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Technical Memorandum

SURVEYS OF FALLOUT SHELTER -- A COMPARISON
BETWEEN AERIAL PHOTOGRAPHIC AND DOCUMENTARY METHODS

By
D. C. Kleinecke

Civil Defense Research Project

SERIES NO. 2

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TECHNICAL MEMORANDUM

SURVEYS OF FALLOUT SHELTER -- A COMPARISON
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By

D. C. Kleinecke

ABSTRACT

In 1959 a large part of Contra Costa County, California was surveyed for fallout shelter areas by a contractor of the Office of Civil and Defense Mobilization. This survey was based on an examination of the tax assessor's records of existing buildings. A portion of this area was also surveyed, independently, by a method based on aerial photography. A statistical comparison of the results of these two surveys indicates that the aerial photographic method was more efficient than the documentary method in locating potential shelter space in buildings of heavy construction. This statistical result, however, is probably not operationally significant. There is every reason to believe that a combination of these two survey methods could be devised which would be operationally preferable to either method.

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INTRODUCTION: Recently the Office of Civil and Defense Mobilization began a series of surveys of the existing fallout shelter potential in selected areas of the United States. It would appear to be very costly to survey the entire United States by any method whatsoever; therefore, considerable interest has been shown in survey methods which might increase the efficiency, or decrease the cost, of shelter surveys.

One method of surveying existing constructions which has had great success in similar survey problems is that of aerial photographic interpretation. Undoubtedly, aerial photographic interpretation is a means of examining many structures very rapidly and economically. However, it is not obvious that such intimate details of construction as shelter potential can be deduced from the necessarily distant viewpoint of aerial photography.

It did not seem profitable to continue theoretical discussions of the capability and limitations of aerial photography without some practical experience as a foundation. The only useful practical experience seemed to be that derived from a direct comparison of the results of a photographic survey of shelter potential with the results of some other type of survey. Since the Office of Civil and Defense Mobilization was, in 1959, already engaged in several surveys, it seemed opportune to duplicate a portion of one of these surveys by a survey based on aerial photography.

The Civil Defense Research Project of the Institute of Engineering Research at the University of California, a contractor of the Office of Civil and Defense Mobilization, undertook to administer the test survey by aerial photographic methods and compare the results of the two surveys.

A subcontract for the aerial photographic interpretation was let to Capt. Robert B. Monier (Ret.), Professor of Geography at Plymouth Teachers College, Plymouth, New Hampshire, and a recognized authority on photo-interpretation.

The scope of the aerial survey and the area to be covered were determined in informal discussions between Capt. Monier and members of the Civil Defense Research Project. A slightly edited version of Capt. Monier's summary report to this project is included as Appendix I to the present report. The entire report has been deposited with the Office of Civil and Defense Mobilization, Battle Creek, Michigan.

A "documentary" survey of the east part of Contra Costa County, California, was selected as a convenient example of a survey based on methods other than aerial photography. This work was carried out for the Office of Civil and Defense Mobilization by the firm of Robert E. Alexander and Associates of Los Angeles. The reports of the documentary survey were available to the Civil Defense Research Project and the work sheets, on file at the Office of the Civil Defense Director of Contra Costa County, were also available.

The next two sections contain brief descriptions of documentary and aerial surveys and their results. Then, a quantitative and statistical comparison of these results is presented. Finally, in a discussion of the comparisons, some tentative conclusions and recommendations are presented. It should be emphasized that shelter surveying is still an undeveloped art, and the results of the comparative study reported here must not be considered as final.

The interest and assistance of many people made this study possible. In particular, we must acknowledge the wholehearted cooperation of Will H. Perry, Jr., Director of the Contra Costa County Office of Civil Defense and Disaster, and his staff.

DOCUMENTARY SURVEY: The survey conducted for the Office of Civil and Defense Mobilization by Alexander and Associates covered the entire eastern, nonmetropolitan portion of Contra Costa County, California. The following brief

description is based on the survey reports, and personal communications from Donald L. Stofle, Project Engineer in charge of the survey.

The survey was intended as an analysis of all buildings (or other constructions) in the survey area which possessed a shielding effectiveness of at least two as computed in the Guide for Fallout Shelter Surveys issued by the Office of Civil and Defense Mobilization. Within such a structure, people would receive, at most, one-half the radiation dose from fallout received by unprotected people. The analysis included a calculation of the shielding effectiveness, the amount of shelter area, the habitability of the shelter area, and the cost of improving these items by additional construction.

The detailed analysis was carried out by inspectors who visited each potential shelter building in person. It was not possible to visit every structure in the survey area, so that the survey proceeded in two steps. First, a listing of potential shelters was compiled by special clerks from the tax assessor's records; and, second, each of these buildings was inspected.

The survey clerks examined each item in the tax assessor's records and noted each structure which appeared to be a shelter structure. The tax assessor's records in Contra Costa County are excellent (possibly the best in the country), and full descriptions were available for almost every item. For most of the survey area the tax record of each potential shelter was photographically reproduced (except for financial details which were masked out) and a copy kept in the survey files. The inspectors then visited each item noted and made the complete analysis. In the worksheets later examined by the Civil Defense Research Project the habitability calculations were completely represented, but only the results of the shelter effectiveness calculations were available. It is believed that the shelter effectiveness calculation was not performed on formal worksheets.

Unfortunately, publicly owned buildings are not included in the tax assessor's records, and other methods were used to locate this class of structures (which is especially important in a shelter survey). In the records examined by the Civil Defense Research Project, many public buildings were not included. Mr. Stofle believes that the worksheets devoted to these public buildings, which should have been included, must have been misplaced.

Since the shelter effectiveness analyses were not recorded, it was not possible to follow the reasoning behind some of the effectiveness figures which appear on the worksheets. Some of the buildings, for which tax assessor's records were available, had been assigned an effectiveness of less than two in spite of construction which was significantly heavier than wood frame. The shelter effectiveness of each of these buildings was recomputed by the Civil Defense Research Project; and, in 23 cases out of 39, the effectiveness was corrected to some figure greater than two (one as high as 10). The reasons for these differences are not known.

AERIAL PHOTOGRAPHIC SURVEY* : A region around Martinez, the county seat, was selected as a test area for the aerial photographic survey. This area contains about 10 per cent of the structures in the entire area covered by the documentary survey. Martinez was selected because it is an older, less prosperous part of Contra Costa County, and, therefore, more typical of the United States as a whole than much of the rest of the county. Martinez is a town of about 10,000 on the south shore of Carquinez Straits. It is a mercantile and administrative center, but the principal source of income is the nearby Shell Oil Refinery.

Commercial aerial photographs were obtained, since the time available precluded dealing with government sources. These photographs dated from 1957, but

* See also Appendix I.

there has been very little significant building in the survey area since 1957, and the results of photo-interpretation needed virtually no correction before they were compared with 1959 documentary survey. The photographs covered the survey area in overlapping strips (so that stereographic techniques were possible) at a 6,000:1 scale. No difficulties were encountered with the photographs.

The photo-interpreters divided the survey area into 379 smaller areas, usually a city block, which were each individually reported on 5 x 8 cards. On each card there is an outline map of the area reported; and a code figure for each structure observed is given in the approximate position of the structure. The code used is given as an appendix. In the downtown area, structural shapes were reproduced. Figure 1 illustrates the appearance of two typical blocks.

