U.S. Army Corps of Engineers

New England Division
Waltham, Massachusetts

FORT DEVENS SUDBURY TRAINING ANNEX
SUDBURY, MASSACHUSETTS

Contract No. DACW33-95-D-0004
Delivery Order No. 0005
DCN: SAL-052297-AAFN

CONTAMINATED SOIL REMOVAL
STUDY AREA P28

FINAL ACTION MEMORANDUM

MAY 1997

WESTON
MANAGERS DESIGNERS CONSULTANTS

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STUDY AREA P28
SUDBURY TRAINING ANNEX
SUDBURY, MASSACHUSETTS

FINAL
ACTION MEMORANDUM

Contract No. DACW33-95-D-0004
Delivery Order 0005
Work Order 03886-118-005-0128-00
DCN: SAL-052297-AAFN

May 1997

Prepared for

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Prepared by

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1 Wall Street
Manchester, NH 03101

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EXECUTIVE SUMMARY

This Action Memorandum summarizes the time-critical removal action at the P28 Study Area located on the southern portion of the Fort Devens Sudbury Training Annex, Sudbury, MA. Soil contaminated with arsenic was removed from the location to eliminate associated potential human health and ecological risks. This time-critical removal action and development of this document were conducted by Roy F. Weston, Inc. in coordination with the New England District of the Army Corps of Engineers (CENED), the Massachusetts Department of Environmental Protection (MADEP) and the U.S. Environmental Protection Agency (EPA).

A site investigation performed by ABB Environmental Services, Inc. (ABB) revealed a presence of arsenic above background levels in the area. Concerned by the levels of contamination, the MADEP requested the performance of an Imminent Hazard Evaluation. The evaluation concluded that the levels of arsenic in the area posed a risk to human health under a specific site usage scenario.

The area of contamination was delineated through sampling efforts by ABB. The area of P28 designated for removal can be described as a section 100 feet by 250 feet in area with a depth of four feet. The excavation and removal was performed by Roy F. Weston, Inc. in August 1996.

The contaminated soil was removed and consolidated as part of the subgrade at A7 where a landfill cap was being constructed as part of another remedy. The placement of the soil at the site landfill was appropriate in that it allowed for a timely removal, saved costs associated with typical disposal scenarios, and it decreased the need for additional fill required for the construction of the landfill cap. The RCRA Subtitle C (double-barrier) landfill cap was completed in November 1996.

Confirmation sampling at P28 revealed no concentrations of arsenic above the clean up level of 250 part per million (ppm). Therefore, the excavation was successful in eliminating the human health associated with Study Area P28.

Based on the confirmatory sampling results, the removal action has addressed the imminent hazard. Further study of arsenic soil contamination is being addressed in the facility wide arsenic investigation.

SECTION 1
INTRODUCTION

1.1 General

This memorandum documents the time-critical removal action for contaminated soil at Study Area (SA) P28 located at the Fort Devens Sudbury Training Annex. The Removal Action and Action Memorandum were completed by Roy F. Weston, Inc. (WESTON®) under a delivery order from the U.S. Army Corps of Engineers New England District (CENED).

1.2 Purpose

The purpose of this Action Memorandum is to document the time-critical removal of contaminated soil at the specified location of SA P28 at the Fort Devens Sudbury Training Annex. In addition, this document presents background information related to the site, details on the removal action and confirmatory samples, and recommendations on further actions. This Action Memorandum was prepared in accordance with current U.S. Environmental Protection Agency (USEPA) guidance (USEPA, 540/P-90/004, December 1990).

1.3 Background

The Fort Devens Sudbury Annex is a military installation located in the towns of Sudbury, Maynard, Stow, and Hudson in the Commonwealth of Massachusetts. The annex occupies approximately 2,750 acres.

Former uses at the site include use as an ammunitions depot in the 1940s and storage and training in the 1950s. Other activities include use for ammunitions and explosives testing, fire-fighting exercises, and laboratory waste and debris disposal. The area was also used as a railroad classification yard for inspections and switching operations. The tracks were removed in 1967. Some unauthorized activities, such as camping, biking, walking, and municipal dumping occurred over the years.

Fort Devens took custody of the annex from the Natick Research Laboratories in 1982 and has maintained the facility for storage and training. In 1980, environmental studies began at the annex. These studies were performed according to the Installation Restoration Program (IRP) developed by the Department of Defense (DOD).

A Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Preliminary Assessment of the annex was performed by NUS Corporation in 1985. A CERCLA Site Investigation was performed in 1987. Based on the results of the assessment and investigation, the U.S. EPA determined that the site should be included on the National Priorities List (NPL). The site was placed on the NPL on February 16, 1990.

A Master Environmental Plan was developed by OHM, Inc. in 1992 and was supplemented by Ecology and Environment, Inc. in 1993. This plan was developed in accordance with the objectives of the IRP. The Master Environmental Plan identified 68 study areas at the site. One of these areas, Study Area (SA) P28 is the focus of this memorandum. See Figure 1-1 for the site location.

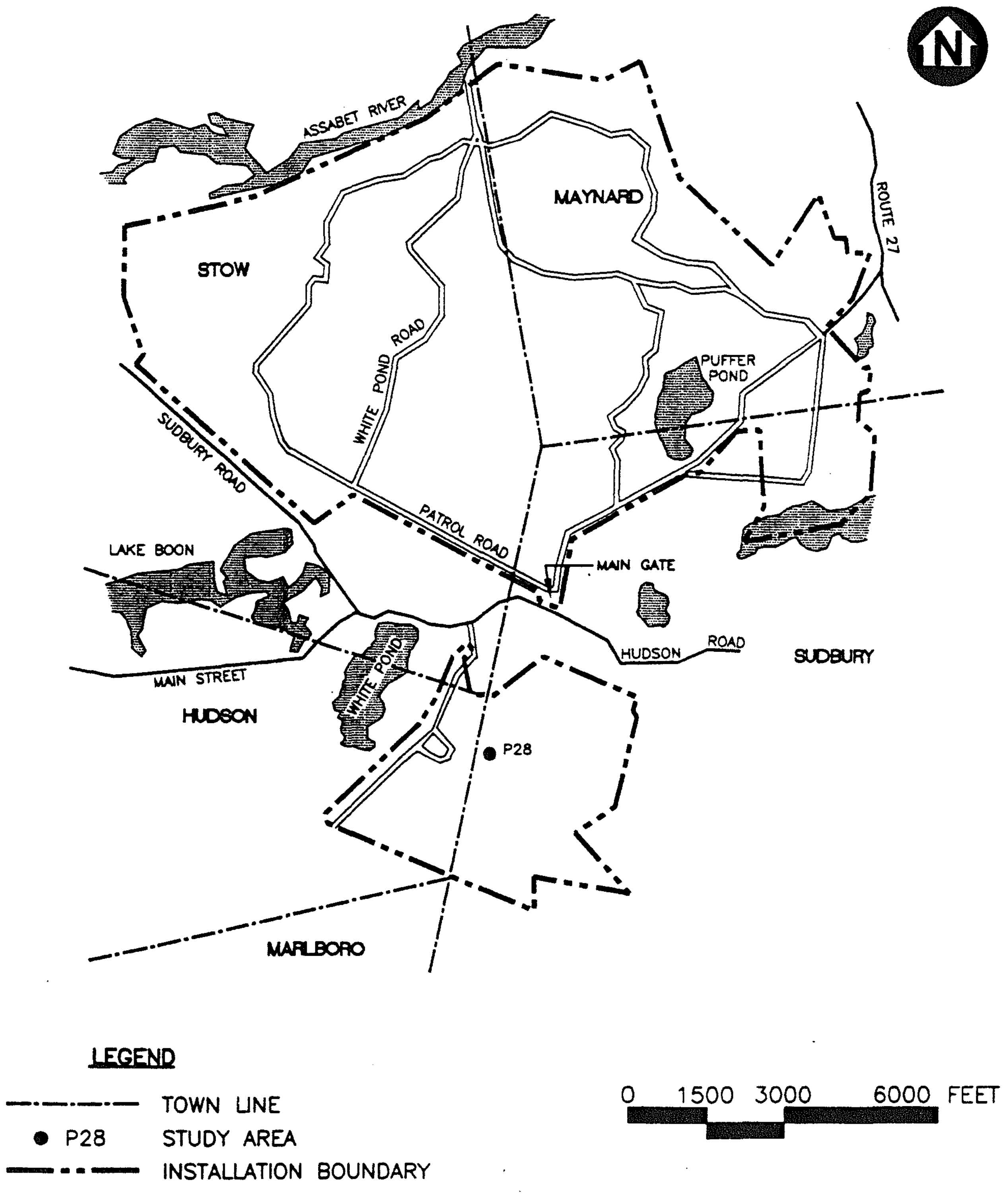

FIGURE 1-1
LOCATION OF STUDY AREA P28
SUPPLEMENTAL SITE INVESTIGATION
FORT DEVENS SUDBURY TRAINING ANNEX
MIDDLESEX COUNTY, MASSACHUSETTS

ABB Environmental Services

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SECTION 2
STUDY AREA P28 SITE CONDITIONS

2.1 Site Description

2.1.1 Study Area Background

SA P28 is located in the southern portion of the Sudbury Training Annex (south of Hudson Road). Historical information indicates that this area was used as a railroad classification yard, including railroad inspections and car switching operations. Other information suggests that rocket testing took place here. Evidence also indicates that the area has been used recreationally, for such activities as walking, jogging, and dirt biking.

