UNITED STATES
DEPARTMENT OF THE INTERIOR

DAMAGE PREDICTION FOR AN EARTHQUAKE IN SOUTHERN CALIFORNIA

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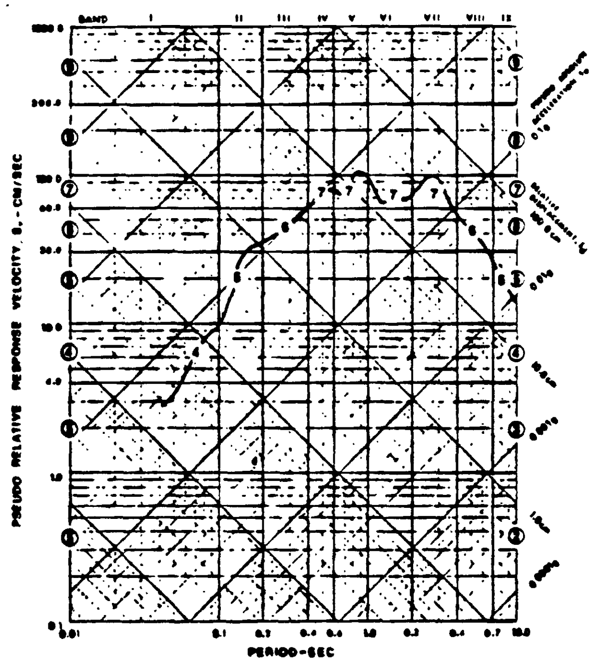
EXECUTIVE SUMMARY

The objective of this study was to estimate the nature and distribution of damage to structures in the southern California area caused by a hypothetical earthquake which is located on the San Andreas fault, has a rupture length of 300 km, and spans the area between Cholame to the north and Cajon Junction to the south. Its Richter magnitude was given as 8.1. The Engineering Intensity Scale (EIS) technique was used to make the damage estimation. Two unique features of the EIS technique, which establish the nature and character of the predictions made, are: (1) damage is established from response spectrum values of ground motion, and (2) damage estimates consist of a definition of the areas in which structures might be damaged and a general evaluation of the incidence and degree of damage that such structures might sustain. Detailed structure inventories are beyond the scope of this evaluation, but exposure in the affected area is generally identified.

Basic earthquake information was provided by the U.S. Geological Survey and included the length of rupture, the magnitude of the hypothetical earthquake, and the geological conditions of the affected area. Rossi-Forel intensity maps were also provided; these were used to make a preliminary estimate of the study area for structural data-gathering purposes. The procedure used for generating the EIS values was as follows. First, peak ground acceleration at a particular site of interest was determined. The parameters required to determine acceleration are distance from the causative fault, magnitude of the earthquake, and specific density and shear wave velocity of the ground at a site. Next, response spectra were generated. Four basic spectrum shapes were established to represent the influences of site geology on response spectra. Finally, EIS values for three period bands (less than 0.4 sec, 0.4 to 2.0 sec, greater than 2.0 sec) were determined from the response spectrum curves for each site.

The EIS values represent 5%-damped response spectrum amplitudes. The range of spectral velocity (S_v) and period (T) applicable to civil engineering structures is represented as a 10 x 9 matrix, as shown below. The range of S_v values, from 0.001 to 1000.0 cm/sec, is divided into ten levels that are

assigned EI numbers from 0 to 9. The T range, from 0.01 to 10 sec, is divided into nine period bands from I to IX.



Note: EI levels ① (0.01 to 0.1 cm/sec) and ⓪ (0.001 to 0.01 cm/sec) not shown.

ENGINEERING INTENSITY SCALE MATRIX
SUPERIMPOSED ON EXAMPLE SPECTRUM

By referring to the period columns, the EI scale can be reported as nine-digit, three-digit, or one-digit numbers, or by all three, in a standard format. The more digits reported, the greater the amount of information for the period bands. For this study, three-digit and one-digit representations were used to show the EIS values. The values were averaged within the period range of interest to obtain the three-digit representation. For the example spectrum shown above, a nine-digit representation would be 456,777,765. A three-digit representation reduces to 5,7,6: an average EI of 5 in period bands I, II, III (less than 0.4 sec); 7 in period bands IV, V, VI (0.4 to 2.0 sec), and 6 in period bands VII, VIII, IX (greater than 2.0 sec). A one-digit EI is obtained by averaging the values of the three-digit EI. The three-digit EI of 5,7,6 is thus reduced to a one-digit EI of 6.

Structures considered in this study include buildings and other structures found in communities as well as major areawide hydraulic, transportation, and utility systems and facilities found in the study area. The structure information was obtained from various sources for the 14 counties in southern California (Fresno, Kern, Kings, Los Angeles, Monterey, Orange, Riverside, San Benito, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Tulare, and Ventura) that are affected by the postulated earthquake. Because an EIS prediction is conceived as only a generalized damage assessment, structures were categorized according to function, type of construction, height, etc. Most of the structures in a particular community are common to all communities of the study area. Furthermore, the number of structures in a community is generally proportional to the population of the community; this premise was used extensively for making this preliminary damage estimate.

In the study area, which covers approximately 154,000 km^2, the highest three-digit EI is 7,8,8. This three-digit EI corresponds to a one-digit EI of 8-. The highest EI for a city, 6,8,8 (one-digit EI: 7-), is for a community with a population of approximately 10,000. Although there are a number of large cities in the 5,7,7; 5,7,6; and 5,6,6 zones (one-digit EI: 6+, 6, and 6-, respectively), most of the major metropolitan areas (including Los Angeles) are in the 4,6,5 and 4,5,5 zones (one-digit EIs: 5 and 5-). The number of cities reported in census data for each one-digit EI zone is tabulated below. The combined population of these cities for each EI zone is also shown in the table.

NUMBER OF CITIES AND CORRESPONDING POPULATION*
IN RESPECTIVE ONE-DIGIT EI ZONES

1-Digit EI Zone	Number of Cities	Combined Population of Cities (in thousands)
7+	1	9
7	-	-
7-	-	-
6+	3	36
6	2	28
6-	2	133
5+	7	149
5	14	291
5-	104	6,122
4+	37	1,232
4	23	1,221
4-	41	487
3+	13	82
3	7	77

*From 1970 census data; does not include population for small communities.

The EI-damage relationships developed from the San Fernando earthquake of 1971 indicated that an EI of 6 in the short-period range (less than 0.4 sec) would produce a damage cost of approximately 9% of the replacement value for typical low-rise buildings. Similarly, an EI of 7 in the intermediate-period range (0.4 to 2.0 sec) would produce a damage cost of about 6.5% of the replacement value for high-rise buildings. For structures for which no EI-damage statistics were available, damage cost was estimated from a comparison of the seismic design coefficients of the structures with those of typical buildings. The damage cost for structures with special design considerations was estimated to be lower than that for typical buildings. On the other hand, some poorly constructed structures such as precode unreinforced masonry buildings, which have a lesser seismic-resistance capability, were expected to have a higher damage cost. For a typical community, the three-digit EI of 6,7,7 (one-digit EI: 7-) is estimated to produce a damage cost of 9% of the replacement value of the structures. For EIs of 5,6,6 (one-digit EI: 6-) and 4,5,5 (one-digit EI: 5-), the values are 2% and 0.3%, respectively. Although damage prediction for specific cities is not provided, a damage estimation for several EI levels is described for a hypothetical community. The procedure for applying these damage calculations to a specific community is also described.

Because residential buildings make up the major portion of the buildings in a community, losses from these buildings figure heavily in the total dollar loss to the community from an earthquake. The total damage to private buildings from the hypothetical earthquake is estimated to be about $600 million; an equal amount is estimated for damage to public buildings and other public structures. This figure is an estimate of the mean or expected damage for the entire area. The actual damage cost may vary, depending on the distribution of damage for the many communities involved. Observed statistical variations from previous earthquake studies, for both the spectral values and the motion-damage relationships, will no doubt be repeated for any future earthquake. A rigorous estimate of the statistical variation of damage for the hypothetical earthquake is beyond the scope of this study, but a one-sigma geometric variation could be several times the mean value. Error in the mean predicted value is not expected to be as large. Also, the above estimate does not take into consideration the damage resulting from the possible catastrophic failure of major facilities (e.g., a dam) and the secondary damage that may result.

Deaths and injuries (with the exception of immediate physiological effects such as heart attacks) are the secondary effects of earthquakes, occurring as a consequence of structure damage and failure. They may result from objects falling from buildings, collapse of buildings, failure of dams, and other primary earthquake effects. Thus a higher incidence of deaths and injuries is associated with structures that have high damage potential than with those having lower damage potential (e.g., precode unreinforced masonry buildings versus modern buildings with earthquake-resistive structural details). On the basis of past experience, deaths are not expected in areas with a one-digit EI less than 6-, but injuries could extend to areas with a one-digit EI of 5.

All of the major areawide systems and facilities of the study area would be severely affected by the hypothetical earthquake. Some of the facilities are very close to the fault, and portions of the systems closely parallel the entire fault break, actually crossing the fault at several locations. The following table summarizes the number of major facilities in the high-EI zones.

SUMMARY TABULATION OF NUMBER OF MAJOR FACILITIES* IN THE HIGH-EI ZONES

Type of Facility	Number of Facilities								
	Study Area	One-Digit EI Zone							
		5	5+	6-	6	6+	7-	7	7+
Concrete Dams	50	-	-	-	-	-	-	-	-
Earth and/or Rock Fill Dams	219	-	1	5	3	2	-	1	-
Hydraulic Fill Dams	11	-	-	1	-	-	3	-	-
California Aqueduct Facilities	15	-	2	3	1	3	-	-	2
Highway Overcrossings > 500 ft in Length	148	-	1	2	-	-	-	-	-
Public Airports	108	-	-	1	4	1	-	-	2
Military Airports	16	-	-	-	-	1	-	-	-
Natural Gas Transmission Facilities	16	-	-	-	-	1	-	-	-
Electric Power Generation and Distribution Facilities	343	3	5	5	6	12	2	5	2
Petroleum Pumping, Terminal, and Refinery Facilities	93	1	-	4	4	6	-	1	-

*Related conveyance systems are not included in the tabulation.

An EIS evaluation is only a preliminary step in the evaluation of earthquake effects on structures. EIS data and results are intended to provide only an overall identification and summary of the extent of the effects from a predicted earthquake. Should more definitive indications of an imminent earthquake appear, the data provided can be used to systematically perform more detailed evaluations.

For those areas with a one-digit EI equal to or greater than 6-, more detailed inventories and evaluations than those that were employed for this study should be made. For structures in a one-digit EI zone equal to or greater than 7-, a detailed engineering review should be carried out to evaluate the possible hazard to life and to determine remedial measures that might be implemented.

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INTRODUCTION

The objective of the study was to estimate the nature and distribution of damage that could occur to structures in southern California as a result of a large earthquake on the San Andreas fault.

The Postulated Earthquake

The hypothetical earthquake, postulated by the U.S. Geological Survey (USGS) as plausible in connection with the current ground surface anomaly in the vicinity of Palmdale, California, is geologically similar to the Fort Tejon earthquake of 1857.[1] From comparison with that earthquake and from the geographical location of the Palmdale Uplift, the postulated earthquake was given as one producing a 300-km rupture that would span the area between Cajon Junction, on the south, and Cholame, on the north. Its magnitude was given by USGS as 8.1. Figure 1 shows the position of the hypothetical fault break and the boundaries of the counties in the study area.

Damage Prediction Procedure

Effects prediction for a postulated earthquake can vary from a cursory answer to the question of whether or not lives will be lost and economic losses suffered to a detailed response that evaluates every column and beam in a structure for the possibility of failure. The work required for prediction increases significantly with the degree of precision required, which in turn varies according to the purpose and needs of the investigation.

During the past decade, URS/John A. Blume & Associates, Engineers, has been engaged in the development of three distinct but interrelated methodologies for predicting seismic damage. The methods that have evolved are:

- the Engineering Intensity Scale (EIS)[2]
- the Spectral Matrix Method (SMM)[3,4]
- the Threshold Evaluation Method (TEM)[5]

These procedures, summarized in Reference 6, were developed for the U.S. Department of Energy to provide a means for making progressively more de-

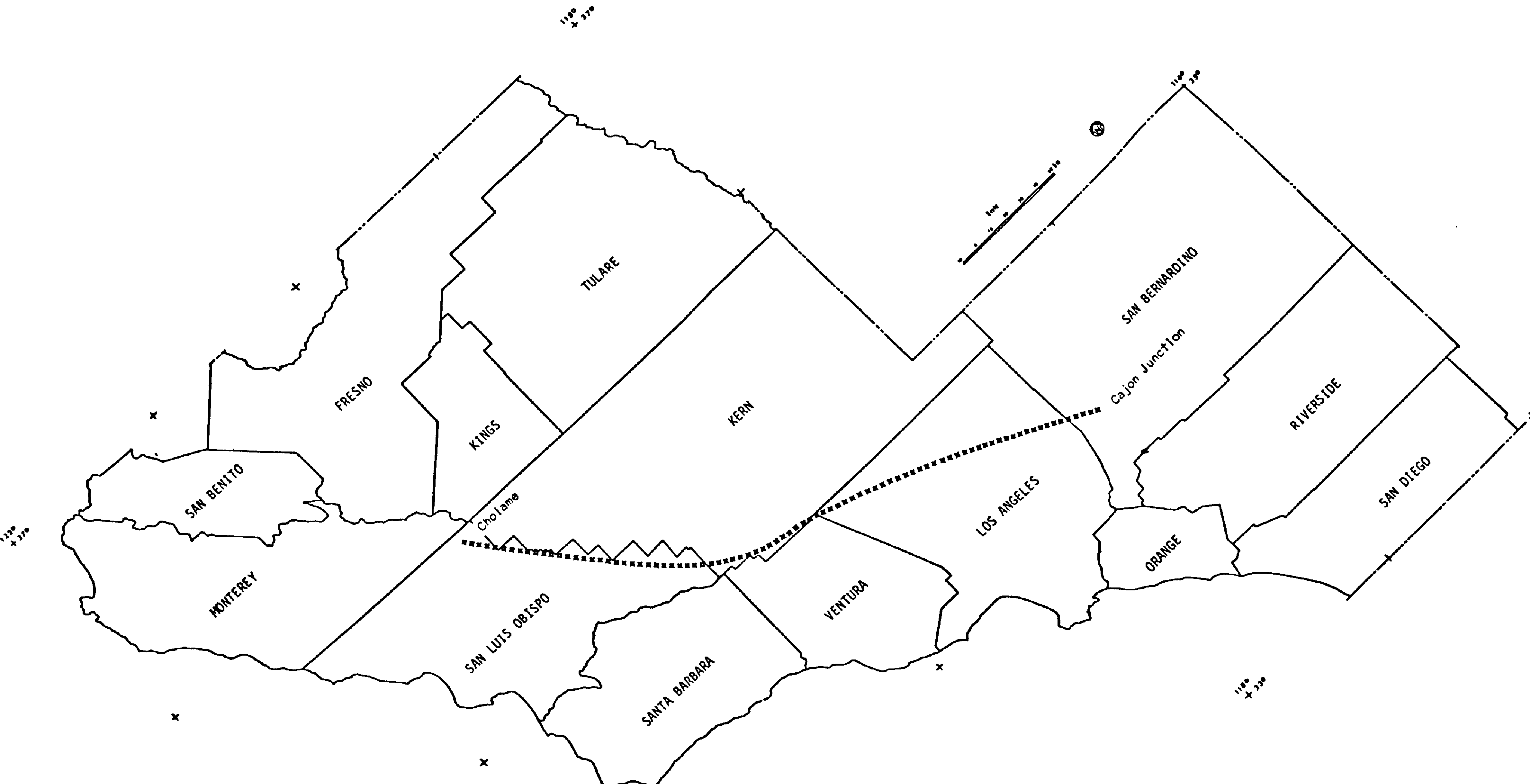


FIGURE 1 HYPOTHETICAL FAULT BREAK AND PRINCIPAL COUNTIES IN THE STUDY AREA

tailed predictions of the structure effects of seismic motions. Each of the methodologies was developed from theoretical principles of structural engineering and dynamic response and from laboratory or field test data. All three have been used successfully for predicting the effects of underground nuclear explosions (UNEs), which produce motion essentially the same as that from an earthquake. Where possible, the methods have been calibrated or verified using observed data on damage caused by ground motion. Although effects prediction requirements for UNEs are not identical to those for earthquakes, all of the basic development work for these methodologies done so far is applicable to earthquake damage prediction.

One of the first steps necessary in predicting the effects of an earthquake is to estimate the extent of the geographic area in which structures are susceptible to damage. The next step is to make a general evaluation of the incidence and degree of damage that might be sustained. The EIS procedure was developed to accomplish both steps and is the method used in this study. A description of the EIS method is provided in Appendix A.

Scope

When the present study of the Palmdale Uplift was commissioned, a general effects prediction was deemed appropriate because of prevailing opinion that the uplift phenomenon could be a precursor to a great earthquake. Consistent with this view, the purpose of this study is to make a general overall estimate of damage that would be caused by the anticipated earthquake. Should more definitive indications of an imminent earthquake appear, more detailed effects predictions would be warranted.

The work necessary to predict the effects of the postulated earthquake is identified by two features of the EIS procedure: (1) damage is established from predicted engineering intensity values of ground motion, and (2) damage estimates consist of a generalized identification of exposure and probable loss. The initial effort of the study involved prediction of ground motion amplitudes, response spectrum amplitudes, and engineering intensities (EI) and identification of the vulnerable region. Next, the numbers and types of structures in the region were estimated on the basis of data available from existing sources (e.g., reports, community brochures) and from limited surveys. Finally, the EIS procedure was applied to provide a generalized estimate of the incidence and degree of damage to various classes of structures in the vulnerable area.

ENGINEERING INTENSITY (EI) PREDICTION

As already stated, effects predictions that make use of the EIS procedure are based on estimated response spectrum amplitudes. In general, response spectrum values for a given site are a function of the magnitude of the energy release, the type of rupture it produces, distance from the source of ground motion, and the geologic characteristics of the travel path and of the receiving site. For the purposes of this study, response spectrum values were determined through a two-step process: estimation of peak ground acceleration and normalization of four basic spectrum shapes for the various geologic conditions of the region.

In predicting peak ground acceleration and response spectrum shapes, information provided by USGS on site-specific geologic conditions was used. The USGS's digital representation of the types of rocks distributed throughout the study area is presented as Figure B-1 of Appendix B. The figure was based on a California Division of Mines and Geology map of the general area, digitized at every 30 minutes of latitude and longitude. The rocks represented on the figure are of ten geologic types, as described in Table 1.

The USGS Rossi-Forel (RF) intensities for the hypothetical earthquake were also provided as background information for the study, together with the computer program used in generating the intensities. RF intensities were used primarily to make an initial estimate of the extent of the study area. The procedure for determining RF intensity is discussed in References 7 and 8. Figure B-2 of Appendix B, the RF intensity map of the general area adjusted for geologic conditions, is presented for reference. A discussion in which RF intensities are compared with EIS values is also presented in Appendix B.

Ground Acceleration Estimates

The peak ground acceleration at a site is taken to depend on earthquake magnitude, the shortest distance to the rupture, and the constitution of upper-layer materials. The SAM V prediction method[9] for earthquake magnitude ≥ 6.5 was used to obtain median peak ground acceleration, which is expressed as:

TABLE 1

GEOLOGIC CATEGORIZATION

Symbol	Geologic Type
A	Granitic and Metamorphic
B	Paleozoic Sedimentary
C	Early Mesozoic Sedimentary
D	Cretaceous to Eocene Sedimentary
E	Undivided Tertiary Sedimentary
F	Oligocene to Middle Pliocene Sedimentary
G	Plio-Pleistocene Sedimentary
H	Tertiary Volcanic
I	Quaternary Volcanic
J	Quaternary Sediments

$$a = 26.0e^{0.432M}\ 29^{1.22\overline{b}}\ (R + 25)^{-1.22\overline{b}}$$

where:

a = ground acceleration (gal)

M = earthquake magnitude

R = shortest distance to rupture (km)

$\overline{b}$ = 1/2 log (ρV_s)

ρ = specific gravity

V_s = site near-surface shear velocity (ft/sec)

Response Spectrum Values

Statistical studies have indicated that observed variation in the shapes of response spectra can in part be attributed to differences in near-surface geologic characteristics. With response spectra normalized to a common peak ground acceleration, the most pronounced effect is an increase in the longer-period ($T \geq 0.5$ sec) spectral amplitudes, corresponding with sites of lower acoustic impedance. There also appears to be a tendency for the higher-frequency response ($f \geq 5$ Hz) to be slightly greater at sites of higher acoustic impedance.

To maintain consistency with response spectrum prediction technology, the ten rock types shown in Table 1 were condensed into four categories of surficial geological constitution, as shown in Table 2. The representative near-surface shear-wave velocities and densities given in Table 2 were used to prescribe the effect of local surface geology on peak ground acceleration and on response spectrum shapes.

Figure 2 shows the basic median-level 5%-damped response spectrum shapes used for the four geologic categories of Table 2. These shapes were based on statistical studies performed on a number of significant earthquake records to develop standardized design spectrum shapes for use in the seismic design of nuclear power plant facilities.[10,11] The characteristics of these median-level spectra are listed in Table 3. Note that the response spectrum for geologic category CC (Plio-Pleistocene Sedimentary) is practically the same as the median determined in Reference 10.

TABLE 2

GROUPING OF GEOLOGIC TYPES FOR GROUND MOTION PARAMETER DETERMINATION

Rock Type Symbols	Average V_s (ft/sec)	ρ (specific gravity)	Abbreviated Group
A, H, I	6000	2.65	AA
B, C, D, E, F	2500	2.4	BB
G	1500	2.0	CC
J	1050	1.9	DD

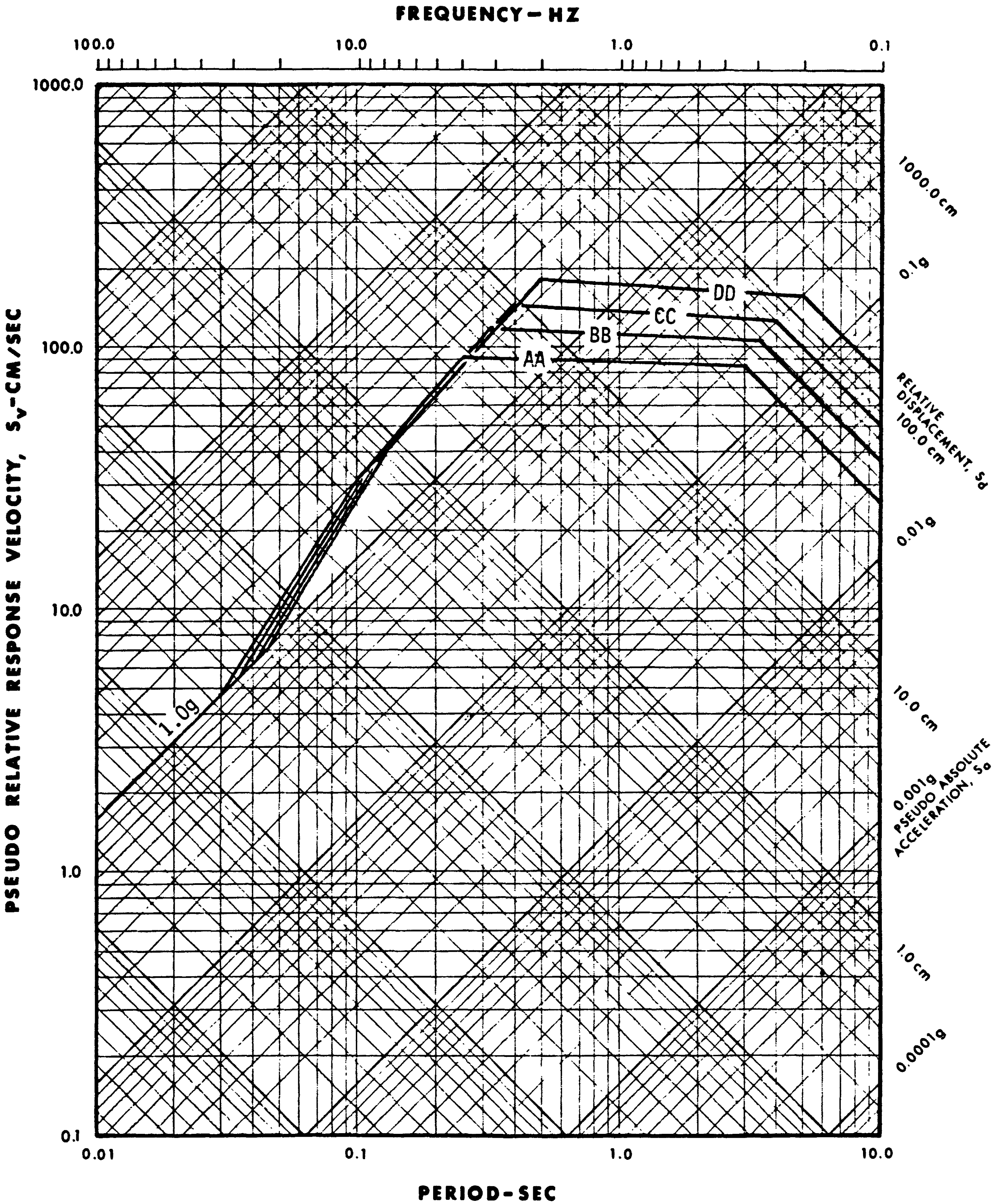


FIGURE 2 SPECTRAL SHAPES, NORMALIZED TO 1.0g PEAK GROUND ACCELERATION

TABLE 3

RESPONSE SPECTRUM CHARACTERISTICS*

(Damping = 5% of Critical)

Rock Type, Abbreviated Group	T (sec) ≤	a (g)	T (sec)	a (g)	T (sec)	a (g)	T (sec)	d (cm)
AA	.03	1.0	.1	2.0	.25	2.3	3	40
BB	.035	1.0	.11	2.0	.32	2.3	3.4	57
CC	.04	1.0	.12	2.0	.4	2.3	4	80
DD	.045	1.0	.13	2.0	.5	2.3	5	125

*Normalized to acceleration of 1.0g (see Figure 2).

EIS Maps

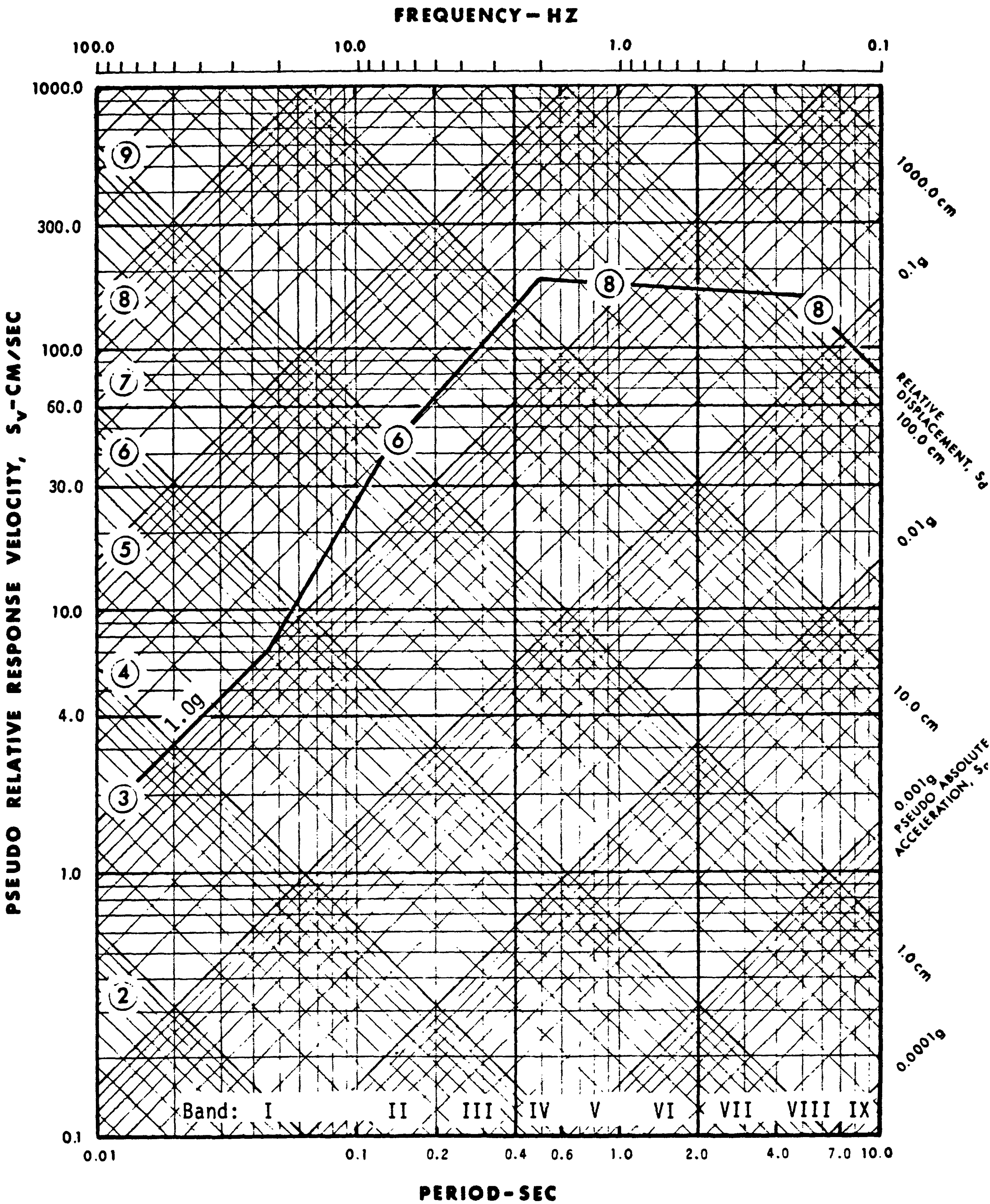
Once the peak ground acceleration and the response spectrum for a particular site have been determined, the EIS values for various period bands can be obtained by superimposing the response spectrum on the EIS matrix. As shown in Figure 3, a peak ground motion of 1.0g for spectrum shape DD (from Figure 2) can be represented by a three-digit EI of 6,8,8, where the first digit represents short-period bands I, II, III ($T < 0.4$ sec); the second represents intermediate-period bands IV, V, VI ($T = 0.4$ to 2.0 sec); and the third represents long-period bands VII, VIII, IX ($T > 2.0$ sec). The same peak ground acceleration for spectrum shape AA can be represented by an EI of 6,7,6. Similarly, peak ground acceleration of 0.1g for spectrum shape DD can be represented by an EI of 4,5,5, and so on, for other peak ground motions and spectrum shapes.

To show the EI levels for the entire study area, isointensity contour maps were developed for each of the three period ranges. Figure 4 is an EIS isointensity map of the short-period bands; Figures 5 and 6 are maps of the intermediate- and long-period bands, respectively. (Transparent copies of these figures are enclosed in a pocket inside the back cover of the report. For evaluation purposes, they may be superimposed on the structure data maps of the study area presented in a later section.)

EI Distribution

In the short-period range, the highest EIS value observed was 7; however, its occurrence is limited to a few isolated locations immediately adjacent to the fault (Figure 4). The next highest EIS value is 6, observed to a distance of approximately 10 km from the fault over an area of approximately 6,400 km^2. The area in which EI 5 appeared covered approximately 12,000 km^2; EI 4 covered an area of about 33,000 km^2. EI 3 was observed in most of the remaining area, with the exception of extreme corners of the study area.

The highest EIS value observed in the intermediate-period range was 8 (Figure 5). Because of the high dependence of EI in this period range on the local geologic conditions, no simple description of areal distribution is possible. Comparing Figures 4 and 5, the areas with EIS values of 5 and 6 in the short-period range are dominated by EI 6, 7, and 8 in the intermediate-period range.



(N) = Engineering Intensity (EI = 1 and 0 not shown)

FIGURE 3 EXAMPLE OF THREE-DIGIT ENGINEERING INTENSITY

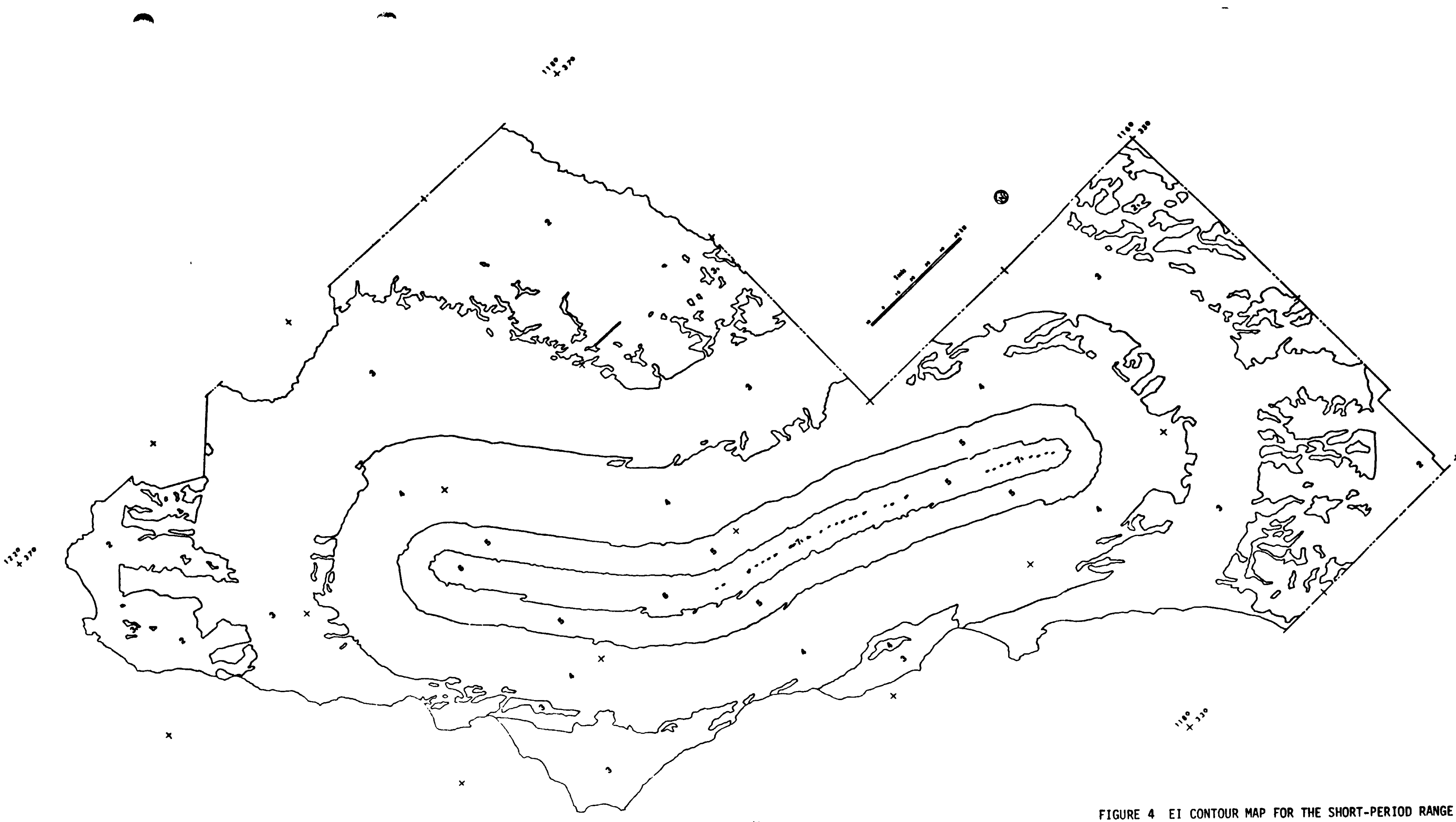


FIGURE 4 EI CONTOUR MAP FOR THE SHORT-PERIOD RANGE (BANDS I, II, III) FOR M = 8.1

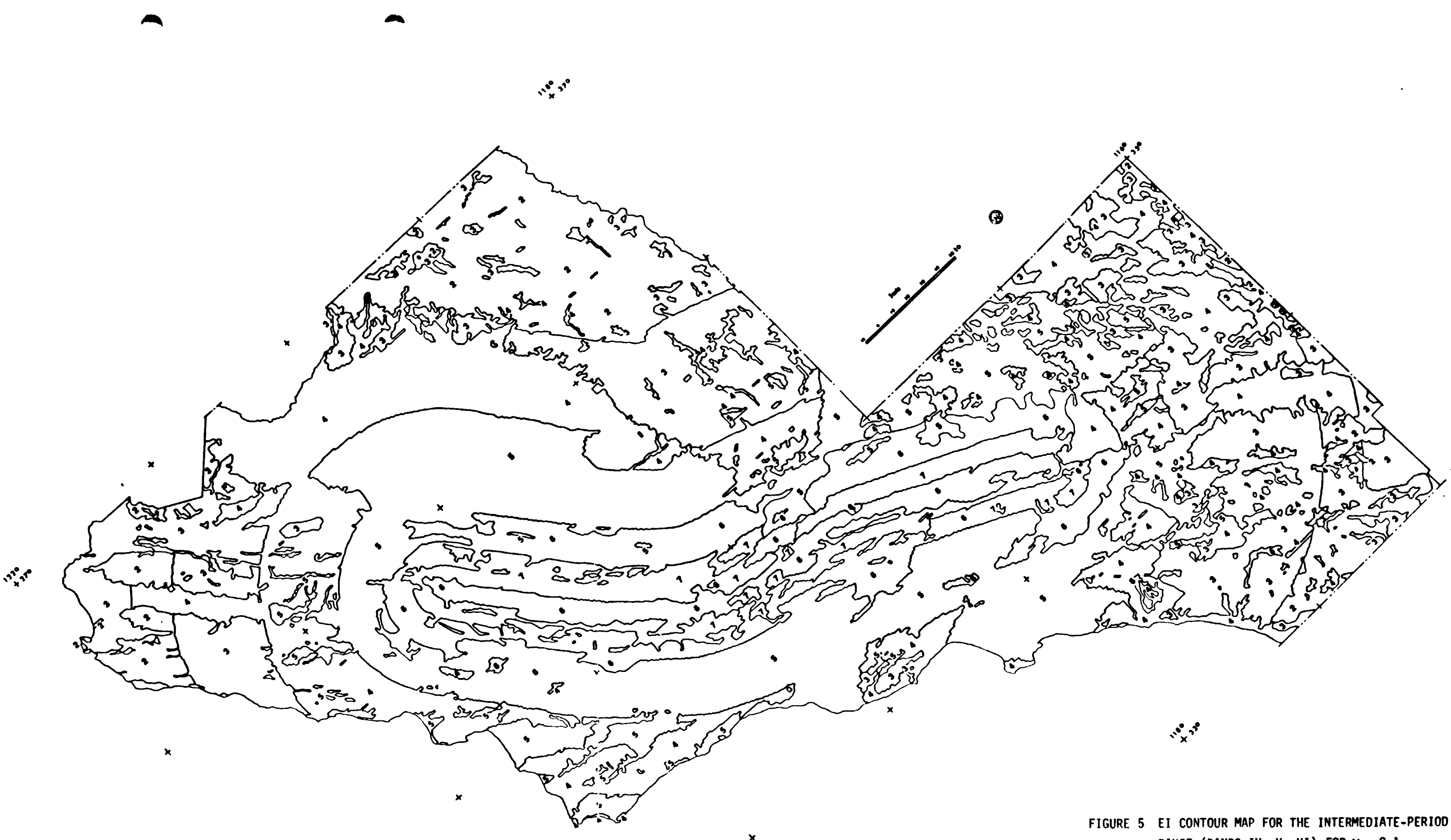


FIGURE 5 EI CONTOUR MAP FOR THE INTERMEDIATE-PERIOD RANGE (BANDS IV, V, VI) FOR M = 8.1

FIGURE 6 EI CONTOUR MAP FOR THE LONG-PERIOD RANGE (BANDS VII, VIII, IX) FOR $M = 8.1$

The EI distribution in the long-period range is quite similar to that of the intermediate-period range (Figure 6). Again, because of the dependence of EI on local geology, a mixture of values is generally observed.