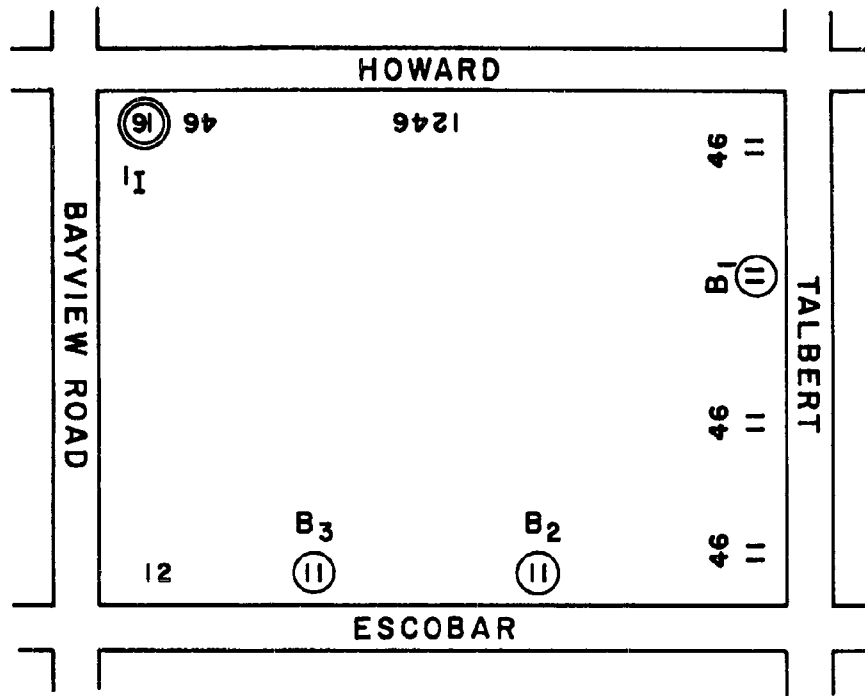
Those structures which the photo-interpreters believed to be built of material significantly heavier than wood frame construction and those believed to possess basements which were more than 50 per cent below grade were specially designated as "I" and "B" structures, respectively, ("I" taking priority). Each "I" and "B" structure was individually reported, and the dimensions, number of floors, roof type, construction, and separation from nearby structures were recorded.

No attempt was made to include habitability data in the aerial survey.

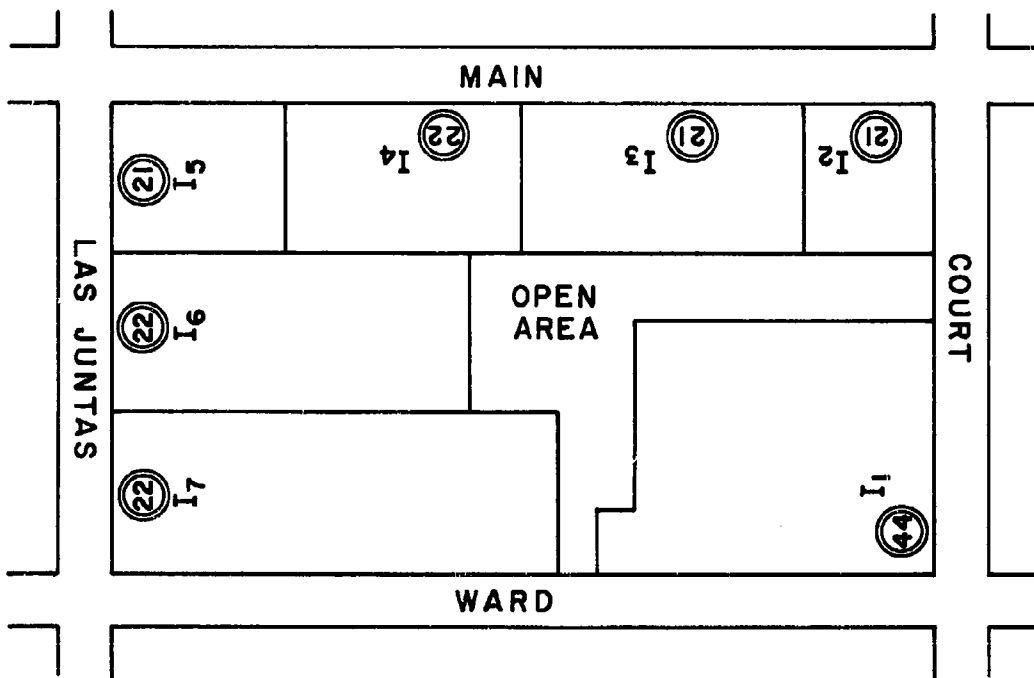
The results of photo-interpretation were verified in a brief ground survey. This verification survey was not monitored by the Civil Defense Research Project, and there is, therefore, no firsthand information available for evaluating this particular operation.

It must be emphasized that the aerial photographic survey results correspond only to the shelter effectiveness part of the documentary survey. The actual aerial photographic data is in the form of "I" and "B" listings; there

FIGURE 1
TYPICAL BLOCK RECORDS



- RESIDENTIAL BLOCK -



- DOWNTOWN BLOCK -

is enough data available for each of these listings, however, to permit a calculation of shielding effectiveness which is as accurate as the gross division into six shelter groupings (lettered A through F) suggested in the Guide for Fallout Shelter Surveys.

Thus, the aims of the two surveys were not identical, and cost data is not directly comparable. Moreover, both surveys must be considered in part as explorations of technique, rather than examples of refined survey procedure, and the costs reflect a certain amount of experimentation in technique. For these reasons, it was concluded that the dollar costs of surveying were not really established for either technique and should not be used in a comparison.

During the course of the comparative studies, the test area for aerial photography was slightly reduced -- some of the outlying areas and the Shell Oil property were removed. The outlying areas are not significant, and a slight reduction was very convenient. The Shell Oil property does not appear to have been interpreted, or the results were not entered in the records. There are at least 15 structures of heavier construction in this area which were analyzed in the documentary survey as adequate shelters. If the Shell Oil property were included, the number of heavier structures not noted would be almost doubled; and the aerial photographic survey would appear to be much less effective.

COMPARATIVE RESULTS: Items analyzed in the documentary survey may be of any of the following mutually exclusive kinds:

1. Basements noted in the tax records but analyzed as inadequate in shielding effectiveness (i.e., inadequate basements),
2. Heavier structures noted in the tax records but analyzed as inadequate in shielding effectiveness (i.e., inadequate heavier structures),

3. Basements with adequate shielding effectiveness (i.e., adequate basements),
4. Heavier structures analyzed as inadequate in the original survey but raised to adequate in the recomputation by the Civil Defense Research Project (i.e., recomputed adequate heavier structures),
5. Heavier structures (possibly with basements) with adequate shielding effectiveness (i.e., original adequate heavier structures).

Items noted in the aerial photographic survey may be of any of the following mutually exclusive kinds:

1. "B" structures,
2. "I" structures which, when analyzed, prove to be inadequate in shielding effectiveness (i.e., inadequate "I" structures),
3. "I" structures with adequate effectiveness (i.e., adequate "I" structures).

In both of the listings above, the shielding is assumed to be adequate if its effectiveness is, at least, two. All of the "I" structures were analyzed, either from the tax records when available, or by an additional inspection of the actual structure.

These two breakdowns, together with an additional group of heavier structures, which neither survey noted, can be combined into a two-way classification with 25 possible groupings. These groupings are tabulated in Table 1 and the different groupings are located on a map of the test area in Figures 2 through 7.

