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RESIDENTIAL FIRE SPRINKLERS RETROFIT DEMONSTRATION PROJECT

Final Report

Phase I:
Multifamily
Structures
Case Studies

FEDERAL EMERGENCY MANAGEMENT AGENCY

UNITED STATES FIRE ADMINISTRATION

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CASE STUDIES

RESIDENTIAL FIRE SPRINKLERS
RETROFIT DEMONSTRATION
PROJECT

Phase I: Multifamily Structures

Cooperative Agreement No. HA-12963

U.S. Fin Administration
Emmitsburg, MD 21727

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The United States Fire Administration funded the design and installation of quick-response residential fire sprinklers in multifamily residences undergoing rehabilitation in low-income sections of Austin, Texas: Boston, Massachusetts; Harrisburg, Pennsylvania; Prince George's County, Maryland; and St. Louis, Missouri. In conjunction with USFA funding, the U.S. Department of Housing and Urban Development, as part of its effort to rehabilitate and improve urban housing. funded the NAHB National Research Center to provide technical assistance relating to fire sprinkler system design and installation.

The major goals of the project were to:

- investigate technical, regulatory, and administrative barriers to residential fire sprinkler installation in multifamily buildings undergoing rehabilitation
- evaluate residential fire sprinkler design standards as they relate to multifamily building rehabilitation
- demonstrate the latest residential fire sprinkler technology
- enhance the fire safety of buildings that house low-income high-risk urban populations

The major considerations for design of the residential sprinkler systems were adequacy of existing water service, coverage and location of sprinkler heads, response time of sprinkler heads, and sprinkler plumbing.

Total square foot costs for installation and design ranged from a low of $1.51, to a high of $3.80, with the six-system average being $2.40. Costs were pushed upward in some buildings by the need to upgrade the water service. Conversely, costs were lowered in some buildings by donated labor and/or materials from companies wishing to participate in this federally funded technical assistance project.

In all cases standards published by the National Fire Protection Association, were used to guide design of the sprinkler systems. In all but one system chlorinated polyvinyl chloride pipe (CPVC) was used; in the other case polybutylene was used. Local fire officials decided on the type of pipe, as well as other technical considerations such as adequacy of existing water service for fire sprinkler operation, location of sprinkler heads, water flow- activated alarms, shut-off valves, and external water connections. Local water and/or housing officials detailed requirements for water metering, connections to domestic and public water service, and back-flow prevention. In addition, fire officials reviewed sprinkler system plans, witnessed static pressure tests, and for systems with flow alarms, required a flow-test.

Immediate tangible economic benefits to building owners included discounts on insurance premiums, as well as construction alternatives. Other benefits included a possible positive effect on rental income and a reduced chance of fire related property losses.

Each participating jurisdiction conducted a public outreach program to publicize the project in specific and fire safety in general. Outreach activities included production and distribution of a brochure on fire sprinklers: presentation of a training course for local plumbers; and organization of a public information event featuring speakers, a tour of a sprinklered residence, and a sprinkler demonstration trailer.

Residential fire safety is the primary concern of the United States Fire Administration (USFA), an operating division of the Federal Emergency Management Agency. Based on their mandate, USFA funded the design and installation of quick-response residential fire sprinklers in multifamily residences that were rehabilitated in low-income sections of Austin, Texas; Boston, Massachusetts; Harrisburg, Pennsylvania; Prince George's County, Maryland; and St. Louis, Missouri. The project included various types and sizes of residential buildings. In conjunction with USFA funding, the U.S. Department of Housing and Urban Development (HUD), as part of its effort to rehabilitate and improve urban housing, funded the NAHB National Research Center (National Research Center) to provide technical assistance relating to fire sprinkler system design and installation. Each of the jurisdictions participating in the project are recipients of funds from two HUD programs, the Community Development Block Grant Program (CDBG) and the Rental Rehabilitation Program (RRP).

Funding for this project came from USFA's fiscal year 1986 appropriation directing them to focus on fire safety among "high-risk" populations. The five jurisdictions were included in the first phase of a three-year project sponsored together by HUD and USFA. Most of the jurisdictions participating in the fire safety project were receiving HUD-funded technical assistance regarding residential energy efficiency in low-income neighborhoods provided by the National Research Center. It was recognized by USFA, HUD and the National Research Center that the goals of the fire sprinkler project would be served by continuing provision of technical assistance in the same neighborhoods.

The major goals of the project were to:

- investigate technical, regulatory, and administrative barriers to residential fire sprinkler installation in multifamily buildings undergoing rehabilitation
- evaluate residential fire sprinkler design standards as they relate to multifamily building rehabilitation
- demonstrate the latest residential fire sprinkler technology
- enhance the fire safety of buildings that house low-income high-risk urban populations

Statistics have shown low-income families to be at a disproportionately high risk of death or injury from fire, as are the elderly, the very young, and the physically immobile. Each recipient city or county has a sizeable low-income population.

This project began with selection of a building that met the criteria concerning occupants and that was imminently scheduled for substantial rehabilitation. Design of the sprinkler system began after the building was selected and the owner agreed to participate in the sprinkler project.

Standards for sprinkler design, installation, and maintenance have been developed by the National Fire Protection Association (NFPA) and are known as NFPA 13 (1987) for large buildings, NFPA 13D (1987) for one- and two-family residences and mobile homes, and NFPA 13R (1989) for residential structures up to four stories high, NFPA 13R was not available at the time the sprinkler systems were designed for this project. The variety in size, use, and configuration among the buildings allowed for design of fire sprinkler systems based on a modified NFPA 13D standard.

NFPA 13 was developed for property protection as well as for life safety and usually applies to large buildings. NFPA 13D was developed primarily for life safety and is used for one- and two-family residential buildings and mobile homes. The major difference lies in the fact that the sprinkler heads in a 13D system are quick-response, and are designed to ensure life safety over property protection, Quick-response heads are designed to suppress incipient fires and provide additional time for occupants to escape. One philosophy behind NFPA 13D is provision of 10 minutes of escape time. The more complex NFPA 13 systems require extra connections and control mechanisms, including flow alarms and external water connections and higher water pressure necessary to cover larger areas. In addition, NFPA 13 delineates many technical variations regarding numerous types of occupancies, building materials, and levels of hazard. The extensive technical requirements of a 13 system make it more expensive than a 13D system.

Principal considerations in the sprinkler system

design and installation process included:

- interpretation and application of NFPA sprinkler standards in rehabilitated multifamily dwellings as they pertain to hardware (e.g., pipe and fittings), external fire department connections, and placement of sprinkler heads including sprinklering non-living spaces
- plan review, inspection, and testing requirements and procedures
- water service connections, metering, fees, and backflow prevention; adequacy of existing water service in satisfying hydraulic requirements of residential fire sprinkler systems
- licensure requirements for sprinkler designers and installers

These questions were resolved by relevant authorities during design and installation of the system and are discussed throughout this report. Requirements and guidance were received from respective fire departments, water departments, community and economic development agencies, and building commissioners or building inspectors.

Evaluation of a fire safety system must also consider costs and benefits. Total cost for design and installation of the fire sprinkler systems are presented in the individual case studies. Although there are not enough data to perform a formal cost/benefit analysis, specific benefits are discussed including reduction in fire insurance premiums. and construction alternatives.

THE CASE STUDY APPROACH

This case study is intended to investigate whether or not it is feasible, as well as cost effective, to install residential fire sprinkler systems in multifamily buildings undergoing rehabilitation, The information is offered as a learning tool to help home builders, local officials, and others concerned about residential fire safety evaluate innovations in fire safety systems and, perhaps, take advantage of opportunities afforded during rehabilitation to retrofit residences with sprinklers. The case study outlines the experiences of those involved in design and installation of the fire sprinklers and discusses specific project characteristics and history. At the end of each chapter is a description of the population, income, housing, and residential production and rehabilitation programs in the subject community.

FIRE SPRINKLER SYSTEM DESIGN AND INSTALLATION

The major considerations for design of the residential sprinkler systems were:

- adequacy of existing water service
- coverage and location of sprinkler heads
- response time/activation of sprinkler heads
- sprinkler system plumbing

Each of these items is addressed by NFPA standards and/or by local codes or other building codes enforced in each community. A general discussion of the technical considerations is included in this section. The following chapters discuss the unique technical considerations of fire sprinkler systems in the five participating jurisdictions.

Water Service

The water service in each of the subject buildings was evaluated for sufficient pressure and flow to operate a sprinkler system. In making this determination, the project team evaluated the size of the existing water service connection to the public water supply. supply pressure at the connection, building height, anticipated pressure losses within the system, and maximum number of heads for which simultaneous flow is required.

According to NFPA 13D (Section 4- 1.1). the flow rate at a sprinkler head in a protected area requiring only one head must be no less than 18 gallons per minute (GPM). and in each compartment requiring two heads the heads must deliver no less than 13 GPM simultaneously. Engineering design protocol is that if these requirements are met at the sprinkler head(s) that calculations indicate will have the lowest flow rate (usually the farthest heads), it is generally assumed that they will be met or exceeded throughout the system. Therefore water delivery design must include pressure and flow-rate calculations at the sprinkler head most hydraulically remote from the water source and, in a “two-head” (or a “four-head”) system, at the two (or four) heads located in the most hydraulically remote compartment (room) large enough to require two (or four) heads. Two-head designs are more common for residential systems because rooms large enough to require four

sprinkler heads are rarely encountered. Furthermore, in NFPA-13D the maximum number of heads for which simultaneous flow must be accomodated is two. Four-head systems are required by NFPA 13 but not by NFPA 13D.

Coverage and Location of Sprinkler Heads

One step in system design is to calculate the number and location of sprinkler heads. This calculation is primarily related to the square footage of the rooms and areas to be sprinklered, although the geometry or shape of each area is also a factor. NFPA 13D (Section 4-l 4.1) states the requirement for the maximum area covered by a single head to be 144 square feet. Spacing requirements found in NFPA 13D (Section 4-l 4.2). call for pendent heads to be one to four inches (4'6" for sidewalls) from the ceiling. 'The maximum distance between sprinklers shall not exceed 12 feet on or between pipelines and the maximum distance to a wall or partition shall not exceed 6 feet. The minimum distance between sprinklers within a compartment shall be 8 feet. NFPA 13D requires installation of sprinklers in all areas with the following exceptions noted in Section 4-6:

- bathrooms not exceeding 55 square feet with noncombustible fixtures
- closets where the least dimension does not exceed 3 feet (0.9 m.) and area does not exceed 24 square feet and the walls and ceiling are surfaced with noncombustible materials
- open attached porches, garages, carports and similar structures
- attics, crawl spaces not used or intended for living purposes or storage
- entrance foyers which are not the only means of egress

Many fire protection engineers would like to see sprinkler heads installed in the areas noted as exceptions, though simplification of sprinkler systems for affordability in residential settings encourages making the noted exceptions. Excepting the areas listed above is viewed as posing only a minimal life safety risk, and including sprinkler heads in those areas would likely add significantly to the cost of a residential fire sprinkler system.

Response Time/Activation of Sprinkler Heads

Occupant response time is a crucial factor in fire safety. Most deaths from residential fires result from inhalation of smoke or toxic gases such as carbon monoxide that can spread faster than flames. Sleeping or mobility-impaired persons in particular can be asphyxiated before they can escape. In order to protect occupants under conditions in which smoke detectors may be insufficient, sprinklers must activate early in a fire's sequence of events. One philosophy behind NFPA 13D is to provide 10 minutes of fire suppression in the room of fire origin to protect occupants during their escape.

Sprinkler head activation occurs when a soft metal link on the sprinkler head melts and releases a metal disk thus allowing water to flow. Melting the link requires exposure to a certain temperature for a certain duration. The links on commercial heads have a greater mass than on residential heads and require higher temperatures and take longer to melt, making them slower to discharge. For safety, heads are generally set to discharge at no less than a maximum ambient temperature plus 35°F. generally between 135°F and 170°F in a residential environment.

Sprinkler System Plumbing

During system design the project design team selected pipe and fitting material. Historically, sprinkler systems were fabricated of iron or steel piping materials. In recent years residential sprinkler designs have increasingly specified plastic pipe and fittings in fire sprinkler systems. Plastic has become the preferred material due to both lower material and installation costs made possible by its flexibility and ease of assembly. Two plastic materials are available for use in sprinkler systems. They are polybutylene and chlorinated polyvinyl chloride (CPVC). CPVC's listing allows it to be installed uncovered in protected compartments; its joints are solvent-welded together using an adhesive primer and a compound made, in part. of liquified CPVC that drys to help form a single piece of pipe. By contrast, polybutylene must be covered by material with a 30-minute fire suppression rating and its joints are formed by heat welding.

FIRE SPRINKLER SYSTEM COSTS

Specific costs for each sprinkler system installed during this project are presented in the chapters, Costs per square foot ranged from a high of $3.80 to a low of $1.51, with an average cost per

square foot of $2.40. There were several major factors driving either up or down the final costs of each system. In two cases sprinkler system materials were donated or greatly discounted; conversely, the costs of upsizing water service added significant cost to some of the systems. Sprinkler supply vendors, making little or no profit from this project, were interested in establishing reputations in the market for residential fire sprinklers. Staff engineers from the National Research Center estimated the cost for the sprinkler systems where materials costs were well below what they would have been for other building owners. Also, in two cases, National Research Center staff designed the sprinkler system at no cost to the grantees. In these two cases the cost of design was included in the cost table in order to present more accurate data on fire sprinkler systems.

Operation and Maintenance Costs

Fire sprinkler systems are subject to various costs whether or not a fire occurs in a building equipped with them. Costs may include water fees, inspection, testing and maintenance, a monitoring and response service, increased property taxes reflecting a higher tax assessment, damage from leakage or accidental discharge, and financing charges where a loan is involved. Further, in the event of a fire large enough to cause sprinkler activation (or false activation), there will be costs for replacement of heads, water service, and potentially other repair and maintenance costs. There may also be water damage to the building or its contents,

Economic Benefits to Owners of Building with Fire Sprinklers

The principal benefits from any residential fire protection strategy are potential reductions in losses from fires and reduction in the underlying probability of fire. The major categories of benefits are improved life safety and a positive effect on rental income, reduced insurance premiums, reduced property damage costs, reduced costs of indirect fire losses, and construction alternatives. This section discusses these benefits in general, while the chapters on each jurisdiction discuss specific benefits to the participating owners of the buildings. National Bureau of Standards Technical Note 1203 (Ruegg and Fuller, 1984) presents a more detailed analysis of the benefits of a hypothetical sprinkler system.

Improved Life Safety

Occupants of units with sprinklers benefit from a reduction in probability of death or injury from fire. Statistics (in each chapter below) showing local fire death experience give an indication of potential for reduction in fire related fatalities. As noted above, one philosophy behind NFPA 13D is to provide 10 minutes of fire suppression to protect occupants during their escape: and when a residential fire sprinkler system is supplied by stored water, NFPA 13D section 2-1 states the supply should be sufficient to provide 10 minutes of flow.

Owners (non-occupants) of sprinklered multifamily buildings ordinarily would benefit from the effect of sprinklers on rental income. Two factors predominantly determine the extent of effect on rental income: economic conditions in the housing market such as vacancy rate and median income of area residents, and regulatory authority by federal, state, or local governments who control rent levels and/or subsidize rental payments.

Property Insurance Discount and Reduced Property Damage Costs

Rate decisions in the insurance industry are guided by an advisory organization, the Insurance Services Office (ISO). IS0 has recommended that companies offer discounts of up to 10 percent on fire insurance policies covering rental structures that have “partial” sprinkler coverage and up to 20 percent for buildings that have “full” coverage. Insurance companies are free to offer higher or lower discounts with regulatory approval. The discount on any particular policy is determined on a case-by-case basis, particularly for large policies, and is dependent on evaluation of an underwriter. An underwriter bases actual rates on the reliability, maintainability, and expected performance of a fire sprinkler system, in addition to standard risk factors such as the local community fire protection rating and distance to the nearest fire hydrant and fire station.

Many fire insurance policies provide only partial coverage. An owner may not be reimbursed for some of the costs of property destroyed by a fire, due to a deductible, a low policy limit, or type of coverage (e.g., replacement value or less). An owner in this situation will benefit from any system that reduces the likelihood of property damage from fire. Also, several types of damage and costs from a fire will not be covered by insurance. Examples include demolition of

remaining property in preparation of construction, security of remaining property, and special administrative procedures in response to loss of property. Further, tenants may have insurance policies protecting against losses in their units, and reduced probability of fire may benefit those with such policies.

Construction Alternatives

Many jurisdictions enforce local building codes as well as codes used throughout large regions or nationally. Many codes require a variety of fire safety measures and systems such as an emergency egress from upper floors of multifamily buildings or use of material with a prescribed fire suppression rating in walls separating individual units or stairwells that serve as emergency egress. However, in recognition of protection provided by fire sprinklers, local building officials often waive such requirements, thus reducing some costs of owning or rehabilitating a building.

LOCAL FIRE EXPERIENCE

High-risk populations include the elderly, the very young, and people with limited ability to move without assistance. In Austin, 6.5 percent of the population is 65 years old or older and 7.6 percent is five years old or younger. Further, physical handicaps limit the mobility of 0.2 percent of the population. To respond to the fire protection needs of the city, the Austin Fire Department maintains the forces listed in Table 1-1.

TABLE 1-1
AUSTIN FIRE DEPARTMENT

Stations (engine and ladder) (average coverage of 8.8 square miles per station)	30
Engine Companies	31
Ladder Truck Companies (average coverage of 6.3 square miles per combined types of companies)	11
Rescue/hazardous material stations	3
Firefighters	800
Firefighters on duty during each of 3 shifts	225
Fire chiefs	30
Fire chiefs on duty during each of 3 shifts	6
Fire Districts (average of 53 square miles per district)	6
Fire hydrants	12,000

Source: Austin Fire Department, Research Division.

It is likely that a city as large as Austin will experience residential fire fatalities during a given year and that a disproportionate share of victims will be either elderly or very young. Although the over-65 and under-five population combined represent only 14 percent of Austin's population, Table 1-2 shows that these groups accounted for 40 percent of the fire fatalities during an 11 year period. Further, fire deaths are more likely to occur in low-income neighborhoods, defined as neighborhoods where property values are lower than average and a higher than average proportion of people live in poverty. East Austin, site of the sprinkler project, is such a neighborhood, and as Table 1-2 shows, accounts for 39 percent of Austin's fire fatalities even though only 6 percent of the city's population resides there. East Austin is the area bounded by Manor Road to the north, Interstate highway 35 to the west, the Austin town lake to the south, and Ed Bluestein Boulevard to the east. Table 1-2 shows the recent trends for both the city as a whole and for East Austin, while Figure 1 plots the location of the fatalities on a map of the city.

TABLE 1-2
RESIDENTIAL CIVILIAN FIRE
FATALITIES AUSTIN

YEAR	NO. OF CIVILIAN FIRE DEATHS (RESI)	65 & OLDER OR 5 & YNGER #	%	EAST #	AUSTIN %
1977	6	3	50	33	33
1978	0	0	-	0	-
1979	2	1	50	0	0
1980	6	1	17	2	33
1981	4	2	50	1	25
1982	6	4	67	3	47
1983	15*	5	33	7	47
1984	6	3	50	2	33
1985	12	6	50	2	33
1986	9	2	22	5	56
1987	3	1	33	1	33
TOTAL	69	28	40	27	39

*One fire with 4 deaths, one fire with 3 deaths.

Source: Austin Fire Department. Investigations Section.

PROJECT INITIATION

The National Research Center's tentative selection of Austin led to an invitation to the Housing and Community Services Department (HCSD) to participate in the (federally-funded) technical assistance program. The National Research Center notified HCSD of availability of Federal money to increase fire safety among urban low-income populations, though the funding sources (USFA and HUD) required the funds to be used in conjunction with other CDBG funds allocated to rehabilitation of low-income housing. Therefore, the National Research Center informed HCSD of the agency's responsibility to identify buildings imminently scheduled to undergo CDBG-assisted rehabilitation and occupied (or scheduled to be) by low-income tenants. In addition, the National Research Center assisted HCSD in evaluating buildings for technical feasibility with fire sprinkler installation before final selection of the subject building. Further, HCSD staff contacted other city departments concerned with aspects of fire safety: the Austin Fire Department and the Austin Water Department. They also identified a building as a tentative site for the program. The decision of Mayor Frank Cooksey formally initiated Austin's

participation in the fire sprinkler technical assistance project.

At an orientation meeting in Austin in October 1986. National Research Center staff met with Chief Malcom Light of the Austin Fire Department, and Laura Phillips and Vincent Cobalis of the HCSD. National Research Center staff outlined the project and ensuing discussion highlighted ambiguities in application of NFPA fire standards 13 and 13D in multifamily buildings. NFPA 13 was developed for property protection as well as for life safety and usually applies to large buildings.

Even though ambiguity over application of NFPA 13 and 13D could be resolved through design of a system using a modified NFPA 13 standard, the parties agreed that the Austin project should in part focus on development of a new sprinkler standard for multifamily residences. Any new standard would have to balance adequate fire protection with affordability concerns. Chief Light, stating that the fire department was in favor of the use of sprinkler systems in multifamily buildings, noted that the department would encourage their use. Soon after the initiation meeting, HCSD began the selection process to identify a building that met the stated criteria. After review of several potential sites. HCSD chose a townhouse complex consisting of two two-story buildings located at 5810 and 5812 Sweeney Circle. The fire sprinkler system was designed as an NFPA 13 system based on the fire department requirement that, although a building is not required to be sprinklered. any system installed in a building with more than four units must comply with NFPA 13. Installation of a system in the selected building that would comply with NFPA 13 was estimated to cost $23,000, excluding modifications to the building that may have been necessary to facilitate sprinkler installation. Project participants agreed that this amount was beyond the scope of the project and another (smaller) building would have to be selected. The estimated costs dictated investigation of a new standard for future application.

