE concentrations are not expected to adversely affect groundwater quality.

PRGs for groundwater were established using RBCs identified in the risk assessment and established by EPA Region III, and from ARARs.

In developing sitewide alternatives, general response actions for groundwater were identified and process options and remedial technologies were screened. Screening criteria included effectiveness, implementability, and relative cost.

Process options and remedial technologies surviving the initial screening were then combined to develop media-specific remedial alternatives that were then used to develop sitewide remedial action alternatives for groundwater. Six remedial alternatives were carried forward from the preliminary evaluation, and evaluated against the seven evaluation criteria defined in the National Contingency Plan (NCP). These include:

- Alternative 1—No action
- Alternative 2—Institutional Controls and natural attenuation
- Alternative 3—Sitewide groundwater extraction and discharge to the Site 1 treatment plant
- Alternative 4—Sitewide groundwater extraction, air stripping, and discharge to the storm sewer
- Alternative 8—Focused groundwater extraction, air stripping, and discharge to the storm sewer
- Alternative 9—Focused groundwater extraction and discharge to the Site 1 treatment plant

A comparative analysis of the sitewide remedial alternatives is summarized in Table ES-1.

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Table ES-1
Comparative Analysis of Remedial Alternatives for Site 10 Groundwater

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
OVERALL PROTECTION OF HUMAN HEALTH AND ENVIRONMENT						
Exposure to contaminated groundwater	No reduction in risk of exposure over current levels.	Restrictive covenants will reduce potential for exposure.	See Alternative 2. Extraction and treatment will minimize potential for exposures to contaminants above PRGs.	See Alternative 3.	See Alternative 2. Focused extraction and treatment will prevent future exposures to the most contaminated portion of the aquifer. Natural attenuation will eventually reduce concentrations in the remainder of the aquifer.	See Alternative 8.
Prevent or minimize offsite migration	Contamination would continue to migrate at present levels.	Offsite migration will not be prevented, but natural attenuation appears to be reducing contaminant concentrations to below instrument detection limits.	Sitewide extraction will capture the entire TCE plume, thereby preventing offsite migration.	See Alternative 3.	Focused extraction will prevent future offsite migration. Contaminants in the more dilute portion of the aquifer will not be prevented from mirating offsite before natural degradation completes remediation. However, natural attenuation appears to be reducing contaminant concentrations to below instrument detection limits	See Alternative 8.

Table ES-1
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COMPLIANCE WITH ARARS						
Chemical-Specific ARARs	Does not comply with chemical-specific ARARs for groundwater.	Will not comply with ARARs in the short term, but may meet ARARs during the 30 year study period.	Will likely comply with ARARs within a 30 year period.	See Alternative 3.	ARARs will be met in theTCE hot spot more quickly than with sitewide extraction alternatives. Natural attenuation will likely take several decades to meet ARARs in the remainder of the aquifer.	See Alternative 8.
Location-Specific ARARs	Not relevant.	There are no location-specific ARARs for this alternative.	See Alternative 2.	See Alternative 2.	See Alternative 2.	See Alternative 2.
Action-Specific ARARs	Not relevant. No action taken.	Does not specifically comply with the State Groundwater Protection Act, which disallows alternatives relying solely on dilution and dispersion.	State Groundwater Protection Act prefers above ground piping if practical. This is not practical at ABL due to potential freezing.	See Alternative 3.	See Alternative 3.	See Alternative 8.

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LONG-TERM EFFECTIVENESS AND PERMANENCE						
Groundwater	Source not remediated; risk remains at current levels.	Risk may be reduced during 30 year study period. However, risk will remain above PRGs for several decades.	There will be minimal risk following completion of remediation. Alternative is effective and permanent.	See Alternative 3.	There will be minimal risk following completion of remediation. However, it will likely be decades before completion of remediation due to reliance on natural attenuation.	See Alternative 8.
Need for Five Year Review	Because contaminated material remains onsite, five year reviews would be required.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME						
Groundwater	None provided.	Natural attenuation will slowly reduce toxicity, mobility, and volume over several decades or more.	Sitewide extraction will capture the entire plume, minimizing mobility. Treatment will significantly reduce toxicity and volume.	See Alternative 3.	Will reduce toxicity, mobility, and volume of the most contaminated portion of the aquifers. Mobility and volume of the more dilute portion of the aquifer will remain the same, but toxicity will be gradually reduced through natural attenuation processes.	See Alternative 8.

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SHORT-TERM EFFECTIVENESS						
Groundwater	Not relevant	There will be no significant impacts on the facility.	Installation of the discharge pipeline will require roads to be temporarily closed	See Alternative 3.	See Alternative 3. This alternative would require the largest amount of material import. Therefore, the amount of construction traffic would be the largest under this alternative.	
Time Until Action is Complete	Not applicable.	30 years or more	Four months to complete construction. Approximately 15 years to remediate the aquifers. Presence of VOCs in silty clay layer may complicate extraction, lengthening remediation period.	Four to five months to complete construction. Approximately 15 years to remediate the aquifers. Presence of VOCs in silty clay layer may complicate extraction, lengthening remediation period.	Four months to complete construction. Approximately 30 years to remediate the aquifers.	Three to four months to complete construction. Approximately 30 years to remediate the aquifers.
IMPLEMENTABILITY						
Ability to Construct and Operate	Not applicable.	Easily implemented.	Site 1 treatment system will require modification, which could be complex.	Alternative is easily implemented using standard construction practices.	See Alternative 4.	See Alternative 3.
Ease of Doing Additional Action if Needed	Very easy to implement additional action.	Very easy to implement additional action.	Additional extraction wells can be installed. However, increased flow may require treatment plant upgrades.	See Alternative 3.	See Alternative 3.	See Alternative 3.

Table ES-1
Comparative Analysis of Remedial Alternatives for Site 10 Groundwater

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
Ability to Monitor Effectiveness	Easily monitored during five year site reviews.	A groundwater monitoring program will be implemented, and used to effectively monitor natural attenuation and potential offsite migration.	Groundwater monitoring wells will be used to confirm extraction wells are achieving capture of the entire TCE plume and potential offsite migration.	See Alternative 3.	Monitoring wells will be used to confirm extraction wells are attaining capture, natural attenuation is occurring, and potential offsite migration.	See Alternative 8.
COST						
Capital Cost	$0	$50,000	$700,000	$770,000	$540,000	$450,000
First-Year Annual O&M Cost	$0	$25,000	$80,000	$100,000	$80,000	$70,000
Present-Worth	$0	$400,000	$1,500,000	$1,800,000	$1,400,000	$1,200,000

Section 1

Introduction

Allegany Ballistics Laboratory (ABL), located in Rocket Center, West Virginia, is a government-owned (Navy), contractor-operated (Alliant Techsystems[1]) research, development, testing, and production facility for solid propellant rocket motors. In 1994, CH2M HILL was contracted by the Atlantic Division of the Naval Facilities Engineering Command (Navy) to perform a remedial investigation/feasibility study (RI/FS) at the ABL Superfund Site. Previous environmental investigations were performed at ABL by the Navy and Hercules under the Navy's Installation Restoration Program (IRP). On May 31, 1994, ABL was added to the National Priorities List (NPL).

ABL includes multiple sites. The Phase II RI (CH2M HILL, August 1996) indicates that Site 10 presents a potential threat to human health and the environment. Therefore, this focused FS (FFS) has been developed to address potential threats associated with soil and groundwater contamination at Site 10. This FFS uses information gathered during the RI (CH2M HILL, January 1996), the Phase II RI, and Phase I Aquifer Testing (CH2M HILL, October 1996) as a basis for developing and evaluating cost-effective remedial alternatives to address Site 10 soil and groundwater contamination. The remedial alternatives are designed to meet remedial action objectives (RAOs) and address risks associated with Site 10 contaminants to be consistent with the National Contingency Plan (NCP).

Purpose and Organization of the FFS Report

The FFS report documents the analyses and evaluations used to develop remedial action alternatives for Site 10 soil and groundwater contamination. The information presented herein will be used by the Navy to select a cost-effective remedial alternative that complies with the requirements of the NCP. The NCP states that a remedy is cost-effective if its costs are proportional to its overall effectiveness (40 CFR 300.430(e)).

[1] All site work through the Phase II RI was performed when Hercules Aerospace Company (Hercules) operated the facility. Currently, Alliant Techsystems is the operator.

The FFS report is not intended to be a design document; rather, it gives a conceptual overview of remedial alternatives to evaluate their feasibility. The report discusses criteria used to evaluate remedial alternatives and to determine the effects of implementing them. The organization of the report and the process by which remedial alternatives were evaluated are illustrated in Figure 1-1.

Section 1 discusses the site background, geology, hydrogeology, nature and extent of contamination, and human-health and environmental risk assessments for Site 10.

Site 10 Background Information

The following discussion of the site background is summarized from the *Phase II Remedial Investigation at Allegany Ballistics Laboratory Superfund Site* Report (CH2M HILL, August 1996) (Phase II RI Report), and the *Remedial Investigation of the Allegany Ballistics Laboratory* Report (CH2M HILL, January 1996) (RI Report). Site 10 is referred to in the RI and Phase II RI reports as Site PWA.

Site 10 Description and History

ABL consists of two plants and several additional sites (Figure 1-2). Plant 1 occupies approximately 1,572 acres which is owned by the Navy and operated by Alliant Techsystems. Plant 2, a 56-acre area adjacent to Plant 1, is owned exclusively by Alliant Techsystems. As shown in Figure 1-3, Site 10 is defined as the area around Building 157, adjacent to which a trichloroethene (TCE) still reportedly operated from 1959 until the early 1960s. Figure 1-3 also shows the locations of wells PWA and PWC, former production wells which are no longer used as potable water sources because they were found to contain volatile organic compounds (VOCs) that may have originated at Site 10.

Site 10 Investigations

Several investigations have been conducted at ABL during which Site 10 was either directly or indirectly involved. Between 1984 and 1987, a Confirmation Study (CS) was conducted at several Plant 1 sites recommended for further investigation in the Initial Assessment Study, 136194.FS.DR/d1/03/wdc11/96.dlw

SECTION 1

Introduction
- Purpose and organization of FFS report
- Site 10 background information
- Geology
- Hydrogeology
- Nature and extent of contamination
- Contaminant fate and transport
- Baseline human-health risk assessment
- Baseline ecological risk assessment

↓

SECTION 2

Remedial Action Objectives, ARARs, and PRGs
- Identify CERCLA/SARA and NCP goals
- Identify site-specific remedial action objectives
- Identify ARARs and PRGs

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SECTION 3

Development and Screening of Remedial Action Alternatives
- Preliminary screening of remedial technologies for groundwater, surface water and sediment
- Final screening of remedial technologies for groundwater, surface water and sediment
- Develop remedial action alternatives for:
  - soil
  - groundwater
- Screen remedial action alternatives on the basis of:
  - effectiveness
  - implementability
  - cost

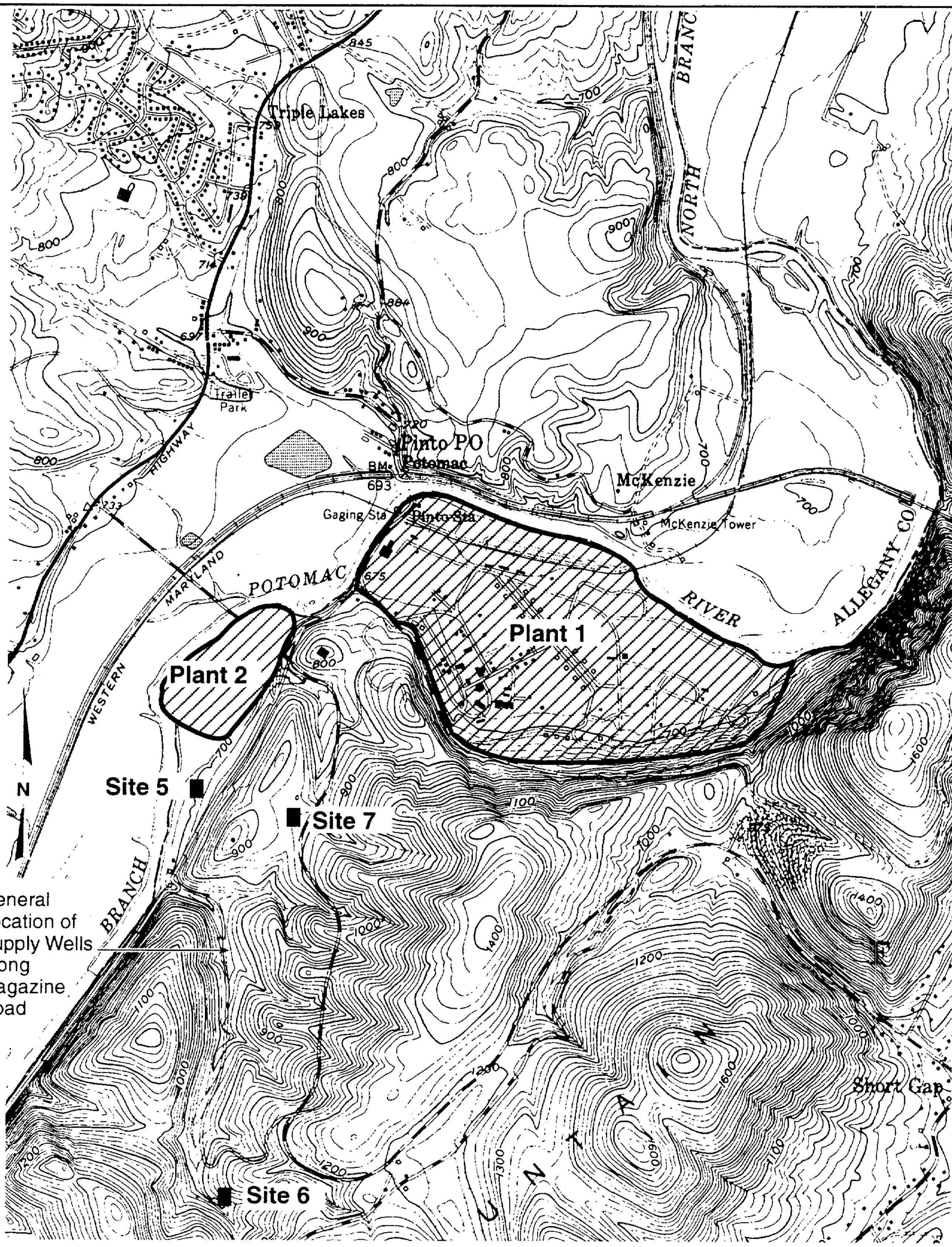
↓

SECTION 4

Detailed Analysis of Alternatives
- Assemble site-wide remedial action alternatives
- Evaluate site-wide remedial action alternatives in terms of:
  - short-term effectiveness
  - long-term effectiveness
  - reduction of toxicity, mobility, and volume
  - protection of human health
  - implementability
  - cost
  - compliance with ARARs

Figure 1-1
ORGANIZATIONAL SCHEMATIC
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

CH2M HILL



Source: USGS 7.5 minute Cresaptown, WV-MD quadrangle map.

0 1000 2000

Scale in Feet

Figure 1-2
LOCATION MAP
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

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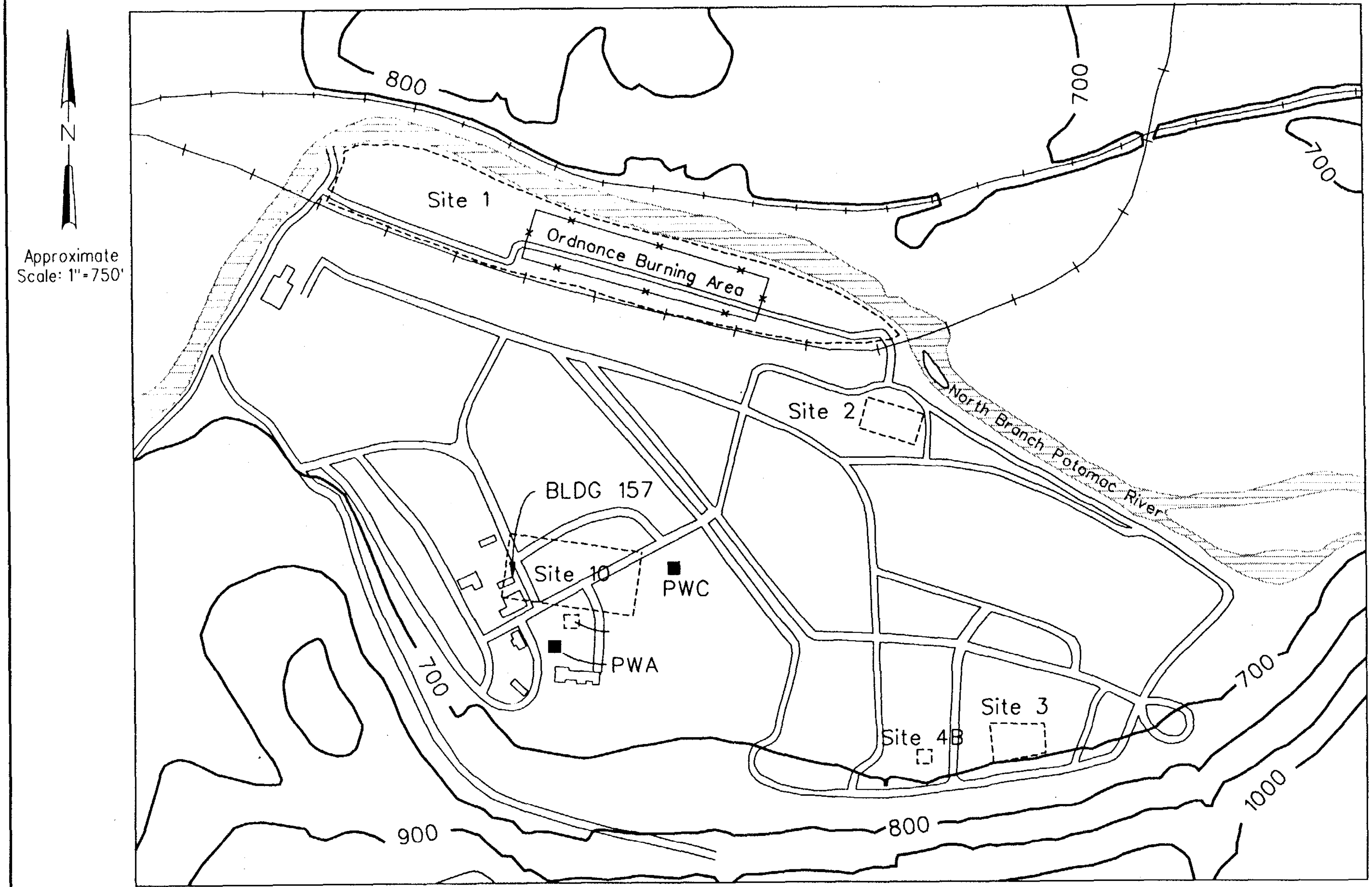


LEGEND

■ Production Well

⬚ Approximate Site Boundaries

— 900 — Topographic Contour (Elevation in ft above msl)

—+— Railroad

—×— Fence

Figure 1-3
PLANT 1 FEATURES AND SITE LOCATIONS
SITE 10 FOCUSED FEASIBILITY STUDY
Allegany Ballistics Laboratory

CH2M HILL

which was completed in 1983 under the Navy Assessment and Control of Installation Pollutants Program (NACIP) (Environmental Science and Engineering, January 1983). During the CS, production well PWA, which is located approximately 400 feet south of the former TCE still at Building 157, was evaluated and found to contain detectable concentrations of TCE, 1,1,1-trichloroethane (1,1,1-TCA), and several other VOCs. The CS defined Site PWA as the former production well PWA.

As a result of the Superfund Amendments and Reauthorization Act (SARA) of October 1986, the Navy changed its NACIP terminology and scope under the IRP to follow the rules, regulations, guidelines, and criteria established by the United States Environmental Protection Agency (EPA) for the Superfund program. For this reason, the results of the CS are documented in the Interim Remedial Investigation (Interim RI) Report (Weston, October 1989). The Interim RI Report recommended further investigation at six of the seven sites, including Site PWA.

Following the recommendations of the Interim RI Report and in accordance with the Navy's changed IRP policy, Hercules contracted CH2M HILL to conduct an RI following EPA's RI/FS format under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The RI, initiated in May 1992 and completed in October 1992 (final document dated January 1996), was conducted to define the nature and extent of contamination at a number of ABL sites. The RI defined Site PWA as the area around Building 157, including former production well PWA. Activities conducted by CH2M HILL during the RI included a focused facility audit to determine possible sources of VOC contamination at a number of sites, including Site PWA. Soil sampling and well testing also were conducted at Site PWA during the RI.

The RI Report (CH2M HILL, January 1996) indicated additional investigation at Site PWA was necessary to better define the nature and extent of contamination and to support human health and environmental risk assessments. Therefore, CH2M HILL was contracted by the Navy in 1994 to conduct a Phase II RI at a number of ABL sites, including Site PWA. The Phase II RI activities at Site PWA consisted of additional soil and groundwater sampling at Site PWA (CH2M HILL, August 1996).

In order to remain consistent with the designation of sites at ABL, Site PWA was renamed Site 10 in 1995. All further discussion will use the "Site 10" designation.

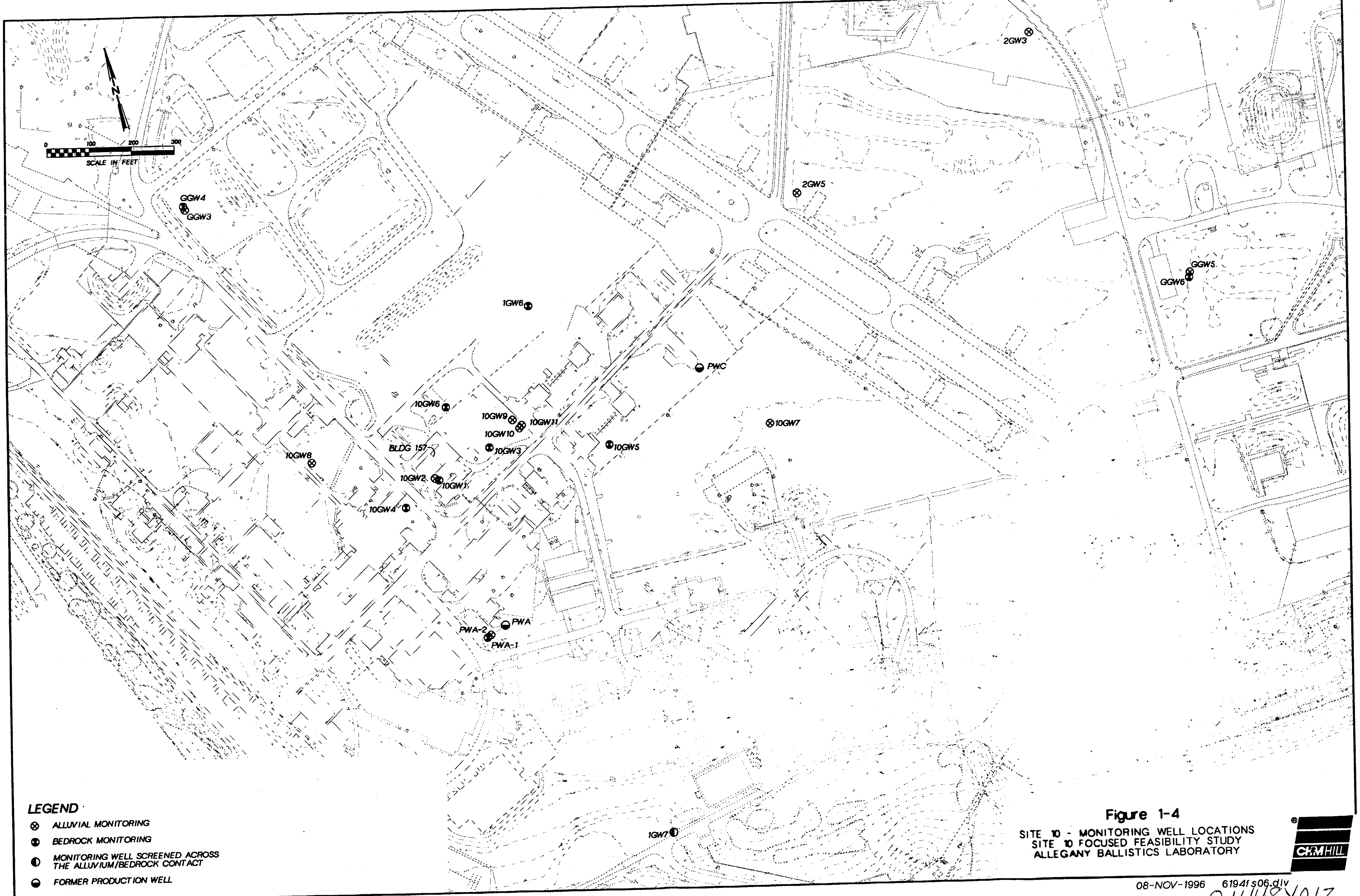
Because the results of previous investigations at Site 10 suggested that the former TCE still at Building 157 was a likely source of both soil and groundwater contamination, a Phase I Aquifer Testing program was conducted at Site 10 to further define the extent of groundwater contamination and to collect hydraulic information necessary for the potential design of a groundwater extraction system at the site. Specific activities conducted during Phase I Aquifer Testing included a Geoprobe® groundwater investigation to determine the direction and extent of VOC contaminant migration, well installation and testing, and groundwater sampling. The Phase I Aquifer Testing program is documented in the draft Phase I Aquifer Testing Report (CH2M HILL, October 1996). Figure 1-4 shows the locations of all wells installed at Site 10 and vicinity during Phase I Aquifer Testing and previous investigations.

Geology

Site 10 is underlain by two distinct lithologies: (1) unconsolidated alluvial deposits of clay, silt, sand, and gravel; and (2) predominantly shale bedrock. Drilling activities at Site 10 indicated that the unconsolidated deposits overlying the bedrock generally become coarser with depth, culminating in a silty gravel zone up to several feet thick just above the bedrock.

It is assumed that the depositional history of unconsolidated deposits at Site 10 was similar to that at Site 1, where the deposits consist of two distinct layers of material. The upper, or surficial, layer consists of silty clay and is considered floodplain deposits of the North Branch Potomac River. While the thickness of this layer has not been rigorously measured at Site 10, boring logs from nearby wells and drilling at Site 10 indicate that this layer extends from the ground surface to an average depth of approximately 10 to 15 feet below ground surface (bgs). This is an average elevation of the bottom of the silty clay layer of between 652 and 657 feet above mean sea level (msl).

Similar to Site 1, below the silty clay layer at Site 10 is a sand and gravel layer containing pebbles and cobbles, with variable amounts of clay and silt. This layer is considered alluvial



LEGEND

- ⊗ ALLUVIAL MONITORING
- BEDROCK MONITORING
- ◐ MONITORING WELL SCREENED ACROSS THE ALLUVIUM/BEDROCK CONTACT
- FORMER PRODUCTION WELL

Figure 1-4

SITE 10 - MONITORING WELL LOCATIONS
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

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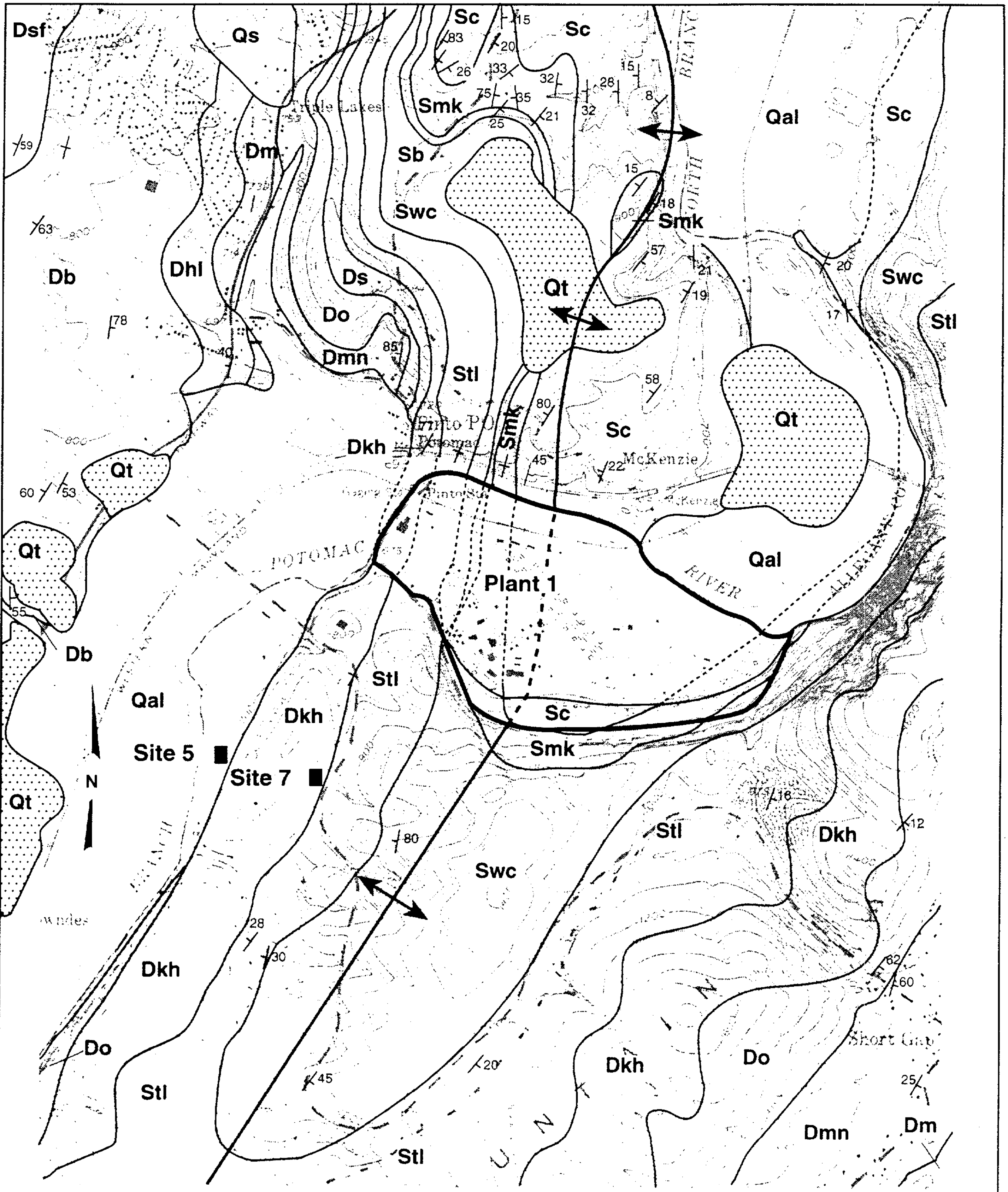
deposits of the North Branch Potomac River. Several feet of the sand and gravel layer overlie the predominantly shale bedrock, which was found at an average depth of approximately 22.5 feet bgs (i.e., 645 feet msl).

Figure 1-5 shows the approximate location of the Wills Mountain anticlinal axis with respect to Plant 1. Because of the limited space in the figure, the explanation of each formation designation is presented in Table 1-1. The Wills Mountain anticlinorium is asymmetrical. To the east and southeast of the anticlinal axis, the strata dip relatively gently to the southeast at approximately 30 degrees (Dyott, 1956). The strata on the northwest limb of the anticline are generally vertical to slightly overturned (Shultz, 1989). Figure 1-5 shows that the anticlinal axis may pass close to Site 10, indicating that the site may lie within a transitional zone of the anticlinal axis where the beds grade between vertical and subhorizontal orientations. Therefore, bedding-dip directions beneath this site may vary considerably due to complex folding similar to that identified in bedrock outcrops across the North Branch Potomac River from Plant 1.

During the Phase I Aquifer Testing activities, four of the five bedrock wells installed at Site 10 (i.e., 10GW1, 10GW3, 10GW4, and 10GW6) were evaluated to determine the nature and distribution of their fractures, as well as to assess which fractures were significant in terms of groundwater production. Summaries of the fractures identified in the four wells are presented in Table 1-2. This table shows that at Site 10 there is a fracture zone between approximately 603 and 610 feet msl. Furthermore, a set of fractures at an elevation of 607 feet msl was identified during a previous investigation in bedrock well PWA-1, which is located approximately 375 feet southeast of Site 10 (Figure 1-4).

Hydrogeology

Prior to the Phase I Aquifer Testing activities, little was known concerning the direction of groundwater flow in the alluvium and bedrock at Site 10. Piezometric-surface maps generated for the Phase II RI Report (CH2M HILL, August 1996) estimated the directions of flow from the few wells sparsely located in the vicinity of Site 10. Therefore, water-level measurements were taken within a 2-hour period in all Site 10 wells installed during Phase I



Basemap: USGS 7.5 minute Cresaptown, WV-MD quadrangle map.

0 1000 2000
Scale in Feet

LEGEND

Location of Wills Mountain Anticlinal Axis, dashed where inferred (from Eddy, 1964 and Glaser, 1994)

Normal strike and dip

Vertical Strike

Figure 1-5
GEOLOGIC MAP OF THE REGION SURROUNDING ABL
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

CH2M HILL

Table 1-1
Bedrock Stratigraphic Units in the Vicinity of the ABL Facility

System	Unit	Map Designation	Description	Approximate Thickness (ft)
Quaternary	Alluvium	Qal	Unconsolidated sand, silt, and gravel, pale to dark gray, weathering orange to red-brown, poorly sorted, dominantly quartzose, but abundant rock fragments	10 to 40[1]
Tertiary	Terrace Deposits and Colluvium	Qt/Qs	Unconsolidated sand, gravel, loam, and sandy loam, tan to reddish- or orange-brown, weathering darker and limonitic, Qt is remnant fluvial-alluvial deposits and colluvium and Qs is slide deposits	15 to 20[1]
Devonian	Scherr/Foreknobs Formations	Dsf	Scherr is shale, siltstone, and subordinate sandstone, shale light-olive to greenish-gray, siltstone and sandstone medium gray/Foreknobs is siltstone, sandstone, conglomerate, and minor shale, olive-gray, reddish-gray, or yellowish-gray,	> 3,000[1]
	Brallier Shale	Db	Interbedded shale and siltstone, minor sandstone, medium dark gray, olive-gray, and olive-green, fissile	2,000 to 2,500[1]
	Harrell Shale	Dhl	Shale, slightly calcareous, homogeneous, dark gray	150[1]
	Mahantango Formation[4]	Dm	Shale and mudrock, silty, subordinate siltstone, and fine sandstone, medium to dark gray, weathering to gray brown chips, fossiliferous	600[1]
	Marcellus Shale/Needmore Shale	Dmn	Shale, mudrock, and minor limestone, Marcellus is thinly laminated to fissile, pyritic, olive gray to gray black/Needmore is calcareous, non-fissile, medium dark gray	350[2]
	Oriskany Sandstone	Do	Sandstone, minor conglomerate, and pebbly sandstone, bluish gray to medium gray, weathering to pale gray to white	140 to 150[1]
	Shriver Chert[5]	Ds	Chert, argillite, siltstone, and subordinate limestone, dark gray to nearly black	115[2]
	Keyser Limestone/Helderberg Limestone	Dkh	Keyser is limestone with chert and minor calcareous shale, medium gray to dark blue, clastic, fossiliferous/Helderberg is limestone, subordinate shale, and chert, limestone and shale light to dark gray, chert dark gray, weathering white, fossiliferous	350[1,2]
Silurian	Tonoloway Limestone	Stl	Limestone and calcareous shale, dark gray to dark blue,	600[1,2]
	Wills Creek Formation	Swc	Shale, calcareous mudrock, and subordinate argillaceous limestone, shale dark gray to olive gray, pale green, and pale red, limestone dark blue to medium gray, Williamsport Sandstone at base (21 feet thick[2])	430[1,2]
	Bloomsburg Formation[6]	Sb	Siltstone, shale, subordinate sandstone, and limestone, mottled red, gray green, and red green, limestone medium gray to grayish red, weathering yellow, rusty surfaces, shale hackly	36 to 45[1]
	McKenzie Formation[7]	Smk	Shale, calcareous, olive to pale gray, and interbedded argillaceous limestone, bluish gray to nearly black	200 to 300[1,2]

Table 1-1
Bedrock Stratigraphic Units in the Vicinity of the ABL Facility

System	Unit	Map Designation	Description	Approximate Thickness (ft)
Silurian con't	Clinton Group:	Sc		
	Rochester Shale		Shale, calcareous, fissile, interbedded with fossiliferous limestone, olive to pale gray	25 to 42[1,2]
	Keefer Sandstone		Sandstone, quartzitic, hematitic, yellowish-gray to pale-gray, overlain by a thin seam of oolitic hematite of the Roberts Iron Ore[3]	12 to 14[1]
	Rose Hill Shale		Shale, homogeneous, greenish-gray to pale-olive, interbedded with minor sandstone, few beds of highly argillaceous dolomitic limestone near the top of the formation	540 to 580[1]

Notes:
This table provides the descriptions of the lithologic units designated in Figure 1-5.
Sources of Lithologic Descriptions and Thicknesses: Glaser (1994) and Eddy (1964)
[1] Glaser (1994)
[2] Eddy (1964)
[3] Swartz et al. (1923)
[4] Eddy (1964) refers to this unit as the Hamilton Formation
[5] Eddy (1964) does not separate Shriver Chert from Oriskany Sandstone
[6] Eddy (1964) does not separate Bloomsburg Formation from Williamsport Sandstone
[7] Glaser (1994) includes the Rochester Shale in the mapped area of the McKenzie Formation

Table 1-2
Summary of Fractures and Voids in Bedrock at Site 10
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

Bedrock Well	Location	Fracture Set or Void Elevation (ft msl)	Fracture Set or Void Depth (ft bgs)
10GW1	Site 10	603, 616	51, 64
10GW3	Site 10	586, 604 to 608	58 to 62, 80
10GW4	Site 10	588, 606 to 608, 613, 624 to 636	30 to 42, 53, 58 to 60, 78
10GW6	Site 10	610 to 638, 608 to 610	56 to 58, 28 to 56
PWA1	South Central Plant 1	607	63

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Aquifer Testing and existing wells 1GW6, PWA1, and PWA2 (Figure 1-4). The water-level measurements, presented in Table 1-3, were used to evaluate the piezometric surfaces in the alluvial and bedrock aquifers at Site 10.

Figure 1-6 is an interpretive piezometric-surface map for the alluvial aquifer at Site 10, based on the water-level measurements presented in Table 1-3. A limited number of closely-spaced water levels were used to construct the piezometric surface. Figure 1-6 indicates that the alluvial groundwater in the vicinity of Site 10 is moving in an approximately eastward direction. While some undulations appear to exist in the piezometric surface, the horizontal hydraulic gradient across the site was calculated to be approximately 0.005.

Phase I Aquifer Testing at Site 10 suggested that the transmissivity of the alluvium at Site 10 is approximately 0.8 square foot per minute (ft^2/min) and that the saturated thickness is about 20 feet. Therefore, the alluvial hydraulic conductivity at Site 10 is calculated to be 57 feet per day (ft/day). Using an assumed alluvial effective porosity of 20 percent and the calculated horizontal hydraulic gradient of 0.005, the average linear groundwater velocity at Site 10 is estimated to be approximately 520 feet per year (ft/yr).

An interpretive piezometric-surface map of the bedrock aquifer at Site 10 also was developed from the water-level measurements in Table 1-3. The piezometric surface, as shown in Figure 1-7, is inferred over much of its area because of the limited number of monitoring wells existing in that part of the plant. However, based on Figure 1-7, the direction of groundwater flow in the bedrock is similar to that in the overlying alluvium (i.e., eastward across the site), with an average horizontal hydraulic gradient of approximately 0.007.

The transmissivity of the bedrock at Site 10 is approximately 1 ft^2/day. Unlike the alluvial aquifer, lateral groundwater flow in the bedrock aquifer is confined mainly to fractures and partings along bedding planes.

Alluvial well 10GW2 is located adjacent to bedrock well 10GW1 in the vicinity of Building 157 (Figure 1-4). Water-level measurements collected during Phase I Aquifer Testing from these paired wells were compared to determine the direction and magnitude of the vertical component of hydraulic gradient between the alluvium and bedrock at this location. The

Table 1-3
Summary of Water-Level Elevations
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

Well Name	Ground Elevation (ft msl)	Top of Casing Elevation (ft msl)	Screen Depth Interval (ft bgs)	Screened Unit	Measurement Date	Depth to Water (ft btoc)	Water-Level Elevation (ft msl)
10GW1	667.52	669.40	31 - 90[b]	B	3/26/96	4.25	665.15
10GW2	667.65	669.59	9 - 24	A	3/26/96	4.49	665.10
10GW3	666.84	668.49	30 - 90[b]	B	3/26/96	3.66	664.83
10GW4	667.31	668.68	30 - 90[b]	B	3/26/96	3.38	665.30
10GW5	666.56	668.25	30 - 90[b]	B	3/26/96	5.52	662.73
10GW6	666.46	667.96	30 - 90[b]	B	3/26/96	2.84	665.12
10GW7	664.14	666.18	8.5 - 18.5	A	3/26/96	4.21	661.97
10GW8	667.85	669.86	9 - 19	A	3/26/96	3.26	666.60
10GW9	668.95	670.83	8.5 - 23.5	A	3/26/96	5.99	664.84
10GW10	669.26	671.06	6 - 21	A	3/26/96	6.34	664.72
10GW11	669.28	670.90	10 - 25	A	3/26/96	6.19	664.71
1GW6	666.83	669.77	24 - 35[a]	B	3/26/96	5.10	664.67
PWA1	669.63	671.23	63 - 78	B	3/26/96	6.74	664.49
PWA2	669.39	671.68	20 - 35	A	3/26/96	7.16	664.52

Notes:
"ft msl" = feet above mean sea level; "ft bgs" = feet below ground surface; "ft btoc" = feet below top of casing
B = Bedrock; A = Alluvium; AB = Well screened across the alluvium/bedrock contact
[a] Effective screen interval listed; surface casing shrouds a portion of the screen
[b] No screen installed; listed depth is open borehole interval

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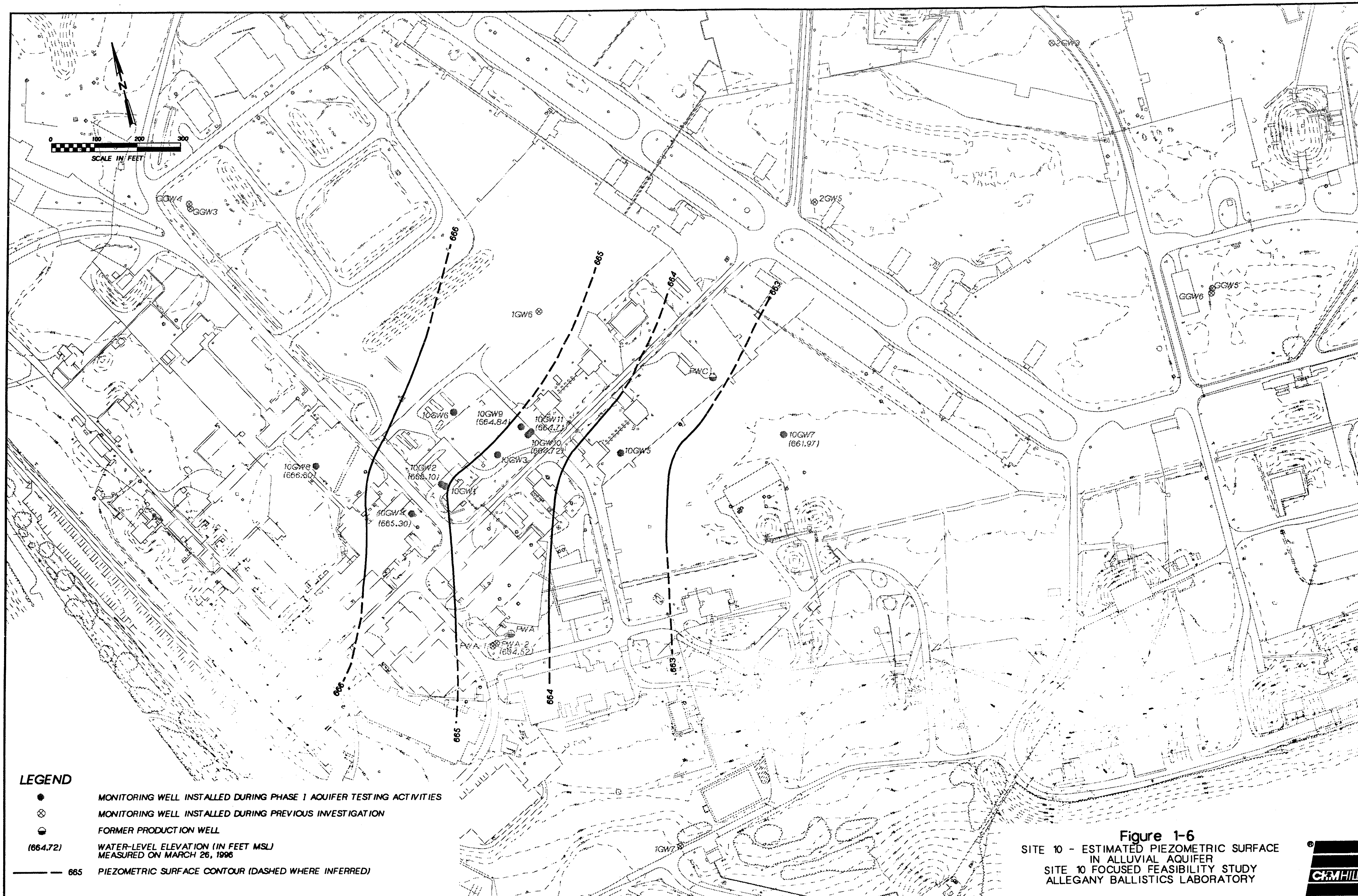

Figure 1-6
SITE 10 - ESTIMATED PIEZOMETRIC SURFACE IN ALLUVIAL AQUIFER
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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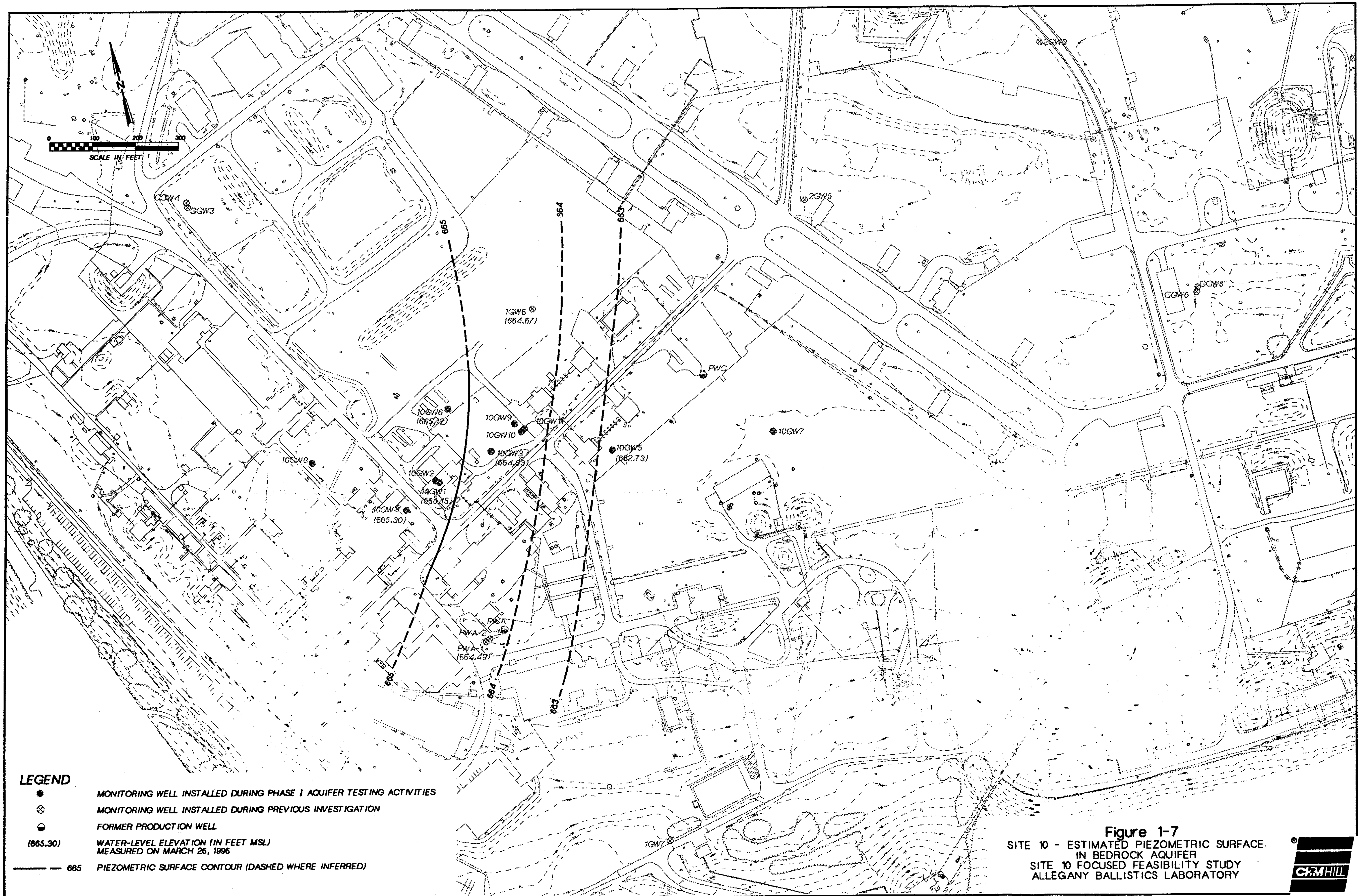

Figure 1-7
SITE 10 - ESTIMATED PIEZOMETRIC SURFACE IN BEDROCK AQUIFER
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

results of these calculations, presented in Table 1-4, indicate that there is a small upward component of flow. However, it should be noted that the measured difference between the water levels in these two wells was only 0.05 feet. This indicates that there is a good hydraulic connection between the alluvium and bedrock aquifers at this location.

Nature and Extent of Contamination

This subsection summarizes the nature and extent of contamination in Site 10 soil and groundwater. More detailed discussions of contaminant nature and extent can be found in the Phase II RI Report and the Phase I Aquifer Testing Report.

Soil Contamination

During the RI, 28 soil samples were collected at Site 10 and surrounding areas for both onsite and offsite analysis for VOCs. Two of the soil samples were collected from the location of the former TCE still near Building 157 and six others from three adjacent locations near Building 157. Additional samples were collected at the former TCE still location during the Phase II RI. The samples collected during the Phase II RI were analyzed for semivolatile organic compounds (SVOCs), inorganics, and total organic carbon (TOC). Table 1-5 lists all soil samples collected during the RI and Phase II RI, their sample depths, and their respective analysis(es). Figure 1-8 shows all RI and Phase II RI soil sample locations.

Figure 1-9 shows the TCE concentrations in all soil samples collected at and near Site 10 during the RI. As shown in the figure, the only TCE concentrations greater than 9 micrograms per kilogram (µg/kg) were detected in the vicinity of the former TCE still at Building 157. TCE concentrations between 52 µg/kg and 280 µg/kg were detected at these four locations.

The two soil samples collected at the former TCE still location during the Phase II RI did not contain detectable concentrations of SVOCs and their inorganics concentrations were similar to those detected in "background" soil samples collected elsewhere at Plant 1.

Table 1-4
Calculated Vertical Component of Hydraulic Gradient at Site 10 Well Pair
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

Well Pair	Distance Between Well Screens[b] (ft - max/min)	Measured Difference in Water-Level Elevations[d] (ft)	Vertical Component of Hydraulic Gradient[e] (max/min)	Direction of Vertical Component of Flow
Alluvial/Bedrock[a]				
10GW2/10GW1	81/7[c]	0.05	0.0071/0.0006	up

Notes:

[a] alluvial well/bedrock well

[b] max = top of screen for alluvial well minus bottom of screen for bedrock well
min = bottom of screen for alluvial well minus top of screen for bedrock well

[c] no screen installed in bedrock well; calculation uses bottom of surface casing and bottom of borehole

[d] difference calculated by subtracting the water level in the alluvial well from the water level in the bedrock well;
a positive difference indicates an upward vertical component of flow

[e] calculated by dividing the difference in water-level elevations in column 3 by the max/min values in column 2

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Table 1-5
Summary of Site 10 Soil Samples
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

Sample Number	Investigation	Sample Depth (ft bgs)	Analysis Performed
HCS-PWA-1	RI	3 - 4	VOCs
HCS-PWA-2	RI	3 - 4	VOCs
HCS-PWA-3	RI	3 - 4	VOCs
HCS-PWA-4	RI	3 - 4	VOCs
HCS-PWA-5	RI	3 - 4	VOCs
HCS-PWA-6	RI	10 - 11	VOCs
HCS-PWA-7	RI	10 - 11	VOCs
HCS-PWA-8	RI	3 - 4	VOCs
HCS-PWA-9	RI	3 - 4	VOCs
HCS-PWA-10	RI	3 - 4	VOCs
HCS-PWA-11	RI	3 - 4	VOCs
HCS-PWA-12	RI	10 - 11	VOCs
HCS-PWA-13	RI	3 - 4	VOCs
HCS-PWA-14	RI	11 - 12	VOCs
HCS-PWA-15	RI	3 - 4	VOCs
HCS-PWA-16	RI	11 - 12	VOCs
HCS-PWA-17	RI	3 - 4	VOCs
HCS-PWA-18	RI	11 - 12	VOCs
HCS-PWA-19	RI	3 - 4	VOCs
HCS-PWA-20	RI	9 - 10	VOCs
HCS-PWA-21	RI	10 - 11	VOCs
HCS-PWA-22	RI	11 - 12	VOCs
HCS-PWA-23	RI	10 - 11	VOCs
HCS-PWA-24	RI	11 - 12	VOCs
HCS-PWA-25	RI	11 - 12	VOCs
HCS-PWA-26	RI	11 - 12	VOCs
HCS-PWA-27	RI	11 - 12	VOCs
HCS-PWA-28	RI	11 - 12	VOCs
HCS-PWA-29	Phase II RI	4 - 6	SVOCs, Inorganics, TOC
HCS-PWA-29S	Phase II RI	0 - 1	SVOCs, Inorganics, TOC

Notes:
"ft bgs" = feet below ground surface
VOCs = volatile organic compounds
SVOCs = semivolatile organic compounds
TOC = total organic carbon

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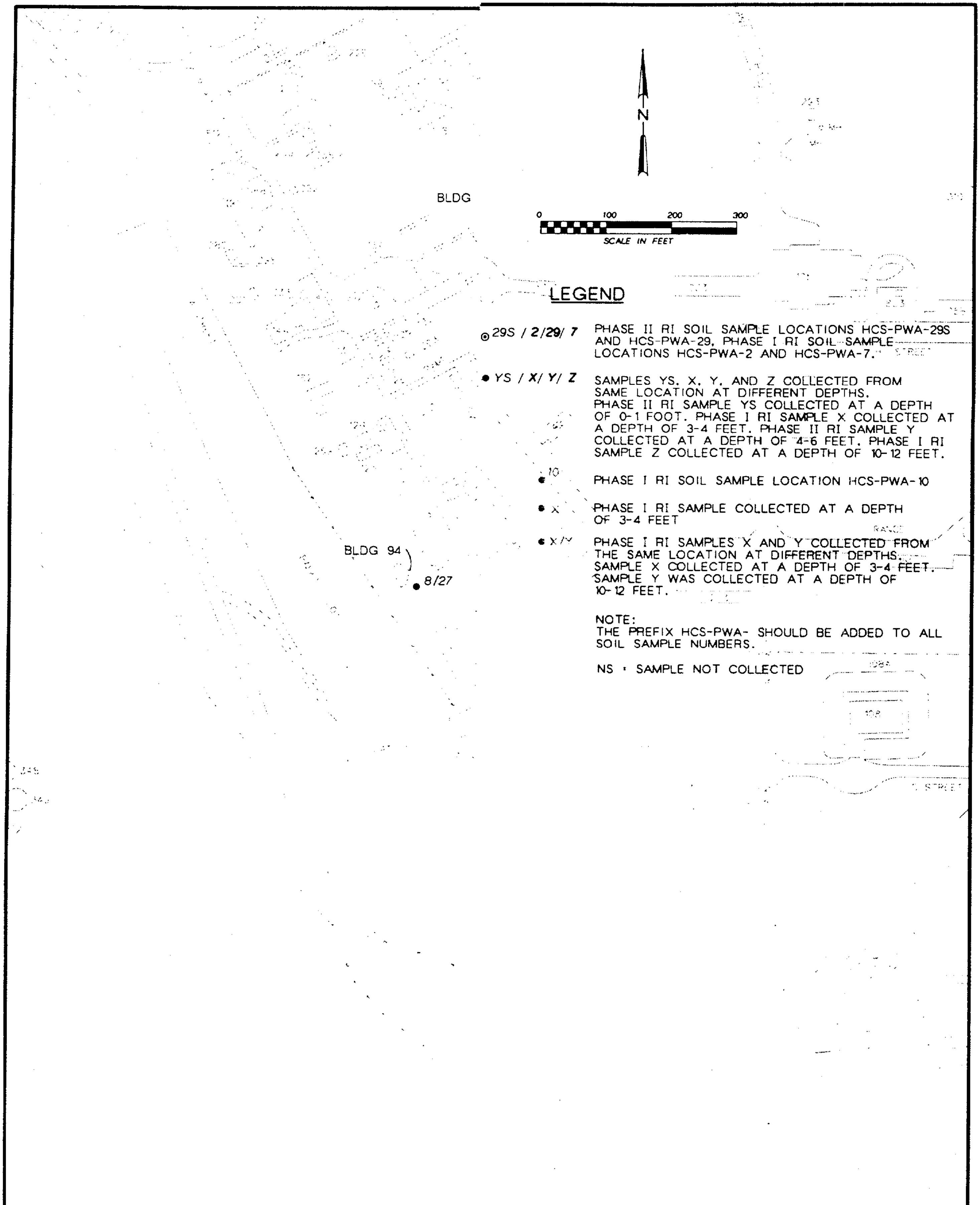

Figure 1-8
SITE 10 SAMPLE LOCATIONS
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

CH2M HILL

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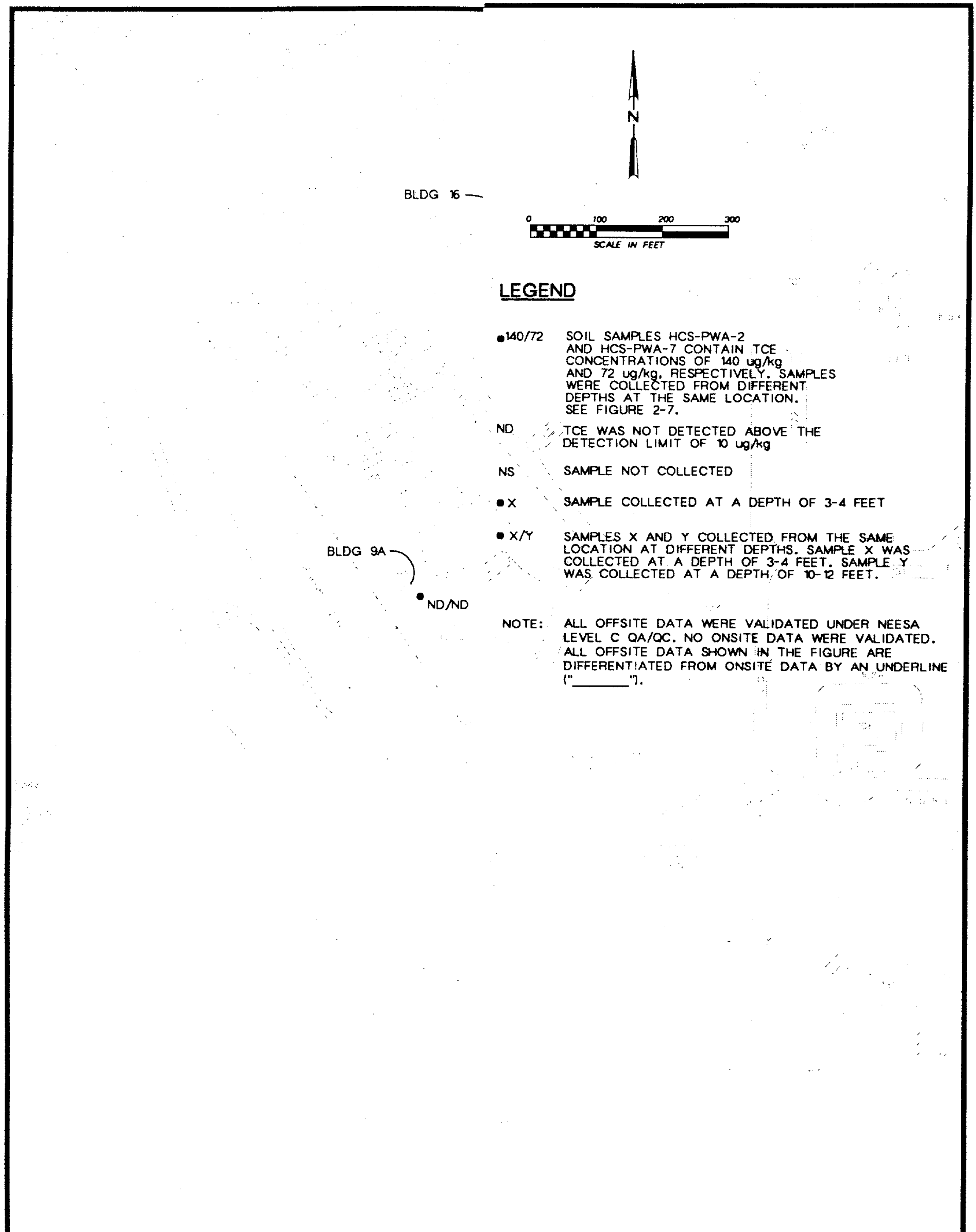

Figure 1-9
TCE CONCENTRATIONS DETECTED IN SOIL
10 FOCUSED FEASIBILITY STUDY
GANY BALLISTICS LABORATORY

CH2M HILL

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Groundwater Contamination

As part of the Phase I Aquifer Testing, groundwater samples were collected from all Site 10 wells to determine the nature and extent of groundwater contamination at and adjacent to Site 10. Groundwater samples also were collected by the Geoprobe® sampling method during the Phase II RI and Phase I Aquifer Testing. Wells in the vicinity of Site 10 were sampled during previous investigations. The analytical results of all groundwater samples collected are discussed below.

