Health Consultation

OLD FORT LOWELL

TUCSON, PIMA COUNTY, ARIZONA

EPA FACILITY ID: AZR000504282

Prepared by the
Arizona Department of Health Services

JUNE 2, 2010

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Office of Environmental Health
Environmental Health Consultation Services
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Summary

In the Old Fort Lowell, the Arizona Department of Health Services' (ADHS') top priority is to ensure that the local residents have the best information possible to safeguard their health.

The City of Tucson officials had planned to redevelop the site as a recreational park. The initial soil sampling results indicated elevated levels of lead, arsenic and polynuclear aromatic hydrocarbons. ADHS was asked to perform a health consultation to evaluate whether exposure to contaminants in soil will harm people's health, either currently or during possible future reuse of the land

The 5.5-acre property is located at the southwest corner of Fort Lowell and Craycroft Roads, Tucson, Arizona. The site includes a proportion of a prehistoric site known as the Hardy Site. The site was developed in the 1870's as a portion of the Camp Lowell Army Post, later called Fort Lowell. It was used as a supply base for other army posts, protection for citizens against Indian attacks, a guard for supply trains, and protection of settlers. After the post was abandoned in 1891, the site was used as a tuberculosis sanitarium beginning in 1905. In 1928, a family purchased the property, continued to run the tuberculosis sanitarium, and ran a steel and tank manufacturing company from 1934 to 2006. In addition the family operated a trucking company from the site (SCS Engineers 2008).

The City of Tucson intended to make this site become a part of Fort Lowell Park. The park will include both historic elements such as Ft. Lowell museum, Officer's kitchen and Officer's quarters as well as park amenities such as ball fields, picnic tables, playground, and walking trails. However, the 70 years of manufacturing operation resulted in significant environmental impairment.

The City of Tucson conducted site cleanup activities to remove large quantities of hazardous materials and petroleum products in 2006 and 2007. Agency for Toxic Substances and Disease Registry (ATSDR) and ADHS visited the site in December 2008 to observe the current site conditions. Our observations included:

- Existing physical hazards: significant amount of debris, metal shards, unstable buildings, and soil staining in many locations
- Potential chemical hazards as a result of reported inappropriate disposal of waste including batteries, metal scrap, and drums of unknown substances on the property

This health consultation will focus on the potential chemical hazards. It will evaluate the impacts they may have on the health of recreational users, if the property were redeveloped without remediation.

All the data analyzed in this health consultation were collected by SCS Engineers under contract with the City of Tucson. In an attempt to characterize the nature and degree of the contamination that would impact the health of students and staff, ADHS reviewed all the data available from the City of Tucson.

ADHS reached the following conclusion about the Old Fort Lowell in Tucson, Arizona:

Current:

- Based on the available information, ADHS concludes that metals and polynuclear aromatic hydrocarbons at the site are not likely to harm people's health due to an incomplete exposure pathway. The site is fenced and the general public does not have access to the site.

Future:

- Future redevelopment of the property as a recreational park area is likely to encourage access to the property. Based on the available information, ADHS concludes that without remediation, exposures to metals and polynuclear aromatic hydrocarbons in contaminated soils from walking or exercising at the Fort Lowell site are not expected to result in non-cancer health effects among adults and children. The estimated cancer risk even without remediation is within the EPA's guidance range for protection of human health. However, without remediation, the exiting physical hazards including significant amount of debris, metal shards, and unstable buildings can cause injuries as well as bacterial infection among adults and children

To ensure the health and safety of students and staff, ADHS recommended/supported the City of Tucson to

- Restrict access to the site before remediation activities are completed
- Remediate the site before it is reused as a recreational park

Purpose

This report presents an assessment of human health risks from exposure to contaminated surface soil in the Old Fort Lowell site, 5450 E. Ft. Lowell, Tucson, AZ. City of Tucson officials had planned to redevelop the site as a recreational park. The initial soil sampling results indicated elevated levels of lead, arsenic and polynuclear aromatic hydrocarbons. The Arizona Department of Health Services (ADHS), Risk Assessment & Health Consultation Program was asked to perform a health consultation to evaluate whether exposure to contaminants in soil will harm people's health, either currently or during possible future reuse of the land.

Background and Statement of Issues

The 5.5-acre property is located at the southwest corner of Fort Lowell and Craycroft Roads, Tucson, Arizona; the street address of the site is 5450 East Fort Lowell Road. The site consists of a vacant residential/commercial property crossed by unpaved driveways. Buildings include a former shop, three former residences, adobe ruins, and a few sheds. Properties adjoining the site consist of vacant desert, a park, a church, and residences (See Appendix A).

