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CITY OF DALLAS

A STUDY EVALUATING THE CITY OF DALLAS CODES TO IDENTIFY CODE MODIFICATIONS COROLLARY TO THE PROPOSED EXPANSION OF AUTOMATIC SPRINKLER REQUIREMENTS

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PREFACE

This report summarizes a comprehensive study of the City of Dallas codes and related ordinances as a result of a contract with the City of Dallas. This study was funded, in part, by a grant from the Federal Emergency Management Agency (FEMA). Documents examined in this study included the current editions of the City of Dallas Building Code, Fire Prevention Code, Mechanical Code, Plumbing Code, Development Code and Waterworks ordinances.

The purpose of this study is to identify those requirements of the current city codes and ordinances which could be amended in order to provide an improved level of fire safety for the citizens of Dallas, and their property, without imposing an economic hardship. Specifically, the City of Dallas codes have been analyzed to identify provisions which could be amended, given the more stringent requirements for the installation of automatic sprinklers which were proposed by the City of Dallas in 1981.

Major changes proposed to the Dallas Building Code in 1981 included:

- Modification to Section 1807(a) to require buildings with more than 1,000 people above or below grade level to comply with the "high-rise" requirements. Presently, this section applies only to Group B, Division 2 office buildings and Group R, Division 1 residential buildings more than 75 feet above grade.

- Modification to Section 1807(a) to eliminate the compartmentation option thereby requiring all high-rise buildings to be sprinklered.

- Modification to Section 1807(g) to require smoke control systems for buildings with more than 1,000 people above or below grade level. Presently, this section applies only to Group B, Division 2 office buildings more than 75 feet above grade.

- Modification to Section 3802(b) to require the entire building to be sprinklered when the building area exceeds 7,500 square feet. This represents a significant expansion of the current sprinkler requirements. Presently, only specific occupancies exceeding specified minimum floor areas are required to be sprinklered.

Prior to incorporating the above modifications into the Dallas Building Code, the City of Dallas contracted Schirmer Engineering Corporation to conduct an intensive study of all applicable city codes and ordinances culminating in a report which:

- Analyzes the current building code and identifies building features that are required because of an anticipation that the building will not be equipped with an automatic fire extinguishing system.

- Evaluates the total building fire resistance and life safety requirements that could be diminished, or eliminated, if an automatic fire extinguishing system was installed.

- Includes adequate wording for each affected section of the building code to maintain the intent and integrity of the code while providing a high level of fire safety through the installation of an automatic fire extinguishing system.

- Evaluates the impact and estimated costs for the installation of an automatic fire extinguishing system in four example buildings, and

- Evaluates the potential conflict between automatic fire extinguishing systems and smoke removal or control equipment.

This report is a result of an analysis of pertinent records of the Dallas Building Inspection Division, the Dallas Fire Department, the Dallas Department of Planning and Development; a review of related literature; and, an evaluation of the impact and cost for four typical buildings.

Schirmer Engineering Corporation retained the services of RTKL Associates, Inc., Architects, Dallas, Texas, to assist in the identification of architectural features required by the current city code which should be amended, and to develop the building examples and associated construction costs for the cost impact portion of this report.

An introductory section of the report briefly describes the evolution of typical building code regulations upon which the nation's model building codes were based. The Dallas Building Code in effect at the time this analysis began is based upon one such model code -- the 1979 edition of the Uniform Building Code, published by the International Conference of Building Officials, Whittier, California. (The City of Dallas recently adopted the 1982 edition of the Uniform Building Code, with local amendments, which will be effective January 1, 1983.) The current editions of several model codes were included in the literature search and, along with experience and engineering judgment, form the bases for the code change proposals included in this report. The introductory section of the report also includes a discussion of the systems concept of fire protection engineering which was utilized, in part, as the basis of comparing "equivalency" in the analysis of both current and proposed features of the codes.

Following the introductory section of this report is a summary of the data acquired in our review of Dallas Building Inspection Division and Fire Department records which are indicative of certain trends when compared to other large municipalities and the nation as a whole. A chapter-by-chapter summary of the code changes and supporting rationale is presented in the report followed by a chapter describing the functional and cost impact of the proposals upon four typical buildings. The actual proposed code change language is included in the appendix of this report.

This report is not intended to represent a comprehensive study of the operations, staffing or equipment allocation of the Dallas Fire Department or Building Inspection Division.

The cooperation and valuable assistance of the City of Dallas Fire Department and the City of Dallas Building Inspection Division in conducting this study is greatly appreciated.

EXECUTIVE SUMMARY

An analysis was made of the current City of Dallas codes and related ordinances to identify those requirements which could be amended to provide an improved level of fire safety for the citizens of Dallas, without imposing an economic hardship. These amendments are based upon a proposed requirement for automatic sprinkler protection in all new buildings which have an area greater than 7,500 square feet.

The requirement for automatic sprinkler protection for buildings greater than 7,500 square feet is based upon an analysis which demonstrates that manual fire extinguishment of fires of this magnitude cannot reasonably be accomplished.

An analysis methodology known as the systems concept was utilized in this project. This methodology identifies the relationship at a relative importance of various fire protection features to achieving a fire safety objective. This methodology also identifies those redundent features necessary for a high probability of achieving the fire safety objective.

The reliability of automatic sprinkler systems was examined. To the extent practicable, mechanisms for automatic sprinkler system failure have been "designed out" of the proposed Dallas Code. Fire experience shows that automatic sprinkler protection designed and installed in accordance with similar provisions recommended for the City of Dallas have a level of satisfactory performance exceeding 99.5 percent. In addition, there has been no reported loss of life due to fire in a fully sprinklered building other than those persons who were intimately involved with the fire ignition. Nevertheless, a sufficient degree of redundancy has been incorporated into the building code to asure that a high level of fire safety will result.

Growth trends in terms of population and building construction for the City of Dallas were analyzed. Results of the 1980 census for the City of Dallas show a population increase of 7.1 percent over that of 1970. Population projections indicate that the city will have a population of 1 million persons prior to 1990. By the year 2000, the City of Dallas is also expected to have a substantial growth in the number of jobs -- 48 percent greater than the 1978 level. These projections indicate continuing growth both in the commercial and residential segments of the construction industry.

Recent fire experience in the City of Dallas was analyzed to determine the relative magnitude of the fire problem when related to that of other similar sized cities and fire experience on a state and national level. Fire loss data for the period 1970 through September, 1982 was analyzed. The annual number of fires increased substantially during the first seven years of the period, but has shown an overall decline in recent years. In the period reviewed, the number of fire fatalities in the City of Dallas averaged 33 deaths per year with a high of 45 deaths in 1976 and a low of 24 deaths in fiscal year 1979-80. In the last five years, the average number of fire fatalities is slightly less than that of the entire period, indicative of a downward trend.

More than 35,000 fires were reported to the Dallas Fire Department during the analyzed period, averaging 2,725 fires per year. The overall pattern is indicative of an increasing number of fires in the period through 1977 followed by a decline in the most recent five years. Similarly, the population-based rate of fires per 1,000 persons indicates an upward trend until 1977, followed by a steady downward trend in the last five years.

Direct property losses for the period 1970 through September, 1982 show a steady increase. However, this increase is partially offset by inflation. Yet, a slightly increasing trend in property loss is evident.

Residential fire losses in the City of Dallas account for a substantial number of total fires and fire fatalities, similar to the rest of the nation.

The operating expenditures of the Dallas Fire Department for fiscal years 1969-70 through 1980-81 show an upward trend. However, when adjusted for inflation, fire department operating expenditures have been relatively constant since fiscal year 1974-75. Similarly, adjusted per capita operating expenditures for the fire department have remained relatively constant since fiscal year 1974-75.

The number of uniformed personnel has increased in recent years, but when expressed in terms of fire fighters per square mile of the city, a downward trend is evident since 1972. The number of fire fighters per 1,000 population has remained relatively constant since 1972. It is apparent that substantial additional costs would be required for the fire department operating budget to materially affect the level of fire protection in the City of Dallas. The proposed code changes are intended to provide a higher level of fire protection while stabilizing or ultimately reducing fire department costs for suppression services.

Major changes have been proposed to Subchapter 5 of the Dallas Building Code which addresses general requirements for limitations on the allowable height and floor size of a building, the degree of fire resistance required for structural members of a building and requirements for buildings that house more than one occupancy. Since automatic sprinkler systems have proven to be a much more effective method of suppression than manual means, increases in the allowable heights and areas over present code requirements have been proposed without sacrificing the high level of safety intended by the code. The changes for Subchapter 5 represent a significant potential reduction in costs of construction which will partially or fully offset the cost of the required sprinkler protection.

A comprehensive proposal for covered mall shopping center buildings is included in this report. Although the proposal parallels requirements contained in the 1982 Uniform Building Code, certain overly redundant features have been deleted. However, the proposal does not allow the construction of an unlimited area building of Type III (masonry/wood joist) or Type V (frame) construction.

A revision has been proposed to Table 9-A of the Dallas Building Code which specifies maximum quantities of hazardous materials which may be allowed in a building. The proposed modification allows the quantities of materials specified in this table to be utilized on the basis of multiples of building area rather than being totally independent of building area.

An amendment has been proposed to Section 1705(b)5 of the Dallas Building Code to allow the use of nonrated construction for corridors serving an occupant load of 30 or more persons in a fully sprinklered building.

Comprehensive requirements for atrium buildings have also been proposed in this report. These provisions, again, parallel the requirements contained in the 1982 Uniform Building Code. However, certain overly redundant requirements have been proposed to be deleted from the Dallas Building Code; much broader, performance-type requirements are included.

Modifications have been proposed to Subchapter 18 concerning high-rise residential and business buildings. A careful analysis was made to determine which of the currently required fire protection features could be reduced or eliminated in these buildings when they are fully sprinklered, even though the current Dallas Building Code provides for certain reductions in fire protection elements for a sprinklered building. Additional reductions have been proposed.

Current requirements for the provision of smoke and heat venting in unlimited area buildings are proposed to be deleted on the basis of their unquantifiable benefits and possible detrimental effects on the control of a fire.

Modifications have been proposed to Chapter 33 of the Dallas Building Code concerning the calculation procedure for exit facilities in sprinklered buildings. Essentially, these changes do not require cumulative loading from floors above and below the floor under consideration for purposes of determining the number exits and exit width. A modification is also proposed concerning the arrangement of exits to allow a reduction in the required separation between exits in sprinklered buildings by one-half.

As a means of assuring a high level of reliability of the sprinkler system, additional requirements for electrical supervision of sprinkler systems have been proposed. Section 3802(c) will require that automatic sprinkler systems be supervised for waterflow, valve position and other conditions which may impair the operation of the system by an approved agency, or by a local alarm which will provide an audible signal at a constantly attended location. This arrangement of the sprinkler system is similar to that which has proven to provide a very high level of reliability.

Modifications have been proposed to the section of the Dallas Building Code dealing with standpipes which will only require Class I (fire department use only) standpipes in those buildings where standpipes are presently required. In addition, standpipes will only need to be located in exit enclosures; the criteria requiring all areas of the building to be covered by a 130-foot hose and stream will not be applicable in sprinklered buildings.

Modifications are proposed to the code which allow increased use of plastic roof panels and plastic skylights in buildings which are completely equipped with an automatic sprinkler system. This change is made consistent with currently proposed national code language.

Modifications have been proposed to the Fire Code which formally recognized the fire flow requirements of a sprinklered building as being less than an unsprinklered building.

Modifications have been proposed to the Water Works Ordinance clarifying that an elaborate check valve and meter is not required for closed fire protection systems which have an automatic waterflow alarm system. In addition, the monthly charges associated with water connections for automatic sprinkler systems has been proposed to be deleted. Both of the changes to the Water Works Ordinances are intended to remove the disincentives which currently exists for the installation of automatic sprinkler systems.

An estimate of the cost impact of the proposed changes was demonstrated with four example building types: high-rise office, high-rise residential, low-rise office and low-rise residential. In the case of a high-rise office building, the proposed code changes show a net cost reduction of $0.49 per square foot for the proposed sprinklered building over the current sprinklered building. This is in addition to the cost advantage which currently exists for the sprinklered building over the unsprinklered building. In the case of a high-rise residential building, the proposed modifications to the Dallas Building Code will provide an additional cost differential $0.45 per square foot over the current code requirements.

The case for a two-story office building demonstrated a significant reduction in construction cost due to a reduction in the building construction type. This resulted in an additional cost savings of $1.02 per square foot.

No significant cost reduction was readily apparent for the case of a low-rise residential building. Additional incentives are recommended to be explored to help set the cost of sprinkler installations in this type of occupancy.

Other benefits resulting from the proposed automatic sprinkler requirement include a reduction in the number of fire-related fatalities and injuries, a property damage reduction and a reduction in indirect fire losses.

Ultimately, a reduction in the cost of providing public fire suppression services will result. Evidence of such a reduction exists in another municipality which has adopted extensive automatic sprinkler requirements.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

In recent years, the subject of fire safety has received increased attention, both from within and without the fire protection community. The impact of building codes on the fire problem has also been the subject of increased study. At the same time, interest has been directed toward the costs and associated benefits of building regulations, including building codes and retrospective requirements of fire prevention codes.

This report represents a comprehensive analysis of the City of Dallas codes and ordinances for the purpose of identifying specific provisions which can be reduced or eliminated, without materially affecting the level of safety, if automatic sprinklers are mandated for a larger number of buildings.

