# Feasibility Study/Corrective Measures Study

for

# Off-Site Southern Area Plume

## Naval Weapons Industrial Reserve Plant

Calverton, New York

**Engineering Field Activity Northeast**
**Naval Facilities Engineering Command**

**Contract Number N62472-03-D-0057**
**Contract Task Order 004**

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# FEASIBILITY STUDY/CORRECTIVE MEASURES STUDY FOR OFF-SITE SOUTHERN AREA PLUME

## NAVAL WEAPONS INDUSTRIAL RESERVE PLANT CALVERTON, NEW YORK

## COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

**Submitted to:**
Engineering Field Activity Northeast
Environmental Branch Code EV2
Naval Facilities Engineering Command
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Lester, Pennsylvania 19113-2090


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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ARAR | Applicable or Relevant and Appropriate Requirement |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| AWQC | Ambient Water Quality Criterion |
| BCF | Bioconcentration factor |
| BDAT | Best-demonstrated available technology |
| bgs | Below ground surface |
| BNP | Bimetallic nanoscale particle |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |
| °C | Degrees Celsius |
| CAA | Clean Air Act |
| CAMU | Corrective Action Management Unit |
| CAO | Corrective Action Objective |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| cfs | Cubic foot/feet per second |
| CLEAN | Comprehensive Long-Term Environmental Action Navy |
| CMS | Corrective Measures Study |
| COC | Contaminant of concern |
| CRQL | Contract-required quantitation limit |
| CSF | Cancer slope factor |
| CTO | Contract Task Order |
| CWA | Clean Water Act |
| DOT | Department of Transportation |
| DPT | Direct-push technology |
| EBCT | Empty bed contact time |
| ECL | Environmental Conservation Law |
| E.O. | Executive Order |
| EPA | United States Environmental Protection Agency |
| °F | Degrees Fahrenheit |
| FS | Feasibility Study |
| $ft^2$ | Square feet |
| ft/day | feet per day |
| GAC | Granular activated carbon |
| GOCO | Government-Owned Contractor-Operated |
| gpm | Gallon(s) per minute |

| | |
|---|---|
| HNUS | Halliburton NUS Corporation, Inc. |
| HRC® | Hydrogen-release compound |
| HQ | Hazard Quotient |
| IAS | Initial Assessment Study |
| IR | Installation Restoration |
| IRIS | Integrated Risk Information System |
| $K_{oc}$ | Organic carbon partition coefficient |
| $K_{ow}$ | Octanol-water partition coefficient |
| LDR | Land disposal restriction |
| LOAEL | Lowest-observed-adverse-effect level |
| MCL | Maximum Contaminant Level |
| MCLG | MCL Goal |
| MDL | Method detection limit |
| MF | Modifying factor |
| MI | Mobility index |
| NAAQS | National Ambient Air Quality Standard |
| NEPA | National Environmental Policy Act |
| NESHAP | National Emission Standards for Hazardous Air Pollutant |
| NOAA | National Oceanic and Atmospheric Administration |
| NOAEL | No-observed-adverse-effect level |
| NPDES | National Pollutant Discharge Elimination System |
| NSPS | New Source Performance Standard |
| NWIRP | Naval Weapons Industrial Reserve Plant |
| NYCRR | New York State Code of Rules and Regulations |
| NYSDEC | New York State Department of Environmental Conservation |
| O&M | Operation and maintenance |
| ORC® | Oxygen-release compound |
| ORNL | Oak Ridge National Laboratory |
| OSWER | Office of Solid Waste and Emergency Response |
| PAH | Polynuclear Aromatic Hydrocarbon |
| PCB | Polychlorinated biphenyl |
| POTW | Publicly owned treatment works |
| PPE | Personal protective equipment |
| PQL | Practical quantitation limit |
| PRG | Preliminary Remediation Goal |
| RBC | Risk-Based Concentration |
| RCRA | Resource Conservation and Recovery Act |

| | |
|---|---|
| RFA | RCRA Facility Assessment |
| RfD | Reference dose |
| RFI | RCRA Facility Investigation |
| RI | Remedial Investigation |
| SCV | Secondary Chronic Value |
| SDWA | Safe Drinking Water Act |
| SMCL | Secondary MCL |
| SPDES | State Pollutant Discharge Elimination System |
| SQUIRT | Screening Quick Reference Table |
| TAGM | Technical and Administrative Guidance Memorandum |
| TBC | To Be Considered |
| TCLP | Toxicity Characteristics Leaching Procedure |
| TDS | Total dissolved solids |
| TOC | Total organic carbon |
| TOGS | Technical and Operational Guidance Series |
| TSD | Treatment, storage, and disposal |
| TtNUS | Tetra Tech NUS, Inc. |
| TU | Temporary unit |
| UF | Uncertainty factor |
| USC | United States Code |
| USGS | United States Geological Survey |
| VOC | Volatile organic compound |

# 1.0 INTRODUCTION

## 1.1 SCOPE AND OBJECTIVES

The Naval Facilities Engineering Command, Engineering Field Activity Northeast has issued Contract Task Order (CTO) 004 to Tetra Tech NUS, Inc. (TtNUS) under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N62472-03-D-0057 to perform a Feasibility Study (FS) and Resource Conservation and Recovery Act (RCRA) Corrective Measure Study (CMS) for the Off-Site Southern Area Plume at the Naval Weapons Industrial Reserve Plant (NWIRP) located in Calverton, New York. Contaminant migration from Sites 6A and 10B caused groundwater contamination observed in the Southern Area. This CMS addresses the off-site component of the Southern Area groundwater plume. A separate CMS was prepared to address the on-site component of the Southern Area groundwater plume (TtNUS, 2005b).

This work is part of the Navy's Installation Restoration (IR) Program, which is designed to identify contamination at Navy and Marine Corps lands/facilities resulting from past operations and to institute corrective measures, as needed. There are typically four distinct stages. Stage 1 is the Preliminary Assessment [formerly known as the Initial Assessment Study (IAS)]. Stage 2 is a RCRA Facility Assessment (RFA) - Sampling Visit (also referred to as a Site Investigation), which augments the information collected in the Preliminary Assessment. Stage 3 is the RCRA Facility Investigation (RFI)/CMS [also referred to as a Remedial Investigation (RI)/FS], which characterizes the contamination at a facility and develops options for remediation of the site. Stage 4 is the Remedial Action, which results in the control or cleanup of contamination at a site. This report has been prepared under Stage 3 (CMS).

This work was conducted in accordance with the requirements of the New York State RCRA Hazardous Waste Permit for the facility (NYSDEC 1-4730-00013/00001-0), dated March 25, 1992. New York State Department of Environmental Conservation (NYSDEC) is the lead oversight agency. This work was also conducted in accordance with the requirements of the previous United States Environmental Protection Agency (EPA) facility permit (EPA ID Number NYD003995198), dated May 11, 1992. The EPA supports NYSDEC in its oversight activities. The requirements of both permits appear to be the same, although the terminology and format vary. The facility is also a State Superfund site. The FS/CMS was conducted in accordance with the requirements of the NYSDEC Division of Solid and Hazardous Materials Part 373 Permit that was issued to the Navy on April 18, 2000 under the NYSDEC implementing regulations [6 New York State Code of Rules and Regulations (NYCRR) Part 621]. This permit supercedes and replaces the original Part 373 Permit to Operate a Hazardous Waste Storage Facility that was issued to then Grumman Aerospace Corporation on March 25, 1992. The new permit, issued only to the

Department of the Navy, deals exclusively with those Solid Waste Management Units that remain on the former NWIRP Calverton property and any corrective actions that may be required to adequately address each site. Although the Part 373 Permit is the enforceable document governing the Navy's remedial actions, the NYSDEC State Superfund group, located in the Albany office, retains primary responsibility for regulatory oversight of the Navy's actions. The Navy has agreed to a request by the NYSDEC State Superfund group to utilize terminology associated with the NYSDEC State Superfund program, which is closely related to the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program. The CERCLA terminology parallels the RCRA terminology. The implementation phases of each program have been determined to meet the substantive requirements of both programs and will also satisfy the corrective action requirements included in Module III of the Part 373 Permit.

The objectives of the CMS are as follows:

- Identify Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) criteria.

- Identify risk-based action levels that are protective of human health and the environment.

- Develop Corrective Action Objectives (CAOs), which identify chemicals of concern, receptors, pathways, and preliminary remediation goals (PRGs). The preliminary remediation goals are based on chemical-specific ARARs, TBCs, and risk-based action levels.

- Identify and screen Corrective Measures Technologies.

- Develop Corrective Measures Alternatives.

- Conduct a detailed analysis and comparative analysis of Corrective Measures Alternatives.

## 1.2 ORGANIZATION OF CORRECTIVE MEASURES STUDY

This CMS consists of five sections. Section 1.0 is this introduction. Section 2.0 provides a description of current site conditions. Section 3.0 identifies ARARs, TBCs, and CAOs. The identification and screening of Corrective Measure Technologies and the development of Corrective Measure Alternatives are conducted in Section 4.0. Section 5.0 presents the evaluation of Corrective Measures Alternatives.

## 1.3 ACTIVITY BACKGROUND INFORMATION

### 1.3.1 Facility Location

The Southern Area begins on NWIRP property in Calverton, Suffolk County, New York and extends off-site to the southeast towards the Peconic River (see Figures 1-1 and 1-2). The facility is located within the Town of Riverhead. Calverton is located on Long Island approximately 80 miles east of New York City.

The NWIRP consists of four separate parcels of land totaling approximately 358 acres. Eight Navy IR sites are included within these parcels as follows. The location of the parcels and sites are presented in Figure 1-2.

Parcel A (32 acres)

Site 2 - Fire Training Area

Parcel B1 (40 acres)

Site 6A - Fuel Calibration Area
Site 10B - Engine Test House

Parcel B2 (131 acres)

Southern Area

Parcel C (10 acres)

Site 7 - Fuel Depot
Site 10A - Jet Fuel Systems Laboratory

Parcel D (145 acres)

Site 1 - Northeast Pond Disposal Area
Site 9 - ECM Area

### 1.3.2 Facility History

The NWIRP Calverton has been owned by the United States Navy since the early 1950s. At that time, the property was purchased from a number of private owners. The facility was expanded in 1958 through additional purchases of privately owned land. Northrop Grumman Corporation (previously Grumman Corporation) has operated the facility since its construction (Navy, 1986).

The NWIRP Calverton was constructed in the early 1950s for use in the development, assembly, testing, refitting, and retrofitting of Naval combat aircraft. Northrop Grumman was the sole operator of the facility, which was known as a Government-Owned-Contractor-Operated (GOCO) installation. Construction was completed in 1954. The facility supported aircraft design and production at the Northrop Grumman Bethpage, New York NWIRP.

The majority of industrial activities at the facility were confined to the developed area in the center and south-central portion of the facility, between the two runways. Industrial activities at the facility were related to the manufacturing and assembly of aircraft and aircraft components. Hazardous waste generation at the facility was related to metal finishing processes such as metal cleaning and electroplating. The painting of aircraft and components resulted in additional waste generation (Navy, 1986; HNUS, 1992).

Northrop Grumman operations at the facility ended in February 1996. In September 1998, the majority of the land within the developed section of the facility was transferred to the Town of Riverhead for redevelopment. Because of the need for additional environmental investigation and the potential need for remediation, the Navy retained four parcels of land within the developed section. The four parcels and associated Navy IR Sites are presented on Figure 1-2.

In September 1999, 2,935 acres of undeveloped land outside of the fenced areas were transferred to NYSDEC, which will continue to manage the property for resource conservation and recreational uses. An additional 140 acres of the northwestern buffer zone was transferred to the Department of Veterans Affairs and will be used for expansion of the Calverton National Cemetery.

## 1.4 PHYSICAL CHARACTERISTICS OF STUDY AREA

### 1.4.1 Climate and Meteorology

The NWIRP Calverton is located in an area classified as a humid-continental climate. Its proximity to the Atlantic Ocean and Long Island Sound add maritime influences to this classification (NOAA, 1982).

The average yearly temperature at the National Oceanic and Atmospheric Administration (NOAA) Riverhead Research Station, located 4.5 miles northeast of the site, is 52.2 degrees Fahrenheit (°F), with a mean maximum average monthly temperature of 73.3°F in July and a minimum average monthly mean temperature of 30.9°F in January. Annual precipitation at the Riverhead Station averages 45.32 inches. The highest monthly average precipitation is 4.46 inches occurring in December, and the lowest is 2.90 inches occurring in July. The average yearly evapotranspiration rate is 29 inches, resulting in a net annual precipitation rate of 16.32 inches. A 2-year, 24-hour rainfall can be expected to bring 3.4 inches of precipitation (NOAA, 1982; United States Department of Commerce, 1961).

### 1.4.2 Topography

The NWIRP Calverton is located in an area underlain by permeable glacial material and characterized by limited surface water drainage features. Normal precipitation at the facility is expected to infiltrate rapidly into the soil. The majority of the facility is located within the Peconic River drainage basin. Extensive wetland areas and glacially formed lakes and ponds are located southwest and south of the facility. NWIRP Calverton occupies a relatively flat, intermorainal area. The topographic relief at NWIRP is 54 feet; elevations range from approximately 30 to 84 feet above mean sea level.

### 1.4.3 Surface Water Hydrology

The majority of the facility is located within the Peconic River drainage basin. Extensive wetland areas and glacially formed lakes and ponds are located southwest and south of the facility. The eastward-flowing Peconic River is located approximately 2,000 feet south of the facility at its closest point. The surface water in the Peconic River is classified as Class C, which is suitable for fish propagation and survival and for primary and secondary contact recreation. The State of New York designated the upper 10.5-mile reach of the Peconic River as a Scenic River and the lower 5.5-mile reach as a Recreational River.

Based on topography, groundwater is expected to flow southward and discharge to the ponds and wetland areas to the south and southwest, and ultimately be received by the Peconic River via overland flow. The Peconic River flows into Peconic Lake. The Peconic River is tidally influenced downstream of the dam on Peconic Lake, located 3.2 stream miles downstream from the site, and discharges to Peconic Bay, which is 8.5 stream miles downstream from the facility.

Major surface water features near the Calverton facility include McKay Lake, the Northeast Pond, and the North Pond. McKay Lake is a groundwater recharge basin located north of River Road, midway along the southern site border. The Northeast Pond is located at the northeastern corner of the facility (Site 1 - Northeast Pond Disposal Area), and North Pond is located near the southwestern corner of the facility. Several small drainage basins exist near Site 6A. All of these ponds and drainage basins are land locked, with the exception of McKay Lake, which has an intermittent discharge to Swan Pond located 1,500 feet to the south. Swan Pond, approximately 55 acres in size, discharges to the Peconic River 1.6 stream miles south of McKay Lake via a series of cranberry bogs (USGS, 1967; Navy, 1986).

The Northeast Pond area actually consists of two ponds, a 2.3-acre pond directly east of Site 1 and an approximately 1-acre pond located less than 500 feet to the southeast of Site 1 (Shannon's Pond). Both of these ponds lie in land-locked depressions and may be of glacial origin. Observations made during RFI soil boring drilling activities at Site 1 indicated that the main pond elevations are similar to the local groundwater elevations. As stated earlier, no outfalls exist from the ponds; they are expected to receive limited overland surface water flow from surrounding land in the northeastern corner of the site (USGS, 1967).

The small drainage basins located near Site 6A are land locked and receive limited surface water runoff from immediately adjacent areas. Surface water runoff from Site 6A is collected by drainage ditches paralleling the southern and eastern edges of the paved area. The ditches enter a southward-flowing culvert at the southeastern corner of Site 6A; the culvert ends approximately 250 feet west of Site 10B, south of the road. A drainage ditch flows southward 500 feet from the outfall and enters a depression containing two small ponds. These ponds are located approximately 1,500 feet south of Site 6A. Runoff from Site 2 flows to the southeast; the nearest potential receiving water is Swan Pond, located 2,000 feet to the southeast. Runoff from Site 7 flows eastward via a very shallow slope into woodlands. No direct drainage pathway to a surface water body exists. Surface water runoff for the area at the end on Runway 32-14 is expected to flow approximately 500 feet south to the Peconic River. The elevation of the end of the runway is approximately 20 feet above the river in this area.

### 1.4.4 Geology and Soils

#### Geologic Setting

NWIRP Calverton lies within the Atlantic Coastal Plain Physiographic Province. Generally, this region can be characterized as an area of relatively undissected, low-lying plains. The Atlantic Coastal Plain is underlain by a thick sequence of unconsolidated deposits. The surface topography has been created or modified by Pleistocene glaciation (Isbister, 1966).

Ground surface elevations on Long Island range from sea level to approximately 400 feet above mean sea level. The two most prominent topographic features in the Long Island area are the Ronkonkoma terminal moraine and the Harbor Hill end moraine. These east-west trending highlands mark the southern terminus or maximum extent of two glacial advances. The older Harbor Hill moraine lies along the northern shore of Long Island, the younger Ronkonkoma moraine basically bisects the island. NWIRP Calverton occupies a relatively flat, intermorainal area between these two features. The topographic relief at NWIRP is 54 feet; elevations range from approximately 30 to 84 feet above mean sea level (McClymonds and Franke, 1972).

NWIRP Calverton is underlain by approximately 1,300 feet of unconsolidated sediments consisting of four distinct geologic units. These units, in descending order, are the Upper Glacial Formation, the Magothy Formation, the Raritan Clay Member of the Raritan Formation, and the Lloyd Sand Member of the Raritan Formation (McClymonds and Franke, 1972).

The glacial sediments beneath the NWIRP have a maximum thickness of approximately 250 feet and consist of both glacial till and outwash deposits. Till is deposited directly by the ice, while outwash deposits are laid down by meltwater-supplied glaciofluvial systems. The till in Suffolk County ranges from 0 to 150 feet in thickness and generally consists of poorly sorted to unstratified sediments. The outwash deposits consist chiefly of well-sorted and stratified sand and gravel. One important characteristic of outwash deposits is their high degree of heterogeneity. Lithologies may vary widely over relatively short vertical and horizontal distances.

The Cretaceous-age Magothy Formation underlies the Upper Glacial Formation and is approximately 520 feet thick. The Magothy Formation chiefly consists of stratified, fine to coarse sand and gravel.

The Cretaceous-age Raritan Clay Member of the Raritan Formation underlies the Magothy Formation and is approximately 170 feet thick. The Raritan Clay consists of clay and silty clay.

The Lloyd Sand Member of the Raritan Formation underlies the Raritan Clay and is approximately 400 feet thick. The Lloyd Sand consists chiefly of fine to coarse sand and gravel.

The unconsolidated sediments beneath the site unconformably overlie crystalline bedrock consisting of schist, gneiss, and granite. The regional dip is to the south and southeast. All of the geologic units dip in these directions, although to varying degrees (McClymonds and Franke, 1972).

### 1.4.5 Hydrogeology

The unconsolidated sediments that underlie the NWIRP are generally coarse grained with high porosities and permeabilities. These factors create aquifers with high yields and high transmissivities.

The Upper Glacial Formation, the Magothy Formation, and the Lloyd Sand are the major regional aquifers. The Upper Glacial and Magothy aquifers are of principal importance in Suffolk County because of their proximity to the land surface. The Lloyd Sand is not widely exploited because of its depth (McClymonds and Franke, 1972).

The Upper Glacial aquifer is widely used as a source of potable water in Suffolk County. The water table beneath the NWIRP lies within this aquifer. Porosities in excess of 30 percent have been calculated for the Upper Glacial aquifer in adjoining Nassau County, Long Island. The estimated hydraulic conductivity of this aquifer is 270 feet per day (ft/day).

The Magothy aquifer is widely used as a source of potable water in Suffolk County. The most productive units are the coarser sands and gravels. The permeability of the Magothy is high; hydraulic conductivities have been calculated in excess of 70 ft/day.

The Upper Glacial and Magothy aquifers are believed to be hydraulically interconnected and to function as a single unconfined aquifer. On-site well logs, previous hydrogeological investigations, and geologic mapping indicate that although clay lenses are present in both aquifers that may create locally confining and/or perched conditions, these lenses are not widespread and do not function as regional aquitards (McClymonds and Franke, 1972; Fetter, 1976).

The Raritan Clay has a very low permeability (approximately $3 \times 10^{-5}$ ft/day) and hydrologically acts as a regional confining layer. The confining nature of this unit is believed to minimize potential contamination migration to the underlying Lloyd Sand aquifer (McClymonds and Franke, 1972).

The Lloyd Sand is a potential aquifer that has not been extensively developed due to its depth and the abundant water available in the overlying aquifers. Estimated hydraulic conductivities for the Lloyd Sand range from 20 to 70 ft/day.

The NWIRP Calverton saddles a regional groundwater divide, with groundwater beneath the northern half flowing to the northeast and groundwater beneath the southern half of the NWIRP flowing to the southeast. Based on water level measurements obtained during the RFI, the groundwater flow direction at both Site 2 and Site 6A is to the southeast, the groundwater flow direction at Site 7 is to the east, and the groundwater flow direction at Site 1 is to the northeast (HNUS, 1995).

The Peconic River basin is the likely discharge point for groundwater in the shallow aquifer zones in the southern portion of the NWIRP. Long Island Sound is the likely discharge point for groundwater in the shallow aquifer zones in the northern portions of the facility.

### 1.4.6 Water Supply

Groundwater serves as the source of drinking water for the population residing within a 4-mile radius of the facility. Private wells, wells on two government-owned facilities (Town of Riverhead and Brookhaven National Laboratory), and three municipal water systems (Riverhead Water District, Shorewood Water Company, and Suffolk Water Company) supply the drinking water needs of the study area. Two public water supply wells (former production wells) are located on the former NWIRP Calverton property. These wells continue to operate with carbon treatment to address low concentrations of volatile organic compounds (VOCs).

### 1.4.7 Surrounding Land Use

The land surrounding the Calverton facility in all directions is primarily agricultural or wooded, with scattered residences and commercial establishments. Wildwood State Park and Long Island Sound are located 2.3 miles and 2.75 miles north, respectively. The Town of Riverhead is located 4.25 miles to the east. A golf course, Swan Pond, and a large area of swamps, wetlands, and cranberry bogs are located immediately south of the facility. The Long Island Railroad passes within 1,000 feet of the southeastern corner of the facility. Brookhaven National Laboratory is located 2 miles southwest of the facility.

### 1.4.8 Ecology

According to the United States Department of the Interior, Fish and Wildlife Service, no federally listed endangered or threatened species reside within a 4-mile radius of the study area. Transient individuals of endangered species such as the Bald Eagle (*Haliaeetus leucocephalus*) may occur within the study area.

Information provided by NYSDEC and the New York Natural Heritage program indicated that several New York State endangered and threatened animal species exist within the study area. The most notable, tiger salamander (*Ambystoma tigrinum*), may occur on site in the ponds adjacent to Site 6A, and possibly at the Northeast Pond Disposal Area. Other species include the northern cricket frog (*Acris crepitans*) and the least tern (*Sterna Antillarum*). Additional endangered and threatened plant species occur within the Calverton facility boundary and may be present in the Southern Area. According to the information supplied by NYSDEC, the wetland areas surrounding the Peconic River, including Swan Pond, include significant habitat for many State endangered and threatened animals and plants. Portions of these wetland areas would be within the off-site portion of the Southern Area.

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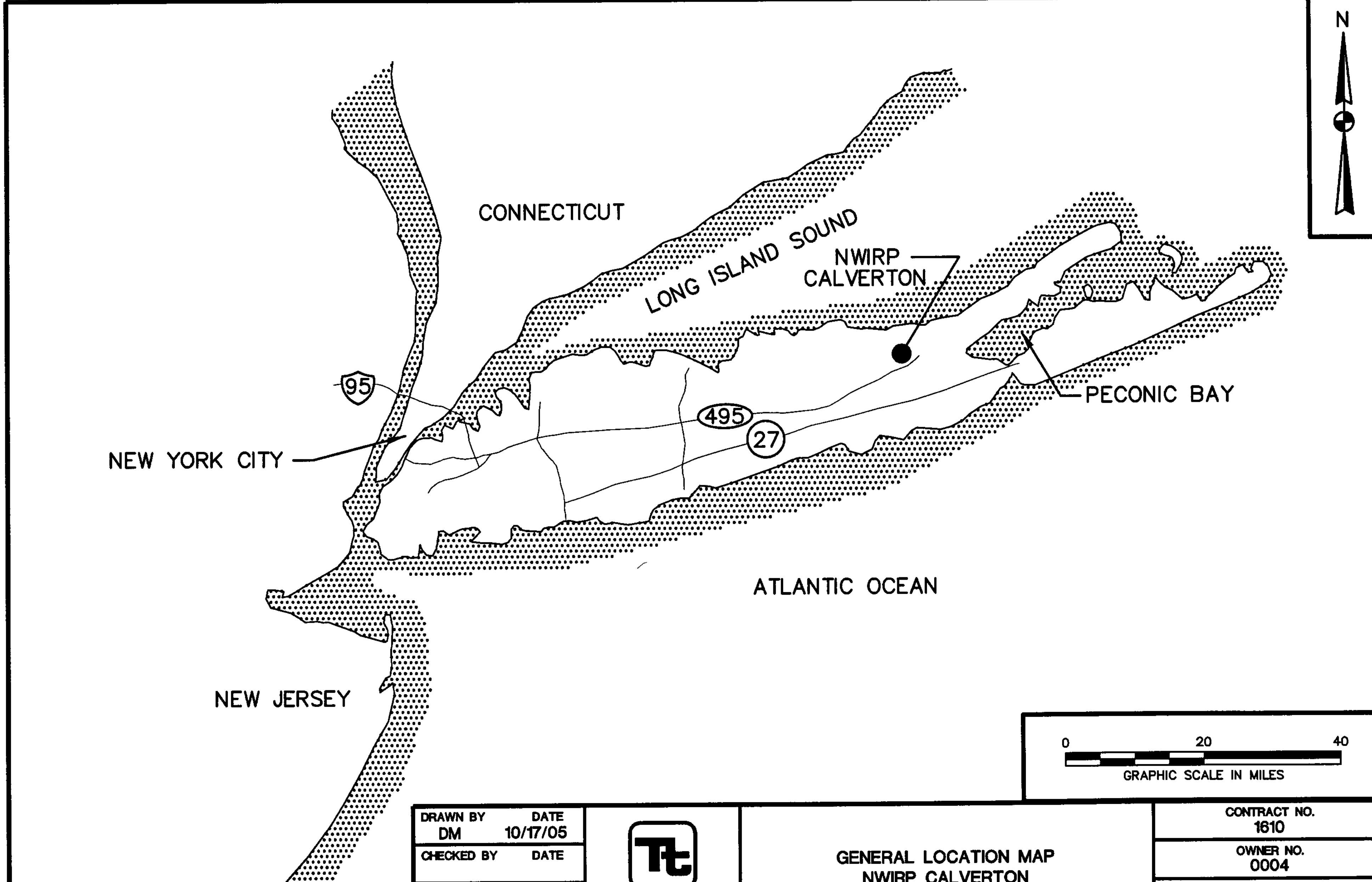


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| DRAWN BY DM / DATE 10/17/05 | Tetra Tech NUS, Inc. | GENERAL LOCATION MAP<br>NWIRP CALVERTON<br>CALVERTON, NEW YORK | CONTRACT NO. 1610 |
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| SCALE AS NOTED | | | | DRAWING NO. FIGURE 1-2 / REV. 0 |

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# 2.0 DESCRIPTION OF CURRENT CONDITIONS

This section presents a summary of the current conditions at the off-site portion of the Southern Area. Some of the discussions were extracted from other documents including the Phase 2 RI for Site 6A - Fuel Calibration Area, Site 10B - Engine Test House, and Southern Area (TtNUS, 2001) and the Data Summary Report for Site 6A and Southern Area (TtNUS, 2005a). The following information is presented for the sites:

- Site description
- Geology and hydrogeology
- Nature and extent of contamination
- Contaminant fate and transport
- Risk assessment
- Contaminants of concern (COCs)

## 2.1 SITE DESCRIPTION

The Southern Area begins within NWIRP boundaries to the southeast of Site 10B and extends off site to the southeast (see Figure 2-1). The area was investigated because a Suffolk County monitoring well indicated the presence of chlorinated VOCs in groundwater downgradient of the facility. There are no known or suspected contaminant sources within this area. However, this area is hydraulically downgradient of Site 10B, Site 6A, and the general industrial complex at the facility. Groundwater flow through this area is to the southeast, with the Peconic River being the most likely discharge point.

The area is mostly wooded, and includes two shallow ponds near the northern edge. The ponds receive runoff through a drainage swale and culvert from Site 6A. From the late 1980s to the early 1990s, groundwater from Site 6A was discharged into this drainage swale and culvert and into the western pond. As a result, the presence of chlorinated VOC-contaminated groundwater in the Southern Area may be attributable to Site 6A.

## 2.2 GEOLOGY

The geology at NWIRP Calverton consists of a mixture of sandy and clayey deposits. Figure 2-2 is a cross section location map and Figure 2-3 is a geological cross section for the Southern Area. The upper 120 to 130 feet of subsurface materials consist primarily of fine to medium sand, with thin to thick clayey layers also encountered within the predominantly sandy deposits.

Minor amounts of fill, consisting primarily of a mixture of sand, silt, and clay, were also found at shallow depths (0 to 6 feet) in some areas. From this depth to approximately 60 feet below ground surface (bgs), fine to medium sand is present. A silty clay layer was encountered at depths of approximately 60 to 90 feet across the site. In the Off-Site Southern Area, this clay unit appears to pinch out and was not encountered in the borings drilled near the Peconic River. Underlying this silty clay unit is approximately 40 feet of fine to medium sand. Another silty clay unit was encountered from 130 to 180 feet bgs. This unit appears to be continuous throughout the area.

The geologic units encountered within the study area appear to be generally flat lying, consistent with what would be expected for the glacial deposits on Long Island. The upper contact of the Magothy Formation, being an erosional surface, is expected to be flat lying to undulating, reflecting the former topography, even though the formation itself is known to dip to the south.

## 2.3 HYDROGEOLOGY

During the Phase 2 RI (TtNUS, 2001), a focused groundwater investigation was performed in the Southern Area to determine whether the Peconic River was the discharge point for contaminated groundwater (to a depth of 100 feet bgs) that migrated from the facility, or conversely whether some groundwater bypassed the river and migrated to areas further south. The study involved the installation of several well clusters on both sides of the river and in the immediate vicinity of the river, the installation of two staff gauges in the river, and the collection of four rounds of water level data from the wells and staff gauges. Potentiometric surface interpretations based on water level data from the well clusters indicate that the river is the ultimate groundwater discharge point in this area because the water levels along the river were lower than water levels for both shallow and deep wells in well clusters located several hundred feet from the river on both sides (see Figure 2-4). Groundwater in the study area was found to be migrating east-southeast towards the river, while on the opposite side of the river, the groundwater flow direction is generally northward towards the river.

Additional groundwater data were collected in 2005 to refine the information collected for the Phase 2 RI. Figure 2-5 is a potentiometric surface map for the Off-Site Southern Area wells. Groundwater was encountered at approximately 10 feet bgs in the Off-Site Southern Area. A vertical flow net was constructed using data from selected well clusters and the staff gauges, illustrating flow to the river from both sides (Figure 2-6). Based on the interpretation of the data collected, any groundwater contamination that may reach the river is expected to discharge to the river and not migrate beyond it to the south.

In 1997, the Nature Conservancy – Long Island Chapter prepared several water table contour maps for the general Calverton area. These maps indicate that the groundwater flow direction within the Southern Area is generally to the east-southeast, towards the Peconic River. An overall groundwater flow gradient across the study area of approximately 0.0012 was calculated based on the water table contour maps. This overall flow gradient was in good agreement with site-specific groundwater flow gradients calculated based on data from the RFI.

The hydraulic characteristics of the Upper Glacial aquifer at the NWIRP were evaluated during the RFI through slug tests performed at several sites and the performance of a pumping test at Site 2. Based on slug testing, the shallow portion of the Upper Glacial aquifer at NWIRP has an average hydraulic conductivity of about 111 ft/day, while the average hydraulic conductivity of the deeper sediments is approximately 36 ft/day. Pumping test results indicate an average horizontal hydraulic conductivity of 91 ft/day, vertical hydraulic conductivity of 8.5 ft/day, and specific yield of 0.07 for the Upper Glacial aquifer. These tests were all performed in and are representative of the uppermost portion of the Upper Glacial aquifer, above the clay layer found at a depth of approximately 60 feet. The porosity of the aquifer was assumed to be 0.25 (fine to medium sand).

The nearest drinking water well was located at a sportsman club in the Off-Site Southern Area near Connecticut Avenue and River Road. This well was shut down because chlorinated solvent contamination was detected in it. Another private well is located approximately 1 mile east of the NWIRP in Calverton. There was no evidence of groundwater contamination in that area. The nearest pubic water supply well is located approximately 0.5 mile west of Site 6A.

## 2.4 NATURE AND EXTENT OF CONTAMINATION

The Southern Area is a general area of groundwater contamination located downgradient of Sites 6A and 10B. The groundwater contamination is believed to have resulted from either intermittent releases at Sites 6A and 10B or from potential overland migration through a series of ditches and ponds in the area. The Southern Area extends from Sites 6A and 10B to near the Peconic River (see Figure 2-7). This CMS address only the off-site portion of the Southern Area, which includes the area south of River Road.

The area was investigated during the Phase 2 RI (TtNUS, 2001) and Site 6A and Southern Area Supplemental Investigation (TtNUS, 2005a). The investigations were conducted in 1997, 2000, and 2004/2005, and groundwater samples were collected from temporary wells, piezometers, and vertical profile borings during the investigations. Surface water samples were also collected from the Peconic River during the 2004/2005 Supplemental Investigation. The results of the investigations are summarized below.

## Groundwater

A summary of the maximum groundwater contaminant concentrations detected during the investigations is provided in Table 2-1. New York State Groundwater Quality Standards are included in the table for comparison purposes. Contaminant concentrations that exceed the standards are highlighted. The groundwater contaminants in the Off-Site Southern Area Plume include chlorinated VOCs, Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX), Freon, and several miscellaneous VOCs (e.g., acetone, 2-butanone, etc.). Similar contaminants were detected in groundwater at Site 6A, Site 10B, and the On-Site Southern Area Plume.

Contaminants detected during all three rounds of sampling at the Off-Site Southern Area include 1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, and chloroform. Nine contaminants were detected in excess of groundwater quality standards including 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, benzene, chloroethane, toluene, and total xylenes. 1,1-Dichloroethane was the dominant VOC present in the groundwater, and it was detected at a maximum concentration of 292 µg/L (SA-VPB-114 at 92 feet bgs). Maximum concentrations of the other contaminants were one to two orders of magnitude lower than the 1,1-dichloroethane maximum concentration. Most of the contaminants detected at concentrations greater than groundwater standards were detected in samples collected near the Pistol Range Area at the Peconic River Sportsman Club and Connecticut Avenue (e.g., SA-TW-108, SA-TW-113, SA-VPB-114, and SA-PZ-123I).

Figure 2-7 shows the estimated horizontal extent of the entire Southern Area contaminant plume. The off-site portion of the plume is approximately 92 acres (3,991,000 square feet). VOC contamination was generally detected at depths of 60 feet to 90 feet bgs, or 50 feet to 80 feet below the water table. At 130 feet bgs, there is a silty clay unit that would prevent deeper migration of contamination. Using a contaminated aquifer thickness of 30 feet, the area of the plume (92 acres), and a porosity of 0.25, the volume of contaminated groundwater is estimated to be 224 million gallons. The total masses of chlorinated VOC and other VOC contamination in the Off-Site Southern Area Plume were estimated to be 670 pounds and 120 pounds, respectively (see Appendix A).

## Surface Water

Two surface water samples were collected from the Peconic River during the 2004/2005 Supplemental Investigation. SA-SW-01 was collected from one of the culverts near Connecticut Avenue, and SA-SW-103 was collected approximately 2,200 feet downstream of SA-SW-101 (see Figure 2-2). No VOCs were detected in the samples, indicating that surface water is not being impacted by contaminated groundwater in the Off-Site Southern Area.

## 2.5 CONTAMINANT FATE AND TRANSPORT

This section contains information on various aspects of contaminant fate and transport and the chemical properties affecting contaminant migration at the Off-Site Southern Area. Contaminants detected in excess of New York State Groundwater Quality Standards are evaluated in this section. Chemical contaminant trends and the potential for natural attenuation of contaminants at the site are also evaluated in this section.

### 2.5.1 Chemical and Physical Properties Impacting Fate and Transport

Table 2-2 presents the physical and chemical properties of the contaminants detected at the site. These properties can be used to determine the environmental mobility and fate of site contaminants. The properties of interest include the following:

- Specific gravity
- Vapor pressure
- Water solubility
- Octanol/water partition coefficient ($K_{ow}$)
- Organic carbon partition coefficient ($K_{oc}$)
- Henry's Law constant
- Bioconcentration factor (BCF)
- Mobility index (MI)

**Specific Gravity**

Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a chemical will have a tendency to float or sink in water if it is present as a pure chemical. Chemicals with a specific gravity greater than 1 will tend to sink, and chemicals with a specific gravity less than 1 will tend to float. The specific gravity of chemical mixtures will sink or float based on the average properties of the mixture. This parameter becomes important in discussions regarding the potential presence of free product in non-aqueous-phase liquids.

Of the chemicals detected in the Off-Site Southern Area, monocyclic aromatics (e.g., benzene) have a specific gravity less than 1, and halogenated aliphatics (e.g., 1,1,1-trichloroethane) typically have a specific gravity greater than 1. Most of the contaminants were detected at depths of 50 feet to 80 feet below the water table.

**Vapor Pressure**

Vapor pressure provides an indication of the rate at which a chemical volatilizes from both soil and water. It is of primary importance at environmental interfaces such as surface soil/air and surface water/air. Volatilization is not as important when evaluating contaminated groundwater and subsurface soils that are not exposed to the atmosphere. Vapor pressures for monocyclic aromatics and halogenated aliphatics are generally higher than vapor pressures for other contaminants (e.g., PAHs). Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Volatilization is a significant loss process for VOCs in surface water or surface soil.

Because the contaminants in the Off-Site Southern Area groundwater are at depth (50 to 80 feet below the water table), it is unlikely that they would volatilize to soil gas or the atmosphere. However, if contaminated groundwater discharges to the Peconic River, volatilization would result in significant contaminant concentration decreases.

**Water Solubility**

The rate at which a chemical is leached from a waste source by infiltrating precipitation is proportional to its water solubility. More soluble chemicals are more readily leached than less soluble chemicals. VOCs are generally more soluble than other chemicals. All of the contaminants in the Off-Site Southern Area Plume are VOCs that are relatively soluble.

**Octanol/Water Partition Coefficient**

The $K_{ow}$ is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between the $K_{ow}$ and the uptake of chemicals by fatty tissues of animal and human receptors (the BCF) has been established (Lyman et al., 1990). $K_{ow}$ is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available. VOCs are less likely to partition to fatty tissues or sorb to organic soils then chemicals such as pesticides and polychlorinated biphenyls (PCBs). The $K_{ow}$ is also used to estimate BCFs in aquatic organisms.

**Organic Carbon Partition Coefficient**

The $K_{oc}$ indicates the tendency of a chemical to adhere to soil particles containing organic carbon. Chemicals with high $K_{oc}$s generally have low water solubilities and vice versa. This parameter may be used to infer the relative rates at which the more mobile chemicals (monocyclic aromatics and halogenated aliphatics) are transported in groundwater. VOCs such as those detected in the Off-Site Southern Area Plume are relatively mobile in the groundwater.

**Henry's Law Constant**

Both vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and groundwater. The ratio of these two parameters (the Henry's Law constant) is used to calculate equilibrium chemical concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings. In general, chemicals having a Henry's Law constant of less than $1x10^{-5}$ atm-$m^3$/mole should volatilize very little and be present only in minute amounts in the atmosphere or soil gas. For chemicals with a Henry's Law constant greater than $5x10^{-3}$ atm-$m^3$/mole, such as many of the monocyclic aromatics and halogenated aliphatics, volatilization and diffusion in soil gas could be significant.

Because the contaminants in the Off-Site Southern Area groundwater are at depth (50 to 80 feet below the water table), it is unlikely that they would volatilize to soil gas or the atmosphere. However, if contaminated groundwater discharges to the Peconic River, volatilization would result in significant contaminant concentration decreases.

**Bioconcentration Factor**

The BCF represents the ratio of aquatic-animal-tissue concentration to water concentration. The ratio is both contaminant and species specific. When site-specific values are not measured, literature values are used or the BCF is derived from the $K_{ow}$. Chemicals such as pesticides, PCBs, and polynuclear aromatic hydrocarbons (PAHs) will bioconcentrate at levels three to five orders of magnitude greater than those concentrations found in the water, but VOCs such as the monocyclic aromatics and halogenated aliphatics detected in the Off-Site Southern Area Plume are not as readily bioconcentrated.

**Mobility Index**

The MI is a quantitative assessment of mobility that uses water solubility (S), vapor pressure (VP), and the $K_{oc}$ (Laskowski, 1983). It is defined as follows:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI as presented by Ford and Gurba (1984) is as follows:

| Relative MI | Mobility Description |
|---|---|
| > 5 | extremely mobile |
| 0 to 5 | very mobile |
| -5 to 0 | slightly mobile |
| -10 to -5 | immobile |
| < -10 | very immobile |

The MIs of most of the monocyclic aromatics and halogenated aliphatics detected in the Off-Site Southern Area Plume range from 0 to 5, indicating that these chemicals are very mobile.

### 2.5.2 Contaminant Transport Pathways

This section presents a brief overview of contaminant fate and transport issues for the Off-Site Southern Area Plume. Based on the evaluation of existing conditions, the following potential contaminant transport pathways may have previously existed or currently exist at the site:

- Migration of groundwater contaminants
- Migration of contaminants in surface water
- Volatilization from groundwater and/or surface water

**Migration of Groundwater Contaminants**

Contaminants can migrate with groundwater in either a dissolved phase or as an immiscible liquid (free product). Contaminant concentrations may be affected by one or more mechanisms during transport. Volatilization or precipitation may physically transform contaminants. Contaminants may be chemically transformed through photolysis, hydrolysis, or oxidation/reduction. Contaminants may also be biologically transformed by biodegradation. Additionally, contaminants may accumulate in one or more media.

Organic contaminants that have leached into groundwater can migrate as dissolved constituents in groundwater. Three general processes govern the migration of dissolved constituents in groundwater: advection, dispersion, and retardation. Advection is a process by which solutes are carried by groundwater movement. Dispersion is a mixing of contaminated and uncontaminated water during advection. Retardation is a slowing of contaminant migration caused by the reaction of the solute with the particulate-type matter in the aquifer. The distribution of dissolved contaminants in groundwater at the Off-Site Southern Area indicates that the halogenated aliphatics are the most mobile contaminants.

A contaminant present in water at a concentration greater than its solubility concentration will form an immiscible liquid. Based on the specific gravity of the contaminant, it will either float or sink in the water.

In the case of chlorinated solvents (e.g., 1,1,1-trichloroethane), pure liquid solvents will typically sink in water because they have higher specific gravities than water. For most petroleum compounds including jet fuel, the pure product will float. Mixtures of chlorinated solvents will either sink or float based on average properties. None of the contaminant concentrations detected in the Off-Site Southern Area Plume were near their solubility concentrations; therefore, it is unlikely that any immiscible liquids are present.

**Migration of Contaminants in Surface Water**

When contaminated groundwater discharges to surface water, the contaminants can migrate as dissolved constituents in surface water in the direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: movement caused by the flow of surface water, movement caused by the irregular mixing of water, and chemical mechanisms occurring during the movement of surface water. Sediment particles can disassociate from the sediment into surface water and migrate by one of the aforementioned methods. The flow net presented on Figure 2-6 indicates that the contaminated groundwater at the Off-Site Southern Area will discharge to the Peconic River.

**Volatilization from Groundwater and Surface Water**

VOC vapors in groundwater may migrate through the overlying soil layers and into ambient air. Studies have shown that vapors can move either horizontally or vertically in the subsurface. The vapors may also enter buildings through cracks in building foundations or walls. Upon entering ambient air, the vapors are not expected to persist for long periods of time because their half-lives in the atmosphere are typically measured in hours to a few days. Vapors may also be released to ambient air from groundwater during excavation activities. Because the contaminants in the Off-Site Southern Area groundwater are at depth (50 to 80 feet below the water table), it is unlikely that they would volatilize to soil gas or the atmosphere.

The results of previous investigations indicate that the contaminated groundwater at the Off-Site Southern Area discharges to the Peconic River. After the groundwater discharges to the surface water, the VOCs would volatilize to the atmosphere and contaminant concentrations in surface water would be significantly lower than concentrations in groundwater. No VOCs were detected in surface water samples collected from the Peconic River.

### 2.5.3 Chemical Fate and Persistence

Several transformation mechanisms affect chemical persistence, such as hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. The following classes of compounds were detected in the Off-Site Southern Area:

- Monocyclic aromatics (BTEX)
- Halogenated aliphatics (solvents)

**Monocyclic Aromatics**

Monocyclic aromatic compounds such as benzene are not considered to be persistent in the environment. Monocyclic aromatics are subject to degradation via the action of aquatic microorganisms. The biodegradation of these compounds in the soil matrix is dependent on the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, etc. In the event that these compounds discharge to surface water bodies, volatilization and biodegradation may occur relatively rapidly. For example, a reported first-order biodegradation rate constant for benzene is 0.11 $day^{-1}$ in aquatic systems (Lyman et al., 1990). This corresponds to an aquatic half-life of approximately 6 days. Other monocyclic aromatics are subject to similar degradation processes in aquatic environments (EPA, 1982).

Additional environmental degradation processes, such as hydrolysis and photolysis, are considered to be insignificant fate mechanisms for monocyclic aromatics in aquatic systems (EPA, 1982). However, some monocyclic aromatics such as benzene and toluene have been shown to undergo clay, mineral, and soil-catalyzed oxidation (Dragun, 1988).

**Halogenated Aliphatics**

In general, halogenated aliphatic hydrocarbons are subject to abiotic dehydrohalogenation. This process is an elimination reaction that results in the formation of an ethene from a saturated halogenated compound. Research indicates that microbial degradation of highly chlorinated ethanes is a relatively slow process. Hydrolysis, photolysis, and oxidation are generally not considered to be significant fate processes for the chlorinated ethanes.

Under certain conditions, volatilization is a significant fate process for these compounds. Volatilization is only significant at the air/soil or air/water interface. Compounds volatilize rapidly to the atmosphere from surface water. Adsorption should not be considered an important fate for these types of compounds when compared to more hydrophobic compounds.

Photolysis is not considered a relevant degradation mechanism for this class of compounds (EPA, 1982). Limited hydrolysis of saturated aliphatics (i.e., alkanes) may occur, but it does not appear to be a significant degradation mechanism for unsaturated species (i.e., alkenes) (EPA, 1982).

**Observed Chemical Contaminant Trends**

Monocyclic aromatic compounds have been detected sporadically across the Off-Site Southern Area Plume. No significant increasing trends are evident from the available data.

Halogenated aliphatics such as 1,1,1-tichloroethane, 1,1-dichloroethane, and 1,1-dichloroethene have been detected consistently in the groundwater of the Off-Site Southern Area Plume since 1997. Maximum detected concentrations of the contaminants generally increased between 1997 and 2005; however, multiple rounds of data from individual locations are not available, and it is unclear if the higher concentrations are a reflection of new data from hot spots or increasing contaminant trends. During previous investigations, groundwater samples were collected from temporary wells, piezometers, and vertical profile borings that were subsequently abandoned and could not be resampled.

It is believed that overland transport and reinfiltration of contaminated Site 6A groundwater associated with operation of the free product recovery system was the major historical source of contamination for the Off-Site Southern Area Plume. The Site 6A free product recovery system is no longer operational; therefore, it is no longer a continuing source of contamination. Groundwater contamination may continue to increase in extent as a result of the previous releases and dissolved contaminant transport, but soluble contaminant concentrations are much lower now than in the past and as such contaminant concentrations should not increase significantly.

**Natural Attenuation Evaluation**

Natural attenuation processes for the contaminants in the Off-Site Southern Area Plume depend on the contaminant type. Fuel-type chemicals such as benzene, toluene, and xylenes generally degrade in groundwater through aerobic biodegradation processes, and carbon dioxide and water are formed. Chlorinated solvents generally degrade in groundwater through anaerobic biodegradation processes. The primary anaerobic degradation pathway for 1,1,1-trichloroethane is as follows: 1,1-dichloroethane, chloroethane, acetate, ethane, and methane/carbon dioxide/water/chloride. 1,1-Dichloroethene can also be formed during the degradation of 1,1-dichloroethane. Chloroethane, methane, and ethane are readily biologically degraded under aerobic conditions to form carbon dioxide and water. The degradation compounds of 1,1-dichloroethane, 1,1-dichloroethene, and chloroethane were all detected in the Off-Site Southern Area Plume, which indicates that biodegradation and natural attenuation of the chlorinated VOCs are occurring to some extent.

## 2.6 RISK ASSESSMENT

A qualitative risk assessment was completed for the Off-Site Southern Area groundwater to evaluate potential risks to human and ecological receptors.

- Qualitative Risk Assessment: The focus of the qualitative risk assessment was to identify regulations (ARARs) and other standards (TBCs) that are exceeded by measured site contaminant levels. Both human and ecological receptors were considered because the groundwater in the Off-Site Southern Area Plume has been previously used as a drinking water source and it discharges to the Peconic River. The standards presented are those that have been developed for groundwater and surface water for the protection of human receptors (Tables 2-3 and 2-4) and for surface water and sediment for the protection of ecological receptors (Table 2-5). A summary of the results of the qualitative risk assessment is presented below.

- Human Health - Groundwater: Analytical results for groundwater were compared to federal and State Maximum Contaminant Levels (MCLs) and State Groundwater Quality Standards, and the results are presented in Table 2-3. Maximum concentrations of all of the chlorinated and fuel-related VOCs were greater than federal or State MCLs and/or State Groundwater Quality Standards in at least one sample. These results indicate that the groundwater poses potential adverse risks to human receptors if it is extracted and used for domestic use (ingestion of groundwater) without treatment.

- Human Health - Surface Water: Analytical results for groundwater were compared to federal and State water quality standards that are protective of human health based on fish consumption, and the results are presented in Table 2-4. The Peconic River is a productive habitat for warmwater fisheries. Some of the species present in the river include largemouth bass, bluegill, carp, brown bullhead, yellow perch, black crappie, and banded sunfish. An attenuation factor of 30 was calculated and applied to the standards prior to the comparison to groundwater data to account for the mixing and dilution associated with the Peconic River. This factor does not account for other attenuation processes such as volatilization and photo degradation in the surface water. The calculations for the Peconic River attenuation factor are provided in Appendix A. None of the maximum concentrations of the chlorinated and fuel-related VOCs in groundwater were greater than the standards with the attenuation factor applied. These results indicate that the groundwater does not pose potential adverse risks to human receptors that ingest fish caught in the Peconic River. These results are supported by the fact that VOCs were not detected in surface water samples collected from the Peconic River.

- Ecological – Surface Water: Analytical results for groundwater were compared to available surface water criteria [NOAA Screening Quick Reference Tables (SQUIRTs) and Oak Ridge National

Laboratory (ORNL) secondary chronic values] to evaluate potential impacts to aquatic receptors in the Peconic River. The results are presented in Table 2-5. An attenuation factor of 30 was applied to the surface water standards to account for the mixing and dilution associated with the Peconic River (see Appendix A). None of the maximum concentrations of chlorinated and fuel-related VOCs in groundwater were greater than standards with the attenuation factor applied. These results indicate that the groundwater does not pose potential adverse risks to aquatic receptors in the Peconic River. These results are supported by the fact that VOCs were not detected in surface water samples collected from the Peconic River.

- Ecological – Sediment: Analytical results for groundwater were compared to available sediment criteria (ORNL secondary chronic values) to evaluate potential impacts to benthic invertebrates, and the results are presented in Table 2-5. The ORNL sediment values were developed by equilibrium partitioning using the ORNL surface water secondary values. The assumption was that the sediment value is the level where the sediment pore water concentration was equal to the ORNL surface water secondary value. Therefore, the maximum groundwater concentrations were compared directly to the ORNL surface water secondary values without the attenuation factor of 30 to determine potential impacts to sediment pore water. Maximum concentrations of 1,1,1-trichloroethane, 1,1-dichloroethane, toluene, and total xylenes were greater than the standards by factors ranging from 1.03 to 10.2. These results indicate that the contaminated groundwater poses potential adverse risks to benthic invertebrates in the sediment of the Peconic River. There are uncertainties in this evaluation because the actual chemical concentrations in the pore water are likely to be lower than the maximum concentrations in groundwater because of mixing with less contaminated groundwater and attenuation within the soil and sediment.

## 2.7 CONTAMINANTS OF CONCERN

The existing Off-Site Southern Area Plume data, which are presented above, were reviewed to determine the COCs that should be carried forward and evaluated in the CMS. A chemical was selected as a COC if one or both of the following conditions were met:

- The maximum groundwater concentration exceeded federal or State of New York standards or guidance for protection of human health (MCL, Groundwater Quality Standard, Groundwater Effluent Standard, TAGM 4046, or Water Quality Standards) (see Tables 2-3 and 2-4).

- The maximum groundwater concentration exceeded screening values for protection of ecological receptors (see Table 2-5).

### 2.7.1 Off-Site Southern Area

The following contaminants were identified as COCs for human and ecological receptors for the Off-Site Southern Area Plume:

- 1,1,1-Trichloroethane (human and ecological)
- 1,1,2-Trichloroethane (human)
- 1,1-Dichloroethane (human and ecological)
- 1,1-Dichloroethene (human)
- 1,2-Dichloroethane (human)
- Benzene (human)
- Chloroethane (human)
- Toluene (human and ecological)
- Total xylenes (human and ecological)

TABLE 2-1

**SUMMARY OF MAXIMUM DETECTED GROUNDWATER CONCENTRATIONS**
**OFF-SITE SOUTHERN AREA PLUME**
**NWIRP CALVERTON, NEW YORK**

| CAS No. | Parameter | New York State GW Quality Standard [1] | Maximum Result | | | | Location of Overall Maximum | Sample with Overall Maximum | Sample Date for Overall Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1997 | 2000 | 2004/2005 | Overall | | | |
| VOLATILE ORGANICS (UG/L) | | | | | | | | | |
| 71-55-6 | 1,1,1-TRICHLOROETHANE | 5 | 15.1 | 24 | 21.1 | 24 | SATW113 | SAGW11360 | Jul-00 |
| 79-00-5 | 1,1,2-TRICHLOROETHANE | 1 | 1.88 | --- | --- | 1.88 | SATW101 | SAGW10172 | Jun-97 |
| 75-34-3 | 1,1-DICHLOROETHANE | 5 | 31.27 | 220 | 292 | 292 | SAVPB114 | SAVPB114092 | Sept-04 |
| 75-35-4 | 1,1-DICHLOROETHENE | 5 | 1.15 | 21 | 21.7 | 21.7 | SAPZ123I | SA-PZ-123D | Mar-05 |
| 107-06-2 | 1,2-DICHLOROETHANE | 0.6 | 1.57 | --- | 1.1 | 1.57 | SATW108 | SAGW10878 | Nov-97 |
| 106-46-7 | 1,4-DICHLOROBENZENE | 3 | --- | --- | 1.3 | 1.3 | SAVPB114 | SAVPB114092 | Sept-04 |
| 67-64-1 | ACETONE | 50[2] | --- | 12 | 4.6 | 12 | SATW111 | SAGW11110 | Jul-00 |
| 78-93-3 | 2-BUTANONE | 50[2] | --- | --- | 4.4 | 4.4 | SAPZ122D | SA-PZ-122DD | Mar-05 |
| 71-43-2 | BENZENE | 1 | --- | --- | 1.4 | 1.4 | SAVPB114 | SAVPB114092 | Sept-04 |
| 75-15-0 | CARBON DISULFIDE | 60[2] | --- | 4 | --- | 4 | SATW111 | SAGW11125 | Jul-00 |
| 75-00-3 | CHLOROETHANE | 5 | --- | 7 | 7.9 | 7.9 | SAVPB114 | SAVPB114092 | Sept-04 |
| 67-66-3 | CHLOROFORM | 7 | 4.72 | 3 | 3.5 | 4.72 | SATW101 | SAGW10132 | Jun-97 |
| 156-59-2 | CIS-1,2-DICHLOROETHENE | 5 | --- | --- | 0.6 | 0.6 | SAVPB114 | SAVPB114092 | Sept-04 |
| 100-41-4 | ETHYLBENZENE | 5 | 2.93 | --- | --- | 2.93 | SATW102 | SAGW10211 | Jun-97 |
| 1634-04-4 | METHYL TERT-BUTYL ETHER | 10[2] | --- | --- | 7.45 | 7.45 | SAVPB116 | SAVPB116052 | Sept-04 |
| 75-09-2 | METHYLENE CHLORIDE | 5 | --- | --- | 1.2 | 1.2 | SAVPB114/ SAVPB115 | SAVPB114022/ SAVPB115052 | Sept-04 |
| 108-88-3 | TOLUENE | 5 | 0.98 | --- | 10.1 | 10.1 | SAPZ123I | SA-PZ-123D | Mar-05 |
| 1330-20-7 | TOTAL XYLENES | 5 | 18.36 | --- | --- | 18.36 | SATW102 | SAGW10211 | Jun-97 |
| 156-60-5 | TRANS-1,2-DICHLOROETHENE | 5 | 2.54 | --- | --- | 2.54 | SATW104 | SAGW10432 | Jul-97 |
| 79-01-6 | TRICHLOROETHENE | 5 | --- | --- | 0.29 | 0.29 | SAPZ123I | SA-PZ-123DD | Mar-05 |
| 75-69-4 | TRICHLOROFLUOROMETHANE | 5 | 2.63 | --- | --- | 2.63 | SATW101 | SAGW10132 | Jun-97 |
| 75-01-4 | VINYL CHLORIDE | 2 | 1.7 | 2 | --- | 2 | SATW112 | SAGW11255 | Jul-00 |

GW - Groundwater.
1 - 6 NYCRR Part 703, Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, NYSDEC, Section 703.5, Table 1.
2 - TOGS 1.1.1, Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, Table 1 and 2000 Addendum to Table 1.
Shading indicates parameter concentration exceeds the New York State GW Quality Standard.