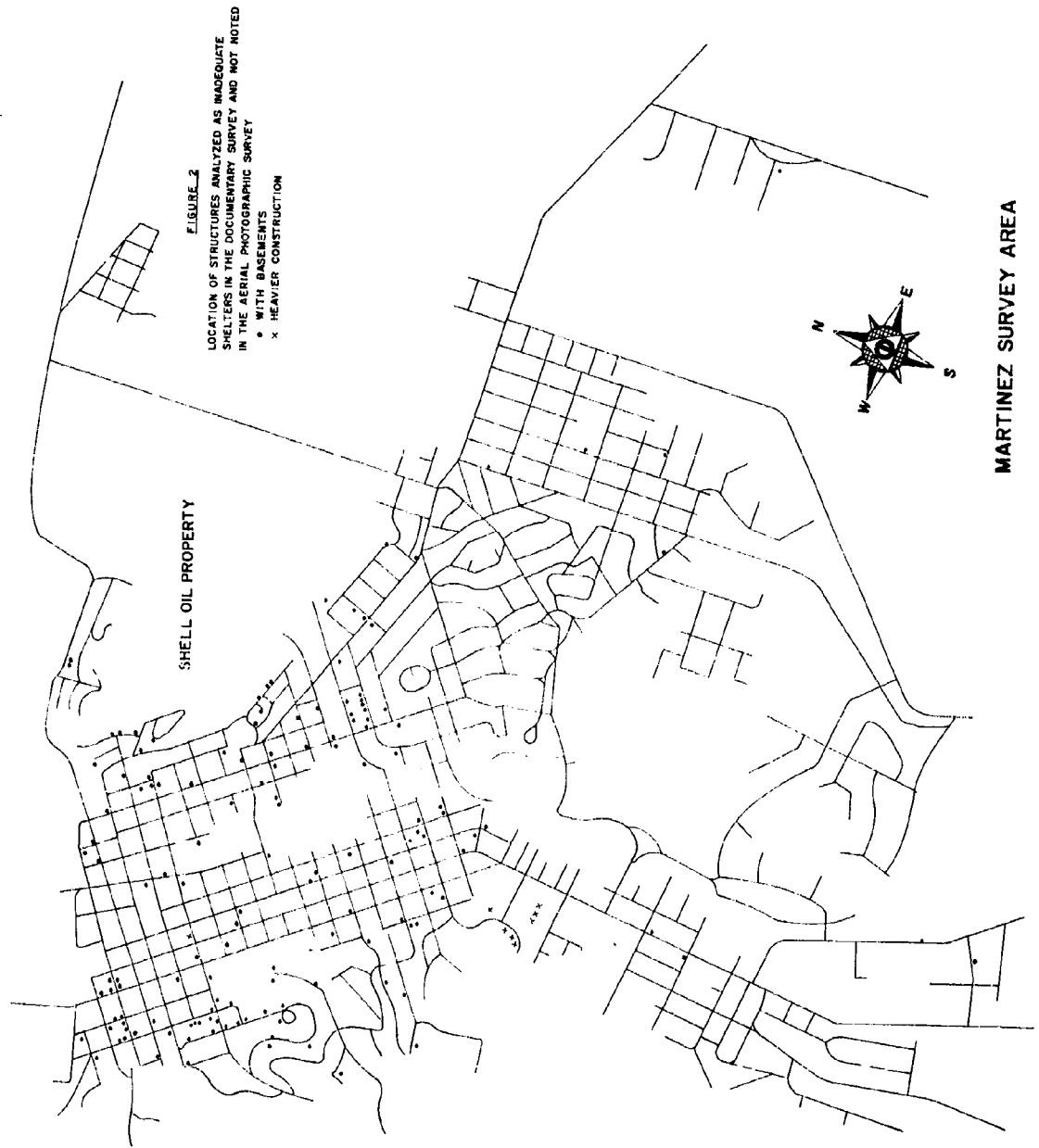
Figure 2 shows those structures which were analyzed by the documentary survey as inadequate in shelter effectiveness and not noted in the aerial photographic survey. Figure 3 shows those structures of this type which were noted in the aerial photographic survey as "B" structures. The problem of "B" structures is discussed in more detail below.

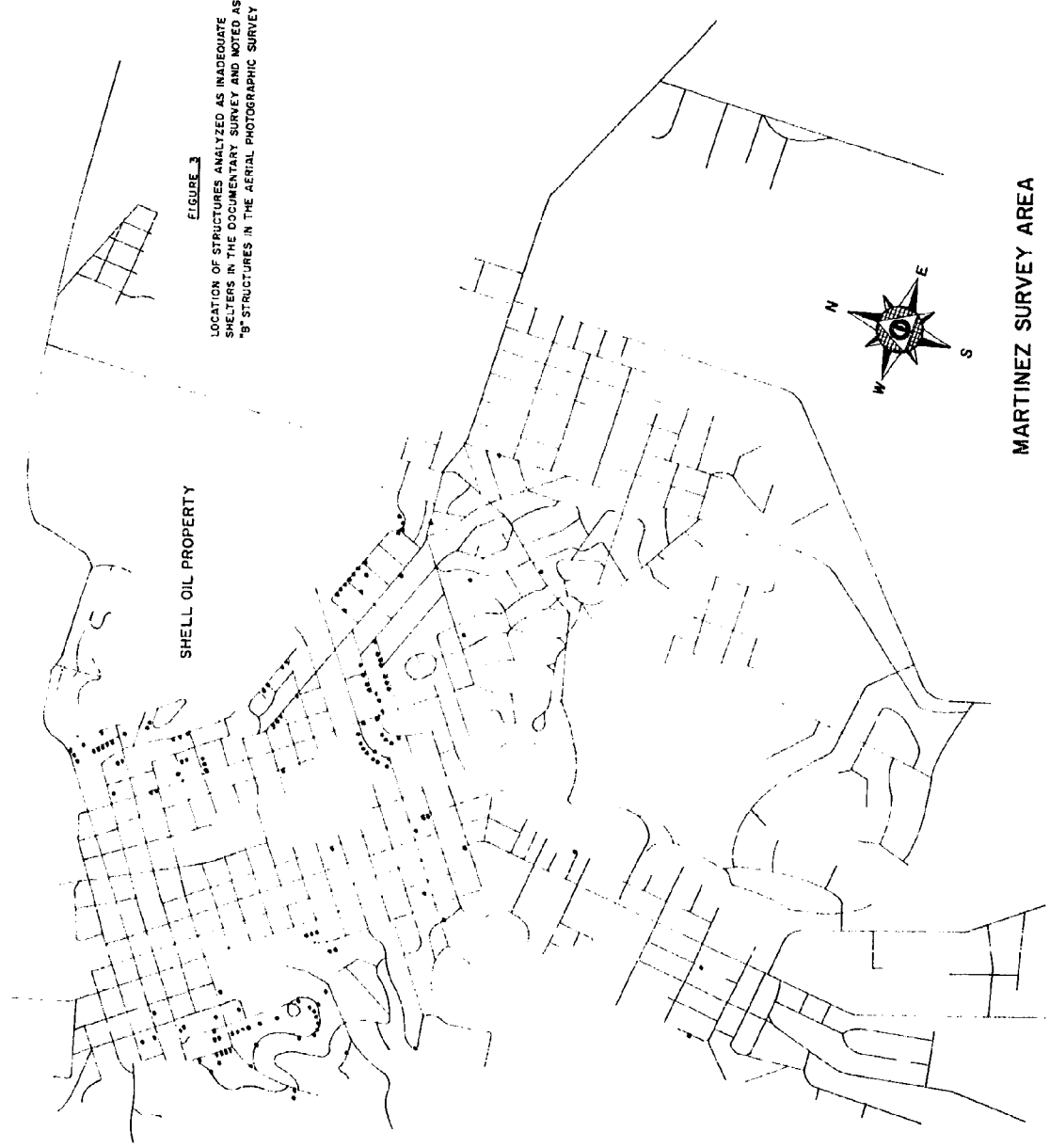
TABLE 1

COMPARISON OF SURVEY RESULTS*

<u>Documentary Survey</u>	<u>Aerial Photographic Survey</u>			
	<u>Not Noted</u>	<u>"B" Structures</u>	<u>"I" Structures</u>	
			<u>Inadequate</u>	<u>Adequate</u>
Not Analyzed	-	549	49	58
Inadequate Basements	139	141	11	0
Inadequate Heavier	9	0	16	0
Adequate Basements	26	25	0	16
Heavier (Recomputed)	7	0	0	12
Heavier (Original)	11	0	0	93

*There are 7 heavier structures in neither survey.