VOCs

Figure 1-10 presents the analytical results for seven VOCs in groundwater samples collected during both the Geoprobe® investigations and from Site 10 and vicinity alluvial monitoring wells. Figure 1-11 presents the analytical results for the same VOCs in groundwater samples collected from bedrock wells at and adjacent to Site 10.

Figures 1-10 and 1-11 show that TCE is the primary VOC detected in the alluvial and bedrock aquifers at Site 10. The figures also show that, in general, the highest concentrations of other VOCs are associated with samples containing the highest concentrations of TCE.

Figure 1-10 shows that the highest concentrations of VOCs in the alluvial aquifer were detected approximately 225 feet downgradient of the former TCE still adjacent to Building 157. TCE concentrations in Geoprobe® groundwater samples as high as 6,800 μg/l (Site10-GW-9) were detected in this area. TCE concentrations in samples collected from wells 10GW9 and 10GW11 were 240 μg/l and 830 μg/l, respectively. The discrepancy between the Geoprobe® and well sample results is likely due to the differences in the collection techniques and nature of the samples. The analytical results for the Geoprobe® groundwater samples should be interpreted as semi-quantitative because a Geoprobe® sample is collected from a discrete depth, usually just below the water table, and is generally very turbid as a result of the sampling technique. This is unlike a well sample, which is representative of the groundwater over a much larger portion of the aquifer and is generally free of suspended solids which can adsorb contaminants.

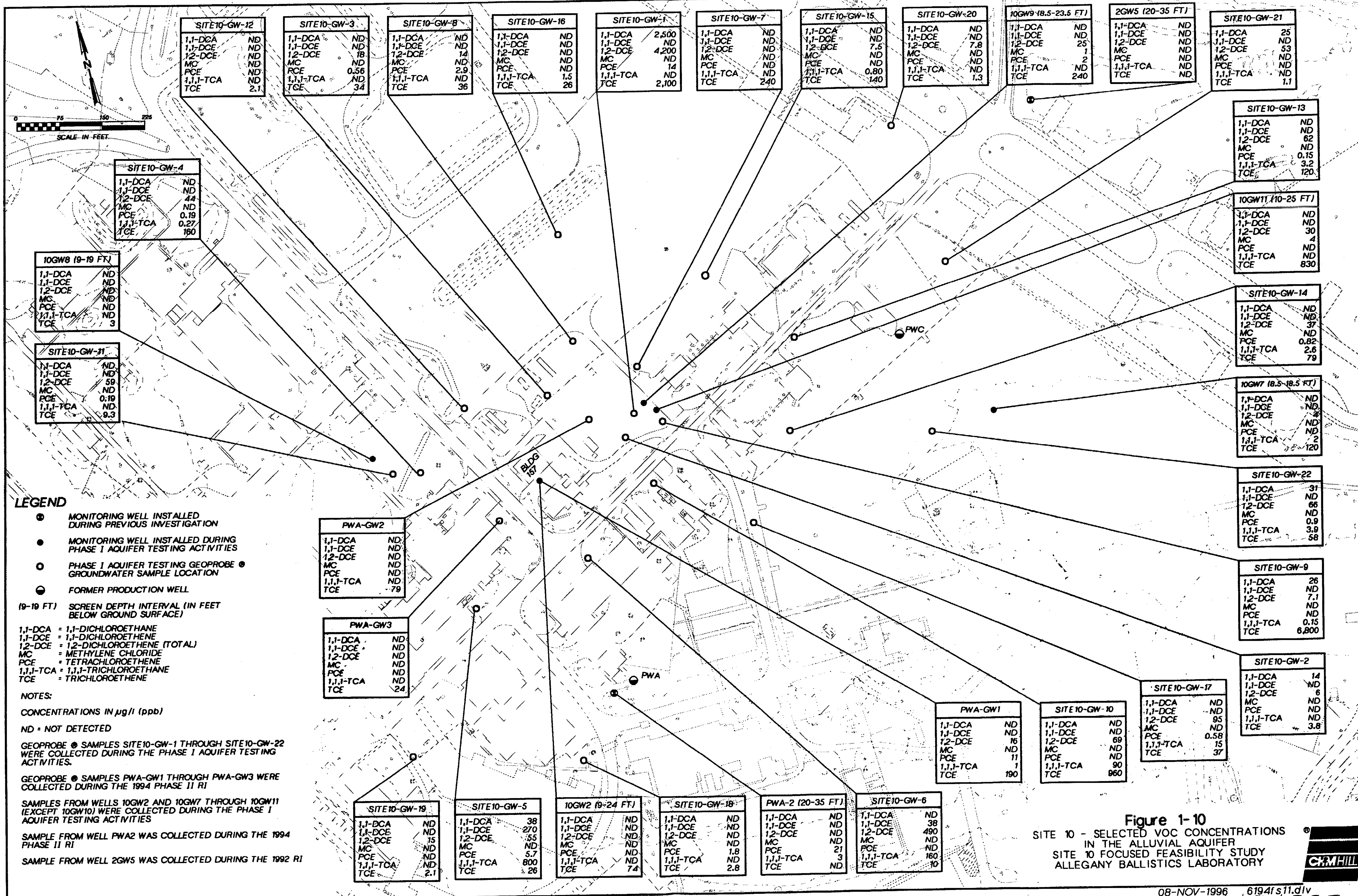

Figure 1-10
SITE 10 - SELECTED VOC CONCENTRATIONS IN THE ALLUVIAL AQUIFER
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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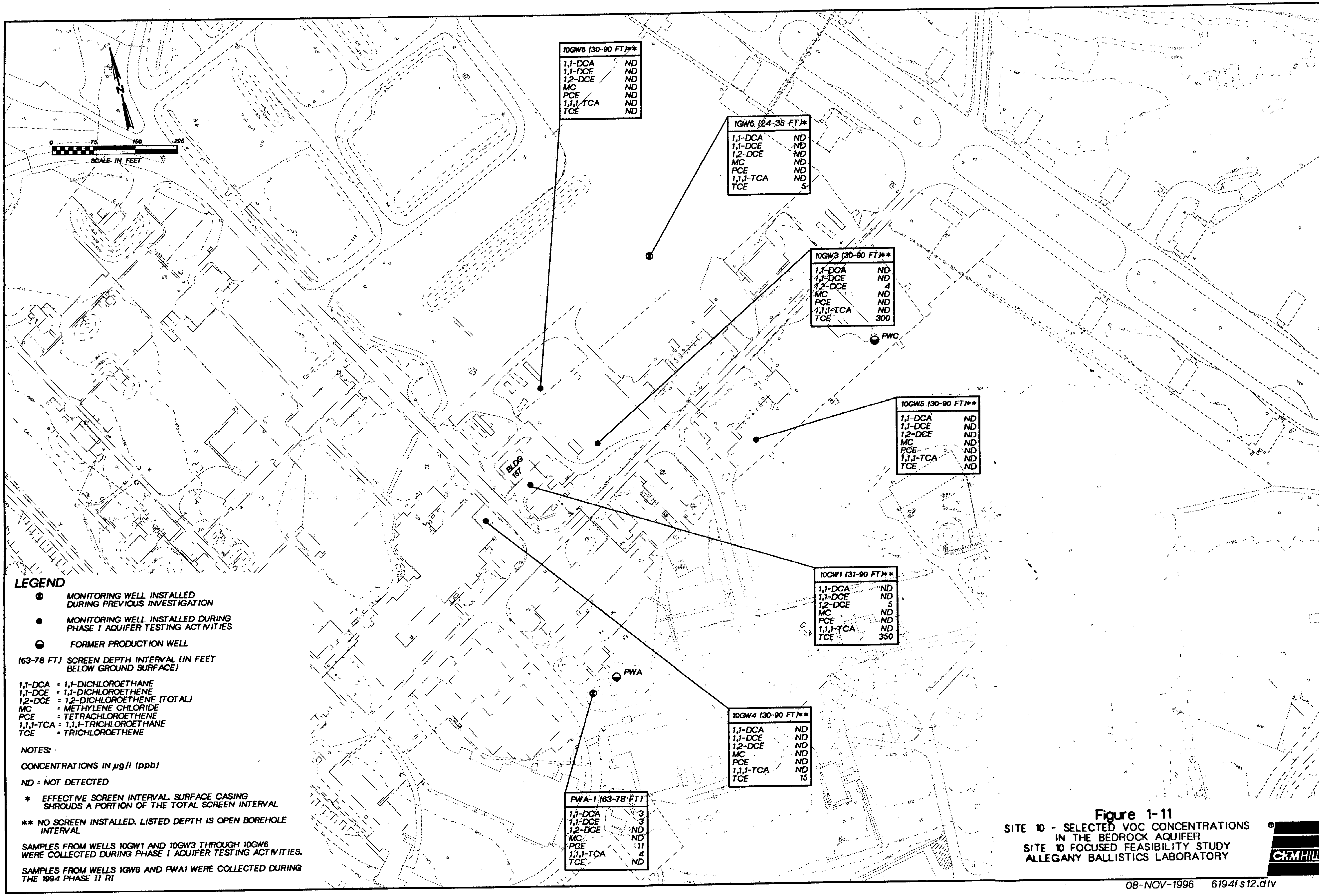

Figure 1-11
SITE 10 - SELECTED VOC CONCENTRATIONS IN THE BEDROCK AQUIFER
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

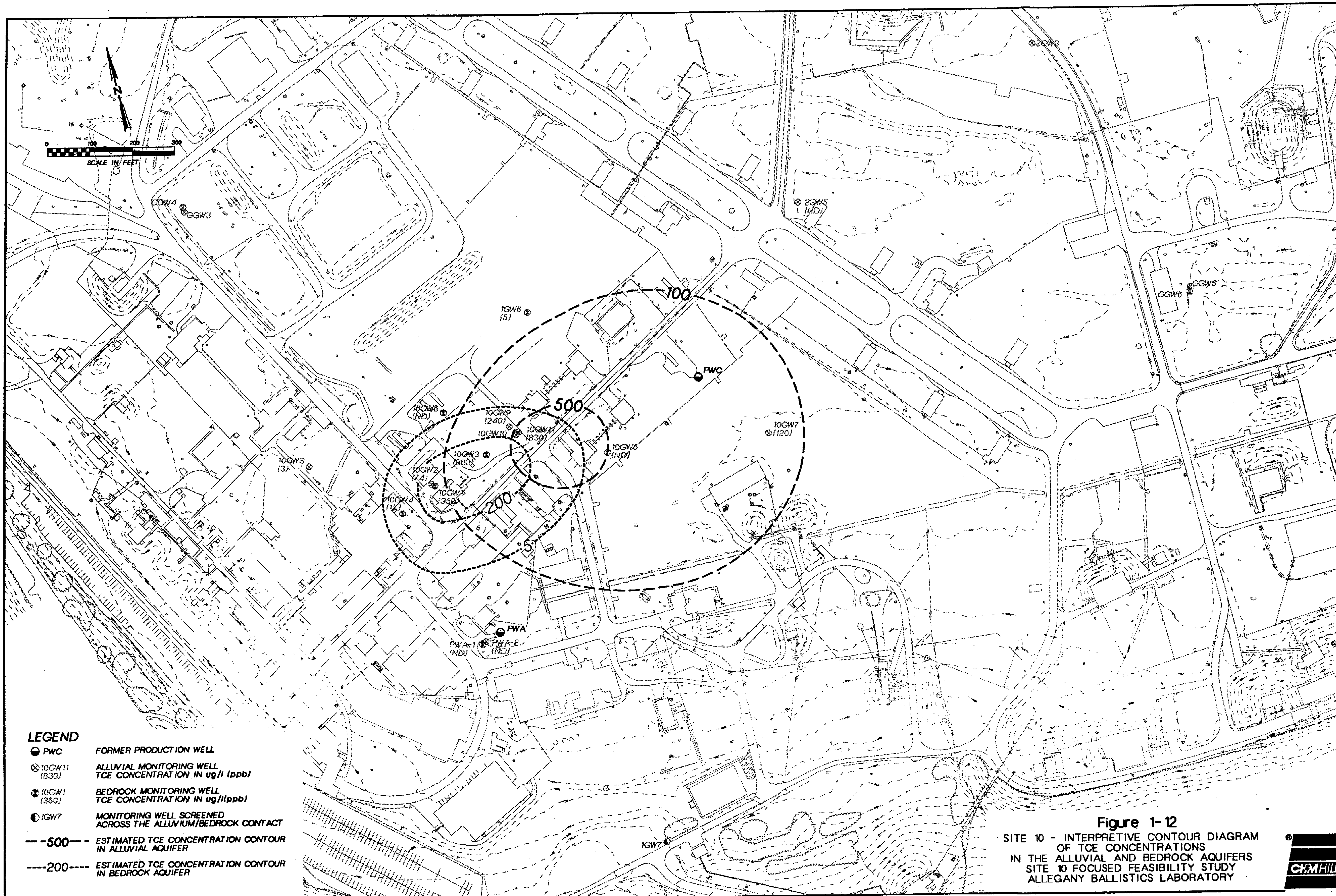

Figure 1-12
SITE 10 - INTERPRETIVE CONTOUR DIAGRAM OF TCE CONCENTRATIONS IN THE ALLUVIAL AND BEDROCK AQUIFERS
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

Figure 1-10 also shows that the Geoprobe® sample (PWA-GW1) and the well sample (10GW2) collected at the location of the former TCE still contained appreciably lower concentrations of TCE (i.e., 190 μg/l and 74 μg/l, respectively) than did the samples collected 225 feet downgradient. This suggests that the most concentrated portion of the alluvial contaminant plume originating at the former TCE still has moved downgradient.

Figure 1-11 shows that the highest concentrations of VOCs in the bedrock aquifer were found in samples collected from the wells closest to the former TCE still. Well 10GW1, at the location of the former TCE still, contained 350 μg/l of TCE and approximately 150 feet downgradient, well 10GW3 was found to contain 300 μg/l of TCE.

Based on the TCE concentrations displayed in figures 1-10 and 1-11, an interpretive contour diagram of the TCE concentrations in monitoring wells in the alluvial and bedrock aquifers at Site 10 was produced. Figure 1-12 indicates that the most concentrated portion of the TCE contaminant plume in the alluvium is centered approximately between alluvial well 10GW11 and bedrock well 10GW5, suggesting that the center of mass of the plume has migrated approximately 300 feet downgradient of the suspected source at Building 157. Conversely, the TCE contaminant plume in the bedrock has not moved far from the suspected source at Building 157 and, compared to the alluvial contaminant plume, has remained relatively condensed.

SVOCs

Geoprobe® groundwater sample PWA-GW1 (Figure 1-10), collected at the former TCE still location during the Phase II RI, was the only Site 10 groundwater sample to be analyzed for TCL SVOCs. No SVOCs were detected in the sample.

Inorganics

During the Phase I Aquifer Testing activities, samples collected from aquifer-test wells 10GW1 (bedrock) and 10GW11 (alluvium) were analyzed for inorganics to estimate the levels in groundwater potentially requiring pretreatment if extracted from Site 10.

The results of inorganics analysis on the samples collected from wells 10GW1 and 10GW11 suggested that, in general, the concentrations of most inorganics at Site 10 are similar to or lower than those at Site 1 (CH2M HILL, August 1995).

Of the total inorganics of concern from a treatment standpoint, calcium was detected at similar concentrations in both the alluvium (75,000 micrograms per liter [µg/L]) and bedrock (85,000 µg/L); approximately twice as much magnesium (Mg) and sodium (Na) was detected in the bedrock (16,000 µg/L Mg and 17,000 µg/L Na) than in the alluvium (7,000 µg/L Mg and 9,000 µg/L Na); and approximately four times as much iron was detected in the alluvium (5,000 µg/L) than in the bedrock (1,400 µg/L).

Of the total inorganics of concern from a human health or environmental risk standpoint, similar concentrations of arsenic (As) and barium (Ba) were detected in the alluvium (4 µg/L As and 50 µg/L Ba) and the bedrock (9 µg/L As and 70 µg/L Ba), but approximately seven times as much manganese was detected in the bedrock (210 µg/L) than in the alluvium (30 µg/L).

Contaminant Fate and Transport

This section summarizes the chemical and physical properties of contaminants detected at Site 10 that affect contaminant migration through various media. It also combines the interpretations discussed in the preceding subsections into a conceptual model of Site 10. This model is used to provide a qualitative description of the fate and transport of VOCs, SVOCs, and inorganics through media at Site 10.

Chemical and Physical Properties

Some of the chemical and physical properties of contaminants and the environment that affect the migration of contaminants through various media are the water solubility, volatility, Henry's Law Constant, carbon/water partition coefficient (K_{oc}), total organic carbon (TOC) content of the media, bioconcentration factor (BCF), and persistence.

In general VOCs have relatively high water solubilities and metals have relatively low water solubilities. However, the solubilities of metals can be greatly enhanced in the presence of organic solvents and when complexed with other chemicals.

The volatility of a chemical depends on its vapor pressure and water solubility. Chemicals with high vapor pressures and low water solubilities have a greater tendency to volatilize than chemicals with low vapor pressures and high water solubilities. Henry's Law Constants quantify the relationship between vapor pressure and water solubility and are more appropriate than vapor pressure alone for estimating releases of chemicals from water to air. In general, VOCs are more volatile than SVOCs, which are much more volatile than inorganics.

The partition coefficient (K_{oc}) is used to estimate the extent to which a chemical will partition between the organic material in the soil and the water moving through the soil. In general, chemicals with low K_{oc} values will preferentially move into the water phase, whereas chemicals with high K_{oc} values will tend to adsorb to the soil matrix. The distribution coefficient (K_d) is defined as the product of the K_{oc} and the fraction of organic carbon (foc). The foc is calculated from values of the total organic carbon (TOC) content of the soil, which are determined from analysis of soil samples collected in the field.

The BCF is the ratio of the concentration of a chemical in aquatic animal tissue to its concentration in water. The ratio is both contaminant-specific and biological species-specific. The higher the BCF, the greater the accumulation in living tissue is likely to be. Typically, pesticides and metals have higher BCFs than VOCs have.

Persistence, which is expressed in terms of a half-life, is a measure of how long a chemical will exist in air, water, or soil. Because persistence depends on many processes, such as chemical degradation and biodegradation, which are themselves highly variable, degradation rates have a high degree of variability. In general, metals are much more persistent in water and soil than VOCs and SVOCs.

Fate and Transport

As discussed above, the fate and transport of any contaminant depends on a combination of its chemical and physical properties and the properties of the media through which it is moving. The following subsections describe how the various contaminants of concern move between the media at Site 10.

VOCs

Data collected during the RI indicate that TCE was the most common VOC found in soil at and around Site 10. In fact, most of the TCE detections occurred in the vicinity of the former TCE still and that in this area, soil TCE concentrations up to approximately 300 μg/kg were detected. Because the TCE still has not operated for over 35 years and TCE is a very mobile compound, the TCE concentrations recently detected in the surrounding soil suggest that the still was a significant source of VOC contamination and that most of the TCE has migrated from the soil into the groundwater. Some TCE likely has degraded to other VOCs such as 1,1-DCE and 1,2-DCE.

Groundwater data collected at Site 10 during the Phase II RI and Phase I Aquifer Testing suggest that the former TCE still was a source of significant VOC groundwater contamination. As shown in Figure 1-10, the highest concentrations of VOCs, TCE in particular, in alluvial groundwater were detected approximately 225 feet downgradient of the former TCE still. Here, concentrations of TCE up to 6,800 μg/L and 830 μg/L were detected in Geoprobe® and well samples, respectively.

Figure 1-11 shows that the highest concentrations of VOCs in bedrock groundwater at Site 10 were detected at the location of the former TCE still. The figure also shows that the bedrock contaminant plume has also migrated downgradient, but to a lesser extent than the contaminant plume in the alluvium.

VOC data from Site 10 suggest that the VOCs released from the former TCE still adjacent to Building 157 were solubilized by infiltrating precipitation and transported to the alluvial and bedrock groundwater. Figure 1-12 shows that the process of dispersion has had an impact on the alluvial and bedrock contaminant plume. Dispersion reduces VOC concentrations along a flowpath by moving some VOC molecules ahead of the center of mass while causing others to lag behind and still others to move horizontally and vertically perpendicular to the flow direction. Dispersion may explain why TCE and other VOCs were detected in wells PWA, PWA1, and PWA2, which are located approximately 400 feet south of Building 157. Over time, it is conceivable that the VOCs entering the groundwater in the vicinity of the former TCE still could have migrated laterally with respect to the direction of primary groundwater flow. Additionally, well PWA was used historically as a plant production well. During pumping of well PWA, the horizontal hydraulic gradients in the vicinity of the well likely were altered such that the direction of groundwater flow in the vicinity of the former TCE still was toward the production well.

SVOCs

Data collected during the Phase II RI at the location of the former TCE still show that no SVOCs were detected in soil or alluvial groundwater, indicating that the still was not a significant source of SVOC contamination at Site 10.

Inorganics

Data collected during the RI and Phase II RI at Site 10 indicate that soil inorganics concentrations are similar to those of "background" soil samples and that elevated levels of inorganics are not found in wells PWA, PWA1, PWA2, 10GW1, or 10GW11. This suggests that there is not a significant source of inorganics at Site 10.

Baseline Human-Health Risk Assessment

The baseline risk assessment characterizes risks to human health at the site. This characterization is based on the assumption that site conditions will remain unchanged (contaminant concentrations will not increase or decrease in the reasonable foreseeable future). The risk assessment, primarily based on USEPA risk assessment guidance, is described fully in the Phase II RI Report and summarized here. It is important to note that the risk assessment was not revised using new data generated from the Phase I Aquifer Testing. This is because the basic conclusion that groundwater contamination exceeds maximum contaminant levels (MCLs) and therefore, must be addressed, would not change.

Identification of Chemicals of Potential Concern

A selection process was used to reduce the field of detected chemicals to those considered to be the most important to the human health evaluation (chemicals of potential concern [COPC]). Identification of the COPC was based on methods described in *Risk Assessment Guidance for Superfund* (USEPA, 1989a, 1991b), *Guidance for Data Usability in Risk Assessment* (USEPA, 1992a), and *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening* (USEPA, 1993b). The maximum detected contaminant concentrations were screened against risk-based concentrations (RBCs) and background concentrations. The lowest RBC from all receptors and exposure routes for a particular medium was selected for this comparison. Human nutrients and constituents detected in less than 5 percent of the total samples were not considered COPC. Constituents that exceeded RBCs and background concentrations, that are not human nutrients, and were detected in greater than 5 percent of the samples were selected as COPC.

The chemicals identified as COPC at Site 10 are provided in Table 1-6 and were carried through the quantitative risk-assessment process if toxicity values were available from USEPA's IRIS, HEAST, or ECAO.

Exposure Assessment

This section identifies the pathways associated with potential exposures to COPC for Site 10. It addresses exposures under current site conditions and exposures that could result from potential uses of the site and surrounding area in the future (assuming no action). The magnitude, frequency, and duration of exposure are needed to quantify risks.

Table 1 - 6 Screening of Contaminants of Potential Concern Site 10 Focused Remedial Investigation						
	Surface Soil				Subsurface Soil	Groundwater
	Current	Future			Future	Future
Compound	Adult	Resident		Construction	Construction	Resident*
	Worker	Child	Adult	Worker	Worker	
Volatile Organics						
Acetone	NA	NA	NA	NA	ND	R
1,1-Dichloroethane	NA	NA	NA	NA	ND	R
1,1-Dichloroethene	NA	NA	NA	NA	ND	X
1,2-Dichloroethene (total)	NA	NA	NA	NA	ND	X
1,2-Dichloroethene (cis)	NA	NA	NA	NA	R	NA
Methylene chloride	NA	NA	NA	NA	ND	X
Tetrachloroethene	NA	NA	NA	NA	R	X
1,1,1-Trichloroethane	NA	NA	NA	NA	ND	R
Trichloroethene	NA	NA	NA	NA	R	X
Inorganics						
Aluminum	R	X	X	R	R	R
Arsenic	X	X	X	X	X	X
Barium	R	R	R	R	R	R
Beryllium	R	X	X	R	R	ND
Cadmium	ND	ND	ND	ND	R	ND
Calcium	H	H	H	H	H	H
Chromium, total	R	R	R	R	R	ND
Cobalt	R	R	R	R	R	ND
Copper	R	R	R	R	R	R
Iron	H	H	H	H	H	H
Lead	R	R	R	R	R	R
Magnesium	H	H	H	H	H	H
Manganese	R	R	R	X	R	X
Mercury	ND	ND	ND	ND	ND	R
Nickel	R	R	R	R	R	R
Potassium	ND	ND	ND	ND	ND	H
Silver	ND	ND	ND	ND	R	ND
Sodium	ND	ND	ND	ND	ND	H
Vanadium	R	R	R	R	R	ND
Zinc	R	R	R	R	R	R

Notes

H - Eliminated as a COPC because constituent is a human nutrient and was detected below toxic levels.
R - Eliminated as a COPC because the maximum concentration was less than the risk-based screen.
T - Eliminated as a COPC for quantitative evaluation because toxicity value not available. Constituent was qualitatively evaluated.
X - Constituent was selected as a COPC.
ND - Not detected.
NA - Not analyzed.
* - Future Resident screen is for adult and child.
Table only includes constituents which have been detected at Site PWA.

Land Use and Elements of Exposure

ABL is an industrial facility, but there are residential areas bordering the site. These local residences use groundwater for their potable water supply. Access to Site 10 is currently restricted to onsite workers by fences and security guards.

The human health risk assessment was conducted under the assumption that the site will remain in its present state and that no restrictions will be placed on its future use. Therefore, residential use is a potential future exposure setting.

Exposure Pathways and Potential Receptors

Site 10 consists of the area between former production wells PWA and PWC, including the location of the former TCE still at Building 157. Reportedly, a TCE still operated adjacent to Building 157 from 1959 to 1960. The former TCE still is the probable source of TCE contamination detected in Site 10 wells and wells PWA and PWC.

On the basis of a review of the area setting, the nature and extent of contamination, plausible exposure pathways, and USEPA guidance, potential receptors at the site are depicted in Figure 1-13. Under the current scenario, potential receptors were quantified for onsite workers. Under the future land use scenario, potential exposures were quantified for a child and adult resident and a construction worker.

Site 10 is likely to remain industrial; however, exposure to surface soil was assumed for a future residential scenario, as suggested by USEPA guidance. A construction worker could be exposed to both surface and subsurface soil during excavation and construction and, therefore, exposure to both were evaluated.

Exposure to groundwater was evaluated for the future resident scenario for both the alluvial and bedrock aquifers. If the groundwater on the site was used by a future resident, exposure could occur through ingestion of drinking water, inhalation of volatile constituents while showering, and dermal contact while bathing or washing. Ingestion and inhalation exposure were evaluated for an adult, and ingestion and dermal exposure were evaluated for a child.

Medium | **Release Mechanism/Pathway** | **Exposure Routes & Potential Receptors**

Soils

- Surface
  - Volatiles or airborne particulates
  - Direct contact
- Subsurface

Groundwater

- Alluvial
- Bedrock

Current Scenario: Worker, Recreational Youth, Recreational Adult
Future Scenario: Child Resident, Adult Resident, Construction Worker

Soils – Surface (Volatiles or airborne particulates; Direct contact)

	Worker	Recreational Youth	Recreational Adult	Child Resident	Adult Resident	Construction Worker
Inhalation						•
Ingestion	•			•	•	•
Dermal	•			•	•	•

Soils – Subsurface

	Worker	Recreational Youth	Recreational Adult	Child Resident	Adult Resident	Construction Worker
Inhalation						•
Ingestion						•
Dermal						•

Groundwater (Alluvial, Bedrock)

	Worker	Recreational Youth	Recreational Adult	Child Resident	Adult Resident	Construction Worker
Inhalation	x				•	
Ingestion	x			•	•	
Dermal	x			•		

• Denotes exposure pathways and routes selected for quantitative risk assessment.
x Denotes exposure pathways selected for qualitative risk assessment.

Figure 1-13
EXPOSURE MODEL FOR SITE 10
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

Exposure Quantification

Quantifying exposure required estimating exposure-point concentrations (EPCs) for COPC and calculating intakes. Exposures were quantified for the plausible receptors and pathways portrayed in Figure 1-13. Two scenarios were identified for exposure quantification; (1) the reasonable maximum exposure (RME) case, and (2) the most likely exposure case; both of which are defined in the Phase II RI Report.

Risk Characterization

The noncancer hazard indices (HIs) and cancer risks and major sources of risk at Site 10 are discussed below for exposure to surface soil, subsurface soil, and groundwater. Table 1-7 presents the risk estimates for each medium and receptor. If the site use and exposure levels in the future remain similar to the current conditions, then the risks estimated for the current site use will approximate the future risks. However, unrestricted residential land use is assumed for the future.

Surface Soil Exposure Pathways

Risk estimates were calculated for the onsite worker and residential receptors potentially exposed to surface soil via incidental ingestion and dermal contact and for the construction worker exposed to surface soil via incidental ingestion, dermal contact, and inhalation. The surface soil risks are discussed below.

Current Onsite Worker. The cumulative hazard indices for ingestion of and dermal contact with surface soil for Site 10 are less than 1. The cumulative ingestion and dermal contact cancer risk is 5×10^{-6}, well within EPA's target risk range of 1×10^{-6} to 1×10^{-4}.

Future Construction Worker. The cumulative noncancer hazard index and cancer risk from exposure via inhalation of volatiles and fugitive dust and ingestion of and dermal contact with Site 10 surface soil are 0.1 and 8×10^{-7}, respectively, both of which are below EPA's target values.

Table 1-7
Risk Summary By Media and Receptor
Site 10 Focused Feasibility Study

	Current		Future				
	Worker Adult		Resident			Construction Worker	
			Child and Adult[1,2]	Child	Adult		
	Cancer	Noncancer	Cancer	Noncancer	Noncancer	Cancer	Noncancer
Surface Soil							
Inhalation						1.4E-08	2.1E-04
Ingestion	1.7E-06	1.1E-02	2.3E-05	4.0E-01	4.2E-02	6.5E-07	1.0E-01
Dermal	3.5E-06	2.2E-02	1.8E-05	2.3E-01	5.7E-02	1.4E-07	2.2E-02
Total	**5E-06**	**3E-02**	**4E-05**	**6E-01**	**1E-01**	**8E-07**	**1E-01**
Subsurface Soil							
Inhalation						2.7E-08	1.0E-01
Ingestion						1.3E-06	4.4E-01
Dermal						2.8E-07	5.9E-02
Total						**2E-06**	**6E-01**
Groundwater							
Reasonable Maximum							
Inhalation			2.7E-05		1.9E+00		
Ingestion			9.6E-05	3.0E+00	1.3E+00		
Dermal			1.2E-05	1.2E+00			
Total			**1E-04**	**4E+00**	**3E+00**		
Most Likely							
Inhalation			1.3E-05		3.3E-01		
Ingestion			6.6E-05	8.3E-01	3.6E-01		
Dermal			4.1E-06	2.3E-01			
Total			**8E-05**	**1E+00**	**7E-01**		

All total numbers are rounded to the nearest whole number

[1] The soil cancer risk for a combined child and adult (age-adjusted).

[2] The groundwater cancer risk for inhalation is for an adult, the ingestion is a combined child and adult (age-adjusted), and the dermal is for the child.

Future Resident. The cumulative hazard index and cancer risk associated with future residential exposure to surface soil at Site 10 are 0.1 (0.6 for child resident) and 4×10^{-5}, respectively, which are below or within EPA's target values.

Subsurface Soil Exposure Pathways

Risk estimates were calculated for the future construction worker potentially exposed to subsurface soil via incidental ingestion, dermal contact, and inhalation. The subsurface soil risks are discussed below.

Future Construction Worker. The cumulative hazard index and cancer risk associated with future construction worker exposure to Site 10 subsurface soil by inhalation, ingestion, and dermal contact are 0.6 and 2×10^{-6}, respectively.

Groundwater Exposure Pathways

There is no current exposure to contaminated groundwater at Site 10 because groundwater is no longer used as a drinking water source at ABL. Groundwater risks for potential future exposure scenarios were calculated using the most likely residential water supply source and a reasonable maximum residential water supply source. The majority of the residences in the vicinity of the site are supplied by individual wells that are in the bedrock aquifer. Therefore, the most likely future groundwater supply for Site 10 was assumed to be the bedrock aquifer. Although the alluvial aquifer may not be able to sustain a sufficient yield for use as a domestic or industrial groundwater supply, it was conservatively considered as a potentially complete future groundwater exposure pathway. Therefore, the alluvial aquifer was evaluated as a reasonable maximum exposure scenario per directions from EPA Region III (USEPA, 1995a).

Future adult resident exposure pathways for groundwater consist of ingestion of groundwater, inhalation of VOCs while showering, and dermal contact with contaminated groundwater while washing or bathing. Future child resident exposure pathways for groundwater are ingestion of groundwater and dermal contact while bathing.

Risks for the Most Likely Water Supply Scenario. The adult noncancer hazard index and cancer risk associated with exposure to groundwater were below or within EPA's target levels. The child noncancer hazard index was just above EPA's target value.

> *Child.* The cumulative hazard index for ingestion is 0.83 (Table 1-7), which is below the threshold level of 1. The cumulative hazard index for dermal contact while bathing is 0.23. The cumulative hazard index across pathways is 1.06, just above the EPA threshold value of 1.

> *Adult.* The cumulative hazard index for inhalation, ingestion, and dermal contact with contaminated groundwater is 0.7 (Table 1-7), which is below the threshold value of 1.

Risks for the Reasonable Maximum Water Supply Scenario. The noncancer hazard index values for inhalation, ingestion, and dermal contact with groundwater at Site 10 were all above EPA recommended levels. Individual cancer risks associated with exposure to groundwater were within EPA recommended levels.

> *Child.* The cumulative hazard index for ingestion is 3.0 (Table 1-7), which exceeds the threshold level of 1. TCE contributes 67 percent of the ingestion hazard. The cumulative hazard index for dermal contact while bathing is 1.2 (Table 1-7), which slightly exceeds the threshold level of 1. TCE contributes 88 percent of the dermal hazard due to bathing with groundwater.

> *Adults.* The cumulative hazard indices for inhalation of volatiles from groundwater while showering (1.9) and ingestion of groundwater (1.3) (Table 1-7), are both above the threshold level of 1. TCE contributes 88 percent of the inhalation hazard and 67 percent of the ingestion hazard. The oral reference dose (RfD) for TCE was used to quantify inhalation hazards because there is no published inhalation RfD. The total age-adjusted cancer risk for groundwater exposure including inhalation while showering for the adult, dermal contact while bathing for the child, and ingestion is 1.4×10^{-4}, which is above the upper bound of the EPA target risk range.

Summary

The contamination present at Site 10 can be attributed to a TCE still. The results of the excess lifetime cancer risks and noncancer hazard indices calculations for exposure to Site 10 surface soil, subsurface soil, and groundwater are summarized in Table 1-8. The potentially exposed receptor populations are current onsite workers, potential future residential children and adults, and potential future workers. Under current conditions, the cumulative noncancer risk due to surface soil exposure by industrial workers is almost two orders of magnitude below the threshold value of 1 for Site 10. The total excess lifetime cancer risk to the current worker at Site 10 is 5×10^{-6}.

The pathways that were combined to get the total noncancer and cancer risks for the future residential scenario were the surface soil and the most likely groundwater supply exposures. The bedrock aquifer is the most likely groundwater source for the site because the alluvial aquifer is not believed to sustain enough yield to be used as a water source. The total noncancer risk from all pathways for a potential future residential child is twice the EPA risk level of 1. The total noncancer risk for a future residential adult at Site 10 is 0.8. The age-adjusted cancer risk at Site 10 (1.2×10^{-4}) is just above the EPA recommended target risk range of 1×10^{-6} to 1×10^{-4}. TCE is the main driver for this risk. Combining the risk due to alluvial groundwater usage (reasonable maximum groundwater supply) with the residential soil exposure risk increases the risk to future residents by less than an order of magnitude.

Baseline Ecological Risk Assessment

The intent of the baseline ecological risk assessment (ERA) was to characterize potential receptors and to estimate the potential hazard or risk to environmental receptors. Existing environmental information was compiled from the RI and Phase II RI and compared to accepted guidelines and criteria. Contaminant pathways were identified to evaluate receptors potentially at risk. The ERA generally followed USEPA guidance for performing ecological risk assessments.

Table 1-8
NONCANCER AND CANCER RISK SUMMARY
Site 10 Focused Feasibility Study

Current Industrial Site Use

	Site Worker				Recreational River User			
	Hazard Index	% of Total	Cancer Risk	% of Total	Hazard Index	% of Total	Cancer Risk	% of Total
Surface Soil	3E-02	100	5E-06	100				
Surface Water	NCP		NCP		NCP		NCP	
Sediment	NCP		NCP		NCP		NCP	
Total (rounded)	3E-02		5E-06					

Future Residential Use Scenario

	Child		Adult		Age-adjusted	
	Hazard Index	% of Total	Hazard Index	% of Total	Cancer Risk	% of Total
Surface Soil	6E-01	37	1E-01	13	4E-05	33
Groundwater (reasonable max.)	4E+00	249	3E+00	406	1E-04	109
Groundwater (most likely)	1E+00	63	7E-01	87	8E-05	67
Total (rounded)*	2E+00		8E-01		1E-04	

Future Use Scenario (Construction)

	Construction Worker	
	Hazard Index	Cancer Risk
Surface Soil	1E-01	8E-07
Subsurface Soil	6E-01	2E-06
Maximum	6E-01	2E-06

NCP - not a complete pathway

* Total is sum of the surface soil and the most likely groundwater scenario

Source Characterization and Exposure Pathways

Sources of contamination were determined based on analytical results of groundwater and soil. Exposure pathways are identified and discussed below.

Source Characterization

Analytical data compiled for the RI and Phase II RI were analyzed using USEPA Region III's guidance for determining environmental effects quotients (EEQs). EEQs were calculated for Site 10 soil only. EEQs were not derived for groundwater because the connection between potentially contaminated groundwater and ecological resources is via the surface water of the North Branch Potomac River.

The soil data were compared to screening values presented in EPA (1995) for flora and fauna. Based on EPA guidance, EEQs greater than 1 represent a potential risk, greater than 10 potentially represent moderately adverse effects, while EEQs greater than 100 represent a significant potential for adverse effects.

TCE and cis-1,2-dichloroethene (cis-1,2-DCE) were the only VOCs detected in Site 10 soil samples. No SVOCs were detected in Site 10 soil samples. Several inorganics, including aluminum, lead, and chromium, were detected in Site 10 soils at concentrations representing substantial environmental effects.

Exposure Pathways

Site 10 is subject to frequent physical disturbances by mowing and other regular maintenance activities. In addition, human activity is a regular occurrence as people pass through the area during working hours. Because of these human encroachments, any wildlife usage of this area is limited to those species that are readily adaptable to the presence of human activity. The biological resources that may occur include a variety of insects, invertebrates, mammals, birds, amphibians, and reptiles. The extent to which wildlife use Site 10 is a function of the normal operation and maintenance (O&M) activities at ABL. The frequent human disturbances and the limited habitat provided result in biological communities that involve fewer numbers and types of wildlife than would occur in natural, larger and less disturbed settings.

Exposure Assessment

TCE and cis-1,2-DCE were the only VOCs detected in Site 10 soil samples. The EEQs for both VOCs are less than 1.0. Therefore, these compounds are not contaminants of concern at this site.

No SVOCs were detected in Site 10 soil, but because EEQs are determined using half the detection limit for all non-detects, the EEQs for most SVOCs exceeded 1.0. However, SVOCs are not considered contaminants of concern in Site 10 soil.

Thirteen inorganics exceeded an EEQ of 1 for Site 10 soil. Similar to other ABL sites, aluminum had the highest EEQ, followed by chromium, lead, thallium, iron, beryllium, and vanadium. Sample PWA-29 had four inorganics that exceeded EEQs for background soil conditions. The arsenic level in PWA-29 was 13.1 milligrams per kilogram (mg/kg), which is approximately twice that in the background soil samples. The EEQ for arsenic was 0.04, indicating arsenic in Site 10 soil does not represent a potential risk. The EEQ for cadmium (0.92) exceeded background but was less than 1. The EEQ for iron was 413, which is more than two times less than iron detected in background soil samples. Iron in sample PWA-29S (EEQ of 272) was slightly greater than background (EEQ of 239). The concentrations of manganese in sample PWA-29 resulted in EEQs of approximately 3.2 to 3.6, which represents a potential risk. EEQs for lead were over 1,500 in Site 10 soil samples; however, this level is approximately one half of the value detected in representative background soil samples.

Characterization of Ecological Effects

SVOCs, specifically polycyclic aromatic hydrocarbons (PAHs), show little tendency for long-term bioaccumulation because most PAHs are rapidly and extensively metabolized. In some plants growing in highly contaminated areas, assimilation of PAHs may exceed metabolism and degradation, resulting in accumulation in plant tissues. PAHs are moderately persistent in the environment and therefore may cause significant effects to vegetation, wildlife, and fish. The carcinogenicity of individual PAHs differs, but is often related to their molecular weights.

The inorganic parameters of concern at Site 10 include manganese, iron, and arsenic. All of these elements occur in relatively low concentrations in Site 10 soil and all are essential for normal growth in most plants and animals. Excessive concentrations of inorganics may have a variety of effects, both acute and chronic.

Risk Characterization

The presence of arsenic, iron, and manganese at Site 10 at levels above background does not appear to represent a risk to wildlife at this site. The area undergoes frequent disturbances, which limits the type and abundance of wildlife at this site. Because of the relatively low EEQs, the consistency of Site 10 data with background concentrations, the disturbed and low quality habitat, and the relatively small area of habitat, the site appears to represent a moderate to high risk to ecological resources.

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Section 2
Remedial Action Objectives and ARARs

This section presents general and site-specific RAOs and identifies corresponding applicable or relevant and appropriate requirements (ARARs) to address human and environmental health risks associated with soil and groundwater contamination at Site 10.

General RAOs are defined by the NCP and CERCLA (as amended by SARA), which are applicable to all Superfund sites. CERCLA defines the statutory requirements for developing remedies.

Site-specific RAOs relate to specific contaminated media (soil and groundwater) and to potential exposure routes. Site-specific objectives, which require an understanding of the contaminants and the physical properties in their respective media, are based on an evaluation of the risks to humans and the environment along with the ARARs.

NCP and CERCLA Objectives

The NCP requires that the selected remedy meets the following objectives:

- Each remedial action selected shall be protective of human health and the environment (40 CFR 300.430 (f)(ii)(A)).
- Onsite remedial actions that are selected must attain those ARARs that are identified at the time of the Record of Decision (ROD) signature (40 CFR 300.430(f)(ii)(B)).
- Each remedial action selected shall be cost-effective. A remedy shall be cost-effective if its costs are proportional to its overall effectiveness (40 CFR 300.430 (f)(ii)(D)).

- Each remedial action shall use permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable (40 CFR 300.430 (f)(ii)(E)).

The statutory scope of CERCLA was amended by SARA to include the following general objectives for remedial action at all CERCLA sites:

- Remedial actions "shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a minimum which assures protection of human health and the environment" (Section 121(d)).

- Remedial actions "in which treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element" (Section 121(b)) are preferred. If the treatment or recovery technologies selected are not a permanent solution, an explanation must be published.

- The least-favored remedial actions are those that include "offsite transport and disposal of hazardous substances or contaminated materials without treatment where practicable treatment technologies are available" (Section 121(b)).

- The selected remedy must comply with or attain the level of any "standard, requirement, criteria, or limitation under any federal environmental law. . .or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation" (Section 121(d)(2)(A)).

Development of Site-Specific Objectives

Site-specific RAOs are based on the exposure setting for which protection would be provided (e.g., protection from ingestion of or direct contact with contaminated soil). The potential exposure routes and risks for Site 10 were identified in the risk assessments presented in the Phase II RI and summarized in Section 1 of this FFS.

Identification of Environmental Media

The Phase II RI, which included baseline human health and ecological risk assessments, identified the following environmental media as posing a potential risk to human health and the environment:

- Surface and subsurface soil
- Groundwater beneath the site in the alluvial and shallow bedrock aquifers

Site-specific RAOs were established for each medium.

Site-Specific Remedial Action Objectives

Site-specific RAOs have been established to address the potential risks posed by each medium. Both the level of contamination and the potential exposure route are considered when developing RAOs for protecting human health and the environment. The future protection of environmental resources and the means of minimizing long-term disruption to existing facility operations are also considered.

The site-specific RAOs for surface and subsurface soil are:

- Prevent or minimize the exposure of future site residents and construction workers to contaminated soil.

- Prevent or minimize migration and leaching of contaminants from the soil that may result in contamination of groundwater above health-based criteria and ARARs.

The site-specific RAOs for groundwater in the alluvial and bedrock aquifers are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.

- Prevent or minimize offsite migration of contamination originating from Site 10.

Cleanup goals for each contaminant of concern have not been identified in the site-specific RAOs for each medium at this time. Cleanup goals will be presented in the proposed remedial action plan for Site 10.

Development of Preliminary Remediation Goals for Soil

The first step in setting cleanup goals is to establish PRGs for each contaminant of concern in soil and groundwater. Soil and groundwater cleanup goals will be based on ARARs and on risk-based concentrations (RBCs) established by the EPA. Data to be used for establishing PRGs for the contaminants of concern in surface and subsurface soil are presented in Table 2-1.

Table 2-1 presents surface and subsurface soil RBCs and ARARs for the COPCs identified in the human health risk assessment. The surface soil COPCs include aluminum, arsenic, and beryllium, and the subsurface soil COPCs include arsenic and manganese. The ARARs included in the table are the EPA Region III RBCs for soil ingestion under residential and industrial exposure scenarios. Background concentrations for each COPC are also shown. The background concentrations were developed in a memorandum from the Navy to the USEPA and the West Virginia Department of Environmental Protection (WVDEP) in which a facility-wide statistical analysis of inorganic analytical results was performed to develop inorganic background concentrations specific to the ABL facility.

From Table 2-1 it is evident that the maximum detected concentration of each surface soil COPC is equal to or below the background concentration. In addition, the maximum detected concentrations of aluminum and arsenic are below the residential RBC. The maximum detected concentration of beryllium is below the industrial RBC. Therefore, no surface soil preliminary remediation goals (PRGs) will be established, and no remedial alternatives will be developed in this FFS to remediate Site 10 surface soil.

Table 2-1
Chemical-Specific ARARs and RBCs for Surface and Subsurface Soil
Allegany Ballistics Laboratory - Site 10

Constituents [a]	Maximum Detected Concentration (mg/kg)	Background Concentration (mg/kg)	Residential RBC (mg/kg) [b]	Industrial RBC (mg/kg) [b]	Carcinogenic RBC (mg/kg) [c]
Surface Soil					
Aluminum	9,040	9,119	78,000	1,000,000	7800 [d]
Arsenic	6.5	7.6	23	610	0.43 [d]
Beryllium	1.2	1.2	0.15	1.3	0.15 [d]
Subsurface Soil					
Arsenic	13.1	7.7	23	610	6.4 [e]
Manganese	1,200	838	390	10000	510 [e]

[a] Constituents included in this table were identified as COPC in the human health risk assessment.

[b] The residential and industrial RBCs are from the EPA Region III Risk-Based Concentration Table (January-June 1996), and are based on the ingestion pathway.

[c] The human health risk assessment determined that there were no noncarcinogenic hazard indices greater than the threshold value of 1.0. Therefore, only carcinogenic RBCs are included.

[d] RBC is based on the age-adjusted future resident scenario-ingestion pathway, which produces the lowest RBC of all applicable exposure scenarios and pathways.

[e] RBC is based on the future construction worker scenario-ingestion and inhalation pathway.

The subsurface soil COPCs are arsenic and manganese. Table 2-1 shows that the maximum detected concentrations of arsenic and manganese are greater than the risk assessment RBCs and residential RBCs but less than the industrial RBCs. In addition, the human health risk assessment concluded that the carcinogenic risks to future construction workers are within and at the lower end of the EPA risk range. The noncarcinogenic risk to future construction workers is below the hazard index of 1. Therefore, no subsurface soil PRGs will be established, and no remedial alternatives will be developed in this FFS to remediate Site 10 subsurface soil.

The human health risk assessment did not identify any VOC constituents as surface or subsurface soil COPCs. However, the VOC constituents present in Site 10 soil were compared to EPA Region III RBCs for transfer from soil to groundwater in order to develop soil PRGs which are protective of the underlying aquifers. Based on this comparison, TCE is the only VOC present at a concentration greater than the RBC for transfer from soil to groundwater.

PRGs for VOCs were developed for Site 1 (the ordnance burning ground) soil in a memorandum from the Navy to the USEPA and the WVDEP. The Site 1 soil PRGs were developed using the Summers method (Summers et al., 1980) which is a simple analytical fate and transport model used to simulate the migration of contaminants from unsaturated soil to the aquifer. This model was used to develop PRGs which are based on preventing the leaching of soil contaminants to the aquifers at concentrations which would exceed maximum containment levels (MCLs) in the aquifers. On the basis of the Summers method, the PRG for TCE is 152 μg/kg. The maximum detected TCE concentration above the water table in Site 10 soil is 140 μg/kg. Therefore, the TCE contaminant concentrations in soil are already below the PRGs for protection of the aquifers. No remedial alternatives will be developed in this FFS to remediate Site 10 soil because the existing TCE concentrations are not expected to adversely affect groundwater quality.

Table 2-2
Chemical-Specific ARARs, RBCs, and PRGs for Groundwater in the Alluvial and Shallow Bedrock Aquifers
Allegany Ballistics Laboratory - Site 10

Constituents	Maximum Detected Concentration (µg/kg)	EPA Safe Drinking Water Act		Noncarcinogenic RBC (µg/kg) [c]
		Maximum Contaminant Level (µg/kg)	MCL Goal (µg/kg)	
1,1-Dichloroethene	270	7	7	NA
1,2-Dichloroethene (*cis*)	4,200	70	70	NA
Methylene chloride	26	5	0 [b]	NA
Tetrachloroethene	21	5	0 [b]	NA
1,1,1-Trichloroethane	800	200	200	NA
Trichloroethene [a]	6,800	5	0 [b]	1.3 [d]

[a] Trichloroethene is the only constituent included on the basis of human health risk assessment conclusions.
[b] Only non-zero MCLGs may be considered ARARs.
[c] Only the noncarcinogenic RBC is included. The human health risk assessment concluded that all carcinogenic risk is below the EPA risk range.
[d] RBC is based on the future child resident exposure scenario-ingestion pathway, which is the lowest of all applicable RBCs.
NA Not applicable. Constituent was not identified as a COPC in the human health risk assessment.
The shaded cell is the PRG for the constituent.

Development of Preliminary Remediation Goals for Groundwater

Table 2-2 presents the RBCs, ARARs, and PRGs for Site 10 groundwater. TCE is the only constituent included in the table on the basis of the human health risk assessment. The risk assessment was used to select the COPCs which should be added to the table. TCE was selected for inclusion because it is the main driver contributing to a cumulative noncancer risk above 1 using the reasonable maximum exposure scenario. The cumulative cancer risk from all exposure pathways using the reasonable maximum exposure scenario is within the EPA risk range. Therefore, no COPCs have been added to Table 2-2 on the basis of cancer risk. However, VOC data generated during the Phase I Aquifer Testing would likely indicate an unacceptable cancer risk exists in the alluvial aquifer (reasonable maximum scenario). There are three exposure pathways with a hazard index greater than 1. They are:

- The future adult resident scenario based on the inhalation pathway. The hazard index for the inhalation pathway is 1.9, and TCE contributes over 88 percent of the risk.
- The future child and adult resident scenario based on the ingestion pathway. The hazard indices for the child and adult scenario are 3.0 and 1.3, respectively, and TCE contributes over 67 percent of the risk.
- The future child resident scenario based on the dermal exposure pathway. The hazard index is 1.2, and TCE contributes over 88 percent of the risk.

Table 2-2 also contains the groundwater constituents which were detected at maximum concentrations above the MCLs, but were not determined in the risk assessment to be main drivers contributing to cumulative risk. The shaded cells in Table 2-2 are the PRGs.

The West Virginia Groundwater Protection Act, Chapter 20, Article 12, of the West Virginia State Code, §22-12-4 requires:

> *Where the concentration of a certain constituent exceeds such standard due to human-induced contamination, no further contamination by that constituent is allowed, and every reasonable effort shall be made to identify, remove or*

mitigate the source of such contamination, and to strive where practical to reduce the level of contamination over time to support drinking water use.

Therefore, state ARARs also stipulate MCLs for groundwater chemical-specific ARARs.

In addition, remedial actions must meet standards as defined by the ARARs of EPA and WVDEP. If the ARARs do not address a particular situation, remedial actions must be based on the "to-be-considered" criteria or guidelines. ARARs and the "to-be-considered criteria are described below.

Applicable or Relevant and Appropriate Requirements

As required by Section 121 of CERCLA, remedial actions carried out under Section 104 or secured under Section 106 must attain the levels of standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal and state environmental laws and state facility-siting laws, unless waivers are obtained. According to EPA guidance, remedial actions also must be based on nonpromulgated "to-be-considered" criteria or guidelines if the ARARs do not address a particular situation.

ARARs are distinguished by the EPA as either being applicable to a situation or relevant and appropriate to it. These distinctions are critical to understanding the constraints imposed on remedial alternatives by environmental regulations other than CERCLA. The definitions of ARARs below are from the EPA guidance (EPA, 1988).

"Applicable requirements" are standards and other environmental protection requirements of federal or state law dealing with a hazardous substance, pollutant, or contaminant and its remedial action. For example, the Clean Water Act (CWA) is "applicable" to a response action for discharging treated effluent. Also, the Corrective Action Management Unit (CAMU) regulations are "applicable" to actions requiring excavation and onsite placement of soil from the site.

"Relevant and appropriate requirements" are standards and environmental protection criteria of federal or state law that, although not "applicable" to a hazardous substance or remedial action, address situations sufficiently similar to those at the CERCLA site that their use is suitable. For example, although RCRA regulations are not applicable to closing a site containing hazardous waste that was disposed of before 1980, the regulations may be relevant and appropriate.

A requirement may be "relevant" to a particular situation but not "appropriate" because of differences in the duration of the regulated activity or the physical characteristics of the affected media. For example, some of the requirements for designing and operating a waste pile that are found in 40 *Code of Federal Regulations* (CFR) 264.251, such as using a liner of sufficient strength and thickness to prevent failure caused by pressure gradients, might be considered relevant and appropriate, although the requirement to install a liner to cover all surrounding earth in potential contact with the waste might not be appropriate if the earth already is contaminated, and the eventual remedy is to remove all the contaminated earth.

A requirement that is relevant and appropriate must be met as if it were applicable. Relevant and appropriate requirements that are more stringent than applicable requirements take precedence. However, more discretion is allowed in determining relevant and appropriate requirements than in determining applicable requirements.

Another factor in determining which response or remedial requirements must be met is whether the requirement is substantive or administrative. Onsite CERCLA response actions must meet substantive requirements but not administrative requirements. Substantive requirements are those dealing directly with actions or with conditions in the environment. Administrative requirements implement the substantive requirements by prescribing procedures such as fees, permitting, and inspection that make substantive requirements effective. This distinction applies to onsite actions only; offsite response actions are subject to all applicable standards and regulations, including administrative requirements such as permits.

Other Criteria or Guidelines To Be Considered

Many federal and state programs have criteria, advisories, guidelines, and proposed standards that provide recommended procedures if no ARARs exist or if existing ARARs are inadequate. In such situations, the "to-be-considered" criteria or guidelines should be used to set remedial action levels. Examples of criteria to be considered are reference doses and potency factors for ingestion of noncarcinogenic and carcinogenic compounds used in the human health risk assessment to determine RBCs.

