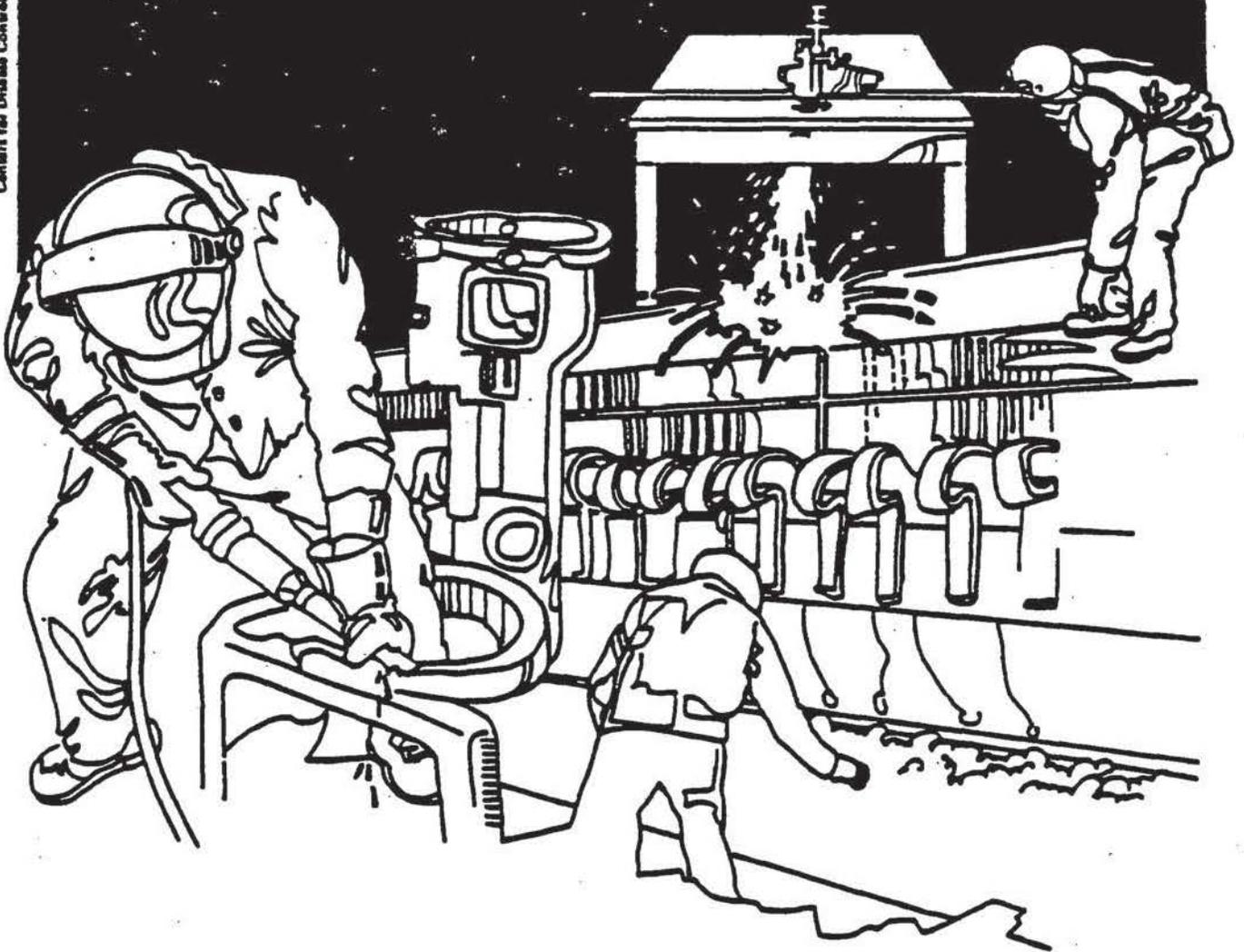


# NIOSH



## Health Hazard Evaluation Report

HETA 85-527-1704  
CANYON DE CHELLY  
NATIONAL MONUMENT  
CHINLE, ARIZONA

## PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HEPA 85-527-1704  
JUNE 1986  
CANYON DE CHELLY NATIONAL MONUMENT  
CHINLE, ARIZONA

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1. Summary

On September 5, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request for assistance from the National Park Service to: (1) recommend appropriate medical follow-up of five Park Service employees who became ill after exposure to a pesticide (malathion) which had been applied around the visitor center at Canyon de Chelly National Monument, Chinle, Arizona on September 2, 1985; and (2) to determine the adequacy of decontamination of the visitor center.