TABLE 2-2

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
OFF-SITE SOUTHERN AREA PLUME
NWIRP, CALVERTON, NEW YORK

| Chemical | Specific Gravity (@ 20/4°C)(1) | Vapor Pressure (mm Hg @ 20°C)(1) | Solubility (mg/L @ 20°C)(1) | Octanol/Water Partition Coefficient(1) | Organic Carbon Partition Coefficient(2) | Henry's Law Constant (atm-m$^3$/mole)(1) | Bioconcentration Factor (mg/L/mg/kg)(2) | Mobility Index log((solubility*VP)/$K_{oc}$) |
|---|---|---|---|---|---|---|---|---|
| **MONOCYCLIC AROMATICS** | | | | | | | | |
| Benzene | 0.8765 | 9.50E+01 | 1.75E+03 | 1 35E+02 | 5 89E+01 | 5 55E-03 | 3.70E+01 | 3.45E+00 |
| Toluene | 0 8669 | 2 8E+1 (25°C) | 5 15E+02 | 4 90E+02 | 1 82E+02 (4) | 5 92E-3 (25°C) | 1 48E+02 | 1 90E+00 |
| Xylenes (Total) | 0.86104-0.8801 | 1E+1 (27 3-32.1°C) | 1 6E+2-1.75E+2(3) | 5.89E+2-1.58E+3 | 3.63E+02-4 07E+02(4) | 4 184E-3-6 662E-3 (25°C) | 7.5E+1-1 59E+2(5) | 6 44E-01-6 33E-01 |
| **HALOGENATED ALIPHATICS** | | | | | | | | |
| 1,1,1-Trichloroethane | 1.339 | 1 00E+02 | 4 40E+03 | 2 95E+02 | 1 10E+02(4) | 4 08E-3 (25°C) | 8 10E+01 | 3 60E+00 |
| 1,1,2-Trichloroethane | 1 4397 | 2.50E+01 | 4 42E+02 | 1 12E+02 | 5 01E+01 | 9 13E-04 | 1 90E+01 | 2 34E+00 |
| 1,1-Dichloroethane | 1 1757 | 2 34E+2 (25°C) | 5.50E+03 | 1 67E+01 | 3 13E+01(4) | 5 871E-3 (25°C) | 1 90E+01 | 4 61E+00 |
| 1,1-Dichloroethene | 1 218 | 5 91E+2 (25°C) | 2 1E+2 (25°C) | 3 02E+01 | 5 89E+01(4) | 2 286E-2 (25°C) | 5 30E+01 | 3 32E+00 |
| 1,2-Dichloroethane | 1 2351 | 7.90E+01 | 8 52E+02 | 2.95E+01 | 1 74E+01 | 9.79E-04 | 8 10E+00 | 3 59E+00 |
| Chloroethane | 0 92 (0/4°C) | 1 00E+03 | 5.74E+03 | 1 54E+00 | 1 52E+00 | 8 48E-3 (25°C) | 6 7E-01-8 6E-01 | 6 58E+00 |

**Notes:**

1 - EPA, September 1992, Handbook of RCRA Groundwater Monitoring Constituents Chemical and Physical Properties
2 - EPA, December 1982, Aquatic Fate Process Data for Organic Priority Pollutants.
3 - ATSDR, October 1989, Toxicity Profile for Xylenes.
4 - EPA, July 1996, Soil Screening Guidance.
5 - Lyman et al , 1990, Eq. 5-2

TABLE 2-3

## ARARs AND TBC STANDARDS FOR POTENTIAL GROUNDWATER CONTAMINANTS OF CONCERN
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP CALVERTON, NEW YORK

| CAS Number | Parameter | Maximum Detection (µgL) | Location/Date of Detection | Federal MCLs[1] (µg/L) | New York State Standards/Guidance (µg/L) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | MCLs[2] | GW Quality Standards[3] | GW Effluent Standards[4] | TAGM 4046[5] |
| **Volatile Organic Compounds** | | | | | | | | |
| 71-55-6 | 1,1,1-Trichloroethane | 24 | SATW113/2000 | 200 | 5 | 5 | NA | 5 |
| 79-00-5 | 1,1,2-Trichloroethane | 1.9 | SATW101/1997 | 5 | 5 | 1 | 1 | NA |
| 75-34-3 | 1,1-Dichloroethane | 292 | SAVPB114/2004 | NA | 5 | 5 | NA | 5 |
| 75-35-4 | 1,1-Dichloroethene | 21.7 | SAPZ123I/2005 | 7 | 5 | 5 | NA | 5 |
| 107-06-2 | 1,2-Dichloroethane | 1.6 | SATW108/1997 | 5 | 5 | 0.6 | 0.6 | 5 |
| 71-43-2 | Benzene | 1.4 | SAVPB114/2004 | 5 | 5 | 1 | 1 | 0.7 |
| 75-00-3 | Chloroethane | 7 | SAVPB114/2004 | NA | 5 | 5 | NA | 50 |
| 108-88-3 | Toluene | 10.1 | SAPZ123I/2005 | 1000 | 5 | 5 | NA | 5 |
| 1330-20-7 | Total Xylenes | 18.4 | SATW102/1997 | 10000 | 5 | 5 | NA | 5 |

GW - Groundwater.
MCL - Maximum Contaminant Level.
NA - Not available.
1 - 2004 (Winter) Edition of the Drinking Water Standards and Health Advisories, Office of Water, EPA (EPA-822-R-04-005).
2 - New York Public Supply Regulations, 10 NYCRR Part 5, Subpart 5-1 Public Water Systems, Table 3 - Organic Chemicals Maximum Contaminant Level Determination and Table 9D - Organic Chemicals - Principal Organic Contaminants.
3 - 6 NYCRR Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, NYSDEC, Section 703.5, Table 1.
4 - 6 NYCRR Part 703, Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, NYSDEC, Section 703.6, Table 3.
5 - Technical and Administrative Guidance Memorandum 4046, Determination of Soil Cleanup Objectives and Cleanup Levels, Table 1.
Shading indicates parameter concentration exceeds standard.

TABLE 2-4

ARARs AND TBC STANDARDS FOR POTENTIAL PECONIC RIVER SURFACE WATER CONTAMINANTS OF CONCERN
HUMAN HEALTH
OFF-SITE SOUTHERN AREA PLUME
NWIRP, CALVERTON, NEW YORK

| CAS Number | Parameter | Maximum Groundwater Detection (ug/L) | Surface Water Criteria (ug/L) | | |
|---|---|---|---|---|---|
| | | | Human Health | | Minimum Criteria with Attenuation Factor(3) |
| | | | NYSDEC Surface Water Quality Standards(1) | Federal WQC(2) | |
| 71-55-6 | 1,1,1-Trichloroethane | 24 | NA | NA | NA |
| 79-00-5 | 1,1,2-Trichloroethane | 1.9 | NA | 16 | 480 |
| 75-34-3 | 1,1-Dichloroethane | 292 | NA | NA | NA |
| 75-35-4 | 1,1-Dichloroethene | 21.7 | NA | 7,100 | 213,000 |
| 107-06-2 | 1,2-Dichloroethane | 1.6 | NA | 37 | 1110 |
| 71-43-2 | Benzene | 1.4 | 10 | 51 | 300 |
| 75-00-3 | Chloroethane | 7.9 | NA | NA | NA |
| 108-88-3 | Toluene | 10.1 | 6,000 | 15,000 | 180000 |
| 1330-20-7 | Total Xylenes | 18.4 | NA | NA | NA |

NA - Not Available.
NYSDEC - New York State Department of Environmental Conservation.
1 - Peconic River is Class C Surface Water; 6 NYCRR Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, Section 703.5, Table 1, Human Health Fish Consumption.
2 - National Recommended Water Quality Criteria: November 2002 (EPA-822-R-02-047), Human Health, Organism Only, and Revised National Recommended Water Quality Critiera: December 2003 (EPA-822-F-03-012), Human Health, Organism Only.
3 - A Peconic River surface water attenuation factor of 30 was applied to the minimum surface water criterion to determine an allowable groundwater concentration. Attenuation factor calculations are provided in Appendix A.

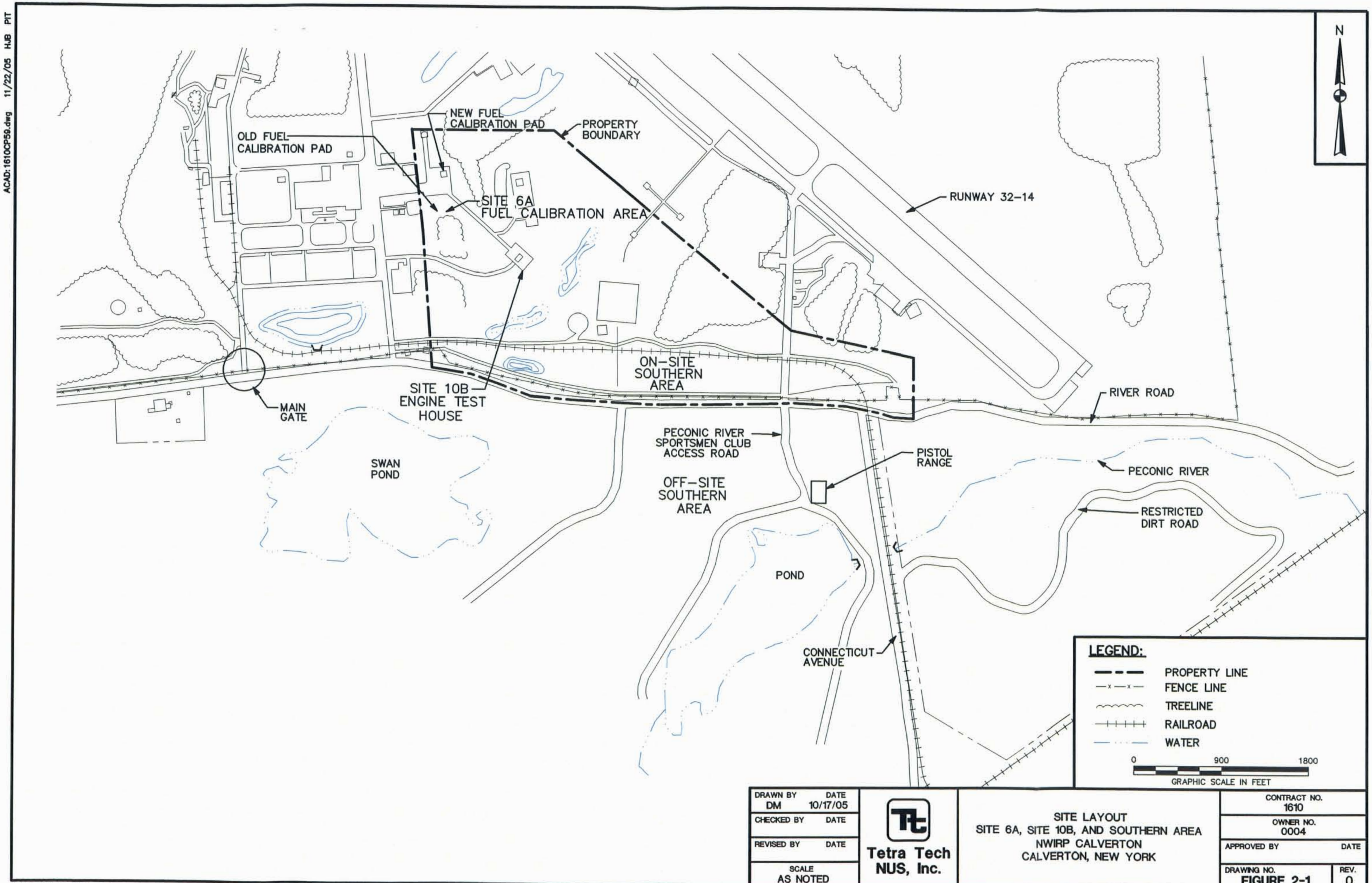
TABLE 2-5

**ARARs AND TBC STANDARDS FOR POTENTIAL PECONIC RIVER SURFACE WATER AND SEDIMENT CONTAMINANTS OF CONCERN ECOLOGICAL**
**OFF-SITE SOUTHERN AREA PLUME**
**NWIRP, CALVERTON, NEW YORK**

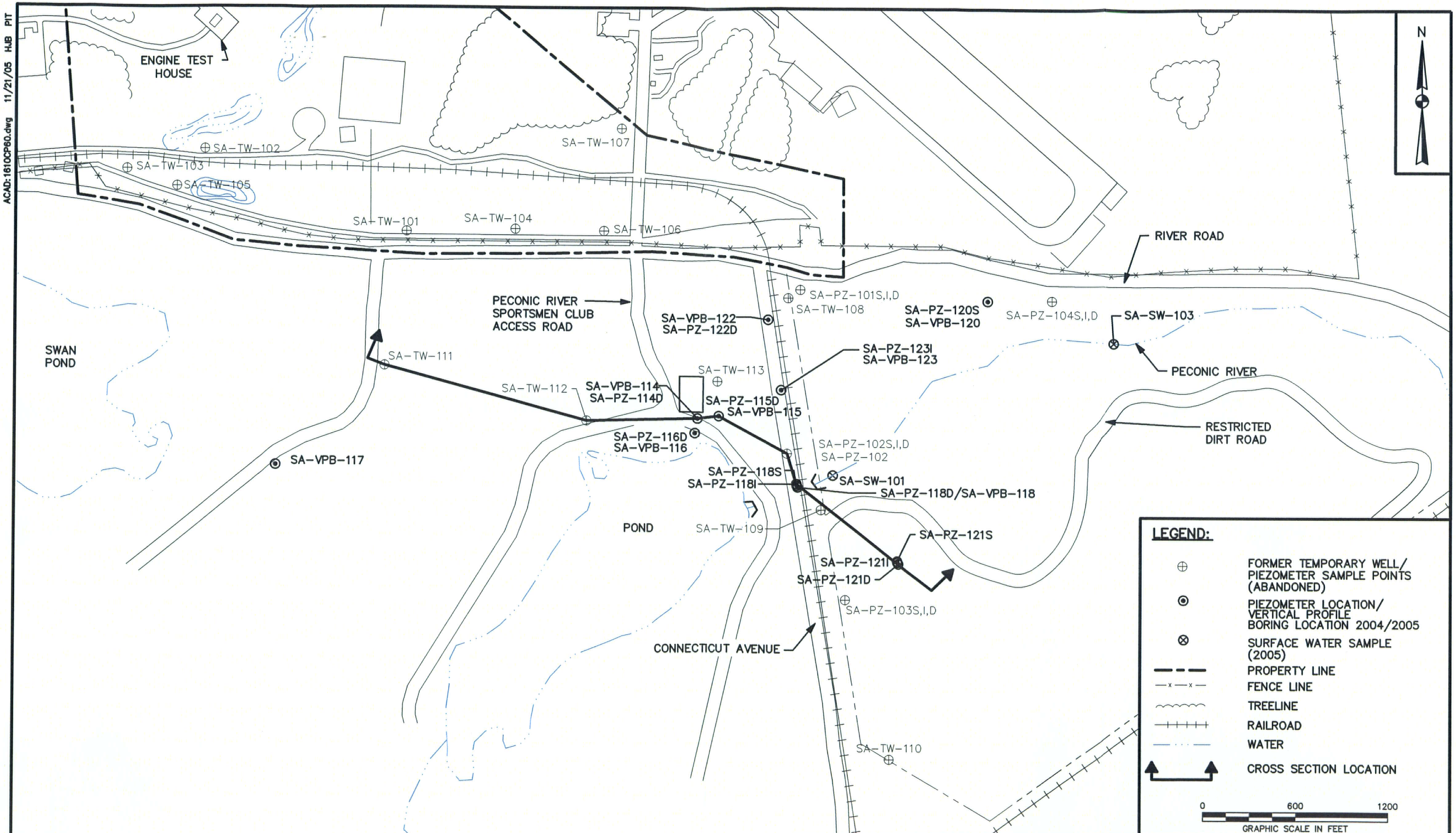
| CAS Number | Parameter | Maximum Groundwater Detection (ug/L) | Surface Water Criteria (ug/L) | | | Sediment Criteria (ug/kg) |
|---|---|---|---|---|---|---|
| | | | Ecological | | Minimum Criteria with Attenuation Factor[3] | |
| | | | NOAA SQUIRTs[1] | ORNL Surface Water[2] | | ORNL Sediment[4] |
| 71-55-6 | 1,1,1-Trichloroethane | 24 | 18000[5] | 11 | 330 | 30 |
| 79-00-5 | 1,1,2-Trichloroethane | 1.9 | 9400[6] | 1200 | 36000 | 1200 |
| 75-34-3 | 1,1-Dichloroethane | 292 | NA | 47 | 1410 | 27 |
| 75-35-4 | 1,1-Dichloroethene | 21.7 | 11600[5] | 25 | 750 | 31 |
| 107-06-2 | 1,2-Dichloroethane | 1.6 | 20000[6] | 910 | 27300 | 250 |
| 71-43-2 | Benzene | 1.4 | 5300[5] | 130 | 3900 | 160 |
| 75-00-3 | Chloroethane | 7.9 | NA | NA | NA | NA |
| 108-88-3 | Toluene | 10.1 | 17500[5] | 9.8 | 294 | 50 |
| 1330-20-7 | Total Xylenes | 18.4 | NA | 1.8 | 54 | 25 |

NA - Not available.
NYSDEC - New York State Department of Environmental Conservation.
1 - Buchman, M. F., 1999. NOAA Screening Quick Reference Tables (SQUIRTs) (Freshwater Ambient Water Quality Criteria), NOAA HAZMAT Report 99-1, Seattle, Washington, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration.
2 - Oak Ridge National Laboratory (surface water) - Table 1 (secondary chronic values), Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision (Suter and Tsao, 1996).
3 - A Peconic River surface water attenuation factor of 30 was applied to the minimum surface water criterion to determine an allowable groundwater concentration. Attenuation factor calculations are provided in Appendix A.
4 - Oak Ridge National Laboratory (sediment) - Table 3 (secondary chronic values), Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision (Jones et al., 1997). Benchmarks are based on protection of ecological receptors in the sediment pore water.
5 - Acute Lowest Observable Effects Level.
6 - Chronic Lowest Observable Effects Level.
Shading indicates parameter concentration exceeds ORNL Surface Water Benchmark, indicating that benthic receptors exposed to sediment pore water could be at risk.

ACAD:1610CP59.dwg 11/22/05 HJB PIT




FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98




| DRAWN BY DM | DATE 6/24/05 |
|---|---|
| CHECKED BY | DATE |
| REVISED BY | DATE |
| SCALE AS NOTED | |

Tetra Tech NUS, Inc.

SAMPLE LOCATION
AND CROSS SECTION LOCATION MAP
SOUTHERN AREA
NWIRP CALVERTON
CALVERTON, NEW YORK

CONTRACT NO. 1610

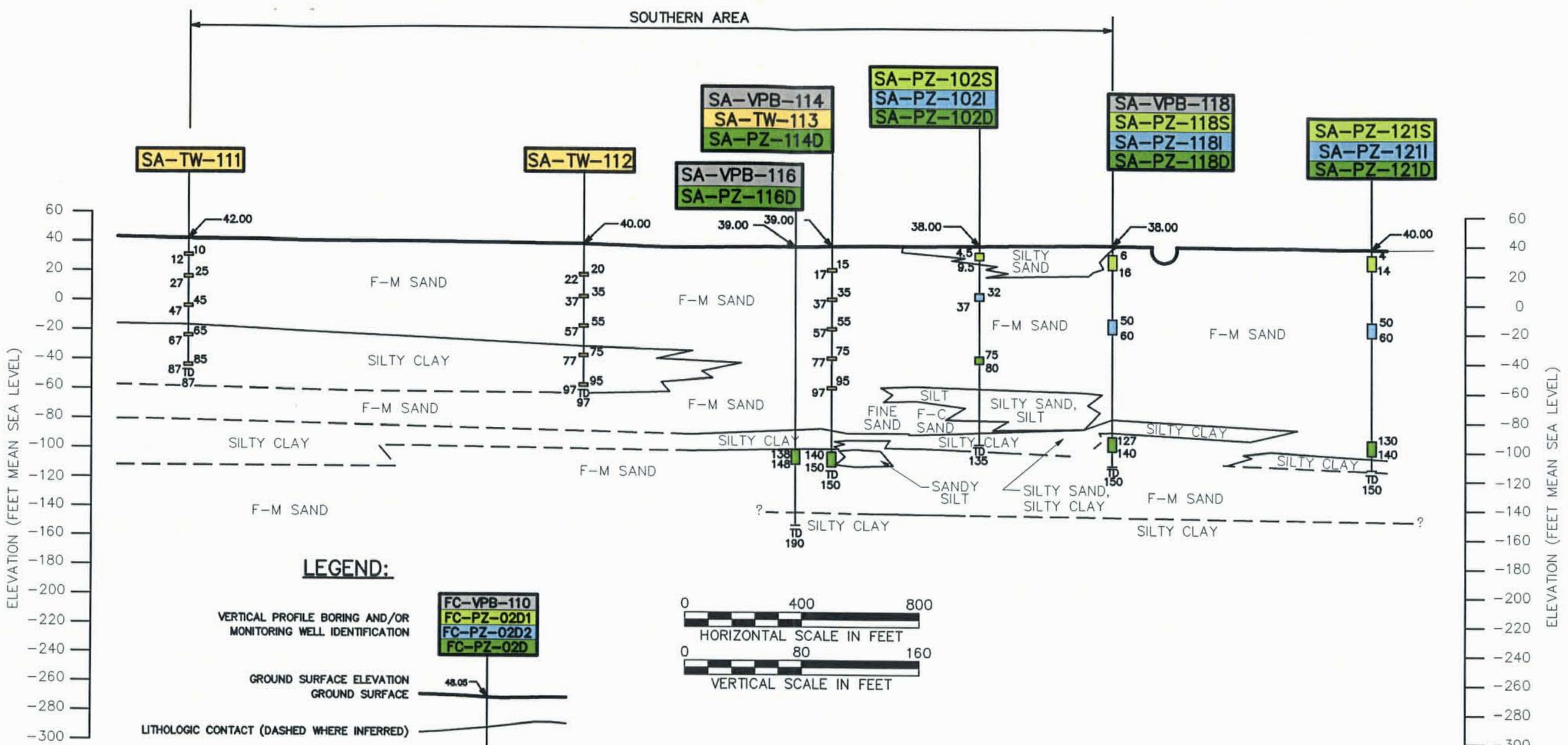
OWNER NO. 0000

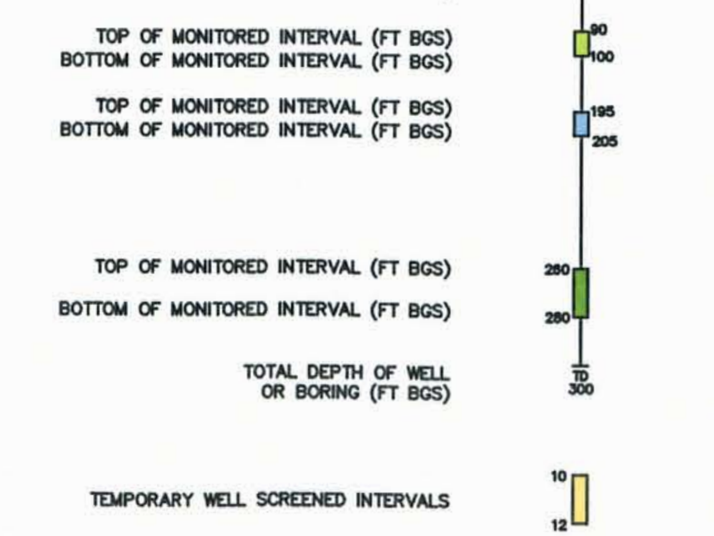
APPROVED BY — DATE

DRAWING NO. FIGURE 2-2 — REV. 0

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

ACAD:1610CX14.dwg 11/21/05 HJB PIT




## NOTES:

1.) WELL CLUSTERS ARE PROJECTED AND REPRESENTED AS A SINGLE VERTICAL BORING/MONITORING WELL.

2.) VERTICAL PROFILE BORINGS (VPB) WERE COMPLETED AFTER WELL/BORING INSTALLATION.

3.) TEMPORARY WELLS ARE VARIABLY SCREENED THROUGHOUT VERTICAL SECTIONS.

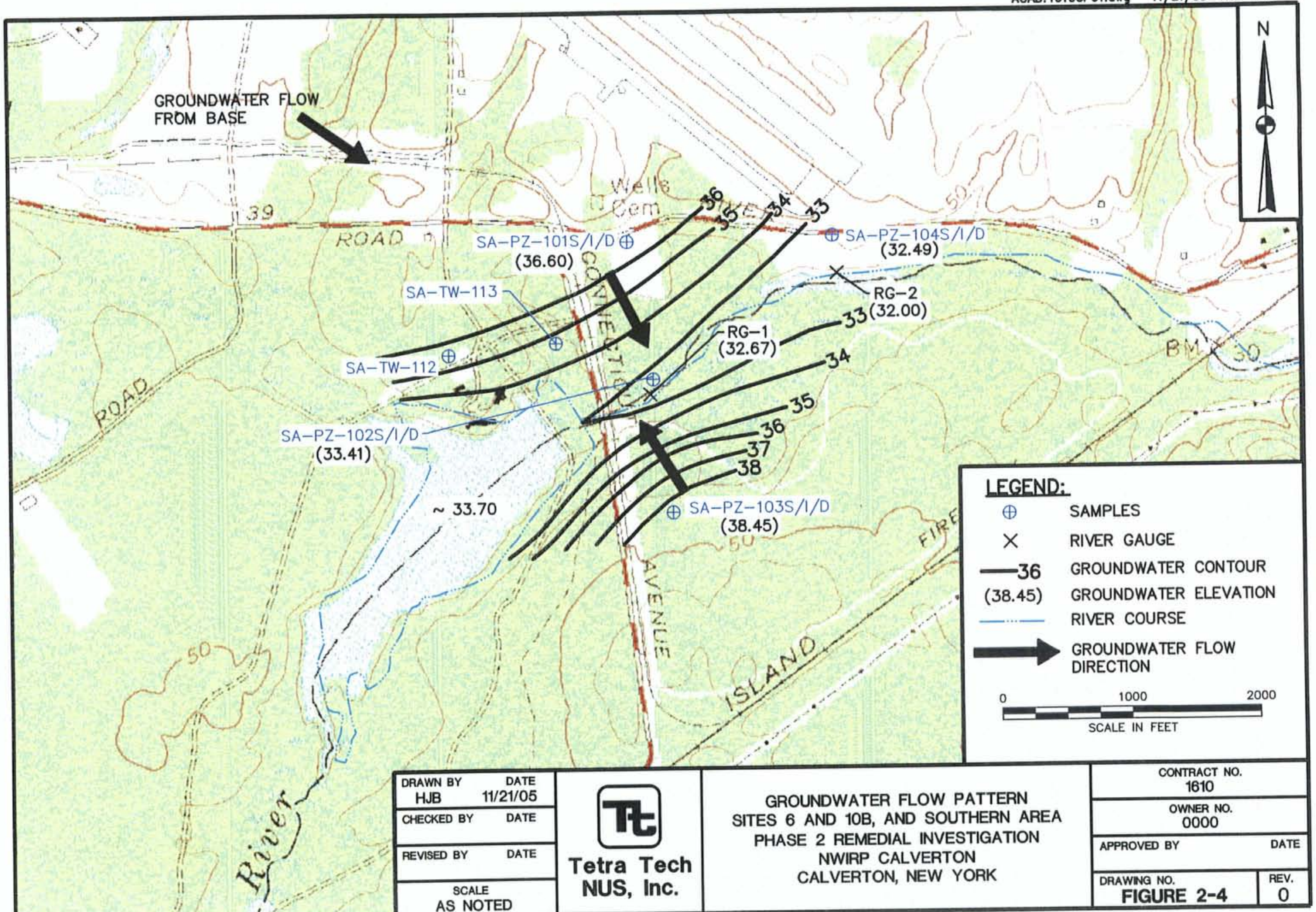
| | |
|---|---|
| DRAWN BY: DM | DATE: 10/17/05 |
| CHECKED BY | DATE |
| REVISED BY | DATE |
| SCALE: AS NOTED | |

Tetra Tech NUS, Inc.

GEOLOGICAL CROSS SECTION
SOUTHERN AREA
NWIRP CALVERTON
CALVERTON, NEW YORK

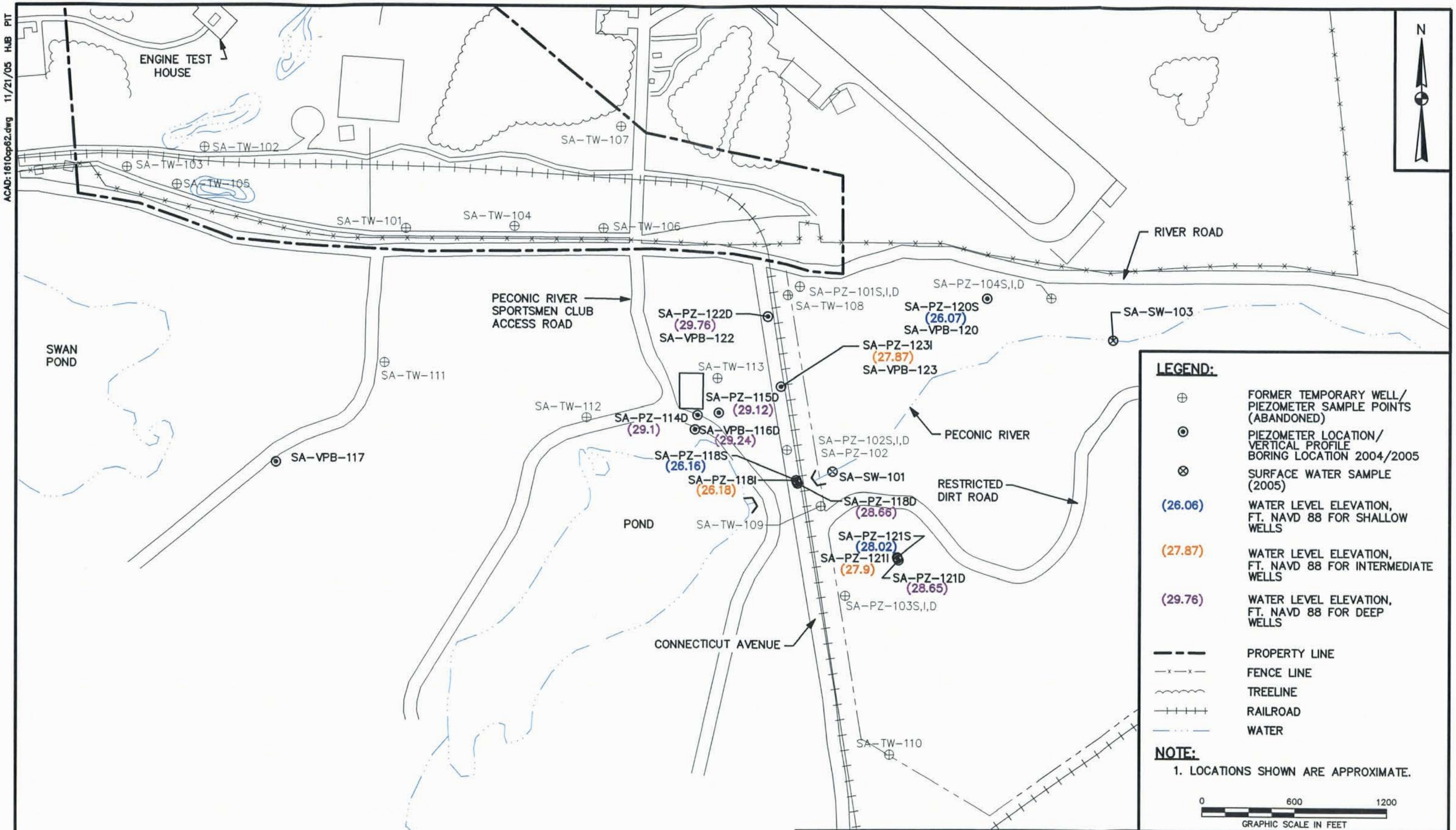
| | |
|---|---|
| CONTRACT NO. 1610 | |
| OWNER NO. 0004 | |
| APPROVED BY | DATE |
| DRAWING NO. FIGURE 2-3 | REV. 0 |

ACAD:1610CP61.dwg 11/21/05 HJB PIT




FORM CADD NO. TTNUS-AH.DWG – REV 1 -9/10/98

ACAD:1610cp62.dwg 11/21/05 HJB PIT



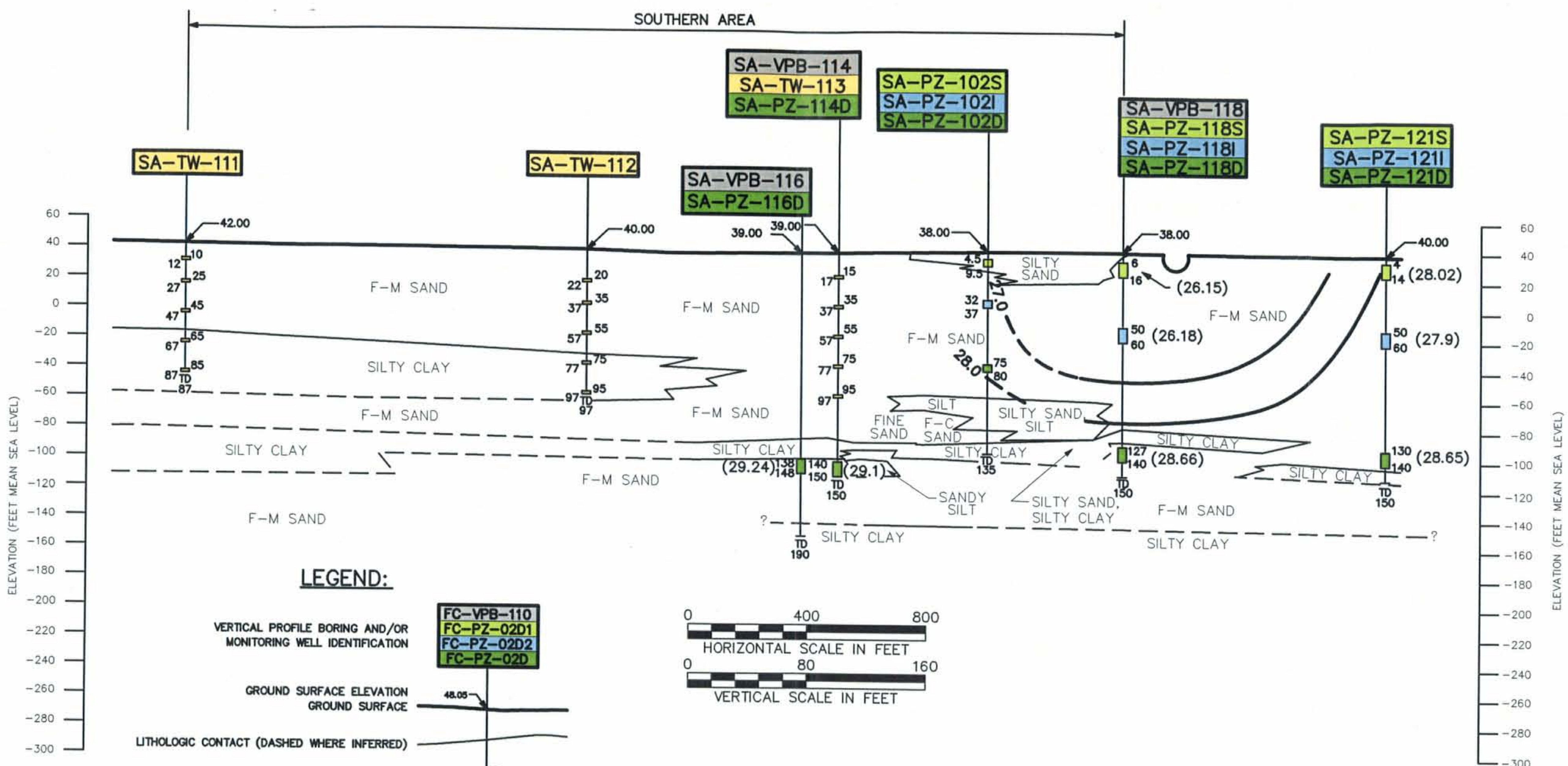

| DRAWN BY HJB | DATE 7/7/05 |
|---|---|
| CHECKED BY SRA | DATE 7/15/05 |
| REVISED BY | DATE |
| SCALE AS NOTED | |

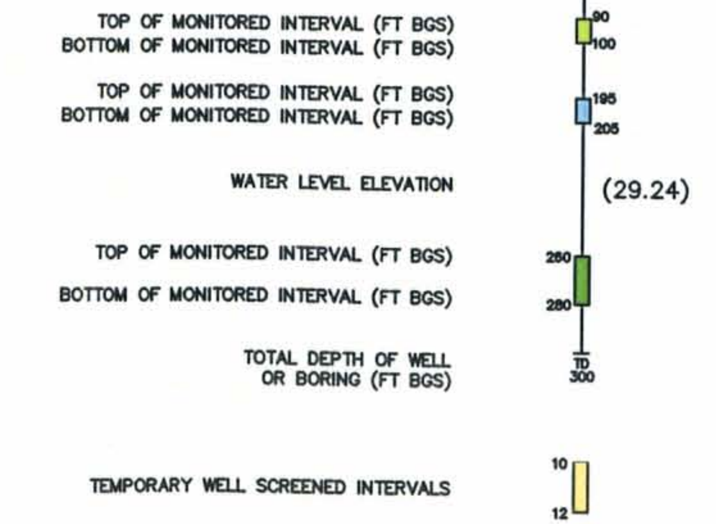
Tetra Tech NUS, Inc.

POTENTIOMETRIC MAP FOR THE SOUTHERN AREA WELLS ON MARCH 28, 2005
SOUTHERN AREA
NWIRP CALVERTON
CALVERTON, NEW YORK

| CONTRACT NO. 1610 | |
|---|---|
| OWNER NO. 0000 | |
| APPROVED BY | DATE |
| DRAWING NO. FIGURE 2-5 | REV. 0 |

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98




## NOTES:

1.) FOR CLARIFICATION, WELL CLUSTERS ARE PROJECTED AND REPRESENTED AS A SINGLE VERTICAL BORING/ MONITORING WELL.

2.) VERTICAL PROFILE BORINGS (VPB) WERE COMPLETED AFTER WELL/BORING INSTALLATION.

3.) TEMPORARY WELLS ARE VARIABLY SCREENED THROUGHOUT VERTICAL SECTIONS.

| | | | |
|---|---|---|---|
| DRAWN BY DM — DATE 10/17/05 | Tetra Tech NUS, Inc. | VERTICAL FLOW NET FOR SOUTHERN AREA WELLS ON MARCH 28, 2005 NWIRP CALVERTON CALVERTON, NEW YORK | CONTRACT NO. 1610 |
| CHECKED BY SRA — DATE 7/20/05 | | | OWNER NO. |
| REVISED BY — DATE | | | APPROVED BY — DATE |
| SCALE AS NOTED | | | DRAWING NO. FIGURE 2-6 — REV. 0 |

DRAWING NO.
FIGURE 2-7
REV.
0
N
PROPERTY BOUNDARY
RUNWAY 32-14
FC-MW-01-I
FC-MW-01-S
FC-MW-08-S
FC-MW-04-I
FC-MW-04-S
FC-MW-02-I
FUEL CALIBRATION AREA
FC-MW-03-S
FC-MW-02-S
FC-MW-07-S
FC-MW-06-S
FC-MW-05-I
FC-MW-05-S
ET-TW-8A
SA-TW-11A
SA-TW-7A
ET-TW-05A
ET-TW-03A
ET-TW-02A
ET-TW-15A
ET-TW-01A
ENGINE TEST HOUSE
SA-TW-107
SA-TW-102
SA-TW-103
SA-TW-105
SA-TW-101
SA-TW-104
SA-TW-106
RIVER ROAD
MAIN GATE
RIVER ROAD
SA-PZ-101S,I,D
SA-TW-108
SA-PZ-120S
SA-VPB-120
SA-PZ-104S,I,D
SA-SW-103
PECONIC RIVER SPORTSMEN CLUB ACCESS ROAD
SA-VPB-122
SA-PZ-122D
SWAN POND
SA-TW-111
SA-PZ-123I
SA-VPB-123
PECONIC RIVER
SA-TW-112
SA-VPB-114
SA-PZ-114D
SA-PZ-115D
SA-VPB-115
RESTRICTED DIRT ROAD
SA-PZ-116D
SA-VPB-116
SA-PZ-102S,I,D
SA-PZ-102
SA-VPB-117
SA-PZ-118S
SA-PZ-118I
SA-SW-101
SA-PZ-118D/SA-VPB-118
POND
SA-TW-109
SA-PZ-121S
SA-PZ-121I
SA-PZ-121D
SA-PZ-103S,I,D
CONNECTICUT AVENUE
SA-TW-110
LEGEND:
FORMER TEMPORARY WELL/ PIEZOMETER SAMPLE POINTS (ABANDONED)
PIEZOMETER LOCATION/ VERTICAL PROFILE BORING LOCATION 2004/2005
SURFACE WATER SAMPLE (2005)
WELL/PIEZOMETER WITHIN PLUME WITH (MAXIMUM VOC CONCENTRATION > 5.0 ug/L)
ONSITE SOUTHERN AREA PLUME (MAXIMUM VOC CONCENTRATION > 5.0 ug/L)
OFFSITE SOUTHERN AREA PLUME (MAXIMUM VOC CONCENTRATION > 5.0 ug/L)
PROPERTY LINE
FENCE LINE
TREELINE
RAILROAD
WATER
CROSS SECTION LOCATION
0 400 800
GRAPHIC SCALE IN FEET
DRAWN BY DM DATE 10/17/05
CHECKED BY DATE
REVISED BY DATE
SCALE AS NOTED
Tetra Tech NUS, Inc.
ON-SITE AND OFF-SITE SOUTHERN AREA GROUNDWATER CONTAMINANT PLUMES NWIRP, CALVERTON CALVERTON, NEW YORK
CONTRACT NO. 1610
OWNER NO. 0004
APPROVED BY DATE
DRAWING NO. FIGURE 2-7
REV. 0
ACAD:1610CP63.dwg 11/22/05 HJB PIT
FORM CADD NO. TTNUS-B-STD.DWG - REV 1 - 9/11/98

# 3.0 CORRECTIVE ACTION OBJECTIVES

The following section describes the development of the proposed CAOs for the Off-Site Southern Area Plume at NWIRP Calverton. These CAOs and media clean-up standards are based on promulgated federal and State of New York requirements, risk-derived standards, data and information gathered during previous investigations, and additional applicable guidance documents.

## 3.1 INTRODUCTION

CAOs are developed for a site as medium-specific and contaminant-specific objectives that will result in the protection of human health and the environment. The development of CAOs for a site is based on human health and environmental criteria, RFI/RI gathered information, EPA guidance, and applicable federal and State regulations. Typically, CAOs are developed based on promulgated standards (e.g., New York State Groundwater Quality Standards), background concentrations determined from a site-specific investigation, and human health and ecological risk-based concentrations developed in accordance with the EPA risk assessment guidance. A complete description of the nature and extent of contamination, contaminant fate and transport, and the qualitative human health and ecological risk assessment for the Off-Site Southern Area Plume are presented in Section 2.0. The purpose of this section is to identify ARARs and develop CAOs for remediation of the contaminated groundwater in the Off-Site Southern Area Plume. The CAOs are based on the contaminants, the results of the risk assessment, and compliance with risk-based (generally guidance) and ARAR-based action levels.

## 3.2 ARARs AND MEDIA OF CONCERN

### 3.2.1 ARARs

#### 3.2.1.1 Introduction

The ARARs, which include the requirements, criteria, or limitations promulgated under federal and State law that address a contaminant, action, or location at a site, are presented in this section.

The definition of an ARAR is as follows:

- Any standard, requirement, criterion, or limitation under federal environmental law.
- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-citing law that is more stringent than the associated federal standard, requirement, criterion, or limitation.

One of the primary concerns during the development of corrective action alternatives for hazardous waste sites under RCRA is the degree of human health and environmental protection afforded by a given remedy. Consideration should be given to corrective measures that attain or exceed ARARs.

Definitions of the two types of ARARs, as well as TBC criteria, are given below:

- Applicable Requirements means those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site.

- Relevant and Appropriate Requirements means those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable," address problems or situations sufficiently similar (relevant) to those encountered at the site that their use is well suited (appropriate) to the particular site.

- TBC Criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing Corrective Measures Alternatives and for determining action levels that are protective of human health or the environment.

These requirements are included to provide decision makers with a complete evaluation of potential ARARs in developing, identifying, and selecting a Corrective Measures Alternative.

#### 3.2.1.2 ARAR and TBC Categories

ARARs fall into three categories, based on the manner in which they are applied, as follows:

- Chemical Specific: Health-risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples of chemical-specific ARARs include MCLs and Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC). Chemical-specific ARARs govern the extent of site clean-up.

- Location Specific: Restrictions based on the concentrations of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of site. Examples of location-specific ARARs include RCRA location requirements and floodplain management requirements. Location-specific ARARs pertain to special site features.

- Action Specific: Technology- or activity-based controls or restrictions on activities related to management of hazardous waste. Action-specific ARARs pertain to implementing a given remedy.

Table 3-1 presents a summary of potential federal and State ARARs and TBCs for corrective measures undertaken at the Off-Site Southern Area Plume at NWIRP Calverton.

### 3.2.1.3 Chemical-Specific ARARs and TBCs

This section presents a summary of federal and State chemical-specific ARARs of potential concern for the Off-Site Southern Area Plume. The ARARs provide medium-specific guidance on "acceptable" or "permissible" concentrations of contaminants.

The Safe Drinking Water Act (SDWA) promulgated National Primary Drinking Water Standard MCLs [40 Code of Federal Regulations (CFR) Part 141]. MCLs are enforceable standards for contaminants in public drinking water supply systems. They consider not only health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. Secondary MCLs (40 CFR Part 143) are not enforceable but are intended as guidelines for contaminants that may adversely affect the aesthetic quality of drinking water, such as taste, odor, color, and appearance, and may deter public acceptance of drinking water provided by public water systems.

The SDWA also established Maximum Contaminant Level Goals (MCLGs) for several organic and inorganic compounds in drinking water. MCLGs indicate the levels of contaminants in drinking water at which no known or anticipated health effects would occur, allowing for an adequate margin of safety. MCLGs are non-enforceable public health goals.

Table 2-3 provides federal SDWA requirements that may be applicable to corrective actions involving groundwater in the Off-Site Southern Area Plume. Drinking water standards will also be considered as discharge criteria for alternatives which include groundwater treatment.

The CWA sets EPA AWQC that are non-enforceable guidelines developed for pollutants in surface waters pursuant to Section 304(a)(1) of the CWA. Although AWQC are not legally enforceable, they should be considered as potential ARARs. AWQC are available for the protection of human health from exposure to contaminants in surface water as well as from ingestion of aquatic biota and for the protection of freshwater and saltwater aquatic life. AWQC may be considered when groundwater discharges into surface waters and for actions that involve groundwater treatment and/or discharge to nearby surface waters. Information indicates that groundwater from the Off-Site Southern Area Plume discharges to the

Peconic River. Table 2-4 provides AWQCs that may be applicable to corrective actions involving groundwater in the Off-Site Southern Area Plume.

Reference Dose (RfD), as defined in the EPA Integrated Risk Information System (IRIS), is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are developed for chronic and/or subchronic human exposure to hazardous chemicals and are based on the assumption that thresholds exist for certain toxic effects. The RfD is usually expressed as an acceptable dose (mg) per unit body weight (kg) per unit time (day). The RfD is derived by dividing the no-observed-adverse-effect level (NOAEL) or the lowest-observed-adverse-effect level (LOAEL) by an uncertainty factor (UF) times a modifying factor (MF).

EPA Cancer Slope Factor (CSF), as defined in the IRIS, is an upper bound, approximating a 95-percent confidence limit, on the increased cancer risk from a lifetime exposure to a chemical. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg/day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100.

EPA Region III Risk-Based Concentrations (RBCs) are medium-specific (water, air, fish tissue, and soil) screening levels calculated using equations combining exposure information assumptions with EPA toxicity data for a target Hazard Quotient (HQ) of 1.0 for noncarcinogenic effects and a target risk of $1.0x10^{-6}$ for carcinogenic effects. RBCs have several important limitations. Specifically excluded from consideration are (1) transfers from soil to air, (2) cumulative risk from multiple contaminants or media, and (3) dermal risk. Additionally, the risks for inhalation of vapors from water are based on a very simple model, whereas detailed risk assessments may use more detailed showering models. In general, EPA does not recommend that RBCs be used to set clean-up or no-action levels at CERCLA sites or RCRA corrective action sites.

The Clean Air Act (CAA) [42 United States Code (USC) 7401] consists of three programs or requirements that may be ARARs: National Ambient Air Quality Standards (NAAQSs) (40 CFR Parts 50 and 53), National Emission Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61), and New Source Performance Standards (NSPSs) (40 CFR Part 60). NESHAPs, which are emission standards for source types (i.e., industrial categories) that emit hazardous air pollutants, are not likely to be applicable or relevant and appropriate for NWIRP because they were developed for a specific source. EPA requires the attainment and maintenance of primary and secondary NAAQSs to protect public health and public welfare, respectively. These standards are not source specific but rather are national limitations on ambient air quality. States are responsible for assuring compliance with NAAQSs. NSPSs are established for new sources of air emissions to ensure that the new stationary sources minimize emissions. These standards are for categories of stationary sources that cause or contribute to air pollution that may endanger public health or welfare. Standards are based on the best-demonstrated available technology (BDAT).

RCRA Subtitle C Hazardous Waste Identification and Listing (40 CFR Part 261) requirements are used to identify a material that is a hazardous waste and thus determine applicability or relevance of RCRA Subtitle C hazardous waste rules.

Oak Ridge National Laboratory (ORNL) Tier II Surface Water Secondary Chronic Values (SCVs) are non-enforceable screening levels developed for evaluating impacts to aquatic organisms from pollutants in surface water. Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for AWQCs. Tier II values are concentrations expected to be higher than AWQCs in no more than 20 percent of cases (Suter and Tsao, 1996). Because of the limited data set available to calculate some of the Tier II values, various adjustment factors are used to account for the uncertainty in not having a larger data set. The adjustment factors are larger when fewer data points are available. Although ORNL surface water SCVs are not legally enforceable, they should be considered as potential TBCs. Surface water SCVs may be considered for actions that involve groundwater treatment and/or discharge to nearby surface waters. Table 2-5 provides ORNL surface water SCVs that may be applicable to corrective actions involving groundwater in the Off-Site Southern Area Plume.

ORNL Sediment SCVs are non-enforceable screening levels developed for evaluating impacts to benthic invertebrates from pollutants in sediment. The sediment SCVs were calculated by equilibrium partitioning using the surface water screening levels (ORNL surface water SCVs), $K_{oc}$ values for each chemical, and an assumed total organic carbon (TOC) value of 1 percent. The assumption for the equilibrium partitioning model is that the sediment SCV is the level at which the sediment pore water concentration is equal to the surface water SCV. Although ORNL sediment SCVs are not legally enforceable, they should be considered as potential TBCs. Table 2-5 provides ORNL sediment SCVs that may be applicable to corrective actions involving groundwater in the Off-Site Southern Area Plume.

National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQUIRTs) include non-enforceable screening levels developed for evaluating impacts to aquatic organisms from pollutants in surface water. The screening levels are basically a compilation of existing screening levels from other sources, including the AWQC. Although NOAA SQUIRT values are not legally enforceable, they should be considered as potential TBCs. Surface water SCVs may be considered for actions that involve groundwater treatment and/or discharge to nearby surface waters. Table 2-5 lists NOAA SQUIRT values that may be applicable to corrective actions involving groundwater in the Off-Site Southern Area Plume.

New York Ambient Air Quality Standards (6 NYCRR Parts 256 and 257) provide four general classifications of social and economic development and resulting pollution potential upon which standards are based. In addition, air quality standards are established to provide protection from adverse health effects of air contamination and to protect and conserve natural resources and the environment. Part 256 provides the air quality classification standards. The NWIRP is probably classified as Level II (predominantly single and two family residences, small farms, and limited commercial services and industrial development). Part 257 provides air quality standards for regulated contaminants, which include sulfur dioxide, particulates, carbon monoxide, photochemical oxidants, non-methane hydrocarbons, nitrogen dioxide, fluorides, beryllium, and hydrogen sulfide.

New York Public Water Supply Regulations (10 NYCRR Part 5) provide requirements for State public water supplies. Refer to Table 2-3 for State MCLs applying to NWIRP Off-Site Southern Area Plume compounds.

New York Water Classifications and Quality Standards (6 NYCRR Parts 609 and 700 to 705) regulate reclassification of water based on use and value, including protection and propagation of fish, shellfish and wildlife, recreation in and on the water, public water supplies, and agricultural, industrial, and other purposes including navigation. Additionally, these standards regulate the discharge of sewage, industrial waste, or other wastes so as not to cause impairment of the best usages of the receiving water as specified by the water classifications at the location of discharge that may be affected by such discharge. Both quantitative standards as well as narrative water quality standards (turbidity, solids, oil, etc.) are provided (see action-specific ARARs for Groundwater Effluent Standards that would be applicable for alternatives including reinjection to the aquifer).

Part 701 provides the classification of surface water and groundwater. The surface water in the Peconic River is classified as Class C, which is suitable for fish propogation and survival and for primary and secondary contact recreation. Surface water quality standards (Class C) for the Peconic River are provided in Table 2-4. Groundwater beneath the NWIRP would be classified as Class GA. Groundwater quality standards (Class GA) for the Off-Site Southern Area Plume are provided in Table 2-3. Also for Class C surface water and Class GA groundwater, pH is required to be between 6.5 and 8.5 and total dissolved solids (TDS) cannot exceed 500 mg/L. In addition, the dissolved oxygen concentration cannot be less than 4.0 mg/L for Class C surface water.

New York Technical and Operational Guidance Series (TOGS), Division of Water (TOGS 1.1.1) provides a compilation of ambient water quality guidance values and groundwater effluent limitations for use where there are no regulatory ambient water quality standards (in 6 NYCRR Part 703.5) or effluent limitations (in 6 NYCRR Part 703.6). For the convenience of the user, the standards in Part 703.5 and the limitations in Part 703.6 are included in this document. The guidance values are appropriate for actions involving groundwater plume remediation and reinjection of treated groundwater into the aquifer (see Table 2-3).

New York Technical and Administrative Guidance Memorandum on Determination of Soil Cleanup Objectives and Cleanup Levels (TAGM 4046) provides a basis and procedure to determine soil clean-up levels. Soil clean-up objectives are based on human health-based levels that correspond to excess lifetime cancer risks, human health-based levels for systemic toxicants calculated from RfDs, environmental concentrations that are protective of groundwater/drinking water quality based on promulgated or proposed New York State Standards, background values for contaminants, or detection limits. Clean-up objectives should be greater than method detection limits (MDLs) and preferably greater than contract-required quantitation limits (CRQLs). Groundwater quality standards from TAGM 4046 were considered during evaluation of the Off-Site Southern Area Plume (see Table 2-3).

#### 3.2.1.4 Location-Specific ARARs and TBCs

This section presents a summary of federal and State location-specific ARARs of potential concern for the Off-Site Southern Area Plume. The potential ARARs and TBCs are as follows:

Federal Protection of Wetlands Executive Order (E.O. 11990) requires federal agencies, in carrying out their responsibilities, to take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands (unless there is no practical alternative to that construction), to minimize the harm to wetlands (if the only practical alternative requires construction in the wetlands), and to provide early and adequate opportunities for public review of plans involving new construction in wetlands. Corrective measures for the Off-Site Southern Area may impact regulated wetland areas. The Peconic River and several ponds, which are considered wetlands, are located adjacent to or within the Southern Area.

Endangered Species Act of 1978 (16 USC 1531) (50 CFR Part 17) provides for consideration of the impacts on endangered and threatened species and their critical habitats. Corrective measures actions, if required, would need to be conducted in a manner such that the continued existence of any endangered or threatened species is not jeopardized or its critical habitat is not adversely affected. Consultation with the United States Fish and Wildlife Service is also required. There are no endangered or threatened species known to reside at or near the Off-Site Southern Area. However, migrating species may move through the area.

Fish and Wildlife Coordination Act (16 USC 661) provides for consideration of the impacts on wetlands and protected habitats. The act requires that federal agencies, before issuing a permit or undertaking federal action for the modification of any body of water, consult with the appropriate state agency exercising jurisdiction over wildlife resources to conserve those resources. Consultation with the United States Fish and Wildlife Service is also required.

Federal Floodplains Management Executive Order (E.O. 11988) provides for consideration of floodplains during corrective actions. This E.O. requires that activities be conducted to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupation or modification of floodplains. Floodplain development should be avoided whenever there are practicable alternatives and should minimize potential harm to floodplains when there are no practical alternatives. Portions of the Off-Site Southern Area are within the 100-year floodplain of the Peconic River.

The Archaeological and Historic Preservation Act (16 USC Section 469) (36 CFR Part 65) establishes requirements relating to potential loss or destruction of significant scientific, historical, or archaeological data as a result of any proposed remedy. The Secretary of the Interior must be notified if a federal agency finds that its activities, in connection with any federal construction project, might cause loss or destruction of such data. No historic artifacts are expected to be uncovered in the Off-Site Southern Area.

New York Freshwater Wetlands Act [Environmental Conservation Law (ECL) Article 24 and Title 23 of Article 71 of the New York ECL] regulates activities within wetlands. New York Freshwater Wetlands Regulations (6 NYCRR Parts 662 to 664) provide regulations to preserve, protect, and conserve freshwater wetlands and regulate use and development of the wetlands. Activities within or adjacent to a wetland with an area of at least 12.4 acres or, if smaller, unusual local importance as determined by the State, require a permit or letter of approval. The adjacent area is considered the area within 100 feet of the wetland. Wetlands are classified according to the benefit of the wetlands, with Class I wetlands being the most beneficial and Class IV being the least beneficial. Corrective measures for the Off-Site Southern Area may impact regulated wetland areas. The Peconic River and several ponds, which are considered wetlands, are located adjacent to and within the Off-Site Southern Area.

New York Endangered and Threatened Species of Fish and Wildlife; Species of Special Concern (6 NYCRR Part 182) provides a list of regulated species. A State endangered species (*Ambystoma tigrinum*, tiger salamander) has been confirmed at the NWIRP Calverton but not at the Off-Site Southern Area. This species is a State-regulated species but is not federally regulated (Natural Resources Management Plan, 1989). A permit or license is required to take, import, transport, possess, or sell any endangered or threatened species.

New York Regulation for Administration and Management of the Wild, Scenic, and Recreational Rivers System in New York State Excepting the Adirondack Park (6 NYCRR Part 666) is authorized under the New York Wild, Scenic, and Recreational Rivers System Act (Title 27 of Article 15 of the New York ECL) and provides regulations for the management, protection, enhancement, and control of land use and development in river areas on all designated wild, scenic, and recreational rivers (except within the Adirondack Park). The Peconic River and some of its tributaries are classified as a Scenic River. Certain kinds of activities and developments within the defined river corridor are restricted or require a permit. Any new direct discharge of any substance into a Scenic River must meet water quality standards, (6 NYCRR Parts 701 and 702). Corrective measures for the Off-Site Southern Area may affect the Peconic River.

Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites Guidance (Division of Fish and Wildlife, NYSDEC, July 18, 1991) provides guidance for the evaluation of fish and wildlife concerns associated with the remediation of inactive hazardous waste sites. This guidance provides the required elements for a complete impact analysis including site description, contaminant-specific impact analysis, ecological effects of remedial alternatives, implementation of selected alternatives in design, and monitoring program.

### 3.2.1.5 Action-Specific ARARs and TBCs

This section presents a summary of federal and State action-specific ARARs of potential concern in the case of the Off-Site Southern Area. The potential ARARs and TBCs are as follows:

RCRA Subtitle C regulates the treatment, storage, and disposal of hazardous waste from its generation until its ultimate disposal. In general, RCRA Subtitle C requirements for the treatment, storage, or disposal of hazardous waste will be applicable if:

- The waste is a listed or characteristic waste under RCRA.
- The waste was treated, stored, or disposed (as defined in 40 CFR 260.10) after the effective date of the RCRA requirements under consideration.
- The activity at the site constitutes current treatment, storage, or disposal as defined by RCRA.

