

U.S. Army Corps of Engineers

Engineering Evaluation/Cost Analysis Former Benicia Arsenal Solano County, California

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LIMITATIONS

The information presented in this Engineering Evaluation/Cost Analysis (EE/CA) for the Former Benicia Arsenal has been provided in accordance with principles and practices generally employed in the environmental consulting profession.

Recommendations set forth in this document are based upon the following: (1) data and literature provided by government sources; (2) documentation of prior clearances; (3) field investigations including geophysical mapping and ordnance and explosives (OE) sampling performed by the Earth Tech project team; (4) results of the OECert (a U.S. Army Corps of Engineers [USACE] risk model) risk analysis; and (5) observations made and verbal information obtained during site visits. Information developed by other government agencies and independent contractors has been accepted as authentic and true as stated, unless otherwise noted.

The recommendations reflect an analysis of available information, current and projected future land uses, and professional judgment. The recommendations presented in this EE/CA are subject to change based upon receipt of new information regarding the potential presence or evidence of OE within the Former Benicia Arsenal. This EE/CA is not intended to be a decision document but should be used as a tool to assist in making knowledgeable and comprehensive decisions regarding the disposition of the Former Benicia Arsenal.

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Date

EXECUTIVE SUMMARY

1
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3
4 The U.S. Army Engineering and Support Center, Huntsville (CEHNC), and the
5 U.S. Army Corps of Engineers (USACE), Sacramento District (CESPK), teamed
6 to produce an Engineering Evaluation/Cost Analysis (EE/CA) for the Former
7 Benicia Arsenal in order to assess the ordnance and explosives (OE) risk and
8 present and evaluate alternatives to reduce the potential risk of exposure to
9 unexploded ordnance (UXO) to the public.

10
11 The Former Benicia Arsenal encompasses 2,728 acres in the city of Benicia,
12 Solano County, California. The Former Benicia Arsenal is situated along
13 Interstate Highways 680 and 780 (I-680 and I-780) approximately 25 miles
14 northeast of San Francisco. The Former Benicia Arsenal and surrounding area
15 consists of industrial and residential areas with undeveloped marshland along the
16 Carquinez Strait to the south and rolling hills to the north.

17
18 The Former Benicia Arsenal began as the Benicia Barracks in 1849. During its
19 existence, the Former Benicia Arsenal supplied arms and serviced weaponry
20 during the Civil War, Spanish-American War, World Wars I and II, and the
21 Korean Conflict. The Former Benicia Arsenal manufactured targets for seacoast,
22 field, and mobile artillery firing practice. In addition, the arsenal assembled
23 powder charges and rapid-fire ammunition, and filled armor-piercing projectiles
24 with high explosives. As part of the Cold War build-up, the Former Benicia
25 Arsenal reconditioned NIKE guided missiles. Two NIKE test sites were situated
26 in the northwest portion of the arsenal.

27
28 Eventually, operations at the arsenal slowed, and in 1961, the Department of
29 Defense (DOD) announced that it planned to decommission the Benicia Arsenal.
30 Final closure of the Benicia Arsenal occurred in 1964.

31
32 Today, owners of the Former Benicia Arsenal include Benicia Industries, Inc., the
33 city of Benicia, Exxon, Pacific Gas and Electric (PG & E), Granite Management
34 Corporation, and numerous other private, commercial, and residential parcels.
35 Granite Management Corporation began development in 1997, north and west of
36 the Revetment area (Tourtelot Property), until ordnance was encountered during
37 excavation activities. Construction was halted, and the USACE began to perform
38 additional research to determine potential occurrence of OE and Hazardous,
39 Toxic and Radioactive Waste (HTRW) within the Former Benicia Arsenal.

40
41 The arsenal histories in the Archives Search Report (ASR) and ASR Supplement
42 indicate that a variety of OE (including assorted fuzes, mortars, small arms
43 ammunition, 37-millimeter [mm] shrapnel, and 75-mm rounds) was handled,
44 stored, and destroyed at the Former Benicia Arsenal.

45
46 Based on the review of available documents and site visits, three main areas
47 were identified at the arsenal for having the potential for OE. To facilitate the field
48 investigation, the areas were divided into five sectors in accordance with the
49 Ordnance and Explosives Cost-Effectiveness Risk Tool (OECert) program. For

analysis purposes, Sector 3 was further subdivided into three subsectors: 3A, 3B, and 3C. The rationale for selecting sector boundaries includes different prior, current, or potential future land use than surrounding property, in addition to specific past DOD activities such as demolition operations or test firing of artillery rounds.

The field investigation at the Former Benicia Arsenal was conducted in two phases during the first few months of 1999. The first phase involved performing a geophysical investigation to detect and map metallic objects that could be related to OE. The second phase of the field investigation involved subsurface sampling.

During the EE/CA field investigation, 17 UXO items were recovered from two of five sectors where subsurface sampling was performed. Two of the UXO items were recovered from Sector 3B (Tourtelot Property), and 15 UXO items were recovered from Sector 5 (Camel Barn Area). Table ES-1 lists the depth, type, and location of each of the UXO items recovered.

Table ES-1. Former Benicia Arsenal UXO Summary Table

Sector Number	Sector Name	Number of UXO	UXO type	UXO Depth
1	Revetment Area	0	--	--
2 ^(a)	Artillery Test Area	0	--	--
3A	Tourtelot Property	0	--	--
3B	Tourtelot Property	2	(1) 75-mm Shrapnel Projectile (Unfuzed) (1) 37-mm Projectile (Fuzed)	6" 24"
3C	City Property Adjacent to Tourtelot Property	0	--	--
4	Demolition Site on Exxon Property	0	--	--
5	Camel Barn Area	15	(1) Grenade (2) Grenade (1) Base Fuze (1) 75-mm Shrapnel Projectile (Fuzed) (1) 3"/50 APHE (Unfuzed) (3) Grenade (1) Stokes Mortar Fuze (3) 3"/50 APHE (Unfuzed) (1) Grenade (1) 3"/50 APHE (Fuzed)	0" 4" 4" 16" 16" 30" 30" 30" 32" 32"
Grid OT01 ^(b)	Overtumed Truck Area	--	--	--
Total UXO at the Former Benicia Arsenal		17		

Note: (a) OE sampling results for Sector 2 include only those from Grid 0202.
 (b) OE sampling was not performed in Grid OT01 because right-of-entry could not be granted.
 APHE = Armor Piercing High Explosive
 mm = millimeter
 UXO = unexploded ordnance

1 Using the results of the EE/CA field investigation and data previously collected in
2 Sector 3 by the property owner, a risk evaluation of the Former Benicia Arsenal
3 was performed that considered the risk reduction effects of four risk management
4 alternatives. These alternatives were evaluated in terms of OE density and
5 current and future land uses. The four alternatives include: (1) Alternative 1 - No
6 Further Action (NoFA); (2) Alternative 2 - Institutional Controls; (3) Alternative 3 -
7 Surface Clearance of UXO; and (4) Alternative 4 - Detection and Clearance of
8 UXO to Depth.

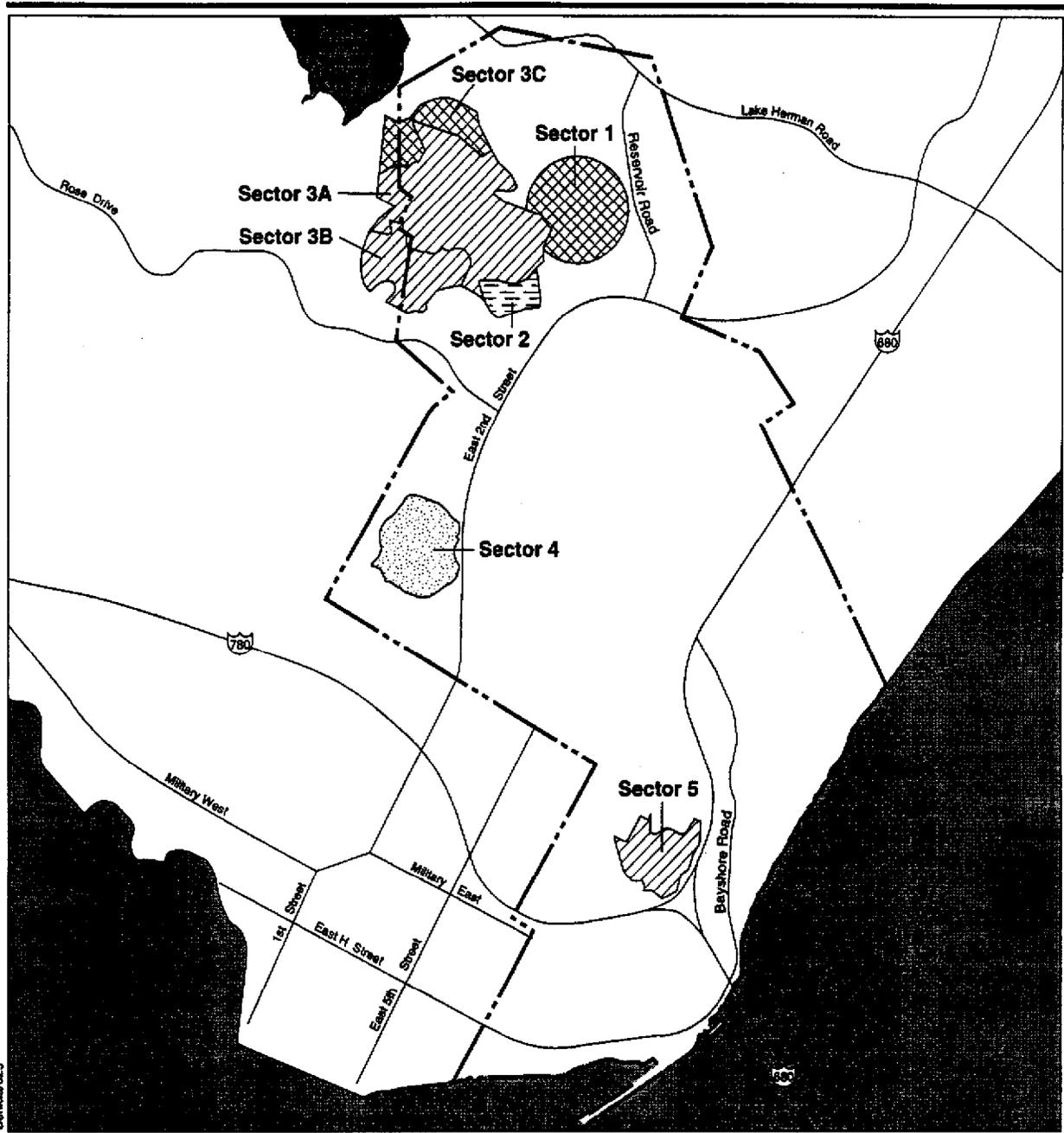
9
10 These alternatives were then evaluated for each sector in terms of effectiveness,
11 implementability, and cost and ranked from best (1st) to least (4th) preferable for
12 these criteria.

13
14 Based upon the results of the risk analysis and sector evaluation, review of site
15 history, and review of current and future land uses, there are four areas in which
16 clearance actions are recommended. These include Sector 2 (Artillery Test
17 Area), Sectors 3A and 3B (Tourtlet Property), and Sector 5 (Camel Barn Area).
18 Institutional Controls are recommended for Sector 4 (Demolition Site on Exxon
19 Property). Specific recommendations for these areas are discussed in detail in
20 Section 7.2, Recommendations for Individual OE Sites. A brief description of the
21 recommendation for each sector follows:

- 22
- 23 • Sector 1 - No Further Action is recommended.
- 24
- 25 • Sector 2 - A surface clearance of the valley walls with a subsurface clearance
26 of the valley floor is recommended. Following the clearance action, warning
27 signs should be posted on existing trails and fences.
- 28
- 29 • Sectors 3A and 3B - A subsurface clearance to a depth of 4 feet is
30 recommended.
- 31
- 32 • Sector 3C - No Further Action is recommended.
- 33
- 34 • Sector 4 - It is recommended that warning signs be posted on the existing
35 fence that surrounds the sector and is maintained by the property owner.
- 36
- 37 • Sector 5 - A subsurface clearance to a depth of 4 feet is recommended.
- 38

39 Figure ES-1 outlines the general location of the areas for which clearance actions
40 are recommended.

41
42 For all other areas within the Former Benicia Arsenal, based on the results of the
43 EE/CA investigation, analysis of risk, and review of the hazards associated with
44 the types of OE found at the site, No Further Action is recommended. NoFA
45 does not include any U.S. Army-initiated actions under current or anticipated
46 future land use. A surface or subsurface OE clearance would not occur.
47 However, if significant new information is presented for an OE site, the project
48 may be reopened.
49



EXPLANATION

- Sector 1 Revetment Area (66 acres)
- Sector 2 Artillery Test Area (15 acres)
- Sector 3A Tourtelot Property (131 acres)
- Sector 3B Tourtelot Property (47 acres)
- Sector 3C City Property Adjacent to Tourtelot Property (34 acres)
- Sector 4 Demolition Site on Exxon Property (54 acres)
- Sector 5 Camel Barn Area (35 acres)
- Grid OT01 Overturned Truck Area (0.23 acre)

- Interstate Highway
- Former Benicia Arsenal Boundary (estimated)
- Subsurface Clearance to Depth
- Surface and Subsurface Clearance
- No Further Action
- Institutional Controls



Recommended Clearance Areas

Figure ES-1

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1.0 INTRODUCTION

The U.S. Army Engineering and Support Center, Huntsville (CEHNC), and the U.S. Army Corps of Engineers (USACE), Sacramento District (CESPK), have teamed to produce an engineering evaluation/cost analysis (EE/CA) for the Former Benicia Arsenal. The EE/CA is the means by which the decision process to remediate the Former Benicia Arsenal is documented.

In 1998, Earth Tech, Inc. (Earth Tech), was contracted by the CEHNC to prepare an EE/CA report for the 2,728-acre Former Benicia Arsenal, in the city of Benicia, Solano County, California, approximately 25 miles northeast of San Francisco (Figure 1-1). Earth Tech contracted with USA Environmental, Inc. (USAE), of Tampa Florida, to provide explosive ordnance disposal (EOD)-qualified personnel to escort non-EOD-trained personnel and conduct OE sampling for the EE/CA investigation. The geophysical data collection, processing, and analysis tasks of the OE sampling effort were subcontracted to Blackhawk Geometrics (Blackhawk) of Golden, Colorado. QuantiTech, Inc. (QuantiTech), of Huntsville, Alabama, provided technical oversight of the statistical sampling methods used to characterize the site, and prepared the Ordnance and Explosives Cost-Effectiveness Risk Tool (*OECert*) risk analysis report for the Former Benicia Arsenal while subcontracted to Earth Tech.

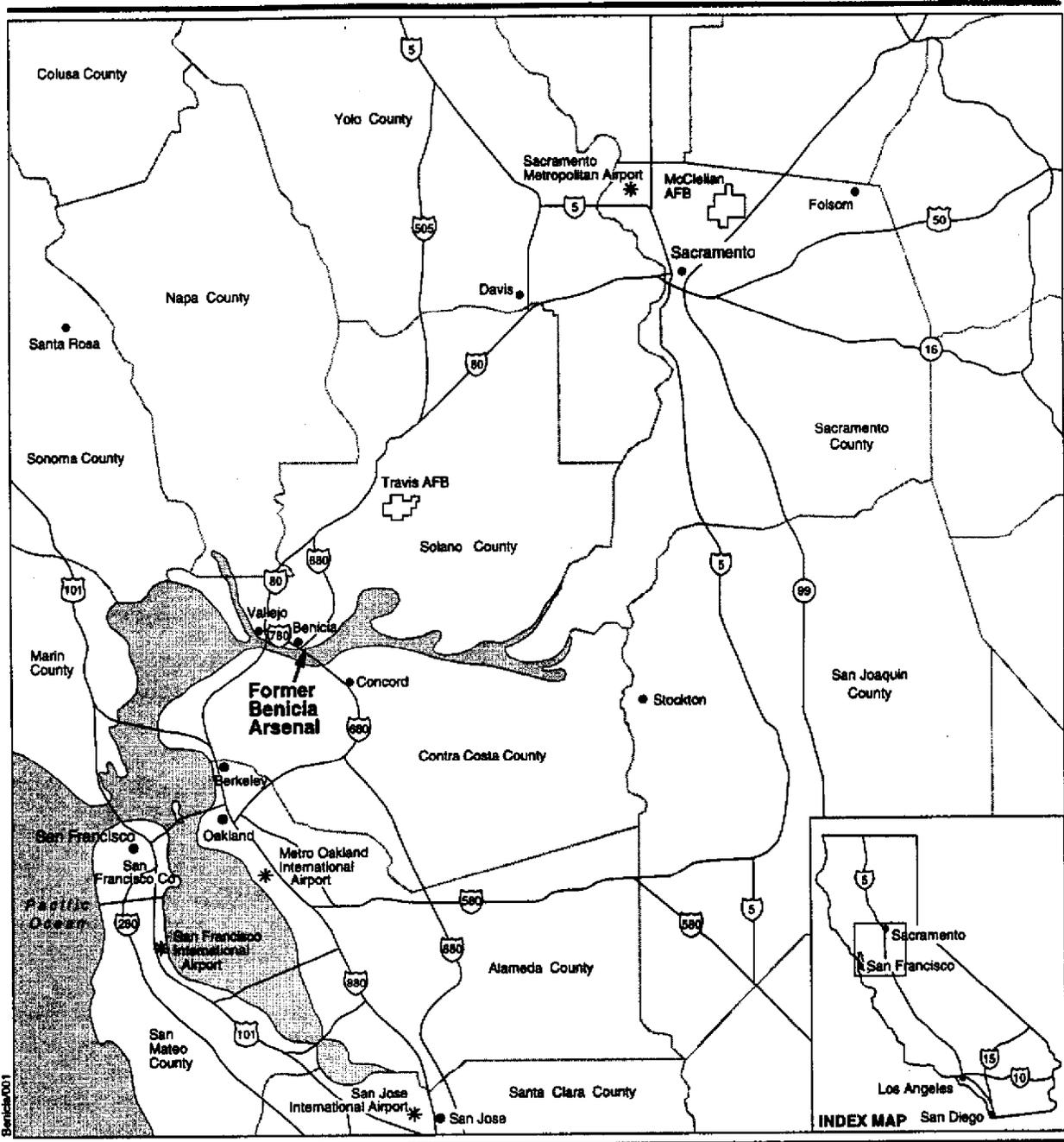
The results of the ordnance and explosives (OE) sampling conducted under the EE/CA investigation were examined and input into a risk assessment model (*OECert*). *OECert* was utilized in order to estimate the residual risk from unexploded ordnance (UXO) to the public in terms of exposures and to compare the number of injuries or deaths that may result from those exposures. Exposures, as defined by *OECert*, do not indicate that an incident or injury will occur. The comparative risk analysis methodology translates the accumulated UXO exposures into the chance of a UXO-related injury or death (as discussed in Section 2.6). Additionally, *OECert* was used to estimate the expected reduction in risk to the public under various risk management alternatives.

Once the EE/CA is approved by the CEHNC, an EE/CA Action Memorandum will be prepared to document the decision by which the alternatives will be implemented at the Former Benicia Arsenal. The U.S. Army realizes it will maintain a residual responsibility to ensure that implemented alternatives are effective in reducing the risk associated with UXO at the Former Benicia Arsenal.

1.1 EE/CA PURPOSE AND OBJECTIVE

The purpose of the EE/CA is to evaluate potential ordnance risk and develop alternative plans of action. The objective of the EE/CA is to support an informed decision for clean up of the site.

The objective of the EE/CA for the Former Benicia Arsenal has been accomplished by (1) conducting OE sampling to estimate the amount of UXO present at the Former Benicia Arsenal, and (2) determining the amount and depth



EXPLANATION

- * Airports
- (99) California State Highway
- (101) U.S. Highway
- (290) Interstate Highway
- County Boundary



Regional Map

Figure 1-1

1 to which UXO may be removed in order to reduce the risk associated with UXO at
2 the Former Benicia Arsenal, depending upon current and future land use of the
3 property.
4

5 This report identifies and evaluates four risk management alternatives. These
6 alternatives include No Further Action (NoFA) and risk reduction actions.
7

8 The development and use of the Former Benicia Arsenal has a direct influence
9 on the life and livelihood of several stakeholders including the public; many
10 federal, state, and local agencies; and other interested parties. This EE/CA is a
11 work in progress; necessary input includes consideration of the concerns of the
12 stakeholders involved. New information and further discoveries may affect the
13 findings and recommendations of this EE/CA.
14

15 For this process to be successful, close coordination and cooperation between
16 the stakeholders, community, regulators, and technical support personnel must
17 occur. In serving as a cornerstone for the risk management effort, this EE/CA
18 identifies and evaluates reasonable alternatives and makes recommendations for
19 action, where appropriate.
20

21 This EE/CA provides the background, approach, and evaluation process for
22 determining the potential risk that UXO poses to the public at the Former Benicia
23 Arsenal. It also summarizes field activities and outlines recommendations for
24 future actions based on the methodology described in this document.
25

26 Evaluations and recommendations are based upon the following four alternatives:
27

- 28 • Alternative 1: NoFA
- 29
- 30 • Alternative 2: Institutional Controls
- 31
- 32 • Alternative 3: Surface Clearance of UXO
- 33
- 34 • Alternative 4: Detection and Clearance of UXO to Depth
- 35

36 1.2 EE/CA REPORT FORMAT

37

38 This report is organized as follows:
39

- 40 • **Chapter 1.0 - Introduction:** Discusses the purpose and objective of
41 the EE/CA and presents the organization of the EE/CA report and the
42 overall risk reduction process.
43
- 44 • **Chapter 2.0 - Site Characterization:** Provides the following:
45
 - 46 - A brief history of the Former Benicia Arsenal, including the types
47 of ordnance previously detected at the site.
 - 48
 - 49 - An overview of all areas of potential OE (OE sites) that have
50 been documented at the Former Benicia Arsenal, including a
51 discussion of how each site is considered in the EE/CA.