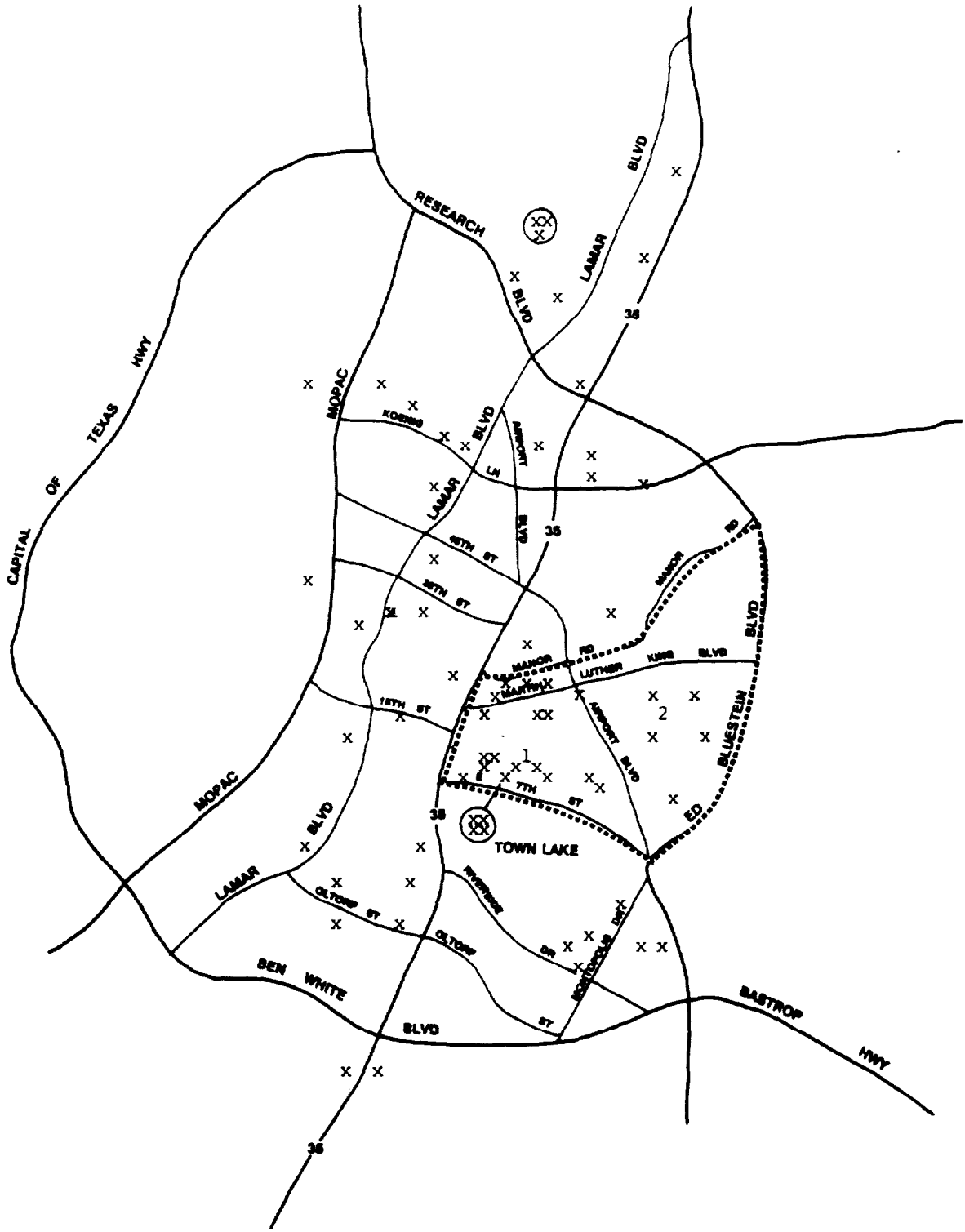
HCSD evaluated several duplexes and identified two as likely sites. The duplexes are located at 3501 Pennsylvania Avenue and 2601 Sol Wilson Avenue. Both are in East Austin, an economically depressed area targeted by HCSD for housing rehabilitation, (Refer to Figure 1 for location of the buildings). They are one-story wood frame structures with “pier and beam” raised wood basement floors. Each consists of two housing units and was built around 1945. Total area in Sol Wilson is approximately 1,370 square feet, total area in Pennsylvania Avenue is approximately 1.280. Prior to rehabilitation, one of two units was occupied in the Sol Wilson Avenue duplex, while the Pennsylvania Avenue duplex had been condemned and was vacant. [Figure 2 shows the floor plan and sprinkler configuration of one of the buildings). HCSD contacted by letter the owner of both buildings, Mr. Mike Leff, and informed him of the project goals. Soon after being invited to participate, Mr. Leff agreed to join the project.

The letter from HCSD stated the department’s willingness to reimburse Mr. Leff for the costs of installing a fire sprinkler system, including design and site work. Funds for reimbursement would come from a grant to HCSD from USFA. contingent upon execution of a written agreement between HCSD and Mr. Leff Costs were to be in accordance with the budget approved by USFA. with fire sprinkler installation costing up to $12.800 and site work up to $5,000. Site work included water taps, water lines, and trenching. Mr. Leff agreed to pay any additional sprinkler installation costs above the budgeted amount. In addition, the fire department and HCSD agreed to a USFA request to conduct a public outreach program for the project, budgeted at $5,000. Grant provisions disallowed transfer of funds in excess of 5 percent between cost categories without approval from USFA

Contractors working on exterior of 3501 Pennsylvania Avenue.

FIGURE 1

LOCATION OF BUILDINGS, "EAST AUSTIN," FIRE FATALITIES IN AUSTIN

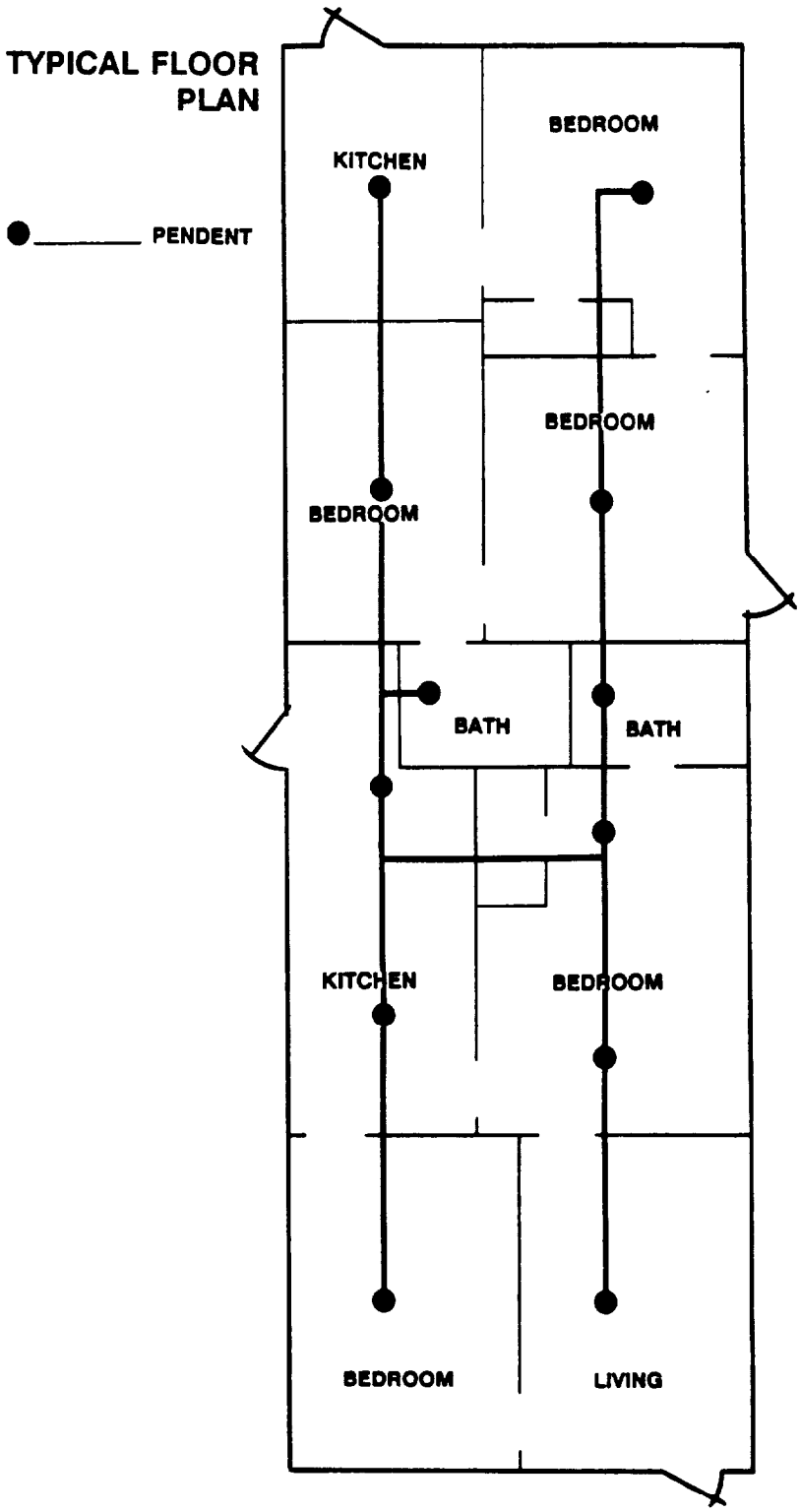


AUSTIN, TEXAS

CHAPTER 1 AUSTIN, TEXAS

FIGURE 2

FLOOR PLAN AND SPRINKLER CONFIGURATION



Austin, Texas

All participants agreed to communicate regularly during the design and installation phases, with meetings scheduled in Austin as necessary and, if possible, in conjunction with site visits by National Research Center personnel. The parties also agreed that telephone conversations and/or written communication would be necessary to secure input regarding system design. Photographs of the rehabilitation of the buildings would be taken by the National Research Center including installation of the sprinkler systems, together with "before and after" views of construction.

After informing all participants of their roles and of the overall goals of the program, National Research Center began the design phase of the sprinkler system.

Exterior view of 2601 Sol Wilson Avenue.

BUILDING REHABILITATION

Both duplexes were substantially rehabilitated including new floors, walls, roofs, ceilings, doors, windows, and utilities. The total cost forrehabilitation design and construction (excluding the tire sprinkler system) was $15,000 per building. Further, HUD asked the National Research Center to identify ways the buildings could be made more energy efficient. National Research Center staff engineers made the following recommendations that were Included in the construction:

- insulation in flooring and underneath each building (R- 18)
- replace kitchen appliances

Foundation of 3501 Pennsylvania Avenue.

Underside of 3501 Pennsylvania Avenue Prior to Skirting.

Interior of 3501 Pennsylvania Avenue during rehabilitation with new window and insulation installed in walls.

Interior of 3501 Pennsylvania Avenue prior to rehabilitation.

SYSTEM DESIGN AND INSTALLATION

Since the city of Austin would not allow a sole source contract to be let. the National Research Center and HCSD developed and sent a procurement notice to three licensed sprinkler system contractors (the state of Texas requires licensure). The National Research Center and the city specified that the contract include system design and cost analysis as well as installation. Sandberg Fire Protection, Inc., (SFP) submitted the low bid of $12,000 and was awarded the contract.

The fire department agreed to use NFPA 13D criteria for the design with no requirements for fire alarms or system monitoring. The fire department, having become more familiar with the technical assistance project, agreed to review the plans in shorter time than the four months for review of plans for the Sweeney Circle buildings.

The sprinkler system design was a coordinated effort between the National Research Center, Mike Parker of SFP. Bill Cooper of the Austin Fire Department, and Mike Leff the owner. As mentioned, NFPA 13D guided design. An overview of major issues in designing sprinkler systems is presented in the introduction.

Water Service

The hydraulic calculations and subsequent tests were based on two heads open simultaneously, a "two-head design." (See Appendix A for an example of the hydraulic calculations for these buildings). The Sol Wilson duplex has a single, metered water supply serving both units while the Pennsylvania Avenue duplex has a separately metered water supply for each unit. Flow requirements revealed that a new one-inch line would be needed at Sol Wilson and that two existing three-quarter inch water supplies could be tied together into one service line for the sprinkler system on Pennsylvania Avenue.

The Austin Water Department required the sprinkler systems to be tapped into each building's main water supply after (downstream of) the meter, thus metering any water discharged from the sprinkler system. Friction loss within the meter is likely to cause a 5-10 pound per square inch drop in the water pressure of the buildings. The water department also required installation of a single back-flow preventer (rather than a double) to prevent standing water in the sprinkler pipes from flowing back into the domestic water supply. Friction loss in the back-flow preventers is likely to cause a 5-10 pound per square inch reduction in the water pressure of the sprinkler systems, and these losses have been factored into the design delivery of the sprinkler heads. In the Sol Wilson duplex, the control manifold was installed in the hot water closet, and, in the Pennsylvania Avenue duplex, it was installed under the sink in the kitchen of the front unit. Each control manifold has a pressure gauge and a drain and test valve. The sprinkler systems can be shut off without special equipment. There are no external water connections.

Whereas the building on Sweeney Circle would have required a valve-pit at the connection to the city water supply (a cost of $9,000) as well as installation of a new supply line, the total additional cost for water service for this project was $2,500.

Coverage, Location, and Activation of Sprinkler Heads

In both duplexes, there are 16 quick-response heads located a maximum of six feet from the wall, with 12 feet between pipes and sprinklers, and a minimum of eight feet between heads. The installer is assumed to be responsible for replacement of defective heads, and no spare heads have been stored on the premises. As per specification of the Austin Fire Department sprinklers were installed in one large bathroom in each duplex, and they were not installed in closets. The sprinkler heads were produced by the Central Sprinkler Corporation, Inc., of Pennsylvania, and are their Omega R-l model. They are a pendent type that protrude through drop ceilings. The use of drop ceilings simplifies installation because of the flexibility of raising or lowering the ceiling for sprinkler installation and for access to the system, but they are less sturdy and of lower aesthetic quality than wallboard ceilings (See Figure 2 for location of pipes and heads).

For safety, sprinkler heads are generally set to discharge at no less than a maximum ambient temperature plus 35°F., generally between 135°F. and 170°F. in a residential environment. In the Austin buildings, the heads are designed to discharge at 160°F.

Domestic water supplies tied together into one supply for sprinklers (3501 Pennsylvania Avenue).

Sprinkler System Plumbing

The pipes and risers in both subject buildings are made of CPVC. In the Pennsylvania Avenue duplex and one-half of the Sol Wilson duplex, however, piping in the walls and ceilings is located behind a 30-minute fire-rated wallboard. In the other half of Sol Wilson, piping is behind wood paneling with no fire rating. Although CPVC is rated as fire-safe in exposed

applications. exposed piping is usually unsightly as well as more susceptible to accidental damage or vandalism.

Tied together water supply with shutoff and test valves.

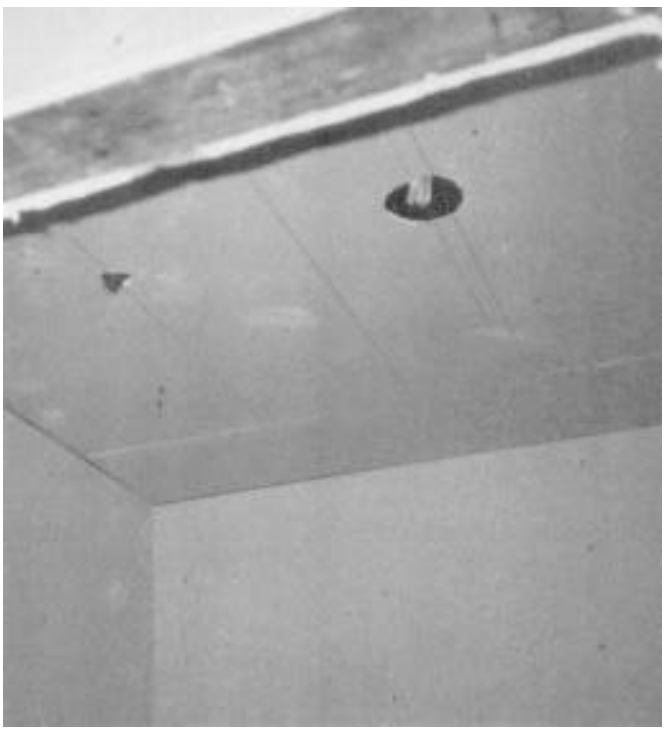
View of control manifold with back-flow preventer, drain and teat valves, and pressure gauge, in heater closet at 2601 Sol Wilson.

View of control manifold with back-flow preventer, drain and test valves, and pressure. gauge, in heater closet at 2601 Sol Wilson.

Water connectton from city water main, and sprinkler drain pipe (2601 Sol Wilson).

Lateral pipe with sprinkler connections in ceiling.

Adjacent water systems, sprinkler, and domestic sanitary vent stack (3501 Pennsylvania Avenue).



Sprinkler head through drywall ceiling (2601 Sol Wilson).

Sprinkler runs before relocating behind wall (2601 Sol Wilson].

Sprinkler connections and other utility connections (2601 Sol Wilson).

INSTALLATION AND TESTING

After a series of meetings among city officials, Mr. Leff, and staff from the National Research Center, design of the systems for the duplexes was completed in November 1987. The contractor began installation in the Pennsylvania Avenue building on January 7, 1988. and in the Sol Wilson Avenue building on January 14. 1988. Installation of the sprinkler systems took three weeks, with both systems installed by the end of January. During the first week of February, the fire department witnessed the code-required hydrostatic test in each duplex. Mr. Leff requested that the control valve in Pennsylvania Avenue be relocated from above to below the kitchen sink in the front unit, a change accomplished by February 15. Overall rehabilitation of Pennsylvania Avenue, more comprehensive than Sol Wilson, was finished on March 1. and Sol Wilson Avenue was finished on March 15.

SYSTEM COSTS

Design and Installation Costs

Table l-3 lists the costs for design and installation of the two sprinkler systems. Total costs for design and installation and the costs per square foot were significantly affected by the costs of increasing the water service. The increased water service necessary to operate a sprinkler system, as determined by hydraulic calculations, while required in this case may not be in other cases. The increased water service at 2601 Sol Wilson added an additional 53 percent to the cost of the sprinkler system, and combining the water lines at 3501 Pennsylvania added 19 percent to the cost of that sprinkler system. The Sol Wilson case indicates it may be cost prohibitive to increase water service for operation of a fire sprinkler system in a small building. Installation of new water service usually requires trenching and other special operations whose costs of materials, equipment, and labor may not be cost effective in small buildings.

TABLE 1-3
SPRINKLER SYSTEM COSTS

2601 WILSON AVENUE DUPLEX	
Design (Includes plan revtew by fire department)	$1,100.00
Installation	$1.600.00
Materials	$ 710.00
Increased water service (new 1” main)	$1.800.00
TOTAL	$5.210.00
COST PER SQUARE FOOT	$ 3.80
3501 PENNSYLVANIA DUPLEX	
Design (Includes plan review by fire department)	$1.100.00
Installation (Includes equipment)	$1.900.00
Materials	$ 703.00
Combining water service line	$ 700.00
TOTAL	**$4.403.00**
COST PER SQUARE FOOT	$ 3.44
TOTAL COST FOR TWO DUPLEXES	$9.613.00
AVERAGE COST PER UNIT	$2,403.25
AVERAGE COST PER SQUARE FOOT	$ 3.62

SOURCE; Sandberg Fire Protection Inc., National Research Center

As stated in the introduction, a major goal of the sprinkler technical assistance project was to demonstrate sprinkler technology that may potentially decrease fire danger among ‘high risk’ urban populations. This goal, established by congressional mandate, led USFA through HUD to subsidize installation of sprinklers in buildings being rehabilitated with money from other Federal programs such as CDBG or RRP. This meant owners of the particular buildings selected

for participation (Mr. Leff in Austin) paid little or no design and installation costs.

Oparation and Maintenance Costs

Mr. Leff estimates that his costs for routine inspection and testing will be negligible, and the property taxes did not rise. It is too soon to assess costs from leakage and/or false activation. As mentioned above, there were no financing costs, no annual fee for water (water use if any will be metered), and there is no external monitoring service.

ECONOMIC BENEFITS

Improved Life Safety - Effect on Rental Income

As a participant in the Federal Section 8 housing voucher program, Mr. Leff must limit rents to "fair market" amounts as set by the U.S. Department of Housing and Urban Development. The Austin Housing Authority distributes vouchers to tenants chosen from an established waiting list and informs them of buildings eligible for use of vouchers. Tenants must pay no more than 30 percent of their gross income for rent, and the vouchers make up the difference between that amount and the federally set market rent. The fact that the two duplexes owned by Mr. Leff contained fire sprinklers may have shortened the time the units remained vacant because prospective tenants are free to choose any eligible dwelling on the basis of features, and enhanced fire safety may be one of the more popular features.

Reduced Property Damage Costs. and Property Insurance

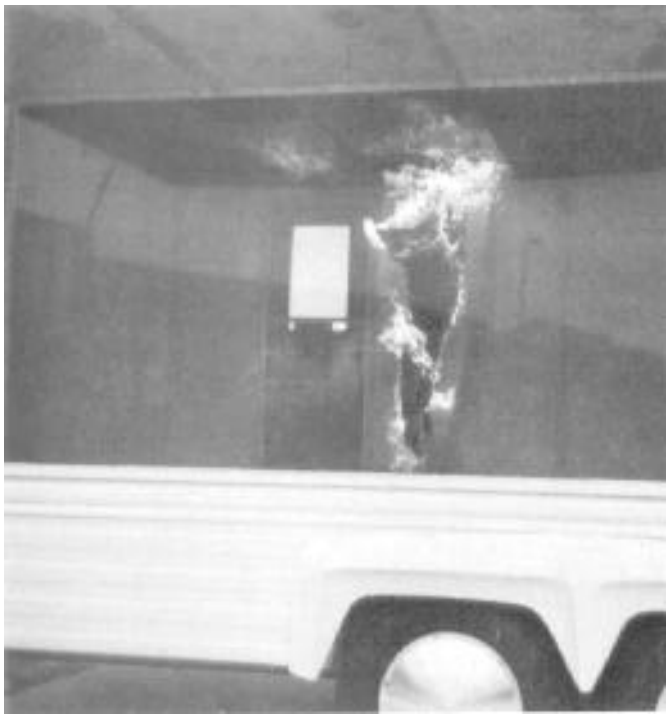
Mr. Leff has a property insurance policy that covers up to $45,000 for property loss for each of the duplexes, currently considered to be full replacement value. The deductible is $250, and therefore, currently, that sum should be the most Mr. Leff can lose in direct property damages caused by fire. It is also possible for him to incur property losses not directly related to a fire such as demolition and/or security of remaining property. Therefore, the reduced likelihood of a destructive fire in the two duplexes reduces the chance of such losses.

The Texas State Board of Insurance sets rates for specific types of dwellings and conditions. The board requires their engineering department inspect a fire sprinkler system before an insurance company can cite the presence of a fire sprinkler system as the basis for deviation from a set rate. Currently, there is no deviation allowed for buildings with NFPA 13D fire sprinkler systems. The life safety versus property protection emphasis of NFPA 13D is the rationale for disallowing discounts on property insurance policies. Therefore, Mr. Leff did not receive a discount on his insurance premium.

COMMUNITY OUTREACH

A public information event was held in Austin on March 16, 1988. The first phase of the event was a walk-through tour of 2601 Sol Wilson Avenue guided by Mike Leff Mr. Leff, along with Mike Parker of Sandberg Fire Protection, Inc., (the contractor hired to install the systems), and Carey Lively of the National Research Center described the sprinkler system and some of the decisions that were made in the course of design and installation. Mr. Clyde Bragdon, Administrator of the U.S. Fire Administration, discussed the goals and objectives of the residential fire sprinkler program. Mr. Eliseo Garza. Jr., Deputy Director of the Austin Housing and Community Services Department, discussed the Rental Rehabilitation Program and other housing programs offered by the city of Austin.

