REMEDIAL INVESTIGATION OF SITE D AT NAVAL SUBMARINE BASE BANGOR, WA

Harry D. Craig
U.S. Environmental Protection Agency, Region 10
Oregon Operations Office
Portland, Oregon

Andy Markos
B&V Waste Science and Technology Corp.
Tacoma, Washington

Hope Lewis
Engineering Field Activity, Northwest
Naval Facilities Engineering Command
Silverdale, Washington

Craig E. Thompson
Washington Department of Ecology
Toxics Cleanup Program
Olympia, Washington

ABSTRACT

This paper describes the Remedial Investigation/Feasibility Study (RI/FS) of Site D at the U.S. Naval Submarine Base (SUBASE) near Bangor, Washington. Site D is a 22 acre former ordnance disposal area used by the U.S. Navy from 1946 to 1965. Due to the heterogeneous nature of ordnance compounds in soil and size of the area to be characterized, a combination of field screening and laboratory methods were used to define the extent of contamination.

SUBASE Bangor was listed on EPA's National Priorities List (NPL) for past waste disposal practices in August 1990. Waste disposal areas at Site D included a small arms incinerator, a burn trench, and smaller burn mounds. Contaminants burned or detonated primarily included ordnance wastes containing TNT (2,4,6-trinitrotoluene) and RDX (hexahydro 1,3,5-trinitro 1,3,5-triazine).

The analytical results indicate contaminant migration away from identified source areas due to surface erosion. Results from field screening and laboratory methods showed similar contamination profiles and allowed for complete characterization of the site. The risk assessment conducted indicates elevated lifetime excess cancer risks and non-carcinogenic risks for current and future land use scenarios.

Further work includes development of final remedial action objectives (RAO) and evaluation of bench scale bioremediation treatability studies for explosives contaminated soils.

INTRODUCTION

SUBASE Bangor consists of 7,000 acres of semi-rural land located on Hood Canal 10 miles north of Bremerton, Washington. Naval activities began at Bangor in 1944, when it was used as a Pacific storage and shipment point for ammunition and explosives during World War II and the Vietnam War. The last shipment to Vietnam was completed in 1973. In 1977, the base was converted to a home port for TRIDENT submarines.

SUBASE Bangor was listed on EPA's National Priorities List (NPL) for past waste disposal practices in August 1990. Under the scope of a Federal Facilities Agreement (FFA) for SUBASE Bangor signed by the U.S. Navy, U.S. Environmental Protection Agency, Region 10 (EPA), and the Washington Department of Ecology (WDOE) in January 1990, the Navy initiated Remedial Investigation/Feasibility Studies (RI/FS) for seven operable units at the facility. Site D was identified as Operable Unit Six (OU-6) under the FFA, and an RI/FS of Site D was conducted by the Naval Facilities Engineering Command, Engineering Field Activity, Northwest from 1991 to 1992[1]. The purpose of the RI/FS was to investigate the nature and extent of contamination at suspected source areas identified by previous studies, and to use analytical data to conduct a baseline risk assessment in accordance with CERCLA/SARA, and the State of Washington Model Toxics Control Act (MTCA).

SITE BACKGROUND

Site D consists of a 22 acre former ordnance disposal area adjacent to Escolar Road (Figure 1). The primary disposal practices consisted of burning and detonating ordnance on site; some material was also buried. Site D served as the principal ordnance disposal area from 1946 to 1963, and was used spo-

radically until 1965. Waste disposal areas included a small arms incinerator, a suspected burn trench, and smaller burn areas or mounds. Based on historical aerial photographs, dimensions of the suspected burn trench were approximately 15 to 20 feet wide and 200 feet long. The depth of the trench, although unknown, was suspected to be less than 10 feet deep because of the presence of shallow groundwater within a perched aquifer. The exact location of the trench was not apparent during site visits, and was located using geophysical techniques. Historical documents and aerial photographs identified the active burn and detonation area with approximate dimensions of 600 by 600 feet.