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- A general discussion of the current status of the Former Benicia Arsenal and existing facilities.
- A general discussion of current and future land use.
- A discussion of the natural features of the Former Benicia Arsenal (e.g., soil, topography, sensitive ecology, cultural resources).
- A discussion of the field work undertaken including the geophysical investigation and OE sampling procedures.
- A discussion of the applicable or relevant and appropriate requirements (ARARs) that apply to the Former Benicia Arsenal.
- A discussion of the risk analysis process including the OECert approach.
- **Chapter 3.0 - Alternative Identification Process:** Presents the process used to identify risk management alternatives to be evaluated for the EE/CA.
- **Chapter 4.0 - Identification of Risk Management Alternatives:** Presents the four alternatives that are considered in the EE/CA and a discussion of the various clearance technologies available for the project site.
- **Chapter 5.0 - Evaluation Criteria:** Discusses the evaluation criteria for each alternative.
- **Chapter 6.0 - Sector Evaluations:** Discusses the applicability of the various alternatives in terms of their effectiveness, implementability, and cost.
- **Chapter 7.0 - Recommended Alternatives:** Presents the recommendations for reducing the potential risk of exposures to UXO at the Former Benicia Arsenal.
- **Chapter 8.0 - References:** Provides an inventory of the reference material used in the preparation of the EE/CA.
- **Chapter 9.0 - Glossary of Terms and Acronyms/Abbreviations:** Provides a detailed list of terms used throughout this EE/CA. For each term, a detailed and complete definition is provided. A list of acronyms and abbreviations is also included for reference.
- **Chapter 10.0 - List of Preparers:** Includes a list of personnel who contributed to the preparation of the EE/CA.
- **Appendix A - OECert Analysis Report:** Includes the results of the risk analysis conducted for the Former Benicia Arsenal.
- **Appendix B - EE/CA Contractor Statement of Work:** Includes the statement of work (SOW) for Earth Tech.

- **Appendix C - Summary of OE Sampling Results:** Provides a summary of the total number of anomalies investigated in each sector and the number of anomalies containing UXO, OE scrap, and non-OE scrap.
- **Appendix D - Recovered OE Items by Grid:** Provides a table of OE items recovered during the field investigation and grid maps for each sector.
- **Appendix E - Institutional Analysis Report:** Documents which government agencies have jurisdiction over lands within the project area and assesses their capability and willingness to assert institutional controls that would protect the public from explosive hazards.
- **Appendix F - Cost Estimate Data:** Provides the costs associated with Alternatives 2 through 4.

1.3 WORK PERFORMED

Work on this project was performed in accordance with the Final Work Plan (Earth Tech, 1998) prepared for the EE/CA investigation at the Former Benicia Arsenal. The EE/CA process is consistent with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and the National Contingency Plan (NCP). The work performed in support of this EE/CA is described below.

1.3.1 Site Visit and Records Review

Earth Tech conducted a site visit from 13-17 July 1998 to gather information necessary to create an executable project Work Plan.

1.3.2 Equipment Field Test

An equipment field test was conducted from 22-24 November 1998 to verify the recommended geophysical mapping methodology and approach established for detection of subsurface OE at the Former Benicia Arsenal met the performance criteria. Additionally, the geophysical data previously collected by others was validated. The test bed consisted of inert OE and simulants that were buried at depths varying from 1.5 to 4 feet below ground surface (bgs). The results of the field test were documented in a letter report and attached as an appendix to the Final Work Plan.

1.3.3 Work Plan

The Final Work Plan is the guide for all EE/CA-related activities including geophysical mapping, OE sampling, and survey work within the Former Benicia Arsenal. The Work Plan includes a detailed history of OE anticipated to be found at the Former Benicia Arsenal and an overview of previous OE clearance actions. It addresses specific acreage to be investigated, the number of grids to be

1 sampled, and the site-specific approach to the EE/CA investigation at the Former
2 Benicia Arsenal. The Final Work Plan for the Former Benicia Arsenal is available
3 for public review at the Benicia Public Library.
4

5 **1.3.4 Land Survey and Geophysical Mapping**

6
7 A land survey was performed to establish the boundaries of grids (i.e., areas to
8 be sampled). Brush clearing was performed in selective grids so that geophysical
9 equipment could maneuver freely within each grid. Transient Electromagnetic
10 (TEM) Metal Detectors equipped with data recorders were used to detect and
11 map the location of subsurface anomalies and record the geophysical character
12 of each search grid. Using this data, dig maps indicating the number of the grid,
13 global coordinates, and locations of each target anomaly within the grid were
14 generated.
15

16 **1.3.5 Performance of OE Sampling**

17
18 OE sampling for the Former Benicia Arsenal began in February 1999. A
19 command post was established at the intersection of McAllister and Piercy
20 Drives.
21

22 Using the dig maps generated for each grid, the survey crews located each of the
23 sampling grids and placed a pin flag above the target anomaly location for the OE
24 Dig Team. Each target anomaly location was confirmed by a geophysical
25 instrument prior to excavation of the suspected anomaly. The Dig Team
26 searched for and excavated each of the selected target anomalies.
27

28 All discovered UXO were disposed of on site (i.e., explosively destroyed). No
29 UXO items were transported off the arsenal.
30

31 **1.3.6 Turn-in of Recovered Inert Ordnance and OE-Related Scrap**

32
33 Disposal of scrap was coordinated with a local scrap metal recycler as required to
34 ensure that inert ordnance and OE-related scrap were handled in accordance
35 with applicable regulations and procedures.
36

37 **1.3.7 Preparation of Institutional Analysis**

38
39 An Institutional Analysis Report (Appendix E) was prepared to support
40 development of institutional control alternative plans of action. The Institutional
41 Analysis concludes that the city of Benicia's *General Plan* (November 1998),
42 when adopted, will provide opportunity for institutional controls to be implemented
43 (if required) in addition to the existing access controls (i.e., fencing) at the
44 arsenal.
45

46 **1.3.8 Preparation of EE/CA Report**

47
48 Earth Tech has prepared and submitted this EE/CA report, fully documenting the
49 data collected during the geophysical mapping and OE sampling activities. Earth

1 Tech has used these data for evaluation of the risk management alternatives and
2 recommendations made in this EE/CA.
3

4 **1.3.9 Action Memorandum**

5
6 After public review of the EE/CA, an Action Memorandum documenting the
7 government's decision for the selected alternatives will be prepared for the
8 Former Benicia Arsenal.
9

10 **1.3.10 Community Relations Support**

11
12 All community relations support is conducted in accordance with the Community
13 Relations Plan prepared by the USACE, Sacramento District. Community
14 relations support includes public availability sessions, various newsletters, and
15 video presentations.
16

17 **1.4 EE/CA FOLLOW-ON ACTIVITIES**

18
19 Once the EE/CA is approved by the CEHNC, follow-on activities will be
20 implemented. These will include the following:
21

22 **Action Memorandum.** Following the Final EE/CA, an Action Memorandum will
23 be prepared to document the decision by which the alternatives will be
24 implemented at the Former Benicia Arsenal.
25

26 **Risk Management Design.** A risk management design will be prepared
27 consistent with the Action Memorandum. An Explosives Safety Submission
28 document must be prepared. This document will be submitted to and must be
29 approved by the Department of Defense Explosives and Safety Board (DDESB)
30 prior to implementation.
31

32 **Risk Management Action.** The selected Risk Management Action will be
33 implemented based on the approved design. For clearance actions, a clearance
34 report must be prepared to document the clearance activities, UXO items that are
35 recovered and disposed of, and exposure data. A clearance certificate will also
36 be prepared.
37

38 The schedule for implementing the selected risk management actions will be
39 based, in part, upon available funding and the time associated with securing the
40 funding. Other factors, such as safety issues and land development, will also be
41 important considerations.
42

43 **Residual Risk Management Activities.** After the risk management actions
44 have been completed, it is possible that additional UXO may be encountered. If
45 this occurs, existing procedures as described in Army Field Manual 9-15, dated
46 8 May 1996, may guide Department of Defense (DOD) response to protect
47 human health. If the public encounters potential UXO on any former site, the
48 local law enforcement authority must initially respond. The Department of the
49 Army Explosive Ordnance Disposal Units, located throughout the United States,
50 are responsible for responding to incidents involving military ordnance on

1 public/private property. The Army responds at the request of the local law
2 enforcement authority. If numerous items are found in a particular area, the
3 geographic Corps District should be contacted to determine if further action is
4 warranted.

5
6 **1.5 OTHER ONGOING STUDIES**

7
8 Under the requirements of CERCLA, the U.S. Army Corps of Engineers,
9 Sacramento District, is currently investigating and identifying potential Hazardous,
10 Toxic, and Radioactive Waste (HTRW) sites at the Former Benicia Arsenal.
11 Under this program, a Records Research Report (Jacobs Engineering, 1999)
12 identifying several potential HTRW and OE sites was prepared. All OE sites have
13 been investigated under the EE/CA program. All other sites identified in the
14 report will be addressed under the CERCLA program. Should OE be
15 encountered during the HTRW investigation, the site will be evaluated, and
16 appropriate risk reduction measures will be employed.

2.0 SITE CHARACTERIZATION

This section provides a summary of background information for the Former Benicia Arsenal including location, historical background, existing facilities and future land uses, regional geology, and both biological and cultural resources. Information regarding military operations at the Former Benicia Arsenal was obtained primarily from data presented in the *Archives Search Report Findings, Benicia Arsenal, Benicia, Solano County, California* (U.S. Army Corps of Engineers, St. Louis District, 1994a); *Archives Search Report Conclusions and Recommendations, Benicia Arsenal, Benicia, Solano County, California* (U.S. Army Corps of Engineers, St. Louis District, 1994b), *Supplement to the March 1994 Archives Search Report for Benicia Arsenal, Benicia, Solano County, California* (U.S. Army Corps of Engineers, St. Louis District, 1997); *Draft Environmental Assessment, Benicia Arsenal Site Investigation, Benicia, California* (U.S. Army Corps of Engineers, Sacramento District, 1997); and *Final Benicia Arsenal Records Research Report* (Jacobs Engineering, 1999).

2.1 SITE DESCRIPTION AND BACKGROUND

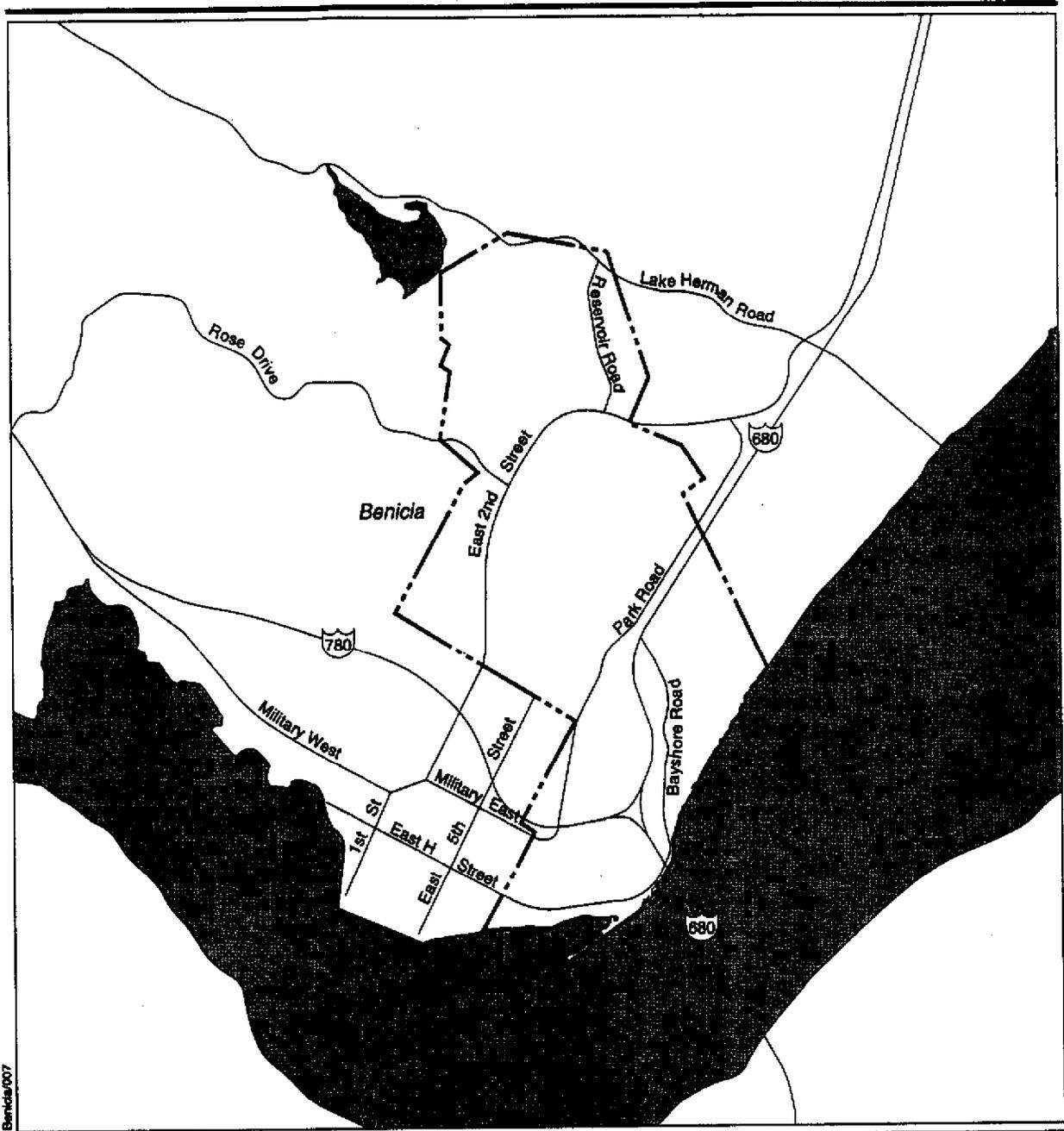
2.1.1 Location of Former Benicia Arsenal

The Former Benicia Arsenal is in the city of Benicia, Solano County, California, approximately 25 miles northeast of San Francisco (see Figure 1-1). Benicia is built on a peninsula of land that reaches south from the main body of Solano County and creates a prominent bend in the Carquinez Strait. Although part of Solano County, Benicia is closely linked to Contra Costa County across the Strait. The former arsenal is bordered by downtown Benicia and the Carquinez Strait to the south, Suisun Bay to the east, and residential neighborhoods to the west. The property consists of approximately 2,728 acres extending from the Carquinez Strait and marshland along the southern portion of the site to rolling hills in the northern portion (Figure 2-1).

To facilitate the field investigation, five sectors (Figure 2-2) were developed in order to use the OECert (QuantiTech, Inc., 1995) program. For investigation purposes, Sector 3 was divided into three subsectors: 3A, 3B, and 3C. The rationale for selecting sector boundaries includes different prior, current, or potential future land use than surrounding property, in addition to specific activities related to each sector. A total of 131 grids (i.e., 100- by 100-foot areas of investigation) were selected for the field investigation. Of these, 104 grids were investigated. Twenty-seven grids were not sampled for various reasons (i.e., no right-of-entry, steep terrain). These included additional grids randomly placed throughout each of the five sectors in order to increase the confidence of the OE risk analysis.

2.1.2 History of the Former Benicia Arsenal

The Former Benicia Arsenal began as the Benicia Barracks in 1849. Soon after, the California Ordnance Depot was established on land adjoining the Barracks to



Benicia/007

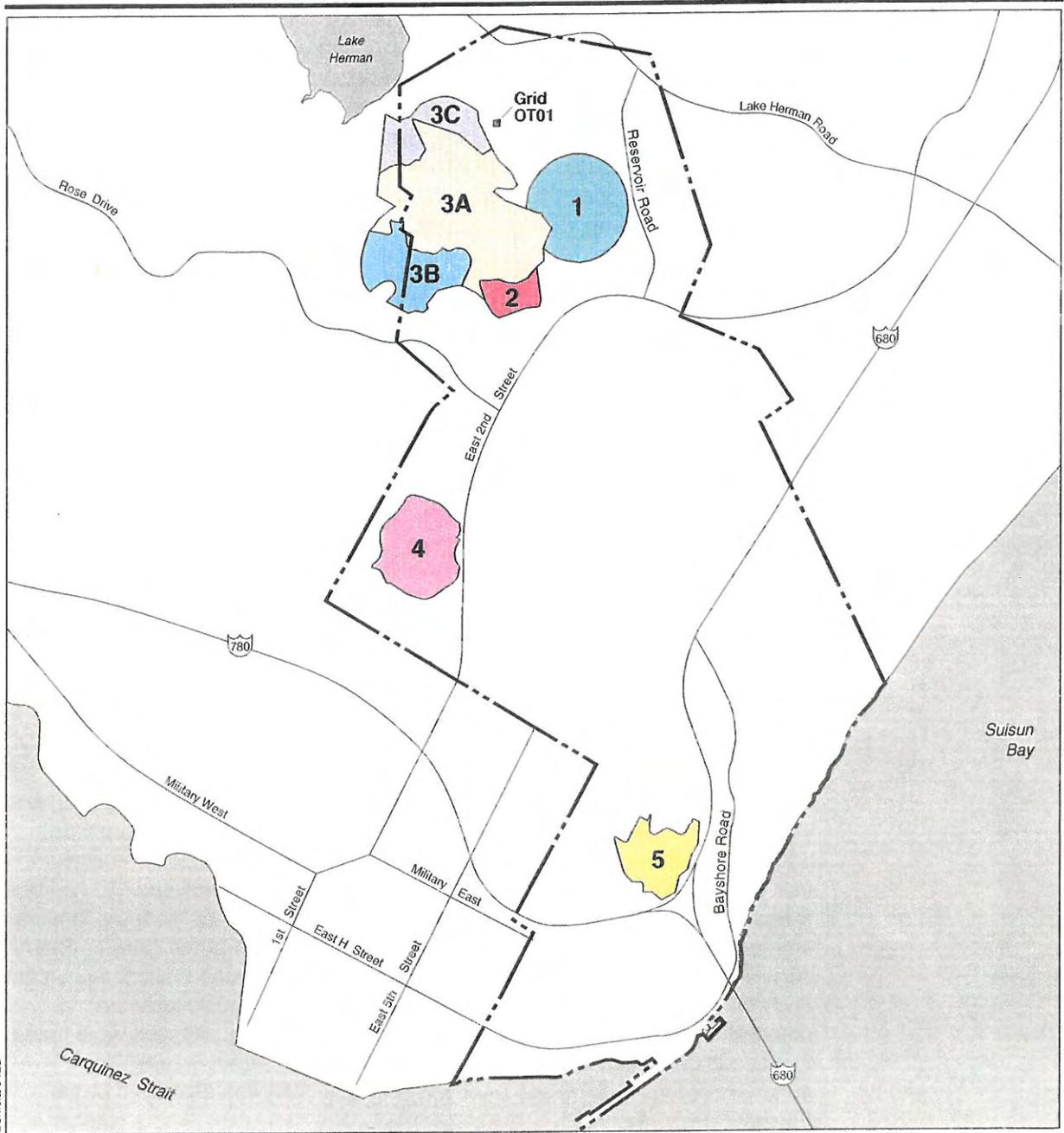
EXPLANATION

-  Interstate Highway
-  Former Benicia Arsenal Boundary (estimated)

Site Location of Former Benicia Arsenal



Figure 2-1



EXPLANATION

- Sector 1 Revetment Area (68 acres)
- Sector 2 Artillery Test Area (15 acres)
- Sector 3A Tourtelot Property (131 acres)
- Sector 3B Tourtelot Property (47 acres)
- Sector 3C City Property Adjacent to Tourtelot Property (34 acres)
- Sector 4 Demolition Site on Exxon Property (54 acres)
- Sector 5 Camel Barn Area (35 acres)
- Grid OT01 Overturned Truck Area (0.23 acre)

- Interstate Highway
- Former Benicia Arsenal Boundary (estimated)



Former Benicia Arsenal Sectors

Figure 2-2

1 the east. The United States acquired a total of 2,728 acres for the Benicia
2 Arsenal between 1849 and 1958. Leases for 575 acres were terminated between
3 1945 and 1960. In 1962, the Benicia Arsenal was declared excess by the
4 Department of Defense and was reported to the General Services Administration
5 (GSA), which immediately reported 361 acres of public domain/license/easement/
6 lease property as excess. From 1964 to 1965, 1.33 acres of public domain
7 property was reassigned to the Benicia Arsenal Cemetery, and the city of Benicia
8 received the remaining 1,790 acres through GSA quitclaim deeds.
9

10 The Former Benicia Arsenal supplied arms to arsenals along the Atlantic coast
11 during the Civil War. In 1898, supplies of ordnance were shipped from Benicia to
12 the Philippines during the Spanish-American War.
13

14 By the early 1900s, the Former Benicia Arsenal was manufacturing targets for
15 seacoast, field, and mobile artillery firing practice. In addition, the arsenal
16 assembled powder charges and rapid-fire ammunition, and filled armor-piercing
17 projectiles with high explosives. In 1912, a fire devastated Storehouse 29,
18 igniting 15 million rounds of small arms ammunition, 34,000 rifles, and other
19 supplies. In 1922, another notable fire occurred when a spark ignited powder on
20 the ground at the Benicia Barracks, destroying a powder magazine and some
21 nearby living quarters.
22

23 During World War I, the Former Benicia Arsenal supplied Pacific Army posts and
24 serviced weaponry destined for Europe. In 1924, the Benicia Barracks and
25 Benicia Arsenal were combined into one entity, which was referred to as the
26 Benicia Arsenal Reservation.
27

28 World War II was a time of great expansion at the Former Benicia Arsenal. An
29 additional 1,847 acres of land were acquired, and construction of more than
30 200 structures took place. A deepwater concrete wharf, capable of docking up to
31 four ships simultaneously, was built. Other improvements included 109 concrete
32 igloos for ammunition storage, warehouses, and extension of rail spurs into the
33 ammunition and industrial areas. Following the war, the Former Benicia Arsenal
34 served as a reclamation center, receiving unused arms, ammunition, equipment,
35 and other supplies. Much of the material returned required servicing in
36 preparation for sale as salvage, or to be placed in storage. Repairs were made to
37 thousands of handguns, machine guns, and artillery pieces. In addition,
38 hundreds of tons of damaged or obsolete ammunition was destroyed by the
39 Former Benicia Arsenal.
40

41 More expansion took place prior to and following the Korean Conflict. New
42 structures included warehouses and transitory storage shelters. During this time,
43 the nearby Stockton Ordnance Depot was decommissioned and its operations
44 were transferred to the Former Benicia Arsenal. Supplies and materials from
45 Stockton, coupled with incoming shipments destined for Korea and existing
46 supplies returned from World War II, flooded Benicia. Open fields had to be used
47 to contain the abundance of supplies as there were not enough structures to
48 store everything. At the end of the Korean Conflict, 21 ships loaded with
49 unserviceable, obsolete, and surplus supplies headed to the Former Benicia
50 Arsenal.