A summary of the approximate distribution of EIS values in the study area is presented in Table 4.

TABLE 4

TOTAL LAND AREA* ASSOCIATED WITH EACH EI LEVEL

EI Level	Period Band		
	I, II, III (< 0.4 sec)	IV, V, VI (0.4 to 2.0 sec)	VII, VIII, IX (> 2.0 sec)
8	--	4,869	1,786
7	51	9,283	5,430
6	7,337	16,200	14,188
5	15,654	47,594	38,237
4	46,920	44,156	44,890
3	70,518	41,111	43,666

*A unit represents an area of one-half degree latitude by one-half degree longitude (≈ 0.7 km^2).

EIS DATA FOR DAMAGE ESTIMATION

Typical Buildings

In order to predict the effects of a hypothetical earthquake, it is first necessary to determine, theoretically or empirically, the relationship between ground motion and damage. For the low-rise and high-rise buildings found in the study area, that information was available from previous investigation of the 1971 San Fernando earthquake.[12] Correlation of damage level, expressed as mean damage cost factor (m_{DF}), with engineering intensity showed that for low-rise buildings the relationship was:

$$\log m_{DF} = 8.86 \log (EI) - 7.94$$

where:

EI = engineering intensity for (short-period) bands I, II, III

For multistory buildings in the intermediate-period range, the relationship was found to be:

$$\log m_{DF} = 10.8 \log (EI) - 10.3$$

where:

EI = engineering intensity for (intermediate-period) bands IV, V, VI

Unreinforced Masonry Buildings

Among the buildings most often and most severely damaged during earthquakes are structures with unreinforced masonry load-bearing walls. Such structures can be found in most of the communities in the area affected by the postulated earthquake. Many of them, built before seismic code requirements were instituted (and often referred to as precode masonry buildings), have limited capacity to resist lateral forces because of the inadequate connection of structural elements. In estimating the damageability of structures in this class, it was assumed from past experience[13-15] that their lateral-force-resisting capacity is one-half that of the typical buildings noted above.

Mobile Homes

Because there are no seismic design requirements for mobile homes, estimates of damage must rely upon previous experience. EI values for the short-period range[12] and a limited amount of other data[14] were available for the San Fernando earthquake. From those data, summarized in Table 5, the following relationship was established for the short-period range:

$$m_{DF} = 0.015\ (EI) - 0.049$$

Special Structures

Because they are important to the general welfare, some structures are required to be designed and constructed according to standards that are higher than those for typical buildings. Although no damage statistics from EIS evaluation of previous earthquakes are currently available, it can be assumed that these structures are able to withstand higher seismic forces than can be resisted by typical buildings. Therefore, the damage cost factor for such structures was estimated from comparison of their design requirements with the design requirements[16] and EIS damage statistics for typical buildings.

Some of the structures with special design considerations are:

- public school buildings[17]
- hospital buildings[18]
- State Water Project facilities[19]
- nuclear power plant structures[20]

The seismic coefficients of required design for these buildings and for typical buildings are shown on Figure 7 in terms of response spectra. The response spectra for some of these facilities are developed on the basis of the seismicity of specific sites and for the various types of structures in each facility. Where the design values were given in terms of base shear coefficients rather than spectral values (e.g., the *UBC* values), a conversion was made using a standard building configuration. The base shear coefficient, C_b, is given by the equation $C_b = CKZ$, where K (structural frame coefficient) and Z (seismic zone coefficient) were assumed to be unity. C (lateral force coefficient) was calculated as a function of period, T, using

TABLE 5

DAMAGE STATISTICS FOR MOBILE HOMES

A. Comparison of Damage Cost and EI Values at Corresponding Locations:

	Distance from Fault (mile)		
	5-10	10-15	15-20
Cost of Damaged Items[14] ($)			
Coach	410	280	70
Awning and skirt	150	110	20
Contents	180	150	80
Total	740	540	170
Damage Cost Factors*			
High	0.053	0.039	0.012
Low	0.026	0.019	0.006
EI Range			
Bands I, II, III[12]	5.5 - 6.0	4.5 - 5.0	4.0 - 4.5

B. Estimated Mean Damage Cost Factor (m_{DF}):

$$m_{DF} \simeq 0.015\,(EI) - 0.049$$

*Middle range of unit cost for mobile homes was estimated to be $10,000 to $25,000, with an additional $4,000 for accessories.

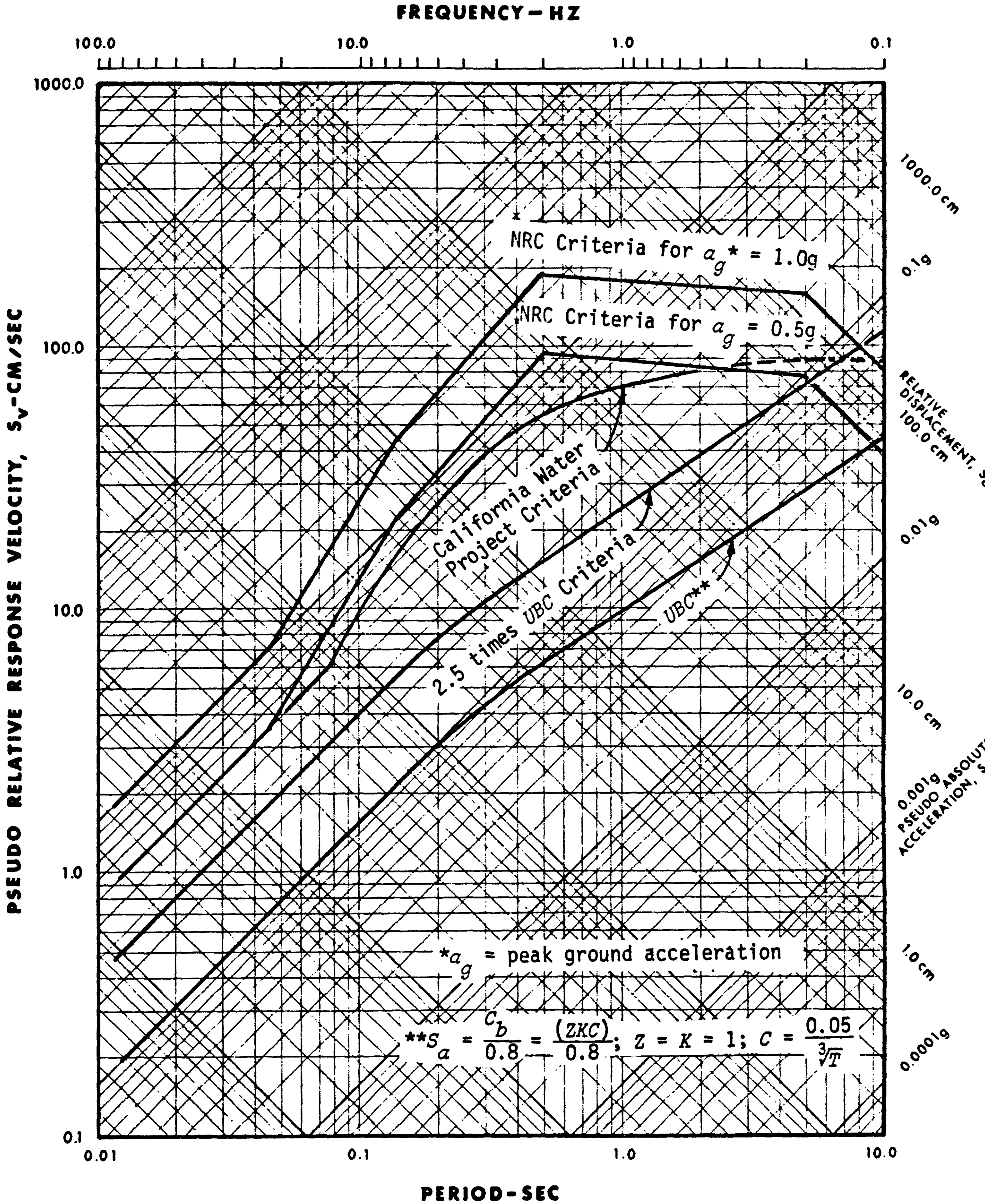


FIGURE 7 SEISMIC DESIGN COEFFICIENT IN TERMS OF RESPONSE SPECTRA

the formula $C = 0.05/\sqrt[3]{T}$. To convert C_b to spectral acceleration, S_a, a C_b/S_a ratio of 0.8 was used.[6,21]

Damage Statistics for Special Structures

As already stated, estimation of m_{DF} in terms of EI for typical buildings was obtained from an earlier study of the San Fernando earthquake.[12] As a means for extending these data to other structures, a comparative study to determine the relationship between these estimates and the seismic design coefficients of typical buildings was made. For each EI level, a ratio of the spectral velocity of EI levels and the spectral velocity of the seismic design coefficients was determined and then compared with the m_{DF} at specific EI levels. A fairly good correlation was observed for the low-rise and high-rise building categories (Figure 8).

To apply this relationship to other structure categories, it was assumed that the damage cost factors and the seismic design coefficients were related in the same proportion for all structure types. To estimate m_{DF} for other structures, spectral velocity ratios of EI versus design were determined. Using these spectral ratios, m_{DF} values were determined using the data in Figure 8. Table 6 provides a summary of this approach for structures with seismic coefficients of 2.5 times *UBC*. A similar approach was used to estimate m_{DF} for other types of structures, as illustrated in Figures 9 through 11. This approximation is based on engineering judgment; there are no experimental data currently available to verify or negate this approach.

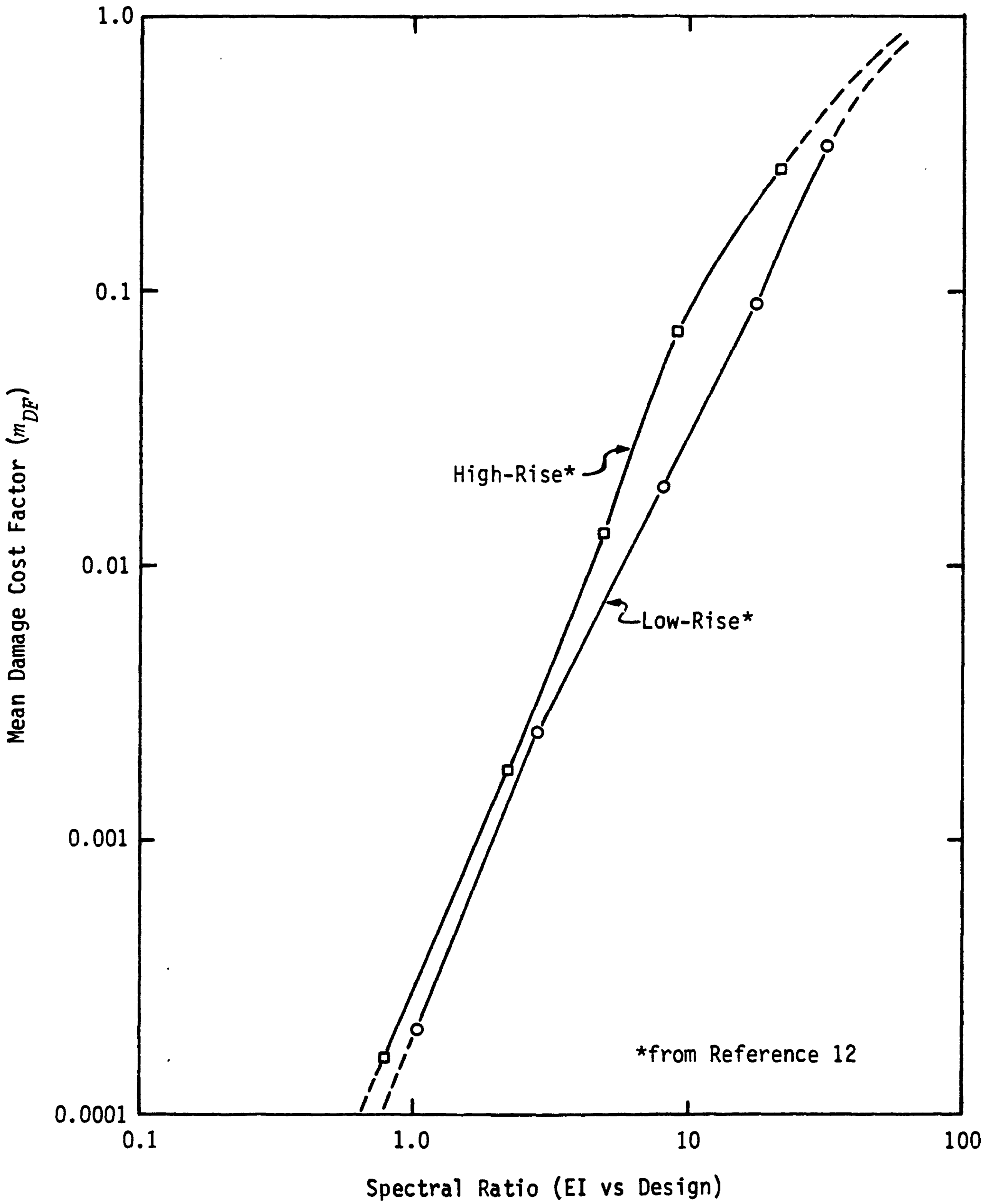


FIGURE 8 COMPARISON OF m_{DF} VERSUS SPECTRAL RATIO

TABLE 6

EXAMPLE DETERMINATION OF DAMAGE STATISTICS

(Seismic design coefficient of 2.5 times *UBC*)

EI Level	Average Spectral Velocity at EI Level (cm/sec)	Period Band					
		Less than 0.4 sec		0.4 to 2.0 sec		Greater than 2.0 sec	
		Spectral Ratio* (EI/Design)	Damage Cost Factor**	Spectral Ratio* (EI/Design)	Damage Cost Factor**	Spectral Ratio* (EI/Design)	Spectral Ratio* Factor**
9	650	--	--	23.6	0.33	6.7	0.02
8	200	30.8	0.35	7.3	0.04	2.1	0.001
7	80	12.3	0.05	2.9	0.0035	0.82	0.00015
6	45	6.9	0.013	1.6	0.0009	--	--
5	20	3.1	0.00025	0.73	0.0001	--	--
4	7	1.1	0.00016	--	--	--	--

*Average design spectral velocity values of 6.5 cm/sec for period less than 0.4 sec; 27.5 cm/sec for period from 0.4 to 2.0 sec; and 97.5 cm/sec for period greater than 2.0 sec were used.

**Determined from spectral ratios shown in Figure 8.

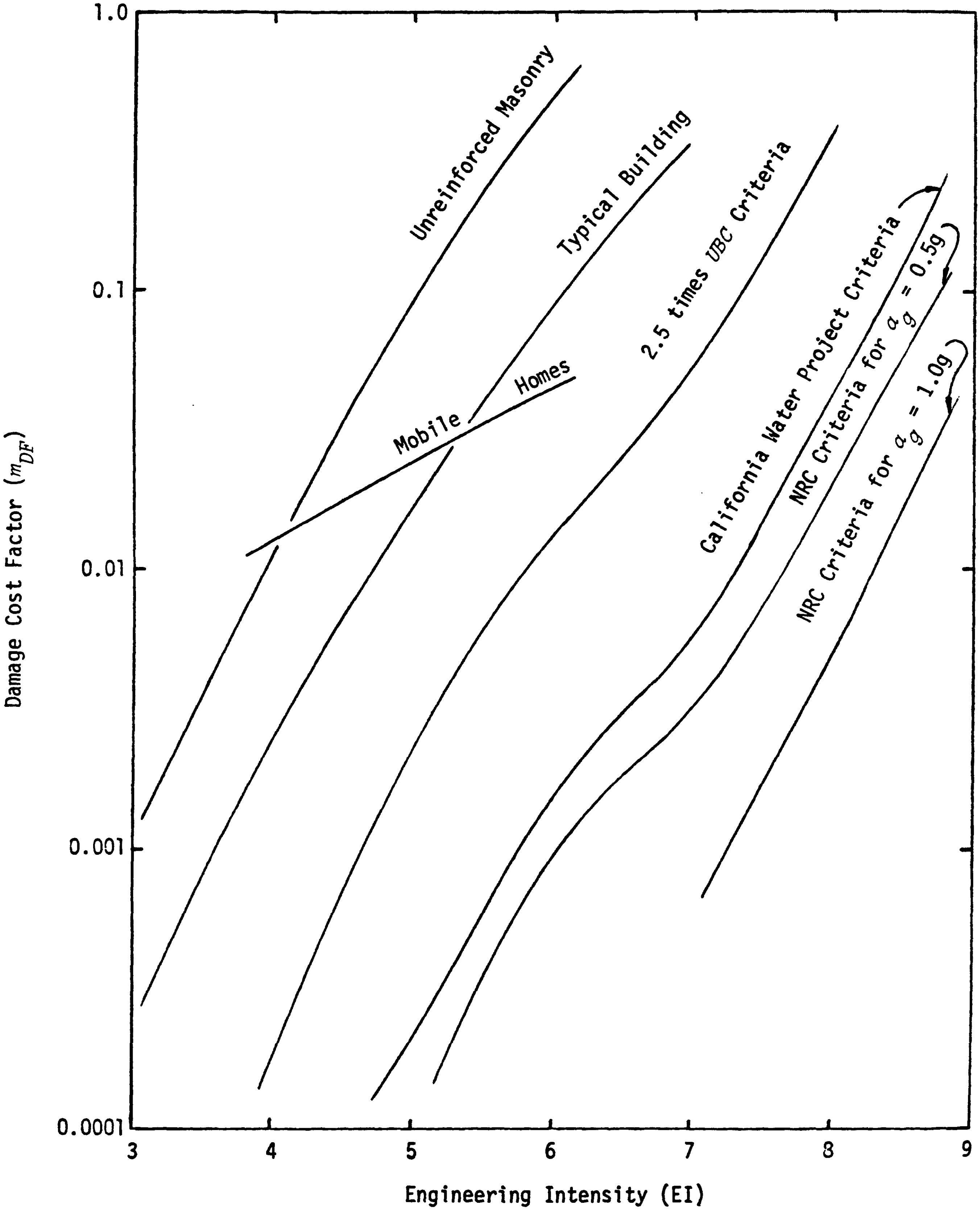


FIGURE 9 m_{DF} VERSUS EI IN THE SHORT-PERIOD BANDS (I, II, III)

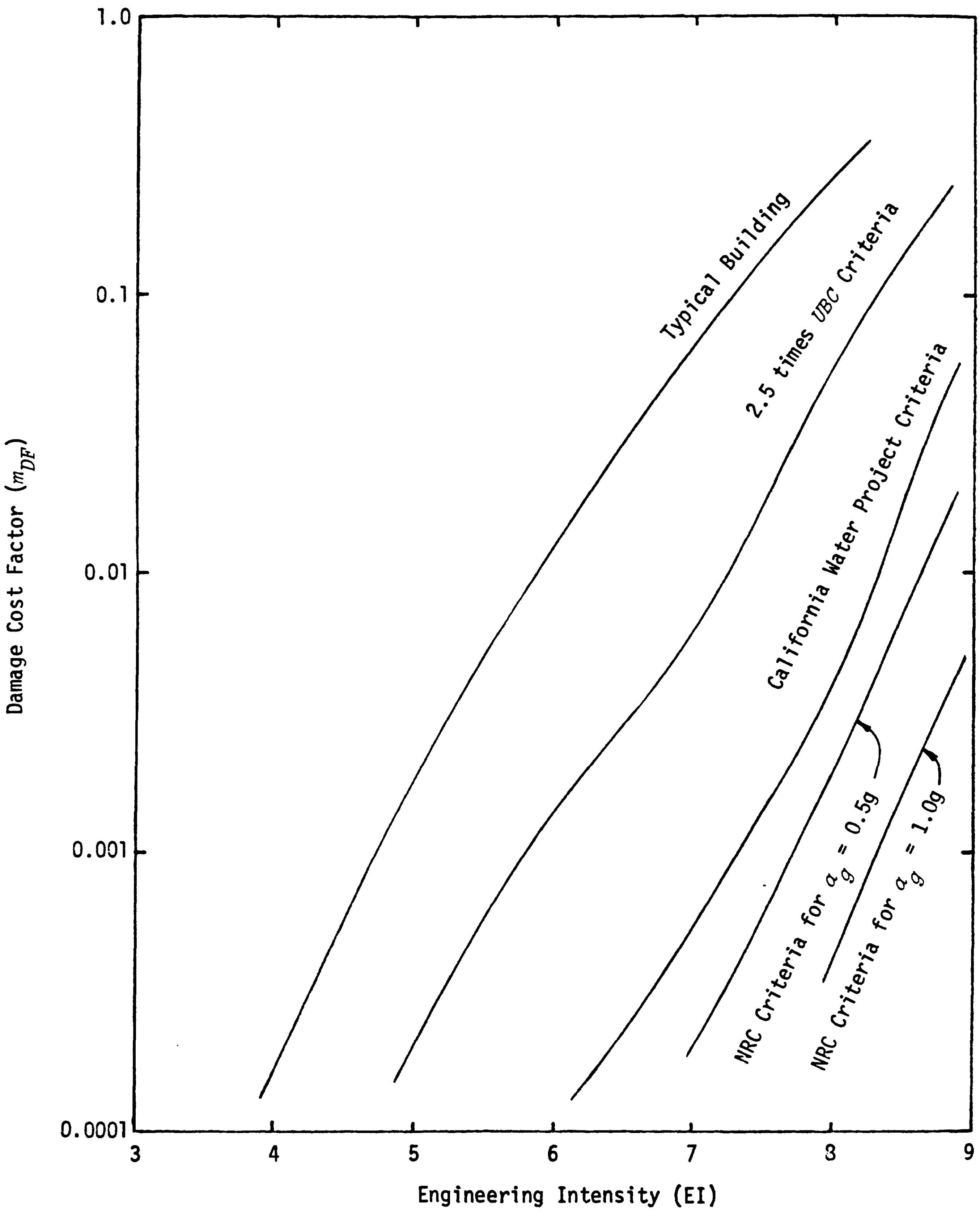


FIGURE 10 m_{DF} VERSUS EI IN THE INTERMEDIATE-PERIOD BANDS (IV, V, VI)

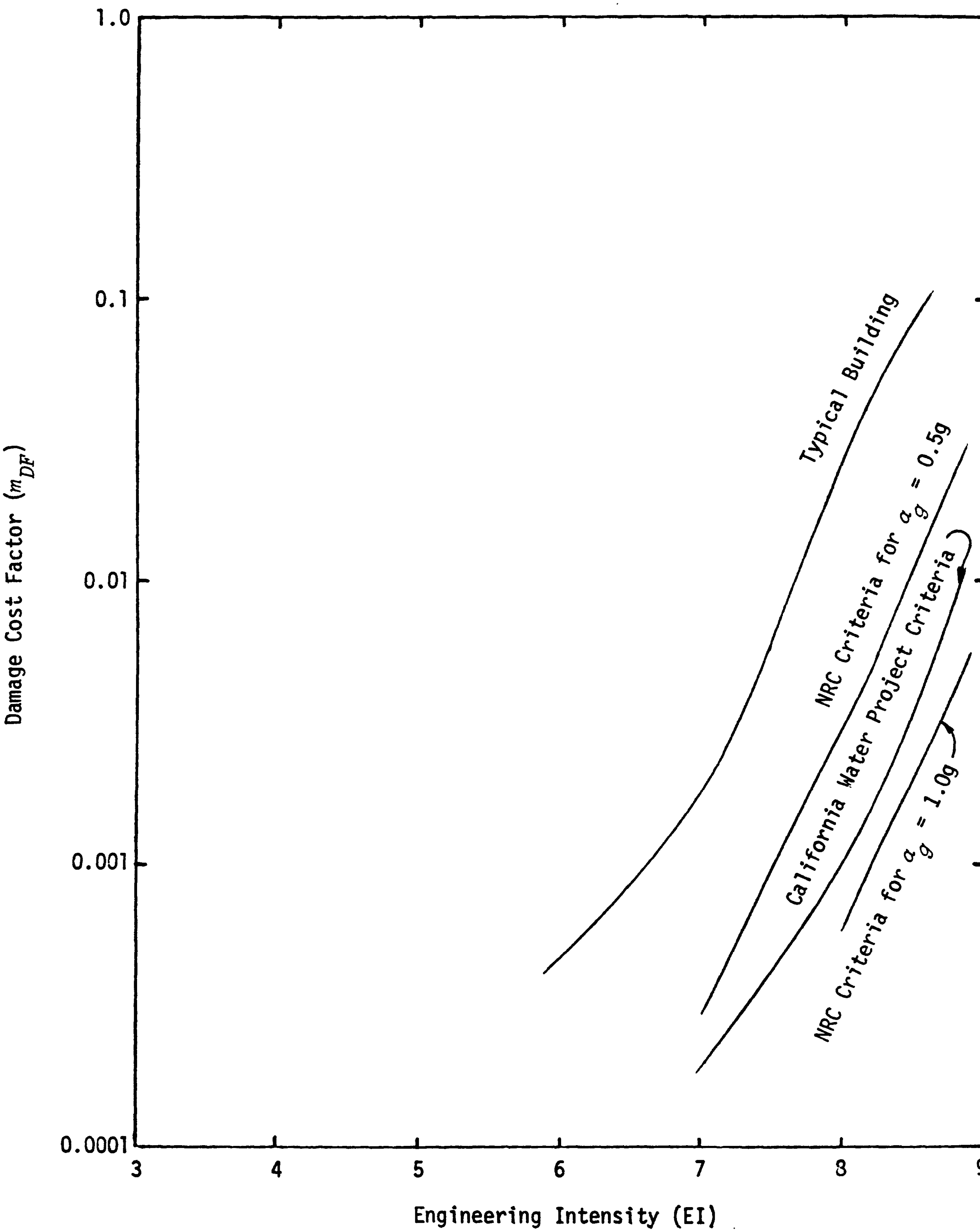


FIGURE 11 m_{DF} VERSUS EI IN THE LONG-PERIOD BANDS (VII, VIII, IX)

STRUCTURE INVENTORY DATA

In an effects prediction effort such as this, identification of the structures in the area affected by the hypothetical earthquake is equally as important as the ground motion prediction. However, because the investigation is intended to provide only a general or overall evaluation of damage, acquisition of detailed information on individual structures was not warranted. An estimate of the numbers and types of structures, their location, and their classification according to function and dynamic response behavior is the information necessary for an EIS evaluation. An example structure check list, useful for structure inventory planning purposes, is given in Appendix C.

The structures most prevalent in the study area have been grouped into two major classifications: community structures and areawide structures. Allowing for variations in population, the types of structures found in individual communities are, with some minor exceptions, common to all communities in the study area. Thus population was an important parameter in estimating the numbers and types of structures in the study area. Areawide structures include transportation, utility, hydraulic, and energy network facilities. This chapter summarizes the structure data obtained for the study.

Population Distribution

Parts or all of 14 counties in southern California, identified in Table 7, are included in the area that is expected to be affected by the postulated earthquake. This study area covers approximately 154,000 km^2 of southern California. Almost 65% of the population of the study area is concentrated in Los Angeles County; another 25% is found in the cities of adjacent counties. The city of Los Angeles, with an estimated 1976 population of approximately 2.74 million (1970 census population: approximately 2.82 million), has the highest population of any city in the study area. Several cities in the immediate vicinity of Los Angeles have more than 100,000 inhabitants.

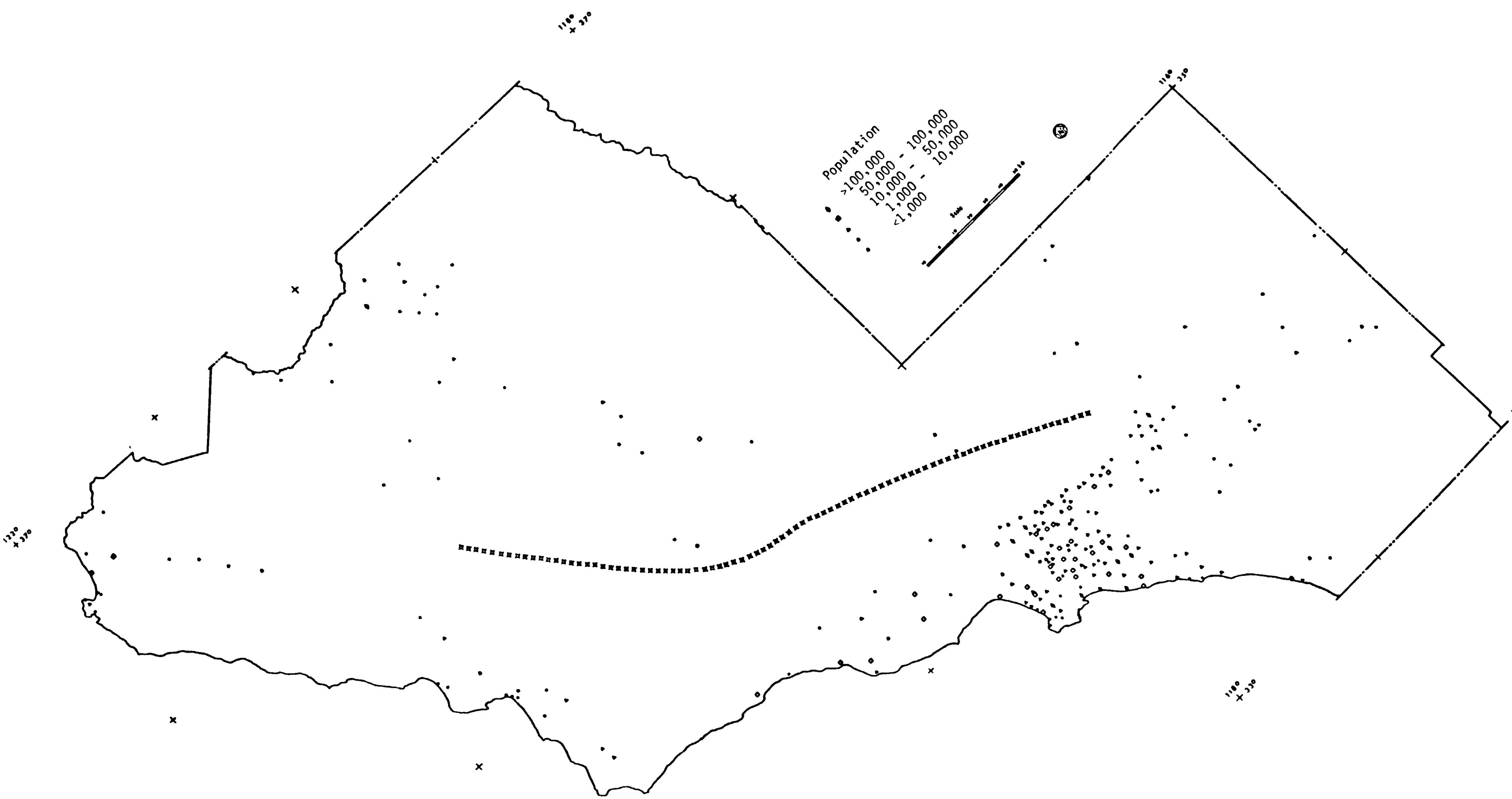
The population of cities in the study area is represented graphically in Figure 12. Cities with a population greater than 50,000 are listed in Table

TABLE 7

COMPARISON OF 1970 POPULATION IN STUDY AREA TO TOTAL COUNTY POPULATION

County	Study Area Population		Population Outside Study Area	Total 1970 County Population
	Population of Cities*	Remaining County Population		
Fresno	239,614	134,303	39,412 (north of 37°N)	413,329
Kern	157,029	120,237	52,968 (east of 118°W)	330,234
Kings	36,892	29,825	0	66,717
Los Angeles	6,722,641	319,339	0	7,041,980
Monterey	168,742	78,708	0	247,450
Orange	1,333,114	88,119	0	1,421,233
Riverside	336,707	54,445	67,922 (east of 116°W)	459,074
San Benito	9,085	9,141	0	18,226
San Bernardino	497,673	151,826	32,734 (east of 116°W)	682,233
San Diego	115,371	71,543	1,170,940 (south of 33°N)	1,357,854
San Luis Obispo	79,732	25,958	0	105,690
Santa Barbara	172,495	91,829	0	264,324
Tulare	101,629	86,693	0	188,322
Ventura	297,636	80,861	0	378,497
Total	10,268,360	1,342,827	1,363,976	12,975,163

*Includes only the communities listed in Appendix G.