The site includes a proportion of a prehistoric site known as the Hardy Site, which was occupied by the Hohokam people between 650-750 AD and 1000-1300 AD. The site was developed in the 1870's as a portion of the Camp Lowell Army Post, later called Fort Lowell. It was used as a supply base for other army posts, protection for citizens against Indian attacks, a guard for supply trains, and protection of settlers. After the post was abandoned in 1891, the site was used as a tuberculosis sanitarium beginning in 1905. In 1928, a family purchased the property, continued to run the tuberculosis sanitarium, and ran a steel and tank manufacturing company from 1934 to 2006. In addition the family operated a trucking company from the site (SCS Engineers 2008).

The City of Tucson purchased the site in 2006 in cooperation with Pima County. It is intended to become a part of Fort Lowell Park. Master planning for the park is proceeding under the management of the Pima County Cultural Resources Department. The park will include both historic elements such as Ft. Lowell museum, Officer's kitchen and Officer's quarters as well as park amenities such as ball fields, picnic tables, playground, and walking trails.

The 70 years of manufacturing operation resulted in significant environmental impairment. Operations included cutting, bending, welding, and grinding steel in the manufacturing of steel tanks. The City of Tucson conducted site cleanup activities to remove large quantities of hazardous materials and petroleum products in 2006 and 2007. Materials collected included a diesel fuel aboveground storage tank, a 3,000-gallon gasoline underground storage tank, a 450 gallon diesel fuel underground storage tank, 55-gallon drums, rust coating, vehicle batteries, oils, paint, etc. Agency for Toxic Substances and Disease Registry (ATSDR) and ADHS visited the site in December 2008 to observe the current site conditions. Our observations included:

- Existing physical hazards: significant amount of debris, metal shards, unstable buildings, and soil staining in many locations

- Potential chemical hazards as a result of reported inappropriate disposal of waste including batteries, metal scrap, and drums of unknown substances on the property

This health consultation will focus on the potential chemical hazards. It will evaluate the impacts they may have on the health of recreational users, if the property were redeveloped without remediation.

Discussion

Available Environmental Data for the Site

ADHS evaluated the available environmental sampling information for potential exposure to contaminants at the Old Fort Lowell site. From November 07 to August 08, a total of 114 soil samples were collected to evaluate the extent of contamination (see Appendix B for sampling locations). The soil samples were collected by SCS Engineers under contract with the City of Tucson. The soil samples were analyzed according to US Environmental Protection Agency's (EPA) SW-846 Methods. The soil samples were analyzed for Polynuclear Aromatic Hydrocarbons (PAHs), metals, Volatile Organic Compounds (VOCs), Semivolatile Organic Compounds (SVOCs) and Polychlorinated Biphenyls (PCBs) according to EPA methods 8310, 6010B/7471A, 8260, 8270 and 8083, respectively. Sampling failed to detect VOC, SVOC and PCB contamination.

Evaluation Process

ADHS provides site-specific public health recommendations on the basis of toxicological literature, levels of environmental contaminants detected at a site compared to accepted comparison values (CVs), an evaluation of potential exposure pathways and duration of exposure, and the characteristics of the exposed population. ADHS used this approach to determine if contamination in the Old Fort Lowell site could harm people's health.

Comparison values are screening tools used with environmental data relevant to the exposure pathways. CVs are conservatively developed based on the available scientific data and consideration for the most sensitive groups (e.g. children). If public exposure concentrations related to a site are below the corresponding CV, then the exposures are not considered of public health concern and no further analysis is conducted. However, while concentrations below the CV are not expected to lead to any observable adverse health effect, it should not be inferred that a concentration greater than the CV will necessarily lead to adverse health effects. Depending on site-specific environmental exposure factors (e.g. duration and amount of exposure) and individual human factors (e.g. personal habits, occupation, and/or overall health), exposure to levels above the comparison value may or may not lead to a health effect. Therefore, the CVs should not be used to predict the occurrence of adverse health effects.

ADHS used the following CVs for the screening process to identify contaminants of interest for this document:

- Arizona Residential Soil Remediation Level (ASRL)
- Reference Dose Media Evaluation Guides (RMEGs)
- Minimum Risk Levels (MRLs)

Exposure Pathway Analysis

In evaluating this and every site, ADHS uses established methodologies for determining how people may be exposed to contamination from a site and what effects, if any, may result from exposure to those contaminants. The ways that people may come into contact with chemical contaminants (such as breathing air and drinking water) are called exposure pathways. Exposure pathways have been divided into three categories: Completed, Potential, and Eliminated. There are five elements to be considered when identifying exposure pathways:

- Source of Contamination,
- Environmental Medium through which chemicals travel
- Point of Exposure
- Route of Exposure
- Receptor Population

A completed exposure pathway is observed when all five elements are present. In a potential exposure pathway, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. In an eliminated exposure pathway, at least one element of the pathway is not present and either will never be present or is extremely unlikely to ever be present. Identifying an exposure pathway does not necessarily indicate the presence or concentration of potential contaminants; it is simply a way of determining the possibility of exposure if the contaminants were present in the medium.

