An Employee-Owned Company

Focused Feasibility Study

Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Focused Feasibility Study
EPA Task Order No. 0028-RI-CO-0117

REMEDIAL ACTION CONTRACT
No. EP-S1-06-03

FOR

U.S. Environmental Protection Agency
Region 1

BY

Nobis Engineering, Inc.

Nobis Project No. 80028

May 2010

U.S. Environmental Protection Agency

Region 1
5 Post Office Square, Suite 100
Boston, Massachusetts 02109-3919

Nobis Engineering, Inc.

Lowell, Massachusetts
Concord, New Hampshire

Phone (800) 394-4182
www.nobisengineering.com

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Peter W. Delano, P.E. Program Manager

Liyang Chu
Project Manager

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ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CD	Consent Decree
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
cm/sec	centimeters per second
COC	Contaminant of Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	Conceptual Site Model
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
DNAPL	Dense non-aqueous phase liquid
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
ERA	ecological risk assessment
ESD	Explanation of Significant Differences
FEMA	Federal Emergency Management Agency
FFS	Focused Feasibility Study
FS	Feasibility Study
ft	feet
gpm	gallons per minute
HHRA	human health risk assessment
HI	Hazard Index
IRIS	Integrated Risk Information System
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCL-SSL	MCL-based Soil Screening Level
MSL	Mean Sea Level
MSW	municipal solid waste

ACRONYMS (cont.)

mg/Kg	milligrams per kilogram
mg/L	milligrams per liter
NAPL	Non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDA	Northern Disposal Area
Nobis	Nobis Engineering, Inc.
NPL	National Priorities List
OU	Operable Unit
ORP	oxidation-reduction potential
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PDEI	Pre-Design Engineering Investigation
PDI	Pre-Design Investigation
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI	Remedial Investigation
RIDEM	Rhode Island Department of Environmental Management
RIDEM GA	RIDEM GA Groundwater Objectives
RIDEM GA-LC	RIDEM GA Leachability Criteria
RI/FS	Remedial Investigation/Feasibility Study
Risk-SSL	Risk-based Soil Screening Level
RME	reasonable maximum exposure
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SDA	Southern Disposal Area
SVOC	semi-volatile organic compound
Site	Davis Liquid Waste Superfund Site

ACRONYMS (cont.)

SP	Settling Party
TBC	To-Be-Considered
TCLP	Toxicity Characteristic Leaching Protocol
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
TCE	trichloroethene
µg/L	microgram per liter
µg/Kg	microgram per kilogram
VI	vapor intrusion
VOC	volatile organic compound

ES EXECUTIVE SUMMARY

This Focused Feasibility Study (FFS) report was prepared to address the remaining contamination at the Davis Liquid Waste Superfund Site (Site) located in Smithfield, Rhode Island. This FFS developed and evaluated a range of remedial alternatives for contaminated groundwater to manage the health risks associated with potential exposure to contaminants present in the overburden and bedrock plumes. Using criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a remedy will be selected and documented in a Record of Decision (ROD) Amendment.

a. Site History and Background

The Davis Liquid Waste Superfund Site is situated on approximately 10 to 15 acres in Smithfield, approximately 6 miles northwest of Providence. The Site is bounded on the east and west by forested uplands, and on the north and south by wetlands and Nipsachuck Swamp and Latham Brook (Figure 1-1). In the Site's vicinity, the land use is mostly semi-rural with low-density residential dwellings. The Site consists of mostly undeveloped land vegetated by shrubs, trees, and wetland plants. The former Source Area is the area where past disposal and releases of hazardous substances occurred, and is approximated by the excavation footprint of the 1999 source control component of the Remedial Action (Figure 1-6).

The Site was reportedly used for a 5-year period in the 1960s and early 1970s for the disposal of municipal solid wastes by the Town of Smithfield. Between 1976 and 1977, the owner, William Davis, used the Site to dispose of a variety of liquid and solid wastes containing hazardous substances.

Wastes were directly discharged from tank trucks into unlined lagoons and seepage pits. Drums containing chemicals and laboratory containers were buried onsite or were crushed. The 1986 Remedial Investigation (RI) determined that the uncontrolled release of chemicals at the Site caused soil in the disposal areas to become heavily contaminated by volatile organic compounds (VOCs) including tetrachloroethene (PCE), trichloroethene (TCE), ethylbenzene, benzene, toluene, and xylene. Other contaminants identified included semi-volatile organic compounds (SVOCs), metals, polychlorinated biphenyls, and pesticides. Wastes disposed at the Site allowed chemical contaminants (including PCE, TCE, chloroform, and benzene) to

migrate and enter into groundwater, and into surface water and sediments in the adjacent wetlands. Twenty-three nearby private drinking water wells were found to be contaminated.

The 1987 ROD specified the Remedial Action for the Site:

- design and installation of a new water supply system (Operable Unit 1 [OU1]),
- installation of a groundwater extraction and treatment system and soil flushing system that addressed contaminated groundwater and contaminated saturated soil (OU2), and
- excavation and on-site thermal treatment (incineration) of raw waste and contaminated unsaturated soil (OU3), with a cleanup goal of 2 mg/Kg of total VOCs in soil, and disposal of hazardous residuals in an on-site hazardous waste landfill.

Based on new performance data, the source control component of the Remedial Action was modified under the 1996 Explanation of Significant Differences (ESD) from on-site incineration to on-site low-temperature thermal desorption because of lowered costs and comparable levels of protection.

From 1994 through 2001, several components of the ROD cleanup were completed. In 1997, a new water supply system was installed and residential properties with contaminated wells were connected to the water line (OU1). Between 1999 and 2001, approximately 20,000 tons of contaminated soil, wastes, and debris were removed and disposed offsite. Approximately 78,000 tons of contaminated soil were excavated, treated, and backfilled at the Site (OU3). The disturbed areas were revegetated and over 300 trees were planted to help stabilize the Site and restore habitat value.

Between 1991 and 2008, additional hydrogeologic and groundwater investigations were conducted by the Settling Parties to develop information on how best to implement the groundwater cleanup (OU2) called for in the ROD.

b. Geology, Hydrogeology, and Groundwater Use

The overburden subsurface lithology of the Site consists primarily of sandy ground moraine deposits (Pleistocene-Wisconsin in age) and local swamp deposits. Ground moraine deposits generally consist of an upper till layer consisting of loose medium to coarse sands, and a lower till of compacted clayey sands. Thickness of the overburden deposits is highly variable across the Site, and range from 8 to 37 feet.

The overburden materials at the Site are primarily underlain by two bedrock formations: Nipsachuck Gneiss and Absalona. An intrusive diorite dike (Triassic in age), trending north-south and extending north to Log Road was identified during previous investigations. Depth to bedrock is highly variable across the Site, ranging from 8 to 37 feet below ground surface.

Overburden groundwater flow originating from upland areas in the west, south, and southeast converges towards the central portions of the Site (abutting Nipsachuck Swamp) before discharging through the area where Latham Brook exits the Site (Figure 1-4). Groundwater flow within the bedrock mimics overburden flow as it converges towards the wetlands and central portions of the basin from the surrounding uplands (Figure 1-5). Bedrock groundwater flow is predominately from the southern and western upland areas towards the east in a direction perpendicular to the diorite dike area.

Groundwater underlying the Site and adjacent areas is classified as GA by the Rhode Island Department of Environmental Management (RIDEM), which is suitable as a potable supply. Currently, groundwater underlying the Site is not used as a potable supply. There are no known water supply wells installed in the overburden and bedrock groundwater plumes.

c. Nature and Extent of Contamination

Evaluation of soil and groundwater data acquired from past and current investigations determined that contaminated soil at the former Source Area is a continuing source of groundwater contamination (Figure 1-6). Both overburden and bedrock groundwater have been contaminated by VOCs, SVOCs, pesticides, and metals, at concentrations that exceed drinking water standards or State GA aquifer quality standards.

Soil - Contaminated soil previously treated using low-temperature thermal desorption and backfilled within the footprint of the former Source Area met the ROD's 2 mg/Kg remediation goal for VOCs. However, more recent analysis of Site soil indicates the treated backfill may contain residual VOCs that can leach into and contaminate the underlying groundwater.

Saturated (below water table) unexcavated soil located beneath the footprint of the former Source Area contains VOCs (PCE, TCE, vinyl chloride, cis-1,2-dichlororethene [cis-1,2-DCE], and 1,2-DCA) at concentrations that can degrade groundwater quality. For the FFS, this contaminated soil is considered to be the core of the overburden plume as it resides below the water table.

Groundwater - Contaminated overburden groundwater, with VOCs, SVOCs, pesticides, and metals exceeding drinking water standards (Federal Maximum Contaminant Levels [MCLs]) or State groundwater quality standards (RIDEM GA Objectives), extend approximately 1,100 feet downgradient (north, northeast) of the former Source Area (Figure 1-9 of FFS). Five VOCs (PCE, TCE, cis-1,2-DCE, vinyl chloride, and 1,1-DCA), comprise the primary contaminants of concern (COCs). One SVOC (bis-2(chloroethyl)ether [BCEE]), one pesticide (aldrin), and two metals (arsenic and manganese) are also COCs.

Contaminated bedrock groundwater, with VOCs exceeding MCLs or RIDEM GA Objectives extend approximately 1,700 feet downgradient (north) of the former Source Area (Figure 1-10 of FFS). Six VOCs (PCE, TCE, cis-1,2-DCE, vinyl chloride, 1,1-DCA, and benzene) comprise the primary contaminants of concern. One SVOC (bis-2(chloroethyl)ether [BCEE], one pesticide (dieldrin), and two metals (arsenic and manganese) are also COCs.

Reductive Dechlorination - The 2008 groundwater VOC and geochemistry data were evaluated to assess the potential for reductive dechlorination. Current subsurface conditions indicate a strongly reducing subsurface environment. Natural attenuation in the overburden and bedrock groundwater appears to be robust in the former Source Area and downgradient to OW-043 and OW-007, respectively (Figure 1-15 and Figure 1-16). The PCE and TCE extent in groundwater exceeding MCLs approximates this zone of reductive dechlorination. The natural attenuation screening results suggest that subsurface conditions are conducive for the reductive dechlorination of highly chlorinated VOCs such as PCE, TCE, and a lesser extent, cis-1,2-DCE. However, outside these zones of reductive dechlorination, anaerobic degradation of cis-1,2-

DCE to vinyl chloride or of vinyl chloride to ethene is likely very slow or nonexistent, and further degradation of cis-1,2-DCE and vinyl chloride appear to have stalled. The absence of electron donors is likely the reason for the cessation of reductive dechlorination in the downgradient portion of the plumes.

d. Threats to Human Health

Risk evaluations based on potential groundwater use for drinking water were prepared to identify potential COCs. The evaluations are summarized below:

Overburden Groundwater – The cancer risk estimate and non-cancer total Hazard Index (HI) for residents exposed to overburden groundwater as drinking water, based on the 2008 groundwater sampling data, are 1.1 E-02 and 27, respectively. Vinyl chloride, PCE, TCE, ethylbenzene, and 1,1-DCA are the greatest contributors to cancer risks while vinyl chloride and cis-1,2-DCE are the greatest contributors to the total Site HI. VOC COCs for overburden groundwater that pose potential risk and exceed MCLs or the RIDEM GA Objectives include: vinyl chloride, PCE, TCE, 1,1-DCA, and cis-1,2-DCE. Ethylbenzene concentrations are below the MCL and is not included as a contaminant of concern.

Bedrock Groundwater - Using the 2008 groundwater sampling data, the cancer risk estimate and non-cancer total HI for residents exposed to bedrock groundwater as drinking water are 8.2 E-03 and 54, respectively. Vinyl chloride, carbon tetrachloride, PCE, TCE, 1,1-DCA, ethylbenzene, benzene, and 1,1,2-TCA are the greatest contributors to cancer risks while Cis-1,2-DCE, carbon tetrachloride, and vinyl chloride are the greatest contributors to the total Site HI. VOC COCs for bedrock groundwater that pose potential risk and exceed MCLs include vinyl chloride, PCE, TCE, 1,1-DCA, and benzene. The other VOCs that were identified as primary risk contributors were eliminated as potential contaminants of concern because they were infrequently detected.

e. Threats to the Environment

The 2008 surface water results suggest that groundwater may be discharging to surface water closer to (or perhaps adjacent to) the wetland area that feeds into the stream where the surface water samples were collected. If groundwater from the former Source Area is discharging into

the adjacent wetlands, it is possible that sediments may also be contaminated. During the pre-design investigation to implement the selected groundwater remedy, additional sampling of surface water and sediment in the vicinity of the former Source Area should be performed and the data evaluated to assess potential threats to environmental receptors and possibly to human health.

f. Remedial Action Objectives (RAOs)

Saturated soil underlying the former Source Area has been determined to be a continuing source of VOCs and degrading groundwater quality. The contaminated saturated soil is considered as part of the groundwater plume core, and will be addressed as part of the groundwater remedy.

Based on the risk evaluations and the anticipated future use of the Site and surrounding parcels, the following groundwater RAOs were developed:

Protection of Human Health Groundwater RAOs

- Prevent exposure to groundwater with contaminant concentrations that exceed MCLs, non-zero MCLGs, the RIDEM GA Objective, or pose excess cancer risk of 1E-06 or a non-carcinogenic risk exceeding an HI of 1.0.

- Restore groundwater quality to below MCLs, non-zero MCLGs, the RIDEM GA Objective, or chemical concentrations that result in excess cancer risk of 1E-06 or less, or a non-carcinogenic HI of 1.0 or less.

Protection of the Environment Groundwater RAO

- Prevent the further migration of contaminants beyond their current extent.

Preliminary Remediation Goals

Preliminary Remediation Goals (PRGs) selected for the potential COCs are summarized in the following table.

Groundwater PRG Levels			
Chemical	**PRG**	**Chemical**	**PRG**
1,1-dichloroethane	6 µg/L	Bis(2-chloroethyl)ether	0.03 µg/L
Benzene	2 µg/L	Aldrin	0.002 µg/L
Cis-1,2-dichloroethene	70 µg/L	Dieldrin	0.002 µg/L
Tetrachloroethene	5 µg/L	Arsenic	10 µg/L
Trichloroethene	5 µg/L	Manganese	190 µg/L
Vinyl chloride	2 µg/L		

For this FFS, VOC COCs were evaluated in the technology screening and alternatives development stages because they represented the majority of cancer risks in the overburden (99%) and bedrock (86%) aquifers. BCEE and the two pesticides were infrequently detected in both plumes and pose relatively low risk. BCEE and pesticide concentrations will decline through natural attenuation processes. Elevated arsenic and manganese concentrations are the result of the ongoing reductive dechlorination of chlorinated VOCs; once aquifer geochemical conditions return to normal, these metal concentrations will decline. Therefore, the technology screening and alternatives development will not specifically address SVOCs, pesticides, or metals.

g. Remedial Alternatives

Potentially viable remedial technologies and process options for VOCs that are COCs were identified and screened according to their applicability to the groundwater contaminants and subsurface conditions, and consideration of their technical and institutional implementability.

The candidate remedial technologies were assembled into an array of remedial alternatives that address the RAOs. Six groundwater remedial alternatives were developed and are summarized below:

1. **<u>Alternative GW1</u> – No Action**

   Alternative GW1, the No Action alternative is a baseline with which to compare the other alternatives.

2. **<u>Alternative GW2</u> – Limited Action - Institutional Controls, Monitored Natural Attenuation, Long-Term Monitoring, and Five-Year Reviews**

   Alternative GW2 was developed as an alternative that involves no treatment, but provides protection of human health by preventing or controlling potential exposures to contaminated groundwater through limited actions such as institutional controls and monitored natural attenuation. GW2 includes:

   - <u>Institutional controls</u> - Use restrictions will prohibit use of contaminated groundwater.

   - <u>Natural Attenuation</u> – VOCs and other contaminants (SVOCs and metals) in groundwater will gradually diminish over time as the result of natural ongoing biological, abiotic, and geochemical processes. The contaminants in groundwater will require a long time to diminish to below drinking water standards.

   - <u>Long-term Monitoring</u> – Monitoring of groundwater, surface water, and sediment will be performed to: verify that natural attenuation of contaminants is progressing, evaluate groundwater contaminant plume migration, and assess whether any habitable structures may be subject to vapor intrusion.

   - <u>Five-Year Reviews</u> – Because contaminants will be left in place, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires a review of site conditions every 5 years to assess the protectiveness of this alternative.

3. **<u>Alternative GW3A</u> - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews**

Alternative GW3A uses active treatment of contaminated saturated soil in the former Source Area (plume core) and monitored natural attenuation of the overburden and bedrock plumes. Available data indicate that PCE and TCE are already undergoing natural active reductive dechlorination processes. GW3A consists of the following:

- <u>In-Situ Chemical Treatment</u> – The representative chemical reducing agent and electron donor consists or very fine, pure, iron filings (called Zero Valent Iron [ZVI]) in a solution will be injected into the plume core to chemically break down the chlorinated compounds. By eliminating the VOC mass in the plume's core, less VOCs enter into groundwater and the overburden and bedrock plumes can attain cleanup goals sooner. ZVI, in conjunction with amendments, can also be effective in degrading BCEE, aldrin and dieldrin. ZVI is also capable, under the right conditions to remove dissolved arsenic through adsorption.

- <u>Enhanced Biodegradation</u> – Nutrients and other chemicals will be used to promote the growth of naturally occurring microbes in soil and groundwater, which can multiply and degrade VOCs through reductive dechlorination.

- <u>Natural Attenuation</u> – For the overburden and bedrock plumes downgradient of the former Source Area, the VOCs and other contaminants will be naturally degraded by ongoing biological, abiotic, and geochemical processes.

- <u>Institutional controls</u> – Similar to Alternative GW2, these controls will be applied to the properties where the overburden and bedrock plumes occur.

- <u>Long-term Monitoring</u> – As described for Alternative GW2, monitoring of the natural attenuation will be performed to observe the plume status and to protect nearby properties.

- <u>Five-Year Reviews</u> – Similar to Alternative GW2, these reviews are required because contaminants will remain in the aquifer for an extended period.

4. **<u>Alternative GW3B</u> - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews**

   Alternative GW3B is similar to Alternative GW3A, but will use active treatment of both the saturated soil in the former Source Area (plume core) and the downgradient overburden plume (outside of the wetland areas), and in the most contaminated bedrock well. The remainder of the bedrock plume will be naturally attenuated.

   - <u>In-Situ Chemical Treatment</u> – Similar to Alternative GW3A, ZVI, as the representative chemical reducing agent and electron donor) in solution will be injected throughout the former Source Area and the portion of the overburden plume underlying areas without wetlands to degrade chlorinated compounds. By decreasing the mass of contaminants in the overburden aquifer, cleanup goals can be attained sooner.

   - <u>Enhanced Biodegradation</u> – Similar to GW3A. Promotes growth of subsurface microbes to help degrade VOCs in the former Source Area and the overburden plume.

   - <u>Natural Attenuation</u> – For the bedrock plume and the untreated portions of the overburden plume, the VOCs and other contaminants will be naturally degraded by ongoing biological, abiotic, and geochemical processes.

   - <u>Institutional Controls</u> – Similar to Alternative GW3A.

   - <u>Long-term Monitoring</u> – Similar to Alternative GW3A.

   - <u>Five-Year Reviews</u> – Similar to Alternative GW3A.

5. **<u>Alternative GW4</u> - Groundwater Extraction, Treatment, and Discharge, Long-Term Monitoring, Institutional Controls, and Five-Year Reviews**

   Alternative GW4 was developed to address the 1987 ROD's selected groundwater remedy. However, additional investigations after the ROD indicated that reinfiltration of treated groundwater to flush VOCs from the contaminated saturated soil was difficult. GW4 was developed to assess the potential effectiveness of a groundwater extraction and treatment option.

   - <u>Groundwater Extraction</u> – 23 extraction wells will be installed in both the overburden and bedrock plumes pumping an estimated 30 gallons per minute. Highly contaminated groundwater will be captured in the former Source Area to prevent its migration into downgradient areas. Extraction wells located at the plumes' downgradient periphery will keep contaminated groundwater from migrating further towards private homes. Extraction will remove contaminants from the subsurface and enhance groundwater recovery. The extracted groundwater will be conveyed to an on-site treatment system.

   - <u>Groundwater Treatment</u> – A treatment system will be constructed in the former Source Area to remove contaminants from the extracted groundwater. The treated groundwater will then be discharged into Latham Brook.

   - <u>Institutional controls</u> – Similar to Alternative GW3A.

   - <u>Long-term Monitoring</u> – Similar to GW3A.

   - <u>Five-Year Reviews</u> – Similar to GW3A.

6. **<u>Alternative GW5</u> - In-Situ Thermal Treatment (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews**

   Alternative GW5 employs a thermal treatment process to desorb the VOCs from the saturated soil in the former Source Area. Once the VOCs mass is removed from the plume core, contaminants in the downgradient portion of the overburden plume can dissipate faster through natural attenuation. The bedrock plume will be naturally attenuated.

- In-Situ Thermal Treatment - A series of electrodes and vapor extraction wells will be installed throughout the former Source Area. Electrical current will be applied to the subsurface and the heated soil moisture will generate steam, which will dissolve and vaporize VOCs and other organic contaminants from the soil and groundwater. Thermal treatment will remove the contaminant mass from the plume core and prevent further leaching of contaminants to groundwater, allowing the downgradient overburden plume to reach cleanup goals sooner.

- Soil Vapor Extraction – vapor extraction wells will be installed throughout the former Source Area to collect the heated gases (VOCs and organics) generated by in-situ thermal treatment.

- Ex-Situ Treatment – The recovered gases will be condensed and the liquid would be treated using granular activated carbon (GAC) to capture the organic compounds. The recovered chemicals and spent GAC will be disposed off site.

- Natural Attenuation – For the bedrock plume and the overburden plume outside of the former Source Area, the contaminants will be naturally attenuated by ongoing biological, abiotic, and geochemical processes.

- Institutional controls – Similar to GW3A.

- Long-term Monitoring – Similar to GW3A.

- Five-Year Reviews – Similar to GW3A.

h. Comparative Analysis of Alternatives

After completion of the detailed evaluation of alternatives, a comparative analysis of the alternatives was performed to identify the alternative that satisfies the two threshold criteria of protection of human health and the environment and compliance with ARARs. The alternatives are then assessed to determine which option is the best based on the five balancing criteria. The comparative analysis from this FFS is summarized below.

Threshold Criteria

1. Overall Protection of Human Health and the Environment

Alternative GW1 provides the least long-term effectiveness because no action will be taken to control exposure risk, to restore the aquifer, or to prevent migration of groundwater contaminants.

Alternatives GW2, GW3A, GW3B, GW4, and GW5 would use institutional controls (groundwater use restrictions) to prevent exposure of current and future residents to groundwater contamination.

Alternatives GW3A, GW3B, GW4, and GW5 employ active in-situ treatment to destroy or remove contaminants from the former Source Area soils so that the remaining overburden plume can reach cleanup goals sooner.

2. Compliance with ARARs

Alternatives GW1 and GW2 will not meet chemical-specific ARARs (MCLs and RI GA Objectives) in a reasonable time frame because they rely only on natural attenuation processes to gradually deplete the contaminants from overburden and bedrock plumes.

Alternatives GW3A, GW3B, GW4, and GW5 will comply with the State's groundwater regulations sooner because contaminants degraded in-situ or are actively removed from the subsurface allowing groundwater to reach the cleanup goals sooner.

Alternatives GW3A, GW3B, GW4, and GW5 would also be designed and implemented so that they would comply with regulations that govern wetlands and floodplains, and use of equipment to treat and handle hazardous substances.

Balancing Criteria

3. Long-term Effectiveness and Permanence

Alternatives GW1 would be the least protective because no measures will be taken to remove contaminants or to control risks due to exposure to contaminants in groundwater.

GW2 would be more protective than GW1 because restrictions on groundwater use will prevent potential exposures to groundwater contaminants.

For Alternatives GW3A, GW3B, GW4, and GW5, active remediation will permanently restore the groundwater quality thereby limiting future exposures to groundwater contaminants. Once active remediation begins, contaminated groundwater migration to the wetlands and Latham Brook will also be reduced.

4. Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives GW1 and GW2 do not contain any measures to reduce the toxicity, mobility, or volume of contaminants through treatment.

Alternatives GW3A and GW3B both use chemical treatment and enhanced biodegradation to degrade and destroy the organic contaminants in the subsurface. GW3A and GW3B may also be able to reduce the mobility of dissolved arsenic through reactions with the ZVI. Alternatives GW4 and GW5 recover VOCs from the subsurface, but the recovered VOCs and treatment residuals will require further handling and disposal. Alternative GW4 will also remove BCEE, pesticides, and dissolved metals on on-site treatment. Alternatives GW3A, GW3B, GW4, and GW5 will diminish contaminant toxicity, mobility, and volume through treatment.

5. **Short-term Effectiveness**

Because no remedial actions will be performed by Alternative GW1, there would be no risks to the community, site workers, or the environment due to its implementation. Groundwater quality will be restored through natural attenuation.

Alternative GW2 involves the installation of monitoring wells and implementation of institutional controls. Wells installation and sampling pose limited risks to site workers and have minimal impact to the wetlands.

During implementation of Alternatives GW3A and GW3B, risks to workers are limited. The reagents (ZVI and nutrient solution) are non-toxic. All chemical and biodegradation reactions will occur in the subsurface, and pose minimal impacts to site workers, nearby residents, and the environment.

Implementation of Alternative GW4 would result in typical risks associated with heavy construction for the extraction wells and the treatment system. Operation and maintenance of the system would risk in limited risks to onsite workers and the public. With groundwater extraction, drawdown may occur and may dewater some portions of the wetlands.

With Alternative GW5, installation of the heating wells and application of electricity for the resistive heating array pose some risks to construction and remediation workers, however, these can be managed with proper controls.

The time required to achieve safe levels in groundwater are summarized below:

Time to Attain RAOs (years)	GW1	GW2	GW3A	GW3B	GW4	GW5
Overburden	100	100	45	40-45	<100	45
Bedrock	80	80	80	80	80	80

6. **Implementability**

Alternative GW1 would be the easiest to implement because no actions are required.

Alternative GW2 can be readily implemented because installing and sampling monitoring wells are standard environmental investigation methods. Institutional controls such as deed restrictions are administratively feasible to obtain.

Alternatives GW3A and GW3B only require minimal construction. While specialized personnel, equipment, and materials are needed, these are commercially available and the actual implementation is not difficult. A number of firms are available to provide this service.

For GW4, experienced firms are readily available to design and construct groundwater extraction wells, a treatment system, and discharge structures. Equipment and materials are readily available. Alternative GW5 requires firms with specialized experience and equipment, which are limited.

Additional actions can be implemented under all alternatives. GW1 and GW2 are readily implementable. GW3A and GW3B, while more difficult to implement, can be more readily implemented than GW4 or GW5. Numerous items need to be constructed or installed, operated, and maintained under GW5 including: thermal wells and vapor extraction wells, vapor condensations system, and gas phase VOCs treatment systems. Because of the complexity of GW5, it is less implementable than GW4.

Of the alternatives where active remediation will be performed, Alternatives GW3A and GW3B would use the least amount of energy because all VOCs degradation processes do not require any additional energy. GW3A and GW3B would also have no air emissions because all reactions occur in the subsurface.

7. Cost

Alternative GW5 is the most expensive alternative, followed by GW4, GW3A, GW3B, GW2, and lastly, alternative GW1.

Cost Category	GW1	GW2	GW3A	GW3B	GW4	GW5
Capital Costs	$0	$235,000	$4,739,000	$6,153,000	$3,367,000	$23,598,000
Total Present Value (30 yrs @ 7% Discount Rate)	$0	$5,330,000	$9,866,000	$11,280,000	$16,214,000	$28,693,000

1.0 INTRODUCTION

This Focused Feasibility Study (FFS) report was prepared by Nobis Engineering, Inc. (Nobis) for the U.S. Environmental Protection Agency (EPA) under Contract No. EP-S1-06-03, Task Order No. 0028-RI-CO-0117. This FFS was prepared to address the remaining contamination at the Davis Liquid Waste Superfund Site (Site) located in Smithfield, Rhode Island. The EPA CERCLIS identification number for the Site is RID980523070.

This FFS was prepared consistent with the requirements of: the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 Code of Federal Regulations (CFR) 300; and the *Interim-Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988).

1.1 Purpose of the Report

The purpose of this FFS is to develop and evaluate a range of remedial alternatives that addresses contaminated groundwater present at the Site, and associated potential health risks. The remedial options developed in this FFS will be used by EPA to select a remedy, which will be documented in an amended Record of Decision (ROD). The FFS report includes the following:

- Section 1 - presents the descriptions of the Site and its history, contaminant nature and extent, contaminant migration and transformation processes, previous response actions, and the results of the risk evaluations. These assessments identify the contaminants of concern that pose potential health risk threats or can degrade environmental quality.

- Section 2 - presents the formulation of remedial action objectives (RAOs), which incorporate target cleanup goals protective of human health and the environment. The RAOs specify the contaminants, media of interest, exposure pathways, and preliminary remediation goals (PRGs), which are numeric criteria developed using chemical-specific applicable or relevant and appropriate requirements (ARARs), and site-specific risk-related factors.

- Section 3 - develops the general response actions that address each medium of interest to satisfy the RAOs. The volumes, masses, or areas of contamination are estimated and remedial technologies applicable to each general response action are selected. Remedial technologies and process options that are not technically implementable are eliminated. Representative process options for the remaining technologies are then evaluated for their effectiveness, implementability, and cost.

- Section 4 - assembles potential remedial technologies into remedial action alternatives that encompass a wide-range of treatment and containment combinations. Each of the alternatives is further refined by characterizing factors such as contaminant volumes or masses to be addressed, interactions and fluxes between media, sizing, configuration, and spatial requirements of treatment/containment systems, duration of activities, distances to off-site treatment/disposal facilities, and local, state, and federal regulations.

- Section 5 - presents the detailed evaluation of remedial alternatives based upon the following criteria: protection of human health and the environment, compliance with ARARs, short-term and long-term effectiveness and permanence, reduction of mobility, toxicity, or volume through treatment, implementability, and cost.

- Section 6 - presents the comparative analyses of alternatives. The engineering cost estimates presented in this FFS were prepared for comparison purposes consistent with EPA guidance; actual costs may vary. More detailed cost estimates will be prepared as part of a Remedial Design/Remedial Action (RD/RA).

This FFS was prepared based on the review and summary of information and data developed in the 1986 Remedial Investigation (RI) (CDM, 1986), pre-design investigations, and monitoring data collected from 2001 to 2005 (subsequent to the source control component of the remedial action that commenced in 1999).

As part of the FFS process, a Conceptual Site Model (CSM) was developed to summarize the nature and extent of onsite contamination, summarize the associated risks to human health and the environment, and develop a preliminary contaminant fate and transport assessment (Nobis, 2009a).

Additional soil, groundwater, and surface water analytical data were obtained by the Potentially Responsible Parties (PRPs) in September and October 2008 to supplement the previously available data, and to provide more current assessments of soil and groundwater contamination at the Site. The CSM was amended to include analysis of the 2008 data (Nobis, 2009b).

1.2 Background Information

This section presents the description and history of the Site, and summarizes past investigations and response actions.

1.2.1 Site Description

The Site is located in the Town of Smithfield, Providence County, Rhode Island. The Site is located on approximately 10 to 15 acres in a semi-rural, residential section of Smithfield (CDM, 1986) and includes all locations where contamination has come to be located.

The Site is bounded on the east and west by forested uplands, and on the north and south by wetlands and swamp areas of the Nipsachuck Swamp, which constitute the headwaters of Latham Brook (Figure 1-1). Much of the Site is located within a Federal Emergency Management Agency (FEMA) Flood Zone A (i.e., within the 100-year flood zone) (Smithfield, 2008b). Land within a 1-mile radius of the Site is mostly semi-rural in nature and some low-density residential dwellings are situated nearby. Residential development in the area has increased and has included the construction of larger subdivisions as well (EPA, 1996).

A large portion of the Site is located on Lot 9 of Plat 50 of the Town of Smithfield Tax Assessor's maps. The current owner is listed as the William Eleanor Real Estate, Inc. (Smithfield, 2008b). Additionally, it appears that a portion of the Site is located on the abutting parcel, Lot 29, Plat 50. The Site does not abut any named road and is situated between Tarkiln Road and Log Road (Figure 1-1). Access to the Site is from Tarkiln Road on an unpaved roadway/easement west of the Site and a right-of-way to Log Road located north of the Site (Smithfield, 2006; Smithfield, 2008a) (Figure 1-2). The Site consists of primarily undeveloped land that is vegetated by shrubs, trees, and wetlands flora.

For this FFS, the former Source Area is defined as the area where past disposal and releases of hazardous substances occurred and is bounded approximately by the excavation footprint of the

source control remedial action initiated in 1999 (Figure 1-3). During the RI, the primary disposal and release areas that were identified included the Northern Disposal Area (NDA), the Southern Disposal Area (SDA), the Western Access Road, the Drum Removal Area, and the Bunker C Area.

1.2.2 Site Topography, Geology, Hydrogeology, and Hydrology

The Site topography, geology, hydrogeology, and hydrology are summarized below.

Site Topography and Surface Features - The Site is vegetated by grass and by small trees planted after the completion of the source control remedial action (1999 to 2001). The ground surface is relatively flat with elevations ranging from 404 to 410 feet above mean sea level (MSL). In the upland areas to the west, north, and south of the Site, ground surface can reach 480 feet MSL (URS, 2006). Surface drainage flows east with the general site topography into an adjacent wetland.

Geology - The overburden subsurface lithology of the Site consists primarily of sandy ground moraine deposits (Pleistocene-Wisconsin in age) and local swamp deposits (Holocene in age) (CDM, 1986; ESS, 2004). Ground moraine deposits generally consist of an upper till layer consisting of loose medium to coarse sands, and a lower till of compacted clayey sands. During the previous Phases 2 and 4 soil boring investigations, organic peat deposits were observed to be present in the areas immediately under and adjacent to the wetlands. In the vicinity of the source control remedial action footprint where wetland and bog areas are present, organic peat deposits appear to be present and underlie the wetlands (URS, 2006; ESS, 2009). The thickness of the overburden deposits is highly variable across the Site, and range from 8 to 37 feet.

While the upper till unconsolidated deposits appear to be widespread and uniform across the Site, the lower till deposits are not as frequently observed, except in the vicinity of monitoring well locations OW-101(R) and OW-103(O, R) where sandy silt deposits were observed directly above the bedrock surface (ESS, 2004).

The overburden materials at the Site are primarily underlain by two bedrock formations: Nipsachuck Gneiss and Absalona Formation. Additionally, thin layers of quartzite within the

Nipsachuck Gneiss have been identified in several borings throughout the Site. The Absalona Formation (also Pre-Cambrian in age) is characterized as a porphyroblastic biotite gneiss and is primarily located in the southeast quadrant of the Site (ESS, 2004).

An intrusive diorite dike (Triassic in age), trending north-south and extending north to Log Road, was identified during previous investigations in the northeast and southeast quadrants of the Site. The dike is located in the general area of the basin outlet at Latham Brook (CDM, 1986; WCC, 1993; and ESS, 2004) and is characterized as a low-hydraulic conductivity feature, which is believed to have strong influences on groundwater flow conditions in both the overburden and bedrock (URS, 2006).

Depth to bedrock is highly variable across the Site, ranging from 8 to 37 feet below ground surface (bgs). Bedrock topography generally slopes from the surrounding upland areas towards the central portion of the Site before becoming relatively level in the wetland and bog areas. Moving east of the wetlands towards the basin discharge area, the bedrock elevation drops steeply beyond the diorite dike.

Evidence of weathered bedrock is highly variable at the Site, where the upper 10 to 30 feet of bedrock is fractured or severely weathered (URS, 2006). Complete to moderately weathered bedrock was observed at boring locations OW-102(R), OW-105(R), OW-107(O, R), and OW-111(R), where the moderately weathered bedrock is characterized as often exhibiting weathering effects such as slight mineral discoloration, interbedded sand lenses, and significantly reduced strength when compared to competent rock (ESS, 2004).

Bedrock fractures observed in the vicinity of the Site during drilling activities appear to exhibit a north-south striking trend while dipping to the east and west. Observations conducted in the Nipsachuck Formation (granitic gneiss) demonstrate fractures dipping to the east at approximately 30° (ESS, 2004). As in most bedrock settings, groundwater flow within the crystalline rock is inferred to be primarily transmitted via various types of discontinuities (i.e., fractures, joints, bedding planes, etc.) as well as being driven by local and regional hydraulic gradients (ESS, 2004). To date, no borehole geophysical investigations have been performed, so information is limited with respect to the bedrock fracture network.

Hydrogeology - Hydraulic conductivities for unconsolidated sediments at the Site have been estimated to be between 0.5 ft/day and 510 ft/day, which are consistent with published values for well-sorted sands associated with glacial outwash deposits (CDM, 1986; WCC, 1993; and ESS, 2004). Using a representative average site-wide overburden hydraulic conductivity of 28.35 ft/day (1 x 10-2 cm/sec), a hydraulic gradient of 0.002 ft/ft (as measured across the central portion of the Site downgradient of the former disposal areas), and a literature value for porosity of 0.2 (Fetter, 2001), an average linear groundwater velocity of approximately 0.3 ft/day (110 ft/year) was calculated for the overburden (ESS, 2004).

Overburden groundwater flow originating from upland areas in the west, south, and southeast converges towards the central portions of the Site (Nipsachuck Swamp) before discharging through the area where Latham Brook exits the Site (Figure 1-4). Overburden groundwater flow near the former disposal areas is generally towards the northeast into the wetland and bog areas. A “weir-like” effect at the basin outlet created by the diorite dike has been postulated (WCC, 1993). It suggested that overburden groundwater would over-top the top of the diorite dike in a fashion similar to a weir. This weir effect would cause upgradient overburden groundwater to pool and flatten at an equilibrated elevation, consistent with observations in existing monitoring wells.

Computed hydraulic conductivities for the Nipsachuck Gneiss bedrock ranged from 2.8×10^{-6} ft/day at OW-82 to 28 ft/day at OW-94(R). The hydraulic conductivity of the diorite dike ranged from 28×10^{-6} to 30×10^{-4} ft/day based on data from OW-80 (CDM, 1986).

Because of heterogeneities associated with bedrock hydraulic conductivity and porosity as a result of fracturing and weathering, it is difficult to calculate a representative groundwater velocity with a level of certainty. Groundwater velocity within the bedrock aquifer is expected to be significantly lower than groundwater velocities within the overburden aquifer based on initial comparisons of estimated hydraulic conductivities (ESS, 2004).

Weathered bedrock was observed at various boring locations across the Site, particularly in the eastern portion of the study area. The weathering in these zones may allow vertical flow of groundwater from the overlying unconsolidated deposits into the bedrock or vice versa. In some areas, weathered bedrock may exhibit lower hydraulic conductivities due to the presence of silts

and clays derived in place during the weathering process, and may limit vertical flow of groundwater (ESS, 2004).

Bedrock aquifer elevations from the September 2006 data are similar to the overburden elevations and range from 382.80 feet MSL (OW-025) to 411.28 feet MSL (OW-95-R). These measurements are also consistent with previous seasonal measurements. Groundwater flow within the bedrock mimics overburden flow as it converges towards the wetlands and central portions of the basin from the surrounding uplands (Figure 1-5). The bedrock groundwater elevation data confirm previous findings that bedrock flow is predominately from the southern and western upland areas towards the east in a direction perpendicular to the diorite dike area (ESS, 2007).

Vertical hydraulic gradients at the Site are variable and reversible, depending on the season. However, historic groundwater elevation measurements in well couplets (collected during Phase 1, Phase 2, Phase 3, and Pre-Design investigations) generally reflect flat to slightly upward vertical gradients in the central portion of the Site, particularly in well pairs located near the former disposal areas. These observations suggest the horizontal groundwater flow is dominant in both the overburden and bedrock aquifers. Observations of slight upward vertical gradients are indicative of bedrock groundwater flow up into the overburden prior to discharging into Latham Brook. Downward vertical gradients (i.e., flow from overburden to bedrock) have been observed in wells upgradient of the former Source Area, consistent with these areas serving as recharge zones from precipitation (ESS, 2004; URS 2006).

Surface Water Hydrology - The Site is located within the Latham Brook watershed, which is a sub-basin of the Woonasquatucket River Basin. The Site is situated within the Nipsachuck Swamp (Figure 1-1), which is the headwaters of Latham Brook. The Brook drains into the Stillwater Reservoir (not a drinking water supply) and the Woonasquatucket River, and eventually into Narragansett Bay at Providence. Annual precipitation in the area ranges between 42 and 46 inches based on climatic data from nearby monitoring stations (ESS, 2004; URS, 2006).

Deposits within the swamp consist of peat, silt, and clay and are characterized as having a high porosity and low permeability, which allow for ample storage of groundwater but function poorly for lateral and/or vertical transport of groundwater and contaminants (CDM, 1986). The

wetlands provide a large area for floodwater detention, groundwater discharge, and evapotranspiration (URS, 2006).

Latham Brook receives water from surface runoff, direct discharge from groundwater, and direct discharge from wetland water, acting as the outlet for these sources from the basin. Monthly flow rates were estimated to range from 83 gallons per minute (gpm) in October to 278 gpm in February at the upstream weir of the brook (CDM, 1986).

Latham Brook is classified by the Rhode Island Department of Environmental Management [RIDEM]) as a Class B water body. According to July 2006 Water Quality Regulations Class B water bodies are defined as follows: *"These waters are designated for fish and wildlife habitat and primary and secondary contact recreational activities. They shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses. These waters shall have good aesthetic value."*

1.2.3 Land and Groundwater Use

The Site and surrounding areas are zoned residential (R-200) and the nearest residence is located approximately 1,300 feet northeast of the Site (Smithfield, 2008a; USGS 1975). As of 1986, there were approximately 240 people living within 1 radial mile, and 4,700 people living within 3 radial miles of the Site (it is presumed that this population has increased since the 1986 RI). Currently, the Site is undeveloped.

Groundwater underlying the Site and adjacent areas are classified as GA by RIDEM, which designates resources that are known or presumed to be suitable for drinking water use without treatment. Currently, groundwater underlying the Site is not used as a potable supply. There are no known water supply wells installed in the overburden and bedrock groundwater plumes (see descriptions in Section 1.3.2) that extend downgradient from the former Source Area.

The nearest well at the time of the RI was located approximately 300 feet away (CDM, 1986). When a public drinking water supply main was installed by EPA and RIDEM in 1997 along Forge Road, Log Road, Burlingame Road, and Bayberry Road (all located north of the Site), the private wells nearest to the Site were removed from service.

1.2.4 Site History

Details regarding the usage of the Site prior to its operation as a disposal area are not known. During an approximate 5-year period in the late 1960s and early 1970s, municipal solid waste (MSW) from the Town of Smithfield was reportedly disposed of at the Site. Additionally, construction debris was also reportedly burned at the Site (Ensafe, 1998). Key events are summarized as follow:

- 1976 to 1977 - The then-owner, William Davis, used the Site to dispose of a variety of liquid and solid wastes containing hazardous substances including: sludge (paint pigments and metals), solvents (halogenated and non-halogenated), inks, laboratory pharmaceuticals, manufacturing residues and miscellaneous chemical processing wastes (acids, caustics, pesticides, phenols, halogens, and metals), solids (fly ash and metals), MSW, tires, salvaged vehicles, machine parts, and waste oils.

  - Wastes were disposed of via direct-discharge of tank truck contents to unlined lagoons and seepage pits, direct burial of drums and laboratory containers, or bulk storage (CDM, 1986).

  - Wastes and contaminated soil were reportedly excavated from the lagoons and pits, dumped at several onsite locations, and covered with available soil (CDM, 1986).

  - Minimal records were available concerning waste disposal; therefore it is not possible to determine the quantity of waste disposed of at the Site (CDM, 1986).

  - The proximity of these disposal areas to the water table and surrounding wetland areas allowed contaminants to migrate and infiltrate into the surface water and groundwater (EPA, 1987).

  - Other onsite operations included the collection of salvaged vehicles and machine parts, tire storage/disposal, metal recycling, and tire shredding (WCC, 1992).

- Mid 1970s – Nearby residents complained to local and state officials regarding chemical odors emanating from the Site area.

- 1977 – An on-site tire fire prompted Town residents to pursue the disposal activities with the Town Council.

- 1978 – Approximately 23 off-site drinking water supply wells were identified as having been contaminated with hazardous materials including volatile organic compounds (VOCs). The Rhode Island Superior Court (the Court) ordered the prohibition of further disposal of hazardous substances at the Site.

- 1980 – The Court further ruled in 1980 that RIDEM conduct a comprehensive environmental investigation at the Site. Surface water and groundwater samples collected from the Site indicated the presence of tetrachloroethene (PCE), chloroform, trichloroethene (TCE), and benzene; however, lack of site access prevented RIDEM from conducting additional investigations. Six residences with private drinking water wells were provided with bottled water, as the sample results from these wells were in excess of the EPA health advisory concentrations in effect at the time (EPA, 1987).

- 1983 and 1984 - EPA listed the Site on the National Priorities List (NPL), and RIDEM took the lead in investigating the nature and extent of Site contamination. Access restrictions again halted the RIDEM investigation activities. EPA assumed the lead investigation role in October 1984.

1.2.5 Previous Response Actions

Previous response actions conducted at the Site are summarized as follow:

- 1986 – Due to the observation of leaking drums of hazardous materials, EPA initiated an immediate response action at the Site to remove and dispose of approximately 600 drums.

- 1986 - The completed RI identified extensive contamination of soil, overburden and bedrock groundwater, sediment, and surface water at the Site as well as several source areas including: the Western Access Road, the Northern Disposal Pit, the Southern Disposal Pit, the Drum Staging Area, the Ridge Line Area, the Bunker Oil impoundment,

and an extensive tire pile (estimated to include between 10 and 30 million tires). Contamination of each media consisted primarily of VOCs including PCE, TCE, ethylbenzene, benzene, toluene, and xylene. The RI also identified elevated concentrations of semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, and metals in environmental media (EPA, 1987 and 1996). The individual source areas were combined into larger areas exhibiting similar characteristics. The area referred to as the SDA consisted of the Southern Disposal Pit, the Drum Staging Area, the Ridge Line Area, and the Bunker Oil impoundment (CDM, 1986) (Figure 1-3). The FS, completed in 1987, developed a range of source control and management of migration remedial alternatives (CDM, 1987).

- 1987 – EPA issued a ROD to address source control and management of migration of contaminated groundwater at the Site. The Site was divided into three operable units: Operable Unit One (OU1) addressed contaminated private drinking water wells. Operable Unit Two (OU2) addressed groundwater contamination. Finally, Operable Unit Three (OU3) addressed soil contamination. Additional details for the three Operable Units are presented in Section 1.2.6.

- 1991 – A pre-design engineering investigation (PDEI) was completed in 1991 to acquire additional soil samples within the former Source Area to characterize VOCs, SVOCs, and metals presence. The subsurface investigation was conducted to provide additional data to assist in the design of a groundwater extraction and treatment system (WCC, 1992). A follow-up hydrogeologic investigation was completed in 1994 to support the design effort (Ebasco, 1994).

- 1993 and 1994 – The follow-up hydrogeologic investigation was conducted to support the design of the ROD-designated groundwater extraction, treatment, and soil flushing system (Ebasco, 1994). Hydrogeologic evaluations and pumping tests were completed to assess the viability of capturing contaminated overburden and bedrock groundwater and to reinfiltrate the extracted groundwater. While the investigations determined that an extraction well system pumping 25 gallons per minute (gpm) could capture contaminated groundwater in the former Source Area, the testing determined that it was not possible to reinfiltrate treated groundwater at this rate. The direct discharge of the treated groundwater to Latham Brook was incorporated into the design of an extraction

and treatment system. Because reinfiltration of treated groundwater at the former Source Area was not possible, the groundwater flushing recirculation cell envisioned in the 1986 ROD could not be implemented.

- 1994 and 1995 - The State of Rhode Island entered into an agreement with the property owner to remove stored tires from the property. While conducting this operation, the property owner notified EPA and RIDEM officials of the discovery of nine drums of waste materials (later found to be hazardous) in various stages of decay. These drums were removed and disposed of by EPA in April 1995 (EPA, 1996). However, the removal of the tires was not fully completed.

- 1996 – EPA issued an Explanation of Significant Differences (ESD), which changed the source control component of the remedial action from on-site incineration to on-site low-temperature thermal desorption. Section 1.2.6 provides additional details of the ESD. A November 1996 Consent Decree (CD) negotiated between EPA and 54 Settling Parties (SPs) was lodged with the U.S. District Court for the District of Rhode Island. The CD required the SPs to perform the source control remedial action at the Site.

- 1998 - Approximately 5,000 tons of a mixture of hazardous/municipal solid waste and soil were taken off site for disposal and over 800 drums, drum parts, and/or pails and smaller containers were discovered, overpacked, and transported off site for disposal (LEA, 2001).

- 1997 to 2000 – The SPs initiated the source control remedial action in March 1997 with the removal of tires from areas of the Site that were thought to be contaminated. As the tires were removed, partially- and fully-buried drums were often encountered. Drums that had been contained within the tire pile were removed and stored on the Site for later disposal. Drums that were buried were left in-place to be removed during subsequent soil response actions. By December 2000, approximately 6.4 million tires were removed from the Site. The buried drum excavations were initiated in July 1997 and continued through December 2000. In total, approximately 1,400 drums and 15,000 laboratory containers were excavated, repackaged and disposed of off-site. A pre-design investigation (PDI) was completed by the SPs' contractor in fall and winter of 1997. The PDI included a grid-approach soil sampling program, and was intended to determine the

extent of soil contamination in excess of the ROD-stated remedial goal of 2 mg/Kg of total VOCs (LEA, 2001).

- 1997 - A new water distribution system was completed by EPA and RIDEM that served 127 lots along Forge Road, Log Road, Burlingame Road, and Bayberry Road. This response action constituted OU1 for the Site.

- 1999 through 2001 – Contaminated soil was excavated to an elevation of 404.6 ft MSL, screened, and stockpiled for treatment using an on-site low-temperature thermal desorption system housed in temporary buildings constructed on the Site. Treatment consisted of placing contaminated soil on heated radiant floor panels, mechanical turning of the soil over several days, and vapor recovery. Samples were collected of each treatment batch to assure treatment goals were met and were also evaluated to determine whether metals leached in excess of the Toxicity Characteristic Leaching Protocol (TCLP). After successful treatment (total VOCs less than 2 mg/Kg; which in several samples included PCE at concentrations approaching 2 mg/Kg), the soil was removed from the treatment building and stockpiled on the Site for later use as excavation backfill. Soil that failed to meet the VOCs treatment standard or failed to meet the 40 CFR 261.24 toxicity criteria (metals leaching in excess of allowable standards using the TCLP test), and screened contaminated materials were transported off-site for proper disposal. The approximate extent of the soil excavation footprint and the treated soil backfill area are depicted in Figure 1-6.

  Approximately 78,000 tons of soil was successfully treated and replaced as backfill, while approximately 20,000 tons of off-specification contaminated soil and miscellaneous wastes were shipped off-site for disposal. After completion of the soil treatment phase, the buildings were decontaminated and dismantled, and the work area was regraded. The excavation was backfilled with a layer of clean bank-run gravel that was overlain by treated soil. Once graded, the entire disturbed area was covered with a 6-inch layer of topsoil. The disturbed areas were then planted with grass and over 300 trees to help stabilize the Site and restore the wildlife habitat value. The tree planting consisted mainly of native species ranging in size from small saplings to large established plants (LEA, 2001). This response action constituted OU3 for the Site.

- 2001 to the present – In an effort to determine the most-appropriate implementation method for the management of migration remedy (OU2) the SPs have been conducting groundwater and surface water investigations. The monitoring coupled with a groundwater model was intended to provide the information needed to finalize the design of the groundwater extraction and treatment system or potentially change the groundwater remedy (ESS, 2007).

- Fall 2008 – A subsurface investigation (Phase 4) was completed to assess whether unexcavated soil in the saturated zone underlying the former Source Area represented a continuing source of groundwater contamination. Five additional overburden monitoring wells were installed and a round of groundwater samples was collected to expand the existing dataset (ESS, 2009).

1.2.6 Record of Decision and Explanation of Significant Differences

The requirements of the 1987 ROD and the subsequent 1996 ESD are summarized below.

Record of Decision

The selected remedy for the 1988 Record of Decision consisted of the following components:

- Source Control - The source control (OU3) component of the remedial action consisted of the excavation of approximately 25,000 cubic yards of raw waste and contaminated soil located in the unsaturated zone, to the seasonal low groundwater elevation (an average depth of 4 feet) onsite treatment by high temperature thermal destruction (incineration for VOCs and extractables (SVOCs)), and the disposal of hazardous treatment residuals in an on-site Resource Conservation and Recovery Act (RCRA) Subtitle C landfill. A soil cleanup goal of 2 milligrams per kilogram (mg/Kg) of total VOCs was established based on a net contribution of contaminants from the soils into the groundwater, assuming groundwater was potentially used as a potable drinking water source and anticipating achievement of an estimated cancer risk level of 1 E-05 for exposures to groundwater as drinking water. Wetland areas affected by the remedial action would be restored with equivalent wetland types.

- Management of Migration - The selected management of migration component of the remedy consisted of the design and installation of an alternate water supply system (OU3), and the design and construction of an on-site groundwater extraction, treatment, and soil flushing system (OU2) to remediate the aquifer. Contaminated overburden and bedrock would be extracted from wells, treated, and the treated water would then be redistributed (recirculated) over the former Source Area. Unexcavated contaminated soil in the recirculation zone would be flushed and remaining VOCs would be removed. VOCs in the extracted groundwater would be treated using air stripping and activated carbon adsorption, while metals (arsenic and lead) would also be removed. Cleanup goals of 5 ug/L were established for benzene, PCE, and TCE in on-site wells.

Explanation of Significant Differences

Additional information for the performance and use of full-scale thermal desorption systems became available after the 1987 ROD. Based on new performance data, the source control component of the remedial action was modified from on-site incineration to on-site low-temperature thermal desorption because of lowered costs and comparable levels of protection. The ESD allowed treated soil that met the ROD treatment standard and met the 40 CFR 261.24 toxicity criteria (metals did not leach in excess of allowable standards using TCLP) to be used as backfill. In addition, the ESD allowed treated materials that did not pass the 40 CFR 261.24 toxicity criteria to be disposed of in an onsite RCRA Subtitle C landfill or at an offsite facility approved by EPA.

1.3 Nature and Extent of Contamination

This section presents the interpreted current nature and extent of soil, groundwater, and surface water contamination (primarily consisting of VOCs) at the Site following the source control remedial action completed in 2001.

1.3.1 Soil Contaminant Nature and Extent Summary

The soil at the Site can be separated into three categories: unexcavated unsaturated soil, treated unsaturated soil backfill, and saturated unexcavated soil. The areas of treated unsaturated soil backfill and saturated unexcavated soil areas are shown in plan view on Figure 1-6 while the unexcavated unsaturated soil are situated outside of the areas occupied by the

first two soil categories. A cross-sectional view of Transect A-A' and the three soil categories are depicted in Figure 1-7.

The soil analytical results were compared with several soil leaching criteria to help identify chemicals that pose potential threats to groundwater quality. These criteria include EPA's Regional Screening Levels (RSLs) (presented at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm), and RIDEM's Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases (or Remediation Regulations) GA Leachability Criteria (RIDEM GA-LC) (Nobis, 2009b).

The EPA RSLs are not ARARs; however, they are to-be-considered (TBC) guidelines that can be used to screen chemical concentrations that pose potential threats to human health. The EPA RSLs include Maximum Contaminant Level (MCL)-Based Protection of Groundwater Soil Screening Levels (MCL-SSL) and Risk-based Soil Screening Levels (Risk-SSL) if an MCL-SSL was not available.

The three types of soil identified in the former Source Area include:

- Unexcavated Unsaturated Soil (adjacent to the former Source Area) - Unsaturated soil samples collected from adjacent to the former Source Area were collected during the RI and subsequent preliminary design investigations from locations outside of the source control remedial action area. Table 1-1 provides a summary of VOCs detected in soil samples collected during the pre-design investigations by the SPs. The areas where the samples were collected are depicted in Figure 1-6.

  VOCs exceeding the screening criteria included: 1,2-dichloroethane (1,2-DCA), methylene chloride, chloroform, PCE, and TCE.

- Treated Unsaturated Soil Backfill (former Source Area) - Table 1-2 presents a summary of VOCs data for treated soil that were backfilled into the excavation (Figure 1-6). This data set was based on confirmation testing of thermally treated soil during the source control remedial action completed in 2001 to verify that the ROD-specified remediation goal of 2 mg/Kg of total VOCs was met for each batch of contaminated soil. Ten VOCs were identified at concentrations that could leach into and degrade groundwater quality.

In 1999, four of the ten VOCs (cis-1,2-dichloroethene [cis-1,2-DCE], PCE, TCE, and 1,1-dichloroethane [1,1-DCA]) were also detected in groundwater samples at concentrations that exceeded MCLs or tap water screening values.

- Saturated Unexcavated Soil – Samples were collected in 2008 in the saturated unexcavated soils underlying the footprint of the former Source Area. These soils were not part of the source control remedial action as they were situated below the water table. Table 1-3 presents a summary of the 2008 saturated soil data and identifies the VOCs that were detected at concentrations that exceed leaching screening values (MCL-SSL, Risk-SSL, or RIDEM GA-LC). Figure 1-8 depicts the 2008 sample locations for saturated soil, and their relative magnitude above the MCL-SSL screening levels, which are used as indicators of the leaching potential for these VOCs. Ten VOCs exceeded the leaching screening values, which suggested that these VOCs are present in soil at concentrations that could result in groundwater concentrations that exceed MCLs, the RIDEM's Remediation Regulations GA Groundwater Objectives (also referred to as RIDEM GA Objectives), or exceed risk-based concentrations that are protective of human health.

  Table 1-4 summarizes the 2008 sampling results for overburden monitoring wells. Of the 10 soil VOCs identified in Table 1-3 as potential threats to groundwater quality, four VOCs were identified in groundwater (as shown on Table 1-4 and Table 1-5) at concentrations that exceed either the MCLs or RIDEM GA Objectives including: cis-1,2-DCE; PCE; TCE; and vinyl chloride. One VOC, 1,1-DCA, for which there is no MCL, was detected in groundwater exceeding EPA's RSL for tap water. Similarly, the four VOCs (PCE, TCE, vinyl chloride, and 1,1-DCA) detected in saturated unexcavated soils were also detected frequently in bedrock groundwater (presented in Table 1-5). These results indicate that five VOCs, present in saturated soil underlying the area previously excavated and backfilled during the source control component of the remedial action, are sources of contamination and are likely continuing to migrate into and degrading groundwater quality.

1.3.2 Groundwater Contaminant Nature and Extent Summary

The 2008 groundwater analytical results were evaluated to assess the current extent of groundwater contamination in the overburden and the bedrock aquifers (ESS, 2009). The groundwater analytical results were compared with standards and criteria for human health protection, should the groundwater be used as a potable supply.

Groundwater data were screened against the federal MCLs and RIDEM GA Objectives to identify the extent of contaminants present in the overburden and bedrock aquifers that exceed regulatory criteria. The MCLs and the RIDEM GA Objectives limits are numerically the same. If there is no MCL or RIDEM GA Objectives, the results were screened against EPA's tap water RSLs. Results of the VOCs screening are presented in Table 1-4 and Table 1-5 and are depicted in Figure 1-9 and Figure 1-10 for overburden and bedrock groundwater samples, respectively.

VOCs – VOCs that were detected at a frequency of 1/20 or lower were not considered to be primary contaminants of concern for the purpose of FFS technology screening and selection. VOCs that were most frequently detected and exceeded screening values include the six compounds described below. These six VOCs are representative of all VOCs detected in overburden and bedrock groundwater that contribute to aquifer contamination and pose potential health risks. The most recent groundwater analytical data for each of the identified contaminants with exceedances of screening criteria are summarized as follow:

- Tetrachloroethylene - In the overburden, PCE concentrations that exceed the 5 micrograms per liter (µg/L) MCL or RIDEM GA Objectives extend approximately 350 feet north and downgradient of the former Source Area to monitoring well OW-51. Detected PCE concentrations range between 52 µg/L (OW-94-O, in the Source Area) and 3 J µg/L (OW-45).

  In bedrock, PCE appears to be localized in two areas: in the former Source Area and in the area bounded approximately by OW-007, OW-112-R, OW-36, and by OW-33. PCE exceeding the MCL or RIDEM GA Objectives extends to the north and approximately 1700 feet downgradient of the former Source Area. Detected PCE concentrations range between 0.8 µg/L (OW-103-R) and 17 µg/L (OW-112R).

- Trichloroethylene - In the overburden, TCE concentrations that exceed the 5 µg/L MCL extend approximately 800 feet northeast and downgradient of the former Source Area to OW-043, at the northern limit of the mapped wetland areas. Detected TCE concentrations ranged between 480 µg/L (OW-300-O) and 1 J µg/L (OW-038, OW-055, and OW-302-O).

  In bedrock, the TCE distribution mimics that of PCE; two areas of TCE contamination are present with detected concentrations ranging between 1 µg/L (OW-007) and 570 µg/L (OW-094-R). TCE concentrations in the former Source Area are much greater than the TCE concentrations in the downgradient area (a maximum of 34 µg/L in OM-033). TCE was detected approximately 1650 feet downgradient of the NDA.

- Cis-1,2-Dichloroethylene - In the overburden, cis-1,2-DCE concentrations exceeding the MCL extend approximately 1,100 feet northeast and downgradient of the former Source Area to between OW-043 and OW-046. Detected cis-1,2-DCE concentrations ranged between 390 µg/L (at OW-045) and 0.8 J µg/L (at OW-034).

  The distribution of cis-1,2-DCE concentrations in bedrock groundwater that exceed the MCL is limited to the former Source Area. Detected concentrations of cis-1,2-DCE range between 1 J µg/L (OW-079) and 1,700 µg/L (OW-094-R). In bedrock, cis-1,2-DCE was detected approximately 1400 feet downgradient of the NDA.

- Vinyl Chloride - In the overburden, vinyl chloride concentrations exceeding the MCL extend northeast and downgradient of the former Source Area to slightly beyond OW-038. Because the low vinyl chloride MCL of 2 µg/L is close to the detection limit, the downgradient limit of vinyl chloride detections in overburden groundwater is also at OW-038, located approximately 800 feet downgradient from the NDA. Detected vinyl chloride concentrations ranged between 460 µg/L (at OW-052) and 4 µg/L (at OW-300-O).

  Two areas of vinyl chloride concentration in bedrock groundwater that exceed the MCL exist at the Site (Figure 1-10). The primary area extends north from the former Source Area, while a smaller area is associated with monitoring well OW-033. The detection of

vinyl chloride generally mimics the MCL-exceedance distribution. Detected concentrations range between 1 µg/L (OW-041) and 340 µg/L (OW-094-R in the former Source Area). In the bedrock aquifer, vinyl chloride extent is approximately 830 feet downgradient from the NDA.

- Benzene – In the overburden, benzene was detected in two wells; neither benzene concentration exceeded either the MCL or the RIDEM GA Objectives.

  In the bedrock aquifer, benzene concentrations exceeded the MCL and the RIDEM GA Objectives in two wells (OW-101-R and OW-041).

- 1,1-Dichloroethane - The distribution of 1,1-DCA RSL exceedances in overburden groundwater resembles the distribution of vinyl chloride in overburden groundwater in that it extends northeast and downgradient of the former Source Area to slightly beyond OW-038. The downgradient limit of 1,1-DCA detections in the overburden aquifer extends approximately 1,000 feet downgradient of the NDA. Detected 1,1-DCA concentrations ranged between 1 J µg/L (OW-034 and OW-103-O) and 64 µg/L (OW-043).

  The limit of 1,1-DCA concentrations in bedrock groundwater that exceed the EPA RSL is greater than the extent of 1,1-DCA in the overburden aquifer, and extends north and downgradient of the former Source Area to monitoring well OW-007. Detected concentrations range between 2 J µg/L (OW-007) and 160 µg/L (OW-094-R). 1,1-DCA was detected in the bedrock aquifer up to 1,600 feet downgradient of the NDA.

SVOCs - The most recent groundwater SVOCs data are from 2003 (ESS, 2004). Table 1-6 and Table 1-7 identify SVOCs detected in the overburden and bedrock groundwater samples, respectively. SVOCs that were frequently detected (i.e., greater than 1/20 frequency) include bis(2-chloroethyl)ether (BCEE) and naphthalene. The other SVOCs are also likely site-related. Figure 1-11 and Figure 1-12 depict the positive detections of BCEE and naphthalene. In the overburden, the majority of the SVOCs detected were associated with monitoring well OW-094-O, which is located in the former Source Area. Only naphthalene was detected frequently (3/20) and exceeded the RSL; however, none of the detections exceeded the RIDEM GA Objective (there is no naphthalene MCL).

In bedrock groundwater, while several SVOCs were infrequently detected, BCEE was detected in 4 of 21 samples, exceeding the EPA tap water RSL (0.14 ug/L). BCEE was only detected in bedrock monitoring wells situated downgradient of the former Source Area. Review of RI groundwater data indicated that BCEE was detected in samples collected from monitoring wells located in the former Source Area, and is site-related.

Pesticides/PCBs – The most recent groundwater pesticide and PCBs (aroclor) data were collected in 2003 (ESS, 2004). Table 1-8 indicates the detection of several pesticides (aldrin, dieldrin, and heptachlor), but no PCBs. There are no MCLs or RIDEM GA Objectives for aldrin and dieldrin; however, these two pesticides exceeded the EPA tapwater RSLs. The single detection of heptachlor exceeded the tapwater RSL, but not its MCL. The pesticide concentrations in groundwater represent relatively low risk (i.e., 10^{-6} cancer risk range and HI in the 10^{-3} range) and therefore, do not represent a significant threat to groundwater quality.

Metals – The metals data considered for this evaluation were obtained during groundwater sampling rounds completed in 2003 and 2005. Table 1-9 and Table 1-10 provide summaries of the metals data for overburden and bedrock groundwater, respectively. In overburden groundwater, arsenic, cobalt, iron, manganese and mercury exceeded their tapwater RSLs; arsenic and mercury also exceeded the MCLs. In bedrock groundwater, arsenic, iron, and manganese exceeded the tapwater RSL; only arsenic exceeded the MCL. Figure 1-13 and Figure 1-14 depict the detections of arsenic and manganese in overburden and bedrock groundwater, respectively. Arsenic and manganese were detected frequently in groundwater at concentrations that exceeded the MCL, the RIDEM GA Objectives, or the tap water RSLs. Mercury and cobalt were each detected in one sample in only one sampling round. Arsenic exceeded the MCL or the RIDEM GA Objectives.

1.3.3 Dense Non-Aqueous Phase Liquids (DNAPLs)

The potential for DNAPL presence at the Site was assessed through an evaluation of various lines of evidence. Past disposal history (i.e., direct discharge to ground, burial of drums, etc.) and the types chemicals released (i.e., spent chlorinated solvents, paints, inks, industrial chemicals), and relatively shallow depth to the water table, suggest that DNAPLs may be present at the Site. However, during the 2008 soil investigation, field tests detected only the

presence of a Non-Aqueous Phase Liquid (NAPL), which could not be confirmed as a DNAPL by laboratory analytical results. Review of soil and groundwater data is inconclusive regarding the potential presence of DNAPLs.

Within the southeastern portion of the former Source Area, there appears to be a sorbed VOC mass present, which may possibly be DNAPL, either in the soil and/or in the aquifer that causes the persistent, elevated groundwater VOC concentrations. However, the detected groundwater concentrations are not indicative of DNAPL presence, as the detected concentrations were well below the 1 percent of the pure solubility value used to assess the potential for DNAPL presence.

1.3.4 Surface Water Contaminant Nature and Extent Summary

Results of the 2008 surface water sampling for VOCs are summarized in Table 1-11. The analytical results for three samples indicate the continued presence of VOCs above detection limits in surface water. VOCs detected in the surface water samples are similar to those detected in groundwater samples and include: 1,1,1-trichloroethane (1,1,1-TCA); 1,1-DCA; cis-1,2-DCE; PCE; TCE; and vinyl chloride. However, groundwater samples collected from nearby overburden and bedrock monitoring wells (i.e., OW-109-O, OW-111-O, OW-110-R, OW-080, OW-109-R) closest to the surface water sample stations did not contain detectable concentrations of these VOCs. These results suggest that: 1) groundwater may be discharging to surface water closer to (or perhaps adjacent to) the wetland area that feeds into the stream where the surface water samples were collected, or 2) groundwater may be migrating from the Site to Latham Brook via a pathway that is not currently in the vicinity of an existing monitoring well.

Table 1-11 provides a summary of the sample results compared with aquatic life or human health screening criteria. The detected VOC concentrations are below the aquatic life screening values. The risk assessment performed as part of the 1986 RI did not consider Latham Brook useful for swimming or as a drinking water source and therefore, human ingestion risks were considered negligible. For human health, vinyl chloride was detected in surface water samples at concentrations that exceeded the Rhode Island Ambient Water Quality Criteria (RI AWQC) for the Consumption of Aquatic Organism Only, Human Health Criteria.

If groundwater is discharging to surface water closer to (or perhaps adjacent to) the wetland area in the vicinity of the former Source Area, it is likely that VOCs may be present at higher concentrations and may pose potential risk.

There is no current information regarding other possible chemicals (SVOCs or metals) that may be discharging to the wetlands adjacent to the former Source Area. During the RI, contaminants detected in surface water samples included VOCs, SVOCs (including BCEE and naphthalene), pesticides, and metals (lead, manganese, iron, and zinc). If groundwater from the former Source Area is discharging into the wetlands, it is possible that sediments may also be contaminated. However, there are no current sediment data for evaluation.

During the pre-design investigation to implement the selected groundwater remedy, additional sampling of surface water and sediment in the vicinity of the former Source Area should be performed and the data evaluated to assess whether additional threats may be posed by groundwater discharge to the wetlands and to sediment and surface water quality.

1.4 Vapor Intrusion

The 2008 overburden and bedrock groundwater analytical results were compared with the screening values presented in the EPA's *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (EPA, 2002) to evaluate whether VOCs from groundwater could pose a potential threat to current and future occupied structures above the groundwater plume through vapor intrusion.

The results indicate that overburden and bedrock VOC concentrations exceeding the EPA Vapor Intrusion Guidance screening values are limited to residential parcels 50-9, 50-29, 50-27A, and 50-27, as depicted in Figure 1-17 and Figure 1-18 for overburden and bedrock groundwater, respectively. Tables 1-12 and 1-13 provide summaries of the chemical concentrations compared with screening benchmark values derived from the Vapor Intrusion Guidance. VOCs exceeding the screening values included: benzene, ethylbenzene; cis-1,2-DCE; PCE; TCE; and vinyl chloride.

Although the parcels are not currently developed or occupied, they are zoned for residential use. The depths to groundwater in these areas are shallow (15 feet or less, based on 2008

water level measurements), and therefore may pose potential vapor intrusion threats if residences or buildings are constructed and occupied on these parcels. The depth to groundwater will need to be confirmed during a pre-design investigation. There are no current potential risks posed by vapor intrusion due to VOCs in groundwater because there are no current residences residing above the contaminated groundwater plume.

1.5 Groundwater Contaminant Fate and Transport

Soil in the former Source Area (underlying the excavation footprint and treated soil backfill) contains sorbed VOCs and other contaminants that will continually leach into and contaminate overburden and bedrock groundwater.

Groundwater concentrations in overburden, in particular the chlorinated aliphatics (PCE and TCE) and aromatic hydrocarbons (i.e. benzene, toluene, ethylbenzene, and xylenes [BTEX compounds]), appear to have undergone moderate to extensive natural attenuation or biodegradation as indicated by the initial rapid decline in VOC concentrations since the early 1980s. Generally, the VOC plume extent in the overburden and bedrock appears to have stabilized.

Overburden Groundwater - Overburden groundwater contaminant levels at the Site were highest in 1979 and 1980, and experienced a substantial decrease between 1980 and 1991. Sharp decreases of overburden total VOCs occurred between 1984 and 1991, before experiencing more gradual decreases or stabilizing over the next 17 years (through 2008). These early rapid decreases in total VOC concentrations are generally reflective of PCE and TCE degradation, accompanied by increases in vinyl chloride concentrations and unchanged cis-1,2-DCE concentrations (CDM, 1986; Nobis, 2009a).

Bedrock Groundwater - Decreases in VOC concentrations also appeared to have occurred in the bedrock groundwater. Concentrations in bedrock monitoring well OW-007, located approximately 1,000 feet north of the northern edge of the wetlands, decreased by approximately three orders of magnitude between 1984 and 2008. Concentration decreases are generally occurring at a slower rate in the bedrock groundwater (i.e., OW-094-R) compared to overburden groundwater. This is most likely a consequence of bedrock groundwater being

located farther from the wetlands, and, therefore, farther from the greater reducing conditions and retardation of organic chemical transport that are provided by the wetlands (Nobis 2009a).

Reductive Dechlorination - Reductive dechlorination is a process where chlorinated VOCs (i.e., PCE, TCE) can be degraded through the replacement of the chlorine ions by hydrogen. Reductive dechlorination can occur through biotic or abiotic processes. During biological reductive dechlorination, the chlorinated VOCs are used by microbes as electron acceptors during oxidation-reduction reactions that provide energy for the microbes' metabolic processes when the chlorine ions on the VOC molecules are substituted by hydrogen ions.

Under anaerobic conditions, PCE can degrade readily to TCE and cis-1,2-DCE through reductive dechlorination. However, the degradation from cis-1,2-DCE to vinyl chloride or the degradation of vinyl chloride to ethene is much slower. Vinyl chloride can be degraded through oxidation to carbon dioxide, water, and chloride. However, in a reducing environment, degradation of vinyl chloride can diminish or stall, leading to vinyl chloride accumulation. The principal electron acceptors in groundwater near disposal sites in decreasing hierarchy of usage by microbes include: dissolved oxygen (DO), nitrate, manganese (IV), iron (III), sulfate, carbon dioxide, and chlorinated VOCs (solvents). Typically a consortium of microbes that are capable of using different redox processes exist in the subsurface environment. Reductive dechlorination usually occurs under sulfate-reducing and methanogenic conditions.

At the Site, there are significant lines of evidence that indicate biological reductive dechlorination has previously occurred and is currently ongoing in certain areas of the Site. This assessment is based on the decreasing concentrations of chlorinated VOCs, DO, nitrate, sulfate, and carbon dioxide downgradient of the flow path from the former Source Area (including the NDA and SDA). In addition, a plume with active reductive dechlorination would typically have increasing concentrations of certain constituents including nitrite, sulfide, methane, hydrogen, alkalinity, chloride, Fe (II), Mn (II), ethene, and chlorides. The formation of cis-1,2-DCE and vinyl chloride are also indications of reductive dechlorination.

Groundwater samples were analyzed for these natural attenuation geochemical parameters including chloride and dissolved gases (ethane, ethane, and methane). DO and oxidation-reduction potential (ORP) were also collected during 2002 and 2003 that provided indications of

geochemical suitability for reductive dechlorination. Indications of on-going reductive dechlorination are supported by the following geochemical lines of evidence (URS, 2006):

- Depleted concentrations of DO (generally < 0.5 milligrams per liter [mg/L]);
- Low ORP values (generally < 0), suggestive of reducing conditions;
- Elevated concentrations of sulfate, ferrous iron (Fe II), and manganese (Mn), which are suggestive of reducing conditions;
- Elevated concentrations of ethane, ethene, and methane, indicative of biodegradation proceeding to complete mineralization of contaminants; and
- Elevated concentrations of carbon dioxide and chloride (compared to background conditions), which imply biodegradation is occurring.

The 2008 groundwater VOC and geochemistry data were evaluated to assess the potential for reductive dechlorination using the natural attenuation screening protocol (EPA, 1998). The geochemical data for each monitoring well were assigned scores (Appendix A) and the results for the overburden and bedrock plumes are depicted in Figure 1-15 and Figure 1-16, respectively. The results of the evaluation indicated the following (Nobis, 2008):

- Natural attenuation in the overburden aquifer appears to be robust in the former Source Area and downgradient to OW-043. The footprint of the PCE and TCE extent exceeding MCLs approximates this zone of reductive dechlorination.

- In the overburden, current subsurface conditions indicate a strongly reducing subsurface environment. PCE and TCE concentrations will likely continue to decline. However, cis-1,2-DCE and vinyl chloride presence downgradient of the PCE and TCE extent are increasing and accumulating, indicating that reductive dechlorination has stalled in this portion of the aquifer because of unfavorable subsurface and reduction/oxidation conditions. In part, the electron donors in the downgradient portions of the plumes appear to have been depleted

- Natural attenuation in the bedrock aquifer appears to be active in the former Source Area and downgradient to OW-007. The footprint of the PCE and TCE extent approximates this zone of reductive dechlorination.

- In the bedrock, there are two zones of PCE and TCE presence: one in the former Source Area and the second in the area north of the wetlands area. Vinyl chloride is primarily associated with the former Source Area. In the second area, the vinyl chloride presence is limited.

The natural attenuation screening results suggest that subsurface conditions are conducive for the reductive dechlorination of highly chlorinated VOCs such as PCE, TCE, and to a lesser extent, cis-1,2-DCE. However, outside these zones of reductive dechlorination, anaerobic degradation of cis-1,2-DCE to vinyl chloride or of vinyl chloride to ethene is likely very slow or nonexistent, and further degradation of cis-1,2-DCE and vinyl chloride have stalled.

Attenuation generally occurred/occurs faster in the overburden groundwater as a result of transport to the wetlands and the large amount of aromatic hydrocarbons (i.e., BTEX) disposed directly to the overburden soil with the liquid wastes that provided an impetus for reductive dechlorination.

Additionally, attenuation of the groundwater contaminant plume also appears to be due to the 1999 through 2001 source removal action.

1.6 Human Health Risk Evaluation

A human health risk assessment (HHRA) was prepared in 1986 in support of the RI (CDM, 1986). Because of the age of the data and the evaluation, a streamlined human health risk evaluation was completed as part of this FFS using the 2008 groundwater VOC data (ESS, 2009). Potential exposures to SVOCs, pesticides, PCBs, and metals in groundwater were also evaluated using data collected prior to 2008 (ESS, 2007). The methods used and results of the risk evaluation are presented in the *Conceptual Site Model Technical Memorandum Addendum* (Nobis, 2009b).

Although the Site groundwater is not currently used as potable water, the risk evaluation conservatively assumed that groundwater could potentially be used as potable water. The risk evaluation quantified potential risks to future on-site residents from exposures to VOCs in groundwater if groundwater was used as a potable supply. Because the 2008 samples were only analyzed for VOCs, review of groundwater data collected prior to 2008 was also performed

to discuss risks from non-VOCs. Limited SVOCs, pesticide, PCBs, and metals groundwater data, collected during 2003 and 2004 monitoring, were qualitatively used to estimate drinking water risks from non-VOCs.

Results for the evaluation of potential exposures to Site contaminants are presented in the following sections.

1.6.1 VOCs Risk Evaluation

Risks from exposures to VOCs in groundwater were evaluated separately for overburden and bedrock groundwater data collected in 2008. Ingestion of potable water was evaluated quantitatively using maximum VOC concentrations and standard reasonable maximum exposure assumptions for residential drinking water exposure scenarios. Dermal contact and inhalation exposure to potable water were evaluated qualitatively, as recommended by EPA, by setting the dermal contact plus inhalation risks for VOCs equal to the risk calculated for the ingestion pathway.

Results of the risk evaluation indicated that exposure to groundwater VOCs may pose potential carcinogenic and non-carcinogenic risks:

- The cancer risk estimate for residents exposed to VOCs in overburden groundwater as drinking water is 1.1 E-02 (Table 1-4). Vinyl chloride, PCE, TCE, ethylbenzene, and 1,1-DCA are the greatest contributors to cancer risks in overburden groundwater with individual cancer risks exceeding 1 E-05. In addition, cancer risks from 1,1,2-trichloroethane (1,1,2-TCA), benzene, and 1,4-dichlorobenzene exceed 1 E-06.

- The total Site HI for residents exposed to VOCs in overburden groundwater as drinking water is 27. Vinyl chloride and cis-1,2-DCE are the greatest contributors to the total Site HI in overburden groundwater with individual HIs exceeding 1.0.

- The cancer risk estimate for residents exposed to VOCs in bedrock groundwater as drinking water is 8.2 E-03 (Table 1-5). Vinyl chloride, carbon tetrachloride, PCE, TCE, 1,1-DCA, ethylbenzene, benzene, and 1,1,2-TCA are the greatest contributors to cancer

risks in bedrock groundwater with individual cancer risks exceeding 1 E-05. In addition, cancer risks from 1,2-DCA, methylene chloride, and 1,4-dichlorobenzene exceed 1 E-06.

- The total Site HI for residents exposed to VOCs in bedrock groundwater as drinking water is 54. Cis-1,2-DCE, carbon tetrachloride, and vinyl chloride are the greatest contributors to the total Site HI in bedrock groundwater with individual HIs exceeding 1.0.

- Risk calculations were not performed for tetrahydrofuran detected in 2008 groundwater sampling because there are no fully vetted toxicity values available.

1.6.2 SVOCs Risk Evaluation

Risks from exposures to SVOCs in groundwater were evaluated separately for overburden and bedrock groundwater data collected in 2003. The risk estimates applied a ratio approach based on comparison of maximum groundwater concentrations to risk-based screening criteria. These rough qualitative risk estimates for the most current groundwater SVOCs data (2003) are presented in Table 1-6 and Table 1-7. Results of the risk evaluation indicated that exposure to groundwater SVOCs may pose potential carcinogenic risks:

- Total cancer risk from exposures to SVOCs in overburden and bedrock groundwater used as drinking water are estimated at 2.5 E-04 and 2.1 E-03, respectively. Bis(2-chloroethyl)ether, nitrobenzene, naphthalene, and pentachlorophenol, each with individual cancer risks exceeding 1E-06, are the only contributors to the cancer risk estimate for overburden groundwater. However, bis(2-chloroethyl)ether, nitrobenzene, and pentachlorophenol were infrequently detected (1 in 20 samples each). Bis(2-chloroethyl)ether and naphthalene, each with individual cancer risks exceeding 1E-06, are the only contributors to the cancer risk estimate for bedrock groundwater. However, naphthalene was detected in only 1 of 21 samples.

- The 2003 groundwater data indicate that naphthalene was detected in samples collected from three overburden monitoring wells within the former Source Area and in one bedrock monitoring well at a downgradient location.

- The 2003 groundwater data indicate that BCEE was detected only in samples collected from monitoring wells (one overburden and four bedrock) situated downgradient of the former Source Area.

- The estimated total Site HIs from exposures to SVOCs in overburden and bedrock groundwater used as drinking water are each less than 1.0.

1.6.3 Pesticides/PCBs Risk Evaluation

Risks from exposures to pesticides and PCBs in groundwater were evaluated for groundwater data collected in 2003. Overburden and bedrock data were not evaluated separately. The risk estimates applied a ratio approach based on comparison of maximum groundwater concentrations to risk-based screening criteria. These rough qualitative risk estimates for the most current groundwater pesticides data (2003) are presented in Table 1-8. PCBs were not detected in any of the 2003 groundwater samples; PCBs do not appear to be a COC for the Site. Results of the risk evaluation indicated that exposure to groundwater pesticides may pose relatively small potential carcinogenic risks:

- Total cancer risk from exposures to pesticides in Site groundwater used as drinking water is estimated at 7.3 E-06. Primary contributors to risk are aldrin, dieldrin, and heptachlor, each with individual cancer risks exceeding 1E-06.

- The estimated total Site HI from exposures to pesticides in groundwater used as drinking water is less than 1.0.

1.6.4 Metals Risk Evaluation

Risks from exposures to metals in groundwater were evaluated separately for overburden and bedrock groundwater data collected in 2004. The risk estimates applied a ratio approach based on comparison of maximum groundwater concentrations to risk-based screening criteria. These rough qualitative risk estimates for the most current groundwater metals data (2004) are presented in Table 1-9 and Table 1-10. Results of the risk evaluation indicated that exposure to groundwater metals poses potential carcinogenic and non-carcinogenic risks:

- Total estimated cancer risks from exposures to metals in Site overburden and bedrock groundwater used as drinking water are 4.3 E-04 and 3.9 E-04, respectively. Arsenic is the sole contributor to the cancer risk estimates for both aquifers.

- The estimated total Site HIs for metals in overburden and bedrock groundwater used as drinking water are 65 and 10, respectively. The prime contributors to the HI for metals in the overburden are mercury and manganese, each with individual HIs exceeding 1.0. The prime contributor to the HI for metals in the bedrock is manganese, with individual HI of 9.1. Iron and cobalt in the overburden groundwater and iron in the bedrock groundwater also contribute to the total HI for metals with individual HIs of slightly less than 1. Manganese appears to be naturally occurring in soil at the Site, but reductive dechlorination conditions within the plume result in conversion of manganese to a more soluble and mobile state leading to higher manganese concentrations than would be typically found in groundwater.

- Because mercury was infrequently detected (1 of 159 samples collected during 2001 through 2005 groundwater monitoring), risk from mercury exposure is not a site-wide issue. Mercury is not considered a groundwater contaminant.

- While iron is a contributor to the total HI, iron is not considered to represent potential risk because the RSL used to estimate risk is based on concentrations needed to protect against nutritional deficiency rather than on toxicity.

1.6.5 Cumulative Health Risks Summary

As noted above, risk estimates were based on maximum site-wide concentrations in each aquifer. Adding the risk estimates for the various contaminant groups discussed in Section 1.6.1 through Section 1.6.4 yields the following total site contaminant cancer risks and HIs for exposures to groundwater as drinking water:

- Total estimated cancer risks from exposures to contaminants in Site overburden groundwater used as drinking water are 1.2 E-2.
- Total estimated cancer risks from exposures to contaminants in Site bedrock groundwater used as drinking water are 1.1E-2.

- For both aquifers, vinyl chloride is the primary contributor to cancer risks. Other VOCs, SVOCs, arsenic, and pesticides contribute to lesser degrees.
- The estimated total Site HI from exposures to contaminants in Site overburden groundwater used as drinking water is 92.
- The estimated total Site HI from exposures to contaminants in Site bedrock groundwater used as drinking water is 64.
- For the overburden aquifer, mercury, vinyl chloride, manganese, and cis-1,2DCE are the primary contributors to non-cancer risks.
- For the bedrock aquifer, cis-1,2DCE, carbon tetrachloride, vinyl chloride, and manganese are the primary contributors to non-cancer risks.

1.6.6 Well-by-Well Risk Evaluation

To better evaluate the extent of groundwater risks from VOCs across the Site, a rough estimate of well-by-well risks was developed and presented in the CSM Addendum (Nobis, 2009b). Appendix B, Table B-1, and Table B-2, present well-by-well risks expanded to include the primary contributors to risks from SVOCs, metals, and pesticides, as well as, VOCs. These well-by-well risk estimates are based on comparison of 2008 VOC and the most recent non-VOC (2003 and 2004) individual contaminant groundwater concentrations for the primary contributors to risk (as discussed in Section 1.6.1 through Section 1.6.4) to risk-based screening criteria. Total risks and HIs at each well and total risks and HIs by chemical group at each well are presented. In addition, to the far right, average well risks and HIs for each contaminant and the cumulative totals of the average well risks and HIs are presented. These average well risks and HIs for the overburden and bedrock aquifers are presented in Table 1-14A and Table 1-14B, respectively. Individual well risks and HIs are depicted on Figure 1-19 and Figure 1-20. The well-by-well risks are summarized below:

- Total carcinogenic risks in the overburden plume range from zero to 3E-2 (OW-052). Overburden groundwater within the contaminant plume with total carcinogenic risks exceeding 1 E-05 extends from the former Source Area and downgradient beyond OW-038 (Figure 1-19). The majority of the carcinogenic risks in overburden groundwater are driven by vinyl chloride concentrations, and to a lesser extent by PCE, TCE, and arsenic. Total HIs in the overburden plume range from zero to 63 (OW-045).

