FINAL REPORT

Raytheon Company

Phase IV Remedy Implementation Plan

Former Raytheon Facility
430 Boston Post Road
Wayland, Massachusetts

Tier IB Permit No. 133939

30 December 2002

143.65

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1.0 INTRODUCTION

1.1 BACKGROUND

On behalf of Raytheon Company (Raytheon), Environmental Resources Management (ERM) has prepared this Remedy Implementation Plan (RIP) for an approximately 83-acre property located at 430 Boston Post Road in Wayland, Massachusetts (defined as the "Site", Figure 1). The Site, surrounding properties and physical features are shown on Figure 2.

The Phase IV is the fourth part of a five-phase process required under the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) for assessment and remediation of a release(s) of oil and/or hazardous materials (OHM) to the environment. Cleanup will be initiated under Phase IV to abate OHM impacts to Site wetland soil/sediment and groundwater that pose a potential risk to human health and the environment, as identified in the Phase II–Comprehensive Site Assessment (Phase II; ERM, 2001a). The technologies utilized as part of Phase IV are those selected in the Phase III–Remedial Action Plan (Phase III; ERM, 2001b). The Phase IV includes design, construction and implementation of the Comprehensive Remedial Response Action identified in the Phase III. The Phase IV Transmittal Form BWSC-108 is included as Appendix A.

Subsequent to submission of the Phase II and Phase III reports in November 2001, Raytheon received public comments as part of the Public Involvement Plan (PIP) process for the Site. Raytheon prepared a response to these comments, dated 24 December 2001, in which they agreed to conduct additional Site characterization activities to address concerns raised by the public.

In December 2001, in response to a request from the Town of Wayland Water Department, the Department of Environmental Protection (DEP or Department) initiated a subsurface investigation to locate potential sources of OHM to the Town's Baldwin Pond wellfield. Trace levels of chlorinated hydrocarbon and petroleum-related volatile organic compounds (VOCs) had been detected in the wellfield since 1997. A summary of VOCs historically detected in the wellfield is presented in a memorandum prepared by the Department, dated 18 July 2002 in Appendix B. Results of the Department's investigation indicated the presence of chlorinated VOCs (CVOCs) in groundwater to the north of the former Raytheon facility.

In response to public comments, results of the Department's investigation, and the need to conduct pre-remedial characterization activities, Raytheon developed a work plan entitled "Revised Scope of Work: Additional Site Characterization Activities," dated 20 June 2002. This work plan was provided to the public and the Department for review and comment, and modified in response to comments received. In the summer of 2002, ERM implemented a series of investigations consistent with the work plan to further characterize the nature and extent of CVOC impact to groundwater and OHM impact to wetland sediments at the Site. These data were evaluated as part of Phase IV with respect to their impact on remedial activities at the Site.

Results of these investigations indicate that additional groundwater assessment will be required to fully delineate the northern extent of CVOC impact. The detection of CVOCs in groundwater in the northern portion of the Site at concentrations higher than those previously detected could be interpreted as a new release condition, thus to be conservative the data will be reported to the Department. Based on discussions with the Department, Raytheon will submit a RNF within the 120-day notification period.

To further address CVOC impacts in this portion of the Site, Raytheon will install permanent monitoring wells during December 2002. Proposed well locations are shown on Figure 2. Groundwater data obtained from these wells will be used to develop a Scope of Work that will be submitted for public review. Once this Scope of Work is finalized, Raytheon will coordinate to obtain access to abutting properties, as necessary, and prepare an amendment to the existing Notice of Intent (NOI) for submission to the Wayland Conservation Commission (WCC) for work within the wetland and/or wetland buffer zones. Continued investigation will commence following WCC approval.

Because the northern portion of the Site will be addressed as a separate RTN, this document is intended to document those remedial activities proposed for the southern, eastern and western portions of the Site, where the nature and extent of impact have been characterized, and where risk has been assessed.

Pursuant to 310 CMR 40.0874, the RIP documents the engineering concepts and design criteria to be used for the design and construction of the Comprehensive Remedial Action for the Site. Following construction and implementation of the remedy, an As-Built Construction Report, Final Inspection Report and Phase IV Completion Statement will be prepared in fulfillment of remaining Phase IV requirements.

1.2 PURPOSE & SCOPE

The purpose of the RIP is to ensure that the information, plans and reports related to the design, construction and implementation of the selected remedial action alternative are sufficiently developed and documented to support implementation of the Comprehensive Remedial Action. In accordance with 310 CMR 40.0874, the RIP includes the following:

- A list of relevant contacts including:
  1) names, addresses, and telephone numbers of the responsible party (RP), potentially responsible party (PRP) or Other Persons responsible for submittal of the RIP;
  2) name, address, and telephone number of the licensed site professional (LSP); and
  3) identification of those persons who will own, operate and/or maintain the selected remedial action alternative during and following construction.
- Engineering concepts and design criteria to be used for the design and construction of the Comprehensive Remedial Action including:
  1) goals of the remedial action, including performance requirements of the remedial systems, and/or the requirements for achieving a Response Action Outcome under 310 CMR 40.1000;
  2) any significant changes in or new information related to disposal site conditions which were not included in previous submittals;
  3) disposal site maps showing existing disposal site features and proposed locations of activities associated with the remedial action;
  4) a description of the characteristics, quantity, and location of environmental media or materials to be treated or otherwise managed;
  5) a description and conceptual plan of the activities, treatment units, facilities, and processes to be used to implement the selected remedial action alternative including flow diagrams;
  6) relevant design and operation parameters, including:
     a) design criteria, assumptions and calculations;
     b) expected treatment, destruction, immobilization, or containment efficiencies and documentation of how that degree of effectiveness was determined; and
     c) demonstration that the selected remedial action alternative will achieve the identified remedial goals (may include information

from pilot or treatability tests, similar operations, or scientific literature);

7) design features for control of OHM spills and accidental discharge or system malfunction, including without limitation: containment structures, leak detection devices, run-off controls, pressure valves, bypass systems, or safety cutoffs;

8) a description of the methods for management or disposal of any treatment residual, contaminated soils, and other waste materials containing OHM generated as a result of the selected remedial action alternative;

9) identification of site-specific characteristics which may affect or be affected by the design, construction, or operation of the selected remedial action alternative, including, but not limited to:

   a) relationship of the selected remedial action alternative to existing disposal site activities or operations;

   b) drainage features;

   c) natural resource areas, local planning and development issues; and

   d) soil characteristics and groundwater characteristics;

10) a discussion of measures to be incorporated into the design, construction and operation of the remedial action alternative to avoid any deleterious impact on environmental receptors and natural resource areas (including any surface water or wetland), or where it is infeasible to avoid any such impact, a discussion of measures to minimize or mitigate any impact; and

11) a general description of inspections and monitoring which will be performed to ensure adequate construction and performance of the remedial action.

   a) Construction plans prepared in conformance with appropriate engineering and construction standards and practices, and regulations applicable to construction plans and activities including, as appropriate: plans, material specifications, and procedures related to the construction of the selected remedial action alternative; and

12) a schedule for the design and construction of the remedial action alternative.

- An Operation, Maintenance, and/or Monitoring plan including, as appropriate:

1) name and telephone number of the person(s) conducting operation, maintenance and/or monitoring activities;

2) general operating procedures, including start-up, testing, maintenance, shutdown, and emergency or contingency procedures; and

3) specification of the type, frequency and duration of monitoring, and testing or inspections to ensure and confirm that the remedial action is performing as designed. The frequency of monitoring and/or inspections shall be consistent with the Response Action Performance Standard, as described in 310 CMR 40.0191, and in conformance with the terms of applicable permits, approvals or licenses. At a minimum, the results from operation, maintenance and/or monitoring of a remedial action shall be documented and submitted to the Department every six months in report form as described in 310 CMR 40.0892.

- A health and safety plan to be followed during the construction and implementation of the Comprehensive Remedial Action.
- A list of any necessary federal, state or local permits, licenses and/or approvals required for the design, construction and/or operation of the selected remedial action alternative and a description of any additional information needed to meet these requirements.
- A discussion of any property access issues which are relevant to the implementation of the Comprehensive Remedial Action, and a plan and timetable for resolving property access problems, as appropriate.
- This document is not intended to provide final design specifications for remedial activities at the Site. Additional pilot study testing, coordination and permitting activities must be completed prior to finalizing design specifications. Results of these additional activities and final design specifications will be provided as an addendum to the RIP. As noted above, an As-Built Construction Report, Final Inspection Report and Phase IV Completion Statement will also be submitted as part of Phase IV, but are not included in the RIP.

1.3 REPORT ORGANIZATION

The report is organized to satisfy the requirements of the MCP (310 CMR 40.0874). The report contains the following sections:

Section 1.0 *Introduction*- describes the background, purpose and scope of the RIP.

Section 2.0 *Site Information*- includes a summary of new information obtained since submission of the Phase II and Phase III reports, and relevant Site contacts.

Section 3.0	*Design Basis*- includes the identification of target cleanup levels and areas of OHM impacted media (i.e., groundwater and wetland soil/sediment) requiring abatement to achieve remedial goals.
Section 4.0	*Conceptual Design – Wetland Remediation*- includes the: engineering design; construction plans and specifications; operation, maintenance and/or monitoring plans, as appropriate; health and safety plan; list of necessary permits; and, property access issues pertaining to the wetland remediation.
Section 5.0	*Conceptual Design – Groundwater Remediation* - includes the: engineering design; construction plans and specifications; operation, maintenance and/or monitoring plans, as appropriate; health and safety plan; list of necessary permits; and, property access issues pertaining to the groundwater remediation.
Section 6.0	*Implementation Schedule*- includes a proposed schedule to complete implementation of the Comprehensive Remedial Action.
Section 7.0	*References*

2.0 NEW SITE INFORMATION

2.1 BACKGROUND

Since completion of the Phase II and Phase III reports (ERM, 2001a, b), a number of ongoing activities have been undertaken to support the remedial design and to further evaluate Site conditions. These activities include:

- Release Abatement Measure (RAM) to evaluate the efficacy of in-situ chemical oxidation (ISCO) to treat CVOC impacts to groundwater;
- additional Site characterization activities in response to public comments; and
- pre-remedial characterization activities to support remedial design and implementation.

2.2 IN-SITU CHEMICAL OXIDATION PILOT STUDY

An in-situ chemical oxidation (ISCO) pilot study is being conducted at the Site as a Release Abatement Measure (RAM) (ERM, 2001c, 2002a, b, c) to evaluate the effectiveness of ISCO and its effectiveness in reducing the concentrations of chlorinated VOCs in groundwater. In Phase III, ISCO was selected as the preferred remedial technology to abate VOC impacts to groundwater at the Site (ERM, 2001b). The RAM was conducted in two areas (Figure 3), which were designed to evaluate two different delivery methods for introducing oxidants to the subsurface and two different oxidant concentrations. The two injection methods were: gravity feed (i.e., passive injection; MW-43 Pilot Study Area) and high-pressure injection (i.e., pneumatic fracturing and liquid atomized injection (PFLAI); MW-33 Pilot Study Area).

In October 2001, approximately 2,500 gallons of 2% potassium permanganate was injected under pressure in the MW-33 Pilot Study Area and approximately 250 gallons of 4% sodium permanganate was injected via gravity feed injection in the MW-43 Pilot Study Area.

Following the oxidant injections, 22 rounds of groundwater elevation and field parameter monitoring were conducted over a nine-month period (ERM, 2002a, b). Groundwater samples were collected for laboratory analysis of CVOCs by Environmental Protection Agency (EPA) Method 8021C during seven of these monitoring rounds:

- 12 – 13 November 2001
- 10 – 12 December 2001
- 15 – 16 January 2002
- 18 February 2002
- 1 - 4 March 2002
- 11 – 12 April 2002
- 6 June 2002

Monitoring well construction data are presented in Table 1. Well gauging and groundwater elevation data are presented in Table 2. Groundwater field parameter data are presented in Table 3a-e. Groundwater VOC data are presented in Table 4.

Results of the initial pilot studies indicated that permanganate was effective at reducing CVOC concentrations in groundwater in the two pilot study areas by up to 84% (ERM, 2002b). Based on these results, a RAM Plan – Modification #1 (ERM, 2002c) was developed to expand the MW-43 pilot study. This work is ongoing and results will be presented in RAM status reports and RIP addendum, as appropriate.

2.3 ADDITIONAL SITE ASSESSMENT ACTIVITIES

2.3.1 Methods

Cone Penetrometer Profiling

The purpose of this task was to better resolve the degree of horizontal and vertical heterogeneity within unconsolidated overburden deposits in the southern portion of the Site in support of the remedial design. On 22 June 2002, a compression model electronic piezo cone penetrometer (CPT) was advanced to refusal at 10 locations (aggregate of approximately 685 vertical feet) using a truck-mounted cone penetration rig (Figure 2). The upper six to eight feet of each borehole was advanced using a vacuum boring rig in order to minimize the potential for damage to subsurface utilities.

The CPT was fitted with a 15 square centimeter (cm^2) tip and a 225-cm2 friction sleeve. As the cone was advanced, tip resistance (Qc), sleeve friction (Fs) and dynamic pore water pressure (Ut) were measured at five-centimeter intervals. These data were used to resolve variations in the unconsolidated deposits stratigraphy. A series of depth vs. parameter plots was prepared depicting these CPT data at five-centimeter resolution. The following table summarizes the total depth of each boring:

Summary of CPT Boring Depths

Boring	Depth (feet)	Boring	Depth (feet)
B-201	65.6	B-206	78.4
B-202	57.7	B-207	84.3
B-203	64.3	B-208	72.8
B-204	77.4	B-215	54.6
B-205	72.2	B-216	57.3

CPT boring logs are presented in Appendix C.

Waterloo Profiling

The purpose of this task was to further characterize the distribution of CVOCs within unconsolidated deposits. A modified Waterloo Profiler was used to simultaneously collect continuous hydrogeologic data and depth-discrete groundwater samples in a single push. The groundwater samples were analyzed in real time using a mobile field laboratory (i.e., by gas chromatography (GC)), in order to provide compound-specific CVOC screening data. This approach enabled interpretation of the data generated at each boring location to guide the selection of subsequent locations. The goal was to attempt lateral and vertical delineation of groundwater impacts.