In order to identify such provisions, fire loss records of the City of Dallas for the recent period, national fire loss data, related literature, code provisions of other jurisdictions, fire department staffing and budget data were reviewed.

The Systems Concept

There is presently no generally accepted methodology for the evaluation, analysis or design of fire protection. In contrast with other engineering disciplines, fire protection engineering, as related to building design, relies to a greate extent upon tradition, experience and empirical methods. It is not possible, for example, to quantify the level of fire safety of a building to a point where one can measure the safety of additional fire protection measures, or, to say that the fire protection design of a building has a specific factor of safety. Recent analysis techniques are striving toward such quantification, but there is no widespread agreement in the building community with respect to this approach.

The prevailing method of fire safety evaluation in the United States is by code compliance. Building codes are legal documents which set forth minimum requirements to protect public health, safety and welfare in structures. The code categorizes structures by occupancy, construction and the presence or absence of sprinkler protection, and then applies specific provisions to each resulting class. Buildings, however, are becoming more complex both in terms of occupancy and with respect to their subsystems. Frequently, a large building will contain significant areas of multiple occupancy which seemingly defies traditional occupancy classification.

The development of code provisions has largely been a response to specific fires and the desire to prevent the recurrence of undesirable events. For example, many of the present requirements for life safety were implemented as a result of the Cocoanut Grove night club fire, the Chicago school fire and, more recently, the MGM Hotel fire in Las Vegas. The outcome of this process is that new provisions are typically added to existing ones without evaluation of the net resultant impact on efficiency of fire safety. This provides the potential for expensive redundancy in building design.

Thus, the justification for code requirements is more sociological than scientific. Many of the provisions are based on historical procedures without technical merit. Many provisions derived in this manner assume a greater degree of stature over the course of time. There is simply inadequate technical input to consider code requirements as a valid measure of fire safety.

A fundamental deficiency in the traditional building code approach to fire safety is the lack of a specified level of performance. Even within a single code there are various (unspecified) levels of safety. Although building codes are trending toward performance rather than specification criteria, there is little variation permitted within code requirements.

Unlike the vast majority of structures in the U.S., the property of the federal government does not fall under the jurisdiction of commonly used building codes. In this light, the U.S. General Services Administration (GSA) was able to deviate from the accepted practice of code compliance and formulate the Goal Oriented Systems Approach, first presented at the Airlie House Conference in 1971.[1]

This method has since evolved and has become known as the "Systems Approach" to fire safety analysis. The National Fire Protection Association "Committee on Systems Concepts" has developed a similar version of the GSA systems approach, the NFPA "Decision Tree" (Figure 1). The systems approach provides an organized approach to a building's fire safety with respect to established goals for the life safety, property protection and/or business continuity which may not be related to the unspecified goals contained in a building code. Similarly, the use of the Decision Tree allows the evaluation of a particular building component, a public address system for example, with respect to the established goals.

There are two approaches or uses possible with regard to the Decision Tree. One is the objective approach. This approach develops mathematical probability goals. For example, it could be decided that the goal was 99.7 percent probability of success in having not more than one fire death per 100,000,000 man hours of exposure and 99.6 percent probability of success in preventing any fire from exceeding $100,000 in property damage or $250,000 in business interruption loss.

The General Services Administration used this approach in several of their building designs. They establish parameters such as 99.999 percent probability of success in confining a fire to a work station, a room, a floor, or a building.

The objective use of the systems approach requires development of success probabilities related to all components of a building's fire safety system. In some cases, statistical data is available to develop these probabilities with a good degree of confidence. In other cases, fire test data makes it possible to accept basic assumptions. Unfortunately, this is not true with regard to all aspects of the Decision Tree and, as a result, many assumptions are purely judgmental. Other than the natural reluctance of the code community in accepting the systems approach, the lack of a data base is the primary weakness of this methodology at the present time. As statistical bases expand and as fire test data becomes more and more available, the objective use of the tree can become extremely advantageous.

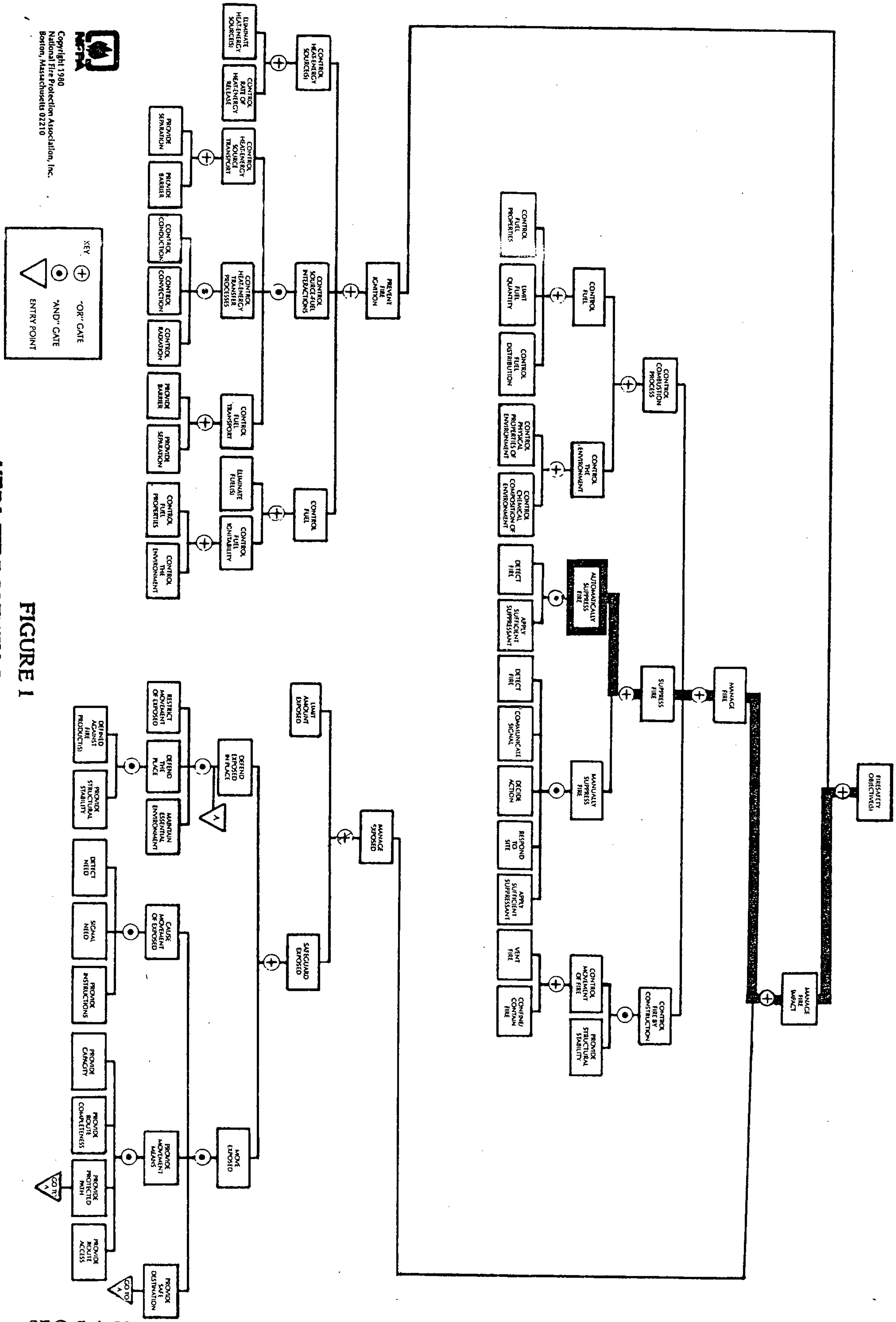


FIGURE 1

NFPA FIRE SAFETY CONCEPTS TREE

Source: Building Standards, January/February, 1982.

The second approach to the use of the Decision Tree is subjective. In this case the Decision Tree is used as a method of organizing thoughts regarding the design for fire safety. It disciplines the design team and the regulatory authorities in investigating alternate approaches. Further, it facilitates recognition of alternate solutions or equivalencies. The subjective use of the tree provides an excellent communication tool between the fire protection engineer, the owner, the architect and the local authorities.

In both the objective and subjective approaches to the tree, it is first necessary to establish goals. These will relate to the ability to limit loss of life or the size of a fire. One may think in terms of a fire not spreading beyond the place of origin, the room of origin, the floor of origin, the building of origin, etc. Each of these relates to an exposure in terms of a number of people and/or dollars. A decision is necessary as to the acceptable level of loss with a full recognition that "100 percent safe" is not possible.

In reviewing the Decision Tree, it should be noted that two types of "gates" are provided below the various levels of decision. These include "or" gates (+) which indicate that either solution below a particular gate will satisfy the objective above it if they are totally successful or that proportions of each combined will totally satisfy the objective. The "and" gates (.) indicate that in order to satisfy the goal immediately above the "and" gate, all items in the level immediately below it must be satisfied.

An overall view of the Decision Tree would indicate that the left side, "Prevent Fire Ignition," refers primarily to those items which would be normally contained within a fire prevention code. The right side of the tree under "Manage Fire Impact" deals primarily with those items which would be included within a building code. The Decision Tree indicates that it is possible to achieve a fire safety objective by either preventing fire ignition or by managing the fire impact.

In reviewing the "Prevent Fire Ignition" items, it can be seen that only in extremely rare instances would it be possible to achieve a high degree of success in these items and, therefore, make it necessary to consider items relating to managing the fire impact. As an example, consider the item referring to the control of heat-energy sources which would be one method of preventing fire ignition. In order to accomplish this, it it possible to either limit the rate of heat-energy release or limit the presence of a heat-energy source. In the case of a flammable liquids operation, this would most likely be accomplished by complete elimination of smoking and smoking materials, strict control over electrical installations (including explosion-proof equipment), preventative measures regarding static electricity discharge, etc.

A lack of maintenance, however, could still result in overheated bearings which could provide an ignition source, and, a severe fire. A simple human error should not be allowed to result in a catastrophic failure in the achievement of the fire safety objective. It is quite obvious that control of fire ignition cannot be 100 percent successful as the sole means of providing for life safety. Therefore, we must consider "Managing Fire Impact."

When we consider "Managing Fire Impact," we can decide either to "Manage the Fire" or "Manage the Exposed."

It is possible, in part, to manage the fire by construction. This requires controlling the movement of the fire and the provision of structural integrity. Within building codes, this would relate to the fire resistance requirements of the structural elements plus compartmentation or area limitations which might be introduced. Considering the fact that the model building codes will allow unlimited building area when fire resistive construction is used in many occupancy classes, it becomes questionable whether any defined fire safety objectives were involved in the original promulgation of area limitations within these codes. This may account for some of the severe life loss and property loss fires which have occurred within "fire resistive" buildings.

The compartmentation option suggested by building codes is not always usable as it may well defeat an open office landscaping scheme originally decided upon by the owner or developer. In addition, the integrity of rated barriers is often violated by penetrations after construction, leaving the owner and occupants with a false sense of security.

However, the use of building integrity as a basic part of our fire safety system should not be discarded. The protection of vertical openings, for example, is a fundamental principle of fire protection which is not minimized by the systems approach. Nevertheless, total success in controlling the fire by construction alone is difficult or impossible and would make it necessary that the fire be suppressed.

Within the Decision Tree, fire suppression may be either manual or automatic. In the case of manual extinguishment, the human element must be considered. Numerous opportunities for failure to meet the fire safety goal exist in each of the following steps for manual suppression, <u>all</u> of which must be successful:

- The detection of the fire.
- The communication of a fire signal to responsible persons.
- The decision to act.
- The response to the affected area.
- The initiation of the suppressant.
- The achievement of fire control.

A great length of time can elapse between the time of origin of a fire and its detection. Additional time can also be expended between the detection of a fire and the communication to responsible persons.

In considering detection, it is apparent that those areas of the building that are normally unoccupied or normally not visible to occupants present the possibility of a delay in detection which could be significant in the fire safety of the building, particularly if the areas contain a large amount of combustibles. Numerous large-loss fires have occurred due to "delay in detection" and/or "delay in alarm." Even with automatic fire detection systems, the elapsed time between fire detection and the initiation of suppressant can be of a magnitude to jeopardize the overall fire safety of the building.

It is apparent that the immediate application of suppressant by automatic means during the early stages of a fire, without human intervention, offers a much higher degree of reliability in controlling or extinguishing fires as demonstrated by the record of performance of systems that are properly installed and maintained. The most widely used method of automatic suppression is the automatic sprinkler system. In recent years, most major building codes have required the installation of sprinkler protection in an ever increasing number of occupancies. The installation cost in new construction is usually partially or fully offset by a reduction in a building's structural fire resistance, increased travel distance, etc. According to the National Fire Protection Association's Fire Protection Handbook,

> Automatic sprinklers, properly installed and maintained, provide effective safeguards against loss of life by fire. Their value is psychological as well as physical; they give a sense of security to the occupants of buildings, and minimize the possibility of panic.

If we choose to control the fire by automatic suppression, it becomes apparent (refering to the Tree) that lesser degrees of attention could be given to other methods of reaching our fire safety objective. Referring to Figure 1, it is clear that several methods, or combinations of methods, may be used to meet the fire safety objective. For example, it becomes questionable as to whether the same degree of fire resistance is necessary as if no suppression system was installed. The degree of reduction which might be allowed would depend to an extent upon the nature of the occupancy and the reliability of the suppression system. In the case of automatic sprinklers, this would require that a close review be made of sprinkler performance history for the particular occupancy and that the various modes of failure be "designed out" of the system to the greatest extent possible.

