STREAMLINED REMEDIATION SYSTEM EVALUATION (RSE-LITE) FOR A GROUND WATER PUMP AND TREAT SYSTEM

ENGELHARD CORPORATION FACILITY
PLAINVILLE, MASSACHUSETTS

SUBMITTED:

AUGUST 3, 2005

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Office of Solid Waste
and Emergency Response
(5102G)

EPA 542-R-05-026
August 2005
www.epa.gov/tio
clu-in.org/optimization

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The U.S. Environmental Protection Agency funded the preparation of this document by Geotrans, Inc. under EPA Contract No. 68-C-00-181 Task Order #40 to Tetra Tech EM, Inc, Chicago, Illinois.

For further information about this report, please contact the EPA's Office of Solid Waste, Mike Fitzpatrick, (703) 308-8411, fitzpatrick.mike@epa.gov or the EPA's Office of Superfund Remediation and Technology Innovation, Ellen Rubin, (703) 603-0141, rubin.ellen@epa.gov.

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EXECUTIVE SUMMARY

A Streamlined Remediation System Evaluation (RSE-Lite) involves a team of expert hydrogeologists and engineers, independent of the site, conducting a third-party evaluation of a ground water pump and treat system or other remedy of environmental contamination. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site exit strategy. The evaluation includes reviewing site documents, communicating with the site team, and compiling a report that includes recommendations to improve the efficiency and effectiveness of the remedy. Recommendations with cost and cost savings are provided in the following four categories:

- Improvements in remedy effectiveness
- Reductions in operation and maintenance costs
- Technical improvements
- Gaining site closeout

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation by the RSE-lite team, and represent the opinions of the RSE team. These recommendations do not constitute requirements for future action, but rather are provided for the consideration of all site stakeholders.

The Engelhard Corporation facility ("Engelhard") is a RCRA Corrective Action facility. The site was nominated based on its long history, type and nature of volatile organic chemical presence, and performance of the ongoing ground water remedy.

Initial site investigation and remedial activities have been conducted at Engelhard since the mid 1980's. The ground water contaminant plume consisting of tetrachloroethene (PCE) and 1,1,1-trichloroethane (TCA) have migrated beyond the property boundary. A Corrective Action consent order was signed by Engelhard facility and EPA in 1993. As a result, a ground water stabilization measure (GSM) pump and treat system consisting of six deep bedrock extraction wells and a vertical high-density polyethylene (HDPE) barrier membrane was installed and began operating in 1998. The objective of GSM is to contain the plume along the HDPE barrier membrane and establish a gradient reversal to capture contamination that may be present immediately downgradient of the GSM.

The RSE-lite team found a site team committed to improving the existing remedy through a number of pro-active actions to comply with the consent order. The RCRA Facility Investigation is ongoing, and the data are being used to evaluate the existing remedy and its potential for use as a final remedy. Some increases in site-related contamination were detected on the downgradient side of the GSM during recent years of operation, and this has triggered concerns about the effectiveness of the remedy in its current form. Between 2003 and 2004 Engelhard conducted two separate evaluations of the GSM that included field work, and have made recommendations to upgrade the remedy based on its findings. The RSE-lite team has reviewed the site documents, these recent reports, comments provided by EPA, and responses to those comments from Engelhard.

Based on the document review and RSE-lite conference call, the RSE-lite team has provided recommendations for both improving the effectiveness of the system and reducing operating costs.

The effectiveness recommendations focus on developing figures that would improve the site conceptual model and the evaluation of plume capture. The RSE-lite team notes that achieving "gradient reversal" as indicated in the site objectives generally requires more pumping than is necessary for adequate capture. Despite the recent evaluations conducted by Engelhard, the RSE-lite team does not see conclusive evidence that supports or does not support capture. The RSE-lite recommendations, therefore, suggest an alternative, cost-effective approach for evaluating capture. The RSE-lite recommendations also generally support the technical recommendations offered by Engelhard in its recent evaluations. Although EPA's comments on the recent Engelhard reports have merit, the RSE-lite team would rather see the site team focus on the recommendations in this RSE-lite report and upgrading the GSM rather than revisiting the previous reports to retroactively address EPA's comments. EPA's comments, however, should be duly noted and considered for future site efforts and reports.

The cost-reduction recommendations focus on simplifying the treatment train to reduce chemical and materials costs as wells as potentially reduce operator labor. One recommendation suggests considering eliminating the metals removal aspect of the treatment plant, and another recommendation suggests eliminating the use of liquid phase granular activated carbon (GAC) given that the air stripper provides adequate and reliable treatment of volatile organic compounds (VOCs).

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1.0 INTRODUCTION

1.1 PURPOSE

In 2003 and 2004, the EPA Corrective Action program and the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) sponsored independent optimization evaluations called Remediation System Evaluations (RSEs) at five RCRA sites with pump and treat (P&T) systems. These RSEs involved an independent team of experts reviewing site documents, interviewing site stakeholders, and providing recommendations for improving remedy effectiveness, reducing costs, and gaining site closure.

A RSE involves a team of expert hydrogeologists and engineers, independent of the site, conducting a third-party evaluation of site operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site exit strategy. The evaluation includes reviewing site documents, visiting the site for 1 to 1.5 days, and compiling a report that includes recommendations to improve the system.

Based on the positive results of these RSEs, EPA Technology Innovation Field Services Division (OERR) and the Office of Solid Waste (OSW) have commissioned a new pilot study that involves developing and piloting a streamlined RSE process that reduces the cost of resources relative to a full-scale RSE based on the consideration that many sites do not require a full-scale RSE and a streamlined RSE will provide same level of beneficial results for those sites with the reduction of cost. This streamlined RSE or “RSE-lite” evaluation includes reviewing site documents, conducting conference calls with the site team, and compiling a report of recommendations.

For this new pilot study, up to five RCRA Corrective Action facilities with operating remedies have been selected to receive RSE-lites. The site managers have been asked to provide site documents for review by the RSE-lite team. After reviewing the documents, the RSE-lite team has communicated with the site managers to learn more about the sites and fill in information gaps not covered by the site documents. As part of this streamlined effort, no site visit has been conducted.

This RSE-lite report for the Engelhard Corporation facility (“Engelhard”) is one of the RSE-lites from this new pilot study. Engelhard was nominated based on its long history and ongoing ground water remedy. The report consists of the following elements:

- A brief summary on site history, site conceptual model, ground water remedial system, remedy goals, and costs

- Recommendations to improve remedy effectiveness and efficiency of the operating pump and test system (an interim remedy that is only one component of the site-wide remedy)

1.2 RSE-LITE PROCESS

Once a site is selected, a representative of the RSE-lite team contacts the site project manager to obtain site documents for review. The documents typically include information pertaining to site investigations, remedy design, and remedy operations and maintenance (O&M). Upon reviewing this information, the RSE-lite team conducts a conference call with the remedy project manager to address questions that may have arisen as part of the document review or other information gaps. Based on the site documents and the information from communications with the site project manager, the RSE-lite team prepares a short report documenting recommendations for improving efficiency and effectiveness. The text of the RSE-lite report includes a brief background of the site, series of findings from the document review and conference call, site-specific recommendations, and a cost summary table summarizing estimated costs and cost savings associated with implementing each recommendation.

1.3 PARTICIPANTS ON RSE-LITE CONFERENCE CALL

The following individuals participated in the conference call as part of RSE-lite:

- Tom Brown, Engelhard Corporation
- John Scaramuzzo, Tetra Tech EC (project manager of ground water P&T system)
- Joe Francis, Tetra Tech EC (system operator)
- Steve Graham, LFR (PM for ground water assessment)
- Rick Kuhlthau, (EPA Contractor)
- Bob Brackett, RPM, EPA Region 1
- Ellen Rubin, EPA HQ
- Doug Sutton, GeoTrans, Inc.
- Peter Rich, GeoTrans, Inc.
- Yan Zhang, GeoTrans, Inc.