Mr. Clyde Bradgon. Administrator. U.S. Fire Administration. speaking at Public Information Event, Austin, Texas, March 16. 1988.



Fire demonstration trailer from Texas A&M University at Public lnformation Event, Austin. Texas. March 16, 1988.

Ms. Paula Philips, Director. Austin Department of Housing and Community Services, being interviewed by KTBC Television Austin at Public Information Event, Austin, Texas, March 16, 1988.

The second phase of the event was held at the South Plaza Hotel. Chief Bill Roberts of the Austin Fire Department made the opening remarks, and, in addition to technical presentations, Lieutenant Steve Cook of the Austin Fire Department discussed statistics on fire safety and sprinkler systems. After the presentations, participants watched residential sprinkler heads douse flames inside a sprinkler demonstration trailer donated for use in this event by Texas A & M University and operated by Mr. Jack Sneed.

CBS affiliate television station KTBC (channel 7 in Austin) filmed portions of the day's events for broadcast during regular news shows at 5:00 and 6:00 p.m. A VHS copy of the portion of the broadcast concerning the sprinkler event was purchased from Teleclip Inc., (Austin) by the National Research Center for its files.

AUSTIN, TEXAS, THE CITY AND ITS HOUSING MARKET

The U.S. Census Bureau's December 1985 population estimate for the City of Austin was 470,000, an increase of 36 percent since the 1980 U.S. Census. Inmigration of new residents and annexation of existing communities accounted for most of the city's population gain. According to a 1985 mid-year field survey, Austin contained roughly 181.000 housing units, (2.6 persons per unit) of which 55 percent were single-family structures, 38 percent were multifamily structures with five or more units, 5 percent were two- to four-unit structures, and 2 percent were mobile homes. Austin's housing stock is the newest among the cities that participated in the sprinkler project, with 50 percent built since 1960. Despite the relatively young age of the stock, official local survey data (1986) indicate that 15 percent of the city's housing is in substandard condition, Table 1-4 presents a limited profile of the population and housing characteristics of the city.

Since 1982, construction of multifamily units in Austin has exceeded that of single-family units. In 1985, for example, 69 percent of all building permits issued were for multifamily units. With the predominance of new multifamily construction, the balance of renter- versus owner-occupied units has reversed from 52 percent owner-occupied and 48 percent renter-occupied in 1970, to 46 percent owner-occupied and 54 percent renter-occupied in 1980.

The shift from owner-occupied to rental housing was paralleled by a large increase in the cost of housing in Austin. By mid-1986, the median

TABLE 14
Austin, Texas,
Community Profile

Population (1985 estimates)	470,000
Population below poverty level	15.8%
Population 65 years old and older	6.5%
Population 5 years old and younger	7.6%
Population with limited mobility (U.S. Census defined as persons with limited ability to use public transit)	0.2%
Total Housing Units (1985)	181,000
Multifamily (five or more units)	38%
Single-Family	55%
Multifamily (two to four units)	
Population density par square mile	1,772
population density per housing unit	2.6
Housing units built after 1960	59%
Median Price (1985)	
Single-Family	$115.000
One-Bedroom Rental	$382
Vacancy rate-overall (1985)	6.9%
Rental vacancy rate	19.3%
Subsidized housing vacancy rate	0%

SOURCE: Austin Department of Housing and Community Services: and Austin Housing Authority

cost for a single-family house in Austin had risen to $115,000. well above the national median of $82,400. The cost of rental housing had risen as well. In 1980, median monthly rent in Austin for a one-bedroom apartment was $250; by 1986. it had risen to $382, an increase of 53 percent.

As for income distribution, 15.8 percent of Austin's population fell below the poverty level in 1980, compared to 14.7 percent for the state of Texas and 12.4 percent for the United States. The retrenchment that has occurred in the oil industry during the 1980s has had a major economic impact on Texas. Austin has felt the effects of the economic downturn, although to a lesser degree than other areas of the state because Austin's economy is more diversified and less dependent on oil. Nevertheless, the rate of growth in total employment for the Austin metropolitan statistical area (MSA) dropped from the 10 percent average annual increase between 1982 and 1985 to a 2.7 percent rate in 1986. Unemployment within the Austin MSA increased to 5.6 percent during 1986, well above rates experienced during the previous five years. Declines in the employment rate were most evident in the manufacturing and construction sectors.

As further indication of Austin's current economic condition, city staff noted that the number of building permits is down and there is little rehabilitation activity beyond that initiated by the City.

The Structure of the Multifamily Rehabilitation Program

According to the staff of HCSD, the city's rental rehabilitation program (RRP) is designed to upgrade target neighborhoods, assist low- and moderate-income households in securing decent and affordable housing, and reduce the number of blighted areas and substandard housing. As noted above, there are over 25,000 substandard housing units in Austin, offering substantial opportunity for residential rehabilitation.

In 1986, owners submitted applications for rehabilitation of 322 units under the RRP. Of these, the city accepted three buildings containing a total of 52 units and carried over two buildings with a total of 46 units for 1987. As of December 1986. rehabilitation work had begun in two projects totalling 38 units: work began in two other buildings totalling 46 units in 1987.

In general, rehabilitated structures are two- or three-story buildings of masonry/construction. Individual units average between 700 and 800 square feet and are 15 to 20 years old. The condition of the structures varies widely across the city. The city promotes its rental rehabilitation program to owners through advertisements, newspaper articles, public notices, and presentations to organizations. The Housing and Community Services Department obtains leads from responses to promotional activities as well as through referrals from the Building Inspection Department and the Austin Housing Authority.

After the city accepts a structure for rental rehabilitation and performs an initial inspection, its involvement is largely administrative. The building owner is responsible for preparing bid specifications and retaining a contractor to specify and perform the work. The specific types of rehabflitation to be carried out are determined through use of a standard inspection instrument and through consultations with the city rehabilitation specialist and the owner. Fire safety audits are not a routine part of the initial inspection that precedes development of rehabilitation specifications. Even in the absence of routine fire safety inspections, the Austin Housing and Community Services Department recommends some fire-related improvements for incorporation into rehabilitated properties, including new high efficiency heating/cooling

equipment and new windows if existing windows do not provide emergency egress as required. In addition the city of Austin requires smoke detectors in all rehabilitated units.

Owner-occupied rehabilitation projects are financed through a variety of sources, including CDBG, Section 312 (low interest construction loans), RRP, and city funds. Standard owner-occupied rehabilitation projects are eligible for lo-year deferred payment or for a 3 percent loan for 10 to 20 years. Rehabilitation projects financed by the RRP are eligible for lo-year zero interest loans issued as promissory notes. The city provides a $5,000 subsidy for each unit, the maximum amount permitted under federal program guidelines.

LOCAL FIRE EXPERIENCE

The populations generally considered at high risk from fire include the elderly, the very young, and people with limited mobility. In Boston, 19 percent of the population is over 55 years old. 6 percent is under four years old, and 2 percent of the population suffers from limited mobility due to physical handicaps. To respond to the firefighting needs of the city, the Boston Fire Department maintains the forces listed in Table 2-1:

TABLE 2-l
BOSTON FIRE DEPARTMENT

Stations (engine and ladder) (average coverage of 0.8 square miles per station)	66
Rescue stations	2
Firefighters	1675
5 Fire fighters on duty during each of 4 shifts	300
Fire chiefs	65
Fire chiefs on duty during each 4 shifts	14
Fire Districts (average of 4 square miles per district)	12
Fire hydrants	13000

Source: Boston Fire Department, Public Information Division

It is likely that a city as large as Boston will experience residential fire fatalities during a given year and that a disproportionate share of victims will be either elderly or very young. Although the over 55 and under 4 population combined represent only 25 percent of Boston's population, these groups accounted for 47 percent of fire fatalities in a recent four year period. Further, fire deaths are more likely to occur in low-income neighborhoods where property values are lower than average and a higher proportion of people live in poverty. In Boston, 32 percent of the population lives in the five districts with the highest incidence of poverty (including Roxbury), yet the fire fatalities in those districts made up 43 percent of the total fatalities. Table 2-2 shows recent fire experience in Boston, and Figure 3 plots the general location of the fatalities on a map of Boston's 16 planning districts.

TABLE 2-2
RESIDENTIAL CIVILIAN FIRE FATALITIES

YEAR	NO. OF CIVILIAN FIRE DEATHS (RESI)	55 & OLDER OR 4 & YNGER		IN LOW-INCOME NEIGHBORHOOD	
		NO.	%	NO.	%
1985	13	9	69	9	69
1986	14	2	14	5	36
1987	13	2	14	1	20
1988 (thru March)	9	7	78	6	67
Total	49	23	47	21	43

Source: Boston Fire Department

PROJECT INITIATION

National Research Center's tentative selection of Boston led to an invitation to the Public Facilities Department (PFD) to participate in the (federally-funded) technical assistance program. The National Research Center notified PFD of availability of federal money to increase fire safety among urban low- and moderate-income populations, though the funding sources (the U.S. Fire Administration and the U.S. Department of Housing and Urban Development) required this money to be used in conjunction with other CDBG funds allocated to rehabilitation of low-income housing. Therefore, the National Research Center informed PFD of the agency's responsibility to identify buildings imminently scheduled to undergo CDBG-assisted rehabilitation and occupied (or scheduled to be) by low-income tenants. In addition, the National Research Center assisted PFD in evaluating buildings for technical feasibility with fire sprinkler installation before final selection of the subject building. Further, PFD staff contacted other city departments relevant to fire safety. In this regard, PFD communicated with the Boston Fire Department, the Boston Water Department, and the Boston Inspection Services Department. They also identified a building as a tentative target for the program. The decision of Mayor Raymond Flynn formally activated Boston's participation in the fire sprinkler technical assistance project.

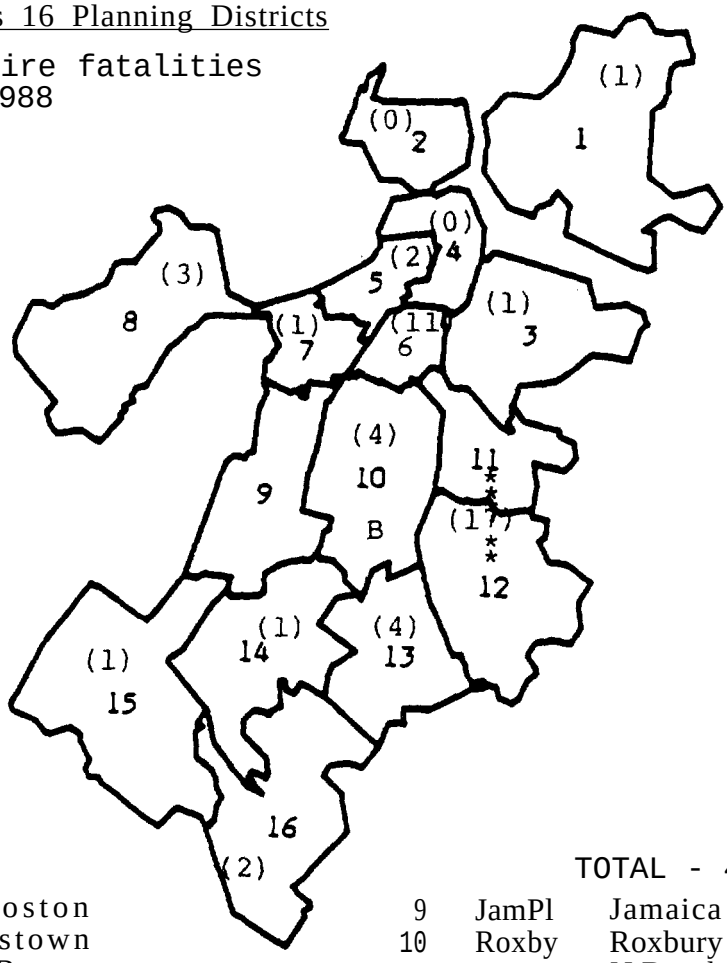
At an orientation meeting in Boston on October 23. 1986, National Research Center staff met with the following city officials:

FIGURE 3

LOCATION OF BUILDING, ROXBURY, FIRE FATALITIES IN BOSTON

Figure K: Boston's 16 Planning Districts

Locations of fire fatalities
1985 - March 1988



TOTAL - 49

1	EBos	East Boston
2	Chast	Charlestown
3	SBos	South Boston
4	Centr	Central
5	BB/BH	Back Bay/Beacon Hill
6	SEnd	South End
7	Fen/K	Fenway/Kenmore
8	Al/Br	Allston/Brighton
9	JamPl	Jamaica Plain
10	Roxby	Roxbury
11	NDor	N.Dorch/Uphams Corner
12	SDor	S.Dorch/Fields Corner
13	MatFr	Mattapan/Franklin
14	Rosdl	Roslindale
15	WRox	West Roxbury
16	HydPk	Hyde Park

B - Building is in Location 10

Source - Boston Fire Department

- Boston Fire Departement: Chief John White, Chief Paul Cook, and Chief Martin Fisher

- Inspection Services Department: Paul Donga. Tom McNichols, and Robert Fairbanks

- CDBG Coordinator: Miriam Colon

Hugh Kelly and Cinote Ibrahim, the owner and engineer, respectively, of a building tentatively selected for installation of fire sprinklers were also in attendance. National Research Center staff outlined the project and the ensuing discussion highlighted ambiguities in application of NFPA fire standards 13 and 13D in multifamily buildings. NFPA 13 was developed for property protection as well as for life safety and usually applies to large buildings. Even though ambiguity over application of NFPA 13 and 13D could be resolved through design of a system using a modified NFPA 13 standard, the parties agreed that the Boston project should in part focus on development of a new sprinkler standard for multifamily residences. Any new standard would have to balance adequate fire protection with affordability concerns. Chief White, stating that the fire department was in favor of the use of sprinkler systems in multifamily buildings, noted that the fire department would encourage use of sprinkler systems. He was uncertain about application of NFPA standards for a multifamily building but agreed to a modified standard for the project on an experimental basis. Inspection Services Department employees also agreed to use of a modified NFPA 13 as long as adequate fire protection was provided throughout the building. Mr. Kelly expressed his enthusiasm for the project and his willingness to comply with the city's decisions regarding use of NFPA standards. A further complication concerned the building's multiple uses: parts of the first floor and basement are used as a training center for guards employed by a commercial security agency. The multiple use issue would be resolved during design of the system.

In December 1986, Patrick McGuigan, Deputy Director for Neighborhood Development of the Boston Public Facilities Department, sent a letter to Mr. Kelly, formally notifying him that a building owned and managed by his firm (KVC Associates) had been selected for participation in the fire sprinkler technical assistance project. The building, located at 777-779 Huntington Avenue (Mission Hill section of Roxbury) is a four-story (including basement with laundry facility) masonry structure with commercial space on the first floor and 22 residential units. There are eight two-bedroom apartments, 12 three-bedroom apartments, and two four-bedroom apartments. Each floor is 5,400 square feet, for a total building size of 21,600 square feet. The structure was built around 1900. Before rehabilitation, the building was occupied despite such problems as exposed electric wiring and leaky plumbing. (See Figure 4 for a typical floor-plan.)

The letter from PFD stated the departments intention to reimburse Mr. Kelly for the costs of installing a fire sprinkler system, including design and site work. Funds for reimbursement would come from a grant to PFD from USFA. forwarded to Mr. Kelly, contingent upon execution of a written agreement between PFD and Mr. Kelly. Costs were to be in accordance with the budget approved by USFA, with fire sprinkler installation costing up to $17,600 and site work up to $5,000. Site work included water taps, water meter lines, and trenching. Mr. Kelly agreed to pay any additional sprinkler installation costs above the budgeted amount. In addition, the fire department and PFD agreed to a USFA request to conduct a public outreach program for the project budgeted at $5,000. Grant provisions disallowed transfer of funds over 5 per cent between cost categories without approval from the Project Assistance Officer at FEMA.

In response to the letter, Mr. Kelly wrote to Miriam Colon, Development Specialist with PFD. to acknowledge his formal participation in the project. He enclosed a copy of the contract executed between his company, KVC Associates, and Fire Protection Plus, Inc., (FPP) of Framingham. Massachusetts. According to Mr. Kelly, FPP was chosen to install the sprinklers with concurrence from the National Research Center for the following reasons:

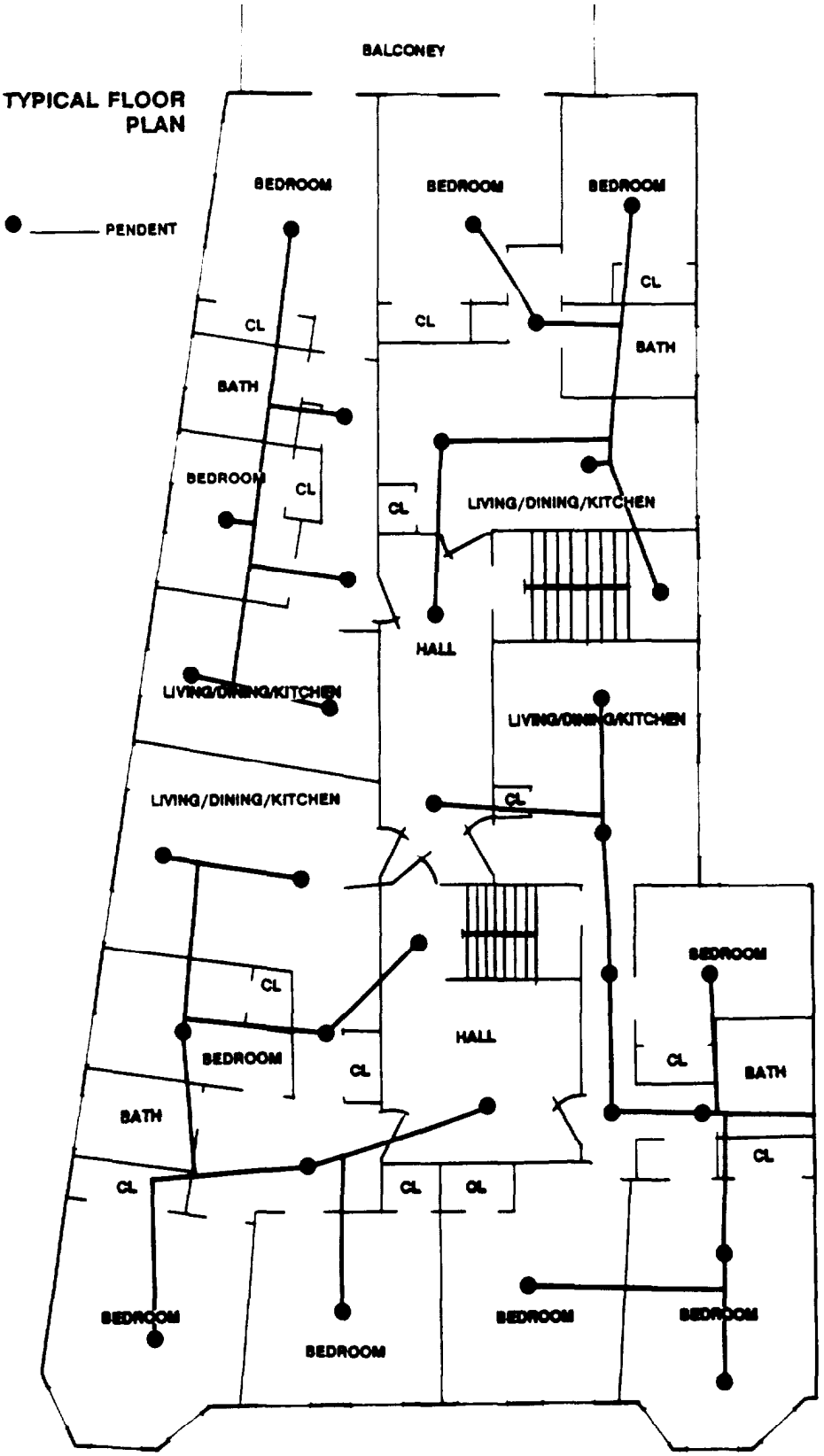
- their experience in design and installation of fire sprinkler systems

- their credibility with the Boston Fire Department, Building Department, and Water and Sewer Commission

- the favorable price quotation in the interest of participating in the initial technical assistance project

FIGURE 4

FLOOR PLAN AND SPRINKLER CONFIGURATION



Boston, Massachusetts

At the time, Boston did not require a special license to install fire sprinklers.

All participants agreed to communicate regularly during the design and installation phases, with meetings scheduled in Boston as necessary and, if possible, in conjunction with site visits by National Research Center personnel. The parties also agreed that telephone conversations and/or written communication would be necessary to secure input regarding system design. Photographs of the rehabilitation of the building would be taken by the National Research Center including installation of the sprinkler system, together with "before and after" views of construction.

After informing all participants of their roles and of the overall goals of the program, the National Research Center began the design phase of the sprinkler system.

BUILDING REHABILITATION

The subject building was substantially rehabilitated including new floors, walls, ceilings and roofs, doors, windows, and utilities. Total cost for rehabilitation design and construction (excluding the fire sprinkler system) was $800.000. Further, HUD asked the National Research Center to identify ways the building could be made more energy efficient. National Research Center staff engineers made the following recommendations that were included in the construction:

- double pane glass and aluminum windows
- thermally insulated exterior doors
- new insulation: 6.5 inch Batts (R- 19) below roof, covered with a vapor barrier; 3.5 inch Batts (R-l 1) in walls
- individual electric meters in residential units
- central gas-fired high-recovery hot water heater

FIRE SPRINKLER SYSTEM DESIGN AND INSTALLATION

The fire department decided on use of NFPA standards, as well as other technical requirements of the sprinkler system. The sprinkler system design was a coordinated effort between the National Research Center, Tom Rinoldo of FPP. Paul Donga, (assigned to the Boston Inspection Services Department from the Boston Fire Department), and Hugh Kelly, the building owner. An overview of major issues in designing sprinkler systems is presented in the Introduction.

Water Service

Due to the requirements of the Boston Fire Department who were unsure of the fire protection level of an NFPA 13D "two-head" system, a "four-head" system was installed in the building on Huntington Avenue. Such requirement was primarily due to the size of the building. (See Appendix B for an example of the hydraulic calculations for the building).

Flow requirements of the fire sprinkler system demanded an additional two-inch supply line in the building. The Boston Water Department required the line to be connected directly to the city water main rather than to a feeder line within the building's domestic water service. The fire sprinkler line was installed in addition to a new two-inch line for domestic water supply that replaced the old three-quarter inch line as part of the rehabilitation. Local authorities required installation of a control manifold with double check-valves on the dedicated sprinkler supply lines to prevent backflow of standing water from the sprinkler pipes to the domestic water supply. Friction loss in the back-flow preventer is likely to cause a 5-10 pound per square inch reduction in the water pressure of the sprinkler system, and this loss has been factored into the design delivery of the sprinkler heads. The control manifold has a pressure gauge, drain and test valve, and a flow-activated alarm switch. In addition, a shutoff valve operable without special equipment was not allowed by the fire department on the sprinkler water supply to prevent a potentially disastrous disabling of the sprinkler system. External connections were provided making it possible to supply the sprinkler system with water from a fire department pumper truck (or other external source) in the event of disrupted water supply. There is a flow switch connected to external alarms.