In considering "Manage Fire Impact," it is possible to choose to "Manage the Exposed" rather than to "Manage the Fire." This refers to protection of people or possibly, to protection of valuable records, computer tapes, or another object being considered. Again, a number of choices are involved including the limiting of the amount exposed (e.g., control of occupant loads) or safeguarding the exposed.

The "Safeguard Exposed" concept allows an individual to be either defended in place or moved. The "Defend in Place" concept relates to areas of refuge and compartmentation presently included within many of our codes. It is interesting to note, however, that if we have successfully managed the fire via an automatic suppression system, an area of refuge is redundant and unnecessary.

A movement means is called for within the Decision Tree which relates to the exiting system normally called for within building codes. The traditional consideration of building life safety in the event of a fire is based upon rapid removal of the building occupants from the affected area. The movement means must have adequate exit facilities for each floor of the building. The number and size of exits is based upon two basic principles: travel distance and exit capacity. Travel distance is the maximum allowed distance to reach an exit from any point (on any floor) in the building. Exit capacity relates to the width of doors and stairways and is dependent upon the occupant load and use of the building.

Depending upon the occupant load and use, the code may require a minimum number of exits for each space or on each floor. Aside from providing adequate capacity and meeting travel distance requirements, multiple exits also provide an additional factor of safety should one of the exits become unusable.

It is not the intent of this discussion to delve into a detailed analysis of systems application to code or design methodology. It is, however, intended to identify an analysis method which can provide a reasonable design for fire and life safety. The method provides an outline for the thought process which should be involved in the design. It encourages definition of goals for the level of protection desired. It also provides a basis for evaluation of the contribution of individual code provisions, and, thus, was utilized in this project.

The method is applicable to a universe of structures, ranging from the one and two family dwelling -- our nation's most challenging fire problem -- to the major structure or multi-use complex. The method provides a means of analyzing present code approaches and guiding future code developments.

In summary, the elements employed in fire protection for buildings can be generally categorized. Aside from preventing fire ignitions and controlling the fuel environment within a building, fire protection goals for most structures may be accomplished by managing the fire impact either by:

- Construction (compartmentation),
- Suppression, or,
- Managing the exposed (i.e., people) by moving them out of the affected area via an exiting system.

These three methods are considered to represent the basic components of a building's fire protection strategy. It is important to note that good fire protection practice dictates that reliance for safety to life not depend solely upon a single feature. The NFPA Life Safety Code states:

> The design of exits and other safetguards shall be such that reliance for safety to life in case of fire or other emergency will not depend solely on any single safeguard; additional safeguards shall be provided for life safety in case any single safeguard is ineffective due to some human or mechanical failure.

Therefore, in most cases, two of the above three methods for providing fire safety should be incorporated into a building. This principle is utilized in the application of the Fire Safety Evaluation System (FSES) developed by the National Bureau of Standards and included in Appendix C of the NFPA Life Safety Code. Essentially, the FSES is a systems application used to measure an equivalent level of safety intended by the Life Safety Code. Successful use of the FSES in measuring equivalency requires that a minimum standard be met in each of three areas: containment safety (construction), extinguishment safety (suppression) and people movement safety (exits).

Reliance upon building construction as the sole means for preventing fire spread has, in recent years, received serious reconsideration. Even in relatively well-compartmented buildings, smoke from an uncontrolled fire can spread to other portions of the building by way of stairways, elevator shafts and ventilating systems. In addition, there is an uncertainty regarding the integrity of fire resistant barriers over a period of time. Frequently, repairs, extension of utilities and general use can render these barriers and opening protective devices (e.g., fire doors) vulnerable to fire. For these reasons, many communities have included mandatory sprinkler provisions into their codes.

Similarly, the reliability of automatic sprinkler systems is routinely questioned when reductions in building construction requirements are discussed. Various statistics are available concerning sprinkler reliability.[2,3] Results of these studies are summarized in Table 1. It is important to note that the successful performance ratio of studies included in Table 1 has a relationship to the thoroughness of the reporting system. In Australia and New Zealand, all sprinkler actuations are reported by law.

TABLE 1
AUTOMATIC SPRINKLER PERFORMANCE SUMMARY

Study	Number of Incidents	Statisfactory Performance (%)
Australia and New Zealand (1886-1968)	5,734	99.8
Australia and New Zealand (1968-1976)	1,945	99.5
New York City High-Rise (1969-1978)	1,648	98.4
U.S. Dept. of Energy (1952-1980)	115	98.3
National Fire Protection Association (1925-1969)	81,425	96.2
New York City Low-Rise (1969-1978)	4,061	95.8
U.S. Navy (Shore Facilities, 1964-1977)	724	95.7
Factory Mutual (1970-1977)	3,292	86.1
Oregon State Fire Marshal (1970-1978)	1,648	85.8

The NFPA has stopped reporting sprinkler performance data after 1970 since:

> ...it became apparent that the data being used were biased by collection criteria which concentrated on fires causing large dollar loss. This bias led to an apparent and misleading decline in sprinkler effectiveness. Informationof sprinkler effectiveness from insurers is also biased toward the larger property loss and the possible failure because of the widespread use of deductibles. Many fires which are extinguished by a small number of sprinklers and result in small property loss are never reported to the insurer.[4]

More important than the reasons for successful performance are the reasons for unsuccessful performance. Such an identification allows one to take the necessary steps to "design out" all the failure mechanisms reasonably possible. For example, the NFPA statistics show that more than 25 percent of the failures are due to inadequate water for the sprinklers as a result of closed valves or empty storage tanks.[5] These potential failure points can be electrically monitored (supervised) to provide an alarm at a constantly attended location which would indicate a sprinkler impairment.

A reason for the very high successful performance of sprinkler systems in Australia and New Zealand is that essentially all systems are electrically supervised for impairments and for sprinkler waterflow. A sprinkler waterflow alarm, monitored at a constantly attended location, results from the operation of a sprinkler system and is indicative of a fire. Responsible persons receiving either a sprinkler waterflow alarm or a sprinkler supervisory alarm can then contact appropriate parties, such as the fire department or building personnel, for corrective action. With electrical supervision of those components which can cause sprinkler impairment -- control valves, fire pump power, water storage tank level, tank temperature, etc. -- and monitoring of sprinkler waterflow signals, the reliability of the sprinker systems proposed for the City of Dallas will approach a level as high as practicable.

Records of the NFPA and in Australia and New Zealand attest to the superior life safety protection of sprinklered buildings: there has been no reported multiple life loss (3 or more fatalities) due to fire in fully sprinklered buildings. Fatalities have occurred in sprinklered buildings as the result of explosions or where the individual has had intimate involvement with the fire origin.

Nevertheless, even with such systems proposed for the City of Dallas Building Code, the related code changes allowing a reduction in certain construction elements were carefully reviewed to provide a degree of redundancy in either structural integrity, exit facilities, or both. This approach is consistent with the philosophy stated in the NFPA Life Safety Code that safety not depend upon a single safetguard. As will be seen in a following section of this report, fire-resistance ratings for structural elements, generally consistent with expected fire loads, are maintained for tall buildings where fire resistance is considered a necessary redundant feature. In addition, little, if any, changes are proposed to the current requirements for exit facilities for further redundancy.

Fire Department Operations

A determining factor in the requirement of automatic sprinkler protection for buildings greater than 7,500 square feet is the ability of the fire department to manually control and extinguish a fire. The theoretical quantity of water necessary to extinguish a fire is roughly represented by the relationship:[6]

$$Q = \frac{V}{100},$$

where Q = Waterflow rate in gpm, and
V = Volume of the fire.

Other empirical relationships suggest that the number of fire personnel required to deliver that water quantity at a fire is approximated by:[7]

$$M = \frac{Q}{50},$$

where M = The number of fire fighters, and
Q = Waterflow rate in gpm.

Assuming a 5,000 square foot, 10 foot high space involved in fire, the theoretical water demand would be 500 gpm with an associated manpower demand of 10 fire fighters. It can be seen that the amount of necessary water, fire pumpers and personnel will grow rapidly with the size of the fire.

A relationship describing the probability of manual fire extinguishment versus fire size has been developed by Wilson (Figure 2).[8] It can be seen that the probability of successful manual extinguishment is very low for an area of 3,200 square feet, even for the best trained and equipped fire departments. Other studies of water quantities and manpower versus fire size define the practical limit at 5,000 square feet. The figure of 7,500 square feet utilized in the proposed Dallas Ordinance represents an intermediate floor area between these theoretical values and current requirements for sprinklers.

Summary

The proposed code changes in this report resulted from an extensive study of the Dallas codes with consideration of automatic sprinkler system reliability, structural fire resistance and exiting availability to provide a level of redundancy consistent with a high level of safety. It should be noted that the proposed code changes were prepared as a composite proposal. The adoption of only a portion of the proposals may have an effect upon other code sections which would require further study.

The proposed code changes and supporting rationale should not be considered to preclude other alternate designs which may be based in part upon the presence of automatic sprinkler protection in a given building.

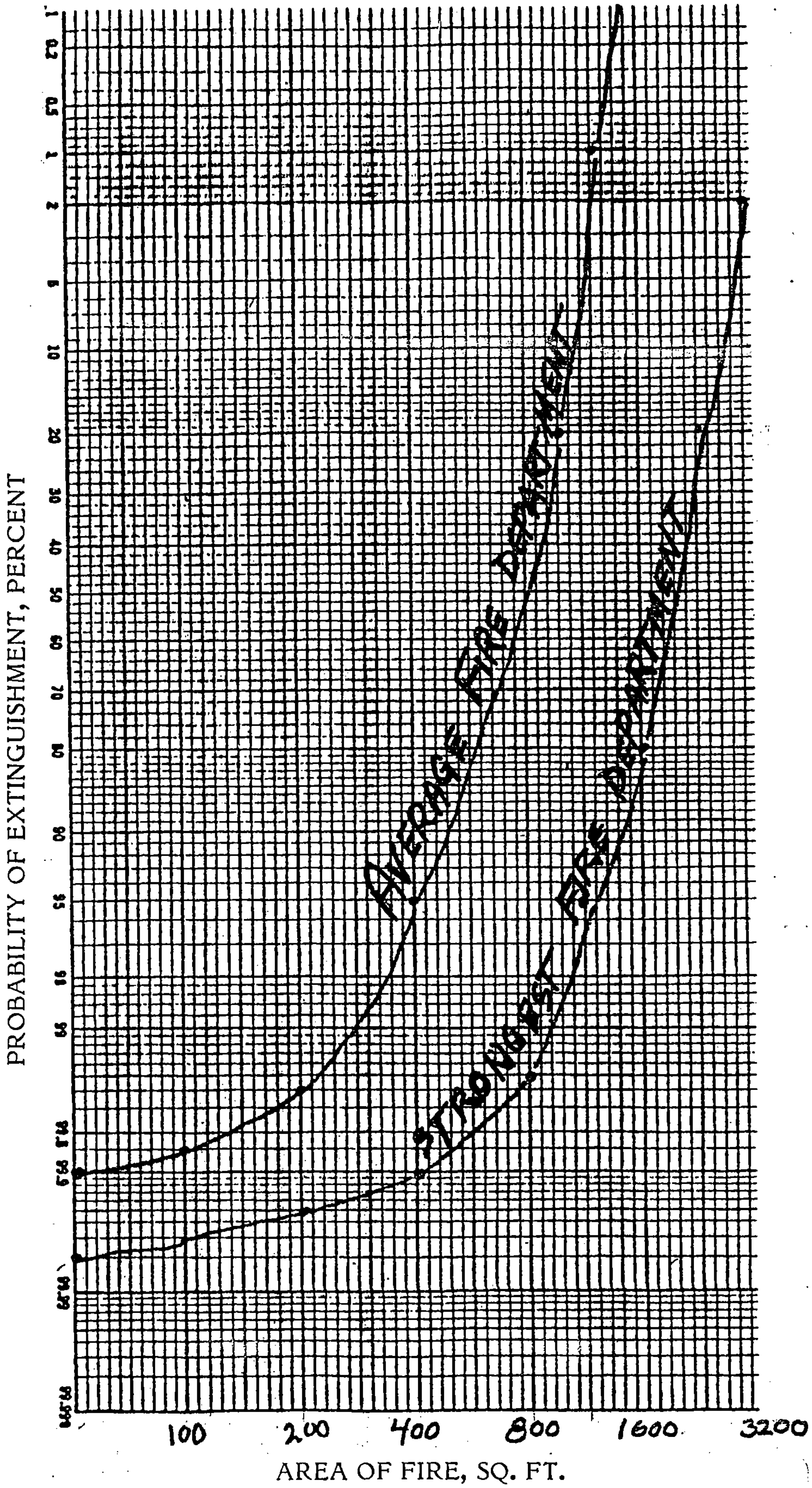


FIGURE 2

FIRE DEPARTMENT CAPABILITY

STATISTICAL BASE

In order to help assess the need and possible impact of the proposed code changes, certain statistical data were developed. These include population and area history of the city, building valuation, building construction activity, fire experience and fire department manpower and budget. These data were examined to determine both current information as well as possible trends.