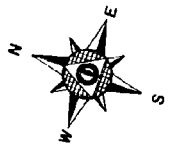




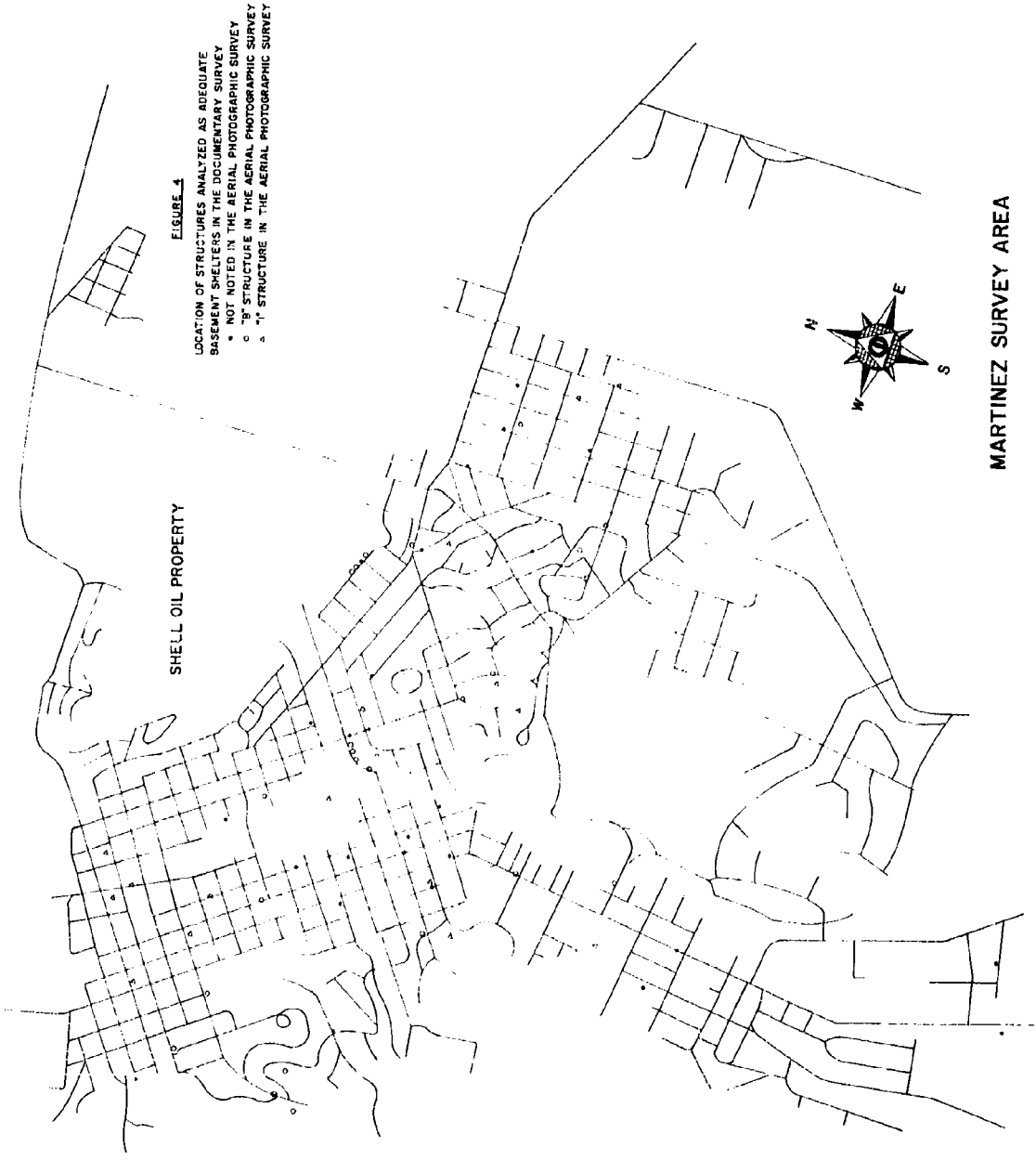
SHELL OIL PROPERTY

FIGURE 3

LOCATION OF STRUCTURES ANALYZED AS INADEQUATE SHELTERS IN THE DOCUMENTARY SURVEY AND NOTED AS "B" STRUCTURES IN THE AERIAL PHOTOGRAPHIC SURVEY



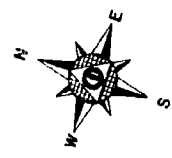
MARTINEZ SURVEY AREA



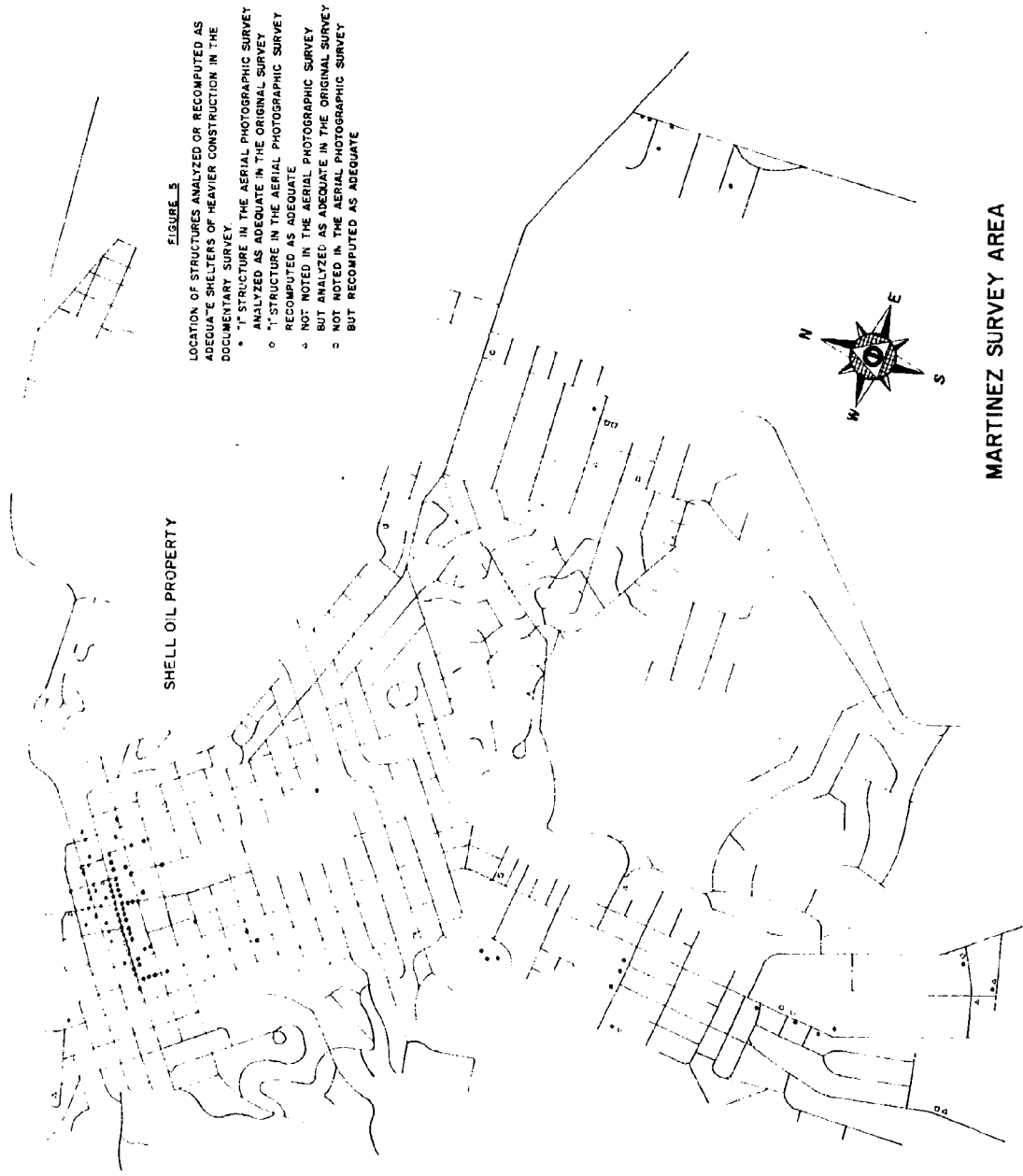
SHELL OIL PROPERTY

FIGURE 4

LOCATION OF STRUCTURES ANALYZED AS ADEQUATE
BASEMENT SHELTERS IN THE DOCUMENTARY SURVEY
• NOT NOTED IN THE AERIAL PHOTOGRAPHIC SURVEY
○ "B" STRUCTURE IN THE AERIAL PHOTOGRAPHIC SURVEY
◻ "I" STRUCTURE IN THE AERIAL PHOTOGRAPHIC SURVEY