The primary non-carcinogenic risk drivers were mercury, manganese, vinyl chloride, and to a much lesser extent cis-1,2-DCE.

- Total carcinogenic risks in the bedrock plume range from zero to 2E-2 (OW-094R). Bedrock groundwater within the contaminant plume with total carcinogenic risks exceeding 1 E-05 extends from the former Source Area and downgradient to OW-007 (Figure 1-20). The majority of the carcinogenic risks are caused by vinyl chloride, BCEE, PCE, arsenic, and to a lesser degree by TCE, carbon tetrachloride, ethylbenzene, benzene, and 1,1-DCA. Total HIs in the bedrock plume range from zero to 13 (OW-94-R). The primary non-carcinogenic risk drivers were manganese, vinyl chloride, and to a lesser extent PCE, cis-1,2-DCE, carbon tetrachloride, arsenic, and naphthalene.

Average well risks, presented on Table 1-14A and Table 1-14B, provide a clearer understanding of the contribution of each contaminant to risks across the plume:

- For the overburden aquifer, total average well cancer risks are 4.4E-3, with 97 percent of the risk resulting from exposures to vinyl chloride. Total average well HI is 10 with 87 percent resulting from exposures to iron, mercury, and manganese combined, 9 percent from vinyl chloride and 2 percent from cis-1,2-DCE.

- For the bedrock aquifer, total average well cancer risks are 1.7E-3, with 81 percent of the risk resulting from exposures to vinyl chloride, 11 percent from BCEE, and 2 percent from arsenic. Total average well HI is 5 with 82 percent resulting from exposures to iron, manganese, and arsenic combined, 7 percent from vinyl chloride, 6 percent from cis-1,2-DCE, and 4 percent from carbon tetrachloride.

2.0 REMEDIAL OBJECTIVES

Remedial alternatives are developed by assembling combinations of technologies into an appropriate range of alternatives that address the site contaminants and potential risks posed by exposure to the contaminants. This section presents the development of remedial action objectives (RAOs), which are goals used in the development of remedial alternatives (Section 3 and Section 4). The overall RAO process consists of the following steps:

- Identify applicable or relevant and appropriate requirements (ARARs) and non-regulatory guidances or criteria and potential risks associated with exposure to site contaminants that need to be considered in the RAOs formulation.

- Develop RAOs that are protective of human health and the environment and specify the contaminants, media of concern (i.e., groundwater), and exposure pathways.

- Develop PRGs that permit a range of treatment and containment alternatives.

2.1 Applicable or Relevant and Appropriate Requirements (ARARs)

Section 300.430 (f) of the NCP requires that on-site remedial actions at CERCLA sites meet ARARs under federal or state environmental or facility siting laws unless there are grounds for invoking a waiver. A waiver is required if ARARs cannot be achieved. Other federal and state advisories, criteria, or guidance, as appropriate, are to be considered in formulating the remedial action.

ARARs are promulgated, enforceable federal and state environmental or public health requirements. ARARs requirements under CERCLA pertain to on-site activities only. There are two categories of requirements: "applicable" and "relevant and appropriate." These categories are defined below:

Applicable Requirements - Section 300.5 of the NCP defines applicable requirements as "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site."

Relevant and Appropriate Requirements - Section 300.5 of the NCP defines relevant and appropriate requirements as "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site."

To-be-considered (TBC) guidelines are non-promulgated criteria, advisories, and guidance issued by the federal or state governments. Along with ARARs, TBCs may be used to develop the interim action limits necessary to protect human health and the environment.

ARARs and TBCs are divided into three categories: chemical-specific, location-specific, and action-specific; these are briefly described in Section 2.1.1 through Section 2.1.3. The evaluation of compliance of remedial alternatives with ARARs is presented in Section 5.0.

2.1.1 Chemical-Specific ARARs

Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies, when applied to site-specific conditions, result in the determination of numerical values that establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Typically, chemical-specific requirements are set for a single chemical or a closely related group of chemicals. These requirements do not consider the mixture of chemicals.

2.1.2 Location-Specific ARARs

Location-specific ARARs are typically restrictions placed on the concentrations of hazardous substances, or the conduct of activities solely because they are in specific areas. Typically, the location-specific ARARs are pertinent to wetlands, floodplains, or the presence of endangered species at sites where remedial actions may occur.

2.1.3 Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are generally focused on actions taken to remediate, handle, treat, transport, or dispose of hazardous wastes. These action-specific requirements may not in themselves determine the remedial alternative; rather, they may indicate how a selected alternative must be implemented.

2.2 Development of Remedial Action Objectives

RAOs consist of media-specific goals for protecting human health and the environment. The RAOs specify the media and contaminants of concern, exposure routes and receptors, and PRGs for each exposure route. By specifying both exposure pathways and PRGs, the RAOs permit the development of a range of alternatives that may achieve protection by reducing exposure to contaminated media (i.e., reducing groundwater contaminant concentrations, institutional controls).

The RAOs for the Davis Liquid Waste Site define specific remediation goals that will reduce the unacceptable risks identified in the risk evaluations and address the risk-based concentrations or chemical-specific standards that are likely to be exceeded if no action is taken. RAOs are limited to media, geographic areas, and chemicals for which estimated risk exceeds EPA target risk ranges or chemical-specific standards.

Evaluation of past RI and PDEI data has determined that soil contaminants in the former Source Area above the water table (unsaturated) pose potential threats to groundwater quality through leaching.

VOCs have been identified in the saturated unexcavated soil residing below the water table in the former Source Area, and constitute the core of the groundwater VOC plumes. RAOs for groundwater were developed based on the results of the RI, the human health risk assessment, evaluation of 2008 soil and groundwater data and the associated risks, and ARARs identification. This section presents the three major components of the RAO development process: formulating RAOs, identifying COCs, and determining PRGs.

Basis for Action

The basis for action for the Site includes the following:

- Soil
  - The VOCs sorbed to untreated saturated soil (below water table) in the former Source Area are continually leaching into and degrading groundwater quality such that state aquifer and drinking water standards are exceeded.

  - The VOCs still remain in treated unsaturated soil backfill (above water table) in the former Source Area and may be leaching into and degrading groundwater.

  - VOCs are present in the former Source Area soil at concentrations that exceed allowable standards (RIDEM's Remediation Regulations Leaching Criteria) or criteria (EPA's leaching-based Soil Screening Levels), which indicate that contaminated soil will continue to degrade groundwater quality in excess of drinking water standards (MCLs) and the RIDEM groundwater GA Objectives.

- Groundwater
  - The cumulative excess carcinogenic risk to an individual that may use groundwater affected by Site contamination exceeds E-04 (using reasonable maximum exposure [RME] assumptions for either the current or reasonably anticipated future land use).

  - The non-carcinogenic HI for use of contaminated groundwater is greater than 1.0 (using RME assumptions for either the current or reasonably anticipated future land use).

  - Chemical-specific standards (MCLs and RIDEM GA Objectives) are exceeded and exposure to contaminants as a result of these levels is predicted for the RME scenario.

2.2.1 Identification of Media of Concern

The media of concern for the Site were identified based on the results of the site-specific RI human health risk assessment, evaluation of the potential of soil contaminant leaching to groundwater, and the risk evaluations of potential exposures to groundwater (tap water scenario) that were performed as part of the FFS development process.

Soil

The *Conceptual Site Model Technical Memorandum Addendum* (Nobis, 2009b) identified soil as a medium of concern. VOCs in the untreated saturated soil (below water table) and possibly in the treated unsaturated soil backfill (above water table) in the former Source Area represent continuing sources of groundwater contamination based on: screening of contaminant concentrations against MCL-based and risk-based various leaching criteria, extent of soil contamination, and presence of contaminants in groundwater exceeding MCLs or risk-based concentrations that are protective of human health.

Based on the assessment of Phase 4 (2008) data, five VOCs detected in the untreated saturated soil in the former Source Area were identified as contaminants of concern (COCs) that may pose threats to groundwater quality. These COCs include: PCE, TCE, cis-1,2-DCE, vinyl chloride, and 1,1-DCA. Review of post-treatment data from the 1999 source control remedial action indicated that VOCs were present in the previously treated unsaturated soil backfill in the former Source Area that can contribute to groundwater contamination.

The untreated saturated soil (below the water table) and the treated unsaturated soil backfill (above the water table) in the former Source Area constitute the sources of contamination to the overburden and bedrock groundwater plumes. **For the purpose of this FFS, the untreated saturated soil and the treated unsaturated soil backfill in the former Source Area are collectively defined as the "plume core" and will be addressed under the groundwater response alternatives.**

Groundwater

Groundwater at the Site was identified as a medium of concern in the RI Report (CDM, 1986), assuming the future use of Site groundwater as drinking water for future on-site residents. Further evaluation of risk from groundwater was performed in the *Conceptual Site Model Technical Memorandum Addendum* (Nobis, 2009b) using 2008 (Phase 4) groundwater VOCs data.

Overburden and bedrock groundwater occurring beneath the former Source Area and downgradient portions of the aquifers pose potential excess health risks if used as a potable supply. Potential COCs for overburden groundwater that pose potential risk include: vinyl chloride, PCE, TCE, ethylbenzene, 1,1-DCA, 1,1,2-TCA, benzene, 1,4-dichlorobenzene, and cis-1,2-DCE. Potential COCs for bedrock groundwater that pose potential risk include: vinyl chloride, carbon tetrachloride, PCE, TCE, 1,1-DCA, ethylbenzene, benzene, 1,1,2-TCA, 1,2-DCA, methylene chloride, 1,4-dichlorobenzene, and cis-1,2-DCE. Risk calculations were not performed for the tetrahydrofuran detected in 2008 groundwater sampling because there are no fully vetted toxicity values available. Also, bis(2-chloroethyl)ether remains a potential COC in groundwater based on a rough risk estimate performed through comparison of maximum groundwater concentrations in samples collected from 2001 through 2005 to risk-based screening criteria (Nobis, 2009b).

2.2.2 Groundwater Remedial Action Objectives

Groundwater RAOs were developed to: meet ARARs; address human health risks posed by potential exposure to Site contaminants; address contaminated groundwater migration; and to take into consideration the NCP's expectation to return groundwaters to their beneficial uses, whenever practicable, within a time frame that is reasonable (per 40 CFR 300.430 (a)(1)(iii)(F)). Based on the risk evaluations and the anticipated future use of the Site and surrounding parcels, the following groundwater RAOs were developed:

Protection of Human Health Groundwater RAOs

- Prevent exposure to groundwater with contaminant concentrations that exceed MCLs, non-zero MCLGs, the RIDEM-GA, or pose excess cancer risk of 1E-06 or a non-carcinogenic risk exceeding an HI of 1.0.

- Restore groundwater quality to below MCLs, non-zero MCLGs, the RIDEM-GA, or chemical concentrations that result in excess cancer risk of 1E-06 or less, or a non-carcinogenic HI of 1.0 or less.

Protection of the Environment Groundwater RAO

- Prevent the further migration of contaminants beyond their current extent.

2.3 Contaminants of Concern (COCs)

Potential COCs are identified and evaluated, and COCs are selected that pose human health risks, exceed ARARs, or pose potential threats to the environment.

2.3.1 Potential COCs

Potential groundwater COCs were identified based on the available Site data and risk evaluations. Groundwater contaminants with estimated cancer risks greater than 1 E-06 or HIs greater than 1.0, as identified in Section 1.6, were included as potential groundwater COCs. Table 2-1A and Table 2-1B present the potential COCs identified as the result of the risk screening process. These tables present human health risk screening results developed in the *Conceptual Site Model Technical Memorandum Addendum* (Nobis, 2009b) and as presented in Section 1.6 of the FFS. Table 2-1A and Table 2-1B present the chemicals along with ARARs (federal MCLs and RIDEM GA Objectives), To-Be-Considered values (EPA RSLs), estimated maximum and average risks, maximum plume concentrations, and frequency above screening values (federal MCLs, RIDEM GA Objectives, or EPA RSLs, if MCLs or RIDEM GA Objectives are not available).

VOCs

The *Conceptual Site Model Technical Memorandum Addendum* (Nobis, 2009b) indicates that cancer risks from exposures to both overburden and bedrock groundwater exceeded EPA's target risk range of 1 E-06 to 1 E-04 and RIDEM's benchmark of 1 E-05. Cancer risks from exposures to overburden groundwater were greater than 1 E-06 for vinyl chloride, PCE, TCE, ethylbenzene, 1,1-DCA, 1,1,2-TCA, benzene, and 1,4-dichlorobenzene. Non-cancer HIs exceeded 1.0 for vinyl chloride and cis-1,2-DCE. Cancer risks from exposures to bedrock groundwater were greater than 1 E-06 for vinyl chloride, carbon tetrachloride, PCE, TCE, 1,1-DCA, ethylbenzene, benzene, 1,1,2-TCA, 1,2-DCA, methylene chloride, and 1,4-dichlorobenzene. Non-cancer HIs exceeded 1.0 for cis-1,2-DCE, carbon tetrachloride, and vinyl chloride. These potential COCs for overburden and bedrock groundwater were carried forward into the COC selection process.

SVOCs

The risk evaluation process also identified the SVOCs BCEE, naphthalene, nitrobenzene, and pentachlorophenol as potential COCs based on cancer risk exceeding 1E-06. BCEE was detected in one overburden and three bedrock monitoring wells situated downgradient of the former Source Area (out of 41 samples). BCEE is a potential groundwater COC. Naphthalene was detected in overburden groundwater in the former Source Area and in downgradient overburden and bedrock groundwater at concentrations that pose potentials risks and exceeded the EPA RSL. Naphthalene is a potential groundwater COC. Nitrobenzene and pentachlorophenol were each detected in one sample that exceeded the EPA tapwater RSL, and both are potential COCs.

Metals

The risk evaluation identified arsenic, manganese, and mercury in the groundwater as posing potential health risks. Arsenic was detected in only three monitoring wells downgradient of the former Source Area. Evaluation of soil and groundwater data determined that the former Source Area did not appear to be a source of arsenic in groundwater. Arsenic is a potential groundwater COC. Cancer risks from exposure to arsenic exceeded 1E-06.

Manganese was identified in most groundwater throughout the Site posing excess non-carcinogenic risks. Individual HIs from exposure to manganese in overburden and in the bedrock exceeded 1.0. Evaluation of the RI and PDEI data determined that soil manganese concentrations in the former Source Area were comparable to those in the background locations. Naturally occurring manganese appears to have been mobilized as the result of the ongoing reductive dechlorination of chlorinated VOCs that were released at the Site and are present in and downgradient of the former Source Area. Manganese is a potential groundwater COC.

Mercury was detected in only one overburden location exceeding the MCL and the EPA tapwater RSL, and the individual HI from exposure to mercury in the overburden exceeded 1.0. However, mercury is not considered a potential COC because of its infrequent detection in both the overburden and bedrock aquifers.

Pesticides

The risk evaluation identified the presence of aldrin, dieldrin, and heptachlor in groundwater at concentrations that exceeded screening criteria or represented carcinogenic risks exceeding 1 E-06. These three pesticides are potential groundwater COCs.

2.3.2 Selection of COCs

Table 2-1A and Table 2-1B present the COC selection process for overburden and bedrock groundwater, respectively. Potential COCs are selected as COCs if maximum or average concentration for that chemical exceeds ARARs (MCLs or RIDEM GA Objectives), or in the absence of ARARs, if human health cancer risk results exceed 1E-06 or Hazard Index of 1.0 and the RSL is exceeded. If a chemical was infrequently detected (i.e. 1 in 20 or fewer) above the screening level, it was not included as a COC even if it exceed ARARs or posed potential excess risks. If a chemical poses risk, but all detected concentrations are below the MCL or RIDEM GA Objectives, it was not selected as a COC.

The selection of the COCs is to facilitate the evaluation and selection of remedial technologies and process options. Chemicals that are not selected as COCs may still be related to the release of wastes and contaminants at the former Source Area, and contribute to the overall

human health risks. The primary COCs will be used to represent all contaminants in the FS technology screening process. It is anticipated that the selection of remedial technologies to address the COCs will also be applicable to other Site contaminants that have similar physical or chemical characteristics.

Overburden Groundwater COCs

In overburden groundwater (Table 2-1A), a number of VOCs were identified as potential COCs that contributed significantly to risk or exceeded screening criteria. Several VOCS were infrequently detected or did not exceed ARARs, and are not considered to be COCs including: 1,1,2-trichlorethane; 1,4-dichlorbenzene; ethylbenzene; and methylene chloride. Vinyl chloride, PCE, TCE, 1,1-DCA, and cis-1,2-DCE were selected as the VOC COCs based on the risks posed and their presence in the plume.

The SVOCs BCEE, naphthalene, nitrobenzene, and pentachlorophenol were identified as posing excess risk. However, naphthalene concentrations did not exceed the RARAs and nitrobenzene and pentachlorophenol were infrequently detected in groundwater. These SVOCs are not considered COCs. BCEE was selected as the SVOC COC based on the risks posed and exceedance of the EPA tapwater RSL.

Arsenic and manganese concentrations exceeded screening levels and are therefore COCs. Mercury was infrequently detected (only 1 in 20 samples) in overburden groundwater, and not at all in bedrock. Because mercury is seldom found in groundwater, it is not a groundwater COC. Cobalt and iron concentrations did not exceed the screening values and, therefore, are not groundwater COCs.

The pesticide aldrin exceeded the screening values and is a COC. Dieldrin and heptachlor concentrations did not exceed screening values and are not overburden groundwater COCs.

Bedrock Groundwater COCs

In bedrock groundwater (Table 2-1B), similar to the overburden, several VOCs were identified as potential COCs that contributed significantly to risk or exceeded screening criteria. However, because a number of the detected VOCs were infrequently detected or did not

exceed ARARs, these were not selected as COCs including: 1,2-DCA; 1,1,2-trichloroethane; 1,4-dichlorobenzene; carbon tetrachloride; cis-1,2-DCE, ethylbenzene; and methylene chloride. Vinyl chloride, PCE, TCE, benzene, and 1,1-DCA were selected as the VOC COCs based on the risks posed and their presence in the plume.

The SVOCs BCEE and naphthalene were identified as posing excess cancer risks. However, naphthalene concentrations did not exceed ARARs and is not considered a COC. The SVOC BCEE was selected as the SVOC COC based on the risks posed and exceedance of the EPA RSL.

Arsenic and manganese concentrations exceeded screening levels and are COCs. Iron concentrations did not exceed the screening value and, therefore, is not a COC.

The pesticide dieldrin exceeded the screening values and is a COC. Aldrin and heptavhlor did not exceed the screening values and, therefore, are not groundwater COCs in bedrock.

2.4 Preliminary Remediation Goals (PRGs)

PRGs were developed for the Site to establish target cleanup goals for potential remedial actions that may be required to reduce concentrations of contaminants in groundwater, or to mitigate unacceptable risks to human health and the environment. The PRGs are proposed cleanup levels that are based on human health risks and ARARs and are intended to be protective of human health. Final cleanup goals selected for the Site remedial action will be documented in an amended Record of Decision

PRGs are developed to determine the degree of remediation necessary to protect human health and the environment. The PRGs must be protective of each of the principal receptors identified at the Site, and they should be reasonable and practical to implement. PRGs can be developed based on chemical-specific ARARs, when available, or risk-based factors.

Potential groundwater PRGs were calculated (as shown in Appendix B) using several different threshold values for human cancer and non-cancer risks, to provide risk managers with a wider range of options for reducing human health risks at the Site: these risk threshold values were 1E-06, 1E-05, and 1E-04 (cancer risk) and an HI of 1.0 (non-cancer risk). These PRGs were

calculated for groundwater COCs identified in Section 2.3, Table 2-1A, and Table 2-1B assuming a residential drinking water scenario. Although groundwater at the Site is not currently used for drinking water and there are no plans to use groundwater at the Site for drinking water in the future, no restrictions on such use are currently in place. Therefore, a drinking water use scenario was evaluated (Nobis, 2009b) and human health risk-based PRGs were developed for this residential scenario.

Under the exposure scenario of groundwater as a drinking water source, human health risk-based PRGs were derived for groundwater using the equations presented in Appendix B, Table B-3, and Table B-4. Drinking water exposure assumptions are the same for both overburden and bedrock aquifers, therefore, a single set of risk-based PRGs is developed for application to both aquifers. Appendix B, Table B-3, and Table A-4 present cancer risk-based PRGs and non-cancer hazard index-based PRGs, respectively.

Table 2-2 presents the risk-based PRGs for groundwater under the drinking water exposure scenario based on the 1 E-06 cancer risk level and/or an HI of 1.0 as well as an evaluation of ARARs. Cancer risk-based PRGs based on 1 E-06 cancer risk level represent the most conservative of the cancer-risk based PRGs, and therefore, these were selected as the most protective of cancer risks for consideration in the selection of proposed PRGs. This approach ensures that the aggregate cancer risk from all contaminants combined will not exceed 1 E-05. For contaminants with both cancer-based and non-cancer-based PRGs, the lower of the two values presented on Table 2-2 was selected as the human health risk-based PRG. For the majority of contaminants, cancer-risk-based PRGs are less than non-cancer (HI)-based PRGs. Table 2-2 also includes chemical-specific ARARs for groundwater. Proposed groundwater PRGs and the basis for their selection are presented to the far right. The proposed PRGs are the concentrations that would provide the highest level of protection of human health given the nature of the Site, the availability of a regulatory standard, and are reasonably achievable by current remediation techniques. PRGs were selected generally from the MCLs because these are legally enforceable standards for drinking water that are protective of human health.

3.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

Remedial alternatives were developed through the assembly of technologies and process options that are effective, implementable, and have reasonable costs to address Site contamination and to mitigate potential risks. The technology screening process consists of the identification of general response actions that might be used, which consist of general categories of actions that can address the RAOs. The technology types associated with each general response action are then identified along with the specific process options for those response actions. The technology types and process options are screened against effectiveness, implementability, and cost criteria to identify technology types and representative process options that can be assembled into alternatives.

In researching viable response actions and technologies, the following data sources were consulted:

- U.S. EPA Innovative Technology Program Contaminated Site Cleanup Information (CLU-IN) website: http://www.clu-in.org/
- Federal Remediation Technology Roundtable (FRTR) website: http://www.frtr.gov/matrix2/top_page.html
- Superfund Innovative Technology Evaluation (SITE) Program
- *Site Characterization and Technology Selection For CERCLA Sites With Volatile Organic Compounds In Soils and the User's Guide to the VOCs in Soils Presumptive Remedy* (EPA 540/F-96/008)
- *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (EPA 540/R-96/023)

Once technology types have been selected, specific process options are evaluated in greater detail in order to select representative process options that may be selected for the formulation of remedial alternatives. The RI/FS guidance suggests that the evaluation focus on the effectiveness criterion with less of an emphasis on the implementability and relative costs of the technology/process option. A general summary of each of the evaluation criteria is presented below:

- Effectiveness – The effectiveness criteria focuses on the potential success of candidate process options in managing the anticipated volume and mass of contaminants while achieving RAOs, given site-specific constraints. Additionally, the effectiveness criterion considers the potential impacts to human health and the environment during implementation and how proven or reliable the process may be with respect to site conditions or contaminants.

- Implementability – The implementability criterion consists of the technical and institutional feasibility of applying a candidate process option. The preliminary technology screening eliminates clearly unworkable or ineffective candidate process options based on technical limitations. The implementability evaluation also considers the institutional components such as: the availability of off-site treatment, storage, and disposal facilities, availability of equipment and vendors to implement the technology, and the ability to obtain permits for off-site actions.

- Relative Cost – The relative cost evaluation criterion is not weighed heavily in this screening step. The analysis is based upon engineering judgment as to whether the relative costs are "High", "Medium", or "Low" when compared to similar process options or other candidate technologies.

3.1 Estimated Volumes and Mass of Contaminated Media

The volumes of contaminated media or contaminant masses are considered during the technology and process option screening steps, and are of importance during the detailed cost evaluations. Volumes and masses considered in this FFS include:

- **Saturated Soil Volumes and Mass:**

  - **Untreated Saturated Soil** – Based on the 2008 soil contaminant analytical results, there is an estimated 170,000 yd^3 of contaminated saturated soil with 237 Kg of total VOCs sorbed mass underlying the former Source Area (Nobis, 2009b). **This contaminant mass, residing below the water table, is part of the core of the groundwater plumes.** Any groundwater remedial alternative will need to consider this mass for treatment evaluations or to determine natural attenuation durations.

- **Treated Unsaturated Soil Backfill** – Using data from the post-remediation test results, there is an estimated 38 Kg of total VOCs mass in the 45,000 yd^3 of treated backfill. **This contaminant mass, residing above the water table, is also a component of core of the groundwater plumes.**

- **Groundwater Volumes and Mass:**

  - **Overburden Groundwater** – Based on the Fall 2008 sampling results, there is an estimated 14,300,000 gallons of contaminated overburden groundwater that contains a total VOC mass of 24 Kg. These estimates represent the portion of groundwater that contains VOCs exceeding the MCLs or RIDEM GA Objectives, or have total estimated cancer risks exceeding 1 E-05. The portion of the overburden plume outside of and downgradient of the former Source Area is approximately 8,340,000 gallons (Nobis, 2009b).

  - **Bedrock Groundwater** – Available information regarding the bedrock fractures are somewhat limited**.** However, assuming the upper 30 feet of the fractured bedrock behaves as an equivalent porous medium, there is an estimated 9,000,000 gallons of contaminated bedrock groundwater that exceeds MCLs or RIDEM GA Objectives, or has total estimated cancer risks exceeding 1 E-05. Within the footprint of the bedrock contaminant plume, approximately 144 Kg of total VOCs are estimated to be present (Nobis, 2009b).

3.2 Groundwater General Response Actions and Remedial Technologies

In this section, potentially viable remedial technologies and process options are identified and screened according to their applicability to the contaminants in groundwater and subsurface conditions, and their technical and institutional implementability.

3.2.1 Identification and Screening of Groundwater Technologies and Process Options

VOCs, SVOCs, pesticides, and metals were identified as groundwater COCs. For this FFS, the technology screening focuses on the VOCs while the other COCs would be addressed primarily

through natural attenuation. VOCs, principally vinyl chloride, PCE, and TCE, represent 98 percent and 84 percent of the carcinogenic risks in overburden and bedrock groundwater, respectively (see Table 1-14A and Table 1-14B). BCEE (SVOC) represents 11 percent of the carcinogenic risks in bedrock.

Developing remedial alternatives that address these chlorinated VOCs will address the majority of the carcinogenic risks. BCEE is only present in a few bedrock locations and is relatively soluble and will likely be attenuated through dilution.

The elevated arsenic and manganese concentrations are the result of the ongoing reductive dechlorination of chlorinated VOCs. Once chlorinated VOCs are destroyed or degraded, the aquifer geochemical conditions will return to normal and these two metal concentrations will decline.

The two pesticides, aldrin and dieldrin, both represent very small fractions of total risk in the overburden and bedrock plumes. With attenuation by dilution, the pesticide concentrations are expected to decline below the EPA tapwater RSLs.

Contaminated saturated and unsaturated treated soils backfill in the former Source Area have been identified as continuing sources of groundwater contamination. Any remedial technology that addresses groundwater will also be able to address the saturated fill. Some remedial technologies that address contaminated groundwater can also address the contaminants in the unsaturated treated soil backfill. The technology evaluation will consider whether a technology type or process option can also address both contaminated soil. Contaminated soils are expected to be remediated, at a minimum, to meet the RIDEM's Remediation Regulations GA Leachability Criteria.

Table 3-1 summarizes the groundwater RAOs, the general response actions that may be used to attain the RAOs, and the preliminary identification of remedial technology types and process options that may be applicable to groundwater contaminants.

The general response actions developed for the Site groundwater include: No Action; Natural Attenuation; Limited Action; Containment; Collection, Treatment, and Discharge; and In-Situ Treatment.

3.2.2 Evaluation and Selection of Groundwater Process Options

Table 3-2 summarizes the evaluation of the candidate technologies and process options that are potentially applicable.

As a result of the screening evaluation, all technology types were retained while several process options were eliminated. Some of the vertical barrier containment technologies were eliminated due to the lack of a viable aquitard above the fractured bedrock surface to key into for adequate containment, which would prevent adequate vertical control of contaminated groundwater migration. Additionally, these technologies would not address contamination in the bedrock aquifer. Some other process options were eliminated because of incompatibility with Site contaminants, the relatively low concentrations of VOCs present, or the inability to recharge treated groundwater into the subsurface due to local geologic conditions. Some of the in-situ physical treatment technologies were eliminated due to an inadequate thickness of the vadose zone outside of the former Source Area, rendering vapor extraction ineffective.

Technology types and process options that were retained include:

- No Action

- Natural Attenuation – Biological Processes
  - Aerobic biodegradation
  - Anaerobic biodegradation

- Natural Attenuation – Physical Processes
  - Advection/dispersion
  - Adsorption

- Limited Action
  - Long-Term Monitoring
  - Sampling
  - Institutional Controls

- Containment – Vertical Barriers
  - Hydraulic containment

- Collection, Treatment, and Discharge – Collection/Extraction
  - Extraction Wells

- Collection, Treatment, and Discharge – Physical Treatment
  - Equalization
  - Dewatering
  - Sedimentation
  - Oil/water separation
  - Filtration
  - Air stripping
  - Carbon adsorption

- Collection, Treatment, and Discharge – Chemical Treatment
  - Ion exchange
  - Enhanced oxidation
  - Neutralization
  - Flocculation/precipitation

- Collection, Treatment, and Discharge – Discharge
  - Direct discharge

- In-Situ Treatment – Thermal Treatment
  - Conductive or electrical resistive/heating and vapor recovery

- In-Situ Treatment - Chemical Treatment
  - Chemical oxidation
  - Chemical reduction

- In-Situ Treatment - Biological Treatment
  - Enhanced biodegradation

4.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

This section presents the rationale and formulation of remedial alternatives.

4.1 Rationale for Development of Remedial Action Alternatives

The development of remedial alternatives consists of identifying statutory, regulatory and policy considerations, identifying considerations of human health and environmental protection, and assembling the previously identified potential response actions and technologies (Section 3.0) into remedial action alternatives that address Site contaminants and can attain the RAOs.

4.1.1 Statutory, Regulatory, and Policy Considerations

The National Oil and Hazardous Substances Contingency Plan ((NCP) 40 CFR 300.430 (a)(1)(iii)(A-F)) and the *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) were followed in the alternatives development. The NCP encourages developing alternatives that favor treatment technologies to address principal threats, whenever practicable, and alternatives that employ engineering controls to address relatively low long-term threats. A combination of methods was used to achieve the protection of human health and the environment. Additionally, the NCP suggests developing a range of treatment alternatives, including one or more engineering control alternatives (such as containment), one or more innovative treatment alternatives, and the baseline no action alternative. Institutional controls can be used to supplement the engineering controls. The NCP expects to return usable groundwater to beneficial uses whenever practicable.

4.1.2 Protection of Human Health Considerations

Groundwater contaminants to be addressed are identified in Section 2.3 and Table 2-2 presents the preliminary remediation goals for each contaminant of concern. As presented in Section 1.6, the human health risk evaluation examined the potential exposure by future residential adult and child receptors to Site groundwater that may be used as a future domestic water supply. The risk evaluation determined that if Site groundwater from the overburden or bedrock plumes were to be used for drinking water, then excess carcinogenic risks to humans would exceed EPA's acceptable risk range of 1 E-04 to 1 E-06 and HI would exceed 1.0. Therefore, remedial alternatives developed in this FFS need to address the chemicals present in excess of drinking

water criteria and health risk-based concentrations. No active drinking water supply wells are located within the footprint of the known overburden/bedrock plume areas. The remedial alternatives will need to address the protection of human health through restoring groundwater quality to acceptable drinking water criteria.

An evaluation of potential vapor intrusion threat posed by contaminated groundwater was presented in Section 1.4 of this FFS. The results indicate the possibility that VOCs in the plumes may pose potential threats. However, there is insufficient information to make definitive assessments. Therefore, to protect human health and to prevent potential exposure to groundwater VOCs through vapor intrusion, an evaluation will be performed during each annual long-term monitoring event and during each Five-Year Review. The evaluation will consist of verifying whether a habitable structure has been constructed on any parcel overlying the groundwater plumes. If a structure has been constructed, then an assessment must be performed to determine whether vapor intrusion is causing VOCs to migrate into the occupied structure. The assessment will conform with the guidelines presented in the *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*, November 2002 (EPA530-D-02-004). A risk evaluation will then be performed to determine the carcinogenic and non-carcionogenic risks posed by vapor intrusion. As appropriate, response actions will then be developed to address the vapor intrusion exposure.

4.1.3 Protection of Environment Considerations

Contaminants have been detected in overburden and bedrock groundwater at concentrations that exceed federal MCLs and the RIDEM GA Objectives. Evaluation of the data leads to the conclusion that past releases at the Site and current conditions are causing contaminants to leach from saturated soil and treated backfill into groundwater and migrate beyond the former Source Area. The overburden and bedrock aquifers underlying and downgradient of the former Source Area are being degraded and are not suitable as domestic water supply sources. Current interpretations of hydrogeologic conditions indicate that contaminated Site groundwater is discharging to Latham Brook. Current data indicate that VOCs are discharging to Latham Brook, but there is insufficient information to assess whether other contaminants may be migrating into the brook or the wetlands adjoining the former Source Area.

By achieving the RAOs, contaminated soils in the former Source Area would be addressed and groundwater quality would be restored. The groundwater alternatives need to address the restoration of groundwater in the long-term (which, in turn, is protective of human health and the environment).

4.1.4 Alternatives Screening

To streamline the FFS process and to assemble a concise array of plausible alternatives, effectiveness, implementability, and cost were considered in developing the array of alternatives. As a result, only a limited number of alternatives were assembled and all the alternatives developed are considered to be technically, administratively, and economically feasible based upon an initial evaluation. The alternatives screening step (in which alternatives are evaluated generally with regard to effectiveness, implementability, and cost) was integrated with the formulation of alternatives.

4.2 Groundwater Response Action Alternatives

Six groundwater response action alternatives were developed including: a no action alternative (GW1), alternatives that use limited action (GW2), and four representative treatment alternatives (GW3A, GW3B, GW4, and GW5), that would achieve the protection of human health and protection of groundwater RAOs. These groundwater alternatives address contaminated groundwater that exceeds MCLs, RIDEM GA Objectives or risk higher than 1E-05 or HI = 1.

The alternatives were also developed to address either the groundwater plume core (at the former Source Area), which consists of the saturated untreated soil and the unsaturated treated soil backfill present in the former Source Area, or the overburden plume, or both. None of the in-situ treatment alternatives (GW3A, BW3B, and GW5) will address contaminated bedrock groundwater due to technical implementability considerations. GW4 will address the bedrock plume.

One limited action alternative, GW2, using institutional controls and monitored natural attenuation, was developed that involves little or no treatment, but provides protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances.

Groundwater remedial alternatives GW3A and GW3B employ in-situ chemical treatment and enhanced biodegradation of VOCs. Alternative GW3A includes injection of treatment reagents into the plume core (former Source Area) coupled with monitored natural attenuation in the downgradient overburden and bedrock plumes. Alternative GW3B includes injection treatments in the plume core and the overburden plume coupled with monitored natural attenuation in the bedrock plume. For the FFS, chemical reduction was selected as the representative in-situ chemical treatment method. The rationale for selecting chemical reduction and enhanced biodegradation includes: 1) proven effectiveness in treating Site contaminants; 2) the aquifer is already in a chemically reduced state and these processes can be further enhanced; if chemical oxidation were to be applied, then extensive additional chemical treatment will be required to counteract the natural system; 3) relatively low impact the surrounding wetlands; and 4) the ability of the technology to stimulate on-going biologically-mediated dechlorination processes. Institutional controls, similar to GW2's, will also be required.

Remedial alternative GW4 is similar to the groundwater extraction and ex-situ treatment and discharge approach selected in the 1987 ROD. GW4 employs groundwater extraction, pre-treatment for suspended solids and dissolved inorganics, treatment of chlorinated VOCs using air stripping coupled with liquid- and vapor-phase activated carbon, and direct discharge of treated groundwater to Latham Brook. Institutional controls, similar to GW2's, will also be required.

Groundwater remedial alternative GW5 was developed as an in-situ thermal treatment option to address VOCs in the plume core, and would be coupled with monitored natural attenuation of the dissolved overburden and bedrock groundwater plumes downgradient of the former Source Area. Institutional controls, similar to GW2's, will also be required.

Summaries of the key components of Alternatives GW1 through GW5 are presented in Table 4-1. The detailed descriptions of groundwater response action alternatives are presented in the following narratives. Layouts and schematics for Alternatives GW2 through GW5 are depicted in Figure 4-1 through Figure 4-7.

4.2.1 Alternative GW1 – No Action

Under Alternative GW1, no further action will be taken at the Site. Any reduction in risk at the Site would occur through natural abiotic and biotic attenuation processes. Although this alternative does not achieve the RAOs, it is retained as a baseline alternative for comparison in accordance with the NCP and the RI/FS Guidance.

4.2.2 Alternative GW2 – Limited Action - Institutional Controls Monitored Natural Attenuation, and Five-Year Reviews

GW2 was developed as an alternative that involves no active (biological, physical, or chemical treatment), but provides protection of human health by preventing or controlling potential exposures to contaminated groundwater through institutional controls, and using monitored natural attenuation to gradually diminish contaminant mass. Figure 4-1 depicts parcels that may require institutional controls and the long-term monitoring network for groundwater and surface water.

Alternative GW2's limited actions consist of:

- Institutional Controls - Institutional controls proposed for Alternative GW2 may include placing legal restrictions on properties within the limits of the overburden and bedrock contaminant plumes, encompassing four parcels (50-9, 50-29, 50-27, and 50-27A, as depicted in Figure 4-1). The restrictions would prohibit the use of contaminated groundwater (that exceed drinking water criteria or risk-based concentrations) and restrict the installation of new potable supply wells or modification of already-in-place wells to serve as potable supply wells until contaminant concentrations have diminished to below drinking water criteria and RIDEM GA Objectives (i.e. 1E-05 excess cancer risk or HI=1).

- Monitored Natural Attenuation – Contaminated saturated soils in the groundwater plume core are continuing sources of groundwater contamination. Although no active remediation would occur under Alternative GW2, it is anticipated that contaminant concentrations in the aquifers will gradually diminish over time as the result of natural ongoing geochemical processes, the same as Alternative GW1's. Both biotic and abiotic natural degradation processes will gradually attenuate the VOCs, SVOCs, and

pesticides mass over an extended period, until all groundwater concentrations are decreased to below PRGs. Once groundwater conditions return to normal geochemical conditions and reductive dechlorination has ceased, metal concentrations will return to ambient levels.

- Long-Term Monitoring – To monitor natural attenuation processes and to evaluate conditions in environmental media, groundwater, surface water, and sediment would be sampled and analyzed on a triennial basis for the first 5 years, and annually thereafter. Groundwater samples would be collected from the plume core and the downgradient portions of the plume, and surface water and sediment samples would be collected from wetlands adjacent to the former Source Area and from Latham Brook. For the purpose of the FFS cost estimate, it is assumed that the annual monitoring would continue for 25 years. However, the time needed to for groundwater concentrations to attain the PRGs may exceed 30 years. Samples would be collected from approximately 43 existing monitoring wells (as was completed during the Phase 4 groundwater monitoring event conducted in October 2008), 8 new bedrock wells, 4 new overburden monitoring well, totaling 55 groundwater samples. Samples will be analyzed for VOCs, SVOCs, pesticides, metals, and geochemical parameters (chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen). The lateral and vertical contaminant migration in the overburden and bedrock aquifers will be monitored. As necessary, a number of these wells may need to be redeveloped to remove siltation that typically occurs.

  To provide a more fully characterized bedrock aquifer, four additional deep bedrock monitoring wells will be installed in areas that are down-dip of the former Source Area. These wells will complement the existing monitoring well network. Four new overburden and bedrock monitoring well pairs will be installed at the downgradient periphery of the overburden and bedrock plumes to provide a network of sentry wells between the plumes and residences along Log Road.

  An estimated 10 surface water and sediment sampling locations in the adjacent wetlands and Latham Brook would be monitored to assess the potential migration of site-related contaminants to surface water. Surface water samples will be analyzed for VOCs, SVOCs, and metals. Sediment samples, collocated with the surface water

samples, will be collected and analyzed for VOCs, SVOCs, pesticides, PCBs, and metals to assess whether contaminated groundwater discharge from the former Source Area may have resulted in degraded sediment quality.

The frequency of monitoring and types may be adjusted based on findings of the Five-Year Reviews.

As described in Section 4.1.2, to protect human health, an evaluation will be performed to assess the potential for vapor intrusion threats. During each annual monitoring event, a review will be performed to determine whether a habitable structure has been constructed on any parcel overlying the groundwater plumes. If a structure has been constructed, then an assessment must be performed to determine whether vapor intrusion is causing VOCs to migrate into the occupied structure. A risk evaluation will then be performed to determine the carcinogenic and non-carcinogenic risks posed by vapor intrusion. As appropriate, response actions will then be developed to address the vapor intrusion exposure.

- Five-Year Reviews - Because contaminants will remain at the Site and in downgradient groundwater for a period of time after implementation of the alternative, a review of Site conditions and risks would be conducted every 5 years, as required by CERCLA. The Five-Year Review will include evaluations of potential risks through use of groundwater as a potable supply or exposure to VOCs through vapor intrusion.

4.2.3 Alternative GW3A – In-Situ Chemical Treatment, Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews

Alternative GW3A uses in-situ chemical treatment and enhanced biodegradation to address the VOCs in the plume core (groundwater and saturated unexcavated soil in the former Source Area), coupled with monitored natural attenuation of the downgradient overburden plume and the entire bedrock plume. Figure 4-2 depicts the proposed treatment area.

Zero-valent iron (ZVI), a reducing agent and an electron donor, was selected as the representative chemical treatment process option. Because the subsurface is already in a

reducing condition, chemical reduction would be simpler to implement than chemical oxidation. A reagent consisting of a mixture of ZVI and an organic liquid substrate will be used to enhance the biodegradation through reductive dechlorination.

GW3A's in-situ treatment targets the VOCs sorbed to the saturated and unsaturated soil and VOCs in overburden groundwater in the former Source Area. Because the upper 30 feet of bedrock is weathered and is in contact with the overburden aquifer, some of the injected reagents could permeate into the weathered bedrock zone. However, significant treatment of the contaminated bedrock groundwater is not expected with this groundwater alternative.

GW3A consists of the following components:

- Pre-Design Investigation (PDI) - A PDI will be performed to ensure that the plume core contamination does not extend outside of the former Source Area. The PDI will also assess the potential contaminant presence in the treated soil backfill in the former Source Area to determine whether residual contaminants pose potential leaching threats to groundwater quality. Approximately 40 soil borings will be advanced to the approximate bedrock surface (30 borings located within the former Source Area, and 10 borings located outside of the former Source Area), a minimum of two soil samples will be collected from each boring and will be submitted for chemical analyses.

  Surface water samples will be collected from 10 locations for the analysis of VOCs, SVOCs, and metals to assess whether groundwater contaminants are migrating into the wetlands and the brook. Sediment samples, collocated with the surface water samples, will be collected and analyzed for VOCs, SVOCs, pesticides, PCBs, and metals to assess whether contaminated groundwater discharge from the former Source Area may have resulted in degraded sediment quality.

- Bench-Scale/Pilot Testing – Concurrent with the performance of the PDI, bench-scale testing using Site saturated soil and groundwater samples will be performed to select the optimal reducing agent and substrate for microbial growth for a field-scale pilot test. The field-scale pilot tests will be performed to ascertain the ability to distribute the reagent in the formation (i.e. variable permeability soils or high water table) and the effectiveness in

addressing contaminants in the overburden plume core. The results of the PDI and these tests will then be incorporated into the remedial design.

- Chemical Reduction – Chemical reduction was selected as the representative chemical treatment process option in the FFS for cost estimating purposes. Much of the plume is already in a chemically reduced state; therefore enhancing this electrochemical condition through the addition of a reducing agent and electron donor will enhance chemical reduction of chlorinated organic compounds. With amendments to ZVI, SVOCs (BCEE), and pesticides (aldrin and dieldrin) may also be treated. The ZVI can also be effective in converting soluble arsenic into an insoluble form.

- Enhanced Biodegradation – In an anaerobic environment, the natural degradation of chlorinated hydrocarbons follows the reductive dechlorination pathway. Adding an organic substrate material such as emulsified vegetable oils, lactic acid, or molasses extracts can enhance the growth of reductive dechlorinating microbes. In-situ enhanced biodegradation can be completed in conjunction with the in-situ chemical reduction or as a stand-alone injection. A slightly buffered solution would be added to assist in the neutralization of any acids that form from reduction processes.

- In-Situ Chemical Reduction and Enhanced Biodegradation – The chemical reduction and enhanced biodegradation can be combined into a single treatment. The organic substrate that promotes microbial growth and reductive dechlorination will be used as the delivery liquid for the ZVI into the plume core (saturated soils and groundwater in the former Source Area). Applications of the reagent follows:

    - Saturated Soil (Plume Core) Treatment - An estimated 136,800 gallons of combined ZVI (approximately 12% by weight) and substrate solution would be injected in four applications into the contaminated saturated soil (plume core) underlying the former Source Area. An estimated 170,000 yd^3 of contaminated saturated soil with an estimated 237 Kg of total VOCs would be treated. The first application of the treatment reagent will occur in 100% of the locations, the second in 75% of the locations, the third in 50% of the locations, and the fourth at 25% of the locations. Applications would be spaced approximately 1 year apart.

The treatment reagent will be injected using direct-push injection points throughout the core of the groundwater plume. The injection points will be advanced to the approximate top of weathered bedrock and 40 gallons of treatment reagent will be injected. Based on the geology in the plume area, a radius of influence (ROI) of 10 feet from injection location is assumed. The drill string will be retracted approximately half the overburden saturated thickness, and a second batch of treatment reagent will be injected. A third 40-gallon injection into the vadose zone could be required in areas of unsaturated contaminated soil located within the former Source Area if deemed necessary based on the PDI results. To address the plume core area (approximately 285,000 square feet), an estimated 684 injection points will be required.

- Backfill Treatment - Based on the results of the PDI, the unsaturated treated soil backfill, possibly containing residual VOCs, may require treatment. For the purpose of the FFS, approximately 45,000 yd^3 of soil including an estimated 38 Kg of VOC contaminant mass are assumed to require treatment under this alternative. Approximately 42,300 gallons of combined ZVI/substrate solution will be injected into the unsaturated soil in four applications.

- Limited Bedrock Injection - Additionally, due to the relatively high hydraulic conductivity and concentrations of VOC contaminants observed in the bedrock monitoring well OW-094-R, the well is a good candidate location for direct bedrock injection. To the extent possible, the well should be evacuated of its contents prior to application of the treatment chemicals. Approximately 40 gallons of treatment chemicals will be injected into the well under a slight pressure to disperse the reagent into the weathered bedrock. The OW-094-R injection would be repeated during each of the four applications. Figure 4-2 provides a summary of the injection layout.

Follow-up confirmation groundwater sampling and soil sampling will be required to ensure that PRGs are attained.

- Institutional Controls – Same as Alternative GW2.

- Monitored Natural Attenuation – Contaminated saturated soils in the groundwater plume core are continuing sources of groundwater contamination. Although active remediation would occur at the former Source Area under Alternative GW3A, it is anticipated that contaminant concentrations in the overburden and bedrock downgradient of the former Source Area will gradually diminish over time as the result of natural ongoing geochemical processes. Both biotic and abiotic natural degradation processes will gradually attenuate the VOCs, SVOCs, and pesticides mass over an extended period, until all groundwater concentrations are decreased to below PRGs. Once groundwater conditions return to normal geochemical conditions and reductive dechlorination has ceased, metal concentrations will return to ambient levels.

- Long-Term Monitoring – For GW3A, monitoring will be similar to GW2's, with modifications. OW-094-R will not be used for monitoring because it will be used to inject treatment reagents and will no longer be viable as a monitoring point. Two additional bedrock monitoring wells downgradient of OW-094-R will be installed and monitored.

- Five-Year Reviews - Contaminants would remain in groundwater above concentrations acceptable for unlimited Site use and unlimited exposure after completion of treatment. A review of Site conditions and risks would be conducted every 5 years, as required by CERCLA. The Five-Year Review will include evaluations of potential risks through use of groundwater as a potable supply or exposure to VOCs through vapor intrusion.

4.2.4 Alternative GW3B – In-Situ Chemical Treatment, Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews

Alternative GW3B is similar to GW3A; however, GW3B will use the in-situ chemical treatment and enhanced biodegradation to address the VOCs in the plume core (saturated soil in the former Source Area) and a portion of the overburden plume, coupled with monitored natural attenuation of the remaining untreated portion of the overburden plume and the bedrock plume.

Alternative GW3B consists of the following components:

- Pre-Design Investigation – A PDI will be performed to ensure that the plume core contamination does not extend outside of the former Source Area. The PDI will also assess the potential contaminant presence in the treated soil backfill in the former Source Area to determine whether residual contaminants pose potential leaching threats to groundwater quality. Approximately 40 soil borings will be advanced to the approximate bedrock surface (30 borings located within the former Source Area, and 10 borings located outside of the former Source Area), a minimum of two soil samples will be collected from each boring and will be submitted for chemical analyses.

  Surface water samples will be collected from 10 locations for the analysis of VOCs, SVOCs, and metals to assess whether groundwater contaminants are migrating into the wetlands and the brook. Sediment samples, collocated with the surface water samples, will be collected and analyzed for VOCs, SVOCs, pesticides, PCBs, and metals to assess whether contaminated groundwater discharge from the former Source Area may have resulted in degraded sediment quality.

- Bench-Scale/Pilot Testing - Concurrent with the performance of the PDI, bench-scale testing using Site saturated soil and groundwater samples will be performed to select the optimal reducing agent and substrate for microbial growth for a field-scale pilot test. The field-scale pilot tests will be performed to ascertain the ability to distribute the reagent in the formation (i.e. variable permeability soils or high water table) and the effectiveness in addressing contaminants in the overburden plume core. The results of the PDI and these tests will then be incorporated into the remedial design.

- Chemical Reduction – Chemical reduction was selected as the representative chemical treatment process option in the FFS for cost estimating purposes. Much of the plume is already in a chemically reduced state; therefore enhancing this electrochemical condition through the addition of a reducing agent and electron donor will enhance chemical reduction of chlorinated organic compounds. With amendments to ZVI, SVOCs (BCEE), and pesticides (aldrin and dieldrin) may also be treated. The ZVI can also be effective in converting soluble arsenic into an insoluble form.

- Enhanced Biodegradation – In an anaerobic environment, the natural degradation of chlorinated hydrocarbons follows the reductive dechlorination pathway. Adding an

organic substrate material such as emulsified vegetable oils, lactic acid, or molasses extracts can enhance the growth of reductive dechlorinating microbes. In-situ enhanced biodegradation can be completed in conjunction with the in-situ chemical reduction or as a stand-alone injection. A slightly buffered solution would be added to assist in the neutralization of any acids that form from reduction processes.

- In-Situ Chemical Reduction and Enhanced Biodegradation – The chemical reduction and enhanced biodegradation can be combined into a single treatment. The organic substrate that promotes microbial growth and reductive dechlorination will be used as the delivery liquid for the ZVI into the plume core (saturated soils and groundwater in the former Source Area) and the overburden plume. Applications of the reagent follows:

  - Saturated Soil (Plume Core) and Plume Treatment - An estimated 202,000 gallons of treatment reagent will be injected in four applications into the plume core and the portion of the overburden plume underlying areas situated outside of the wetlands, as depicted in Figure 4-3. An estimated 170,000 yd^3 of contaminated saturated soil in the former Source Area (237 Kg of total VOCs) and an estimated 9,862,000 gallons of contaminated overburden groundwater (16.3 Kg of total VOCs) are anticipated to be treated.

    The first treatment reagent application will be injected into 100% of the locations, the second in approximately 75% of the locations, the third in approximately 50% of the locations, and the fourth in approximately 25% of the locations. Applications would be spaced approximately 1 year apart. None of the chemical reagent injections will be performed in the wetlands.

    The treatment reagent will be injected using direct-push injection points throughout the core of the groundwater plume as well as upland areas of the downgradient dissolved overburden plume. The injection approach is the same as Alternative GW3A's. To address the plume core area and downgradient dissolved overburden plume (approximately 600,000 square feet), an estimated 1,012 injection points would be required.

- Backfill Treatment - Based on the results of the PDI, the unsaturated treated soil backfill, possibly containing residual VOCs, may require treatment. For the purpose of the FFS, approximately 45,000 yd^3 of soil including 38 Kg of VOC contaminant mass are assumed to require treatment under this alternative. Approximately 42,300 gallons of combined ZVI/substrate solution.

- Limited Bedrock Injection - Additionally, due to the relatively high hydraulic conductivity and high concentrations of VOC contaminants observed in the bedrock monitoring well OW-094-R, the well is a good candidate location for direct bedrock injection. To the extent possible, the well will be evacuated of its contents prior to application of the treatment chemicals. Approximately 40 gallons of treatment chemicals will be injected into the well under a slight pressure to disperse the treatment into the weathered bedrock. The OW-094-R injection would be repeated during each of the four applications.

Follow-up confirmation groundwater sampling and soil sampling will be required to ensure that PRGs are attained.

- Institutional Controls – Institutional controls may include placing legal restrictions on properties within the limits of the overburden and bedrock contaminant plumes, encompassing four parcels (50-9, 50-29, 50-27, and 50-27A, as depicted in Figure 4-1). The restrictions would prohibit the use of contaminated groundwater (that exceed drinking water criteria or risk-based concentrations) and restrict the installation of new potable supply wells or modification of already-in-place wells to serve as potable supply wells until contaminant concentrations have diminished to below drinking water criteria and RIDEM GA Objectives (i.e. 1E-05 excess cancer risk or HI=1).

- Monitored Natural Attenuation – Although active remediation would occur at the former Source Area and portions of the downgradient overburden plume under Alternative GW3B, it is anticipated that contaminant concentrations in the untreated portions of the overburden aquifer and bedrock will gradually diminish over time as the result of natural ongoing geochemical processes. Both biotic and abiotic natural degradation processes will gradually attenuate the VOCs, SVOCs, and pesticides mass over an extended period, until all groundwater concentrations are decreased to below PRGs. Once

groundwater conditions return to normal geochemical conditions and reductive dechlorination has ceased, metal concentrations will return to ambient levels.

- Long-Term Monitoring - To monitor natural attenuation processes and to evaluate conditions in environmental media, groundwater, surface water, and sediment would be sampled and analyzed on a triennial basis for the first 5 years, and annually thereafter. Groundwater samples would be collected from the plume core and the downgradient portions of the plume, and surface water and sediment samples would be collected from wetlands adjacent to the former Source Area and from Latham Brook. For the purpose of the FFS cost estimate, it is assumed that the annual monitoring would continue for 25 years. However, the time needed for groundwater concentrations to attain the PRGs may exceed 30 years. Samples would be collected from approximately 43 existing monitoring wells (as was completed during the Phase 4 groundwater monitoring event conducted in October 2008), 8 new bedrock wells, 4 new overburden monitoring well, totaling 55 groundwater samples. Samples will be analyzed for VOCs, SVOCs, pesticides, metals, and geochemical parameters (chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen). The lateral and vertical contaminant migration in the overburden and bedrock aquifers will be monitored. As necessary, a number of these wells may need to be redeveloped to remove siltation that typically occurs.

  To provide a more fully characterized bedrock aquifer, four additional deep bedrock monitoring wells will be installed in areas that are down-dip of the former Source Area. These wells will complement the existing monitoring well network. Four new overburden and bedrock monitoring well pairs will be installed at the downgradient periphery of the overburden and bedrock plumes to provide a network of sentry wells between the plumes and residences along Log Road.

  An estimated 10 surface water sampling locations in the adjacent wetlands and Latham Brook would be monitored to assess the potential migration of site-related contaminants to surface water. Surface water samples will be analyzed for VOCs, SVOCs, and metals. Sediment samples, collocated with the surface water samples, will be collected and analyzed for VOCs, SVOCs, pesticides, PCBs, and metals to assess whether

contaminated groundwater discharge from the former Source Area may have resulted in degraded sediment quality.

The frequency of monitoring and types may be adjusted based on findings of the Five-Year Reviews.

As described in Section 4.1.2, to protect human health, an evaluation will be performed to assess the potential for vapor intrusion threats. During each annual monitoring event. A review will be performed to determine whether a habitable structure has been constructed on any parcel overlying the groundwater plumes. If a structure has been constructed, then an assessment must be performed to determine whether vapor intrusion is causing VOCs to migrate into the occupied structure. A risk evaluation will then be performed to determine the carcinogenic and non-carcinogenic risks posed by vapor intrusion. As appropriate, response actions will then be developed to address the vapor intrusion exposure.

- Five-Year Reviews - Contaminants would remain in groundwater above concentrations acceptable for unlimited Site use and unlimited exposure after completion of treatment. A review of Site conditions and risks would be conducted every 5 years, as required by CERCLA. The Five-Year Review will include evaluations of potential risks through use of groundwater as a potable supply or exposure to VOCs through vapor intrusion.

4.2.5 Alternative GW4 – Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five-Year Reviews

Alternative GW4 was developed to restore the aquifer through the removal of contaminated groundwater for ex-situ treatment and to prevent the potential migration of VOCs beyond the current plume limits (as defined by MCLs and the RIDEM GA Objectives, the E-05 risk limit). While Alternative GW4 is similar to the management of migration remedy selected in the 1987 ROD, GW4 has been configured to address the current extent of contaminated groundwater in the overburden and bedrock plumes, while the ROD-designated management of migration action only addressed contaminated within and immediately adjacent to the former Source Area.

GW4 consists of the following:

- Pre-Design Investigation – Same as for Alternative GW3A. The PDI will be conducted to obtain additional information that will be used in the remedial design to determine the optimal locations for the extraction wells. The PDI will ascertain the extent of the plume core (for extraction wells locations) and assess potential contaminants presence in the contaminated soil and groundwater (for groundwater treatment design). To assess potential impacts of groundwater discharge to Latham Brook and the adjoining wetlands (and to aid in selection of extraction well locations), surface water and sediment sampling will be conducted.

- Groundwater Extraction – Contaminated overburden and bedrock groundwater will be pumped from the subsurface using an estimated 23 4-inch diameter extraction wells in the configuration depicted in Figure 4-4. One cluster of wells will be installed primarily in the former Source Area to remove contaminated bedrock groundwater from this portion of the Site. The placement of the first well extraction cluster is based on the 1994 hydrogeologic investigation (Ebasco, 1994) and the conceptual design that was developed. A second cluster, situated at the downgradient periphery of the plumes, would capture contaminated overburden and bedrock groundwater that are distal from the former Source Area. All extraction wells are expected to be installed outside of the wetland areas. Appendix C presents the information used to develop the conceptual groundwater extraction system configuration.

- Ex-Situ Groundwater Treatment – The ex-situ groundwater treatment facility would be sited within a 40 feet x 80 feet pre-engineered steel building, outside of the 100-year floodplain as depicted in Figure 4-4 and would be designed for a maximum capacity of approximately 50 gallons per minute (gpm). A process flow diagram for treatment is presented in Figure 4-5. Groundwater would be pumped directly from the extraction wells to a 5,000-gallon, lined, carbon-steel equalization tank. The groundwater would be aerated in the equalization tank and subsequently pumped to a flash-mix tank/flocculation tank for pH adjustment (using hydroxide) and polymer/coagulant addition to precipitate metals, followed by flocculant treatment. The partially treated groundwater would then be pumped to a lamella-style parallel-plate clarifier for solids

settling and then to a clearwell tank prior to polishing filtration through a multi-media filter. From the clearwell tank, the groundwater would be pumped into an air-stripper (2-foot diameter and 20 feet of packing materials) to volatilize and separate the VOCs from the process stream. The air stripper effluent would be polished using liquid-phase activated carbon, acidified to return the pH approximately neutral, and discharged to Latham Brook. The air stripper emissions (resultant vapor stream carrying VOCs) will be heated to prior to vapor-phase activated carbon treatment and atmospheric discharge. Non-VOC organic contaminants would be removed from the process stream using liquid-phase GAC. The solids from the clarifier would be pumped to a plate and frame filter press for dewatering. The resultant liquor would be reintroduced into the equalization tank and the solids would be managed as treatment plant waste.

- Treated Groundwater Discharge – Previous conceptual designs indicated that the most feasible option for discharging treated effluent is to Latham Brook because recharging treated water on the Site was not feasible due to limited soil permeability. The treated groundwater would be piped underground for approximately 1,300 feet to Latham Brook as shown on Figure 4-4. It is estimated that the discharge rate would be approximately 50 gpm, which is not expected to be detrimental to human health or any habitats within Latham Brook or downstream locations.

- Institutional Controls – Same as Alternative GW2.

- Long-Term Monitoring - Same as Alternative GW2.

- Five-Year Reviews - Same as Alternative GW2.

4.2.6 Alternative GW5 – In-Situ Thermal Treatment (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, Long-Term Monitoring, and Five-Year Reviews

Alternative GW5 treats the plume core (contaminated saturated soil and groundwater) within the former Source Area using in-situ electrical resistance heating, which was selected as the representative thermal treatment process option because it is less affected by the local geology or hydrogeology. The volatilized VOCs would be captured using a soil vapor extraction (SVE)

system. VOCs in groundwater outside of and downgradient of the former Source Area will then be degraded through natural attenuation. By removing VOCs from the plume core, thereby removing the primary source of groundwater contaminant mass, the overburden and bedrock plumes are expected to attain remediation goals sooner. Long-term monitoring would be conducted to verify that groundwater VOC concentrations are declining after completion of the in-situ thermal treatment.

GW5 consists of:

- Pre-Design Investigation – Same as Alternative GW3A. The PDI will ascertain the extent of the plume core (for extraction wells locations) and assess potential contaminants presence in the contaminated soil and groundwater (for groundwater treatment design). To assess potential impacts of groundwater discharge to Latham Brook and the adjoining wetlands (and to aid in selection of extraction well locations), surface water and sediment sampling will be conducted.

- In-Situ Thermal Treatment - A series of electrodes and SVE wells would be installed throughout the former Source Area (Figure 4-6). An electrical current would be applied that passes through the natural materials in the treatment zone to generate heat through the electrical resistance. As the subsurface temperature increases, steam is generated from the pore water or saturated media. The steam dissolves, vaporizes, mobilizes, and displaces VOCs and other organic contaminants from the soil. A generalized schematic of the electrical resistance heating is presented in Figure 4-7. Typically, the electrodes would be spaced roughly between 16 and 21 feet apart. Assuming electrode spacing of 20 feet, approximately 470 electrodes would be required at the Site. Soil remediation goals can be achieved through the removal of VOCs from the groundwater plume in the former Source Area.

- Soil Vapor Extraction – SVE wells installed throughout the former Source Area vadose zone would exert a high-flow vacuum and collect the heated gases (VOCs, other organics, and steam), generated by the thermal treatment, for on-site ex-situ treatment. The SVE wells are collocated with the electrodes.

- Ex-Situ Treatment – The recovered gases would be condensed, and the liquid would be treated using liquid phase granular activated carbon (GAC) to capture the VOCs. Vinyl chloride may need to be addressed separately if discharge limits are exceeded. The recovered VOCs and spent GAC would be disposed offsite.

- Institutional Controls – These measures are the same as in GW2 because contaminated overburden and bedrock groundwater downgradient of the former Source Area would remain unaddressed by in-situ treatment.

- Long-Term Monitoring - Same as Alternative GW2.

- Five-Year Reviews - Same as Alternative GW2.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

The remedial alternatives presented in Section 4.0 are analyzed in detail in this section. The detailed analysis of the alternatives provides information necessary to facilitate the selection of a specific remedy or combination of remedies. The detailed analysis of alternatives was conducted in accordance with the NCP (40 CFR 200.430(e)) and the *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, October 1988).

5.1 Evaluation Criteria

The NCP requires that remedial alternatives be assessed against nine evaluation criteria, which are categorized as follows:

Threshold Criteria:

- Overall Protection of Human Health and the Environment – This criterion provides a final check to ensure that the alternative provides adequate protection of human health and the environment.

- Compliance with ARARs – This criterion is used to describe how each alternative will meet ARARs, or in cases where an ARAR (or ARARs) will not be met, the justification of any waiver shall be detailed.

Primary Balancing Criteria:

- Long-Term Effectiveness and Permanence – This criterion details the evaluation of the risks remaining after the remedial alternative has been enacted and the response objectives have been achieved. The primary focus of this evaluation is the evaluation of any procedures or controls that manage risks associated with treatment residuals and/or untreated wastes. Specifically, the magnitude of residual risks and the adequacy and reliability of controls for each alternative are examined.

- Reduction of Toxicity, Mobility, or Volume Through Treatment – This evaluation criterion addresses the statutory preference for selecting remedial alternatives that employ

treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances.

- Short-Term Effectiveness – This criterion requires an evaluation of the impacts to human health (on-site workers and community) and the environment during construction and implementation of the remedial alternatives.

- Implementability – This criterion requires an evaluation of the technical and administrative implementability of the remedial actions, as well as an evaluation of the relative availability of services and materials. The evaluation of the technical implementability generally includes short-term difficulties in construction and operation, the reliability of the technology, the relative ease of undertaking additional remedial actions, and monitoring considerations. Administrative implementability provides an evaluation of the administrative requirements needed to perform the remedy (such as securing rights of way, and permits). The evaluation of the relative availability of services and materials is a determination of the ease of which specialized services, materials, or equipment may be obtained.

- Cost – A detailed cost analysis is performed for each alternative to assess the net present worth cost to implement each alternative. The cost analyses include an estimation of the capital costs and annual operations and maintenance costs for the alternative, the development of costs that fall within a -30% to +50% estimation range, a present worth analysis by discounting to a base year or current year using a 7% discount rate.

Modifying Criteria:

- State Acceptance – To the extent possible, the remedial alternatives have been assembled to assure compliance with State ARARs, as they apply. Any additional concerns that the State agencies may have will be communicated during the comment period after issuance of the Proposed Plan and taken into account in the ROD.

- Community Acceptance – In assembling the remedial alternatives, protection of the community and anticipation of any concerns the community may have associated with

the remedies have been taken into account to the extent possible. Any additional comments or suggestions the community may have will be communicated during the comment period after issuance of the Proposed Plan and taken into account in the ROD.

In conformance with the NCP, the seven criteria included in the Threshold Criteria and the Primary Balancing Criteria noted above were used to evaluate each of the retained alternatives presented in Section 4.0 in the detailed analysis. The last two criteria, State and community acceptance, will be addressed following the public comment period.

5.2 Detailed Analysis of Alternatives

The following remedial action alternatives were retained for detailed analysis:

- GW1 – No Action
- GW2 – Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews
- GW3A - In-Situ Chemical Treatment, Enhanced Biodegradation (Core), Monitored Natural Attenuation (Overburden and Bedrock Plume), Institutional Controls, and Five-Year Reviews
- GW3B - In-Situ Chemical Treatment, Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews
- GW4 – Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five-Year Reviews
- GW5 - In-Situ Thermal Treatment (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, Long-Term Monitoring, and Five-Year Reviews

Table 5-1 summarizes the detailed analyses of the groundwater remedial alternatives.

5.3 Cost Estimation

Cost estimates for each remedial alternative are presented in Table 5-1. The detailed cost evaluations provided in Appendix D were prepared for each alternative using the *EPA Guide to Developing and Documenting Costs Estimates During the Feasibility Study* (EPA, 2000). The guide states that cost estimates developed for an FS are for comparison purposes, only. In general, the FS stage of the remedial design may represent the 0-10% complete design, and as such, the anticipated accuracy range is -30% to +50%. As the remedial design is developed, the estimation accuracy is expected to be between -10% to +15%.

The cost estimates are prepared based on available information at the FFS stage including: the quantities or extent of contamination to be addressed, prices available from standard construction information sources and vendors, and assumptions used to develop the conceptual designs for the remedial alternatives. In addition, the time needed to complete the construction, or to achieve the RAOs is based on best estimates or professional judgment. The costs analyses developed at the FFS stage are for order of magnitude and comparative analysis use in the remedy selection process, and do not represent actual costs needed to implement the remedy fully. As additional information becomes available during the pre-design investigation or the remedial design phase, estimated costs will become more refined and accurate.

A present value analysis (PVA) was prepared as part of the cost analysis for each alternative to normalize long-term expenditures to a base year value. The PVA represents the amount of monies that, if set aside at the initial point in time (base year), with outflows (payments) on an as-required basis, would be sufficient to pay for the remedial action over the anticipated duration of the remedy. A discount rate of 7% was used, in accordance with EPA guidance.

In addition to capital and annual operations and maintenance costs, each alternative's cost estimate includes the following elements:

- Scope and Bid Contingencies that account for uncertainties that could be associated with incomplete site characterization, construction delays due to weather, or unanticipated site conditions.
- Technical services, professional/specialist consulting, and engineering costs as a percentage of capital costs.

- Administrative fees as a percentage of capital costs.

5.4 Identification of ARARs

Section 121(d)(2)(A) of CERCLA requires Superfund remedial actions meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements. State ARARs must be met if they are more stringent than Federal requirements and have been presented to EPA in a timely manner.

Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs may be waived:

- The remedial action selected is only a part of a total remedial action (interim remedy) and the final remedy will attain the ARAR upon its completion.

- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.

- Compliance with the ARAR is technically impracticable from an engineering perspective.

- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.

- A State requirement that the State has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.

- For §104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

Each potential ARAR was reviewed to evaluate the applicability or relevancy and appropriateness according to the procedures identified in *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (OSWER Directive 9355.3-01, EPA 1988) and the *CERCLA Compliance with Other Laws Manual, Part 1 and Part 2* (EPA, 1989).

Evaluations of each alternative's ability to comply with the chemical-specific, location-specific, and action-specific ARARs are presented in Table 5-2A through Table 5-4B.

6.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The analysis of the remedial alternatives is presented in this section. The comparative analysis compares relative performance of each alternative to seven of the nine evaluation criteria specified in the NCP and described in Section 5.0. This comparison assists in the selection of a remedy for the Site based on the advantages and disadvantages of each alternative relative to the NCP evaluation criteria.

6.1 Comparative Analysis Approach

The approach to evaluating each alternative is specified in the NCP and further detailed in *Interim-Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, October 1988). The selection of the preferred remedy must consider the major tradeoffs among the evaluation criteria. The NCP groups the evaluation criteria as described in Section 5.0 (Threshold Criteria, Primary Balancing Criteria, and Modifying Criteria).

6.2 Comparative Analysis

Table 6-1 provides a summary of the comparative analysis results for the retained alternatives. Evaluations based on the five Threshold and two Primary Balancing criteria are presented below. As discussed previously, the Modifying Criteria (State and community acceptance), will be addressed following the public comment period.

6.2.1 Overall Protection of Human Health and the Environment

Alternative GW1 provides the least amount of protection of human health and the environment because no actions will be taken to reduce the risk presented by contamination in groundwater. GW1 would not meet this threshold criterion of the NCP.

Alternative GW2 relies on institutional controls to prevent human exposure to contaminated groundwater. While Alternative GW2 provides some degree of protection of human health, it does not address the groundwater contamination threat to surface water because contaminated groundwater will continue to discharge into the wetlands and surface water adjacent to the former Source Area and migrate unimpeded. Therefore, Alternative GW2 does not provide adequate environmental protection in the long term.

Alternatives GW3A and GW3B provide overall protection of human health and the environment by chemical reduction and enhanced biodegradation of VOCs in groundwater to safe levels. GW3B will address both the plume core (former Source Area) and the downgradient contaminated overburden groundwater, will be more protective than GW3A, and will attain the RAOs sooner. Because both GW3A and GW3B will cause the degradation of the chlorinated VOCs, both alternatives will help to decrease the quantity of contaminated groundwater discharging into the wetland that adjoins the former Source Area. Under GW3A and GW3B, there will be a temporary mobilization of naturally occurring manganese in the soil minerals due to the reducing condition caused by in-situ chemical treatment. In the long term, Alternatives GW3A and GW3B will be protective of the environment.

Alternative GW4 provide overall protection of human health and the environment through the extraction and treatment of contaminated overburden and bedrock groundwater until safe levels are attained. GW4 also prevents the further migration of contaminated from discharging into the wetlands and will be protective of the environment.

Alternative GW5 provides overall protection of human health and the environment through the thermal desorption and removal of VOCs from the saturated untreated soil (plume core) in the former Source Area. Once GW5 is completed, overburden groundwater in the former Source Area will be returned to safe levels. Elimination of the VOCs source will result in the faster natural attenuation of contaminants in the overburden and bedrock plumes. By removing VOCs from the former Source Area, contaminated groundwater discharge into the adjacent wetlands and the brook will be greatly decreased. GW5 will be protective of the environment.

6.2.2 Compliance with ARARs

Compliance with ARARs are summarized in Table 5-2A through Table 5-4B. Table 5-2A and Table 5-2B present the assessment of the alternatives compliance with chemical-specific ARARs. Table 5-3A and Table 5-3B present the assessment of the alternatives compliance with the location-specific ARARs. Table 5-4A and Table 5-4B present the assessment of the alternatives compliance with the action-specific ARARs.

Alternatives GW1 and GW2 will not meet the chemical-specific ARARs including the RIDEM GA Groundwater Objectives, MCLs, non-zero MCLGs, or reduce potential health risks to acceptable levels in a reasonable time frame as they rely on natural attenuation processes to gradually diminish the contaminant mass in overburden and bedrock groundwater.

Alternatives GW3A, GW3B, GW4, and GW5 will meet RIDEM GA Groundwater Objectives, MCLs, and non-zero MCLGs through active remediation. Both GW3A and GW5 will address the contaminated saturated soil and overburden groundwater in the plume core, and will comply with the chemical-specific ARARs for the former Source Area after completion of the remedial actions. GW3B will address greater contaminant extent in the overburden aquifer than GW3A or GW5 and will comply with the action-specific ARARs. While GW4 will address both overburden and bedrock plumes, it will rely on flushing of groundwater contaminants to the extraction wells and will comply with the chemical-specific ARARs in the long term.

Installation of monitoring wells under GW2, GW3A, GW3B, GW4, and GW5 may require limited construction in the wetlands; the alternatives will comply with the location-specific ARARs and avoid damage to wetlands. Implementation of GW4 and GW5 may result in unavoidable impacts to the wetlands. If damage cannot be avoided, then mitigation will be performed under each alternative to comply with the location-specific ARARs.

Implementation of Alternatives GW2, GW3A, GW3B, GW4, and GW5 will comply with the action-specific ARARs. Alternatives GW3A, GW3B, GW4, and GW5 will comply with Federal and State regulations that govern the use, handling, treatment, or storage of chemicals during implementation of remedial actions. Monitoring wells to be installed under GW2 and all four active remediation alternatives, and injections wells will be installed under GW3A and GW3B will comply with State regulations. Treatment systems will be used to capture and consolidate extracted groundwater contaminants or vapors for the active remediation alternatives to comply with State and federal action-specific regulations.

6.2.3 Long-Term Effectiveness and Permanence

Alternative GW1 provides the least long-term effectiveness and permanence because no actions will be taken to control exposure over time or to permanently reduce the level of contaminants in groundwater in the long term. While natural attenuation processes would likely

eventually reduce the contaminant mass in groundwater, the residual risk that remains is significant over a very long time.

Alternative GW2 relies on institutional controls in the long term to prevent potential exposures to contaminated groundwater. No actions will be taken to permanently reduce the contaminant concentrations in groundwater in a reasonable timeframe although some natural attenuation of contaminants will occur. The residual risk remains great as the contaminant mass is unaddressed for an extended period. This alternative is dependent on the proper implementation, monitoring, and enforcement of institutional controls coupled with periodic reviews of land use at the Site and adjacent parcels to remain effective in the long term. As a result, the long-term effectiveness is only as good as the measures taken to ensure the reliability of controls.

Alternatives GW3A, GW3B, GW4, and GW5 provide permanent reduction in the contaminant mass, and therefore will reduce risks to acceptable levels in the long term. Alternatives GW3A and GW3B use in-situ chemical treatment and enhanced biodegradation to address groundwater VOCs plume mass. Because GW3B will treat a larger portion of the overburden plume than GW3A, the magnitude of the residual risk for GW3B will be lower than for GW3A in the near term. Alternative GW4 uses physical groundwater extraction and treatment to permanently decrease contaminant concentrations in both the overburden and bedrock groundwater until safe levels are attained. GW5 will address the plume core, and will have the same risk reduction over the same timeframe as GW3A. In the interim until cleanup levels are achieved, all active remediation alternatives rely on institutional controls to prevent use of contaminated groundwater. All active remediation alternatives are dependent on the proper implementation, monitoring, and enforcement of institutional controls, coupled with periodic reviews of land use at the Site and adjacent parcels, to remain effective in the short term.

Alternatives GW3A, GW3B, GW4, and GW5 are expected to attain cleanup goals. However, Alternatives GW3A, GW3B, and GW5 do not actively treat significant portions of the bedrock aquifer, as the treatment only affects the overburden groundwater. For GW3A and GW3B, any bedrock groundwater treatment would be incidental and likely due to injections at the weathered bedrock/overburden contact. Alternative GW4 includes bedrock groundwater extraction and effectively reduces risk associated with both overburden and bedrock groundwater

contamination. Alternative GW4 adds an additional control measure because the extraction wells can also prevent further migration of the overburden and bedrock plumes.

6.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative GW1 provides no treatment processes and therefore will not satisfy CERCLA's statutory preference for treatment. Natural abiotic and biotic processes may gradually degrade and decrease the contaminant mass in the long term. However, lack of monitoring will prevent any determination of cleanup progress.

Similar to GW1, Alternative GW2 will not satisfy CERCLA's statutory preference for treatment. Natural abiotic and biotic processes (passive treatment) will gradually degrade and decrease the contaminant mass in the long term, but not within an acceptable time frame. Long-term monitoring of groundwater and surface water will provide the necessary data to determine the effectiveness and progress of the natural attenuation process.

Alternatives GW3A, GW3B, GW4, and GW5 all employ active treatment processes to address the groundwater contaminants, and will satisfy CERCLA's statutory preference for treatment. Alternatives GW3A and GW3B include chemical treatment of the dissolved overburden groundwater plume mass coupled with enhanced biodegradation to reduce toxicity, mobility, and volume. The dissolved bedrock aquifer is not actively treated by GW3A and GW3B. Alternative GW4 relies on physical extraction and treatment of both dissolved overburden and bedrock contamination to reduce contaminated groundwater volume . GW5 will remove VOCs from the plume core through in-situ thermal treatment thereby reducing toxicity, mobility, and volume. Once remedial actions are implemented, they would be irreversible for GW3A, GW3B, GW4, and GW5 because contaminants will be degraded or removed from the aquifer.

Treatment residuals associated with Alternatives GW3A and GW3B include iron complexes, dissolved gases (oxygen, carbon dioxide, hydrogen, methane, ethane, and ethene), and an increased population of halo-respiring bacteria in overburden groundwater. It is anticipated that the bacteria will slowly die off as the contaminant mass is depleted. Incomplete biologic degradation of chlorinated ethenes can lead to an accumulation of vinyl chloride; however, proper engineering of these alternatives could minimize or eliminate the formation of vinyl chloride, and will not be expected to pose residual risks.

Treatment residuals associated with GW4 include captured VOCs from treated air emissions, spent vapor-phase and liquid-phase activated carbon, and sludge from metals precipitation. Annually, an estimated 16,000 pounds of granular activated carbon will require removal and either recharge or disposal, and an estimated 8 cubic yards (approximately 16,000 pounds) of sludge will require treatment or disposal.

The in-situ thermal treatment residuals associated with GW5 include other organic compounds (such as acetone) that result from the degradation of natural organic matter. These residuals are not expected to be long-lived and should dissipate due to groundwater advection. The ex-situ treatment residuals associated with GW5 include captured VOCs, and spent activated carbon, which will require treatment or disposal.

6.2.5 Short-Term Effectiveness

No active remedial actions are associated with groundwater alternative GW1, therefore no risks to the community, site workers, or the environment from implementation of this alternative. Based on an analytical model of groundwater contaminant decay (Appendix E), overburden groundwater will achieve RAOs and PRGs in approximately 100 years while the bedrock groundwater contamination will achieve RAOs and PRGs in approximately 80 years.

For Alternative GW2, implementation of this alternative will not impact the community as no actions other than the installation of monitoring wells is required. Site workers will use proper personal protection equipment and appropriate health and safety protocols will be followed when installing the monitoring wells. Some monitoring wells will need to be installed in wetland areas because there is no practical alternative for collecting monitoring data elsewhere.

Alternatives GW3A and GW3B include the active in-situ chemical treatment and enhanced biodegradation, but is not expected to have an impact on the community in the short term because the Site is relatively isolated from nearby populations (nearest resident is at least 1,000 feet away), and treatment will be performed in-situ. The pressurized injection of treatment reagents increases the on-site worker's risk of exposure to the treatment reagents. However, the risk of harm to the on-site worker can be ameliorated through implementation of proper engineering controls and health and safety procedures. Administrative and engineering

controls, and communication with local officials will ensure the safe transportation, storage, and injection of these materials, and will be included as part of the remedial design and project planning. The potential risks to on-site workers and the community are expected to be minimal with proper controls. Short-term environmental impacts may include the temporary mobilization of some naturally occurring metals in soils, such as arsenic and manganese, which will be subjected to chemical reduction. Increased in dissolved iron concentrations will also occur as the ZVI becomes oxidized. However, once the groundwater oxidation-reduction potential in the groundwater plumes return to normal, the naturally occurring arsenic and manganese will no longer be soluble.

Under Alternative GW4, there will be minimal risk to on-site workers and the environment from installation of extraction and monitoring wells, similar to Alternative GW2A's. Construction of the active groundwater extraction, treatment, and discharge system pose minimal risks to on-site workers and the community. Risks will generally be consistent with typical construction projects. Additional potential risk due to exposure to groundwater contaminants during drilling of extraction wells and operations and maintenance of the treatment system is present, but is also minimal with the proper implementation of a health and safety program.

Alternative GW5's in-situ thermal treatment is not expected to have an impact on the community in the short term because the Site is relatively isolated from nearby populations (nearest resident is at least 1,000 feet away), and treatment will be performed in-situ. Construction of the electrical resistive heating array, the vapor recovery system, use of electrical equipment, heat resulting from treatment implementation, and operation of the vapor recovery system and handling of recovered VOCs could present a risk to site workers during implementation of GW5. However, the risk of harm to the on-site worker can be minimized through implementation of proper engineering controls and health and safety procedures.

Environmental impact to the wetlands resulting from monitoring wells installation for all alternatives other than GW1 are expected to be minimal. As needed, mitigation will be performed to address unavoidable impacts during wells installation. All construction for Alternatives GW3A, GW3B, GW4, and GW5 will occur outside of wetland areas and will not affect the wetlands. Implementation of GW4, groundwater extraction, may have potential impacts to wetlands because the water table discharging to the wetlands could be depressed, decreasing the volume of groundwater feeding the wetlands. If impacts to wetlands are

unavoidable under GW4, then mitigation will be implemented. Treated air and water discharges concentrations under GW4 and GW5 are expected to be below allowable discharge criteria, which would not represent impacts to the environment.

Modification to the subsurface geochemistry (GW3A and GW3B) or subsurface temperature (GW5) may have temporary impacts greater than for GW1 or GW2. However, once in-situ treatment stops, the subsurface conditions are expected to gradually return to ambient conditions.

Implementation of GW1 will require no time while 1 year is required to implement GW2. For both GW1 and GW2, based on analytical modeling, natural attenuation will result in the attainment of safe levels in approximately 100 years for overburden groundwater and 80 years for bedrock groundwater.

Implementation of GW3A and GW3B will require approximately 4 to 5 years (including pre-remedial design, bench/pilot-scale testing, design, implementation of four injections, and follow-up confirmation soil sampling). For GW3A, after the plume core is remediated, safe levels in the overburden and bedrock groundwater will be attained in approximately 45 years and 80 years, respectively.

For GW3B, after the plume core and a portion of the overburden plume are remediated, safe levels in bedrock groundwater will be attained in approximately 80 years. Because the in-situ chemical treatment of groundwater will only be performed in the non-wetland areas, the untreated portions of overburden plume will be naturally attenuated in approximately 40 years to 45 years. Although a portion of the overburden plume will attain remediation goals after completion of the in-situ treatment, elevated VOC concentrations remain in the untreated portion of the overburden plume.

GW4 will require an estimated 2 years to design and implement. Once extraction and treatment are initiated, overburden groundwater will achieve RAOs in a period less than 100 years, while bedrock groundwater will achieve these goals in approximately 80 years.

Implementation of GW5 will require approximately 20 months (including pre-remedial design, pilot-scale testing, design, implementation and follow-up soil sampling). For GW5, after the

plume core is remediated, safe levels in the overburden and bedrock groundwater will be attained in approximately 45 years and 80 years, respectively.

6.2.6 Implementability

With no proposed actions, alternative GW1 is the easiest to implement, when compared with Alternatives GW2, GW3A, GW3B, GW4, and GW5.

Alternative GW2 includes institutional controls and long-term monitoring, which are readily implementable. The natural attenuation process requires no implementation. The sole construction activity associated with GW2 is the installation of additional monitoring wells, which can be easily constructed by a number of firms. Typically there are administrative implementability issues associated with implementing institutional controls. However, none of these issues is significant or would prevent implementation of these actions. GW2 is implementable, and only slightly more difficult to implement than GW1. In addition, there are no limitations in availability firms, equipment, or materials that would limit the implementation of this remedial alternative.

GW3A and GW3B will require firms with specialized experience, equipment and reagents to implement the in-situ chemical reduction treatment. A number of firms are available that can provide this remediation service, and the necessary equipment and reagents (or their components) are commercially available. GW3A and GW3B require minimal construction (aside from monitoring well installations). Temporary direct-push injection boreholes are advanced in the treatment zone, and there are no permanent features remaining. GW3A and GW3B are implementable, and are more difficult to implement than GW2.

GW4 will require the construction of access roads, a groundwater extraction system, a groundwater treatment facility, groundwater discharge conduit, and all associated aboveground and underground utilities. Extensive upgrades to the nearby electrical system may be required to implement the GW4 alternative. Fluctuations in the electrical supply or power failures can limit the reliability of the GW4 alternative. Multiple vendors are available to design, construct, and operate GW4's remedial action. While implementable, GW4 is slightly more difficult to implement than GW3A or GW3B.

GW5 also requires firms with specialized experience and equipment. The number of firms with experienced personnel and equipment to perform the work is limited. Extensive upgrades to the nearby electrical system may be required to implement the in-situ electrical resistive heating. Because GW5 has a high power demand, fluctuations in the electrical supply or power failures can limit its reliability. GW5 is more difficult to implement than GW4.

Once the GW3A or GW3B in-situ chemical treatment, or GW5's in-situ thermal treatment is completed, no additional operations or maintenance will be required; continued monitoring of the aquifer will be needed. Alternative GW4 will require operations, maintenance, and monitoring for approximately 45 years after the construction completion. Typically, naturally occurring dissolved metals can foul groundwater extraction and treatment equipment and can be addressed through the use of a robust pre-treatment step, which is included in GW4. Insufficient pre-treatment of the waste stream commonly limits the reliability and effectiveness of the air stripping treatment. GW3A and GW3B are more easily implemented than GW4 or GW5.