Determination of ARARs

There are three classifications of ARARs: chemical-specific, location-specific, and action-specific. Potential chemical-specific ARARs for soil and groundwater are summarized in tables 2-1 and 2-2, respectively. Potential location-specific and action-specific federal ARARs for the site are summarized in the tables in Appendix A. The tables summarize the potential ARARs by classification and the "to-be-considered" criteria are included as appropriate for each classification. Tables developed by WVDEP and the Maryland Department of the Environment (MDE), summarizing their state ARARs, are also presented in Appendix A. ARARs from the State of Maryland are included because the ABL facility is located on the Maryland border, and remedial alternatives may include potential groundwater discharges to the North Branch of the Potomac River, which is within the boundaries of Maryland.

The remedial action alternatives developed in the FFS were analyzed for compliance with the potential federal and state ARARs. The analysis involved identifying potential requirements for each of the alternatives, evaluating their applicability or relevance, and determining if the remedial alternatives can achieve the ARARs. Results of that analysis are found in Section 4 of this report.

Chemical-Specific Requirements

Chemical-specific requirements set health-based concentration limits or discharge limits in various environmental media for specific hazardous substances, pollutants, or contaminants. Examples of federal chemical-specific requirements include RCRA toxicity characteristics, MCLs and MCL goals, and federal and state ambient water quality criteria. Potential chemical-specific requirements for contaminated soil at the site are presented in Table 2-1. Potential chemical-specific requirements for groundwater are presented in Table 2-2.

Location-Specific Requirements

Location-specific requirements are design requirements or activity restrictions that are based on the geographic position of a site. An example is RCRA location requirements that set EPA policy for carrying out provisions of Executive Order 11988 (Flood Plain Management) and Executive Order 11990 (Protection of Wetlands). Other location-specific requirements pertain to protection of critical wildlife habitats (Endangered Species Act), wilderness areas (Wilderness Act), and wildlife refuges (USC 668). Potential location-specific requirements for the site are presented in Appendix A.

Action-Specific Requirements

Action-specific requirements set performance, design, or other standards for particular activities in managing hazardous substances or pollutants. For example, the design requirements for landfilling hazardous waste, established in RCRA Section 264.310, are action-specific. RCRA contains the greatest number of action-specific ARARs because it regulates hazardous waste management. Action-specific ARARs for Site 10 are presented in Appendix A.

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Section 3

Development of Remedial Alternatives

This section discusses the remedial alternatives which have been developed to address the RAOs for Site 10. Potential remedial technologies are identified for use in remediating contaminated groundwater. The technologies, which undergo an initial screening to determine their suitability based on site-specific characteristics, are then grouped into remedial alternatives.

General Response Actions

General response actions are broad classes of responses, remedies, or technologies developed to meet the site's RAOs. Each general response action is intended to address specific contaminants and the possible migration pathways and exposure routes in each environmental medium. Although a response action may be capable of meeting the objective for a given medium, combinations of actions may later prove to be more cost-effective in meeting all the objectives for the site. Therefore, the general response actions are normally combined to form site-wide remedial alternatives which comply with the site RAOs.

General Response Actions for Groundwater

The general response actions listed below have been identified as being potentially applicable for remediation of Site 10 groundwater in the alluvial and bedrock aquifers:

- No Action
- Institutional Control Actions
- Containment
- Collection
- Treatment
- Discharge

Under the *no action response*, aquifer contamination will not be remediated. The no action response is included in the study because the NCP requires a no action alternative be included as a baseline for evaluating remedial alternatives.

Institutional control actions is a category of alternatives that can be used singly or as part of a response action. Institutional controls include restricting the use of groundwater through land use or deed restrictions, and monitoring the migration of groundwater.

Containment response actions are technologies that prevent the migration of contaminants. A typical containment technology is a vertical barrier such as a slurry wall or sheet piling.

Collection response actions are methods of removing contaminated groundwater from the aquifers. Response actions include groundwater extraction wells or extraction trenches. Groundwater collection will be employed in conjunction with other response actions such as treatment and/or discharge.

Treatment response actions are methods of reducing the toxicity, mobility, or volume of the contaminants in the groundwater. Treatment includes biological, chemical, or physical processes. Groundwater may be treated after extraction or *in situ*.

Discharge response actions include groundwater reinjection, discharge to a sanitary sewer, or discharge to a surface water, either directly or via the storm sewer.

Identification and Screening of Remedial Technologies and Process Options

The next step in the feasibility study process is to identify remedial technologies and process options for each general response action. Remedial technologies are general categories of technologies such as groundwater extraction, chemical and physical treatment, or vertical barriers. Process options are specific processes within each technology type. For example, the chemical treatment remedial technology would include process options such as precipitation, ion exchange, and oxidation/reduction.

Technologies and process options that potentially apply have been screened initially on the basis of their suitability for site-specific characteristics. Characteristics that generally influence screening are the contaminant types, quantities and concentrations, and the physical site conditions. The preliminary screening of remedial technologies and process options for groundwater is shown in Table 3-1.

Table 3-2 summarizes the preliminary screening of remedial technologies and process options for addressing air emissions that may occur during remedial activities. The preliminary screening generated a list of potentially applicable technologies and process options for addressing air emissions that could occur when the selected remedial action is implemented. The technologies and process options will not be evaluated further because the need for and objectives of air emission controls will not be known until alternatives have been developed.

The remedial technologies and process options that were suitable, on the basis of the initial screening, were evaluated in greater detail to eliminate nonviable technologies and to simplify the development of remedial alternatives. The next step of the evaluation is limited to the effectiveness, implementability, and relative cost of each process option and remedial technology applied only to the general response actions they are intended to satisfy and not to the site as a whole. Because of this limitation, the evaluation focuses mainly on effectiveness and less on implementability and cost. Specific remedial technologies or process options were evaluated on the basis of their potential performance relative to other remedial technologies and process options within the same general response action.

In the screening process, *effectiveness* pertains to:

- The capability of the technology to attain the RAOs for the specific media
- The capability of a remedial technology to handle the estimated areas or volumes of media and to prevent or minimize the release of hazardous substances to potential receptors

Table 3-1
Preliminary Screening of Remedial Technologies for Groundwater

General Response Action	Remedial Action or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
No Action	None	Not applicable	No action	X		Retain as baseline alternative.
Institutional Control Actions	Administrative restrictions	Restrictive covenants on deed	Restrictive covenants placed on deed, restricting groundwater use.	X		Potentially applicable.
	Monitoring	Groundwater monitoring	Collection and analysis of groundwater samples to monitor extent and migration of groundwater contamination.	X		Technically feasible.
Containment	Vertical Barriers	Sheet piling	Metal sheeting mechanically driven into ground, forming a hydraulic barrier around areas of contamination.		X	Not technically feasible. Sheet piling can not be installed in bedrock, and alluvial and bedrock aquifers are interconnected. Could only be used in conjunction with groundwater extraction.
		Slurry wall	Trench around areas of contamination filled with a low-permeability soil-bentonite or cement-bentonite slurry material.		X	Not technically feasible. Slurry wall can not be installed throughout the bedrock aquifer, and alluvial and bedrock aquifer are interconnected. Could only be used in conjunction with groundwater extraction.
Collection	Extraction	Extraction wells	Series of wells to extract contaminated groundwater.	X		Potentially applicable for both aquifers.
		Extraction trenches	Perforated pipe in trenches backfilled with porous media to collect groundwater.	X		Potentially applicable for alluvial aquifer. Not technically feasible for bedrock aquifer.
In Situ Treatment	Biological treatment	Aerobic methanogenic co-metabolism	Organics degraded by methanogens in an aerobic environment. Methanogens degrade methane, and co-metabolize halogenated organics.		X	Recent research indicates the methanogens can only compete with diverse microbial populations for approximately one week. Then, the methanogens become inactivated and other species, which do not metabolize halogens, begin to dominate.

Table 3-1
Preliminary Screening of Remedial Technologies for Groundwater

General Response Action	Remedial Action or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
In Situ Treatment (cont.)	Biological treatment (cont.)	Anaerobic	Organics degraded by microorganisms in an anaerobic environment.		X	Chlorinated organics are slowly degraded at low concentrations in an anaerobic environment.
	Physical/Chemical treatment	Natural Attenuation	Volatile organics are allowed to degrade through natural processes including biological degradation, volatilization, and geochemical reactions.	X		Technically feasible. May attain PRGs for groundwater in the 30 year study period.
		Metal-enhanced reductive dechlorination (Funnel and Gate System)	Halogenated organics degraded in situ by an iron reactor.		X	Potentially applicable for alluvial aquifer. However, the funnel and gate system will increase the alluvial aquifer hydraulic head, likely driving groundwater into the bedrock aquifer, and beneath the funnel and gate system. Not feasible for bedrock.
		Air Sparging	Air is injected into the aquifer to maximize contaminant volatilization to the vapor phase.		X	Not technically feasible in soil with hydraulic conductivity less than 10^{-5} cm/sec. Soil heterogeneity causes preferential flow paths to be treated primarily. Not feasible for bedrock.
		Bioventing	Injection of pressurized air into contaminated aquifer, resulting in biological oxidation as well as physical removal of volatile organics.		X	Air flow through soil is sensitive to changes in soil density and permeability. Technology is not technically feasible in "tight" heterogeneous soil existing in alluvium at Site 10.

Table 3-1
Preliminary Screening of Remedial Technologies for Groundwater

General Response Action	Remedial Action or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
In Situ Treatment (cont.)	Physical/Chemical Treatment	In-well aeration	Air, extracted from a well, creates a water column in the well. Air is injected into the water column, stripping out VOCs in the well.		X	Not technically feasible in soil with hydraulic conductivity less than 10^{-5} cm/sec, or in bedrock.
Ex Situ Treatment	Physical/Chemical Treatment	Air stripping	Contaminants are exposed to air amid turbulence to maximize volatilization to vapor phase.	X		Potentially applicable.
		Carbon adsorption	Contaminants adsorbed onto activated carbon by passing contaminated groundwater through carbon column.	X		Potentially applicable.
		Ambersorb ™ (Ambersorb is a trademark of the Rohm and Haas Corporation)	Contaminants are adsorbed onto this proprietary synthetic resin. Adsorption is claimed to be 5 to 10 times greater than on coal-based carbon.		X	Technology has not been developed to full-scale application. However, bench-scale testing has yielded promising results.
		Filtration	Contaminated groundwater passed through a filtration system to reduce solids content.	X		Potentially applicable for pretreatment of suspended solids. Not applicable for removal of organics.
		Water softening (cation exchange)	Removal of dissolved-phase calcium, magnesium, and iron by cation exchange resin in a typical water softener.	X		Potentially applicable for pretreatment of inorganics which cause scaling or fouling. Not applicable for removal of organics.
		Reverse osmosis	Forced passage of water through a membrane, leaving contaminants behind.		X	Not applicable for the removal of organics. However, may be applicable for treatment of metals, if required.

Table 3-1 Preliminary Screening of Remedial Technologies for Groundwater						
General Response Action	**Remedial Action or Technology**	**Process Options**	**Description**	**Screening Action**		**Screening Comments**
				Retain	**Reject**	
Ex Situ Treatment (cont.)	Physical/Chemical Treatment (cont.)	Ion exchange	Contaminated water passed through a resin bed where ions exchange between resin and water.		X	Not applicable for the removal of organics. However, may be applicable for treatment of metals, if required.
		Chemical precipitation	pH of contaminated groundwater is raised, facilitating precipitation of dissolved solids. Resulting sludge is removed from waste stream.		X	Not applicable for the removal of organics. However, may be applicable for treatment of metals, if required.
		Chemical oxidation/UV oxidation	Contaminated water mixed with an oxidant to destroy organic compounds.	X		Potentially applicable.
Discharge	Discharge of treated groundwater	Surface water	Groundwater discharged to Potomac River via the storm sewer.	X		Potentially applicable. Groundwater will require treatment to meet surface water discharge limits.
		Existing onsite treatment plant	Groundwater discharged to existing onsite treatment plant.		X	Treatment plant lacks additional capacity.
		Site 1 treatment plant	Groundwater piped to the Site 1 treatment system for treatment and subsequent discharge to the North Branch of the Potomac River.	X		Potentially applicable.
		Injection well	Groundwater reinjected into the aquifer via an injection well.	X		Potentially applicable; groundwater will require treatment to federal drinking water standards before reinjection.

Table 3-1 Preliminary Screening of Remedial Technologies for Groundwater						
General Response Action	Remedial Action or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
Discharge (cont.)	Discharge of treated groundwater (cont.)	Infiltration bank	Groundwater discharged to groundwater infiltration bank or trench.		X	Not technically feasible due to tight soil, which would require a large surface area due to the low infiltration rate.

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Table 3-2
Preliminary Screening of Remedial Technologies for Air Emissions During Remedial Action

General Response Action	Remedial Action or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
No Action	None	Not applicable	No action	X		Retain as baseline alternative. Some technologies do not require air emission controls.
Institutional Control Actions	Air monitoring	Oxygen meter	Measures "real-time" oxygen concentrations	X		Potentially applicable.
		Toxic gas analyzers (PID, OVA, Draeger tubes)	Measures "real-time" concentrations of toxic gases.	X		Potentially applicable.
		Vapor-in-air samplers	Collects air samples to identify specific contaminants.	X		Potentially applicable.
		Opacity meters	Measures "real-time" particulate concentrations in air.	X		Potentially applicable.
		Particulate-in-air samplers	Collects air samples over time to get average particulate concentrations.	X		Potentially applicable.
		Weather station	Determines wind direction and speed and other meteorological conditions at the site.	X		Potentially applicable.
	Engineering controls	Scheduling	Perform work under climates not conducive to dust or vapor emissions.	X		Potentially applicable.
Containment	Dust and vapor control	Water	Regular application of water on ground surface to suppress dust.	X		Potentially applicable.
		Salt-based mixtures	Regular application of inorganic salt-based mixtures to suppress dust.	X		Potentially applicable.
		Organic-based mixtures	Regular application of organic oils to suppress dust.	X		Potentially applicable.
		Wind screen	Physical barriers to protect area from wind.	X		Potentially applicable.
		Covers	Plastic sheeting to suppress dust and vapors.	X		Potentially applicable.
		Encapsulation	Enclose work site with air- or self-supported, portable structures.	X		Potentially applicable.
		Foam	Regular applications of dust and vapor suppressant foam.	X		Potentially applicable.

Table 3-2 Preliminary Screening of Remedial Technologies for Air Emissions During Remedial Action						
General Response Action	**Remedial Action or Technology**	**Process Options**	**Description**	**Screening Action**		**Screening Comments**
				Retain	**Reject**	
Treatment	Chemical treatment	Granular activated carbon (GAC)	Removes volatile organics resulting from vapor emissions.	X		Potentially applicable.
		Scrubbers	Removes particulates and removes/neutralizes inorganic compounds from air stream.	X		Potentially applicable.
	Physical treatment	Cyclones	Separates particulates from air stream by particle size.	X		Potentially applicable.
		Baghouses	Filters particulates from air stream.	X		Potentially applicable.
	Thermal treatment	Catalytic oxidation	Destroys volatile organics using heat in the presence of a catalyst.	X		Potentially applicable. A special halogen destruct catalyst is required so that the catalyst is not poisoned from chlorinated VOCs.
		Afterburner	Destroys volatile organics using high heat.	X		Potentially applicable.
		Thermal oxidation	Destroys volatile organics using high heat.	X		Potentially applicable.

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- The degree of protection afforded to human health and to the environment during construction and implementation of the remedial technology
- The reliability and performance of the technology with respect to the site conditions

Implementability pertains to:

- The availability and capacity of off-facility treatment, storage, and disposal services
- The constructability of the remedial technology under facility conditions
- The time needed to implement the remedial technology, to achieve beneficial results, and to satisfy the RAOs

Relative cost screening considered the general capital and O&M costs for the process options. Detailed, site-specific cost estimates were not developed. The relative cost of process options was considered only if the cost of an option was believed to be significantly higher than the cost for other process options comparably effective or implementable. Therefore, the emphasis was placed on effectiveness and implementability.

Where possible, a single process option was selected as representative of a general response action. In some cases, more than one process option was selected because the options could not be differentiated in terms of effectiveness, implementability, or relative cost. The following sections discuss the remedial technologies and process options that passed the effectiveness, implementability, and cost screening for each general response action.

Remedial Technologies and Process Options for Groundwater

Table 3-3 presents an evaluation of the groundwater process options that were retained after the preliminary screening (Table 3-1). The discussion below addresses the process options that passed the subsequent evaluation for effectiveness, implementability, and cost.

Table 3-3
Evaluation of Remedial Process Options for Groundwater

General Response Action	Remedial Action or Technology	Process Options	Effectiveness	Implementability	Cost	Evaluation Action: Retain	Evaluation Action: Reject	Screening Comments
No Action	None	Not applicable	Does not protect human health or environment. Does not satisfy remedial action objectives.	Easily implemented.	None	X		Retain as baseline alternative.
Institutional Control Actions	Administrative restrictions	Restrictive covenants on deed	Effectiveness depends on continued future implementation if the ABL property were to be privately developed. Does not reduce contamination.	Easily implemented on ABL property.	Low	X		Will likely be used with other technologies.
	Monitoring	Groundwater monitoring	Effective in tracking contaminant migration. Does not reduce risk by itself. Does not satisfy remedial action objectives.	Easily implemented. Existing monitoring wells may be used for a groundwater monitoring program.	Low capital, low O&M	X		Will likely be used with other technologies.
Collection	Extraction	Extraction wells	Effective for relatively thick, transmissive aquifers. Groundwater extraction is feasible in both bedrock and alluvial aquifers.	Effective for relatively thick, transmissive aquifers. More aggressive extraction well network required with fractured bedrock and heterogeneous alluvium. However, extraction is feasible.	Moderate capital, low O&M	X		Feasible in alluvial and bedrock aquifers. Retained as an option because of inapplicability of *in situ* methods.
		Extraction trenches	Effective for shallow groundwater; can become plugged in aquifers with high solids.	More difficult to implement than extraction wells. Will not address contamination in bedrock aquifer.	High capital, low O&M		X	High groundwater solids content would most likely cause fouling. Will not address bedrock.
Treatment	Physical/ chemical treatment	Natural Attenuation	Likely effective in remediating extracted groundwater to below MCLs during the 30 year study period.	Easily implemented. Will use existing monitoring wells to monitor degradation and contaminant movement.	Low capital, low O&M	X		Technically feasible for remediating extracted groundwater contamination to below MCLs.
		Air stripping	Effective in remediating extracted groundwater to below MCLs or surface water discharge limits.	Easily implemented. May require pretreatment for particulate/dissolved solids removal and/or biological fouling.	Low capital, low O&M	X		Technically feasible for remediating extracted groundwater.
		Carbon adsorption	Effective in remediating most groundwater contaminants to below MCLs or surface water discharge limits. Some contaminants may exhibit rapid breakthrough times.	Easily implemented. May require pretreatment for particulate/dissolved solids removal and biological fouling.	Moderate capital, moderate O&M	X		Technically feasible for remediating extracted groundwater.

Table 3-3
Evaluation of Remedial Process Options for Groundwater

General Response Action	Remedial Action or Technology	Process Options	Effectiveness	Implementability	Cost	Evaluation Action		Screening Comments
						Retain	Reject	
Treatment (cont.)	Physical/ chemical treatment (cont.)	Filtration	Effective in reducing solids content of extracted groundwater.	Easily implemented. Associated residual may require treatment/disposal as a hazardous waste.	Low capital, low O&M	X		Retained as an option; will most likely be combined with other treatment options.
		Water softening (cation exchange)	Effective in reducing dissolved ionic forms of calcium, magnesium, and iron.	Easily implemented. Water softeners are off-the-shelf units typically installed in residences, restaurants, and industrial facilities.	Low capital, low O&M	X		Retained as an option; will most likely be combined with other treatment options.
		UV/Oxidation	Effective in remediating most groundwater contaminants to below MCLs. Presence of saturated organics, such as the alkanes (DCA, TCA), may require UV/Reduction with the use of an iodine catalyst to expedite the reaction.	Easily implemented. UV/oxidation system requires pretreatment to remove dissolved calcium. No offgas treatment or process byproducts are produced.	High capital, high O&M	X		Technically feasible for remediating organic contaminants to below MCLs.
Discharge	Discharge of treated groundwater	Surface water discharge via the storm sewer	Effective and reliable.	Easily implemented. Groundwater would be discharged to North Branch of the Potomac River via an existing storm sewer which traverses Site 10. The capacity of the sewer must be verified prior to design.	Low capital, low O&M	X		Retained as a discharge option.
		Site 1 treatment plant	Effective and reliable.	Will require very lengthy piping run across the ABL facility. Site 1 system can be designed to handle the additional flow.	high capital, moderate O&M	X		Retained as a discharge option. Site 1 system can be designed to handle additional flow.
		Injection well	Effective. Well screen and soil may become clogged if groundwater contains significant concentrations of dissolved iron, manganese, and carbonates.	Groundwater quality must meet MCLs. Groundwater modeling is required to validate the implementability of reinjection.	Moderate capital, moderate O&M	X		Retained as discharge option.

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No Action

The no action response is required by the NCP and was retained to provide a basis for comparison with the other actions. This action, however, does not reduce the contamination present in the aquifers and does not meet the RAOs for the site.

Institutional Control Actions

The institutional controls which were retained include deed restrictions and groundwater monitoring. Neither option reduces groundwater contamination, although both can reduce the risk to human health by eliminating the potential for exposures.

The effectiveness of restrictive covenants in preventing the use of contaminated aquifers as a source of potable water, or in preventing the possible spread of contamination caused by future well pumping, depends on their continued implementation. Restrictive covenants on the deed would prevent the installation of wells for groundwater use. Therefore, the risks from future residential exposures to Site 10 groundwater would be significantly minimized. However, institutional controls will not stop the potential migration of contaminants to off-site sources.

Groundwater monitoring will provide data to determine whether conditions have changed to the extent that further actions need to be taken. The monitoring well network would consist of existing wells and, if necessary, newly installed wells. Groundwater samples would be collected from the monitoring wells periodically and analyzed for the constituents listed in Table 2-2, which are present above human-health RBCs or MCLs. The constituents are 1,1-DCE, *cis*-1,2-DCE, methylene chloride, PCE, 1,1,1-TCA, and TCE.

Collection

Extraction wells can be used to collect groundwater from the aquifers. The wells would be placed within the contaminant plume to recover the groundwater for treatment and/or disposal and to avoid spreading contaminants to downgradient areas. The wells would be pumped until contaminant concentrations in the aquifers are reduced to the PRGs listed in Table 2-2.

Treatment

No *in situ* treatment options were retained for detailed evaluation. Technologies which were eliminated include aerobic and anaerobic degradation, metal-enhanced reductive dechlorination (funnel and gate system), air sparging, bioventing, and in-well aeration.

Aerobic and anaerobic degradation (bioremediation) technologies were eliminated for several reasons. Most microorganisms cannot directly oxidize chlorinated solvents to produce energy and biomass. However, the methanogens (methane oxidizing bacteria) have the ability to co-metabolize PCE and TCE with the enzyme methane monooxygenase (MMO). MMO is usually used to degrade methane for energy and biomass, so PCE/TCE are competitive inhibitors to methane utilization. MMO processing of TCE produces TCE epoxide. TCE epoxide binds with the enzyme and inactivates it so that it is not available for methane uptake. Therefore, the consequences of long term TCE uptake lead to enzyme activation and eventual cell death. No full-scale biodegradation of TCE has been successfully implemented. One vendor claims to be able to methanogenically degrade TCE for a week, then other competing microbial species begin to dominate, and the methanogens are inactivated. Another problem with aerobic TCE degradation is that a byproduct of the reaction is vinyl chloride, which is more toxic to human receptors than TCE. The vinyl chloride tends to be more persistent before microbial decay is initiated.

Anaerobic degradation of TCE has been shown to occur under laboratory conditions. But the establishment of complete anaerobic conditions is difficult to establish in the field. Also, microbial reductive chlorination occurs rapidly at first, but the reaction rate decreases quickly as the VOC concentrations decrease.

Site 10 has unfavorable hydrogeological characteristics for *in situ* bioremedation. Bioremediation is not recommended when the saturated hydraulic conductivity of the soil is less than 10^{-4} cm/sec due to the difficulty in introducing electron acceptors (e.g., oxygen or nitrate) and nutrients into the soil to stimulate activity (Wagner et al., 1986). Hydraulic conductivity is also a limiting factor for air sparging and bioventing systems.

Key factors in the determination of the applicability of air sparging and bioventing are the soil hydraulic conductivity and homogeneity. Air sparging is the introduction of discrete air bubbles into the aquifer to cause contaminant volatilization and then subsequent vapor capture with a soil vapor extraction system. Low hydraulic conductivities limit the ability to transfer oxygen throughout the aquifer. Soil heterogeneity is more detrimental than hydraulic conductivity. Any changes in soil structure will cause an uneven distribution of oxygen so that preferential flow paths will receive air, and more dense soil fractions will go untreated.

Metal-enhanced reductive dechlorination was eliminated due to the presence of fractured bedrock beneath the alluvial aquifer. A funnel and gate system can only be practically installed in unconsolidated material. Any fractures in the underlying bedrock will act as conduits for groundwater to pass underneath the funnel and gate. This phenomenon will be promoted because the funnel and gate system, which is constructed of sheet piles or a slurry wall, will increase the alluvial aquifer's hydraulic head as the water table elevation increases behind the wall, thereby creating additional force to drive alluvial groundwater beneath the funnel and gate.

In-well aeration cannot be practically implemented in soil with hydraulic conductivities greater than 10^{-5} cm/sec. The Site 10 soil, which is a silty clay in the vadose zone and top portion of the alluvial aquifer, likely has a hydraulic conductivity greater than 10^{-5} cm/sec. Soil heterogeneity also creates preferential flow paths, as with air sparging. Also, the presence of the water table within several feet of ground surface limits the ability to cause mounding and allow effective recharge of treated water, as required by these systems.

Treatment process options that were not eliminated during the evaluation process include air stripping, carbon adsorption, filtration, water softening (cation exchange), and oxidation by ultraviolet (UV) radiation in combination with hydrogen peroxide (H_2O_2) (UV/H_2O_2 oxidation). Water softening and filtration are potential pretreatment technologies which may be required to protect the primary treatment processes from fouling or clogging due to the presence of particulate and dissolved species in the influent waste stream. Air stripping, carbon adsorption, and UV/H_2O_2 oxidation are potential primary treatment processes used for removal of VOCs from water.

A water softener consists of a pressure tank filled with cation exchange resin. The resin consists of highly porous plastic beads loaded with "exchange sites" that preferentially remove hardness ions from water and replace them with sodium, a "soft" ion. Hardness ions include calcium, magnesium, iron, and manganese. At the beginning of a softening cycle, sodium ions occupy the resin's exchange sites. As water passes through it, the resin's stronger attraction for the hardness ions causes it to take on the hardness ions and give up the sodium ions. Once the resin has become saturated with hardness ions, it is backwashed with a solution of sodium chloride (salt). A large excess of sodium ions causes the resin to release its hold on the hardness ions, and take up the sodium ions. The hardness ions are drained from the system (Culligan, 1995).

Filtration technologies, which remove suspended solids from water, are classified by the minimum particle size they are capable of removing. They range from strainers for coarse filtration to micro- and ultrafiltration units which are capable of removing particles to the submicron level. Bag filters, which are the most applicable for pretreatment of Site 10 groundwater, are generally applicable for removing particles 1 micron and larger. A bag filter consists of a metal housing which is fitted with a perforated lining (bag). Influent water is passed through the bag, trapping suspended solids. Once the bag develops excessive headloss, it is removed and disposed of. Alternatively, a backwashable unit can be specified so that filter solids are removed at a predetermined headloss, and flushed to a drain.

An air stripping system consists of a stripper unit and an air blower. Atmospheric air is drawn into the blower and discharged to the bottom of the air stripper. Recovered groundwater is sprayed into the top of the stripper and flows downward, against the flow of air, through baffled, perforated trays. As the air bubbles through the groundwater, VOC constituents are transferred (stripped) from the groundwater into the air. Treated groundwater is discharged from the bottom of the stripper to the receiving stream. The contaminant-laden air is either directly discharged to the atmosphere, or treated (via carbon adsorption or thermal oxidation) prior to atmospheric discharge.

Carbon adsorption accomplishes removal of organics by adsorption, which is the physicochemical attraction of contaminants to a solid surface such as carbon. A carbon adsorption system typically consists of canisters, filled with granular activated carbon (GAC), arranged in series. Contaminant-laden water is introduced into the top of an adsorber, and flows downward through the GAC. Organic contaminants are strongly attracted to the carbon sites, and are transferred from the water to the carbon. Treated water flows out the bottom of the adsorber. Once the carbon becomes saturated with VOCs, it is removed from the canisters, transported offsite, and thermally reactivated. Carbon adsorbers must be periodically backwashed to remove particulate matter and biological formations which clog the adsorbers.

Ultraviolet oxidation destroys the chemical bonds of VOC contaminants in the groundwater. The most common UV/oxidation process is the use of UV with hydrogen peroxide. Ultraviolet light is used to split the hydrogen peroxide molecule, producing very reactive hydroxyl radicals (•OH). These hydroxyl radicals then quickly react with organic contaminants in the water, eventually breaking them down to the end products carbon dioxide, water, and dissolved chloride ions. There are no air emissions associated with oxidation.

A typical oxidation system consists of a small tank containing a UV lamp, and a hydrogen peroxide tank with a metering pump. Contaminated groundwater and hydrogen peroxide is introduced into the tank, and the breakdown products exit the tank. The UV lamp is fitted with a wiper blade to remove metals which have precipitated on it.

Discharge

After extraction and/or treatment, groundwater will require discharge. Discharge options that were retained include discharge to surface water via the storm sewer, discharge to the Site 1 treatment plant, and reinjection into the groundwater aquifer. Discharge to surface water will require that the groundwater be treated to achieve discharge requirements complying with EPA and West Virginia Pollutant Discharge Elimination System requirements. Groundwater would be discharged to the North Branch of the Potomac River via a storm sewer which currently passes through Site 10. Discharge to the Site 1 treatment plant entails constructing a pipe across ABL to Site 1. The Site 1 treatment plant will need to be designed to a larger capacity to handle the additional flow, and discharged water must meet the West Virginia Pollutant Discharge Elimination System requirements for surface water discharge. Discharge by reinjection entails installing groundwater injection wells and pumping groundwater back into the aquifer. The groundwater must be treated prior to reinjection to meet State mandated federal SDWA MCLs (§47-13-13.7).

Remedial Alternatives

Ten remedial alternatives were developed for Site 10 groundwater on the basis of the general response actions previously discussed in this section. The alternatives identified for detailed evaluation include the following:

- Alternative 1–No action
- Alternative 2–Institutional controls and natural attenuation
- Alternative 3–Sitewide groundwater extraction and discharge to the Site 1 treatment plant
- Alternative 4–Sitewide groundwater extraction, air stripping, and discharge to the storm sewer
- Alternative 5–Sitewide groundwater extraction, carbon adsorption, and discharge to the storm sewer
- Alternative 6–Sitewide groundwater extraction, UV/H_2O_2 oxidation, and discharge to the storm sewer

- Alternative 7–Sitewide groundwater extraction, air stripping, and reinjection

- Alternative 8–Focused groundwater extraction, air stripping, and discharge to the storm sewer

- Alternative 9–Focused groundwater extraction and discharge to the Site 1 treatment plant

- Alternative 10–Focused groundwater extraction, air stripping, and reinjection

The major components of each remedial alternative are defined in the following subsections, and each alternative is evaluated on the basis of effectiveness, implementability, and cost.

Alternative 1–No Action

Description. The no action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no action alternative. Under this alternative, no controls or remedial technologies will be implemented. CERCLA (Section 121(c)), as amended by SARA (1986), requires that the site be reviewed every five years since contamination would remain onsite.

Effectiveness. Since no action would be undertaken, this alternative will not be effective in meeting the groundwater RAOs.

Implementability. There are no implementability issues associated with this alternative.

Cost. There is no cost associated with this alternative. Costs for the five year site reviews are not included in this FFS.

Alternative 2–Institutional Controls and Natural Attenuation

Description. This alternative involves limiting access to groundwater and monitoring groundwater quality, migration, and degradation. Techniques available for limiting groundwater access include locking up or abandoning existing wells, and adding restrictive covenants to the property deed which stipulate groundwater use restrictions. Groundwater quality, contaminant migration, and degradation will also be monitored. An annual monitoring program will be established where groundwater samples will be taken and analyzed for the six VOC constituents listed in Table 2-2. Because the site will remain contaminated, the NCP requires 5-year site reviews to be conducted to reevaluate the residual risk associated with groundwater contamination.

Effectiveness. The Site 10 groundwater RAOs are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.

- Prevent or minimize offsite migration of contamination originating from Site 10.

This alternative will effectively satisfy the first RAO. Groundwater use restrictions will minimize the potential for exposures above health based criteria by preventing contact with contaminated groundwater. However, contaminant migration will continue under this alternative, and the second RAO may not be met if contaminants do not naturally attenuate before reaching the river.

There are no potential receptors located immediately adjacent to the Site 10 boundaries. The groundwater flows across Site 10 and further into the ABL facility from Site 10 (see figures 1-6 and 1-7 for the piezometric surface in the alluvial and bedrock aquifer, respectively). In addition, the North Branch of the Potomac River, which is the northern boundary of the ABL facility, is over one-third of a mile from Site 10, and ABL does not currently use groundwater from beneath the facility as a potable water supply source.

It is likely that Site 10 contaminant concentrations will be significantly reduced through dispersion in the aquifer and degradation to concentrations below detection limits before reaching the North Branch of the Potomac River. During the Phase I Aquifer Testing program, no Site 10 contaminants were detected in monitoring well 2GW5, which is the furthest monitoring well hydraulically downgradient from Site 10 (see Figure 1-4). This could be because the contaminant plume has not yet reached the well, but this is unlikely because the TCE still at Building 157 was in operation over 35 years ago, and the Draft Phase I Aquifer Testing Report indicated that the rate of TCE movement through the alluvium at Site 10 is estimated to be 50 ft/yr. It is more likely that TCE and the other VOCs are subject to significant dispersion, degradation, and volatilization prior to reaching the well.

The natural attenuation process would allow the Site 10 contaminants to be remediated by natural processes such as dispersion (natural dilution in the aquifer), chemical and biological degradation, and volatilization, and groundwater monitoring would be used to confirm that site related contamination does not reach the river.

Implementability. Groundwater monitoring programs are easily implemented. The establishment of restrictive covenants on the deed could be complicated if local government agencies do not have programs established to handle the request.

Cost. The capital cost for this alternative is approximately $50,000. Capital items include the institution of groundwater use restrictions. The actual cost required to implement restrictive covenants will vary, depending on the amount of effort and coordination required to work with local agencies. A sufficient number of monitoring wells are currently installed at the site. Therefore few, if any, additional wells will likely be needed. For purposes of costing the alternative it has been assumed that six wells will be sampled annually. The annual cost of sampling, laboratory analysis, and trend analysis and documentation of groundwater migration and degradation is $25,000. The cost of the 5-year reviews have not been included in this FFS.

Conclusion. Institutional controls will minimize future exposure to groundwater contamination above the PRGs, but groundwater use restrictions and monitoring will not provide a reduction in the toxicity, mobility, or volume of contamination. However, contaminants will be subject to natural attenuation processes including dispersion, physical and biological degradation, and volatilization so that contaminant concentrations will likely be significantly reduced prior to reaching the nearest surface water receptor. Alone, institutional controls may not satisfy both of the groundwater RAOs, which include minimizing exposures, and preventing offsite migration. However, there are no receptors located adjacent to, and downgradient of Site 10. In addition, the groundwater flow path is across the ABL facility, and ABL does not use the underlying aquifers as a potable water supply source. The closest surface water receptor is the North Branch of the Potomac River, which is more than one third of a mile from Site 10. Therefore, Alternative 2 will be carried forward for detailed evaluation.

Groundwater Flow Modeling

The remaining alternatives are based on groundwater extraction from the alluvial aquifer beneath Site 10. Aquifer testing and groundwater flow modeling was recently completed to support the design of groundwater extraction and remediation systems at sites 1 and 10. The results are documented in the Draft Phase I Aquifer Testing Report, and the Site 10 groundwater flow modeling work is summarized in Appendix B of this report. Appendix B should be consulted for a complete discussion of the development of the Site 10 flow model.

Site 10 groundwater flow modeling (see Appendix B) indicated that extraction from the alluvial aquifer is feasible, and is capable of attaining capture of the TCE contaminant plume shown in Figure 1-12. The proposed extraction- and monitoring-well configuration is shown in Figure B-6. The extraction system consists of five alluvial wells, each pumping at a flow rate of 15 gallons per minute (gpm), for a combined flow of 75 gpm. Groundwater flow modeling indicated that extraction from the alluvial aquifer will cause a hydraulic gradient reversal between the alluvial and bedrock aquifers. Therefore, it is likely that alluvial extraction will remediate the bedrock aquifer as well. Alluvial monitoring wells in the vicinity of the linear alignment of extraction wells (see Figure 1-12) will help to evaluate the capture zones and hydraulic gradient reversals. The bedrock monitoring wells in the vicinity of the upgradient alluvial extraction well will help to evaluate whether or not extraction in the alluvium is drawing contaminated bedrock groundwater up into the alluvium. Finally, the new alluvial monitoring well north of Site 10 will be used to ensure that the alluvial contaminant plume is not influenced by the groundwater extraction system which will be installed at Site 1 in the near future.

The extraction- and monitoring-wells shown in Figure B-6 are currently being installed at Site 10. Preliminary indications are that the final extraction configuration may be somewhat different in layout and flow than the modeling configuration. Costs for installation of the extraction and monitoring wells will not be included in this FFS due to their previous installation. Costs for extraction pumps, flow control and instrumentation, and collection piping will be included where appropriate.

Development of Preliminary Groundwater Treatment Criteria

The groundwater discharge process options which remain after the initial screening include discharge to the Site 1 treatment plant (and subsequent discharge to the North Branch of the Potomac River), discharge to the North Branch of the Potomac River via the storm sewer, and reinjection into the aquifers beneath the ABL facility. Site 10 groundwater extracted from the aquifers will likely require treatment, to varying levels, to meet the different discharge limits which will be imposed under the three discharge process options. Preliminary discharge limits, which have been developed for the three process options, are described in the following sections.

Discharge to the Site 1 Treatment Plant

A proposed plan has recently been issued for public comment (issued in October, 1996) for remediation of groundwater at ABL's Site 1. In accordance with the proposed plan, a groundwater treatment plant will be constructed at Site 1 to remediate VOC and inorganic contaminants in the alluvial and bedrock aquifers at the site. Development of the Site 1 treatment plant is documented in the Site 1 Focused Feasibility Study for Groundwater at the Allegany Ballistics Laboratory Superfund Site (September 1996) (Site 1 FFS). The Site 1 treatment plant is expected to have a maximum design capacity of approximately 220 gpm in order to handle the flow from the Site 1 extraction wells. The Site 1 extraction configuration, developed in the Draft Phase 1 Aquifer Testing Report, consists of alluvial and bedrock wells pumping at a combined flowrate of approximately 190 gpm. Discharge of Site 10 groundwater to the Site 1 treatment plant will require the treatment plant's capacity to be increased to 275 gpm.

Based on previous discussions with the EPA and the states of Maryland and West Virginia, discharges to the North Branch of the Potomac River from the Site 1 treatment plant will be regulated by West Virginia based upon the water quality standards listed in Appendix E of the Legislative Rules, West Virginia Water Quality Resources Board, Series 1, Requirements Governing Water Quality Standards (1985) or the federal water quality standards, whichever is more protective. The federal ambient water quality criteria (FAWQC) (chronic), EPA Region III RBC table, and BTAG Screening Levels will also be consulted if appropriate, as a TBC when developing discharge requirements. In accordance with the Clean Water Act, state law requires that the industry based best available technology (BAT) limitations promulgated in 40 CFR 414.101 are imposed when these are more stringent than limitations derived from the West Virginia water quality standards. The State of Maryland has the right to review the discharge limitations imposed by West Virginia, and, further, may impose more stringent limitations as allowable under the authority of current Maryland NPDES policies and regulations. The reader should note that the Site 1 treatment plant discharge criteria developed in the Site 1 FFS are preliminary in nature, and were used to develop preliminary groundwater treatment process flow diagrams and cost estimates. Final discharge limits will be developed and approved by the EPA, State of Maryland, and State of West Virginia as part of the predesign.

The State of West Virginia, Office of Water Resources has developed the Toxic Pollutant Control Strategy which is used to determine preliminary NPDES discharge limits. This method was used in the Site 1 FFS to develop discharge limits for the Site 1 treatment plant. Appendix D of the Site 1 FFS presents the required procedure. The Toxic Pollutant Control Strategy conservatively considers the assimilative capacity of the receiving stream to calculate discharge limits. Appendix D of that report also contains correspondence from the State which details the requirements of the Toxic Pollutant Control Strategy.

The preliminary discharge limits for the 220 gpm Site 1 treatment plant have been included in Appendix C of this FFS. The discharge limits will be more stringent if Site 10 groundwater is discharged to the plant.

The Toxic Pollutant Control Strategy was used to recalculate the preliminary discharge limits for the Site 1 treatment plant based on a combined flow of 275 gpm. The West Virginia water quality standards and background concentrations for this calculation are the same as those used in Appendix D of the Site 1 FFS. Therefore, the calculation will not be represented here. The preliminary discharge limits for the combined flow are included in Appendix C of this report.

Table 3-4 lists the preliminary discharge limits for the 275 gpm treatment plant as well as those for the 220 gpm plant for comparison. If Site 10 groundwater is discharged to the Site 1 treatment plant, it must be treated to the 275 gpm discharge limits listed in Table 3-4.

Discharge to Surface Water via the Storm Sewer

Discharge to the North Branch of the Potomac River via the storm sewer was also retained as a viable process option. As will be discussed in subsequent sections, an existing storm sewer passes directly through Site 10 and discharges to the North Branch of the Potomac River. The discharge outfall is approximately one quarter of a mile downstream from the Site 1 treatment plant discharge location.

Preliminary NPDES discharge limits will be developed because the storm sewer discharges to the river. The Site 10 discharge rate is estimated to be 75 gpm. As previously described, the West Virginia Toxic Pollutant Control Strategy was used to calculate discharge limits. An example calculation and the preliminary discharge limits are presented in Appendix D of this report. Table 3-5 lists the Site 10 contaminants requiring treatment in order to meet the preliminary discharge limits, as well as those constituents requiring treatment to protect equipment in the treatment plant.

The Toxic Pollutant Control Strategy is based upon the 7Q10 flow of the receiving stream. The 7Q10 flow is defined as the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years. According to WVDEP, the 7Q10 flow for that portion of the North Branch of the Potomac River adjacent to ABL is 117.48 cubic feet per second.

Table 3-4
Preliminary Surface Water Discharge Limits for the Site 1 Treatment Plant
Based on a Combined Flow of 275 gpm

Constituent	Influent Concentration to the Treatment Plant (µg/L)	Preliminary Discharge Limits 220 gpm Discharge Flow (µg/L)	Preliminary Discharge Limits 275 gpm Discharge Flow (µg/L)
Antimony	4.92/3.59 *	687	552
Arsenic	32/24	2,452	1,973
Barium	685/511	45,638	36,733
Chromium (II)	69/50	143	117
Mercury	0.13/0.095	0.10	0.10
Lead	97/72	42	34
Nickel	129/95	1,690	1,690
Manganese	2,761/2,028	9,047	7,441
Silver	4.08/2.98	53	44
Thallium	0.13/0.09	83	67
Zinc	353/268	1,050	991
Chloroform	2/1	9	7
1,1,1-trichloroethane	756/559	22	22
1,1-dichloroethane	77/130	22	22
1,1-dichloroethene	61/47	1.47	1.18
1,2-dichloroethene (total)	1,536/1,271	25	25
Methylene chloride	727/533	36	36
Toluene	49/36	28	28
Trichloroethene	25,612/19,047	26	26
1,2-Dichloroethane	0/0	1.72	1.38
Tetrachloroethene	8/7	39.2	32
Vinyl chloride	1/0.75	97	79

* x/y = Site 1 groundwater only/Site 1 and Site 10 groundwater combined.

Shaded column contains the preliminary discharge limits for the combined flow from the Site 1 treatment plant.

Table 3-5
Preliminary Surface Water Discharge Limits
for Discharge of 75 gpm from Site 10 to the Storm Sewer

Constituent	Influent Concentration to the Site 10 Treatment Plant (µg/L)	Preliminary Discharge Limits for Discharge of 75 gpm from Site 10 to the Storm Sewer (µg/L)
Calcium *	72,400	NA
Magnesium *	9,680	NA
1,1,1-trichloroethane	28	22
1,1-dichloroethane	274	22
1,1-dichloroethene	10	2.85
1,2-dichloroethene (total)	552	25
Trichloroethene	1,296	26

* This constituent does not have a discharge limit, but requires treatment in order to protect plant equipment.

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The Toxic Pollutant Control Strategy determines the discharge limit by allowing for dilution of the discharge into the 7Q10 flow. Existing upstream contamination is also accounted for by assuming the 7Q10 flow contains a background concentration of contaminants. The calculation of background concentrations is presented in Appendix D. Two upstream surface water samples were used, as well as the preliminary discharge limits from the Site 1 treatment plant. The surface water samples are 5SW-1 and 5SW-2 from the Phase II RI Report.

The purpose of the Toxic Pollutant Control Strategy is to determine allowable discharge limits. The methodology is based upon the West Virginia water quality standards in Appendix E of the State regulations. According to the State, the North Branch of the Potomac River is classified "B1" for aquatic life, "A" for public water supply intake, and "C" for water contact recreation. Many of the water quality standards listed in Appendix D have a different value corresponding to each use classification identified above. State regulations require that the lowest water quality standard from the above classifications be used in the calculation of preliminary discharge limits. Once the lowest water quality standard is chosen, it must be compared to the FAWQC (chronic) for each constituent. The lower of West Virginia water quality standard and the FAWQC is the applicable water quality standard. This water quality standard is then compared to the contaminant's concentration in the river (background concentration). If the background concentration is higher than the water quality standard, then the background concentration becomes the water quality standard. If neither of these standards is available for a constituent, then the EPA Region III BTAG Screening Level is used as the water quality standard. If the river background concentration is higher than the BTAG Screening Level, then the background concentration is used as the water quality standard. Water quality standards developed using this procedure are included in Appendix D.

After the background concentration and water quality standard are established for each constituent, the Toxic Pollutant Control Strategy is used to determine the average monthly concentration (AMC). The AMC is the surface water discharge limit. The calculations used to determine the AMC and the preliminary discharge limits (AMCs) are presented in Appendix D.

The State requires that the preliminary discharge limits calculated using the Toxic Pollutant Control Strategy be compared with the federal BAT effluent limitations. The BAT effluent limitations are listed in Appendix D. State guidance is that the applicable discharge standard is the lower of the Toxic Pollutant Control Strategy discharge limits and the BAT effluent limitations. The preliminary discharge limits developed with this procedure are listed in Table 3-5. These are the preliminary discharge limits for discharge of Site 10 groundwater to the storm sewer.

It should be noted that there are several Site 10 contaminants which do not have a water quality standard or a BAT effluent limitation. The West Virginia Office of Water Resources may request the determination of a non-detrimental discharge level for these contaminants based upon data from literature or specific bioassay studies (§46-1-9, Establishment of Safe Concentration Values).

The contaminants listed in Table 3-5 are those which require treatment in order to meet the preliminary discharge limits. Table 3-5 indicates that only organic constituents will require treatment. However, the table also includes calcium and magnesium which, due to their presence in elevated concentrations, may require treatment to protect plant equipment.

Discharge by Reinjection

Reinjection was retained as a viable process option. As will be discussed in subsequent sections, discharge of Site 10 groundwater by reinjection is technically feasible.

The State of West Virginia regulates injection of water into State aquifers through Title 47, Series 13 (Underground Injection Control regulations); Title 47, Series 9 (Underground Injection Control Fee Schedule); and Title 47, Series 9A (Class 5 Injection Well Type Descriptions). According to the State regulations (§47-9A-2.8.3), wells which are used to prevent, control or remediate aquifer pollution, including but not limited to Superfund sites, are classified "5X26".

The State regulations require that reinjected water must meet SDWA MCLs (§47-13-13.7). A phone conversation was initiated with the WVDEP, Office of Water Resources, Groundwater/Underground Injection Control Office to confirm the State requirements for reinjection. A copy of the phone log is included in Appendix E. The phone conversation confirmed that reinjection is acceptable at Site 10 as long as the injected water meets MCLs.

Table 3-6 lists the Site 10 contaminants requiring treatment to meet MCLs, as well as the MCLG. The MCLs are the preliminary discharge limits for reinjection of groundwater at Site 10. Table 3-6 also lists calcium and magnesium which, due to their presence in high concentrations, may require treatment in order to effectively operate a treatment and reinjection system.

The following subsections discuss Alternatives 3 through 10, which include groundwater extraction and discharge.

Alternative 3–Sitewide Groundwater Extraction and Discharge to the Site 1 Treatment Plant

Description. This alternative involves extracting groundwater from the alluvial aquifer beneath Site 10, and discharging it to the Site 1 treatment plant. Groundwater treatment is required to meet the surface water discharge limits included in Table 3-4. The major components of this alternative are:

- Institutional controls including restrictive covenants on the property deed preventing groundwater use and groundwater monitoring.
- Groundwater extraction from five existing wells.
- Installation of a pipeline in the location shown on Figure 3-1 to transport groundwater from Site 10 to the Site 1 treatment plant.
- Modifications to the Site 1 treatment plant to incorporate the additional flow and the more stringent surface water discharge limits listed in Table 3-4 (last column).

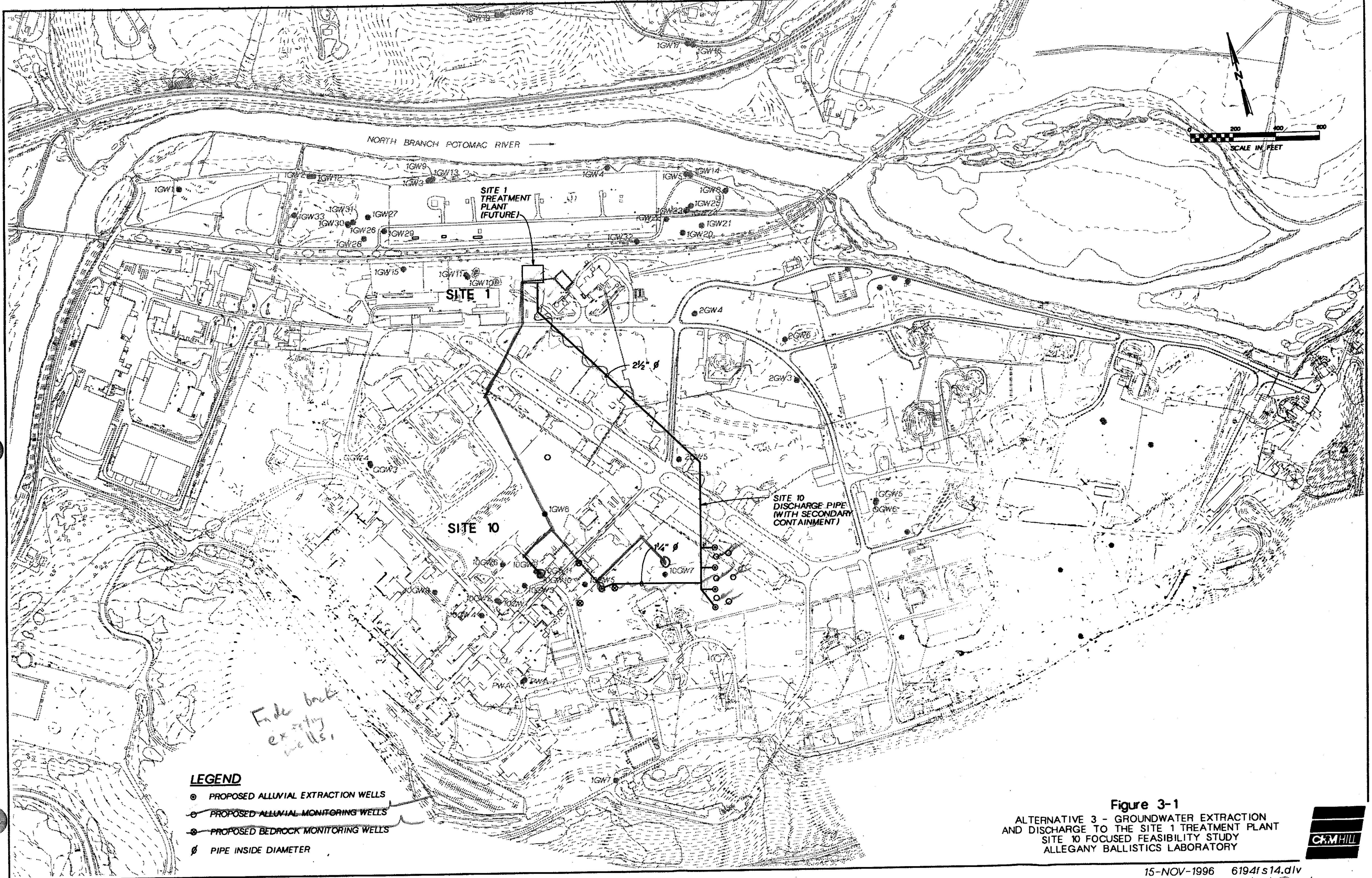

Figure 3-1
ALTERNATIVE 3 - GROUNDWATER EXTRACTION AND DISCHARGE TO THE SITE 1 TREATMENT PLANT
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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Table 3-6
Preliminary Discharge Limits for Groundwater Reinjection

Constituent	Influent Concentration to the Site 10 Treatment Plant (µg/L)	MCL/MCLG (Preliminary Discharge Limits for Groundwater Reinjection) (µg/L)
Calcium [a]	72,400	NA
Magnesium [a]	9,680	NA
1,1-dichloroethene	10	7
1,2-dichloroethene (total)	·552	70
Methylene chloride	9	5
Trichloroethene	1,296	1.3 [b]

[a] This constituent does not have a discharge limit, but requires treatment in order to protect plant equipment.

[b] Reinjection discharge limit is the noncarcinogenic RBC developed in the human health risk assessment, and identified as the PRG in Table 2-2.

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- Discharge to the North Branch of the Potomac River adjacent to Site 1.

The discharge pipeline will range in size from 1 1/4 inches to 2 1/2 inches in diameter, and will be installed below grade. The pipe will be double-walled to provide secondary containment of the transported groundwater. The interstitial space will be monitored by a leak detection system consisting of probes located at low points in the piping run. The total length of piping from the general vicinity of Site 10 to the Site 1 treatment plant is approximately 1,600 feet.

The assumption has been made that the Site 10 aquifers will be remediated within approximately 15 years. According to the Draft Phase I Aquifer Testing Report, the most contaminated portion of the Site 10 TCE plume will reach the closest extraction well within five years. This estimate is based upon natural-flow conditions. Groundwater extraction will increase the hydraulic gradient, which will increase the rate of TCE migration to the extraction wells. On the basis of these factors, remediation may be complete after 15 years, and groundwater extraction will cease at that time. This information will be incorporated into the cost assumptions for this alternative.

Figure 3-2 is the Site 1 treatment plant process flow diagram. Treatment plant design criteria for both the 220 gpm and 275 gpm treatment plant are included in Appendix F so that a comparison can be made between equipment sizes, motor horsepowers, and building sizes.

The treatment plant includes the following processes in sequence: flow equalization, metals precipitation, gravity filtration, air stripping, ion exchange, sludge dewatering, and off gas treatment by flare and scrubber. All the equipment included in the system is standard and readily available from a variety of vendors. Each of the processes are fully described in the Site 1 FFS.

The process flow diagram (Figure 3-2) is preliminary in nature. Additional information on the influent contaminant concentrations is required prior to design. The nature of the inorganics must be determined (particulate- versus dissolved-phase) so the appropriate unit processes can be selected for their removal. Surface water discharge limits must also be

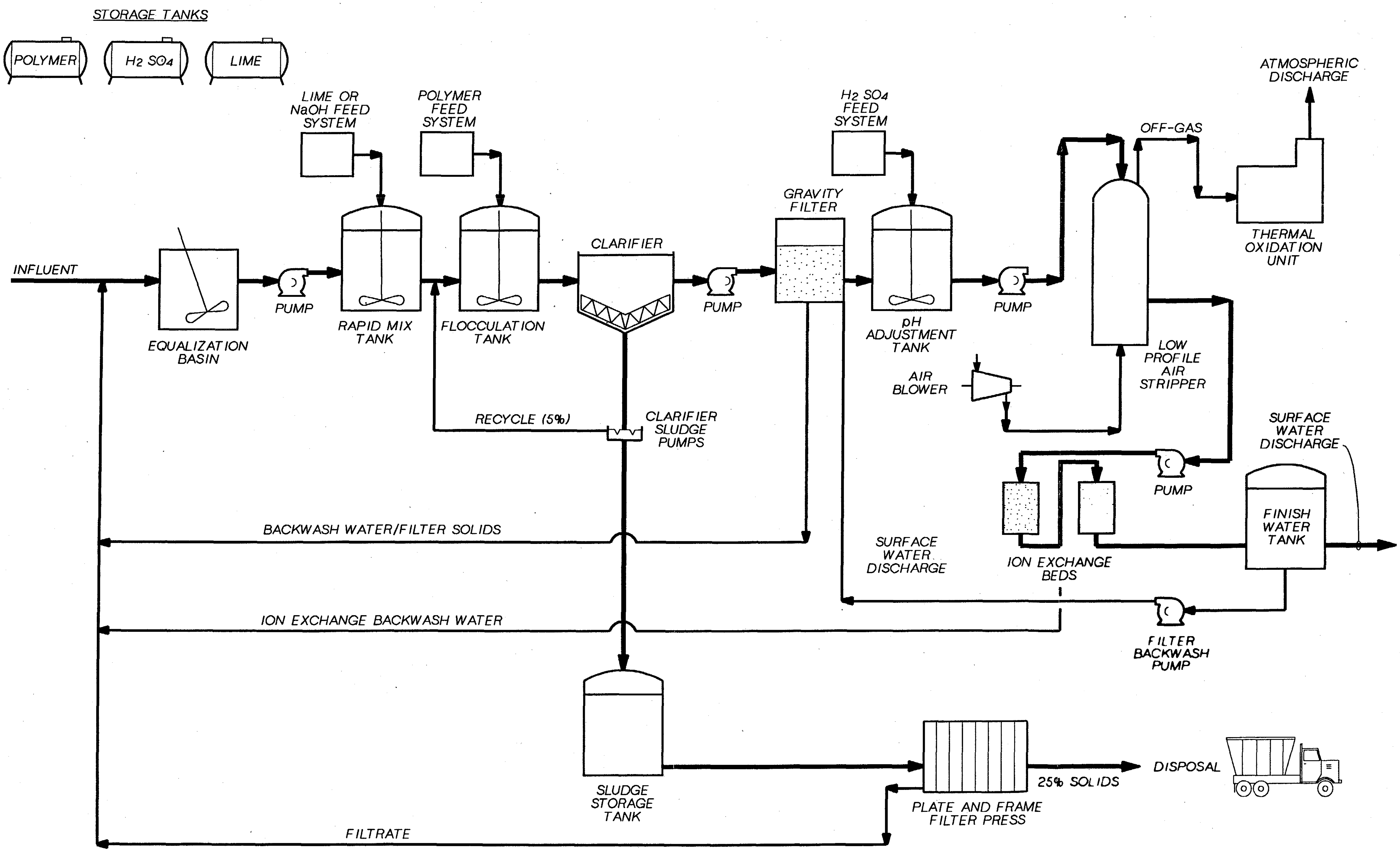

Figure 3-2
ALTERNATIVE 3 TREATMENT PLANT
PROCESS FLOW DIAGRAM
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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finalized. Treatability studies are required in order to size the metals precipitation and ion exchange processes.