The modified Waterloo Profiler was used to collect continuous relative hydraulic conductivity data, referred to as the index of hydraulic conductivity (I_k). The I_k data were generated by continuously injecting a small volume of deionized water into the formation through the sampling ports and monitoring variations in injection pressures. The I_k data were evaluated in real time to determine groundwater sampling intervals. In general, groundwater samples were collected from higher conductivity zones and analyzed for selected CVOCs (vinyl chloride (VC), trans-1,2-dichloroethene (t1,2-DCE), 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA), cis-1,2-dichloroethene (c1,2-DCE), 1,1,1-trichloroethane (TCA), trichloroethene (TCE) and tetrachloroethene (PCE)). Physico-chemical properties for each sample (pH, temperature, specific conductance, dissolved oxygen and oxidation-reduction potential (ORP)) were monitored to ensure that a representative sample was obtained. The equilibrated physico-chemical properties for each sample are presented in Appendix D.

On 22 and 23 June 2002, ERM collected a total of 29 groundwater samples for CVOC analysis at six locations in the southern portion of the Site. Between 12 and 23 August 2002, ERM collected a total of 107 groundwater samples at 22 locations in the vicinity of MW-TP-3 (i.e., northern portion of the Site) for CVOC analysis. Four split samples were submitted to Alpha Analytical Laboratory, Inc. in Westborough, Massachusetts for laboratory analysis of VOCs by EPA Method 8260. CVOC field screening data and laboratory confirmation data are presented in Table 5. Waterloo Profiler boring locations are presented in Figure 2. Waterloo Profiler I_k data, field parameter data and field laboratory sheets are presented in Appendix D.

Investigation of the 22 locations completed in the northern portion of the Site represents an increase from the original Work Plan submitted to the Department. In accordance with the Work Plan, ERM expanded this field program in response to real-time data collected using the Waterloo Profiler, used to delineate the lateral and vertical extent of CVOC impacts to groundwater on the northern portion of the Site. Raytheon is committed to install a network of permanent monitoring wells in this portion of the Site during December 2002 to verify groundwater conditions and to facilitate long-term groundwater monitoring.

Borehole Advancement and Well Installation

The purpose of this task was to collect soil samples, evaluate subsurface geologic conditions and install permanent monitoring wells at the Site. Boreholes were advanced using truck-mounted drill rigs, all-terrain vehicle drill rigs, direct-push drill rigs, hand-held equipment and a tripod drilling apparatus. Boreholes were advanced using hollow-stem auger (HSA), drive and wash casing, hand auger and direct push drilling techniques. The upper six to eight feet of each borehole was advanced using a vacuum boring rig to minimize the potential for damage to subsurface utilities. Utility clearance activities were completed in areas known or suspected of containing underground utilities. Soil samples were collected at various intervals in each boring and screened for total VOCs using a photoionization detector (PID). PID screening results are presented in the boring logs in Appendix E. Soil samples were submitted for laboratory analysis of one or more of the following parameters:

- VOCs by EPA Method 8260/5035,
- PAHs by EPA Method 8270,
- PCBs by EPA Method 8082, and

- total PP13 metals.

Results of laboratory analyses of soil are presented in Table 6. Dates of drilling activities and borehole/monitoring well numbers are presented below (see Figure 2 for locations):

- From 22 June through 2 July 2002, five soil borings (B-209, B-211 through B-214) were advanced and eight monitoring wells (MW-209, MW-212, MW-217S/M/D and MW-218S/M/D) were installed in the southern portion of the Site and three monitoring wells were installed in the northern portion of the Site (MW-1S/M/D).
- On 20 July 2002, 31 monitoring wells (MW-201S/M/D through MW-208S/M/D, MW-210, MW-211, MW-213, MW-214, MW-216S/M/D) were installed in the southern and eastern portions of the Site.
- From 10 through 15 August 2002, three monitoring well triplets (MW-215S/M/D, MW-219S/M/D and MW-220S/M/D) were installed in the southern and eastern portions of the Site.
- On 20 August 2002, 12 soil borings (B-301 through B-312) were advanced and one monitoring well (MW-307) was installed in the western portion of the Site.
- From 26 through 30 August 2002, three monitoring well couplets (MW-313S/D, MW-314S/D and MW-315S/D) were installed in the wetland.
- From 9 through 12 September 2002, 18 soil borings (B-243 through B-260) were advanced in the northern portion of the Site and one monitoring well couplet (MW-221M/D) was installed in the southern portion of the Site.

A combination of single monitoring wells and monitoring well clusters were installed. In general, deep wells were generally set at the top of a glacial till deposit, intermediate wells were generally installed at the top of a gray, silt unit and shallow wells were generally installed so that the well screen straddled the water table. A summary of monitoring well construction data is presented in Table 1. Monitoring well and boring locations are shown on Figure 2. Monitoring well and boring logs are presented in Appendix E.

Surveying and Water Elevation Measurement

To accurately determine groundwater flow directions across the Site, ERM subcontracted Chas. H. Sells, Inc. to survey the locations and elevations of all newly installed borings and monitoring wells on Site. Elevations were surveyed relative to mean sea level in October 2002. Ground surface and monitoring well elevation data are presented in Table 1. On 10 October

2002, ERM gauged groundwater depths in 114 wells. Groundwater elevation data are presented in Table 2. Shallow overburden and deep overburden groundwater elevation data are presented on Figures 4 and 5, respectively.

Groundwater Sampling

The purpose of this task was to collect groundwater quality data. Prior to the sampling of each well, ERM gauged the depth to groundwater using an electronic water-level indicator. Groundwater samples were collected using low-flow sampling techniques. Physico-chemical parameters (pH, temperature, specific conductance, dissolved oxygen and ORP) were monitored during purging to achieve equilibration prior to the collection of groundwater samples. Groundwater samples were collected through a series of sampling events corresponding to rounds of well installation. The groundwater monitoring rounds are summarized below:

- On 9 and 10 July 2002, ERM collected groundwater samples from six wells (MW-33S/M/D/B and MW-43S/D) for laboratory analyses of the following parameters:
    - Physiologically available cyanide by the DEP Method
    - Boron by EPA Method 200.7/6010B
    - Phosphorous by EPA Method 365.2
    - Chloride by EPA Method 325.2
    - Fluoride by EPA Method 300.0
    - Ammonia as Nitrogen by EPA Method 350.1
    - Nitrate as Nitrogen by EPA Method 350.1
    - Aldehydes by EPA Method 8315
    - Alcohols by ASTM D 3695
    - Glycols by ASTM E 202
    - Polychlorinated dibenzo-p-dioxins (PCDDs) by EPA Method 1613b
    - Polychlorinated dibenzo-p-dibenzofurans (PCDFs) by EPA Method 8290
    - Polychlorinated biphenyls (PCBs) by EPA Method 8082
    - Polynuclear aromatic hydrocarbons (PAHs) by EPA Method 8270
- On 30 July 2002, ERM collected groundwater samples from seven wells

(MW-45S/M/D/B and MW-47S/M/D) for laboratory analyses of the above parameters.

- On 10 and 11 July 2002, ERM collected groundwater samples from ten wells (MW-209, MW-212, MW-1S/M/D, DEP19S, DEP-19M, DEP-19D, DEP-20 and DEP-21) for laboratory analysis of VOCs by EPA Method 8260.
- On 22 and 23 July 2002, ERM collected groundwater samples from ten wells (MW-210, MW-211, MW-213, MW-214, MW-217S/M/D and MW-218S/M/D) for laboratory analysis of VOCs by EPA Method 8260.
- On 12 and 13 August 2002, ERM collected groundwater samples from seven wells (MW-203S/ M/ D, MW-205S/ M/ D and MW-TP-3) for laboratory analysis of VOCs by EPA Method 8260.
- On 5 September 2002, ERM collected groundwater samples from six wells (MW-219S/M/D and MW-220S/M/D) for laboratory analysis of VOCs by EPA Method 8260.
- On 18 and 20 September 2002, ERM collected groundwater samples from 11 wells (MW-202S/M/D, MW-215S/M/D, MW-216S/ M/ D and MW-221M/D) for laboratory analysis of VOCs by EPA Method 8260.
- On 19 and 20 September 2002, ERM collected groundwater samples from seven wells (MW-307, MW-313S/D, MW-314S/D, and MW-315S/D) for laboratory analysis of the following parameters:
    - VOCs by EPA Method 8260
    - Dissolved PP13 metals by EPA Method 200.7
    - PCBs by EPA Method 8082
    - PAHs by EPA Method 8270

Groundwater elevation data are presented in Table 2. Groundwater field parameter data are presented in Table 3. Groundwater analytical results are presented in Tables 4 and 7. Groundwater sampling locations are shown in Figure 2. Laboratory analytical reports are presented in Appendix F.

Wetland Sediment Sampling

The purpose of this task was to screen wetland soil/sediment for additional analytical parameters in the Area of Readily Apparent Harm (ARAH). Soil/sediment samples were collected from six locations (Figure 2) using stainless steel shovels at a sampling depth of six to 12 inches below grade. Composite samples were taken at three sample locations (SS-21, SS-23, SS-26) using stainless steel shovels and composted in a stainless steel mixing bowl. The remaining three samples (SS-22, SS-24, SS-25) were collected as grab samples. Sampling equipment was decontaminated between sampling locations. For Quality Assurance/Quality Control (QA/QC) purposes, ERM collected one duplicate sample, one equipment blank and used one trip blank provided by the laboratory. Soil/sediment samples were analyzed for the following parameters:

- VOCs - EPA Method 8260
- PCDDs and PCDFs– EPA Methods 1613b and 8290
- Physiologically Available Cyanide –DEP Method
- Boron – EPA Method 200.7/6010B
- Fluoride by IC – EPA Method 300.0
- Ammonia as Nitrogen – EPA Method 350.1
- Aldehydes – EPA Method 8045
- Alcohols – ASTM D 3695
- Glycol Ethers – ASTM E 202
- Waste Characterization, including Toxic Characterization Leaching Procedure (TCLP) metals, VOCs, pesticides, herbicides and semi-volatile organic compounds (SVOCs)

Specific PCDD and PCDF analytes are summarized below.

Specific analytes for the PCDD/PCDF analysis

PCDD Congeners	PCDF Congeners
2,3,7,8-TCDD	2,3,7,8-TCDF
1,2,3,7,8-PeCDD	1,2,3,7,8-PeCDF
1,2,3,4,7,8-HxCDD	2,3,4,7,8-PeCDF
1,2,3,6,7,8-HxCDD	1,2,3,4,7,8-HxCDF
1,2,3,7,8,9-HxCDD	1,2,3,6,7,8-HxCDF
1,2,3,4,6,7,8-HpCDD	2,3,4,6,7,8-HxCDF
1,2,3,4,6,7,8,9,-OCDD	1,2,3,7,8,9-HxCDF
	1,2,3,4,6,7,8-HpCDF
	1,2,3,4,7,8,9-HpCDF
	1,2,3,4,6,7,8,9-OCDF

Wetland soil/sediment analytical results are summarized in Table 8. Laboratory analytical reports are presented in Appendix F.

2.3.2 *Results*

The results presented in this section are organized into four distinct portions of the Site, each having a known or suspected source area(s) and associated area(s) of impact:

- Groundwater elevation data are presented for the entire Site following the results above.
- Northern Area – VOC impacts to soil and groundwater potentially associated with the MW-TP-3 area (ERM, 2001a). As noted above, Raytheon is committed to further evaluating this portion of the Site under a separate Release Tracking Number in accordance with timelines presented in the MCP.
- Eastern Area – VOC impacts to groundwater associated with a former dry well DW-05 (ERM, 2001a).
- Southern Area – VOC impacts to soil and groundwater associated with a former manhole W-4 (ERM, 2001a) and a former hazardous waste storage area (i.e., vicinity of MW-33 well cluster).
- Western Area – PCB and metal impacts to wetland soil/sediment associated with outfall OF-1 (ERM, 2001a).

Groundwater Elevation Data

ERM conducted a comprehensive round of groundwater gauging on 10 October 2002, which was incorporated with a Site-wide location and elevation survey, to establish groundwater elevations. Groundwater elevation data are presented in Table 2. Schematic groundwater elevation contour maps for shallow overburden (i.e., predominantly water table wells) and deep overburden (i.e., predominantly wells set at the top of till or bedrock) are presented in Figures 4 and 5.

Groundwater elevations at the Site are generally lower than during any previous monitoring round. MW-34, located in the northeast corner of the Site, was dry, likely a result of the lower groundwater table. For the purposes of evaluating groundwater flow directions, ERM prepared two groundwater elevation contour maps representing "shallow overburden" and "deep overburden." The shallow overburden map used wells screened across the water table (i.e., the piezometric surface or upper five feet of the groundwater table), where available, or the most shallow well at locations where no water table wells have been installed. The deep overburden map was intended to represent groundwater elevations for the sand unit beneath the gray silt unit that is present across much of the Site. To develop the deep overburden map, wells screened at the top of bedrock were used, where available, or the deepest well set above bedrock. Bedrock wells were not used since they represent the fractured bedrock aquifer and wells screened within the silt layer were not used since they represent a silt aquitard.

In general, the shallow overburden groundwater elevation contours are consistent with historical data, with the exception of the northern portion of the Site. Historically, groundwater elevation data for the wells installed in the northern portion of the Site indicated that groundwater flowed generally to the west. During 2002 the Department installed a series of drive-point wells north of the former Raytheon property, one of which is a shallow overburden well (DEP-19S). By incorporating this well into the shallow overburden well network for the Site, shallow overburden groundwater in the northern portion of the Site appears to flow to the north. It is important to note that this apparent change in shallow overburden groundwater flow direction in the northern portion of the Site is controlled by one data point. Raytheon is committed to installing a series of additional monitoring wells in this portion of the Site. The data will be documented and shared with the public.

Review of the shallow overburden groundwater flow data indicates that this northerly flow in shallow overburden is controlled by the presence of an intermittent stream and small wetland immediately north of the former

Raytheon property. Wetlands and streams in eastern Massachusetts typically represent a location where the ground surface topography intersects the water table (i.e., piezometric surface). Thus, it is common to observe localized shallow overburden groundwater flow toward a surface water body (e.g., stream or wetland). However, this does not necessarily represent regional groundwater flow.

To evaluate regional groundwater flow at the Site, ERM developed a deep overburden groundwater contour map (Figure 5). Deep overburden groundwater across the entire Site appears to flow generally to the west. Therefore, groundwater in the regional deep overburden aquifer generally flows from highlands in the east to the Sudbury River in the west.