MARTINEZ SURVEY AREA



SHELL OIL PROPERTY

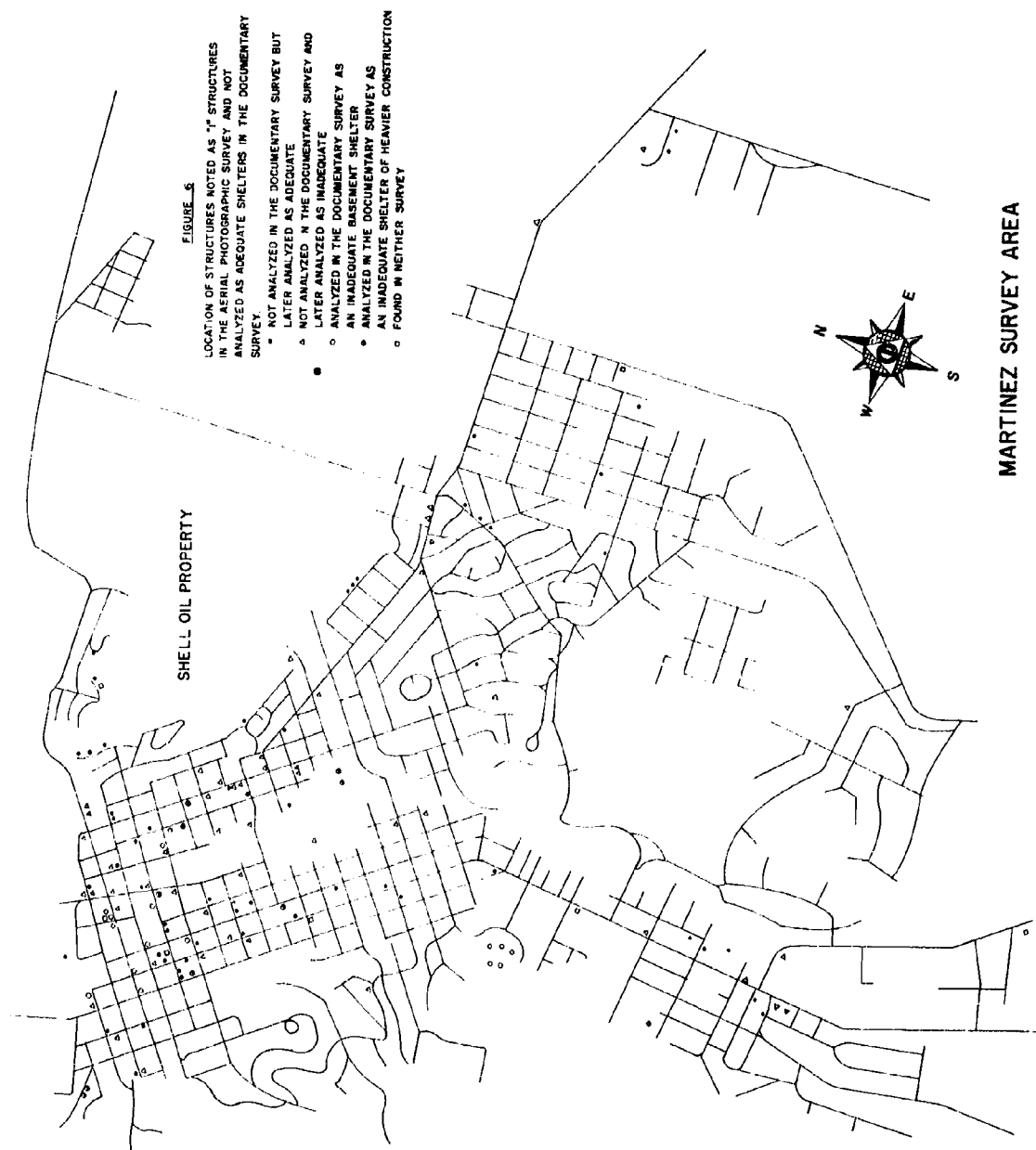
FIGURE 3

LOCATION OF STRUCTURES ANALYZED OR RECOMPUTED AS ADEQUATE SHELTERS OF HEAVIER CONSTRUCTION IN THE DOCUMENTARY SURVEY.

- 1" STRUCTURE IN THE AERIAL PHOTOGRAPHIC SURVEY ANALYZED AS ADEQUATE IN THE ORIGINAL SURVEY
- ◊ 1" STRUCTURE IN THE AERIAL PHOTOGRAPHIC SURVEY RECOMPUTED AS ADEQUATE
- ▲ NOT NOTED IN THE AERIAL PHOTOGRAPHIC SURVEY BUT ANALYZED AS ADEQUATE IN THE ORIGINAL SURVEY
- ◻ NOT NOTED IN THE AERIAL PHOTOGRAPHIC SURVEY BUT RECOMPUTED AS ADEQUATE



MARTINEZ SURVEY AREA



SHELL OIL PROPERTY

MARTINEZ SURVEY AREA

FIGURE 5

LOCATION OF STRUCTURES NOTED AS "I" STRUCTURES IN THE AERIAL PHOTOGRAPHIC SURVEY AND NOT ANALYZED AS ADEQUATE SHELTERS IN THE DOCUMENTARY SURVEY.

- NOT ANALYZED IN THE DOCUMENTARY SURVEY BUT LATER ANALYZED AS ADEQUATE
- ▲ NOT ANALYZED IN THE DOCUMENTARY SURVEY AND LATER ANALYZED AS INADEQUATE
- ANALYZED IN THE DOCUMENTARY SURVEY AS AN INADEQUATE BASEMENT SHELTER
- ◆ ANALYZED IN THE DOCUMENTARY SURVEY AS AN INADEQUATE SHELTER OF HEAVIER CONSTRUCTION
- FOUND IN NEITHER SURVEY

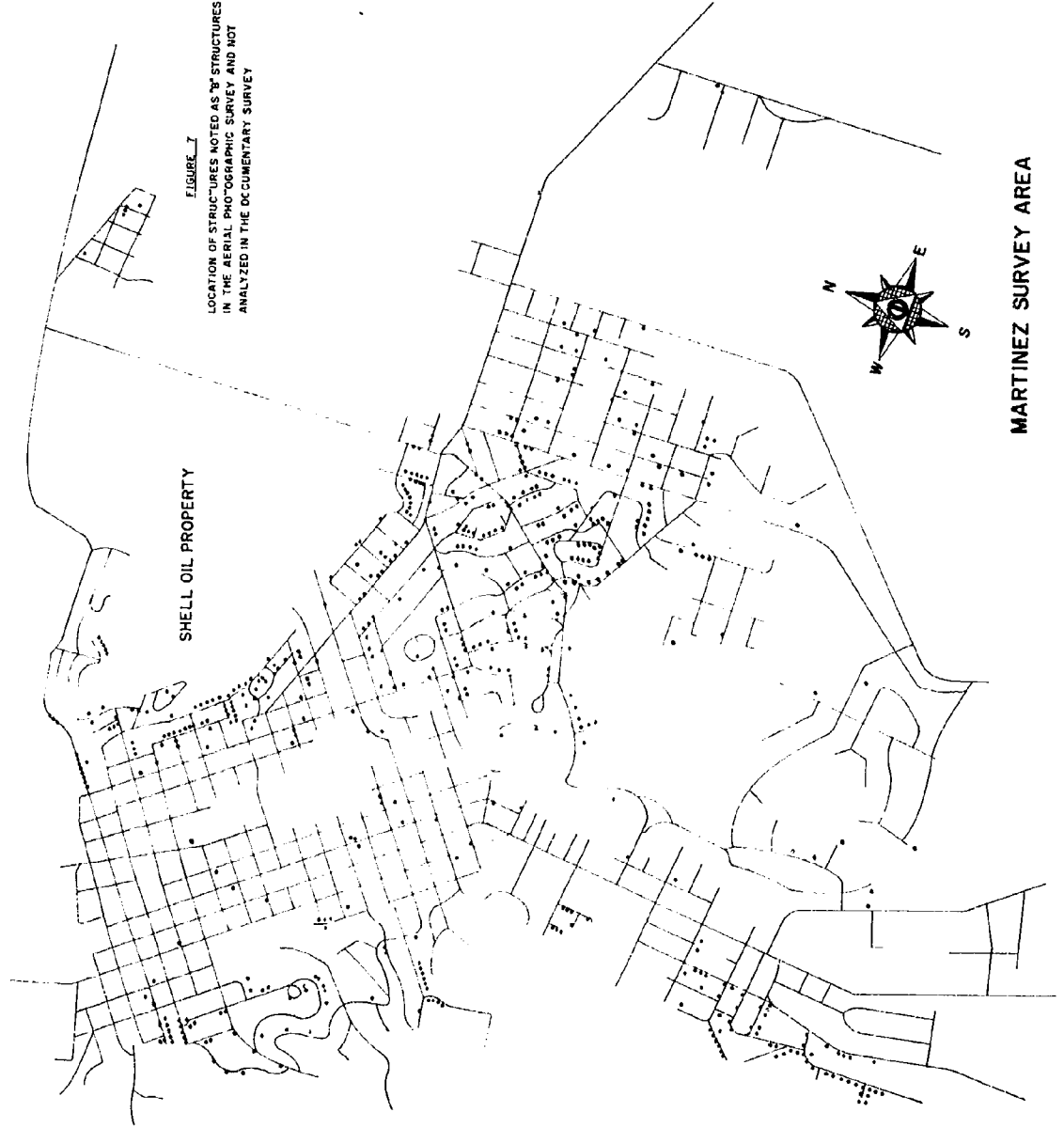


FIGURE 1
LOCATION OF STRUCTURES NOTED AS "X" STRUCTURES
IN THE AERIAL PHOTOGRAPHIC SURVEY AND NOT
ANALYZED IN THE DOCUMENTARY SURVEY

MARTINEZ SURVEY AREA

Figure 4 shows the structures with basements analyzed in the documentary survey as adequate shelters. There are three subgroupings depending on whether they were not noted, noted as "B", or noted as "I", in the aerial photographic survey.