An environmental and medical survey was conducted on September 8-10, 1985. All environmental sampling (air and wipe) and biologic monitoring was obtained after decontamination of the facility was completed on September 6. A bulk sample of the pesticide was confirmed by chemical analysis to contain malathion. The five air samples contained less than 0.03 ug of malathion per cubic meter of air. The current Occupational Safety and Health Administration (OSHA) standard for airborne malathion is 15 mg (15,000 ug) per cubic meter of air. Seventeen wipe samples taken throughout the building showed the malathion concentrations ranged from less than 0.05 ug per 100 sq cm to 50 ug per 100 sq cm.

Eighteen of the 21 employees who were potentially exposed on September 2 and 3, 1985 were surveyed for symptoms of organophosphate poisoning, using a self-administered questionnaire. Serum and erythrocyte (RBC) cholinesterase levels were drawn from all employees completing the questionnaire. Follow-up tests were obtained on 14 of the original 18 study participants in October 1985 or January 1986. No visitors to the center were surveyed, nor were any known to have been ill.

Four employees met the requirements of a case definition for illness. Predominate symptoms included headaches, nausea, runny nose, and eye or throat irritation. The differences in serum and RBC cholinesterase levels were analyzed using a paired Student t-test for employees for whom initial and follow up test results were available. No significant difference was noted for serum cholinesterase levels. The mean difference in RBC cholinesterase levels was 0.68 (standard error = .18) at  $p < \text{less than } 0.002$ . The changes in serum and RBC cholinesterase levels among cases and non-cases were also compared using a Student t-test. No significant difference was noted for serum or RBC cholinesterase levels. However, when RBC cholinesterase level of one

non-case (ID #1) was eliminated as an outlier (level greater than 3 1/2 times the SD), the mean differences between the initial and follow up blood levels were significantly greater for cases compared to non-cases, at  $p < 0.015$ .

It was determined that employees in the Canyon de Chelly National Monument Visitor Center were exposed to potentially toxic concentrations of malathion vapors and particulates for the first 36 hours after the pesticide had been applied around or near the building. Seven days following exposure, RBC cholinesterase levels of exposed employees were significantly lower when compared to follow-up levels (assumed to approximate baseline levels). After decontamination of the building and the adjacent areas was completed, environmental monitoring data confirmed that there was no further risk of toxic exposure.

KEYWORD: SIC 9199 (National Monuments - General Government)  
Cholinesterase, Malathion

## II. INTRODUCTION

On September 5, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a phone request from the National Park Service to recommend appropriate medical follow-up of five Park Service employees who became ill after exposure to a pesticide which had been used around the visitor center at Canyon de Chelly National Monument, Chinle, Arizona, and finally, to determine if the subsequent clean-up of pesticide residue at the site was complete.

The environmental and medical survey was conducted on September 8-10, 1985. The site visit by NIOSH was made after the clean-up was completed. All environmental and medical data collected was post exposure.

## III. BACKGROUND

Canyon de Chelly National Monument is located in Chinle, Arizona. A combination office and visitor center is located at the entrance to the monument. On Monday, September 2, 1985, a maintenance worker applied three to four pounds of a granular pesticide around the front and rear entrance to the center, in the front and rear patio area, and in two restrooms which are entered through the front patio area (see visitor center diagram, Figure 1). The pesticide was believed by Park Service employees to be malathion and had been stored on the premises for 13 to 15 years. It was being used in an effort to control ants around the visitors center.