The Old Fort Lowell site is currently vacant land secured with a gate and fences. With the current condition, people are not allowed access to the site without permission. The City's future plans for this site call for: walking trails, a parking area, scenic overlooks, benches, and interpretive signage. In the future, if the site is not remediated the most likely human exposures in the area are occasional ingestion or infrequent dermal contact with contaminated surface soil. This exposure occurs when people have direct contact with soils in their environment. For instance, when children play outside, or when adults walk dogs, contaminated soil or dust particles cling to their hands. People can then accidentally swallow the contaminants when they put their hands on or into their mouths, as children often do. Factors that affect whether or not people have contact with contaminated soil include the amount of grass cover, weather conditions, the amount of time spent outside, and personal habits. While dermal and inhalation exposure can sometimes be a concern for soil and dust, the primary pathway of concern is ingestion. Table 2 summarizes the pathways for this site. If one or more of the exposure

pathways are potential or complete, ADHS then considers whether exposure to the chemicals present may be harmful to people.

Table 2. Exposure pathway evaluation

Exposure Pathway Elements					Time frame	Type of exposure pathway
Source	Media	Point of exposure	Route of exposure	Potentially exposed population		
Waste piles/spill	Soil	On-site	Incidental ingestion, inhalation, skin contact	Trespassers	Past, Current	Eliminated
				Recreational users	Future	Complete (without remediation)

Selecting Chemicals of Interest

The investigation results indicated contaminants are unevenly distributed in soil with some high concentrations and many non-detected concentrations at the Old Fort Lowell site. ADHS used averaged concentrations to select chemicals of interest and to evaluate the potential health effects because they are most representative of the concentration that would be contacted at a site, over time. For example, if we assume that an exposed individual moves randomly across an exposure area, the spatially averaged soil concentration can be used to estimate the true average concentration contacted over time. In this example, the average concentration contacted over time would equal the spatially averaged concentration over the exposure area. While an individual may not actually exhibit a truly random pattern of movement across an exposure area, the assumption of equal time spent in different parts of the area is a reasonable approach.

The average concentrations of PAHs and metals were computed by ProUCL using the Nonparametric Kaplan-Meier Estimation Method. This provides conservative, protective evaluation but will not result in significant overestimation. The evaluation results indicated that the sum of all carcinogenic polynuclear aromatic hydrocarbons (cPAHs) toxic equivalent in the area exceeded its respective CV (Table 3).

Table 3. Chemicals of interest in soil were identified by comparing them to their respective comparison values

Chemical	Number of Samples	Ranges of detected concentration (mg/kg)	Averaged concentration (mg/kg)	Health-based CVs[a] (mg/kg)	Type of CV	Is it a chemical of interest?
Arsenic	92	< 5 − 98	8.26	10	RSRL[b]	No
Barium	92	51 − 1,300	156	15,000	RSRL	No
Cadmium	92	< 1 − 15	1.69	39	RSRL	No

Chemical	Number of Samples	Ranges of detected concentration (mg/kg)	Averaged concentration (mg/kg)	Health-based CVs[a] (mg/kg)	Type of CV	Is it a chemical of interest?
Chromium	92	< 5 − 170	18.96	200	RSL[c]	No
Lead	92	5 − 860	124.6	400	RSRL	No
Selenium	92	< 5 − 6	< 6	390	RSRL	No
Silver	92	< 5	< 5	390	RSRL	No
Mercury	92	< 0.083 − 2	0.15	23	RSRL	No
Benzo[g,h,i]perylene	96	0.04 – 6.8	0.17	2,000[d]		No
Fluoranthene	96	0.04 − 12	0.33	800	EMEG[e]	No
Naphthalene	96	0.1 – 2.3	< 0.63	56	RSRL	No
Phenanthrene	96	0.08 − 8	0.19	2,000[d]		No
Pyrene	96	0.04 − 12	0.32	2,000	EMEG	No
Benz[a]anthracene	96	0.04 – 2	0.12	0.69	RSRL	cPAH[f]
Benzo[a]pyrene	96	0.01 – 4.8	0.18	0.069	RSRL	cPAH
Benzo[b]fluoroanthene	96	0.04 – 3.4	0.13	0.69	RSRL	cPAH
Benzo[k]fluoranthene	96	0.04 – 1.3	0.08	6.9	RSRL	cPAH
Chrysene	96	0.04 – 2.6	0.12	68	RSRL	cPAH
Indeo[1,2,3-cd]pyrene	96	0.02 – 6.1	0.21	0.69	RSRL	cPAH
Total cPAH TEQ[f]	—	0.01 – 6.1	0.24	0.069	RSRL	**Yes**