Site investigations suggest that there may have been previous use of herbicides. The application of herbicides was likely performed for railroad and "line-of-sight" maintenance.

2.1.2 Removal Site Evaluation

A supplemental site investigation (SSI) for SA P28 was performed by ABB Environmental Services, Inc. (ABB) in November 1995. The site investigation revealed the presence of soil contaminated with arsenic. In particular, high levels of arsenic were associated with a localized section of SA P28. This localized section is the focus of the removal action associated with this document.

Subsequent to the findings in the SSI, the Massachusetts Department of Environmental Protection (MADEP) requested that an Imminent Hazard Evaluation for arsenic at the P28 Study Area (see the Imminent Hazard Evaluation in the Attachments). The results of the evaluation indicated that the area of SA P28 with a high concentration of arsenic did pose a risk to human health. The remaining area of SA P28 did not pose a substantial risk. Therefore, it was determined to remove the contaminated soil from the isolated area at the site to eliminate the potential health risk.

The hot spot area of P28 had concentrations of arsenic as high as 5,200 ppm, with an average of 2,300 ppm for the isolated area. The remainder of the P28 site had an average arsenic concentration of 169 ppm.

2.1.3 Physical Location and Description

SA P28 is located in the northern section of the southern part of the annex. The southern part of the annex is just south of Hudson Road, which divides the annex into north and south sections. The SA P28 location is also situated adjacent to the Capehart housing complex, a residential area.

The main corridor consists of an area about 3600 feet long and 100 feet wide and includes a gravel roadway. This area consists of a sandy-gravely surface that is relatively flat. No vegetation exists along this corridor. The surrounding area contains tall grass, brush, and is moderately forested.

The isolated section of SA P28 with the high concentration of arsenic is situated in the southern section of SA P28. This isolated section is about 100 feet by 250 feet in area. No vegetation exists in the area surrounding the highest concentrations of arsenic. See Figure 2-1 for the location of the contaminated area.

2.2 Other Actions to Date

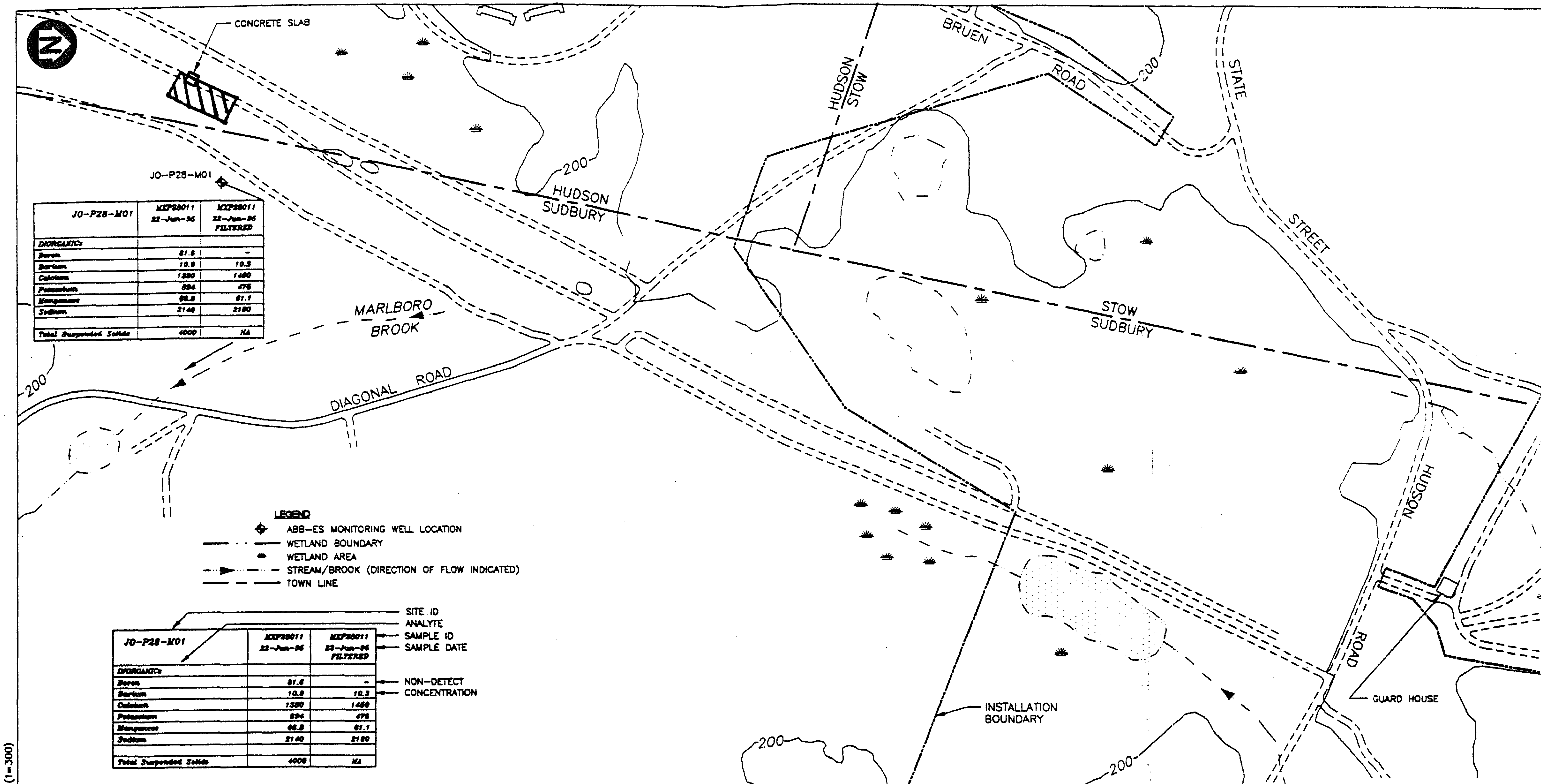
Prior to the removal action associated with this document, an unauthorized removal of soil occurred (March of 1995). Surface soil in the P28 area was excavated and stockpiled and some was used to fill in a roadway in the area. After learning of this activity, the Fort Devens Environmental Management Office had the soil covered and limited access to the area.

The incident was reported to the MADEP and the EPA. This soil was subsequently re-excavated and was shipped to Study Area A-7 for placement in the landfill and eventual use as subgrade for landfill capping in the fall of 1996. Confirmatory sampling in the excavated areas including roads showed that the improperly placed soil had been entirely removed.

Other actions at the site included the installation of perimeter fencing for the isolated area with high arsenic concentrations. The fence was put in place by ABB.

2.3 State and Local Authorities Role

The MADEP, in cooperation with CENED and the EPA, provided regulatory guidance for the project. Also, the local fire-fighting departments provided assistance in the development of emergency response procedures.



JO-P28-M01	*MXP28011 22-Jun-96*	*MXP28011 22-Jun-96 FILTERED*
INORGANICs		
Boron	*81.6*	*-*
Barium	*10.9*	*10.3*
Calcium	*1380*	*1450*
Potassium	*894*	*476*
Manganese	*66.8*	*61.1*
Sodium	*2140*	*2180*
Total Suspended Solids	*4000*	*NA*

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Notes:

1. Concentrations are in micrograms per liter
2. NA = Not Analyzed
3. – = Not Detected
4. Samples presented in blue and italicized are off-site analytical samples

0 150 300 600 FEET

Figure 2-1 Location of Contaminated Soil: P-28

SUPPLEMENTAL SITE INVESTIGATION
FORT DEVENS SUDBURY TRAINING ANNEX
MIDDLESEX COUNTY, MASSACHUSETTS

ABB Environmental Services

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SECTION 3
THREATS TO HUMAN HEALTH OR PUBLIC WELFARE

3.1 Threats to Human Health or Public Welfare

3.1.1 Actual or Potential Exposure to Hazardous Substances or Pollutants or Contaminants By Nearby Populations or the Food Chain

Potential health risks associated with SA P28 were evaluated by ABB in the April 3, 1996 Imminent Hazard Evaluation (IHE). This evaluation considered the levels of contamination, use of the site, and potential exposure to humans. The determination was made by comparing the analytical data with site-specific Screening Levels for Short-Term Exposure (SLSTE) based on expected site use. The site is known to be used recreationally by walkers, joggers, and bikers.

The arsenic SLSTE for the site, developed by ABB, was determined to be 250 ppm. The methodology for determining this figure can be found in the IHE, included in the Attachments.

In one area, the average arsenic value in the soil was 2,358 ppm, with the maximum concentration at 5,200 ppm. Based on this information, it was determined that a significant risk to health was present for dirt-bikers in this isolated area.

The remaining area of SA P28 has an average level of 169 ppm of arsenic in the soil, and thus does not present a significant risk to human health.