The upgraded water supply cost $5,000 to design and install, including such materials as pipe and fittings, as well as trenching and other labor. The city will charge an annual flat fee of $165 for the water in the sprinkler system rather than meter actual consumption as other jurisdictions might do.

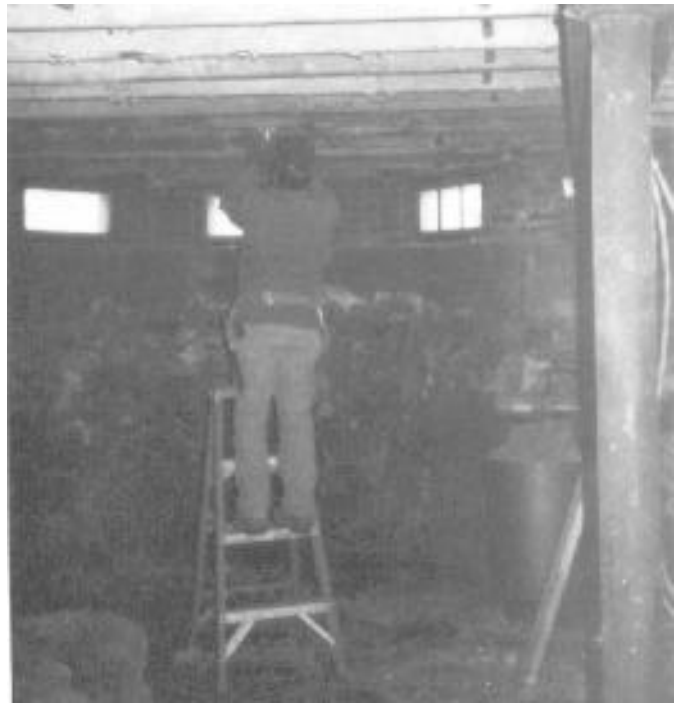
Adjacent risers, sprinkler system, domestic water, waste and vent.

Adjacent horizontal laterals, sprinkler and electric systems.

Coverage, Location, and Activation of Sprinkler Heads

In the residential areas of the subject building there are 190 quick-response sprinkler heads and in the commercial area there are 20 quick-response sprinkler heads located in compliance with the spacing requirements of NFPA 13D. The Boston Fire Department required sprinklers be installed in the foyers, bathrooms, and hallways.

Pendent-type sprinkler heads were installed in the subject building. In one section they are installed in sheetrock ceilings, and in the other section they protrude through a drop-ceiling. The drop ceiling simplified installation because of the flexibility of raising or lowering the ceiling for sprinkler installation, but is less sturdy and less visually appealing than the sheetrock ceiling (see Figure 4 for location of pipes and heads). For safety, heads are generally set to discharge at no less than a maximum ambient temperature plus 35°F., generally between 135°F. and 170°F. in a residential environment. In the subject building, the heads are designed to discharge at 160°F.



contractor installing sprinkler head to branch pipe cut through joists in basement.

Blocking in joists for sprinkler head connection.

Sprinkler System Plumbing

CPVC has been certified for use in open areas and was left exposed in the basement of 777 Huntington Avenue. Polybutylene was used throughout the rest of the sprinkler system. In this case polybutylene, less expensive to supply and more flexible and elastic than CPVC, was the preferred pipe despite the covering requirement. On the third floor the pipe runs in the ceiling are protected from freezing by 6.5 inch fiberglass BATTS (R-19). placed above the pipes.

Double check valves, flow alarm switch, pressure guage, and drain valve located at water service connection.

Sprinkler head connection through nearly complete ceiling.

INSTALLATION AND TESTING

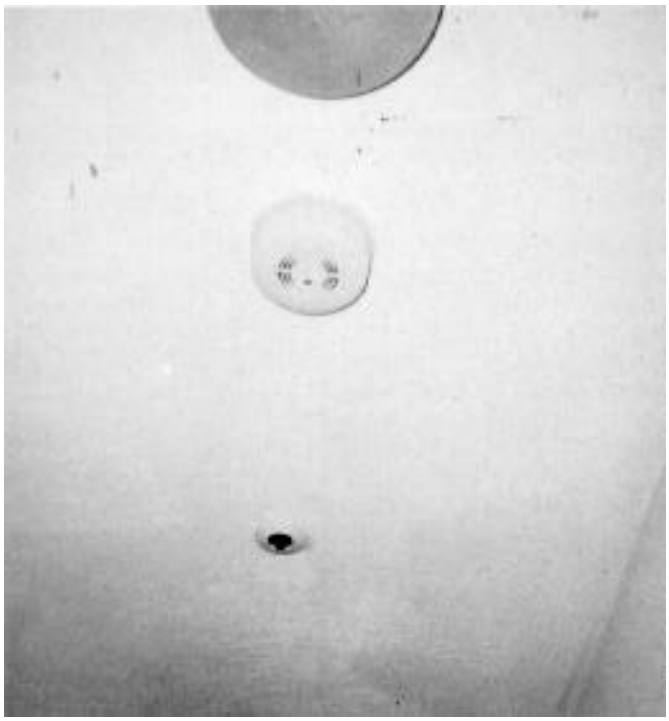
After a series of meetings among city officials, Mr. Kelly, and staff from the National Research Center. installation work was begun at 779 Huntington Avenue (11 units) in January 1987. Acting as his own general contractor Mr. Kelly hired Fire Protection Plus, Inc., to install the sprinkler system.

Review of sprinkler design and of the rehabilitation construction led to a field change in the system design. It was decided by Mr. Kelly in conjunction with FPP and the National Research Center that rather than using one large vertical riser with large horizontal supply lines to supply the living units, four smaller one and one-quarter-inch vertical risers and one horizontal feed in the basement would be preferable. This change decreased the cost of the system due to reduced need for drilling through joists and studs. Mr. Kelly needed to decide what to do about replacement of drywall ceilings in the hallways, and therefore decided to replace all drywall in the building.

Installation was completed in March 1987, with few problems or other changes in the original plans. A pressure test for leaks was performed by FPP and Mr. Kelly in March, and a flow test was witnessed and certified by the Boston Fire Department on April 4, 1987. The first phase of building construction was completed on May 15, 1987. The escutcheons retaining the sprinkler heads were installed after the drywall and paint were completed. The fire alarm panel system, also contracted to FPP. was installed in the hall of the phase-one unit on April 25, 1987. An occupancy permit for the units was issued by the City of Boston in the morning of May 15, 1987, and tenant reoccupation began that afternoon.

Installation of the sprinkler system on the second half of the building (777 Huntington Avenue) began in July 1987, following completion of demolition in late June 1987. Other than the change to CPVC noted earlier, there were no changes in the plans, Mr. Kelly covered the lateral pipe runs in the hallway with a drop ceiling with a 30-minute fire rating. The second half of the system was completed in October 1987. The hydrostatic test was performed early in the month by Mr. Kelly and FPP, and the flow test witnessed and certified by the Boston Fire Department was performed late in the month. The drywall and paint were completed on November 15, 1987. An occupancy permit for these units was issued by the City of Boston on November 17, 1987, and tenant reoccupation began that afternoon.

View of finished units.



Fire Control Panel.

Finished common hallway.

SYSTEM COSTS

Design and Installation Costs

Table 2-3 presents the costs of the sprinkler system.

TABLE 2-3
SPRINKLER SYSTEM COSTS

WORK CATEGORY	MATERIALS	LABOR	TOTAL
SYSTEM DESIGN	$ 0	$ 2,250	$2,250
SYSTEM INSTALLATION (With Discounts)	$8,100	$12,150	$20,250
SYSTEM INSTALLATION (National Research Center Estimate w/o Discounts)	$12,060	$18,090	$ 30,150
INCREASED WATER SERVICE	NA	NA	$ 5,000
UPGRADED CAPABILITY OF FIRE PANEL	NA	NA	$ 2,000
WITH DISCOUNTS			
TOTAL			$29,500
PER SQUARE FOOT			$ 1.37
PER UNIT INCLUDING COMMERCIAL			$ 1.283
PER RESIDENTIAL UNIT			$ 1,341
WITHOUT DISCOUNT			
TOTAL			
PER SQUARE FOOT			$ 39,400
PER UNIT INCLUDING COMMERCIAL			
PER RESIDENTIAL UNIT			$ 1,713

Source: Fire Protection Plus Inc., National Research Center

As mentioned above, it is important to point out that the contractor offered a substantial price reduction in order to participate in a federally funded technical assistance project. National Research Center staff worked with the contractor to establish the estimated cost of the system had there been no discount. The sprinkler contractor was not asked by the project team to report costs separately for labor and materials and therefore the percentage of total costs attributable to labor and to materials was estimated by National Research Center staff; 60 percent of total cost was attributable to labor and 40 percent to materials. In addition, it is important to note that the fire alarm panel was upgraded to include the sprinkler system per the requirement of the Boston Fire Department. The panel would have cost $7.000 without connections to the fire sprinkler system and actually cost $9,000, an increase of 29 percent.

The design and installation costs and the costs per square foot (non-discounted) are well within what would be expected for a building the size and shape of 777-779 Huntington Avenue. The increased water service, necessary to operate a fire sprinkler system as determined by hydraulic calculations, while required in this case, may not be in other cases. The increased water service added an additional 14 percent to the non-discounted cost of the system. The fire panel, upgraded for supplementing the sprinkler system as required by the Boston Fire Department, added 5 percent to the total cost of the sprinkler system. In future rehabilitation projects such panels may become redundant with fire sprinkler systems and dropped from fire department requirements.

As stated in the introduction, a major goal of this technical assistance project was to demonstrate fire sprinkler technology that may potentially decrease fire danger among “high risk” urban populations. This goal, established by congressional mandate, led USFA through HUD to subsidize installation of sprinklers in buildings being rehabilitated with money from other federal programs such as CDBG or RRP. This meant the owners of the buildings selected for participation (Mr. Kelly in Boston) paid either none or only a small portion of the design and installation costs.

Operation and maintenance costs

Mr. Kelly estimates that his costs for routine inspection and testing will be approximately $200 per year. His property taxes rose due to the rehabilitated condition of the building, and he estimates that any portion of the increase attributable to the sprinklers was negligible. It is too early to assess costs from leakage and/or false activation. As mentioned above, there were no financing costs and the annual flat rate for water is $165.00. The monitor and summoning service costs $120 per year.

Mr. Hugh Kelly, building owner.

Exterior view of 777-779 Huntington Avenue.

ECONOMIC BENEFITS

Improved Life Safety - Positive Effect on Rental Income

In the Boston building, rents on 14 of the 22 units are set by the Boston Housing Authority (BHA) as part of a subsidized housing program (including two first floor units specially built for the physically disabled). Although the other eight units are not rent controlled, Mr. Kelly reports the same rent is charged for these units as for the subsidized units. The low vacancy rate in Boston makes it easy to rent units, and the sprinklered apartments in this case were no exception.

Property Insurance Discount and Reduced Property Damage

Mr. Kelly reports that his carrier reduced the insurance premiums for protection against liability and property loss at 777-779 Huntington Avenue by more than 40 percent as a direct response to sprinkler installation. This savings, realized annually, will amount to the contract cost of the system within a few years. The insurance company reviewed the sprinkler plans prior to installation and sent an engineer to observe installation of the sprinkler system. The insurance policy covers full replacement value for property loss. The deductible is $1,000, which thus should be the most Mr. Kelly can lose in direct property damage per fire. It is also possible for him to incur property losses not directly related to a fire such as demolition and/or security of remaining property. Therefore the reduced likelihood of a destructive fire in 777-779 Huntington Avenue reduces the chance of such losses. Further, tenants may have insurance policies protecting against loss or damage to their personal property. Reduced probability of fire and potential discounts on tenants contents insurance will therefore benefit tenants as well.

COMMUNITY OUTREACH

A public information event was held in Boston on July 11, 1989. The first phase of the event was held at the Codman Square Branch Library. Joe Lewin. Deputy Director of the Boston PFD, gave the opening remarks, followed by Boston Fire Commissioner Leo Stapleton who discussed fire safety and fire prevention efforts in Boston. Mr. Clyde Bragdon, Administrator of the U.S. Fire Administration, discussed the goals and objectives of the residential fire sprinkler program, and noted the importance of up to date fire safety systems. Mr. Barry Berman, project manager at the PFD, discussed the successful merger of fire safety programs with federally funded housing rehabilitation, and the continuation of such efforts by his department. Mr. Hugh Kelly, the participating building owner, discussed the design and installation of the sprinkler system in his building and presented a short slide show of the installation.

After the presentations, participants watched residential sprinkler heads douse flames inside a sprinkler demonstration trailer donated for use in this event by the Massachusetts State Fire Academy and operated by Mr. Fred Piechota.

The second phase of the event was a walk-through tour of a building across the street from the library that was recently rehabilitated by Mr. Kelly. The fire sprinkler system in that building is identical to the one in 777 Huntington Avenue, and Mr. Kelly discussed features of the system.

The PFD will publicize the event and stand ready to offer information to the public on sprinklers and/or residential fire safety and housing rehabilitation.

Public Information Event.

Mr. Clyde Bragdon, Administrator, U.S.F.A.. and Commissioner Leo Stapleton, Boston Fire Department at Public Information Event.

Spreading flames inside sprinkler demonstration trailer.....

....seconds later.

BOSTON, MASSACHUSETTS: THE CITY AND ITS HOUSING MARKET

In 1985, Boston had a population of 604,000 persons and a housing stock of 249.000 units, an average of 2.4 people per housing unit. One-half of the stock was in private rental apartment units, nearly one-third was in owner-occupied units, and less than one-fifth were either subsidized or publicly owned. Forty-three percent of the stock was in multifamily structures containing five or more units. Many of these multifamily units have recently been converted from rental units to condominium ownership. Since 1970. 25 percent of the private rental apartments have been converted into condominiums. The trend is clear, in 1985. there were 4525 such conversions, more than during the 1970s. The Roxbury planning district (location of the building installed with sprinklers) had the highest level of assisted housing at 43 percent.

Citywide, vacancy rates were exceptionally low in 1985. Local surveys conducted that year revealed an overall vacancy rate of 2.5 percent and a rental vacancy rate of 0.9 percent. The vacancy rate for regulated and rent-controlled rental dwellings was 0.7 percent.

In 1985, the rate of housing production in Boston approached 2,000 units, almost equally divided between new construction and

conversion of existing structures. Current growth in demand far exceeds production, which has led to record inflation of housing and rental values in the city. In the six-year period between 1979 and 1984, citywide median values for one-, two-, and three-unit structures increased 20 percent annually. The increase in value from 1984 to 1985 was 37 percent. pushing the citywide mean for such structures to over $110,000. In 1985, the median market rent in Boston was $350 without utilities and $400 with utilities. Table 2-4 presents a limited profile of the population and housing characteristics of the city.

TABLE 24
Boston, Massachusetts.
community Profile

Population (1985 estimate)	604,000
Population below poverty level	21%
Population 55 years old and over	19%
Population four years old and under	6%
Population with limited mobility (U.S. Census defined as persons with limited ability to use public transit)	2%
Total Housing Units (as of 1985)	249,000
Multifamily (five or more units)	43%
Multifamily (two to four units)	41%
Single-Family	16%
Population Density per square mile	12.500
Population Density per housing unit	2.4
Housing built prior to 1939	63%
Median Price (as of 1985)	
One-, two-, three-unit structures	$110,000
Median Rental Payment (with utilities)	$400
Vacancy Rate-overall (as of 1985)	2.5%
Rental vacancy rate	0.9%
Subsidized housing vacancy rate	0.7%

Source: Boston Redevelopment Authority

Boston's housing stock is the oldest among the cities participating in the fire sprinkler technical assistance project. According to 1980 U.S. Census data, 63 percent of all existing units were constructed prior to 1939. Despite its age, however, the housing is generally in good condition. According to 1984 Boston Redevelopment Authority data. 92 percent of the stock was found to be in "very good" or "good" condition.

In 1985, 21 percent of Boston's population was classified as "impoverished" (an income below the $10,600 poverty level for a family of four), and almost one-half of the city's population was classified as "low-income" (at or slightly above the poverty level). At the same time, the stock of affordable units has been decreasing as multifamily rental structures are rehabilitated and upgraded to higher-rent units or converted to condominium ownership. Between 1980 and 1985. the number of private apartments in multifamily structures citywide decreased by nearly 12,000 units. In the same period, the rate of state- and federally-assisted production dropped to 560 units annually, 25 percent of the rate of a decade earlier. Low-income households are thus increasingly vulnerable to being priced out of their present housing during periods of inflation.

Boston's Neighborhood Development and Employment Agency, together with the Boston Housing Authority, experiences no difficulty placing families in units rehabilitated by the city. At the same time, however, the strong demand for rehabilitated rental housing can deter owners from incorporating fire safety improvements into their projects. In this "seller's market," owners may be less inclined to plan, design, obtain approvals for, and install complex fire safety measures in rehabilitated units and structures because housing demand is great and the units are easily rented without such improvements.

THE STRUCTURE OF THE MULTIFAMILY REHABILITATION PROGRAM

Boston's Public Facilities Department (PFD). as part of an ongoing effort, is in the process of rehabilitating 87 buildings in targeted neighborhoods throughout the city. Though not all multifamily structures, the buildings average 2.5 units. The city actively promotes its rehabilitation efforts but. given current low interest rates and competing investment opportunities. also recognizes that it must market rehabilitation aggressively to realtors and owners of vacant buildings to ensure a steady supply of affordable rental housing.

The rehabilitation program is targeted to specific neighborhoods based on area income and housing condition but does not include provisions relating specifically to fire sprinklers. The city does, however, require that the following fire safety systems be installed during rehabilitation of buildings: smoke and heat detectors, emergency lighting in common corridors in buildings with three or more units, and fire alarm pull stations outside all units in buildings with six or more units. In addition, the city requires that "gut rehabilitation" include new windows, new heating systems, and other improvements considered standard practice that may improve overall fire safety through reduced hazards and/or improved egress.

The 12 PFD rehabilitation specialists have not been trained to assess the need for sprinklers or other fire safety systems or to evaluate the plumbing capabilities and requirements of specific buildings. Further, the specialists have not generally attempted to calculate payback or

other investment evaluation data from the installation of a residential sprinkler system.

Boston's rehabilitation program relies on "gap financing," encouraging owners to borrow as much as possible through conventional channels. The PFD can, however, help owners arrange financing by referring them to banks that will lend on the value of the property. Both federal and state funds are available for housing rehabilitation under the federal CDBG, RRP, and Section 312 programs and through the Massachusetts Housing Finance Agency. PFD uses the federal Section 8 and state Section 707 voucher programs (both low-income housing assistance programs) to assist tenants.

LOCAL FIRE EXPERIENCE

High-risk populations include the elderly, the very young, and people with limited ability to move without assistance. In Harrisburg, 27 percent of the population is 55 years old or older and 8 percent is four years old or younger. Further, physical handicaps limit the mobility of 1.2 per cent of the population. To respond to the firefighting needs of the city, the Harrisburg Fire Department maintains the forces listed in Table 3-1.

TABLE 3-1
HARRISBURG BUREAU OF FIRE SAFETY

Stations (engine and ladder) (average coverage of 1.9 square miles ner station)	4
Engine Companies	5
Ladder Truck Companies (average coverage of 1.0 square miles per combined types of companies)	3
Rescue/hazardous material stations	1
Sworn personnel, chiefs and firefighters	102
Firefighters on duty during each of 4 shifts	15
Fire chiefs on duty during each of 4 shifts	2
Fire Districts (average of 1.9 square miles per district)	4
Fire hydrants	1,400

Source: Harrisburg Bureau of Fire Safety, Research Division.

Any city as large as Harrisburg is likely to experience residential fire fatalities each year, and a disproportionate share of victims will be either elderly or very young. Although the over-55 and under-5 population combined represent only 35 percent of Harrisburg's population, these groups accounted for 63 percent of the fire fatalities during an 11 year period. Further, fire deaths are more likely to occur in low-income neighborhoods [defined as neighborhoods where property values are lower than average and a higher than average proportion of people live in poverty). The Harrisburg enterprise development area (EDA) is such a neighborhood and accounted for 65 percent of Harrisburg's fire fatalities from 1982 to 1987 even though only approximately 25 percent of the city's population resides there. Table 3-2 shows the recent trends for both the city as a whole and for the EDA, while Figure 5 is a map of the city with the EDA outlined.

TABLE 3-2
RESIDENTIAL CIVILIAN F I R E F A T -

YEAR	NO. CIVILIAN FIRE DEATHS (RESI)	55 & OLDER OR 5 & YNGER #	%	IN ENTERPRISE DEVEL. AREA #	%
1977	5	NA		NA	
1978	2	NA		NA	
1979	2	NA		NA	
1980	4	NA		NA	
1981	2	NA		NA	
1982	5	NA		3	60
1983	2	NA		1	50
1984	4	NA		3	75
1985	4	NA		3	50
1986	3	NA		3	100
1987	1	NA		0	0
TOTAL	32	20	63	11*	65

l 1982 to 1987 only.

SOURCE: Harrisburg Fire Department. Investigations Section.