Additional actions can be easily implemented under all alternatives because contaminants, at varying degrees remain in the aquifer for extended periods. However, GW3A, GW3B, and GW5 cause temporary alterations in subsurface conditions (i.e., geochemistry or temperature) that will deter additional remedial actions until subsurface conditions return to ambient conditions. Implementation of GW4 would not inhibit or preclude performance of additional remedial actions, as the subsurface geochemistry would remain unaltered.

Technologies to be used with GW3A, GW3B, GW4, and GW5 have been implemented and demonstrated to be effective at other sites with similar contamination.

Monitoring requirements for all alternatives are easily implemented and are mostly the same for all alternatives, with the exception of GW1. The same long-term monitoring network can be used to evaluate natural attenuation progress (GW2), effectiveness of treatment and progress in the attenuation of the remaining overburden and bedrock plumes (GW3A, GW3B, GW5), or to monitor the progress and effectiveness of groundwater extraction and status of the overburden and bedrock plumes (GW4).

Communication with stakeholders will occur during planned activities to the extent appropriate. For GW4, if discharge of treated groundwater has to occur offsite, then an approval will be needed for discharge to Latham Brook.

Implementation of Alternative GW4 or GW5 will result in generation of wastes (accumulated VOCs, spent activated carbon, etc.). Facilities capable of managing wastes associated with implementation of these two alternatives are readily available. There are no significant administrative feasibility issues associated with either GW3 or GW4 other than those related to institutional controls.

The EPA Region 1's *Clean and Green Policy for Contaminated Sites* (EPA, 2010) advocates strategies and practices to reduce the environmental footprint during remediation and restoration actions, to the extent feasible. This policy supports green remediation goals, where practical and appropriate, that include: minimizing total energy use, minimizing air emissions and greenhouse gases, minimize water use and impacts to water resources, reduce, resuse and recycle materials and wastes, and support sustainable reuse of remediated land. As part of the evaluation of implementability, this green policy Of the alternatives where active remediation will be performed, Alternatives GW3A and GW3B would use the least amount of energy because all treatment processes do not require any additional energy. Once the ZVI reagent has been injected into the subsurface, the VOCs degradation will occur through in-situ chemical and biological processes. Alternatives GW4 will require electricity to power the extraction well, to pump groundwater to the treatment plant, and to treat and discharge the treated water. Alternative GW5 would require electricity to heat up the subsurface of the former Source Area, to capture and condense the heated gases, and to treat the condensed gases. Generation of electricity for GW4 and GW5 will also result in the emissions of combustion byproducts including carbon dioxide, nitrogen oxides, sulphur dioxide, particulates, volatile organic compounds, and heavy metals. Implementation of either GW3A or GW3B would not result in air emissions because all reactions occur in the subsurface and do not require any external sources of energy. Alternatives GW4 and GW5 will result in the handling of extracted groundwater and vapors, respectively, and some releases may occur due to fugitive emissions.

Overall, GW1 and GW2 are readily implementable. GW3A and GW3B, while more difficult to implement than the No Action and Limited alternatives, can be more readily implemented than GW4 or GW5. Under GW5, numerous items need to be constructed or installed, operated, and

maintained including: thermal wells and vapor extraction wells, vapor condensations system, and gas phase VOCs treatment systems. Because of the complexity of GW5, it is less implementable than GW4.

6.2.7 Cost

Detailed breakdowns of capital costs, operations and maintenance costs, and present value analyses for each groundwater alternative (aside from GW1, which has no costs) are provided in Appendix D. A summary of the alternative costs is included in Table 5-1.

Alternative GW5 is the most expensive alternative, followed by GW4, GW3A, GW3B, GW2, and lastly, alternative GW1.

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TABLES

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Table 1-1
Summary of Unexcavated Unsaturated Soil VOCs Data (Outside of Excavation Footprint)
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc. [1]	Maximum Conc. [1]	Units	Location of Maximum Concentration	Detection Frequency	Soil Leachability Screening [(2)]				
							RIDEM GA Leachability Criteria		EPA Soil Screening Levels		
							Screening Value	Frequency Above Screening Criterion	Screening Value	Sreening Value Source	Frequency Above Screening Criterion
71-55-6	1,1,1-Trichloroethane	0.0014	0.0065	mg/Kg	07SB6A	6/26	11	0/26	0.072	MCL-SSL	0/26
95-50-1	1,2-Dichlorobenzene	0.18	0.23	mg/Kg	SWG02	5/21	41	0/21	0.66	MCL-SSL	0/21
106-46-7	1,4-Dichlorobenzene	0.26	0.26	mg/Kg	SWG02	2/20	41	0/20	0.081	MCL-SSL	0/20
107-06-2	1,2-Dichloroethane	0.0014	0.022	mg/Kg	SOSB4	18/24	0.1	0/24	0.0015	Risk-SSL	**16/24**
78-93-3	2-Butanone	0.65	15	mg/Kg	SWG02	4/23	NA	--	NA	NA	--
67-64-1	Acetone	0.0014	0.81	mg/Kg	SWB03	32/44	NA	--	4.4	Risk-SSL	0/44
67-66-3	Chloroform	0.0014	0.0056	mg/Kg	SOSB4	13/33	NA	--	0.055	MCL-SSL	**1/33**
100-41-4	Ethylbenzene	0.0013	0.025	mg/Kg	SWG02	12/29	27	0/29	0.89	MCL-SSL	0/29
75-09-2	Methylene chloride	0.0013	0.17	mg/Kg	SWD07	16/32	NA	--	0.0013	MCL-SSL	**15/32**
100-42-5	Styrene	0.0045	0.01	mg/Kg	MWSB4	2/8	2.9	0/8	0.12	MCL-SSL	0/8
127-18-4	Tetrachloroethylene	0.0012	1.6	mg/Kg	A06	24/62	0.1	**7/62**	0.0024	MCL-SSL	**16/62**
108-88-3	Toluene	0.0012	0.21	mg/Kg	X01	35/40	32	0/40	0.76	MCL-SSL	0/40
79-01-6	Trichloroethylene	0.0011	0.16	mg/Kg	07SB2	20/39	0.2	0/39	0.0019	MCL-SSL	**13/39**
1330-20-7	Xylene (Total)	0.0012	1.2	mg/Kg	M104	23/28	540	0/28	11	MCL-SSL	0/28

Notes:

1. Data sources: *Preliminary Design Report: Davis Liquid Waste Site* (Ensafe, 1999); *Draft Remedial Action Report, Davis Liquid Waste Site* (LEA, 2001); *Pre-Design Engineering Reports I & 2: Davis Liquid Waste Site* (WCC, 1992 & 1993).

2. Screening Values derived from the following sources:
   - EPA MCL-SSL: MCL-Based Soil Screening Level (SSL) from EPA Regional Screening Levels. Source: http://www.epa.gov/reg3hwmd/Risk/human/rb-concentration_table/index.htm
   - EPA Risk-SSL: Risk-Based SSL (Cancer Risk =1E-06 or Hazard Index =1.0) from EPA Regional Screening Levels. Source: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.
   - RIDEM GA LC - Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Leachability Criteria GA Category

   NA = Screening values are not available from the cited source.

   Exceedances of soil screening criteria are highlighted by yellow background.

Table 1-2
Summary of Treated Unsaturated Soil Backfill VOCs Data
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc. [1]	Maximum Conc. [1]	Units	Detection Frequency	Soil Leachability Screening [2]				
						RIDEM GA Leachability Criteria		EPA Soil Screening Levels		
						Screening Value (ug/Kg)	Freq. above RIDEM GA LC	Screening Value (ug/Kg)	Screening Value Source	Freq. above EPA Screening Level
75-34-3	1,1-Dichloroethane	160	160	ug/Kg	1/73	NL	--	0.7	EPA Risk-SSL	**1/73**
95-50-1	1,2-Dichlorobenzene	42	1000	ug/Kg	38/73	3,200	0/73	660	EPA-MCL-SSL	**2/73**
78-93-3	2-Butanone	140	140	ug/Kg	1/73	NL	--	1,500,000	EPA Risk-SSL	0/73
95-49-8	2-Chlorotoluene	58	140	ug/Kg	6/73	NL	--	800	EPA Risk-SSL	0/73
67-64-1	Acetone	380	750	ug/Kg	12/73	NL	--	4,400	EPA Risk-SSL	0/73
74-83-9	Bromomethane	45	93	ug/Kg	12/73	NL	--	2.2	EPA Risk-SSL	**12/73**
75-15-0	Carbon Disulfide	120	650	ug/Kg	2/73	NL	--	270	EPA Risk-SSL	**1/73**
108-90-7	Chlorobenzene	190	190	ug/Kg	1/73	NL	--	75	EPA-MCL-SSL	**1/73**
67-66-3	Chloroform	38	38	ug/Kg	1/73	NL	--	0.055	EPA Risk-SSL	**1/73**
156-59-2	cis-1,2-Dichloroethylene	46	1900	ug/Kg	16/73	1,700	**1/73**	21	EPA-MCL-SSL	**16/73**
100-41-4	Ethylbenzene	23	130	ug/Kg	6/73	27,000	0/73	890	EPA-MCL-SSL	0/73
75-09-2	Methylene Chloride	100	430	ug/Kg	23/73	NL	--	1.3	EPA-MCL-SSL	**23/73**
100-42-5	Styrene	45	45	ug/Kg	1/73	2,900	0/73	120	EPA-MCL-SSL	0/73
127-18-4	Tetrachloroethylene	47	1800	ug/Kg	61/73	100	**38/73**	2.4	EPA-MCL-SSL	**61/73**
108-88-3	Toluene	23	310	ug/Kg	10/73	32,000	0/73	760	EPA-MCL-SSL	0/73
79-01-6	Trichloroethylene	32	940	ug/Kg	23/73	200	**3/73**	1.9	EPA-MCL-SSL	**23/73**
1330-20-7	Xylene (total)	45	720	ug/Kg	27/73	540,000	0/73	11,000	EPA-MCL-SSL	0/73

Notes:

1. Data based on post-treatment batch test results for materials backfilled into excavated areas. *Draft Remedial Action Report* (LEA, 2001).
2. Screening Values derived from the following sources:
   - EPA MCL-SSL: MCL-Based Soil Screening Level (SSL) from EPA Regional Screening Levels. Source: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
   - EPA Risk-SSL: Risk-Based SSL (Cancer Risk =1E-06 or Hazard Index =1.0) from EPA Regional Screening Levels. Source: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.
   - RIDEM GA LC - Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Leachability Criteria GA Category
   - NL - no limit established

Exceedances of soil screening criteria are highlighted by yellow background.

Table 1-3
Summary of 2008 Saturated Unexcavated Soil VOCs Data
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc. [1]	Maximum Conc. [1]	Units	Location of Maximum Concentration	Detection Frequency	Soil Leachability Screening [2]				
							RIDEM GA Leachability Criteria		EPA Soil Screening Levels		
							Screening Value (ug/Kg)	Freq. above RIDEM GA LC	Screening Value (ug/Kg)	Screening Value Source [2]	Freq. above EPA Screening Level
75-34-3	1,1-Dichloroethane	74	660	ug/Kg	NE5_11.512	4/79	NL	--	0.7	EPA Risk-SSL	**4/79**
120-82-1	1,2,4-Trichlorobenzene	86	930	ug/Kg	SW5_14.515	6/79	140,000	0/79	110	EPA MCL-SSL	**4/79**
95-50-1	1,2-Dichlorobenzene	68	5400	ug/Kg	SW2_1717.5	3/79	NL	--	660	EPA MCL-SSL	**1/79**
106-46-7	1,4-Dichlorobenzene	44	500	ug/Kg	NW5_1313.5	6/79	NL	--	81	EPA MCL-SSL	**3/79**
67-64-1	Acetone	610	2100	ug/Kg	NE6_11.512.25	3/79	NL	--	4,400	EPA Risk-SSL	0/79
75-15-0	Carbon disulfide	110	250	ug/Kg	SW5_20.521	4/79	NL	--	270	EPA Risk-SSL	0/79
108-90-7	Chlorobenzene	60	60	ug/Kg	SW2_1717.5	1/79	3,200	0/79	75	EPA MCL-SSL	0/79
156-59-2	cis-1,2-Dichloroethylene	47	270	ug/Kg	SE7_1212.5	12/79	1,700	0/79	21	EPA MCL-SSL	**12/79**
100-41-4	Ethylbenzene	56	5100	ug/Kg	NE6_1415	12/79	27,000	0/79	890	EPA MCL-SSL	**3/79**
103-65-1	Isopropylbenzene	59	4300	ug/Kg	NE6_11.512.25	5/79	NL	--	NL	--	--
127-18-4	Tetrachloroethylene	52	9500	ug/Kg	SE2_2121.5	12/79	100	**7/79**	2.4	EPA MCL-SSL	**12/79**
108-88-3	Toluene	150	240	ug/Kg	SE4_14.515	3/79	32,000	0/79	760	EPA MCL-SSL	0/79
79-01-6	Trichloroethylene	75	330	ug/Kg	SE2_2121.5	6/79	200	**2/79**	1.9	EPA MCL-SSL	**6/79**
75-01-4	Vinyl chloride	55	130	ug/Kg	SE7_1212.5	2/79	300	0/79	0.7	EPA MCL-SSL	**2/79**
1330-20-7	Xylene (total)	140	17000	ug/Kg	NE6_1415	14/79	540,000	0/79	11000	EPA MCL-SSL	**1/79**

Notes:

1. Data provided by ESS, Inc. in the *Draft Phase 4 Supplemental Field Investigation Report (Fall 2008)*, (ESS, 2009).
2. Screening Values derived from the following sources:
   - EPA MCL-SSL: MCL-Based Soil Screening Level (SSL) from EPA Regional Screening Levels. Source: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
   - EPA Risk-SSL: Risk-Based SSL (Cancer Risk =1E-06 or Hazard Index =1.0) from EPA Regional Screening Levels. Source: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.
   - RIDEM GA LC - Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Leachability Criteria GA Category
   - NL - no limit established

Exceedances of soil screening criteria are highlighted by yellow background.
All soil data presented were collected from the saturated zone.

Table 1-4
Summary of 2008 Overburden Groundwater VOCs Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Concentration [1]	Maximum Concentration [1]	Units	Location of Maximum Concentration	Detection Frequency	ARAR/TBC-Based Screening			Risk Summary[3]	
							Screening Value (ug/L)	Screening Value Source [2]	Frequency above Screening Value	Total Hazard Index	Total Cancer Risk
71-55-6	1,1,1-Trichloroethane	1	150	ug/L	OW-094-O	15/27	200	MCL/RIDEM-GA	0/27	0.01	---
79-00-5	1,1,2-Trichloroethane	0.9	2	ug/L	OW-301-O	7/27	5	MCL/RIDEM-GA	0/27	0.06	**3.4E-06**
75-34-3	1,1-Dichloroethane	1	64	ug/L	OW-043	16/27	2.4	EPA RSLs	**12/27**	0.04	**1.1E-05**
75-35-4	1,1-Dichloroethylene	0.9	4	ug/L	OW-045	8/27	7	MCL/RIDEM-GA	0/27	0.01	---
120-82-1	1,2,4-Trichlorobenzene	1	2	ug/L	OW-304-O	3/27	70	MCL/RIDEM-GA	0/27	0.03	2.2E-07
95-50-1	1,2-Dichlorobenzene	1	19	ug/L	OW-043	11/27	600	MCL/RIDEM-GA	0/27	0.03	---
541-73-1	1,3-Dichlorobenzene	1	1	ug/L	OW-051	1/27	600	MCL/RIDEM-GA	0/27	0.001	---
106-46-7	1,4-Dichlorobenzene	3	8	ug/L	OW-051	6/27	75	MCL/RIDEM-GA	0/27	---	**1.3E-06**
71-43-2	Benzene	0.6	2	ug/L	OW-043	6/27	5	MCL/RIDEM-GA	0/27	0.06	**3.3E-06**
108-90-7	Chlorobenzene	1	3	ug/L	OW-051	6/27	100	MCL/RIDEM-GA	0/27	0.02	---
75-00-3	Chloroethane	2	10	ug/L	OW-301-O	6/27	21000	EPA RSLs	0/27	---	---
67-66-3	Chloroform	0.9	0.9	ug/L	OW-094-O	2/27	80	MCL*	0/27	0.01	8.3E-07
156-59-2	cis-1,2-Dichloroethylene	0.8	390	ug/L	OW-045	19/27	70	MCL/RIDEM-GA	**9/27**	**5.0**	---
60-29-7	Diethyl ether	18	18	ug/L	OW-043	1/27	7300	EPA RSLs	0/27	0.01	---
100-41-4	Ethylbenzene	11	500	ug/L	OW-300-O	8/27	700	MCL/RIDEM-GA	0/27	0.6	**1.6E-04**
103-65-1	Isopropylbenzene	1	25	ug/L	OW-300-O	9/27	NL	--	--	0.03	---
127-18-4	Tetrachloroethylene	3	52	ug/L	OW-094-O	12/27	5	MCL/RIDEM-GA	**6/27**	0.7	**8.4E-04**
109-99-9	Tetrahydrofuran	8	98	ug/L	OW-043	2/27	NL	--	--	---	---
108-88-3	Toluene	0.9	61	ug/L	OW-300-O	9/27	1000	MCL/RIDEM-GA	0/27	0.1	---
156-60-5	trans-1,2-Dichloroethylene	1	11	ug/L	OW-045	12/27	100	MCL/RIDEM-GA	0/27	0.07	---
79-01-6	Trichloroethylene	1	480	ug/L	OW-301-O	15/27	5	MCL/RIDEM-GA	**8/27**	---	**1.9E-04**
75-01-4	Vinyl chloride	4	460	ug/L	OW-051	13/27	2	MCL/RIDEM-GA	**13/27**	**19.6**	**9.9E-03**
1330-20-7	Xylene (total)	3	990	ug/L	OW-300-O	8/27	10000	MCL/RIDEM-GA	0/27	0.6	---
									Total VOCs Risks	**27**	**1.1E-02**

Notes:

1. Data provided by ESS, Inc. in the *Draft Phase 4 Supplemental Field Investigation Report (Fall 2008)*, (ESS, 2009).
2. Screening Values derived from the following sources:
   - MCL - Federal Maximum Contaminant Level
   - MCL* - Federal Maximum Contaminant Level for total trihalomethanes
   - RIDEM-GA - Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; GA Groundwater Objectives. The GA Groundwater Objectives for these VOCs are identical to EPA MCLs.
   - EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario obtained from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
3. Risk summary = calculated risks based on residential drinking water exposures to the **maximum** detected concentrations. See CSM Addendum, Appendix B (Nobis 2009).

Exceedances of screening values highlighted by yellow background, and exceedance of E-06 cancer risk or HI of 1 highlighted by red text.

Table 1-5
Summary of 2008 Bedrock Groundwater VOCs Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Concentration [1]	Maximum Concentration [1]	Units	Location of Maximum Concentration	Detection Frequency	ARAR/TBC-Based Screening			Risk Summary[3]	
							Screening Value (ug/L)	Screening Value Source [2]	Frequency Above Screening Value	Total Hazard Index	Total Cancer Risk
71-55-6	1,1,1-Trichloroethane	2	560	ug/L	OW-094-R	5/20	200	MCL/RIDEM-GA	1/20	0.04	---
79-00-5	1,1,2-Trichloroethane	0.9	6	ug/L	OW-094-R	2/20	5	MCL/RIDEM-GA	1/20	0.19	1.0E-05
75-34-3	1,1-Dichloroethane	2	160	ug/L	OW-094-R	8/20	2.4	EPA-RSL	7/20	0.10	2.7E-05
75-35-4	1,1-Dichloroethylene	1	45	ug/L	OW-094-R	4/20	7	MCL/RIDEM-GA	1/20	0.12	---
120-82-1	1,2,4-Trichlorobenzene	2	2	ug/L	OW-101-R	1/20	70	MCL/RIDEM-GA	0/20	0.03	2.2E-07
95-50-1	1,2-Dichlorobenzene	13	57	ug/L	OW-094-R	4/20	600	MCL/RIDEM-GA	0/20	0.08	---
107-06-2	1,2-Dichloroethane	1	2	ug/L	OW-101-R	3/20	5	MCL/RIDEM-GA	0/20	0.01	5.4E-06
541-73-1	1,3-Dichlorobenzene	1	1	ug/L	OW-101-R	1/20	600	MCL/RIDEM-GA	0/20	0.00	---
106-46-7	1,4-Dichlorobenzene	2	8	ug/L	OW-101-R	2/20	75	MCL/RIDEM-GA	0/20	---	1.3E-06
78-93-3	2-Butanone	17	17	ug/L	OW-094-R	1/20	7100	EPA-RSL	0/20	0.00	---
67-64-1	Acetone	6	100	ug/L	OW-094-R	4/20	22000	EPA-RSL	0/20	0.01	---
71-43-2	Benzene	0.7	11	ug/L	OW-041	5/20	5	MCL/RIDEM-GA	2/20	0.35	1.8E-05
75-15-0	Carbon disulfide	2	2	ug/L	OW-041	1/20	1000	EPA-RSL	0/20	0.00	---
56-23-5	Carbon tetrachloride	91	91	ug/L	OW-094-R	1/20	5	MCL/RIDEM-GA	1/20	16.62	3.5E-04
108-90-7	Chlorobenzene	1	3	ug/L	OW-101-R	2/20	100	MCL/RIDEM-GA	0/20	0.02	---
75-00-3	Chloroethane	2	61	ug/L	OW-112-R	4/20	21000	EPA-RSL	0/20	---	---
67-66-3	Chloroform	1	1	ug/L	OW-112-R	1/20	80	MCL*	1/20	0.01	9.3E-07
156-59-2	cis-1,2-Dichloroethylene	1	1700	ug/L	OW-094-R	8/20	70	MCL/RIDEM-GA	1/20	21.74	---
60-29-7	Diethyl ether	4	130	ug/L	OW-041	8/20	7300	EPA RSLs	0/20	0.08	---
100-41-4	Ethylbenzene	1	78	ug/L	OW-101-R	4/20	700	MCL/RIDEM-GA	0/20	0.10	2.6E-05
103-65-1	Isopropylbenzene	2	21	ug/L	OW-101-R	3/20	NL	MCL/RIDEM-GA	--	0.03	---
75-09-2	Methylene chloride	13	13	ug/L	OW-112-R	1/20	5	MCL/RIDEM-GA	1/20	0.03	2.9E-06
127-18-4	Tetrachloroethylene	0.8	17	ug/L	OW-112-R	7/20	5	MCL/RIDEM-GA	4/20	0.22	2.7E-04
109-99-9	Tetrahydrofuran	19	830	ug/L	OW-112-R	8/20	NL	MCL/RIDEM-GA	--	---	---
108-88-3	Toluene	0.7	50	ug/L	OW-094-R	3/20	1000	MCL/RIDEM-GA	0/20	0.08	---
156-60-5	trans-1,2-Dichloroethylene	3	45	ug/L	OW-094-R	4/20	100	MCL/RIDEM-GA	0/20	0.29	---
79-01-6	Trichloroethylene	1	570	ug/L	OW-094-R	8/20	5	MCL/RIDEM-GA	4/20	---	2.2E-04

Table 1-5
Summary of 2008 Bedrock Groundwater VOCs Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Concentration [1]	Maximum Concentration [1]	Units	Location of Maximum Concentration	Detection Frequency	ARAR/TBC-Based Screening			Risk Summary[3]	
							Screening Value (ug/L)	Screening Value Source [2]	Frequency Above Screening Value	Total Hazard Index	Total Cancer Risk
75-01-4	Vinyl chloride	0.5	340	ug/L	OW-094-R	5/20	2	MCL/RIDEM-GA	4/20	14.49	7.3E-03
1330-20-7	Xylene (total)	4	66	ug/L	OW-094-R	4/20	10000	MCL/RIDEM-GA	0/20	0.04	---
									Total VOCs Risks	**54**	**8.2E-03**

Notes:

1. Data provided by ESS, Inc. in the *Draft Phase 4 Supplemental Field Investigation Report (Fall 2008)* , (ESS, 2009).
2. Screening Values derived from the following sources:
   - MCL - Federal Maximum Contaminant Level
   - MCL* - Federal Maximum Contaminant Level for total trihalomethanes
   - RIDEM-GA - Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; GA Groundwater Objectives. The GA Groundwater Objectives are identical to EPA Maximum Contaminant Levels (MCLs)
   - EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario obtained from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
3. Risk summary = calculated risks based on residential drinking water exposures to the **maximum** detected concentrations. See CSM Addendum, Appendix B (Nobis 2009).

Exceedances of screening values highlighted by yellow background, and exceedance of E-06 cancer risk or HI of 1 highlighted by red text.

Table 1-6
Summary of 2003 Overburden Groundwater SVOCs Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc.	Maximum Conc.	Average Conc.	Units	Location of Maximum	Detection Frequency	EPA Regional Screening Levels for Tap Water			RIDEM GA/MCL Objectives		Cancer risk estimate	Hazard Index estimate
								Criteria Value (2)		Frequency of Detects Above Criteria	Criteria Value (1)	Frequency of Detects Above Criteria	(3)	(4)
105-67-9	2,4-Dimethylphenol	1	1	1.1	ug/L	OW-054	1/20	73	N	0/20	NA	0/20	NA	1.4E-03
91-57-6	2-Methylnaphthalene	1	4	0.35	ug/L	OW-094-O	3/20	15	N	0/20	NA	0/20	NA	2.7E-02
106-44-5	4-Methylphenol	2	15	1.4	ug/L	OW-109-O	2/20	18.0	N	0/20	NA	0/20	NA	8.3E-02
98-86-2	Acetophenone	3	3	0.15	ug/L	OW-094-O	1/20	370	N	0/20	NA	0/20	NA	8.1E-04
111-44-4	Bis(2-chloroethyl)ether	2	2	0.10	ug/L	OW-043	1/20	0.012	C	**1/20**	NA	0/20	**1.7E-04**	NA
91-20-3	Naphthalene	3	5	0.60	ug/L	OW-094-O	3/20	0.14	C	**3/20**	20 *	0/20	**3.6E-05**	NA
98-95-3	Nitrobenzene	5	5	0.25	ug/L	OW-052	1/20	0.12	C	**1/20**	NA	0/20	**4.2E-05**	NA
87-86-5	Pentachlorophenol	4	4	0.20	ug/L	OW-094-O	1/20	0.56	C	**1/20**	1	1/20	**7.1E-06**	NA
												Total risks from SVOCs	**2.5E-04**	**1.1E-01**

Notes:

NA - Values for cited substances are not available. * - RIDEM GA, only.

Data from ESS 2006, postive detect analytes shown.

(1) - RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Table 3 GA Groundwater Objectives

(2) - EPA Regional Screening Levels September 2008; Tap Water Scenario. C = Cancerous; N = Noncancerous. Non-cancer based values have been adjusted to correspond to HQ=0.1.

(3) - Cancer risk = maximum concentration/cancer based screening value x 10^{-6}

(4) - Hazard Index = maximum concentration/non-cancer based screening value x 0.1

Exceedances of screening values highlighted by yellow background, and exceedance of E-06 cancer risk or HI of 1 highlighted by red text.

Table 1-7
Summary of 2003 Bedrock Groundwater SVOCs Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc.	Maximum Conc.	Average Conc.	Units	Location of Maximum	Detection Frequency	EPA Regional Screening Levels for Tap Water			RIDEM GA/MCL Objectives		Cancer risk estimate	Hazard Index estimate
								Criteria Value (2)		Frequency of Detects Above Criteria	Criteria Value (1)	Frequency of Detects Above Criteria	(3)	(4)
105-67-9	2,4-Dimethylphenol	2	2	0.09	ug/L	OW-094-R	1/21	73	N	0/21	NA	0/21	NA	2.7E-03
91-57-6	2-Methylnaphthalene	2	2	0.09	ug/L	OW-101-R	1/21	15	N	0/21	NA	0/21	NA	1.3E-02
95-48-7	2-Methylphenol	1	1	0.05	ug/L	OW-094-R	1/21	180	N	0/21	NA	0/21	NA	5.6E-04
106-44-5	4-Methylphenol	7	7	0.32	ug/L	OW-101-R	1/21	18.0	N	0/21	NA	0/21	NA	3.9E-02
98-86-2	Acetophenone	3	3	0.14	ug/L	OW-101-R	1/21	370	N	0/21	NA	0/21	NA	8.1E-04
111-44-4	Bis(2-chloroethyl)ether	4	25	2.1	ug/L	OW-101-R	4/21	0.012	C	4/21	NA	0/21	**2.1E-03**	NA
91-20-3	Naphthalene	5	5	0.23	ug/L	OW-101-R	1/21	0.14	C	1/21	20 *	0/21	**3.6E-05**	NA
108-95-2	Phenol	1	3	0.18	ug/L	OW-094-R	2/21	1100	N	0/21	NA	0/21	NA	2.7E-04
												Total risks from SVOCs	**2.1E-03**	**5.7E-02**

Notes:

NA - Values for cited substances are not available. * - RIDEM GA, only.

Data from ESS 2006, postive detect analytes shown.

(1) - RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Table 3 GA Groundwater Objectives

(2) - EPA Regional Screening Levels September 2008; Tap Water Scenario. C = Cancerous; N = Noncancerous. Non-cancer based values have been adjusted to correspond to HQ=0.1.

(3) - Cancer risk = maximum concentration/cancer based screening value x 10^{-6}

(4) - Hazard Index = maximum concentration/non-cancer based screening value x 0.1

Exceedances of screening values highlighted by yellow background, and exceedance of E-06 cancer risk or HI of 1 highlighted by red text.

Table 1-8
Summary of 2003 Groundwater Pesticides/PCBs Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc.	Maximum Conc.	Average Conc.	Units	Location of Maximum	Detection Frequency	EPA Regional Screening Levels for Tap Water			RIDEM GA Objectives/MCLs		Cancer risk estimate	Hazard Index estimate
								Criteria Value (2)		Frequency of Detects Above Criteria	Criteria Value (1)	Frequency of Detects Above Criteria	(3)	(4)
72-54-8	4,4'-DDD	0.00086	0.022	0.0072	ug/L	OW-045C	4/14	0.28	C	0/4	NA	--	7.85E-08	NA
72-55-9	4,4'-DDE	0.0054	0.0054	0.0054	ug/L	OW-093-OA	1/13	0.20	C	0/1	NA	--	2.70E-08	NA
50-29-3	4,4'-DDT	0.0011	0.01	0.0032	ug/L	OW-093-OA	6/14	0.20	C	0/6	NA	--	5.00E-08	NA
309-00-2	Aldrin	0.0018	0.012	0.0069	ug/L	OW-052B	5/14	0.004	C	**4/5**	NA	--	**3.00E-06**	NA
319-84-6	alpha-BHC	0.00044	0.00052	0.0005	ug/L	OW-084B	2/14	0.011	C	0/2	NA	--	4.87E-08	NA
5103-71-9	alpha-Chlordane	0.00045	0.0022	0.0012	ug/L	OW-051C	3/14	0.19	C	--	NA	--	1.16E-08	NA
60-57-1	Dieldrin	0.0016	0.0072	0.0044	ug/L	OW-101-RB	2/14	0.0042	C	**1/2**	NA	--	**1.71E-06**	NA
959-98-8	Endosulfan I	0.00045	0.011	0.0047	ug/L	OW-052B	3/14	22	N	--	NA	--	NA	5.00E-05
33213-65-9	Endosulfan II	0.0015	0.0015	0.0015	ug/L	OW-051C	1/14	22	N	--	NA	--	NA	6.82E-06
1031-07-8	Endosulfan sulfate	0.0025	0.0025	0.0025	ug/L	OW-094-RA	1/14	22	N	--	NA	--	NA	1.14E-05
72-20-8	Endrin	0.0012	0.012	0.0042	ug/L	OW-094-OA	5/14	1.1	N	0/5	NA	--	NA	1.09E-03
53494-70-5	Endrin ketone	0.00087	0.0035	0.0019	ug/L	OW-093-OA	3/14	1.1	N	--	NA	--	NA	3.18E-04
58-89-9	gamma-BHC	0.00089	0.0025	0.0013	ug/L	OW-094-OA	4/14	0.061	C	0/4	NA	--	4.10E-08	NA
5103-74-2	gamma-Chlordane	0.00072	0.024	0.0060	ug/L	OW-052B	9/14	0.19	C	--	NA	--	1.26E-07	NA
76-44-8	Heptachlor	0.00064	0.031	0.0097	ug/L	OW-052B	4/14	0.015	C	0/4	0.4	0/4	**2.07E-06**	NA
1024-57-3	Heptachlor epoxide	0.0005	0.00085	0.0007	ug/L	OW-051C	3/14	0.0074	C	0/3	NA	--	1.15E-07	NA
												Total risks from Pesticides	**7.28E-06**	1.48E-03

Notes:

All concentrations are reported in ug/L

No detectable concentrations of PCBs in groundwater samples

NA - Values for cited substances are not available.

Data from ESS 2006, postive detect analytes shown.

(1) - RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Table 3 GA Groundwater Objectives; Federal Maximum Contaminant Levels

(2) - EPA Regional Screening Levels September 2008; Tap Water Scenario. C = Cancerous; N = Noncancerous. Non-cancer based values have been adjusted to correspond to HQ=0.1.

Endrin screening values have been used for endrin ketone.

Endosulfan screening values have been used for endosulfan I, endosulfan II, and endosulfan sulfate.

Chlordane screening values have been used for alpha-chlordane and gamma-chlordane.

(3) - Cancer risk = maximum concentration/cancer based screening value x 10^{-6}

(4) - Hazard Index = maximum concentration/non-cancer based screening value x 0.1

Exceedances of screening values highlighted by yellow background, and exceedance of E-06 cancer risk or HI of 1 highlighted by red text.

Table 1-9
Summary of 2004 Overburden Groundwater Metals Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc.	Maximum Conc.	Average Conc.	Units	Location of Maximum	Detection Frequency	EPA Regional Screening Levels for Tap Water			RIDEM GA/MCL Objectives		Cancer risk estimate	Hazard Index estimate
								Criteria Value (2)		Frequency of Detects Above Criteria	Criteria Value (1)	Frequency of Detects Above Criteria	(3)	(4)
7429-90-5	Aluminum	25	348	17.8	ug/L	OW-055	2/20	3700	N	0/20	NA	0/20	NA	9.41E-03
7440-38-2	Arsenic	19.2	19.2	0.96	ug/L	OW-105-O	1/20	0.045	C	**1/20**	10	**1/20**	**4.27E-04**	
7440-39-3	Barium	5.8	56.9	20.6	ug/L	OW-055	20/20	730	N	0/20	2000	0/20	NA	7.79E-03
7440-70-2	Calcium	1730	34600	11977	ug/L	OW-043	20/20	NA		0/20	NA	0/20	NA	
7440-48-4	Cobalt	5.5	9.6	0.72	ug/L	OW-034	2/20	1.1	N	**2/20**	NA	0/20	NA	8.73E-01
7439-89-6	Iron	221	25600	6197	ug/L	OW-052	14/20	2600	N	**8/20**	NA	0/20	NA	9.85E-01
7439-92-1	Lead	3.3	3.3	0.17	ug/L	OW-109-O	1/20	15		0/20	15	0/20	NA	
7439-95-4	Magnesium	422	4100	2130	ug/L	OW-021	20/20	NA		0/20	NA	0/20	NA	
7439-96-5	Manganese	24.3	4780	1424	ug/L	OW-94-O	20/20	88	N	**16/20**	NA	0/20	NA	**5.43E+00**
7439-97-6	Mercury (elemental)	33.1	33.1	1.7	ug/L	OW-045	1/20	0.057	N	**1/20**	2	**1/20**	NA	**5.81E+01**
7440-09-7	Potassium	530	5520	2675	ug/L	OW-102-O	20/20	NA		0/20	NA	0/20	NA	
7440-23-5	Sodium	2350	19800	6343	ug/L	OW-103-O	20/20	NA		0/20	NA	0/20	NA	
7440-66-6	Zinc	134	155	13.8	ug/L	OW-055	2/20	1100	N	0/20	NA	0/20	NA	1.41E-02
												Total risks from Metals	**4.27E-04**	**6.54E+01**

Notes:

All concentrations are reported in ug/L

NA - Values for cited substances are not available.

Data from ESS 2006, postive detect analytes shown.

(1) - RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Table 3 GA Groundwater Objectives

(2) - EPA Regional Screening Levels September 2008; Tap Water Scenario. C = Cancerous; N = Noncancerous. Non-cancer based values have been adjusted to correspond to HQ=0.1.

(3) - Cancer risk = maximum concentration/cancer based screening value x 10^{-6}

(4) - Hazard Index = maximum concentration/non-cancer based screening value x 0.1

Exceedances of screening values highlighted by yellow background, and exceedance of E-06 cancer risk or HI of 1 highlighted by red text.

Table 1-10
Summary of 2004 Bedrock Groundwater Metals Data and Risk Estimates
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc.	Maximum Conc.	Average Conc.	Units	Location of Maximum	Detection Frequency	EPA Regional Screening Levels for Tap Water			RIDEM GA/MCL Objectives		Cancer risk estimate	Hazard Index estimate
								Criteria Value (2)		Frequency of Detects Above Criteria	Criteria Value (1)	Frequency of Detects Above Criteria	(3)	(4)
7429-90-5	Aluminum	237	2340	152	ug/L	OW-109-R	2/17	3700	N	0/17	NA	0/17	NA	6.32E-02
7440-38-2	Arsenic	11.8	17.6	1.7	ug/L	OW-109-R	2/17	0.045	C	**2/17**	10	**2/17**	**3.91E-04**	NA
7440-39-3	Barium	5	332	50	ug/L	OW-041	12/17	730	N	0/17	2000	0/17	NA	4.55E-02
7440-70-2	Calcium	7750	270000	57085	ug/L	OW-112-R	17/17	NA		0/17	NA	0/17	NA	NA
7439-89-6	Iron	266	22800	2755	ug/L	OW-101-R	10/17	2600	N	**4/17**	NA	0/17	NA	**8.77E-01**
7439-92-1	Lead	3.9	3.9	0.23	ug/L	OW-109-R	1/17	15		0/17	15	0/17	NA	NA
7439-95-4	Magnesium	352	25900	3812	ug/L	OW-103-R	17/17	NA		0/17	NA	0/17	NA	NA
7439-96-5	Manganese	13.3	7960	1122	ug/L	OW-101-R	13/17	88	N	**8/17**	NA	0/17	NA	**9.05E+00**
7440-09-7	Potassium	1510	15000	4562	ug/L	OW-103-R	17/17	NA		0/17	NA	0/17	NA	NA
7440-23-5	Sodium	4090	266000	30698	ug/L	OW-103-R	17/17	NA		0/17	NA	0/17	NA	NA
7440-66-6	Zinc	117	117	6.9	ug/L	OW-102-R	1/17	1100	N	0/17	NA	0/17	NA	1.06E-02
												Total risks from Metals	**3.91E-04**	**1.00E+01**

Notes:

All concentrations are reported in ug/L

NA - Values for cited substances are not available.

Data from ESS 2006, postive detect analytes shown.

(1) - RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; Table 3 GA Groundwater Objectives

(2) - EPA Regional Screening Levels September 2008; Tap Water Scenario. C = Cancerous; N = Noncancerous. Non-cancer based values have been adjusted to correspond to HQ=0.1.

(3) - Cancer risk = maximum concentration/cancer based screening value x 10^{-6}

(4) - Hazard Index = maximum concentration/non-cancer based screening value x 0.1

Exceedances of screening values highlighted by yellow background, and exceedance of E-06 cancer risk or HI of 1 highlighted by red text.

Table 1-11
Summary of 2008 Surface Water VOCs Data
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc. [1]	Maximum Conc. [1]	Units	Location of Max. Conc.	Detection Frequency	Aquatic Life Risk Screening			Human Health Risk Screening		
							Screening Value (ug/L)	Screening Value Source [2]	Frequency above Screening Value	Screening Value (ug/L)	Screening Value Source [3]	Frequency above Screening Value
71-55-6	1,1,1-Trichloroethane	1	2	ug/L	SW-102	2/3	62	1996ORNL	0/3	NL	--	0/3
75-34-3	1,1-Dichloroethane	2	3	ug/L	SW-102	2/3	47	1996ORNL	0/3	NL	--	0/3
156-59-2	cis-1,2-Dichloroethylene	5	18	ug/L	SW-102	3/3	590	1996ORNL	0/3	NL	--	0/3
127-18-4	Tetrachloroethylene	1	4	ug/L	SW-102	3/3	5.3	RIAWQC-AL	0/3	33	RIAWQC-HH	0/3
79-01-6	Trichloroethylene	2	3	ug/L	SW-102	2/3	43	RIAWQC-AL	0/3	300	RIAWQC-HH	0/3
75-01-4	Vinyl chloride	3	7	ug/L	SW-102	2/3	930	EPAR5-SWSC	0/3	2.4	RIAWQC-HH	2/3

Notes:

1. Preliminary October 2008 data provided by ESS, Inc. (ESS, 2009)
2. Screening Values derived from:
   - RIAWQC-AL - Rhode Island Ambient Water Quality Critera; Freshwater Chronic Aquatic Life Risk Screening Value; from 1996 Rhode Island Water Quality Regulations
   - EPAR5-SWSC - EPA Region V Surface Water Screening Criteria; Oak Ridge National Laboratory Risk Assessment Information System Ecological Benchmark Database found here: http://rais.ornl.gov/homepage/benchmark.shtml
   - 1996ORNL - Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision: Oak Ridge National Laboratory, Risk Assessment Program, Health Sciences Research Division, Oak Ridge, TN
3. Screening Values derived from:
   - RIAWQC-HH - Rhode Island Ambient Water Quality Critera; Consumption of Aquatic Organism Only, Human Health Criteria; from 1996 Rhode Island Water Quality Regulations

NL - Screening value is not listed

Table 1-12
Vapor Intrusion Screening of 2008 Overburden Groundwater VOCs
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc. [1]	Maximum Conc. [1]	Units	Location of Max. Conc.	Detection Frequency	Vapor Intrusion Screening		
							Screening Value (ug/L)	Screening Value Source [2]	Frequency above Screening Value
71-43-2	Benzene	0.6	2	ug/L	OW-043	4/25	1.36	EPA-VI	1/25
67-66-3	Chloroform	0.9	0.9	ug/L	OW-094-O	1/25	0.705	EPA-VI	1/25
156-59-2	cis-1,2-Dichloroethylene	0.8	390	ug/L	OW-045	17/25	210	EPA-VI	4/25
100-41-4	Ethylbenzene	11	500	ug/L	OW-300-O	6/25	6.91	EPA-VI	6/25
127-18-4	Tetrachloroethylene	3	52	ug/L	OW-094-O	10/25	0.55	EPA-VI	10/25
79-01-6	Trichloroethylene	1	480	ug/L	OW-301-O	13/25	2.89	EPA-VI	10/25
75-01-4	Vinyl chloride	4	250	ug/L	OW-051	11/25	0.251	EPA-VI	11/25

Notes:

1. Preliminary October 2008 data provided by ESS, Inc.
2. Screening Values derived from:

- EPA Vapor Intrusion Guidance (EPA-VI), 2002 Table 2c. Values for contaminants with updated toxicity values have been revised to reflect current toxicity values in IRIS or the EPA's Regional Screening levels [http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm]. Table 2c values based on MCLs have been replace by risk-based values.

Yellow highlight indicates frequently observed (more than 1 in 20).

Table 1-13
Vapor Intrusion Screening of 2008 Bedrock Groundwater VOCs
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Minimum Conc. [1]	Maximum Conc. [1]	Units	Location of Maximum Concentration	Detection Frequency	Screening		
							Screening Value (ug/L)	Screening Value Source	Frequency Above Screening Value
79-00-5	1,1,2-Trichloroethane	0.9	6	ug/L	OW-094-R	2/20	4.11	EPA-VI	1/20
71-43-2	Benzene	0.7	11	ug/L	OW-041	5/20	1.36	EPA-VI	4/20
56-23-5	Carbon tetrachloride	91	91	ug/L	OW-094-R	1/20	5	EPA-VI	1/20
67-66-3	Chloroform	1	1	ug/L	OW-112-R	1/20	0.705	EPA-VI	1/20
156-59-2	cis-1,2-Dichloroethylene	1	1700	ug/L	OW-094-R	8/20	210	EPA-VI	1/20
100-41-4	Ethylbenzene	1	78	ug/L	OW-101-R	4/20	6.91	EPA-VI	3/20
127-18-4	Tetrachloroethylene	0.8	17	ug/L	OW-112-R	7/20	0.55	EPA-VI	7/20
79-01-6	Trichloroethylene	1	570	ug/L	OW-094-R	8/20	2.89	EPA-VI	7/20
75-01-4	Vinyl chloride	0.5	340	ug/L	OW-094-R	5/20	0.251	EPA-VI	5/20

Notes:
1. Preliminary October 2008 data provided by ESS, Inc.
2. Screening Values derived from:
   - EPA Vapor Intrusion Guidance (EPA-VI), 2002 Table 2c. Values for contaminants with updated toxicity values have been revised to reflect current toxicity values in IRIS or the EPA's Regional Screening levels [http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm]. Table 2c values based on MCLs have been replace by risk-based values.

Table 1-14A
Average Well Risks in Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Average of All Wells				
Chemical	**cancer risk**	**hazard index**	**percent of total**	
			cancer risk	**hazard index**
1,1-Dichloroethane	**5.9E-06**	**0.00**	0.1%	0%
1,2-Dichloroethane	**0.0E+00**	**0.00**	0%	0%
1,1,2-Trichloroethane	**1.3E-06**	**0.00**	0.0%	0%
1,4-Dichlorobenzene	**2.5E-06**	**0.00**	0.1%	0%
Benzene	**5.2E-07**	**0.00**	0.0%	0%
Carbon tetrachloride	**0.0E+00**	**0.00**	0%	0%
cis-1,2-Dichloroethylene	**0.0E+00**	**0.21**	0%	2.0%
Ethylbenzene	**2.2E-05**	**0.03**	0.5%	0.2%
Methylene chloride	**0.0E+00**	**0.00**	0%	0%
Tetrachloroethylene	**4.1E-05**	**0.02**	0.9%	0.2%
Trichloroethylene	**1.4E-05**	**0.00**	0.3%	0%
Vinyl chloride	**4.2E-03**	**0.94**	97%	9.2%
Arsenic	**2.1E-05**	**0.09**	0.5%	0.8%
Cobalt	**0.0E+00**	**0.07**	0%	0.7%
Iron	**0.0E+00**	**4.12**	0%	40%
Manganese	**0.0E+00**	**1.62**	0%	16%
Mercury	**0.0E+00**	**3.06**	0%	30%
Aldrin	**9.0E-07**	**0.00**	0.0%	0%
Dieldrin	**1.6E-07**	**0.00**	0.0%	0%
Heptachlor	**2.9E-07**	**0.00**	0.0%	0%
Bis(2-chloroethyl)ether	**8.3E-06**	**0.00**	0.2%	0%
Naphthalene	**4.3E-06**	**0.10**	0.1%	0.9%
Nitrobenzene	**2.1E-06**	**0.02**	0.0%	0.2%
Pentachlorophenol	**3.6E-07**	**0.00**	0.0%	0%
Total average well risks	**4.4E-03**	**10.28**	100%	100%
Total average well VOC risks	**4.3E-03**	**1.21**	99%	12%
Total average well Metals risks	**2.1E-05**	**8.96**	0.5%	87%
Total average well Pesticides risks	**1.4E-06**	**0.00**	0.0%	0%
Total average well SVOCs risks	**1.5E-05**	**0.11**	0.3%	1.1%

Notes:

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Table 1-14B
Average Well Risks in Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Average of All Wells				
Chemical	**cancer risk**	**hazard index**	**percent of total**	
			cancer risk	**hazard index**
1,1-Dichloroethane	**8.2E-06**	**0.00**	0.5%	0%
1,2-Dichloroethane	**2.4E-06**	**0.00**	0%	0%
1,1,2-Trichloroethane	**1.1E-06**	**0.00**	0.1%	0%
1,4-Dichlorobenzene	**1.2E-06**	**0.00**	0.1%	0%
Benzene	**3.4E-06**	**0.03**	0.2%	1%
Carbon tetrachloride	**2.4E-05**	**0.20**	1%	4%
cis-1,2-Dichloroethylene	**0.0E+00**	**0.25**	0%	5.5%
Ethylbenzene	**5.6E-06**	**0.01**	0.3%	0.1%
Methylene chloride	**1.4E-07**	**0.00**	0%	0%
Tetrachloroethylene	**2.8E-05**	**0.01**	1.6%	0.3%
Trichloroethylene	**2.0E-05**	**0.00**	1.2%	0%
Vinyl chloride	**1.4E-03**	**0.30**	81%	6.6%
Arsenic	**4.1E-05**	**0.17**	2.4%	3.6%
Cobalt	**0.0E+00**	**0.00**	0%	0.0%
Iron	**0.0E+00**	**2.09**	0%	45%
Manganese	**0.0E+00**	**1.52**	0%	33%
Mercury	**0.0E+00**	**0.00**	0%	0%
Aldrin	**6.3E-08**	**0.00**	0.0%	0%
Dieldrin	**3.2E-07**	**0.00**	0.0%	0%
Heptachlor	**5.1E-08**	**0.00**	0.0%	0%
Bis(2-chloroethyl)ether	**1.9E-04**	**0.00**	11.0%	0%
Naphthalene	**1.7E-06**	**0.04**	0.1%	0.8%
Nitrobenzene	**0.0E+00**	**0.00**	0.0%	0.0%
Pentachlorophenol	**0.0E+00**	**0.00**	0.0%	0%
Total average well risks	**1.7E-03**	**4.63**	100%	100%
Total average well VOC risks	**1.5E-03**	**0.82**	86%	18%
Total average well Metals risks	**4.1E-05**	**3.78**	2.4%	82%
Total average well Pesticides risks	**4.3E-07**	**0.00**	0.0%	0%
Total average well SVOCs risks	**1.9E-04**	**0.04**	11.1%	0.8%

Notes:

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Table 2-1A
Selection of COCs for Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Potential Contaminant of Concern	Human Health Risk (1) Maximum		Human Health Risk (2) Average Well		ARAR		To Be Considered	Groundwater Chemical Concentrations	Frequency Above Screening Value (5)	Selection as COC?
	Cancer Risk	Hazard Quotient	Cancer	Hazard Quotient	Federal MCL (µg/L)	RIDEM GA (3) (µg/L)	EPA Regional Screening Level for Tap Water (4) (µg/L)	Maximum Plume Conc. (µg/L)		(Yes or No?)
1,1-Dichloroethane	1.1E-05	0.04	5.9E-06	0.00	NA	NA	2.4	64	12/27	Yes. Exceeds Risk and RSL.
1,2-Dichloroethane	NA	NA	0.0E+00	0.00	5	5	0.15	nd	0/27	No. Not detected in overburden.
1,1,2-Trichloroethane	3.4E-06	0.06	1.3E-06	0.00	5	5	0.24	2	0/27	No. Less than MCL and RIDEM-GA.
1,4-Dichlorobenzene	1.3E-06	NA	2.5E-06	0.00	75	75	0.43	8	0/27	No. Less than MCL and RIDEM-GA.
Benzene	3.3E-06	0.06	5.2E-07	0.00	5	5	0.41	2	0/27	No. Less than MCL and RIDEM-GA.
Carbon tetrachloride	NA	NA	0.0E+00	0.00	5	5	0.2	nd	0/27	No. Not detected in overburden.
cis-1,2-Dichloroethylene	NA	5	0.0E+00	0.21	70	70	370	390	9/27	Yes. Exceeds HQ=1, MCL, and RIDEM-GA.
Ethylbenzene	1.6E-04	0.6	2.2E-05	0.03	700	700	1.5	500	0/27	No. Less than MCL and RIDEM-GA.
Methylene chloride	NA	NA	0.0E+00	0.00	5	5	4.8	nd	0/27	No. Not detected in overburden.
Tetrachloroethylene	8.4E-04	0.7	4.1E-05	0.02	5	5	0.11	52	6/27	Yes. Exceeds Risk, MCL, and RIDEM-GA.
Trichloroethylene	1.9E-04	NA	1.4E-05	0.00	5	5	1.7	480	8/27	Yes. Exceeds Risk, MCL, and RIDEM-GA.
Vinyl chloride	9.9E-03	19.6	4.2E-03	0.94	2	2	0.016	460	13/27	Yes. Exceeds Risk, HQ=1, MCL, and RIDEM-GA.
Arsenic	4.3E-04	NA	2.1E-05	0.09	10	10	0.045	19.2	1/20	Yes. Exceeds Risk, MCL, and RIDEM-GA.
Cobalt	NA	0.87	0.0E+00	0.07	NA	NA	11	9.6	0/20	No. Less than screening value.
Iron	NA	0.98	0.0E+00	4.12	NA	NA	26000	25600	0/20	No. Less than screening value.
Manganese	NA	5.4	0.0E+00	1.62	NA	NA	880	4780	1/20	Yes. Exceeds HQ=1 and RSL.
Mercury	NA	58	0.0E+00	3.06	2	2	0.57	33.1	1/20	No. Infrequently detected in overburden.
Aldrin	3.0E-06	NA	9.0E-07	0.00	NA	NA	0.004	0.012	3/8	Yes. Exceeds Risk and RSL.
Dieldrin	9.3E-07	NA	1.6E-07	0.00	NA	NA	0.0042	0.0039	0/8	No. Less than screening value.
Heptachlor	2.1E-06	NA	2.9E-07	0.00	0.4	0.4	0.015	0.031	0/8	No. Less than MCL and RIDEM-GA.
Bis(2-chloroethyl)ether	1.7E-04	NA	8.3E-06	0.00	NA	NA	0.012	2	1/20	Yes. Exceeds Risk and RSL.

Table 2-1A
Selection of COCs for Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Potential Contaminant of Concern	Human Health Risk (1) Maximum		Human Health Risk (2) Average Well		ARAR		To Be Considered	Groundwater Chemical Concentrations	Frequency Above Screening Value (5)	Selection as COC?
	Cancer Risk	Hazard Quotient	Cancer	Hazard Quotient	Federal MCL (µg/L)	RIDEM GA (3) (µg/L)	EPA Regional Screening Level for Tap Water (4) (µg/L)	Maximum Plume Conc. (µg/L)		(Yes or No?)
Naphthalene	3.6E-05	NA	4.3E-06	0.10	NA	20	0.14	5	0/20	No. Less than RIDEM-GA.
Nitrobenzene	4.2E-05	NA	2.1E-06	0.02	NA	NA	0.12	5	1/20	No. Infrequently detected in overburden.
Pentachlorophenol	7.1E-06	NA	3.6E-07	0.00	1	1	0.56	4	1/20	No. Infrequently detected in overburden.

Notes:

(1) Maximum Risks presented in Tables 1-4 through 1-11. For VOCs, these are calculated risks based on reasonable maximum exposure assumptions; for SVOCs, pesticides, and metals, these risks were determined using a ratio of maximum concentrations to RSLs.
(2) Well-by-Well Risks estimated in Appendix A, Table A-1.

(3) RIDEM – GA – Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; GA Groundwater Objectives. The GA Groundwater Objectives are identical to EPA Maximum Contaminant Levels (MCLs).
(4) EPA Regional Screening Level for Tap Water, September 2008. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.html
(5) Frequency above MCL or RIDEM GA or, in the absense of one of these ARARs, frequency above RSL. See Tables 1-4 through 1-11.

MCL – Maximum Contaminant Level
NA – Not applicable, or no criteria available
ND – not detected
MAX – Maximum detected concentration in overburden aquifer

VOCs Data from ESS Phase 4 Subsurface Investigation 2008.
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Table 2-1B
Selection of COCs for Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Potential Contaminant of Concern	Human Health Risk (1) Maximum		Human Health Risk (2) Average Well		ARAR		To Be Considered	Groundwater Chemical Concentrations	Frequency Above Screening Value (5)	Selection as COC?
	Cancer	Hazard Quotient	Cancer	Hazard Quotient	Federal MCL (µg/L)	RIDEM GA (3) (µg/L)	EPA Regional Screening Level for Tap Water (4) (µg/L)	Maximum Plume Conc. (µg/L)		(Yes or No?)
1,1-Dichloroethane	2.7E-05	0.1	8.2E-06	0.00	NA	NA	2.4	160	7/20	Yes. Exceeds Risk and RSL.
1,2-Dichloroethane	5.4E-06	0.01	2.4E-06	0.00	5	5	0.15	2	0/20	No. Less than MCL and RIDEM-GA.
1,1,2-Trichloroethane	1.0E-05	0.2	1.1E-06	0.00	5	5	0.24	6	1/20	No. Infrequently detected above screening.
1,4-Dichlorobenzene	1.3E-06	0.015	1.2E-06	0.00	75	75	0.43	8	0/20	No. Less than MCL and RIDEM-GA.
Benzene	1.8E-05	0.4	3.4E-06	0.03	5	5	0.41	11	2/20	Yes. Exceeds Risk, MCL, and RIDEM-GA.
Carbon tetrachloride	3.5E-04	16.6	2.4E-05	0.20	5	5	0.2	91	1/20	No. Infrequently detected above screening.
cis-1,2-Dichloroethylene	NA	21.7	0.0E+00	0.25	70	70	370	1700	1/20	No. Infrequently detected above screening.
Ethylbenzene	2.6E-05	0.1	5.6E-06	0.01	700	700	1.5	78	0/20	No. Less than MCL and RIDEM-GA.
Methylene chloride	2.9E-06	0.03	1.4E-07	0.00	5	5	4.8	13	1/20	No. Infrequently detected above screening.
Tetrachloroethylene	2.7E-04	0.2	2.8E-05	0.01	5	5	0.11	17	4/20	Yes. Exceeds Risk, MCL, and RIDEM-GA.
Trichloroethylene	2.2E-04	NA	2.0E-05	0.00	5	5	1.7	570	4/20	Yes. Exceeds Risk, MCL, and RIDEM-GA.
Vinyl chloride	7.3E-03	14.5	1.4E-03	0.30	2	2	0.016	340	4/20	Yes. Exceeds Risk, HQ=1, MCL, and RIDEM-GA.
Arsenic	3.9E-04	NA	4.1E-05	0.17	10	10	0.045	17.6	2/17	Yes. Exceeds Risk, MCL, and RIDEM-GA.
Cobalt	NA	NA	0.0E+00	0.00	NA	NA	11	nd	0/17	No. Not detected in bedrock.
Iron	NA	0.88	0.0E+00	2.09	NA	NA	26000	22800	0/17	No. Less than screening value.
Manganese	NA	9.0	0.0E+00	1.52	NA	NA	880	7960	5/17	Yes. Exceeds Risk and RSL.
Mercury	NA	NA	0.0E+00	0.00	2	2	0.57	nd	0/17	No. Not detected in bedrock.
Aldrin	3.3E-07	NA	6.3E-08	0.00	NA	NA	0.004	0.0013	0/5	No. Less than screening value.
Dieldrin	1.6E-06	NA	3.2E-07	0.00	NA	NA	0.0042	0.0067	1/5	Yes. Exceeds Risk and RSL.
Heptachlor	2.6E-07	NA	5.1E-08	0.00	0.4	0.4	0.015	0.0039	0/5	No. Less than MCL and RIDEM-GA.
Bis(2-chloroethyl)ether	2.1E-03	NA	1.9E-04	0.00	NA	NA	0.012	25	4/21	Yes. Exceeds Risk and RSL.
Naphthalene	3.6E-05	NA	1.7E-06	0.04	NA	20	1.4	5	0/21	No. Less than RIDEM-GA.
Nitrobenzene	NA	NA	0.0E+00	0.00	NA	NA	3.4	nd	0/21	No. Not detected in bedrock.
Pentachlorophenol	NA	NA	0.0E+00	0.00	1	1	0.56	nd	0/21	No. Not detected in bedrock.

Table 2-1B
Selection of COCs for Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Notes:

(1) Maximum Risks presented in Tables 1-4 through 1-11. For VOCs, these are calculated risks based on reasonable maximum exposure assumptions; for SVOCs, pesticides, and metals, these risks were determined using a ratio of maximum concentrations to RSLs.

(2) Well-by-Well Risks estimated in Appendix A, Table A-2.

(3) RIDEM – GA – Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; GA Groundwater Objectives. The GA Groundwater Objectives are identical to EPA Maximum Contaminant Levels (MCLs).

(4) EPA Regional Screening Level for Tap Water, September 2008. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.html

(5) Frequency above MCL or RIDEM GA or, in the absense of one of these ARARs, frequency above RSL. See Tables 1-4 through 1-11.

MCL – Maximum Contaminant Level
NA – Not applicable, or no criteria available
ND – not detected
MAX – Maximum detected concentration in overburden aquifer

VOCs Data from ESS Phase IV Subsurface Investigation 2008.
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Table 2-2
Proposed Preliminary Remediation Goals for Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Groundwater							
Contaminant of Concern	**Overburden or Bedrock**	**Risk-based PRGs**			**MCL/ RIDEM GA (µg/L)**	**Proposed Numerical PRG (µg/L)**	**Basis for Selection**
		10^{-6} cancer risk-based (µg/L)	**HQ=1 non-cancer hazard- based (µg/L)**	**Lower of risk-based PRGs (µg/L)**			
VOCs							
1,1-Dichloroethane	Both	5.9	1600	5.9	NA	6	cancer risk-based
Benzene	Bedrock	0.61	31	0.61	5	5	MCL/RIDEM GA
cis-1,2-Dichloroethene	Overburden	NA	78	78	70	70	MCL/RIDEM GA
Tetrachloroethene	Both	0.06	78	0.06	5	5	MCL/RIDEM GA
Trichloroethene	Both	2.6	NA	2.6	5	5	MCL/RIDEM GA
Vinyl Chloride	Both	0.05	24	0.05	2	2	MCL/RIDEM GA
SVOCs							
Bis(2-chloroethyl)ether	Both	0.03	NA	0.03	NA	0.03	cancer risk-based
Pesticides							
Aldrin	Overburden	0.002	0.24	0.002	NA	0.002	cancer risk-based
Dieldrin	Bedrock	0.002	0.39	0.002	NA	0.002	cancer risk-based
Metals							
Arsenic	Both	0.02	2.4	0.02	10	10	MCL/RIDEM GA
Manganese	Both	NA	190	190	NA	190	non-cancer hazard-based

Notes:

NA – Not Available.
HQ – Hazard Quotient
MCL – Maximum Contaminant Level
RIDEM GA – Rhode Island Department of Environmental Management Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases; GA Groundwater Objectives. The GA Groundwater Objectives are identical to EPA Maximum Contaminant Levels (MCLs).
PRGs selected for both overburden and bedrock groundwater.

Table 3-1
Groundwater Remedial Action Objectives, General Response Actions, Technology Types and Process Options
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Action (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Groundwater	**<u>Protection of Human Health</u>** • Prevent exposure to groundwater with contaminant concentrations that exceed MCLs, non-zero MCLGs, or pose excess cancer risk of 1E-06 or a non-carcinogenic risk exceeding a HQ of 1.0. • Restore groundwater quality to below MCLs, non-zero MCLGs, the RIDEM GA Objectives, or chemical concentrations that result in excess cancer risk of 1E-06 or less, or a non-carcinogenic HQ of 1.0 or less. **Protection of the Environment** • Prevent the further migration of contaminants beyond their current extent.	No Action	No Action	Not applicable. Baseline specified in the NCP.
		Natural Attenuation	Biological processes	Aerobic biodegradation or anaerobic biodegradation.
			Chemical processes	Hydrolosis, oxidation, or reduction.
			Physical processes	Advection, dispersion, or dissolution.
		Limited Action	Long-term monitoring	Groundwater monitoring.
			Institutional Controls	Deed restrictions, land use restrictions, or local ordinances.
		Containment	Vertical Barriers	Slurry wall, grout curtain, sheet-piles, or hydraulic containment (extraction wells or trench).
		Collection, Treatment, and Discharge	Collection/Extraction	Extraction wells, or collection trench.
			Physical Treatment	Equalization, dewatering, sedimentation, oil-water separation, filtration, reverse osmosis, air stripping, carbon adsorption, distillation, or evaporation.
			Chemical Treatment	Ion exchange, chemical oxidation, UV oxidation, neutralization, precipitation, flocculation, or dechlorination.
			Biological Treatment	Aerobic biodegradation or anaerobic biodegradation.
			Discharge	On-site use.
			Beneficial re-use	Irrigation supply.
			Surface discharge	Direct surface discharge or indirect surface discharge.
			Subsurface discharge	Infiltration gallery.
			Off-site treatment	POTW or off-site treatment facility.
		In-situ Treatment	Physical Treatment	Air sparging coupled with vapor extraction, enhanced flushing, or air-sparge barrier.
			Thermal Treatment	Steam, conductive, or electrical heating with vapor recovery.
			Chemical Treatment	Permeable reactive barrier, or chemical oxidation or reduction.
			Biological Treatment	Enhanced biodegradation through aerobic or anaerobic processes.

Table 3-2
Screening of Groundwater Process Options
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness	Implementability	Relative Cost	Screening Comments
No Action	No Action	Not applicable	No active source remediation conducted. No monitoring conducted.	The lack of action will not achieve RAOs.	Simple to implement.	Capital Costs: None O&M Costs: None	Baseline, as required by the NCP. Retained.
Natural Attenuation	Biological processes	Aerobic biodegradation	Native microorganisms in the subsurface degrade dissolved-phase VOCs in the presence of oxygen. No enhancements to the in-place system are made.	Not the primary Site-related contaminant degradation pathway. Could eventually achieve clean-up goals, given sufficient time. Process has been demonstrated for Site contaminants.	Simple to implement. May require monitoring to ensure that the process remains on-going.	Capital Costs: Low O&M Costs: Low	Some VOCs in the existing plume may be degrading through this process. Retained.
		Anaerobic biodegradation	Native microorganisms in the subsurface degrade the dissolved-phase VOCs under anoxic conditions. No enhancements to the in-place system are made.	Currently on-going at the Site. Primary degradation pathway for Site contaminants (reductive dechlorination). Limited effectiveness on vinyl chloride. Could eventually achieve clean-up goals given sufficient time. Process demonstrated at many sites.	Simple to implement. May require monitoring to ensure that the process remains on-going.	Capital Costs: Low O&M Costs: Low	Some VOCs in the existing plume may be degrading through this process. Retained.
	Physical processes	Advection/Dispersion	Process by which a chemical contaminant propagates within the subsurface. With time, the contaminant mass dissipates/dilutes as it gets further from the source area. No enhancements to this process are made.	Currently on-going at the Site. Given sufficient time, this process could eventually achieve clean-up goals. Well demonstrated at many sites.	Simple to implement, but may require monitoring to ensure that the process remains on-going.	Capital Costs: Low O&M Costs: Low	This process is on-going process. Retained.
		Adsorption	As organic-contaminated groundwater moves through the subsurface, the organic contaminants interact with organic matter within the soil matrix and become adsorbed into the soil matrix. The contaminants remain adsorbed until the dissolved contaminant concentrations in the groundwater diminish (due to advection, dissolution, etc.) allowing the adsorbed contaminants to desorbs into groundwater.	Currently on-going at the Site. Given sufficient time, this process could eventually reach clean-up goals. Well demonstrated at many sites.	Simple to implement, but may require monitoring to ensure that the process remains on-going.	Capital Costs: Low O&M Costs: Low	This process is on-going process. Retained.
Limited Action	Long-term monitoring	Groundwater sample collection	No active remedial processes will be taken to address the contamination. Groundwater samples will be collected to monitor the plume status for changes in conditions or concentrations.	Frequently coupled as a component of a remedial alternative. Provides data to determine if remedial actions are effective. Monitoring network is scalable with area and volume. Minimal impacts to human health and the environment.	Easily implemented. Qualified contractors are numerous. Stakeholder approval of the monitoring program is required.	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained.
	Institutional Controls	Deed restrictions, Town ordinances	No active remedial processes will be taken to address the contamination. These controls can include deed restrictions preventing certain activities on designated properties, land use restrictions, or Town ordinances that prevent certain activities within a designated area.	Frequently coupled as a component of a remedial alternative. Effective at minimizing risks to human health. Control areas are scalable with contaminated areas/volumes. Effective only if implemented, monitored, and enforced.	Administrative implementation is possible, will require action involving Local, State and Federal officials, and property owners.	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained.
Containment	Vertical Barriers	Slurry Wall	A trench is excavated along the perimeter of (or a portion of) the contaminated groundwater plume and is filled with a low-permeability slurry to prevent migration of contaminated groundwater.	Has been shown effective at containing overburden groundwater contaminated with Site COCs. Will require extensive construction, which could damage nearby wetlands and streams. Lack of viable aquitard to seat the wall into will limit effectiveness.	Readily implementable using standard excavation and construction techniques. A number of companies can provide this service.	Capital Costs: Medium O&M Costs: Low	Limited effectiveness, potential significant damage to wetlands. Eliminated.
	Vertical Barriers	Sheet-pile wall	Vertical steel sheet piles are driven into the subsurface (usually to bedrock or an aquitard) along the perimeter (or a portion of) the contaminated groundwater plume to prevent the further migration of contaminated groundwater. Individual sheets are interlocking, and the knuckles are filled with grout or similar low-permeability material, creating an low-permeability or impermeable barrier.	Has been shown effective at containing overburden groundwater contaminated with Site COCs. Will require construction activities that could damage nearby wetlands and streams. Lack of viable aquitard to seat the wall into will limit effectiveness.	Readily implementable using standard pile installation and construction techniques. A number of companies can provide this service.	Capital Costs: Medium O&M Costs: Low	Limited effectiveness, potential significant damage to wetlands. Eliminated.
		Grout Curtain	Grout is injected into soil pore spaces to prevent groundwater from migrating through the pores. The injection locations are set such that the resulting grout injections provide a barrier to continued groundwater migration.	Has been shown effective at containing overburden groundwater contaminated with Site cocs. Will require construction activities that could damage nearby wetlands and streams. Lack of viable aquitard to seat the wall into will limit effectiveness.	Readily implementable using drilling and grout injection and construction techniques. A number of companies can provide this service.	Capital Costs: Medium O&M Costs: Low	Limited effectiveness, potential significant damage to wetlands. Eliminated.
		Hydraulic containment	A series of extraction wells or trenches are constructed to pump groundwater from a designated area to prevent lateral (and limited vertical) migration beyond the capture zone. Same as extraction wells below).	Has been shown to be successful at containing contaminated groundwater at many sites. Capable of being scaled to accommodate a variety of areas/volumes. Minimal impact on human health/environment during construction. Can achieve RAOs, given sufficient time. Could dewater wetlands.	Readily available using conventional drilling techniques. Numerous companies available to design and construct extraction and treatment systems.	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained.

Table 3-2
Screening of Groundwater Process Options
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Collection, Treatment, and Discharge	Collection/Extraction	Extraction Wells	Large-diameter extraction wells are installed to capture groundwater to prevent or minimize contaminant migration. This technology is typically associated with an ex-situ treatment system.	Has been shown to be successful at capturing contaminated groundwater. Capable of being scaled to accommodate a variety of areas/volumes. Minimal impact on human health/environment during construction. Can achieve RAOs, given sufficient time. Wetlands could be dewatered.	Readily available using conventional drilling techniques. Numerous companies available to design and construct extraction and treatment systems.	Capital Costs: Medium O&M Costs: Low	Potentially applicable. Retained.
		Extraction Trench	A trench and recovery system can be installed to capture contaminated groundwater for ex-situ treatment.	Effective means for containing contaminant migration and collecting groundwater for treatment. Effective in overburden, very limited effectiveness in the fractured bedrock aquifer. May be difficult to address large areas.	Implementable using standard excavation techniques. Bedrock excavation may require specialized blasting contractors.	Capital Costs: Medium O&M Costs: Low	Limited effectiveness at controlling the bedrock plume. Eliminated
	Physical Treatment	Equalization	Groundwater extraction flow dampening and/or contaminant concentration variation in a vessel to promote constant discharge rate and water quality. Generally this technology is a pretreatment process incorporated into a treatment train.	Component of a ex-situ treatment train. Effective method for normalizing contaminant concentrations volumes and flows. Minimal impact on human health & environment during construction/implementation. Scalable with anticipated volumes.	Easily implemented. Qualified contractors are numerous. Permit from State may be required for groundwater treatment and discharge to brook (if off-site location required).	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained.
		Dewatering	Mechanical removal of free water from treatment residuals reducing the residuals volume and mass. Generally this technology is post-treatment process incorporated into a treatment train.	Component of a treatment train. Very effective at reducing the mass of solid residuals (sludges, etc.) associated with ex-situ groundwater treatment. Scalable with anticipated volumes.	Easily implemented. Materials and equipment are available. Must be permitted by the State as part of a groundwater treatment and discharge permit (if off-site location required).	Capital Costs: Medium O&M Costs: Medium	Potentially applicable. Retained
		Sedimentation	Gravity separation of suspended solids in a vessel. Generally this technology is a pretreatment process that is incorporated into a treatment train.	Component of a treatment train. Effective in conjunction with flocculation and coagulation to remove suspended solids from an aqueous waste stream. Scalable with anticipated volumes.	This process option readily available with specialty subcontractors. Must be permitted by the State as part of a groundwater treatment and discharge permit (if off-site location required).	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained
		Oil/Water Separation	Separation of immiscible liquids from water using forces of gravity. Generally this technology is incorporated as part of a treatment train.	Component of a treatment train. This process option does not treat dissolved contaminants, but is effective at removing non-aqueous phase liquids. Scalable with anticipated volumes.	This process option readily available with specialty subcontractors. No administrative barriers to implementation. TSDF available for spent materials disposition.	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained
		Filtration	Separation of particles from water using entrapment technologies. Typically this is a pre-treatment technology implemented as part of a treatment train.	Often a critical component of a treatment train. Very effective at capturing suspended solids in an aqueous waste stream. Scalable with anticipated volumes.	This process option readily available with specialty subcontractors. Replacement filter media is readily available through multiple vendors.	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials from water.	This method has been shown to be effective at treating Site COCs. Highly susceptible to inorganic fouling. Anticipated maintenance requirements could limit its effectiveness. Scalable with anticipated volumes, but generally most-successful with small volumes.	Implementable. Offered by numerous specialty contractors.	Capital Costs: Medium O&M Costs: Medium	Efficiency and effectiveness are questionable. Eliminated.
		Air Stripping	Extracted groundwater is sprayed on packing within air stripping columns. A counter current of air is passed through the water desorbing contaminants into the vapor phase, which are captured and treated subsequently.	Well-demonstrated technology for treating Site COCs. Effectiveness of the process can be limited by high inorganic content in the waste stream. Minimal impact on human health & environment during construction/implementation.	Components of the system are easily obtainable and constructible. Rigorous pre-treatment and ongoing maintenance may be required to keep the system operational. Must be permitted by the State as part of a groundwater treatment and discharge permit.	Capital Costs: Low O&M Costs: Medium	Potentially applicable. Costing is variable with contaminant loading and the effectiveness of pretreatment steps. Retained.
		Carbon Adsorption	Extracted groundwater is pumped through granular activated carbon causing dissolved contaminants to adsorb onto the carbon. This can also be applied to a contaminated airstream (as in the case of an air-stripping technology).	Well-demonstrated technology for treating Site COCs. Scalable with anticipated treatment volumes. Limited effectiveness at treating vinyl chloride and tetrahydrofuran. Minimal impact on human health & environment during construction or implementation.	Readily implementable. Replacement carbon and replacement parts are easily obtainable. Must be permitted by the State as part of a groundwater treatment and discharge permit. Permits for off-site disposable can be obtained. TSDF available to received spent carbon.	Capital Costs: Low O&M Costs: Medium/High	Potentially applicable. Costing is variable with contaminant loading and the effectiveness of pretreatment steps. Retained.
		Distillation	Vaporization and subsequent condensation of extracted groundwater.	This process option is not effective at treating waste streams containing dilute mixtures of contaminants.	Readily implementable. Materials required are easily obtained. Must be permitted by the State as part of a groundwater treatment and discharge permit. Will likely require air emissions permits.	Capital Costs: Medium O&M Costs: Medium/High	This process option is not effective on the Site contaminants. Eliminated.
		Irrigation/Evaporation	Combined treatment and discharge technology that sprays extracted groundwater onto the ground surface to enhance vaporization of contaminants into the atmosphere.	This process option could be effective at treating Site COCs. A large expanse of land will be required to manage the wastestream. Potential for human health and environmental impacts during implementation.	Air emissions permits will be required. It is not likely that this treatment technique would be permitted as a viable process at the Site.	Capital Costs: Low O&M Costs: Low	This process option is not implementable. Eliminated.

Table 3-2
Screening of Groundwater Process Options
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Collection, Treatment, and Discharge (cont.)	Chemical Treatment	Ion Exchange	Ion exchange removes ions from the aqueous phase by the exchange of cations or anions between the contaminants and the exchange medium. Ion exchange materials may consist of resins made from synthetic organic materials that contain ionic functional groups to which exchangeable ions are attached.	Component of a treatment train. Effective at reducing the inorganic contents in a waste stream prior to additional treatment. Scalable with anticipated volumes.	Materials are available from a variety of vendors. Must be permitted by the State as part of a groundwater treatment and discharge permit. Permits can be obtained for off-site disposal of spent media. TSDFs available.	Capital Costs: Medium O&M Costs: Medium	Potentially applicable. Retained
		Enhanced Oxidation	Extracted groundwater is pretreated to decrease turbidity, mixed with a strong oxidizer (such as hydrogen peroxide or ozone), and exposed to UV light. UV light with oxidizers form free radicals that destroy the organic contaminants.	Effective at oxidizing Site COCs. Use of hydrogen peroxide or other oxidant with UV light could increase risk to process operators. Minimal impact on the environment. Scalable with anticipated volumes. O&M may pose hazards to workers due to chemicals, UV, and electricity.	This process option is available through several specialty contractors. Must be permitted by the State as part of a groundwater treatment and discharge permit. May require arrangements with local electrical utilities to supply a significant amount of electricity.	Capital Costs: Medium O&M Costs: Medium/High	Potentially applicable. Retained
		Neutralization	Modification of incoming groundwater pH using acids/bases. This technology is typically used as a pretreatment step in a treatment train.	Component of a treatment train. Adjustment of pH has been show to be effective at minimizing inorganics in a wastestream. Handling of acids/bases could increase the risk to human health during implementation. Scalable with anticipated volume.	This process option is easily implemented using typical installation techniques. Replacement reagents are easily obtained through a variety of chemical vendors. Must be permitted by the State as part of a groundwater treatment and discharge permit.	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained
		Flocculation / Precipitation	Amendments are added to the extracted groundwater to neutralize surface charges and promote agglomeration of colloidal particles to enhance settling.	Component of a treatment train. Has been shown to be effective at reducing suspended solids in a waste stream. Scalable with anticipated volume. Minimal risk to human health and the environment during construction or implementation.	This process option is easily implemented using typical installation techniques. Replacement reagents are easily obtained through a variety of chemical vendors. Must be permitted by the State as part of a groundwater treatment and discharge permit.	Capital Costs: Low O&M Costs: Low	Potentially applicable. Retained
	Biological Treatment	Aerobic Degradation/Bioreactor	Groundwater is stored in a vessel or pond for treatment. Suspended growth or attached film using aerobic microbes degrade organic matter and chemicals.	Process not commonly utilized at environmental cleanups. Minimal effectiveness on treating Site COCs. Requires large treatment reactors and lengthy treatment times.	Implementable using typical construction technologies. Will require air emissions and treatment/discharge permits. Typically requires a moderate to high degree of maintenance.	Capital Costs: Medium O&M Costs: Medium	Not effective; limited implementability. Eliminated.
		Anaerobic biodegradation	Groundwater is stored in a vessel. Suspended growth or attached film using anaerobic microbes degrade organic matter and chemicals.	Process not commonly utilized at environmental cleanups. Could require a large treatment reactor volume. Anticipate an extended treatment duration.	Implementable using typical construction technologies. Will require air emissions and discharge permits. Typically requires a moderate to high degree of maintenance.	Capital Costs: Medium O&M Costs: Medium	Questionable effectiveness and implementability. Eliminated.
	Discharge	Beneficial re-use / Surface Discharge	Treated water is of sufficient potable quality to use as a irrigation source.	This method has been used successfully at other sites. Site topography and hydrogeology would limit the effectiveness of this discharge method. Scalable with anticipated treatment volumes, but large areas are required.	Components available, easily built using typical construction methods. Would require State discharge permits.	Capital Costs: Low O&M Costs: Low	Limited effectiveness. Eliminated.
		Direct discharge	Treated water is discharged to Latham Brook or other suitable receiving water.	Has been used successfully at numerous sites. Discharge limitations are protective of human health and the environment. Scalable with anticipated volumes, but not easily modified once installed.	Implementable using widely-available construction methods. Permits for discharge to a water of the State of Rhode Island will be required.	Capital Costs: Medium O&M Costs: Low	Potentially applicable. Retained
		Subsurface discharge	Treated water is injected below ground through a reinjection gallery.	This method has been used successfully at other sites. Insufficient infiltration would limit the effectiveness of this discharge method. Scalable with anticipated treatment volumes, but large areas are required.	Easily-obtainable components, and easily constructible using typical construction methods. Would require State discharge permits.	Capital Costs: Medium O&M Costs: Medium	Limited effectiveness. Eliminated.
	Physical Treatment	Off-site treatment	Treated water is directed to a publicly-owned treatment system.	This method has been used successfully at numerous other sites. Minimal impact on human health and the environment. Scalable with anticipated volume. Very difficult to modify once installed.	No Town sewer is available near the Site, which would require extensive construction and administrative components.	Capital Costs: High O&M Costs: High	Not easily implemented. Eliminated.
		Air-Sparge Wells/Barrier with Vapor Extraction	Wells are installed to pump air into the overburden aquifer to volatilize VOC from groundwater. Air and VOCs are extracted through the vadose zone by an SVE system. The vapors are then directed to a treatment system such as vapor phase carbon adsorption.	Has been shown effective at treating COCs in a saturated environment. Minimal vadose zone thickness is present outside of the source area, limiting the effectiveness of a soil vapor extraction system. Minimal impact on human health/environment during construction or implementation. Scalable with increased treatment volume/area.	Constructed using conventional drilling and construction methods. Sparge/vapor extraction system available through many vendors. May require State Underground Injection Control Program permits. Will require air emissions permits. Contaminated knockout water will require management.	Capital Costs: Medium O&M Costs: Medium	Not effective outside the Source Area. Eliminated.

Table 3-2
Screening of Groundwater Process Options
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness	Implementability	Relative Cost	Screening Comments
In-situ Treatment	Physical Treatment (cont.)	Circulating Wells/Vapor Extraction	Air is injected into a double screened well, lifting the water in the well and forcing it out the upper screen. Simultaneously, additional water is drawn in the lower screen. Once in the well, some of the VOCs in the contaminated ground water are transferred from the dissolved phase to the vapor phase by air bubbles. The contaminated air rises in the well to the water surface where vapors are drawn off and treated by an SVE system.	Projects have shown successful treatment of Site COCs using this method. Limited effectiveness in a moderately-permeable heterogeneous aquifer. Minimal damage to human health or environmental receptors. Scalable with anticipated volumes and areas. Numerous wells will be required spread throughout the plume area. Minimal vadose zone thickness in areas outside the Source Area will limit effectiveness.	Constructable using conventional drilling and wells installation techniques. Will require State air emissions and potentially State underground injection control program permits. Permits can be obtained for offsite transport and disposal of captured VOCs. TSDFs available fo VOCs diposal.	Capital Costs: Medium O&M Costs: Medium	Not effective due to Site conditions. Eliminated.
	Thermal Treatment	Steam heating and vapor recovery	Forces steam into the aquifer to vaporize organic chemicals. The vaporized chemicals are recovered using an SVE system, which are treated in a vapor-phase carbon treatment system and discharged into the air.	The technology may not be effective for desorb VOCs from saturated contaminated soils. Cold groundwater entering treatment zone will cause decline in subsurface temperature, reducing VOCs extraction. Thickness of unsaturated zone may not be sufficient for good vapor control or recovery in some areas of the Site. Potential short-term impacts to onsite workers involving exposure to high temperatures and high pressure, high temperature contaminated fluids. Also, technology considered to have limited technical feasibility considering the large volume of saturated soil to be treated.	This process option is offered by a limited number of vendors. Specialty equipment and personnel are required. Permits (waste manifests/bills of lading) can be obtained for off-site transport and disposal of captured VOCs. TSDFs are available to receive captured VOCs.	Capital Costs: High O&M Costs: High	Process option may not be effective due to limitations of applying steam heating to saturated zone. Eliminated.
		Conductive/electrical resistance heating and vapor recovery	Electrodes installed within the contaminated zones are electrified and slowly heat the soil and groundwater, and volatilized VOCs and vapor are captured in SVE system, condensed, and treated prior to discharge.	This technology can potentially achieve RAOs. Effectiveness is not dependent upon soil permeability or homogeneity. Colder groundwater entering treatment zone would not affect thermal treatment and VOCs desorption as with steam heating. Extensive energy required. Potential short-term impacts to on-site workers including high temperatures and electrical arcing, which can be controlled. Has been implemented at full-scale on several sites.	This process option is available with specialty subcontractors. Large treatment area would require large number of electrode and extraction wells. Permits can be obtained for off-site disposal of recovered VOCs. TSDFs are available to receive captured VOCs.	Capital Costs: High O&M Costs: High	The technology can be effective in removing VOCs and is independent of aquifer conditions. The treatment period required can be relatively short compared to other alternatives. Retained.
		Vitrification	Aquifer materials are heated to high temperatures, forming a glass, thereby destroying the VOCs. Offgases need to be captured, condensed, and treated before discharging to the ambient air.	This technology may achieve RAOs for the Source Area soils. However, process option is not well demonstrated due to implementation problems in the past associated with recovery/control of extremely hot gases. Short-term impacts to workers include potentially high gas temperatures, extensive period needed to cool down treatment zone. Impacts to wetlands adjoing Source Area likely.	There are no current vendors that market this process option. Speciality equipment and personnel are required. Permits can be obtained for off-site disposal of recovered VOCs. TSDFs are available to receive captured VOCs.	Capital Costs: High O&M Costs: High	Vitrification not well demonstrated at full-scale, no current vendor for process option. Eliminated
	Chemical Treatment	Permeable reactive barrier	A trench is excavated and a permeable reaction wall is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants by employing such agents as zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, microbes, biomass, and others.	Effective technology at treating Site COCs. Construction of this technology could be detrimental to nearby wetlands and Latham Brook. Not effective for bedrock aquifer since trenching will be required.	This technology is readily available using specialty contractors. Permits can be obtained for offsite transport and disposal of captured VOCs. TSDFs available fo VOCs diposal.	Capital Costs: High O&M Costs: Medium	Not effective. Eliminated.
		Chemical Oxidation	Wells are drilled into the saturated zone for the purpose of injecting a specified chemical oxidant into the subsurface. The contaminants are destroyed or converted to less-toxic substances through a series of oxidation reactions.	This process option has been shown to be effective in treating Site COCs. Limited effectiveness outside of the Source Area due to high organic content soil (peat). Certain oxidants could potentially damage adjacent wetlands. Potential hazards to workers during implementation.	Several specialty contractors offer the product and injection services. Materials are obtainable from suppliers. Oxidant quantities that can be stored on site may be limited by U.S. Dept. of Homeland Security. Coordination with the Rhode Island Underground Injection Program may be required.	Capital Costs: Medium O&M Costs: Low	Limited effectiveness outside of Source Area. Retained.