1 As part of the Cold War build-up, the Former Benicia Arsenal began
2 reconditioning NIKE guided missiles in 1954. Two NIKE test sites were situated
3 in the northwest portion of the arsenal. In addition, NIKE launch racks were
4 situated throughout the arsenal's hills. By 1958, operations at the arsenal slowed,
5 and the Small Arms Shop was shut down. The following year, most World War II
6 surplus supplies were sold or transferred. In 1961, DOD announced that it
7 planned to decommission the Benicia Arsenal and transfer its operations to
8 Tooele Ordnance Depot in Utah. By 1962, Tooele had already assumed most of
9 the mission elements that were being conducted at Benicia. Final closure of the
10 Benicia Arsenal occurred in 1964 (Jacobs Engineering, 1999).

11 12 **2.1.3 History, Description, and Investigation Area of Individual Ordnance** 13 **Sites within the Former Benicia Arsenal**

14
15 According to historical documents, there are approximately 15 areas of OE
16 interest (Figure 2-3) identified within the Former Benicia Arsenal. These areas
17 include the following: Historical Ordnance Storage Bunkers, Igloo Storage
18 Bunkers, Demolition Area/Firing Range on Exxon Property, Revetment Area,
19 Artillery Testing Area, Howitzer Test Area, Modified Cistern, chemical warfare
20 material (CWM) Storage Igloos, Dunnage Burn Area, Fill Sites, Demolition Area
21 on Tourtelot Property, Small Arms Range, Small Arms Ammunition Disposal
22 Structure, Primer Disposal Area, and the Overturned Truck Area. No other areas
23 were identified.

24 25 **2.1.3.1 Sites Requiring No Further Evaluation.**

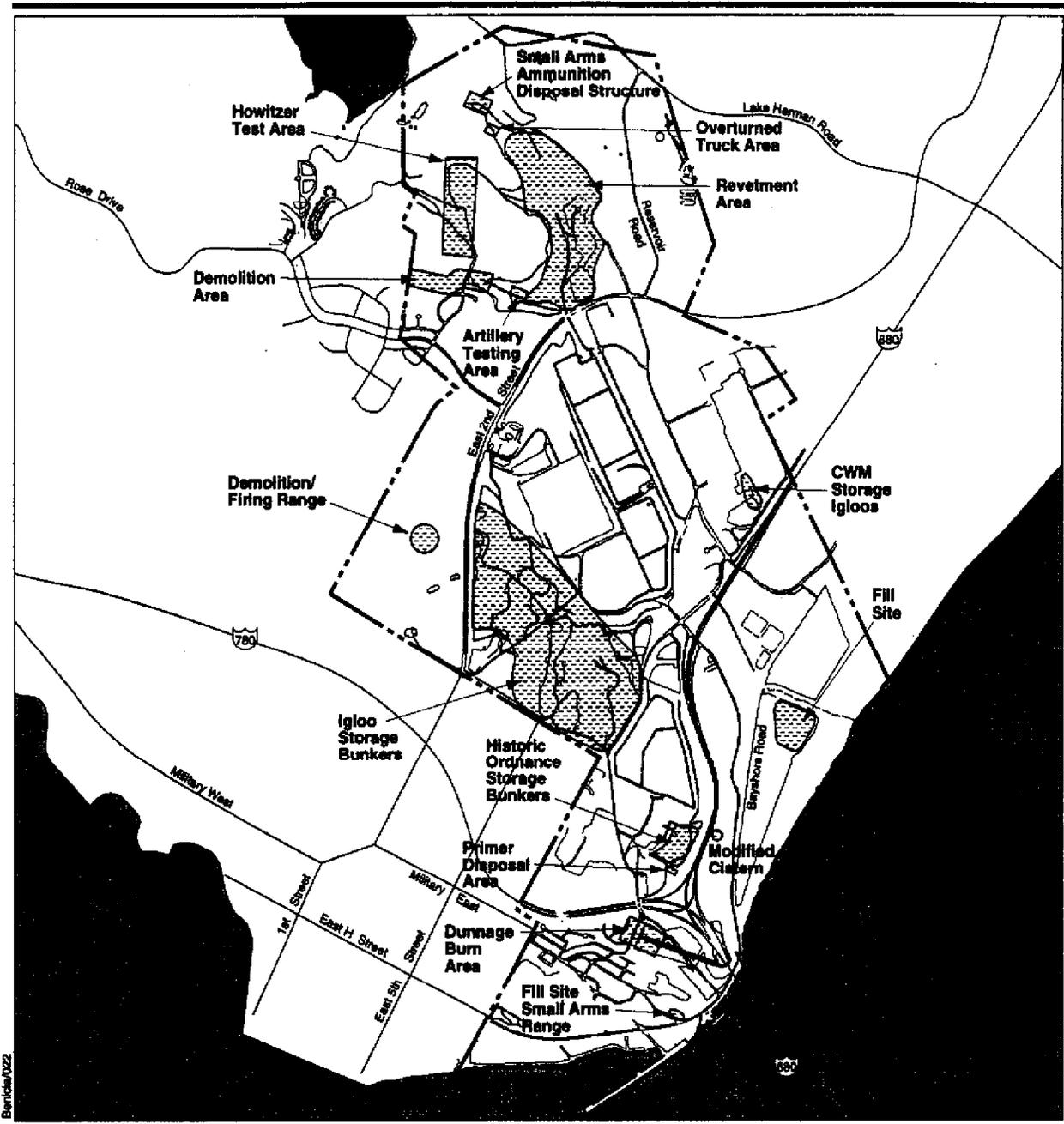
26
27 Several of the individual sites of OE interest mentioned in the previous subsection
28 were determined not to require further study based on records review and site
29 inspection. These areas included the following: CWM Storage Igloos, Igloo
30 Storage Bunkers, Modified Cistern, Dunnage Burn Area, Fill Sites, Small Arms
31 Range, Small Arms Ammunition Disposal Structure, and the Primer Disposal
32 Area. The following subsections provide a description of each site and the
33 reasons they were determined not to require further study.

34 35 **2.1.3.1.1 CWM Storage Igloos.**

36
37 It is uncertain exactly which two igloos stored the CWM; however, an outdoor
38 storage location believed to have been used for CWM was situated between
39 igloos D512 and D513. These igloos were destroyed during development of the
40 Benicia Industries industrial park. No CWM was found when the igloos were
41 destroyed, or during the initial site visits for the Archives Search Report (ASR).
42 Additionally, the area suspected to have stored CWM is newly paved. Therefore,
43 this area was not included in the EE/CA field investigation.

44 45 **2.1.3.1.2 Igloo Storage Bunkers.**

46
47 The Igloo Storage Area is defined as Area 2 in the ASR and is referred to as
48 Area S in the Records Research Report. The area consists of 23 ordnance
49 storage bunkers remaining on Exxon property. Of the 78 bunkers that were once
50 in this area, only 23 remain, and they are west of the main refinery. The others
51 were destroyed during the construction of the oil refinery.



Benicia/022

EXPLANATION

-  Activity Areas
-  Interstate Highway
-  Former Benicia Arsenal Boundary (estimated)

**Former Benicia Arsenal
Historical Activities**



Figure 2-3

1 Various types of ordnance was stored in these igloos, including propelling
2 charges and possible components for NIKE missiles. Also within this area was a
3 test track and a tank repair facility. The test track was used from approximately
4 1955 to 1964. NIKE missile sites were also situated in this area during the mid-
5 1950s. The NIKE missile sites and the test track are in an area west of the
6 refinery (i.e., near the remaining 23 igloos) that remains largely undisturbed since
7 the depot closed in 1964.
8

9 During the site visit conducted for the ASR, most of these igloos were inspected,
10 and no evidence of ordnance was observed. The Records Research Report
11 indicated that there may have been three possible burn/disposal areas between
12 igloos A211 and A215, along with a structure similar to a burn cage. The
13 burn/disposal areas were identified through review of historical aerial photos.
14 Currently, the remaining igloos are used for storage by Exxon. Because this area
15 has been inspected thoroughly and contains little or no evidence of ordnance
16 disposal activities, it was not included in the EE/CA field investigation.
17

18 **2.1.3.1.3 Modified Cistern.**

19 The modified cistern is referred to as Area 6 in the ASR and is included in the
20 discussion for Area M in the Records Research Report. It is the location of a
21 former cistern that was converted to a CWM storage magazine in 1926 (Jacobs
22 Engineering, 1999). Eventually, the cistern became Magazine #12 and was used
23 for pyrotechnic storage. Construction of Interstate Highway (I)-680 destroyed the
24 former cistern/magazine. Because no evidence of the cistern remains, this area
25 was not included in the EE/CA field investigation.
26

27 **2.1.3.1.4 Dunnage Burn Area.**

28 The Dunnage Burn Area is referred to as Area 8 in the ASR and was used to burn
29 dunnage, or wooden shipping material. This area is now an open field. Because
30 no evidence of OE has been identified here, this area was not included in the
31 EE/CA field investigation.
32

33 **2.1.3.1.5 Fill Sites.**

34 There were as many as five possible fill sites/quarries at the former arsenal. The
35 ASR supplement refers to two fill sites, Area 9, west of the Clock Tower in a open
36 field, and Area 10, adjacent to Suisun Bay just west of the discharge point for the
37 drainage channel. The Area 10 fill site is currently paved and used for storage of
38 new cars for the Toyota Motor Corporation.
39

40 The Records Research Report indicates an additional landfill/fill site near Former
41 Building #71. Benicia Industries destroyed Building #71 in the 1980s with no
42 reports of UXO being encountered. There are several old rock quarries at the
43 arsenal. It was common practice at the time these quarries were closed to use
44 them as landfills. Most of the quarries were destroyed during the development of
45 the industrial park with no reports of UXO being encountered. Because little
46 evidence of OE disposal has been identified, these areas were not included in the
47 EE/CA field investigation.
48
49
50

1 **2.1.3.1.6 Small Arms Range.**

2
3 The Small Arms Range was about 500 yards long and is identified as a small
4 arms firing range on a 1918 drawing. The construction of I-780 destroyed the
5 target berm. The area around the firing house later became part of the Dunnage
6 Burn Area and is now a paved parking lot. Its use is believed to have been
7 limited to small arms, and it contains no evidence of OE. Consequently, this area
8 was not included in the EE/CA field investigation.

9
10 **2.1.3.1.7 Small Arms Ammunition Disposal Structure.**

11
12 The Small Arms Ammunition Disposal Structure is referred to as Area 15 in the
13 ASR Supplement. The site, which is situated at the north end of the former patrol
14 road in the Revetment Area, has been described by former arsenal employees as
15 a special structure constructed for the disposal of small arms ammunition. The
16 available historical aerial photos were reviewed, and no structures and/or
17 disturbed ground were identified. During the EE/CA site visit, the area was
18 inspected and no evidence of a structure was noted. Its use is believed to have
19 been limited to small arms, and it contains no evidence of OE. Consequently, this
20 area was not included in the EE/CA field investigation.

21
22 **2.1.3.1.8 Primer Disposal Area.**

23
24 The Primer Disposal Area was described by a former employee as a steep ravine
25 approximately 150 feet east of Building 10 and about 800 feet east of the Camel
26 Barns (U.S. Army Corps of Engineers, St. Louis District, 1997). If this location is
27 correct, the area has been filled in with soil. However, the Records Research
28 Report indicates that a much larger ravine, associated with Sandstone Quarry #2,
29 is a more likely location. By 1973, the ravine associated with the quarry had been
30 leveled as a result of the freeway construction (Jacobs Engineering, 1999).
31 Because no evidence of OE has been identified in these areas and the probable
32 site locations have been filled in, the possible locations for the Primer Disposal
33 Area were not included in the EE/CA field investigation.

34
35 **2.1.3.2 Areas Investigated in the EE/CA.**

36
37 Based on the risk analysis approach (see Section 2.4), topography, and
38 anticipated future development within the Former Benicia Arsenal, the remaining
39 areas were grouped into five sampling areas (sectors). Within each sector, a
40 series of grids (100- by 100-foot areas) were randomly placed using the statistical
41 sampling tool SiteStats (see Section 2.4). The SiteStats program provides a
42 minimum to maximum number of grids to be sampled to characterize a sector.
43 For this EE/CA investigation, the maximum number of grids was initially selected
44 for each sector.

45
46 The majority of the grids were randomly placed. Some grids were strategically
47 placed in some of the sectors in order to avoid structural features (i.e., buildings,
48 roads, fences, paved areas), steep terrain, and potentially sensitive habitat areas
49 such as drainages. Grids were also strategically placed in areas of known OE
50 use, such as the Howitzer Test Area and the Demolition Area (see Figure 2-3). In

1 addition to the five sectors, a 100- by 100-foot grid was strategically placed in the
 2 area referred to as the Overturned Truck Area.
 3

4 The following sections provide descriptions of each of the five sectors and the
 5 Overturned Truck Area within the Former Benicia Arsenal (see Figure 2-2).
 6 Table 2-1 provides a brief description of each sector. The oversized map
 7 (Plate 1) at the end of Chapter 2.0 provides detailed locations of sector
 8 boundaries, grid locations, and other pertinent area features.
 9
 10

Table 2-1. Former Benicia Arsenal Sector Summary

Sector Number	Sector Name	Total Size (acres)	Investigation Area (acres)	Grid Size ^(c) (acres)	Number of Grids Sampled for OE
1	Revetment Area	68	5.52	0.23	24
2	Artillery Test Area	15	0.23	0.23	1 ^(a)
3A	Tourtlot Property	131	4.82	0.23	21
3B	Tourtlot Property	47	2.30	0.23	10
3C	City Property Adjacent to Tourtelot Property	34	1.84	0.23	8
4	Demolition Site on Exxon Property	54	4.59	0.23	20
5	Camel Barn Area	35	4.59	0.23	20
Grid OT01 ^(b)	Overturned Truck Area	0.23	--	0.23	--
Total		384.23	23.89	--	104

Notes: (a) Sampling results include only those for Grid 0202.
 (b) OE sampling was not performed because right-of-entry could not be granted.
 (c) 0.23 acre equals 10,000 square feet (100- by 100-foot grids).

11
 12
 13 **2.1.3.3 Sector 1: Revetment Area.**
 14

15 **History.** The Revetment Area has been identified on historical maps as the
 16 explosives holding yard. The area was designed to control or contain any
 17 damage from explosions, and its features included seven railroad spurs, a
 18 perimeter road around the railroad tracks, burn cages, and drainage channels.
 19 Ammunition was piled throughout the Revetment Area during 1946 and 1947.
 20 According to eye witness accounts from former arsenal employees, a fire burned
 21 in the Revetment Area (see Figure 2-3) in 1946 or 1947. The 12-hour-long fire
 22 exploded countless rounds of .50 caliber ammunition and scattered shell casings
 23 throughout the Revetment Area (Jacobs Engineering, 1999).
 24

25 **Description.** Sector 1 consists of a total of 68 acres and is in the north-central
 26 area of the Former Benicia Arsenal (see Figure 2-2). The sector is relatively flat
 27 and is characterized by short grasslands (Photograph 2-1), buildings, roads,
 28 fences, and paved areas.
 29

30 **Investigation Area.** For investigation purposes, 32 grids totaling 7.35 acres
 31 were randomly placed throughout the sector. During the field investigation, 7 of
 32 the 32 grids were unable to be sampled for OE because right-of-entry could not

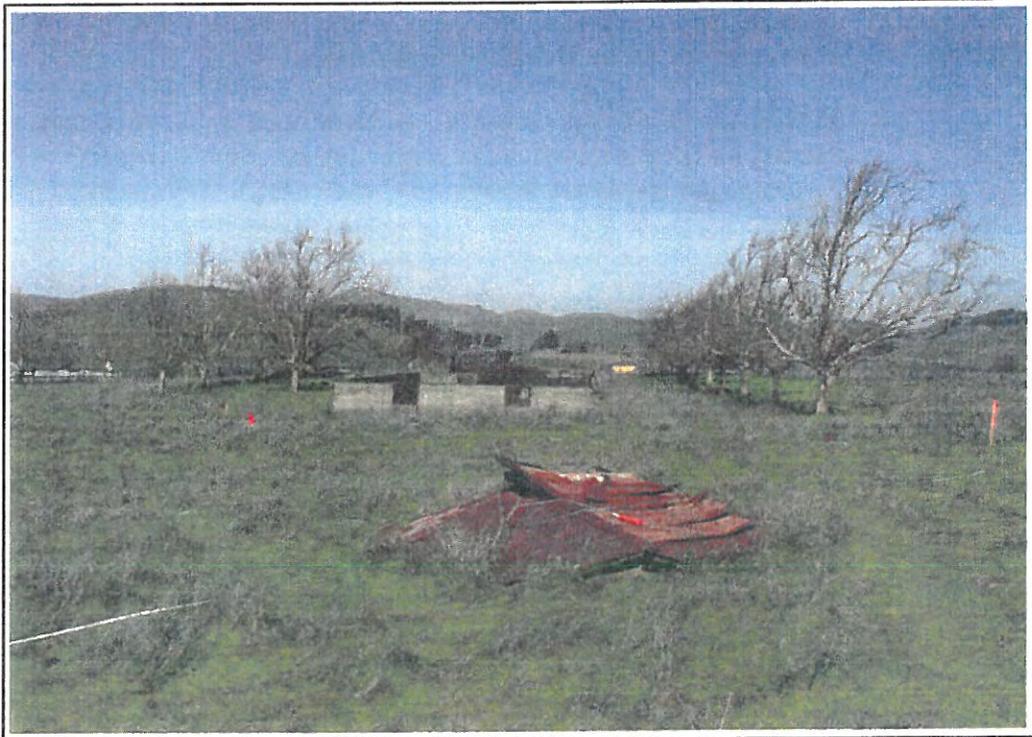


Photo 2-1. Sector 1 - Revetment Area.



Photo 2-2. Sector 2 -Artillery Test Area.

1 be granted. One additional grid was unable to be sampled for OE due to steep
2 terrain. The locations of grids contained in Sector 1 are shown on Plate 1.
3

4 **2.1.3.4 Sector 2: Artillery Testing Area.** 5

6 **History.** The Artillery Testing area is reported to have been at the west end of
7 Spur A of the Revetment Area (Jacobs Engineering, 1999). The impact point was
8 to the west of the area at the top of a steep drainage (see Figure 2-3).
9

10 Based on review of available historical aerial photographs (1945, 1947, 1952,
11 1962), the actual location of the firing point and/or impact point for the artillery
12 testing area could not be specifically determined. The Final Records Research
13 Report indicated that only the firing mechanisms for the artillery rounds were
14 tested in the area. The report also stated that the rounds were fired into a berm.
15

16 **Description.** Sector 2 consists of a total of 15 acres and is situated in the north-
17 central area of the Former Benicia Arsenal (see Figure 2-2). The sector
18 boundaries are defined by West Channel Road to the southeast, the McAllister
19 Land Bridge to the west, the Sector 3 boundary to the north, and the top of the
20 valley to the south. The majority of the sector is undeveloped and is
21 characterized by steep terrain and scattered trees (Photograph 2-2).
22

23 **Investigation Area.** OE sampling was performed in only one of the 17 grids
24 (0.23 acre) in Sector 2. Right-of-entry could not be obtained during the EE/CA
25 field investigation for the remaining 16 grids. The locations of grids contained in
26 Sector 2 are shown on Plate 1. After sampling crews demobilized from the site,
27 right-of-entry was granted for the remaining areas. A site visit was conducted to
28 determine the location of the test area. No physical evidence on the ground
29 surface was noted during the site visit which would indicate the location of the
30 firing or impact points for the test area.
31

32 **2.1.3.5 Sector 3: Tourtelot Property and City Property Adjacent to** 33 **Tourtelot Property.** 34

35 **History.** According to the ASR, this area (and surrounding potential "kick out"
36 area) contains a number of different sites, including the Howitzer Test Area, the
37 Primer Destruction Area, the Dynamite Burn Area, the Ammunition Renovation
38 Area, and the Demolition Area (see Figure 2-3). It also includes part of the
39 potential range for the Artillery Test Area.
40

41 **Description.** For analysis purposes, Sector 3 was divided into three subsectors
42 (3A, 3B, and 3C), which are situated in the northwestern section of the Former
43 Benicia Arsenal. The Sector 3 boundary is irregularly shaped and is generally
44 defined to the south and west by existing homes and graded building pads. The
45 northern boundary roughly coincides with the former lease boundary of the
46 arsenal. The south and east boundaries follow the former lease/army owned land
47 property boundary (Tourtelot Property Boundary). Sector 3A is generally marked
48 by steep terrain and was developed as a subsector based on future land use
49 (residential). Sector 3B is southwest of Sector 3A and is adjacent to residential
50 homes in the area (Photograph 2-3). Sector 3B was developed based on future

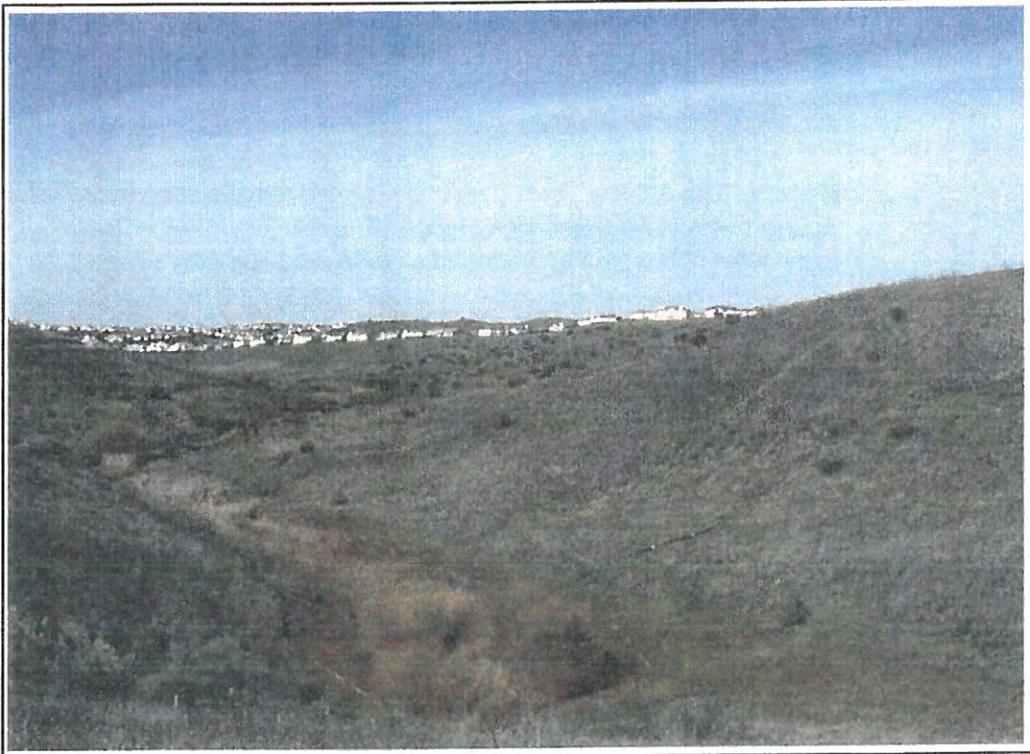


Photo 2-3. Sector 3 - Tourtelot Property.