Note: Data taken from References 22 and 23.

FIGURE 12 CITY POPULATION

8, which also shows the distance from individual cities to the closest point on the rift zone of the hypothetical earthquake. A complete list of study area cities and their population is provided in Appendix D. Population figures were taken mainly from the 1970 census,[22] in some cases supplemented with data from the *California Statistical Abstract*[23] for 1975 and 1976.

Community Structures

Residential Buildings. Residential structures include single- and multifamily dwellings and mobile homes. The breakdown of these buildings for the study area was derived from housing information contained in the 1970 census.[22] For the purpose of an EIS analysis, housing information is divided into the following categories:

- fewer than 5 units per structure
- from 5 to 49 units per structure
- more than 49 units per structure
- mobile homes and trailers

The number of buildings in these categories for cities with population greater than 10,000 is shown in Appendix D. Data for cities of population less than 10,000 was not available.

Categorization of buildings into number of units per structure permits their classification according to EIS period bands. Buildings with fewer than five units (single residences, duplexes, or small apartments) have a fundamental period of 0.2 sec or less. Those with 5 to 49 units are in most cases buildings with a response period of less than 0.4 sec. Consequently, these two categories of buildings fall within the EIS short-period range. Those with more than 49 units per structure are usually multistory buildings. Their expected fundamental period is in the range of 0.4 to 2.0 sec, placing them in the EIS intermediate-period range.

Because of the nature of the structure system and anchorage of mobile homes, classification of these structures is slightly different from that of buildings. Most often, mobile homes are mounted on pedestals, without

TABLE 8

CITIES WITH POPULATION GREATER THAN 50,000

City	County	1970 Census Population	Distance from Fault (km)
Fresno	Fresno	165,972	119
Bakersfield	Kern	69,575	56
Alhambra	Los Angeles	62,125	47
Bellflower	"	51,454	68
Burbank	"	88,871	45
Carson	"	71,150	80
Compton	"	78,611	70
Downey	"	88,445	60
East Los Angeles (u)	"	105,033	55
El Monte	"	69,837	44
Glendale	"	132,752	46
Hawthorne	"	53,304	73
Inglewood	"	89,985	63
Lakewood	"	82,985	63
Long Beach	"	358,633	80
Los Angeles	"	2,816,061	55
Norwalk	"	91,827	62
Pasadena	"	113,327	42
Pico Rivera	"	54,170	55
Redondo Beach	"	56,075	81
Santa Monica	"	88,289	63
South Gate	"	56,909	62
Torrance	"	134,584	80
West Covina	"	68,034	40
Whittier	"	72,863	55
Salinas	Monterey	58,896	158
Anaheim	Orange	166,701	62
Buena Park	"	63,646	66
Costa Mesa	"	72,660	81
Fullerton	"	85,826	62
Garden Grove	"	122,524	72
Huntington Beach	"	115,960	75
Orange	"	77,374	65
Santa Ana	"	156,601	70
Westminster	"	59,865	66
Riverside	Riverside	140,089	36
Ontario	San Bernardino	64,118	30
San Bernardino	"	104,251	27
Santa Barbara	Santa Barbara	70,215	153
Oxnard	Ventura	71,225	155
Simi Valley	"	56,464	117
Ventura	"	55,797	165

(u) = unincorporated city.

any firm connection. When they vibrate, there is no simple fundamental period of response. However, they have been classified as short-period structures for this study.

Commercial Buildings. Typical commercial buildings in the study area are designed in accordance with *Uniform Building Code* (*UBC*)[16] requirements for seismic zone 3. They exhibit a variety of construction materials and structure systems and range in height from one story to more than 60 stories. The response period of a building is determined by the type of structure system and the building materials used as well as by height; however, for the general identification of building types and structure distribution required here, the fundamental period of commercial buildings is assumed to vary with number of stories.

Low-rise commercial buildings, which are in the short-period EIS range, can be found in all communities of the study area. Most of the multistory buildings are in the intermediate-period range and are found in moderately populated areas. Variation in their number and distribution is in most cases a function of population. From a study of sample cities, it was determined that these buildings can be found in all cities with a population of more than 10,000. Buildings with long periods -- usually very tall buildings -- occur only in a few major metropolitan areas. An example of such a metropolitan area is provided in Table 9, which shows the distribution of multistory buildings in Los Angeles and Orange counties.

School Buildings. The design of school buildings in California is governed by the building standards of the *California Administrative Code*.[17] The special seismic design requirements for schools are more rigorous than for buildings in most other classes of occupancy.

In almost all cases, elementary and secondary school buildings in the study area are limited to one or two stories and are therefore in the short-period EIS-band category. Table 10 summarizes the distribution of schools for 66 communities in 13 counties. In general, the distribution is directly proportional to population. With the exception of several small communities, there is at least one elementary, junior high, and high school in each community. Some schools receive students from adjoining communities in the

TABLE 9

DISTRIBUTION OF MULTISTORY BUILDINGS IN LOS ANGELES AND ORANGE COUNTIES*

District	Number of Buildings				Square Footage	Permit Valuation
	8-11 Floors	12-19 Floors	20+ Floors	Total		
Beverly Hills	19	4	0	23	3,371,000	$ 87,600,000
Century City	1	6	6	13	6,343,002	216,400,000
Downtown Los Angeles	17	21	13	51	22,969,000	673,000,000
Hollywood - Sunset Strip	9	8	1	18	2,550,000	64,000,000
Airport Marina Area	12	10	0	22	3,963,000	91,500,000
Long Beach - South Bay Area	8	5	0	13	1,950,000	60,600,000
Miracle Mile and Vicinity	4	5	4	13	3,053,000	77,500,000
San Fernando Valley	8	11	0	19	2,600,000	70,300,000
San Gabriel Valley	9	3	0	12	2,347,000	60,900,000
Westwood	1	4	3	8	2,731,000	82,200,000
Wilshire-6th Street Area	9	19	6	34	8,550,000	232,900,000
Rest of Los Angeles County	13	4	1	18	2,410,000	67,900,000
Total, Los Angeles County	110	100	34	244	62,837,000	1,784,800,000
Orange County	15	7	0	22	3,962,000	92,400,000
Total, Los Angeles and Orange Counties	125	107	34	266	66,799,000	$1,877,200,000

*Summary statistics, 1947 through 1973. For additional data on Los Angeles area, see Appendix E.

Source: Western Economic Research Co., Sherman Oaks, California.

TABLE 10

NUMBER OF PUBLIC SCHOOLS FOR SAMPLE CITIES

County	City	1970 Population	Elementary School	Junior High School	High School
Fresno	Clovis	13,856	10	1	1
	Coalinga	6,161	1	1	1
	Fresno	165,972	60	14	6
	Reedley	8,131	7	2	1
	Sanger	10,088	11	1	1
	Selma	7,459	7	1	1
Kern	Bakersfield	69,515	45	9	9
	Delano	14,559	5	1	1
	Wasco	8,269	2	1	1
Kings	Avenal	3,035	1	0	1
	Corcoran	5,249	4	1	1
	Handford	15,179	6	1	2
	Lemoore	4,219	3	1	1
Los Angeles	Azuza	25,217	14	3	2
	Claremont	23,464	8	2	1
	Downey	88,445	13	4	3
	El Segundo	15,620	2	1	1
	Glendale	132,752	23	5	3
	Lakewood	82,973	18	5	4
	Long Beach	358,633	56	15	8
	Montebello	42,807	5	3	2
	Monterey Park	49,166	8	2	3
	Norwalk	91,827	25	8	4
	Paramount	34,734	8	2	1
	Santa Fe Springs	14,750	4	2	1
	Santa Monica	88,289	9	2	2
	S. Pasadena	134,584	25	7	5
Monterey	Salinas	58,896	20	2	3
Orange	Anaheim	166,701	32	16	9
	Buena Park	63,646	19	2	1
	Cypress	31,026	10	2	1
	Fullerton	85,826	18	4	4
	Placientia	21,948	11	2	2
	Santa Ana	156,601	18	4	4
Riverside	Banning	12,034	3	1	1
	Beaumont	5,484	3	1	2
	Coachella	8,353	3	1	1
	Corona	27,519	11	3	1
	Desert Hot Springs	3,728	1	0	0
	Lake Elsinore	3,530	3	1	1
	Hemet	12,252	7	1	1
	Indio	14,459	8	2	2
	Norco	14,511	4	1	1
	Palm Desert	6,171	2	1	0
	Palm Springs	20,936	7	2	1
	Perris	4,228	2	1	1
	Riverside	140,089	33	7	6
	San Jacinto	4,385	2	1	2
San Bernardino	Barstow	17,442	16	2	3
	Ontario	64,118	24	5	2
	San Bernardino	104,251	37	8	4
	Upland	32,551	9	2	1
San Diego	Escondido	36,792	9	3	5
	Oceanside	40,494	13	2	2
San Luis Obispo	Paso Robles	7,168	4	0	1
	San Luis Obispo	28,036	11	2	1
Santa Barbara	Lompoc	25,204	13	2	2
	Santa Maria	32,749	23	4	3
Tulare	Dinuba	7,917	4	1	1
	Lindsay	5,206	2	2	1
	Porterville	12,602	7	2	2
	Tulare	16,235	6	2	2
Ventura	Fillmore	6,285	3	1	1
	Santa Paula	18,001	7	1	1
	Simi Valley	56,464	24	5	3
	Ventura	55,797	21	4	3

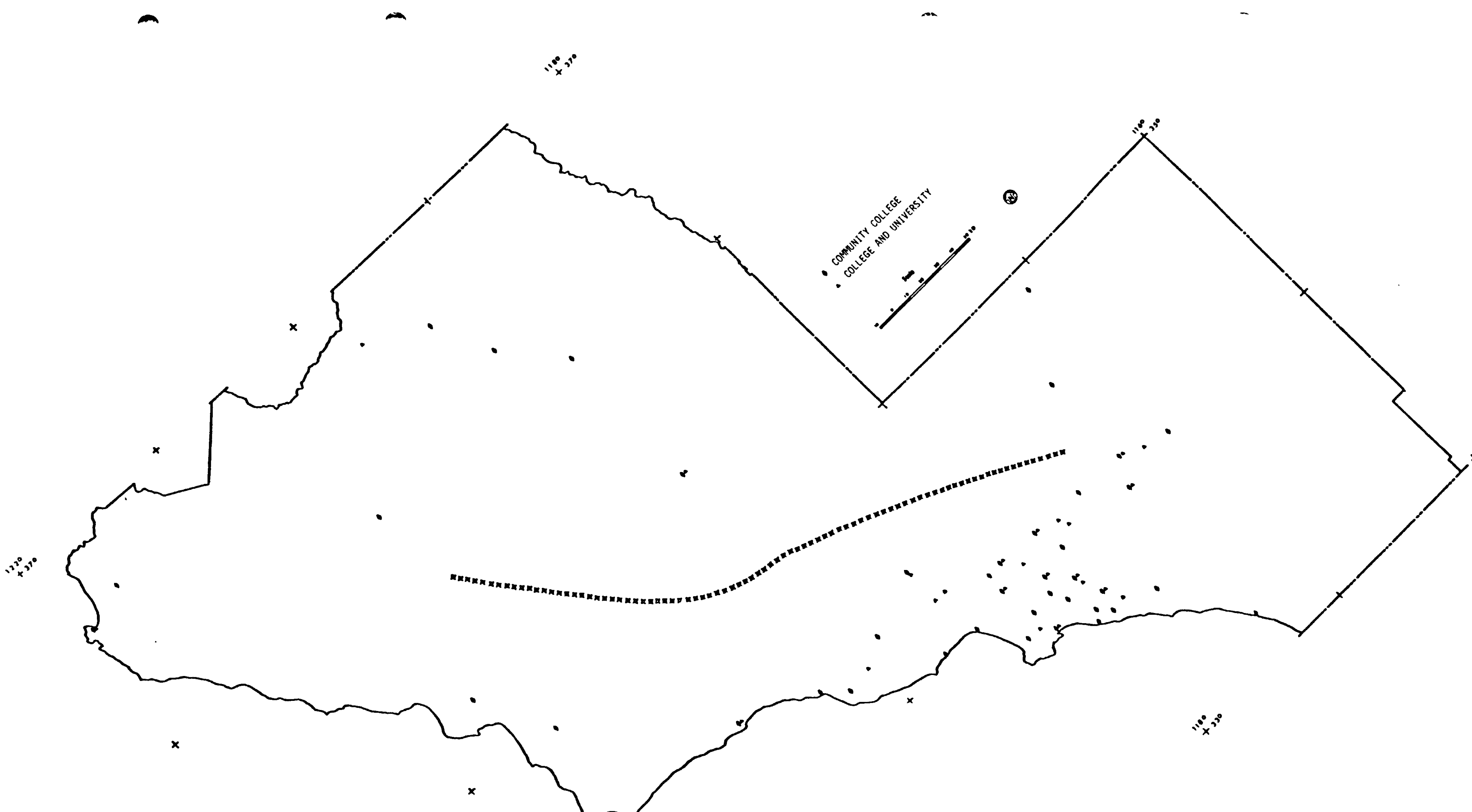
same county. Because the number of buildings in a school depends on the enrollment, those communities with a higher-than-average ratio of number of schools to population have fewer buildings per school than those with a lower ratio. Statistics on the distribution of schools were obtained from References 24 and 25.

The location of colleges and universities is presented in Figure 13. Buildings for these schools generally have short periods although some multistory buildings in the intermediate-period category can be found. The design and construction of these structures are governed in most cases by the *UBC* or by local codes. Consequently, in the absence of detailed analysis, they were assumed to have a motion-damage relationship similar to that of commercial buildings.

Hospital Buildings. As in the case of schools, current seismic design requirements for hospital facilities in California are higher than those for most other buildings. The legislation that specifies these requirements was enacted after the San Fernando earthquake of 1971. Prior to that time, the design of hospital buildings was governed by the *UBC* or by local building codes. Consequently, most of the hospital buildings in the area under investigation were designed under the less stringent requirements. The significance of this fact is discussed as a part of the analysis of EIS results.

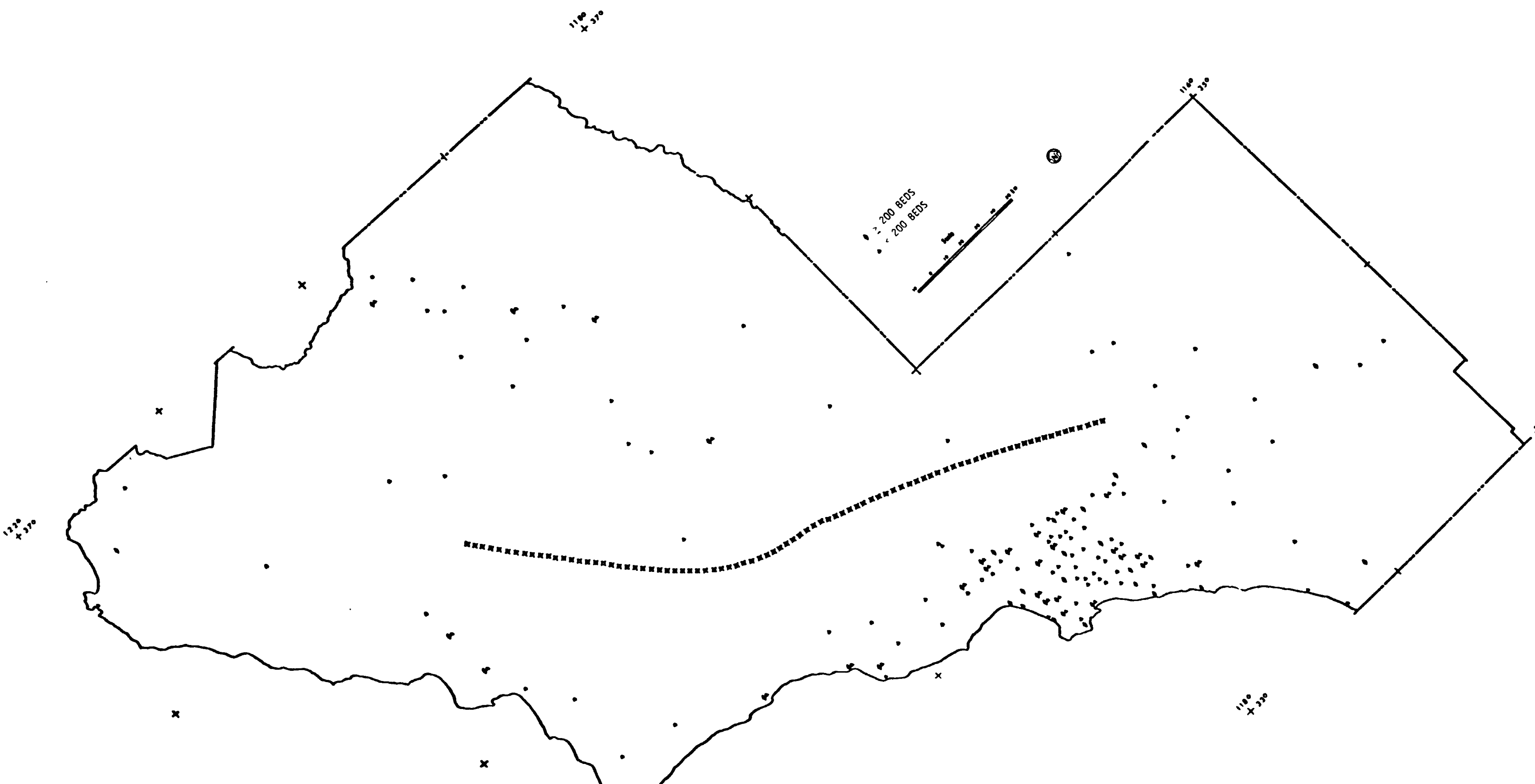
The location of hospitals in the affected area is presented in Figure 14. For purposes of this analysis, they were classified on the basis of capacity (number of beds). Information represented in the figure was obtained from the *Directory of Health Facilities*[26] for the State of California.

Data from a sample of several hospitals indicate that low-rise buildings are associated with facilities having a capacity of 200 beds or less while hospitals with more than 200 beds are likely to have both low-rise and multistory buildings. In terms of EIS classification, the former group are short-period buildings; the larger facilities contain buildings in both the short-period and intermediate-period EIS categories.



Note: Data taken from References 24 and 25.

FIGURE 13 COLLEGES AND UNIVERSITIES



Note: Data taken from Reference 26.

FIGURE 14 GENERAL HOSPITALS

Other Community Structures. Among structures essential to community functioning are those associated with emergency services (law enforcement and fire fighting) and lifeline systems (water, sanitation, energy, communication, and transportation). Structures in these categories are found in nearly every community in the study area. Their distribution is in almost all cases proportional to population. Because no more than an identification of such structures in the community is required for the present level of analysis, the information presented in this section is limited to sample data and a general discussion.

Table 11, which summarizes data from a sample of 23 communities in 10 counties of the study area, shows that in all of the communities in the sample but one there is at least one structure associated with law enforcement; every community has at least one fire station. The table also shows variation in the number of police and fire stations as a function of population.

Public utility systems affect all areas of human need. Their safe operation during an earthquake and the rapid recovery of their normal operation afterward is essential. In the study area, the seismic design of many of the structures associated with utility systems exceeds minimum requirements. Specific identification of these lifeline structures is beyond the scope of this study; however, it is noteworthy that failure (severe in localized areas) of some facilities was observed during the 1971 San Fernando earthquake.[14]

Hypothetical Community Characterizations. To illustrate the extent of damage that might be expected throughout the study area under various EI conditions, estimation of damage for several hypothetical communities was found to be useful. Postulation of such hypothetical communities was appropriate for this study because, as stated earlier, in the area vulnerable to damage from the postulated earthquake, the types of structures found in individual communities are, with the exception of a few special structures, common to communities in all parts of the study area. The number of structures of a particular type is generally found to correspond to the size of the community. The overall distribution of structures in the study area is also a function of population; while high-rise buildings do not occur in some small communities, the number of such structures in the larger communities

TABLE 11

NUMBER OF POLICE AND FIRE STATIONS FOR SAMPLE CITIES

County	City	1970 Population	Police		Fire	
			Stations	Personnel	Stations	Personnel
Fresno	Fowler	2,239	1	7	1	12
	Fresno	165,972	1*	388	10	262
	Selma	7,459	1*	17	2	20
Kern	Bakersfield	69,515	1*	200	8	3
	California City	1,945	1	8	1	18
	Delano	14,554	1*	30	1	14
Kings	Avenal	3,500	0**	5	1	20
	Hanford	15,179	1*	36	1***	22
Los Angeles	Long Beach	358,879	1	680	22	466
	Monterey Park	49,166	1	61	3	48
	Torrance	134,584	1	276	5	172
Orange	Anaheim	170,980	1	287	9	228
	Cypress	39,700	1	46	2	23
	Placentia	21,948	1	34	2	34
	Santa Ana	156,600	1*	240	10	246
San Bernardino	Ontario	64,118	1*	92	5	69
	San Bernardino	106,337	1*	254	10	173
	Upland	32,624	1	48	2	27
San Diego	Oceanside	40,494	1	96	5	71
San Luis Obispo	San Luis Obispo	32,250	1*	52	3	38
Santa Barbara	Lompoc	25,284	1*	29	1	12
Ventura	Conejo Valley	52,350	1****	67	4	66
	Ventura	57,900	1*	88	4	70

*Sheriff's Department is at another location in the city.
**Served by Sheriff's Department at Hanford.
***County Fire Department is at another location in the city.
****Sheriff's Department occupies same building.

appears to be proportional to population. Table 12 indicates various categories of buildings typically found in communities having populations ranging from 1,000 to 100,000. The number of structures in each category was estimated for the hypothetical communities. These data are presented in Table 13. Damage estimate scenarios for the hypothetical communities are presented in the next chapter.

Areawide Systems and Facilities

In the vulnerable area, there are several systems and facilities that encompass large areas and serve many communities. These facilities vary from simple one-story buildings to highly complex structures. Design and construction practice also varies with type of facility and governing agency. Failure of any one of these facilities can have serious impact on the communities in its service area.

Hydraulic Structures. Three major aqueducts supply water to southern California, mainly to Los Angeles and the surrounding communities.[19,27] As shown in Figure 15, the routes of these aqueducts sometimes run close to the San Andreas fault, in places actually crossing the fault. The California Aqueduct, in particular, parallels the entire length of rupture of the hypothetical earthquake and twice crosses the fault.

In the 14 counties under investigation, there are 300 dams within the jurisdiction of the State of California and the federal government.[28] Eleven of these dams were constructed with the use of hydraulic fill and in this respect are similar to the lower San Fernando Dam, which failed during the San Fernando earthquake of 1971. Table 14 summarizes the characteristics of these dams according to various classifications. The breakdown of state and federal dams by county is shown in Appendix E.

Energy Networks. Figure 16 shows the location of major gas transmission lines and related facilities for the study area.[29] Similar information for electric power generation and transmission facilities[30] appears in Figure 17. Data for petroleum-handling facilities[31] are presented in Figure 18.

TABLE 12
POPULATION AND COMMUNITY STRUCTURES

Type of Structure	Population				
	greater than 100,000	50,000 to 100,000	10,000 to 50,000	1,000 to 10,000	less than 1,000
Single-Family Dwellings	X	X	X	X	X
Mobile Homes	X	X	X	X	X
Multifamily Dwellings					
Low-Rise	X	X	X	X	X
Intermediate Height	X	X	X		
High-Rise	X				
Commercial Buildings					
Low-Rise*	X	X	X	X	X
Unreinforced Masonry	X	X	X	X	X
Intermediate Height	X	X	X		
High-Rise	X	X	X		
Industrial Buildings	X	X	X	X	
Public Buildings	X	X	X	X	X
Hospital Buildings	X	X	X		

*Also includes light industrial and precode unreinforced masonry buildings.

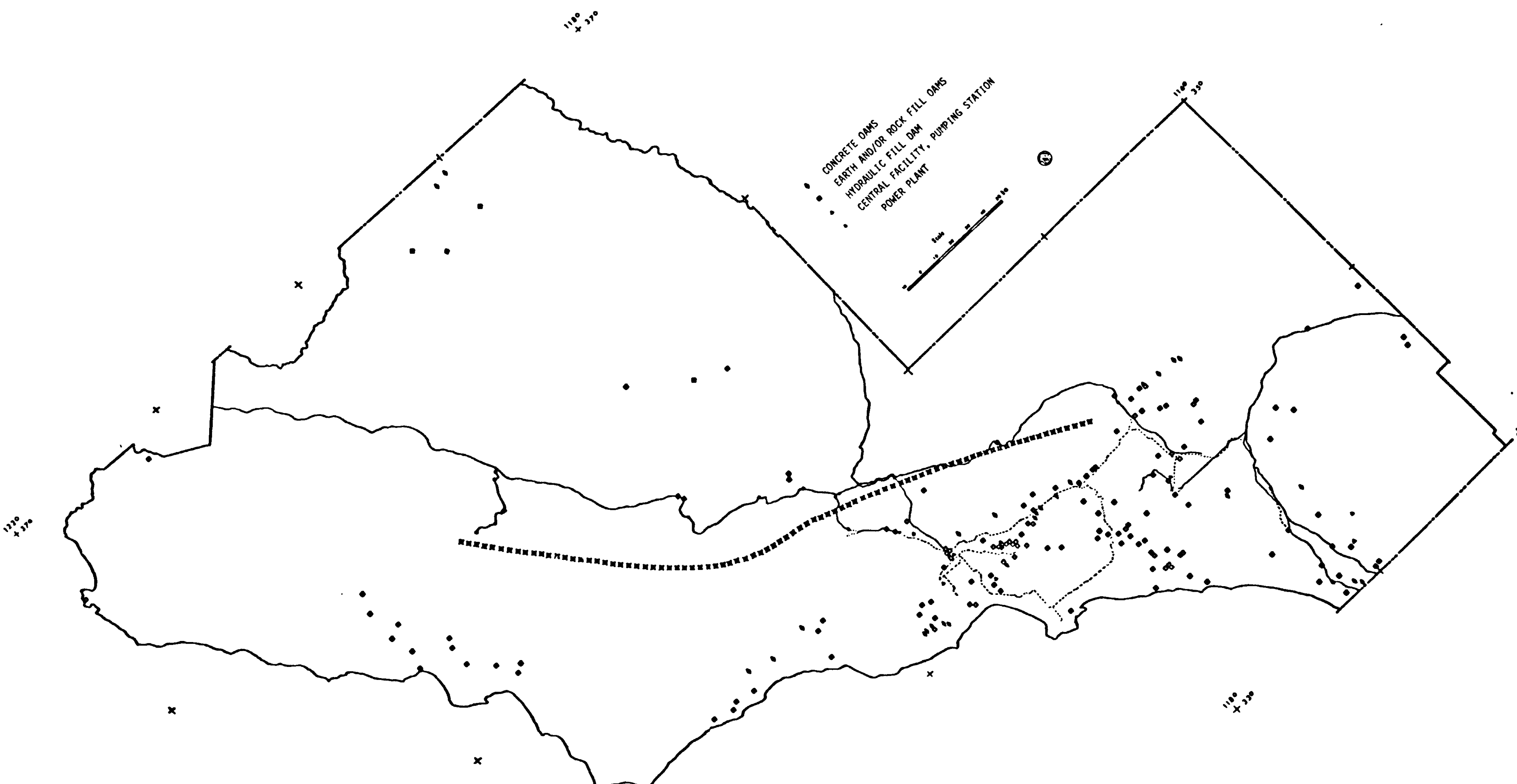
TABLE 13

STRUCTURE DISTRIBUTION FOR HYPOTHETICAL COMMUNITIES

Type of Structure	Population: 200,000		Population: 75,000		Population: 25,000		Population: 5,000	
	Units	Structures	Units	Structures	Units	Structures	Units	Structures
Single-Family Dwellings	50,000	50,000	20,000	20,000	7,000	7,000	1,400	1,400
Mobile Homes	2,000	2,000	800	800	300	300	50	50
Multifamily Dwellings								
Low-Rise	10,000	1,000	3,000	300	1,000	100	200	20
Intermediate Height	2,000	40	500	10	100	2	--	--
High-Rise	500	5	50	1	--	--	--	--
Commercial Buildings								
Typical Low-Rise*	--	2,000	--	750	--	250	--	50
Unreinforced Masonry	--	200	--	100	--	30	--	10
Intermediate Height	--	30	--	10	--	1	--	1
High-Rise	--	10	--	3	--	5	--	--
Public Buildings**	--	20	--	10	--	--	--	2
Hospital Buildings**	--	5	--	2	--	--	--	--

*Also includes light industrial buildings.

**Small communities sometimes share the facilities of adjacent communities.



Note: Data taken from References 19, 27, and 28.

FIGURE 15 DAMS AND MAJOR AQUEDUCT SYSTEMS AND FACILITIES

TABLE 14

CLASSIFICATION OF DAMS

a. CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION (14 COUNTIES)

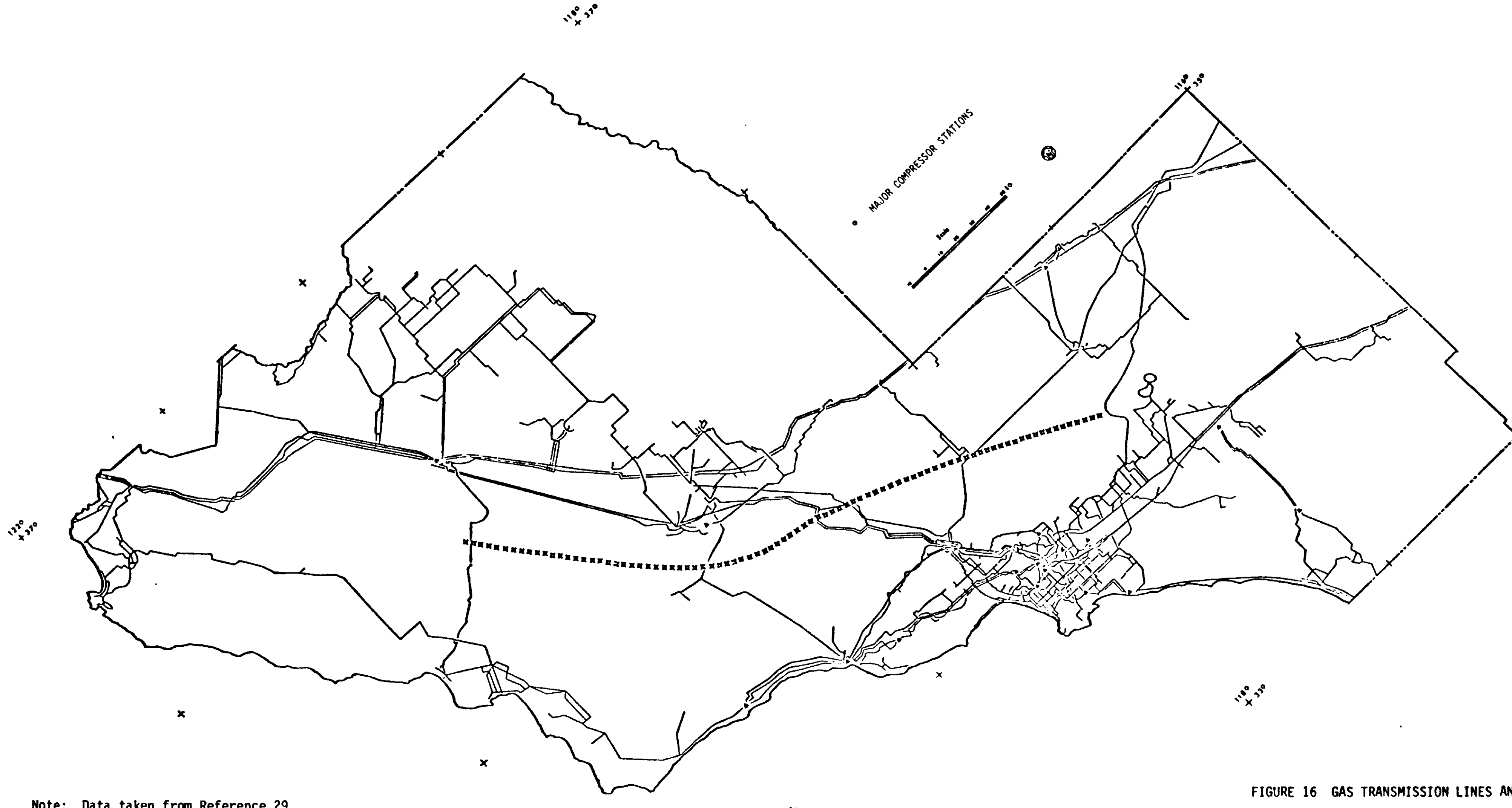
TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45 Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-6	6-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity	12	4	4	4	1	4	3	3	1		1		5		3	1			2
Constant Radius Arch	15	2	11	2	5	5	4	1			1	2	2	2	1				1
Variable Radius Arch	11	2	4	5	1	3	4	3			3	1	4	2	1				
Multiple Arch	6		4	2		1	2	3			2		2	2					
Earth	177	81	73	23	43	83	31	13	7		2	7	44	31	36	17	18	9	13
Earth and Rock	7	1	4	2	3	1	2	1					4	1	1			1	
Rock Fill	8	3		5	2	1		1	4				1		2		3	2	
Hydraulic Fill	11	1	8	2	1	3	4	2	1						5	3	3		
Flashboard & Buttress	9	9			4	4	1				2	2	1	1					3
Slab & Buttress	1	1			1							1							
Crib																			
Reinforced Conc Tank	10	8	1	1	9	1					4	2							4
TOTALS	267	112	109	46	70	106	51	27	13		21	15	63	39	49	21	24	12	23
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

b. CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION (14 COUNTIES)

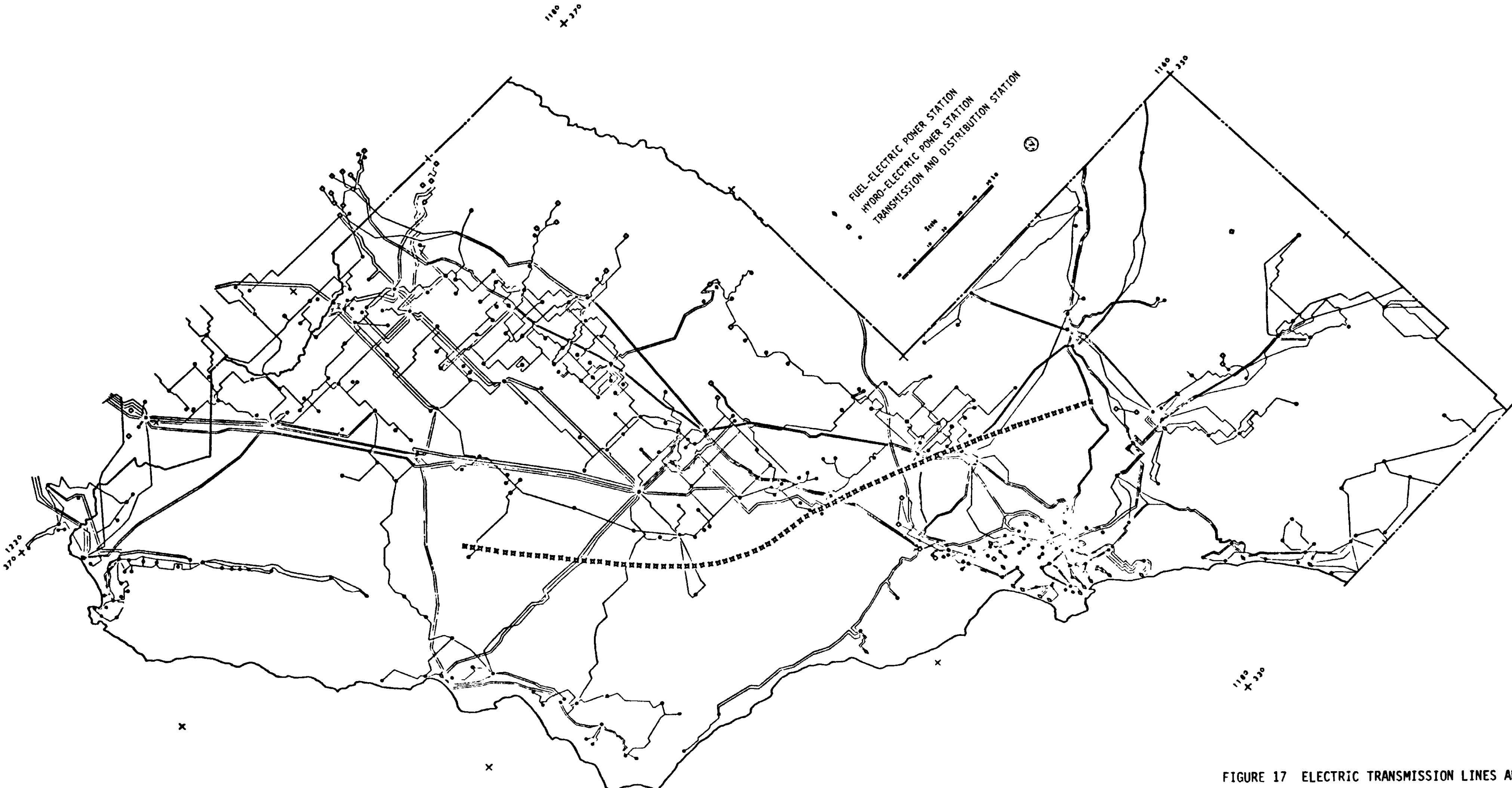
TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-6	6-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity	2			2					2								2		
Constant Radius Arch	1		1			1						1							
Variable Radius Arch	2		1	1				1	1					1			1		
Multiple Arch	1		1				1												1
Earth	23	7	12	5	2	4	8	3	5	1			1		5	3	6	8	
Earth and Rock	4	2		2	1				2	1			1					2	
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	33	9	15	10	3	5	9	4	10	2		1	2	1	5	3	9	10	1
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified



Note: Data taken from Reference 29.