Table 3-2
Screening of Groundwater Process Options
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

General Response Action	Remedial Technology Type	Process Option	Process Option Description	Effectiveness	Implementability	Relative Cost	Screening Comments
In-situ Treatment (cont.)	Chemical Treatment (cont.)	Chemical Reduction (Zero-valent Iron)	Wells or injection points are advanced into the subsurface to inject reducing substances such as a zero-valent iron solution into the subsurface. Contaminants are destroyed by reduction reactions, which also promote natural reductive dechlorination in the subsurface. ZVI, alone or in conjunction with other amendments, can also be used to address BCEE, arsenic, aldrin, and dieldrin.	This process option has been shown to be effective in treating Site COCs. Scalable to any treatment area or volume. Enhances biological activity in the subsurface. Minimally-invasive injection strategy. Capable of operating within wetlands with sufficient weight dispersion. Has been demonstrated at a number of sites. May also be effective on other COCs.	Several specialty contractors offer the reagents and injection services. Coordination with the Rhode Island Underground Injection Control Program may be required.	Capital Costs: Medium O&M Costs: Low	Potentially applicable. Retained.
		Nano-particle zero-valent iron	Wells are drilled into the saturated zone for the purpose of injecting a nano-scale slurry containing zero-valent iron into the subsurface. The iron in the fluid causes reductive dechlorination, and also serves to enhance any natural reductive dechlorination processes.	Few project have selected this remedy. Has been shown to be successful in full-scale applications. Damage to human health and the environment from nanoparticles has not been sufficiently evaluated. Reliability is questionable.	Very specialized with few specialty contractors available. May require coordination with the Rhode Island Underground Injection Control Program. Difficult to implement.	Capital Costs: Medium O&M Costs: Low	Effectiveness is questionable, and implementation is difficult. Eliminated.
	Biological Treatment	Enhanced biodegradation	Injections are performed to stimulate or supplement the on-going in-place aerobic or anaerobic natural attenuation processes. Wells are drilled into the saturated zone to deploy biostimulants, carbon sources, nutrients, and possibly inject of naturally-occurring or bio-engineered bacterium into the subsurface.	Has been shown to be effective at reducing contaminants similar to Site COCs. Limited risks to workers and to human health. Bio-engineered bacteria may displace indigenous bacteria. Scalable to any area or contaminant volume. Minimally-invasive injection strategy. Capable of operating within wetlands with sufficient weight dispersion. Ananerobic degradation possible for chlorinated solvents. Aerobic degradation may be effective on vinyl chloride, but has limited effectiveness for chlorinated COCs.	Several specialty contractors offer the reagents and injection services. Coordination with the Rhode Island Underground Injection Control Program may be required.	Capital Costs: Medium O&M Costs: Medium	Potentially applicable. Retained.

Notes:
- The process technologies cited above will likely require some level of bench-scale testing, field-scale pilot testing, and design prior to full-scale implementation.

Process option is eliminated

Table 4-1
Summary of Key Components of the Remedial Alternatives
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Remedial Alternative	Components										
	Institutional Controls	Long-Term Monitoring & Monitored Natural Attenuation	Five-Year Reviews	Pre-Design Investigation and Bench/Field Pilot Testing	In-Situ Chemical Reductant Injection	Injection of Stimulants to Enhance Biodegradation	Groundwater Extraction Through Wells	Ex-Situ Groundwater Treatment	Treated Groundwater Discharge	In-Situ Electrical Resistance Heating	VOCs Vapor Treatment
GW1 - No Action											
GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	✓	✓	✓								
GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plume), Institutional Controls, and Five-Year Reviews	✓	✓	✓	✓	✓	✓					
GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	✓	✓	✓	✓	✓	✓					
GW4 - Groundwater Extraction, Treatment, and Discharge, Long-Term Monitoring, Institutional Controls, and Five-Year Reviews	✓	✓	✓	✓			✓	✓	✓	✓	
GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Plume), Institutional Controls, and Five-Year Reviews	✓	✓	✓	✓					✓	✓	✓

Table 5-1
Detailed Analysis of Groundwater Remedial Alternatives
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Detailed Analysis Criteria		GW1 No Action	GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews	GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	GW4 - Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five Year Reviews	GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Overburden and Bedrock Plumes), Institutional Controls, and Five-Year Reviews
Overall Protection of Human Health and the Environment	Human health protection	No reduction in risk in the near term. Reduction of risk in the long term will occur gradually. No monitoring is included to evaluate contaminated plume status. No mechanisms in place to prevent improper use or exposure to groundwater contaminants.	Can reduce current and future risks if institutional controls are implemented, monitored, and enforced. Long-term monitoring will be used to track progress monitored natural attenuation (MNA) progress. Monitorng will also provide early warning if contaminant migration may affect potential groundwater supplies or pose potential vapor intrusion threats. Institutional controls will limit potential exposure to groundwater contaminants by restricting its use as a potable supply.	Effectively reduces current and future risks through remediation of contaminated groundwater and by preventing exposure. In-situ chemical reduction and enhanced biodegradation will address VOCs in the former Source Area (plume core). Overburden plume downgradient of former Source Area and bedrock groundwater will be naturally attenuated. Long-term monitoring will track the MNA progress and decreases in contaminant concentrations, and will provide early warning if contaminant migration can affect downgradient areas. Institutional controls will limit potential exposure to groundwater contaminants by restricting its use as a potable supply. Decreases time for groundwater to attain RAOs and PRGs.	Effectively reduces current and future risks through remediation of contaminated groundwater and by preventing exposure. In-situ chemical reduction and enhanced biodegradation will address VOCs in the former Source Area (plume core) and a portion of the overburden plume. Bedrock groundwater will be naturally attenuated. Long-term monitoring will track the MNA progress and decreases in contaminant concentrations, and will provide early warning if contaminant migration can affect downgradient areas. Institutional controls will limit potential exposure to groundwater VOCs by restricting its use as a potable supply. Decreases time for groundwater to attain RAOs and PRGs.	Pumping and treating will prevent further migration of contaminated groundwater, and effectively reduce potential current and future risks through removal and treatment of contaminated groundwater. Pumping and treating will address contaminants in overburden and bedrock groundwater, and prevent further contaminant migration. Long-term monitoring will track the treatment progress and effectiveness of the extraction wells to prevent expansion of the plumes. Will provide early warning if contaminant migration can affect downgradient areas. Institutional controls will limit potential exposure to groundwater contaminants by restricting its use as a potable supply. Decreases time for groundwater to attain RAOs and PRGs.	Effectively reduces current and future risks through remediation of contaminated groundwater and by preventing exposure. VOCs will be thermally desorbed from soils in the former Source Area, preventing or limiting further leaching to groundwater. Overburden plume downgradient of former Source Area and bedrock groundwater will be naturally attenuated. Monitoring program during remediation protects workers and nearby residents. Long-term monitoring will provide early warning if contaminant migration can affect downgradient areas. Decreases time for groundwater to attain RAOs and PRGs. Institutional controls will limit potential exposure to groundwater VOCs by restricting its use as a potable supply.
	Protection of the environment	Will not prevent potential contaminant migration in groundwater and discharge to wetlands. No mechanisms in place to evaluate contaminated plume status. Groundwater quality will not be restored in the near term, but will improve very gradually through natural attenuation.	Will not prevent potential contaminant migration in groundwater and discharge to wetlands. Long-term monitoring will allow evaluation of contaminated plume status. Groundwater quality will not be restored in the near term, but will improve very gradually through natural attenuation.	In-situ chemical reduction and enhanced biodegradation can destroy chlorinated VOCs, and will help prevent migration of contaminated groundwater into nearby wetlands and Latham Brook. Long-term monitoring will allow evaluation of contaminated bedrock plume status and evaluation of groundwater to surface water interactions. Will restore groundwater quality in the near term.	In-situ chemical reduction and enhanced biodegradation can destroy chlorinated VOCs in the former Source Area, and will help prevent migration of contaminated groundwater into nearby wetlands and Latham Brook. Long-term monitoring will allow evaluation of contaminated bedrock plume status and evaluation of groundwater to surface water interactions. Will restore groundwater quality in the near term.	Groundwater extraction and treatment will prevent further expansion of contaminated groundwater, prevent discharge of contaminated groundwater into wetlands and Latham Brook, and will restore groundwater quality in the long term. Long-term monitoring will allow evaluation of groundwater restoration as groundwater extraction and treatment are implemented.	Remediation decreases VOCs in the former Source Area, protecting groundwater quality, and prevents discharge of contaminated groundwater into wetlands and Latham Brook. Will restore groundwater quality in the near term. Long-term monitoring will allow evaluation of contaminated bedrock plume status and evaluation of groundwater to surface water interactions.
Compliance with ARARs	Chemical-Specific ARARs	See Table 5-2A for chemical-specific ARARs. GW1 will not comply with RI Remediation Regulations GA Objectives and will not meet drinking water standards.	See Table 5-3A for chemical-specific ARARs. GW2 will not comply with RI Remediation Regulations GA Objectives and will not meet drinking water standards (TBC).	See Table 5-4A for chemical-specific ARARs. GW3A will comply with RI Remediation Regulations GA Objectives, and will meet drinking water standards in the near term.	See Table 5-5A for chemical-specific ARARs. GW3A will comply with RI Remediation Regulations GA Objectives, and will meet drinking water standards in the near term.	See Table 5-6A for chemical-specific ARARs. GW4 will comply with RI Remediation Regulations GA Objectives, and will meet drinking water standards in the near term.	See Table 5-7A for chemical-specific ARARs. GW5 will comply with RI Remediation Regulations GA Objectives, and will meet drinking water standards in the near term.
	Location-Specific ARARs	There are no location-specific ARARs for GW1.	See Table 5-3B for chemical-specific ARARs. Installation of monitoring wells may encroach into wetlands. GW2 will attempt to avoid impacts to the wetlands. If impacts are unavoidable, mitigation will be performed and GW2 will comply with the location-specific ARARs.	See Table 5-4B for location-specific ARARs. Injection of reagents will be conducted to avoid intrusion into the wetlands. All work will be performed outside of the wetlands.	See Table 5-5B for location-specific ARARs. Injection of reagents will be conducted to avoid intrusion into the wetlands. All work will be performed outside of the wetlands.	See Table 5-6B for location-specific ARARs. GW4 will be implemented by avoiding installation of extraction wells in wetlands, and groundwater extraction will be conducted to avoid impacts to the wetlands.	See Table 5-7B for location-specific ARARs. GW5 will be implemented to avoid working in the wetlands and to avoid impacts to wetlands.
Compliance with ARARs (cont.)	Action-Specific ARARs	There are no action-specific ARARs for GW1.	There are no action-specific ARARs for GW2.	See Table 5-4C for action-specific ARARs. All action-specific ARARs will be met.	See Table 5-5C for action-specific ARARs. All action-specific ARARs will be met.	See Table 5-6C for action-specific ARARs. All action-specific ARARs will be met.	See Table 5-7C for action-specific ARARs. All action-specific ARARs will be met.

Table 5-1
Detailed Analysis of Groundwater Remedial Alternatives
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Detailed Analysis Criteria		GW1 No Action	GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews	GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	GW4 - Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five Year Reviews	GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Overburden and Bedrock Plumes), Institutional Controls, and Five-Year Reviews
Long-Term Effectiveness & Permanence	Magnitude of residual risk	This alternative does not eliminate any risk in the short term. Risk in the long term will gradually be diminished through natural attenuation. The residual risk is moderate to high.	While the time required to attenuate the contaminated saturated soil and plume is long, the potential risks from exposure to contaminated groundwater (i.e., use as potable supply) will be reduced through institutional controls. Current overburden groundwater cancer and non-cancer risks are 1.1 E-02 (for RME scenario) and HI of 27, respectively. Current bedrock groundwater cancer and non-cancer risks are 8.2 E-03 and HI of 54, respectively. Risks will slowly decrease over time. Five-Year Reviews will be required because contaminants will remain at the Site at levels that will not allow unrestricted use.	GW3A's in-situ chemical treatment and enhanced biodegradation are anticipated to decrease potential risks in the former Source Area in the short term, and in overburden groundwater to approximately E-05 excess cancer risk (risk associated with PRGs) in the long term. Bedrock groundwater will not be directly affected by treatment. Potential cancer and non-cancer health risks for bedrock groundwater remain at 8.2 E-03 and HI of 54, respectively, in the near term, and will gradually decline as the plume attenuates. Direct injection of reagents into the core of the bedrock groundwater plume using existing wells may treat localized contamination, but widespread dissipation is not anticipated. Five-Year Reviews will be required because contaminants will remain in the groundwater for some period until RAOs are attained at levels that will allow unrestricted use.	GW3B's in-situ chemical treatment and enhanced biodegradation are anticipated to decrease potential risks in the former Source Area and in the overburden plume in the short term. Bedrock groundwater will not be directly affected by treatment. Potential cancer and non-cancer health risks for bedrock groundwater remain at 8.2 E-03 and HI of 54, respectively, in the near term, and will gradually decline as the plume attenuates. Direct injection of reagents into the core of the bedrock groundwater plume using existing wells may treat localized contamination, but widespread dissipation is not anticipated. Five-Year Reviews will be required because contaminants will remain in the groundwater for some period until RAOs are attained at levels that will allow unrestricted use.	GW4's removal of contaminated groundwater is anticipated to reduce potential risks in overburden and bedrock groundwater groundwater to approximately E-05 excess cancer risk (risk associated with PRGs) in the long term. Current overburden and bedrock risks will diminish as contaminated groundwater and VOCs are extracted and removed for aboveground treatment. Five-Year Reviews will be required because contaminants remain on site until RAOs are attained.	GW5's in-situ thermal treatment are anticipated to reduce potential risks in the former Source Area in the short term, and in overburden groundwater to approximately E-05 excess cancer risk (risk associated with PRGs) in the long term. The bedrock groundwater plume will not be directly affected by treatment. Potential cancer and non-cancer health risks for bedrock groundwater remain at 8.2 E-03 and HI of 54, respectively, in the near term, and will gradually decline as the plume attenuates. Five-Year Reviews will be required because contaminants remain in the bedrock aquifer until RAOs are attained.
	Adequacy and reliability of controls	No controls are in place to prevent improper use or exposure to groundwater.	If properly implemented, monitored, and enforced, institutional controls and periodic reviews of site conditions may be reliable in decreasing potential exposures. Long-term monitoring will consist of standard groundwater sampling and analysis methods, which are readily available.	In-situ chemical and biodegradation treatment are innovative measures, capable of achieving remediation goals. Treatment methods have been applied at other sites with similar contaminants; reliability of treatment is expected to be high. Once remediation of the former Source Area is completed, there will be no long-term O&M or management requirements to address this portion of the Site. However, monitoring of the overburden plume downgradient of the former Source Area and the bedrock plume will be required. In-ground treatment residuals are expected to be minimal and should not require additional control measures. If properly implemented, monitored, and enforced, institutional controls and periodic reviews of site conditions and land use may be reliable in decreasing exposure to contaminated groundwater until safe levels are reached.	In-situ chemical and biodegradation treatment are innovative measures, capable of achieving remediation goals. Treatment methods have been applied at other sites with similar contaminants; reliability of treatment is expected to be high. Once remediation of the former Source Area and the overburden groundwater plume is completed, there will be no long-term O&M or management requirements for these portions of the Site. In-ground treatment residuals are expected to be minimal and should not require additional control measures. If properly implemented, monitored, and enforced, institutional controls and periodic reviews of site conditions and land use may be reliable in decreasing exposure to contaminated groundwater until safe levels are reached.	Groundwater extraction and treatment are well established remediation and hydraulic containment measures that are capable of achieving remediation goals in the long-term. Treatment methods have been applied at other sites with similar contaminants; reliability of treatment is expected to be high. Long-term O&M or management is required because an active extraction and treatment system will remain in operation until contaminants in the aquifer diminish to PRGs. As the extraction and treatment system ages, damaged or worn components will need to be replaced. In-ground residuals are not expected and should not require additional control measures. If properly implemented, monitored, and enforced, institutional controls and periodic reviews of site conditions and land use may be reliable in decreasing exposure to contaminated groundwater until safe levels are reached.	In-situ thermal treatment is an innovative measure, capable of achieving remediation goals. This remediation method has been applied at other sites with similar contaminants; reliability of treatment is expected to be high. Once remediation of the former Source Area is completed, there will be no long-term O&M or management requirements to address this portion of the Site. Treatment residuals include the captured VOCs and spent carbon, which will be disposed of offsite. In-ground treatment residuals are expected to be minimal. If properly implemented, monitored, and enforced, institutional controls and periodic reviews of site conditions and land use may be reliable in decreasing exposure to contaminated groundwater until safe levels are reached.

Table 5-1
Detailed Analysis of Groundwater Remedial Alternatives
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Detailed Analysis Criteria		GW1 No Action	GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews	GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	GW4 - Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five Year Reviews	GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Overburden and Bedrock Plumes), Institutional Controls, and Five-Year Reviews
Reduction of Toxicity, Mobility, & Volume Through Treatment	Treatment process used & materials treated	No treatment of contaminated media is proposed, which will not satisfy statutory preference for treatment. Contaminant mass in groundwater will gradually be decreased through natural attenuation.	No treatment of contaminated media is proposed, which will not satisfy statutory preference for treatment. Contaminant mass in groundwater will gradually be decreased through natural attenuation.	Active treatment using injected chemicals and enhancers to stimulate chemical reduction and biological reductive dechlorination will satisfy statutory preference. Principal threat VOCs will be addressed. ZVI and amendments may also be effective for BCEE, arsenic, aldrin, and dieldrin. Bench- and pilot-scale tests required to select appropriate reagents and treatment regime. Pre-design investigation may be needed to better delineate treatment area.	Active treatment using injected chemicals and enhancers to stimulate chemical reduction and biological reductive dechlorination will satisfy statutory preference to treat contaminated groundwater. Principal threat VOCs will be addressed. ZVI and amendments may also be effective for BCEE, arsenic, aldrin, and dieldrin. Bench- and pilot-scale tests required to select appropriate reagents and treatment regime. Pre-design investigation may be needed to better delineate treatment area.	Active treatment process using groundwater extraction/containment and ex-situ air-stripping and GAC adsorption will satisfy statutory preference for treatment to treat contaminated groundwater. Pre-design investigation may be needed to better delineate treatment area.	Active in-situ thermal treatment will remove VOCs from saturated soil and will satisfy statutory preference. Principal threat VOCs will be addressed. Pre-design investigation may be needed to better delineate treatment area.
	Amount of hazardous materials removed or treated	Although there is no treatment, through natural attenuation processes, the estimated 328 Kg of VOCs (38 Kg sorbed to the treated soil, 237 sorbed to saturated soil, 24 Kg in overburden groundwater, and 29 Kg in bedrock groundwater) will gradually degrade and become mineralized.	Although there is no treatment, through natural attenuation processes, the estimated 328 Kg of VOCs (38 Kg sorbed to the treated soil, 237 sorbed to saturated soil, 24 Kg in overburden groundwater, and 29 Kg in bedrock groundwater) will gradually degrade and become mineralized.	GW3A's chemical reduction and enhanced biodegradation will destroy an estimated 275 Kg of VOCs (38 Kg in treated soil, 237 in saturated soil) in the former Source Area (plume core). While some of the chemicals injected into the overburden may migrate into bedrock fractures, VOCs in bedrock groundwater will gradually diminish principally through natural attenuation in the long term.	GW3B's chemical reduction and enhanced biodegradation will destroy an estimated 275 Kg of VOCs in the former Source Area and 24 Kg in overburden groundwater, and treat an estimated 8,340,000 gallons of contaminated groundwater. While some of the chemicals injected into the overburden may migrate into bedrock fractures, VOCs in bedrock groundwater will gradually diminish principally through natural attenuation in the long term.	Groundwater extraction and treatment will remove an estimated 275 Kg of VOCs from the former Source Area, 24 Kg from overburden groundwater, and 29 Kg from bedrock groundwater. Non-VOCs would also be removed and addressed in the treatment system. Approximately 8,340,000 gallons of overburden groundwater and 10,000,000 gallons of bedrock groundwater are anticipated, per flush volume.	GW5 will thermally desorb and remove an estimated 275 Kg of VOCs (38 Kg in treated soil, 237 in saturated soil) in the former Source Area (plume core) for recovery and offsite disposal. Non-VOC organics (BCEE, aldrin, and dieldrin) may also be removed with the water vapor from the subsurface under GW5 andwill be treated. An estimated 45,000 CY unsaturated and 170,000 CY of saturated soil in the former Source Area will be treated.
	Degree of expected reductions in toxicity, mobility, and volume	No reduction of mass, toxicity, mobility, or volume through treatment will occur. However, contaminant mass will gradually be depleted through natural attenuation. Under natural reductive dechlorination processes, vinyl chloride, a degradation daughter product, which is more toxic and mobile, may accumulate.	No reduction of mass. toxicity, mobility, or volume through treatment will occur. However, contaminant mass will gradually be depleted through natural attenuation. Under natural reductive dechlorination processes, vinyl chloride, a degradation daughter product, which is more toxic and mobile, may accumulate.	Under GW3A, VOC mass, toxicity, mobility, and volume in former Source Area will be decreased through treatment. After elimination of the VOCs source, overburden groundwater VOC concentrations will gradually diminish through natural attenuation and will attain MCLs, RI GA Objectives, and risk-based PRGs. Natural attenuation of bedrock groundwater VOCs will occur more slowly, and will attain MCLs, RI GA Objectives, and risk-based PRGs. in the long term. Direct treatment of the former Source Area will result in the chemical reduction of approximately 275 Kg of contaminant mass. Attenuation of the dissolved overburden and bedrock plumes (53 Kg) is also expected over the long term.	Under GW3B, VOC mass, toxicity, mobility, and volume in the former Source Area and in the overburden plume will be decreased through treatment. Groundwater VOC concentrations in the former Source Area and overburden plume will attain MCLs, RI GA Objectives, or risk-based PRGs. Natural attenuation of bedrock groundwater plume VOCs will occur more slowly, and will attain MCLs, RI GA Objectives, and risk-based PRGs in the long term. Direct treatment of the former Source Area and the overburden plume will result in the chemical reduction of approximately 299 Kg of contaminant mass. Attenuation of the dissolved bedrock plume (29 Kg) is also expected over the long term.	Groundwater extraction and treatment will decrease VOCs mass, toxicity, mobility, and volume as VOCs are desorbed from soil through flushing until MCLs, GA Objectives, or risk-based PRGs are attained. An estimated 328 Kg of VOCs will be removed by GW4.	Under GW5, VOC mass, toxicity, mobility, volume, in former Source Area will be decreased through treatment. Overburden groundwater VOC concentrations will attain MCLs, RI GA Objectives, or risk-based PRGs. Natural attenuation of overburden and bedrock groundwater VOCs downgradient of the former Source area will occur more slowly, and will attain the MCLs, RI GA Objectives, or risk-based PRGs in the long term. Direct treatment of the former Source Area will result in the thermal desorption of approximately 275 Kg of contaminant mass from the subsurface. Attenuation of the dissolved overburden and bedrock plumes (53 Kg) is also expected over the long term.
	Degree to which the treatment is reversible	Natural attenuation of VOCs in groundwater is irreversible.	Natural attenuation of VOCs in groundwater is irreversible.	In-situ chemical reduction and enhanced biodegradation treatment in the former Source Area are irreversible. In the bedrock, natural attenuation is irreversible.	In-situ chemical reduction and enhanced biodegradation treatment in the former Source Area and in the overburden are irreversible. In the bedrock, natural attenuation is irreversible.	Groundwater extraction and treatment are irreversible. VOCs will be removed permanently from the former Source Area and the overburden and bedrock units under GW4.	Neither the thermal treatment nor the natural attenuation process are reversible.

Table 5-1
Detailed Analysis of Groundwater Remedial Alternatives
Davis Liquid Waste Superfund Site
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Detailed Analysis Criteria		GW1 No Action	GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews	GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	GW4 - Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five Year Reviews	GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Overburden and Bedrock Plumes), Institutional Controls, and Five-Year Reviews
Reduction of Toxicity, Mobility, & Volume Through Treatment (cont.)	Type/quantity of residuals remaining after treatment	While there is no active treatment, natural attenuation processes will, in the very long term, result in the gradual mineralization of VOCs to only non-hazardous chemicals such as ethene, oxygen, carbon dioxide, chlorides, and hydrogen.	While there is no active treatment, natural attenuation processes will, in the very long term, result in the gradual mineralization of VOCs to only non-hazardous chemicals such as ethene, oxygen, carbon dioxide, chlorides, and hydrogen.	The residuals vary with selected reagents and could include inorganic salts and products of incomplete VOCs destruction. Degradation of VOCs will leave primarily non-hazardous and non-toxic residuals such as ethene, ethane, oxygen, carbon dioxide, hydrogen, and chlorides, and iron complexes (oxides, carbonates, sulfides). Residual VOCs will be present in the aquifer after treatment at or below PRGs will represent E-05 or lower risk cancer risk, if groundwater is used as a potable supply.	The residuals vary with selected reagents and could include inorganic salts and products of incomplete VOCs destruction. Degradation of VOCs will leave primarily non-hazardous and non-toxic residuals such as ethene, ethane, oxygen, carbon dioxide, hydrogen, and chlorides, and iron complexes (oxides, carbonates, sulfides). Residual VOCs will be present in the aquifer after treatment at or below PRGs will represent E-05 or lower risk cancer risk, if groundwater is used as a potable supply.	Treatment residuals will include metals precipitate sludge (~16,000 pounds annually), spent activated carbon (~16,000 pounds annually). remaining contamination below PRGs. Residual VOCs in the aquifer present at or below PRGs will represent E-05 or lower risk cancer risk, if groundwater is used as a potable supply.	During thermal treatment, other VOCs may be formed (i.e., acetone) through the degradation of natural organic materials, but will soon dissipate due to groundwater advection. Residual VOCs will be present in the aquifer after treatment at or below PRGs, which represent E-05 or lower risk cancer risk, if groundwater is used as a potable supply.
Short-Term Effectiveness	Protection of community during remedial actions	Because there will not be any construction activities, there will be no risks to the community.	Implementation of institutional controls and long-term monitoring will pose no risks to the community.	Engineering and administrative controls pertaining to the storage and injection of treatment reagents will be implemented. Communication and coordination with local, State, and Federal officials, as needed, regarding the storage and injection of treatment reagents will help ensure safety of the community. Risks to the community during implementation are low because treatment reactions occur in the subsurface and there is substantial distance between the treatment area and residences. Risks due to storage of ZVI and substrate (both non-hazardous and non-toxic) onsite are low. Institutional controls will minimize potential exposure to contaminated bedrock groundwater until safe levels are achieved.	Engineering and administrative controls pertaining to the storage and injection of treatment reagents will be implemented. Communication and coordination with local, State, and Federal officials, as needed, regarding the storage and injection of treatment reagents will help ensure safety of the community. Risks to the community during implementation are low because treatment reactions occur in the subsurface and there is substantial distance between the treatment area and residences. Risks due to storage of ZVI and substrate (both non-hazardous and non-toxic) onsite are low. Institutional controls will minimize potential exposure to contaminated bedrock groundwater until safe levels are achieved.	Risks to the community for extraction treatment of groundwater are expected to be minimal and are associated with the discharge of treated air and water, and off-site transport and disposal of sludge and spent carbon . Institutional controls will minimize potential exposure to contaminated groundwater until safe levels are achieved.	Communication and coordination with appropriate parties prior to start of remediation to ensure no trespassing into treatment zone. Risks to the community during implementation are low because treatment will occur in the subsurface, and there is substantial distance from the treatment area to nearby residences.
	Protection of workers during remedial actions	Because there will not be any construction activities, there will be no risks to workers.	Only minimal risk to on-site workers for the long-term groundwater and surface water sampling program. Implementation of proper field health and safety procedures and use of appropriate personal protective equipment will be protective of workers during the long-term monitoring program.	Protection of on-site workers can be achieved through advance planning and implementation of a comprehensive field health and safety program for pressurized injections of treatment reagents and operation of heavy equipment. Chemical reductants are not hazardous or dangerous to manage. Chemical oxidants, if selected, may be hazardous and can be extremely reactive in certain situations (i.e., in the presence of moisture and organic matter). The substrate are typically food-grade materials, which pose no risk to workers. Other risks are similar to those of a groundwater and saturated soil sampling program, which are minimal.	Protection of on-site workers can be achieved through advance planning and implementation of a comprehensive field health and safety program for pressurized injections of treatment reagents and operation of heavy equipment. Chemical reductants are not hazardous or dangerous to manage. Chemical oxidants, if selected, may be hazardous and can be extremely reactive in certain situations (i.e., in the presence of moisture and organic matter). The substrate are typically food-grade materials, which pose no risk to workers. Other risks are similar to those of a groundwater and saturated soil sampling program, which are minimal.	Protection of on-site workers can be achieved through advance planning and implementation of a comprehensive field health and safety program for construction and the operation and maintenance of the extraction and treatment system. The worker risks for GW4 are typical for construction and environmental sampling and are expected to be low. For groundwater sampling, risks to workers are minimal.	Protection of on-site workers can be achieved through advance planning and implementation of a comprehensive field health and safety program for drilling, electrical work, resistive heating of the subsurface, and operation of heavy equipment. For confirmation sampling of groundwater, risks to workers are minimal.

Table 5-1
Detailed Analysis of Groundwater Remedial Alternatives
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Detailed Analysis Criteria		GW1 No Action	GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews	GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	GW4 - Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five Year Reviews	GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Overburden and Bedrock Plumes), Institutional Controls, and Five-Year Reviews
Short-Term Effectiveness (cont.)	Environmental impacts	Without any active remediation or construction activities, there are no short-term impacts to the environment.	Only minimal to no impact to the environment is expected for installing new monitoring wells, and for the long-term groundwater and surface water monitoring program. No impacts are expected for institutional controls.	Installation of additional monitoring wells may result in minimal, temporary disturbance to limited portions of wetlands. However, measures will be taken to avoid impacts to wetland areas. Measures will be taken to avoid damage to wetlands may occur during the chemical injection programs. Subsurface redox conditions will be changed during remediation for about 3 to 5 years, and will then return to natural conditions. Temporary increases in manganese and iron concentrations are expected.	Installation of additional monitoring wells may result in minimal, temporary disturbance to limited portions of wetlands. However, measures will be taken to avoid impacts to wetland areas. Measures will be taken to avoid damage to wetlands may occur during the chemical injection programs. Subsurface redox conditions will be changed during remediation for about 3 to 4 years, and will then return to natural conditions. Temporary increases in manganese and iron concentrations are expected.	Installation of additional monitoring wells may result in minimal, temporary disturbance to limited portions of wetlands. However, measures will be taken to avoid impacts to wetland areas. Aggressive pumping of extraction wells could dewater and result in permanent damage to wetlands. Impacts associated with construction of the treatment plant are minimal.	Installation of additional monitoring wells and thermal treatment operations will be conducted outside of the wetland areas. Activities will be managed to avoid impacts to the wetlands. Subsurface soil temperatures will be temporarily elevated to approximately 100 degrees C, and will then return to natural conditions.
	Time until remedial action objectives are achieved	Approximately 100 years until RAOs are achieved in both overburden and bedrock groundwater through natural attenuation processes.	Approximately 100 years until RAOs are achieved in both overburden and bedrock groundwater through natural attenuation processes.	An estimated 5-6 years will be required to complete the treatment and achieve RAOs in the former Source Area. Approximately 45 years will be required to attenuate the remaining VOCs mass in the overburden plume, and 100 years in the bedrock plume.	An estimated 5-6 years will be required to complete the treatment and achieve RAOs in the former Source Area. For eastern wetland area, approximately 40.5 years will be required to attenuate the remaining VOCs mass in the overburden plume, and 100 years in the bedrock plume. For western wetland area, approximately 45 years will be required to attenuate the remaining VOCs mass in the overburden plume, and 100 years in the bedrock plume.	It is anticipated that approximately 2 years will be required to design, permit, and implement the remedy. Approximately 45 years will be required to attenuate the remaining VOCs mass in the overburden plume, and 20 years in the bedrock plume	Approximately 9 months of treatment will be required to achieve the RAOs in the former Source Area. Approximately 45 years will be required to attenuate the remaining VOCs mass in the overburden plume, and 100 years in the bedrock plume.
Implementability	Ability to construct and operate the technology	This alternative does not include construction.	Construction will only consist of monitoring wells installation; there are no difficulties anticipated for implementation.	Standard direct-push drilling methods coupled with slurry injection equipment will be used. Subsurface geologic conditions do not pose any significant difficulties for direct-push of injectors or reagent injections into the overburden formation. In-situ chemical reduction treatment will only be effectively applied in the overburden aquifer. Other than limited dispersal of treatment reagents at the bedrock surface, the bedrock aquifer is not treated by this alternative. There are no difficulties anticipated for implementation.	Standard direct-push drilling methods coupled with slurry injection equipment will be used. Subsurface geologic conditions do not pose any significant difficulties for direct-push of injectors or reagent injections into the overburden formation. In-situ chemical reduction treatment will only be effectively applied in the overburden aquifer. Other than limited dispersal of treatment reagents at the bedrock surface, the bedrock aquifer is not treated by this alternative. There are no difficulties anticipated for implementation.	Extraction and treatment system will be built using standard construction and installation techniques. Additional monitoring wells will be installed using standard drilling techniques. Insufficient electrical service in the area, will require an extensive utility expansion to provide three-phase power to the Site. Treatment plant experience will be required to operate the system, but should not pose any problem for implementation.	No implementation barriers are anticipated in the construction and installation of electrodes and soil vapor extraction wells. Subsurface geologic conditions do not pose any difficulties for electrical resistive heating treatment. Electrical power is currently unavailable, but necessary power lines can be extended to the treatment area. There are no difficulties anticipated for implementation.

Table 5-1
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Davis Liquid Waste Superfund Site
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Detailed Analysis Criteria		GW1 No Action	GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews	GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	GW4 - Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five Year Reviews	GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Overburden and Bedrock Plumes), Institutional Controls, and Five-Year Reviews
Implementability (cont.)	Reliability of the technology	No technology is implemented, therefore no reliability can be examined.	Some natural attenuation is ongoing. However, safe levels will not be attained for a long time. Institutional controls are only reliable if implemented, monitored, and enforced.	Previous application of these remediation methods on similar sites with similar contaminants have been demonstrated to be implementable and effective. No technical issues anticipated. Tailoring the injection to the site-specific characteristics through bench and pilot testing is crucial to the overall success of the alternative. Very "low technology" method, does not depend on outside power or controls, therefore technology reliability expected to be high. There are no difficulties anticipated for implementation.	Previous application of these remediation methods on similar sites with similar contaminants have been demonstrated to be implementable and effective. No technical issues anticipated. Tailoring the injection to the site-specific characteristics through bench and pilot testing is crucial to the overall success of the alternative. Very "low technology" method, does not depend on outside power or controls, therefore technology reliability expected to be high.	Extraction wells and treatment system are susceptible to organic and inorganic fouling. Proper O&M can result in effective capture and treatment of contaminated groundwater. Hydraulic capture of contaminated groundwater in a fractured bedrock environment may be difficult due to heterogeneities.	Previous applications on similar projects have been shown to be successful. However, the technology is more complex and requires more controls to ensure proper treatment. Power fluctuations or difficulties with controlling subsurface heating could lead to difficulties with treatment.
	Ease of undertaking additional remedial actions, if necessary	Additional remedial actions can be readily implemented.	Additional remedial actions can be readily implemented.	Injection of zero valent iron to the subsurface could cause excess fouling problems if a groundwater extraction and treatment alternative was to be implemented in the future. Creating a highly reduced aquifer could inhibit or prevent future in-site oxidation treatment.	Injection of zero valent iron to the subsurface could cause excess fouling problems if a groundwater extraction and treatment alternative was to be implemented in the future. Creating a highly reduced aquifer could inhibit or prevent future in-site oxidation treatment.	Additional remedial actions can be implemented by shutting down the extraction and treatment system. However, the presence of numerous extraction wells and monitoring wells will need to be considered, depending on the nature of the additional responses.	No problems with performing additional remedial actions are anticipated.
	Ability to monitor effectiveness of the remedy	No monitoring is included in this alternative.	Evaluating natural attenuation can be readily implemented using standard groundwater sampling and analysis methods. Effectiveness of institutional controls can be monitored.	Monitoring the progress of the injection and the overall success of treatment can be accomplished through collection and analysis of groundwater samples from the existing monitoring well network, as well as a series of additional monitoring wells installed specifically for monitoring of the injection progression. Effectiveness of institutional controls can be monitored.	Monitoring the progress of the injection and the overall success of treatment can be accomplished through collection and analysis of groundwater samples from the existing monitoring well network, as well as a series of additional monitoring wells installed specifically for monitoring of the injection progression. Effectiveness of institutional controls can be monitored.	Monitoring the progress of the extraction and treatment can be accomplished through collection and analysis of groundwater samples from the monitoring well network. Effectiveness of institutional controls can be monitored.	Progress of the thermal treatment and confirmation of overall treatment success can be accomplished through standard groundwater and soil sampling and analysis methods. Effectiveness of institutional controls can be monitored.
	Ability to obtain approvals from other agencies	None required.	Implementing institutional controls and long-term monitoring is administratively feasible. No approvals are required. Agreement on the specific requirements to be included in the institutional controls will be required.	In-situ treatment is administratively feasible. No approvals are required. All work will be conducted onsite, so permits will be not required. The substantive requirements for underground injection control will need to be met. Agreement on the specific conditions to be included in the institutional controls will be required.	In-situ treatment is administratively feasible. No approvals are required. All work will be conducted onsite, so permits will be not required. The substantive requirements for underground injection control will need to be met. Agreement on the specific conditions to be included in the institutional controls will be required.	Groundwater extraction and treatment is administratively feasible. Permits required for off-site transport and disposal of treatment byproducts (sludge and spent carbon) can be readily obtained. All work will be conducted onsite, so permits will be not required. The discharge of treated water to Latham Brook may require a permit, if conducted offsite. Agreement on the specific conditions to be included in the institutional controls will be required.	Permits can be required for off-site transport and disposal of drilling spoils and condensates from the thermal treatment action.

Table 5-1
Detailed Analysis of Groundwater Remedial Alternatives
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Detailed Analysis Criteria		GW1 No Action	GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plumes), Institutional Controls, and Five-Year Reviews	GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	GW4 - Groundwater Extraction, Treatment, Discharge, Institutional Controls, Long-Term Monitoring, and Five Year Reviews	GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Overburden and Bedrock Plumes), Institutional Controls, and Five-Year Reviews
Implementability (cont.)	Coordination with other agencies	Coordination with other agencies will not be required.	Implementation and recording of institutional controls will require some coordination. One or more parties will need to be designated with the long-term monitoring responsibilities.	Coordination and communication to the extent necessary will be maintained prior to and during the remedial action to minimize potential problems or delays. Implementation and recording of institutional controls will require some coordination. One or more parties will need to be designated with the long-term monitoring responsibilities.	Coordination and communication to the extent necessary will be maintained prior to and during the remedial action to minimize potential problems or delays. Implementation and recording of institutional controls will require some coordination. One or more parties will need to be designated with the long-term monitoring responsibilities.	Coordination and communication to the extent necessary will be maintained prior to and during the remedial action to minimize potential problems or delays. Implementation and recording of institutional controls will require some coordination. One or more parties will need to be designated with the long-term monitoring responsibilities.	Communication/coordination should be maintained prior to and during the remedial action to minimize potential problems or delays.
	Availability of off-site treatment, storage, and disposal services and capacity	No disposal activities are associated with this alternative.	Investigation derived wastes from sampling may require disposal off-site TSDFs, which are readily available.	Investigation derived wastes from sampling may require disposal off-site TSDFs, which are readily available.	Investigation derived wastes from sampling may require disposal off-site TSDFs, which are readily available.	Off-site treatment/disposal of treatment sludge and spent activated carbon well be required at TSDFs, which are readily available. Waste characterization results will dictate the disposal options. Hazardous waste disposal options are more limited than for non-hazardous materials (i.e., solid waste).	Contaminated drilling spoils and Investigation derived wastes from sampling may require disposal off-site TSDF, which are readily available. Waste characterization results will dictate the disposal options. Hazardous waste disposal options are more limited than for non-hazardous materials (i.e., solid waste).
	Availability of necessary equipment and specialists	None required.	Environmental services firms that perform sampling and analysis, equipment, and materials are readily available for long-term monitoring. Experienced regulators and attorneys are available to develop the institutional controls.	In-situ chemical treatment and biodegradation treatment services, while specialized, are available from a number of vendors. A smaller number of vendors can provide combined chemical and biodegradation treatment. Equipment, personnel, and materials needed to implement this alternative are available. Sufficient lead time may be required to ensure adequate supply of reagents. Environmental services firms that perform sampling and analysis, equipment, and materials are readily available for long-term monitoring. Experienced regulators and attorneys are available to develop the institutional controls.	In-situ chemical treatment and biodegradation treatment services, while specialized, are available from a number of vendors. A smaller number of vendors can provide combined chemical and biodegradation treatment. Equipment, personnel, and materials needed to implement this alternative are available. Sufficient lead time may be required to ensure adequate supply of reagents. Environmental services firms that perform sampling and analysis, equipment, and materials are readily available for long-term monitoring. Experienced regulators and attorneys are available to develop the institutional controls.	Groundwater extraction and treatment services are readily available through a number of firms. Equipment, personnel, and materials needed to implement this alternative are readily available. Lead time may be required to ensure adequate supply of reagents and activated carbon. Environmental services firms that perform sampling and analysis, equipment, and materials are readily available for long-term monitoring. Experienced regulators and attorneys are available to develop the institutional controls.	Electrical resistive heating remediation is very specialized is only offered by a few firms. Specialized equipment and personnel will be required. Sufficient lead time may be required to schedule the remediation firm to perform work during warm weather conditions. Environmental services firms that perform sampling and analysis, equipment, and materials are readily available for long-term monitoring. Experienced regulators and attorneys are available to develop the institutional controls.
	Availability of prospective technologies	None required.	Key elements of the alternative are widely available.	The in-situ chemical reduction and biodegradation have been demonstrated to be effective at a number of sites. Full-scale application has been implemented. Several vendors are available and the remediation can be competitively bid.	The in-situ chemical reduction and biodegradation have been demonstrated to be effective at a number of sites. Full-scale application has been implemented. Several vendors are available and the remediation can be competitively bid.	Groundwater extraction and treatment technologies are relatively standardized and has been applied full-scale at numerous sites. Multiple firms can implement this alternative and provide competitive bids.	The in-situ thermal treatment using electrical resistive heating have been demonstrated to be effective at a number of sites. Full-scale application has been implemented. Several vendors are available and the remediation can be competitively bid.
Cost	Capital	$0	$235,000	$4,739,000	$6,153,000	$3,367,000	$23,598,000
	O&M (PV)	$0	$5,095,000	$5,127,000	$5,127,000	$12,847,000	$5,095,000
	Total Cost	$0	$5,330,000	$9,866,000	$11,280,000	$16,214,000	$28,693,000

Table 5-2A
Chemical-Specific ARARs and TBCs – Alternatives GW1, GW2, and GW3A
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Requirement	Status	Requirement Synopsis	Action To Attain ARAR		
			Alternative GW1	Alternative GW2	Alternative GW3A
Federal Regulatory Requirements					
Safe Drinking Water Act - Maximum Contaminant Levels (MCLs) (40 CFR 141.11-14116 and Maximum Contaminant Level Goals (MCLGs) (40 CFR 141.50-141.55))	Relevant and Appropriate	MCLs and non-zero MCLGs have been promulgated for a number of common organic and inorganic contaminants to regulate the concentration of contaminants in public drinking water supply systems. MCLs and non-zero MCLGs may be relevant and appropriate for the Davis Liquid Waste Site groundwater because the aquifer underlying the site and downgradient is a drinking water supply.	MCLs and non-zero MCLGs were used to derive groundwater remediation goals for human health protection. GW1 would not be consistent with the MCLs and non-zero MCLGs because no action will be taken to attain the remedial goals.	MCLs and non-zero MCLGs were used to derive groundwater remediation goals for human health protection. GW2 will partially comply with the MCLs and non-zero MCLGs because use restrictions and monitoring will be implemented to prevent exposure to groundwater used as a potable supply that contains contaminants.	MCLs and non-zero MCLGs were used to derive groundwater remediation goals for human health protection. GW3A will comply with this ARAR in the former Source Area because in-situ chemical reduction will decrease contaminant levels to MCLs and non-zero MCLGs. Remediation of the plume core will accelerate the natural attenuation of the overburden plume downgradient of the former Source Area and the bedrock. MCLs and non-zero MCLGs will eventually be attained in all portions of the aquifer. Until MCLs and non-zero MCLGs are attained, use restrictions will be put in place and monitoring will be performed to prevent exposure to groundwater used as a potable supply that contains contaminants.
Federal Criteria, Advisories, and Guidance					
National Recommended Water Quality Criteria - Clean Water Act Section 304(a)(1)	Relevant and Appropriate	Recommended freshwater and salt water criteria, for acute and chronic conditions, for approximately 150 pollutants that are protective of aquatic life and human health. These criteria are published pursuant to Section 304(a) of the Clean Water Act and provide guidance for states and tribes to use in adopting water quality standards.	These guidelines were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. For GW1, this ARAR will not be met in the foreseeable future.	These guidelines were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. For GW2, this ARAR will not be met in the foreseeable future. Groundwater contaminants will only slowly diminish through natural attenuation. Monitoring will be conducted to assess the plume status and discharges to the wetland.	These guidelines were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under Alternative GW3A, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by treating groundwater contaminants. Monitoring will be conducted to assess effectiveness this alternative.
Heath Advisories, EPA Office of Water, EPA 822-R-09-011, Fall 2009, updated Oct. 2009	To be Considered	Health Advisories (HAs) provide estimates of acceptable drinking water concentrations for chemicals based on health effects information; the HAs are not legally enforceable Federal standards, but serve as technical guidance to assist Federal, State, and local officials.	The HAs were considered during the human health evaluation. GW1 would not be consistent with the HAs because no action will be taken to attain the criteria.	The HAs were considered during the human health evaluation. GW2 will partially comply with the HAs because use restrictions and monitoring will be implemented to prevent exposure to groundwater used as a potable supply that contains contaminants.	HAs were considered during the human health evaluation. GW3A will comply with this ARAR in the former Source Area because in-situ chemical reduction may decrease contaminant levels to HAs. Remediation of the plume core will accelerate the natural attenuation of the overburden plume downgradient of the former Source Area and the bedrock. The HAs will eventually be attained in these areas of the aquifer. Until HAs are attained, use restrictions will be put in place and monitoring will be performed to prevent exposure to groundwater used as a potable supply that contains contaminants.
EPA Risk Reference Doses (RFDs) and EPA Carcinogen Assessment Group Potency Factors	To Be Considered	A reference dose is an estimated daily oral exposure to a contaminant by humans that is unlikely to have an appreciable risk of non-carcinogenic effects. The cancer potency factor (CPF) is used as qualitative weight-of-evidence judgment as to the likelihood of a chemical being a carcinogen.	RFDs and CPFs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	RFDs and CPFs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	RFDs and CPFs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.
EPA Carcinogenicity Slope Factors (CSFs)	To Be Considered	Slope factors are developed by EPA from health effects assessments and provide the most current information on cancer risks caused by exposure to contaminants.	CSFs were used to evaluate carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	CSFs were used to evaluate carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	CSFs were used to evaluate carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.

Table 5-2A
Chemical-Specific ARARs and TBCs – Alternatives GW1, GW2, and GW3A
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Requirement	Status	Requirement Synopsis	Action To Attain ARAR		
			Alternative GW1	Alternative GW2	Alternative GW3A
EPA Regional Screening Levels (RSLs) for Chemical Contamination at Superfund Sites (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)	To Be Considered	Provides risk-based screening levels for various environmental media, for residential and industrial exposure scenarios, and for leaching of contaminants to groundwater.	RSLs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants and were used to develop media-specific remediation goals. GW1 would not be consistent with the RSLs because no action will be taken to attain the remediation goals.	RSLs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants. GW2 will be consistent with the RSLs because use restrictions and monitoring will be performed to prevent exposure to groundwater contaminants.	RSLs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants. GW3A will be consistent with this TBC in the former Source Area because in-situ chemical reduction will decrease contaminant levels to MCLs. Remediation of the plume core will accelerate the natural attenuation of the overburden plume downgradient of the former Source Area and the bedrock and eventual attainment of the PRGs. In these portions of the aquifer, use restrictions and monitoring will be implemented to prevent exposure to groundwater used as a potable supply that contains contaminants.
State Regulatory Requirements					
Rhode Island Rules and Regulation for the Investigation and Remediation of Hazardous Materials Releases (DEM-DSR-01-93) (8.02 (B)(ii))	Applicable	The Method 1 Soil Objectives Leachability Criteria (LC) identify allowable chemical concentrations that when leached from soil, would be protective of human health and the environment.	GW1 will not attain this ARAR because no actions will be taken to address soil that exceeds these criteria.	GW2 will not attain this ARAR because no actions will be taken to address soil that exceeds these criteria.	GW3A will treat all soil in the former Source Area using in-situ chemical reduction so that these criteria are met.
Rhode Island Rules and Regulation for the Investigation and Remediation of Hazardous Materials Releases (DEM-DSR-01-93) (8.03(B)(i))	Applicable	Groundwater that is classified as GA/GAA, categorized as suitable for drinking without treatment, and contains hazardous substances will need to be remediated to the GA Groundwater Objectives and the Groundwater Quality Regulations.	GW1 will not attain this ARAR because no actions will be taken to remediate the groundwater contamination.	GW2 will not attain this ARAR because no actions will be taken to remediate the groundwater contamination.	GW3A will attain this ARAR in the former Source Area in the short term through remediation using in-situ chemical reduction, and will attain the ARAR in the long term in the overburden plume and bedrock plume through natural attenuation.
Rhode Island Rules and Regulation for Groundwater Quality (Mar 2005)	Applicable	Defines requirements to protect and restore groundwater quality to drinking water use or beneficial uses. Provides classification of groundwater throughout the state. Sets groundwater remediation objectives and chemical-specific numerical standards by environmental medium.	GW1 will not attain this ARAR because no actions will be taken to remediate the groundwater contamination.	GW2 will not attain this ARAR because no actions will be taken to remediate the groundwater contamination.	GW3A will attain this ARAR in the former Source Area in the short term through remediation using in-situ chemical reduction, and will attain the ARAR in the long term in the overburden plume and bedrock plume through natural attenuation.
RIDEM Water Quality Regulations (Jul 2006, amended Dec 2009)	Applicable	Establishes requirements to protect surface water from pollutants that are detrimental to the value and use of this resource. Provide classification of water bodies for beneficial uses. Establishes allowable numerical criteria, based on classification, for the pollutants under specified flow conditions.	These standards were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. For GW1, this ARAR will not be met in the foreseeable future.	These standards were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. For GW2, this ARAR will not be met in the foreseeable future. Groundwater contaminants will only slowly diminish through natural attenuation. Monitoring will be conducted to assess the plume status and discharges to the wetland.	These standards were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under this alternative, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by treating groundwater contaminants in the plume core. Monitoring will be conducted to assess effectiveness this alternative.

Table 5-2B
Chemical-Specific ARARs and TBCs – Alternatives GW3B, GW4, and GW5
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Requirement	Status	Requirement Synopsis	Action To Attain ARAR		
			Alternative GW3B	Alternative GW4	Alternative GW5
Federal Regulatory Requirements					
Safe Drinking Water Act - Maximum Contaminant Levels (MCLs) (40 CFR 141.11-141.16) and Maximum Contaminant Level Goals (MCLGs) (40 CFR 141.50-141.55	Relevant and Appropriate	MCLs and non-zero MCLGs have been promulgated for a number of common organic and inorganic contaminants to regulate the concentration of contaminants in public drinking water supply systems. MCLs and non-zero MCLGs may be relevant and appropriate for the Davis Liquid Waste Site groundwater because the aquifer underlying the site and downgradient is a drinking water supply.	MCLs and non-zero MCLGs were used to derive groundwater remediation goals for human health protection. GW3B will comply with this ARAR in the former Source Area and the overburden plume because in-situ chemical reduction will decrease contaminant levels to MCLs and non-zero MCLGs. Remediation of the plume core will accelerate the natural attenuation of the bedrock and eventual attainment of the MCLs and non-zero MCLGs.	MCLs and non-zero MCLGs were used to develop groundwater remediation goals for human health protection. GW4 will comply with this ARAR in the former Source Area because groundwater extraction and treatment will decrease contaminant levels to MCLs and non-zero MCLGs in the long term. GW4 will enhance the natural attenuation of the overburden and bedrock plumes downgradient of the former Source Area.	MCLs and non-zero MCLGs were used to derive groundwater remediation goals for human health protection. GW5 will comply with this ARAR in the former Source Area because in-situ thermal treatment using ERH will decrease contaminant levels to MCLs and non-zero MCLGs. Remediation of the plume core will accelerate the natural attenuation of the overburden plume downgradient of the former Source Area and the bedrock and eventual attainment of the MCLs and non-zero MCLGs.
National Emission Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR 61, Subparts F & J)	Relevant and Appropriate	Establishes allowable numerical limits for emissions of benzene and vinyl chloride for specific stationary source categories. Applies to benzene emissions if the facility produces more than 1,102 tons per year of benzene. Applies to specific vinyl chloride process units if numerical limits are exceeded.	Not applicable. In-situ treatment would not result in emission of benzene or vinyl chloride to ambient air.	Implementation of GW4 will result in the generation of VOC offgases that need to be captured and treated. Use of proper collection and control systems will ensure compliance with this ARAR under GW4.	Implementation of GW5 will result in the generation of offgases that need to be captured and treated. Use of proper collection and control systems will ensure compliance with this ARAR.
Federal Criteria, Advisories, and Guidance					
National Recommended Water Quality Criteria - Clean Water Act Section 304(a)(1)	Relevant and Appropriate	Recommended freshwater and salt water criteria, for acute and chronic conditions, for approximately 150 pollutants that are protective of aquatic life and human health.	These guidelines were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under this alternative, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by treating groundwater contaminants in the plume core and the overburden plume. Monitoring will be conducted to assess effectiveness this alternative.	These guidelines were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under this alternative, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by using wells to extract contaminated groundwater from both the overburden and bedrock plumes. Monitoring will be conducted to assess effectiveness this alternative.	These guidelines were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under this alternative, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by thermally treating groundwater contaminants in the plume core. Monitoring will be conducted to assess effectiveness this alternative.
EPA Risk Reference Doses (RFDs) and EPA Carcinogen Assessment Group Potency Factors	To Be Considered	A reference dose is an estimated daily oral exposure to a contaminant by humans that is unlikely to have an appreciable risk of non-carcinogenic effects. The cancer potency factor (CPF) is used as qualitative weight-of-evidence judgment as to the likelihood of a chemical being a carcinogen.	RFDs and CPFs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	RFDs and CPFs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	RFDs and CPFs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.
EPA Carcinogenicity Slope Factors (CSFs)	To Be Considered	Slope factors are developed by EPA from health effects assessments and provide the most current information on cancer risks caused by exposure to contaminants.	CSFs were used to evaluate carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	CSFs were used to evaluate carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.	CSFs were used to evaluate carcinogenic health risks associated with site–related contaminants, and were used to develop media-specific remediation goals.

Table 5-2B
Chemical-Specific ARARs and TBCs – Alternatives GW3B, GW4, and GW5
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Requirement	Status	Requirement Synopsis	Action To Attain ARAR		
			Alternative GW3B	Alternative GW4	Alternative GW5
EPA Regional Screening Levels (RSLs) for Chemical Contamination at Superfund Sites (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)	To Be Considered	Provides risk-based screening levels for various environmental media, for residential and industrial exposure scenarios, and for leaching of contaminants to groundwater.	RSLs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants. GW3B will be consistent with this TBC in the former Source Area and the overburden plume because in-situ chemical reduction will decrease contaminant concentrations to safe levels. Remediation of the plume core will accelerate the natural attenuation in the bedrock and eventual attainment of the PRGs. In bedrock groundwater, use restrictions and monitoring will be implemented to prevent exposure to groundwater used as a potable supply that contains contaminants.	RSLs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants. GW4 will be consistent with this TBC because extracting and treating contaminated groundwater will decrease contaminant concentrations to safe levels in the long term. GW4 will enhance the natural attenuation of the overburden and bedrock plumes downgradient of the former Source Area. During remediation, use restrictions will be put in place and monitoring will be performed to prevent potential exposure to groundwater contaminants.	RSLs were used to evaluate non-carcinogenic and carcinogenic health risks associated with site–related contaminants. GW5 will be consistent with this TBC in the former Source Area because in-situ thermal treatment will decrease contaminant concentrations to safe levels. Remediation of the plume core will accelerate the natural attenuation of the overburden plume downgradient of the former Source Area and the bedrock and eventual attainment of the PRGs. For these portions of the aquifer, use restrictions and monitoring will be implemented to prevent exposure to groundwater used as a potable supply that contains contaminants.
State Regulatory Requirements					
Rhode Island Rules and Regulation for the Investigation and Remediation of Hazardous Materials Releases (DEM-DSR-01-93) (8.02 (B)(ii))	Applicable	The Method 1 Soil Objectives Leachability Criteria (LC) identify allowable chemical concentrations that when leached from soil, would be protective of human health and the environment.	GW3B will attain this ARAR by treating contaminated soil in the former Source Area using in-situ chemical reduction.	GW4 will not attain this ARAR.	GW5 will attain this ARAR in the former Source Area by using in-situ thermal treatment to address contaminated soil.
Rhode Island Rules and Regulation for the Investigation and Remediation of Hazardous Materials Releases (DEM-DSR-01-93) (8.03(B)(i))	Applicable	Groundwater that is classified as GA/GAA, categorized as suitable for drinking without treatment, and contains hazardous substances will need to be remediated to the GA Groundwater Objectives and the Groundwater Quality Regulations.	GW3B will attain this ARAR in the former Source Area and the overburden aquifer in the short term through remediation using in-situ chemical reduction, and will attain the ARAR in the long term in the bedrock plume through natural attenuation.	GW4 will attain this ARAR through extraction of contaminated groundwater that removes VOCs from the aquifer to these levels and will attain this ARAR.	GW5 will attain this ARAR in the former Source Area in the short term through remediation using in-situ thermal treatment, and will attain the ARAR in the long term in the overburden plume and bedrock plume through natural attenuation.
Rhode Island Rules and Regulation for Groundwater Quality (Mar 2005)	Applicable	Defines requirements to protect and restore groundwater quality to drinking water use or beneficial uses. Provides classification of groundwater throughout the state. Sets groundwater remediation objectives and chemical-specific numerical standards by environmental medium.	GW3B will attain this ARAR in the former Source Area and the overburden plume in the short term through remediation using in-situ chemical reduction, and will attain the ARAR in the long term in the bedrock plume through natural attenuation.	GW4 will attain this ARAR in the former Source Area in the short term through remediation using in-situ chemical reduction, and will attain the ARAR in the long term in the overburden plume and bedrock plume through natural attenuation.	GW5 will attain this ARAR in the former Source Area in the short term through remediation using in-situ thermal treatment, and will attain the ARAR in the long term in the overburden plume and bedrock plume through natural attenuation.
RIDEM Water Quality Regulations (Jul 2006, amended Dec 2009)	Applicable	Establishes requirements to protect surface water from pollutants that are detrimental to the value and use of this resource. Provide classification of water bodies for beneficial uses. Establishes allowable numerical criteria, based on classification, for the pollutants under specified flow conditions.	These standards were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under this alternative, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by treating groundwater contaminants in the plume core and in the overburden plume. Monitoring will be conducted to assess the effectiveness of this alternative.	These standards were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under this alternative, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by extracting and treating contaminated groundwater. Monitoring will be conducted to assess the effectiveness of this alternative.	These standards were used to assess whether water quality in the adjacent wetlands and Latham Brook may have been affected by contaminated groundwater discharges. Under this alternative, action will be taken to the extent practical to limit the discharge of contaminated groundwater to surface water and wetlands by treating groundwater contaminants. Monitoring will be conducted to assess the effectiveness of this alternative.

Table 5-3A
Location-Specific ARARs and TBCs – Alternatives GW1, GW2, and GW3A
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO ATTAIN ARAR		
			GW1	GW2	GW3A
Federal Regulatory Requirements					
Protection of Wetlands (Executive Order 11990) Statement of Procedures on Floodplain Management and Wetland Protection (June 5, 1979)	Applicable	Federal agencies are required to avoid undertaking or providing assistance for new construction located in wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Not applicable or relevant and appropriate. No action will be implemented.	Wetlands have been identified adjacent to the Source Area and in downgradient areas. Well installation (for monitoring) will occur in or near wetlands. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Actions will be taken to minimize potential impacts to the wetlands and mitigate damage. The Proposed Plan will solicit comments for this action.	Wetlands have been identified adjacent to the former Source Area and in downgradient areas. Well installation (for monitoring or injection) will occur in or near wetlands. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Actions will be taken to minimize potential impacts to the wetlands and mitigate damage. The Proposed Plan will solicit comments for this action. Implementation of in-situ chemical treatment will not be performed in the wetland areas, and Alternative GW3A will comply with this ARAR.
Floodplain Management (Executive Order 11988), 40 CFR 6.302(b) and 40 CFR 6, App. A (Policy on Implementing E.O. 11988)	Applicable	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	Not applicable or relevant and appropriate. No action will be implemented.	Floodplains have been identified in portions of the Site (but not the Source Area). Implementation of GW2, installation of monitoring wells will not result in occupancy and modification of the floodplain. GW2 will comply with this ARAR.	Floodplains have been identified in portions of the Site (but not the Source Area). Implementation of GW3A will not result in occupancy and modification of the floodplain. GW3A will comply with this ARAR.
Clean Water Act (33 U.S.C. 1251 *et seq.*); Section 404, Compensatory Mitigation for Losses of Aquatic Resources (40 CFR 230)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impacts.	Not applicable or relevant and appropriate. No action will be implemented.	If installation of monitoring wells results in unavoidable damage to wetlands, then a mitigation measure will be completed to comply with this ARAR.	If installation of monitoring wells results in the unavoidable damage to wetlands, then a mitigation measure will be completed under GW3A to comply with this ARAR.
Endangered Species Act (16 U.S.C. 1531 et seq.; 40 CFR 6.302(h))	Applicable, if endangered species are identified	This statute requires that federal agencies avoid activities that jeopardize threatened or endangered species or adversely modify habitats essential to their survival. Mitigation measures should be considered if a listed species or habitat may be jeopardized.	Not applicable or relevant and appropriate. No action will be implemented.	As part of the pre-design investigation, an evaluation for endangered or threatened species will be performed. If these species are identified onsite, work will be conducted to avoid jeopardizing the listed species or adversely affecting their habitats. GW2 will comply with this ARAR.	As part of the pre-design investigation, an evaluation for endangered or threatened species will be performed. If these species are identified onsite, work will be conducted to avoid jeopardizing the listed species or adversely affecting their habitats. GW3A will comply with this ARAR.
National Historic Preservation Act (16 U.S.C. 470 et seq., 40 CFR 800)	Applicable, if such resources are identified	Pursuant to Sections 106 and 110(f) of the NHPA, as amended, CERCLA response actions are required to take into account the effects of the response activities on any historic property included or eligible for inclusion on the National Register of Historic Places.	Not applicable or relevant and appropriate. No action will be implemented.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of these regulations will be followed. GW2 will comply with this ARAR.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of the NHPA and its implementing regulations will be followed. GW3A will comply with this ARAR.
State Regulatory Requirement					
Rules and Regulations Governing the Administration and Enforcement of the Fresh Water Wetlands Act	Applicable	These regulations outline requirements to preserve, protect, and restore the integrity of fresh water wetlands. Governs increases or deceases of runoff or groundwater that discharges into wetlands. Preference for avoidance or minimization of wetland alterations. If alternations are unavoidable, then mitigation will be required.	Not applicable or relevant and appropriate. No action will be implemented.	Installation of monitoring wells in the wetlands is necessary to monitor groundwater contaminant status and is unavoidable. Actions will be taken to minimize potential impacts and mitigate damage.	Installation of monitoring wells in the wetlands to monitor groundwater contaminant status during remediation is necessary and unavoidable. Actions will be taken to minimize potential impacts and mitigate damage.
RI Historic Preservation Act (RI General Laws 42-45)	Applicable, if such resources are identified	This statute adopts the federal Nat'l Historic Preservation Act (and other laws)	Not applicable or relevant and appropriate. No action will be implemented.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of this statute will be followed.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of this statute will be followed. GW3A will comply with this ARAR.

Table 5-3B
Location-Specific ARARs and TBCs – Alternatives GW3B, GW4, and GW5
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO ATTAIN ARAR		
			GW3B	GW4	GW5
Federal Regulatory Requirements					
Protection of Wetlands (Executive Order 11990), Statement of Procedures on Floodplain Management and Wetland Protection (June 5, 1979)	Applicable	Federal agencies are required to avoid undertaking or providing assistance for new construction located in wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Wetlands have been identified adjacent to the former Source Area and in downgradient areas. Well installation (for monitoring or injection) will occur in or near wetlands. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Actions will be taken to minimize potential impacts to the wetlands and damage will be mitigated. The Proposed Plan will solicit comments for this action. Implementation of in-situ chemical treatment will not be performed in the wetland areas, and Alternative GW3B will comply with this ARAR.	Wetlands have been identified adjacent to the former Source Area and in downgradient areas. Well installation (for monitoring or injection) will occur in or near wetlands. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Under GW4, groundwater extraction may cause dewatering in portions of the wetlands adjacent to some of the extraction wells. Actions will be taken to minimize potential impacts to the wetlands and damage will be mitigated. The alternative cannot be selected unless a determination is made that there is no practical alternative. The Proposed Plan will solicit comments for this action.	Wetlands have been identified adjacent to the former Source Area and in downgradient areas. Well installation (for monitoring) will occur in or near wetlands. Under GW5, in-situ thermal treatment may cause adverse effects to portions of wetlands immediately adjacent to the former Source Area. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Actions will be taken to minimize potential impacts to the wetlands and damage will be mitigated. The alternative cannot be selected unless a determination is made that there is no practical alternative. The Proposed Plan will solicit comments for this action.
Floodplain Management (Executive Order 11988), Statement of Procedures on Floodplain Management and Wetland Protection (June 5, 1979)	Applicable	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	Floodplains have been identified in portions of the Site (but not the Source Area). This alternative will be implemented outside of the floodplain. GW3B will comply with this ARAR.	Floodplains have been identified in portions of the Site (but not the Source Area). Implementation of GW4 will not result in the loss of flood storage capacity during the remediation. The groundwater treatment system for GW4 would be constructed outside of the 100-year floodplain. GW4 will comply with this ARAR.	Floodplains have been identified in portions of the Site (but not the Source Area). Implementation of GW5 will not result in the loss of flood storage capacity during the remediation. Equipment and supporting structures for in-situ thermal treatment will be constructed outside of the 100-year floodplain. GW5 will comply with this ARAR.
Clean Water Act (33 U.S.C. 1251 *et seq.*); Section 404, Compensatory Mitigation for Losses of Aquatic Resources (40 CFR 230)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impacts.	Wetlands have been identified adjacent to the former Source Area and in downgradient areas. Well installation (for monitoring or injection) will occur in or near wetlands. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Actions will be taken to minimize potential impacts to the wetlands and damage will be mitigated. The Proposed Plan will solicit comments for this action. Implementation of in-situ chemical treatment will not be performed in the wetland areas, and Alternative GW3B will comply with this ARAR.	Wetlands have been identified adjacent to the former Source Area and in downgradient areas. Well installation (for monitoring or injection) will occur in or near wetlands. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Under GW4, groundwater extraction may cause dewatering in portions of the wetlands adjacent to some of the extraction wells. Actions will be taken to minimize potential impacts to the wetlands and damage will be mitigated. The alternative cannot be selected unless a determination is made that there is no practical alternative. The Proposed Plan will solicit comments for this action.	Wetlands have been identified adjacent to the former Source Area and in downgradient areas. Well installation (for monitoring) will occur in or near wetlands. Under GW5, in-situ thermal treatment may cause adverse effects to portions of wetlands immediately adjacent to the former Source Area. Because elevated concentrations of contaminants are in or beneath the wetlands, there is no practicable alternative to performing the required activities. Actions will be taken to minimize potential impacts to the wetlands and damage will be mitigated. The alternative cannot be selected unless a determination is made that there is no practical alternative. The Proposed Plan will solicit comments for this action.
Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.); Fish and Wildlife Protection (40 CFR 6.302(g))	Applicable	Any modification of a body of water requires consultation with the US Fish and Wildlife Service and the appropriate state agency to develop measures to prevent, mitigate, or compensate for project-related losses of fish and wildlife.	Not applicable or relevant and appropriate. Implementation of GW3B will not result in a modification of water bodies.	If modifications to water bodies occur, these requirements will be met.	If modifications to water bodies occur, these requirements will be met.
Endangered Species Act (16 U.S.C. 1531 et seq.; 40 CFR 6.302(h))	Applicable, if endangered species are identified	This statute requires that federal agencies avoid activities that jeopardize threatened or endangered species or adversely modify habitats essential to their survival. Mitigation measures should be considered if a listed species or habitat may be jeopardized.	As part of the pre-design investigation, an evaluation for endangered or threatened species will be performed. If these species are identified onsite, work will be conducted to avoid jeopardizing the listed species or adversely affecting their habitats. GW3A will comply with this ARAR.	As part of the pre-design investigation, an evaluation for endangered or threatened species will be performed. If these species are identified onsite, work will be conducted to avoid jeopardizing the listed species or adversely affecting their habitats. GW4 will comply with this ARAR.	As part of the pre-design investigation, an evaluation for endangered or threatened species will be performed. If these species are identified onsite, work will be conducted to avoid jeopardizing the listed species or adversely affecting their habitats. GW5 will comply with this ARAR.

Table 5-3B
Location-Specific ARARs and TBCs – Alternatives GW3B, GW4, and GW5
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO ATTAIN ARAR		
			GW3B	GW4	GW5
National Historic Preservation Act (16 U.S.C. 470 et seq., 40 CFR 800)	Applicable, if such resources are identified	Pursuant to Sections 106 and 110(f) of the NHPA, as amended, CERCLA response actions are required to take into account the effects of the response activities on any historic property included or eligible for inclusion on the National Register of Historic Places.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of the NHPA and its implementing regulations will be followed. GW3B will comply with this ARAR.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of the NHPA and its implementing regulations will be followed. GW4 will comply with this ARAR.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of the NHPA and its implementing regulations will be followed. GW5 will comply with this ARAR.
State Regulatory Requirement					
Rules and Regulations Governing the Administration and Enforcement of the Fresh Water Wetlands Act	Applicable	These regulations outline requirements to preserve, protect, and restore the integrity of fresh water wetlands. Governs increases or deceases of runoff or groundwater that discharges into wetlands. Preference for avoidance or minimization of wetland alterations. If alternations are unavoidable, then mitigation will be required.	Installation of monitoring wells is unavoidable. Actions will be taken to minimize potential impacts and mitigate damage.	Installation of monitoring wells is unavoidable. Actions will be taken to minimize potential impacts and mitigate damage.	Installation of monitoring wells is unavoidable. Actions will be taken to minimize potential impacts and mitigate damage.
RI Historic Preservation Act (RI General Laws 42-45)	Applicable, if such resources are identified	This statute adopts the federal Nat'l Historic Preservation Act (and other laws)	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of this statute will be followed. GW3B will comply with this ARAR.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of this statute will be followed. GW4 will comply with this ARAR.	If significant historic properties (including prehistoric or archaeological) are identified, then the requirements of this statute will be followed. GW4 will comply with this ARAR.

Table 5-4A
Action-Specific ARARs and TBCs – Alternatives GW1, GW2, and GW3B
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO ATTAIN ARAR		
			GW1	GW2	GW3A
Federal Regulatory Requirements					
Underground Injection Control Regulations (40 CFR Parts 144, 145, 146, and 147)	Applicable	These regulations provide compliance standards for treatment facilities that inject wastes underground. The injection of fluids that allow contaminant migration into water supply aquifers resulting in exceedances of drinking water criteria or risk-based criteria is prohibited.	Not applicable or relevant and appropriate. No action will be implemented.	Not applicable or relevant and appropriate. No injection will be implemented in GW2.	Injection of chemicals for in-situ treatment of contaminated groundwater under GW3A will be conducted in accordance with these regulations.
RCRA Groundwater Monitoring Requirements (42 U.S.C. 6901 et seq.) (40 CFR 264.94 and .95, subpart F)	Relevant and Appropriate	The regulation set requirements for groundwater monitoring at facilities that store, treat, or dispose of hazardous wastes. In-situ treatment is similar to the regulated activity.	Not applicable or relevant and appropriate. No action will be implemented.	Not applicable or relevant and appropriate. No treatment, storage or disposal of hazardous wastes will occur under GW2.	A groundwater monitoring program will be implemented in accordance with these regulations; GW3A will comply with this ARAR.
National Emission Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR 61, Subparts F & J)	Relevant and Appropriate	Regulates VOC emissions from specific source categories. Establishes allowable numerical limits for emissions of benzene and vinyl chloride for specific stationary source categories. Applies to benzene emissions if the facility produces more than 1,102 tons per year of benzene. Applies to specific vinyl chloride process units if numerical limits are exceeded. Provides requirements for monitoring, testing, reporting, and repairs.	Not applicable or relevant and appropriate. No active remediation will be performed.	Not applicable or relevant and appropriate. No active remediation will be performed.	Not applicable. In-situ treatment would not result in emission of benzene or vinyl chloride to ambient air.
RCRA Corrective Action Program(42 U.S.C. 6901 et seq.); (40 CFR 264.100)	Relevant and Appropriate	These regulations require that corrective actions be taken if the groundwater protection standard is exceeded. A monitoring program will be instituted to demonstrate and report the effectiveness of the corrective action.	Not applicable or relevant and appropriate. No action will be implemented.	Not applicable or relevant and appropriate.	These regulations require that corrective actions be taken if the groundwater protection standard is exceeded. A monitoring program will be instituted to demonstrate and report the effectiveness of the corrective action.
State Regulatory Requirements					
Rhode Island Rules and Regulation for Groundwater Quality	Applicable	Sets requirements for monitoring well installation and abandonment, subsurface borings, wellhead protection, and methods for the determination of compliance.	Not applicable or relevant and appropriate. No action will be implemented.	All borings and monitoring wells will be completed in accordance with these requirements. GW2 will comply with this ARAR.	All borings and wells will be completed in accordance with these requirements. GW3A will comply with this ARAR.
Rhode Island Underground Injection Control Program Rules and Regulations	Applicable	These regulations provide compliance standards for treatment facilities that inject wastes underground. The injection of fluids that allow contaminant migration into water supply aquifers resulting in exceedances of drinking water criteria or risk-based criteria is prohibited.	Not applicable or relevant and appropriate. No action will be implemented.	Not applicable or relevant and appropriate. No injection will be implemented under GW2.	Injection of chemicals for in-situ treatment of groundwater contaminants will be conducted consistent with these regulations. GW3A will comply with this ARAR.
Regulations for the Rhode Island Pollutant Discharge Elimination System	Applicable	The regulations set standards to restore, preserve, and enhance the quality of the surface waters and protect the waters from discharges of pollutants to surface waters.	Not applicable or relevant and appropriate. No action will be implemented.	Not applicable or relevant and appropriate. No discharges will occur under GW2.	Not applicable or relevant and appropriate. No discharges anticipated under GW3A.
Rhode Island Air Pollution Control Regulation No. 1, Visible Emissions	Applicable	These regulations prohibit emissions from any source equal to or greater than 20 percent opacity for a period or periods aggregating more than 3 minutes in any 1 hour.	Not applicable or relevant and appropriate. No action will be implemented.	All work will be conducted so that these requriements are met.	All work will be conducted so that these requriements are met.
Rhode Island Air Pollution Control Regulation No. 5, Fugitive Emissions	Applicable	These regulations prohibit the generation of airborne particulate matter beyond the property line during construction activities or during vehicular transport of materials. Reasonable precautions are required to prevent fugitive dust emissions that exceed these requirements.	Not applicable or relevant and appropriate. No action will be implemented.	All work will be conducted so that these requriements are met.	Work will be performed in accordance with these reguirements.
Rhode Island Rules and Regulations for Hazardous Waste Management (DEM OWM-HW01-07)	Applicable	These regulations are intended to minimize environmental hazards associated with the generation, transportation, treatment, storage and disposal of hazardous wastes, and the operation of hazardous waste treatment, storage and disposal facilities.	Not applicable. No action will be implemented.	Not applicable. No wastes are anticipated to be treated, stored, or disposed of under GW2.	Not applicable. No wastes are anticipated to be treated, stored, or disposed of under GW3A.

Table 5-4B
Action-Specific ARARs and TBCs – Alternatives GW3B, GW4, and GW5
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO ATTAIN ARAR		
			GW3B	GW4	GW5
Federal Regulatory Requirements					
Underground Injection Control Regulations (40 CFR Parts 144, 145, 146, and 147)	Applicable	These regulations provide compliance standards for treatment facilities that inject wastes underground. The injection of fluids that allow contaminant migration into water supply aquifers resulting in exceedances of drinking water criteria or risk-based criteria is prohibited.	Injection of chemicals for in-situ treatment of contaminated groundwater under GW3B will be conducted in accordance with these regulations.	Not applicable or relevant and appropriate. No underground injection will be conducted under GW4.	Not applicable or relevant and appropriate. No underground injection will be conducted under GW5.
RCRA Groundwater Monitoring Requirements (42 U.S.C. 6901 et seq.) (40 CFR 264.94 and .95, subpart F)	Relevant and Appropriate	The regulation set requirements for groundwater monitoring at facilities that store, treat, or dispose of hazardous wastes. In-situ treatment is similar to the regulated activity.	A groundwater monitoring program will be implemented in accordance with these regulations; GW3B will comply with this ARAR.	A groundwater monitoring program will be implemented in accordance with these regulations because extracted groundwater with contaminants will be treated and treatment residuals may be stored on site temporarily. GW4 will comply with this ARAR.	A groundwater monitoring program will be implemented in accordance with these regulations because recovered from the vaporized groundwater will be collected and treated, and treatment residuals will be stored temporarily on site. GW5 will comply with this ARAR.
National Emission Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR 61, Subparts F & J)	Relevant and Appropriate	Establishes allowable numerical limits for emissions of benzene and vinyl chloride for specific stationary source categories. Applies to benzene emissions if the facility produces more than 1,102 tons per year of benzene. Applies to specific vinyl chloride process units if numerical limits are exceeded.	Not applicable. In-situ treatment would not result in emission of benzene or vinyl chloride to ambient air.	Implementation of GW4 will result in the generation of VOC offgases that need to be captured and treated. Use of proper collection and control systems will ensure compliance with this ARAR under GW4.	Implementation of GW5 will result in the generation of offgases that need to be captured and treated. Use of proper collection and control systems will ensure compliance with this ARAR.
RCRA Corrective Action Program(42 U.S.C. 6901 et seq.); (40 CFR 264.100)	Relevant and Appropriate	These regulations require that corrective actions be taken if the groundwater protection standard is exceeded. A monitoring program will be instituted to demonstrate and report the effectiveness of the corrective action.	If the implementation of in-situ chemical and biological treatment results in the exceedance of groundwater standards, corrective actions will be implemented	On-site treatment and storage of treatment residuals are unlikely to result in groundwater degradation. If the groundwater standard is exceeded, GW4 will implement corrective actions and monitor the effectiveness of the corrective action. GW4 will comply with this ARAR.	On-site treatment and storage of treatment residuals are unlikely to result in groundwater degradation. If the groundwater standard is exceeded, GW5 will implement corrective actions and monitor the effectiveness of the corrective action. GW5 will comply with this ARAR.
Clean Water Act, National Pollutant Discharge Elimination System (NPDES), 33 U.S.C. 1342 (40 CFR 122-125, 131)	Applicable	These standards govern the discharge pollutants from point sources into the waters of the United States. Sets requirements for permits to regulate pollutant discharges that incorporate numeric limits, establishes periodic monitoring of effluent. Address stormwater and non-stormwater discharges. Rhode Island is authorized to administer this program (RIPDES).	Not applicable or relevant and appropriate. No discharges anticipated under GW3B.	Treated groundwater will need to be discharged to Latham Brook. The treated discharge will meet the substantive requirements for discharges to surface water set by the State under the federal NPDES program. Periodic monitoring will also be performed. GW4 will comply with this ARAR.	Treated water vapor, once condensed, will need to be discharged to Latham Brook. The treated discharge will meet the substantive requirements for discharges to surface water set by the State under the federal NPDES program. Periodic monitoring will also be performed. GW5 will comply with this ARAR.
RCRA 40 CFR 264 Subpart AA, Air Emission Standards for Process Vents	Relevant and Appropriate, if threshold limit is exceeded	Provides requirements and treatment limits applicable to air stripping facilities that treat RCRA wastes with total VOCs of 10 ppm by weight or greater.	Not applicable or relevant and appropriate. No air emissions anticipated under GW3B.	If threshold limits are exceeded, the offgases from the groundwater treatment will be treated by vapor control systems to meet the requirements, thereby complying with this ARAR.	The offgases from the in-situ thermal desorption will be treated by vapor control systems to meet the requirements, thereby complying with this ARAR.
RCRA 40 CFR 264 Subpart BB, Air Emission Standards for Equipment Leaks	Relevant and Appropriate, if threshold limit is exceeded	This regulation contains air pollutant emission standards for equipment leaks at hazardous waste TSD facilities. This subpart applies to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Not applicable or relevant and appropriate. No air emissions anticipated under GW3B.	Extracted groundwater VOCs will be treated using air stripping and activated carbon adsorption under GW4. If threshold concentrations are met, a leak detection and repair program will be implemented and GW4 will comply with this ARAR.	Treatment of contaminated water vapor and VOCs in on-site equipment will include a leak detection and repair program, if threshold concentrations are met. If equipment leaks occur during treatment, the response under GW5 will comply with this ARAR.
RCRA 40 CFR 264 Subpart CC, Air Emission Standards for Tanks, Surface Impoundments, and Containers	Relevant and Appropriate, if threshold limit is exceeded	Specific types of controls are required on tanks and containers that have VOC concentrations of 500 ppm by weight or greater.	Not applicable or relevant and appropriate. No air emissions anticipated under GW3B.	If threshold limits are exceeded during the implementation of GW4, offgases resulting from treatment of extracted groundwater will be controlled using appropriate equipment and processes such that the requirements of the ARAR are met.	If implementation of in-situ thermal treatment generate off gases that meet the threshold levels in the process equipment, GW5 will use the appropriate controls to treat the VOCs such that the requirements of the ARAR are met.

Table 5-4B
Action-Specific ARARs and TBCs – Alternatives GW3B, GW4, and GW5
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO ATTAIN ARAR		
			GW3B	GW4	GW5
State Regulatory Requirements					
Rhode Island Rules and Regulation for Groundwater Quality	Applicable	Sets requirements for monitoring well installation and abandonment, subsurface borings, wellhead protection, and methods for the determination of compliance.	All borings and wells will be completed in accordance with these requirements. GW3B will comply with this ARAR.	All borings and monitoring extraction and wells will be completed in accordance with these requirements. GW4 will comply with this ARAR.	Borings and monitoring wells to be installed under GW5 will be completed in accordance with these requirements. GW5 will comply with this ARAR.
Rhode Island Underground Injection Control Program Rules and Regulations	Applicable	These regulations provide compliance standards for treatment facilities that inject wastes underground. The injection of fluids that allow contaminant migration into water supply aquifers resulting in exceedances of drinking water criteria or risk-based criteria is prohibited.	Injection of chemicals for in-situ treatment of groundwater contaminants will be conducted consistent with these regulations. GW3B will comply with this ARAR.	Not applicable or relevant and appropriate. Underground injection will be not conducted under GW4.	Not applicable or relevant and appropriate. Underground injection will be not conducted under GW5.
Regulations for the Rhode Island Pollutant Discharge Elimination System	Applicable	The regulations set standards to restore, preserve, and enhance the quality of the surface waters and protect the waters from discharges of pollutants to surface waters.	Not applicable or relevant and appropriate. No discharges anticipated under GW3B.	Extracted groundwater under GW4 will be treated to meet the permit limits (or the substantive requirements) prior to discharge to Latham Brook. GW4 will comply with this ARAR.	Treated water vapor, once condensed, will need to be discharged to Latham Brook. The treated discharge will meet the substantive requirements for discharges to surface water set by the State. Periodic monitoring will also be performed. GW5 will comply with this ARAR.
Rhode Island Air Pollution Control Regulation No. 1, Visible Emissions	Applicable	These standards prohibit emissions from any source equal to or greater than 20 percent opacity for a period or periods aggregating more than 3 minutes in any 1 hour.	All work will be conducted so that these requriements are met.	All work will be conducted so that these requriements are met.	All work will be conducted so that these requriements are met.
Rhode Island Air Pollution Control Regulation No. 5, Fugitive Emissions	Applicable	These regulations prohibit the generation of airborne particulate matter beyond the property line during construction activities or during vehicular transport of materials. Reasonable precautions are required to prevent fugitive dust emissions that exceed these requirements.	Work will be performed in accordance with these reguirements.	As needed, dust suppression measures will be used during construction and well installation activities of GW4, to ensure compliance with this ARAR.	As needed, dust suppression measures will be used during construction and well installation activities of GW4, to ensure compliance with this ARAR.
Rhode Island Air Pollution Control Regulation No. 16, Operation of Air Pollution Control Systems	Applicable	Air pollution control systems are required to be operated in accordance with design specifications whenever a regulated source of air pollution is in operation or is emitting air pollutants.	Not applicable or relevant and appropriate. No air emissions anticipated under GW3B.	Because GW4 will generate off gases as treatment byproducts, appropriate air pollution control systems (condenser, activated carbon, catalytic oxidizer etc.) will be use to ensure compliance with this ARAR.	Because GW5 will generate off gases as treatment byproducts, appropriate air pollution control systems (condensers, activated carbon, catalytic oxidizer, etc.) will be use to ensure compliance with this ARAR.
Rhode Island Air Pollution Control Regulation No. 22, Air Toxics	Applicable	Establishes limits for air toxics from stationary sources such that that emissions do not cause ground level concentrations that exceed Acceptable Ambient Levels.	Not applicable. In-situ-treatment is not expected to produce emissions to ambient air.	Because GW4 will generate off gases as byproducts of treating extracted groundwater, appropriate air pollution control systems (condensers, activated carbon, etc.) will be use to ensure compliance with this ARAR.	Because GW5 will generate off gases as byproducts of treating extracted groundwater, appropriate air pollution control systems (condensers, activated carbon, etc.) will be use to ensure compliance with this ARAR.
Rhode Island Rules and Regulations for Hazardous Waste Management (DEM OWM-HW01-07)	Applicable	These regulations are intended to minimize environmental hazards associated with the generation, transportation, treatment, storage and disposal of hazardous wastes, and the operation of hazardous waste treatment, storage and disposal facilities.	Not applicable or relevant and appropriate. No wastes are anticipated to be treated, stored, or disposed of under GW3B.	VOCs and treatment residuals (hazardous wastes) generated as the result of groundwater treatment will be managed in compliance with the requirements, and GW4 will therefore comply with this ARAR.	VOCs and treatment residuals (hazardous wastes) generated as the result of contaminated water vapor treatment will be managed in compliance with the requirements, and GW5 will therefore comply with this ARAR.