In addition to evaluating horizontal groundwater flow at the Site, ERM calculated vertical hydraulic gradients were calculated for well clusters (i.e., two or more wells installed in close proximity to one another) at the Site. Where possible, vertical gradients were calculated using groundwater elevation data from a water table well and deep overburden well (i.e., top of till or bedrock) at each location. However, in cases where a deep overburden well does not exist, an intermediate overburden well was used. Vertical gradients were not calculated between overburden and bedrock wells, since only two bedrock wells currently exist at the Site. Raytheon is committed to installing three additional bedrock wells in the northern portion of the Site during December 2002.

In general, downward vertical gradients were measured across the eastern portion of the Site. These data are generally consistent with the regional hydrogeologic setting, which consists of a local groundwater flow divide located coincident with a topographic high immediately east of the Site and a regional discharge boundary (i.e., the Sudbury River) located south-southwest of the Site. In New England, vertical gradients are typically downward in the vicinity of a recharge boundary (e.g., area of high ground) indicating that groundwater is seeking to achieve a lower elevation, consistent with the regional water table. Regional water tables are typically controlled by regional discharge boundaries (e.g., large rivers). Therefore, groundwater in the eastern portion of the Site flows both horizontally and vertically downward.

As groundwater flows from the recharge boundary toward the discharge boundary, vertical gradients typically become less downward and transition to upward gradients as groundwater approaches the regional discharge boundary, in this case, the Sudbury River. This transition from downward vertical gradients to upward vertical gradients is observed immediately west of the main Site building beneath the parking lot. Upward vertical hydraulic gradients generally exist across the entire western portion of the Site. In theory, vertical hydraulic gradients should continue to be upward up to the discharge boundary (e.g., center line of the Sudbury River). However, the three well couplets installed in the wetland at the Site exhibit a downward vertical gradient during October 2002. This is likely due to two factors:

- Well couplet construction – the well couplets installed in the wetlands consist of a shallow overburden well screened generally across or slightly below the water table (i.e., the water table in the wetlands is closely tied to surface water elevations, therefore, at some times of the year the water table may intersect the ground surface in this portion of the Site) and an intermediate overburden well screened within a thick, low conductivity silt unit, which is considered to be an aquitard (i.e., a confining unit that retards, but does not prevent the flow of water to or from an adjacent aquifer or surface water body). The presence of an aquitard beneath the wetlands can result in "perched" groundwater following recharge events (e.g., precipitation events or river flooding).
- Well couplet location – the well couplets installed in the wetlands are located within the flood plain for the Sudbury River. Thus, when the Sudbury River overflows its banks, surface water recharges groundwater (i.e., downward vertical gradients) for a period of time until the river returns to normal flow conditions, resulting in downward vertical gradients.

Therefore, the downward vertical gradients measured during October 2002 likely represent a transient condition. Further review of groundwater elevation data for these well couplets supports this position. An upward vertical hydraulic gradient was measured in the MW-315S/D well couplet in September 2002 (Table 2). Vertical hydraulic gradient data are presented in the following table. Positive values represent downward vertical gradients and negative values represent upward gradients.

Summary of Vertical Gradient Data for October 2002

Shallow/Deep Well	Vertical Gradient (feet/foot)	Upward/Downward Gradient
MW-33S/MW-33D	0.006	Downward
MW-37/MW-37M	0.040	Downward
MW-40/MW-40S	0.005	Downward
MW-43S/MW-43D	0.034	Downward
MW-44S/MW-44D	-0.002	Upward
MW-45S/MW-45D	-0.014	Upward
MW-46S/MW-46M	0.049	Downward
MW-47S/MW-47D	0.025	Downward
MW-1S/MW-1D	0.055	Downward
MW-201S/MW-201D	-0.004	Upward
MW-202S/MW-202D	0.023	Downward
MW-203S/MW-203D	-0.028	Upward
MW-204S/MW-204D	-0.021	Upward
MW-205S/MW-205D	-0.020	Upward
MW-206S/MW-206D	-0.016	Upward
MW-207S/MW-207D	-0.014	Upward
MW-208S/MW-208D	-0.020	Upward
MW-215S/MW-215D	0.011	Downward
MW-216S/MW-216D	0.022	Downward
MW-217S/MW-217D	-0.012	Upward
MW-218S/MW-218D	-0.026	Upward
MW-219S/MW-219D	-0.012	Upward
MW-220S/MW-220D	-0.001	Upward
MW-221S/MW-221D	0.005	Downward
MW-313S/MW-313D	0.108	Downward
MW-314S/MW-314D	0.034	Downward
MW-315S/MW-315D	0.055	Downward
DEP-19S/DEP-19D	-0.048	Upward

Note:
(-) vertical gradient represents upward groundwater flow
(+) vertical gradient represents downward groundwater flow

Northern Area

Groundwater analytical results for the MW-1 well triplet and samples collected by ERM from Department wells are presented in Table 4. No VOCs were detected in the newly installed MW-1 triplet (i.e., shallow, intermediate and deep overburden wells) in the northeastern portion of the Site. This well triplet was installed adjacent to well MW-1, a small diameter, steel-drive point screened across the water table. The well triplet was installed during the Phase I investigation to evaluate potential impacts from former filter beds associated with an historic wastewater treatment plant (ERM, 1996). MW-1 was replaced by MW-1S (shallow overburden well) and augmented by MW-1M (intermediate overburden well) and MW-1D (deep overburden well). The MW-1 well triplet was installed to address the Department's concern that VOCs may be present at depth associated with the historic filter beds.

The Waterloo Profiler investigation in the northern portion of the Site was implemented as a screening tool to evaluate the nature and extent of VOC impacts to groundwater previously identified in monitoring well MW-TP-3 (ERM, 2001a). This phase of the investigation included the collection of 107 groundwater samples, which were analyzed using a field laboratory for CVOCs. Field laboratory screening results are presented in Table 5 and summarized below.

VOC Screening Results (Waterloo Profiler Data) – Northern Area

CVOC Compound	**Number of Detections (out of 107 analyses)**	**Concentration Range (µg/L)**	**Reportable Concentration (RCGW-1) (µg/L)**
PCE	33	ND - 560	5
TCE	54	ND - 17,040	5
c1,2-DCE	43	ND – 9,910	70
t1,2-DCE	3	ND - 30	100
VC	9	ND - 230	2
TCA	9	ND - 30	200
1,1-DCA	4	ND – 34	70

Note:
ND = Not Detected

Review of the Waterloo Profiler field screening data indicate that chlorinated ethenes (i.e., PCE, TCE, c1,2-DCE and VC) are the primary constituents of concern in the northern portion of the Site (i.e., MW-TP-3 area). Of the chlorinated ethenes detected, TCE was detected at the highest concentrations in this portion of the Site, followed by c1,2-DCE, PCE and VC. TCE concentrations in the northern portion of the site are summarized in plan view on Figure 6 and in cross-sectional view on Figures 7a and 7b.

PCE and TCE are considered to be "parent" compounds. The compounds c1,2-DCE and VC are biological degradation products of PCE and TCE. Therefore, the location(s) where PCE and TCE are present at the highest concentrations is considered to be a likely source area. The highest TCE concentration was detected in boring B-241 (17,040 μg/L) at 20.1 feet below ground surface (bgs), located approximately 140 feet south-southwest of MW-TP-3. The highest PCE concentration (560 μg/L) was also detected in B-241. TCE and PCE were not detected at concentrations above the field laboratory detection limit of 5 μg/L at locations northeast, east and south of B-241, suggesting that B-241 is likely in close proximity to the potential point/source of release. A series of 18 soil borings was installed in the vicinity of B-241 to further evaluate the potential for a residual source in this area. Continuous soil samples were collected in 17 of the borings from ground surface to approximately 15 feet bgs, and in B-260 from ground surface to 20 feet bgs. Soil analytical results are presented in Table 6. Soil field screening and laboratory analytical data did not suggest the presence of a shallow residual solvent source in the soil of the northern portion of the Site.

TCE concentrations in groundwater are summarized in plan view on Figure 6 and in cross-sectional view on Figures 7a and 7b. Correlation of the I_k data with CVOC distribution indicate that groundwater impacts appear to be confined to a relatively higher permeability sand unit that is bound by interbedded silt and clay units. The top of this sand unit is located at a depth of about 20 feet bgs at B-241 and dips to 65 feet bgs in the northwestern portion of the former Raytheon facility, at B-237. Therefore, the CVOC plume increases in depth with distance from the apparent source area. Raytheon is committed to install permanent monitoring wells in the northern portion of the Site during December 2002 to determine groundwater flow directions and gradients, and to verify groundwater chemistry in both the sand and silt units in this portion of the Site. Raytheon will also conduct further investigations in the northern portion of the Site to characterize the source(s), nature and extent of CVOC impacts to environmental media in this portion of the Site.

Southern Area

Field investigation activities conducted in the southern portion of the Site were intended to address the following issues:

- refine the southern extent of CVOC impact in groundwater;
- further evaluate the potential for impact to soil;
- conduct a detailed investigation of CVOC distribution in groundwater within the known area of impact to support design of an ISCO remedial system; and
- evaluate whether other potential chemical constituents were historically used at the Site.

To evaluate the downgradient extent of CVOCs in groundwater, ERM installed four well triplets (MW-217S/M/D through MW-220S/M/D) and one well couplet (MW-221M/D) on properties owned by the Russell's Garden Center. Groundwater analytical results for these wells are presented in Table 4. Monitoring well locations are shown on Figure 2. A total of 12 VOCs were detected in these wells, consisting of both CVOCs and petroleum hydrocarbons. Of these compounds, only TCE was detected at concentrations above Massachusetts Maximum Contaminant Levels (MMCLs). TCE was detected in wells MW-217M and MW-221D at concentrations of 8.2 μg/L and 5.9 μg/L, respectively, which exceed the MMCL of 5 μg/L.

In the Phase II Report, ERM estimated that the projected downgradient extent of TCE in groundwater in the southern portion of the Site was the Sudbury River (ERM, 2001a). TCE concentrations in groundwater discharging to the Sudbury River were estimated up to 160 μg/L. Results of recent investigations indicate that this projection was conservative. Based on VOC data collected from the MW-220 well triplet (i.e., no VOCs detected), TCE does not appear to reach the river.

To evaluate potential impacts to soil at the Site, ERM collected 14 soil samples for laboratory analysis of VOCs. Soil analytical results are summarized in Table 6. Soil boring and monitoring well locations are shown on Figure 2. No VOCs were detected at concentrations above laboratory method detection limits in 11 of the 14 soil samples collected. Petroleum hydrocarbon related VOCs were detected in soil samples collected from three borings and CVOCs were detected in soil from one boring. Of the VOCs detected, only naphthalene was detected at a concentration above the applicable Reportable Concentration for soil (RCS-1). This soil sample was collected from B-211 in the courtyard and exhibited a noticeable staining that is related to a historic No. 6 fuel oil release, previously characterized and remediated by Haley and Aldrich (H&A, 1999). This portion of the Site is subject to an Activity and Use Limitation (AUL) that was filed in conjunction with a Class A-3 Response Action Outcome (RAO) Statement for the No. 6 fuel oil release (H&A, 1999). The soil data collected do not suggest the presence of any residual CVOC source areas and are consistent with the RAO.

The following pre-remedial characterization activities were completed in the southern portion of the Site:

- An aggregate advancement of 443 feet of CPT borings to provide a detailed characterization of Site geology.
- An aggregate advancement of 320 feet of Waterloo Profiler borings to provide a detailed characterization of Site hydrogeology and collected 29 groundwater samples for field screening analysis of CVOCs to determine the relationship between groundwater quality and hydrogeology (i.e., to address whether Site hydrogeology controls dissolved-phase CVOC migration in groundwater).
- Installation of 50 monitoring wells to confirm groundwater field screening data and expand the monitoring well network.
- Collection of 35 groundwater samples from selected newly installed monitoring wells for laboratory analyses, in order to refine the nature and extent of CVOC impacts to groundwater.

Data generated by this program indicate that geology appears to control CVOC migration in and around the main building. The highest CVOC concentrations in this portion of the Site were generally detected at the top of a silt unit that is present at depths ranging from 18 to 26 feet bgs around the main building complex. This silt unit dips to the west and is present at a depth of 65 feet bgs at well triplet MW-207 (Figures 7c). In addition, the silt unit appears to coarsen, thin or pinch out about 80 feet west of the main building, allowing CVOCs to migrate vertically through the silt into the underlying sand unit. Therefore, the vertical extent of CVOCs in groundwater is deeper beneath the parking lot than around the main building.

The highest CVOC concentrations (i.e., greater than 100 µg/L) have been detected in MW-33S, MW-43S, MW-45M, MW-47M, MW-102, MW-201S and MW-204M. CVOC concentrations decrease rapidly with horizontal and vertical distance from each of these wells. Based on the spatial separation of these areas of elevated CVOC concentrations, it appears that primary areas for remediation in the southern portion of the Site are:

- former manhole W-4 (vicinity of MW-43 well couplet) and downgradient areas; and

- former hazardous waste storage (vicinity of MW-33 well cluster) and downgradient areas.

TCE concentrations in MW-33S have historically ranged from 170 to 560 µg/L. Groundwater flow directions in this area are generally to the west (see discussion below), resulting in the transport of CVOCs to the west with advective flow of groundwater. CVOCs in groundwater from the MW-43S source area flow to the southwest. CVOCs in groundwater from the MW-102 area flow generally west-southwest. The MW-102 and MW-33 plumes appear to converge beneath the parking lot and flow to the west-southwest. The downgradient extent of CVOC impacts to groundwater in the southern portion of the Site is shown on Figure 6. Figure 7c shows the vertical distribution of TCE in the southern portion of the Site.

In addition to the CVOCs detected in the southern portion of the Site, VOCs associated with gasoline (i.e., methyl tert butyl ether (MTBE), benzene, toluene and xylenes) were also detected in eight wells. All of these compounds were detected at concentrations below applicable Reportable Concentrations for groundwater (RCGW-1), with the exception of MTBE in one well. MTBE was detected in MW-202M at a concentration of 120 µg/L, which exceeds RCGW-1 of 70 µg/L. This condition constitutes a 120-day reporting requirement under the MCP. Raytheon will submit a RNF for this condition within the required timeframe.

ERM collected groundwater samples from four well clusters (MW-33, MW-43, MW-45 and MW-47) in the southern portion of the Site for analysis of a variety of analytical parameters noted in Section 2.2.1. Analysis of these parameters was incorporated into the work plan, in response to public concerns. Groundwater analytical results for these miscellaneous parameters are presented in Table 7. None of these analytes were detected in groundwater at concentrations above applicable RCGW-1.