3.1.2 Actual or Potential Contamination of Drinking Water Supplies

ABB installed groundwater monitoring well JO-P28-M01 for sampling and observations. A groundwater sample collected from this well was analyzed for metals. Arsenic was not detected in this sample, nor were any other analytes detected in exceedance of health-based risk screening values. Therefore, it was determined that no substantial risks to human health exist from exposure to groundwater.

3.1.3 Hazardous Substances, Pollutants, or Contaminants in Drums, Barrels, Tanks, or Other Bulk Storage Containers that may Pose a Threat of Release

At the time of site investigations, there was no evidence of such described materials located within the boundaries of SA P28. During excavation of soil from the area in August 1996, there also was no evidence of such described materials.

3.1.4 High Levels of Hazardous Substances or Pollutants or Contaminants in Soils Largely at or Near the Surface that may Migrate

Arsenic values exceeded background levels in soil samples collected throughout SA P28. The location of the arsenic concentrations are indicative of past use of herbicides. The pattern of detected concentrations of arsenic follows a roadway which includes a 100 foot wide corridor clear of vegetation. The extent of past migration is uncertain, although the arsenic concentrations are not found at high levels beyond the corridor. Information from previous investigations have not indicated a concern for the migration of contaminants.

3.1.5 Weather Conditions That May Cause Hazardous Substances, Pollutants or Contaminants to Migrate or to be Released

The only weather conditions that may have had the potential to cause the contaminants in the soil to migrate would have been wind and precipitation. Considering the area was sparsely vegetated, wind may have caused contaminants to become air borne through dust. Rain may have caused lateral and vertical migration. However, contaminants were not detected in the groundwater at SA P28 indicating that surface conditions did not affect groundwater quality.

3.1.6 Threat of Fire or Explosion

No threat of fire or explosion associated with SA P28 has been identified.

SECTION 4
ENDANGERMENT DETERMINATION

As determined in the Imminent Hazard Evaluation, soil located in the isolated area at SA P28 would have the potential to pose risks to human health. The risk-based scenario applies to the expected use of the area by dirt-bikers. Ingestion, dermal and inhalation exposure to the open, sandy soils presents a human health risk under these circumstances.

The remaining area in SA P28 does not pose any endangerment as indicated in previous studies performed to date, however, a facility wide arsenic investigation is being conducted to address potential human health and ecological risks from arsenic contamination in surface soils along former transportation corridors and the Patrol Road fenceline.

SECTION 5
REMOVAL ACTIONS AND ESTIMATED COSTS

5.1 Proposed Action

5.1.1 Proposed Action Description

The proposed action for the isolated section of SA P28 was to excavate and remove the soil containing arsenic concentrations greater than 250 ppm. This area was approximately 100 feet by 250 feet, with a proposed depth of four feet. A total of approximately 4,000 cubic yards of soil were proposed for removal.

The intent of the action was to remove soil containing the highest concentrations of arsenic. These highest concentrations were located in the center of the 100 by 250 foot grid. The soil boring, located in the center of the grid, indicated a presence of arsenic greater than 250 ppm at a depth of four feet.

5.1.1.1 Mobilization/Site Preparation

Prior to mobilization to the site, certain steps were taken to ensure worker health and safety and to ensure efficient removal procedures. These steps included the development of a site safety and health plan (SSHP) and a site sampling and analysis plan (SAP).

The SSHP was developed in accordance with 29 CFR 1910.120(b)(4) and previous SSHPs prepared for work at Fort Devens. The SSHP established safety guidelines for the work operations, and included key personnel, medical surveillance, training, site control, hazardous waste operations, equipment operations, personal protection, construction safety, and an Emergency Response Plan

The SAP detailed field sampling protocols and laboratory procedures for the confirmation sampling. The intent of the SAP was to ensure the removal of soil containing arsenic concentrations above the clean up goal of 250 ppm.

A decontamination pad was constructed at the site for the cleaning of vehicles transporting soil from the area. This pad was constructed with sand and stone, and was lined with plastic.

Health and safety equipment such as fire extinguishers, first aid kits, eye wash station, and mobile communications were available on-site during removal activities.

5.1.1.2 Soil Excavation and Disposal

The soil located in the isolated area was excavated with a tracked excavator. Soil was loaded directly into dump trucks for transportation to landfill at A7. The excavation took place within the established work area. The soil was placed at this location as subgrade fill for the landfill cap.

5.1.1.3 Confirmation Soil Sampling

The limits of excavation were 100 feet by 250 feet by 4 feet in depth. Soil samples were collected at every 25 feet along the sidewalls and along an established grid on the floor. Side wall samples consisted of the composite of two grab samples collected from depths of approximately 2 and 4 feet below ground surface. Floor samples consisted of the composite of four corner samples and one center sample from each floor quadrant. A total of 25 sidewall and 8 floor samples were collected. See Figure 5-1 for locations of samples.

An additional grab sample (P28E1BF01) was collected from the center of the excavation and analyzed for arsenic. A former soil sample (JO-P28-B10) collected by others at this location previously exhibited the highest levels of arsenic. Arsenic in additional soil sample P28E1BF01 was detected at a level of 111 mg/kg, which is below the clean-up level of 250 mg/kg

Soil samples were shipped to a CENED validated off-site laboratory for analysis of arsenic. Levels of arsenic in all samples were below the risk based clean-up level of 250 mg/kg.

5.1.1.4 Demobilization

Upon completion of the excavation, all equipment was decontaminated and removed from the site. The decontamination soil residue was removed and placed at the disposal location at the SA A7 landfill. The excavated area was backfilled to original grade with soil from the on-site borrow source located at P22.. The section of roadway removed was also backfilled and compacted.

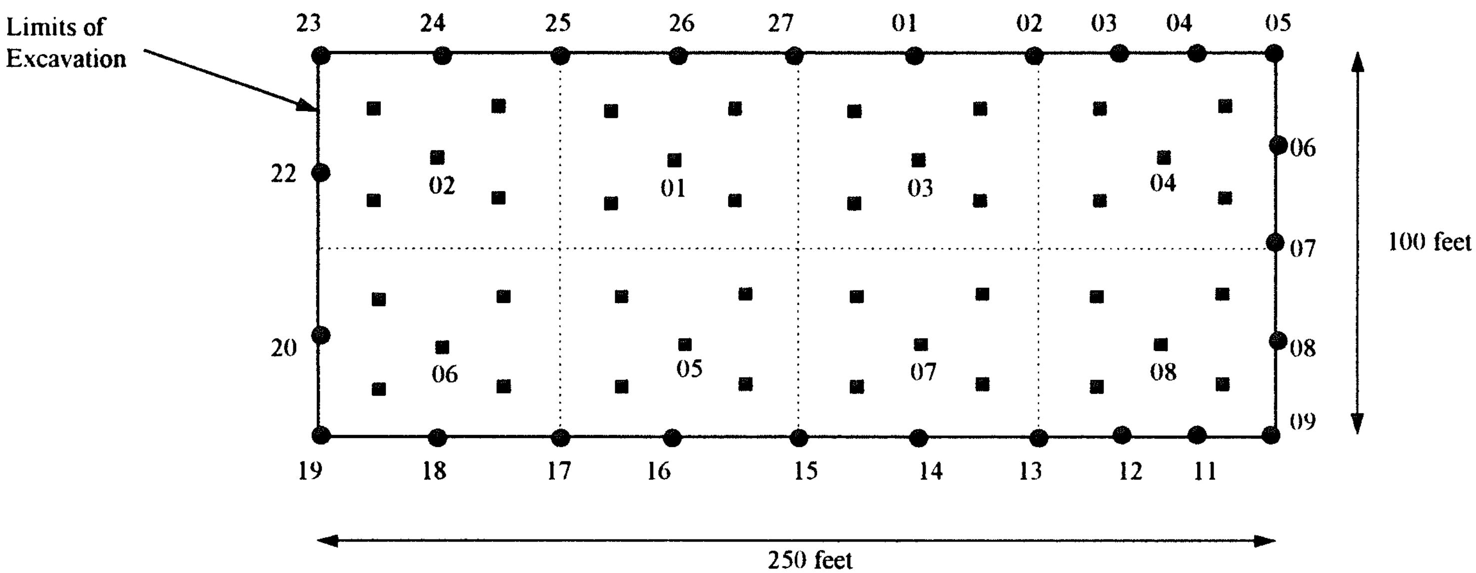
5.1.1.5 Project Schedule

The removal action at the isolated section of SA P28 took place from August 5th through August 10th. Site restoration work, backfilling and compaction, were completed during the first weeks of October, 1996.

5.1.2 Contribution to Remedial Performance

The removal of the contaminated soils from SA P28 significantly reduces or eliminates potential of future risks to human health. The removal action contributes to the reduction of overall site risks. Soil removed from the area was designated as material posing health risks.

Diagram of Confirmatory Sample Locations within the P28 Excavation



Notes:

- Perimeter wall samples 1-27 are designated with ● ; and are prefixed with "P28E1AW"
- Grab floor samples are designated with ■ ; and are prefixed with "P28E1AF", composite samples are from 5 grab samples from each grid separated by dashed lines.

Figure 5-1

5.1.3 Description of Alternative Technologies

Because of the health risks associated with the contaminated soil at the site, it was determined to remove the soil from the location.