Because the weather was warm and dry and the building had no central air conditioning, the front and rear doors were propped open throughout the day. Normal air currents and intermittent gusting wind conditions are believed to have brought pesticide particulate and vapor into the building. In addition, tracking of the compound upon entry or after restroom use by employees or visitors to the center is assumed to have occurred. There were 365 visitors to the center on September 2, 1985. A visitor count for September 3 was not made, as the center was closed by early afternoon after five employees became ill. Predominant symptoms reported among the five ill employees included headaches, dizziness, nausea, runny nose, red and tearing eyes, or sore throat. Park Service employees swept and hosed down the area around the center the day after the pesticide had been applied. A commercial hazardous waste clean-up firm was contracted and by September 6, 1985, decontamination of the building and adjacent areas was completed. NIOSH was requested to recommend appropriate medical follow-up for the affected employees and to determine the adequacy of the cleanup. A NIOSH industrial hygienist and a physician arrived late September 8, 1985, and began their investigation.

#### IV. EVALUATION DESIGN

##### A. Environmental

Five general area samples were collected. The samples were collected on fibrous glass filters at a flow rate of 2 liters per minute for 1110 minutes (18.5 hours). The samples were analyzed for pesticide residues using a modification of NIOSH method No. S-370-1. Seventeen wipe samples were taken on flat surfaces from diverse sites throughout the inside and outside of the building. The samples were collected by wiping a 100-square-centimeter (sq cm) area with a pre-extracted cotton gauze saturated with hexane. The samples were analyzed using a modification of NIOSH method number S-370-1. A bulk sample of the pesticide was also analyzed. All samples were analyzed using mass spectrophotometry and gas chromatography.

##### B. Medical

A self-administered questionnaire and testing for serum and red blood cell cholinesterase levels was offered to all available employees known to have entered the visitors center on September 2, or 3, 1985. Eighteen of 21 eligible employees participated in the study. No visitors to the center were surveyed, nor were any known to have become ill.

At a one month follow-up, 12 of the original 18 employees were retested. Five samples were lost because of breakage during transport. At a later follow-up in January 1986, six employees who were either unavailable at the time of the first follow-up, or whose specimens were lost, were retested. Initial and follow-up test results of serum and RBC cholinesterase were available on 13 and 14 employees respectively, at the time of data analysis.

#### V. EVALUATION CRITERIA

##### A. Environmental

As a guide to the evaluation to the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual

susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucus membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The current OSHA standard for airborne malathion is 15 mg per cubic meter ( $\text{mg}/\text{m}^3$ ) of air. NIOSH, in its document "Criteria for a Recommended Standard . . . Occupational Exposure to Malathion,"<sup>(1)</sup> states that "when skin exposure is prevented, exposure in the workplace shall be controlled so that employees are not exposed to malathion at a TWA (time weighted average) concentration greater than 15 mg per cu meter of air." Because malathion can be absorbed through the skin and ingested, symptoms can occur even when air concentrations are very low.

#### B. Medical

Malathion is one in a family of organophosphate pesticides. Its chemical formulation is O,O-dimethyl S-(1,2-dicarboethoxyethyl) dithiophate. Absorption may occur via inhalation, ingestion, or dermal contact. Mild effects of malathion intoxication may include headache, dizziness, nausea, fatigue, visual disturbance, and anxiety. After moderate poisoning, tearing, miosis (pinpoint pupils), salivation, shortness of breath, vomiting, abdominal cramps, diarrhea, and fasciculations (uncontrolled muscle twitching) may be present. In severe cases, ataxia (difficulty with balance), seizures, cardiac arrhythmias, respiratory arrest, coma and death can occur. Onset of signs and symptoms of poisoning after malathion exposure has varied from a few minutes to several hours. Malathion acts by combining with and inactivating acetylcholinesterase at the neuromuscular junction. Acetylcholine accumulates at the junction and produces the symptoms described above. The degree of enzyme activity can be measured in both the serum and red blood cells. Although there is normally substantial variation of cholinesterase activity, a 30 to 50 percent reduction in enzyme activity is usually considered medically significant (2). The time until recovery of enzyme activity after exposure may vary. RBC cholinesterase regenerates at a rate of 0.8 percent to 1

percent per day (3,4). This estimate is based on the replacement rate of the red blood cell. Serum enzyme recovery rate after exposure is faster, occurring at the rate of approximately 25 percent over a period of 7 to 10 days (3,4).