Photo 2-4. Sector 5 - Camel Barn Area.

1 land use (open space) and past land use (demolition area). Sector 3C is north of
2 Sector 3A and 3B and is characterized by rolling hills and grasslands. Sector 3C
3 was developed based on current and future land use (open space).
4

5 **Investigation Area.** Sector 3A (131 acres) consists of 21 grids totaling
6 4.82 acres. Sector 3B (47 acres) consists of 10 grids totaling 2.30 acres.
7 Sector 3C (34 acres) consists of 8 grids totaling 1.84 acres. All of the grids were
8 sampled for OE within each subsector. A majority of the grids were randomly
9 placed throughout each subsector. Some grid locations were strategically
10 selected in areas of known OE use, such as the Howitzer Test Area and the
11 Demolition Area (see Figure 2-3); other grid locations have been selected to
12 cover suspected trench or burial locations. Grids for each subsector are shown
13 on Plate 1.
14

15 **2.1.3.6 Sector 4: Demolition Site on Exxon Property.**

16 **History.** A 1942 map of the arsenal identified this site as a demolition area.
17 However, a former arsenal employee and a 1956 drawing of the base indicated
18 that this area was used as a firing range (U.S. Army Corps of Engineers, St. Louis
19 District, 1997). The design and location of the area are consistent with those of a
20 demolition area. A service road from the ordnance storage igloos east of the
21 area continues across East 2nd Street and leads directly to this area, further
22 indicating that the area may have been used as a demolition site.
23
24

25 **Between 1945 and 1952, various berms and/or trenches were constructed on the**
26 **north and south sides of the area. Neither the road leading to the demolition site**
27 **nor the site itself was paved until after 1952. A 1957 aerial photograph shows the**
28 **area as paved with a berm constructed at the west end of the circular area.**
29 **Currently, the area is paved, with encroaching vegetation.**
30

31 **Description.** Sector 4 consists of a total of 54 acres and is situated in the west-
32 **central area of the Former Benicia Arsenal (see Figure 2-2). The sector**
33 **boundaries are irregularly shaped and were selected based on topography. The**
34 **sector lies in the center of an undeveloped parcel of land owned by Exxon. The**
35 **parcel boundary is defined by East 2nd Street to the east, residential homes to**
36 **the west and north, and Rose Drive to the northeast. The sector is characterized**
37 **by steep terrain and scattered trees. The suspected demolition site is easily**
38 **identified by a circular paved area at the end of an abandoned road leading from**
39 **the former igloo storage area.**
40

41 **Investigation Area.** For investigation purposes, 22 grids totaling 5.05 acres
42 were both randomly and strategically placed (in order to avoid steep terrain and
43 potential sensitive habitat areas) throughout the sector. During the field
44 investigation, 2 of the 22 grids were unable to be sampled for OE because of
45 steep terrain. The locations of grids contained in Sector 4 are shown on Plate 1.
46

47 **2.1.3.7 Sector 5: Camel Barn Area.**

48 **History.** The general area surrounding the Camel Barn Museum is suspected to
49 have OE remaining either near the surface or potentially buried as a result of the
50

1 1922 fire that burned through the arsenal. The fire completely destroyed at least
2 one magazine (Magazine #1). No records of an organized clearance of the area
3 after the fire were documented. During the construction of Open Storage (OS) 25
4 and OS 25A (now paved open storage areas north of the museum),
5 approximately 6-7 tons of ordnance were recovered from a trench presumably
6 dug and filled with OE after the 1922 fire. The area also lies within the "kick out"
7 area for the primer destruction facility presumably destroyed during the
8 construction of I-780.
9

10 **Description.** Sector 5 consists of a total of 35 acres and is situated in the south-
11 central portion of the Former Benicia Arsenal. The sector lies directly north of the
12 I-680 and I-780 freeway interchange (see Figure 2-2) and is characterized by
13 rolling hills, grasslands, and scattered trees, with several buildings situated
14 primarily in the central area of the site. The Camel Barn Museum, the main point-
15 of-interest in Sector 5, is accompanied by a parking lot and surrounding
16 structures (Photograph 2-4).
17

18 **Investigation Area.** For investigation purposes, 20 grids totaling 4.59 acres
19 were sampled for OE within this sector. The grids were both randomly and
20 strategically placed throughout the sector (in order to avoid buildings, roads, and
21 paved areas). The grids are shown on Plate 1.
22

23 **2.1.3.8 Grid OT01: Overturned Truck Area.**

24

25 **History.** In 1948, a truck loaded with small arms ammunition experienced brake
26 failure, lost control, and careened off the hillside at the north end of the
27 Revetment Area (see Figure 2-3) along the former patrol road. Ammunition that
28 appeared to be damaged is believed to have been left behind or buried in this
29 area (Jacobs Engineering, 1999).
30

31 **Description.** The overturned truck area is in the northernmost area of the
32 Former Benicia Arsenal (see Figure 2-2) and can be described as a steep hillside
33 characterized by grasslands. There are no trees or structures near the area
34 suspected to be the location of the overturned truck.
35

36 **Investigation Area.** A 100- by 100-foot grid (Grid OT01) was strategically placed
37 in the area suspected to have been the site of the overturned truck. Grid OT01
38 (0.23 acre) was unable to be sampled for OE during the field investigation
39 because right-of-entry could not be obtained.
40

41 **2.1.4 Current and Future Land Use**

42

43 The existing and future land uses for the Former Benicia Arsenal are reported in
44 the *Institutional Analysis Report, Former Benicia Arsenal, Benicia, California*
45 (Earth Tech, 1999), provided in Appendix E. A summary of existing facilities and
46 land use is provided in the following subsections.

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2.1.4.1 Site Access and Roads.

Current policy regarding use of roads and trails at the Former Benicia Arsenal is primarily dependent upon ownership of individual properties and current use. Both paved and unpaved roads can be found throughout the arsenal. Generally, roads that access developed areas within the Former Benicia Arsenal are paved and unrestricted. Roads that access undeveloped areas within the Former Benicia Arsenal are generally unpaved, restricted by locking gates, and can be accessed only by private landowners.

Access to the Former Benicia Arsenal is provided through several road entrances and is served by a simple road network (Figure 2-4). Site access to the southern area of the Former Benicia Arsenal is easily obtained by a paved, marked road allowing direct access to the Camel Barn Museum and surrounding points of interest (i.e., historical markers). East 2nd Street is a north-south-trending paved road providing access to the site from the south. Military East Road is an east-west paved road providing access to the site from the west.

2.1.4.2 Existing Facilities.

There are several facilities currently in use within the Former Benicia Arsenal. These include the Camel Barn Museum, an industrial park, an oil refinery, a shipping/manufacturing area, residential housing, and numerous historic buildings (i.e., clock tower) that were at one point part of the main center of operations for the Former Benicia Arsenal.

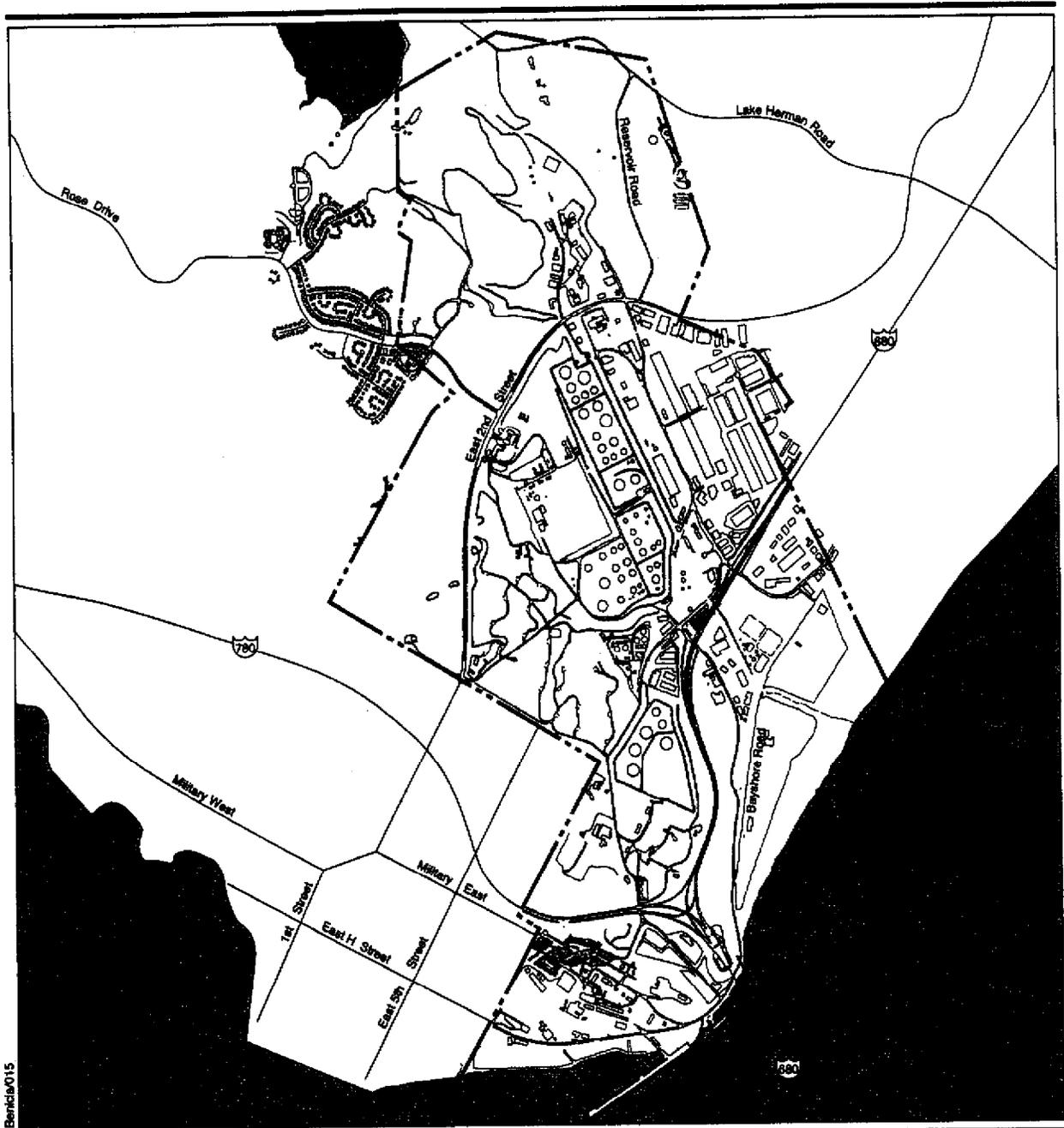
The Camel Barn Museum is in Sector 5 and draws public interest for its historic memorabilia relating to previous activities at the Former Benicia Arsenal. The sandstone buildings, now referred to as the Benicia Camel Barn Museum, were originally constructed as warehouses. The buildings gained their name and fame during a brief period in 1863-1864 when they were used to stable a herd of camels imported by the U.S. Army for transportation in the American desert.

The majority of the arsenal is developed as an industrial park. The southern area does have mixed use with residential areas intermittent with light industrial buildings. The northern portion of the arsenal is largely undeveloped and is generally used as open space.

2.1.4.3 Current and Future Land Use.

Future land use for the Former Benicia Arsenal (Figure 2-5) was developed from the city of Benicia's *Edited Draft General Plan* (November 1998).

Land use on the Former Benicia Arsenal is primarily industrial, with limited residential development in the northern portion of the site. Benicia Industries, Inc., owns a large portion of the former arsenal and maintains an industrial park throughout the central and southern portions of the property, including a port along the Carquinez Strait. Exxon Oil Company operates a refinery on approximately 400 acres.



Benicia015

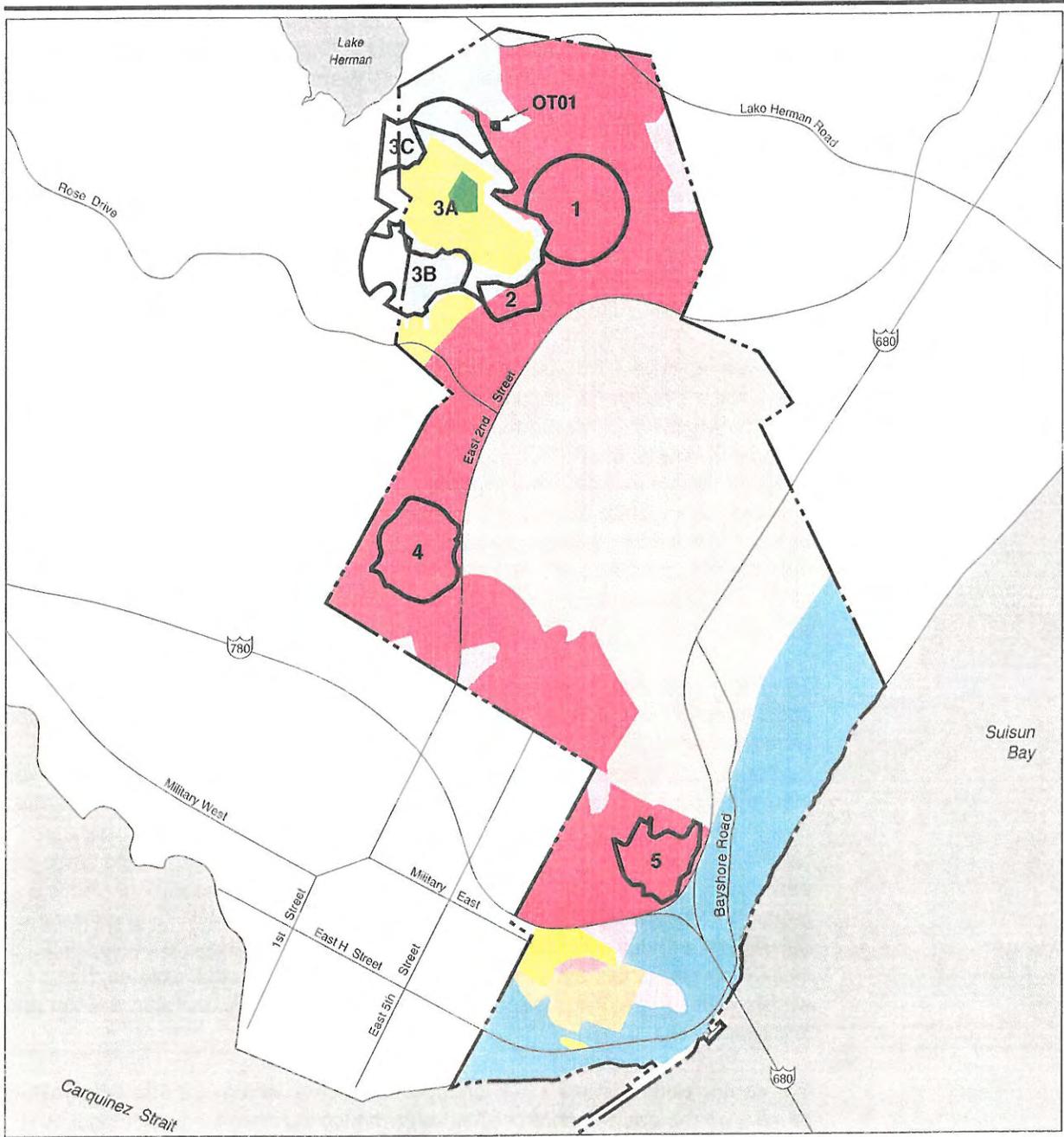
EXPLANATION

-  Interstate Highway
-  Former Benicia Arsenal Boundary (estimated)

**Site Access, Roads,
and Structures**



Figure 2-4



Benicia/011

EXPLANATION

- | | | |
|-------------------------------|-------------|---|
| Industrial/General | Residential | Interstate Highway |
| Industrial/Limited | Open Space | Former Benicia Arsenal Boundary (estimated) |
| Industrial/Waterfront Related | Parks | 5 Sector Number |
| Public/Quasi-Public | | |
| Mixed Use | | |



Source: City of Benicia, 1998. Edited Draft General Plan, November.

**Future Land Use
Former Benicia Arsenal**

Figure 2-5

1 Additional landowners of the Former Benicia Arsenal include the city of Benicia,
2 Pacific Gas and Electric, Granite Management Corporation, and numerous other
3 private, commercial, and residential parcels (Earth Tech, 1999).
4

5 Developed areas on the Former Benicia Arsenal are concentrated in the southern
6 and central portion of the property. Benicia Industries and the city of Benicia
7 occupy the southern portion of the site. This area is primarily used as a shipping
8 port, industrial warehousing, and for manufacturing; however, some residential,
9 commercial, and quasi-public land uses exist within the southern area. There are
10 single-family homes to the northwest, and new housing tracts are planned for the
11 northern portion of the property.
12

13 The area between I-780 and the water-related industrial lands is characterized by
14 older, historic buildings, and a multiplicity of uses and tenants, including studios,
15 small professional offices, and small industrial activities, such as cabinet making.
16 The lower arsenal mixed use area includes residential live/work, office, retail
17 development, churches, limited industrial, and general commercial uses. The city
18 proposes to increase the number and types of spaces available for living and
19 working to encourage a mix of compatible uses in areas of the Lower Arsenal to
20 promote the upgrading of existing buildings, the preservation and adaptive reuse
21 of historic buildings, and to allow new, compatible buildings to house mixed use
22 activities.
23

24 The Port of Benicia, which is leased to and partially owned by Benicia Industries,
25 specializes in the shipment of automobiles and petroleum products. These lands
26 were granted to the city by the state legislation in 1964 for uses that include a
27 harbor to accommodate and promote commerce and navigation, commercial and
28 industrial activities, transportation facilities related to commerce and navigation,
29 public buildings and facilities, recreation, fishing, and marinas and associated
30 facilities. The legislation provided that the city could lease the granted lands for
31 periods of up to 66 years for purposes consistent with the legislation. Benicia
32 Industries leased the entire arsenal port area in 1965 and in 1975 acquired the
33 upland port areas in fee. Long-term development in the port area is expected to
34 include port terminals and water-dependent, related industrial uses such as
35 warehousing and storage, support transportation services, and ship maintenance
36 and repair.
37

38 The central portion of the site is occupied by Exxon, which operates a petroleum
39 refinery on the eastern portion of the area, which is zoned for general industrial
40 use. The western portion of the Exxon property is currently vacant and zoned for
41 limited industrial. An open-space buffer approximately 200 feet wide is required
42 between the industrial area and residential land use to the east of the Former
43 Benicia Arsenal. Limited industrial land uses allowed in this area include
44 manufacturing, assembly, and packaging of goods primarily from previously
45 prepared materials; wholesale, distribution, and storage facilities; research and
46 development facilities; and related industrial and commercial services. The
47 western portion of the Exxon property, while zoned for limited industrial use, is
48 expected to remain vacant.