Demographics

The Dallas-Ft. Worth "metroplex," like many other metropolitan areas of the South and West, has experienced rapid growth in the last decade. Results of the 1980 census of the City of Dallas show a population of 904,078 persons, an increase of 7.1 percent over the population count of 1970. Similarly, the city's area has increased as a result of annexations. An additional 10 percent population gain is expected for "sunbelt" states (including Texas) over the next ten years. Population projections indicate that the city will have a population of one million persons prior to 1990 (Table 2).

The census data also included an identification of the city's population by age group, as follows:

0-4 years:	67,126 persons (7.4 percent).
5-17 years:	176,666 persons (19.6 percent).
18-34 years:	308,529 persons (34.1 percent).
35-64 years:	265,782 persons (29.4 percent).
65 years and over:	85,975 persons (9.5 percent).

By the year 2000, the City of Dallas is also expected to have substantial growth in the number of jobs (67 percent greater than the 1977 level).[9] This, of course, translates into an expected demand for additional commercial and industrial development in the city with an accompanying demand for additional retail space and residential units.

TABLE 2

CITY OF DALLAS POPULATION AND AREA, 1940 - 2000

Year	Population No. of Persons	Area Square Miles
1940	294,735	45.6
1951	441,521	121.9
1952	473,440	142.7
1953	515,778	170.3
1954	523,911	175.6
1955	538,029	184.8
1956	558,439	198.1
1957	676,906	236.2
1958	662,789	266.1
1959	671,689	271.4
1960	679,684	277.1
1961	693,156	293.4
1962	708,058	293.4
1963	724,840	288.6
1964	741,050	289.4
1965	756,333	290.6
1966	771,779	295.1
1967	790,688	295.3
1968	807,652	295.3
1969	828,411	295.5
1970	844,401	296.5
1971	863,000	296.9
1972	866,500	298.4
1973	871,500	298.4
1974	872,000	301.3
1975	869,000	301.4
1976	873,500	340.2 *
1977	882,500	360.9 *
1978	887,500	378.1 *
1979	898,000	378.1 *
1980	904,078	378.1 *
1981	910,000	378.1 *
1982	916,000	378.1 *
1990	1,056,700	N.A.
2000	1,139,200	N.A.

* Area includes annexation of Lake Ray Hubbard lands -- approximately 37 square miles of water.

Sources: North Central Texas Council of Governments and Dallas Department of Planning and Development.

In the ten year period ending with the City of Dallas fiscal year 1980-81, the valuation of property in the city (for tax assessment purposes) grew by 197 percent over that of fiscal year 1971-72. Adjusted for inflation, the growth in property valuation over the period was 41 percent.[10]

Census data (1980) indicates a total of 390,226 housing units, 9 percent of which were vacant. The mean value of owner-occupied housing units was $60,443. Owner-occupied housing units accounted for 48.5 percent of all housing units in the city.

Building Construction Activity

To determine the impact the code change proposals would have on future construction, it was necessary to determine trends and approximate dollar figures for new construction in Dallas. The sources examined for this information are the Annual Reports of the Building Inspection Division of the Department Housing and Urban Rehabilitation.

Examination of the Annual Reports for the eleven year period of 1971 to 1981 indicates a definite growth pattern since the recession of the middle 1970's.

The valuation of total construction for each year is constituted by the value of construction in four categories.

- Non-residential construction.
- Residential construction.
- Additions, alterations, repair and conversion construction.
- Publicly financed construction.

These categories are listed in Table 3 with corresponding actual dollar values and inflation adjusted dollar values.

TABLE 3

CONSTRUCTION VALUATION, 1971-81 - ACTUAL DOLLARS AND INFLATION ADJUSTED DOLLARS[1]

	Dollars in Thousands										
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Non-Residential	102,465	129,109	120,109	124,462	75,856	148,138	145,802	287,807	296,996	559,883	948,275
	248,639	**280,005**	**245,164**	**244,002**	**134,296**	**237,981**	**215,291**	**387,089**	**357,839**	**612,869**	**948,275**
Residential											
One- & Two-Family	64,033	77,230	56,076	43,622	63,351	107,539	170,518	231,238	256,607	260,711	220,726
	155,381	**167,493**	**114,462**	**85,519**	**112,157**	**172,759**	**251,786**	**311,006**	**309,176**	**285,384**	**220,726**
Multiple Family	54,543	46,952	32,850	28,154	10,844	45,799	104,785	137,369	146,680	107,850	143,946
	132,352	**101,824**	**67,053**	**55,195**	**19,198**	**73,543**	**154,725**	**184,756**	**176,729**	**118,057**	**143,946**
Alterations, Additions Repairs and Conversions											
Residential	11,123	10,962	8,064	8,531	11,325	14,285	20,225	19,815	30,201	31,743	34,505
	26,991	**23,774**	**16,460**	**16,725**	**20,049**	**22,949**	**29,864**	**26,650**	**36,388**	**34,747**	**34,505**
Non-Residential	29,866	37,459	46,762	48,930	33,537	42,672	50,303	104,609	84,868	122,949	137,106
	72,472	**81,239**	**95,449**	**95,925**	**59,374**	**68,551**	**74,277**	**140,695**	**102,254**	**134,585**	**137,106**
Publicly Financed Construction	15,830	48,959	37,630	16,056	38,925	27,842	31,272	59,672	139,096	78,926	55,777
	38,413	**106,180**	**76,809**	**31,477**	**68,913**	**44,728**	**46,176**	**80,256**	**167,591**	**86,395**	**55,777**
Total	277,860	350,671	292,400	275,755	233,838	386,255	522,905	842,511	954,448	1,162,062	1,540,341
	674,248	**760,518**	**615,397**	**540,604**	**413,989**	**620,512**	**772,119**	**1,133,145**	**1,149,977**	**1,272,036**	**1,540,341**

1. Values in normal print are actual dollar values. Values in **bold** print are actual values in the line above adjusted to 1981 dollars per the Dallas Building Cost Index (BCI) as reported by the "Engineering News Record."

Graphically illustrated in Figure 3 is the value of new construction, including additions, alterations, repairs and publicly financed buildings, as reported in building permit applications for each year of the period. The values shown have been adjusted for inflation to 1981 dollars using the City of Dallas Building Cost Index (BCI) reported by the "Engineering News Record." Since the height of the recession in 1975, 1981-dollar value of new construction has risen from $414 million to $1.54 billion in 1981.

The valuation history of non-residential construction, which includes hotels, office buildings, retail stores, industrial buildings, hospitals, churches, parking garages and recreational buildings is shown in Figure 4. Similar to the upward trend for total new construction, the valuation of non-residential construction shows a significant overall increase from 1975 to 1981.

The trend of new residential construction value is illustrated in Figure 5. Both multiple-family and one- and two-family housing units have seen an increase from 1975 to 1978, $105 million and $199 million, respectively. From 1978 to 1981, a $133 million decrease in residential valuation occurred which is attributable to the economic slow-down in the entire housing industry. Multiple-family housing, however, showed a slight upturn from 1980 to 1981 which may indicate a developing need for more housing at lower costs and a demand for rental units.

The third contributory category to total new construction value is the valuation assigned to new additions, alterations, repairs and conversions. Figure 6 indicates the trend of this category's valuation for both residential and non-residential construction. Non-residential additions, alterations, repairs and conversions track with the upward trend for total new construction values. The valuation of additions, alterations, repairs and conversions for residential construction, although gradually increasing, has seen no significant change over the eleven year period.

While the valuation histories of the first three categories do exhibit noticeable trends, the fourth category, publicly financed construction, is generally affected by specific city improvements, such as the building of city hall, rather than demographics. Therefore, the valuation history of publicly financed construction is not considered an applicable indication of activity and growth. The other categories, however, are considered strong indicators of activity and growth in Dallas.