## VI. RESULTS AND DISCUSSION

### A. Environmental

Analysis of a bulk sample of the pesticide confirmed the presence of malathion; this equaled 16 percent of the total sample. In addition, 2 percent of the bulk sample was determined to be an organosulfur compound. This may have been an impurity from the synthesis of malathion, or a degradation product produced while the malathion was stored. No commercial preparation of malathion is entirely free of impurities (5). Breakdown of malathion is likely with time, particularly when it is in the form of water-wettable powders (5). Malaoxon, a breakdown product of malathion and a compound originally reported to be present in the sample, was not identified.

Five general air samples were collected in the reception area, the display area, library, center entrance, and the hallway near the entrance to the employee offices. The locations and results are shown on Figure 1 and Table 1. All five samples contained less than 0.03 ug (0.00003 mg) malathion per cubic meter of air. This is less than 1 percent (.0002%) of the NIOSH recommended exposure limit of 15,000 ug (15 mg) per cubic meter of air. Unfortunately, an estimate of airborne levels of malathion at the time of employee illness is not possible without information on concentration or distribution of the pesticide before decontamination was completed.

Seventeen wipe samples were taken on various surfaces such as counter tops, floors, and shelves to determine the presence of malathion. The locations and results are shown in Figure 2 and Table 2. The results can be summarized as follows:

<u>Number of Samples</u>	<u>ug/100 sq. cm.</u>
4	less than 0.05
7	0.05 - 1
2	1 - 10
3	10 - 20
1	50

Five of the six samples that were above 1 ug malathion per 100 sq cm were in the main entry corridor of the building. The highest quantity was 50 ug/100 sq cm and was on the front patio where the malathion had been applied. On the back patio, there was 14 ug/100 sq cm. In the main walking corridor to the information desk, there were measurements of 14 and 18 ug/100 sq cm. This suggests that the pesticide had been tracked in on the shoes of the visitors or aerosolized and brought into the building with the air currents. After a NIOSH investigator walked around the area for several hours, there was 8 ug of malathion per 100 square centimeters on the bottom of his shoes.

The highest concentration of malathion measured inside the building was 18 ug/100 square centimeters. The counter tops, table tops, and shelves all contained less than 0.1 ug/100 square centimeters. While these are areas where hand contamination followed by accidental ingestion is possible, at these concentrations, the potential for a substantial ingestion is extremely low. Assuming an equal distribution of the maximum measured concentration over the entire floor area, and assuming the worst case, that all the malathion suddenly was to become airborne and equally distributed within the room, the air concentration would be approximately 0.6 mg per cubic meter of air. This is less than 4 percent of the occupational exposure criterion for airborne malathion. These quantities do not constitute a risk to health from inhalation, skin absorption, or ingestion.

#### B. Medical

In the medical evaluation of possible employee exposure to malathion, a case definition was developed and included: (1) entry into the visitors center on September 2, or 3, 1985; (2) symptom onset within six hours of possible exposure; (3) at least four of the following eight symptoms-headaches, dizziness, red or tearing eyes, blurred vision, salivation, nausea, vomiting, or diarrhea. Although 5 of the 18 employees were symptomatic, only 4 met the case definition of probable acute pesticide toxicity. The distribution of symptoms reported on September 2 or 3, 1985 among all employees is presented in Table 3. Headache, dizziness, nausea, and runny nose were the most commonly reported symptoms.

Results of initial and follow-up RBC and serum cholinesterase testing are presented in Table 4. Initial samples were obtained seven or eight days after potential exposure. Follow-up samples are assumed to approximate baseline levels, as all were obtained at least one month after any potential for exposure had ceased.

