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Office of Solid Waste and Emergency Response
Office of Superfund Remediation and
Technology Innovation

Optimization Review
Baird & McGuire Superfund Site

Town of Holbrook, Norfolk County, Massachusetts

www.epa.gov/superfund/remedytech | www.clu-in.org/optimization | www.epa.gov/superfund/cleanup/postconstruction

OPTIMIZATION REVIEW

BAIRD & MCGUIRE SUPERFUND SITE
TOWN OF HOLBROOK, NORFOLK COUNTY, MASSACHUSETTS

Report of the Optimization Review
Site Visit Conducted at the Baird & McGuire Superfund Site on
February 28, 2012

May 17, 2013

EXECUTIVE SUMMARY

Optimization Background

The U.S. Environmental Protection Agency (EPA) defines optimization as the following:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness. Contractors, states, tribes, the public, and PRPs are also encouraged to put forth opportunities for the Agency to consider."* (1)

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews.

An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. 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 review, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the relevant State and EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

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[1] U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

Site-Specific Background

The Baird & McGuire Superfund Site is located at 775 South Street in Holbrook, Norfolk County, Massachusetts, approximately 18 miles south of Boston. The site consists of an approximately 32.5-acre parcel at the former Baird & McGuire Company, Inc. property. The property is bordered by the Cochato River to the east and by woodland areas to the north and south. The site-related contamination has included various volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, and arsenic. The site remedial activities are currently managed and funded by the Massachusetts Department of Environmental Protection (MassDEP). The site was nominated for an optimization review by MassDEP as part of a group of optimization evaluations for three long-term remedies in Massachusetts.

EPA issued three Records of Decision (ROD) for the Site, defining four operable units (OU) and describing selected remedial alternatives, as follows:

- The first ROD, issued in September 1986, specified groundwater extraction and treatment at an onsite treatment plant (OU-1) and soil excavation with treatment of the soil at an onsite incinerator and disposal of the resulting ash on-site (OU-2).

- The second ROD, issued in September 1989, addressed contamination in sediments of the Cochato River (OU-3).

- The final ROD, issued by EPA in 1990, called for reopening the Donna Road well field to replace the lost water supply resulting from contamination of the South Street well field (OU-4). An Explanation of Significant Difference (ESD) was issued in August 2003 for OU-4 stating that the reactivation of the Donna Road well field was not necessary and no further action would be taken for OU-4.

The current pump and treat (P&T) system consists of eight extraction wells (EW-2, EW-3, EW-4A, and EW-5 through EW-9), a groundwater treatment facility and four recharge basins to return treated groundwater to the aquifer. In 1996, light non-aqueous phase (LNAPL) was discovered in subsurface soil and groundwater in the central portion of the site. LNAPL recovery began in 1999 and nearly 11,000 gallons of LNAPL were recovered as of April 2004. Subsequently, LNAPL recovery via this system has diminished to increasingly negligible amounts. Due to a lack of LNAPL recovery, the LNAPL recovery system was inactivated in March 2009. Although LNAPL has subsequently been detected within the wells associated with the LNAPL system, the specific gravity of the LNAPL appears to be close to that of water indicating that all LNAPL may not be present as a distinct LNAPL layer within the well and LNAPL volumes may be higher than indicated by the LNAPL thickness in a well.

Summary of Conceptual Site Model

Operations from a chemical mixing and batching facility over a 70-year history resulted in contaminant releases to soil and groundwater from leaking above-ground and below-ground tanks, waste disposal to the land surface, and other sources. Releases of site-related contamination to the Cochato River included direct discharges from pipes, contaminated surface water runoff, contact of flood waters with waste disposal areas and discharge from groundwater to surface water. Contaminants included (but were not limited to) VOCs, SVOCs, pesticides and arsenic.

Site conditions have improved significantly due to a combination of factors that include the following:

- discontinuation of site operations by 1983
- removal actions performed by EPA
- soil excavation
- sediment excavation
- P&T operation

The remaining contamination at the site that drives current remediation efforts is the LNAPL contamination and the dissolved arsenic plume. During the site visit, the site team described the remaining LNAPL as having a specific gravity near 1.0 and as emulsified in groundwater, making LNAPL measurement and LNAPL recovery by extraction and separation difficult. Residual (immobile and unrecoverable) LNAPL is also likely still present beneath the water table through much of the area where LNAPL was identified in the 1997 investigation. The known extent of LNAPL contamination at the time of the investigation is shown in Figure B-4 in Attachment B, however, it is unclear if LNAPL was present outside of this area. The current extent of residual LNAPL is not well understood. The optimization review team speculates that LNAPL (which contains arsenic) continues to provide an ongoing source of dissolved groundwater contamination for VOCs, SVOCs and arsenic.

While concentrations of naphthalene, other SVOCs and VOCs have declined substantially throughout the site as the result of remedial activities, the dissolved arsenic plume continues to exhibit high concentrations throughout the plume. Arsenic concentrations have decreased mildly at some locations over time, but not nearly as much as the organic contaminants. The dissolved arsenic plume extends from the principal source area in the vicinity of EW-8 to the Cochato River. The optimization review team speculates that the remaining organic contamination (for example, VOCs, SVOCs, and potentially other petroleum hydrocarbons) serves as electron donor for microbes in groundwater and decreases the oxidation-reduction potential (ORP) in much of the aquifer. The optimization review team further speculates that the lower ORP contributes to mobilization of arsenic from native soils and or soil remedy ash, potentially resulting in an additional ongoing source of arsenic. To the extent these speculations are correct, as long as sufficient dissolved organic carbon is present in groundwater, widespread continuing sources of arsenic will persist.

The goal of the groundwater remedy is to return the aquifer to drinking water standards. However, much of the site is within the 100-year flood plain and or is wetlands, which limits future use of the land or underlying water resource. The Cochato River is the only media at the site that provides a current potentially complete exposure pathway to human or ecological receptors.

Summary of Findings

The following findings are either apparent in the optimization review team's interpretation of the CSM or are explicitly stated in the findings section:

- The soil remedy has significantly reduced VOC and SVOC groundwater contamination and only a few locations remain above applicable standards.

- The optimization review team speculates that residual LNAPL present throughout much of the site may continue to serve as a source of arsenic. The extent of residual LNAPL has not been fully delineated.

- The optimization review team speculates that residual LNAPL throughout much of the site may continue to serve as a source of dissolved organic carbon, resulting in low ORP.

- The optimization review team speculates that low ORP is contributing to mobilization of arsenic from native soils and soil remedy ash. Arsenic concentrations in groundwater remain elevated significantly above applicable standards.

- Significant arsenic impacts between EW-7 and EW-9 have recently been identified but contamination in this area of the site has not been definitively linked to a specific source area. Unlike other areas of elevated arsenic contamination, there are no data in that area of the site for LNAPL, VOCs, SVOCs or ORP.

- The arsenic plume may be captured in the area of EW-7, but other portions of the plume are likely not captured by the extraction system (such as near EW-9 or between EW-7 and EW-9).

- No sampling has been conducted on sediments or fish tissue in the Cochato River since 2002, thus current contaminant concentrations in river sediments and fish tissue are unknown. The effect contaminated groundwater may potentially have on river sediments and or fish tissue under pumping or non-pumping conditions is unknown.

- The groundwater extraction system is in poor and deteriorating condition. The extraction rate in 2001 was approximately 127 gallons per minute (gpm) but has decreased over time to a current extraction rate under 60 gpm, in part due to underperforming or deteriorating extraction wells. The site team notes that the construction of the monitoring wells includes dissimilar metals and the associated corrosion is causing the screen to separate from the casing. EW-5 was recently shut down due to this type of problem. EW-9 never provided the anticipated flow and typically operated at an average extraction rate of less than 1 gpm.

- The groundwater treatment system is also in deteriorating condition and has several underperforming components, although the system routinely meets regulatory discharge requirements.

- The current annual operation & maintenance (O&M) cost is approximately $900,000 per year.

Summary of Recommendations

Recommendations are provided to improve remedy effectiveness, reduce cost, provide technical improvement and assist with accelerating site closure. The recommendations in these areas are summarized below. A flowchart summarizing potential remediation scenarios associated with some of the recommendations is included in this report (Figure 6-1).

Improving effectiveness – Recommendations include the following:

- Resume fish tissue sampling (current conditions and then every five years). Specific fish types and quantities are suggested. Also, the optimization review team recommends that data quality objectives for analyzing fish tissue moving forward be clearly documented.

- Sample the Cochato River sediments under current conditions, and then annually, using the incremental sampling methodology (ISM) at each of the five stations on a move forward basis. This approach is being recommended to provide data that will allow comparison of conditions over time.

- Conduct speciation analysis for arsenic in groundwater samples from select monitoring wells to better understand arsenic mobility.

- Add laboratory analysis for total petroleum hydrocarbons (TPH) and total organic carbon (TOC) to the routine groundwater monitoring program to better correlate residual organic contamination with low ORP and high arsenic concentrations.

- Perform leaching tests on ash to better understand if ash is a continuing source of arsenic.

Reducing cost – Recommendations include the following:

- Reduce groundwater treatment plant reporting because developing both daily and weekly reports provides limited benefit to managing the site but require additional labor.

- If the existing treatment plant is going to operate for five years or less, optimize the metals removal system by adjusting the ORP and pH set points, modifying the type of oxidant used and modifying the plumbing to the clarifier. If the treatment plant is going to operate for longer, redesigning and replacing the metals removal system and other treatment components would likely be more cost effective.

- Discontinue aeration in the activated sludge units and use those units for solids settling only, because the aeration is providing little benefit to overall water treatment but is likely contributing to biofouling of the granular activated carbon (GAC) units.

- Potential long-term cost savings from remediation scenarios “A” through “D” on Figure 6-1 are also discussed. The optimization team believes the approach that likely has the greatest potential to reduce long-term (such as, life-cycle) costs is to pursue more aggressive source area remediation, because the goal of such efforts would be to ultimately eliminate the need for long-term containment which currently costs on the order of $900,000 per year for an indefinite period. A modified P&T system in the future, for example, might cost on the order of $500,000 per year. The payoff period would depend on the ultimate up-front cost of the active remediation, whether or not it is successful at eliminating the need for long-term P&T, and the avoided costs per year for long-term P&T after it is decommissioned. Note that an ultimate decision regarding a path forward (such as, the most appropriate remediation scenario) will depend on evaluation of future data collection and testing that is recommended in this optimization review report.

Technical improvement – Record and report ORP results with groundwater monitoring data so that ORP measurements can be correlated with the arsenic concentrations.

Site closure – Recommendations include the following:

- Determine if the primary focus of the response to this site going forward will be additional soil and groundwater source remediation or continue to operate and improve the existing containment remedy.

    - If the primary focus is to continue with the containment remedy, the optimization review team believes that significant up-front modifications to the current P&T system in the short term will be required, due to the expectation of long-term P&T operation for a containment-focused remedy. In addition, definition of a target capture zone, a capture zone evaluation and several improvements to the extraction system will be needed.

  - If the primary focus is additional aggressive source area remediation (to avoid the need for long-term migration control), the primary objective would be to address the organic contamination, including residual LNAPL that the optimization review team speculates is 1) serving as a continuous source of arsenic and 2) is causing low ORP that allows arsenic to remain mobile and may mobilize arsenic from site soils. Based on current information, the optimization review team believes *in situ* chemical oxidation (ISCO) may be an appropriate technology for the source area due to the relatively low upfront costs (as compared to other technologies) and the ability to adjust the level of effort and costs based on remedy performance.

- If additional aggressive source area remediation is to be pursued, pilot testing and LNAPL characterization is suggested to evaluate the feasibility and cost of full-scale source area remediation. Also, considerations are provided regarding migration control during the period of aggressive source area remediation (for example, no P&T, limited P&T extraction, expanded P&T extraction).

Green Remediation – No green remediation recommendations are provided. Recommendations are focused on remedial effectiveness and remedial strategy. Green remediation practices can be considered once the site team has decided on the optimal remedial approach.
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NOTICE

Work described herein was performed by Tetra Tech for the U.S. Environmental Protection Agency (EPA). Work conducted by Tetra Tech, including preparation of this report, was performed under Work Assignment 2-58 of EPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the United States Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) (2). The project contacts are as follows:

Organization	Key Contact	Contact Information
EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Kirby Biggs	EPA Technology Innovation and Field Services Division 1200 Pennsylvania Ave., NW (5203P) Washington, DC 20460 biggs.kirby@epa.gov phone: 703-823-3081
Tetra Tech, Inc. (Contractor to EPA)	Jody Edwards, P.G.	Tetra Tech 1881 Campus Commons Drive, Suite 200 Reston, VA 20191 jody.edwards@tetratech.com phone: 802-288-9485
	Doug Sutton, PhD, P.E.	Tetra Tech 2 Paragon Way Freehold, NJ 07728 phone: 732-409-0344 doug.sutton@tetratech.com

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[2] U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

LIST OF ACRONYMS

µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
Amsl	above mean sea level
ARARs	applicable or relevant and appropriate requirements
AS/SVE	air sparging / soil vapor extraction
bgs	below ground surface
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CHES	Clean Harbors Environmental Services
COC	chemical of concern
CSIA	compound specific isotope analysis
CSM	conceptual site model
DDT	dichlorodiphenyltrichloroethane
DEQE	Department of Environmental Quality Engineering
DU	decision unit
EDR	Environmental Data Resources Inc.
EPA	United States Environmental Protection Agency
ERT	Environmental Response Team
ESD	Explanation of Significant Difference
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act of 1947
FS	feasibility study
ft	feet
ft^2	feet squared
ft^3	cubic feet
FYR	Five Year Review
GAC	granular activated carbon
gpm	gallons per minute
GWTF	groundwater treatment facility
HHRA	human health risk assessment
HI	hazard index
HP	horsepower
IC	institutional controls
ISCO	*in situ* chemical oxidation
ISM	incremental sampling methodology
ISTT	*in situ* thermal treatment
ITRC	Interstate Technology Regulatory Council
K	hydraulic conductivity
LNAPL	light non-aqueous phase liquid

LTM	long term monitoring
LTRA	Long-Term Response Action
MassDEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant limit
MCP	Massachusetts Contingency Plan
MGD	millions of gallons per day
mg/kg	milligrams per kilogram
MSL	mean sea level
MTCA	Model Toxics Control Act
MTL	materials testing laboratory
MW	monitoring well
NPL	National Priorities List
O&M	Operation & Maintenance
ORP	oxidation reduction potential
OSRTI	Office of Superfund Remediation and Technology Innovation
OU	operable unit
P&T	pump and treat
PAH	polycyclic aromatic hydrocarbon
PCE	tetrachloroethylene (perchloroethylene)
PLC	programmable logic controller
PRP	potentially responsible party
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAO	remedial action objective
RG	remediation goal
RI	remedial investigation
ROD	Record of Decision
RSE	remedial system evaluation
SDWA	Safe Drinking Water Act
SIM	selected ion monitoring
SPLP	synthetic precipitation leaching procedure
SU	sampling unit
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
TAB	Technical Assistance to Brownfields
TCE	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TIFSD	Technology Innovation and Field Services Division
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 independent site optimization reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and various States). Due to the opportunities for system optimization that arose from those RSEs, U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *OSWER Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, EPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). EPA has since expanded the definition of optimization to encompass investigation stage optimization using Triad Approach best management practices (BMP), optimization during design, RSEs and long-term monitoring optimization (LTMO). EPA defines optimization as the following:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness. Contractors, states, tribes, the public, and PRPs are also encouraged to put forth opportunities for the Agency to consider."* (3)

As stated in the definition, optimization refers to a "systematic site review," indicating that the site as a whole is often considered in the review. Optimization can also be applied to a specific aspect of the remedy (for example, focus on LTMO or focus on one particular operable unit [OU]), but other site or remedy components are typically considered to the degree that they affect the focus of the optimization. An optimization review typically considers the goals of the remedy, available site data, CSM, remedy performance, protectiveness, cost-effectiveness and closure strategy.

A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, OSRTI has developed a *Methodology for Understanding and Reducing a Project's Environmental Footprint* and supporting *Spreadsheets for Environmental Footprint Analysis* (SEFA) to assist the conduct of environmental footprint analyses for site cleanup (www.cluin.org/greenremediation), and now routinely considers green remediation and environmental footprint reduction during optimization reviews.

The optimization review includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness

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[3] U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. 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, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the State of Massachusetts, the Region, and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization review recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA OSRTI.

The Baird & McGuire Superfund Site is located at 775 South Street in Holbrook, Norfolk County, Massachusetts, which is approximately 18 miles south of Boston. Figure 1 of the 4th Quarter 2011 Quarterly Extraction Well Report (see Attachment A) indicates the general site location. The site consists of an approximately 32.5-acre parcel at the former Baird & McGuire Company, Inc. property. The property is bordered by the Cochato River to the east and by woodland areas to the north and south. The site-related contamination has included various volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, and arsenic. The site remedial activities are currently managed and funded by the Massachusetts Department of Environmental Protection (MassDEP). The site was nominated for an optimization review by MassDEP as part of a group of optimization evaluations for three long-term remedies in Massachusetts.

1.2 TEAM COMPOSITION

The optimization review team consisted of the following individuals:

Table 1-1. Optimization Review Team Members

Name	Affiliation	Phone	Email
Rob Greenwald	Tetra Tech GEO	732-409-0344	Rob.Greenwald@tetratech.com
Peter Rich	Tetra Tech GEO	410-990-4607	Peter.Rich@tetratech.com
John Schaffer	Tetra Tech GEO	973-630-8530	John.Schaffer@tetratech.com
Doug Sutton	Tetra Tech GEO	732-409-0344	Doug.Sutton@tetratech.com

The following individuals from the EPA OSRTI also participated in the optimization site visit:

- Kathy Yager
- Ed Gilbert
- Gary Newhart

1.3 DOCUMENTS REVIEWED

The following site documents were reviewed. The reader is directed to these documents for additional site information not provided in this report.

- *Remedial Investigation Report, Baird & McGuire Site, Holbrook, MA; Volume I* (GHR Engineering Associates, Inc. – May 22, 1985)
- *Remedial Investigation Report, Baird & McGuire Site, Holbrook, MA; Volume II* (GHR Engineering Associates, Inc. – May 22, 1985)
- *Remedial Investigation Report, Baird & McGuire Site, Holbrook, MA; Volume III* (GHR Engineering Associates, Inc. – May 22, 1985)
- *Draft Addendum Report, Remedial Investigation Phase II Baird & McGuire Site* (GHR Engineering Associates, Inc. – April 4, 1986)
- *Draft Feasibility Study Report, Baird & McGuire Site* (GHR Engineering Associates, Inc. – April 4, 1986)
- *Record of Decision, Remedial Alternative Selection* (EPA Region 1 – September 29, 1986)
- *Record of Decision Summary, Baird & McGuire Site/Sediment Study Area* (EPA Regions 1 – September 14, 1989)
- *Site Maintenance Plan for the Baird & McGuire Groundwater Treatment Plant Extraction/Recharge System* (Metcalf & Eddy, Inc. – February 25, 1989)
- *Final Focused Feasibility Study, Baird & McGuire Site, Cochato River Sediment* (EPA – June 1989)
- *Evaluation of Extraction System Performance at the Baird & McGuire Superfund Site* (Metcalf & Eddy, Inc. – July 1995)
- *Baird & McGuire Superfund Site Operating Unit #3 Monitoring Results* (Environmental Engineering and Hydraulics Branch Water Control Division Engineering Directorate, Department of the Army – September 1996)
- *Light Non-Aqueous Phase Liquid Field Investigation Summary Report* (McCulley, Frick & Gilman, Inc. – January 30, 1998)
- *Evaluation of Potential Future Reuse Opportunities for the Baird & McGuire Site* (Metcalf & Eddy, Inc. – June 5, 1998)
- *Potential for Advection of Volatile Organic Compounds in Ground Water to the Cochato River, Baird & McGuire Superfund Site, Holbrook, Massachusetts, March and April 1998* (Jennifer G. Savoie, Forest P. Lyford, USGS and Scott Clifford, EPA – 1999)
- *Results of Third Year of Long-Term Monitoring of Sediments and Soils at Baird & McGuire* (Department of the Army, New England District, Corps of Engineers – January 1999)
- *Fish Ingestion Risk Assessment, Baird and McGuire* (Office of Research and Standards, DEP – January 7, 1999)
- *Draft Interim Interpretive Report for Cochato River Sampling and Analysis, Holbrook, MA* (Battelle – May 31, 2000)

- *Data Evaluation Report for Cochato River Sampling in November 2001* (Metcalf & Eddy – July 2002)
- *Data Evaluation Report for Cochato River Sampling in November 2001, Appendices* (Metcalf & Eddy – July 2002)
- *Site Maintenance Plan (August 28, 2003)*
- *Evaluation of Groundwater Remediation Progress at the Baird and McGuire Superfund Site* (Metcalf & Eddy, Inc. – September 2003)
- *Data Evaluation Report for Cochato River Sampling in September/October 2002* (Metcalf & Eddy, Inc. – November 2003)
- *Data Evaluation Report for Cochato River Sampling in September/October 2002; Appendices* (Metcalf & Eddy, Inc. – November 2003)
- *Trend Evaluation Report for the Baird and McGuire Superfund Site, Holbrook, Massachusetts* (Metcalf & Eddy, Inc. – September 2004)
- *Evaluation of Groundwater Remediation Progress at the Baird & McGuire Superfund Site* (Metcalf & Eddy, Inc. – October 2004)
- *Explanation of Significant Difference, Baird & McGuire Superfund Site, Holbrook, MA, Operable Units 1 and 2, Groundwater and Source Control Remedies* (EPA – April 6, 2005)
- *Baseline Report for Operable Unit-1 at the Baird & McGuire Superfund Site, Final Draft* (SAIC Engineering, Inc. – December 2005)
- November 02, 2007 LNAPL Analysis (GeoLabs, Inc.)
- *Third Five-Year Review Report* (EPA Region 1 – September 29, 2009)
- *Quarterly Extraction Well Report, 1st Quarter 2011* (Clean Harbors Environmental Services, Inc. – Draft April, 2011)
- *Quarterly Extraction Well Report, 4th Quarter 2010* (Clean Harbors Environmental Services, Inc. – May 9, 2011)
- *Arsenic Summary Investigation Report – Part II/IIA, Baird & McGuire Superfund Site* (Clean Harbors Environmental Services, Inc. – Draft August 2011)
- *Limited Subsurface Investigation, Baird and McGuire, Holbrook, MA* (Pine & Swallow Environmental – August 3, 2011)
- Monitoring Well Analytical Results July 2010 (Clean Harbors Environmental Services – August 23, 2011)
- *Quarterly Extraction Well Report, 2nd Quarter 2011* (Clean Harbors Environmental Services, Inc. – Draft September, 2011)
- *Quarterly Extraction Well Report, 3rd Quarter 2011* (Clean Harbors Environmental Services, Inc. – Draft October 12, 2011)
- November 11, 2011 LNAPL Analysis (GeoLabs, Inc.)
- December 5, 2011 LNAPL Analysis (Columbia Analytical Services, Inc.)
- Monitoring Well Analytical Results July 2011 (Clean Harbors Environmental Services – January 15, 2012)

- *Evaluation of Groundwater Remediation Progress, Annual Report – Operable Unit-1, October 1, 2009 through September 30, 2010* (Clean Harbors Environmental Services, Inc. – February 28, 2012)
- *Quarterly Extraction Well Report, 4th Quarter 2011* (Clean Harbors Environmental Services, Inc. – March 21, 2012)

1.4 QUALITY ASSURANCE

This optimization review utilized existing environmental data to interpret the CSM, evaluate remedy performance and make recommendations to improve the remedy. The quality of the existing data is evaluated by the optimization review team prior to using the data for these purposes. The evaluation for data quality included a brief review of how the data were collected and managed (where practical, the site QAPP was considered), the consistency of the data with other site data, and the use of the data in the optimization review. Data that were of suspect quality were either not used as part of the optimization review or were used with the quality concerns noted. Where appropriate, this report provides recommendations made to improve data quality.

1.5 PERSONS CONTACTED

A site visit was conducted on February 28, 2012. In addition to the optimization review team, the following persons were present for the site visit:

Table 1-2. Site Visit Attendees

Name	Affiliation	Email Address
Dorothy Allen	MassDEP (DEP RPM)	dorothy.t.allen@state.ma.us
Kimberly White	EPA Region 1 (EPA RPM)	white.kimberly@epa.gov
Jay Naparstek	MassDEP	
Steve Mahoney	MassDEP	
Paul Craffey	MassDEP	
Maggie DeLegorete	Clean Harbors Environmental Services (CHES)	
Lisa Irwin	CHES	
John Irwin	CHES	
Derrick Golden	EPA Region 1 (Regional Optimization Liaison)	
Margaret McDonough	EPA Region 1	
Kathy Yager	EPA TIFSD	
Ed Gilbert	EPA TAB	
Gary Newhart	EPA ERT	

Email contact information is provided for the site managers only. Communication with other participants can be coordinated through the site managers.

CHES operates the current treatment plant under contract to MassDEP. CHES also performs long-term groundwater monitoring under contract to MassDEP. Ed Gilbert and Gary Newhart from EPA were present as observers.

2.0 SITE BACKGROUND

2.1 LOCATION

The Baird & McGuire Superfund Site is located at 775 South Street in Holbrook, Norfolk County, Massachusetts, approximately 18 miles south of Boston. Figure 1 of the 4th Quarter 2011 Quarterly Extraction Well Report (see Attachment A) indicates the general site location. Figure 2 of the same report (see Attachment A) provides a site plan with well locations. The site consists of an approximately 32.5-acre parcel at the former Baird & McGuire Company, Inc. property. The property is bordered by the Cochato River to the east and by woodland areas to the north and south. The west side of the site is adjacent to South Street, which contains both residential and commercial properties. For the purpose of increased security and access control measures during remedial actions, additional fencing was constructed in some areas beyond the site boundary (for example, around the groundwater treatment plant, recharge basins and beyond the southern site boundary).

Ground elevations range from approximately 170 feet (ft) above mean sea level (MSL) on the southwest corner of the site to approximately 130 ft above MSL to the northeast and in the central portions of the site. From the west central portion of the site, the topography slopes down to approximately 119 ft above MSL on the east side of the site at the Cochato River. Wetlands are present in portions of the site. An unnamed brook, flowing from west to east across the northern portion of the site, drains into the wetland area in the central portion of the site. The wetlands and unnamed brook discharge into the Cochato River. Based on a wetland boundary delineation conducted during the remedial investigation (RI), wetlands occupied approximately 44 percent of the site, and 66 percent of the site was determined to be within the 100-year floodplain.

2.2 SITE HISTORY

2.2.1 HISTORIC LAND USE AND OPERATIONS

Baird & McGuire Inc. operated a chemical mixing and batching facility from 1912 to 1983. Manufactured products included herbicides, pesticides, disinfectants, soaps, floor waxes and solvents. Waste disposal methods at the site included direct discharge into the soil, a nearby brook and wetlands and a former gravel pit in the eastern portion of the site. Underground disposal systems were also used.

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

The third Five-Year Review states:

> "*The state became involved between 1954 and 1977 and fined the company at least thirty-five times for violations of the Federal Insecticide, Fungicide and Rodenticide Act of 1947 (FIFRA). In 1981 and 1982 the Massachusetts Department of Environmental Quality Engineering (DEQE) documented a number of questionable disposal practices. Baird & McGuire Inc. performed voluntary remedial actions from February to April of 1982. In May 1982, the Board of Selectmen of Holbrook revoked Baird & McGuire's permit to store chemicals at the site and ordered that existing storage facilities be dismantled. As a result,*

> *operations were terminated. Operations at the site resulted in contamination of groundwater, surface water, soil, and river sediments by organic and inorganic compounds, pesticides, and herbicides*."

A hydrological study was completed by EPA which initiated some removal actions in 1983. These actions included the removal of 1,020 cubic yards of contaminated soil, 1 ton of waste creosote, 25 gallons of waste coal tar, 155 pounds of solid hazardous waste and 47 drums of flammable liquids and solids and 2 drums of corrosives. EPA also oversaw construction of a clay cap, installation of a groundwater interception-recirculation system, and erection of fencing. The site was added to the National Priority List (NPL) on September 8, 1983. EPA constructed a security fence in July 1985 to enclose the site.

A Remedial Investigation/Feasibility Study (RI/FS) (I985/1986a, GHR) identified and described the presence of a groundwater contamination plume originating from the Baird & McGuire property and extending beyond the Cochato River. EPA issued three Records of Decision (ROD) for the site, defining four operable units (OU) and describing selected remedial alternatives, as follows:

- The first ROD, issued in September 1986, specified groundwater extraction and treatment at an onsite treatment plant (OU-1) and soil excavation with treatment of the soil at an on-site incinerator, and disposal of the resulting ash on-site (OU-2).

- The second ROD, issued in September 1989, addressed contamination in the sediments of the Cochato River (OU-3).

- The final ROD, issued by EPA in 1990, called for reopening the Donna Road well field to replace the lost supply resulting from contamination of the South Street well field (OU-4).

The following are brief summaries describing the remedies for each OU:

OU-1: Groundwater. The site remediation program for impacted groundwater at OU-1 has been in continuous operation since January 1994 and is ongoing. The current system consists of eight extraction wells (EW-2, EW-3, EW-4A and EW-5 through EW-9), a groundwater treatment facility and four recharge basins to return treated groundwater to the aquifer. In 1996, light non-aqueous phase liquid (LNAPL) was discovered in subsurface soil and groundwater in the central portion of the site. LNAPL recovery began in 1999 and nearly 11,000 gallons of LNAPL were recovered as of April 2004. Subsequently, LNAPL recovery via this system has diminished to increasingly negligible amounts. Due to a lack of LNAPL recovery, the LNAPL recovery system was inactivated in March 2009. Although some LNAPL has subsequently been detected within the wells associated with the LNAPL system, the specific gravity of the LNAPL appears to be close to that of water indicating that all LNAPL may not be present as a distinct LNAPL layer within the well and LNAPL volumes may be higher than indicated by the LNAPL thickness in a well.

- *OU-2: Soil*. The source control remedy (removal and treatment of contaminated soils) commenced in June 1995 and was completed in July 1997. Source removal involved the excavation and onsite thermal incineration of approximately 248,000 tons of contaminated soil and sediment. The thermally-processed soil from the thermal incineration process was emplaced onsite by backfilling an excavation area of approximately 12.5 acres within the central portion of the Site (M&E 1995). All soils excavation and treatment facilities have been decommissioned and removed and remediation of onsite soil is considered complete.

- *OU-3: Sediments in Cochato River*. The remedy for OU-3 involved removal of contaminated sediments from the Cochato River. This remedy commenced in May 1994 and was completed in June 1995. Sediments were dredged to a minimum depth of 6 inches and a maximum depth of 24 inches along a 2,100-foot reach of the Cochato River. A total of 4,712 cubic yards of sediments were removed. A small portion of the riverbed where contaminated groundwater was suspected to discharge to the river was backfilled with clean organic fill (approximately 438 cubic yards). The ROD also required erosion control, wetlands restoration, placement of organic fill in the excavated areas of the river in the vicinity of the groundwater plume and long-term monitoring of downstream portions of the river where sediments were not excavated. To minimize the disruption of wetlands, sediments were not to be removed from areas of the river where contaminant concentrations were low, calculated risks were low and no impacts were observed. Remediation of Cochato River sediment is considered complete. In accordance with the ROD for OU-3, long-term monitoring is to be conducted to evaluate remaining contaminant levels and their behavior over time (EPA, 1989).

- *OU-4: Replace Water Supply Due to Closing of South Street Municipal Well Field*. The remedy for OU-4 called for reopening the Donna Road well field to replace the lost supply resulting from contamination of the South Street municipal well field. On August 21, 2003, an Explanation of Significant Differences (ESD) document was issued for the groundwater remedy (OU-1) specified in the 1986 ROD. The ROD was changed to include excavation of approximately 400,000 cubic yards of soil from the Upper Reservoir/Great Pond located in Braintree and Randolph to provide additional storage capacity, resulting in an estimated additional supply of 0.31 million gallons per day (MGD) to be used in the interim to supplement the community's drinking water until the groundwater remedial action was complete. An ESD was also issued in August 2003 for OU-4 stating that, due to expansion of the water capacity in the Upper Reservoir/Great Pond, the reactivation of the Donna Road well field was not necessary, and no further action would be taken for OU-4.

Thus, the only OU with continuing active remediation is OU-1 (with ongoing monitoring anticipated for OU-3). Until June 2004, EPA was responsible for the long-term response action (LTRA) at OU-1, including the P&T system, monitoring (groundwater, surface water, sediment, fish and wetlands), evaluation of long-term protectiveness of the remedies and the need for institutional controls (ICs). In June 2004, after the 10 year LTRA period, MassDEP assumed responsibility for operations and maintenance (O&M) of the OU-1 remedy. In 2005, EPA issued an ESD to incorporate comprehensive ICs into the OU-1 and OU-2 remedies.

2.3 POTENTIAL HUMAN AND ECOLOGICAL RECEPTORS

Site documents indicate that exposure to contaminated groundwater, soil, sediments and fish tissue are the primary potential pathways for human exposure to site-related contamination. The third Five-Year Review indicates that exposure to contamination from the vapor intrusion (VI) pathway could be a concern if contamination remains in place and the site is developed, but also notes that site development may be discouraged because much of the site is within the 100-year flood plain and or is wetlands. Based on previous site documents, human risks associated with exposure to surface water were determined to be sufficiently low to be protective of human health and the environment either due to low levels of contamination or incomplete exposure pathways.

2.4 EXISTING DATA AND INFORMATION

The information provided in this section is intended to represent data already available from existing site documents. Interpretations included in this section are generally interpretations from the documents from which the information was obtained. The optimization review team's interpretation of this data is discussed in Sections 4.0 and 5.0.

2.4.1 SOURCES OF CONTAMINATION

Baird & McGuire, Inc. was a chemical mixing and batching company that operated from 1912 to 1983. The most prominent site-related contaminants currently observed in groundwater are arsenic, SVOCs (primarily naphthalene), and pesticides. VOCs are present but are below cleanup standards in most sampling locations. Contamination stems from plant operations as well as disposal components and practices that included:

- laboratory sinks that drained indirectly to a nearby surface water
- storage tanks overflowed and leaked
- an uncovered "beehive" cesspool
- an unlined and undiked tank farm,
- breach of a creosote collection lagoon

Although these aboveground sources have been addressed by historic remedial activities, ongoing sources of groundwater contamination likely remain in the subsurface. LNAPL, in the form of free and or residual product, and contaminated saturated soil beneath the soil excavation remedy likely serve as potential continuing sources for SVOCs, pesticides and arsenic (that is, the LNAPL contains SVOCs, pesticides and arsenic). In addition, buried soil and ash from previous site excavation and incineration have elevated arsenic concentrations (incineration did not removed or destroy the arsenic) and may serve as a continuing source of arsenic to groundwater under certain conditions.

2.4.2 GEOLOGY SETTING AND HYDROGEOLOGY

Prior to site excavation, the subsurface at the Baird & McGuire site was mainly glacial outwash overburden which extended from the surface to fractured bedrock at an elevation of approximately 129 ft above MSL to the west and approximately 20 ft above MSL to the east. Maps of bedrock elevation are provided in Figures 7 and 7a of a 1985 geophysical investigation (GHR, 1985/1986a), and geologic cross-sections are presented in Figures 4-1, 4-2, and 4-3 of the RI (see Attachment A). The majority of the glacial outwash is fine to coarse sand underlain by glacial till. Fine sands and silt underlay the river. In the wetland and topographically low areas of the site, the glacial deposits are overlain by organic soils. In the eastern portion of the site, near the Cochato River, the total thickness of overburden material is approximately 50 ft (GHR 1986).