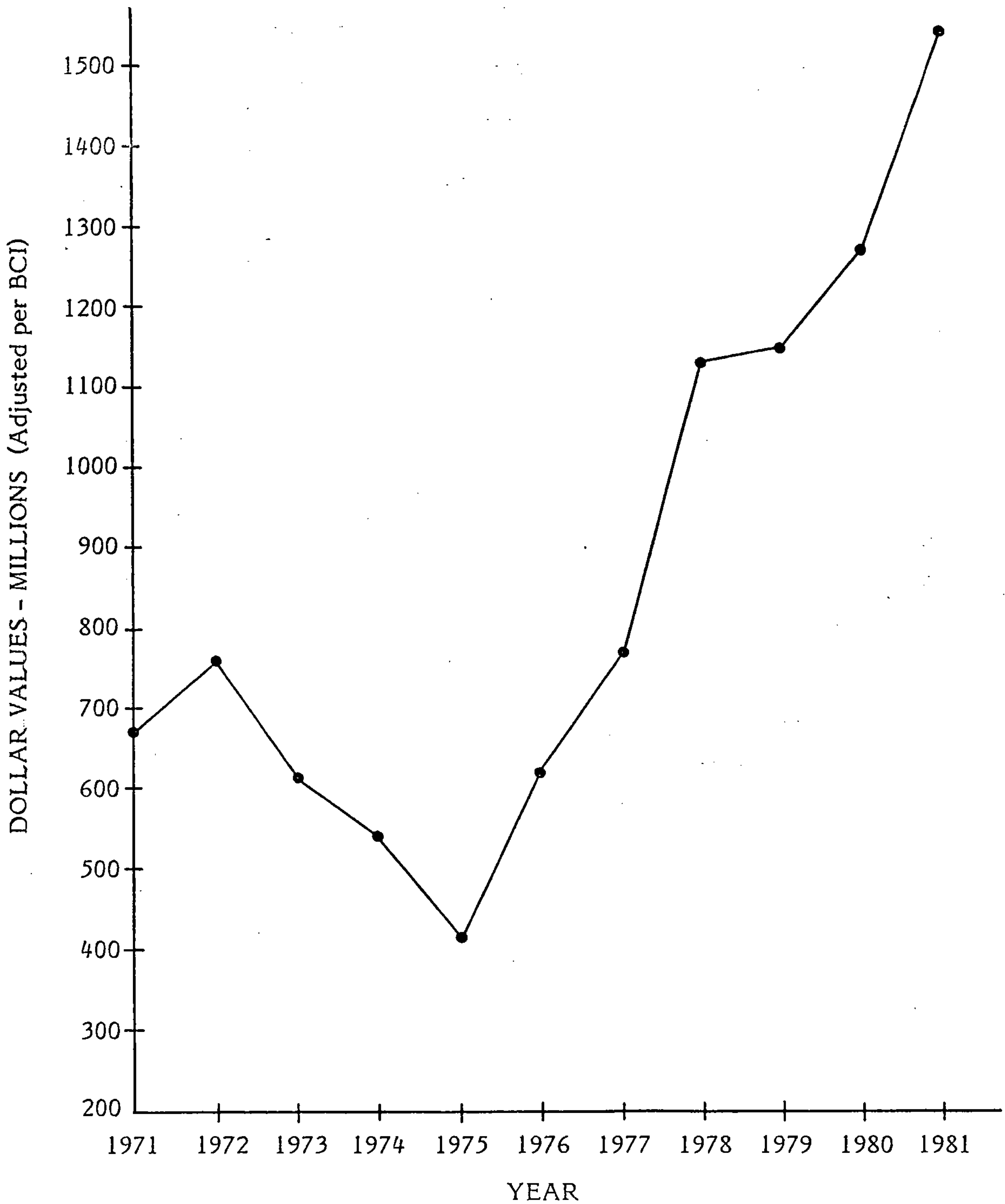


FIGURE 3

TOTAL CONSTRUCTION VALUATION HISTORY, 1971-1981

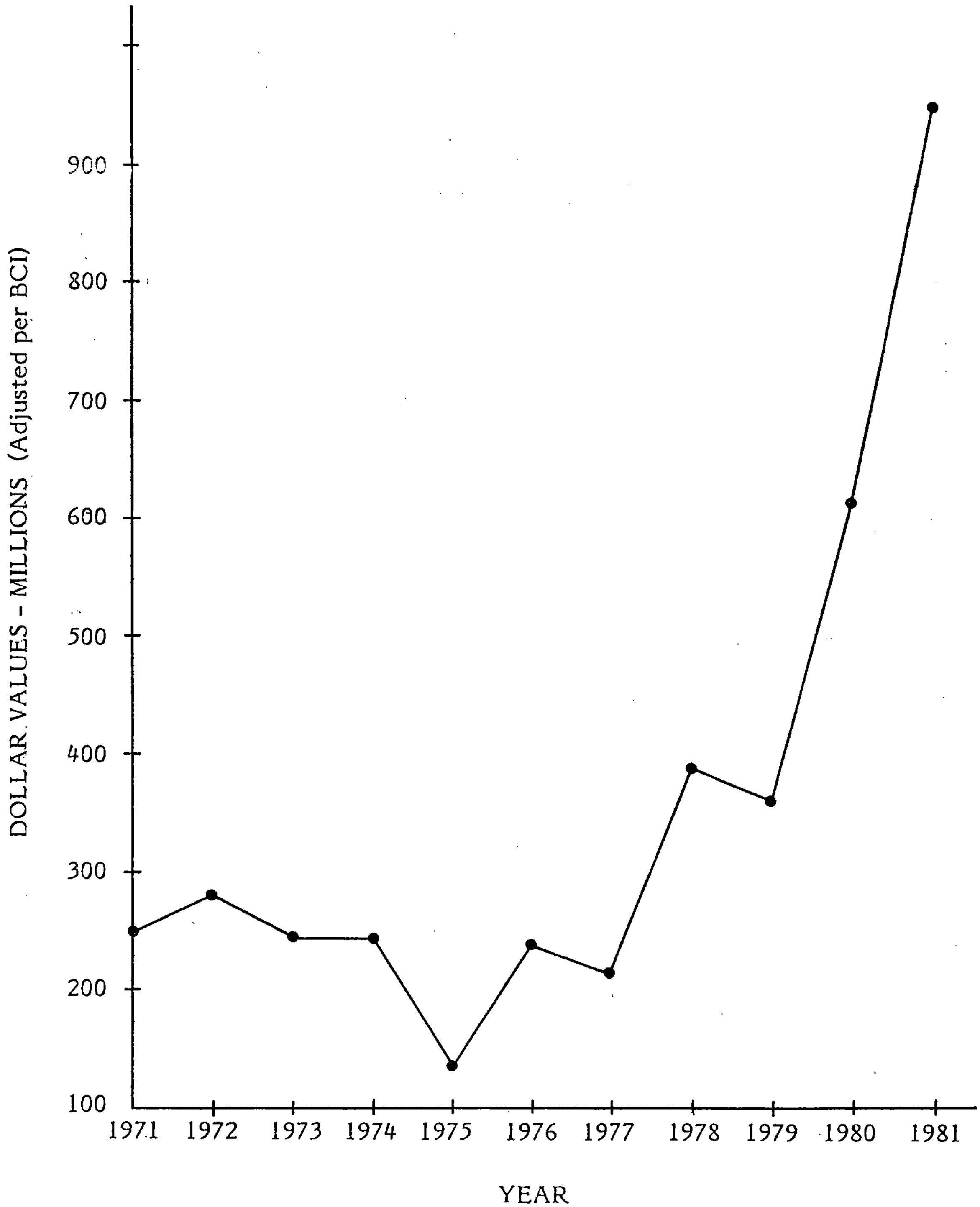


FIGURE 4

NON-RESIDENTIAL CONSTRUCTION VALUATION HISTORY, 1971-1981

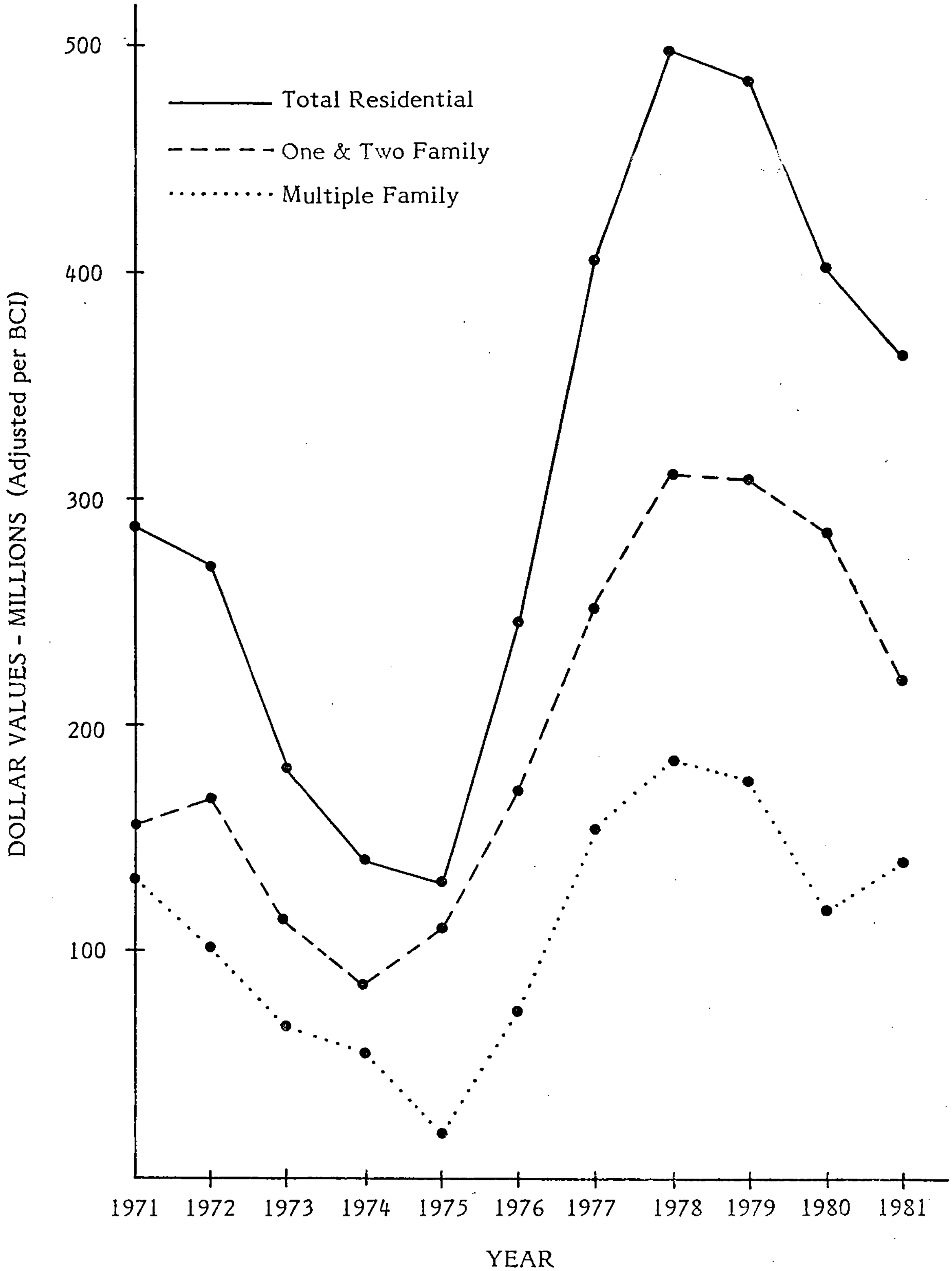


FIGURE 5

RESIDENTIAL CONSTRUCTION VALUATION HISTORY, 1971-1981

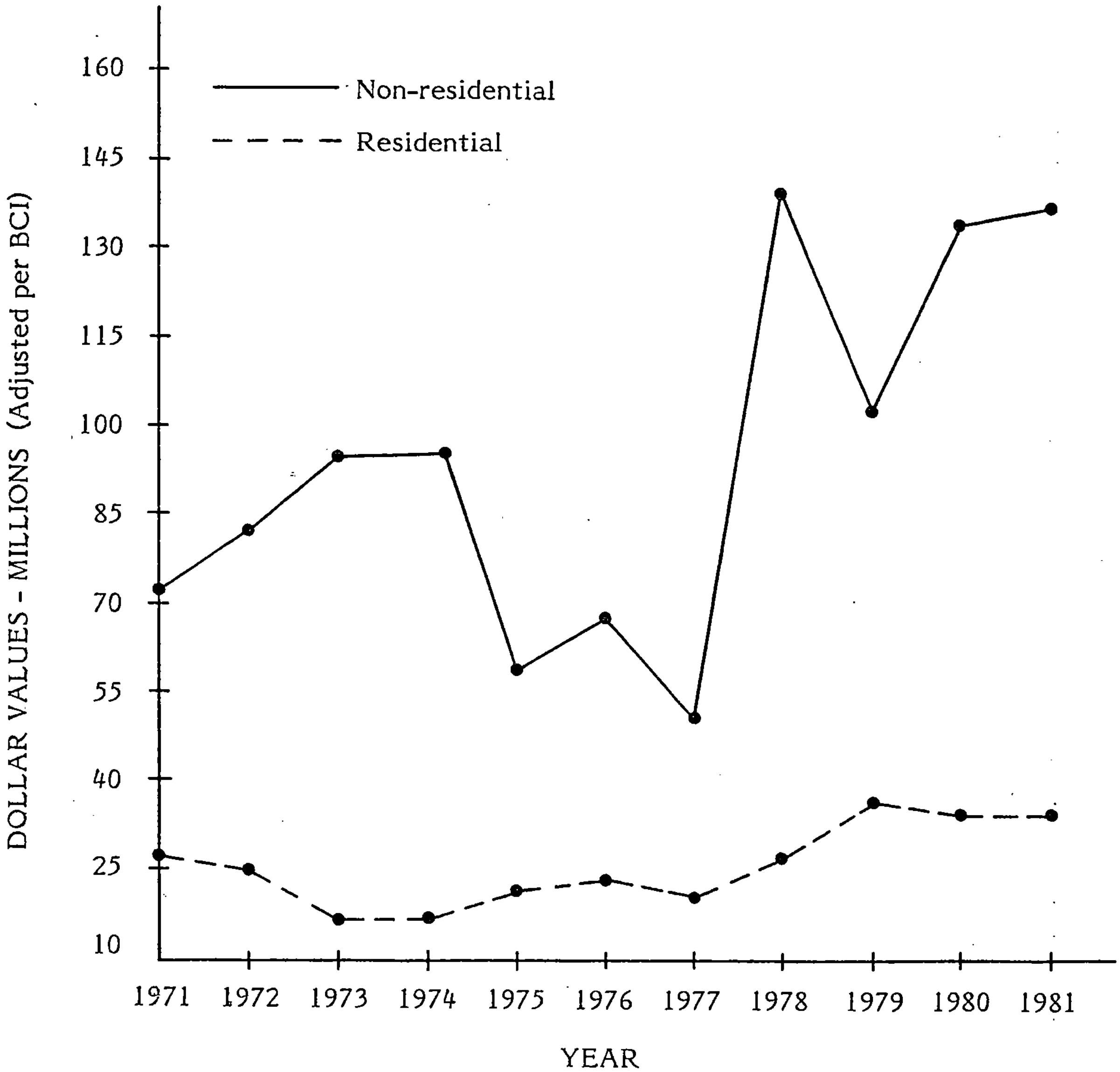


FIGURE 6

ADDITIONS, ALTERATIONS, REPAIRS CONVERSION

CONSTRUCTION VALUATION HISTORY, 1971-1981

Based on the construction valuation trends, the overall outlook for Dallas is one of continued growth. This is expected as Americans and business continue to migrate from the northeast and midwest to the sunbelt regions of the country, with Texas cited as one of the biggest gainers by the Commerce Department. Although residential construction has declined since 1979, it is expected to be only a temporary trend which will change with increased demand for housing, caused by increasing population and commercial activity projected to the end of the decade.

Dallas Fire Experience

Recent fire experience of the City of Dallas was analyzed to determine the relative magnitude of the current fire problem in the city when related to that of other similar sized cities, as well as fire experience on a state and national level. Records of the Dallas Fire Department for the period 1970 through September, 1982 were reviewed in order to obtain, where possible, the annual number of fires, occupancy description, fire fatalities, fire injuries and annual property loss. (Beginning in 1979, fire department data was reported on a fiscal year basis, from October 1 to September 30 of the following calendar year.)

Table 4 summarizes fire casualties in the City of Dallas for the period 1970 through September, 1982. This table includes the annual number of fires, civilian fire fatalities and civilian fire injuries. (There were five fire department fatalities during this period: three in 1975 and two in 1981. Fire injury data of Dallas Fire Department personnel during this period were not available.)

It is apparent that the annual number of fires increased substantially during the first seven years of the period, but has shown an overall decline in recent years. When adjusted to a population-based rate (the number of fires per thousand persons population), a slight increase in the fire rate is apparent during this period.

TABLE 4

DALLAS CIVILIAN FIRE CASUALTIES, 1970 THROUGH FY 1981-82

Year[1]	Number of Structural Fires	Number of Structural Fires per Thousand Population	Fire Fatalities	Fatalities per Million Population	Fire Injuries (Estimated)	Fire Injuries per 100,000 Population
1970	2,233	2.64	40	47.4	155	18.36
1971	2,314	2.68	27	31.3	128	14.83
1972	2,407	2.78	39	45.0	103	11.89
1973	2,256	2.59	35	40.2	85	9.75
1974	2,857	3.28	29	33.3	82	9.40
1975	2,855	3.29	26	34.5	112	12.89
1976	3,010	3.45	**45**	**51.5**	132	15.11
1977	**3,581**	**4.06**	37	41.9	87	9.86
1978	2,943	3.32	38	42.8	86	9.67
1979	2,711	3.02	28	31.2	100	11.14
FY 79-80[2]	2,876	3.18	24	26.5	206	22.79
FY 80-81	2,824	3.10	31	34.1	**225**	**24.73**
FY 81-82	2,553	2.79	36	39.3	**225**	24.56
Average	2,725	3.09	33	38.4	133	15.00

1. Calendar year unless otherwise noted as fiscal year (October 1 through September 30).

2. Data in fiscal year 1979-1980 duplicates three months of data in calandar year 1979.

Source: Dallas Fire Department.

Fire loss data for other cities and on a state and national basis were not always available for direct comparison with the Dallas data. Only in recent years has the data base been broadened by both FEMA and the NFPA to allow such comparisons. National civilian fire fatality data indicates an overall decline in the period 1971 to 1981 from a high of approximately 9,000 deaths in 1971 to a low of approximately 7,600 deaths in 1980. In terms of deaths per million persons, the US fire death rate also showed a decline in the same period, from a high of 43.7 deaths per million persons in 1971 to a low of 33.6 deaths per million persons in 1980. (In 1981, the national civilian fire death rate was 33.1, down slightly from the 1980 rate. The estimate of the number of national fire fatalities remain the same as in 1980.)[11]

In the period reviewed, the number of fire fatalities in the City of Dallas averaged 33 deaths per year with a high of 45 fatalities in 1976 and a low of 24 fatalities in fiscal year 1979-80. It should be noted that the average number of fire fatalities in the last five years is slightly less than that of the entire period, indicative of a downward trend.