1.4 DOCUMENTS REVIEWED

The following documents were reviewed as part of this RSE-lite:

- Conceptual Design Report Groundwater Treatment System, Foster Wheeler Environmental Corporation, November 1995

- Final Design Report Groundwater Stabilization System, Foster Wheeler Environmental Corporation, December 1996

- Selected sections from Draft RCRA Facility Investigation report, September 30, 1999

- Groundwater Stabilization Measure (GSM) Evaluation Report, ECS, June 2004

- Groundwater Treatment Plan Operation and Maintenance Quarterly Status Report – No. 26 Year 7 – 2nd Quarter (April 1, 2004 through June 31, 2004), Tetra Tech FW, Inc., November 2004

- Groundwater Treatment Plan Operation and Maintenance Quarterly Status Report – No. 27 Year 7 – 3rd Quarter (July 1, 2004 through September 30, 2004), Tetra Tech FW, Inc., January 2005

- Groundwater Stabilization Measure (GSM) Upgrade Report, ECS, February 2005

- Draft comments on the 6/24/04 groundwater stabilization measure report

- Draft responses to draft USEPA comments on the June 24, 2004 groundwater stabilization measure report

- Draft comments on the 7/15/04 monitored natural attenuation report

2.0 BACKGROUND

2.1 SITE HISTORY

The Engelhard Corporation facility is located at 30 Taunton Street in Plainville, Massachusetts. The facility, which was constructed in the late 1950's, was primarily involved in the manufacture of various precious metal products. Environmental investigation and remedial activities have been conducted at the site since the mid 1980's. EPA and Engelhard signed a 3008(h) Corrective Action consent order in 1993 that, among other items, requires Engelhard: to investigate several potential areas of concern (AOC); to assess the potential migration of constituents; to evaluate the potential human health and ecological risks posed by the presence of these constituents in the AOCs; and to implement certain specified stabilization measures at the site.

In addition to requiring Engelhard to conduct a RCRA Facility Investigation (RFI) and several stabilization measures, the 1993 Consent Order required that Engelhard install a ground water pump and treat (P&T) system as a near-term stabilization measure which would reduce off-site migration of contaminated ground water and be compatible with, and part of, a likely final remedy. As a result, a ground water P&T system was installed in 1997 and began full-scale operation in January 1998.

Beginning in the Spring of 2003, Engelhard conducted a series of activities to evaluate the efficacy of the on-site ground water contaminant system, involving review of prior data, new field investigations and pumping tests, and further data evaluation. This evaluation was undertaken as part of a review of operations at the five-year (1998-2002) period of performance, and also occurred in response to an increase in volatile organic compounds (VOC) concentrations observed in monitoring wells downgradient of the system during the 2002 annual ground water sampling event.

2.2 SITE CONCEPTUAL MODEL

Source Area and Contaminants of Concern

Six VOCs are consistently detected in ground water: cis-1,2-dichloroethene (1,2-DCE); 1,1-dichloroethene (1,1-DCE); 1,1-dichloroethane (1,1,-DCA); 1,1,1-trichloroethane (TCA); trichloroethene (TCE); and tetrachloroethene (PCE). In general, 1,1,1-TCA and PCE are detected at the highest concentrations, followed by TCE, 1,1-DCA, and 1,1-DCE. VOC concentrations in the bedrock wells are generally higher than those observed in corresponding overburden wells. Figures generated by the site contractor are included as an attachment to this document to illustrate well locations and the extent of contamination in both the overburden and bedrock.

The highest contaminant concentrations during the January 1995 – October 2003 sampling events are listed in the following table:

Concentration	**1,1,1-TCA (ug/L)**	**PCE (ug/L)**	**TCE (ug/L)**	**1,1-DCA (ug/L)**	**1,1-DCE (ug/L)**	**Cis-1,2-DCE (ug/L)**
Overburden Zone	5,300	16,000	1,100	220	300	340
Bedrock Zone	43,000	36,000	1,700	1,200	1,300	350

Hydrogeology

Two principal geologic zones underlying the facility include an unconsolidated (glacial-till) overburden zone and a consolidated bedrock zone. The overburden zone represents Quaternary glacial deposits, which consists of poorly sorted and poorly stratified, brown gravelly sand with occasional lenses of gray silty sand. The overburden material is found at an average depth of approximately 25 feet below ground surface (bgs). The thickness of this unit generally varies from 18 feet to 36 feet. The ground water gradient in this overburden zone ranges from 0.015 to 0.04 feet/feet. The hydraulic conductivity ranges between 2.25×10^{-3} cm/sec and 6.90×10^{-3} cm/sec with an arithmetical mean value of 5.33×10^{-3} cm/sec.

The bedrock zone is comprised of the Rhode Island Formation, which consists of a light to dark grey, hard, well fractured, slightly weathered to fresh, meta-sediment. The thickness of the bedrock zone is approximately 150 feet and extends to a depth of approximately 180 feet bgs. The bedrock is fractured media consisting of solid rock with a low porosity and hydraulic conductivity (less than 10^{-7} cm/sec), and fracture zones with a higher hydraulic conductivity that create a secondary porosity and a network for ground water and contaminant movement. The ground water gradient in the bedrock is similar to that of the overburden and ranges between 0.015 to 0.04 feet/feet. The average hydraulic conductivity as determined from a pump test is 2.78×10^{-4} cm/sec, which approximately one order of magnitude lower than that of the overburden.

In general, the ground water flow direction in the overburden and bedrock zones is from the southwest to northeast. Beneath the facility, the vertical hydraulic gradient in the overburden is generally downward into the bedrock zone, due to ground water recharge from Turnpike Lake, particularly at the facility’s western boundary. The vertical hydraulic gradient generally reverses in the low-lying area east of the site, due to upwelling of ground water to the unnamed streams east of the facility. The presence of VOCs in surface water corresponds to this ground water flow pattern. VOCs are not present in localized areas of surface water near the site but are present in surface water in low-lying areas east of the site where impacted ground water discharges to surface water.

Potential Receptors

The primary ecological receptor is the surface water located to the east of the site where VOC impacted ground water has been surfacing at a distance of 600 to 800 feet from Engelhard facility property boundary.

Potential human receptors include nearby wells at private residences. North of the stream, approximately a half mile to one mile away, there are residential bedrock wells at 50-100 residences. These residential wells were previously sampled and no site-related contamination was found. The majority of the residences use city water. There are three municipal wells located near Turnpike Lake, which is upgradient of the site contamination. The 1999 Draft RCRA Facility Investigation also indicates that there is an irrigation well to the east of the facility that is no longer active but has not been properly abandoned. There was no information reviewed by the RSE-lite team that indicates whether or not this irrigation well has been impacted. To date, the site team reports that sampling results indicate that no supply wells in the area have been impacted by site-related contamination.

2.3 GROUND WATER REMEDIAL SYSTEM

The ground water remedial system was constructed between June and November 1997, with system start-up occurring in December 1997 and full-scale operation beginning in January 1998.

A vertical barrier and an extraction system were installed to provide capture and reverse the hydraulic gradient along the property boundary. The extracted ground water is subjected to metal removal (via pH adjustment, coagulation, and precipitation), air stripping, filtration, carbon adsorption, and discharged to Turnpike Lake. The ground water remedial system consists of following components:

- Six deep bedrock extraction wells and a vertical high-density polyethylene (HDPE) barrier membrane extending to the depth of bedrock (see figures attached at the end of this report)
- Equalization tank with bubble diffuser
- Metal precipitation for iron and manganese
- Inclined tube/plate clarifier
- Sludge storage tank
- Low-profile NEEP air stripper
- Bag filter
- Filter press

- Two liquid phase granular activated carbon (GAC) units
- Two vapor phase GAC units for off-gas treatment
- Effluent tank
- Discharge to surface water

The treatment system is designed to operate at a flow rate of 110 gpm. The design influent concentrations for five primary contaminants of concern (COCs) are listed below.