Based on information in the FS (GHR, 1985/1986a), average values of hydraulic conductivity of the principal overburden units at the site are 1×10^{-3} centimeters per second (cm/sec) for silty sands, sand and silt; 1.6×10^{-2} cm/sec for fine to medium and fine to coarse grained sands; and 3.5×10^{-3} cm/sec for glacial till. The RI reported that hydraulic conductivity of bedrock fractures from packer testing ranged from 3.3×10^{-3} cm/sec to 7.0×10^{-1} cm/sec, indicating variability in bedrock competence. The vertical extent of fractured bedrock is also variable, ranging from a few ft in many areas to significantly deeper in other areas. The ash from excavation and onsite incineration was re-deposited onsite to reshape the landscape similar to its prior geomorphology. During the optimization review site visit, it was stated that the ash is highly heterogeneous, and no tests to date have been performed on the permeability of the backfilled ash. It was also stated that the "ash" primarily consists of native soil particles and materials that were not combusted and, thus may give a false impression that the material is very fine clay-like material.

Groundwater elevations at the site range from approximately 130 ft above MSL in the west to approximately 120 ft above MSL in the east, with flow toward the Cochato River. Depth to groundwater in the area of OU-1 ranges from the ground surface (adjacent to the river and in the wetlands) to approximately 50 ft below ground surface (bgs) near EW-8. The P&T system is intended to capture impacted groundwater prior to discharge to the Cochato River, but no detailed capture zone evaluation (including full plume delineation) is available to adequately determine the extent of hydraulic capture that is currently achieved. Potentiometric surface maps prepared by CHES for overburden and bedrock under pumping are presented in Figures 3 and 4 from the 4th Quarter 2011 Quarterly Extraction Well Report (see Attachment A).

Site hydrogeology is described further in Sections 4.0 and 5.0.

2.4.3 GROUNDWATER CONTAMINATION

Recent sampling, including the July 2011 sampling event, indicates that naphthalene is the predominant SVOC remaining in groundwater. Figure B-1 in Attachment B illustrates the extent of SVOCs sampling in July 2011. Figure B-2 in Attachment B illustrates the extent of arsenic contamination in groundwater in July 2011. Figure B-3 in Attachment B illustrates the extent of pesticides in groundwater in July 2011. Each of these figures also indicates the monitoring wells that had observable LNAPL in 2009 or 2010. VOCs were detected in several site monitoring wells at concentrations less than an order of magnitude above their respective cleanup standards.

LNAPL extent and thickness was investigated in 1997 (see Figure B-4 in Attachment B). Direct-push borings, temporary piezometers and monitoring wells were used in addition to visual observation, photoionization detectors, Sudan dye, and ultraviolet (UV) fluorescence. Focus was placed on evaluating the extent of measurable LNAPL in the interval from 6 ft above to 4 ft below the water table. Significant LNAPL collection has occurred since this time. Although the extent of measureable, mobile LNAPL is limited based on current gaging events (for example, Figure B-4 in Attachment B also indicates the limited observations of LNAPL between October 2009 and September 2010), there may still be significant extent of residual LNAPL.

2.4.4 COCHATO RIVER SEDIMENT/SOIL AND SURFACE WATER CONTAMINATION

Based on site reports, sediment/soil and surface water sampling events have included:

- Sediments sampled in 1996, 1997, and 1998 by the U.S. Army Corps of Engineers (USACE).
- Sediments and fish sampled in 1999 by Battelle under contract to USACE.
- Sediment, surface water and fish sampling was taken over by M&E under contract to EPA in 2000.
- Sediment, surface water and fish sampling performed by M&E in 2001 and 2002.
- Three surface water samples (RS-1 through RS-3) were collected from the Cochato River in conjunction with the annual sampling event that began on July 26, 2010. Sample RS-1 was

> collected upstream of the site’s property line as a background sample for arsenic analysis; sample RS-2 was collected approximately 25 ft downstream from monitoring well MW97-10 for arsenic analysis; and sample RS-3 was collected from the river at a location approximately even with monitoring well BM-31B and analyzed for pesticides. The samples were collected using a peristaltic pump and dedicated tubing for each sample location. No detectable concentrations above the respective detection levels were reported, and the detection limits were all below the Maximum Contaminant Level (MCL) or GW-1 Standard.

Contaminants of concern detected in Cochato River sediments within the project area include VOCs, polynuclear aromatic hydrocarbons (PAHs) (which are a subset of SVOCs), pesticides (including dichlorodiphenyltrichloroethane [DDT] and chlordane), and arsenic. Sediments and fish tissue sampling in the Cochato River have not occurred since 2002. However, sediment and surface water sampling was conducted in 2011 for arsenic in the unnamed brook at the site that discharges to the Cochato River.

The Third Five-Year Review states:

> *“The second five-year review concluded that there was likely negligible risk to human recreational receptors exposed to surface water impacted by the site, based on sampling data collected in 2000. No further surface water sampling was recommended based on this conclusion. Surface water data from 2000 are compared…to 2009 tap water risk-based screening levels (EPA, 2009), adjusted upward by a factor of 40 to account for differential ingestion of tap water and surface water while swimming (2 liters per day for tap water vs. 0.05 liters per swimming event). This comparison confirms that there is negligible risk associated with surface water exposure and corroborates the 2004 conclusion that no further surface water sampling is required.”*

Sediment sampling results are discussed further in Sections 4.0 and 5.0.

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

The information provided in this section is intended to represent information already available from existing site documents. Interpretation included in this section is generally interpretation from the document from which the information is obtained. The optimization review team's interpretation of this information and evaluation of remedy components are discussed in Sections 4.0 and 5.0 of this report.

3.1 REMEDY AND REMEDY COMPONENTS

3.1.1 SOIL REMEDIATION

The Third Five-Year Review describes the implemented soil remedy (OU-2 remedy) as follows:

> The source control remedy (removal and treatment of contaminated soils) commenced in June 1995 and was completed in July 1997. All soils excavation and treatment facilities have been decommissioned and removed. To summarize, the OU-2 remedial activities consisted of the following:
>
> - Approximately 248,000 tons of soil and sediment were excavated and treated by on-site incineration. Soils were excavated to approximately one foot below the seasonal low water table within the excavation limits, with excavation depths ranging from approximately 3 to 33 ft bgs;
> - Approximately 250,000 tons of the treated soil (ash) was backfilled into the 12.5-acre excavation area (shown in Figure 1 of the *Evaluation of Potential Future Reuse Opportunities for the Baird & McGuire Site*, see Attachment A of this report);
> - Toxicity Characteristic Leachate Potential (TCLP) tests were performed on the ash, and approximately 320 tons of ash which failed the leaching criteria were stabilized with cement prior to backfilling to reduce the potential for leaching of contaminants;
> - The incinerator building and equipment were demobilized and removed from the site and the incinerator building foundation was crushed and buried on-site; and
> - Approximately 7.4 acres of forested and scrub/shrub floodplain wetlands underwent onsite restoration, including a small peat bog and 1,000 linear ft of the unnamed brook.
>
> EPA and M&E concluded from the site visit conducted for the First Five-Year Review that, although the wetland was not restored with the organic soils recommended in the Final Restoration Plan, the mitigative measures required by EPA and USACE were met. Initially, the wetland was monitored annually in order to assess the success of the wetland restoration effort. It was reported that during a site visit on June 23, 2009, it appeared that the restored wetland was well established and in good condition.

3.1.2 SEDIMENT EXCAVATION

The Third Five-Year Review describes the implemented sediment remedy (OU-3 remedy) as follows:

> *The remedy for OU-3 involved removal of contaminated sediments from the Cochato River. This remedy commenced in May 1994 and was completed in June 1995. Major components of the sediment remedy were site preparation, sediment dredging, placement of organic fill and monitoring.*
>
> *In preparation for river excavation, the river banks were cleared and grubbed. A detention basin was built in the river just downstream of the Union Street bridge to trap suspended sediments during dredging and then subsequently removed. Temporary haul roads were constructed and then removed after testing showed no residual contamination. Sediments were dredged from a 2,100-foot reach of river extending from the Baird & McGuire Site to the Union Street bridge. Sediments were dredged to a minimum depth of six inches and a maximum depth of 24 inches in some areas. Dredged material was placed in sealable containers and transported to the Baird & McGuire exclusion zone where it was stored for subsequent incineration. A total of 4,712 cubic yards of material were removed from the river. Dredged material was transported to the incineration facility, incinerated, and placed as backfill within the OU-2 soil excavation area. Wetlands adversely impacted by the dredging and the installation of haul roads were restored under the OU-2 Final Restoration Plan.*
>
> *The portion of the river where contaminated groundwater underlies the riverbed was backfilled with approximately 438 cubic yards of clean organic fill. This organic fill was intended to act as a filter to attenuate concentrations in contaminated groundwater that might discharge into the river.*
>
> *Following completion of the remedy, EPA implemented a long-term monitoring plan for the Cochato River downstream of the dredged area, including analyses of sediment and fish. The plan included collection and analysis of sediment samples annually for the first five years and fish samples every 5 years, followed by a review of the data and trends. Sediment and fish tissue samples were last collected from the Cochato River in 2002.*

3.1.3 EXTRACTION SYSTEM

The groundwater treatment and extraction systems were installed in 1993, and with the exception of the discontinued use of two extraction wells and several treatment train components, have been in use since 1993. During the onsite soils remedy (1993-1997) the treatment plant was primarily used to treat the discharge from the onsite incinerator and the dewatering water from deep excavations.

The original extraction system included six groundwater extraction wells (EW-1 to EW-6). EW-1 was decommissioned due to low well yield and minimal contaminant removal. In 1998, EW-7 was installed and continues to be in operation. EW-8 was added in 1999 in an area of pooled LNAPL. EW-4 was replaced with EW-4A in 2004 based on groundwater model simulations that suggested EW-4A would provide improved contaminant recovery. EW-9 was also added in 2004 to extract high levels of contamination in the northern portion of the site, but EW-9 extracts very little water relative to the expected extraction rate of 10 gpm. Operation of EW-2 was discontinued in 2006 and operation of EW-5 was discontinued in 2011. Discontinuation of these wells was due to problems with the wells rather than a decrease in mass removal. The wells pump the groundwater via separate pipes to an extraction well control building, located south of the extraction system, where the water converges to a single header pipe that conveys the water to the groundwater treatment facility (GWTF). All extraction system controls (for example, valves, flow meters, electrical switches) are housed within the extraction system control building. The wells are operated remotely through use of a programmable logic controller (PLC) located at the GWTF. Each pump motor has a variable frequency drive.

The extraction well locations are shown in Figure 2, 7 and 7a provided in Attachment A. The following table provides the extraction rates and contaminant concentrations for the operating extraction wells in December 2011, as reported in the 4th Quarter 2011 Quarterly Extraction Well Report.

Table 3-1. Extraction Well Rates and Influent Concentrations from December 2011

Well	**Typical Flow Rate (gpm)**	**Arsenic Concentration (µg/L)**	**Naphthalene (µg/L)**	**Total Pesticides (µg/L)**
*MCP Method 1 GW-1 Standard**		*10*	*140*	-
EW-3	3.5	517	385	< GW-1
EW-4	18.1	469	531	< GW-1
EW-6	2.1	200**	258	4.69
EW-7	26.4	305	< GW-1	< GW-1
EW-8	8.3	326	4,830	2.284
EW-9	0.63	4,460	< GW-1	< GW-1***

**Cleanup standards have not been formally established for the site, but the Massachusetts Contingency Plan (MCP) Method 1 GW-1 Standards are likely candidates for the cleanup standards and are currently used in site documents.*
***Average of original and field duplicate samples.*
"<GW-1" indicates concentrations are below the MCP Method 1 GW-1 Standard.
**** Pesticides were detected above GW-1 in 5 of 14 sampling events since 2007.*
µg/L = micrograms per liter

3.1.4 GROUNDWATER TREATMENT SYSTEM

The original plant design included:

- two activated sludge biotreatment units
- a fume incinerator
- a two-stage metals removal system that used lime for pH adjustment, ferric chloride, and a polymer
- pressure filters
- granular activated carbon (GAC).

Due to an insufficient supply of organics in the plant influent to support biological growth in the activated sludge, the biotreatment units were decommissioned and are now used as air strippers. In addition, two Value Engineering Proposals resulted in the replacement of the fume incinerator with vapor phase carbon in 1997 and the use of potassium permanganate for metals removal in 2000.

The current treatment train consists of the following processes:

- equalization tank
- potassium permanganate addition
- rapid mix tank for metals removal
- clarifying tanks

- pH neutralization tanks (no longer required as pH adjustment is no longer needed for metals removal)
- air strippers converted from activated sludge or biological clarifier units
- pressure filter feed tank
- pressure filters
- liquid phase GAC units for removal of organic contaminants from process water
- vapor phase GAC units for removal of organic contaminants from air stripper and process tank off-gas
- effluent tank

Water from the pressure filter feed tank is sent in semi-batch mode through the pressure filters and carbon. The treated water is discharged to one of four infiltration basins (on a rotating basis) at approximately 150 gpm.

A conceptual schematic of the treatment process is presented in Figure 2A of the 2009/2010 Annual Report (see Attachment A). Individual treatment processes and the typical pathway of water through the system are also shown; however, pumps, system controls and pathways for recycling of process water are not shown.

3.1.5 LNAPL RECOVERY SYSTEM

As an enhancement to the groundwater extraction and treatment systems, a system to recover LNAPL was installed in 1999. The system was designed to pump directly from three wells (EW-8, MW-97-1 and MW-98-1) through an oil-water separator to a collection tank. Recovered LNAPL is disposed off-site. Until June 2004, the LNAPL was mixed with an absorbent (crushed corncobs) prior to off-site disposal. Starting in June 2004, the State shipped the LNAPL off-site in liquid form. Due to the difficulty in separating emulsified LNAPL from water, the LNAPL system has not been operated in its original form for the past few years. LNAPL is occasionally removed with absorbent material on an intermittent basis.

3.2 REMEDIAL ACTION OBJECTIVES AND STANDARDS

3.2.1 GROUNDWATER

The remedial action objectives (RAO) for OU-1 groundwater are:

- Remediate the contaminated aquifer within a reasonable time period to prevent present or future impacts to groundwater drinking supplies;

- Protect surface waters from future contaminant migration; and

- Minimize long-term damage and or maintenance requirements.

The goal of the extraction and treatment system as documented in the ROD (dated September 30, 1986) is to contain and remediate the groundwater “within a reasonable time” and to protect groundwater and surface water. Specific cleanup levels were not specified in the ROD, but the ROD specifies that the aquifer is a possible source of drinking water. The GWTF was designed to treat groundwater to meet Safe Drinking Water Act (SDWA) MCLs, which are intended to protect public health and the environment. Initially, after five years of operation, the EPA was to determine if the restoration target levels are achievable and if they are adequate to protect public health and the environment. EPA has been using MCLs as target cleanup levels. Currently, plant effluent discharge standards must be below the MCLs, or when no MCL is given, the applicable standard is based on the MCP Method 1 GW-1 Risk Standards (GW-1 Standards). For contaminants that have an MCL, the GW-1 Standard equals the MCL. Therefore, it is appropriate to refer to the GW-1 Standards for the purpose of this report. Table 3-2 provides the GW-1 Standards for contaminants of concern:

Table 3-2. GW-1 Standards for Contaminants of Concern

Contaminant	**GW-1 Standards (µg/L)**		**Contaminant**	**GW-1 Standards (µg/L)**
Metals			**VOCs**	
Arsenic	10*		Benzene	5*
Pesticides			**SVOCs**	
4-4 DDD	0.2**		2-Methylnaphthalene	10**
Chlordane	2*		Acenaphthene	20**
Dieldrin	0.1**		Naphthalene	140**
			Pentachlorophenol	1*

** MCL equals GW-1 Standard*
*** No MCL*

3.2.2 SEDIMENTS

The remedial action objectives for site sediments include:

- Reduce human exposure to arsenic, DDT, PAHs, and chlordane in sediment by excavating to an average depth of six (6) inches and by achieving the following levels of contaminants, which correspond to a 1 x 10^{-5} to 1 x 10^{-6} excess cancer risk level;

Table 3-3. ROD-Specified Human Health Target Levels for Sediment Contaminants of Concern

Compound	**Target level (10^{-5} risk) (mg/kg)**	**Target level (10^{-6} risk) (mg/kg)**
Arsenic	2,500	250
Total DDT	190	19
Total Chlordane	50	5
Total PAHs	22	2.2

- Reduce environmental exposure to the same 4 contaminants of concern to concentrations corresponding to the mean sediment quality criteria (SQC) in the river bed, and to the upper bound SQC in the wetland area north of ice pond.

The ROD anticipated that natural degradative, depositional, and dispersal processes will gradually reduce contaminant concentrations in the sediment and that sampling in the areas of excavation, in conjunction with long-term monitoring of downstream portions of the Cochato River that were not excavated, would confirm the remaining contaminant levels and their behavior over time.

The 2009 Five Year Review evaluated the current risk based on updated risk assessment data. Due to changes in the risk assessment methods and assumptions that occurred since 1986, including new toxicity information and the requirement to evaluate compounds with mutagenic modes of action, the potential risks associated with the 1989 cleanup goals were evaluated. The risks associated with the sediment cleanup goals using this updated information, as reported in the FYR, were as follows:

Table 3-4. 2009 Revised Risk Estimates Associated with 1989 Sediment Cleanup Goals

	1989 OU-3 ROD Cleanup Goals (mg/kg)	**2009 Third Five-Year Review Risk Associated with 1989 Cleanup Goal (mg/kg)**
Arsenic	250	6 x 10^{-5}
Total DDT	19	1 x 10^{-6} *(See note 1)*
Total Chlordane	5	Less than 1 x 10^{-6} *(See note 2)*
Total PAHs	22	1 x 10^{-4} *(See note 3)*

Notes

1. *The 2009 Third Five-Year Review shows that the concentration associated with 1 x 10^{-6} is 20 mg/kg, or approximately the same as the 1989 cleanup goal.*
2. *The 2009 Third Five-Year Review shows that the concentration associated with 1x 10^{-6} is 19 mg/kg which is greater than the 1989 cleanup goal of 5 mg/kg. Therefore the risk associated with the 5 mg/kg goal is less than 1 x 10^{-6}.*
3. *The risk estimate for PAHs is overly conservative because it is based on the assumption that all PAHs present are the most toxic compound (benzo[a]pyrene). PAHs of lesser toxic potency are likely to be most prevalent.*

The optimization review team notes that specific limits to be used for evaluating fish tissue sampling results moving forward are not clear with respect to values, or with respect the specific source, basis and or methodology for calculation of the limits. However, the site team indicated that the intent is to evaluate site-specific risks relative to an acceptable excess cancer risk in the range of 1×10^{-4} to 1×10^{-6}.

3.3 PERFORMANCE MONITORING PROGRAMS

3.3.1 GROUNDWATER

The monitoring network consists of 66 monitoring wells screened in the glacial overburden, 13 monitoring wells screened in the underlying bedrock and the operating extraction wells. Water levels are measured quarterly from the monitoring wells, and the measurements are used to develop separate potentiometric surface maps for the overburden and bedrock.

The 2009-2010 Annual Report indicates that seven extraction wells are sampled on a quarterly basis and 21 monitoring wells are sampled on an annual basis with low-flow sampling. All samples are analyzed for field parameters (pH, conductivity, temperature, dissolved oxygen, ORP, and turbidity). All operating extraction wells are sampled for SVOCs, pesticides and arsenic. The suite of analyses conducted on the monitoring well samples vary from well to well but typically include one or more of the following analyses: VOCs, SVOCs, pesticides, arsenic and mercury. In 2011, the site team conducted a more comprehensive sampling event. Samples were collected from all operating extraction wells (5 wells in 2011) and from approximately 60 monitoring wells. All samples were analyzed for metals (including arsenic and mercury), pesticides, SVOCs and VOCs. The scope of the monitoring program on a move-forward basis is uncertain at this time.

3.3.2 SEDIMENT AND FISH TISSUE SAMPLING

Long-term monitoring of sediments in the Cochato River was performed on an annual basis from 1996 to 2002. The OU-3 ROD called for long-term monitoring of sediments in portions of the Cochato River downstream of the portion of the river where sediments were excavated as part of the remedy. Long-term monitoring has also included analysis of fish tissue in order to monitor the impact of the sediments on the fish population. Fish tissue sampling was conducted in 1992, 1996 and annually from 1999 through 2002. Surface water samples were collected from the Cochato River in 2000 to establish baseline surface water quality for the project.

Based on data trends identified from samples collected between 2000 and 2002, a sediment and fish tissue sampling frequency of every five years was recommended. No further surface water sampling was recommended in the Second Five-Year Review. No additional sediment or fish samples from the Cochato River have been collected since 2002.

The Third Five-Year Review recommended that additional sediment samples be collected to determine if long-term cleanup goals are being attained. In addition, fish tissue sampling was also recommended in order to determine concentration trends and confirm concentrations due not cause an unacceptable risk. In the interim, warning signs installed along the river cautioning recreational users about the potential dangers associated with the ingestion of fish caught from the river are expected to be maintained to comply with the Department of Public Health advisory for pesticides

4.0 CONCEPTUAL SITE MODEL

This section discusses the optimization review team's interpretation of existing characterization and remedy operation data and site visit observations to explain how historic events and site characteristics have led to current conditions. This CSM may differ from that described in other site documents. CSM elements discussed are based on data obtained from the site team and discussed in the preceding sections of this report, and in some cases is based on speculation of the optimization review team. This section is intended to include interpretation of the CSM only. It is not intended to provide findings related to remedy performance or recommendations for improvement. The findings and recommendations are provided in Sections 5.0 and 6.0, respectively.

4.1 CSM OVERVIEW

Operations from a chemical mixing and batching facility over a 70-year history resulted in releases to soil and groundwater from leaking above-ground and below-ground tanks, waste disposal to the land surface, and other sources. Releases of site-related contamination to the Cochato River included direct discharges from pipes, contaminated surface water runoff, contact of flood waters with waste disposal areas and discharge from groundwater to surface water. Contaminants included (but were not limited to) VOCs, SVOCs, pesticides, and arsenic.

Site conditions have improved significantly due to a combination of factors that include the following:

- Discontinuation of site operations by 1983
- Removal actions performed by EPA
- Soil excavation
- Sediment excavation
- P&T operation

Soil contaminated with organic compounds (VOCs, SVOCs, pesticides) is no longer present in unsaturated soil and there does not appear to be a continuing source of groundwater contamination from unsaturated soil for these specific contaminants. Contaminated river sediments as of the last sampling event in 2002 were orders of magnitude lower than concentrations detected during the investigation stage.

With only a few exceptions, the VOC groundwater plume (excluding naphthalene, which is also analyzed as an SVOC) has been remediated below applicable standards. Similarly, concentrations of SVOCs (predominantly acenaphthene, naphthalene and 2-methylnaphthalene) are generally more than 10 times above standards within 200 ft of EW-8 (see Figure B-1 in Attachment B), and pesticides are generally only above standards within 200 ft of EW-8 (see Figure B-3 in Attachment B). Therefore, the remaining contamination at the site that drives current remediation efforts is the LNAPL and the dissolved arsenic plume (see Figure B-2 in Attachment B).

It is unclear if the historic extent of measureable LNAPL (see Figure B-4 in Attachment B) was due to overland transport followed by infiltration, subsurface migration as a separate phase product, or a combination of both. LNAPL recovery by extraction and oil-water separation was conducted up through approximately 2009 with decreasing yield. During the site visit, the site team described the remaining LNAPL as having a specific gravity near 1.0 and as emulsified in groundwater, making LNAPL measurement and LNAPL recovery by extraction and separation difficult. Residual (immobile and unrecoverable) LNAPL is also likely still present beneath the water table through much of the area where LNAPL was identified in the 1997 investigation. Laboratory analysis of an LNAPL sample from EW-6 in 2011 indicated that the sample was comprised of approximately 1% pesticides, 1% PAHs, 0.1% VOCs, and 0.01% arsenic by mass. The remaining mass is likely water and total petroleum hydrocarbons (TPH). LNAPL observed in different portions of the site may have different compositions if it originated from different source areas. For example, LNAPL near EW-6 contains pesticides and PAHs based on the 2011 analyses, and these contaminants are detected in groundwater samples from nearby monitoring wells. By contrast, LNAPL was historically identified in the vicinity of wells MW-97-12, MW-97-21 and MW-97-22 (GP-3, GP-3A, GP-3C, and GP-6.5 from the 1997 study), and pesticides are not detected in these wells. PAH concentrations and VOC concentrations are also low in these monitoring wells suggesting that degradation has occurred over time, but the ORP is still very low (around -100 millivolts [mV]) and dissolved iron is very high, indicating the presence of substantial degradable organic compounds in this area. The degradable organic compounds could be residual petroleum hydrocarbons associated with previously observed LNAPL or could be from the nearby wetlands. The 1997 investigation focused on LNAPL thickness and the potential for LNAPL recovery. The known extent of LNAPL contamination at the time of the investigation is shown in Figure B-4 in Attachment B, but it is unclear if LNAPL was present outside of this area. The current extent of residual LNAPL and dissolved organic compounds throughout the site are not well understood.

While concentrations of naphthalene, other PAHs and VOCs have declined substantially throughout the site, the dissolved arsenic plume continues to exhibit high concentrations throughout the plume. Arsenic concentrations have decreased mildly at some locations over time, though not nearly as much as the organic contaminants. The dissolved arsenic plume extends from the principal source area in the vicinity of EW-8 to the Cochato River. Therefore, the mechanisms responsible for the substantial PAH and VOC remediation (for example, the soil remedy, LNAPL collection, P&T and biodegradation) have had a less substantial effect on arsenic contamination. Potential sources of observed arsenic groundwater contamination include remaining LNAPL (free and or residual product), contaminated soils beneath the excavation remedy, native soils and potentially ash deposited on-site after the soil remedy. Arsenic is tightly bound to iron hydroxides in the subsurface, but reducing conditions (low ORP) can mobilize iron (as evidenced by high dissolved iron concentrations in groundwater) and the arsenic previously adsorbed to it.

The optimization review team speculates that the remaining organic contamination (VOCs, SVOCs, and potentially other petroleum hydrocarbons) serves as electron donor for microbes in groundwater and decreases the ORP in much of the aquifer. The optimization review team further speculates that the lower ORP mobilizes iron within the soil, effectively mobilizing arsenic that was adsorbed to that iron in native soils and or soil remedy ash. To the extent these speculations are correct, as long as sufficient dissolved organic carbon is present in groundwater, widespread continuing sources of arsenic will persist. The wetlands may also contribute to reducing conditions. The relative contributions of arsenic from native soils, contaminated saturated soil not fully addressed by the excavation, soil remedy ash and LNAPL cannot be readily determined. Based on data from the 2009-2011 Arsenic Investigation (Clean Harbors Environmental Services, Inc., 2011), the soil remedy ash generally has a higher arsenic concentration than native soils; however, arsenic mobilization from native soils is likely sufficient to cause arsenic concentrations in groundwater above applicable standards. For example, TCLP testing of an arsenic soil sample from ASB-22 yielded a concentration of 0.534 milligram per liter (mg/L) of arsenic, and the low ORP of the site groundwater is also likely effective at mobilizing arsenic. The arsenic plume is not fully delineated, and arsenic contaminated groundwater appears to have been discharging to the river for more than a decade, particularly in the area of EW-9 and potentially between EW-9 and EW-7.

The goal of the groundwater remedy is to return the aquifer to drinking water standards. Much of the site is within the 100-year flood plain and or is wetlands, which limits future use of the land or underlying water resource. The Cochato River is the only current potential exposure pathway to human or ecological receptors.

4.2 CSM DETAILS AND EXPLANATION

4.2.1 GROUNDWATER

Role of ORP in Arsenic Groundwater Contamination

The VOC and SVOC trends at several wells provided in the 2004 Evaluation of Groundwater Remediation Progress (see Attachment C) provide an indication of the success of various remedy components, as follows:

- VOC concentrations at EW-2, EW-4 and EW-5 decreased by two orders of magnitude between 1995 and 1997, presumably as a result of the soil remedy and associated groundwater extraction.
- VOC concentrations at EW-3 and EW-6 started a gradual decline since the wells became operational in 1994.
- VOC concentrations at EW-7 and EW-8 have also significantly declined.
- VOC concentrations at downgradient wells MW-97-11 and MW-97-12 also declined significantly following the soil remedy.
- Similar trends have been observed for SVOCs, with the exception that SVOCs generally remain elevated closer to the source area (EW-3, EW-4a, EW-6 and EW-8) and the immediately surrounding monitoring wells.

By contrast, arsenic concentrations have remained elevated well above the arsenic cleanup standard of 10 µg/L in many locations, including areas where naphthalene concentrations have declined to well below the naphthalene cleanup standard of 140 µg/L. In some locations the arsenic concentrations have remained stable and at other locations the arsenic concentrations have decreased but remain significantly above applicable standards. Two examples are provided:

- MW-97-21 (located close to the Cochato River, just upgradient from EW-7) - Arsenic concentrations at MW-97-21 have remained above 1 mg/L. The arsenic concentrations in groundwater have declined (from 2,200 µg/L in April 2002 and 1,310 µg/L in April 2004 to 1,150 µg/L in July 2010 and 989 µg/L in July 2011) but remain well above the arsenic cleanup standard of 10 µg/L, whereas the naphthalene concentrations in groundwater declined more substantially over the same period (from 1,200 µg/L in April 2002 and 560 µg/L in April 2004 to 55 µg/L in July 2010) and are well below the naphthalene cleanup standard of 140 µg/L. Data from the 2011 Draft Arsenic Summary Investigation Report – Part II/IIA (Clean Harbors Environmental Services, Inc., 2011) indicate that groundwater at ASB-12 (in the vicinity of MW-97-21) is in contact with soil remedy ash that has an arsenic concentration of 29.6 milligrams per kilogram (mg/kg). The ORP at MW-97-21 was -100.4 mV in July 2010 and -111 mV in July 2011. The iron in groundwater at MW-97-21 is also elevated (16 mg/L), indicating that iron, that might otherwise adsorb arsenic, has been mobilized. The combined VOC and SVOC concentration (VOC + SVOC) is approximately 200 ug/L. This relatively small degree of VOC + SVOC contamination is not likely the sole driver of the low ORP. Potential contributors to the reducing conditions may include VOC or SVOC tentatively identified compounds (TICs) that are not reported by the laboratory, TPHs (which are not analyzed for) or organic matter from the wetlands.

- MW-97-17 (located near the predominant source area, just east of EW-8) - The arsenic concentration in 1998 at MW-97-17 (further upgradient from MW-97-21) remain have remained stable (from 470 µg/L in April 2002 and 390 µg/L in April 2004 to 425 µg/L in June 2010) well above the arsenic cleanup standard of 10 µg/L, whereas the naphthalene concentrations in groundwater declined substantially over the same period (from 420 µg/L in April 2002 and 200 µg/L in April 2004 to 6 µg/L in June 2010) and are well below the naphthalene cleanup standard of 140 µg/L. Samples of soil ash are not available for this location. The ORP at MW-97-17 was -105 mV in July 2010 and -54.7 mV in July 2011. The VOC and SVOC concentrations at this location are even lower than those at MW-97-21, and the monitoring point is not co-located with wetlands. VOC, SVOC or TICs that are not reported by the laboratory or TPHs (which are not analyzed for) are likely the cause of the low ORP.

Figures B-5 through B-8 (See Appendix A) illustrate the relationship between ORP and arsenic and iron mobilization in the vicinity of these two wells and several other wells. One of the other wells is MW-97-20, for which the ORP is higher and the arsenic and iron concentrations are significantly lower. Figure B-9 plots the ORP vs. arsenic concentration for the July 2011 sampling data. The following observations and interpretations are noteworthy:

- For samples collected from unconsolidated material within the former excavation, low ORP (for example, less than -50 mV) correlates to high arsenic concentrations.

- Samples with ORP above -50 mV have low arsenic concentrations and samples with ORP above 0 mV have generally undetectable arsenic.

- Samples of bedrock groundwater have very low ORP and no arsenic. These results confirm that arsenic is not present in the bedrock groundwater. The low ORP of the bedrock is likely due to the geologically old groundwater that has low dissolved oxygen and a low ORP resulting from interactions with various mineral species rather than microbial metabolism of organic contaminants.

The strong correlation between arsenic and ORP shows a relationship, but does not necessarily demonstrate that the low ORP is the cause of the high arsenic. For example, it is possible that the LNAPL is the cause of the high arsenic and also provides organic compounds that foster microbial activity and lower the ORP. However, the documented effect that low ORP has on mobilizing iron and arsenic suggests that there likely is a causal relationship. The low ORP might be a potential mechanism for releasing adsorbed arsenic and is also likely a cause for inhibiting dissolved arsenic from adsorbing to soils.

Although the 2011 arsenic investigation included Synthetic Precipitation Leaching Procedure (SPLP) testing of the ash from various locations, the SPLP test considers reduced pH but does not consider a lower ORP. Therefore, the SPLP testing may not have accurately represented the potential for arsenic mobility at this site. One TCLP test (on ash from ASB#22), which uses a lower pH than the SPLP test but also does not consider a low ORP, resulted in leaching 0.5 mg/L of arsenic from site soils, suggesting the potential for some arsenic to be mobilized from some site soils.

Distribution of Arsenic

Figure B-2 provides a general plan view of horizontal arsenic distribution. Until the recent arsenic investigation, the arsenic plume maps did not portray arsenic in the vicinity of soil borings ASB-9, ASB-

10, ASB-16, and ASB-22 ("ASB-22 area"). Rather, arsenic was depicted primarily along the area of known LNAPL extent and as an isolated hot spot near the location of current well EW-9. The identification of this new area of high-level (greater than 1 mg/L) arsenic groundwater contamination raises the question as to the source of this arsenic. The following are potential considerations when evaluating potential sources of this arsenic:

- This area was not known to have LNAPL; however, this historic interpretation may be due to the general lack of data in the area.
- Site soils (both replaced incinerated soil and saturated soil) have high levels of arsenic in this area as evidenced by samples from ASB-22. Furthermore, TCLP testing of incinerated soil from ASB-22 shows that soil in this area is capable of releasing significant levels of arsenic to groundwater under certain conditions. Note that SPLP testing also showed arsenic leaching, but to a much lesser extent and below GW-1 Standards.
- This area lies directly between the river and the known source area of arsenic near EW-6 and EW-4A, suggesting the potential that arsenic contaminated groundwater could be migrating into this area on its way from the source area to the river. Arsenic concentrations over 1 mg/L and low ORP (below -100 mV) were observed in samples from MW-97-28 and MW-04-01 during the July 2011 groundwater sampling event. These two wells are installed in a location that could be considered upgradient of the ASB-22 area.
- The observed LNAPL in the area of known LNAPL extent (to the southeast of the ASB-22 area) might have migrated by overland flow and subsequent infiltration rather than, or in addition to, subsurface migration. If this is the case, the contamination in the area of known LNAPL extent could be due primarily to overland flow, and the contamination in the ASB-22 area could be due to the principal direction of groundwater flow coupled with contaminated soils in contact with groundwater.

The arsenic investigation also clarifies the vertical distribution of arsenic in groundwater. The highest arsenic concentrations (over 1 mg/L) were detected between the shallowest sampling intervals and 20 ft bgs. All detected arsenic concentrations below 20 ft bgs were below 0.2 mg/L and most were below 0.1 mg/L, suggesting a significant attenuation of arsenic contamination with depth. The arsenic concentrations in groundwater at the soil boring ASB-22 location are presented below.

Sample Interval (ft bgs)	**Sample Depth Below Water Table (ft)**	**Arsenic Concentration (mg/L)**
3-5	At water table	0.697
8-10	5-7	0.791
11-13	8-10	NA
13-15	10-12	2.07
15-18	12-15	NA
18-20	15-17	2.92
20-23	17-20	NA
23-25	20-22	0.701
25-28	22-25	NA
28-30	25-27	0.0254
30-40	27-37	NA

A plume core appears to be present from as shallow as 8 ft below the water table to as deep as 20 ft below the water table. Elevated concentrations (above 0.7 mg/L) are present above and below this plume core. The data support the potential for contribution of arsenic from the unsaturated zone, from upgradient, and or shallow saturated soils.