Previous site investigations included personal interviews indicating that photo flash bombs and ammonium nitrate blocks were detonated on site. Additionally, items burned or detonated may have included smokeless powder, black powder, rocket propellant, white phosphorus (WP) shells, Composition B (TNT and RDX), Amatol (ammonium nitrate and TNT), and ordnance wastes containing TNT and RDX. In conjunction with these activities, a small arms incinerator was in operation prior to 1964. The quantities of wastes disposed of at Site D could not be determined from existing records[2] (See Figure 1),

Due to the heterogeneous nature of ordnance compounds in soil and the size of the area to be investigated, a screening site investigation was initiated using colorimetric methods recently developed for the determination of TNT and RDX in soils.[3,4] Based on the results of the field screening investigation, a limited subset of theses samples (15%) were submitted for full laboratory analysis for ordnance compounds, and used for development of the baseline risk assessment.

PHYSICAL SETTING

The region in the vicinity of SUBASE Bangor is designated as western upland plateau. The surficial geology and topography is characterized by flat topped ridges, ranging in elevation from 300 to 500 feet above mean sea level (MSL) with steep flanks sloping to sea level. The uplands are cut by deep post-glacial ravines that discharge to Hood Canal.

Site D is on the west side of north-trending highlands located between Hood Canal and the Clear Lake drainage. Site D slopes from east to west between the elevations of 200 and 110 feet. The area downslope from Site D is intercepted by Devils Hole Lake, which drains to the northwest into Hood Canal. The site is covered by alder, pine, and fir in scattered stands with moderate to lush grass and assorted underbrush.

The soils of SUBASE Bangor formed primarily in glacial drift deposited by the last glacial advance. The predominant deposit of the last glacial event and the soil parent material for the majority of the soils is glacial till. The remaining soils formed in either the advance or recessional outwash materials of a glaciolacustrine environment.

The surface soil of Site D is composed of weathered sands, silts, and gravels of the Vashon Recessional Outwash. The soil profile on Site D ranges from less than 1 foot to maximum of 3 feet. The vadose zone extends from the ground surface to the top of the perched aquifer. It ranges from 0 to 30 feet thick and consists of a mixture of topsoil and Vashon Recessional Outwash. The upper stratigraphic section of Site D is mantled with clay, peat, and organic silt layer that extends downward from the surface to a depth of approximately 15 feet.

The western portion of Site D is an area that is saturated during the high precipitation months of November through April. This wet area, in the lower elevations within the site, is the result of perched aquifer surfacing. Sediment samples from the seasonally wet area consisted of medium brown, coarse-grained sand with gravels, silt, and organic debris.

FIELD SCREENING - PHASE I

Two surface soil sampling grids were established over Site D to characterize the surface soil contamination associated with identified features. The first grid was 425 feet by 325 feet in the southeastern quadrant of the site. The second grid, 100 by 125 feet, is in the northern area of suspected contamination. Each grid was divided into 25 foot square cells for sampling purposes. Field sampling locations were determined by selecting points on the grid using a random number generator (See Figure 2).

Eighty percent of the 25 by 25 foot cells within the southern grid were analyzed for TNT and RDX using the colorimetric field screening methods. The results of the Phase I field screening identified contamination at the northern and western boundaries of the original sampling grid. As a result, a modified program was implemented to fill in data gaps and identify the extent of contamination across the site.

The Phase II field screening program consisted of expanding the sampling grid boundaries to the north and west, and sampling all remaining unsampled cells in the original grid to further define the extent of concentration of TNT and RDX in Site D surface soils (Figure 3). Phase I results indicated that detectable RDX values were less in concentration and fewer in frequency than detectable TNT values. A modification to the field screening procedure was implemented where, if TNT was detected, the sample location was also screened for RDX.

In addition to the grid samples, 24 biased samples were collected across the site. Biased samples were used to further define the extent of contamination in areas exhibiting characteristics of historical burn/detonation activities and at areas having anomalous geophysical readings. Sample locations included four areas near the small arms incinerator (one sample at each corner of the facility's foundation), six samples from the burn trench area, with the remainder based on geophysical results (See Figure 3).