At the time of the proposed removal action, additional work was being performed at the Sudbury Training Annex. This work included the construction of a RCRA-Subtitle C landfill cap at the A7 Landfill. The construction of the cap required placement of fill in order to achieve the design elevations and grades for the subgrade. As a sandy-gravely material, the contaminated soil from SA P28 met the requirements for subgrade fill material. Since it was possible to fill the needs of the landfill cap construction and complete the removal of contaminated soil from SA P28, a determination was made to remove the soil from P28 and place it in the landfill.

Other remedial alternatives considered were off-site disposal and on-site treatment. However, because costs for both of these options were not economical, further evaluation for off-site disposal or on-site treatment were not considered for this removal action.

5.1.4 Engineering Evaluation/Cost Analysis

Because the removal or treatment of contaminated soil was necessary at the P28 site, a cost would be incurred. The options included removal of the soil or treatment at the site. The cost for on-site treatment included mobilization of equipment and treatment materials and the cost of treatment performance. The costs for disposal included the transportation of materials to a regulated landfill or treatment facility as well as a facility handling/disposal fee.

The chosen option was to remove the soil and the place it at the site landfill at Study Area A7. This option eliminated the need for off-site transportation and disposal fees associated with landfills and treatment facilities. Therefore, the removal of the soil from P16, and the placing of it at the A7 landfill, was a cost effective approach for the removal action. /28

5.1.5 Applicable or Relevant and Appropriate Requirements

Applicable or Relevant and Appropriate Requirements (ARARS) are federal and state public health and environmental requirements used to evaluate the appropriate extent of site cleanup, plan removal action alternatives, and govern the implementation of a selected removal action.

The scope of the removal action is unrelated to groundwater or surface water and therefore there were no ARARs developed for these media. ARARs for soil were not specifically addressed but can be related to the SLSTEs developed in the Imminent Hazard Evaluation. The SLSTEs for P28 were developed using risk assessment methods described in the MADEP's Risk Characterization Guidance and the EPA's Risk Assessment Guidance for Superfund. The lowest SLSTE, 250 ppm, became the clean up level for the soil removal action.

5.2 <u>Estimated Project Cost</u>

The removal action at SA P28 was estimated and performed for approximately $50,400.

SECTION 6

EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN

If the removal action had been delayed or not performed, the human health risk associated with the area would not have been reduced or eliminated. Based upon expected site usage, the risk to human health would have remained continuous until the time of the contaminated soil removal.

SECTION 7
OUTSTANDING POLICY ISSUES

No outstanding policy issues relative to this Action Memorandum were identified.

SECTION 8
ENFORCEMENT

The lead agency for the removal action was the Army Corps of Engineers - New England Division (CENED). All oversight was performed by CENED, in coordination with the EPA and MADEP. However, specific enforcement measures were not applicable to this site.

SECTION 9
RECOMMENDATION

This document is a written account of the removal action conducted at SA P28 and a summary of selected site investigations. Based upon the Imminent Hazard Evaluation, it was recommended to remove the soil identified as posing a risk to human health.

Confirmation sample results identified no area within the removal action location as containing arsenic above the clean up goal. Therefore, the isolated soil that posed a human health risk was successfully removed. A facility wide arsenic investigation is being conducted to address potential human health and ecological risks from arsenic contamination in surface soils along former transportation corridors and the Patrol Road fenceline.

SECTION 10
REFERENCES

ABB Environmental Services, Inc., 1996. Imminent Hazard Evaluation, Fort Devens Sudbury Training Annex Study Area P28. ABB Environmental Services, Inc. 110 Free Street, Portland, Maine.

ABB Environmental Services, Inc., 1996. Supplemental Site Investigation Data Package, Study Area P28 - Railroad Classification Yard. Fort Devens Sudbury Training Annex, Middlesex County, MA. ABB Environmental Services, Inc., Wakefield, MA.

Stone & Webster Environmental Technology & Services, 1995. Final Action Memorandum, Study Areas A1, A2, P2, and P39, Fort Devens Sudbury Training Annex. Stone & Webster, Boston, MA.

APPENDIX A

IMMINENT HAZARD EVALUATION

TDE

ASEA BROWN BOVERI

8720-01
April 3, 1996

U.S. Army Environmental Center
Attn: SFIM-AEC-IRB/Mr. Ted Ruff
Building E-4480
Aberdeen Proving Ground, MD 21010-5401

Subject: **Contract No. DACA31-94-D-0061**
Fort Devens Sudbury Training Annex
Transmittal of Imminent Hazard Evaluation for Arsenic

Dear Mr. Ruff:

The Imminent Hazard Evaluation for arsenic at the Fort Devens Sudbury Training Annex is enclosed for your review and comment. The evaluation focuses on Study Area (SA) P28 on the South Annex, the SA nearest residences and documented to have concentrations of arsenic in soil significantly in excess of the soil screening level and background concentration.

Please call at your convenience if you have questions about the enclosed Imminent Hazard Evaluation.

Sincerely,

ABB ENVIRONMENTAL SERVICES, INC.

Thomas R. Eschner

Thomas R. Eschner, R.G.
Project Manager/Principal Hydrogeologist

cc: T. Strunk/Sudbury BEC
J. Cuccaro (w/o enclosure)
D. Pierce
File No. 2.55

H:\AEC\TR049601.ltr 8720-01

(Include in P28 AM)
Due 60 days After P28

DEPARTMENT OF THE ARMY
DEVENS RESERVE FORCES TRAINING AREA
DEVENS, MASSACHUSETTS
01433

REPLY TO
ATTENTION OF

AFRC-FMD-CF (200-1)

17 April 1995

MEMORANDUM FOR RECORD

SUBJECT: Imminent Hazard Evaluation at Sudbury Training Annex.

1. Reference Imminent Hazard Evaluation for Arsenic report, April 1996. Prepared by ABB Environmental Services, Inc. (ABB-ES) for U.S. Army Environmental Center.

2. After review of the November 1995 SSI Data Package for the Sudbury Annex, Massachusetts Department of Environmental Protection (MDEP) requested that an Imminent Hazard Evaluation be conducted for a localized part of Study Area P28, the former railroad classification yard in the southern portion of the Sudbury Annex.

3. The site contains an area of exposed sandy soil some 3000 feet long and 100 feet wide and is known to be frequented by dirt-bikers, walkers and joggers. In one 100 by 200 foot hot spot soil samples have revealed an average arsenic level of 2,358 ppm. Arsenic levels over the rest of Area P28 average 169 ppm.

4. Results of the evaluation indicate that the hot spot area at P28 poses an imminent hazard to human health based upon the dirt-biker exposure scenario. The rest of Area P28 does not pose an imminent hazard.

5. On 15 April 1966 ABB-ES placed a fence around the hot spot to limit exposure.

6. A removal action strategy is now under consideration by the Sudbury Annex BRAC Cleanup Team.

7. POC is the undersigned at (508) 796-3839.

Thomas Strunk
BRAC Environmental Coordinator
Sudbury Training Annex

CF:

MAJ Hevenor, BTC

IMMINENT HAZARD EVALUATION

IMMINENT HAZARD EVALUATION

A risk evaluation was conducted to determine whether concentrations of arsenic in soils at the Fort Devens Sudbury Training Annex pose an imminent threat to human health under current land use conditions. Although specific conditions (per the Massachusetts Contingency Plan [MCP]) that require 2-hour notification of a release that could pose and imminent hazard do not exist, the location and nature of arsenic in surface soils, and the presence of human receptors who could be exposed to the arsenic in soil under current and foreseeable conditions, suggest that imminent threats to human health might exist in areas of Sudbury Annex. This evaluation determined that an imminent threat to a dirt-biker does exist for a hot spot area at SA P28. The area surrounding the hot spot does not pose an imminent threat.

Imminent threat, as evaluated in this assessment, is a hazard which may pose a significant risk to human health over a short duration of exposure. In this assessment "significant risk" is considered an excess lifetime cancer risk (ELCR) above 1 in one-hundred thousand or a hazard index (HI) above 1, and "short duration" is considered exposures over a five-year duration. Based on available information regarding current land uses as Sudbury Annex, it is believed that school-aged children and adults may use portions of the Annex for recreational activities. Children (aged 10 - 15 years) are thought to use portions of the Annex for dirt-biking, and adults are thought to use portions of the Annex for walking and jogging. Therefore, short-term exposures to these two receptor groups were evaluated. The determination of whether imminent hazards may exist was made by comparing analytical arsenic data for soils sampled at Sudbury Annex to site-specific Screening Levels for Short-Term Exposures (SLSTE) developed for these two receptor groups. Exposure areas with arsenic exposure concentrations above the SLSTE trigger a concern for an imminent threat. Exposure areas were identified as areas where dirt-biking and/or walking and jogging are likely to occur. Hot spots, defined as discrete areas with average concentrations at least ten-times greater than the average concentration in surrounding areas, were evaluated as separate exposure areas. The average arsenic concentration within an exposure area was used as the exposure concentration to which the SLSTE was compared.