4.2.2 COCHATO RIVER SEDIMENTS

The Cochato River is the only current potential exposure pathway for human or ecological receptors to site-related contamination. Some of the contamination may remain in sediments following the sediment remedy (OU-3 remedy), and some arsenic contamination may continue to discharge to the river from groundwater. Due to the absence of consistent sediment sampling, it is difficult to determine if the discharge of arsenic to the river from groundwater is sufficient to increase impacts to sediment or fish tissue over time. Conceptually, arsenic that precipitates after discharging to the river could add to sediment impacts over time near the site and or downstream from the site. In contrast, arsenic generally is not expected to bioconcentrate in fin fish. It is also difficult to determine if a discontinuation in pumping would result in a noticeable difference in sediment arsenic concentrations over time. Due to the effectiveness of the soil and groundwater remedies, little or no PAH or pesticide contamination appears to be discharging to the river from groundwater. Sediment sampling results are discussed further in Section 5.0.

4.3 DATA GAPS

There are several data gaps associated with the CSM, including the following:

- The extent of residual LNAPL, horizontally and vertically and above and below the water table, is unknown.
- The extent of arsenic contaminated soil, horizontally and vertically below the water table, is unknown.
- The extent of the arsenic plume and pathways for arsenic migration are not fully understood, including a potential link between the area of wells EW-4A, EW-6 and EW-8 and the area of soil borings ASB-4, ASB-9, ASB-10 and ASB-16.
- The extent and magnitude of the dissolved organic carbon plume and the primary compounds comprising this plume are unknown.
- The relative contribution of the wetlands to the reducing conditions that may be mobilizing arsenic is not known.
- It is not known if sufficient iron is available in native soils to adsorb all of the arsenic if the ORP is increased.
- Current contaminant concentrations in river sediments and fish tissue are unknown.
- The effect contaminated groundwater has on river sediments and or fish tissue under pumping or non-pumping conditions is unknown.

4.4 IMPLICATIONS FOR REMEDIAL STRATEGY

Although water quality data suggest that arsenic groundwater contamination drives the remedy, the optimization review team speculates that the groundwater remedy may actually be driven by low ORP conditions that either mobilizes arsenic from site soils or allows arsenic from other sources (for example, the LNAPL) to remain mobile. The optimization review team further speculates that the low ORP conditions contributing to arsenic mobility are likely the result of residual organic contamination. If these speculations are correct, timely remediation would require focusing on reducing residual organic contamination and increasing the ORP in groundwater. If the site team chooses to improve the existing migration control remedy, a target capture zone needs to be determined. In addition, if the site team chooses to continue to operate and or upgrade the containment remedy, the contaminant transport pathways and areas of continuing sources need to be better identified so that extraction wells can be properly located to provide long-term migration control.

5.0 FINDINGS

The observations below are the interpretations of the optimization review team offered as constructive information in the best interest of the EPA and the public. They are not intended to imply a deficiency in the work of the system designers, system operators or site managers. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

5.1 SOURCES

5.1.1 THE SOIL REMEDY HAS SIGNIFICANTLY REDUCED VOC AND SVOC GROUNDWATER CONTAMINATION

See Section 4.0 for details.

5.1.2 RESIDUAL LNAPL THROUGHOUT MUCH OF THE SITE MAY CONTINUE TO SERVE AS A SOURCE OF LNAPL AND DISSOLVED ORGANIC CARBON

See Section 4.0 for details.

5.1.3 LOW ORP (POTENTIALLY CAUSED BY RESIDUAL DISSOLVED ORGANIC CARBON) MAY BE MOBILIZING ARSENIC FROM SITE SOILS AND SOIL REMEDY ASH AND IS ALLOWING ARSENIC IN GROUNDWATER TO REMAIN MOBILE

See Section 4.0 for details.

5.2 GROUNDWATER

5.2.1 LNAPL DELINEATION

The extent of residual LNAPL has not been delineated. See Section 4.0 for more information.

5.2.2 PLUME DELINEATION

The arsenic plume and migration pathways are not clearly understood because significant arsenic impacts between EW-7 and EW-9 have recently been identified but this area of contamination has not been definitively linked to a specific source area. Unlike other areas of elevated arsenic contamination, there are no data in that area for LNAPL, VOCs, SVOCs or ORP. The optimization review team believes a reasonable explanation for arsenic in this area is migration from the source area in the vicinity of wells EW-4A, EW-6 and EW-8.

5.2.3 PLUME CAPTURE

The arsenic plume may be captured in the area of EW-7, but the optimization review team speculates that other portions of the plume are likely not captured. Contamination from the 2009-2011 Arsenic Investigation (Clean Harbor Environmental Services, Inc., 2011) identified arsenic between wells EW-7 and EW-9. Monitoring well BM-31B is one of the few monitoring wells in this area, and in 2007 and 2008, this well had some of the highest arsenic and pesticide concentrations detected in site monitoring wells. It is unclear if these detections are indicative of a core area of plume migration or if the detections of total arsenic and pesticides are a manifestation of the sampling procedure (for example, a turbid sample). The well is indicated as damaged, and no distinct migration pathway between the principal source area and this well has been delineated. No extraction wells are located in the area between EW-7 and EW-9. EW-4A may have been installed to intercept contamination along this migration pathway, but insufficient data are available to evaluate the effectiveness of EW-4A to capture the plume in this area. In addition, the plume is likely not captured in the vicinity of EW-9 due to the underperformance of EW-9 due to the actual flow rate being significantly lower than the expected flow rate from previous groundwater modeling. The design extraction rate for EW-9 was 10 gpm; however, the well yields less than 1 gpm on average. The width of the arsenic plume in the vicinity of EW-9 is also not well-defined.

5.2.4 GROUNDWATER CONTAMINANT CONCENTRATIONS

VOC and SVOC concentrations in groundwater have declined significantly and only a few locations remain above applicable standards. Arsenic concentrations remain elevated significantly above applicable standards over a much larger extent, particularly near the Cochato River in the vicinity of EW-7 where naphthalene concentrations have decreased below standards.

5.3 SEDIMENT

Table 3 of the report "*Operating Unit 3 Monitoring Results*" (USACE, September 1996) provides results of samples from sediments remaining after the sediment excavation was performed. The Third Five-Year Review discusses sampling results from the latest event in 2002. Sediment-related observations provided by the optimization review team include the following:

- For arsenic, the samples for sediments left in place were all below the 1989 250 mg/kg cleanup goal. The maximum concentration of arsenic in sediment from the 1989 sampling was 154 mg/kg, and the maximum arsenic concentration from the latest sampling in 2002 was 110 mg/kg. The risk associated with potential exposure to these concentrations of arsenic, using updated toxicity values are within the acceptable risk range.

- For total PAHs, the samples for sediments left in place were mostly below the 1989 22 mg/kg cleanup level (seven of 46 were above 22 mg/kg, with three above 100 mg/kg. The maximum concentration from the most recent sampling in 2002 is 11 mg/kg.

- For pesticides, the samples of sediments left in place were all below the 1989 cleanup goals.

The risks associated with the concentrations in sediment were evaluated as part of the Third Five-Year Review using updated toxicity information. The risks are within the EP acceptable risk range. The 2004 Trend Evaluation Report (Metcalf & Eddy, Inc., 2004) presents trends in sediment concentrations from 1996 through 2002 collected from five stations as depicted in Figure 3 of the same report (see Attachment A). The optimization review team provides the following observations:

- The DDT and chlordane concentrations in sediments remained relatively stable over the sampling period.

- The PAH concentrations showed significantly more variation over the sampling period as compared to pesticides. Increases in PAH concentrations were noted in two stations in the 2000 to 2001 time period, followed by decreases. One of the stations with a substantial increase was Station E, which is adjacent to the site.

- The arsenic concentrations were relatively consistent over the sampling period, with the largest variability found in Stations C and D which are located more than 3,000 ft downstream from the site. The arsenic concentrations in the stations near and upgradient of the site were generally close to the 6.1 mg/kg criteria established in the 2009 Five-Year Review. The samples downgradient of the site were generally higher than the 6.1 mg/kg criteria but within the acceptable range for excess risk of 1×10^{-4} to 1×10^{-6}.

The number of samples collected relative to the area of interest, the frequency of data collection (specifically, no samples since 2002), potential changes in sampling methodologies and fluctuating nature of the results, make it difficult to determine the effect of the soil and groundwater remedy on contaminant concentrations in sediment.

5.4 TREATMENT SYSTEM COMPONENT PERFORMANCE

5.4.1 EXTRACTION SYSTEM

The extraction system is in poor and deteriorating condition. The extraction rate in 2001 was approximately 127 gpm but has decreased over time to a current extraction rate under 60 gpm, in part due to underperforming or deteriorating extraction wells. The site team notes that the construction of the monitoring wells includes dissimilar metals and the associated corrosion is causing the screen to separate from the casing. EW-5 was recently shut down due to this type of problem. EW-9 never provided the anticipated flow and typically operated at an average extraction rate of less than 1 gpm.

5.4.2 TREATMENT SYSTEM

The treatment system is also in deteriorating condition and has several underperforming components. Some of the components of the original design are no longer appropriate. The optimization review team notes some of these issues:

- The site team reports that multiple tanks are showing signs of corrosion and some tanks have required patching to replace leaks caused by corrosion.

- Solids removal is apparently problematic causing relatively frequent GAC change outs (approximately 4 per year) relative to the frequency expected due to chemical loading. Poor solids removal appears to be caused by undersized metals removal system clarifiers, inadequate oxidation, and or other aspects with the metals removal system and filtration system. The site team reports less frequent GAC change outs recently, but this is due to the lower extraction rate. The site team's experience with attempting to bypass the former activated sludge (biological clarifiers) and the ongoing need to remove solids from these units suggests carryover of solids from the metals removal system clarifiers that are settling in the aeration basins, filtered by the pressure filters, and or passing through the pressure filters. Turbidity readings entering and leaving the pressure filters meet the design criteria, but the optimization review team has seen cases where turbidity readings were not adequate for evaluating solids removal.

- The system has a two-stage metals removal system. Each stage has a reaction tank and clarifier. A treatment plant with one appropriately designed and operated metals removal system should be adequate.

- The system relies on former activate sludge or biological clarifier units as air strippers and solids settling capacity. The units were originally intended to be used as bioreactors to treat influent with high organic contaminant concentrations. However, the organic contaminant concentrations have been lower than expected since system operation began, and the systems (which have concentric circular compartments for aeration and settling) have been used as inefficient air strippers and clarifiers.

5.5 REGULATORY COMPLIANCE

The system routinely meets discharge requirements.

5.6 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

Table 5-1 provides a breakdown of the approximately $900,000 annual routine costs for the current remedy in 2011 based on information provided by the site team. The total extraction rate during this time period was generally under 70 gpm. GAC, permanganate and polymer usage, and waste generation, reflect this relatively low extraction rate. The other categories are relatively insensitive to flow rate.

Table 5-1. Summary of Current Annual O&M Costs

Category	2011 Cost	Comments
Project Management	$ 52,000	These are contractor costs and includes monthly lump sum $2,716 for plant operation as well as monitoring well sampling and analytical results reporting
Operations Labor	$ 573,000	This includes operators as well as mechanic's time
Materials	$ 44,000	GAC, polymer and permanganate. Includes the following: • two GAC change outs at $8,080 per change out • approximately 6,000 pounds of potassium permanganate at $4 per pound* • approximately 500 pounds of polymer at approximately $10 per pound*
Waste Disposal	$ 11,000	For approximately 30 tons of non-hazardous waste*
Utilities – Electric	$ 79,000	$0.126/ kilowatt-hour (kWh)
Utilities – Gas	$ 15,000	$1.082/therm (100,000 British thermal units)
Groundwater sampling	$ 86,000	Includes the annual sampling of wells which includes analytical and yearly report
Laboratory analytical	$ 21,000	Operations and field samples includes quarterly samples (but not annual sampling event)
Other routine costs	$ 44,000	Includes replacement parts and supplies
Total	***$ 889,000***	***Approximate total for routine O&M costs in 2011***

** Estimated by the optimization review team*

In 2011 there were also non-routine costs of approximately $30,000 pertaining to the Five-Year Review activities and arsenic studies.

5.7 APPROXIMATE ENVIRONMENTAL FOOTPRINTS ASSOCIATED WITH REMEDY

The following table presents the approximate environmental footprint on an annual basis for operation of the existing P&T system operating at approximately 60 to 70 gpm. The footprint is calculated in general accordance with the EPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA, February 2012).

Table 5-2. Estimated Environmental Footprint for Annual P&T Operation

Core Element	Metric		Unit of Measure	Metric Value*
Materials & Waste	M&W-1	Refined materials used on-site	tons	**20**
	M&W-2	Percent of refined materials from recycled or waste material	percent	**None**
	M&W-3	Unrefined materials used onsite	tons	**None**
	M&W-4	Percent of unrefined materials from recycled or waste material	percent	**None**
	M&W-5	Onsite hazardous waste generated	tons	**None**
	M&W-6	Onsite non-hazardous waste generated	tons	**30**
	M&W-7	Percent of total potential on-site waste that is recycled or reused	percent	**None**
Water		Onsite water use (by source)		
	W-1	- Potable water: chemical blending, injected to aquifer	millions of gals	**Limited**
	W-2	- Groundwater: treatment, reinjected to aquifer	millions of gals	**34**
	W-3	- Source: use, fate combination #3	millions of gals	**None**
	W-4	- Source: use, fate combination #4	millions of gals	**None**
Energy	E-1	Total energy use	MMBtu	**10,250**
	E-2	Total energy voluntarily derived from renewable resources		
	E-2A	- Onsite generation or use and biodiesel use	MMBtu	**None**
	E-2B	- Voluntary purchase of renewable electricity	MWh	**None**
	E-2C	- Voluntary purchase of Renewable Energy Certificates (REC)	MWh	**None**
Air	A-1	On-site NOx, SOx and PM10 emissions	Lbs	**None**
	A-2	On-site HAP emissions	Lbs	**None**
	A-3	Total NOx, SOx and PM10 emissions	Lbs	**10,546**
	A-4	Total HAP emissions	Lbs	**139**
	A-5	Total GHG emissions	tons CO_2e	**751**
Land & Ecosystems	No significant effect on land and ecosystems.			

** Estimated metric value for one year of operation*
NOx = nitrogen oxide
SOx = sulphur oxide
PM10 = Particulate Matter
HAP = hazardous air pollutants
GHG = greenhouse gas
gals = gallons
MMBtu = 1 million British Thermal Units
MWh = megawatt-hour
lbs = pounds
CO_2e = carbon dioxide equivalent

The primary contributor to the materials metric is the virgin GAC that is used for treatment. The primary contributors to the energy use are the electricity use (more than 70 percent of the total energy use) and natural gas use (more than 15 percent of the total energy use). These contributors are also among the largest contributors to the air emissions footprints. The GAC contributes almost 20 percent of the GHG emissions.

5.8 SAFETY RECORD

The site team did not report any safety concerns or incidents.

6.0 RECOMMENDATIONS

Several recommendations are provided in this section related to remedy effectiveness, cost control, technical improvement and site closure strategy. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and QAPPs.

Cost estimates provided herein have levels of certainty comparable to those done for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) FSs (-30%/+50%), and these cost estimates have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. The costs presented do not include potential costs associated with community or public relations activities that may be conducted prior to field activities. The cost impacts of these recommendations are summarized in Tables 6-1 and 6-2.

Figure 6-1 presents a flowchart that summarizes potential remediation scenarios (identified as “A” through “D” on Figure 6-1), and some of the decisions that will determine which scenario ultimately occurs. Figure 6-1 is referenced in the discussion of some of the recommendations provided below.

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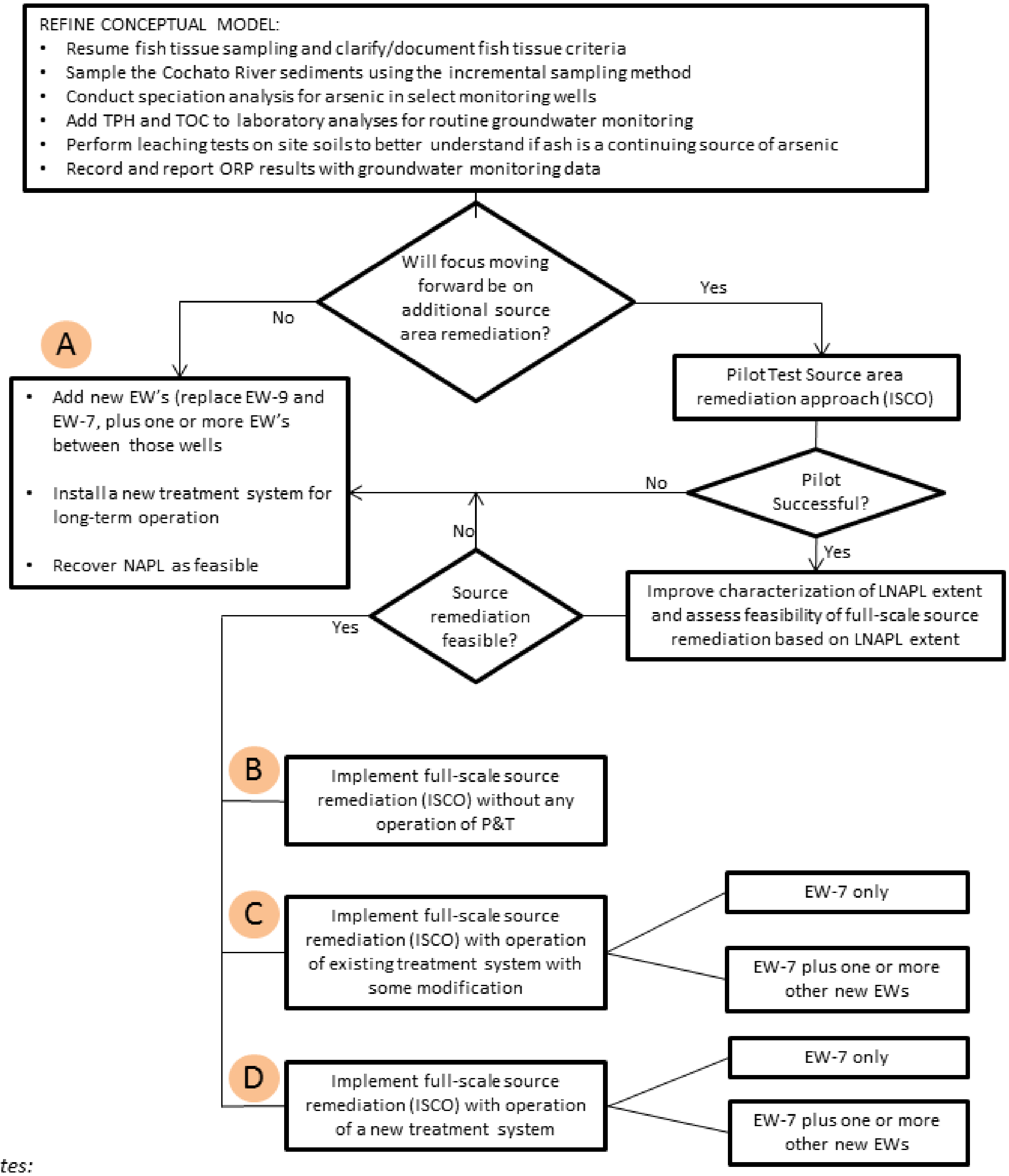
Figure 6-1. Flowchart Summarizing Potential Remediation Scenarios



Notes:

1) *For all scenarios (A to D) periodic sediment and fish tissue sampling in the future is recommended.*
2) *For scenarios B and C, a decision regarding the need for subsequent actions (e.g., P&T with upgraded treatment plant and/or additional source area remediation) would be deferred until after results of the source area remediation are known, which provides a realistic opportunity to avoid incurring the up-front costs for treatment plant upgrades.*
3) *A decision to pursue scenario B rather than scenario C or D could be based on results of current baseline sampling for sediments compared to previous results (see text).*
4) *For scenarios C and D, a decision to extract from EW-7 only versus adding new EWs could be based on results of current baseline sampling for sediments compared to previous results (see text).*

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 RESUME FISH SAMPLING

As indicated on the flowchart presented on Figure 6-1 (see Appendix A), the optimization review team recommends that fish tissue sampling be performed under existing conditions, and then periodically at the frequency recommended in the Third Five-Year Review (every five years) to monitor future concentrations. Also, the optimization team recommends that data quality objectives for analyzing fish tissue moving forward be clearly documented. At the request of site stakeholders, the optimization provides specific recommendations below for collecting fish tissue samples, and suggests that the site team use this as a starting point to finalize a sampling approach with respect to fish tissue that will be acceptable to all site stakeholders for evaluating protectiveness.

The optimization review team does not recommend sampling different stations (upstream, adjacent and downstream). Rather, the optimization review team recommends that fish sampling be performed in the location closest to the site (adjacent to or downstream from the site) where fishing might reasonably occur by the general public for purposes of consumption. It is recommended that the sampling focus on the following fish:

- Abundant fish (for example, sunfish species such as bluegill and or pumpkinseed) – these are expected to be relatively abundant, and therefore are good species to target for long-term trends

- Predatory fish (for example, largemouth bass and or brown bullhead) – these represent large fish that are desirable for consumption. The largemouth bass may be more plentiful.

Although American eel has been collected in previous studies, they are migratory (less desirable) and also more difficult to collect and handle and may not be present in sufficient numbers to collect a representative sample as individual replicate samples. It is recommended that three individual fish from one of the selected sunfish species, and three individual fish from one of the selected predatory species, be collected per event. For abundant fish, filets can be sampled for fish longer than 6 inches, and whole-body analysis can be performed for fish less than 6 inches. For predatory fish, all fish collected for sampling should be larger than 6 inches.

The preliminary costs for preparing an updated sampling plan for fish tissue sampling is estimated to be $9,000. The estimated cost to conduct the fish tissue sampling is estimated to be approximately $25,000. The costs for clarifying and documenting the criteria have not been estimated.

6.1.2 SAMPLE THE COCHATO RIVER SEDIMENTS USING THE INCREMENTAL SAMPLING METHODOLOGY

Sediment sampling provides two benefits for the remedy. First, it helps track the quality of the river over time subsequent to remedial activities to date. Second, it helps evaluate the effectiveness of continuing remedial activities in protecting river sediments from further contamination. The sampling data to date are subject to significant variability that makes data interpretation difficult. Sampling has previously been conducted at five stations. Four stations (A through D) were divided into nine intervals, and three intervals at each station were selected at random to be sampled in each event. Stations A, B and D are approximately 450-foot stretches of river (9 intervals of 50 ft each), and Station C is a 900-foot stretch of river (9 intervals of 100 ft each). Only one sample was collected from Station E. The samples from the three intervals per station (except Station E) were therefore used to represent sediment concentrations for each 450-foot or 900-foot station. The ranges of the sampling results for a given year were sometimes higher than the year to year variability, making it difficult to evaluate changes in river condition over time. One potential way of collecting more representative samples from each interval is to use the incremental sampling methodology (ISM) as described in the Interstate Technology Regulatory Council (ITRC) web-based ISM document (www.itrcweb.org/Team/Public?teamID=11). ISM has the benefit of submitting fewer samples for laboratory analysis and providing more representative results for each station.

Because sediment sampling is suggested to be performed to evaluate conditions over time, rather than to delineate specific target areas for remediation, the optimization review team recommends considering the use of ISM for sediment sampling for future samplings at each of the five stations. The optimization review team recognizes that there has not been widespread use of ISM for sediments to date, but given the intended use of the data, the use of ISM for sediment sampling at this site seems appropriate. The specific details of an ISM work plan are too detailed to provide in this report, but a general description with site-specific context is provided.

Using the ISM terminology, the site team could consider each existing station both a “decision unit (DU)” and a “sampling unit (SU)”. Each DU/SU (station) would be sampled over time and used to determine if sediment concentrations are generally increasing or decreasing over time in that DU/SU. Each DU/SU would be divided into a sub-network of perhaps 45 equally-sized grid areas. Sediments are collected as sample increments from each of the 45 grid areas in a single DU/SU and combined into a single “incremental sample” for laboratory analysis. The result for each sampling station is a single laboratory sample that averages the contaminant concentrations from 45 locations, rather than the previous approach where three discrete laboratory samples are analyzed and then averaged. Although additional “incremental samples” could be collected for each station, the optimization review team does not believe that additional benefit from these samples merits the additional cost given the intended use of the data. The applicability of using an ISM approach over a more traditional grid or transect approach can be assessed, if desired, by also collecting a limited number of discrete samples.

Repeated ISM sampling on an annual basis will provide increased confidence in the results with each event that is conducted and hopefully provide a meaningful data set for evaluating trends over time. The optimization review team estimates that up to $15,000 will be required for developing an ISM sampling plan. The optimization review team also estimates that the sampling could be conducted within five days per event with a two-person crew. Six samples (including one QA/QC sample) would be submitted to a laboratory for analysis for SVOCs, pesticides and arsenic. Results can be reported in the annual report. The estimated cost for each annual event, including sampling, laboratory analysis, data management and reporting should be approximately $15,000.

6.1.3 CONDUCT SPECIATION ANALYSIS FOR ARSENIC IN SELECT MONITORING WELLS

Arsenic can be present in the subsurface as arsenate (oxidized and potential to be immobilized), arsenite (reduced and mobile), and organic (methylated) arsenic (mobile). Eliminating the organic contamination (for example, VOCs, SVOCs and TPH) and increasing the ORP can convert the arsenite to arsenate and allow the arsenate to adsorb to the soil matrix; however, this change in ORP will not address organic arsenic. The relationship between ORP and arsenic is fairly well established for the areas near EW-7 and EW-8; however, insufficient data are available for evaluating the ORP/arsenic relationship in the area of ASB-9 and ASB-16. The optimization review team recommends conducting one round of arsenic speciation analysis (including methylated arsenic) on wells MW-97-12, MW-97-28 and MW-04-02. In addition, during the next mobilization of a direct-push rig to the site, one or more groundwater samples from the vicinity of ASB-9 and ASB-16 should be analyzed for VOCs, SVOCs, TPH, ORP and speciated arsenic samples. The additional cost of this recommendation, if coordinated with other direct-push sampling, should be under $5,000.

6.1.4 ADD TOTAL PETROLEUM HYDROCARBONS AND TOTAL ORGANIC CARBON TO LABORATORY ANALYSES FOR ROUTINE GROUNDWATER MONITORING

The CSM discussed in Section 4.0 incorporates speculation by the optimization review team that ongoing arsenic contamination and continued arsenic mobility in groundwater could be linked to low ORP that might be caused by microbial degradation of organic contaminants. The VOCs and SVOCs are only a part of the organic compounds contributing to the low ORP. TPHs are also a potential source. To better evaluate a potential correlation between residual organic contamination versus low ORP (see recommendation in Section 6.3.1) and high arsenic concentrations, the optimization review team recommends adding TPH and total organic carbon (TOC) to the analyte list for the groundwater monitoring program. Assuming 30 wells monitoring wells are sampled on an annual basis, including these additional analytes in the monitoring program would add an additional $3,000 per year in laboratory costs.

6.1.5 PERFORM LEACHING TESTS ON SITE SOILS TO BETTER UNDERSTAND IF SITE SOILS ARE A CONTINUING SOURCE OF ARSENIC

To further address the speculation by the optimization review team that ongoing arsenic contamination could be linked to low ORP that might be caused by microbial degradation of organic contaminants, it is recommended that some controlled tests be designed and performed to assess the leaching of arsenic from the site soils (saturated soils and incinerated soil/ash) under varying conditions of ORP. It is suggested that tests be performed using site soils from several key locations where high arsenic concentrations have been identified and source material might be suspected, and that different tests be performed using site water versus “lab water”. The “lab water” would represent variants of TCLP tests with water adjusted for both ORP and pH. The use of site water has the advantage of representing actual site water chemistry. However, since the site water is already in contact with the soil and already has elevated arsenic concentrations, interpretation of results from site water may be complicated. Designing the specific details of such a test is beyond the scope of this optimization review, but the optimization review team estimates the cost to design and implement such tests to be on the order of $25,000.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 REDUCE TREATMENT PLANT REPORTING

Daily, weekly, monthly, quarterly and annual reports are prepared. The daily reports and weekly reports provide limited benefit to managing the site but require additional labor. The optimization review team, therefore, suggests eliminating the daily and weekly reports and maintaining the same level of information in the monthly reports. This recommendation along with other labor reducing recommendations may result in a meaningful reduction in operator and or reporting labor (such as, reduction in treatment plant staffing), but specific cost savings due to this specific recommendation have not been quantified.

6.2.2 OPTIMIZE METALS REMOVAL SYSTEM

If the existing treatment plant is expected to operate for more than five years, the optimization review team suggests replacing it with a new treatment system to streamline operations. However, if the existing treatment plant is going to operate for five years or less, the optimization review team recommends considering optimizing the existing metals removal system as described below. Modifications to chemical use and clarification may also be appropriate as discussed below.

Potassium permanganate has proven to be effective at oxidizing the arsenic at the head of the treatment plant. However, potassium permanganate requires manual chemical blending and daily maintenance of the system. Hydrogen peroxide is also an effective oxidant for arsenic removal and is used, for example, at the Vineland Chemical Superfund Site in New Jersey for an arsenic removal system. Hydrogen peroxide can be transported to the site as a 50 percent aqueous solution and added to the process stream with a feed pump. No manual batching would be required, and maintenance would be negligible.

The Vineland Chemical Superfund Site is also able to remove arsenic with a significantly lower ORP (for example, approximately 350 mV) than the target ORP at Baird and McGuire of approximately 700 mV. The set point of 700 mV is comparable to the set point used for treating pathogens and may be higher than necessary for arsenic oxidation. Although historic tests may have been performed to determine the optimal ORP set point for the site, the water quality has changed significantly over time, and the required ORP may now be lower. The ORP/Eh vs. pH plots shown in Figures B-5 through B-8, indicate that an Eh (typical ORP measurement + 200 mV to correct for the offset associated with the reference electrode) of 150 mV should be adequate at a pH between 6.5 and 7 to co-precipitate arsenic with iron. A higher ORP is likely needed to provide the response time needed in a treatment plant. Typically, the optimization review team sees a higher ORP setting of approximately 350 mV, which is higher than 150 mV but significantly lower than the currently used 700 mV. The optimization review team recommends revisiting the ORP set point to see if adequate arsenic removal at this site can be accomplished with a lower ORP. A lower ORP set point would translate to lower chemical usage regardless of the oxidant used.

The site team could test hydrogen peroxide as a potential oxidant (as is done at the Groveland Wells Site in Region 1) and determine if using hydrogen peroxide would be more cost-effective than potassium permanganate. Part of the cost savings associated with using hydrogen peroxide would be from reduced labor if the labor reductions associated with a switch to hydrogen peroxide can be combined with other labor reducing recommendations to eliminate an operator or mechanic position. Testing lower ORP set points and testing hydrogen peroxide could be done on a trial basis with the treatment plant. The optimization review team estimates that $10,000 would be sufficient for planning the test, implementing the test, and conducting the additional arsenic analyses to support the test.

Iron and arsenic removal with iron co-precipitation is sensitive to the pH because the charge on the iron hydroxide floc changes with pH. Arsenic in the oxidized state (for example, arsenate, $H2AsO_4^-$) has a negative charge. The iron floc, therefore, should have a positive charge to attract the negative arsenate ion, and anionic polymer (negative charge) should be used for coagulation of the positive iron/arsenic floc. An optimal pH set point for this overall chemistry is likely 6.5. The pH of the influent to the treatment plant ranges from approximately 6.7 to 7 with no pH adjustment. Decreasing the pH to 6.5 may improve flocculation, coagulation and settling. The polymer used and or the polymer dosing might also be modified based on the pH, ORP set point and oxidant used. The site team might consider working with a polymer vendor to conduct bench scale studies to identify the optimal pH, ORP, oxidant and polymer to improve settling within the metals removal system clarifiers. Testing within the plant can also be conducted and might be accomplished for under $10,000.

The metals removal system clarification step might also be improved by increasing the capacity of the clarification step. Little benefit is achieved from the second stage of the metals removals system. To improve settling, the site team might consider replumbing the plant to arrange the two metals removal clarifiers in parallel. This would decrease the flow rate in each clarifier and should improve settling. To evaluate the potential effectiveness of this change, the site team should compare turbidity after the first stage metals removal from periods when the flow rate was over 100 gpm, to the turbidity after the first stage metals removal from periods when the flow rate was approximately 60 gpm. If there is a noticeable difference in the two turbidity measurements, then arranging the two clarifiers in parallel should improve settling and reduce the solids loading on the pressure filters. Arranging flow through the metals removal clarifiers in parallel would likely cost under $10,000.

Savings from implementing the above recommendations is difficult to quantify. Savings might be realized in reduced labor, chemical usage and GAC usage that could potentially result in cost savings of $10,000 per year or more.

6.2.3 DISCONTINUE AERATION IN ACTIVATED SLUDGE UNITS

The activated sludge units that are currently used as air strippers are providing little benefit to overall water treatment, and the aeration is likely contributing to biofouling of the GAC units. Although the aeration removes some mass, the GAC units are changed out prematurely due to fouling rather than due to chemical loading. Therefore, the mass removal from aeration is not translating to a reduction in GAC use. The optimization review team recognizes that the clarifier compartments of these activated sludge units are critical to current treatment plant operation given the underperformance of the existing metals removal clarifiers. The optimization review team recommends discontinuing operation of the aeration blowers and using the units for solids settling only. Discontinuing blower operation would reduce electrical costs by approximately $9,000 per year and may reduce the biofouling of the GAC, which could potentially decrease the number of GAC changeouts.

6.2.4 POTENTIAL LONG-TERM COST SAVINGS FROM REMEDIATION SCENARIOS

Figure 6-1 presents a flowchart that summarizes potential remediation scenarios for this site (identified as “A” through “D” on Figure 6-1). The long-term costs for this site, and potential cost-savings versus the status quo, will be highly dependent on which scenario ultimately occurs. That will depend on several key decisions and outcomes moving forward, including the following:

- Will the primary focus moving forward be on source area remediation (scenarios “B”, “C” or “D”), or will the focus be on containment of impacted groundwater prior to discharge to the Cochato River (scenario “A”)?

- If the focus is on additional source area remediation, will it be successful enough to eliminate P&T in the long-term, and will that success be fast enough to eliminate the need for a new treatment plant in the short-term (scenarios “B” or “C”) or will a new treatment plant be required anyway (scenario “D”)?

- If the focus is on additional source area remediation, will the results of the sediment sampling (current baseline and comparison to previous results) indicate that containment of impacted groundwater near the Cochato River is not required during source area remediation so that P&T can be eliminated during the source area remediation (scenario “B”), or perhaps containment will only needed in the vicinity of EW-7 (options for scenarios “C” and “D”)?

- If the focus is on additional source area remediation, how much up-front-cost will ultimately be required for successful implementation of aggressive source area remediation based on the extent of LNAPL that is not yet fully characterized?

These items are discussed in detail in Section 6.4, along with initial cost estimates for some of the scenarios. The approach that likely has the greatest potential to reduce life-cycle costs is to pursue more aggressive source area remediation, because the goal of such efforts would be to ultimately eliminate the need for long-term containment, which currently costs on the order of $900,000 per year for an indefinite period. A modified P&T system in the future potentially might cost on the order of $500,000 per year. The payoff period would depend on the ultimate up-front cost of the active remediation, whether or not it is successful at eliminating the need for long-term P&T, and the avoided costs per year for long-term P&T after it is decommissioned. Note that an ultimate decision regarding a path forward (such as, the most appropriate remediation scenario) will depend on evaluation of future data collection and testing that is recommended in this optimization review report.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 RECORD AND REPORT ORP RESULTS WITH GROUNDWATER MONITORING DATA

The CSM discussed in Section 4.0 incorporates speculation by the optimization review team that ongoing arsenic contamination could be linked to low ORP that might be caused by microbial degradation of organic contaminants. The optimization review team recommends reporting the ORP results in the monitoring reports and correlating the ORP measurements with the arsenic concentrations as well as TPH and TOC (see Section 6.1.4). Implementing this recommendation should not require any significant additional cost.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

The discussion of considerations for gaining site closeout in the following sections references Figure 6-1, which presents a flowchart that summarizes potential remediation scenarios for this site (identified as “A” through “D” on Figure 6-1).