Contaminants	Design Influent Concentration (ug/L)
Trichloroethene	602.5
1,1,1-trichloroethane	3,127.6
1,1-dichloroethene	2.1
Tetrachloroethene	3,332.8
1,1-dichloroethane	15.3

2.4 REMEDY GOALS

As required in Consent Order, the general performance standards for stabilization of ground water include: a) designing, installing, operating, and maintaining a ground water P&T system that utilizes pumping wells to significantly reduce migration of contaminated ground water off-site by causing a reversal of the natural hydraulic gradient in the bedrock and overlying unconsolidated saturated zones along an approximately 540 foot line running parallel to Route 152; and b) treating recovered ground water to the extent necessary to comply with applicable discharge standards. The extraction wells are located approximately 50 feet to the west of Route 152 (i.e., the facility-side of Route 152 as indicated in the figures attached at the end of this report). In addition to owning the property where the facility is located, the site team reports that Engelhard also has partial control over property that extends approximately 200 feet east of Route 152.

The requirements for GWTP aqueous effluent discharge to local surface water, Turnpike Lake, are contained in the National Pollution Discharge Elimination System (NPDES) Permit Exclusion dated July 2, 1997. The specific guidance for the discharge of vapor from the remediation system is governed by the Massachusetts Bureau of Waste Site Cleanup (BWSC) Policy No. WSC-94-150 “Off-Gas Treatment of Point Source Remedial Air Emissions”, which requires the destruction or removal of 95% of the VOCs in an off-gas system.

The discharge criteria for discharging treated ground water to Turnpike Lake are listed in the following table.

Contaminants	Discharge Limit (ug/L)
1,1,1-trichloroethane	200
1,1-dichloroethene	7
Tetrachloroethene	5
Trichloroethene	5
Benzene	1
Total BTEX	100
MTBE	70
Methylene Chloride	5
Cis-1,2-DCE	70
Trans-1,2-DCE	100
1,1-DCA	100
Chloroethane	100
Chloroform	100
TPH	5,000

2.5 COSTS

The 2004 budgeted costs for treatment plant O&M are listed below. This budget does not include costs associated with ground water sampling, the ongoing investigation/evaluation efforts, or the project management and reporting.

Cost Category	2004 Budget
Labor (Operator and Home Office)	$79,595
Chemical/Bag Filters	$2,500
Lab Analysis	$6,000
Maintenance, Calibration, & Repair	$13,000
Parts, Tools, & Equipment	$13,500
Health & Safety Supplies	$1,500
Service Tech (Carbon)	$9,500
Sludge	$7,500
Waste Disposal	$0
ODCs	$7,905
Total	***$141,000***

3.0 RSE-LITE FINDINGS

The findings indicated below are not intended to suggest a deficiency in the remedy design or operation. These findings are not intended to suggest requirements for the site. Rather, these findings are the opinions of a third-party evaluation team and are only provided for consideration by the site team.

3.1 FINDINGS PERTAINING TO REMEDY PROTECTIVENESS

- The RCRA Facility Investigation (RFI) is ongoing and one of the recommendations is to include 1,4-dioxane on the list of analytes. The site team reports that it sampled for 1,4-Dioxane and found it to be non-detect during the 1995 RCRA Facility Investigation. These results were not available for review during the RSE-lite.

- The P&T system is operating continuously except for minimal downtime due to short scheduled shutdowns for minor maintenance. The average flow rate of the system is approximately 40 gpm to 45 gpm based on the December 2004 and February 2005 O&M reports, which is less than the 55 gpm that the site team previously established to maintain the ground water gradient reversal and is much less than the design flow rate of 110 gpm. It should be noted that the site team is discussing whether or not gradient reversal is practical, or even achievable, especially below 60 feet bgs. Recent studies by Engelhard reveal that capture provided by the GSM, particularly along its southern half (PW-1 through PW-3), is insufficient to prevent contaminant migration.

- The 2002 sampling results indicate the presence of elevated VOC concentrations downgradient of the barrier wall. In particular, at one well downgradient of GSM, MW-17, 1,1,1-TCA and PCE concentrations had increased from 6,500 ug/L to 35,000 ug/L and from 4,600 ug/L to 36,000 ug/L, respectively, from 1995 to 2002. This increase in the wells downgradient of barrier wall might have resulted from the temporary shutdown of PW-3, and the decrease of concentrations in those wells noted during the 2003 sampling event is possibly due to resuming pumping at PW-3. The site team reports that concentrations have continued to decline in these wells in subsequent sampling events.

- The June 24, 2004 Ground water Stabilization Measure Report documents evaluations that Engelhard conducted on the effectiveness of the GSM. Engelhard and its contractors reviewed existing site information and conducted field work in 2003 and early 2004 with the following objectives:

    - Assess the ground water flow patterns near the facility in the absence of pumping
    - Develop an updated site conceptual model of ground water flow under actual pumping conditions

- Identify the relative effectiveness of individual extraction wells to control ground water flow
- Evaluate the efficiency of the GSM in terms of plume capture

The field work consisted of 10 additional piezometers in the vicinity of the GSM, pump tests for each of the six pumping wells, and ground water sampling of bedrock piezometers. The following conclusions were reached:

- The GSM is not effectively capturing all VOC contamination and the GSM may be pulling contamination into the bedrock
- A fault trending west to east may be present near PW-2, providing a conduit for preferential ground water flow and contaminant transport
- The capture zones of the extraction wells in the southern part of the GSM (PW-1 through PW-3) do not provide sufficient overlap such that the loss of one well cannot be compensated by increased pumping from additional wells

The following recommendations were provided:

- Evaluate the condition of the existing pumping wells
- Install an overburden/shallow bedrock well screen at PW-2
- Reduce the pumping rate at PW-6
- Decommission PW-4 and/or PW-5 as extraction wells
- Potentially convert P1a and P12a into extraction wells

EPA had a number of comments on this report, including the following:

- The usage and designation of “rock quality designation” (RQD) needs to be clarified.
- EPA raised a number of concerns regarding data quality due to how the tests were conducted and how the data were interpreted. Concerns included the observation of rising water levels during pumping tests, the method used for interpreting pump test data, not allowing the aquifer to stabilize in between pump tests, using water levels from pumping wells during pump tests rather than nearby piezometers.
- The figures presented in the report show hydraulic influence and not hydraulic control.

In general, Engelhard appeared to acknowledge the comments but maintained that the information collected was semi-qualitative in nature and sufficiently accurate for moving forward with recommending and pursuing GSM upgrades.

- The RSE-lite team identified a reporting error in the June 2004 report that does not appear to have greatly affected site decisions but should be noted. The reported hydraulic conductivity values in the June 2004 GSM report from recent pump tests are likely in error. The report uses the following equation for determining transmissivity (which, in turn, is used to estimate the hydraulic conductivity).

$$T = \frac{264 \times Q}{\Delta s}$$

where

T is the transmissivity
Q is the pumping rate
Δs is the drawdown observed over one $\log_{10}$ cycle of time (e.g., 50 min. to 500 min.)

This is only an appropriate equation to use when parameters are input using specific units (gpm for the pumping rate and feet for drawdown with transmissivity calculated in gpd/ft). However, it appears that inappropriate units were used. The following general equation for consistent units (*Driscoll*, 1986) is correct:

$$T = \frac{2.3 \times Q}{4\pi\Delta s}$$

where

T is the transmissivity (ft^2/day)
Q is the pumping rate (ft^3/day)
Δs is the drawdown (ft) observed over one $\log_{10}$ cycle of time (e.g., 50 min. to 500 min.)