Eastern Area

A release of CVOCs to groundwater from a former dry well DW-05 was noted in the Phase II report (ERM, 2001a). As part of the Phase II investigation, shallow and intermediate overburden wells (MW-40 and MW-40S, respectively) were installed to evaluate groundwater quality. The CVOCs PCE and TCE were historically detected in both MW-40 and MW-40S at concentrations ranging from below the laboratory method detection limit (i.e., ND) to 3.3 µg/L and from below the laboratory method detection limit to 16 µg/L, respectively. Therefore, only TCE has been detected in this portion of the Site at concentrations above MMCLs.

Shallow groundwater in this portion of the Site flows generally to the south-southeast. A shallow overburden monitoring well (MW-39) was installed and sampled as part of the Phase II investigation, but was destroyed during facility renovation activities. Groundwater analytical results from this well (May and November 1998) indicated that no VOCs were detected above laboratory method detection limits (ERM, 2001a).

Two monitoring well triplets (MW-215S/M/D and MW-216S/M/D), consisting of shallow, intermediate and deep overburden wells, were installed south-southeast of the MW-40/40S couplet to further evaluate the extent of CVOC impacts to groundwater in this area. No VOCs were detected in the shallow overburden wells. The following VOCs were detected in the intermediate and deep overburden wells at concentrations below applicable RCGW-1 and MMCLs: PCE, TCE, chloroform, bromodichloromethane and acetone. Therefore, the lateral and vertical extent of TCE impacts to groundwater in the eastern portion of the Site appears to be defined.

ERM collected one soil sample for laboratory analysis of VOCs from MW-216S. No VOCs were detected in this sample. Soil sampling analytical results are summarized in Table 6.

Western Area

Findings of the Phase II report (ERM, 2001a) indicated that wetland soil/sediment is impacted by PAHs, PCBs and metals associated with historic releases to the stormwater and sanitary conveyance system and discharge at outfall OF-1 (Figure 2). In response to public comments, Raytheon agreed to conduct the following additional investigation activities to further characterize the source, nature and extent of OHM impact in the wetland:

- Evaluation of the uplands embankment as a potential source of release due to alleged historical filling activities.
- Evaluation of soil quality at depth and install monitoring wells to evaluate potential impacts to groundwater beneath the wetland.
- Evaluation other potential chemical constituents that were historically used at the Site.

ERM conducted a soil boring and analysis program in the uplands area parallel to the edge of the wetland. Initially 12 soil samples from these borings were analyzed for VOCs, PAHs, and 13 priority pollutant (PP13) metals. Arsenic was detected in the soil sample from B-312 at a concentration of 36 milligrams per kilogram (mg/kg), which exceeds the applicable RCS-1 of 30 mg/kg. This sample was collected in close proximity to a former outdoor exercise station constructed of pressure treated lumber. Given that pressure treated lumber is historically known to contain arsenic and has been demonstrated to affect local soil quality, ERM advanced three additional soil borings around B-312 and collected three additional soil samples to evaluate the spatial extent of arsenic in soil. Soil samples from the three addition soil borings (B-316 through B-318) were below applicable RCS-1, suggesting that the arsenic in soil detected at B-312 was localized and may be associated with the pressure treated lumber. Based on the data collected to date, it is ERM's opinion that arsenic in soil does not constitute a reportable condition, pursuant to 310 CMR 40.0317(14). All other analytes were either below laboratory method detection limits or were detected at concentrations below applicable RCS-1. One monitoring well (MW-307) was installed in the uplands to evaluate groundwater quality. No VOCs were detected above laboratory method detection limits in groundwater from this well.

To evaluate soil quality at depth and groundwater quality beneath the wetland, ERM installed three well couplets consisting of shallow and intermediate overburden wells (MW-313S/D through MW-315S/D). Soil samples were collected from a depth of five to seven feet bgs during installation of the shallow monitoring wells and analyzed for VOCs, PAHs, PCBs and PP13 metals. PCBs and PAHs were not detected above method detection limits. PP-13 metals and VOCs were detected below applicable RCGW-1.

Groundwater samples were collected from the three wetland well couplets and one upland well for analyses of VOCs, PAHs, PCBs and PP13 metals. Volatile organic compounds (VOCs), PCBs and PAHs were not detected above method detection limits. Zinc was detected in groundwater from two wells at concentrations below the applicable RCGW-1.

Arsenic was detected in groundwater from all seven wells at concentrations ranging from 28 μg/L to 158 μg/L. Arsenic was detected in five groundwater samples at concentrations above the applicable RCGW-1 of 50 μg/L. Arsenic has not been previously detected in groundwater at the Site.

ERM reviewed recent and historical arsenic concentrations for soil samples collected from across the entire Site. A total of 52 soil samples have been analyzed for arsenic and 43 contained arsenic at concentrations above the laboratory method detection limit, with detected concentrations ranging from 2.7 mg/kg to 36 mg/kg. A total of 179 sediment samples have been analyzed for arsenic. Of these, 126 samples contained arsenic at concentrations above the laboratory method detection limit, with concentrations ranging from 1.8 mg/kg to 160 mg/kg.

Arsenic mobility in groundwater is dependent on oxidation-reduction conditions (i.e., arsenic is mobile in groundwater under reducing conditions and immobile under oxidizing conditions). In general groundwater samples collected from the wetland and the adjacent upland wells are reducing, based on generally negative ORP values. However, because arsenic was detected in groundwater at a concentration above the applicable Reportable Concentration (RCGW-1), this condition constitutes a 120-day reporting requirement under the MCP. Raytheon will submit a RNF for this condition within the required timeframe.

ERM collected sediment samples from six locations in the wetland for analysis of parameters listed in Section 2.2.1, in response to public comments. Sediment analytical results were compared to EPA sediment screening criteria (Table 8). The following analytes were not detected above laboratory method detection limits: alcohols, glycols, boron, TCLP metals, TCLP SVOCs, TCLP pesticides, TCLP herbicides and TCLP VOCs. None of the detected compounds were detected above sediment screening criteria.

To date, ERM has not received analytical data for dioxin and dibenzofuran analyses as these analyses generally take a several months. In addition, two composite samples were collected and submitted for laboratory analysis of disposal characterization parameters presented in Section 2.2.1.

2.4 CONCEPTUAL SITE MODEL

Based on data collected to date, ERM has developed conceptual site models for impacts to groundwater and wetland sediments at the Site. Two distinct conceptual models have been developed for environmental impacts at the Site: one for the southern area and one for wetland sediments.

2.4.1 Groundwater – Southern Area

Source areas in the southern portion of the Site include:

- manhole W-4 in the courtyard (vicinity of MW-43S); and
- a former hazardous waste storage area that was located near the southwest corner of the facility (vicinity of MW-33 well cluster).

As discussed in the Phase II report (ERM, 2001a), manhole W-4 was cleaned and sealed during building decommissioning activities. Therefore, the suspected source of release in this area no longer exists. The former hazardous waste storage area has not been active since 1996. Therefore, the suspected source of release in this area no longer exists. The geologic sequence beneath both of these source areas is similar and consists of the following geologic units (from top to bottom):

- Moderate conductivity, partially saturated, sand unit;
- Low permeability, saturated, silt unit; and
- Moderate conductivity, saturated sand unit.

Following the initial release, TCE migrated downward through the sand unit and likely collected at the top of the upper, low conductivity, silt unit (i.e., an aquitard). Over time, the TCE migrated into the silt unit via gravity flow and/or flushing by recharge events. Due to the presence of some clay minerals in this unit, TCE sorbed onto the clay minerals resulting in a residual source that continues to exist within the silt unit. In general, CVOCs have not been detected beneath the silt unit near the building, suggesting that the silt unit is either semi-confining (i.e., an aquitard) or has an adequate sorption capacity to prevent downward vertical migration of CVOCs.

In the area immediately around the building, CVOC migration appears to be limited to the upper sand unit above the silt unit. Though downward vertical hydraulic gradients exist in this portion of the Site, CVOCs have not been detected at significant levels beneath the silt unit. Therefore, the silt unit appears to be restricting downward migration of CVOC-impacted groundwater. However, west of the building beneath the parking lot, it appears that the silt unit thins, coarsens, pinches out or separates, allowing downward vertical migration of CVOC-impacted groundwater into the lower sand unit. Beneath the parking lot, CVOCs have been detected both above and below the silt unit, with higher concentrations typically detected in the upper sand unit. Vertical hydraulic gradients shift from generally downward to generally upward beneath the parking lot. This is likely due to the influence of the Sudbury River, which is a regional discharge boundary. CVOC concentrations steadily decrease along the flow path beneath the parking lot via natural attenuation processes (i.e., dispersion, diffusion, dilution and some degradation) and achieve non-detectable levels prior to reaching the Sudbury River.

2.4.2 *Wetland Sediments*

Historical data suggest that inadvertent releases of PCBs, PAHs and metals may have occurred via the stormwater and sanitary conveyance system resulting in a discharge to the wetland at outfall OF-1. The organic contaminants were deposited in the wetland sediments near the outfall, and were immobilized as a result of high organic content in the sediment. The metals are more widely dispersed within the wetland, and the highest levels are detected near the outfall.

2.5 *RELEVANT CONTACTS*

The following table provides contact information for Site owners and those persons who will operate and/or maintain the selected remedial action alternative(s) during and following construction.

Name	*Role*	*Contact Information*
John Drobinkski	LSP-of Record	ERM 399 Boylston St., 6th Fl Boston, MA 02116
Ronald Slager	Raytheon Representative Restoration Program Manager	Raytheon Company 1001 Boston Post Road MW-1-2-1567 Marlborough, MA 01752
Paula Phillips	Wayland Business Center Representative	Wayland Business Center LLC c/o Congress Group Ventures One Memorial Drive Cambridge, MA 02142
Devens Hamlen	Property Owner	Devens Hamlin 87 Old Conn Path Wayland, MA 01778

3.0 DESIGN BASIS

3.1 IMPACTED AREAS

3.1.1 Wetland Sediment/Soil

Wetland soil/sediment is impacted by PAHs, PCBs and metals (chromium and copper) presumably associated with historic and inadvertent releases to the stormwater conveyance system and discharge at outfall OF-1. Evaluation of the average concentrations of primary constituents of concern (COCs) versus distance from the outfall indicates concentrations are highest within 50 feet of the outfall, and then flatten to approach background level at 400 feet from the outfall, or 325 feet from the Sudbury River (Figures 8 and 9). The distribution between organic analytes (PAHs, PCBs and extractable petroleum hydrocarbons (EPH)) is somewhat similar. The distributions of inorganic analytes (chromium and copper) appear to extend over a larger area than the organic analytes, suggesting the higher mobility of metals in the wetland environment. The highest concentrations of chromium and copper extend approximately 300 feet from the outfall (to Transect 10), revealing a fairly even distribution. The vertical extent of impact appears to be largely limited to the top 18 inches of sediment, confined by an underlying continuous silt/clay unit beneath the wetland.

Stunted vegetation (mainly cattail growth) attributable to Site OHM has been mapped within an approximately 0.6 acre portion of the wetland adjacent to OF-1 (Figure 10). Under the MCP, this condition constitutes a condition of "readily apparent harm", which requires abatement.

Quantitative evaluation of the potential risk posed by OHM in wetland soil/sediment similarly indicate that PCBs, PAHs and metals in wetland soil/sediment pose a condition of "significant risk" to human health and the environment, requiring abatement. The condition of "significant risk" is attributed to the 0.6-acre area of "readily apparent harm" (ARAH) and an estimated 0.9 acres of adjacent wetland where OHM concentrations are similar to those within the ARAH. Therefore, to achieve a condition of "no significant risk" consistent with MCP performance standards for a Permanent Solution, abatement of an estimated 1.5 acres of wetland soil/sediment designated as the Expanded ARAH (Figure 11) will be required.

3.1.2 Groundwater

Groundwater is impacted primarily by TCE and associated degradation products, likely to be associated with suspected historic and inadvertent release(s) of chlorinated solvents. Recent Site investigation activities identified high concentrations of TCE in groundwater in the northern portion of the Site (Figure 6). To facilitate assessment activities in the northern portion of the Site and to allow for continued response actions (i.e., clean up) in the remainder of the Site, Raytheon will submit an RNF for the northern area.

Five chlorinated VOCs have been detected in Site groundwater at concentrations above RCGW-1: PCE, TCE, c1,2-DCE, 1,1-dichloroethene (1,1-DCE) and VC. TCE concentrations for the most recent monitoring rounds are shown in plan view (Figure 6) and cross-section (Figure 7a, 7b and 7c). A minor plume extends southwest from manhole W-4 and the primary southern plume extends southwest from the MW-102 and west from the former hazardous waste storage area, and generally appears to be limited to depths of approximately 80 feet bgs by underlying till and bedrock deposits. There is no apparent VOC plume associated with the DW-05 release, only localized impact to groundwater.

VOCs in groundwater pose a condition of “significant risk” to human health because the Site is located within a DEP-approved Zone II Aquifer Protection Zone where groundwater quality must meet MMCLs for drinking water. It is important to note that groundwater screening data from the northern portion of the Site have not been incorporated into the risk assessment. Raytheon is committed to conducting additional Site assessment activities in the northern portion of the Site, which will include a re-evaluation of risks posed by the Site to human health, public safety and the environment.

This condition is based on the potential for future exposure by hypothetical receptors (i.e., assumes that drinking water wells are located within the Site boundary, and that groundwater from within the area of impact is withdrawn for consumption). Under current land use conditions, risks to human health are considered negligible since the area of impact is remote from Baldwin Pond wellfield so that there is currently no complete exposure pathway to impacted groundwater (i.e., groundwater within the zone of impact is not currently utilized as a source of drinking water).

3.2 REMEDIAL GOALS

3.2.1 Wetland Sediment/Soil

Results of the human health and environmental risk characterizations presented in the Phase II (ERM, 2001a) indicate that PAHs, PCBs and metals in wetland soil/sediment pose a condition of "significant risk" of harm to human health and the environment. Target cleanup goals for wetland soil/sediment represent residual OHM concentrations in soil/sediment that would remain following abatement of those areas that pose a condition of "significant risk." Target cleanup goals were developed by first determining a "risk-based" goal; the average residual OHM concentration in soil/sediment remaining following abatement of those areas and volumes of wetland soil/sediment that pose a condition of "significant risk." The risk-based goals, which included areas and volumes of wetland soil/sediment, were then evaluated. The evaluation was based on consideration of applicable state and federal regulations governing wetland remediation, applicable state and federal regulations governing the management of remediation wastes and consideration of the feasibility of abatement to background. Proposed target cleanup goals and corresponding areas and volumes of wetland soil/sediment targeted for abatement were selected to maximize the reduction in risk necessary to meet MCP performance standards for achievement of a Permanent Solution and to minimize temporary destruction of wetland habitat and to reduce the loss of functional values.