1 The northern portion of the site is primarily open space with some residential
2 housing. The area is zoned for limited industrial, public/quasi-public, parks, and
3 residential. A small portion of the northwest corner of the Former Benicia Arsenal
4 is used for single-family residential housing. The portion of the Former Benicia
5 Arsenal north of the Exxon Refinery is planned for limited industrial, residential,
6 open space, and parks. While there are no current plans to develop the limited
7 industrial area, the residential area is expected to be developed into single-family
8 housing units at a density of up to seven units per acre.
9

10 Based upon information presented in *the Institutional Analysis Report* (Earth
11 Tech, 1999), future land use for each sector was evaluated in terms of their
12 likelihood of involving public access and intrusive activities that would result in
13 excavation of the soil, thereby potentially exposing the public to UXO. The future
14 land use for each sector at the Former Benicia Arsenal can be described as
15 follows:
16

- 17 • Sector 1 (Revetment Area) - Limited Industrial
- 18 • Sector 2 (Artillery Testing Area) - Limited Industrial/Open Space
- 19 • Sector 3A (Tourtelot Property) - Residential/Parks/Open Space
- 20 • Sector 3B (Tourtelot Property) - Open Space
- 21 • Sector 3C (City Property Adjacent to Tourtelot Property) - Open
22 Space
- 23 • Sector 4 (Demolition Site on Exxon) - Limited Industrial
- 24 • Sector 5 (Camel Barn Area) - Limited Industrial

25 Although future land use for Sector 4 is designated as Light Industrial, the area is
26 currently undeveloped and may be considered as open space land use.
27 Currently, Exxon does not have any future development plans for the area.
28

29 **2.1.5 Meteorology**

30 The area climate is generally mild, moderated by the influence of the marine air.
31 Daytime temperatures typically range from 55 to 80 degrees (°) Fahrenheit (F) in
32 the summer and from 38°F to 53°F in the winter. Annual precipitation averages
33 16 inches. Most precipitation falls from October to April (average 15 inches).
34 During the summer, a marine wind blows eastward through the Carquinez Strait
35 with speeds ranging from 15 miles per hour (mph) in the morning to 25 mph in
36 the afternoon.
37

38 **2.1.6 Physiography and Topography**

39 The Former Benicia Arsenal lies along the eastern flank of the Coast Ranges
40 Geomorphic Province. The Sulphur Springs Mountains that begin at Benicia
41 stretch northwest and form a ridge defining the eastern flank of the Napa Valley.
42 The Carquinez Strait along the southern boundary of the arsenal is a submerged
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1 canyon cutting through the Coast Ranges formed by the ancestral flow of the
2 Sacramento and San Joaquin River drainages. The strait is a narrow, deep
3 channel cut simultaneously with the uplift and folding of the Coast Ranges. The
4 local topography at the arsenal varies from low-lying tidal flats on the east side to
5 rolling hills and steep drainages within the central portion of the Former Benicia
6 Arsenal. The elevation at the site varies from near sea level along the strait to the
7 957-foot summit of the Sulphur Springs Mountains in the northern portion of the
8 site.

9 10 **2.1.7 Surface Drainage**

11
12 The majority of the surface runoff within the Former Benicia Arsenal boundaries is
13 captured in a drainage channel that flows from north to south and discharges into
14 Suisun Bay. Most other smaller drainages on the arsenal flow southeast or
15 southwest into the main drainage channel. The low-lying area east of the Exxon
16 refinery along Industrial Way is subject to flooding during high runoff periods.

17 18 **2.1.8 Geology, Soils, and Hydrogeology**

19
20 The arsenal lies at the southern end of the Sulphur Springs Mountains, which
21 generally consist of lower Cretaceous-age (approximately 50-150 million years
22 old) marine siltstones and sandstones overlain by Plio-Pleistocene-age
23 (approximately 1 to 3 million-year-old) marine clays. Most of the valleys have a
24 sequence of older alluvium overlain by younger (recent deposits) alluvium. The
25 majority of the development at the arsenal has occurred in the valleys, and
26 various amounts of artificial fill cover the recent alluvial deposits. Where
27 undisturbed, the surface soil is silty organic clay, or pale brown to dark grayish-
28 brown clay. Soils mostly have low slope strength, low permeability, and high
29 runoff potential (California State Parks Service, 1991). Several surficial
30 landslides were noted in the steep drainage areas at the arsenal during the site
31 investigation.

32
33 The Plio-Pleistocene-age rocks (Merced Formation) are generally a light olive
34 brown to blue gray, silty, organic, fossiliferous (oyster-bearing) marine clay. The
35 alluvium on the arsenal postdates and overlies the Merced Formation (Norris and
36 Webb, 1990). A thin veneer of vertebrate, fossil-bearing alluvial gravels
37 (pediment) may be found at higher elevation overlying the Merced Formation; this
38 is sometimes referred to as the North Merced Gravel. The thickness of the
39 Merced Formation varies from a few inches to 40 feet throughout the arsenal
40 (Jacobs Engineering, 1999).

41
42 In the upland areas of the arsenal, bedrock outcrops may be present. The
43 bedrock consists of steeply dipping, fractured, marine siltstones, sandstones, and
44 shales of the Paleocene-age Martinez Formation and lower Cretaceous-age
45 Great Valley Sequence (Jacobs Engineering, 1999). These generally strike
46 northwest and dip west-southwest. The siltstones and sandstones are typically
47 tan to yellowish brown. Shale, where present, is red to reddish brown.

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2.1.9 Biological Resources

The Former Benicia Arsenal and surrounding areas support a number of biological resources. The following sections provide information pertaining to vegetation, wildlife, and sensitive species that occur on or near the arsenal.

2.1.9.1 Vegetation.

The Former Benicia Arsenal is characterized primarily by nonnative grasslands. Grazing has affected much of the native grassland, allowing nonnative species to invade and take over. Lake Herman and its drainage supports riparian vegetation and possibly some freshwater marsh habitat. The former arsenal boundary extends to the Carquinez Strait and Suisun Bay, which support coastal marsh habitat.

Grasslands. Much of the California grasslands has been impacted by agriculture, grazing, and development. The invasion of nonnative species in the resulting disturbed habitat is a common phenomenon. The Former Benicia Arsenal has not been excluded from these impacts. The grassland areas support primarily nonnative grasses that include wild oat (*Avena fatua*), riggut brome (*Bromus diandrus*), soft chess (*Bromus mollis*), and foxtail barley (*Hordeum jubatum*). Other nonnative, weedy invasive plant species such as wild radish (*Raphanus sativus*), fennel (*Foeniculum vulgare*), cheeseweed (*Marva parviflora*), and Italian thistle (*Carduus pycnocephalus*) are common on the Former Benicia Arsenal. Many of the annual wildflowers are native and include California wild poppy (*Eschscholzia californica*), various lupines (*Lupinus* spp.), and blue dicks (*Dichelostemma capitatum*) (U.S. Army Corps of Engineers, Sacramento District, 1997).

Willow Riparian Areas. The edges of Lake Herman, its drainage, and associated stream courses support willow riparian habitat. Trees and shrubs supported in this habitat include several willow species (*Salix* spp.), Fremont cottonwood (*Populus fremontii*), blackberry (*Rubus ursinus*) and wild rose (*Rosa* sp.). These areas, especially the understory, have also been impacted by grazing (U.S. Army Corps of Engineers, Sacramento District, 1997).

Coastal Marsh. This habitat is supported along the edges of Suisun Bay and Carquinez Straits, which is adjacent to the southeastern boundary of the Former Benicia Arsenal property. Coastal marsh areas provide habitat to many unique and sensitive plants in California. The brackish conditions of the water require plants to be able to tolerate a certain level of salinity. Plant species in these areas are generally grouped according to increasing elevations from the water level and the amount of inundation experienced by tidal fluctuations. Cordgrass (*Spartina* sp.) grows at the lowest elevations in the open-water habitat and is half-submerged much of the time. Pickleweed (*Salicornia* sp.) is the dominant plant of the mid-littoral zone and diked wetland areas. These succulent plants have only their roots submerged during the highest tides and store salty water in their tissues. This habitat is not within the EE/CA investigation area.

1 **2.1.9.2 Wildlife.**
2

3 Habitat for wildlife at the Former Benicia Arsenal includes urbanized areas,
4 nonnative grasslands, wetland and willow riparian areas, and coastal marshlands.
5

6 Urban areas at the arsenal have, in general, been greatly disturbed and often
7 support species associated with disturbance. Birds often use landscaped trees
8 and shrubs as cover for nest sites. Common species that utilize this manmade
9 habitat include American robin (*Turdus migratorius*), California ground squirrel
10 (*Spermophilus beecheyi*), and house mouse (*Mus musculus*). Some grassland
11 species such as the western fence lizard (*Sceloporus occidentalis*) and Pacific
12 gopher snake (*Pituophis melanoleucus catenifer*) may utilize edges of urban
13 areas.
14

15 Grasslands provide habitat for many mammals, reptiles, and birds. Small
16 animals, such as lesser gold finch (*Carduelis psaltria*), Bottae pocket gopher
17 (*Thomomys bottae*), and black-tailed jackrabbit (*Lepus californicus*) can be found
18 in these open areas. This prey base creates prime foraging habitat for many
19 raptors, including the black-shouldered kite (*Elanus caeruleus*), American kestrel
20 (*Falco sparverius*), and red-tailed hawk (*Buteo jamaicensis*). Mammalian
21 predators on the site include gray fox (*Urocyon cinereoargenteus*), long-tailed
22 weasel (*Mustela frenata*), and bobcat (*Lynx rufus*). Mule deer (*Odocoileus*
23 *hemionus*) are present on the site and may be hunted by mountain lions (*Felis*
24 *concolor*) in undeveloped regions.
25

26 Willow Riparian Areas. These riparian areas that follow stream courses provide
27 wildlife movement corridors through the area for the larger grassland mammals.
28 Neotropical migrant songbirds, such as the yellow-rumped warbler (*Dendroica*
29 *coronata*), can be found roosting in this vegetation as a stopover resting area.
30 The aquatic marshy areas provide habitat for the Pacific tree frog (*Hyla*
31 *cadaverina*), California newt (*Taricha torosa*), and western toad (*Bufo boreas*).
32

33 Wetlands occur in several areas of the Former Benicia Arsenal, including the
34 deep drainage that transects the demolition and artillery test areas. The upper
35 portion of the drainage leading from Lake Herman may also be considered as a
36 wetland.
37

38 **2.1.9.3 Sensitive Species.**
39

40 Table 2-2 lists threatened, sensitive, or special status species potentially
41 occurring at the Former Benicia Arsenal.
42

43 Area federally endangered species include the American peregrine falcon (*Falco*
44 *peregrinus anatum*), which may potentially forage over portions of the Former
45 Benicia Arsenal but does not appear likely to nest in the area due to lack of
46 suitable cliff sites. The California freshwater shrimp and callippe silverspot
47 butterfly are both listed as endangered. The callippe silverspot butterfly is
48 primarily found in native grassland but may occur on the arsenal property if its
49 larval foodplant, Johnny jump-up (*Viola pedunculata*), is present. Suitable habitat
50 for the California freshwater shrimp may occur on the northern portion of the

Table 2-2. Threatened, Endangered, and Candidate Species that may occur on or near the Former Benicia Arsenal

Common Name	Scientific Name	Federal Status	Habitat at Former Benicia Arsenal
Mammals			
Salt marsh harvest mouse	<i>Reithrodontomys raviventris</i>	E	No habitat within EE/CA area
San Joaquin Valley woodrat	<i>Neotoma fuscipes riparia</i>	C	Potentially occurring along streamside vegetation
Birds			
American peregrine falcon	<i>Falco peregrinus anatum</i>	E	May forage in grassland
California brown pelican	<i>Pelecanus occidentalis californicus</i>	E	No habitat within EE/CA area
California clapper rail	<i>Rallus longirostris obsoletus</i>	E	No habitat within EE/CA area
Western snowy plover	<i>Charadrius alexandrinus nivosus</i>	T	No habitat within EE/CA area
Bald eagle	<i>Haliaeetus leucocephalus</i>	T	May forage in grassland
Reptiles			
Alameda whipsnake	<i>Masticophis lateralis euryxanthus</i>	T	No habitat within EE/CA area
Giant garter snake	<i>Thamnophis couchii gigas</i>	T	Potentially occurring in drainages and swales
Amphibians			
California red-legged frog	<i>Rana aurora draytonii</i>	T	Potentially occurring in drainages and swales
California tiger salamander	<i>Ambystoma californiense</i>	C	Potentially occurring in swales
Fish			
Winter-run chinook salmon	<i>Oncorhynchus tshawytscha</i>	E	No fish habitat was disturbed by EE/CA activities
Winter-run chinook salmon critical habitat	<i>Oncorhynchus tshawytscha critical habitat</i>	E	No fish habitat was disturbed by EE/CA activities
Delta smelt	<i>Hypomesus transpacificus</i>	T	No fish habitat was disturbed by EE/CA activities
Delta smelt critical habitat	<i>Hypomesus transpacificus critical habitat</i>	T	No fish habitat was disturbed by EE/CA activities
Central Valley steelhead	<i>Oncorhynchus mykiss</i>	PE	No fish habitat was disturbed by EE/CA activities
Sacramento splittail	<i>Pogonichthys macrolepidotus</i>	PT	No fish habitat was disturbed by EE/CA activities
Invertebrates			
Callippe silverspot butterfly	<i>Speyeria callippe callippe</i>	E	Potentially occurring in grasslands containing Johnny jump-up plants
California freshwater shrimp	<i>Syncaris pacifica</i>	E	Potentially occurring in vernaly filled swales and pools
Vernal pool fairy shrimp	<i>Branchinecta lynchi</i>	T	Potentially occurring in vernaly filled swales and pools

C = candidate for listing
 E = endangered
 EE/CA = engineering evaluation/cost analysis
 PE = proposed endangered
 PT = proposed threatened
 T = threatened

1 arsenal in the vicinity of the riparian/marsh areas below Lake Herman. Federally
2 listed threatened species that may be present at the site include the California
3 red-legged frog (*Rana aurora draytonii*), giant garter snake (*Thamnophis couchii*
4 *gigas*), and the bald eagle (*Haliaeetus leucocephalus*). The Suisun Song
5 Sparrow (*Melospiza melodia maxillaris*) and black rail (*Laterallus jamaicensis*) are
6 both considered Species of Concern (SC) by the U.S. Fish and Wildlife Service
7 (USFWS).
8

9 **2.1.10 Cultural Resources**

10 This project has been coordinated with the CESPCK Project Archaeologist for the
11 Former Benicia Arsenal. Several of the historic arsenal buildings are protected
12 under the National Historic Preservation Act (NHPA). None of these buildings
13 were affected during EE/CA field investigation activities.
14

15 **2.2 PREVIOUS INVESTIGATIONS**

16 **2.2.1 Findings and Determination of Eligibility**

17 In December 1990, a Findings and Determination of Eligibility (FDE) was
18 prepared by the U.S. Army Corps of Engineers, Sacramento District. The FDE
19 determined no evidence of unsafe conditions resulting from DOD use of the site.
20

21 **2.2.2 Archives Search Reports**

22 In March 1994, two separate ASRs were prepared by the U.S. Army Corps of
23 Engineers, St. Louis District. The first report, known as the *Archives Search*
24 *Report Findings, Benicia Arsenal, Benicia, Solano County, California*, details site
25 history, description and characterization of the immediate surrounding area, real
26 estate ownership information, findings of the site inspection, and evaluation of
27 potential OEW (Ordnance and Explosives Waste) and CWM contamination. The
28 purpose of the report was to determine the possible use or disposal of CWM or
29 OEW on the site. The second report, known as the *Archives Search Report*
30 *Conclusions and Recommendations, Benicia Arsenal, Benicia, Solano County,*
31 *California*, compiles information obtained through historical research at various
32 archives and record-holding facilities, interviews with persons associated with the
33 Former Benicia Arsenal, and a site inspection. The purpose of this report was to
34 present conclusions concerning the OEW/CWM Site Analysis.
35

36 In 1997, a supplement to the March 1994 ASR was prepared by the U.S. Army
37 Corps of Engineers, St. Louis District. This report provided additional data to the
38 original ASR prepared in March 1994.
39

40 **2.2.3 Records Research Report**

41 A Records Research Report (Jacobs Engineering, 1999) was prepared that
42 documents the arsenal's 115 years of military activity and 35 years of post-
43 closure nonmilitary activity. The report is an accumulation of facts from many
44 sources and includes the history of each building, utility, and activity in order for
45 decisions to be made concerning the potential for long-term environmental
46
47
48
49
50

1 damage to soil, surface water, groundwater, and air quality caused by military
2 activities. Numerous figures, maps, and aerial photographs are also included in
3 the report and show detailed locations of buildings, structures, and areas of
4 concern associated with previous activities at the Former Benicia Arsenal.
5

6 **2.2.4 Ordnance and Explosives-Related Actions**

7

8 The only report of previous DOD clearance activities at the arsenal is associated
9 with the Demolition Area on the Tourtelot Property. The ASR Supplement
10 indicated that this area was cleared in 1955. However, during a later inspection
11 of the area in 1955, several UXO items were found, and it was recommended that
12 a clearance be performed in the area. No record of a possible second clearance
13 was found during the ASR investigation. The only other report of DOD clearance
14 activities is associated with the cleanup of the UXO encountered during the
15 construction of OS 25 and 25A.
16

17 Granite Management Corporation, current owner of the Tourtelot Property,
18 encountered ordnance during grading activities on that property. Granite
19 Management Corporation hired an ordnance contractor (Explosive Disposal
20 Engineering and Technology) to remove and clear OE from the property. During
21 clearance activities, six UXO items were encountered, and the clearance
22 operation was suspended pending further investigation of the arsenal by the
23 USACE. No other reports of clearance activities are reported for the arsenal.
24

25 **2.3 GEOPHYSICAL INVESTIGATION**

26

27 Geophysical methods were utilized to investigate the OE distribution at the
28 Former Benicia Arsenal because they provide the only reliable means of
29 detecting relatively small metallic objects, including UXO items that may lie below
30 ground level. Further, use of geophysical methods allowed a non-intrusive,
31 controlled investigation of the subsurface, which minimized the potential for
32 explosive hazards to personnel and the environment. The safety of project
33 personnel and the general public was at all times the foremost consideration for
34 all activities.
35

36 The Tourtelot Property was investigated by using previously collected
37 magnetometer data (for Sectors 3A and 3B). For all other sectors, a Geonics
38 EM61 High-Sensitivity Metal Detector was used to detect and map the location of
39 subsurface anomalies (Photograph 2-5) and record the geophysical character of
40 the majority of the selected grids during the EE/CA field investigation. A total of
41 84 grids (19.28 acres) were geophysically mapped using the EM61. Previously
42 collected magnetometer data was used to identify anomalies for a total of
43 20 grids within Sector 3.
44

45 From the standpoint of the geophysical survey, the main difficulty was associated
46 with sloping terrain and washes impeding uniform travel over the grids.
47 Geophysical survey transects were laid out to limit the impact of these types of
48 obstacles; however, three grids (one in Sector 1 and two in Sector 4) were unable
49 to be geophysically mapped because of steep terrain.



Photo 2-5. Geophysical Mapping.

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2.3.1 Performance Criteria

Prior to deployment of the EM61 or use of the magnetometer data, the instruments were evaluated by means of a test plot with seeded metallic items simulating OE items expected to be encountered during the field investigation. The test plot construction, performance criteria, and results are explained in detail in Chapter 8.0 of the Final Work Plan. Data collected by the EM61 and magnetometers met or exceeded the performance criteria for the investigation.

2.3.2 Methodology

2.3.2.1 EM61.

The EM-61 is a high resolution, time-domain metal detector used to detect both ferrous and nonferrous metallic objects. The system measures the electrical potential in a receiver antenna caused by the presence of a secondary field generated by currents induced by a pulsed primary signal from the system transmitter antenna. Only the secondary signal is measured because the transmitter is turned off during the measurement period. The magnitude of the secondary signal is controlled by the conductivity of the material in a half-sphere of subsurface volume investigated with each measurement and the elapsed time after current cut-off from the transmitter. All such signals decay with time. The rate at which the signals decay is related to conductivity.

As with any geophysical technique, it is the contrast between the host matrix (soil in this case) and some other body (i.e., UXO) that is detected. The EM61 system parameters are such that only the effects of near-surface materials are considered, with an effective radius of investigation limited to approximately 10 feet in any direction, laterally or vertically. The system is designed to measure the secondary signal at just one time very late in the decay process. As a consequence, the secondary signal contributions from objects with very little electrical contrast with the host soil (i.e., cobbles, boulders) are negligible, whereas the signal contribution from items with a very great contrast (i.e., metallic UXO) is pronounced.

As the EM system is traversed over the ground surface, the apparent background will vary as the conductivity of the half-sphere volume of the host soil changes. These changes in conductivity are reflected as gradational increases or decreases in the amplitude of the total measured potential due to the secondary signals, and are clearly seen in the geophysical data collected at the Former Benicia Arsenal.

The geophysical system digitally captures instrument readings in a data logger, coincident with grid coordinates. Navigation and instrument positioning were based upon the established grid corners. Field data were collected using a 16-inch separation height between the bottom of the sensor and ground level.

Geophysical data were collected at 2.5-foot transect spacings and measurements made at less than 1-foot station intervals. Because of the steep terrain, only man-towed single trailer EM61s were deployed. Digital data were downloaded to

1 an IBM-compatible personal computer (PC). Data were formatted in xyz
2 American Standard Code for Information Interchange (ASCII) files, with the
3 survey values coincident with California State Plane coordinate locations.
4

5 **2.3.2.2 Magnetometry.**

6
7 In 1997, NORCAL Geophysical Consultants, Inc. (NORCAL), performed a total
8 magnetic field (TMF) vertical gradient survey over approximately 400 acres
9 (Figure 2-6) of the Former Benicia Arsenal property in an effort to determine if
10 any UXO existed within the area. This survey comprised investigation of
11 contiguous, 200- by 200-foot grids utilizing cesium vapor magnetometers arrayed
12 to measure the vertical gradient of the total magnetic field. The investigation
13 covered a majority of the Tourtelot Property in the northern portion of the Former
14 Benicia Arsenal that was included in the EE/CA investigation. The magnetometer
15 survey did not include grids in the borrow areas within the Tourtelot property
16 where surficial materials had been stripped and the ground surface regraded. A
17 total of 20 grids (4.59 acres) in Sector 3A and 3B were sampled for OE during the
18 EE/CA field investigation using data previously collected by NORCAL.