A total of 403 surface soil samples were field screened for TNT and RDX. The results for the Phase I and II field screening for TNT are shown in Figure (4). TNT was detected in 151 of 403 surface soil samples. Five primary surface soil surface plumes with high TNT contamination were identified for areas of TNT concentration greater than 30 mg/kg at the base and downgradient of the burn trench. The 30 mg/kg contamination contour was selected as defining contour between areas of high and low contamination because TNT concentrations above this level were well defined, and this level corresponds with surface soil preliminary remediation goals (PRGs) utilized by EPA Region 10 at other ordnance remediation sites. A secondary surface soil plume was defined for TNT concentrations between 10 and 30 mg/kg. TNT detections of less than 10 mg/kg were scattered throughout the site, however, these detections are based on field screening analysis of soil with appreciable humic material, which may give false positive TNT readings.

RDX was detected during field screening in 79 of 262 samples collected. All detections were below 8 mg/kg except for two samples in the vicinity of the burn trench, at 13 and 16 mg/kg (See Figure 4).

To confirm the field screening results and test areas exhibiting high and/or anomalous geophysical readings outside

the areas that were field screened, 60 samples and 6 duplicates were collected and shipped to an offsite laboratory for ordnance analysis. A modified SW-846 method utilizing gas chromatography-electon capture device (GC-ECD) instrumentation was used for ordnance analysis which provided analytical procedures, deliverables, and quality assurance/quality control (QA/QC) procedures equivalent to EPA Level IV. Analytes for the ordnance method are shown in Table (1).

Table 1 - Ordnance Method Analytes

Acronym	Compound Name
TNT	2,4,6-Trinitrotoluene
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
Tetryl	Methyl-2,4,6-trinitrophenylnitramine
2,4-DNT	2,4-Dinitrotoluene
2,6-DNT	2,6-Dinitrotoluene
TNB	1,3,5-Trinitrobenzene
DNB	1,3-Dinitrobenzene
NB	Nitrobenzene
Picric Acid	2,4,6-Trinitrophenol
Picramic Acid	2-amino-4,6-Dinitrophenol

Thirty five soil borings were drilled on to assess the surface contamination and to provide sufficient laboratory analytical data to conduct a baseline risk assessment. The locations of the borings were selected based on the known locations trenches and burn mounds, and to confirm the findings of the field screening results. Fifteen borings were at biased locations, one near the incinerator, 2 in the burn trench, and 2 at each of the 6 previously identified mounds. Twenty additional borings were completed to confirm areas of highest contamination determined from the TNT and RDX field screening results. The borings were completed using a hollow-stem auger drilling rig. Soil borings were sampled continuously using a 2-inch diameter split spoon (See Figure 5).

The estimated extent of TNT surface soil contamination utilizing laboratory data is shown in Figure (6). The results indicate three areas with TNT concentration greater than 30 mg/kg. The largest area is approximately 75 by 150 feet. The other areas are smaller, downgradient of the burn trench. The estimated 2,4-DNT plume approximates the TNT surface plume. The extent of 2,4-DNT contamination is shown in Figure (7). Two areas showed concentrations greater than 1 mg/kg, with only 4 samples above 10 mg/kg. The TNT impurity and degradation products 2,6-DNT, 1,3,5-TNB, 1,3-DNB, and NB were also detected, although less frequently and at much lower concentrations than TNT and 2,4-DNT. The highest concentrations detected were 5.6 mg/kg for 2,6-DNT, 3.4 mg/kg for 1,3,5-TNB and 2.4 mg/kg 1,3-DNB. NB was detected at two locations at 0.073 and 0.075 mg/kg. Picric acid was detected at two locations at 2 mg/kg and 6 mg/kg (See Figures 6 & 7).

RISK ASSESSMENT

A risk assessment was conducted to assess the human health and environmental impacts associated with surface soil contamination. The primary exposure pathways evaluated for exposure to surface soils were dust inhalation, soil ingestion, and dermal absorption. Reasonable Maximum Exposure (RME) concentrations were based on the 95% upper confidence limits of the arithmetic mean of soil sampling data. The land use scenarios quantitatively evaluated were (1) current industrial use, (2) future industrial use, and (3) future residential use, utilizing EPA standard default exposure parameters.[5] Toxicity values were obtained from the EPA Integrated Risk Information System (IRIS) and Health Effects Summary Tables (HEAST) for carcinogenic Slope Factors (SF) and non-carcinogenic Reference Dose (RfD). Dermal absorption values for ordnance compounds were provided by the EPA Environmental Criteria and Assessment Office (ECAO) in Cincinnati, OH.[6]

EPA classifies the data regarding carcinogenicity according to weight-of-evidence classification. Group B carcinogens such as 2,4-DNT and 2,6-DNT were evaluated utilizing carcinogenic slope factors. Group C carcinogens, such as TNT and RDX, were evaluated for carcinogenic and non-carcinogenic risks, utilizing both slope factors and reference doses. Group D carcinogens, such as TNB were evaluated using non-carcinogenic RfDs only.