6.4.1 DETERMINE IF PRIMARY FOCUS WILL BE SOURCE REMEDIATION OR CONTAINMENT

A significant decision moving forward is if the primary focus will be on source area remediation, or if the primary focus will be on containment of impacted groundwater prior to discharge to the Cochato River. Four potential “scenarios” moving forward are illustrated on Figure 6-1 and in Table 6-2. Scenario “A” focuses on containment, whereas Scenarios B to D focus on source area remediation. The optimization review team believes additional information and testing will be required to determine the primary future focus of the remediation, and initial steps are suggested in Sections 6.1.1 to 6.1.4 of this optimization review report to develop the information required to make that decision. O&M of the current system should continue as the suggested data are acquired and evaluated by MassDEP and EPA Region 1. Depending on the outcome, MassDEP and EPA Region 1 will also need to determine the need (if any) for updates to decision documents and or programmatic classification of the remedy.

Detailed discussion of four potential "scenarios" illustrated on Figure 6-1 is provided below.

- ***Scenario "A" – Future Focus on Containment***. If the future focus of remediation will be on containment (scenario "A"), significant up-front modifications to the current P&T system will be required, due to the expectation of long-term P&T operation for a containment-focused remedy. As an aside, the optimization review team believes a long-term *in situ* barrier using air sparging, as an alternative to P&T, would likely suffer from excessive fouling due to the continuous loading of dissolved iron into the sparge area. Modifications would be made to the extraction system to improve containment, and modifications to the treatment plant would be made to improve performance and streamline operation. LNAPL would be collected from the subsurface to the extent feasible.

    - Extraction system modifications would include installation of new extraction wells (for example, replace EW-9 and add one or more extraction well between EW-7 and EW-9), addition of piping and controls for the new extraction well locations, and substantial upgrades to the current treatment plant. Installation of the extraction wells, piping the wells to the treatment plant, conducting pumping tests and conducting a capture zone evaluation to determine appropriate extraction rates, which will include development of a "target capture zone" and will likely incorporate groundwater modeling, will likely cost on the order of $250,000.

    - Modifications to the treatment system would involve removing all of the existing equipment, installing new equipment and commissioning the new equipment. These substantial changes are suggested because the current system requires a substantial amount of labor due to the deteriorating condition of the existing equipment and because a large number of treatment components in the process stream do not provide a beneficial function (for example, second stage of metals removal) or are inefficient (for example, use of activated sludge units for aeration and settling). The current system requires approximately 200 hours of staffing per week, whereas a new system should require only 40 to 80 hours of staffing per week. The optimization review team estimates that the suggested changes would require as much as $200,000 to remove the existing equipment, approximately $1 million to furnish and install new equipment and approximately $300,000 to commission the system for a total of $1.5 million. A lower cost option may be available if the metals removal and solids handling equipment with appropriate specifications from another site's treatment plant are available for use at the Baird and McGuire site. For example, the metals removal and solids handling equipment at the Groveland Wells treatment plant was designed to handle approximately 150 gpm and would likely be appropriate for the Baird and McGuire, site if available. The costs for moving equipment, installing the equipment and commissioning the new plant would likely be under $1 million.

  This scenario (focus on containment) will make it highly probable that there will be long-term O&M costs on the order of $500,000 per year or more for an indefinite period (such as, many decades), since the sources of organics that cause the reducing conditions (and resulting high dissolved arsenic concentrations in groundwater) will not be addressed and long-term containment will likely be required due to the "additive nature" of long-term arsenic discharge to sediments of the Cochato River under this scenario. However, the significant up-front costs associated with aggressive source area remediation will be avoided under this scenario.

- ***Scenarios "B" to "D" – Future Focus on Source Area Remediation*** If the future focus is on source area remediation (scenarios "B", "C" or "D"), more significant up-front costs will be required to implement additional active source remediation such as ISCO (a summary of potential technologies is described below). However, the goal of such efforts would be to ultimately eliminate the need for long-term P&T, which currently costs on the order of $900,000 per year. A modified P&T system in the future potentially might cost on the order of $500,000 per year. As indicated on Figure 6-1, it is also possible that short-term addition of new extraction wells and extensive treatment plant upgrades (for example, a new treatment plant) could be avoided with this approach, and require only minor short-term modifications (on the order of $100,000) to the existing treatment system (see Section 6.4.2). The payoff period for the source area remediation would depend on the ultimate up-front cost of the source area remediation, whether or not it is successful at eliminating the need for long-term P&T, and the avoided costs per year for long-term P&T that are ultimately eliminated.

The optimization review team suggests the following three primary technology options for source area remediation:

- Air sparging and soil vapor extraction (AS/SVE)
- *In situ* chemical oxidation (ISCO)
- *In situ* thermal remediation (ISTT)

The primary objective of these technologies would be to address the organic contamination (including residual LNAPL) that is speculated by the optimization review team to be causing exceedances of some VOC and SVOC compounds and causing the low ORP that is either mobilizing the arsenic or allowing it to remain mobile. Pesticide contamination may not be directly addressed but in the absence of residual LNAPL the remaining pesticides are expected to adsorb to soils and not be detected above GW-1 Standards in groundwater samples. Each of the technologies is discussed below assuming a target remediation area of 150,000 square ft, corresponding to a remediation volume of approximately 60,000 cubic yards if a 10-foot thickness of impacts is assumed. The conceptual remediation area of 150,000 square ft generally corresponds to the approximate area of the LNAPL extent indicated on Figure B-4 in Attachment B and assumes that the contamination between EW-7 and EW-9 would attenuate once the upgradient source is removed. This is a key assumption that would need to be evaluated after additional characterization has been conducted (See Section 6.1.5 and Section 6.4.2) because conducting source area remediation in this area would significantly increase the costs provided in this section. The conceptual target volume for remediation would be refined with additional characterization prior to remediation, potentially resulting in increases or decreases to the target volume. The potential technologies are summarized below.

- ***AS/SVE*** – This approach would involve injecting air into the saturated zone with the intent of volatilizing some of the VOCs, SVOCs and TPH and adding oxygen to the subsurface to enhance microbial degradation of organic contamination. The technology would also include SVE wells to remove off-gas from the sparging and to address residual contamination above the water table. For conceptual purposes the radius of influence for sparging wells (for volatilization and oxygen delivery) is assumed to be approximately 10ft, and the radius of influence for SVE wells is assumed to be approximately 20 ft. Also for conceptual purposes, the average depth for sparge wells is assumed to be 30 ft and the average depth for SVE wells is assumed to be 15 ft. Based on these assumptions, approximately 2,000 sparge wells and 500 SVE wells would be required. Assuming the system is operated on a pulsed/rotating basis to reduce the compressor and blower capacity, construction costs would be close to $10 million and operating costs would be approximately $600,000 per year. Assuming the system requires approximately 4 years of operation, the total cost for this system would be on the order of $12.4 million. The following are advantages and disadvantages of using this technology approach:

AS/SVE Advantages and Disadvantages

Advantages	Disadvantages
• Directly addresses issue of low ORP by removing organics and adding oxygen to source area • Operating costs decrease if portions of the system can be shut down • Whole system or part of system can continue to operate for additional years with relatively low overall cost • Addresses vadose zone contamination	• Relatively high capital costs • Does not directly remove or destroy pesticides • Potential for fouling from biological activity or iron precipitation • Does not address organic arsenic, if present • Results in large amount of infrastructure in ground
Key Unknowns	
• Actual extent of treatment zone • Actual system performance • Duration of operation • Presence or absence of organic arsenic • Degree of fouling and effect of fouling on remedy performance	

- ***ISCO*** – This approach would involve injecting chemical oxidants into the saturated zone with the intent of directly destroying VOCs, SVOCs, TPH, and some pesticides. Due to the required oxidant strength for this site, Fenton's reagent or activated persulfate would be appropriate oxidants. For conceptual purposes the radius of influence for the injection wells is assumed to be approximately 15 ft. The treatment volume assumed for the AS/SVE remedy is used and would translate to approximately 850 injection locations. Given this large number of injection locations, the preference to inject at multiple intervals to improve reagent distribution, and the need to conduct multiple injection events, it may be preferable to purchase two direct-push rigs, supporting injection equipment, and full-time operators rather than install permanent injection points or contract the injection from a chemical injection vendor. The direct-push rigs and supporting equipment would likely cost approximately \$500,000. Two full-time injection crews of two individuals each would cost approximately \$600,000 per year. An additional \$100,000 per year could be allocated for performance sampling with the same crews, and \$150,000 per year could be allocated for project management, engineering support and reporting. The two crews should be able to conduct injections at 10 locations per day allowing for more than two injection events per year. The cost for reagents for a full-scale application would be approximately \$1,500,000 per event. Assuming four full-scale events can be conducted in two years, the total cost of the ISCO remedy would be approximately \$8.2 million. If recoverable LNAPL is identified in any of the direct-push points, the crews could install temporary piezometers to recover the LNAPL prior to injection.

ISCO Advantages and Disadvantages

Advantages	Disadvantages
• Remedy is applied in a relatively short time frame • Directly address issue of low ORP by destroying organics and adding oxidants to source area • Low capital cost • Injection costs decrease as injection points are eliminated • Strong oxidants should address some pesticides • Strong oxidants will convert organic arsenic into arsenate • Leaves little or no infrastructure in place	• Large quantities of costly reagents are required • Requires purchase and maintenance of direct-push rigs and injection hardware • May be difficult to address contamination present in vadose zone
Key Unknowns	
• Actual extent of treatment zone • Oxidant demand • Number of injection events required	

- ***<u>ISTT</u>*** – This approach would involve heating the subsurface to volatilize and potentially destroy organic contaminants, and then extracting the volatilized contaminants. Steam-enhanced extraction or thermal conduction would likely be used for this setting and contaminant types. Assuming the same treatment volume as the AS/SVE and ISCO options, the cost for thermal remediation would likely be approximately $15 million. For reference, the conceptual treatment volume discussed here is approximately three times larger than the treatment volume that was thermally treated at the Groveland Wells site, which cost approximately $6 million for ISTT. Two factors that could increase the cost at this site compared to the Groveland Wells site are target temperature and the distribution of the treatment volume. The Baird and McGuire remedy would require higher heating temperatures due to the contaminant types and the treatment volume being spread over a much larger area. Although some cost efficiencies would be recognized with a larger project, these two items would tend to increase the unit cost for treatment.

ISTT Advantages and Disadvantages

Advantages	Disadvantages
• Remedy is applied in a relatively short time frame • High heating temps should address pesticides • Heating helps address residual contamination locked in relatively impermeable zones • Residual heat after active heating assists with microbial degradation	• High capital costs • A different technology may be needed if additional polishing is needed • Existing PVC monitoring wells in the heating area would be destroyed during heating
Key Unknowns	
• Actual extent of treatment zone • Actual cost of remedy • Site conditions following heating application	

Based on the above preliminary conceptual analysis, the optimization review team believes that the ISCO option appears to be most appropriate of the source remediation approaches due to the relatively low up-front costs (relative to the other technologies) and the ability to adjust the level of effort and costs based on remedy performance. The results from source area characterization and pilot testing, as discussed below, may result in changes to the above preliminary analysis.

6.4.2 PILOT TESTING AND LNAPL CHARACTERIZATION IN CONJUNCTION WITH MORE AGGRESSIVE SOURCE REMEDIATION

Pilot testing and additional characterization are highly recommended before proceeding with a full-scale remedy. If the site team decides to address the source area, then the optimization review team recommends high-resolution site characterization (HRSC) of the source area and ISCO pilot testing. Given the presence of LNAPL with PAHs, laser-induced fluorescence (LIF) would be an appropriate tool for real-time measurements applied using a HRSC strategy. However, if much of the organic mass is in alkanes (straight chains) rather than aromatics (hydrocarbon rings like naphthalene), then LIF may not be appropriate. The optimization review team recommends selecting a target area at the upgradient edge of the known historic LNAPL extent to demonstrate the applicability of LIF. The demonstration would involve using LIF with a cone-penetrometer (CPT) to collect real-time fluorescence (for example, from PAH) and lithology data. It would also involve use of a direct-push rig to collect soil grab samples for SVOCs and TPH. The two target areas could be each be 50-ft by 50-ft. The LIF/CPT testing could likely log more than 250 ft per day, providing continuous vertical information to 40 ft at 6 or more locations. A direct-push rig could likely grab 5 to 10 discrete soil samples during a day. The demonstration area could be thoroughly investigated in two days. The discrete samples would be qualitatively compared to the LIF/CPT results to determine if the LIF/CPT provides a reasonable signal given the contamination observed from the soil samples. The cost for the demonstration would likely be approximately $60,000, including a work plan, field work, analysis and reporting.

ISCO can then be pilot-tested in the characterized demonstration area. Pilot testing is not recommended in the downgradient areas because recontamination of the downgradient areas is likely if upgradient sources are still present. Pilot testing should be conducted using a direct-push rig to inject Fenton’s reagent into the impacted intervals delineated during the characterization. Up to five events should be conducted with performance sampling conducted in between each event. The objectives of the pilot would be to evaluate the amount of reagent used, the radius of influence of the injections, resulting reductions in all types of organic contamination (including pesticides), and immobilization of arsenic. Based on the results, the site team can revisit the cost analysis to see if the remedy would be practical at full scale, recognizing that the pilot test plot may require significantly more oxidant than other portions of the plume. The optimization review team estimates that the cost for the pilot testing, including work plans, four rounds of injections, four rounds of direct-push sampling to evaluate performance and reporting would be under $300,000.

If the pilot test is successful in removing organic contamination, increasing the ORP, and immobilizing arsenic, then the site team could move forward with full-scale source characterization of LNAPL, including the area between EW-7 and EW-9 where high arsenic has been identified but limited information is available about organic contamination. The approach to characterization will be dependent on the outcome of the LIF/CPT demonstration. If LIF/CPT can be used with limited collaborative data from direct-push sampling, then full-scale characterization might be cost approximately $400,000, including a dynamic work plan, approximately 30 days of field work with a LIF/CPT rig and a separate direct-push rig, supporting analytical work and reporting.

6.4.3 CONSIDERATIONS FOR IMPROVING MIGRATION CONTROL IN CONJUNCTION WITH MORE AGGRESSIVE SOURCE REMEDIATION

As indicated on Figure 6-1, if more aggressive source area remediation is pursued there are several potential approaches regarding groundwater migration control during that several-year period, as follows:

- No P&T during aggressive source area remediation (scenario “B”)
- P&T to provide containment during aggressive source area remediation (scenarios “C” and “D”)
    - Using the existing treatment plant with some minor modifications (scenario “C)
    - Using a newly-installed treatment plant (scenario “D”)

If P&T can be avoided during the source area remediation (scenario “B”), there would be savings for O&M of the P&T system (currently on the order of $900,000 per year) as well as savings for any short-term modifications to the extraction and treatment system. These savings could be applied towards the cost of the aggressive remediation. The optimization review team notes that there has likely been incomplete containment for many years of previous system operation (for example, near EW-9 and between EW-7 and EW-9), so the only major difference from those conditions if P&T was eliminated would be near EW-7. If the suggested sediment sampling (See Section 6.1.2) indicates there are similar sediment concentrations adjacent to EW-7 and further downstream (particularly for arsenic), and that the sediment concentrations are not much higher than previous sampling events from 2002 and earlier, it would suggest that discharges to groundwater for a few years during aggressive source remediation will likely not cause significant degradation of the Cochato River, and site stakeholders may find it acceptable to eliminate P&T while the aggressive source remediation proceeds.

If scenario “B” (no P&T during aggressive source remediation) is not acceptable, the next least costly option regarding migration control during aggressive source remediation would be scenario “C” (P&T using the existing treatment system with some modifications). This should be feasible for a period of aggressive source remediation that lasts several years. One option would be to only pump at EW-7 during this period (generally consistent with capture near the Cochato River provided by the current system). A more costly option would be to add additional extraction wells to the north (such as a replacement for EW-9, and one or more extraction wells between EW-7 and EW-9). Deciding between these options may depend on the results of the suggested sediment sampling (See Section 6.1.2). If the sediment results are not elevated under current conditions near EW-9, or between EW-7 and EW-9, then several additional years of discharge to surface water similar to current conditions may be acceptable to site stakeholders while the aggressive source remediation is performed. This would eliminate the need for new extraction wells and associated equipment and or piping.

Scenario “D” would be the most costly option regarding migration control during additional, aggressive source remediation because it would include design, capital purchase and installation of a new treatment plant. The optimization review team does not favor this scenario, because it believes that additional, aggressive source remediation should only be attempted if it is believed it will be successful in ultimately eliminating the long-term need for migration control, therefore, it is not desirable to invest in a new treatment plant in conjunction with additional aggressive source area remediation.

6.5 RECOMMENDATIONS RELATED TO GREEN REMEDIATION

No green remediation recommendations are provided. Recommendations are focused on remedial effectiveness and remedial strategy. Green remediation practices can be considered once the site team has decided on the optimal remedial approach.

6.6 SUGGESTED APPROACH TO IMPLEMENTING RECOMMENDATIONS

The optimization review team recommends implementing the recommendations in Section 6.1 and Section 6.3.1, and then following the decision flow chart presented in Figure 6-1 and Section 6.4. Recommendations in Sections 6.2.1, 6.2.2, and Section 6.2.3 can be considered if consistent with the decisions made during implementation of recommendations in Sections 6.2.4 and 6.4.

Table 6-1. Cost Summary Table

Recommendation	Category	Additional Capital Cost	Change in Annual Cost	Change in Life-Cycle Cost (3% discount rate)
6.1.1 RESUME FISH TISSUE SAMPLING	Effectiveness	$9,000	$25,000 once every five years	30 years* $125,000
6.1.2 SAMPLE THE COCHATO RIVER SEDIMENTS USING THE INCREMENTAL SAMPLING METHOD	Effectiveness	$15,000	$15,000	30 years* $309,000
6.1.3 CONDUCT SPECIATION ANALYSIS FOR ARSENIC IN SELECT MONITORING WELLS	Effectiveness	$5,000	$0	30 years* $5,000
6.1.4 ADD TPH AND TOC TO LABORATORY ANALYSES FOR ROUTINE GROUNDWATER MONITORING	Effectiveness	$0	$3,000	30 years* $59,000
6.1.5 PERFORM LEACHING TESTS ON SITE SOILS TO BETTER UNDERSTAND IF SITE SOILS ARE A CONTINUING SOURCE OF ARSENIC	Effectiveness	$25,000	$0	$25,000
6.2.1 REDUCE TREATMENT PLANT REPORTING	Cost Reduction	Not Estimated		
6.2.2 OPTIMIZE METALS REMOVAL SYSTEM	Cost Reduction	$30,000	($10,000)	5 years* ($20,000)
6.2.3 DISCONTINUE AERATION IN ACTIVATED SLUDGE UNITS	Cost Reduction	$0	($9,000)	30 years* ($176,000)
6.2.4 POTENTIAL LONG-TERM COST SAVINGS FROM REMEDIATION SCENARIOS	Cost Reduction	See Section 6.4		
6.3.1 RECORD AND REPORT ORP RESULTS WITH GROUNDWATER MONITORING DATA	Technical Improvement	$0	$0	$0
6.4.1 DETERMINE IF PRIMARY FOCUS WILL BE SOURCE REMEDIATION OR CONTAINMENT	Site Closeout	See Table 6-2		
6.4.2 PILOT TESTING AND LNAPL CHARACTERIZATION	Site Closeout	See Table 6-2		
6.4.3 CONSIDERATIONS FOR IMPROVING MIGRATION CONTROL IN CONJUNCTION WITH MORE AGGRESSIVE SOURCE REMEDIATION	Site Closeout	See Table 6-2		

**Time frame indicated is a representative time frame selected by the optimization team for cost estimating purposes.*

Table 6-2. Estimated Cost Summary Matrix for Site Closeout Considerations

	Estimated Costs			
	Scenario A	**Scenario B**	**Scenario C**	**Scenario D**
Extraction system improvements and capture zone analysis	$250,000		Up to $250,000*	Up to $250,000*
Treatment system upgrades	$1,250,000**		$100,000	$1,250,000**
Source area characterization		$460,000	$460,000	$460,000
Pilot testing		$300,000	$300,000	$300,000
Source remedy equipment		$500,000	$500,000	$500,000
Annual costs (and duration in years) for treatment plant operation	$500,000 (30+)	$0	$900,000 (4)	$500,000 (5)
Annual costs (and duration in years) for source remedy operation	$0	$3,850,000 (2)	$3,850,000 (2)	$3,850,000 (2)
Estimated life-cycle cost (no discounting)	**$11,300,000 to over $16,500,000**	**$8,960,000**	**$12,910,000**	**$12,960,000**

Scenario A – Containment only with continued LNAPL recovery (estimated life-cycle cost range based on various assumptions regarding duration and discounting over the long operation period.
Scenario B – Source remediation without containment (no discounting of costs to present value)
Scenario C – Source remediation with containment provided by existing system (assumes all repairs and modifications to treatment plant are conducted with the annual O&M cost) (no discounting of costs to present value).
Scenario D – Source remediation with containment provided by new system (no discounting of costs to present value)

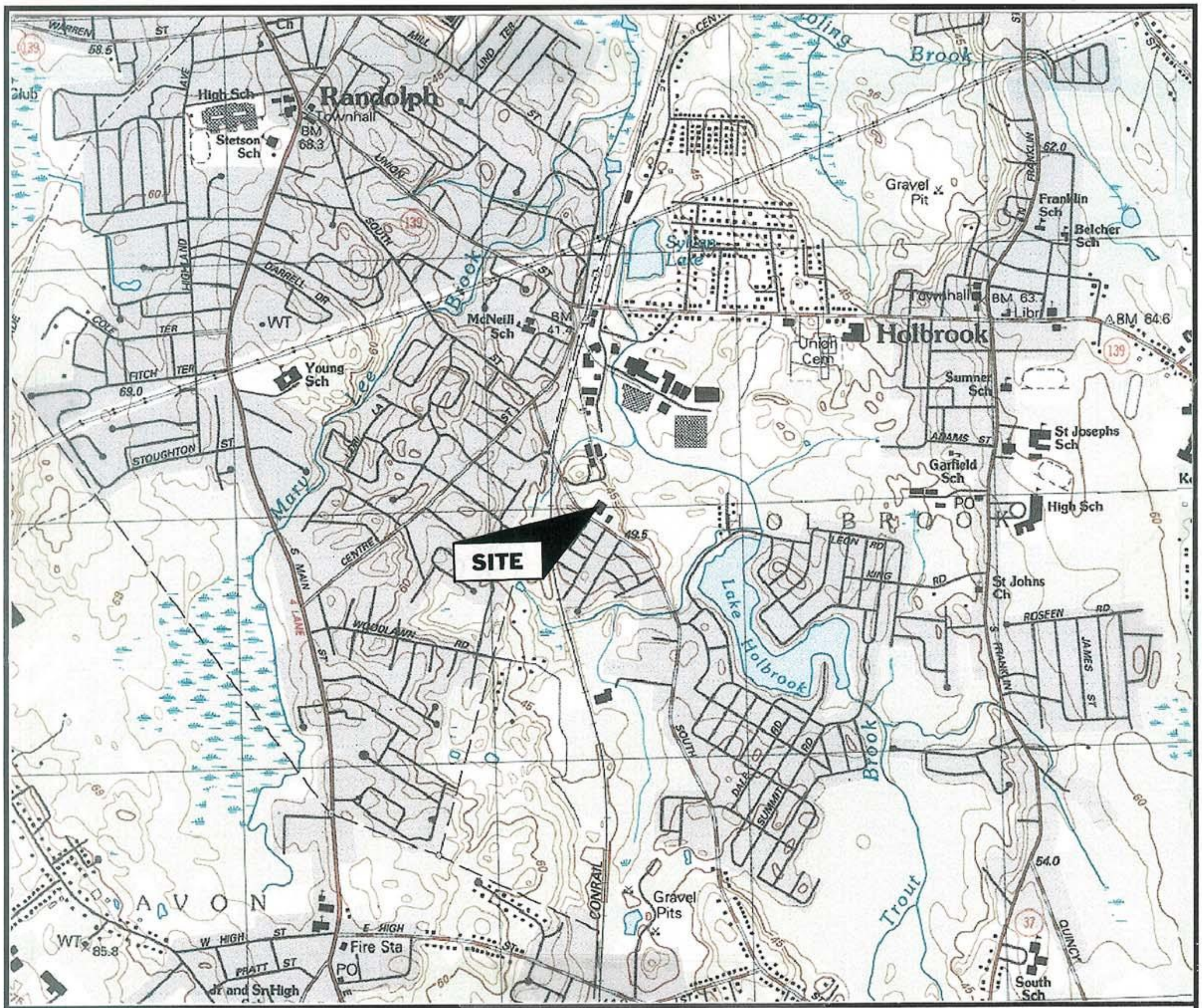
All source remediation scenarios cost estimates assume the ISCO approach as presented in the text and a target area similar in size to the LNAPL extent identified on Figure B-4 (See Appendix A). The actual source area for treatment could be smaller or larger depending on the outcome of the source area characterization.

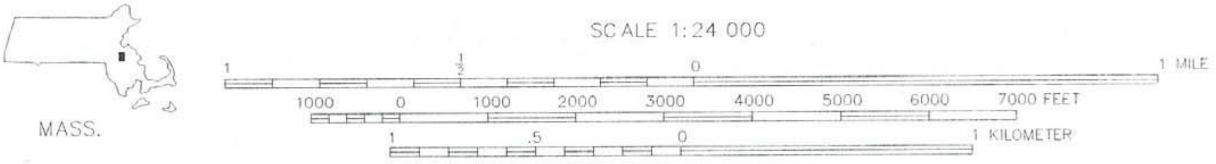
All cost estimates are feasibility level cost estimates and are depending on findings from additional characterization and pilot studies.

**Containment strategies could range from partial containment by operating EW-7 only, which would require little or no capture zone analysis and extraction system improvements, or more comprehensive capture that could require up to $250,000.*

*** Presented estimated cost represents an average of two presented costs ($1,000,000 and $1,500,000).*

ATTACHMENT A: Figures from Existing Site Reports





COORDINATES UTM: NAD83 332494mE; 4668219mN	A	RTN 3-0333	LI	CJM	CJM	1/08
	ISSUE	DESCRIPTION	DRWN.	CHKD.	APPR.	DATE

BASE MAP: USGS TOPOGRAPHIC MAP PRINTED FROM TOPO! 1998 WILDFLOWER PRODUCTIONS

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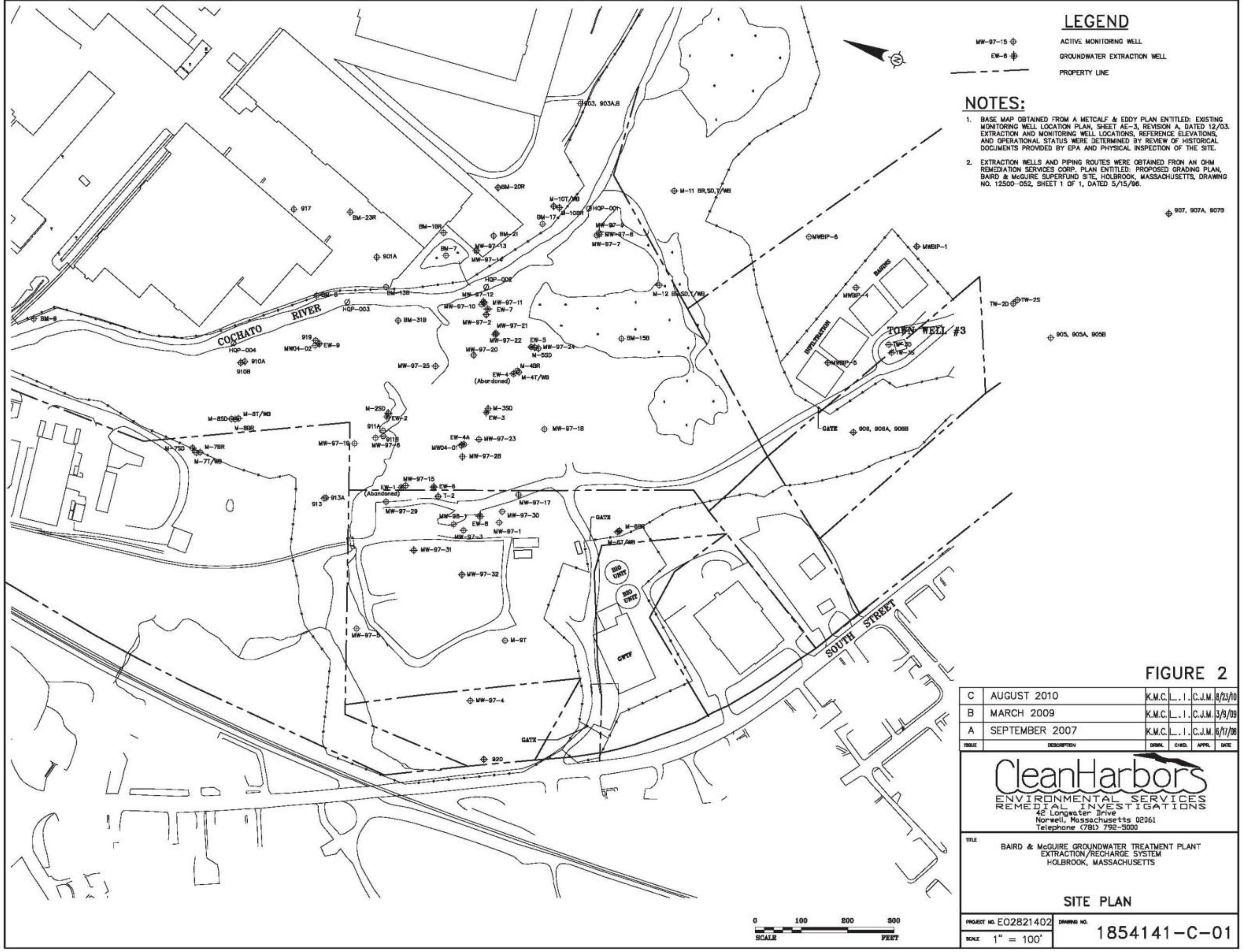
42 Longwater Drive
Norwell, Massachusetts 02061
Telephone (781) 792-5000

BAIRD & MCGUIRE SUPERFUND SITE
775 SOUTH STREET
HOLBROOK, MASSACHUSETTS

LOCUS MAP

PROJECT NO. E01604547 SCALE AS NOTED	DWG. NO. 4547-A-01	FIGURE 1



LEGEND

MW-97-15 ⌖	ACTIVE MONITORING WELL
EW-6 ⌖	GROUNDWATER EXTRACTION WELL
— — — —	PROPERTY LINE

NOTES:

1. BASE MAP OBTAINED FROM A METCALF & EDDY PLAN ENTITLED: EXISTING MONITORING WELL LOCATION PLAN, SHEET AE-3, REVISION A, DATED 12/03. EXTRACTION AND MONITORING WELL LOCATIONS, REFERENCE ELEVATIONS, AND OPERATIONAL STATUS WERE DETERMINED BY REVIEW OF HISTORICAL DOCUMENTS PROVIDED BY EPA AND PHYSICAL INSPECTION OF THE SITE.
2. EXTRACTION WELLS AND PIPING ROUTES WERE OBTAINED FRON AN OHM REMEDIATION SERVICES CORP. PLAN ENTITLED: PROPOSED GRADING PLAN, BAIRD & McGUIRE SUPERFUND SITE, HOLBROOK, MASSACHUSETTS, DRAWING NO. 12500-052, SHEET 1 OF 1, DATED 5/15/96.

FIGURE 2

ISSUE	DESCRIPTION	DRWN.	CHKD.	APPR.	DATE
C	AUGUST 2010	K.M.C.	L. . I .	C.J.M.	8/23/10
B	MARCH 2009	K.M.C.	L. . I .	C.J.M.	3/9/09
A	SEPTEMBER 2007	K.M.C.	L. . I .	C.J.M.	6/17/08

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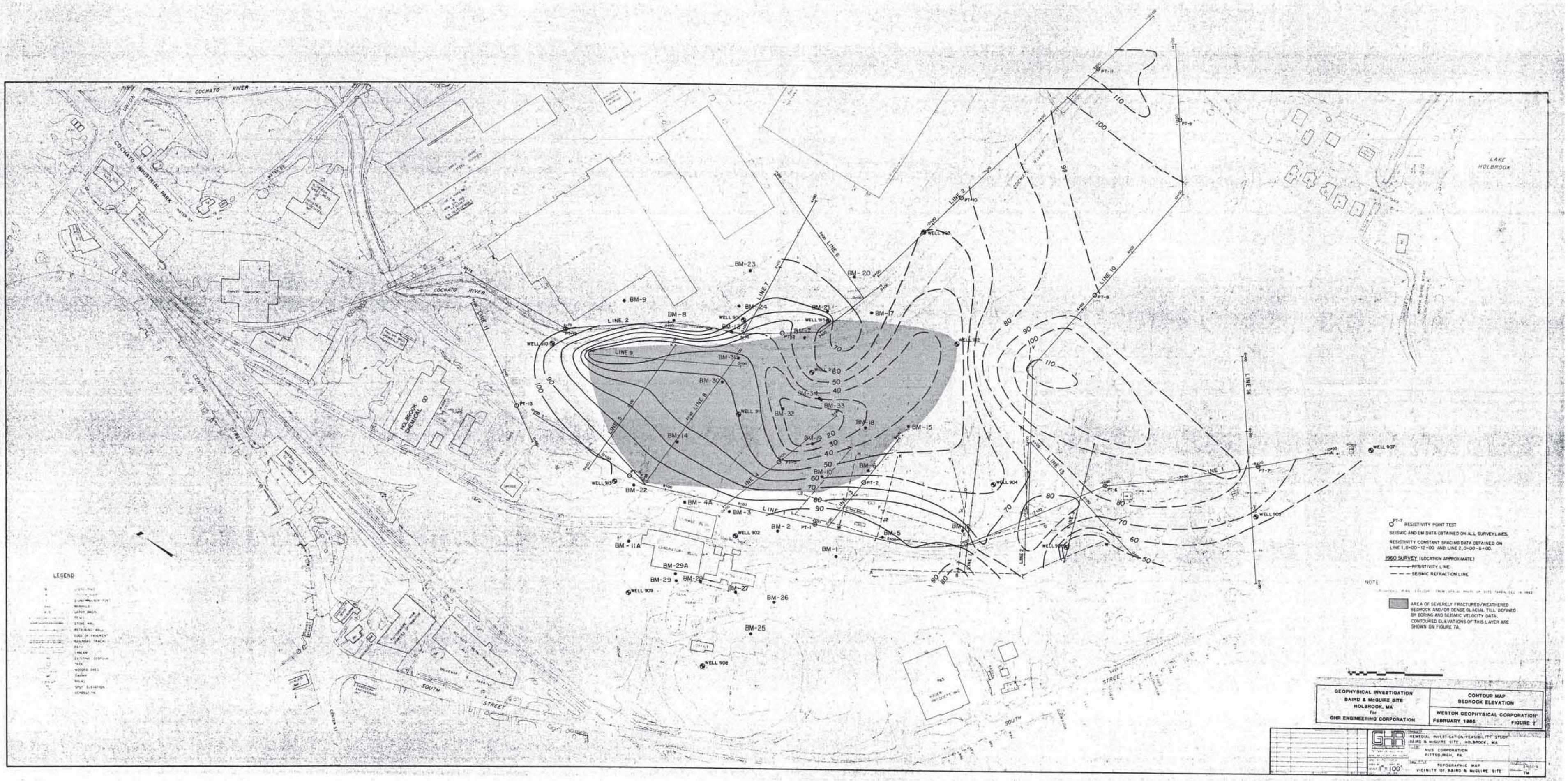
TITLE
BAIRD & McGUIRE GROUNDWATER TREATMENT PLANT
EXTRACTION/RECHARGE SYSTEM
HOLBROOK, MASSACHUSETTS

SITE PLAN

PROJECT NO. EO2821402
SCALE 1" = 100'
DRAWING NO. 1854141-C-01



PT-7 RESISTIVITY POINT TEST

SEISMIC AND EM DATA OBTAINED ON ALL SURVEYLINES.

RESISTIVITY CONSTANT SPACING DATA OBTAINED ON LINE 1,0+00-12+00 AND LINE 2,0+00-6+00.