Table 6-1
Comparative Analysis of Alternatives Summary
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Groundwater Alternatives	Protection of Human Health & Environment	Compliance with ARARs	Long-Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, & Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost	State Acceptance	Community Acceptance
GW1 - No Action	☐	☐	☐	☐	☐	■	low	TBD	TBD
GW2 - Limited Action, Institutional Controls, Monitored Natural Attenuation, and Five-Year Reviews	◪	☐	◪	☐	☐	■	low	TBD	TBD
GW3A - In-Situ Chemical Treatment and Enhanced Biodegradation (Core), Monitored Natural Attenuation (Plume), Institutional Controls, and Five-Year Reviews	◪	☐	◪	☐	☐	■	med	TBD	TBD
GW3B - In-Situ Chemical Treatment and Enhanced Biodegradation (Core, Overburden Plume), Monitored Natural Attenuation (Bedrock Plume), Institutional Controls, and Five-Year Reviews	■	■	■	■	◪	◪	med	TBD	TBD
GW4 - Groundwater Extraction, Treatment, and Discharge, Long-Term Monitoring, Institutional Controls, and Five-Year Reviews	■	■	◪	■	◪	◪	high	TBD	TBD
GW5 - In-Situ Thermal Treatment (Core) and Monitored Natural Attenuation (Plume), Institutional Controls, and Five-Year Reviews	■	■	◪	■	◪	◪	high	TBD	TBD

Legend

☐	Does not meet criterion
◪	Partially meets criterion
■	Meets criterion
TBD	To be determined and addressed during the proposed plan stage

FIGURES

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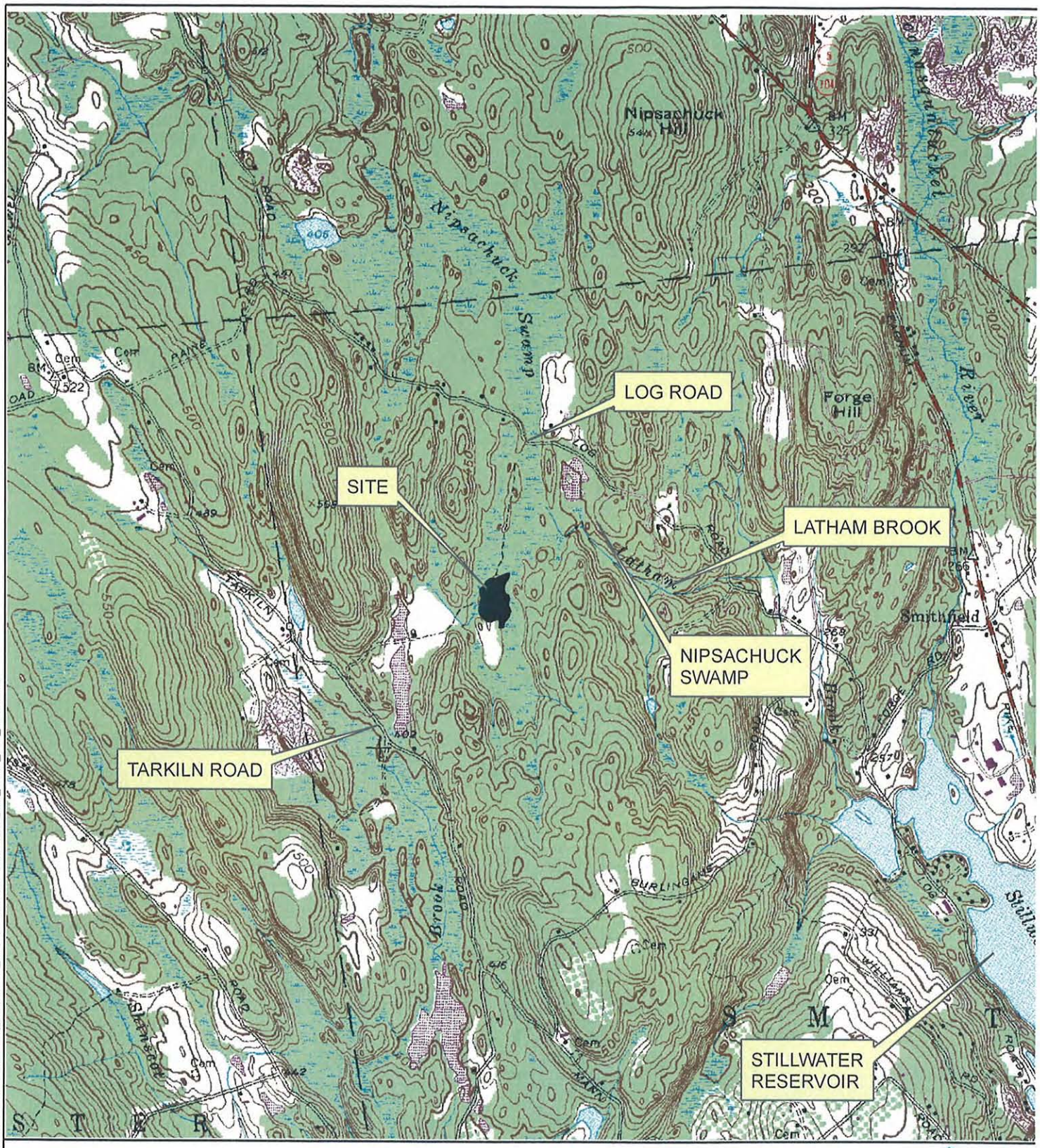

Quadrangle Location

USGS TOPOGRAPHIC MAP

GEORGIAVILLE, RHODE ISLAND

1954; (Photo-revised 1970, 1975)

APPROXIMATE SCALE
1" = 2,000 FEET

FIGURE 1-1	DAVIS LIQUID WASTE SITE SMITHFIELD, RHODE ISLAND LOCUS PLAN	Nobis Nobis Engineering, Inc. 585 Middlesex Street Lowell, MA 01851 (978) 683-0891 www.nobisengineering.com	DATE: 05/26/09 REV. 00 PROJECT NO. 80028 PREPARED BY: D. McGRATH CHECKED BY: L. CHU	N

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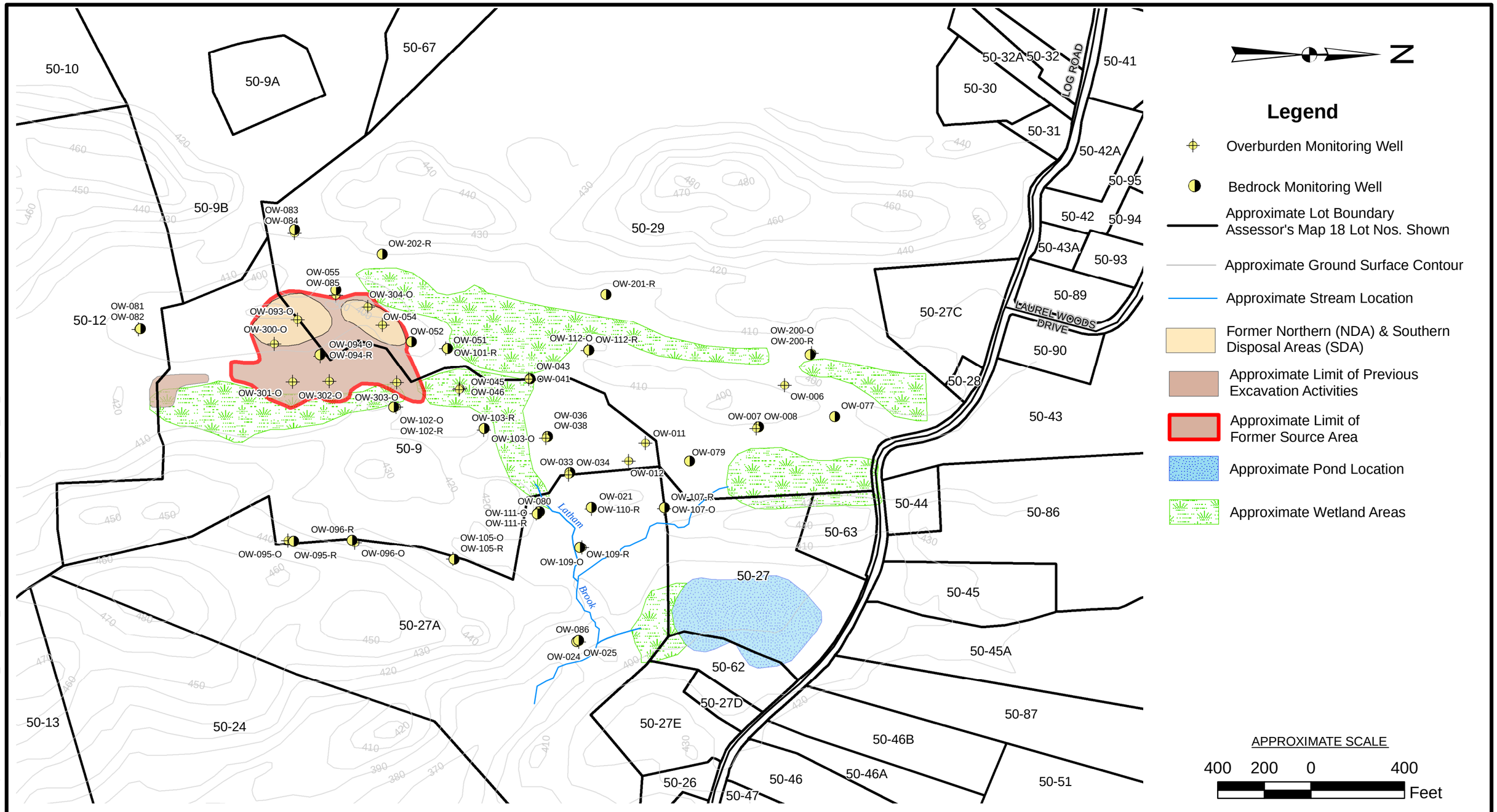

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Well Locations based on ESS Phase 4 Draft Supplemental Field Investigation Report (ESS, 2009).
4. Tax Assessor's map lot lines were obtained from the Smithfield Tax Assessor's Office.

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FIGURE 1-2

SITE AND SURROUNDING AREA
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

PREPARED BY: DFM	CHECKED BY: LC
PROJECT NO. 80028	DATE: 09/28/09 Rev. 00

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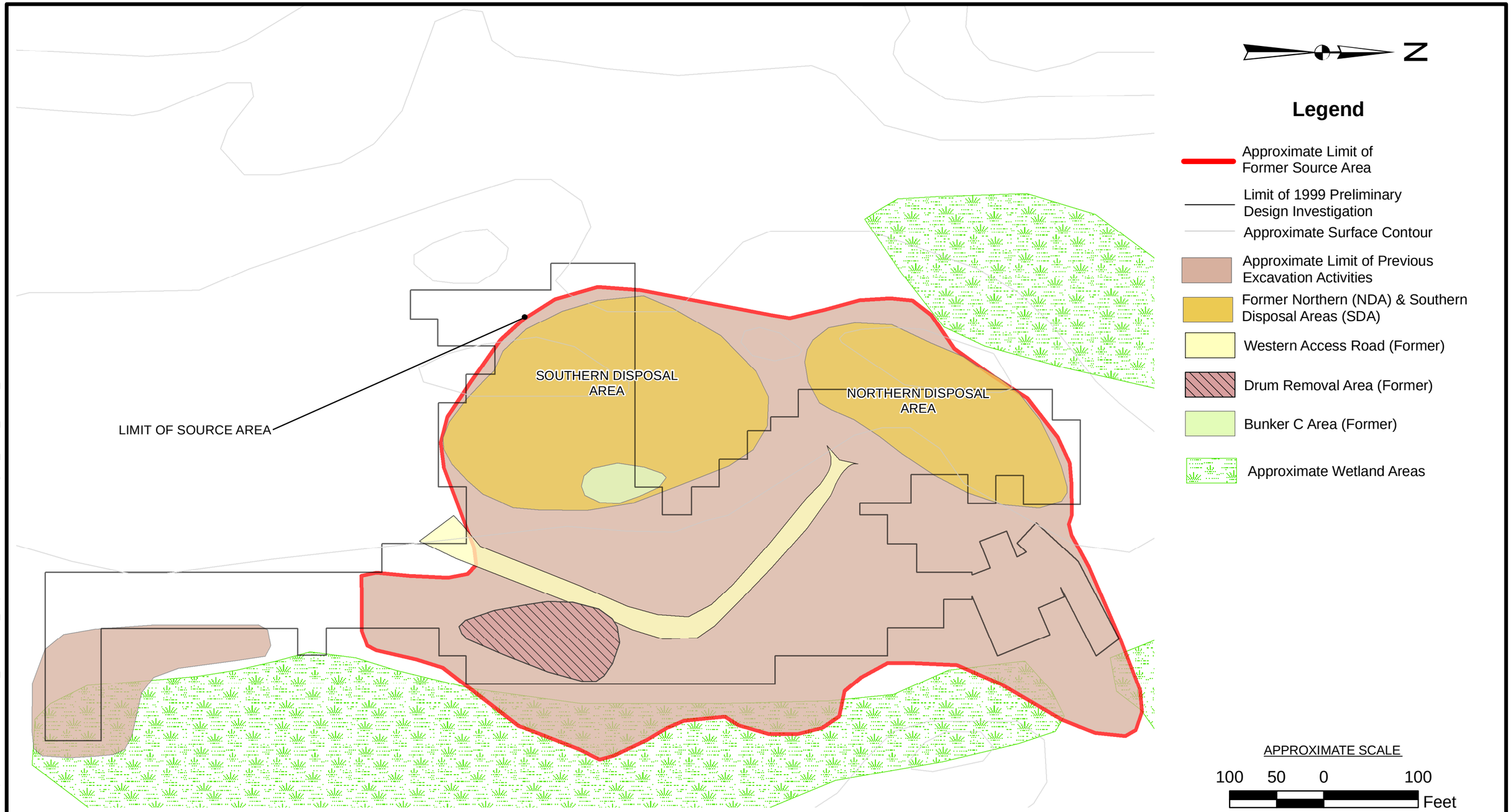

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of Preliminary Design Investigation, excavation, and disposal areas are based on Remedial Action Report (LEA, 2001).

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FIGURE 1-3

FORMER WASTE AREA LOCATIONS
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

PREPARED BY: DFM	CHECKED BY: LC
PROJECT NO. 80028	DATE: 09/28/09 Rev 00

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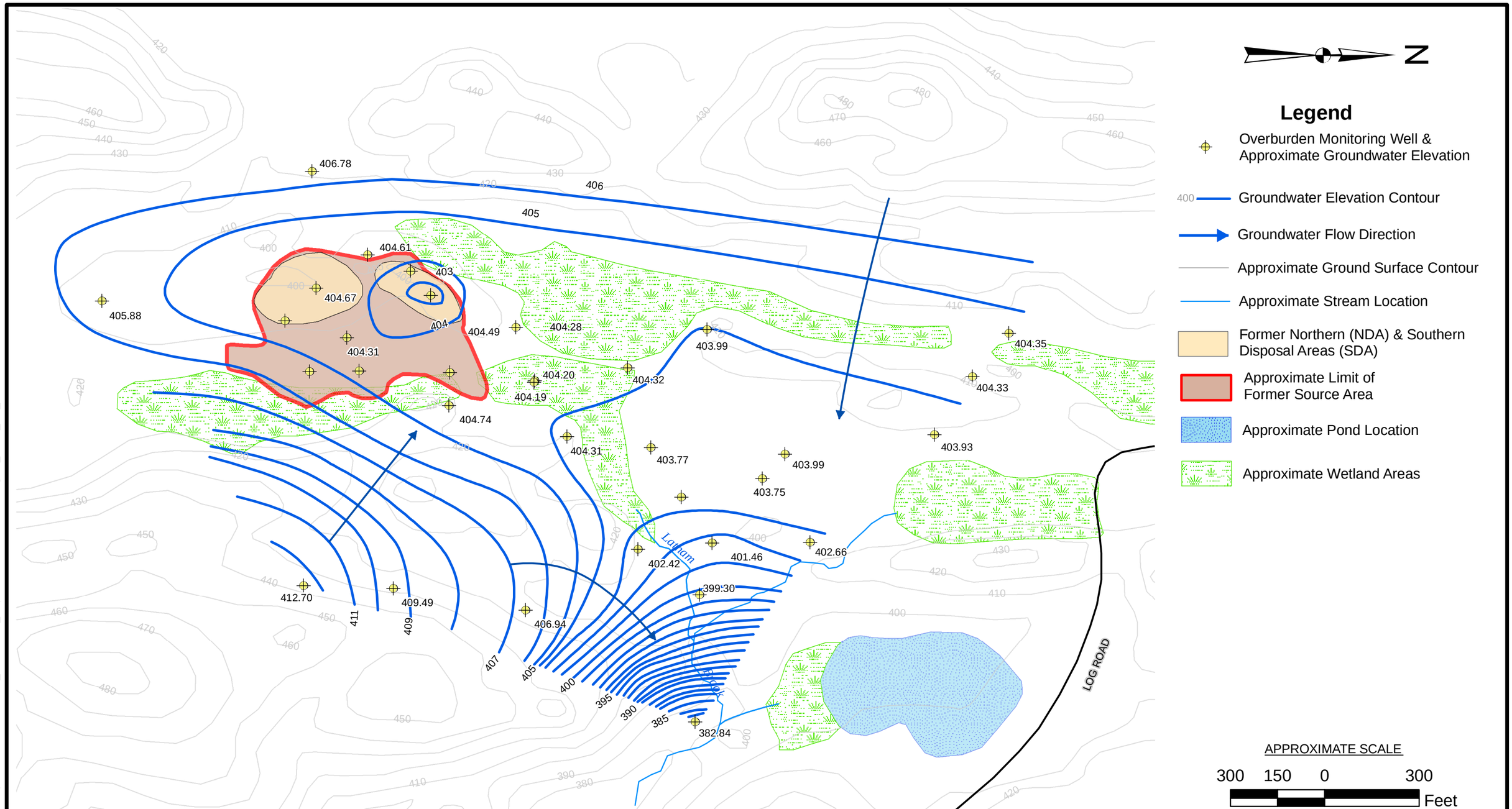

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Well Locations based on ESS Phase IV Draft Supplemental Field Investigation Report (ESS, 2009).

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FIGURE 1-4

OVERBURDEN POTENTIOMETRIC CONTOUR MAP
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 06/02/09 Rev. 00

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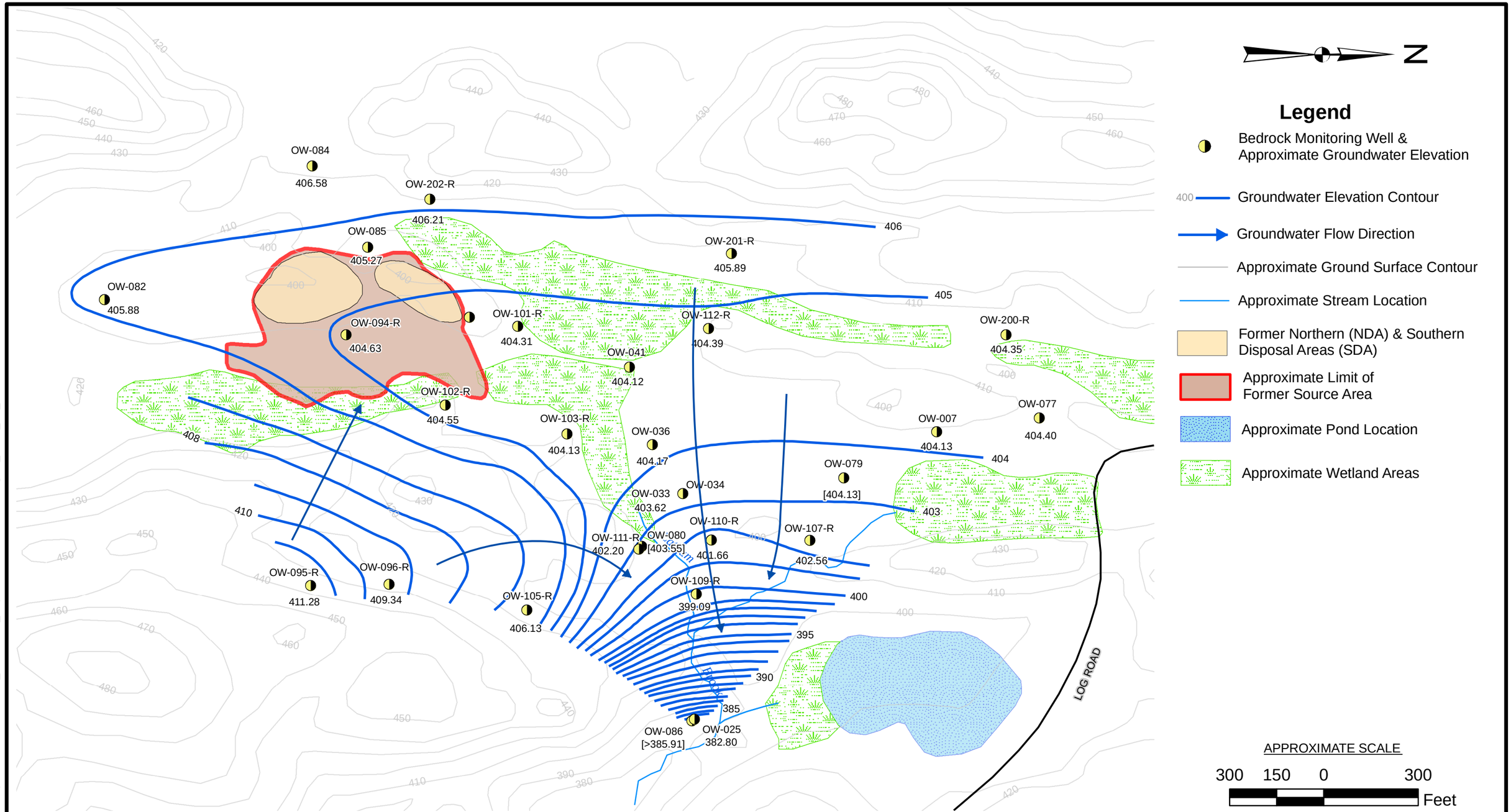

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Well Locations based on ESS Phase IV Draft Supplemental Field Investigation Report (ESS, 2009).

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FIGURE 1-5

BEDROCK POTENTIOMETRIC CONTOUR MAP
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 06/02/09 Rev. 00

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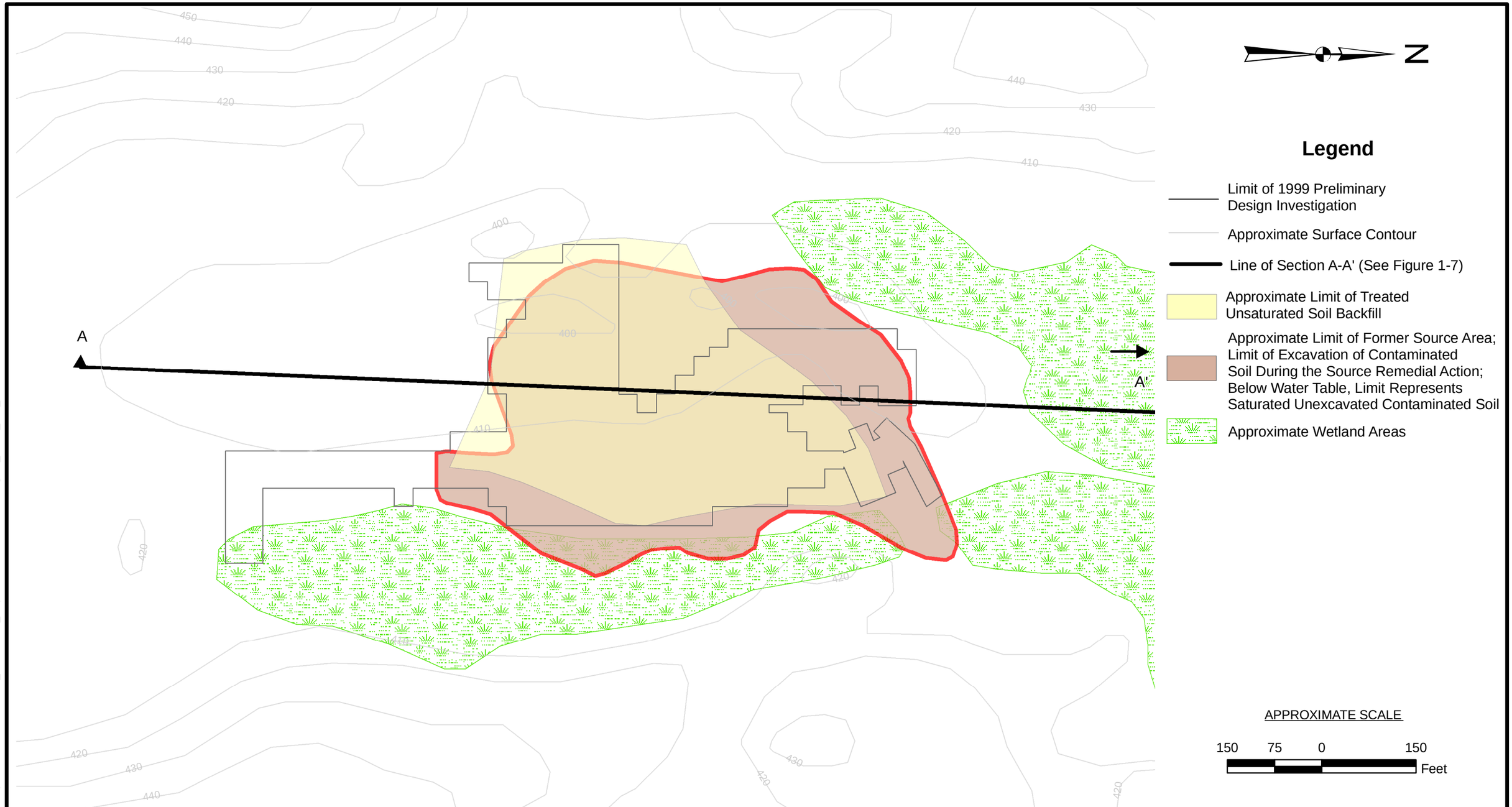

NOTES:
1. Surface contours based upon Round 6 Report (ESS, 2007).
2. Limit of Preliminary Design Investigation, excavation, and treated soil deposition are based upon Remedial Action Report (LEA, 2001).
3. The unsaturated unexcavated soil area include on-site areas not located within the excavation limit or limit of treated soil deposition.

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FIGURE 1-6

CURRENT AREAS OF SOIL CONTAMINATION
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 09/28/09 Rev 00

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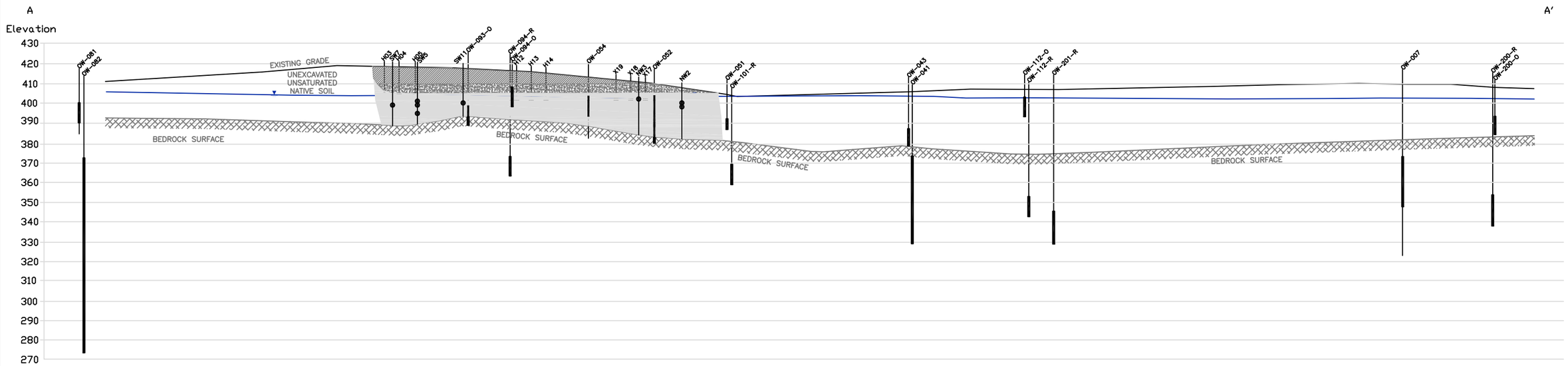

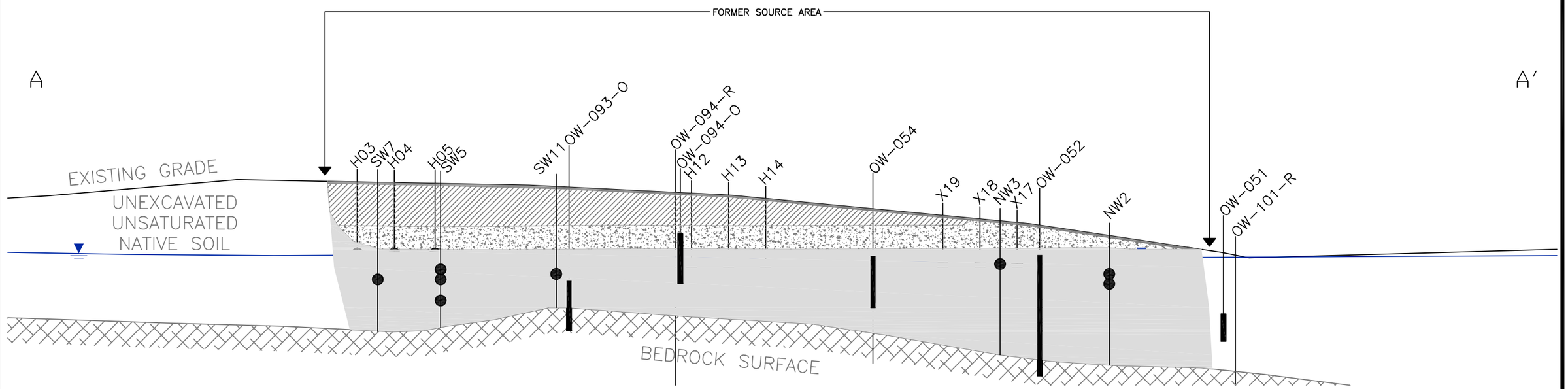

LEGEND

- CONTAMINATED SATURATED UNEXCAVATED SOIL
- TREATED UNSATURATED SOIL BACKFILL
- EXCAVATED SOIL; BACKFILLED WITH CLEAN SAND BACKFILL
- GROUNDWATER SURFACE ELEVATION
- MONITORING WELL AND SCREENED INTERVAL
- SOIL BORING LOCATION DEPICTING DEEPEST SOIL SAMPLE LOCATION

APPROXIMATE SCALE

0' 40' 80' 160'

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FIGURE 1-7

POST-EXCAVATION CROSS SECTION
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DRAWN BY:	DFM	APPROVED BY:	LC
PROJECT:	80028.00	09/29/09	

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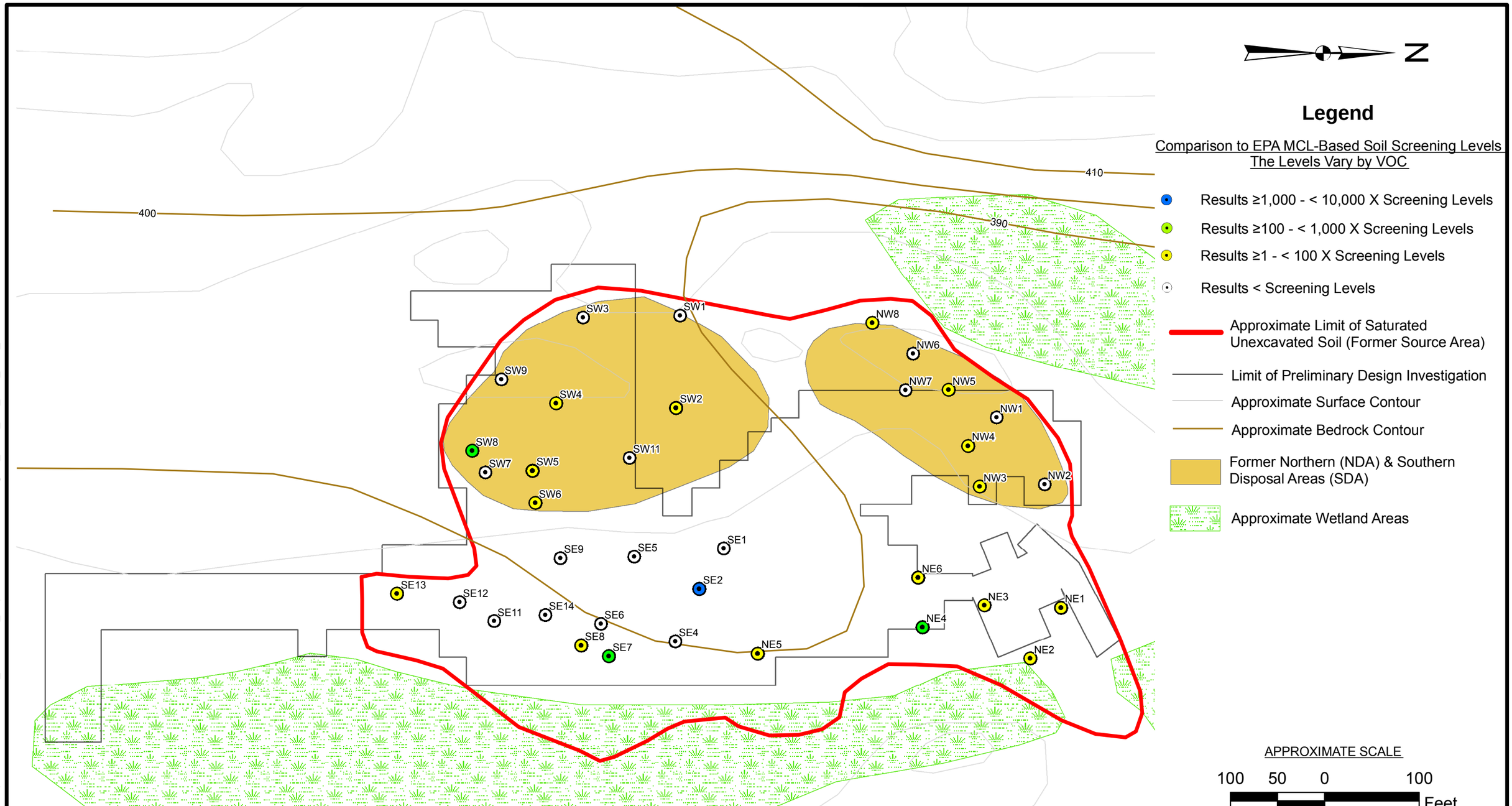

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of Preliminary Design Investigation, excavation, and disposal areas are based on Remedial Action Report (LEA, 2001).
3. Data presented include only VOC data collected by ESS in Fall 2008 for saturated soil.
4. Where more than one result exists for one location, the concentration yielding the greatest difference to screening levels is depicted.
5. EPA MCL-Based Soil Screening Levels from EPA Regional Screening Levels (2009) as presented in http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

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FIGURE 1-8

SOIL VOCs LEACHING SCREENING
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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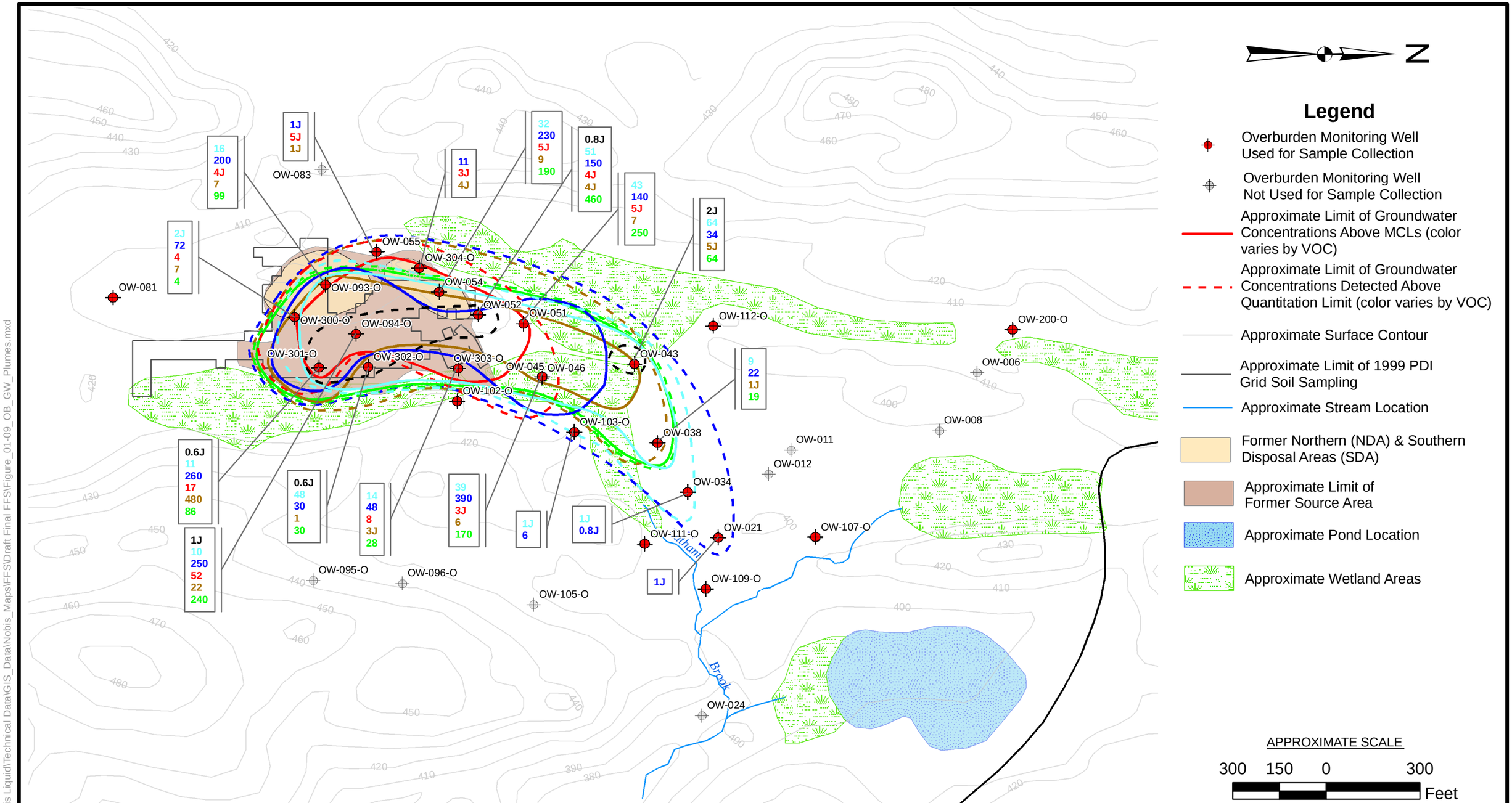

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. VOC concentration interpretations based on groundwater data collected during ESS' Phase 4 monitoring event in October 2008 (ESS, 2009).
4. 1,1-Dichloroethane does not have an MCL value. EPA Regional Screening Concentration for the Tapwater Scenario of 2.4 ug/L was used for screening. Maximum Contaminant Level (MCL) and Regional Screening Level (RSL) values obtained from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Substance	MCL	RSL
Benzene	5	0.41
1,1-Dichloroethane	--	2.4
cis-1,2-Dichloroethene	70	370
Tetrachloroethene	5	0.11
Tichloroehtene	5	1.7
Vinyl Chloride	2	0.016

VOC Data Color Scheme
All data in ug/L

11 Benzene
32 1,1-Dichloroethane
230 cis-1,2-Dichloroethene
5J Tetrachloroethene
9 Trichloroethene
190 Vinyl Chloride

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FIGURE 1-9

EXTENT OF 2008 VOCs IN OVERBURDEN GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028 | DATE: 09/29/09 Rev. 00

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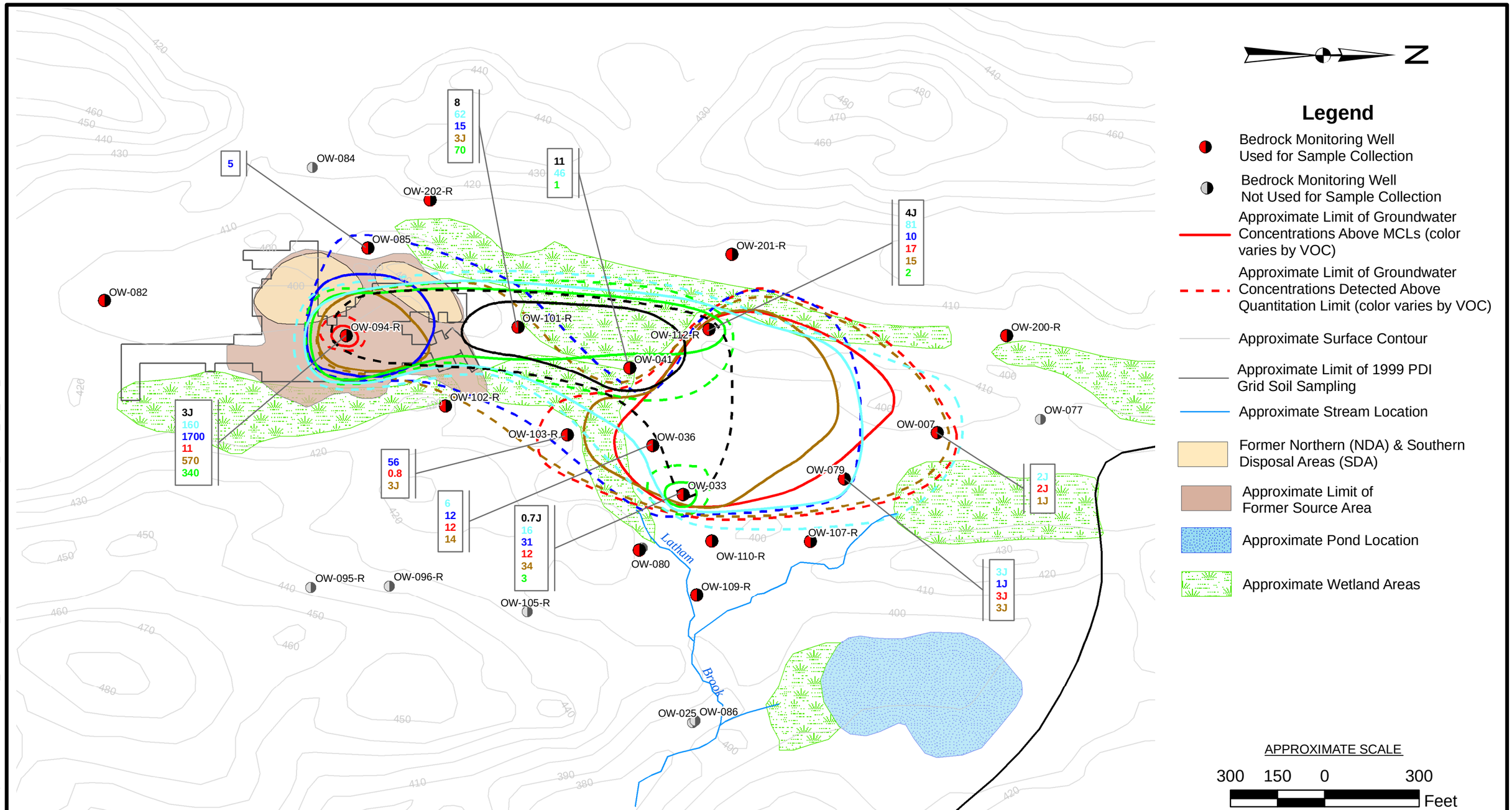

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. VOC concentration interpretations based on groundwater data collected during ESS' Phase 4 monitoring event in October 2008 (ESS, 2009).
4. 1,1-Dichloroethane does not have an MCL value. EPA Regional Screening Concentration for the Tapwater Scenario of 2.4 ug/L was used for screening. Maximum Contaminant Level (MCL) and Regional Screening Level (RSL) values obtained from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Substance	MCL	RSL
Benzene	5	0.41
1,1-Dichloroethane	--	2.4
cis-1,2-Dichloroethene	70	370
Tetrachloroethene	5	0.11
Tichloroehtene	5	1.7
Vinyl Chloride	2	0.016

VOC Data Color Scheme
All data in ug/L

11	Benzene
32	1,1-Dichloroethane
230	cis-1,2-Dichloroethene
5J	Tetrachloroethene
9	Trichloroethene
190	Vinyl Chloride

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FIGURE 1-10

EXTENT OF 2008 VOCs IN BEDROCK GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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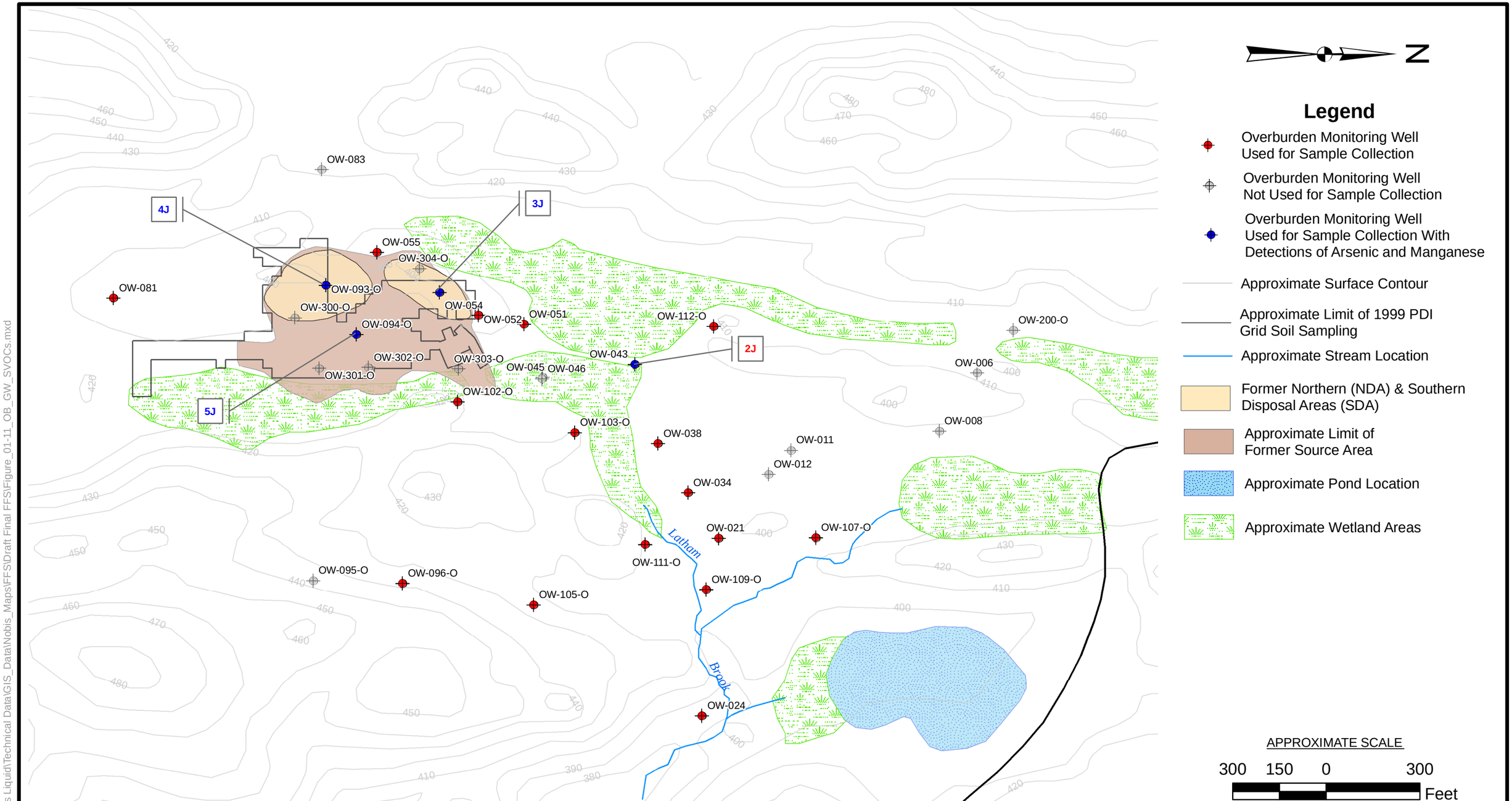

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. SVOC data obtained from Spring 2003 round of groundwater sampling.
4. Regional Screening Levels (RSL) obtained from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Substance	MCL	RSL
bis(2-Chloroethyl)ether	--	0.012
Naphthalene	--	0.14

SVOCs Data Color Scheme
All data in ug/L

25 bis(2-Chloroethyl)ether
6J Naphthalene

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FIGURE 1-11

EXTENT OF SPRING 2003 SVOCS IN OVERBURDEN GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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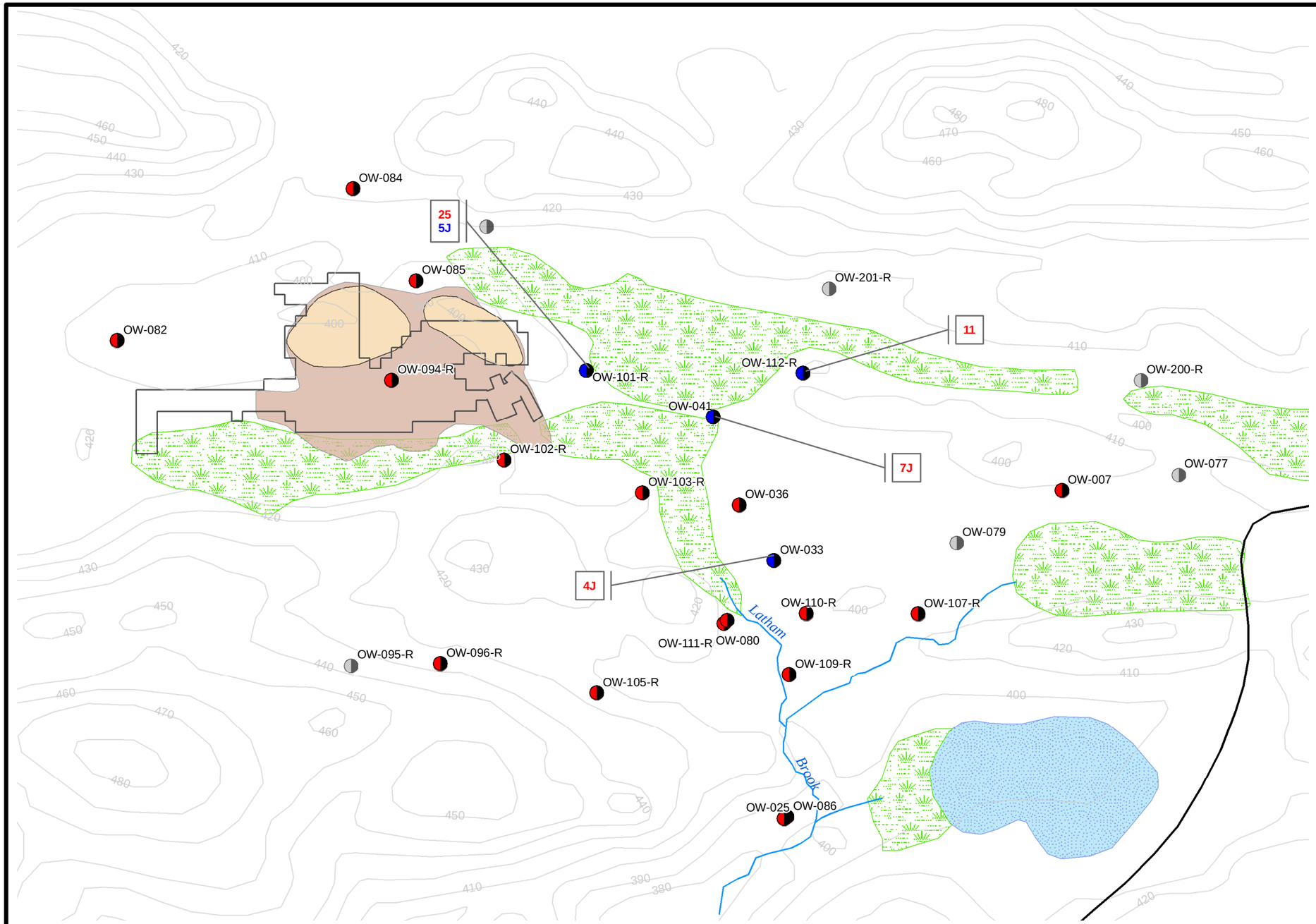

Legend

- Overburden Monitoring Well Used for Sample Collection
- Overburden Monitoring Well Not Used for Sample Collection
- Overburden Monitoring Well Used for Sample Collection With Detections of Arsenic and Manganese
- Approximate Surface Contour
- Approximate Limit of 1999 PDI Grid Soil Sampling
- Approximate Stream Location
- Former Northern (NDA) & Southern Disposal Areas (SDA)
- Approximate Limit of Former Source Area
- Approximate Pond Location
- Approximate Wetland Areas

APPROXIMATE SCALE

300 150 0 300

Feet

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. SVOC data obtained from Spring 2003 round of groundwater sampling.
4. Regional Screening Levels (RSL) obtained from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Substance	MCL	RSL
bis(2-Chloroethyl)ether	--	0.012
Naphthalene	--	0.14

SVOCs Data Color Scheme
All data in ug/L

25 bis(2-Chloroethyl)ether
6J Naphthalene

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FIGURE 1-12

EXTENT OF SPRING 2003 SVOCS IN BEDROCK GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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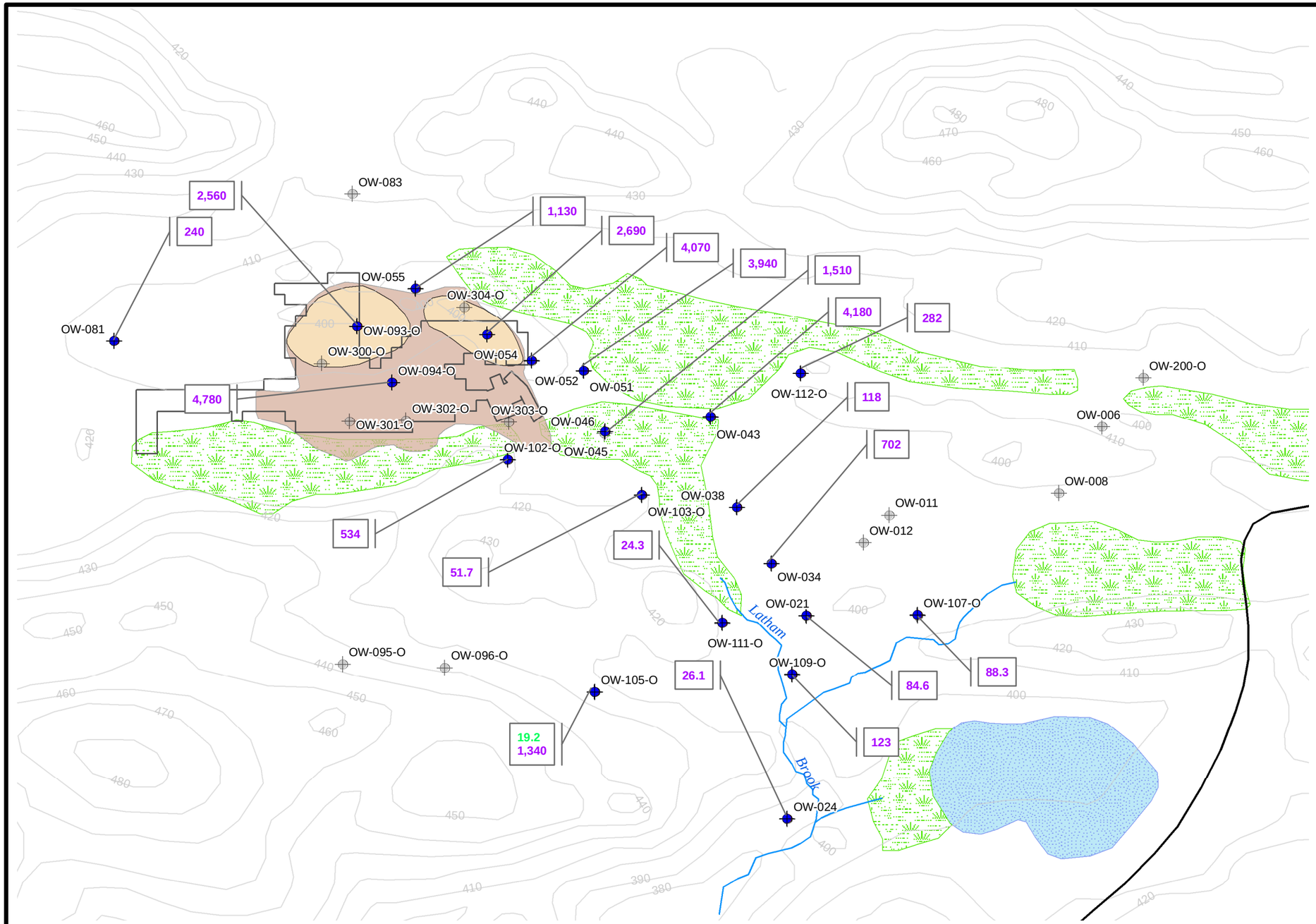

Legend

- Overburden Monitoring Well Used for Sample Collection
- Overburden Monitoring Well Not Used for Sample Collection
- Overburden Monitoring Well Used for Sample Collection With Detections of Arsenic and Manganese
- Approximate Surface Contour
- Approximate Limit of 1999 PDI Grid Soil Sampling
- Approximate Stream Location
- Former Northern (NDA) & Southern Disposal Areas (SDA)
- Approximate Limit of Former Source Area
- Approximate Pond Location
- Approximate Wetland Areas

APPROXIMATE SCALE

300 150 0 300 Feet

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Arsenic and manganese data obtained from Fall 2004 round of groundwater sampling.
4. Maximum Contaminant Limit (MCL) and Regional Screening Level (RSL) values obtained from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
5. MCL value cited for Manganese is a secondary drinking water value, not a primary MCL.

Substance	MCL	RSL
Arsenic	10	0.045
Manganese	50	880

Metals Data Color Scheme
All data in ug/L

19.2 Arsenic
1,340 Manganese

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FIGURE 1-13

EXTENT OF FALL 2004 METALS IN OVERBURDEN GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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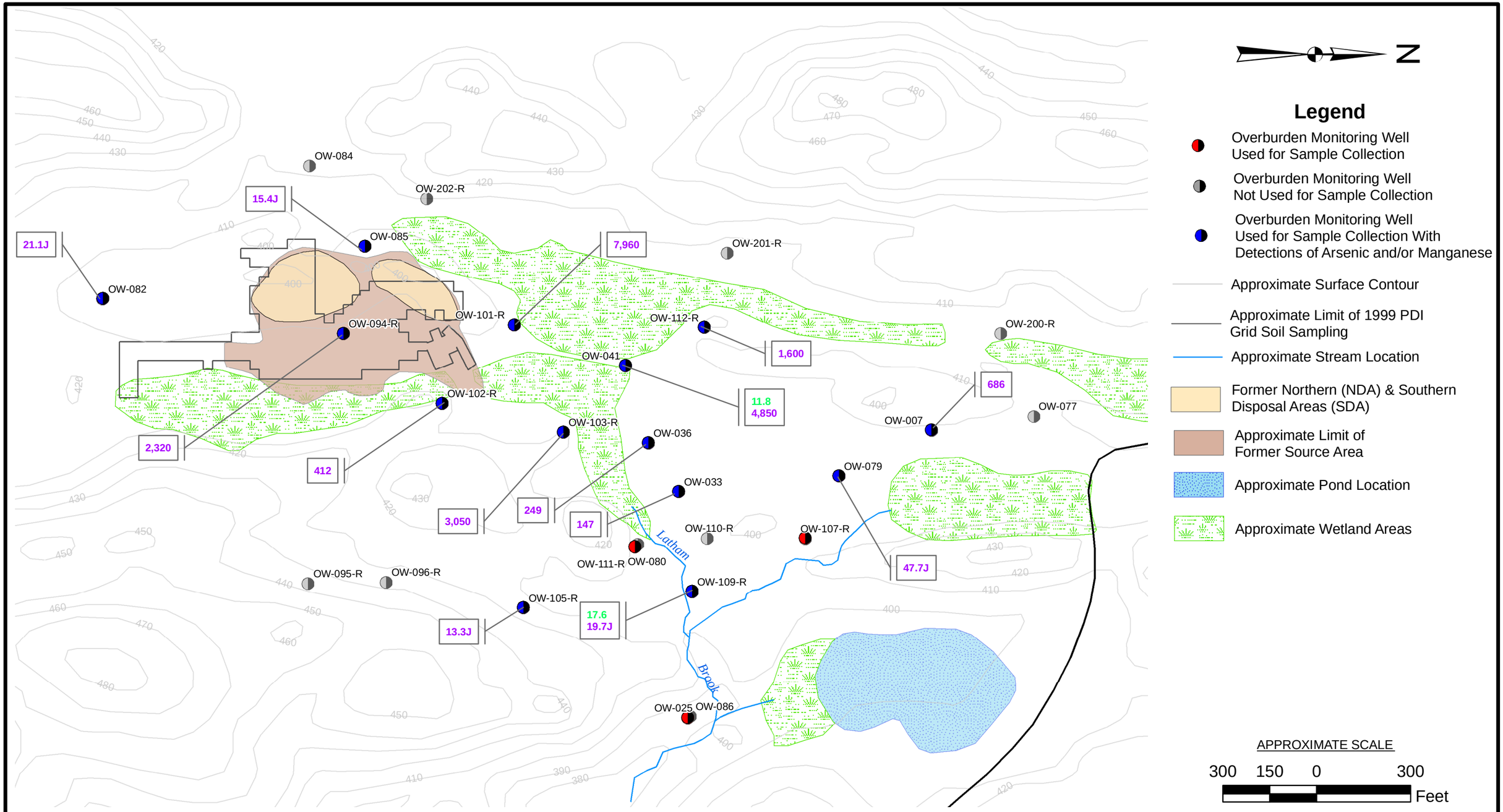

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Arsenic and manganese data obtained from Fall 2004 round of groundwater sampling.
4. Maximum Contaminant Limit (MCL) and Regional Screening Level (RSL) values obtained from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
5. MCL value cited for Manganese is a secondary drinking water value, not a primary MCL.

Substance	MCL	RSL
Arsenic	10	0.045
Manganese	50	880

Metals Data Color Scheme
All data in ug/L

19.2 Arsenic
1,340 Manganese

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FIGURE 1-14

EXTENT OF FALL 2004 METALS IN BEDROCK GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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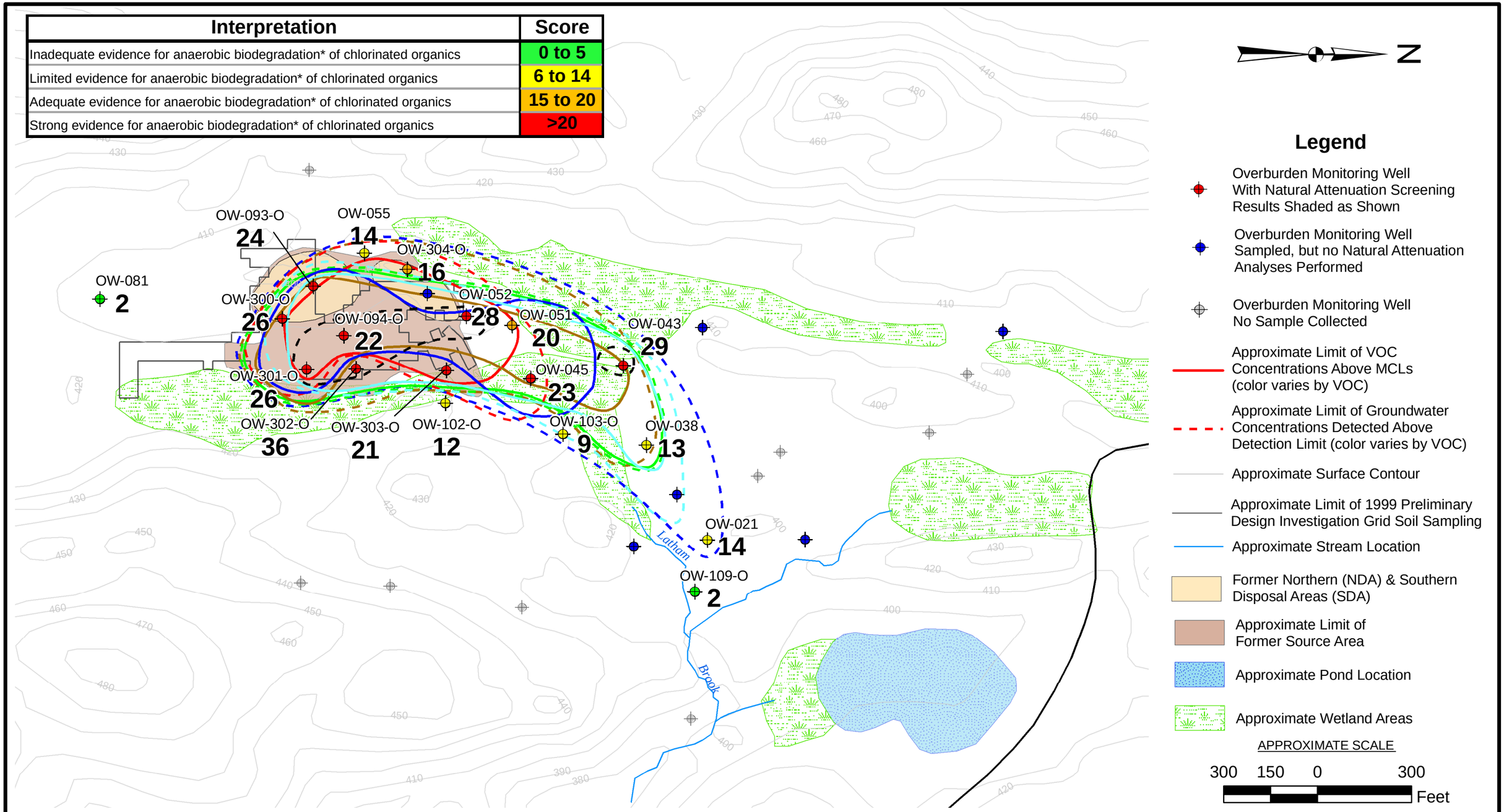
Interpretation	Score
Inadequate evidence for anaerobic biodegradation* of chlorinated organics	0 to 5
Limited evidence for anaerobic biodegradation* of chlorinated organics	6 to 14
Adequate evidence for anaerobic biodegradation* of chlorinated organics	15 to 20
Strong evidence for anaerobic biodegradation* of chlorinated organics	>20



NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based upon Remedial Action Report (LEA, 2001).
3. Natural attenuation screening scores based on data from Phase IV Supplemental Field Investigation Program (Fall 2008) (ESS, 2009).
4. Natural attenuation screening performed using the EPA BIOCHLOR Natural Attenuation Screening Protocol
5. No listed MNA Screening values indicates that no MNA parameters were collected
6. * = Biodegradation by reductive dechloination.

VOC Color Scheme
- Benzene
- 1,1-Dichloroethane
- cis-1,2-Dichloroethene
- Tetrachloroethene
- Trichloroethene
- Vinyl chloride

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FIGURE 1-15

NATURAL ATTENUATION SCREENING FOR OVERBURDEN GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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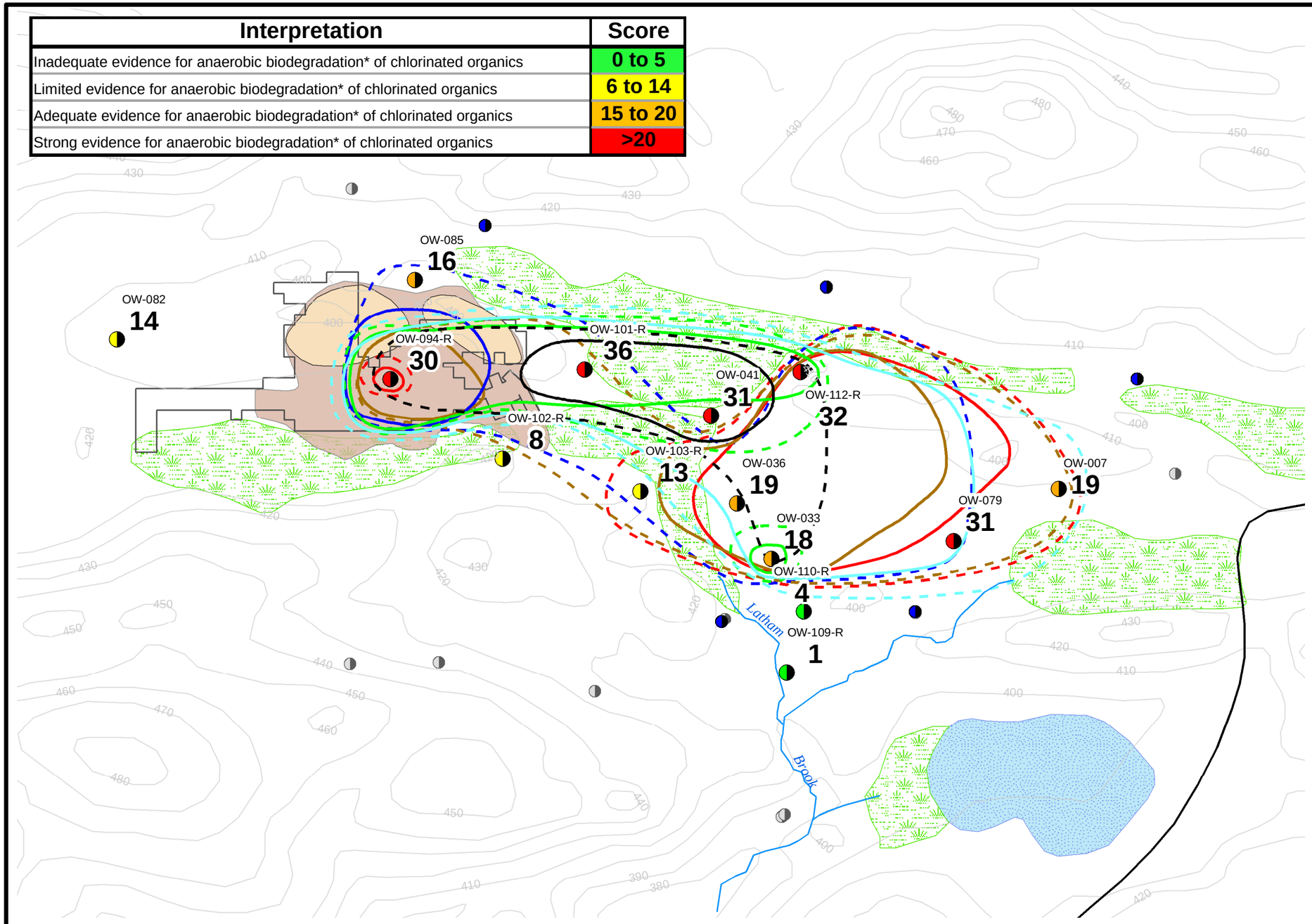
Interpretation	Score
Inadequate evidence for anaerobic biodegradation* of chlorinated organics	0 to 5
Limited evidence for anaerobic biodegradation* of chlorinated organics	6 to 14
Adequate evidence for anaerobic biodegradation* of chlorinated organics	15 to 20
Strong evidence for anaerobic biodegradation* of chlorinated organics	>20



Legend

- Bedrock Monitoring Well With Natural Attenuation Screening Results Shaded as Shown
- Bedrock Monitoring Well Sampled, but no Natural Attenuation Analyses Performed
- Bedrock Monitoring Well No Sample Collected
- Approximate Limit of VOC Concentrations Above MCLs (color varies by VOC)
- Approximate Limit of Groundwater Concentrations Detected Above Detection Limit (color varies by VOC)
- Approximate Surface Contour
- Approximate Limit of 1999 Preliminary Design Investigation Grid Soil Sampling
- Approximate Stream Location
- Former Northern (NDA) & Southern Disposal Areas (SDA)
- Approximate Limit of Former Source Area
- Approximate Pond Location
- Approximate Wetland Areas

APPROXIMATE SCALE

300 150 0 300 Feet

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based upon Remedial Action Report (LEA, 2001).
3. Natural attenuation screening scores based on data from Phase IV Supplemental Field Investigation Program (Fall 2008) (ESS, 2009).
4. Natural attenuation screening performed using the EPA BIOCHLOR Natural Attenuation Screening Protocol
5. No listed MNA Screening values indicates that no MNA parameters were collected
6. * = Biodegradation by reductive dechloination.

VOC Color Scheme
- Benzene
- 1,1-Dichloroethane
- cis-1,2-Dichloroethene
- Tetrachloroethene
- Trichloroethene
- Vinyl chloride

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FIGURE 1-16

NATURAL ATTENUATION SCREENING FOR BEDROCK GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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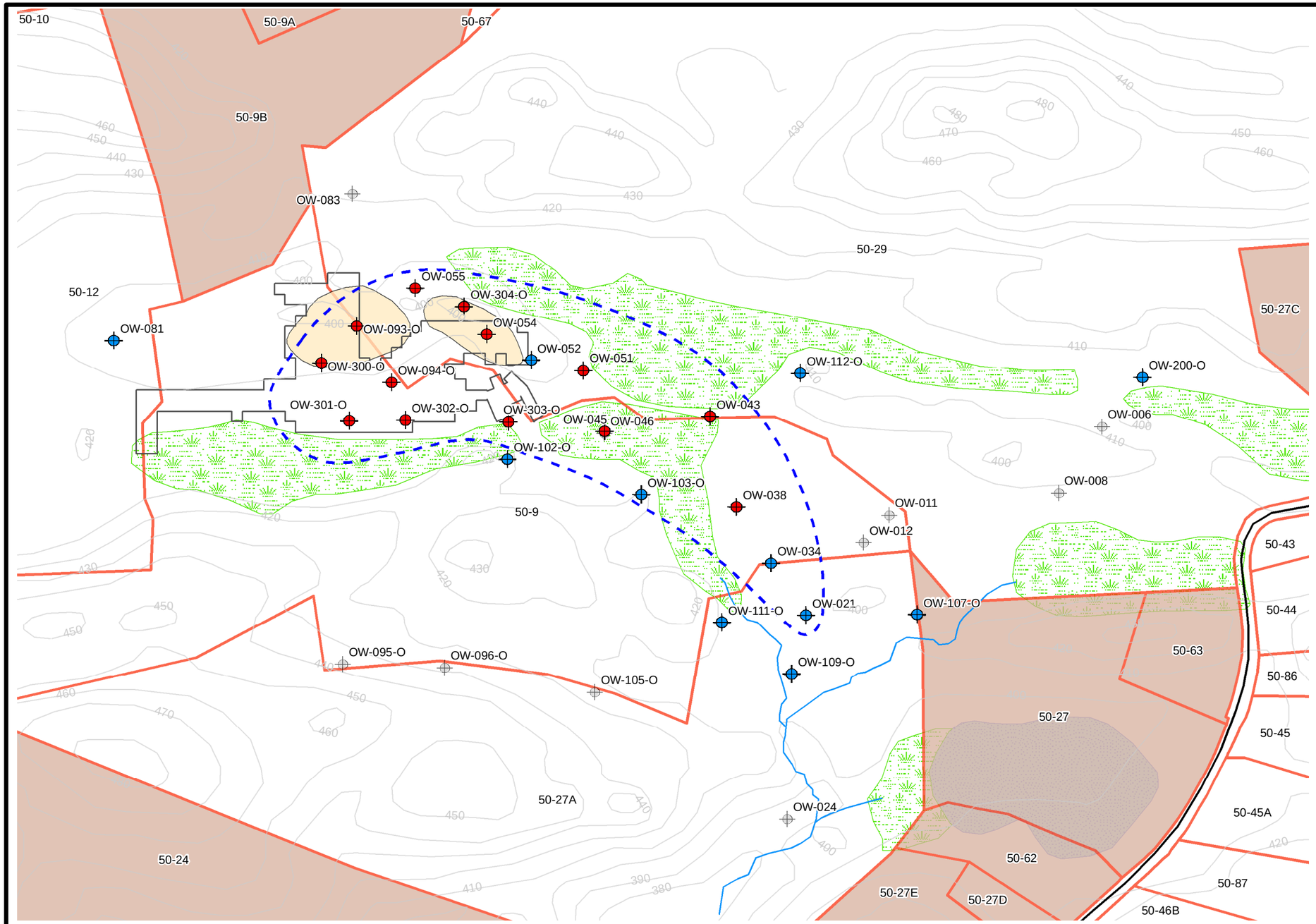

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Legend

- VOC Results Exceed EPA Vapor Intrusion Screening Guidance Values (2002)
- Sample Collected; but results do not exceed EPA VI Screening Guidance Values (2002)
- Overburden Monitoring Well Not Used for Sample Collection
- Approximate Limit of Groundwater Concentrations Detected Above Detection Limit
- Approximate Surface Contour
- Approximate Limit of Ensafe Grid Soil Sampling
- Approximate Stream Location
- Former Northern & Southern Disposal Areas
- Parcel Containing Residences
- Approximate Pond Location
- Approximate Wetland Areas

APPROXIMATE SCALE

300 150 0 300 Feet

NOTES:
1. Surface contours based upon Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based upon Remedial Action Report (LEA, 2001).
3. VOC concentration interpretations based on groundwater data collected during ESS' Phase IV monitoring event in October 2008.

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FIGURE 1-17

OVERBURDEN GROUNDWATER VAPOR INTRUSION SCREENING
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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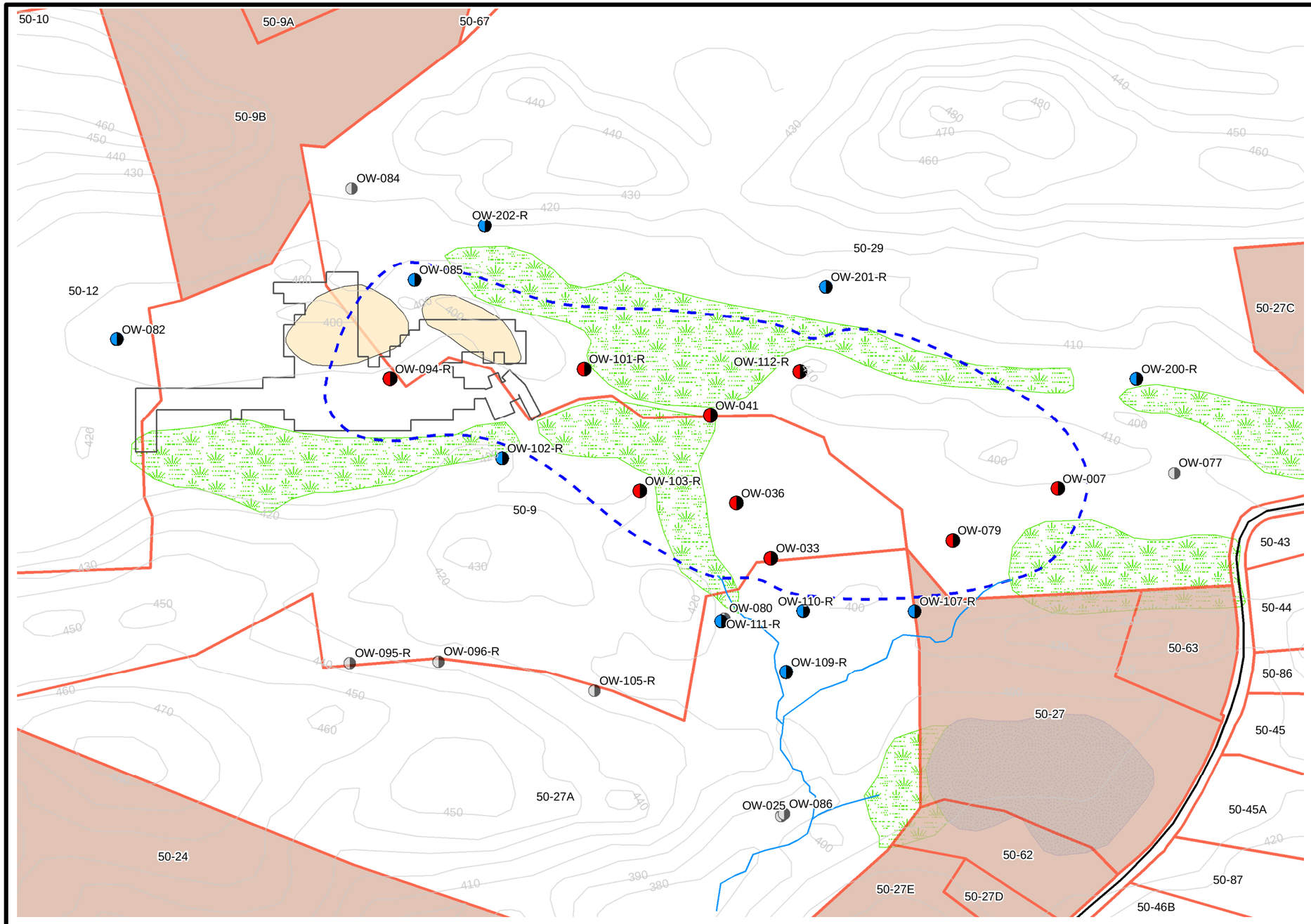

N

Legend

- VOC Results Exceed EPA Vapor Intrusion Screening Guidance Values (2002)
- Sample Collected; but results do not exceed EPA VI Screening Guidance Values (2002)
- Bedrock Monitoring Well Not Used for Sample Collection
- Approximate Limit of Groundwater Concentrations Detected Above Detection Limit
- Approximate Surface Contour
- Approximate Limit of Ensafe Grid Soil Sampling
- Approximate Stream Location
- Former Northern & Southern Disposal Areas
- Parcel Containing Residences
- Approximate Pond Location
- Approximate Wetland Areas

APPROXIMATE SCALE

300 150 0 300 Feet

NOTES:
1. Surface contours based upon Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based upon Remedial Action Report (LEA, 2001).
3. VOC concentration interpretations based on groundwater data collected during ESS' Phase IV monitoring event in October 2008.

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FIGURE 1-18

BEDROCK GROUNDWATER VAPOR INTRUSION SCREENING
DAVIS LIQUID WASTE SITE
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PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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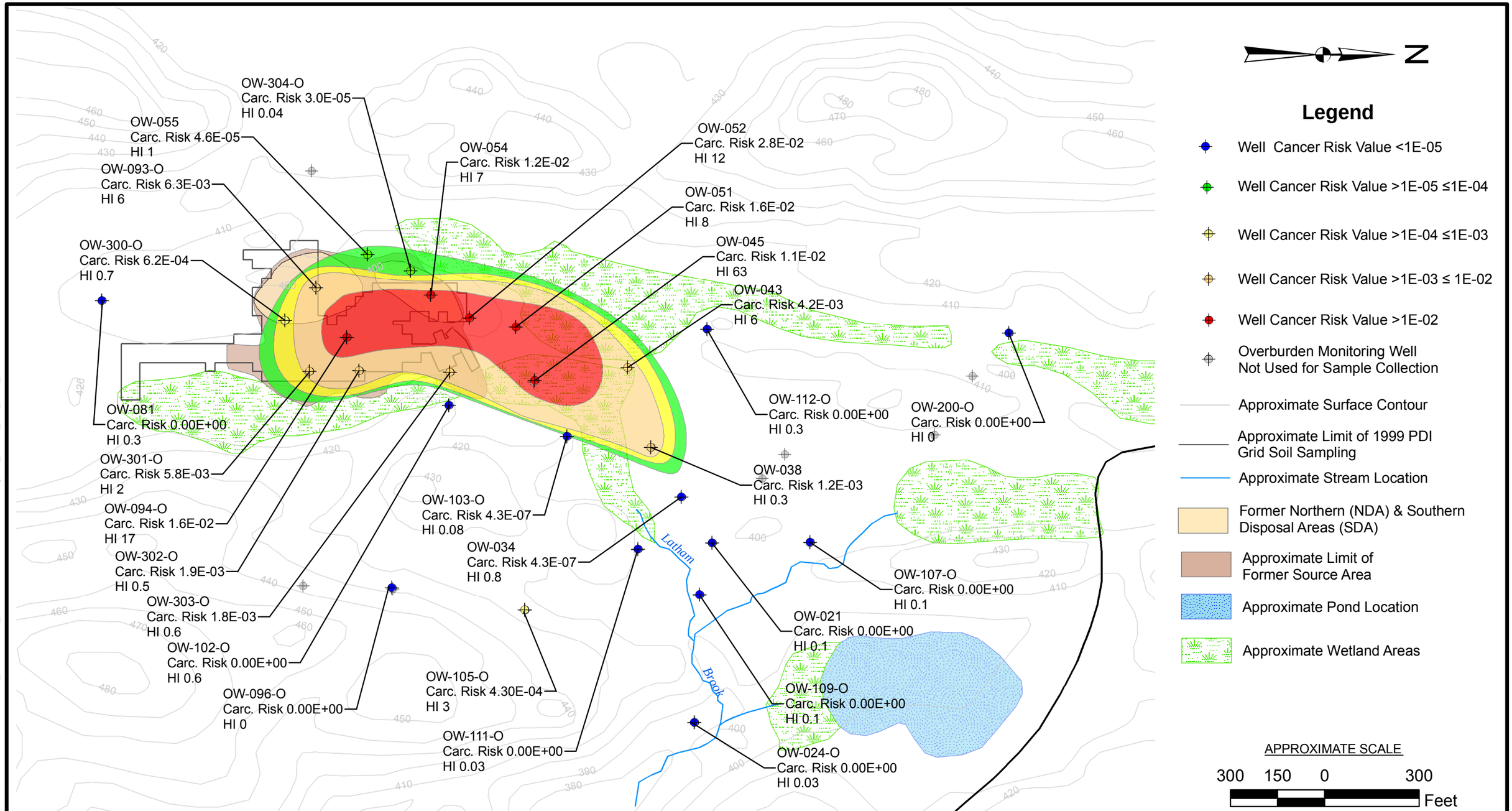

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Risk calculations performed using EPA Regional Screening Levels; Tapwater Scenario Obtained from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
4. VOC concentration used in this evaluation based on groundwater data collected during ESS' Phase 4 monitoring event in October 2008 (ESS, 2009).
5. SVOC data used in this evaluation collected during ESS' Phase II monitoring event in June 2003 (ESS, 2004).
6. Metals data used in this evaluation collected during ESS' Phase II monitoring event in October 2004 (ESS, 2005).