The following table includes the hydraulic conductivity measurements reported in the June 2004 GSM report along with the correct hydraulic conductivity measurements using the general equation with consistent units.

Location	**(Incorrect) Hydraulic Conductivity Range June 2004 GSM (cm/sec)**	**(Correct) Hydraulic Conductivity Range Using Consistent Units (cm/sec)**
PW-1	$3.92\times10^{-3} – 2.38\times10^{-1}$	$2.72\times10^{-6} – 1.65\times10^{-4}$
PW-2	$2.06\times10^{-1} – 5.00\times10^{-1}$	$1.43\times10^{-4} – 3.47\times10^{-4}$
PW-3	$1.08\times10^{-2} – 4.89\times10^{-2}$	$7.5\times10^{-6} – 3.40\times10^{-5}$
PW-4	$7.36\times10^{-3} – 1.54\times10^{-2}$	$5.1\times10^{-6} – 1.07\times10^{-5}$
PW-5	$1.18\times10^{-2} – 8.97\times10^{-2}$	$8.19\times10^{-6} – 6.23\times10^{-5}$
PW-6	$4.31\times10^{0} – 1.4\times10^{1}$	$2.99\times10^{-3} – 9.72\times10^{-3}$

As is evident, the hydraulic conductivity measurements using the consistent units are a factor of 1440 lower than those reported in the June 2004 GSM report and are comparable to (or even lower than) the measurements that were provided in the *Conceptual Design Report*. The values from the *Conceptual Design Report* were used for the designing the site and for consideration during the RSE-lite. As a result, the RSE-lite team believes that the correct information has been used in making major site decisions and that the hydrogeological analysis provided in the RSE-lite report is a reasonable representation of the site hydrogeology.

- To address data gaps and provide useful information for upgrading the GSM, the facility and its contractor conducted a series of evaluations including collecting water quality samples from each of the extraction wells, hydraulic conductivity testing of upgradient piezometers, evaluation of the extraction wells, and sampling of extraction wells for parameters that could lead to well fouling. The data and analysis is included in the February 2005 Ground water Stabilization Measure (GSM) Upgrade Report.

  The report documents that the highest contaminant concentrations are found in the area between PW-1 and PW-3 (the highest are at PW-2). The report suggests short-circuiting of the GSM and cites the following reasons:

  - Poor control of ground water in the overburden near PW-2 and several other extraction wells
  - Limitation in the amount of water that is extracted from PW-1 through PW-5
  - Excessive extraction from PW-6

  The report also provides the following recommendations:

  - Installation of a well screen at PW-2
  - Installation of a high capacity pump at PW-2
  - Implementation of alternative discharge pipe connections
  - Implementation of a well maintenance program
  - Replace the PW-6 pump with a lower capacity pump
  - Adjust the wells screens of PW-1 and PW-3 to increase extraction from the overburden
  - Ground water monitoring for three months to monitor changes associated with these upgrades

3.2 FINDINGS PERTAINING TO COST-EFFECTIVENESS

- The site team appears to operate a very cost-effective remedy. Based on the O&M reports that were reviewed during the RSE-lite, the air stripper is successful at meeting the discharge requirements and has the appropriate failsafes. The GAC polishing appears to focus more as a redundant treatment component rather than an active aspect of VOC removal.

- The majority of costs associated with O&M are related to operator labor, which is required at the current levels due to operations of the metals removal components.

- The other significant component of costs can likely be attributed to ongoing site investigations and evaluations of the GSM. The cost-effectiveness of the remedy will largely rely on the site team's ability to efficiently conduct the necessary investigations and modify the GSM to provide the necessary level of plume capture.

3.3 FINDINGS PERTAINING TO REMEDY PROGRESS AND SITE CLOSURE

Sampling results at the site, both near the GSM and upgradient of the GSM, suggest the presence of dense non-aqueous phase liquids (DNAPL), which would make it very difficult for aquifer restoration to be achieved in a reasonable time frame (i.e., on the order of 30 years).

4.0 RSE-LITE RECOMMENDATIONS

4.1 RECOMMENDATIONS TO IMPROVE SYSTEM PROTECTIVENESS

4.1.1 Improve Documentation and Illustration of the Site Conceptual Model

Cross sections showing water levels, potentiometric contours, physical features, and contaminant concentrations would help with illustrating the site conceptual model. In addition, potentiometric surface maps (in plan view) for both the overburden and bedrock would be helpful. When determining potentiometric contours (in cross section or plan view) the water level measurements from operating extraction wells should not be used because they typically are lower than representative water levels from the aquifer (due to well losses and other factors) and may tend to overestimate plume capture. It is likely appropriate to collect water level measurements on a quarterly basis (rather than the current monthly basis) for eight quarters while adjustments are made to the GSM; however, after these eight quarters, it may be appropriate to further reduce the frequency to semi-annual.

The reduction in the frequency of measuring water levels will likely save several hours of labor per quarter, but it is unclear if this will translate to a reduction in labor costs if the measurements are collected by the operator. The cost of generating these figures is relatively low, particularly since base maps have already been prepared. Including these figures in future reports may increase annual costs by approximately $5,000 per year.

4.1.2 Evaluate Current Level of Capture

The site team should attempt to evaluate the degree of plume capture offered by the current GSM. The RSE-lite team recognizes that the recent work has had this as one of objectives, but the RSE-lite team does not see conclusive evidence one way or the other regarding plume capture or the lack of plume capture.

Site documentation indicates that the remedy objective requires gradient reversal. Gradient reversal generally requires more pumping than is necessary for adequate capture. Therefore, the degree of capture offered by the system may be adequate for plume control although gradient reversal may not be achieved (now or in the future). Furthermore, although a substantial data set is available for the site, the RSE-lite team has not seen a presentation of the data that indicates whether or not capture (or gradient reversal) is adequate.

The RSE-lite team recommends cost-effectively evaluating capture with the following approaches:

- water budget analysis
- interpretation of a capture zone with potentiometric maps and cross-sections
- monitoring of contaminant concentrations in downgradient performance wells

The water budget analysis compares the amount of contaminated water flowing through or past the area of interest (in this case, the 540-foot line along the property boundary and Route 152) and the amount of water that is extracted. Using the parameters from Section 2.2 of this report, the amount of water flowing through the overburden is approximately 38 gpm and the amount of water flowing through the bedrock is approximately 10 gpm. Given that the extraction rate is close to this value suggests that pumping might be adequate for capture. However, the pumping is heavily weighted toward PW-6, and preferential pathways are likely present in other areas along the GSM that may prevent the other pumping wells from intercepting all of the contaminated water. For this reason, the results of the water budget analysis are generally confirmed with other lines of evidence such as interpretation from potentiometric surface maps and concentration trends at downgradient wells.

The potentiometric surface maps recommended in Section 4.1.1 can be used to evaluate the extent of capture for both the overburden and bedrock. The number of wells and piezometers near the GSM should provide above average resolution for illustrating both horizontal and vertical gradients. Flow lines can be drawn using these maps to indicate what areas are captured by what wells. The potentiometric surface maps may indicate that the capture zone extends beyond the extraction wells, which means that even though the gradient may not be reversed in every location, capture does extend beyond the GSM and is pulling contamination toward the wells. A review of the site plan indicates that the only two locations with sufficient data to observe gradient reversal based on water level pairs are between P4/4a and P3/3a and between P8/8a and P7/7a (other points appear to require water levels from operating extraction wells). The gradients may not be reversed in these two locations, but, once again, capture may be adequate, and the potentiometric surface maps should provide a more comprehensive indication of that capture.