RCRA Subtitle C requirements may be relevant and appropriate when the waste is sufficiently similar to a hazardous waste and/or the on-site corrective action constitutes treatment, storage, or disposal and the particular RCRA requirement is well suited to the circumstances of the contaminant release and site. RCRA Subtitle C requirements may also be applicable when the corrective action constitutes generation of a hazardous waste.

The following requirements included in the RCRA Subtitle C regulations may pertain to the Southern Area at NWIRP Calverton:

- Hazardous waste identification and listing regulations (40 CFR Part 261).

- Hazardous waste generator requirements (40 CFR Part 262).

- Transportation requirements (40 CFR Part 263).

- Standards for owners and operators of hazardous waste treatment, storage, and disposal (TSD) facilities (40 CFR Part 264).

- Interim status standards for owners and operators of hazardous waste TSD facilities (40 CFR Part 265).

- Land disposal restrictions (LDRs) (40 CFR Part 268).

Hazardous Waste Identification and Listing Regulations (40 CFR Part 261) define those solid wastes that are subject to regulation as hazardous waste under 40 CFR Parts 262 to 265 and Parts 124, 270, and 271.

A generator that treats, stores, or disposes of hazardous waste on site must comply with RCRA Standards Applicable to Generators of Hazardous Waste (40 CFR Part 262). These standards include manifest, pre-transport (i.e., packaging, labeling, and placarding), record keeping, and reporting requirements. The standards are applicable if actions taken at the Off-Site Southern Area constitute generation of a hazardous waste (e.g., generation of water treatment residues).

Standards Applicable to Transporters of Hazardous Waste (40 CFR Part 263) are applicable to off-site transportation of hazardous waste. These regulations include requirements for compliance with manifest and record keeping systems and requirements for immediate action and clean-up of hazardous waste discharges (spills) during transportation. The standards are potentially applicable if corrective actions involve off-site transportation of hazardous waste from the Off-Site Southern Area.

Standards and Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR Parts 264 and 265) are applicable to corrective actions that may be taken at the Off-Site Southern Area and to off-site facilities that receive hazardous waste from the site for treatment and/or disposal. Standards for TSD facilities include requirements for preparedness and prevention, corrective action requirements, closure and post-closure care, use and management of containers, and design and operating standards for tank systems, surface impoundments, waste piles, landfills, and incinerators. These standards are potentially applicable if corrective actions involve the on-site treatment or disposal of hazardous waste at the Off-Site Southern Area.

RCRA LDR Requirements (40 CFR Part 268) restrict certain wastes from being placed or disposed on the land unless they meet specific BDAT treatment standards [expressed as concentrations, total or in the toxicity characteristic leaching procedure (TCLP) extract, or as specified technologies]. Removal and treatment of a RCRA hazardous waste or movement of the waste outside of a Corrective Action Management Unit (CAMU), thereby constituting "placement," would trigger the LDR requirements.

Placement of hazardous waste into underground injection wells constitutes "land disposal" under the LDRs. Furthermore, RCRA Section 3020(a) bans hazardous waste disposal by underground injection into or above an underground source of drinking water. RCRA Section 3020(b), however, exempts from the ban all reinjection of treated contaminated groundwater into such formations undertaken as part of a RCRA corrective action. The contaminated groundwater must be treated to substantially reduce hazardous constituents before such injection, and the corrective action must be sufficient to protect human health and the environment upon completion. LDRs would be potentially applicable if corrective actions at the Off-Site Southern Area include off-site disposal of wastes in a landfill or reinjection of treated groundwater.

RCRA Corrective Action Management Units and Temporary Units, Final Rule (40 CFR Parts 260, 264, 265, 268, 270, and 271) addresses two new units, CAMUs and temporary units (TUs), under RCRA corrective action authorities. These special provisions were proposed as part of a more comprehensive rulemaking on July 27, 1990. The final regulations became effective on April 19, 1993 and were amended on November 30, 1998 to include staging piles.

When a site, or portion of a site, receives a CAMU designation, the designated area qualifies for certain exemptions from RCRA Subtitle C requirements. LDRs are not triggered when hazardous remediation waste is placed in a CAMU, when remediation wastes generated at a facility outside a CAMU are consolidated into a CAMU, or when remediation wastes are moved between two or more CAMUs. In addition, remediation wastes can be excavated from a CAMU, treated in a separate unit, and redeposited in the CAMU without triggering LDRs. TUs are containers and tanks used on a temporary basis. TUs and staging piles may be subject to reduced minimum technology standards and closure requirements. This rule should not be applicable or relevant and appropriate for handling and disposal of groundwater from the Off-Site Southern Area.

RCRA Subtitle D includes guidelines for regional solid waste plans, design and operating criteria for solid (non-hazardous) waste landfills, and upgrading of open dumps.

Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171 to 179) regulate the transport of hazardous materials, including packaging, shipping equipment, and placarding. These rules are considered applicable to wastes shipped off site for laboratory analysis, treatment, or disposal.

National Environmental Policy Act (NEPA) (42 USC 4321 et seq) and implementing regulations (40 CFR Part 6) require federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit, or implement.

The CWA, as amended, governs point-source discharges through the National Pollutant Discharge Elimination System (NPDES), discharge of dredge or fill material, and oil and hazardous waste spills to United States waters. NPDES requirements (40 CFR Part 122) will be applicable if the direct discharge of pollutants into surface waters is part of the corrective action (i.e., discharge of effluent from a groundwater treatment system). These regulations contain discharge limitations, monitoring requirements, and best management practices.

Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites [Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-28] is a TBC that guides the control of air emissions from air strippers. For sites located in areas that are not attaining NAAQSs for ozone, add-on emission controls are required for an air stripper with an actual emission rate in excess of 3 pounds per hour, an actual emission rate in excess of 15 pounds per day, or a potential (i.e., calculated) emission rate of 10 tons per year of total VOCs. Generally, the guidelines are suitable for VOC air emissions from other vented extraction techniques (e.g., soil vapor extraction) but not from area sources (e.g., soil excavation). NWIRP Calverton is in a non-attainment area for ozone.

General Pretreatment Regulations for Existing and New Sources of Pollutants (40 CFR Part 403) controls the indirect discharge of pollutants to publicly owned treatment works (POTWs). The goal of the pretreatment program is to protect municipal wastewater treatment plants and the environment from damage that may occur when hazardous, toxic, or other non-domestic wastes are discharged in a sewer system. The regulations include general and specific prohibitions on discharges to POTWs. The regulations are potentially applicable if treated or untreated groundwater is discharged to a local POTW.

Underground Injection Control Program (40 CFR Parts 144 and 147) contains provisions for the control and prevention of pollutant injection into groundwater. Class IV wells are used to inject hazardous waste into or above a formation that, within ¼ mile of the well, contains an underground drinking water source. Operation or construction of Class IV wells is prohibited and allowed only for the reinjection of treated wastes as part of a CERCLA or RCRA clean-up. The regulations are potentially applicable if groundwater is removed, treated, and reinjected into the formation from which it was withdrawn.

Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Directive 9200.4-17P) contains guidelines for the use of monitored natural attenuation for the remediation of contaminated soil and groundwater. This guidance is a TBC criterion if monitored natural attenuation is a component of the corrective action at the Off-Site Southern Area.

Occupational Health and Safety Act (29 USC Sections 651 through 678) regulates worker health and safety during implementation of remedial actions.

New York ECL (New York Consolidated Laws, Chapter 43-B) concerns the conservation, improvement, and protection of State natural resources and environment and controls water, land, and air pollution.

The following requirements included in the ECL in particular may pertain to remedial activities at the Southern Area at NWIRP Calverton:

- Article 17 - Water Pollution Control provides policy to require use of all known available and reasonable methods to prevent and control the pollution of State waters consistent with public health and use, propagation and protection of fish and wildlife, and the industrial development of the State.

- Article 19 - Air Pollution Control Act provides policy to maintain the quality of the air resources of the State. Regulations for implementing this act are provided in 6 NYCRR Parts 200 to 257. This act also provides trial burn requirements for burning of hazardous waste.

- Article 27 - New York Solid and Hazardous Waste Management Laws address solid and hazardous waste management, including waste transport permits, solid waste management and resource recovery facilities, industrial hazardous waste management, siting of hazardous waste facilities, and inactive hazardous waste disposal sites. A preferred State-wide hazardous management practices hierarchy is also provided (1) to reduce or eliminate to the maximum extent practical the generation of hazardous waste, (2) to recover, reuse, or recycle to the maximum extent practical generated hazardous waste, (3) to utilize detoxification, treatment, or destruction technology for hazardous waste that cannot be reduced, recovered, reused or recycled, and (4) to minimize land disposal of industrial hazardous waste, except treated residuals posing no significant threat to the public health or environment. Special provisions for land burial and disposal in Nassau and Suffolk Counties are provided. No new landfills (or expansions to existing landfills) are allowed in a deep flow recharge area. For new landfills outside a deep flow recharge area, hazardous waste is prohibited and the landfill can only accept material that is a product or resource recovery, incineration or composting. Regulations to implement these laws are included in 6 NYCRR Parts 360 to 483.

- Article 70 - Uniform Procedures establish uniform review procedures for major regulatory programs of the NYSDEC and establishes time periods for NYSDEC action on permits under such programs. Procedures are provided for coordinating permitting for a project requiring one or more NYSDEC permit.

New York Air Pollution Control Regulations (6 NYCRR Parts 200 to 257) regulate emissions from specific sources. Part 212, General Process Emission Sources, provides general requirements. NWIRP is located in Suffolk County, which is considered part of the New York City Metropolitan Area. The degree of air cleaning required for the different contaminant ratings are as follows. For the most stringently rated contaminants (Rating A), for emission rate potentials greater than 1 pound per hour, 99 percent or more removal or best available control technology if required. For emission rate potentials less than 1 pound per hour, the degree of air cleaning required shall be specified by the State. For Ratings of B, C, or D and for emission rate potentials of 3.5 pounds per hour or less, the degree of air cleaning required shall be specified by the State (Ratings B or C), or no cleaning is required (Rating D). For emission rate potentials greater than 3.5 pounds per hour, reasonably available control technology shall be used. Part 231 regulates new source review for air contamination source projects in non-attainment areas. To be applicable, annual emissions (within a non-attainment area) from the source must exceed the de minimus emission limits. The de minimus emission limit is 40 tons per year for volatile organics and 25 tons per year for particulates.

New York Waste Management Facilities Rules (6 NYCRR Part 360) regulate solid waste management facilities (other than hazardous waste management facilities subject to Parts 373 and 374). Siting requirements for solid waste management facilities include that the facility must not be constructed or operated in such a manner that may have an adverse affect on any endangered or threatened species or their critical habitat and that the facility cannot be located within the boundary of a regulated wetland. A permit is required to construct, operate, modify, or expand a solid waste management facility. However, temporary storage, treatment, incineration, and process facilities (including temporary mobile processing facilities) may be exempt from permitting requirements if the facility is located at an industrial or commercial establishment and is used exclusively for solid wastes generated at that location or at a location under the same ownership within a single region of the NYSDEC. The rules specify that excavated petroleum-contaminated soils cannot be stored on site for more than 60 days unless otherwise approved by the NYSDEC. Non-hazardous petroleum-contaminated soil that has been decontaminated and is being used in an acceptable manner is considered beneficial use (this includes incorporation into asphalt pavement by an authorized facility). These rules may be applicable if contaminated soil is stored or landfilled on site.

New York Rules for Siting Industrial Hazardous Waste Facilities (6 NYCRR Part 361) regulate the siting of new industrial hazardous waste facilities located wholly or partially within the State. Evaluation criteria for siting include consideration of population density, transportation route, contamination of groundwater and surface water, air quality, and preservation of endangered, threatened, and indigenous species.

New York Waste Transport Permit Regulations (6 NYCRR Part 364) govern the collection, transport, and delivery of regulated waste originating or terminating at a location within the State. These regulations are potentially applicable if contaminated soils or groundwater treatment residuals are hauled off site for treatment or disposal.

New York General Hazardous Waste Management System Regulations (6 NYCRR Part 370) provide general definitions and set forth State procedures for making information available to the public, confidentiality, petitioning equivalent testing methods, and petitioning for exclusion of a waste from a particular facility. These regulations are potentially applicable if excavated soil or treatment residuals would be classified as a hazardous waste.

New York Identification and Listing of Hazardous Wastes Regulations (6 NYCRR Part 371) establish procedures for identifying solid wastes subject to regulation as hazardous wastes. These regulations would be used to determine whether contaminated soil or treatment residuals meet the definition of a hazardous waste.

New York Hazardous Waste Manifest System Regulations (6 NYCRR Part 372) establishes standards for hazardous waste generators, transporters, and TSD facilities associated with the use of the manifest system and its record keeping requirements. These regulations are potentially applicable if corrective actions involve off-site transportation of hazardous waste.

New York Hazardous Waste Treatment, Storage, and Disposal Facility Permitting Requirements (6 NYCRR Subpart 373-1) regulate hazardous waste management facilities located within the State. These regulations are potentially applicable if corrective actions involve on-site treatment, storage, or disposal of hazardous waste.

New York Final Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (6 NYCRR Subpart 373-2) establish minimum State standards that define the acceptable management of hazardous waste. These standards are potentially applicable if corrective actions involve on-site treatment or disposal of hazardous waste at the Off-Site Southern Area.

New York Interim Status Standards for Owners and Operators of Hazardous Waste Facilities (6 NYCRR Subpart 373-3) establish minimum State standards that define the acceptable management of hazardous waste during the period of interim status and until certification of closure. These standards are potentially applicable if corrective actions involve on-site treatment or disposal of hazardous waste.

New York Standards for the Management of Specific Hazardous Wastes and Hazardous Waste Management Facilities (6 NYCRR Part 374-1) contain requirements for generators and transporters of hazardous waste and for owners and operators of facilities managing hazardous wastes. The regulation specifically addresses recyclable materials, hazardous waste or used oil burned for energy recovery, and reclaimed lead-acid batteries. These standards would be potentially applicable in the unlikely event that recyclable hazardous waste materials are used in a manner constituting disposal.

New York Rules for Inactive Hazardous Waste Disposal Sites (6 NYCRR Part 375) apply to the development and implementation of programs to address inactive hazardous waste disposal sites. The goal for a specific site is to restore it to pre-disposal conditions, to the extent feasible and authorized by law. At a minimum, the remedy selected shall eliminate or mitigate significant threats to the public health and the environment. State review and concurrence with the selected remediation scheme is required. The hierarchy of remedial technologies is as follows: destruction, separation/treatment, solidification/chemical fixation, and control and isolation.

New York LDR Regulations (6 NYCRR Part 376) identify hazardous wastes that are restricted from land disposal and define limited circumstances under which an otherwise prohibited waste may be land disposed. LDRs would be potentially applicable if corrective actions at the Off-Site Southern Area include land disposal of hazardous waste.

New York Rules on Hazardous Waste Program Fees (6 NYCRR Parts 483) address generator fees, TSD facility fees, and waste transporter fees.

New York Water Classifications and Quality Standards (6 NYCRR Parts 609 and 700 to 706) Parts 700 to 706 provide regulations for the discharge of sewage, industrial waste, or other wastes so as not to cause impairment of the best usages of the receiving water as specified by the water classifications at the location of discharge that may be affected by such discharge. Part 703.6 provides groundwater effluent limitations. Treated groundwater may be reinjected to groundwater and would need to comply with groundwater effluent limitations (see Table 3-2). The NWIRP site is in Suffolk County and will additionally have to comply with a maximum concentration of 1,000 mg/L TDS and 10 mg/L total nitrogen (as N).

New York Regulations on State Pollutant Discharge Elimination System (6 NYCRR Parts 750 to 758) prescribe procedures and substantive rules concerning discharges to State waters. A State Pollutant Discharge Elimination System (SPDES) permit or NPDES permit is required to discharge to surface water. Amendments to these regulations will be proposed to repeal the current portions of Parts 750 through 758 that have been suspended by other laws and regulations and to renumber the remaining sections to develop a new comprehensive Part 750.

## 3.3 CORRECTIVE ACTION OBJECTIVES

CAOs are developed in this section to address contaminated groundwater in the Off-Site Southern Area Plume. CAOs generally identify COCs, receptors, pathways, and action levels (PRGs). Site- and medium-specific CAOs and corresponding PRGs are presented in the following sections.

The CAOs address the identified environmental risks at the Off-Site Southern Area at NWIRP Calverton. Contaminated groundwater represents a potential threat to human health at the site through ingestion, dermal contact, and inhalation.

### 3.3.1 Corrective Action Objectives for Groundwater

The CAOs for contaminated groundwater for the Off-Site Southern Area Plume are as follows:

- Prevent human exposure (through ingestion, inhalation, dermal contact) to groundwater having contaminants at concentrations greater than groundwater PRGs.
- Minimize discharge of groundwater having contaminants at concentrations greater than surface water PRGs to surface waters to reduce exposure and impacts to ecological receptors.
- Restore contaminated groundwater quality to the PRGs to the maximum extent that is technically feasible.
- Comply with contaminant-specific, location-specific, and action-specific ARARs and guidance.

If groundwater PRGs cannot be achieved or if the aquifer cannot be restored, then at a minimum, the following objectives should be met:

- Reduce human exposure (ingestion, inhalation, dermal contact) to groundwater having contaminants at concentrations greater than PRGs.
- Minimize the discharge of contaminated groundwater with contaminants that could cause adverse effects on ecological receptors to adjacent surface water bodies.
- Minimize the migration of contaminants that could cause adverse effects on other downgradient receptors.

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PRGs for the Off-Site Southern Area Plume contaminated groundwater are provided in Table 3-2. All of the selected PRGs are greater than PQLs.

## TABLE 3-1

## SUMMARY OF ARARs AND TBC CRITERIA
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK


| Requirement | Citation | Status | Synopsis | Comment |
|---|---|---|---|---|
| **Chemical-Specific** | | | | |
| **Federal** | | | | |
| Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs)<br>Secondary MCLs (SMCLs)<br>MCL Goals (MCLGs) | 42 United States Code (USC) 300f et seq.<br>40 Code of Federal Regulations (CFR) Parts 141 to 143 | MCLs are relevant and appropriate; SMCLs and MCLGs are To Be Considered (TBC) | MCLs, SMCLs, and MCLGs established under this act are health-based limits for certain chemical substances in drinking water. | Relevant and appropriate or TBC for determining PRGs. Groundwater was identified as a concern during the investigation. |
| Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) | 33 USC 1251 et seq. Section 304(a)(1) | TBC | AWQC are non-enforceable guidance and are used in conjunction with the designed use for a stream segment to establish water quality standards under CWA Section 304. | During remedial activities, groundwater or treatment by-products may be collected. AWQCs are TBC if this water is discharged to surface waters AWQCs are also TBC for the groundwater from the Off-Site Southern Area Plume that discharges to the Peconic River. |
| Reference Doses (RfDs) from Integrated Risk Information System | NA | TBC | EPA Office of Research and Development guidelines used in the public health assessment. | TBC for determining PRGs. |
| Cancer Slope Factors (CSFs) | NA | TBC | EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group guidelines used in the public health assessment. | TBC for determining PRGs. |
| Risk-Based Concentrations (RBCs) | EPA Region III, October 1998 | TBC | RBCs are screening levels calculated for a target Hazard Quotient of 1.0 for noncarcinogenic effects and a target risk of 1 x $10^{-6}$ for carcinogenic effects. | TBC for determining PRGs. |
| Clean Air Act (CAA) | 42 USC 7401 et seq. | Relevant and Appropriate | Federal legislation that addresses air pollution control. | Pertinent sections of this act are discussed as follows. |
| National Ambient Air Quality Standards (NAAQSs) | 40 CFR Part 50 | Relevant and Appropriate | Non-source-specific limitations for ambient air quality. | Any air emission would require appropriate controls to meet NAAQSs. |
| New Source Performance Standards (NSPSs) | 40 CFR Part 60 | Relevant and Appropriate | Emission standards established for new sources of air emissions. | Relevant and appropriate if the pollutants emitted and the technology employed (e.g., air stripping) during the clean-up action are sufficiently similar to the pollutant and source category regulated by an NSPS and are well suited to the circumstances at the site. |
| National Emission Standards for Hazardous Air Pollutants (NESHAPs) | 40 CFR Part 61 | NA | Emission standards for source types (i.e., industrial categories) that emit hazardous air pollutants. | Not likely to be applicable or relevant and appropriate because NESHAPs were developed for specific sources. |

**SUMMARY OF ARARs AND TBC CRITERIA**
**OFF-SITE SOUTHERN AREA PLUME**
**NWIRP, CALVERTON, NEW YORK**



| Requirement | Citation | Status | Synopsis | Comment |
|---|---|---|---|---|
| **Chemical-Specific (Continued)** | | | | |
| **Federal (Continued)** | | | | |
| Resource Conservation and Recovery Act (RCRA) Subtitle C – Hazardous Waste Identification and Listing Regulations | 40 CFR Part 261 | Applicable | These rules are used to identify a material as a hazardous waste, and thus determine applicability or relevance of RCRA Subtitle C hazardous waste management requirements. | Alternative implementation may involve treatment residuals/wastes which may exceed Toxicity Characteristics Leaching Procedure (TCLP) criteria. If so, management of these residuals/wastes should be conducted in compliance with RCRA requirements |
| Oak Ridge National Laboratory Tier II Surface Water Secondary Chronic Values (SCVs) | NA | TBC | These non-enforceable screening values were developed for evaluating impacts to aquatic organisms from pollutants in surface water | Contaminated groundwater from the Off-Site Southern Area Plume may discharge to the Peconic River. These screening values can be used to evaluate potential impacts to aquatic organisms. The surface water SCVs will be considered during PRG development. |
| Oak Ridge National Laboratory Sediment SCVs | NA | TBC | These non-enforceable screening values were developed for evaluating impacts to benthic invertebrates from pollutants in sediment The sediment SCVs were developed from the surface water SCVs using equilibrium partitioning. | Contaminated groundwater from the Off-Site Southern Area Plume may discharge to the Peconic River. These screening values can be used to evaluate potential impacts to benthic invertebrates The sediment SCVs will be considered during PRG development. |
| National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQUIRTs) | NA | TBC | These non-enforceable screening values were developed for evaluating impacts to aquatic organisms from pollutants in surface water. The screening values are a compilation of existing screening levels from other sources including AWQC. | Contaminated groundwater from the Off-Site Southern Area Plume may discharge to the Peconic River. These screening values can be used to evaluate potential impacts to aquatic organisms. The values will be considered during PRG development. |
| **State** | | | | |
| New York Ambient Air Quality Standards | 6 New York State Code of Rules and Regulations (NYCRR) Parts 256 and 257 | Applicable | Regulations for the control and prevention of air pollutants. The NWIRP site area is classified as Level II. | Particulate and non-methane hydrocarbon standards will be applicable to the site. |
| New York Public Water Supply Regulations | 10 NYCRR Part 5 | Applicable | Drinking water quality standards for New York | Drinking water standards impact selection of groundwater remediation goals, as well as treatment goals for reinjection of treated effluent to the aquifer. |

## TABLE 3-1

## SUMMARY OF ARARs AND TBC CRITERIA
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK


| Requirement | Citation | Status | Synopsis | Comment |
|---|---|---|---|---|
| **Chemical-Specific (Continued)** | | | | |
| **State (Continued)** | | | | |
| New York Water Classifications and Quality Standards | 6 NYCRR Parts 609 and 700 to 705 | Applicable | Regulations for the control and prevention of water pollutants. NWIRP is in Suffolk County with groundwater classified as GA, requiring reinjected groundwater to have a maximum concentration of 1,000 mg/L total dissolved solids (TDS) and 10 mg/L total nitrogen. Provides a compilation of ambient water quality guidance values and groundwater effluent limitations for use when there are no regulatory standards and limitations. | Standards applicable for actions involving the selection of groundwater plume remediation goals as well as treatment goals for reinjection of treated effluent to the aquifer. |
| New York Technical and Operational Guidance Series (TOGS), Division of Water | TOGS 1.1.1 | TBC | Provides a compilation of ambient water quality guidance values and groundwater effluent limitations for use when there are no regulatory standards and limitations. | TBC for actions involving groundwater plume remediation. |
| New York Technical and Administrative Guidance Memorandum (TAGM) 4046 on Determination of Soil Cleanup Objectives and Cleanup Levels | TAGM 4046 | TBC | Provides a basis and procedure to determine soil clean-up levels. Groundwater criteria/standards are included to develop soil clean-up objectives that are protective of groundwater. | Groundwater criteria/standards are TBC if alternative implementation involves groundwater plume remediation. |
| **Location-Specific** | | | | |
| **Federal** | | | | |
| Federal Protection of Wetlands Executive Order | Executive Order (E.O.) 11990 | NA | Requires the action of federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. | Wetlands are located at or adjacent to the Off-Site Southern Area that may be impacted by corrective actions. |
| Endangered Species Act of 1978 | 16 USC 1531<br>50 CFR Part 17 | Potentially Applicable | Requires federal agencies to ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the future existence or critical habitat of any endangered or threatened species. | No endangered or threatened species are known to permanently reside in the vicinity of NWIRP. However, migrating species may occasionally move through the area. |
| Fish and Wildlife Coordination Act | 16 USC 661 | NA | Provides for consideration of the impacts on wetlands and protected habitats. | Wetlands are located at or adjacent to the Off-Site Southern Area that may be impacted by corrective actions. |
| Federal Floodplains Management Executive Order | E.O 11988 | NA | Provides for consideration of floodplains during corrective actions. | Portions of the Off-Site Southern Area are within the 100-year floodplain of the Peconic River. |
| Archaeological and Historic Preservation Act | 16 USC 469<br>36 CFR 65 | Potentially Applicable | Prior to site activities as well as during excavation, actions must be taken to identify, recover, and preserve artifacts. | No historic artifacts are expected to be uncovered in the vicinity of the Off-Site Southern Area; however, artifacts may be discovered during site work. |

## TABLE 3-1

## SUMMARY OF ARARs AND TBC CRITERIA
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK



| Requirement | Citation | Status | Synopsis | Comment |
|---|---|---|---|---|
| **Location-Specific (Continued)** | | | | |
| **State** | | | | |
| New York Freshwater Wetlands Act and New York Freshwater Wetlands Regulations | Environmental Conservation Law (ECL) Article 24 and Title 23 of Article 71 6 NYCRR Parts 662 to 664 | Potentially Applicable | Activities within or adjacent to State-regulated wetlands requires a permit or letter of approval. Adjacent area is considered the area within 100 feet of the wetlands. | Wetlands are located at or adjacent to the Off-Site Southern Area that may be impacted by corrective actions. |
| New York Endangered and Threatened Species of Fish and Wildlife, Species of Special Concern | 6 NYCRR Part 182 | Potentially Applicable | A permit or license is required to take, import, transport, possess, or sell any endangered or threatened species. | A State endangered species has been confirmed at NWIRP, although not at the Off-Site Southern Area. |
| Regulation for Administration and Management of the Wild Scenic and Recreational Rivers System in New York State Excepting Adirondack Park | 6 NYCRR Part 666 | Potentially Applicable | Certain kinds of activities and developments within the defined river corridor are restricted or require a permit. | The Peconic River and some of its tributaries are classified as a Scenic River Corrective measures for the Off-Site Southern Area may affect the Peconic River. |
| Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Site Guidance | Division of Fish and Wildlife, NYSDEC July 18, 1991 | TBC | Provides guidance for the evaluation of fish and wildlife concerns associated with the remediation of inactive hazardous waste sites. | Considered during the evaluation of corrective measure alternatives |
| **Action-Specific** | | | | |
| **Federal** | | | | |
| RCRA Subtitle C | 42 USC 6921 et seq. | Potentially Applicable | Establishes design and operating criteria for hazardous waste landfills | Potentially applicable if waste is determined to be hazardous. |
| Identification and Listing of Hazardous Waste | 40 CFR Part 261 | Potentially Applicable | Regulations that govern the procedures for identifying if a material is a hazardous waste. | Specific materials at the site may be classifiable as listed hazardous waste. |
| RCRA Standards Applicable to Generators of Hazardous Waste | 40 CFR Part 262 | Potentially Applicable | Regulations with which a generator that treats, stores, or disposes of hazardous waste on site must comply. | Applicable for removed wastes determined to be hazardous. |
| Standards Applicable to Transporters of Hazardous Waste | 40 CFR Part 263 | Potentially Applicable | Regulations for the manifest and record keeping systems and for the immediate action and clean-up of hazardous waste discharges (spills) during transportation. | Applicable for removed wastes determined to be hazardous that are transported off site. |
| Standards and Interim Standards for Owner's and Operators of Hazardous Waste Treatment Storage, and Disposal (TSD) Facilities | 40 CFR Part 264 and 265 | Potentially Applicable | Regulations that govern the treatment, storage, and disposal of hazardous waste. | These regulations would be applicable to waste removed from the site including both on-site and off-site management. |
| Land Disposal Restrictions (LDRs) | 40 CFR Part 268 | Potentially Applicable | Regulations that govern the treatment and disposal of certain hazardous waste. | Treatment or disposal of wastes and/or treatment residuals may be considered hazardous waste subject to LDRs. |

# TABLE 3-1

## SUMMARY OF ARARs AND TBC CRITERIA
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK


| Requirement | Citation | Status | Synopsis | Comment |
|---|---|---|---|---|
| **Action-Specific (Continued)** | | | | |
| **Federal (Continued)** | | | | |
| Corrective Action Management Units and Temporary Units (CAMU), Final Rule | 40 CFR Parts 260, 264,265,268,270, and 271 | Potentially Applicable | CAMU-designated areas qualify for certain exemptions from RCRA Subtitle C requirements. Particularly, remediation wastes can be moved between sites within the designated area and can be treated and replaced without triggering LDRs. | Site work at NWIRP may involve the use of CAMUs. |
| RCRA Subtitle D | 40 USC 6941 et seq. | Potentially Applicable | Establishes design and operating criteria for solid waste (non-hazardous) landfills. | Potentially applicable if wastes and/or treatment residuals are determined to be nonhazardous |
| Department of Transportation (DOT) Rules for Hazardous Materials Transport | 49 CFR Parts 107 and 171 to 179 | Potentially Applicable | Regulations for the transportation of hazardous materials. Requirements cover packaging, marking, labeling, and transportation methods. | Off-site shipments of any wastes/treatment residuals that are classified as a hazardous material from this site would have to comply with these regulations. |
| National Environmental Policy Act (NEPA) | 42 USC 4321<br>40 CFR Part 6 | Potentially Applicable | Requires federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit, or implement. | Alternatives could constitute significant activities, thereby making NEPA requirements Applicable or Relevant and Appropriate Requirements (ARARs). |
| CWA – National Pollution Discharge Elimination System (NPDES) | 40 CFR Part 122 | Potentially Applicable | Regulations for discharge, dredge, or fill materials and oil or hazardous waste spills into United States waters | These requirements are applicable for all alternatives that include a discharge to surface water. |
| Control of Air Emission from Superfund Air Strippers at Superfund Sites | Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-28 | TBC | Guidelines for control of air emissions from air strippers at Superfund groundwater remediation sites. | Restoration at the Off-Site Southern Area may include air stripping of groundwater, and the site is in an NAAQS ozone non-attainment area. |
| General Pretreatment Regulations for Existing and New Sources of Pollutants | 40 CFR Part 403 | Potentially Applicable | Regulations for pretreatment of contaminated water prior to discharge to a publicly-owned treatment works (POTW). | Effluent from a groundwater treatment system at the Off-Site Southern Area may be discharged to a local POTW. |
| Underground Injection Control Program | 40 CFR Parts 144 and 147 | Potentially Applicable | Regulations for the control and prevention of pollutants injection into groundwater. | Effluent from treatment of groundwater may be reinjected (Class IV well) into the same formation from which it was withdrawn. |
| Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites | OSWER Directive 9200.4-17P | TBC | Guidelines for use of monitored natural attenuation for the remediation of contaminated soil and groundwater sites. | TBC if monitored natural attenuation is one of the selected corrective actions. |
| Occupational Health and Safety Act (OSHA) | 29 USC Sections 651 through 678 | Potentially Applicable | Regulates worker health and safety during implementation of remedial actions. | Applicable for site workers during all investigations and corrective actions at the Off-Site Southern Area |
| **State** | | | | |
| New York Air Pollution Control Regulations | 6 NYCRR Parts 200 to 257 | Potentially Applicable | Regulations for the control and prevention of air pollutants. | Remedial activities (air stripping) may adversely impact air quality |
| New York Waste Management Facilities Rules | 6 NYCRR Part 360 | Potentially Applicable | Provides standards for solid waste management facilities, including closure requirements. | Remedial activities may need to consider standards for solid waste management facilities |

# TABLE 3-1

## SUMMARY OF ARARs AND TBC CRITERIA
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK



| Requirement | Citation | Status | Synopsis | Comment |
|---|---|---|---|---|
| **Action-Specific (Continued)** | | | | |
| **State (Continued)** | | | | |
| New York Rules for Siting Industrial Hazardous Waste Facilities | 6 NYCRR Part 361 | Potentially Applicable | Provides evaluation criteria for siting new industrial hazardous waste facilities. | Remedial alternatives may need to consider criteria for industrial hazardous waste facilities. |
| New York Waste Transport Permit Regulations | 6 NYCRR Part 364 | Applicable | Regulates off-site transport of wastes. | Transport of wastes and/or treatment residuals need to comply with these regulations. |
| New York General Hazardous Waste Management System | 6 NYCRR Part 370 | Potentially Applicable | Regulations that govern the management of hazardous waste. | Residuals from treatment could be considered as hazardous waste subject to these regulations. |
| New York Identification and Listing of Hazardous Wastes | 6 NYCRR Part 371 | Potentially Applicable | Regulations that govern the procedures for identifying a material as a hazardous waste. | Specific materials at the site may be classifiable as listed hazardous wastes or may test to be characteristic hazardous wastes. |
| New York Hazardous Waste Manifest System | 6 NYCRR Part 372 | Potentially Applicable | Regulations that govern the procedures for manifesting a material that is a hazardous waste. | Transport of wastes and/or treatment residuals need to comply with these regulations |
| New York Hazardous Waste Management Facilities | 6 NYCRR Part 373 | Potentially Applicable | Regulations that govern the treatment, storage, and disposal of hazardous waste. | Treatment and/or storage activities may take place on site. Site remediation activities must meet both administrative and substantive technical permitting requirements. |
| New York Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities | 6 NYCRR Part 374-1 | Potentially Applicable | Regulations that govern the management of specific hazardous wastes. | Although unlikely, NWIRP site remedial alternatives may include product recovery. |
| New York Rules for Inactive Hazardous Waste Sites | 6 NYCRR Part 375 | Potentially Applicable | Requires State review and concurrence of the selected remediation scheme. The hierarchy of remedial technologies is as follows. (1) destruction, (2) separation/ treatment, (3) solidification/chemical fixation, and (4) control and isolation | Off-Site Southern Area work should comply with these regulations. |
| New York Land Disposal Restrictions | 6 NYCRR Part 376 | Potentially Applicable | Regulations that govern the treatment and disposal of certain hazardous waste. | Contaminated wastes and/or treatment residuals may be considered hazardous waste subject to LDRs |
| New York Rules on Hazardous Waste Program Fees | 6 NYCRR Parts 483 | Potentially Applicable | State hazardous waste program fees related to remedial actions. | Waste transporter program fees will be required for offsite disposal of wastes or treatment residuals. |
| New York Water Classifications and Quality Standards | 6 NYCRR Parts 609 and 700 to 706 | Potentially Applicable | Regulations for the control and prevention of water pollutants. NWIRP site groundwater is classified as Class GA. Surface water in the Peconic River is classified as Class C. | Standards applicable for actions involving the selection of groundwater plume remediation goals as well as treatment goals for reinjection of treated effluent to the aquifer. |
| New York State Pollutant Discharge Elimination System (SPDES) | 6 NYCRR Parts 750 to 758 | Potentially Applicable | Regulations for the control of wastewater and storm water discharges in accordance with the CWA and controls of point source discharges. | Permits (SPDES or NPDES) would be required for discharges to surface water. |

## TABLE 3-1

## SUMMARY OF ARARs AND TBC CRITERIA
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK


| Requirement | Citation | Status | Synopsis | Comment |
|---|---|---|---|---|
| **Action-Specific (Continued)** | | | | |
| **State (Continued)** | | | | |
| New York Proposed SPDES | Proposed Subpart 750-1 and 750-2 | TBC | Proposed regulation for the control of wastewater and storm water discharges in accordance with the CWA and controls of point source discharges to groundwater as well as surface water. Once adopted, current Parts 750 to 758 will be repealed. | TBC as a proposed regulation, which may be in place prior to implementation of alternative. Treatment goals for discharge or reinjection of treated effluent. |

NA = Not applicable.

TABLE 3-2

**OVERALL ARAR- AND TBC-BASED STANDARDS FOR POTENTIAL GROUNDWATER CONTAMINANTS OF CONCERN (µg/L)**
**OFF-SITE SOUTHERN AREA PLUME**
**NWIRP CALVERTON, NEW YORK**

| Parameter | Maximum Detection | PQL | Minimum Standards/Guidance | | | PRG[4] |
|---|---|---|---|---|---|---|
| | | | Groundwater[1] | Surface Water - Human Health[2] | Surface Water -Ecological[3] | |
| **Volatile Organic Compounds** | | | | | | |
| 1,1,1-Trichloroethane | 24 | 0.5 | 5 | NA | 11 | 5 |
| 1,1,2-Trichloroethane | 1.9 | 0.5 | 1 | 480 | 1200 | 1 |
| 1,1-Dichloroethane | 292 | 0.5 | 5 | NA | 47 | 5 |
| 1,1-Dichloroethene | 21.7 | 0.5 | 5 | 213,000 | 25 | 5 |
| 1,2-Dichloroethane | 1.6 | 0.5 | 0.6 | 1110 | 910 | 0.6 |
| Benzene | 1.4 | 0.5 | 1 | 300 | 130 | 1 |
| Chloroethane | 7.9 | 0.5 | 5 | NA | NA | 5 |
| Toluene | 10.1 | 0.5 | 5 | 180000 | 9.8 | 5 |
| Total Xylenes | 18.4 | 0.5 | 5 | NA | 1.8 | 5 |

NA - Not available.
PQL - Practical quantitation limit.
1 - See Table 2-3.
2 - See Table 2-4.
3 - See Table 2-5.
4 - The most stringent promulgated standard (federal MCL, New York State MCL, and Groundwater Quality Standard) was selected as the groundwater PRG.

# 4.0 IDENTIFICATION AND SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

## 4.1 IDENTIFICATION AND PRELIMINARY SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

This section provides an initial identification and preliminary screening of Corrective Measures Technologies for groundwater in the Off-Site Southern Area. The preliminary screening of technologies is conducted to eliminate those technologies that clearly would not apply to the site. Section 4.2 presents a more detailed identification and screening of technologies passing the preliminary screening.

The preliminary screening of technologies is based on their overall applicability (technical implementability) to the medium (groundwater), primary contaminants (chlorinated solvents and BTEX), and conditions present in the Off-Site Southern Area (shallow, high-yield aquifer and sandy soils). The purpose of this screening effort is to investigate all available technologies and process options and to eliminate those obviously not applicable for the site based on the established CAOs and a comparison of the concentrations of contaminants detected at the site to PRGs.

### 4.1.1 Groundwater

Initial screening of groundwater technologies, including screening comments, is presented in Table 4-1. The following factors were considered during the screening to determine the appropriate technologies required to address groundwater in the Off-Site Southern Area:

- The water table aquifer is contaminated at the site, and it consists of fine to medium sand and is approximately 120 feet thick. Most contamination is present at 50 to 80 feet below the water table. A clay layer is present at the bottom of the aquifer (approximately 130 feet bgs) that limits the overall vertical migration of contamination. Groundwater flow near the Peconic River is upward toward the river.

- Maximum concentrations of COCs in the Off-Site Southern Area Plume ranged from 1.4 µg/L (benzene) to 292 µg/L (1,1-dichloroethane). Most of the contaminants detected at concentrations greater than groundwater standards were detected in samples collected near the Pistol Range Area at the Peconic River Sportsman Club and Connecticut Avenue.

The groundwater technologies retained from this preliminary screening are summarized in Table 4-2.

## 4.2 SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

The technologies retained in the initial screening are briefly evaluated in this section. Technologies that are retained for a site will be evaluated in the detailed analysis section for the site. The evaluation of technologies utilizes three criteria: effectiveness, implementability, and relative cost, which are defined as follows:

- Effectiveness - This criterion focuses on the potential effectiveness of process options in protecting human health and the environment and in meeting the CAOs. This criterion considers potential impacts to human health and the environment during construction and implementation and how proven and reliable the process is with respect to the contaminants and conditions at the site.

- Implementability - Implementability is a measure of both the technical and administrative feasibility of implementing a technology. It provides a means of evaluating the ability of a technology to be adapted to site-specific conditions. Technical feasibility includes consideration of construction and operational issues, demonstrated performance, and adaptability to site conditions. Administrative feasibility considerations include the ability to obtain any necessary permits or easements or adherence to applicable non-environmental laws and concerns of other regulatory agencies. General availability of necessary equipment and resources is also evaluated.

- Cost - Cost evaluations allow a relative comparison between similar technologies. Cost plays a limited role in technology screening. The cost analysis is based on engineering judgement, and each technology is evaluated as to whether costs are high, low, or medium relative to the other options in the same technology type. If there is only one process option, costs are compared to other candidate technologies.

One representative process option is selected, if possible, for each technology type, to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design.

### 4.2.1 Corrective Measures Technologies for Groundwater

The following general actions for groundwater are discussed below:

- No action
- Limited Action
- Removal
- Disposal

- Ex-Situ Treatment
- In-Situ Treatment

#### 4.2.1.1 No Action

No action consists of allowing the groundwater to remain in its current status. Under this condition, the contamination in the groundwater will remain at original concentrations, and any reduction will be due to natural attenuating factors such as dilution, dispersion, biodegradation, adsorption, infiltration, etc.

**Effectiveness:** The no-action scenario would not achieve remediation goals for groundwater at the Off-Site Southern Area Plume. Under this scenario, groundwater with contaminant concentrations greater than the PRGs would remain for a long time. Groundwater would continue to discharge to the Peconic River and potentially impact ecological receptors in the river. The effectiveness of any natural reduction in contaminant concentrations would be unknown because no monitoring would be conducted. Without restrictions, groundwater could be used as a potable water supply.

**Implementability:** Because there would be no activity, there would be no implementability considerations associated with the no-action scenario.

**Cost:** Because no action would be taken, there would be no costs associated with this option.

**Conclusion:** No action is retained to provide a baseline for comparison with other alternatives.

#### 4.2.1.2 Limited Action

Limited action for groundwater includes institutional controls (deed notifications), monitoring, and natural attenuation. Deed notifications are institutional controls used to restrict future activities such as placement of new wells or construction on privately owned property. An alternative water supply should not need to be provided because the contaminated groundwater is not used as a drinking water source. According to Suffolk County, there are no potable water wells in the area. Groundwater monitoring would be used to determine groundwater contaminant trends and the extent of contaminant migration. Monitoring (groundwater/surface water) can also be used to monitor the progress of groundwater remediation and natural attenuation processes. Natural attenuation refers to inherent processes that affect the rate of migration and the concentrations of contaminants. The most important processes are biodegradation, advection, hydrodynamic dispersion, dilution from recharge, sorption, and volatilization.

**Effectiveness:** Institutional controls would allow contamination present in groundwater to remain at the site. Deed notifications could be used to ensure that no drinking water wells would be installed to extract contaminated groundwater, thereby reducing the potential risk to human health associated with ingestion/inhalation of contaminated groundwater. However, this type of restriction, over the long term, may not be reliable and is difficult to enforce especially when the site is not under government control. Groundwater monitoring would not provide any additional protection of the environment because contaminated groundwater would continue to spread into uncontaminated or lesser-contaminated areas. Groundwater would also continue to discharge to the Peconic River and potentially impact ecological receptors in the river. Groundwater monitoring would be used to evaluate contaminant trends and plume expansion. Groundwater and surface water monitoring would also be helpful in measuring and evaluating the effectiveness of groundwater remediation and natural attenuation processes. Natural attenuation is effective if the rate of biodegradation, aided by sorption and dilution, is rapid enough to prevent significant migration by advection and dispersion. The effectiveness of natural attenuation would be improved if any remaining contaminant sources (e.g., Sites 6A and 10B) are addressed. Monitoring is a key component in confirming the effectiveness of any groundwater alternative.

**Implementability:** Institutional controls are readily implementable for contaminated groundwater because only administrative action and limited remedial activities would be required. Deed notifications could be implemented by the Navy but would require negotiations with the current land owners of the Off-Site Southern Area. The area is currently owned by the Peconic River Sportsman Club and the State of New York. Limited equipment and personnel would be required for groundwater monitoring. Local and State permits may be required for monitoring well installation. Monitoring of natural attenuation would be readily implementable; however, monitoring would be required for an extended period of time (possibly greater than 30 years) until PRGs are reached.

**Cost:** Costs of implementing institutional controls are low, and costs of implementing monitoring and natural attenuation are low to moderate.

**Conclusion:** Institutional controls (deed notifications), monitoring, and natural attenuation will be retained to be used alone or in combination with other process options for groundwater at the Off-Site Southern Area. There are no off-site users of groundwater as a drinking water source; therefore, an alternative water supply does not need to be provided, and this option will not be retained for further evaluation. Institutional controls would not prevent continued contaminant migration in the groundwater or groundwater discharge to the Peconic River; however, most of the site contaminants will naturally attenuate, and monitoring would determine whether contaminants are continuing to migrate and potentially impacting the Peconic River. Chlorinated solvents may continue to migrate because they would be less likely to biodegrade. The overall effectiveness of natural attenuation will be improved if the on-site sources of groundwater contamination (e.g., Sites 6A and 10B) are addressed.

#### 4.2.1.3 Removal

Contaminated groundwater can be extracted using extraction wells. Due to the depth of the contaminated groundwater (approximate maximum depth of 90 feet bgs), extraction wells would be well suited for the Off-Site Southern Area Plume. For the extraction option, a series of pumping wells would be completed in the overburden aquifer and used to capture contaminated groundwater for treatment. The wells used in the capture system would be designed and located to provide optimum efficiency in capturing contaminated groundwater while minimizing the collection of uncontaminated groundwater. The extraction system can be designed for hydraulic control to contain the contaminated groundwater plume from migrating further downgradient or to remediate the contaminated groundwater plume.

The extraction option involves the active manipulation and management of groundwater to contain or remove a plume. The selection of the appropriate well system depends on the depth of contamination and the hydrologic and geologic characteristics of the aquifer. Well systems are very versatile and can be used to contain, remove, divert, or prevent development of plumes under a variety of site conditions.

**Effectiveness:** The effectiveness of an extraction well system depends largely on the type and extent of contamination and the geology and hydrogeology of the site. For this site, extraction wells should effectively control the migration of contaminants and remove the contaminated groundwater for subsequent treatment and/or disposal. More mobile chemicals will be more readily removed than less mobile chemicals. The use of wells to extract contaminated groundwater should eventually attain the PRGs. The time required to reach PRGs would decrease if on-site groundwater contaminant sources are addressed. The technology is reliable, and minimal effects on human health are expected. If high pumping rates are required to contain or remediate the plume, it is possible that the extraction system could negatively impact (dewater) wetlands, ponds, and the Peconic River in the Off-Site Southern Area and the ecological receptors that live in these water bodies. Reduced pumping rates would minimize the impacts to surrounding surface water bodies and ecological receptors, but they would also reduce the effectiveness of the extraction system for plume treatment/containment.

**Implementability:** Groundwater extraction through a pumping well system can be readily implemented. The technology uses readily available equipment and techniques and has proven to be effective in similar situations. Implementation of this technology would require long-term operation and maintenance (O&M). Maintenance may require periodic replacement of mechanical components and well cleaning/flushing to remove iron scaling and fine-grained material that may clog the wells. Local and State permits may be required for installation of extraction wells. Extracted groundwater would require treatment prior to disposal. Potential impacts of the extraction system on the surrounding wetlands, ponds, and Peconic River would need to be considered prior to implementing the system.

**Cost:** Costs for installing a groundwater extraction system are low to moderate, but costs for O&M of the system can be moderate to high depending on the size of the system and the duration of pumping.

**Conclusion:** Groundwater extraction is retained for consideration for groundwater in the Off-Site Southern Area Plume. Groundwater extraction of the Off-Site Southern Area Plume would be completed to gain hydraulic control and prevent the contaminated groundwater plume from migrating to the Peconic River and to remediate the contaminated groundwater plume. Potential negative impacts of the extraction system on wetlands, ponds, and the Peconic River in the Off-Site Southern Area need to be considered.

#### 4.2.1.4 Disposal

The direct discharge and reinjection options were retained for disposal of extracted groundwater during the initial technology screening. Direct discharge involves disposing of treated groundwater to a local surface water body. The Peconic River, which is located along the southeastern boundary of the Off-Site Southern Area, would be the likely receiving surface water body. Reinjection consists of disposing of treated groundwater in the original aquifer from which it was removed. Based on the relatively shallow groundwater table at the site, infiltration galleries would be the best option. Reinjection may be used to increase contaminant removal by creating artificial hydraulic gradients that direct groundwater toward extraction wells. Reinjection can be coupled with extraction wells to balance pumping and injection rates.

**Effectiveness:** Direct discharge may be an effective means for disposing of the volumes of water generated by a groundwater pumping/treatment system; however, surface water flow rates in the Peconic River would need to be determined to ensure that the effluent discharge rate did not negatively impact the river. If it was determined that all of the effluent could not be discharged to the river, then a combination of direct discharge and reinjection could be used for disposal of the treated groundwater.

Reinjection via infiltration galleries is an effective means of disposing of the volumes of water generated by a groundwater pumping/treatment system. Infiltration galleries offer the advantage of decreasing groundwater remediation time by increasing groundwater flow through the aquifer. The vertical infiltration of treated groundwater through the vadose zone will create elevated groundwater conditions (i.e., groundwater mounding) in the vicinity of the infiltration gallery. The effectiveness of reinjection depends on hydraulic conductivity, aquifer thickness, and hydraulic gradient/aquifer recharge rate.

Both methods of disposal would require treatment of the water to meet PRGs. The use of either method would avoid transporting and disposing of the groundwater off site.

**Implementability:** Installation of a direct discharge system for disposal in a surface water body and an infiltration gallery system for underground injection are implementable using established procedures. Vendors and equipment for installation are commercially available.

Direct discharge of effluent to the Peconic River could have detrimental impacts to the flood potential, water quality, and ecological receptors. Direct discharge of the effluent into the Peconic River would require State and local permits. The permits would set limitations on contaminant concentrations, water quality, and flow rates of treated water. The PRGs would need to be achieved prior to direct discharge. The permits may be difficult to obtain because the State of New York has designated the Peconic River as a Scenic River, and sensitive ecological receptors are present in the river.

Reinjected water could potentially force contaminated groundwater into less-contaminated areas. The groundwater extraction system should be designed so that it adequately captures the contaminated groundwater. Periodic groundwater monitoring would be needed to assess the impacts of reinjection. The extracted groundwater would require treatment to PRGs prior to reinjection. Reinjection of water into the aquifer may require State and local permits. The permits would set limitations on contaminant concentrations and possible flow rates of treated water. The permits should be obtainable provided that PRGs are achieved prior to reinjection.

**Cost:** Costs for construction and O&M of a direct discharge system would be low, and the costs for a reinjection system (infiltration gallery) would be low to moderate.

**Conclusion:** Direct discharge and reinjection (infiltration gallery) will both be retained for consideration for disposal of treated groundwater from the Off-Site Southern Area Plume. The processes can be used separately or in combination depending on the disposal requirements. These processes will be used in combination with other technologies such as extraction and ex-situ treatment.

#### 4.2.1.5 Ex-Situ Treatment

Ex-situ treatment consists of the use of technologies for treatment of groundwater after extraction. Air stripping was determined to be the best primary process option for the COCs in groundwater at the site after the initial screening of technologies. Adsorption using activated carbon would also be a treatment option for the groundwater COCs. A treatability study would be required to determine the best use of the two technologies. Other processes such as dewatering, equalization, filtration, flotation, clarification, neutralization, flocculation, and precipitation would be secondary process options that could be used as necessary, depending on site conditions, with air stripping or adsorption to enhance the effectiveness of the treatment system. The processes applicable for treatment of site-specific groundwater contamination will be assembled into a treatment system in the detailed analysis. These technologies may also be appropriate for treatment of water removed during dewatering activities.

Air Stripping

Air stripping is a mass transfer process in which volatile contaminants (compounds with Henry's Law constants greater than $3.0 \times 10^{-3}$ atm-m$^3$/mol) in water or soil are transferred to gas. There are five basic equipment configurations used to airstrip liquids: packed columns, cross-flow towers, coke tray aerators, diffused air basins, and mixing jets.

Air stripping is frequently accomplished in a packed tower equipped with an air blower. The packed tower works on the principle of countercurrent flow. The water stream flows down through the packing while the air flows upward and is exhausted through the top of the tower. Volatile, soluble components have an affinity for the gas phase and tend to leave the aqueous stream for the gas phase. In the cross-flow tower, water flows down through the packing as in the countercurrent packed column; however, the air is pulled across the water flow path by a fan. The coke tray aerator is a simple, low-maintenance process requiring no blower. The water being treated is allowed to trickle through several layers of trays. This produces a large surface area for gas transfer. Diffused aeration stripping and induced draft stripping use aeration basins similar to wastewater treatment aeration basins. Water flows through the basin from top to bottom or from one side to another with the air dispersed through diffusers at the bottom of the basin. The air-to-water ratio is significantly lower than in either the packed column or the cross-flow tower. Mixing jet systems involve high-intensity mixing of pressurized air and water. The air-to-water flow ratio, temperature of the water, and height of packing may be adjusted to achieve adequate removal of VOCs to meet discharge standards. Typically, pretreatment for removal of suspended solids, inorganics, and scaling constituents would be required for air stripping.

**Effectivenes:** Air stripping is a well proven and reliable technology that would be effective for removing VOCs from groundwater. Removal efficiencies greater than 99 percent can theoretically be achieved for the VOCs. A treatability study would be required to confirm the effectiveness of air stripping. Because air stripping only removes contaminants from water and concentrates them in the off-gas, the off-gas may have to be treated by other means such as granular activated carbon adsorption, catalytic oxidation, or thermal destruction. The need and type of off-gas treatment depends on the specific contaminants and their concentrations. Each of the noted off-gas treatment technologies should be effective for the contaminants in groundwater at the Off-Site Southern Area.

**Implementability:** Air stripping would be readily implementable at the site. Vendors that provide air-stripping technology are readily available. In order to meet State Ambient Air Quality Standards, control of off-gas emissions and an air permit may be required. Construction permits may also be required. Both permits should be obtainable, but the air permit may be difficult to obtain.

A maintenance problem associated with air stripping is the channeling of flow resulting from clogging in packing material. Common causes of clogging include high concentrations of oils, suspended solids, iron, and slightly soluble salts such as calcium carbonate. Pretreatment of contaminated groundwater would be required prior to air stripping to remove such materials.

**Cost:** Costs are low to moderate for air stripping and will depend on influent contaminant concentrations, the degree of removal required, and the type of off-gas treatment required.

**Conclusion:** Air stripping is retained for treatment of groundwater extracted from the Off-Site Southern Area Plume.

<u>Activated Carbon Adsorption</u>

A large variety of organic contaminants and some inorganic ionic species commonly found in groundwater are amenable to removal by adsorption onto activated carbon. Contaminants adsorb to the internal pore surfaces of activated carbon particles as the contaminated water passes through a column of the activated carbon. When the available surface area of the activated carbon particles is occupied, the column must be replaced by fresh activated carbon. The exhausted carbon must then be either regenerated or disposed according to federal or State regulations. Removal efficiency exceeding 99 percent is possible depending on the type of organic solute and system operating parameters such as retention time and carbon replacement frequency.

Among organic contaminants, long-chain, low solubility, less polar compounds have a greater affinity for adsorption than others. The adsorption of organic acids is favored by low pH conditions in the water, whereas that of organic bases is favored by high pH conditions.

The presence of high levels of suspended solids can clog the flow of water through the column. The presence of organic free product can hinder the adsorption of target dissolved contaminants by coating the surfaces and exhausting the column quickly. Because of the nonselective nature of this technology, the presence of naturally occurring organic substances can significantly increase the consumption rate of activated carbon.

Typical activated carbon adsorption treatment systems include gravity flow or pressure flow columns in series and/or parallel configuration some with backwashing capability. Granular activated carbon (GAC) is generally used in these systems. Common flow rates range from 0.5 to 5.0 gallons per minute (gpm) per square feet ($ft^2$). Factors such as pH and temperature of the influent, empty bed contact time (EBCT), surface area/volume ratio of the activated carbon, and solubilities of the organic compounds will affect the carbon adsorption process.

**Effectiveness:** Carbon adsorption is a well-proven, reliable technology; however, it is not very effective for the primary chlorinated solvent at the site (e.g., dichloroethane). Generally, the most effective application of carbon adsorption would be for dilute concentrations of organics that result in relatively low carbon consumption. Removal efficiencies exceeding 99 percent, with nondetected organics in effluents, are commonly achievable. Spent carbon containing the removed organic contaminants would have to be regenerated or disposed in a hazardous waste landfill.

**Implementability:** Carbon adsorption would be readily implementable. There are a sufficient number of vendors that provide carbon adsorption units. Construction permits may also be required. These permits should be obtainable.

Pretreatment may be required if the influent has a suspended solids concentration greater than 15 mg/L, an oil and grease concentration greater than 10 mg/L, or a calcium or magnesium concentration greater than 500 mg/L to prevent clogging and large pressure drops.

Implementation factors include planning for disposal or regeneration of the spent carbon. Thermal, steam, and solvent treatments are the most common types of regeneration technologies, which are typically conducted off site.

**Cost:** Costs are low to moderate, depending on the carbon usage rate, which is a function of influent contaminant concentrations.

**Conclusion:** Carbon adsorption is a viable technology for treating some of the site organics. It is retained for further consideration in combination with air stripping for treatment of groundwater extracted from the Off-Site Southern Area Plume.

#### 4.2.1.6 In-Situ Treatment

In-situ treatment involves the remediation of groundwater within an aquifer with no or limited extraction and injection. The primary technologies that passed the initial screening were air sparging and biological treatment.

Air Sparging

In-situ air sparging consists of injection of contaminant-free air into the saturated zone within the contaminated plume. The injected air bubbles disperse within the saturated zone and contact the contaminants. In this process, the VOCs adsorbed on the soil particles and dissolved in the water are volatilized, like an in-situ air stripping process. The VOCs are then carried into the vadose zone by the air phase, within the radius of influence of an operating vapor extraction system.

Air sparging is often used in combination with SVE and bioventing. With this technology, the removal of contaminants is achieved by air stripping/biodegradation of VOCs. Most solvents and petroleum hydrocarbon contaminants are amenable to removal from the saturated zone using this technology. Air stripping and biodegradation of contaminants can occur simultaneously in groundwater as well as in saturated zone soils.