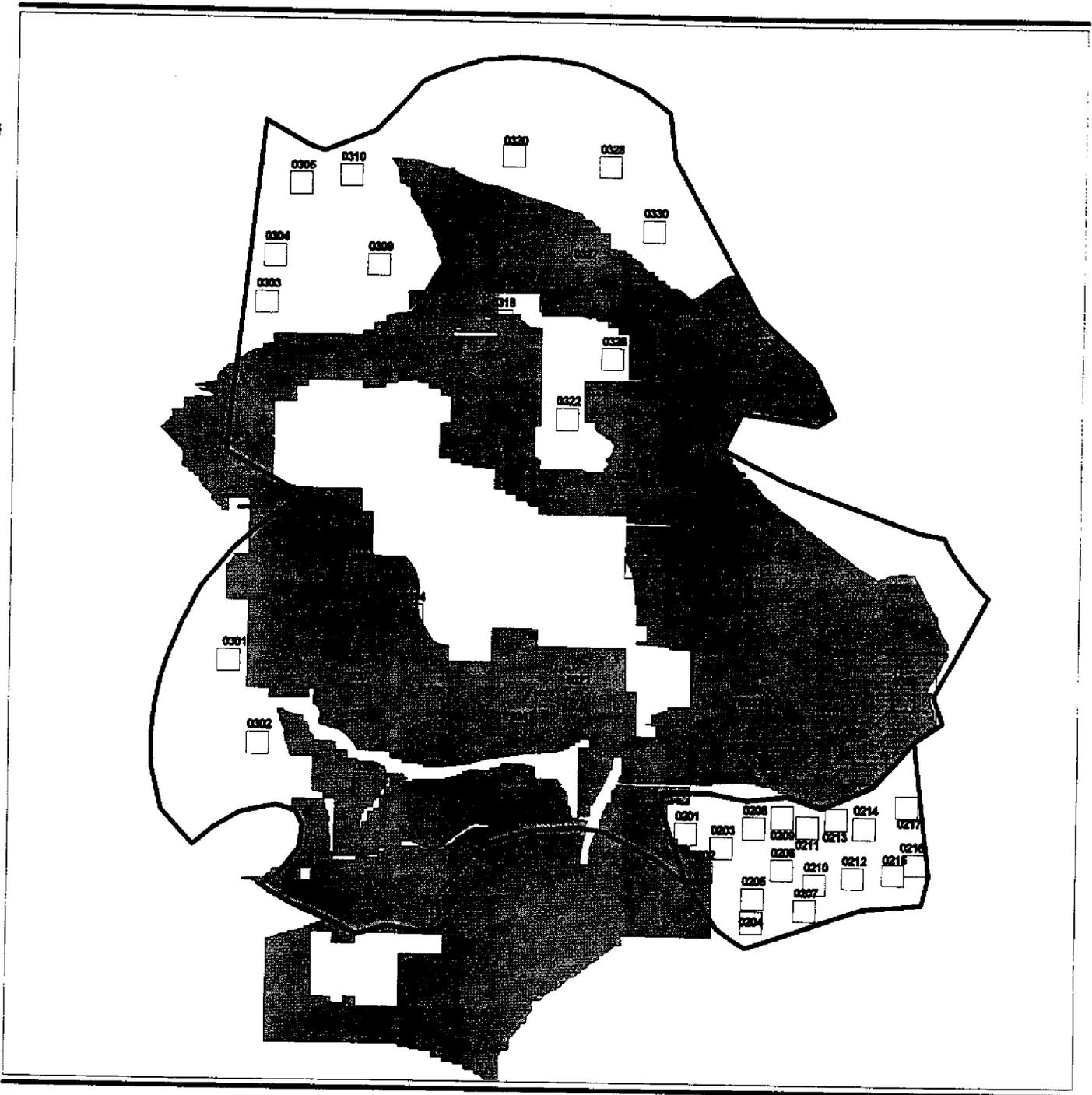
19
20 These data were collected along east-west traverses spaced 5 feet apart.
21 Measurements were recorded at (nominally) 1-foot intervals along each traverse,
22 as interpolated from 50-foot fiducials marked along each line. The data were
23 recorded relative to grid origins and transformed into California State Plane
24 coordinates (NAD27) by reference to the coordinate location of the grid origin as
25 tied to the California State Plane system by a land surveyor.

26
27 The magnetic gradiometers were deployed with a 0.5-meter sensor height above
28 ground level. Vertical separation between the magnetometers was 1 meter.
29 Man-portable arrays were used because they provide greater site accessibility
30 than trailered arrays and minimize measurement noise in the collected data.

31
32 The detection resolution provided by the survey parameters was sufficient to
33 meet the performance required to identify OE sampling locations. A performance
34 baseline for the TMF data was established by evaluating similarly arrayed cesium
35 vapor magnetometer gradiometer measurements collected over the equipment
36 test plot described in the Final Work Plan.

37
38 The combined magnetometer gradiometer data set for all grids was accessed via
39 the California State Plane coordinates because the survey results were digitally
40 recorded on electronic media. The magnetic data corresponding to the selected
41 sampling grids were windowed and processed to discriminate possible UXO-
42 induced anomalies. To evaluate the comparative anomaly detection resolution of
43 the survey parameters used to collect the magnetometer data, EM data were
44 collected over 10 percent of the OE sampling grids and processed to identify
45 anomalies of interest. The EM data collected by Earth Tech and the
46 magnetometer gradiometer data collected in 1997 were then compared to the
47 data from OE sampling grids and the equipment test plot results.

48
49 The conclusions of this comparison indicated that magnetometers did not
50 perform as well as EM systems in detecting small, near-surface targets, and the



EXPLANATION

-  Previously Mapped Area
-  Previously Cleared Area
-  Sector Boundary

**Previously Mapped
and Cleared Areas**

0.05 0 0.05 0.1 Miles



Figure 2-6

1 line spacing (5 feet versus the 2.5 feet to be used for the EM data) was too great
2 to adequately resolve targets that are more distant from the traverse centerline.
3 However, the magnetic data was sufficient to discriminate an adequate range of
4 target types (as evaluated from the test plot), and the previously collected
5 magnetometer data was used to resolve potential UXO in the surveyed grids.
6

7 **2.3.2.3 EM61 Versus Magnetometry.**

8
9 The EM61 was used for all subsurface geophysical survey recording and
10 anomaly detection for selected grids within the Tourtelot Property and all grids in
11 Sectors 1, 4, and 5. Two grids in Sector 3A and one grid in Sector 3B that were
12 previously surveyed with the magnetometer were geophysically mapped during
13 the EE/CA field investigation using the EM61. The EM61 results were directly
14 compared to magnetometer data results. The direct comparison indicated that
15 the EM61 did detect more targets, as expected. However, review of the OE
16 sampling results indicated that the additional targets identified by the EM61 were
17 smaller than the smallest OE item of concern, a 37-millimeter (mm) projectile. All
18 items with dimensions greater than 37-mm were detected by the EM61 and
19 identified in the magnetometer data. Therefore, the data was found to be valid
20 and acceptable for use in the EE/CA.
21

22 **2.3.3 Survey Grid Design**

23
24 Sampling grids were laid out to facilitate surveying with the origin (0, 0) of each
25 grid being the southwest corner. Grid corners were laid out with an optical laser
26 survey system (total station). A survey tape was stretched along each boundary
27 with an additional survey tape stretched in the center of the grid opposite the
28 traverse direction. Twenty 5-foot-wide by 100-foot-long lanes were established
29 within each OE sampling grid. Lanes were marked by string, cones, or other
30 suitable methods, as determined by the height and density of vegetation in the
31 particular grid. The marking methods provided clear recognition of the search
32 lane to ensure complete coverage of the grid.
33

34 **2.3.4 Data Collection**

35
36 Data collection was accomplished following the specific procedures detailed in
37 Chapter 8.0 of the Final Work Plan. The quality of mapping data was assured by
38 continuous tracking, adjustment, and visualization of the field data. Data quality
39 was further assured by adherence to the quality assurance/quality control
40 (QA)/(QC) requirements also specified in Chapter 8.0 of the Final Work Plan,
41 Geophysical Investigation Plan.
42

43 The position of the instrumentation array was continuously tracked and monitored
44 during data collection to assure complete coverage of the areas of interest. This
45 was accomplished either by use of traverse markings, or by maintaining
46 alignment of the instrument array relative to transect endpoints (e.g., stake,
47 cones, string). The procedures used were determined by the size and
48 configuration of the area to be surveyed. The methods of monitoring survey
49 progress were documented in the daily logbook.

1 **2.3.5 Data Processing**
2

3 Digital geophysical data (amplitude and position) were periodically downloaded
4 each day to avoid possible data loss or corruption. All data collected by
5 Blackhawk, including standardization measurements, field notes, maps, and
6 digital data, were delivered to Earth Tech before the close of each day's activities.
7 Earth Tech reviewed the deliverables for the data quality objectives (DQOs)
8 described in the following paragraphs. Blackhawk performed a similar review and
9 inventory, processed the data to identify potential UXO-related anomalies, and
10 then forwarded the processed geophysical data detailing anomaly locations
11 (Figure 2-7) to the Earth Tech field command post for preparation of the dig
12 maps. The quality of processed data was assessed by experienced Earth Tech
13 geophysicists familiar with the fieldwork and the instrument response to probable
14 targets and noise sources. Unusable or incomplete data delivered for any single
15 grid were remapped.
16

17 Data processing consisted of numerous steps. Use of an encoder wheel results
18 in some loss of positional precision whenever the surface of the survey area is
19 uneven or if it is difficult to maintain a straight line path over the grid. Data were
20 edited to correct the start and stop station value for each survey line. This results
21 in extrapolating measurement position over the length (100 feet) of each line.
22 Typical length corrections were on the order of 10 to 20 percent, which equates to
23 0.2 feet per surveyed foot. Line numbers, sequentially recorded in the field from
24 the southwest corner of each grid, were converted to survey distance by
25 multiplying by line separation (nominally 2.5 feet). The result is an xyz file that
26 provides distance east, distance north, and measured electrical potential (in
27 millivolts).
28

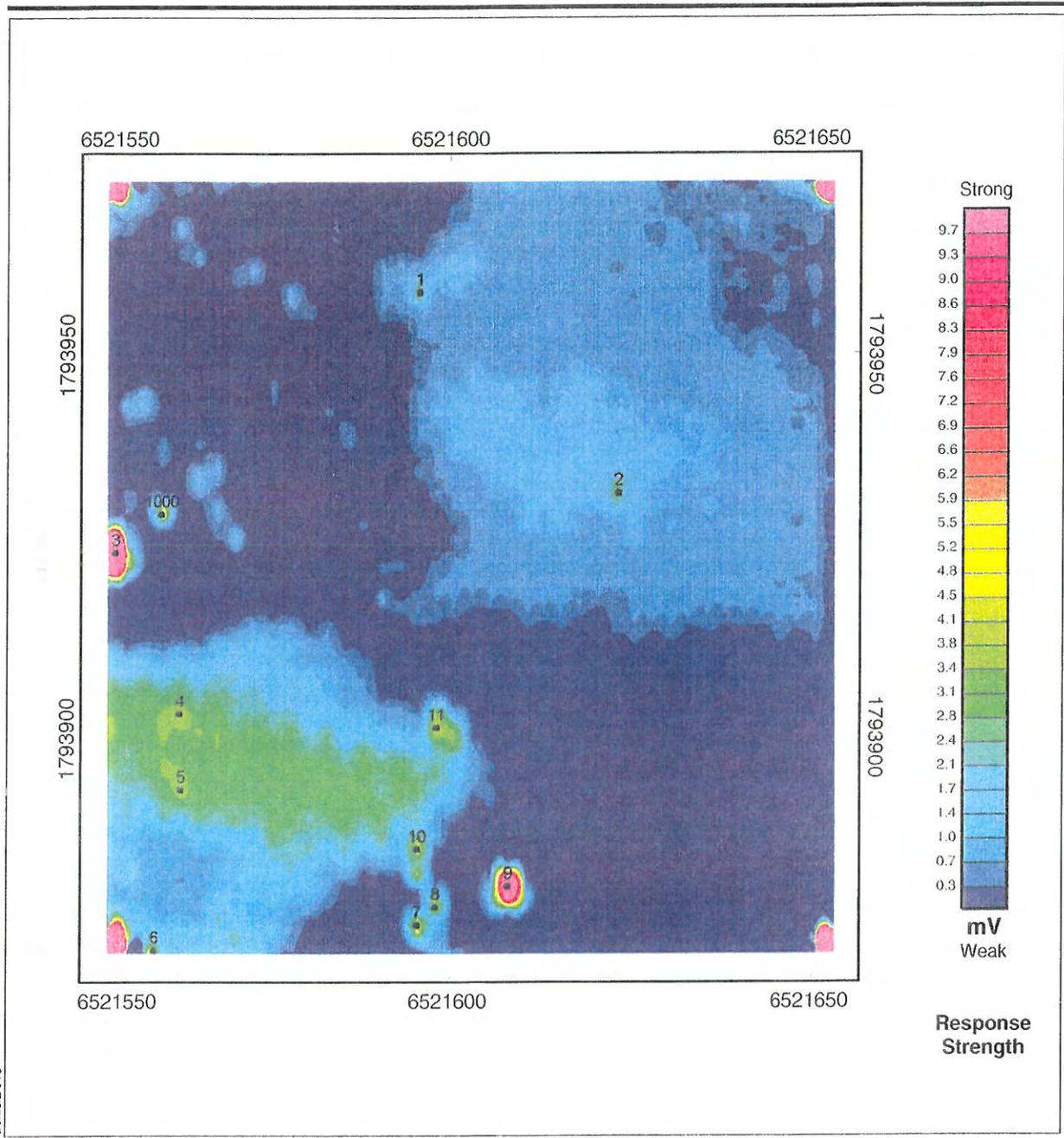
29 The data were then visually inspected for extraneous, single-measurement,
30 noise-spike anomalies. The receiver antennas are approximately 3 feet wide.
31 The measurement interval along each line was approximately 0.6 to 0.8 feet.
32 Anomalies caused by sources external to the EM system must contain at least
33 three points. Accordingly, single-point anomalies were identified as induced by
34 electromagnetic (EM) system noise and deleted from the data set.
35

36 The remainder of the process consists of generating a contouring grid mesh and
37 plotting the data as an isogram (contour or color) image. A 0.6- by 0.6-foot node
38 mesh was chosen for use as being representative of data collected. The data
39 was then contoured using GeoSoft Oasis Software™.
40

41 **2.3.6 Data Quality Objectives**
42

43 Data quality was assured, in part, by the routine measurement across a standard
44 underground target at the beginning and end of each survey, and monitoring
45 these measurements over time. The Standard Response transects were
46 established in areas with no EM anomalies other than those created by the buried
47 targets.
48

49 Instrument standardization was accomplished using a test plot staked in Sector 3
50 with multiple buried target items to establish a standard traverse. The test plot



EXPLANATION

- Anomaly Location
- 10 Anomaly Number
-  Color Bar indicating signal response in milliVolts (mV)

**Sample Grid
Geophysical Data/
Dig Map**



Figure 2-7

1 consisted of three traverse lines that were each 150 feet long oriented north to
2 south. Each line had multiple targets buried at depths between 0.3 and 4 feet.
3 The targets were various-sized pipe lengths and inert OE items. The minimum-
4 sized target was a 20-mm projectile. The maximum sized target was a piece of
5 pipe approximately the size of a 155-mm Howitzer projectile.
6

7 The standard response was the average of multiple runs over the standard target
8 minus the average background value for each deployed EM system. The
9 standard target was a 3-inch steel sphere. In addition, once the standard
10 response was established, the instrument response over standard target was
11 recorded before and after each grid was surveyed. This allowed an immediate
12 assessment of instrument performance that was unaffected by environmental
13 variables or measurement geometry error, and provided added QC for system
14 response and measurement drift. No degradation of instrument response was
15 found. All measurements were within the required acceptance range calculated
16 for the standard response.
17

18 Complete coverage of the grids, detection performance, and reasonableness of
19 the geophysical data were assured by daily reviews of the collected data and a
20 comparison of processed results with the anomaly maps produced in the field for
21 each grid investigated. The only limitations or difficulties encountered during the
22 geophysical field effort were from dense brush and sloping terrain. Tall
23 vegetation made it difficult to maintain precise positional control along the
24 transects, because the data were recorded using an encoder wheel trigger.
25 Sampling station precision requires the odometer wheel to maintain traction and
26 continuous contact with the ground surface. However, these sources of error
27 were limited by removing the brush prior to mapping and, where possible,
28 traversing the grid normal to the slope of terrain.
29

30 The following items were assessed to ensure data quality was maintained:
31

- 32 • Correct Survey Location - Position of the data collection system was
33 properly recorded
- 34
- 35 • Properly Operating Instruments - Daily documentation of the
36 standardization response within acceptance range was required for
37 each sensor system deployed
- 38
- 39 • Complete Grid Survey - Data were collected in such a manner that a
40 3-foot by 1-foot mesh could be generated for each grid
- 41
- 42 • Geophysical Reasonableness - Data were reviewed by experienced
43 geophysicists to assess usefulness of data for detecting and
44 resolving OE anomalies.
45

46 Earth Tech has performed an independent analysis of all geophysical mapping
47 data to verify the geophysical reasonableness of the collected field data and the
48 geophysical data analyses. The results of the independent analysis were used to
49 determine whether the DQOs were met and if a grid needed to be remapped or
50 the data reprocessed. As a result of this analysis, it was concluded that all
51 DQOs, as outlined in the Final Work Plan, were met.

2.4 ORDNANCE AND EXPLOSIVES FIELD SAMPLING PROCEDURES

The method used to determine public risk at OE sites is *OECert*. *OECert* analyzes homogeneous sectors, and within those sectors, the amount of ordnance, or ordnance density, must be estimated based on the results of subsurface sampling. *OECert* is used in sectors that have been found to contain UXO and/or OE during the EE/CA field investigation. *OECert*, for purposes of this analysis, was not run in Sectors 1, 3C, and Grid OT01 (for reasons discussed in Section 2.6.2).

Prior to beginning intrusive operations, the Former Benicia Arsenal was divided into five sectors, based on a number of factors. These sectors are areas identified to have common factors associated with them, such as land use (including past, current, and projected), infrastructure, topography, elevation, soils, vegetation, and other. To ensure that a statistically significant sample was taken from each of the sectors, a statistical sampling tool, *SiteStats/GridStats*, was used to develop the sectors and grids. Sector boundaries and OE sampling grid locations are shown on Plate 1.

SiteStats is designed to prove out homogeneity of sectors, within given cost and risk error bounds. Tests made for homogeneity of a sector are real time and iterative. *SiteStats* determines the number of grids to sample based upon the size of the sector.

GridStats, which can be run as a stand-alone software or as a module within *SiteStats*, analyzes individual grids within a sector to evaluate when the grid has been sufficiently sampled, and provides statistical estimates of UXO density. The software generates random locations within the grid for sampling geophysical anomalies; the results of the OE sampling are loaded into *GridStats*, and it calculates whether more information (i.e., additional sampling) is required in order to characterize the grid. This iterative process is continued until the software has enough information to stop sampling in that grid.

The OE sampling conducted at the Former Benicia Arsenal consisted of intrusively investigating 104 randomly and strategically selected 100-foot by 100-foot grids (as discussed in Section 2.1.3.2). The 104 sampling grids included approximately 2,630 known subsurface anomalies.

Geophysical anomaly locations were identified by geophysical data analysis process. These locations were provided to the site surveyor in California State Plane coordinates. Anomaly sampling locations within each grid were recovered by the surveyor using a total station optical laser survey system. Each sampling location was marked with a plastic flag. A "dig map" showing relative anomaly locations (see Figure 2-7) within the grids and a sampling data form were provided to the OE Dig Teams. Where grids had 20 or fewer anomalies identified, each anomaly location was staked and sampled. Where grids contained more than 21 identified anomalies, approximately 40 percent of the anomalies (or 20, whichever was greater) were selected at random and staked.

1 The Dig Team identified the center of the staked target anomaly by traversing a
2 Foerster Mark 26 or magnetometer over the surveyed location (Photograph 2-6).
3 An area 6 feet in diameter originating from the pin flag placed at the original
4 anomaly location was searched (Photograph 2-7). The location of the anomaly
5 center was noted relative to the original staked location.
6

7 The exploration progressed in concentric circles of increasing radius and depth
8 originating at the anomaly location staked to identify the centroid of the EM
9 anomaly. The intrusive exploration continued until a suitable anomaly source was
10 identified or an exploratory pit 2 feet in diameter and 2 feet bgs had been
11 excavated (Photograph 2-8). The dig teams utilized a fluxgate gradiometer
12 (Schonstedt or Foerster) as a screening aid to ensure personnel safety during the
13 progress of the excavation.
14

15 The exploratory excavations were left open until the UXO Supervisor had verified
16 the absence of additional metal sources within the perimeter of the excavated pit.
17 Verification was accomplished with a Foerster Mk-26 fluxgate magnetic
18 gradiometer, and it was determined that no detectable anomalies could be
19 identified.
20

21 The QA/QC process involved the review of all recovered items in order to ensure
22 that the geophysical response signal for the anomaly was representative of the
23 recovered item. All DQOs, as stated above, were met.
24

25 **2.5 NATURE AND EXTENT OF CONTAMINATION**

26 **2.5.1 Results of Subsurface OE Sampling**

27 The OE items recovered during the field investigation are summarized in this
28 section. OE includes bombs and warheads, artillery and mortar, rocket
29 ammunition, mines, and propellants; and all similar and related items or
30 components, explosive in nature or otherwise designed to cause damage to
31 personnel or material. The vast majority of OE recovered during the EE/CA field
32 investigation was not explosively configured (UXO). UXO was identified within
33 two of the five sectors at the Former Benicia Arsenal (Plate 1). UXO (as a subset
34 of OE) is defined by CEHNC as:
35
36
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38 military munitions that have been primed, fuzed, armed, or otherwise
39 prepared for action, and have been fired, dropped, launched, projected,
40 or placed in such a manner as to constitute a hazard to operations,
41 installation personnel, or material, and remain unexploded either by
42 malfunction, design, or any other cause.
43

44 OE scrap includes inert items such as gravel or plaster filled Howitzer rounds,
45 expended 105-mm projectiles, and fragments of functioned ordnance. All other
46 items found during the field investigation are referred to as non-OE scrap. Non-
47 OE scrap indicates those items that are non-ordnance-related. These items
48 include, but are not limited to: wooden boxes, wire, banding material, trash, auto
49 parts, and nails.



Photo 2-6. Geophysical Verification.



Photo 2-7. Ordnance and Explosives (OE) Sampling.