The carcinogenic risk and non-carcinogenic Hazard Index (HI) calculated for each of the three land use scenarios evaluated is shown in Table 2.

Table 2

Land Use Scenario	Lifetime Excess Cancer Risk	Non-Cancer Hazard Index
Current Industrial	4×10^{-5}	7
Future Industrial	4×10^{-4}	70
Future Residential	1×10^{-3}	200

These data indicate elevated lifetime excess cancer risks and non-carcinogenic risks for current and future land use scenarios based on CERCLA National Contingency Plan (NCP) criteria, EPA policy guidance, and State of Washington MTCA criteria.[7,8,9]

FEASIBILITY STUDY

A Feasibility Study was initiated to evaluate remedial action alternatives for explosives contaminated soil based on the unacceptably high risk detailed in the risk assessment. Preliminary Remediation Goals (PRGs) established for soil cleanup were set at 30 mg/kg for TNT and 9 mg/kg for RDX. These levels correspond to lifetime excess cancer risks between 1×10^{-5} and 1×10^{-6} under CERCLA and MTCA criteria and are protective for non-carcinogenic effects. Soil quantities exceeding PRGs at Site D were estimated at 1220 tons.

Treatment technologies evaluated for destruction of explosives contaminated soils include incineration and solid phase bioremediation (composting). Incineration has been used effectively in the past for treatment of similar wastes and recent pilot scale treatability studies have demonstrated the ability of composting to achieve risk based cleanup levels. Destruction and removal efficiencies (DRE) for incineration of explosives contaminated soils has been demonstrated to be greater than 99.9999% during full scale remediation and greater than 99.0% for composting in pilot scale tests.[10,11] For a soil quantity of 1220 tons, total remediation costs for on-site rotary kiln incineration were estimated a $1,390,000 ($1138/ton) and windrow composting costs were estimated at $680,000 ($557/ton). Based on these results, a bench scale treatability study was initiated to evaluate the efficacy of composting using native microbial populations in conjuction with nutrient soil amendments, such as manure, sawdust, and vegetable processing wastes. A Record of Decision (ROD) will be prepared in 1993 detailing these remedial action alternatives.

The decision to utilize innovative technologies is consistent with the NCP, where innovative technologies offer the potential for comparable performance with less adverse impacts, or lower costs for similar levels of performance as compared to demonstrated technologies.

CONCLUSIONS

The major conclusions of this study were:

- The analytical results indicate migration of ordnance contamination away from identified source areas due to surface erosion.
- Results from field screening and laboratory methods showed similar contamination profiles and allowed for complete characterization of the site.
- The risk assessment conducted indicates elevated lifetime excess cancer risks and non-carcinogenic risks for current and future land use scenarios.
- Further work includes development of final remedial action objectives and evaluation of bench scale bioremediation treatability studies.