**Effectiveness.** Air sparging should be effective for the volatile contaminants (chlorinated solvents, BTEX, and other VOCs) detected in groundwater in the Off-Site Southern Area Plume. However, its effectiveness may be reduced because of the depth of the contaminant plume (50 to 80 feet below the water table). Due to size of the plume (92 acres) air sparging would not be effective for active remediation of the entire plume. A more effective use of the technology would be to create an air sparge curtain to contain and treat the contaminated groundwater as it migrates downgradient. Removal of volatile contaminants from the aquifer would be by volatilization, whereas removal of any remaining organics would be by volatilization and/or biodegradation. Air sparging is a proven technology; however, treatability work would be required. In combination with SVE, it should be very reliable and there should not be any significant risks to human health and the environment. Without SVE, contaminant vapors may migrate to the ground surface and discharge to the atmosphere at unacceptable levels or migrate laterally to adjacent buildings, which may result in risks to human health and the environment. Air sparging may cause groundwater mounding in the treatment area and result in gradients that cause contamination to migrate in new directions. Groundwater monitoring would be required to track contaminant migration.

**Implementability:** Air sparging would be implementable at the Off-Site Southern Area. Permits should not be required for the air sparging component. It is unlikely that an SVE system would be required because of the relatively low concentrations of contaminants. Vendors are available to perform this work. The depth of the contaminant plume may reduce the implementability of air sparging. In addition, the width of the contaminant plume (approximately 2,000 feet) and the roadways in the vicinity may create some implementation issues.

**Cost:** The costs associated with air sparging are low to moderate depending on the size of the system and the duration that the system is operational.

**Conclusion:** Air sparging (air sparge curtain) will be retained for further consideration for the Off-Site Southern Area Plume. The need for SVE and air monitoring will be evaluated.

In-Situ Biological Treatment

In-situ bioremediation is the process by which microorganisms biologically degrade organic compounds to less harmful degradation products such as carbon dioxide, methane, and water. This process is conducted in the subsurface by providing indigenous microorganisms optimum conditions for growth, such as controlled pH and nutrient feed. In-situ bioremediation is generally not applicable to sites with free product or high contaminant concentrations.

Biodegradation can be conducted under aerobic conditions by supplying a sufficient source of oxygen or under anaerobic conditions by removing oxygen from the subsurface. The conditions chosen (i.e., aerobic or anaerobic) are dependent on the chemical compounds to be remediated and ease of implementation. BTEX compounds are known to be more susceptible to aerobic biodegradation, and chlorinated solvents generally degrade better under anaerobic biodegradation. Incomplete anaerobic biodegradation of chlorinated compounds can lead to the formation of intermediate compounds that are more toxic. Biodegradation may also cause sorbed phase contaminants to become mobile and in the short-term result in higher dissolved phase concentrations and potential for downgradient migration. Anaerobic bioremediation can cause iron to be mobilized, which can impact downgradient water quality issues (primarily aesthetic). It can also generate methane gas.

The following parameters can aid in evaluating the effectiveness and implementability of in-situ treatment:

- Hydrology/aquifer characteristics.
- Geochemical/water quality conditions.
- Nature of contaminants.
- Presence of biodegradable compounds (measured by oxygen demand for oxidation), nutrients (nitrogen and phosphorus), micronutrients (trace metals, salts, sulfur), calcium and TDS.
- Composition and activity of native microbial communities.

Aerobic Bioremediation

Aerobic bioremediation involves stimulation of indigenous aerobic microflora in the subsurface to enhance the biodegradation of contaminants by providing a supply of oxygen and nutrients. In some cases, a cometabolite or an additional carbon source is necessary to achieve biodegradation. Oxygen may be provided in the form of air, pure oxygen, hydrogen peroxide, or oxygen-release compound (ORC®). The oxygen may either be added to extracted groundwater prior to reinjection, directly bubbled in through spargers (air sparging), or supplied by in-line injection of pure oxygen. The use of hydrogen peroxide leads to certain advantages such as a greater supply of oxygen and control of biofouling of the wells.

Nutrients such as nitrogen and phosphate are essential for microorganisms and may be present in limited concentrations in the subsurface. The forms of nitrogen and phosphorus are not critical. However, the decision to add salts as nutrients must be based not only on laboratory tests for microbes, but also on potential interaction with the site geochemistry. Certain nutrients such as phosphates could result in the precipitation of calcium phosphate, which may clog pores and reduce the permeability of the subsurface. If the contamination is relatively low, it may be necessary to add an additional carbon source to support sufficient bacterial growth. The selection of this additional carbon source is critical. The compound selected must not be preferentially biodegraded over the COCs. In addition, the compound should be innocuous so that it will not adversely affect the groundwater. Other microbial nutrients such as potassium, magnesium, calcium, sulfur, sodium, manganese, iron, and trace metals may be already present in the groundwater.

The amount and extent of bioremediation would be dependent on the success of achieving adequate dispersion of nutrients and oxygen, which are vital factors for bioremediation. Aquifer conditions and distribution methods (injection points, injection wells, etc.) have a significant impact on adequate dispersion of nutrients and oxygen. In-situ biological degradation (in the aqueous phase) can be accomplished in combination with an extraction/recirculation system to reduce the total time of remediation.

Anaerobic Bioremediation

Anaerobic bioremediation involves stimulation of indigenous aerobic microflora in the subsurface to enhance the biodegradation of contaminants by providing a supply of hydrogen and nutrients. In some cases, a cometabolite or an additional carbon source is necessary to achieve biodegradation. Hydrogen may be provided in the form of hydrogen-release compound (HRC®) or it can be generated by the addition and fermentation of lactate, molasses, or vegetable oil.

Similar to aerobic degradation, nutrients such as nitrogen and phosphorous may need to be added to foster anaerobic biodegradation. In addition, the amount and extent of bioremediation would be dependent on the success of achieving adequate dispersion of nutrients and hydrogen and anaerobic conditions capable of completely degrading the chlorinated solvents.

**Effectiveness:** Bioremediation should be effective for the treatment of most chlorinated solvents and BTEX dissolved in groundwater in the Off-Site Southern Area Plume. Bioremediation is not typically effective if the source of groundwater contamination is not addressed first. The processes are proven, but extensive treatability work could be required. The reliability of bioremediation is dependent on how well amendments and nutrients are introduced and distributed through the aquifer. In some cases, multiple injections of amendments and nutrients are required to complete treatment, and in other cases, bioaugmentation is required to enhance the indigenous microorganism population to complete treatment. Extensive case studies are available involving the use of HRC® and ORC®. Chlorinated solvents are the most prevalent COCs in the Off-Site Southern Area Plume. It is likely that enhancing anaerobic biodegradation of the chlorinated solvents dissolved in groundwater with HRC® would be the most effective remediation approach. HRC® could be injected over a grid system to address the hot spots in the plume, but it would not be effective to treat the entire Off-Site Southern Area Plume by HRC® injection over a grid system because of the size of the plume (i.e., 92 acres). A more effective method of treating the entire plume would be to inject HRC® to create a biobarrier to contain and treat the contaminant plume. The BTEX COCs in the Off-Site Southern Area Plume do not typically degrade under anaerobic conditions; however, they would probably be consumed as a carbon/food source by the anaerobic microbes during the degradation of the chlorinated solvents. This process should reduce the concentrations of the BTEX COCs. Groundwater monitoring would be required to determine the progress of bioremediation.

**Implementability:** Bioremediation should be implementable. Permits may be required for the injection of amendments (HRC®) and nutrients into the aquifer, and because the aquifer is a sole-source aquifer, the permits may be difficult to obtain. There are only a limited number of vendors of HRC®-type products, although there are a sufficient number to perform this work.

**Cost:** The costs associated with bioremediation are proportional to the volume of groundwater to be treated, amount of amendments, and number of treatments required to completely treat the contaminated groundwater. The costs would be moderate when compared to other technologies.

**Conclusion:** Bioremediation using HRC® will be retained for further consideration for the dissolved contaminants in the Off-Site Southern Area Plume. Remediation of the on-site sources of contamination (Sites 6A and 10B) will improve the effectiveness of bioremediation.

## 4.3 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

The following sections provide the development of Corrective Measures Alternatives to address the contaminated groundwater in the Off-Site Southern Area.

### 4.3.1 Off-Site Southern Area Plume

The following information is known about the groundwater contamination in the Off-Site Southern Area Plume and was used to select appropriate Corrective Measures Alternatives:

- The size of the Off-Site Southern Area Plume groundwater contamination, as shown on Figure 2-7, is approximately 92 acres. The estimated volume of contaminated groundwater in the plume is 224 million gallons. The groundwater COCs and PRGs are provided in Table 3-2. Based on the maximum detected concentrations, there is an estimated 790 pounds of organic contamination (670 pounds of chlorinated solvents, 61 pounds of BTEX, and 59 pounds of miscellaneous VOCs) present in the groundwater.

#### 4.3.1.1 Alternative 1: No Action

The No Action alternative maintains the site at the status quo. This alternative is retained to provide a baseline for comparison to other alternatives; it does not address the contamination in the groundwater. There would be no reduction in toxicity, mobility, or volume of the contaminants in the Off-Site Southern Area Plume by treatment other than that which would result from natural dispersion, dilution, biodegradation, or other attenuating factors. Existing remedial activities, monitoring programs, and institutional controls would be discontinued, and the property would be available for unrestricted use.

#### 4.3.1.2 Alternative 2: Deed Notifications, Natural Attenuation, and Monitoring

This alternative consists of implementing deed notifications for the Off-Site Southern Area Plume and performing monitoring to track natural attenuation of contamination and potential impacts to the Peconic River. Calculations for this alternative are provided in Appendix B.

Deed notifications would be incorporated into the existing deeds of the owners of the property impacted by the Off-Site Southern Area Plume. These controls would restrict access and use of the contaminated groundwater in the Off-Site Southern Area Plume, which covers approximately 92 acres, to minimize risks to human health and the environment.

This alternative would also monitor decreases in groundwater contaminant concentrations through natural attenuation processes. Based on historical site information, it appears that the Off-Site Southern Area Plume was created as a result of the reinfiltration of contaminated groundwater that was extracted from Site 6A during free product recovery efforts and discharged to the local surface water drainage ditches and/or periodic overland transport of contaminated surface water. The contaminated groundwater migrated off site. Previous groundwater modeling for the on-site groundwater contamination predicted that if the source of contamination was not addressed, it would require up to 100 years for natural attenuation to address the groundwater contamination. Assuming the contaminant source was removed (90 percent), the modeling predicted that contaminant concentrations in groundwater may attenuate in less than 10 years. For evaluation purposes, it was assumed that remediation of the Off-Site Southern Area Plume would occur within 30 years.

Approximately 12 monitoring wells (seven new monitoring wells and five existing piezometers) would be included in the network for the Off-Site Southern Area Plume monitoring program. In addition, three surface water monitoring stations (one new and two existing) would be included in the monitoring network to evaluate impacts to the Peconic River. Monitoring would be conducted quarterly at the 12 wells and three surface water monitoring stations for the first year to evaluate seasonal trends and provide a baseline data set for the site. Monitoring would be conducted annually for the next 29 years. The approximate locations of these wells and stations are shown on Figure 4-1. It was assumed that the groundwater and surface water samples would be analyzed for VOCs and water quality parameters. The field water quality parameters that will be measured in the groundwater include temperature, turbidity, specific conductivity, oxidation-reduction potential, dissolved oxygen, pH, and divalent iron. The same field water quality parameters will be measured in the surface water with the exception of divalent iron. Additional groundwater quality parameters would be measured by a laboratory during the first year of sampling. These additional parameters include methane, carbon dioxide, ethene, ethane, chloride, nitrate, sulfate, and sulfide. It is expected that the analytical program would be optimized during the monitoring program. All well installation and sampling activities would be performed in accordance with State and federal regulations. The five existing piezometers would be converted to permanent monitoring wells and fully developed prior to being used for the monitoring program.

Groundwater and surface water analytical data would be reviewed periodically to evaluate the effectiveness of natural attenuation. Additional groundwater contaminant fate and transport modeling would be conducted as necessary to predict contaminant migration and natural attenuation. A reevaluation of the site would be performed every 5 years as long as contaminant concentrations are greater than PRGs to determine if any changes to the controls or remedy would be required.

#### 4.3.1.3 Alternative 3: Deed Notifications, Groundwater Extraction (Wells), Treatment (Air Stripping/Activated Carbon), Disposal (Direct Discharge and Reinjection), and Monitoring

This alternative consists of implementing deed notifications for the Off-Site Southern Area Plume, extracting the contaminated groundwater, treating and disposing the water, and monitoring the progress of groundwater remediation and potential impacts to the Peconic River. Calculations for this alternative are provide in Appendix B.

Deed notifications would be implemented for the Off-Site Southern Area Plume similar to those implemented for Alternative 2. These controls would restrict access and use of the contaminated groundwater in the Off-Site Southern Area Plume, which covers approximately 92 acres, to minimize risks to human health and the environment.

Two groundwater extraction and treatment systems would be installed to address the Off-Site Southern Area Plume. The layout of the extraction system is shown on Figure 4-2, and a schematic of the treatment system is shown on Figure 4-3. Groundwater extraction systems can be developed for source area treatment, downgradient plume containment, or a combination of both. Due to the size of the Off-Site Southern Area Plume, this alternative was mainly developed to contain and prevent further downgradient migration of the contaminated groundwater. However, if the systems are operated long enough, they should also remediate the plume. It was assumed for this alternative that there are no significant remaining sources of contamination to groundwater.

Based on preliminary calculations, the extraction systems would include six 8-inch extraction wells (two wells in one system and four wells in the other). The wells would be placed in hot spot areas and along the downgradient edge of the plume near the Peconic River (see Figure 4-2). The wells would be constructed to capture groundwater from the interval of 60 to 90 feet bgs in the overburden aquifer. The Off-Site Southern Area Plume wells would extract a total of approximately 960 gpm of contaminated groundwater, and it was estimated that the systems would be operational for 16 years.

Extracted groundwater would be treated to meet PRGs prior to direct discharge or reinjection. A typical groundwater treatment system is shown in Figure 4-3 and consists of the following unit operations/processes: equalization/chemical precipitation, clarification, filtration, and air stripping. Two treatment systems would be installed to treat the extracted groundwater. One would handle flow from four extraction wells and the other would handle flow from two extraction wells. A treatability test would be conducted on the systems for the Off-Site Southern Area Plume to confirm that they treat the groundwater to the required PRGs.

The groundwater extracted from the Off-Site Southern Area Plume would be transferred to an equalization tank to dampen flow and contaminant surges. The equalization tank would be designed to provide 30 minutes of detention under design flow conditions. Caustic would be added for pH control, and permanganate would be added for iron and manganese oxidation. Precipitated metals would be removed in the clarifier. The precipitate would then be disposed off site. The clarified water would be pumped to a bag filter for suspended solids removal and then to an air stripper. A low-profile multi-tray air stripper would be used for VOC removal. Alternately, liquid phase GAC could be used. Based on the low VOC concentrations in the groundwater, off-gas treatment would probably not be required for the system.

After treatment, the effluent would be disposed by two methods: direct discharge to the Peconic River and reinjection to the overburden aquifer via injection galleries placed upgradient of the extraction systems. Both types of disposal will be used for the alternative because it is likely that the extraction systems will impact surface water flow rates in the Peconic River. It was estimated that under average flow conditions, groundwater recharge from the Off-Site Southern Area Plume provides 404 gpm [0.9 cubic feet per second (cfs)] to the total flow rate of the Peconic River of 7,360 gpm (16.4 cfs) (see calculations in Appendix B). Based on the estimated groundwater extraction rate of 960 gpm (2.14 cfs), approximately 404 (0.9 cfs) would need to be directly discharged to the Peconic River to sustain the average flow rate and minimize impacts, and 552 gpm (1.23 cfs) would be reinjected into the overburden aquifer via injection galleries. Additional details for the disposal of the effluent would need to be developed as part of the design and permitting of the systems. The layout of the injection galleries are shown on Figure 4-2. The infiltration galleries would be sized to accommodate an effluent flow rate of 552 gpm (1.23 cfs). Clearing and grubbing would be required prior to installation of the galleries because the proposed areas are currently wooded. Effluent monitoring of the systems would be conducted weekly for the first month of operation and then monthly for the duration of system operation (16 years). The effluent samples would be analyzed for VOCs.

Monitoring would be conducted quarterly for the first year and then annually thereafter to monitor the progress of groundwater remediation. Thirteen monitoring wells (four new monitoring wells, six extraction wells, and three existing piezometers) would be sampled as part of the monitoring program (see Figure 4-2). The groundwater extraction system would be shut down during the monitoring events. In addition, three surface water monitoring stations (one new and two existing) would be included in the monitoring network to evaluate groundwater impacts on the Peconic River. The groundwater and surface water samples would be analyzed for VOCs. The field water quality parameters included in Alternative 2 would also be collected during each sampling event. Groundwater and surface water analytical data would be reviewed periodically to evaluate the effectiveness of the groundwater extraction systems and the impacts to the Peconic River. If the results of the monitoring show that the groundwater extraction systems are not effective at reaching the groundwater PRGs, the systems would be shut down and a remedy similar to Alternative 2 (institutional controls, natural attenuation, and monitoring) would be implemented. However, for this alternative it was assumed that the remedy would not change and that the Off-Site Southern Area Plume systems would be operational for 16 years. All well installation and sampling activities would be performed in accordance with State and federal regulations. The three existing piezometers would be converted to permanent monitoring wells and fully developed prior to being used for the monitoring program.

### 4.3.1.4 Alternative 4: Deed Notifications, In-Situ Biological Treatment (Hot Spot Treatment with HRC®), Natural Attenuation, and Monitoring

Alternative 4 was developed as an active in-situ bioremediation alternative. This alternative consists of implementing deed notifications, treating hot spots in the Off-Site Southern Area Plume with HRC® to biologically treat the highest concentrations of COCs and minimize future contaminant discharge to the Peconic River, and conducting monitoring. Calculations for this alternative are presented in Appendix B.

Deed notifications would be implemented for the Off-Site Southern Area Plume similar to those implemented for Alternative 2 to minimize risks to human health and the environment.

Groundwater treatment systems can be developed for source area treatment, downgradient plume containment, or a combination of both. This alternative was developed to treat the hot spots in the plume and to minimize future downgradient contaminant migration to the Peconic River. Based on previous sample results, chlorinated solvents are the primary COCs (e.g., 1,1-trichloroethane, 1,1-dichloroethane, and chloroethane) in the Off-Site Southern Area Plume that would require treatment. These solvents will degrade by anaerobic reductive dechlorination and the addition of HRC® would enhance aquifer conditions and promote biodegradation by this process. Higher concentrations of chlorinated solvents (concentrations greater than 120 µg/L) were detected in three general locations including one near the Peconic River Sportsmen Club Pistol Range (292 µg/L in SA-VPB-114) and two along Connecticut Avenue (125 µg/L in SA-PZ-123I and 220 µg/L in SA-PZ-101I). HRC® would be the most effective additive for treatment of these COCs. Treatment with HRC® is generally most effective to address dissolved contaminants in the aquifer after the source of contamination has been addressed. It was assumed for this alternative that all sources of contamination to groundwater would be remediated. A pilot study would be conducted to determine the effectiveness of biological stimulation prior to full implementation of the remedial alternative.

HRC® would be injected at each hot spot over a grid system covering 200 feet by 200 feet. The HRC® would be injected in 56 points on spacings of 15 feet (within row) by 50 feet (between rows). Calculations indicate that approximately 13,000 pounds of HRC® would need to be injected through the 56 injection points to address each of the hot spots in the Off-Site Southern Area Plume. The HRC® would be injected into the most contaminated portion of the aquifer (i.e., between 60 and 90 feet bgs) using direct-push technology (DPT). It was estimated that the HRC® would be effective at treating the chlorinated solvents for 1 year. It was assumed that two treatments would be required to fully treat each hot spot. Therefore the HRC® would need to be injected twice at each hot spot.

Monitoring would be conducted to determine the effectiveness of the HRC® treatment and to evaluate the progress of natural attenuation of the remaining contamination in the plume. Approximately 13 monitoring wells (10 new monitoring wells and three existing piezometers) would be included in the monitoring program (see Figure 2-4). The three existing piezometers would be converted to permanent monitoring wells and fully developed prior to being used for the monitoring program. In addition, three surface water monitoring stations (one new and two existing) would be included in the monitoring network to evaluate groundwater impacts on the Peconic River. The analytical program for monitoring would be similar to the one in Alternative 2. Sampling would be conducted quarterly for the first year of the alternative to provide baseline information. It is expected that monitoring will continue annually for the next 9 years until contaminant concentrations decrease to PRGs by natural attenuation. This sampling would be performed in accordance with State and federal regulations. A re-evaluation of the site would be performed after 5 years to determine if any changes to the remedy or controls would be required.

#### 4.3.1.5 Alternative 5: Deed Notifications, In-Situ Biological Treatment (Biobarrier with HRC®), Natural Attenuation, and Monitoring

Alternative 5 was developed as a passive in-situ bioremediation alternative. This alternative consists of implementing deed notifications, creating and maintaining two HRC® barriers to biologically treat COCs prior to discharge to the Peconic River, and conducting monitoring. Calculations for this alternative are presented in Appendix B.

Land use controls/deed notifications would be implemented for the Off-Site Southern Area Plume similar to those implemented for Alternative 2 to minimize risks to human health and the environment.

Groundwater treatment systems can be developed for source area treatment, downgradient plume containment, or a combination of both. This alternative was developed to contain the plume and prevent further downgradient migration to the Peconic River. Based on previous sample results, chlorinated solvents are the primary COCs in the Off-Site Southern Area Plume that would require treatment. HRC® would be the most effective additive for treatment of these COCs. Creation of a biological barrier with HRC® is generally most effective if used to address dissolved contaminants in the aquifer after the source of contamination has been addressed. It was assumed for this alternative that all sources of contamination to groundwater would be remediated. A pilot study would be conducted to determine the effectiveness of biological stimulation prior to full implementation of the remedial alternative.

Two treatment barriers using HRC® would be completed for the Off-Site Southern Area Plume: one running north to south along the Connecticut Avenue and one running east to west to the east of the Peconic River Sportsmen Club Pistol Range (see Figure 4-5). The HRC® would be injected in two rows to create the barriers. Calculations indicate that approximately 137,000 pounds of HRC® would need to be injected through 420 injection points (on 5-foot centers) to create one of the barriers. Both barriers would be similar and require the same amount of HRC®. The HRC® would be injected into the aquifer between 60 and 90 feet bgs using DPT. It was estimated that the HRC® barriers would be effective at treating the chlorinated solvents for 1 year. Assuming COC concentrations in the plume would decrease below PRGs within 16 years, the barrier would need to be maintained for this duration. Therefore, the HRC® would need to be injected 16 times.

Groundwater monitoring would be conducted to determine the effectiveness of the HRC® barrier. Approximately 15 monitoring wells (10 new monitoring wells and five existing piezometers) would be included in the monitoring program (see Figure 4-5). The five existing piezometers would be converted to permanent monitoring wells and fully developed prior to being used for the monitoring program. In addition, three surface water monitoring stations (one new and two existing) would be included in the monitoring network to evaluate groundwater impacts on the Peconic River. The analytical program for monitoring would be similar to the one in Alternative 2. Sampling would be conducted quarterly for the first year of the alternative to provide baseline information and then annually for the next 15 years while the barriers are in place. This sampling would be performed in accordance with State and federal regulations. A re-evaluation of the site would be performed after 5 years to determine if any changes to the remedy or controls would be required.

#### 4.3.1.6 Alternative 6: Deed Notifications, In-Situ Physical Treatment (Air Sparge Curtain), Natural Attenuation, and Monitoring

Alternative 6 was developed as an in-situ treatment alternative. This alternative consists of implementing deed notifications, creating and maintaining two air sparge curtains to physically treat COCs prior to discharge to the Peconic River, and conducting groundwater monitoring. The layouts of the systems are shown on Figure 4-6. A schematic of the air sparging system is present in Figure 4-7. Calculations for this alternative are presented in Appendix B.

Land use controls/deed notifications would be implemented for the Off-Site Southern Area Plume similar to those implemented for Alternative 2 to minimize risks to human health and the environment.

Groundwater treatment systems can be developed for source area treatment, downgradient plume containment, or a combination of both. This alternative was developed to contain the plume and prevent further downgradient migration to the Peconic River. Based on previous sample results, chlorinated solvents are the primary COCs in the Off-Site Southern Area Plume that would require treatment. Air sparging would be effective for treatment of these COCs. It was assumed for this alternative that all sources of contamination to groundwater would be remediated. A pilot study would be conducted to determine the effectiveness of air sparging prior to full implementation of the remedial alternative.

Two separate air sparge curtains (one running north to south along the Connecticut Avenue and one running east to west to the east of the Peconic River Sportsmen Club Pistol Range) would be installed to contain/treat the plume (see Figure 4-5). Air injection causes volatilization of VOCs in groundwater and also supplies oxygen to enhance biodegradation in the groundwater. Each curtain would include a total of approximately 45 injection wells distributed in two rows. The wells would be installed to a depth of approximately 100 feet below the ground surface. Air would be injected into the saturated zone to create each air sparge curtain through two 300 cubic feet per minute blowers at approximately 50 pounds per square inch. Air sparging is usually used in combination with soil vapor extraction. Based on fugitive emission calculations (see Appendix B), vapor extraction is not required for the Off-Site Southern Area Plume. Assuming COC concentrations in the plume would decrease below PRGs within 16 years, the curtains would need to be maintained for this duration.

Groundwater monitoring would be conducted to determine the effectiveness of the air sparge curtains. Approximately 15 monitoring wells (10 new monitoring wells and five existing piezometers) would be included in the monitoring program (see Figure 4-6). The five existing piezometers would be converted to permanent monitoring wells and fully developed prior to being used for the monitoring program. In addition, three surface water monitoring stations (one new and two existing) would be included in the monitoring network to evaluate groundwater impacts on the Peconic River. The analytical program for monitoring would be similar to the one in Alternative 5. Sampling would be conducted quarterly for the first year of the alternative to provide baseline information and then annually for the next 15 years while the curtains are in place. This sampling would be performed in accordance with State and federal regulations. A re-evaluation of the site would be performed after 5 years to determine if any changes to the remedy or controls would be required.

## TABLE 4-1

## SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK


| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| No Action | No Action | No Action | No activities conducted at site to address contamination. | Required by law. Retain for baseline comparison to other technologies. | * |
| Limited Action | Monitoring | Groundwater Monitoring | Sampling and analysis to evaluate contaminant trends within the aquifer, the downgradient migration of contaminants, and the effectiveness of remediation. | Groundwater monitoring is viable for assessing the effectiveness of natural attenuation and containment or treatment measures, during and following remediation. Monitoring would be used in combination with other technologies if contaminated groundwater remains in place. | * |
| | Institutional Controls | Passive Controls: Deed Restrictions and Land Use Controls | Administrative action used to restrict groundwater use and future site activities. | Land use controls would not be applicable because the Navy does not own the property. The Navy and current land owners would need to implement deed notifications. Notifications are viable, in combination with other technologies, because contaminated groundwater may remain in place. The control would ban well installation and use of groundwater from existing wells. | * |
| | | Active Controls: Physical Barriers/Security Guards | Fencing, markers, and warning signs to restrict site access. | Site is not currently located within a restricted area; however, groundwater is not available for direct contact. These controls may not be effective if site conditions change. | x |
| | | Alternative Water Supply | Replacement of contaminated groundwater source with alternative water supply for end user. | No current off-site groundwater users in the Southern Area. It is unlikely that another water supply will need to be provided because of the lack of additional groundwater users. | * |

TABLE 4-1

SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER
OFF-SITE SOUTHERN AREA PLUME
NWIRP, CALVERTON, NEW YORK


| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| Limited Action (Continued) | Natural Attenuation | Natural Attenuation | Monitoring groundwater to assess the natural processes that affect the rate of migration and the concentrations of contaminants. | Many of the groundwater contaminants (chlorinated solvents and BTEX) are amenable to natural attenuation. Use in combination with other technologies if groundwater remains in place. Most effective if contaminant source is addressed first. | * |
| Containment | Capping | Capping | Use of impermeable or semi-permeable materials (e.g., soil, clay, synthetic membrane, asphalt) to prevent exposure to contamination and/or to reduce the vertical migration of contaminants to groundwater. | Capping will not address groundwater contamination. Contaminants are already present in the groundwater, and on-site sources of contamination will be addressed. | x |
| | Cut-Off Barriers | Slurry Wall | Clay wall used to restrict horizontal migration of contaminants. | This technology would not be appropriate for the Off-Site Southern Area Plume because of the low concentrations of contaminants and the depth of the clay confining unit (130 feet below the ground surface) into which the barrier can be tied. The process is capital cost intensive, and it does not treat groundwater contamination or reduce the clean-up time. | x |
| | | Sheet Piling | Sheet made of wood, pre-cast concrete, or steel used as a retaining wall to restrict horizontal migration of contaminants. | This technology would not be appropriate for the Off-Site Southern Area Plume because of the low concentrations of contaminants and the depth of the clay confining unit (130 feet below the ground surface) into which the barrier can be tied. The process is capital cost intensive, and it does not treat groundwater contamination or reduce the clean-up time. | x |

## TABLE 4-1

## SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK



| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| Containment (Continued) | Cut-Off-Barriers (Continued) | Bank Revetment | Riprap, piling, etc. used to protect and stabilize slopes of river bank. | Slopes requiring stabilization are not present at the site. | x |
| | Horizontal Barriers | Jet Grouting Curtain | Use of pressure-injected cement to restrict vertical migration of contaminants to groundwater. | A clay confining unit is present at approximately 130 feet below the ground surface. Vertical migration of contamination was not identified as a significant concern. | x |
| Removal | Extraction | Extraction Wells | Discrete pumping wells strategically placed to remove contaminants from the entire plume. | Contaminated groundwater would be extracted via pumping wells and treated prior to discharge. | * |
| | | Collection Trench | A permeable trench used to intercept and collect groundwater. | An effective permeable trench could probably not be installed at the site because the contamination is present at 60 to 90 feet bgs. No significant contamination is present in the upper portions of the aquifer. | x |
| | | Product Removal | Discrete extraction wells designed to recover either floating product or sinking product. | No free product is present in the Off-Site Southern Area. | x |
| | Enhanced Removal | Enhanced Removal | Blasting or hydrofracturing of bedrock to promote access to groundwater in bedrock fractures. | Enhanced removal is not necessary based on site geology. The surficial aquifer is sandy and sufficiently permeable to extract groundwater via conventional means. | x |
| Disposal | Beneficial Reuse | Beneficial Reuse as Process Water/ Potable Water | On-site reuse of groundwater from which the contaminants have been removed. | Beneficial reuse of treated effluent as process water/potable water is not warranted because there is no need for process water/potable water services at this time. | x |

## TABLE 4-1

**SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER**
**OFF-SITE SOUTHERN AREA PLUME**
**NWIRP, CALVERTON, NEW YORK**


| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| Disposal (Continued) | Surface Discharge | Direct Discharge | Discharge of collected/treated water to local surface water. | Direct discharge of effluent is a viable option. The Peconic River is located in close proximity of the site. Permits would be required. | * |
| | | Indirect Discharge | Discharge of collected/treated water to a publicly owned treatment works (POTW). | Indirect discharge (POTW) of effluent is not a viable option. A POTW is not available in the area. | x |
| | | Off-Site Treatment Facility | Treatment and disposal of hazardous or nonhazardous materials at permitted off-site facilities. | Off-site treatment facility is not feasible because the volume of contaminated groundwater is too large to effectively transport and treat off site. | x |
| | Subsurface Discharge | Reinjection | Use of reinjection, spray irrigation, or infiltration to discharge collected/treated groundwater to the underground. | Reinjection of untreated effluent is not a viable option. Reinjection of treated effluent may be appropriate to discharge treated water and enhance contaminant removal. Injection wells, infiltration galleries, and spray irrigation are potential options. The shallow groundwater table may limit the use of injection wells and infiltration galleries. Spray irrigation requires relatively large areas. Also, spray irrigation cannot be operated during the winter because of freezing problems. | * |
| Ex-Situ Treatment | Physical | Solvent Extraction | Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the contaminants of concern. | Solvent extraction is typically utilized for high concentration wastewater streams and is rarely utilized for groundwater remediation. | x |
| | | Dewatering | Mechanical removal of free water from wastes using equipment such as a filter press or a vacuum filter. | Dewatering of sludges resulting from precipitation processes for metals removal may be required in combination with other technologies. | ** |

## TABLE 4-1

## SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK


| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| Ex-Situ Treatment (Continued) | Physical (Continued) | Detonation | Detoxification of explosive waste by setting off a charge. | Detonation is not applicable because none of the contaminants are explosives. | x |
| | | Equalization | Dampening of flow and/or contaminant concentration variation in a large vessel to promote constant discharge rate and water quality. | Equalization is feasible at the front end of a groundwater treatment system for equalizing flow and contaminant concentrations. Would be used in combination with other technologies. | ** |
| | | Filtration | Separation of materials from water via entrapment in a bed or membrane separation. | Filtration may be required for suspended solids and particulate metals removal. Would be used in combination with other technologies. | ** |
| | | Flotation | Separation of oils and suspended solids less dense than water by flotation methods. | This process would be appropriate for any free product. No free product is present in the Off-Site Southern Area. | x |
| | | Reverse Osmosis/ Ultrafiltration | Use of high pressure and membranes to separate dissolved materials, including organics and inorganics, from water. | Reverse osmosis/ultrafiltration is effective for removal of dissolved contaminants. This technology is considered only when other feasible options are not available. | x |
| | | Volatilization | Contact of contaminated water with air to remove volatile compounds. Air stripping method is typically employed. | Air stripping would be effective for removal of volatile contaminants from groundwater. The technology would be effective for chlorinated solvents and BTEX. | * |
| | | Gravity Settling/ Clarification | Flow of water through a quiescent tank to allow gravity settling of solids. | If sufficient suspended solids are present in the groundwater, this technology will be considered as a secondary technology. | ** |
| | | Adsorption | Adsorption of contaminants onto activated carbon, resins, or activated alumina. | Adsorption may be considered for removal of VOCs from groundwater as a secondary technology. | ** |

TABLE 4-1

SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER
OFF-SITE SOUTHERN AREA PLUME
NWIRP, CALVERTON, NEW YORK


| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| Ex-Situ Treatment (Continued) | Physical (Continued) | Evaporation | Change from the liquid to the gaseous state at a temperature below the boiling point. | Evaporation is typically utilized for high concentration wastewater streams and is rarely utilized for groundwater remediation. | x |
| | | Electrodialysis | Recovery of anions or cations using special membranes under the influence of an electrical current. | Electrodialysis is typically utilized for high concentration wastewater streams. This technology is considered only when other feasible options are not available. | x |
| | Biological | Aerobic/Anaerobic Biodegradation | Suspended growth or fixed film process employing aeration and biomass recycle or anaerobic biomass to decompose biodegradable organic components. | Aerobic biodegradation would be applicable for BTEX. Anaerobic biodegradation would be effective for chlorinated solvents. However, the dissolved contaminant concentrations in the Off-Site Southern Area groundwater are too low to allow this technology to be effective. | x |
| | Chemical | Ion Exchange | Process in which ions, held by electrostatic forces to charged functional groups on the ion exchange resin surface, are exchanged for ions of similar charge in a water stream. | Ion exchange is a well-established technology for removal of heavy metals and hazardous anions from dilute solutions. None of these were identified as COCs at this site. The reliability of ion exchange is affected by the presence of suspended solids, organics, and oxidants. This technology is considered only when other feasible options are not available. | x |

TABLE 4-1

SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER
OFF-SITE SOUTHERN AREA PLUME
NWIRP, CALVERTON, NEW YORK


| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| Ex-Situ Treatment (Continued) | Chemical (Continued) | Electrolytic Recovery | Passage of an electric current through a solution with resultant ion recovery on positive and negative electrodes. | Electrolytic recovery is typically utilized for high concentration wastewater streams and is rarely utilized for groundwater remediation. | x |
| | | Enhanced Oxidation | Use of strong oxidizers such as ultraviolet light, ozone, peroxide, chlorine, or permanganate to chemically oxidize materials. Oxidation may also be accomplished through the use of high temperatures, pressures, and air. | Enhanced oxidation would be effective for the destruction of BTEX in the groundwater; however, it would be less effective for removal of other site organics [chlorinated solvents (alkanes)]. | x |
| | | Reduction | Use of strong reducers such as sulfur dioxide, sulfite, or ferrous iron to chemically reduce the oxidation state of materials. | Reduction would not be effective for the BTEX, but it may be effective for chlorinated solvents, which degrade best under anaerobic conditions. | x |
| | | Neutralization | Use of acids or bases to counteract excessive pH or to adjust pH to optimum for a given technology. | Neutralization may be required in conjunction with pretreatment requirements for a given technology. | ** |
| | | Dechlorination | Use of chemicals to remove chlorine from chlorinated compounds. | Dechlorination is typically utilized for high concentration wastewater streams and is rarely utilized for groundwater remediation. | x |
| | | Flocculation/ Coagulation | Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling. | Flocculation/coagulation may be warranted to improve suspended solids removal. | ** |
| | | Precipitation | Use of reagents to convert soluble materials into insoluble materials. | Precipitation may be warranted for dissolved metals removal. | ** |

TABLE 4-1

SCREENING OF TECHNOLOGIES/PROCESS OPTIONS FOR GROUNDWATER
OFF-SITE SOUTHERN AREA PLUME
NWIRP, CALVERTON, NEW YORK


| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| In-Situ Treatment | Physical | Air Sparging or Air Sparging/Vapor Extraction | Volatilization and enhancement of biodegradation of organic compounds by supply of air with or without capture and treatment of volatilized compounds. | Site contaminants are amenable to volatilization and/or biodegradation. The depth of the contamination (50 to 80 feet below the water table) may reduce the effectiveness of this technology. Technology may be effective at reducing contaminant concentrations and minimizing contaminant migration. | * |
| | | Permeable Reactive Barriers or Biological Barriers | Use of permeable barrier that allows the passage of groundwater and reacts with contaminants. | Process could be effective on site contaminants. Difficult to implement because different barrier media would be required for the chlorinated solvents and BTEX present in the groundwater. | x |
| | Biological - Biostimulation | Aerobic/Anaerobic | Enhancement of biodegradation of organics in an aerobic and/or anaerobic environment by injection of nutrients and ORC®/HRC® or by injection of Bimetallic Nanoscale Particles (BNP). | Aerobic biodegradation using ORC® would be effective on the BTEX present in the groundwater, and anaerobic biodegradation using HRC® or BNP would be effective on the chlorinated solvents in the groundwater. BTEX may enhance effectiveness of HRC®. | * |
| | Biological - Bioaugmentation | Aerobic/Anaerobic | Enhancement of biodegradation of organics in an aerobic and/or anaerobic environment by injection of microbes, inoculum, and/or bacterium. | Aerobic/anaerobic biodegradation could be effective on the BTEX and chlorinated solvents, respectively, in the groundwater. Process would not be effective as a primary technology, but it could be used to improve effectiveness of other biological treatment options (biostimulation). | x |

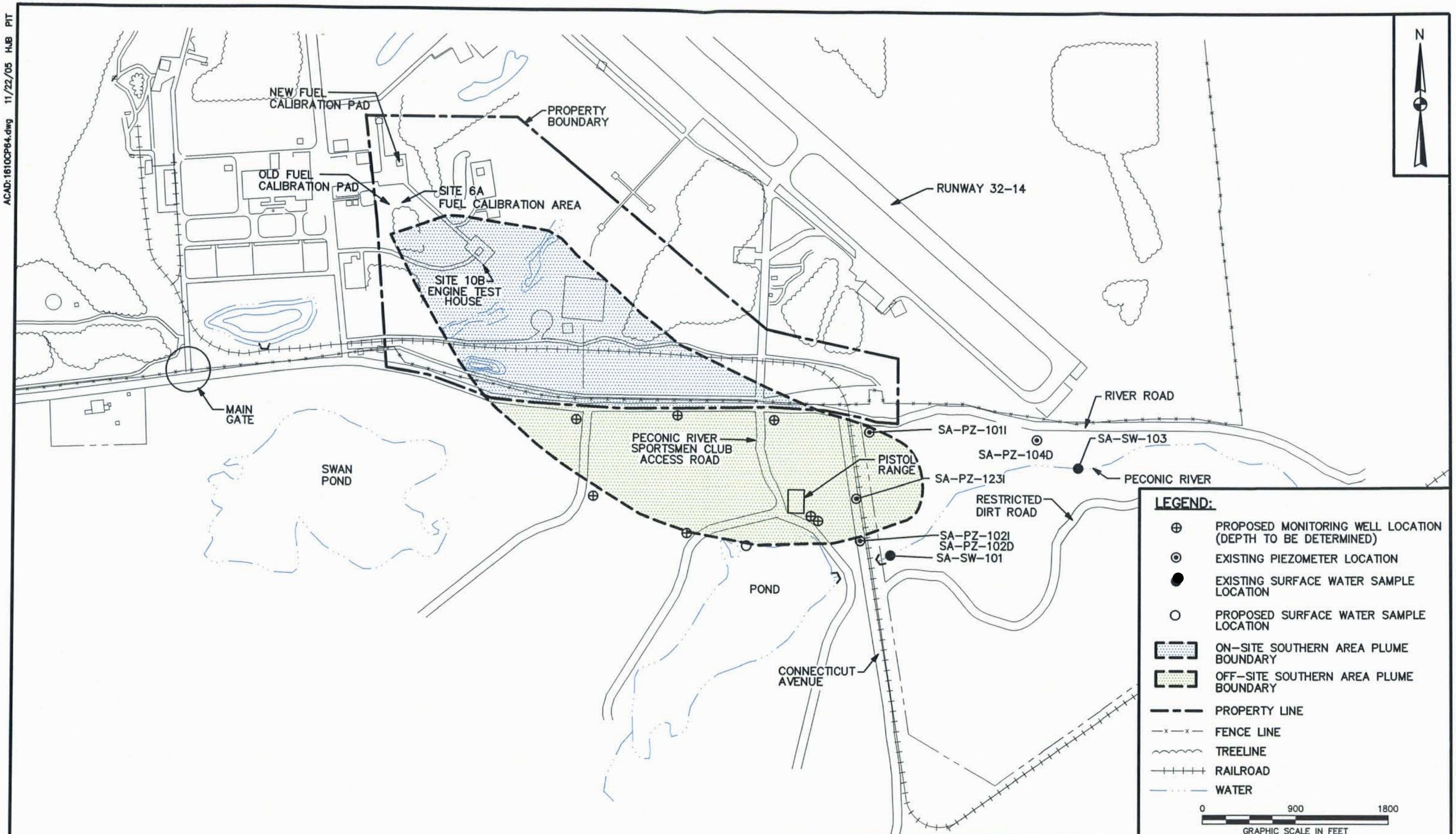
| General Action | Technology | Process Options | Description | General Screening | |
|---|---|---|---|---|---|
| In-Situ Treatment (Continued) | Biological | Aerobic Biodegradation (Bioventing) | Enhancement of in-place biodegradation by addition of nutrients and control of environment. | Removal of contaminants from groundwater is achieved by air stripping/bioventing of contaminants. Contaminants must be able amenable to volatilization or aerobic biodegradation. May not be effective on the chlorinated solvents. The depth of the contamination (50 to 80 feet below the water table) may limit the effectiveness of this technology. | x |
| | Thermal | Dynamic Underground Stripping/Electrical Resistive Heating/ Thermal Conductive Heating | Steam injection/electrical current/ conductive heating elements are used to create a high-temperature zone resulting in the vaporization of volatile compounds bound to soil and the movement of contaminants to an extraction well. | Other processes are more effective at removing or treating the site groundwater contaminants. The process has a relatively high cost. | x |
| | Chemical | Enhanced Oxidation | Chemical destruction of organic COCs through oxidation with hydrogen peroxide and ferrous iron (Fenton's Reagent) or potassium permanganate. | Process would be more effective for BTEX than chlorinated solvents (ethanes). Significant amounts of dissolved BTEX contamination has not been detected in the Off-Site Southern Area. | x |
| | | Precipitation | Adjustment of soil/groundwater chemistry to decrease the solubility of metals. Actions may include the additional of calcium hydroxide to increase the groundwater pH and/or oxygen to convert the metals to less soluble ions. | This process would not be effective for the primary site contaminants (BTEX and chlorinated solvents). | x |

* Potentially applicable as a primary technology.
** Potentially applicable as a secondary technology (i.e., handling of treatment residuals resulting from a primary technology). Discussed as appropriate under applicable alternatives.
x Not applicable as a primary or secondary technology.

## TABLE 4-2

## SUMMARY OF RETAINED PRIMARY GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
## OFF-SITE SOUTHERN AREA PLUME
## NWIRP, CALVERTON, NEW YORK

| General Action | Technology | Process Option |
|---|---|---|
| No Action | No Action | No Action |
| Limited Action | Institutional Controls | Deed Restrictions |
| | Monitoring | Groundwater and Surface Water Monitoring |
| | Natural Attenuation | Natural Attenuation |
| Removal | Extraction | Extraction Wells |
| Disposal | Surface Discharge | Direct Discharge |
| | Subsurface Discharge | Reinjection (Infiltration Gallery) |
| Ex-Situ Treatment | Physical | Volatilization (Air Stripping) |
| In-Situ Treatment | Physical | Air Sparging |
| | Biological - Biostimulation | Aerobic (ORC®)/Anaerobic (HRC®) |




| DRAWN BY HJB | DATE 10/18/05 | Tetra Tech NUS, Inc. | ALTERNATIVE 2 MONITORING WELL NETWORK OFF-SITE SOUTHERN AREA PLUME NWIRP CALVERTON CALVERTON, NEW YORK | CONTRACT NO. 1610 |
|---|---|---|---|---|
| CHECKED BY | DATE | | | OWNER NO. 0004 |
| REVISED BY | DATE | | | APPROVED BY / DATE |
| SCALE AS NOTED | | | | DRAWING NO. FIGURE 4-1 / REV. 0 |

ACAD:1610CP64.dwg 11/22/05 HJB PIT

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

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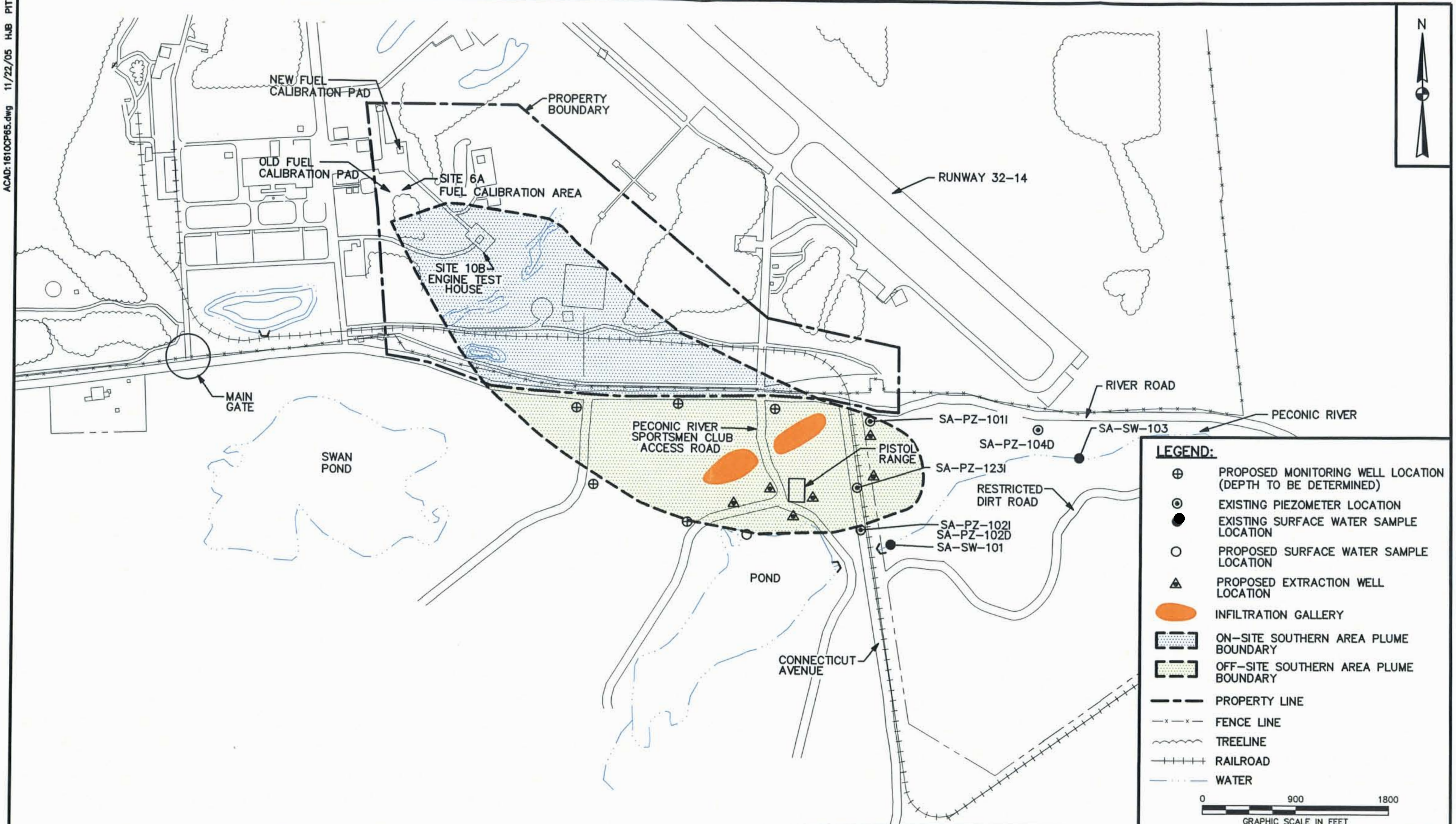


| DRAWN BY HJB | DATE 10/18/05 | Tetra Tech NUS, Inc. | ALTERNATIVE 3<br>EXTRACTION WELLS, INFILTRATION GALLERIES, AND MONITORING WELLS<br>OFF-SITE SOUTHERN AREA PLUME<br>NWIRP CALVERTON<br>CALVERTON, NEW YORK | CONTRACT NO. 1610 | |
|---|---|---|---|---|---|
| CHECKED BY | DATE | | | OWNER NO. 0004 | |
| REVISED BY | DATE | | | APPROVED BY | DATE |
| SCALE AS NOTED | | | | DRAWING NO. FIGURE 4-2 | REV. 0 |

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

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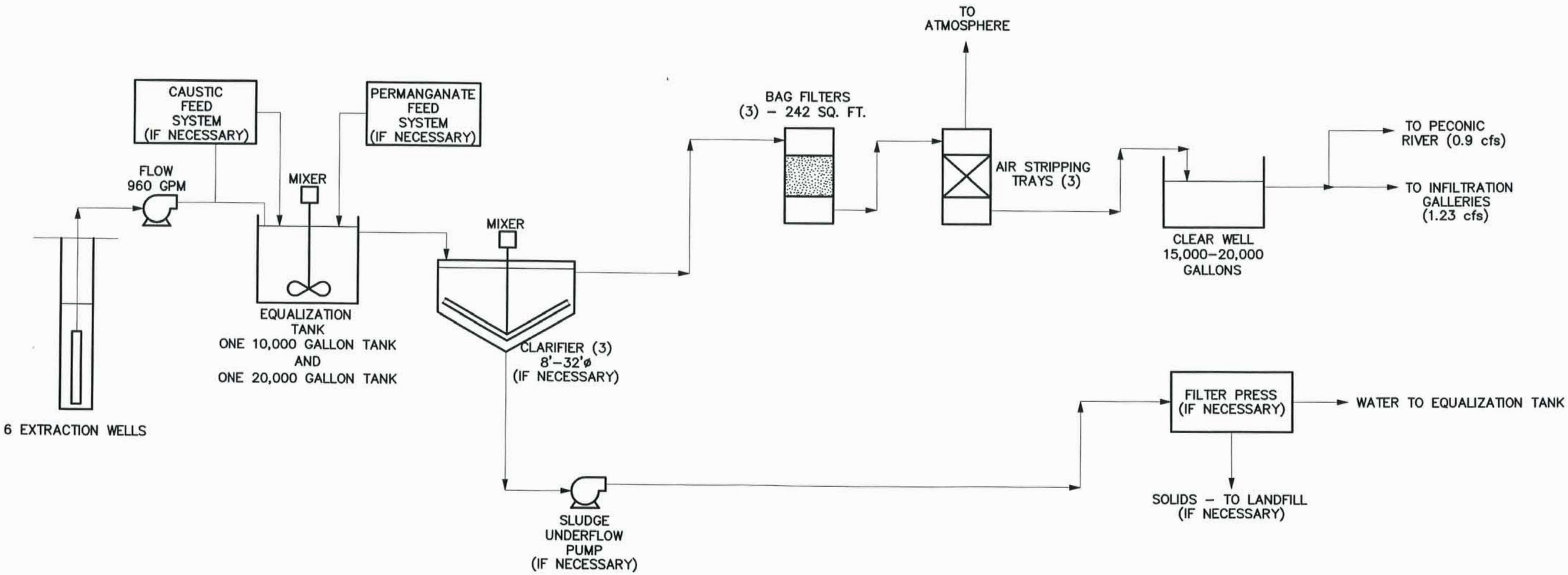


| | | | | |
|---|---|---|---|---|
| DRAWN BY HJB / DATE 10/18/05 | Tetra Tech NUS, Inc. | ALTERNATIVE 3<br>GROUNDWATER EXTRACTION, TREATMENT, AND DISPOSAL<br>NWIRP CALVERTON<br>CALVERTON, NEW YORK | CONTRACT NO. 1610 | |
| CHECKED BY / DATE | | | OWNER NO. 0004 | |
| REVISED BY / DATE | | | APPROVED BY | DATE |
| SCALE AS NOTED | | | DRAWING NO. FIGURE 4-3 | REV. 0 |

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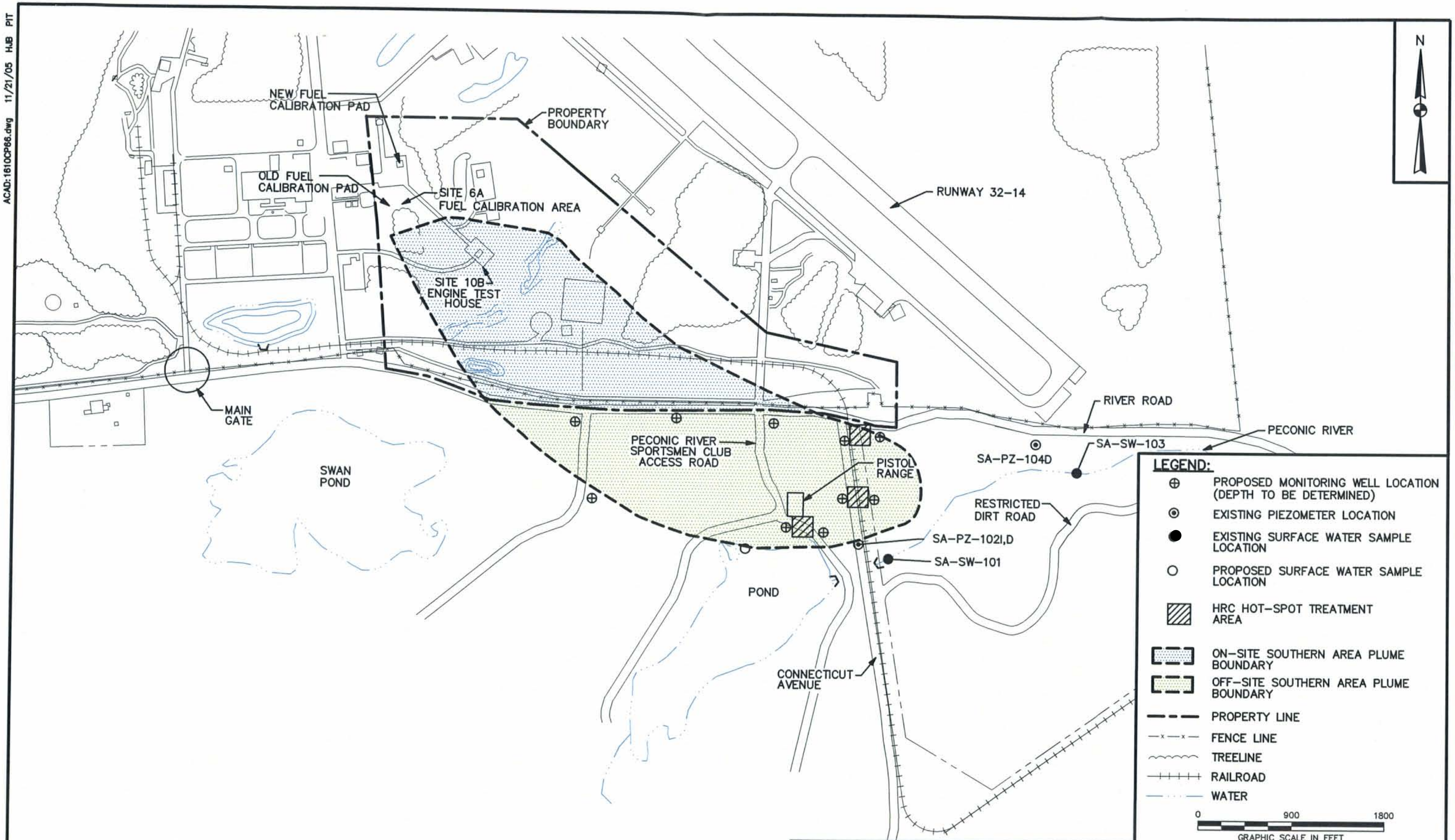


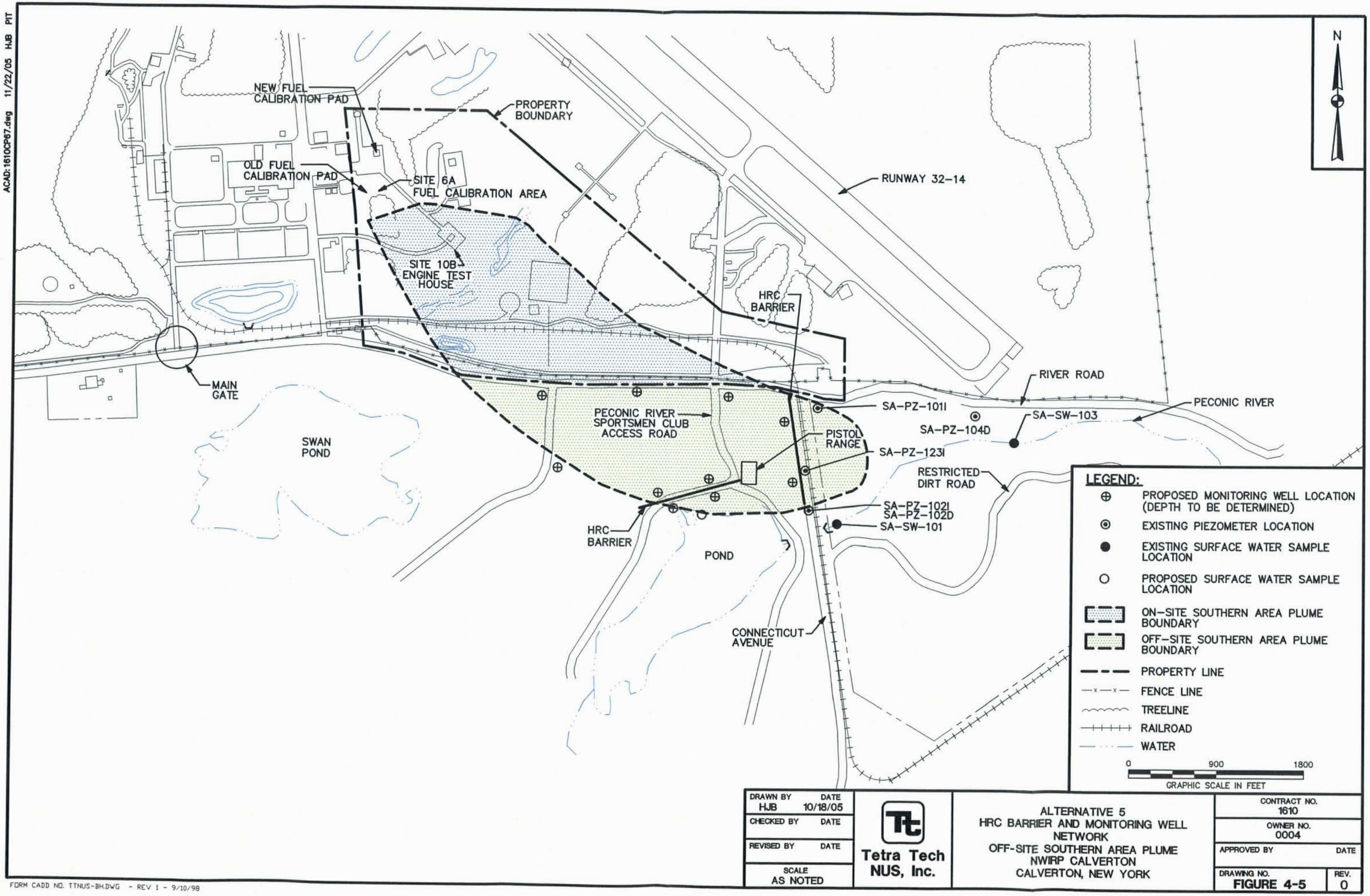

| DRAWN BY | DATE |
|---|---|
| HJB | 10/18/05 |
| CHECKED BY | DATE |
| REVISED BY | DATE |
| SCALE AS NOTED | |

Tetra Tech NUS, Inc.