One of the better indications of capture is whether or not concentrations at downgradient wells are decreasing to background concentrations. However, because concentration trend monitoring takes time, this evaluation should be accompanied by the previous two approaches (a water budget analysis and the use of potentiometric surface maps). The concentrations at monitoring wells that are in the capture zone will not decrease and should not be used for this type of evaluation. Therefore, wells such as MW-4, MW-14, MW-16, MW-17, etc. may not be appropriate. A review of the potentiometric surface maps should provide an indication if these wells are inside of the capture zone or downgradient of it. For this site, it may be most appropriate to monitor the wells in Ring 1 (e.g., the MW-40, MW-41, MW-22, MW-30, and MW-8 clusters). The new piezometers immediately downgradient of the GSM, along with the MW-04 cluster and MW-25 cluster, may or may not be appropriate for monitoring concentration trends as part of a capture zone analysis, but the MW-03 cluster is almost certainly too close to a pumping well to be outside of its capture zone and would therefore be inappropriate for monitoring concentration trends for the purpose of evaluating capture. The locations of existing monitoring wells and extraction wells are indicated in the figures (developed by the site contractors) that are attached at the end of this report.

The cost for this type of analysis should be reasonable compared with other site activities. The water budget analysis is a set of simple analytical calculations, the potentiometric contour figures (plan view and cross-section) were recommended in Section 4.1.1, and monitoring concentrations in monitoring wells is a typical exercise associated with P&T system O&M. The only additional cost is for interpreting the data from these multiple lines of evidence, forming a conclusion, and documenting the work. The above-described work could likely be done for under $10,000 at this site.

4.1.3 Increase Bedrock Extraction Rate

The preliminary water budget analysis conducted in Section 4.1.2 suggests that the current extraction rate is very close to the extraction rate required to provide capture. Given that the pumping is not uniform and preferential flow paths likely exist, it is very likely that the GSM extraction rate needs to be increased, particularly near PW-2 and PW-3. Site data suggest that the highest concentrations both at the GSM and upgradient of the GSM are in the bedrock. As a result, the RSE-lite team believes that the increased extraction should likely occur from the bedrock. There should be little concern in pulling contamination down from the overburden to the bedrock near the GSM because the contamination from the overburden (along with the contamination that is already present in the bedrock in this area) would be removed by the GSM once the extraction rate has been appropriately adjusted. The RSE-lite team agrees with Engelhard's recommendations for installing a higher capacity pump in PW-2 and for implementing a well maintenance program to reduce well fouling. If this action item does not provide adequate extraction, additional wells between PW-2 and PW-3 would likely be appropriate. This additional pumping should not significantly increase the O&M costs for the treatment plant because the highest O&M cost is associated with operator labor, which should not change with an increase in the extraction rate. If additional pumping would significantly increase O&M costs, the site team might be able to reduce pumping from PW-6, if that reduction does not compromise capture in the northern part of the GSM.

The RSE-lite has not provided estimated costs for addressing this recommendation. The RSE-lite team defers to the site team and their knowledge of site-specific costs.

4.1.4 Reconsider Increased Overburden Extraction

The RSE-lite team does not believe that enhanced extraction from the overburden is as a high priority. Concentrations at MW-14, MW-16, and MW-17 (which are bedrock and deep bedrock wells) increased shortly after the GSM came on line. As the site team suggests, the increases in these wells may result from the overburden ground water mounding behind the vertical membrane and pushing water under the membrane. However, because the GSM is in place, improving extraction in the bedrock should provide adequate capture of contaminated ground water that is migrating from upgradient in the bedrock or migrating downward from the overburden to the bedrock. Installing an overburden well screen at PW-2 would certainly result in the extraction of additional water and would not be detrimental to system operation. Therefore, although the RSE-lite team does not see this as a priority, it would not dissuade Engelhard from following through with this action item. In contrast, the RSE-lite team sees little benefit to extending the overburden well screens for PW-1 and PW-3 toward the high water table mark. This may slightly increase the yield of these wells, but the increased exposure of the well screen to air would likely increase the rate of fouling, and the concerns regarding fouling may likely exceed the benefits of increased extraction in these locations.

The RSE-lite has not provided estimated costs for addressing this recommendation. The RSE-lite team defers to the site team and their knowledge of site-specific costs.

4.1.5 Sample and Analyze for 1,4-Dioxane in Continued Source Area Investigations

The presence of high concentrations of 1,1,1-TCA makes it a possibility that 1,4-Dioxane is present at the site. The site team reports that it sampled for 1,4-Dioxane and found it to be non-detect during the 1995 RCRA Facility Investigation. As the site team continues its investigation of other source areas, it is recommended that sampling and analysis include 1,4-Dioxane, especially in the areas with the highest concentrations of 1,1,1-TCA. The added cost for this analysis should be negligible with respect to other site costs.

4.2 RECOMMENDATIONS TO REDUCE SYSTEM COST

4.2.1 Consider Eliminating the Metals Removal Equipment

The site team reports that there currently is no discharge limit for iron and manganese, and it appears that the metals removal equipment is present for removing iron and manganese to prevent fouling of downstream treatment components. The influent concentration of iron ranges from 1 mg/L to 3 mg/L (manganese concentrations are lower), and these concentrations typically do not present a problem for running an air stripper if a suitable maintenance program is in place. Such a program might involve cleaning the air stripper trays with a pressure wash wand (estimated twice per month) and periodically taking the system apart for a more thorough cleaning (potentially quarterly rather than the current semiannual frequency). This type of maintenance program is generally much less costly than running a metals removal system for less than 1 pound per day of iron (2 mg/l at 40 gpm). The elimination or bypassing of the metals removal equipment (excluding cost reductions associated with decreased labor) should reduce annual costs by about $20,000 based on the costs reported in Section 2.5 of this report for chemicals, sludge disposal, maintenance, calibration, repairs, parts, etc.). As a first step, the site team should consider bypassing the metals removal system for a period of time to test the effectiveness of the air stripper and the cleaning program in the absence of active metals removal. If successful, the site team could then consider permanently bypassing or eliminating the metals removal components of the treatment system.

4.2.2 Remove Liquid Phase GAC Units

The air stripper by itself based on the quarterly report review removes VOCs to non-detectable concentrations and based on the document review and RSE-lite conference call has appropriate failsafes. It appears that the GAC unit is not necessary for effective operation. If the GAC units are removed, the weekly bag filter change-outs, twice monthly GAC backwashes, and GAC change-outs may be eliminated. Not including labor reductions the savings in GAC and bag filter cost are estimated at approximately $2,000 per year.

Discontinuing metals removal (Section 4.2.1) and the use of GAC would remove all the labor-intensive system activities except air stripper cleaning. Even if 8 hours per week were still assumed for operation, the labor cost reduction would be approximately $40,000 per year.

4.2.3 Remove Select Monitoring Wells from Routine Sampling

As the site team becomes comfortable with the degree of capture and how it will be interpreted, a routine monitoring program should be established. It is unclear what wells the site team will choose to include, but the RSE-lite team has the following suggestions that could save costs.

Because aquifer restoration will not happen for decades, the RSE-lite team recommends a well sampling program that is geared toward evaluating plume capture and the effectiveness of monitored natural attenuation for the downgradient plume. Wells that are within the capture zone, immediately upgradient of the extraction system, or in the source area will remain contaminated and will not assist with either of these two objectives. As a result, those wells should be either eliminated from the sampling program or sampled on a relatively infrequent basis (once every year or two years). Furthermore, changes in the downgradient portion of the plume will likely occur over a relatively long time period, and annual monitoring may be appropriate.

Because a routine monitoring program has not yet been established, the potential cost savings associated with this recommendation cannot be calculated.

4.3 Recommendations for Technical Improvement

No recommendations have been made in this category.