Photo 2-8. Anomaly Excavation.



Photo 2-9. Ordnance and Explosives (OE) Scrap.

1 Through the geophysical methods described above, a total of 2,630 anomalies
 2 was identified for investigation throughout the five sectors at the Former Benicia
 3 Arsenal. Of this total, 1,483 anomalies were intrusively investigated (i.e.,
 4 sampled for OE). Of the 1,483 anomalies investigated, 10 (less than 1 percent)
 5 were classified as UXO, 386 (26 percent) were classified as OE scrap, and
 6 946 (64 percent) were classified as non-OE scrap. A total of 141 anomalies
 7 (10 percent of those sampled) were intrusively investigated and classified as
 8 "False Positives." False positives are those anomalies that when intrusively
 9 investigated produced no metallic source (i.e., nothing was found).

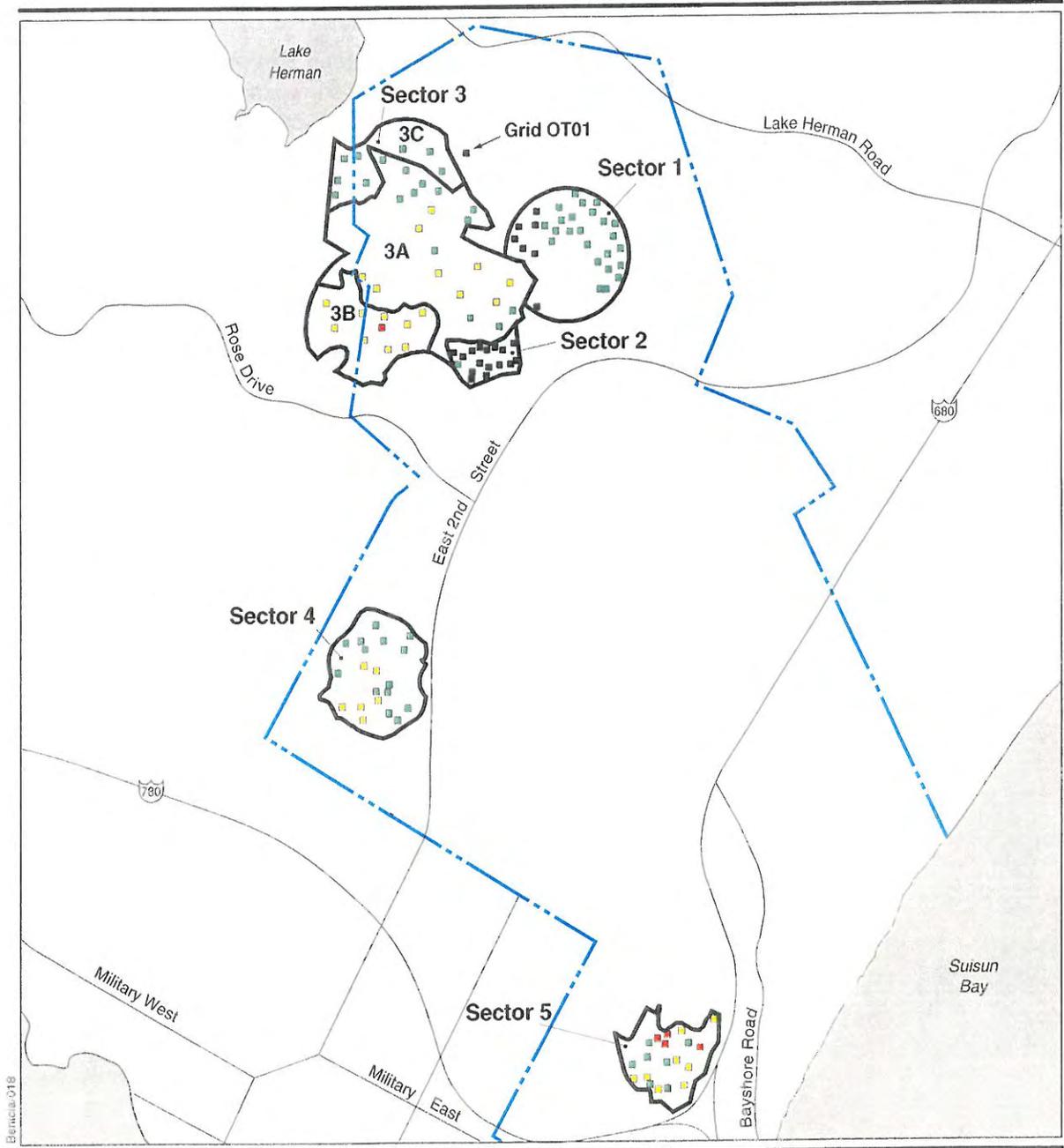
11 Approximately 500 OE scrap items (approximately 730 pounds) were recovered
 12 during OE sampling (Photograph 2-9). The OE items were inspected and turned
 13 over to a local scrap dealer.

14 The locations of the grids contained in Sectors 1 through 5 are shown on Plate 1
 15 at the end of Chapter 2.0. The total number of geophysical anomalies reported in
 16 sampling grids in each sector during the field investigation is presented in
 17 Appendix C. The OE items recovered during subsurface sampling are reported
 18 in detail in Appendix D and tabulated in Table 2-3. Figure 2-8 provides a
 19 graphical representation of grids where OE items were found during the field
 20 investigation.
 21
 22
 23

Table 2-3. Former Benicia Arsenal UXO Summary Table

Sector Number	Sector Name	Number of UXO	UXO type	UXO Depth
1	Revetment Area	0	--	--
2 ^(a)	Artillery Test Area	0	--	--
3A	Tourtlot Property	0	--	--
3B	Tourtlot Property	2	(1) 75-mm Shrapnel Projectile (Unfuzed) (1) 37-mm Projectile (Fuzed)	6" 24"
3C	City Property Adjacent to Tourtlot Property	0	--	--
4	Demolition Site on Exxon Property	0	--	--
5	Camel Barn Area	15	(1) Grenade (2) Grenade (1) Base Fuze (1) 75-mm Shrapnel Projectile (Fuzed) (1) 3"/50 APHE (Unfuzed) (3) Grenade (1) Stokes Mortar Fuze (3) 3"/50 APHE (Unfuzed) (1) Grenade (1) 3"/50 APHE (Fuzed)	0" 4" 4" 16" 16" 30" 30" 30" 32" 32"
Grid OT01 ^(b)	Overtured Truck Area	--	--	--
Total UXO at the Former Benicia Arsenal		17		

Note: (a) OE sampling results for Sector 2 include only those from Grid 0202.
 (b) OE sampling was not performed in Grid OT01 because right-of-entry could not be granted.
 APHE = Armor Piercing High Explosive
 mm = millimeter
 UXO = unexploded ordnance



EXPLANATION

- Grids where UXO was found during sampling
- Grids where OE Scrap was found during sampling
- Grids where Non-OE Scrap/Nothing was found during sampling
- Grids with No Right-of-Entry
- Sector Boundary
- Former Benicia Arsenal Boundary (estimated)



**EE/CA Field Investigation Results
Former Benicia Arsenal**

Figure 2-8

1 **2.5.2 OE Sampling Results by Sector**

2
3 **Sector 1 - Revetment Area.** During subsurface sampling, a total of
4 660 anomalies were identified, of which 404 (61 percent) were intrusively
5 investigated. Of this number, 380 (94 percent) were classified as non-OE scrap,
6 and 24 (6 percent) were classified as false positives (i.e., nothing was found).
7 There were no OE scrap or UXO recovered in Sector 1 during the EE/CA field
8 investigation.

9
10 **Sector 2 - Artillery Test Area.** Only one of the 17 grids in Sector 2 was sampled
11 for OE during the EE/CA field investigation. The remaining 16 grids were unable
12 to be sampled for OE because right-of-entry was not granted during the EE/CA
13 field investigation. During subsurface sampling, a total of seven anomalies were
14 identified, all of which were intrusively investigated. Of this number, five
15 (71 percent) were classified as non-OE scrap, and two (29 percent) were
16 classified as false positives (i.e., nothing was found). There were no OE scrap or
17 UXO recovered in Sector 2 during subsurface sampling.

18
19 **Sector 3A - Tourtelot Property.** During subsurface sampling, a total of
20 525 anomalies were identified, of which 245 (47 percent) were intrusively
21 investigated. Of this number, 89 (36 percent) were classified as OE scrap,
22 132 (54 percent) were classified as non-OE scrap, and 24 (10 percent) were
23 classified as false positives (i.e., nothing was found). There were no UXO items
24 recovered in Sector 3A during the EE/CA field investigation.

25
26 **Sector 3B - Tourtelot Property.** During subsurface sampling, a total of
27 465 anomalies were identified, of which 219 (47 percent) were intrusively
28 investigated. Of this number, 183 (84 percent) were classified as OE scrap,
29 21 (10 percent) were classified as non-OE scrap, and 13 (6 percent) were
30 classified as false positives (i.e., nothing was found). A total of two UXO items
31 were recovered in Sector 3B during the EE/CA field investigation (see Table 2-3).

32
33 **Sector 3C - City Property Adjacent to Tourtelot Property.** During subsurface
34 sampling, a total of 35 anomalies were identified, of which 34 (97 percent) were
35 intrusively investigated. Of this number, 27 (79 percent) were classified as non-
36 OE scrap, and 7 (21 percent) were classified as false positives (i.e., nothing was
37 found). There were no OE scrap or UXO items recovered in Sector 3C during the
38 EE/CA field investigation.

39
40 **Sector 4 - Demolition Site on Exxon Property.** During subsurface sampling, a
41 total of 247 anomalies were identified, of which 177 (72 percent) were intrusively
42 investigated. Of this number, 38 (21 percent) were classified as OE scrap,
43 108 (61 percent) were classified as non-OE scrap, and 31 (18 percent) were
44 classified as false positives (i.e., nothing was found). There were no UXO items
45 recovered in Sector 4 during the EE/CA field investigation.

46
47 **Sector 5 - Camel Barn Area.** During subsurface sampling, a total of 691
48 anomalies were identified, of which 397 (57 percent) were intrusively investigated.
49 Of this number, 76 (19 percent) were classified as OE scrap, 273 (69 percent)
50 were classified as non-OE scrap, and 40 (10 percent) were classified as false

1 positives (i.e., nothing was found). A total of 15 UXO items were recovered in
2 Sector 5 during the EE/CA field investigation (see Table 2-3). Two of the
3 recovered UXO items are shown in Photograph 2-10.
4

5 **Grid OT01 - Overturned Truck Area.** As stated in Section 2.1.3.8, subsurface
6 sampling was not performed in Grid OT01 because right-of-entry could not be
7 granted.
8

9 Of the 1,483 anomalies intrusively investigated at the Former Benicia Arsenal,
10 approximately 1,232 (83 percent) were recovered at depths ranging from 0 to
11 12 inches (i.e., within the first foot). A total of 233 anomalies (16 percent) were
12 recovered at depths ranging from 12 to 24 inches. A total of 14 anomalies
13 (1 percent) were recovered between 24 and 36 inches, and less than 1 percent of
14 the anomalies were recovered at depths ranging from 36 to 48 inches. There
15 were no anomalies recovered at depths greater than 48 inches bgs.
16

17 All UXO items or suspected UXO recovered during the EE/CA field investigation
18 were disposed of on site (i.e., explosively destroyed) (Photograph 2-11). No UXO
19 or suspected UXO items were transported off the arsenal.
20

21 2.6 RISK ANALYSIS

22

23 An important element of an EE/CA is a risk evaluation, which considers the
24 potential endangerment to human safety and health should remedial efforts to
25 clean up a site not be undertaken. The risk evaluation provides a baseline public
26 risk against which alternatives are measured. For OE sites, the risk evaluation
27 should consider residual UXO density, the probability of exposure to residual
28 UXO, and the comparative risk of injury from residual UXO.
29

30 2.6.1 Statistical Approach to Characterization of OE

31

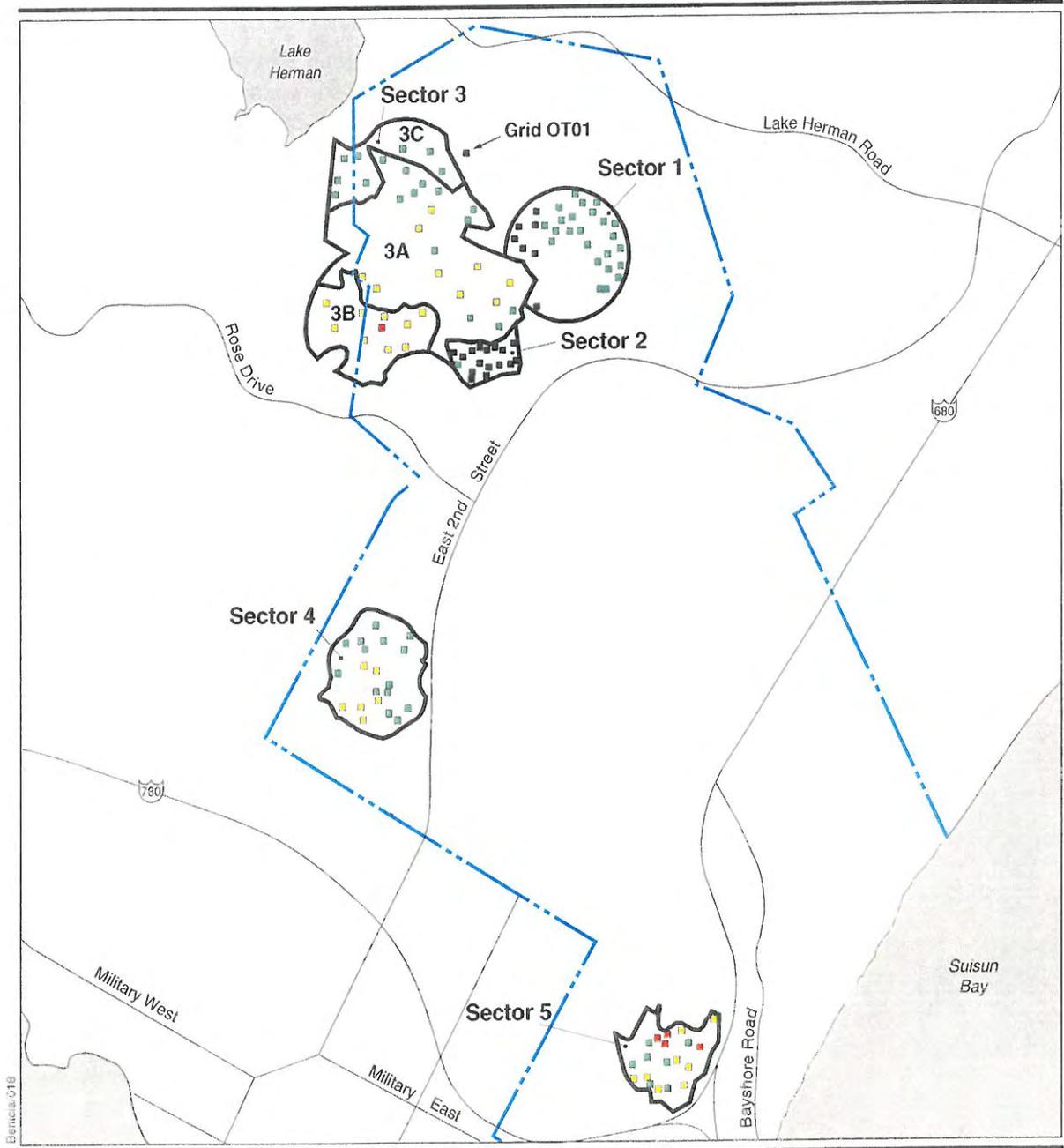
32 In addition to SiteStats and GridStats (as discussed in Section 2.4), UXO
33 Calculator (a statistical analysis tool) was used both in sectors where UXO was
34 found and in sectors where no UXO was found. This statistical analysis yields a
35 probabilistic UXO density estimate based on sector area, area sampled, and the
36 number of UXO items recovered during subsurface sampling. The calculated
37 probabilistic density estimate for each sector was used as the maximum density
38 input for OECert exposure calculations.
39

40 2.6.2 Ordnance Explosives Exposure Risk (OECert)

41

42 OECert estimates risks based on the density of UXO, demographics, and
43 activities allowed in a sector. A risk estimate was provided for the following
44 alternatives:
45

- 46 • Alternative 1: No Further Action (NoFA)
- 47 • Alternative 3: Surface Clearance of UXO
- 48 • Alternative 4: Detection and Clearance of UXO to Depth



EXPLANATION

- Grids where UXO was found during sampling
- Grids where OE Scrap was found during sampling
- Grids where Non-OE Scrap/Nothing was found during sampling
- Grids with No Right-of-Entry
- Sector Boundary
- Former Benicia Arsenal Boundary (estimated)



**EE/CA Field Investigation Results
Former Benicia Arsenal**

Figure 2-8

1 A risk evaluation of Institutional Controls (Alternative 2) was not performed
2 because the human behavior modifications associated with Institutional Controls
3 cannot be readily quantified. The expected risk reduction is believed to be
4 between NoFA (Alternative 1) and the Surface Clearance (Alternative 3).
5

6 Two risk estimates were calculated for each sector, one based upon the
7 estimated range of UXO density as calculated by SiteStats/GridStats. The other
8 is a probabilistic UXO density estimate calculated for the purposes of this EE/CA.
9 The probabilistic UXO density estimate is:

10
11 The density limit (i.e., total number of UXO items 'x' in the
12 sector) at which there is 90 percent probability that, given the
13 amount of sampling that occurred in the sector, at least one
14 UXO item would have been found. In other words, if the true
15 number of UXO items in the sector was greater than the
16 density limit, 90 percent of the time at least one UXO item
17 would have been found given the sampling that occurred in
18 the sector.
19

20 The minimum UXO density estimate and the maximum UXO density estimate for
21 each sector at the Former Benicia Arsenal are shown in Table 2-4. The expected
22 annual exposures to the public for each of the four alternatives are shown in
23 Table 2-5. Density estimates and UXO exposures were not calculated for
24 Sector 1 and Sector 3C because there were no UXO or OE items recovered in
25 these two sectors during subsurface sampling. Density estimates and UXO
26 exposures were also not calculated for Grid OT01 (Overtumed Truck Area)
27 because intrusive OE sampling did not occur in this grid (no right-of-entry).
28 Because intrusive OE sampling was limited to one grid in Sector 2 (for reasons
29 discussed in Section 2.1.3.4), the UXO density applied in the Sector 2 risk
30 assessment was derived via analogy to the UXO density estimated for the
31 southern portion of Sector 3. This analogy is considered appropriate due to the
32 similar historical land uses and the geographic proximity of Sectors 2 and 3.
33 Additional details concerning this analogy are discussed in the OECert Risk
34 Analysis Report (Appendix A).
35

36 A copy of the *Former Benicia Arsenal OECert Analysis Report* (QuantiTech, Inc.,
37 1999) is included in Appendix A of this report.
38

39 **2.6.3 Ordnance and Explosives Comparative Risk.**

40
41 The comparative risk assessment examines the chance of injury or death from
42 UXO and provides a comparison to common public risks. The comparative risk
43 methodology was developed to address the relative UXO risk from public use of
44 the OE sites as compared to selected everyday common risks. This assessment
45 incorporates OECert analysis results at 38 other Formerly Used Defense Sites
46 (FUDS) and Base Realignment and Closure Sites. Common risks were
47 quantified from the accident facts collected and compiled from United States
48 population statistics.

Table 2-4. UXO Density Estimates for the Former Benicia Arsenal

Investigation Area	Minimum Estimated UXO Density (UXO/Acre)	Maximum Estimated UXO Density (UXO/Acre)
Sector 1 - Revetment Area ^(a)	--	--
Sector 2 - Artillery Test Area	2.09	5.55 (1 UXO in 0.2 acre)
Sector 3A - Tourtelot Property	2.11	4.31 (1 UXO in 0.2 acre)
Sector 3B - Tourtelot Property	2.09	5.55 (1 UXO in 0.2 acre)
Sector 3C - City Property Adjacent to Tourtelot Property ^(a)	--	--
Sector 4 - Demolition Site on Exxon Property	0	0.53 (1 UXO in 1.9 acres)
Sector 5 - Camel Barn Area	3.69	6.89 (1 UXO in 0.1 acre)
Grid OT01 - Overturned Truck Area ^(b)	--	--

Note: UXO = Unexploded Ordnance

UXO density estimates are based upon data collected during OE sampling.

(a) = UXO Density Estimates are not calculated for Sectors 1 and 3C for reasons discussed in Section 2.6.2.

(b) = OE sampling was not performed in Grid OT01.

1
2

Table 2-5. Expected Range of Annual UXO Exposures at Former Benicia Arsenal

Investigation Area	No Further Action	After Surface Clearance	After UXO Clearance to Depth
Sector 1 ^(a)	--	--	--
Sector 2	51-148	25-78	1-3
Sector 3A	3,761-7,682	291-593	41-82
Sector 3B	2,287-6,069	114-301	25-65
Sector 3C ^(a)	--	--	--
Sector 4	0-17	0-1	0-1
Sector 5	3,617-6,752	153-287	39-73
Grid OT01 ^(b)	--	--	--

Note: (a) Exposure data is not presented for Sectors 1 and 3C for reasons discussed in Section 2.6.2.

(b) OE sampling was not performed in Grid OT01.

UXO = unexploded ordnance

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UXO risk at these 38 sites was estimated by applying OECert methods for calculating exposure to UXO to the public. Also during the assessment, as detailed in each site's ASR, the number of injuries and deaths attributable to exposure to UXO was counted. The ASR period usually covers more than 50 years of site history. Each site's OECert UXO exposure results and the number of injuries and deaths were then statistically correlated. A curve fit of the data was completed using statistical regression techniques. This statistical fit to the UXO accident data resulted in a high correlation between UXO exposures at a site and an estimated time between potential UXO accidents. Based on these results, a projection of time between possible UXO accidents can be calculated.