ALTERNATIVE 4
HRC INJECTION AT HOT SPOTS AND MONITORING WELL NETWORK
OFF-SITE SOUTHERN AREA PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK

CONTRACT NO. 1610
OWNER NO. 0004
APPROVED BY / DATE
DRAWING NO. **FIGURE 4-4** REV. 0

ACAD:1610CP67.dwg 11/22/05 HJB PIT




FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

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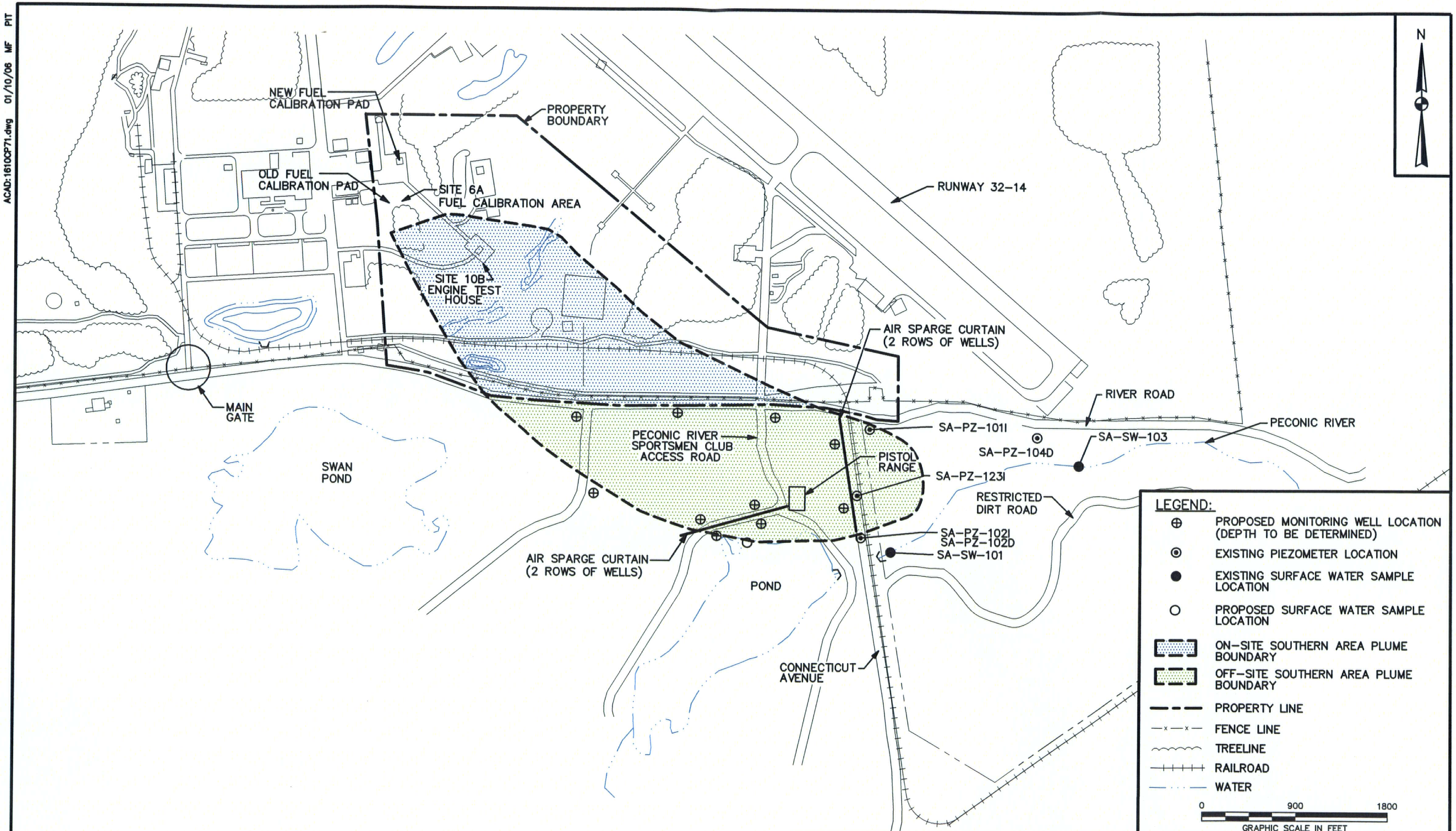
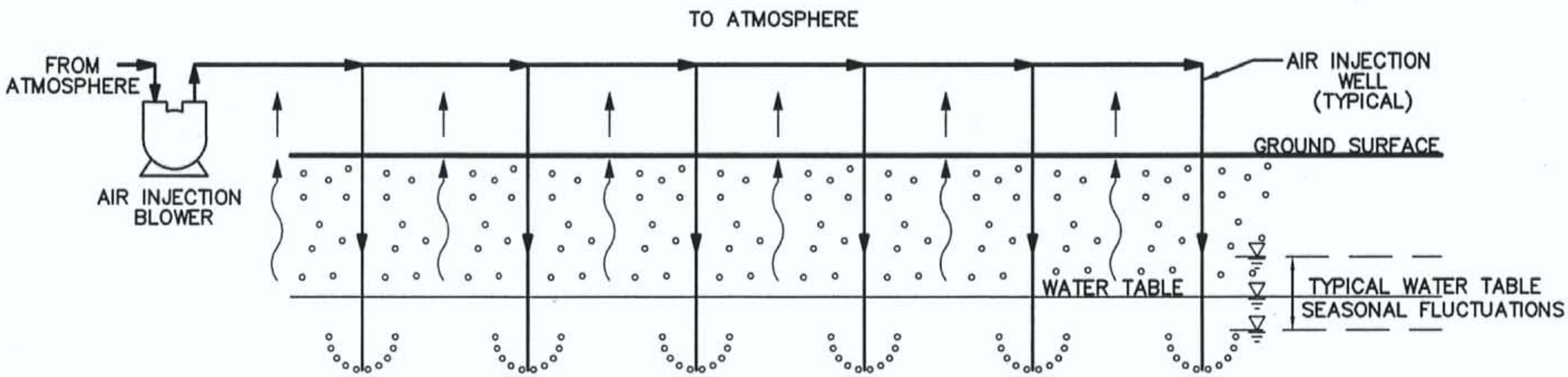



| | | | | |
|---|---|---|---|---|
| DRAWN BY MF | DATE 1/10/06 | Tetra Tech NUS, Inc. | ALTERNATIVE 6<br>AIR SPARGE CURTAINS AND MONITORING WELL NETWORK<br>OFF-SITE SOUTHERN AREA PLUME<br>NWIRP CALVERTON<br>CALVERTON, NEW YORK | CONTRACT NO. 1610 |
| CHECKED BY | DATE | | | OWNER NO. 0004 |
| REVISED BY | DATE | | | APPROVED BY / DATE |
| SCALE AS NOTED | | | | DRAWING NO. FIGURE 4-6 / REV. 0 |

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98




| DRAWN BY | DATE | | | CONTRACT NO. |
|---|---|---|---|---|
| MF | 1/10/06 | Tetra Tech NUS, Inc. | ALTERNATIVE 6<br>AIR SPARGING SYSTEMS<br>OFF-SITE SOUTHERN AREA PLUME<br>NWIRP CALVERTON<br>CALVERTON, NEW YORK | 1610 |
| CHECKED BY | DATE | | | OWNER NO. 0004 |
| REVISED BY | DATE | | | APPROVED BY / DATE |
| SCALE AS NOTED | | | | DRAWING NO. FIGURE 4-7 / REV. 0 |

# 5.0 EVALUATION OF THE CORRECTIVE MEASURES ALTERNATIVES

## 5.1 PROCEDURE FOR EVALUATING CORRECTIVE MEASURES ALTERNATIVES

The Corrective Measures Alternatives described in Section 4.3 are evaluated in this section. The alternatives are evaluated against technical, environmental, human health, and institutional criteria. Costs estimates are also provided. The format of the evaluation follows RCRA guidance; however, all of the CERCLA criteria used to evaluate remedial alternatives, except support agency and community acceptance, are addressed. Support agency and community acceptance are usually addressed after the preferred alternative has been identified.

## 5.2 EVALUATION OF OFF-SITE SOUTHERN AREA PLUME GROUNDWATER CORRECTIVE MEASURES ALTERNATIVES

### 5.2.1 <u>Alternative 1: No Action</u>

Alternative 1 addresses the Off-Site Southern Area Groundwater Plume. Under this alternative, there would be no activities.

#### 5.2.1.1 Protection of Human Health and the Environment

Alternative 1 is considered primarily for comparison to the other corrective measures. This alternative is somewhat protective of human health. Although contaminants would remain in groundwater for extended periods of time, they would slowly biodegrade and attenuate. Because there are no current users of groundwater, there are no current risks to human health. Under future potential scenarios, people could be directly exposed to groundwater if groundwater wells would be installed and the groundwater used for potable purposes without treatment. Under these scenarios, Alternative 1 would not be protective of human health.

Based on the concentrations of the contaminants (1,1,1-trichloroethane, 1,1-dichloroethane, toluene, and total xylenes) and the distance of the plume to the Peconic River (less than 300 feet), the groundwater contamination has the potential to pose significant risks to ecological receptors in the Peconic River (i.e., benthic invertebrates) in a localized area. These potential risks were determined by comparing maximum groundwater concentrations to screening criteria. There are uncertainties associated with this approach because actual chemical concentrations in the sediment pore water are likely to be lower than the maximum groundwater concentrations due to natural attenuation processes (dispersion, dilution, volatilization, etc.) that would reduce groundwater contaminant concentrations prior to discharge to the river. Potential risks to other ecological receptors are not anticipated. Therefore, Alternative 1 is not expected to be completely protective of all ecological receptors.

#### 5.2.1.2 Media Clean-Up Standards

Alternative 1 would not comply with the PRGs, which are protective of human health and the environment. Groundwater could discharge to the Peconic River. Future contaminant migration would not be known.

#### 5.2.1.3 Source Control

Alternative 1 involves no additional source control because no action would be performed for the Off-Site Southern Area Plume. One of the potential sources of contamination to the Off-Site Southern Area Plume (i.e., discharges of contaminated groundwater from the former Site 6A free product recovery system to drainage swales, overland transport, and reinfiltration) has been eliminated. If left uncontrolled, the other contaminant sources at Site 6A and 10B may continue to contribute contamination to the Off-Site Southern Area Plume. The magnitude of the impact from these sources would be unknown because no monitoring would be conducted under this alternative.

#### 5.2.1.4 Waste Management Standards

There are no actions to be implemented for Alternative 1; therefore, no waste would be generated.

#### 5.2.1.5 Other Factors

<u>Long-Term Reliability and Effectiveness</u>

The future potential threat to human health and the environment would remain because there would be no access controls or removal or treatment of the contaminants. Organic contaminants would decrease through natural attenuation but would remain in the Off-Site Southern Area Plume at levels greater than PRGs and may migrate to the Peconic River. Because monitoring would not be conducted, the long-term reliability and effectiveness of this alternative would not be known.

<u>Reduction in Toxicity, Mobility, and Volume</u>

Alternative 1 involves no reduction in toxicity, mobility, or volume of contaminants in the Off-Site Southern Area Plume other than that which would result from natural dispersion, dilution, or other attenuating factors. No treatment processes would be employed; therefore, no materials would need to be treated or destroyed.

Short-Term Effectiveness

Alternative 1 involves no action; therefore, it would not pose any risks to on-site workers during implementation. No environmental impacts would be expected. This alternative would not achieve any of the CAOs.

Implementability

Because no actions would occur, this alternative is readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost Analysis

There are no costs associated with the No Action alternative.

### 5.2.2 Alternative 2: Deed Notifications, Natural Attenuation, and Monitoring

This alternative involves limiting access to and use of the Off-Site Southern Area groundwater.

#### 5.2.2.1 Protection of Human Health and the Environment

Alternative 2 would be protective of human health by limiting site access and land use within the Off-Site Southern Area Plume. Also, contaminant concentrations within the plume and the potential for migration would be monitored.

Alternative 2 may not be protective of ecological receptors. Existing contaminants within the plume (1,1,1-trichloroethane, 1,1-dichloroethane, toluene, and total xylenes) pose current and potential future risks to ecological receptors in the Peconic River. These potential risks were determined by comparing maximum groundwater concentrations to screening criteria. There are uncertainties associated with this approach because actual chemical concentrations in the sediment pore water are likely to be lower than the maximum groundwater concentrations due to natural attenuation processes (dispersion, dilution, volatilization, etc.) that would reduce groundwater contaminant concentrations prior to discharge to the river. Potential risks to other ecological receptors are not anticipated. No actions would be taken under Alternative 2 to minimize the potential risks. Monitoring would be performed to confirm contaminant concentrations in the river and actual risks to ecological receptors.

Because the Navy does not own the property impacted by the Off-Site Southern Area Plume, deed notifications would be created and placed with the deeds to inform current and future landowners of contaminants in groundwater and to prohibit the use of the groundwater for potable water without treatment. The State of New York and local regulators may also use reclassification and zoning to restrict groundwater use in the area.

Sampling of groundwater and surface water are included in Alternative 2 to monitor contaminant migration and to determine the effectiveness of natural attenuation. Periodic review of the site (every 5 years) would be necessary to ensure that contaminant concentrations were not increasing or migrating off site and to determine whether additional measures would be necessary to protect human health and the environment.

#### 5.2.2.2 Media Clean-Up Standards

In the short term, Alternative 2 would not comply with PRGs. Because the contaminants present are biodegradable and/or subject to other natural attenuation processes, groundwater would ultimately achieve the PRGs and impacts to the adjacent Peconic River would be eliminated. However, the length of time required and the potential for contamination to migrate to currently uncontaminated areas is uncertain. Predictions indicate that it could take over 30 years to attain PRGs for some COCs. Deed notifications would be used to prevent exposure to groundwater with contaminant concentrations greater than clean-up standards.

#### 5.2.2.3 Source Control

Alternative 2 does not involve additional source control because only deed notifications would be implemented. One of the potential sources of contamination to the Off-Site Southern Area Plume (i.e., discharges of contaminated groundwater from the former Site 6A free product recovery system to drainage swales, overland transport, and reinfiltration) has been eliminated. If left uncontrolled, the other contaminant sources at Site 6A and 10B may continue to contribute contamination to the Off-Site Southern Area Plume. For this alternative, the magnitude of the impact from these sources would be evaluated through monitoring.

#### 5.2.2.4 Waste Management Standards

Alternative 2 involves no direct removal of contaminated groundwater; therefore, this alternative would not generate any wastes. However, under this alternative incidental amounts of groundwater would be removed during groundwater monitoring activities, and this groundwater would be stored, transported, treated, and disposed in accordance with applicable State and federal regulations.

#### 5.2.2.5 Other Factors

Long-Term Reliability and Effectiveness

Although no removal would occur in Alternative 2, the potential threats to human health would be minimized. This limited action alternative would use deed notifications to limit future use of the area. Deed notifications have uncertain long-term effectiveness because they need to be maintained by the land owner. The Navy does not own the impacted property. The protection of existing and future human receptors would depend on effective administration and management of the notifications by the Navy, existing property owners, and the State of New York. The State of New York and local regulators may also use reclassification and zoning to restrict groundwater use in the area, which may prove to be more effective than deed notifications. A re-evaluation of the site would be performed every 5 years to determine whether any changes to the controls would be required.

Also, because there is the possibility that contaminated groundwater would migrate faster than it is attenuating, currently uncontaminated areas and the Peconic River could be impacted. Monitoring would be used to address this concern and to evaluate the effectiveness of natural attenuation. In the event that contaminant concentrations are increasing in the downgradient areas and impacting the Peconic River, additional actions may be required.

Reduction in Toxicity, Mobility, and Volume

Alternative 2 would not result in reduction in toxicity, mobility, or volume through treatment of the hazardous substances within the Off-Site Southern Area Plume other than that which would result from natural dispersion, dilution, or other attenuating factors.

Short-Term Effectiveness

Alternative 2 would involve groundwater and surface water monitoring, administration of deed notifications, and potential restriction of residential land use. The short-term risks associated with these limited remedial activities would be minimal. Sampling personnel would wear the required personal protective equipment (PPE) and receive the appropriate health and safety training. There would be no potential risk to the community or environmental impacts upon the implementation of institutional controls.

Implementability

Alternative 2 is expected to be implementable; however, it may be more difficult to implement because the Navy does not own the land impacted by the Off-Site Southern Area Plume, and it cannot directly enforce rules and local ordinances. The Navy would need to reach agreements with current land owners, the State of New York, and local regulators regarding the deed notifications and other land use controls. Restrictions for future property use would require legal assistance and regulatory approval, which could extend the time required for implementation. The sampling and analysis tasks to be conducted under Alternative 2 are readily implemented.

Cost Analysis

The following costs are estimated for Alternative 2:

| | |
|---|---|
| Capital Costs: | $97,600 |
| O&M Costs: | $0 |
| Monitoring Costs: | $50,800 per year (Year 1) |
| | $17,900 per year (Years 2 through 30) |
| | $23,000 per year (every 5 years) |
| 30-Year Present Worth: | $400,000 |

Detailed cost estimates are included in Appendix C.

### 5.2.3 Alternative 3: Deed Notifications, Groundwater Extraction (Wells), Treatment (Air Stripping/Activated Carbon), Disposal (Direct Discharge and Reinjection), and Monitoring

This alternative consists of implementing deed notifications for the Off-Site Southern Area Plume, extracting the contaminated groundwater, treating and disposing of the water, and monitoring the progress of groundwater remediation and evaluating impacts to the Peconic River.

#### 5.2.3.1 Protection of Human Health and the Environment

Alternative 3 would eventually be protective of human health and the environment by containing and treating contaminated groundwater in the Off-Site Southern Area Plume. Contamination present in the aquifer downgradient of the extraction systems prior to its installation may continue to pose a threat to ecological receptors in the Peconic River until the contaminants decrease to PRGs via natural biodegradation and other attenuation processes. The extracted groundwater would be treated to PRGs using air stripping prior to discharge. The effluent would be disposed by a combination of direct discharge to the Peconic River and reinfiltration to the shallow aquifer. This approach is necessary to minimize potential extraction system impacts (dewatering) on wetlands and the Peconic River. Long-term monitoring of groundwater and surface water would be conducted to determine the effectiveness of this alternative.

Restrictions on groundwater use would be implemented to prevent exposure to contaminated groundwater during the remediation process.

#### 5.2.3.2 Media Clean-Up Standards

In the short term, Alternative 3 would not comply with groundwater PRGs. Contaminated groundwater would be extracted to prevent additional contaminant migration and then treated prior to disposal. It is expected that groundwater contaminants would ultimately decrease to PRGs through groundwater extraction and treatment and natural attenuation processes. However, the length of time required to achieve the PRGs is expected to be 16 years.

Similar to Alternative 2, deed notifications or other regulatory controls would be implemented and enforced to prevent exposure to groundwater while contaminant concentrations are greater than PRGs.

#### 5.2.3.3 Source Control

This alternative would extract and treat contaminated groundwater and reduce the potential for direct contact with contaminated groundwater and further contaminant migration. The major historical source of contamination to the Off-Site Southern Area Plume (i.e., discharges of contaminated groundwater from the former Site 6A free product recovery system to drainage swales, overland transport, and reinfiltration) has been eliminated. If left uncontrolled, the other contaminant sources at Site 6A and 10B would continue to contribute contamination to the Off-Site Southern Area Plume. For this alternative, it was assumed that a majority of both sources would be addressed. The fuel calibration and engine testing previously conducted at Sites 6A and 10B are no longer conducted; therefore, no additional contaminant releases should occur at these sites. No other sources of contamination are known to be present in the Off-Site Southern Area.

#### 5.2.3.4 Waste Management Standards

Groundwater extracted from the Off-Site Southern Area Plume would be treated on site and disposed by direct discharge to the Peconic River and reinjection to the surficial aquifer. Both direct discharge and reinjection of the effluent would be managed under State and federal regulations, and permits would be required.

Treatment residues generated during the groundwater treatment process include metal sludges and possibly spent GAC. The off-gas from the air stripper would be treated if required. Sludges and/or possibly GAC residuals would be loaded into suitable containers and transferred to appropriate off-site treatment/disposal facilities.

Incidental amounts of soil cuttings generated during installation of extraction and monitoring wells and groundwater generated during groundwater monitoring would be managed in accordance with State and federal regulations. They would be loaded into suitable containers and transferred to appropriate off-site treatment/disposal facilities.

Equipment used on site during implementation of this alternative may come in contact with potentially hazardous chemicals in the contaminated groundwater. The equipment would be decontaminated prior to leaving the site. Decontamination water would be collected, sampled, and if required, properly treated and disposed.

#### 5.2.3.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative 3 would provide good long-term effectiveness because groundwater extraction would be very effective at containing contaminated groundwater and somewhat effective at contaminant reduction. Long-term monitoring would be conducted to determine the effectiveness of this alternative.

Contaminant concentrations in groundwater commonly level off at concentrations greater than PRGs during implementation of groundwater extraction alternatives. If this occurs, the alternative would continue to be effective for containment, but it would not be effective for contaminant reduction. If containment is no longer a concern, the systems could be shut down and the alternative switched to natural attenuation.

Groundwater extraction and treatment systems require periodic maintenance of mechanical components. Components susceptible to failure include wells (due to clogged screens due to iron scaling or fine-grained material), pumps, and electrical components. Proper O&M of the system would be required to maintain its reliability and effectiveness.

The effectiveness of the groundwater treatment system would be monitored through confirmation sampling of the treated effluent and gas emissions of the air stripper. The effectiveness of the treatment system residuals would be confirmed by sampling and testing before the material is shipped off site for treatment/disposal.

During the installation and monitoring of the systems, PPE would be used and monitoring conducted to ensure that exposure of workers to potentially contaminated material is minimized.

Reduction in Toxicity, Mobility, and Volume

Alternative 3 would utilize treatment of contaminated groundwater to reduce the toxicity, mobility, and volume of the waste. The toxicity of the VOCs would be eliminated through photochemical degradation in the atmosphere, thermal destruction during regeneration of activated carbon, if required, and/or natural in-situ biodegradation. The treatment residuals would be transported off site to a permitted treatment/disposal facility.

Short-Term Effectiveness

Alternative 3 would be effective in the short term by following safe work practices. The contaminant concentrations within the groundwater of the Off-Site Southern Area Plume are expected to be relatively low, and exposure to groundwater by site workers would be managed by appropriate health and safety practices and PPE during implementation. If air stripping is used to treat the groundwater, the off-gas would be treated as required to comply with State requirements. One potential risk to the community would be during transport of the contaminated treatment residuals off site for treatment and disposal. The residues to be collected are not anticipated to be hazardous; therefore, this risk is anticipated to be minimal. Because of the relatively high groundwater extraction rates, this alternative may in the short-term dewater sensitive wetlands in localized areas and impact ecological receptors.

Implementability

The system components of Alternative 3 are readily implementable; however, the legal, regulatory, and permitting components of the alternative may make it difficult to implement. Drilling contractors and equipment are readily available for extraction well installation, and treatment equipment is also readily available for ex-situ treatment of the groundwater. The remedial technologies are well proven and established in the remediation and construction industries. Groundwater extraction and treatment systems would require O&M. Contractors and equipment are available to conduct the O&M. Treatment/disposal facilities are available for the treatment system residuals. Sampling and analysis are also readily implementable.

The Navy does not own the land impacted by the Off-Site Southern Area Plume, and it cannot directly enforce rules and local ordinances, which may make implementation of Alternative 3 more difficult. Some of the Off-Site Southern Area contains sensitive ecological habitat (wetlands and Peconic River), and it is within the 100-year flood plain of the Peconic River. Certain kinds of activities and development are restricted or require permits in these types of areas, which may make implementation of Alternative 3 difficult. The Navy would also need to reach agreements with current land owners, the State of New York, and local regulators regarding the deed notifications/other land use controls and placement of extraction wells, treatment facility, and infiltration galleries. Significant site preparation work (e.g., clearing and grubbing) would be required prior to installing the infiltration galleries. Permits would be required for well installation and effluent disposal by direct discharge and reinfiltration.

Cost Analysis

The following costs are estimated for Alternative 3:

| | |
|---|---|
| Capital Costs: | $4,285,000 |
| O&M Costs: | $226,900 per year (Year 1) |
| | $224,200 per year (Year 2 through Year 16) |
| Monitoring Costs: | $52,500 per year (Year 1) |
| | $18,100 per year (Year 2 through Year 16) |
| | $23,000 per year (every 5 years) |
| 30-Year Present Worth: | $6,644,000 |

Detailed cost estimates are provided in Appendix C.

### 5.2.4 Alternative 4: Deed Notifications, In-Situ Biological Treatment (Hot Spot Treatment with HRC®), Natural Attenuation, and Monitoring

Alternative 4 was developed as an active in-situ bioremediation alternative. This alternative consists of implementing deed notifications, treating hot spots in the Off-Site Southern Area Plume with HRC® to reduce contaminant concentrations and to minimize future contaminant migration and discharge to the Peconic River, and conducting monitoring.

#### 5.2.4.1 Protection of Human Health and the Environment

Alternative 4 would eventually be protective of human health and the environment by treating groundwater hot spots in the Off-Site Southern Area Plume to minimize downgradient contaminant migration to the Peconic River. HRC®-assisted bioremediation would degrade the majority of contaminants in the groundwater hot spots. Contamination in the aquifer outside of the hot spot treatment areas may continue to pose a threat to ecological receptors in the Peconic River until contaminant concentrations decrease to PRGs via natural biodegradation and other attenuation processes.

HRC® treatment may mobilize iron in the groundwater that could precipitate out when it discharges to the Peconic River causing iron staining. The iron staining should not impact human health or the environment, but it may present an aesthetic problem in the Peconic River, which is classified as a Scenic River. One of the three hot spots is close enough to the Peconic River for iron staining to be a potential problem.

Monitoring (groundwater and surface water) would be conducted to determine the effectiveness of the alternative and whether additional action would be necessary. Controls would be implemented to ensure contaminated groundwater would not be extracted or used for drinking until groundwater concentrations were less than PRGs.

#### 5.2.4.2 Media Clean-Up Standards

Alternative 4 would eventually comply with most groundwater PRGs. The use of HRC® would expedite remediation of most contaminants in groundwater, especially the chlorinated solvents, when compared to natural attenuation. Natural attenuation processes would ultimately reduce the remaining contaminant concentrations to the PRGs. PRG attainment is expected to take up to 10 years. Monitoring would be conducted to determine contaminant concentration trends. Deed notifications would be used to prevent exposure to groundwater with contaminant concentrations greater than PRGs.

#### 5.2.4.3 Source Control

This alternative would use HRC®-assisted bioremediation to treat in situ the groundwater hot spots with contaminant concentrations in excess of PRGs. This action would reduce the potential for further migration of contaminated groundwater that could pose a threat to human health and the environment. The major historical source of contamination to the Off-Site Southern Area Plume (i.e., discharges of contaminated groundwater from the former Site 6A free product recovery system to drainage swales, overland transport, and reinfiltration) has been eliminated. If left uncontrolled, the other contaminant sources at Site 6A and 10B would continue to contribute contamination to the Off-Site Southern Area Plume. For this alternative, it was assumed that a majority of both sources would be addressed. The fuel calibration and engine testing previously conducted at Sites 6A and 10B are no longer conducted; therefore, no additional contaminant releases should occur at these sites. No other sources of contamination are known to be present in the Off-Site Southern Area.

#### 5.2.4.4 Waste Management Standards

During implementation of Alternative 4, contaminated groundwater would be treated in situ using HRC®-assisted bioremediation and natural attenuation processes, and minimal waste would be generated that would require off-site treatment and disposal. Waste management practices would be used during implementation of the alternative to avoid spreading contamination. Minor amounts of drill cuttings and purge water would be generated during monitoring well installation and monitoring. These wastes would be loaded into suitable containers for transportation to an off-site treatment/disposal facility.

Equipment used on site may come in contact with potentially hazardous chemicals (contaminated groundwater). The equipment would be decontaminated prior to leaving the site. Decontamination water would be collected, sampled, and if required, properly treated and disposed.

#### 5.2.4.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative 4 is expected to provide reasonable long-term effectiveness because HRC®-assisted bioremediation is expected to be very effective at treating solvent-contaminated groundwater hot spots, and natural attenuation can be effective for treating the remaining BTEX- and solvent-contaminated groundwater. It is expected that two doses of HRC® will be applied to each hot spot to improve the effectiveness of the treatment. Long-term monitoring would be conducted to determine the effectiveness of this alternative.

Contaminant concentrations in groundwater commonly level off at concentrations greater than PRGs during implementation of in-situ groundwater treatment alternatives. This alternative includes implementation of natural attenuation as well as hot spot treatment with HRC® to complete groundwater remediation to the PRGs.

During each installation of HRC® and each round of monitoring, PPE would be used and monitoring conducted to ensure that exposure of workers to potentially contaminated material is minimized.

Reduction in Toxicity, Mobility, and Volume

Alternative 4 would utilize treatment of contaminated groundwater by in-situ bioremediation to reduce the toxicity, mobility, and volume of the waste. The treatment process would convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, and/or inert.

Short-Term Effectiveness

Alternative 4 would be effective in the short term by following safe work practices. Site workers would receive the appropriate health and safety training and would wear the required PPE during implementation. HRC® is a nonhazardous product (non-toxic, food-grade, soluble polylactate ester mixture). The minor amounts of contaminated material generated during monitoring for this alternative should have no significant impact on the community during transportation off site for treatment/disposal.

Potential human exposure to contaminated groundwater and impacts to downgradient ecological receptors in the Peconic River would be reduced through implementation of this alternative. It is unlikely that implementation of this alternative would result in any environmental impacts.

Implementability

Alternative 4 is considered to be implementable, but some components may be difficult to implement. The alternative involves biostimulation/bioremediation with HRC®, which is considered an innovative technology, and natural attenuation. Contractors and equipment are available for injection of the HRC® and installation of additional wells. The remedial technologies of HRC® and natural attenuation have been the subject of studies that have established them as viable for fuel- and solvent-contaminated groundwater. Sampling and analysis are also readily implementable.

The Navy does not own the land impacted by the Off-Site Southern Area Plume, and it cannot directly enforce rules and local ordinances, which may make implementation of Alternative 4 more difficult. Some of the Off-Site Southern Area contains sensitive ecological habitat (wetlands and Peconic River), and it is within the 100-year flood plain of the Peconic River. Certain kinds of activities and development are restricted or require permits in these types of areas, which may make implementation of Alternative 4 difficult. The Navy would also need to reach agreements with current land owners, the State of New York, and local regulators regarding the deed notifications/other land use controls and placement of monitoring wells. Permits would be required for well installation and HRC® injection.

Cost Analysis

The following costs are estimated for Alternative 4:

| | |
|---|---|
| Capital Costs: | $391,400 (Year 0) |
| | $1,010,000 per year (Years 0 through 1) |
| O&M Costs: | $0 |
| Monitoring Costs: | $52,500 per year (Year 1) |
| | $18,100 per year (Years 2 through 10) |
| | $23,000 per year (every 5 years) |
| 30-Year Present Worth: | $2,532,000 |

Detailed cost estimates are provided in Appendix C.

### 5.2.5 Alternative 5: Deed Notifications, In-Situ Biological Treatment (Biobarrier with HRC®), Natural Attenuation, and Monitoring

Alternative 5 was developed as a passive in-situ bioremediation alternative. This alternative consists of implementing deed notifications, creating and maintaining HRC® barriers to biologically treat the COCs prior to downgradient migration, and conducting monitoring.

#### 5.2.5.1 Protection of Human Health and the Environment

Alternative 5 would eventually be protective of human health and the environment by treating groundwater in the Off-Site Southern Area Plume prior to downgradient migration to the Peconic River. HRC®-assisted bioremediation would degrade the majority of contaminants in the groundwater plume. Contamination present in the aquifer downgradient of the treatment barriers prior to their installation may continue to pose a threat to ecological receptors in the Peconic River until contaminant concentrations decrease to PRGs via natural biodegradation and other attenuation processes.

HRC® treatment may mobilize iron in the groundwater that could precipitate out when it discharges to the Peconic River causing iron staining. The iron staining should not impact human health or the environment, but it may present an aesthetic problem in the Peconic River, which is classified as a Scenic River. Because of their location and the required treatment duration (16 years), it is likely that the two treatment barriers would cause iron staining in the Peconic River.

Monitoring (groundwater and surface water) would be conducted to determine the effectiveness of the alternative and whether additional action would be necessary. Controls would be implemented to ensure contaminated groundwater would not be extracted or used for drinking until groundwater concentrations were less than PRGs.

#### 5.2.5.2 Media Clean-Up Standards

Alternative 5 would eventually comply with most groundwater PRGs. The use of HRC® would address most contaminants in groundwater, especially the chlorinated solvents. Natural attenuation processes would ultimately reduce the remaining contaminant concentrations to the PRGs. PRG attainment is expected to take up to 16 years. Monitoring would be conducted to determine contaminant concentration trends. Deed notifications would be used to prevent exposure to groundwater with contaminant concentrations greater than PRGs.

#### 5.2.5.3 Source Control

This alternative would use HRC®-assisted bioremediation to contain and treat in situ the groundwater with contaminant concentrations in excess of PRGs. This action would reduce the potential for further migration of contaminated groundwater that could pose a threat to human health and the environment. The major historical source of contamination to the Off-Site Southern Area Plume (i.e., discharges of contaminated groundwater from the former Site 6A free product recovery system to drainage swales, overland transport, and reinfiltration) has been eliminated. If left uncontrolled, the other contaminant sources at Sites 6A and 10B would continue to contribute contamination to the Off-Site Southern Area Plume. It was assumed for this alternative that a majority of both sources would be addressed. The fuel calibration and engine testing previously conducted at Sites 6A and 10B are no longer conducted; therefore, no additional contaminant releases should occur at those sites. No other sources of contamination are known to be present in the Off-Site Southern Area.

#### 5.2.5.4 Waste Management Standards

During implementation of Alternative 5, contaminated groundwater would be contained and treated in situ using HRC®-assisted bioremediation and natural attenuation processes, and minimal waste would be generated that would require off-site treatment and disposal. Waste management practices would be used during implementation of the alternative to avoid spreading contamination. Minor amounts of drill cuttings and purge water would be generated during monitoring well installation and monitoring. These wastes would be loaded into suitable containers for transportation to an off-site treatment/disposal facility.

Equipment used on site may come in contact with potentially hazardous chemicals (contaminated groundwater and soil). The equipment would be decontaminated prior to leaving the site. Decontamination water would be collected, sampled, and if required, properly treated and disposed.

#### 5.2.5.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative 5 is expected to provide reasonable long-term effectiveness because HRC®-assisted bioremediation is expected to be very effective at treating solvent-contaminated groundwater, and natural attenuation can be effective for treating both BTEX- and solvent-contaminated groundwater. Long-term monitoring would be conducted to determine the effectiveness of this alternative.

Contaminant concentrations in groundwater commonly level off at concentrations greater than PRGs during implementation of in-situ groundwater treatment alternatives. This alternative includes implementation of natural attenuation as well as an HRC® barrier to complete groundwater remediation to the PRGs.

During each installation of the HRC® barrier and groundwater monitoring, PPE would be used and monitoring conducted to ensure that exposure of workers to potentially contaminated material is minimized.

Reduction in Toxicity, Mobility, and Volume

Alternative 5 would utilize treatment of contaminated groundwater by in-situ bioremediation to reduce the toxicity, mobility, and volume of the waste. The treatment process would convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, and/or inert.

Short-Term Effectiveness

Alternative 5 would be effective in the short term by following safe work practices. Site workers would receive the appropriate health and safety training and would wear the required PPE during implementation. The minor amounts of contaminated material generated during groundwater and surface water monitoring for this alternative should have no significant impact to the community during transportation off site for treatment/disposal. HRC® is a nonhazardous product (non-toxic, food-grade, soluble polylactate ester mixture). The potential for environmental impacts from the implementation of this alternative are considered to be relatively low. Because large quantities of HRC® would be injected into the aquifer under this alternative to maintain the barrier for 16 years, it is possible that all of the HRC® may not be consumed by biodegradation in the aquifer and it could migrate to the Peconic River. If significant quantities of HRC® migrate and discharge to the river, it would increase the BOD loading to the river, reducing dissolved oxygen in the river and causing potential impacts to ecological receptors. The impacts would be greatest during low flow conditions in the river. Potential human exposure to contaminated groundwater and impacts to downgradient ecological receptors in the Peconic River would be reduced through implementation of this alternative.

Implementability

Alternative 5 is considered to be implementable, but some components may be difficult to implement. It involves biostimulation/bioremediation with HRC®, which is considered an innovative technology, and natural attenuation. Contractors and equipment are available for injection of the HRC® and installation of additional wells. The remedial technologies of HRC® and natural attenuation have been the subject of studies that have established them as viable for BTEX- and solvent-contaminated groundwater. Sampling and analysis are also readily implementable.

The Navy does not own the land impacted by the Off-Site Southern Area Plume, and it cannot directly enforce rules and local ordinances, which may make implementation of Alternative 5 more difficult. Some of the Off-Site Southern Area contains sensitive ecological habitat (wetlands and Peconic River), and it is within the 100-year flood plain of the Peconic River. Certain kinds of activities and development are restricted or require permits in these types of areas, which may make implementation of Alternative 5 difficult. The Navy would also need to reach agreements with current land owners, the State of New York, and local regulators regarding the deed notifications/other land use controls and placement of monitoring wells. Permits would be required for well installation and HRC® injection.

Cost Analysis

The following costs are estimated for Alternative 5:

| | |
|---|---|
| Capital Costs: | \$391,400 (Year 0) |
| | \$5,648,000 (Years 0 through 15) |
| O&M Costs: | \$0 |
| Monitoring Costs: | \$60,400 per year (Year 1) |
| | \$19,500 per year (Years 2 through 16) |
| | \$23,000 per year (every 5 years) |
| 30-year Present Worth: | \$57,733,000 |

Detailed cost estimates are provided in Appendix C.

### 5.2.6 Alternative 6: Deed Notifications, In-Situ Physical Treatment (Air Sparge Curtain), Natural Attenuation, and Monitoring

Alternative 6 was developed as an in-situ physical treatment alternative. This alternative consists of implementing deed notifications, creating and maintaining two air sparge curtains to contain/treat the COCs prior to downgradient migration, and conducting monitoring.

#### 5.2.6.1 Protection of Human Health and the Environment

Alternative 6 would eventually be protective of human health and the environment by treating groundwater in the Off-Site Southern Area Plume prior to downgradient migration to the Peconic River. The air sparge curtains would volatilize the majority of contaminants in the groundwater plume. Contamination present in the aquifer downgradient of the air sparge curtains prior to their installation may continue to pose a threat to ecological receptors in the Peconic River until contaminant concentrations decrease to PRGs via natural biodegradation and other attenuation processes.

The injection of air through the air sparge curtains should not adversely impact human health or the environment, and it may improve dissolved oxygen concentrations in the groundwater that discharges to the Peconic River, which is classified as a Scenic River.

Because of their location and the required treatment duration (16 years), it is likely that the two air sparge curtains may cause groundwater mounding and contaminant migration in new directions. Monitoring (groundwater and surface water) would be conducted to determine the effectiveness of the alternative and whether additional action would be necessary. Controls/deed notifications would be implemented to ensure contaminated groundwater would not be extracted or used for drinking until groundwater concentrations were less than PRGs.

#### 5.2.6.2 Media Clean-Up Standards

Alternative 6 would eventually comply with most groundwater PRGs. The use of air sparging would address most contaminants in groundwater. Natural attenuation processes would also aid in reducing contaminant concentrations to the PRGs. PRG attainment is expected to take up to 16 years. Monitoring would be conducted to determine contaminant concentration trends. Deed notifications would be used to prevent exposure to groundwater with contaminant concentrations greater than PRGs.

#### 5.2.6.3 Source Control

This alternative would use air sparge curtains to contain and treat in situ the groundwater with contaminant concentrations in excess of PRGs. This action would reduce the potential for further migration of contaminated groundwater that could pose a threat to human health and the environment. The major historical source of contamination to the Off-Site Southern Area Plume (i.e., discharges of contaminated groundwater from the former Site 6A free product recovery system to drainage swales, overland transport, and reinfiltration) has been eliminated. If left uncontrolled, the other contaminant sources at Sites 6A and 10B would continue to contribute contamination to the Off-Site Southern Area Plume. It was assumed for this alternative that a majority of both sources would be addressed. The fuel calibration and engine testing previously conducted at Sites 6A and 10B are no longer conducted; therefore, no additional contaminant releases should occur at those sites. No other sources of contamination are known to be present in the Off-Site Southern Area.

#### 5.2.6.4 Waste Management Standards

During implementation of Alternative 6, contaminated groundwater would be contained and treated in situ using air sparging and natural attenuation processes, and minimal waste would be generated that would require off-site treatment and disposal. Waste management practices would be used during implementation of the alternative to avoid spreading contamination. Minor amounts of drill cuttings and/or purge water would be generated during well installation (air sparge and monitoring wells) and monitoring. These wastes would be loaded into suitable containers for transportation to an off-site treatment/disposal facility.

Equipment used on site may come in contact with potentially hazardous chemicals (contaminated groundwater and soil). The equipment would be decontaminated prior to leaving the site. Decontamination water would be collected, sampled, and if required, properly treated and disposed.

#### 5.2.6.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative 6 is expected to provide reasonable long-term effectiveness because air sparging and natural attenuation are expected to be very effective at treating VOC-contaminated groundwater. Natural attenuation processes would act as a pre-treatment process by reducing existing contaminant concentrations as the plume migrates downgradient to the air sparge curtains. The major historical source of contamination to the Off-Site Southern Area Plume has been eliminated. It is expected that the other contaminant sources at Sites 6A and 10B would be addressed and not continue to contribute contamination to the Off-Site Southern Area Plume. Long-term monitoring would be conducted to determine the effectiveness of this alternative.

During installation of the air sparge curtains and groundwater monitoring, PPE would be used and monitoring conducted to ensure that exposure of workers to potentially contaminated material is minimized.

Reduction in Toxicity, Mobility, and Volume

Alternative 6 would utilize treatment of contaminated groundwater by in-situ air sparging to reduce the toxicity, mobility, and volume of the waste. The treatment process would transfer contaminants from liquid phase to a gas that will dissipate in the atmosphere.

Short-Term Effectiveness

Alternative 6 would be effective in the short term by following safe work practices. Site workers would receive the appropriate health and safety training and would wear the required PPE during implementation.

The minor amounts of contaminated material generated during groundwater and surface water monitoring for this alternative should have no significant impact to the community during transportation off site for treatment/disposal. Safe work practices would also need to be followed during the installation of the additional electrical service and pressurized air supply lines required for the air sparge systems.

The potential for environmental impacts from the implementation of this alternative are considered to be relatively low. Potential human exposure to contaminated groundwater and impacts to downgradient ecological receptors in the Peconic River would be reduced through implementation of this alternative.

Implementability

Alternative 6 is considered to be implementable, but some components may be difficult to implement. Contractors and equipment are available for installation and operation of the air sparge curtains. Operation of the systems for 16 years would pose operation and maintenance issues. Redundant equipment would need to be incorporated into the systems to allow for maintenance issues. Air sparging at depths of 90 to 100 feet has been implemented at other sites to remediate VOCs, but it is considered somewhat innovative. Sampling and analysis are readily implementable.

The Navy does not own the land impacted by the Off-Site Southern Area Plume, and it cannot directly enforce rules and local ordinances, which may make implementation of Alternative 6 more difficult. Some of the Off-Site Southern Area contains sensitive ecological habitat (wetlands and Peconic River), and it is within the 100-year flood plain of the Peconic River. Certain kinds of activities and development are restricted or require permits in these types of areas, which may make implementation of Alternative 6 difficult. The Navy would also need to reach agreements with current land owners, the State of New York, and local regulators regarding the deed notifications/other land use controls and placement of monitoring wells. Permits would be required for well installation.

Cost Analysis

The following costs are estimated for Alternative 6:

| | |
|---|---|
| Capital Costs: | $2,406,000 (Year 0) |
| O&M Costs: | $398,200 (Years 1 through 16) |
| Monitoring Costs: | $60,400 per year (Year 1) |
| | $19,500 per year (Years 2 through 16) |
| | $23,000 per year (every 5 years) |
| 30-year Present Worth: | $6,426,000 |

Detailed cost estimates are provided in Appendix C.

## 5.3 JUSTIFICATION

### 5.3.1 Technical

No actions would occur under Alternative 1; therefore, there would be no technical issues associated with implementation of the alternative. All of the alternatives, excluding Alternative 1, would include monitoring requirements and deed notifications in transfer documents until groundwater PRGs are met. Alternative 2 would passively address groundwater contamination with natural attenuation and controls. Alternatives 3, 5, and 6 would contain the groundwater plume and prevent downgradient migration. Alternative 4 would treat the contaminant hot spots in the groundwater and address the remaining contamination with natural attenuation and controls. All four alternatives (3, 4, 5, and 6) would provide some type of treatment of contaminants in the groundwater. Alternatives 3 and 6 would include O&M during its implementation. Alternative 5 would require 16 annual treatments with HRC®. Alternative 2 would remediate all of the contaminated groundwater in approximately 30 years. Alternatives 3, 5, and 6 would address the contaminated groundwater within a shorter period of time (approximately 16 years). Alternative 4 is expected to address the Off-Site Southern Area Plume within 10 years. All five alternatives are implementable.

### 5.3.2 Human Health

Alternative 1 would not be protective of human health or the environment because the alternative does not include controls on potential future groundwater use or reduce the potential for downgradient contaminant migration. Immediate risks from direct contact with contaminated groundwater would be addressed by implementing deed notifications and other controls in Alternatives 2, 3, 4, 5, and 6. Alternative 2 would allow natural attenuation to slowly remediate groundwater contamination and ultimately protect human health. Alternatives 3, 5, and 6 would contain and ultimately treat the contaminated groundwater to protect human health. Alternative 4 would treat the contaminated groundwater in three hot spots and then allow natural attenuation to remediate the remaining groundwater contamination and ultimately protect human health. Alternatives 3, 5, and 6 would be equally protective, followed by Alternative 4 and then Alternative 2.

### 5.3.3 Environmental

Implementation of Alternatives 1, 2, 4, and 6 are not expected to adversely affect the environment; however, implementation of Alternatives 3 and 5 may adversely affect the environment. Alternative 3 may cause localized dewatering wetlands and ponds and Alternative 5 may result in increased BOD loading to the Peconic River which could reduce dissolved oxygen concentrations. Alternatives 3, 4, 5, and 6 would minimize the migration of contaminated groundwater off site and the impacts to downgradient environmental receptors. Alternatives 1 and 2 would allow contaminant concentrations in groundwater to remain greater than PRGs longer than the other alternatives, resulting in an increased potential for downgradient migration and impact to environmental receptors in the Peconic River.

### 5.3.4 Cost Estimates

The estimated capital, O&M, and net present worth costs of all groundwater alternatives are presented in Table 5-1.

TABLE 5-1

SUMMARY OF CAPITAL, ANNUAL, O&M, AND PRESENT WORTH COSTS ESTIMATES
OFF-SITE SOUTHERN AREA PLUME
NWIRP CALVERTON, NEW YORK

| Alternative | Capital Cost | Annual Cost | O&M | Net Present Worth |
|---|---|---|---|---|
| **OFF-SITE SOUTHERN AREA PLUME** | | | | |
| Alternative 1 - No Action | $0 | $0 | $0 | $0 |
| Alternative 2 - Deed Notifications, Natural Attenuation, and Monitoring | $97,600 | Year 1 $50,800<br>Years 2 - 30 $17,900<br>Every 5 Years $23,000 | --- | $400,000 |
| Alternative 3 - Deed Notifications, Groundwater Extraction (Wells), Treatment (Air Stripping/Activated Carbon), Disposal (Direct Discharge and Re-Injection), and Monitoring | $4,285,000 | Year 1 $52,500<br>Years 2 - 16 $18,100<br>Every 5 Years $23,000 | Year 1 $226,900<br>Years 2 - 16 $224,200 | $6,644,000 |
| Alternative 4 - Deed Notifications, In-Situ Biological Treatment (Hot Spot Treatment with HRC), Natural Attenuation, and Monitoring | Year 0 $391,400<br>(Plans and Monitoring Well Installation)<br>Years 0 - 1 $1,010,000<br>( HRC® Injection) | Year 1 $52,500<br>Years 2 - 10 $18,100<br>Every 5 Years $23,000 | --- | $2,532,000 |
| Alternative 5 - Deed Notifications, In-Situ Biological Treatment (Biobarrier with HRC), Natural Attenuation, and Monitoring | Year 0 $391,400<br>(Plans and Monitoring Well Installation)<br>Years 0 - 15 $5,648,000<br>(HRC® Injection) | Year 1 $60,400<br>Years 2 - 16 $19,500<br>Every 5 Years $23,000 | --- | $57,733,000 |
| Alternative 6 - Deed Notifications, In-Situ Physical Treatment (Air Sparge Curtain), Natural Attenuation, and Monitoring | $2,406,000 | Year 1 $60,400<br>Years 2 - 16 $19,500<br>Every 5 Years $23,000 | Years 1 - 16 $398,200 | $6,426,000 |

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# APPENDIX A

## VOLUME, MASS, AND ATTENUATION FACTOR CALCULATIONS

A.1 VOLUME AND MASS CALCULATIONS

A.2 ATTENUATION FACTOR CALCULATIONS

## A.1 VOLUME AND MASS CALCULATIONS

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 | |
|---|---|---|---|
| SUBJECT: Volume and Mass Calculations (Off-Site Southern Area) | | | |
| BASED ON: Attached Figure | | DRAWING NUMBER: | |
| BY: CAR<br>Date: 11-04-05 | CHECKED BY: MJS<br>Date: 11/11/05 | APPROVED BY: | DATE: |

**OBJECTIVE:**

Calculate the volume of contaminated groundwater and the mass of dissolved contaminants within the Off-Site Southern Area groundwater contaminant plume.

**DISCUSSION:**

Several phases of investigation have been completed to delineate the extent of the groundwater contaminant plume in the Off-Site Southern Area (See Section 2 of this CMS). Based on the groundwater PRGs, the groundwater COCs include the following:

| | | |
|---|---|---|
| 1,1,1-Trichloroethane | 1,1-Dichloroethene | Chloroethane |
| 1,1,2-Trichloroethane | 1,2-Dichloroethane | Toluene |
| 1,1-Dichloroethane | Benzene | Total Xylenes |

**REFERENCES:**

(1) Phase 2 Remedial Investigation for Site 6A - Fuel Calibration Area, Site 10B - Engine Test House, and Southern Area. Naval Weapons Industrial Reserve Plant, Calverton, New York. Northern Division, Naval Facilities Engineering Command. Prepared by Tetra Tech NUS, Inc. July 2001.

(2) Data Summary Report for Site 6A - Fuel Calibration Area and Southern Area. Naval Weapons Industrial Reserve Plant, Calverton, New York. Engineering Field Activity Northeast, Naval Facilities Engineering Command. Prepared by Tetra Tech NUS, Inc. September 2005.

**CALCULATION:**

**(1) Volume of Contaminated Groundwater in the Off-Site Southern Area Plume**

Estimate the volume of contaminated groundwater in the Off-Site Southern Area Plume. To calculate the volume of contaminated groundwater, the area of the plume, the average thickness of the plume, and the porosity of the soil is required.

From Figure A-1 (Page 3 of 3) the Off-Site Southern Area Plume = 3,991,000 square feet.

The average plume thickness was estimated to be 30 feet.

Volume of plume is calculated by multiplying the area, depth, and soil porosity.

Soil porosity is assumed to be: 0.25 fraction (fine/medium sand)

Volume of plume = 29,932,500 cf

Converting to gallons using a conversion factor of 7.48 gallons per cubic foot;

Volume of plume = 223,910,700 gallons

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 |
|---|---|---|
| SUBJECT: Volume and Mass Calculations (Off-Site Southern Area) | | |
| BASED ON: Attached Figure | | DRAWING NUMBER: |
| BY: CAR<br>Date: 11-04-05 | CHECKED BY: MJS<br>Date: 11/11/05 | APPROVED BY: DATE: |

**(2) Dissolved Mass of COCs in Off-Site Southern Area Plume**

Determine the dissolved contaminant mass in the Off-Site Southern Area Plume. Consider all detected contaminants and use the maximum results from the 3 rounds of analytical data (1997, 2000, and 2005). All data are from temporary wells or vertical profile borings. Each round of data generally covers different areas of the Off-Site Southern Area Plume and no comprehensive round of data is available.

**Off-Site Southern Area Plume**

| | | Max Conc. (ug/L) | GW Volume (L) | Mass (kg) | Mass (lbs) | |
|---|---|---|---|---|---|---|
| **CVOCs** | 1,1,1-Trichloroethane | 24 | 8.48E+08 | 20.3 | 44.7 | |
| | 1,1,2-Trichloroethane | 1.88 | 8.48E+08 | 1.6 | 3.5 | |
| | 1,1-Dichloroethane | 292 | 8.48E+08 | 247.5 | 544.4 | |
| | 1,1-Dichloroethene | 21.7 | 8.48E+08 | 18.4 | 40.5 | |
| | 1,2-Dichloroethane | 1.57 | 8.48E+08 | 1.3 | 2.9 | |
| | Chloroethane | 7.9 | 8.48E+08 | 6.7 | 14.7 | |
| | Chloroform | 4.72 | 8.48E+08 | 4.0 | 8.8 | |
| | cis-1,2-Dichloroethene | 0.6 | 8.48E+08 | 0.5 | 1.1 | |
| | trans-1,2-Dichloroethene | 2.54 | 8.48E+08 | 2.2 | 4.7 | |
| | Methylene Chloride | 1.2 | 8.48E+08 | 1.0 | 2.2 | |
| | Trichloroethene | 0.29 | 8.48E+08 | 0.2 | 0.5 | **Subtotal** |
| | Vinyl chloride | 2 | 8.48E+08 | 1.7 | 3.7 | 672 |
| **VOCs** | 1,4-Dichlorobenzene | 1.3 | 8.48E+08 | 1.1 | 2.4 | |
| | 2-Butanone | 4.4 | 8.48E+08 | 3.7 | 8.2 | |
| | Acetone | 12 | 8.48E+08 | 10.2 | 22.4 | |
| | Benzene | 1.4 | 8.48E+08 | 1.2 | 2.6 | |
| | Carbon Disulfide | 4 | 8.48E+08 | 3.4 | 7.5 | |
| | Ethylbenzene | 2.93 | 8.48E+08 | 2.5 | 5.5 | |
| | MTBE | 7.45 | 8.48E+08 | 6.3 | 13.9 | |
| | Toluene | 10.1 | 8.48E+08 | 8.6 | 18.8 | |
| | Total Xylenes | 18.36 | 8.48E+08 | 15.6 | 34.2 | **Subtotal** |
| | Trichlorofluoromethane | 2.63 | 8.48E+08 | 2.2 | 4.9 | 120 |
| | | | | Total | 792 | |

The contaminant concentrations used in the calculation were taken from Table 2-1 of the CMS.