The SLSTEs are soil arsenic concentrations which correspond to a fixed level of "significant" risk for various human receptor short-term exposures. The SLSTEs used in this evaluation were developed for cancer and non-cancer endpoints, based on an ELCR of $1x10^{-5}$ and a non-cancer HI of 1, respectively. They were developed for short-term exposures to children dirt-biking and adults walking/jogging, based on the exposure routes which are thought to significantly contribute to arsenic exposures. For the older child dirt-biker (ages 10-15), incidental ingestion, dermal contact, and fugitive dust inhalation exposure routes were identified as those which may significantly contribute to surface soil exposures during dirt-biking. SLSTEs were developed for a five-year exposure duration and a one-year subchronic exposure duration. The one-year exposure was evaluated to provide an SLSTE that is protective for non-cancer effects to the maximally exposed child (ages 10-11) within the 10-15 year age group. For the adult walker/jogger (ages >18), dermal contact and fugitive dust inhalation exposure routes were identified as those which may significantly contribute to surface soil exposures during walking or jogging. SLSTEs were developed for a five-year exposure duration. For each receptor exposure scenario, SLSTEs were developed for cancer and non-cancer effects. The lowest SLSTE among the various exposure scenarios, for cancer and non-cancer endpoints, was selected as the final SLSTE. The final SLSTE was compared to analytical soil data for arsenic to determine whether an imminent threat may be present.

The results of the imminent hazard evaluation follow. The technical approach used to derive the SLSTEs, including details of the exposure scenarios upon which the SLSTEs are based, is presented in Attachment A. As indicated in Attachment A, Table A-1, SLSTEs for the three exposure scenarios, for cancer and non-cancer endpoints, ranged from 250 mg/kg (older child dirt-biker (5-year exposure); carcinogenic effects) to 50,000 mg/kg (adult walker/jogger; non-cancer effects). The lowest SLSTE (250 mg/kg) was chosen as the final SLSTE for comparison to the analytical arsenic data.

RESULTS

Imminent hazards were identified by comparing analytical arsenic data for soils to the SLSTE. As described above, the SLSTE is a soil arsenic concentration above which "significant risks" may be posed to receptors from short-term exposures to soils during activities which are likely to occur under current land-use conditions. SLSTEs were developed for an older child dirt-biker and an adult walker/jogger. The lowest SLSTE, for the older child dirt-biker, was compared to the analytical arsenic data. The results of this comparison are presented below.

Key to determining whether an imminent hazard may exist is identifying areas where 1) arsenic has been detected in surface soils at concentrations near the SLSTE, and 2) dirt-biking is known to occur. Based on a review of available arsenic data for surface soils, and an identification of areas at Sudbury Annex where dirt-biking is known to occur, Study Area (SA) P28 was identified as a candidate for an imminent hazard evaluation. Study Area P28, a former railroad classification yard, is located adjacent to the Capehart housing complex in an area sometimes referred to as "The Desert" by local residents. The SA contains an area of exposed sandy soil approximately 3600 feet long and 100 feet wide where dirt-biking has been observed. Arsenic has been detected at elevated concentrations in this area, although the sample location closest to the housing area is more than 600 feet from the residence nearest to SA P28. Although arsenic was detected in surface soils at other areas of Sudbury Annex at concentrations near the SLSTE, dirt-biking is not known to occur at these areas (e.g., exposure conditions such as thick brush and forest prevent dirt-biking). The lowest SLSTE for the adult walker/jogger of 3,846 mg/kg, based on the cancer endpoint (Table A-1), is well above the highest arsenic concentrations detected at these areas. Based on the available arsenic data and exposure information for surface soils, only SA P28 appears potentially to pose an imminent hazard.

A total of 58 surface soil samples were collected in the open area at SA P28. A summary of the arsenic data (both on-site and off-site laboratory analyses) for these samples is presented in Table 1. As indicated in Table 1, the range of detected concentrations in these samples ranged from 27 mg/kg to 5,200 mg/kg, with an average concentration of 358 mg/kg. However, a review of the analytical data indicated that a discrete area of elevated arsenic concentrations is present at the southern end of the area sampled. A hot spot analysis concluded that this area represented a hot spot. Arsenic concentrations detected in five samples located adjacent to each other in this area (JO-P28-S14 through JO-P28-S17 and JO-P28-B10) range from 890 mg/kg to 5,200 mg/kg, with an average concentration of 2,358 mg/kg. Arsenic concentrations in the 53 remaining samples collected at SA P28 range from 27 mg/kg to 480 mg/kg, with an average concentration of 169 mg/kg. Since the average concentration in these five samples is more than ten-times the average concentration in the surrounding samples, a hot spot is present.

Comparison of the average concentration for the non hot-spot samples (169 mg/kg) to the SLSTE (250 mg/kg) demonstrates that the SLSTE is not exceeded, indicating that an imminent hazard is not posed by arsenic concentrations in the non-hot spot area of SA P28. However, because the average arsenic concentrations in the hot spot area (2,358 mg/kg) exceed the SLSTE (250 mg/kg), it is concluded that the hot spot area poses an imminent threat to older children using SA P28 for dirt-biking.

In conclusion, the hot spot area at SA P28 poses an imminent hazard to human health, based on the dirt-biker exposure scenario. The remainder of SA P28 does not pose an imminent hazard.

ATTACHMENT A

TECHNICAL APPROACH FOR DEVELOPING SLSTEs

As discussed previously, SLSTEs were derived for two receptors and three receptor exposure scenarios that may occur under current land use conditions: older child dirt-biker (one-year exposure), older child dirt-biker (five-year exposure), and adult walker/jogger (five-year exposure). The technical approach used to develop the SLSTEs is described below. In summary, SLSTEs were developed by calculating cancer and non-cancer risk estimates for each of the three exposure scenarios (based on an arbitrary arsenic concentration), and using those risk estimates to calculate soil arsenic concentrations which correspond to an ELCR of $1x10^{-5}$ and a non-cancer HI of 1. The lowest calculated soil concentration among the three exposure scenarios, for cancer and non-cancer endpoints, was chosen as the final SLSTE upon which the imminent threats were evaluated. Table A-1 provides documentation for the derivation of SLSTEs.

The risk estimates and SLSTEs were developed using standard risk assessment methods, as described in MADEP's Risk Characterization Guidance (MADEP, 1995), and USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989).

Exposure Assessment

Based on available information, there is seasonally a complete exposure pathway for children and adults who are involved in recreational activities (i.e., dirt-biking and walking/jogging, respectively) at the Annex.

Children aged 10 to 15 years (and 10-11 years for a worst-case exposure scenario) are assumed to be exposed to surface soils via incidental ingestion, dermal contact, and inhalation of fugitive dusts while dirt-biking at the Sudbury Annex. Dirt-biking is assumed to occur 48 days per year for a 5 year period (1 year for subchronic exposures). Exposure time is estimated to be 2 hours per dirt-biking event. Forty-eight days per year represents roughly two days of exposure per week for a twenty-four week exposure period (roughly May through October) each year. Rainy weather and other childhood activities would make seven day per week exposures extremely unlikely. Incidental soil ingestion rates were assumed to be 50 mg per event (MADEP, 1995). Age-adjusted dermal exposures were calculated assuming that hands, arms, and legs are exposed to soil. The exposure parameters for these exposure routes are summarized in Table A-2. From these exposure parameters, normalized average soil ingestion and contact rates were calculated as specified by MADEP (1995) (Table A-2). These values were used in the risk calculations for 5-year (Table A-3) and 1-year (Table A-5) exposures.

Fugitive dust inhalation exposures were estimated using a fugitive dust emission model for dirt-biking. The model is based on an emission factor equation for truck traffic on unpaved roads given in USEPA's Superfund Exposure Assessment Manual (1988). Although this model is intended to be used for four-wheeled vehicles weighing over three tons, it was used in this evaluation for lack of a better model or measured data. The model was used to calculate respirable dust concentrations (PM10) [concentration of particulates $< 10\ \mu m$ in diameter]. The PM10 was then used to estimate arsenic dust exposures in the risk calculation spreadsheet. The equations used to calculate PM10, and documentation of input parameters to the model, are presented in Table A-4a. When available, site-specific data obtained at SA P28 were used for the emission model. Parameters based on site-specific data include soil silt fraction (based on the average sieve analysis results for two SA P28 surface soil samples), and dirt-bike track size, which was assumed to represent twice the length of a cleared road-like area at SA P28 (thereby representing a track "loop") where the majority of SA P28 soil arsenic samples were collected. Dirt-biker exposure parameters and exposure dose estimates are presented in Tables A-4 and A-6 for 5-year and 1-year exposures, respectively.

Nearby adult (ages > 18 years) residents are assumed to be exposed to surface soils while walking or jogging at the Annex. These activities are assumed to occur 90 days per year. Ninety days per year represents occurrences at the facility roughly every other day for a twenty-four week period (roughly May through October) each year. To evaluate potential hazards posed by a short-term exposure, it is assumed that the nearby resident uses the facility for 5 years. Surface soil exposures are assumed to occur through dermal contact with soil and inhalation of fugitive dusts. Dermal contact rates for the walker/jogger were obtained from the literature (Kissel et al., 1996), and are based on geometric mean dermal soil loadings measured in juvenile male soccer players (aged 13 - 15) following a 40 minute practice session on a dirt and grass field. These loading values were multiplied by appropriate skin surface areas for head, hands, arms, and legs to obtain dermal exposure estimates (Table A-7). Use of dermal soil loading values for soccer players provides a conservative approach because the values are based on high-activity contact, assuming that receptors always wear shorts and short-sleeved shirts. Fugitive dust emissions were assumed to occur from wind erosion of soils and agitation of soils during walking or jogging, and were estimated using a default PM10 value published by MADEP (MADEP, 1995). Exposure parameters and normalized average soil contact rates are presented in Table A-7, and were used to calculate risks (Tables A-8 and A-9).