1960 SURVEY (LOCATION APPROXIMATE)

RESISTIVITY LINE

SEISMIC REFRACTION LINE

NOTE

▨ AREA OF SEVERELY FRACTURED/WEATHERED BEDROCK AND/OR DENSE GLACIAL TILL DEFINED BY BORING AND SEISMIC VELOCITY DATA. CONTOURED ELEVATIONS OF THIS LAYER ARE SHOWN ON FIGURE 7A.

GEOPHYSICAL INVESTIGATION BAIRD & McGUIRE SITE HOLBROOK, MA for GHR ENGINEERING CORPORATION	CONTOUR MAP BEDROCK ELEVATION WESTON GEOPHYSICAL CORPORATION FEBRUARY 1985 FIGURE 7

GHR

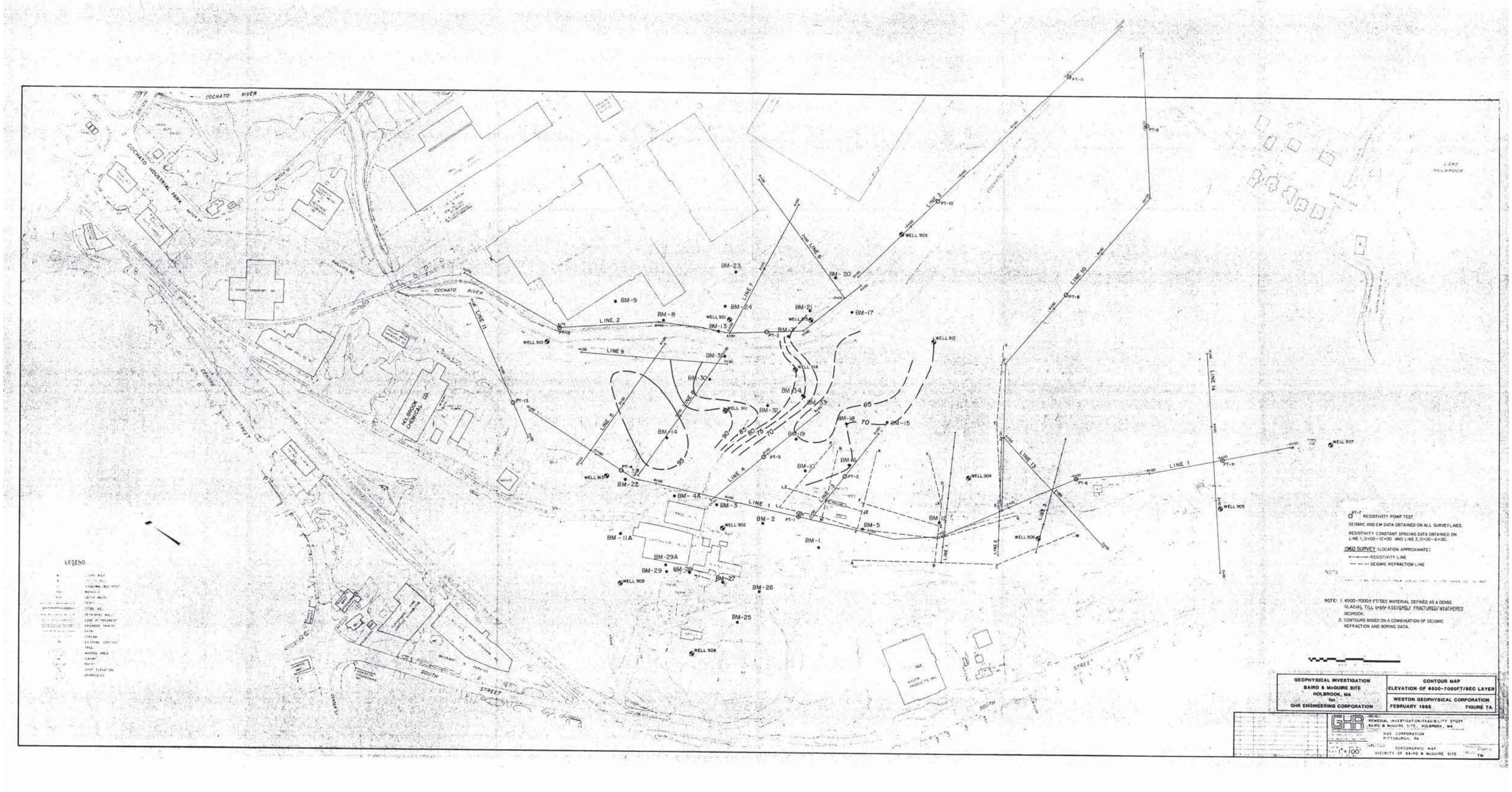
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BAIRD & McGUIRE SITE, HOLBROOK, MA

NUS CORPORATION
PITTSBURGH, PA

SCALE 1" = 100'

TOPOGRAPHIC MAP
VICINITY OF BAIRD & McGUIRE SITE

TM



PT-7 RESISTIVITY POINT TEST

SEISMIC AND EM DATA OBTAINED ON ALL SURVEYLINES.

RESISTIVITY CONSTANT SPACING DATA OBTAINED ON LINE 1, 0+00-12+00 AND LINE 2, 0+00-6+00.

1960 SURVEY (LOCATION APPROXIMATE)

RESISTIVITY LINE

SEISMIC REFRACTION LINE

NOTE: 1. 6500-7000± FT/SEC MATERIAL DEFINED AS A DENSE GLACIAL TILL and/or A SEVERELY FRACTURED/WEATHERED BEDROCK.

2. CONTOURS BASED ON A COMBINATION OF SEISMIC REFRACTION AND BORING DATA.

GEOPHYSICAL INVESTIGATION BAIRD & McGUIRE SITE HOLBROOK, MA for GHR ENGINEERING CORPORATION	CONTOUR MAP ELEVATION OF 6500-7000FT/SEC LAYER
	WESTON GEOPHYSICAL CORPORATION FEBRUARY 1986 FIGURE 7A

GHR

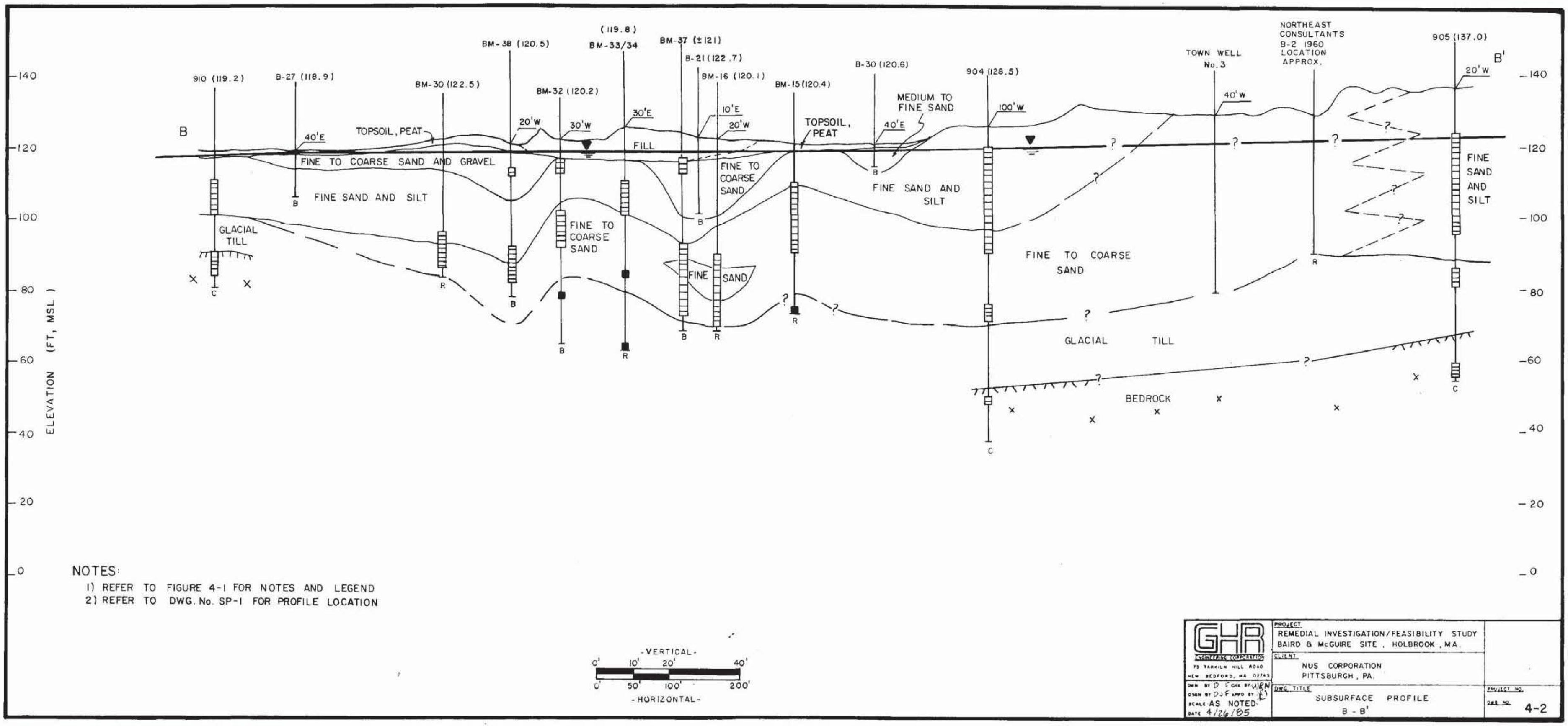
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BAIRD & McGUIRE SITE, HOLBROOK, MA

NUS CORPORATION
PITTSBURGH, PA

1" = 100'

TOPOGRAPHIC MAP
VICINITY OF BAIRD & McGUIRE SITE

TM



NOTES:

1) REFER TO FIGURE 4-1 FOR NOTES AND LEGEND
2) REFER TO DWG. No. SP-1 FOR PROFILE LOCATION

GHR
ENGINEERING CORPORATION
73 TARKILN HILL ROAD
NEW BEDFORD, MA 02745

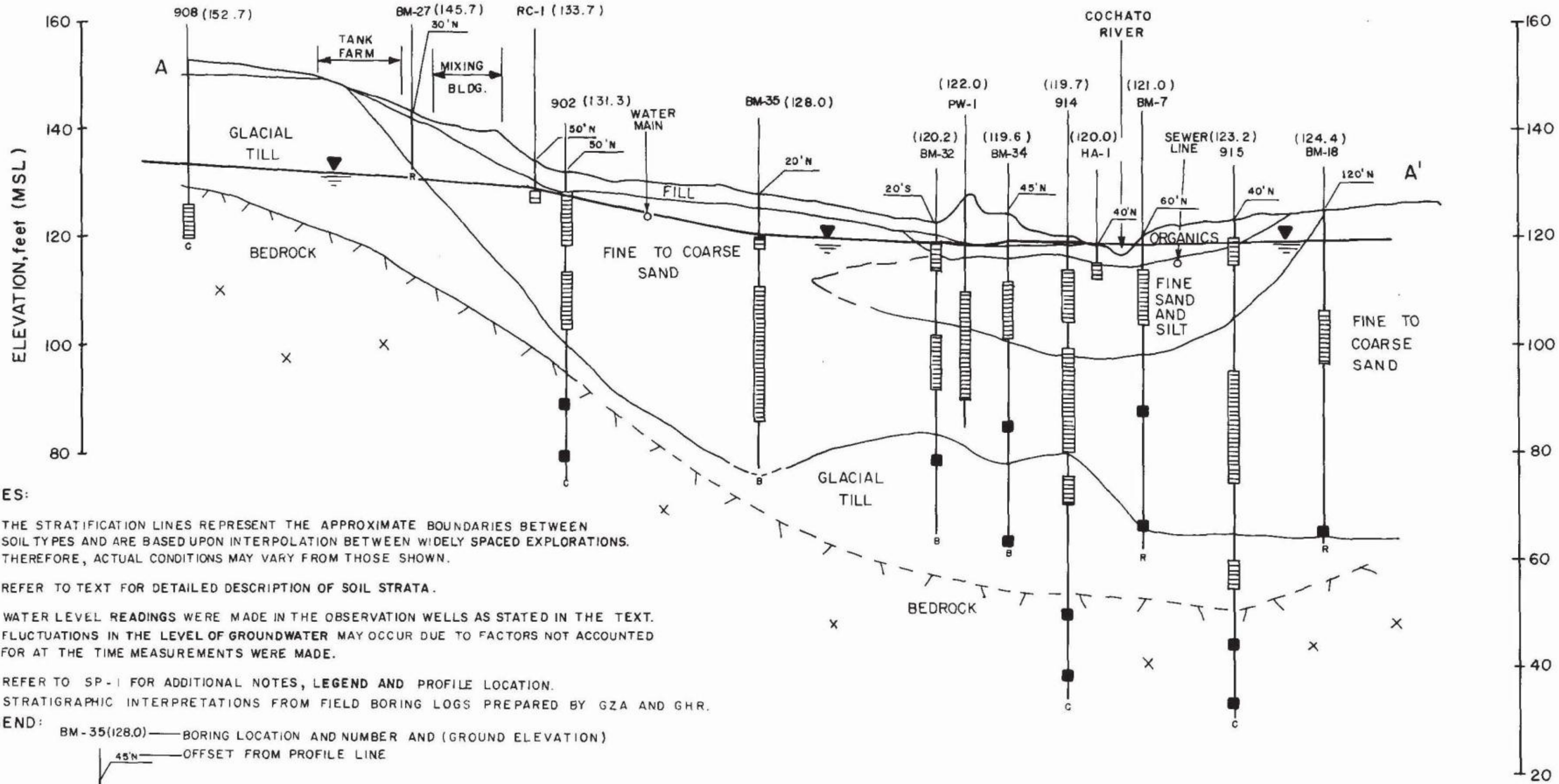
DWN BY D F CHK BY WRN
DSGN BY DJF APPD BY
SCALE AS NOTED
DATE 4/26/85

PROJECT
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BAIRD & McGUIRE SITE, HOLBROOK, MA.

CLIENT
NUS CORPORATION
PITTSBURGH, PA.

DWG. TITLE
SUBSURFACE PROFILE
B - B'

PROJECT NO.
DWG. NO. 4-2



NOTES:

1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND ARE BASED UPON INTERPOLATION BETWEEN WIDELY SPACED EXPLORATIONS. THEREFORE, ACTUAL CONDITIONS MAY VARY FROM THOSE SHOWN.

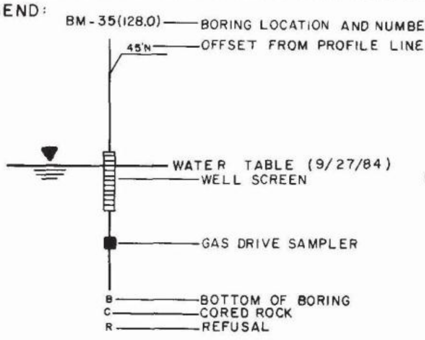
2) REFER TO TEXT FOR DETAILED DESCRIPTION OF SOIL STRATA.

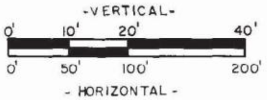
3) WATER LEVEL READINGS WERE MADE IN THE OBSERVATION WELLS AS STATED IN THE TEXT. FLUCTUATIONS IN THE LEVEL OF GROUNDWATER MAY OCCUR DUE TO FACTORS NOT ACCOUNTED FOR AT THE TIME MEASUREMENTS WERE MADE.

4) REFER TO SP-1 FOR ADDITIONAL NOTES, LEGEND AND PROFILE LOCATION.

5) STRATIGRAPHIC INTERPRETATIONS FROM FIELD BORING LOGS PREPARED BY GZA AND GHR.

LEGEND:





GHR
ENGINEERING CORPORATION
75 TARKILN HILL ROAD
NEW BEDFORD, MA 02745

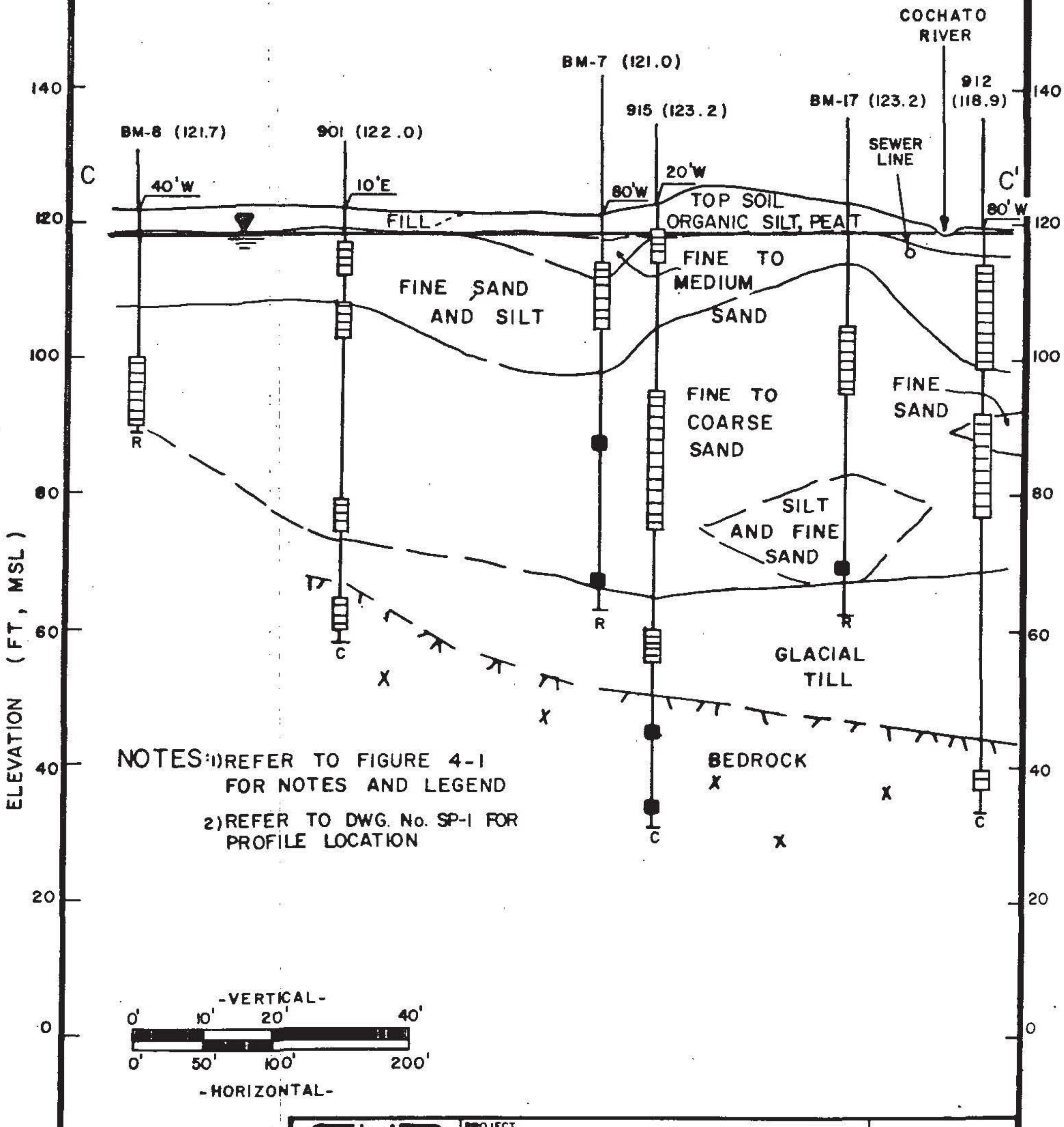
PROJECT
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BAIRD & McGUIRE SITE, HOLBROOK, MA.

CLIENT
NUS CORPORATION
PITTSBURGH, PA.

DWN BY DJF CHK BY WRN
DSGN BY DJF APPD BY
SCALE AS NOTED
DATE 4/26/85

DWG TITLE
SUBSURFACE PROFILE
A - A'

PROJECT NO.
DWG NO. 4-1



NOTES: 1) REFER TO FIGURE 4-1 FOR NOTES AND LEGEND

2) REFER TO DWG. No. SP-1 FOR PROFILE LOCATION

GHR ENGINEERING CORPORATION
75 TARKILN HILL ROAD
NEW BEDFORD, MA 02745

DWN. BY: D.J.F. CHK. BY: WR ?
DSGN. BY: D.J.F. APPD. BY:
SCALE: AS NOTED
DATE: 4/26/85

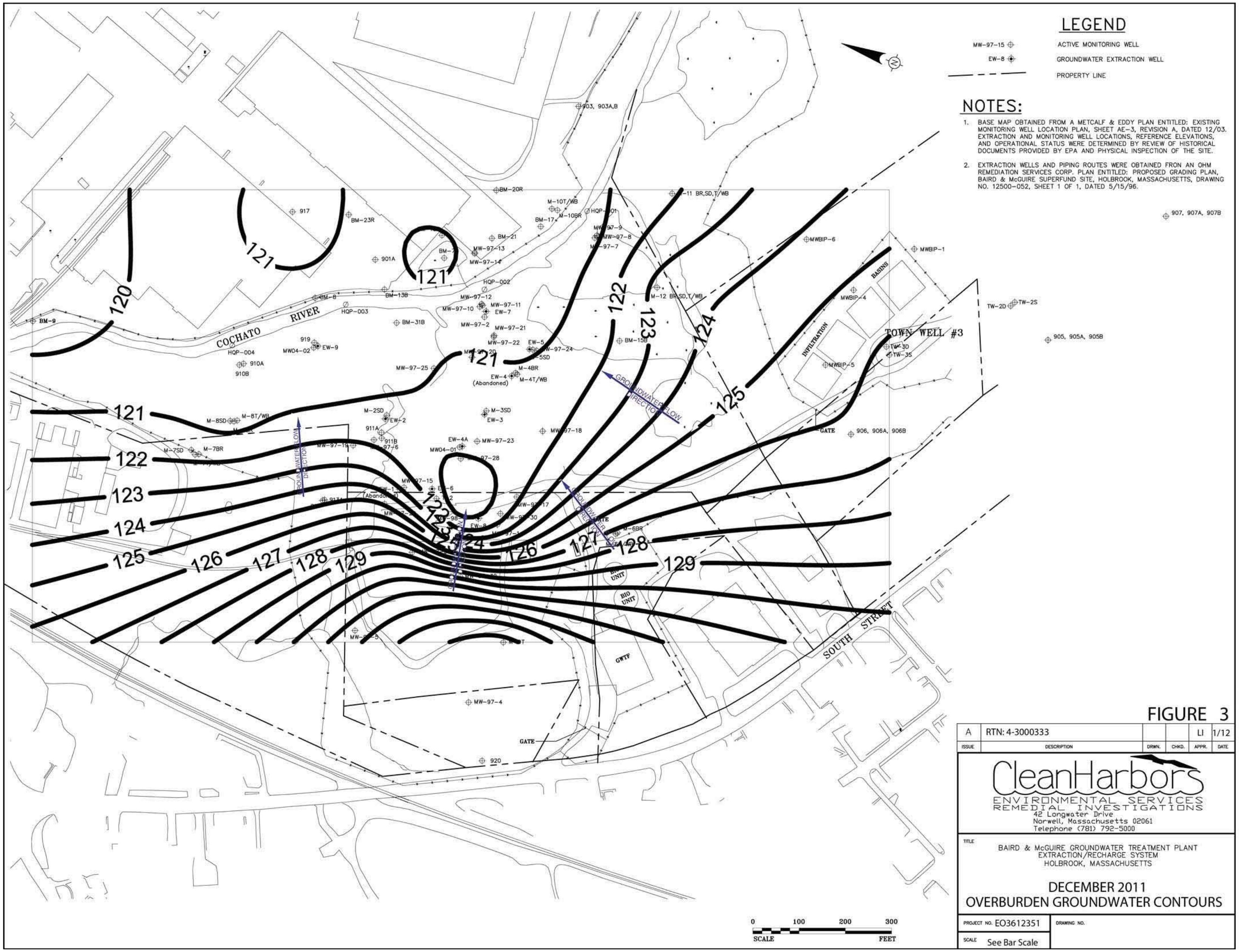
PROJECT
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BAIRD & McGUIRE SITE, HOLBROOK, MA.

CLIENT
NUS CORPORATION
PITTSBURGH, PA.

DWG. TITLE
SUBSURFACE PROFILE
C - C'

PROJECT NO.

DWG. NO. 4-3



LEGEND

MW-97-15 ⊕	ACTIVE MONITORING WELL
EW-8 ⊙	GROUNDWATER EXTRACTION WELL
— — —	PROPERTY LINE

NOTES:

1. BASE MAP OBTAINED FROM A METCALF & EDDY PLAN ENTITLED: EXISTING MONITORING WELL LOCATION PLAN, SHEET AE-3, REVISION A, DATED 12/03. EXTRACTION AND MONITORING WELL LOCATIONS, REFERENCE ELEVATIONS, AND OPERATIONAL STATUS WERE DETERMINED BY REVIEW OF HISTORICAL DOCUMENTS PROVIDED BY EPA AND PHYSICAL INSPECTION OF THE SITE.
2. EXTRACTION WELLS AND PIPING ROUTES WERE OBTAINED FRON AN OHM REMEDIATION SERVICES CORP. PLAN ENTITLED: PROPOSED GRADING PLAN, BAIRD & McGUIRE SUPERFUND SITE, HOLBROOK, MASSACHUSETTS, DRAWING NO. 12500-052, SHEET 1 OF 1, DATED 5/15/96.

FIGURE 3

ISSUE	DESCRIPTION	DRWN.	CHKD.	APPR.	DATE
A	RTN: 4-3000333			LI	1/12

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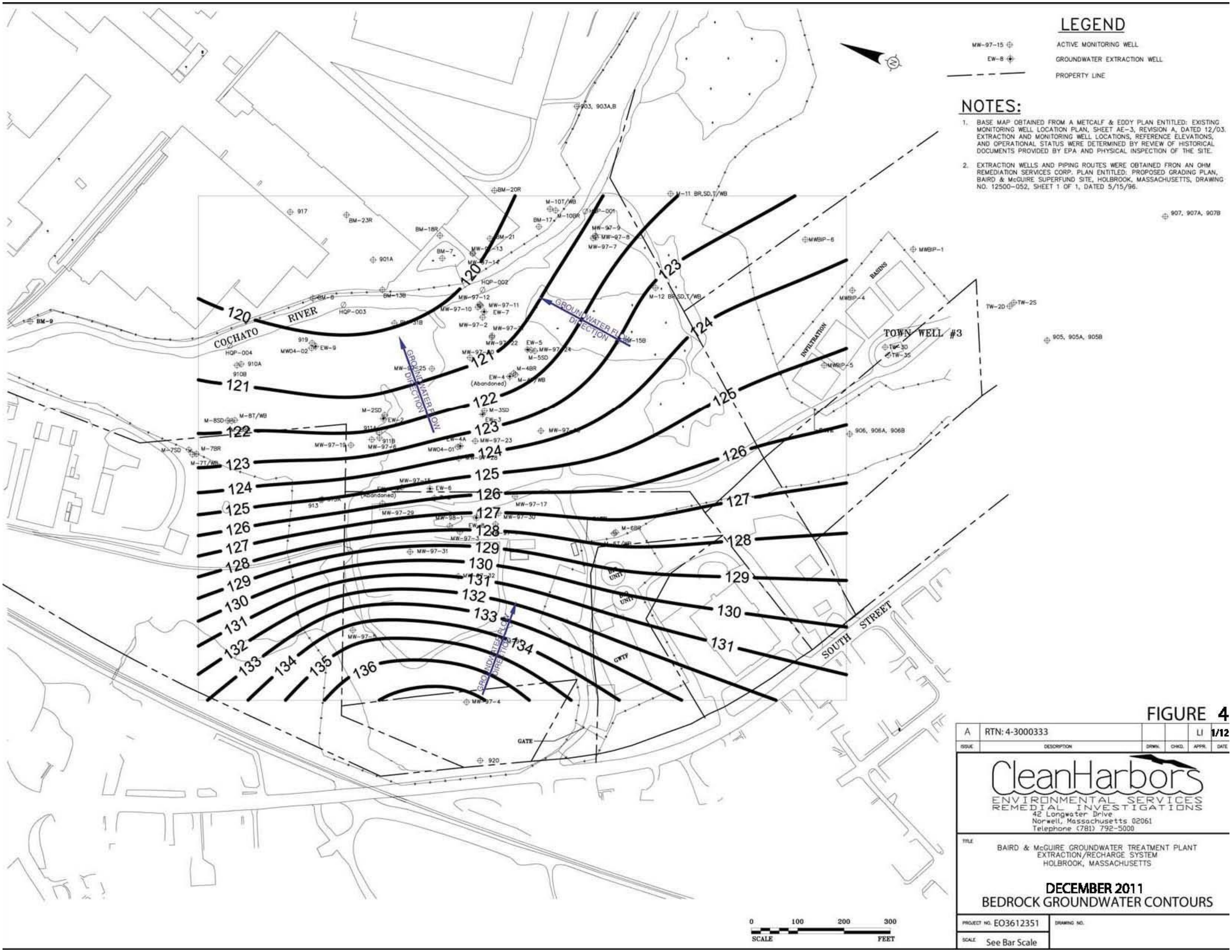
TITLE
BAIRD & McGUIRE GROUNDWATER TREATMENT PLANT
EXTRACTION/RECHARGE SYSTEM
HOLBROOK, MASSACHUSETTS

DECEMBER 2011
OVERBURDEN GROUNDWATER CONTOURS

PROJECT NO. EO3612351
DRAWING NO.
SCALE See Bar Scale



LEGEND

MW-97-15 ⊕	ACTIVE MONITORING WELL
EW-8 ⊕	GROUNDWATER EXTRACTION WELL
— — —	PROPERTY LINE

NOTES:

1. BASE MAP OBTAINED FROM A METCALF & EDDY PLAN ENTITLED: EXISTING MONITORING WELL LOCATION PLAN, SHEET AE-3, REVISION A, DATED 12/03. EXTRACTION AND MONITORING WELL LOCATIONS, REFERENCE ELEVATIONS, AND OPERATIONAL STATUS WERE DETERMINED BY REVIEW OF HISTORICAL DOCUMENTS PROVIDED BY EPA AND PHYSICAL INSPECTION OF THE SITE.
2. EXTRACTION WELLS AND PIPING ROUTES WERE OBTAINED FRON AN OHM REMEDIATION SERVICES CORP. PLAN ENTITLED: PROPOSED GRADING PLAN, BAIRD & McGUIRE SUPERFUND SITE, HOLBROOK, MASSACHUSETTS, DRAWING NO. 12500-052, SHEET 1 OF 1, DATED 5/15/96.

FIGURE 4

ISSUE	DESCRIPTION	DRWN.	CHKD.	APPR.	DATE
A	RTN: 4-3000333			LI	1/12

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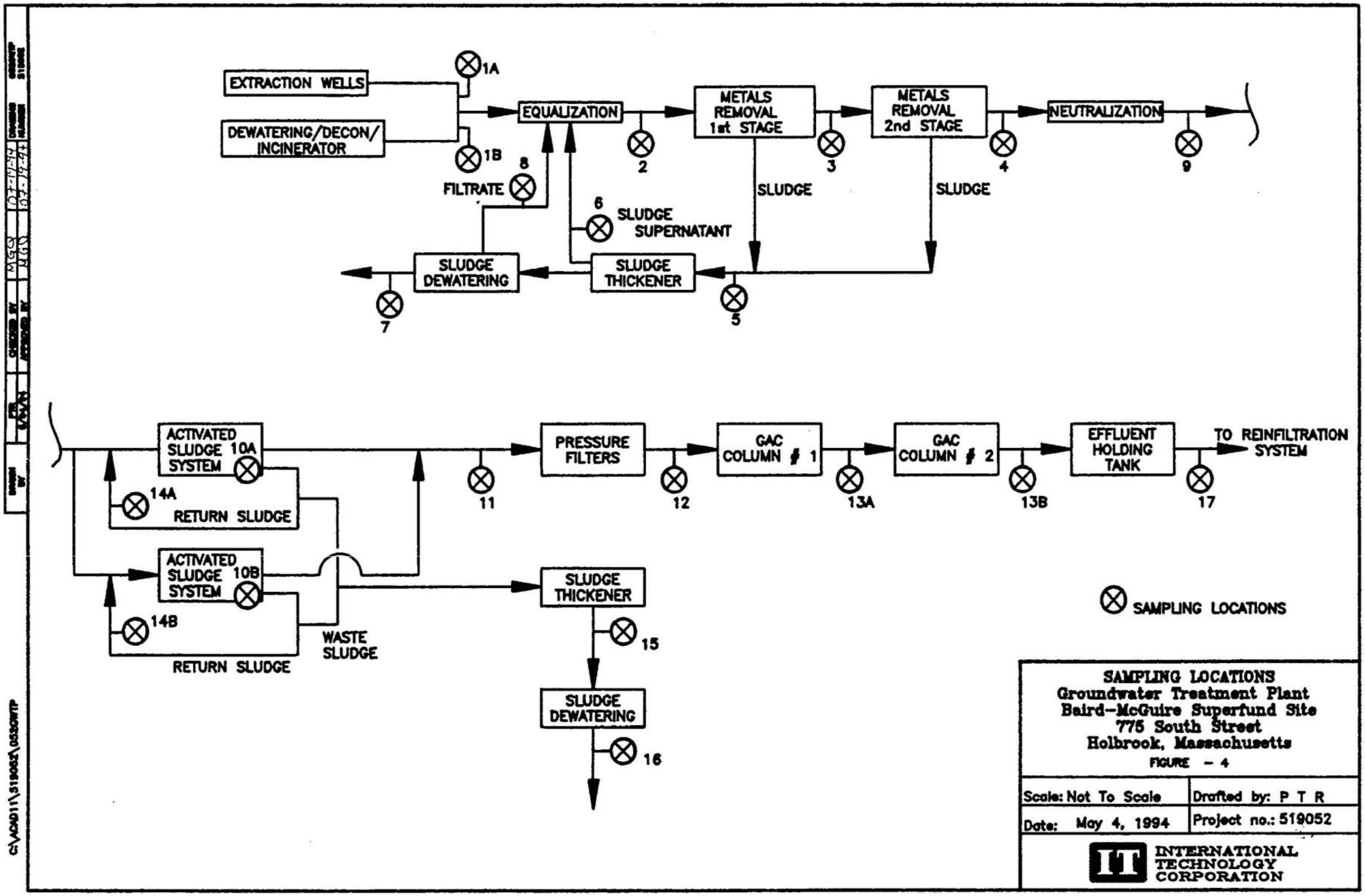
REMEDIAL INVESTIGATIONS
42 Longwater Drive
Norwell, Massachusetts 02061
Telephone (781) 792-5000

TITLE
BAIRD & McGUIRE GROUNDWATER TREATMENT PLANT
EXTRACTION/RECHARGE SYSTEM
HOLBROOK, MASSACHUSETTS

DECEMBER 2011
BEDROCK GROUNDWATER CONTOURS

PROJECT NO. EO3612351
DRAWING NO.
SCALE See Bar Scale



SAMPLING LOCATIONS
Groundwater Treatment Plant
Baird-McGuire Superfund Site
775 South Street
Holbrook, Massachusetts
FIGURE - 4