Effectiveness. Groundwater extraction will likely be effective in remediating VOC contamination in the alluvial and bedrock aquifers. According to the Draft Phase I Aquifer Testing Report, the most contaminated portion of the TCE plume will likely reach the closest alluvial extraction well within five years under natural flow conditions. With the implementation of groundwater extraction, this time will decrease due to the increased hydraulic gradient. However, VOCs occurring in the silty clay layer in the alluvium may resist removal and lengthen time of remediation.

This alternative satisfies both of the Site 10 groundwater RAOs. Extraction will eventually reduce the VOC concentrations in the aquifer so that future residential exposures to contamination above health-based criteria will be eliminated. The extraction configuration shown in Figure B-6 will also prevent the offsite migration of groundwater contamination originating from Site 10. Groundwater use restrictions will prevent exposures to groundwater contamination during the remediation process.

Implementability. The installation of extraction pumps and piping is easily implemented. The presence of underground utilities must be determined prior to pipeline installation. Sufficient power is available at ABL to run the extraction pumps and the treatment system.

The treatment plant includes a combination of technologies which may make construction complex. However, the technologies are readily available from equipment vendors. It is likely that the treatment plant will be constructed and in operation prior to the commencement of Site 10 extraction. If this is the case, it will be necessary to disrupt Site 1 extraction in order to add additional equipment to the treatment plant. Alternatively, the plant can be designed and built for the 275 gpm flow. When Site 10 extraction begins, it will only be necessary to connect the Site 10 pipeline to the treatment plant header pipe and perform modifications to the plant's control system.

The ion exchange process is often difficult and costly to operate and maintain. Treatability testing is required to determine if metals precipitation and/or ion exchange can reach the preliminary discharge limits.

Cost. To cost this alternative it has been assumed that a 275 gpm treatment plant will be designed and installed, instead of modifying a 220 gpm plant to handle the additional flow and more stringent discharge limits. Modifications may be more costly. Therefore the capital cost includes the additional cost required to construct the larger treatment plant, and the cost to install the double-walled pipeline and Site 10 extraction wells. The total capital cost is approximately $700,000, of which $380,000 is for the treatment plant component, and $320,000 is for the pipeline and extraction component. O&M costs will consist primarily of additional electricity, labor, chemical, and sludge disposal costs for the larger plant. The O&M cost is assumed to be $80,000.

Conclusion. Combined with groundwater extraction, this alternative will minimize future human exposure to groundwater contamination via reduction in the toxicity, mobility, and volume of VOC contaminants, and will meet both of the groundwater RAOs. Therefore, it will be carried forward for detailed evaluation.

Alternative 4–Sitewide Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer

Description. This alternative includes groundwater extraction, treatment at Site 10 by air stripping, and discharge to the storm sewer. Groundwater treatment is required to meet the surface water discharge limits included in Table 3-5. The major components of this alternative are:

- Institutional controls, consisting of restrictive covenants on the deed preventing groundwater use, and a groundwater monitoring program.
- Groundwater extraction from five existing wells. Each well will be pumped at 15 gpm, for a combined flow of 75 gpm (see the Draft Phase I Aquifer Testing Report).

- Construction of a treatment system at Site 10, and treatment of the groundwater by air stripping. The treatment system process flow diagram is shown on Figure 3-3, and the design criteria are contained in Appendix F. The treatment building would be located as shown on Figure 3-4.

- Discharge of treated water to an existing storm sewer which runs adjacent to Site 10. The storm sewer is shown on Figure 3-4.

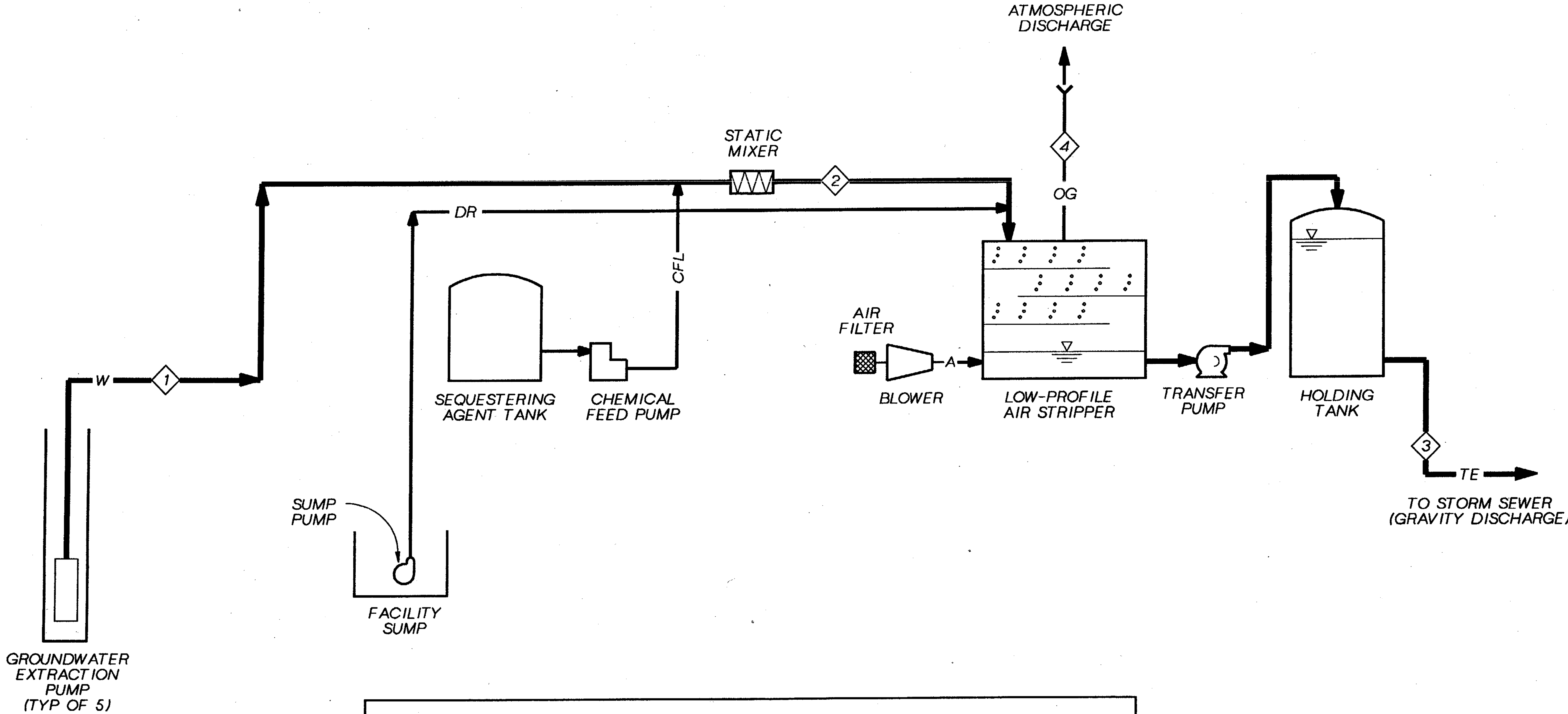
As previously discussed, the assumption has been made that Site 10 groundwater will be remediated within approximately 15 years, and groundwater extraction will cease at that time.

The extraction pipeline will range in size from 1 1/4 inches to 2 1/2 inches in diameter, and will be installed below grade. The pipe will be single-walled since it will be located only over a contaminated aquifer.

Figure 3-3 is the Site 10 treatment plant process flow diagram. The system consists of metals sequestration and air stripping. All the equipment included in the system is standard and readily available from a variety of vendors. Each process is described below.

Site 10 groundwater contains high concentrations of dissolved calcium and magnesium, which are contributors to "hardness." These "hardness" ions form scale on equipment, reducing removal efficiencies and creating operational problems. A sequestering agent will be used to complex the hardness ions, preventing them from precipitating on equipment.

There are many brands of sequestering agents on the market. One product is a blend of chelants, sequestering agents, and dispersants designed to prevent the precipitation and deposition of metallic oxides and hardness salts. Another product is a blended ortho-polyphosphate. The recommended feed method is by continuous injection of the product directly into the influent line. A static mixer will be used to mix the sequestering agent and groundwater influent. According to vendor claims, the complexing action will break down within several hours, releasing the hardness ions from solution. Two vendors contacted claim to have federal and state approvals for use of their product for potable water usage. Sequestering agents can be fed with the use of a chemical feed pump directly from a



FLOW STREAM IDENTIFICATION

A	AIR SERVICE
W	UNTREATED GROUNDWATER
CFL	CHEMICAL FEED LINE
TE	TREATED EFFLUENT
DR	SUMP DRAIN
OG	OFF GAS

MASS BALANCE

PARAMETER	1	2	3	4
FLOWRATE	75 gpm	75 gpm	75 gpm	600SCFM (MIN)
1,1,1-TRICHLOROETHANE (μg/l)	28	28	0.018	27.98 (6.8 lb/yr)
1,1-DICHLOROETHANE (μg/l)	274	274	3	271 (65.6 lb/yr)
1,1-DICHLOROETHENE (μg/l)	10	10	0.002	9.99 (2.4 lb/yr)
1,2-DICHLOROETHENE (TOTAL) (μg/l)	552	552	13	539 (131 lb/yr)
TRICHLOROETHENE (μg/l)	1,296	1,296	4	1,292 (314 lb/yr)
SEQUESTERING AGENT (MG/L)	-	30	-	-

[1] BASED ON VENDOR REPORTED AIR STRIPPER REMOVAL EFFICIENCY.

Figure 3-3
ALTERNATIVE 4
GROUNDWATER TREATMENT
AT SITE 10 BY AIR STRIPPING
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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55-gallon drum. However, a permanent tank will be installed at Site 10 to reduce O&M costs.

Air stripping is a process used to remove VOCs from water. This process will target the removal of the VOCs listed in Table 3-5. The air stripping technology facilitates the mass transfer of VOCs from water to air. An air blower is used to push air up through the air stripper. Contaminated groundwater is injected into the top of the stripper, and flows downward by gravity whereby the contaminants are stripped from the water and transferred to the air. The VOC-laden air is discharged through the top of the stripper.

Because of the low VOC concentrations and groundwater flow rate, air stripper off-gas will likely not require treatment. Preliminary calculations indicate that a maximum of 315 pounds of TCE will be discharged in the stripper off-gas per year. State regulations limit the yearly discharge of TCE to 10,000 pounds (§45-27, "To Prevent and Control the Emissions of Toxic Air Pollutants"). Therefore, the VOC-laden off-gas will not be treated prior to atmospheric discharge.

Treated water, which meets the surface water discharge limits listed in Table 3-5, will be discharged to a storm sewer which currently runs adjacent to the groundwater extraction location. The storm sewer is shown on Figure 3-4. According to ABL engineering personnel, the majority of the sewer was constructed in the 1940s. Recent sewer modifications have been made by ABL in an effort to eliminate the number of river outfalls from the facility. The sewer pipe consists of 8-inch vitrified clay pipe in the vicinity of Site 10, and 10-inch plastic pipe nearer to the river. No information on the pipe's capacity is available, but preliminary calculations indicate the pipe can most likely can handle additional flow during common storm events.

During predesign, the storm pipe's capacity must be further investigated. This would entail unloading a water truck into the storm sewer, and monitoring the flow rate and increase in water level in the manhole. In this FFS, the assumption has been made that the sewer can handle additional flow during common storm events, but will not accept additional flow during larger storms. Therefore, the treatment plant will discharge to a holding tank, as

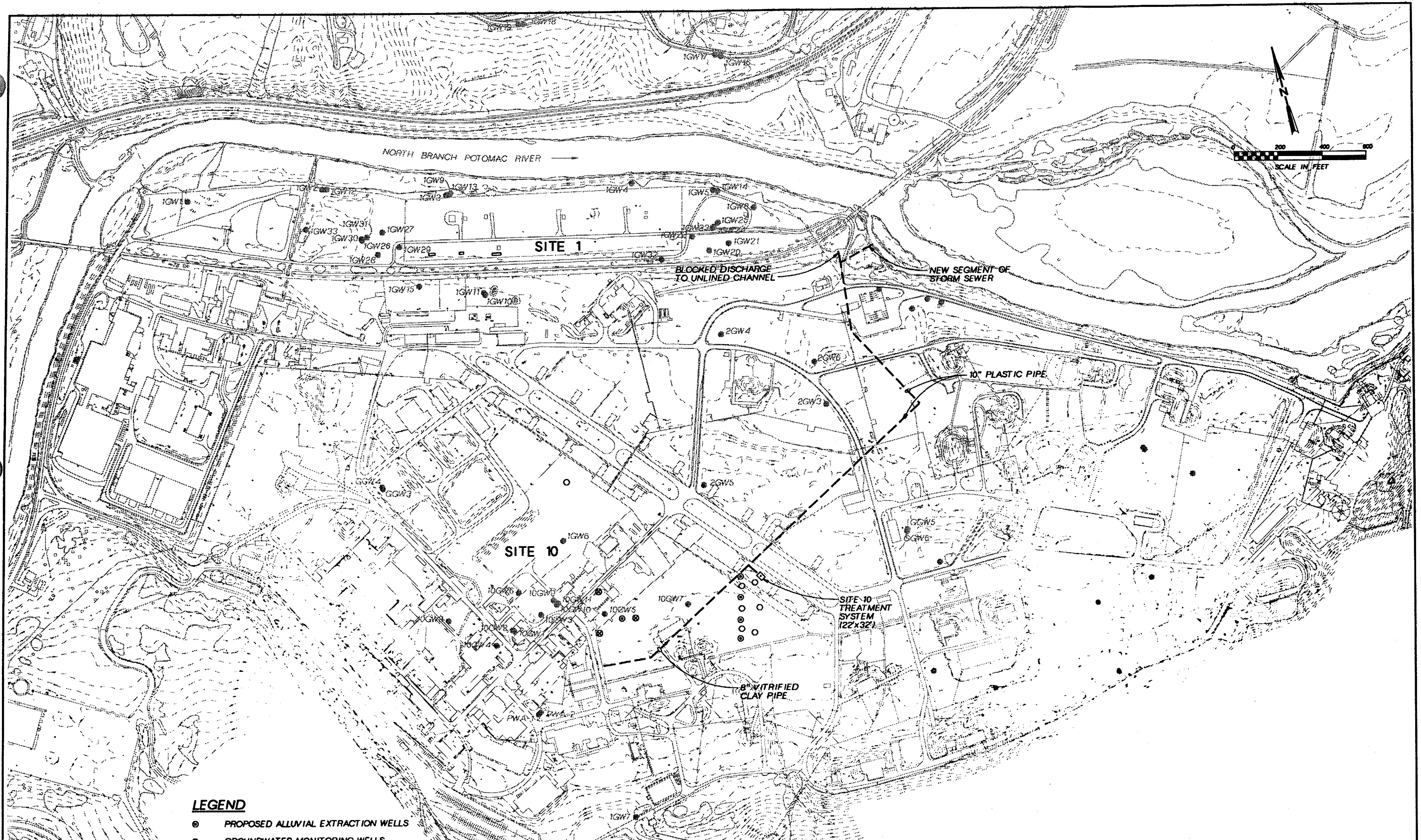

Figure 3-4
LOCATION OF SITE 10 TREATMENT SYSTEM
AND DISCHARGE TO STORM SEWER
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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shown on Figure 3-3. The holding tank will have a one-hour retention time so that, during large storms, the groundwater treatment system can remain operational if the storm sewer is temporarily surcharged with runoff.

The storm sewer currently discharges into an open unlined channel approximately 160 feet prior to discharge to the river. According to ABL engineering personnel, the channel is considered a natural water of the State. Therefore, discharges to it would be based on the calculation of discharge limits based on the 7Q10 flow in the channel. The unlined channel currently accepts process water from the steam plant, treated water from the wastewater treatment plant, and storm runoff.

In this alternative, the discharge point to the unlined channel will be blocked. A new 160-foot segment of storm sewer will be constructed in order to discharge Site 10 groundwater directly to the river. The location of the new segment is shown on Figure 3-4. As part of the Site 10 monitoring program, the new discharge point will be monitored to comply with ABL's future NPDES permit requirements. Following the completion of remediation, the connection to the unlined channel will be re-established.

Effectiveness. As previously discussed, groundwater extraction will likely be effective in remediating VOC contamination in the alluvial and bedrock aquifers. According to the Draft Phase I Aquifer Testing Report, the most contaminated portion of the TCE plume will likely reach the closest alluvial extraction well within five years under natural flow conditions. With the implementation of groundwater extraction, this time will decrease due to the increased hydraulic gradient. Therefore, the assumption has been made that aquifer remediation may be complete after 15 years.

The treatment components of the Site 10 treatment system are capable of meeting the surface water discharge limits in Table 3-5. Air stripping is a proven technology, and vendors will provide a guarantee of the stripper's removal efficiency. Metals sequestration will likely be effective in complexing hardness ions, preventing precipitation and deposition in the air stripper. Metals sequestration is effective and time tested.

Discharge to the storm sewer is effective and reliable. The available capacity of the storm sewer must be verified during predesign. Installation of a segment of sewer piping to prevent discharge to the unlined channel will also be effective in directing discharge to the river. The holding tank located in the treatment building will allow storage of treated water during large storm events so that groundwater extraction and treatment will not be interrupted.

This alternative satisfies both of the Site 10 groundwater RAOs. Extraction will eventually reduce the VOC concentrations in the aquifer so that future residential exposures to contamination above health-based criteria will be eliminated. However, the occurrence of VOCs in the silty clay layer may complicate remediation and lengthen schedule. The extraction configuration shown in Figure B-6 will also prevent the offsite migration of groundwater contamination originating from Site 10. Groundwater use restrictions will prevent exposures to groundwater contaminants during the remediation process.

Implementability. There are no difficulties associated with the implementation of this alternative. Groundwater extraction is easily implemented and monitorable. The treatment system includes two technologies which are very common, widely understood, and available from a variety of vendors. Discharge to the storm sewer is also easily implemented. Installation of the 160-foot storm sewer extension is a standard construction practice.

Cost. The capital cost of this alternative includes the extraction pumps and piping, treatment system construction, and storm sewer extension. The treatment system will be housed within a building to protect the equipment from freezing and weathering. The building dimensions are approximately 22 feet by 32 feet. The total capital cost is approximately $770,000. O&M costs include labor to operate the treatment system, electricity, sequestering agent, and treatment system performance monitoring (including laboratory analysis). The annual O&M cost is approximately $100,000.

Conclusion. Groundwater extraction and treatment at Site 10 will minimize future human exposure to groundwater contamination via a reduction in the toxicity, mobility, and volume of VOC contaminants, and will meet both of the groundwater RAOs. Therefore, it will be carried forward for detailed evaluation.

Alternative 5–Sitewide Groundwater Extraction, Carbon Adsorption, and Discharge to the Storm Sewer

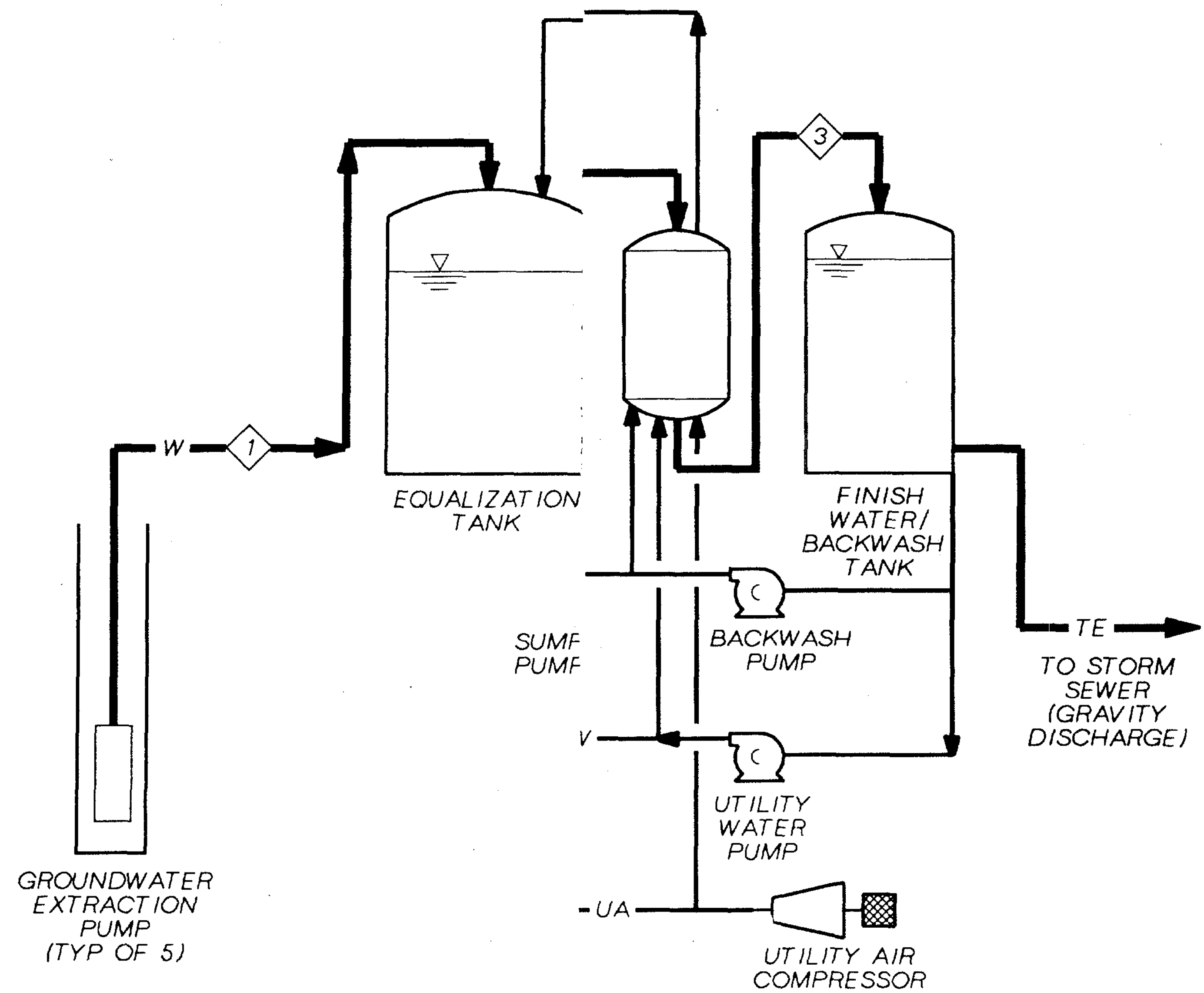
Description. This alternative is very similar to Alternative 4. It includes institutional controls, groundwater extraction, treatment at Site 10 by carbon adsorption, and discharge to the storm sewer. Groundwater treatment will be undertaken to meet the surface water discharge limits listed in Table 3-5.

The major components of this alternative are identical to Alternative 4. Five wells will be pumped at a combined flow rate of 75 gpm, and the groundwater will be treated on site. Treated water will be discharged to the storm sewer, as described previously. As previously discussed, the assumption has been made that Site 10 groundwater will be remediated within 15 years, and groundwater extraction will cease at that time.

Figure 3-5 is the Site 10 treatment plant process flow diagram. The system consists of a bag filter, metals sequestration, and carbon adsorbers. The metals sequestration process, which has been described in the previous alternative, will be very similar for carbon adsorption. However, the sequestering agent dosage must be higher because carbon tends to deactivate the complexation of hardness ions. The bag filter and carbon adsorption technologies are described below.

Carbon adsorption is a conventional process used to remove VOCs from water. This process will target the removal of the VOCs listed in Table 3-5. Carbon adsorption does not provide preferential treatment of individual contaminants. Therefore, all organic constituents in the influent will be adsorbed to a lesser or greater extent.

Organic molecules in solution tend to be hydrophobic and are preferentially attracted to the surface of organic carbon. Each contaminant has a distinct affinity for carbon, and will adsorb to the carbon surface at a specific rate. Carbon usage rates can be predicted using Freundlich Isotherms, which can be used to produce laboratory generated curves of VOC adsorption versus VOC influent concentration. Once the carbon usage rate is known, the



FLOW STREAM IDENTIFICATIOṆ

W	UNTREATED GROUNDWATER
TE	TREATED EFFLUENT
DR	SUMP DRAIN
UA	UTILITY AIR
UW	UTILITY WATER
FBS	FILTER BACKWASH SUPPLY
FB	FILTER BACKWASH
CFL	CHEMICAL FEED LINE

Figure 3-5
ALTERNATIVE 5
GROUNDWATER TREATMENT
AT SITE 10 BY CARBON ADSORPTION
SITE 10 FOCUSED FEASIBILITY STUDY
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time to contaminant breakthrough of each carbon bed can be determined, and an estimate of the time intervals between carbon bed changeout can be made.

Estimated carbon usage was calculated using LGAC_R1, a computer program developed by CH2M HILL. According to the program, the yearly carbon demand from Site 10 groundwater is approximately 28,000 pounds. 1,1-DCA will exhibit the largest carbon demand because it is poorly adsorbed by carbon.

Carbon adsorbers must be periodically backwashed to remove biological growth and precipitants. A finish water/backwash tank will store water for the backwash cycle. After backwashing, the backwash water will be transferred to the equalization tank at the head of the treatment system. Bag filters will be used to remove particulates from the backwash cycle and in the influent stream. Once the bag filters become spent, they must be manually removed and disposed of offsite, most likely in a RCRA Subtitle C landfill.

Treated water will be discharged to the storm sewer which was identified in the previous alternative. The storm sewer is shown on Figure 3-4. As with the previous alternative, it will be necessary to construct a 160-foot segment of storm sewer at the outfall to the river, and block the current outfall to the unlined channel (See Figure 3-4). It will also be necessary to verify the capacity of the storm sewer during predesign.

Effectiveness. The discussion of effectiveness will be limited to treatment by carbon adsorption. Other effectiveness issues are identical to those discussed in Alternative 4.

Carbon adsorption is effective and capable of meeting the surface water discharge limits in Table 3-5. The technology is proven and has been used at numerous installations. This technology must be monitored more closely than air stripping so that contaminant breakthrough can be determined, and the carbon beds replaced.

Discharge to the storm sewer is effective and reliable. The available capacity of the storm sewer must be verified during predesign. Installation of a segment of sewer piping to prevent discharge to the unlined channel will also be effective in directing discharge to the river. The holding tank located in the treatment building will allow storage of treated water during large storm events so that groundwater extraction and treatment will not be interrupted.

This alternative satisfies both of the Site 10 groundwater RAOs. Extraction will eventually reduce the VOC concentrations in the aquifer so that future residential exposures to contamination above health-based criteria will be eliminated. The extraction configuration shown in Figure B-6 will also prevent the offsite migration of groundwater contamination originating from Site 10. Groundwater use restrictions will prevent exposures to groundwater contaminant during the remediation process.

Implementability. There are no difficulties associated with the implementation of this alternative. Groundwater extraction is easily implemented and monitorable. Carbon adsorption is a very common technology which is widely understood. However, the technology is more difficult to implement than air stripping because the spent carbon must be hauled offsite for reactivation. The carbon adsorbers must also be periodically backwashed to removal biological growth and precipitants, and the volume of backwash water is usually excessive. Discharge to the storm sewer is easily implemented. Installation of the 160-foot storm sewer extension is a standard construction practice.

Cost. The capital cost of this alternative includes the extraction pumps and piping, treatment system construction, and storm sewer extension. The treatment system will be housed within a building to protect the equipment from freezing and weathering. The building dimensions are approximately 40 feet by 40 feet. The total capital cost is approximately $1,230,000. O&M costs include labor to operate the treatment system, electricity, sequestering agent, carbon changeouts, and treatment system performance monitoring (including laboratory analysis). The annual O&M cost is approximately $200,000.

Conclusion. Groundwater extraction and treatment at Site 10 will minimize future human exposure to groundwater contamination via a reduction in the toxicity, mobility, and volume of VOC contaminants, and will meet both of the groundwater RAOs. Therefore, it will be carried forward for detailed evaluation.

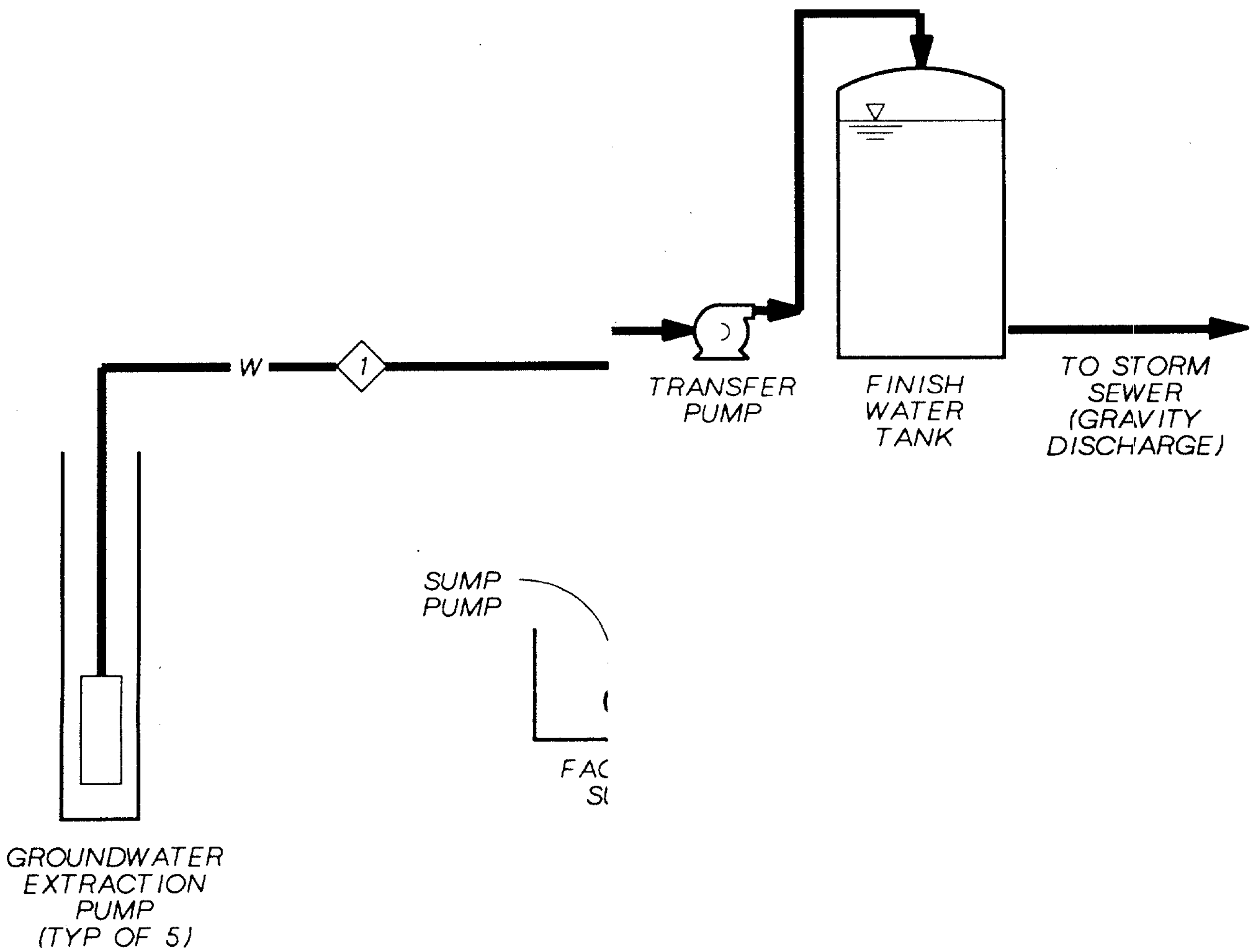
Alternative 6–Sitewide Groundwater Extraction, UV/H_2O_2 Oxidation, and Discharge to the Storm Sewer

Description. This alternative is identical to the previous two alternatives, except for the use of a UV/H_2O_2 oxidation unit to remediate VOCs instead of an air stripper or carbon adsorption unit. It includes groundwater extraction, treatment at Site 10 by UV/H_2O_2 oxidation, and discharge to the storm sewer. Treated water will meet the preliminary surface water discharge limits listed in Table 3-5. The major components of this alternative include groundwater extraction from five existing wells, treatment of 75 gpm at Site 10 by UV/H_2O_2 oxidation, and discharge to the storm sewer. As previously discussed, the assumption has been made that the aquifers will be remediated within 15 years, and groundwater extraction will cease at that time.

Figure 3-6 is the Site 10 treatment plant process flow diagram. The system consists of a hydrogen peroxide tank and an oxidation module. According to oxidation vendors, the influent calcium and magnesium concentrations.do not pose an operational problem because the UV lamp is fitted with a wiper mechanism which continuously cleans the lamp.

In recent years, UV/H_2O_2 oxidation has become a conventional process used to remove VOCs from water. The technology will target the removal of the VOCs listed in Table 3-5. UV/H_2O_2 oxidation utilizes the reaction of UV light with hydrogen peroxide to generate highly reactive hydroxyl radicals. The hydroxyl radicals created by the UV light oxidize contaminants in the water to form nontoxic by-products. The process by-products are water, carbon dioxide, and chloride ions. The complete destruction of the contaminants offered by this technology is a distinguishing feature over air stripping and carbon adsorption, both of which transfer the contaminant to another phase. In addition to providing complete destruction, there is no off-gas produced by the reaction. Most oxidation vendors will provide a guarantee of the removal efficiency provided by their units.

As with carbon, the limiting contaminant for oxidation is 1,1-DCA. This compound requires the largest UV dose in order to break the carbon bonds. According to vendors, a 120 kilowatt (kW) system will be needed to oxidize the contaminants to the discharge limits in Table 3-5.



FLOW STREAM IDENTIFICATION

W	UNTREATED GROUNDWATER
DR	SUMP DRAIN
CFL	CHEMICAL FEED LINE
TE	TREATED EFFLUENT

Figure 3-6
ALTERNATIVE 6
GROUNDWATER TREATMENT
AT SITE 10 BY UV/OXIDATION
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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As with alternatives 3 and 4, treated water will be discharged to the storm sewer shown on Figure 3-4. It will be necessary to verify the capacity of the sewer during predesign. The treatment system will include a finish water holding tank so that the system can remain in operation during large storm events. It may be possible to eliminate this tank from the design if it is verified that the storm sewer has significant excess capacity.

Effectiveness. As with the previous two alternatives, groundwater extraction will likely be effective in remediating the aquifers. The extraction configuration developed in the Draft Phase I Aquifer Testing Report will likely attain capture of the TCE plume and increase the hydraulic gradient so that remediation is complete within 15 years. However, VOCs in the silty clay layer may complicate removal and lengthen time of remediation.

UV/H_2O_2 oxidation is time tested and proven. The only moving parts in the system are the peroxide feed pump and the wiper blade on the UV lamp. Therefore, the O&M requirements are minimal. Metals sequestration will likely not be required, as with the other technologies examined.

As with the previous alternatives, this alternative satisfies both of the Site 10 groundwater RAOs. The extraction configuration will prevent offsite migration of groundwater contamination originating from Site 10, and will remove the VOC contaminants from the aquifer so that future exposures to contaminants above health-based criteria are prevented. Groundwater use restrictions will prevent exposures to groundwater contaminants during the remediation process.

Implementability. As with the previous two alternatives, there are no difficulties associated with the implementation of this alternative. Groundwater extraction is easily implemented and monitorable. UV/H_2O_2 oxidation is a widely understood technology, and is available from several specialty vendors. The availability of storm sewer capacity must be verified during predesign.

Cost. The treatment building dimensions are approximately 32 feet by 34 feet. The total capital cost is approximately $1,400,000. O&M costs include labor to operate the treatment system, electricity, hydrogen peroxide, and treatment system performance monitoring (including laboratory analysis). The annual O&M cost is approximately $110,000.

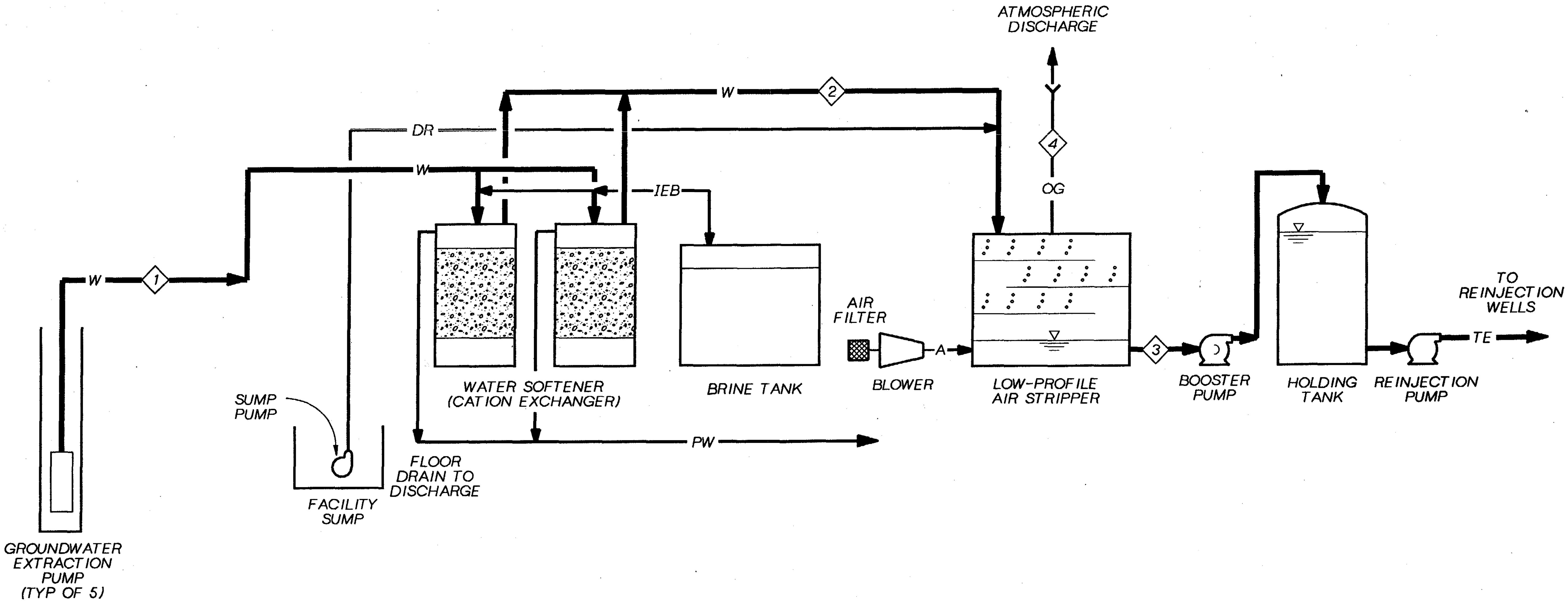
Conclusion. Groundwater extraction and treatment at Site 10 will minimize future human exposure to groundwater contamination via a reduction in the toxicity, mobility, and volume of VOC contaminants, and will meet both of the groundwater RAOs. Therefore, it will be carried forward for detailed evaluation.

Alternative 7–Sitewide Groundwater Extraction, Air Stripping, and Reinjection

Description. This alternative includes institutional controls and groundwater extraction as previously discussed, treatment at Site 10, and discharge by groundwater reinjection. Treated water must meet the reinjection discharge limits in Table 3-6, which consist primarily of MCLs. For costing purposes, the assumption has been made that extracted groundwater will be treated by air stripping. However, carbon adsorption or UV/H_2O_2 oxidation are equally acceptable technologies. Following treatment, groundwater will be discharged to a gallery of reinjection wells. The extraction component of this alternative is identical to Alternative 4, and will not be redescribed here.

The treatment plant process flow diagram for this alternative is shown on Figure 3-7. The unit processes are similar to the process flow diagram shown on Figure 3-3, however water softening has been used to pretreat the influent instead of metals sequestration.

A water softener will be used to reduce calcium and magnesium to concentrations which do not foul the air stripper or reinjection well screen. Metals sequestration is not appropriate since the sequestering agent degrades within a relatively short time, and would not prevent hardness ions from precipitating on the well screens. A water softener consists of a pressure tank filled with cation exchange resin. The resin consists of plastic beads loaded with "exchange sites" that preferentially remove hardness ions from water and replace them with sodium, a "soft" ion. Iron is also considered a hardness ion, and will be removed as well. Once the resin has become saturated with hardness ions, it is backwashed with a solution of



MASS BALANCE

PARAMETER	1	2	3	4
FLOWRATE	75 gpm	75 gpm	75 gpm	900SCFM (MIN)
METHYLENE CHLORIDE (µg/l)	9	9	0.234	8.8 (2.10 lb/yr)
1,1-DICHLOROETHENE (µg/l)	10	10	0.001	9.99 (2.4 lb/yr)
1,2-DICHLOROETHENE (TOTAL) (µg/l)	552	552	3	549 (134 lb/yr)
TRICHLOROETHENE (µg/l)	1.296	1.296	0.131	1,295.8 (315 lb/yr)
CALCIUM (DISSOLVED) (MG/L)	72	5	5	-

[1] BASED ON VENDOR REPORTED AIR STRIPPER REMOVAL EFFICIENCY.

FLOW STREAM IDENTIFICATION

A	AIR SERVICE
W	UNTREATED GROUNDWATER
PW	PROCESS WASTE
TE	TREATED EFFLUENT
DR	SUMP DRAIN
IEB	ION EXCHANGE BACKWASH
OG	OFF GAS

Figure 3-7
ALTERNATIVE 7
GROUNDWATER TREATMENT AT SITE 10
BY AIR STRIPPING AND REINJECTION
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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sodium chloride (salt). A large excess of sodium ions causes the resin to release its hold on the hardness ions, and take up the sodium ions. The hardness ions are drained from the system (Culligan, 1995).

Water softeners are commonly seen in both residential and industrial settings. A duplex water softener will be used for the Site 10 treatment system. When one water softening tank becomes saturated and must be backwashed, it will automatically be taken off line, and a second water softener will be brought on line. Backwash water will be discharged to the floor drain.

While air stripping has been included as the treatment technology, carbon adsorption and UV/H_2O_2 oxidation are also suitable for use in meeting the reinjection discharge limits listed in Table 3-6.

Groundwater flow modeling and field testing are required to determine the feasibility of reinjecting treated groundwater into the aquifers. Neither have been performed. The assumption has been made in this FFS that reinjection is technically feasible. For cost purposes, it was assumed that 1.5 injection wells would be required for each extraction well. This would entail installing a reinjection system at Site 10 consisting of seven to eight wells in order to handle the flow from the five extraction wells. While this is an approximation, and is dependent upon site characteristics, this assumption will be used due to a lack of groundwater flow modeling information at this time. Once the reinjection system is installed, additional field testing will be required to verify each well's reinjection capacity and hydraulic head loss characteristics so that reinjection pumps can be correctly sized.

During recent field work in support of the Draft Phase I Aquifer Testing program, the water level in the vicinity of Building 157 was observed to be within 1 to 2 feet of the ground surface. A high water table is common over the majority of Site 10, and in the vicinity of the proposed extraction wells. Therefore, groundwater reinjection is likely impractical in these areas. A potential reinjection location is approximately 800 feet south of Site 10 at the base of Knobly Mountain near monitoring well 1GW7 (see Figure 1-4). The thickness of the vadose zone significantly increases in this area.

Reinjection at Site 10 may also be inappropriate due to the potential interference created by the injected water on the extraction well configuration. Groundwater flow modeling will be used before well installation to evaluate the impact of reinjected water on the extraction system. Flow modeling may indicate that a suitable reinjection location can be chosen upgradient of Site 10 to increase the aquifer's hydraulic gradient, thereby shortening contaminant travel time and the duration of aquifer remediation.

Effectiveness. As with the previous extraction alternatives, groundwater extraction will likely be effective in remediating the aquifers. The extraction configuration developed in the Draft Phase I Aquifer Testing Report will likely attain capture of the TCE plume and increase the hydraulic gradient so that remediation is complete within 15 years. However, the presence of VOCs in the silty clay layer may resist removal lengthening remediation. It may be possible to increase the aquifer's hydraulic gradient by reinjecting groundwater upgradient of the extraction wells, thereby decreasing the time to remediation.

Air stripping will be effective at meeting the reinjection discharge limits in Table 3-6. There are fewer discharge requirements for reinjection than there are for surface water discharge. However, the discharge limit for TCE, which is based on the human health risk assessment, is much lower than the TCE surface water discharge limit. However, air stripping will have no difficulty in reaching either discharge limit.

Implementability. There are no significant difficulties associated with the implementation of this alternative. However, groundwater reinjection is more complex than surface water discharge. The complexity lies in properly controlling the reinjection rate at each well head so that the flow is properly distributed amongst the wells. It is often the case that each reinjection well may have a different injection rate by design, depending on the location of the well and the hydrogeologic characteristics in the location of the well. In these cases it may be necessary to use flow ratio controllers and a sophisticated control system to automatically split the treatment plant effluent into the proper flow rate for each reinjection well. However, this is a design issue which can easily be overcome with the appropriate flow control equipment.

Reinjected groundwater will likely be saturated with oxygen due to processing in the air stripper. Therefore, ferrous and manganous ions will precipitate, likely before groundwater reinjection. Calcium will also have the tendency to form calcium bicarbonate scale in the presence of the bicarbonate ion. Water softening will be required to reduce the concentrations of calcium, magnesium, iron and manganese so that these constituents do not clog the well screens upon reinjection. It may be necessary to periodically flush the wells with an acid solution to resolubilize precipitants and restore the well screen. However, this process will likely not be required very often due to the use of a water softener.

Cost. The treatment building dimensions are approximately 34 feet by 36 feet. Air stripping for reinjection will be slightly more costly than air stripping for surface water discharge due to the lower reinjection discharge limit for TCE (1.3 μg/L for reinjection as opposed to 26 μg/L for surface water discharge). In addition, the treatment building will be larger in order to house reinjection pumps and the water softener. The total capital cost is approximately $1,500,000. O&M costs include labor to operate the treatment system, electricity, salt for water softening, and treatment system performance monitoring (including laboratory analysis). The annual O&M cost is approximately $130,000.

Conclusion. Groundwater extraction, treatment, and reinjection will minimize future human exposure to groundwater contamination via a reduction in the toxicity, mobility, and volume of VOC contaminants, and will meet both of the groundwater RAOs. However, this alternative will not be carried forward for detailed evaluation due to the higher cost associated with field testing, modeling, installation of the system, and O&M over the other alternatives. However, reinjection may have advantages over the other discharge options because it may be possible to enhance extraction in the bedrock by creating an upward gradient.

Alternative 8–Focused Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer

Description. In each of the groundwater extraction alternatives discussed so far, the entire TCE plume shown on Figure 1-12 has been designated for remediation. This approach has been taken to prevent the spread and further migration of groundwater contamination originating from Site 10. The majority of the TCE plume is composed of fairly low TCE concentrations, with a much smaller fraction containing significantly higher concentrations. This "hot spot" is located in the general vicinity of Building 157, and contains TCE concentrations as high as 830 µg/L (detected in monitoring wells). Geoprobe sampling detected TCE concentrations as high as 6,800 µg/L in this area. For purposes of discussion, it has been assumed that the "hot spot" generally coincides with the 500 µg/L TCE isopleth (see Figure 1-12).

In this alternative, extraction will occur only from the TCE hot spot. Preliminary calculations performed during groundwater flow modeling conducted during the Phase I Aquifer Testing program indicated that two wells, each pumping at 15 gpm, can be installed in the hot spot area, achieving capture of the entire 500 µg/L isopleth and more quickly remediate the hot spot than the extraction configuration shown on Figure B-6. The VOC hot spot will likely be remediated more quickly than the entire VOC plume (see Figure 1-12), because the contamination is centralized, and would be pumped at a higher rate. The assumption has been made that the hot spot will be remediated within 10 years, and groundwater extraction will cease at that time. However, the presence of VOCs in the silty clay layer in the alluvium may complicate removal and lengthen the time of remediation.

The remainder of the VOC plume will be remediated through natural attenuation. Institutional controls will be implemented, consisting of groundwater use restrictions and a groundwater monitoring program. As discussed in Alternative 2, VOCs in the aquifer will likely be reduced to concentrations below instrument detection limits prior to reaching the North Branch of the Potomac River due to dispersion, geochemical and biological degradation, and volatilization as they migrate from Site 10. Although it would be expected, no Site 10 contaminants were detected in monitoring well 2GW5, which is the hydraulically furthest well from Building 157. The TCE still operated over 35 years ago. However, based on the rate of TCE movement, TCE should have reached the well within 20 to 25 years.

Extraction wells located in the hot spot will prevent any future migration of VOCs from the site. Hot spot extraction will also likely remediate the most contaminated portion of the aquifers within a shorter period than sitewide extraction. Therefore, once more dilute VOC contamination is remediated via natural attenuation, and the hot spot is remediated, the aquifers could be returned to normal use.

Groundwater extracted from the VOC hot spot will be remediated by air stripping. The treatment system will consist of the process flow diagram shown on Figure 3-3. The preliminary discharge limits for this alternative are almost identical to those listed in Table 3-4. This is because the BAT effluent limitations for most of the VOCs are lower than the West Virginia preliminary discharge limits. Therefore, the BAT effluent limitations are the preliminary discharge limits. The only exception is 1,1-DCE. At 30 gpm, the preliminary discharge limit increases to 7.1 μg/L (from 2.85 μg/L at 75 gpm). However, this has no significant impact on treatment system design.

Effectiveness. This alternative will likely be effective in remediating the aquifers within the 30 year study period established by the NCP. Hot spot extraction will most likely remediate the most severe contamination within a shorter duration than sitewide extraction would. However, the presence of VOCs in silty clay layer in the alluvium may complicate removal and lengthen the time of remediation. Also, extraction from the hot spot will prevent continued offsite migration of Site 10 contaminants. Natural attenuation processes, which consist of dispersion, degradation, and volatilization, already appear to be in progress at Site 10. This alternative will include monitoring in order to track the effectiveness of natural attenuation. Groundwater use restrictions will be administered to prevent exposures during the remediation process.

Implementability. There are no significant difficulties associated with the implementation of this alternative. Surface water discharge limits are slightly less stringent in this alternative than in previous alternatives. The treatment technologies are very effective in remediating the Site 10 VOCs. The treatment system will be smaller due to the lower flow rate.

Cost. The treatment building dimensions are approximately 16 feet by 24 feet. The air stripping unit will be smaller and less costly in this alternative due to the lower flow rate. The total capital cost is approximately $540,000. O&M costs include labor to operate the treatment system, electricity, sequestering agent, and treatment system performance monitoring (including laboratory analysis). The annual O&M cost is approximately $80,000.

Conclusion. Coupled with natural attenuation, groundwater extraction, treatment, and discharge to storm sewer will minimize future human exposure to groundwater contamination via a reduction in the toxicity, mobility, and volume of VOC contaminants, and will meet both of the groundwater RAOs. Therefore, it will be carried forward for detailed evaluation.

Alternative 9–Focused Groundwater Extraction and Discharge to the Site 1 Treatment Plant

Description. This alternative is similar to Alternative 8. In Alternative 9, institutional controls and natural attenuation will be administered across the site, and groundwater will be extracted within the 500 µg/L TCE isopleth shown on Figure 1-12. Extracted water will be discharged to the Site 1 treatment plant for treatment, then discharged to the North Branch of the Potomac River. The remainder of the plume, which is composed of more dilute VOC concentrations, will be remediated through natural attenuation.

As discussed in Alternative 8, flow modeling work conducted during the Phase I Aquifer Testing program indicated that two wells could be installed in the hot spot area, each pumping at 15 gpm. This higher flow rate would likely remediate hot spot contamination more quickly than sitewide extraction, thereby more quickly eliminating the source of groundwater contamination. Extracted groundwater would be discharged to the Site 1 treatment plant. The combined flow rate from Site 1 and Site 10 would be approximately 220 gpm. Therefore, the 220 gpm discharge limits in Table 3-4 would govern groundwater discharge to the North Branch of the Potomac River.

The composition of the discharge pipeline from Site 10 to Site 1 was discussed in Alternative 3. The pipe will be double-contained since it will transfer contaminated groundwater through clean soil areas. The pipe's interstitial space will be monitored by leak detection sensors.

Minimal modifications to the Site 1 treatment plant will be required under this alternative. The plant will be initially designed and constructed to handle a maximum flow rate of 220 gpm. Modifications will consist of reconfiguring the plant's control system to monitor the pipeline's leak detection sensor, and flow rate, water level, and on/off status of the Site 10 wells.

The remainder of the VOC plume will be remediated through natural attenuation. As discussed in the previous alternative, VOCs in the aquifer will likely be reduced to concentrations below instrument detection limits prior to reaching the North Branch of the Potomac River due to dispersion, geochemical and biological degradation, and volatilization as they migrate from Site 10. Hot spot extraction will eliminate the source of groundwater contamination. Therefore, future offsite migration of Site 10 contamination will be minimized. Potential exposures will also be minimized through the administration of groundwater use restrictions.

Effectiveness. This alternative will likely be effective in remediating the Site 10 aquifers within the 30 year study period established by the NCP. However, the presence of VOCs in the silty clay layer may complicate removal and lengthen the time of remediation. Extraction from the hot spot will likely remediate the most severe contamination within a shorter duration than sitewide extraction would. Also, hot spot extraction will minimize offsite migration of Site 10 contaminants. Natural attenuation processes, which consist of dispersion, degradation, and volatilization, already appear to be in progress at Site 10. This alternative will include monitoring in order to track the effectiveness of natural attenuation.

Implementability. There are no significant difficulties associated with the implementation of this alternative. The Site 1 treatment plant will require minor modifications in order to effectively treat Site 10 groundwater. The plant will need to be taken off line for a short duration in order to modify the control system, and to connect the Site 10 discharge pipeline.

Cost. Capital costs include modifications to the Site 1 treatment system, and installation of the Site 10 discharge pipeline and extraction pumps. The total capital cost is approximately $450,000. O&M costs include a minor amount of additional labor to operate the treatment system, electricity, and treatment system performance monitoring (including laboratory analysis). The annual O&M cost is approximately $70,000.

Conclusion. Coupled with natural attenuation, focused groundwater extraction and discharge to the Site 1 treatment plant will likely meet both of the groundwater RAOs during the 30-year study period. Therefore, it will be carried forward for detailed evaluation.

Alternative 10–Focused Groundwater Extraction, Air Stripping, and Reinjection

Description. This alternative is very similar to Alternative 8. Groundwater will be extracted from within the 500 μg/L TCE isopleth shown on Figure 1-12 and treated onsite. The remainder of the groundwater contamination will be remediated through natural attenuation. Institutional controls, including groundwater use restrictions and monitoring will be administered to prevent exposure during remediation and to monitor contaminant migration.

The groundwater will be treated onsite by air stripping as described in Alternative 8. It is estimated that a maximum of 30 gpm will require treatment. A water softener will be used to reduce the influent hardness so the reinjection well screens do not become clogged with precipitants.

Groundwater flow modeling and field testing are required to determine the appropriate number of reinjection wells required, and a suitable location. It may be possible to reinject groundwater in the vicinity of Site 10 due to the lower flow rate associated with this alternative. However, the conservative assumption has been made that reinjection at Site 10 is not feasible, and that treated water must be piped 800 feet to the base of Knobly Mountain. The vadose zone is much thicker in the vicinity of monitoring well 1GW7. Groundwater reinjection is normally accompanied by a surcharge of the water table (mounding). A sufficient depth to the water table is typically required to prevent reinjected water from rising above ground surface.

Effectiveness. As with the previous alternative, Alternative 10 will likely be effective in remediating the aquifers within the 30-year study period established by the NCP. The treatment technology has assumed to be air stripping. However, both carbon adsorption and UV/H_2O_2 oxidation are equally capable of meeting the reinjection discharge limits in Table 3-6. Groundwater reinjection is an effective disposal option. This alternative will include monitoring in order to track the effectiveness of natural attenuation.

Implementability. There are no significant difficulties associated with the implementation of this alternative. Groundwater reinjection is more complex to implement than other discharge options. An appropriately designed control system is needed to ensure each reinjection well receives the proper flow. Reinjection wells can also become clogged with metal oxides or hardness ions which precipitate on the well screen. However, water softening should help in alleviating this problem.

Cost. The treatment building dimensions are approximately 22 feet by 24 feet. The air stripping unit will be smaller and less costly in this alternative due to the lower flow rate. However, the reinjection pumps and reinjection control system will require additional space. The total capital cost is approximately $900,000. O&M costs include labor to operate the treatment system, electricity, sodium chloride for the water softener, and treatment system performance monitoring (including laboratory analysis). The annual O&M cost is approximately $100,000.

Conclusion. Groundwater extraction, treatment, and reinjection will minimize future human exposure to groundwater contamination via a reduction in the toxicity, mobility, and volume of VOC contaminants, and will meet both of the groundwater RAOs. However, this alternative will not be carried forward for detailed evaluation due to the higher cost associated with field testing, modeling, installation of the system, and O&M over the other discharge alternatives. Reinjection may have advantages over the other discharge options because it may be possible to enhance extraction in the bedrock by creating an upward gradient.

Evaluation of Remedial Alternatives

The appropriate remedial alternatives developed in this section will be evaluated in detail in Section 4. The alternatives will be evaluated against the nine criteria defined in the NCP.

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Section 4
Detailed Analysis of Remedial Alternatives

The remedial alternatives that were carried forward from the evaluation in Section 3 will be evaluated in detail in this section as appropriate. Each alternative was developed to address threats to human health and the environment posed by continued migration of contaminated groundwater. The NCP requires that the remedial alternatives be evaluated against the nine criteria listed below, as defined in the NCP. The first seven criteria are addressed in this FFS. The last two criteria will be addressed in the record of decision (ROD). The nine criteria are:

- Protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Evaluation Criteria

The detailed alternative analysis is performed to assemble and evaluate technical and policy considerations in order to develop the rationale for selecting a remedy. The following paragraphs define and detail each of the nine criteria.

Overall Protection of Human Health and Environment

This evaluation criterion is an assessment of whether each alternative achieves and maintains adequate protection of human health and the environment. The overall appraisal of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Another consideration is the statutory preference for onsite remedial actions.

Compliance with ARARs

This evaluation criterion is used to determine whether an alternative would meet all federal, state, and local ARARs that have been previously identified. Significant ARARs are identified for each alternative, and descriptions on how they are met would be given. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA would be discussed. A discussion of the compliance of each alternative with chemical-, location-, and action-specific ARARs is included.