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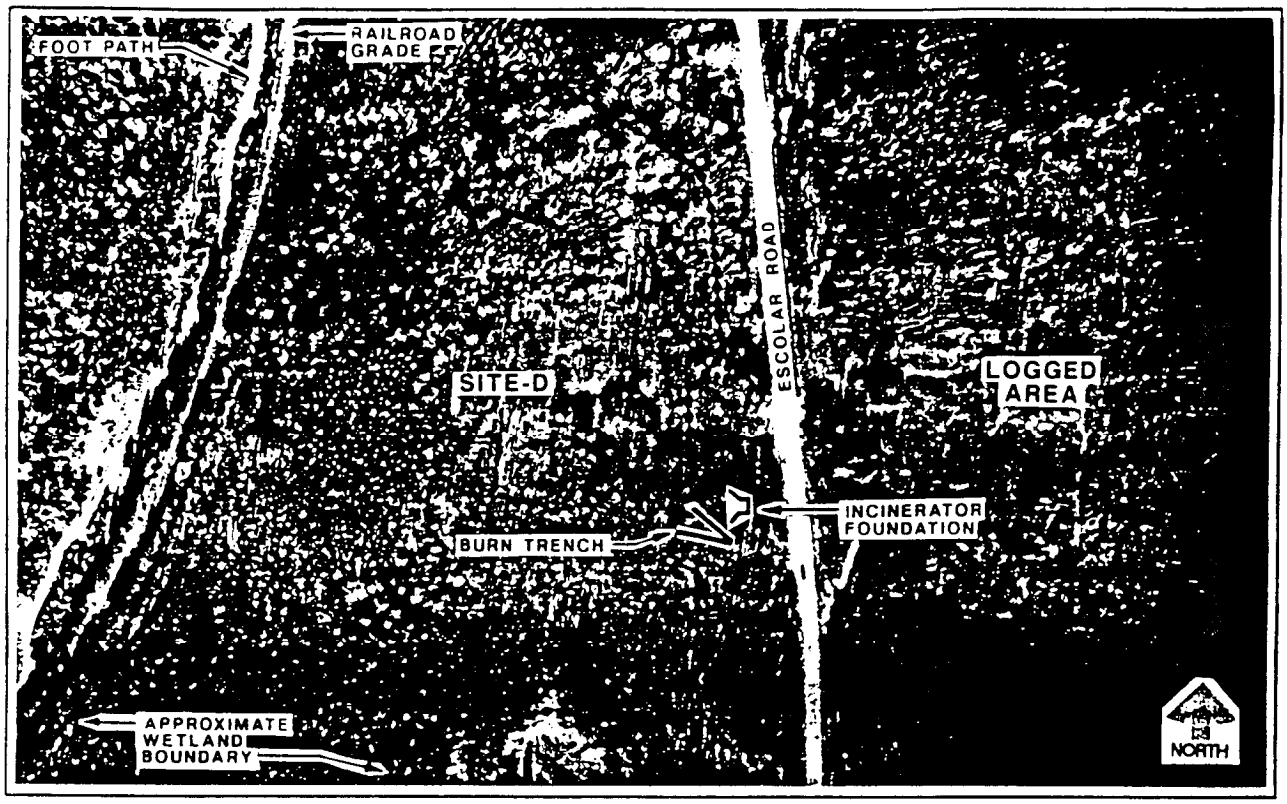