Estimated Cancer Risk Value

- >1E-02 Cancer Risk
- >1E-03 - ≤1E-02 Cancer Risk
- >1E-04 - ≤1E-03 Cancer Risk
- >1E-05 ≤1E-04 Cancer Risk

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FIGURE 1-19

DISTRIBUTION OF ESTIMATED CANCER RISKS IN OVERBURDEN GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

PREPARED BY: DFM	CHECKED BY: LC
PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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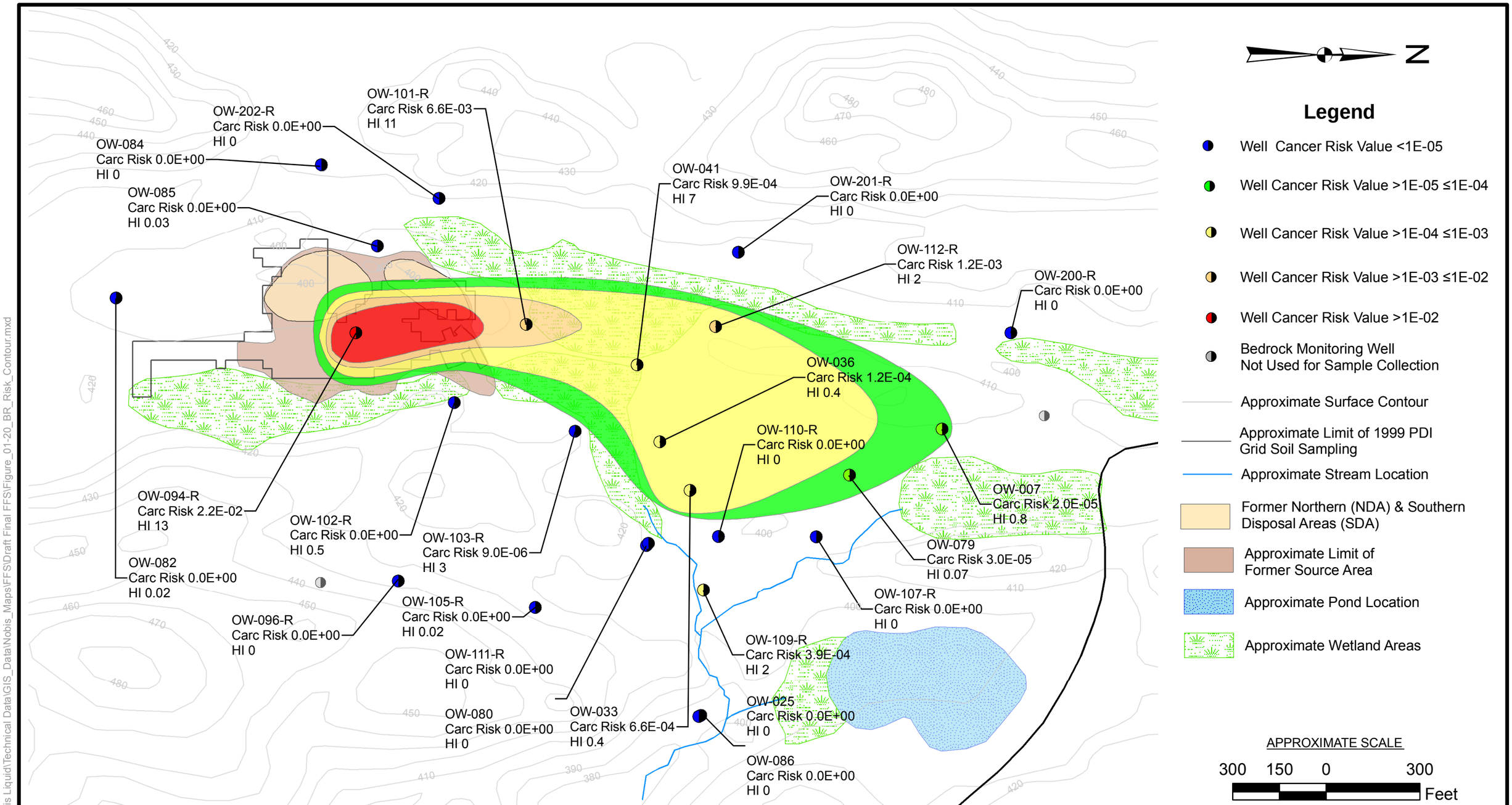

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Risk calculations performed using EPA Regional Screening Levels; Tapwater Scenario Obtained from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
4. VOC concentration used in this evaluation based on groundwater data collected during ESS' Phase 4 monitoring event in October 2008 (ESS, 2009).
5. SVOC data used in this evaluation collected during ESS' Phase II monitoring event in June 2003 (ESS, 2004).
6. Metals data used in this evaluation collected during ESS' Phase II monitoring event in October 2004 (ESS, 2005).

Estimated Cancer Risk Value

- >1E-02 Cancer Risk
- >1E-03 - ≤1E-02 Cancer Risk
- >1E-04 - ≤1E-03 Cancer Risk
- >1E-05 ≤1E-04 Cancer Risk

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FIGURE 1-20

DISTRIBUTION OF ESTIMATED CANCER RISKS IN BEDROCK GROUNDWATER
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

PREPARED BY: DFM	CHECKED BY: LC
PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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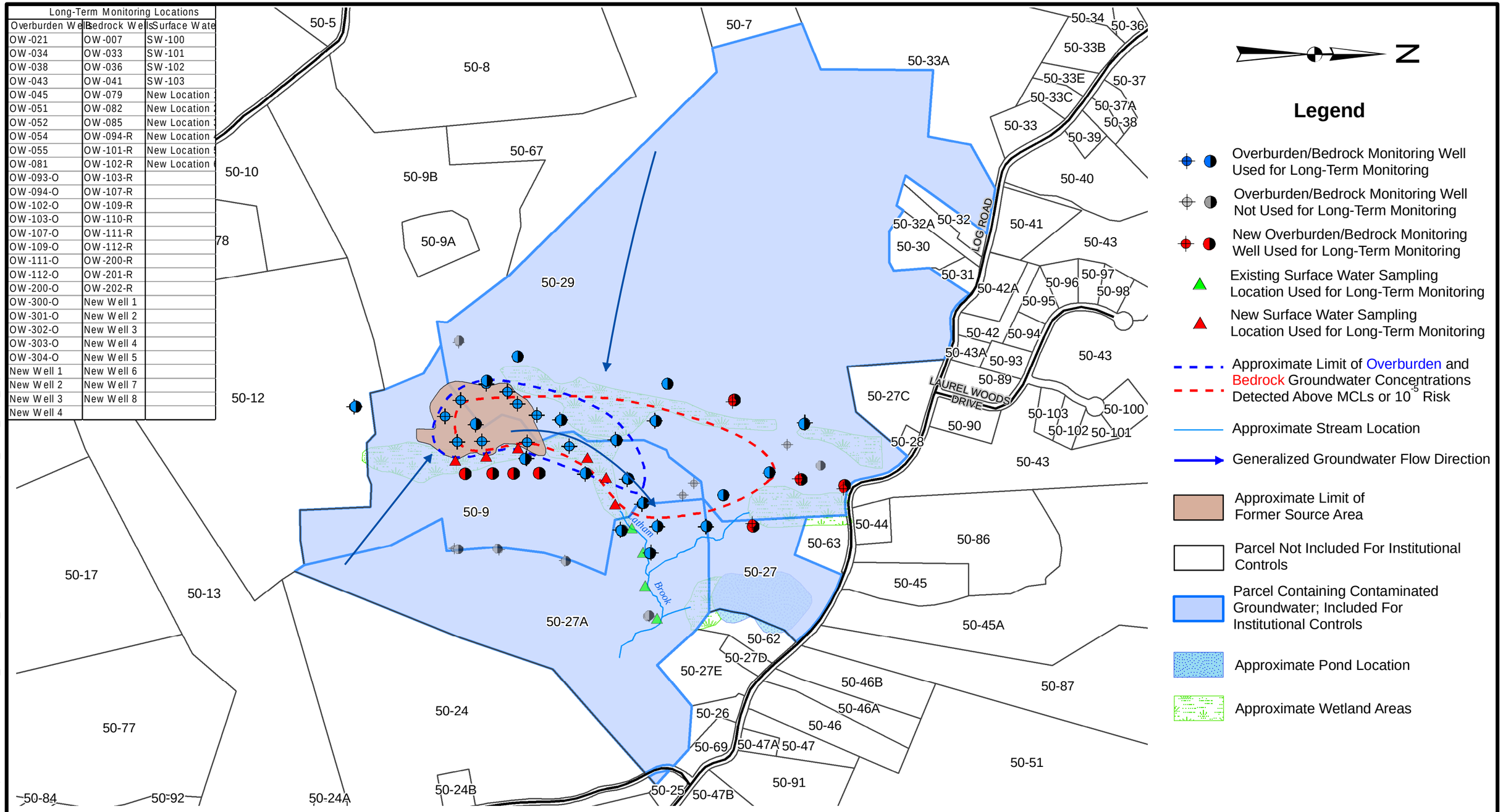
Long-Term Monitoring Locations		
Overburden Well	Bedrock Well	Surface Wate
OW-021	OW-007	SW-100
OW-034	OW-033	SW-101
OW-038	OW-036	SW-102
OW-043	OW-041	SW-103
OW-045	OW-079	New Location
OW-051	OW-082	New Location
OW-052	OW-085	New Location
OW-054	OW-094-R	New Location
OW-055	OW-101-R	New Location
OW-081	OW-102-R	New Location
OW-093-O	OW-103-R	
OW-094-O	OW-107-R	
OW-102-O	OW-109-R	
OW-103-O	OW-110-R	
OW-107-O	OW-111-R	
OW-109-O	OW-112-R	
OW-111-O	OW-200-R	
OW-112-O	OW-201-R	
OW-200-O	OW-202-R	
OW-300-O	New Well 1	
OW-301-O	New Well 2	
OW-302-O	New Well 3	
OW-303-O	New Well 4	
OW-304-O	New Well 5	
New Well 1	New Well 6	
New Well 2	New Well 7	
New Well 3	New Well 8	
New Well 4		



APPROXIMATE SCALE

600 300 0 600 Feet

NOTES:
1. Limit of disposal areas are based upon Remedial Action Report (LEA, 2001).
2. Tax Assessor's map lot lines were obtained from the Smithfield Tax Assessor's Office.

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FIGURE 4-1

LAYOUT OF GROUNDWATER ALTERNATIVE GW2
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

PREPARED BY: DFM	CHECKED BY: LC
PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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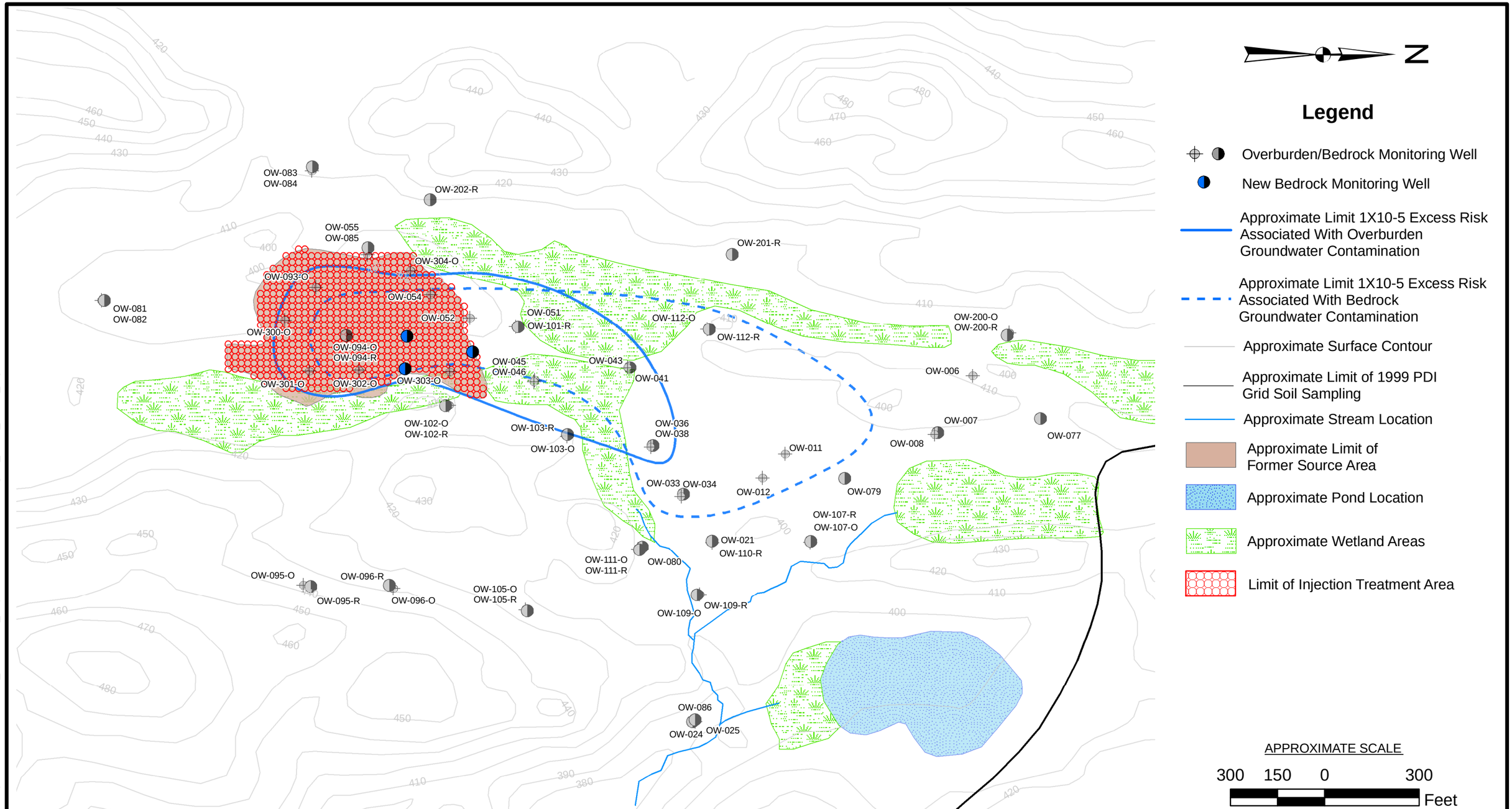

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Risk calculations performed using EPA Regional Screening Levels; Tapwater Scenario Obtained from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.html
4. VOC concentration used in this evaluation based on groundwater data collected during ESS' Phase 4 monitoring event in October 2008.

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FIGURE 4-2

LAYOUT OF GROUNDWATER ALTERNATIVE GW3A
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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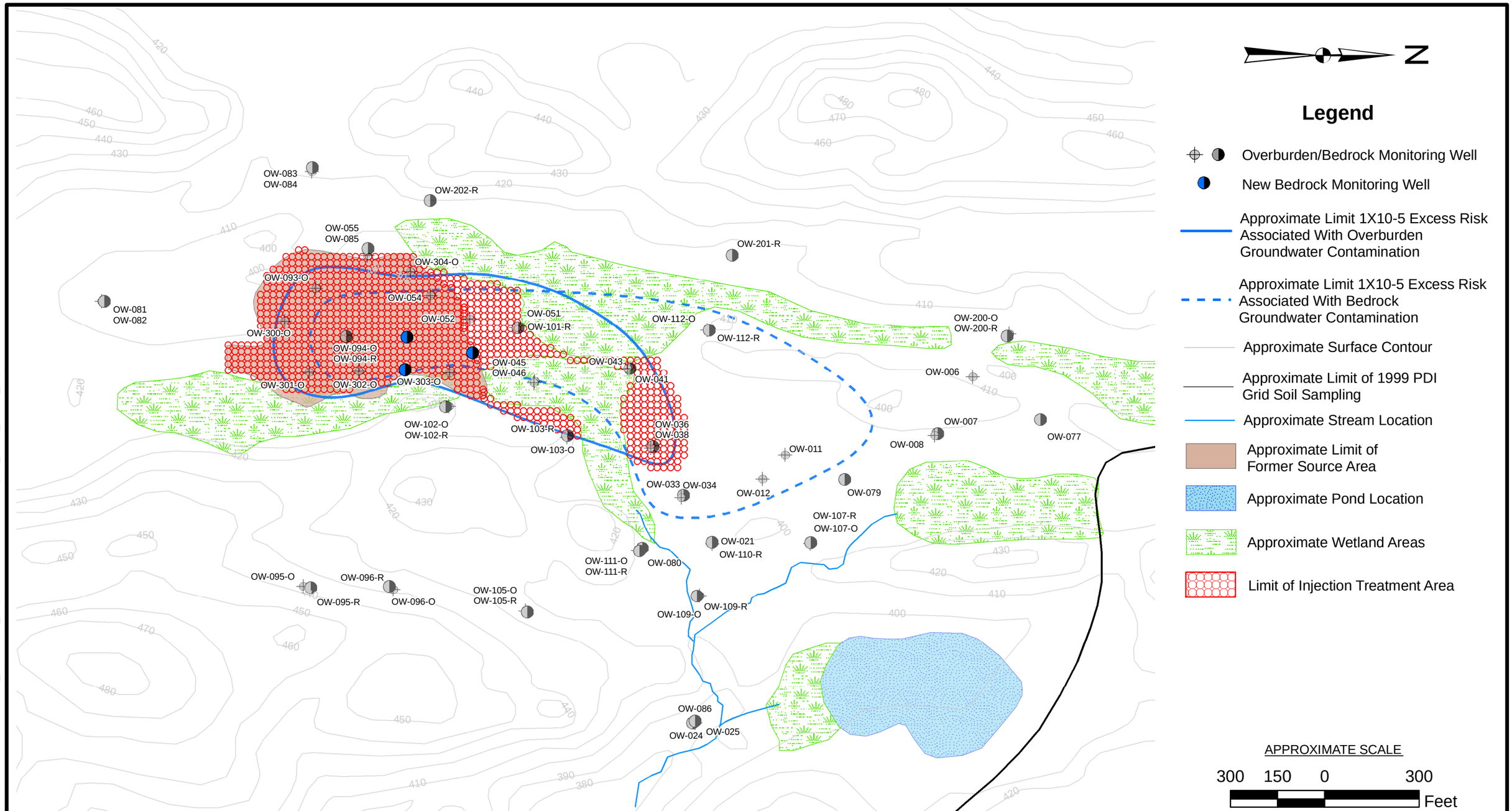

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Risk calculations performed using EPA Regional Screening Levels; Tapwater Scenario Obtained from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.html
4. VOC concentration used in this evaluation based on groundwater data collected during ESS' Phase 4 monitoring event in October 2008.

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FIGURE 4-3

LAYOUT OF GROUNDWATER ALTERNATIVE GW3B
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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PROJECT NO. 80028	DATE: 09/29/09 Rev. 00

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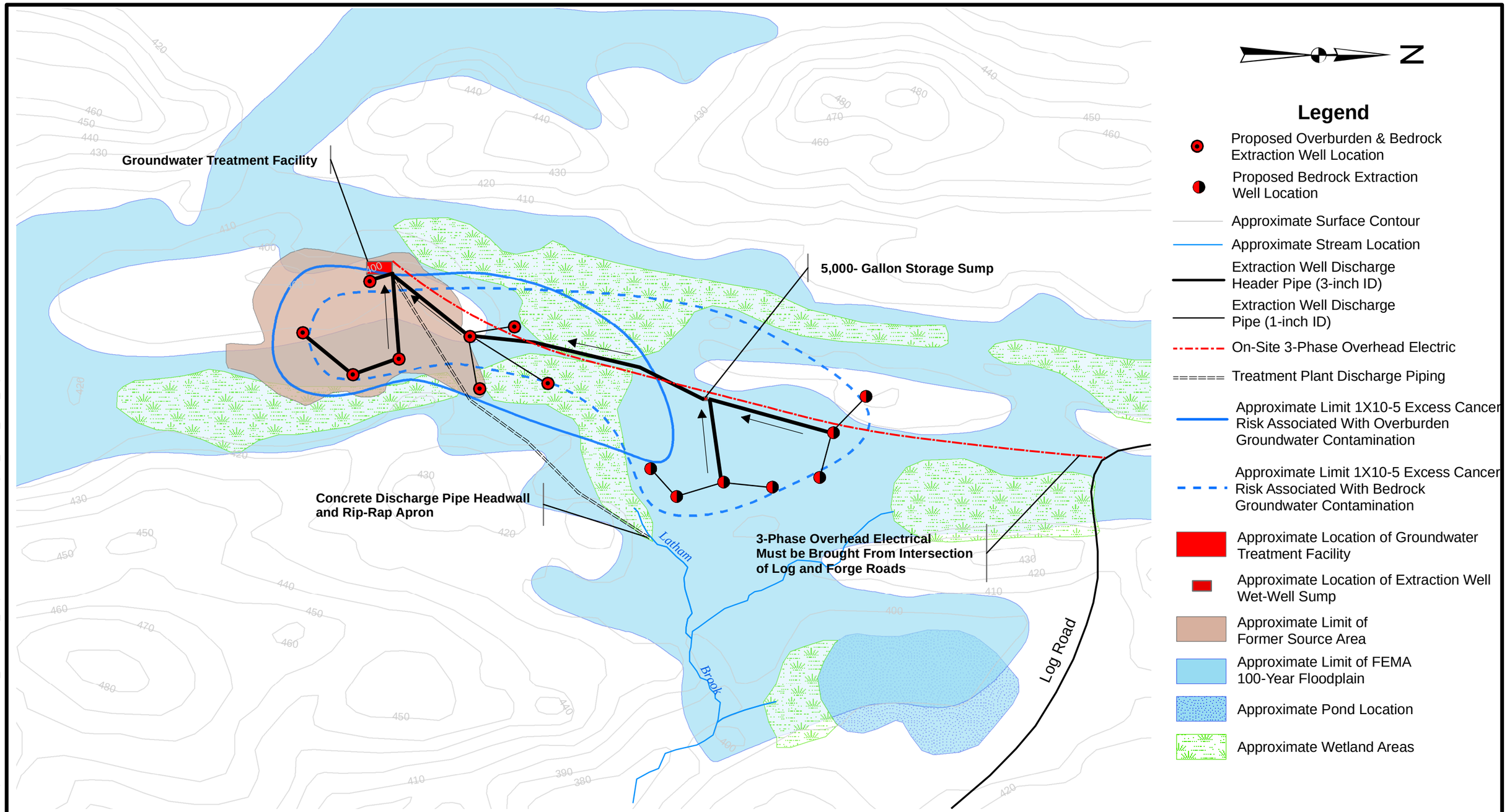

APPROXIMATE SCALE

300 150 0 300 Feet

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2007).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).

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FIGURE 4-4

LAYOUT OF GROUNDWATER ALTERNATIVE GW-4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

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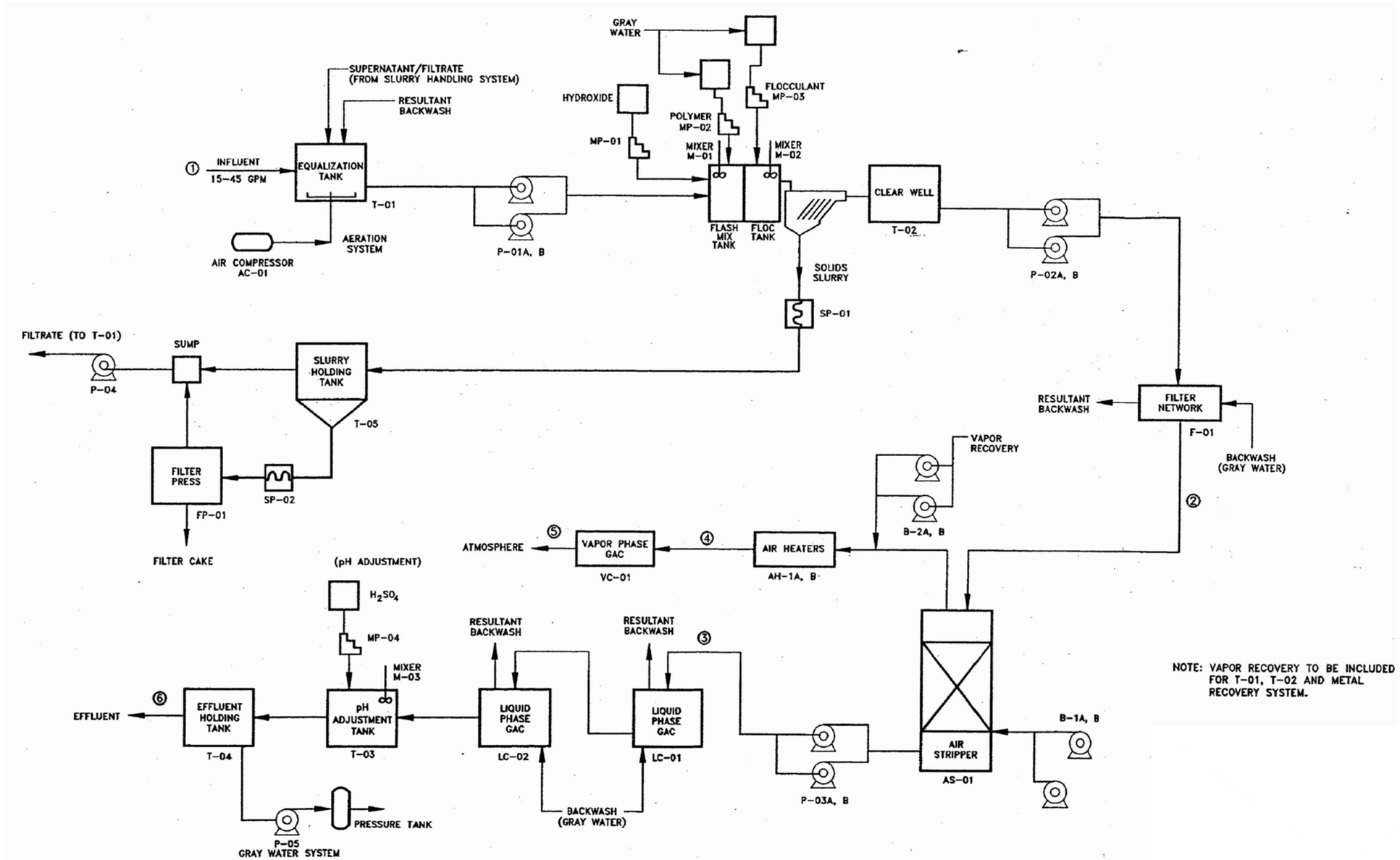

Notes:
1. Schematic obtained from Appendix L, Figure L-7, *Final Criteria Summary Report; Perform Predesign Investigation and Develop Design Criteria at Davis Liquid Waste Superfund Site; Smithfield, RI. Ebasco, 1994.*

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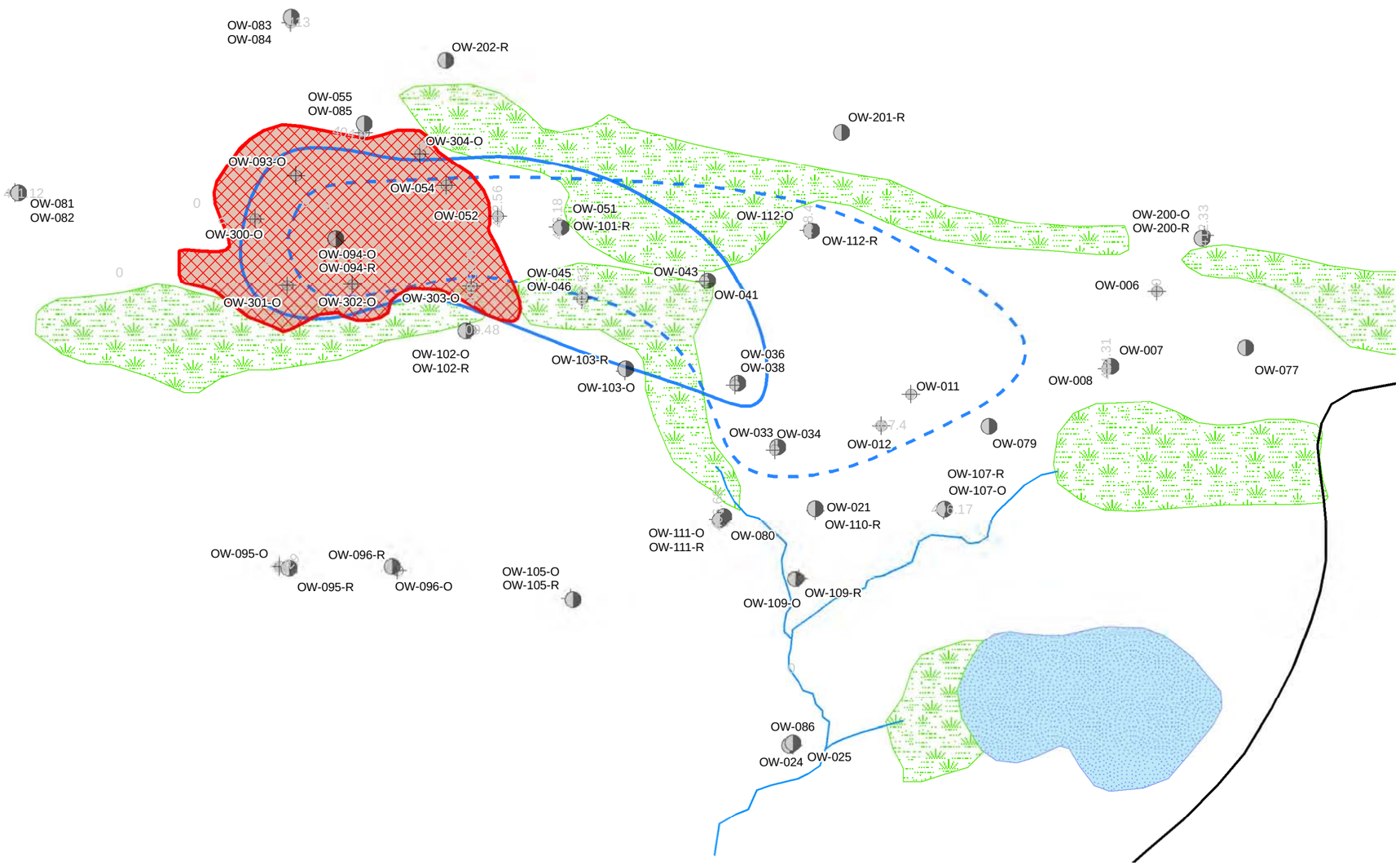
FIGURE 4-5

PROCESS FLOW SCHEMATIC
ALTERNATIVE GW4

DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DRAWN BY:	DFM	APPROVED BY:	LC
PROJECT:	80028.00		09/29/09



Legend

- Overburden/Bedrock Monitoring Well
- Approximate Limit 1X10-5 Excess Risk Associated With Overburden Groundwater Contamination
- Approximate Limit 1X10-5 Excess Risk Associated With Bedrock Groundwater Contamination
- Approximate Surface Contour
- Approximate Limit of 1999 PDI Grid Soil Sampling
- Approximate Stream Location
- Approximate Limit of ERH Thermal Treatment
- Approximate Limit of Former Source Area
- Approximate Pond Location
- Approximate Wetland Areas

APPROXIMATE SCALE

300 150 0 300

Feet

NOTES:
1. Surface contours based on Round 6 Report (ESS, 2006).
2. Limit of disposal areas are based on Remedial Action Report (LEA, 2001).
3. Risk calculations performed using EPA Regional Screening Levels; Tapwater Scenario Obtained from:
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.html
4. Data presented include only VOC data collected by ESS in Fall 2008.
5. Where more than one result exists for one location, the concentration yielding the greatest difference to screening levels is depicted.
6. EPA MCL-Based Soil Screening Levels from EPA Regional Screening Levels (Sept. 2008) as presented in
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

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Lowell, MA 01851
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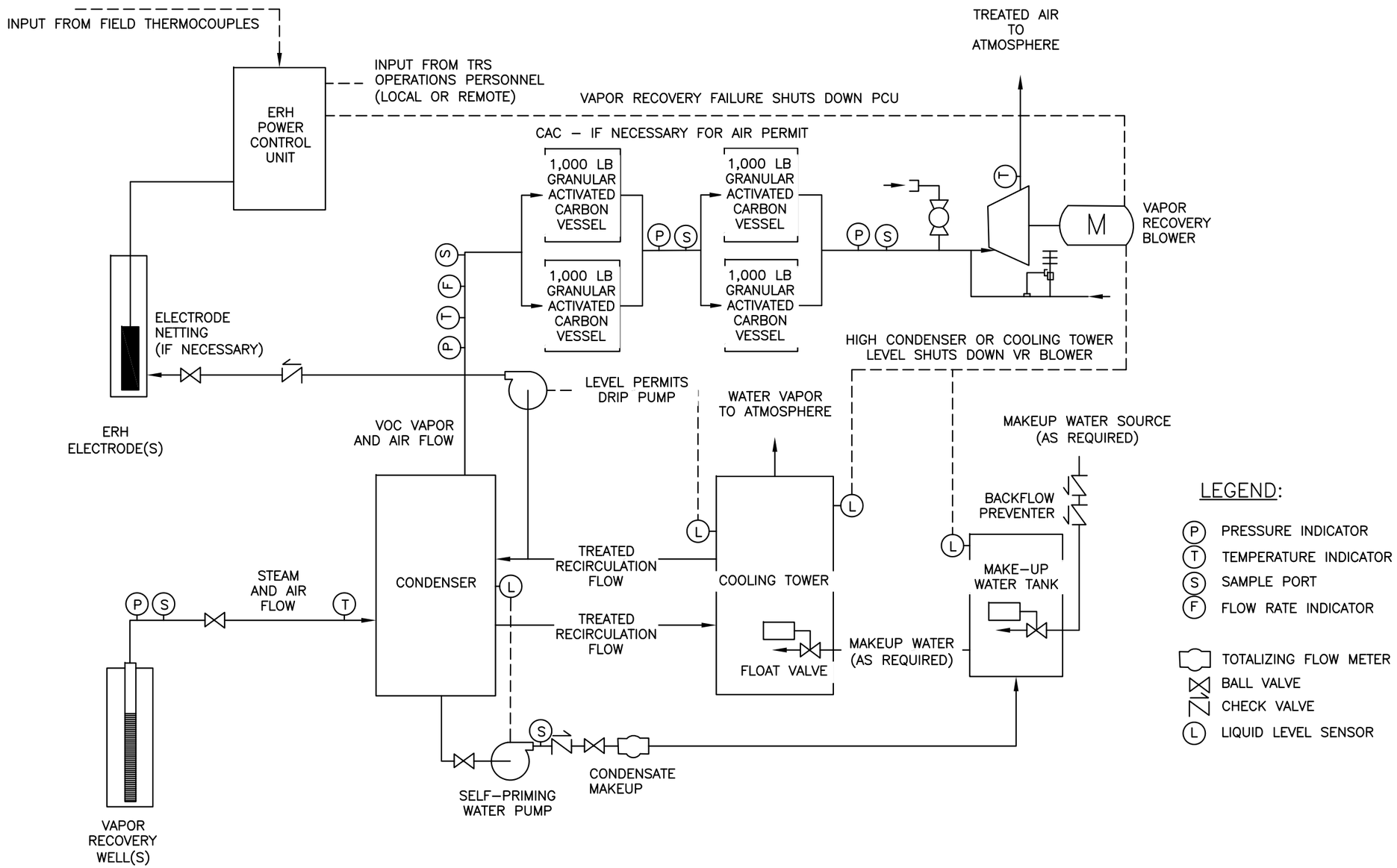
FIGURE 4-6

LAYOUT OF GROUNDWATER ALTERNATIVE GW5
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

PREPARED BY: DFM	CHECKED BY: LC
PROJECT NO. 80028	DATE: 02/04/10 Rev. 01

R:\80000 Task Orders\80028 Davis Liquid\Technical Data\GIS_Data\Nobis_Maps\FFS\Final FFS\Figure_04-06_GW5_Layout.mxd



Notes:
1. Schematic is a generalization; specific modificationsmay be required to address site-specific issues identified during remedial design.
2. Schematic obtained from Powell, T. et al. *New Advancements for In Situ Treatment Using Electrical Resistance Heating* from the Spring 2007 edition of Remediation.

Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
Tel (978) 683-0891
Fax (978) 683-0966
www.nobisengineering.com

FIGURE 4–7

PROCESS FLOW SCHEMATIC
ALTERNATIVE GW5

DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DRAWN BY:	DFM	APPROVED BY:	LC
PROJECT:	80028.00		09/29/09

APPENDIX A

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Appendix A
Natural Attenuation Screening Protocol Scores by Well
Davis Liquid Waste Superfund Site
Smithfield, RI

Screening Points Awarded

Analysis	Concentration in Most Contaminated Zone	Interpretation	Value	OW-007	OW-021	OW-033	OW-034	OW-036	OW-038	OW-041	OW-043	OW-045	OW-051	OW-052	OW-054	OW-055	OW-079	OW-081	OW-082	OW-085	OW-093	OW-094	OW-94-R	OW-101-R
Oxygen*	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	3	3	3	0	3	3	3	3	3	0	0	0	3	3	0	3	3	3	3	0	0
	> 5mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	0	0	0	0	0	0
Nitrate*	<1 mg/L	At higher concentrations may compete with reductive pathway	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Iron II*	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)-reducing conditions	3	0	3	0	0	0	0	0	0	0	3	3	3	0	0	0	0	0	3	3	0	3
Sulfate*	<20 mg/L	At higher concentrations may compete with reductive pathway	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2
Sulfide*	>1 mg/L	Reductive pathway possible	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane*	<0.5 mg/L	VC Oxidizes	0	0	0	0	0	0	0	3	3	0	0	0	0	0	3	0	0	0	0	0	3	3
	>0.5 mg/L	Ultimate reductive daughter product, VC Accumulates	3																					
Oxidation Reduction Potential* (ORP)	<50 millivolts (mV)	Reductive pathway possible	1	1	1	0	1	1	0	1	1	1	0	1	1	0	1	0	1	1	0	0	1	1
	<-100mV	Reductive pathway likely	2	2	0	0	2	2	0	2	2	2	0	2	2	0	2	0	2	2	0	0	2	2
pH*	5 < pH < 9	Optimal range for reductive pathway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	0	0	0	0	0	0
	5 > pH >9	Outside of optimal range	-2																					
TOC	>20 mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature*	>20°C	At T >20°C biochemical process is accelerated	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alkalinity	>2x background	Results from interaction of carbon dioxide with aquifer minerals	1	1	1	1	0	1	0	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1
Chloride*	>2x background	Daughter product of organic chlorine	2	2	0	2	2	2	2	2	2	2	2	2	2	0	2	0	0	0	0	0	2	2
Hydrogen	>1 nM	Reductive pathway possible, VC may accumulate	3	0	0	0	0	0	0	0	0	0	0	3	3	3	0	3	3	3	3	3	0	3
Volatile Fatty Acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BTEX*	>0.1 mg/L	Carbon and energy source; drives dechlorination	2	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	2	2
PCE*		Material released	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCE*		Material released / Daughter product of PCE [a/]	0 / 2	2	0	2	0	2	2	2	2	2	2	2	2	2	2	0	0	0	2	2	2	2
DCE*		Material Released / Daughter product of TCE. If cis is greater than 80% of total DCE it is likely a daughter product of TCE[a/]; 1,1-DCE can be a chem. reaction product of TCA	0 / 2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	2	2	2	2	2
VC*		Material Released / Daughter product of DCE[a/]	0 / 2	0	0	2	0	0	2	2	2	2	2	2	2	0	2	0	0	0	2	2	2	2
1,1,1- Trichloroethane*		Material released	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DCA		Daughter product of TCA under reducing conditions	2	2	0	2	2	2	2	2	2	2	2	2	2	0	2	0	0	0	2	2	2	2
Carbon Tetrachloride		Material released	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chloroethane*		Daughter product of DCA or VC under reducing conditions	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	2	2
Ethene/Ethane	>0.01 mg/L	Daughter product of VC/ethene	2	0	0	0	0	0	0	2	2	2	2	2	2	0	2	0	0	0	2	2	2	2
	>0.1 mg/L	Daughter product of VC/ethene	3	0	0	0	0	0	0	3	3	0	0	0	0	0	3	0	0	0	0	0	3	3
Chloroform		Material released / Daughter product of Carbon Tetrachloride	0 / 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dichloromethane		Material released / Daughter product of Chloroform	0 / 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Natural Attenuation Screening Protocol Score		**19**	**14**	**18**	**13**	**19**	**17**	**31**	**29**	**23**	**20**	**28**	**28**	**14**	**31**	**2**	**14**	**16**	**24**	**22**	**30**	**36**

Notes:
* required analysis
a/ Points awarded only if it can be shown that the compound is a daughter product (i.e., not a constituent of the source NAPL)

Source: *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*, EPA/600/R-98/128, Office of Research and Development, September 1998.

Appendix A
Natural Attenuation Screening Protocol Scores by Well
Davis Liquid Waste Superfund Site
Smithfield, RI

Screening Points Awarded

Analysis	Concentration in Most Contaminated Zone	Interpretation	OW-102	OW-102-R	OW-103	OW-103-R	OW-109	OW-109-R	OW-110-R	OW-112-R	OW-300	OW-301	OW-302	OW-303	OW-304
Oxygen*	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	0	0	0	3	0	0	0	3	0	0	0	3	3
	> 5mg/L	Not tolerated; however, VC may be oxidized aerobically	0	0	0	0	-3	0	0	0	0	0	0	0	0
Nitrate*	<1 mg/L	At higher concentrations may compete with reductive pathway	2	2	2	0	2	0	0	0	2	2	2	2	2
Iron II*	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)-reducing conditions	3	0	0	0	0	0	0	0	3	3	3	0	3
Sulfate*	<20 mg/L	At higher concentrations may compete with reductive pathway	2	2	2	2	2	0	0	0	2	0	2	0	2
Sulfide*	>1 mg/L	Reductive pathway possible	0	0	0	0	0	0	0	0	0	0	3	0	0
Methane*	<0.5 mg/L	VC Oxidizes	3	0	0	0	0	0	0	3	3	3	3	3	0
	>0.5 mg/L	Ultimate reductive daughter product, VC Accumulates													
Oxidation Reduction Potential* (ORP)	<50 millivolts (mV)	Reductive pathway possible	1	1	0	1	0	0	1	1	1	0	1	0	1
	<-100mV	Reductive pathway likely	0	2	0	2	0	0	2	2	2	0	2	0	0
pH*	5 < pH < 9	Optimal range for reductive pathway	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 > pH >9	Outside of optimal range													
TOC	>20 mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	0	0	0	0	0	0	0	0	0	0	2	0	0
Temperature*	>20°C	At T >20°C biochemical process is accelerated	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	0	0	0	0	0	0	0	0	0	0	0	0	0
Alkalinity	>2x background	Results from interaction of carbon dioxide with aquifer minerals	1	1	1	1	1	1	1	1	1	1	1	1	1
Chloride*	>2x background	Daughter product of organic chlorine	0	0	0	0	0	0	0	2	2	2	2	2	0
Hydrogen	>1 nM	Reductive pathway possible, VC may accumulate	0	0	0	0	0	0	0	3	0	0	0	0	0
Volatile Fatty Acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	0	0	0	0	0	0	0	0	0	0	0	0	0
BTEX*	>0.1 mg/L	Carbon and energy source; drives dechlorination	0	0	0	0	0	0	0	0	2	0	0	0	0
PCE*		Material released	0	0	0	0	0	0	0	0	0	0	0	0	0
TCE*		Material released / Daughter product of PCE [a/]	0	0	0	2	0	0	0	2	2	2	2	2	2
DCE*		Material Released / Daughter product of TCE. If cis is greater than 80% of total DCE it is likely a daughter product of TCE[a/]; 1,1-DCE can be a chem. reaction product of TCA	0	0	2	2	0	0	0	2	2	2	2	2	2
VC*		Material Released / Daughter product of DCE[a/]	0	0	0	0	0	0	0	2	2	2	2	2	0
1,1,1- Trichloroethane*		Material released	0	0	0	0	0	0	0	0	0	0	0	0	0
DCA		Daughter product of TCA under reducing conditions	0	0	2	0	0	0	0	2	2	2	2	2	0
Carbon Tetrachloride		Material released	0	0	0	0	0	0	0	0	0	0	0	0	0
Chloroethane*		Daughter product of DCA or VC under reducing conditions	0	0	0	0	0	0	0	2	0	2	2	2	0
Ethene/Ethane	>0.01 mg/L	Daughter product of VC/ethene	0	0	0	0	0	0	0	2	0	2	2	0	0
	>0.1 mg/L	Daughter product of VC/ethene	0	0	0	0	0	0	0	3	0	3	3	0	0
Chloroform		Material released / Daughter product of Carbon Tetrachloride	0	0	0	0	0	0	0	2	0	0	0	0	0
Dichloromethane		Material released / Daughter product of Chloroform	0	0	0	0	0	0	0	0	0	0	0	0	0
		Natural Attenuation Screening Protocol Score	**12**	**8**	**9**	**13**	**2**	**1**	**4**	**32**	**26**	**26**	**36**	**21**	**16**

Score Interpretation	Score
Inadequate evidence for anaerobic biodegradation (reductive dechlorination) of chlorinated organics	0 to 5
Limited evidence for anaerobic biodegradation (reductive dechlorination) of chlorinated organics	6 to 14
Adequate evidence for anaerobic biodegradation (reductive dechlorination) of chlorinated organics	15 to 20
Strong evidence for anaerobic biodegradation (reductive dechlorination) of chlorinated organics	>20

Notes:
* required analysis
a/ Points awarded only if it can be shown that the compound is a daughter product (i.e., not a constituent of the source NAPL)

Source: *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*, EPA/600/R-98/128, Office of Research and Development, September 1998.

APPENDIX B

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Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-021					OW-024					OW-034				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U				0%						1 J	4.2E-07	0.00	100%	0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U				0%						5 U			0%	0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U				0%						5 U			0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U				0%						5 U			0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U				0%						5 U			0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U				0%						5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	1 J		0.00		0%						0.8 J		0.00	0%	0%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U				0%						5 U			0%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U				0%						5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U				0%						5 U			0%	0%
79-01-6	Trichloroethylene	C	1.7		5 U				0%						5 U			0%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U				0%						1 U			0%	0%
7440-38-	Arsenic	C/NC	0.045	11	10 U				0%	10 U				0%	10 U			0%	0%
7440-48-	Cobalt	NC		11	5 U				0%	5 U				0%	9.8		0.89	0%	38%
7439-89-	Iron	NC		1500	2360		1.57		94%	200 U				0%	952		0.63	0%	27%
7439-96-	Manganese	NC		880	84.6		0.10		6%	26 J		0.03		100%	702		0.80	0%	34%
7439-97-	Mercury	NC		0.57	0.2 U				0%	0.2 U				0%	0.2 U			0%	0%
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U				0%	10 U				0%	10 U			0%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U				0%	10 U				0%	10 U			0%	0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U				0%	10 U				0%	10 U			0%	0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U				0%	3 U				0%	3 U			0%	0%
				Total well risks		**0.0E+00**	**1.67**				**0.0E+00**	**0.03**				**4.2E-07**	**2.33**		
				Total well VOC risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**4.2E-07**	**0.00**		
				Total well Metals risks		**0.0E+00**	**1.67**				**0.0E+00**	**0.03**				**0.0E+00**	**2.32**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-038					OW-043					OW-045				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	9	3.8E-06	0.00	0%	0%	64	2.7E-05	0.01	1%	0%	39	1.6E-05	0.01	0%	0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U			0%	0%	0.9 J	3.8E-06	0.01	0%	0%	1 J	4.2E-06	0.01	0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%	5 J	1.2E-05	0.01	0%	0%	5 U			0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U			0%	0%	2 J	4.9E-06	0.05	0%	0%	5 U			0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	22		0.06	0%	13%	34		0.09	0%	1%	390		1.05	0%	2%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U			0%	0%	11	7.3E-06	0.01	0%	0%	5 U			0%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U			0%	0%	5 U			0%	0%	3 J	2.7E-05	0.01	0%	0%
79-01-6	Trichloroethylene	C	1.7		1 J	5.9E-07		0%	0%	5 J	2.9E-06		0%	0%	6	3.5E-06		0%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	19	1.2E-03	0.26	100%	58%	64	4.0E-03	0.89	95%	9%	170	1.1E-02	2.36	100%	4%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
7440-48-	Cobalt	NC		11	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
7439-89-	Iron	NC		1500	200 U			0%	0%	6220		4.15	0%	42%	221		0.15	0%	0%
7439-96-	Manganese	NC		880	118		0.13	0%	29%	4180		4.75	0%	48%	1510		1.72	0%	3%
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%	0.2 U			0%	0%	33.1 J		58.07	0%	92%
309-00-2	Aldrin	C/NC	0.004	1.1											0.0099 UJ			0%	0%
60-57-1	Dieldrin	C/NC	0.0042	1.8											0.02 UJ			0%	0%
76-44-8	Heptachlor	C/NC	0.015	18											0.01 UJ			0%	0%
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	2 J	1.7E-04		4%	0%	10 U			0%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U			0%	0%	3 U			0%	0%	3 U			0%	0%
				Total well risks		**1.2E-03**	**0.46**				**4.2E-03**	**9.95**				**1.1E-02**	**63.37**		
				Total well VOC risks		**1.2E-03**	**0.32**				**4.1E-03**	**1.05**				**1.1E-02**	**3.44**		
				Total well Metals risks		**0.0E+00**	**0.13**				**0.0E+00**	**8.90**				**0.0E+00**	**59.93**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**1.7E-04**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-051					OW-052					OW-054				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	43	1.8E-05	0.01	0%	0%	51	2.1E-05	0.01	0%	0%	32	1.3E-05	0.00	0%	0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	0.9 J	3.8E-06	0.01	0%	0%	2 J	8.3E-06	0.01	0%	0%	0.9 J	3.8E-06	0.01	0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	8	1.9E-05	0.01	0%	0%	6	1.4E-05	0.01	0%	0%	4 J	9.3E-06	0.00	0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U			0%	0%	0.9 J	2.2E-06	0.02	0%	0%	5 U			0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	140		0.38	0%	2%	155		0.42	0%	1%	230		0.62	0%	4%
100-41-4	Ethylbenzene	C/NC	1.5	1300	19	1.3E-05	0.01	0%	0%	86	5.7E-05	0.07	0%	0%	110	7.3E-05	0.08	1%	1%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 J	4.5E-05	0.02	0%	0%	3.5	3.2E-05	0.02	0%	0%	5 J	4.5E-05	0.02	0%	0%
79-01-6	Trichloroethylene	C	1.7		7	4.1E-06		0%	0%	4	2.4E-06		0%	0%	9	5.3E-06		0%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	250	1.6E-02	3.47	99%	19%	450	2.8E-02	6.25	99%	22%	190	1.2E-02	2.64	99%	18%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
7440-48-	Cobalt	NC		11	5.5		0.50	0%	3%	5 U			0%	0%	5 U			0%	0%
7439-89-	Iron	NC		1500	13700		9.13	0%	51%	25600		17.07	0%	59%	11900		7.93	0%	53%
7439-96-	Manganese	NC		880	3940		4.48	0%	25%	4070		4.63	0%	16%	2690		3.06	0%	21%
7439-97-	Mercury	NC		0.57	1 U			0%	0%	0.2 U			0%	0%	0.2 U			0%	0%
309-00-2	Aldrin	C/NC	0.004	1.1	0.011 J	2.8E-06	0.01	0%	0%	0.012 J	3.0E-06	0.01	0%	0%	0.0057 J	1.4E-06	0.01	0%	0%
60-57-1	Dieldrin	C/NC	0.0042	1.8	0.0038 UJ			0%	0%	0.0038 UJ			0%	0%	0.0039 UJ			0%	0%
76-44-8	Heptachlor	C/NC	0.015	18	0.02 UJ			0%	0%	0.031 J	2.1E-06	0.00	0%	0%	0.0033 J	2.2E-07	0.00	0%	0%
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%	10 U			0%	0%	3 J	2.1E-05	0.48	0%	3%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	5 J	4.2E-05	0.33	0%	1%	10 U			0%	0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U			0%	0%	3 U			0%	0%	3 U			0%	0%
				Total well risks		**1.6E-02**	**18.03**				**2.8E-02**	**28.84**				**1.2E-02**	**14.86**		
				Total well VOC risks		**1.6E-02**	**3.91**				**2.8E-02**	**6.80**				**1.2E-02**	**3.38**		
				Total well Metals risks		**0.0E+00**	**14.11**				**0.0E+00**	**21.69**				**0.0E+00**	**10.99**		
				Total well Pesticides risks		**2.8E-06**	**0.01**				**5.1E-06**	**0.01**				**1.6E-06**	**0.01**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**4.2E-05**	**0.33**				**2.1E-05**	**0.48**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
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Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-055					OW-081					OW-093-O				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U			0%	0%	5 U			0%	0%	16	6.7E-06	0.00	0.1%	0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	1 J		0.00	0%	0%	5 U			0%	0%	200		0.54	0%	4%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U			0%	0%	5 U			0%	0%	25	1.7E-05	0.02	0.3%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 J	4.5E-05	0.02	99%	2%	5 U			0%	0%	4 J	3.6E-05	0.02	0.6%	0%
79-01-6	Trichloroethylene	C	1.7		1 J	5.9E-07		1%	0%	5 U			0%	0%	7	4.1E-06		0%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U			0%	0%	1 U			0%	0%	99	6.2E-03	1.38	99%	10%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
7440-48-	Cobalt	NC		11	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
7439-89-	Iron	NC		1500	200 U			0%	0%	200 U			0%	0%	13000		8.67	0%	61%
7439-96-	Manganese	NC		880	1130		1.28	0%	98%	240		0.27	0%	100%	2560		2.91	0%	21%
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%	0.2 U			0%	0%	0.2 U			0%	0%
309-00-2	Aldrin	C/NC	0.004	1.1	0.0019 UJ			0%	0%	0.0019 UJ			0%	0%	0.0019 UJ			0%	0%
60-57-1	Dieldrin	C/NC	0.0042	1.8	0.0038 UJ			0%	0%	0.0016 J	3.8E-07	0.00	100%	0%	0.0039 UJ			0%	0%
76-44-8	Heptachlor	C/NC	0.015	18	0.0019 UJ			0%	0%	0.0019 UJ			0%	0%	0.00064 J	4.3E-08	0.00	0%	0%
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%	10 U			0%	0%	4 J	2.9E-05	0.65	0%	5%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	10 U			0%	0%	10 U			0%	0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U			0%	0%	3 U			0%	0%	3 U			0%	0%
				Total well risks		**4.6E-05**	**1.31**				**3.8E-07**	**0.27**				**6.3E-03**	**14.18**		
				Total well VOC risks		**4.6E-05**	**0.03**				**0.0E+00**	**0.00**				**6.3E-03**	**1.96**		
				Total well Metals risks		**0.0E+00**	**1.28**				**0.0E+00**	**0.27**				**0.0E+00**	**11.58**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**3.8E-07**	**0.00**				**4.3E-08**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**2.9E-05**	**0.65**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-094-0					OW-096-O					OW-102-O				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	10	4.2E-06	0.00	0%	0%						5 U				0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U			0%	0%						5 U				0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U			0%	0%						5 U				0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%						5 U				0%
71-43-2	Benzene	C/NC	0.41	44	1 J	2.4E-06	0.02	0%	0%						5 U				0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%						5 U				0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	250		0.68	0%	3%						5 U				0%
100-41-4	Ethylbenzene	C/NC	1.5	1300	41	2.7E-05	0.03	0%	0%						5 U				0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%						5 U				0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	52	4.7E-04	0.24	3%	1%						5 U				0%
79-01-6	Trichloroethylene	C	1.7		22	1.3E-05		0%	0%						5 U				0%
75-01-4	Vinyl chloride	C/NC	0.016	72	240	1.5E-02	3.33	96%	16%						1 U				0%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%						10 U				0%
7440-48-	Cobalt	NC		11	5 U			0%	0%						5 U				0%
7439-89-	Iron	NC		1500	14900		9.93	0%	49%						18900		12.60		95%
7439-96-	Manganese	NC		880	4780		5.43	0%	27%						534		0.61		5%
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%						0.2 U				0%
309-00-2	Aldrin	C/NC	0.004	1.1	0.003 UJ			0%	0%										
60-57-1	Dieldrin	C/NC	0.0042	1.8	0.0039 J	9.3E-07	0.00	0%	0%										
76-44-8	Heptachlor	C/NC	0.015	18	0.0013 UJ			0%	0%										
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	10 U					10 U				0%
91-20-3	Naphthalene	C/NC	0.14	6.2	5 J	3.6E-05	0.81	0%	4%	10 U					10 U				0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	10 U					10 U				0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	4 J	7.1E-06	0.00	0%	0%	3 U					3 U				0%
				Total well risks		**1.6E-02**	**20.48**				**0.0E+00**	**0.00**				**0.0E+00**	**13.21**		
				Total well VOC risks		**1.6E-02**	**4.30**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**15.37**				**0.0E+00**	**0.00**				**0.0E+00**	**13.21**		
				Total well Pesticides risks		**9.3E-07**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**4.3E-05**	**0.81**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-103-O					OW-105-O					OW-107-O				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	1 J	4.2E-07	0.00	100%	0%						5 U				0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U			0%	0%						5 U				0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U			0%	0%						5 U				0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%						5 U				0%
71-43-2	Benzene	C/NC	0.41	44	5 U			0%	0%						5 U				0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%						5 U				0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	6		0.02	0%	22%						5 U				0%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U			0%	0%						5 U				0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%						5 U				0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U			0%	0%						5 U				0%
79-01-6	Trichloroethylene	C	1.7		5 U			0%	0%						5 U				0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U			0%	0%						1 U				0%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%	19.2	4.3E-04	1.75	100%	15%	10 U				0%
7440-48-	Cobalt	NC		11	5 U			0%	0%	5 U			0%	0%	5 U				0%
7439-89-	Iron	NC		1500	200 U			0%	0%	12800		8.53	0%	72%	200 U				0%
7439-96-	Manganese	NC		880	51.7		0.06	0%	78%	1340		1.52	0%	13%	88		0.10		100%
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%				0%	0%	0.2 U				0%
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	10 U			0%	0%	10 U				0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%	10 U			0%	0%	10 U				0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	10 U			0%	0%	10 U				0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U			0%	0%	3 U			0%	0%	3 U				0%
				Total well risks		**4.2E-07**	**0.08**				**4.3E-04**	**11.80**				**0.0E+00**	**0.10**		
				Total well VOC risks		**4.2E-07**	**0.02**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**0.06**				**4.3E-04**	**11.80**				**0.0E+00**	**0.10**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

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Table B-1
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Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-109-O					OW-111-O					OW-112-O				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U				0%	5 U				0%	5 U				0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U				0%	5 U				0%	5 U				0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U				0%	5 U				0%	5 U				0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U				0%	5 U				0%	5 U				0%
71-43-2	Benzene	C/NC	0.41	44	5 U				0%	5 U				0%	5 U				0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U				0%	5 U				0%	5 U				0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	5 U				0%	5 U				0%	5 U				0%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U				0%	5 U				0%	5 U				0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U				0%	5 U				0%	5 U				0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U				0%	5 U				0%	5 U				0%
79-01-6	Trichloroethylene	C	1.7		5 U				0%	5 U				0%	5 U				0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U				0%	1 U				0%	1 U				0%
7440-38-	Arsenic	C/NC	0.045	11	10 U				0%	10 U				0%	10 U				0%
7440-48-	Cobalt	NC		11	5 U				0%	5 U				0%	5 U				0%
7439-89-	Iron	NC		1500	###		1.01		88%	265		0.18		86%	1410		0.94		75%
7439-96-	Manganese	NC		880	123		0.14		12%	24 J		0.03		14%	282		0.32		25%
7439-97-	Mercury	NC		0.57	0.2 U				0%	0.2 U				0%	0.2 U				0%
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U				0%	10 U				0%	10 U				0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U				0%	10 U				0%	10 U				0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U				0%	10 U				0%	10 U				0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U				0%	3 U				0%	3 U				0%
				Total well risks		**0.0E+00**	**1.15**				**0.0E+00**	**0.20**				**0.0E+00**	**1.26**		
				Total well VOC risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**1.15**				**0.0E+00**	**0.20**				**0.0E+00**	**1.26**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-200-O					OW-300-O					OW-301-O				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U					2 J	8.3E-07	0.00	0%	0%	11	4.6E-06	0.00	0%	0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U					5 U			0%	0%	5 U			0%	0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U					5 U			0%	0%	2 J	8.3E-06	0.01	0%	1%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U					5 U			0%	0%	5 U			0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U					5 U			0%	0%	0.6 J	1.5E-06	0.01	0%	1%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U					5 U			0%	0%	5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	5 U					72		0.19	0%	30%	260		0.70	0%	35%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U					500	3.3E-04	0.38	53%	59%	5 U			0%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U					5 U			0%	0%	5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U					4 J	3.6E-05	0.02	6%	3%	17	1.5E-04	0.08	3%	4%
79-01-6	Trichloroethylene	C	1.7		5 U					7	4.1E-06		1%	0%	480	2.8E-04		5%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U					4	2.5E-04	0.06	40%	9%	86	5.4E-03	1.19	92%	60%
7440-38-	Arsenic	C/NC	0.045	11															
7440-48-	Cobalt	NC		11															
7439-89-	Iron	NC		1500															
7439-96-	Manganese	NC		880															
7439-97-	Mercury	NC		0.57															
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012																
91-20-3	Naphthalene	C/NC	0.14	6.2															
98-95-3	Nitrobenzene	C/NC	0.12	15															
87-86-5	Pentachlorophenol	C/NC	0.56	1100															
				Total well risks		**0.0E+00**	**0.00**				**6.2E-04**	**0.65**				**5.8E-03**	**2.00**		
				Total well VOC risks		**0.0E+00**	**0.00**				**6.2E-04**	**0.65**				**5.8E-03**	**2.00**		
				Total well Metals risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-302-O					OW-303-O					OW-304-O				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	48	2.0E-05	0.01	1%	1%	14	5.8E-06	0.00	0%	0%	5 U			0%	0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%	5 U			0%	0%	3 J	7.0E-06	0.00	19%	6%
71-43-2	Benzene	C/NC	0.41	44	0.6 J	1.5E-06	0.01	0%	3%	5 U			0%	0%	5 U			0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	30		0.08	0%	16%	48		0.13	0%	23%	11		0.03	0%	64%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U			0%	0%	8	7.3E-05	0.04	4%	7%	3 J	2.7E-05	0.01	75%	29%
79-01-6	Trichloroethylene	C	1.7		1 J	5.9E-07		0%	0%	3 J	1.8E-06		0%	0%	4 J	2.4E-06		6%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	30	1.9E-03	0.42	99%	80%	28	1.8E-03	0.39	96%	70%	1 U			0%	0%
7440-38-	Arsenic	C/NC	0.045	11															
7440-48-	Cobalt	NC		11															
7439-89-	Iron	NC		1500															
7439-96-	Manganese	NC		880															
7439-97-	Mercury	NC		0.57															
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012																
91-20-3	Naphthalene	C/NC	0.14	6.2															
98-95-3	Nitrobenzene	C/NC	0.12	15															
87-86-5	Pentachlorophenol	C/NC	0.56	1100															
				Total well risks		**1.9E-03**	**0.52**				**1.8E-03**	**0.56**				**3.7E-05**	**0.05**		
				Total well VOC risks		**1.9E-03**	**0.52**				**1.8E-03**	**0.56**				**3.7E-05**	**0.05**		
				Total well Metals risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-1
Estimated Drinking Water Risks from Overburden Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	Average of all wells				
						cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300		**5.9E-06**	**0.00**	0.1%	0%
79-00-5	1,2-Dichloroethane	C/NC	0.15	640		**0.0E+00**	**0.00**	0%	0%
75-34-3	1,1,2-Trichloroethane	C/NC	0.24	150		**1.3E-06**	**0.00**	0.0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000		**2.5E-06**	**0.00**	0.1%	0%
71-43-2	Benzene	C/NC	0.41	44		**5.2E-07**	**0.00**	0.0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24		**0.0E+00**	**0.00**	0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370		**0.0E+00**	**0.21**	0%	2.0%
100-41-4	Ethylbenzene	C/NC	1.5	1300		**2.2E-05**	**0.03**	0.5%	0.2%
75-09-2	Methylene chloride	C/NC	4.8	1100		**0.0E+00**	**0.00**	0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220		**4.1E-05**	**0.02**	0.9%	0.2%
79-01-6	Trichloroethylene	C	1.7			**1.4E-05**	**0.00**	0.3%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72		**4.2E-03**	**0.94**	97%	9.2%
7440-38-	Arsenic	C/NC	0.045	11		**2.1E-05**	**0.09**	0.5%	0.8%
7440-48-	Cobalt	NC		11		**0.0E+00**	**0.07**	0%	0.7%
7439-89-	Iron	NC		1500		**0.0E+00**	**4.12**	0%	40%
7439-96-	Manganese	NC		880		**0.0E+00**	**1.62**	0%	16%
7439-97-	Mercury	NC		0.57		**0.0E+00**	**3.06**	0%	30%
309-00-2	Aldrin	C/NC	0.004	1.1		**9.0E-07**	**0.00**	0.0%	0%
60-57-1	Dieldrin	C/NC	0.0042	1.8		**1.6E-07**	**0.00**	0.0%	0%
76-44-8	Heptachlor	C/NC	0.015	18		**2.9E-07**	**0.00**	0.0%	0%
111-44-4	Bis(2-chloroethyl)ether	C	0.012			**8.3E-06**	**0.00**	0.2%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2		**4.3E-06**	**0.10**	0.1%	0.9%
98-95-3	Nitrobenzene	C/NC	0.12	15		**2.1E-06**	**0.02**	0.0%	0.2%
87-86-5	Pentachlorophenol	C/NC	0.56	1100		**3.6E-07**	**0.00**	0.0%	0%
				Total well risks	**Total average well risks**	**4.4E-03**	**10.28**	100%	100%
				Total well VOC risks	**Total average well VOC risks**	**4.3E-03**	**1.21**	99%	12%
				Total well Metals risks	**Total average well Metals risks**	**2.1E-05**	**8.96**	0.5%	87%
				Total well Pesticides risks	**Total average well Pesticides risks**	**1.4E-06**	**0.00**	0.0%	0%
				Total well SVOCs risks	**Total average well SVOCs risks**	**1.5E-05**	**0.11**	0.3%	1.1%

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
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Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2

Estimated Drinking Water Risks from Bedrock Groundwater

Davis Liquid Waste Superfund Site

Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-007					OW-025					OW-033				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	2 J	8.3E-07	0.00	4%	0%						16	6.7E-06	0.00	1%	1%
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640	5 U			0%	0%						5 U			0%	0%
75-34-3	1,2-Dichloroethane	C/NC	0.24	150	5 U			0%	0%						5 U			0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%						5 U			0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U			0%	0%						0.7 J	1.7E-06	0.02	0%	4%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%						5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	5 U			0%	0%						31		0.08	0%	23%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U			0%	0%						5 U			0%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%						5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	2 J	1.8E-05	0.01	93%	1%						12	1.1E-04	0.05	17%	15%
79-01-6	Trichloroethylene	C	1.7		1 J	5.9E-07		3%	0%						34	2.0E-05		3%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U			0%	0%						3	1.9E-04	0.04	28%	11%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%	10 U					10 U			0%	0%
7440-48-	Cobalt	NC		11	5 U			0%	0%	5 U					5 U			0%	0%
7439-89-	Iron	NC		1500	200 U			0%	0%	200 U					200 U			0%	0%
7439-96-	Manganese	NC		880	686		0.78	0%	99%	5 U					147		0.17	0%	46%
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%	0.2 U					0.2 U			0%	0%
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	10 U					4 J	3.3E-04		51%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%	10 U					10 U			0%	0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	10 U					10 U			0%	0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U			0%	0%	3 U					3 U			0%	0%
				Total well risks		**2.0E-05**	**0.79**				**0.0E+00**	**0.00**				**6.6E-04**	**0.37**		
				Total well VOC risks		**2.0E-05**	**0.01**				**0.0E+00**	**0.00**				**3.2E-04**	**0.20**		
				Total well Metals risks		**0.0E+00**	**0.78**				**0.0E+00**	**0.00**				**0.0E+00**	**0.17**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**3.3E-04**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2

Estimated Drinking Water Risks from Bedrock Groundwater

Davis Liquid Waste Superfund Site

Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-036					OW-041					OW-079				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	6	2.5E-06	0.00	2%	0%	46	1.9E-05	0.01	2%	0%	3 J	1.3E-06	0.00	4%	0%
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
75-34-3	1,2-Dichloroethane	C/NC	0.24	150	5 U			0%	0%	1 J	4.2E-06	0.01	0%	0%	5 U			0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%	2 J	4.7E-06	0.00	0%	0%	5 U			0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U			0%	0%	11	2.7E-05	0.25	3%	2%	5 U			0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	12		0.03	0%	9%	5 U			0%	0%	1 J		0.00	0%	0%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U			0%	0%	50	3.3E-05	0.04	3%	0%	5 U			0%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	12	1.1E-04	0.05	91%	15%	5 U			0%	0%	3 J	2.7E-05	0.01	90%	0%
79-01-6	Trichloroethylene	C	1.7		14	8.2E-06		7%	0%	5 U			0%	0%	3 J	1.8E-06		6%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U			0%	0%	1	6.3E-05	0.01	6%	0%	1 U			0%	0%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%	11.8	2.6E-04	1.07	26%	9%	10 U			0%	0%
7440-48-	Cobalt	NC		11	5 U			0%	0%	5 U			0%	0%	5 U			0%	0%
7439-89-	Iron	NC		1500	200 U			0%	0%	7760		5.17	0%	43%	###		3.79	0%	98%
7439-96-	Manganese	NC		880	249		0.28	0%	76%	4850		5.51	0%	46%	48 J		0.05	0%	1%
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%	0.2 U			0%	0%	0.2 U			0%	0%
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	7 J	5.8E-04		59%	0%					
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%	10 U			0%	0%					
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	10 U			0%	0%					
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U			0%	0%	3 U			0%	0%					
				Total well risks		**1.2E-04**	**0.37**				**1.0E-03**	**12.07**				**3.0E-05**	**3.86**		
				Total well VOC risks		**1.2E-04**	**0.09**				**1.5E-04**	**0.32**				**3.0E-05**	**0.02**		
				Total well Metals risks		**0.0E+00**	**0.28**				**2.6E-04**	**11.76**				**0.0E+00**	**3.85**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**5.8E-04**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2
Estimated Drinking Water Risks from Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-080					OW-082					OW-084				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300						5 U				0%					
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640						5 U				0%					
75-34-3	1,2-Dichloroethane	C/NC	0.24	150						5 U				0%					
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000						5 U				0%					
71-43-2	Benzene	C/NC	0.41	44						5 U				0%					
56-23-5	Carbon tetrachloride	C/NC	0.2	24						5 U				0%					
156-59-2	cis-1,2-Dichloroethylene	NC		370						5 U				0%					
100-41-4	Ethylbenzene	C/NC	1.5	1300						5 U				0%					
75-09-2	Methylene chloride	C/NC	4.8	1100						5 U				0%					
127-18-4	Tetrachloroethylene	C/NC	0.11	220						5 U				0%					
79-01-6	Trichloroethylene	C	1.7							5 U				0%					
75-01-4	Vinyl chloride	C/NC	0.016	72						1 U				0%					
7440-38-	Arsenic	C/NC	0.045	11						10 U				0%					
7440-48-	Cobalt	NC		11						5 U				0%					
7439-89-	Iron	NC		1500						4360		2.91		99%					
7439-96-	Manganese	NC		880						21.1 J		0.02		1%					
7439-97-	Mercury	NC		0.57															
309-00-2	Aldrin	C/NC	0.004	1.1						0.0019 UJ				0%	0.0020 UJ				
60-57-1	Dieldrin	C/NC	0.0042	1.8						0.0038 UJ				0%	0.0040 UJ				
76-44-8	Heptachlor	C/NC	0.015	18						0.0019 UJ				0%	0.0020 UJ				
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U					10 U				0%	10 U				
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U					10 U				0%	10 U				
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U					10 U				0%	10 U				
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U					3 U				0%	3 U				
				Total well risks		**0.0E+00**	**0.00**				**0.0E+00**	**2.93**				**0.0E+00**	**0.00**		
				Total well VOC risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**0.00**				**0.0E+00**	**2.93**				**0.0E+00**	**0.00**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2
Estimated Drinking Water Risks from Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-085					OW-086					OW-094-R				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U				0%						160	6.7E-05	0.02	0.3%	0%
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640	5 U				0%						6 J	4.0E-05	0.01	0.2%	0%
75-34-3	1,2-Dichloroethane	C/NC	0.24	150	5 U				0%						10 U			0%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U				0%						10 U			0%	0%
71-43-2	Benzene	C/NC	0.41	44	5 U				0%						3 J	7.3E-06	0.07	0%	0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U				0%						91	4.6E-04	3.79	2%	21%
156-59-2	cis-1,2-Dichloroethylene	NC		370	5		0.01		1%						1700		4.59	0%	25%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U				0%						31	2.1E-05	0.02	0.1%	0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U				0%						10 U			0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U				0%						11	1.0E-04	0.05	0.4%	0%
79-01-6	Trichloroethylene	C	1.7		5 U				0%						570	3.4E-04		2%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U				0%						340	2.1E-02	4.72	95%	26%
7440-38-	Arsenic	C/NC	0.045	11	10 U				0%						10 U			0%	0%
7440-48-	Cobalt	NC		11	5 U				0%						5 U			0%	0%
7439-89-	Iron	NC		1500	1990		1.33		98%						3390		2.26	0%	12%
7439-96-	Manganese	NC		880	15.4 J		0.02		1%						2320		2.64	0%	15%
7439-97-	Mercury	NC		0.57											0.2 U			0%	0%
309-00-2	Aldrin	C/NC	0.004	1.1	0.0019 UJ				0%						0.0020 UJ			0%	0%
60-57-1	Dieldrin	C/NC	0.0042	1.8	0.0038 UJ				0%						0.0039 UJ			0%	0%
76-44-8	Heptachlor	C/NC	0.015	18	0.0019 UJ				0%						0.0020 UJ			0%	0%
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U				0%	10 U					10 U			0%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U				0%	10 U					10 U			0%	0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U				0%	10 U					10 U			0%	0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U				0%	3 U					3 U			0%	0%
				Total well risks		**0.0E+00**	**1.36**				**0.0E+00**	**0.00**				**2.2E-02**	**18.18**		
				Total well VOC risks		**0.0E+00**	**0.01**				**0.0E+00**	**0.00**				**2.2E-02**	**13.28**		
				Total well Metals risks		**0.0E+00**	**1.34**				**0.0E+00**	**0.00**				**0.0E+00**	**4.90**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2

Estimated Drinking Water Risks from Bedrock Groundwater

Davis Liquid Waste Superfund Site

Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-096-R					OW-101-R					OW-102-R				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300						62	2.6E-05	0.01	0.4%	0%	5 U				0%
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640						0.9 J	6.0E-06	0.00	0.1%	0%	5 U				0%
75-34-3	1,2-Dichloroethane	C/NC	0.24	150						2 J	8.3E-06	0.01	0.1%	0%	5 U				0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000						8	1.9E-05	0.01	0.3%	0%	5 U				0%
71-43-2	Benzene	C/NC	0.41	44						8	2.0E-05	0.18	0.3%	1%	5 U				0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24						5 U			0%	0%	5 U				0%
156-59-2	cis-1,2-Dichloroethylene	NC		370						15		0.04	0%	0%	5 U				0%
100-41-4	Ethylbenzene	C/NC	1.5	1300						78	5.2E-05	0.06	0.8%	0%	5 U				0%
75-09-2	Methylene chloride	C/NC	4.8	1100						5 U			0%	0%	5 U				0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220						5 U			0%	0%	5 U				0%
79-01-6	Trichloroethylene	C	1.7							3 J	1.8E-06		0%	0%	5 U				0%
75-01-4	Vinyl chloride	C/NC	0.016	72						70	4.4E-03	0.97	66%	4%	1 U				0%
7440-38-	Arsenic	C/NC	0.045	11						10 U			0%	0%	10 U				0%
7440-48-	Cobalt	NC		11						5 U			0%	0%	5 U				0%
7439-89-	Iron	NC		1500						22800		15.20	0%	58%	1000		0.67		59%
7439-96-	Manganese	NC		880						7960		9.05	0%	34%	412		0.47		41%
7439-97-	Mercury	NC		0.57						0.2 U			0%	0%	0.2 U				0%
309-00-2	Aldrin	C/NC	0.004	1.1						0.001265 J	3.2E-07	0.00	0%	0%					
60-57-1	Dieldrin	C/NC	0.0042	1.8						0.0067 J	1.6E-06	0.00	0%	0%					
76-44-8	Heptachlor	C/NC	0.015	18						0.00385 J	2.6E-07	0.00	0%	0%					
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U					25	2.1E-03		31%	0%	10 U				0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U					5 J	3.6E-05	0.81	1%	3%	10 U				0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U					10 U			0%	0%	10 U				0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U					3 U			0%	0%	3 U				0%
				Total well risks		**0.0E+00**	**0.00**				**6.6E-03**	**26.34**				**0.0E+00**	**1.13**		
				Total well VOC risks		**0.0E+00**	**0.00**				**4.5E-03**	**1.29**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**0.00**				**0.0E+00**	**24.25**				**0.0E+00**	**1.13**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**2.2E-06**	**0.01**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**2.1E-03**	**0.81**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
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- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
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Table B-2
Estimated Drinking Water Risks from Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-103-R					OW-105-R					OW-107-R				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U			0%	0%						5 U				0%
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640	5 U			0%	0%						5 U				0%
75-34-3	1,2-Dichloroethane	C/NC	0.24	150	5 U			0%	0%						5 U				0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%						5 U				0%
71-43-2	Benzene	C/NC	0.41	44	5 U			0%	0%						5 U				0%
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%						5 U				0%
156-59-2	cis-1,2-Dichloroethylene	NC		370	6		0.02	0%	0%						5 U				0%
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U			0%	0%						5 U				0%
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U			0%	0%						5 U				0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220	0.8 J	7.3E-06	0.00	80%	0%						5 U				0%
79-01-6	Trichloroethylene	C	1.7		3 J	1.8E-06		20%	0%						5 U				0%
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U			0%	0%						1 U				0%
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%	10 U				0%	10 U				0%
7440-48-	Cobalt	NC		11	5 U			0%	0%	5 U				0%	5 U				0%
7439-89-	Iron	NC		1500	1270		0.85	0%	20%	330		0.22		94%	266		0.18		100%
7439-96-	Manganese	NC		880	3050		3.47	0%	80%	13 J		0.02		6%	5 U				0%
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%	0.2 U				0%	0.2 U				0%
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U			0%	0%	10 U				0%	10 U				0%
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%	10 U				0%	10 U				0%
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%	10 U				0%	10 U				0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U			0%	0%	3 U				0%	3 U				0%
				Total well risks		**9.0E-06**	**4.33**				**0.0E+00**	**0.24**				**0.0E+00**	**0.18**		
				Total well VOC risks		**9.0E-06**	**0.02**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**4.31**				**0.0E+00**	**0.24**				**0.0E+00**	**0.18**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

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- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
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Table B-2
Estimated Drinking Water Risks from Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-109-R					OW-110-R					OW-111-R				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U					5 U			0%	0%	5 U				
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640	5 U					5 U			0%	0%	5 U				
75-34-3	1,2-Dichloroethane	C/NC	0.24	150	5 U					5 U			0%	0%	5 U				
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U					5 U			0%	0%	5 U				
71-43-2	Benzene	C/NC	0.41	44	5 U					5 U			0%	0%	5 U				
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U					5 U			0%	0%	5 U				
156-59-2	cis-1,2-Dichloroethylene	NC		370	5 U					5 U			0%	0%	5 U				
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U					5 U			0%	0%	5 U				
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U					5 U			0%	0%	5 U				
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U					5 U			0%	0%	5 U				
79-01-6	Trichloroethylene	C	1.7		5 U					5 U			0%	0%	5 U				
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U					1 U			0%	0%	1 U				
7440-38-	Arsenic	C/NC	0.045	11	10 U					17.6	3.9E-04	1.60	100%	63%	10 U				
7440-48-	Cobalt	NC		11	5 U					5 U			0%	0%	5 U				
7439-89-	Iron	NC		1500	200 U					1390		0.93	0%	36%	200 U				
7439-96-	Manganese	NC		880	5 U					19.7 J		0.02	0%	1%	5 U				
7439-97-	Mercury	NC		0.57	0.2 U					0.2 U			0%	0%	0.2 U				
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		10 U					10 U			0%	0%	10 U				
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U					10 U			0%	0%	10 U				
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U					10 U			0%	0%	10 U				
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 U					3 U			0%	0%	3 U				
				Total well risks		**0.0E+00**	**0.00**				**3.9E-04**	**2.55**				**0.0E+00**	**0.00**		
				Total well VOC risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**0.00**				**3.9E-04**	**2.55**				**0.0E+00**	**0.00**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2
Estimated Drinking Water Risks from Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-112-R					OW-200-R					OW-201-R				
					result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index	result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	81	3.4E-05	0.01	3%	1%	5 U					5 U				
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640	5 U			0%	0%	5 U					5 U				
75-34-3	1,2-Dichloroethane	C/NC	0.24	150	2 J	8.3E-06	0.01	1%	1%	5 U					5 U				
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U			0%	0%	5 U					5 U				
71-43-2	Benzene	C/NC	0.41	44	4 J	9.8E-06	0.09	1%	4%	5 U					5 U				
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U			0%	0%	5 U					5 U				
156-59-2	cis-1,2-Dichloroethylene	NC		370	10		0.03	0%	1%	5 U					5 U				
100-41-4	Ethylbenzene	C/NC	1.5	1300	1 J	6.7E-07	0.00	0%	0%	5 U					5 U				
75-09-2	Methylene chloride	C/NC	4.8	1100	13	2.7E-06	0.01	0%	1%	5 U					5 U				
127-18-4	Tetrachloroethylene	C/NC	0.11	220	17	1.5E-04	0.08	12%	4%	5 U					5 U				
79-01-6	Trichloroethylene	C	1.7		15	8.8E-06		1%	0%	5 U					5 U				
75-01-4	Vinyl chloride	C/NC	0.016	72	2	1.3E-04	0.03	10%	1%	1 U					1 U				
7440-38-	Arsenic	C/NC	0.045	11	10 U			0%	0%										
7440-48-	Cobalt	NC		11	5 U			0%	0%										
7439-89-	Iron	NC		1500	200 U			0%	0%										
7439-96-	Manganese	NC		880	1600		1.82	0%	87%										
7439-97-	Mercury	NC		0.57	0.2 U			0%	0%										
309-00-2	Aldrin	C/NC	0.004	1.1															
60-57-1	Dieldrin	C/NC	0.0042	1.8															
76-44-8	Heptachlor	C/NC	0.015	18															
111-44-4	Bis(2-chloroethyl)ether	C	0.012		11	9.2E-04		73%	0%										
91-20-3	Naphthalene	C/NC	0.14	6.2	10 U			0%	0%										
98-95-3	Nitrobenzene	C/NC	0.12	15	10 U			0%	0%										
87-86-5	Pentachlorophenol	C/NC	0.56	1100	3 UJ			0%	0%										
				Total well risks		**1.3E-03**	**2.08**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well VOC risks		**3.4E-04**	**0.26**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**1.82**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well Pesticides risks		**0.0E+00**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		
				Total well SVOCs risks		**9.2E-04**	**0.00**				**0.0E+00**	**0.00**				**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2
Estimated Drinking Water Risks from Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	OW-202-R result ug/l	cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300	5 U				
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640	5 U				
75-34-3	1,2-Dichloroethane	C/NC	0.24	150	5 U				
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000	5 U				
71-43-2	Benzene	C/NC	0.41	44	5 U				
56-23-5	Carbon tetrachloride	C/NC	0.2	24	5 U				
156-59-2	cis-1,2-Dichloroethylene	NC		370	5 U				
100-41-4	Ethylbenzene	C/NC	1.5	1300	5 U				
75-09-2	Methylene chloride	C/NC	4.8	1100	5 U				
127-18-4	Tetrachloroethylene	C/NC	0.11	220	5 U				
79-01-6	Trichloroethylene	C	1.7		5 U				
75-01-4	Vinyl chloride	C/NC	0.016	72	1 U				
7440-38-	Arsenic	C/NC	0.045	11					
7440-48-	Cobalt	NC		11					
7439-89-	Iron	NC		1500					
7439-96-	Manganese	NC		880					
7439-97-	Mercury	NC		0.57					
309-00-2	Aldrin	C/NC	0.004	1.1					
60-57-1	Dieldrin	C/NC	0.0042	1.8					
76-44-8	Heptachlor	C/NC	0.015	18					
111-44-4	Bis(2-chloroethyl)ether	C	0.012						
91-20-3	Naphthalene	C/NC	0.14	6.2					
98-95-3	Nitrobenzene	C/NC	0.12	15					
87-86-5	Pentachlorophenol	C/NC	0.56	1100					
				Total well risks		**0.0E+00**	**0.00**		
				Total well VOC risks		**0.0E+00**	**0.00**		
				Total well Metals risks		**0.0E+00**	**0.00**		
				Total well Pesticides risks		**0.0E+00**	**0.00**		
				Total well SVOCs risks		**0.0E+00**	**0.00**		

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

Table B-2
Estimated Drinking Water Risks from Bedrock Groundwater
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

CAS Number	Chemical	Basis	Regional Screening Level Tap water (ug/L) 10^{-6} Cancer risk based	Regional Screening Level Tap water (ug/L) Hazard Index (1.0) based	Average all wells				
						cancer risk	hazard index	percent of total cancer risk	percent of total hazard index
75-34-3	1,1-Dichloroethane	C/NC	2.4	7300		**8.2E-06**	**0.00**	0.5%	0%
79-00-5	1,1,2-Trichloroethane	C/NC	0.15	640		**2.4E-06**	**0.00**	0.1%	0%
75-34-3	1,2-Dichloroethane	C/NC	0.24	150		**1.1E-06**	**0.00**	0.1%	0%
106-46-7	1,4-Dichlorobenzene	C/NC	0.43	1000		**1.2E-06**	**0.00**	0.1%	0%
71-43-2	Benzene	C/NC	0.41	44		**3.4E-06**	**0.03**	0.2%	0.7%
56-23-5	Carbon tetrachloride	C/NC	0.2	24		**2.4E-05**	**0.20**	1.4%	4.3%
156-59-2	cis-1,2-Dichloroethylene	NC		370		**0.0E+00**	**0.25**	0%	5.5%
100-41-4	Ethylbenzene	C/NC	1.5	1300		**5.6E-06**	**0.01**	0.3%	0.1%
75-09-2	Methylene chloride	C/NC	4.8	1100		**1.4E-07**	**0.00**	0.0%	0%
127-18-4	Tetrachloroethylene	C/NC	0.11	220		**2.8E-05**	**0.01**	1.6%	0.3%
79-01-6	Trichloroethylene	C	1.7			**2.0E-05**	**0.00**	1.2%	0%
75-01-4	Vinyl chloride	C/NC	0.016	72		**1.4E-03**	**0.30**	81%	6.6%
7440-38-	Arsenic	C/NC	0.045	11		**4.1E-05**	**0.17**	2.4%	3.6%
7440-48-	Cobalt	NC		11		**0.0E+00**	**0.00**	0%	0%
7439-89-	Iron	NC		1500		**0.0E+00**	**2.09**	0%	45%
7439-96-	Manganese	NC		880		**0.0E+00**	**1.52**	0%	33%
7439-97-	Mercury	NC		0.57		**0.0E+00**	**0.00**	0%	0%
309-00-2	Aldrin	C/NC	0.004	1.1		**6.3E-08**	**0.00**	0.0%	0%
60-57-1	Dieldrin	C/NC	0.0042	1.8		**3.2E-07**	**0.00**	0.0%	0%
76-44-8	Heptachlor	C/NC	0.015	18		**5.1E-08**	**0.00**	0.0%	0%
111-44-4	Bis(2-chloroethyl)ether	C	0.012			**1.9E-04**	**0.00**	11%	0%
91-20-3	Naphthalene	C/NC	0.14	6.2		**1.7E-06**	**0.04**	0.1%	0.8%
98-95-3	Nitrobenzene	C/NC	0.12	15		**0.0E+00**	**0.00**	0%	0%
87-86-5	Pentachlorophenol	C/NC	0.56	1100		**0.0E+00**	**0.00**	0%	0%
				Total well risks	**Total average well risks**	**1.7E-03**	**4.63**	100%	100%
				Total well VOC risks	**Total average well VOC risks**	**1.5E-03**	**0.82**	86%	18%
				Total well Metals risks	**Total average well Metals risks**	**4.1E-05**	**3.78**	2.4%	82%
				Total well Pesticides risks	**Total average well Pesticides risks**	**4.3E-07**	**0.00**	0.0%	0%
				Total well SVOCs risks	**Total average well SVOCs risks**	**1.9E-04**	**0.04**	11%	0.8%

VOCs Data from ESS Phase 4 Subsurface Investigation, 2008
SVOC Data from ESS 2006, collected June 2003.
Metals Data from ESS 2006, collected Fall 2004.
Pesticides Data from ESS 2006, collected Fall 2003.