Long-Term Effectiveness and Permanence

Under this criterion the results of a remedial alternative are evaluated in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the actions or controls that may be required to manage the risk posed by treatment residuals or untreated wastes. Factors to be considered and addressed are magnitude of residual risk, adequacy of controls, and reliability of controls. Magnitude of residual risk is the assessment of the risk remaining from untreated waste or treatment residuals after remediation. Adequacy and reliability of controls is the evaluation of the controls that can be used to manage treatment residuals or untreated wastes that remain at the facility. The evaluation may include an assessment of containment systems and institutional controls to determine whether they are sufficient to ensure that any exposure to human and environmental receptors is within protective levels.

Reduction of Toxicity, Mobility, and Volume

This evaluation criterion addresses the statutory preference for selecting remedial actions that, as their principal element, use technologies that permanently remediate and significantly reduce the toxicity, mobility, or volume of the hazardous substances. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction of contaminant mobility, or reduction of total volume of contaminated media. When evaluating this criterion, an assessment is made as to whether remediation is used to reduce principal threats, including the extent to which toxicity, mobility, or volume are reduced either separately or in combination with one another. Factors that would be focused on include:

- Remediation processes employed by the remedy
- Amount of hazardous materials that would be remediated
- Degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction
- Degree to which the remediation would be irreversible
- Type and quantity of treatment residuals that would remain following remediation
- Whether the alternative would satisfy the statutory preference for treatment as a principal element

Short-Term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until RAOs are met. Alternatives would be evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The following factors would be addressed for each alternative:

- Protection of the community during remedial actions
- Protection of workers during remedial actions

- Environmental impacts during remedial actions
- Time until RAOs are achieved

Implementability

The implementability criterion addresses the technical and administrative feasibility of executing an alternative and the availability of various services and materials required during its implementation. Technical feasibility includes construction, operation, reliability of technology, ease of undertaking additional remedial action, and monitoring. Administrative feasibility refers to the activities needed to coordinate with other offices and agencies (e.g., local permits). Availability of services and materials includes availability of adequate off-facility treatment, storage capacity, and disposal services; necessary equipment and specialists; services and materials; and prospective technologies.

Cost

For the detailed cost analysis of alternatives, the expenditures required to complete each measure are estimated in terms of both capital and annual O&M costs. Using these values, a present-worth calculation for each alternative then can be made for comparison.

Capital costs consist of direct and indirect costs. Direct costs include the cost of construction, equipment, land and site development, treatment, transportation, and disposal. Indirect costs include engineering expenses, license or permit costs, and contingency allowances.

Annual O&M costs are the post-construction costs required to ensure the continued effectiveness of the remedial action. Components of annual O&M cost include the cost of operating labor, maintenance materials and labor, auxiliary materials and energy, residue disposal, purchased services, administration, insurance, taxes, licensing, maintenance reserve and contingency funds, rehabilitation, monitoring, and periodic site reviews.

Expenditures that occur over different time periods were analyzed using present worth, which discounts all future costs to a common base year. Present-worth analysis allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the life of the remedial project. Assumptions associated with the present-worth calculations include a discount rate of 5 percent before taxes and after inflation, cost estimates in the planning years in constant dollars, and a period of performance that would vary depending on the activity, but would not exceed 30 years.

The cost estimates for this section are provided to an accuracy of +50 percent to -30 percent. The alternative cost estimates are in 1996 dollars and are based on conceptual design from information available at the time of this study. The actual cost of the project would depend on the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. Most of these factors are not expected to affect the relative cost differences between alternatives.

State Acceptance

This assessment evaluates the technical and administrative issues and concerns the states may have regarding each of the alternatives. This criterion is not discussed in this report, but would be addressed in the ROD once comments on the RI/FS have been received.

Community Acceptance

This assessment evaluates the issues and concerns the public may have regarding each of the alternatives. As with state acceptance, this criterion is not discussed in this report, but would be addressed in the ROD once comments on the RI/FS have been received.

Analysis of Remedial Alternatives

In Section 3, ten remedial alternatives, including the No Action alternative, were developed with the goal of meeting the site-specific RAOs. All of the remedial alternatives except alternatives 7 and 10 (reinjection alternatives) were retained after the preliminary evaluation phase, and are suitable to be carried forward to Section 4 for detailed evaluation. However, the components of alternatives 4, 5, and 6 are nearly identical, varying only by the treatment process (air stripping, carbon adsorption, and UV/H_2O_2 oxidation) employed to remediate the VOCs extracted from the groundwater. Therefore, only Alternative 4 will be evaluated in this section, and the results of the evaluation will generally be applicable to alternatives 5 and 6. Note that alternatives 5 and 6 remain feasible since both will meet the Site 10 RAOs, and may have certain advantages and disadvantages when compared to Alternative 4.

The six groundwater extraction alternatives that will be evaluated in detail are:

- Alternative 1—No Action
- Alternative 2—Institutional controls and natural attenuation
- Alternative 3—Sitewide groundwater extraction and discharge to the Site 1 treatment plant
- Alternative 4—Sitewide groundwater extraction, air stripping, and discharge to the storm sewer
- Alternative 8—Focused groundwater extraction, air stripping, and discharge to the storm sewer
- Alternative 9—Focused groundwater extraction and discharge to the Site 1 treatment plant

Section 3 describes each alternative in detail. The alternatives will be evaluated in this section on the basis of the seven criteria previously discussed. Table 4-1 presents a summary of the main components of each alternative. A summary of the detailed evaluation for each alternative is presented in Table 4-2.

Alternative 1—No Action

Under this alternative no further effort or resources will be expended at Site 10. Because contaminated media will be left on the site, a review of site conditions will be required every 5 years. The review is specified by the NCP. Alternative 1 serves as the baseline against

Table 4-1 Sitewide Groundwater Alternatives						
Site-Specific Components	**Alternative 1 No Action**	**Alternative 2 Institutional Controls and Natural Attenuation**	**Alternative 3 Sitewide Extraction and Discharge to Site 1**	**Alternative 4 Sitewide Extraction and Discharge to Storm Sewer**	**Alternative 8 Focused Extraction and Discharge to Storm Sewer**	**Alternative 9 Focused Extraction and Discharge to Site 1**
No Action	●					
Institutional Controls		●	●	●	●	●
Natural Attenuation		●			●	●
Sitewide Extraction			●	●		
Focused Extraction					●	●
Treatment at Site 1			●			●
Treatment at Site 10				●	●	
Discharge to Site 1 Treatment System			●			●
Discharge to Storm Sewer				●	●	

Table 4-2
Summary of Evaluation for Site 10 Remedial Alternatives

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/ Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
Protection of Human Health and the Environment	Does not meet either groundwater RAO.	Satisfies the first RAO through the use of restrictive covenants. The second RAO may be met during the 30 year study period.	Satisfies both RAOs. Groundwater treatment will minimize exposures to contaminants, and sitewide extraction will prevent offsite migration.	See Alternative 3.	Alternative will likely meet both RAOs during the 30 year study period.	See Alternative 8.
Compliance with ARARs	Does not meet the chemical-specific ARARs. There are no location- or action-specific ARARs.	May attain chemical-specific ARARs within the 30 year study period. Does not specifically comply with the State Groundwater Protection Act, which disallows alternatives relying solely on dilution and dispersion.	Will likely attain chemical-specific ARARs. The State Groundwater Protection Act has a preference for above grade piping in feasible applications. Above grade piping is not feasible at ABL.	See Alternative 3.	See Alternative 3.	See Alternative 3.
Long-Term Effectiveness and Permanence	Provides no long-term effectiveness and permanence.	Alternative relies solely on natural attenuation. However, it will likely be decades before the completion of remediation due to reliance on natural attenuation.	There will be no significant residual risk following completion of remediation. Alternative is effective and permanent.	See Alternative 3.	There will likely be minimal risk following completion of remediation. It is possible aquifers will be remediated within 30 years, and residual risk will be insignificant at the time.	See Alternative 8.

Table 4-2 Summary of Evaluation for Site 10 Remedial Alternatives						Page 2 of 2
Evaluation Criteria	**Alternative 1 No Action**	**Alternative 2 Institutional Controls/ Natural Attenuation**	**Alternative 3 Sitewide Extraction, Discharge to Site 1**	**Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge**	**Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge**	**Alternative 9 Focused Extraction, Discharge to Site 1**
Reduction of Toxicity, and Volume	None provided.	Institutional controls will reduce toxicity by preventing exposures. Contaminant mobility and volume will remain the same.	Sitewide extraction will capture the entire plume, minimizing mobility. Treatment will significantly reduce toxicity and volume.	See Alternative 3.	Will reduce toxicity, mobility, and volume of the most con-taminated portion of the aquifers. Mobility and volume of the more dilute portion of the aquifer will remain the same, but toxicity will be gradually reduced through natural processes.	See Alternative 8.
Short-Term Effectiveness	Not relevant.	There will be no significant impacts on the facility.	Installation of the discharge pipeline will require roads to be temporarily closed.	There will be no significant disturbance to the facility under this alternative.	See Alternative 4.	See Alternative 3.
Implementability	Not relevant. No action taken.	No technical issues. Five year site reviews will be required because contaminants will remain on the facility.	Site 1 treatment system must be extensively modified to accept the additional flow. Five year site reviews will be required.	See Alternative 2.	See Alternative 2.	Site 1 treatment system must be modified. Five year site reviews will be required.
Capital Cost	$0	$50,000	$700,000	$770,000	$540,000	$450,000
First Year O&M	$0	$25,000	$80,000	$100,000	$80,000	$70,000
Present-Worth	$0	$400,000	$1,500,000	$1,800,000	$1,400,000	$1,200,000

which the effectiveness of other alternatives are judged. This alternative is required under the NCP.

Overall Protection of Human Health and the Environment

Implementation of Alternative 1 would not protect human health or the environment. The risk posed by contaminated groundwater would not be decreased because the risk of potential future exposures would continue. Alternative 1 does not prevent migration of groundwater contamination from Site 10. Residual risks are identical to those identified in the baseline risk assessment.

Compliance with ARARs

Chemical-Specific ARARs—Alternative 1 fails to comply with the chemical-specific ARARs for the aquifer which require contaminants to be remediated to the PRGs listed in Table 2-2. The PRGs (chemical-specific ARARs) consist primarily of SDWA MCLs. However, the PRG for TCE is an RBC developed in the human health risk assessment for Site 10.

Location-Specific ARARs—There are no location-specific ARARs for this alternative since no remedial actions will be undertaken.

Action-Specific ARARs—There are no action-specific ARARs because no action will be undertaken in this alternative.

Long-Term Effectiveness and Permanence

Alternative 1 does not provide long-term effectiveness and permanence. The risk currently associated with the site would not be decreased and may be increased through migration of groundwater contaminants. Long-term and potential future risks posed by the site are described in the baseline risk assessment. Because contaminants are left at the site, a review of site conditions would be required every 5 years.

Reduction of Toxicity, Mobility, and Volume

This alternative would not provide any reduction in contaminant toxicity, mobility, or volume and does not meet the statutory preference for treatment.

Short-Term Effectiveness

No increased risk to the surrounding community would be realized by implementation of this alternative. Because no action would be undertaken, the level of risk to human health and the environment is described in the baseline risk assessment.

Implementability

This alternative does not have a monitoring or construction component associated with it. Therefore, there are no issues concerning implementation.

Cost

Taking no action would require no capital expenditure. As part of the five year review process, monitoring may be required and time expended on preparing a report detailing the risk associated with the site. However, these costs have not been included in this FFS.

Alternative 2—Institutional Controls and Natural Attenuation

The major components of this sitewide alternative were described in detail in Section 3, and include limiting access to groundwater, and monitoring groundwater quality, contaminant migration, and rate of degradation. Techniques available for limiting groundwater access include locking up or abandoning existing wells, and adding restrictive covenants to the property deed which stipulate groundwater use restrictions.

Groundwater quality, and contaminant migration and rate of degradation will also be monitored. An annual monitoring program will be established during which groundwater samples will be collected and analyzed for the six VOC constituents listed in Table 2-2.

Because site groundwater will remain contaminated, the NCP requires 5-year site reviews to be conducted to reevaluate the residual risk associated with groundwater contamination.

Overall Protection of Human Health and the Environment

The site-specific RAOs for Site 10 groundwater are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.

- Prevent or minimize offsite migration of contamination originating from Site 10.

This alternative will meet the first RAO. Future exposures can be effectively minimized by locking existing wells and by placing restrictive covenants on the property deed so that future residential well installation is not allowed.

The second RAO will not be met in the short term, but may be met during the 30-year study period required by the NCP. While groundwater contamination has migrated beyond the boundaries of Site 10, there are no downgradient receptors which could potentially be affected because Site 10 is located within the boundaries of the ABL facility, and Site 10 groundwater contamination migrates further into the facility. Groundwater is not currently used by ABL as a potable water supply source.

The North Branch of the Potomac River, which is the northern boundary of the ABL facility, is the closest surface water receptor of groundwater contamination. The river is over one-third of a mile from the site, and Site 10 groundwater contaminants do not appear to have migrated to the river.

Natural attenuation processes appear to be currently remediating the Site 10 aquifers. It is likely that Site 10 contaminant concentrations will continue to be significantly reduced through dispersion in the aquifer and degradation to concentrations below detection limits before reaching the North Branch of the Potomac River. During the Phase I Aquifer Testing program, no Site 10 contaminants were detected in monitoring well 2GW5, which is the furthest Site 10 monitoring well hydraulically downgradient from the site. This could be because the contaminant plume has not yet reached the well, but this is unlikely because the TCE still at Building 157 was in operation over 35 years ago, and the Draft Phase I Aquifer Testing Report indicated that the rate of TCE movement through the alluvium at Site 10 is estimated to be 50 ft/yr. It is more likely that TCE and the other VOCs are subject to significant dispersion, degradation, and volatilization prior to reaching the well.

Natural attenuation would allow the Site 10 contaminants to be remediated by natural processes, such as dispersion (natural dilution in the aquifer), chemical and biological degradation, and volatilization, and groundwater monitoring would be used to confirm that site-related contamination does not reach the river. Therefore, the second RAO may be met during the 30-year study period.

Compliance with ARARs

Chemical-Specific ARARs—The aquifers will remain out of compliance with chemical-specific ARARs for several decades because the organic contaminants listed in Table 2-2 will remain present at concentrations above their PRGs. However, natural attenuation processes may continue to reduce the contaminant concentrations to below their PRGs within the 30-year study period. This alternative includes an annual groundwater monitoring program to monitor contaminant migration and concentrations, thereby confirming whether natural attenuation will meet the PRGs within the study period.

Location-Specific ARARs—Appendix A, Table A-1 contains the federal location-specific ARARs for Site 10. Appendix A also contains the State ARARs. There are no location-specific ARARs associated with this alternative.

Action-Specific ARARs—Appendix A, Table A-2 contains the federal action-specific ARARs for Site 10. The State ARARs are also listed in Appendix A. There are no federal action-specific ARARs associated with this alternative.

The State of West Virginia Groundwater Protection Act (§47CSR58-8.1.2) requires that cleanup actions shall not rely primarily on dilution and dispersion if active remedial measures are technically and economically feasible. While this alternative does rely on dilution and dispersion, contaminants also will be remediated through biological degradation and volatilization. This is evidently occurring because contaminants such as 1,1-DCE and 1,1-DCA have been detected. These constituents are products of biotic and abiotic TCE degradation.

Long-Term Effectiveness and Permanence

Factors to be considered and addressed in this evaluation criterion are the magnitude of residual risk remaining after implementation of the alternative, and the adequacy and reliability of controls to manage the residual risk.

Magnitude of Residual Risks—Following implementation of this alternative, the magnitude of the residual risk associated with groundwater contamination will be reduced. While contaminant concentrations will remain at current levels for several decades, institutional controls and monitoring will assist in reducing their associated risk.

Institutional controls will include placing restrictive covenants on the deed and locking existing monitoring wells, thereby significantly reducing the potential for future exposures to groundwater contamination. An annual groundwater monitoring program will be implemented so that groundwater quality and contaminant migration will be closely monitored. Therefore, the residual risk associated with continued groundwater migration will be reduced as well.

Adequacy and Reliability of Controls—The adequacy of restrictive covenants is based solely on their continued use. The restrictive covenants, which prevent future installation of extraction wells for potable water, and prevent the use of existing monitoring wells, must be enforced until groundwater monitoring indicates that natural processes have met the groundwater PRGs.

Groundwater monitoring is adequate and can be reliably used to track groundwater quality and contaminant migration. An evaluation of the existing monitoring well network must be made prior to implementation of this alternative to determine if it is adequate. Additional wells can be installed, if required, to reliably predict contaminant movement from Site 10.

Reduction of Toxicity, Mobility, and Volume

This alternative will not provide any reduction in the toxicity, mobility, or volume of the groundwater contaminants during the short term. However, it is likely that toxicity, mobility, and volume will be significantly reduced by natural processes during the 30-year study period.

Short-Term Effectiveness

There will be no effect on the community during implementation of this alternative.

Implementability

Implementability evaluation includes technical feasibility, administrative feasibility, and availability of services and materials.

Technical Feasibility—There are no technical difficulties or unknowns associated with the implementation of this alternative. Groundwater monitoring wells can easily be installed and used to monitor groundwater quality.

Administrative Feasibility—Groundwater will likely remain contaminated for several decades under this alternative. Therefore, long term administrative resources must be expended to conduct the 5-year site reviews required by the NCP. Administrative resources will be required on an annual basis as well in order to administer the annual groundwater monitoring program.

The implementation of restrictive covenants on the deed must be coordinated with local government agencies. This process could be complicated if the local agencies do not have programs in place to handle the request.

Availability of Services and Materials—A variety of environmental engineering firms are available to conduct the annual groundwater monitoring program, and to assist in the establishment of deed restrictions.

Cost

The capital cost of this alternative consists primarily of implementing restrictive covenants on the deed. The capital cost is estimated to be $50,000. The annual O&M cost consists primarily of field labor and analytical costs to collect groundwater data, and office labor to analyze trends and prepare a monitoring report. The annual O&M cost is estimated to be $25,000. The present worth, assuming a 30-year project life, is $400,000. The cost estimate is included as Table 1 in Appendix G.

Alternative 3—Sitewide Groundwater Extraction and Discharge to the Site 1 Treatment Plant

This alternative, which was fully developed in Section 3, includes the following major components:

- Institutional controls, including restrictive covenants on the deed to prevent groundwater use, and groundwater monitoring.
- Groundwater extraction from five wells at a combined flow rate of 75 gpm, and discharge to the Site 1 treatment plant via the pipeline shown on Figure 3-1.
- Modifications to the Site 1 treatment plant to incorporate the additional flow and the more stringent surface water discharge limits listed in Table 3-4 (last column).
- Discharge to the North Branch of the Potomac River adjacent to Site 1.

Figure 3-2 is the Site 1 treatment plant process flow diagram. Treatment plant design criteria for both the 220-gpm and 275-gpm treatment plant are included in Appendix F so that a comparison can be made between equipment sizes, motor horsepowers, and building sizes.

The treatment plant includes the following processes in sequence: flow equalization, metals precipitation, gravity filtration, air stripping, ion exchange, sludge dewatering, and off-gas treatment by flare and scrubber. Each of the processes are fully described in the Site 1 FFS.

Overall Protection of Human Health and the Environment

The site-specific RAOs for Site 10 groundwater are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.
- Prevent or minimize offsite migration of contamination originating from Site 10.

This alternative will meet both RAOs. Groundwater flow modeling conducted as part of the Phase I Aquifer Testing program indicated that the extraction configuration shown on Figure 3-1 will effectively achieve capture of the entire TCE plume. The simulated capture zones have been superimposed over the TCE plume on Figure B-5.

According to the Draft Phase I Aquifer Testing Report, based on the rate of TCE movement, the furthest edge of the TCE plume will reach the closest extraction well within 5 years under natural flow conditions. With the implementation of groundwater extraction, the rate of TCE movement will increase due to the increase in hydraulic gradient. It is possible that the PRGs in Table 2-2 will be met after 15 years. However, the presence of TCE contamination in the silty clay layer in the alluvium may complicate removal and lengthen the time of remediation. Therefore, groundwater extraction will minimize future exposures to groundwater contamination, and will prevent offsite contaminant migration.

Compliance with ARARs

Chemical-Specific ARARs—The chemical-specific ARARs (PRGs) for groundwater are listed in Table 2-2. It is likely that ARARs will be met within the 30-year study period. On the basis of the rate of TCE movement determined in the Draft Phase I Aquifer Testing Report, it is possible that aquifer remediation may be complete within 15 years. However, the presence of TCE contamination in the silty clay layer in the alluvium may complicate removal and lengthen the time of remediation.

Under this alternative, extracted groundwater will be treated and discharged to the North Branch of the Potomac River. Chemical-specific ARARs for surface water discharge require that contaminant concentrations meet federal and state discharge limits. The surface water discharge limits, which were developed in Section 3, are listed in Table 3-4. The Site 1 treatment plant will likely meet the surface water discharge limits. Treatability studies will be required to determine the design pH and settling rate for metals precipitation, the need for a polymer to enhance metal floc settling, and the proper ion exchange resin if ion exchange is a required process component:

Location-Specific ARARs—Appendix A contains the federal and state location-specific ARARs for Site 10. Location-specific ARARs associated with construction of the Site 1 treatment plant were discussed in the Site 1 FFS. In brief, the treatment plant must not be located within the 100-year floodplain unless it is designed and constructed to avoid washout (40 CFR 264.18(b)). Also, stormwater and soil erosion controls must be implemented to avoid causing adverse affects on the Potomac River during treatment plant construction (Wild and Scenic Rivers Act (16 USC 1271 et seq. and Section 7(a))).

Action-Specific ARARs—Appendix A contains the federal and state action-specific ARARs for Site 10. 40 CFR 262.34 (RCRA 42 USC 6901 et seq.) requires that generators of hazardous waste may accumulate waste onsite for a maximum of 90 days. Any accumulation longer than 90 days would be subject to the substantive RCRA requirements for storage facilities. If sludge from the metals precipitation process is determined to be a hazardous waste, this action-specific ARAR may apply.

The State of West Virginia Groundwater Protection Act (§47CSR58-4.7 to 4.7.4) indicates that pipelines that convey contaminants shall preferentially be installed above ground where feasible. Above ground installation is not feasible for the Site 10 discharge pipeline because the pipe alignment will cross several roads. Therefore, the pipe will be installed below grade and will be double-walled to contain potential leaks. The interstitial space between the pipe walls will be monitored by a leak detection system.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risks—No residual risk will remain at Site 10 following completion of remediation because the groundwater contaminants will be reduced to concentrations below PRGs. However, because it will likely take at least 15 years for contaminant concentrations to reach the PRGs, the aquifers will contain residual risk during remediation.

Adequacy and Reliability of Controls—The groundwater extraction system will adequately control the residual risk associated with groundwater contamination during the remediation process. As shown on Figure B-5, the extraction configuration will capture the entire TCE plume, thereby preventing offsite migration of Site 10 contaminants.

Reduction of Toxicity, Mobility, and Volume

The groundwater extraction system will significantly reduce the mobility of contaminants in the groundwater by preventing further offsite migration. The Site 1 treatment system will significantly reduce the toxicity and volume of contamination by remediating the groundwater to the discharge limits listed in Table 3-4.

Short-Term Effectiveness

There will be no significant affects on the ABL facility during implementation of this alternative. Several of the facility's roads may need to be closed in order to install the discharge pipeline. Pipeline installation will be in clean soil areas. Expansion of the Site 1 treatment system should have minor impacts on the facility as well. The majority of the modifications to the treatment system will occur within the treatment building, and will likely not be noticed.

It will be necessary to shut down the Site 1 extraction wells to perform modifications to the treatment system. Modifications will include connecting the Site 10 discharge pipeline and modifying the plant's control system so the flow rate, water level, and on/off status of the Site 10 extraction pumps can be controlled. Each unit process (metals precipitation, filtration, air stripping, etc.) must also be evaluated to assess whether the current equipment can handle the additional flow, or if additional equipment must be installed. It will likely take two to three months to modify equipment and the control system, and restart the plant at the higher flow rate.

Implementability

Technical Feasibility—There are no technical difficulties or unknowns associated with the installation of the groundwater extraction system. Extraction wells can easily be installed and effectively controlled.

Modifications to the treatment plant will be more complex. The surface water discharge limits will be more stringent at the higher flow rate. Each unit process must be analyzed to ascertain if the additional flow can be effectively treated. It is likely that the metals precipitation and clarification processes will be relatively unaffected. A second filter and additional ion exchange units may need to be installed. The building should be initially oversized in order to accommodate the need for the additional equipment.

Administrative Feasibility—Groundwater will remain contaminated during the short term under this alternative. Therefore, long term administrative resources must be expended to conduct the 5-year site reviews required by the NCP. Administrative resources will also be required to administer the O&M of the Site 1 treatment plant.

Availability of Services and Materials—The Site 1 treatment system will likely be operational prior to groundwater extraction at Site 10. Therefore, the treatment plant will be available for discharge. It is preferable that the original contractor perform modifications to the treatment system for continuity. However, the modifications will be incorporated into a design package which can be implemented by many qualified contractors.

Cost

The cost assumption has been made that the extraction wells will be previously installed. Therefore, the capital cost includes the extraction pumps, discharge pipeline, and modifications to the treatment plant equipment and control system. The capital cost is estimated to be $700,000. The annual O&M cost includes groundwater data collection and laboratory analysis, and additional chemical, labor, electricity, and sludge disposal costs required to operate the treatment system. The annual O&M cost is estimated to be $80,000. The present worth, assuming a 15-year project life, is $1,500,000. The cost estimate is included as tables 2a and 2b in Appendix G. Table 2a is the cost estimate of the 220 gpm system, and Table 2b is the estimate of the 275 gpm system.

Alternative 4—Sitewide Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer

This alternative, which was fully developed in Section 3, includes the following major components:

- Institutional controls, including restrictive covenants on the deed to prevent groundwater use, and groundwater monitoring.
- Groundwater extraction from five existing wells. Each well will be pumped at 15 gpm, for a combined flow of 75 gpm.
- Construction of a treatment system at Site 10, and treatment of the groundwater by metals sequestration and air stripping. The treatment system process flow diagram is shown on Figure 3-3, and the design criteria are contained in Appendix F. The treatment building would be located as shown on Figure 3-4.

- Discharge of water, which meets the discharge limits listed in Table 3-5, to an existing storm sewer which runs adjacent to Site 10. The storm sewer is shown on Figure 3-4.

As discussed in Section 3, the assumption has been made that Site 10 groundwater will be remediated within 15 years, and groundwater extraction will cease at that time.

Overall Protection of Human Health and the Environment

The site-specific RAOs for Site 10 groundwater are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.

- Prevent or minimize offsite migration of contamination originating from Site 10.

This alternative will meet both RAOs. As discussed in the previous alternative, groundwater flow modeling conducted as part of the Phase I Aquifer Testing program indicated that the extraction configuration shown on Figure 3-1 will effectively achieve capture of the entire TCE plume. The simulated capture zones have been superimposed over the TCE plume on Figure B-5.

According to the Draft Phase I Aquifer Testing Report, it is likely that the furthest edge of the TCE plume will reach the closest extraction well within 5 years under natural flow conditions. With the implementation of extraction, the aquifer's hydraulic gradient will increase, thereby increasing the rate of TCE movement. Therefore, it may be likely that the TCE plume is remediated after 15 years. However, the presence of contamination in the silty clay layer in the alluvium may complicate removal and lengthen the time of remediation. Therefore, groundwater extraction and treatment will minimize future exposures to groundwater contamination, and prevent offsite contaminant migration. Groundwater use restrictions will prevent exposures to contaminated groundwater during the remediation process.

Compliance with ARARs

Chemical-Specific ARARs—The chemical-specific ARARs for groundwater are listed in Table 2-2. As with Alternative 3, it is likely that ARARs will be met within the 30-year study period. On the basis of the rate of TCE movement determined in the Draft Phase I Aquifer Testing Report, it is possible that aquifer remediation may be complete within 15 years. However, the presence of contamination in the silty clay layer in the alluvium may complicate removal and lengthen the time of remediation.

Under this alternative, extracted groundwater will be discharged to the North Branch of the Potomac River via the storm sewer. Chemical-specific ARARs for surface water discharge require that contaminant concentrations meet federal and State discharge limits. The surface water discharge limits, which were developed in Section 3, are listed in Table 3-5. Air stripping is capable of meeting the surface water discharge limits. While this alternative is based on treatment by air stripping, carbon adsorption and UV/H_2O_2 oxidation are equally capable of meeting the surface water discharge limits.

Location-Specific ARARs—The Site 10 treatment system will not be located within the 100 year floodplain, in an ecologically sensitive area, in a wetlands, or on the banks of a scenic river. Therefore, there are no location-specific ARARs for this alternative.

Action-Specific ARARs—The Clean Water Act (33USC 1251 et seq. (40 CFR 122.44(a))) requires the use of the BAT economically achievable to control toxic and nonconventional pollutants. Air stripping is the BAT for the organic constituents listed in Table 3-5. Therefore, this ARAR is met. Note however that other technologies can be used besides air stripping as long as they will provide equal or better removal efficiencies.

The State of West Virginia Groundwater Protection Act (§47CSR58-4.7 to 4.7.4) indicates that pipelines that convey contaminants shall preferentially be installed above ground where feasible. Above ground installation is not feasible at Site 10 due to the potential for water freezing in the pipe in the winter. Therefore, the pipe will be installed below grade. The pipe will be single walled because it will be located directly over an aquifer contaminated with the same constituents.

Long-Term Effectiveness and Permanence

The discussion of long-term effectiveness and permanence for this alternative is identical to the discussion presented in Alternative 3.

Magnitude of Residual Risks—No residual risk will remain at Site 10 following completion of remediation. It will likely take at least 15 years for the aquifer to be remediated to the PRGs. Therefore, there will be residual risk during groundwater extraction, but the residual risk will continue to decrease as remediation is completed.

Adequacy and Reliability of Controls—The groundwater extraction system will adequately control the residual risk associated with groundwater contamination during the remediation process. As shown on Figure B-5, the extraction configuration will capture the entire TCE plume, thereby preventing offsite migration of Site 10 contaminants.

The Site 10 treatment system will effectively treat the organic contaminants to below their discharge limits so that offsite exposures to concentrations above human health and ecologically based standards are prevented. The treatment system will consist of an air stripper which is a widely understood and heavily utilized technology for the removal of organics. Air stripper vendors will usually provide a guarantee of their stripper's removal efficiency. Although this alternative is based on air stripping, carbon adsorption and UV/H_2O_2 oxidation are also capable of effectively meeting the discharge limits. As with air stripping, UV/H_2O_2 oxidation vendors will usually provide a guarantee of removal efficiency. Carbon adsorption vendors usually will not because the carbon units must be closely monitored to determine when contaminant breakthrough occurs.

An air stripper's removal efficiency can be significantly reduced in the presence of high metal oxide and hardness concentrations. Dissolved metal oxides such as ferrous and manganous ions will precipitate when aerated, thereby clogging the air stripper's internals and reducing the mass transfer properties of the unit. Hardness ions such as calcium and magnesium will also form scale on the air stripper's internals. In this alternative, a sequestering agent will be injected into the influent prior to the air stripper to complex the metal oxides and hardness ions, preventing them from precipitating and scaling. Therefore, the air stripper will operate at peak removal efficiency.

Reduction of Toxicity, Mobility, and Volume

The toxicity, mobility, and volume of groundwater contaminants will be significantly reduced by this alternative. The groundwater extraction configuration has been designed to achieve complete capture of the TCE plume, thereby minimizing the mobility of the contaminants. The Site 10 treatment system will reduce the toxicity and volume of contamination by remediating the groundwater to the discharge limits listed in Table 3-5.

Short-Term Effectiveness

There will be no significant affects on the ABL facility during implementation of this alternative. Construction activities will occur primarily in an open field. Excavation activities to install the building foundation and lay the extraction pipeline will occur in clean soil. Therefore, there will be no significant air emissions of toxic pollutants. The total construction duration is approximately four to five months.

It will likely take over a decade to remediate Site 10. Contaminant concentrations will remain present above PRGs during this time. It will be necessary to perform continuous extraction and treatment during this time in order to prevent offsite contaminant migration and to prevent exposures to concentrations above PRGs.

Implementability

Technical Feasibility—Groundwater extraction is implementable. The effectiveness of the extraction configuration is based on properly modeling the groundwater flow conditions. There are no significant technical difficulties associated with installing or operating extraction wells.

The treatment system will be relatively simple to construct and operate. The air stripper is "off-the-shelf" equipment. The Navy's remedial action contractor (RAC) has the experience to construct the system. O&M work will consist primarily of influent, effluent, and groundwater sampling and laboratory analysis, periodically refilling the sequestering agent tank, and cleaning equipment.

The storm sewer must be modified in this alternative. The storm sewer currently discharges to an unlined drainage channel which is believed to be considered "natural waters" of the State. In this alternative, the drainage channel discharge will be blocked, and a new 160-foot segment of sewer pipe will be installed so that the Site 10 treatment system discharges directly to the river. Storm sewer construction is a common construction activity and is easily implemented.

The capacity of the existing storm sewer must be verified prior to design. Verification will consist of discharging water from a tanker truck to a manhole in the vicinity of Site 10, and monitoring the flow rate the sewer will accept under gravity flow conditions. The conceptual layout of the treatment system includes a treated water holding tank. The purpose of the holding tank is to store water during large storm events when the storm pipe is operating at full capacity. It may be possible to eliminate the holding tank if storm sewer testing indicates that the sewer pipe has significant excess capacity.

Administrative Feasibility—As with all of the extraction alternatives which will be discussed, long term administrative resources must be expended to conduct five year site reviews. Five-year site reviews will be required because the groundwater will remain contaminated for at least 15 years after the commencement of groundwater extraction. Administrative resources will also be required to administer the O&M of the Site 10 treatment plant.

Availability of Services and Materials—All of the services, equipment, and materials required to implement this alternative are readily available.

Cost

The cost assumption has been made that the extraction wells will be previously installed. The capital cost includes the extraction pumps, treatment system, and storm sewer modifications. The capital cost is estimated to be $770,000. The annual O&M cost includes influent, effluent, and groundwater data collection and laboratory analysis, sequestering agent, labor, and electrical costs required to operate the treatment system. The annual O&M cost is estimated to be $100,000. The present worth, assuming a 15-year project life, is $1,800,000. The cost estimate is included as Table 3 in Appendix G.

Alternative 8—Focused Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer

In each of the groundwater extraction alternatives discussed so far, the entire TCE plume shown on Figure 1-12 has been designated for remediation. This approach has been taken to prevent the spread and further migration offsite of groundwater contamination originating from Site 10. The majority of the TCE plume is composed of fairly low TCE concentrations, with only a smaller fraction containing significantly higher concentrations. This TCE "hot spot" is located in the general vicinity of Building 157, and contains TCE concentrations as high as 830 μg/L which were detected in monitoring well samples. TCE concentrations as high as 6,800 μg/L were detected in geoprobe samples in this area. For purposes of discussion, it has been assumed that the "hot spot" generally coincides with the 500 μg/L TCE isopleth (see Figure 1-12).

In this alternative, extraction will occur only from the TCE hot spot. Preliminary calculations performed during groundwater flow modeling conducted during the Phase I Aquifer Testing program indicated that two wells, each pumping at a sustained rate of 15 gpm, can be installed in the hot spot area, achieving capture of the entire 500 μg/L isopleth and more quickly remediate the hot spot than the extraction configuration shown on Figure 3-1. Extracted groundwater will be treated by an air stripper prior to discharge to the storm sewer.

The remainder of the VOC plume will be remediated through natural attenuation. As discussed with Alternative 2, VOCs in the aquifer will likely be reduced to concentrations below instrument detection limits prior to reaching the North Branch of the Potomac River due to dispersion, geochemical and biological degradation, and volatilization as they migrate from Site 10. Groundwater monitoring wells will be used to confirm that natural degradation is taking place, and to confirm that the TCE contaminant plume is not migrating further from Site 10. Groundwater use restrictions will be administered to prevent groundwater use during the remediation process.

Overall Protection of Human Health and the Environment

The site-specific RAOs for Site 10 groundwater are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.

- Prevent or minimize offsite migration of contamination originating from Site 10.

This alternative may likely meet both of the RAOs within the 30-year study period. Extraction wells located in the hot spot will prevent any future migration of VOCs from the site. Hot spot extraction will also likely remediate the most contaminated part of the aquifers within a shorter period than sitewide extraction. Therefore, once more dilute VOC contamination is remediated via natural attenuation the aquifers could be returned to normal use.

Compliance with ARARs

Chemical-Specific ARARs—The chemical-specific ARARs for groundwater are listed in Table 2-2. It is likely that the ARARs will be met within the 30-year study period. The chemical-specific ARARs for discharge to surface water consist primarily of those listed in Table 3-4. This is because the BAT effluent limitations for most of the VOCs are lower than the West Virginia preliminary discharge limits. Therefore, the BAT effluent limitations are the preliminary discharge limits. The only exception is 1,1-DCE. At 30 gpm, the preliminary discharge limit increases to 7.1 μg/L (from 2.85 μg/L at 75 gpm).

Location-Specific ARARs—There are no location-specific ARARs for this alternative.

Action-Specific ARARs—The State of West Virginia's preference for piping to be installed above grade (§47CSR58-4.7 to 4.7.4) is the only ARAR for this alternative. As discussed, installation of above grade piping is not feasible because the likelihood that conveyed groundwater will freeze in the winter time. In addition, all extraction piping will be located over contaminated aquifers.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risks—This alternative will likely be effective in remediating the aquifers within the 30-year study period established by the NCP. However, chemical-specific ARARs will likely not be met for decades. Therefore, the magnitude of the residual risk remaining during remediation will remain high. Once remediation is complete, there will be no significant residual risk associated with the site.

The residual risk to offsite sources during remediation is considered to be low. Analytical results in the Phase II RI Report indicate that significant dispersion, degradation, and volatilization is occurring because no VOCs were detected in monitoring well 2GW5, which is the furthest well downgradient from Building 157. Monitoring wells will assist in confirming that significant offsite migration is not occurring, thereby further reducing the residual risk.

Adequacy and Reliability of Controls—Wells installed in the TCE hot spot will adequately control groundwater contamination during remediation. Groundwater monitoring wells will be used to determine if contaminant migration is occurring, and additional extraction wells can be installed if necessary.

Reduction of Toxicity, Mobility, and Volume

The toxicity, mobility, and volume of groundwater contaminants will be significantly reduced by this alternative. Hot spot extraction will reduce the mobility of the most contaminated portion of the aquifer, and air stripping will reduce the toxicity and volume of groundwater contamination.

Natural attenuation processes may possibly reduce the toxicity and volume of groundwater contaminants within the 30-year study period. However, contaminant mobility will not be changed by this alternative.

Short-Term Effectiveness

There will be no significant affects on the ABL facility during implementation of this alternative. Construction activities will occur primarily in an open field. Excavation activities to install the building foundation and lay the extraction pipeline will occur in clean soil. The total construction duration is approximately four months.

Implementability

Technical Feasibility—There are no significant difficulties associated with the implementation of this alternative. Surface water discharge limits are slightly less stringent than in previous alternatives. The treatment technologies are very effective in remediating the Site 10 VOCs. The treatment system will be smaller due to the lower flow rate.

Administrative Feasibility—As with all of the extraction alternatives which have been discussed, long term administrative resources must be expended to conduct five year site reviews. Five-year site reviews will be required because the groundwater will remain contaminated for several decades after the commencement of groundwater extraction. Administrative resources will also be required to administer the O&M of the Site 10 treatment plant.

Availability of Services and Materials—All of the services, equipment, and materials required to implement this alternative are readily available.

Cost

The cost assumption has been made that the extraction wells will be previously installed. The capital cost includes the extraction pumps, treatment system, and modifications to the storm sewer. The capital cost is estimated to be $540,000. The annual O&M cost includes influent, effluent, and groundwater data collection and laboratory analysis, sequestering agent costs, labor, and electricity required to operate the treatment system. The annual O&M cost is estimated to be $80,000. The present worth, assuming a 30-year project life, is $1,400,000. The cost estimate is included as Table 4 in Appendix G.

Alternative 9—Focused Groundwater Extraction and Discharge to the Site 1 Treatment Plant

This alternative is very similar to Alternative 8, with the only difference being the method of discharge. As with Alternative 8, the most contaminated portion of the aquifer will be remediated by groundwater extraction, while the more dilute portion of the aquifer will be remediated through natural attenuation. It has been assumed that groundwater extraction will occur within the 500 μg/L TCE isopleth (see Figure 1-12).

As discussed in Alternative 8, it is likely that two extraction wells can be installed in the TCE hot spot and pumped at a sustained rate of 15 gpm each. Extracted groundwater will be discharged to the Site 1 treatment system via the discharge pipeline shown on Figure 3-1.

The remainder of the VOC plume will be remediated through natural attenuation. As discussed in Alternative 8, it appears that natural attenuation of the TCE plume is in progress. It is likely that the VOCs in the aquifer will likely be reduced to concentrations below instrument detection limits before reaching the North Branch of the Potomac River due to dispersion, geochemical and biological degradation, and volatilization as they migrate from Site 10. Groundwater monitoring wells will be used to confirm that natural degradation is taking place, and to confirm that the TCE contaminant plume is not migrating offsite into the river. Groundwater use restrictions will be administered to prevent the use of groundwater during the remediation process.

Overall Protection of Human Health and the Environment

The site-specific RAOs for Site 10 groundwater are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.
- Prevent or minimize offsite migration of contamination originating from Site 10.

The discussion of overall protection of human health and the environment is very similar to Alternative 8. This alternative may potentially meet both of the Site 10 RAOs within the 30-year study period. Hot spot extraction will prevent potential exposures to the most contaminated portion of the aquifer relatively quickly, and will prevent the future spread of contamination from the site. Therefore, once more dilute VOC contamination is remediated via natural attenuation, and the hot spot is remediated, the aquifers could be returned to normal use.

Compliance with ARARs

Chemical-Specific ARARs—The chemical-specific ARARs for groundwater are listed in Table 2-2. The ARARs will likely be met in the TCE hot spot area within the 30-year study period. It appears that natural attenuation processes are currently in progress at the site. Groundwater monitoring will be required to confirm the decline in VOC concentrations, and to confirm whether chemical-specific ARARs will be met throughout the Site 10 aquifers within the 30-year study period.

The chemical-specific ARARs will be based on discharge to the Site 1 treatment system. The Site 1 treatment system will be designed with an initial capacity of 220 gpm, and the Site 1 extraction system will utilize 190 gpm of this capacity. Therefore, with the addition of Site 10, the total flow will be 220 gpm. The surface water discharge limits for the 220 gpm flow will govern discharge to the North Branch of the Potomac River. These limits are listed in Table 3-4.

Location-Specific ARARs— Location-specific ARARs associated with construction of the Site 1 treatment plant were discussed in the Site 1 FFS. In brief, the treatment plant must not be located within the 100 year floodplain unless it is designed and constructed to avoid washout (40 CFR 264.18(b)). Also, stormwater and soil erosion controls must be implemented to avoid causing adverse affects on the Potomac River during treatment plant construction (Wild and Scenic Rivers Act [16 USC 1271 et seq. and Section 7(a)]). These ARARs will be addressed during design and construction of the Site 1 treatment plant.

Action-Specific ARARs—40 CFR 262.34 (RCRA 42 USC 6901 et seq.) requires that generators of hazardous waste may accumulate waste onsite for a maximum of 90 days. Any accumulation longer than 90 days would be subject to the substantive RCRA requirements for storage facilities. If sludge from the metals precipitation process is determined to be a hazardous waste, this action-specific ARAR will apply.

The State of West Virginia Groundwater Protection Act (§47CSR58-4.7 to 4.7.4) indicates that pipelines which convey contaminants shall preferentially be installed above ground where feasible. Above ground installation is not feasible for the Site 10 discharge pipeline because the pipe alignment will cross several roads. Therefore, the pipe will be installed below grade and will be double-walled to contain potential leaks. The interstitial space between the pipe walls will be monitored by a leak detection system.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risks—The discussion of long-term effectiveness and permanence is identical to Alternative 8. This alternative will likely be effective in remediating the aquifers within the 30 year study period established by the NCP. However, chemical-specific ARARs will likely not be met for decades. Therefore, the magnitude of the residual risk remaining during remediation will remain high. Once remediation is complete, there will be no significant residual risk associated with the site.

The residual risk to offsite sources during remediation is considered to be low. Analytical results in the draft Phase II RI Report indicate that significant dispersion, degradation, and volatilization is occurring because no VOCs were detected in monitoring well 2GW5, which is the furthest well downgradient from Building 157.

Adequacy and Reliability of Controls—Wells installed in the TCE hot spot will adequately control groundwater contamination during remediation. Groundwater monitoring wells will be used to determine if contaminant migration is occurring.

Reduction of Toxicity, Mobility, and Volume

The toxicity, mobility, and volume of groundwater contaminants will be reduced significantly by this alternative. Hot spot extraction will reduce the mobility of the most contaminated portion of the aquifer, and the Site 1 treatment plant will reduce the toxicity and volume of groundwater contamination.

Natural attenuation processes may reduce the toxicity and volume of groundwater contaminants within the 30-year study period. However, contaminant mobility will not be changed by this alternative.

Short-Term Effectiveness

There will be no significant affects on the ABL facility during implementation of this alternative. Several of the facility's roads may need to be closed in order to install the discharge pipeline. Pipeline installation will be in clean soil areas. Expansion of the Site 1 treatment system should have minor impacts on the facility. The majority of the treatment system modifications will occur within the treatment building, and will likely not be noticed.

It will likely be necessary to shut down the Site 1 extraction wells to perform minor modifications to the treatment system. Modifications will include connecting the Site 10 discharge pipeline and modifying the plant's control system so the flow rate, water level, and on/off status of the Site 10 extraction pumps can be controlled. The treatment plant will be initially designed to handle an additional 30 gpm. Therefore, no modifications to the unit processes (metals precipitation, filtration, air stripping, etc.) will likely be required. It will take 1 to 2 months to modify the control system and restart the plant at the higher flow rate.

Implementability

Technical Feasibility—There are no significant difficulties associated with the implementation of this alternative. The Site 1 treatment plant will be initially designed to handle an additional 30 gpm of flow. Therefore, only minor modifications will be required.

Administrative Feasibility—As with all of the extraction alternatives which have been discussed, long-term administrative resources must be expended to conduct 5-year site reviews. Five-year site reviews will be required because the groundwater will remain contaminated for several decades after the commencement of groundwater extraction. Administrative resources will also be required to administer the O&M of the Site 1 treatment plant.

Availability of Services and Materials—All of the services, equipment, and materials required to implement this alternative are readily available.

Cost

The cost assumption has been made that the extraction wells will be previously installed. The capital cost includes the extraction pumps, double-walled discharge pipeline, and minor modifications to the Site 1 treatment plant. The capital cost is estimated to be $450,000. The annual O&M cost includes groundwater data collection and laboratory analysis, and additional labor, electricity, chemical, and sludge disposal costs to operate the Site 1 treatment plant. The annual O&M cost is estimated to be $70,000. The present worth, assuming a 30-year project life, is $1,200,000. The cost estimate is included as Table 5 in Appendix G.

Table 4-3
Comparative Analysis of Remedial Alternatives for Site 10 Groundwater

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
OVERALL PROTECTION OF HUMAN HEALTH AND ENVIRONMENT						
Exposure to contaminated groundwater	No reduction in risk of exposure over current levels.	Restrictive covenants will reduce potential for exposure.	See Alternative 2. Extraction and treatment will minimize potential for exposures to contaminants above PRGs.	See Alternative 3.	See Alternative 2. Focused extraction and treatment will prevent future exposures to the most contaminated portion of the aquifer. Natural attenuation will eventually reduce concentrations in the remainder of the aquifer.	See Alternative 8.
Prevent or minimize offsite migration	Contamination would continue to migrate at present levels.	Offsite migration will not be prevented, but natural attenuation appears to be reducing contaminant concentrations to below instrument detection limits.	Sitewide extraction will capture the entire TCE plume, thereby preventing offsite migration.	See Alternative 3.	Focused extraction will prevent future offsite migration. Contaminants in the more dilute portion of the aquifer will not be prevented from mirating offsite before natural degradation completes remediation. However, natural attenuation appears to be reducing contaminant concentrations to below instrument detection limits	See Alternative 8.

Table 4-3
Comparative Analysis of Remedial Alternatives for Site 10 Groundwater

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
COMPLIANCE WITH ARARS						
Chemical-Specific ARARs	Does not comply with chemical-specific ARARs for groundwater.	Will not comply with ARARs in the short term, but may meet ARARs during the 30 year study period.	Will likely comply with ARARs within a 30 year period.	See Alternative 3.	ARARs will be met in theTCE hot spot more quickly than with sitewide extraction alternatives. Natural attenuation will likely take several decades to meet ARARs in the remainder of the aquifer.	See Alternative 8.
Location-Specific ARARs	Not relevant.	There are no location-specific ARARs for this alternative.	See Alternative 2.	See Alternative 2.	See Alternative 2.	See Alternative 2.
Action-Specific ARARs	Not relevant. No action taken.	Does not specifically comply with the State Groundwater Protection Act, which disallows alternatives relying solely on dilution and dispersion.	State Groundwater Protection Act prefers above ground piping if practical. This is not practical at ABL due to potential freezing.	See Alternative 3.	See Alternative 3.	See Alternative 8.

Table 4-3
Comparative Analysis of Remedial Alternatives for Site 10 Groundwater

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
LONG-TERM EFFECTIVENESS AND PERMANENCE						
Groundwater	Source not remediated; risk remains at current levels.	Risk may be reduced during 30 year study period. However, risk will remain above PRGs for several decades.	There will be minimal risk following completion of remediation. Alternative is effective and permanent.	See Alternative 3.	There will be minimal risk following completion of remediation. However, it will likely be decades before completion of remediation due to reliance on natural attenuation.	See Alternative 8.
Need for Five Year Review	Because contaminated material remains onsite, five year reviews would be required.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.	See Alternative 1.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME						
Groundwater	None provided.	Natural attenuation will slowly reduce toxicity, mobility, and volume over several decades or more.	Sitewide extraction will capture the entire plume, minimizing mobility. Treatment will significantly reduce toxicity and volume.	See Alternative 3.	Will reduce toxicity, mobility, and volume of the most contaminated portion of the aquifers. Mobility and volume of the more dilute portion of the aquifer will remain the same, but toxicity will be gradually reduced through natural attenuation processes.	See Alternaive 8.

Table 4-3
Comparative Analysis of Remedial Alternatives for Site 10 Groundwater

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
SHORT-TERM EFFECTIVENESS						
Groundwater	Not relevant	There will be no significant impacts on the facility.	Installation of the discharge pipeline will require roads to be temporarily closed	See Alternative 3.	See Alternative 3. This alternative would require the largest amount of material import. Therefore, the amount of construction traffic would be the largest under this alternative.	
Time Until Action is Complete	Not applicable.	30 years or more	Four months to complete construction. Approximately 15 years to remediate the aquifers. Presence of VOCs in silty clay layer may complicate extraction, lengthening remediation period.	Four to five months to complete construction. Approximately 15 years to remediate the aquifers. Presence of VOCs in silty clay layer may complicate extraction, lengthening remediation period.	Four months to complete construction. Approximately 30 years to remediate the aquifers.	Three to four months to complete construction. Approximately 30 years to remediate the aquifers.
IMPLEMENTABILITY						
Ability to Construct and Operate	Not applicable.	Easily implemented.	Site 1 treatment system will require modification, which could be complex.	Alternative is easily implemented using standard construction practices.	See Alternative 4.	See Alternative 3.
Ease of Doing Additional Action if Needed	Very easy to implement additional action.	Very easy to implement additional action.	Additional extraction wells can be installed. However, increased flow may require treatment plant upgrades.	See Alternative 3.	See Alternative 3.	See Alternative 3.

Table 4-3
Comparative Analysis of Remedial Alternatives for Site 10 Groundwater

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/Natural Attenuation	Alternative 3 Sitewide Extraction, Discharge to Site 1	Alternative 4 Sitewide Extraction, Air Stripping, Storm Sewer Discharge	Alternative 8 Focused Extraction, Air Stripping, Storm Sewer Discharge	Alternative 9 Focused Extraction, Discharge to Site 1
Ability to Monitor Effectiveness	Easily monitored during five year site reviews.	A groundwater monitoring program will be implemented, and used to effectively monitor natural attenuation and potential offsite migration.	Groundwater monitoring wells will be used to confirm extraction wells are achieving capture of the entire TCE plume and potential offsite migration.	See Alternative 3.	Monitoring wells will be used to confirm extraction wells are attaining capture, natural attenuation is occurring, and potential offsite migration.	See Alternative 8.
COST						
Capital Cost	$0	$50,000	$700,000	$770,000	$540,000	$450,000
First-Year Annual O&M Cost	$0	$25,000	$80,000	$100,000	$80,000	$70,000
Present-Worth	$0	$400,000	$1,500,000	$1,800,000	$1,400,000	$1,200,000

Comparative Analysis of Sitewide Remedial Alternatives

In the following analysis, the sitewide remedial alternatives are evaluated in relation to one another based on each of the seven criteria. The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. Table 4-3 contains a summary of this analysis. The groundwater alternatives are listed below to assist in the clarity of this discussion:

- Alternative 1—No Action
- Alternative 2—Institutional controls and natural attenuation
- Alternative 3—Sitewide groundwater extraction and discharge to the Site 1 treatment plant
- Alternative 4—Sitewide groundwater extraction, air stripping, and discharge to the storm sewer
- Alternative 8—Focused groundwater extraction, air stripping, and discharge to the storm sewer
- Alternative 9—Focused groundwater extraction and discharge to the Site 1 treatment plant

It is apparent from the previous evaluation of the remedial alternatives that the performance of each alternative is somewhat similar. Therefore, the comparative analysis will focus on factors that provide distinctions between the alternatives.

Protection of Human Health and Environment

The RAOs are:

- Prevent or minimize exposure of potential future site residents and construction workers to contaminated groundwater originating from Site 10.

- Prevent or minimize offsite migration of contamination originating from Site 10.

The No Action alternative will not meet either RAO. Alternative 2 will meet the first RAO through the use of restrictive covenants on the deed and groundwater use restrictions. The second RAO may be met during the 30-year study period through natural attenuation of the VOC contaminants. Annual groundwater monitoring is required in order to identify trends in contaminant reduction, and in order to make a better estimate of the time to remediation.

Alternatives 3 and 4 will meet both RAOs. These alternatives incorporate sitewide groundwater extraction, which will prevent offsite migration of groundwater contaminants. Each alternative incorporates a treatment component, which will reduce the toxicity of the groundwater contaminants, thereby preventing exposures of future site residents and construction workers to contaminant concentrations above PRGs.

Alternatives 8 and 9 will likely meet both of the RAOs during the 30-year study period. These alternatives incorporate focused groundwater extraction from the TCE hot spot, and allow the more dilute portion of the TCE plume to be remediated through natural attenuation. Groundwater monitoring will be used to confirm that offsite migration is not occurring, and natural attenuation processes are degrading the VOC contaminants so their concentrations are reduced to the PRGs. In each of these alternatives, extracted groundwater will be treated, thereby minimizing the potential for future exposures to contaminants above PRGs.

Compliance with ARARs

Chemical-Specific ARARs—There are no ARARs for the No Action alternative. In Alternative 2, the aquifers will remain out of compliance with chemical-specific ARARs for decades because the organic contaminants listed in Table 2-2 will remain present at concentrations above their PRGs. However, it may be likely that natural attenuation processes will continue to reduce the contaminant concentrations to below their PRGs within the 30 year study period.

Alternatives 3 and 4 will likely achieve the ARARs for groundwater within the 30-year study period. According to the Draft Phase I Aquifer Testing Report, based on the rate of TCE movement in the alluvial aquifer, the furthest edge of the TCE plume will likely reach the closest groundwater extraction well in five years under natural flow conditions. Groundwater extraction will increase the hydraulic gradient, thereby increasing the rate of TCE movement. It is likely that chemical-specific ARARs will be met within 15 years. However, the presence of VOCs in the silty clay layer of the alluvium may complicate removal and lengthen the time of remediation.

In Alternatives 8 and 9, chemical-specific ARARs will likely be achieved in the TCE hot spot. Preliminary calculations performed during groundwater flow modeling indicated that the hot spot area can be pumped at a higher rate than what is planned for in the sitewide extraction alternatives. Therefore, it is likely that the hot spot will be remediated more quickly in these alternatives, and the chemical-specific ARARs will be met sooner in this portion of the aquifers than with sitewide extraction alternatives. Natural attenuation is a slower process. Therefore, it will take longer for chemical-specific ARARs to be met on the remainder of the site. However, hot spot extraction will prevent continued migration of contaminants from the site, so the natural attenuation process will only be required to remediate the more dilute portions of the contaminant plume. Therefore, it is likely that Alternatives 8 and 9 will meet the chemical-specific ARARs for groundwater within the 30-year study period.

Location-Specific ARARs—There are no location-specific ARARs for any of the alternatives except alternatives 3 and 9. In these two alternatives, extracted groundwater will be discharged to the Site 1 treatment plant. The location-specific ARARs for the Site 1 treatment plant were addressed in the Site 1 FFS.

Action-Specific ARARs—There are no action-specific ARARs for alternatives 1 and 2. The remainder of the alternatives rely on piping to convey water from the extraction wells to a treatment system. The State of West Virginia Groundwater Protection Act (§47CSR58-4.7 to 4.7.4) indicates that pipelines which convey contaminants shall preferentially be installed above ground where feasible. Above ground installation is not feasible either because pipelines will cross roads and because the potential for freezing exists. In Alternatives 3 and 9, extracted groundwater will be conveyed to the Site 1 treatment plant through a double-walled pipe in order to provide additional safeguards against the spread of contamination to clean areas.

The State of West Virginia Groundwater Protection Act (§47CSR58-8.1.2) requires that cleanup actions shall not rely primarily on dilution and dispersion if active remedial measures are technically and economically feasible. Alternatives 2 and 8 and 9 to a lesser extent, rely on natural attenuation processes to remediate groundwater contamination. While this alternative does rely on dilution and dispersion, contaminants will also be remediated (to a lesser extent) through biological degradation and volatilization. This is evidently occurring because contaminants such as 1,1-DCE and 1,1-DCA, which are breakdown products of TCE degradation, have been detected.

Long-Term Effectiveness and Permanence

All of the alternatives (except the No Action alternative) will provide a minimal amount of residual risk following implementation of the alternative. Alternative 2 relies solely on natural attenuation. It is possible that the Site 10 aquifers will naturally remediate themselves during the 30-year study period, and the residual risk following completion of remediation will be minimal. However, the site will remain contaminated for a much longer period than with the other alternatives.

There is no significant distinction between Alternatives 3 and 4 in meeting this evaluation criterion. These alternatives incorporate sitewide extraction and treatment, and in doing so, will remediate the aquifer to PRGs. Alternatives 8 and 9 rely on focused groundwater extraction from the TCE hot spot, and natural attenuation for the remainder of the TCE plume. It is likely that only minimal residual risk will remain following completion of these alternatives. However, it will take longer for these alternatives to be completed than with Alternatives 3 and 4.