The differences in serum and RBC cholinesterase levels were analyzed using a paired Student t-test for employees for whom initial and follow-up test results were available. Thirteen paired serum cholinesterase and 14 paired RBC cholinesterase samples were available from the original 18 employees surveyed. No significant difference was noted for serum cholinesterase levels. The mean difference in RBC cholinesterase levels was 0.68 (standard error = 0.18) at p less than 0.002. The differences in serum and RBC cholinesterase levels were also analyzed using a Student t-test between those employees designated cases and non-cases. No significant difference was noted for serum or RBC cholinesterase levels. However, when the RBC cholinesterase level of one non-case (ID #1) was eliminated as an outlier (the RBC cholinesterase level was greater than 3 1/2 times the standard deviation), the mean differences between the initial and follow-up blood levels was 0.98 (standard deviation = 0.22) for cases and 0.38 (standard deviation = .52) for the non-cases. This was significant at p less than 0.015.

Since the initial samples were collected seven or eight days after exposure, the RBC enzyme activity is expected to be a better marker for exposure. The recovery rate of RBC cholinesterase enzyme activity is slower, approximately 0.8 percent to 1 percent per day. The recovery rate of serum cholinesterase is approximately 25 percent over a 7 to 10 day period. No significant correlation was found between RBC and serum cholinesterase change and total number of symptoms, total time spent in the center, or total number of trips by employees into and out of the center.

#### VII. SUMMARY AND CONCLUSION

NIOSH investigators have determined that those employees and visitors who entered the building were potentially exposed to toxic concentrations of malathion vapors and particulates during the first 36 hours after application of the pesticide. Employees were probably exposed to malathion levels sufficient to cause depression of RBC cholinesterase with symptoms of organophosphate toxicity. Air and wipe samples collected after decontamination of the building found only trace amounts of malathion residues. These levels pose no risk of further toxic exposure.

#### VIII. REFERENCES

1. Criteria for a Recommended Standard... Occupational Exposure to Malathion. DHEW (NIOSH) Publication No. 76-205, June 1976.
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**X. DISTRIBUTION AND AVAILABILITY OF REPORT**

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Canyon de Chelly National Monument
2. The National Institute for Occupational Safety and Health (NIOSH) Region IX.
3. The Occupational Safety and Health Administration (OSHA) Region IX.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

MALATHION AIR SAMPLE RESULTS  
CANYON DE CHELLY NATIONAL MONUMENT  
CHINLE, ARIZONA  
SEPTEMBER 8 AND 9, 1986

<u>Sample Number</u>	<u>Sample Location</u>	<u>Sample Time (minutes)</u>	<u>Sample Volume (liters)</u>	<u>Malathion ug/cu m</u>
1	Entrance to Offices (hall)	1110	2000	less than 0.03
2	Library	1110	2000	less than 0.03
3	Foyer Entrance	1110	2000	less than 0.03
4	Display area	1110	2000	less than 0.03
5	Reception Desk	1110	2000	less than 0.03

TABLE 2

MALATHION WIPE SAMPLE RESULTS  
 CANYON DE CHELLY NATIONAL MONUMENT  
 VISITOR CENTER  
 CHINLE, ARIZONA  
 SEPTEMBER 9, 1986

<u>Sample Number</u>	<u>Sample Location</u>	<u>Malathion ug/100 sq. cm.</u>
11	Reception Desk Counter Top	less than 0.05
12	Foyer - On Top Silversmith's Buffing Unit	7.6
13	Foyer Floor between the Two Sets of Doors	14
14	Flat Surface of Book Display	less than 0.05
15	Cement in Front of Bldg. where malathion was applied	50
16	Mens Restroom	0.52
17	Womens Restroom	0.90
18	Tile Floor - Middle of Reception Area	18.
19	Bottom of Investigator's Shoe	7.8
20	Library Table Top	0.7
21	Administration Office Desk Top	0.8
22	Superintendent's Office Desk Top	0.6
23	Chief Park Ranger's Office - Cabinet Top	less than 0.05
24	Office - Desk Top	less than 0.05
25	Back Patio - By Door	14
26	Display Area - Top of A Display Case	0.10
27	Display Area - Display Shelf	0.07