Notes: Screening Values derived from the following sources:
- EPA RSLs - EPA Regional Screening Levels; Tapwater Scenario

Abbr: C=Carcinogen
NC=Non-carcinogenic effects

TABLE B-3
CANCER RISK BASED PRELIMINARY REMEDIATION GOALS
FUTURE RESIDENTIAL EXPOSURE TO GROUNDWATER AS DRINKING WATER
DAVIS LIQUID WASTE SUPERFUND SITE
SMITHFIELD, RHODE ISLAND

COCs	Oral Exposure Factor (L-mg/kg-µg-d)	CSForal (mg/kg-d)	PRG based on 10^{-6} cancer risk (µg/L)	PRG based on 10^{-5} cancer risk (µg/L)	PRG based on 10^{-4} cancer risk (µg/L)
1,1-Dichloroethane	1.49E-05	5.70E-03	5.87E+00	5.87E+01	5.87E+02
Benzene	1.49E-05	5.50E-02	6.09E-01	6.09E+00	6.09E+01
cis-1,2-Dichloroethylene	1.49E-05	---	---	---	---
Tetrachloroethylene	1.49E-05	5.40E-01	6.20E-02	6.20E-01	6.20E+00
Trichloroethylene	1.49E-05	1.30E-02	2.58E+00	2.58E+01	2.58E+02
Vinyl chloride	1.49E-05	7.20E-01	4.65E-02	4.65E-01	4.65E+00
Arsenic	1.49E-05	1.50E+00	2.23E-02	2.23E-01	2.23E+00
Manganese	1.49E-05	---	---	---	---
Aldrin	1.49E-05	1.70E+01	1.97E-03	1.97E-02	1.97E-01
Dieldrin	1.49E-05	1.60E+01	2.09E-03	2.09E-02	2.09E-01
Bis(2-chloroethyl)ether	1.49E-05	1.10E+00	3.04E-02	3.04E-01	3.04E+00

Age-Adjusted Ingestion Rate = ((Ingestion Rate $_{child}$ * Exposure Duration $_{child}$)/Body Weight $_{child}$) +
((Ingestion Rate $_{adult}$ * Exposure Duration $_{adult}$)/Body Weight $_{adult}$)
= ((1 L/d * 6 y)/15 kg) + ((2 L/d * 24 y)/70 kg) = 1.09 L-y/kg-d

Oral Exposure Factor = Age-adjusted Ingestion Rate * Exposure Frequency*Conversion Factor/Averaging Time
= (1.09 L-y/kg-d * 350 d/y * 10-3 mg/ug)/(70 y * 365 d/y)

Dermal plus inhalation risks are presumed to equal ingestion risks.

PRG = Target Cancer Risk/(2*Exposure Factor *CSF)

TABLE B-4
NON-CANCER HAZARD INDEX BASED PRELIMINARY REMEDIATION GOALS
FUTURE RESIDENTIAL EXPOSURE TO GROUNDWATER AS DRINKING WATER
DAVIS LIQUID WASTE SUPERFUND SITE

SMITHFIELD, RHODE ISLAND

COCs	Oral Exposure Factor (L-mg/kg-µg-d)	RfDoral (mg/kg-d)	PRG based on HI=1.0 (µg/L)
1,1-Dichloroethane	6.39E-05	2.0E-01	1.56E+03
Benzene	6.39E-05	4.0E-03	3.13E+01
cis-1,2-Dichloroethylene	6.39E-05	1.0E-02	7.82E+01
Tetrachloroethylene	6.39E-05	1.0E-02	7.82E+01
Trichloroethylene	6.39E-05	---	---
Vinyl chloride	6.39E-05	3.0E-03	2.35E+01
Arsenic	6.39E-05	3.0E-04	2.35E+00
Manganese	6.39E-05	2.4E-02	1.88E+02
Aldrin	6.39E-05	3.0E-05	2.35E-01
Dieldrin	6.39E-05	5.0E-05	3.91E-01
Bis(2-chloroethyl)ether	6.39E-05	---	---

Oral Exposure Factor = Ingestion Rate * Exposure Frequency*Exposure Duration*Conversion Factor/ BW*Averaging Time
= (1L/d * 350 d/y * 6 y * 10-3 mg/µg)/(15 kg * 6 y * 365 d/y)

PRG = (Target Hazard quotient*RfD)/(2*Exposure Factor)
Dermal plus inhalation hazards are presumed to equal ingestion hazards.
HI=Hazard Index

APPENDIX C

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Appendix C

Groundwater Recovery System

As part of the development of the Focused Feasibility Study, Nobis evaluated previous groundwater investigations and groundwater recovery system designs. In order to properly design the ground water recovery and treatment system, Nobis recommends the design described by Ebasco Services Incorporated in their Final Criteria Design Summary Report (FCDSR), Perform PreDesign Investigation and Develop Design Criteria at Davis Liquid Waste Superfund Site, Smithfield RI, and Volume IIA Appendix D-Groundwater Modeling Report. After a thorough review, Nobis believes the well documented and thoroughly calibrated ground water model by the Ebasco team, will allow the ground water extraction design to proceed. The final model calibration parameters are contained in Table 1. As with any ground water recovery system, the actual final flow rates from each well should be adjusted in the field after construction of the system.

Former Source Area Recovery System

The steady state modeling simulations were performed and demonstrated that an eight well pair (overburden and bedrock) configuration pumping 28.9 gpm (Table 2) is capable of capturing contamination from the designated extraction area. The model actually predicted that only 6 well pairs (overburden and bedrock) pumping 22.5 gpm would be necessary for complete capture. However, based on the uncertainties in the model, particularly with respect to the hydraulic conductivity and the assumption that the bedrock acts as a porous media, Ebasco recommended 8 pairs as shown on Figure 5-2 the FCDSR. Nobis recommends that all 8 well pairs be installed initially to evaluate capture and then adjust flow rates seasonally to maximize capture but minimizing wetlands dewatering. Nobis also recommends shifting extraction well pair 8 approximately 150 feet east.

The proposed flow rates in Table 2 have not been simulated in the calibrated Ebasco model but the rates were derived from previous model runs (of 22.5 gpm) to yield a flow rate of 28.9 gpm. It is recommended that once the system is constructed and operated, water levels measured, the system can be adjusted to meet specific performance criteria. Ebasco performed transient simulations using the 22.5 gpm which they refer to as the winter flow rate because ET is negligible and the water table is seasonally higher than summer.

Table 2 contains the estimated flow rates for a total flow rate of 28.9 gpm from individual wells from the 8 pairs. The transient runs indicate the wells reach steady state and more of the drawdown occurs in the first 140 days. After that heads drop at a much slower rate and will be influenced by seasonal factors such as ET and rainfall. Sensitivity analyses showed water levels dropping in the wetland areas during low recharge time periods (summer).

Uncertainty analysis also indicated that the pumping rate would be too low to maintain capture if overburden hydraulic conductivities were higher than those modeled. The most critical value of hydraulic conductivity may be found in the northern wetland area. Some of the values measured by CDM and WWC were higher than the 25 feet/day used by Ebasco to calibrate the model. This is particularly true in the northeast corner of the grid where a wide range of HC values have been measured. Additional uncertainty may arise if discrete flow zones exist in the bedrock instead of the medium acting as a porous media as the modeling simulated. Large

zones on contaminants in bedrock could be isolated from capture if the fracturing is not widespread and interconnected as the Ebasco and URS models assumes.

In summary, Nobis proposes that 16 extraction wells installed at 8 locations (overburden and bedrock) in the source area as shown on Figure 1 would be effective in controlling and treating ground water contaminants at the Davis Liquid Superfund Site although there may be several factors which could impact the resultant capture as described here.

Downgradient Extraction Wells

Nobis utilized the results of Ebasco's simulations in the source area to estimate the number of wells required to contain downgradient groundwater contamination. The method employed used average areas of influence for the source area extraction wells as well as the combined average predicted pumping rates of these wells.

It is anticipated that both overburden and bedrock groundwater could be recovered using bedrock wells. This is based on the results of bedrock pumping tests conducted by WWC in August 1992. The pumping test observed drawdown in overburden wells during the pumping test conducted in the bedrock wells. In addition, recovery of groundwater in overburden wells would be impractible in the downgradient plume area because the saturated thickness in the overburden is small and drawdown around these wells would be limited. Thus, only bedrock groundwater recovery wells are necessary in this area. Based on the average areas of influence of the recovery wells presented in the Ebasco reports, it is anticipated that 7 bedrock groundwater recovery wells would be adequate to contain downgradient groundwater. Based on the Ebasco predicted pumping rates for the source area, the average pumping rate for the wells is estimated to be equal to the maximum bedrock pumping rate predicted in Table 1 (1.6 gallons per minute) for a total downgradient recovery system flow of approximately 11 gallons per minute.

As discussed above, there are many uncertainties and limitations that must be resolved prior to the detailed design of a downgradient recovery system. If this alternative is pursued, Nobis recommends additional, additional predesign investigations in this area to collect more detailed design information.

Table 1
Summary of Final Calibrated Groundwater Model Parameters
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Parameter or Condition	Values
Model Grid Resolution	25 ft in extraction areas; 50 ft elsewhere
Model Layer Thickness	1.5 ft in wetlands
	2-15 ft in upper overburden
	2-15 ft in lower overburden
	5-30 ft in upper bedrock
Layer Top Elevations	Layer 1 is surveyed ground surface
	Layer 2 = Layer 1 - 2 ft
	Layer 3 = 0.5*(Layer 1 + Layer 4)
	Layer 4 = interpolated top of rock
Bottom of Model	Contoured bottom of 'fractured' bedrock
	1,000 ft/day in wetlands
Horizontal Hydraulic Conductivities	Variable in upper overburden (1-100 ft/day)
(See Figures 3-1 to 3-3)	Variable in lower overburden (1-100 ft/day)
	Variable in upper bedrock (.001 - 1 ft/day)
Vertical Conductivities	10:1 horizontal to vertical anisotropy, except in tighter materials where it is < 1 ft/day, (Freeze & Cherry, 1979)
Porosity	0.35 in overburden (Freeze & Cherry, 1979)
	0.05 in bedrock (Freeze & Cherry, 1979)
Storage Coefficients	0.005 in overburden (mean of site values)
	* Model also uses primary storage coefficient of 0.35 for sand and silt deposits based on drainable porosity.
	0.0075 in bedrock (mean of site values)
Boundary Conditions	Fixed heads along S & N and River
	* No flow along E & W
Fixed and Initial Heads	Interpolated from 12/91 data
Precipitation	0.004 ft/day in uplands; 0.0 ft/day in low lands
Potential Evapotranspiration (PET)	1.21 in/month (0.003 ft/day) (Blaney-Criddle for 41°N and temperatures at North Foster. Adjusted for limited pan evaporation at Kingston Station.)
Extraction Wells	6 wells at 8 locations pumping 28.9 gpm as shown on Table 2

SOURCE: *Final Criteria Summary Report, Ebasco, 1994.*

Table 2
Estimated Pumping Rates for Scenario Groundwater Extraction Well System
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Well Number	Estimated Flowrates (gpm)
1-O	1.6
1-R	0.6
2-O	3.7
2-R	1.6
3-O	3.7
3-R	1.6
4-O	2.1
4-R	1.1
5-O	1.6
5-R	0.6
6-O	1.6
6-R	0.6
7-O	3.7
7-R	1.6
8-O	2.1
8-R	1.1
Totals	**28.9**

Notes:
"O' - indicates overburden well
"R" - indicates bedrock well
SOURCE: *Final Criteria Summary Report, Ebasco, 1994.*

APPENDIX D

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PRESENT VALUE ANALYSIS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW2
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

Year	Capital	O&M	5-Year Review [1]	Total	Discount Rate	Present Value
0	$235,167	$0	$0	$235,167	7.0%	$235,167
1	$0	$ 640,918.60	$0	$640,919	7.0%	$598,989
2	$0	$ 640,918.60	$0	$640,919	7.0%	$559,803
3	$0	$ 640,918.60	$0	$640,919	7.0%	$523,180
4	$0	$ 640,918.60	$0	$640,919	7.0%	$488,954
5	$0	$ 640,918.60	$50,000	$690,919	7.0%	$492,615
6	$0	$ 283,878.60	$0	$283,879	7.0%	$189,160
7	$0	$ 283,878.60	$0	$283,879	7.0%	$176,785
8	$0	$ 283,878.60	$0	$283,879	7.0%	$165,220
9	$0	$ 283,878.60	$0	$283,879	7.0%	$154,411
10	$0	$ 283,878.60	$50,000	$333,879	7.0%	$169,727
11	$0	$ 283,878.60	$0	$283,879	7.0%	$134,869
12	$0	$ 283,878.60	$0	$283,879	7.0%	$126,045
13	$0	$ 283,878.60	$0	$283,879	7.0%	$117,800
14	$0	$ 283,878.60	$0	$283,879	7.0%	$110,093
15	$0	$ 283,878.60	$50,000	$333,879	7.0%	$121,013
16	$0	$ 283,878.60	$0	$283,879	7.0%	$96,160
17	$0	$ 283,878.60	$0	$283,879	7.0%	$89,869
18	$0	$ 283,878.60	$0	$283,879	7.0%	$83,989
19	$0	$ 283,878.60	$0	$283,879	7.0%	$78,495
20	$0	$ 283,878.60	$50,000	$333,879	7.0%	$86,281
21	$0	$ 283,878.60	$0	$283,879	7.0%	$68,560
22	$0	$ 283,878.60	$0	$283,879	7.0%	$64,075
23	$0	$ 283,878.60	$0	$283,879	7.0%	$59,883
24	$0	$ 283,878.60	$0	$283,879	7.0%	$55,966
25	$0	$ 283,878.60	$50,000	$333,879	7.0%	$61,517
26	$0	$ 283,878.60	$0	$283,879	7.0%	$48,883
27	$0	$ 283,878.60	$0	$283,879	7.0%	$45,685
28	$0	$ 283,878.60	$0	$283,879	7.0%	$42,696
29	$0	$ 283,878.60	$0	$283,879	7.0%	$39,903
30	$0	$ 283,878.60	$50,000	$333,879	7.0%	$43,861
TOTAL	**$235,167**					**$5,329,654**

Note: Discount rate of 7% per EPA 540-R-00-002, OSWER 9355.0-75, July 2000, p. 4-5.

1 Five-year review lump sum cost of approximately $50,000

CAPITAL COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW2
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
1.0 Institutional Controls						
1.1	Record Survey	4	LS	$10,000	$40,000	Vendor quote; see assumptions
1.2	Attorney's Fees	4	LS	$3,100.00	$12,400	see assumptions
	Subtotal				**$52,400**	
2.0 Monitoring Well Construction						
2.1	Mobilize Drill Rig and Crew	1	LS	$340.00	$340	see assumptions
2.2	8 bedrock boreholes and 4 overburden monitoring wells	1	LS	$60,000.00	$60,000	see assumptions
2.3	Dedicated tubing for all wells	1	LS	$6,000.00	$6,000	see assumptions
2.4	IDW Disposal	1	LS	$10,000.00	$10,000	see assumptions
2.5	Oversight and Rig Geologist	180	HR	$85	$15,300	see assumptions
2.6	Oversight and Rig Geologist travel & MIE	4	Week	$1,200	$4,800	see assumptions
	Subtotal				**$96,440**	
3.0 Technical Support & Project Management						
3.1	Project Management/Engineering Support (estimate 33%)	1	LS	$49,117.20	$49,117	see assumptions
	Subtotal				**$49,117**	
4.0 Contingencies						
4.1	10% Scope & 15% Bid (25% total)	1	LS	$37,210.00	$37,210	see assumptions
	Subtotal				**$37,210**	
TOTAL DIRECT COSTS					**$235,167**	
TOTAL CAPITAL COST FOR ALTERNATIVE GW2					**$235,167**	

Notes:

OPERATIONS AND MAINTENANCE COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW2
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
OM.1.0 Groundwater Monitoring (per event)						
OM.1.1	Sampling Equipment Rental	1	LS	$5,500	$5,500	see cost assumptions
OM.1.2	Disposable equipment costs	55	EA	$20	$1,100	see cost assumptions
OM.1.3	Event Mobiliation/Demobe - FOL	12	HR	$75	$900	see cost assumptions
OM.1.4	Event Mobiliation/Demobe - Sampler (2)	24	HR	$65	$1,560	see cost assumptions
OM.1.5	Sampling Labor - FOL	138	HR	$75	$10,350	see cost assumptions
OM.1.6	Sampling Labor - Sampler (2)	276	HR	$65	$17,940	see cost assumptions
OM.1.7	Analytical Costs	103	EA	$1,050	$108,150	see cost assumptions
OM.1.8	Sampling Travel and MIE	1	EA	$9,720	$9,720	see cost assumptions
OM.1.9	Data Validation	103	HR	$100	$10,300	see cost assumptions
OM.1.10	Report Preparation	1	LS	$13,000	$13,000	see cost assumptions
	Subtotal				**$178,520**	
OM.2.0 Annual Review of Regional Land and Resource Usage						
OM.2.1	Town data review	10	HR	$65	$650	see cost assumptions
OM.2.2	Report Preparation	1	LS	$500	$500	see cost assumptions
	Subtotal				**$1,150**	
OM.3.0 Monitoring and Annual Reporting Engineering and Manangement Support						
OM.3.1	Project Management/Engineering Support (estimate 33%)	1	LS	$59,291	$59,291	see cost assumptions
	Subtotal				**$59,291**	
OM.4.0 O&M Contingencies						
OM.4.1	10% Scope & 15% Bid (25% total)	1	LS	$44,918	$44,918	see cost assumptions
	Subtotal				**$44,918**	
FY.1.0 Five-Year Reviews						
FY.1.1	Five-Year Review report preparation	1	LS	$50,000	$50,000	see cost assumptions
	Subtotal				**$50,000**	

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW2
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

Capital Cost Assumptions		
1.0 Institutional Controls		
1.1	Record Boundary Survey	Approximate costs per parcel for a deed record survey including meets and bounds. Assumes 2 parcels, the remaining 2 parcels are managed under the source control remedy.
1.2	Attorney's Fees	Attorney's fees associated with title research, drafting the restrictive covenants, and attaching a restriction to a deed for a single parcel (assume 4), includes any registry fees ($84 for the first page, $1 for each additional page).
2.0 Monitoring Well Construction		
2.1	Mobilize Drill Rig and Crew	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
2.2	8 bedrock boreholes and 4 overburden monitoring wells	Drilling depths: four new bedrock wells east of source area at 200 feet per boring, through a 6" borehole assumes no clearing/grubbing will be required. Drilling depths for four new bedrock wells north of the source area at 100 feet per boring. Four new overburden monitoring wells located north of the source area to a depth of 30 feet. Bedrock boreholes will be fitted with 2" Schedule 80 PVC wells installed (20-foot 10-slot screen size). Overburden wells will be constructed of 2" Schedule 40 PVC (10-foot 10-slot screens). Assumes drilling can be completed in 18 days, with 15 overnight stays. Overburden drilled using drive and wash drilling, with SPT every 5 feet. Bedrock drilled using 6" air hammer.
2.3	Dedicated tubing for all wells	Assumes approximately 4000 feet of bonded tubing (one side Teflon-lined).
2.4	IDW Disposal	Assumes <20 tons of drill cuttings, characterization (VOCs, RCRA8 metals, characteristics), and a mobilization/fuel fee.
2.5	Oversight and Rig Geologist	Assumes 1 rig geologist travel and stay on-site for 10 10-hour days plus travel
2.6	Oversight and Rig Geologist travel & MIE	Assumes GSA Per-Diem lodging and MIE for 1 person over two weeks in Providence County.
3.0 Technical Support & Project Management		
3.1	Project Management/Engineering Support (estimate 33%)	As expected capital costs are between $100,000 and $500,000, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS, the costs associated with remedial design (15%), routine project management (8%), engineering support, oversight, and bid preparations (10%) are carried as percentages (as indicated) of the expected capital costs.
4.0 Contingencies		
4.1	10% Scope & 15% Bid (25% total)	A 10% scope contingency and 15% bid contingency was used. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design.

Operations and Maintenance Cost Assumptions		
OM.1.0 Groundwater Monitoring (per event)		
Groundwater monitoring costs were estimated for a single monitoring event. For long-term O&M, it was assumed that monitoring would occur triannually for the first five (5) years after construction, and annually thereafter. One annual summary and assessment report is assumed.		
OM.1.1	Sampling Equipment Rental	Includes groundwater pumps (3), controllers (3), and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1). For a period of two weeks. Costs based upon vendor rental quote.
OM.1.2	Disposable equipment costs	Includes a bladder replacement kit for each sample, based upon a vendor quote.
OM.1.3	Event Mobilization/Demobe - FOL	Travel time to and from Site = 4 hours per week, three weeks
OM.1.4	Event Mobilization/Demobe - Sampler (2)	Travel time to and from Site = 4 hours per week, three weeks
OM.1.5	Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee 2 samplers, manage and track analytical sample collection, collect samples as available, and conduct field audits. Level D PPE
OM.1.6	Sampling Labor - Sampler (2)	Assume samples collected from 55 wells at 10 hours per day over three weeks per event. Time required for QC sample collection not specifically included. SW sample (10 samples) and SED samples time required to collect the sample considered minimal. Level D PPE.
OM.1.7	Analytical Costs	Analyses include: GW - VOCs, SVOCs, pesticides, metals, chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen; SW - VOCs, SVOCs, Pest, metals; SED - SVOCs, pest, metals. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, trip blanks considered negligible. Costs based upon a variety of vendor-supplied costs.
OM.1.8	Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and two staff scientists in Providence County, two rental vehicles and fuel (assume $720 per week) for a period of 3 weeks per event.
OM.1.9	Data Validation	Assume 1 HR per sample analysis for data validation.
OM.1.10	Report Preparation	Assume 120 hours for report preparation at $100/HR. Other direct costs (copying/printing/delivery) at $1,000.

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW2
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

OM.2.0 Annual Review of Regional Land and Resource Usage		
OM.2.1	Town data review	Travel time to and from the Site = 4 hours; 6 hours record review/interview time for $65/hour worker. Reviews performed annually to examine the land use and water withdrawals in the area for any changes. Large changes in either of these categories may require additional investigation to determine if the remedy is protective.
OM.2.2	Report Preparation	Assume 4 HR for report preparation at $100/HR. Other costs (copying/printing/delivery) at $100
OM.3.0 O&M Contingencies		
OM.3.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design.
OM.4.0 Technical Support and Project Management		
OM.4.1	Project Management/Engineering Support	As expected capital costs are between $100,000 and $500,000, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS, the costs associated with remedial design (15%), routine project management (8%), engineering support, oversight, and bid preparations (10%) are carried as percentages (as indicated) of the expected capital costs.
FY.1.0 Five-Year Reviews		
FY.1.1	Five-Year Review Preparation	Estimated at $50,000 each report, based upon current estimates of in-progress work. Management and technical support costs are included in this cost. No contingencies are applied.

PRESENT VALUE ANALYSIS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW3A
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

Year	Capital	O&M	5-Year Review [1]	Total	Discount Rate	Present Value
0	$4,738,912	$0	$0	$4,738,912	7.0%	$4,738,912
1	$0	$ 645,107.20	$0	$645,107	7.0%	$602,904
2	$0	$ 645,107.20	$0	$645,107	7.0%	$563,462
3	$0	$ 645,107.20	$0	$645,107	7.0%	$526,600
4	$0	$ 645,107.20	$0	$645,107	7.0%	$492,149
5	$0	$ 645,107.20	$50,000	$695,107	7.0%	$495,602
6	$0	$ 285,727.20	$0	$285,727	7.0%	$190,392
7	$0	$ 285,727.20	$0	$285,727	7.0%	$177,937
8	$0	$ 285,727.20	$0	$285,727	7.0%	$166,296
9	$0	$ 285,727.20	$0	$285,727	7.0%	$155,417
10	$0	$ 285,727.20	$50,000	$335,727	7.0%	$170,667
11	$0	$ 285,727.20	$0	$285,727	7.0%	$135,747
12	$0	$ 285,727.20	$0	$285,727	7.0%	$126,866
13	$0	$ 285,727.20	$0	$285,727	7.0%	$118,567
14	$0	$ 285,727.20	$0	$285,727	7.0%	$110,810
15	$0	$ 285,727.20	$50,000	$335,727	7.0%	$121,683
16	$0	$ 285,727.20	$0	$285,727	7.0%	$96,786
17	$0	$ 285,727.20	$0	$285,727	7.0%	$90,454
18	$0	$ 285,727.20	$0	$285,727	7.0%	$84,536
19	$0	$ 285,727.20	$0	$285,727	7.0%	$79,006
20	$0	$ 285,727.20	$50,000	$335,727	7.0%	$86,758
21	$0	$ 285,727.20	$0	$285,727	7.0%	$69,007
22	$0	$ 285,727.20	$0	$285,727	7.0%	$64,492
23	$0	$ 285,727.20	$0	$285,727	7.0%	$60,273
24	$0	$ 285,727.20	$0	$285,727	7.0%	$56,330
25	$0	$ 285,727.20	$50,000	$335,727	7.0%	$61,857
26	$0	$ 285,727.20	$0	$285,727	7.0%	$49,201
27	$0	$ 285,727.20	$0	$285,727	7.0%	$45,982
28	$0	$ 285,727.20	$0	$285,727	7.0%	$42,974
29	$0	$ 285,727.20	$0	$285,727	7.0%	$40,163
30	$0	$ 285,727.20	$50,000	$335,727	7.0%	$44,104
TOTAL	**$4,738,912**					**$9,865,932**

Note: Discount rate of 7% per EPA 540-R-00-002, OSWER 9355.0-75, July 2000, p. 4-5.

1 Five-year review lump sum cost of approximately $50,000

CAPITAL COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW3A
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
1.0 Institutional Controls						
1.1	Record Survey	2	LS	$10,000	$20,000	Vendor quote; see assumptions
1.2	Attorney's Fees	2	LS	$3,100.00	$6,200	see assumptions
	Subtotal				**$26,200**	
2.0 Monitoring Well Construction						
2.1	Mobilize Drill Rig and Crew	1	LS	$340.00	$340	see assumptions
2.2	10 bedrock boreholes and 4 overburden monitoring wells	1	LS	$66,000.00	$66,000	see assumptions
2.3	Dedicated tubing for all wells	1	LS	$6,000.00	$6,000	see assumptions
2.4	IDW Disposal	1	LS	$10,000.00	$10,000	see assumptions
2.5	Oversight and Rig Geologist	200	HR	$85	$17,000	see assumptions
2.6	Oversight and Rig Geologist travel & MIE	4	Week	$1,200	$4,800	see assumptions
	Subtotal				**$104,140**	
3.0 Pre-Design Investigation						
3.1	Mobilize Drill Rig and Crew	1	LS	$340.00	$340	see assumptions
3.2	40 Overburden borings drilled	1	LS	$111,420.00	$111,420	see assumptions
3.3	Oversight Geologist	1	LS	$16,520.00	$16,520	see assumptions
3.4	Soil, Groundwater , Surface Water, Sediment Analytical	1	LS	$102,346.00	$102,346	see assumptions
3.5	PDI Completion and Summary Report Preparation	1	LS	$34,810.00	$34,810	see assumptions
	Subtotal				**$265,436**	
4.0 In-Situ Chemical Reduction & Biodegradation Injections						
4.1	Pre-Design Bench/Pilot-Scale Testing & Evaluation	1	LS	$400,000.00	$400,000	see assumptions
4.2	Site Facilities, Utilities, Laydown Area Preparation	1	LS	$14,732.00	$14,732	see assumptions
4.3	Potable Water Supply (saturated soil)	19	Delivery	$275.00	$5,225	Vendor quote; see assumptions
4.4	Potable Water Storage	10	Month	$1,036.00	$9,842	Vendor quote; see assumptions
4.5	Potable Water Storage Spot Charge	4	LS	$3,000.00	$12,000	Vendor quote; see assumptions
4.6	Injection Site Preparation	0	LS	$6,600.00	$0	see assumptions
4.7	Weight Dispersion	0	LS	$600.00	$0	see assumptions
4.8	Injection Contractor Mobe/Demobe	4	LS	$1,000.00	$4,000	Vendor quote; see assumptions
4.9	Chemical Reductant & Substrate Fluid (saturated soil)	136,800	Gallon	$2.16	$295,488	see assumptions
4.10	Injection of Chemical Reductant (saturated soil)	1,710	per location	$482.00	$824,220	see assumptions
4.11	Injection Contractor Project/Construction Management	4	LS	$41,000.00	$164,000	Vendor quote; see assumptions
4.12	Potable Water Supply (unsaturated soil)	6	Delivery	$275.00	$1,650	Vendor quote; see assumptions
4.13	Chemical Reductant & Substrate Fluid (unsaturated soil)	42,300	Gallon	$2.16	$91,368	see assumptions
4.14	Injection of Chemical Reductant (unsaturated soil)	952	per location	$241.00	$229,432	see assumptions
	Subtotal				**$2,051,957**	
5.0 In-Situ Chemical Reduction & Biodegradation Injection Oversight & Monitoring						
5.1	Oversight and Construction Monitoring	2,309	HR	$85.00	$196,223	see cost assumptions
5.2	Oversight and Construction Monitoring Travel & MIE	43	Week	$1,200.00	$51,300	see cost assumptions
5.3	Post-Injection GW Sampling Equipment Rental	4	LS	$5,500.00	$22,000	see cost assumptions
5.4	Post-Injection GW Disposable equipment costs	70	EA	$20.00	$1,400	see cost assumptions
5.5	Post-Injection GW Event Mobiliation/Demobe - FOL	16	HR	$85.00	$1,360	see cost assumptions
5.6	Post-Injection Event Mobiliation/Demobe - Samplers	20	HR	$65.00	$1,300	see cost assumptions
5.7	Post-Injection GW Sampling Labor - FOL	250	HR	$85.00	$21,250	see cost assumptions
5.8	Post-Injection GW Sampling Labor - Sampler (1)	250	HR	$65.00	$16,250	see cost assumptions
5.9	Post-Injection GW Sampling Travel and MIE	5	EA	$2,040.00	$10,200	see cost assumptions
5.10	Post-Injection GW Analytical Costs	130	EA	$700.00	$91,000	see cost assumptions
5.11	Post-Injection Confirmation Drilling Mobilization	1	LS	$340.00	$340	Vendor quote; see assumptions
5.12	Post-Injection Confirmation Case & Wash Drilling	1	LS	$74,000.00	$74,000	Vendor quote; see assumptions
5.13	Post-Injection Confirmation Drilling IDW Disposal	1	LS	$3,750.00	$3,750	see cost assumptions
5.14	Post-Injection Confirmation Drilling Equipment Rental	1	LS	$800.00	$800	Vendor quote; see assumptions
5.15	Oversight and Rig Geologist	216	HR	$85.00	$18,360	see cost assumptions
5.16	Oversight and Rig Geologist travel & MIE	4	Week	$1,200.00	$4,800	see cost assumptions
5.17	Post-Injection Confirmation Soil Sample Analyses	100	EA	$110.00	$11,000	see cost assumptions
5.18	Post-Injection Data Validation	230	HR	$100.00	$23,000	see cost assumptions
5.19	Post-Injection Completion Report Preparation	1	LS	$150,000.00	$150,000	see cost assumptions
	Subtotal				**$698,333**	
6.0 In-Situ Chemical Reduction & Biodegradation Injection Engineering and Manangement Support						
6.1	Permit preparation & regulatory interface	100	HR	$85.00	$8,500	see assumptions
6.2	Project Management/Engineering Support (estimate 30%)	1	LS	$864,189	$864,189	see assumptions
6.3	**Subtotal**				**$872,689**	

CAPITAL COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW3A
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
7.0 Contingencies						
7.1	10% Scope & 15% Bid (25% total)	1	LS	$720,157	$720,157	see assumptions
	Subtotal				**$720,157**	
TOTAL DIRECT COSTS					**$4,738,912**	
TOTAL CAPITAL COST FOR ALTERNATIVE GW3A					**$4,738,912**	

Notes:

OPERATIONS AND MAINTENANCE COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW3A
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
OM.1.0 Groundwater Monitoring (per event)						
OM.1.1	Sampling Equipment Rental	1	LS	$5,500	$5,500	see cost assumptions
OM.1.2	Disposable equipment costs	56	EA	$20	$1,120	see cost assumptions
OM.1.3	Event Mobiliation/Demobe - FOL	12	HR	$75	$900	see cost assumptions
OM.1.4	Event Mobiliation/Demobe - Sampler (2)	24	HR	$65	$1,560	see cost assumptions
OM.1.5	Sampling Labor - FOL	138	HR	$75	$10,350	see cost assumptions
OM.1.6	Sampling Labor - Sampler (2)	276	HR	$65	$17,940	see cost assumptions
OM.1.7	Analytical Costs	104	EA	$1,050	$109,200	see cost assumptions
OM.1.8	Sampling Travel and MIE	1	EA	$9,720	$9,720	see cost assumptions
OM.1.9	Data Validation	104	HR	$100	$10,400	see cost assumptions
OM.1.10	Report Preparation	1	LS	$13,000	$13,000	see cost assumptions
	Subtotal				**$179,690**	
OM.2.0 Annual Review of Regional Land and Resource Usage						
OM.2.1	Town data review	10	HR	$65	$650	see cost assumptions
OM.2.2	Report Preparation	1	LS	$500	$500	see cost assumptions
	Subtotal				**$1,150**	
OM.3.0 Monitoring and Annual Reporting Engineering and Manangement Support						
OM.3.1	Project Management/Engineering Support (estimate 33%)	1	LS	$59,677	$59,677	see cost assumptions
	Subtotal				**$59,677**	
OM.4.0 O&M Contingencies						
OM.4.1	10% Scope & 15% Bid (25% total)	1	LS	$45,210	$45,210	see cost assumptions
	Subtotal				**$45,210**	
FY.1.0 Five-Year Reviews						
FY.1.1	Five-Year Review report preparation	1	LS	$50,000	$50,000	see cost assumptions
	Subtotal				**$50,000**	

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Capital Cost Assumptions		
1.0 Institutional Controls		
1.1	Record Boundary Survey	Approximate costs per parcel for a deed record survey including meets and bounds. Assumes 2 parcels.
1.2	Attorney's Fees	Attorney's fees associated with title research, drafting the restrictive covenants, and attaching a restriction to a deed for a single parcel (assume 2), includes any registry fees ($84 for the first page, $1 for each additional page).
2.0 Monitoring Well Construction		
2.1	Mobilize Drill Rig and Crew	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
2.2	10 bedrock boreholes and 4 overburden monitoring wells	Drilling depths: four new bedrock wells east of source area at 200 feet per boring, through a 6" borehole assumes no clearing/grubbing will be required. Drilling depths for four new bedrock wells north of the source area at 100 feet per boring. Four new overburden monitoring wells located north of the source area to a depth of 30 feet. Bedrock boreholes will be fitted with 2" Schedule 80 PVC wells installed (20-foot 10-slot screen size). Two new bedrock wells north of OW-094-R at the edge of the former source area at 100 feet per boring. Overburden wells will be constructed of 2" Schedule 40 PVC (10-foot 10-slot screens). Assumes drilling can be completed in 20 days, with 15 overnight stays. Overburden drilled using drive and wash drilling, with SPT every 5 feet. Bedrock drilled using 6" air hammer.
2.3	Dedicated tubing for all wells	Assumes approximately 4000 feet of bonded tubing (one side Teflon-lined).
2.4	IDW Disposal	Assumes <20 tons of drill cuttings, characterization (VOCs, RCRA8 metals, characteristics), and a mobilization/fuel fee.
2.5	Oversight and Rig Geologist	Assumes 1 rig geologist travel and stay on-site for 20 10-hour days plus travel
2.6	Oversight and Rig Geologist travel & MIE	Assumes GSA Per-Diem lodging and MIE for 1 person over two weeks in Providence County.
3.0 Pre-Design Investigation		
3.1	Mobilize Drill Rig and Crew	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
3.2	40 Overburden borings drilled	Drilling using drive and wash techniques to the bedrock surface with continuous split spoon sampling.
3.3	Oversight Geologist	Assumes 1 rig geologist travel and stay on-site for 14 10-hour days plus travel
3.4	Soil, Groundwater , Surface Water, Sediment Analytical	Assumes two soil samples per boring and 15 groundwater samples analyzed for VOCs, SVOCs, PCBs, metals.
3.5	PDI Completion and Summary Report Preparation	Report that summarizes the findings of the PDI including revised mass estimates, identification of significant differences between the current conceptual site model and the obtained data, risk evaluation for non-VOC contaminants, and an evaluation of the unsaturated contaminated soil zone. Assumes data validation is completed on both soil and groundwater datasets.
4.0 In-Situ Chemical Reduction & Biodegradation Injections		
4.1	Pre-Design Bench/Pilot-Scale Testing & Evaluation	Assumption based upon past experience with similar technologies as well as vendor-supplied suggestions. Assumes the bench testing of several potentially-viable treatment reagents to determine the most cost-effective substance and an anticipated loading rate, and the field pilot-scale testing of the selected substance to gauge in-field implementation, injection details, and aquifer response. Pre-Design Investigation also includes costs to determine if the soil contamination in the saturated zone is indeed limited to the source area, as currently defined. The pilot test includes post-test soil and groundwater sample collection and a completion/evaluation report.
4.2	Site Facilities, Utilities, Laydown Area Preparation	Includes one 40' storage container (doors at both ends) ($106/month), one 36X10 office trailer with steps and security screens ($350 per month), one-time charges for trailer delivery/pickup, hurricane straps installation, security screen installation, deadbolt installation, and steps setup/knockdown (lump sum of $800), one tow-behind generator (with weekly diesel refills of 40 gallons at $4.00/gallon delivered) ($440/month), electrician to hookup and knockdown connection between generator and trailer ($1,000), dumpster with weekly solid waste removal services ($315/month), one portable restroom with weekly cleaning ($95/month), cellular phone (email and internet capability at $100/month), laptop computer & printer ($1,000), camera ($250), and expendables (assume $200/month). Assume the duration of the project is 24 months.
4.3	Potable Water Supply (saturated soil)	Estimated volume of 137,000 gallons delivered in 7,500 gallon tanker loads. This volume assumes 4 injections; the first at 100% of the targeted volume, the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the target volume. These volumes are based on the presumption that as the injections proceed, less reagent will be required to reduce the remaining contaminant mass.
4.4	Potable Water Storage	Assumes 1 21,000-gallon mobile storage tank for a period of 10 months (assumed duration of the injection programs).
4.5	Potable Water Storage Spot Charge	Assumes 4 separate mobilizations of the storage tank.

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4.0 In-Situ Chemical Reduction & Biodegradation Injections (Continued)		
4.6	Injection Site Preparation	Work area is currently reasonable flat and open. No preparation is required.
4.7	Weight Dispersion	Work area is stable, no dispersion is required.
4.8	Injection Contractor Mobe/Demobe	Vendor estimate. Mobilization from southeastern Massachusetts.
4.9	Chemical Reductant & Substrate Fluid (saturated soil)	Vendor estimate for a combined injection of substrate and reductant at 80 gallons per location (684 injection locations). Four injections are proposed that are pro-rated as follows: the first at 100% of the targeted volume (approximately 55,000 gallons), the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the target volume. Assumes subcontractor crew, labor, equipment, travel and MIE for approximately 214 injection days. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.10	Injection of Chemical Reductant (saturated soil)	Over the course of four injections, a total of 1,710 individual injection locations based on an estimated 10-foot radius of influence will be advanced. A daily injection rate of 8 locations is anticipated. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.11	Injection Contractor Project/Construction Management	Vendor estimate for management of each injection event. It is assumed that roughly the same amount of management and preparation time will be required regardless of the volume of the injections. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.12	Potable Water Supply (unsaturated soil)	Estimated volume of 42,300 gallons delivered in 7,500 gallon tanker loads. This volume assumes 4 injections; the first at 100% of the targeted volume, the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the target volume. These volumes are based on the presumption that as the injections proceed, less reagent will be required to reduce the remaining contaminant mass.
4.13	Chemical Reductant & Substrate Fluid (unsaturated soil)	Vendor estimate for a combined injection of substrate and reductant at 40 gallons per location (423 injection locations). Four injections are proposed that are pro-rated as follows: the first at 100% of the targeted volume (approximately 72,000 gallons), the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the target volume. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.14	Injection of Chemical Reductant (unsaturated soil)	Over the course of four injections, a total of 952 individual injection locations based on an estimated 10-foot radius of influence will be advanced. A daily injection rate of 8 locations is anticipated. The costs supplied by the vendor were based on two injections per location. This per-injection cost of $241 was used to estimate the injection costs associated with unsaturated soil injections. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.

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5.0 In-Situ Chemical Reduction & Biodegradation Injection Oversight & Monitoring		
5.1	Oversight and Construction Monitoring	Assumes one project engineer at a loaded rate of $85/hour for each of the four injections (total of 43 weeks, at 10 hours per day plus 4 hours travel per week) and the pre-injection site setup (assume 1 week per event plus 4 hours travel per week).
5.2	Oversight and Construction Monitoring Travel & MIE	Includes the GSA per-diem lodging and MIE for one project engineer in Providence County, rental vehicle and fuel (assume $360 per week) for a period of 43 weeks.
5.3	Post-Injection GW Sampling Equipment Rental	Includes groundwater pumps, controllers, and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1) for two weeks for each event. Costs based upon vendor rental quote. Assume one post-injection monitoring per injection (4 separate injections), and an additional round approximately 1 year after treatment.
5.4	Post-Injection GW Disposable equipment costs	Assume 14 locations at the end of each injection.
5.5	Post-Injection GW Event Mobilization/Demobe - FOL	Assume 4 hour round trip per event for 5 events for one project engineer
5.6	Post-Injection Event Mobilization/Demobe - Samplers	Assume 4 hour round trip per event for 5 events for one staff scientist
5.7	Post-Injection GW Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee sampler, manage and track analytical sample collection, collect samples as available, and conduct field audits.
5.8	Post-Injection GW Sampling Labor - Sampler (1)	Each event includes samples collected from 14 wells at 10 hours per day over one week. Time required for QC sample collection not specifically included, but is likely negligible at this scale. Five events are planned.
5.9	Post-Injection GW Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and one staff scientist in Providence County, one rental vehicle and fuel for a period of 1 week total. Five events are planned.
5.10	Post-Injection GW Analytical Costs	Analyses include: VOCs, chloride, sulfate, sulfide, iron, manganese, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, trip blanks considered negligible. Costs based upon a variety of vendor-supplied costs. 70 samples are proposed (plus QC samples).
5.11	Post-Injection Confirmation Drilling Mobilization	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
5.12	Post-Injection Confirmation Case & Wash Drilling	Assumes 40 boreholes to the bedrock surface, with continuous soil sampling. Decon between borehole locations. Backfill boreholes with grout. Assume four weeks worth of drilling at two boreholes per day.
5.13	Post-Injection Confirmation Drilling IDW Disposal	Assumes <5 tons of drill cuttings, characterization (VOCs, RCRA8 metals, characteristics), and a mobilization/fuel fee.
5.14	Post-Injection Confirmation Drilling Equipment Rental	Assumes four weeks rental of a PID.
5.15	Oversight and Rig Geologist	Assume four weeks oversight for one rig geologist at 10 hours per day plus four hours per week of travel time.
5.16	Oversight and Rig Geologist travel & MIE	Assumes GSA Per-Diem lodging and MIE for 1 person over two weeks in Providence County.
5.17	Post-Injection Confirmation Soil Sample Analyses	Assume 80 soil samples and 20 QC samples for VOC (8260b).
5.18	Post-Injection Data Validation	Assume 1 HR per sample analysis for data validation.
5.19	Post-Injection Completion Report Preparation	Report to summarize the injection events, observations, monitoring, analytical results obtained, and an evaluation of remedial goals. Costs based upon a scale-up of the report preparation costs associated with the long-term monitoring. An additional evaluation of remedial success and comparison to remedial goals and reduction efficiency were also included.
6.0 In-Situ Chemical Reduction & Biodegradation Injection Engineering and Management Support		
6.1	Permit preparation & regulatory interface	Cost estimate to include permit procurement for underground injection, activities within a wetland, and general discussion with State and local regulators.
6.2	Project Management/Engineering Support (estimate 30%)	Costs assume that each injection event will require coordination and engineering support to complete as the events are modified to meet the goal of each injection. The capital costs associated with each event fall within the $500,000 to $2,000,000 range, and according to the EPA Guide to Developing and Documenting Cost Estimates During the FS, a technical support and project management capital cost percentage of 28% is recommended. This was increased to 30% to account for the difficulties expected associated with the underground injection of materials.
7.0 Capital Contingencies		
7.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design. Given the presented scope activities includes a variety of potential difficulties, a scope contingency of 10% was carried. Given the lack of an extensive subsurface profile, a bid contingency of 15% was carried.

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Operations and Maintenance Cost Assumptions		
OM.1.0 Groundwater Monitoring (per event)		
Groundwater monitoring costs were estimated for a single monitoring event. For long-term O&M, it was assumed that monitoring would occur triannually for the first five (5) years after construction, and annually thereafter. One annual summary and assessment report is assumed.		
OM.1.1	Sampling Equipment Rental	Includes groundwater pumps (3), controllers (3), and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1). For a period of two weeks. Costs based upon vendor rental quote.
OM.1.2	Disposable equipment costs	Includes a bladder replacement kit for each sample, based upon a vendor quote.
OM.1.3	Event Mobilization/Demobe - FOL	Travel time to and from Site = 4 hours per week, three weeks
OM.1.4	Event Mobilization/Demobe - Sampler (2)	Travel time to and from Site = 4 hours per week, three weeks
OM.1.5	Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee 2 samplers, manage and track analytical sample collection, collect samples as available, and conduct field audits. Level D PPE
OM.1.6	Sampling Labor - Sampler (2)	Assume samples collected from 55 wells at 10 hours per day over three weeks per event. Time required for QC sample collection not specifically included. SW sample (10 samples) and SED samples time required to collect the sample considered minimal. Level D PPE.
OM.1.7	Analytical Costs	Analyses include: GW - VOCs, SVOCs, pesticides, metals, chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen; SW - VOCs, SVOCs, Pest, metals; SED - SVOCs, pest, metals. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, trip blanks considered negligible. Costs based upon a variety of vendor-supplied costs.
OM.1.8	Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and two staff scientists in Providence County, two rental vehicles and fuel (assume $720 per week) for a period of 3 weeks per event.
OM.1.9	Data Validation	Assume 1 HR per sample analysis for data validation.
OM.1.10	Report Preparation	Assume 120 hours for report preparation at $100/HR. Other direct costs (copying/printing/delivery) at $1,000.
OM.2.0 Annual Review of Regional Land and Resource Usage		
OM.2.1	Town data review	Travel time to and from the Site = 4 hours; 6 hours record review/interview time for $65/hour worker. Reviews performed annually to examine the land use and water withdrawals in the area for any changes. Large changes in either of these categories may require additional investigation to determine if the remedy is protective.
OM.2.2	Report Preparation	Assume 4 HR for report preparation at $100/HR. Other costs (copying/printing/delivery) at $100
OM.3.0 O&M Contingencies		
OM.3.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design.
OM.4.0 Technical Support and Project Management		
OM.4.1	Project Management/Engineering Support	As expected capital costs are between $100,000 and $500,000, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS, the costs associated with remedial design (15%), routine project management (8%), engineering support, oversight, and bid preparations (10%) are carried as percentages (as indicated) of the expected capital costs.
FY.1.0 Five-Year Reviews		
FY.1.1	Five-Year Review Preparation	Estimated at $50,000 each report, based upon current estimates of in-progress work. Management and technical support costs are included in this cost. No contingencies are applied.

PRESENT VALUE ANALYSIS
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Year	Capital	O&M	5-Year Review [1]	Total	Discount Rate	Present Value
0	$6,152,524	$0	$0	$6,152,524	7.0%	$6,152,524
1	$0	$ 645,107.20	$0	$645,107	7.0%	$602,904
2	$0	$ 645,107.20	$0	$645,107	7.0%	$563,462
3	$0	$ 645,107.20	$0	$645,107	7.0%	$526,600
4	$0	$ 645,107.20	$0	$645,107	7.0%	$492,149
5	$0	$ 645,107.20	$50,000	$695,107	7.0%	$495,602
6	$0	$ 285,727.20	$0	$285,727	7.0%	$190,392
7	$0	$ 285,727.20	$0	$285,727	7.0%	$177,937
8	$0	$ 285,727.20	$0	$285,727	7.0%	$166,296
9	$0	$ 285,727.20	$0	$285,727	7.0%	$155,417
10	$0	$ 285,727.20	$50,000	$335,727	7.0%	$170,667
11	$0	$ 285,727.20	$0	$285,727	7.0%	$135,747
12	$0	$ 285,727.20	$0	$285,727	7.0%	$126,866
13	$0	$ 285,727.20	$0	$285,727	7.0%	$118,567
14	$0	$ 285,727.20	$0	$285,727	7.0%	$110,810
15	$0	$ 285,727.20	$50,000	$335,727	7.0%	$121,683
16	$0	$ 285,727.20	$0	$285,727	7.0%	$96,786
17	$0	$ 285,727.20	$0	$285,727	7.0%	$90,454
18	$0	$ 285,727.20	$0	$285,727	7.0%	$84,536
19	$0	$ 285,727.20	$0	$285,727	7.0%	$79,006
20	$0	$ 285,727.20	$50,000	$335,727	7.0%	$86,758
21	$0	$ 285,727.20	$0	$285,727	7.0%	$69,007
22	$0	$ 285,727.20	$0	$285,727	7.0%	$64,492
23	$0	$ 285,727.20	$0	$285,727	7.0%	$60,273
24	$0	$ 285,727.20	$0	$285,727	7.0%	$56,330
25	$0	$ 285,727.20	$50,000	$335,727	7.0%	$61,857
26	$0	$ 285,727.20	$0	$285,727	7.0%	$49,201
27	$0	$ 285,727.20	$0	$285,727	7.0%	$45,982
28	$0	$ 285,727.20	$0	$285,727	7.0%	$42,974
29	$0	$ 285,727.20	$0	$285,727	7.0%	$40,163
30	$0	$ 285,727.20	$50,000	$335,727	7.0%	$44,104
TOTAL	**$6,152,524**					**$11,279,544**

Note: Discount rate of 7% per EPA 540-R-00-002, OSWER 9355.0-75, July 2000, p. 4-5.

1 Five-year review lump sum cost of approximately $50,000

CAPITAL COST SUMMARY
FOCUSED FEASIBILITY STUDY
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DAVIS LIQUID WASTE SITE
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	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
1.0 Institutional Controls						
1.1	Record Survey	2	LS	$10,000	$20,000	Vendor quote; see assumptions
1.2	Attorney's Fees	2	LS	$3,100.00	$6,200	see assumptions
	Subtotal				**$26,200**	
2.0 Monitoring Well Construction						
2.1	Mobilize Drill Rig and Crew	1	LS	$340.00	$340	see assumptions
2.2	10 bedrock boreholes and 4 overburden monitoring wells	1	LS	$66,000.00	$66,000	see assumptions
2.3	Dedicated tubing for all wells	1	LS	$6,000.00	$6,000	see assumptions
2.4	IDW Disposal	1	LS	$10,000.00	$10,000	see assumptions
2.5	Oversight and Rig Geologist	180	HR	$85	$15,300	see assumptions
2.6	Oversight and Rig Geologist travel & MIE	4	Week	$1,200	$4,800	see assumptions
	Subtotal				**$102,440**	
3.0 Pre-Design Investigation						
3.1	Mobilize Drill Rig and Crew	1	LS	$340.00	$340	see assumptions
3.2	40 Overburden borings drilled	1	LS	$111,420.00	$111,420	see assumptions
3.3	Oversight Geologist	1	LS	$16,520.00	$16,520	see assumptions
3.4	Soil, Groundwater , Surface Water, Sediment Analytical	1	LS	$102,346.00	$102,346	see assumptions
3.5	PDI Completion and Summary Report Preparation	1	LS	$34,810.00	$34,810	see assumptions
	Subtotal				**$265,436**	
4.0 In-Situ Chemical Reduction & Biodegradation Injections						
4.1	Pre-Design Bench/Pilot-Scale Testing & Evaluation	1	LS	$175,000.00	$175,000	see assumptions
4.2	Site Facilities, Utilities, Laydown Area Preparation	1	LS	$28,321.00	$28,321	see assumptions
4.3	Potable Water Supply (Saturated Soil and dissolved groundwater)	27	Delivery	$275.00	$7,421	Vendor quote; see assumptions
4.4	Potable Water Storage	14	Month	$1,036.00	$14,562	Vendor quote; see assumptions
4.5	Potable Water Storage Spot Charge	4	LS	$3,000.00	$12,000	Vendor quote; see assumptions
4.6	Injection Site Preparation	1	LS	$3,300.00	$3,300	Means, 2005; see assumptions
4.7	Weight Dispersion	0	LS	$600.00	$0	Vendor quote; see assumptions
4.8	Injection Contractor Mobe/Demobe	4	LS	$1,000.00	$4,000	Vendor quote; see assumptions
4.9	Chemical Reductant & Substrate Fluid (saturated soil and dissolved groundwater)	202,400	Gallon	$2.16	$437,184	see assumptions
4.10	Injection of Chemical Reductant (saturated soil and dissolved groundwater)	2,530	per location	$482.00	$1,219,460	see assumptions
4.11	Injection Contractor Project/Construction Management	4	LS	$77,000.00	$308,000	Vendor quote; see assumptions
4.12	Potable Water Supply (unsaturated soil)	6	Delivery	$275.00	$1,650	Vendor quote; see assumptions
4.13	Chemical Reductant & Substrate Fluid (unsaturated soil)	42,300	Gallon	$2.16	$91,368	see assumptions
4.14	Injection of Chemical Reductant (unsaturated soil)	952	per location	$241.00	$229,432	see assumptions
	Subtotal				**$2,531,698**	
5.0 In-Situ Chemical Reduction & Biodegradation Injection Oversight & Monitoring						
5.1	Oversight and Construction Monitoring	3,163	HR	$85.00	$268,813	see cost assumptions
5.2	Oversight and Construction Monitoring Travel & MIE	63	Week	$1,200.00	$75,900	see cost assumptions
5.3	Post-Injection Sampling Equipment Rental	5	LS	$5,500.00	$27,500	see cost assumptions
5.4	Post-Injection Disposable equipment costs	235	EA	$20.00	$4,700	see cost assumptions
5.5	Post-Injection Event Mobiliation/Demobe - FOL	20	HR	$85.00	$1,700	see cost assumptions
5.6	Post-Injection Event Mobiliation/Demobe - Samplers (2)	40	HR	$65.00	$2,600	see cost assumptions
5.7	Post-Injection Sampling Labor - FOL	500	HR	$85.00	$42,500	see cost assumptions
5.8	Post-Injection Sampling Labor - Sampler (2)	1,000	HR	$65.00	$65,000	see cost assumptions
5.9	Post-Injection Sampling Travel and MIE	5	EA	$3,240.00	$16,200	see cost assumptions
5.10	Post-Injection Analytical Costs	345	EA	$700.00	$241,500	see cost assumptions
5.11	Post-Injection Confirmation Drilling Mobilization	1	LS	$340.00	$340	Vendor quote; see assumptions
5.12	Post-Injection Confirmation Case & Wash Drilling	1	LS	$74,000.00	$74,000	Vendor quote; see assumptions
5.13	Post-Injection Confirmation Drilling IDW Disposal	1	LS	$3,750.00	$3,750	see cost assumptions
5.14	Post-Injection Confirmation Drilling Equipment Rental	1	LS	$800.00	$800	Vendor quote; see assumptions
5.15	Oversight and Rig Geologist	216	HR	$85.00	$18,360	see cost assumptions
5.16	Oversight and Rig Geologist travel & MIE	4	Week	$1,200.00	$4,800	see cost assumptions
5.17	Post-Injection Confirmation Soil Sample Analyses	100	EA	$110.00	$11,000	see cost assumptions
5.18	Post-Injection Data Validation	345	HR	$100.00	$34,500	see cost assumptions
5.19	Post-Injection Completion Report Preparation	1	LS	$300,000.00	$300,000	see cost assumptions
	Subtotal				**$1,193,963**	

CAPITAL COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW3B
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
5.0 In-Situ Chemical Reduction & Biodegradation Injection Engineering and Manangement Support						
5.1	Permit preparation & regulatory interface	100	HR	$85.00	$8,500	see assumptions
5.2	Project Management/Engineering Support (estimate 30%)	1	LS	$1,259,789.45	$1,259,789	see assumptions
	Subtotal				**$1,268,289**	
6.0 Contingencies						
6.1	10% Scope & 15% Bid (25% total)	1	LS	$1,029,934.10	$1,029,934	see assumptions
	Subtotal				**$1,029,934**	
TOTAL DIRECT COSTS					**$6,152,524**	
TOTAL CAPITAL COST FOR ALTERNATIVE GW3B					**$6,152,524**	

OPERATIONS AND MAINTENANCE COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW3B
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
OM.1.0 Groundwater Monitoring (per event)						
OM.1.1	Sampling Equipment Rental	1	LS	$5,500	$5,500	see cost assumptions
OM.1.2	Disposable equipment costs	56	EA	$20	$1,120	see cost assumptions
OM.1.3	Event Mobiliation/Demobe - FOL	12	HR	$75	$900	see cost assumptions
OM.1.4	Event Mobiliation/Demobe - Sampler (2)	24	HR	$65	$1,560	see cost assumptions
OM.1.5	Sampling Labor - FOL	138	HR	$75	$10,350	see cost assumptions
OM.1.6	Sampling Labor - Sampler (2)	276	HR	$65	$17,940	see cost assumptions
OM.1.7	Analytical Costs	104	EA	$1,050	$109,200	see cost assumptions
OM.1.8	Sampling Travel and MIE	1	EA	$9,720	$9,720	see cost assumptions
OM.1.9	Data Validation	104	HR	$100	$10,400	see cost assumptions
OM.1.10	Report Preparation	1	LS	$13,000	$13,000	see cost assumptions
	Subtotal				**$179,690**	
OM.2.0 Annual Review of Regional Land and Resource Usage						
OM.2.1	Town data review	10	HR	$65	$650	see cost assumptions
OM.2.2	Report Preparation	1	LS	$500	$500	see cost assumptions
	Subtotal				**$1,150**	
OM.3.0 Monitoring and Annual Reporting Engineering and Manangement Support						
OM.3.1	Project Management/Engineering Support (estimate 33%)	1	LS	$59,677	$59,677	see cost assumptions
	Subtotal				**$59,677**	
OM.4.0 O&M Contingencies						
OM.4.1	10% Scope & 15% Bid (25% total)	1	LS	$45,210	$45,210	see cost assumptions
	Subtotal				**$45,210**	
FY.1.0 Five-Year Reviews						
FY.1.1	Five-Year Review report preparation	1	LS	$50,000	$50,000	see cost assumptions
	Subtotal				**$50,000**	

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
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DAVIS LIQUID WASTE SITE
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Capital Cost Assumptions		
1.0 Institutional Controls		
1.1	Record Boundary Survey	Approximate costs per parcel for a deed record survey including meets and bounds. Assumes 2 parcels. The remaining 2 parcels are managed under the source control remedy.
1.2	Attorney's Fees	Attorney's fees associated with title research, drafting the restrictive covenants, and attaching a restriction to a deed for a single parcel (assume 4), includes any registry fees ($84 for the first page, $1 for each additional page).
2.0 Monitoring Well Construction		
2.1	Mobilize Drill Rig and Crew	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
2.2	10 bedrock boreholes and 4 overburden monitoring wells	Drilling depths: four new bedrock wells east of source area at 200 feet per boring, through a 6" borehole assumes no clearing/grubbing will be required. Drilling depths for four new bedrock wells north of the source area at 100 feet per boring. Four new overburden monitoring wells located north of the source area to a depth of 30 feet. Bedrock boreholes will be fitted with 2" Schedule 80 PVC wells installed (20-foot 10-slot screen size). Two new bedrock wells north of OW-094-R at the edge of the former source area at 100 feet per boring. Overburden wells will be constructed of 2" Schedule 40 PVC (10-foot 10-slot screens). Assumes drilling can be completed in 20 days, with 15 overnight stays. Overburden drilled using drive and wash drilling, with SPT every 5 feet. Bedrock drilled using 6" air hammer.
2.3	Dedicated tubing for all wells	Assumes approximately 4000 feet of bonded tubing (one side Teflon-lined).
2.4	IDW Disposal	Assumes <20 tons of drill cuttings, characterization (VOCs, RCRA8 metals, characteristics), and a mobilization/fuel fee.
2.5	Oversight and Rig Geologist	Assumes 1 rig geologist travel and stay on-site for 10 10-hour days plus travel
2.6	Oversight and Rig Geologist travel & MIE	Assumes GSA Per-Diem lodging and MIE for 1 person over two weeks in Providence County.
3.0 Pre-Design Investigation		
3.1	Mobilize Drill Rig and Crew	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
3.2	40 Overburden borings drilled	Drilling using drive and wash techniques to the bedrock surface with continuous split spoon sampling.
3.3	Oversight Geologist	Assumes 1 rig geologist travel and stay on-site for 14 10-hour days plus travel
3.4	Soil, Groundwater , Surface Water, Sediment Analytical	Assumes two soil samples per boring and 15 groundwater samples analyzed for VOCs, SVOCs, PCBs, metals.
3.5	PDI Completion and Summary Report Preparation	Report that summarizes the findings of the PDI including revised mass estimates, identification of significant differences between the current conceptual site model and the obtained data, risk evaluation for non-VOC contaminants, and an evaluation of the unsaturated contaminated soil zone. Assumes data validation is completed on both soil and groundwater datasets.
4.0 In-Situ Chemical Reduction & Biodegradation Injections		
4.1	Pre-Design Bench/Pilot-Scale Testing & Evaluation	Assumption based upon past experience with similar technologies as well as vendor-supplied suggestions. Assumes the bench testing of several potentially-viable treatment reagents to determine the most cost-effective substance and an anticipated loading rate, and the field pilot-scale testing of the selected substance to gauge in-field implementation, injection details, and aquifer response. The pilot test includes post-test soil and groundwater sample collection and a completion/evaluation report.
4.2	Site Facilities, Utilities, Laydown Area Preparation	Includes one 40' storage container (doors at both ends) ($106/month), one 36X10 office trailer with steps and security screens ($350 per month), one-time charges for trailer delivery/pickup, hurricane straps installation, security screen installation, deadbolt installation, and steps setup/knockdown (lump sum of $800), one tow-behind generator (with weekly diesel refills of 40 gallons at $4.00/gallon delivered) ($440/month), electrician to hookup and knockdown connection between generator and trailer ($1,000), dumpster with weekly solid waste removal services ($315/month), one portable restroom with weekly cleaning ($95/month), cellular phone (email and internet capability at $100/month), laptop computer & printer ($1,000), camera ($250), and expendables (assume $200/month). Assume the duration of the project is 24 months.
4.3	Potable Water Supply (Saturated Soil and dissolved groundwater)	Estimated volume of 202,000 gallons delivered in 7,500 gallon tanker loads. This volume assumes 4 injections; the first at 100% of the targeted volume, the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the targeted volume. These volumes are based on the presumption that as the injections proceed, less reagent will be required to reduce the remaining contaminant mass.
4.4	Potable Water Storage	Assumes 1 21,000-gallon mobile storage tank for a period of 19 months (assumed duration of the injection programs).

COST ASSUMPTIONS
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4.0 In-Situ Chemical Reduction & Biodegradation Injections (Continued)		
4.5	Potable Water Storage Spot Charge	Assumes 4 separate mobilizations of the storage tank.
4.6	Injection Site Preparation	Assumes two laborers at prevailing wage in Providence County with hand tools and vehicle to clear a pathway through brush. The occasional felling of a tree may be required to access certain locations. The entire treatment area is 4 acres+/-, assume that 10% of this area will require thinning. Assumes two GSA per-diem lodging and MIE rates for 0.5 weeks.
4.7	Weight Dispersion	Assumes 50 0.75-inch BC or CDX plywood sheets will not be needed to access areas, as no wetland injections are proposed.
4.8	Injection Contractor Mobe/Demobe	Vendor estimate. Mobilization from southeastern Massachusetts.
4.9	Chemical Reductant & Substrate Fluid (saturated soil and dissolved groundwater)	Vendor estimate for a combined injection of substrate and reductant at 80 gallons per location (1,012 injection locations). Four injections are proposed that are pro-rated as follows: the first at 100% of the targeted volume (approximately 81,000 gallons), the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the target volume. Assumes subcontractor crew, labor, equipment, travel and MIE for approximately 316 injection days. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.10	Injection of Chemical Reductant (saturated soil and dissolved groundwater)	Over the course of four injections, a total of 2,530 individual injection locations based on an estimated 10-foot radius of influence will be advanced. A daily injection rate of 8 locations is anticipated. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.11	Injection Contractor Project/Construction Management	Vendor estimate for management of each injection event. It is assumed that roughly the same amount of management and preparation time will be required regardless of the volume of the injections. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.12	Potable Water Supply (unsaturated soil)	Estimated volume of 42,300 gallons delivered in 7,500 gallon tanker loads. This volume assumes 4 injections; the first at 100% of the targeted volume, the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the target volume. These volumes are based on the presumption that as the injections proceed, less reagent will be required to reduce the remaining contaminant mass.
4.13	Chemical Reductant & Substrate Fluid (unsaturated soil)	Vendor estimate for a combined injection of substrate and reductant at 40 gallons per location (423 injection locations). Four injections are proposed that are pro-rated as follows: the first at 100% of the targeted volume (approximately 72,000 gallons), the second at 75% of the targeted volume, the third at 50% of the targeted volume, and the fourth at 25% of the target volume. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
4.14	Injection of Chemical Reductant (unsaturated soil)	Over the course of four injections, a total of 952 individual injection locations based on an estimated 10-foot radius of influence will be advanced. A daily injection rate of 8 locations is anticipated. The costs supplied by the vendor were based on two injections per location. This per-injection cost of $241 was used to estimate the injection costs associated with unsaturated soil injections. This does not include performance guarantees. A performance guarantee may increase the cost as much as 400%.
5.0 In-Situ Chemical Reduction & Biodegradation Injection Oversight & Monitoring		
5.1	Oversight and Construction Monitoring	Assumes one project engineer at a loaded rate of $85/hour for each of the three injections (total of 87 weeks, at 10 hours per day plus 4 hours travel per week) and the pre-injection site setup (assume 1 week per event plus 4 hours travel per week).
5.2	Oversight and Construction Monitoring Travel & MIE	Includes the GSA per-diem lodging and MIE for one project engineer in Providence County, rental vehicle and fuel (assume $360 per week) for a period of 87 weeks.
5.3	Post-Injection GW Sampling Equipment Rental	Includes groundwater pumps, controllers, and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1) for two weeks for each event. Costs based upon vendor rental quote. Assume monitoring post Injection 1, Post Injection 2, Post Injection 3, Post Injection 4, and one year after Injection 4.
5.4	Post-Injection GW Disposable equipment costs	Assume 47 locations per monitoring event (5 events total).
5.5	Post-Injection GW Event Mobilization/Demobe - FOL	Assume 4 hour round trip per event for 5 events for one project engineer
5.6	Post-Injection Event Mobilization/Demobe - Samplers	Assume 4 hour round trip per event for 5 events for two staff scientists
5.7	Post-Injection GW Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee 2 samplers, manage and track analytical sample collection, collect samples as available, and conduct field audits.

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5.0 In-Situ Chemical Reduction & Biodegradation Injection Oversight & Monitoring (Continued)		
5.8	Post-Injection GW Sampling Labor - Sampler (1)	Assume samples collected from 47 wells at 10 hours per day over two weeks (maximum), per event (assume 4 events). Time required for QC sample collection not specifically included, but is likely negligible at this scale.
5.9	Post-Injection GW Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and two staff scientists in Providence County, two rental vehicles and fuel for a period of 2 weeks per event.
5.10	Post-Injection GW Analytical Costs	Analyses include: VOCs, chloride, sulfate, sulfide, iron, manganese, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, and 5 trip blanks per event. Costs based upon a variety of vendor-supplied costs.
5.11	Post-Injection Confirmation Drilling Mobilization	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
5.12	Post-Injection Confirmation Case & Wash Drilling	Assumes 40 boreholes to the bedrock surface, with continuous soil sampling. Decon between borehole locations. Backfill boreholes with grout. Assume four weeks worth of drilling at two boreholes per day.
5.13	Post-Injection Confirmation Drilling IDW Disposal	Assumes <5 tons of drill cuttings, characterization (VOCs, RCRA8 metals, characteristics), and a mobilization/fuel fee.
5.14	Post-Injection Confirmation Drilling Equipment Rental	Assumes four weeks rental of a PID.
5.15	Oversight and Rig Geologist	Assume four weeks oversight for one rig geologist at 10 hours per day plus four hours per week of travel time.
5.16	Oversight and Rig Geologist travel & MIE	Assumes GSA Per-Diem lodging and MIE for 1 person over two weeks in Providence County.
5.17	Post-Injection Confirmation Soil Sample Analyses	Assume 80 soil samples and 20 QC samples for VOCs.
5.18	Post-Injection Data Validation	Assume 1 HR per sample analysis for data validation.
5.19	Post-Injection Completion Report Preparation	Report to summarize the injection events, observations, monitoring, analytical results, and an evaluation of remedial goals. Costs based upon a scale-up of the report preparation costs associated with the long-term monitoring. An additional evaluation of remedial success and comparison to remedial goals and reduction efficiency were also included.
6.0 In-Situ Chemical Reduction & Biodegradation Injection Engineering and Management Support		
6.1	Permit preparation & regulatory interface	Cost estimate to include permit procurement for underground injection, activities within a wetland, and general discussion with State and local regulators.
6.2	Project Management/Engineering Support (estimate 30%)	Costs assume that each injection event will require coordination and engineering support to complete as the events are modified to meet the goal of each injection. The capital costs associated with each event fall within the $500,000 to $2,000,000 range, and according to the EPA Guide to Developing and Documenting Cost Estimates During the FS, a technical support and project management capital cost percentage of 28% is recommended. This was increased to 30% to account for the difficulties expected associated with the underground injection of materials.
7.0 Capital Contingencies		
7.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design. Given the presented scope activities includes a variety of potential difficulties, a scope contingency of 10% was carried. Given the lack of an extensive subsurface profile, a bid contingency of 15% was carried.

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW3B
DAVIS LIQUID WASTE SITE
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Operations and Maintenance Cost Assumptions		
OM.1.0 Groundwater Monitoring (per event)		
Groundwater monitoring costs were estimated for a single monitoring event. For long-term O&M, it was assumed that monitoring would occur triannually for the first five (5) years after construction, and annually thereafter. One annual summary and assessment report is assumed.		
OM.1.1	Sampling Equipment Rental	Includes groundwater pumps (3), controllers (3), and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1). For a period of two weeks. Costs based upon vendor rental quote.
OM.1.2	Disposable equipment costs	Includes a bladder replacement kit for each sample, based upon a vendor quote.
OM.1.3	Event Mobilization/Demobe - FOL	Travel time to and from Site = 4 hours per week, three weeks
OM.1.4	Event Mobilization/Demobe - Sampler (2)	Travel time to and from Site = 4 hours per week, three weeks
OM.1.5	Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee 2 samplers, manage and track analytical sample collection, collect samples as available, and conduct field audits. Level D PPE
OM.1.6	Sampling Labor - Sampler (2)	Assume samples collected from 56 wells at 10 hours per day over three weeks per event. Time required for QC sample collection not specifically included. SW sample (10 samples) time required to collect the sample considered negligible. Level D PPE
OM.1.7	Analytical Costs	Analyses include: GW - VOCs, SVOCs, pesticides, metals, chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen; SW - VOCs, SVOCs, Pest, metals; SED - SVOCs, pest, metals. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, trip blanks considered negligible. Costs based upon a variety of vendor-supplied costs.
OM.1.8	Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and two staff scientists in Providence County, two rental vehicles and fuel (assume $720 per week) for a period of 3 weeks per event.
OM.1.9	Data Validation	Assume 1 HR per sample analysis for data validation.
OM.1.10	Report Preparation	Assume 120 hours for report preparation at $100/HR. Other direct costs (copying/printing/delivery) at $1,000.
OM.2.0 Annual Review of Regional Land and Resource Usage		
OM.2.1	Town data review	Travel time to and from the Site = 4 hours; 6 hours record review/interview time for $65/hour worker. Reviews performed annually to examine the land use and water withdrawals in the area for any changes. Large changes in either of these categories may require additional investigation to determine if the remedy is protective.
OM.2.2	Report Preparation	Assume 4 HR for report preparation at $100/HR. Other costs (copying/printing/delivery) at $100
OM.3.0 O&M Contingencies		
OM.3.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design.
OM.4.0 O&M Contingencies		
OM.4.1	Project Management/Engineering Support	As expected capital costs are between $100,000 and $500,000, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS, the costs associated with remedial design (15%), routine project management (8%), engineering support, oversight, and bid preparations (10%) are carried as percentages (as indicated) of the expected capital costs.
FY.1.0 Five-Year Reviews		
FY.1.1	Five-Year Review Preparation	Estimated at $50,000 each report, based upon current estimates of in-progress work. Management and technical support costs are included in this cost. No contingencies are applied.

PRESENT VALUE ANALYSIS
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

Year	Capital	O&M	5-Year Review [1]	Total	Discount Rate	Present Value
0	$3,363,786	$0	$0	$3,363,786	7.0%	$3,363,786
1	$0	$1,258,962.00	$0	$1,258,962	7.0%	$1,176,600
2	$0	$1,258,962.00	$0	$1,258,962	7.0%	$1,099,626
3	$0	$1,258,962.00	$0	$1,258,962	7.0%	$1,027,688
4	$0	$1,258,962.00	$0	$1,258,962	7.0%	$960,456
5	$0	$1,298,962.00	$50,000	$1,348,962	7.0%	$961,791
6	$0	$ 901,922.00	$0	$901,922	7.0%	$600,989
7	$0	$ 901,922.00	$0	$901,922	7.0%	$561,672
8	$0	$ 901,922.00	$0	$901,922	7.0%	$524,927
9	$0	$ 901,922.00	$0	$901,922	7.0%	$490,586
10	$0	$ 941,922.00	$50,000	$991,922	7.0%	$504,243
11	$0	$ 901,922.00	$0	$901,922	7.0%	$428,497
12	$0	$ 901,922.00	$0	$901,922	7.0%	$400,464
13	$0	$ 901,922.00	$0	$901,922	7.0%	$374,266
14	$0	$ 901,922.00	$0	$901,922	7.0%	$349,781
15	$0	$ 941,922.00	$50,000	$991,922	7.0%	$359,518
16	$0	$ 901,922.00	$0	$901,922	7.0%	$305,512
17	$0	$ 901,922.00	$0	$901,922	7.0%	$285,525
18	$0	$ 901,922.00	$0	$901,922	7.0%	$266,846
19	$0	$ 901,922.00	$0	$901,922	7.0%	$249,389
20	$0	$ 941,922.00	$50,000	$991,922	7.0%	$256,331
21	$0	$ 901,922.00	$0	$901,922	7.0%	$217,826
22	$0	$ 901,922.00	$0	$901,922	7.0%	$203,576
23	$0	$ 901,922.00	$0	$901,922	7.0%	$190,258
24	$0	$ 901,922.00	$0	$901,922	7.0%	$177,811
25	$0	$ 941,922.00	$50,000	$991,922	7.0%	$182,761
26	$0	$ 901,922.00	$0	$901,922	7.0%	$155,307
27	$0	$ 901,922.00	$0	$901,922	7.0%	$145,147
28	$0	$ 901,922.00	$0	$901,922	7.0%	$135,651
29	$0	$ 901,922.00	$0	$901,922	7.0%	$126,777
30	$0	$ 941,922.00	$50,000	$991,922	7.0%	$130,306
TOTAL	**$3,363,786**					**$16,213,911**

Note: Discount rate of 7% per EPA 540-R-00-002, OSWER 9355.0-75, July 2000, p. 4-5.

1 Five-year review lump sum cost of approximately $50,000

CAPITAL COST SUMMARY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
1.0 Institutional Controls						
1.1	Record Survey	2	LS	$10,000	$40,000	Vendor quote; see assumptions
1.2	Attorney's Fees	2	LS	$3,100.00	$12,400	see assumptions
	Subtotal				**$52,400**	
2.0 Monitoring Well Construction						
2.1	Mobilize Drill Rig and Crew	1	LS	$340.00	$340	see assumptions
2.2	8 bedrock boreholes and 4 overburden monitoring wells	1	LS	$60,000.00	$32,000	see assumptions
2.3	Dedicated tubing for all wells	1	LS	$6,000.00	$3,750	see assumptions
2.4	IDW Disposal	1	LS	$10,000.00	$3,750	see assumptions
2.5	Oversight and Rig Geologist	180	HR	$85	$9,350	see assumptions
2.6	Oversight and Rig Geologist travel & MIE	4	Week	$1,200	$2,400	see assumptions
	Subtotal				**$51,590**	
3.0 Extraction Well Construction						
3.1	Driller/Development Rig Mobilization	1	LS	$10,000.00	$10,000	see Assumptions
3.2	Overburden Drilling	460	FT	$70.00	$32,200	see assumptions
3.3	Bedrock Drilling	450	FT	$35.00	$15,750	see assumptions
3.4	Well Construction Materials	860	FT	$80.00	$68,800	see assumptions
3.5	Well Development	92	Hour	$400.00	$36,800	see assumptions
3.6	Drill Rig Decontamination	23	LS	$500.00	$11,500	see assumptions
3.7	Extraction Well Pumps	25	EA	$1,800.00	$45,000	Vendor quote; see assumptions
3.8	Down-Well Extraction Piping	820	FT	$0.60	$492	see assumptions
3.9	Down-Well Pump Security Cables	900.00	FT	$0.40	$360	McMaster-Carr
3.10	Extraction Well Float Switches	50	EA	$75.00	$3,750	McMaster-Carr
3.11	Extraction Well Pitless Adapters	23	EA	$50.00	$1,150	McMaster-Carr
3.12	Extraction Well Caps	23	EA	$50.00	$1,150	McMaster-Carr
3.13	Lodging & MIE Per Person Per Week	16	Week	$1,200.00	$19,200	see assumptions
	Subtotal				**$246,152**	
4.0 Surface Well Completion, Trenching, Extraction System Electric & Piping Construction, and Discharge Construction						
4.1	Excavation Contractor Mobilization	1	LS	$1,100.00	$1,100	see assumptions
4.2	Extraction Well Vault Excavation	23	EA	$100.00	$2,300	see assumptions
4.3	Extraction Well Vault and Lid	23	EA	$900.00	$20,700	see assumptions
4.4	Extraction Well Vault Installation	23	EA	$300.00	$6,900	see assumptions
4.5	Extraction Well Utility Trenching & Backfilling/Compaction	2,000	CY	$22.00	$44,000	see assumptions
4.6	Trench Bedding Sand	1,000	CY	$15.00	$15,000	see assumptions
4.7	1" Tubing From Well to 3" Headers	2,000.00	FT	$0.60	$1,200	see assumptions
4.8	3" Tubing Headers to Treatment Building	2,500.00	FT	$8.30	$20,750	see assumptions
4.9	6" Containment pipe throughout for all underground pipe.	4,500	FT	$0.50	$2,250	see assumptions
4.10	Power Cable From Well to Treatment Building	4,500	FT	$2.00	$9,000	see assumptions
4.11	Wire Trace Cable From Well to Treatment Building	4,500	FT	$0.09	$405	see assumptions
4.12	Discharge Trenching & Backfill to Brook	800	CY	$25.00	$20,000	see assumptions
4.13	4" Dicharge Piping from Treatment Building to Brook	1,325	FT	$0.30	$398	see assumptions
4.14	Supply and Installation of Outfall Structure & Rip Rap Apron	1	LS	$1,500.00	$1,500	see assumptions
4.15	Supply and Installation of Wet-well Sump Structure.	1	LA	$5,500.00	$5,500	see assumptions
	Subtotal				**$151,003**	
5.0 Site Preparation, Major Utilities Installation, and Treatment Plant Bulding Construction						
5.1	Clearing/Grubbing of Treatment Plant Buliding Area	1	LS	$4,000.00	$4,000	see assumptions
5.2	Erosion/Sedimentation Control Installation	3,000	FT	$8.20	$24,600	see assumptions
5.3	Grading of Treatment Plant Building Area	1	LS	$1,000.00	$1,000	see assumptions
5.4	Concrete Slab, Footings, and Raised Sidewalls	1	LS	$64,000.00	$64,000	see assumptions
5.5	Concrete Sump Installations in Building Floor	2	EA	$500.00	$1,000	see assumptions
5.6	Pre-Engineered Steel Building	1	EA	$48,000.00	$48,000	see assumptions
5.7	Superintendant	160	HR	$70.00	$11,200	see assumptions
5.8	Equipment Operator	80	HR	$50.00	$4,000	see assumptions
5.9	Laborer	160	HR	$42.00	$6,720	see assumptions
5.10	Electrician	40	HR	$75.00	$3,000	see assumptions
5.11	Electric/Telephone Service to Treatment Plant	1	LS	$735,000.00	$735,000	see assumptions
	Subtotal				**$902,520**	

CAPITAL COST SUMMARY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
6.0 Treatment Train Evaluation and Construction						
6.1	Bench Testing of Precipitants	1	EA	$20,000.00	$20,000	see assumptions
6.2	Equalization Tank	1	EA	$8,200.00	$8,200	see assumptions
6.3	Lamella Gravity Settler	1	EA	$32,000.00	$32,000	see assumptions
6.4	Slurry Holding Tank	1	EA	$5,400.00	$5,400	see assumptions
6.5	Plate & Frame Filter Press	1	EA	$171,000.00	$171,000	see assumptions
6.6	Clear Well Tank	1	EA	$4,200.00	$4,200	see assumptions
6.7	Filter Network System	1	EA	$67,000.00	$67,000	see assumptions
6.8	Air Stripper	1	EA	$200,600.00	$200,600	see assumptions
6.9	Air Stripper Feed Pumps	2	EA	$4,740.00	$9,480	see assumptions
6.10	Vapor-Phase Carbon System	1	EA	$16,000.00	$16,000	see assumptions
6.11	Liquid-Phase Carbon	1	EA	$18,000.00	$18,000	see assumptions
6.12	pH Adjustmant Tank	1	EA	$2,300.00	$2,300	see assumptions
6.13	Neutralization System	1	EA	$100,000.00	$100,000	see assumptions
6.14	Effluent Equalization Tank	1	EA	$8,200.00	$8,200	see assumptions
6.15	Chemical Holding Tanks	4	EA	$990.00	$3,960	see assumptions
6.16	Chemical Metering Pumps	4	EA	$1,000.00	$4,000	see assumptions
6.17	Liquid Phase Carbon Feed Pumps	2	EA	$500.00	$1,000	see assumptions
6.18	Air Compressor	1	EA	$6,500.00	$6,500	see assumptions
6.19	Slurry Tank Feed Pumps	1	EA	$1,700.00	$1,700	see assumptions
6.20	Gray-Water Recirculation Pump	1	EA	$400.00	$400	see assumptions
6.21	Gray-Water Preassure Tank	1	EA	$1,000.00	$1,000	see assumptions
6.22	pH Adjustment Tank Mixer	1	EA	$3,500.00	$3,500	see assumptions
6.23	Superintendant	300	HR	$70.00	$21,000	see assumptions
6.24	Interior 3" PVC Piping	320	FT	$10.00	$3,200	see assumptions
6.25	Interior 2" PVC Piping	320	FT	$8.00	$2,560	see assumptions
6.26	Miscl. 3" PVC Fittings	1	LS	$2,000.00	$2,000	Estimate
6.27	Miscl. 2" PVC Fittings	1	LS	$2,000.00	$2,000	Estimate
6.28	Discharge Flow Totalizer	1	EA	$750.00	$750	McMaster-Carr
6.29	Inflow Totalizer	23	EA	$250.00	$5,750	Granger Catalog
6.30	High-Level Switches for Sumps and Tanks	20	EA	$75.00	$1,500	Granger Catalog
6.31	Misc. Parts and Supplies	1	LS	$5,000.00	$5,000	Estimate
6.32	Wet-Well Sump Centrifugal Transfer Pump	1	LS	$750.00	$750	Granger Catalog
	Subtotal				**$728,950**	
7.0 Interior Electric and Climate Control Construction						
7.1	Process Logic Control Panel & Programming	1	EA	$20,000.00	$20,000	see assumptions
7.2	Main Emergency Power Switch	1	EA	$500.00	$500	see assumptions
7.3	Lighting	40	EA	$142.00	$5,680	see assumptions
7.4	Electric Heater	2	EA	$5,500.00	$11,000	see assumptions
7.5	Interior Wiring & Electrical & Telephone Work	160	HR	$75.00	$12,000	see assumptions
7.6	Telemetry Installation & Programming	40	HR	$75.00	$3,000	see assumptions
	Subtotal				**$52,180**	
8.0 Other Direct Capital Costs						
8.1	Delivered Diesel for Heavy Equipment	600	GAL	$4.00	$2,400	see assumptions
8.2	Portable Restrooms	3	MO	$95.00	$285	see assumptions
8.3	Dumpster Rental and Construction Waste Disposal	3	MO	$315.00	$945	see assumptions
8.4	Office Trailer and Associated Appurtenances	3	MO	$350.00	$1,050	see assumptions
8.5	Storage Container	3	MO	$212.00	$636	see assumptions
8.6	Generator	2	MO	$440.00	$880	see assumptions
8.7	O&M Manual Development	1	LS	$5,000.00	$5,000	see assumptions
8.8	As-Built Survey	1	LS	$10,000.00	$10,000	see assumptions
	Subtotal				**$21,196**	
9.0 Construction Management and Oversight						
9.1	Resident Engineer	500	Hour	$70.00	$35,000	see assumptions
9.2	Resident Engineer Travel & MIE	10	Week	$1,200.00	$12,000	see assumptions
9.3	Staff Engineer	500	Hour	$60.00	$30,000	see assumptions
9.4	Staff Engineer Travel & MIE	10	Week	$1,200.00	$12,000	see assumptions
9.5	Rig Geologist	200	Hour	$60.00	$12,000	see assumptions
9.6	Rig Geologist Travel & MIE	4	Week	$1,200.00	$4,800	see assumptions
9.7	Hydrogeologist Oversight	20	Hour	$80.00	$1,600	see assumptions
9.8	Hydrogeologist Travel & MIE	1	Week	$1,200.00	$600	see assumptions
	Subtotal				**$108,000**	

CAPITAL COST SUMMARY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
10.0 Construction Engineering, Procurement, and Project Manangement Support						
10.1	Permit preparation & regulatory interface	100	HR	$85.00	$8,500	see assumptions
10.2	Project Management/Engineering Support (estimate 15%)	1	LS	$462,798.10	$462,798	see assumptions
	Subtotal				**$471,298**	
11.0 Contingencies						
11.1	10% Scope & 15% Bid (25% total)	1	LS	$578,497.63	$578,498	see assumptions
	Subtotal				**$578,498**	
TOTAL DIRECT COSTS					**$3,363,786**	
TOTAL CAPITAL COST FOR ALTERNATIVE GW4A					**$3,363,786**	

Notes:

OPERATIONS AND MAINTENANCE COST SUMMARY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
OM.1.0 Groundwater Monitoring (per event)						
OM.1.1	Sampling Equipment Rental	1	LS	$5,500	$5,500	see cost assumptions
OM.1.2	Disposable equipment costs	55	EA	$20	$1,100	see cost assumptions
OM.1.3	Event Mobiliation/Demobe - FOL	12	HR	$75	$900	see cost assumptions
OM.1.4	Event Mobiliation/Demobe - Sampler (2)	24	HR	$65	$1,560	see cost assumptions
OM.1.5	Sampling Labor - FOL	138	HR	$75	$10,350	see cost assumptions
OM.1.6	Sampling Labor - Sampler (2)	276	HR	$65	$17,940	see cost assumptions
OM.1.7	Analytical Costs	103	EA	$1,050	$108,150	see cost assumptions
OM.1.8	Sampling Travel and MIE	1	EA	$9,720	$9,720	see cost assumptions
OM.1.9	Data Validation	103	HR	$100	$10,300	see cost assumptions
OM.1.10	Report Preparation	1	LS	$13,000	$13,000	see cost assumptions
	Subtotal				**$178,520**	
OM.2.0 Annual Review of Regional Land and Resource Usage						
OM.2.1	Town data review	10	HR	$65	$650	see cost assumptions
OM.2.2	Report Preparation	1	LS	$500	$500	see cost assumptions
	Subtotal				**$1,150**	
OM.3.0 Extraction Well System Maintenance						
OM.3.1	Redevelopment of Extraction Wells	1	Event	$40,000	$40,000	see cost assumptions
OM.3.2	Vault Repairs	1	Event	$500	$500	see cost assumptions
	Subtotal				**$40,500**	
OM.4.0 Building Maintenance						
OM.4.1	Building Repairs and Upkeep	1	Yearly	$3,000	$3,000	see cost assumptions
OM.4.2	Telephone Usage Charges	12	Monthly	$100	$1,200	see cost assumptions
OM.4.3	Electricity Usage Charges	12	Monthly	$1,700	$20,400	see cost assumptions
	Subtotal				**$24,600**	
OM.5.0 Treatment Plant Operation & Maintenance						
OM.4.1	Treatment Plant Operator	1,300	HR	$75	$97,500	see cost assumptions
OM.4.2	Air Strip Packing Reconditioning	1	EA	$3,170	$3,170	see cost assumptions
OM.4.3	Blower Maintenance	4	EA	$640	$2,560	see cost assumptions
OM.4.4	Transfer, Metering, and Diaphram Pump Maintenan	12	EA	$640	$7,680	see cost assumptions
OM.4.5	Vapor-Phase Carbon Changeout	4	EA	$5,700	$22,800	see cost assumptions
OM.4.6	Liquid-Phase Carbon Changeout	1	EA	$6,400	$6,400	see cost assumptions
OM.4.7	Precipitation/Floculation/Coagulation	1	Year	$12,000	$12,000	see cost assumptions
OM.4.10	Sludge Disposal	1	EA	$8,000	$8,000	see cost assumptions
	Subtotal				**$160,110**	
OM.6.0 Monitoring and Annual Reporting Engineering and Manangement Support						
OM.3.1	Project Management/Engineering Support (estimate 33%)	1	LS	$452,067	$452,067	see cost assumptions
	Subtotal				**$452,067**	
OM.4.0 O&M Contingencies						
OM.4.1	10% Scope & 15% Bid (25% total)	1	LS	$84,975	$84,975	see cost assumptions
	Subtotal				**$84,975**	
FY.1.0 Five-Year Reviews						
FY.1.1	Five-Year Review report preparation	1	LS		$50,000	see cost assumptions
	Subtotal				**$50,000**	

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

Capital Cost Assumptions		
1.0 Institutional Controls		
1.1	Record Boundary Survey	Approximate costs per parcel for a deed record survey including meets and bounds. Assumes 2 parcels. The remaining 2 parcels are managed under the source control remedy.
1.2	Attorney's Fees	Attorney's fees associated with title research, drafting the restrictive covenants, and attaching a restriction to a deed for a single parcel (assume 2), includes any registry fees ($84 for the first page, $1 for each additional page).
2.0 Monitoring Well Construction		
2.1	Mobilize Drill Rig and Crew	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
2.2	8 bedrock boreholes and 4 overburden monitoring wells	Drilling depths: four new bedrock wells east of source area at 200 feet per boring, through a 6" borehole assumes no clearing/grubbing will be required. Drilling depths for four new bedrock wells north of the source area at 100 feet per boring. Four new overburden monitoring wells located north of the source area to a depth of 30 feet. Bedrock boreholes will be fitted with 2" Schedule 80 PVC wells installed (20-foot 10-slot screen size). Overburden wells will be constructed of 2" Schedule 40 PVC (10-foot 10-slot screens). Assumes drilling can be completed in 18 days, with 15 overnight stays. Overburden drilled using drive and wash drilling, with SPT every 5 feet. Bedrock drilled using 6" air hammer.
2.3	Dedicated tubing for all wells	Assumes approximately 4000 feet of bonded tubing (one side Teflon-lined).
2.4	IDW Disposal	Assumes <20 tons of drill cuttings, characterization (VOCs, RCRA8 metals, characteristics), and a mobilization/fuel fee.
2.5	Oversight and Rig Geologist	Assumes 1 rig geologist travel and stay on-site for 10 10-hour days plus travel
2.6	Oversight and Rig Geologist travel & MIE	Assumes GSA Per-Diem lodging and MIE for 1 person over two weeks in Providence County.
3.0 Extraction Well Construction		
3.1	Driller/Development Rig Mobilization	Mobilization of a rotary/air hammer, air compressor, Support Truck, all necessary well construction materials, and Smeal-like development rig & equipment. Level D PPE
3.2	Overburden Drilling	Assumes a 10-inch temporary casing or hollow-stem auger installation with SPT every 5 feet. Eight wells installed to top of bedrock (20' bgs+/-)
3.3	Bedrock Drilling	Assumes a 8-inch air-hammer bedrock borehole. Drilled 30' into bedrock. Assume 15 extraction wells.
3.4	Well Construction Materials	Assumes Schedule 80 PVC well materials, filter pack, bentonite, and cement/bentonite grout. Assume wells set approximately 2' below grade.
3.5	Well Development	Assumes crew (2) and equipment (Smeal rig using surge and pump method) sufficient to develop a 4" extraction well. Assume 4 hours per well.
3.6	Drill Rig Decontamination	Assumes construction of 1 decontamination pad and decontamination of drill tooling between boring locations.
3.7	Extraction Well Pumps	Assume Grundfos 4-inch 10E submersible pump and 0.5-HP single-phase motor (assume 2 extra pumps purchased)
3.8	Down-Well Extraction Piping	McMaster-Carr Catalog. Assumes 1" ID chemical-resistance HDPE tubing, compression-fitted onto barb fittings or heat-sealed. No joints will be present on the riser, only continuous pieces to be used. Assume pitless adapter is set 4 feet below grade.
3.9	Down-Well Pump Security Cables	1/8" Stainless steel cable with U clamp and compression fittings.
3.1	Extraction Well Float Switches	McMaster-Carr Catalog.
3.11	Extraction Well Pitless Adapters	McMaster-Carr Catalog.
3.12	Extraction Well Caps	McMaster-Carr Catalog.
3.13	Lodging & MIE Per Person Per Week	GSA 2009 Lodging rate for Providence County + MIE (75% on travel days)

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

4.0 Surface Well Completion, Trenching, Extraction System Electric & Piping Construction, and Discharge Construction		
4.1	Excavation Contractor Mobilization	Assume 1 excavator with 3/4-cubic yard bucket mobilized from a local contractor.
4.2	Extraction Well Vault Excavation	Assumes an excavation of 1 cubic yard of earth for each vault.
4.3	Extraction Well Vault and Lid	Assumes pre-cast or steel hand-hold-sized vault with lockable diamond plate lid.
4.4	Extraction Well Vault Installation	Assumes 1 laborer, quick-setting concrete, and equipment to install the vault and backfill void space.
4.5	Extraction Well Utility Trenching & Backfilling/Compaction	
4.6	Trench Bedding Sand	Assumes a 2-foot layer of bedding sand surrounding the extraction well discharge piping and power conduits and the treatment plant discharge piping.
4.7	1" Tubing From Well to 3" Headers	Assumes 1" HDPE heat-sealed tubing.
4.8	3" Tubing Headers to Treatment Building	Assumes 3" HDPE head-sealed tubing.
4.9	6" Containment pipe throughout for all underground pipe.	This piping will surround each run of extraction well piping as secondary containment.
4.10	Power Cable From Well to Treatment Building	Assumes 4-guage 4-wire direct burial submersible pump cable.
4.11	Wire Trace Cable From Well to Treatment Building	Assumes 16-guage insulated wire to act as a tracer wire for pipe location.
4.12	Discharge Trenching & Backfill to Brook	Assumes a 1,325-foot trench that is 5-feet deep and 3 feet wide (as specified in the Ebasco conceptual treatment plan design). This will require a small trench-box. This also includes transport of excess excavation spoils not replaced as backfill (due to pipe bedding placement).
4.13	4" Discharge Piping from Treatment Building to Brook	Assumes a 4-inch corrugated PVC direct-burial piping. The corrugations are sufficient to slow the pipe flow velocity at discharge.
4.14	Supply and Installation of Outfall Structure & Rip Rap Apron	Assume a small pre-cast discharge headwall with approximately 10-feet of 6-inch rip rap apron extending to Latham Brook.
4.15	Supply and Installation of Wet-well Sump Structure.	Assume one pre-cast concrete 5,000-gallon sump installed below ground to serve as a discharge point for the extraction wells located to the north. Water will be pumped from here to the treatment plant using a high-head centrifugal pump.
5.0 Site Preparation, Major Utilities Installation, and Treatment Plant Building Construction		
5.1	Clearing/Grubbing of Treatment Plant Building Area	Assumed using Means Heavy Construction Cost Data 2008 edition. Assumes the use of hand-tools and one piece of heavy equipment such as a backhoe.
5.2	Erosion/Sedimentation Control Installation	Assumed using Means Heavy Construction Cost Data 2008 edition.
5.3	Grading of Treatment Plant Building Area	Includes rough grading of parking area at the treatment building and fine grading within the treatment building slab area.
5.4	Concrete Slab, Footings, and Raised Sidewalls	Assumed using Means Heavy Construction Cost Data 2008 edition. Assumes formed sidewalls and anchor-bolt installation and a 10" slab sufficient for a 40' by 80' building.
5.5	Concrete Sump Installations in Building Floor	Assume two small pre-cast sumps in the floor of the building affixed with steel grates.
5.6	Pre-Engineered Steel Building	Vendor cost estimate. Assume one 40' by 80' building with two regular doorways and one roll-up door. The building is insulated along the walls and ceiling and has been given rough consideration for local coding. Cost includes delivery and freight, and construction. Construction should take two weeks using two skilled laborers, and an operator. Manufacturer suggested a typical unit cost for construction is $6 per square foot of floor space.
5.7	Superintendant	Assume a local contractor at 4 weeks time for site preparation and concrete forming,
5.8	Equipment Operator	Assume a local contractor at 2 weeks time for site preparation.
5.9	Laborer	Assume a local contractor at 4 weeks time for site preparation and erosion control installation.
5.10	Electrician	Assume one week of electrician time (using a local contractor hourly estimate) to electrify the treatment plant building and install necessary exterior lighting.
5.11	Electric/Telephone Service to Treatment Plant	Estimate using the conceptual design presented in the Ebasco Final Criteria Summary Report, June 1994. Scaled the costs presented using the consumer price index as presented by the Bureau of Labor Statistics (the multiplier was approximately 1.48). Electrical requirements are 3-phase, 225 amps, 400 volts.