Reduction of Toxicity, Mobility, and Volume

Alternative 2 relies on natural attenuation and institutional controls. Institutional controls will reduce the toxicity of groundwater contaminants to potential receptors by limiting potential exposures. Contaminant mobility and volume will not be reduced in the short term because aggressive treatment methods will not be used. However, it is likely that the toxicity, mobility, and volume of groundwater contamination will be reduced through natural attenuation during the 30-year study period.

Alternatives 3 and 4 will provide an equal degree of reduction in toxicity, mobility, and volume. In these alternatives, sitewide extraction will be used to capture the entire TCE plume, and treatment technologies will be used to reduce contaminant concentrations to chemical-specific ARARs.

Alternatives 8 and 9 will provide a lesser degree of reduction in toxicity, mobility, and volume of groundwater contaminants than Alternatives 3 and 4 in the short term because these alternatives rely on focused extraction and natural attenuation. These alternatives will more effectively meet this evaluation criterion than Alternative 2.

Short-Term Effectiveness

There will be no significant impacts to the ABL facility under any of the alternatives. Alternatives 3 and 9 will likely produce the largest disturbance due to the installation of the Site 10 discharge pipeline which must be installed across facility roads. In these alternatives, the Site 1 treatment system must also be temporarily shut down for modifications. Alternatives 4 and 8 will have a minor impact on the facility, and Alternatives 1 and 2 will have virtually no impact on the facility.

Implementability

There are no significant technical difficulties associated with any of the alternatives. Alternative 3 will likely be the most challenging to implement. In this alternative, the Site 1 treatment system must be extensively modified to accept an additional flow of 75 gpm from

Site 10. Alternative 9 will also rely on the Site 1 treatment system for treatment, but the treatment system will be initially designed to handle an additional 30 gpm of flow.

Five-year site reviews will be required in all of the alternatives because contaminated media will remain on site after implementation of each alternative.

Cost

Table 4-3 presents a comparative cost summary of the alternatives.

WDCR1053/016.DOC

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USEPA. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A, Interim Final.* Office of Solid Waste and Emergency Response. EPA/540/1-89/002. December 1989a.

USEPA. *Human Health Evaluation Manual, Part B: "Development of Risk-based Preliminary Remedial Goals.".* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-01B. December 13, 1991b.

USEPA. *Guidance for Data Useability in Risk Assessment (Part A).* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-09A. December 1989a.

USEPA. *Selecting Exposure Routes and Contaminants of Concern by Risk-based Screening.* Region III, Hazardous Waste Management Division, Office of Superfund Programs. (EPA/903/R-93-001). January 1993b.

USEPA. Conference call with EPA Region III. Parties Involved: Bruce Beach, EPA RPM; Roy Smith, EPA Toxicologist; Greg Mott, CH2M HILL Task Manager; Holly Rosnick, Roni Warren, and Ann West, CH2M HILL Risk Assessors. March 8, 1995a.

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Appendix A
ARARs

Table A-1
Federal Location-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Hazardous Waste Control Act (HWCA)*					
Within 61 meters (200 feet) of a fault displaced in Holocene time	New treatment, storage or disposal of hazardous waste prohibited.	Resource Conservation and Recovery Act (RCRA) hazardous waste; treatment, storage, or disposal of hazardous waste.	40 CFR 264.18 (a)	Not an ARAR	Site 1 is not located near a fault displaced in Holocene time.
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	40 CFR 264.18 (b)	Potentially applicable or relevant and appropriate to removal and treatment activities.	Site 1 is located in a 100-year floodplain. Requirements applicable to hazardous waste facilities constructed in the floodplain. Relevant to construction of facilities for management of materials similar to hazardous waste.
Within salt dome formation, underground mine, or cave	Placement of non-containerized or bulk liquid hazardous waste prohibited.	RCRA hazardous waste; placement.	40 CFR 264.18 (c)	Not an ARAR	Placement of hazardous material into any salt dome formation, underground mine, or cave, will not occur during the response action at site 1.
Executive Order 11988, Protection of Floodplains*					
Within floodplain	Actions taken should avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values.	Action that will occur in a floodplain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Potentially applicable.	As indicated above, Site 1 is located, at least partially, within the floodplain. Therefore, facilities or activities located within the floodplain must comply with this order.
National Archaeological and Historical Preservation Act*					
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	Construction on previously undisturbed land would require an archaeological survey of the area.	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archaeologic data.	Substantive requirements of 36 CFR 65	Not an ARAR	Construction at Site 1 will not occur on previously undisturbed land.

Table A-1 Federal Location-Specific ARARs Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site					
Location	**Requirement**	**Prerequisite**	**Citation**	**ARAR Determination**	**Comments**
National Historic Preservation Act, Section 106*					
Historic project owned or controlled by federal agency	Action to preserve historic properties; planning of action to minimize harm to properties listed on or eligible for listing on the National Register of Historic Places.	Property included in or eligible for the National Register of Historic Places.	Substantive Requirements of 36 CFR 800.	Not an ARAR	There is no property included in or eligible for the National Register of Historic Places at Site 1.
Endangered Species Act of 1973*					
Critical habitat upon which endangered species or threatened species depend.	Action to conserve endangered species or threatened species, including consultation with the Department of the Interior.	Determination of effect upon endangered or threatened species or its habitat.	16 USC 1536(a)	Applicable	There area endangered plant and animal species located in the vicinity of Site 1. If remediation activities could impact these species, consultation with the Department of the Interior is required to determine the appropriate action.
Executive Order 11990, Protection of Wetlands*					
Wetland	Action to minimize the destruction, loss, or degradation of wetlands.	Wetlands as defined by Executive Order 11990 Section 7.	40 CFR 6, Appendix A excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Not an ARAR	Wetlands are not present in the vicinity of Site 1.
Clean Water Act, Section 404*					
Wetland	Action to prohibit discharge of dredged or fill material into wetland without permit.	Wetland as defined by Executive Order 11990 Section 7.	40 CFR 230.10; 40 CFR 231 (231.1, 231.2, 231.7, 231.8)	Not an ARAR	Discharge of dredged or fill material is not planned as part of the response action. Wetlands are not present in the vicinity of Site 1.
Wilderness Act*					
Wilderness area	Area must be administered in such a manner as will leave it unimpaired as wilderness and preserve its wilderness character.	Federally owned area designated as wilderness area.	50 CFR 35.1 et seq.	Not an ARAR	Allegany Ballistics Laboratory - Site 1 is not located in a federally owned wilderness area.

Table A-1
Federal Location-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
National Wildlife Refuge System*					
Wildlife refuge	Only actions allowed under the provisions of 16 USC Section 688 dd(c) may be undertaken in areas that are part of the National Wildlife Refuge System.	Area designated as part of National Wildlife Refuge System.	50 CFR 27	Not an ARAR	Allegany Ballistics Laboratory - Site 1 is not located in an area designated as a part of the National Wildlife Refuge System.
Fish and Wildlife Coordination Act, Section 662*					
Area affecting stream or other water body	Action taken should protect fish or wildlife.	Diversion, channeling or other activity that modifies a stream or other water body and affects fish or wildlife.	16 USC 662	Not an ARAR	Response actions will not involve a form of modification to the North Branch Potomac River.
Wild and Scenic Rivers Act*					
Within area affecting national wild, scenic, or recreational river.	Avoid taking or assisting in action that will have direct adverse effect on scenic river.	Activities that affect or may affect any of the rivers specified in Section 1276(a).	16 USC 1271 et seq. and Section 7(a)	Potentially applicable.	Construction activities near the North Branch Potomac may have an adverse effect on the river. Applicable if the river is classified as a national wild, scenic, or recreational river.
Coastal Zone Management Act*					
Within coastal zone	Conduct activities in a manner consistent with approved State management programs.	Activities affecting the coastal zone including lands thereunder and adjacent shoreland.	Section 307(c) of 16 USC 1456(c); also see 15 CFR 930 and 923.45	Not an ARAR	Allegany Ballistics Laboratory - Site 1 is not located within or adjacent to a coastal zone.
Coastal Barrier Resources Act, Section 3504*					
Within designated coastal barrier	Prohibits any new federal expenditure within the Coastal Barrier Resource System.	Activity within the Coastal Barrier Resource System.	16 USC 3504	Not an ARAR	Allegany Ballistics Laboratory - Site 1 is not located within a coastal barrier.
Historic Sites, Buildings, and Antiquities Act*					
Historic sites	Avoid undesirable impacts on landmarks.	Areas designated as historic sites.	16 USC 461-467	Not an ARAR	There are no designated historic sites at site 1.

Table A-1
Federal Location-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Rivers and Harbors Act of 1890*					
Navigable waters	Permits required for structures or work in or affecting navigable waters.	Activities affecting navigable wasters.	33 USC 403	Applicable	The North Branch Potomac River is classified as a navigable waterway. Therefore, this requirement is applicable to response activities that affect the river.
Migratory Bird Treaty Act of 1972*					
Migratory bird area	Protects almost all species of native birds in the U.S. from unregulated "take" which can include poisoning at hazardous waste sites.	Presence of migratory birds.	16 USC Section 703	Applicable	Migratory birds are encountered in the river near Site 1. These requirements are applicable to any response actions that could result in unregulated "taking" of native birds.
Marine Mammal Protection Act*					
Marine mammal area	Protects any marine mammal in the U.S. except as provided by international treaties from unregulated "take".	Presence of marine mammals.	16 USC 1372(2)	Applicable	Marine mammals may be encountered along the North Branch Potomac, although the site is not near a coastal area. These requirements would be applicable to response actions that could fatally impact marine mammals.
Magnuson Fishery Conservation and Management Act*					
Fishery under management	Provides for conservation and management of specified fisheries within specified fishery conservation zones.	Presence of managed fisheries.	16 USC 1081, et seq.	Not an ARAR	The North Branch Potomac is not a fishery.

Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that DON accepts the entire statutes or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.

ARARs - Applicable or relevant and appropriate requirements.
HWCA - Hazardous Waste Control Act
RCRA - Resource Conservation and Recovery Act
USC - United States Code
CFR - Code of Federal Regulations

References:

"Draft Focused Remedial Investigation, Allegany Ballistics Laboratory Superfund Site," CH2M Hill, Inc., April 1995.

Table A-2
Federal Action-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Resource Conservation and Recovery Act (RCRA) 42 USC 6901 et seq.*					
Onsite waste generation	Waste generator shall determine if that waste is hazardous waste.	Generator of hazardous waste.	40 CFR 262.10 (a), 262.11	Applicable.	Applicable for any operation where waste is generated. Portions of the extracted groundwater or soil may be characteristic. RCRA hazardous waste because of leachable TCE concentrations.
Hazardous waste accumulation	Generator may accumulate waste on-site for 90 days or less or must comply with requirements for operating a storage facility.	Accumulate hazardous waste.	40 CFR 262.34	Potentially applicable.	If waste generated at Site 1 is determined to be hazardous, any storage of the hazardous waste will not exceed 90 days. Accumulation of hazardous wastes onsite for longer than 90 days would be subject to the substantive RCRA requirements for storage facilities.
Recordkeeping	Generator must keep records.	Generate hazardous waste.	40 CFR 262.40	Not an ARAR.	Administrative requirements are not ARARs for onsite CERCLA actions.
Container storage	Containers of RCRA hazardous waste must be: - Maintained in good condition. - Compatible with hazardous waste to be stored. - Closed during storage except to add or remove waste.	Storage of RCRA hazardous waste not meeting small quantity generator criteria held for a temporary period greater that 90 days before treatment, disposal or storage elsewhere, in a container.	40 CFR 264.171, 172, 173	Potentially applicable.	To be determined. Container storage requirements are applicable only if hazardous wastes are generated during remedial activities and are stored onsite for greater than 90 days.
	Inspect container storage areas weekly for deterioration.	Storage of RCRA hazardous waste not meeting small quantity generator criteria held for a temporary period greater that 90 days before treatment, disposal or storage elsewhere, in a container.	40 CFR 264.174	Potentially applicable.	

Table A-2
Federal Action-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Container storage	Place containers on a sloped, crack-free base, and protect from contact with accumulated liquid. Provide containment system with a capacity of 10 percent of the volume of containers of free liquids. Remove spilled or leaked waste in a timely manner to prevent overflow of the containment system.		40 CFR 264.175(a) and (b)	Potentially applicable.	To be determined. Container storage requirements are applicable only if hazardous wastes are generated during remedial activities and are stored onsite for greater than 90 days.
	Keep containers of ignitable or reactive waste at least 50 feet from the facility property line.		40 CFR 264.176	Potentially applicable.	
	Keep incompatible materials separate. Separate incompatible materials stored near each other by a dike or other barrier.		40 CFR 264.177	Potentially applicable.	
	At closure, remove all hazardous waste and residues from the containment system, and decontaminate or remove all containers, liners.		40 CFR 264.178	Potentially applicable.	
Excavation	Movement of excavated materials to new location and placement in or on land will trigger land disposal restrictions for the excavated waste or closure requirements for the unit in which the waste is being placed.	Materials containing RCRA hazardous wastes subject to land disposal restrictions are placed in another unit.	40 CFR 268.40	Potentially applicable.	Applicable to disposal of soil containing land disposal restricted RCRA hazardous waste.
Waste pile	Use single liner and leachate collection system. Waste put into waste pile subject to land ban regulations.	RCRA hazardous waste, non-containerized accumulation of solid, nonflammable hazardous waste that is used for treatment or storage.	40 CFR 264.251 (except 251(j), 251(e)(11))	Potentially applicable.	To be determined. Wastes may be managed in waste piles as part of the response action at Site 1. These wastes maybe RCRA hazardous wastes.

Table A-2
Federal Action-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Closure with no postclosure care	General performance standard requires elimination of need for further maintenance and control; elimination of postclosure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products.	Land based unit containing hazardous waste. RCRA hazardous waste placed at site, or placed in another unit. Cleanup to health-based standards that will not require long-term management. Not applicable to material treated, stored, or disposed only before the effective date of the requirements, or if treated in-situ, or consolidated within area of contamination.	40 CFR 264.111	Potentially applicable or relevant and appropriate.	To be determined. This requirement could apply to active (not in-situ) management of wastes if wastes at Site 1 are determined to be RCRA hazardous wastes. May be relevant to active management of wastes which are sufficiently similar to hazardous wastes.
Clean closure	Removal or decontamination of all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate, and management of them as hazardous waste.	Surface impoundments, container of tank liners and hazardous waste residues, or contaminated soil (including soil from dredging or soil disturbed in the course of drilling or excavation) returned to land.	40 CFR 264.111 and 264.228 (a, b, e through k, m, o, p, q).	Not an ARAR.	Not applicable to sites with groundwater contamination.
RCRA corrective action	An area at a RCRA facility may be designated as a corrective action management unit (CAMU). Placement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes nor creation of a unit subject to minimum technology requirements.	RCRA corrective action management unit.	40 CFR 264.552	Not applicable.	Not an ARAR. No actions that would require designation of a CAMU are planned.

Table A-2 Federal Action-Specific ARARs Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site					
Location	**Requirement**	**Prerequisite**	**Citation**	**ARAR Determination**	**Comments**
Placement of waste in land disposal unit	Attain land disposal treatment standards before putting waste into landfill in order to comply with ban restrictions.	Placement of RCRA hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, or underground mine or cave.	40 CFR 268.40	Potentially applicable	To be determined. This requirement may apply if land disposal of RCRA land disposal restricted hazardous waste is planned as part of the response action at Site 1.
Use of equipment that contacts hazardous waste with organic concentrations greater than 10 percent by weight	Air emission standards for process vents or equipment leaks.	Equipment that contains or contacts hazardous waste with organic concentrations of at least 10 percent by weight or process vents associated with specified operations the manage hazardous wastes with organic concentrations of at least 10 percent by weight.	40 CFR 264.1030 through 1034 (excluding 1030(c), 1033(j), 1034(c)(2), 1034 (d)(2)); 40 CFR 264.1050 through 1063 (excluding 1015(c), 1050(d), 1057(g)(2), 1061(d), 1063(d)(3)	Not an ARAR.	Organic contaminant concentrations in groundwater and soil at Site 1 are less than 10 percent by weight.

Table A-2
Federal Action-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Discharge to groundwater from regulated unit	Groundwater Protection Standards: Owners/operators of RCRA treatment, storage, or disposal facilities must comply with conditions in this section that area designed to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for contaminants of concern set forth under Section66264.94 in the upper-most aquifer underlying the waste management area beyond the point of compliance.	Uppermost aquifer underlying a waste management unit beyond the point of compliance; RCRA hazardous waste, treatment, storage, or disposal.	40 CFR 264.94(a)(1), (a)(3), (c), (d), and (e).	Not an ARAR.	Site 1 is not a RCRA TSD facility.
Clean Water Act (CWA), 33 USC 1251 et seq.*					
Discharge to POTW	Pretreatment standards. Control the introduction of pollutants into POTWs so as to: prevent interference with the operation of a POTW; prevent pass through of pollutants through a treatment works; and improve opportunities to recycle and reclaim municipal and industrial wastewater and sludges.		40 CFR 403	Applicable.	Applicable to groundwater extraction or treatment or discharge to POTW.
Discharge of treatment system effluent	Best available technology. Use of Best Available Technology (BAT) economically achievable is required to control toxic and nonconventional pollutants. Use of best conventional pollutant control technology (BCT) is required to control conventional pollutants.	Point source discharge to waters of United States.	40 CFR 122.44(a)	Applicable.	Applicable to groundwater extraction or treatment with discharge to North Branch Potomac River.
	Water Quality Standards.		40 CFR 122.44(a)	Applicable.	

Table A-2 Federal Action-Specific ARARs Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site					
Location	**Requirement**	**Prerequisite**	**Citation**	**ARAR Determination**	**Comments**
Discharge of treatment system effluent (continued)	Best Management Practices. Develop and implement a Best Management Practice program to prevent the release of toxic constituents to surface waters.		40 CFR 125.100	Applicable.	
	Monitoring Requirements. Discharge must be monitored to assure compliance. Comply with additional substantive requirements such as; mitigate any adverse effects of any discharge, and proper operation and maintenance of treatment systems.		40 CFR 122.41 (i), (j)	Not an ARAR.	Administrative requirements are not ARARs. Substantive requirements are applicable.
Clean Air Act (CAA)	**40 USC 7401 et seq.***				
Discharge to air	Provisions of State Implementation Plan (SIP) approved by EPA under Section 110 of CAA.	Major sources of air pollutants	40 USC Section 7140; portions of 40 CFR 52.220	Not an ARAR.	Applicable for emissions from air stripper only if the emission would qualify as a major source. Specific pertinent rules are listed below.
NAAQS Attainment areas	New major stationary sources shall apply best available control technology for each pollutant, subject to regulation under the Act, that the source would have potential to emit in significant amounts.	Major stationary sources as identified in 40 CFR 52.21(b)(1)(i)(a) that emits, or has the potential to emit, 100 tons per year or more of any regulated pollutant; any other stationary source that emits, or has the potential to emit, 250 tons per year or more of any regulated pollutant.	40 CFR 52.21(j) (CAA)	Not an ARAR.	Air stripper emissions would not exceed 100 tons of pollutants per year, and therefore, not be classified as a major source.

Table A-2 Federal Action-Specific ARARs Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site					
Location	**Requirement**	**Prerequisite**	**Citation**	**ARAR Determination**	**Comments**
NAAQS non-Attainment areas	Source must obtain emission offsets in Air Quality Control Region of greater than one-to-one	Any stationary facility or source of air pollutants that directly emits, or has the potential to emit, 100 tons per year or more of any air pollutant (including any major emitting facility or source of fugitive emissions of any such pollutants).	CAA Part D, Section 173(1)	Not an ARAR.	Emissions from the air stripper will not exceed 100 tons per year of any pollutants.
	Source subject to "lowest achievable emission rate (LAER)" as defined in 40 CFR 51.18(j)(xiii)		CAA Part D, Section 173(2)		
	All major stationary sources owned or operated by any person in the State are in compliance, or on a schedule for compliance, with all applicable emission standards.		CAA Part D, Section 173(3)		
U.S. Department of Transportation, 49 USC 1802, et seq.					
Hazardous Materials Transportation	No person shall represent that a container or package is safe unless it meets the requirements of 49 USC 1802, et seq. or represent that a hazardous material is present in a package or motor vehicle if it is not.	Interstate carriers transporting hazardous waste and substances by motor vehicle. Transportation of hazardous material under contract with any department of the executive branch of the Federal Government.	49 CFR 171.2(f)	Potentially applicable.	To be determined. Substantive portions of these requirements would be ARARs for transport of hazardous materials onsite. Offsite transport of hazardous materials must comply with both substantive and administrative requirements.
	No person shall unlawfully alter or deface labels, placards, or descriptions, packages, containers, or motor vehicles used for transportation of hazardous materials.		49 CFR 171.2(g)	Potentially applicable.	

Table A-2
Federal Action-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Hazardous Materials Marking, Labeling, and Placarding	Each person who offers hazardous material for transportation or each carrier that transports it shall mark each package, container, and vehicle in the manner required.	Person who offers hazardous material for transportation; carries hazardous material; or packages, labels, or placards hazardous material.	49 CFR 172.300	Potentially applicable.	To be determined. Substantive portions of these requirements would be ARARs for transport of hazardous materials onsite. Offsite transport of hazardous materials must comply with both substantive and administrative requirements.
	Each person offering non-bulk hazardous materials for transportation shall mark the proper shipping name and identification number (technical name) and consignee's name and address.		49 CFR 172.301	Potentially applicable.	
	Hazardous materials for transportation in bulk packages must be labeled with proper identification (ID) number, specified in 49 CFR 172.101 table, with required size of print. Packages must remain marked until cleaned or refilled with material requiring other marking.	Person who offers hazardous material for transportation; carries hazardous material; or packages, labels, or placards hazardous material.	49 CFR 172.302	Potentially applicable.	
	No package marked with a proper shipping name or ID number may be offered for transport or transported unless the package contains the identified hazardous material or its residue.		49 CFR 172.303	Potentially applicable.	To be determined. Substantive portions of these requirements would be ARARs for transport of hazardous materials onsite. Offsite transport of hazardous materials must comply with both substantive and administrative requirements.
	The marking must be durable, in English, in contrasting colors, unobscured, and away from other markings.		49 CFR 172.304	Potentially applicable.	

Table A-2 Federal Action-Specific ARARs Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site					
Location	**Requirement**	**Prerequisite**	**Citation**	**ARAR Determination**	**Comments**
Hazardous Materials Marking, Labeling, and Placarding (continued)	Labeling of hazardous material packages shall be as specified in the list.	Person who offers hazardous material for transportation; carries hazardous material; or packages, labels, or placards hazardous material.	49 CFR 172.400	Potentially applicable.	
	Non-bulk combination packages containing liquid hazardous materials must be packed with closures upward, and marked with arrows pointing upward.		49 CFR 172.312	Potentially applicable.	
	Each bulk packaging or transport vehicle containing any quantity of hazardous material must be placarded on each side and each end with the type of placards listed in Tables 1 and 2 of 49 CFR 172.504.		49 CFR 172.504	Potentially applicable.	

Table A-2
Federal Action-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Criteria for Classification of Solid Waste Disposal Facilities and Practices, 40 CFR Part 257					
Solid Waste Disposal	A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary or a court- or State-established alternative.	Solid waste disposal facility and practices except agricultural wastes, overburden resulting from mining operations, land application of domestic sewage, location and operations of septic tanks, solid or dissolved materials in irrigation return flows, industrial discharges that are point sources subject to permits under CWA, source special nuclear or by-product material as defined by the Atomic Energy Act, hazardous waste disposal facilities that are subject to regulation under RCRA subtitle C, disposal of solid waste by under-ground injection, and municipal solid waste landfill units.	40 CFR 257.3-4 and Appendix I	Potentially applicable.	The response action may include the disposal of wastes in a solid waste disposal facility. Substantive requirements would be applicable to an onsite disposal facility for non-hazardous wastes.
	A facility shall not cause a discharge of pollutants into waters of the U.S. that is in violation of the substantive requirements of the NPDES under CWA Section 402, as amended.		40 CFR 257.3-3(a)	Potentially applicable.	See above comment.

Table A-2 Federal Action-Specific ARARs Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site					
Location	**Requirement**	**Prerequisite**	**Citation**	**ARAR Determination**	**Comments**
Solid Waste Disposal (continued)	A facility shall not cause discharge of dredged material or fill material to waters of the U.S. that is in violation of the substantive requirements of CWA Section 404.		40 CFR 257.3-3	Not an ARAR.	The response action at Site 1 will not include the disposal of dredge or fill material into the river.
	A facility or practice shall not cause nonpoint source pollution of waters of the U.S. that violates applicable legal substantive requirements implementing an areawide or Statewide water quality management plan approved by the Administrator under CWA Section 208, as amended.		40 CFR 257.3-3(a)	Potentially applicable.	The response action may include the disposal of wastes in a solid waste disposal facility. Substantive requirements would be applicable to an onsite disposal facility for non-hazardous wastes.
	The facility or practice shall not engage in open burning of residential, commercial, institutional, or industrial solid waste.	Not applicable to infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, land clearing debris from emergency cleanup operations, and ordnance.	40 CFR 257.3-7(a)	Not an ARAR.	No open burning is planned as part of the response action at Site 1.

Table A-2
Federal Action-Specific ARARs
Focused Feasibility Study of Site 1 at Allegany Ballistics Laboratory Superfund Site

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Solid Waste Disposal (continued)	The facility shall not violate applicable requirements developed under a State Implementation Plan (SIP) approved or promulgated by the Administrator pursuant to CAA Section 110, as amended.		40 CFR 257.3-7(b)	Not an ARAR.	No solid waste management units that would impact the SIP are planned.

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs. Specific potential ARARs are addressed in the table below each general heading.

ACLS - Alternate concentration limits.
ARAR - Applicable or relevant and appropriate requirement.
BACT - Best available control technology
BDAT - Best demonstrated available technologies.
CAA - Clean Air Act.
CAMU - Correction action management unit.
RCRA - Resource Conservation and Recovery Act.
CFR - Code for Federal Regulations.
CWA - Clean Water Act
DOT - U.S. Department of Transportation.
EPA - U.S. Environmental Protection Agency.
LAER - Lowest achievable emission rate.
MCLs - Maximum contaminant levels.
MCLGs - Maximum contaminant level goals.
NAAQS - National Ambient Air Quality Standards (primary and secondary).
NESHAPS - National emission standards for hazardous air pollutants.
NCP - National Contingency Plan.
NPDES - National Pollutant discharge elimination system.
POTW - Publicly owned treatment works.
ppm - Parts per million.
ppmw - Parts per million by weight.
RA - Relevant and appropriate.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act.
SDWA - Safe Drinking Water Act.
SIP - State Implementation Plan
SMCLs - Secondary maximum contaminant levels.
TBC - To be considered.
UIC - Underground injection control.
USC - United States Code.
USDW - Underground source of drinking water.

DIVISION OF ENVIRONMENTAL PROTECTION

1356 Hansford Street
Charleston, WV 25301-1401

GASTON CAPERTON
GOVERNOR

LAIDLEY ELI McCOY, PH. D.
DIRECTOR

May 6, 1996

Mr. Jeff Kidwell
Atlantic Division, Code 1823
NAVFACENGCOM
1510 Gilbert Street
Norfolk, Virginia 23511-2699

RE: Response to your request for State ARARs'

Dear Mr. Kidwell:

The following attachments have been identified as Applicable or Relevant and Appropriate Requirements by the Office of Waste Management/ Site Investigation and Response (OWM/SIR), for the groundwater remedial action at Site 1 at Allegany Ballistics Laboratory in Mineral county West Virginia.

If there are any questions, or if you require further clarification, please contact me at (304) 558-2745.

Sincerely,

Thomas L. Bass
Environmental Resource Specialist II
Site Investigation and Response
Office of Waste Management

TLB/MSo

cc: Bruce Beach, EPA
Wendy Noe, MDE
Greg Mott, CH2Mhill

Type of Statue	Statue/Title	Regulation	Classification	Requirement Synopsis
Air Pollution Control Act	22-5-1 and 22-5-4	45CSR7-4.2	Applicable	Allowable mineral acids stack gas concentration.
Air Pollution Control Act and the Hazardous Waste Management Act	22-5-1 and 22-18-1	45CSR25-4.3	Relevant and Appropriate	Facility design, construction, maintain, and operate in a manner to minimize hazardous waste constituents to the air.
Air Pollution Control Act	22-5-1	45CSR27-3.1 thru 45-27-3.5	Applicable	Best Available Technology requirements for the discharge of emissions of toxic air pollutants.
Air Pollution Control Act	22-5-1	45CSR27-4.1 thru 4.2	Applicable	Best Available Technology requirements for Fugitive Emissions of Toxic Air Pollutants.
Groundwater Protection Act	22-12-2	46CSR12-3.1 thru 3.3 plus Appendix A; 47CSR58-1 to 47CSR58-12	Relevant and Appropriate	This establishes the minimum standards of water purity and quality for groundwater located in the state.
Division of Environmental Protection	22-1-13, 22-1-15, 22-1-16, 22B-1-2, 22B-1-7, and 20-5A-1 through 24.	38CSR11	Relevant and Appropriate	Requirements for spill prevention
Water Pollution Control Act	22-11	47CSR10	Applicable	Requirements for NPDES
Air Pollution Control Act	22-5-5	45CSR30	Applicable	Requirements for the air quality permitting system.

Type of Statue	Statue/Title	Regulation	Classification	Requirement Synopsis
Groundwater Protection Act	22-12-2	47CSR58-4.2	Relevant and Appropriate	Subsurface borings of all types shall be constructed, operated and closed in a manner which protects groundwater.
Groundwater Protection Act	22-12-2	46CSR12-3.3	Applicable	Constituents in groundwater shall not cause a violation of the standards found at 46 CSR in any surface water.
Groundwater Protection Act	22-12-2	47CSR58-4.7 to 4.7.4	Relevant and Appropriate	Pipelines conveying contaminants shall preferentially be in stalled above ground. Ditches conveying contaminants must have appropriate liners. Pumps and related equipment must be installed to prevent or contain any leaks or spills.
Groundwater Protection Act	22-12-2	47CSR58-4.9.4 to 4.9.7	Applicable	Groundwater monitoring stations shall be located and constructed in a manner that allows accurate determination of groundwater quality and levels, and prevents contamination of groundwater through the finished well hole or casing. All groundwater monitoring stations shall be accurately located utilizing latitude and longitude by surveying, or other acceptable means, and coordinates shall be included with all data collected.
Groundwater Protection Act	22-12-5	47CSR58-8.1.2	Relevant and Appropriate	Clean up actions shall not rely primarily on dilution and dispersion if active remedial measures are technically and economically feasible.
Groundwater Protection Act	22-12-5	47CSR58-4.10	Relevant and Appropriate	Facility or activity design must adequately address the issues arising from locating in Karst, wetlands, faults, subsidence, delineated wellhead protection areas determined vulnerable.
Groundwater Protection Act	22-12-5	47CSR59-4.1 to 4.7	Relevant and Appropriate	Monitoring well Drillers certification.
Groundwater Protection Act	22-12-5	47CSR60-1 to 23	To Be Considered	Monitoring well design standards.

Type of Statue	Statue/Title	Regulation	Classification	Requirement Synopsis
Water Pollution Control Act	22-11-4	46CSR1-1 to 9	Relevant and Appropriate	Requirements governing water quality standards

MARYLAND DEPARTMENT OF THE ENVIRONMENT
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MDE

Parris N. Glendening
Governor

Jane T. Nishida
Secretary

August 3, 1995

Mr. Jeff Kidwell
LANTDIV
Naval Facilities Engineering Command
1510 Gilbert Street
Norfolk, Virginia 23511-2699

RE: State Applicable or Relevant and Appropriate Requirements (ARARs) for Allegany Ballistics Laboratory

Dear Mr. Kidwell:

Enclosed is the Maryland Department of the Environment, Waste Management Administration's table which identifies State ARARs for the Allegany Ballistics Laboratory site.

If you have any questions, please feel free to contact me or Mr. John Fairbank at (410) 631-3440.

Sincerely,

Wendy True Noe
Remedial Project Manager
Federal/NPL Superfund Division

WTN:sg

Enclosure

cc: Mr. Tom Bass, WV DEP
Mr. Bruce Beach, EPA Region III
Mr. Dave McBride, Allegany Ballistics Laboratory
Mr. J. Greg Mott, CH2M Hill
Mr. Lou Williams, NAVSEA
Mr. Richard W. Collins
Mr. Robert A. DeMarco

State of Maryland Applicable or Relevant and Appropriate Requirements for Allegany Ballistics Laboratory

Type	Name	Legal Citation	Classification	Requirement Synopsis	Connection to Site Characteristics or Remedy	Evidence of Enforceability
Location	Endangered and Threatened Fish Species	COMAR 08.02.12	Applicable	Requires action to conserve endangered fish species and the critical habitats they depend on.	Some of the State of Maryland's endangered species and habitats are not included in the Federal Endangerment Species Act.	Promulgated in regulation of the State of Maryland.
Location	Threatened and Endangered Species	COMAR 08.03.08	Applicable (for activities in Maryland) TBC	Requires action to conserve endangered species and the critical habitats they depend on.	Some of the State of Maryland's endangered species and habitats are not included in the Federal Endangerment Species Act.	Promulgated in regulation of the State of Maryland.
Action	Water Appropriation or Use	COMAR 08.05.02	Applicable (for wells drilled in Maryland) TBC	Mechanism of maintaining a current database of wells and groundwater use in Maryland.	Groundwater monitoring wells are needed for and to assess groundwater treatment.	Promulgated in regulation of the State of Maryland.
Action/Location	Construction on Nontidal Waters and Floodplains	COMAR 08.05.03	Applicable (for Potomac River)	Alterations to waterways and/or floodplains in the State of Maryland must follow these regulations.	Any remedial actions involving alterations to the Potomac River or floodplains (including temporary construction) are subject to these requirements.	Promulgated in regulation of the State of Maryland.

Type	Name	Legal Citation	Classification	Requirement Synopsis	Connection to Site Characteristics or Remedy	Evidence of Enforceability
Location	Nontidal Wetlands Wetland Regulations	COMAR 08 05 04 08 05 07	TBC	Serves to protect non-tidal wetlands of the State of Maryland from dredging, filling, removing, or otherwise being altered	Wetlands in Maryland must be protected.	Promulgated in regulation of the State of Maryland
Action	Hearing Procedures for Waterway Obstruction, Waterway Construction, and Water Appropriation and Use Permits	COMAR 08 05 06	Applicable	Provides requirements for public information/notification of the use of State of Maryland water resources.	Construction on or use of the Potomac River or other Maryland waterways are subject to these regulations.	Promulgated in regulation of the State of Maryland.
Action	Consumptive Use of Surface Water in the Potomac River Basin	COMAR 08 05 09	Applicable	Provides regulations for consumptive use of surface waters, including permit requirements.	Consumptive use of water from the Potomac River is subject to these regulations.	Promulgated in regulation of the State of Maryland.
Action	Control of Noise Pollution	COMAR 26 02 03	TBC	Provides limits on the levels of noise, protective of the health, welfare, $ property of the people in the State of Maryland	During site remediation work, maximum allowable noise levels should not be exceeded at the site boundaries.	Promulgated in regulation of the State of Maryland.

Type	Name	Legal Citation	Classification	Requirement Synopsis	Connection to Site Characteristics or Remedy	Evidence of Enforceability
Action	Well Construction	COMAR 26.04.04	Relevant and Appropriate (for wells installed in Maryland) TBC	Provides specifications for well construction and abandonment. Also serves as a mechanism to provide a statewide (Maryland) database of existing and abandoned wells.	Any wells installed, decommissioned, and/or abandoned in Maryland are subject to these requirements.	Promulgated in regulation of the State of Maryland.
Action/Chemical	Solid Waste Management	COMAR 26.04.07	TBC	These regulations provide proper closure of a landfill that is protective of the health, welfare, & property of the people of the State of Maryland.	Remedial alternatives involving landfill capping are dependent upon these regulations.	Promulgated in regulation of the State of Maryland.
Action	Board of Well Drillers	COMAR 26.25.01	Applicable (for wells drilled in Maryland)	Provides licensing requirements of persons drilling and installing wells.	Assures that monitoring wells are installed by qualified persons.	Promulgated in regulation of the State of Maryland.
Chemical	Water Quality Discharge Limitations Permits	COMAR 26.08.02 26.08.03 26.08.04	Applicable	Regulations that protect and maintain the quality of surface water in the State of Maryland. Establishes criteria and standards for discharge limitations and policy for anti-degradation of the State's surface water.	Any contaminated groundwater entering surface water must meet toxic substance water quality criteria. Discharge of treated groundwater must meet State NPDES limits.	Promulgated in regulation of the State of Maryland

Type	Name	Legal Citation	Classification	Requirement Synopsis	Connection to Site Characteristics or Remedy	Evidence of Enforceability
Action Action/ Location	Erosion and Sediment Control Stormwater Management	COMAR 26.09.01 26.09.02	TBC	Any land clearing, grading, other earth disturbances require an erosion and sediment control plan, with some exceptions.	An erosion and sediment control plan must be approved before construction activities begin at the site. Storm water must be managed to prevent off-site sedimentation and maintain current site conditions.	Promulgated in regulation of the State of Maryland.
Action/Chemical	Air Quality	COMAR 26.11	TBC	Provides ambient air quality standards, general emissions standards, and restrictions for air emissions from construction activities, vents, and treatment technologies. Regulations include nuisance and odor control.	Construction activities will emit particulate matter into the ambient air. Remedial activities must follow regulations.	Promulgated in regulation of the State of Maryland.
Chemical	Standards Applicable to Transporters of Hazardous Waste	COMAR 26.13.04	Applicable (for activities in Maryland) TBC	Provides regulations for the transport of hazardous waste.	Any hazardous waste found during site remediation must be disposed of according to regulations. Any residues or by-products from treatment systems which are hazardous must be disposed of properly.	Promulgated in regulation of the State of Maryland.

Type	Name	Legal Citation	Classification	Requirement Synopsis	Connection to Site Characteristics or Remedy	Evidence of Enforceability
Chemical	Annotated Code of Maryland, Environment	Environmental Article Titles 1-13	TBC	This law provides for protection of the environment in the State of Maryland.	Remedial actions in Maryland must follow these laws.	State law.

Appendix E:
Groundwater Flow Modelling

Appendix B
Groundwater Flow Modeling

This section describes the use of numerical and mathematical groundwater flow models to support the design of a groundwater remediation system at Site 10. For Site 10, mathematical models based on the superposition of standard well hydraulics solutions were used to simulate groundwater flow in the contaminated areas of alluvium and bedrock. The modeled area of Site 10 is shown in Figure B-1.

Design of the extraction well system for Site 10 was done using mathematical models of the alluvial and bedrock aquifers. Individual models for the alluvial and bedrock aquifers were developed for the site because of the nature of the code used to simulate groundwater flow and extraction. All simulations were based on hydraulic properties determined from aquifer tests conducted on alluvial and bedrock test wells at the site.

Modeling Objectives

The Site 10 groundwater flow models were developed to serve as analytical tools for the design and evaluation of multi-well groundwater remediation systems. The models were intended to represent aquifer behavior using hydraulic parameters derived from the predesign aquifer tests at the site. Furthermore, the models were to give realistic estimates of practical pumping rates of the multiple, mutually interfering wells in the planned extraction systems and to realistically simulate their hydraulic capture zones. These models were designed only for evaluating the interactions of groundwater recovery systems with the natural bedrock and alluvial flows observed in the focused areas of study. They were not intended for use as general purpose aquifer simulation models.

Model Development and Implementation

Figure B-1 shows the location of the Site 10 model described in this section, its area of coverage, and its grid spacing. This subsection describes the conceptual model developed for Site 10, and how the selected code was used to implement this conceptual model and simulate groundwater flow and extraction.

Code Selection

The groundwater flow models developed for Site 10 were based on the two-dimensional analytical code WELSIM. This code was developed by CH2M HILL to calculate piezometric heads in saturated porous media by the superposition of the analytical solutions from the theory of well hydraulics.

The results of groundwater flow and extraction simulations using WELSIM were used as input to the particle-tracking program TRAK3D. TRAK3D was developed by CH2M HILL to delineate captures zones produced by the simulated groundwater extraction networks modeled using WELSIM. It uses the output of a WELSIM simulation to trace the flow paths of imaginary particles injected into the simulated flow field.

Conceptual Model

As shown in Figure B-1, the model grid used by WELSIM for Site 10 covers and area 1,800 feet by 1,400 feet. The grid is oriented such that it covers the area around Site 10 as well as several hundred feet hydraulically downgradient of the site. The size and orientation of the grid was selected so that capture of the entire estimated alluvial contaminant plume (Figure B-2) could be simulated.

For the purposes of the WELSIM simulations, the conceptual model for Site 10 is relatively uncomplicated. Similar to Site 1, the flow regime at Site 10 consists of an unconfined, alluvial silty sand and gravel aquifer, saturated in its lower 20 feet, overlying a predominantly shale, significantly fractured bedrock aquifer of undetermined thickness. In the vicinity of Site 10, no confining unit between the alluvium and bedrock is identifiable and flow between the two aquifers occurs readily. Although the alluvial aquifer is considered to be unconfined, it was simulated using the solutions to the leaky-aquifer equations. This is considered to be a valid approximation as long as the drawdown in the simulated recovery wells is not great compared to the actual available drawdown. During the aquifer test conducted on alluvial well 10GW11, the maximum drawdown measured in the well, which was pumping at approximately 30.5 gpm, was 7.75 feet. This was equivalent to approximately 40 percent of its saturated thickness.

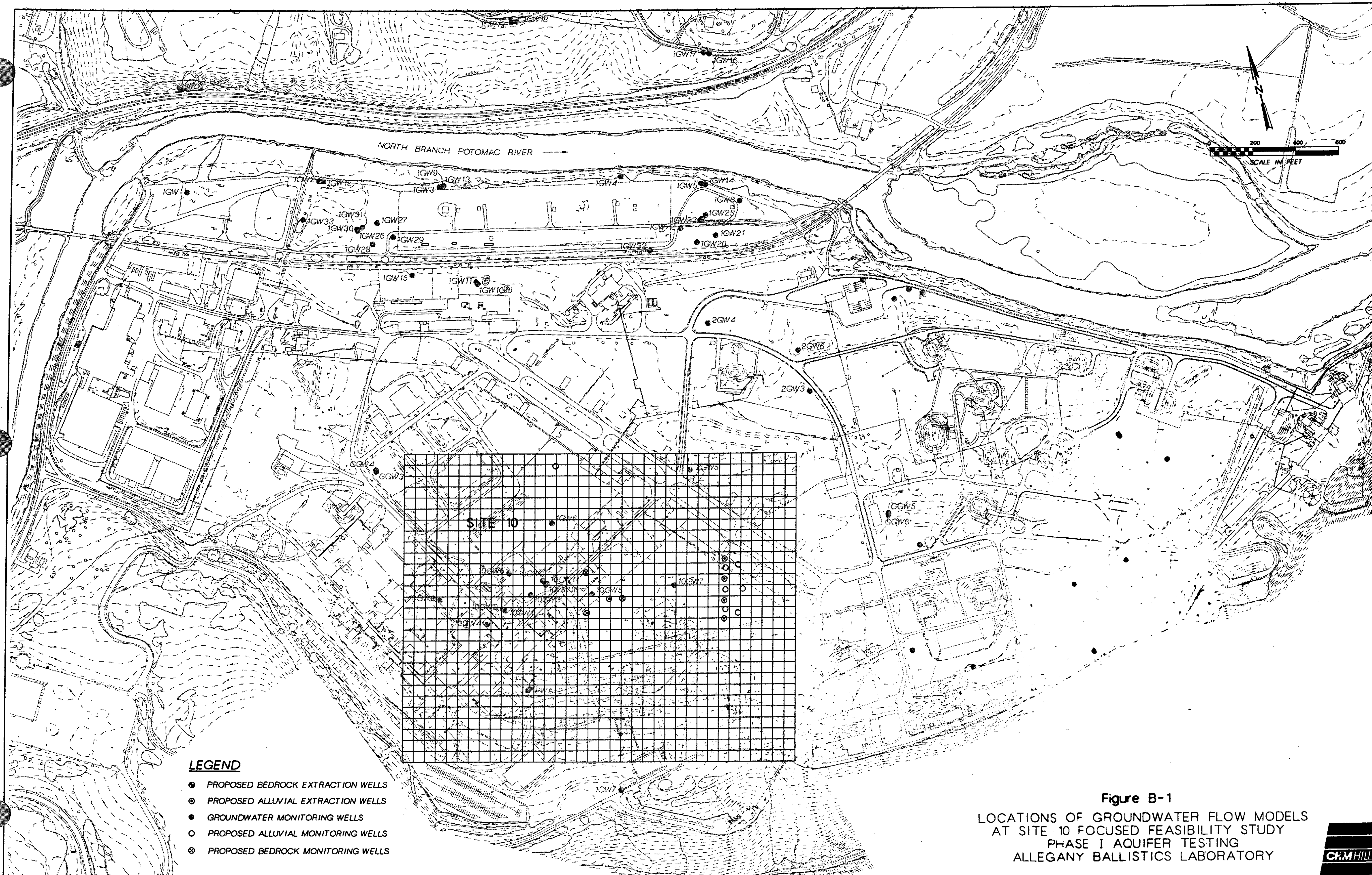

Figure B-1

LOCATIONS OF GROUNDWATER FLOW MODELS
AT SITE 10 FOCUSED FEASIBILITY STUDY
PHASE I AQUIFER TESTING
ALLEGANY BALLISTICS LABORATORY

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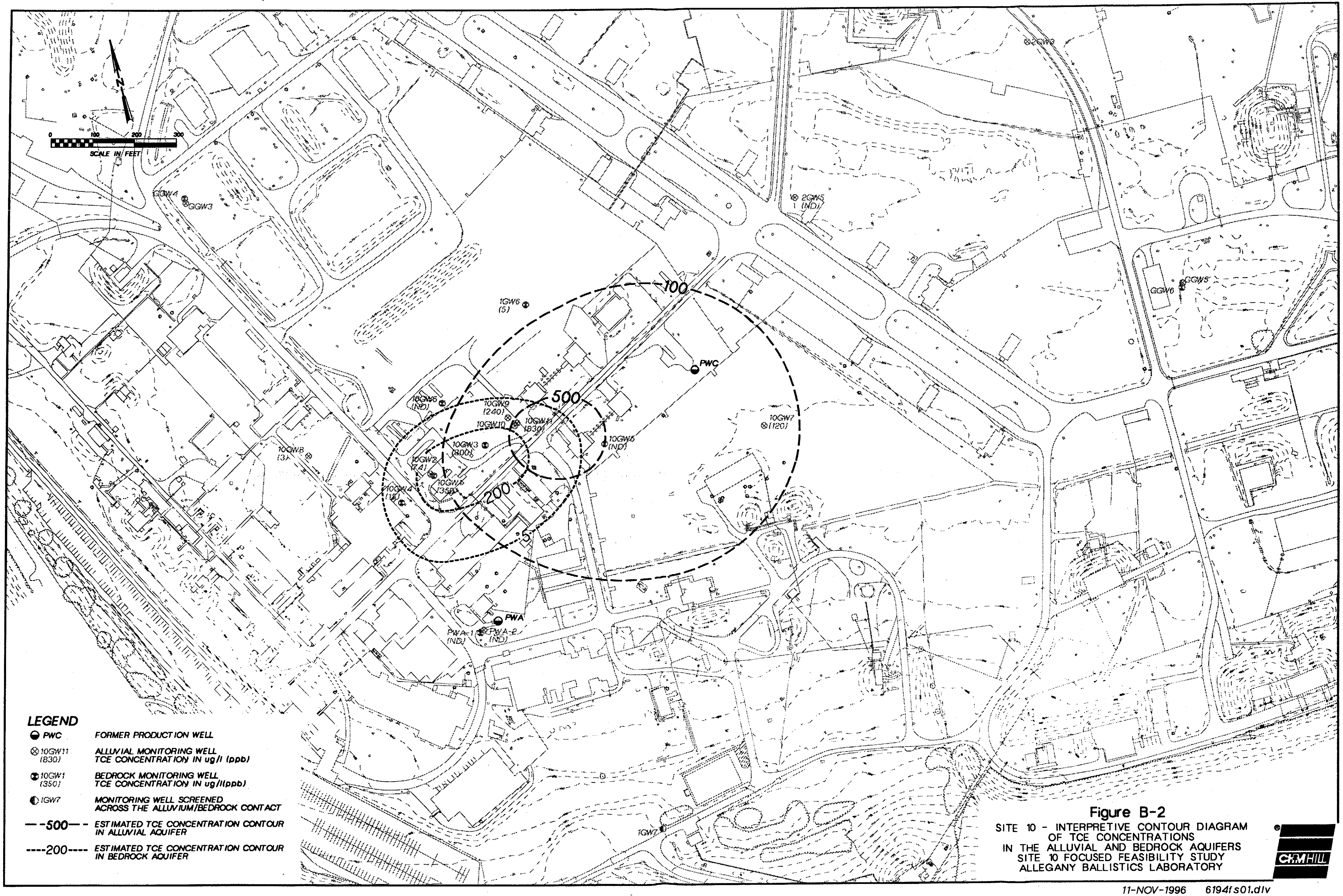

Figure B-2
SITE 10 - INTERPRETIVE CONTOUR DIAGRAM OF TCE CONCENTRATIONS IN THE ALLUVIAL AND BEDROCK AQUIFERS
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

While some variations may exist, groundwater in both the alluvium and bedrock appears to generally flow eastward across Site 10. Therefore, the natural groundwater flow in the conceptual model of this site (for both alluvium and bedrock) is idealized as being uniformly parallel to the northern and southern boundaries of the modeled area.

Model Implementation

Because WELSIM simulates groundwater flow and extraction in two-dimensions, two models were developed for Site 10. One model simulated flow in and extraction from the alluvial aquifer and one simulated flow in and extraction from the bedrock. Hydraulic interaction between the two aquifers was simulated in each model by supplying a leakance factor, based on the results of aquifer testing, and solving the equations for steady-state flow in a leaky aquifer.

Grid Configuration

The horizontal configuration of the model grid for both the alluvial and bedrock simulations is illustrated in Figure B-1. The grid consists of 28 rows and 36 columns of square cells. The grid spacing along rows and columns is a uniform 50 feet. Because groundwater flow and extraction in both models was simulated by solving the leaky-aquifer equations, no layer thickness was required. Furthermore, because the WELSIM simulations are conducted by solving equations analytically, no boundary conditions are required.

Model Input

Each groundwater extraction simulation using WELSIM's leaky-aquifer solution required input definitions for various hydraulic properties of the aquifer as well as several well-specific properties.

Definition of Aquifer-Specific Properties

For leaky-aquifer simulations, WELSIM requires input values for the aquifer's transmissivity (in gallons per day per foot (gpd/ft)) and leakance (in gallons per day per cubic foot (gpd/ft^3). For the alluvial-aquifer simulations, the transmissivity and leakance values calculated from alluvial aquifer-test data using De Glee's Method (i.e., 1,133 ft^2/day and 0.03 day^{-1}, respectively) were expressed in terms of the required units and used as input for the alluvial model simulations.

For the bedrock aquifer at Site 10, the average transmissivity value (i.e., approximately 1,500 ft^2/day) determined from the 10GW1 aquifer test was expressed in the required units and used as input for the bedrock model simulations. Because the leakance calculations from the drawdown records from wells 10GW3 and PWA1 differed by an order of magnitude (i.e., 0.04 day^{-1} and 0.004 day^{-1}, respectively), an estimated leakance of 0.1 gpd/ft^3 (i.e., 0.0134 day^{-1}) was used as input for the bedrock model simulations.

The final aquifer-specific property required as input is the regional gradient. Regional gradients of 0.005 and 0.007 were input for the alluvial and bedrock model simulations, respectively.

Definition of Well-Specific Properties

For each well included in a simulation, WELSIM requires the coordinates of the well and its pumping rate (in gpm). Several model simulations were conducted for both the alluvial and bedrock aquifers at Site 10. As stated above, the purpose of the groundwater extraction system at Site 10 is to remove the contaminant plumes from the alluvium and bedrock. To achieve this goal in the alluvium, a final configuration of five alluvial recovery wells, each pumping at 15 gpm, was developed to capture the alluvial contaminant plume. Positioning of the wells with respect to the contaminant plume is discussed below. In the bedrock, a final configuration of three recovery wells, each pumping at 20 gpm, was necessary to attain capture of the bedrock contaminant plume.

Groundwater Extraction Simulations

Groundwater extraction simulations were conducted for both the alluvium and bedrock at Site 10 using WELSIM. The final simulation for each aquifer showed that capture was attainable at reasonable pumping rates by extraction wells simulated in the same aquifer. However, aquifer testing at the site indicated that there is significant hydraulic communication between the two aquifers. Therefore, groundwater extraction from the alluvium is likely to draw groundwater up from the bedrock into the alluvium, where it can be captured by alluvial recovery wells. Similarly, groundwater extraction from the bedrock would likely draw contaminated alluvial groundwater down into the bedrock. Because this was not considered a desirable effect, and because it is anticipated that an alluvial extraction network will draw contaminated bedrock groundwater up into the alluvium, only an alluvial recovery-well configuration was considered for the proposed groundwater remediation system. Therefore, only the final alluvial model simulation will be presented and discussed here.

Alluvial Recovery Wells

Figure B-2 indicates that the estimated TCE contaminant plume at Site 10 is composed of a relatively confined, highly concentrated portion and a much broader, less concentrated portion. Because the objective of the Site 10 groundwater extraction system is to remove the contaminant plume while minimizing additional downgradient migration, two sets of alluvial recovery wells were simulated in the model. One set consisted of one recovery well immediately downgradient of the most concentrated portion of the plume in order to remove this portion of the plume as quickly as possible, while minimizing further diffusion. The other set of recovery wells consisted of an alignment of four wells, spaced 100 feet apart, oriented approximately north-south, and positioned downgradient enough to capture the less concentrated portion of the contaminant plume, as shown in Figure B-2.

Although the pumping rate during the alluvial aquifer test conducted during Phase I Aquifer Testing was approximately 30 gpm, a pumping rate of 15 gpm was simulated for each of the five alluvial recovery wells. This was done to provide a conservative estimate of the ability to attain capture with wells that are not able to sustain 30 gpm. Furthermore, the set of four alluvial extraction wells relies on mutual interference to produce a barrier to further downgradient migration. This mutual interference will likely result in the wells having to be pumped at a lower rate than what each one could pump if operating alone.

Simulation of Planned Recovery System

Figure B-3 shows the simulated locations of the alluvial recovery wells and the simulated potentiometric surface and capture zones in the alluvium. Each capture zone is defined by a dashed line. The position of this line was determined by using the particle tracking program

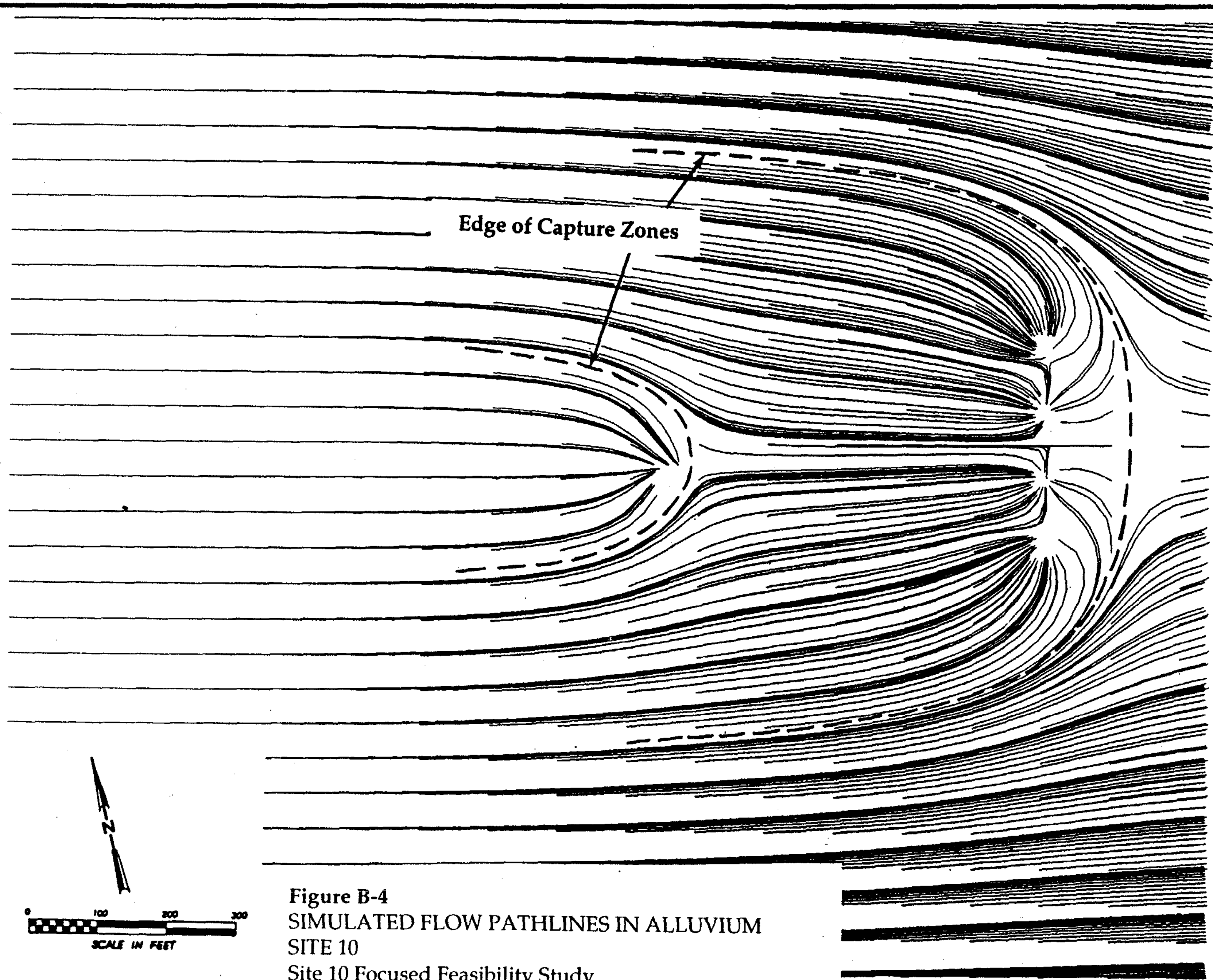

Figure B-4
SIMULATED FLOW PATHLINES IN ALLUVIUM
SITE 10
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

TRAK3D. As an example of the results produced by TRAK3D, Figure B-4 shows the simulated pathlines of particles injected in the alluvium. The distinction between particles that are captured by the recovery wells and the particles that escape is indicated by the edge of the capture zone in this figure.