4.4 Recommendations to Speed Site Closeout

4.4.1 Revisit MNA Criteria for the Downgradient 1,1-DCE Plume

Once the GSM is effectively controlling plume migration, the site team may want to revisit the standards associated with MNA for the downgradient plume. The GW-2 standards that EPA is apparently considering are very strict due to the 1 ug/L standard for 1,1-DCE, which are reportedly based on risks associated with potential vapor intrusion. If there are no residences or other structures that would be potentially impacted by vapor intrusion now or in the future, other criteria for VOCs (especially for 1,1-DCE) that are based on more realistic exposure points, such as use of ground water as a potential drinking water supply or discharge of ground water to surface water.

4.4.2 Continue with a Source Control/Containment Remedy

The RSE-lite team was asked to evaluate the GSM and was not provided information pertaining to ongoing investigations and pilot tests in the source area. In addition, subsequent to the RSE-lite conference call, the site team indicated to the RSE-lite team that DNAPL is present in the overburden and that multi-phase extraction has been piloted. As a result, the RSE-lite team is not providing a specific recommendation regarding the source area. Rather, the RSE-lite team provides the following thoughts for consideration by the site team. The RSE-lite team notes that ground water monitoring results suggest the presence of DNAPL in both the overburden and bedrock. While source zone remediation in the overburden may prove effective at removing contaminant mass, the RSE-lite team believes source zone remediation in the bedrock would likely be substantially more difficult and costly. When it comes to addressing DNAPL contamination in bedrock, the site team may want to focus on source zone containment with the GSM rather than pursue source zone removal.

Because the source area mass removal efforts (in both the overburden and bedrock) will not likely be sufficient reduce concentrations to the point where the GSM can be discontinued, the RSE-lite team believes the prime focus for the site team should be on upgrading the GSM and demonstrating that it is effectively capturing the plume. The RSE-lite team suggests implementing the recommendations provided in this report and moving forward with GSM upgrades rather than revisiting the already completed reports to address EPA's comments. EPA provided useful comments on the recent reports, but the RSE-lite team suggests that the feedback be considered for similar work that is conducted at the site in the future so as not to detract from making the upgrades.

Cost Summary Table

Recommendation	Reason	Estimated Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)
4.1.1 Improve Documentation and Illustration of the Site Conceptual Model	Protectiveness	$0	$2,500
4.1.2 Evaluate Current Level of Capture	Protectiveness	$10,000	$0
4.1.3 Increase Bedrock Extraction Rate	Protectiveness	Not quantified	Not quantified
4.1.4 Reconsider Increase Overburden Extraction	Protectiveness	Not quantified	Not quantified
4.1.5 Review Past Data and/or Resample for 1,4-Dioxine	Protectiveness	$0	$0
4.2.1 Eliminate Metal Removal Equipment	Cost Reduction	$0	($20,000)
4.2.2 Remove Liquid Phase GAC Units	Cost Reduction	$0	($42,000)
4.2.3 Remove Select Monitoring Wells from Routine Sampling	Cost Reduction	Not quantified	Not quantified
4.4.1 Revisit MNA Criteria for the Downgradient 1,1-DCE Plume	Site Closeout	Not quantified	Not quantified
4.4.2 Continue with a Source Control/Containment Remedy	Site Closeout	Not quantified	Not quantified

Costs in parentheses imply cost reductions.