Remedial action objectives for wetland soil/sediment were developed to satisfy the following criteria:

- Achieve a condition of "no significant risk" to human health (a Hazard Index (HI) < 1.0, Excess Lifetime Cancer Risk (ELCR) $< 1E-05$).
- Achieve a condition of "no significant risk" to the environment (a Hazard Quotient (HQ) < 1.0).
- Achieve or approach background levels where feasible.
- Comply with applicable local, state and federal regulations.
- Maximize the benefit of remedial response actions to the environment.

Analysis of remedial scenarios for target areas suggests that abatement of the ARAH, and adjacent and isolated locations where OHM concentrations are highest, would best meet the above objectives (hashed area on Figure 11). These locations include:

- Transect 7, locations T-7-A, 1, 2, 3, 4, 5;
- Transect 8, locations T-8-11; and

- Transect 10, locations 2, 3, 4 and GMS-9.

Proposed remedial action objectives for wetland soil/sediment are summarized in the following table and represent the arithmetic average concentrations of selected residual OHM following remediation.

Proposed Target Cleanup Goals for Wetland Soil/Sediment

Compound	***Cleanup Goal*** ***Arithmetic Average Concentration (ppm)***
Total PCBs	2.0
Total PAHs	9.0
Arsenic	11
Chromium (trivalent)	332
Copper	372
Lead	210
Silver	13

Note: The arithmetic mean concentrations listed above reflect combined wetland soil and sediment data.

3.2.2 Groundwater

Since the Site is located within a potential current drinking water source area (a Zone II aquifer protection zone for the Baldwin Pond Wellfield), abatement measures must reduce the concentrations of VOCs in groundwater to applicable MMCLs in order to achieve a Permanent Solution. A reduction in VOC concentrations to MMCLs would achieve a condition of "no significant" risk to human health under future conditions (i.e., groundwater is not currently used as a source of drinking water within the defined or projected extent of the plume).

The level and extent of TCE, PCE or VC in groundwater is not anticipated to adversely impact down-gradient surface water quality or potential environmental receptors. A reduction in the concentrations of VOCs to MMCLs would meet Response Action Performance Standards (RAPS, 310 CMR 40.0191) for achievement of a condition of "no significant risk." Therefore, MMCLs are adopted as initial target cleanup goals for VOCs in groundwater. The extent of TCE impact in groundwater is shown in Figure 6.

To achieve a Permanent Solution, RAPS also require consideration of abatement to background levels, if feasible. Department guidance indicates that "achievement" of background is considered "generically infeasible" for chlorinated hydrocarbons in groundwater, but indicates that a reduction in contaminant concentrations should "approach" background levels (i.e., one half the applicable cleanup standard), if feasible. Therefore, as a secondary target cleanup goal, abatement of TCE, PCE and VC in groundwater will attempt to "approach" background levels, if feasible. The feasibility of abatement of VOCs in groundwater to these levels, will be based on the success of remedial measures at reducing VOC concentrations in groundwater to MMCLs.

4.0 *CONCEPTUAL DESIGN – WETLAND REMEDIATION*

4.1 *OVERVIEW*

The excavation of the targeted remedial area will be conducted as a Limited Project in accordance with the Wetland Protection Act (310 CMR 10.53 (8) (9). Remedial activities will require the excavation of an estimated 3,700 yd^3 of wetland soil/sediment material from the floodplain wetland (See Figure 11). The surface area that will be directly disturbed encompasses approximately 1.5-acres down to an average depth of 1.5 feet bgs. Remedial activities will cause a temporary loss of habitat in this area. Construction activities could cause temporary indirect impacts. These issues are addressed in the remedial design to minimize indirect impacts and restore the areas of direct impacts.

Another component of the remedy design is the habitat restoration plan, which is the on-Site, in-kind replacement of the excavated targeted remedial area. This is a three-phase process involving:

1) re-soiling and grading to pre-construction contours,

2) replanting with similar species, and

3) ecological monitoring.

Monitoring will serve to ensure the process is completed as designed and performance standards are met.

4.2 *DESIGN AND CONSTRUCTION*

4.2.1 *Pre-Construction Activities*

Prior to remedial activities, piezometers will be strategically installed in the spring in the wetland area to collect baseflow data. This data will provide information for replication design activities, including re-soiling topography and composition. Piezometers will also detail the quantity of groundwater infiltration to the surface soils. The estimation of groundwater infiltration will indicate the amount of dewatering activities in the excavation area that may be necessary.

The wastewater/stormwater outfall, OF-1, must be redirected during remedial activities. OF-1 typically discharges to the drainage swale in the wetland. At the time of year construction is targeted, the drainage swale is not hydraulically connected to the Sudbury River, therefore discharged waters pool in the wetland. To prevent this from occurring within the remedial area, the drainage swale will be re-directed with temporary piping to discharge beyond the targeted remedial area and flood control measures. Appropriate approvals for temporarily relocating the discharge will be required from the Town of Wayland, DEP, and EPA NPDES program.

4.2.2 *Excavation and Staging*

Excavation and removal of impacted wetland soil/sediment material will occur in the least environmentally damaging manner. The excavation process within the targeted remedial area has the potential to create temporary indirect impacts, including:

- a reduction in flood control capacity;
- increased erosion;
- vegetation and soil disturbance from flood protection measures;
- disturbance associated with deployment of necessary flood control measures outside the limits of the remedial area;
- disturbance associated with the placement of construction staging areas and access ways;
- the generation of remediation wastewater in the management of soil/sediment remediation wastes;
- disturbance to wildlife.

Construction planning and following specific state and federal Best Management Practices (BMPs) will aim to eliminate and/or minimize the potential for most of these impacts.

Access Roads

The construction road will be temporary, and will be comprised of a pre-fabricated series of interlocking platforms (Appendix G), construction mats, or improved corduroy that rests on the ground surface. The access road will be placed within the area to be excavated in a pattern that allows access to the entire area (Figure 12). The objective is to minimize the need to import and remove fill material, increase construction efficiency and minimize compaction of the remaining soil layers. This type of system eliminates the need for filling and removing a raised roadbed; platforms can be moved to access the various portions of the remedial area, providing flexibility in access. The access road will be the shortest distance from the remedial waste staging area into the remedial area. The road will be the minimum width necessary for the designated construction equipment to ingress and egress the area.

Existing roadways and paths will be utilized as access roads in the upland to the staging areas. Minimal clearing and grubbing will be required to establish the roadways. Any disturbed vegetation will be re-established during restoration activities. A fence is currently located between the wetland and the developed portion of the Site. A portion of this fence may be temporarily removed to enable heavy equipment access to the wetland. The platforms or another mat-type surface will be used in loading and unloading areas to provide temporary cover and containment of remediation wastes during transfer operations.

Flood Protection

The purpose of these flood prevention measures is to establish contingencies in the event a storm event raises the river level; it is not to attenuate a consistently high river level that may be approaching flood stage. Proper timing of the construction activities is important in minimizing the potential for flooding from the Sudbury River into the remediation area. Flooding during the excavation or re-grading processes would delay the remediation and could cause erosion and mobilization of remedial waste. Floodwaters could destroy the access road and cause the sides of the remedial area to slump inward, creating significant areas of turbid waters. ERM will conduct the excavation process during the season with the lowest local water table.

Flood prevention measures will be utilized within the construction area to prevent a significant potential source of erosion and to prevent construction delays.

Traditional flood protection methods such as earthen berms will be avoided, as they would require extensive construction to build and dismantle, creating additional adverse environmental impacts. A portable dam system (Appendix G) will be erected to fully surround the waterward portion of the remedial area. The temporary dam will be of sufficient height to prevent floodwaters from overtopping the structure, based on historic gauging data (greater than 3.5 feet). The wetland floods at a river flow greater than 254 cubic feet per minute (cfm). These flood-prevention measures will be implemented on the river side of the access road to the remedial area. A traction backhoe may be suitable for this construction; otherwise, a temporary construction road will be needed to access the area for placement of the flood prevention device. Some minor temporary impact to vegetation and soil compaction will result, but should be quickly abated by natural processes.

Erosion Control

Erosion control practices will be implemented to minimize the potential for sediment to enter the Sudbury River. Standard erosion control methods using a staked silt fence and hay bales will be deployed to protect against runoff into the adjacent floodplain wetland (Figure 13). Erosion control measures will be placed along the perimeter of the targeted remedial areas. Siltation or erosion should not be a significant factor in the remedial area, since the excavated area will slope landward toward the upland. Erosion control measures will also be placed along the landward edge of the wetland especially along the staging areas. Erosion control within the remedial area will not be required around temporary construction roads using prefabricated panels.

Dewatering

Groundwater and precipitation entering the excavation will require de-watering including pumping, collection and discharge. Suspended solids will be removed by directing withdrawn water to a settling tank. Sediments and water will be analyzed prior to off-Site disposal, reuse and/or discharge. Water treatment may include OHM removal via activated carbon or other appropriate technologies. The discharge will be dissipated by either spraying or pumping across a low-flow weir or spreader swale to the wetland, but downstream of the remedial area.

Excavation

The excavation plan will guide the sequential removal of the impacted areas. Removal of wetland soil and sediment will begin at the western boundary of the remedial area and work back toward the bank and staging areas in each quadrant (Figure 14). For example, quadrants BC and BD will be excavated prior to quadrants CA and AD. Excavation will be consistent with verification sampling sequence outlined in Section 4.3.2.

Wide-base track mounted machinery will be utilized for removal of impacted wetland soil/sediment. Heavy equipment such as excavators, front-end loaders and bulldozers will access the remedial area via temporary roadways described above. Based on the delineation of the impacts to wetland soil/sediment, it is anticipated that approximately 1.5 acres will be removed to an average depth of eighteen inches (See Figure

15a, 15b, and 15c), although removal will be guided by Site-specific field observations regarding the distribution of OHM and underlying deposits. The process will avoid the removal of underlying clays or minimize such removal to the extent necessary, in order to meet remedial action objectives. Removal is estimated to generate approximately 3,700 yd^3 of remediation waste. Small dump trucks will be loaded on these roadways and transport impacted material to the staging area.

Four locations in the area of Transect Ten (T-10-2, T-10-3, T-10-4 and GMS-9) will require hand removal (Figure 11). This area is removed from the primary remediation area by approximately 125 feet. Utilizing heavy equipment to remove this estimated 2,000-ft2 area would disturb approximately five times such an area, in order to access it. Therefore, hand removal will be accomplished using stainless steel hand shovels and soil/sediments transported via wheel barrels. Abatement of this area is estimated to require removal of approximately 100 yd^3 of soil/sediment. A small boarded footpath will be utilized to access this area. Manual removal will also be utilized to manage other impacted areas that may exist as "fingers" from the primary remedial area determined to require removal during the closure/excavation process.

Staging

The staging area for management of remedial waste will be located outside the Buffer Zone in the upland area; 100 feet landward of the wetland edge to meet state and local Buffer Zone setbacks (See Figure 12). The remedial waste staging area will consists of three areas A, B and C. Each area will be approximately 75 feet by 150-feet. Concrete jersey barriers will be placed around the perimeter of each area and lined with a heavy-duty poly-liner. A minimum of one water collection trench will be excavated in each area, which will collect water runoff from the contaminated soil.

Water will be collected in a sump, and pumped to a settling tank. Water samples will be collected and analyzed for the following constituents of concern:

- PCB extraction by EPA Method 608 and/or analysis by EPA Method 8082
- PAH analysis by EPA Method 8270C
- RCRA metals by EPA Method 6010B/7470A

If additional treatment, such as carbon adsorption, is deemed necessary, a system will be implemented. Collected (and treated, if necessary) water will be discharged to the wetland under a National Pollution Discharge

Elimination System (NPDES) exclusion permit, if it meets appropriate discharge criteria. If water treated on-Site cannot meet discharge criteria, it will be contained and shipped off-Site for disposal. Workers in this area will be required to follow the Site-specific Health and Safety Plan (Appendix H).

A "clean" staging area will be established outside the target remedial area. Clean soil for the restoration and wetland plants will be placed in the clean staging area immediately prior to completion of excavation to avoid a delay in final restoration activities. Excavation and re-soiling (filling) of the remedial area will be sequenced as to minimize impacts and avoid cross-contamination. Excavation will begin at the perimeter of the remedial area and work landward toward the upland. New soil will be placed at approximate final grade (Figure 15b) as soon as excavation is completed and confirmatory samples are determined to meet cleanup objectives. Fill work will begin in the same sequence, beginning at the perimeter of the excavation and working landward.

Cleaning and Decontamination of Equipment and Sampling Equipment

Any non-dedicated manual sampling equipment used to collect soil samples will be cleaned and decontaminated prior to its initial use, between each sampling location and after the final use. Samples collected using the mechanical coring device will be collected in dedicated new PVC liner tubes. The following general procedures will be followed concerning decontamination efforts:

1) If visual signs (i.e., discoloration) suggest that decontamination was insufficient, the equipment will again be decontaminated. If the situation persists, the equipment will be taken out of service until the situation can be corrected.

2) Verification of the non-dedicated sampling equipment cleaning procedures will be documented by the collection of field blanks (equipment rinsate).

3) All properly decontaminated equipment will be stored in aluminum foil and plastic bags during storage and transport.

The following step-by-step decontamination procedures will be followed for all non-dedicated sampling tools and for the appropriate set of analytes:

PCBs/PAH Only	*PCBs/PAH and Metals*	*Metals Only*
1. Non-phosphate detergent wash	1. Non-phosphate detergent wash	1. Non-phosphate detergent wash
2. Tap water rinse	2. Tap water rinse	2. Tap water rinse
3. Methanol rinse	3. Methanol rinse	3. 0.1 N NHO_3 Rinse
4. Triple deionized/distilled water rinse	4.Triple deionized/distilled water rinse	4. Triple deionized/distilled water rinse
5. Air dry	5. 0.1 N NHO_3 rinse	5. Air dry
	6. Triple deionized/distilled water rinse	
	7. Air dry	

Heavy equipment will be decontaminated outside the remedial zone, in a designated upland location. Heavy equipment will be parked on a decontamination pad, which will collect liquids generated during cleaning, and steamed clean. Liquids generated during any decontamination process will be collected, contained and appropriately labeled for disposal or discharged via the NPDES exclusion permit discharge. Waste liquids will be stored on-Site until potential hazard class and final disposition have been determined.