To better estimate the success of the recovery wells at meeting the objective, the capture zones shown in Figure B-3 were superimposed on the figure showing the approximate location of the VOC contaminant plume in the alluvium at Site 10 (i.e., Figure B-2). Figure B-5 shows that under the assumption of uniform alluvial hydraulic conductivity and leakance values across Site 10, capture of the alluvial contaminant plume is possible with five alluvial extraction wells, each pumping at a rate of 15 gpm.

Estimation of Recovery Duration

An estimation was made of the time required to remove the alluvial contaminant plume, as shown in Figure B-2. To do this, an estimate of the retardation of the VOC plume had to be made. Because TCE is the primary VOC composing the contaminant plume, it was used to develop the retardation estimate. The movement of a solute in groundwater is given by the following retardation equation:

$$v_c = \frac{v_x}{\left[1+(P_b / n)(K_d)\right]} \qquad (1)$$

where:

v_x = average linear velocity

v_c = velocity of the solute front

P_b = dry bulk mass density of aquifer material

n = effective porosity of aquifer material

K_d = distribution coefficient for the solute = F_{oc}*K_{oc}

K_{oc} = solute's water-organic carbon partition coefficient

T_{oc} = total organic carbon in aquifer material in mg/kg

$F_{oc} = T_{oc}/10^6$

$[1+(P_b/n)(K_d)]$ = retardation factor (r)

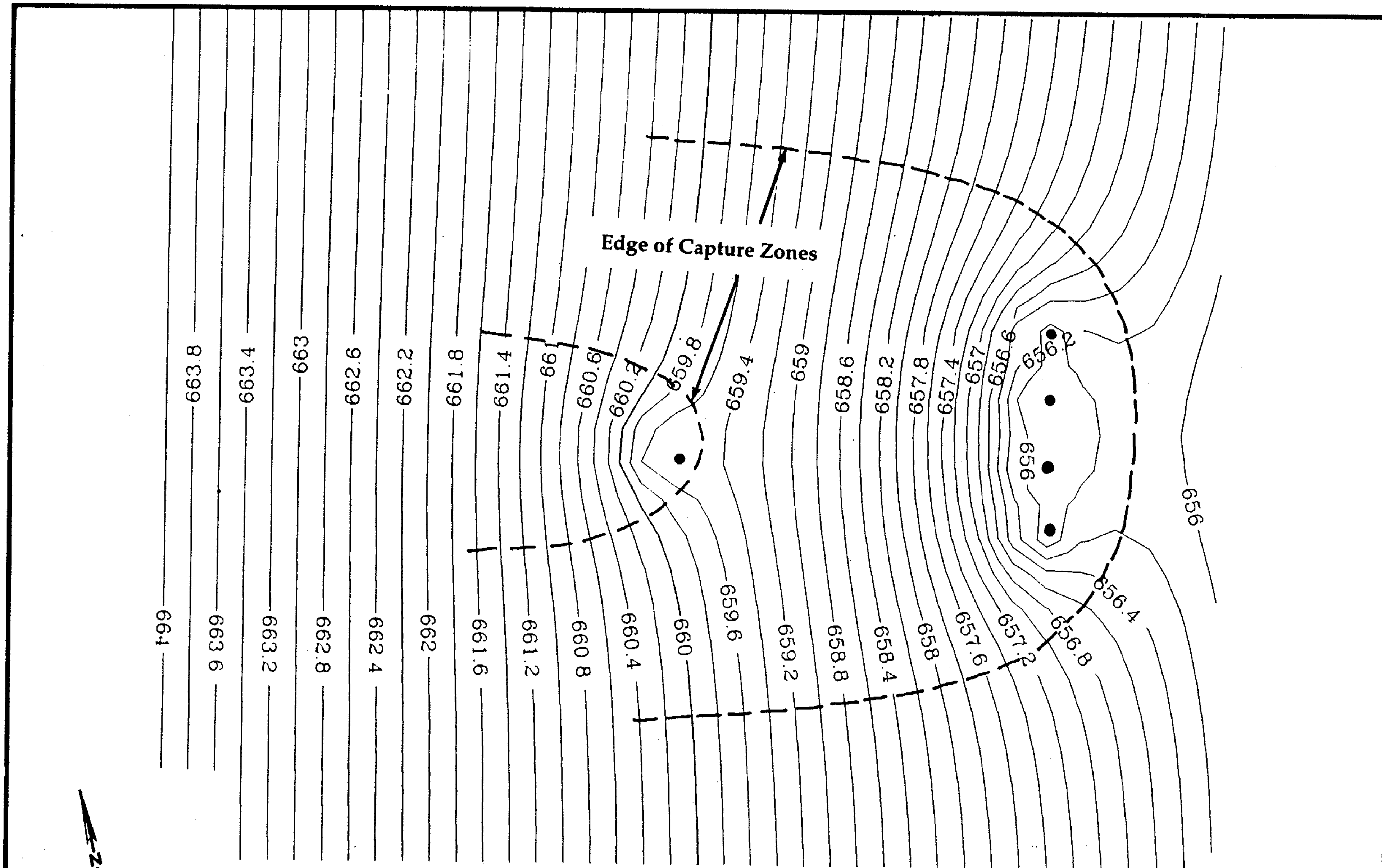

Figure B-3
SIMULATED RECOVERY WELLS, POTENTIOMETRIC SURFACE, AND HYDRAULIC CAPTURE ZONE IN ALLUVIUM
SITE 10
Site 10 Focused Feasibility Study
Allegany Ballistics Laboratory

CH2M HILL

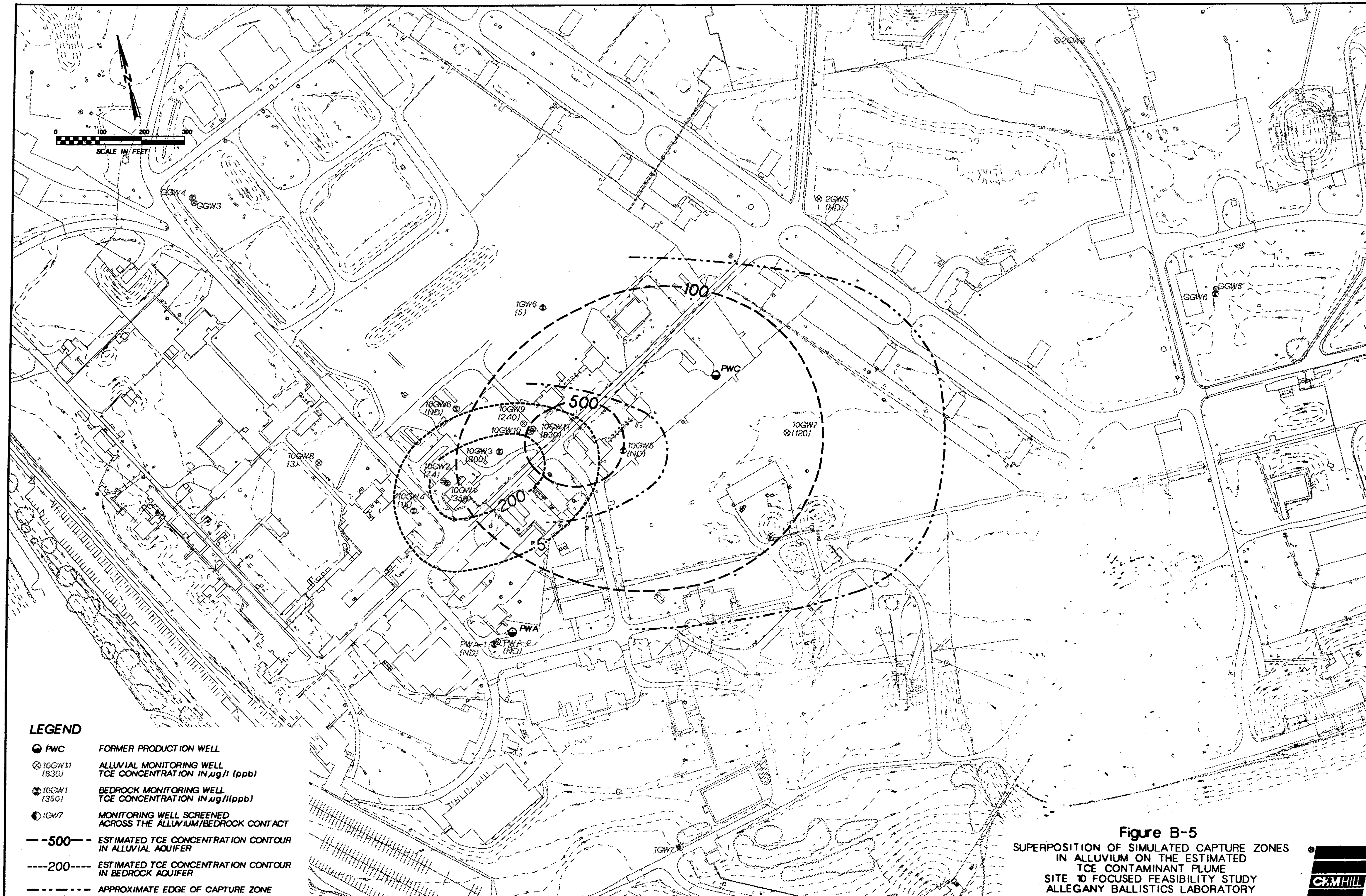

Figure B-5
SUPERPOSITION OF SIMULATED CAPTURE ZONES IN ALLUVIUM ON THE ESTIMATED TCE CONTAMINANT PLUME
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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The values of the above variables were determined for Site 10 as follows: an average dry bulk density of 1.89 grams per cubic centimeter (gm/cm^3) for the silty sand and gravel (Lambe and Whitman, 1969); an effective porosity of 20 percent (Freeze and Cheery, 1979); a T_{oc} of 6,550 mg/kg (CH2M HILL, August 1996); and a K_{oc} for TCE of 152 ml/g (Fetter, 1988).

Using the above values, the retardation factor (r) was calculated as follows:

$$r = 1 + \left(\frac{1.89 \text{ g} / \text{cm}^3}{0.2} \right) \left[(0.00655)(152 \text{ ml} / \text{g}) \right] = 10.4$$

Using the calculated average linear velocity in the alluvium of 520 ft/yr (CH2M HILL, October 1996), the rate of movement of TCE through the alluvium at Site 10 is estimated to be 50 ft/yr. Applying this rate of movement for the TCE contaminant plume displayed in Figure B-5 suggests that all of the most contaminated portion of the plume will reach the closest alluvial extraction well within approximately 5 years. The broader portion of the TCE plume will take approximately 25 years to completely reach the alignment of extraction wells to the east of Site 10.

It should be noted that the assumptions made in the above TCE rate calculations were conservative. For example, the average linear velocity value is based on the horizontal hydraulic gradient in the alluvium under natural-flow conditions. Groundwater extraction will increase these gradients, especially in the vicinity of the recovery wells, which will increase the rate of migration of the TCE contaminant plume to the wells. Also, the T_{oc} value used in the retardation factor calculation was determined for an unsaturated soil sample collected from 4 to 6 feet bgs at Site 10. In general, the amount of organic matter decreases with depth, especially within the saturated zone. Therefore, it is likely that the actual T_{oc} for the sand and gravel portion of the alluvium at Site 10 is significantly lower than the value used for the retardation factor calculation. This too would have the effect of increasing the migration rate of the TCE contaminant plume to the recovery wells and decreasing the cleanup time.

Proposed Site 10 Extraction and Monitoring Wells

Figure B-6 is the extraction- and monitoring-well configuration proposed for groundwater recovery at Site 10. The five alluvial extraction wells simulated using WELSIM are shown, together with a network of monitoring wells positioned to evaluate the operation of the recovery system. Alluvial monitoring wells in the vicinity of the linear alignment of extraction wells will help to evaluate the developing capture zones and hydraulic gradient reversals. The bedrock monitoring wells in the vicinity of the upgradient alluvial extraction well are recommended for evaluating whether extraction in the alluvium is drawing the contaminated bedrock groundwater up into the alluvium or promoting downgradient migration in the bedrock. Finally, the new alluvial monitoring well north of Site 10 will be used to ensure that the alluvial contaminant plume is not influenced by the groundwater extraction system at Site 1.

Based on the model simulations, all five of the alluvial extraction wells at Site 10 will be pumped at an estimated rate of 15 gpm, for a total of 75 gpm produced by the Site 10 extraction-well network. The groundwater extracted at Site 10 may be treated at the same groundwater treatment plant that will treat the estimated combined flow rate of 190 gpm from the Site 1 extraction-well network.

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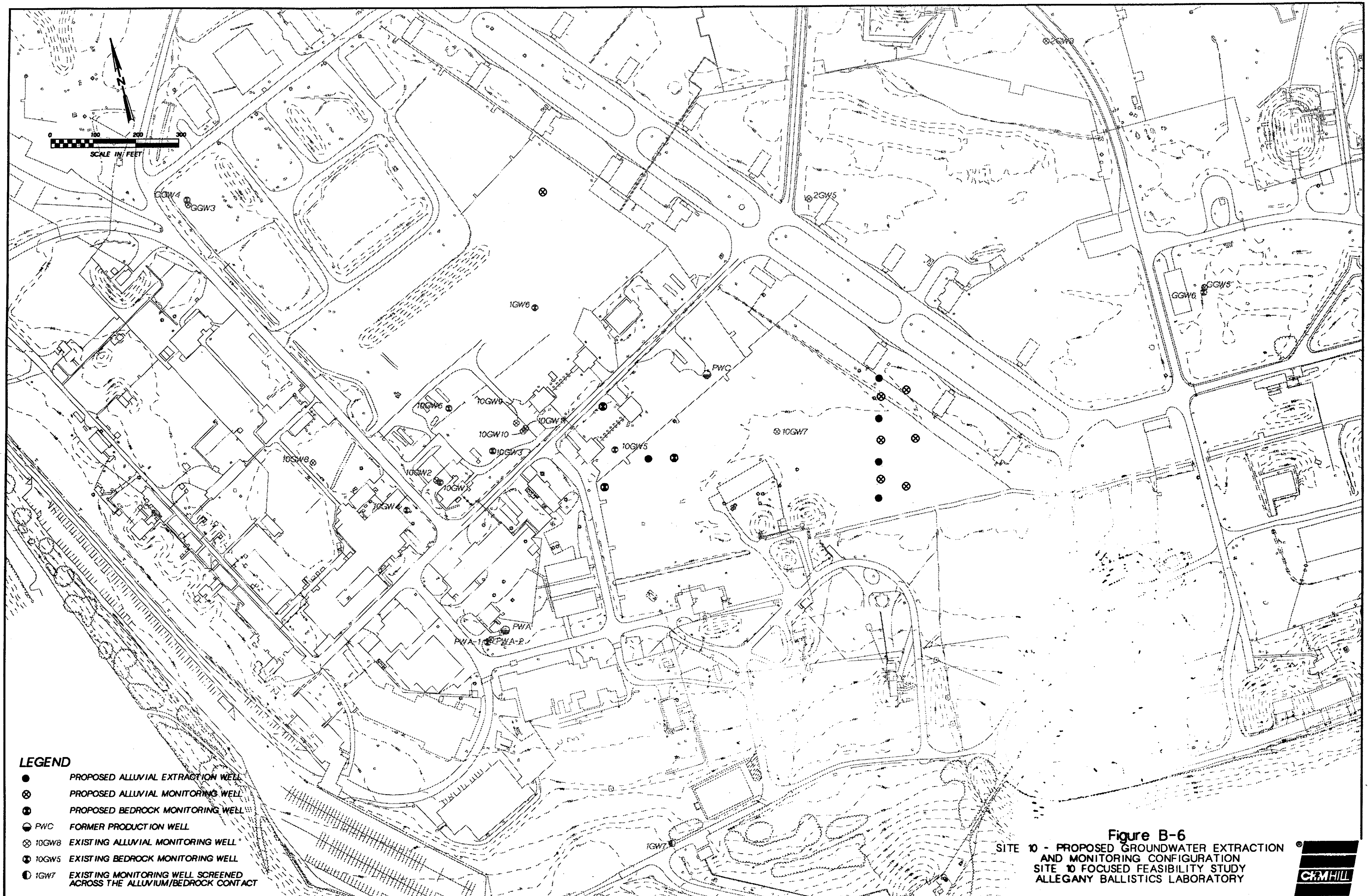

Figure B-6
SITE 10 - PROPOSED GROUNDWATER EXTRACTION AND MONITORING CONFIGURATION
SITE 10 FOCUSED FEASIBILITY STUDY
ALLEGANY BALLISTICS LABORATORY

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Appendix C

Site 1 Surface Water Discharge Limits

Appendix C
Site 1 Surface Water Discharge Limits

Preliminary surface water discharge limits were developed in the Site 1 FFS for discharge of treated groundwater from a future treatment plant at Site 1. The discharge limits were developed using the West Virginia Toxic Pollutant Control Strategy. The reader should consult Appendix D of the Site 1 FFS for complete documentation of the development of discharge limits for Site 1.

The Site 1 preliminary discharge limits developed in the Site 1 FFS have been included in this appendix. These limits, which are listed in tables C-1 and C-2, are based on a discharge flow of 220 gpm, which is the maximum expected flow from the Site 1 treatment plant. Several changes have been made in the calculation of these discharge limits since the preparation of the Site 1 FFS. Most notably, the 7Q10 flow, which was provided by the WVDEP, has increased from 61.58 cfs to 117.48 cfs. Also, the Site 1 FFS Appendix D calculations were based on discharge flows of 175 gpm and 540 gpm, which were considered to be the range of possible flows from Site 1. Recent aquifer testing, which is documented in the Phase I Aquifer Testing Report, indicates that the maximum discharge flow will be approximately 190 gpm. 220 gpm has been conservatively used in the calculations in tables C-1 and C-2. This assumption is conservative because the discharge limits become more stringent as the discharge flow increases.

A potential discharge option in this FFS is to discharge Site 10 groundwater to the Site 1 treatment plant. If this option were selected, the discharge limits for the Site 1 treatment plant would need to be revised because the calculations are based on discharge flow. If Site 10 groundwater were discharge to Site 1, the combined surface water discharge flow would be approximately 275 gpm. Tables C-3 and C-4 present the preliminary discharge limits from the Site 1 treatment plant based on the combined discharge flow.

The calculations used to develop the revised discharge limits are the same as those presented in Appendix D of the Site 1 FFS. The reader should consult that document for development of the background river concentrations and water quality standards used in the calculation.

Table C-1
Preliminary Surface Water Discharge Limits for VOCs in Site 1 Groundwater
Based on a Treatment Plant Discharge of 220 gpm

Organic Constituents	Background Concentration[1] (µg/l)	Water Quality Standard (µg/l)	Alluvium (µg/l)		Bedrock (µg/l)		Treatment Plant Influent Concentration[2]	Water Quality Based Discharge Limit[3]		BAT Effluent Limitation[4]		Preliminary Discharge Limit
			Mean	Max	Mean	Max	(µg/l)	Daily Max. (µg/l) A	Ave. Monthly (µg/l) A	Daily Max. (µg/l)	Ave. Monthly (µg/l)	(µg/l)
1,1,1-Trichloroethane(1)	0	12000[6]	1,010	7,700	162	1,500	756	882,707.84	588,471.89	127	22	22
1,1-Dichloroethane	0	160000[7]	80	800	69	920	77	3,122,359.47	2,081,572.98	59	22	22
1,1-Dichloroethene(1)	0	0.03[6]	87	870	0	0	61	2.21	1.47	60	22	1.47
1,2-Dichloroethane(1)	0	0.035[6]	0	0	0	0	0	2.57	1.72	574	180	1.72
1,2-Dichloroethene(Tot)(1)	0	11600[7]	1,693	12,000	1,171	12,000	1,536	226,371.06	150,914.04	66	25	25
Methylene Chloride(1)	0	11000[7]	912	8,000	295	4,000	727	214,662.21	143,108.14	170	36	36
Tetrachloroethene(1)	0	0.8[6]	11	78	1	12	8	58.85	39.23	164	52	39.2
Toluene	0	6800[6]	70	700	0	0	49	500,201.11	333,467.41	74	28	28
Trichloroethene(1)	0	2.7[6]	33,896	240,000	6,284	71,000	25,612	198.61	132.41	69	26	26
Vinyl Chloride(1)	0	2.0[6]	0	0	3	41	1	147.1	98.1	172	97	97

(1) Chemical of Potential Concern (COPC)

1 North Branch Potomac River upstream concentration. Value is an average based on two surface water samples collected during RI work. Sample analytical results are documented in the Phase II RI for surface water samples 5SW-1 and 5SW-2. Non-detect anlytical results were assumed to equal zero.

2 Treatment plant influent concentrations were calculated assuming 70% of flow is from alluvial aquifer, and 30% is from bedrock aquifer. Concentrations are based on flow-weighted averages.

3 The Daily Maximum and Average Monthly Concentrations are the allowable discharge limits calculated using the State of West Virginia, Office of Water Resources Toxic Pollutant Control Strategy. The discharge limits are based on the appropriate water quality standard.

4 Best Available Technology (BAT) Effluent Limitations are reported in 40CFR414.101.

5 Required treatment plant end-of-pipe discharge limit. The concentration is based on the lower of the Water Quality Based Discharge Limit and the BAT Effluent Limitation.

6 West Virginia water quality standards (WQS); Appendix E, Requirements Governing Water Quality Standards, Title 46, Series I (1985).

7 EPA Region III BTAG Screening Level. No West Virginia WQS or Federal Ambient Water Quality Criteria (FAWQC) are available for this constituent.

8 No West Virginia WQS, FAWQC (chronic), or BTAG Screening Level is available for this constituent.

All units are µg/l.

Alluvium and bedrock contaminant concentrations are averages of the analytical results from both the 1992 RI and the Focused RI for Site 1.

Table C-4
Preliminary Surface Water Discharge Limits for Inorganics in Site 1 Groundwater
Based on a Treatment Plant Discharge of 275 gpm

Inorganic Constituents	Background Concentration[1] (µg/l)	Water Quality Standard (µg/l)	Site 1 Influent Concentration[2]		Site 10 Influent Concentration		Treatment Plant Influent Concentration		Water Quality Based Discharge Limit[3]	BAT Effluent Limitation[4]	Preliminary Discharge Limit[5]
			Total Metals (µg/l)	Dissolved Metals (µg/l)	Total Metals (µg/l)	Dissolved Metals (µg/l)	Total Metals (µg/l)	Dissolved Metals (µg/l)	Ave. Monthly (µg/l)	Ave. Monthly (µg/l)	(µg/l)
Aluminum	0	87 [6]	48297.40	141.575	35	25.3	35266.55	110.18	923	NA	923
Antimony(1)	0	14 [6]	4.92	2.06	0	0	3.59	1.50	552	NA	552
Arsenic(1)	0	50 [6]	31.52	0.435	2.8	2.5	24	0.99	1,973	NA	1,973
Barium	70.8	1000 [6]	684.88	76.845	39.4	36.7	511	66	36,733	NA	36,733
Beryllium	0	.0077 [6]	4.26	0	0	0	3.11	0.00	0	NA	0
Cadmium	0	1.1 [10]	8.52	0	0	0	6.22	0.00	12	NA	12
Calcium	74050	NA [8]	97096.43	69917.5	72400	72200	90428.39	70533.78	---	NA	NA
Chromium (III)	0	210 [10]	68.94	0	0	0	50.33	0.00	2,229	1110	2,229
Chromium (VI)	0	11 [10]	68.94	0	0	0	50.33	0.00	117	1110	117
Cobalt	0	35000 [7]	53.19	3.415	0	0	38.83	2.49	371,488	NA	371,488
Copper	4.2	12 [10]	129.98	0.495	97	4	121.07	1.44	87	1450	87
Iron	0	1500 [6]	116371.60	327.025	358	287	85047.93	316.22	15,921	NA	15,921
Lead	0	3.2 [10]	96.52	0	7	3.9	72.35	1.05	34	320	34
Magnesium	15150	NA [9]	27697.86	14930	8680	8414	22,563	13170.68	---	NA	NA
Manganese(1)	330	1000 [6]	2760.95	551.53	48	41	2,028	413.69	7,441	NA	7,441
Mercury(1)	0.1	0.1 [9]	0.13	0.01	0	0	0.095	0.007	0.10	NA	0.100
Nickel(1)	14.6	160 [10]	129.49	3	0	0	95	2.47	1,558	1690	1,690
Potassium	5940	NA [8]	8320.89	1,504	1,170	1,011	6,390	1,371	----	NA	NA
Selenium	0	5 [6]	0.00	0	0	0	0.00	0.00	53	NA	53
Silver	0	4.1 [10]	4.08	0	0	0	2.98	0.00	44	NA	44
Sodium	44650	NA [8]	144560.84	70,304	9,687	9,594	108,145	53,912	---	NA	NA
Thallium(1)	0	1.7 [6]	0.13	0	0	0	0.09	0.35	67	NA	67
Vanadium	0	10000 [7]	81.23	0	1	1	60	0.31	106,139	NA	106,139
Zinc(1)	18.4	110 [10]	352.96	15	38	9	268	13.60	991	1050	991
pH		6 TO 9									6 to 9

(1) Chemical of Potential Concern (COPC)

1 North Branch Potomac River upstream concentration. Value is an average based on two surface water samples collected during RI work. Sample analytical results are documented in the Phase II RI for surface water samples 5SW-1 and 5SW-2. Non-detect analytical results were assumed to equal zero.

2 Treatment plant influent concentrations were calculated assuming 70% of flow is from alluvial aquifer, and 30% is from bedrock aquifer. Concentrations are based on flow-weighted averages.

3 The Daily Maximum and Average Monthly Concentrations are the allowable discharge limits calculated using the State of West Virginia, Office of Water Resources Toxic Pollutant Control Strategy. The discharge limits are based on the appropriate water quality standard.

4 Best Available Technology (BAT) Effluent Limitations are reported in 40CFR414.101.

5 Required treatment plant end-of-pipe discharge limit. The concentration is based on the lower of the Water Quality Based Discharge Limit and the BAT Effluent Limitation.

6 West Virginia water quality standards (WQS), Appendix E, Requirements Governing Water Quality Standards, Title 46, Series 1 (1985).

7 EPA Region III BTAG Screening Level. No West Virginia WQS or Federal Ambient Water Quality Criteria (FAWQC) are available for this constituent.

8 No West Virginia WQS, FAWQC (chronic), or BTAG Screening Level is available for this constituent.

9 Background concentration is higher than West Virginia WQS and FAWQC (chronic). Therefore, the background concentration is the WQS.

10 FAWQC (chronic)

Alluvium and bedrock contaminant concentrations are averages of the analytical results from both the 1992 RI and the Focused RI for Site 1.

Table C-3
Preliminary Surface Water Discharge Limits for VOCs in Site 1 Groundwater
Based on a Treatment Plant Discharge of 275 gpm

Organic Constituents	Background Concentration[1] (µg/l)	Water Quality Standard (µg/l)	Site 1 Influent Concentration (µg/l)	Site 10 Influent Concentration (µg/l)	Treatment Plant Influent Concentration[2] (µg/l)	Water Quality Based Discharge Limit[3]		BAT Effluent Limitation[4]		Preliminary Discharge Limit (µg/l)
						Daily Max. (µg/l)	Ave. Monthly (µg/l)	Daily Max. (µg/l)	Ave. Monthly (µg/l)	
1,1,1-Trichloroethane(1)	0	12000 [6]	756	28	559	710,202.99	473,468.66	127	22	22
1,1-Dichloroethane	0	160000 [7]	77	274	130	2,547,343.31	1,698,228.88	59	22	22
1,1-Dichloroethene(1)	0	0.03 [6]	61	10	47	1.78	1.18	60	22	1.18
1,2-Dichloroethane(1)	0	0.035 [6]	0	0	0	2.07	1.38	574	180	1.38
1,2-Dichloroethene(Tot)(1)	0	11600 [7]	1,536	552	1,271	184,682.39	123,121.59	66	25	25
Methylene Chloride(1)	0	11000 [7]	727	9	533	175,129.85	116,753.24	170	36	36
Tetrachloroethene(1)	0	0.8 [6]	8	4	7	47.35	31.56	164	52	31.6
Toluene	0	6800 [6]	49	0	36	402,448.36	268,298.91	74	28	28
Trichloroethene(1)	0	2.7 [6]	25,612	1,296	19,047	159.80	106.53	69	26	26
Vinyl Chloride(1)	0	2.0 [6]	1	0	1	118.37	78.91	172	97	79

(1) Chemical of Potential Concern (COPC)

1 North Branch Potomac River upstream concentration. Value is an average based on two surface water samples collected during RI work. Sample analytical results are documented in the Phase II RI for surface water samples 5SW-1 and 5SW-2. Non-detect anlytical results were assumed to equal zero.

2 Treatment plant influent concentrations were calculated assuming 70% of flow is from alluvial aquifer, and 30% is from bedrock aquifer. Concentrations are based on flow-weighted averages.

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8 No West Virginia WQS, FAWQC (chronic), or BTAG Screening Level is available for this constituent.

All units are µg/l.

Alluvium and bedrock contaminant concentrations are averages of the analytical results from both the 1992 R, the Focused RI for Site 1, and the Phase I Aquifer Testing Report.

Table C-2
Preliminary Surface Water Discharge Limits for Inorganics in Site 1 Groundwater
Based on Treatment Plant Discharge of 220 gpm

Inorganic Constituents	Background Concentration[1] (µg/l)	Water Quality Standard (µg/l)	Alluvium (µg/l) Total Metals		Alluvium (µg/l) Dissolved Metals		Bedrock (µg/l) Total Metals		Bedrock (µg/l) Dissolved Metals		Treatment Plant Influent Concentration[2]		Water Quality Based Discharge Limit[3]	BAT Effluent Limitation[4]	Preliminary Discharge Limit[5]
			Mean	Max	Mean	Max	Mean	Max	Mean	Max	Total Metals (µg/l)	Dissolved Metals (µg/l)	Ave. Monthly (µg/l)	Ave. Monthly (µg/l)	(µg/l)
Aluminum	0	87 [6]	46230.5	420000	202.25	17	53120.16	125000.00	0.00	0	48297.40	141.58	1,132	NA	1,132
Antimony(1)	0	14 [6]	7.03	70	0	16	0.00	0.00	6.87	41	4.92	2.06	687	NA	687
Arsenic(1)	0	50 [6]	34.51	322	0	1	25	80	1.45	5	32	0.44	2,452	NA	2,452
Barium	70.8	1000 [6]	651.31	5350	65.95	105	763	1780	102	204	685	77	45,638	NA	45,638
Beryllium	0	.0077 [6]	4.601	45	0	0	3	8	0	0	4	0.00	0.38	NA	0.38
Cadmium	0	1.1 [10]	11.31	110	0	2	2	18	0.00	0.00	8.52	0.00	14	NA	14
Calcium	74050	NA [8]	99400	157000	63575	122000	91721	105000	84,717	124000	97096	69918	---	NA	NA
Chromium (III)	0	210 [10]	67.4	301	0	1.5	73	113	0.00	0.00	69	0.00	2,732	1110	1,110
Chromium (VI)	0	11 [10]	67.4	301	0	1.5	73	113	0.00	0.00	69	0.00	143	1110	143
Cobalt	0	35000 [7]	61.01	470	4.6	4	35	143	0.65	4.00	53	3.42	455,344	NA	455,344
Copper	4.2	12 [10]	151.51	1210	0	3	80	123	1.65	3.00	130	0.50	106	1450	106
Iron	0	1500 [6]	129022	1210000	246.25	37	86854	194000	515.50	923.00	116372	327.03	19,515	NA	19,515
Lead	0	3.2 [10]	126.07	1160	0	0	28	56	0.00	0.00	97	0.00	42	320	42
Magnesium	15150	NA [9]	26800	98400	12550	28400	29793	58400	20483.33	30200.00	27698	14930.00	---	NA	NA
Manganese(1)	330	1000 [6]	3042.62	24700	677.9	2640	2104	2860	256.67	757.00	2761	551.53	9,047	NA	9,047
Mercury(1)	0.1	0.1 [9]	0.1	1	0	0	0	0.78	0.03	0.20	0	0.01	0.10	NA	0.10
Nickel(1)	14.6	160 [10]	131	1,030	4	4	126	345	1.55	9.00	129	3	1,906	1690	1,690
Potassium	5940	NA [8]	6,243	38,800	1,060	2,090	13,169	31,800	2,538	3,580	8,321	1,504	----	NA	NA
Selenium	0	5 [6]	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	65	NA	65
Silver	0	4.1 [10]	6	56	0	2	0.54	8.00	0.00	0.00	4.08	0.00	53	NA	53
Sodium	44650	NA [8]	187,336	10,000	82,470	9,340	44,752	100,000	41,917	123,000	144,561	70,304	---	NA	NA
Thallium(1)	0	1.7 [6]	0	0	0	6	0.42	4.00	1.60	5.00	0.13	0.48	83	NA	83
Vanadium	0	10000 [7]	86	796	0	0	69	142	0.00	0.00	81	0.00	130,098	NA	130,098
Zinc(1)	18.4	110 [10]	406	3,480	19	13	230	393	7	18	353	15	1,210	1050	1,050
pH		6 TO 9	6.52 (min)	6.81 (max)			6.62 (min)	7.41 (max)							[illegible]

(1) Chemical of Potential Concern (COPC)

1 North Branch Potomac River upstream concentration. Value is an average based on two surface water samples collected during RI work. Sample analytical results are documented in the Phase II RI for surface water samples 5SW-1 and 5SW-2. Non-detect analytical results were assumed to equal zero.

2 Treatment plant influent concentrations were calculated assuming 70% of flow is from alluvial aquifer, and 30% is from bedrock aquifer. Concentrations are based on flow-weighted averages.

3 The Daily Maximum and Average Monthly Concentrations are the allowable discharge limits calculated using the State of West Virginia, Office of Water Resources Toxic Pollutant Control Strategy. The discharge limits are based on the appropriate water quality standard.

4 Best Available Technology (BAT) Effluent Limitations are reported in 40CFR414.101.

5 Required treatment plant end-of-pipe discharge limit. The concentration is based on the lower of the Water Quality Based Discharge Limit and the BAT Effluent Limitation.

6 West Virginia water quality standards (WQS), Appendix E, Requirements Governing Water Quality Standards, Title 46, Series I (1985).

7 EPA Region III BTAG Screening Level. No West Virginia WQS or Federal Ambient Water Quality Criteria (FAWQC) are available for this constituent.

8 No West Virginia WQS, FAWQC (chronic), or BTAG Screening Level is available for this constituent.

9 Background concentration is higher than West Virginia WQS and FAWQC (chronic). Therefore, the background concentration is the WQS.

10 FAWQC (chronic)

Alluvium and bedrock contaminant concentrations are averages of the analytical results from both the 1992 RI, the Focused RI for Site 1, and the Phase I Aquifer Testing Report

Appendix D
Site 10 Surface Water Discharge Limits

Appendix D
Site 10 Surface Water Discharge Limits

Discharge to the North Branch of the Potomac River via the Storm Sewer

This appendix presents the procedure for determining State of West Virginia surface water discharge limits, as required by the West Virginia Office of Water Resources Toxic Pollutant Control Strategy, for discharge of Site 10 groundwater to the North Branch of the Potomac River via the storm sewer. The procedure is described in a letter from the West Virginia Department of Environmental Protection, provided at the end of this appendix.

The discharge limits calculated using this method are included as tables D-3 and D-4 at the end of this appendix. The discharge limits are the last column in tables D-3 and D-4.

The following calculations are based on discharge of 75 gpm, which is extracted from Site 10, to the North Branch of the Potomac River via a storm sewer. This same method was used in the Site 1 FFS to calculate preliminary discharge limits for the Site 1 treatment plant. The Site 1 discharge limits, based on a flow rate of 220 gpm, are included in Appendix C.

Toxic Pollutant Control Strategy

Data Requirements:

1. 7Q10 flow (river low flow, determined by the State of West Virginia) = 117.48 cfs
2. Maximum discharge flow = 75 gpm = 0.17 cfs = 0.108 MGD
3. River ("background") concentration of chemical constituents.
4. Water quality standards, from Appendix E of the West Virginia Water Quality Resources Board, Series I, Requirements Governing Water Quality Standards (1985).

Step 1 - Calculate the river ("background") concentration of site contaminants upstream from the site.

The storm sewer outfall is approximately 1,500 feet downstream from the outfall for the Site 1 treatment plant. Background was assumed to consist of a mass balance between the average river concentration upgradient of the Site 1 treatment plant, and the Site 1 treatment plant preliminary discharge limits, listed in tables C-1 and C-2 of Appendix C.

Table D-1 lists the constituents and the background river concentration calculated by the mass balance approach. Two surface water samples, 5SW-1 and 5SW-2, collected adjacent to Site 5, were used to calculate an average river concentration upgradient of the Site 1 treatment plant outfall. This average concentration was combined in a mass balance with the Site 1 preliminary discharge limits, to determine the average river background concentration which is listed in the last column of Table D-1.

Step 2 - Determine the water quality standard for the constituents of concern. The water quality standard is the lower of the West Virginia water quality standards and the Federal AWQC (chronic). If the river background concentration is higher than these standards, then the background concentration is the water quality standard. If neither of these standards is available, then the EPA Region III BTAG Screening Levels are used. If the river background concentration is higher than the BTAG Screening Level, the background concentration is the water quality standard. Use Appendix E of the West Virginia Water Resources Board, Series I, Requirements Governing Water Quality Standards (1985). Appendix E defines the water quality standards based on the use classifications which are applicable to the surface water is to receive the discharge. The applicable use classification will determine the allowable assimilative capacity. The above approach has been used to determine the applicable water quality standard for each Site 10 constituent, which is listed in Table D-2.

The remaining steps describe the calculations required to derive the West Virginia water quality based discharge limits. An example calculation based on the constituent TCE is provided with each calculation. The calculations have been put into a spreadsheet format (tables D-3 and D-4), and the water quality based discharge limit for each constituent has been indicated.

Table D-1
Determination of Average Background River Concentrations

Constituent	5SW-1 [1]	5SW-2	Average of Wells 5SW-1 and 5SW-2	Site 1 Treatment Plant Discharge Limits [3]	Background River Concentration (Mass Balance) [4]
aluminum	0 [2]	0	0	690	5.01
antimony	0	0	0	4.5	0.03
arsenic	0	0	0	42.75	0.31
barium	63.8	77.8	70.8	732	75.60
beryllium	0	0	0	0.22	0.002
cadmium	0	0	0	9	0.07
calcium	66000	82100	74050	50000	73875.53
chromium (III)	0	0	0	46.5	0.34
chromium (VI)	0	0	0	46.5	0.34
cobalt	0	0	0	59.25	0.43
copper	4	4.3	4.15	66	4.60
cyanide	0	0	0	0	0.00
iron	0	0	0	11894	86.29
lead	0	0	0	25	0.18
magnesium	13400	16900	15150	29672	15255.35
manganese	288	372	330	2601	346.48
mercury	0.2	0	0.1	0	0.10
nickel	16.6	12.6	14.6	142.5	15.53
potassium	5200	6680	5940	10646	5974.14
selenium	0	0	0	0	0.00
silver	0	0	0	4.5	0.03
sodium	39400	49900	44650	22352	44488.24
thallium	0	0	0	0.75	0.01
vanadium	0	0	0	84.75	0.61
zinc	0	36.7	18.35	326	20.58
1,1,1-trichloroethane	0	0	0	22	0.16
1,1-dichloroethane	0	0	0	22	0.16
1,1-dichloroethene	0	0	0	0.86	0.01
1,2-dichloroethane	0	0	0	0	0.00
1,2-dichloroethene (total)	0	0	0	25	0.18
methylene chloride	0	0	0	36	0.26

Table D-1 Determination of Average Background River Concentrations					
Constituent	5SW-1 [1]	5SW-2	Average of Wells 5SW-1 and 5SW-2	Site 1 Treatment Plant Discharge Limits [3]	Background River Concentration (Mass Balance) [4]
tetrachloroethene	0	0	0	6	0.04
toluene	0	0	0	28	0.20
trichloroethene	0	0	0	26	0.19
vinyl chloride	0	0	0	1.5	0.01

[1] All units are in µg/L.

[2] All nondetects were assumed to equal 0 µg/L.

[3] Discharge limits are preliminary. If the treatment system influent concentration was lower than the discharge limit, then 75% of the influent concentration was assumed to be present in the system effluent.

[4] The background concentration was calculated using a simple mass balance of the average concentration from wells 5SW-1 and 5SW-2, and the Site 1 treatment plant discharge limits. The flow used for the upstream samples is the 7Q10 flow of 117.48 cfs. The flow used for the Site 1 treatment plant discharge is 0.45 cfs (220 gpm).

Table D-2
Selection of Water Quality Standards for Site 10 Discharge to the North Branch of the Potomac River via the Storm Sewer

Constituent	Water Quality Standard [7]
aluminum	87 [1]
antimony	14 [2]
arsenic	50 [2]
barium	1000 [2]
beryllium	0.0077 [2]
cadmium	1.1 [3]
calcium	NA [6]
chromium (III)	210 [3]
chromium (VI)	11 [3]
cobalt	35000 [5]
copper	12 [3]
cyanide	5 [1]
iron	1500 [1]
lead	3.2 [3]
magnesium	NA [6]
manganese	1000 [1]
mercury	0.10 [4]
nickel	160 [3]
potassium	NA [6]
selenium	5 [1]
silver	4.1 [3]
sodium	NA [6]
thallium	1.7 [2]
vanadium	10000 [5]
zinc	110 ~~100 [2]~~
1,1,1-trichloroethane	12000 [2]
1,1-dichloroethane	160000 [5]
1,1-dichloroethene	0.03 [2]
1,2-dichloroethane	0.035 [2]
1,2-dichloroethene (total)	11600 [5]
methylene chloride	11000 [5]
tetrachloroethene	0.8 [2]
toluene	6800 [2]
trichloroethene	2.7 [2]
vinyl chloride	2.0 [2]

[1] West Virginia WQS, use classification B1.
[2] West Virginia WQS, use classification A or C.
[3] Federal Ambient Water Quality Criteria (FAWQC) (chronic).
[4] Background river concentration.
[5] EPA Region III BTAG Screening Level (lower of flora and fauna).
[6] No WV WQS, FAWQC, or BTAG is available.
[7] All units are in µg/L.

Step 3 - Calculate the allowable in stream load for each constituent in pounds per day. This result is referred to as the upstream assimilative capacity (Acup).

Allowable (lb/day) = 7Q10(WQS-BackgroundConc.)/0.185

where:

-7Q10 is 117.48 cfs for the segment of the river adjacent to Site 1

-WQS is the WV water quality standard from Appendix E of the regulations

-Backgroundconc. is the river's mean concentration of the constituent

-(0.185) is a conversion factor

For TCE: Allowable (lb/day) = 117.48 cfs[0.0027 mg/l-0.00019 mg/l]/0.185 = 1.594 lb/day

Step 4 - Calculate the percent of the allowable daily load to be applied using an in stream waste concentration (IWC) approach. The result is termed the wasteload allocation (WLA).

IWC = Qd/(Qd+Qs)x100

where:

-Qd is the discharge flow

-Qs is the 7Q10 flow

For TCE: IWC = 0.17 cfs/(0.17 cfs + 117.48 cfs)x100 = 0.14%

According to State guidance, for IWCs less than 1%, a WLA will be derived based on 5% of the receiving stream assimilative capacity. For IWCs less than or equal to 5% and greater that 1% a WLA will be derived based upon 10% of the receiving stream assimilative capacity upstream of the discharge point. However, when using water quality standards corresponding to use classification "A" or "C", use 20% instead of 5 or 10%.

Based on this the WLA is calculated as follows:

$$WLA = Qd(WQS)8.34+(Acup)$$

For TCE: WLA=0.108 MGD(0.0027 mg/l)8.34+0.2(1.594 lb/day)=0.321 lb/day

Note that a factor of 0.2 (20%) was used because the water quality standard for TCE is based upon the public water intake use classification "A".

Step 5 - Convert the allowable pounds per day into the average monthly concentration (AMC):

$$AMC(mg/l)=WLA/[8.34(Qd)]$$

For TCE: AMC = 0.321 lb/day/[8.34(0.108 MGD)] = 0.356 mg/l = 356 μg/l

Step 6 - Determine the daily maximum concentration:

$$\text{Daily maximum}=1.5(AMC)$$

For TCE: Daily maximum=1.5(356 μg/l)=575 μg/l

Step 7 - The State will allow discharges to the North Branch of the Potomac River which meet the water quality based discharge limits calculated using this procedure, unless the values exceed the effluent limitations in 40 CFR 414.101. This Federal regulation contains best available technology (BAT) effluent limitations which the State uses as "never to exceed" discharge limits. Therefore, the remaining step is to compare the values calculated using the West Virginia Toxic Pollutant Control Strategy to the BAT effluent limitations, and to choose the lower value as the governing discharge limit. An excerpt from 40 CFR 414.101, which contains the BAT effluent limitations, is attached at the end of this appendix.

The BAT AMC effluent limitation for TCE is 26 μg/l, which is lower than the calculated AMC. Therefore, the BAT effluent limitation governs for average monthly discharge from the plant.

WDCR1056/018.DOC

DIVISION OF ENVIRONMENTAL PROTECTION
1356 Hansford Street
Charleston, WV 25301-1401

GASTON CAPERTON
GOVERNOR

LAIDLEY ELI MCCOY, Ph.D.
DIRECTOR

April 4, 1995

Mr. Jeff Kidwell
LANTDIV
Naval Facilities Engineering Command
1510 Gilbert Street (Code 1823)
Norfolk, Virginia 23511-2699

Re: Methodology for determining NPDES discharge requirements for the proposed Ground Water Treatment Plant for Site 1 at the Allegany Ballistics Laboratory, Mineral County, WV.

Dear Mr. Kidwell:

Any contaminant listed in 40 CFR 414.101 shall at a minimum meet the Best Available Technology effluent limitations. Additionally, contaminants in the discharge shall not be such that in stream water quality standards (WQSs) promulgated in Appendix E of Chapter 46 Code of State Regulations Series 1 are exceeded.

The following use categories are applicable to the North Branch of the Potomac River: warm water fishery - category B1, public water supply - category A, and water contact recreation - category C. The more stringent use category water quality standard for a particular constituent, as promulgated in Appendix E. shall apply.

In lieu of mixing zone calculations, when standards promulgated to be protective of aquatic life (use category B1) are the more stringent, the Office of Water Resources will accept the method described below. This policy, the Office of Water Resources Toxic Pollutant Control Strategy, conservatively considers the assimilative capacity of the receiving stream to calculate discharge limitations.

Step 1: Calculate the allowable in stream load for each constituent in pounds per day. This result is referred to as the upstream assimilative capacity (ACup).

$$\text{Allowable(lbs.per day)} = \frac{7Q10(\text{WQS-Background Conc.})}{0.185}$$

Where:
- 7Q10 is 61.58 cfs for that stretch of the North Branch of the Potomac
- WQS is the WV Water Quality Standard from Appendix E
- Background concentration is the upstream concentration
- (0.185) converts the combination milligrams per liter and cubic feet per second to pounds per day.

*Concentrations must be expressed in mg/l. Flow must be expressed in cfs.

Step 2: Calculate the percent of the allowable daily load to be applied using an instream water concentration (IWC) approach. The final result is termed the Wasteload Allocation (WLA).

$$IWC = Qd/(Qd+Qs) X100\%$$

Where:
- Qd is the discharge flow
- Qs is the 7Q10

*Units of volume and time must be consistent for each flow.

The policy states "For IWCs less than or equal to 5% and greater than 1%, a wasteload allocation will be derived based upon 10% of the receiving assimilative capacity upstream of the discharge point. The pollutant mass that would be associated with the discharge at Water Quality Standards will be added to the allocation. The wasteload allocation will be converted to a concentration limitation using the applicable discharge flow, and the concentration limitation will be imposed as a monthly average limitation. A daily maximum will be imposed equal to 1.5 times the monthly average limitation."

$$WLA = Qd(WQS)8.34 + 0.1(ACup)$$

Where:
- Qd is the anticipated daily discharge flow in MGD.
- ACup is the upstream assimilative capacity calculated in step 1.
- WLA is the wasteload allocation in pounds per day.

Step 3. Convert the allowable pounds per day into the Average Monthly Concentrations (AMCs).

$$AMC(mg/l) = \frac{WLA}{[8.34(Qd)]}$$

Step 4. Determine the daily maximum concentration.

$$Daily\ Maximum\ (mg/l) = 1.5\ (AMC)$$

For design flows that yield an IWC of one percent or less the policy states, "..., a wasteload allocation will be derived based upon 5% of the receiving stream assimilative capacity. The wasteload allocation will be converted to a concentration limitation using the applicable discharge flow, and the concentration limitation will be imposed as a monthly average limitation . A daily maximum limitation will be imposed equal to 1.5 times the monthly average limitation."

For this circumstance, IWC less than one percent, the receiving stream assimilative capacity may be calculated using the 7Q10 flow plus the discharge flow.

$$Allowable(lbs.\ per\ day) = \frac{(7Q10+Qd)\ (WQS-Background\ Conc.)}{0.185}$$

When use categories A or C, public water intake or contact recreation, are the more stringent the IWC approach is not employed. For these cases, use 20% of the upstream assimilative capacity calculated in step one to determine the wasteload allocation and the average monthly and daily maximum concentrations.

$$WLA = Qd(WQS)\,8.34 + 0.2\,(ACup)$$

The establishment of background concentrations should consider the results of a minimum of ten upstream sampling events and, or, other supporting data in proximity of the discharge point. Ideally, events to determine background concentrations should have a minimum of one week time interval between each event.

§46-1-5 provides the state criteria for mixing zones. A considerable amount of additional information, and additional review time, would be required to establish limitations based upon a mixing zone. To ensure that the promulgated criteria are not exceeded, the Office of Water Resources may recommend or require the installation of a diffuser at the end of pipe.

If you require additional information, I may be contacted at (304)558-2745.

Sincerely,

Peter Costello

Peter Costello
Site Investigation and Response
Office of Waste Management

PC/MS/o
cc: Bruce Beach, EPA
Greg Mott, CH2MHILL
John McGillen, MDE
Mohammad Shafiei, WV-DEP
Tom Bass, WV-DEP

414.101

Toxic pollutant effluent limitations and standards for direct discharge point sources that do not use end-of-pipe biological treatment.

414.101(a)

(a) Any point source subject to this subpart must achieve discharges not exceeding the quantity (mass) determined by multiplying the process wastewater flow subject to this subpart times the concentrations in the following table.

414.101(b)

(b) In the case of chromium, copper, lead, nickel, zinc, and total cyanide, the discharge quantity (mass) shall be determined by multiplying the concentrations listed in the following table for these pollutants times the flow from metal-bearing waste streams for the metals and times the cyanide-bearing waste streams for total cyanide. The metal-bearing waste streams and cyanide-bearing waste streams are defined as those waste streams listed in Appendix A of this part, plus any additional OCPSF process wastewater streams identified by the permitting authority on a case-by-case basis as metal or cyanide bearing based upon a determination that such streams contain significant amounts of the pollutants identified above. Any such streams designated as metal or cyanide bearing must be treated independently of other metal or cyanide bearing waste streams unless the permitting authority determines that the combination of such streams, prior to treatment, with the Appendix A waste streams will result in substantial reduction of these pollutants. This determination must be based upon a review of relevant engineering, production, and sampling and analysis information.

Effluent characteristics	BAT effluent limitations and NSPS 1	
	Maximum for any one day	Maximum for monthly average
Acenaphthene	47	19
Acenaphthylene	47	19
Acrylonitrile	232	94
Anthracene	47	19
Benzene	134	57
Benzo(a)anthracene	47	19
3,4-Benzofluoranthene	48	20
Benzo(k)fluoranthene	47	19
Benzo(a)pyrene	48	20
Bis(2-ethylhexyl) phthalate	258	95
Carbon Tetrachloride	380	142
Chlorobenzene	380	142
Chloroethane	295	110
Chloroform	325	111
Chrysene	47	19
Di-n-butyl phthalate	43	20
1,2-Dichlorobenzene	794	196
1,3-Dichlorobenzene	380	142
1,4-Dichlorobenzene	380	142
1,1-Dichloroethane	59	22
1,2-Dichloroethane	574	180
1,1-Dichloroethylene	60	22
1,2-trans-Dichloroethylene	66	25
1,2-Dichloropropane	794	196
1,3-Dichloropropylene	794	196
Diethyl phthalate	113	46
2,4-Dimethylphenol	47	19
Dimethyl phthalate	47	19
4,6-Dinitro-o-cresol	277	78
2,4-Dinitrophenol	4,291	1,207

Ethylbenzene	380	142
Fluoranthene	54	22
Fluorene	47	19
Hexachlorobenzene	794	196
Hexachlorobutadiene	380	142
Hexachloroethane	794	196
Methyl Chloride	295	110
Methylene Chloride	170	36
Naphthalene	47	19
Nitrobenzene	6,402	2,237
2-Nitrophenol	231	65
4-Nitrophenol	576	162
Phenanthrene	47	19
Phenol	47	19
Pyrene	48	20
Tetrachloroethylene	164	52
Toluene	74	28
Total Chromium	2,770	1,110
Total Copper	3,380	1,450
Total Cyanide	1,200	420
Total Lead	690	320
Total Nickel	3,980	1,690
Total Zinc 2	2,610	1,050
1,2,4-Trichlorobenzene	794	196
1,1,1-Trichloroethane	59	22
1,1,2-Trichloroethane	127	32
Trichloroethylene	69	26
Vinyl Chloride	172	97

1 All units are micrograms per liter.

2 Total Zinc for Rayon Fiber Manufacture that uses the viscose process and Acrylic Fibers Manufa uses the zinc chloride/solvent process is 6,796 µg/l and 3,325 µg/l for maximum for any one day an for monthly average, respectively.

[52 FR 42568, Nov. 5, 1987, as amended at 54 FR 27352, June 29, 1989; 55 FR 26692, June 29, 1990; 56 FR 63897, December 06, 1991; 57 FR 2238, January 21, 1992; 58 FR 36872, July 9, 1993]

Table D-3
Preliminary Surface Water Discharge Limits for Site 10 Groundwater VOCs
Based on Discharge of 75 gpm to the Storm Sewer

Organic Constituents	Background Concentration[1] (µg/l)	Water Quality Standard (µg/l)	Treatment Plant Influent Concentration[2] (µg/l)	Water Quality Based Discharge Limit[3]		BAT Effluent Limitation[4]		Preliminary Discharge Limit[5] (µg/l)
				Daily Max. (µg/l)	Ave. Monthly (µg/l)	Daily Max. (µg/l)	Ave. Monthly (µg/l)	
1,1,1-Trichloroethane(1)	0.16	12,000 [7]	28	2,556,000	1,704,000	127	22	22
1,1-Dichloroethane	0.16	160,000 [8]	274	8,700,000	5,800,200	59	22	22
1,1-Dichloroethene(1)	0.01	0.03 [7]	10	4.28	2.85	60	22	7.08
1,2-Dichloroethane(1)	0	0.035 [7]	0	7.46	4.97	574	180	12.37
1,2-Dichloroethene(Tot)(1)	0.18	11,600 [8]	552	630,760	421,000	66	25	25
Methylene Chloride(1)	0.26	11,000 [8]	9	598,100	398,800	170	36	36
Tetrachloroethene(1)	0.04	0.8 [7]	4	161.9	107.96	164	52	52
Toluene	0.2	6,800 [7]	0	1,448,400	965,600	74	28	28
Trichloroethene(1)	0.19	2.7 [7]	1,296	534.9	356.6	69	26	26
Vinyl Chloride(1)	0.01	2.0 [7]	0	423.9	282.6	172	97	97

1 North Branch Potomac River upstream concentration. Value is a mass balance based on two surface water samples from Site 5, and on Site 1 treatment system discharge limits. The surface water samples are 5SW-1 and 5SW-2. Non-detect analytical results were assumed to equal zero.
2 Treatment plant influent concentrations were calculated assuming 70% of flow is from alluvium, and 30% is from bedrock.
3 Daily Maximum and Average Monthly Concentrations are the allowable discharge limits calculated using the State of West Virginia, Office of Water Resources Toxic Pollutant Control Strategy. The discharge limits are based on the appropriate water quality standard.
4 Best Available Technology (BAT) Effluent Limitations are reported in 40CFR414.101.
5 Required treatment plant end-of-pipe discharge limit. The concentration is based on the lower of the Water Quality Based Discharge Limit and the BAT Effluent Limitation.
6 West Virginia water quality standards (WQS)-use classification B1; Appendix E, Requirements Governing Water Quality Standards, Title 46, Series I (1985).
7 West Virginia water quality standards (WQS)-use classification A or C; Appendix E, Requirements Governing Water Quality Standards, Title 46, Series I (1985).
8 EPA Region III BTAG Screening Level. No West Virginia WQS or Federal Ambient Water Quality Criteria (FAWQC) are available for this constituent.
9 No West Virginia WQS, FAWQC (chronic), or BTAG Screening Level is available for this constituent.

All units are µg/l.

Shaded constituents require treatment in order to meet the preliminary discharge limits.