Toxicity Assessment

Incidental ingestion and dermal risk estimates were calculated using the oral cancer slope factor (CSF) of 1.5 $(mg/kg/day)^{-1}$ (Integrated Risk Information System [IRIS], USEPA 1996), and subchronic and chronic oral reference doses (RfDs) of $3x10^{-4}$ mg/kg/day each (USEPA, 1996). Dermal exposure estimates were modified by the dermal relative absorption factor of 3% (MADEP, 1992). Inhalation risk estimates were calculated using the inhalation CSF of 50 $(mg/kg/day)^{-1}$ (USEPA, 1996); no inhalation RfDs are available for non-cancer effects. The dose-response values are presented in the risk calculation spreadsheets in Attachment A.

Risk Characterization

Cancer and non-cancer risks were quantified for each exposure route, for each receptor exposure scenario, based on an arbitrary arsenic concentration of 1 mg/kg. Risk estimate calculations are documented in the risk calculation spreadsheets, and are summarized in Table A-1. Because an inhalation RfD for arsenic was unavailable, non-cancer risks were not calculated for this exposure route. For each exposure scenario, cancer and non-cancer risk estimates for each exposure route were summed to provide total cancer and non-cancer risk estimates (Table A-1). The total cancer and non-cancer risk estimates were used for calculating SLSTEs, as described below.

Calculation of SLSTEs

SLSTEs were developed for cancer and non-cancer endpoints, for each of the three exposure scenarios evaluated. SLSTEs were derived by calculating a soil arsenic concentration corresponding to an ELCR of $1x10^{-5}$ or a HI equal to one, using the total receptor risk estimates that were calculated for the arbitrary arsenic concentration, as summarized in the simple ratio below:

$$\frac{\textit{Total Recptor Risk}}{\textit{Arbitrary Arsenic Soil Concentration}} = \frac{\textit{Target Risk}}{\textit{SLSTE}}$$

where: Total risk is the ELCR or HI calculated for a given receptor at the arbitrary arsenic concentration (i.e, 1 mg/kg), and
Target Risk is ELCR $= 1x10^{-5}$ *or HI* $= 1$

Table A-1 presents the total receptor risk estimates and SLSTEs for each exposure scenario evaluated. From these SLSTEs, the lowest SLSTE was selected as the final SLSTE. The final SLSTE was compared to the analytical soil arsenic data in the imminent hazard evaluation.

Table A-1
Calculation and Presentation of Screening Levels for Short-Term Exposures

Sudbury Annex
Sudbury, Massachusetts

RECEPTOR	RISKS AT ARBITRARY SOIL CONCENTRATION [1]			CALCULATION OF SLSTEs	
Exposure Scenario	Exposure Route	ELCR at 1 mg/kg	HQ at 1 mg/kg	Arsenic Concentration at ELCR = $1x10^{-6}$ (mg/kg)[8]	Arsenic Concentration at HI = 1 (mg/kg)[9]
Older Child Dirt-Biker: 5 year exposure	Ingestion [2]	2E-08	0.0005	250	1,111
	Dermal [2]	1E-08	0.0004		
	Inhalation [3]	1E-08	ND		
	Total:	4E-08	0.0009		
Older Child Dirt-Biker: 1 year exposure	Ingestion [4]	8E-09	0.001	679	435
	Dermal [4]	5E-09	0.001		
	Inhalation [5]	1E-09	ND		
	Total:	1E-08	0.002		
Adult Walker/Jogger: 5 year exposure	Dermal [6]	6E-10	0.00002	3,846	50,000
	Inhalation [7]	2E-09	ND		
	Total:	3E-09	0.00002		
FINAL SLSTE [10]:	250 mg/kg				

Notes:
SLSTE = Screening Level for Short-Term Exposures
ND = No Data; No dose-response values were available and, therefore, risk estimates could not be calculated.
NA = Not Applicable
[1] Risk estimates were calculated for an artibrary soil arsenic concentration of 1 mg/kg; these risk estimates were used only to establish as baseline for the calculation of SLSTEs
[2] Risk calculations presented in Table A-3
[3] Risk calculations presented in Table A-4
[4] Risk calculations presented in Table A-5
[5] Risk calculations presented in Table A-6
[6] Risk calculations presented in Table A-8
[6] Risk calculations presented in Table A-9
[7] Calculated using the following equality: (risk at 1 mg/kg) / (Total ELCR at 1 mg/kg) = (SLSTE) / (Target ELCR [$1x10^{-5}$])
[8] Calculated using the following equality: (risk at 1 mg/kg) / (HI at 1 mg/kg) = (SLSTE) / (Target HI [1])
[9] The Final SLSTE is the lowest SLSTE among the three exposure scenarios, for cancer and non-cancer effecets.

Table A-2
Exposure Parameters for Older Child Dirt-Biker and Calculation of Normalized Soil Ingestion and Contact Rates

Sudbury Annex
Sudbury, Massachusetts

Age Group	Soil Ingestion Rate [1] (mg/day)	Exposure Frequency [2] (days)	Average Daily Soil Ingestion Rate [3] (mg/day)	Surface Area of Exposed Body Parts [1,4] (cm^2)	Median Body Weight [1] (kg)	Daily Soil Ingestion Rate for the Time Period (mg*yr/kg*day) [5]	Daily Soil Dermal Contact Rate for the Time Period (mg*yr/kg*day) [1,6]
10<11	50	48	6.6	2,683	34.3	0.192	4.2
11<12	50	48	6.6	2,981	40	0.164	4.0
12<13	50	48	6.6	3,423	45.2	0.145	4.1
13<14	50	48	6.6	3,544	48.6	0.135	3.9
14<15	50	48	6.6	3,712	52.8	0.125	3.8
			Normalized Average Daily Soil Ingestion Rate (NADSIR) [7]:			0.152	–
			Normalized Lifetime Average Daily Soil Ingestion Rate (NLADSIR) [8]:			0.010	–
			Normalized Average Daily Soil Contact Rate (NADSCR) [7]:			–	4.0
			Normalized Lifetime Average Daily Soil Contact Rate (NLADSCR) [8]:			–	0.27

Notes:
[1] MADEP Risk Characterization Guidance. Interim Final Policy WSC/ORS-95-141. July, 1995.
[2] 2 days per week for 24 weeks (May through October).
[3] Calculated as follows: (Soil Ingestion rate x Exposure frequency) / Exposure duration [365 days]
[4] Total body surface area of body parts which are exposed (hands, forearms, lower legs)
[5] Calculated as follows: Average daily soil ingestion rate / median body weight
[6] Calculated as follows: {(Body surface area x soil adherence factor [0.51 mg/cm^2] x fraction adhered material derived from soil [0.8] x exposure frequency) / exposure duration [365 days]} / median body weight
[7] Calculated by summing rates for the time period and dividing by the number of years in the time period.
[8] Calculated by summing rates for the time period and dividing by 75 years.

TABLE A-3
DIRECT CONTACT AND INCIDENTAL INGESTION OF SOIL - ARSENIC
RECEPTOR: CHILD DIRT-BIKER AGES 10 THRU 15
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

TABLEA3	02-Apr-96

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS		mg/kg	
NORM. SOIL INGESTION	NADSIR	0.152	mg(soil)/kg/day	
NORM. SOIL DERMAL CONTACT	NADSCR	4.0	mg(soil)/kg/day	
NORM. LIFETIME SOIL INGESTION	NLADSIR	0.010	mg(soil)/kg/day	
NORM. LIFETIME SOIL DERMAL CONTACT	NLADSCR	0.270	mg(soil)/kg/day	
CONVERSION FACTOR	C	0.000001	kg/mg	

EXPOSURE PARAMETERS AND DOCUMENTATION OF NORMALIZED INGESTION AND DERMAL CONTACT VALUES ARE PRESENTED IN TABLE A-2

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

CANCER	INTAKE ingestion =	OHMsoil x NLADSIR x RAF x C
	INTAKE dermal =	OHMsoil x NLADSCR x RAF x C
NONCANCER	INTAKE ingestion =	OHMsoil x NADSIR x RAF x C
	INTAKE dermal =	OHMsoil x NADSCR x RAF x C

TABLE A-4
POTENTIAL EXPOSURE TO DUST INHALATION - ARSENIC
RECEPTOR: CHILD DIRT-BIKER AGES 10 THRU 15
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