Decontamination protocols will be strictly adhered to in order to minimize the potential for cross-contamination between sampling locations and contamination of off-Site areas. More specific decontamination procedures are addressed in the Health & Safety Plan (Appendix H)

4.2.3 *Management of Remedial Waste*

Removal/Dewatering/Stockpiling

Impacted soil will be excavated using a track-mounted excavator and transported to temporary staging areas via temporary roadways. Excavated wetland soils will be segregated into stockpiles in the staging area. Each staging area will have a capacity to hold 2,000 cubic yards of material, as described in Section 4.2.2. Stockpiled material may be placed staging area in layers approximately six to twelve inches thick to aid dewatering of the saturated wetland soil/sediment. All stockpiles will be covered and secured when not in use. All remedial wastewater will be collected and treated as described in Section 4.2.2

If passive dewatering is not sufficient, a method of active dewatering such as mechanical dewatering or on-Site stabilization of the remedial waste may be required so that the material is deemed suitable for shipment.

Characterization for Disposal

Stockpiled wetland soil will be sampled to confirm disposal options and to satisfy requirements of the disposal facility. A composite sample will be collected for every 250 - 500 yd^3 of material to be contained for off-Site disposal, depending on the disposal facilities requirements. Stockpiled material may remain on-Site and covered, for no longer than thirty days.

Stockpiled material will be sampled for the following constituents. This list may change to meet the requirements of the selected disposal facility:

- PCBs extraction by EPA Method 3500B/3540C or 3500B/3550B and analysis by EPA Method 8082.
- PAHs analysis by EPA Method 8270.
- Resource Conservation and Recovery Act (RCRA) metals by EPA Method 6010 and 7000, if appropriate.

Upon receipt of characterization data, stockpiled material will be released for shipment if it meets the anticipated contaminant levels for characterization. Preliminary TCLP data indicate that the sediment is not a RCRA material. However, if additional characterization data indicates that the stockpiled material does not meet pre-determined categories (Toxic Substance Control Act (TSCA)& RCRA, Non-RCRA, TSCA), it will be either re-classified as appropriate or resorted to other stockpiled areas.

Transportation and Disposal

Stockpiled material will be shipped to the designated disposal facility via truck or rail. When segregated material has been released from the staging area, it will be loaded into dump trailers or roll-offs utilizing front-end loaders and other earth moving equipment. Trucks will transport this material to the destination facility or to a rail facility. If the material is transported via rail, the excavated soil will be transferred to rail containers at the rail facility prior to shipment. Raytheon will coordinate with the Town of Wayland to develop an appropriate traffic management plan for these transportation activities.

Hazardous material shipped from the Site will be properly manifested or shipped under a bill of lading if the material is non-hazardous. A log will be maintained to track all shipments that leave the Site. The following information will be tracked:

- Container ID, date, and time container left Site
- Hauler
- Approximate volume
- Weight (when measured)
- Waste classification
- Manifest number
- Date of receipt of Manifest copy

Excavated material will be disposed of at a disposal or recycling facility approved by Raytheon. Any disposal facility selected must be properly permitted to handle RCRA, TSCA or combination hazardous waste streams. Non-hazardous waste will be disposed of or recycled at an appropriately permitted facility.

Any treated remediation wastewater that does not meet discharge requirements will be contained and shipped off-Site for treatment and disposal.

4.2.4 Wetland Restoration

Introduction

This section documents the restoration plan for the remedial area. The remedial area shall be substantially restored to preexisting hydrology and topography. In addition, indirect impacts may occur to adjacent wetland and upland areas, during construction, for which restoration will be needed. This restoration plan outlines activities necessary to comply with the requirements of the Massachusetts Wetlands Protection Act (WPA) as administered by the Wayland Conservation Commission (WCC) and the DEP.

Areas requiring initial restoration fall into three categories: the remedial area, temporary impacts within the access road and staging areas, and temporary impacts from flood protection, erosion control, and de-watering. Similarly, the restoration plan describes initial activities corresponding to three categories: complete restoration including re-soiling and re-vegetating, minor re-grading and re-vegetating, and re-vegetating. Each of these activities is described in detail below.

The proximity of the restoration area to the remaining deep emergent marsh will greatly improve the likelihood of success of re-establishing the wetland. Proximity of the created wetland to a natural wetland has an effect on the development of the plant community. Created wetlands closer to established wetlands had higher levels of native species and diversity (Reinartz and Warne 1993). The use of a mulch topsoil can be effective for creating a freshwater marsh and is generally more effective than simply using overburden or topsoil that does not have wetland plant seeds (Erwin and Best 1985, Shuey and Swanson 1979).

Data from similar restoration projects suggests that invertebrate populations can become established in as little as four months, regardless of the hydrologic connection. Fish and amphibians have colonized wetland areas very rapidly when those wetlands were connected to a wetland or watercourse, but reptiles were relatively slow to colonize (Tilton and Dension 1992).

The restoration effort proposes to meet the wetland restoration goals and objectives as outlined by the Society of Wetland Scientists (SWS, 2000). The restoration effort will be integrated with the surrounding and adjacent landscape. The resulting wetland community will be a persistent and resilient ecosystem, but will likely require some future maintenance activities. The restoration effort will provide a wetland community consistent with the historic deep emergent marsh, but improved over the adjacent system that is heavily infested with invasive species.

The restoration area will require re-soiling to pre-excavation grade using an improved soil medium that will encourage the growth of wetland plants. Re-vegetating will include seeding and planting with selected wetland species. Studies of wetland creation projects have documented that the use of commercially produced soils and a wetland seed mix can quickly establish an herbaceous wetland community. Establishing a dense ground cover and using a soil that does not contain root stock or seeds of exotic and invasive species helps prevent the colonization by these species (Jarman et al. 1991). Created wetlands seeded with wetland species had much higher diversity and native species richness than unseeded sites. Cattails (Typha spp.) dominated in the unseeded sites and were approaching monocultures in those sites. Cattail coverage was less in the seeded sites than in the unseeded sites (Reinartz and Warne 1993).

The access road and staging areas may impact a small portion of wetland adjacent to the remediation area and vegetated upland buffer. Some grading will be needed for the access road to negotiate the steep bluff that extends down to the floodplain from the upland. The remaining portions of the access road can be prefabricated panels, which eliminated the need for fill and re-grading. The staging areas can be re-graded as needed and all of these areas will be re-vegetated by seeding and planting. Floodplain areas could be disturbed by the placement of the temporary dike, a "porta dam" or "aqua dam" (See Section 4.2.2). It is also anticipated that minor impacts could result from the de-watering and stormwater management practices. Both of these impacts are expected to be limited to the loss of vegetation and possible very minor soil disturbance.

All temporary structures and work areas (i.e. access road, staging areas, flood prevention devices) within, or adjacent to, resource areas shall be removed within 30 days of completion of the remedial activities. Re-vegetation will involve the establishment of a deep emergent floodplain community, with an areal coverage of 75% native wetland species within two growing seasons.

Re-Soiling

Re-soiling the remedial area will be completed by filling the excavated area with a loamy topsoil to promote the establishment of herbaceous wetland species. Soils used will be free of invasive species and should provide an acceptable growing medium. The proposed soil specifications (provided in Appendix I) are based on established industry standards and have proven successful for wetland replication. Proposed soil specifications will not mimic the exact extant soil composition for several reasons:

The extant soil is an alluvium of highly variable composition that would probably be difficult, if not impossible, to exactly reproduce. The extant soil has a high organic content that would require extensive compost or use of excavated organic wetland soil to reproduce, again these specifications are probably not reproducible. Furthermore, the wetland plant species endemic to this area can survive in a variety of wetland soil types and hydrologic conditions.

Manufactured soil will meet specifications for high quality compost and soil material. These specifications stipulate that the soil must be free of weed seeds, have at least 12% organic content, be of a relatively balanced pH, be reasonably high in nutrient value, and not contain excessive salts. The 12% organic matter content is a guideline required by the Army Corps of Engineers (ACOE).

If these specifications are met, then the soil should have the appropriate microbial activity, including beneficial bacteria and fungi. The importance of the belowground components of an ecosystem and the success of restoration efforts is discussed in Miller (1985). Restoration efforts have used composted leaf litter for inoculating with mycorrhizal fungi (Baird 1989). Soil microbes, bacteria, fungi, and invertebrates can also be added to manufactured soil through potted plants and bare root seedlings (Baird 1989). The high organic content referenced above should support native species and may even help keep invasive species out. Improving the soil organic matter content, through the addition of soil amendments such as compost, will improve the probability of establishing emergent perennials such as sedges (*Carex* spp.) (van der Valk et al. 1999). Higher organic content of wetland soils used for restoration may favor native species over exotics (Zentner 1997).

Prior to re-soiling, a soil sample will be analyzed by a certified laboratory to determine organic content and the presence of pollutants. Additional organic compost will be added if the soil organic content is below 12%. The soil will be mixed and fully prepared before on-Site delivery. The soil will be spread into the restoration area directly from its manufacturing site.

Approximately 18 inches of manufactured topsoil will be placed loosely over the Site with an excavator to bring it to the finished pre-construction grade. A small bulldozer can be used to level the soil and provide final grading. Shallow ruts and mounds will remain at finished grade to create a varied micro-topography. This technique will help create slightly variable hydrologic conditions that will be conducive to higher flora and fauna diversity and better surface water retention.

Re-vegetation

Each of wetland and upland communities that are included in this restoration plan will involve specific planting and seeding measures following final grading. Table 9a contains a summary of the seeding composition and Table 9b contains the erosion control seeding mixture designed to provide quick coverage using facultative wet and facultative species. The general planting methods described below will be applied in all the restoration areas.

Seeding

Following re-grading and re-soiling, all newly-exposed soils in each mitigation area will be seeded and mulched to provide a quick cover to control erosion of topsoil and to minimize colonization by weedy herbaceous species such as hybrid cattail (*Typha* x *glauca*), common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*). Some of the species may survive and contribute to the final vegetative community, but most will probably provide erosion control and soil stabilization.

Seeding with the native wetland species mix (Table 10) and mulching with weed-free straw will occur immediately following final grading to minimize soil erosion and desiccation.

Wetland species and erosion control seeding mix rates will be approximately 17 pounds per acre. The erosion control mixture will be applied at a rate of 15 pounds per acre. Both will be broadcast onto the restoration area. A layer of annual rye grass will also be applied to the upland buffer restoration areas to prevent erosion on the bank slope.

Planting

The purpose of the re-planting effort is to establish a self-sustaining deep emergent community. The intent is to provide an improvement over the highly infested community that exists in the adjacent areas. The species chosen for planting are all native and indigenous to Massachusetts, and none are considered invasive (Table 10). The species selections are based on their compatibility with the proposed hydrologic and soil conditions, and because they are commonly found in the existing wetland communities of Middlesex County. Many of these species are found in the adjacent deep emergent marsh, but in relatively small quantities. Plants will be of bareroot sizing, except for the small number of buttonbush (*Cephalanthus occidentalis*) and ferns, which will be from one-gallon containers. Plant materials will be obtained from a regional nursery. Compatible, similar species will be chosen as substitutes when planned species are unavailable, subject to prior approval from the WCC and DEP.

Herbaceous plantings will be spaced on one-foot centers, which equates to approximately 63,000 plants. Buttonbush will be installed in a random pattern, to mimic the sparse density found on-Site.

Planting Methods

Individual planting holes will be dug at least two inches larger in all directions than the root ball. Soil will be firmly placed around the root ball, and brought up to the original growing level, which is usually marked by a dark stain on the trunk. The entire hole will be filled in with soil ensuring that no air pockets are left around the root ball. Care will be taken to minimize trampling and excessive soil compaction in the planting areas, to prevent adverse affects on herbaceous plant growth. Fertilizer will not be used for any of the plantings. Shrubs and herbaceous plantings will be watered, as needed, for the first six weeks after planting, depending on the amount of precipitation.

Coarse Woody Debris

Dead and dying woody debris (logs and stumps) will be spread over the mitigation area after final grading, seeding, mulching, and planting have been completed. This coarse woody debris will cover approximately 1% of the ground surface, and will be in various stages of decomposition. Where possible, the material will be salvaged from the upland buffer area, as it is anticipated that some tree removal will be required in that area. These materials will not include plant species considered to be invasive or nuisance. This material will be used to improve Site micro-topography; as habitat structure for invertebrates, reptiles, amphibians, and small mammals, and to act as an additional source of organic material.

Construction Monitoring

A qualified, professional wetland scientist will be on-Site to monitor construction of each phase of the restoration to ensure compliance with this plan. Grading, seeding, planting, and erosion control measures will be monitored to ensure that they are implemented according to the plans and specifications. The limits of construction will be clearly marked with colored survey flagging or erosion control fencing to minimize disturbance to soils and vegetation in the adjacent non-remedial areas.

An as-built plan will be submitted to the WCC and DEP upon completion of the grading, seeding, and planting activities. The plans will show finish grades at the restoration Sites that involve re-soiling and re-grading, including two cross-sectional views of the Sites showing upland/wetland boundaries, and general hydrologic conditions. Actual planting details, if significantly different than proposed, will also be shown on the as-built plans, where applicable.

Invasive and Nuisance Species

Risk of Invasion

Invasive and nuisance species are well established on the Site, being comprised of purple loosestrife, common reed, and reed canary grass. Newly established soil and any re-graded areas represent areas of high potential for invasion by these species. These species are also present on the adjacent floodplain areas; therefore infestation of the restoration areas is likely. Control of these species should focus on prevention, early maintenance, and long-term maintenance. Prevention involves using a clean weed free soil and seeding mix, cleaning vehicles that enter the restoration areas, establishing a clean staging area, and preventing any soil from the adjacent areas from entering the restoration area. The best preventative measure is the establishment of a dense, vegetative community of native species. Short-term control, for a five-year period, would involve the regular inspections of the restoration areas for the presence of these species and selective herbicide treatment. Manual removal may be a short-term option when invasive plant numbers are very small, but can have negative results if the full root or rhizome system is not removed for cattails and purple loosestrife. Long-term approaches could involve coordinating eradication and control efforts with the Great Meadows National Wildlife Refugee (GMNWR). A long-term control effort is needed, since the probability of these species becoming established is high. Seed mixes proposed for use in the restoration areas will be free of invasive species. Imported soil will be specified to be free of the plants, roots, or rhizomes of purple loosestrife, common reed, and reed canary grass.