Table D-4
Preliminary Surface Water Discharge Limits for Site 10 Groundwater Inorganics
Based on Discharge of 75 gpm to the Storm Water

Inorganic Constituents	Background Concentration[1] (µg/l)	Water Quality Standard (µg/l)	Treatment Plant Influent Concentration[2]		Water Quality Based Discharge Limit[3]	BAT Effluent Limitation[4]	Preliminary Discharge Limit[5]
			Total Metals (µg/l)	Dissolved Metals (µg/l)	Ave. Monthly (µg/l)	Ave. Monthly (µg/l)	(µg/l)
Aluminum	5.01	87 [6]	35	25.3	2,977	NA	2,977
Antimony(1)	0.03	14 [7]	0	0	1,984	NA	1,984
Arsenic(1)	0.31	50 [7]	2.8	2.5	7,057	NA	7,057
Barium	75.6	1000 [7]	39.4	36.7	131,344	NA	131,344
Beryllium	0.002	0.0077 [7]	0	0	0.81	NA	0.81
Cadmium	0.07	1.1 [11]	0	0	37	NA	37
Calcium	73875.53	NA [9]	72400	72200	---	NA	NA
Chromium (III)	0.34	210 [11]	0	0	7,601	1110	1,110
Chromium (VI)	0.34	11 [11]	0	0	387	1110	387
Cobalt	0.43	35000 [8]	0	0	1,268,773	NA	1,268,773
Copper	4.6	12 [11]	97	4	273	1450	273
Cyanide	0	5 [6]	0	0	181	420	181
Iron	86.29	1500 [6]	358	287	51,335	NA	51,335
Lead	0.18	3.2 [11]	7	3.9	110	320	110
Magnesium	15255.35	NA [9]	9680	8414	---	NA	NA
Manganese(1)	346.48	1000 [6]	48	41	24,037	NA	24,037
Mercury(1)	0.1	0.10 [10]	0	0	0.10	NA	0.10
Nickel(1)	15.53	160 [11]	0	0	5,253	1690	1,690
Potassium	5974.14	NA [9]	1,170	1,011	----	NA	NA
Selenium	0	5 [6]	0	0	181	NA	181
Silver	0.03	17 [6]	0	0	615	NA	615
Sodium	44488.24	NA [9]	9,687	9,594	---	NA	NA
Thallium(1)	0.01	1.7 [7]	0	0	240	NA	240
Vanadium	0.61	10000 [8]	1	2	362,489	NA	362,489
Zinc(1)	20.58	100 [7]	38	9	11,299	1050	1,050
pH		6 TO 9					6 to 9

Table D-4
Preliminary Surface Water Discharge Limits for Site 10 Groundwater Inorganics
Based on Discharge of 75 gpm to the Storm Water

1 North Branch Potomac River upstream concentration. Value is a mass balance based on two surface water samples from Site 5, and on Site 1 treatment system discharge limits. The surface water samples are 5SW-1 and 5SW-2. Non-detect analytical results were assumed to equal zero.
2 Treatment plant influent concentrations assume 70% of flow is from alluvium, and 30% is from bedrock aquifer. Concentrations based on flow-weighted averages.
3 Average Monthly Concentrations are the allowable discharge limits calculated using State of West Virginia, Office of Water Resources Toxic Pollutant Control Strategy. The discharge limits are based on the appropriate water quality standard.
4 Best Available Technology (BAT) Effluent Limitations are reported in 40CFR414.101.
5 Required treatment plant end-of-pipe discharge limit. The concentration is based on the lower of the Water Quality Based Discharge Limit and the BAT Effluent Limitation.
6 West Virginia water quality standards (WQS)-use classification B1; Appendix E, Requirements Governing Water Quality Standards, Title 46, Series 1 (1985).
7 West Virginia water quality standards (WQS)-use classification A or C; Appendix E, Requirements Governing Water Quality Standards, Title 46, Series 1 (1985).
8 EPA Region III BTAG Screening Level. No West Virginia WQS or Federal Ambient Water Quality Criteria (FAWQC) are available for this constituent.
9 No West Virginia WQS, FAWQC (chronic), or BTAG Screening Level is available for this constituent.
10 Background concentration is higher than West Virginia WQS and FAWQC (chronic). Therefore, the background concentration is the WQS.
11 FAWQC (chronic)

Appendix E

West Virginia Groundwater Reinjection Requirements

Appendix E
West Virginia Groundwater Reinjection Requirements

This appendix contains a telephone conversation record of a conversation with the WVDEP Water Resources Division, Groundwater/Underground Injection Control Office. The conversation was initiated with WVDEP to determine the State's requirements for groundwater reinjection, and to determine the specific State regulations governing reinjection.

An Underground Injection Control Permit application is also included in this appendix. The application identifies the information and fee which must be submitted for receipt of a reinjection permit.

WDCR1056/024.DOC

CH2M HILL *TELEPHONE CONVERSATION RECORD*

CALL TO: Mark Priddy
Water Resources Division-Well
Installation

West Virginia Department of
Environmental Protection

PHONE NO.: 304-558-2108

DATE: 10/17/96

CALL FROM: Lee Davis

TIME: 2:30PM

MESSAGE TAKEN BY: Lee Davis

PROJECT NO.: 136194

SUBJECT: ABL-Site 10
Reinjection of Treated Groundwater

I explained to Mark that I wanted an interpretation of Title 47, Series 13 Underground Injection Control. because our client may want to reinject 75 gpm of treated water into the aquifer at the Allegany Ballistics Laboratory (ABL) Superfund Site. The treated water would be extracted from the aquifer at ABL's Site 10, treated to meet Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs), and then reinjected into the same aquifer.

Mark indicated that we are allowed to reinject the water into the aquifer as long as it is treated to below MCLs. He said that there is no requirement as to what aquifer you reinject to. As long as the water meets MCLs, it can be injected into an aquifer which is considered to be a potential water supply source.

Mark said he would send me an application for injection well installation which provides additional information regarding well installation. According to the application, groundwater remediation reinjection wells are designated type 5X26, which coincides with reinjection well types in the federal regulations. Mark said the federal regulations have been incorporated into the State regulations in Title 47, Series 9 and 9A. However, the application will contain all the information we need. Mark said the application fee will probably be $1,500.

DIVISION OF ENVIRONMENTAL PROTECTION
1201 Greenbrier Street
Charleston, WV 25311-1088

GASTON CAPERTON
GOVERNOR

LAIDLEY ELI MCCOY, Ph.D.
DIRECTOR

October 18, 1996

CH2NHILL for ABL
Attn.: Mr. Lee Davis
625 Herndon Parkway
Herndon, VA 20170

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Re: Underground Injection Control Permit
Application No.: 0163-96-057

Dear Mr. Davis:

Enclosed are the papers constituting Permit Application Number 0163-96-057 for the issuance of a Class V Underground Injection Control Permit. One copy of the completed permit application and fee must be returned no later than ninety (90) days after receipt, and at least ninety (90) days before a new facility begins operation. Retain the second copy for your records. Please note that all sections of the form require an answer. For any sections that may not apply, it should be so indicated by N/A (Not Applicable). No line by line instructions are provided as the application should be self-explanatory. A well prepared and accurate application will reduce the time necessary for the agency to act upon it.

In accordance with the West Virginia Code, Chapter 22, Article 11, Section 6A, a permit application fee shall accompany the permit application. Permit application fees may be determined by referring to Attachment 3 of the Permit Application Package. Permit applications which are deemed incomplete shall be returned and a resubmission fee shall accompany the refiled application.

In accordance with the West Virginia Legislative Rules, Title 47, Series 13, Section 13.24.c.2 issued pursuant to Chapter 22, Article 11, Code of West Virginia, the Chief, of the Office of Water Resources, is required to publish a public notice as a Class I legal advertisement of the preparation of a draft permit. The rules also require that the cost of the publication be borne by the applicant. In order to comply with the above regulatory requirements, your authorization is required on the attached Statement For Billing. Please note that this Statement For Billing must be notarized. Your application cannot be deemed complete without this notarized authorization.

Completed applications should be mailed to:

Chief
Office of Water Resources
1201 Greenbrier St.
Charleston, WV 25311
Attn: Ground Water/UIC Office

Make check for Permit Application Fee payable to: **West Virginia Division of Environmental Protection.** Please put your Permit Application Number on your check. If there are any questions regarding the preparation of the application, please contact me at (304) 558-2108.

Very truly yours,

OFFICE OF WATER RESOURCES

Mark S. Priddy
Geologist
Ground Water/UIC Office

Enclosure

PERMIT APPLICATION NO.: 0163-96-057

STATEMENT FOR BILLING

The ____,
(name of company, facility, or proprietor)

of which I am an authorized representative, has applied for a West Virginia Underground Injection Control Permit from the West Virginia Division of Environmental Protection, Office of Water Resources, Ground Water/UIC Office. Under State Legislative Rules, Title 47, Series 13, section 13.24.c.2, the costs of publishing a Class I legal advertisement are to be paid by the applicant who must also send the certificate of publication to the Office of Water Resources upon publication.

The ____,
(name of company, facility, or proprietor)

hereby agrees to pay the cost of such legal advertisement. The publishing newspaper should send the certificate of publication and bill to:

____
company, facility, or proprietor name and address

____

Sworn and subscribed to before me this ____________ day of ________________, 19____.

____
Signature of Authorized Representative

____
Notary Public

____
Commission Expires

UIC-501
Rev. 02-95

CLASS V
UNDERGROUND INJECTION CONTROL
PERMIT APPLICATION

PERMIT APPLICATION NUMBER: 0163-96-057

(Collected under the authority of the West Virginia Code, 20-5A-6.)

I. FACILITY NAME

____ Phone ____________

Type of Business ____

SIC Codes __________ __________ __________ __________

Enter up to four. Use Standard Industrial Classification (SIC) manual from the Office of Management and Budget or consult your local library.

Status (circle one): Federal, State, Private, Public, other.

II. FACILITY ADDRESS

Street Address ____

P.O. Box ____

City or Town ____

State ____________________ Zip Code ________________

III. OWNERSHIP INFORMATION

Owner name ____________________________ Phone ____________

Street or P.O.Box ____

City or Town ____

State ____________________ Zip Code ________________

IV. OPERATOR INFORMATION

Operator name ____________________________ Phone ____________

V. APPLICANT REQUEST

A. Reissue existing Class V UIC Permit ___Yes ___No
If yes provide permit number ____________

PERMIT APPLICATION NUMBER: 0163-96-057

B. Modify existing Class V UIC Permit ___Yes ___No
If yes provide permit number ______________

C. Apply for Class V UIC Permit ___Yes ___No

Note: Provide detailed explanation of Class V activities in Comments section (Attach additional sheets if necessary)

VI. **PRIOR PERMITS:** Is the facility currently permitted under any of the following programs?

		PERMIT NUMBER
A.	Hazardous Waste Management Code	______________
B.	NPDES program	______________
C.	Prevention of Significant Deterioration (PSD)	______________
D.	Nonattainment program (Clean Air act)	______________
E.	National Emission Standards for Hazardous Pollutants (NESHAPS)	______________
F.	Dredge of Fill permits (section 404 of CWH)	______________
G.	Other relevant permits: ______________	______________

VII. **TYPE OF PERMIT REQUESTED**

A. Area Permit (More than one disposal well per site) ______

B. Site Permit (Only one disposal well) ______

C. Total number of injection well(s) ______

VIII. **WELL LOCATION(S)**

	deg. min. sec.	deg. min. sec.
A.1	Latitude ______________	Longitude ______________
A.2	Latitude ______________	Longitude ______________
A.3	Latitude ______________	Longitude ______________
A.4	Latitude ______________	Longitude ______________

B. Name(s) of field(s) or project(s). ______________

C. Complete Attachment 1.

IX. **WELL TYPE** (See Attachment 2)

A. Well Type(s) - enter code(s) ______________

B. Number of wells per type. ______________

PERMIT APPLICATION NUMBER: 0163-96-057

C. What is the current method of disposal for the fluids? ____________________

____

____

X. COMMENTS (Provide any additional pertinent information in the space below.)

____

____

____

____

____

XI. CERTIFICATION

(All permit applications must be signed by a responsible corporate officer for a corporation, by a general partner for a partnership, by the proprietor of a sole proprietorship, and by a principal executive or ranking elected official for a public agency.)

A. Name and title of person applying for permit:

____________________ ____________________

B. Signature and Date.

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

____________________ ____________________

PERMIT APPLICATION NUMBER: 0163-96-057

XII. FINANCIAL RESPONSIBILITY

A. Name and title of person(s) who will: 1) assume financial responsibility in the event of contamination. 2) maintain resources necessary for proper closure of the well.

____
____
____

B. Signature(s) and date.

____________________________ __________
____________________________ __________
____________________________ __________

UIC CLASS V PERMIT APPLICATION NUMBER: 0163-96-057

ATTACHMENT 1
FORM D

The following Attachment must be addressed in detail and submitted with an application for a Class V Injection Well.

A. Map of Well\Area of Review - Submit a topographic map, extending at least one mile beyond the property boundary, showing the Class V injection well(s) (i.e. septic system, dry well, cesspool) for which a permit is being sought. The map must identify all ground water supply sources, including all public and private drinking water wells, springs, and surface water bodies within one-quarter mile of the property boundary.

B. Operating Data - Submit a comprehensive narrative describing, in detail, the process(es) and\or activities which generate the waste stream disposed of in the Class V injection well (septic system\dry well\cesspool). Indicate average and maximum daily rate of disposal, injection pressure, and an estimate of the total volume of fluids entering the well(s) daily. Also include an analysis of the chemical and biological characteristics of the fluid being discharged and an evaluation of any effects that the system\well has on these characteristics (i.e. dilution, adsorption, neutralization, settling).

C. Construction Details - Submit schematic or other appropriate drawings of the surface and subsurface construction details of the well(s) and surrounding facilities including waste water system layout. Indicate the depth and other dimensions, including diameter, of the well(s) or septic system.

D. Monitoring Program - Submit the details of a monitoring program which must be implemented and which will ensure that the waste disposal system is not compromising the quality of underground sources of drinking water. This monitoring program should include a discussion of the monitoring devices, sampling frequency, and monitoring parameters which will routinely characterize the chemical constituents of the waste stream. Also, a plan must be developed and submitted which describes the measures which will be taken to prevent spills or additions of unintentional wastes to the permitted waste stream.

E. Plugging and Abandonment - Submit a plan detailing procedures for abandonment of the Class V injection well when the useful life is complete.

ATTACHMENT 1
FORM D

F. Groundwater Protection Plan(GPP) - The GPP is to be submitted and reviewed as part of the facility's or activity's permit application and shall contain the following from Title 47 Series 58 of the Legislative Rules:

4.11.1 An inventory of all operations that may reasonably be expected to contaminate the groundwater resources with an indication of the potential for soil and groundwater contamination from those operations;

4.11.2 A description of procedures designed to protect groundwater from the identified contamination sources, with specific attention given to:

4.11.2.a Manufacturing facilities;

4.11.2.b Materials handling;

4.11.2.c Equipment cleaning;

4.11.2.d Construction activities;

4.11.2.e Maintenance activities;

4.11.2.f Pipelines carrying contaminants;and

4.11.2.g Sumps and tanks containing contaminants.

4.11.3 A list of procedures to be employed in the design of any new equipment/operations;

4.11.4 A summary of all activities carried out under other regulatory programs that have relevance to groundwater protection; and

4.11.5 A discussion of all available information reasonably available to the facility/activity regarding existing groundwater quality at, or which may be affected by the site.

4.11.6 A clarification that no wastes be used for deicing, fills, etc., unless provided for in existing regulations.

4.11.7 Provisions for all employees to be instructed and trained on their responsibility to ensure groundwater protection. Job procedures shall provide direction on how to prevent groundwater contamination.

ATTACHMENT 1
FORM D

4.11.8 The GPP shall include provisions for quarterly inspections to ensure that all elements and equipment of the sites groundwater protection program are in place, properly functioning and appropriately managed.

A copy of Title 47, Series 58 - Groundwater Protection Regulations or Title 47, Series 13 - Underground Injection Control Regulations can be obtained by contacting the Secretary of State's office at (304) 558-6000.

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
	Drainage Wells (a.k.a. Dry Wells)
5F1	Agricultural Drainage Wells - receive irrigation tailwaters, other field drainage, animal yard, feedlot, or dairy runoff, etc.
5D2	Storm Water Drainage Wells - receive storm water runoff from paved areas, including parking lots, streets, residential subdivisions, building roofs, highways, etc.
5D3	Improved Sinkholes - receive storm water runoff from developments located in karst topographic areas.
5D4	Industrial Drainage Wells - wells located in industrial areas which primarily receive storm water runoff but are susceptible to spills, leaks, or other chemical discharges.
5G30	Special Drainage Wells - used for disposing water from sources other than direct precipitation. Examples of this well type include: landslide control drainage wells, potable water tank overflow drainage wells, swimming pool drainage wells, and lake level control drainage wells.
	Geothermal Reinjection Wells
5A5	Electric Power Reinjection Wells - reinject geothermal fluids used to generate electric power - deep wells.
5A6	Direct Heat Reinjection Wells - reinject geothermal fluids used to provide heat for large buildings or developments - deep wells.
5A7	Heat Pump/Air Conditioning Return Flow Wells - reinject groundwater used to heat or cool a building in a heat pump system - shallow wells.
5A8	Groundwater Aquaculture Return Flow Wells - reinject groundwater or geothermal fluids used to support aquaculture. Non-geothermal aquaculture disposal wells are also included in this category (e.g. Marine aquariums in Hawaii use relatively cool sea water).

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
	Domestic Wastewater Disposal Wells
5W9	Untreated Sewage Waste Disposal Wells - receive raw sewage wastes from pumping trucks or other vehicles which collect such wastes from single or multiple sources. (No treatment)
5W10	Cesspools - including multiple dwelling, community, or regional cesspools, or other devices that receive wastes and which must have an open bottom and sometimes have perforated sides. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Settling of solids)
5W11	Septic Systems (Undifferentiated disposal method) - used to inject the waste or effluent from a multiple dwelling, business establishment, community, or regional business establishment septic tank. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Primary Treatment)
5W31	Septic Systems (Well Disposal Method) - examples of wells include actual wells, seepage pits, cavitettes, etc. The largest surface dimension is less than or equal to the depth dimension. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Less treatment per square area than 5W32)
5W32	Septic Systems (Drainfield Disposal Method) - examples of drainfields include drain or tile lines, and trenches. Must serve more than 20 persons per day if receiving solely sanitary wastes. (More treatment per square area than 5W31)
5W12	Domestic Wastewater Treatment Plant Effluent Disposal Wells - dispose of treated sewage or domestic effluent from small package plants up to large municipal treatment plants. (Secondary or further treatment)
	Mineral and Fossil Fuel Recovery Related Wells
5X13	Mining, Sand, or Other Backfill Wells - used to inject a mixture of fluid and sand, mill tailings, and other solids into mined out portions

ATTACHMENT 2

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
5X13	of subsurface mines whether what is injected is a radioactive waste or not. Also includes special wells used to control mine fires and acid mine drainage wells.
5X14	Solution Mining Wells - used for in-situ solution mining in conventional mines, such as stopes leaching.
5X15	In-situ Fossil Fuel Recovery Wells - used for in-situ recovery of coal, lignite, oil shale, and tar sands.
5X16	Spent-Brine Return Flow Wells - used to reinject spent brine into the same formation from which it was withdrawn after extraction of halogens or their salts.
	Oil Field Production Waste Disposal Wells
5X17	Air Scrubber Waste Disposal Wells - inject wastes from air scrubbers used to remove sulfur from crude oil which is burned in steam generation for thermal oil recovery projects. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.)
5X18	Water Softener Regeneration Brine Disposal Wells - inject regeneration wastes from water softeners which are used to improve the quality of brines used for enhanced recovery. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.)
	Industrial/Commercial/Utility Disposal Wells
5A19	Cooling Water Return Flow Wells - used to inject water which was used in a cooling process, both open and closed loop processes.
5W20	Industrial Process Water and Waste Disposal Wells - used to dispose of a wide variety of wastes and wastewaters from industrial, commercial, or utility processes. Industries include refineries, chemical plants, smelters, pharmaceutical plants, laundromats and dry cleaners, tanneries, laboratories, (e.g. petroleum storage facilities (storage tank condensation water); electric power gen-

WELL CODE	NAME OF WELL TYPE AND DESCRIPTION
5W20	eration plants (mixed waste stream of laboratory drainage, fireside water, and boiler blowdown); car wash (mixed waste stream of detergent, oil and grease, and paved area washdown); electroplating industries (spent solvent wastes); etc.).
5X28	Automobile Service Station Disposal Wells - repair bay drains connected to a disposal well.
	Recharge Wells
5R21	Aquifer Recharge Wells - used to recharge depleted aquifers and may inject fluids from a variety of sources such as lakes, streams, domestic wastewater treatment plants, other aquifers, etc.
5B22	Saline Water Intrusion Barrier Wells - used to inject water into fresh water aquifers to prevent intrusion of salt water into fresh water aquifers.
5S23	Subsidence Control Wells - used to inject fluids into a non-oil or gas producing zone to reduce or eliminate subsidence associated with overdraft of fresh water and not used for the purpose of oil or natural gas production.
	Miscellaneous Wells
5N24	Radioactive Waste Disposal Wells - all radioactive waste disposal wells other than Class IV wells.
5X25	Experimental Technology Wells - wells used in experimental or unproven technologies such as pilot scale in-situ solution mining wells in previously unmined areas.
5X26	Aquifer Remediation Related Wells - wells used to prevent, control, or remediate aquifer pollution, including but not limited to Superfund sites.
5X29	Abandoned Drinking Water Wells - used for disposal of waste.
5X27	Other Wells - any other unspecified Class V wells. Well type/purpose and injected fluids must be specified.

ATTACHMENT 3
UIC CLASS V PERMIT APPLICATION

PERMIT APPLICATION NUMBER: 0163-96-057

Complete the following permit application fee worksheet and return it with the permit application. The minimum permit application fee is $25.00 and the maximum permit application fee is $1,500.00. The minimum annual permit fee is $25.00 and the maximum annual permit fee is $500.00. Permits are issued for a period of five years and the annual permit fee is due on the anniversary of the date the permit was issued.

I. FEE CALCULATION:

Use Tables A, B, and C to calculate your application fee using the following formula:

Permit Application Fee =
(Volume Fee) X (Treatment Factor) X (Well Type Factor)

EXAMPLE:
If you input 450 gallons per day into a Type 5W32 well (septic system with drainfield) the permit application fee would be as follows:

Fee = (Volume Fee) X (Treatment Factor) X (Well Type Factor)
= $75.00 x 2.5 x 1
= $187.50

CALCULATE THE PERMIT APPLICATION FEE FOR YOUR FACILITY IN THE SPACE BELOW.

Fee = (Volume Fee) X (Treatment Factor) X (Well Type Factor)

Fee = ____________ X ____________ X ____________
(Table A) (Table B) (Table C)

Calculated Permit Application Fee = ____________

ACTUAL PERMIT APPLICATION FEE = ____________
(Minimum $25.00; Maximum $1500.00)

PERMIT APPLICATION NUMBER: 0163-96-057

II. ANNUAL PERMIT FEE

The Annual Permit Fee is calculated using the following formula:

Annual Permit Fee =
(Volume Fee) X (Treatment Factor) X (Well Type Factor) X 0.333

USE THE SPACE BELOW TO CALCULATE THE ANNUAL PERMIT FEE FOR THIS FACILITY.

Fee = ____________ X ____________ X ____________ X 0.333
(Table A) (Table B) (table C)

Calculated Annual Permit Fee = ____________________

ACTUAL ANNUAL PERMIT FEE = ____________________
(Minimum $25.00; Maximum $500.00)

ATTACHMENT 3

TABLE A
VOLUME FEES

If the daily discharge (in gallons) is:	The Volume Fee is:
<250	$ 50.00
250 - 500	75.00
501 - 1000	150.00
1001 - 5000	200.00
5001 - 50,000	400.00
50,001 - 100,000	600.00
>100,000	850.00

TABLE B
TREATMENT FACTORS

LEVEL OF TREATMENT	TREATMENT FACTOR
NO TREATMENT	3
PRIMARY TREATMENT	2.5
SECONDARY TREATMENT	2
TERTIARY TREATMENT	1.5
>TERTIARY TREATMENT	1

ATTACHMENT 3
TABLE C -- WELL TYPE FACTORS

WELL TYPE	FACTOR
DRAINAGE WELLS	
5F1	1
5D2	1
5D3	2
5D4	3
5G30	1
GEOTHERMAL REINJECTION WELLS	
5A5	3
5A6	3
5A7	1
5A8	3
DOMESTIC WASTEWATER DISPOSAL WELLS	
5W9	3
5W10	1
5W11	2
5W31	2
5W32	1
5W12	1
MINERAL AND FOSSIL FUEL RECOVERY RELATED WELLS	
5X13	3
5X14	2
5X15	2
5X16	2
OIL FIELD PRODUCTION WASTE DISPOSAL WELLS	
5X17	3
5X18	2
INDUSTRIAL/COMMERCIAL/UTILITY DISPOSAL WELLS	
5A19	2
5W20	3
RECHARGE WELLS	
5R21	1
5B22	1
5S23	1
MISCELLANEOUS WELLS	
5N24	4
5X25	3
5X26	1
5X29	3
5X27	3

Appendix F

Design Criteria

Alternative 3 - Site 1 Treatment System (220 gpm Capacity) WASTEWATER TREATMENT EQUIPMENT AND DESIGN CRITERIA	
EQUPMENT ITEM/CRITERIA	**DESIGN VALUE**
Extraction Pumps	
No. of Pumps	32
Type of Pump	Electric, submersible
Capacity/Head	150 feet
Horspower (average)	1/2 hp
Material	Stainless steel
Facility Sump	
Sum pumps	
No. of Pumps	2
Type of Pump	Electric, submersible
Capacity/Head	80 feet
Horspower	1 hp
Material	Ductile Iron
Transfer Pumping	
Pumps	
No. of Pumps	6
Type of Pump	Centrifugal
Capacity/Head	50 feet
Horspower	7.5 hp
Material	Ductile Iron
Equalization	
Tank	
Volume	18,000 gal
Detention Time	1 hour plus backwash storage volume
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horspower	10 hp
Material	Stainless Steel

Rapid Mix Tank	
Tank	
Volume	500 gal.
Detention Time	2 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	3 hp
Material	Stainless Steel
Chemical Feed System	
Chemical	Caustic (NaOH)
Chemical Feed Rate	9.9 gph
Flocculation Tank	
Tank	
Volume	4,000 gal.
Detention Time	15 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	3 hp
Material	Stainless Steel
Chemical Feed System	
Chemical	Polymer
Chemical Feed Rate	0.25 gph

Clarifier	
Tank (Lamella)	
Apparent Diameter	26 feet
Overflow Rate	600 gpd/ft2
Sludge Production	250 lbs/day
Material	Steel
Sludge Pumps	
No. of Pumps	2
Type of Pump	Progressive Cavity
Horsepower	7.5 hp
Material	Stainless Steel
Gravity Filtration	
Filter	
Type of Filter	Pressure
Normal Loading Rate	2 gpm/ft2
pH Adjustment Tank	
Tank	
Volume	4000 gal.
Detention Time	15 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	3 hp
Material	Stainless Steel
Chemical Feed System	
Chemical	Sulfuric acid
Chemical Feed Rate	4.75 gph

Air Stripper	
Type of Stripper	Low Profile (1 4-tray unit)
Air/Water Ratio	74.8
Type of Blower	Centrifugal
Capacity	900 scfm @ 18 in W.C.
Material	cast iron
Sludge Dewatering	
Sludge Storage Tank	
Volume	10000 gal.
Detention Time	30 days of storage
Material	FRP
Plate and Frame Press	
Press Capacity	1 ft3
Cycles Per Day	1
UV/H2O2 Oxidation	
H2O2 Usage Rate	75 ppm, 50% solution, 20.5 gpd
Power Requirement	60 kW
Building for Equipment	
Area for 110 ft x 120 ft building	13,200 ft2
Building material	Pre-engineered, metal panel
Chemical Storage Tanks	
Caustic Storage Tank	
Material	Carbon Steel
Size	12,000 gal.
Sulfuric Acid Storage Tank	
Material	Carbon Steel
Size	8,000 gal.

Alternative 3 - Site 1 Treatment System (270 gpm Capacity) WASTEWATER TREATMENT EQUIPMENT AND DESIGN CRITERIA	
EQUPMENT ITEM/CRITERIA	**DESIGN VALUE**
Extraction Pumps	
No. of Pumps	37
Type of Pump	Electric, submersible
Capacity/Head	150 feet
Horspower (average)	1/2 hp
Material	Stainless steel
Facility Sump	
Sump pumps	
No. of Pumps	2
Type of Pump	Electric, submersible
Capacity/Head	80 feet
Horspower	1.5 hp
Material	Ductile Iron
Transfer Pumping	
Pumps	
No. of Pumps	6
Type of Pump	Centrifugal
Capacity/Head	50 feet
Horspower	7.5 hp
Material	Ductile Iron
Equalization	
Tank	
Volume	22,000 gal
Detention Time	1 hour plus backwash storage volume
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horspower	15 hp
Material	Stainless Steel

Rapid Mix Tank	
Tank	
Volume	500 gal.
Detention Time	2 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	3 hp
Material	Stainless Steel
Chemical Feed System	
Chemical	Caustic (NaOH)
Chemical Feed Rate	12 gph
Flocculation Tank	
Tank	
Volume	4,000 gal.
Detention Time	15 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	3 hp
Material	Stainless Steel
Chemical Feed System	
Chemical	Polymer
Chemical Feed Rate	0.35 gph

Clarifier	
Tank (Lamella)	
Apparent Diameter	26 feet
Overflow Rate	600 gpd/ft2
Sludge Production	250 lbs/day
Material	Steel
Sludge Pumps	
No. of Pumps	2
Type of Pump	Progressive Cavity
Horsepower	7.5 hp
Material	Stainless Steel
Gravity Filtration	
Filter	
Type of Filter	Pressure
Normal Loading Rate	2 gpm/ft2
pH Adjustment Tank	
Tank	
Volume	4000 gal.
Detention Time	15 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	3 hp
Material	Stainless Steel
Chemical Feed System	
Chemical	Sulfuric acid
Chemical Feed Rate	6.63 gph

Air Stripper	
Type of Stripper	Low Profile (1 4-tray unit)
Air/Water Ratio	74.8
Type of Blower	Centrifugal
Capacity	900 scfm @ 18 in W.C.
Material	cast iron
Sludge Dewatering	
Sludge Storage Tank	
Volume	12500 gal.
Detention Time	30 days of storage
Material	FRP
Plate and Frame Press	
Press Capacity	1 ft3
Cycles Per Day	1
UV/H2O2 Oxidation	
H2O2 Usage Rate	75 ppm, 50% solution, 29.7 gpd
Power Requirement	90 kW
Building for Equipment	
Area for 115 ft x 130 ft building	14950 ft2
Building material	Pre-engineered, metal panel
Chemical Storage Tanks	
Caustic Storage Tank	
Material	Carbon Steel
Size	12,000 gal.
Sulfuric Acid Storage Tank	
Material	Carbon Steel
Size	8,000 gal.

Alternative 4 - Site 10 Air Stripping Treatment System WASTEWATER TREATMENT EQUIPMENT AND DESIGN CRITERIA	
EQUPMENT ITEM/CRITERIA	**DESIGN VALUE**
Extraction Pumps	
No. of Pumps	5
Type of Pump	Electric, submersible
Capacity/Head	84 feet
Horspower	1.5 hp
Material	Stainless steel
Facility Sump	
Sum pumps	
No. of Pumps	1
Type of Pump	Electric, submersible
Capacity/Head	50 feet
Horspower	0.5 hp
Material	Ductile Iron
Transfer Pumping	
Pumps	
No. of Pumps	1
Type of Pump	Centrifugal
Capacity/Head	50 feet
Horspower	3 hp
Material	Ductile Iron
Holding Tank	
Tank	
Volume	5000 gal.
Detention Time	1 hour
Material	FRP
Sequestration Tank	
Tank	
Volume	1000 gal.
Storage	10 months
Material	Stainless steel

Alternative 4 - Site 10 Air Stripping Treatment System WASTEWATER TREATMENT EQUIPMENT AND DESIGN CRITERIA	
EQUPMENT ITEM/CRITERIA	**DESIGN VALUE**
Mixer	
No. of Mixers	1
Type of Mixer	Inline static
Material	Stainless Steel
Chemical Feed System	
Chemical	Sequestering agent
Chemical Feed Rate	0.13 gph
Air Stripper	
Type of Stripper	Low Profile (1 4-tray unit)
Air/Water Ratio	59.8
Stripper Blower	
Type of Blower	centrifugal
Capacity	600 scfm @ 20 in W.C.
Horsepower	10 hp
Material	Cast iron
Building for Equipment	
Area for 22 ft x 32 ft building	704 ft2
Building materials	Pre-engineered metal panel

Alternative 8 - Site 10 Air Stripping Treatment System WASTEWATER TREATMENT EQUIPMENT AND DESIGN CRITERIA	
EQUPMENT ITEM/CRITERIA	**DESIGN VALUE**
Extraction Pumps	
No. of Pumps	2
Type of Pump	Electric, submersible
Capacity/Head	84 feet
Horspower	1.5 hp
Material	Stainless steel
Facility Sump	
Sum pumps	
No. of Pumps	1
Type of Pump	Electric, submersible
Capacity/Head	50 feet
Horspower	0.5 hp
Material	Ductile Iron
Transfer Pumping	
Pumps	
No. of Pumps	1
Type of Pump	Centrifugal
Capacity/Head	50 feet
Horspower	1.5 hp
Material	Ductile Iron
Holding Tank	
Tank	
Volume	2000 gal.
Detention Time	1 hour
Material	FRP
Sequestration Tank	
Tank	
Volume	250 gal.
Storage	6 months
Material	Stainless steel

Alternative 8 - Site 10 Air Stripping Treatment System WASTEWATER TREATMENT EQUIPMENT AND DESIGN CRITERIA	
EQUPMENT ITEM/CRITERIA	**DESIGN VALUE**
Mixer	
No. of Mixers	1
Type of Mixer	Inline static
Material	Stainless Steel
Chemical Feed System	
Chemical	Sequestering agent
Chemical Feed Rate	0.10 gph
Air Stripper	
Type of Stripper	Low Profile (1 3-tray unit)
Air/Water Ratio	74.8
Stripper Blower	
Type of Blower	centrifugal
Capacity	300 scfm @ 12 in W.C.
Horsepower	5 hp
Material	Cast iron
Building for Equipment	
Area for 16 ft x 24 ft building	384 ft2
Building materials	Pre-engineered metal panel

Appendix G

Remedial Alternative Cost Estimates

Table 1

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 2 - Institutional Controls and Natural Attenuation
DESCRIPTION: Groundwater Monitoring

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Groundwater Use Restrictions	1	LS	$50,000.00					$50,000
GRAND TOTAL - CAPITAL								$50,000
Annual Expenses - Field Work								
2 Technicians @ 40h/yr/ea	80	HR	$60.00	$4,800	$960	$0	$864	$6,624
Lab. analysis (EPA method 8240)	10	EA	$150.00	$1,500	$300	$0	$270	$2,070
Per diem	8	EA	$70.00	$560	$112	$0	$101	$773
FEDEX ice chest	4	EA	$80.00	$320	$64	$0	$58	$442
Gas mileage	450	MI	$0.32	$144	$29	$0	$26	$199
Pump rental	1	LS	$200.00	$200	$40	$0	$36	$276
Truck rental	5	DAYS	$65.00	$325	$65	$0	$59	$449
Annual Expenses - Office Preparation								
Project Manager	20	HR	$90.00	$1,800	$360	$0	$0	$2,160
Staff scientist	80	HR	$75.00	$6,000	$1,200	$0	$0	$7,200
Cadd technician	16	HR	$60.00	$960	$192	$0	$0	$1,152
Technical support staff	8	HR	$48.00	$384	$77	$0	$0	$461
Senior scientist	20	HR	$130.00	$2,600	$520	$0	$0	$3,120
Reprographics	1,000	SHTS	$0.05	$50	$10	$0	$9	$69
FEDEX	6	EA	$12.00	$72	$14	$0	$13	$99
GRAND TOTAL - ANNUAL								$25,000

PRESENT WORTH =	$400,000

Table 2a

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 3 - Sitewide Extraction and Treatment at Site 1
DESCRIPTION: **220gpm** Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
GROUNDWATER TREATMENT								
GROUNDWATER TREATMENT PLANT								
Sump Pumps								
Pumps	2	EA	$600.00	$1,200	$240	$72	$227	$1,739
Transfer Pumps								
Pumps (7.5 hp)	6	EA	$2,765.00	$16,590	$3,318	$995	$3,136	$24,039
Equalization								
Tank (18,000 gal.)	1	EA	$22,600.00	$22,600	$4,520	$1,356	$4,271	$32,747
Mixer	1	EA	$12,250.00	$12,250	$2,450	$735	$2,315	$17,750
Rapid Mix								
Tank (FRP)	1	EA	$3,150.00	$3,150	$630	$189	$595	$4,564
Mixer (3 hp)	1	EA	$5,730.00	$5,730	$1,146	$344	$1,083	$8,303
Caustic Feed System	1	EA	$7,200.00	$7,200	$1,440	$432	$1,361	$10,433
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$2,630.00	$2,630	$526	$158	$497	$3,811
Flocculation								
Tank (4,000 gal.)	1	EA	$6,300.00	$6,300	$1,260	$378	$1,191	$9,129
Mixer (3 hp)	1	EA	$5,730.00	$5,730	$1,146	$344	$1,083	$8,303
Polymer Feed System	1	EA	$8,400.00	$8,400	$1,680	$504	$1,588	$12,172
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$2,630.00	$2,630	$526	$158	$497	$3,811
Clarifier								
Clarifier w/platform	1	EA	$84,000.00	$84,000	$16,800	$5,040	$15,876	$121,716
Sludge Pumps	2	EA	$12,950.00	$25,900	$5,180	$1,554	$4,895	$37,529
Filtration								
Pressure Filter	1	EA	$126,000.00	$126,000	$25,200	$7,560	$23,814	$182,574
UV Oxidation								
60 kW Unit	1	EA	$180,000.00	$180,000	$36,000	$10,800	$34,020	$260 820
Air Stripper								
Low profile air stripper	1	EA	$56,000.00	$56,000	$11,200	$3,360	$10,584	$81,144
PH adjustment tank								
Tank (4,000 gal.)	1	EA	$6,300.00	$6,300	$1,260	$378	$1,191	$9,129
Mixer (3 hp)	1	EA	$5,730.00	$5,730	$1,146	$344	$1,083	$8,303
Sulfuric acid feed system	1	EA	$7,200.00	$7,200	$1,440	$432	$1,361	$10,433
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$2,630.00	$2,630	$526	$158	$497	$3,811

Table 2b

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 3 - Sitewide Extraction and Treatment at Site 1
DESCRIPTION: **275gpm** Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
GROUNDWATER TREATMENT								
GROUNDWATER TREATMENT PLANT								
Sump Pumps								
Pumps	2	EA	$600.00	$1,200	$240	$72	$227	$1,739
Transfer Pumps								
Pumps (7.5 hp)	6	EA	$2,765.00	$16,590	$3,318	$995	$3,136	$24,039
Equalization								
Tank (22,000 gal.)	1	EA	$26,450.00	$26,450	$5,290	$1,587	$4,999	$38,326
Mixer	1	EA	$15,100.00	$15,100	$3,020	$906	$2,854	$21,880
Rapid Mix								
Tank (FRP)	1	EA	$3,150.00	$3,150	$630	$189	$595	$4,564
Mixer (3 hp)	1	EA	$5,730.00	$5,730	$1,146	$344	$1,083	$8,303
Caustic Feed System	1	EA	$7,200.00	$7,200	$1,440	$432	$1,361	$10,433
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$2,630.00	$2,630	$526	$158	$497	$3,811
Flocculation								
Tank (4,000 gal.)	1	EA	$6,300.00	$6,300	$1,260	$378	$1,191	$9,129
Mixer (3 hp)	1	EA	$5,730.00	$5,730	$1,146	$344	$1,083	$8,303
Polymer Feed System	1	EA	$8,400.00	$8,400	$1,680	$504	$1,588	$12,172
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$2,630.00	$2,630	$526	$158	$497	$3,811
Clarifier								
Clarifier w/platform	1	EA	$84,000.00	$84,000	$16,800	$5,040	$15,876	$121,716
Sludge Pumps	2	EA	$12,950.00	$25,900	$5,180	$1,554	$4,895	$37,529
Filtration								
Pressure Filter	1	EA	$151,000.00	$151,000	$30,200	$9,060	$28,539	$218,799
UV Oxidation								
60 kW Unit	1	EA	$180,000.00	$180,000	$36,000	$10,800	$34,020	$260,820
Air Stripper								
Low profile air stripper	1	EA	$84,000.00	$84,000	$16,800	$5,040	$15,876	$121,716
PH adjustment tank								
Tank (4,000 gal.)	1	EA	$6,300.00	$6,300	$1,260	$378	$1,191	$9,129
Mixer (3 hp)	1	EA	$5,730.00	$5,730	$1,146	$344	$1,083	$8,303
Sulfuric acid feed system	1	EA	$7,200.00	$7,200	$1,440	$432	$1,361	$10,433
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$2,630.00	$2,630	$526	$158	$497	$3,811

Table 2b

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 3 - Sitewide Extraction and Treatment at Site 1
DESCRIPTION: **275gpm** Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Sludge Dewatering								
Sludge storage tank	1	EA	$22,050.00	$22,050	$4,410	$1,323	$4,167	$31,950
Plate and frame filter press	1	EA	$123,000.00	$123,000	$24,600	$7,380	$23,247	$178,227
Platform	1	EA	$7,200.00	$7,200	$1,440	$432	$1,361	$10,433
Chemical Storage								
Caustic storage tank	1	EA	$13,350.00	$13,350	$2,670	$801	$2,523	$19,344
Sulfuric acid storage tank	1	EA	$6,700.00	$6,700	$1,340	$402	$1,266	$9,708
Peroxide storage tank	1	EA	$7,500.00	$7,500	$1,500	$450	$1,418	$10,868
Building (110'X130')								
Structure	14,950	SF	$40.00	$598,000	$119,600	$35,880	$113,022	$866,502
HVAC	14,950	SF	$16.00	$239,200	$47,840	$14,352	$45,209	$346,601
Site 10 Discharge Pipe								
Double-walled pipe	1,600	LF	$20.00	$32,000	$6,400	$1,920	$6,048	$46,368
Leak Detection System	1,600	LF	$10.00	$16,000	$3,200	$960	$3,024	$23,184
Concrete Slab								
Slab concrete	280	CY	$190.00	$53,200	$10,640	$3,192	$10,055	$77,087
Granular Fill	280	CY	$30.00	$8,400	$1,680	$504	$1,588	$12,172
Excavation	560	CY	$10.00	$5,600	$1,120	$336	$1,058	$8,114
Backfill/Compaction	280	CY	$21.00	$5,880	$1,176	$353	$1,111	$8,520
Treatment Plant Subtotal				$1,785,950	$357,190	$107,157	$337,545	$2,587,842
Miscellaneous Metals			1%	$26,656	$5,331	$1,599	$5,038	$38,625
Finishes			2%	$53,312	$10,662	$3,199	$10,076	$77,249
Sitework			5%	$133,280	$26,656	$7,997	$25,190	$193,123
Miscellaneous Structural			5%	$133,280	$26,656	$7,997	$25,190	$193,123
Miscellaneous Mechanical			10%	$266,560	$53,312	$15,994	$50,380	$386,245
Electrical/I&C			10%	$266,560	$53,312	$15,994	$50,380	$386,245
Treatment Plant Total				$2,665,597	$533,119	$159,936	$503,798	$3,862,450
GROUNDWATER EXTRACTION SYSTEM								
Pumps	37	EA	$5,200.00	$192,400	$38,480	$11,544	$36,364	$278,788
Well vaults, prefab concrete	37	EA	$8,300.00	$307,100	$61,420	$18,426	$58,042	$444,988
Down the well piping, SST	3,330	LF	$20.00	$66,600	$13,320	$3,996	$12,587	$96,503
GW Extraction Subtotal				$566,100	$113,220	$33,966	$106,993	$820,279
Miscellaneous Metals			1%	$11,100	$2,220	$666	$2,098	$16,084
Finishes			2%	$22,200	$4,440	$1,332	$4,196	$32,168
Sitework			5%	$55,500	$11,100	$3,330	$10,490	$80,420
Miscellaneous Structural			1%	$11,100	$2,220	$666	$2,098	$16,084

Table 2b

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 3 - Sitewide Extraction and Treatment at Site 1
DESCRIPTION: **275gpm** Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Mechanical/Yard Piping			20%	$222,000	$44,400	$13,320	$41,958	$321,678
Electrical/I&C			20%	$222,000	$44,400	$13,320	$41,958	$321,678
GW Extraction Total				$1,110,000	$222,000	$66,600	$209,790	$1,608,390
SITE TOTAL								$5,500,000
GW Use Restrictions	1	LS						$50,000
GRAND TOTAL - CAPITAL								$5,550,000
Treatment Plant Annual Expenses								
Sludge disposal	50	TON	$300.00	$15,000	$3,000	$0	$2,700	$20,700
Miscellaneous electrical (110 kW)	930,000	Kwh	$0.05	$46,500	$9,300	$0	$8,370	$64,170
Chemical Costs								
NaOH (25%)	104,000	Gal	$0.56	$58,240	$11,648	$0	$10,483	$80,371
H2SO4 (93%)	58,000	Gal	$0.53	$30,740	$6,148	$0	$5,533	$42,421
Polymer	2,750	Gal	$13.50	$37,125	$7,425	$0	$6,683	$51,233
Peroxide (50%)	9,375	Gal	$4.73	~~$44,344~~	$8,869	$0	~~$7,982~~	~~$61,194~~
Labor	832	HR	$25.00	$20,800	$4,160	$0	$3,744	$28,704
Extraction System Annual Expenses								
Miscellaneous electrical	190,000	Kwh	$0.05	$9,500	$1,900	$0	$1,710	~~$13,110~~
Monitoring/Analyses	4	#/yr	$15,000.00	$60,000	$12,000	$0	$10,800	$82,800
O&M /System Evaluation Labor	360	HR	$25.00	$9,000	$1,800	$0	$1,620	$12,420
GRAND TOTAL - ANNUAL								$460,000

PRESENT WORTH = $12,600,000

Table 3

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 4 - Sitewide Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer
DESCRIPTION: 75gpm Treatment Plant

GROUNDWATER TREATMENT

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
GROUNDWATER TREATMENT PLANT								
Process Equipment and Control								
Sump pump	1	EA	$450.00	$450	$90	$27	$85	$652
Transfer pump (3 hp)	1	EA	$2,352.00	$2,352	$470	$141	$445	$3,408
Chemical feed pump	1	EA	$2,800.00	$2,800	$560	$168	$529	$4,057
Air Stipper (600 scfm blower)	1	EA	$25,000.00	$25,000	$5,000	$1,500	$4,725	$36,225
Static mixer	1	EA	$3,220.00	$3,220	$644	$193	$609	$4,666
Sequestering Tank (1,000gal SS)	1	EA	$5,610.00	$5,610	$1,122	$337	$1,060	$8,129
Holding Tank (5,000gal fiberglass)	1	EA	$8,810.00	$8,810	$1,762	$529	$1,665	$12,766
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$6,500.00	$6,500	$1,300	$390	$1,229	$9,419
Magmeter	1	EA	$5,510.00	$5,510	$1,102	$331	$1,041	$7,984
Autodialer w/remote monitoring	1	EA	$3,335.00	$3,335	$667	$200	$630	$4,832
Control panel	1	EA	$9,570.00	$9,570	$1,914	$574	$1,809	$13,867
Motor control center (MCC)	1	EA	$40,600.00	$40,600	$8,120	$2,436	$7,673	$58,829
Storm Sewer Extension								
Manhole	2	EA	$1,200.00	$2,400	$480	$144	$454	$3,478
Concrete pipe (12")	160	LF	$8.60	$1,376	$275	$83	$260	$1,994
Building (22'X32')								
Structure	704	SF	$45.00	$31,680	$6,336	$1,901	$5,988	$45,904
Heating/ventilation	704	SF	$12.00	$8,448	$1,690	$507	$1,597	$12,241
Concrete Slab								
Slab concrete	51	CY	$190.00	$9,690	$1,938	$581	$1,831	$14,041
Granular Fill	35	CY	$30.00	$1,050	$210	$63	$198	$1,521
Excavation	156	CY	$10.00	$1,560	$312	$94	$295	$2,260
Backfill/Compaction	105	CY	$21.00	$2,205	$441	$132	$417	$3,195
Treatment Plant Subtotal				$172,166	$34,433	$10,330	$32,539	$249,469
Miscellaneous Metals			2%	$6,752	$1,350	$405	$1,276	$9,783
Finishes			2%	$6,752	$1,350	$405	$1,276	$9,783
Sitework			5%	$16,879	$3,376	$1,013	$3,190	$24,458
Miscellaneous Structural			3%	$10,127	$2,025	$608	$1,914	$14,675
Miscellaneous Mechanical			12%	$40,510	$8,102	$2,431	$7,656	$58,698
Electrical/I&C			25%	$84,395	$16,879	$5,064	$15,951	$122,288
Treatment Plant Total				$337,580	$67,516	$20,255	$63,803	$489,154
GROUNDWATER EXTRACTION SYSTEM								
Extraction well pump (1/2 hp)	5	EA	$3,600.00	$18,000	$3,600	$1,080	$3,402	$26,082
Turbine flow meter	5	EA	$1,792.00	$8,960	$1,792	$538	$1,693	$12,983

Table 3

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 4 - Sitewide Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer
DESCRIPTION: 75gpm Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.0%	MOB/DEMOB/INS 6.00%	OH&P 15.0%	TOTAL
Well vaults, prefab concrete	5	EA	$8,300.00	$41,500	$8,300	$2,490	$7,844	$60,134
Down the well piping, SST	150	LF	$20.00	$3,000	$600	$180	$567	$4,347
GW Extraction Subtotal				$71,460	$14,292	$4,288	$13,506	$103,546
Miscellaneous Metals			2%	$3,176	$635	$191	$600	$4,602
Finishes			2%	$3,176	$635	$191	$600	$4,602
Sitework			5%	$7,940	$1,588	$476	$1,501	$11,505
Miscellaneous Structural			1%	$1,588	$318	$95	$300	$2,301
Mechanical/Yard Piping			20%	$31,760	$6,352	$1,906	$6,003	$46,020
Electrical/I&C			25%	$39,700	$7,940	$2,382	$7,503	$57,525
GW Extraction Total				$158,800	$31,760	$9,528	$30,013	$230,101
SITE TOTAL								$719,255
Deed Restrictions								$50,000
GRAND TOTAL - CAPITAL								$770,000
Treatment Plant Annual Expenses								
Monthly inf/eff sampling	1	LS	$4,000.00	$4,000	$800	$0	$720	$5,520
Quarterly storm pipe sampling	1	LS	$2,400.00	$2,400	$480	$0	$432	$3,312
Quarterly GW sampling	1	LS	$10,600.00	$10,600	$2,120	$0	$1,908	$14,628
Flow rate/water level monitoring	1	LS	$8,600.00	$8,600	$1,720	$0	$1,548	$11,868
Sequestering Agent	1,110	Gal	$16.00	$17,760	$3,552	$0	$3,197	$24,509
Small tools/consumables	1	LS	$1,000.00	$1,000	$200	$0	$180	$1,380
Labor	312	HR	$65.00	$20,280	$4,056	$0	$3,650	$27,986
Electricity	228,000	kWh	$0.05	$11,400	$2,280	$0	$2,052	$15,732
GRAND TOTAL - ANNUAL								$100,000

PRESENT WORTH = $1,800,000

Table 4

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 8 - Focused Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer
DESCRIPTION: 30gpm Treatment Plant

DESCRIPTION	QTY	UNITS	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
GROUNDWATER TREATMENT								
GROUNDWATER TREATMENT PLANT								
Process Equipment and Control								
Sump pump	1	EA	$450.00	$450	$90	$27	$85	$652
Transfer pump (1.5 hp)	1	EA	$1,810.00	$1,810	$362	$109	$342	$2,623
Chemical feed pump	1	EA	$2,800.00	$2,800	$560	$168	$529	$4,057
Air Stipper (300 scfm blower)	1	EA	$22,400.00	$22,400	$4,480	$1,344	$4,234	$32,458
Static mixer	1	EA	$2,875.00	$2,875	$575	$173	$543	$4,166
Sequestering Tank (1,000gal SS)	1	EA	$1,580.00	$1,580	$316	$95	$299	$2,289
Holding Tank (2,000gal fiberglass)	1	EA	$5,750.00	$5,750	$1,150	$345	$1,087	$8,332
Back pressure valves, pulsation dampers, pressure release valves	1	JOB	$5,600.00	$5,600	$1,120	$336	$1,058	$8,114
Magmeter	1	EA	$5,510.00	$5,510	$1,102	$331	$1,041	$7,984
Autodialer w/remote monitoring	1	EA	$3,335.00	$3,335	$667	$200	$630	$4,832
Control panel	1	EA	$6,380.00	$6,380	$1,276	$383	$1,206	$9,245
Motor control center (MCC)	1	EA	$31,500.00	$31,500	$6,300	$1,890	$5,954	$45,644
Storm Sewer Extension								
Manhole	2	EA	$1,200.00	$2,400	$480	$144	$454	$3,478
Concrete pipe (12")	160	LF	$8.60	$1,376	$275	$83	$260	$1,994
Building (16'X24')								
Structure	384	SF	$45.00	$17,280	$3,456	$1,037	$3,266	$25,039
Heating/ventilation	384	SF	$12.00	$4,608	$922	$276	$871	$6,677
Concrete Slab								
Slab concrete	28	CY	$190.00	$5,320	$1,064	$319	$1,005	$7,709
Granular Fill	19	CY	$30.00	$570	$114	$34	$108	$826
Excavation	86	CY	$10.00	$860	$172	$52	$163	$1,246
Backfill/Compaction	58	CY	$21.00	$1,218	$244	$73	$230	$1,765
Treatment Plant Subtotal				$123,622	$24,724	$7,417	$23,365	$179,128
Miscellaneous Metals			2%	$4,848	$970	$291	$916	$7,025
Finishes			2%	$4,848	$970	$291	$916	$7,025
Sitework			5%	$12,120	$2,424	$727	$2,291	$17,562
Miscellaneous Structural			3%	$7,272	$1,454	$436	$1,374	$10,537
Miscellaneous Mechanical			12%	$29,088	$5,818	$1,745	$5,498	$42,148
Electrncal/I&C			25%	$60,599	$12,120	$3,636	$11,453	$87,808
Treatment Plant Total				$242,396	$48,479	$14,544	$45,813	$351,232

Table 4

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 8 - Focused Groundwater Extraction, Air Stripping, and Discharge to the Storm Sewer
DESCRIPTION: 30gpm Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
GROUNDWATER EXTRACTION SYSTEM								
Extraction well pump (1/2 hp)	2	EA	$3,600.00	$7,200	$1,440	$432	$1,361	$10,433
Turbine flow meter	2	EA	$1,792.00	$3,584	$717	$215	$677	$5,193
Well vaults, prefab concrete	2	EA	$8,300.00	$16,600	$3,320	$996	$3,137	$24,053
Down the well piping, SST	60	LF	$20.00	$1,200	$240	$72	$227	$1,739
GW Extraction Subtotal				$28,584	$5,717	$1,715	$5,402	$41,418
Miscellaneous Metals			2%	$1,906	$381	$114	$360	$2,761
Finishes			2%	$1,906	$381	$114	$360	$2,761
Sitework			5%	$4,764	$953	$286	$900	$6,903
Miscellaneous Structural			1%	$953	$191	$57	$180	$1,381
Mechanical/Yard Piping			25%	$23,820	$4,764	$1,429	$4,502	$34,515
Electrical/I&C			35%	$33,348	$6,670	$2,001	$6,303	$48,321
GW Extraction Total				$95,280	$19,056	$5,717	$18,008	$138,061
SITE TOTAL								$489,293
Deed Restrictions								$50,000
GRAND TOTAL - CAPITAL								$540,000
Treatment Plant Annual Expenses								
Monthly inf/eff sampling	1	LS	$4,000.00	$4,000	$800	$0	$720	$5,520
Quarterly storm pipe sampling	1	LS	$2,400.00	$2,400	$480	$0	$432	$3,312
Quarterly GW sampling	1	LS	$10,600.00	$10,600	$2,120	$0	$1,908	$14,628
Flow rate/water level monitoring	1	LS	$5,200.00	$5,200	$1,040	$0	$936	$7,176
Sequestering Agent	445	Gal	$16.00	$7,120	$1,424	$0	$1,282	$9,826
Small tools/consumables	1	LS	$1,000.00	$1,000	$200	$0	$180	$1,380
Labor	312	HR	$65.00	$20,280	$4,056	$0	$3,650	$27,986
Electricity (20 kwh)	175,000	kWh	$0.05	$8,750	$1,750	$0	$1,575	$12,075
GRAND TOTAL - ANNUAL								$80,000

PRESENT WORTH = $1,400,000

Table 5

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 9 - Focused Extraction and Treatment at Site 1
DESCRIPTION: 220gpm Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 6.00%	OH&R 15.00%	TOTAL
GROUNDWATER TREATMENT								
GROUNDWATER TREATMENT PLANT								
Misc. Electrical								
Modify Control Panel	1	LS	$25,000.00	$25,000	$5,000	$1,500	$4,725	$36,225
Modify MCC	1	LS	$20,000.00	$20,000	$4,000	$1,200	$3,780	$28,980
Leak Detection Control Panel	1	LS	$5,200.00	$5,200	$1,040	$312	$983	$7,535
Treatment Plant Subtotal				$50,200	$10,040	$3,012	$9,488	$72,740
Miscellaneous Metals			2%	$1,969	$394	$118	$372	$2,853
Finishes			2%	$1,969	$394	$118	$372	$2,853
Sitework			5%	$4,922	$984	$295	$930	$7,131
Miscellaneous Structural			0%	$0	$0	$0	$0	$0
Miscellaneous Mechanical			15%	$14,765	$2,953	$886	$2,791	$21,394
Electrical/I&C			25%	$24,608	$4,922	$1,476	$4,651	$35,657
Treatment Plant Total				$98,431	$19,686	$5,906	$18,604	$142,627
GROUNDWATER EXTRACTION SYSTEM								
Site 10 Discharge Pipe								
Double-walled pipe	1,600	LF	$20.00	$32,000	$6,400	$1,920	$6,048	$46,368
Leak Detection System	1,600	LF	$10.00	$16,000	$3,200	$960	$3,024	$23,184
Extraction Wells								
Pumps	2	EA	$5,200.00	$10,400	$2,080	$624	$1,966	$15,070
Well vaults, prefab concrete	2	EA	$8,300.00	$16,600	$3,320	$996	$3,137	$24,053
Turbine flow meter	2	EA	$1,792.00	$3,584	$717	$215	$677	$5,193
Down the well piping, SST	60	LF	$20.00	$1,200	$240	$72	$227	$1,739
GW Extraction Subtotal				$79,784	$15,957	$4,787	$15,079	$115,607
Miscellaneous Metals			1%	$1,564	$313	$94	$296	$2,267
Finishes			2%	$3,129	$626	$188	$591	$4,534
Sitework			5%	$7,822	$1,564	$469	$1,478	$11,334
Miscellaneous Structural			1%	$1,564	$313	$94	$296	$2,267
Mechanical/Yard Piping			20%	$31,288	$6,258	$1,877	$5,913	$45,336
Electrical/I&C			20%	$31,288	$6,258	$1,877	$5,913	$45,336
GW Extraction Total				$156,439	$31,288	$9,386	$29,567	$226,680
SITE TOTAL								$400,000
GW Use Restrictions	1	LS						$50,000
GRAND TOTAL - CAPITAL								$450,000

Table 5

Estimate Summary

PROJECT: ABL
ALTERNATIVE: 9 - Focused Extraction and Treatment at Site 1
DESCRIPTION: 220gpm Treatment Plant

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 0.00%	OH&P 15.00%	TOTAL
Treatment Plant Annual Expenses								
Sludge disposal	2	TON	$300.00	$600	$120	$0	$108	$828
Miscellaneous electrical (100 kW)	10,000	Kwh	$0.05	$500	$100	$0	$90	$690
Chemical Costs								
NaOH (25%)	11,500	Gal	$0.56	$6,440	$1,288	$0	$1,159	$8,887
H2SO4 (93%)	6,180	Gal	$0.53	$3,275	$655	$0	$590	$4,520
Polymer	350	Gal	$13.50	$4,725	$945	$0	$851	$6,521
Peroxide (50%)	1,182	Gal	$4.73	$5,591	$1,118	$0	$1,006	$7,715
Extraction System Annual Expenses								
Miscellaneous electrical	160,000	Kwh	$0.05	$8,000	$1,600	$0	$1,440	$11,040
Quarterly GW sampling	1	LS	$10,600.00	$10,600	$2,120	$0	$1,908	$14,628
O&M /System Evaluation Labor	360	HR	$25.00	$9,000	$1,800	$0	$1,620	$12,420
GRAND TOTAL - ANNUAL								$70,000

PRESENT WORTH = $1;200,000