Figure 5 shows the heavier structures analyzed in the documentary survey as adequate, or recomputed as adequate. There are four subgroupings depending on whether or not they were noted as "I" in the aerial photographic survey, and whether they were analyzed in the original survey as adequate or recomputed as adequate. None of these structures were noted as "B" in the aerial photographic survey.

Figure 6 shows the structures noted in the aerial photographic survey as "I" structures (and the heavier structures missed by both surveys). There are four subgroupings of "I" structures -- one of structures analyzed as adequate, and three of structures analyzed as inadequate.

Figure 7 shows the "B" structures not analyzed in the documentary survey.

The number of structures in each grouping is shown in Table 1. Out of about 6,000 structures in the test area 1,168 appear in one of the groupings.

Because there were 549 "B" structures which were not analyzed in the documentary survey, no attempt was made to check this classification by actual inspection. Moreover, it is believed that the method of the Guide for Fallout Shelter Surveys is not applicable to computing the shelter effectiveness of partially exposed hillside basements. Mr. Stoffle recognized this fact, and his clerks were instructed not to record the data on hillside basements during the survey. This instruction was followed in somewhat spotty fashion as Figures 6 and 7 should make clear. Until such time as a method of computing the shelter effectiveness of partially exposed hillside basements is available, there does not seem to be much to be learned from a detailed analysis of the data in the photographic survey.

Since no inspection of basements was attempted, there is very little that can be deduced from the data on basements in Table 1. The aerial photographic survey located 41 out of 77 basements analyzed in the documentary survey as adequate shelters. On the basis of these numbers, it can be estimated, with 95 per cent confidence, that the aerial photographic survey is at least 42 per cent as efficient in locating shelter basements. It may be much better than this if an appreciable number of the 549 "B" structures which were not analyzed should happen to be adequate shelters.

Since every "I" structure was analyzed, it is possible to say a great deal more about the efficiency of the surveys in locating heavier structures which are adequate shelters. Both surveys can make type I errors (rejecting acceptable items) and not find adequate shelter structures. The documentary survey is, virtually a priori, immune to type II errors (accepting rejectable items) and never analyzes an inadequate shelter structure as adequate. The aerial photographic survey, however, is quite susceptible to type II errors, and 76 "I" structures were analyzed as inadequate with 179 analyzed as adequate. This indicates that, with 90 per cent confidence, between 22 per cent and 35 per cent of the "I" structures in an aerial survey are likely to be inadequate (usually because they are not really heavier constructions).

The aerial photographic survey appears to have been statistically more efficient than the documentary survey in locating heavier shelter structures. The relevant groupings in Table 1 can be combined so as to produce Table 2.

TABLE 2

EFFICIENCY IN LOCATING HEAVIER STRUCTURES

<u>Documentary Survey</u>	<u>Aerial Photographic Survey</u>	
	<u>Not Noted</u>	<u>"I" Structure</u>
Not Analyzed	(7)	58
Adequate	18	121

The number 7 in parentheses is a maximum likelihood estimate. From the data in Table 2, it can be concluded, with 99 per cent confidence, that the aerial photographic survey will note at least 80 per cent and the documentary survey at most 79 per cent of the adequate shelter structures. Thus, the aerial photographic survey is statistically more efficient than the documentary survey.

The efficiency of the aerial photographic survey would be insignificantly greater (or, possibly even less) than that of the documentary survey if the data from the Shell Oil property were included or a more complete record of the documentary survey of public buildings were found. If the computations of efficiency should be based on the number of buildings noted as "I" structures (including type II errors), the difference between the two survey methods is no longer statistically significant.

DISCUSSION: The statistical discussion in the last section leads to statements of the following sort -- the survey based on aerial photography may be significantly more efficient in locating heavier construction than the survey based on tax assessor's records, but it is also susceptible to type II errors. There is no utility theory which compares type I and type II errors without the aid of an externally defined "worth" of some type. This kind of a "worth"

cannot be defined for a shelter survey, since it requires a knowledge of how much a supposed shelter which is not adequate is worth in terms of adequate shelters which are not found. This kind of apples-and-oranges comparison might be possible if it was desired to optimize some well defined variable -- for example, to minimize casualties -- and the functional relationships of the different variables were known. None of this is true for present day shelter surveys.

Without a precise theory it is impossible to do more than observe that the type II errors detract from the value of the greater efficiency in locating shelters. Moreover, there is some doubt whether the statistics leading to the conclusion that the aerial photographic survey has greater efficiency in locating shelters are justified. Therefore, the "practical" conclusion would seem to be that the aerial photographic survey is not operationally superior to the documentary survey. The converse should be obvious.

This conclusion can be important, because it has been argued (by different people) that either one or the other form of approach shows clear cut and overwhelming advantages.

Up to this point, very little of the practical experience gained in this comparison has been discussed. A few thoughts that have arisen in the course of this study should be mentioned.

First, no satisfactory method of displaying the results of a survey has yet been devised. The maps presented in Figures 2 through 7 represent a format devised by the Civil Defense Research Project -- it would be unfortunate if no better method were possible. The block cards illustrated in Figure 1 are fairly effective, though tedious to use; but they are very susceptible to clerical errors in preparation. Enlarged aerial photographs (perhaps 1,000:1) might be cut to block size for the same purpose without introducing many

clerical errors. The filed worksheets of the documentary survey are almost unusable for a variety of reasons, the most important being that they were not designed as a consulting file.

Second, there is no purpose in making a preliminary selection covering the buildings in the downtown area, since virtually every building must be analyzed. It seems reasonable to draw a boundary around the downtown (and other heavily built-up areas) and perform a 100 per cent survey within this boundary. The remainder of a town or a city can then be handled by selective techniques.

Third, there is no reason for separating an aerial photographic survey from actual ground contact with the structures involved. By combining aerial surveying with liberal ground inspection, it should be possible to retain the best features of both surveys.

Fourth, there is a need for an adequate method of evaluating hillside basements which are partially exposed, particularly on the downhill side.

Fifth, the habitability analysis of common structure types is not helpful. It appears that a great deal of effort was expended in making detailed analyses of relatively poor shelters. Habitability analyses should be restricted to large buildings containing significant amounts of very highly effective shelter.

Appendix I

Report on an Aerial Photographic Urban Survey of Martinez, California

Capt. Robert B. Monier (Ret)
Phillip C. Tapply
Edward C. Desmond
John C. Foley
Earle A. Potwin

This pilot research project was undertaken to determine the feasibility of using aerial photographic interpretation as a more economical, time-saving, efficient, and standardized means of providing initial structure surveys of selected areas. The general objectives were as follows:

1. To demonstrate that aerial photo collection is a quicker, more economical, and more easily adaptable method of providing basic information concerning the number of structures, type of structures, and distribution of these structures in any given area.

2. To develop standard procedures for all required collection, collation, and recording activities. Such standard procedures would provide comparative data from an aerial photographic structure study of any selected area.

3. To illustrate the practical use of a small centrally located research group to carry out such photographic surveys for the purpose of providing basic structural data for any given area.

Specifically, the project initiated procedures to provide for:

1. Structure enumeration
2. Classification of structures
3. Location and identification of all structures for ground observation
4. Delineation of specific types of structures (protection level of E or better).

- a) Those with basements (symbol B)
 - b) Those over two stories in height (symbol I)
 - c) Those built of materials which provide better shielding than wood* (symbol I).
5. Provision for exterior dimensions of all structures under categories "I" and "B".
6. Recording of photo observations in a simple, efficient manner to allow for:
- a) Selection for statistical sampling
 - b) Collation of all observations
 - c) Validation of findings
 - d) Orientation of photo observations to ground location of each individual structure so that additional studies which might be conducted in related research can easily, quickly, and economically locate any single structure, group of structures, classification of structures, or any particular combination of the above.