FIGURE 16 GAS TRANSMISSION LINES AND RELATED FACILITIES



Note: Data taken from Reference 30.

FIGURE 17 ELECTRIC TRANSMISSION LINES AND RELATED FACILITIES

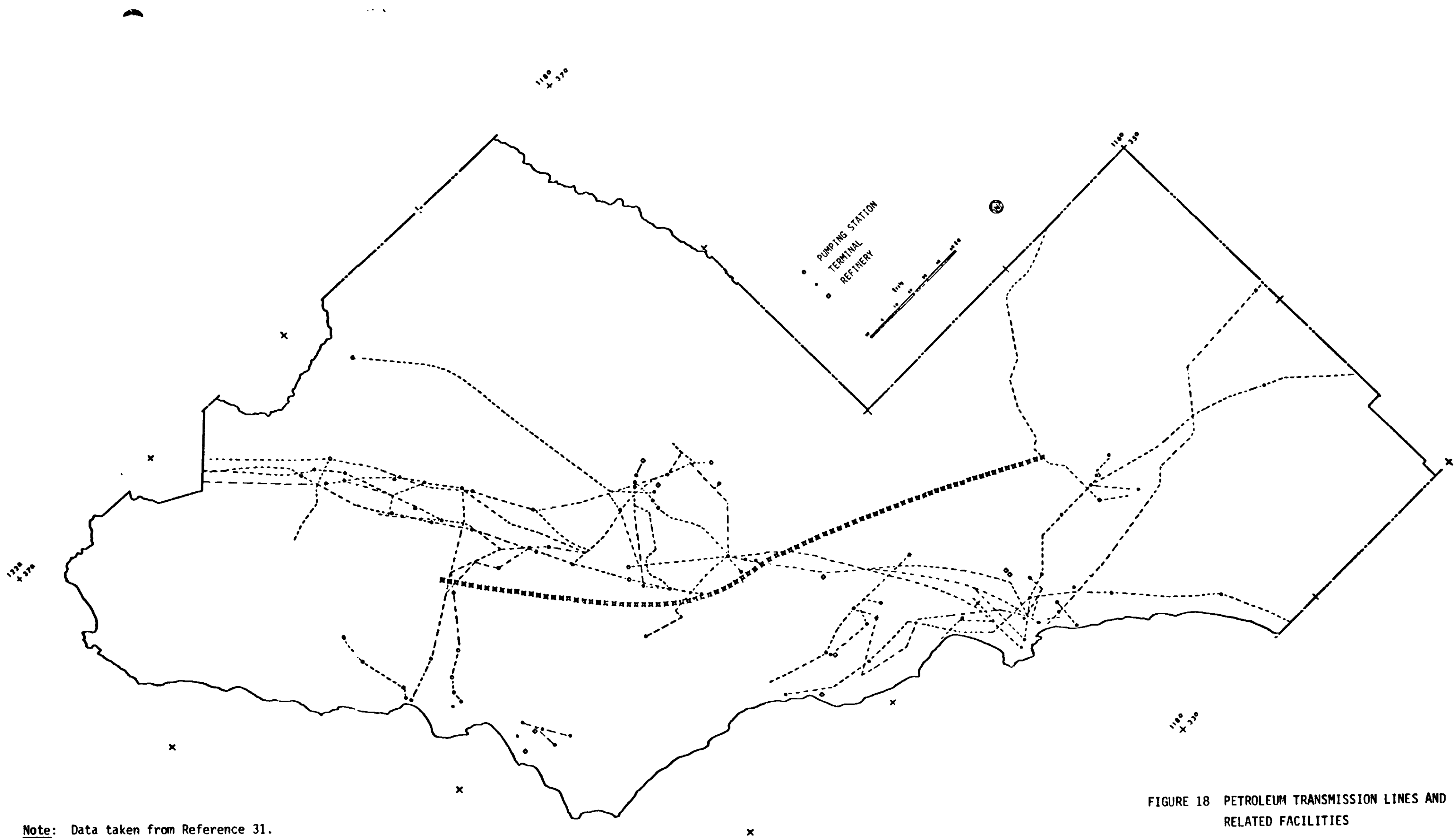


FIGURE 18 PETROLEUM TRANSMISSION LINES AND RELATED FACILITIES

Note: Data taken from Reference 31.

Transportation Systems. In general, transportation systems of concern to studies predicting earthquake effects are highways, railroads, airports, harbors, and mass transit lines. For the present investigation, highways, railroads, and airports are identified. Because all of the harbors and their related facilities in the study area are located some distance from the source of the earthquake under consideration, and effects are expected to be minimal, no further identification was necessary for this study. There are no mass rail transit lines in the study area. Mass public transportation is by means of busses; damage from the postulated earthquake would, for the most part, result from secondary effects of the failure of roads and bridges. The transportation structures most severely affected during the 1971 San Fernando earthquake were highway overcrossings. These structures are therefore treated more extensively here than are other structures associated with transportation systems.

Since the 1971 San Fernando earthquake, the design and details for new highway structures have been modified considerably, and some of the structures that existed in 1971 have been strengthened. Information on highways and highway overcrossings was obtained from the *Log of Bridges of State Highways*[32] of the California Division of Highways (CALTRANS). That document provides location, description, structure type, vertical clearance, length, and other pertinent information for all of the highway overcrossings in California. Table 15 summarizes data on the California road system for the entire state.

It is reported[33] that there is, on the average, one bridge for every mile of highway in the state highway system (including both interstate and primary routes); one bridge for every five miles of secondary routes; and one bridge for every 17 miles of other roads and streets. Unlike the determination of period for buildings designed under *UBC* requirements, there is no simple way to approximate the period of highway bridges. Their vibration characteristics depend on the size of the structure as well as on the structure system and materials employed. Because it is neither possible nor necessary to evaluate every bridge in the study area for determination of period, the length of the overcrossing was used as the criterion for EIS-band classification. On the basis of CALTRANS design examples[34] and experience of the San Fernando earthquake of 1971,[35] it was determined that most freeway

TABLE 15

CALIFORNIA ROAD SYSTEMS[32]*

System	Miles	Bridges	Miles per Bridge
State Highway Routes			
Interstate and Primary	13,000	13,000	1
Secondary Routes			
Rural and Urban	22,000	4,000	5.5
All Other Roads and Streets			
Rural and Urban	137,000	8,000	17
Total	172,000	25,000	

*Data shown are for the entire state.

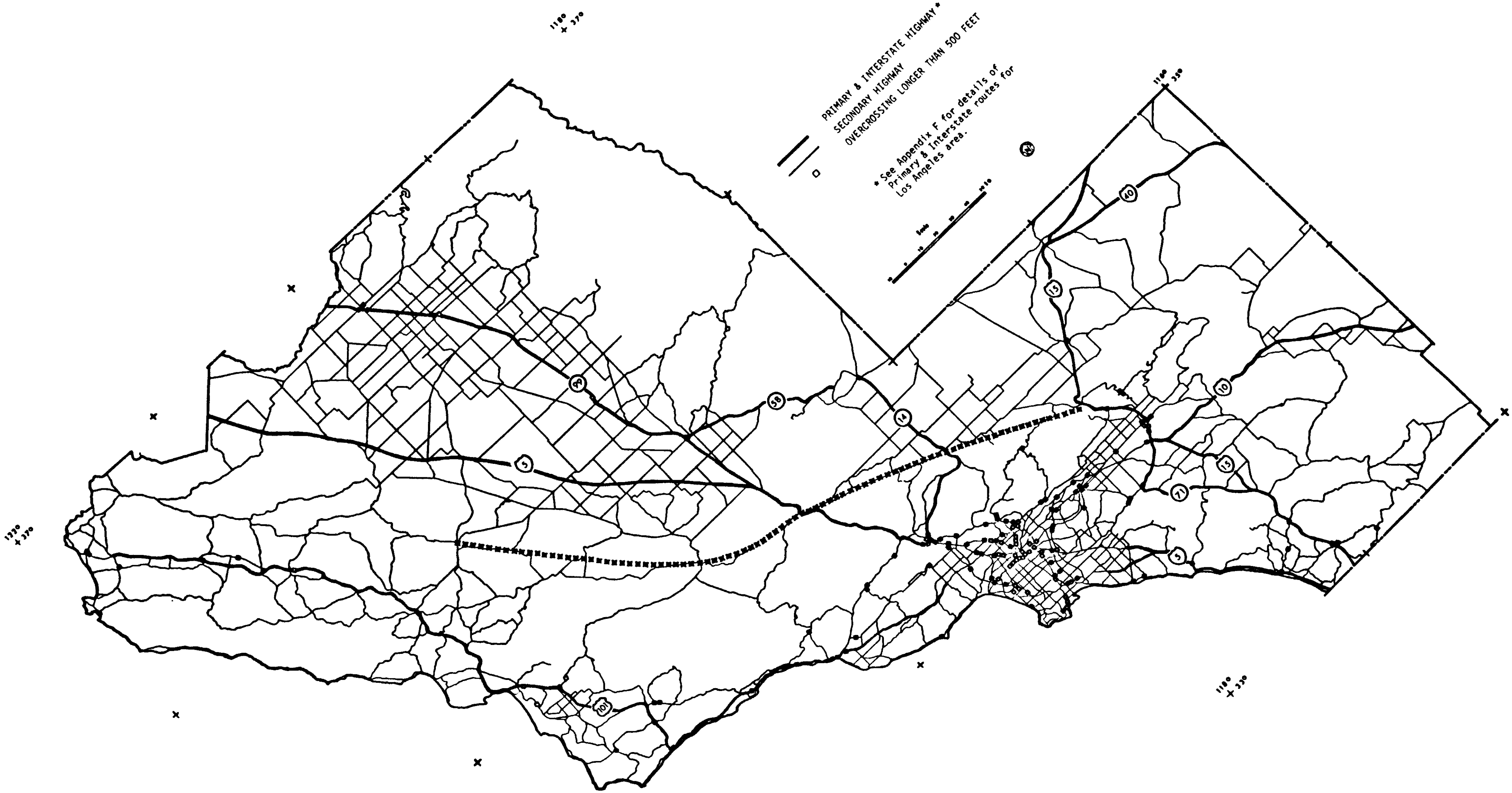
bridges are in the intermediate-period EIS range. Some bridges are stiffer and are included in the short-period EIS range; those that are more flexible than most come under the long-period EIS classification. Figure 19 shows the location of overcrossings in the study area that are 500 ft or more in length. These bridges are classified as intermediate- or long-period structures. Bridges in the short-period range can be found at many locations along all highways.

Information on railroads is presented in Figure 20, which shows railroad lines[36] in the area investigated in this study, and in Appendix F, which provides details of these and other structures for the Los Angeles area.[27]

The terminal (airport) is the most important part of an air transportation system. Within airports, the structures associated with air traffic control are the most vital. Figure 21 shows the location of airports in the study area. There are 108 public-use airports as well as many heliports and a limited number of private-use airports.[37] In addition, several military and other federal airports are found in the area under investigation.

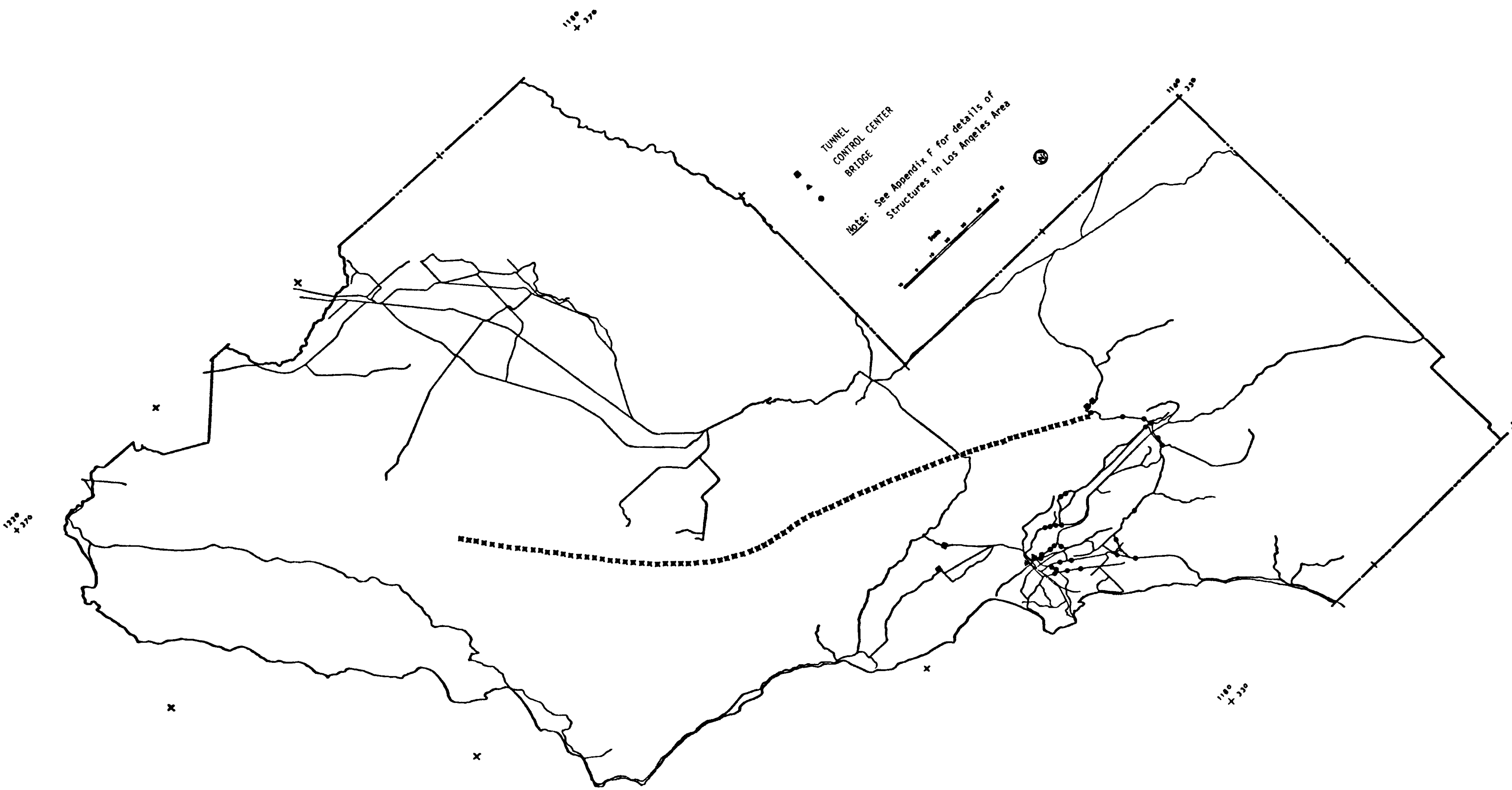
Period-Band Classification of Structures

For the purpose of damage estimation, structures in the study area were categorized into three EIS period groups. Although it was not possible to categorize some structures without additional information, structures associated with major facilities were assumed to be represented in all three period ranges. Most structures presented no difficulty for classification. For example, single-family dwellings and other low-rise buildings are in the short-period range, and most high-rise buildings correspond to the intermediate-period range although some very tall or very flexible buildings may be classified as long-period structures. Table 16 summarizes the categorization of structures in the study area according to EIS bands.



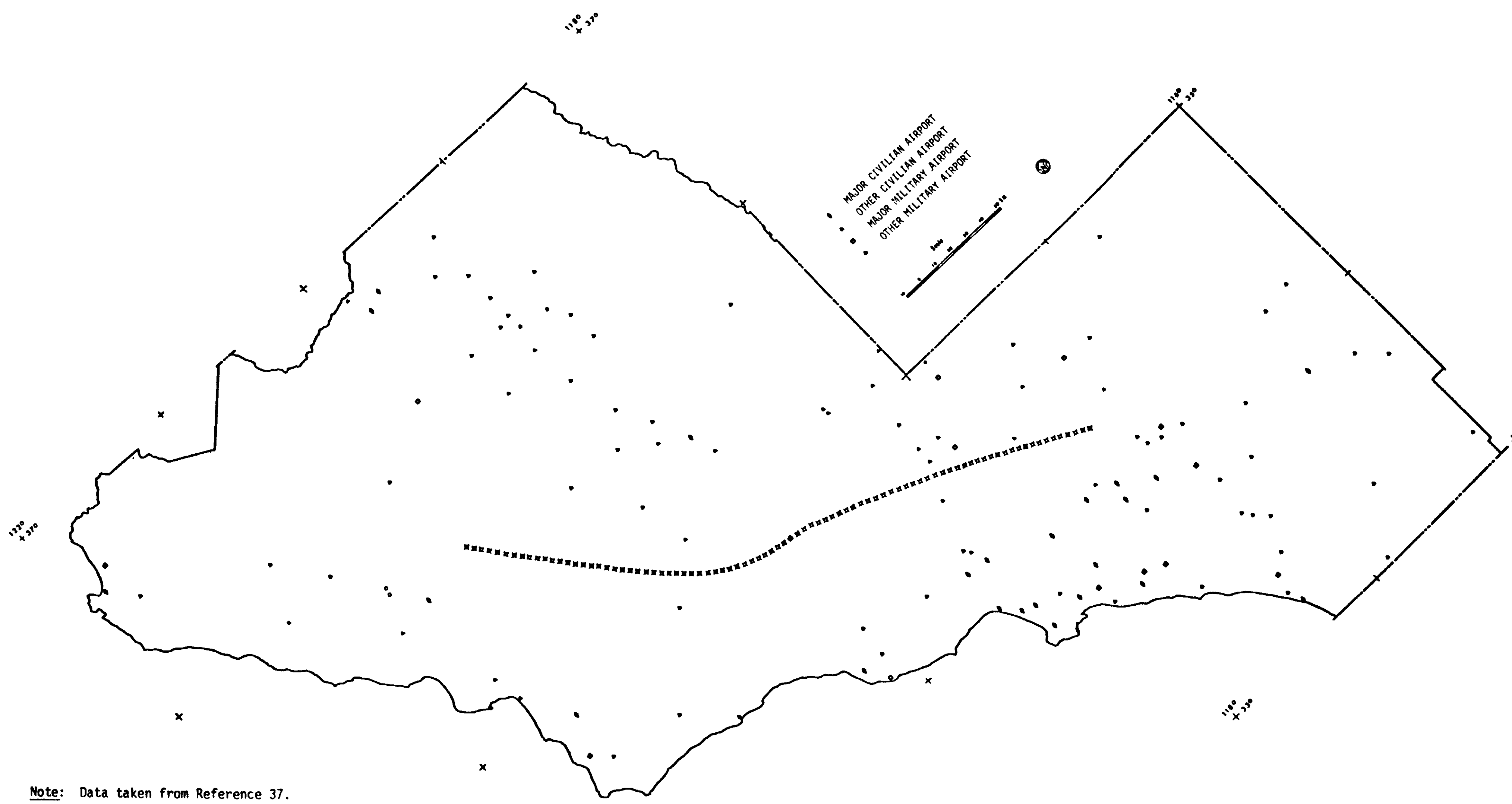
Note: Data taken from Reference 32.

FIGURE 19 HIGHWAYS AND HIGHWAY OVERCROSSINGS



Note. Data taken from References 27 and 36.

FIGURE 20 RAILROAD LINES



Note: Data taken from Reference 37.

FIGURE 21 AIRPORT TERMINALS

TABLE 16

CATEGORIZATION OF STRUCTURES INTO EIS BANDS

Type of Structure	EIS Band		
	I, II, III (0.01-0.4 sec)	IV, V, VI (0.4-2.0 sec)	VII, VIII, IX (2.0-10.0 sec)
Single-Family Dwellings	X		
Mobile Homes	X		
Multifamily Dwellings			
Low-Rise	X		
Intermediate Height	X	X	
High-Rise		X	
Commercial Buildings			
Low-Rise*	X		
Unreinforced Masonry	X		
Intermediate Height	X	X	
High-Rise		X	X
Public Buildings	X	X	
Hospital Buildings	X	X	
Aqueduct Systems and Facilities	X	X	X
Highway Overcrossings	X	X	X
Railway Bridges	X	X	X
Airport Structures	X	X	
Utility Structures	X	X	X

*Also includes light industrial and precode unreinforced masonry buildings.

DAMAGE ESTIMATION

Damage estimations for various types of structures follow directly from combining the structure inventory data provided in the preceding chapter with the EI-damage relationship information presented earlier. This chapter presents damage estimates for the various structure categories identified in the preceding chapter. Where possible, damage estimates are made quantitatively in terms of expected dollar loss. For structures for which no information on motion-damage relationships currently exists, qualitative descriptions of damage are provided.

Community Buildings

To estimate damage on a community basis, it is first necessary to determine the types of structures in the community and the number of structures of each type. Because damage potential differs among buildings of various types, each group must be estimated separately. The nature of this study does not warrant a specific damage prediction for each study area community; therefore, no detailed structure inventories of communities were conducted. To facilitate damage estimation for community buildings in the study area, damage factors for a hypothetical community subjected to various EI ratings were calculated. The following sections give: the EI ratings for each of the study area communities, a description of how the mean damage cost factors for the hypothetical communities were calculated, and a discussion regarding application of the damage factors for the hypothetical communities to specific communities.

EIs for Study Area Communities. The EI distribution in the study area for the short-period, intermediate-period, and long-period ranges was presented earlier (Figures 4, 5, and 6). The highest EI in the study area for any range of period bands was 7,8,8, for the short-period band. However, because the occurrence of the EI 7 value is limited to a few isolated, sparsely populated locations near the fault, the next highest value, 6, becomes the significant figure for estimation of damage to structures in the short-period band.

A complete list of study area cities and their EI ratings is presented in Appendix G. EI distribution for cities with population greater than 50,000 is shown in Table 17. In both cases, information reported is for the center of cities. Note that in some cases cities that are approximately the same distance from the fault have somewhat different EI ratings. These differences show the effect of site-specific geologic conditions.

Palmdale, a community of more than 10,000[23] inhabitants that is very near the fault, showed the highest EI values of any city in the study area, with a three-digit rating of 6,7,7. Among cities with a population of more than 100,000,[23] San Bernardino showed the highest values, with a rating of 5,6,6. Most of the communities in the Los Angeles area -- the most densely populated portion of the area under investigation -- are estimated to have an EI distribution of 4,5,5.

Damage Factors for a Hypothetical Community. Of the hypothetical communities identified in the previous chapter, mean damage cost factors were calculated for the community having a population of 75,000 persons. That community size was selected because it is to some extent directly applicable to several communities in the study area. The community was then analyzed for three different patterns of EI distribution: one of the highest patterns found in the study area (6,7,7); that of the most densely populated portion of the study area (4,5,5); and an intermediate pattern (5,6,6).

To obtain the damage cost factor for the hypothetical community, a replacement value was assigned to each type of building postulated for the community. Assuming a three-digit EI of 6,7,7 to be experienced by the community, the mean damage cost factors corresponding to that EI rating were determined (from Figures 8 through 11), as shown in Table 18. By multiplying the mean damage cost factor by the replacement value of each structure type, the damage cost of each structure type was calculated. For EI 6,7,7, the average damage cost factor was determined to be 9% of the total replacement value. The same procedure was applied to evaluate the effect of EI levels of 5,6,6 and 4,5,5. It was found that the average damage cost factors were 2% and 0.3%, respectively, for these two EI ratings, as shown in Tables 19 and 20.

TABLE 17

EI FOR CITIES WITH POPULATION GREATER THAN 50,000

City	County	1970 Census Population	3-Digit EI
Fresno	Fresno	165,972	3,4,4
Bakersfield	Kern	69,575	4,5,5
Alhambra	Los Angeles	62,125	4,5,5
Bellflower	"	51,454	3,5,5
Burbank	"	88,871	4,5,5
Carson	"	71,150	4,5,5
Compton	"	78,611	4,5,5
Downey	"	88,445	4,5,5
East Los Angeles (u)	"	105,033	4,5,5
El Monte	"	69,837	4,5,5
Glendale	"	132,752	4,5,5
Hawthorne	"	53,304	3,5,5
Inglewood	"	89,985	3,5,5
Lakewood	"	82,985	3,5,5
Long Beach	"	358,633	3,5,4
Los Angeles	"	2,816,061	4,5,5
Norwalk	"	91,827	4,5,5
Pasadena	"	113,327	4,5,5
Pico Rivera	"	54,170	4,5,5
Redondo Beach	"	56,075	3,5,4
Santa Monica	"	88,289	3,5,4
South Gate	"	56,909	4,5,5
Torrance	"	134,584	3,5,4
West Covina	"	68,034	4,5,5
Whittier	"	71,863	4,5,5
Salinas	Monterey	58,896	2,3,3
Anaheim	Orange	166,701	4,5,5
Buena Park	"	63,646	4,5,5
Costa Mesa	"	72,660	3,5,4
Fullerton	"	85,826	4,5,5
Garden Grove	"	122,524	3,5,5
Huntington Beach	"	115,960	3,5,4
Orange	"	77,374	4,5,5
Santa Ana	"	156,601	3,5,5
Westminster	"	59,865	3,5,5
Riverside	Riverside	140,089	4,5,5
Ontario	San Bernardino	64,118	4,6,6
San Bernardino	"	104,251	5,6,6
Santa Barbara	Santa Barbara	70,215	4,5,5
Oxnard	Ventura	71,225	3,5,4
Simi Valley	"	56,464	4,5,5
Ventura	"	55,797	4,5,5

(u) = unincorporated city.

TABLE 18

DAMAGE ESTIMATION FOR A HYPOTHETICAL

COMMUNITY IN THREE-DIGIT EI 6,7,7 AREA

(Population: 75,000)

Type of Structure	Period Band	EI	m_{DF}	Replacement Value*	Damage Cost*
Single-Family Dwellings	I, II, III	6	0.09	960	86.4
Mobile Homes	I, II, III	6	0.045	20	0.9
Multifamily Dwellings					
Low-Rise	I, II, III	6	0.09	90	8.1
Intermediate Height	I, II, III	6	0.09	10	0.9
Intermediate Height / High-Rise	IV, V, VI	7	0.065	10	0.7
High-Rise	VII, VIII, IX	7	0.002	3	<0.1
Commercial Buildings**					
Typical Low-Rise	I, II, III	6	0.09	150	13.5
Unreinforced Masonry	I, II, III	6	0.5	20	10.0
Intermediate Height	I, II, III	6	0.09	25	2.3
Intermediate Height / High-Rise	IV, V, VI	7	0.065	50	3.3
High-Rise	VII, VIII, IX	7	0.002	20	<0.1
			Total	1,358	126.1

Damage Cost Factor for the Community = 0.09

$$\text{Loss per Capita} = \frac{\$126,100,000}{75,000} = \$1,680$$

*In millions of 1977 dollars.

**Includes light industrial, public, and emergency buildings.

TABLE 19

DAMAGE ESTIMATION FOR A HYPOTHETICAL COMMUNITY IN THREE-DIGIT EI 5,6,6, AREA

(Population: 75,000)

Type of Structure	Period Band	EI	m_{DF}	Replacement Value*	Damage Cost*
Single-Family Dwellings	I, II, III	5	0.016	960	15.4
Mobile Homes	I, II, III	5	0.025	20	0.5
Multifamily Dwellings					
Low-Rise	I, II, III	5	0.016	90	1.4
Intermediate Height	I, II, III	5	0.016	10	0.2
Intermediate Height / High-Rise	IV, V, VI	6	0.013	10	0.1
High-Rise	VII, VIII, IX	6	0.0005	3	<0.1
Commercial Buildings**					
Typical Low-Rise	I, II, III	5	0.016	150	2.4
Unreinforced Masonry	I, II, III	5	0.09	20	1.8
Intermediate Height	I, II, III	5	0.016	25	0.4
Intermediate Height / High-Rise	IV, V, VI	6	0.013	50	0.7
High-Rise	VII, VIII, IX	6	0.0005	20	<0.1
			Total	1,358	22.9

Damage Cost Factor for the Community = 0.02

$$\text{Loss per Capita} = \frac{\$22,900,000}{75,000} = \$305$$

*In millions of 1977 dollars.

**Includes light industrial, public, and emergency buildings.

TABLE 20

DAMAGE ESTIMATION FOR A HYPOTHETICAL COMMUNITY IN THREE-DIGIT EI 4,5,5 AREA

(Population: 75,000)

Type of Structure	Period Band	EI	m_{DF}	Replacement Value*	Damage Cost*
Single-Family Dwellings	I, II, III	4	0.0025	960	2.40
Mobile Homes	I, II, III	4	0.012	20	0.24
Multifamily Dwellings					
Low-Rise	I, II, III	4	0.0025	90	0.23
Intermediate Height	I, II, III	4	0.0025	10	0.03
Intermediate Height / High-Rise	IV, V, VI	5	0.0018	10	0.02
High-Rise	VII, VIII, IX	5	0.0001	3	<0.01
Commercial Buildings**					
Typical Low-Rise	I, II, III	4	0.0025	150	0.38
Unreinforced Masonry	I, II, III	4	0.011	20	0.22
Intermediate Height	I, II, III	4	0.0025	25	0.06
Intermediate Height / High-Rise	IV, V, VI	5	0.0018	50	0.09
High-Rise	VII, VIII, IX	5	0.0001	20	<0.01
			Total	1,358	4.12

Damage Cost Factor for the Community = 0.003

$$\text{Loss per Capita} = \frac{\$4,120,000}{75,000} = \$55$$

*In millions of 1977 dollars.

**Includes light industrial, public, and emergency buildings.

Estimating Damage for Study Area. The damage cost factor for a community depends on the specific distribution of structures in the community. Comparison of the structure distribution and EI rating for a particular community with similar data obtained for a hypothetical community (Tables 18, 19, and 20) affords a simple approximation of the damage cost factor that might be expected to result for the community. For example, a rough estimate for a community with a population of 150,000 in a three-digit EI of 4,5,5 can be obtained by multiplying the total damage cost in Table 20 (which is an example for population of 75,000) by 2. For a population of 25,000, the estimate would be one-third of that figure.

More rigorously, damage for a specific community can be estimated by completing a table similar to Table 18, 19, or 20 for an overall mean damage calculation. To do this, the distribution of structures and the replacement values of these structures are first obtained. The EI levels for the three period ranges are then determined from Figures 4, 5, and 6. Using these EIs, mean damage factors for the various types of structures can be determined from Figures 9, 10, and 11. The damage cost factor can then be determined by multiplying the replacement values by the respective mean damage cost factors.

Other Community Structures

As discussed previously, structures associated with the general welfare are in many cases subject to seismic design and construction criteria more stringent than those for typical buildings and are therefore expected to be able to withstand higher forces than can be resisted by typical buildings. Procedures for estimating damage cost factors for these structures are discussed in the paragraphs that follow.

Hospitals and Schools. The hospital code enacted in 1974 requires that the seismic coefficients for hospital facilities be about 2.5 times those required under the provisions of the *UBC*. Although seismic design coefficients for schools are essentially the same as for typical buildings, the rigorous material and construction requirements for schools should produce structures with higher seismic resistance. Incorporating this assumption into the procedure for estimation of damage that was discussed previously, m_{DF} for these buildings is estimated to be somewhat lower than that for typical buildings.

In the short-period band, m_{DF} at the EI 6 level is 9% for typical buildings: for the buildings considered here, the value is slightly higher than 1%. Similarly, in the intermediate-period band, m_{DF} for these buildings is 5% at an EI level of 8 but is 28% for typical buildings. Facilities affected can be determined by superimposing Figures 4, 5, and 6 onto Figures 13 and 14.

It should be kept in mind that the foregoing discussion is based on data for buildings that have been designed or strengthened to meet current criteria. Most of the hospital buildings in the study area were designed and constructed prior to the enactment of the 1974 legislation; treating these structures as typical buildings therefore produces a more accurate estimate of damage.

An extensive review of hospital facilities is currently being conducted by the California Department of Health to identify the structures under the department's jurisdiction that need to be strengthened in order to conform to present seismic design criteria. A similar California Department of Education program, reviewing school facilities to bring them up to the provisions of the Field Act of 1933,[17] has been in progress for many years. Between 1968 and 1976, the number of school buildings that did not meet the requirements of the Field Act was reduced from 2,032 to 19 for the entire state.[38]

Community Lifelines. Structures associated with lifeline networks include transportation, communication, energy, water, and sewage systems, which affect the needs of any community. During the San Fernando earthquake of 1971, most lifeline systems and facilities were damaged to some degree.[14] Some of the damage included overpasses, electric power converter stations, filtration plants, and underground utilities. Most of these facilities were located in the high-ground-motion area. Damage to underground systems in particular was associated with ground failure.

Areawide systems and facilities associated with lifeline networks are discussed in the section that follows. The failure of these systems and facilities would have a serious effect on communities. It is therefore necessary to consider these major systems and facilities in the evaluation of community lifelines.

Areawide Systems and Facilities

Areawide systems or facilities for which special seismic design requirements are implemented include those of the California Department of Transportation for highway overcrossings; the California Department of Water Resources for State Water Project facilities; and the Nuclear Regulatory Commission for nuclear power plant facilities. The following is a discussion of the damage potential for buildings associated with some of these facilities.

Hydraulic Systems. As discussed earlier, the buildings associated with State Water Project facilities were designed and constructed with consideration for the areawide importance of the system and for the location of the facilities relative to the San Andreas fault. For structures that have a fundamental period less than 0.15 sec and are within 19 km of the fault, a maximum uniform horizontal acceleration of 0.5g was considered in the design. For structures with a fundamental period greater than 0.15 sec, a response spectrum as shown in Figure 7 was used. For points farther than 19 km from the fault, ground motion was considered to be attenuated with distance. Within 19 km of the fault, the short-period EI resulting from the earthquake under consideration is 6. There are several facilities within this area. The mean damage cost factor for these structures is estimated to be 0.15% of replacement cost. (To determine affected facilities, superimpose Figures 4, 5, and 6 on Figure 15.) Although earthquake damage cost is one consideration, secondary effects from the disruption of water distribution could also be a major problem. The aqueduct routes parallel almost the entire fault and actually cross the fault at several locations. The operations plan for State Water Project facilities[19] provides for response to emergencies (e.g., a rupture of the canal) by stopping the flow downstream from the failure and reducing the flow upstream to an amount equal to that delivered to water consumers upstream from the failure. This is accomplished through a system of check structures located at strategic points along the aqueduct. The emergency plan calls for rapidly reacting to any adverse operating condition through the aqueduct control facilities and immediately adjusting the check structures and pumping plants.