Invasive Species Control Plan

The restoration areas will be monitored annually during the early to mid growing season for signs of invasive species. Annual monitoring and invasive species control will be completed for a five-year period. If any invasive species are identified during monitoring activities, a Site-specific plan for each species will be developed and implemented with the goal of eliminating the plants or minimizing their spread. Exotic and nuisance species control should involve the use of selective herbicide treatments in the wetland area. The herbicide Rodeo can be safely and effectively used to control these invasive species. The special conditions of the permits for the remediation and restoration should allow for the use of this herbicide under specified conditions. Removal of flowering or seed heads of cattails and purple loosestrife will precede the herbicide application. Herbicide will be applied after spring floodwaters have receded and the restored wetland is not inundated. Herbicide will be applied selectively only to those plants targeted for control. Selective application includes spraying from a low-pressure applicator, brushing, and wicking. Herbicide will not be broadcast onto any areas. Biological control may be a long-term maintenance option, especially if coordinated with the GMNWR and WCC. Should biological control be implemented to control purple loosestrife then additional permitting will be required, as this method is generally available only to government agencies. Notification to the WCC will also be completed prior to any exotic and nuisance species removal. Any herbicide applications will be made by a licensed applicator.

4.3 OPERATION PARAMETERS

4.3.1 Verification Sampling

Sampling Objectives

The proposed sampling plan will focus on satisfying TSCA requirements in accordance with 40 CFR 761 Subpart O, for verification sampling that is necessary to confirm whether or not remedial goals have been achieved. Closure sampling data will be statistically analyzed and compared to Site clean up goals (See Section 3.1.1). Additional sampling of the excavation bottom and sidewalls will be conducted to guide excavation activities and will be integrated as appropriate to meet TSCA requirements for verification sampling.

Sample Locations, Depths and Frequency

A square sampling grid will be established over the remedial area. Each cell within the grid will be a twenty-foot square. Four quadrants will be established over the grid (AC, BC, BD, and AD) (see Figure 14). Within each quadrant, ERM will collect and analyze wetland soil/sediment to evaluate if clean-up goals have been met. The sampling strategy is to collect representative samples from each quadrant via the grid-sampling plan.

Wetland soil/sediment samples will be collected in each grid cell at a depth of 7.5 cm. Within each grid cell, nine grab samples will be taken and composited into one sample for laboratory analysis (see Figure 14). Specific sampling and composite procedures are described below.

Sampling Procedures

Wetland soil/sediment samples will be collected manually utilizing a stainless steel hand auger that has a diameter greater than two cm and less than three cm or a small hand shovel if wetland soil/sediments are too difficult to collect with the hand auger (i.e. saturated or sandy). Samples from nine locations within each sampling grid will be homogenized into a composite sample in accordance with Standard Operating Procedures (SOPs) in Appendix J.

Verification of Remedial Action Objectives

In general, the following procedures will be taken to assess data received from the laboratory:

1) Assure that all required data packages QA/QC reports have been received.

2) Determine if there are any irregularities with the QA/QC and rectify issues with the laboratory.

3) The usable data set that has been identified will be pooled with historical data to determine remaining levels of OHM of concern at the Site. The historical data was collected in the same manner as the sample SOP in Appendix J, using the same analytical methods for PCBs. The historical data has no known limitations.

4) The usable data will be statistically evaluated to determine representative soil concentrations within grid cells and quadrants as discussed below.

5) The soil concentrations determined using step four will be compared to the target cleanup goals to determine if remedial action objectives have been achieved.

6) If goals are not met then corrective actions will be determined, which may include additional sampling and/or additional soil removal, followed by additional sampling.

Statistical Analysis Procedures for Calculation of Residual Contaminant Concentrations

ERM will combine the results of closure sampling collected during remedy implementation with existing data for surrounding areas not subject to remediation. Where the existing data indicate PCB distributions reflect a high variability, ERM may elect to group quadrants or collect additional closure samples. This may be necessary in order to achieve the statistical degrees of freedom that would result in a workable standard error of the mean (for calculating the upper-confidence limits (UCLs)). The 95% UCL will establish that the target cleanup goals, based on average residual concentrations across the Site, have been achieved.

In those grid cells with more than one sample (i.e. perimeter samples or duplicates), ERM will average the samples to represent the concentration for that grid cell. The statistical analysis will include:

Tests to determine the distribution of the cell estimates (i.e. T-test); if lognormal, then transform;

1. Weighting of each cell estimate by area of cell, if appropriate;
2. Calculation of an area-weighted 95% UCL.

The area weighting would be done using a method such as described in Gilbert (1987), or EPA cleanup guidance based on Gilbert. For statistical purposes, samples with non-detects will be represented by one-half the method detection limit.

The statistical tests will be: H_o: 95% UCL_{metals} < X mg/kg;
H_o: 95% UCL_{PAH} < X mg/kg; and
H_o: 95% UCL_{PCBs} < X mg/kg.

where X represents target cleanup goal value.

4.3.2 *Perimeter Sampling*

Perimeter sampling around the area targeted for remediation will be used to ensure that, after removal of soil and replacement by clean fill, clean up goals are met.

Sampling will be performed at 10 pre-determined locations on the perimeter of the remediation area. Contamination concentrations in the perimeter samples will then be included in the calculation of average residual contaminant concentrations along with existing data from outside the area remediated and data for sample locations within the area remediated.

PCBs

Clean fill soil will be placed into the area remediated. PCB concentrations of the samples in the fill area will be set to a value of ½ the method detection limit for PCBs. As a proxy for this value, the lowest detection limit for the historical samples was used, which equals 0.184 ppm. Based on this approach, sample locations in the area of clean fill were set to 0.092 (1/2 the detection limit) to reflect the replacement of contaminated soil with clean soil.

Two criteria will be used to determine if additional removal of sediments is necessary to meet clean-up goals. First, perimeter sample points in excess of 50 ppm total PCBs will be evaluated for additional action. Such sample points would have been included in the ARAH according to its definition in the ERC. Second, if the average remaining contaminant concentrations exceed the target clean-up goals, further remedial action will be evaluated.

The maximum allowable mean concentration in the 10 perimeter samples such that clean-up goals would be achieved. Using the arithmetic mean of sample points, the 10 perimeter samples must have a mean PCB concentration of less than 20.0 ppm to meet target cleanup goal of an average residual concentration of 2 ppm PCBs.

Metals

A similar analysis was conducted for metals (copper and chromium). To meet clean up goals, the 10 perimeter samples must have average copper concentrations less than 2,824 ppm, and average chromium concentrations less than 2,534 ppm.

4.3.3 Annual Monitoring

Post-construction monitoring is necessary to determine whether wetland restoration efforts have been successful in meeting project and statutory goals and objectives. The monitoring plan will contain: 1) specific performance standards that will be used to evaluate whether the objectives have been met; 2) detailed methods for evaluating those performance standards; and 3) a list of potential deficiencies and corresponding remedial measures to be instituted, if necessary. Monitoring will continue for five years after restoration task completion.

Standards for Success

The restoration will be considered successful if, at the end of two years following seeding and planting, the following four success standards are met:

1) ***Survivorship of Planted Stock:*** The herbaceous plantings have 75% survival and 80% survival of planted buttonbush. The herbaceous plantings are healthy and vigorous and show evidence of propagating. The buttonbush and upland tree plantings are at least 18 inches tall and are vigorous and healthy. Additionally, the following number of non-exotic species, including planted and volunteer species, are found within the mitigation area. Volunteer species should provide functions consistent with the design goals. To count a species, it must be well represented on the Site (e.g., at least 50 individuals of that species per acre).

2) ***Percent Areal Cover:*** The restoration area shall attain at least 75% areal cover of native, noninvasive wetland species, within two growing seasons after seeding and planting. For the purpose of this success standard, invasive hydrophyte species include, but are not limited to: common reed, purple loosestrife, reed canary grass, and cattails.

3) ***Invasive Species Control:*** Common reed, purple loosestrife, reed canary grass, cattails, and any other exotic and nuisance species plants within the mitigation area are being controlled, as referenced above.

4) ***Erosion Control:*** All slopes within, and adjacent to, the mitigation area have been stabilized.

Monitoring Methods

The primary objective of monitoring will be to determine the extent to which performance standards are being met. Monitoring will include assessments of wetland hydrology, vegetation, plant survivorship, general wildlife use, and general Site characteristics. Inspections of the restoration areas to collect data for annual monitoring reports will be completed (Appendix K). The report will briefly describe methods used to collect data, results for the monitoring year, and any necessary remedial actions implemented or planned.

The area to be remediated will be monitored for five years after completion of the restoration activities. Monitoring visits will occur in the spring to document early season hydrology, winter damage, wildlife use, and early detection of invasive species. Mid-growing season monitoring will document the areal cover of vegetation, hydrology, wildlife use, and survival of planted stock. Late summer/fall monitoring will document the growth of the vegetative community over the course of the growing season and wildlife use. The overall success of the mitigation will be evaluated at the end of the second year (after two growing seasons). Monitoring will continue for three more years in order to address deficiencies, exotic and nuisance species maintenance needs, and to determine if additional monitoring or corrective measures are necessary.

Vegetation monitoring transects will be established to sample vegetation and hydrology. Transects will be located to allow for the most comprehensive sampling of planted areas. Multiple transects will be established on the Site, as needed, to provide adequate sampling intensity. Vegetation data will be collected in square-meter plots located every 10 meters along each transect length. Data collected in each plot will include:

- a list of the well-represented (>5% areal coverage) species in the plot;
- percent areal coverage by species;
- overall percent areal coverage; and
- general hydrologic conditions (i.e., saturated to surface, inundated, etc.).

General site information will also be recorded including:

- collecting data on general wildlife use or observed activity throughout the Site; and

- taking representative photographs of the Site and mitigation area from established points to provide year-to-year comparisons of the vegetative and hydrologic conditions.

4.3.4 *Annual Monitoring Reports*

The Site shall be monitored and monitoring reports shall be submitted to the WCC, DEP and ACOE no later than December 15 of the year being monitored, for each of the five growing seasons following the restoration. Wetland activities will also be documented in Immediate Response Action (IRA) Status Reports and Completion Reports. Each report coversheet shall indicate the report number, permit recipient, and permit numbers. The reports shall address the standards for success as described in Appendix K. The first year of monitoring shall be the first year that the Site has been through a full growing season after completion of construction and planting.

As necessary, remedial measures will be implemented to attain the four success standards described above within two growing seasons after completion of mitigation construction. Measures requiring earth movement or changes in hydrology will not be implemented without prior written approval from the WCC, DEP and ACOE.

Corrective Remediation

To ensure restoration success, problems identified during monitoring will be addressed in a timely manner. Regulatory agencies will be consulted on a case-by-case basis regarding the need for remedial measures. Possible measures may include additional seeding, supplementing of organic topsoil, light re-grading, and replacing dead shrubs and trees.

Long-Term Management

Once vegetation becomes well established within the mitigation area, it is anticipated that the desired conditions will persist with no need for long-term management.

Verification of Compliance

Once the mitigation plan is approved and construction of the proposed mitigation area is complete, it is anticipated that the DEP and ACOE will issue a letter verifying compliance with the mitigation plan. Similar verification of compliance is expected after the final annual monitoring report has been submitted and it is determined that the project has satisfied the restoration goals and objectives.

4.4 IMPLEMENTATION PROGRAM

4.4.1 Spill Prevention Control and Countermeasures

A copy of the Spill Prevention Control and Countermeasures Plan is located in Appendix L.

4.4.2 Site and Environmental Impacts

The proposed remedial activities will be conducted in a floodplain wetland, adjacent to the Sudbury River. Mitigation of environmental impacts associated with remedial activities has been addressed in Section 4.0 of the text.

4.4.3 Inspections and Monitoring

Inspection and monitoring of the wetland area is described in Section 4.3.3 of the text. The monitoring will be conducted as described in Appendix K.

4.4.4 Health and Safety Issues

The Site specific Health and Safety plan was prepared in accordance with 310 CMR 40.0018. A copy of the plan is included in Appendix H.

4.4.5 Required Permits

The reach of the Sudbury River adjacent to the Site is designated Wild and Scenic under the Wild and Scenic Rivers Act. It is also part of the GMNWR. Since a portion of the Site is a wetland and located in a regulated area, a rigorous permitting process is required to meet requirements of:

- The Wetlands Protection Act (310 CMR 10.000);
- The Rivers and Harbors Act, Section 10;
- The Clean Waters Act, Section 401 (Water Quality Criteria) and Section 404 (Wetlands Regulations);
- Army Corps of Engineers Regulations (33 CFR 200-399);
- The Massachusetts Environmental Protection Act (MEPA) (301 CMR 11.00); and,

- The Toxic Substance Control Act (40 CFR 750 and 761).

The following permits will be prepared to satisfy the above regulations:

- *Notice of Intent (NOI)* – An NOI is required by the Wetlands Protection Act. The completed application will be submitted to the WCC for approval of the proposed work. The WCC will issue an Order of Conditions outlining measures to be taken during excavation activities to minimize the impact to the wetland. The Order of Conditions cannot be issued until the Massachusetts Natural Heritage and Endangered Species Program (MANHESP) has communicated its opinion to the commission.

- *Environmental Notification Form (ENF)* – A project is subject to a Massachusetts Environmental Protection Act (MEPA) review if the review threshold is met, and any agency action or permit is required. The ENF must be completed and submitted to the Executive Office of Environmental Affairs (EOEA) to publish in the Environmental Monitor.

- *Environmental Impact Report (EIR)* – If categorically included under MEPA, or if determined to be required by EOEA, then a draft EIR will be submitted. The draft EIR will be finalized following approval by EOEA.

- *401 Water Quality Certification* – A request for determination must be submitted to DEP to establish if the project is located in a floodplain or in an Outstanding Resource Water. Based on this determination one of two paths (Major Fill/Excavation Project or Major Dredging Project) will be followed.

- *ACOE Section 404* Review – A Department of the Army permit application must be completed and submitted to the Army Corps of Engineers, with EPA and National Park Service providing comments.

- *Chapter 91, Waterways Licensing Program* - A request for determination will be submitted to the DEP to decide if the wetland is subject to Massachusetts waterways regulations. If the DEP determines a Chapter 91 permit is necessary, then the application will be prepared and submitted.