[a.] Note that the health-based CVs refer to an average concentration. Average soil concentrations are used for screening and dose assessment because exposure to soil occurs over a large area and duration of time.
[b.] RSRL: Arizona Residential soil Remediation Level
[c.] RSL: Regional Screen Level (EPA)
[d.] ATSDR Cancer Risk Evaluation Guideline for Benzo[a]pyrene was used as a surrogate
[e.] EMEG: Environmental Media Evaluation Guides for pica children's exposure (ATSDR)
[f.] cPAH TEQ: sum of all carcinogenic polynuclear aromatic hydrocarbons (cPAH) toxic equivalent, all cPAH are added using the TEQ approach to obtain Total cPAH TEQ.

Public Health Implications

Polynuclear aromatic hydrocarbons (PAHs) are a group of more than 100 chemicals that are general found in the environment as mixtures, not as single compounds. They are generated by the incomplete combustion of organic matter, including oil, wood, and coal. They are found in materials such as creosote, coal, coal tar, and used motor oil. Based on structural similarities, metabolism, and toxicity, PAHs are often grouped together when one is evaluating their potential for adverse health effects. EPA has classified some PAHs – called cPAHs – as probable human carcinogens (B2) as a result of sufficient evidence of carcinogenicity in animals and inadequate evidence in humans (ATSDR 1995).

Benzo(a)pyrene is the only cPAH for which EPA has derived a cancer slope factor. The benzo(a)pyrene cancer slope factor was used as a surrogate to estimate the total cancer risk of

cPAHs in soil. It should be noted, benzo(a)pyrene is considered the most carcinogenic of the cPAHs. The use of its cancer slope factor as a surrogate for total cPAH carcinogenicity may overestimate risk. To address this issue, Department of Health and Human Services made an adjustment for each cPAH based on the relative potency to benzo(a)pyrene toxic equivalent (TEQ) using established toxic equivalency factors (ATSDR 1995).

ADHS evaluated the potential health impacts associated with exposure to current site conditions (i.e. without remediation) by using the Total cPAH TEQ of 0.24 mg/kg. If the property is re-used for a recreational area, it is anticipated that people will be encouraged to use the property and increase the potential exposure to site contaminants. ADHS assumed that the general population would spend 48 hours/week (i.e. ~6.9 hours/day) at this property.

A mathematical model was used to estimate a hypothetical opportunity of a person developing cancer from accidental ingestion of soil containing a specified concentration of a chemical. The theoretical ingestion cancer risk for future recreational users is 3.1×10^{-7} (see Appendix C). That indicates that there will be about 3 additional occurrences of cancer in a population of 10,000,000 for future recreational users due to exposure to cPAH contaminated soil[1]. The estimated excess cancer risk is within US EPA's guidance range (10^{-6} to 10^{-4}) for the protection of human health.

Child Health Considerations

ADHS considers children in its evaluations of all exposures, and we use health guidelines that are protective of children. In general, ADHS assumes that children are more susceptible to chemical exposures than are adults. ADHS has taken into account that children are at a greater risk for exposure than are adolescents or adults because the normal behavior of children might result in higher rates of ingestion of contaminated soil and dust. Children might also receive a higher dose of contaminants because they have lower body weights than do adults. ADHS has considered these factors in the development of its conclusions for this site. The CVs used in this health consultation are developed to be protective of susceptible populations such as children.

Hot Spot Exposure

The original data set shows that four soil samples have lead concentration above 400 mg/kg, exceeding the health-based comparison value. These samples include AD-1S: 870 mg/kg, AD-3S: 470 mg/kg, AD-19S: 410 mg/kg, and AD-21S: 860 mg/kg. In this health consultation, ADHS also evaluated the potential health effects associated with the hot spot exposure because children are the primary concern when it comes to exposure to lead.