Scale: Not To Scale
Drafted by: P T R
Date: May 4, 1994
Project no.: 519052

INTERNATIONAL TECHNOLOGY CORPORATION

FIGURE 2A

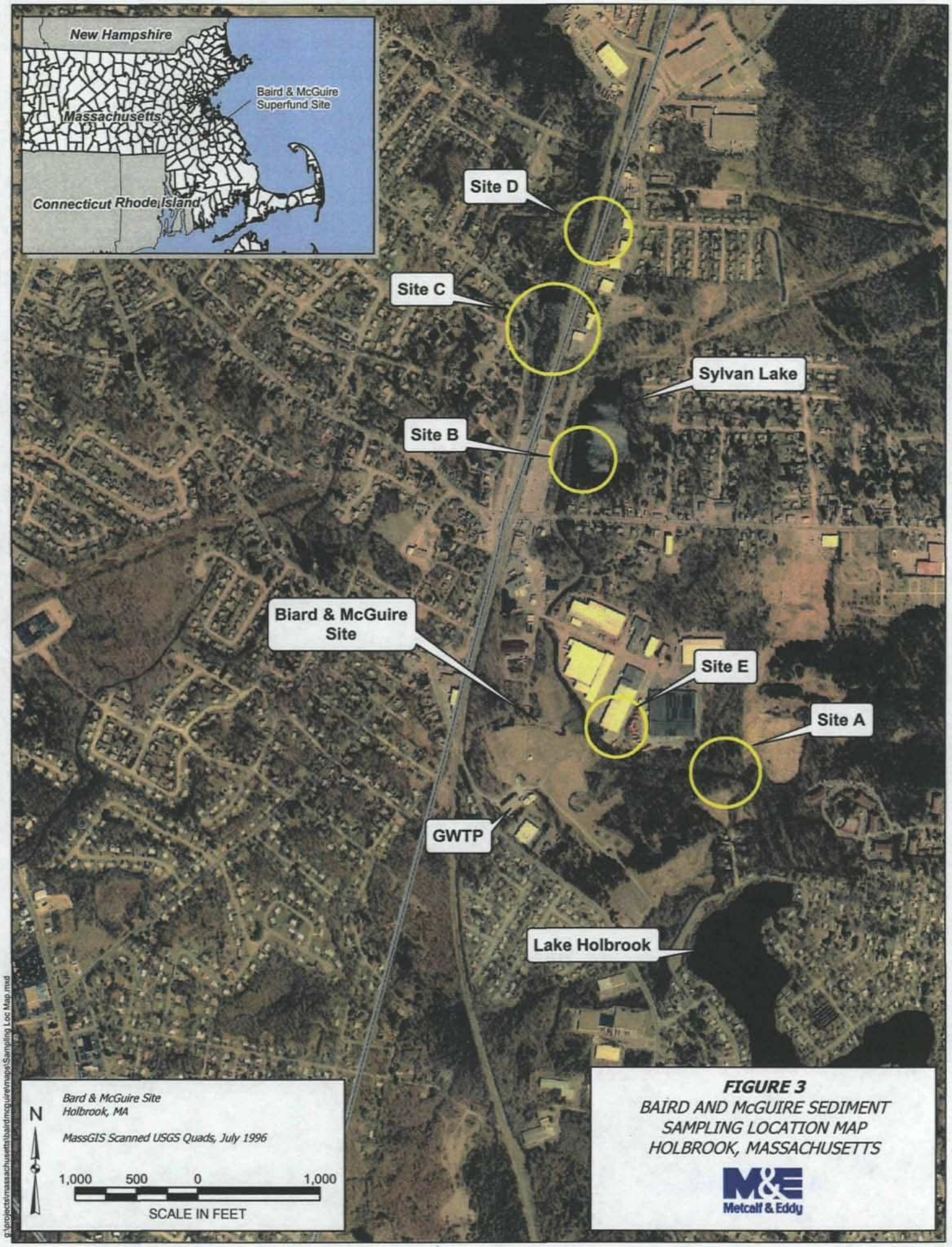
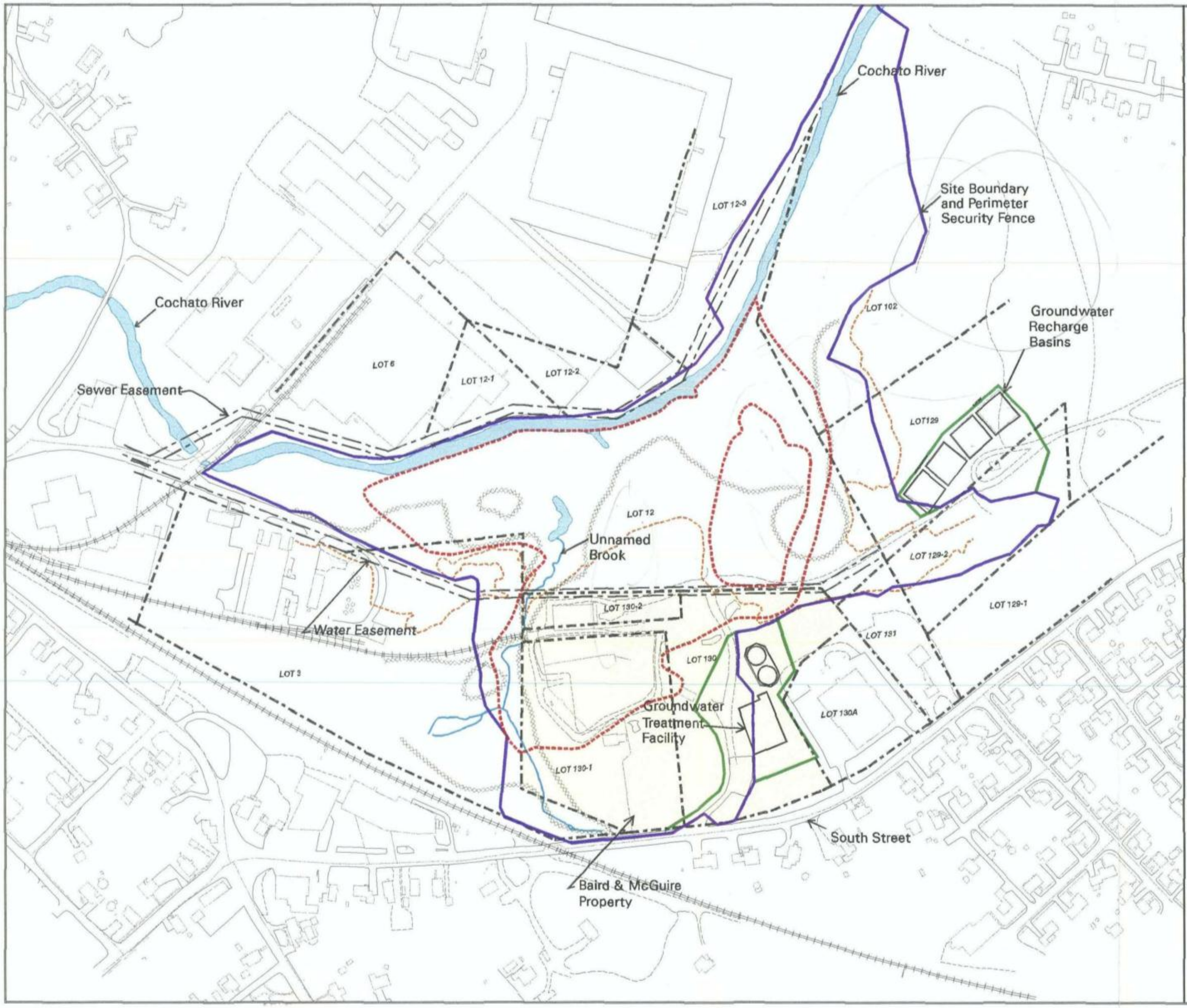


FIGURE 3
BAIRD AND McGUIRE SEDIMENT SAMPLING LOCATION MAP
HOLBROOK, MASSACHUSETTS

M&E
Metcalf & Eddy

g:\projects\massachusetts\bairdmcguire\maps\Sampling Loc Map.mxd



MAP SOURCE:
Base Map is from Eastern Topographics (May 4, 1988).
Site features are compiled from numerous project
plans and documents. All locations are approximate.

Metcalf & Eddy

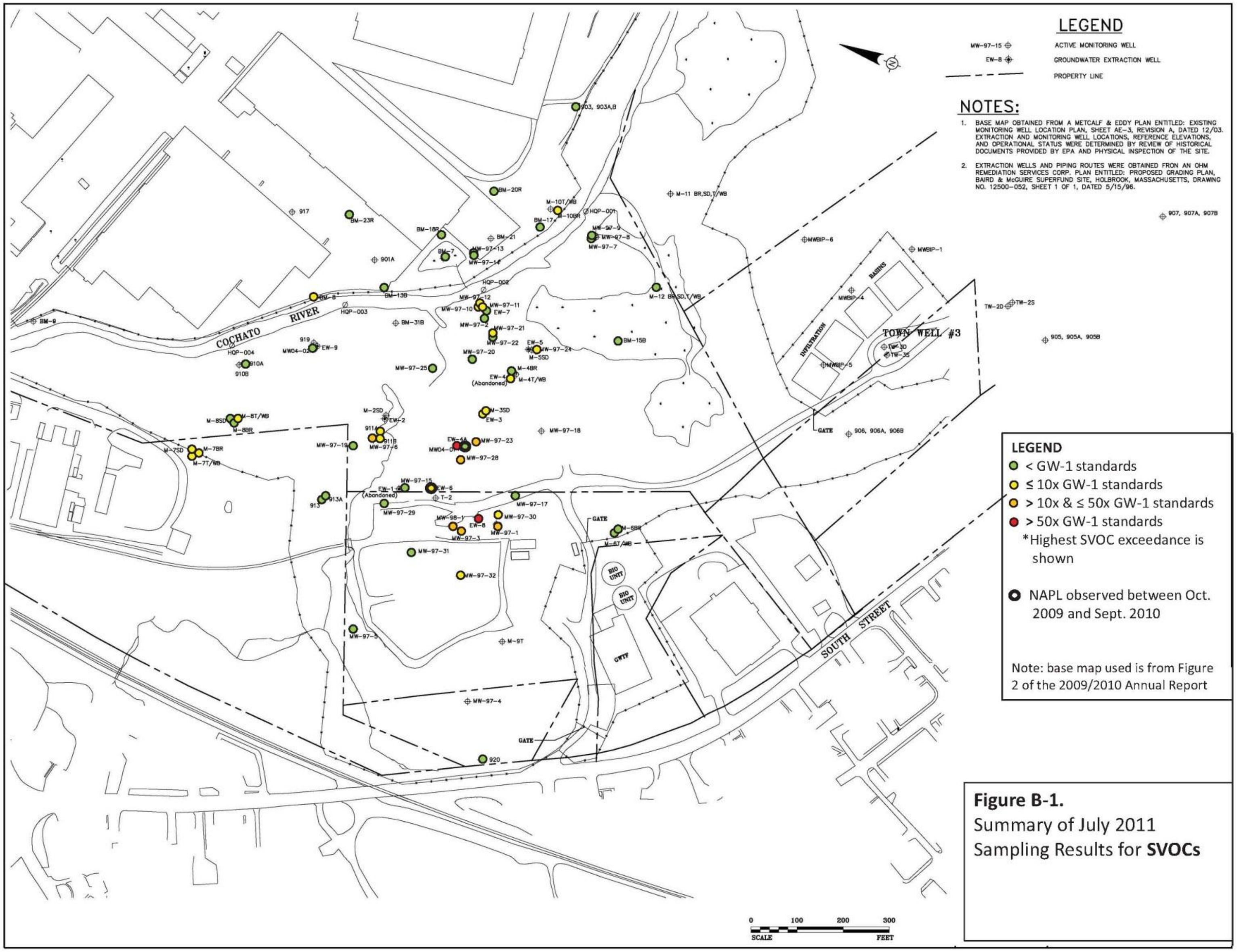
Figure 1.

BAIRD & McGUIRE
SITE FEATURES.

BAIRD & McGUIRE SUPERFUND SITE
M&E Print Date: May 21, 1998

figure2

ATTACHMENT B: : Figures Prepared by Optimization Team



NOTES:

1. BASE MAP OBTAINED FROM A METCALF & EDDY PLAN ENTITLED: EXISTING MONITORING WELL LOCATION PLAN, SHEET AE-3, REVISION A, DATED 12/03. EXTRACTION AND MONITORING WELL LOCATIONS, REFERENCE ELEVATIONS, AND OPERATIONAL STATUS WERE DETERMINED BY REVIEW OF HISTORICAL DOCUMENTS PROVIDED BY EPA AND PHYSICAL INSPECTION OF THE SITE.

2. EXTRACTION WELLS AND PIPING ROUTES WERE OBTAINED FRON AN OHM REMEDIATION SERVICES CORP. PLAN ENTITLED: PROPOSED GRADING PLAN, BAIRD & McGUIRE SUPERFUND SITE, HOLBROOK, MASSACHUSETTS, DRAWING NO. 12500-052, SHEET 1 OF 1, DATED 5/15/96.

LEGEND

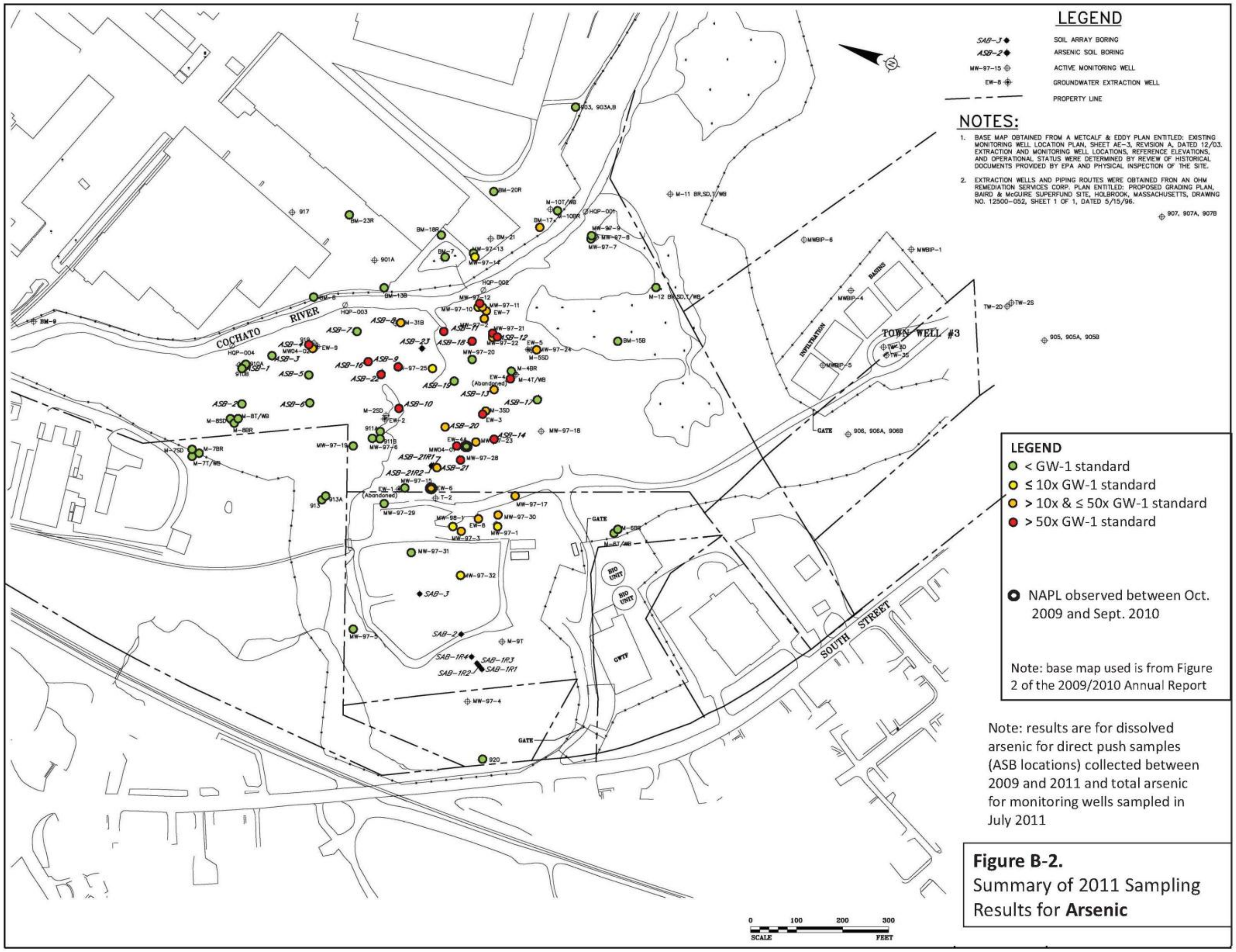
- 🟢 < GW-1 standards
- 🟡 ≤ 10x GW-1 standards
- 🟠 > 10x & ≤ 50x GW-1 standards
- 🔴 > 50x GW-1 standards

*Highest SVOC exceedance is shown

○ NAPL observed between Oct. 2009 and Sept. 2010

Note: base map used is from Figure 2 of the 2009/2010 Annual Report

Figure B-1.
Summary of July 2011 Sampling Results for **SVOCs**



LEGEND

SAB-3 ◆	SOIL ARRAY BORING
ASB-2 ◆	ARSENIC SOIL BORING
MW-97-15 ⌖	ACTIVE MONITORING WELL
EW-8 ⌖	GROUNDWATER EXTRACTION WELL
— — — —	PROPERTY LINE

NOTES:

1. BASE MAP OBTAINED FROM A METCALF & EDDY PLAN ENTITLED: EXISTING MONITORING WELL LOCATION PLAN, SHEET AE-3, REVISION A, DATED 12/03. EXTRACTION AND MONITORING WELL LOCATIONS, REFERENCE ELEVATIONS, AND OPERATIONAL STATUS WERE DETERMINED BY REVIEW OF HISTORICAL DOCUMENTS PROVIDED BY EPA AND PHYSICAL INSPECTION OF THE SITE.
2. EXTRACTION WELLS AND PIPING ROUTES WERE OBTAINED FRON AN OHM REMEDIATION SERVICES CORP. PLAN ENTITLED: PROPOSED GRADING PLAN, BAIRD & McGUIRE SUPERFUND SITE, HOLBROOK, MASSACHUSETTS, DRAWING NO. 12500-052, SHEET 1 OF 1, DATED 5/15/96.

LEGEND

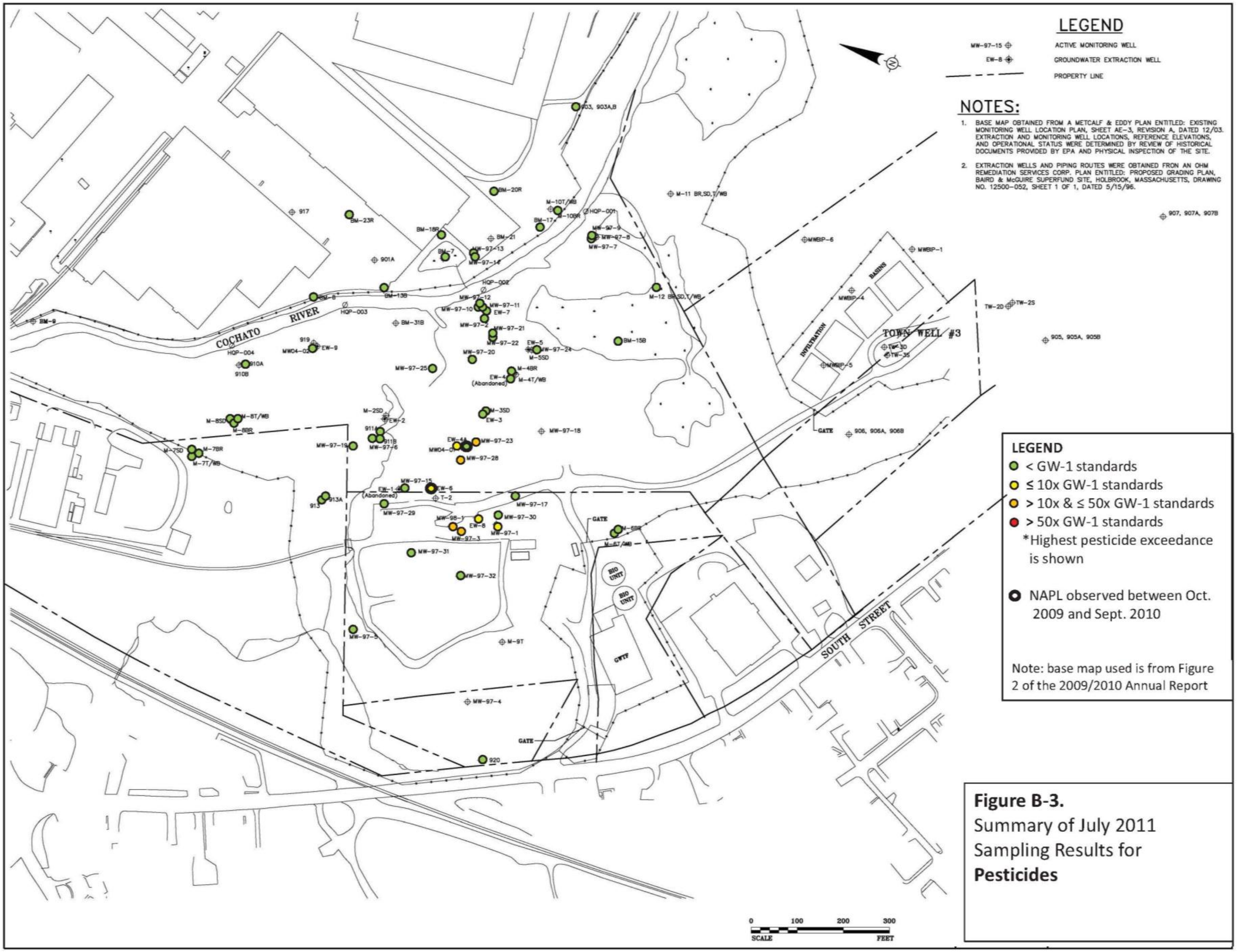
- 🟢 < GW-1 standard
- 🟡 ≤ 10x GW-1 standard
- 🟠 > 10x & ≤ 50x GW-1 standard
- 🔴 > 50x GW-1 standard

- ○ NAPL observed between Oct. 2009 and Sept. 2010

Note: base map used is from Figure 2 of the 2009/2010 Annual Report

Note: results are for dissolved arsenic for direct push samples (ASB locations) collected between 2009 and 2011 and total arsenic for monitoring wells sampled in July 2011

Figure B-2.
Summary of 2011 Sampling Results for **Arsenic**



LEGEND

MW-97-15 ⌖ ACTIVE MONITORING WELL
EW-8 ⌖ GROUNDWATER EXTRACTION WELL
— — — PROPERTY LINE

NOTES:

1. BASE MAP OBTAINED FROM A METCALF & EDDY PLAN ENTITLED: EXISTING MONITORING WELL LOCATION PLAN, SHEET AE-3, REVISION A, DATED 12/03. EXTRACTION AND MONITORING WELL LOCATIONS, REFERENCE ELEVATIONS, AND OPERATIONAL STATUS WERE DETERMINED BY REVIEW OF HISTORICAL DOCUMENTS PROVIDED BY EPA AND PHYSICAL INSPECTION OF THE SITE.
2. EXTRACTION WELLS AND PIPING ROUTES WERE OBTAINED FRON AN OHM REMEDIATION SERVICES CORP. PLAN ENTITLED: PROPOSED GRADING PLAN, BAIRD & McGUIRE SUPERFUND SITE, HOLBROOK, MASSACHUSETTS, DRAWING NO. 12500-052, SHEET 1 OF 1, DATED 5/15/96.

LEGEND

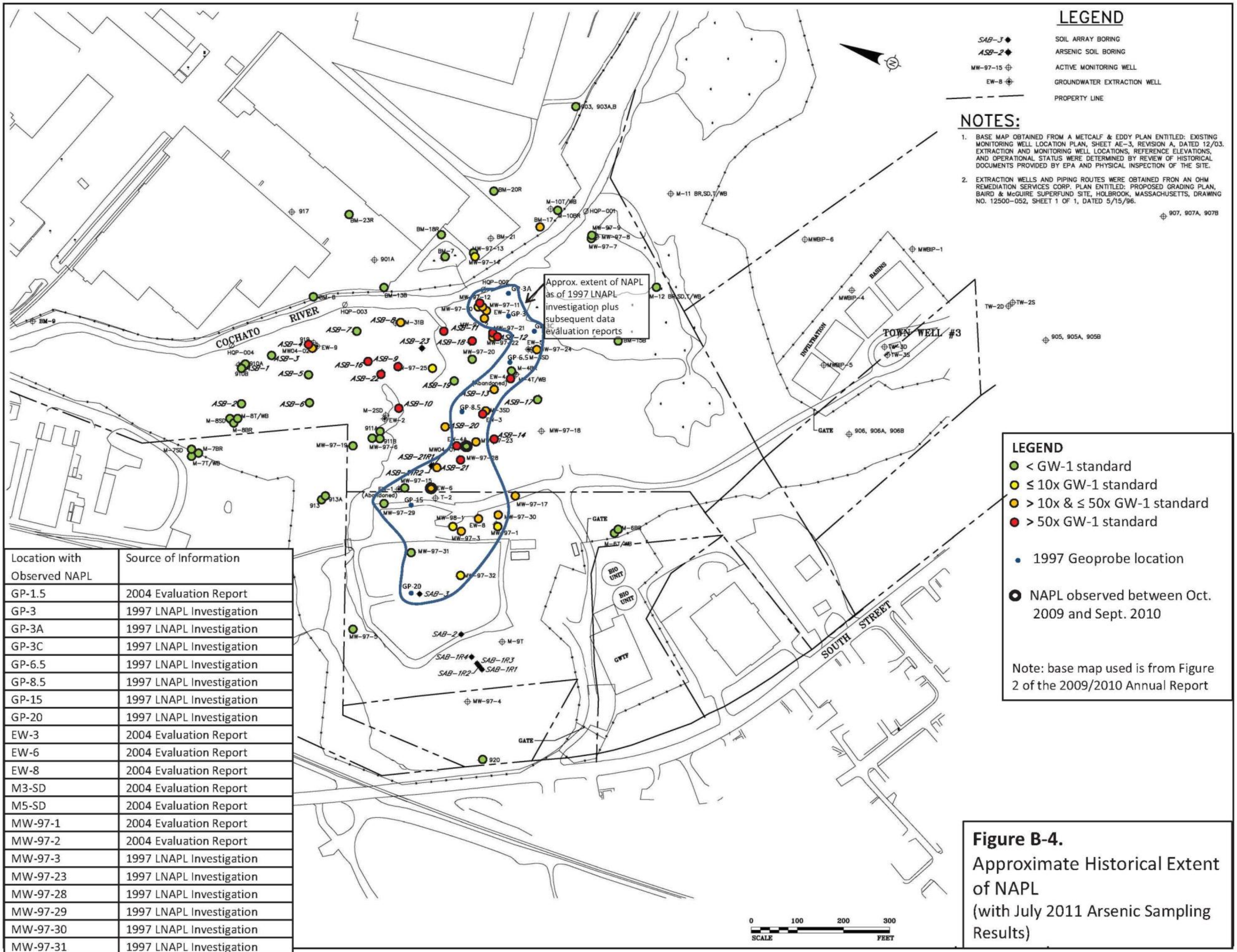
- 🟢 < GW-1 standards
- 🟡 ≤ 10x GW-1 standards
- 🟠 > 10x & ≤ 50x GW-1 standards
- 🔴 > 50x GW-1 standards

*Highest pesticide exceedance is shown

○ NAPL observed between Oct. 2009 and Sept. 2010

Note: base map used is from Figure 2 of the 2009/2010 Annual Report

Figure B-3.
Summary of July 2011 Sampling Results for **Pesticides**



NOTES:

1. BASE MAP OBTAINED FROM A METCALF & EDDY PLAN ENTITLED: EXISTING MONITORING WELL LOCATION PLAN, SHEET AE-3, REVISION A, DATED 12/03. EXTRACTION AND MONITORING WELL LOCATIONS, REFERENCE ELEVATIONS, AND OPERATIONAL STATUS WERE DETERMINED BY REVIEW OF HISTORICAL DOCUMENTS PROVIDED BY EPA AND PHYSICAL INSPECTION OF THE SITE.
2. EXTRACTION WELLS AND PIPING ROUTES WERE OBTAINED FRON AN OHM REMEDIATION SERVICES CORP. PLAN ENTITLED: PROPOSED GRADING PLAN, BAIRD & McGUIRE SUPERFUND SITE, HOLBROOK, MASSACHUSETTS, DRAWING NO. 12500-052, SHEET 1 OF 1, DATED 5/15/96.

LEGEND

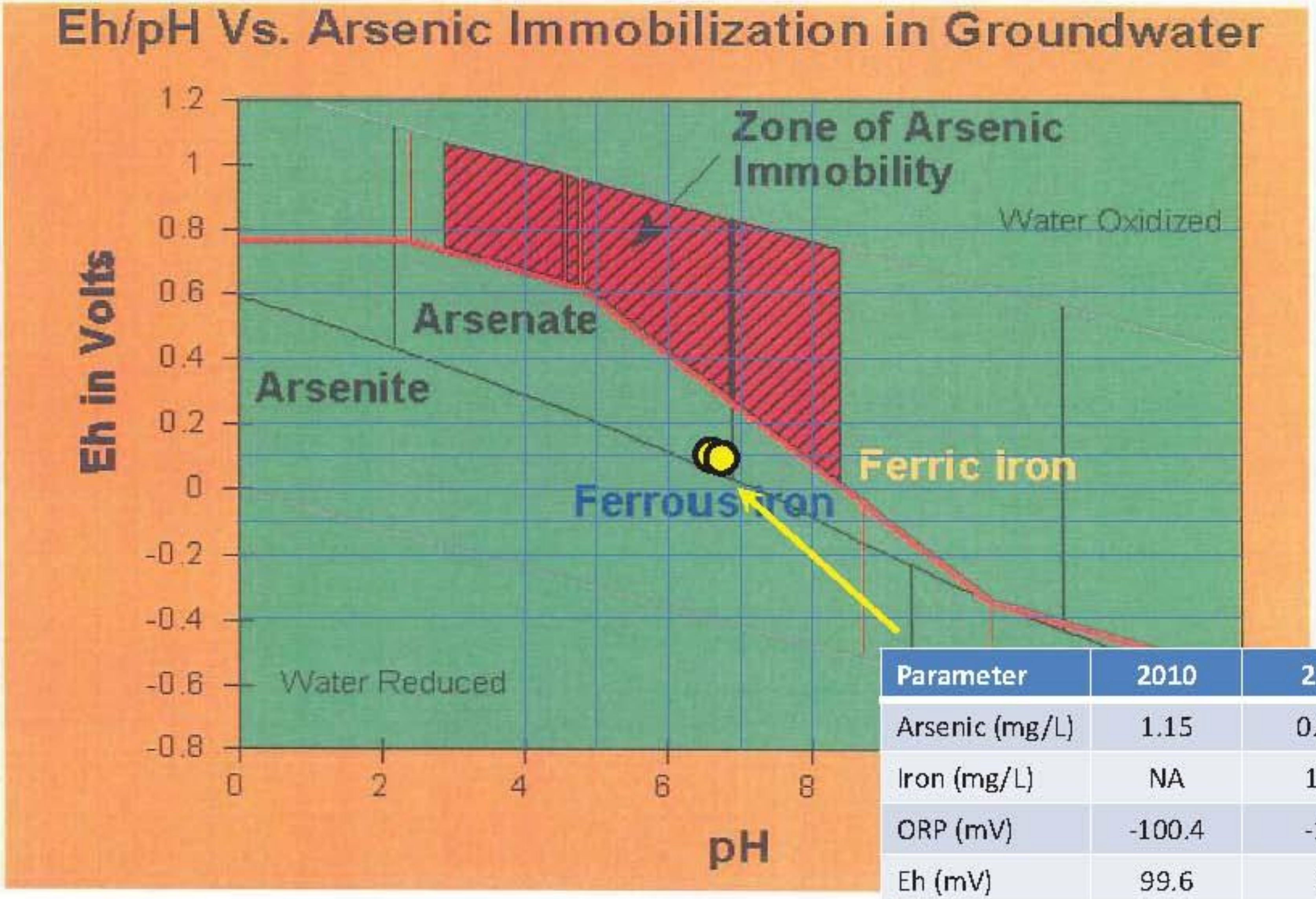
- 🟢 < GW-1 standard
- 🟡 ≤ 10x GW-1 standard
- 🟠 > 10x & ≤ 50x GW-1 standard
- 🔴 > 50x GW-1 standard
- • 1997 Geoprobe location
- ○ NAPL observed between Oct. 2009 and Sept. 2010

Note: base map used is from Figure 2 of the 2009/2010 Annual Report

Location with Observed NAPL	Source of Information
GP-1.5	2004 Evaluation Report
GP-3	1997 LNAPL Investigation
GP-3A	1997 LNAPL Investigation
GP-3C	1997 LNAPL Investigation
GP-6.5	1997 LNAPL Investigation
GP-8.5	1997 LNAPL Investigation
GP-15	1997 LNAPL Investigation
GP-20	1997 LNAPL Investigation
EW-3	2004 Evaluation Report
EW-6	2004 Evaluation Report
EW-8	2004 Evaluation Report
M3-SD	2004 Evaluation Report
M5-SD	2004 Evaluation Report
MW-97-1	2004 Evaluation Report
MW-97-2	2004 Evaluation Report
MW-97-3	1997 LNAPL Investigation
MW-97-23	1997 LNAPL Investigation
MW-97-28	1997 LNAPL Investigation
MW-97-29	1997 LNAPL Investigation
MW-97-30	1997 LNAPL Investigation
MW-97-31	1997 LNAPL Investigation
MW-97-32	1997 LNAPL Investigation

Figure B-4. Approximate Historical Extent of NAPL (with July 2011 Arsenic Sampling Results)

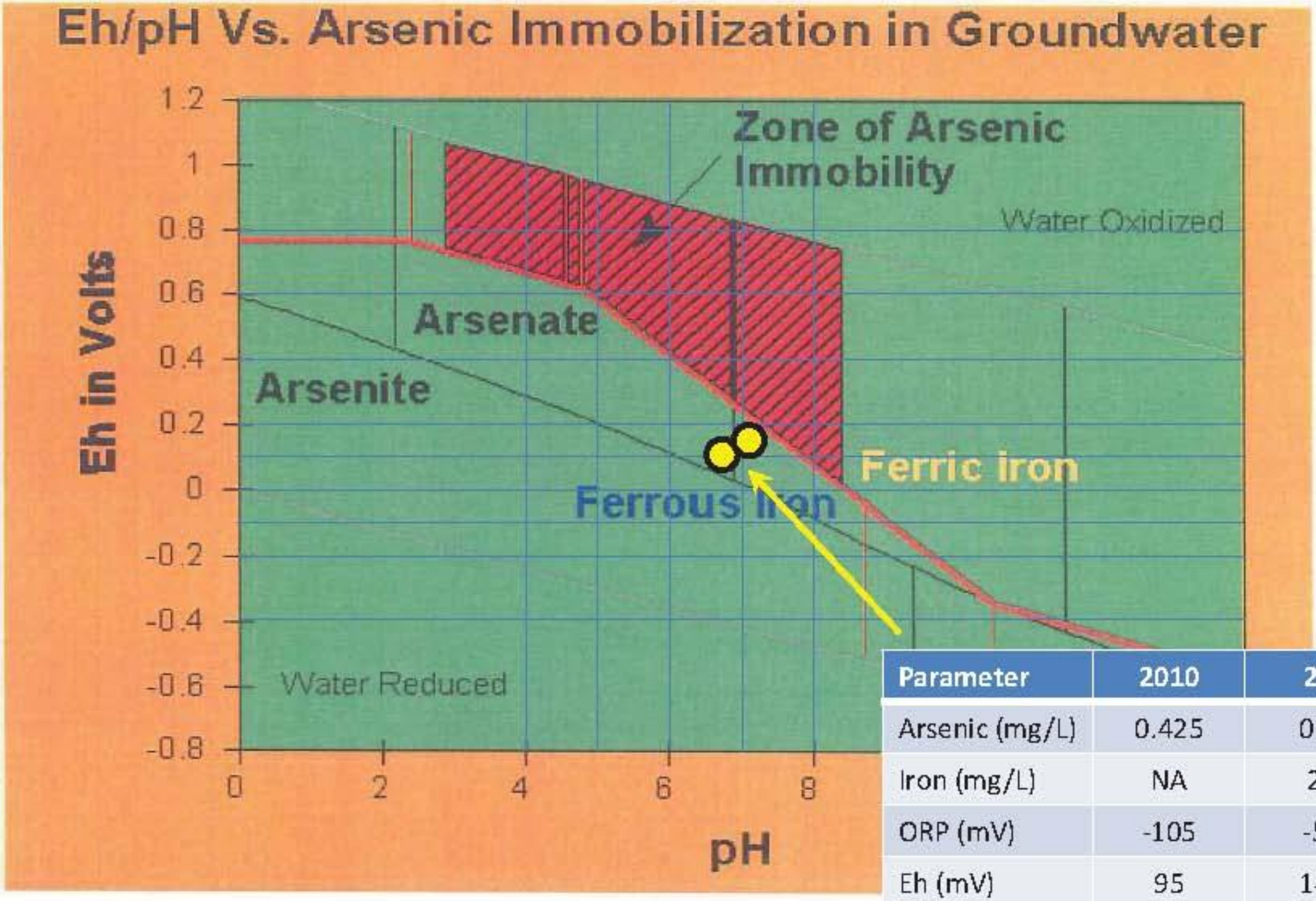
Figure B-5. pH/eH diagram for MW97-21



Parameter	2010	2011
Arsenic (mg/L)	1.15	0.989
Iron (mg/L)	NA	16.1
ORP (mV)	-100.4	-111
Eh (mV)	99.6	89
pH	6.67	6.79