- *National Pollution Discharge Elimination System (NPDES) Exclusion Permit and Construction Permit*– A NPDES exclusion permit is required if treated water from the project is to be discharged to the wetland or river. A NPDES construction permit may be required for stormwater generated in a construction area greater than one acre. It is likely that water from dewatering activities, and/or effluent generated from the treatment of remedial wastewater, will require treatment prior to discharge.

- *TSCA Risk-Based Disposal Approval Application* – This approval is required if residual concentrations of polychlorinated biphenyls (PCBs) greater than one part per million (ppm) are left in the wetland following remedial activities. Residual PCBs at concentrations greater than one ppm constitute "disposal" and require a risk-based method to document the justification for leaving the residual concentrations in place.

Figure 16 presents a flow chart summarizing permitting activities.

4.4.6 *Property Access*

Raytheon is in the process of securing access to the properties listed below to enable implementation of remedial measures. Raytheon intends to secure access to these properties by Summer 2003.

Property Owner	***Town Parcel #***
Wayland Business Center	23-52
Hamlen Trust	22-10
Levco	23-52B

5.0 CONCEPTUAL DESIGN – GROUNDWATER TREATMENT

5.1 OVERVIEW

ISCO is a remedial technology that, through a series of chemical reactions, transforms chlorinated VOCs into neutral by-products, often resulting in production of carbon dioxide, water and salt. A variety of chemical oxidants exist, including hydrogen peroxide, permanganate (potassium and sodium), sodium persulfate and ozone. All of these oxidants have been proven effective at destroying TCE and other contaminants-of-concern present at the Site.

Given the oxidants available, the choice of an oxidant is a function of a number of factors: speed, effectiveness, ease of application, safety and handling, efficiency, and cost. Considering all of the factors (with the exception of efficiency), permanganate is clearly among the best oxidants for treating TCE. The decision to use permanganate is contingent on its efficiency. Efficiency generally is the amount of oxidant that is required to treat a given mass of contaminant. Efficiency is a function of the stoichiometric demand, the stability of the oxidant, and the presence of competing reactions.

Efficiency is often the key factor in deciding the choice of oxidant. Permanganate, peroxide, persulfate and ozone are strong and somewhat non-selective oxidants. This means that, in addition to chlorinated hydrocarbons, they can oxidize other reduced soil and groundwater constituents. These other constituents potentially include natural organic carbons, such as humic and fulvic acids, and reduced minerals. Permanganate appears to be more reactive to soil organics than other oxidants. Therefore, measuring the soil demand is important in assessing its use.

As part of the pilot study conducted at the Site (ERM, 2002), the natural soil oxidant demand (SOD) was determined to range from 0.033 to 0.068 grams per kilogram (g/kg) of wet soil, which translates to a required range of 0.09 to 0.18 pounds of permanganate per yd^3 of soil (assuming a soil density of 100 pounds per ft^3 and 30% porosity). This SOD value is relatively low, which led ERM to select permanganate (potassium or sodium) as the preferred oxidant for use at the Site.

Permanganate (potassium ($KMnO_4$) or sodium ($NaMnO_4$)) has an oxidation potential of 1.68 V, based on the following half reaction:

$$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$$

Unreacted permanganate imparts a purple or pink color to water. This coloration indicates its presence in groundwater, and facilitates the ability to monitor its distribution at a treated site

Successful implementation of ISCO is dependent on the effectiveness of delivering oxidant to the impacted groundwater. As part of the pilot study (ERM, 2002a, b), two injection techniques were evaluated at the Site:

- Pneumatic Fracturing and Liquid Atomized Injection (PFLAI) – high pressure injection; and,
- Gravity feed – low pressure injection.

The PFLAI high-pressure injection resulted in an apparent radius of influence of at least 20 feet. Gravity feed injection resulted in an apparent radius of influence of approximately five to ten feet. Based on results of the initial pilot program, complete destruction of TCE can be achieved in areas where an adequate mass of permanganate is injected and where contact between the permanganate and TCE is achieved.

ERM is currently implementing an expanded pilot study using hydraulic fracturing and liquid atomized injection (HFLAI), which is similar to PFLAI, and sodium permanganate (ERM, 2002c) in the vicinity of MW-43. To date, approximately 9,000 gallons of approximately 23% sodium permanganate were injected into the subsurface as part of this expanded pilot program. Post-injection groundwater monitoring is currently being conducted. Details of the expanded ISCO pilot program are presented in a Release Abatement Measure Plan – Modification #1, submitted to the Department on 22 October 2002.

Based on the preliminary pilot study results and ERM's experience at similar sites, permanganate (potassium and/or sodium) will be injected into the subsurface using a combination of high- and low-pressure injection techniques, depending on the size of the treatment area.

5.2 ISCO DESIGN AND IMPLEMENTATION

Based on the distribution of VOCs in groundwater at the Site, ERM has defined three ISCO treatment areas (Figure 17):

- TA-1 – located beneath the parking lot located west of the main building;
- TA-2 – located south of the southwest corner of the main building in

the vicinity of the MW-33 well cluster; and

- TA-3 –located east of the main building in the vicinity of the MW-40 well couplet.

Data obtained as part of the ongoing pilot study (see Section 2.1) will be evaluated to support design of the ISCO system in these treatment areas. The final design parameters will be presented in the Phase IV addendum report, which will be submitted to the Department prior to implementing the ISCO treatment system.

5.2.1 Establish Baseline Groundwater Data

The purpose of this task is to establish baseline groundwater flow and groundwater quality within the treatment areas prior to permanganate injection. One round of groundwater monitoring will be conducted to establish baseline aquifer geochemistry. The baseline monitoring program will consist of the following field measurements and laboratory analysis:

Baseline Monitoring Program

Analysis	*Method of Analysis*	*Rationale*	*Frequency*
Groundwater Elevation	Field Probe	Evaluate groundwater table elevation	Note 1
pH	Field Flow-Through Cell	Evaluate aquifer conditions	Note 1
Electrical Conductivity	Field Flow-Through Cell	Evaluate aquifer conditions and oxidant	Note 1
Temperature	Field Flow-Through Cell	Evaluate aquifer conditions	Note 1
Eh	Field Flow-Through Cell	Indicator of oxidant	Note 1
Dissolved Oxygen	Field Flow-Through Cell	Evaluate aquifer conditions	Note 1
Color	Field Visual Assessment	Indicator of permanganate	Note 1
Permanganate	Field Colorimetry	Quantify concentration of permanganate in groundwater	Note 1
VOCs	Lab - EPA Method 8021C	Contaminant concentrations	Note 2
Chloride	Lab - EPA Method 300.0	Degradation by-product	Note 2
Sodium	Lab - EPA Method 200.7	Evaluate aquifer conditions and potential tracer	Note 2
Manganese	Lab – EPA Method 200.7	Degradation product of MnO_4	Note 2
Chromium & Hexavalent Chromium	Lab - EPA Method 200.7 Lab – SM 3500Cr-D/EPA 7196A	Oxidation can convert Cr^3 to Cr^6	Note 2

Notes:
1. These parameters will be monitored daily during oxidant addition and weekly thereafter until unreacted permanganate is no longer present or stabilizes
2. These parameters will be monitored during the baseline round and after unreacted permanganate is no longer present or stabilizes. VOCs will be monitored at a minimum of a quarterly basis.

ERM will conduct gauging and groundwater sampling activities in accordance with accepted practices outlined in the DEP's Standard References for Monitoring Wells, WSC-310-91, dated April 1991 and updated July 1994. ERM will apply the draft MCP Analytical Data Enhancement Process to evaluate analytical data quality for the Site. As part of this process, groundwater samples will be preserved on ice and will be documented, consistent with chain-of-custody protocols. For QA/QC purposes, ERM will collect and submit the following samples :

- one duplicate sample per monitoring round;
- one matrix spike per monitoring round; and,
- one matrix spike duplicate per monitoring round.

The laboratory will provide one trip blank per monitoring round.

5.2.2 *Develop Final Remedial Design*

ERM will review the hydrogeologic, geochemical and VOC distribution data for each of the treatment areas to develop the final remedial design.

Using the observed TCE concentrations in groundwater, SOD, anticipated injection radii and lessons from the pilot studies, ERM will determine the following for each of the treatment areas:

- injection method (i.e., high or low pressure);
- number and location of injection points;
- maximum depth of injection;
- mass of permanganate;
- type of permanganate (i.e., sodium or potassium); and,
- concentration and volume of permanganate solution.

This information will be provided to the Department as a Phase IV addendum prior to implementing the ISCO treatment system.

5.2.3 *Oxidant Injection*

The ISCO treatment program will involve the following steps:

- install injection points;
- prepare a permanganate solution (potassium or sodium) by mixing the appropriate mass of concentrated permanganate with either potable water or purged groundwater to the appropriate concentration; and
- inject the permanganate solution using either high- or low-pressure injection techniques.

During the injection process, ERM will monitor for changes in groundwater elevation and baseline field parameters in nearby monitoring wells. The presence of permanganate will be determined based on:

- increases in electrical conductivity, which indicates the presence of potassium/sodium and/or unreacted permanganate;
- Eh value greater than 600 millivolts (mV), which indicates the presence of unreacted permanganate; and,
- visual indication of permanganate, which is visibly pink at a concentration of approximately 0.5 parts per million (ppm).

5.2.4 *Post-Injection Groundwater Monitoring*

The purpose of this task is to monitor the progress of the ISCO treatment system over time. ERM will implement a quarterly groundwater monitoring program following completion of the permanganate injections until such time as permanganate is no longer present in any of the monitoring wells on Site. The quarterly monitoring rounds will include measurements of groundwater elevations and field parameters (i.e., electrical conductivity, color and Eh) in all Site monitoring wells. Groundwater samples will be collected for laboratory analysis of sodium or potassium (depending on oxidant used) and VOCs by EPA Method 8021C on a semi-annual basis.

The final monitoring round will be conducted up to three months after permanganate is no longer visually observed in any monitoring wells on Site and will include laboratory analysis of VOCs using EPA Method 8021C and selected metals (sodium, manganese, chromium using EPA Method 200.7 and hexavalent chromium by SM 3500Cr-D/EPA 7196A).

Following completion of this final ISCO monitoring round, a modified groundwater monitoring program will be developed to monitor the effectiveness of the Phase IV remedial activities over time.

ERM will conduct gauging and groundwater sampling activities in accordance with accepted practices outlined in the DEP's Standard References for Monitoring Wells, WSC-310-91, dated April 1991 and updated July 1994. Groundwater samples will be preserved on ice and will be documented consistent with chain-of-custody protocols. For QA/QC purposes, ERM will collect and submit the following samples :

- one duplicate sample per monitoring round;
- one matrix spike per monitoring round; and,
- one matrix spike duplicate per monitoring round.

The laboratory will provide one trip blank per monitoring round.

5.3 *IMPLEMENTATION PROGRAM*

5.3.1 *Spill Prevention Control and Countermeasures*

A copy of the Spill Prevention Control and Countermeasures (SPCC) Plan is located in Appendix L.

5.3.2 *Residual Material Management*

Any contaminated groundwater, drilling cuttings or drilling fluids generated as part of the ISCO treatment will be containerized and properly disposed of.

5.3.3 *Site Impacts*

Implementation of the ISCO remedial system involves advancement of soil borings and injection of permanganate beneath both paved and unpaved portions of the Site. Permanganate will likely migrate beneath the main building located at the Site. Because permanganate is not a volatile compound, nor does it increase the volatility of VOCs in soil or groundwater, adverse impacts to this structure or its occupants are not anticipated.

The ISCO remedial activities will not affect local drainage features, natural resource areas, or local planning and development issues.

Injection of permanganate will affect soil and groundwater quality within the injection area, but will not result in an adverse impact to soil quality. As noted in Section 5.1, the reaction or degradation of permanganate results in the formation of manganese dioxide (MnO_2), a mineral precipitate. Injection of permanganate will result in short-term impacts to groundwater quality within the treatment area (e.g., increases in oxidation-reduction potential, electrical conductance, dissolved manganese, sodium/potassium), but will not result in an adverse long-term impact to groundwater quality. Based on groundwater flow directions inferred by Figures 4 and 5, results of the pilot study (ERM, 2002) and the locations of proposed ISCO treatment areas (Figure 17), It is unlikely that ISCO remedial activities will impact the Baldwin Pond wellfield.

5.3.4 *Environmental Impacts*

The ISCO remedial activities will be conducted within a mapped Zone II aquifer protection district for the Baldwin Pond wellfield. Pursuant to 310 CMR 40.0046(3), since the application of Remedial Additives (i.e., permanganate) will not be conducted within 100 feet of any private water supply well or within 800 feet of any public water supply well, well field or tributary thereto, Department approval is not required to conduct the ISCO remedial activities within this resource area. Based on results of the pilot study conducted at the Site (ERM, 2002a, b), ERM does not anticipate any adverse impacts to this resource area resulting from the ISCO remedial activities.

Based on results of the pilot study (ERM, 2002a, b), ERM does not anticipate any impacts to down gradient receptors as a result of the ISCO remediation, such as the Sudbury River and its associated wetlands.

5.3.5 Health and Safety Issues

The Site-specific Health and Safety plan was prepared in accordance with 310 CMR 40.0018. A copy of the plan is located in Appendix H.

5.3.6 Required Permits

Pursuant to 310 CMR 40.0046, no permits are required to complete ISCO remedial activities within the proposed treatment areas.

5.3.7 Property Access

Raytheon will have to secure access with the current property owners to enable implementation of remedial measures. Property owners and land parcels requiring approval for access are listed in Section 4.4.6.

6.0 IMPLEMENTATION SCHEDULE

The anticipated schedule for remedial activities at the Site is presented below.

Implementation Schedule for Phase IV RIP

Date	*Event*
December 2002	Complete Phase IV RIP
Winter 2003	Complete Wetlands Permitting
Winter/Spring/Summer/ Fall 2003	Conduct Quarterly Groundwater Monitoring
Spring - Summer 2003	Conduct Pre-construction Monitoring
Summer – Fall 2003	Implementation of Wetland Remedial Action
Summer – Fall 2003	Initiation of Wetland Restoration Activities
Summer – Fall 2003	Submit Phase IV Addendum for Groundwater Remediation
Fall 2003 – Winter 2004	Conduct Permanganate Injections
Winter/Spring/Summer/ Fall 2004	Conduct Quarterly Groundwater Monitoring
2004	As-Built Construction Report
2004	Final Inspection Report
2003- 2008	Annual Monitoring of Wetland Habitat Recovery

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