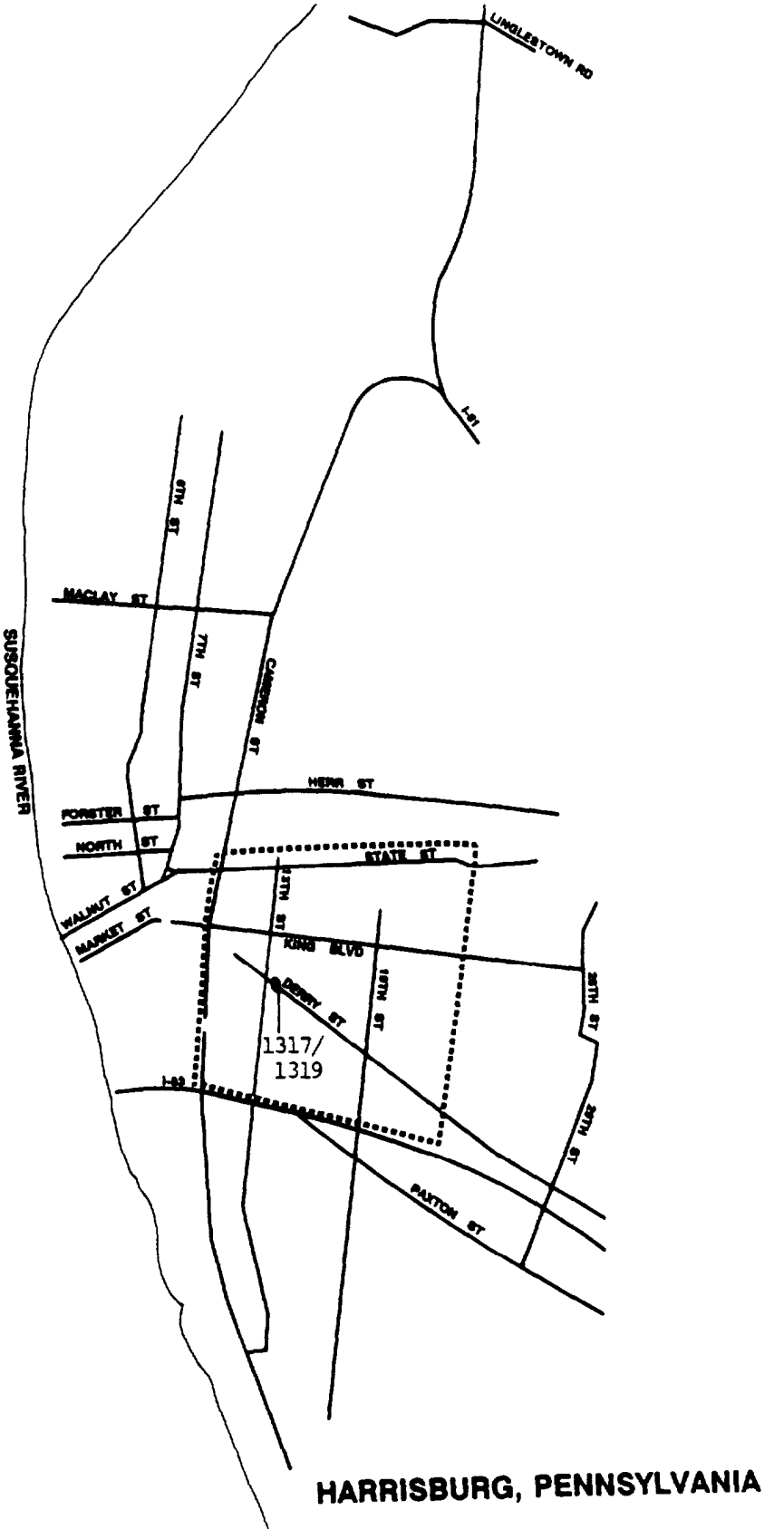
PROJECT INITIATION

The National Research Center's tentative selection of Harrisburg led to an invitation to the Department of Community and Economic Development (DCED) to participate in the federally funded technical assistance program. The National Research Center notified DCED of availability of federal money to increase fire safety among urban low-income populations, though the funding sources (USFA and HUD) required the funds to be used in conjunction with CDBG funds allocated to rehabilitation of low-income housing. Therefore, the National Research Center informed DCED of the agency's responsibility to identify buildings imminently scheduled to undergo CDBG-assisted rehabilitation and occupied (or scheduled to be) by low-income tenants. In addition, the National Research Center assisted DCED in evaluating buildings for technical feasibility with fire sprinkler installation before final selection of the subject building. Further, DCED staff contacted other city departments concerned with aspects of fire safety: the Harrisburg Bureau of Fire Safety and the Harrisburg Water Department. They also identified a building as a tentative site for the program. The decision of Mayor Stephen R Reed formally activated Harrisburg's participation in the fire sprinkler technical assistance project.

At an orientation meeting in Harrisburg in late 1986, National Research Center staff met with Chief Donald Konkle of the Harrisburg Fire Bureau, and Daniel Leppo and Toni Phillips of

FIGURE 5

LOCATION OF BUILDING AND ENTERPRISE DEVELOPMENT AREA



DCED. National Research Center staff outlined the project, and the ensuing discussion highlighted ambiguities in application of NFPA 13 and 13D in multifamily buildings. Even though issues surrounding application of NFPA 13 and NFPA 13D could be addressed through design of a system using a modified NFPA 13 standard, the parties agreed that the Harrisburg project should in part focus on development of a new sprinkler standard for multifamily residences. Any new standard would have to balance adequate fire protection with affordability concerns.

Chief Konkle noted that the fire department supported the passage of a sprinkler ordinance in Harrisburg. The ordinance requires all new buildings with three or more units, and all buildings undergoing rehabilitation worth 50 percent or more of assessed value and with five or more units to have residential fire sprinkler systems installed. It is important to note that although the subject building of this technical assistance project meets the physical profile of buildings covered by the sprinkler ordinance it was not covered by the ordinance due to its having been in the rehabilitation process prior to enactment of the ordinance.

Soon after the project initiation meeting, DCED began the selection process to identify a building that met project criteria. Following a review of several potential sites, DCED chose a building located at 1249-55 Market Street, once known as the Hill Cafe. Design of a sprinkler system for that building progressed until the owners of the building encountered difficulty with financing and could no longer be certain they could go forward with the planned building rehabilitation. The National Research Center. in conjunction with city officials. decided that the project would benefit from designation of another building for installation of sprinklers.

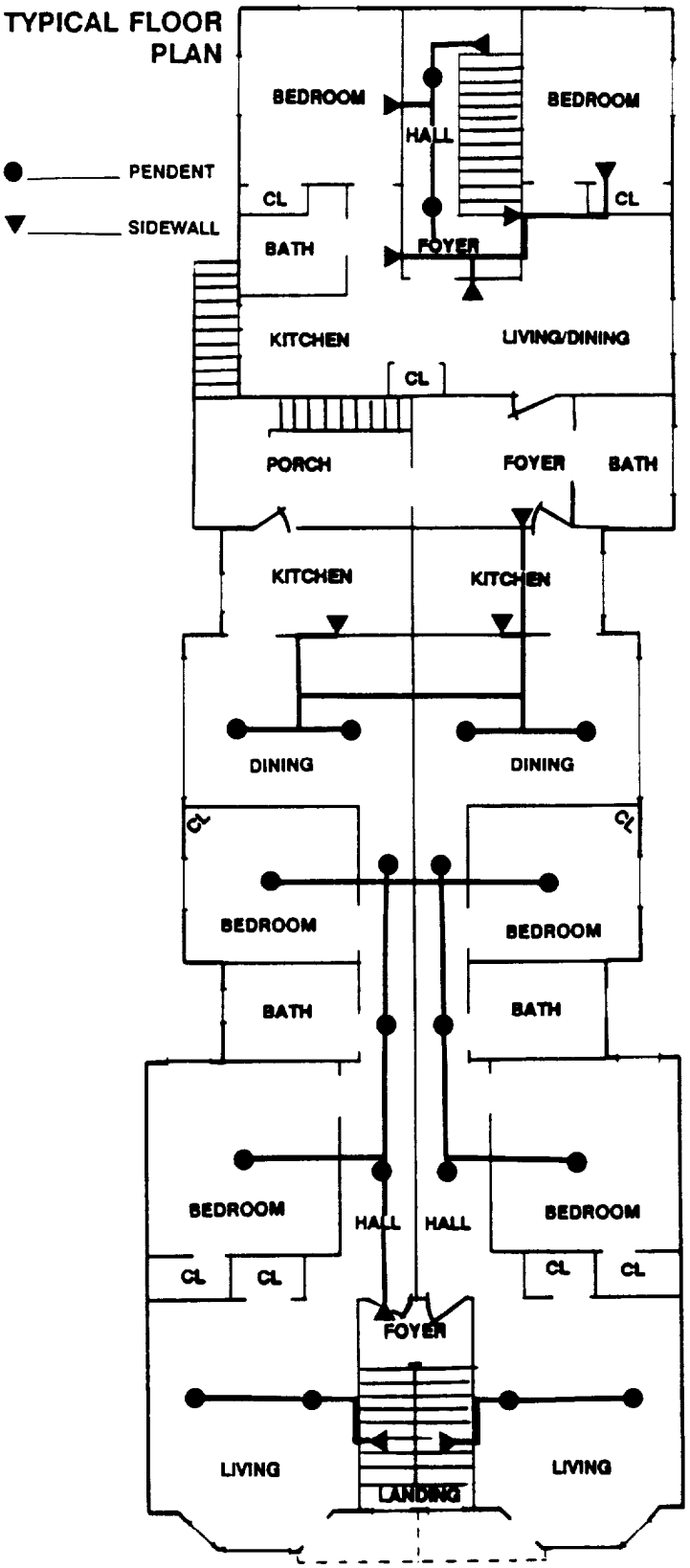
The DCED evaluated several buildings and selected a likely site. The building is located at 1317-19 Derry Street in the economically depressed Allison Hill neighborhood, an area targeted for housing rehabilitation as part of the EDA. Built around 1905, the building is a three-story brick structure with two halves connected by a common stairwell. The first floor has commercial space in the front (formerly used as a church) and a garage in the rear. On the second and third floors there are three two-bedroom apartments, two in front of a foyer and one behind the foyer. Total area of living space is 5.550 square feet, total commercial area is 1.480 square feet, and the garage is 770 square feet, for a building total (excluding basement) of 7,800 square feet. (See Figure 6 for a floor plan of the building), Prior to rehabilitation, the building was in a moderately deteriorated condition and unoccupied. DCED contacted by letter the owner of the building, Inner City Developers, Inc., (owned by Richard and Michael Kushner) and informed them of the project goals. Soon after being invited to participate, Inner City Developers agreed to join the project and assigned Mr. Hal Lanshe of their staff as project manager.

Exterior view of 1317/19 Derry Street.

Exterior view of 1317/19 Derry Street.

FIGURE 6

FLOOR PLAN AND SPRINKLER CONFIGURATION



Harrisburg, Pennsylvania

The Derry Street Neighborhood.

The letter from DCED stated the department's intention to reimburse Inner City for the costs of installing a fire sprinkler system, including design and site work. Funds for reimbursement would come from a grant to DCED from USFA, contingent upon execution of a written agreement between DCED and Inner City. Costs were to be in accordance with the budget approved by USFA, with fire sprinkler installation costing up to $12,800 and site work up to $5,000. Site work included water taps, water meter lines, and trenching. In addition, the fire department and the DCED agreed to a USFA request to conduct a public outreach program for the project budgeted at $5,000. Inner City agreed to pay any additional sprinkler installation costs above the budgeted amount. Grant provisions disallowed transfer of funds in excess of 5 percent between cost categories without approval from FEMA,

All participants agreed to communicate regularly during the design and installation phases, with meetings scheduled in Harrisburg as necessary and, if possible, in conjunction with site visits by National Research Center personnel. The parties also agreed that telephone conversations and/or written communication would be necessary to secure input regarding system design. Photographs of the rehabilitation of the building would be taken by the National Research Center including installation of the sprinkler system, together with "before and after" views of construction.

After informing all participants of their roles and of the overall goals of the program, National Research Center began the design phase of the sprinkler system.

BUILDING REHABILITATION

As per plan, the building was only partially rehabilitated. Changes to be made had to comply with the requirements of the historic society and included patching and painting walls, repairing ceilings and floors (with some replacements), new windows, replaced bathroom and kitchen fixtures, and new lighting. Totalcost for construction (excluding the fire sprinkler system) was $205,000. Further, the National Research Center was asked to identify ways the building could be made more energy efficient and staff engineers recommendations that were included in construction follow:

- installation of storm-windows throughout building
- replacement of old steam boiler and radiators with higher efficiency gas boilers and hydronic baseboard
- roof insulation added throughout building, R-30 in most places
- new kitchen appliances

View of Interior prior to rehabilitation.

View of interior prior to rehabilitation.

Some of the energy improvements also serve to increase the fire safety of the building mostly in terms of the reduced chance of fires caused by faulty heating and electrical systems, and appliances.

FIRE SPRINKLER SYSTEM DESIGN AND INSTALLATION

The sprinkler system design was a coordinated effort between the National Research Center, Charles Shadle of C and S Mechanical Engineers, Inc. (CSME), Larry Stamer of the Harrisburg Fire Department, and Hal Lanshe. CSME is the mechanical and plumbing contractor hired by Inner City for the building rehabilitation including sprinkler design and installation. An overview of major issues in designing sprinkler systems is presented in the Introduction.

Water Service

The hydraulic calculations and subsequent tests were based on two heads open simultaneously, a "two-head design." (See Appendix C for an example of the hydraulic calculations for the building). The Harrisburg Fire Department determined that the water pressure for a sprinkler system was adequate. The Harrisburg Water Department required the sprinkler system to be tapped into the building's main water supply after (downstream of) the meter, thus metering water consumption of the sprinkler system. Friction loss within the meter is likely to cause a 5-10 pound per square Inch drop in the water pressure of the building. The water department also required installation of a single back-flow preventer (rather than a double) to prevent standing water in the sprinkler pipes from mixing with the domestic water supply. Friction loss in the back-flow preventer is likely to cause a 5-10 pound per square inch reduction in the water pressure of the sprinkler system. and this loss has been factored into the design delivery of the sprinkler heads. The control manifold has a pressure gauge and a drain and test valve. The sprinkler system can be shut off without special equipment. There is no connection for a fire department hose or other external source of water. There is an alarm system interconnecting the sprinkler system and the smoke detectors.

Coverage, Location. and Activation of Sprinkler Heads

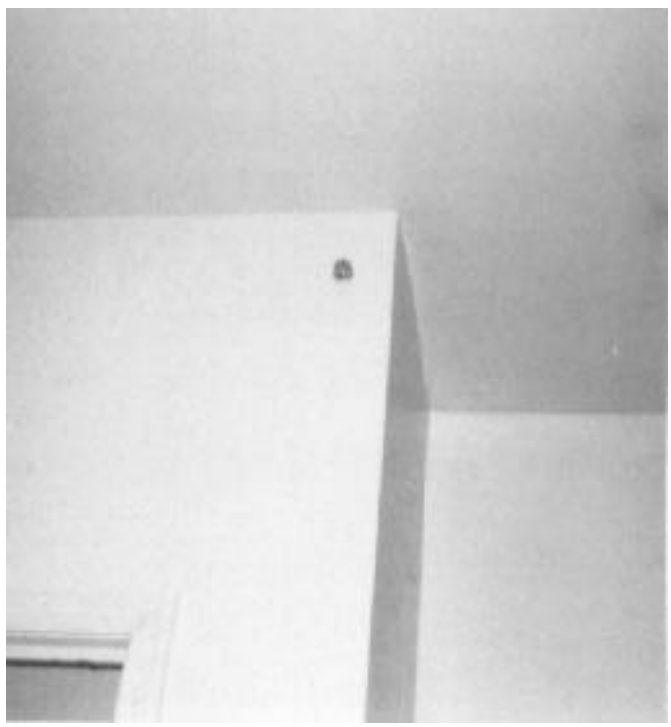
In 1317-19 Derry Street, there are 82 quick-response heads located in compliance with the spacing requirements of NFPA 13D. There are 5 spare heads stored on the premises as per NFPA 13D section A- l-5.1.1 requirement of preparation for immediate head replacement. In the subject building, sprinklers were not installed in the bathrooms in the residential units, nor in closets, the foyer or the garage. There is no crawl space. Sprinklers were installed in common halls. The sprinkler heads were manufactured by Grinnell Fire Protection Systems Company, Inc., and are either a pendent type protruding through drop ceilings or are sidewall mounted. The use of drop ceilings simplifies installation because of the flexibility of raising or lowering the ceiling for sprinkler installation. Drop ceilings, however are less sturdy and usually of less aesthetic quality than wallboard ceilings. Figure 6 is a floor plan of the second floor of the building (the third floor is identical to the second with the exception of the bathroom shown in the rear foyer area) and shows the location of pipes and sprinkler heads.

For safety, heads are generally set to discharge at no less than a maximum ambient temperature plus 35°F., generally between 135°F. and 170°F. in a residential environment. In the subject building, the sprinkler heads are designed to discharge at 160°F. except in the furnace heater room where they will discharge at 185°F.

Sidewall sprinkler head in common hall, ceiling sprinkler head in entrance foyer of apartment.

Pendant type sprinkler heads (capped) in finished interior hallway,

rafters system lateral piping and head fitting cut through ceiling



Sidewall sprinkler head in finished bedroom.

The pipes and risers in the subject building in Harrisburg are made of CPVC (brand name "Blazemaster"), and were left uncovered in the commercial area on the first floor. All other sections of pipe are contained inside walls made of either drywall (new walls) or patched plaster (existing walls). On the third floor the pipe runs in the ceiling are protected from freezing by 9-inch fiberglass RATTS (R-30), placed *between* the pipes and the roof deck.

Sprinkler System Plumbing

Sprinkler system "t" connections adjacent to electric conductors in ceiling rafters.

Sprinkler system laterals and elbows adjacent to other building utility systems.

Sprinkler system laterals in commercial area.

INSTALLATION AND TESTING

National Research Center staff and Mr. Charles Shadle of CSME spoke periodically with Mr. Lanshe to determine when the building would be ready for rehabilitation to begin. Since the work plan developed jointly by CSME and Inner City called only for minor rehabilitation, holes were drilled for sprinkler pipe installation. The project team had a chance to view the structure of the building in more detail after plaster ceilings in the halls were removed and decided to use fewer risers in the sprinkler system than had been initially planned. By reducing the number of risers the team was able to lower the cost of installation by reducing material costs and by making installation easier and less time-consuming.

The hydrostatic test was performed by the project team and witnessed by the fire department on April 18, 1988. The sprinkler system was pumped to 200 pounds per square inch as required by the fire department (it took 45 minutes to pump the system to that level by hand). Two heads leaked and there was a pinhole leak in one of the pipes on the second floor. The small size of the pipe leak indicated that it was caused by a manufacturing defect rather than by handling or installation. The system was drained, the two faulty heads were replaced, and the hole was repaired. The material used to repair the hole required a three-hour wait before refilling the system with water. The project team then pumped the system to 203 PSI and continued the test. The system held the 203 PSI for two hours as required by the fire department and afterwards the fire department declared the fire sprinkler system operational.

Mr. Hal Lanshe pumping system to 203 PSI by hand.

Chief Larry Stamer, Harrisburg Bureau of Fire Safety certifying pressure for system static presure test.

SYSTEM COSTS

Design and Installation

Table 3-3 presents the costs of the sprinkler system.

Most of the materials for the sprinkler system were donated by a major supplier in order to participate in a federally funded technical assistance project. National Research Center staff estimated the cost of the system using estimates of the wholesale and retail costs of donated material. In addition, it is important to note that the installer had to drill holes through existing walls that were not replaced during building rehabilitation, thus increasing the labor costs of sprinkler installation.

The design and installation total costs and costs per square foot (non-discounted) are well within what would be expected for a building the size and shape of 1317-19 Derry Street.

TABLE 3-3
SPRINKLER 8Y8TEM COSTS

Design*	$ 1,750
Materials pipe, fittings, and hangers (wholesale)	$ 1,608
sprinkler heads (wholesale)	$ 802
control manifold (Including double check valve, pressure gauge, relief valve, flow switch, and assorted fittings) (wholesale)	$ 350
ESTIMATED MATERIAL TOTAL (wholesale)	$ 2,760
ESTIMATED MATERIAL TOTAL (30 % markup for retail)	
Site Labor (approximately 180 hours)	$ 7,000
Building expense to install sprinklers (patch floors walls and ceilings	$ 1,500
WITHOUT MATERIAL COSTS	
TOTAL	
COST PER SQUARE FOOT	$ 10,250
COST PER UNIT INCL. COMMERCIAL AREA	$1.464
COST PER RESIDENTIAL UNIT	$1,708
WITH WHOLESALE MATERIAL COSTS	
TOTAL	$13.010
COST PER SQUARE FOOT	$ 1.83
COST PER UNIT INCL. COMMERCIAL AREA	$1,858
COST PER RESIDENTIAL UNIT (wholesale material costs)	$2,168
WITH ESTIMATED RETAIL MATERIAL COSTS	
TOTAL	$13,838
COST PER SQUARE FOOT	$ 1.95
COST PER UNIT INCL. COMMERCIAL AREA	$ 1,977
COST PER RESIDENTIAL UNIT	$ 2,306

* Done by National Research Center

Operation and Maintenance Costs

Mr. Lanshe estimates that costs for routine inspection and testing of the sprinkler system will total approximately $200 per year. As part of the DCED effort to revitalize the Allison Hill area, Inner City has received an abatement that discounts the property tax for 1317/ 1319 Derry Street on a graduated scale for five years, at which time the tax will not be discounted. There is a monitoring and summoning service that costs $5 per month. It is too soon to assess costs from leakage and/or false activation. As mentioned above, the owner incurred no loan financing costs and the sprinkler system water supply is metered along with the building's domestic water.

ECONOMIC BENEFITS

Improved Life Safety - Positive Effect on Rental Income

As a participant in the Federal Section 8 housing voucher program, Inner City must limit rents to "fair market" amounts as set by HUD. The Harrisburg Housing Authority distributes vouchers to tenants chosen from an established waiting list and informs them of buildings eligible for use of the vouchers. Tenants must pay up to 30 percent of their gross income for rent, and the vouchers make up the difference between that amount and the HUD determined market rent. The fact that the building owned by Inner City contained fire sprinklers may have shortened the time units remained vacant. Upon obtaining their vouchers, prospective tenants are free to choose any eligible dwelling. and within certain price ranges would likely choose units with enhanced fire safety. The high vacancy rate and the low income of residents in Harrisburg make it difficult to rent units, and the sprinklered apartments in this case probably would have been no exception if tenants did not have vouchers. Mr. Tom Blaine, leasing agent for Inner City, believes the presence of sprinklers had little effect on his effort to secure tenants for the building. He cites the fact that advertising for the building did not mention fire sprinklers and his experience indicates that fire safety is not among priority items prospective tenants inquire about. Nevertheless the presence of fire sprinklers in multifamily buildings is potentially a beneficial factor for building owners competing for tenants in markets with high vacancy rates.

Property Insurance Discount and Reduced Property Damage

The insurance carrier for Inner City reported to the National Research Center that the multiple peril insurance policy for 1317- 19 Derry Street cost Inner City between 30 and 40 percent less than it would have cost if fire sprinklers were not installed. The policy covers full replacement costs if the building is destroyed by fire. The policy deductible is $500, and therefore, currently, that sum should be the most Inner City can lose in direct property damages caused by fire. It is also possible for them to incur property losses not directly related to a fire such as demolition and/or security of remaining property. Therefore, the reduced likelihood of a destructive fire reduces the chance of such losses. Further, tenants may have insurance policies protecting against losses in their units, and reduced probability of fire will benefit those with such policies.

COMMUNITY OUTREACH

The city officials in attendance at the initial project meeting in Harrisburg stated their intention to have plumbers install the sprinkler system. The National Research Center suggested that plumbers may need special training to be qualified for sprinkler installation, and the city officials agreed. A training course was designed and scheduled for any licensed plumber wishing

to learn about residential fire sprinkler system design and installation, innovative plastic pipe materials, and NFPA fire sprinkler standards. Fire Protection Plus, Inc., (FPP) of Framingham, Massachusetts was known by the National Research Center as a qualified firm in the design and installation of residential fire sprinkler systems due to its successful participation in the sprinkler technical assistance project in Boston, Massachusetts. Mr. Tom Rinoldo of FPP was retained early in the project by the project team to conduct the training program in conjunction with other members of the team. The intention of the Harrisburg fire and community development departments was (in addition to increasing the availability of qualified sprinkler installers) to use the course as an outreach program designed to publicize both the technical assistance project with the National Research Center and the recently initiated fire sprinkler ordinance in that city, Appendix D is a copy of the course outline.