Children's bodies tend to absorb more lead than adults. For example, about 99% of the lead taken into the body of an adult will leave in the body waste within a couple of weeks, but only 32% of the lead taken in by children will be eliminated by the body in the same manner (ATSDR 1997). Children are also more sensitive to the effects of lead than are adults. At low levels, lead

[1] There is a background incidence of cancer in the general population due to everyday exposure to common materials. Nearly half of all men and one-third of all women in US population will develop cancer at some point in their life (American Cancer society 2008).

can affect a child's mental and physical growth. The major effect of intake of excessive amounts of lead into the body is to damage to the blood-forming and nervous systems. Although no threshold has been established for the effects of lead on the blood system and on learning ability in children, the Center for Disease Control and the EPA currently recognize a level of 10 micrograms per deciliter (µg/dL) of blood as being elevated in children.

ADHS estimated the blood lead levels by using ATSDR's regression analysis[2]. The highest detected concentration (i.e. 870 mg/kg) was used to the estimate the blood lead levels in children based on the current site condition (i.e. without remediation) (Table 4). The ADHS assumed that the general population would spend 48 hours/week (i.e. ~6.9 hours/day) at this property if the property is re-used for a recreational area.

Table 4. Estimated blood lead concentrations and contribution of environmental lead to blood lead for children. The estimations are based on current site conditions (i.e. without remediation).

Media	Concentration		Relative Time Spent	Slope Factor		Blood Lead (µg/dL)	
						Low	High
Outdoor Air	0.2	$\mu g/m^3$	0.5	1.92 ± 0.6	(µg/dL)/(µg pb/m^3)	0.13	0.25
Indoor Air	0.06	$\mu g/m^3$	0.5	1.92 ± 0.6		0.04	0.08
Water	4	µg/L	1	0.16	(µg/dL)/(µg pb/L)	0.64	0.64
Diet	5	µg/day	1	0.24	(µg/dL)/(µg pb/day)	1.20	1.20
Park Soil	870	mg/kg	0.29	0.0068 ± 0.00097	(µg/dL)/(µg pb/kg)	1.47	1.96
Background Soil	70	mg/kg	0.71	0.0068 ± 0.00097	(µg/dL)/(µg pb/kg)	0.29	0.39
Dust	70	mg/kg	1	0.00718 ± 0.0009	(µg/dL)/(µg pb/kg)	0.44	0.57
Predicted range of blood lead						*4.21*	*5.08*

Based on the assumed exposure scenario, the predicted results indicated that children are not likely to have elevated blood levels if this property is reused as a recreational area without remediation. Kids undertaking general activities at the site are not expected to experience harmful health effects from lead in soil.

[2] ATSDR has developed this integrated exposure regression analysis which utilizes slope values from select studies to integrate all exposures from various pathways, thus providing a cumulative exposure estimate expressed as total blood lead. The general form of the model is: $PbB = \delta_S TPb_S + \delta_D TPb_D + \delta_W TPb_W + \delta_{OA} TPb_{OA} + \delta_{IA} TPb_{IA} + \delta_F TPb_F$. Where, Pb_S: soil lead concentration; Pb_D: dust lead concentration; Pb_W: water lead concentration; Pb_{OA}: outdoor air lead concentration ; Pb_{IA}: indoor air lead concentration; Pb_F: food lead concentration; T: relative time spent; δ: the respective slope factor for specific media.

Conclusions

Current:

- Based on the available information, ADHS concludes that metals and polynuclear aromatic hydrocarbons at the site do not harm people's health due to an incomplete exposure pathway. The site is fenced and the general public does not have access to the site.

Future:

- Future redevelopment of the property as a recreational park area is likely to encourage access to the property. Based on the available information, ADHS concludes that without remediation, exposures to metals and polynuclear aromatic hydrocarbons in contaminated soils from walking or exercising at the Fort Lowell site are not expected to result in non-cancer health effects among adults and children. The estimated cancer risk even without remediation is within the EPA's guidance range for protection of human health. However, without remediation, the exiting physical hazards including significant amount of debris, metal shards, and unstable buildings can cause injuries as well as bacterial infection among adults and children.

Recommendations

ADHS recommended/supported the City of Tucson to

- Restrict access to the site before remediation activities are completed
- Remediate the site before it is reused as a recreational park

Public Health Action Plan

Completed:

- The City of Tucson restricted access to this site with a gate and fences around the site.
- ADHS submitted a letter on 12/17/08 recommending the City of Tucson's not allow access to the Old Fort Lowell site for an adobe workshop due to the site conditions at the time.

Future:

- The ADHS will continue to review and evaluate data provided for this site.
- The ADHS will attend public meetings, make presentations, develop handout literature, and engage in other actions to notify the property owners in the area of the findings of this health consultation.
- The ADHS will post this report on the ADHS website.
- The City will perform the cleanup (remediation activities) under the Arizona Department of Environmental Quality, Voluntary Remediation Program. Once the site is remediated (cleaned-up), the property is intended to be redeveloped as a park.