FIGURES*

* *Prepared by the site contractor and included for reference*

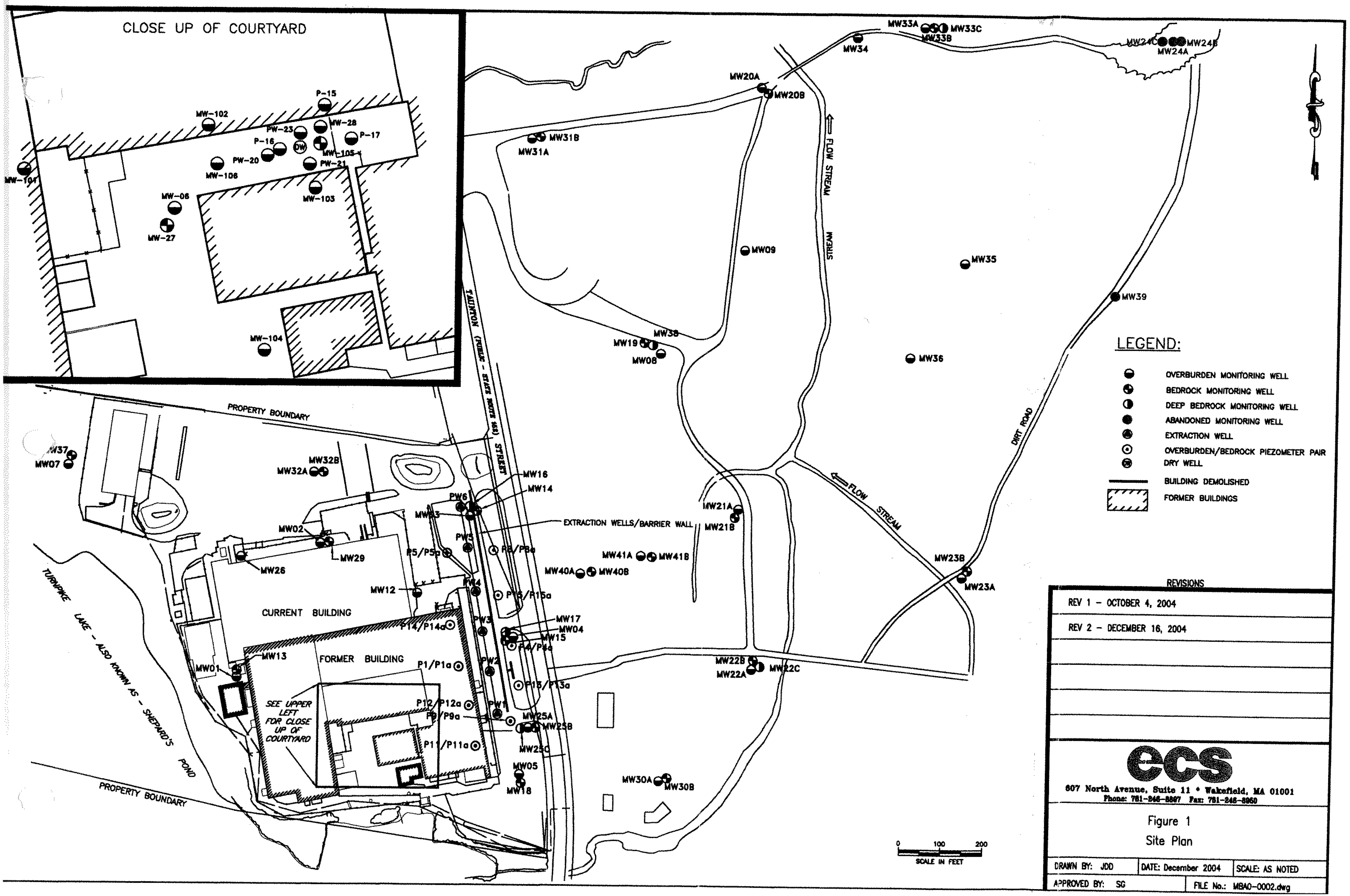

Figure 1
Site Plan

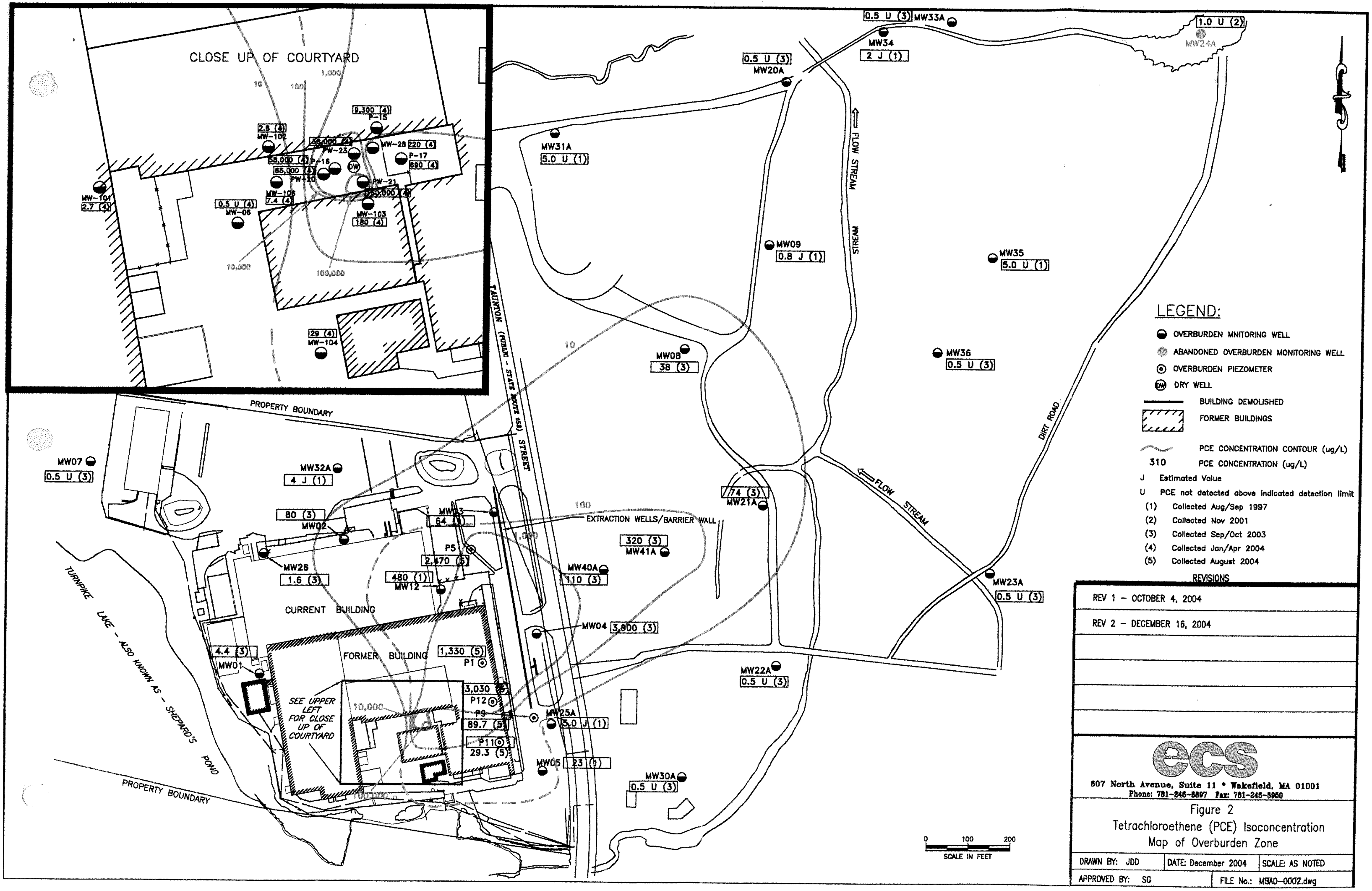

Figure 2
Tetrachloroethene (PCE) Isoconcentration Map of Overburden Zone

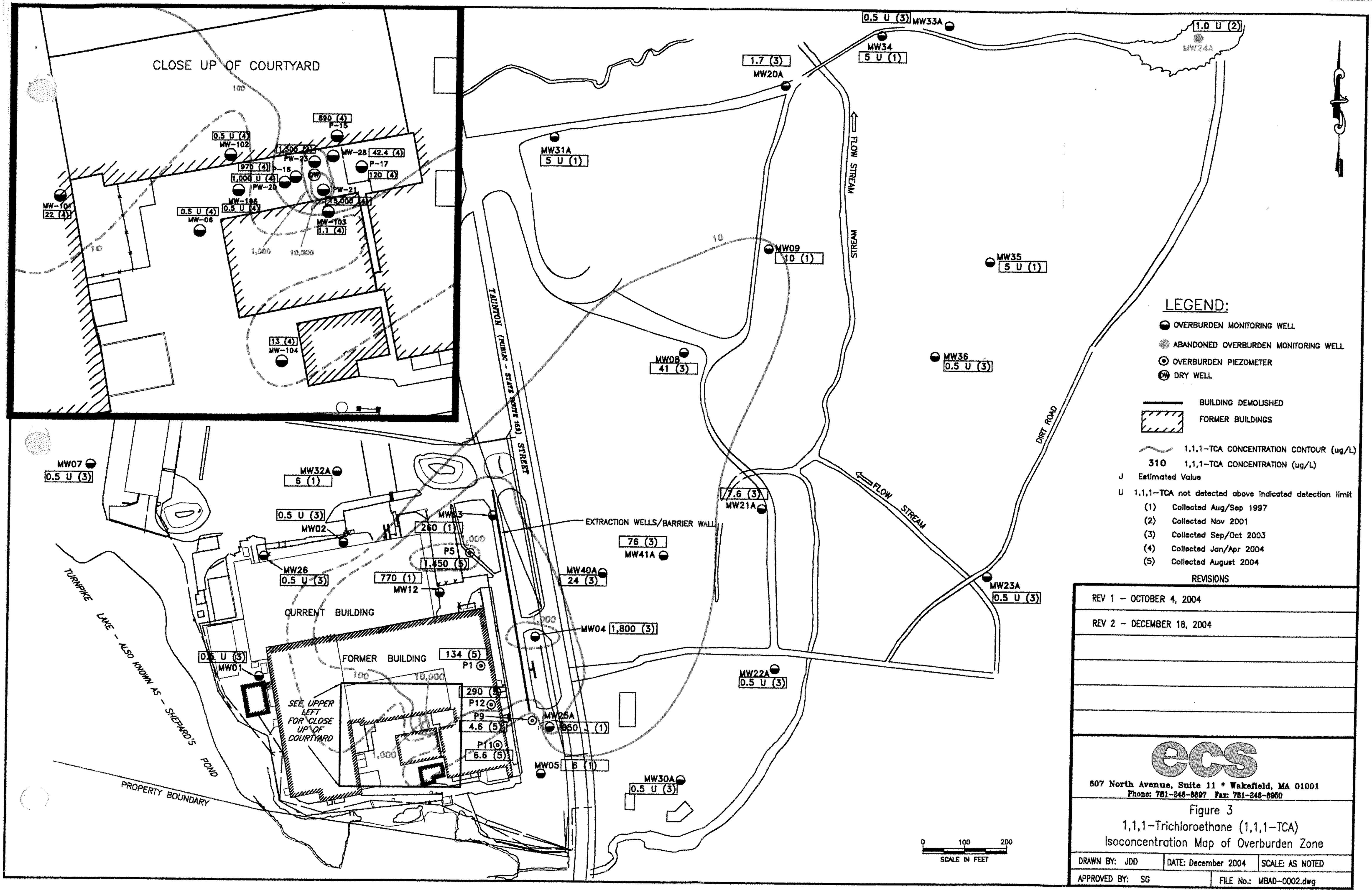

Figure 3
1,1,1-Trichloroethane (1,1,1-TCA)
Isoconcentration Map of Overburden Zone