TABLE 3

SYMPTOM DISTRIBUTION AFTER EXPOSURE TO MALATHION  
ON SEPTEMBER 2 AND 3, 1985, AMONG 18 EMPLOYEES  
AT CANYON DE CHELLY NATIONAL MONUMENT  
CHINLE, ARIZONA

	<u>No.</u>	<u>Percent (%)</u>
Headaches	8	44.4
Dizziness	5	27.7
Nausea	5	27.7
Runny nose	4	22.2
Red or tearing eyes	3	16.6
Sore throat	3	16.6
Salivation	2	11.1
Blurred vision	2	11.1
Diarrhea	2	11.1
Stomach cramps	2	11.1
Chest tightness	2	11.1
Excessive fatigue	2	11.1
Weakness	2	11.1
Vomiting	1	5.5
Tinnitus	1	5.5
Wheezing	1	5.5
Cough	1	5.5
Shortness of breath	1	5.5
Fasciculations	1	5.5

TABLE 4

INITIAL<sup>1</sup> AND FOLLOW-UP<sup>2</sup> ERYTHROCYTE (RBC) AND SERUM CHOLINESTERASE LEVELS  
 AMONG 18 EMPLOYEES EXPOSED TO MALATHION ON SEPTEMBER 2 AND/OR 3, 1985  
 AT CANYON de CHELLY NATIONAL MONUMENT, CHINLE ARIZONA

ID Number	RBC CHOLINESTERASE (International Units/ml)			SERUM CHOLINESTERASE (Units/liter)		
	Initial	Follow-up	% Change <sup>3</sup>	Initial	Follow-up	% Change <sup>3</sup>
01	3.3	5.5	-40.0	5.6	6.2	-9.7
02 *	3.2	3.2	-25.6	4.3	4.3	0
03	3.1	3.5	-11.4	7.2	7.2	0
04	4.9	3.7	-24.5	5.6	5.4	+3.7
05	3.3	X	NA	5.8	6.1	-4.9
06	3.6	X	NA	5.4	5.3	+1.2
07 *	3.6	4.4	-18.2	5.2	X	NA
08	3.1	3.3	-6.1	3.8	3.6	+5.5
09	3.8	3.8	0	6.7	ND	NA
10	3.3	3.9	-15.2	6.6	6.3	+4.8
11 *	3.0	3.9	-23.1	5.0	5.1	+2.0
12	3.5	ND	NA	5.9	ND	NA
13 *	3.4	4.6	-25.1	5.9	5.4	+9.2
14	3.0	3.7	-18.9	4.0	4.9	-18.4
15	4.0	ND	NA	6.4	ND	NA
16	3.9	3.6	+8.3	4.5	ND	NA
17 **	3.4	4.2	-19.0	4.6	4.4	+4.5
18	2.9	2.6	+11.5	6.3	5.8	+8.6

1 = Initial specimens were drawn 7 or 8 days after potential exposure.

2 = Follow-up specimens were obtained at one month (Oct. 1985) or in Jan. 1986.

3 = Percent change after exposure from baseline cholinesterase level. Follow-up results are assumed to approximate the "true" baseline value.

$$\% \text{ Change from baseline} = \frac{\text{Initial} - \text{Follow-up}}{\text{Follow-up}}$$

\* = Met case definition

\*\* = Applicator

X = Specimen lost after broken in transit.