References

SCS Engineers. January 15, 2008. *Phase I Environmental Site Assessment: Former Adkins Properties, 5450 East For Lowell Road, Tucson, Arizona.*

Agency for Toxic Substances and Disease Registry (ATSDR) (1995). Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs) (update). Department of Health and Human Services, Atlanta, GA.

Preparers of Report

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Certification

This Old Fort Lowell, Health Consultation was prepared by the Arizona Department of Health Services under cooperative agreement with the Agency for Toxic Substances and Disease Registry. It is in accordance with approved methodology and procedures existing at the time the exposure investigation report were begun.

Charisse Walcott

Technical Project Officer

CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with the findings.

Alan Yarbrough

Team Leader-Cooperative agreement Program

CAT, CAPEB, DHAC, ATSDR

APPENDIX A

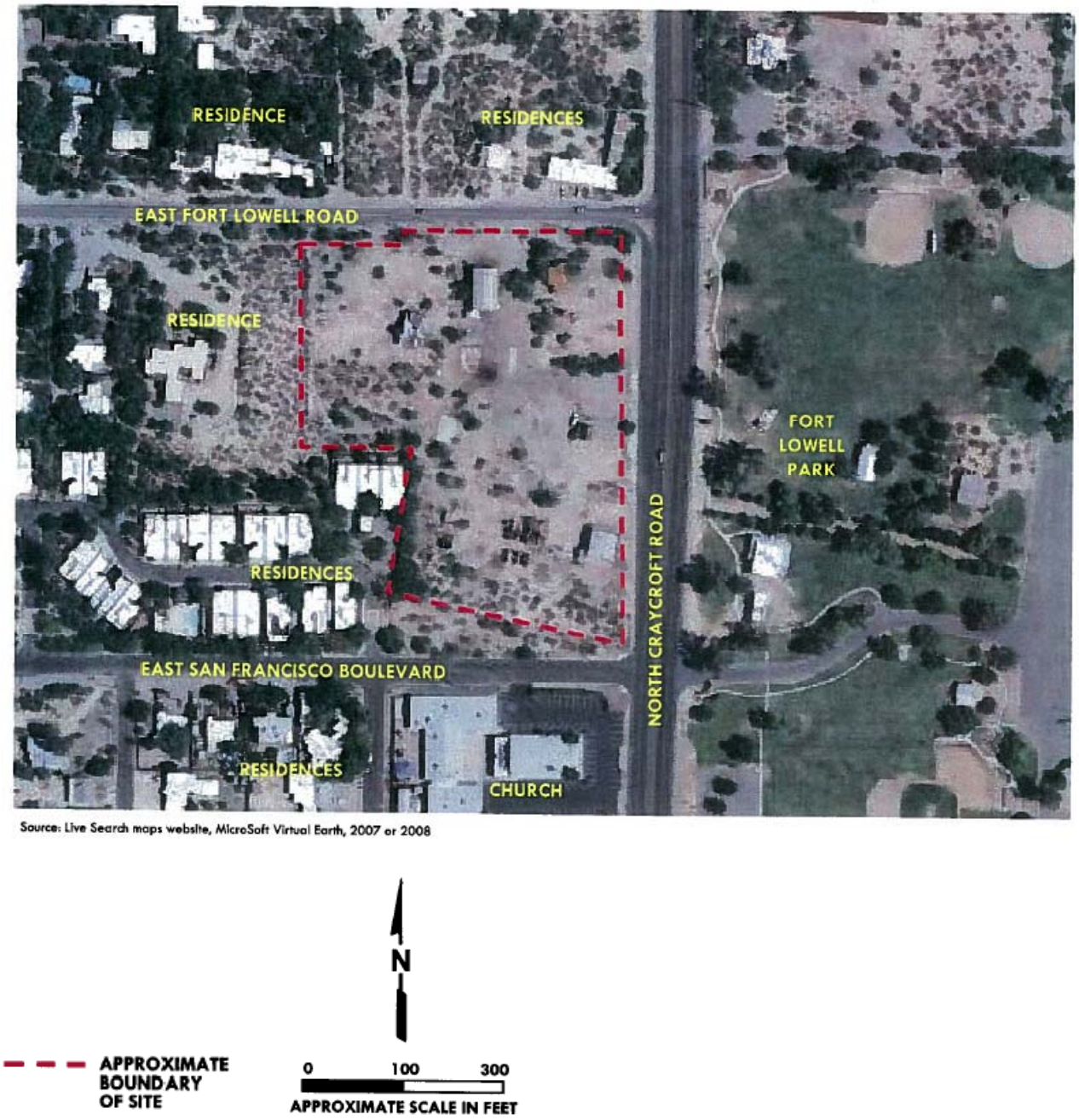


Figure 1. Map shows the location and vicinity of the property. The map is adapted from: *Phase I Environmental Assessment Report* (SCS Engineers 2008).