Sprinkler installation was videotaped by the Harrisburg Bureau of Fire Safety. The tape, along with file footage at the fire department, is being used for outreach and training in Harrisburg and may also be used by other jurisdictions participating in this technical assistance project.

Upon completion of rehabilitation, the building was dedicated in a ceremony attended by Mayor Reed. Mostly a publicity event concerning public/private cooperative housing rehabilitation, the event also highlighted the installation of the fire sprinkler system. Further, the Harrisburg Community and Economic Development newsletter Community Ink published a story (January/February, 1989) specifically covering the sprinkler grant and the city's recently enacted sprinkler ordinance.

HARRISBURG, PENNSYLVANIA, THE CITY AND ITS HOUSING MARKET

The U.S. Census Bureau's December 1986 population estimate for the city of Harrisburg was 51,530, a decrease of 3 percent since the 1980 Census. According to the 1980 U.S. Census, Harrisburg contained 26,006 housing units (2.0 persons per unit), of which 48 percent were single-family attached structures, 10 percent single-family detached structures, and 40 percent multifamily structures with two or more units.

Since 1980, Harrisburg has issued 30 permits with a total value of $9,917.500 for new multifamily residential construction and 5,378 permits with a total value of $39.851,412 for repairs, alterations, and additions to residences. Since 1983, the annual trend for new residential construction has turned sharply upward while spending for rehabilitation has remained nearly constant. In fact, in 1986 there was a 2,000 percent increase over 1983 in the funds spent by the private and public sectors on new housing construction, and only a 39 percent increase in spending on rehabilitation. However, the fact that rehabilitation expenditures have been 400% of new construction expenditures reflects the emphasis placed on rehabilitation by the city.

Table 3-4 presents a limited profile of the population and housing characteristics of the City.

TABLE 3-4
Harrisburg, Pennsylvania, Community ProfIle

Population (1986 estimate)	51.530
Population below poverty level	23.0%
Population 55 years old and older	26.8%
Population 4 years old and younger	7.6%
Population with limited mobility (U.S. Census defined as persons with limited ability to use public transit)	1.2%
Population density per square mile	6,692
Population density per housing unit	2.0
Total Housing Units (1980)	26,006
Multifamily 5 + units	21%
Multifamily 3-4 units	10%
Multifamily 2 units	9%
Single-family (attached)	48%
Single-family (detached)	10%
Other	
Age of Housing Built before 1940	57%
Built 1970-1980	
Median Price Single family (1986)	$40,217
One-bedroom rental (1980)	$ 237
Vacancy Rate - overall (1987)	3.0%
Rental Vacancy Rate	8.0%

SOURCE: Harrisburg Department of Community and Economic Development: U.S. Census Metropolitan Data Book. 1986

The Harrisburg Enterprise Development Area (EDA)

In 1983, the Allison Hill section of Harrisburg (includes Derry Street) was designated as a state enterprise development area (EDA). Overall, this designation allowed the city to combine public and private financing for physical improvements in commercial as well as residential properties. In addition, the city granted tax abatements for investors meeting specified criteria. As part of the effort to use the EDA concept to revitalize housing in Harrisburg, city officials together with the state of Pennsylvania have implemented several programs. Although there are no programs specifically concentrated on fire safety, the city enforces its new fire sprinkler ordinance in addition to requiring smoke detectors be

present in all residential buildings.

Home Mortgage Pool

Started in 1987, the Home Mortgage Pool offers 8.25 percent fixed-rate 30-year mortgages for eligible buyers. The borrower must be an owner-occupant after rehabilitation is complete, though properties of up to four living units are eligible.

Home Improvement Loan Program

Low- and moderate-income homeowners are eligible to receive assistance in securing loans at 6 percent interest for home rehabilitation. In addition, homeowners with incomes up to $50,000 may receive home improvement loans at 10.75 percent. Repayment for these loans ranges from two to 15 years.

Rehabilitation Grants

Grants of up to $15,000 for housing rehabilitation are available to low- and moderate-income owner-occupants. Owners of vacant structures may also receive the same grant if they provide at least 25 percent of the cost of rehabilitation. Between 1983 and 1987, over $2 million in grant monies was distributed.

Basic Systems Repair Program

Low-income homeowners may be eligible to receive grants up to $8,000 for repair of faulty basic systems such as heating, plumbing, and electric.

Nuevos Frentes (New Fronts) Program

Residential properties in commercial areas are eligible for up to $6,000 per unit for exterior repairs as long as the owner matches the grant dollar for dollar. Vacant units must be rented to low- or moderate-income tenants.

Rental Rehabilitation Program

Low-interest deferred payment loans are available in combination with private financing on properties approved for assistance by DCED. Preference is given to vacant structures with between four and 15 units, although some occupied buildings may also qualify. Approved applicants must rent at least 51 percent of units to low-income tenants.

Harrisburg Property Reinvestment Board

Acquisition of vacant structures within the EDA can be expedited through the Harrisburg Redevelopment Authority. Tax delinquent properties or properties with serious code violations may be obtained either through negotiations or eminent domain proceedings. Between 1984 and 1987, 64 properties were acquired by the Property Reinvestment Board. Properties that have been acquired by the city can then be sold either through conventional methods or through use of one or more of the above mentioned programs. To facilitate rehabilitation of abandoned structures, the city uses its "clean and seal" program whereby buildings are readied for immediate rehabilitation. Thus far 200 buildings have been cleaned and sealed citywide, some of which have been sold, while others are likely to be sold in the near future.

Mount Pleasant National Register Historic District

Mount Pleasant is an area within the EDA that has been declared a national historic district by the Federal Government. The designation allows 20 percent of the cost of rehabilitating an eligible building to be credited toward developers' income, thereby reducing their tax liability. To be eligible, the building must become income producing and must be architecturally characteristic of the historic district.

LOCAL FIRE EXPERIENCE

Populations at higher risk of fire include the elderly, the very young, and people with limited ability to move without assistance. In Prince George's County, 12.7 percent of the population is 55 years old or older and 7.0 percent is five years old or younger. Physical handicaps limit the mobility of 0.2 percent of the population. To respond to the fire protection needs of the county. the Prince George's County Fire Department maintains the forces listed in Table 4-1:

TABLE 4-l
Prince George's County Fire Department

Stations (engine and ladder) (average coverage of 10.6 square miles per station)	46
Engine companies	19
Ladder Truck Companies	
Rescue/Hazardous Material Stations	
Firefighters (Professional)	520
Firefighters (volunteer)	1,200
Firefighters on duty during each of 4 shifts (Professional)	160
Firefighters on duty during each of 4 shifts (Volunteer)	NA
Fire chiefs/Battalion Captains	26
Fire Battalions (average of 54 square miles per battalion)	9
Fire Hydrants	13,555•

Source: Prince George's County Fire Department, Division of Fire Rescue Operations.

• Washington Suburban Sanitary commission, Maintenance Services Division.

It is likely that a county as large as Prince George's will experience residential fire fatalities during a given year and that a disproportionate share of the victims will be either elderly or very young. Although the over-55 and under-five population combined represent only 20 percent of Prince George's County's population, Table 4-2 shows that these groups accounted for 58 percent of the fire fatalities during a six-year period. Further, fire deaths are more likely to occur in low-income neighborhoods, defined as neighborhoods where property values are lower than county and regional averages and a higher than average proportion of people live in poverty. Prince George's County is an urban-rural mixture, with the Capital Beltway (Interstates 95 and 495) roughly a "border" between the high density urbanized areas with a large proportion of low-income residents and the low density suburban and rural areas with residents of more affluence. The high-density area (HDA) of Prince George's County (approximately 48 square miles, or 10 percent of county land] is bordered by Washington D.C. on the west, "Langley Park' and Montgomery County (Maryland) on the north, the Beltway on the east, and "Suitland" on the south. The Fairmont Heights neighborhood, location of the subject building of this project, is situated close to the geographic center of the HDA of the county (See Figure 7). Table 4-2 shows 66 percent of Prince George's County's fire fatalities occurred in the HDA even though only 40 percent of the county's population resides there. The downward trend in the percentage of county fatalities occurring in the HDA partly reflects ongoing efforts of the county fire department to reduce fire fatalities in the HDA.

TABLE 4-2
Residential Civilian Fire Fatalities
Prince George's County

FISCAL YEAR	NO. OF CIVILIAN FIRE DEATHS (RESI)*	55 & OLDER OR 5 & YNGER #	%	IN HDA #	%
1979	10	8	80	9	90
1980	4	2	50	3	75
1981	15**	9	60	11	73
1982	16	5	31	11	69
1983	21	15	71	14	67
1964	14	7	50	5	36
6 YR TOTAL	80	46	58	53	66

* excludes suicides by fire
** includes one fire with 5 deaths

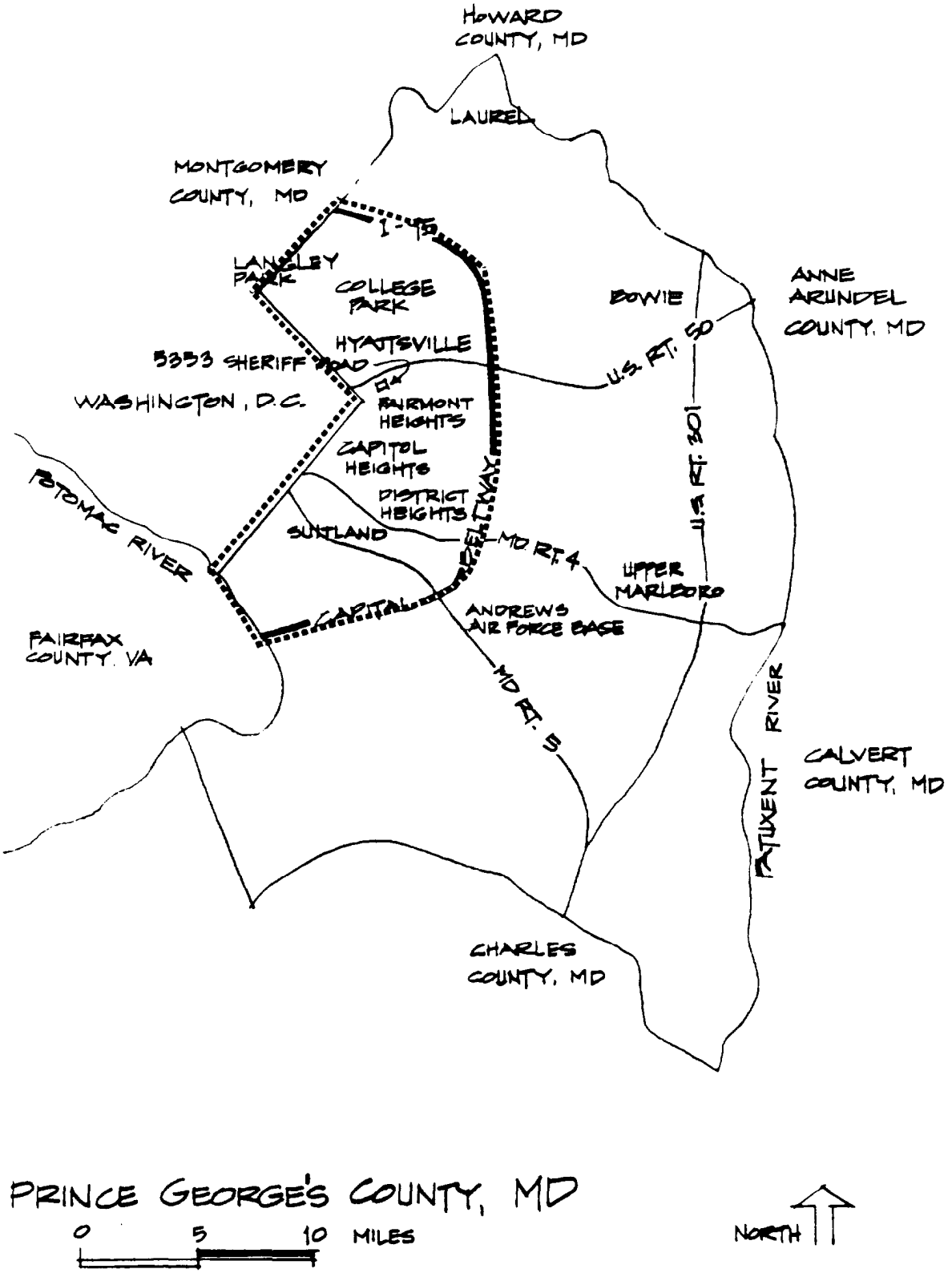
SOURCE: Prince George's County Fire Department, Investigations Section.

PROJECT INITIATION

The National Research Center's tentative selection of Prince George's County led to an invitation to the Department of Housing and Community Development (HCD) to participate in the federally funded technical assistance program. The National Research Center notified HCD of the availability of federal money to increase fire safety among urban low-income populations, though the funding sources--USFA and HUD-- required the funds to be used in conjunction with other CDBG funds allocated to rehabilitation of low-income housing. The National Research Center informed HCD of the agency's responsibility to identify buildings imminently scheduled to undergo CDBG-assisted rehabilitation and occupied (or scheduled to be) by low-income tenants. In addition, the National Research Center assisted

FIGURE 7

GEOGRAPHIC CENTER OF THE HDA
Location of Building and Prince George's County High Density Area



HCD in evaluating buildings for technical feasibility with fire sprinkler installation before final selection of the subject building. Further, HCD staff contacted other departments concerned with aspects of fire safety: the Prince George's County Fire Department and the Washington Suburban Sanitary Commission (WSSC), the water company for Prince George's County. HCD staff also identified a building as a tentative site for the program. The decision of County Executive, Parris Glendening, (highest elected county official) formally initiated Prince George's County's participation in the fire sprinkler technical assistance project.

At an orientation meeting in Prince George's County in October 1986, National Research Center staff met with David Banwarth, Chief Fire Protection Engineer for the Prince George's County Fire Department, and Emelda Johnson-Heller and Leroy Brown of HCD. National Research Center staff outlined the project, and the ensuing discussion highlighted ambiguities in application of NFPA 13 and 13D in multifamily buildings. Even though the issues surrounding application of NFPA 13 and NFPA 13D could be addressed through design of a system using a modified NFPA 13 standard, the parties agreed that the Prince George's County project should in part focus on development of a new sprinkler standard for multifamily residences. Any new standard would have to balance adequate fire protection with aifordability concerns. Chief Banwarth stated that the fire department was in favor of the use of sprinkler systems in multifamily buildings.

Shortly after the project initiation meeting HCD identified two multifamily buildings that met the project criteria. In each case, despite initial interest on the part of the building owners, the sites were dropped from consideration due to uncertain funding and rehabilitation scheduling. After further review, HCD chose a four-story masonry building containing 15 three-bedroom units located at 5353 Sheriff Road in the Fairmont Heights section of Prince George's County. Built in the mid-1960s it is one of five 17,664 square foot buildings in a complex called "The Lodge Apartments" containing a total of 75 units of mixed size and floor plans. (Figure 8 shows typical floor plans of apartments in the subject building). Prior to rehabilitation, the building was partially occupied and had no major physical problems but had many moderate repair and replacement needs. The basement apartments were in a severely deteriorated condition due to flooding from the building's sanitary sewer system. HCD contacted by letter the owner of the building, Mr. Wayne Bowie, and informed him of the project goals. Soon after being invited to participate, Mr. Bowie agreed to join the project.

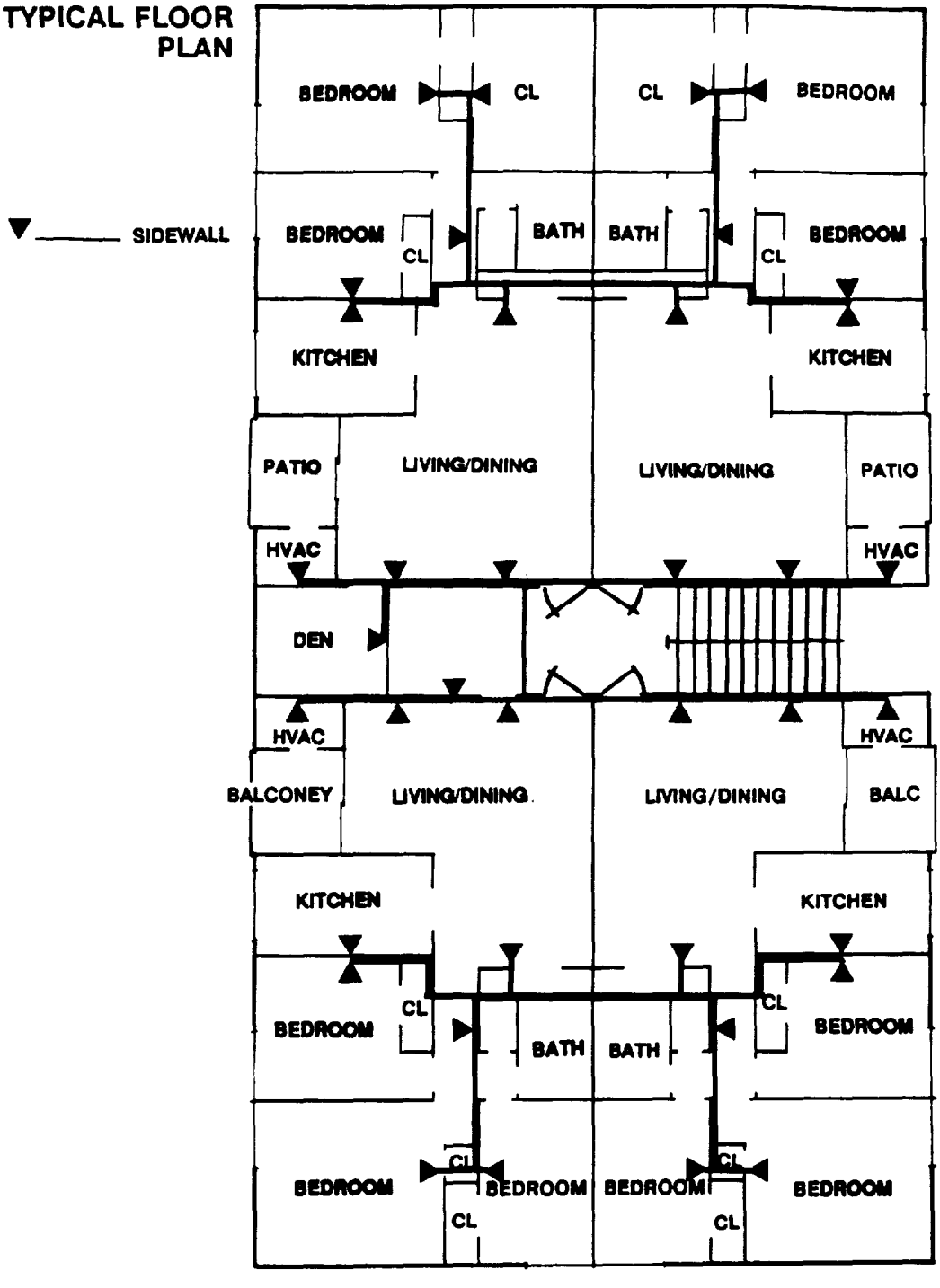
The letter from HCD stated the department's willingness to reimburse Mr. Bowie for the costs of installing a fire sprinkler system, including design and site work. Funds for reimbursement would come from a grant to HCD from USFA. contingent upon execution of a written agreement between HCD and Mr. Bowle.
Costs were to be in accordance with the budget approved by USFA, with fire sprinkler installation costing up to $13,600 and site work up to $5,000. Site work included water taps, water meter lines, and trenching. In addition, the fire department and HCD agreed to a USFA request to conduct a public outreach program for the project budgeted at $5.000. Mr. Bowie agreed to pay any additional sprinkler installation costs above the budgeted amount. Grant provisions disallowed transfer of funds in excess of 5 percent between cost categories without approval from FEMA.

Exterior view of 5353 Sheriff Road.

All participants agreed to communicate regularly during the design and installation phases, with meetings scheduled as necessary. The parties also agreed that telephone conversations and/or written communication would be necessary to secure input regarding system design. Photographs of the rehabilitation of the building would be taken by the National Research Center including installation of the sprinkler system,

FIGURE 8

FLOOR PLANS OF APARTMENTS AND SPRINKLER CONFIGURATION



Prince George's County, Maryland

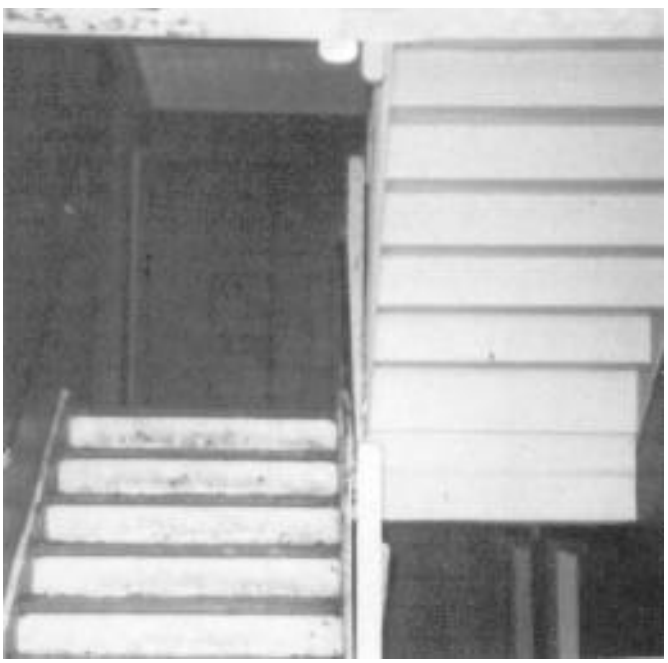
together with "before and after" views of construction.

After informing all participants of their roles and of the overall goals of the program, National Research Center began the design phase of the sprinkler system.

BUILDING REHABILITATION

As per plan, the subject building was only partially rehabilitated. Changes included remodeled kitchens, total rehabilitation of basement apartments (ruined by sanitary sewer flooding), patched and painted walls, renovated sanitary sewer mains, and remodeled laundry rooms. The total cost for rehabilitation design and construction (excluding the fire sprinkler system) was estimated by National Research Center staff to be $215,000 based on a reported cost of $1,075,000 to rehabilitate all 5 buildings. Further, HUD asked the National Research Center to identify ways the building could be made more energy efficient. National Research Center staff engineers made the following recommendations that were included in the construction:

- upgrade replacement windows and sliding glass balcony doors from single- to double-pane
- upgrade apartment entry doors to high-security doors with insulated cores



Common interior stairway at 5353 Sheriff Road.