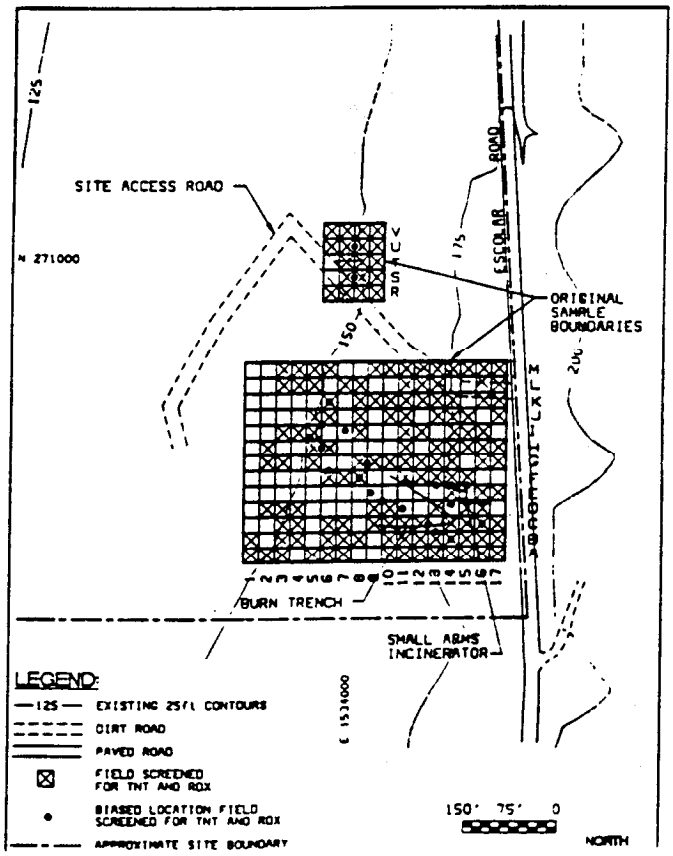


Figure 2

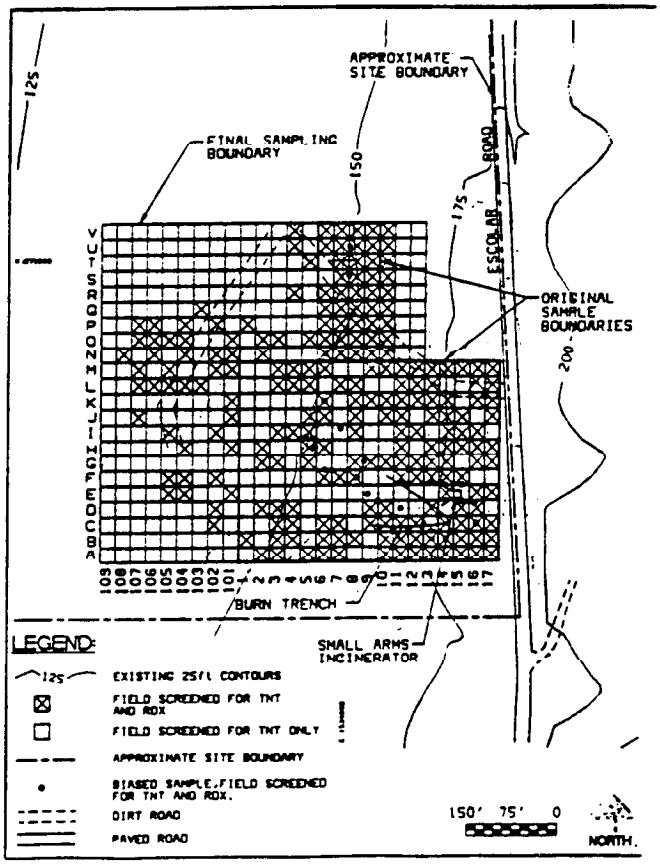
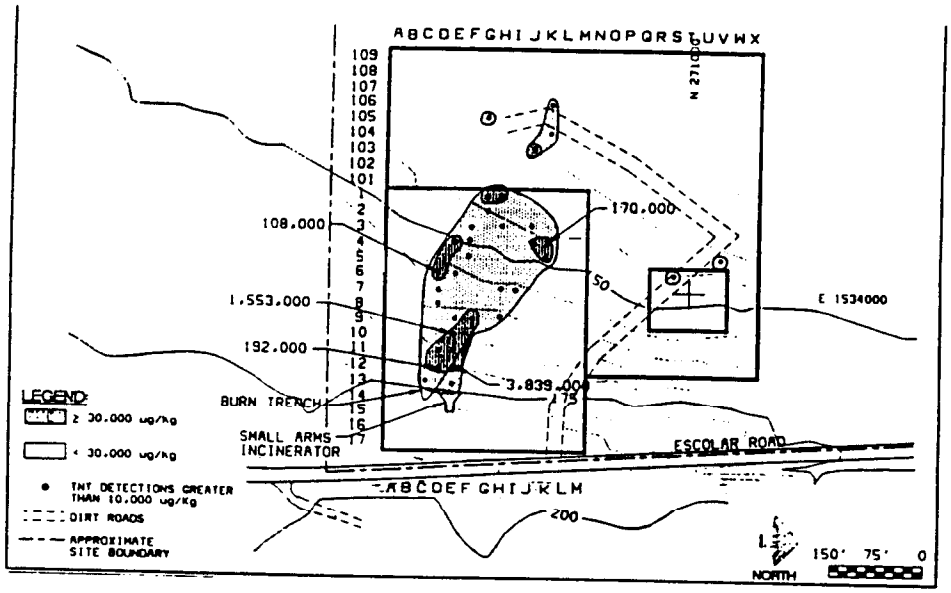