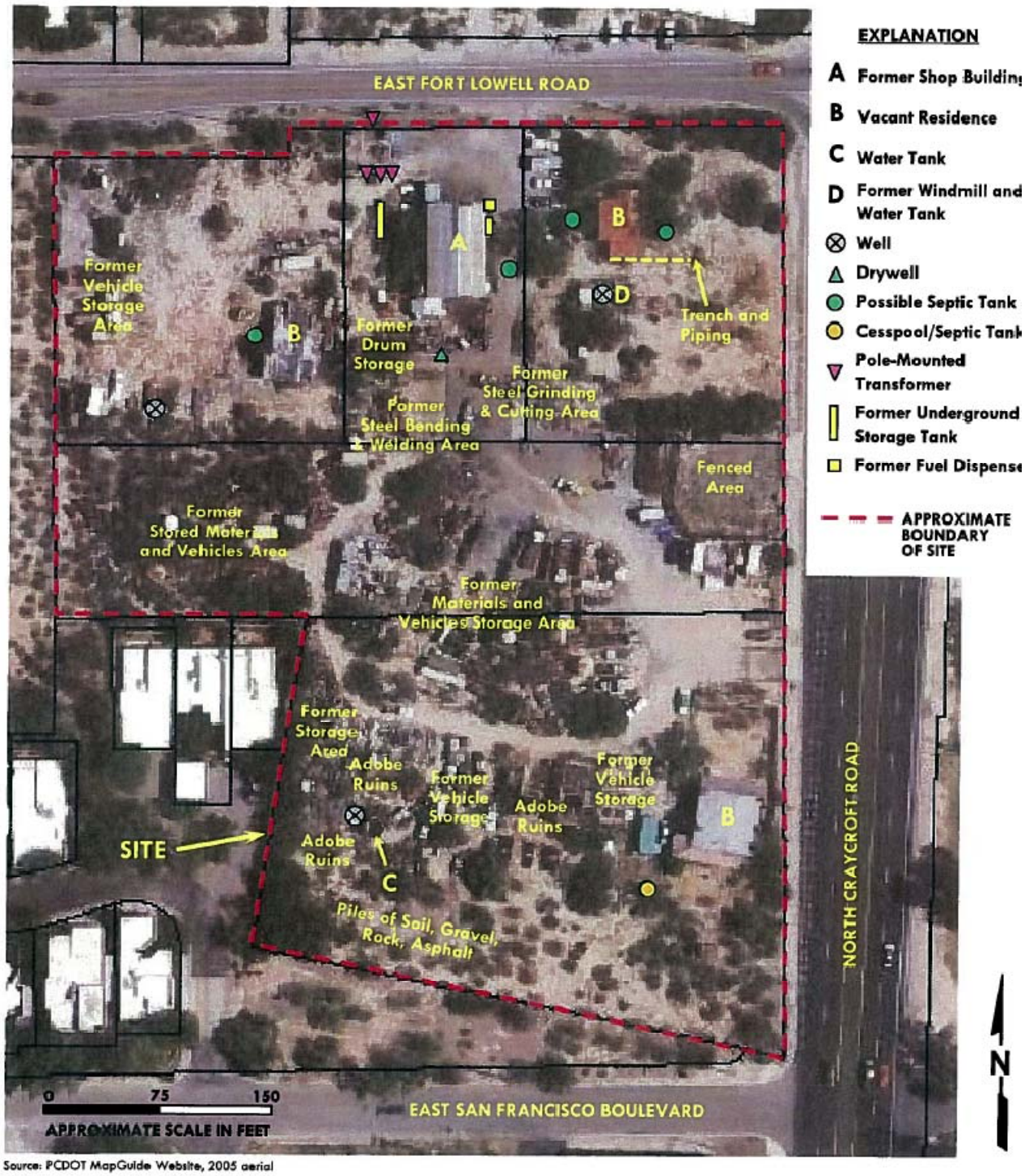
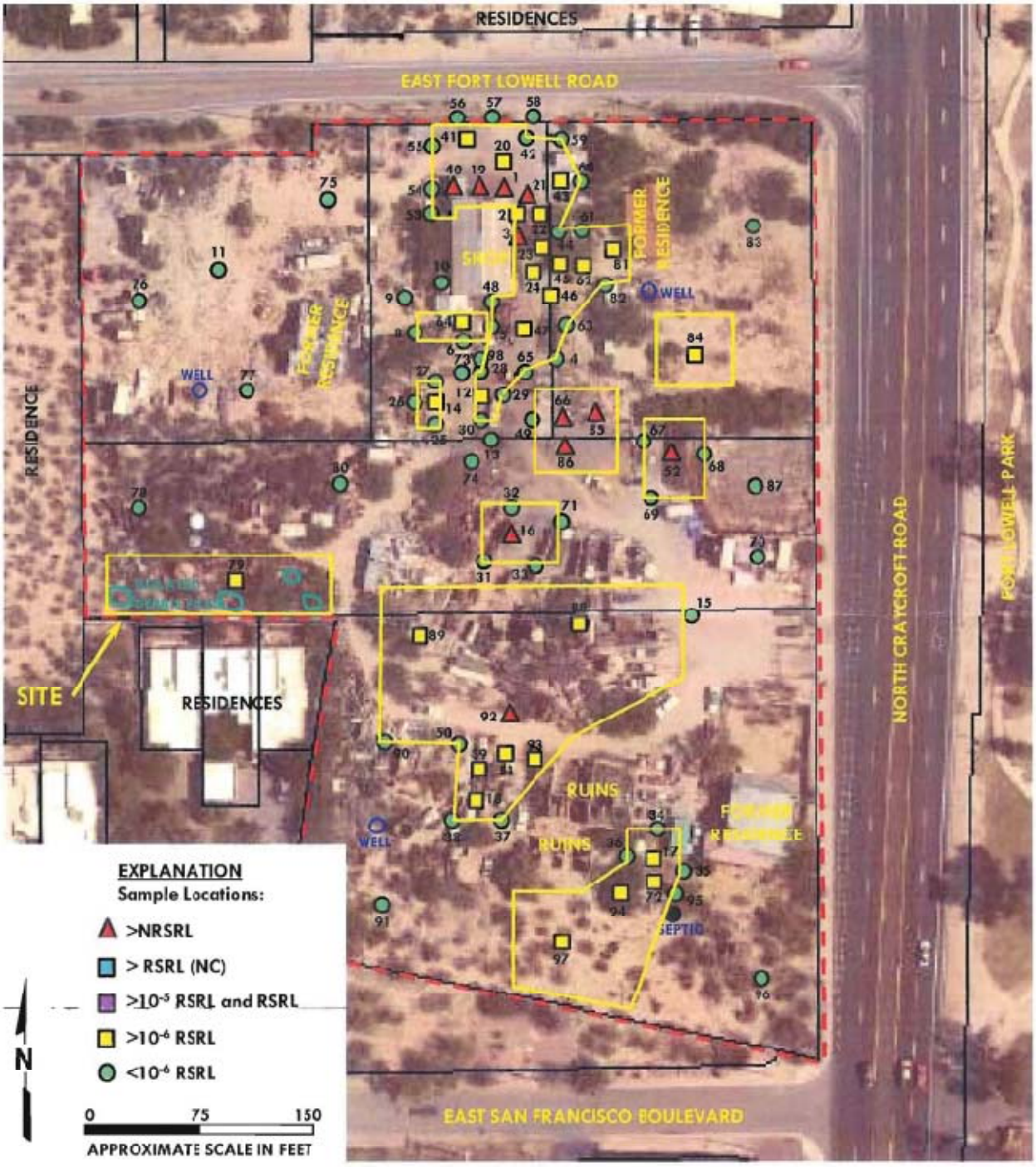


Figure 2. Map shows the former structures and usages of the site. The map is adapted from: *Phase I Environmental Assessment Report* (SCS Engineers 2008).

Appendix B

Soil samplelocation map.



Disclamer: This figure is based on available data. Actual conditions may differ. All locations and dimensions are approximate.

The map is made by SCS Engineers and provided by the City of Tucson.

Appendix C

Formula and assumptions used to calculate cancer risk from accidental soil ingestion:

$$\text{Chronic Daily Intake (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{IR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}; \quad \text{Cancer Risk} = \text{Chronic Daily Intake} \times \text{SF}$$

Variable			
CS	Chemical concentration in soil	mg/kg	0.24
CF	Conversion factor	kg/mg	$1/10^6$
IR	Ingestion rate	mg/day	100
EF	Exposure frequency	days/year	104
ED	Exposure duration	years	30
BW	Body weight	kg	70
AT	Averaging time	days	25,550
SF	Slope Factor	$(\text{mg/kg/day})^{-1}$	7.3
CR	Cancer Risk	unit less	3.1×10^{-7}