TABLEA4	02-Apr-96

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
RESP. PARTICULATES CONC.air	[RP]air		mg/m^3	Calculated
AIR-BORNE CONCENTRATION	PM10	3.05E-07	kg/m^3	Modeled (1)
PROPORTION OF DUST FROM SITE	P	1	unitless	Assumption (2)
INHALATION RATE	VR	2	m^3/hour	USEPA 1989 (3)
BODY WEIGHT	BW	44	kg	MADEP, 1995 (4)
DURATION OF EACH EXPOSURE	D1	2	hours/event	Assumption
EXPOSURE FREQUENCY	F	48	events/year	Assumption (5)
DURATION OF EXPOSURE PERIOD	D2	5	years	Assumption (6)
AVERAGING PERIOD				
CANCER	AP	75	years	MADEP, 1995
NONCANCER	AP	5	years	Assumption (6)

MADEP, 1995. Risk Characterization Guidance (July, 1995)
(1) PM10 calculated in Table A-4a
(2) Only exposure to particulates during dirt-biking occurs at site.
(3) Exposure Factors Handbook; EPA 600/8-89/043 (May, 1989). Value is the average moderate-activity inhalation rate for ages 10-15 years.
(4) Average of median body weights for children aged 10 thru 15 years.
(5) Two events per week for 24 weeks (May - October) = 48 events per year
(6) Exposure period for children aged 10 thru 15 years.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

$$\text{INTAKE} = \frac{[RP]air \times P \times VR \times D1 \times F \times D2}{BW \times AP \times 365\ \text{days/year}}$$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{[RP]air \times P \times VR \times D1 \times F \times D2}{BW \times AP \times 5\ \text{days/workweek}}$$

Note:
[RP]air = Soil Concentration x PM10
For noncarcinogenic effects: AP = ED

Table A-5, cont.

HAZARD INDEX CALCULATIONS
SUBCHRONIC EXPOSURE SCENARIO
MAY THROUGH OCTOBER

CHILD 10-11 YEARS OF AGE, 2 DAYS PER WEEK

ANALYTE	SOIL CONCENTRATION	AVERAGE SOIL INGESTION RATE	UNITS CONVERSION FACTOR	INGESTION RAF	INGESTED CHEMICAL DOSE	AVERAGE SOIL CONTACT RATE	DERMAL RAF	UNITS CONVERSION FACTOR	DERMAL CHEMICAL DOSE	TOTAL CHEMICAL DOSE	SUBCHRONIC RfD	HAZARD QUOTIENT
	MG/KG	MG/KG/DAY	KG/MG		MG/KG-DAY	MG/KG/DAY		KG/MG	MG/KG-DAY	MG/KG-DAY	MG/KG-DAY	
ARSENIC	1	0.416	0.000001	1	4.16E-07	9.1	0.03	0.000001	2.74E-07	6.90E-07	3.00E-04	0.002
										TOTAL HAZARD INDEX =		0.002

Table A-5, cont.

CANCER RISK CALCULATIONS
SUBCHRONIC EXPOSURE SCENARIO
MAY THROUGH OCTOBER

CHILD 10-11 YEARS OF AGE, 2 DAYS PER WEEK

ANALYTE	SOIL CONCENTRATION	AVERAGE SOIL INGESTION RATE	UNITS CONVERSION FACTOR	INGESTION RAF	INGESTED CHEMICAL DOSE	AVERAGE SOIL CONTACT RATE	DERMAL RAF	UNITS CONVERSION FACTOR	DERMAL CHEMICAL DOSE	TOTAL CHEMICAL DOSE	CANCER SLOPE FACTOR	CANCER RISK
	MG/KG	MG/KG/DAY	KG/MG		MG/KG-DAY	MG/KG/DAY		KG/MG	MG/KG-DAY	MG/KG-DAY	$(MG/KG-DAY)^{-1}$	
ARSENIC	1	0.0056	0.000001	1	5.55E-09	0.122	0.03	0.000001	3.65E-09	9.20E-09	1.50E+00	1E-08
										TOTAL CANCER RISK:		1E-08

TABLE A-6
POTENTIAL SUBCHRONIC EXPOSURE TO DUST INHALATION – ARSENIC
RECEPTOR: CHILD DIRT-BIKER AGES 10 THRU 11
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

TABLEA6	02-Apr-96

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
RESP. PARTICULATES CONC.air	[RP]air		mg/m³	Calculated
AIR-BORNE CONCENTRATION	PM10	3.05E-07	kg/m³	Modeled (1)
PROPORTION OF DUST FROM SITE	P	1	unitless	Assumption (2)
INHALATION RATE	VR	2	m³/hour	USEPA 1989 (3)
BODY WEIGHT	BW	44	kg	MADEP, 1995 (4)
DURATION OF EACH EXPOSURE	D1	2	hours/event	Assumption
EXPOSURE FREQUENCY	F	48	events/year	Assumption (5)
DURATION OF EXPOSURE PERIOD	D2	0.46	years	Assumption (6)
AVERAGING PERIOD				
CANCER	AP	75	years	MADEP, 1995
NONCANCER	AP	0.46	years	Assumption (6)

MADEP, 1995. Risk Characterization Guidance (July, 1995)
(1) PM10 calculated in Table A-4a
(2) Only exposure to particulates during dirt-biking occurs at site.
(3) Exposure Factors Handbook; EPA 600/8-89/043 (May, 1989). Value is the average moderate-activity inhalation rate for ages 10-15 years.
(4) Average of median body weights for children aged 10 thru 15 years.
(5) Two events per week for 24 weeks (May – October) = 48 events per year
(6) Exposure duration = 24 weeks or 0.46 year

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

$$\text{INTAKE} = \frac{[RP]air \times P \times VR \times D1 \times F \times D2}{BW \times AP \times 365 \text{ days/year}}$$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{[RP]air \times P \times VR \times D1 \times F \times D2}{BW \times AP \times 5 \text{ days/workweek}}$$

Note:
[RP]air = Soil Concentration x PM10
For noncarcinogenic effects: AP = ED

TABLE A-6, continued
POTENTIAL SUBCHRONIC EXPOSURE TO DUST INHALATION – ARSENIC
RECEPTOR: CHILD DIRT-BIKER AGES 10 THRU 11
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INTAKE (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK
ARSENIC	1	2.2E-11	5.00E+01	1.1E-09
		SUMMARY CANCER RISK		1E-09

TABLE A–6, continued
POTENTIAL SUBCHRONIC EXPOSURE TO DUST INHALATION – ARSENIC
RECEPTOR: CHILD DIRT–BIKER AGES 10 THRU 11
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INTAKE (mg/kg–day)	REFERENCE DOSE (mg/kg–day)	HAZARD QUOTIENT
ARSENIC	1	3.6E–09	ND	
SUMMARY HAZARD INDEX				0E+00

Table A-7

Exposure Parameters for Adult Lesiure Walker and Calculation of Normalized Soil Contact Rates

Sudbury Annex
Sudbury, Massachusetts

Exposure Frequency [1] (days)	Body Part Exposed	Surface Area of Body Part [2] (cm^2)	Adherence Factor [3] (mg/cm^2)	Soil in Contact with Skin (mg) [4]	Daily Soil Dermal Contact Rate for the Time Period (mg*yr/kg*day) [5]
90	Head	1300	0.012	12.5	1.00
	Hands	990	0.11	87.1	
	Arms	2910	0.011	25.6	
	Legs	6400	0.031	158.7	
	Normalized Average Daily Soil Contact Rate (NADSCR) [7]:				0.200
	Normalized Lifetime Average Daily Soil Contact Rate (NLADSCR) [6]:				0.0133

Notes:

[1] Every other day for 24 weeks (May through October).

[2] MADEP Risk Characterization Guidance. Interim Final Policy WSC/ORS-95-141. July, 1995. Value for males aged > 18 years.

[3] Values measured for juvenille male soccer players following 40 minutes of practice on a field composed of dirt and grass (Kissel et al., Risk Analysis; 16:1, 1996. p. 115-125.

[4] Calculated as follows: (body part surface area x soil adherence factor x fraction adhered material derived from soil [0.8 - MADEP, 1995])

[5] Calculated as follows: (Sum of soil in contact with skin x exposure frequency / exposure duration [365 days]) / median body weight [70 kg]

[6] Calculated by dividing the rate for the time period by the number of years in the time period [5 years].

[7] Calculated by dividing the rate for the time period by 75 years.