The procedures by which the individual research tasks were accomplished are described in detail later. However, for those that do not wish to thoroughly study these procedures, a summary of the total research results is provided at this point.

* The criteria for selection of these specific types of "I" and "B" structures was provided by the Civil Defense Research Project. These structures included materials of brick, stone, cinder block, concrete, and still better materials. It would seem that more extensive criteria could be provided for future aerial photo studies. For example, steel buildings would provide shelter against flash burn, shock effects, etc., though they would not shield against fallout effects. Photo surveys might be able to pinpoint specific types of shelters for specific uses.

1. The pilot project enumerated and classified a total of 6,022 structures. From this total, 337 "I" structures and 692 "B" structures were identified. The work was completed by five people in 40 work days (eight hour days). The cost, including equipment, materials, salaries, consulting fees, travel, etc., was \$4,000.00.

2. The procedures which were developed can be applied to any selected area; they will yield factual data which can be recorded, compiled, and collated in exactly the same way for each study. Thus, intercity comparative studies are easily facilitated. They likewise provide for a standard method; they present collected data in formats that can be used in the field as they are, or, can easily be converted to machine cards for statistical processing.

3. In accomplishment of the specific research procedures outlined earlier, the project has been equally successful. All enumerated and classified structures have been located for easy ground identification. All special structures ("I" and "B") have been identified separately for ground study and have been individually analyzed to provide the general dimensions, height in stories, nearness to adjacent structures, and construction materials believed used.

4. All observations have been recorded in easily used photo collection block data books with accompanying ground orientation section maps (photo mosaics and overlays) which can serve as basic data references for other studies of this area. A tabulation of complete enumerations has been provided.

5. Several additional aspects, which were not a part of the original requirements, have been included in the report since it was felt they had a major bearing upon photo survey techniques and, as such, would be of value for inclusion in any further undertakings of this nature. One example is the

construction of transparent overlays locating each individual "I" and "B" structure which can be used directly over the aerial mosaic. Such a system of orientation provides a simple, yet highly effective, means of locating and studying any particular "I" and "B" structure or group of structures.

In addition to facilitating easy identification and location of "I" and "B" structures, this system allows an overview of the density and distribution patterns of these potential shelters in relation to the total area surveyed. Such an overview may be extremely valuable to further studies by local civil defense agencies and for general programming and planning purposes.

6. Such cartographic presentations of data distributions provide a simple yet thorough means of ground validation of the photo collected data with a minimum expenditure of time and personnel.

Design Procedures and Considerations:

The aerial photographic coverage was provided by the Civil Defense Research Project. It was of the common reconnaissance type -- flown in strips of overlapping exposures permitting stereo-study. The basic scale was 1:12,000, and photo prints were furnished for use of the study at 1:6,000 scale. The photographic coverage was flown in 1957 which was determined as being late enough for the purposes of validating the structural data provided from photo observations.

Collateral materials such as land use maps, city block maps, and other ground data were furnished at our request. By this means the research plan allowed for a full range of "control" data for comparison with and verification of the photographic interpretation findings.

The list of photo image keys, normally used in structural identification, was expanded to include keys for the identification of "I" and "B" structures. This addition was necessary in order to further break down the enumerated

structures into categories of interest. A list of detriment features, objective evidence actually present in photo images, was constructed to assist in this special identification. In most instances, identification was accomplished by a combination of items -- such as driveways that went underneath the house, houses located on side of hill, actual oblique views of foundation, etc. However, in other cases, a single item might be the objective key to delineation of an "I" or "B" structure -- such as height and location of structure, facade, concrete steps to public buildings, etc.

Of equal importance was the development of a systematic procedure for recording the photo observations. The coding system outlined in Appendix II proved to be comprehensive and workable for the study.

Another important consideration in the research plan was the selection of the photo collection blocks (sections) to be studied. While the entire area of study had been agreed upon as being representative of land use in this particular area of country, it is necessary in any photo collection work to delineate small, block-like, workable sections in order to increase the effectiveness of the photo interpreters. Careful consideration was given to the selection of the photo collection sections to insure that boundaries would be easily identifiable for ground observation. In most cases, streets, easily identifiable from a city map, were used. In other cases, creeks, open lots, or the back yard line of settled areas were utilized. In all cases, the number of structures to a section was kept to a minimum so that recording of data could be controlled on the 5x8 cards being used. In some cases, a section might be quite large, but the number of structures is still small enough to allow inclusion on a 5x8 card. The farm areas to the west of Martinez are an example of such sections. In those cases where street patterns included an area with a large number of structures, this area was split at a convenient ground

location such as a vacant lot. All photo collection data sections are outlined on a photo mosaic. These mosaics can be used as an overview in locating the sections with respect to their exact position on the ground.

Data Collection:

Individual sketch maps of each photo collection were drawn upon a 5x8 card and all streets, landforms, and other notations necessary to insure ground identification were added. These basic data collection cards become a permanent part of the report and will be utilized in ground observations of the photo collected data. Care was exercised to insure that these cards provide enough information concerning the section from which the basic data was accumulated to allow easy and simple field use and ground location. Each section is also located on the ground orientation section maps (photo mosaics). With this material a ground observer can easily locate his objective.

The photo interpreters proceeded to enumerate and classify each structure within their assigned photo collection sections. While these enumerations (using the codes shown in Appendix II) do not place the structure exactly to scale on the representative collection card, they do locate them in sequence so that by simply counting from any known spot on the card you may completely check the individual structures. Each photo collection section upon being completed by the photo interpreter was checked by a supervisor for number of structures. Spot checks of the classifications were made, and the card was likewise screened for proper location, numbers of structures, etc.

After completing the first phase of interpretation, the supervisors, using their inherent skills and judgment in conjunction with the established determinant photo image keys, indicated those structures they believed to be either "I" or "B". Upon identification as an "I", no further attempt was made to determine whether a basement was also present. This was in accordance with

the instructions provided by the Civil Defense Research Project. The special screening for "I" and "B" structures usually involved three steps: (a) checking for structures over two stories, (b) checking for structures constructed of materials other than wood, and (c) those that seem to have basements on the basis of the combination of photo image keys established.

When the photo collection section had been thoroughly analyzed by photo interpretation, each card was checked against all ground data information available. In many cases, this enabled the project directors to name the structure, the address, its type of business, and, in some cases, its particular function (city hall, etc.).

As a last step in the collection of data, each card was checked for proper orientation (north, south, east, and west), street names for identification, its location and proper positioning on the photo mosaics, and other items such as spelling, code identification, etc. It was then filed and ready for the second phase of operation-field data verification.

When all photo collection sections had been processed through the first phase operations, the cards and the photo mosaics were again checked to make certain all areas of the study had been covered and all recorded in their proper sequence.

Field Data Verification:

Two of the investigators visited Martinez and checked each coded entry on all photo collection section cards from a moving automobile. The percentage of error between their ground verification and the photo recorded data was small. The field observations were accomplished in three and one-half working days. All photo collection sections were covered, and all structures were ground checked. The time, cost, and results were all satisfactory. These facts make it apparent that a ground check of this nature will become an integrated part

of any future photo survey undertaking. Such procedure allows for correction of city map errors in cases where a street is shown to exist when in actuality there is only a right of way. It also facilitates distinct delineation of peculiar transitional buildings such as two-story residential on the commercial fringes which have been converted to apartments and, in some cases, remodeled with brick veneer fronts, thus becoming an "I". This easy ground check also allows the research team to include new structures which have been erected since the aerial photograph was taken, as well as to omit structures which have been destroyed. Many other benefits accrue from such a quick ground verification to the extent that the investigators now consider it a specific part of the procedures for further aerial photo interpretation studies.

From these field observations of the photo collected data, many important photo image keys were validated, and additional new items for future work were discovered. For example, most houses built on hillsides were found to have foundations which extended back into the hill and provided excellent shelter possibilities.

Some of these observations pointed up the need for specific criteria as to what is believed to be a proper shelter potential. While instructions to the project included a notation that 50 per cent exposed basements -- meaning 50 per cent buried -- were considered to be a "B" type structure, no explanation as to how to measure that 50 per cent was included in the criteria. For example, a house designated as a "B" structure actually has a basement which is 100 per cent exposed on one side but 100 per cent buried on the other side.