There are 300 dams in the affected area (see Table 11 and Appendix E). Several of these dams are in the potentially damaging EI area. In the present evaluation, the greatest concern is for hydraulic fill dams similar to the one that failed during the San Fernando earthquake of 1971. Because of the complexity of their behavior under seismic loading, a thorough review of these dams should be made, particularly for those estimated to have high EI levels.

Utility Systems. As is the case for the California Aqueduct system, gas, electric, and petroleum transmission lines and facilities cross or are close to the fault and are expected to have very high EI levels. To estimate damage, an assessment of individual buildings with respect to design and construction criteria must be made. (To determine the affected facilities, superimpose Figures 4, 5, and 6 onto the maps of the respective facilities found in Figures 17, 18, and 19.) For a facility designed and constructed under high requirements, the estimated damage would be lower than if it had been built under less stringent requirements. For example, with an EI of 6 in the short period, the m_{DF} of structures built under 2.5 times the *UBC* requirements is 1.3% but is 9% for structures built under the *UBC* (Figure 9).

Transportation Systems. Transportation systems have been affected by earthquakes in the past. The effect of the hypothetical earthquake is estimated to be similar to the effects of the Kern County earthquake of 1952[13] and the San Fernando earthquake of 1971.[35] Both earthquakes occurred within the area of this study.

The effect on railroad lines was most severe during the Kern County earthquake at points where the right-of-way crossed the fault.[13] A major rerouting of the system was undertaken after the earthquake. Damage due to ground motion was relatively low in comparison to damage from fault displacement. The damage due to ground motion from the hypothetical earthquake is likewise expected to be low compared to that caused by fault movement.

The highway system is in some respects similar to the railroad system, with freeways crossing the fault break. One of the area's primary highways parallels the fault for half of its length until it actually crosses the fault. There are two other primary routes and numerous secondary routes that cross or are very close to the fault. Effects are also similar: damage at freeway overcrossings, landslides blocking traffic in the mountainous regions, and settlement occurring at bridge approaches. During the San Fernando earthquake, major damage to highways was observed at freeway overcrossings. The areas most severely affected by that earthquake were those represented by an EI report of 6,7,6. Some damage was also observed farther away from the fault, in the area with an EI report of 5,6,6. Damage from ground motion ranged from total collapse of the superstructure of the overcrossing to minor damage at abutments. There are numerous overcrossings in the high range of EI levels that result from the hypothetical earthquake. (To determine the affected area, superimpose Figures 4, 5, and 6 onto Figure 19.)

Subsequent to the San Fernando earthquake, major modification of existing structures and of the design requirements for new structures was made. The State of California is presently performing a major retrofitting of highway structures for increased seismic resistance.[39] In addition, recent highway overcrossings have been designed with consideration for their location relative to the various earthquake faults in the state and for local geologic conditions.[34,40]

Comparison with San Fernando Experience

The total estimated loss from the San Fernando earthquake of 1971 for buildings and other structures is reported[14] to be $511 million, as shown in Table 21a. Economic loss for privately owned property in the city of Los Angeles was estimated to be $203.8 million. The breakdown of these figures by type of structure and degree of damage is shown in Table 21b. Estimated dollar losses for other cities are shown in Table 22. Data for several cities in the Greater Los Angeles area extrapolated from EI distribution figures determined for the San Fernando earthquake[12] are presented in Table 23, which also shows EI values for the hypothetical earthquake under consideration. Note that the range of EI values for most cities is the same for both earthquakes. Exceptions in which the San Fernando earthquake showed higher values are the city of San Fernando, which had higher values in all three period bands; Burbank, Glendale, and Vernon, which had higher values in the intermediate-period bands; and Santa Monica, with a higher value in the long-period band. The only instance of a city showing a higher EI value from the hypothetical earthquake is Compton, where the higher value appears in the

TABLE 21a

SUMMARY OF EARTHQUAKE LOSS[14]

(San Fernando Earthquake, 1971)

Economic Sector	Dollar Loss
Private Sector	
Buildings, excluding land and contents:	
Los Angeles City	$154,000,000
San Fernando City	36,000,000
Elsewhere	15,000,000
Nonbuilding structures, excluding land	35,000,000
Public Sector	
Los Angeles City	180,000,000
San Fernando City	34,000,000
Los Angeles unincorporated	13,000,000
Other cities	24,000,000
Porter Ranch (aftershock damage)	8,000,000
Utilities	12,000,000
Total	$511,000,000

TABLE 21b

LOS ANGELES CITY DAMAGE[14]

(San Fernando Earthquake, 1971)

Damage Classification	Units	Buildings	Estimated Dollar Loss
Unsafe for Human Occupancy -- posted "unsafe"			
Single-family dwellings	0	522	$ 13,100,000
Apartments	1,149	54	11,500,000
Nonresidential commercial and industrial	0	190	19,000,000
Major and Moderate Damage -- remaining occupied			
Single-family dwellings	0	2,469	24,700,000
Apartments	0	192	7,700,000
Nonresidential commercial and industrial	0	883	17,700,000
Minor Damage			
Single-family dwellings	0	13,711	6,900,000
Apartments	0	1,748	17,500,000
Nonresidential commercial and industrial	0	5,698	5,700,000
Other Damage (estimated)			
Unreported damage	0	0	30,000,000
Personal property and inventory	0	0	50,000,000
Total	1,149	25,467	$203,800,000

TABLE 22

BUILDING DAMAGE* OUTSIDE OF CITY OF LOS ANGELES[14]

(San Fernando Earthquake, 1971)

City	Buildings Damaged	Posted Unsafe	Buildings Demolished or To Be Demolished			Damaged Chimneys	Estimated Total Dollar Loss
			Residential	Commercial	Churches and Schools		
Alhambra	55	15	0	5	0	400	$ 2,000,000
Beverly Hills	135	0	0	2	0	1,000	800,000
Burbank	445	25	3	3	1	500	4,000,000
Compton	0	0	0	0	0	0	10,000
Glendale	**	31	13	23	5	3,250	2,000,000
Pasadena	10	4	0	0	1	2,000	2,500,000
San Gabriel	0	0	0	0	0	30	9,000
Santa Monica	20	1	0	0	0	30	50,000
South Pasadena	20	1	0	0	0	300	275,000
Vernon	30	5	0	0	0	0	100,000
San Fernando Valley	**	270	95	123***	3	390	$35,500,000

*Does not include publicly owned structures. Data from various sources.

**No data available.

***Posted "unsafe."

TABLE 23

COMPARISON OF EI FOR THE SAN FERNANDO EARTHQUAKE OF 1971 AND THE HYPOTHETICAL EARTHQUAKE

City	San Fernando Earthquake of 1971		Hypothetical Earthquake	
	3-Digit EI	1-Digit EI	3-Digit EI	1-Digit EI
Alhambra	4,5,5	5-	4,5,5	5-
Beverly Hills	4,5,5	5-	4,5,5	5-
Burbank	5,6,5	5+	4,5,5	5-
Compton	3,5,5	4+	4,5,5	5-
Glendale	4,7,5	5+	4,5,5	5-
Los Angeles	4,5,5	5-	4,5,5	5-
Pasadena	4,5,5	5-	4,5,5	5-
San Fernando	6,7,7	7-	4,6,5	5
San Gabriel	4,5,5	5-	4,5,5	5-
Santa Monica	3,5,5	4+	3,5,4	4
South Pasadena	4,5,5	5-	4,5,5	5-
Vernon	4,6,5	5	4,5,5	5-

Note: In instances where the EI value is higher for one of the two earthquakes, the higher value is underscored.

short-period band. However, it is not necessarily true that two earthquakes with the same EI values will produce the same effects; with a difference in magnitude, more damage can be expected from the earthquake with the higher magnitude. The duration of motion is a major contributor to this difference.

Most of the damage that resulted from the San Fernando earthquake occurred in communities corresponding to a three-digit EI rating of 4,5,5 or higher. A detailed description of damage for these communities is available in References 14 and 35. Comparison of data for study area communities and their EI levels (Table 16 and Appendix G) with the data presented in Tables 21 through 23 shows that most of the large cities in the study area are associated with an EI rating of 4,5,5 or higher. Most of the cities in Kern, Kings, Los Angeles, Orange, Riverside, San Bernardino, San Luis Obispo, Santa Barbara, and Ventura counties are within this group. The highest rating (6,8,8) is for Palmdale; several small communities not reflected in the population data available also have this rating. Comparison with damage observed during the San Fernando earthquake indicates that a major impact on lifeline systems (water supply, natural gas transmission, electricity, and communications) can also be expected.

Damage Estimate Variability

The aforementioned damage estimates are given as central or mean values. There are two main sources of uncertainty that may cause the predicted values to vary above or below the mean in addition to expected dispersion from central values of random variables: (1) the EI (spectral velocity) prediction and (2) the motion-damage relationships used. Available and applicable data show geometric standard deviations approximately 1.8[9] and 1.4[10] for the peak ground acceleration and dynamic amplification factor predictions, respectively. Thus, individual predicted spectral values could be several times the expected mean value. Similar uncertainties have been observed in motion-damage relationships from studies of past earthquake damage. For the spectral motion amplitude most important for this study, a geometric standard deviation of about 2 was observed from the study of low-rise and high-rise building damage during the San Fernando earthquake of 1971.[12]

Even with considerable and reliable data, the parameters involved in the earthquake damage problem are complex and are subject to considerable dispersion from their mean or central regions. Thus, various possible combinations of the parameters could lead to considerable deviation above and below estimated mean values. Because the current data available are sparse in many cases, estimated mean values, as well as dispersion from the mean in specific cases, can be expected. A discussion of the rigorous development of the estimated error for this type of problem is given in Reference 41. A rigorous estimate of the statistical variation of damage for the hypothetical earthquake is beyond the scope of this study, but a one-sigma variation could be several times the mean value. Error in the mean predicted value is not expected to be as large.

In addition, it is important to recognize that a predicted mean damage cost factor for a community does not imply that all structures will be damaged. Past studies of earthquake damage have shown that there is considerable scatter in the degree of damage sustained, even for similar structures located close to each other. Not even in communities for which the overall damage cost factor is in the range of 1% to 2% will all buildings be damages.[42]

Damage Estimate Summary

The effects of the postulated earthquake on structures are felt in parts or all of 14 California counties. A study of cities with typical structure distribution indicates that a three-digit EI of 6,7,7 would result in an estimated average damage of 9% of replacement value. The result for EI ratings of 5,6,6 and 4,5,5 is an estimated average damage of 2% and 0.3%, respectively. One city and many small communities have an EI rating of 6,7,7 (one-digit EI: 7-). Within EI areas with a rating equal to or greater than 4,5,5 (one-digit EI: 5-), there are 133 cities (excluding small communities) with a total population of about 7 million. A summary of the number of cities and corresponding population for various EI zones is shown in Table 24.

TABLE 24

NUMBER OF CITIES AND CORRESPONDING POPULATION*

IN RESPECTIVE ONE-DIGIT EI ZONES

1-Digit EI Zone	Number of Cities	Combined Population of Cities (in thousands)	Damage** to Residential and Commercial Buildings (in millions of dollars)
7+	1	9	45.0
7	--	--	--
7-	--	--	--
6+	3	36	33.1
6	2	28	14.8
6-	2	133	38.6
5+	7	149	25.6
5	14	291	29.1
5-	104	6,122	355.1
4+	37	1,232	39.4
4	23	1,221	22.1
4-	41	487	5.1
3+	13	82	0.4
3	7	77	--
			Total 591.1

*Includes only the communities listed in Appendix G.

**1977 dollars.

It is clear from Table 13 and Tables 18 through 20 that residential buildings are predominant in the community and that their damage cost dominates the damage cost for the entire community. The same relationship was observed for the City of Los Angeles after the San Fernando earthquake of 1971 (Table 21b). Removing $50 million (for personal property damage) from the $203.8 million damage total, damage to buildings in the private sector is $153.8 million. Damage in Los Angeles for buildings in the public sector was reported to be $180 million (Table 21a).

Assuming an average occupancy of 3.2 persons per dwelling and an average cost per dwelling of $50,000, the total cost of dwellings for the city of Los Angeles, with population of 2.8 million, is approximately $44 billion. In contrast, the value of high-rise buildings for the city of Los Angeles is about $2 billion (Table 9). Thus high-rise buildings, although individually very important, have only a minor effect on damage cost for large cities. On the basis of these observations, estimation of damage to buildings on a per capita basis seems reasonable. Using Tables 18 through 20, a ratio for loss per capita versus one-digit EI was developed (Figure 22).

Damage to residential and commercial buildings in the private sector, based on per capita damage versus EI, is given in the last column of Table 24. Total damage from the hypothetical earthquake to buildings in this sector is estimated to be about $600 million. From comparison of damage in the private and public sectors during the San Fernando earthquake as discussed above, total damage is estimated to be twice that of damage in the private sector, i.e., $1.2 billion (1977 dollars).

The effects on major systems and facilities are also widespread. Portions of all of these systems and facilities are very close to the fault and some actually cross the fault. Some of the systems and facilities are designed and constructed with due consideration of the fault. The California Aqueduct systems and facilities, for example, were designed and constructed under special seismic considerations. The California Department of Transportation is undergoing a retrofitting program to strengthen highway overcrossings; in addition, new seismic design procedures have been instituted to take into consideration local geologic conditions and the location of the overcrossings relative to earthquake faults. Several other agencies are

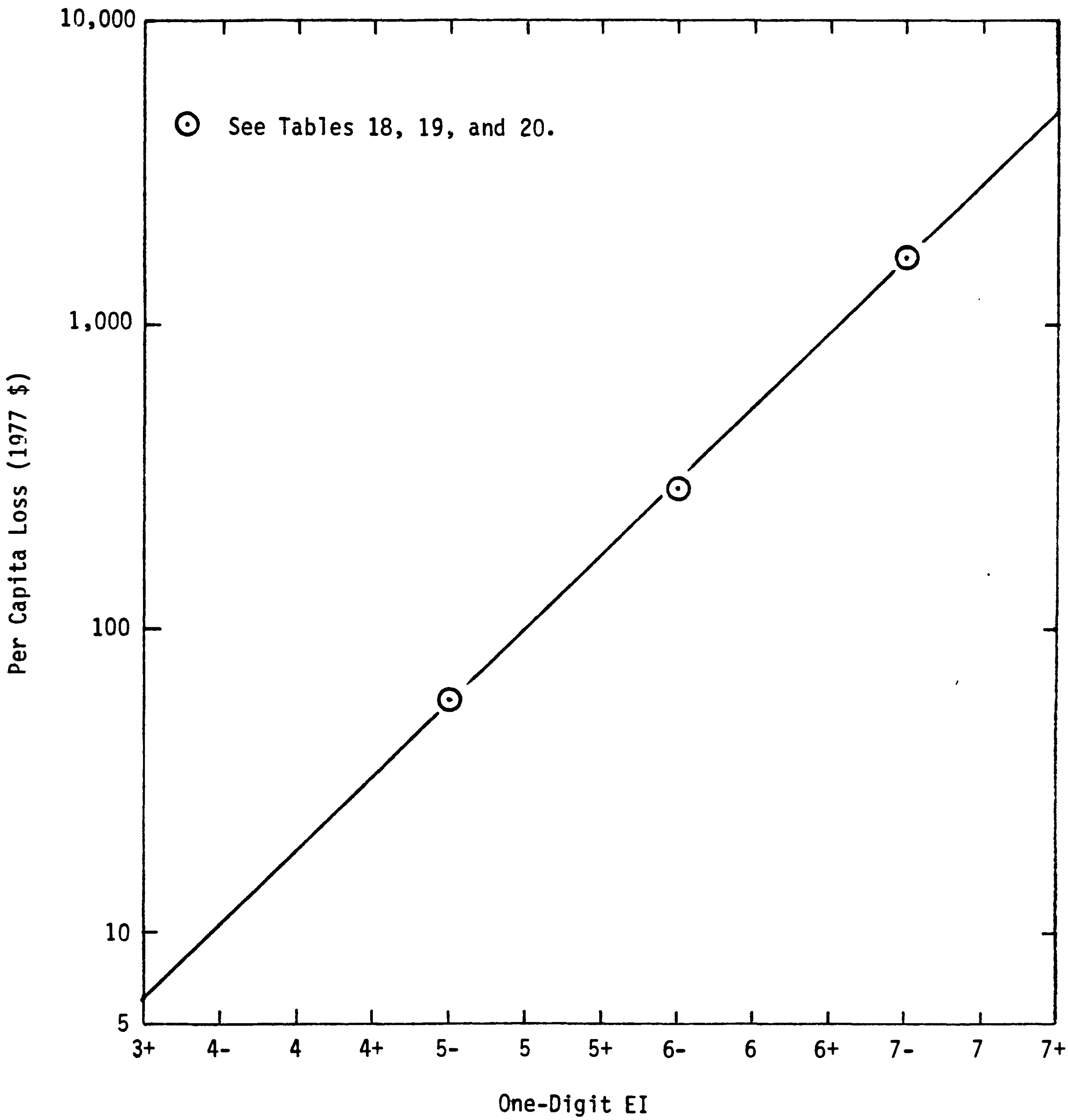


FIGURE 22 LOSS PER CAPITA FOR RESIDENTIAL AND COMMERCIAL BUILDINGS AS A FUNCTION OF EI

undertaking similar evaluations. Despite these measures, some damage is anticipated. Table 25 shows the summary tabulation of major facilities in the high EI zones.

Some of the major systems and facilities damaged during the San Fernando earthquake of 1971 were highway overcrossings, hydraulic fill dams, and water and energy transport systems and facilities. Although in some cases damage was related to fault displacements, in others it was related to severe ground motion. In terms of the one-digit EI, damage to these systems and facilities occurred at EI 7-. As can be seen from Table 25, there are a number of major facilities in one-digit EI areas equal to or greater than 7-. They include dams and hydraulic and energy transport facilities.

TABLE 25

SUMMARY TABULATION OF NUMBER OF MAJOR FACILITIES* IN THE HIGH-EI ZONES

Type of Facility	Number of Facilities								
	Study Area	One-Digit EI Zone							
		5	5+	6-	6	6+	7-	7	7+
Concrete Dams	50	-	-	-	-	-	-	-	-
Earth and/or Rock Fill Dams	219	-	1	5	3	2	-	1	-
Hydraulic Fill Dams	11	-	-	1	-	-	3	-	-
California Aqueduct Facilities	15	-	2	3	1	3	-	-	2
Highway Overcrossings > 500 ft in Length	148	-	1	2	-	-	-	-	-
Public Airports	108	-	-	1	4	1	-	-	2
Military Airports	16	-	-	-	-	1	-	-	-
Natural Gas Transmission Facilities	16	-	-	-	-	1	-	-	-
Electric Power Generation and Distribution Facilities	343	3	5	5	6	12	2	5	2
Petroleum Pumping, Terminal, and Refinery Facilities	93	1	-	4	4	6	-	1	-

*Related conveyance systems are not included in the tabulation.

SUMMARY AND RECOMMENDATIONS

The EIS evaluation of the potential effects of the postulated earthquake on structures took into consideration not only magnitude, distance, and local geology but also the frequency content of the ground motion at the site and the dynamic response parameters of structures at the site. This was accomplished using the response spectra as a basis of evaluation.

Effects were evaluated using the EI-damage relationships determined from past earthquake damage studies. For those structures that had not been studied previously, the EI-damage relationships were obtained by determining the design basis of the structures and then correlating the design coefficients with those of typical buildings. The results appear to be reasonable and are consistent with the results of other, similar studies.

Residential buildings comprise the major portion of the buildings in a community. Consequently, losses from these buildings figure heavily in the total dollar loss to the community from an earthquake. The total damage to private buildings from the hypothetical earthquake is estimated to be about $600 million (1977 value); an equal amount is estimated for damage to public buildings and other public structures. This figure is an estimate of the mean or expected damage for the entire area. The actual damage cost may vary somewhat, depending on the distribution of damage for the many communities involved. Observed statistical variations from previous earthquake studies, for both the spectral values and the motion-damage relationships, will expectedly be repeated for any future earthquake. A rigorous estimate of the statistical variation of damage for the hypothetical earthquake is beyond the scope of this study, but a one-sigma geometric variation could be several times the mean value. Error in the mean predicted value is not expected to be as large. Furthermore, the above estimate does not take into consideration the damage resulting from the possible catastrophic failure of major facilities (e.g., a dam) and the secondary damage that may result.

All of the major systems and facilities of the study area will be affected. Portions of some of these facilities are in high-EI zones, and some systems actually cross the fault. As indicated in the introduction to this report, an EIS evaluation is only a preliminary step in the evaluation of earthquake effects on structures. EIS data and results are intended to provide only an overall identification and summary of the extent of effects from a predicted earthquake. Should more definitive indications of an imminent earthquake appear, the data provided can be used to systematically perform more detailed evaluations.

Deaths and injuries (with the exception of immediate physiological effects such as heart attacks) are the secondary effects of earthquakes. Occurring as a consequence of structure damage and failure, they may result from objects falling from buildings, collapse of buildings, failure of dams, and other primary earthquake effects. Thus a higher incidence of deaths and injuries is associated with structures that have high damage potential than with those having lower damage potential (e.g., precode unreinforced masonry buildings versus modern buildings with earthquake-resistive structural details). On the basis of past experience, deaths are not expected in areas with a one-digit EI less than 6-, but the possibility of injury extends to areas with a one-digit EI of 5.

For those areas with a one-digit EI equal to or greater than 6-, more detailed inventories and evaluations than those that were employed for this study should be made. For structures in a one-digit EI zone equal to or greater than 7-, a detailed engineering review should be carried out to evaluate the possible hazard to life and to determine remedial measures that might be implemented.

Further investigation using motion damage data from future earthquakes is also recommended. As indicated in the report, the EI-damage relationships for this study were based on the data from the San Fernando earthquake of 1971 for low-rise and high-rise buildings. The recommended study should include data from other earthquakes and data for additional structure types as well as the damage evaluations and their corresponding intensity descriptions (Modified Mercalli, Rossi-Forel, etc.) of others.

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APPENDIX A

The Engineering Intensity Scale

THE ENGINEERING INTENSITY SCALE

Formulation of the Engineering Intensity Scale (EIS)

One of the first steps in predicting the effects of an earthquake is to determine the geographic area within which damage to structures can be expected to occur. The next step is to estimate the incidence and degree of damage for the area affected. The Engineering Intensity Scale (EIS) was developed to accomplish both steps.*

In the formulation of the scale, ground motion is characterized by 5%-damped response spectrum velocity (S_v), and structures are characterized by their fundamental-mode vibration properties. Disregarding mode-shape considerations, the variables important for correlating ground motion with damage are S_v amplitude and building period (T). A damping value of 5% was used because damping in many real structures varies from about 2% to 10%, and 5% has become a standard reference level in investigations analyzing the response of structures to ground motion.

The EIS procedure provides an orderly means for relating ground motion amplitudes for various frequencies with structures having specific frequency characteristics. The range of S_v and T values applicable to civil engineering structures is represented as a 10 x 9 matrix, shown in Figure A-1. The range of S_v values, from 0.001 to 1000.0 cm/sec, is divided into ten levels that are assigned engineering intensity (EI) numbers from 0 to 9. The T range, from 0.01 to 10 sec, is divided into nine period bands from I to IX. Table A-1 lists the 5%-damped S_v amplitude boundary values represented by the intensity levels shown on the figure.

EIS Reporting

Three ways of reporting earthquakes in terms of the EIS have been found useful. The most accurate is a nine-digit report in which an EI number is reported for each of the period bands shown in Figure A-1. If the

*Blume, John A., "An Engineering Intensity Scale for Earthquakes and Other Ground Motion, *Bulletin of the Seismological Society of America*, vol. 60, no. 1, February 1970.

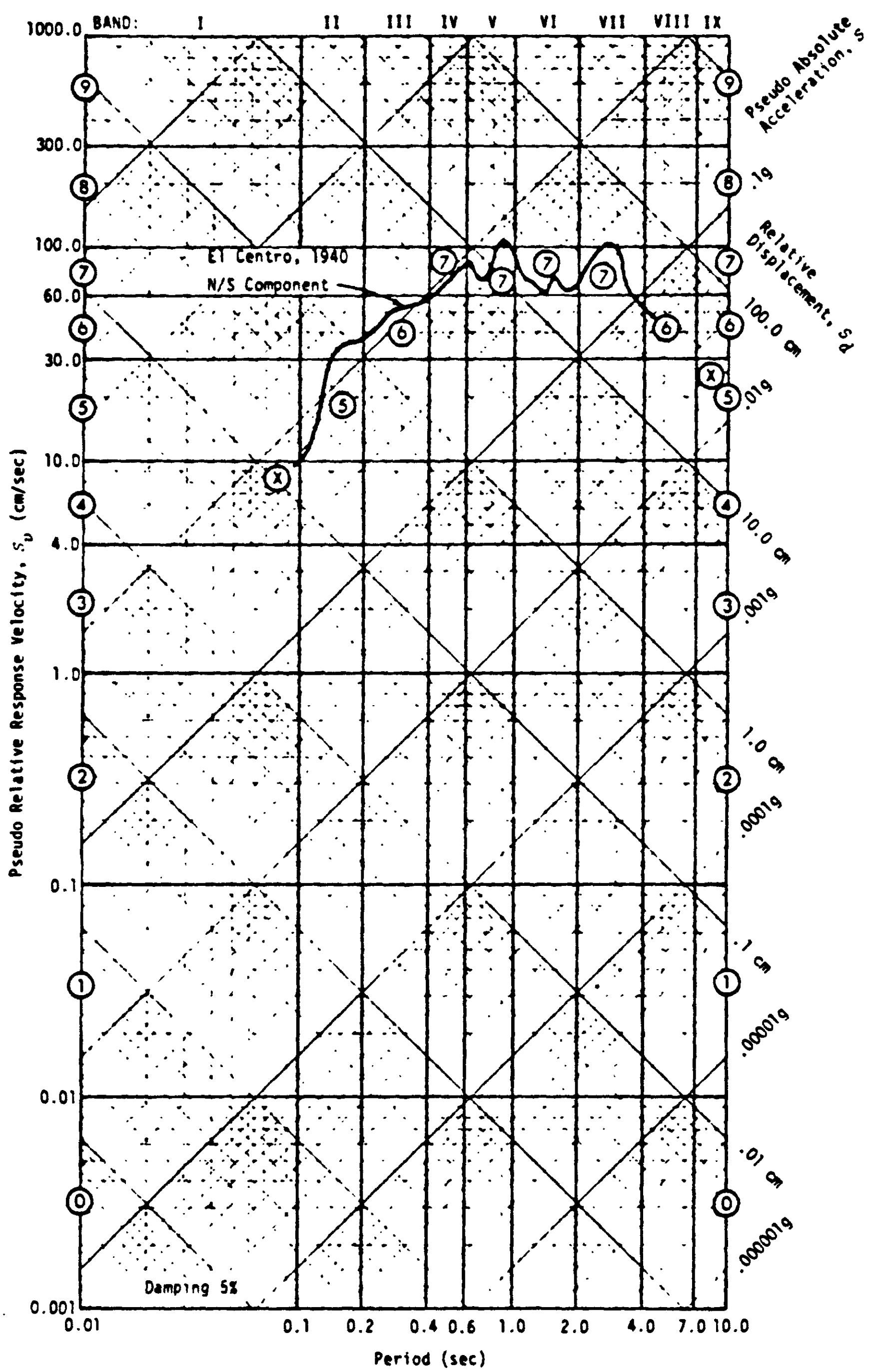


FIGURE A-1 ENGINEERING INTENSITY SCALE MATRIX SUPERIMPOSED WITH EXAMPLE SPECTRUM

TABLE A-1

ENGINEERING INTENSITY SCALE BOUNDARY S_v VALUES

EIS Intensity Level	S_v Value (cm/sec)	(in./sec)	(ft/sec)
9	> 300	> 118	> 9.84
8	100 - 300	39.4 - 118	3.28 - 9.84
7	60 - 100	23.6 - 39.4	1.97 - 3.28
6	30 - 60	11.8 - 23.6	0.984 - 1.97
5	10 - 30	3.94 - 11.8	0.328 - 0.984
4	4 - 10	1.57 - 3.94	0.131 - 0.328
3	1 - 4	0.394 - 1.57	0.0328 - 0.131
2	0.1 - 1	0.039 - 0.394	0.0033 - 0.0328
1	0.01 - 0.1	0.0039 - 0.039	0.00033 - 0.0033
0	< 0.01	< 0.0039	< 0.00033

response spectrum does not cross a particular period band, the letter X is substituted for the EI number of that band. To facilitate reading, groups of three digits in the report are separated by a comma. For applications that require somewhat less detailed reporting, an average of each group of three consecutive EI numbers is taken, which results in a three-digit report. Finally, the most abbreviated and least descriptive report consists of a single digit obtained by averaging the intensity numbers of the three-digit report.

The Nine-Digit Report. The response of the north-south component of the 1940 El Centro earthquake will be used as an example of a nine-digit report. In Figure A-1, S_v values for this earthquake, recorded at El Centro, are shown with the EIS diagram superimposed. The nine-digit intensity for this particular response spectrum would read: X56,777,76X.

The first X indicates that the response spectrum does not enter period band I (from 0.01 to 0.1 sec), often the case because of recordinginstrument limitations or because of inadequately fine digitization of the spectral response calculation. In period band II, S_v generally falls between 10 and 30 cm/sec; in band III, between 30 and 60 cm/sec; and in bands IV through VIII, between 60 and 100 cm/sec. The final X indicates that the response spectrum fails to enter band IX, again possibly because of instrument limitations. The nine digits represent a rough plot of the response spectrum. They are easily transmitted and stored and provide data useful for correlating the frequency content of ground motion with the characteristic responses of structures of various periods.

Note that a number reported for period band I would represent a general indication of peak ground acceleration because damping and dynamic amplification have little effect in the short period of this band. The spectral response is asymptotic to peak ground acceleration. Likewise, a response reported for period band IX is indicative of maximum ground displacement.

An EIS report with relatively high numbers indicates very strong earthquake motion at the locality under consideration. A report with only a few high numbers may indicate a narrow-band spectrum of response to either a small, local energy release or a large, distant energy release.

The Three-Digit Report. Although it gives less information than the nine-digit report, the three-digit report may be more convenient for many purposes.

Before averaging the values in the three groups of period bands of the nine-digit report, X values must be enumerated. This is done by estimating where the response spectrum would fall if extended through the X column, bearing in mind the asymptotic conditions noted above. The value is usually taken to be one unit less than that reported for the adjoining column. For example, the El Cnetro response spectrum reported as X56,777,76X would become 456,777,765. The three-digit report, obtained by averaging each group of three digits, would thus read: 5,7,6. The commas are retained in the notation to identify the scale and the source of the rating.

The period bands of the three-digit report, described as short (T < 0.4 sec), intermediate (T = 0.4 to 2.0 sec), and long (T > 2.0 sec), represent typical classes of buildings. This report shows at a glance where the energy would fall in each period group and how buildings in each class would tend to respond.

The One-Digit Report. For limited purposes, a crude report that merely indicates the overall spectral content of ground motion may be sufficient. This is obtained by averaging the EI numbers of the three-digit report to produce a single number. In the case of the El Centro example, that number would be 6.

If reporting purposes are best served by the use of a single digit to rate a seismic event but at the same time would benefit by a finer comparison among events, a scale of 30 ratings can be obtained by subdividing the S_v range represented by each of the ten EI numbers (see Figure A.1) into three parts. For example, a one-digit report of 6, which represents an S_v range of 30 to 60 cm/sec, can be subdivided into ranges of 30 to 40 cm/sec, 40 to 50 cm/sec, and 50 to 60 cm/sec. These narrower ranges are identified in the EI report by the use of a plus sign, a minus sign, or no sign at all with the single digit. Thus a report of 6- indicates the lowest part of the EI-6 range (30 to 40 cm/sec), 6 indicates the middle of the range (40 to 50 cm/sec), and 6+ the highest part (50 to 60 cm/sec). The narrower range thus reported is based on the result obtained when the numbers of the three-digit report are averaged: the average of a 6,7,6 three-digit report is therefore reported as 6+ while the average of 6,6,5 is reported as 6-.

Combined Report. It is possible, of course, to report all three ratings in order to allow the user to select the one most useful for his purposes. On this basis, the 1940 El Centro north-south component would be reported to have an intensity of:

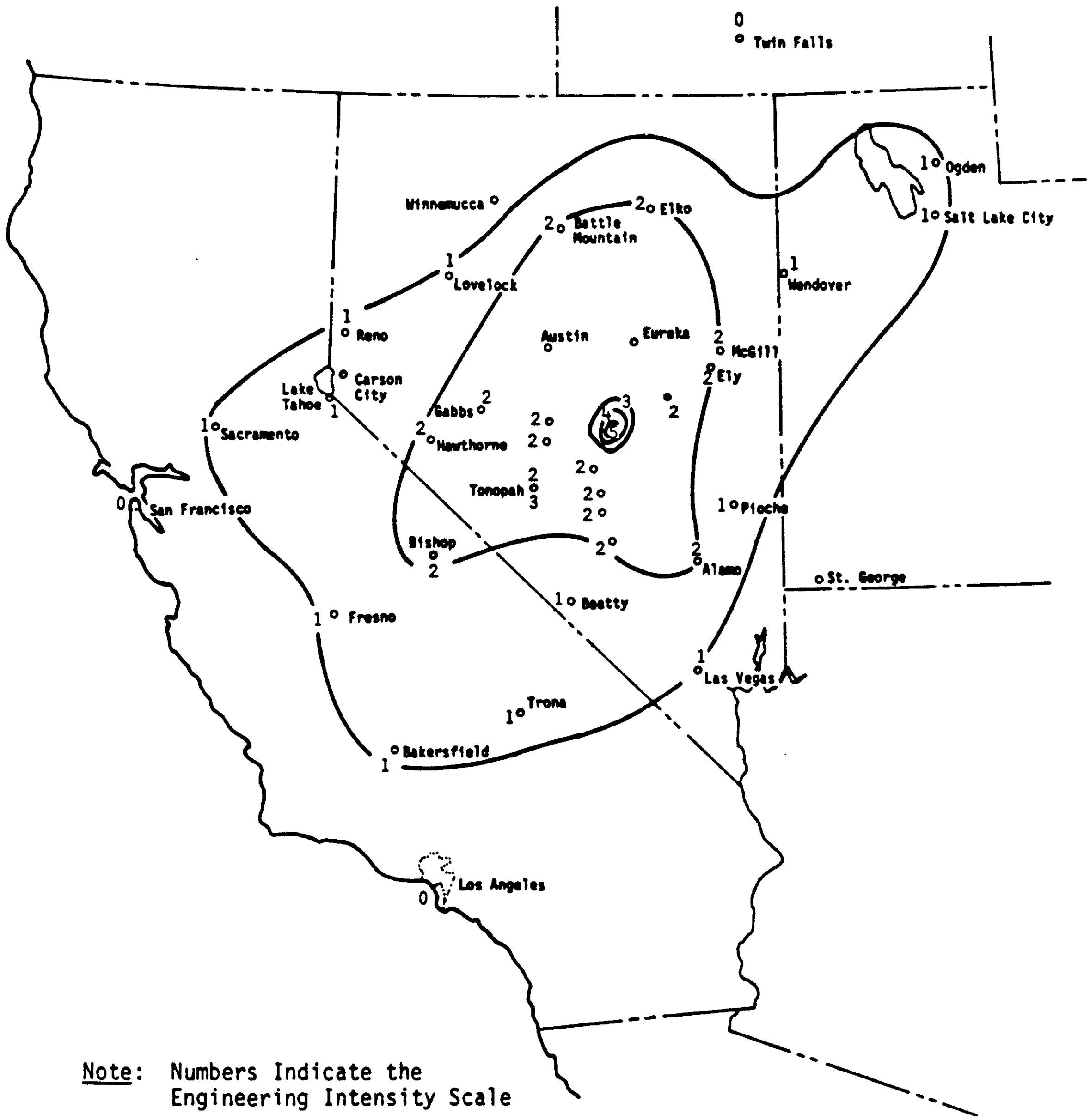
X56,777,76X
5,7,6
6

Experience has shown that, except for special purposes, the three-digit report offers the optimum combination of convenience and usefulness.