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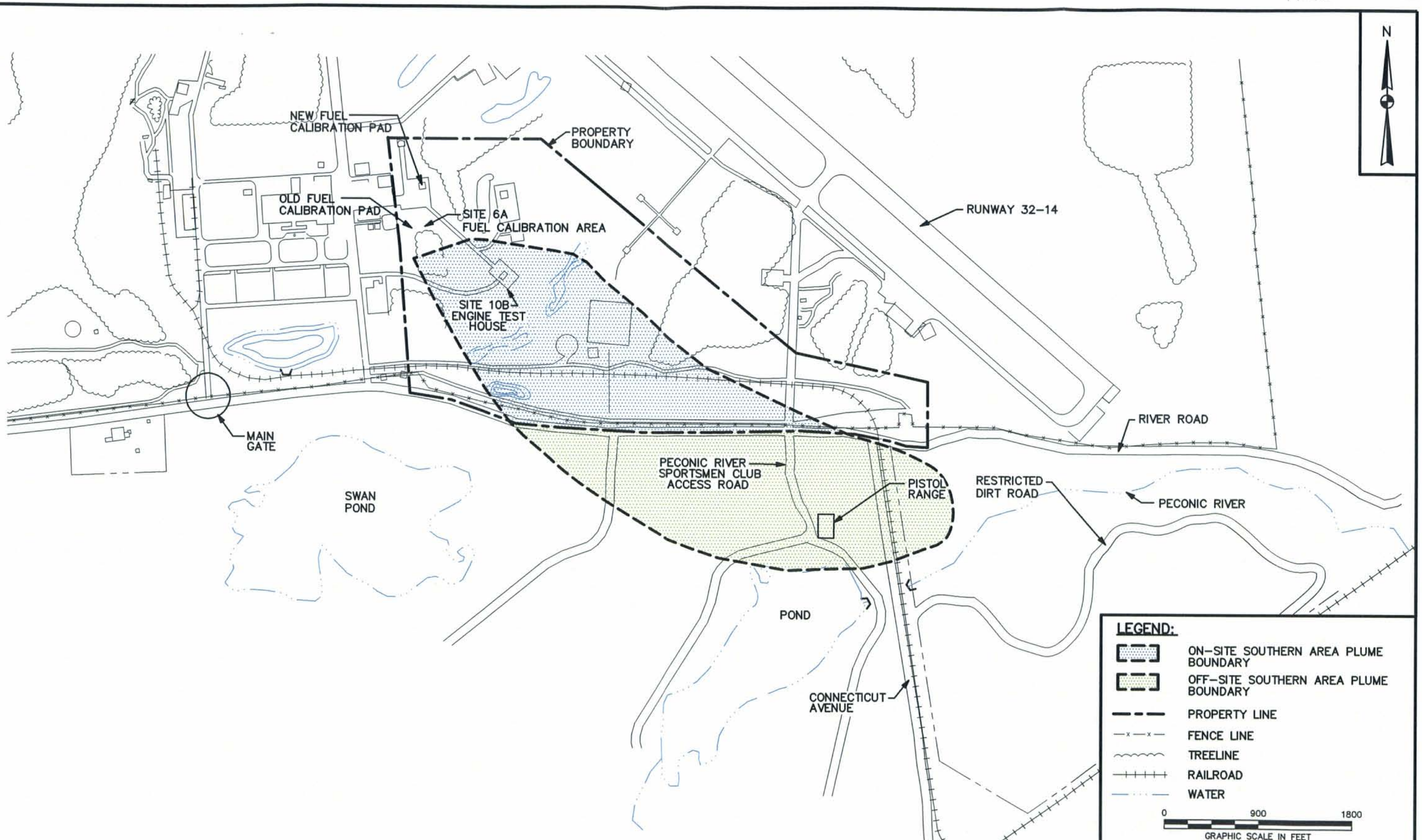



| DRAWN BY | DATE |
|---|---|
| HJB | 10/18/05 |
| CHECKED BY | DATE |
| REVISED BY | DATE |
| SCALE AS NOTED | |

Tetra Tech NUS, Inc.

OFF-SITE SOUTHERN AREA PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK

CONTRACT NO. 1610

OWNER NO. 0004

APPROVED BY | DATE

DRAWING NO. FIGURE A-1 | REV. 0

## A.2 ATTENUATION FACTOR CALCULATIONS

| CLIENT: CALVERTON, NY | JOB NUMBER: [illegible] | |
|---|---|---|
| SUBJECT: SOUTHERN AREA / PECONIC RIVER ATTENUATION FACTOR | | |
| BASED ON | DRAWING NUMBER | |
| BY: CAR 11/9/05 · CHECKED BY | APPROVED BY | DATE |

CALCULATE ATTENUATION FACTOR FOR CONTAMINATED GROUNDWATER DISCHARGING INTO THE PECONIC RIVER.

(I.) DATA:

PECONIC RIVER WATER SHED = 75 $mi^2$ (REF. 1)

PECONIC RIVER LENGTH = 16 mi (REF. 2)

AVERAGE PECONIC RIVER FLOW RATE @ RIVERHEAD = 37 cfs (REF. 3)

AVERAGE PECONIC RIVER FLOW RATE @ SCHULTZ RD = 4.75 cfs (REF. 3)

SEGMENTS ALONG PECONIC RIVER

DISTANCE FROM BAY TO RIVERHEAD ≈ 1.0 mi (REFS. 1 & 2)

DISTANCE FROM RIVERHEAD TO CALVERTON ≈ 6.5 mi (MAP QUEST MAP)

DISTANCE FROM CALVERTON TO SCHULTZ RD ≈ 3.7 mi (REF. 4, SEE ATTACHED FIGURE)

DISTANCE FROM SCHULTZ RD TO PECONIC RIVER HEAD WATERS ≈ 4.8 mi

| CLIENT | | JOB NUMBER | |
|---|---|---|---|
| CALVERTON, NY | | 1610/1110 | |
| SUBJECT: SOUTHERN AREA / PECONIC RIVER ATTENUATION FACTOR | | | |
| BASED ON | | DRAWING NUMBER | |
| BY: CAR | CHECKED BY | APPROVED BY | DATE |

## II. REFERENCES:

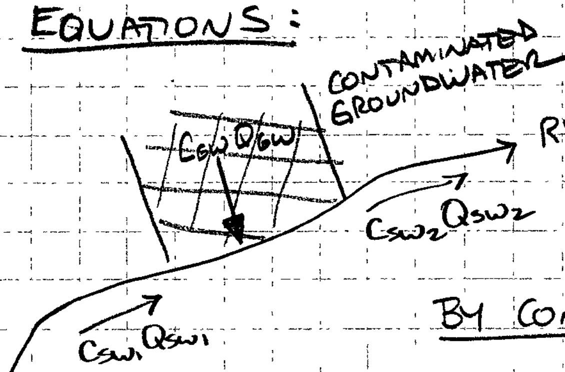

(1) PECONIC RIVER, COASTAL FISH & WILDLIFE HABITAT ASSESSMENT FORM
HTTP://WWW.NYSWATERFRONTS.COM/DOWNLOADS/PDFS/SIG_HAB/LONGISLAND/PECONIC_RIVER.PDF

(2) RIVERS, TRAILS, & CONSERVATION ASSISTANCE PROGRAM; NEW YORK SEGMENTS, M - Z
HTTP://WWW.NPS.GOV/NCRC/PROGRAMS/RTCA/NRI/STATES/NY2.HTML

(3) SULLIVAN, T., ESTIMATION OF POTENTIAL WATER LEVELS IN THE PECONIC RIVER NEAR BROOKHAVEN NATIONAL LABORATORY BASED ON A REVIEW OF HYDROLOGIC DATA, ENVIRONMENTAL RESEARCH & TECHNOLOGY DIVISION, BROOKHAVEN NATIONAL LABORATORY, APRIL 15, 2003.

(4) USGS WADING RIVER QUADRANGLE MAP 1967


## III. EQUATIONS:




$C_{GW}$ = CONC. IN GW
$Q_{GW}$ = FLOW RATE (GW)
$C_{SW_1}$ = CONC. IN $SW_1$
$Q_{SW_1}$ = FLOW RATE ($SW_1$)
$C_{SW_2}$ = CONC. IN $SW_2$
$Q_{SW_2}$ = FLOW RATE ($SW_2$)

BY CONSERVATION OF MASS

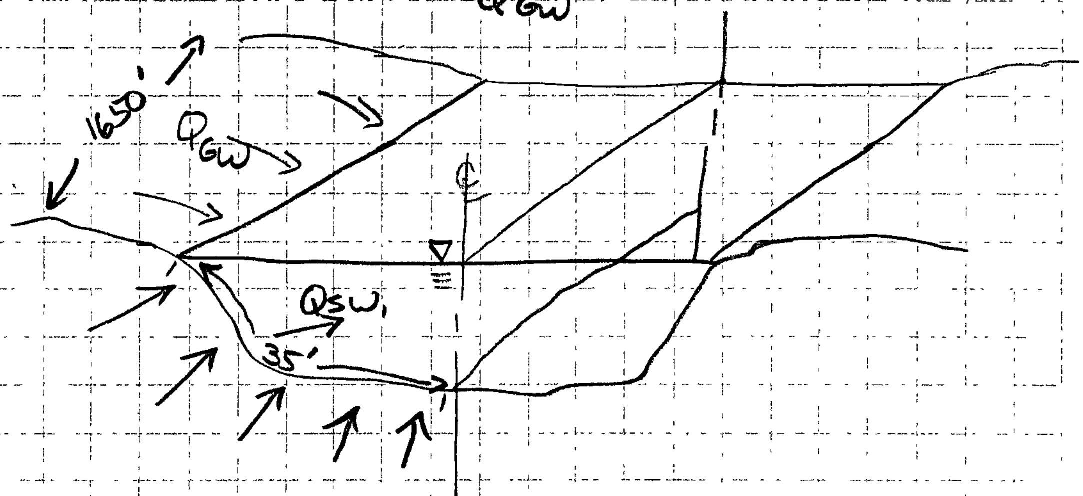
EQN. 1 $$C_{SW_1} Q_{SW_1} + C_{GW} Q_{GW} = C_{SW_2} Q_{SW_2}$$

| CLIENT | JOB NUMBER | | |
|---|---|---|---|
| CALVERTON, NY | 1610/1110 | | |
| SUBJECT: SOUTHERN AREA / PECONIC RIVER ATTENUATION FACTOR | | | |
| BASED ON | DRAWING NUMBER | | |
| BY: CAR | CHECKED BY | APPROVED BY | DATE |

SOLVING EQN. 1 FOR $C_{GW}$ AND ASSUMING $C_{SW_1} = 0$ AND $Q_{SW_2} = Q_{GW} + Q_{SW_1}$ THEN:

$$C_{GW} = \frac{Q_{GW} + Q_{SW_1}}{Q_{GW}} C_{SW_2}$$

$$\text{ATTENUATION FACTOR} = \frac{Q_{GW} + Q_{SW_1}}{Q_{GW}}$$




(*) ASSUME ½ OF $Q_{SW_1}$ IS AVAILABLE FOR DILUTION OF $Q_{GW}$.

(*) AVERAGE FLOW RATE OF PECONIC RIVER ADJACENT TO SOUTHERN AREA ($Q_{SW_1}$)

$$= 4.75\,\text{CFS} + 3.7\,\text{mi}\left(\frac{37\,\text{CFS} - 4.75\,\text{CFS}}{6.5\,\text{mi} + 3.7\,\text{mi}}\right)$$

$$Q_{SW_1} = \underline{16.4\ \text{CFS}}$$

(ASSUMES: LINEAR RELATIONSHIP BETWEEN FLOW RATE AND DISTANCE.)

| | | | |
|---|---|---|---|
| CLIENT: CALVERTON, NY | | JOB NUMBER: 1610/1110 | |
| SUBJECT: SOUTHERN AREA / PECONIC RIVER ATTENUATION FACTOR | | | |
| BASED ON | | DRAWING NUMBER | |
| BY: CAR | CHECKED BY | APPROVED BY | DATE |

(*) GROUNDWATER FLOW RATE BASED ON AQUIFER DATA AND GROUNDWATER PLUME MAP (3-5).

$$Q_{GW} = K i A$$

$K$ = 110 ft/DAY (AVG)

$i$ = 0.003 (FROM WATER LEVEL DATA & MAP)

$A = L \cdot b$

$L$ = 1,650 ft (WIDTH OF PLUME)

$b$ = 35 ft (LENGTH OF RIVER BOTTOM THROUGH WHICH PLUME DISCHARGES)

$$Q_{GW} = (110)(0.003)(1650)(35)$$

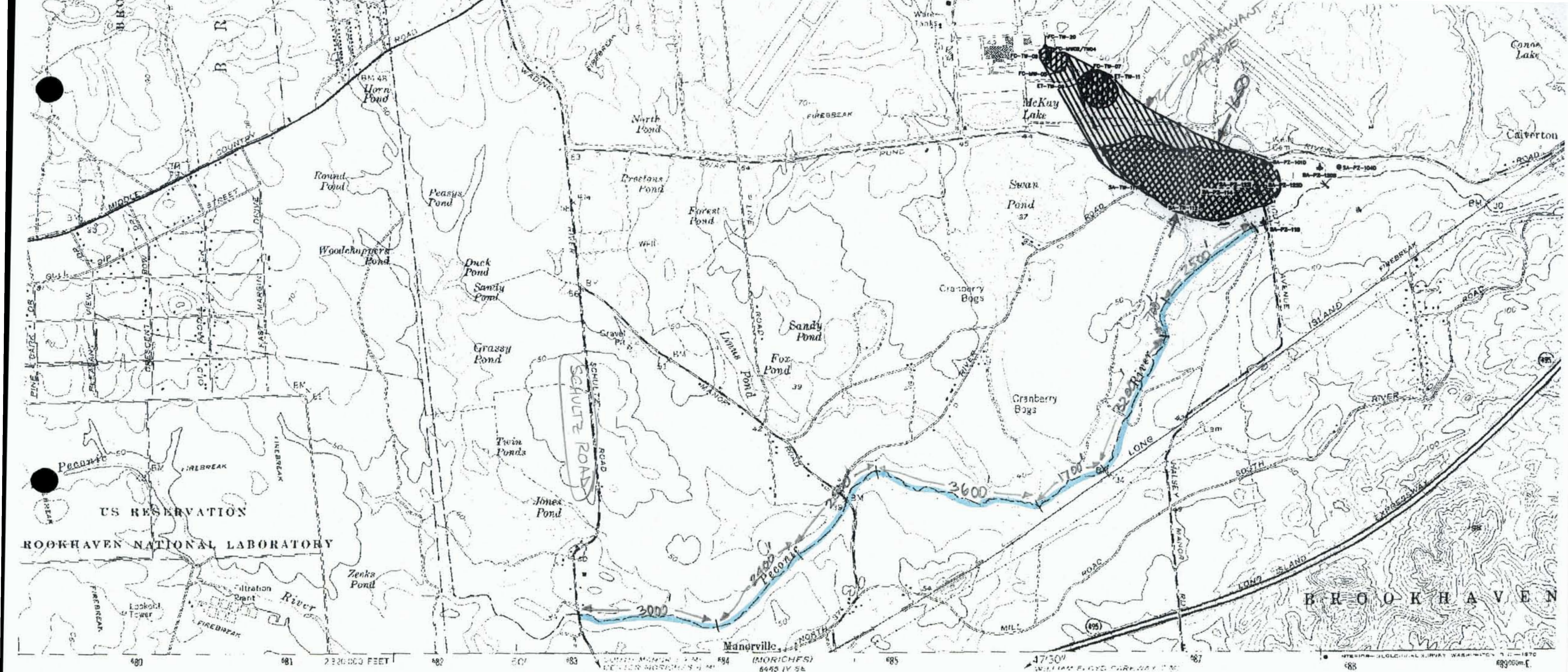
$$= 19,058 \text{ ft}^3/\text{day}$$

$$= \underline{0.22 \text{ cfs}}$$

(*) ATTENUATION FACTOR $= \dfrac{(0.22 \text{ cfs}) + (0.5)(16.4 \text{ CFS})}{(0.22 \text{ CFS})}$

$$= \underline{36.7}$$

PREVIOUS CALCULATIONS ESTIMATED ATTENUATION FACTORS RANGING FROM 25 TO 27 FOR THE PECONIC. TO BE CONSERVATIVE USE AN ATTENUATION FACTOR OF 30 FOR THE OFF-SITE SOUTHERN AREA CMS/FS.




SCALE 1:24 000

ed, edited, and published by the Geological Survey
ed in cooperation with New York Department of Transportation
l by USGS and USC&GS
aphy by photogrammetric methods from aerial photographs
1954. Field checked 1957. Revised from aerial
graphs taken 1966. Field checked 1967
ed hydrographic data compiled from USC&GS Chart 1212 (1967)
nformation is not intended for navigational purposes
onic projection. 1927 North American datum
0-foot grid based on New York coordinate system, Long Island zone
-meter Universal Transverse Mercator grid ticks,
18, shown in blue
red ed lines indicate selected fence and field lines where
al le on aerial photographs. This information is unchecked

UTM GRID AND 1967 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET - DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 5.9 FEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION
Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
State Route

WADING RIVER, N
NE/4 MORICHES 15' QUADRANGLE
N4052.5 — W7245/7
1967
AMS 6465 IV NE—SERIES

# APPENDIX B

# ALTERNATIVE CALCULATIONS

B.1 INVESTIGATION, MONITORING, O&M, AND WASTE DISPOSAL
(ALL ALTERNATIVES)

B.2 GROUNDWATER PUMP AND TREAT
(ALTERNATIVE 3)

B.3 BIOSTIMULATION
(ALTERNATIVES 4 AND 5)

B.4 AIR SPARGING
(ALTERNATIVE 6)

## B.1 INVESTIGATION, MONITORING, O&M, AND WASTE DISPOSAL (ALL ALTERNATIVES)

| CLIENT NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 | |
|---|---|---|---|
| SUBJECT: Alt 2 Groundwater and Surface Water Testing Costs (Off-Site Southern Area) | | | |
| BASED ON: | | DRAWING NUMBER: | |
| BY: NJB<br>Date. 11/21/05 | CHECKED BY:<br>Date: | APPROVED BY | DATE: |

**Groundwater & Surface Water Alt 2**
**12 wells + 3 surface water samples**

water - collect 12 groundwater samples from 12 wells local labor plus 3 surface water samples- say 2 people for 3 days
one day - prep, collect supplies, forms, etc.

total: 2 people 4 days, 10 hour days

| cost item | number | cost/hr | hours | cost/day | days | total cost | |
|---|---|---|---|---|---|---|---|
| supervisor | 1 | $40 | 40 | | | $1,600 | |
| laborer | 1 | $32 | 40 | | | $1,280 | |
| cars & gas | 1 | | | $70 | 4 | $280 | |
| ship, supplies | 1 | | | $300 | 4 | $1,200 | |
| TOTAL COST | | | | Years 2 through 30 ( Alt 2) | | **$4,360** | per round |
| | | | | | Year 1 | **$17,440** | 4 quarters |

Analysis/Groundwater - Year 1

| parameter | medium | | unit cost |
|---|---|---|---|
| TCL VOCs | water | $ | 100.00 |
| anions (chloride, sulfate, nitrate, nitrite) | water | $ | 45.00 |
| sulfide | | $ | 25.00 |
| methane, ethene, ethane, and $CO_2$ | water | $ | 125.00 |
| Lab Subtotal | | $ | 295.00 |
| QA 30% | | $ | 88.50 |
| Lab Total | | $ | 383.50 |
| field test kit (iron) | water | $ | 50.00 |
| Total | | $ | 433.50 |

$ 433.50 x 12 = **$ 5,202.00** per event

$ 5,202.00 x 4 qtrs = **$ 20,808.00** Year 1

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 | |
|---|---|---|---|
| SUBJECT: Alt 2 Groundwater and Surface Water Testing Costs (Off-Site Southern Area) | | | |
| BASED ON: | | DRAWING NUMBER: | |
| BY: NJB<br>Date: 11/21/05 | CHECKED BY:<br>Date: | APPROVED BY: | DATE: |

Analysis/Groundwater - Years 2 through 30

| parameter | medium | | unit cost |
|---|---|---|---|
| TCL VOCs | water | $ | 100.00 |
| Lab Subtotal | | $ | 100.00 |
| QA 30% | | $ | 30.00 |
| Lab Total | | $ | 130.00 |
| field test kit (iron) | water | $ | 50.00 |
| Total | | $ | 180.00 |

$ 180.00 x 12 = **$ 2,160.00** Years 2 through 30 ( Alt 2)

Analysis/Surface Water - Year 1

| parameter | medium | | unit cost |
|---|---|---|---|
| TCL VOCs | water | $ | 100.00 |
| Lab Subtotal | | $ | 100.00 |
| QA 30% | | $ | 30.00 |
| Lab Total | | $ | 130.00 |

$ 130.00 x 3 = **$ 390.00** Years 2 through 30 ( Alt 2)

$ 390.00 x 4 qtrs = **$ 1,560.00** Year 1

**Total - Groundwater and Surface Water (Analyses)**

| | | | | | |
|---|---|---|---|---|---|
| Year 1 (Alt 2) | $ 20,808.00 | + | $ 1,560.00 | = | **$ 22,368.00** |
| Years 2 through 30 ( Alt 2) | $ 2,160.00 | + | $ 390.00 | = | **$ 2,550.00** |

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 |
|---|---|---|
| SUBJECT: Alts 3& 4 Groundwater and Surface Water Testing Costs (Off-Site Southern Area) | | |
| BASED ON: | | DRAWING NUMBER: |
| BY. NJB<br>Date. 11/21/05 | CHECKED BY:<br>Date. | APPROVED BY. DATE: |

**Groundwater and Surface Water Alt 3 & 4**
**(13 wells + 3 surface water samples)**

water - collect 13 groundwater samples from 13 wells local labor plus 3 surface water samples- say 2 people for 3 days
one day - prep, collect supplies, forms, etc.

total: 2 people 4 days, 10 hour days

| cost item | number | cost/hr | hours | cost/day | days | total cost | |
|---|---|---|---|---|---|---|---|
| supervisor | 1 | $40 | 40 | | | $1,600 | |
| laborer | 1 | $32 | 40 | | | $1,280 | |
| cars & gas | 1 | | | $70 | 4 | $280 | |
| ship, supplies | 1 | | | $300 | 4 | $1,200 | |
| TOTAL COST | | | | Years 2 through 16 ( Alt 3) | | **$4,360** | per round |
| | | | | Years 2 through 10 (Alt 4) | | **$4,360** | per round |
| | | | | | Year 1 | **$17,440** | 4 quarters |

Analysis/Groundwater - Year 1

| parameter | medium | unit cost |
|---|---|---|
| TCL VOCs | water | $ 100.00 |
| anions (chloride, sulfate, nitrate, nitrite) | water | $ 45.00 |
| sulfide | | $ 25.00 |
| methane, ethene, ethane, and $CO_2$ | water | $ 125.00 |
| Lab Subtotal | | $ 295.00 |
| QA 30% | | $ 88.50 |
| Lab Total | | $ 383.50 |
| field test kit (iron) | water | $ 50.00 |
| Total | | $ 433.50 |

$ 433.50 x 13 = **$ 5,635.50** per event

$ 5,635.50 x 4 qtrs = **$ 22,542.00** Year 1

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 |
|---|---|---|
| SUBJECT: Alts 3& 4 Groundwater and Surface Water Testing Costs (Off-Site Southern Area) | | |
| BASED ON: | | DRAWING NUMBER. |
| BY: NJB<br>Date: 11/21/05 | CHECKED BY.<br>Date: | APPROVED BY. DATE: |

Analysis/Groundwater - Years 2 through 16 (Alt 3) and Years 2 through 10 (Alt 4)

| parameter | medium | unit cost |
|---|---|---|
| TCL VOCs | water | $ 100.00 |
| Lab Subtotal | | $ 100.00 |
| QA 30% | | $ 30.00 |
| Lab Total | | $ 130.00 |
| field test kit (iron) | water | $ 50.00 |
| Total | | $ 180.00 |

| | | | |
|---|---|---|---|
| $ 180.00 | x 13 = | **$ 2,340.00** | Years 2 through 16 ( Alt 3) |
| | | **$ 2,340.00** | Years 2 through 10 (Alt 4) |

Analysis/Surface Water

| parameter | medium | unit cost |
|---|---|---|
| TCL VOCs | water | $ 100.00 |
| Lab Subtotal | | $ 100.00 |
| QA 30% | | $ 30.00 |
| Lab Total | | $ 130.00 |

| | | | |
|---|---|---|---|
| $ 130.00 | x 3 = | **$ 390.00** | Years 2 through 16 ( Alt 3) |
| | | **$ 390.00** | Years 2 through 10 (Alt 4) |
| $ 390.00 | x 4 qtrs = | **$ 1,560.00** | Year 1 |

**Total - Groundwater and Surface Water (Analyses)**

| | | | | | |
|---|---|---|---|---|---|
| Year 1 (Alts 3 & 4) | $ 22,542.00 | + | $ 1,560.00 | = | **$ 24,102.00** |
| Years 2 through 16 ( Alt 3) | $ 2,340.00 | + | $ 390.00 | = | **$ 2,730.00** |
| Years 2 through 10 (Alt 4) | $ 2,340.00 | + | $ 390.00 | = | **$ 2,730.00** |

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 |
|---|---|---|
| SUBJECT: Alts 5&6 Groundwater and Surface Water Testing Costs (Off-Site Southern Area) | | |
| BASED ON: | | DRAWING NUMBER: |
| BY: NJB<br>Date: 11/21/05 | CHECKED BY:<br>Date: | APPROVED BY: DATE: |

**Groundwater & Surface Water Alts 5&6**
**15 wells + 3 surface water samples**

water - collect 15 groundwater samples from 15 wells local labor plus 3 surface water samples- say 2 people for 4 days
one day - prep, collect supplies, forms, etc.

total: 2 people 5 days, 10 hour days

| cost item | number | cost/hr | hours | cost/day | days | total cost | |
|---|---|---|---|---|---|---|---|
| supervisor | 1 | $40 | 50 | | | $2,000 | |
| laborer | 1 | $32 | 50 | | | $1,600 | |
| cars & gas | 1 | | | $70 | 5 | $350 | |
| ship, supplies | 1 | | | $300 | 5 | $1,500 | |
| TOTAL COST | | | | Years 2 through 16 | | **$5,450** | per round |
| | | | | | Year 1 | **$21,800** | 4 quarters |

Analysis/Groundwater - Year 1

| parameter | medium | | unit cost |
|---|---|---|---|
| TCL VOCs | water | $ | 100.00 |
| anions (chloride, sulfate, nitrate, nitrite) | water | $ | 45.00 |
| sulfide | | $ | 25.00 |
| methane, ethene, ethane, and $CO_2$ | water | $ | 125.00 |
| Lab Subtotal | | $ | 295.00 |
| QA 30% | | $ | 88.50 |
| Lab Total | | $ | 383.50 |
| field test kit (iron) | water | $ | 50.00 |
| Total | | $ | 433.50 |

$ 433.50 x 15 = **$ 6,502.50** per event

$ 6,502.50 x 4 qtrs = **$ 26,010.00** Year 1

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER 1610-1110 | |
|---|---|---|---|
| SUBJECT: Alts 5&6 Groundwater and Surface Water Testing Costs (Off-Site Southern Area) | | | |
| BASED ON: | | DRAWING NUMBER· | |
| BY: NJB<br>Date: 11/21/05 | CHECKED BY:<br>Date: | APPROVED BY. | DATE. |

Analysis/Groundwater - Years 2 through 16

| parameter | medium | | unit cost |
|---|---|---|---|
| TCL VOCs | water | $ | 100.00 |
| Lab Subtotal | | $ | 100.00 |
| QA 30% | | $ | 30.00 |
| Lab Total | | $ | 130.00 |
| field test kit (iron) | water | $ | 50.00 |
| Total | | $ | 180.00 |

$ 180.00 x 15 = **$ 2,700.00** Years 2 through 16

Analysis/Surface Water

| parameter | medium | | unit cost |
|---|---|---|---|
| TCL VOCs | water | $ | 100.00 |
| Lab Subtotal | | $ | 100.00 |
| QA 30% | | $ | 30.00 |
| Lab Total | | $ | 130.00 |

$ 130.00 x 3 = **$ 390.00** Years 2 through 16

$ 390.00 x 4 qtrs = **$ 1,560.00** Year 1

**Total - Groundwater and Surface Water (Analyses)**

| | | | | | |
|---|---|---|---|---|---|
| Year 1 | $ 26,010.00 | + | $ 1,560.00 | = | **$ 27,570.00** |
| Years 2 through 16 | $ 2,700.00 | + | $ 390.00 | = | **$ 3,090.00** |

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 |
|---|---|---|
| SUBJECT: Alt 6 Schedule and Electrical Calculations (Off-Site Southern Area) | | |
| BASED ON: | | DRAWING NUMBER: |
| BY: NJB<br>Date: 12/23/05 | CHECKED BY:<br>Date: | APPROVED BY: DATE: |

Incremental calculations for Calverton Off-Site pump and treat system.

**Alt 6**

Pipe installation will be at a rate of 75 ft per day.

| | | |
|---|---|---|
| | 5000 ft/75 ft/day = | 67 days |
| Total decon time = | | 67 days = |
| | | 3.0 months |
| Add 4 weeks for electrical work + 4 weeks for start-up. Total time for an office trailer is | | |
| | | 5.0 months |
| Drill ninety 100 ft wells at one well per day | Add | 4 months |
| | Total | 9.0 months |
| | Add 1 month for Miscellaneous | 10.0 months |

**Electrical Costs:**

**Off-Site**

| | | | | |
|---|---|---|---|---|
| Compressors | 4 x 100 | 400 | HP | estimate |
| **Total** | | 400 | HP | |
| x 0.7457 x 24 x 365 = | | 2,612,933 | kWh | |

| CLIENT: NWIRP Calverton, New York | | JOB NUMBER: 1610-1110 |
|---|---|---|
| SUBJECT: Alt 3 Schedule and Electrical Calculations (Off-Site Southern Area) | | |
| BASED ON: | | DRAWING NUMBER: |
| BY: NJB<br>Date: 11/21/05 | CHECKED BY:<br>Date: | APPROVED BY: DATE: |

Incremental calculations for Calverton Off-Site pump and treat system.

**Alt 3**

Pipe installation will be at a rate of 75 ft per day.

9000 ft/75 ft/day = 120 days

Total decon time = 120 days = 5.5 months

Add 4 weeks for electrical work + 4 weeks for start-up. Total time for an office trailer is 7.5 months

| | | |
|---|---|---|
| | Say | 8 months |
| Drill 360 ft extraction wells, erect buildings, site restoration | Add | 1 month |
| | Total | 9 months |

**Electrical Costs:**

**Off-Site**

| | | |
|---|---|---|
| Extraction Pumps, 6 @ 7.5 | 45 HP | |
| Mixers 5 + 10 | 15 HP | |
| Cent Pumps 3 x 15 | 45 HP | (only 3 operating at a time) |
| Blower 3 x 3 | 9 HP | estimate |
| **Subtotal** | 114 HP | |
| x 0.7457 x 24 x 365 = | 744,686 kW | |

Add heat for tanks, tracing, and two 7.5 kW heater for building

| | |
|---|---|
| say | 50 kW/hr |
| x 24 hr/day x 30 days/month x 4.5 months/yr | |
| **Subtotal** | 162,000 kW |
| **Total** | 906,686 kWh |

## B.2 GROUNDWATER PUMP AND TREAT (ALTERNATIVE 3)

- EXTRACTION SYSTEM
- TREATMENT SYSTEM
- DISPOSAL FLOW RATES

| | | | |
|---|---|---|---|
| **Project:** | NWIRP Calverton | **Project No.:** | 1610 |
| **Subject:** | Southern Area Plume Groundwater Extraction System FS Designs | | |
| **By:** | JPO | **Date:** | 11/10/2005 |
| **Checked:** | | **Date:** | |

**Project/Design Objective:**

Design a groundwater extraction system for containment/cleanup of the offbase southern area chlorinated VOC/BTEX plume. Project cleanup rates/times assuming that the contaminant sources and hot spots will be removed or otherwise contained. The final design should be capable of remediating contaminated groundwater to target cleanup levels within a reasonable time frame (30 years or less), and should offer significant advantages over natural processes in terms of cleanup rate and/or protection of receptors. This design should be considered as conceptual only - additional data, i.e., aquifer characteristics, contaminant distributions are needed for a final design.

**Basis of Design Data:** (Input cells yellow, blue automatically calculated)

**Groundwater Plume Information**

| | | |
|---|---|---|
| Plume Width (W): | 2000 | ft. |
| Plume Thickness: | 40 | ft. |
| Plume Area: | 4,000,000 | $ft^2$ |
| Volume of Groundwater in Plume: | 40000000 | $ft^3$ |
| Avg Hydraulic Conductivity, Plume Area: | 100 | ft/day |

**Aquifer Characteristics**

| | | |
|---|---|---|
| Thickness (B): | 100 | ft. |
| Avg. Hydraulic Conductivity (K): | 100 | ft/day |
| Transmissivity (T): | 10000 | $ft^2$/day |
| Porosity (n): | 0.25 | |
| Storativity (S): | 0.07 | |
| Fractional Organic Carbon Content (foc): | 0.001 | |
| Flow Gradient (i): | 0.0036 | |

**Contaminant Characteristics**

| | | | |
|---|---|---|---|
| Contaminant A Representative gw conc.: | Xylenes | 18.4 | ug/L |
| Contaminant B Representative gw conc.: | 1,1-DCA | 292 | |
| Koc, Contaminant A: | | 407 | |
| Koc, Contaminant B: | | 31 | |
| Kd, Contaminant A: | | 0.407 | |
| Kd, Contaminant B: | | 0.031 | |
| Half-life, Contaminant A: | | | years |
| Half-life, Contaminant B: | | | years |
| Target Cleanup Level, Contaminant A: | | 5 | ug/L |
| Target Cleanup Level, Contaminant B: | | 5 | ug/L |

**Remedial System Information**

| | | |
|---|---|---|
| Extraction Well Radius, (r) : | 0.25 | ft. |
| Time to Reach Steady-State Drawdown (t): | 30 | days |
| Allowable Drawdown, Single Well, (s): | 5 | ft. |

**Technical Approach:**

Using aquifer characteristics, plume volume, Kd, half-life, and representative groundwater concentration data, calculate the number of pore volume flushes and times required to reach the target groundwater concentration (performed using the attached spreadsheets). Use standard equations to calculate the minimum required pumping rate for plume containment, per-well achievable pumping rates, and well spacings. Develop a preliminary extraction system design based on the calculations, adjusting the design as appropriate based on data limitation considerations and best scientific judgement.

**Required Pumping Rate (Qt) for Total Plume Capture**

Qt = TiW x 2 (2x the natural groundwater flow-thru rate for entire aquifer)

Qt = 72000.00 $ft^3$/day x 2, or 374.01 gpm x 2

Qt = 144000.00 $ft^3$/day, or 748.01 gpm

**Maximum Achievable Pumping Rate in a Single Well (Qa)**

Qa = $[4\pi Ts/2.3] / \log [2.25Tt/r^2S]$

Qa = 33362.45 $ft^3$/day, or 173.30 gpm

**Minimum Number of Extraction Wells Required**

= Qt/Qa

= 4.32 wells

**Plume Cleanup Rate Projections (From Spreadsheet Program or Other Source)**

| | | | | |
|---|---|---|---|---|
| At | 748.0 | gpm, | 21 | years |
| At | 1000.0 | gpm, | 16 | years |
| At | 1250.0 | gpm, | 13 | years |
| At natural GW flow rate: | 374.01 | gpm, | 42 | years |

Contaminant that cleanup rate is based on: Xylenes

**Based on the limiting conditions calculated above, projections regarding cleanup times at various pumping rates (see accompanying spreadsheets), a suitable safety factor based on the degree of confidence in the design data, and best scientific judgement, the following are the number of extraction wells and pumping rates selected for the design:**

| | | | |
|---|---|---|---|
| **Number of Wells:** | 6 | | |
| **Per-well Pumping Rate (Qw):** | 160 | gpm, or | 30801.60 $ft^3$/day |
| **Total System Pumping Rate (Qes):** | 960 | gpm, or | 184809.60 $ft^3$/day |

**Extraction Well Spacings, (WSp), ft Perpendicular to Groundwater Flow Direction**

WSp = $Qw/\pi Ti$, for a 2-well extraction system

WSp = 272.35 ft

or

WSp = $1.26(Qw)/\pi Ti$, for a 3-well extraction system

WSp = 343.16 ft

or

WSp = $1.2(Qw)/\pi Ti$, for an extraction system with 4+ wells

WSp = 326.81 ft

**Downgradient Stagnation Point (SPd) Approximation**

SPd = $Qes/2\pi Ti$, Qes = total extraction system pumping rate, $ft^3$/day

SPd = 817.04 ft

**Alternate Layout of Extraction Well System (I.e., parallel to GW flow direction):**

Position wells in hot spot areas and aligned along the downgradient edge of the plume near the Peconic River. Use 6 wells to provide flexibility to optimize pumping, have the capability to employ a cyclical pumping schedule, allow for selective shutdown of wells once cleanup goals are attained in that area, and provide maximum efficiency r.e. contaminant mass removal. Screen wells from 60-90 feet below ground, to focus pumping efforts within the depth interval of the plume where highest concentrations have been found (see preliminary 2D modeling outputs for capture zones).

**Final Configuration, Groundwater Extraction System:**

Six 8-inch diameter extraction wells, screened from 60 to 90 feet below ground, installed within hot spot area and near the downgradient plume boundary. Each well will pump at a rate of 160 gpm, with an estimated cleanup time of approximately 16-17 years after any residual source is depleted. Reinject treated water through infiltration galleries located outside of the lateral edges of the plume and/or discharge to surface water bodies. Note that this design is preliminary and based on limited data - additional site characterization is needed to finalize a design for a groundwater extraction system.

## Heterogeneous Aquifer Flushing Rate Calculations

| | | | |
|---|---|---|---|
| Project: | Claverton Southern Area | Proj. No.: | 1610 |
| Chemical : | Xylenes | $K_{OC}$ ($K_d$*) : | 407 |
| Concentration units, water & soil (pick 1): | mg/L & mg/Kg | ug/L & ug/Kg | x |

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue; the remaining cells are fixed

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg

* for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's $K_d$ is input directly into the $K_{OC}$ entry cell, with $f_{OC}$ then set to 1. For fractured bedrock, reduce the $f_{OC}$ by 1-2 orders of magnitude to adjust for typical low fracture porosity and resulting high model-perceived mass of aquifer sediments in contact with water.

This spreadsheet calculates flushing rates and cleanup times for a groundwater flow system that consists of up to 3 groundwater "flow units". Flow units are discrete portions of the aquifer that have unique properties, i.e., higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher/lower contaminant concentrations, and/or different organic carbon contents. The spreadsheet factors in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction through the optional use of contaminant half-life data

### Groundwater Flow Unit Physical/Chemical Data

| Flow Unit 1 (U1) | | Flow Unit 2 (U2) | | Flow Unit 3 (U3) | |
|---|---|---|---|---|---|
| $Cw_{01}$ | 18.40 | $Cw_{02}$ | 18.40 | $Cw_{03}$ | 18.40 |
| n | 0.25 | n | 0.25 | n | 0.25 |
| $S_G$ | 2.65 | $S_G$ | 2.65 | $S_G$ | 2.65 |
| $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 |
| $K_d$ | 0.407 | $K_d$ | 0.407 | $K_d$ | 0.407 |
| $M_W$ | 4.600 | $M_W$ | 4.600 | $M_W$ | 4.600 |
| $C_S$ | 7.489 | $C_S$ | 7.489 | $C_S$ | 7.489 |
| $M_S$ | 14.884 | $M_S$ | 14.884 | $M_S$ | 14.884 |
| $M_T$ | 19.484 | $M_T$ | 19.484 | $M_T$ | 19.484 |
| $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 |

$Cw_{0N}$ = Initial contaminant concentration in groundwater flow unit N

### Groundwater Flow Unit Hydrogeologic Characteristics

| Avg. K, ft/d highest to lowest | Relative average K, $K_U$ | Fraction of aquifer volume, $FV_U$ | Fraction of total flow, $FQ_U$ | Flow unit number, U |
|---|---|---|---|---|
| 331 | 1.000 | 0.33 | 0.715 | 1 |
| 100 | 0.302 | 0.34 | 0.220 | 2 |
| 30.2 | 0.091 | 0.33 | 0.065 | 3 |

### Pore Volumes and Pore Volume Removal Rates

| Groundwater discharge rate, gpm | Groundwater discharge rate, $ft^3$/day, $Q_T$ | Total volume occupied by plume, $ft^3$, $PV_T$ |
|---|---|---|
| 374 | 72000.00 | 480,000,000 |

| Discharge rate, Unit 1 $ft^3$/day, $Q_1$ | Discharge rate, Unit 2 $ft^3$/day, $Q_2$ | Discharge rate, Unit 3 $ft^3$/day, $Q_3$ | Plume pore Vol., Unit 1 $ft^3$, $PV_1$ | Plume pore Vol., Unit 2 $ft^3$, $PV_2$ | Plume pore Vol., Unit 3 $ft^3$, $PV_3$ | Time for 1 PV flush, Unit 1, days, $t_1$ | Time for 1 PV flush, Unit 2, days, $t_2$ | Time for 1 PV flush, Unit 3, days, $t_3$ |
|---|---|---|---|---|---|---|---|---|
| 51449.65 | 15856.15 | 4694.20 | 39600000 | 40800000 | 39600000 | 769.68 | 2573.13 | 8435.95 |

### Contaminant Half-Life Data

| | | | |
|---|---|---|---|
| Does contaminant have a decay half-life (yes/no): | no | If yes, half-life (days): | 365 |
| 1st order decay coefficient (k): | 0.001899 | | |

### Average Pumped/Discharged and Residual Plume Concentrations Over Time

| Target Cleanup Concentration : | | 5 | ug/L | |
|---|---|---|---|---|
| Time period | Time span, days, t | Avg pumped GW conc. | Avg residual GW conc. | Time span, years |
| 0 | 0 | 0 | 18.4 | 0 |
| 0.2 | 153.94 | 17.640 | 17.952 | 0.42 |
| 0.3 | 230.91 | 17.274 | 17.735 | 0.63 |
| 0.4 | 307.87 | 16.917 | 17.522 | 0.84 |
| 0.6 | 461.81 | 16.229 | 17.110 | 1.26 |
| 0.8 | 615.75 | 15.575 | 16.714 | 1.69 |
| 1 | 769.68 | 14.953 | 16.335 | 2.11 |
| 1.4 | 1077.56 | 13.797 | 15.620 | 2.95 |
| 1.8 | 1385.43 | 12.750 | 14.960 | 3.79 |
| 2.4 | 1847.24 | 11.360 | 14.062 | 5.06 |
| 3 | 2309.05 | 10.158 | 13.260 | 6.32 |
| 3.6 | 2770.86 | 9.117 | 12.542 | 7.59 |
| 4.2 | 3232.67 | 8.214 | 11.896 | 8.85 |
| 5 | 3848.42 | 7.190 | 11.131 | 10.54 |
| 6 | 4618.11 | 6.147 | 10.305 | 12.64 |
| 7 | 5387.79 | 5.312 | 9.594 | 14.75 |
| 8 | 6157.48 | 4.637 | 8.977 | 16.86 |
| 10 | 7696.85 | 3.639 | 7.956 | 21.07 |
| 12 | 9236.21 | 2.954 | 7.141 | 25.29 |
| 16 | 12314.95 | 2.103 | 5.904 | 33.72 |
| 20 | 15393.69 | 1.603 | 4.991 | 42.15 |
| 19 | 14624.01 | 1.708 | 5.197 | 40.04 |
| 19.5 | 15008.85 | 1.654 | 5.093 | 41.09 |
| 19.7 | 15162.78 | 1.633 | 5.052 | 41.51 |
| 19.8 | 15239.75 | 1.623 | 5.032 | 41.72 |
| 19.9 | 15316.72 | 1.613 | 5.011 | 41.93 |

Adjust the initial time period to auto-adjust the following 19 time periods and obtain the desired range in concentrations.

The last 5 time periods can be modified to more precisely determine the time required to meet a specific residual concentration.

# Heterogeneous Aquifer Flushing Rate Calculations

| Project: | Claverton Southern Area | Proj. No.: | 1610 |
|---|---|---|---|
| Chemical : | Xylenes | $K_{OC}$ ($K_d$*) : | 407 |
| Concentration units, water & soil (pick 1). | mg/L & mg/Kg | ug/L & ug/Kg | x |

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue; the remaining cells are fixed

All groundwater/soil contaminant concentrations are in consistent units, i e , mg/L & mg/Kg, or ug/L & ug/Kg

* for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's $K_d$ is input directly into the $K_{OC}$ entry cell, with $f_{OC}$ then set to 1. For fractured bedrock, reduce the $f_{OC}$ by 1-2 orders of magnitude to adjust for typical low fracture porosity and resulting high model-perceived mass of aquifer sediments in contact with water.

This spreadsheet calculates flushing rates and cleanup times for a groundwater flow system that consists of up to 3 groundwater "flow units". Flow units are discrete portions of the aquifer that have unique properties, i.e., higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher/lower contaminant concentrations, and/or different organic carbon contents. The spreadsheet factors in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction through the optional use of contaminant half-life data.

### Groundwater Flow Unit Physical/Chemical Data

| Flow Unit 1 (U1) | | Flow Unit 2 (U2) | | Flow Unit 3 (U3) | |
|---|---|---|---|---|---|
| $Cw_{01}$ | 18.40 | $Cw_{02}$ | 18.40 | $Cw_{03}$ | 18.40 |
| n | 0.25 | n | 0.25 | n | 0.25 |
| $S_G$ | 2.65 | $S_G$ | 2.65 | $S_G$ | 2 65 |
| $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 |
| $K_d$ | 0.407 | $K_d$ | 0.407 | $K_d$ | 0 407 |
| $M_W$ | 4 600 | $M_W$ | 4.600 | $M_W$ | 4.600 |
| $C_S$ | 7.489 | $C_S$ | 7.489 | $C_S$ | 7.489 |
| $M_S$ | 14.884 | $M_S$ | 14.884 | $M_S$ | 14 884 |
| $M_T$ | 19 484 | $M_T$ | 19.484 | $M_T$ | 19 484 |
| $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 |

$Cw_{0N}$ = Initial contaminant concentration in groundwater flow unit N

### Groundwater Flow Unit Hydrogeologic Characteristics

| Avg. K, ft/d highest to lowest | Relative average K, $K_U$ | Fraction of aquifer volume, $FV_U$ | Fraction of total flow, $FQ_U$ | Flow unit number, U |
|---|---|---|---|---|
| 331 | 1.000 | 0.33 | 0.715 | 1 |
| 100 | 0.302 | 0.34 | 0.220 | 2 |
| 30.2 | 0.091 | 0.33 | 0.065 | 3 |

### Pore Volumes and Pore Volume Removal Rates

| Groundwater discharge rate, gpm | Groundwater discharge rate, $ft^3$/day, $Q_T$ | Total volume occupied by plume, $ft^3$, $PV_T$ |
|---|---|---|
| 748 | 144000.00 | 480,000,000 |

| Discharge rate, Unit 1 $ft^3$/day, $Q_1$ | Discharge rate, Unit 2 $ft^3$/day, $Q_2$ | Discharge rate, Unit 3 $ft^3$/day, $Q_3$ | Plume pore Vol., Unit 1 $ft^3$, $PV_1$ | Plume pore Vol., Unit 2 $ft^3$, $PV_2$ | Plume pore Vol., Unit 3 $ft^3$, $PV_3$ | Time for 1 PV flush, Unit 1, days, $t_1$ | Time for 1 PV flush, Unit 2, days, $t_2$ | Time for 1 PV flush, Unit 3, days, $t_3$ |
|---|---|---|---|---|---|---|---|---|
| 102899 30 | 31712.30 | 9388.40 | 39600000 | 40800000 | 39600000 | 384.84 | 1286 57 | 4217.97 |

### Contaminant Half-Life Data

| Does contaminant have a decay half-life (yes/no): | no | If yes, half-life (days): | 365 |
|---|---|---|---|
| 1st order decay coefficient (k): | 0.001899 | | |

### Average Pumped/Discharged and Residual Plume Concentrations Over Time

| Target Cleanup Concentration : | | 5 | ug/L | |
|---|---|---|---|---|
| Time period | Time span, days, t | Avg pumped GW conc. | Avg residual GW conc. | Time span, years |
| 0 | 0 | 0 | 18.4 | 0 |
| 0.2 | 76.97 | 17.640 | 17.952 | 0 21 |
| 0.3 | 115.45 | 17.274 | 17.735 | 0.32 |
| 0.4 | 153.94 | 16.917 | 17.522 | 0.42 |
| 0.6 | 230.91 | 16.229 | 17.110 | 0 63 |
| 0 8 | 307.87 | 15.575 | 16.714 | 0.84 |
| 1 | 384.84 | 14.953 | 16.335 | 1.05 |
| 1.4 | 538.78 | 13.797 | 15.620 | 1.48 |
| 1 8 | 692.72 | 12.750 | 14.960 | 1.90 |
| 2.4 | 923.62 | 11 360 | 14.062 | 2.53 |
| 3 | 1154.53 | 10.158 | 13.260 | 3.16 |
| 3.6 | 1385.43 | 9.117 | 12.542 | 3.79 |
| 4.2 | 1616.34 | 8.214 | 11.896 | 4.43 |
| 5 | 1924.21 | 7.190 | 11.131 | 5.27 |
| 6 | 2309.05 | 6.147 | 10.305 | 6.32 |
| 7 | 2693.90 | 5.312 | 9.594 | 7.38 |
| 8 | 3078.74 | 4.637 | 8.977 | 8.43 |
| 10 | 3848.42 | 3.639 | 7.956 | 10.54 |
| 12 | 4618.11 | 2.954 | 7.141 | 12.64 |
| 16 | 6157.48 | 2.103 | 5.904 | 16.86 |
| 20 | 7696.85 | 1.603 | 4.991 | 21.07 |
| 19 | 7312.00 | 1.708 | 5.197 | 20.02 |
| 19.5 | 7504.42 | 1.654 | 5.093 | 20.55 |
| 19.7 | 7581.39 | 1 633 | 5.052 | 20.76 |
| 19.8 | 7619.88 | 1.623 | 5.032 | 20.86 |
| 19.9 | 7658.36 | 1.613 | 5.011 | 20.97 |

Adjust the initial time period to auto-adjust the following 19 time periods and obtain the desired range in concentrations.

The last 5 time periods can be modified to more precisely determine the time required to meet a specific residual concentration.

## Heterogeneous Aquifer Flushing Rate Calculations

| Project: | Claverton Southern Area | Proj. No.: | 1610 |
|---|---|---|---|
| Chemical : | Xylenes | $K_{OC}$ ($K_d$*) : | 407 |
| Concentration units, water & soil (pick 1): | mg/L & mg/Kg | ug/L & ug/Kg | x |

This spreadsheet calculates flushing rates and cleanup times for a groundwater flow system that consists of up to 3 groundwater "flow units". Flow units are discrete portions of the aquifer that have unique properties, i.e., higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher/lower contaminant concentrations, and/or different organic carbon contents. The spreadsheet factors in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction through the optional use of contaminant half-life data

NOTE: Input cells are shaded yellow, cells automatically calculated are shaded blue, the remaining cells are fixed

All groundwater/soil contaminant concentrations are in consistent units, i e , mg/L & mg/Kg, or ug/L & ug/Kg

*** for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i e., metals, the compound's $K_d$ is input directly into the $K_{OC}$ entry cell, with $f_{OC}$ then set to 1. For fractured bedrock, reduce the $f_{OC}$ by 1-2 orders of magnitude to adjust for typical low fracture porosity and resulting high model-perceived mass of aquifer sediments in contact with water.**

### Groundwater Flow Unit Physical/Chemical Data

| Flow Unit 1 (U1) | | Flow Unit 2 (U2) | | Flow Unit 3 (U3) | |
|---|---|---|---|---|---|
| $Cw_{01}$ | 18.40 | $Cw_{02}$ | 18.40 | $Cw_{03}$ | 18.40 |
| n | 0.25 | n | 0.25 | n | 0.25 |
| $S_G$ | 2.65 | $S_G$ | 2.65 | $S_G$ | 2.65 |
| $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 |
| $K_d$ | 0 407 | $K_d$ | 0 407 | $K_d$ | 0 407 |
| $M_W$ | 4 600 | $M_W$ | 4 600 | $M_W$ | 4.600 |
| $C_S$ | 7.489 | $C_S$ | 7.489 | $C_S$ | 7.489 |
| $M_S$ | 14 884 | $M_S$ | 14.884 | $M_S$ | 14.884 |
| $M_T$ | 19.484 | $M_T$ | 19.484 | $M_T$ | 19.484 |
| $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 |

$Cw_{0N}$ = Initial contaminant concentration in groundwater flow unit N

### Groundwater Flow Unit Hydrogeologic Characteristics

| Avg. K, ft/d highest to lowest | Relative average K, $K_U$ | Fraction of aquifer volume, $FV_U$ | Fraction of total flow, $FQ_U$ | Flow unit number, U |
|---|---|---|---|---|
| 331 | 1.000 | 0.33 | 0.715 | 1 |
| 100 | 0.302 | 0.34 | 0.220 | 2 |
| 30.2 | 0.091 | 0.33 | 0.065 | 3 |

### Pore Volumes and Pore Volume Removal Rates

| Groundwater discharge rate, gpm | Groundwater discharge rate, $ft^3$/day, $Q_T$ | Total volume occupied by plume, $ft^3$, $PV_T$ |
|---|---|---|
| 1000 | 192513.37 | 480,000,000 |

| Discharge rate, Unit 1 $ft^3$/day, $Q_1$ | Discharge rate, Unit 2 $ft^3$/day, $Q_2$ | Discharge rate, Unit 3 $ft^3$/day, $Q_3$ | Plume pore Vol., Unit 1 $ft^3$, $PV_1$ | Plume pore Vol., Unit 2 $ft^3$, $PV_2$ | Plume pore Vol., Unit 3 $ft^3$, $PV_3$ | Time for 1 PV flush, Unit 1, days, $t_1$ | Time for 1 PV flush, Unit 2, days, $t_2$ | Time for 1 PV flush, Unit 3, days, $t_3$ |
|---|---|---|---|---|---|---|---|---|
| 137565 91 | 42396 12 | 12551.33 | 39600000 | 40800000 | 39600000 | 287 86 | 962 35 | 3155.04 |

### Contaminant Half-Life Data

| Does contaminant have a decay half-life (yes/no): | no | If yes, half-life (days): | 365 |
|---|---|---|---|
| 1st order decay coefficient (k): | 0.001899 | | |

### Average Pumped/Discharged and Residual Plume Concentrations Over Time

| Target Cleanup Concentration : | | | 5 | ug/L |
|---|---|---|---|---|
| Time period | Time span, days, t | Avg pumped GW conc. | Avg residual GW conc. | Time span, years |
| 0 | 0 | 0 | 18.4 | 0 |
| 0.2 | 57.57 | 17.640 | 17.952 | 0.16 |
| 0.3 | 86.36 | 17.274 | 17.735 | 0.24 |
| 0.4 | 115.14 | 16.917 | 17.522 | 0.32 |
| 0.6 | 172.72 | 16.229 | 17.110 | 0.47 |
| 0.8 | 230.29 | 15.575 | 16.714 | 0.63 |
| 1 | 287.86 | 14.953 | 16.335 | 0.79 |
| 1.4 | 403.01 | 13.797 | 15.620 | 1.10 |
| 1.8 | 518.15 | 12.750 | 14.960 | 1.42 |
| 2.4 | 690.87 | 11.360 | 14.062 | 1.89 |
| 3 | 863.59 | 10.158 | 13.260 | 2.36 |
| 3.6 | 1036.30 | 9.117 | 12.542 | 2.84 |
| 4.2 | 1209.02 | 8.214 | 11.896 | 3.31 |
| 5 | 1439.31 | 7.190 | 11.131 | 3.94 |
| 6 | 1727.17 | 6.147 | 10.305 | 4.73 |
| 7 | 2015.03 | 5.312 | 9.594 | 5.52 |
| 8 | 2302.90 | 4.637 | 8.977 | 6.30 |
| 10 | 2878.62 | 3.639 | 7.956 | 7.88 |
| 12 | 3454.34 | 2.954 | 7.141 | 9.46 |
| 16 | 4605.79 | 2.103 | 5.904 | 12.61 |
| 20 | 5757 24 | 1.603 | 4.991 | 15.76 |
| 19 | 5469 38 | 1.708 | 5.197 | 14.97 |
| 19.5 | 5613.31 | 1.654 | 5.093 | 15.37 |
| 19.7 | 5670.88 | 1.633 | 5.052 | 15.53 |
| 19.8 | 5699.67 | 1.623 | 5.032 | 15.60 |
| 19.9 | 5728.45 | 1.613 | 5.011 | 15.68 |

Adjust the initial time period to auto-adjust the following 19 time periods and obtain the desired range in concentrations.

The last 5 time periods can be modified to more precisely determine the time required to meet a specific residual concentration.

## Heterogeneous Aquifer Flushing Rate Calculations

| Project: | Claverton Southern Area | Proj. No.: | 1610 |
|---|---|---|---|
| Chemical : | Xylenes | $K_{OC}$ ($K_d$*) : | 407 |
| Concentration units, water & soil (pick 1): | mg/L & mg/Kg | ug/L & ug/Kg | X |

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue; the remaining cells are fixed.

This spreadsheet calculates flushing rates and cleanup times for a groundwater flow system that consists of up to 3 groundwater "flow units". Flow units are discrete portions of the aquifer that have unique properties, i.e., higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher/lower contaminant concentrations, and/or different organic carbon contents. The spreadsheet factors in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction through the optional use of contaminant half-life data.

All groundwater/soil contaminant concentrations are in consistent units, i.e., mg/L & mg/Kg, or ug/L & ug/Kg

* for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i.e., metals, the compound's $K_d$ is input directly into the $K_{OC}$ entry cell, with $f_{OC}$ then set to 1. For fractured bedrock, reduce the $f_{OC}$ by 1-2 orders of magnitude to adjust for typical low fracture porosity and resulting high model-perceived mass of aquifer sediments in contact with water.