Figure 3



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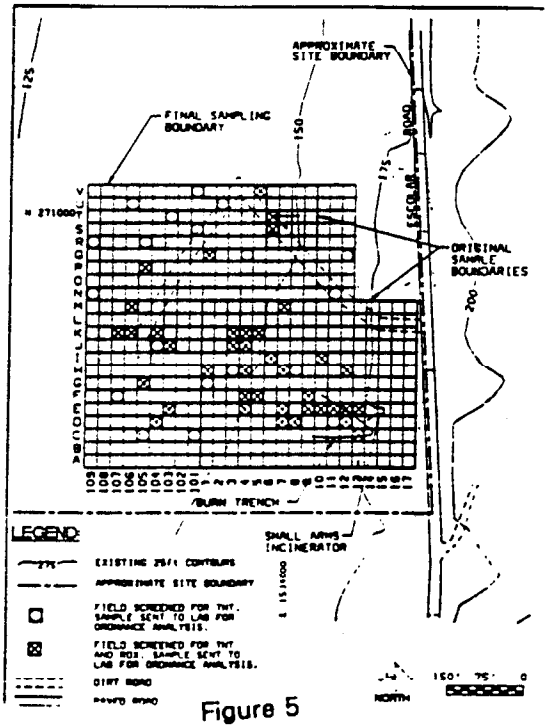

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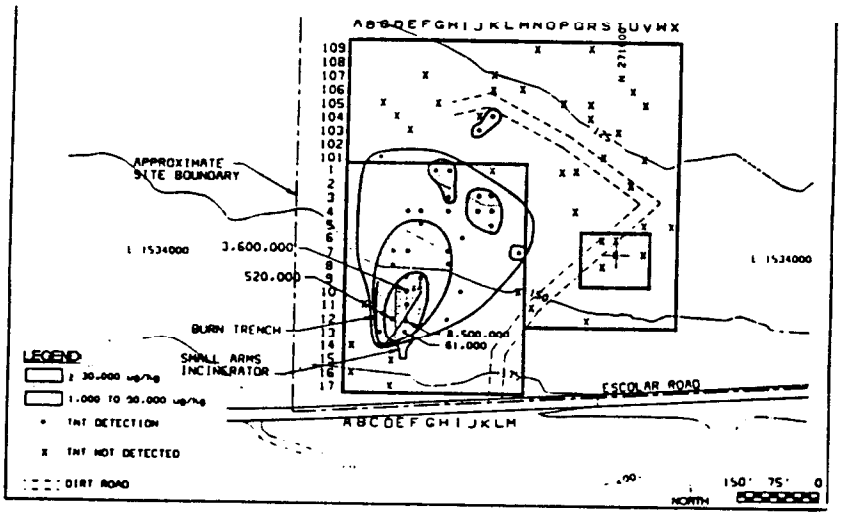

Figure 6

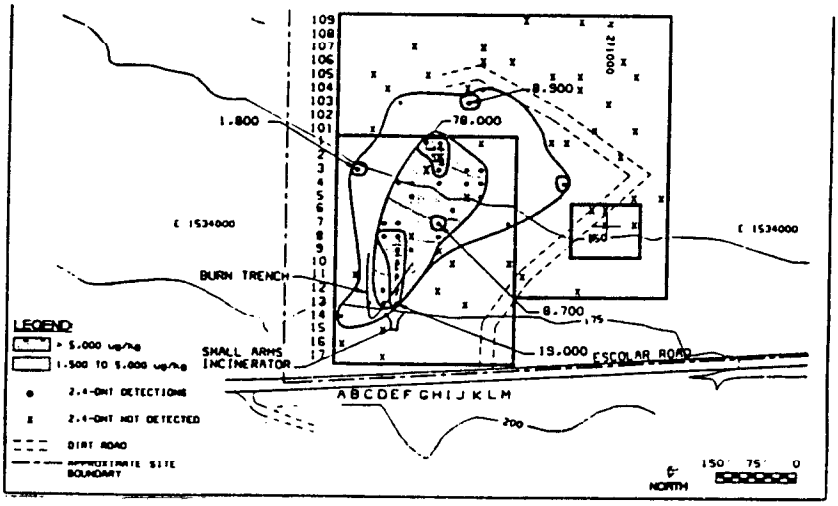

Figure 7