Engineering Intensity Maps

Isointensity (iso-EI) maps can be constructed if sufficient spectral data are available. It is possible to prepare a map for each of the nine period bands, but a convenient alternative is to use the short-period, intermediate-period, and long-period bands of the three-digit report (T < 0.4 sec; T = 0.4 to 2.0 sec; and T > 2.0 sec).

Another alternative is to construct maps for particular narrow-period bands of interest. Figure A-2, an example of such a map, shows iso-EI lines for the period band T < 0.2 sec for an underground nuclear detonation that took place on January 18, 1968 in central Nevada. Spectral response curves were calculated for various stations, as shown in the figure.



Note: Numbers Indicate the Engineering Intensity Scale

FIGURE A-2 ISO-EI LINES FOR PERIOD BAND OF T < 0.4 SECOND, EVENT FAULTLESS

APPENDIX B

Geologic Background Data

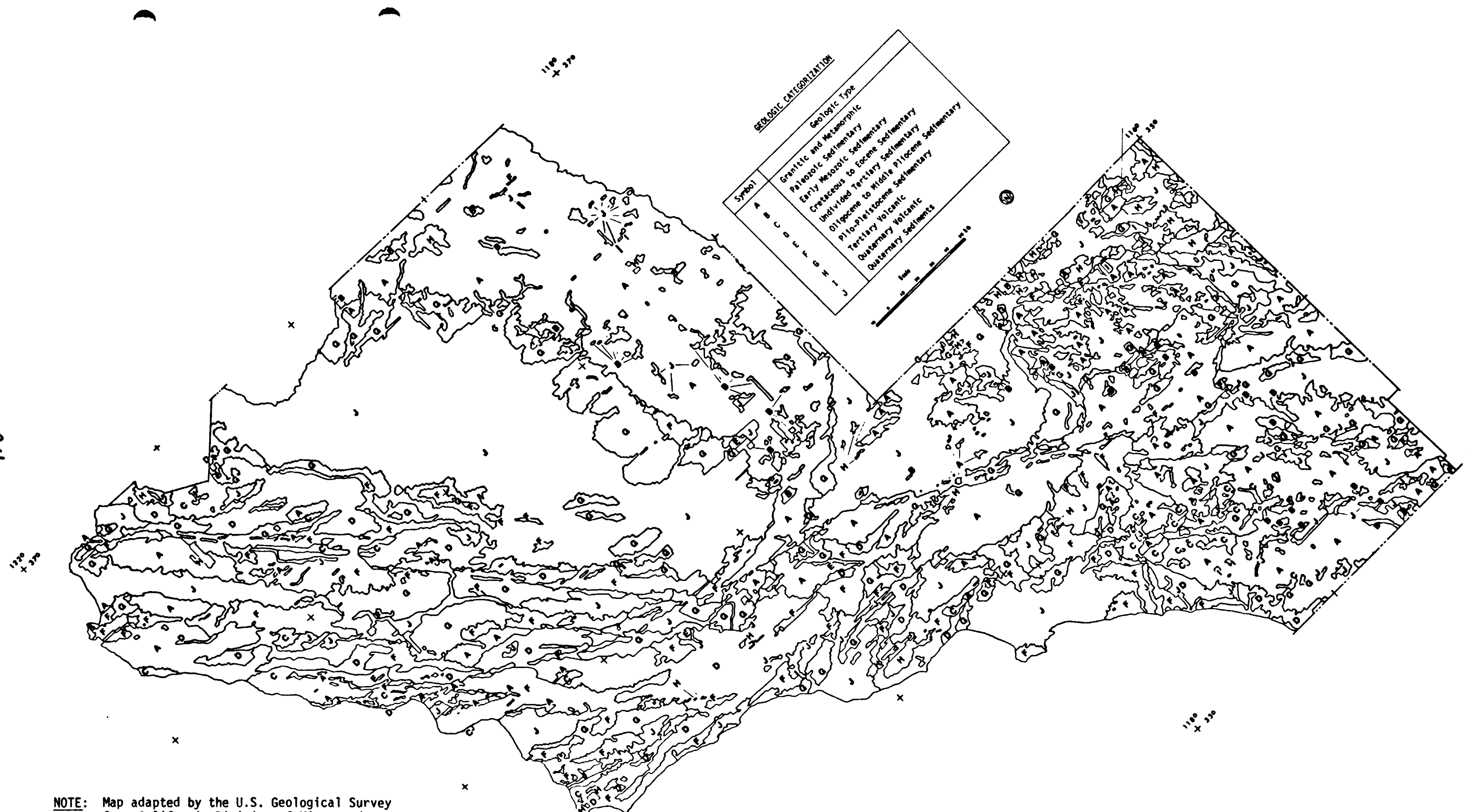
COMPARISON OF ENGINEERING INTENSITY AND ROSSI-FOREL INTENSITY

In addition to the basic earthquake and near-surface geology information shown in Figure B-1, a Rossi-Forel Intensity (RFI) distribution map of the study area was provided by the U.S. Geological Survey and is presented here as Figure B-2. The map shows the RFI numbers associated with units of land corresponding to one-half degree of latitude by one-half degree of longitude. The basic earthquake information used for the prediction was the same as that provided for the present study.

The Engineering Intensity (EI) levels associated with the land units of Figure B-2 were determined for each of the three EIS period bands, and the EIS number and RFI number for each unit were compared. In Table B-1, the sum of the land units represented by each pair of EI and RFI numbers is shown for each period band. A comparison of the average intensities is shown in Figure B-3. With the exception of the EIs of 6 and 7 in bands I, II, III, the comparison shows a consistent trend. In bands I, II, III, there is a consistent trend from an EI of 5 to an EI of 2. In bands IV, V, VI and bands VII, VIII, IX, the trend is consistent from an EI of 8 to an EI of 2; in addition, the average values are nearly equal for these bands.

The inconsistency in the EIs of 6 and 7 for the short-period bands is mostly due to the lack of sample data points. A further explanation is that not only do the intensity numbers used in the two scales describe different intervals but also the scales are derived in a completely different manner. The derivations take different approaches in the treatment of the basic earthquake information and also in the modification of intensity for geologic conditions. Even with these variations, however, there is a reasonable correlation.

Carrying the comparison one step further, RFI is compared to the one-digit EI. For this comparison, it is assumed that the EIs of 6 and 7 in bands I, II, III, have the same trend as other bands. The result is shown in Figure B-3 and in the following table.



NOTE: Map adapted by the U.S. Geological Survey from California Division of Mines and Geology map.

FIGURE B-1 GEOLOGIC MAP OF THE STUDY AREA

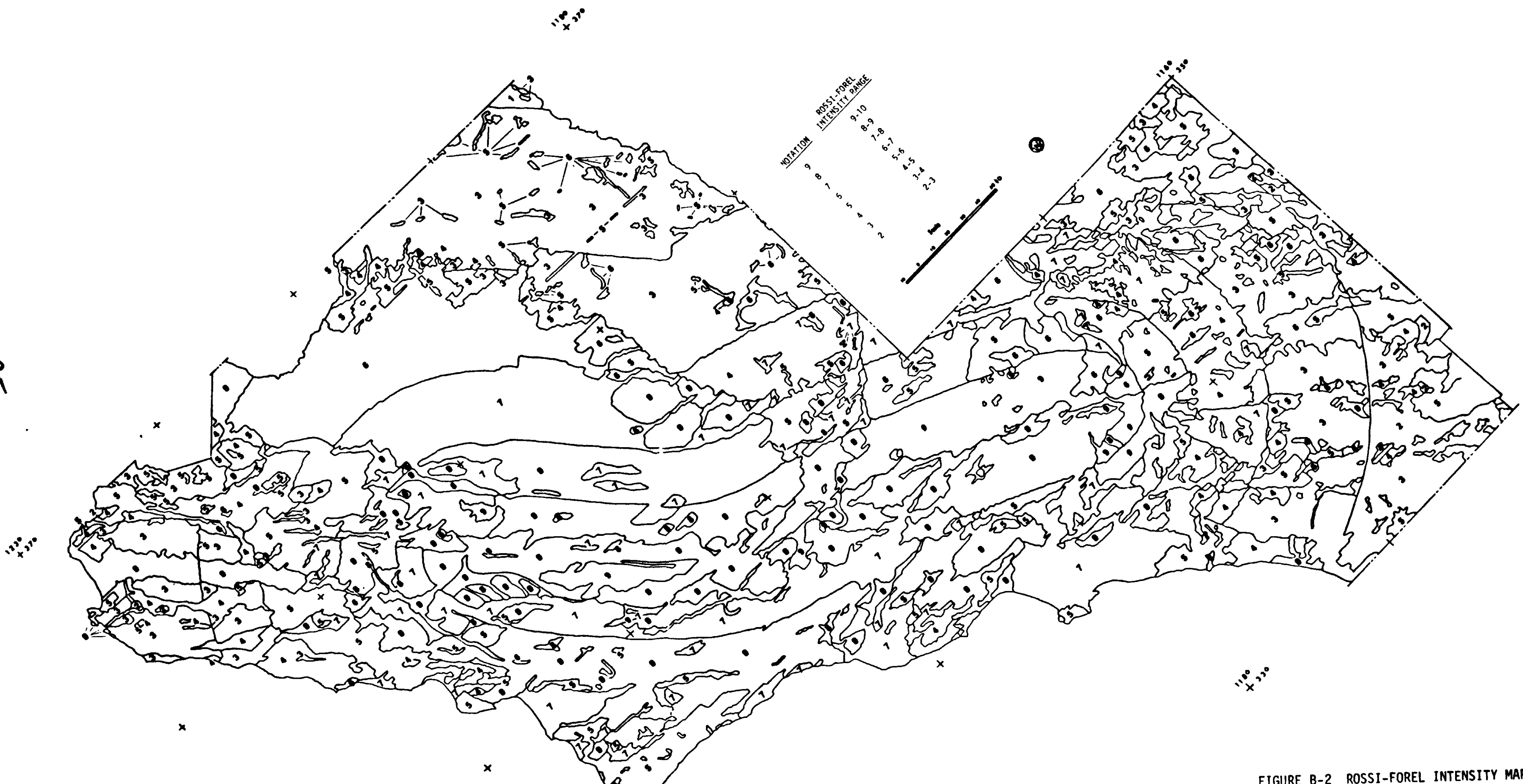


FIGURE B-2 ROSSI-FOREL INTENSITY MAP
FOR M = 8.1

NOTE: Data represented are based on information provided by the U.S. Geological Survey.

TABLE B-1

COMPARISON OF RFI and EI DISTRIBUTION

FOR LAND UNITS* IN STUDY AREA

EIS Bands I, II, III											
Number of Units Corresponding to Intensity Levels											
EI \ RFI	10	9	8	7	6	5	4	3	2	1	Average
9	0	0	0	0	0	0	0	0	0	0	0.00
8	0	0	0	0	0	0	0	0	0	0	0.00
7	0	0	0	51	0	0	0	0	0	0	7.00
6	2130	1391	1744	2070	2	0	0	0	0	0	8.49
5	2627	5173	4504	2092	1258	0	0	0	0	0	8.37
4	0	6259	16367	15493	6596	2168	0	0	0	0	7.38
3	0	0	1070	15484	25877	16410	10896	650	0	0	5.68
2	0	0	0	0	146	4577	5483	24902	7187	0	3.19
1	0	0	0	0	0	0	0	0	0	0	0.00
EIS Bands IV, V, VI											
Number of Units Corresponding to Intensity Levels											
EI \ RFI	10	9	8	7	6	5	4	3	2	1	Average
9	0	0	0	0	0	0	0	0	0	0	0.00
8	2708	1493	542	126	0	0	0	0	0	0	9.39
7	2049	3507	1915	1812	0	0	0	0	0	0	8.62
6	0	7638	5766	2412	260	0	0	0	0	0	8.29
5	0	185	15462	23373	6252	431	0	0	0	0	7.19
4	0	0	0	7467	25270	9426	484	0	0	0	5.93
3	0	0	0	0	2097	13298	15597	6659	0	0	4.29
2	0	0	0	0	0	0	298	18893	7187	0	2.74
1	0	0	0	0	0	0	0	0	0	0	0.00
EIS Bands VII, VIII, IX											
Number of Units Corresponding to Intensity Levels											
EI \ RFI	10	9	8	7	6	5	4	3	2	1	Average
9	0	0	0	0	0	0	0	0	0	0	0.00
8	1663	123	0	0	0	0	0	0	0	0	9.93
7	3074	1894	420	42	0	0	0	0	0	0	9.47
6	20	8484	3781	2021	0	0	0	0	0	0	8.45
5	0	2322	19484	15926	2282	50	0	0	0	0	7.54
4	0	0	0	17201	24740	4090	314	0	0	0	6.27
3	0	0	0	0	6857	19015	12501	4179	0	0	4.67
2	0	0	0	0	0	0	3564	21373	7187	0	2.89
1	0	0	0	0	0	0	0	0	0	0	0.00

*A unit represents an area of one-half degree latitude by one-half degree longitude (≈ 0.7 km^2).

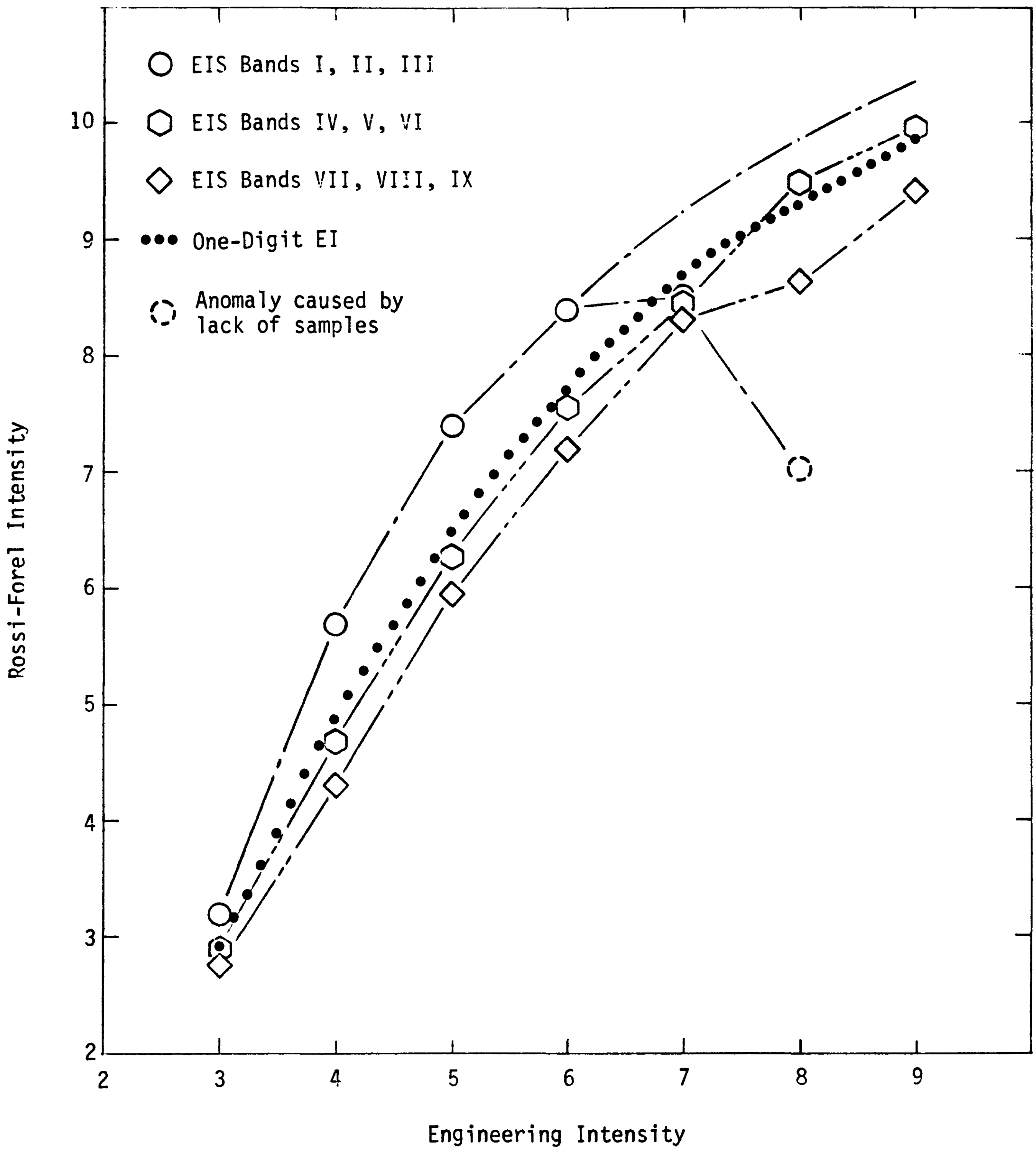


FIGURE B-3 COMPARISON OF AVERAGE ROSSI-FOREL INTENSITY AND ENGINEERING INTENSITY

	Intensity Value							
RFI	3	4	5	6	7	8	9	10
One-digit EI	2	3-	3	4-	4+	5+	6+	8+

While the damage descriptions of RFIs agree fairly well with the damage levels of EIs, the EIS is the only procedure for which quantitative information on motion-damage relationships is currently available.

APPENDIX C

Major Structure Categories

MAJOR STRUCTURE CATEGORIES AND EXAMPLES OF STRUCTURE TYPES*

A. <u>Buildings</u>

1. Residential (houses, apartments)
2. Agricultural (farmhouses, barns, outbuildings)
3. Commercial (stores, gasoline stations)
4. Institutional (schools, hospitals, churches)
5. Industrial (refineries, mills)
6. Special (shrines, ruins)

B. <u>Utility and Transportation Structures</u>

1. Electrical power structures (lines, transformers, switch gear converters, beacons)
2. Communication and microwave stations (reflectors, towers, equipment)
3. Roads, railroads, bridges, overpasses, tunnels, retaining walls
4. Air navigational facilities (beacons, marker stations)
5. Airfields and parking areas
6. Marine and waterfront structures (piers, bulkheads)

C. <u>Hydraulic Structures</u>

1. Earth, rock, or concrete dams, outlet works, control structures
2. Reservoirs, lakes, ponds, sumps, forebays, afterbays, and adjacent shores and slopes (for wave generation)
3. Canals, pipelines, siphons, surge tanks, elevated and surface storage tanks, distribution systems
4. Water storage, cisterns, distribution, processing stations
5. Petroleum products (liquid and gas) storage, handling, piping, processing stations

D. <u>Earth Structures</u>

1. Earth and rock slopes (for potential instability determinations and predictions of damage to roads, fields, stream contamination, hazards to persons)
2. Major existing landslides, land creep areas, snow, ice, or earth avalanche areas, subsidence areas
3. Natural or altered sites with scientific, historical, cultural, or ecological significance (pueblo dwellings, scenic rock formations, historical landmarks, archaeological sites)
4. Berms, dikes, banks

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*URS/John A. Blume & Associates, Engineers, *Effects Prediction Guidelines for Structures Subjected to Ground Motion*, JAB-99-115, July 1975.

E. <u>Special Structures and Items</u>

1. Conveyor systems, tramways, cableways, flumes, ski lifts, trestles, headframes, personnel lifts
2. Ventilation systems, stacks
3. Mobile equipment, rolling stock, vehicles, drillrigs
4. Towers, poles, signs, frames, antennas
5. Material storage, ore heaps, elevated bulk storage, tailings piles, gravel plants, tailings ponds, corrosive fluid storage
6. Agricultural equipment, irrigation lines
7. Furnishings, shelf goods, roof-mounted air conditioners, bric-a-brac, dishes

APPENDIX D

Population and Housing Statistics
for Cities of the Study Area

APPENDIX D

FRESNO COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
CALWA - U	-	5191	1402	-	-	-	-	119
CLOVIS	20750	13856	4347	335	3698	305	9	123
COALINGA	6175	6161	2419	-	-	-	-	44
FIREBAUGH	3420	2517	828	-	-	-	-	123
FOWLER	2250	-	-	-	-	-	-	112
FRESNO	175900	165972	57668	485	47147	7322	714	119
HURON	2140	-	-	-	-	-		54
KERMAN	3370	2667	824	-	-	-	-	110
KINGSBURG	4380	3843	1331	-	-	-	-	107
MENDOTA	3470	2705	796	-	-	-	-	112
ORANGE COVE	3720	3392	921	-	-	-	-	131
PARLIER	2130	-	-	-	-	-	-	118
REEDLEY	9100	8131	2632	-	-	-	-	121
SANGER	10250	10088	2941	-	2817	124	-	126
SAN JOAQUIN	1660	-	-	-	-	-	-	96
SELMA	8325	7459	2436	-	-	-	-	110

APPENDIX D (CONTINUED)

KERN COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
ARVIN	5325	5199	1546	-	-	-	-	43
BAKERSFIELD	76400	69515	24512	91	21834	2416	171	56
DELANO	15250	14559	4418	106	4151	151	10	75
EDWARD - U	-	10331	2313	125	2097	91	-	43
LAMONT - U	-	7007	1994	-	-	-	-	50
MARICOPA	700	-	-	-	-	-	-	11
MCFARLAND	4310	4177	1196	-	-	-	-	70
MOJAVE - U	-	2573	949	-	-	-	-	48
OILDALE - U	-	20897	7989	513	6971	499	6	65
SHAFTER	6050	5327	1741	-	-	-	-	53
TAFT	4160	4285	1761	-	-	-	-	14
TEHACHAPI	4200	4211	1367	-	-	-	-	43
WASCO	8625	8269	2480	-	-	-	-	57

APPENDIX D (CONTINUED)

KINGS COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
AVENAL - U	-	3035	1162	-	-	-	-	33
CORCORAN	5700	5249	1701	-	-	-	-	77
HANFORD	17750	15179	5243	50	4629	555	9	84
LEMOORE	5475	4219	1156	-	-	-	-	74
LEMOORE STATION - U	-	9210	1342	-	-	-	-	65

APPENDIX D (CONTINUED)

LOS ANGELES COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
ALHAMBRA	60500	62125	25955	27	18910	6808	210	47
ALONDRA PARK - U	-	12193	4272	9	3196	825	242	53
ALTADENA - U	-	42415	14326	24	13695	479	128	38
ARCADIA	46400	42868	14396	-	11251	3088	57	38
ARTESIA	15200	14757	4004	4	3709	291	-	66
AVALON	1510	-	-	-	-	-	-	130
AVOCADO HEIGHTS - U	-	9800	2653	-	-	-	-	50
AZUSA	25600	25217	8184	330	6220	1300	334	33
BALDWIN PARK	43650	47285	13656	450	11807	1237	162	40
BELL	21250	21836	9126	352	6626	2060	88	60
BELLFLOWER	51700	51454	18931	1363	12862	4005	701	68
BELL GARDENS	27300	29308	9536	451	7742	1296	47	60
BEVERLY HILLS	32400	33416	15094	5	7614	7429	46	60
BRADBURY	830	-	-	-	-	-	-	33
BURBANK	85000	88871	35996	492	26671	8266	567	45
CARSON	78300	71150	18475	1683	15634	995	163	80
CERRITOS	41400	15856	4686	98	4588	-	-	63
CLAREMONT	24950	23464	6824	-	5894	739	191	29
COMMERCE	9825	10536	3173	67	2805	284	17	56
COMPTON	68700	78611	21746	291	19076	2291	88	70
COVINA	32750	30380	9794	321	7333	1628	215	36
CUDAHY	16250	16998	5467	421	3288	1717	41	62
CULVER CITY	37700	31035	11802	130	7877	3245	370	65
DIAMOND BAR - U	-	12234	2961	-	2961	-	-	36
DOMINGUEZ - U	-	5980	1948	-	-	-	-	82
DOWNEY	85900	88445	31686	228	22885	7501	1072	60
DUARTE	14900	14981	4559	213	3741	511	94	35
E LA MIRADA - U	-	12339	3324	-	2935	332	57	60
E COMPTON - U	-	5853	2006	-	-	-	-	70
E LOS ANGELES - U	-	105033	29814	13	27444	2234	123	55
EL MONTE	66600	69837	23671	1433	18443	2920	875	44
EL SEGUNDO	15400	15620	5989	67	4183	1659	80	75
FLORENCE-GRAHAM - U	-	42900	13640	114	12515	1007	4	50
GARDENA	44350	41021	14694	681	9633	4037	343	73
GLENDALE	132700	132752	56466	103	37064	18168	1131	46
GLENDORA	32700	31349	9372	586	7931	850	5	31
HACIENDA HEIGHTS - U		35969	8815	-	8731	69	15	50
HAWAIIAN GARDENS	9550	9052	2481	-	-	-	-	70
HAWTHORNE	56000	53304	19653	369	13327	5244	713	73
HERMOSA BEACH	19050	17412	7923	103	6533	1212	75	79
HIDDEN HILLS	1550	-	-	-	-	-	-	59
HUNTINGTON PARK	32000	33744	15703	207	10303	5084	109	61
INDUSTRY	600	-	-	-	-	-	-	46

LOS ANGELES COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
INGLEWOOD	86000	89985	38276	465	22442	14634	735	63
IRWINDALE	740	-	-	-	-	-		37
LA CANADA-FLINTRIDGE - U	-	20714	6128	-	6086	42	-	39
LA CRECENTA - U	-	19620	6801	-	5959	796	46	38
LADERA HEIGHTS - U	-	6535	2064	-	-	-	-	55
LANCASTER - U	-	30948	10419	230	9569	609	11	12
LAKEWOOD	81200	82973	24208	156	22694	1280	78	72
LA MIRADA	38800	30808	7810	5	7329	417	59	60
LAPUENTE	29600	31092	7657	91	6444	797	325	45
LA VERNE	17350	12965	4131	638	3375	103	15	28
LAWNDALE	23750	24825	7959	127	6812	931	89	75
LENNOX - U	-	16121	6253	46	4640	1390	177	76
LOMITA	19350	19784	7521	747	5016	1485	273	80
LONG BEACH	339600	358633	149902	1844	99017	45361	3680	80
LOS ANGELES	2720600	2816061	1077309	6146	693754	328063	49328	55
LYNWOOD	38250	43353	15813	100	12596	3037	80	62
MANHATTAN BEACH	33600	35352	13107	5	12351	736	15	77
MAYWOOD	16600	16996	6870	4	5158	1074	34	59
MONROVIA	29000	30015	11449	114	9450	1757	128	35
MONTEBELLO	45650	42807	14448	173	13242	962	71	53
MONTEREY PARK	48350	49166	16323	95	13224	2636	368	49
NEWHALL - U	-	6951	3259	-	-	-	-	32
NORWALK	86500	91827	24176	433	21626	1645	472	62
PALMDALE	10800	8511	5968	-	-	-	-	3
PALOS VERDES E	14650	13641	4021	-	3776	245	-	83
PALOS VERDES PENINSULA - U		38914	10657	-	9759	748	150	83
PARAMOUNT	30950	34734	11597	1454	8624	1496	23	62
PASADENA	109400	113327	47049	34	33208	12855	952	42
PICO RIVERA	53300	54170	14649	354	13006	862	427	55
POMONA	80900	87384	28859	1157	23616	3381	705	33
RANCHO SANTA CLARITA - U	-	4860	1182	-	-	-	-	55
RODONDO BEACH	64400	56075	19634	215	15265	3983	171	81
ROLLING HILLS	2040	-	-	-	-	-	-	85
ROLLING HILLS ESTATE	7550	7545	1766	-	-	-	-	85
ROSEMEAD	39450	40972	13407	443	12078	796	90	45
ROWLAND HEIGHTS - U	-	16881	4340	89	4032	213	6	46
SAN DIMAS	17050	15692	4374	684	3633	57	-	31
SAN FERNANDO	15300	16571	5547	71	4629	810	37	41
SAN GABRIEL	28750	29176	10704	23	8589	2041	51	45
SAN MARINO	13600	14177	4650	-	4585	65	-	42
SANTA FE SPRING	16000	14750	3771	93	3342	265	71	58
SANTA MONICA	93000	88289	41606	574	17244	21655	2133	63
SIERRA MADRE	12050	12140	4439	-	4285	154	-	36

APPENDIX D (CONTINUED)

LOS ANGELES COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
SIGNAL HILL	5625	5588	2403	-	-	-	-	77
S. EL MONTE	14100	13443	3739	494	3067	178	-	48
S. SAN GABRIEL - U	-	5051	1286	-	-	-	-	45
SOUTH GATE	54100	56909	23512	253	19160	4013	86	62
S. PASADENA	22950	22979	9897	-	6429	3305	163	45
S. SAN JOSE HILLS - U	-	12386	2701	-	2614	87	-	43
S WHITTIER - U		46641	12733	88	11646	846	153	55
TEMPLE CITY	30050	29673	10431	4	9670	732	25	42
TORRANCE	134100	134584	45297	549	30477	10296	3975	80
VALENCIA - U	-	4243	1425	-	-	-	-	60
VALINDA - U	-	18837	4534	-	4415	72	47	43
VERNON	230	-	-	-	-	-		58
VIEW PARK-WINDSOR HILLS - U	-	12268	4276	-	3770	496	10	60
WALNUT	7075	5992	1590	-	-	-	-	42
WALNUT PARK - U	-	8925	3704	-	-	-	-	64
W ATHENS - U	-	13311	4843	627	3186	857	173	60
W CARSON - U	-	15918	4365	559	3626	180	-	80
W COMPTON - U	-	5605	1371	-	-	-	-	70
WEST COVINA	74400	68034	19146	99	16749	1568	730	40
W HOLLYWOOD - U	-	29448	17984	15	4448	12403	1118	56
WESTMONT - U	-	29310	9664	37	7412	2185	30	60
W PUENTE VALLEY - U	-	20733	4509	-	4394	30	85	48
W WHITTIER - U	-	20845	6149	221	5349	433	146	55
WHITTIER	71500	72863	25809	171	21401	4098	139	55
WILLOW BROOK - U	-	28705	7774	23	7508	243	-	68

APPENDIX D (CONTINUED)

MONTEREY COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
CARMEL	4700	4525	2820	-	-	-	-	169
CARMEL VALLEY - U	-	3026	1138	-	-	-	-	160
CASTROVILLE - U	-	3235	874	-	-	-	-	171
DEL REY OAKS	1760	-	-	-	-	-		165
GONZALES	2660	2575	741	-	-	-	-	132
GREENFIELD	3360	2608	746	-	-	-	-	105
KING CITY	4320	3717	1294	-	-	-	-	90
MARINA - U	-	8343	2440	-	-	-	-	172
MONTEREY	29250	26302	9424	5	6988	1968	463	170
PACIFIC GROVE	16800	13505	5955	152	4684	636	483	173
SALINAS	68600	58896	18937	445	15839	2324	329	158
SAND CITY	210	-	-	-	-	-	-	167
SEASIDE	33950	35935	8993	264	7841	810	78	167
SOLEDAD	4780	4222	1054	-	-	-	-	118

APPENDIX D (CONTINUED)

ORANGE COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
ANAHEIM	191800	166701	55912	2761	38613	10867	3671	62
BREA	22450	18447	5465	168	4961	309	27	56
BUENA PARK	63200	63646	17696	182	15137	1734	634	66
CAPISTRANO BEACH - U	-	4149	1632	-	-	-	-	94
COSTA MESA	77500	72660	24820	1196	19083	3340	1201	81
CYPRESS	40700	31026	8114	332	7435	329	18	72
DANA POINT - U	-	4745	1880	-	-	-	-	94
EL TORO - U	-	8654	2610	-	-	-	-	77
EL TORO STATION - U	-	6970	950	-	-	-	-	77
FOUNTAIN VALLEY	51100	31826	9064	450	8048	481	85	78
FULLERTON	92900	85826	27959	730	21971	4013	1245	62
GARDEN GROVE	119600	122524	36483	1212	28978	5622	671	72
HUNTINGTON BEACH	146400	115960	35922	2015	29685	3355	867	75
IRVINE	30850	-	-	-	-	-		76
LAGUNA HILLS - U	-	13676	8124	-	4222	4902	-	79
LAGUNA NIGUEL	-	4644	1695	-	-	-	-	88
LAGUNA BEACH	15150	14550	7625	-	6385	1235	5	87
LA HABRA	43800	41350	13081	228	10277	1948	628	58
LA PALMA	14750	9687	2539	-	-	-	-	65
LOS ALAMITOS	11750	11346	3270	154	2753	357	6	76
MISSION VIEJO - U	-	11933	3477	-	3471	6	-	80
NEWPORT BEACH	60300	49422	22180	689	18518	2521	452	85
ORANGE	86100	77374	23840	766	19824	2689	561	65
PLACENTIA	30250	21948	5886	280	5316	225	65	59
SAN CLEMENTE	20850	17063	7485	76	6401	1003	5	96
S J CAPISTRANO	11750	3781	1394	-	-	-	-	88
SANTA ANA	174800	156601	50040	1975	38679	1185	1598	70
SEAL BEACH	27300	24441	11820	144	4667	6949	60	83
S LAGUNA - U	-	2566	1486	-	-	-	-	91
STANTON	23250	17947	5481	542	3686	1003	250	72
TUSTIN	28050	21178	8738	547	4496	2170	1525	67
VILLA PARK	6200	2723	734	-	-	-	-	61
WESTMINSTER	69200	59865	17140	1681	13953	1336	170	66
YORBA LINDA	20700	11856	3417	9	3058	192	159	54

APPENDIX D (CONTINUED)

RIVERSIDE COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
BANNING	12000	12034	4687	312	4277	89	9	69
BEAUMONT	5950	5484	2175	-	-	-	-	61
CATHEDRAL CITY - U	-	3640	1810	-	-	-	-	113
COACHELLA	7950	8353	1971	-	-	-	-	139
CORONA	30400	27519	8473	280	7464	678	51	42
D. HOT SPRINGS	2920	3728	1832	-	-	-	-	98
ELSINORE	3800	3530	2017	-	-	-	-	70
GLEN AVON	-	5759	1924	-	-	-	-	34
HEMET	16700	12252	6101	1925	4065	200	11	76
HEMET E - U	-	8598	3055	-	-	-	-	80
HOME GARDENS - U	-	5116	1505	-	-	-	-	47
INDIAN WELLS	1400	-	-	-	-	-		124
INDIO	17900	14459	4405	234	3512	648	11	131
MIRA LOMA - U	-	8482	2999	-	-	-	-	34
NORCO	16250	14511	4022	53	3512	444	-	39
PALM DESERT	-	6171	3523	-	-	-	-	121
PALM SPRINGS	27350	20936	11949	1424	7833	2346	346	98
PERRIS	5025	4228	1364	-	-	-	-	60
RIVERSIDE	151400	140089	45867	634	39848	4726	659	36
RUBIDOUX - U	-	13969	4684	540	3824	278	42	35
SAN JACINTO	5025	4385	1813	-	-	-	-	73
SUN CITY - U	-	5519	3227	-	-	-	-	71
SUNNYMEAD - U	-	6708	2064	-	-	-	-	47

APPENDIX D (CONTINUED)

SAN BENITO COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
HOLLISTER	8575	-	2575	-	-	-	-	159
S J BAUTISTA	1170	-	-	-	-	-	-	166