The Dallas fire death rate averaged 38.4 deaths per million persons during the period. The fire death rate peaked at 51.5 in 1976 and reached a low of 26.5 in the fiscal year 1979-80. The average fire death rate for the last five years averaged 34.8, indicative of a recent downward trend.

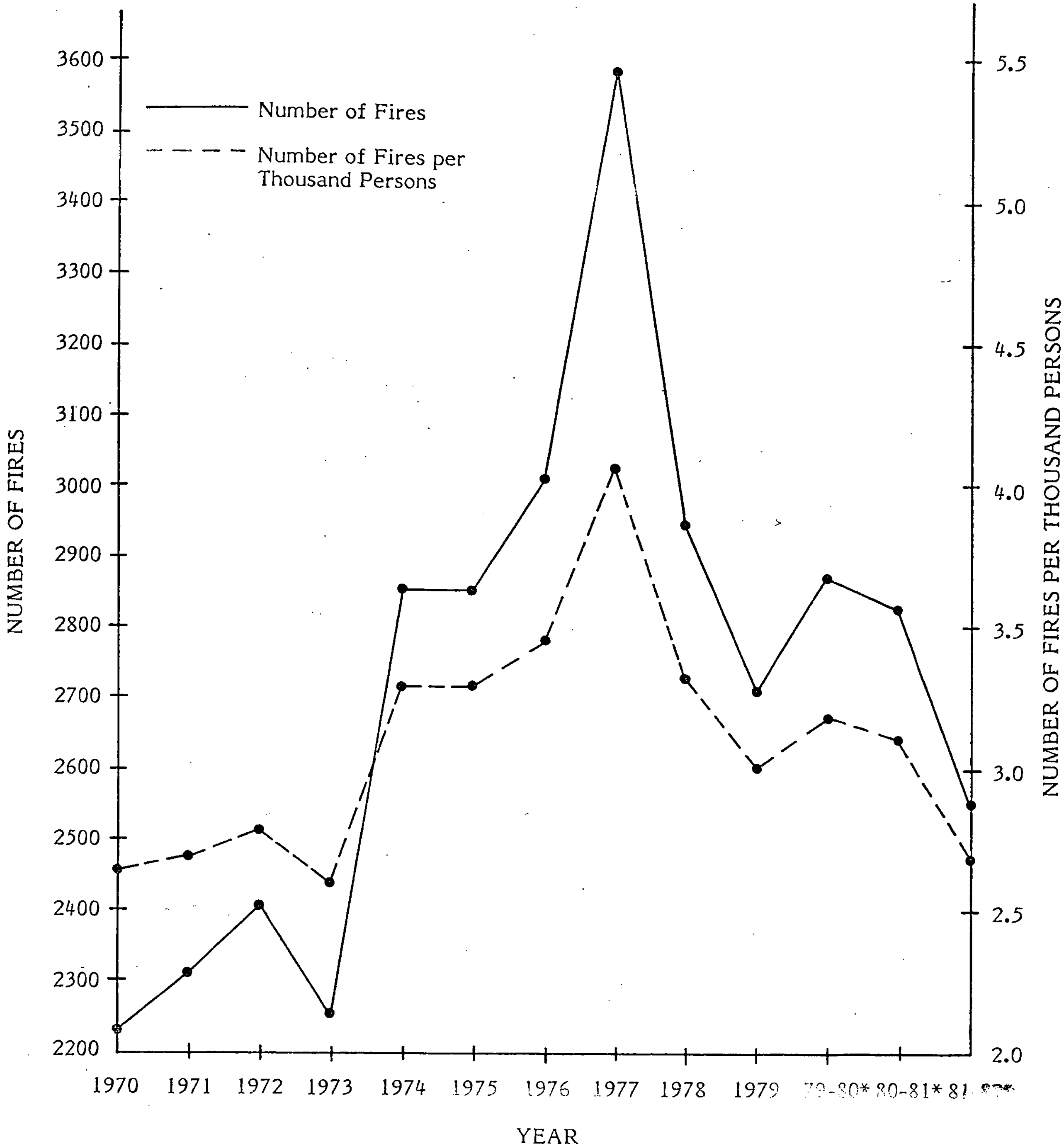
The 1980 average fire death rate for the State of Texas was 31.6 deaths per million persons. (Texas ranked 17th highest of the 50 states and the District of Columbia. Alaska was ranked first with 68.0 fire deaths per million; Hawaii was ranked 51st with 4.1 fire deaths per million.)[12] NFPA fire loss statistics identified the 1979 fire fatality rate for communities of 500,000 or more in southern regions of the United States as approximately 36. Also, the NFPA identified a national fire death rate of approximately 31 fatalities per million persons for communities with a population of 500,000 to 999,999 persons, and approximately 41 fatalities per million persons for communities with one million or more persons for the year 1979. In 1980, these figures were approximately 27 fatalities per million and 41 fatalties per million, respectively.[13] Thus, it could be seen that the fire fatality record of the City of Dallas was approximately the same as national averages for the years [illegible]

The estimated annual number of civilian fire injuries in Dallas reported for the period 1970 through September, 1982 was extremely variable. Fire injuries ranged from a high of 225 in fiscal years 1980-81 and 1981-82, to a low of 82 in 1974. The average number of injuries for the period examined was 133. No details were available describing the nature or the extent of fire injuries. These data were not considered reliable enough to draw firm conclusions as the reported numbers are only estimates. Again, fire-related injuries of Dallas Fire Department personnel were not available.

On a national level, civilian fire injuries for the year 1981 were estimated to be 31,000. It is estimated that there are also 200,000 additional fire related injuries in the United States in 1981 that were not reported to the fire service.[14] The number of fire injuries in the United States has remained nearly constant in the four year period of 1977 to 1980.[15] The average number of civilian injuries for 1980 in communities having a population of 500,000 to 999,999 persons was 96.10. The higher average number of injuries in Dallas in recent years may be attributed to an improved method of estimating such injuries. (A relationship between a higher number of injuries and the lower number of fire deaths in recent years was not established.) Excluding 1980 data, the average estimated number of injuries per year in Dallas for the period of 1977 to 1979 was 91.00.

When computed on a population-based rate, estimated fire injuries in Dallas over the period of 1970 through September, 1982 compare favorably to the national rate established for 1978: 15.00 vs. 62.56 injuries per 100,000 persons, respectively.[16] (National injury rates were not available for other years.) Fire injury rates in Dallas in the period ranged from a high of 24.73 in fiscal year 1980-81 to a low of 9.4 injuries per 100,000 persons population in 1974.

More than 35,000 fires were reported to the Dallas Fire Department during the period of 1970 through September, 1982, averaging 2,725 fires per year. Figure 7 is a representation of the annual number of fires during this period. The overall pattern apparent in Figure 7 is indicitive of an increasing number of fires in the period through 1977, followed by a decline in the recent five years. Similarly, the population-based rate of fires per thousand persons population indicates an upward trend until 1977, followed by a steady downward trend in the last five years to a level comparable with that of the year 1970. The number of fires per thousand persons for the period averaged 3.09 with a high of 4.06 in 1977 and a low of 2.59 in 1973.



*Fiscal year period.

FIGURE 7

DALLAS FIRE FREQUENCY, 1970 THROUGH FY 1981-1982

The number of fires in the United States has, in the period 1977 to 1981, remained relatively constant. More than one million structural fires -- accounting for about 37 percent of all fires -- are estimated to be reported to the fire service annually. An additional thirty million fires per year are believed to be unreported to the fire service.[17,18]

There were approximately 15 fires per thousand persons for communities in the southern portion of the United States having a population more than 500,000 persons in 1980.[19] The Dallas data compares favorably with this national data.

Direct property losses for the period 1970 through September, 1982 are summarized in Table 5. The trend in increasing annual losses is readily apparent. This increase is partially offset by inflation, however, as reflected in Figure 8 where the annual reported property loss figures have been adjusted per the Dallas Consumer Price Index (CPI). Yet, even discounting the extraordinary property loss data of 1980, a slightly increasing trend in property loss is evident. Average property loss per fire and average property loss per capita for each year also shows an upward trend.

Nationally, direct property losses due to fire increased 32 percent over the four year period 1977 to 1980 to an estimated $6.25 billion, 88 percent of which is structural fire loss. When adjusted for inflation, the national property damage is considered constant.[20] In this same period, property losses in Dallas increased 106 percent, or, adjusted for inflation, 45 percent. In 1980, the average direct property loss in communities having a population of 500,000 to 999,999 persons was $16,943,100, 46 percent of which occurred in residential fires. The national per capita direct property loss for 1980 was approximately $27.61 compared with the 1980 per capita loss of $49.36 in Dallas. In 1980, the average structural fire loss was estimated to be $5,121 vs. an average fire loss of $15,518 in Dallas. (These figures are not necessarily indicitive of a severe fire control problem since national loss data may be skewed downward by fires in lower value, rural properties.)

In recent years, the Dallas Fire Department has utilized computer-based methods of assimilating fire loss data in order to assist in directing the resources of the department to those areas where the need is greatest. Fire loss data are analyzed to determine, among other things, building occupancy, ignition factors and geographic distribution of fire frequency and property loss (Figures 9 and 10).

TABLE 5

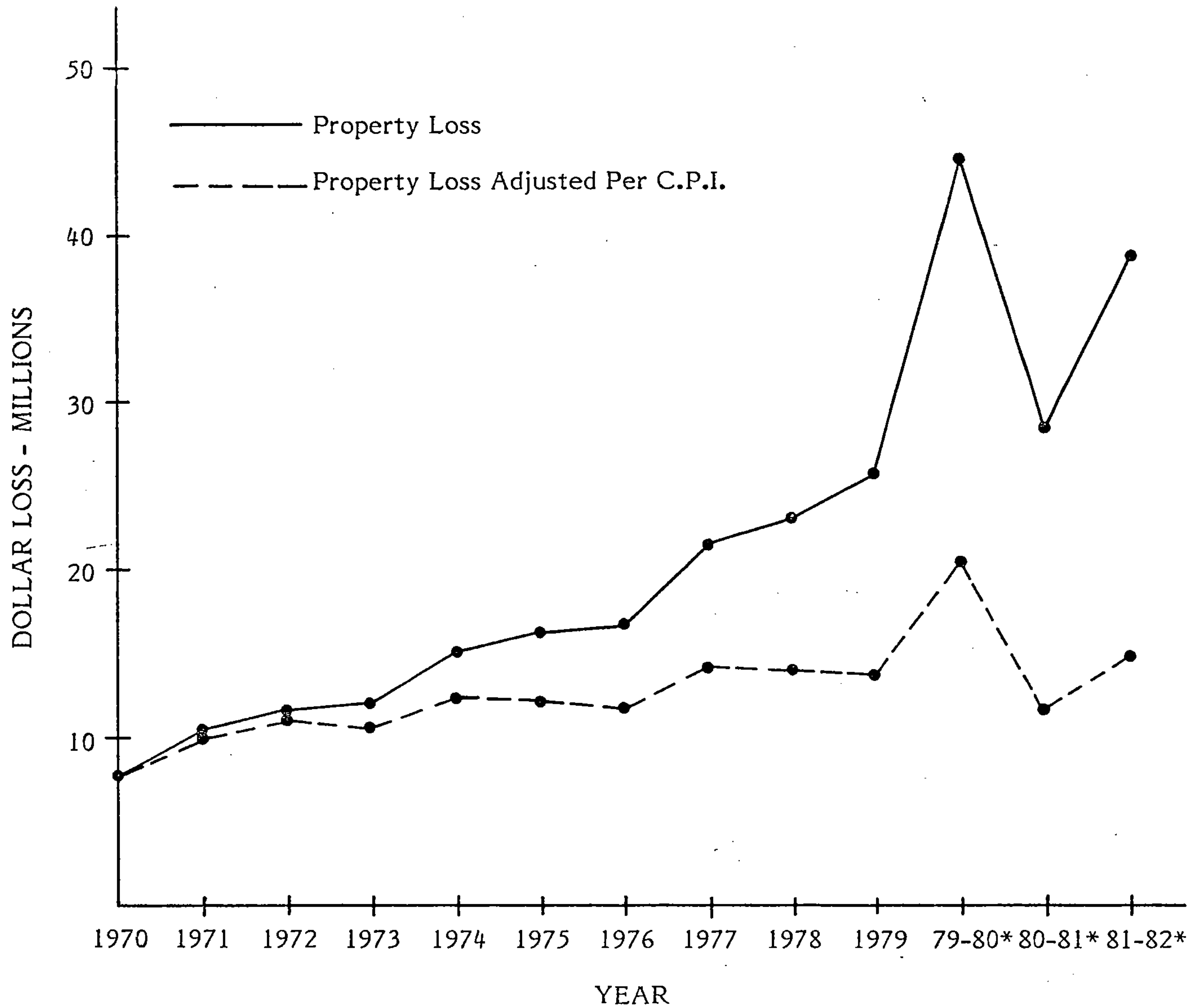
DALLAS FIRE LOSS DATA, 1970 THROUGH FY 1981-82

Year[1]	Structural Fires Total	Structural Fires % Residential	Property Loss Total	Property Loss % Residential	Property Loss per Fire	Property Loss per Capita
1970	2,233	68.2	$ 7,872,816	55.5	$ 3,526	$ 9.32
1971	2,314	70.7	10,433,419	50.3	4,509	12.09
1972	2,407	72.9	11,870,319	61.8	4,932	13.64
1973	2,256	77.7	12,073,826	68.2	5,352	13.85
1974	2,857	76.4	15,289,022	59.6	5,351	17.53
1975	2,855	79.4	16,335,246	66.2	5,722	18.80
1976	3,010	79.7	16,969,871	77.6	5,638	19.43
1977	3,581	79.4	21,698,747	67.3	6,059	24.59
1978	2,943	79.0	23,120,262	69.0	7,856	26.05
1979	2,711	N.A.	25,844,958	N.A.	9,533	28.78
FY 79-80	2,876	78.0	44,629,238	53.3	15,518	49.36
FY 80-81	2,824	75.6	28,363,178	58.4	10,044	31.17
FY 81-82	2,553	N.A.	38,582,637	N.A.	15,113	42.12

N.A. - Not available.