- replace the gas furnace and air conditioning systems with mid-level efficiency units
- add roof insulation in some areas
- replace kitchen appliances

Utility and laundry area with commercial sprinkler system.

Some of the energy improvements may have increased the building's fire safety by reducing the risk of fires caused by faulty heat or electrical systems.

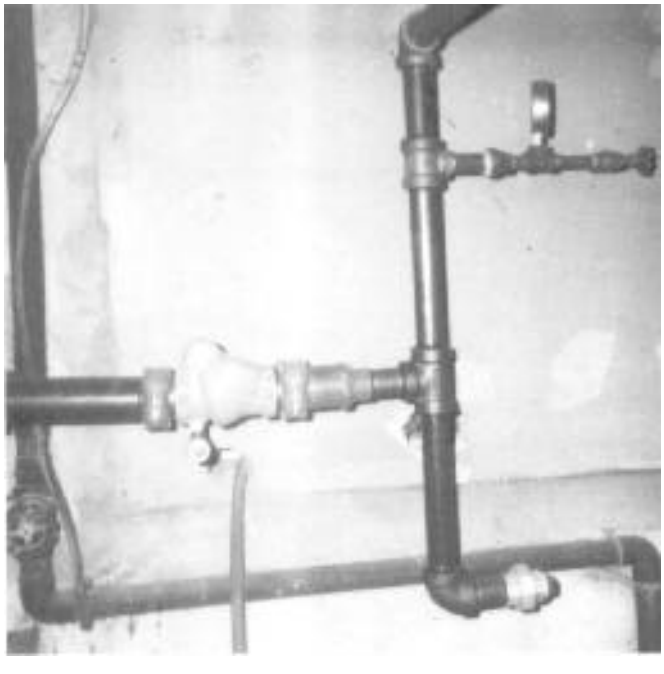
FIRE SPRINKLER SYSTEM DESIGN AND INSTALLATION

The sprinkler system design involved a coordinated effort among the National Research Center, Don Rivetta (rehabilitation job superintendent), and Wayne Bowie (building owner). An overview of major issues in designing sprinkler systems is presented in the Introduction.

Water System

The hydraulic calculations and subsequent tests were based on two heads open simultaneously, a "two-head design." (See Appendix E for an example of the hydraulic calculations for the building). The Prince George's County Fire Department determined that the water pressure

for a sprinkler system was adequate. The sprinkler system is tapped into the main fire supply of the complex, thus any water discharged by the sprinkler system is not metered. Friction loss within the meter is likely to cause a 5-10 pound per square inch drop in the water pressure of the overall water system to the complex. The WSSC required installation of a double (rather than single) back-flow preventer to prevent the standing water in the sprinkler pipes from mixing with the domestic water supply. Friction loss in the back-flow preventer is likely to cause a 5-10 pound per square inch reduction in the water pressure of the sprinkler system, and this loss has been factored into the design delivery of the sprinkler heads. There is a pressure gauge and a drain and test valve, and the sprinkler system can be shut off without special equipment. There is a connection for a fire department hose or other external source of water, and a flow switch connected to external alarm bells.



Valve detail at supply connection, including double back-flow preventer.

Coverage, Location, and Activation of Sprinkler Heads

In the subject building, the sprinkler system includes 143 quick-response heads (excluding the commercial heads that were already in the laundry room) located in compliance with the spacing requirements specified in NFPA 13D. There are five spare heads stored on the premises as per NFPA 13D section A- l-5.1.1.

In the Lodge Apartments, sprinklers were not installed in the bathrooms or interior closets, there are sprinklers in the furnace closets located on each unit's balcony. There is no attic, crawl space, or garage. Sprinklers were not installed in common halls and stairwells.

Holes cut for sprinkler piping through heating duct.

The water pressure in the building was sufficient to allow the use of sidewall sprinkler heads in all rooms other than the laundry and storage areas. There was the need to use one ceiling pendent head in each unit due to the configuration of a corridor between the bedrooms and a bathroom. Sidewall mounted heads eliminate the need for horizontal pipe chases running across the ceilings, thus lowering both material and labor costs. The system design team also had to consider that the rehabilitation plan for the building did not include demolition of existing walls. Customarily, piping is concealed by walls and ceilings, but to do so in this project would have required work not planned and would have significantly raised the cost of the system according to the project team. Instead, the team decided to surface mount and hang the system piping exposed in living areas and then conceal the pipes by constructing special drywall soffits or "boxing" using standard drywall techniques. Although the CPVC pipe used in this project is rated as fire-safe in exposed applications, exposed piping is usually unsightly and is more susceptible to accidental damage or vandalism. Using hung and boxed piping rather than

installing the system inside walls reduced installation costs of the system. (Figure 8 shows a typical floor plan of the sprinkler system in the living units].

Holes for sprinkler piping through finished walls.

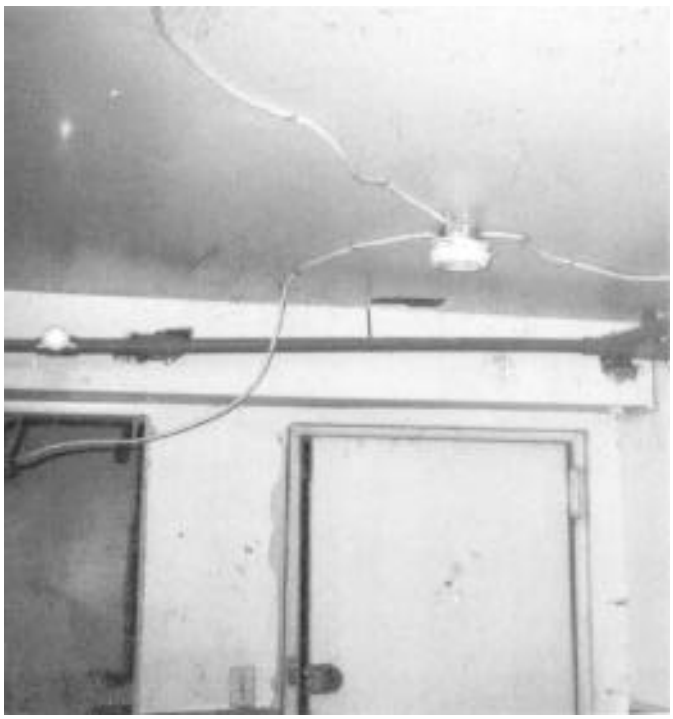
sprinkler head, above closet, during rehabilitation.

In the subject building, the heads are designed to discharge at 165°F.. except the sidewall dry-heads used in the furnace closets that are set to discharge at 286°F. The sprinkler heads were manufactured by Grinnell Fire Protection Systems Company, Inc.

Ceiling pendent head between rooms, with smoke detector and ceiling light fixture.

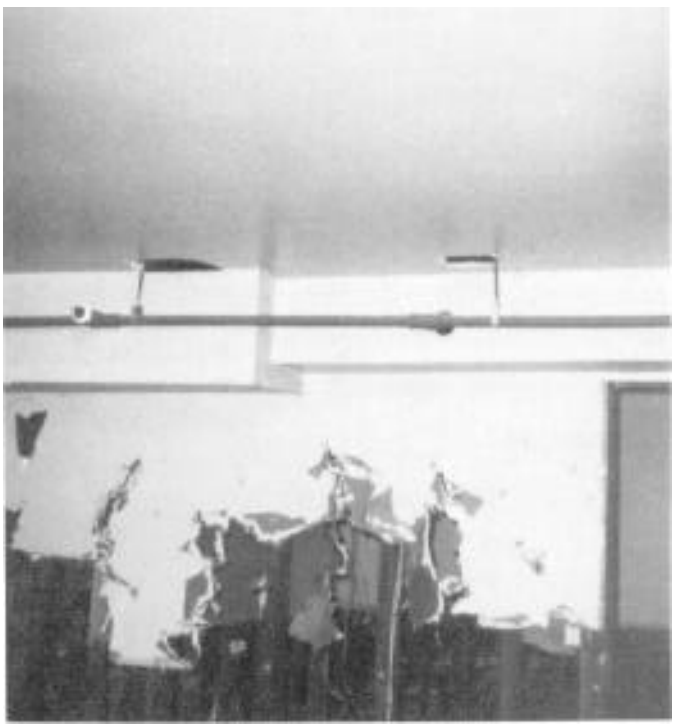
sidewall head not in soffit, above closet.

Sidewall head in finished rehabilitated kitchen.



Sprinkler system adjacent to hard wired smoke detector.

Typical sidewall dry sprinkler head in furnace closet.



CPVC piping hung but not boxed.

Sprinkler System Plumbing

CPVC pipe and fittings were used in the residential areas of the Lodge Apartments, while iron pipe and fittings were used (as required) in the laundry and storage areas.

CPVC piping wrapped around hot air duct work.

INSTALLATION AND TESTING

Fire Department officials approved the sprinkler system plans on December 11, 1987. Mr. Bowie contracted with Livingston Fire Protection Inc., to install the sprinkler system. Prince George's County does not require the licensing of sprinkler installers, The contractor began installation of the system in April, 1988. Installation of the sprinkler system was coordinated with the rest of the building rehabilitation project, and took six months. The system was operational by November 1, 1988. During October, 1988. the fire department witnessed the code-required water pressure test. Overall rehabilitation of the building was finished in early 1989.

SYSTEM COSTS

DESIGN AND INSTALLATION

The grant amount designated for sprinkler installation in Prince George's County fell short of the actual cost by $4,810. and Mr. Bowie paid the difference. The low cost per square foot is attributable to two major factors. First, there was no increase in the water service to the building, and second, there was no drilling or other wall penetration for sprinkler pipes and the soffits were simple and inexpensive to construct. Table 4-3 presents the cost of the sprinkler system.

TABLE 4-5
SPRINKLER SYSTEM COSTS

	LABOR	MATERIAL	TOTAL
Design	$1,750.00*		
Sprinkler Installation	$ 8360.00	$ 5,740.00	$ 1,750,00
Soffits to Conceal Pipe	$ 3,098.00	$ 2.152.00	$ 6,250:00
Preparatory Drilling and Layout	$ 2,520.00	0	$ 2.520.00
Plumbing Hook up to Existing Water supply	$ 826.00	$ 574.00	$ 1,400.00
Electrical Connection to Existing Alarms	$ 63.00	$ 177.00	$ 240.00
TOTAL (lncl. design)	$16,517.00	$ 8643.00	$25,160.00
COST PER SQUARE FOOT	$ 0.99	$ 0.52	$ 1.51
COST PER LIVING UNIT	$ 1.101.00	$ 576.00	$ 1.677.00

* Done by the National Research Center, not funded by grant to Prince George's County

Operation and Maintenance Costs

Mr. Bowie estimates that his costs for routine inspection and testing will be negligible, and believes the property taxes will not be affected by the presence of the sprinkler system. It is too soon to assess costs from leakage and/or false activation. As mentioned above, in this case there were no financing costs, there is no annual fee for water (water use if any will be metered), and there is no external monitoring service.

ECONOMIC BENEFITS

Improved Life Safety - Positive Effect on Rental Income

The W.A. Bowie Company reported that the presence of sprinklers had no clear effect on rent levels, citing the need to limit rents in a low-income apartment complex as well as uncertainty over the marketability of the sprinkler system, The company could not cite a reduction in duration of vacancies attributable to the presence of fire sprinklers.

Property Insurance Discount and Reduced Property Damage

The W.A. Bowie Company purchased a new property insurance policy for their Sheriff Road apartment complex following the rehabilitation. The company sought a new policy in part due to installation of the residential sprinkler system. The new policy annual premium is $21,000, $5,000 less (19 percent) than the previous year. The company reports that $1,000 of the decrease was directly attributable to installation of

sprinklers in one of five buildings covered by the policy. This means sprinkler installation led to a 4 percent decrease in insurance costs.

The property insurance policy for the Lodge Apartments covers up to $2,200,000 of property loss, ($444,000 per building). At present, the insurance is considered to represent full replacement value. The deductible is $250 per building and therefore, currently, that sum should be the most Mr. Bowie can lose in direct property damages caused by fire. It is also possible for him to incur property losses not directly related to a fire such as demolition and/or security of remaining property. Therefore the reduced likelihood of a destructive fire reduces the chance of such losses. Further, tenants may have insurance policies protecting against losses in their units, and reduced probability of fire will benefit those with such policies.

COMMUNITY OUTREACH

The Prince George's County Fire Department has a full-time professional unit dedicated to education and outreach called the Educational Resources Division (ERD), of the Bureau of Fire Prevention and Public Education. The ERD is involved in the ongoing production of presentations regarding a variety of subjects. The ERD has in-house audio/visual facilities and also contracts for productions with outside organizations. The ERD is producing a thirty-minute monthly cable television show to be called "A Fire Line" hosted by Chief Estepp. The theme of the pilot show will be residential fire sprinklers and include a presentation on the Lodge Apartments sprinkler project.

TABLE 4-4
Prince George's County, Maryland Community Profile

Population (1980 Census)	665,071
Popmatlon (1990 estimate)	694,103
Population below poverty level (1980)	6.7%
Population 55 and older (1980)	12.7%
Population 5 and younger (1980)	7.0%
Population with limited mobility (U.S. Census defined as persons with limited ability to use public transit)	0.2%
Population density per square mile (1988)	1,426
Population density per housing unit (1988)	2.8
Total Housing Units (1980)	236,465
Total Housing Units (1987)	256.126
Mulifamily (five or more units) (1980)	43%
Multifamily (five or more units) (1987)	41%
Single family (1980)	52%
Single family (1987)	59%
Age of Housing Built before 1939	5.7%
Median Price (1987)	
Sale Price New Single Family	$124.000.00
Resale Price Single Familv	$108,900.00
Efficiency/Studio Rental	$ 443.00
1 Bedroom Rental	$ 509.00
2 Bedroom Rental	$ 587.00
3 Bedroom Rental	$ 670.00
Overall Vacancy Rate (1985)	4.9%

Source: Prince George's County Department of Housing and Community Development.

PRINCE GEORGE'S COUNTY: THE COUNTY AND ITS HOUSING MARKET

Population

The population of Prince George's County was 665,071 in 1980 according to the U.S. Census and is expected to grow 4.4 percent, to 694.103, by 1990. An important trend is revealed when the population is segmented into three age groups: under five years old, between five and 54 years old, and over 55. The middle group, constituting the vast majority of the population (80 percent in 1980), is predicted to increase by less than 1 percent by 1990, whereas the over-55 age group is predicted to increase by 30 percent and the under-5 age group by 10 percent. As a result of these projected increases, the under-five age group is predicted to increase from 6.9 to 7.3 percent of the total county population, the over-55 group will increase from 12.7 to 15.9 percent, and the 5-54 group will decrease from 80.2 to 76.8 percent of the county's population between 1980 and 1990. In addition, an estimated 6.7 percent of county residents lived below the poverty level in 1980, a figure not expected to change significantly by 1990. County planners will consider trends in high-risk populations when they formulate housing plans and programs for the 1990s.

Housing

According to the 1980 Census, the county reported 236,465 housing units (2.8 people per housing unit), of which 225,824 were occupied; a vacancy rate of 4.5 percent. Single-family units constituted 52 percent and buildings with five or more residential units accounted for 43 percent of the total living units in the county in 1980. In 1987 the median sale price of a new single family home was $124.000. median resale price of an existing single family home was $108,900, and median monthly rental for a three bedroom apartment was $670.

The Multifamily Housing Rehabilitation Program

In order to assist construction or rehabilitation of multifamily and\or special needs housing units, the Department of Housing and Community Development (CHD) administers five state funded programs.

Rental Housing Production Program

In this program, funds are available to private developers, non-profit organizations, and local governments for the acquisition, construction, rehabilitation, or operating costs of buildings to provide rental housing for low-income households. The funds are either in the form of deferred payment or below market interest loans.

Maryland Housing Rehabilitation Program

This program makes funds available specifically for rehabilitation of rental housing for low- and moderate-income households. Interest rates are determined by the incomes of the tenants to be served and range from 0 percent to 7.3 percent.

Water and Sewer Assistance Program

This program makes funds available to provide running water, and septic and sewer services to properties owned and/or occupied by low-income households. Funds may also be used to pay "hook-up" fees where such fees are required.

Handicapped Grants for Structural Modifications

Physically disabled residents are eligible for grants up to $3,000 to effect structural modifications enhancing accessibility.

Elderly Rental Housing Program

This program provides funds for new construction or substantial rehabilitation of housing units specifically for elderly households. The funds are used in tandem with other monies and are provided in the form of deferred payment loans.

The CHD is also the county administrator of federal programs funding housing for low- and moderate-income households such as Section 8, Section 312, Rental Rehabilitation Program, Community Development Block Grants, and Urban Homesteading Program.

In addition to direct financial assistance, HCD has bond authority for tax-exempt financing for rehabilitation and\or acquisition of multifamily units. Although there are no programs specifically concentrated on fire safety, the county enforces its new fire sprinkler ordinance in addition to requiring smoke detectors be present in all residential buildings.

LOCAL FIRE EXPERIENCE

High-risk populations include the elderly, the very young, and people with limited ability to move without assistance. In St. Louis, 18.7 percent of the population is 55 years old or older and 3.7 percent is four years old or younger. Physical handicaps limit the mobility of 1.1 percent of the population. To respond to the firefighting needs of the city, the St. Louis Fire Department maintains the forces listed in Table 5-1:

TABLE 6-l
ST. LOUIS FIRE DEPARTMENT

Stations (engine and ladder) (average coverage of 1.3 square miles per station)	30
Heavy Duty Rescue Squads	2
Firefighters	641
Firefighters on duty during each of 3 shifts	162
Fire chiefs	24
Fire chiefs on duty during each of 3 shifts	8
Fire Districts (average of 6.3 square miles per district)	6
Fire hydrants	15,484

Source: St. Louis Fire Department, Office of Fire Investigations

Any city as large as St. Louis is almost certain to experience residential fire fatalities each year, and a disproportionate share of victims will be either elderly or very young. Although the over-55 and under-4 population combined represent only 22 percent of St. Louis's population, these groups accounted for 56 percent of the fire fatalities during a 3 l/2 year period. Further, fire deaths are more likely to occur in low-income neighborhoods defined as neighborhoods where property values are lower than average and a higher than average proportion of people live in poverty. The central residential district (CRD) of St, Louis, site of the sprinkler project, encompasses nine postal zip codes classified by St. Louis city officials as low- and moderate-income neighborhoods. These neighborhoods (including Lafayette Park) accounted for 66 percent of St. Louis's fire fatalities between 1985 and July, 1988. even though only 55 percent of the city's population resides there. Table 5-2 shows the recent trends for both the city as a whole and for the central residential district while Figure 9 plots the location of the fatalities in the CRD (by zip code) on a map of the city.

TABLE 0-2
RESIDENTIAL CIVILIAN FIRE FATALITIES- ST. LOUIS

YEAR	NO. OF CIVILIAN FIRE DEATHS (RESI)	55 & OLDER OR 4 & YNGER		IN LOW-INCOME NEIGHBORHOODS	
		#	%	#	%
1965	14	7	50	10	71
1986	18*	7	39	12	67
1987	12	10	83	8	67
1988 (Through July)	12	8	67	7	58
TOTAL	56	32	57	37	66

* One fire with 4 deaths

Source: St. Louis Fire Department, Office of Fire Investigations

PROJECT INITIATION

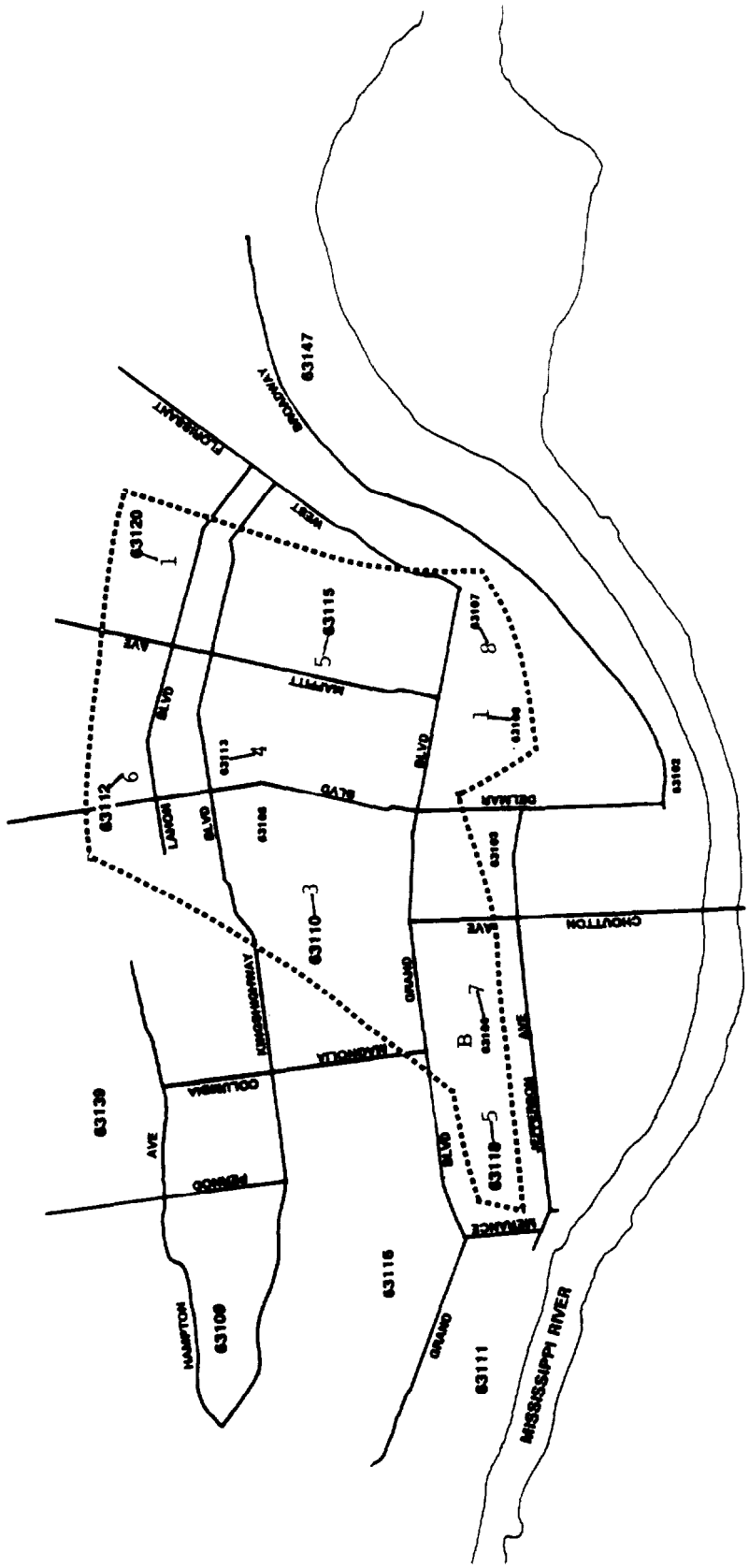
The National Research Center's tentative selection of St. Louis led to an invitation to CDA to participate in the (federally-funded] technical assistance program, The National Research Center notified CDA of availability of federal money to enhance fire safety among urban low-income populations, though the funding sources (USFA and HUD) required the funds to be used in conjunction with other CDBG funds allocated to rehabilitation of low-income housing. Therefore, the National Research Center informed CDA of its responsibility to identify buildings imminently scheduled to undergo CDBG-assisted rehabilitation and occupied (or scheduled to be) by low-income tenants. In addition, the National Research Center assisted CDA in evaluating buildings for technical feasibility with fire sprinkler installation before final selection of the subject building. Further, CDA staff contacted other city departments relevant to fire safety. CDA communicated with the St. Louis Fire Department, the St. Louis Water Department, and the St. Louis Building Commissioner. The decision of Mayor Vincent C. Schoemehl, Jr., formally activated St. Louis participation in the fire sprinkler technical assistance project.