FIGURE 4-2: ARSENIC MOBILITY IN GROUNDWATE
Eh/pH CONDITIONS ON THE SPECIATION OF ARSENIC AND IRON
(WELCH, 2000)

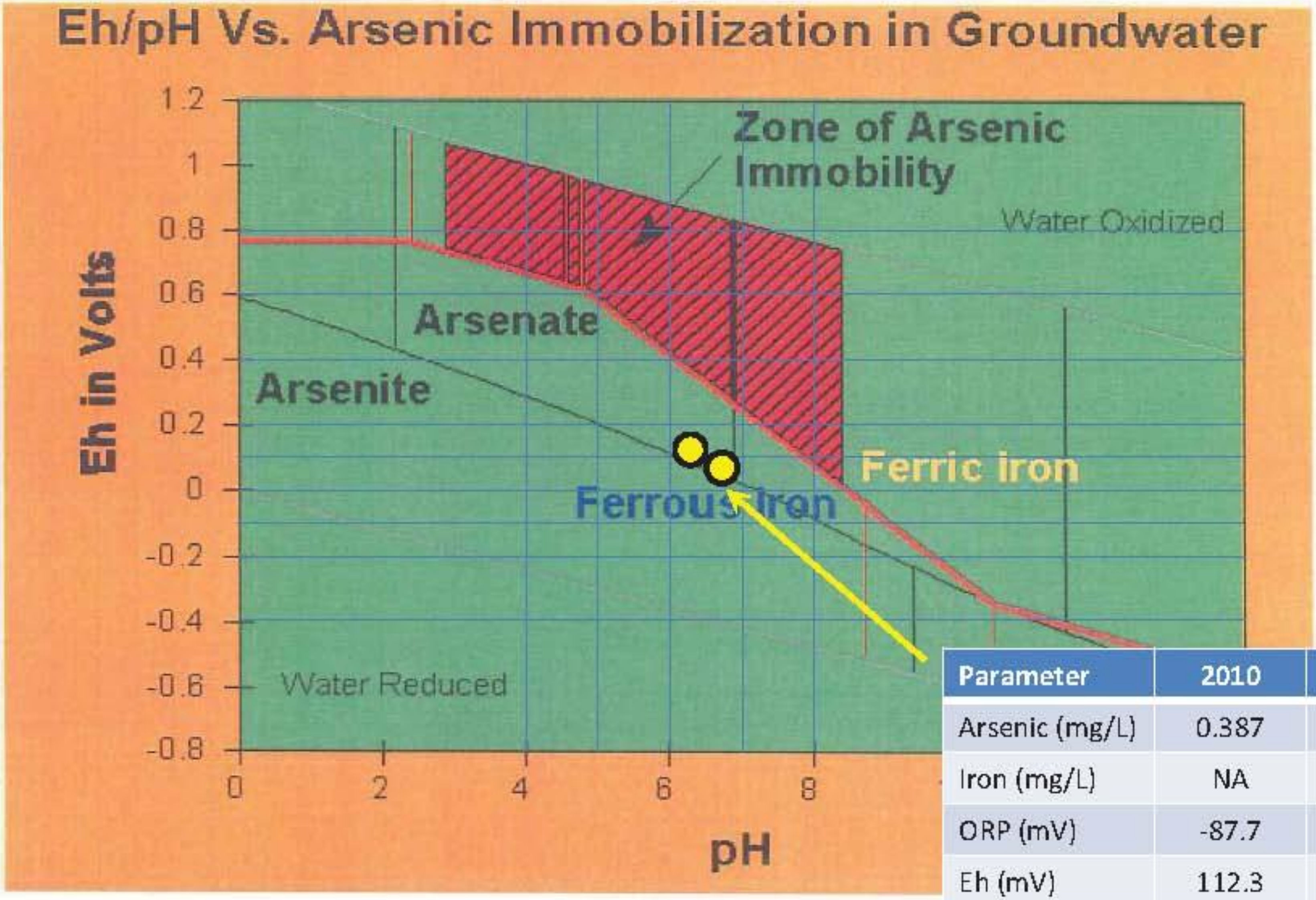
Figure B-6. pH/eH diagram for MW97-17



Parameter	2010	2011
Arsenic (mg/L)	0.425	0.182
Iron (mg/L)	NA	2.15
ORP (mV)	-105	-54.7
Eh (mV)	95	145.3
pH	6.75	7.07

FIGURE 4-2: ARSENIC MOBILITY IN GROUNDWATE
Eh/pH CONDITIONS ON THE SPECIATION OF ARSENIC AND IRON
(WELCH, 2000)

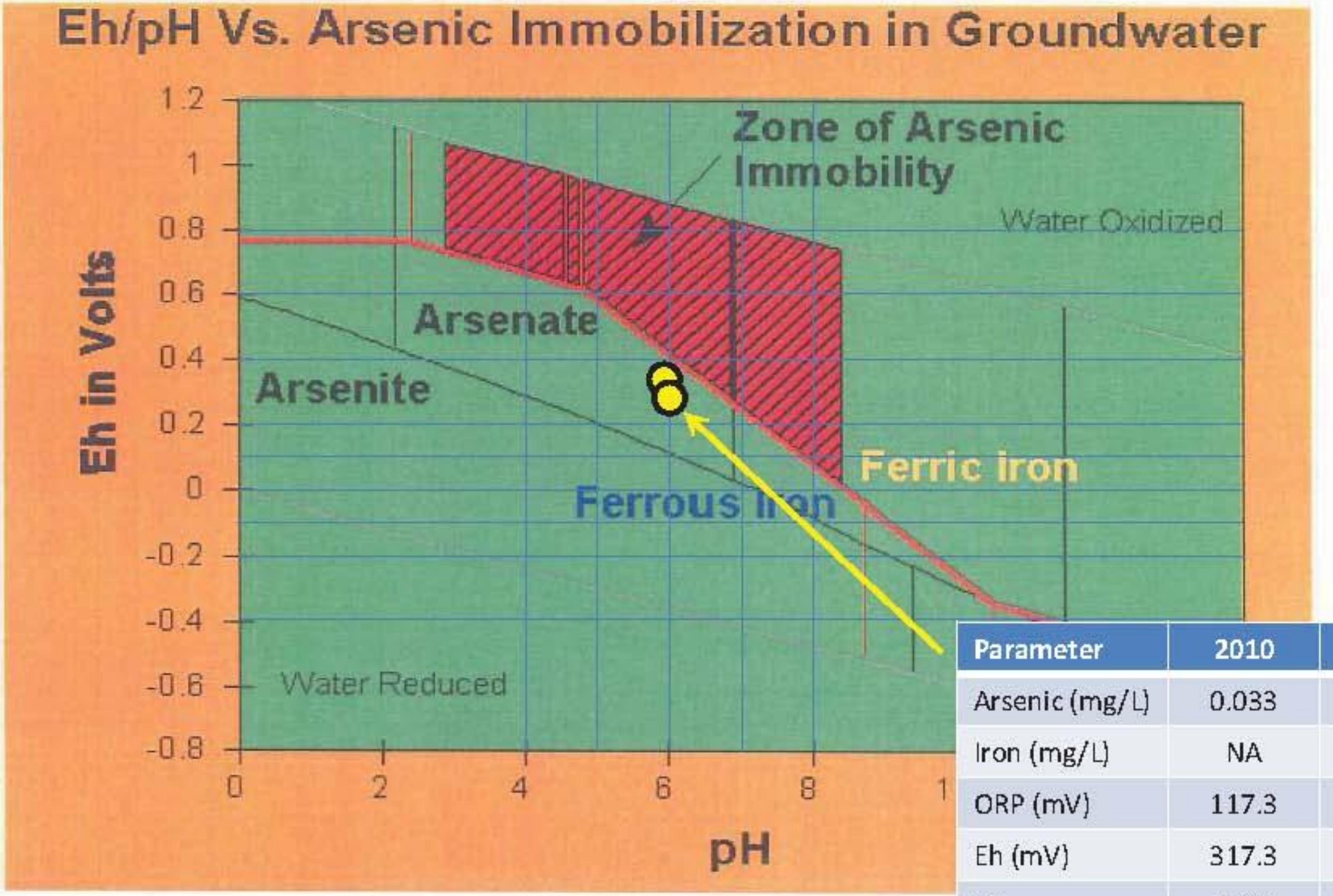
Figure B-7. pH/eH diagram for MW97-12



Parameter	2010	2011
Arsenic (mg/L)	0.387	1.47
Iron (mg/L)	NA	78.3
ORP (mV)	-87.7	-126.8
Eh (mV)	112.3	73.2
pH	6.33	6.63

FIGURE 4-2: ARSENIC MOBILITY IN GROUNDWATER AS
Eh/pH CONDITIONS ON THE SPECIATION OF ARSENIC AND IRON
(WELCH, 2000)

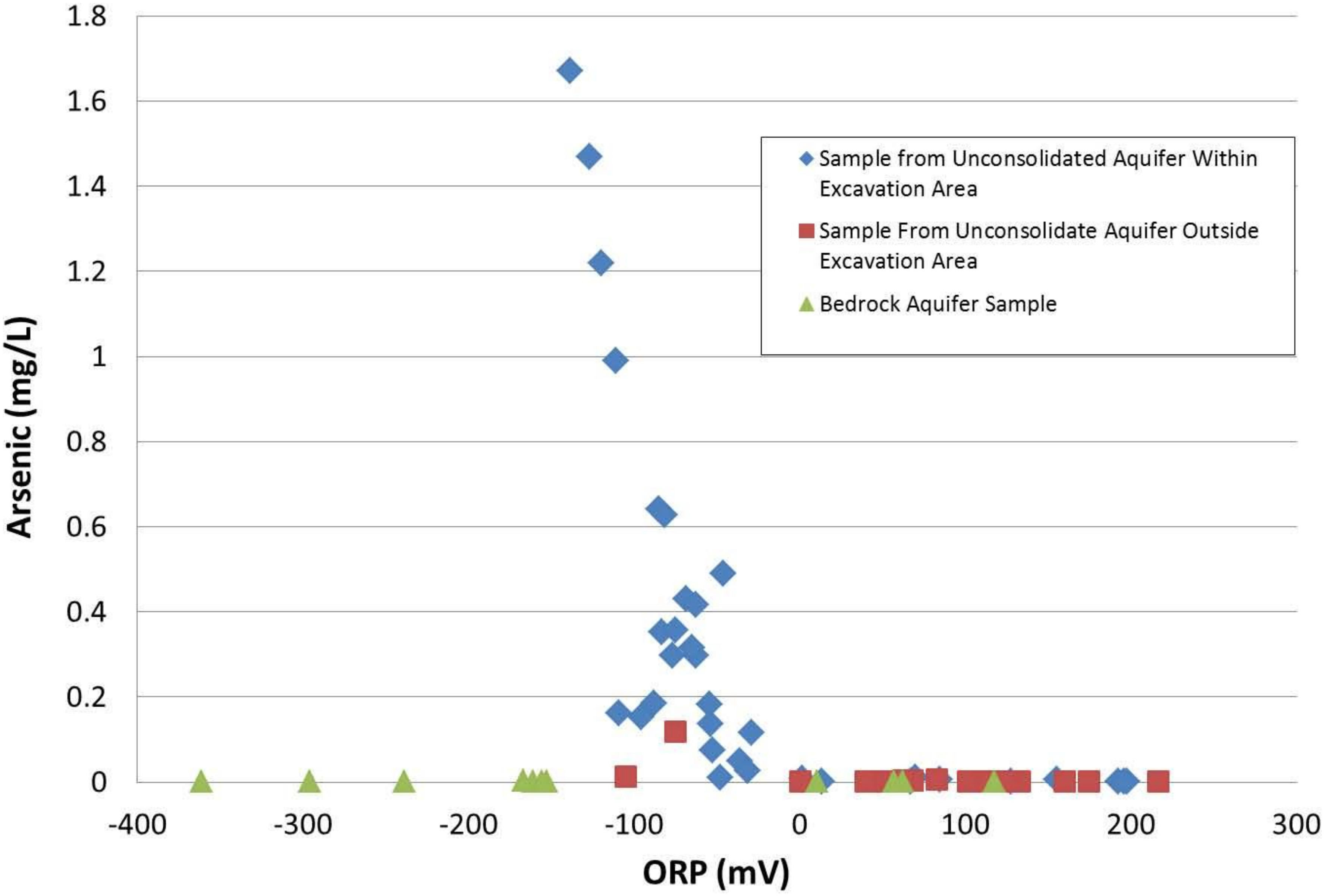
Figure B-8. pH/eH diagram for MW97-20



Parameter	2010	2011
Arsenic (mg/L)	0.033	0.00176
Iron (mg/L)	NA	0.151
ORP (mV)	117.3	67
Eh (mV)	317.3	267
pH	5.92	5.98

FIGURE 4-2: ARSENIC MOBILITY IN GROUNDWATER AS CONTROLLED BY Eh/pH CONDITIONS ON THE SPECIATION OF ARSENIC AND IRON (WELCH, 2000)

Figure B-9. ORP vs. Arsenic for July 2011 Sampling Event



ATTACHMENT C: Historic VOC and SVOC Trends at Selected Wells

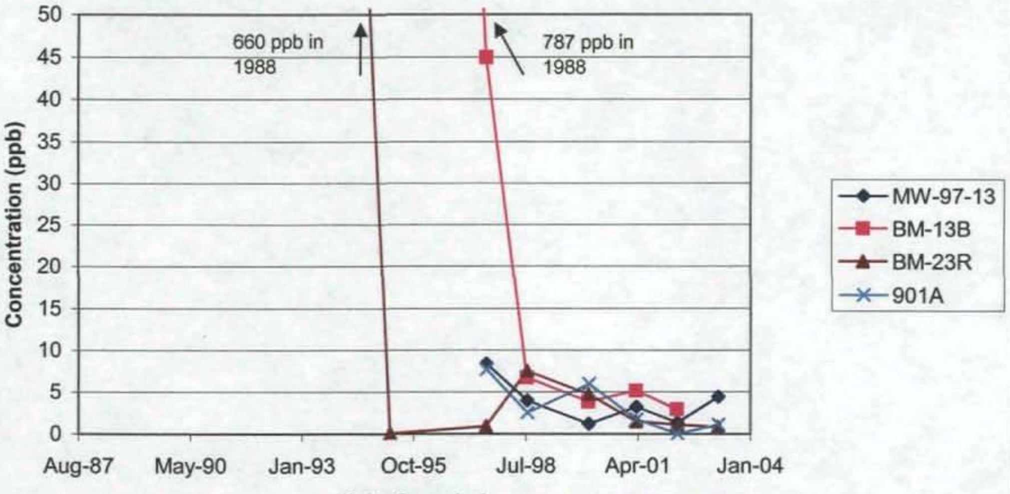


Figure 4. Total VOC Concentrations for Select Overburden Wells in Area A (East Side of River)

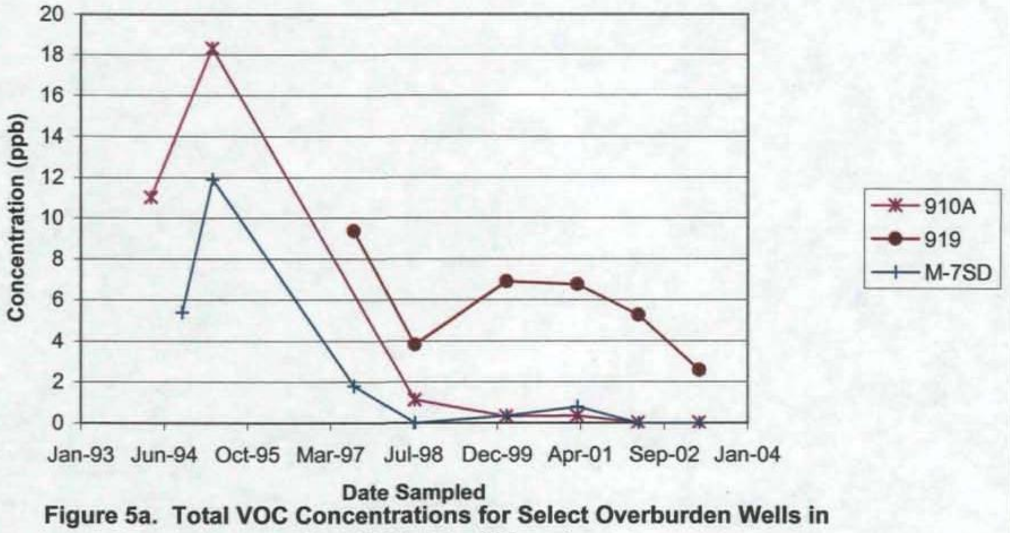


Figure 5a. Total VOC Concentrations for Select Overburden Wells in Area C (North of Plume)

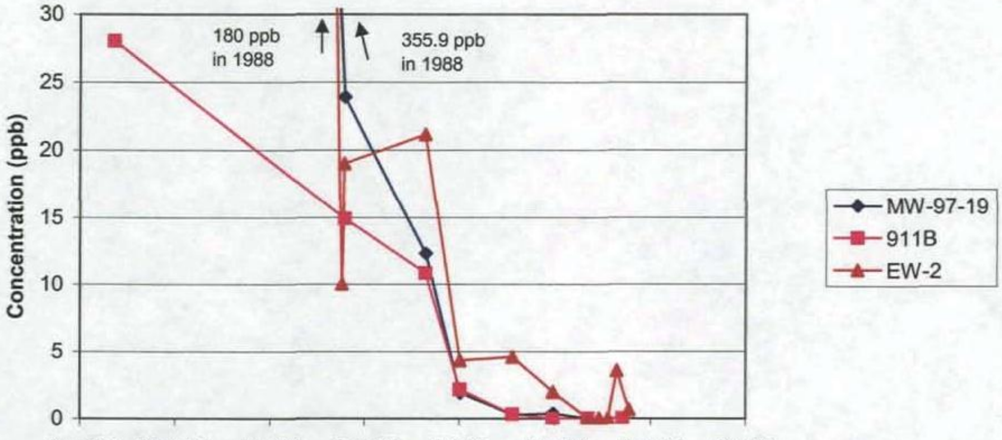


Figure 5b. Total VOC Concentrations for Select Overburden Wells in Area C (North of Plume)

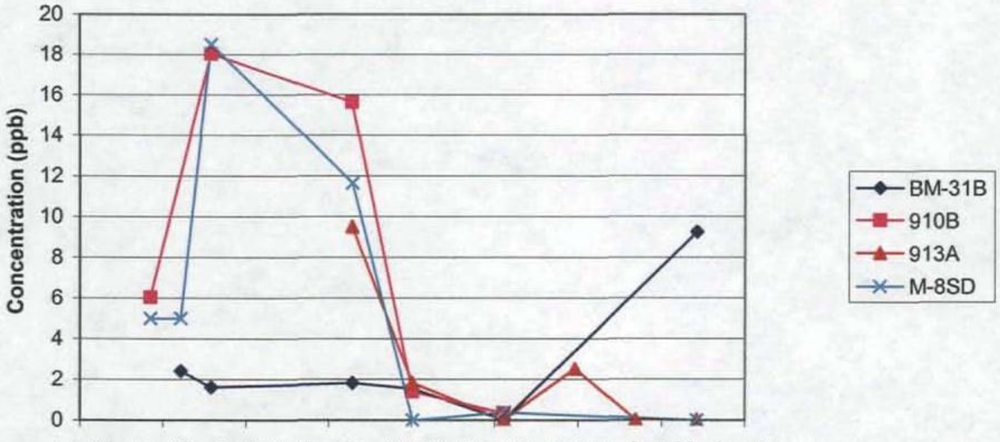


Figure 5c. Total VOC Concentrations for Select Overburden Wells in Area C (North of Plume)

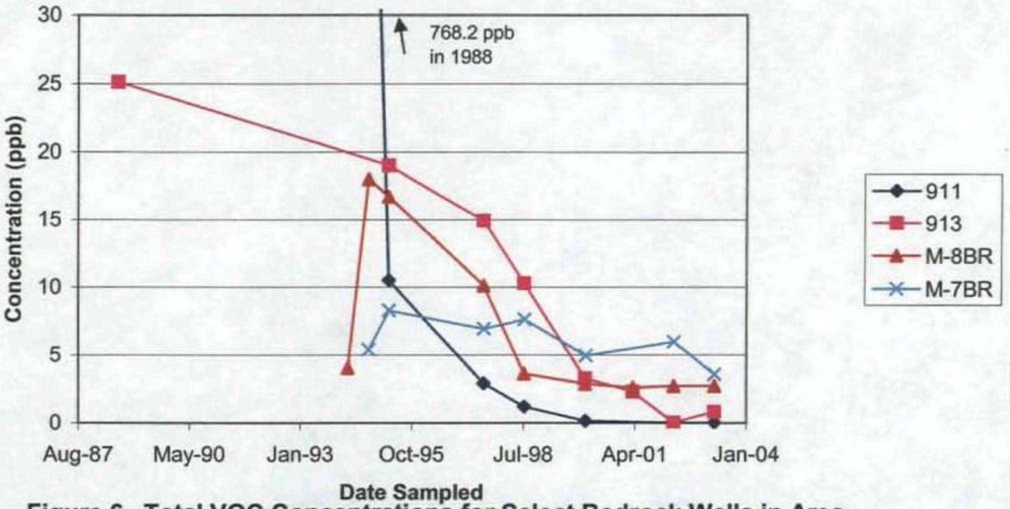


Figure 6. Total VOC Concentrations for Select Bedrock Wells in Area C (North of Plume)

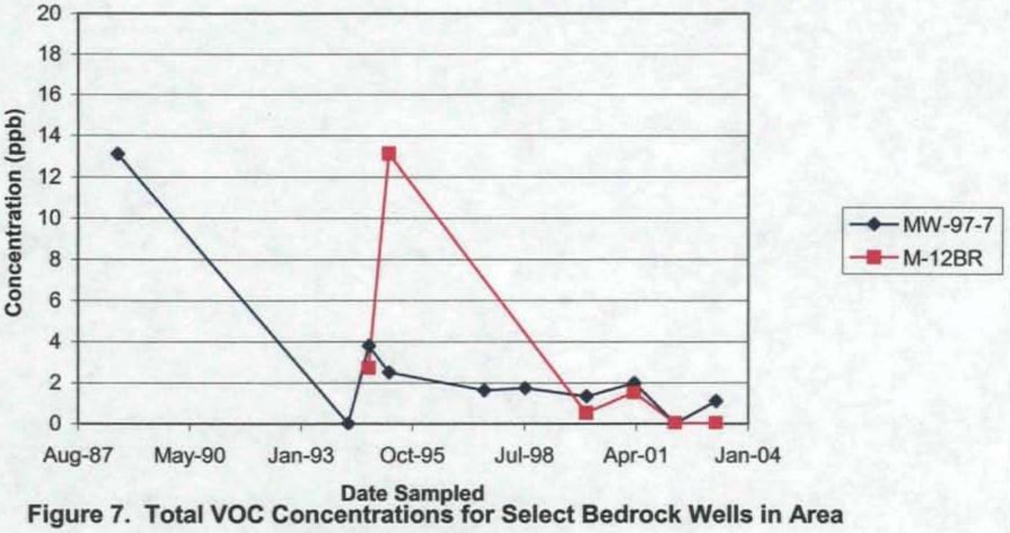


Figure 7. Total VOC Concentrations for Select Bedrock Wells in Area D (South of Plume)

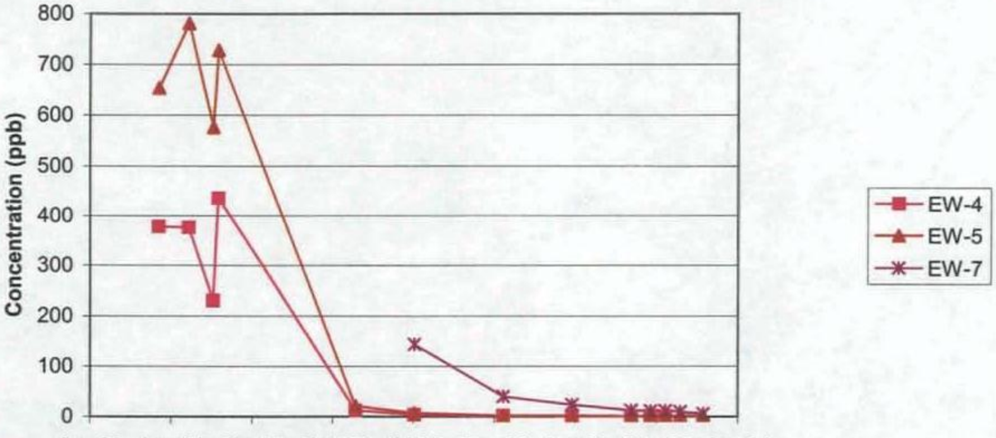


Figure 8a. Total VOC Concentrations for Select Extraction Wells in Area B (Plume Wells)

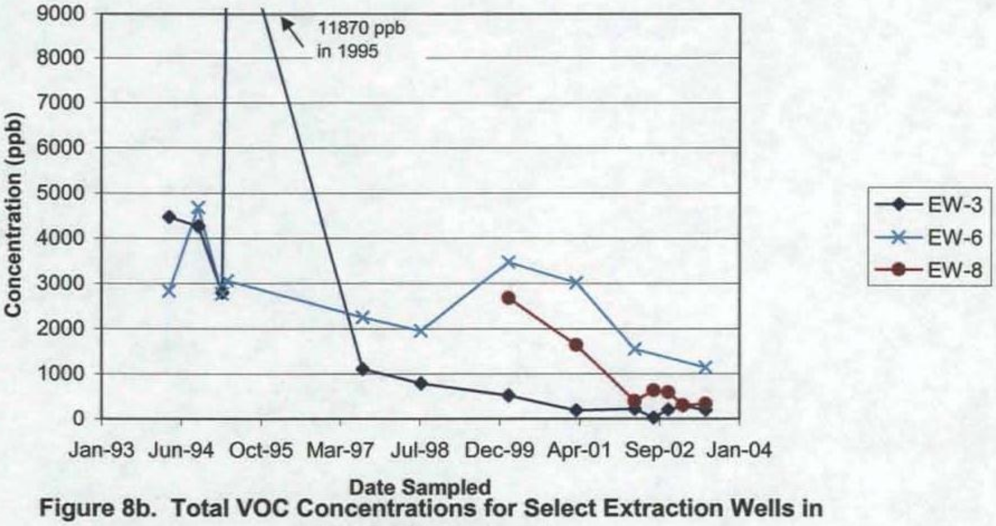


Figure 8b. Total VOC Concentrations for Select Extraction Wells in Area B (Plume Wells)

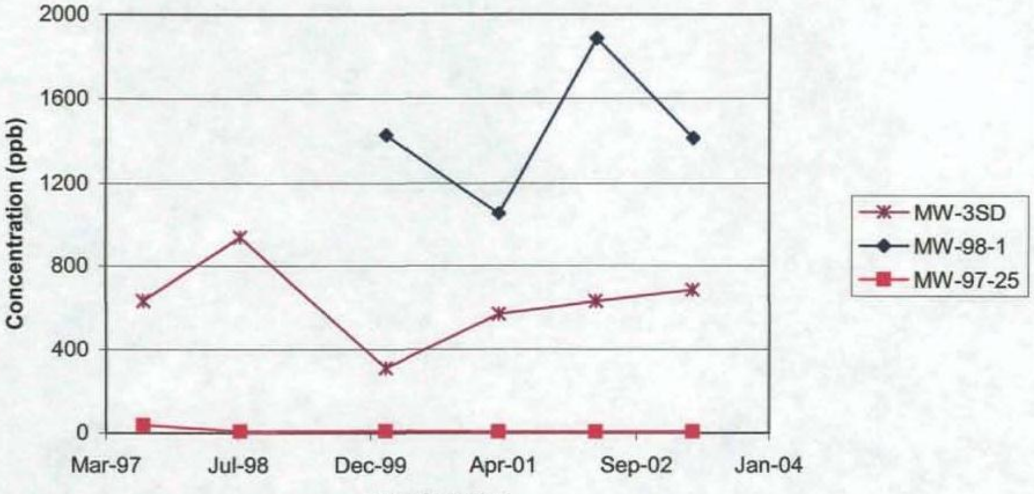


Figure 9a. Total VOC Concentrations for Select Overburden Wells in Area B (Plume Wells)

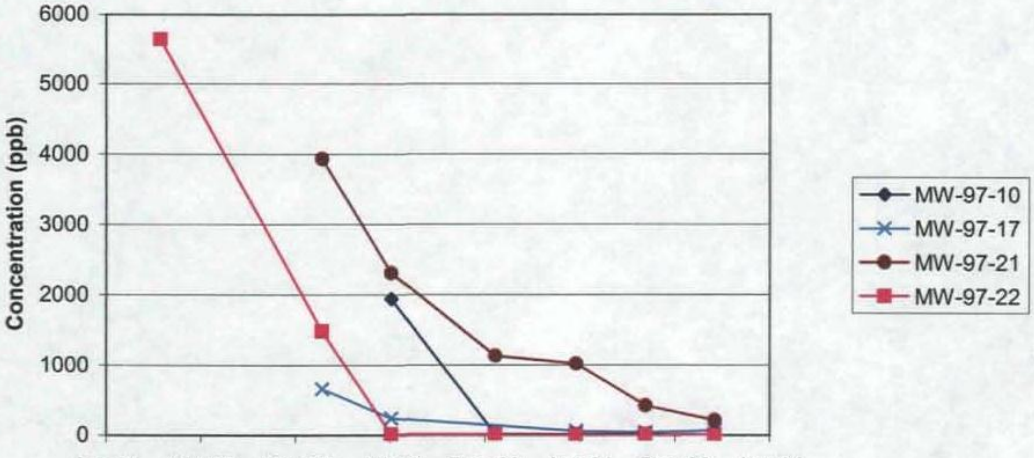


Figure 9b. Total VOC Concentrations for Select Overburden Wells in Area B (Plume Wells)

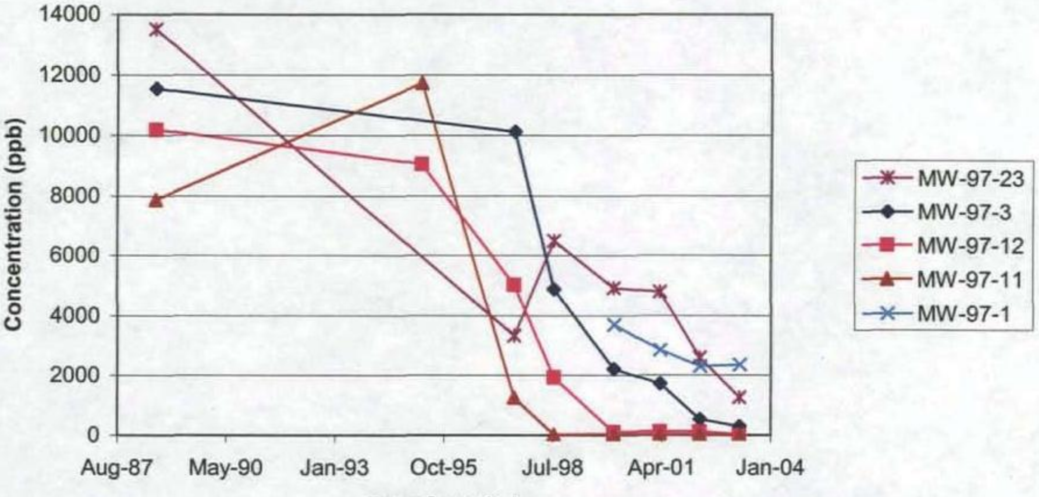


Figure 9c. Total VOC Concentrations for Select Overburden Wells in Area B (Plume Wells)

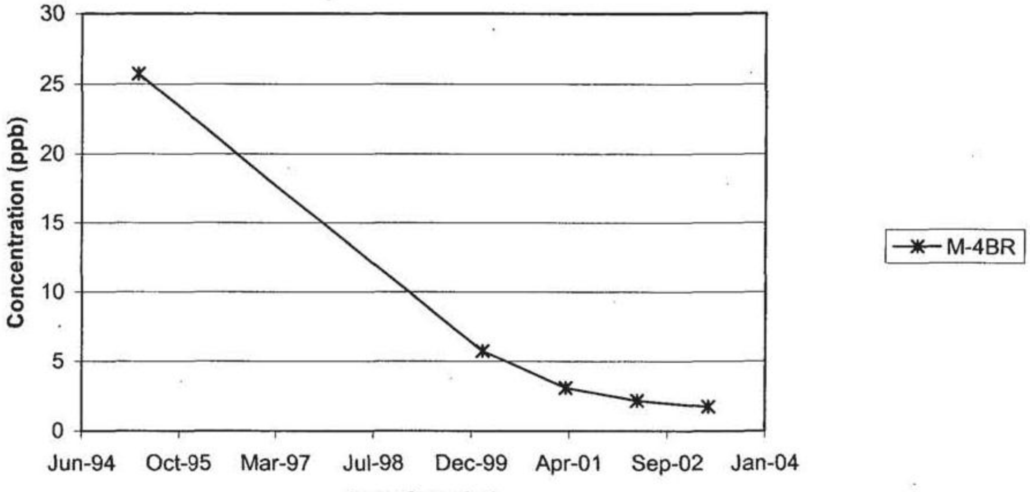


Figure 10. Total VOC Concentrations for Bedrock Well M-4BR in Area B (Plume Wells)

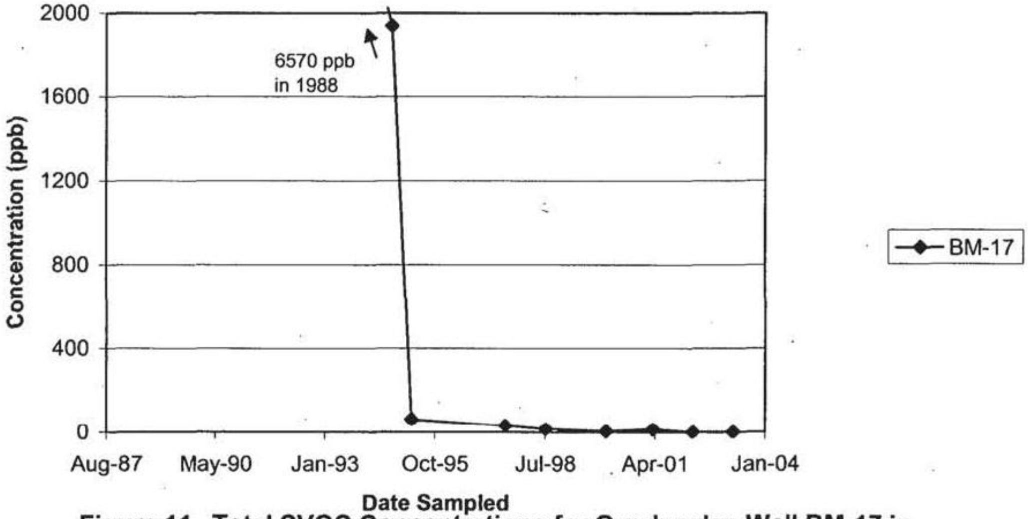


Figure 11. Total SVOC Concentrations for Overburden Well BM-17 in Area A (East Side of River)

Figure 12a. Total SVOC Concentrations for Select Overburden Wells in Area B (Plume Wells)