1. Calendar year unless otherwise noted as fiscal year (October 1 through September 30).

Source: Dallas Fire Department.



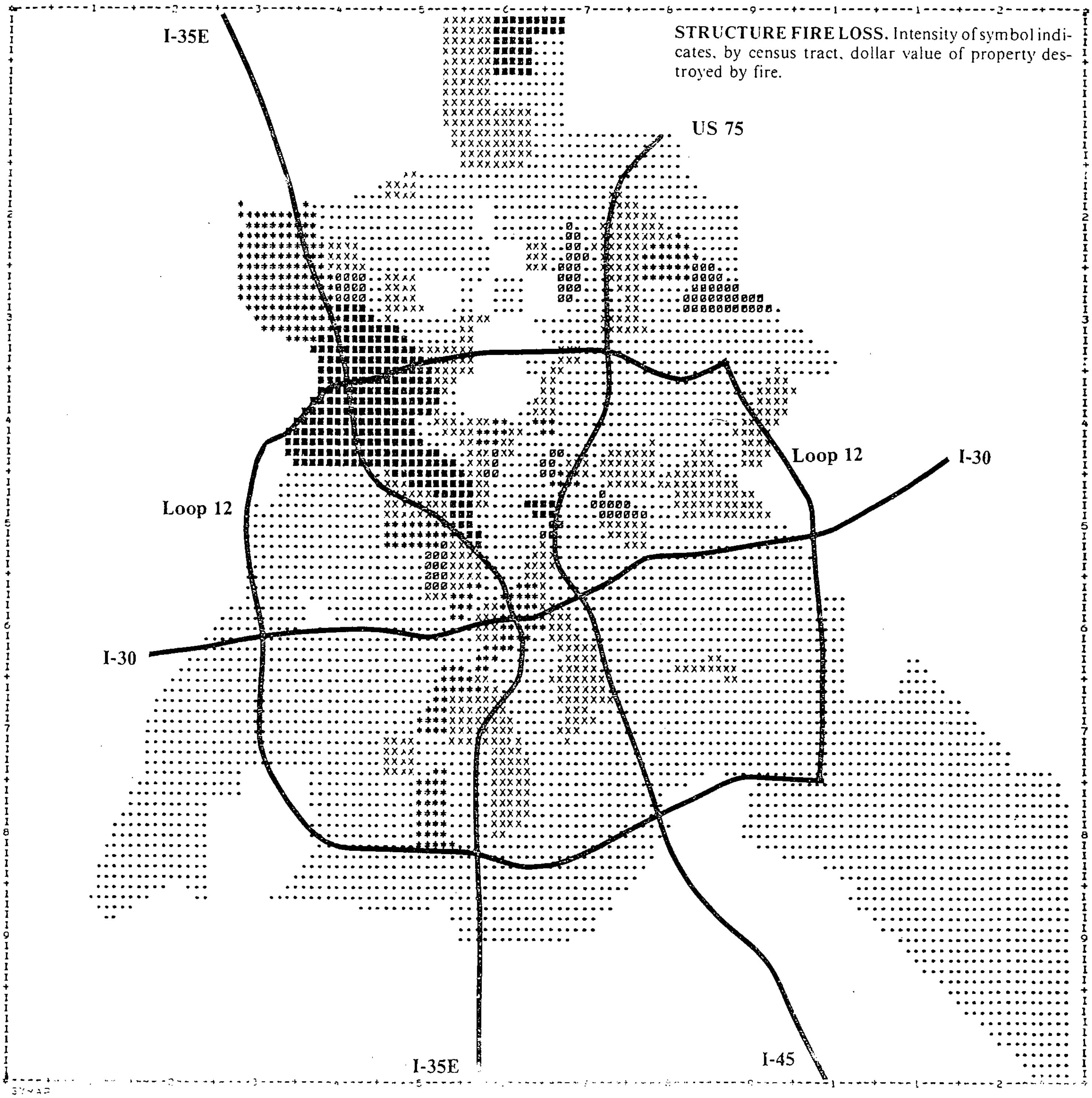
*Fiscal year period.

FIGURE 8

PROPERTY LOSS, 1970 THROUGH FY 1981-1982

FIGURE 9

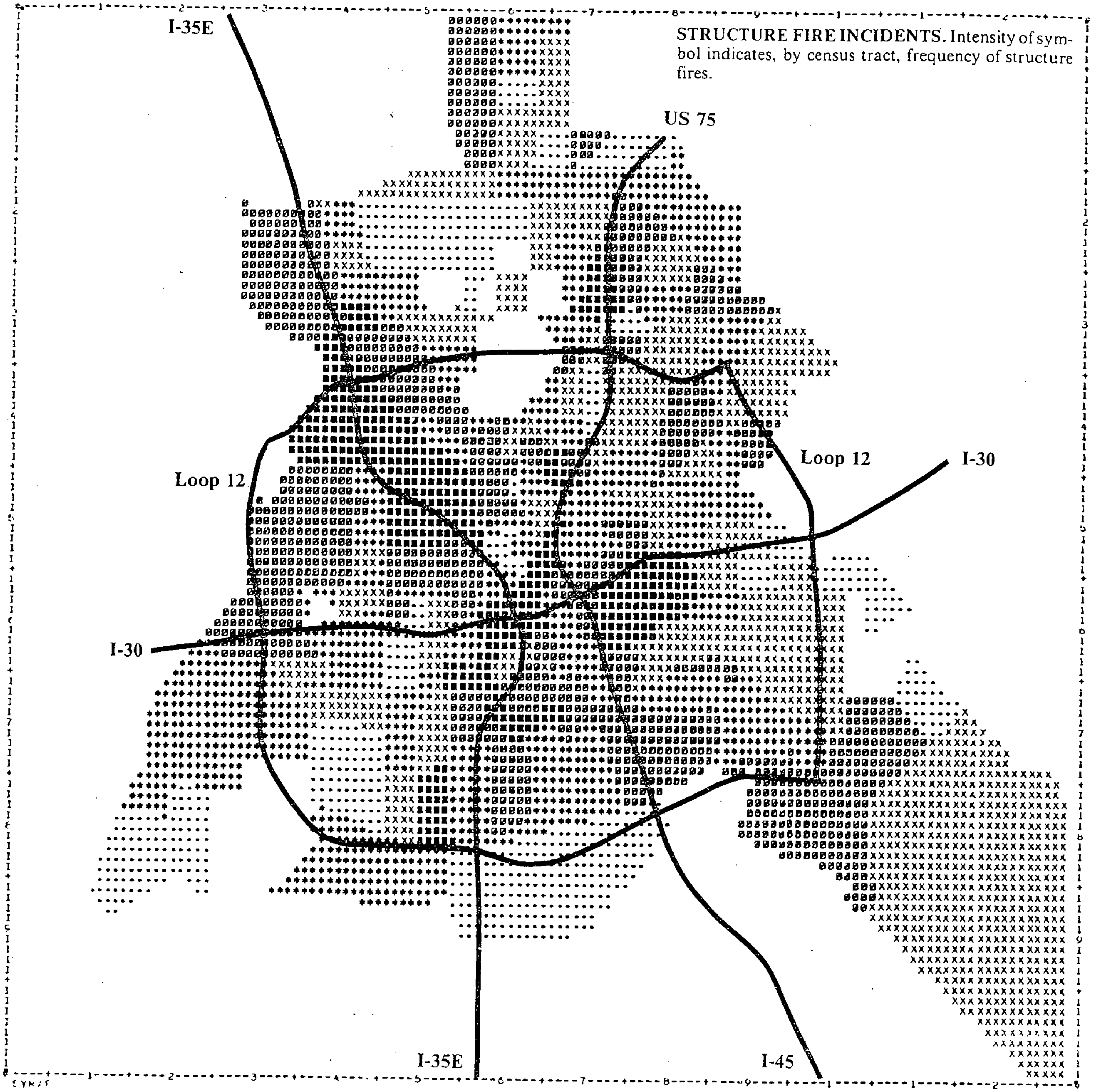
DISTRIBUTION OF STRUCTURE FIRE LOSS



Map Symbol	....	XXXXXXXXX	*********	000000000	■■■■■■■■■
Amount of Loss in Each Increment (Range)	$1- $124,525	$124,526- $233,485	$233,486- $342,444	$342,445 $466,969	$466,970 $1,556,562
Number of Census Tracts in Each Increment	151	38	12	8	5

FIGURE 10

LOCATION OF STRUCTURE FIRES



Map Symbol	....	XXXXXXXXX	*********	000000000	■■■■■■■■■
Number of Structure Fires in Each Increment (Range)	1-5	6-8	9-16	17-26	27-51
Number of Census Tracts in Each Map Increment	30	55	66	47	17

Incendiary fires accounted for approximately 28 percent of all structural fire incidents in Dallas during the period 1970 to September, 1982. Approximately 25 percent of the property damage in Dallas in this period was the result of incendiary fires. This is comparable to the national proportion of incendiary property losses to total property losses. Incendiary fires accounted for approximately 15 percent of all structural fires on a national level for the period 1977 to 1980.

A more detailed examination of Dallas fire records shows a disproportionately large share of fire fatalities and property loss occurring in residential occupancies (Table 5). A detailed analysis of fires and property loss by occupancy was not available for all years in the period of 1970 to 1980. Yet, it can be seen in Table 5 that approximately 75 percent of the fire incidents and more than 60 percent of the property loss occurred in residential occupancies. Detailed occupancy information related to fire incidents and property loss was available for the 5 year period of 1974 to 1978 (Table 6). These data show that residential fires accounted for 78.8 percent of fire incidents and 68.1 percent of the property loss.

More disturbing, however, is the fact that residential fires accounted for about 87 percent of fire fatalities during those years in which building occupancy was identified (Table 7). Seventy-five percent of the fatalities in this period occurred in one- and two-family dwellings, apartments and mobile homes.

Residential fire losses in the City of Dallas are consistent with national fire loss experience. The residential fire problem has received a great amount of national attention in the last several years and much information is available concerning ignition scenarios, distribution of fires by time of day and room of origin, and distribution of fatalities by age and sex. On a national scale, residential fires currently account for approximately 71 percent of structural fires, 80 percent of all fire fatalities, 65 percent of all fire injuries and 50 percent of structural fire losses. Fires in one- and two-family dwellings, apartments and mobile homes alone account for approximately 76 percent of all fire fatalities and 89 percent of structural fire fatalities.

TABLE 6
DALLAS FIRE EXPERIENCE BY OCCUPANCY GROUP
FOR 5 YEAR PERIOD, 1974-78

Occupancy	Number of Fires (%)		Property Loss (%)	
Residential	12,016	(78.8)	$63,602,000	(68.1)
Miscellaneous[1]	796	(5.2)	1,263,000	(1.4)
Mercantile	748	(4.9)	10,777,000	(11.5)
Storage	538	(3.5)	5,358,000	(5.7)
Public Assembly	521	(3.4)	5,901,000	(6.3)
Industrial	233	(1.5)	2,947,000	(3.2)
Business	179	(1.2)	2,980,000	(3.2)
Educational	133	(0.9)	330,000	(0.4)
Institutional	82	(0.6)	192,000	(0.2)
Total	15,246	(100.0)	$93,350,000	(100.0)

1. Garages, barns, sheds and all other property.

Source: Dallas Fire Department.

TABLE 7

WHERE FIRE FATALITIES OCCUR IN DALLAS[1]

Occupancy		Number (%)
Residential		312 (87.4)
1 and 2 Family Dwellings	163	
Apartments	108	
Hotels/Motels	8	
Mobile Homes	4	
Not Identified	29	
Automobile		17 (4.8)
Industrial		11 (3.1)
Automotive Garage		6 (1.7)
Yard		4 (1.1)
Nursing Home		2 (0.5)
Shed		2 (0.5)
Community Center		1 (0.3)
Dance Hall		1 (0.3)
Office		1 (0.3)
Total		357 (100.0)

1. This data reflects the identification of building occupancy involving fire fatalities in the years 1970, 1972-1977, FY 1979-80, FY 1980-81 and FY 1981-82.

Source: Dallas Fire Department.

Dallas fire experience is also consistent with national fire experience in that infants and the elderly account for a disproportionately large share of fire fatalities. For example, in a recent year, fire fatalities among infants in the City of Dallas represented 15.2 percent of the total fire fatalities, even though they accounted for only 7.4 percent of the total population. Similarly, fire fatalities among the elderly represented 21.2 percent of all fire fatalities although the elderly accounted for only 9.5 percent of the population.