SAN BERNARDINO COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
ADELANTO	2200	-	-	-	-	-		10
BARSTOW	18600	17442	5590	262	4746	571	11	79
BIG BEAR - U	-	5268	6843	-	-	-	-	61
BLOOMINGTON - U	-	11957	3528	144	3332	52	-	27
CHINO	26550	20411	4835	136	4450	244	5	35
COLTON	20300	19974	6536	33	5979	473	51	29
CREST FOREST -U	-	3509	4041	-	-	-	-	33
CUCAMONGA - U	-	5796	1625	-	-	-	-	24
FONTANA	23500	20673	6805	110	6283	387	25	21
FORT IRWIN - U	-	2991	652	-	-	-	-	60
GEORGE - U	-	7404	1310	-	-	-	-	38
GRAND TERRACE - U	-	5901	1852	-	-	-	-	50
HESPERIA - U	-	4592	1888	-	-	-	-	23
HIGHLAND	-	12669	3815	140	3458	183	34	33
L ARROWHEAD - U	-	2682	3593	-	-	-	-	30
LENWOOD - U	-	3834	1119	-	-	-	-	74
LOMA LINDA - U	-	9797	3672	-	-	-	-	36
MONTCLAIR	22200	22546	6636	314	5289	962	71	30
MUSCOY - U	-	7091	2443	-	-	-	-	23
ONTARIO	64400	64118	20867	675	18272	1538	382	30
REDLANDS	37500	36355	11836	172	10487	919	258	38
RIALTO	31700	28370	8538	427	7840	267	4	24
SAN BERNARDINO	106300	104251	36385	1293	30919	3733	440	27
29 PALMS - U	-	5667	2489	-	-	-	-	134
29 PALMS BASE - U	-	5647	861	-	-	-	-	135
UPLAND	38400	32551	10610	176	10369	45	20	28
VICTORVILLE	12650	10845	3594	245	3113	236	-	32
YUCAIPA - U	-	19281	8529	2341	5885	201	12	52
YUCCA VALLEY - U	-	3893	2094	-	-	-	-	100

APPENDIX D (CONTINUED)

SAN DIEGO COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
CARLSBAD	20000	14944	5150	222	4074	798	56	127
ESCONDIDO	48050	36792	13606	1905	10197	1449	55	136
OCEANSIDE	54900	40494	14604	1240	8636	1828	185	122
SAN MARCOS	9400	-	1399	-	-	-	-	132
VISTA	28600	24866	8672	920	7198	554	-	124

APPENDIX D (CONTINUED)

SAN LUIS OBISPO COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
ARROYO GRANDE	8525	7454	2450	-	-	-	-	72
ATASCADERO - U	-	10290	3047	168	2766	113	-	44
BAYWOOD-LOS OSOS - U	-	3487	1517	-	-	-	-	66
EL PASO ROBLES	8050	7168	2660	-	-	-	-	36
GROVER CITY	7325	5939	2269	-	-	-	-	73
MORRO BAY	8875	7109	3451	-	-	-	-	63
NIPOMO - U	-	3642	974	-	-	-	-	60
OCEANO - U	-	2564	956	-	-	-	-	67
PISMO BEACH	4850	4043	2008	-	-	-	-	72
SAN LUIS OBISPO	34550	28036	9968	564	7328	1943	133	59

APPENDIX D (CONTINUED)

SANTA BARBARA COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
CARPINTERIA	10200	6982	2433	-	-	-	-	58
E ENCANTO H - U	-	6225	1779	-	-	-	-	68
GUADALUPE	3230	3145	901	-	-	-	-	73
LOMPOC	25450	25284	7991	397	6260	1334	-	90
LOMPAC N - U	-	2699	716	-	-	-	-	88
LOMPAC NW - U	-	4874	1413	-	-	-	-	91
SANTA BARBARA	74000	70215	29566	477	20146	8064	879	62
SANTA MARIA	34250	32749	10803	466	9040	1096	201	65
SANTA MARIA SOUTH - U	-	7129	1900	-	-	-	-	69
VANDENBURG - U	-	13193	2552	384	2134	34	-	85

APPENDIX D (CONTINUED)

TULARE COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
CUTLER - U	-	2503	637	-	-	-	-	125
DINUBA	8850	7917	2623	-	-	-	-	120
EARLIMART - U	-	3080	897	-	-	-	-	82
E PORTERVILLE - U	-	4042	1243	-	-	-	-	112
EXETER	4970	4475	1675	-	-	-	-	122
FARMERSVILLE	3780	3456	1081	-	-	-	-	116
LINDSAY	5625	5206	1944	-	-	-	-	118
PORTERVILLE	14350	12602	3921	42	3399	438	42	112
PORTERVILLE NW U	-	2517	759	-	-	-	-	112
PORTERVILLE W U	-	6200	1974	-	-	-	-	112
OROSI - U	-	2757	705	-	-	-	-	127
TULARE	18100	16235	5458	124	5095	239	-	100
VISALIA	34750	27268	9520	337	8276	763	144	111
WOODLAKE	3800	3371	1009	-	-	-	-	130

APPENDIX D (CONTINUED)

VENTURA COUNTY

CITY	1975 POP.	1970 POP.	1970 HOUSING UNITS: TOTAL	MOBILE HOMES	1-4 UNITS	5-49 UNITS	MORE THAN 50 UNITS	DIST. (KM)
CAMARILLO	24800	19219	5530	14	4800	475	241	66
EL RIO - U	-	6173	2660	-	-	-	-	67
FILLMORE	7750	6285	1935	-	-	-	-	43
MOORPARK - U	-	3380	908	-	-	-	-	54
OAK VIEW - U	-	4872	1519	-	-	-	-	52
OJAI	5850	5591	1983	-	-	-	-	45
OXNARD	85100	71225	20640	1058	15767	3346	469	72
PORT HUENEME	17750	14295	4143	62	3321	691	69	78
SANTA PAULA	18250	18001	5763	526	4839	361	37	52
SIMI VALLEY	69100	56464	13989	231	13703	55	-	53
THOUSAND OAKS	53700	36334	10452	221	9534	474	223	64
VENTURA	62900	55797	19963	536	16424	2237	746	64

APPENDIX E

Classification of Dams within State Jurisdiction
and
Classification of Dams within Federal Jurisdiction

TABLE E-1

CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION

FRESNO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10³ 20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	VOLUME IN CUBIC METRES X 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity	2			2				1	1						2				
Constant Radius Arch	8		7	1	3	3	2				3	2	2		1				
Variable Radius Arch																			
Multiple Arch	1			1				1						1					
Earth	7	3	2	2		3	3		2				1	2	2		1	1	
Earth and Rock	1		1																
Rock Fill	2			2					2								2		
Hydraulic Fill																			
Flashboard & Buttress	3	3			1	1	1												
Slab & Buttress											2								1
Crib																			
Reinforced Conc Tank																			
TOTALS	24	6	10	8	4	7	6	2	5		5	2	3	3	5		3	1	1
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

KERN COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10³ 20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	VOLUME IN CUBIC METRES X 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity	1	1			1						1								
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth																			
Earth and Rock	10	9	1			5	2	2	1				1	3	3	3			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	11	10	1		1	5	2	2	1		1		1	3	3	3			
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-1 (Continued)

CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION

KINGS COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-6	6-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth																			
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress	6	6			3	3						1	1	1					3
Slab & Buttress	1	1			1							1							
Crib																			
Reinforced Conc Tank																			
TOTALS	7	7			4	3						2	1	1					3
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

LOS ANGELES COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-6	6-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity	6	1	3	2		2	3	1					4		1	1			
Constant Radius Arch	4	1	3		2	2					3			1					
Variable Radius Arch	3			3		1	1	1						2	1				
Multiple Arch	2		1	1			2						2						
Earth	48	18	21	9	13	22	7	5	1		1	2	12	7	9	5	7	2	3
Earth and Rock	4	1	1	2	2	1		1	1				1	1	1			1	
Rock Fill	2			2				1									1	1	
Hydraulic Fill	7	1	6		1	1	4	1							3	3	1		
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank	7	6	1		6	1						4	2						1
TOTALS	83	28	36	19	24	30	17	10	2		4	6	21	11	15	9	9	4	4
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-1 (Continued)

CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION

MONTEREY COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10^3 20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	VOLUME IN CUBIC METRES X 10^3 Under 4	4-6	6-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity																			
Constant Radius Arch												1							
Variable Radius Arch	1		1				1												
Multiple Arch																			
Earth	4	1	2	1	1	1	2								1		1		2
Earth and Rock	1		1		1								1						
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	6	1	4	1	2	1	3					1	1		1		1		2
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000-& Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

ORANGE COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10^3 20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	VOLUME IN CUBIC METRES X 10^3 Under 4	4-6	6-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	27	7	17	3	7	11	8	1			1		7	1	9	5	3		1
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank	2	1		1	2														2
TOTALS	29	8	17	4	9	11	8	1			1		7	1	9	5	3		3
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000-& Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-1 (Continued)

CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION

RIVERSIDE COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity	1		1					1					1						
Constant Radius Arch																			
Variable Radius Arch	2		1	1				2					2						
Multiple Arch																			
Earth	20	13	6	1	4	11	4		1			1	6	7	1	2		3	
Earth and Rock																			
Rock Fill																			
Hydraulic Fill	1		1			1									1				
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	24	13	9	2	4	12	4	3	1			1	9	7	2	2		3	
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99,999	100,000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5,000 & Over	

SAN BENITO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	6	5	1			4	1	1					1	2	1	1			
Earth and Rock																			
Rock Fill																			
Hydraulic Fill	1		1			1								1					
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	7	5	2			5	1	1					1	3	1	1			
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99,999	100,000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-1 (Continued)

CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION

SAN BERNARDINO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10³ 20-120	120-1,200	1,200-12,000	12,000-120,000	120,000 & Over	○	VOLUME IN CUBIC METRES X 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch	1	1			1						1								
Multiple Arch	2		2			1		1			2								
Earth	16	10	4	2	9	5	2					1	6	3	3		1	1	1
Earth and Rock																			
Rock Fill	4	3		1	2	1		1					1		2		1	1	
Hydraulic Fill	1							1											
Flashboard & Buttress	-																		
Slab & Buttress																			
Crib																			
Reinforced Conc Tank	1				1														1
TOTALS	25	14	6	3	13	7	2	3			3	1	7	3	5		2	2	2
		HEIGHT IN FEET 6-49	50-147	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

SAN DIEGO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10³ 20-120	120-1,200	1,200-12,000	12,000-120,000	120,000 & Over	○	VOLUME IN CUBIC METRES X 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity																			
Constant Radius Arch	1	1			1														
Variable Radius Arch	1		1			1											1		
Multiple Arch	1		1					1					1	1					
Earth	11	3	6	2	3	5	2	1					3	1	1	1	2		3
Earth and Rock	1		1				1								1				
Rock Fill																			
Hydraulic Fill	1		1						1							1			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	16	4	10	2	4	6	3	2	1				4	2	2	2	3		3
		HEIGHT IN FEET 6-49	50-147	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-1 (Continued)

CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION

SAN LUIS OBISPO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	11	4	5	2	1	7		2	1			1	3	1	3		3		
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	11	4	5	2	1	7		2	1			1	3	1	3		3		
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

SANTA BARBARA COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch	1			1				1						1					
Variable Radius Arch	1		1				1						1						
Multiple Arch																			
Earth	6	2	4		1	4	1						2	2	2				
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	5	2	5	1	1	4	2	1					3	3	2				
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-1 (Continued)

CLASSIFICATION OF DAMS WITHIN STATE JURISDICTION

TULARE COUNTY																			
TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity	3	3				3													3
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	2	1	1		1	1								1					1
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	5	4	1		1	4								1					4
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1,000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99,999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1,000-5,000	5,000 & Over	

VENTURA COUNTY																			
TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch	1	1					1												1
Variable Radius Arch	2	1		1		1	1				1		1						
Multiple Arch																			
Earth	8	4	3	1	3	3		1	1			1	2	1	1		2		1
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	11	6	3	2	3	4	2	1	1		1	1	3	1	1		2		2
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1,000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99,999	100,000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-2

CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION

FRESNO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1,200	1,200-12,000	12,000-120,000	120,000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity	2			2					2								2		
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch	1		1				1												1
Earth	2	1	1				1	1									2		
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	5	1	2	2			2	1	2								4		1
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1,000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

KERN COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1,200	1,200-12,000	12,000-120,000	120,000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	1			1					1								1		
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	1			1					1								1		
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1,000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-2 (Continued)

CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION

KINGS COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth																			
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	0																		
		HEIGHT IN FEET			CAPACITY IN ACRE FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5,000 & Over	

LOS ANGELES COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch	1		1			1						1							
Variable Radius Arch																			
Multiple Arch																			
Earth	6		5	1		1	5								1		2	3	
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	7		6	1		2	5					1			1		2	3	
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5 000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-2 (Continued)

CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION

MONTEREY COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES x 10³						VOLUME IN CUBIC METRES x 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth																			
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	0																		
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1,000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000 & Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5,000 & Over	

ORANGE COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES x 10³						VOLUME IN CUBIC METRES x 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	3	1	2			1		1	1						1		1	1	
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	3	1	2			1		1	1						1		1	1	
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1,000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000 & Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-2 (Continued)

CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION

RIVERSIDE COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10³ 20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	VOLUME IN CUBIC METRES X 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	2	1	1				1		1						1	1			
Earth and Rock	1	1								1				1					
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	3	2	1				1		1	1				1	1	1			
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1 000-9 999	10 000-99 999	100 000 & Over		VOLUME IN 1 000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

SAN BENITO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES X 10³ 20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	VOLUME IN CUBIC METRES X 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth																			
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	0																		
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1 000-9 999	10 000-99 999	100 000 & Over		VOLUME IN 1 000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-2 (Continued)

CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION

SAN BERNARDINO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES x 10³						VOLUME IN CUBIC METRES x 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch	1		1						1								1		
Multiple Arch																			
Earth	2	1		1			1			1						1		1	
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	3	1	1	1			1		1	1						1	1	1	
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

SAN DIEGO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES x 10³						VOLUME IN CUBIC METRES x 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000-& Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth																			
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	0																		
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9 999	10 000-99 999	100 000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1 000-5 000	5 000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-2 (Continued)

CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION

SAN LUIS OBISPO COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch	1			1				1						1					
Multiple Arch																			
Earth																			
Earth and Rock																			
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	1			1				1						1					
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9,999	10 000-99,999	100,000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1,000-5 000	5,000 & Over	

SANTA BARBARA COUNTY

TYPES	Number of Dams	HEIGHT IN METRES			CAPACITY IN CUBIC METRES X 10³						VOLUME IN CUBIC METRES X 10³								
		2-15	15-45	45-Up	20-120	120-1 200	1 200-12 000	12 000-120 000	120 000 & Over	○	Under 4	4-8	8-38	38-76	76-380	380-760	760-3 800	3 800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	5	2	2	1	2	2			1				1		2	1		1	
Earth and Rock	1			1					1									1	
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	6	2	2	2	2	2			2				1		2	1		2	
		HEIGHT IN FEET			CAPACITY IN ACRE-FEET						VOLUME IN 1 000-CUBIC YARDS								
		6-49	50-149	150-Up	15-99	100-999	1 000-9,999	10 000-99,999	100,000-& Over		Under 5	5-10	10-50	50-100	100-500	500-1 000	1,000-5 000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

TABLE E-2 (Continued)

CLASSIFICATION OF DAMS WITHIN FEDERAL JURISDICTION

TULARE COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES x 10³ 20-120	120-1,200	1,200-12,000	12,000-120,000	120,000 & Over	○	VOLUME IN CUBIC METRES x 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	1		1					1										1	
Earth and Rock	1			1					1									1	
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	2		1	1				1	1									2	
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

VENTURA COUNTY

TYPES	Number of Dams	HEIGHT IN METRES 2-15	15-45	45-Up	CAPACITY IN CUBIC METRES x 10³ 20-120	120-1,200	1,200-12,000	12,000-120,000	120,000 & Over	○	VOLUME IN CUBIC METRES x 10³ Under 4	4-8	8-38	38-76	76-380	380-760	760-3,800	3,800 & Over	◇
Gravity																			
Constant Radius Arch																			
Variable Radius Arch																			
Multiple Arch																			
Earth	1			1					1									1	
Earth and Rock	1	1			1								1						
Rock Fill																			
Hydraulic Fill																			
Flashboard & Buttress																			
Slab & Buttress																			
Crib																			
Reinforced Conc Tank																			
TOTALS	2	1		1	1				1				1					1	
		HEIGHT IN FEET 6-49	50-149	150-Up	CAPACITY IN ACRE-FEET 15-99	100-999	1,000-9,999	10,000-99,999	100,000 & Over		VOLUME IN 1,000-CUBIC YARDS Under 5	5-10	10-50	50-100	100-500	500-1,000	1,000-5,000	5,000 & Over	

○ Capacity not specified ◇ Volume not specified

APPENDIX F

Detailed Structure Information for Los Angeles Area*

*Data in this appendix were taken from U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, *A Study of Earthquake Losses in the Los Angeles, California, Area*, 1973.

TABLE F-1

MULTISTORY BUILDING INVENTORY FOR SELECTED CONGESTED AREAS

Construction Material by Story Height	City**									
	Los Angeles (1970)		Long Beach (1969)		Pasadena (1963)		Santa Monica (1963)		Santa Ana (1964)	
	No. of Buildings	Floor Area*	No. of Buildings	Floor Area*	No. of Buildings	Floor Area*	No. of Buildings	Floor Area*	No. of Buildings	Floor Area*
Concrete:										
4-8 stories	367	28,648	34	1,625	22	2,000	11	589	6	286
9-13 stories	100	14,039	10	902	7	693	6	592	4	413
14-up stories	7	1,650	1	144	1	77	1	70	0	0
Steel frame:										
4-8 stories	115	10,752	8	632	10	1,251	9	708	1	74
9-13 stories	140	26,392	10	1,535	4	672	8	841	7	781
14-up stories	44	20,095	5	1,833	1	35	8	996	0	0
***Brick:										
4-8 stories	584	20,893	20	609	10	837	15	635	3	168
9-13 stories	6	614	0	8	0	8	0	8	0	12
14-up stories	0	0	0	0	0	0	0	0	0	0
Mixed construction:										
4-8 stories	8	466	1	24	0	18	0	2	0	2
9-13 stories	1	360	0	8	0	8	0	8	0	12
14-up stories	0	0	0	0	0	0	0	0	0	0
Totals	1,372	123,909	89	7,320	55	5,599	58	4,449	21	1,748

*In thousands of square feet.

**Original figures compiled from Sanborn Maps, current to but not including year indicated for each city. Figures extended using Security Bank data.

***Reinforced and non-reinforced brick walls.

TABLE F-2
AQUEDUCTS CROSSING
SAN ANDREAS AND SAN JACINTO FAULTS

Aqueduct	Owner*	Location (Fault)	Description
Owens Valley	LADWP	Lake Elizabeth (San Andreas)	Unreinforced concrete tunnel, 250 feet deep.
Colorado River	MWD	Near Whitewater (San Andreas - Mission Creek)	Shallow buried reinforced concrete box.
Colorado River	MWD	Near San Jacinto (San Jacinto)	Part in open channel and part in shallow buried steel pipe with some flexibility.
California Water	CDWR	Near Quail Lake (San Andreas)	Open channel.
California Water	CDWR	Near Palmdale (San Andreas)	2 places, in open channel.
California Water	CDWR	Nr. San Bernardino (San Andreas)	Steel pipe.

Source: Information furnished by respective utilities.

*LADWP: Los Angeles Department of Water and Power.
MWD: Metropolitan Water District.
CDWR: California Department of Water Resources.

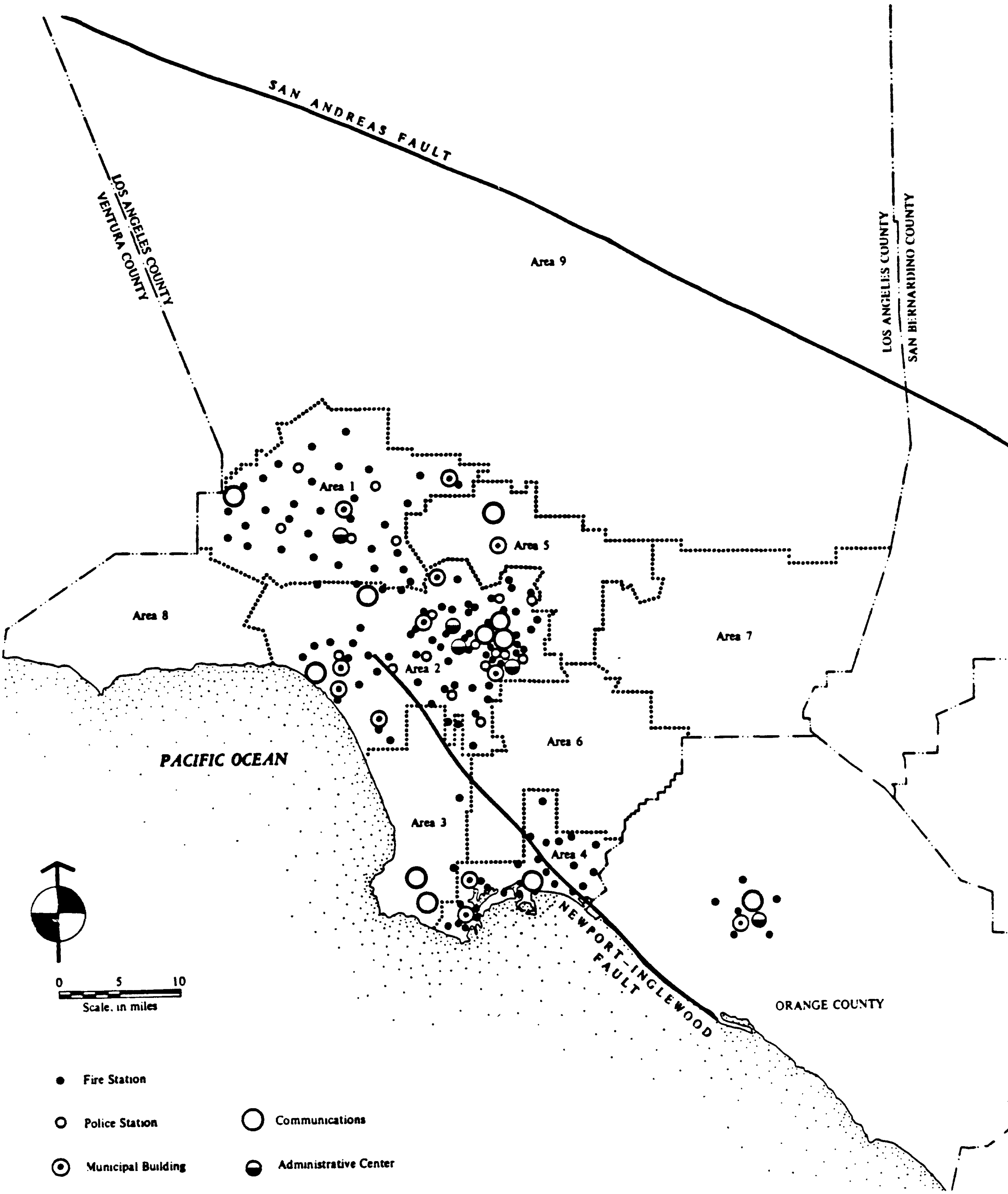

FIGURE F-1 MUNICIPAL BUILDINGS IN CITIES OF LOS ANGELES, LONG BEACH, AND SANTA ANA. (ONE DOT MAY REPRESENT MORE THAN ONE FACILITY.)

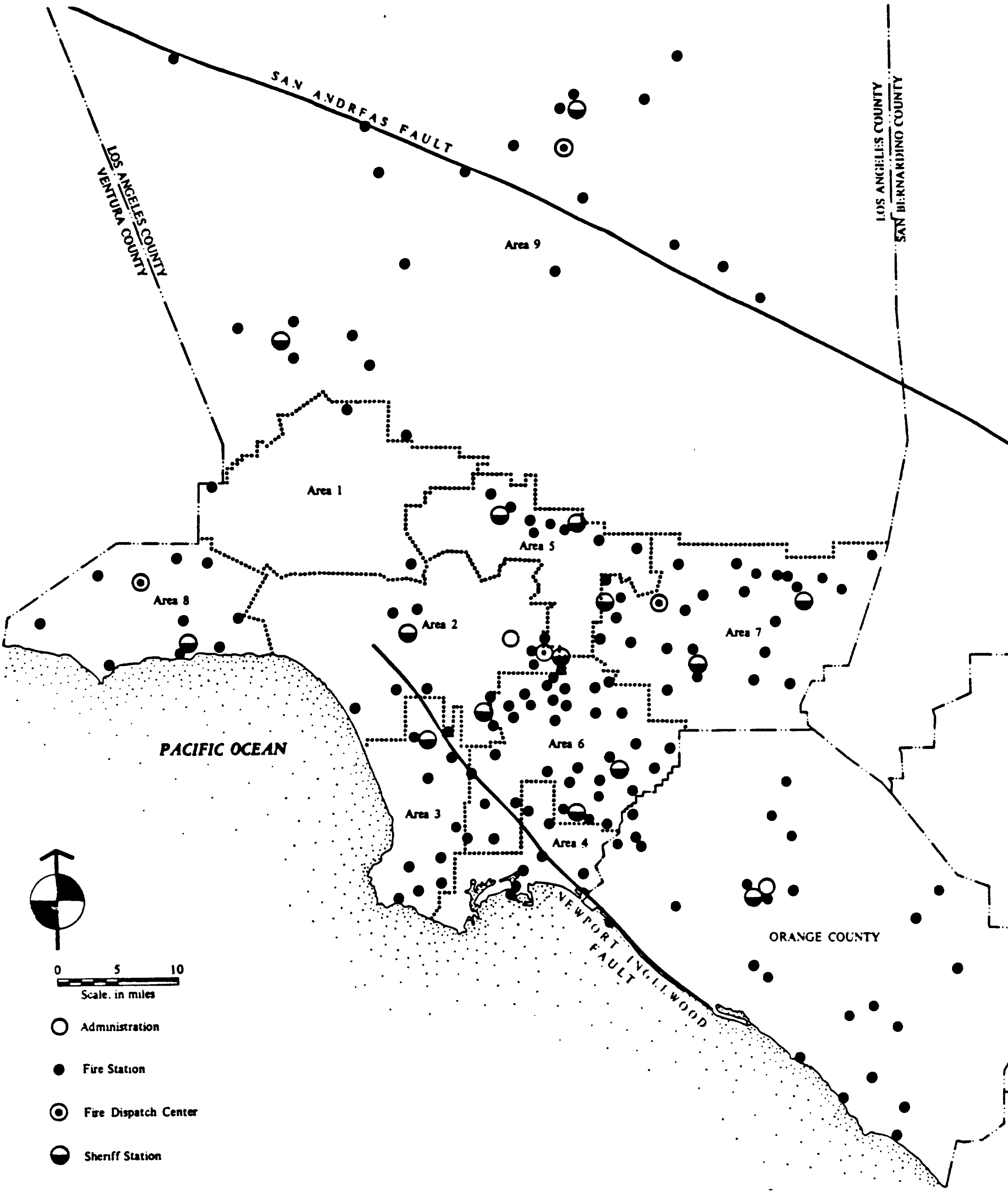

FIGURE F-2 SELECTED COUNTY BUILDINGS. (ONE DOT MAY REPRESENT MORE THAN ONE FACILITY.)

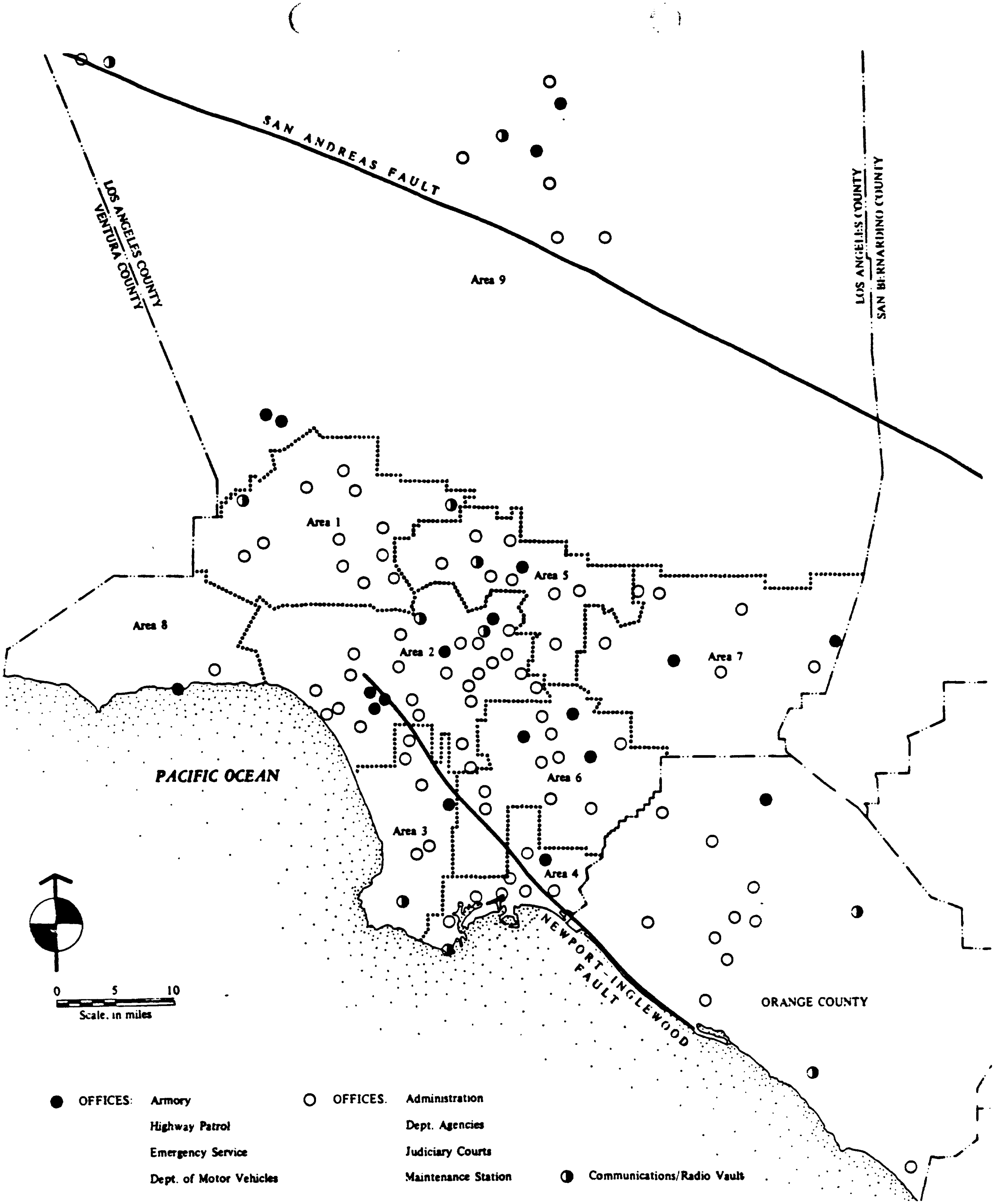

FIGURE F-3 IMPORTANT AND MAJOR STATE BUILDINGS. (ONE DOT MAY REPRESENT MORE THAN ONE FACILITY.)

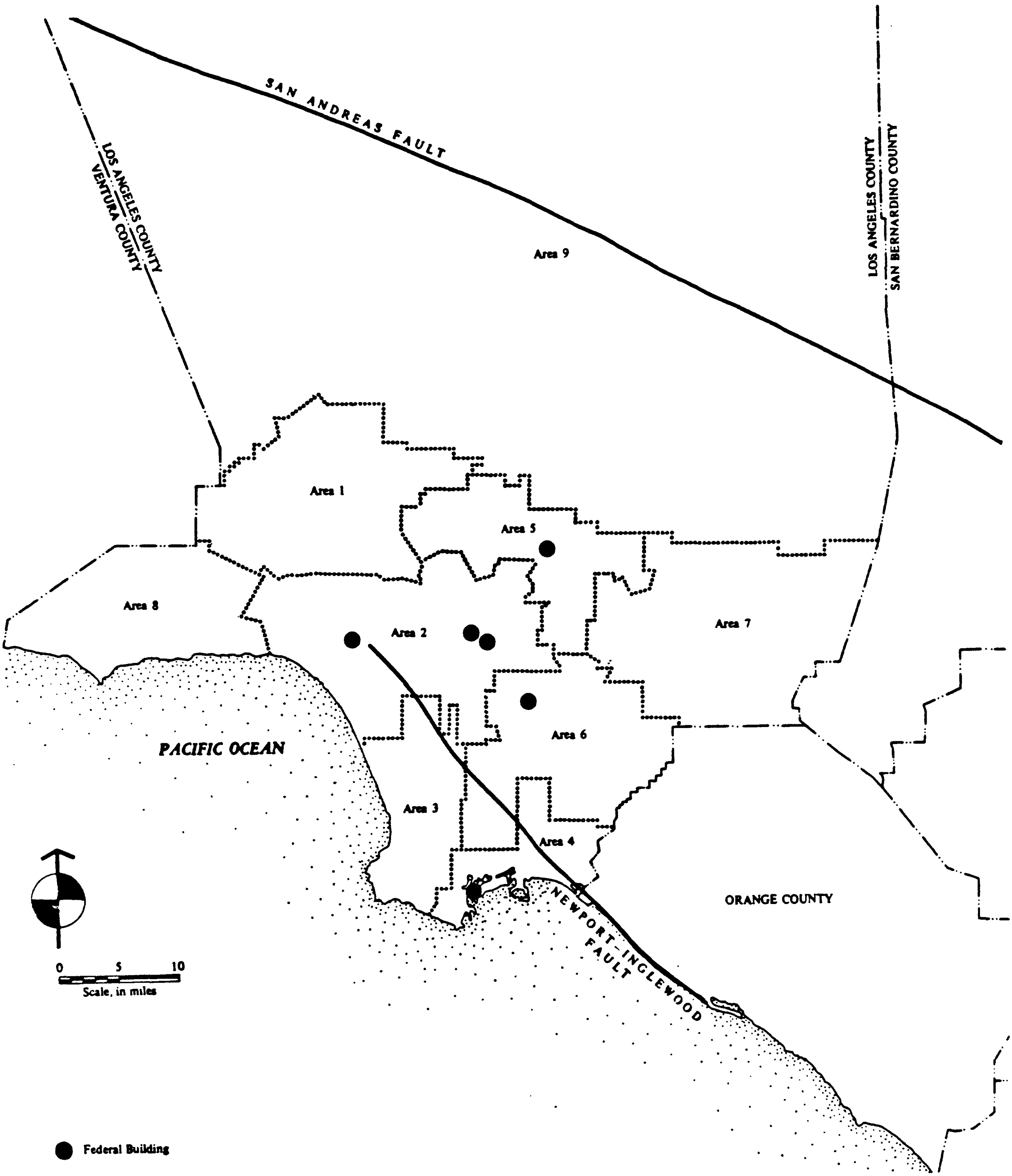

FIGURE F-4 MAJOR FEDERALLY OWNED BUILDINGS. (ONE DOT MAY REPRESENT MORE THAN ONE FACILITY.)