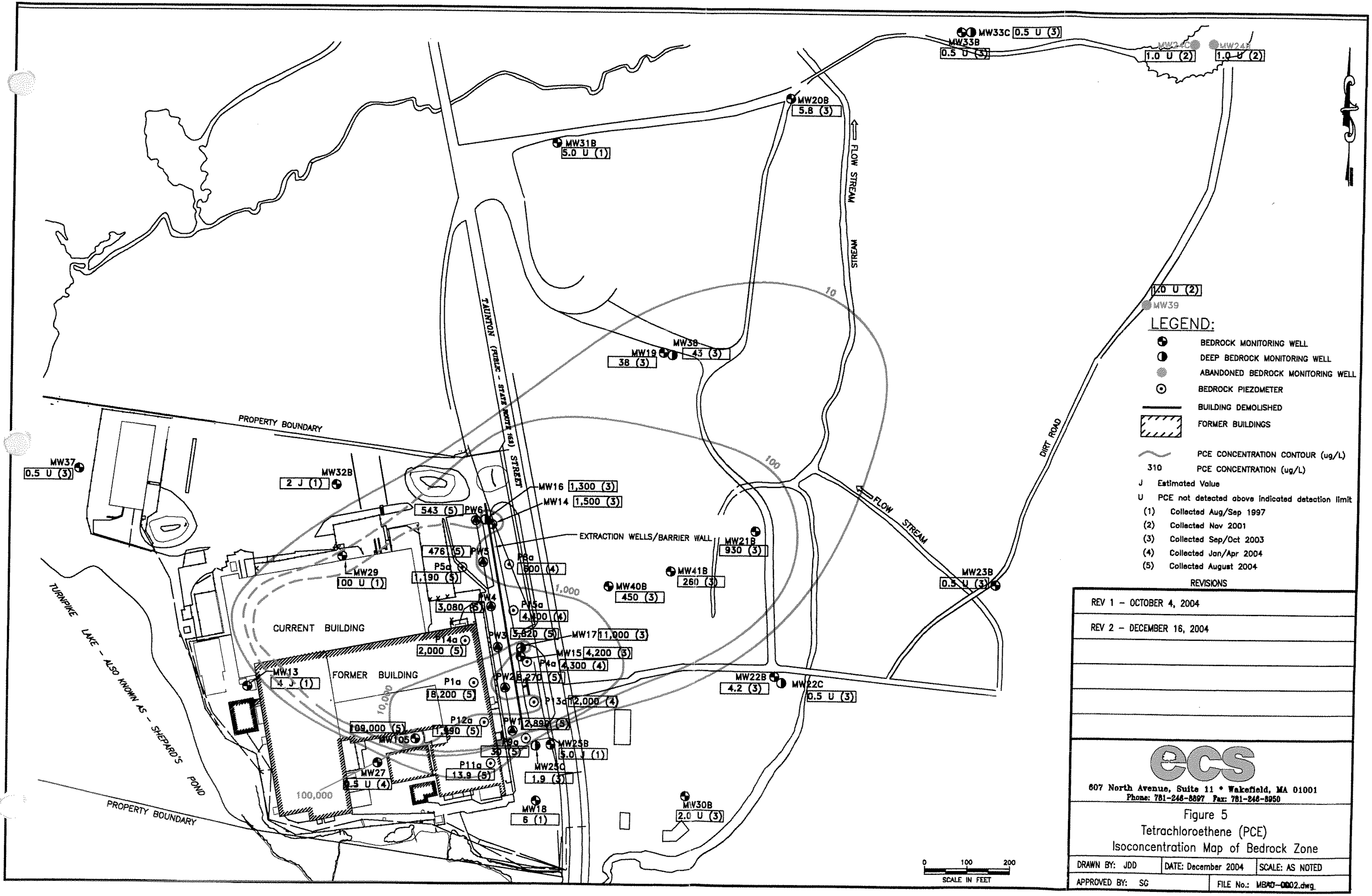

Figure 5
Tetrachloroethene (PCE)
Isoconcentration Map of Bedrock Zone

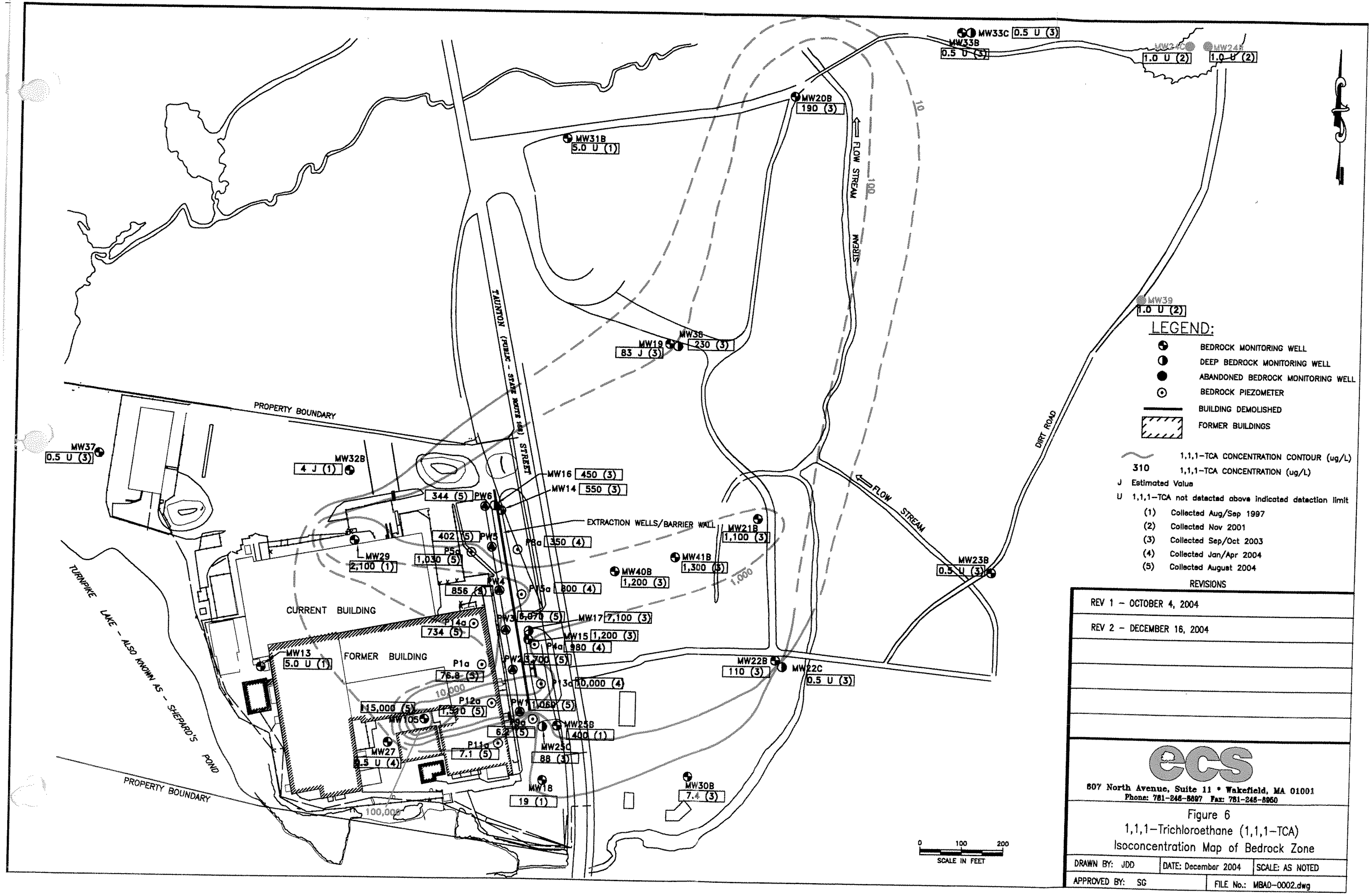

Figure 6
1,1,1-Trichloroethane (1,1,1-TCA)
Isoconcentration Map of Bedrock Zone