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

6.0 Treatment Train Evaluation and Construction		
6.1	Bench Testing of Precipitants	Estimate based upon similar treatability studies performed in the past.
6.2	Equalization Tank	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 5,000 gallon steel tank. Installation labor included.
6.3	Lamella Gravity Settler	
6.4	Slurry Holding Tank	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 3,000 gallon steel conical tank. Installation labor included.
6.5	Plate & Frame Filter Press	25 cubic foot plate & frame filter press with collection tanks and sludge cart. Installation labor included.
6.6	Clear Well Tank	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 2,000 gallon steel tank. Installation labor included.
6.7	Filter Network System	Estimate based upon Means Environmental Cost Data - Assemblies. Assume a tri-vessel multi-media backflushable 6 foot filter network. Installation labor included.
6.8	Air Stripper	Estimate based upon Means Environmental Cost Data - Assemblies. Assume the installation of a 20-foot +/- by 2 foot stripping tower with 20 feet of packing. Additionally, the cost includes estimates for providing and installation of all internal workings, control panels, skids, ladder, blowers, liquid transfer pumps, and vapor capture equipment.
6.9	Air Stripper Feed Pumps	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 1.5-hp 2" influent pump with stainless-steel and cast iron impellers and wetted materials. Includes installation labor.
6.10	Vapor-Phase Carbon System	Estimate based upon Means Environmental Cost Data - Assemblies. Assume a dual bed 500 cfm system containing 2,000 pounds of vapor-phase GAC. Includes installation labor.
6.11	Liquid-Phase Carbon	Estimate based upon Means Environmental Cost Data - Assemblies. Assume an in-line dual bed 50 gpm system containing 4,000 pounds of vapor-phase GAC. Includes installation labor.
6.12	pH Adjustment Tank	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 3,000 gallon steel tank. Installation labor included.
6.13	Neutralization System	Estimate based upon Means Environmental Cost Data - Assemblies. Assume an 70 gpm continuous neutralization system using sulfuric acid. Includes installation labor.
6.14	Effluent Equalization Tank	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 5,000 gallon steel conical tank. Installation labor included.
6.15	Chemical Holding Tanks	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 500-gallon polyethylene tanks for storage of sodium hydroxide, ferric sulfate solution, and a liquid polymer solution. Includes installation labor.
6.16	Chemical Metering Pumps	Estimate based upon Granger 2009 catalog. Assume 120 gallon-per-day metering pumps for addition of precipitation chemicals.
6.17	Liquid Phase Carbon Feed Pumps	Estimate based upon Granger 2009 catalog. Assume 3/4-hp self-priming centrifugal pumps.
6.18	Air Compressor	Estimate based upon Granger 2009 catalog. Assume 20-hp 120 gallon electric air compressor.
6.19	Slurry Tank Feed Pumps	Estimate based upon Granger 2009 catalog. Assume Teflon and stainless steel diaphragm pump 1" inlet size capable of pumping up to 1/8-inch suspended solids.
6.20	Gray-Water Recirculation Pump	Estimate based upon Granger 2009 catalog. Assume 1/3-hp self-priming centrifugal pumps.
6.21	Gray-Water Pressure Tank	Estimate based upon Granger 2009 catalog. Assume 120-gallon pressure tank for pressurizing treated water for backflush purposes.
6.22	pH Adjustment Tank Mixer	Estimate based upon Means Environmental Cost Data - Assemblies. Assume 1/4-hp 3.5-inch diameter mixer. Includes installation labor.
6.23	Superintendant	Assume a local contractor supplying managing the installation of the treatment plant components.
6.24	Interior 3" PVC Piping	Estimate based upon Granger 2009 catalog. Assume schedule 40 PVC sections, for four building lengths. Costs include delivery and installation.
6.25	Interior 2" PVC Piping	Estimate based upon Granger 2009 catalog. Assume schedule 40 PVC sections for four building lengths. Costs include delivery and installation.
6.26	Miscl. 3" PVC Fittings	Bulk estimate
6.27	Miscl. 2" PVC Fittings	Bulk estimate
6.28	Discharge Flow Totalizer	Estimate based upon McMaster-Carr catalog. Estimates based upon 2-inch ID flow meter capable of measuring up to 100 gpm through 99,999,999 gallons. Includes installation labor.
6.29	Inflow Totalizer	Estimate based upon Granger 2009 catalog. 1-inch inflow, 50 gpm maximum.
6.30	High-Level Switches for Sumps and Tanks	Estimate based upon Granger 2009 catalog. Assume at least 3 float switches per tank.
6.31	Misc. Parts and Supplies	Bulk estimate
6.32	Wet-Well Sump Centrifugal Transfer Pump	50 gpm medium-high head centrifugal pump to transfer water from the northern well field wet-well sump to the treatment plant equalization tank.

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

7.0 Interior Electric and Climate Control Construction		
7.1	Process Logic Control Panel & Programming	
7.2	Main Emergency Power Switch	
7.3	Lighting	Assume four banks of 8-foot dual tube fluorescent lights along the long axis of the building.
7.4	Electric Heater	Estimate based upon Granger 2009 catalog. Assume two 1Kw electric space heaters.
7.5	Interior Wiring & Electrical & Telephone Work	Estimate based upon unit rates from a local electrical contractor using prevailing wages and fringes. Assume two people for two weeks.
7.6	Telemetry Installation & Programming	
8.0 Other Direct Capital Costs		
8.1	Delivered Diesel for Heavy Equipment	Cost based on delivered diesel fuel from a local distributor.
8.2	Portable Restrooms	Cost based on an assumed site work duration of 3 months. Includes one restroom cleaned weekly.
8.3	Dumpster Rental and Construction Waste Disposal	Cost based on an assumed site work duration of 3 months. Assume one 8 cubic yard dumpster emptied weekly.
8.4	Office Trailer and Associated Appurtenances	Estimate based on one 36X10 office trailer with steps and security screens ($350 per month), one-time charges for trailer delivery/pickup, hurricane straps installation, security screen installation, deadbolt installation, and steps setup/knockdown (lump sum of $800), electrician to hookup and knockdown connection between generator and trailer ($1,000), cellular phone (email and internet capability at $100/month), laptop computer & printer ($1,000), camera ($250), and expendables (assume $200/month).
8.5	Storage Container	Estimate includes one 40' storage container (doors at both ends) ($106/month)
8.6	Generator	Estimate includes one 14KvA tow-behind diesel generator.
8.7	O&M Manual Development	
8.8	As-Built Survey	
9.0 Construction Management and Oversight		
9.1	Resident Engineer	Assumes 10 weeks of 10-hour days including weekly travel to and from the site.
9.2	Resident Engineer Travel & MIE	Assume GSA lodging rate and MIE for Providence County, Rhode Island.
9.3	Staff Engineer	Assumes 10 weeks of 10-hour days including weekly travel to and from the site.
9.4	Staff Engineer Travel & MIE	Assume GSA lodging rate and MIE for Providence County, Rhode Island.
9.5	Rig Geologist	Assumes 4 weeks of 10-hour days including weekly travel to and from the site.
9.6	Rig Geologist Travel & MIE	Assume GSA lodging rate and MIE for Providence County, Rhode Island.
9.7	Hydrogeologist Oversight	Assumes one half week of continuous on-site time.
9.8	Hydrogeologist Travel & MIE	Assume GSA lodging rate and MIE for Providence County, Rhode Island.
10.0 Construction Engineering, Procurement, and Project Management Support		
10.1	Permit preparation & regulatory interface	Assumes permits will be required for discharge of treated wastewater and discharge of treated air emissions. Additionally, local permits will also be required to be obtained. This estimate is to prepare the permit applications only. The costs for engineering and technical support required to prepare the application is included in section 11.
10.2	Project Management/Engineering Support (estimate 15%)	The capital costs with the construction of this alternative fall within the $2,000,000 to $10,000,000 range, and according to the EPA Guide to Developing and Documenting Cost Estimates During the FS, a technical support and project management capital cost percentage of 15% is recommended. This was increased to 20% to design and permit the treatment system.
11.0 Capital Contingencies		
11.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design. Given the presented scope activities includes a variety of potential difficulties, a scope contingency of 10% was carried. Given the lack of an extensive subsurface profile, a bid contingency of 15% was carried.

COST ASSUMPTIONS
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Operations and Maintenance Cost Assumptions		
OM.1.0 Groundwater Monitoring (per event)		
Groundwater monitoring costs were estimated for a single monitoring event. For long-term O&M, it was assumed that monitoring would occur trianually for the first five (5) years after construction, and annually thereafter. One annual summary and assessment report is assumed.		
OM.1.1	Sampling Equipment Rental	Includes groundwater pumps (3), controllers (3), and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1). For a period of two weeks. Costs based upon vendor rental quote.
OM.1.2	Disposable equipment costs	Includes a bladder replacement kit for each sample, based upon a vendor quote.
OM.1.3	Event Mobilization/Demobe - FOL	Travel time to and from Site = 4 hours per week, three weeks
OM.1.4	Event Mobilization/Demobe - Sampler (2)	Travel time to and from Site = 4 hours per week, three weeks
OM.1.5	Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee 2 samplers, manage and track analytical sample collection, collect samples as available, and conduct field audits. Level D PPE
OM.1.6	Sampling Labor - Sampler (2)	Assume samples collected from 55 wells at 10 hours per day over three weeks per event. Time required for QC sample collection not specifically included. SW sample (10 samples) time required to collect the sample considered negligible. Level D PPE
OM.1.7	Analytical Costs	Analyses include: GW - VOCs, SVOCs, pesticides, metals, chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen; SW - VOCs, SVOCs, Pest, metals; SED - SVOCs, pest, metals. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, trip blanks considered negligible. Costs based upon a variety of vendor-supplied costs.
OM.1.8	Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and two staff scientists in Providence County, two rental vehicles and fuel (assume $720 per week) for a period of 3 weeks per event.
OM.1.9	Data Validation	Assume 1 HR per sample analysis for data validation.
OM.1.10	Report Preparation	Assume 120 hours for report preparation at $100/HR. Other direct costs (copying/printing/delivery) at $1,000.
OM.2.0 Annual Review of Regional Land and Resource Usage		
OM.2.1	Town data review	Travel time to and from the Site = 4 hours; 6 hours record review/interview time for $65/hour worker. Reviews performed annually to examine the land use and water withdrawals in the area for any changes. Large changes in either of these categories may require additional investigation to determine if the remedy is protective.
OM.2.2	Report Preparation	Assume 4 HR for report preparation at $100/HR. Other costs (copying/printing/delivery) at $100
OM.3.0 Extraction Well System Maintenance		
OM.3.1	Redevelopment of Extraction Wells	Assume that half of the extraction wells will require redevelopment or anti-fouling treatments every five years.
OM.3.2	Vault Repairs	Assume that all extraction well vaults will require some level of attention annually. This could include lid painting, replacement parts, or concrete repairs.
OM.4.0 Building Maintenance		
OM.4.1	Building Repairs and Upkeep	Assume that this annual cost will apply to repairs to the roof or siding, repairs to the interior or exterior lighting, snow-plowing services, or repairs to the doors.
OM.4.2	Telephone Usage Charges	Assumes local and long-distance service as for two lines as well as a data and telemetry line.
OM.4.3	Electricity Usage Charges	Assumes typical operating conditions of 18Kw at 2009 commercial electric rates. The monthly cost for heating the building using the electric heaters increases by approximately $6,000 during heating months.
OM.5.0 Treatment Plant Operation & Maintenance		
OM.4.1	Treatment Plant Operator	Assumes an 8-hour visit three times per week by a treatment system operator. During that time, the operator will perform routine maintenance and general upkeep duties.
OM.4.2	Air Strip Packing Reconditioning	It is assumed that the air stripper packing material will be serviced annually.
OM.4.3	Blower Maintenance	It is assumed that the blowers and blower motors will require some level of attention annually.
OM.4.4	Transfer, Metering, and Diaphragm Pump Maintenance	It is assumed that the each of the pumps will require some level of attention annually.
OM.4.5	Vapor-Phase Carbon Changeout	Estimate based upon Means Environmental Cost Data - Assemblies. Assumed annual maintenance includes disconnection of the system, removal and replacement of the carbon, reconnection of the system, and transportation and recharge of the carbon.
OM.4.6	Liquid-Phase Carbon Changeout	Estimate based upon Means Environmental Cost Data - Assemblies. Assumed annual maintenance includes disconnection of the system, removal and replacement of the carbon, reconnection of the system, and transportation and recharge of the carbon.
OM.4.7	Precipitation/Flocculation/Coagulation	Based upon common estimation methods, the estimated consumption of the precipitation, floccing, and coagulation agents amounts to approximately $0.70 per gallon treated.
OM.4.10	Sludge Disposal	The cost includes annual characterization of the treatment system sludge, waste profiling, and sludge disposal. If the sludge is characterized as hazardous, the cost could increase.

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OM.6.0 Monitoring and Annual Reporting Engineering and Management Support		
OM.6.1	Project Management/Engineering Support	As expected capital costs are between $100,000 and $500,000, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS, the costs associated with remedial design (15%), routine project management (8%), engineering support, oversight, and bid preparations (10%) are carried as percentages (as indicated) of the expected capital costs.
OM.7.0 O&M Contingencies		
OM.3.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design.
FY.1.0 Five-Year Reviews		
FY.1.1	Five-Year Review Preparation	Estimated at $50,000 each report, based upon current estimates of in-progress work. Management and technical support costs are included in this cost. No contingencies are applied.

PRESENT VALUE ANALYSIS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW5
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

Year	Capital	O&M	5-Year Review [1]	Total	Discount Rate	Present Value
0	$23,598,273	$0	$0	$23,598,273	7.0%	$23,598,273
1	$0	$ 640,919	$0	$640,919	7.0%	$598,989
2	$0	$ 640,919	$0	$640,919	7.0%	$559,803
3	$0	$ 640,919	$0	$640,919	7.0%	$523,180
4	$0	$ 640,919	$0	$640,919	7.0%	$488,954
5	$0	$ 640,919	$50,000	$690,919	7.0%	$492,615
6	$0	$ 283,879	$0	$283,879	7.0%	$189,160
7	$0	$ 283,879	$0	$283,879	7.0%	$176,785
8	$0	$ 283,879	$0	$283,879	7.0%	$165,220
9	$0	$ 283,879	$0	$283,879	7.0%	$154,411
10	$0	$ 283,879	$50,000	$333,879	7.0%	$169,727
11	$0	$ 283,879	$0	$283,879	7.0%	$134,869
12	$0	$ 283,879	$0	$283,879	7.0%	$126,045
13	$0	$ 283,879	$0	$283,879	7.0%	$117,800
14	$0	$ 283,879	$0	$283,879	7.0%	$110,093
15	$0	$ 283,879	$50,000	$333,879	7.0%	$121,013
16	$0	$ 283,879	$0	$283,879	7.0%	$96,160
17	$0	$ 283,879	$0	$283,879	7.0%	$89,869
18	$0	$ 283,879	$0	$283,879	7.0%	$83,989
19	$0	$ 283,879	$0	$283,879	7.0%	$78,495
20	$0	$ 283,879	$50,000	$333,879	7.0%	$86,281
21	$0	$ 283,879	$0	$283,879	7.0%	$68,560
22	$0	$ 283,879	$0	$283,879	7.0%	$64,075
23	$0	$ 283,879	$0	$283,879	7.0%	$59,883
24	$0	$ 283,879	$0	$283,879	7.0%	$55,966
25	$0	$ 283,879	$50,000	$333,879	7.0%	$61,517
26	$0	$ 283,879	$0	$283,879	7.0%	$48,883
27	$0	$ 283,879	$0	$283,879	7.0%	$45,685
28	$0	$ 283,879	$0	$283,879	7.0%	$42,696
29	$0	$ 283,879	$0	$283,879	7.0%	$39,903
30	$0	$ 283,879	$50,000	$333,879	7.0%	$43,861
TOTAL	**$23,598,273**					**$28,692,759**

Note: Discount rate of 7% per EPA 540-R-00-002, OSWER 9355.0-75, July 2000, p. 4-5.

OPERATIONS MAINTENANCE COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW5
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
1.0 Institutional Controls						
1.1	Record Survey	2	LS	$10,000	$20,000	Vendor quote; see assumptions
1.2	Attorney's Fees	2	LS	$3,100.00	$6,200	see assumptions
	Subtotal				**$26,200**	
2.0 Monitoring Well Construction						
2.1	Mobilize Drill Rig and Crew	1	LS	$340.00	$340	see assumptions
2.2	8 bedrock boreholes and 4 overburden monitoring wells	1	LS	$60,000.00	$60,000	see assumptions
2.3	Dedicated tubing for all wells	1	LS	$6,000.00	$6,000	see assumptions
2.4	IDW Disposal	1	LS	$10,000.00	$10,000	see assumptions
2.5	Oversight and Rig Geologist	180	HR	$85	$15,300	see assumptions
2.6	Oversight and Rig Geologist travel & MIE	4	Week	$1,200	$4,800	see assumptions
	Subtotal				**$96,440**	
3.0 Thermal Treatment Design and Construction						
3.1	Pre-Design Investigation, Remedial Designs and Plans	1	LS	$1,074,073.38	$1,074,073	Vendor information, see assumptions
3.2	Oversight and Construction Monitoring	810	HR	$85.00	$68,850	see assumptions
3.3	Oversight and Construction Monitoring Travel & MIE	15	Week	$1,200.00	$18,000	see assumptions
3.4	Borehole, Electrode and Vapor Extraction Well Installations	1	LS	$2,310,183.46	$2,310,183	Vendor information, see assumptions
3.5	Surface Component Installations	1	LS	$2,310,183.46	$2,310,183	Vendor information, see assumptions
3.6	Electric Service to Treatment Area	1	LS	$735,000.00	$735,000	see assumptions
3.7	Site Demobilization	1	LS	$1,155,091.73	$1,155,092	Vendor information, see assumptions
3.8	Water/Condensate Disposal	1	LS	$1,155,091.73	$1,155,092	Vendor information, see assumptions
3.9	Drill Cuttings & Waste Disposal	1	LS	$150,000.00	$150,000	see assumptions
	Subtotal				**$8,976,474**	
4.0 In-Situ Thermal Treatment Operation, Oversight & Monitoring						
4.1	Operations Oversight and Monitoring	1,230	HR	$85.00	$104,550	see assumptions
4.2	Operations Oversight and Monitoring Rental Vehicle	41	Week	$320.00	$13,120	see assumptions
4.3	Site Facilities, Utilities, Laydown Area Preparation	1	LS	$190,242.00	$190,242	Vendor information, see assumptions
4.4	Electrical Usage	15,000,000	KWh	$0.12	$1,800,000	see assumptions
4.5	Carbon Usage, Transportation & Regeneration	1	LS	$462,036.69	$462,037	Vendor information, see assumptions
4.6	Remediation System Operation	1	LS	$5,544,440.30	$5,544,440	Vendor information, see assumptions
4.7	Post-Treatment GW Sampling Equipment Rental	1	LS	$5,500.00	$5,500	see assumptions
4.8	Post-Treatment GW Disposable equipment costs	14	EA	$20.00	$280	see assumptions
4.9	Post-Treatment GW Event Mobiliation/Demobe - FOL	4	HR	$85.00	$340	see assumptions
4.10	Post-Treatment Event Mobiliation/Demobe - Samplers	8	HR	$65.00	$520	see assumptions
4.11	Post-Treatment GW Sampling Labor - FOL	50	HR	$85.00	$4,250	see assumptions
4.12	Post-Treatment GW Sampling Labor - Sampler (2)	100	HR	$65.00	$6,500	see assumptions
4.13	Post-Treatment GW Sampling Travel and MIE	3	EA	$6,480.00	$19,440	see assumptions
4.14	Post-Treatment GW Analytical Costs	20	EA	$700.00	$14,000	see assumptions
4.15	Post-Treatment GW Data Validation	20	HR	$100.00	$2,000	see assumptions
4.16	Post-Treatment Completion Report Preparation	1	LS	$150,000.00	$150,000	see assumptions
	Subtotal				**$8,317,219**	
5.0 In-Situ Thermal Treatment Engineering and Management Support						
5.1	Permit preparation & regulatory interface	100	HR	$85.00	$8,500	see assumptions
5.2	Project Management/Engineering Support (estimate 11%)	1	LS	$1,915,796.60	$1,915,797	see assumptions
	Subtotal				**$1,924,297**	
6.0 Contingencies						
6.1	10% Scope & 15% Bid (25% total)	1	LS	$4,354,083.19	$4,354,083	see assumptions
	Subtotal				**$4,354,083**	
TOTAL DIRECT COSTS					**$23,598,273**	
TOTAL CAPITAL COST FOR ALTERNATIVE GW5					**$23,598,273**	

Notes:

OPERATIONS AND MAINTENANCE COST SUMMARY
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW5
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE
OM.1.0 Groundwater Monitoring (per event)						
OM.1.1	Sampling Equipment Rental	1	LS	$5,500	$5,500	see cost assumptions
OM.1.2	Disposable equipment costs	55	EA	$20	$1,100	see cost assumptions
OM.1.3	Event Mobiliation/Demobe - FOL	12	HR	$75	$900	see cost assumptions
OM.1.4	Event Mobiliation/Demobe - Sampler (2)	24	HR	$65	$1,560	see cost assumptions
OM.1.5	Sampling Labor - FOL	138	HR	$75	$10,350	see cost assumptions
OM.1.6	Sampling Labor - Sampler (2)	276	HR	$65	$17,940	see cost assumptions
OM.1.7	Analytical Costs	103	EA	$1,050	$108,150	see cost assumptions
OM.1.8	Sampling Travel and MIE	1	EA	$9,720	$9,720	see cost assumptions
OM.1.9	Data Validation	103	HR	$100	$10,300	see cost assumptions
OM.1.10	Report Preparation	1	LS	$13,000	$13,000	see cost assumptions
	Subtotal				**$178,520**	
OM.2.0 Annual Review of Regional Land and Resource Usage						
OM.2.1	Town data review	10	HR	$65	$650	see cost assumptions
OM.2.2	Report Preparation	1	LS	$500	$500	see cost assumptions
	Subtotal				**$1,150**	
OM.3.0 Monitoring and Annual Reporting Engineering and Manangement Support						
OM.3.1	Project Management/Engineering Support (estimate 33%)	1	LS	$59,291	$59,291	see cost assumptions
	Subtotal				**$59,291**	
OM.4.0 O&M Contingencies						
OM.4.1	10% Scope & 15% Bid (25% total)	1	LS	$44,918	$44,918	see cost assumptions
	Subtotal				**$44,918**	
FY.1.0 Five-Year Reviews						
FY.1.1	Five-Year Review report preparation	1	LS	$50,000	$50,000	see cost assumptions
	Subtotal				**$50,000**	

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
ALTERNATIVE GW4
DAVIS LIQUID WASTE SITE
SMITHFIELD, RHODE ISLAND

Capital Cost Assumptions		
1.0 Institutional Controls		
1.1	Record Boundary Survey	Approximate costs per parcel for a deed record survey including meets and bounds. Assumes 2 parcels.
1.2	Attorney's Fees	Attorney's fees associated with title research, drafting the restrictive covenants, and attaching a restriction to a deed for a single parcel (assume 2), includes any registry fees ($84 for the first page, $1 for each additional page).
2.0 Monitoring Well Construction		
2.1	Mobilize Drill Rig and Crew	Lump sum mobilization rate, assuming a mobilization rate of $2.25 (includes any fuel surcharges) and a round-trip of 150 miles. All work completed in Level D PPE
2.2	8 bedrock boreholes and 4 overburden monitoring wells	Drilling depths: four new bedrock wells east of source area at 200 feet per boring, through a 6" borehole assumes no clearing/grubbing will be required. Drilling depths for four new bedrock wells north of the source area at 100 feet per boring. Four new overburden monitoring wells located north of the source area to a depth of 30 feet. Bedrock boreholes will be fitted with 2" Schedule 80 PVC wells installed (20-foot 10-slot screen size). Overburden wells will be constructed of 2" Schedule 40 PVC (10-foot 10-slot screens). Assumes drilling can be completed in 18 days, with 15 overnight stays. Overburden drilled using drive and wash drilling, with SPT every 5 feet. Bedrock drilled using 6" air hammer.
2.3	Dedicated tubing for all wells	Assumes approximately 4000 feet of bonded tubing (one side Teflon-lined).
2.4	IDW Disposal	Assumes <20 tons of drill cuttings, characterization (VOCs, RCRA8 metals, characteristics), and a mobilization/fuel fee.
2.5	Oversight and Rig Geologist	Assumes 1 rig geologist travel and stay on-site for 10 10-hour days plus travel
2.6	Oversight and Rig Geologist travel & MIE	Assumes GSA Per-Diem lodging and MIE for 1 person over two weeks in Providence County.
3.0 Thermal Treatment Design and Construction		
3.1	Pre-Design Investigation, Remedial Designs and Plans	Pre-Design Investigation includes an evaluation of potential "hot-spots" outside of the targeted source area. This investigation will require additional subsurface drilling and sample collection for VOCs, SVOCs, PCBs, and metals. Also includes the completion of site remedial design and subsequent work plan and schedule for construction. Estimate assumed to be approx. 4% of project costs excluding post-remedy monitoring.
3.2	Oversight and Construction Monitoring	Assumes one project engineer at a loaded rate of $85/hour for the duration of the construction period (total of 15 weeks, at 10 hours per day plus 4 hours travel per week).
3.3	Oversight and Construction Monitoring Travel & MIE	Includes the GSA per-diem lodging and MIE for one project engineer in Providence County, rental vehicle and fuel (assume $360 per week) for a period of approx, 15 weeks (assume 3 month construction time).
3.4	Borehole, Electrode and Vapor Extraction Well Installations	Includes the drilling 470 12-inch boreholes, installation of 470 electrodes and co-located vapor extraction wells. No soil samples are collected, and two drill rigs are utilized. Estimate is based upon vendor cost breakdown guidelines coupled with a vendor conceptual system estimate. The guideline suggests approximately 10% of the total project costs, less post-remedy monitoring.
3.5	Surface Component Installations	Assumes the installation of all surface vapor-recovery piping, power cables, power control units (PCUs), vapor recovery system, vapor granular activated carbon (GAC) treatment system, steam/vapor condenser, and cooling tower.
3.6	Electric Service to Treatment Area	Estimate using the conceptual design presented in the Ebasco Final Criteria Summary Report, June 1994. Scaled the costs presented using the consumer price index as presented by the Bureau of Labor Statistics (the multiplier was approximately 1.48). Electrical requirements are 3-phase, 225 amps, 400 volts.
3.7	Site Clearance & Demobilization	Includes costs associated with disassembly and demobilization of the treatment components, removal of electrodes and vapor extraction well components, abandonment of all electrode/vapor extraction wells, and minor site work. Estimate is based upon vendor cost breakdown guidelines coupled with a vendor conceptual system estimate. The guideline suggests approximately 5% of the total project costs, less post-remedy monitoring.
3.8	Water/Condensate Disposal	Includes costs associated with the storage, characterization, transportation, and disposal of water and condensates recovered during the operation of the treatment system. Assumes cost associated with the disposal of vapor condensate during system operations. It is assumed that this material will be transported off-site for disposal. Access to a publicly-owned treatment works is not available. Estimate is based upon vendor cost breakdown guidelines coupled with a vendor conceptual system estimate. The guideline suggests approximately 5% of the total project costs, less post-remedy monitoring.
3.9	Drill Cuttings & Waste Disposal	Assumes up to five waste characterization samples, transportation, and disposal costs associated with the disposal of drill cuttings for up to 300 cubic yards of contaminated (potentially hazardous) soil at approximately $500 per cubic yard.

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
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4.0	**In-Situ Thermal Treatment Operation, Oversight & Monitoring**	
4.1	Operations Oversight and Monitoring	Assumes one project engineer at a loaded rate of $85/hour to visit and monitor the remedy three times per week, assuming each is a 10-hour day. Total treatment duration is approximately 36 weeks. Travel time to and from the Site is lumped into the 10 hour workday.
4.2	Operations Oversight and Monitoring Rental Vehicle	Includes weekly rental vehicle and fuel (assume $360 per week) for a period of 36 weeks.
4.3	Site Facilities, Utilities, Laydown Area Preparation	Includes one 30'X80' sprung-structure temporary building, one 40' storage container (doors at both ends) ($106/month), one 36X10 office trailer with steps and security screens ($350 per month), one-time charges for trailer delivery/pickup, hurricane straps installation, security screen installation, deadbolt installation, and steps setup/knockdown (lump sum of $800), dumpster with weekly solid waste removal services ($315/month), one portable restroom with weekly cleaning ($95/month), cellular phone (email and internet capability at $100/month), laptop computer & printer ($1,000), camera ($250), and expendables (assume $200/month). Assume the duration of the project is 24 months.
4.4	Electrical Usage	An estimated 15,000,000 KWH will be required during treatment.
4.5	Carbon Usage, Transportation & Regeneration	Cost of the GAC, GAC changeout, GAC transportation and regeneration associated with this remedy was provided by vendors as a percentage of the total project cost. The cited percentage is 2% of total cost.
4.6	Remediation System Operation	Estimated costs associated with the ERH-system vendor operation of the system for the duration of the treatment period (approx. 9 months). Cost of vendor-supplied operations and monitoring associated with this remedy was provided by vendors as a percentage of the total project cost. The cited percentage is 24% of total cost.
4.7	Post-Treatment GW Sampling Equipment Rental	Includes groundwater pumps, controllers, and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1) for one week. Costs based upon vendor rental quote. Assume one monitoring event.
4.8	Post-Treatment GW Disposable equipment costs	Assume 47 locations at the end of the injection program (after all injections completed).
4.9	Post-Treatment GW Event Mobilization/Demobe - FOL	Assume 4 hour round trip per event for 1 event for one project engineer
4.10	Post-Treatment Event Mobilization/Demobe - Samplers	Assume 4 hour round trip per event for 1 events for two staff scientists
4.11	Post-Treatment GW Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee 2 samplers, manage and track analytical sample collection, collect samples as available, and conduct field audits.
4.12	Post-Treatment GW Sampling Labor - Sampler (2)	Assume samples collected from 47 wells at 10 hours per day over two weeks (maximum), per event (assume 4 events). Time required for QC sample collection not specifically included, but is likely negligible at this scale.
4.13	Post-Treatment GW Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and two staff scientists in Providence County, two rental vehicles and fuel (assume $720 per week) for a period of 1 weeks total.
4.14	Post-Treatment GW Analytical Costs	Analyses include: VOCs, chloride, sulfate, sulfide, iron, manganese, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, trip blanks considered negligible. Costs based upon a variety of vendor-supplied costs.
4.15	Post-Treatment GW Data Validation	Assume 1 HR per sample analysis for data validation.
4.16	Post-Treatment Completion Report Preparation	Report to summarize the treatment program, observations, monitoring, analytical results obtained, and an evaluation of remedial goals. Costs based upon a scale-up of the report preparation costs associated with the long-term monitoring. An additional evaluation of remedial success and comparison to remedial goals and reduction efficiency were also included.
5.0	**In-Situ Thermal Treatment Engineering and Management Support**	
5.1	Permit preparation & regulatory interface	Cost estimate to include air quality permit procurement (for SVE system), activities within a wetland, and general discussion with State and local regulators.
5.2	Project Management/Engineering Support (estimate 11%)	Costs associated with coordination and engineering support to complete construction and operations. In accordance with the EPA Guide to Developing and Documenting Cost Estimates during the FS, a technical support and project management cost of 11% of the total capital costs associated with that support or management is selected. Construction management and much of the remedial design is accounted for as part of line item 2.1; however, additional engineering and technical support post-design is expected.
6.0	**Contingencies**	
6.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used, in accordance with the EPA Guide to Developing and Documenting Cost Estimates during the FS. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design. Given the presented scope activities, a scope contingency of 10% was carried. Given the lack of an extensive subsurface profile, a bid contingency of 15% was carried.

COST ASSUMPTIONS
FOCUSED FEASIBILITY STUDY
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Operations and Maintenance Cost Assumptions		
OM.1.0 Groundwater Monitoring (per event)		
Groundwater monitoring costs were estimated for a single monitoring event. For long-term O&M, it was assumed that monitoring would occur triannnually for the first five (5) years after construction, and annually thereafter. One annual summary and assessment report is assumed.		
OM.1.1	Sampling Equipment Rental	Includes groundwater pumps (3), controllers (3), and compressed gas (3), water quality monitoring instruments (3), water level indicators (3), air-monitoring instrument (1). For a period of two weeks. Costs based upon vendor rental quote.
OM.1.2	Disposable equipment costs	Includes a bladder replacement kit for each sample, based upon a vendor quote.
OM.1.3	Event Mobilization/Demobe - FOL	Travel time to and from Site = 4 hours per week, three weeks
OM.1.4	Event Mobilization/Demobe - Sampler (2)	Travel time to and from Site = 4 hours per week, three weeks
OM.1.5	Sampling Labor - FOL	Labor hours assume 10 hours per day to oversee 2 samplers, manage and track analytical sample collection, collect samples as available, and conduct field audits. Level D PPE
OM.1.6	Sampling Labor - Sampler (2)	Assume samples collected from 54 wells at 10 hours per day over three weeks per event. Time required for QC sample collection not specifically included. SW sample (10 samples) time required to collect the sample considered minimal. Level D PPE
OM.1.7	Analytical Costs	Analyses include: GW - VOCs, SVOCs, pesticides, metals, chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen; SW - VOCs, SVOCs, Pest, metals; SED - SVOCs, pest, metals. QC samples: 10% duplicate, 5% MS/MSD, 1 PE set per event, trip blanks considered negligible. Costs based upon a variety of vendor-supplied costs.
OM.1.8	Sampling Travel and MIE	Includes the GSA per-diem lodging and MIE for one project engineer and two staff scientists in Providence County, two rental vehicles and fuel (assume $720 per week) for a period of 3 weeks per event.
OM.1.9	Data Validation	Assume 1 HR per sample analysis for data validation.
OM.1.10	Report Preparation	Assume 120 hours for report preparation at $100/HR. Other direct costs (copying/printing/delivery) at $1,000.
OM.2.0 Annual Review of Regional Land and Resource Usage		
OM.2.1	Town data review	Travel time to and from the Site = 4 hours; 6 hours record review/interview time for $65/hour worker. Reviews performed annually to examine the land use and water withdrawals in the area for any changes. Large changes in either of these categories may require additional investigation to determine if the remedy is protective.
OM.2.2	Report Preparation	Assume 4 HR for report preparation at $100/HR. Other costs (copying/printing/delivery) at $100
OM.3.0 O&M Contingencies		
OM.3.1	Scope and Bid	A 10% scope contingency and 15% bid contingency was used. These contingencies are considered to be representative of the potential for cost growth associated with a 0-10% complete remedial design.
OM.4.0 O&M Contingencies		
OM.4.1	Project Management/Engineering Support	As expected capital costs are between $100,000 and $500,000, in accordance with the EPA Guide to Developing and Documenting Cost Estimates During the FS, the costs associated with remedial design (15%), routine project management (8%), engineering support, oversight, and bid preparations (10%) are carried as percentages (as indicated) of the expected capital costs.
FY.1.0 Five-Year Reviews		
FY.1.1	Five-Year Review Preparation	Estimated at $50,000 each report, based upon current estimates of in-progress work. Management and technical support costs are included in this cost. No contingencies are applied.

APPENDIX E

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Appendix E

Biochlor Simulations

In order to consider the impact of the remedial alternatives on groundwater concentrations at the site, Nobis utilized Biochlor (Aziz, et al, 2002) to predict chlorinated solvent concentrations in groundwater near the site under three remediation scenarios: natural attenuation; source removal and source area removal with northern overburden groundwater remediation. The objective of the simulations is to provide approximate times to achieve remedial action objectives.

Approach

Changes in source area concentrations over time were used to calibrate the model. Based on historic data it appears that Davis Liquids started to receive hazardous materials in approximately 1975 (Nobis, 2008). No information is available on groundwater quality in the source area while active dumping was ongoing. Thus, Biochlor was used in conjunction with changes in measured groundwater concentration over time to estimate degradation parameters and average initial source concentrations. Because anaerobic degradation of the source area dominated the time to achieve remedial goals, Biochlor was used to simulate biotransformation in the dissolved phase only for Zone 1 (i.e. anaerobic degradation). Zone 2 (aerobic degradation) was not considered.

The source area degradation rate was estimated using plots of the data presented in ESS (2008). Figures D-1 and D-2 present graphs of the data. Evaluating changes in dissolved phase concentrations with time is an indirect estimate of the source area degradation rate because decreases in groundwater contaminant concentrations with time in the source are wells are the result of the degradation of the source material and degradation of dissolved phase organic contaminants. Biochlor accounts for degradation for both the source material for dissolved phase concentration. The data presented in Figures D-1 and D-2 indicate that the dissolved concentration of some of the contaminants of concern (COC - tetrachlorethene [PCE] and in one well, trichloroethene [TCE]) do not show a consistently downward trend since 2003 (i.e. the slopes of the PCE trend lines and one of the TCE trend lines are positive). It would be anticipated that the PCE data would have a downward trend in the source area because no additional contamination has been introduced into the source area between 2003 and 2008 (the time period of concern in Figures D-1 and D-2). Thus, it appears that there are other influences (e.g., seasonal etc.) in the changes of dissolved contaminant concentration with time and that the trend lines provide an approximation of the decay rate.

As specified in Aziz et al. (2002) the slope of the line of the log of concentration against time produces an estimate of the source degradation constant. These lines are indicated on Figures D-1 and D-2 and the exponents are equal to the estimated degradation rates for each compound. The estimated degradation rates were used as a starting point for the model calibration process. The source degradation rates used in the calibrated models are consistent with those observed in Figures D-1 and D-2.

The calibration procedure estimated source area concentrations using groundwater data collected in 1991 and 2008 and presented by Ebasco (1994) and Nobis (2008) respectively. In the case of the 1991 data, maximum concentrations of PCE, TCE, 1,2, dichloroethene (total) and VC were taken from Appendix C for the overburden and bedrock wells. These values were assumed to characterize the source area concentrations in 1991. In the case of the 2008 data, source area concentrations were assumed to be represented by the results of groundwater samples collected from OW-094-O and OW-094-R for the overburden and bedrock respectively.

Model calibration proceeded by assuming an initial concentration (i.e. time=0 years) and iteratively varying the initial concentrations and the individual constituent degradation rates until a good match was made for the 1991 data (i.e. at time=16 years) and the 2008 data (i.e. time = 34 years). In some cases, the calibration process resulted in utilization of initial dissolved phase concentrations that exceeded the solubility of some of the COCs. This may be indicative of co-solvent affects or the presence of small quantities of Non-Aqueous Phase Liquids in the source area at least initially.

The model calibration procedure indicated that the groundwater transport portion of the model did not significantly impact the time to reach clean-up goals. This is because the source area concentration was usually the highest concentration in the model domain and downgradient groundwater quality was generally below clean-up criteria by the time source area concentrations met clean-up criteria. As a result, clean-up time estimates were insensitive to transport parameters such as dispersivity and organic carbon partitioning coefficients and these parameters were varied to insure model stability. Estimates of the hydraulic conductivity for the overburden and bedrock were based on values presented for the calibrated groundwater model in Ebasco (1994).

Natural Attenuation

Natural attenuation was modeled by using the calibrated model to simulate future degradation of source area groundwater. The duration of the model simulation was varied until predicted groundwater concentrations were below clean-up levels. The time to reach clean-up goals in groundwater was limited by VC. Input and selected output from the model runs are included in Figures D-3 D-4, D-7 and D-8 for overburden and bedrock respectively. Time to achieve remediation goals in the natural attenuation scenarios are based on the calibrated model. The calibrated model uses all of the measured data over time (i.e. starting from the presumed initiation of dumping in 1975). Thus, the number of years to achieve remediation goals indicated in Figures D-4 and D-8 are from 1975. In order to be consistent with the other simulations included in the table, the time to achieve remediation goals indicated in the Table 1 is calculated from 2008.

Source Removal

The estimate of time to reach clean-up standards under the source removal scenario was made by assuming only groundwater outside of the source area remained contaminated. Thus, for the overburden the average concentration for OW-303 and OW-051 were used to characterize the maximum groundwater concentrations. For the bedrock simulations, OW-103R and OW-101R

were used. Input and selected output from the model runs are included in Figures D-5 D-6, D-9 and D-10 for overburden and bedrock respectively.

Source Removal and Northern Overburden Groundwater Treatment Excluding Wetlands

The estimate of time to reach clean-up standards for Alternative GW3B was made assuming overburden groundwater remediation activities extended further north but excluded remediation in the wetlands northeast and northwest of the source area. Biochlor models were developed to simulate degradation and transport of untreated groundwater in the northeast and northwest wetland separately. The maximum groundwater concentration in the northwest wetland was based on the concentrations observed in OW-51. Because the area of OW-51 would be remediated as part of the treatment alternative and there are no other groundwater monitoring wells in this area, the maximum initial groundwater concentration used in the northwest wetland simulation was assumed to be ½ of the values observed in OW-51. Maximum overburden groundwater concentrations in the northeast wetlands were based on values measured in OW-45. The estimate of time to reach clean-up standards was based on the modeled wetland that took the longest time to reach the groundwater clean-up objectives. In this case, it was the northeast wetland. Input and selected output from the model runs are included in Figures D-11 and D-12 for the northwest wetland and D-13 and D-14 for northeast wetland.

The estimated clean-up time of the calibrated models are presented in Table D-1.

Uncertainties

As mentioned above, monitoring results indicate that dissolved contaminant concentrations of PCE did not continuously decrease with time indicating other processes were present in the calibration data beyond contaminant degradation. Thus, the slopes of the lines in figures D-1 and D-2 provide an approximate value for the source area degradation rate. In addition, in some cases, concentrations of individual contaminants did not consistently change with distance from the source. Thus, some uncertainty is introduced into the model by noise in the calibration data. However, use of more than one set of temporal and spatial data is expected to increase the reliability of the model. It is anticipated that the predications of the model will meet the modeling objectives.

Table D-1
Time to Reach Target Clean-Up Levels
Davis Liquids Superfund Sites
Smithfield, RI

	Natural Attenuation	With Source Removal	Overburden Groundwater Remediation Northwest of Source Area	Overburden Groundwater Remediation Northeast of Source Area
Overburden	**100**	**45**	**40**	**45**
Bedrock	**80**	**20**	**-**	**-**

References

Aziz, C.E., C. J. Newell, and J.R. Gonzales P. Haas. 2002. Biochlor, Natural Attenuation Decision Support System V2.2. National Risk Management Research Laboratory, Ada, OK

Ebasco. 1994. Final Criteria Summary Report, Perform Predesign Investigation and Develop Design Criteria at Davis Liquid Waste Superfund Site, Smithfield, RI Volume II A, Appendices A-F.

ESS Group, Inc. 2008. Draft Phase 4 Supplemental Field Investigation Report. Davis Liquid Waste Superfund Site. Smithfield RI.

Nobis, 2008. Draft Conceptual Site Model, Technical Memorandum. Davis Liquid Waste Superfund Site. Smithfield RI.

Figure D-1
Estimate of Source Degradation Rate of Chlorinated Solvents in Overburden Groundwater
Davis Liquids Superfund Site
Smithfield, RI

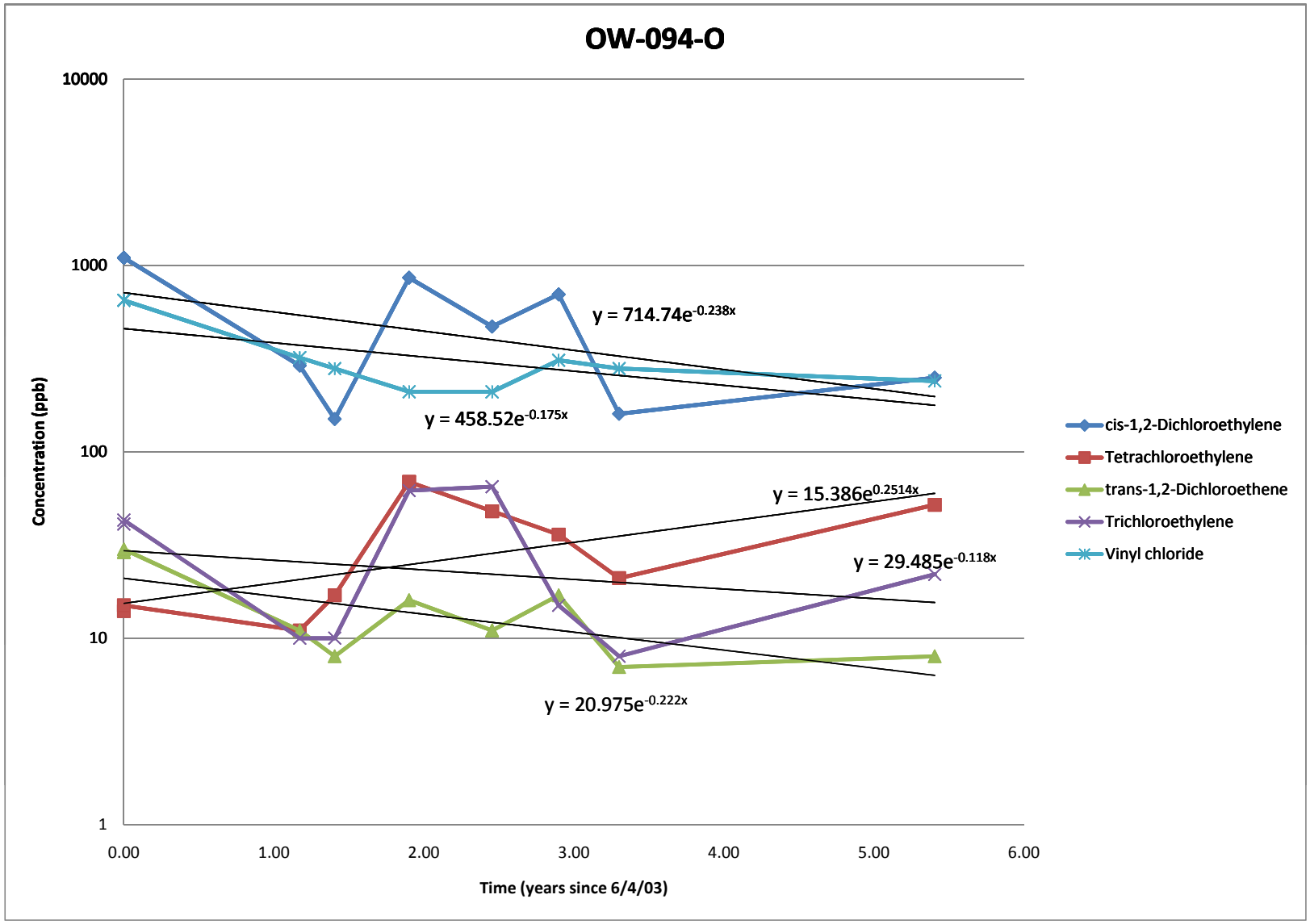


Figure D-2
Estimate of Source Degradation Rate
in Bedrock Groundwater
Davis Liquids Superfund Site
Smithfield, RI

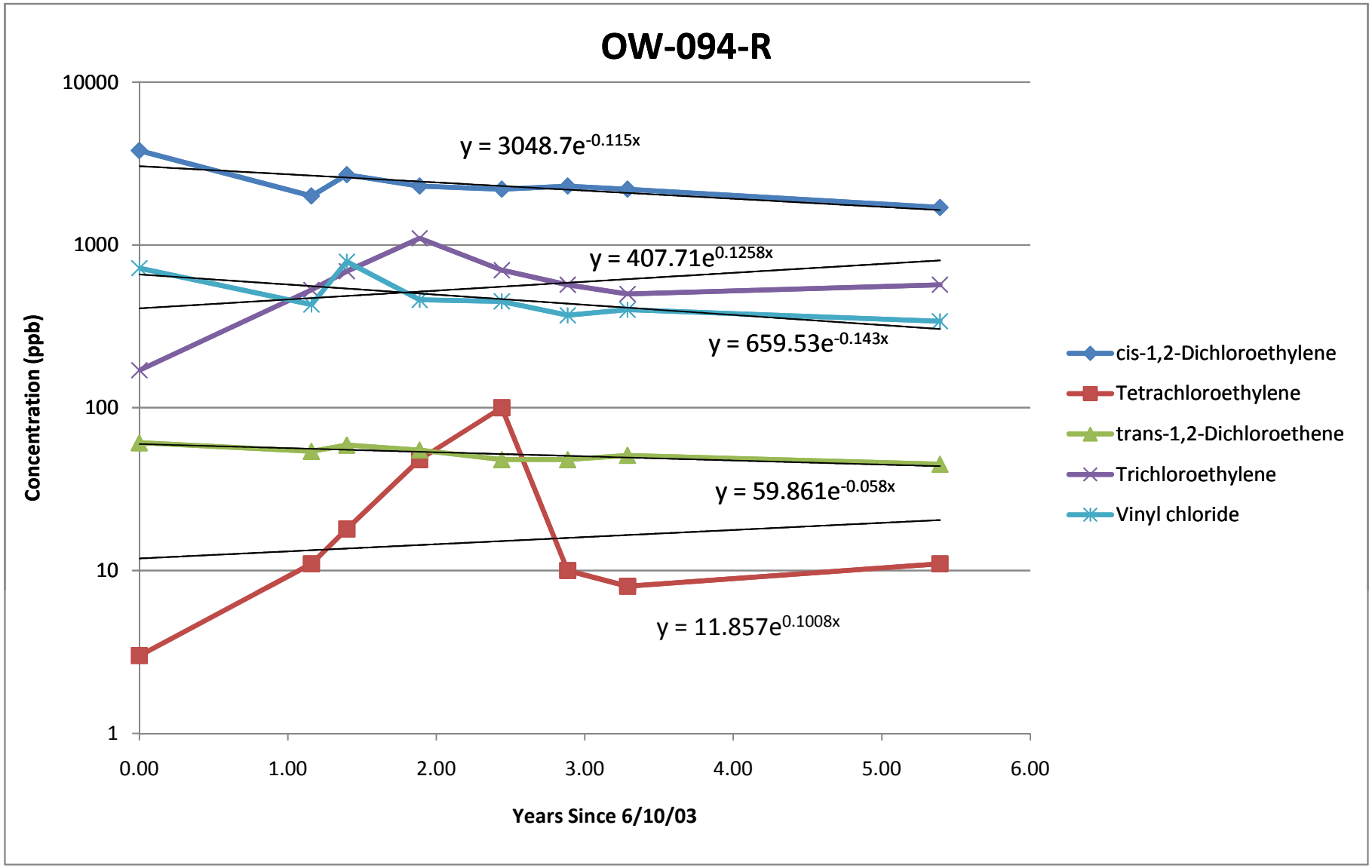


Figure D-3
Overburden Natural Attenuation Input
Davis Liquids Superfund Site
Smithfield, RI

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

Davis Liquid Waste
Overburden
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	53.2	(ft/yr)
or			
Hydraulic Conductivity	K	9.0E-03	(cm/sec)
Hydraulic Gradient	i	0.002	(ft/ft)
Effective Porosity	n	0.35	(-)

2. DISPERSION

Alpha x*	50	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R
or

Soil Bulk Density, rho	1.7	(kg/L)		
FractionOrganicCarbon, foc	9.0E-4	(-)		
Partition Coefficient	Koc			
PCE	389	(L/kg)	2.70	(-)
TCE	126	(L/kg)	1.55	(-)
DCE	126	(L/kg)	1.55	(-)
VC	100	(L/kg)	1.44	(-)
ETH	5	(L/kg)	1.02	(-)
Common R (used in model)* =			**1.55**	

4. BIOTRANSFORMATION -1st Order Decay Coefficient*

Zone 1	λ (1/yr)		half-life (yrs)	Yield
PCE → TCE	1.200	←	9.49	0.79
TCE → DCE	0.900	←	9.48	0.74
DCE → VC	2.500	←	19.00	0.64
VC → ETH	0.160	←		0.45

Zone 2	λ (1/yr)		half-life (yrs)
PCE → TCE	0.000	←	
TCE → DCE	0.000	←	
DCE → VC	0.000	←	
VC → ETH	0.000	←	

λ HELP

5. GENERAL

Simulation Time*	133	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	1050	(ft)
Zone 1 Length*	1050	(ft)
Zone 2 Length*	0	(ft)

L, W

Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

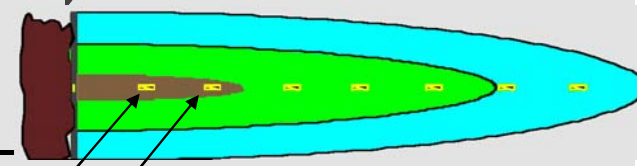
Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 300

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	4.5	0.11
TCE	90.0	0.11
DCE	6000.0	0.11
VC	.1	0.11
ETH	0.001	0.11

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	52.0	8.0	3.0	.001							
TCE Conc. (mg/L)	22.0	3.0	6.0	1.0							
DCE Conc. (mg/L)	250.0	48.0	390.0	22.0							
VC Conc. (mg/L)	240.0	28.0	170.0	19.0							
ETH Conc. (mg/L)	0.1	.1	.01	.01							
Distance from Source (ft)	140	480	750	1180							
Date Data Collected	2008										

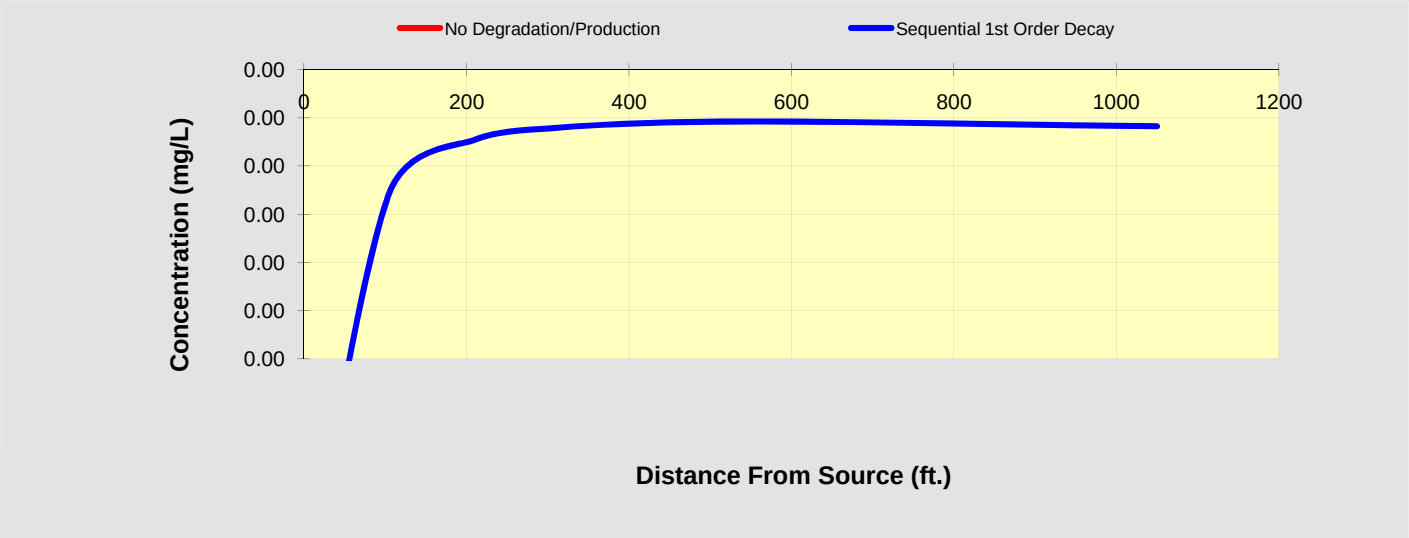
8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

Figure D-4
Overburden Natural Attenuation Output
Vinyl Chloride, Time=133 Years
Davis Liquid Superfund Site
Smithfield, RI

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	105	210	315	420	525	630	735	840	945	1050
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Monitoring Well Locations (ft)										
	140	480	750	1180							
Field Data from Site	240.000	28.000	170.000	19.000							



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

133.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

Figure D-5
Overburden Source Removal Input
Davis Liquids Superfund Site
Smithfield, RI

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

Davis Liquid Waste
Overburden-Source Removed
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	53.2	(ft/yr)
or			
Hydraulic Conductivity	K	9.0E-03	(cm/sec)
Hydraulic Gradient	i	0.002	(ft/ft)
Effective Porosity	n	0.35	(-)

2. DISPERSION

Alpha x*	50	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.7	(kg/L)		
FractionOrganicCarbon, foc	9.0E-4	(-)		
Partition Coefficient	Koc			
PCE	389	(L/kg)	2.70	(-)
TCE	126	(L/kg)	1.55	(-)
DCE	126	(L/kg)	1.55	(-)
VC	100	(L/kg)	1.44	(-)
ETH	5	(L/kg)	1.02	(-)
Common R (used in model)* =			**1.55**	

4. BIOTRANSFORMATION

-1st Order Decay Coefficient*

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	1.200	9.49	0.79
TCE → DCE	0.900	9.48	0.74
DCE → VC	2.500	19.00	0.64
VC → ETH	0.160		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	45	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	1050	(ft)
Zone 1 Length*	1050	(ft)
Zone 2 Length*	0	(ft)

L, W

Zone 2= L - Zone 1

6. SOURCE DATA

TYPE: Decaying Single Planar

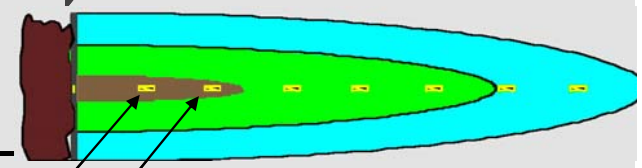
Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 300

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.007	0.11
TCE	.004	0.11
DCE	.094	0.11
VC	.139	0.11
ETH	0.001	0.11

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)											
Date Data Collected	2008										

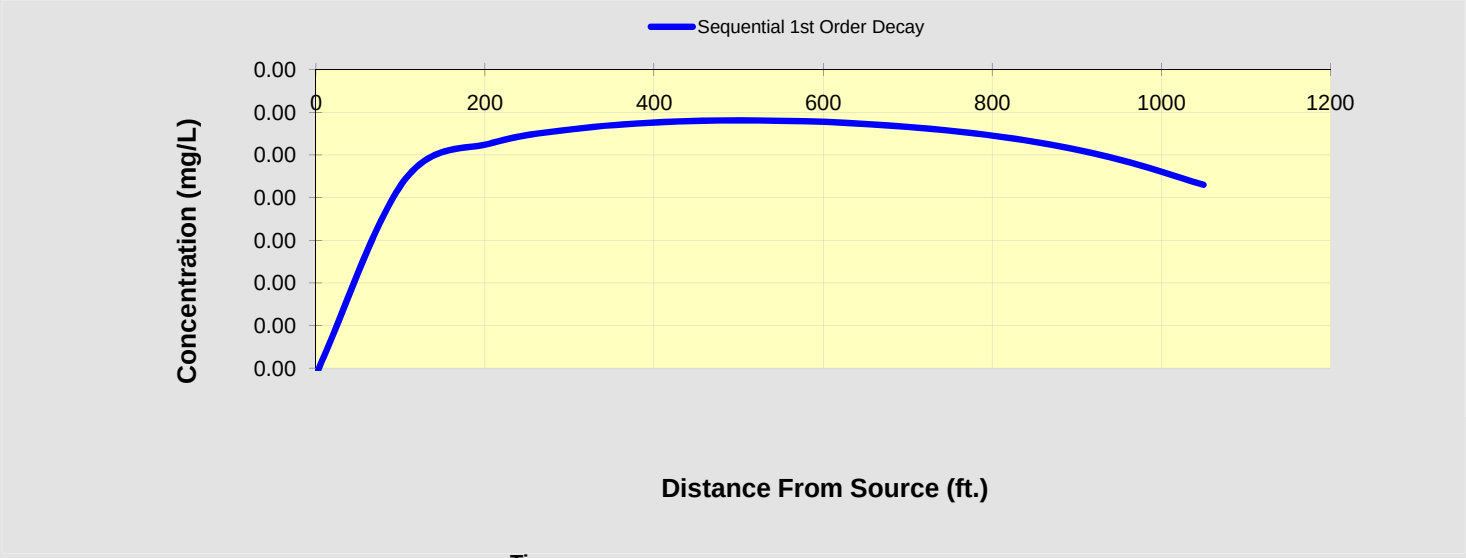
8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

Figure D-6
Overburden Source Removal Output
Vinyl Chloride,
Davis Liquid Superfund Site
Smithfield, RI

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	105	210	315	420	525	630	735	840	945	1050
No Degradation	0.001	0.001	0.002	0.003	0.005	0.007	0.010	0.013	0.017	0.021	0.025
Biotransformation	0.0010	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001
	Monitoring Well Locations (ft)										
Field Data from Site											



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

45.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

Figure D-7
Bedrock Natural Attenuation Input
Davis Liquids Superfund Site
Smithfield, RI

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

Davis Liquid Waste
Bedrock
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	26.7	(ft/yr)
or			
Hydraulic Conductivity	K	3.0E-05	(cm/sec)
Hydraulic Gradient	i	0.0043	(ft/ft)
Effective Porosity	n	0.005	(-)

2. DISPERSION

Alpha x*	10	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R
or

	Koc		R	
Soil Bulk Density, rho	2.3	(kg/L)		
FractionOrganicCarbon, foc	5.0E-5	(-)		
Partition Coefficient				
PCE	300	(L/kg)	7.90	(-)
TCE	126	(L/kg)	3.90	(-)
DCE	126	(L/kg)	3.90	(-)
VC	300	(L/kg)	7.90	(-)
ETH	10	(L/kg)	1.23	(-)
Common R (used in model)* =			**3.90**	

4. BIOTRANSFORMATION -1st Order Decay Coefficient*

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	1.500	9.49	0.79
TCE → DCE	1.300	9.48	0.74
DCE → VC	3.000	19.00	0.64
VC → ETH	0.400		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	112	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	2000	(ft)
Zone 1 Length*	2000	(ft)
Zone 2 Length*	0	(ft)

Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 300

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	3.0	0.135
TCE	40.0	0.135
DCE	500.0	0.135
VC	.001	0.135
ETH	0.001	0.135

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)											
Date Data Collected	2008										

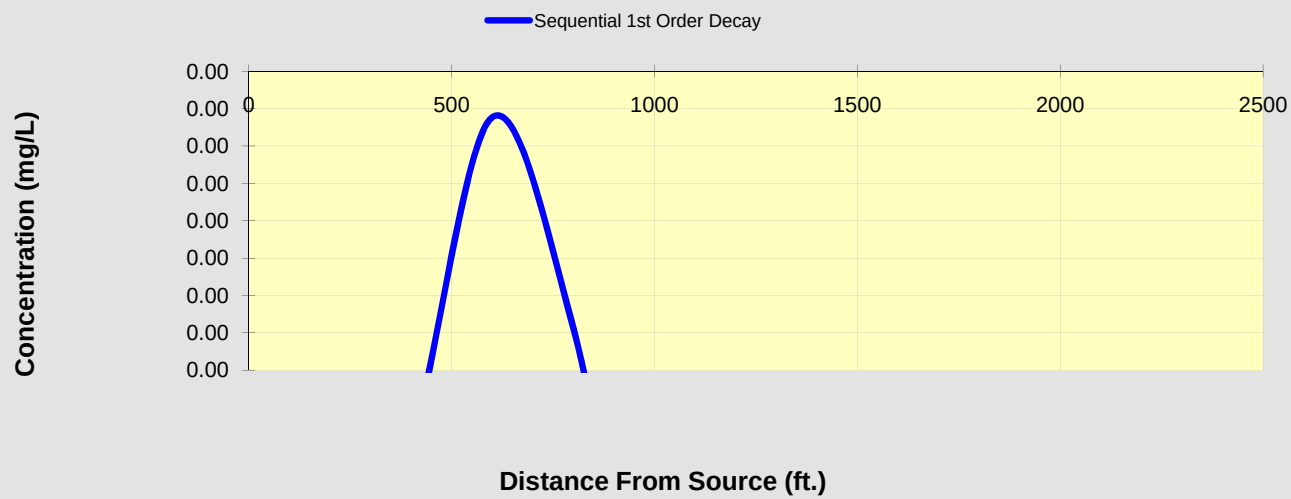
8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

Figure D-8
Bedrock Natural Attenuation Output
DCE at 112 Years
Davis Liquids Superfund Site
Smithfield, RI

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	0.000	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	Monitoring Well Locations (ft)										
Field Data from Site											



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

112.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

Figure D-9
Bedrock Source Removal Input
Davis Liquids Superfund Site
Smithfield, RI

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

Davis Liquid Waste
Source Removal Bedrock
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 ↗ cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	26.7	(ft/yr)
or			
Hydraulic Conductivity	K	3.0E-05	(cm/sec)
Hydraulic Gradient	i	0.0043	(ft/ft)
Effective Porosity	n	0.005	(-)

2. DISPERSION

Alpha x*	10	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R
or

Soil Bulk Density, rho	2.3	(kg/L)		
FractionOrganicCarbon, foc	5.0E-5	(-)		
Partition Coefficient	Koc			
PCE	300	(L/kg)	7.90	(-)
TCE	126	(L/kg)	3.90	(-)
DCE	126	(L/kg)	3.90	(-)
VC	30	(L/kg)		(-)
ETH	302	(L/kg)		(-)
Common R (used in model)* =			**3.90**	

4. BIOTRANSFORMATION **-1st Order Decay Coefficient***

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	1.500	9.49	0.79
TCE → DCE	1.300	9.48	0.74
DCE → VC	3.000	19.00	0.64
VC → ETH	0.400		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	20	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	2000	(ft)
Zone 1 Length*	2000	(ft)
Zone 2 Length*	0	(ft)

Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 300

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.0	0.135
TCE	.003	0.135
DCE	.035	0.135
VC	.035	0.135
ETH		0.135

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)											
Date Data Collected	2008										

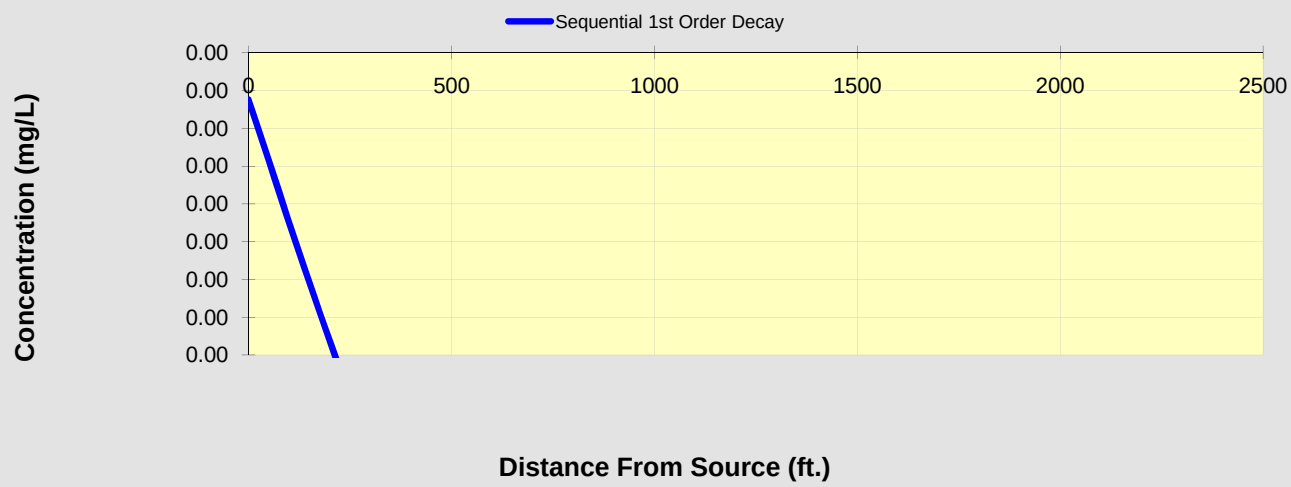
8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

Figure D-10
Bedrock Source Removal Output
Vinyl Chloride
Davis Liquids Superfund Site
Smithfield, RI

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.002	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0024	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Monitoring Well Locations (ft)										
Field Data from Site											



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

20.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

Figure D-11
Alternative GW3B
Remediation of Overburden Groundwater North of Source Area
Vinyl Chloride in Groundwater
Northwest Wetland
Davis Liquids Superfund Site, Smithfield, RI

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

Davis Liquid Waste
Partial Remediation West Wetland
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	532.1	(ft/yr)
or			
Hydraulic Conductivity	K	9.0E-02	(cm/sec)
Hydraulic Gradient	i	0.002	(ft/ft)
Effective Porosity	n	0.35	(-)

2. DISPERSION

Alpha x*	50	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R
or

Soil Bulk Density, rho	1.7	(kg/L)		
FractionOrganicCarbon, foc	9.0E-4	(-)		
Partition Coefficient	Koc			
PCE	389	(L/kg)	2.70	(-)
TCE	126	(L/kg)	1.55	(-)
DCE	126	(L/kg)	1.55	(-)
VC	100	(L/kg)	1.44	(-)
ETH	5	(L/kg)	1.02	(-)
Common R (used in model)* =			**1.55**	

4. BIOTRANSFORMATION **-1st Order Decay Coefficient***

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	1.200	9.49	0.79
TCE → DCE	0.900	9.48	0.74
DCE → VC	2.500	19.00	0.64
VC → ETH	0.160		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	40	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	500	(ft)
Zone 1 Length*	500	(ft)
Zone 2 Length*	0	(ft)

L, W

Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

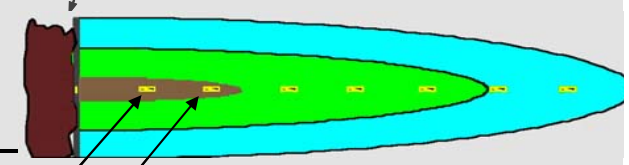
Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 100

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.003	0.11
TCE	.004	0.11
DCE	.07	0.11
VC	.125	0.11
ETH	0.001	0.11

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)											
Date Data Collected	2008										

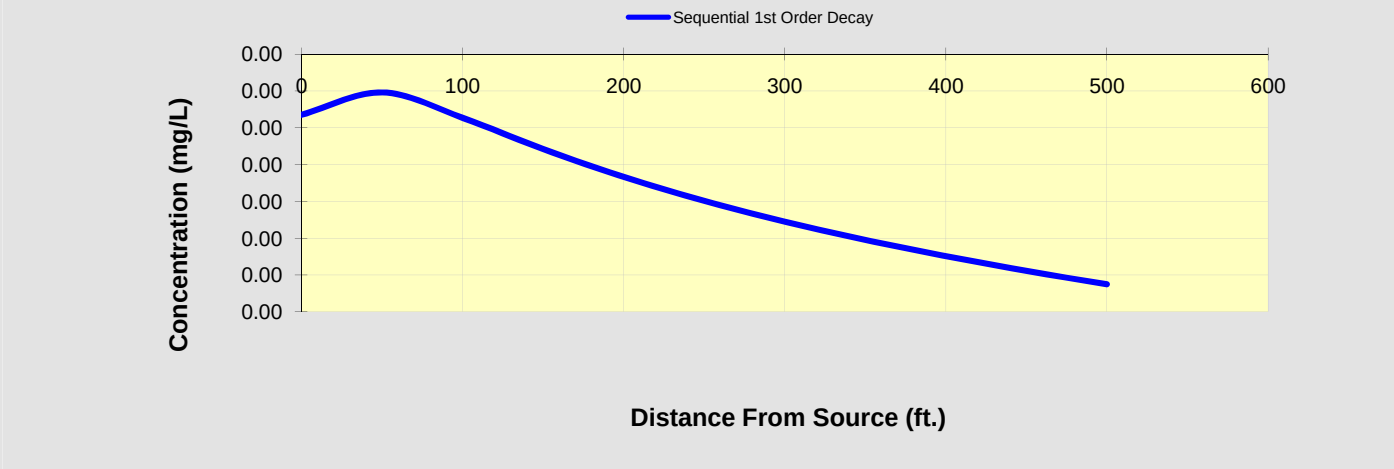
8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

Figure D-12
Alternative GW3B
Remediation of Overburden Groundwater North of Source Area
Vinyl Chloride in Groundwater
Northwest Wetland
Time = 40 years
Davis Liquids Superfund Site
Smithfield, RI

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	50	100	150	200	250	300	350	400	450	500
No Degradation	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Biotransformation	0.0015	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Monitoring Well Locations (ft)										
Field Data from Site											



See PCE
See TCE
See DCE
See VC
See ETH

Prepare Animation

Time:
40.0 Years
Log ⟺ Linear

Return to Input
To All
To Array

Figure D-13
Alternative GW3B
Remediation of Overburden Groundwater North of Source Area
Vinyl Chloride in Groundwater
Norheast Wetland
Davis Liquids Superfund Site, Smithfield, RI

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

Davis Liquid Waste
Partial Rem. East Wetland
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
or
0.02 → 2. Calculate by filling in gray cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	53.2	(ft/yr)
or			
Hydraulic Conductivity	K	9.0E-03	(cm/sec)
Hydraulic Gradient	i	0.002	(ft/ft)
Effective Porosity	n	0.35	(-)

2. DISPERSION

Alpha x*	50	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R
or

Soil Bulk Density, rho	1.7	(kg/L)		
FractionOrganicCarbon, foc	9.0E-4	(-)		
Partition Coefficient	Koc			
PCE	389	(L/kg)	2.70	(-)
TCE	126	(L/kg)	1.55	(-)
DCE	126	(L/kg)	1.55	(-)
VC	100	(L/kg)	1.44	(-)
ETH	5	(L/kg)	1.02	(-)
Common R (used in model)* =			**1.55**	

4. BIOTRANSFORMATION -1st Order Decay Coefficient*

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	1.200	9.49	0.79
TCE → DCE	0.900	9.48	0.74
DCE → VC	2.500	19.00	0.64
VC → ETH	0.160		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	47	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	500	(ft)
Zone 1 Length*	500	(ft)
Zone 2 Length*	0	(ft)

Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 100

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.003	0.11
TCE	.006	0.11
DCE	.39	0.11
VC	.17	0.11
ETH	0.001	0.11

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)											
Date Data Collected	2008										

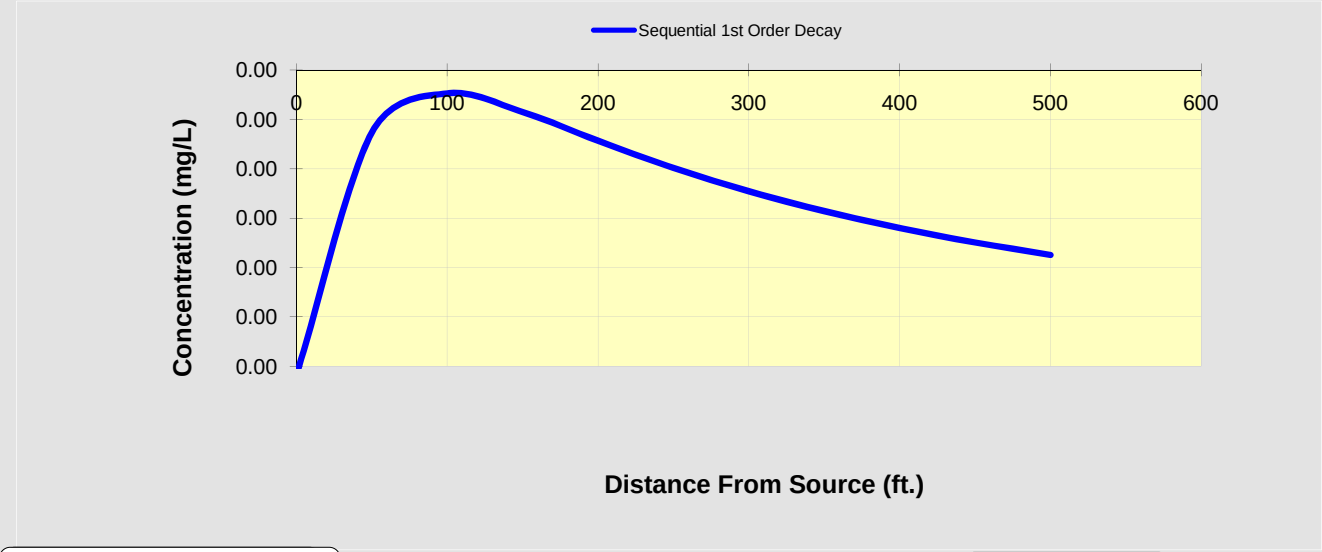
8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

Figure D-14
Alternative GW3B
Remediation of Overburden Groundwater North of Source Area
Vinyl Chloride in Groundwater,
Northeast Wetland
Time=47 Years
Davis Liquid Superfund Site, Smithfield, RI

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	50	100	150	200	250	300	350	400	450	500
No Degradation	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003
Biotransformation	0.0010	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
	Monitoring Well Locations (ft)										
Field Data from Site											



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

47.0 Years

Log ⟺ Linear

Return to Input

To All

To Array