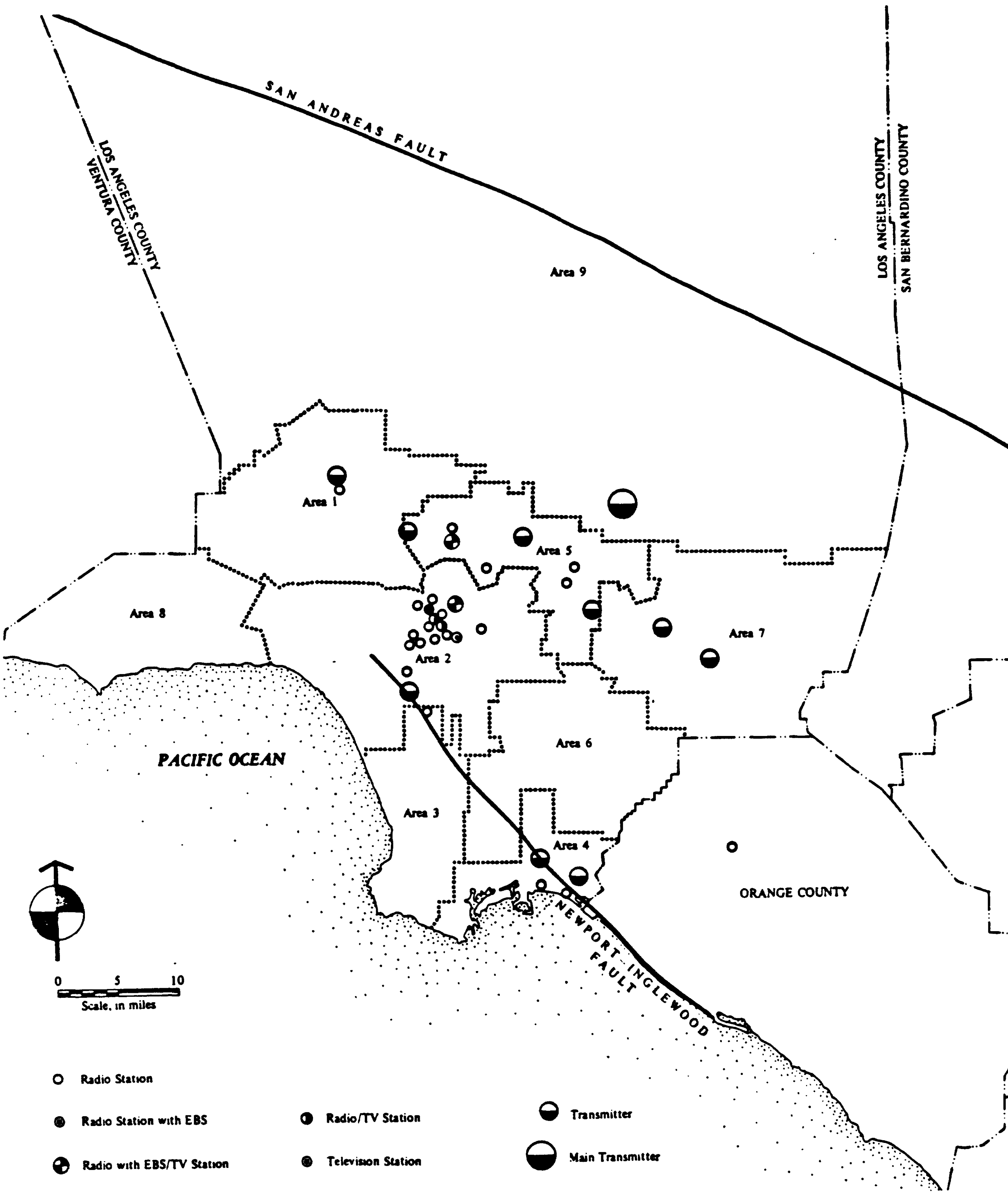

FIGURE F-5 MAJOR RADIO AND TV FACILITIES. (ONE DOT MAY REPRESENT MORE THAN ONE FACILITY.)

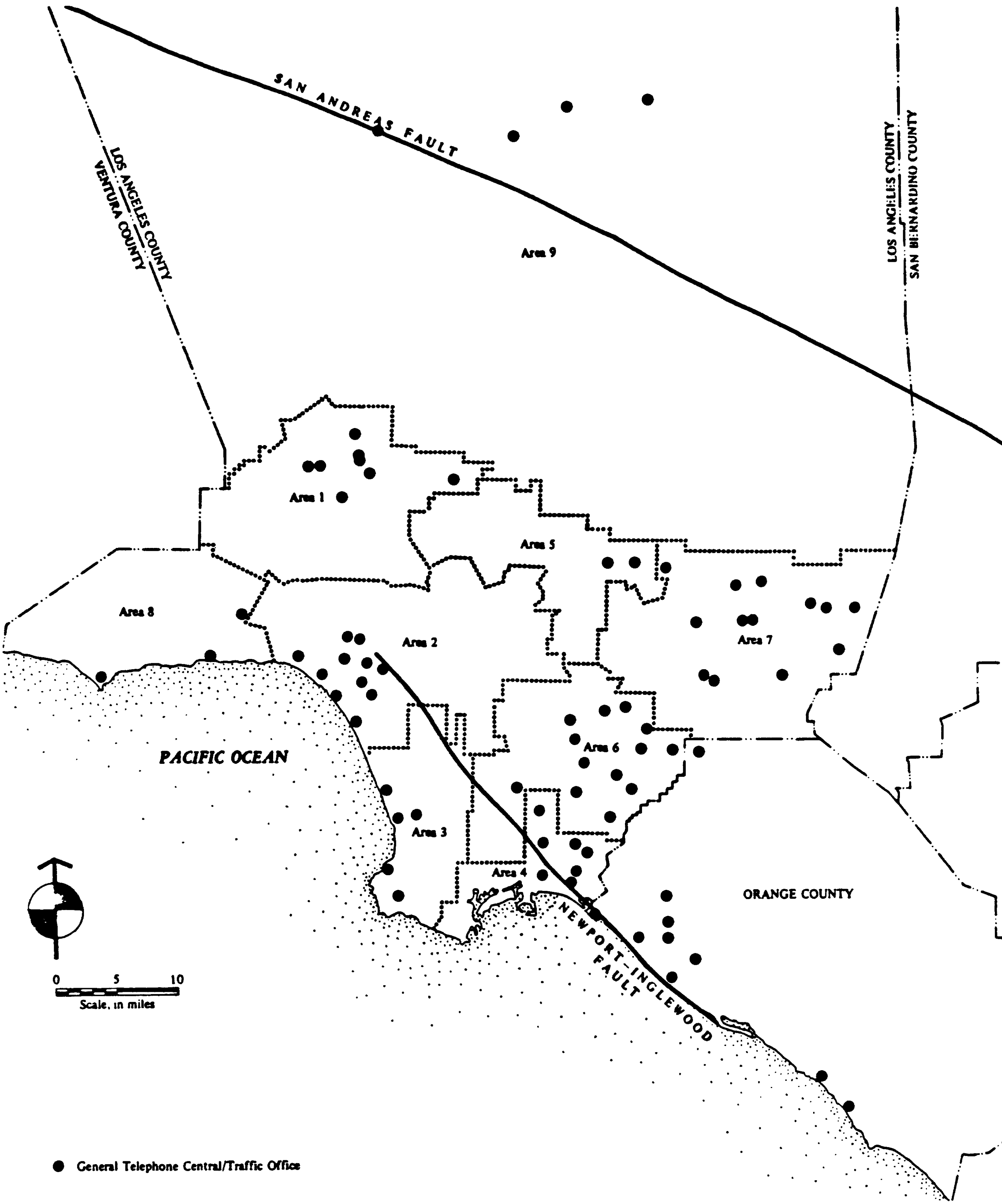

FIGURE F-6 SELECTED TELEPHONE FACILITIES. (ONE DOT MAY REPRESENT MORE THAN ONE FACILITY.)

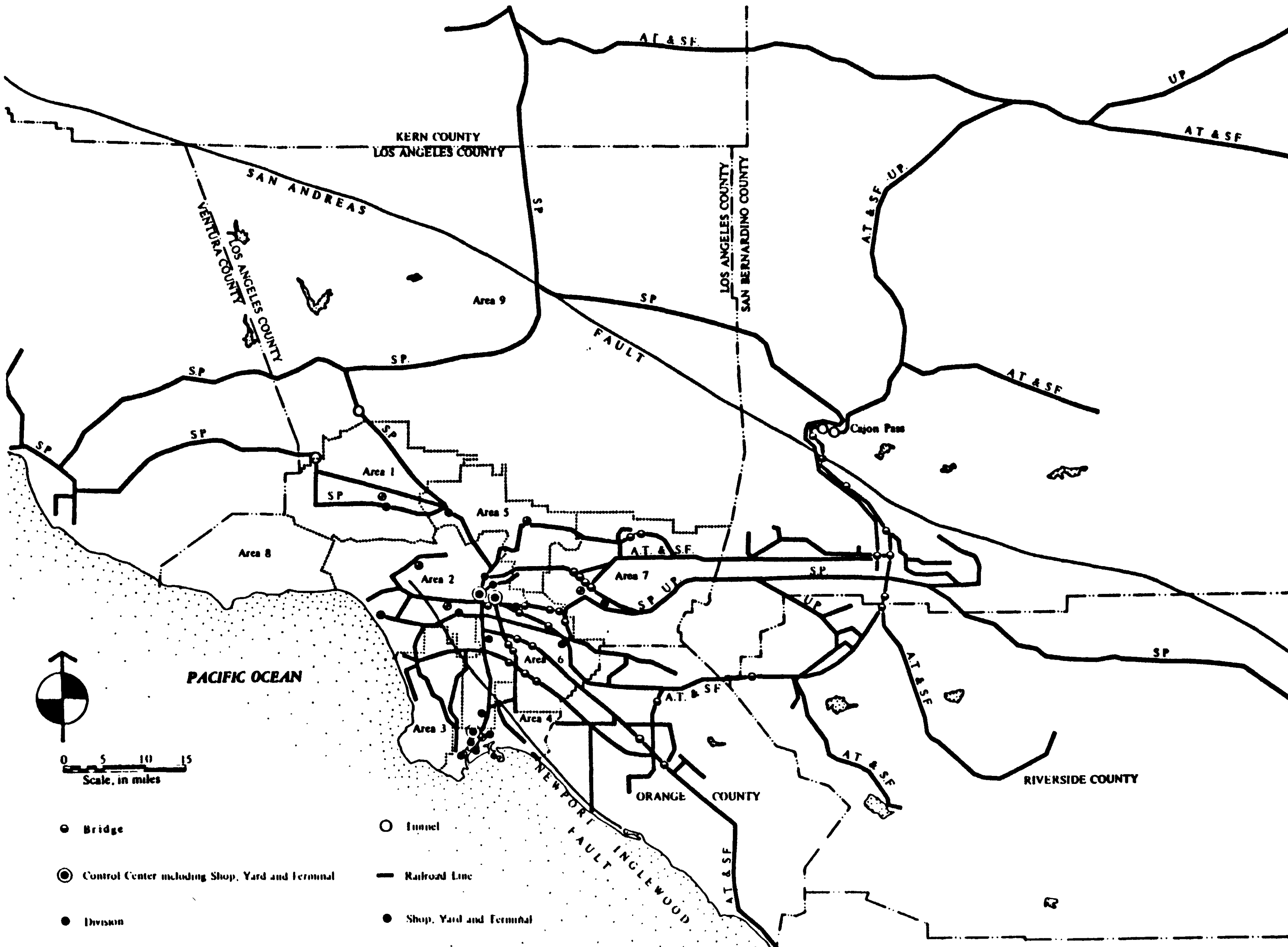

FIGURE F-7 MAJOR RAILROAD LINES AND FACILITIES. NOT ALL BRIDGES AND TUNNELS SHOWN IN AREAS 2, 4, AND 6. (ONE DOT MAY REPRESENT MORE THAN ONE FACILITY.)

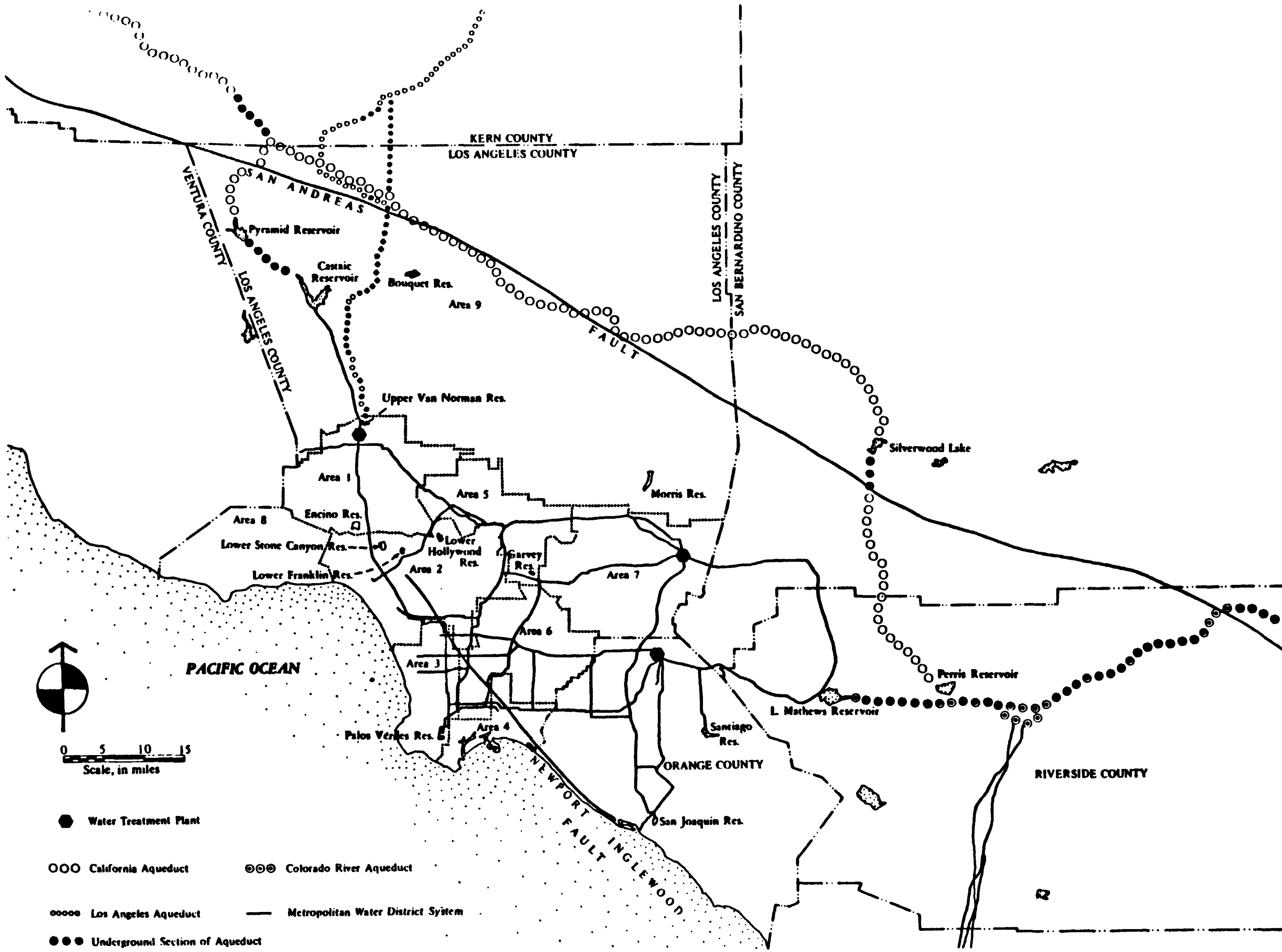

FIGURE F-8 MAJOR AQUEDUCTS SUPPLYING METROPOLITAN LOS ANGELES. ALSO SHOWN ARE MAJOR LINES OF THE METROPOLITAN WATER DISTRICT.

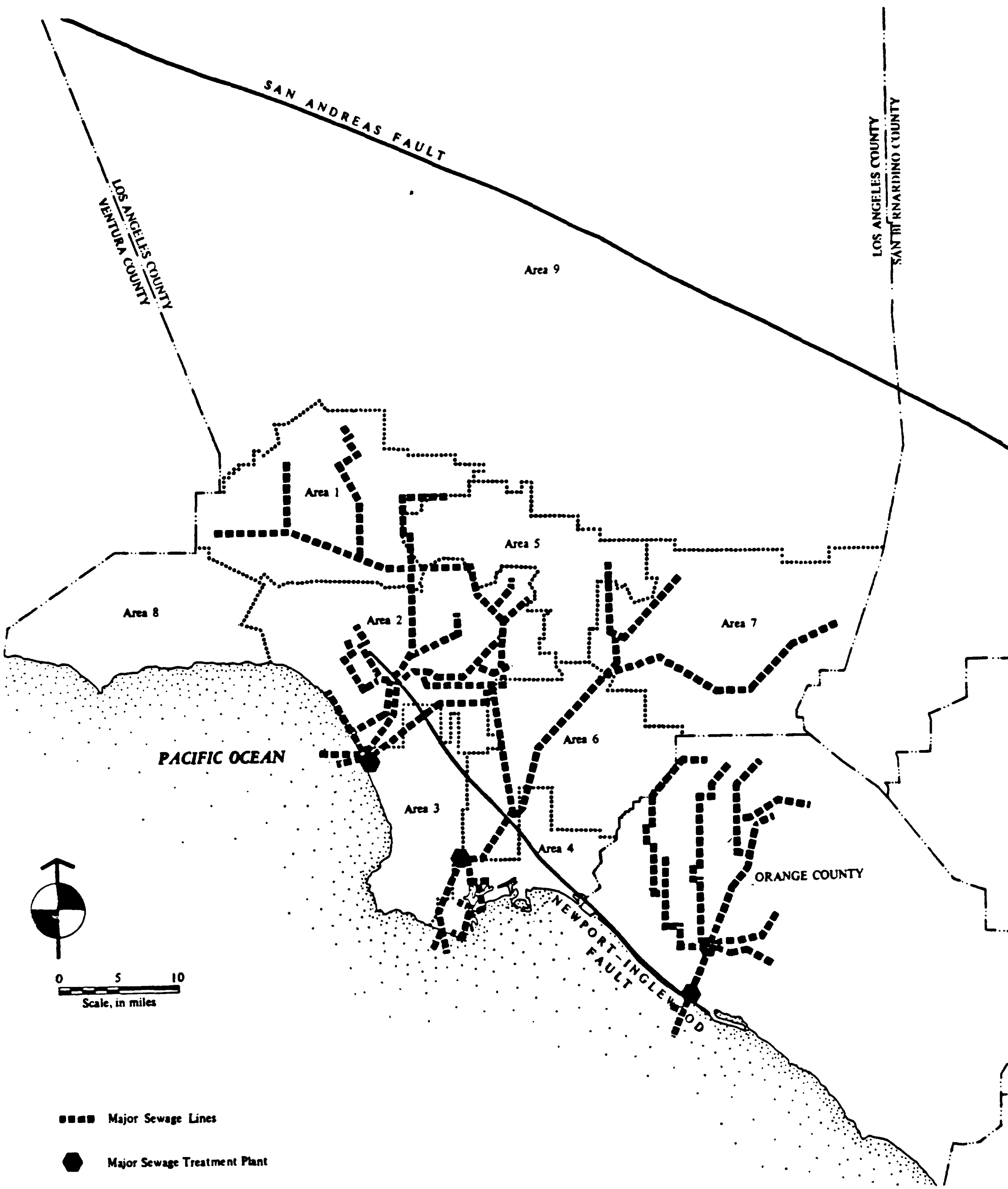

FIGURE F-9 MAJOR SEWAGE LINES, OUTFALLS, AND TREATMENT PLANTS.

APPENDIX G

Population and EI Distribution
for Cities of the Study Area

APPENDIX G

FRESNO COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
CALWA - U	-	5191	3,4,4	4-
CLOVIS	20750	13856	3,4,4	4-
COALINGA	6175	6161	4,5,5	5-
FIREBAUGH	3420	2517	3,4,4	4-
FOWLER	2250	-	3,4,4	4-
FRESNO	175900	165972	3,4,4	4-
HURON	2140	-	4,5,5	5-
KERMAN	3370	2667	3,4,4	4-
KINGSBURG	4380	3843	3,4,4	4-
MENDOTA	3470	2705	3,4,4	4-
ORANGE COVE	3720	3392	3,3,3	3
PARLIER	2130	-	3,4,4	4-
REEDLEY	9100	8131	3,4,4	4-
SANGER	10250	10088	3,4,4	4-
SAN JOAQUIN	1660	-	3,4,4	4-
SELMA	8325	7459	3,4,4	4-

APPENDIX 6 (CONTINUED)

KERN COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
ARVIN	5325	5199	4,5,4	4+
BAKERSFIELD	76400	69515	4,5,5	5-
DELANO	15250	14559	3,5,4	4
EDWARD - U	-	10331	4,5,4	4+
LAMONT - U	-	7007	4,5,4	4+
MARICOPA	700	-	5,7,7	6+
MCFARLAND	4310	4177	3,4,4	4-
MOJAVE - U	-	2573	4,5,5	5-
OILDALE - U	-	20897	4,5,4	4+
SHAFTER	6050	5327	4,6,5	5
TAFT	4160	4285	5,7,7	6+
TEHACHAPI	4200	4211	4,5,6	5
WASCO	8625	8269	4,6,5	5

APPENDIX G (CONTINUED)

KINGS COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
AVENAL - U	-	3035	4,6,6	5+
CORCORAN	5700	5249	3,5,4	4
HANFORD	17750	15179	3,5,4	4
LEMOORE	5475	4219	3,5,4	4
LEMOORE STATION - U	-	9210	3,5,4	4

APPENDIX G (CONTINUED)

LOS ANGELES COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
ALHAMBRA	60500	62125	4,5,5	5-
ALONDRA PARK - U	-	12193	3,5,5	4+
ALTADENA - U	-	42415	4,5,5	5-
ARCADIA	46400	42868	4,6,5	5
ARTESIA	15200	14757	3,5,5	4+
AVALON	1510	-	3,4,3	3+
AVOCADO HEIGHTS - U	-	9800	4,5,5	5-
AZUSA	25600	25217	4,6,5	5
BALDWIN PARK	43650	47285	4,6,5	5
BELL	21250	21836	4,5,5	5-
BELLFLOWER	51700	51454	3,5,5	4+
BELL GARDENS	27300	29308	4,5,5	5-
BEVERLY HILLS	32400	33416	4,5,5	5-
BRADBURY	830	-	4,6,6	5+
BURBANK	85000	88871	4,5,5	5-
CARSON	78300	71150	4,5,5	5-
CERRITOS	41400	15856	4,5,5	5-
CLAREMONT	24950	23464	4,6,6	5+
COMMERCE	9825	10536	4,5,4	4+
COMPTON	68700	78611	4,5,5	5-
COVINA	32750	30380	4,6,5	5
CUDAHY	16250	16998	4,5,5	5-
CULVER CITY	37700	31035	4,5,5	5-
DIAMOND BAR - U	-	12234	4,5,4	4+
DOMINGUEZ - U	-	5980	4,5,5	5-
DOWNEY	85900	88445	4,5,5	5-
DUARTE	14900	14981	4,5,5	5-
E LA MIRADA - U	-	12339	4,5,4	4+
E COMPTON - U	-	5853	3,5,5	4+
E LOS ANGELES - U	-	105033	4,5,5	5-
EL MONTE	66600	69837	4,5,5	5-
EL SEGUNDO	15400	15620	3,5,5	4+
FLORENCE-GRAHAM - U	-	42900	4,5,5	5-
GARDENA	44350	41021	3,5,5	4+
GLENDALE	132700	132752	4,5,5	5-
GLENDORA	32700	31349	4,6,5	5
HACIENDA HEIGHTS - U		35969	4,5,5	5-
HAWAIIAN GARDENS	9550	9052	3,5,5	4+
HAWTHORNE	56000	53304	3,5,5	4+
HERMOSA BEACH	19050	17412	3,5,4	4
HIDDEN HILLS	1550	-	3,4,4	4-
HUNTINGTON PARK	32000	33744	4,5,5	5-
INDUSTRY	600	-	4,5,5	5-

APPENDIX G (CONTINUED)

LOS ANGELES COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
INGLEWOOD	86000	89985	3,5,5	4+
IRWINDALE	740	-	4,6,5	5
LA CANADA-FLINTRIDGE - U	-	20714	4,5,5	5-
LA CRECENTA - U	-	19620	4,6,5	5
LADERA HEIGHTS - U	-	6535	3,5,5	4+
LANCASTER - U	-	30948	5,7,7	6+
LAKEWOOD	81200	82973	3,5,5	4+
LA MIRADA	38800	30808	4,5,4	4+
LAPUENTE	29600	31092	4,5,5	5-
LA VERNE	17350	12965	4,6,6	5+
LAWNDALE	23750	24825	3,5,5	4+
LENNOX - U	-	16121	3,5,5	4+
LOMITA	19350	19784	3,5,4	4
LONG BEACH	339600	358633	3,5,4	4
LOS ANGELES	2720600	2816061	4,5,5	5-
LYNWOOD	38250	43353	4,5,5	5-
MANHATTAN BEACH	33600	35352	3,5,5	4+
MAYWOOD	16600	16996	4,5,5	5-
MONROVIA	29000	30015	4,5,5	5-
MONTEBELLO	45650	42807	4,5,5	5-
MONTEREY PARK	48350	49166	4,5,5	5-
NEWHALL - U	-	6951	4,6,6	5+
NORWALK	86500	91827	4,5,5	5-
PALMDALE	10800	8511	6,8,8	7+
PALOS VERDES E	14650	13641	3,4,3	3+
PALOS VERDES PENINSULA - U		38914	3,4,3	3+
PARAMOUNT	30950	34734	4,5,5	5-
PASADENA	109400	113327	4,5,5	5-
PICO RIVERA	53300	54170	4,5,5	5-
POMONA	80900	87384	4,6,6	5+
RANCHO SANTA CLARITA - U	-	4860	4,5,5	5-
RODONDO BEACH	64400	56075	3,5,4	4
ROLLING HILLS	2040	-	3,4,3	3+
ROLLING HILLS ESTATE	7550	7545	3,4,3	3+
ROSEMEAD	39450	40972	4,5,5	5-
ROWLAND HEIGHTS - U	-	16881	4,5,5	5-
SAN DIMAS	17050	15692	4,5,5	5-
SAN FERNANDO	15300	16571	4,6,5	5
SAN GABRIEL	28750	29176	4,5,5	5-
SAN MARINO	13600	14177	4,5,5	5-
SANTA FE SPRING	16000	14750	4,5,5	5-
SANTA MONICA	93000	88289	3,5,4	4
SIERRA MADRE	12050	12140	4,6,5	5

APPENDIX G (CONTINUED)

LOS ANGELES COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
SIGNAL HILL	5625	5588	3,5,5	4+
S. EL MONTE	14100	13443	4,5,5	5-
S. SAN GABRIEL - U	-	5051	4,5,5	5-
SOUTH GATE	54100	56909	4,5,5	5-
S. PASADENA	22950	22979	4,5,5	5-
S. SAN JOSE HILLS - U	-	12386	3,5,5	4+
S WHITTIER - U		46641	4,5,5	5-
TEMPLE CITY	30050	29673	4,5,5	5-
TORRANCE	134100	134584	3,5,4	4
VALENCIA - U	-	4243	4,6,6	5+
VALINDA - U	-	18837	4,5,5	5-
VERNON	230	-	4,5,5	5-
VIEW PARK-WINDSOR HILLS - U	-	12268	4,5,5	5-
WALNUT	7075	5992	4,5,5	5-
WALNUT PARK - U	-	8925	4,5,5	5-
W ATHENS - U	-	13311	3,5,5	4+
W CARSON - U	-	15918	4,5,5	5-
W COMPTON - U	-	5605	3,5,5	4+
WEST COVINA	74400	68034	4,5,5	5-
W HOLLYWOOD - U	-	29448	4,5,5	5-
WESTMONT - U	-	29310	4,4,4	4
W PUENTE VALLEY - U	-	20733	4,5,5	5-
W WHITTIER - U	-	20845	4,5,5	5-
WHITTIER	71500	72863	4,5,5	5-
WILLOW BROOK - U	-	28705	4,5,5	5-

APPENDIX G (CONTINUED)

MONTEREY COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
CARMEL	4700	4525	2,2,2	2
CARMEL VALLEY - U	-	3026	2,3,3	3-
CASTROVILLE - U	-	3235	2,3,3	3-
DEL REY OAKS	1760	-	2,3,3	3-
GONZALES	2660	2575	3,4,3	3+
GREENFIELD	3360	2608	3,4,3	3+
KING CITY	4320	3717	3,4,3	3+
MARINA - U	-	8343	2,3,3	3-
MONTEREY	29250	26302	2,3,2	2+
PACIFIC GROVE	16800	13505	2,2,2	2
SALINAS	68600	58896	2,3,3	3-
SAND CITY	210	-	2,3,3	3-
SEASIDE	33950	35935	2,3,3	3-
SOLEDAD	4780	4222	3,4,4	4-

ORANGE COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
ANAHEIM	191800	166701	4,5,5	5-
BREA	22450	18447	4,5,4	4+
BUENA PARK	63200	63646	4,5,5	5-
CAPISTRANO BEACH - U	-	4149	3,4,4	4-
COSTA MESA	77500	72660	3,5,4	4
CYPRESS	40700	31026	3,5,5	4+
DANA POINT - U	-	4745	3,4,4	4-
EL TORO - U	-	8654	3,5,5	4+
EL TORO STATION - U	-	6970	3,5,5	4+
FOUNTAIN VALLEY	51100	31826	3,5,4	4
FULLERTON	92900	85826	4,5,5	5-
GARDEN GROVE	119600	122524	3,5,5	4+
HUNTINGTON BEACH	146400	115960	3,5,4	4
IRVINE	30850	-	3,5,5	4+
LAGUNA HILLS - U	-	13676	3,5,5	4+
LAGUNA NIGUEL	-	4644	3,4,3	3+
LAGUNA BEACH	15150	14550	3,4,4	4-
LA HABRA	43800	41350	4,5,4	4+
LA PALMA	14750	9687	4,5,4	4+
LOS ALAMITOS	11750	11346	3,5,5	4+
MISSION VIEJO - U	-	11933	3,5,4	4
NEWPORT BEACH	60300	49422	3,5,4	4
ORANGE	86100	77374	4,5,5	5-
PLACENTIA	30250	21948	4,5,5	5-
SAN CLEMENTE	20850	17063	3,3,3	3
S J CAPISTRANO	11750	3781	3,4,4	4-
SANTA ANA	174800	156601	3,5,5	4+
SEAL BEACH	27300	24441	3,5,4	4
S LAGUNA - U	-	2566	3,4,3	3+
STANTON	23250	17947	3,5,5	4+
TUSTIN	28050	21178	3,5,5	4+
VILLA PARK	6200	2723	4,5,5	5-
WESTMINSTER	69200	59865	3,5,5	4+
YORBA LINDA	20700	11856	4,5,4	4+

APPENDIX G (CONTINUED)

RIVERSIDE COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
BANNING	12000	12034	3,5,5	4+
BEAUMONT	5950	5484	4,5,4	4+
CATHEDRAL CITY - U	-	3640	3,4,4	4-
COACHELLA	7950	8353	3,4,4	4-
CORONA	30400	27519	4,5,5	5-
D. HOT SPRINGS	2920	3728	3,4,4	4-
ELSINORE	3800	3530	3,4,3	3+
GLEN AVON	-	5759	4,5,5	5-
HEMET	16700	12252	3,5,5	4+
HEMET E - U	-	8598	3,5,4	4
HOME GARDENS - U	-	5116	4,5,5	5-
INDIAN WELLS	1400	-	3,4,4	4-
INDIO	17900	14459	3,4,4	4-
MIRA LOMA - U	-	8482	4,5,5	5-
NORCO	16250	14511	4,5,5	5-
PALM DESERT	-	6171	3,4,4	4-
PALM SPRINGS	27350	20936	3,4,4	4-
PERRIS	5025	4228	4,5,5	5-
RIVERSIDE	151400	140089	4,5,5	5-
RUBIDOUX - U	-	13969	4,5,5	5-
SAN JACINTO	5025	4385	3,5,5	4+
SUN CITY - U	-	5519	4,5,5	5-
SUNNYMEAD - U	-	6708	4,5,5	5-

APPENDIX G (CONTINUED)

SAN BENITO COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
HOLLISTER	8575	-	2,3,3	3-
S J BAUTISTA	1170	-	2,3,3	3-

APPENDIX G (CONTINUED)

SAN BERNARDINO COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
ADELANTO	2200	-	4,6,6	5+
BARSTOW	186[illegible]0	17442	3,4,4	4-
BIG BEAR - U	-	5268	4,4,4	4
BLOOMINGTON - U	-	11957	4,6,6	5+
CHINO	26550	20411	4,6,6	5+
COLTON	20300	19974	4,6,6	5+
CREST FOREST -U	-	3509	4,6,6	5+
CUCAMONGA - U	-	5796	5,6,5	5+
FONTANA	23500	20673	5,7,6	6
FORT IRWIN - U	-	2991	4,4,4	4
GEORGE - U	-	7404	4,6,4	5-
GRAND TERRACE - U	-	5901	4,6,6	5+
HESPERIA - U	-	4592	5,6,5	5+
HIGHLAND	-	12669	4,6,6	5+
L ARROWHEAD - U	-	2682	4,5,4	4+
LENWOOD - U	-	3834	3,5,5	4+
LOMA LINDA - U	-	9797	4,6,6	5+
MONTCLAIR	22200	22546	4,6,6	5+
MUSCOY - U	-	7091	5,7,6	6
ONTARIO	64400	64118	4,6,6	5+
REDLANDS	37500	36355	4,6,5	5
RIALTO	31700	28370	5,6,6	6-
SAN BERNARDINO	106300	104251	5,6,6	6-
29 PALMS - U	-	5667	3,4,4	4-
29 PALMS BASE - U	-	5647	3,4,4	4-
UPLAND	38400	32551	4,6,6	5+
VICTORVILLE	12650	10845	4,6,5	5
YUCAIPA - U	-	19281	4,5,5	5-
YUCCA VALLEY - U	-	3893	3,4,3	3+

APPENDIX G (CONTINUED)

SAN DIEGO COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
CARLSBAD	20000	14944	3,4,4	4-
ESCONDIDO	48050	36792	3,3,3	3
OCEANSIDE	54900	40494	3,4,4	4-
SAN MARCOS	9400	-	3,3,3	3
VISTA	28600	24866	2,3,3	3-

APPENDIX G (CONTINUED)

SAN LUIS OBISPO COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
ARROYO GRANDE	8525	7454	4,5,5	5-
ATASCADERO - U	-	10290	4,5,4	4+
BAYWOOD-LOS OSOS - U	-	3487	4,5,5	5-
EL PASO ROBLES	8050	7168	4,5,5	5-
GROVER CITY	7325	5939	4,5,5	5-
MORRO BAY	8875	7109	3,4,4	4-
NIPOMO - U	-	3642	4,5,5	5-
OCEANO - U	-	2564	4,5,5	5-
PISMO BEACH	4850	4043	3,4,4	4-
SAN LUIS OBISPO	34550	28036	3,4,4	4-

APPENDIX G (CONTINUED)

SANTA BARBARA COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
CARPINTERIA	10200	6982	4,5,5	5-
E ENCANTO H - U	-	6725	4,5,5	5-
GUADALUPE	3230	3145	3,5,5	4+
LOMPOC	25450	25284	3,5,4	4
LOMPAC N - U	-	2699	3,5,4	4
LOMPAC NW - U	-	4874	3,5,4	4
SANTA BARBARA	74000	70215	4,5,5	5-
SANTA MARIA	34250	32749	4,5,5	5-
SANTA MARIA SOUTH - U	-	7129	4,5,5	5-
VANDENBURG - U	-	13193	3,4,4	4-

APPENDIX G (CONTINUED)

TULARE COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
CUTLER - U	-	2503	3,3,3	3
DINUBA	8850	7917	3,4,4	4-
EARLIMART - U	-	3080	3,5,4	4
E PORTERVILLE - U	-	4042	3,3,3	3
EXETER	4970	4475	3,4,4	4-
FARMERSVILLE	3780	3456	3,4,4	4-
LINDSAY	5625	5206	3,4,3	3+
PORTERVILLE	14350	12602	3,4,4	4-
PORTERVILLE NW U	-	2517	3,4,4	4-
PORTERVILLE W U	-	6200	3,4,4	4-
OROSI - U	-	2757	3,4,4	4-
TULARE	18100	16235	3,4,4	4-
VISALIA	34750	27268	3,4,4	4-
WOODLAKE	3800	3371	3,3,3	3

APPENDIX G (CONTINUED)

VENTURA COUNTY

CITY	1975 POP.	1970 POP.	3-DIGIT EI	1-DIGIT EI
CAMARILLO	24800	19219	4,5,5	5-
EL RIO - U	-	6173	4,5,5	5-
FILLMORE	7750	6285	4,5,5	5-
MOORPARK - U	-	3380	4,5,5	5-
OAK VIEW - U	-	4872	4,5,5	5-
OJAI	5850	5591	4,5,5	5-
OXNARD	85100	71225	3,5,4	4
PORT HUENEME	17750	14295	3,5,5	4+
SANTA PAULA	18250	18001	4,5,5	5-
SIMI VALLEY	69100	56464	4,5,5	5-
THOUSAND OAKS	53700	36334	4,5,5	5-
VENTURA	62900	55797	4,5,5	5-