As a result of some of these cases, the project personnel may have designated some structures "B" which from an engineering standpoint may not be considered as a "B" type. Another question that arose concerned "I" structures. Having had some experience in shelter capabilities, the project director

recognized there are needs in addition to fallout shelters. For example, flash burn shelters (steel buildings) may not be adequate fallout shelters. It would seem that in the specific criteria for any future work specificity as to classification of potential shelters would assist in determining marginal or unique cases such as described above. There were other questions that came within the purview of the investigators which had to be decided with limited knowledge as to exact needs and purposes. It is very possible that in these marginal or unique cases decisions were made that will be considered incorrect by people who may be validating the findings by using more specific criteria as their method of delineation of "I" and "B" structures.

Data Analysis:

Because this project was designated as a type of basic collection experiment, analysis was limited; yet certain conditions do appear which should be discussed briefly.

In those cases where basements (B) are highly prevalent such as hillsides, older aged structures, and large apartment type downtown structures, there was little difficulty in identifying the "B" classification. In some areas of flat topography where isolated "B" structures were found during field observations, no photo image keys could be developed to locate and identify them. However, they represent less than 2 per cent of the total "B" structures identified, and by including the field verification visitation as part of the survey procedures, they are located, identified, and added to the data collection information.

The delineation of "I" structures was less difficult. They are primarily identified by location, shape, size, and neighborhood relationships. For example, in the downtown area of Martinez, most of the structures were "I's" of varying height. Isolated neighborhood stores are easily spotted, and public buildings such as hospitals, schools, libraries, churches, etc., are identified

with a high degree of accuracy. However, the isolated residential structure which is built of brick or stone is another matter. In some cases, the flat roofs, the rectangular shape, and the size were easy identification keys; but, there were a few (4 per cent) which were missed and later discovered during the field visitation. Once again, though the margin of error is small, the usefulness of a field visitation by the project personnel is apparent.

Throughout the data analysis, primary emphasis was placed upon accurately identifying and locating "I" and "B" structures. The photo observations, recorded on the block photo collection data cards, have a .98 correlation with actual ground observations and represent the type of data collection that this kind of survey can produce.

Conclusions:

On the basis of the results as presented for analysis and comments, it is believed that:

1. The pilot project has been successful in demonstrating the feasibility of utilizing aerial photographic interpretation as a means of surveying any selected area for potential shelter capabilities.
2. The aerial photographic method will provide a quick, efficient means of primary surveys to obtain the basic data upon which further, more detailed, and exhaustive studies can be made of individual structures, groups of structures, or any combination of data collected.
3. The method, as developed in this pilot project, can be utilized to provide similar data for any given area. Such surveys not only provide for individual considerations of any given area but also serve to stimulate comparative studies of different geographical areas.
4. This pilot project demonstrates the usefulness of the small, centrally located research group, with resultant savings in cost, time, and personnel, to

survey any given area desired.

5. The project has established a standard method for surveying any area through the use of aerial photos. The step-by-step procedures to be used are as follows:

- a) There is a selection of an area of study by the agency of employment.
- b) Aerial photographic coverage for interpretive study is obtained (almost all major areas of the country have been aerially photographed in recent times). For those few areas that are not so covered, arrangements can be made with professional aerial surveyors to provide quick and efficient coverage at a reasonable cost.
- c) A brief personal visit by project director and assistant to inspect the area to be studied is made. This allows for programing personnel needs and establishing any specific photo image keys for this study which may be unique to the area. For example, New England towns would have different photo image keys than would Martinez. It likewise permits a personal overview to assist the intuitive interpretation aspects of data collection.
- d) The photo collection sections (blocks) are defined.
- e) Photos are interpreted.
- f) Photo collection sections and ground orientation photo mosaics are checked to ascertain completeness of coverage and accuracy of orientation.
- g) There is a drive-through field observation to correlate photo observations and to make on-the-spot corrections of photo mosaics, ground identification points, and, likewise, to determine any

corrections necessary on photo collection data.

- h) Reports are finally prepared for submission to agency of employment.
- i) Recommendations for further improvement of photo method are submitted.

6. The project procedures and design indicate the ease with which an area of inquiry can be handled. Though in Martinez only 6,000 structures had to be considered, the personnel carrying out this project now represent a trained cadre of experts who are capable of operating on a much larger scale if such research is contracted for. The procedures have been standardized, and additional staff could be easily gathered to work on any size study or group of studies. The flexibility of such undertakings, using aerial photographs as the basic source materials, is clearly demonstrated. In using trained researchers on a part time basis, one is able to utilize more fully the academic proficiency of diverse disciplines without assuming the burden of a continuous payroll of experts. Such flexibility assists in lowering personnel costs and the time expended, and guarantees a sufficient personnel pool to adequately undertake diverse area surveys. In addition, by utilizing a survey group from an area other than that being studied, you minimize any possibilities of on-the-spot friction, political involvement, and high monopolistic cost problems that might conceivably exist.

7. The procedures developed for recording, collating, and orientation of photo collected data to ground observations provide for a cheap, efficient manner of surveying any area. The use of aerial photographic interpretation provides a complete enumeration of all structures and a delineation of the specific structures in which the employing agency might be interested. Normally, a city survey would involve detailed scrutinization of all structures to

determine which structures apply. The aerial photo method quickly, cheaply, and completely covers all structures, records their location, provides for easy ground orientation, and indicates separately these structures in which there is a primary interest. All this is accurately accomplished in a short period of time without extensive record-searching operations or lengthy and complicated ground observations, with a small, skilled staff.

Recommendations:

Based on the results of this pilot project, it is recommended that considerations be given to:

1. Enlarging the scope of aerial photographic survey for the purpose of investigating areas of interest to the OCDM shelter program.
2. Utilizing the aerial photographic method as a means of initial surveying in order to provide the basic data necessary for detailed and exhaustive studies of individual structures, groups of structures, or any combination of classifications desired.
3. Contracting with the existing research group that has undertaken this pilot study for future aerial photographic surveys.

While these specific recommendations have been made in order to assist the OCDM in its search for various methods of surveying selected areas for possible shelter potential, it is further recommended that in any future studies of this type the following steps be added to the project design:

1. Specific criteria be provided indicating just what types of shelter structures are of interest.
2. Clear-cut and well defined specifications be provided as to what constitutes a shelter so as to improve the accuracy and meaningfulness of the delineations of specialized structures (I and B).

3. Direct representation with the OCDM be provided so as to facilitate and clarify needs, interests, findings, expectations, and validation needs and specifications.

Problem Areas:

While no great problems were forthcoming from this undertaking, one area of concern to the project director and his associates was the necessity for clear-cut definitions in order to insure complete uniformity in defining "B" structures. On numerous occasions the research team was called upon to use its own judgment as to whether a specific building fit the generalized established criteria. It is felt a more precise statement of definitions is necessary in order to insure consistency in delineating "B" structures and "I" structures with respect to given criteria. More explicit definition as to the intended function of "I's" and "B's" would be helpful in this regard.

The use of tax record maps (sketches) of the area under study was a second problem area that initially confronted the project. Visual inspection of the tax record maps proved somewhat confusing. While they seemingly presented an excellent method of recording individual structural information, they proved impractical when we attempted to coordinate them with actual ground locations as seen through the photographs. It was impossible to locate and identify individual plots, tax lines, and other vital points. In many cases the tax sections cross streets, cut through blocks, become a tangle of intricate linear designs, and in many other ways defied our efforts at ground location. Because of this, our research personnel found it necessary to abandon the use of these tax forms in order to accurately locate and identify each individual structure or group of structures. In addition, it should be mentioned that such tax record maps or sketches vary considerably, from city to city, and could not be included in procedures of a standard method.

APPENDIX II

Number Code for Structures

Used in the Aerial Photographic Survey

11	Residential	1 story 1 unit
12	"	2 story 1 unit
13	"	1 story 2 or 3 units
14	"	1 story more than 4 units
15	"	2 story more than 2 units
16	"	more than 2 story
21	Commercial	1 story
22	"	2 story
23	"	more than 2 story
24	"	hotel
25	"	motel
26	"	service station
31	Industrial	1 story
32	"	2 story
33	"	more than 3 story
34	"	tank farms, utility yards, etc.
41	Institutional and Public	church
42	"	school
43	"	hospital
44	"	public building
45	Miscellaneous	farm
46	"	other (usually garages)