TABLEA8	02-Apr-96

TABLE A-8
DIRECT CONTACT WITH SOIL - ARSENIC
RECEPTOR: ADULT RECREATIONAL WALKER/JOGGER
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS		mg/kg	
NORM. SOIL INGESTION	NADSIR	0	mg(soil)/kg/day	
NORM. SOIL DERMAL CONTACT	NADSCR	0.200	mg(soil)/kg/day	
NORM. LIFETIME SOIL INGESTION	NLADSIR	0	mg(soil)/kg/day	
NORM. LIFETIME SOIL DERMAL CONTACT	NLADSCR	0.0133	mg(soil)/kg/day	
CONVERSION FACTOR	C	0.000001	kg/mg	
EXPOSURE PARAMETERS AND DOCUMENTATION OF NORMALIZED INGESTION AND DERMAL CONTACT VALUES ARE PRESENTED IN TABLE A-7				

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

CANCER	INTAKE ingestion =	OHMsoil x NLADSIR x RAF x C
	INTAKE dermal =	OHMsoil x NLADSCR x RAF x C
NONCANCER	INTAKE ingestion =	OHMsoil x NADSIR x RAF x C
	INTAKE dermal =	OHMsoil x NADSCR x RAF x C

TABLE A-9
POTENTIAL EXPOSURE TO DUST INHALATION – ARSENIC
RECEPTOR: ADULT WALKER/JOGGER
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

TABLEA9	02-Apr-96

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
RESP. PARTICULATES CONC.air	[RP]air		mg/m³	Calculated
AIR-BORNE CONCENTRATION	PM10	4.40E-08	kg/m^3	MADEP, 1995 (1)
PROPORTION OF DUST FROM SITE	P	1	unitless	Assumption (2)
INHALATION RATE	VR	2.4	m³/hour	USEPA 1989 (3)
BODY WEIGHT	BW	70	kg	MADEP, 1995
DURATION OF EACH EXPOSURE	D1	2	hours/event	Assumption
EXPOSURE FREQUENCY	F	90	events/year	Assumption (4)
DURATION OF EXPOSURE PERIOD	D2	5	years	Assumption (5)
AVERAGING PERIOD				
CANCER	AP	75	years	MADEP, 1995
NONCANCER	AP	5	years	Assumption (5)

MADEP, 1995. Risk Characterization Guidance (July, 1995)
(1) PM10 from MADEP (1995) for maximum annual mean PM10 level recorded in Massachusetts
(2) Exposure to particulates only occurs during walking or jogging at site.
(3) Exposure Factors Handbook; EPA 600/8-89/043 (May, 1989). Value is the average moderate-activity inhalation rate for adult males.
(4) Every other day for 24 weeks (May – October) = 90 events per year
(5) Exposure period is assumed to be 5 years.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x
CANCER SLOPE FACTOR (mg/kg-day)^-1

$$\text{INTAKE} = \frac{[RP]air \times P \times VR \times D1 \times F \times D2}{BW \times AP \times 365\ \text{days/year}}$$

HAZARD QUOTIENT = INTAKE (mg/kg-day) /
REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{[RP]air \times P \times VR \times D1 \times F \times D2}{BW \times AP \times 5\ \text{days/workweek}}$$

Note:
[RP]air = Soil Concentration x PM10
For noncarcinogenic effects: AP = ED

TABLE A-9, continued
POTENTIAL EXPOSURE TO DUST INHALATION - ARSENIC
RECEPTOR: ADULT WALKER/JOGGER
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INTAKE (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK
ARSENIC	1	5.0E-11	5.00E+01	2E-09
SUMMARY CANCER RISK				2E-09

TABLE A-9, continued
POTENTIAL EXPOSURE TO DUST INHALATION - ARSENIC
RECEPTOR: ADULT WALKER/JOGGER
SUDBURY ANNEX
SUDBURY, MASSACHUSETTS

TABLEA9	02-Apr-96

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INTAKE (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT
ARSENIC	1	7.4E-10	ND	
			SUMMARY HAZARD INDEX	0E+00

REFERENCES

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Table 1
Summary of Arsenic Concentrations in Study Area P28 Surface Soils

Sudbury Annex
Sudbury, Massachusetts

Sample ID (SA P28)	Concentration (mg/kg)	Analysis Type (Field or Lab)
JO-P28-S62	109	F
JO-P28-S65	140	F
JO-P28-S66	220	F
JO-P28-S67	43	L
JO-P28-S64	390	F
JO-P28-S57	160	F
JO-P28-S58	92	F
JO-P28-S59	240	F
JO-P28-S60	460	L
JO-P28-S61	330	F
JO-P28-S44	180	F
JO-P28-S43	210	L
JO-P28-S45	130	F
JO-P28-S47	74	F
JO-P28-S46	98	F
JO-P28-S48	150	F
JO-P28-S49	200	F
JO-P28-S50	82	L
JO-P28-S51	110	F
JO-P28-S52	210	F
JO-P28-S53	230	F
JO-P28-S54	190	F
JO-P28-S55	190	F
JO-P28-S56	30	F
JO-P28-S13	239	L
JO-P28-S10	91.5	L
JO-P28-S12	33.5	L
JO-P28-S11	74	L
JO-P28-S40	390	F
JO-P28-S41	100	F
JO-P28-S42	66	F
JO-P28-S35	480	L
JO-P28-S36	27	L
JO-P28-S37	82	F
JO-P28-S38	72	F
JO-P28-S39	130	F
JO-P28-S32	66	F
JO-P28-S33	62	F
JO-P28-S34	58	F
JO-P28-S27	230	F
JO-P28-S28	160	F
JO-P28-S29	56	F
JO-P28-S30	110	F
JO-P28-S31	170	L
JO-P28-S24	120	F
JO-P28-S25	190	F
JO-P28-S26	270	L
JO-P28-S21	160	F
JO-P28-S22	380	F
JO-P28-S23	270	F
JO-P28-S18	160	F
JO-P28-S19	190	L
JO-P28-S20	240	F
JO-P28-B10	5200	L
JO-P28-S16	3300	L
JO-P28-S14	1400	L
JO-P28-S15	1000	L
JO-P28-S17	890	L

Statistical Summary

Sample Group	Arsenic Concentration (mg/kg)
All Samples: Avg	358
All Samples: Min	27
All Samples: Max	5200
Hot Spot Samples: Avg	2358
Hot Spot Samples: Min	890
Hot Spot Samples: Max	5200
Non-Hot Spot Samples: Avg	169
Non-Hot Spot Samples: Min	27
Non-Hot Spot Samples: Max	480

Note: Hot spot samples include JO-P28-S14 thru JO-P28-S17, JO-P28-B10

TABLEA4A

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TABLE A-4a
FUGITIVE DUST GENERATION ASSOCIATED WITH DIRT BIKING
SUDBURY ANNEX

CALCULATE EMISSION FACTOR USING THE UNPAVED ROAD EQUATION FROM USEPA 1988

THE EQUATION USED TO ESTIMATE FUGITIVE DUST GENERATION AS A RESULT OF DIRT BIKING COMES FROM THE SUPERFUND EXPOSURE ASSESSMENT MANUAL AND IS BASED ON VEHICLES TRAVELING ON UNPAVED ROADS

$$E = k(1.7)\ (s/12)\ (Sp/48)\ (W/2.7)^{0.7}\ (w/4)^{0.5}\ (365-Dp/365)$$

where:

E = emission factor (kg PM10/VKT)
k = particle size multiplier (dimensionless)
s = silt content of road surface material (%)
Sp = mean vehicle speed (km/hr)
W = mean vehicle weight (Mg)
w = mean number of wheels
Dp = number of days per year with precipitation exceeding 0.254 mm

VARIABLE	VALUE	UNITS	SOURCE
k	0.45		for PM10, SEAM, USEPA 1988
s	13.2%		assumption based on sieve size analysis
Sp	64	km/hr	assumed 40 mph
W	0.091	Mg	assumed 180 - 200 lbs
w	2		
Dp	140	days	Figure 2-3, USEPA 1988
E	4.57E-04	kg/VKT	calculated here

TABLEA4A

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TABLE A-4a
FUGITIVE DUST GENERATION ASSOCIATED WITH DIRT BIKING
SUDBURY ANNEX

CALCULATE PM10 CONCENTRATION IN AIR ABOVE BIKE TRAIL

$$Q10 = \frac{E \times D}{V}$$

where:

Q10 = PM10 concentration in air above trail (kg PM10/m3)
E = emission factor (kg PM10/VKT)
D = distance traveled per loop through trail (km)
V = volume of breathing zone above track into which fugitive dusts are mixed (m3)

where:

$$V = L \times W \times H$$

and:

L = length of trail (m)
W = width of trail (m)
H = height of breathing zone above trail (m)

VARIABLE	VALUE	UNITS	SOURCE
E	4.57E-04	kg/VKT	calculated previously
D	2.19	km/loop	SA P28 site map
L	2195	m	SA P28 site map
W	1	m	assume track is 1 m wide
H	1.5	m	assume breathing height is 1.5 m
V	3292	m3	calculated here
Q10	3.05E-07	kg PM10/m3	calculated here

Table A-5
Subchronic Exposure Scenario – Arsenic
Sudbury Annex – Sudbury Massachusetts

SUBCHRONIC SOIL EXPOSURE SCENARIO MAY THRU OCTOBER

AGE YRS	SOIL INGESTION RATE MG/DAY	BODYWEIGHT KG	EXPOSURE FREQUENCY DAY/WEEK	EXPOSURE PERIOD WEEKS	AVERAGING PERIOD DAYS	AVERAGE SOIL DOSE MG/KG-DAY
10-11	50	34.3	2	24	168	0.416

AGE YRS	SOIL ADHERENCE RATE MG/SQ CM	SKIN SURFACE EXPOSED SQ CM/DAY	FRACTION DUST FROM SOIL	BODYWEIGHT KG	EXPOSURE FREQUENCY DAY/WEEK	EXPOSURE PERIOD WEEKS	AVERAGING PERIOD DAYS	AVERAGE SOIL DOSE MG/KG-DAY
10-11	0.51	2683	0.8	34.3	2	24	168	9.1