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Each site's common risk population basis was used to convert the total number of injuries and deaths to a chance or probability of individual risk. Similarly, a site's chance for injury or deaths due to UXO was also calculated using the site's population basis with the estimated number of accidents over a 1-year period (Figure 2-9). Based on data presented in this figure, there are 689 annual projected injuries or deaths caused by activities in the home, 379 projected injuries or deaths caused by motor vehicles, and significantly less than one projected injury or death caused by exposure to UXO at the Former Benicia Arsenal (QuantiTech, 1999).

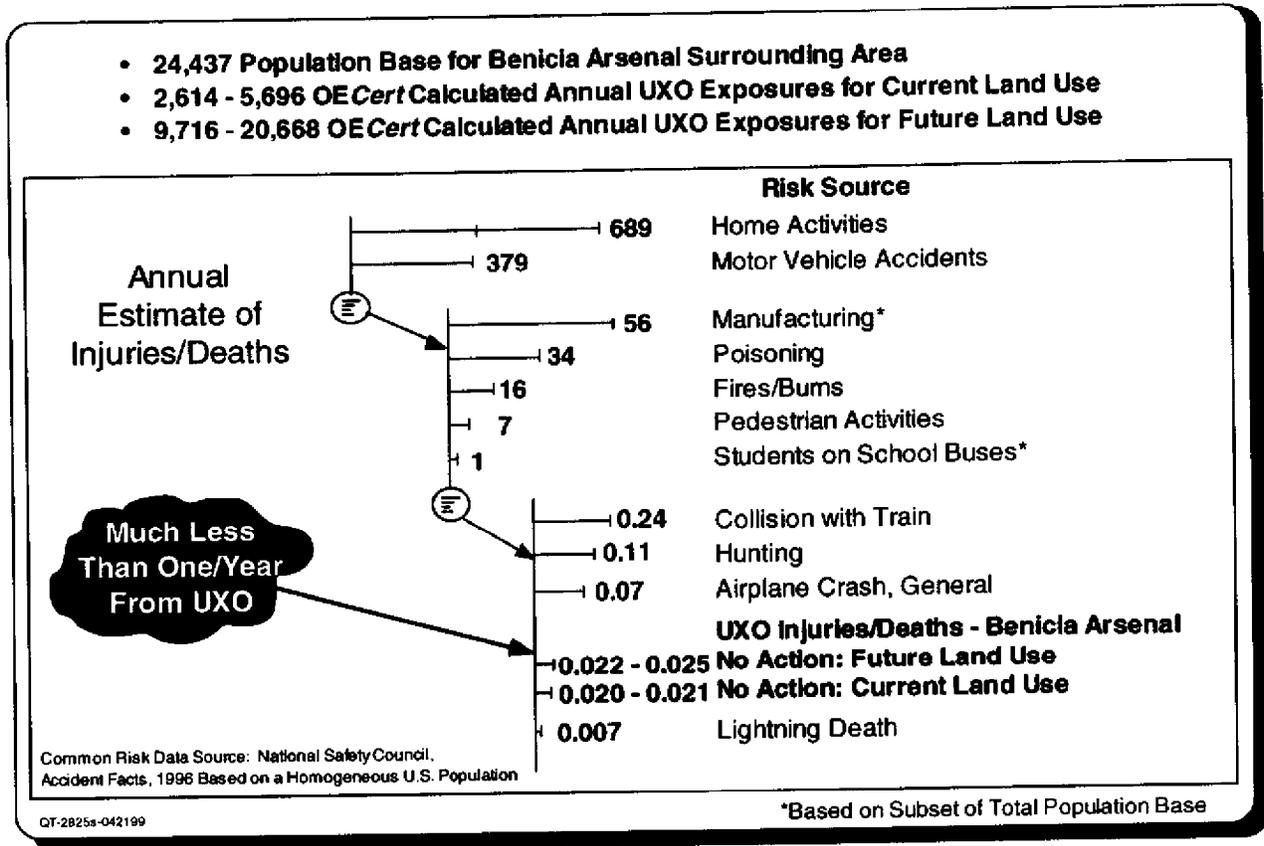


Figure 2-9. Former Benicia Arsenal Comparative Annual Risk Estimate

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2.7 ASSESSMENT OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Section 121 of CERCLA requires that site cleanups comply with federal ARARs, or state ARARs in cases where these requirements are more stringent than federal requirements. ARARs are derived from both federal and state laws. Under CERCLA Section 121(d)(2), the federal ARARs for a remedial action could include requirements under any of the federal environmental laws (e.g., Clean Air Act [CAA], Clean Water Act [CWA], Safe Drinking Water Act [SDWA]). State

1 ARARs include promulgated requirements under state environmental or facility
2 siting laws that are more stringent than federal ARARs and that have been
3 identified in a timely manner, according to 40 Code of Federal Regulations (CFR)
4 Part 300.400(g)(4). A requirement may be either "applicable" or "relevant and
5 appropriate."
6

7 Applicable requirements are defined as those cleanup or control standards, or
8 other substantive environmental protection requirements, criteria, or limitations
9 promulgated under federal or state laws. Applicable requirements are identified
10 on a site-specific basis by determination of whether the jurisdictional prerequisites
11 of a requirement fully address the circumstances at the site or the proposed
12 remedial activity. All pertinent jurisdictional prerequisites must be met for the
13 requirement to be applicable. These jurisdictional prerequisites are as follows:
14

- 15 • The party must be subject to the law
- 16 • The substances or activities must fall under the authority of the law
- 17 • The law must be in effect at the time the activities occur
- 18 • The statute or regulation requires, limits, or protects the types of
19 activities.
20
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23

24 A requirement is applicable if the specific terms (or jurisdictional prerequisites) of
25 the statute or regulation directly address the circumstances at the site.
26

27 If not applicable, a requirement may be relevant and appropriate if circumstances
28 at the site are sufficiently similar to the problems or situations regulated by the
29 requirement. "Relevant and appropriate" refers to those cleanup standards, or
30 other substantive environmental protection requirements, criteria, or limitations
31 promulgated under federal or state law, that, while not necessarily applicable,
32 address problems or situations sufficiently similar to those encountered at the
33 CERCLA site, and whose use is well suited to the particular site (U.S.
34 Environmental Protection Agency, 1993). The relevance and appropriateness of
35 a requirement can be judged by comparing a number of factors including the
36 characteristics of the remedial action, the items in question, or the physical
37 circumstances of the site, with those addressed in the requirement. If there is
38 sufficient similarity between the requirements and circumstances at the site, then
39 determination of the requirement as relevant and appropriate may be made.
40

41 Determining whether a requirement is both relevant and appropriate is a two-step
42 process. First, to determine relevance, a comparison is made between the
43 response action, location, or chemicals covered by the requirement and related
44 conditions at the site, release, or potential remedy. A requirement is relevant if it
45 generally pertains to these conditions. Second, to determine whether the
46 requirement is appropriate, the comparison is further refined by focusing on the
47 nature of the items, the characteristics of the site, the circumstances of the
48 release, and the proposed response action. The requirement is appropriate if,
49 based on such comparison, its use is well suited to the particular site. The facility
50 must comply with requirements that are determined to be both relevant and
51 appropriate.

1 In addition to ARARs, non-promulgated advisories or guidance referred to as "to
2 be considered" (TBC) materials may also apply to the conditions found at a site.
3 TBCs are not legally binding.
4

5 There are certain circumstances under which ARARs may be waived. CERCLA
6 Section 121(d) allows the selection of alternatives that will not attain ARAR status
7 if any of six conditions for a waiver of ARARs exist. However, the selected
8 alternative must be protective even if an ARAR is waived. Only five of the
9 conditions for a waiver may apply to a DOD site. The conditions for a waiver are
10 as follows:

- 11
- 12 • The clearance action selected is only part of a total response action
- 13 that will attain such level or standard of control when completed.
- 14
- 15 • Compliance with such requirement at that site will result in greater
- 16 risk to human health and the environment (e.g., worker safety) than
- 17 alternative options.
- 18
- 19 • Compliance is technically impracticable from an engineering
- 20 perspective.
- 21
- 22 • The clearance action selected will result in a standard of
- 23 performance that is equivalent to an applicable requirement through
- 24 the use of another method or approach.
- 25
- 26 • A state requirement has not been equitably applied in similar
- 27 circumstances on other clearance actions within the state.
- 28
- 29 • A fund-financed clearance action does not provide a balance
- 30 between available monies and the need for protection of the public
- 31 health and environment at the sites where the need is more
- 32 immediate (not applicable to DOD sites).
- 33

34 ARARs that govern actions at CERCLA sites fall into three broad categories
35 based upon the chemical contaminants present, site characteristics, and
36 alternatives proposed for cleanup. These three categories (chemical-specific,
37 location-specific, and action-specific) are described in the following subsections.
38

39 **2.7.1 Chemical-Specific ARARs**

40

41 Chemical-specific ARARs include those environmental laws and regulations that
42 regulate the release to the environment of materials with certain chemical or
43 physical characteristics or that contain specified chemical compounds. These
44 requirements generally set health- or risk-based concentration limits or discharge
45 limits for specific hazardous substances by media. Chemical-specific ARARs are
46 triggered by the specific chemical contaminants found at a particular site. The
47 U.S. Environmental Protection Agency (EPA) presently considers standards
48 developed under the Resource Conservation and Recovery Act (RCRA), the
49 SDWA, the CWA, and federal Ambient Water Quality Criteria for the protection of
50 aquatic life as potential ARARs. A more stringent standard, requirement,
51 criterion, or limitation promulgated pursuant to a state environmental statute is
52 also a potential ARAR.

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2.7.2 Location-Specific ARARs

Location-specific ARARs govern activities in certain environmentally sensitive areas. These requirements are triggered by the particular location and the proposed activity at the site. An example of a location-specific ARAR is compliance with the Endangered Species Act of 1973, as amended, to avoid sensitive ecosystems or habitats. Location-specific ARARs also focus on wetland or floodplain protection areas, or archaeologically significant areas.

2.7.3 Action-Specific ARARs

Action-specific ARARs are restrictions that define acceptable treatment and disposal procedures for hazardous substances. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities. An example might be a state Air Quality Management Authority that sets limitations on fugitive dust generated during grading and excavation activities during clearance action.

In determining whether a requirement was pertinent to OE sampling and clearance actions at the Former Benicia Arsenal, potential ARARs were initially screened for applicability. If determined not to be applicable, the requirement was then reviewed for both relevance and appropriateness. Requirements that are considered to be relevant and appropriate command the same importance as applicable requirements. Potential federal and state ARARs determined to be specific to the Former Benicia Arsenal are listed in Table 2-6.

Table 2-6. Applicable or Relevant and Appropriate Requirements (ARARs), Former Benicia Arsenal, Benicia, California
Page 1 of 6

Requirement	Citation	Description	Type	Applicable or Relevant and Appropriate	Comments
Federal Resource Conservation and Recovery Act (RCRA), Subpart M (Military Munitions Rule)	40 CFR Part 266	Identifies when military munitions become a solid waste, and if these wastes are hazardous, the management standards that apply.	Chemical-specific	Relevant and Appropriate	Recovery, collection, and on-range destruction of UXO and munition fragments are not subject to hazardous waste regulations or permits. Discovered OE in burial pits or trenches could be considered solid waste in accordance with the rule. However, this requirement is not applicable at California sites until the state implements the federal Military Munitions Rule as a state-implemented federal requirement.
Clean Water Act (CWA)	33 U.S.C. 1151 et seq., 1251 et seq., 40 U.S.C. 3906 et seq.	Establishes standards governing all untreated waters including marine, coastal, estuarine, fresh surface water, and groundwater; also governs discharge of dredged or fill material.	Location-specific	Applicable	OE removal and subsequent ground disturbance may be performed in areas delineated as wetlands.
	40 CFR Part 230.10, Section 404(b)(1)	Requires permit from USACE for construction activities in wetlands and alternative analysis to ensure selection of the least damaging practicable alternative.	Location-specific	Applicable	Wetlands are present within the site boundary. Coordination with USACE will be required if any wetland areas are to be disturbed by implementing a clearance action. Methods for reducing disturbance include minimizing excavation area and depth, completing in situ detonation in the least disturbing manner, and setting aside topsoil during excavation to salvage seeds and eggs.
Fish & Wildlife Coordination Act	16 U.S.C. 661 et seq.	Prohibits actions from harming local fish and wildlife	Location-specific	Applicable	Implementation of any of the alternatives that may cause ground disturbance would occur in areas populated with wildlife. Provisions of this Act should be followed.

Table 2-6. Applicable or Relevant and Appropriate Requirements (ARARs), Former Benicia Arsenal, Benicia, California
Page 2 of 6

Requirement	Citation	Description	Type	Applicable or Relevant and Appropriate	Comments
Endangered Species Act	16 U.S.C. 1531-1543	Prohibits federal actions from jeopardizing the continued existence of protected, endangered, or threatened species or modifying critical habitats.	Location-specific	Applicable	Activities may occur in areas populated with fish and wildlife. Provisions of this Act should be followed.
Floodplain Management	EO 11988	Restricts federal activities when projects are sited in floodplains.	Location-specific	Relevant and Appropriate	Activities may occur in low-lying areas designated as floodplain. Provisions of this Act should be followed.
Bald and Golden Eagle Protection Act	16 U.S.C. 668	Prohibits the transport, import, export, taking, selling, purchasing, or barter of any bald or golden eagle, including feathers or other parts, nest eggs, or products, except as allowed by permit. "Take" includes pursuing, shooting at, poisoning, wounding, killing, capturing, trapping, collecting, or disturbing.	Location-specific	Applicable	Although no bald eagles were observed during the field investigation, suitable habitat does exist in the study area. Provisions of this Act should be followed.
Migratory Bird Treaty Act	16 U.S.C. 703-712	Prohibits the taking, possessing, buying, selling, or bartering of any migratory bird, including feathers or other parts, nest eggs, or products, except as allowed by regulations.	Location-specific	Applicable	The Former Benicia Arsenal is situated along the Pacific Flyway.

Table 2-6. Applicable or Relevant and Appropriate Requirements (ARARs), Former Benicia Arsenal, Benicia, California
Page 3 of 6

Requirement	Citation	Description	Type	Applicable or Relevant and Appropriate	Comments
Archaeological Resources Protection Act (ARPA)	16 U.S.C. 470	ARPA prohibits unauthorized excavation of, and sets standards for protection of, archaeological resources. Prohibits disclosure of archaeological resources by federal agencies.	Location-specific	Applicable	If properties are uncovered or affected by OE clearance, conditions of the NHPA and the ARPA must be followed.
National Historic Preservation Act (NHPA)	16 U.S.C. 470	Requires action to be taken to locate, identify, evaluate, and protect cultural resources.	Location-specific	Applicable	If properties are uncovered or affected by OE clearance, conditions of the NHPA and the ARPA must be followed.
Native American Graves Protection and Repatriation Act (NAGPRA)	25 U.S.C. 3001	Prohibits disturbance of Native American remains and funerary objects. Provides a process for repatriation of remains and funerary objects.	Location-specific	Relevant and Appropriate	If any native American remains are uncovered or affected by OE clearance, proper NAGPRA protocol must be followed.
Protection of Wetlands	EO 11990	Restricts federal activities when alterations of wetlands may occur.	Location-specific	Applicable	Prior to removal of OE from wetland areas, action must be taken to minimize impacts. Mitigation and habitat restoration plans include measures to minimize disturbance to wetlands. Goal of restoration plans will be to restore affected wetlands to same acreage and provide same function as before ordnance removal.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	42 U.S.C. 9601-11050	Legislation that finances remediation and creates a national policy to identify and clean up sites contaminated by the release of hazardous substances.	Action-specific	Applicable	Provides factors to be considered in determining the appropriate risk management action and specifies that public affairs must be coordinated in accordance with directives for the CERCLA response action.
RCRA, Subpart M (Military Munitions Rule)	40 CFR Part 266	Identifies when military munitions become a solid waste, and if these wastes are hazardous, the management standards that apply.	Action	Relevant and Appropriate	OE left undisturbed and recovery, collection, and on-range destruction of UXO and munition fragments are not subject to hazardous waste regulations or permits. Discovered OE in burial pits or trenches could be considered solid waste in accordance with this rule.

Table 2-6. Applicable or Relevant and Appropriate Requirements (ARARs), Former Benicia Arsenal, Benicia, California
Page 4 of 6

Requirement	Citation	Description	Type	Applicable or Relevant and Appropriate	Comments
OE Waste Identification	Draft Department of the Army Memorandum	Adopts criterion of 10% explosive content as a measure of contaminated soil reactivity to differentiate between hazardous waste or secondary explosives.	TBC		
Occupational Safety and Health Administration (OSHA)	29 CFR Part 1910.120	Defines the manner in which hazardous waste and emergency response actions must be carried out. Covers emergency response operations for the release of, or substantial threat of, hazardous substances without regard to the location of the hazard.	Action-specific	Applicable	The possibility of a fire or explosion will exist during OE clearance operations. All site personnel must be in compliance with 29 CFR Parts 1910.120, which requires workers to be 40-hour health and safety trained with an 8-hour refresher. An annual medical surveillance examination is also required.
Hazard Communication	29 CFR Part 1910.1200	Specifies that the hazards associated with all chemicals produced or imported be evaluated, and that information concerning their hazards be transmitted to employers and employees.	Action-specific	Applicable	All on-site employees and visitors will be made aware of the hazards associated with the chemicals on site and hazards associated with the OE clearance or avoidance activities.
Hazardous Substance	49 CFR Part 172.101	Details U.S. Department of Transportation (DOT) classifications of hazardous material.	Action-specific	Applicable	Transportation of explosives to be used in the detonation of UXO as a means of on-site disposal must comply with DOT regulations. UXO-qualified personnel must inspect the loading and unloading of the explosives, and the transport vehicle must be properly maintained and placarded.
National Environmental Policy Act (NEPA)	40 CFR Parts 1500-1508	Requires that public officials and citizens be informed of proposed actions so informed decisions can be made (i.e., the analysis of cumulative effects and impacts on cultural/natural resources).	Action-specific	Relevant and Appropriate	Provisions of this Act should be followed.

Table 2-6. Applicable or Relevant and Appropriate Requirements (ARARs), Former Benicia Arsenal, Benicia, California
Page 5 of 6

Requirement	Citation	Description	Type	Applicable or Relevant and Appropriate	Comments
National Contingency Plan (NCP)	40 CFR Part 300.120(c), Part 300.400(e)	Defines format for response from planning to decision making to post-removal monitoring.	Action-specific	Applicable	Permitting is not required for on-site CERCLA response actions.
Occupational Safety and Health Act	29 U.S.C. 651-678	Regulates worker health and safety.	Action-specific	Applicable	Under 40 CFR Part 300.38, requirements of the Act apply to all response activities under the NCP.
Superfund Amendments and Reauthorization Act (SARA)	Chapter 160	Established the Defense Environmental Restoration Program (DERP) that calls for "correction of environmental damage (such as detection and disposal of unexploded ordnance) that creates an imminent and substantial endangerment to public health or welfare or the environment."	Action-specific	Applicable	The contamination of this project area, specifically OE, was the result of past activities conducted by the U.S. Army and constitutes a hazard to human health and the environment.
State California Environmental Health Standards for the Management of Hazardous Waste ^(a)	Title 22, Sections 66261 and 66268.1	Criteria for identifying RCRA hazardous wastes and hazardous wastes that are restricted from the landfill.	Chemical-specific	Applicable	Waste munitions, munition fragments, and soil contaminated with explosives could be considered hazardous if they contain a listed waste or exhibit hazardous waste characteristics (e.g., reactivity). If found to be hazardous, they could be restricted from landfill disposal.
California Clean Air Act (CCAA) ^(b)	AB 2595	Establishes primary and secondary air quality standards necessary to protect human health, welfare, plant and animal life, buildings, materials, and visibility.	Location-specific	Relevant and Appropriate	Provisions of this Act should be followed.

Table 2-6. Applicable or Relevant and Appropriate Requirements (ARARs), Former Benicia Arsenal, Benicia, California
Page 6 of 6

Requirement	Citation	Description	Type	Applicable or Relevant and Appropriate	Comments
OE Waste Identification	Draft Department of the Army Memorandum	Adopts criterion of 10% explosive content as a measure of contaminated soil reactivity to differentiate between hazardous waste or a secondary explosive.	Action-specific	TBC	Soil sampling may be considered as part of a risk management alternative. Provisions of this Act should be followed.

- Notes:
- (a) Title 22 is more stringent than the federal RCRA.
 - (b) CCAA is more stringent than the federal Clean Air Act.
 - AB = Assembly Bill
 - ARPA = Archaeological Resources Protection Act
 - CCAA = California Clean Air Act
 - CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
 - CFR = Code of Federal Regulations
 - CWA = Clean Water Act
 - DERP = Defense Environmental Restoration Program
 - DOT = Department of Transportation
 - EO = Executive Order
 - NAGPRA = Native American Graves Protection and Repatriation Act
 - NCP = National Contingency Plan
 - NEPA = National Environmental Policy Act
 - NHPA = National Historic Preservation Act
 - OE = ordnance and explosives
 - OSHA = Occupational Safety and Health Administration
 - RCRA = Resource Conservation and Recovery Act
 - SARA = Superfund Amendments and Reauthorization Act
 - TBC = to be considered
 - USACE = U.S. Army Corps of Engineers
 - U.S.C. = U.S. Code
 - UXO = unexploded ordnance

AVAILABLE FOR VIEWING
IN THE CITY ATTORNEY'S OFFICE.

Revisions	Date	Approved
Description		

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OLEY DR.
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U.S. ARMY ENGINEERING AND SUPPORT CENTER
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CORPS OF ENGINEERS
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D

 US Army Engineering and Support Center, Huntsville	<p>SECTOR, GRID, AND UXO LOCATIONS</p> <p>FORMER BENICIA ARSENAL</p> <p>ENGINEERING EVALUATION/COST ANALYSIS</p> <p>BENICIA, CALIFORNIA</p>
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Scale: 1" = 500' Date: 05/99	Sheet reference number: Plate 1	Contract No. DACA87-95-D-0017 Task Order: 21 Sheet 1 OF 1
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