The residential data are an indication of where the nation's efforts toward life safety, property protection and fire prevention have been focused. It is readily apparent that a major effort must be directed toward residential occupancies if the nation's -- and Dallas' -- fire experience is to be significantly affected.

Dallas Fire Department

The Dallas Fire Department was organized in 1872 with 14 volunteer fire fighters, 2 hand-operated engines and 10 small extinguishers. In 1981, the fire department operated 48 fire stations housing 48 engines, 22 aerial ladder trucks, 18 mobile intensive care units (ambulances), 4 manpower squads, 5 crash units, 4 booster pumpers, 6 rescue units and 5 boats, in addition to reserve equipment (Figure 11). One additional fire station is scheduled for operation in 1982 and one additional fire station is scheduled for occupancy in 1983.

In fiscal year 1981-82, the department responded to 44,019 fire alarms -- an average of 121 alarms per day. The average fire department response time was 4.14 minutes. In addition, the department responded to 51,251 emergency medical service (EMS) alarms -- an average of 141 alarms per day. The average EMS response time was 5.06 minutes. The Dallas Fire Department has assumed EMS responsibility for the citizens of Dallas since November, 1972.

The Dallas Fire Department's Fire Prevention Education and Inspection Division conducted more than 27,400 inspections and accomplished the correction of more than 30,000 fire hazards in fiscal year 1980-81.

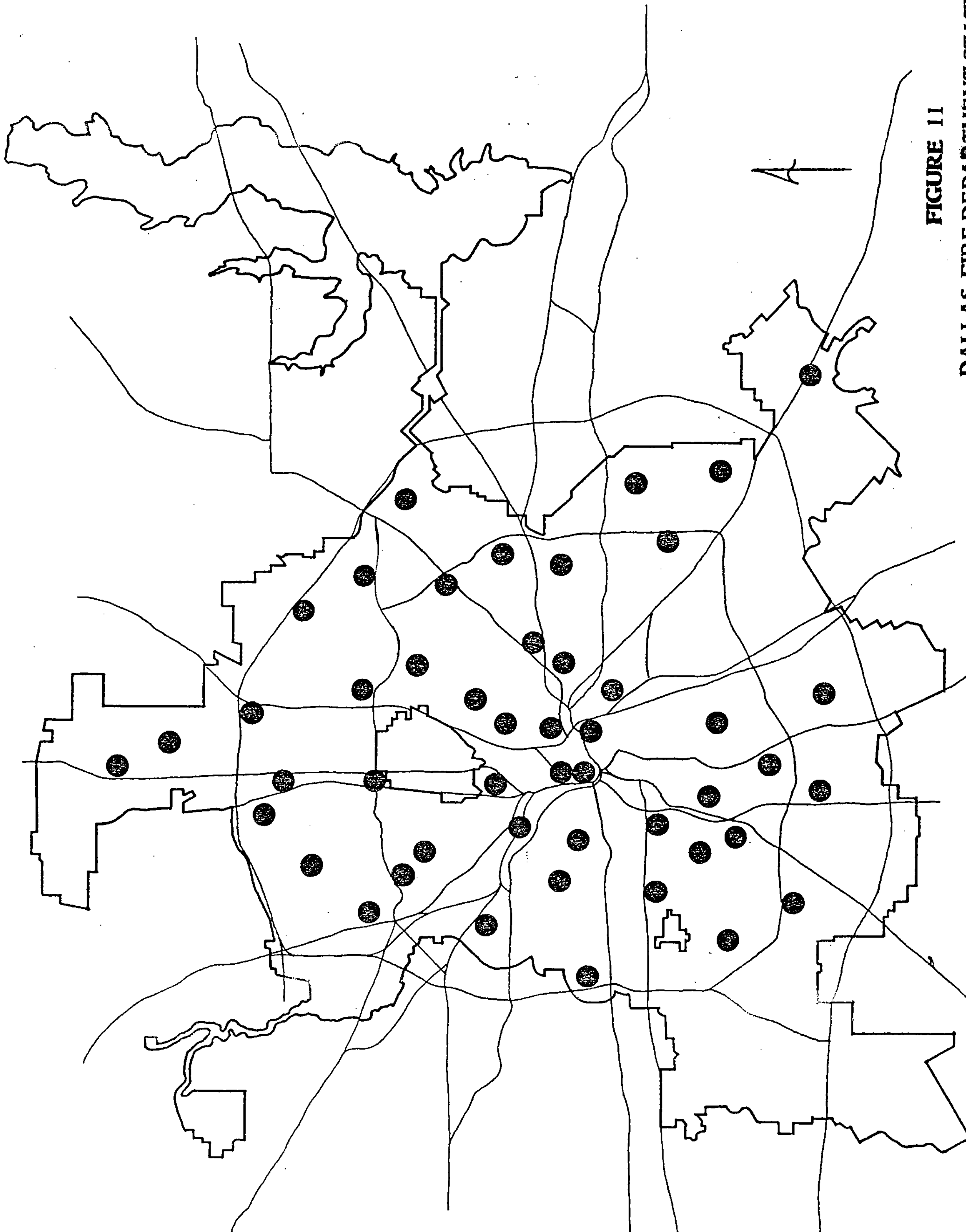


FIGURE 11
DALLAS FIRE DEPARTMENT STATIONS

The fire department's Communications Division coordinates the public's request for fire and emergency medical service by receiving emergency calls, assigning appropriate equipment through the aid of a computer-assisted dispatch (CAD) system, and positioning fire department equipment during periods of heavy demand to assure comprehensive coverage of the city. In 1982, data automation was expanded to provide in-station terminals with visual display and access to a central computer for the entry of fire reports from the stations.

The City of Dallas currently has 1,494 uniformed personnel, approximately 114 of which are assigned to EMS duty. As can be seen in Table 8, the number of uniformed personnel has increased in recent years, yet when expressed in terms of fire fighters per square mile of the city, a downward trend is evident since 1972. The number of fire fighters per thousand population has remained relatively constant since 1972. (EMS personnel were not excluded from the calculation used to produce Table 8 since EMS personnel are also trained as fire fighters.)

The Dallas Fire Department's operating expenditures for fiscal years 1969-70 through 1980-81 are shown in Table 9. A definite upward trend in operating expenditures during the period is evident by this data. When adjusted for inflation, however, fire department operating expenditures have been relatively constant since fiscal year 1974-75 (Figure 12).

Table 9 also identifies the fire department operating budget as a percentage of the city's general fund expenditures for each fiscal year. No trend in this data could be established. However, it is noted that the percentage for the last three fiscal years has exceeded the average for the entire reporting period.

The fire department operating expenditure on a per capita basis is also included in Table 9, both actual and adjusted per the CPI. While the per capita expenditures show a large increase over the reporting period, the adjusted per capita expenditures have remained relatively constant since fiscal year 1974-75 (Figure 12).

TABLE 8

DALLAS FIRE DEPARTMENT MANPOWER, 1970 THROUGH FY 1981-82

Year[1]	No. of Uniformed Fire Fighters[2]	Fire Fighters[2] per Square Mile Area	Fire Fighters[2] per Thousand Population
1970	1,283	4.33	1.52
1971	1,345	4.53	1.56
1972	1,439	4.82	1.66
1973	1,423	4.77	1.63
1974	1,422	4.72	1.63
1975	1,421	4.71	1.64
1976	1,408	4.64 [3]	1.61
1977	1,442	4.45 [3]	1.63
1978	1,486	4.36 [3]	1.67
1979	1,487	4.36 [3]	1.66
FY 79-80	1,454	4.26 [3]	1.61
FY 80-81	1,468	4.30 [3]	1.61
FY 81-82	1,494	4.38 [3]	1.63

1. Calendar year unless otherwise noted as fiscal year (October 1 to September 30).
2. Includes personnel assigned to emergency medical service since November, 1972.
3. Area of Lake Ray Hubbard (37 square miles) not included in calculation.

Sources: Dallas Fire Department and Department of Planning and Development.

TABLE 9

FIRE DEPARTMENT OPERATING[1] EXPENDITURES, FY 1969 - 70 THROUGH FY 1980 - 81

Fiscal Year	Department Expenditures	Percentage of City General Fund Expenditures	Expenditure per Capita	Adjusted[2] Expenditure per Capita
1969-70	$ 14,346,790	17.39	$ 16.99	$ 16.99
1970-71	15,406,791	17.41	17.85	17.34
1971-72	16,806,225	15.61	19.40	18.29
1972-73	18,710,986	16.11	21.47	19.16
1973-74	19,097,889	15.82	21.90	17.76
1974-75	26,159,590	16.88	30.10	22.42
1975-76	27,296,243	16.41	31.25	21.95
1976-77	29,673,560	16.00	33.62	21.98
1977-78	32,969,254	15.98	37.15	22.56
1978-79	38,213,980	16.73	42.55	22.93
1979-80	43,155,694	17.28	47.73	22.00
1980-81	48,288,436	17.20	53.06	21.94

1. Operating expenditures do not include capital funding via general obligation bond issues for fire protection facilities improvement, new construction and land acquisition.

2. Adjusted per Consumer Price Index (CPI) with FY 1969-70 used as base.

Sources: Dallas Fire Department 1979 Annual Report and Dallas 1980-81 Annual Budget.

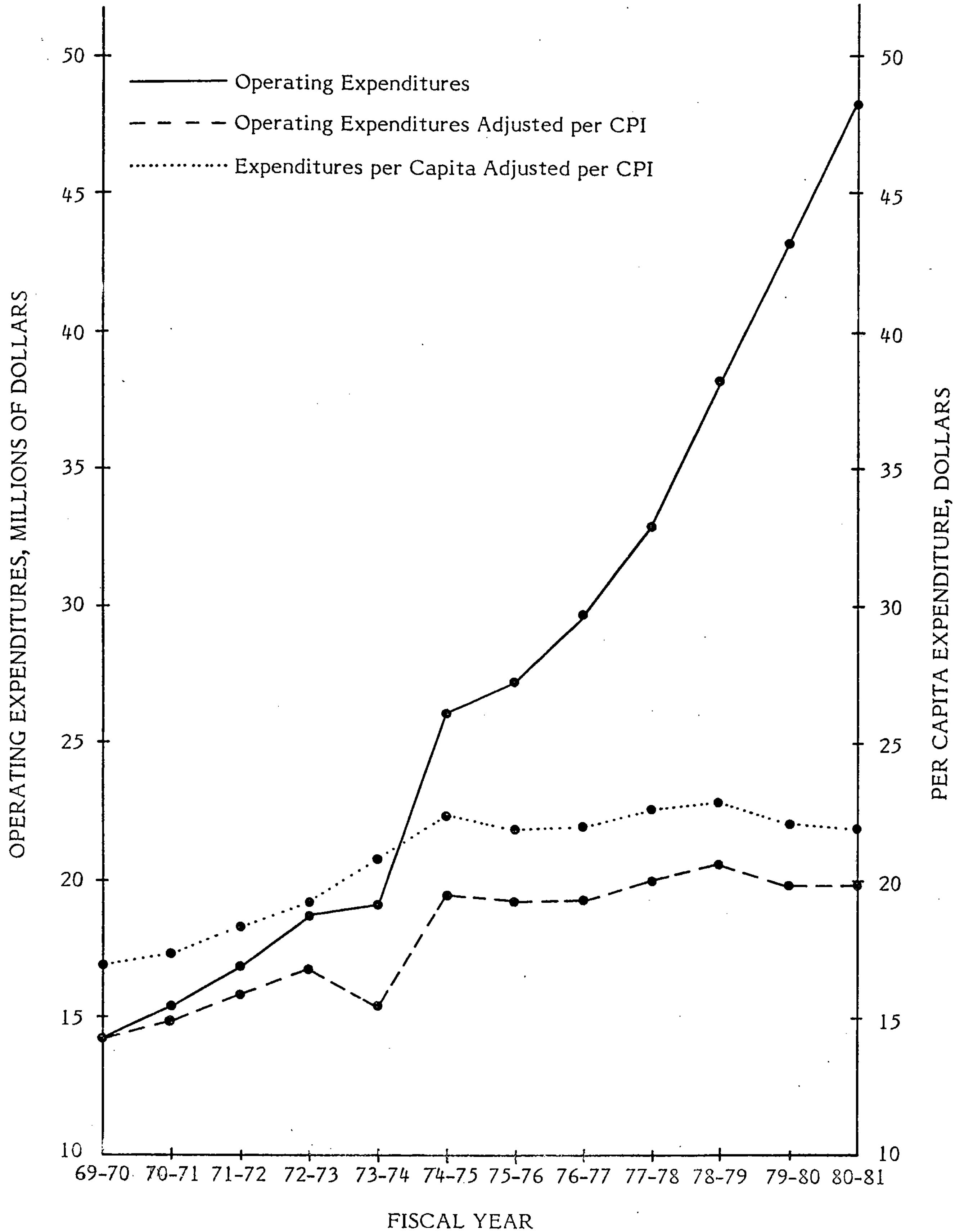


FIGURE 12

FIRE DEPARTMENT OPERATING EXPENDITURES

Operating expenditures included in Table 9 did not include capital funding for fire protection facilities' improvement, new construction and land acquisition. During the 1970's, three bond issues were authorized for the fire department totaling $9.69 million. An additional $12.095 million was approved in the 1982 fire protection bond program. This capital funding is planned to be used for four new fire stations, the first phase of a maintenance facility, and a training facility.