### Groundwater Flow Unit Physical/Chemical Data

| Flow Unit 1 (U1) | | Flow Unit 2 (U2) | | Flow Unit 3 (U3) | |
|---|---|---|---|---|---|
| $Cw_{01}$ | 18.40 | $Cw_{02}$ | 18.40 | $Cw_{03}$ | 18.40 |
| n | 0.25 | n | 0.25 | n | 0.25 |
| $S_G$ | 2.65 | $S_G$ | 2.65 | $S_G$ | 2.65 |
| $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 |
| $K_d$ | 0.407 | $K_d$ | 0.407 | $K_d$ | 0.407 |
| $M_W$ | 4.600 | $M_W$ | 4.600 | $M_W$ | 4.600 |
| $C_S$ | 7.489 | $C_S$ | 7.489 | $C_S$ | 7.489 |
| $M_S$ | 14.884 | $M_S$ | 14.884 | $M_S$ | 14.884 |
| $M_T$ | 19.484 | $M_T$ | 19.484 | $M_T$ | 19.484 |
| $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 |

$Cw_{0N}$ = Initial contaminant concentration in groundwater flow unit N

### Groundwater Flow Unit Hydrogeologic Characteristics

| Avg. K, ft/d highest to lowest | Relative average K, $K_U$ | Fraction of aquifer volume, $FV_U$ | Fraction of total flow, $FQ_U$ | Flow unit number, U |
|---|---|---|---|---|
| 331 | 1.000 | 0.33 | 0.715 | 1 |
| 100 | 0.302 | 0.34 | 0.220 | 2 |
| 30.2 | 0.091 | 0.33 | 0.065 | 3 |

### Pore Volumes and Pore Volume Removal Rates

| Groundwater discharge rate, gpm | Groundwater discharge rate, $ft^3$/day, $Q_T$ | Total volume occupied by plume, $ft^3$, $PV_T$ |
|---|---|---|
| 1250 | 240641.71 | 480,000,000 |

| Discharge rate, Unit 1 $ft^3$/day, $Q_1$ | Discharge rate, Unit 2 $ft^3$/day, $Q_2$ | Discharge rate, Unit 3 $ft^3$/day, $Q_3$ | Plume pore Vol., Unit 1 $ft^3$, $PV_1$ | Plume pore Vol., Unit 2 $ft^3$, $PV_2$ | Plume pore Vol., Unit 3 $ft^3$, $PV_3$ | Time for 1 PV flush, Unit 1, days, $t_1$ | Time for 1 PV flush, Unit 2, days, $t_2$ | Time for 1 PV flush, Unit 3, days, $t_3$ |
|---|---|---|---|---|---|---|---|---|
| 171957.39 | 52995.16 | 15689.16 | 39600000 | 40800000 | 39600000 | 230.29 | 769.88 | 2524.04 |

### Contaminant Half-Life Data

| Does contaminant have a decay half-life (yes/no): | no | If yes, half-life (days): | 365 |
|---|---|---|---|
| 1st order decay coefficient (k): | 0.001899 | | |

### Average Pumped/Discharged and Residual Plume Concentrations Over Time

| Target Cleanup Concentration : | | 5 | ug/L | |
|---|---|---|---|---|
| Time period | Time span, days, t | Avg pumped GW conc. | Avg residual GW conc. | Time span, years |
| 0 | 0 | 0 | 18.4 | 0 |
| 0.2 | 46.06 | 17.640 | 17.952 | 0.13 |
| 0.3 | 69.09 | 17.274 | 17.735 | 0.19 |
| 0.4 | 92.12 | 16.917 | 17.522 | 0.25 |
| 0.6 | 138.17 | 16.229 | 17.110 | 0.38 |
| 0.8 | 184.23 | 15.575 | 16.714 | 0.50 |
| 1 | 230.29 | 14.953 | 16.335 | 0.63 |
| 1.4 | 322.41 | 13.797 | 15.620 | 0.88 |
| 1.8 | 414.52 | 12.750 | 14.960 | 1.13 |
| 2.4 | 552.70 | 11.360 | 14.062 | 1.51 |
| 3 | 690.87 | 10.158 | 13.260 | 1.89 |
| 3.6 | 829.04 | 9.117 | 12.542 | 2.27 |
| 4.2 | 967.22 | 8.214 | 11.896 | 2.65 |
| 5 | 1151.45 | 7.190 | 11.131 | 3.15 |
| 6 | 1381.74 | 6.147 | 10.305 | 3.78 |
| 7 | 1612.03 | 5.312 | 9.594 | 4.41 |
| 8 | 1842.32 | 4.637 | 8.977 | 5.04 |
| 10 | 2302.90 | 3.639 | 7.956 | 6.30 |
| 12 | 2763.48 | 2.954 | 7.141 | 7.57 |
| 16 | 3684.63 | 2.103 | 5.904 | 10.09 |
| 20 | 4605.79 | 1.603 | 4.991 | 12.61 |
| 19 | 4375.50 | 1.708 | 5.197 | 11.98 |
| 19.5 | 4490.65 | 1.654 | 5.093 | 12.29 |
| 19.7 | 4536.71 | 1.633 | 5.052 | 12.42 |
| 19.8 | 4559.73 | 1.623 | 5.032 | 12.48 |
| 19.9 | 4582.76 | 1.613 | 5.011 | 12.55 |

Adjust the initial time period to auto-adjust the following 19 time periods and obtain the desired range in concentrations

The last 5 time periods can be modified to more precisely determine the time required to meet a specific residual concentration.

# Heterogeneous Aquifer Flushing Rate Calculations

| | | | |
|---|---|---|---|
| Project: | Claverton Southern Area | Proj. No.: | 1610 |
| Chemical : | Xylenes | $K_{OC}$ ($K_d$*) : | 407 |
| Concentration units, water & soil (pick 1): | mg/L & mg/Kg | ug/L & ug/Kg | x |

NOTE: Input cells are shaded yellow; cells automatically calculated are shaded blue; the remaining cells are fixed

All groundwater/soil contaminant concentrations are in consistent units, i e , mg/L & mg/Kg, or ug/L & ug/Kg

This spreadsheet calculates flushing rates and cleanup times for a groundwater flow system that consists of up to 3 groundwater "flow units". Flow units are discrete portions of the aquifer that have unique properties, i.e , higher or lower average hydraulic conductivity, porosity, or specific gravity relative to other portions of the aquifer, higher/lower contaminant concentrations, and/or different organic carbon contents. The spreadsheet factors in different flushing rates for discrete portions of the aquifer based on the differences in the physical/chemical characteristics of the flow units. First-order contaminant decay/degradation processes can also be factored into the cleanup rate prediction through the optional use of contaminant half-life data.

* for contaminants that partition between soil and water thru mechanisms other than adsoption onto organic carbon, i e., metals, the compound's $K_d$ is input directly into the $K_{OC}$ entry cell, with $f_{OC}$ then set to 1. For fractured bedrock, reduce the $f_{OC}$ by 1-2 orders of magnitude to adjust for typical low fracture porosity and resulting high model-perceived mass of aquifer sediments in contact with water.

### Groundwater Flow Unit Physical/Chemical Data

| Flow Unit 1 (U1) | | Flow Unit 2 (U2) | | Flow Unit 3 (U3) | |
|---|---|---|---|---|---|
| $Cw_{01}$ | 18.40 | $Cw_{02}$ | 18.40 | $Cw_{03}$ | 18.40 |
| n | 0.25 | n | 0.25 | n | 0.25 |
| $S_G$ | 2.65 | $S_G$ | 2.65 | $S_G$ | 2.65 |
| $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 | $f_{OC}$* | 0.0010 |
| $K_d$ | 0.407 | $K_d$ | 0.407 | $K_d$ | 0.407 |
| $M_W$ | 4.600 | $M_W$ | 4.600 | $M_W$ | 4.600 |
| $C_S$ | 7.489 | $C_S$ | 7.489 | $C_S$ | 7.489 |
| $M_S$ | 14.884 | $M_S$ | 14.884 | $M_S$ | 14.884 |
| $M_T$ | 19.484 | $M_T$ | 19.484 | $M_T$ | 19.484 |
| $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 | $M_S/M_T$ | 0.7639 |

$Cw_{0N}$ = Initial contaminant concentration in groundwater flow unit N

### Groundwater Flow Unit Hydrogeologic Characteristics

| Avg. K, ft/d highest to lowest | Relative average K, $K_U$ | Fraction of aquifer volume, $FV_U$ | Fraction of total flow, $FQ_U$ | Flow unit number, U |
|---|---|---|---|---|
| 331 | 1.000 | 0.33 | 0.715 | 1 |
| 100 | 0.302 | 0.34 | 0.220 | 2 |
| 30.2 | 0.091 | 0.33 | 0.065 | 3 |

### Pore Volumes and Pore Volume Removal Rates

| Groundwater discharge rate, gpm | Groundwater discharge rate, $ft^3$/day, $Q_T$ | Total volume occupied by plume, $ft^3$, $PV_T$ |
|---|---|---|
| 960 | 184812.83 | 480,000,000 |

| Discharge rate, Unit 1 $ft^3$/day, $Q_1$ | Discharge rate, Unit 2 $ft^3$/day, $Q_2$ | Discharge rate, Unit 3 $ft^3$/day, $Q_3$ | Plume pore Vol., Unit 1 $ft^3$, $PV_1$ | Plume pore Vol., Unit 2 $ft^3$, $PV_2$ | Plume pore Vol., Unit 3 $ft^3$, $PV_3$ | Time for 1 PV flush, Unit 1, days, $t_1$ | Time for 1 PV flush, Unit 2, days, $t_2$ | Time for 1 PV flush, Unit 3, days, $t_3$ |
|---|---|---|---|---|---|---|---|---|
| 132063.28 | 40700 28 | 12049.28 | 39600000 | 40800000 | 39600000 | 299 86 | 1002 45 | 3286.50 |

### Contaminant Half-Life Data

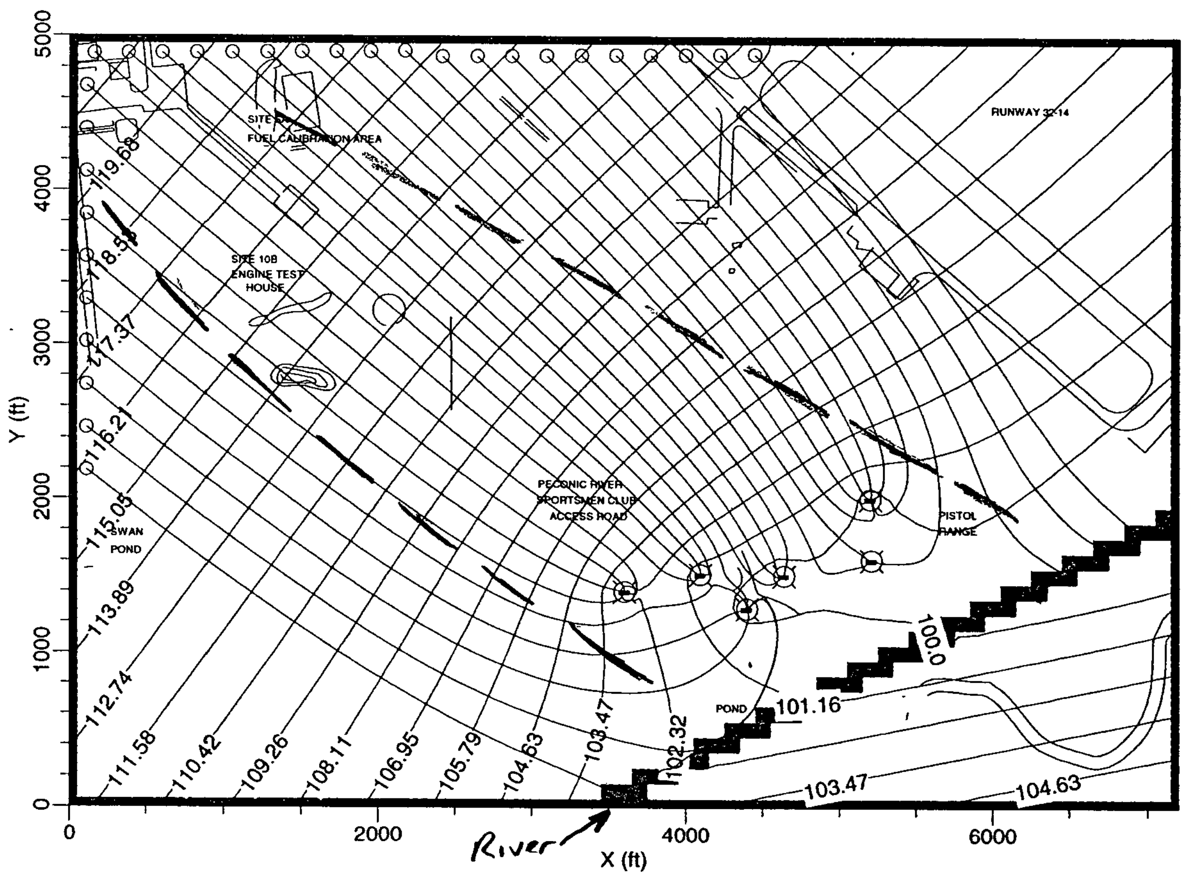
| | | | |
|---|---|---|---|
| Does contaminant have a decay half-life (yes/no): | no | If yes, half-life (days): | 365 |
| 1st order decay coefficient (k): | 0 001899 | | |

### Average Pumped/Discharged and Residual Plume Concentrations Over Time

| Target Cleanup Concentration : | | | 5 | ug/L |
|---|---|---|---|---|
| Time period | Time span, days, t | Avg pumped GW conc. | Avg residual GW conc. | Time span, years |
| 0 | 0 | 0 | 18.4 | 0 |
| 0.2 | 59.97 | 17.640 | 17.952 | 0.16 |
| 0.3 | 89.96 | 17.274 | 17.735 | 0.25 |
| 0.4 | 119.94 | 16.917 | 17.522 | 0 33 |
| 0 6 | 179.91 | 16.229 | 17.110 | 0.49 |
| 0.8 | 239.89 | 15.575 | 16.714 | 0.66 |
| 1 | 299.86 | 14.953 | 16.335 | 0.82 |
| 1.4 | 419 80 | 13 797 | 15.620 | 1.15 |
| 1 8 | 539.74 | 12.750 | 14.960 | 1.48 |
| 2.4 | 719 66 | 11.360 | 14.062 | 1.97 |
| 3 | 899.57 | 10.158 | 13.260 | 2.46 |
| 3.6 | 1079.48 | 9.117 | 12.542 | 2.96 |
| 4.2 | 1259.40 | 8.214 | 11.896 | 3.45 |
| 5 | 1499.28 | 7.190 | 11.131 | 4.10 |
| 6 | 1799.14 | 6.147 | 10.305 | 4 93 |
| 7 | 2098.99 | 5.312 | 9.594 | 5.75 |
| 8 | 2398.85 | 4.637 | 8.977 | 6.57 |
| 10 | 2998.56 | 3.639 | 7.956 | 8.21 |
| 12 | 3598.28 | 2.954 | 7.141 | 9 85 |
| 16 | 4797.70 | 2.103 | 5.904 | 13.14 |
| 20 | 5997.13 | 1.603 | 4.991 | 16.42 |
| 19 | 5697.27 | 1.708 | 5.197 | 15.60 |
| 19.5 | 5847.20 | 1.654 | 5.093 | 16.01 |
| 19.7 | 5907.17 | 1.633 | 5.052 | 16.17 |
| 19.8 | 5937.15 | 1.623 | 5.032 | 16.26 |
| 19.9 | 5967.14 | 1.613 | 5.011 | 16.34 |

Adjust the initial time period to auto-adjust the following 19 time periods and obtain the desired range in concentrations.

The last 5 time periods can be modified to more precisely determine the time required to meet a specific residual concentration.

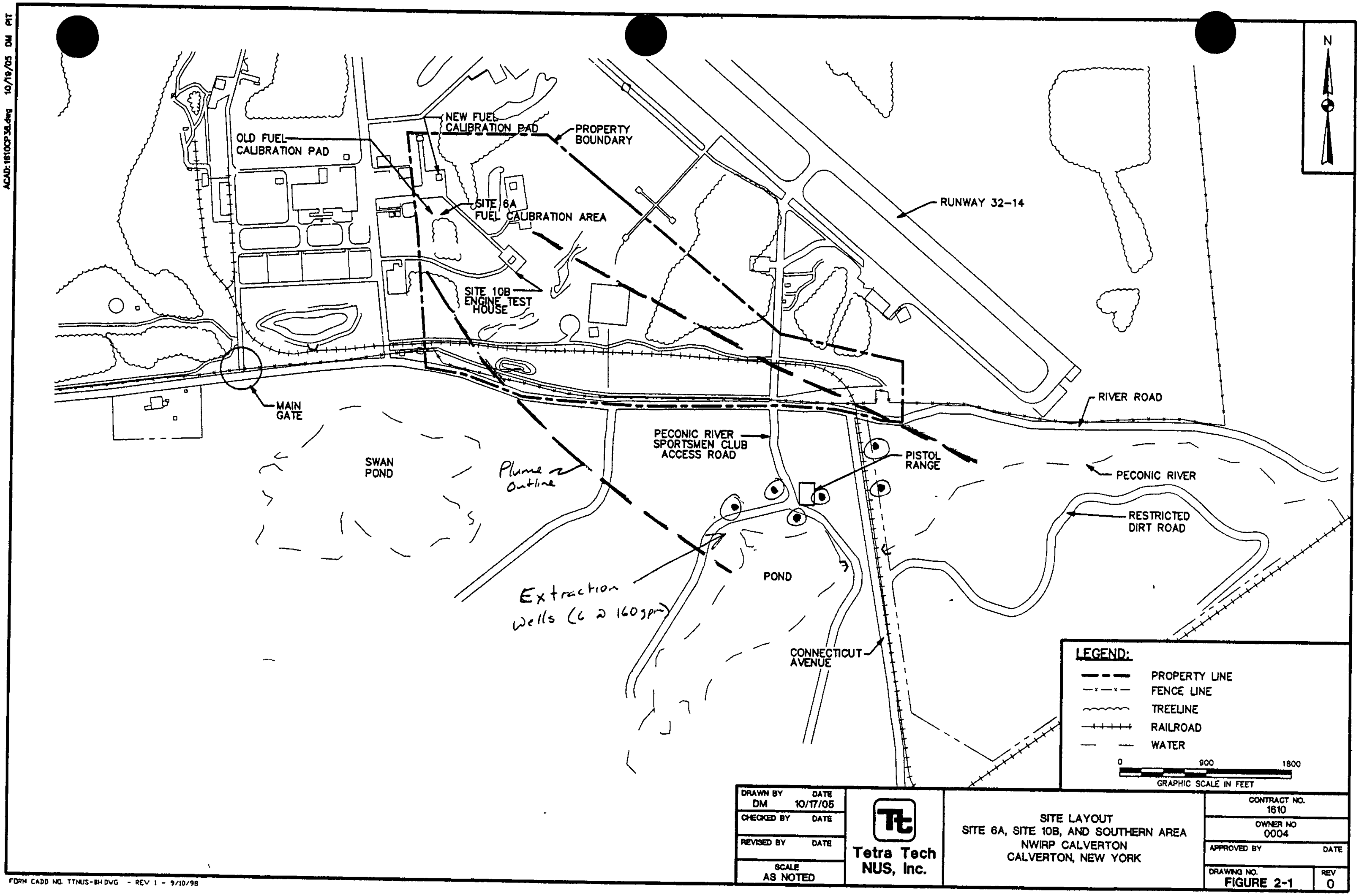



6 wells @ 160 gpm = 960 gpm

Site elevations set to Peconic River assigned elevation of +/- 100 ft.

Project: CALVERTON
Date:11/11/2005 4:17:57 PM

FlowPath II Ver. 1.1
© 1989-1998 WHI


ACAD: 1610CP36.dwg 10/19/05 DM PIT
N
NEW FUEL CALIBRATION PAD
OLD FUEL CALIBRATION PAD
PROPERTY BOUNDARY
RUNWAY 32-14
SITE 6A FUEL CALIBRATION AREA
SITE 10B ENGINE TEST HOUSE
RIVER ROAD
MAIN GATE
PECONIC RIVER SPORTSMEN CLUB ACCESS ROAD
PISTOL RANGE
SWAN POND
Plume Outline
PECONIC RIVER
RESTRICTED DIRT ROAD
POND
Extraction Wells (6 @ 160gpm)
CONNECTICUT AVENUE
LEGEND:
PROPERTY LINE
FENCE LINE
TREELINE
RAILROAD
WATER
0 900 1800
GRAPHIC SCALE IN FEET
DRAWN BY DM
DATE 10/17/05
CHECKED BY DATE
REVISED BY DATE
SCALE AS NOTED
Tetra Tech NUS, Inc.
SITE LAYOUT
SITE 6A, SITE 10B, AND SOUTHERN AREA
NWIRP CALVERTON
CALVERTON, NEW YORK
CONTRACT NO. 1610
OWNER NO 0004
APPROVED BY DATE
DRAWING NO. FIGURE 2-1
REV 0
FORM CADD NO. TTNUS-BH DWG - REV 1 - 9/10/98

B-17

## 1.0 TREATMENT SCHEME

This alternative would consist of installing and operating two (2) "pump-and-treat" systems. Each of these systems would consist of a Groundwater Extraction Well System and an Off-Site Treatment System, suspended solid treatment as required, air stripping, and discharge [reinjection or discharge to creek)).

The treatment system schematic is shown in Figure 4-3 and consists of the following unit operations/processes:

- Equalization/precipitation, clarification, and/or filtration
- Air Stripping

Remedial action duration for groundwater system is provided in the attached calculations based on the extraction system design. For the purpose of this FS, it is assumed that 2 treatment systems will be used for the Off-Site Southern Area Groundwater Plume.

## 2.0 OFF-SITE SOUTHERN AREA GROUNDWATER PLUME TREATMENT SYSTEM DESIGN

### 2.1 Extraction System

Based on groundwater extraction system design calculations, extraction wells are the following

| Item\Site | Off-Site Southern Area Groundwater Plume |
|---|---|
| Number of Extraction Wells | 6 |
| Screened Depth (ft bgs) | 60-90 |
| Location of Extraction Wells | In a hot spot and near the downgradient plume boundary |
| Extraction Rate per well (gpm) | 160 |
| Extraction Rate total (gpm) | 960 |
| Operation (years) | 16-17 |

Calculations and figures for the extraction system design are attached.

### 2.2 Groundwater Extraction Pumps Design

Multi-stage submersible centrifugal pumps would be installed in the above wells as follows:

| | | Pump Design | | |
|---|---|---|---|---|
| | Number Wells | Flow Rate (gpm) | Total Discharge Head (ft) | Motor Size (HP) |
| Off-Site Southern Area Groundwater Plume | 6 | 160 | 150 | 7.5 |
| **Total** | 6 | 960 | --- | --- |

### 2.3 Extracted Groundwater Quality

Based on the estimates of maximum concentrations of COCs for the Off-Site Southern Area Groundwater Plume, the anticipated quality of the groundwater extracted by the system could be summarized as follows:

| Parameter* | New York State GW Quality Standard (1) | Overall Maximum Result (ug/L) |
|---|---|---|
| 1,1,1-TRICHLOROETHANE | 5 | 24 |
| 1,1,2-TRICHLOROETHANE | 1 | 1.88 |
| 1,1-DICHLOROETHANE | 5 | 292 |
| 1,1-DICHLOROETHENE | 5 | 21.7 |
| 1,2-DICHLOROETHANE | 0.6 | 1.57 |
| 1,4-DICHLOROBENZENE | 3 | 1.3 |
| ACETONE | 50(2) | 12 |
| 2-BUTANONE | 50(2) | 4.4 |
| BENZENE | 1 | 1.4 |
| CARBON DISULFIDE | 60(2) | 4 |
| CHLOROETHANE | 5 | 7.9 |
| CHLOROFORM | 7 | 4.72 |
| CIS-1,2-DICHLOROETHENE | 5 | 0.6 |
| ETHYLBENZENE | 5 | 2.93 |
| METHYL TERT-BUTYL ETHER | 10(2) | 7.45 |
| METHYLENE CHLORIDE | 5 | 1.2 |
| TOLUENE | 5 | 10.1 |
| TOTAL XYLENES | 5 | 18.36 |
| TRANS-1,2-DICHLOROETHENE | 5 | 2.54 |
| TRICHLOROETHENE | 5 | 0.29 |
| TRICHLOROFLUOROMETHANE | 5 | 2.63 |
| VINYL CHLORIDE | 2 | 2 |

* Chemicals of concern that exceed the NY State GW standards are highlighted in black
GW - Groundwater
1 - 6 NYCRR Part 703, Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, NYSDEC, Section 703.5, Table 1.
2 - TOGS 1.1.1, Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, Table 1 and 2000 Addendum to Table 1.
Shading indicates parameter concentration exceeds the New York State GW Quality Standard.

## 2.4 ON-SITE TREATMENT SYSTEMS

**2.4.1 Equalization**

The Treatment System would feature two equalization tanks to blend groundwater, one for 2 extraction wells and the other for 4 extraction wells. Each equalization tank would be equipped with a mixer and would feature a closed-top design to control VOCs emission. Equalization tanks would be vented to the inlet of the air stripper blower. Equalization tanks would be sized to provide 30 minutes detention under design flow conditions.

Equalization Tank A Volume: 160 gpm x 2 wells = 320 gallons/minute x 30 minutes = 9,600 gallons

⇒ Call for a 15-foot diameter 10 feet high steel equalization tank with a working capacity of 10,000 gallons. Tank to be of cylindrical vertical configuration. Tank to be of closed-top design with vent.

Mixer A size @ 0.5 HP/1,000 gal: 9,600 gallons x 0.5 HP ÷ 1,000 gallons = 4.8 HP say 5 HP

⇒ Call for a top-mounted 5 HP low-speed turbine-type mixer.

Equalization Tank B Volume: 160 gpm x 4 wells = 640 gallons/minute x 30 minutes = 19,200 gallons

⇒ Call for a 15-foot diameter 20 feet high steel equalization tank with a working capacity of 20,000 gallons. Tank to be of cylindrical vertical configuration. Tank to be of closed-top design with vent.

Mixer B size @ 0.5 HP/1,000 gal: 19,200 gallons x 0.5 HP ÷ 1,000 gallons = 9.6 HP say 10 HP

⇒ Call for a top-mounted 10 HP low-speed turbine-type mixer.

Pumps would be provided to transfer groundwater from equalization tank to downstream treatment processes. Three transfer pumps should be provided, including an installed spare. Pump operation (start/stop) would be controlled by the liquid level in the equalization tank.

⇒ Call for four (one spare) horizontal-centrifugal 320 gpm equalized groundwater transfer pumps (100 ft design TDH – 15 HP motor).

**2.4.2 Clarifier and/or Filtration (may not be required depending on Equalization)**

<u>Clarifier</u> – Used for settling and storage of particulates. Use design factor of 0.4 gpm/sf. Determine surface area of clarifier: 320 gpm ÷ 0.4 gpm/sf = 800 sf

⇒ Call for three (3) 32-foot diameter 8 feet high tank with a working capacity of 48,000 gallons – 1 tank following Equalization Tank A and 2 tanks following Equalization Tank B running a parallel system. Tank to be of cylindrical vertical configuration and manufactured of fiberglass or painted carbon steel. Tank to be of closed-top design with vent.

<u>Filtration</u> - Use bag type filter unit to avoid liquid residual stream from backwashing. Size bag filter unit for replacement of filter bag element no more frequently than once a week.

Assuming approximately 10 mg/L TSS in untreated groundwater and 90% removal, TSS accumulation in the filter within a week would be:

320 gal/min x 1,440 min/day x 7 days/week x 8.34 lbs/gal x [(10 – 1) mg/l] x $10^{-6}$ = 242 lbs dry TSS /week

Assuming a typical solids capture capacity of approximately 1.0 lbs dry TSS per square foot of bag filter element, required surface of bag element is:

242 lbs ÷ 1.0 lbs/$ft^2$ = 242 $ft^2$

⇒ Call four (one spare) multi-bag pressurized filter unit with a total filter area of 242 $ft^2$

### 2.4.3 Air Stripping

Filtered groundwater would be treated in a low-profile multi-tray air stripper for the removal of most of the VOCs. According to the attached calculations sheet, the design of this air stripper may be summarized as follows:

| | |
|---|---|
| Groundwater Flow: | 320 gpm |
| Max VOCs In: | 425 µg/L |
| VOCs Removal Efficiency: | 95% |
| Air-to-Water Ratio: | 56:1 |
| No. of Stripper Trays: | 5 |
| Air Blower Flow: | 2400 cfm |

Air-stripped groundwater would be pumped from the sump of the air stripper to the reinjection wells/trenches or to a ditch for discharge into the creek by three horizontal centrifugal pumps (plus one spare). Pump operation (start/stop) would be controlled by the liquid level in the air stripper sump.

⇒ Call for three low-profile multi-tray type air stripper North East Environmental Products ShallowTray Low Profile Air Stripper Model 41251 or equivalent with five (5) trays and 2400 cfm air blower

⇒ Call for four (one spare) horizontal-centrifugal 320 gpm treated groundwater discharge pumps (100 ft design TDH - 15 HP motor).

Maximum quantity of VOCs in air stripper offgas:

(425 µg/L x 0.95) x 320 gpm x 1,440 min/day x 8.34 lbs/gal x $10^{-9}$ = 1.6 per stripper, say 4.8 pounds per day from entire treatment system (1.6 x 3 strippers)

This is well below the deminimis level of 15 pounds per day; therefore, no offgas treatment system is required for the air stripper.

## 2.5 ESTIMATE QUANTITIES

| Item | Off-Site Southern Area Groundwater Plume |
|---|---|
| Extraction Wells - 90 ft deep, screened 60 to 90 ft | 6 |
| Extraction Wells Pumps | 6 @ 160 gpm – 7.5 hp |
| Equalization – 2 tanks | 15 ft diameter, 10 ft deep, 10,000 |

| Item | Off-Site Southern Area Groundwater Plume |
|---|---|
| | gallon tank with 5 hp mixer<br>15 ft diameter, 20 ft deep, 20,000 gallon tank with 10 hp mixer<br>4 - 320 gpm pumps (15 hp) |
| Clarifier (if needed) - 3 tanks | 32 ft diameter, 8 ft deep, 48,000 gallon tank |
| Filtration (if needed) – 4 bags | Pressurized filters with filter area of 242 sf each |
| Air Stripper – ShallowTray low profile – 3 strippers | NEEP Model 41251 |

**Miscellaneous Items**

Equipment control area/structure to protect the equipment from inclement weather and vandalism.
Control Panel and associated Process and Instrumentation Diagram (P&ID). Operation of the treatment will be controlled by a HAND-OFF-AUTO switch. In the AUTO position, which is the normal mode of operation, but its operation will be interlocked with pumps, high level switches, air stripper, etc. If the switches are tripped, the treatment system will shut down.

**ShallowTray®**
low profile air strippers

## System Performance Estimate

Client and Proposal Information

**Navy Calverton**
**Off-Site Southern Area Groundwater Plume**
**Groundwater Plume**
**Feasibility Study - 1610 1110**

| | | |
|---|---|---|
| Series chosen: | 41200 | |
| Water Flow Rate: | 320 gpm | 72.7 m3/hr |
| Air Flow Rate: | 2400 scfm | 4080 m3/hr |
| Water Temp: | 52 °F | 11 °C |
| Air Temp: | 50 °F | 10 °C |
| A/W Ratio: | 56 :1 | |
| Safety Factor: | 25% | |

| Contaminant | Untreated Influent / Effluent Target | Model 41211 Effluent lbs/hr ppmv %removal | Model 41221 Effluent lbs/hr ppmv %removal | Model 41231 Effluent lbs/hr ppmv %removal | Model 41241 Effluent lbs/hr ppmv %removal | SELECTED MODEL Model 41251 Effluent lbs/hr ppmv %removal |
|---|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | 24 ppb | 4 ppb | <1 ppb | <1 ppb | <1 ppb | <1 ppb |
| Solubility 4,400 ppm | 5 ppb | 0.00 0.06 | 0 00 0 07 | 0.00 0 08 | 0 00 0 08 | 0.00 0 08 |
| Mwt 133.41 | | 83.65% | 97.33% | 99 56% | 99.93% | 99 99% |
| 1,1,2-Trichloroethane | 1.9 ppb | 2 ppb | 1 ppb | 1 ppb | 1 ppb | <1 ppb |
| Solubility 4,500 ppm | 1 ppb | 0 00 0.00 | 0.00 0.00 | 0.00 0.00 | 0.00 0 00 | 0.00 0 00 |
| Mwt 133 41 | | 13.05% | 24.40% | 34.27% | 42 84% | 50 30% |
| 1,1- Dichloroethane | 292 ppb | 93 ppb | 30 ppb | 9 ppb | 3 ppb | <1 ppb |
| Solubility 5,500 ppm | 5 ppb | 0 03 0 85 | 0 04 1.12 | 0 05 1.21 | 0.05 1.23 | 0.05 1.24 |
| Mwt 98 96 | | 68.15% | 89 85% | 96.77% | 98.97% | 99 67% |
| 1,1-Dichloroethylene | 21 7 ppb | 2 ppb | <1 ppb | <1 ppb | <1 ppb | <1 ppb |
| Solubility 500 ppm | 5 ppb | 0.00 0 08 | 0 00 0 09 | 0 00 0 09 | 0 00 0.09 | 0.00 0.09 |
| Mwt 96.94 | | 88.94% | 98.78% | 99 86% | 99.99% | 100.00% |
| 1,2-Dichloroethane | 1.57 ppb | 1 ppb | 1 ppb | 1 ppb | <1 ppb | <1 ppb |
| Solubility 550 ppm | 0 6 ppb | 0 00 0.00 | 0.00 0 00 | 0 00 0.00 | 0.00 0 00 | 0.00 0 00 |
| Mwt 98 96 | | 10 85% | 20 51% | 29.14% | 36.82% | 43.67% |
| Benzene | 1.4 ppb | <1 ppb | <1 ppb | <1 ppb | <1 ppb | <1 ppb |
| Solubility 1,780 ppm | 1 ppb | 0.00 0.01 | 0.00 0 01 | 0.00 0.01 | 0.00 0.01 | 0 00 0.01 |
| Mwt 78 12 | | 72.04% | 92.18% | 97.81% | 99.39% | 99 83% |
| Chloroethane | 7 9 ppb | 2 ppb | <1 ppb | <1 ppb | <1 ppb | <1 ppb |
| Solubility 5,740 ppm | 5 ppb | 0 00 0.04 | 0 00 0.05 | 0.00 0 05 | 0 00 0 05 | 0.00 0 05 |
| Mwt 64.26 | | 75.40% | 93.95% | 98.51% | 99.63% | 99.91% |
| Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY | | | | | | |
| Toluene | 10.1 ppb | 3 ppb | <1 ppb | <1 ppb | <1 ppb | <1 ppb |
| Solubility 515 ppm | 5 ppb | 0 00 0 03 | 0 00 0 04 | 0 00 0 05 | 0.00 0 05 | 0 00 0 05 |
| Mwt 92.13 | | 69 72% | 90.83% | 97.22% | 99.16% | 99.75% |
| Xylenes | 18.36 ppb | 5 ppb | 1 ppb | <1 ppb | <1 ppb | <1 ppb |
| Solubility 175 ppm | 5 ppb | 0 00 0 05 | 0 00 0 07 | 0 00 0.07 | 0.00 0.07 | 0 00 0.07 |
| Mwt 106 | | 72.53% | 92 45% | 97 93% | 99.43% | 99 84% |
| MEK | 4.4 ppb | 4 ppb | 4 ppb | 4 ppb | 4 ppb | 4 ppb |
| Solubility 353,000 ppm | 50 ppb | 0.00 0 00 | 0.00 0 00 | 0 00 0.00 | 0.00 0 00 | 0 00 0.00 |
| Mwt 72.1 | | 0 00% | 0 00% | 0 00% | 0.00% | 0.00% |
| Due to its high solubility, MEK removal is difficult to predict. Call your NEEP representative for more information | | | | | | |
| Chloroform | 4.72 ppb | 2 ppb | <1 ppb | <1 ppb | <1 ppb | <1 ppb |
| Solubility 8,000 ppm | 7 ppb | 0.00 0 01 | 0 00 0.01 | 0 00 0.02 | 0 00 0 02 | 0.00 0 02 |
| MW 119 38 | | 63 39% | 86.60% | 95 09% | 98.20% | 99.34% |
| MTBE | 7.45 ppb | 7 ppb | 7 ppb | 7 ppb | 7 ppb | 7 ppb |
| Solubility 43,000 ppm | 10 ppb | 0.00 0.00 | 0.00 0 00 | 0.00 0.00 | 0.00 0.00 | 0.00 0 00 |
| Mwt 88.15 | | 0 00% | 0 00% | 0 00% | 0.00% | 0 00% |
| **Total ppb** | 396 ppb | 126 ppb | 49 ppb | 25 ppb | 17 ppb | 15 ppb |
| **Total VOC lbs/hr - ppmv** | | 0.04 1.14 | 0.06 1.47 | 0.06 1 57 | 0.06 1.60 | 0 06 1 62 |
| **Total** | | 68 04% | 87.71% | 93.72% | 95.63% | 96 27% |



**Report Generated· 11/18/2005** **Modeler V6 12e 5/24/2001**

| CLIENT | JOB NUMBER |
|---|---|
| CALVERTON, NY | 1610/1110 |

SUBJECT: OFF-SITE SOUTHERN AREA - EFFLUENT DISCHARGE RATES

| BASED ON | DRAWING NUMBER | | |
|---|---|---|---|
| BY | CHECKED BY | APPROVED BY | DATE |
| CAR 11/15/05 | | | |

DETERMINE WHAT PORTION OF EFFLUENT FROM THE GROUNDWATER EXTRACTION SYSTEM SHOULD BE DIRECTLY DISCHARGED TO THE PECONIC RIVER TO SUSTAIN CURRENT CONDITIONS AND MINIMIZE IMPACTS.

(I.) DATA:

AVG. PECONIC RIVER FLOW @ RIVERHEAD = 37 CFS (REF. 1)

AVG. PECONIC RIVER FLOW @ SCHULTZ RD = 4.75 CFS (REF. 1)

AVG. PECONIC RIVER FLOW @ OFF-SITE SOUTHERN AREA = 16.4 CFS (APPDX A - ATTENUATION FACTOR CALCS.)

EXTRACTION SYSTEM FLOW RATE = 960 GPM OR 2.14 CFS (SEE SECTION 4 AND APPDX B)

% OF PECONIC RIVER FLOW FROM GW RECHARGE = 92% (REF. 2)

% OF PECONIC RIVER FLOW FROM SW RUNOFF = 8% (REF. 2)

DISTANCE FROM RIVERHEAD TO CALVERTON = 6.5 MILES

DISTANCE FROM CALVERTON TO SCHULTZ RD = 3.7 MILES

| | |
|---|---|
| CLIENT: CALVERTON, NY | JOB NUMBER: 1610/1110 |
| SUBJECT: OFF-SITE SOUTHERN AREA – EFFLUENT DISCHARGE RATES | |
| BASED ON | DRAWING NUMBER |
| BY: CAR 1/15/05 CHECKED BY: | APPROVED BY: DATE: |

## II.) REFERENCES:

(1) SULLIVAN, T., ESTIMATION OF POTENTIAL WATER LEVELS IN THE PECONIC RIVER NEAR BROOKHAVEN NATIONAL LABORATORY BASED ON A REVIEW OF HYDROLOGIC DATA, ENVIRONMENTAL RESEARCH & TECHNOLOGY DIVISION, BROOKHAVEN NATIONAL LABORATORY, APRIL 15, 2003.

(2) FRANKE, O.L., AND N.E. McCLYMONDS, SUMMARY OF THE HYDROLOGIC SITUATION ON LONG ISLAND, NEW YORK, AS A GUIDE TO WATER MANAGEMENT ALTERNATIVES, GEOLOGIC SURVEY PROFESSIONAL PAPER 627-F, USGS, 1972.

## III. DETERMINE CONTRIBUTION OF OFF-SITE SOUTHERN AREA PLUME TO PECONIC RIVER FLOW RATE BY FACILITY.

(1) PECONIC RIVER FLOW INCREASE PER MILE DOWNSTREAM OF SCHULTZ RD.

$$= \frac{(37\ \text{CFS} - 4.75\ \text{CFS})}{(6.5\ \text{mi} + 3.7\ \text{mi})} = 3.16\ \frac{\text{CFS}}{\text{mi}}$$

(2) FLOW FROM OFF-SITE SOUTHERN AREA PLUME IN PECONIC RIVER

$$= \left(\frac{1{,}650\ \text{FT PLUME WIDTH}}{5280\ \text{FT/MILE}}\right)\left(3.16\ \frac{\text{CFS}}{\text{mi}}\right)$$

$$= 0.99\ \text{CFS}$$

| CLIENT CALVERTON, NY | JOB NUMBER 1610/1110 | | |
|---|---|---|---|
| SUBJECT OFF-SITE SOUTHERN AREA - EFFLUENT DISCHARGE RATES | | | |
| BASED ON | DRAWING NUMBER | | |
| BY CAR 11/15/05 | CHECKED BY | APPROVED BY | DATE |

(3) % OF GW FLOW TO PECONIC RIVER = (0.99 CFS)(0.92) = 0.91 CFS

(4) % OF SW FLOW TO PECONIC RIVER = (0.99 CFS)(0.08) = 0.08 CFS

IV. EFFLUENT PORTIONS TO RIVER AND INFILTRATION GALLERIES

① EFFLUENT FLOW RATE TO PECONIC RIVER UNDER AVERAGE CONDITIONS = **0.91 CFS**

② EFFLUENT FLOW RATE TO INFILTRATION GALLERIES UNDER AVERAGE CONDITIONS = 2.14 CFS − 0.91 CFS

= **1.23 CFS**

## B.3 BIOSTIMULATION
## (ALTERNATIVES 4 AND 5)

# HRC Design Software for Plume Area/Grid Treatment

May 2005

Regenesis Technical Support. USA (949) 366-8000 www regenesis com

**Site Name:** Off-Site Southern Area
**Location:** Calverton, New York
**Consultant:** TtNUS

**Site Conceptual Model/Extent of Plume Requiring Remediation**

| | | | | | |
|---|---|---|---|---|---|
| Width of plume (intersecting gw flow direction) | 200 | ft | | | |
| Length of plume (parallel to gw flow direction) | 200 | ft | | 40,000 | $ft^2$ |
| Depth to contaminated zone | 60 | ft | | | |
| Thickness of contaminated saturated zone | 30 | ft | | | |
| Nominal aquifer soil (gravel, sand, silty sand, silt, clay, etc ) | sand | | | | |
| Total porosity | 0 33 | | Effective porosity | 0 25 | |
| Hydraulic conductivity | 100 | ft/day | | 3 5E-02 | cm/sec |
| Hydraulic gradient | 0 0036 | ft/ft | | | |
| Seepage velocity | 525 6 | ft/yr | | 1 440 | ft/day |
| Treatment Zone Pore Volume | 396,000 | $ft^3$ | | 2,962,476 | gallons |

| Dissolved Phase Electron Donor Demand | Contaminant Conc (mg/L) | Contaminant Mass (lb) | Stoichiometry cont/$H_2$ (wt/wt) |
|---|---|---|---|
| Tetrachloroethene (PCE) | 0 00 | 0 0 | 20 7 |
| Trichloroethene (TCE) | 0 00 | 0 0 | 21 9 |
| cis-1,2-dichloroethene (DCE) | 0 00 | 0 0 | 24 2 |
| Vinyl Chloride (VC) | 0 00 | 0 0 | 31 2 |
| 1,1,1-Trichloroethane (TCA) | 0 02 | 0 6 | 22 2 |
| 1,1-Dichlorochloroethane (DCA) | 0 29 | 7 2 | 24 7 |
| User added, also add stoich demand and Koc (see pull-dowr | 0 00 | 0 0 | 0 0 |
| User added, also add stoich demand and Koc (see pull-dowr | 0 00 | 0 0 | 0 0 |

carbon tetrachloride <- pull-down menu

**Sorbed Phase (SP) Electron Donor Demand**

| | | | | |
|---|---|---|---|---|
| Soil bulk density | 1 76 | $g/cm^3$ = | 110 | lb/cf |
| Fraction of organic carbon (foc) | 0 001 | range 0 0001 to 0 01 | | |

| (Values are estimated using SP = foc*Koc*Cgw) (Adjust Koc as necessary to provide realistic estimates) | Koc (L/kg) | Contaminant Conc (mg/kg) | Contaminant Mass (lb) | Stoichiometry cont/$H_2$ (wt/wt) |
|---|---|---|---|---|
| Tetrachloroethene (PCE) | 371 | 0 00 | 0 0 | 20 7 |
| Trichloroethene (TCE) | 122 | 0 00 | 0 0 | 21 9 |
| cis-1,2-dichloroethene (DCE) | 80 | 0 00 | 0 0 | 24 2 |
| Vinyl Chloride (VC) | 2 5 | 0 00 | 0 0 | 31 2 |
| 1,1,1-Trichloroethane (TCA) | 304 | 0 01 | 1 0 | 22 2 |
| 1,1-Dichlorochloroethane (DCA) | 33 | 0 01 | 1 3 | 24 7 |
| User added, also add stoich demand and Koc (see pull-dowr | 0 | 0 00 | 0 0 | 0 0 |
| User added, also add stoich demand and Koc (see pull-dowr | 0 | 0 00 | 0 0 | 0 0 |

| Competing Electron Acceptors (CEAs) | CEA Conc (mg/L) | CEA Mass (lb) | Stoich (wt/wt) $e^-$ acceptor/$H_2$ |
|---|---|---|---|
| Oxygen Demand | 5 00 | 124 | 8 0 |
| Nitrate Demand | 5 00 | 124 | 12 4 |
| Bioavailable Manganese Demand | 5 00 | 124 | 27 5 |
| Bioavailable Iron Demand | 25 00 | 618 | 55 9 |
| Sulfate Demand | 50 00 | 1,235 | 12 0 |

| | | |
|---|---|---|
| **Microbial Demand Factor** | 3 | Recommend 1-4x |
| **Safety Factor** | 2 | Recommend 1-4x |

**Injection Point Spacing and Application Rate:**

| | | | |
|---|---|---|---|
| Injection spacing within rows (ft) | 15 0 | # points per row | 14 |
| Injection spacing between rows (ft) | 50 0 | # of rows | 4 |
| Advective travel time between rows (days) | 35 | Total # of points | 56 |
| | | Min required HRC application rate (lb/ft) | 7 8 |

| Project Summary | | | |
|---|---|---|---|
| Number of HRC delivery points (adjust as necessary for site) | | | 56 |
| HRC application rate in lbs/ft (adjust as necessary for site) | | | 7 8 |
| Corresponding amount of HRC per point (lb) | | | 234 |
| Number of 30 lb HRC buckets per injection point | | | 7 8 |
| Total number of 30 lb buckets | | | 437 |
| Total amount of HRC (lb) | | | 13,110 |
| HRC unit cost ($/lb) | | $ | 5 50 |
| **Total Material Cost** | | **$** | **72,105** |
| **Shipping and Tax Estimates in US Dollars** | | | |
| Sales tax | rate 8 00% | $ | 5,768 |
| Total material cost | | $ | 77,873 |
| Shipping of HRC (call for quote) | | $ | 1,300 |
| **Total Regenesis Material Cost** | | **$** | **79,173** |

| HRC Installation Cost Estimate (responsibility of customer to contract work) | | | Other Project Costs | | |
|---|---|---|---|---|---|
| Length of each injection point (ft) | | 90 | Design and regulatory issues | $ | - |
| Total length for direct push for project (ft) | | 5,040 | Groundwater monitoring and rpt | $ | - |
| Est daily installation rate (ft per day· 300 for push, 150 for drilling) | | 300 | Other | $ | - |
| Estimated points per day (10 to 30 is typical for direct push) | | 3 3 | Other | $ | - |
| Required number of days | | 17 | Other | $ | - |
| Mobilization/demobilization cost for injection subcontractor | $ | 2,000 | Other | $ | - |
| Daily rate for injection subcontractor | $ | 3,000 | Other | $ | - |
| Total injection subcontractor cost for application | $ | 53,000 | Other | $ | - |
| **Total Install Cost** (not including consultant, lab, etc ) | **$** | **132,173** | **Total Project Cost** | **$** | **132,173** |

# HRC Design Software for Barrier Treatment

May 2005

Regenesis Technical Support: USA (949) 366-8000 www.regenesis.com

**Site Name:** Off-Site Southern Area Plume
**Location:** Calverton, New York
**Consultant:** TtNUS

**Site Conceptual Model/Extent of Plume Requiring Remediation**

| | | | | |
|---|---|---|---|---|
| Length of Barrier (intersecting gw flow direction) | 1050 | ft | | |
| Depth to contaminated zone | 60 | ft | | |
| Thickness of contaminated saturated zone | 30 | ft | | |
| Aquifer soil type (gravel, sand, silty sand, silt, clay, etc.) | sand | | | |
| Effective porosity | 0.25 | | | |
| Hydraulic conductivity | 100 | ft/day | 3.5E-02 | cm/sec |
| Hydraulic gradient | 0.0036 | ft/ft | | |
| Seepage velocity | 525.6 | ft/yr | 1.440 | ft/day |

| Dissolved Phase Electron Donor Demand | Contaminant Conc (mg/L) | Contaminant Mass (lb/yr) | Stoichiometry cont/$H_2$ (wt/wt) |
|---|---|---|---|
| Tetrachloroethene (PCE) | 0.00 | 0.00 | 20.7 |
| Trichloroethene (TCE) | 0.00 | 0.00 | 21.9 |
| cis-1,2-dichloroethene (DCE) | 0.00 | 0.00 | 24.2 |
| Vinyl Chloride (VC) | 0.00 | 0.00 | 31.2 |
| 1,1,1-Trichloroethane (TCA) | 0.02 | 6.20 | 22.2 |
| 1,1-Dichlorochloroethane (DCA) | 0.29 | 75.39 | 24.7 |
| User added, also add stoichiometric demand (see pull-down) | 0.00 | 0.00 | 0.0 |
| User added, also add stoichiometric demand (see pull-down) | 0.00 | 0.00 | 0.0 |

trichlorotrifluoroethane <- pull-down menu

| Competing Electron Acceptors: | CEA Conc (mg/L) | CEA Mass (lb/yr) | Stoich. (wt/wt) $e^-$ acceptor/$H_2$ |
|---|---|---|---|
| Oxygen Demand | 5.00 | 1,290.96 | 8.0 |
| Nitrate Demand | 5.00 | 1,290.96 | 12.4 |
| Bioavailable Manganese Demand | 5.00 | 1,290.96 | 27.5 |
| Bioavailable Iron Demand | 25.00 | 6,454.81 | 55.9 |
| Sulfate Demand | 50.00 | 12,909.62 | 12.0 |

| | | |
|---|---|---|
| **Microbial Demand Factor** | 3 | Recommend 1-4x |
| **Safety Factor** | 2 | Recommend 1-4x |
| **Lifespan for one application** | 1 | Year(s) |

**Injection Spacing and Dose:**

| | | |
|---|---|---|
| Number of rows in barrier | 2 | rows |
| Spacing within rows | 5 | ft on center |
| Effective spacing perpendicular to flow (ft) | 2.5 | |
| Total number of HRC injection locations | 420 | points |
| Minimum required HRC application rate (lb/ft) | 10.8 | |

(Dose amount is high. Please call Regenesis Tech Support to confirm)

| Project Summary | | | | |
|---|---|---|---|---|
| Number of HRC delivery points (adjust as necessary for site) | | | 420 | Call Regenesis for suggestions to minimize no. of points |
| HRC application rate in lbs/ft (adjust as necessary for site) | | | 10.8 | |
| Corresponding amount of HRC per point (lb) | | | 325 | |
| Number of 30 lb HRC buckets per injection point | | | 10.8 | |
| Total number of 30 lb buckets | | | 4552 | |
| Total amount of HRC (lb) | | | 136,560 | |
| HRC unit cost ($/lb) | | $ | 5.00 | |
| **Total Material Cost** | | $ | **682,800** | Cost is relatively high. Please call Regenesis to confirm. |
| **Shipping and Tax Estimates in US Dollars** | | | | |
| Sales Tax | rate: 8.00% | $ | 54,624 | |
| Total Material Cost | | $ | 737,424 | |
| Shipping of HRC (call for quote) | | $ | 13,000 | |
| **Total Regenesis Material Cost** | | $ | **750,424** | |

| HRC Installation Cost Estimate (responsibility of customer to contract work) | | | Other Project Costs | | |
|---|---|---|---|---|---|
| Length of each injection point (ft) | | 90 | Design and Regulatory Issues | $ | - |
| Total length for direct push for project (ft) | | 37,800 | Groundwater monitoring and reporting | $ | - |
| Estimated daily installation rate (ft per day: 300 for push, 150 for drilling) | | 300 | Other | $ | - |
| Estimated points per day (10 to 30 is typical for direct push) | | 3.3 | Other | $ | - |
| Required number of days | | 126 | Other | $ | - |
| Mobilization/demobilization cost for injection subcontractor | $ | 2,000 | Other | $ | - |
| Daily rate for injection subcontractor | $ | 3,000 | Other | $ | - |
| Total injection subcontractor cost for application | $ | 380,000 | Other | $ | - |
| **Total Install Cost (not including consultant, lab, etc.)** | $ | **1,130,424** | **Total Project Cost** | $ | **1,130,424** |

# B.4 AIR SPARGING
# (ALTERNATIVE 6)

## 1.0 TREATMENT SCHEME

The option of Alternative 6 would consist of an air sparging (AS) curtain system. The AS system would feature the following elements:

- AS well array
- AS blower system

Typical remedial action durations for AS systems range from one to five years. Because this alternative is dependent on groundwater flow rates, it was assumed that the remedial action duration would be 16 years.

## 2.0 AS WELL ARRAY

Based upon previous calculations for Site 7 (Fuel Depot Area) at Calverton, the typical radius of influence (ROI) of AS wells is approximately 25 ft.

Area of influence per AS well: $(50)^2 \times \pi/4 = 1{,}963$ ft$^2$, rounded down to 1,950 ft$^2$ for overlap

AS wells will be installed at one depth, screened from approximately 90 to 95 feet below the water table (water table approximately 7 ft bgs - total depth of the wells will be approximately 100 feet bgs) in the area of the plume. Two rows of AS wells will be installed along the edge of the plume – total length of the AS Curtain is approximately 2200 feet

Number of wells for the AS Well Wall: Length of wall in ft ÷ (Diameter of influence per well in ft) = number of wells

= 2200 ÷ 50 = 44 wells - For 2 rows of wells (x 2) = Approximately 90 wells

See the attached Figure 1 for the AS Well Layout.

## 3.0 AS BLOWER SYSTEMS

The typical air sparging flow is approximately 6 to 12 cfm per well.

For the AS System, an individual AS Blower System would supply air to each row and wall – need 4 AS blower systems - to provide redundancy in the system. Design each AS blower/wall system for 25 wells.

Discharge rate of AS Blower: 25 wells x 6 cfm/well = 150 cfm
Discharge rate of AS Blower: 25 wells x 12 cfm/well = 300 cfm

Static head required for the AS Blower: 95 ft $H_2O$ x 0.433 ft/psi = 41 psi

To accommodate line friction losses, increase the design blower discharge pressure 15%. The AS Blower would be designed for a discharge head of 47 psi (use 50 psi).

⇒ Each AS Blower/Curtain System would feature 1 blower. The AS Blower would be rated for 300 cfm @ 50 psi. Four (4) systems would be needed.

## 4.0 FUGITIVE EMISSIONS

As per computations presented in Appendix A (Mass & Volume Calculations), the total quantities of VOC COCs for the site are estimated as follows:

| COC | Quantity | Units |
|---|---|---|
| cVOCs | 670 | pounds |
| BTEX | 61 | pounds |
| Other VOCs | 59 | pounds |
| Total | 790 | pounds |

Of these, it was assumed that 100% of the VOCs in groundwater will eventually be removed by stripping and generate fugitive emissions.

Total Fugitive Emissions for Off-Site Southern Area Plume = 790 pounds.

Because this alternative includes an air-sparge curtain that treats the plume as it migrates downgradient and is dependent on the groundwater flow rate (16 year duration), it was assumed that 15% of the emissions will occur during the first year of operation of the system and that within the first year emissions would occur consistently throughout the year.

Maximum Daily Rate of Fugitive Emissions

790 pounds x 0.15 ÷ 365 = 0.32 pounds per day

Based on the calculated fugitive emission rate (0.32 pounds per day) being less than 15 pounds per day, the AS system would not need to be operated with fugitive emissions controls.

## 5.0 ESTIMATED QUANTITIES

| Item | |
|---|---|
| AS Blowers | Four 300 cfm @ 50 psi |
| AS Wells – ~100 ft deep, screened 95 to 100 ft | 90 Wells<br>9,000 ft |
| AS Piping | 5,000 ft |

**Miscellaneous Items**

Equipment control area/structure to protect the equipment from inclement weather and vandalism.
The AS equipment will be skid-mounted Control Panel and associated Process and Instrumentation Diagram (P&ID)

Controls - Operation of the AS Blower will be controlled by a HAND-OFF-AUTO switch. In the AUTO position, which is the normal mode of operation, the blower will be running continuously, but its operation will be interlocked with a high temperature switch. If the switch is tripped, the system will shut down.

Pressure will be monitored by gauges located immediately upstream of the AS Blower, immediately upstream of the air bleed valve and at each extraction line connecting the AS Blower wells.

Air flow will be monitored by flow indicators. As required, air flow will be adjusted at each AS well array using the manual ball valves provided for this purpose.

Piping – Piping for the AS system will be constructed of PVC. Pipe sizing will consider the head losses in the lines due to friction. Piping located outside the Equipment Control Area will be installed below grade to protect it throughout the duration of system operation. Piping will be buried a maximum of 6 inches below grade. Cover material shall consist of select native fill and shall not contain any debris in excess of one (1) inch in diameter. Topsoil will be used on the top 3" to assure proper soil for revegetation. Flow and pressure gauges and pressure regulators will be installed within the equipment control building for each well group along the header line.

Power Source - An electrical schematic for the AS unit will be provided. Permanent power will be made available to the site (480-volt, 3-phase). Electrical components shall be installed in accordance with National Electric Codes and local requirements. Equipment shall be grounded and wired to provide surge protection.

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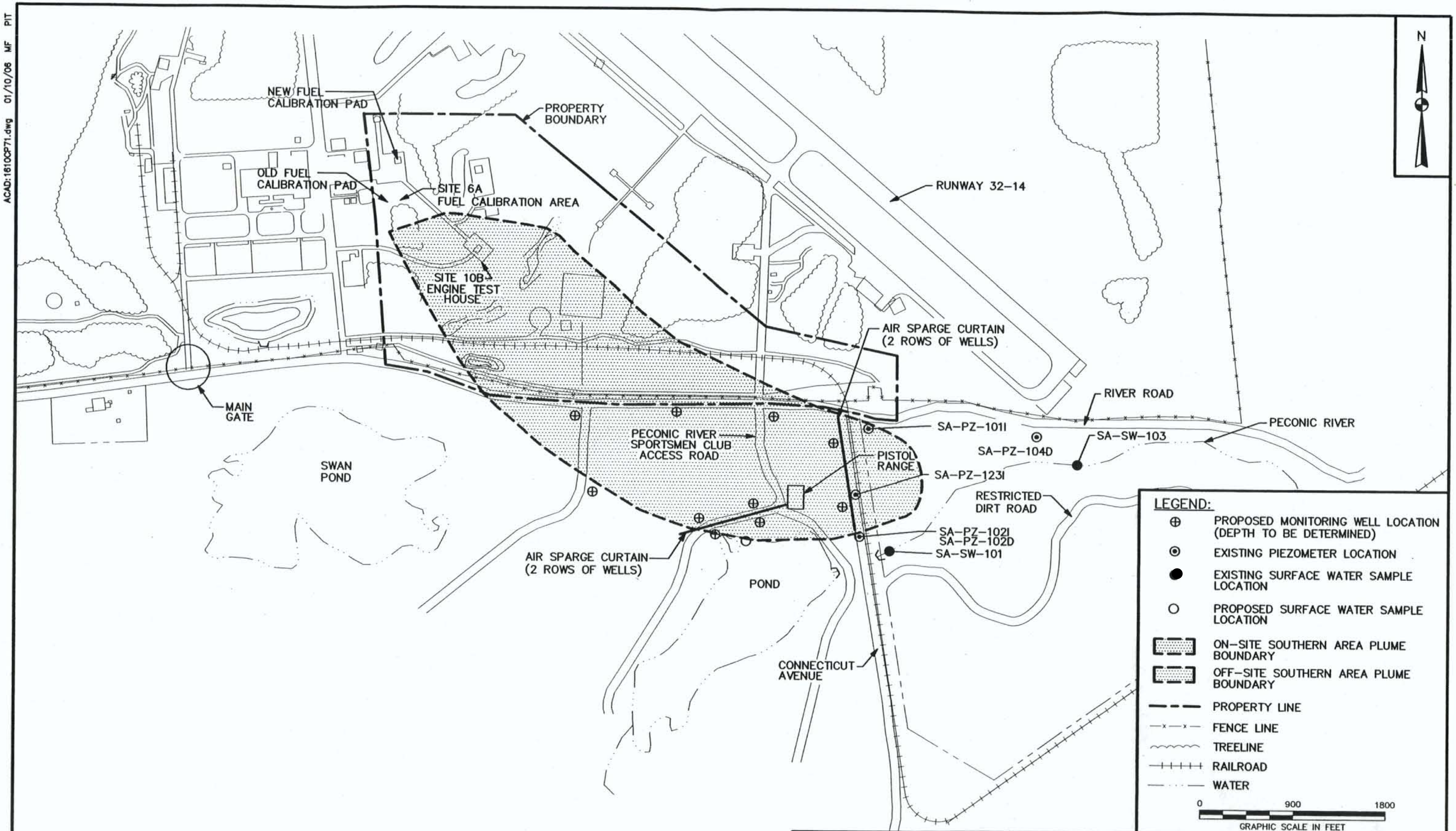


| DRAWN BY MF | DATE 1/10/06 |
|---|---|
| CHECKED BY | DATE |
| REVISED BY | DATE |
| SCALE AS NOTED | |

Tetra Tech NUS, Inc.