ND = Not done

NA = Not available

**FIGURE 1**  
**CANYON DE CHELLY NATIONAL MONUMENT**  
**VISITOR CENTER**

**Malathion Air Samples**

**Sample Number, Location & Results**

Results in ug/cu m

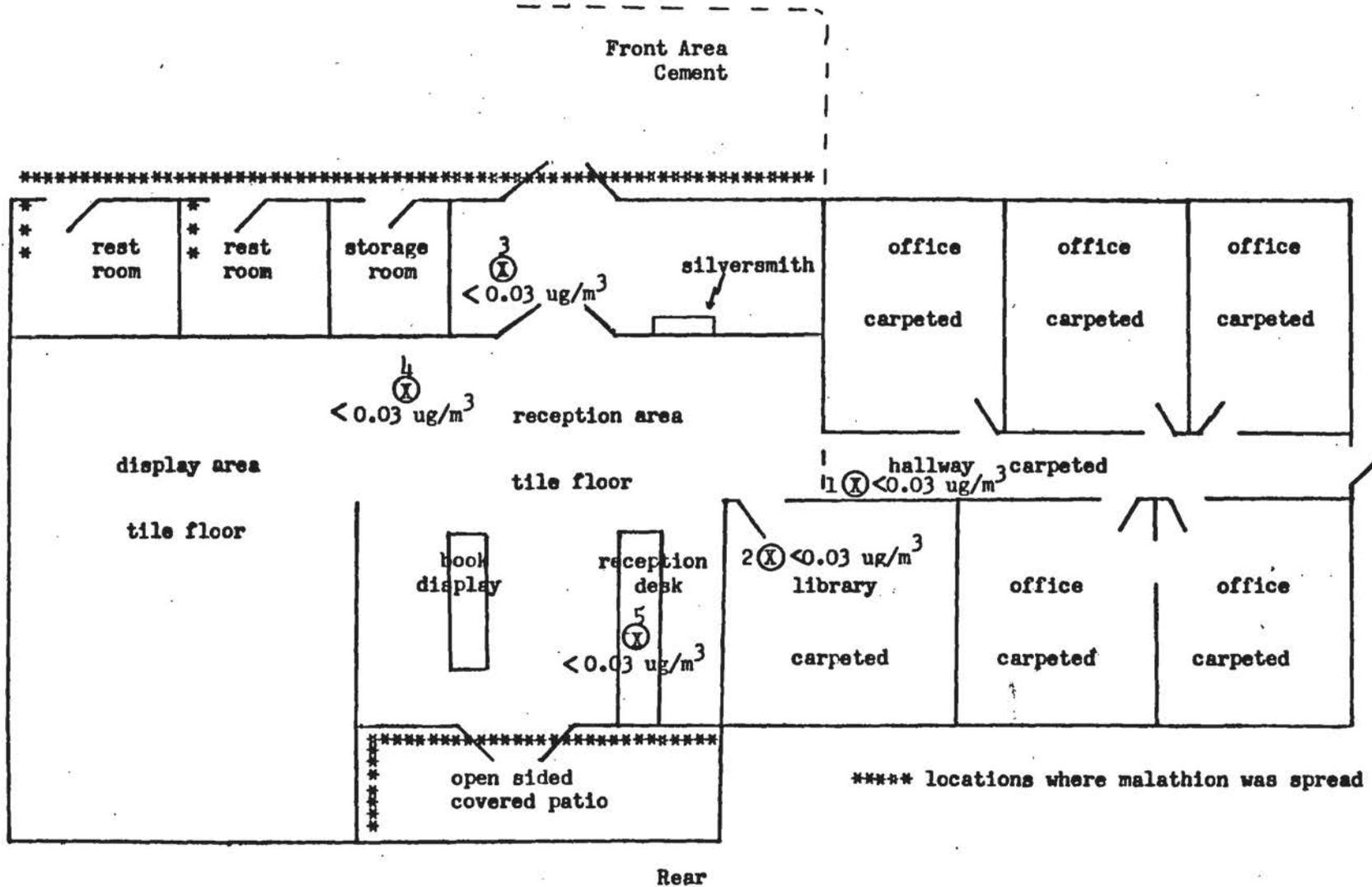


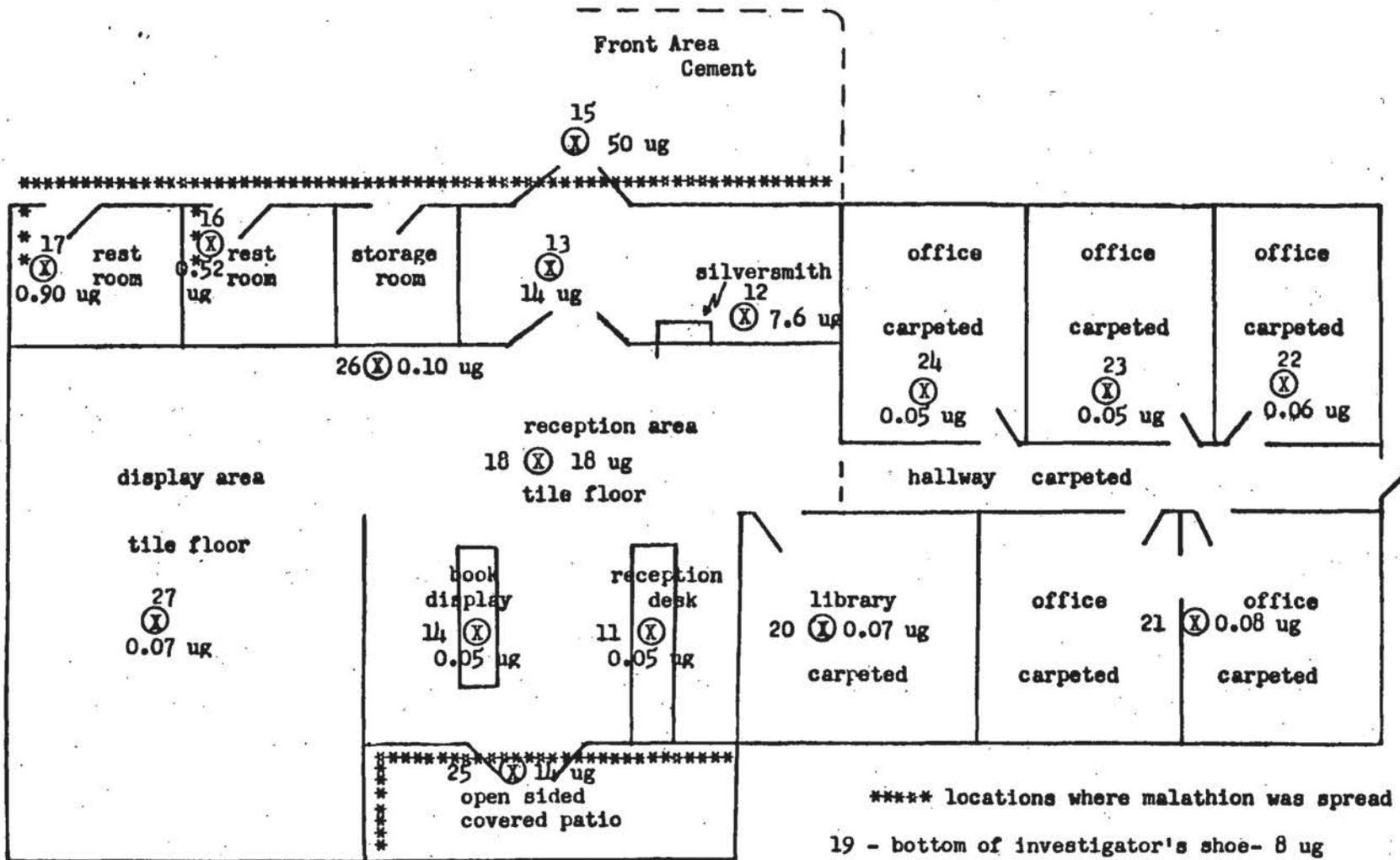
FIGURE 2

CANYON DE CHELLY NATIONAL MONUMENT  
VISITOR CENTER

MALATHION WIPE SAMPLES

Sample Number, Location & Results

Results in ug/100 sq cm



Rear