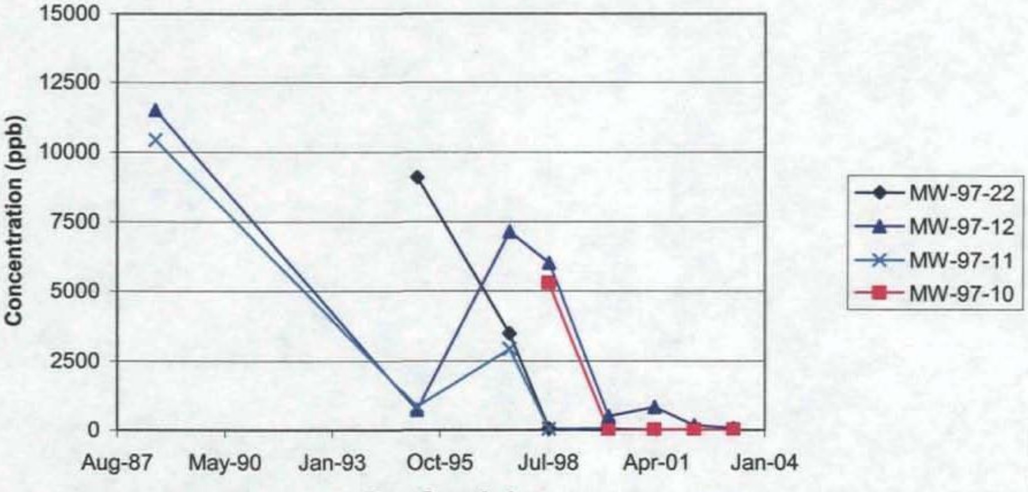


Figure 12b. Total SVOC Concentrations for Select Overburden Wells in Area B (Plume Wells)

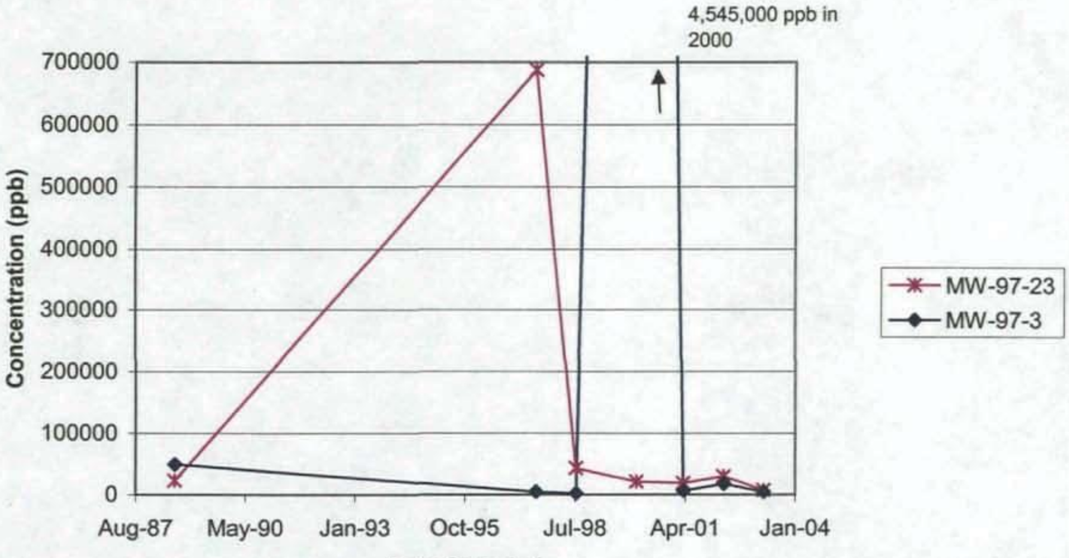


Figure 12c. Total SVOC Concentrations for Select Overburden Wells in Area B (Plume Wells)

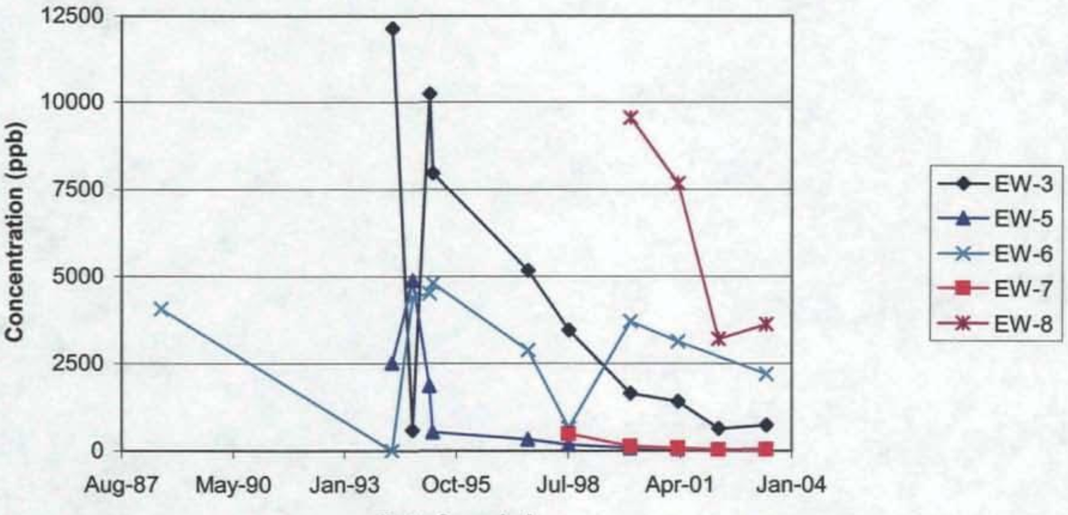


Figure 13. Total SVOC Concentrations for Select Extraction Wells in Area B (Plume Wells)

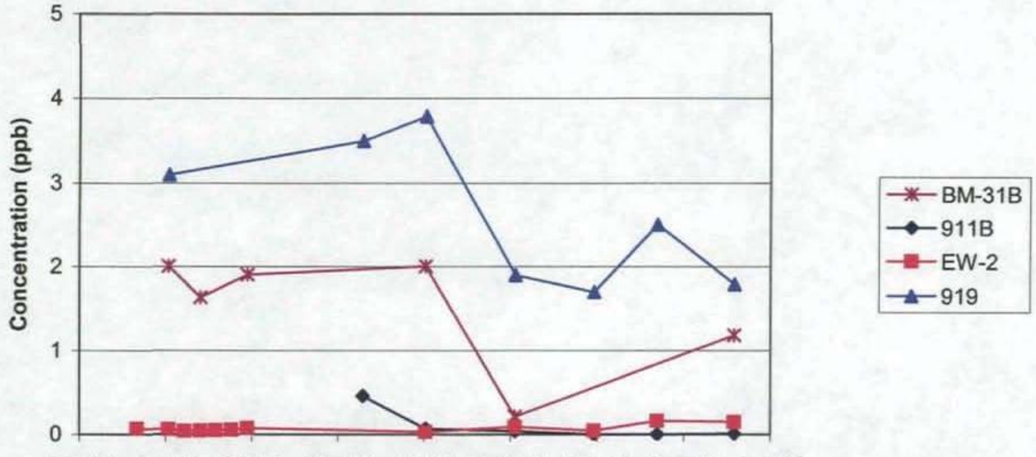


Figure 14. Dissolved Arsenic Concentrations for Select Overburden Wells in Area C (North of the Plume)

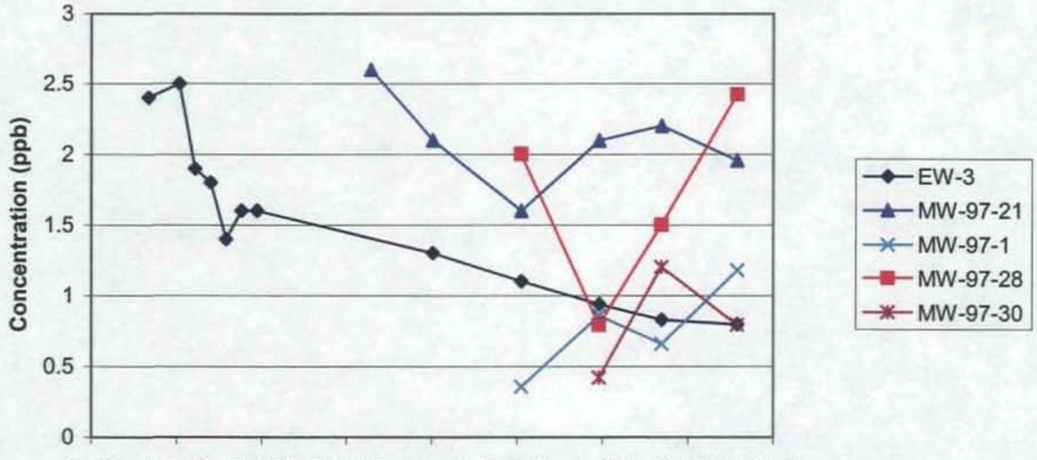
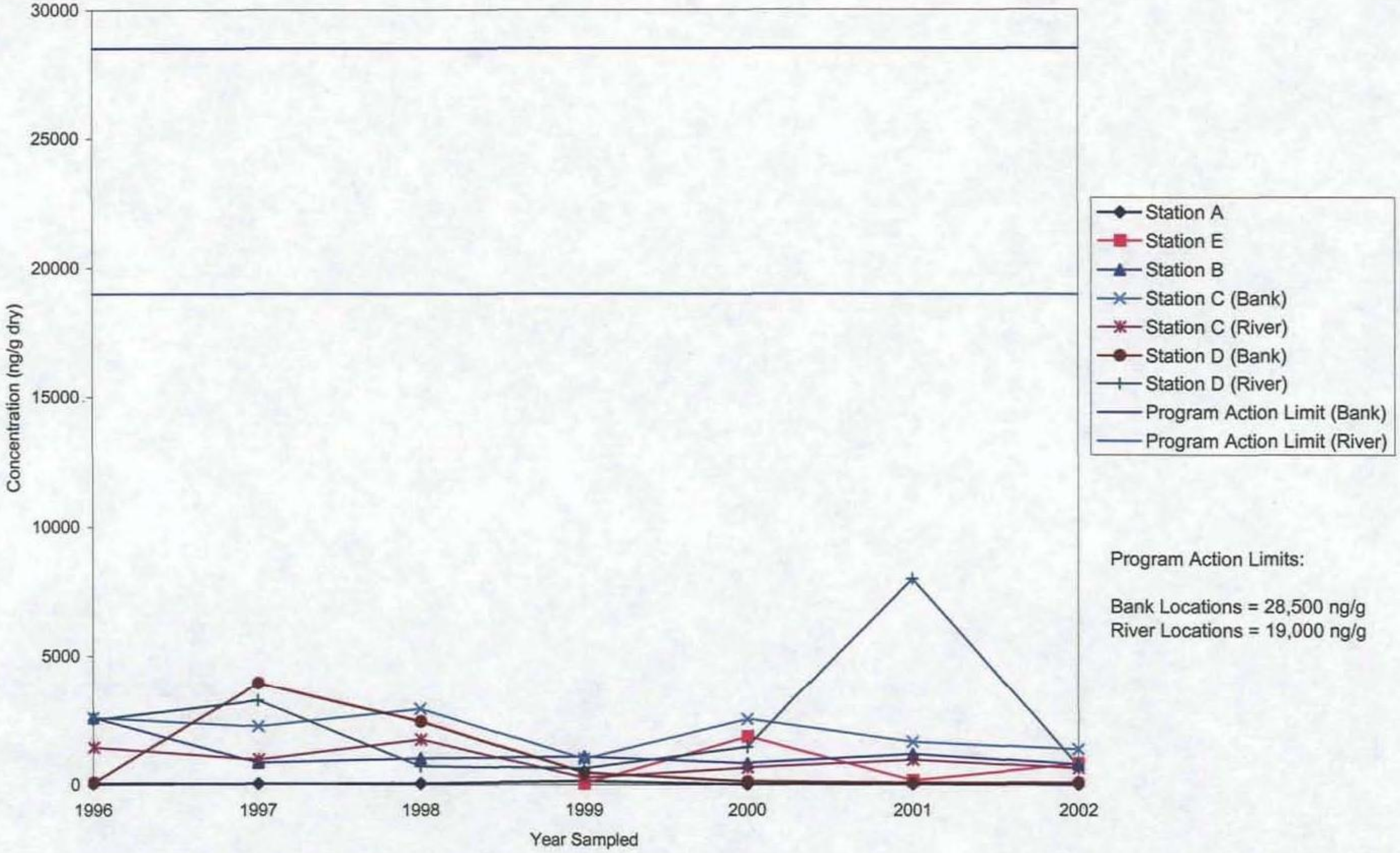


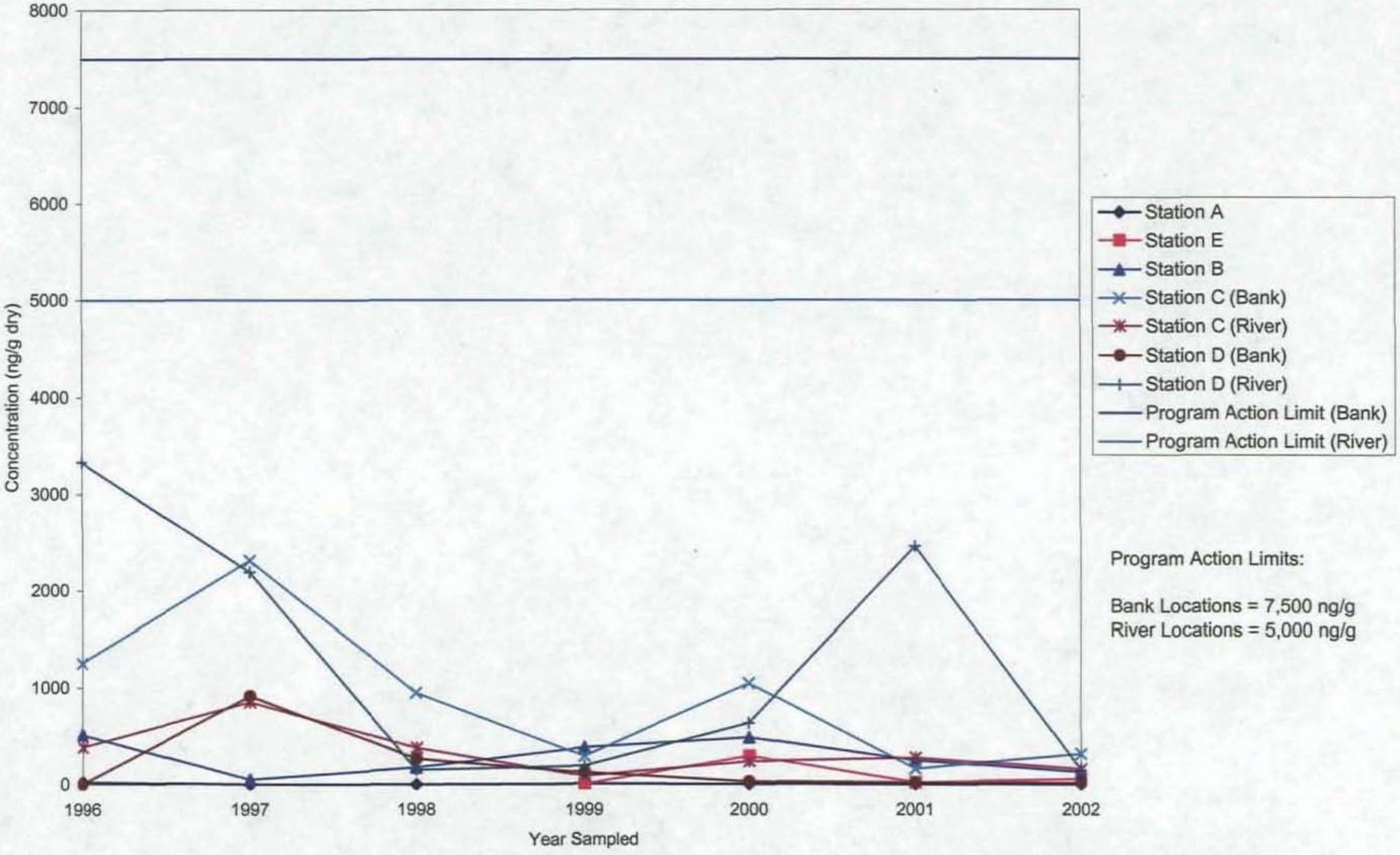
Figure 15. Dissolved Arsenic Concentrations for Select Overburden Wells in Area B (Plume Wells)



Program Action Limits:

Bank Locations = 28,500 ng/g
River Locations = 19,000 ng/g

Figure 16. Station Mean Concentrations of Total DDT in River Sediment and Bank Samples Collected Along the Cochato River from 1996 to 2002



Program Action Limits:

Bank Locations = 7,500 ng/g
River Locations = 5,000 ng/g

Figure 17. Station Mean Concentrations of Total Chlordane in River Sediment and Bank Samples Collected Along the Cochato River from 1996 to 2002

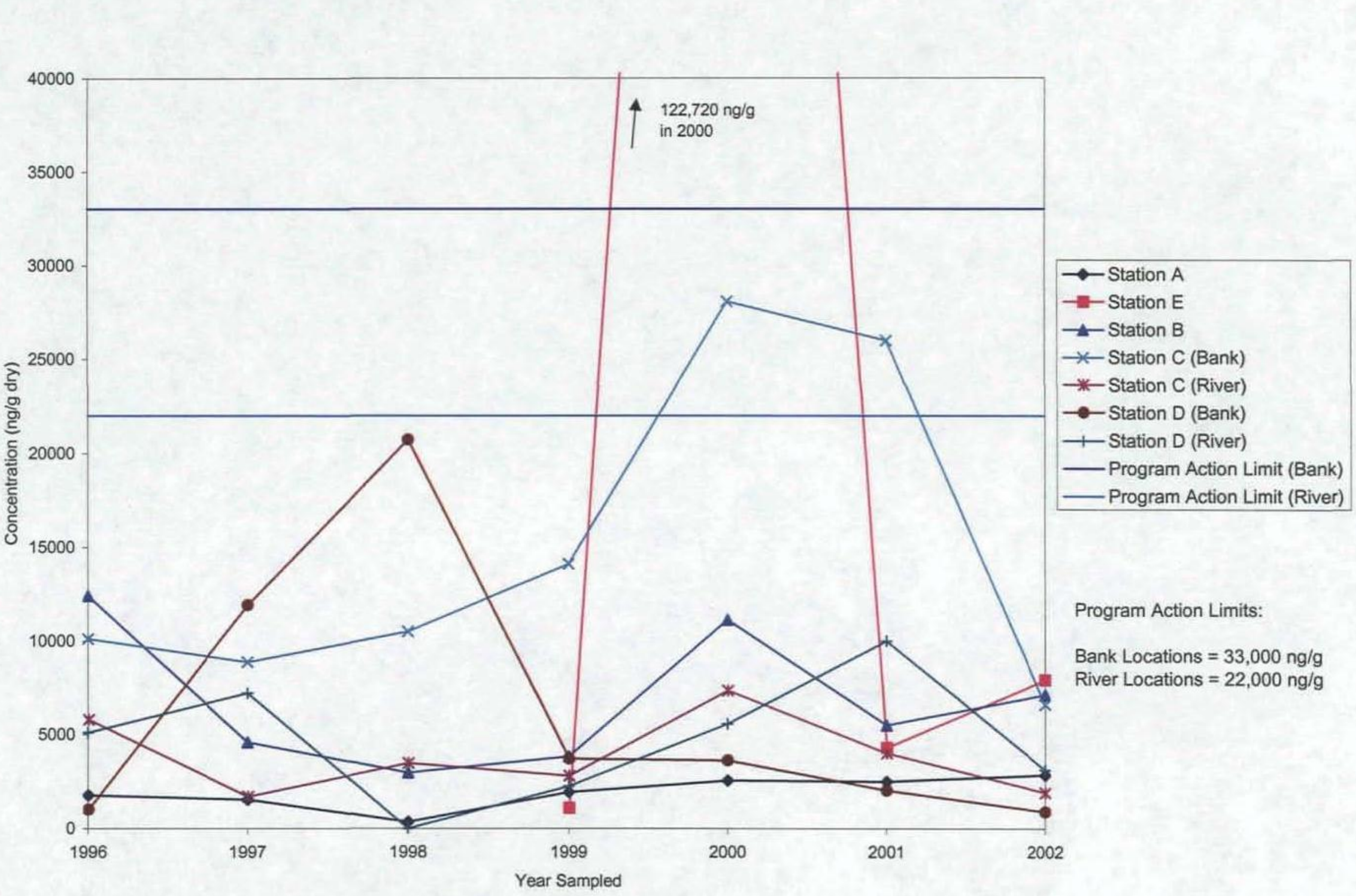


Figure 18. Station Mean Concentrations of Total PAHs in River Sediment and Bank Samples Collected Along the Cochato River from 1996 to 2002

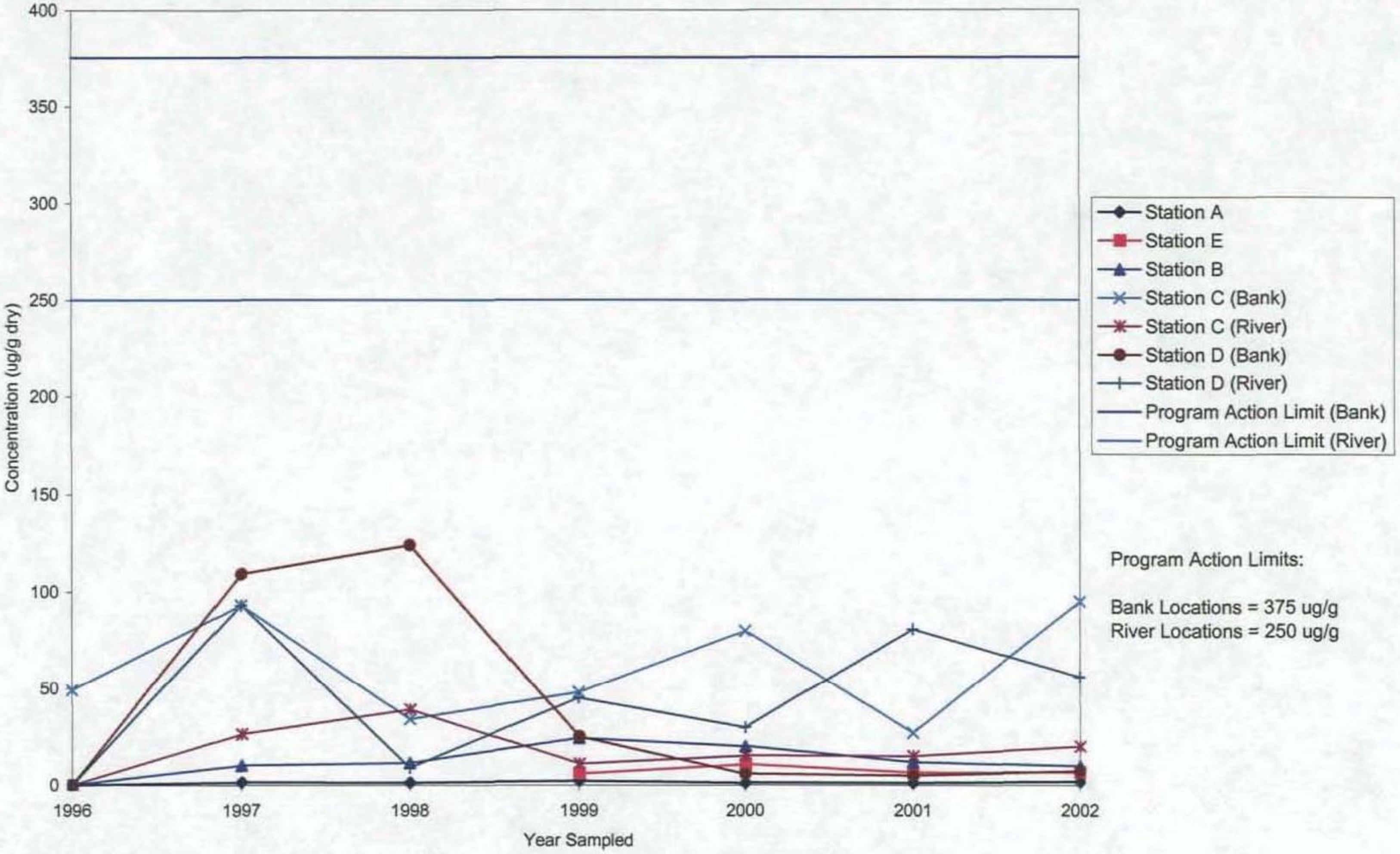


Figure 19. Station Mean Concentrations of Arsenic in River Sediment and Bank Samples Collected Along the Cochato River from 1996 to 2002

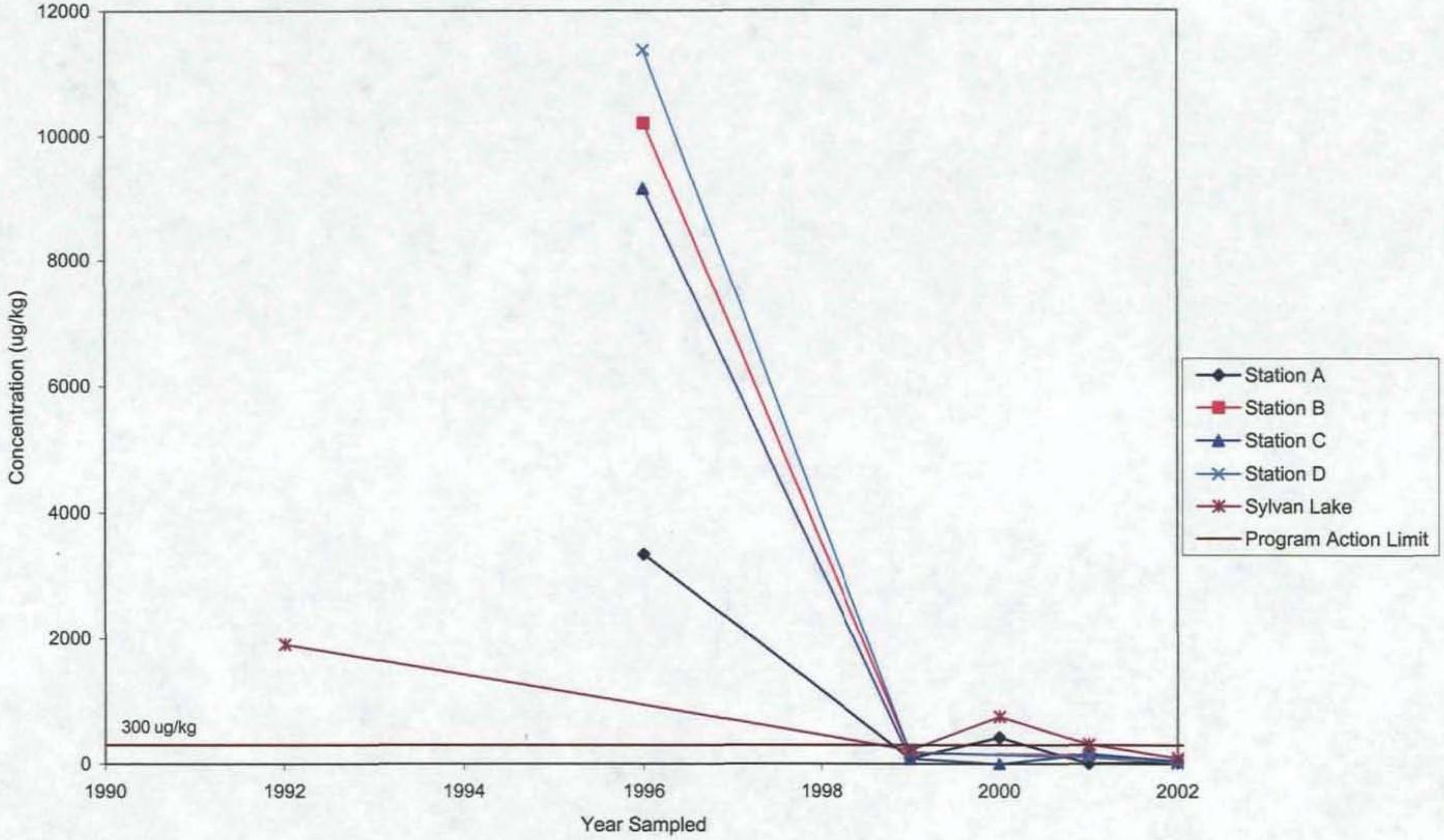


Figure 20. Average Fish Fillet Concentrations: Total DDT

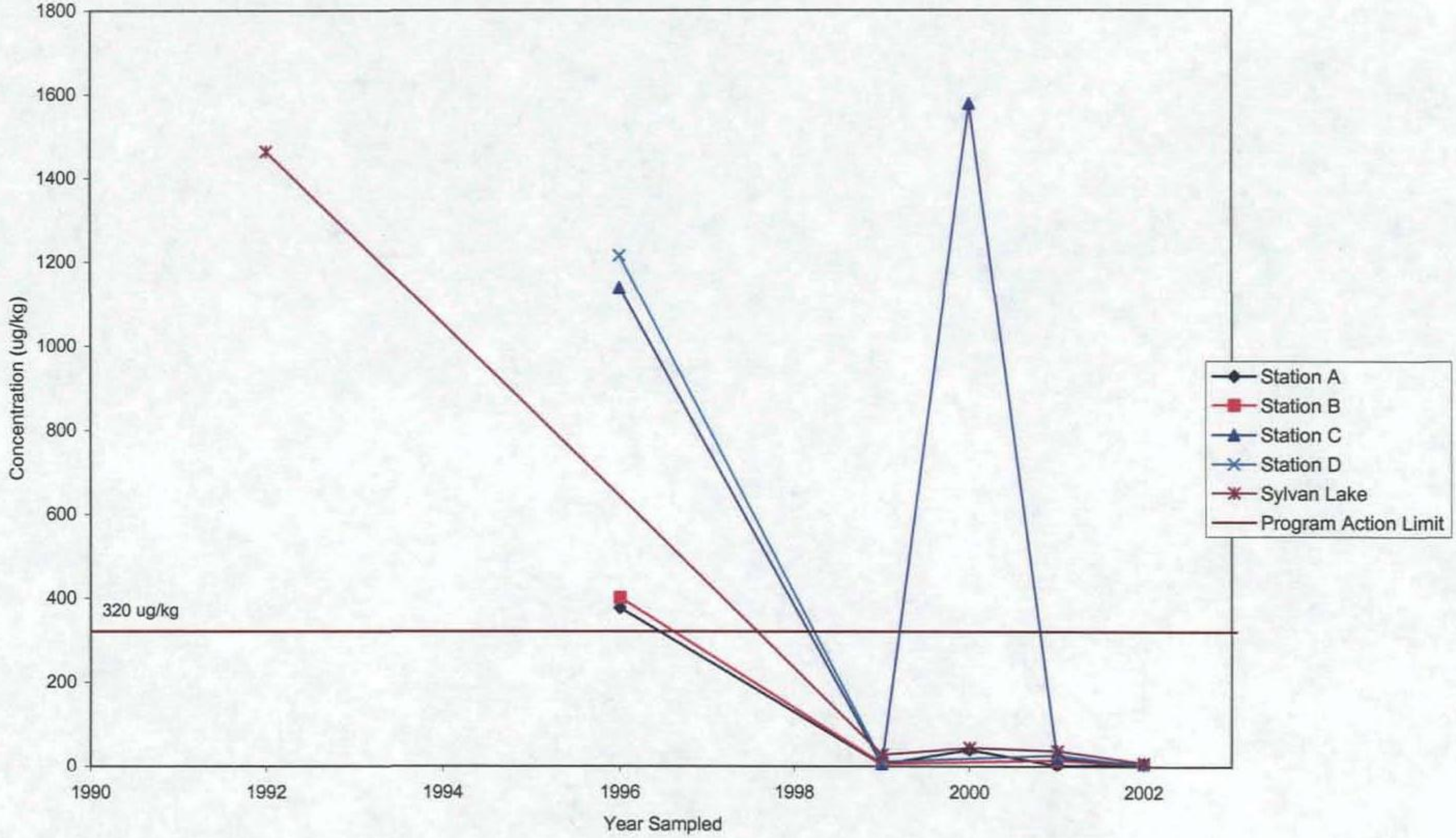


Figure 21. Average Fish Fillet Concentrations: Total Chlordane

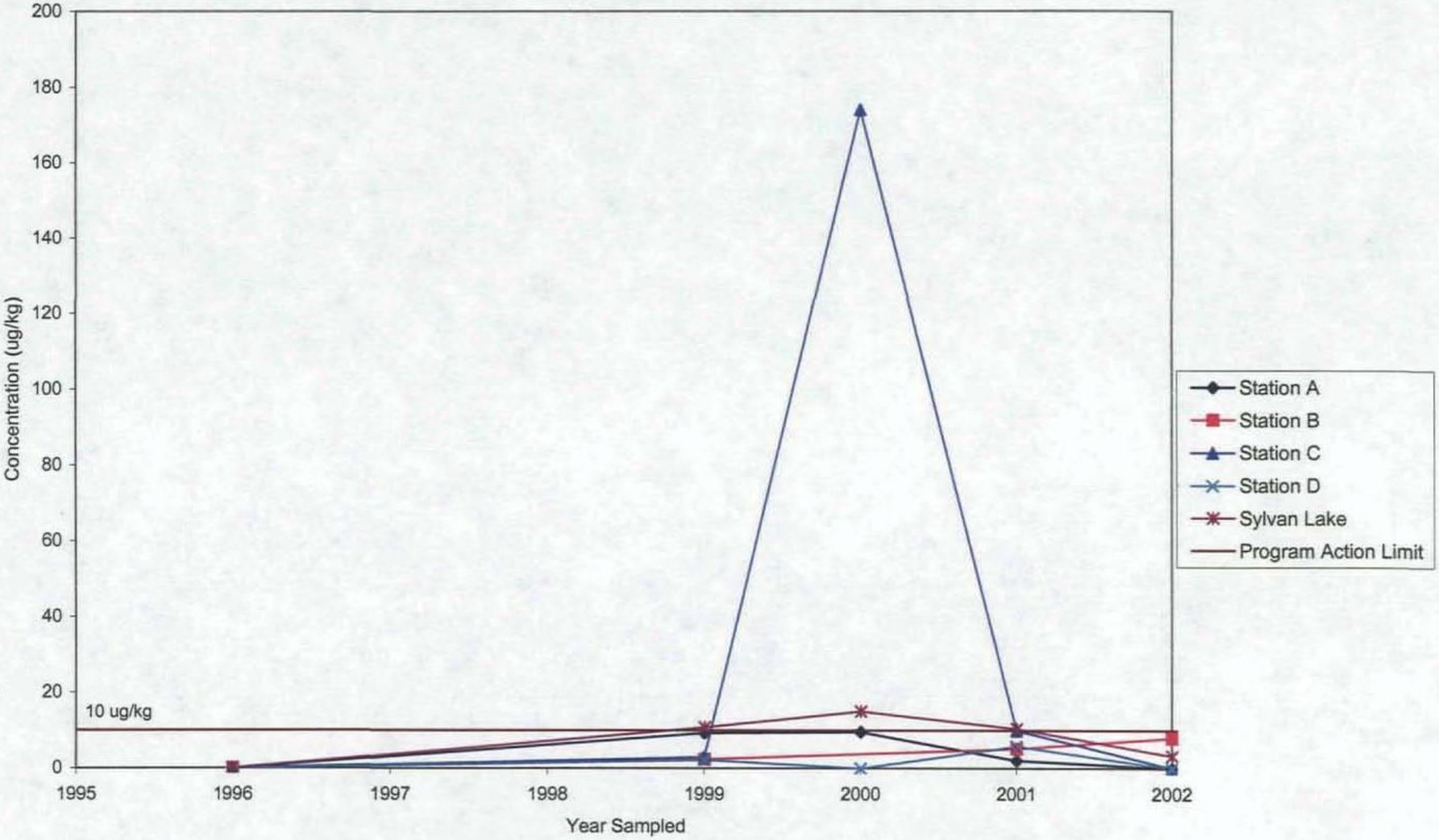


Figure 22. Average Fish Fillet Concentrations: Total PAHs