ALTERNATIVE 6
AIR SPARGE CURTAINS AND MONITORING WELL NETWORK
OFF-SITE SOUTHERN AREA PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK

| CONTRACT NO. 1610 | |
|---|---|
| OWNER NO. 0004 | |
| APPROVED BY | DATE |
| DRAWING NO. FIGURE 1 | REV. 0 |

# APPENDIX C

# COST CALCULATIONS

C.1 ALTERNATIVE 2 - DEED NOTIFICATIONS, NATURAL ATTENUATION, AND MONITORING

C.2 ALTERNATIVE 3 - DEED NOTIFICATIONS, GROUNDWATER EXTRACTION (WELLS), TREATMENT (AIR STRIPPING/ACTIVATED CARBON), DISPOSAL (DIRECT DISCHARGE AND RE-INJECTION), AND MONITORING

C.3 ALTERNATIVE 4 - DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (HOT SPOT TREATMENT WITH HRC®), NATURAL ATTENUATION, AND MONITORING

C.4 ALTERNATIVE 5 - DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (BIOBARRIER WITH HRC®), NATURAL ATTENUATION, AND MONITORING

C.5 ALTERNATIVE 6 - DEED NOTIFICATIONS, IN-SITU PHYSICAL TREATMENT (AIR SPARGE CURTAIN), NATURAL ATTENUATION, AND MONITORING

## C.1 ALTERNATIVE 2

## DEED NOTIFICATIONS, NATURAL ATTENUATION, AND MONITORING

OFF-S[illegible]UTHERN AREA GROUNDWATER PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK
ALT 2: DEED NOTIFICATIONS, NATURAL ATTENTUATION, AND MONITORING
Capital Cost

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING** | | | | | | | | | | | |
| 1.1 Prepare Remedial Action Plan | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| 1 2 Deed Notifications | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| **2 MOBILIZATION/DEMOBILIZATION AND SURVEY** | | | | | | | | | | | |
| 2.1 Construction Survey | 1 | ls | $3,000 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 2 2 Drill Rig Mobilization/Demobilization | 1 | ls | $5,000.00 | | | | $5,000 | $0 | $0 | $0 | $5,000 |
| **3 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 3.1 Install Monitoring Wells, 7 wells, 90 ft each | 630 | ft | $35.00 | | | | $22,050 | $0 | $0 | $0 | $22,050 |
| 3.2 Flushmounts | 7 | ea | $120 00 | | | | $840 | $0 | $0 | $0 | $840 |
| 3.3 Collect/Containerize IDW | 14 | ea | $50 00 | | | | $700 | $0 | $0 | $0 | $700 |
| 3.4 Transport/Dispose IDW Off Site | 14 | drums | $150 00 | | | | $2,100 | $0 | $0 | $0 | $2,100 |
| **5 MISCELLANEOUS** | | | | | | | | | | | |
| 5 1 Prepare Post-Construction Documents | 20 | hours | | | $52.50 | | $0 | $0 | $1,050 | $0 | $1,050 |
| 5 2 Construction Oversight (2p*2week) | 4 | mn-wks | | | $1,200.00 | | $0 | $0 | $4,800 | $0 | $4,800 |
| **Subtotal** | | | | | | | $33,690 | $0 | $16,350 | $0 | $50,040 |
| **Local Area Adjustments** | | | | | | | 100.0% | 112 3% | 130.4% | 130 4% | |
| | | | | | | | $33,690 | $0 | $21,320 | $0 | $55,010 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $6,396 | | $6,396 |
| G & A on Labor Cost @ 10% | | | | | | | | | $2,132 | | $2,132 |
| G & A on Material Cost @ 10% | | | | | | | | $0 | | | $0 |
| G & A on Subcontract Cost @ 10% | | | | | | | $3,369 | | | | $3,369 |
| G & A on Equipment Cost @ 10% | | | | | | | | | | $0 | $0 |
| **Total Direct Cost** | | | | | | | $37,059 | $0 | $29,849 | $0 | $66,908 |
| Indirects on Total Direct Cost @ 35% | | | | | | | | | | | |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $6,691 |
| **Subtotal** | | | | | | | | | | | $73,598 |
| Health & Safety Monitoring @ 2% | | | | | | | | | | | $1,472 |
| **Total Field Cost** | | | | | | | | | | | $75,070 |
| Contingency on Total Field Costs @ 15% | | | | | | | | | | | $11,261 |
| Engineering on Total Field Cost @ 15% | | | | | | | | | | | $11,261 |
| **TOTAL COST** | | | | | | | | | | | **$97,591** |

**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 2: DEED NOTIFICATIONS, NATURAL ATTENTUATION, AND MONITORING**
**Annual Cost**

| Item | Item Cost<br>Year 1 | Item Cost<br>Years 2 through 30 | Item Cost<br>Every 5 Years | Notes |
|---|---|---|---|---|
| Quarterly Groundwater and Surface Water Sampling | $17,440 | | | 12 Wells and 3 Surface Water Stations, 4 times, Labor |
| Quarterly Groundwater and Surface Water Analysis | $22,368 | | | 12 Wells and 3 Surface Water Stations, 4 Times, VOCs, Field and Laboratory Water Quality Parameters |
| Annual Groundwater and Surface Water Sampling | | $4,360 | | 12 Wells and 3 Surface Water Stations, Labor |
| Annual Groundwater and Surface Water Analysis | | $2,550 | | 12 Wells and 3 Surface Water Stations, VOCs, Field Water Quality Parameters |
| Annual Report | $10,000 | $10,000 | | |
| Inspection | $1,000 | $1,000 | | Annual LUC inspection |
| Site Review | | | $23,000 | 5-year review |
| TOTALS | $50,808 | $17,910 | $23,000 | |

2-2

OFF-SITE SOUTHERN AREA GROUNDWATER PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK
ALT 2: DEED NOTIFICATIONS, NATURAL ATTENTUATION, AND MONITORING
Present Worth Analysis

| Year | Capital Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth. |
|---|---|---|---|---|---|
| 0 | $97,591 | | $97,591 | 1.000 | $97,591 |
| 1 | | $50,808 | $50,808 | 0.935 | $47,505 |
| 2 | | $17,910 | $17,910 | 0.873 | $15,635 |
| 3 | | $17,910 | $17,910 | 0.816 | $14,615 |
| 4 | | $17,910 | $17,910 | 0.763 | $13,665 |
| 5 | | $40,910 | $40,910 | 0.713 | $29,169 |
| 6 | | $17,910 | $17,910 | 0.666 | $11,928 |
| 7 | | $17,910 | $17,910 | 0.623 | $11,158 |
| 8 | | $17,910 | $17,910 | 0.582 | $10,424 |
| 9 | | $17,910 | $17,910 | 0.544 | $9,743 |
| 10 | | $40,910 | $40,910 | 0.508 | $20,782 |
| 11 | | $17,910 | $17,910 | 0.475 | $8,507 |
| 12 | | $17,910 | $17,910 | 0.444 | $7,952 |
| 13 | | $17,910 | $17,910 | 0.415 | $7,433 |
| 14 | | $17,910 | $17,910 | 0.388 | $6,949 |
| 15 | | $40,910 | $40,910 | 0.362 | $14,809 |
| 16 | | $17,910 | $17,910 | 0.339 | $6,071 |
| 17 | | $17,910 | $17,910 | 0.317 | $5,677 |
| 18 | | $17,910 | $17,910 | 0.296 | $5,301 |
| 19 | | $17,910 | $17,910 | 0.277 | $4,961 |
| 20 | | $40,910 | $40,910 | 0.258 | $10,555 |
| 21 | | $17,910 | $17,910 | 0.242 | $4,334 |
| 22 | | $17,910 | $17,910 | 0.226 | $4,048 |
| 23 | | $17,910 | $17,910 | 0.211 | $3,779 |
| 24 | | $17,910 | $17,910 | 0.197 | $3,528 |
| 25 | | $40,910 | $40,910 | 0.184 | $7,527 |
| 26 | | $17,910 | $17,910 | 0.172 | $3,081 |
| 27 | | $17,910 | $17,910 | 0.161 | $2,884 |
| 28 | | $17,910 | $17,910 | 0.150 | $2,687 |
| 29 | | $17,910 | $17,910 | 0.141 | $2,525 |
| 30 | | $40,910 | $40,910 | 0.131 | $5,359 |
| | | | | **TOTAL PRESENT WORTH** | $400,184 |

C-3

## C.2 ALTERNATIVE 3

**DEED NOTIFICATIONS, GROUNDWATER EXTRACTION (WELLS), TREATMENT (AIR STRIPPING/ACTIVATED CARBON), DISPOSAL (DIRECT DISCHARGE AND RE-INJECTION), AND MONITORING**

**ALT 3: DEED NOTIFICATIONS, GROUNDWATER EXTRACTION (WELLS), TREATMENT (AIR STRIPPING / ACTIVATED CARBON), RE-INJECTION (INFILTRATION GALLERIES), AND MONITORING**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING AND MOBILIZATION/DEMOBILIZATION** | | | | | | | | | | | |
| 1.1 Prepare Documents & Plans including Permits | 300 | hr | | | $52 50 | | $0 | $0 | $15,750 | $0 | $15,750 |
| 1 2 Deed Notifications | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| **2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT** | | | | | | | | | | | |
| 2 1 Office Trailer | 9 | mo | | $202.50 | | | $0 | $1,823 | $0 | $0 | $1,823 |
| 2.2 Storage Trailer | 9 | mo | | $105.00 | | | $0 | $945 | $0 | $0 | $945 |
| 2 3 Site Utilities (phone & electric) | 9 | mo | | $302.00 | | | $0 | $2,718 | $0 | $0 | $2,718 |
| 2.4 Construction Survey | 1 | ls | $2,000 00 | | | | $2,000 | $0 | $0 | $0 | $2,000 |
| 2 5 Drill Rig Mobilization/Demobilization | 1 | ls | $3,000 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 2 6 Clearing and Grubbing ,Cut & Chip, Heavy, Trees to 24" diam | 5 | ac | | | $4,550 00 | $3,400.00 | $0 | $0 | $22,750 | $17,000 | $39,750 |
| 2 7 Mobilization/Demobilization Construction Equipment | 1 | ea | | | $110 00 | $224 00 | $0 | $0 | $110 | $224 | $334 |
| **3 DECONTAMINATION** | | | | | | | | | | | |
| 3.1 Temporary Decon Pad | 1 | ls | | $500 00 | $450 00 | $155.00 | $0 | $500 | $450 | $155 | $1,105 |
| 3 2 Decontamination Services | 8 | mo | | $210 00 | $1,800 00 | $315.00 | $0 | $1,680 | $14,400 | $2,520 | $18,600 |
| 3 3 Decon Water | 8,000 | gal | | $0 20 | | | $0 | $1,600 | $0 | $0 | $1,600 |
| 3 4 Decon Water Storage Tank, 6,000 gallon | 8 | mo | | | | $645 00 | $0 | $0 | $0 | $5,160 | $5,160 |
| 3.5 Clean Water Storage Tank, 4,000 gallon | 8 | mo | | | | $580 00 | $0 | $0 | $0 | $4,640 | $4,640 |
| 3 6 Disposal of Decon Waste (liquid & solid) | 8 | mo | $900 00 | | | | $7,200 | $0 | $0 | $0 | $7,200 |
| **4 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 4 1 Install Monitoring Wells, 4 wells, 90 ft each | 360 | ft | $35 00 | | | | $12,600 | $0 | $0 | $0 | $12,600 |
| 4.2 Flushmounts | 4 | ea | $120.00 | | | | $480 | $0 | $0 | $0 | $480 |
| 4.3 Collect/Containerize IDW | 8 | ea | $50.00 | | | | $400 | $0 | $0 | $0 | $400 |
| 4.4 Transport/Dispose IDW Off Site | 8 | drums | $150.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| **5 OFF-SITE SOUTHERN AREA PLUME WELL INSTALLATION** | | | | | | | | | | | |
| 5.1 Extraction Wells (6 wells, 8" dia @ 90' deep) | 540 | lf | $110.00 | | | | $59,400 | $0 | $0 | $0 | $59,400 |
| 5 2 Submersible Centrifugal Pumps (160 gpm, 150 ft head, 7 5 HP) | 6 | ea | | $4,512 00 | | | $0 | $27,072 | $0 | $0 | $27,072 |
| 5 3 Excavate/Backfill Pipe 4' Deep Trench | 4,000 | lf | | | $2.74 | $0 79 | $0 | $0 | $10,960 | $3,160 | $14,120 |
| 5 4 6-inch Dia PVC Piping | 4,000 | ft | | $5 99 | $5.75 | $9.45 | $0 | $23,972 | $23,000 | $37,800 | $84,772 |
| **6 OFF-SITE SOUTHERN AREA PLUME TREATMENT SYSTEM** | | | | | | | | | | | |
| 6 1 Building Foundations | 3,000 | sf | $4 06 | | | | $12,180 | $0 | $0 | $0 | $12,180 |
| 6 2 Treatment Buildings | 3,000 | sf | $11.58 | | | | $34,740 | $0 | $0 | $0 | $34,740 |
| 6 3 Building Misc (doors/vent/insulation/heaters/misc.) | 2 | ls | $6,012.00 | | | | $12,024 | $0 | $0 | $0 | $12,024 |
| 6 4 15 Ft Dia, 10 ft High Equalization Tank (10,000 gal)) | 1 | ea | | $11,755.00 | $3,400 00 | $290 00 | $0 | $11,755 | $3,400 | $290 | $15,445 |
| 6 5 Top Mounted Low-Speed Turbine-Type Mixer (5 hp) | 1 | ea | | $22,147.00 | | | $0 | $22,147 | $0 | $0 | $22,147 |
| 6 6 15 Ft Dia, 20 ft High Equalization Tank (20,000 gal)) | 1 | ea | | $20,346 00 | $3,814.00 | $302 00 | $0 | $20,346 | $3,814 | $302 | $24,462 |
| 6 7 Top Mounted Low-Speed Turbine-Type Mixer (10 hp) | 1 | ea | | $32,500 00 | | | $0 | $32,500 | $0 | $0 | $32,500 |
| 6.8 Horizontal-Centrifugal Pump, 320 gpm, 15 HP, 100 ft head | 4 | ea | | $3,015.00 | $587.75 | | $0 | $12,060 | $2,351 | $0 | $14,411 |
| 6.9 32 Ft Diameter, 48,000 Gallon Clarifier Tank | 3 | ea | | $90,750 00 | $39,099.50 | $12,854 60 | $0 | $272,250 | $117,299 | $38,564 | $428,112 |
| 6 10 Bag Filter,multi-bag, 242 sf total | 4 | ea | | $7,300 00 | | | $0 | $29,200 | $0 | $0 | $29,200 |
| 6 11 Air Stripper, 320 gpm, 2400 cfm blower & control panel | 3 | ea | | $56,000.00 | | | $0 | $168,000 | $0 | $0 | $168,000 |
| 6.12 Caustic Feed System | 2 | ea | | $8,655.00 | $2,165 00 | | $0 | $17,310 | $4,330 | $0 | $21,640 |
| 6 13 Potassium Permanganate Feed System | 2 | ea | | $1,085 00 | $2,165 00 | | $0 | $2,170 | $4,330 | $0 | $6,500 |
| 6.14 Overhead Feed, per Power Pole, 50 ft apart | 20 | ea | $3,000 00 | | | | $60,000 | $0 | $0 | $0 | $60,000 |
| 6.15 Transformer, 225KVA | 1 | ea | $9,000 00 | | | | $9,000 | $0 | $0 | $0 | $9,000 |
| 6.16 Switchgear | 1 | ea | $2,600 00 | | | | $2,600 | $0 | $0 | $0 | $2,600 |
| 6 17 Electrical to Connect from Switchgear to Loads | 1 | ls | | $3,680 00 | $1,054 00 | | $0 | $3,680 | $1,054 | $0 | $4,734 |
| 6 18 Heat Tracing | 200 | ft | | $12 00 | $5 00 | | $0 | $2,400 | $1,000 | $0 | $3,400 |
| 6 19 Plumb/Electrify Systems | 1 | ls | | $6,000 00 | $13,056 00 | | $0 | $6,000 | $13,056 | $0 | $19,056 |
| 6 20 Systems Start-Up and Testing | 1 | ls | | $1,000 00 | $3,500 00 | | $0 | $1,000 | $3,500 | $0 | $4,500 |
| 6.21 Excavate/Backfill Pipe 4' Deep Trench to Infilration Beds | 1,000 | lf | | | $2 74 | $0 79 | $0 | $0 | $2,740 | $790 | $3,530 |
| 6 22 4-inch Dia PVC Piping to Infiltration Beds | 1,000 | ft | | $5 99 | $5.75 | $9 45 | $0 | $5,993 | $5,750 | $9,450 | $21,193 |

**ALT 3: DEED NOTIFICATIONS, GROUNDWATER EXTRACTION (WELLS), TREATMENT (AIR STRIPPING / ACTIVATED CARBON), RE-INJECTION (INFILTRATION GALLERIES), AND MONITORING**
**Capital Cost**

| | | | Unit Cost | | | | Extended Cost | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Quantity | Unit | Subcontract | Material | Labor | Equipment | Subcontract | Material | Labor | Equipment | Subtotal |
| 6 23 Excavate/Backfill Pipe 4' Deep Trench / Infiltration Beds | 4,000 | lf | | | $2 74 | $0.79 | $0 | $0 | $10,960 | $3,160 | $14,120 |
| 6.24 Geotextile for Infiltration Beds | 1,200 | sy | | $1 28 | $0 18 | | $0 | $1,536 | $216 | $0 | $1,752 |
| 6.25 Gravel Layer, 2 Beds, Each 500 Ft Long, 6 Inches x 1 Ft | 150 | cy | | $27 50 | $2 47 | $4.22 | $0 | $4,125 | $371 | $633 | $5,129 |
| 6 26 4-inch Dia PVC Piping, Perforated | 4,000 | ft | | $8.99 | $5.75 | $9.45 | $0 | $35,958 | $23,000 | $37,800 | $96,758 |
| **7 MISCELLANEOUS** | | | | | | | | | | | |
| 7 1 Construction Oversite (2p*9 months) | 378 | mn-days | | | $240.00 | | $0 | $0 | $90,720 | $0 | $90,720 |
| 7.2 Post Construction Documents | 200 | hr | | | $52 50 | | $0 | $0 | $10,500 | $0 | $10,500 |
| 7 3 Vegetate Disturbed Areas | 1 | ls | | $1,800.00 | $3,000.00 | $1,200 00 | $0 | $1,800 | $3,000 | $1,200 | $6,000 |
| **Subtotal** | | | | | | | $216,824 | $710,540 | $394,060 | $162,848 | $1,484,271 |
| **Local Area Adjustments** | | | | | | | 100 0% | 112 3% | 130 4% | 130 4% | |
| | | | | | | | $216,824 | $797,936 | $513,854 | $212,354 | $1,740,968 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $154,156 | | $154,156 |
| G & A on Labor Cost @ 10% | | | | | | | | | $51,385 | | $51,385 |
| G & A on Material Cost @ 10% | | | | | | | | $79,794 | | | $79,794 |
| G & A on Equipment Cost @ 10% | | | | | | | | | | $21,235 | $21,235 |
| G & A on Subcontract Cost @ 10% | | | | | | | $21,682 | | | | $21,682 |
| **Total Direct Cost** | | | | | | | $238,506 | $877,729 | $719,396 | $233,589 | $2,069,221 |
| Indirects on Total Direct Cost @ 35% | | | | | | | | | | | $724,227 |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $206,922 |
| **Subtotal** | | | | | | | | | | | $3,000,370 |
| Health & Safety Monitoring @ 2% | | | | | | | | | | | $60,007 |
| **Total Field Cost** | | | | | | | | | | | $3,060,377 |
| Contingency on Subtotal Cost @ 25% | | | | | | | | | | | $765,094 |
| Engineering on Subtotal Cost @ 15% | | | | | | | | | | | $459,057 |
| **TOTAL COST** | | | | | | | | | | | **$4,284,528** |

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**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 3: DEED NOTIFICATIONS, GROUNDWATER EXTRACTION (WELLS), TREATMENT (AIR STRIPPING / ACTIVATED CARBON), RE-INJECTION (INFILTRATION GALLERIE!**
**Operation and Maintenance Costs per Year**

| | Item | Qty | Unit | Unit Cost | Subtotal Cost | Notes |
|---|---|---|---|---|---|---|
| | Year 1 | | | | | |
| 1 | Energy - Electric | 906,686 | kWh | $0.12 | $108,802 | |
| 2 | Maintenance | 1 | ls | $43,060.37 | $43,060 | 5% of Installation Cost |
| 3 | Labor, Per Diem, Supplies | 52 | day | $350.00 | $18,200 | 1 visit per week - 1 day |
| 4 | Caustic Soda | 40 | ton | $435.00 | $17,400 | |
| 5 | Potassium Permanganate | 10800 | lb | $1.65 | $17,820 | |
| 6 | Influent (Six Wells) and Effluent Sampling | 105 | ea | $130.00 | $13,650 | Weekly for first month, then once a month each for VOCs + 30% for quality assurance |
| 7 | Semi-Annual Reports | 2 | ea | $4,000 00 | $8,000 | |
| | Subtotal Cost for One Year Operation | | | | $226,933 | |
| | Years 2 through 16 | | | | | |
| 1 | Energy - Electric | 906,686 | kWh | $0.12 | $108,802 | |
| 2 | Maintenance | 1 | ls | $43,060.37 | $43,060 | 5% of Installation Cost |
| 3 | Labor, Per Diem, Supplies | 52 | day | $350.00 | $18,200 | 1 visit per week - 1 day |
| 4 | Caustic Soda | 40 | ton | $435.00 | $17,400 | |
| 5 | Potassium Permanganate | 10800 | lb | $1.65 | $17,820 | |
| 6 | Influent (Six Wells) and Effluent Sampling | 84 | ea | $130.00 | $10,920 | once a month each for VOCs + 30% for quality assurance |
| 7 | Semi-Annual Reports | 2 | ea | $4,000.00 | $8,000 | |
| | Subtotal Cost for One Year Operation | | | | $224,203 | |

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**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 3: DEED NOTIFICATIONS, GROUNDWATER EXTRACTION (WELLS), TREATMENT (AIR STRIPPING / ACTIVATED CARBON), RE-INJECTION (INFILTRATION GALLERIES), AND MONITORING**
**Annual Cost**

| Item | Item Cost Year 1 | Item Cost Years 2 through 16 | Item Cost Every 5 Years | Notes |
|---|---|---|---|---|
| Quarterly Groundwater and Surface Water Sampling | $17,440 | | | 13 Wells and 3 Surface Water Stations, 4 times, Labor |
| Quarterly Groundwater and Surface Water Analysis | $24,102 | | | 13 Wells and 3 Surface Water Stations, 4 Times, VOCs, Field Water Quality Parameters |
| Annual Groundwater and Surface Water Sampling | | $4,360 | | 13 Wells and 3 Surface Water Stations, Labor |
| Annual Groundwater and Surface Water Analysis | | $2,730 | | 13 Wells and 3 Surface Water Stations, VOCs, Field Water Quality Parameters |
| Annual Report | $10,000 | $10,000 | | |
| Inspection | $1,000 | $1,000 | | Annual LUC inspection |
| Site Review | | | $23,000 | 5-year review |
| TOTALS | $52,542 | $18,090 | $23,000 | |

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**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 3: DEED NOTIFICATIONS, GROUNDWATER EXTRACTION (WELLS), TREATMENT (AIR STRIPPING / ACTIVATED CARBON), RE-INJECTION (INFILTRATION GALLERIES), AND MONITORING**
**Present Worth Analysis**

| Year | Capital Cost | Operation and Maintenance Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth |
|---|---|---|---|---|---|---|
| 0 | $4,284,528 | | | $4,284,528 | 1.000 | $4,284,528 |
| 1 | | $226,933 | $52,542 | $279,475 | 0.935 | $261,309 |
| 2 | | $224,203 | $18,090 | $242,293 | 0.873 | $211,522 |
| 3 | | $224,203 | $18,090 | $242,293 | 0.816 | $197,711 |
| 4 | | $224,203 | $18,090 | $242,293 | 0.763 | $184,869 |
| 5 | | $224,203 | $41,090 | $265,293 | 0.713 | $189,154 |
| 6 | | $224,203 | $18,090 | $242,293 | 0.666 | $161,367 |
| 7 | | $224,203 | $18,090 | $242,293 | 0.623 | $150,948 |
| 8 | | $224,203 | $18,090 | $242,293 | 0.582 | $141,014 |
| 9 | | $224,203 | $18,090 | $242,293 | 0.544 | $131,807 |
| 10 | | $224,203 | $41,090 | $265,293 | 0.508 | $134,769 |
| 11 | | $224,203 | $18,090 | $242,293 | 0.475 | $115,089 |
| 12 | | $224,203 | $18,090 | $242,293 | 0.444 | $107,578 |
| 13 | | $224,203 | $18,090 | $242,293 | 0.415 | $100,551 |
| 14 | | $224,203 | $18,090 | $242,293 | 0.388 | $94,010 |
| 15 | | $224,203 | $41,090 | $265,293 | 0.362 | $96,036 |
| 16 | | $224,203 | $18,090 | $242,293 | 0.339 | $82,137 |

**TOTAL PRESENT WORTH** **$6,644,399**

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## C.3 ALTERNATIVE 4

## DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (HOT SPOT TREATMENT WITH HRC®), NATURAL ATTENUATION, AND MONITORING

OFF-SIT[illegible]HERN AREA GROUNDWATER PLUME
NWIRP CA[illegible]ERTON
CALVERTON, NEW YORK
ALT 4: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (HOT SPOT TREATMENT WITH HRC), NATURAL ATTENTUATION, AND MONITORING
Capital Cost - Wells and Pilot Study

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING** | | | | | | | | | | | |
| 1 1 Prepare Remedial Action Plan | 100 | hr | | | $52.50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| 1 2 Deed Notifications | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| **2 MOBILIZATION/DEMOBILIZATION AND SURVEY** | | | | | | | | | | | |
| 2.1 Construction Survey | 1 | ls | $3,000.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 2 2 Drill Rig Mobilization/Demobilization | 1 | ls | $5,000.00 | | | | $5,000 | $0 | $0 | $0 | $5,000 |
| **3 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 3.1 Install Monitoring Wells, 10 wells, 90 ft each | 900 | ft | $35 00 | | | | $31,500 | $0 | $0 | $0 | $31,500 |
| 3 2 Flushmounts | 10 | ea | $120 00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 3 3 Collect/Containerize IDW | 20 | ea | $50 00 | | | | $1,000 | $0 | $0 | $0 | $1,000 |
| 3 4 Transport/Dispose IDW Off Site | 20 | drums | $150 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| **4 MISCELLANEOUS** | | | | | | | | | | | |
| 4.1 HRC Pilot Study | 1 | ls | $100,000.00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| 4 2 Prepare Post-Construction Documents | 20 | hours | | | $52.50 | | $0 | $0 | $1,050 | $0 | $1,050 |
| 4.3 Construction Oversight (2p*2week) | 4 | mn-wks | | | $1,200.00 | | $0 | $0 | $4,800 | $0 | $4,800 |
| **Subtotal** | | | | | | | $144,700 | $0 | $16,350 | $0 | $161,050 |
| **Local Area Adjustments** | | | | | | | 100 0% | 112 3% | 130 4% | 130 4% | |
| | | | | | | | $144,700 | $0 | $21,320 | $0 | $166,020 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $6,396 | | $6,396 |
| G & A on Labor Cost @ 10% | | | | | | | | | $2,132 | | $2,132 |
| G & A on Material Cost @ 10% | | | | | | | | $0 | | | $0 |
| G & A on Subcontract Cost @ 10% | | | | | | | $14,470 | | | | $14,470 |
| G & A on Equipment Cost @ 10% | | | | | | | | | | $0 | $0 |
| **Total Direct Cost** | | | | | | | $159,170 | $0 | $29,849 | $0 | $189,019 |
| Indirects on Total Direct Cost @ 35% | | | | | | | | | | | $66,156 |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $18,902 |
| **Subtotal** | | | | | | | | | | | $274,077 |
| Health & Safety Monitoring @ 2% | | | | | | | | | | | $5,482 |
| **Total Field Cost** | | | | | | | | | | | $279,558 |
| Contingency on Total Field Costs @ 25% | | | | | | | | | | | $69,890 |
| Engineering on Total Field Cost @ 15% | | | | | | | | | | | $41,934 |
| **TOTAL COST** | | | | | | | | | | | **$391,382** |

OFF-SITE SOUTHERN AREA GROUNDWATER PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK
ALT 4: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (HOT SPOT TREATMENT WITH HRC), NATURAL ATTENTUATION, AND MONITORING
Capital Cost - HRC (Years 0 and 1)

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 PROJECT PLANNING | | | | | | | | | | | |
| 1 1 Prepare Remedial Action Plan | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| 2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT | | | | | | | | | | | |
| 2.1 Office Trailer | 3 | mo | | $202.50 | | | $0 | $608 | $0 | $0 | $608 |
| 2.2 Storage Trailer | 3 | mo | | $105.00 | | | $0 | $315 | $0 | $0 | $315 |
| 2 3 Construction Survey | 3 | ac | $1,200.00 | | | | $3,600 | $0 | $0 | $0 | $3,600 |
| 2 4 DPT Rig Mobilization/Demobilization | 1 | ea | $3,000 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 2 5 Site Utilities | 3 | mo | | $427 00 | | | $0 | $1,281 | $0 | $0 | $1,281 |
| 3 DECONTAMINATION | | | | | | | | | | | |
| 3.1 Temporary Decon Pad | 1 | ls | | $500.00 | $450 00 | $155 00 | $0 | $500 | $450 | $155 | $1,105 |
| 3 2 Decontamination Services | 3 | mo | | $210 00 | $1,800 00 | $315 00 | $0 | $630 | $5,400 | $945 | $6,975 |
| 3 3 Decon Water | 3,000 | gal | | $0 20 | | | $0 | $600 | $0 | $0 | $600 |
| 3.4 Decon Water Storage Tank, 6,000 gallon | 3 | mo | | | | $645 00 | $0 | $0 | $0 | $1,935 | $1,935 |
| 3.5 Clean Water Storage Tank, 4,000 gallon | 3 | mo | | | | $580 00 | $0 | $0 | $0 | $1,740 | $1,740 |
| 3 6 Disposal of Decon Waste (liquid & solid) | 3 | mo | $900 00 | | | | $2,700 | $0 | $0 | $0 | $2,700 |
| 4 HRC INJECTION | | | | | | | | | | | |
| 4 1 HRC Injection (3 x 56 points @ 90' deep) | 51 | day | $3,070 00 | | | | $156,570 | $0 | $0 | $0 | $156,570 |
| 4 2 HRC Material | 39,000 | lb | | $5 86 | | | $0 | $228,540 | $0 | $0 | $228,540 |
| 4.3 Waste/Soil Disposal | 1 | ls | $3,000.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 5 MISCELLANEOUS | | | | | | | | | | | |
| 5.1 Prepare Post-Construction Documents | 150 | hours | | | $52.50 | | $0 | $0 | $7,875 | $0 | $7,875 |
| 8 2 Construction Oversight (2p*3 months) | 126 | mn-days | | | $240 00 | | $0 | $0 | $30,240 | $0 | $30,240 |
| **Subtotal** | | | | | | | $168,870 | $232,474 | $49,215 | $4,775 | $455,334 |
| **Local Area Adjustments** | | | | | | | 100 0% | 112 3% | 130 4% | 130.4% | |
| | | | | | | | $168,870 | $261,068 | $64,176 | $6,227 | $500,341 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $19,253 | | $19,253 |
| G & A on Labor Cost @ 10% | | | | | | | | | $6,418 | | $6,418 |
| G & A on Material Cost @ 10% | | | | | | | | $26,107 | | | $26,107 |
| G & A on Subcontract Cost @ 10% | | | | | | | $16,887 | | | | $16,887 |
| G & A on Equipment Cost @ 10% | | | | | | | | | | $623 | $623 |
| **Total Direct Cost** | | | | | | | $185,757 | $287,175 | $89,847 | $6,849 | $569,628 |
| Indirects on Total Direct Cost @ 25% | | | | | | | | | | | $142,407 |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $56,963 |
| **Subtotal** | | | | | | | | | | | $768,997 |
| Health & Safety Monitoring @ 1% | | | | | | | | | | | $7,690 |
| **Total Field Cost** | | | | | | | | | | | $776,687 |
| Contingency on Total Field Costs @ 25% | | | | | | | | | | | $194,172 |
| Engineering on Total Field Cost @ 5% | | | | | | | | | | | $38,834 |
| **TOTAL COST** | | | | | | | | | | | **$1,009,694** |

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**OFFSITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 4: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (HOT SPOT TREATMENT WITH HRC), NATURAL ATTENTUATION, AND MONITORING**
**Annual Cost**

| Item | Item Cost<br>Year 1 | Item Cost<br>Years 2 through 10 | Item Cost<br>Every 5 Years | Notes |
|---|---|---|---|---|
| Quarterly Groundwater and Surface Water Sampling | $17,440 | | | 13 Wells and 3 Surface Water Stations, 4 times, Labor |
| Quarterly Groundwater and Surface Water Analysis | $24,102 | | | 13 Wells and 3 Surface Water Stations, 4 Times, VOCs, Field and Laboratory Water Quality Parameters |
| Annual Groundwater and Surface Water Sampling | | $4,360 | | 13 Wells and 3 Surface Water Stations, Labor |
| Annual Groundwater and Surface Water Analysis | | $2,730 | | 13 Wells and 3 Surface Water Stations, VOCs, Field Water Quality Parameters |
| Annual Report | $10,000 | $10,000 | | |
| Inspection | $1,000 | $1,000 | | Annual LUC inspection |
| Site Review | | | $23,000 | 5-year review |
| TOTALS | $52,542 | $18,090 | $23,000 | |

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OFF-SITE SOUTHERN AREA GROUNDWATER PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK
ALT 4: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (HOT SPOT TREATMENT WITH HRC), NATURAL ATTENTUATION, AND MONITORING
**Present Worth Analysis**

| Year | Capital Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth |
|---|---|---|---|---|---|
| 0 | $1,401,075 | | $1,401,075 | 1.000 | $1,401,075 |
| 1 | $1,009,694 | $52,542 | $1,062,236 | 0.935 | $993,190 |
| 2 | | $18,090 | $18,090 | 0.873 | $15,793 |
| 3 | | $18,090 | $18,090 | 0.816 | $14,761 |
| 4 | | $18,090 | $18,090 | 0.763 | $13,803 |
| 5 | | $41,090 | $41,090 | 0.713 | $29,297 |
| 6 | | $18,090 | $18,090 | 0.666 | $12,048 |
| 7 | | $18,090 | $18,090 | 0.623 | $11,270 |
| 8 | | $18,090 | $18,090 | 0.582 | $10,528 |
| 9 | | $18,090 | $18,090 | 0.544 | $9,841 |
| 10 | | $41,090 | $41,090 | 0.508 | $20,874 |
| | | | | **TOTAL PRESENT WORTH** | $2,532,481 |

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## C.4 ALTERNATIVE 5

## DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (BIOBARRIER WITH HRC®), NATURAL ATTENUATION, AND MONITORING

OFF-SITE [illegible]HERN AREA GROUNDWATER PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK
ALT 5: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (BIOBARRIER WITH HRC), NATURAL ATTENTUATION, AND MONITORING
Capital Cost - Wells and Pilot Study

| | Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **PROJECT PLANNING** | | | | | | | | | | | |
| 1.1 | Prepare Remedial Action Plan | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| 1 2 | Deed Notifications | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| 2 | **MOBILIZATION/DEMOBILIZATION AND SURVEY** | | | | | | | | | | | |
| 2.1 | Construction Survey | 1 | ls | $3,000.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 2 2 | Drill Rig Mobilization/Demobilization | 1 | ls | $5,000 00 | | | | $5,000 | $0 | $0 | $0 | $5,000 |
| 3 | **MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 3.1 | Install Monitoring Wells, 10 wells, 90 ft each | 900 | ft | $35 00 | | | | $31,500 | $0 | $0 | $0 | $31,500 |
| 3 2 | Flushmounts | 10 | ea | $120 00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 3.3 | Collect/Containerize IDW | 20 | ea | $50 00 | | | | $1,000 | $0 | $0 | $0 | $1,000 |
| 3.4 | Transport/Dispose IDW Off Site | 20 | drums | $150 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 4 | **MISCELLANEOUS** | | | | | | | | | | | |
| 4 1 | HRC Pilot Study | 1 | ls | $100,000 00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| 4 2 | Prepare Post-Construction Documents | 20 | hours | | | $52.50 | | $0 | $0 | $1,050 | $0 | $1,050 |
| 4 3 | Construction Oversight (2p*2week) | 4 | mn-wks | | | $1,200.00 | | $0 | $0 | $4,800 | $0 | $4,800 |
| | **Subtotal** | | | | | | | $144,700 | $0 | $16,350 | $0 | $161,050 |
| | **Local Area Adjustments** | | | | | | | 100 0% | 112 3% | 130.4% | 130.4% | |
| | | | | | | | | $144,700 | $0 | $21,320 | $0 | $166,020 |
| | Overhead on Labor Cost @ 30% | | | | | | | | | $6,396 | | $6,396 |
| | G & A on Labor Cost @ 10% | | | | | | | | | $2,132 | | $2,132 |
| | G & A on Material Cost @ 10% | | | | | | | | $0 | | | $0 |
| | G & A on Subcontract Cost @ 10% | | | | | | | $14,470 | | | | $14,470 |
| | G & A on Equipment Cost @ 10% | | | | | | | | | | $0 | $0 |
| | **Total Direct Cost** | | | | | | | $159,170 | $0 | $29,849 | $0 | $189,019 |
| | Indirects on Total Direct Cost @ 35% | | | | | | | | | | | $66,156 |
| | Profit on Total Direct Cost @ 10% | | | | | | | | | | | $18,902 |
| | **Subtotal** | | | | | | | | | | | $274,077 |
| | Health & Safety Monitoring @ 2% | | | | | | | | | | | $5,482 |
| | **Total Field Cost** | | | | | | | | | | | $279,558 |
| | Contingency on Total Field Costs @ 25% | | | | | | | | | | | $69,890 |
| | Engineering on Total Field Cost @ 15% | | | | | | | | | | | $41,934 |
| | **TOTAL COST** | | | | | | | | | | | **$391,382** |

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OFF-SITE SOUTHERN AREA GROUNDWATER PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK
ALT 5: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (BIOBARRIER WITH HRC), NATURAL ATTENTUATION, AND MONITORING
Capital Cost - HRC (Years 0 through 15)

C-14

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING** | | | | | | | | | | | |
| 1 1 Prepare Remedial Action Plan | 100 | hr | | | $52 50 | | $0 | $0 | $5,250 | $0 | $5,250 |
| **2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT** | | | | | | | | | | | |
| 2 1 Office Trailer | 12 | mo | | $202 50 | | | $0 | $2,430 | $0 | $0 | $2,430 |
| 2 2 Storage Trailer | 12 | mo | | $105 00 | | | $0 | $1,260 | $0 | $0 | $1,260 |
| 2.3 Construction Survey | 3 | ac | $1,200 00 | | | | $3,600 | $0 | $0 | $0 | $3,600 |
| 2 4 DPT Rig Mobilization/Demobilization | 1 | ea | $3,000 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 2.5 Site Utilities | 12 | mo | | $427 00 | | | $0 | $5,124 | $0 | $0 | $5,124 |
| **3 DECONTAMINATION** | | | | | | | | | | | |
| 3 1 Temporary Decon Pad | 1 | ls | | $500 00 | $450 00 | $155 00 | $0 | $500 | $450 | $155 | $1,105 |
| 3 2 Decontamination Services | 12 | mo | | $210 00 | $1,800 00 | $315 00 | $0 | $2,520 | $21,600 | $3,780 | $27,900 |
| 3.3 Decon Water | 12,000 | gal | | $0 20 | | | $0 | $2,400 | $0 | $0 | $2,400 |
| 3 4 Decon Water Storage Tank, 6,000 gallon | 12 | mo | | | | $645 00 | $0 | $0 | $0 | $7,740 | $7,740 |
| 3.5 Clean Water Storage Tank, 4,000 gallon | 12 | mo | | | | $580 00 | $0 | $0 | $0 | $6,960 | $6,960 |
| 3.6 Disposal of Decon Waste (liquid & solid) | 12 | mo | $900 00 | | | | $10,800 | $0 | $0 | $0 | $10,800 |
| **4 HRC INJECTION** | | | | | | | | | | | |
| 4 1 HRC Injection (2 x 420 points @ 90' deep) | 252 | day | $3,070.00 | | | | $773,640 | $0 | $0 | $0 | $773,640 |
| 4 2 HRC Material | 274,000 | lb | | $5.86 | | | $0 | $1,605,640 | $0 | $0 | $1,605,640 |
| 4 3 Waste/Soil Disposal | 1 | ls | $3,000 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| **5 MISCELLANEOUS** | | | | | | | | | | | |
| 5 1 Prepare Post-Construction Documents | 150 | hours | | | $52 50 | | $0 | $0 | $7,875 | $0 | $7,875 |
| 8.2 Construction Oversight (2p*12 months) | 504 | mn-days | | | $240 00 | | $0 | $0 | $120,960 | $0 | $120,960 |
| **Subtotal** | | | | | | | $794,040 | $1,619,874 | $156,135 | $18,635 | $2,588,684 |
| **Local Area Adjustments** | | | | | | | 100 0% | 112.3% | 130 4% | 130 4% | |
| | | | | | | | $794,040 | $1,819,119 | $203,600 | $24,300 | $2,841,059 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $61,080 | | $61,080 |
| G & A on Labor Cost @ 10% | | | | | | | | | $20,360 | | $20,360 |
| G & A on Material Cost @ 10% | | | | | | | | $181,912 | | | $181,912 |
| G & A on Subcontract Cost @ 10% | | | | | | | $79,404 | | | | $79,404 |
| G & A on Equipment Cost @ 10% | | | | | | | | | | $2,430 | $2,430 |
| **Total Direct Cost** | | | | | | | $873,444 | $2,001,030 | $285,040 | $26,730 | $3,186,244 |
| Indirects on Total Direct Cost @ 25% | | | | | | | | | | | $796,561 |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $318,624 |
| **Subtotal** | | | | | | | | | | | $4,301,430 |
| Health & Safety Monitoring @ 1% | | | | | | | | | | | $43,014 |
| **Total Field Cost** | | | | | | | | | | | $4,344,444 |
| Contingency on Total Field Costs @ 25% | | | | | | | | | | | $1,086,111 |
| Engineering on Total Field Cost @ 5% | | | | | | | | | | | $217,222 |
| **TOTAL COST (for Years 0 through 10)** | | | | | | | | | | | **$5,647,778** |

**OF[illegible]E SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 5: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (BIOBARRIER WITH HRC), NATURAL ATTENTUATION, AND MONITORING**
**Annual Cost**

| Item | Item Cost<br>Year 1 | Item Cost<br>Years 2 through 16 | Item Cost<br>Every 5 Years | Notes |
|---|---|---|---|---|
| Quarterly Groundwater and Surface Water Sampling | $21,800 | | | 15 Wells and 3 Surface Water Stations, 4 times, Labor |
| Quarterly Groundwater and Surface Water Analysis | $27,570 | | | 15 Wells and 3 Surface Water Stations, 4 Times, VOCs, Field and Laboratory Water Quality Parameters |
| Annual Groundwater and Surface Water Sampling | | $5,450 | | 15 Wells and 3 Surface Water Stations, Labor |
| Annual Groundwater and Surface Water Analysis | | $3,090 | | 15 Wells and 3 Surface Water Stations, VOCs, Field Water Quality Parameters |
| Annual Report | $10,000 | $10,000 | | |
| Inspection | $1,000 | $1,000 | | Annual LUC inspection |
| Site Review | | | $23,000 | 5-year review |
| TOTALS | $60,370 | $19,540 | $23,000 | |

OFF-SITE SOUTHERN AREA GROUNDWATER PLUME
NWIRP CALVERTON
CALVERTON, NEW YORK
ALT 5: DEED NOTIFICATIONS, IN-SITU BIOLOGICAL TREATMENT (BIOBARRIER WITH HRC), NATURAL ATTENTUATION, AND MONITORING
Present Worth Analysis

| Year | Capital Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth |
|---|---|---|---|---|---|
| 0 | $6,039,159 | | $6,039,159 | 1.000 | $6,039,159 |
| 1 | $5,647,778 | $60,370 | $5,708,148 | 0.935 | $5,337,118 |
| 2 | $5,647,778 | $19,540 | $5,667,318 | 0.873 | $4,947,568 |
| 3 | $5,647,778 | $19,540 | $5,667,318 | 0.816 | $4,624,531 |
| 4 | $5,647,778 | $19,540 | $5,667,318 | 0.763 | $4,324,163 |
| 5 | $5,647,778 | $42,540 | $5,690,318 | 0.713 | $4,057,196 |
| 6 | $5,647,778 | $19,540 | $5,667,318 | 0.666 | $3,774,434 |
| 7 | $5,647,778 | $19,540 | $5,667,318 | 0.623 | $3,530,739 |
| 8 | $5,647,778 | $19,540 | $5,667,318 | 0.582 | $3,298,379 |
| 9 | $5,647,778 | $19,540 | $5,667,318 | 0.544 | $3,083,021 |
| 10 | $5,647,778 | $42,540 | $5,690,318 | 0.508 | $2,890,681 |
| 11 | $5,647,778 | $19,540 | $5,667,318 | 0.475 | $2,691,976 |
| 12 | $5,647,778 | $19,540 | $5,667,318 | 0.444 | $2,516,289 |
| 13 | $5,647,778 | $19,540 | $5,667,318 | 0.415 | $2,351,937 |
| 14 | $5,647,778 | $19,540 | $5,667,318 | 0.388 | $2,198,919 |
| 15 | $5,647,778 | $42,540 | $5,690,318 | 0.362 | $2,059,895 |
| 16 | | $19,540 | $19,540 | 0.339 | $6,624 |
| | | | | TOTAL PRESENT WORTH | $57,732,630 |

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## C.5 ALTERNATIVE 6

## DEED NOTIFICATIONS, IN-SITU PHYSICAL TREATMENT (AIR PSARGE CURTAIN), NATURAL ATTENUATION, AND MONITORING

**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 6: DEED NOTIFICATIONS, IN-SITU PHYSICAL TREATMENT (AIR SPARGE CURTAIN), NATURAL ATTENTUATION AND MONITORING**
**Capital Cost**

| | | | Unit Cost | | | | Extended Cost | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Quantity | Unit | Subcontract | Material | Labor | Equipment | Subcontract | Material | Labor | Equipment | Subtotal |
| **1 PROJECT PLANNING** | | | | | | | | | | | |
| 1 1 Prepare Remedial Action Plan | 300 | hr | | | $52 50 | | $0 | $0 | $15,750 | $0 | $15,750 |
| 1 2 Deed Notifications | 150 | hr | | | $52 50 | | $0 | $0 | $7,875 | $0 | $7,875 |
| **2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT** | | | | | | | | | | | |
| 2 1 Office Trailer | 10 | mo | | $202.50 | | | $0 | $2,025 | $0 | $0 | $2,025 |
| 2.2 Storage Trailer | 10 | mo | | $105 00 | | | $0 | $1,050 | $0 | $0 | $1,050 |
| 2 3 Construction Survey | 1 | ls | $2,000 00 | | | | $2,000 | $0 | $0 | $0 | $2,000 |
| 2 4 Equipment Mobilization/Demobilization, less than 150 HP | 2 | ea | | | $55 00 | $112 00 | $0 | $0 | $110 | $224 | $334 |
| 2.5 Drill Rig Mobilization/Demobilization | 1 | ls | | | $1,000 00 | $4,000 00 | $0 | $0 | $1,000 | $4,000 | $5,000 |
| 2 6 Site Utilities (phone & electric) | 10 | mo | | $302 00 | | | $0 | $3,020 | $0 | $0 | $3,020 |
| **3 DECONTAMINATION** | | | | | | | | | | | |
| 3.1 Temporary Decon Pad | 1 | ls | | $500 00 | $450.00 | $155.00 | $0 | $500 | $450 | $155 | $1,105 |
| 3.2 Decontamination Services | 10 | mo | | $210 00 | $1,800 00 | $315 00 | $0 | $2,100 | $18,000 | $3,150 | $23,250 |
| 3 3 Decon Water | 10,000 | gal | | $0.20 | | | $0 | $2,000 | $0 | $0 | $2,000 |
| 3.4 Decon Water Storage Tank, 6,000 gallon | 10 | mo | | | | $635 00 | $0 | $0 | $0 | $6,350 | $6,350 |
| 3.5 Clean Water Storage Tank, 4,000 gallon | 10 | mo | | | | $570 00 | $0 | $0 | $0 | $5,700 | $5,700 |
| 3 6 Disposal of Decon Waste (liquid & solid) | 10 | mo | $900 00 | | | | $9,000 | $0 | $0 | $0 | $9,000 |
| **4 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 4 1 Install Monitoring Wells, 10 wells, 90 ft each | 900 | ft | $35 00 | | | | $31,500 | $0 | $0 | $0 | $31,500 |
| 4 2 Flushmounts | 10 | ea | $120 00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 4 3 Collect/Containerize IDW | 20 | ea | $50 00 | | | | $1,000 | $0 | $0 | $0 | $1,000 |
| 4 4 Transport/Dispose IDW Off Site | 20 | drums | $150 00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| **5 AIR SPARGING WELL INSTALLATION** | | | | | | | | | | | |
| 5.1 Install Air Sparging Wells, 90 wells, 100 ft each | 9,000 | ft | $32 00 | | | | $288,000 | $0 | $0 | $0 | $288,000 |
| 5 2 2-inch Dia PVC Piping | 5,000 | ft | | $1 72 | $3 93 | $6 45 | $0 | $8,580 | $19,650 | $32,250 | $60,480 |
| 5 3 6" DeepTrench | 5,000 | ft | | | $0 44 | $0 14 | $0 | $0 | $2,175 | $675 | $2,850 |
| 5 4 Piping, Tees, 2" | 90 | ea | | $29 25 | $21 50 | | $0 | $2,633 | $1,935 | $0 | $4,568 |
| 5 5 Roll Off Box for IDW- Mob/Demob/Disposal | 10 | ea | $2,460 00 | | | | $24,600 | $0 | $0 | $0 | $24,600 |
| 5 6 Frac Tank for IDW Water | 4 | mo | $2,000 00 | | | | $8,000 | $0 | $0 | $0 | $8,000 |
| 5.7 Transport/Dispose IDW Water | 40,000 | gal | $0 05 | | | | $2,000 | $0 | $0 | $0 | $2,000 |
| **6 AS SYSTEM INSTALLATION** | | | | | | | | | | | |
| 6.1 Pilot Scale Testing | 1 | ls | $30,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 6.2 Building Foundations, 4 @ 100 sf | 400 | sf | $4.06 | | | | $1,624 | $0 | $0 | $0 | $1,624 |
| 6.3 Compressor Buildings, 4 @ 100 sf | 400 | sf | $11 58 | | | | $4,632 | $0 | $0 | $0 | $4,632 |
| 6.4 Overhead Feed, per Power Pole, 50 ft apart | 20 | ea | $3,000.00 | | | | $60,000 | $0 | $0 | $0 | $60,000 |
| 6.5 Transformer, 300KVA | 1 | ea | $12,000.00 | | | | $12,000 | $0 | $0 | $0 | $12,000 |
| 6.6 Switchgear | 1 | ea | $2,600.00 | | | | $2,600 | $0 | $0 | $0 | $2,600 |
| 6.7 Electrical to Connect from Switchgear to Loads | 1 | ls | | $3,680 00 | $1,054 00 | | $0 | $3,680 | $1,054 | $0 | $4,734 |
| 6 8 Rotary Vane Compressor, 300 cfm, 100 HP | 4 | ea | | $40,180 00 | $855 00 | | $0 | $160,720 | $3,420 | $0 | $164,140 |
| 6 9 Pressure Gages | 16 | ea | | $70 00 | | | $0 | $1,120 | $0 | $0 | $1,120 |
| 6 10 Telemetry System | 4 | ls | $3,000 00 | | | | $12,000 | $0 | $0 | $0 | $12,000 |
| 6.11 Systems Start-up and Testing, 2 People for 8 Weeks | 16 | mn-wks | | | $1,500 00 | | $0 | $0 | $24,000 | $0 | $24,000 |
| **7 MISCELLANEOUS** | | | | | | | | | | | |
| 7 1 Prepare Post-Construction Documents | 200 | hours | | | $35.00 | | $0 | $0 | $7,000 | $0 | $7,000 |
| 7 2 Construction Oversight (2p*5days*43 weeks) | 430 | mn-days | | | $160 00 | | $0 | $0 | $68,800 | $0 | $68,800 |
| **Subtotal Direct Costs less Subcontract** | | | | | | | $493,156 | $187,428 | $171,219 | $52,504 | $904,307 |
| **Local Area Adjustments** | | | | | | | 100 0% | 112 3% | 130 4% | 130 4% | |
| | | | | | | | $493,156 | $210,481 | $223,270 | $68,465 | $995,372 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $66,981 | | $66,981 |

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**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 6: DEED NOTIFICATIONS, IN-SITU PHYSICAL TREATMENT (AIR SPARGE CURTAIN), NATURAL ATTENTUATION AND MONITORING**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| G & A on Labor Cost @ | 10% | | | | | | | | $22,327 | | $22,327 |
| G & A on Material Cost @ | 10% | | | | | | | $21,048 | | | $21,048 |
| G & A on Equipment Cost @ | 10% | | | | | | | | | $6,847 | $6,847 |
| G & A on Subcontract Cost @ | 10% | | | | | | $49,316 | | | | $49,316 |
| **Total Direct Cost** | | | | | | | $542,472 | $231,529 | $312,577 | $75,312 | $1,161,890 |
| Indirects on Total Direct Cost @ | 35% | | | | | | | | | | $406,661 |
| Profit on Total Direct Cost @ | 10% | | | | | | | | | | $116,189 |
| **Subtotal** | | | | | | | | | | | $1,684,740 |
| Health & Safety Monitoring @ | 2% | | | | | | | | | | $33,695 |
| **Total Field Cost** | | | | | | | | | | | $1,718,435 |
| Contingency on Total Field Costs @ | 25% | | | | | | | | | | $429,609 |
| Engineering on Total Field Cost @ | 15% | | | | | | | | | | $257,765 |
| **TOTAL COST** | | | | | | | | | | | **$2,405,809** |

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**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 6: DEED NOTIFICATIONS, IN-SITU PHYSICAL TREATMENT (AIR SPARGE CURTAIN), NATURAL ATTENTUATION AND MONITORING**
**Capital Cost**
**Operation and Maintenance Costs per Year**

| | Item | Qty | Unit | Unit Cost | Subtotal Cost | Notes |
|---|---|---|---|---|---|---|
| | Site 6A | | | | | |
| 1 | Energy - Electric | 2,612,933 | kWh | $0.12 | $313,552 | |
| 2 | Maintenance | 1 | ls | $35,367.38 | $35,367 | 5% of Installation Cost |
| 3 | Labor | 52 | wk | $640.00 | $33,280 | 1 visit per week - 1day |
| 4 | Quarterly Reports | 4 | ea | $4,000.00 | $16,000 | |
| | Subtotal Cost per Year of Operation | | | | $398,199 | |

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**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 6: DEED NOTIFICATIONS, IN-SITU PHYSICAL TREATMENT (AIR SPARGE CURTAIN), NATURAL ATTENTUATION AND MONITORING**
**Annual Cost**

| Item | Item Cost Year 1 | Item Cost Years 2 through 16 | Item Cost Every 5 Years | Notes |
|---|---|---|---|---|
| Quarterly Groundwater and Surface Water Sampling | $21,800 | | | 15 Wells and 3 Surface Water Stations, 4 times, Labor |
| Quarterly Groundwater and Surface Water Analysis | $27,570 | | | 15 Wells and 3 Surface Water Stations, 4 Times, VOCs, Field and Laboratory Water Quality Parameters |
| Annual Groundwater and Surface Water Sampling | | $5,450 | | 15 Wells and 3 Surface Water Stations, Labor |
| Annual Groundwater and Surface Water Analysis | | $3,090 | | 15 Wells and 3 Surface Water Stations, VOCs, Field Water Quality Parameters |
| Annual Report | $10,000 | $10,000 | | |
| Inspection | $1,000 | $1,000 | | Annual LUC inspection |
| Site Review | | | $23,000 | 5-year review |
| TOTALS | $60,370 | $19,540 | $23,000 | |

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**OFF-SITE SOUTHERN AREA GROUNDWATER PLUME**
**NWIRP CALVERTON**
**CALVERTON, NEW YORK**
**ALT 6: DEED NOTIFICATIONS, IN-SITU PHYSICAL TREATMENT (AIR SPARGE CURTAIN), NATURAL ATTENTUATION AND MONITORING**
**Capital Cost**
**Present Worth Analysis**

| Year | Capital Cost | Operation & Maintenance Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth |
|---|---|---|---|---|---|---|
| 0 | $2,405,809 | | | $2,405,809 | 1.000 | $2,405,809 |
| 1 | | $398,199 | $60,370 | $458,569 | 0.935 | $428,762 |
| 2 | | $398,199 | $19,540 | $417,739 | 0.873 | $364,686 |
| 3 | | $398,199 | $19,540 | $417,739 | 0.816 | $340,875 |
| 4 | | $398,199 | $19,540 | $417,739 | 0.763 | $318,735 |
| 5 | | $398,199 | $42,540 | $440,739 | 0.713 | $314,247 |
| 6 | | $398,199 | $19,540 | $417,739 | 0.666 | $278,214 |
| 7 | | $398,199 | $19,540 | $417,739 | 0.623 | $260,252 |
| 8 | | $398,199 | $19,540 | $417,739 | 0.582 | $243,124 |
| 9 | | $398,199 | $19,540 | $417,739 | 0.544 | $227,250 |
| 10 | | $398,199 | $42,540 | $440,739 | 0.508 | $223,896 |
| 11 | | $398,199 | $19,540 | $417,739 | 0.475 | $198,426 |
| 12 | | $398,199 | $19,540 | $417,739 | 0.444 | $185,476 |
| 13 | | $398,199 | $19,540 | $417,739 | 0.415 | $173,362 |
| 14 | | $398,199 | $19,540 | $417,739 | 0.388 | $162,083 |
| 15 | | $398,199 | $42,540 | $440,739 | 0.362 | $159,548 |
| 16 | | $398,199 | $19,540 | $417,739 | 0.339 | $141,614 |
| | | | | | **TOTAL PRESENT WORTH** | $6,426,360 |