In an orientation meeting in St. Louis on December 17, 1986, National Research Center staff met with the following city officials:

- St. Louis Fire Department: Fire Marshal George Jenkerson and Sprinkler Inspector Les Jenkins

FIGURE 9

LOCATION OF BUILDING, CENTRAL RESIDENTIAL DISTRICT, FIRE FATALITIES



ST. LOUIS, MISSOURI

- Building Department: Acting Building Commissioner Ray Dailey and Assistant to the Commissioner John Soell

- Water Department: Chief Engineer Frank Herron

- Community Development Agency: Project Managers Jim Sackett and Don Bollinger

In attendance also were Dave Gagen and Bob Weinschenker, head of the apprentice program and the residential chairman respectively, of the Sprinkler Fitters Union, and Bill Varone, representative of Grinnell Fire Protection Systems Company, Inc., and of the Executive Council of the Sprinklers Contractors Union. The non-city personnel were invited by Fire Marshal Jenkerson to help plan the project. As one of the largest sprinkler contractor companies in the world, Grinnell was in the opinion of the St. Louis Fire Department well qualified to install the sprinkler system. The National Research Center concurred with the fire department's selection of Grinnell owing to Grinnell's experience in design and installation of sprinkler systems and credibility with the St. Louis Fire Department, Building Department, and Water Department.

National Research Center staff outlined the project and in the ensuing discussion, highlighted ambiguities in application of NFPA 13 and 13D in multifamily buildings. Even though ambiguity over application of NFPA 13 and 13D could be resolved through design of a system using a modified NFPA 13D standard, the parties agreed that the St. Louis project should in part focus on development of a new sprinkler standard for multifamily residences. Any new standard would have to balance adequate fire protection with affordability concerns. Chief Jenkerson stated that the fire department was in favor of installing sprinkler systems in multifamily buildings, noting that the department would encourage use of sprinklers.

In the months following the meeting, CDA staff identified buildings as potential sites for sprinkler installation. The CDA received building selection criteria from the National Research Center and then added the agency's requirements for participation in subsidized rehabilitation. Primary among the city's criteria are the need for site control on the part of a developer, location in a targeted neighborhood, projects affordable to moderate-income families, units of three or more bedrooms, and projects encouraging stability of neighborhoods. The city can reject an application to the subsidized rehabilitation program for failing to meet any one of these criteria as well as for a lack of financial feasibility. A part of the building selection process included hydraulic calculations for each candidate site to determine the adequacy of the water supply to support a sprinkler system.

Developer Stephen Beyer of The Pride Organization (Pride) responded to a routine request for proposals. In compliance with city ownership requirements Mr. Beyer formed Lafayette Avenue Limited Partnership as the owner of a building Pride would rehabilitate. The building was scheduled for major rehabilitation and satisfied the other selection criteria for sprinkler installations.

In September 1987, Brian A. Murphy, Housing Section Supervisor, for the St. Louis Community Development Agency, sent a letter to Mr. Beyer to formally notify him that his building had been selected for participation in the fire sprinkler system technical assistance project. The building, located at 2102 Lafayette Avenue has three stories and a basement and contains four units that range in size from 800 to 1750 square feet. It is a free-standing masonry structure built around 1880, situated on a corner lot. Total area is approximately 8.000 square feet. Prior to rehabilitation. the building was unoccupied and in deteriorated condition. The adjacent neighborhood known as Lafayette Park contains mostly townhouses built in the late 19th century, and recently has been the site of much housing rehabilitation. [See Figure 9 for location of the building).

The letter from CDA stated the department's willingness to reimburse Mr. Beyer for the costs of installing a fire sprinkler system, including design and site work. Funds for reimbursement would come from a grant to CDA from USFA. contingent upon execution of a written agreement between CDA and Mr. Beyer. Costs were to be in accordance with the budget approved by USFA, with fire sprinkler installation costing up to $12,800 and site work up to $5.000. Site work included water taps, water lines, and trenching. In addition, the fire department and CDA agreed to a USFA request to conduct a public outreach program for the project budgeted at $5,000. Mr. Beyer agreed to pay any additional sprinkler installation costs above the budgeted amount. Grant provisions disallowed transfer of funds in excess of 5 percent between cost categories without approval from FEMA. Other conditions contained in the letter included: compliance with all rules and regulations of the funding source for the project, including but not limited to inspection of the subject building prior to funding commitment;

CDA approval of the project: execution of a third-party agreement for system work: submission of all required documents; and compliance with any other requirements of CDA. In response to the letter, Mr. Beyer wrote to Jim Sackett, Project Manager with CDA, to acknowledge his formal participation in the project.

All participants agreed to communicate regularly during the design and installation phases, with meetings scheduled in St. Louis as necessary and, if possible, in conjunction with site visits by National Research Center personnel. The parties also agreed that telephone conversations and/or written communication would be necessary to secure input regarding system design. Photographs of the rehabilitation of the building would be taken by the National Research Center including installation of the sprinkler system, together with "before and after" views of construction.

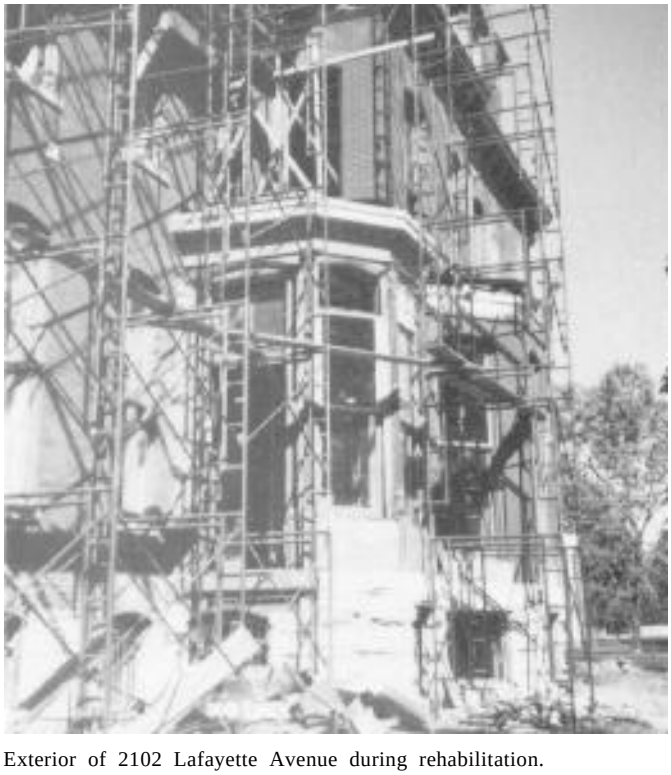
After informing all participants of their roles and of the overall goals of the program, National Research Center began the design phase of the sprinkler system.

Frontal view of 2102 Lafayette Avenue prior to rehabilitation.

Frontal view of 2102 Lafayette Avenue prior to rehabilitation.

Side view prior to rehabilitation.

Portion of Lafayette Avenue with "For Lease" sign in front of No. 2102.



Exterior of 2102 Lafayette Avenue during rehabilitation.

BUILDING REHABILITATION

The subject building was substantially rehabilitated including new floors, walls, ceilings, doors, windows, and utilities. Total cost for rehabilitation design and construction (excluding the fire sprinkler system) was $405.000. Further, HUD asked the National Research Center to identify ways the building could be made more energy efficient. National Research Center staff engineers made the following recommendations that were included in the construction:

- insulation in walls and ceilings (R-l1 and R-30 respectively)
- installation of double glazed windows
- replace kitchen appliances

SPRINKLER SYSTEM DESIGN AND INSTALLATION

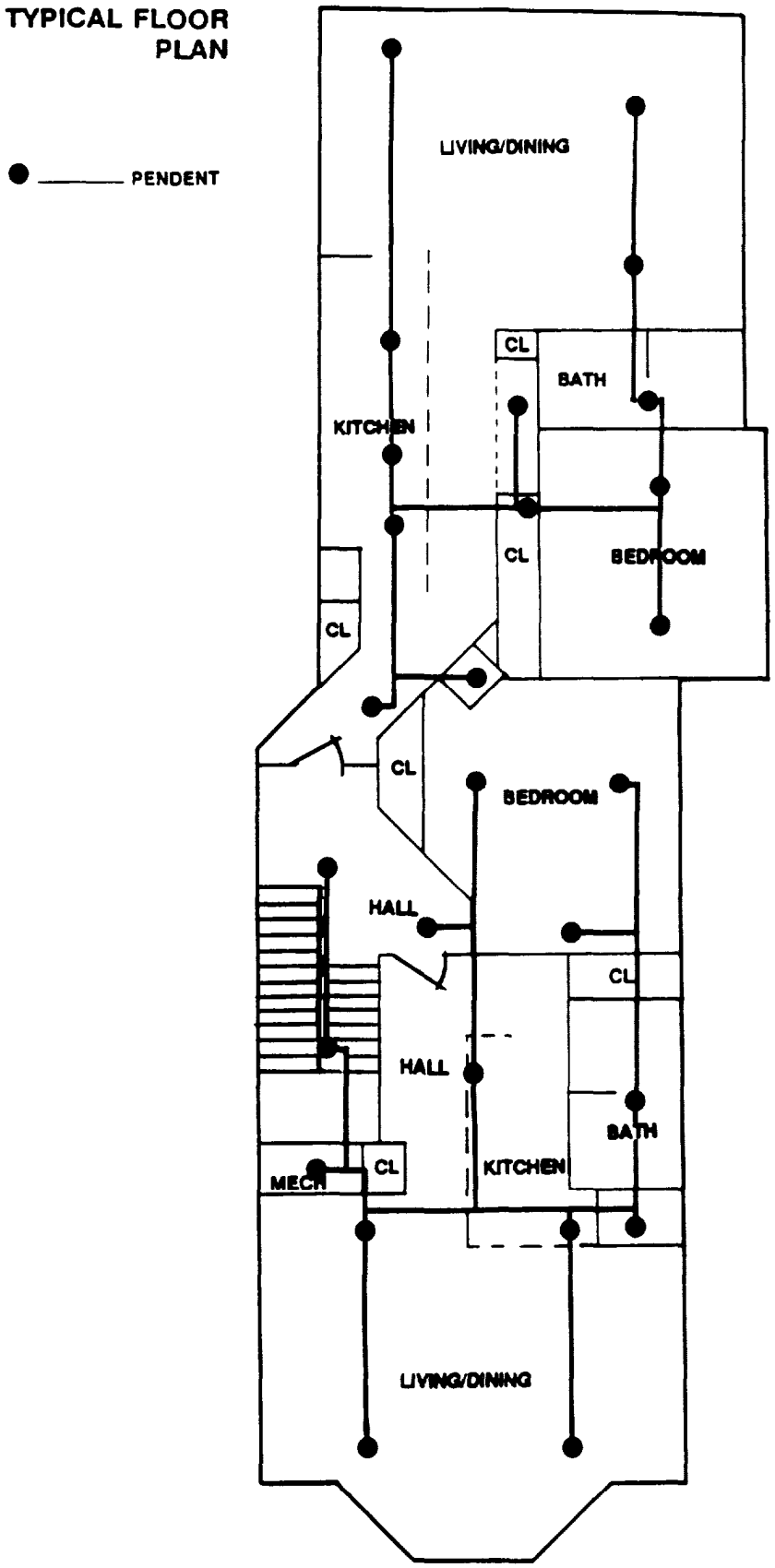
Early in the project, the city brought in Code Consultants. Inc., to design the system. The firm had volunteered to develop the design free of charge as a way to gain publicity in what they saw as a lucrative and expanding residential sprinkler market. At the same time, the fire department selected Grinnell to install the system. As design and planning proceeded, Code Consultants withdrew from the project and Grinnell proceeded with system design. The sprinkler system final design was a coordinated effort between the National Research Center, Grinnell, and Steve Beyer, building owner. An overview of major issues in designing sprinkler systems is presented in the Introduction.

Water Service

The hydraulic calculations and subsequent tests were based on two heads open simultaneously, a “two-head design.” (See Appendix F for an example of the hydraulic calculations for the building). The St. Louis Fire Department determined that the planned installation of a new one-inch water line would need to be upsized to 1 l/2 inches for provision of pressure necessary for the sprinkler system. This meant one-third of the new water service to the building was installed solely for the sprinkler system. Local authorities required installation of a control manifold with single check valve back-flow prevention to stop water in the sprinkler pipes from mixing with the domestic water supply. Friction loss in the back-flow preventer is likely to cause a 5-10 pound per square inch reduction in the water pressure of the sprinkler system,

FIGURE 10

FLOOR PLAN AND SPRINKLER CONFIGURATION



and this loss has been factored into the design delivery of the sprinkler heads. The control manifold has a pressure gauge, drain and test valve, and a flow-activated alarm switch connected to an electric warning bell. In addition, a shutoff valve operable without special equipment was not allowed by the fire department on the sprinkler water supply to prevent a potentially disastrous disabling of the sprinkler system. External connections were provided making it possible to supply the sprinkler system with water from a fire department pumper truck (or other external source) in the event of disrupted water supply.

The additional water supply to the building cost $5,000 to design and install, of which the National Research Center estimates that $1,500 was attributable to the requirements of a residential fire sprinkler system. This expenditure included piping and fittings, trenching equipment, and labor. Because the sprinkler system is fed from the metered domestic water supply, sprinkler system water use also will be metered. Friction loss within the meter is likely to cause a 5-10 pound per square inch drop in the water pressure, although to a level still adequate for operation of sprinklers.

Old water system prior to rehabilitation.

Coverage. Location, and Activation of Sprinkler Heads

In the building at 2102 Lafayette Avenue a total of 107 quick-response heads are located, as per spacing requirements found in NFPA 13D (Section 4-1 4.2).

In the subject building, sprinklers were installed per the requirements of NFPA 13D. in one large bathroom only and not in closets or other areas not required by the code. The sprinkler heads are a pendent type that protrude through drop ceilings. The use of drop ceilings simplifies installation because of the flexibility of raising or lowering the ceiling for sprinkler installation. Drop ceilings however, are less sturdy and often lower the aesthetic quality of the room when compared to sheetrock ceilings (see Figure 10 for location of pipes and heads on a floor plan of the building).

In the subject building, the heads are designed to discharge at 165°F. The heads were produced by Grinnell (Model F991 in the living units, and Model F954 in the basement).

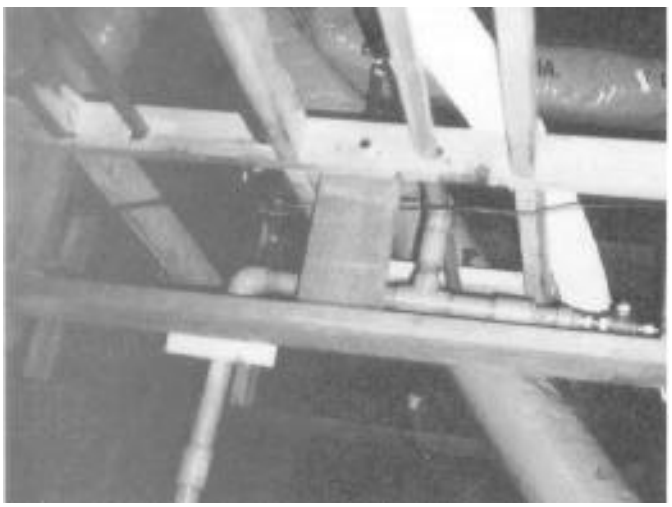
Spinkler Svstem Plumbing

The pipes and risers in the subject building are made of CPVC (brand name "Blazemaster"). Although CPVC is fire rated, for aesthetic purposes the piping in the subject building is concealed. The new water connection to the building from the city main is made of CPVC plastic (other than "Blazemaster") and has no fire rating. Due to potential freezing the pipes in the top (third) floor are covered with R-30 fiberglass BATTS insulation.

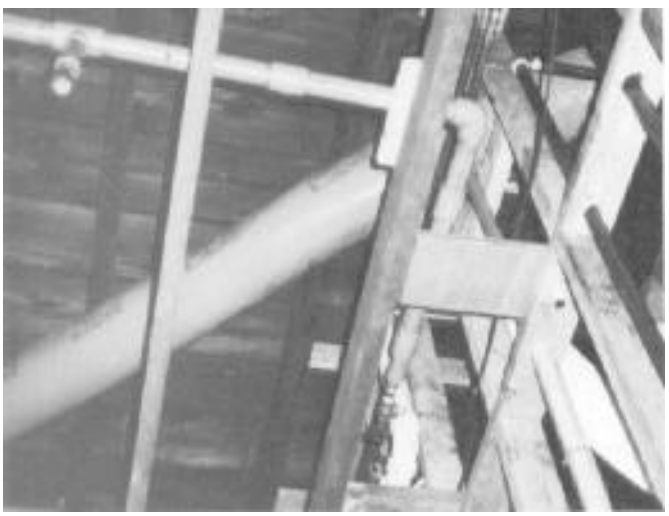
Sprinkler system riser. laterals, and heads "Blazemaster" CPVC Piping-

INSTALLATION AND TESTING

After a series of meetings among city officials, Mr. Beyer, and staff from the National Research Center, Grinnell began installation of the fire sprinkler system at 21O2 Lafayette Avenue in late September 1987, and completed installation in early October 1987. A dry static-test using compressed air to detect leaks was performed by Grinnell and Mr. Beyer in early October. The building rehabilitation construction was completed in early 1988. The escutcheons retaining the sprinkler heads were installed after the drywall and painting were completed. The units were advertised for rent and three of the four units had lease commitments before construction was completed. The fourth unit ***was*** rented shortly thereafter.



Multiple systems. conditioned air. drain-waste-vent, communication, and fire sprinkler.



Adjacent water systems--domestic and sprinkler during rehabilitation.

Sprinkler heads in basement ceiling. and Don Bollinger of St. Louis Community Development Agency.

Sprinkler system through joists.

SYSTEM COSTS

DESIGN AND INSTALLATION COSTS

Table 5-3 lists the costs for the design and installation of the sprinkler system. Total costs for design and installation and the costs per square foot were significantly affected, by the costs of increasing the water service. The increased water service necessary to operate a sprinkler system, as determined by hydraulic calculations, while required in this case may not be in other cases, and added an additional 10 percent to the cost of the sprinkler system.

TABLE 5-3

SPRINKLER SYSTEM COSTS FOR 2102 LAFAYETTE AVENUE

Engineering and Design	$1,500
Material	$ 4,900
Labor	$ 9,168
Water Service Upgrade for Sprinkler Portion of New Water Service	$ 1,500
TOTAL	$17,068
COST PER SQUARE FOOT	$2.13
COST PER LIVING UNIT	$4,267

Operation and maintenance costs

Mr. Beyer estimates that his costs for routine inspection and testing will total approximately $200 per year. As part of the CDA program to target rehabilitation to specific neighborhoods, Mr. Beyer will receive a property tax abatement for ten years, that freezes the tax for 2102 Lafayette Avenue at the amount it was before the building was rehabilitated. It is too early to assess costs from leakage and/or false activation. As mentioned above, the owner incurred no loan financing costs and the sprinkler system water supply is metered along with the building's domestic water. There is no monitoring and summoning service.

ECONOMIC BENEFITS

Improved Life Safety - Positive Effect on Rental Income

Mr. Beyer reports rent increases of approximately 6 percent after the building was rehabilitated. He recognizes the high rental vacancy rate in St. Louis places a ceiling on rents and indicates that any increase in rent directly attributable to the presence of sprinklers was minimal.

Property Insurance Discount and Reduced Property Damage

Mr. Beyer reports that his insurance carrier reduced the annual premium for property insurance on 2102 Lafayette Avenue from $2,250 to $1.800, a reduction of 20 percent, as a direct response to sprinkler installation.

The policy on 2102 Lafayette Avenue covers up to $425,000 for property loss, essentially covering the cost of the rehabilitation and only 65 to 70 percent of replacement value. The deductible is $500. The deductible amount as well as the uncovered portion of replacement value, approximately $200,000, are sums whose likelihood of being lost by Mr. Beyer is reduced by the presence of the fire sprinkler system. Further, tenants with individual insurance policies benefit from reduced risk of uninsured losses.

Construction Alternatives

St. Louis uses the Building Officials and Code Administrators (BOCA) building code. The code requires emergency egress from the third floor of a three-story building as well as use of material with a 60-minute fire suppression rating in walls separating individual units and in stairwells that serve as emergency egress. Due to installation of sprinklers, the building commissioner waived both requirements for the building at 2102 Lafayette Ave. National Research Center staff has estimated that omitting the egress saved $4,500 from the cost of rehabilitation, and the reduction in fire suppression rating saved $150. Conversely, in the absence of a BOCA requirement to install drywall on the basement ceiling, Mr. Beyer was required by the fire department to install drywall to prevent a fire from starting between basement joists. The drywall also serves to prepare the area for future installation of dwelling units. The dry-walled ceilings cost $1.225 though this amount should not be considered attributable to the fire sprinkler system.

COMMUNITY OUTREACH

The National Research Center developed an illustrated brochure in conjunction with the St. Louis Fire Department and CDA. The brochure describes the function and operation of residential fire sprinklers and uses illustrations to support the copy. Common misconceptions about residential sprinklers are discussed and refuted. The original draft of the brochure will be available for either additional production for use in St. Louis or possible adaptation for use by

other jurisdictions. The brochure is being distributed by the fire department to building inspectors, engineering societies especially the Society of Fire Prevention Engineers, community groups, and the general public.

ST. LOUIS, MISSOURI, THE CITY AND ITS HOUSING MARKET

In 1984, the population of St, Louis was 429,296, a decrease of slightly more than 5 percent from the 1980 Census total of 453,085. (The city experienced a population loss of 27 percent during the 1970s.) The 1980 Census reported 202,113 units (2.1 people per housing unit), of which 178.000 units were occupied for a vacancy rate of 11.9 percent. The type of occupancy in the city is 45 percent owner-occupied and 55 percent renter-occupied.

Multifamily structures containing five or more residential units account for 21 percent of all units. Much of St. Louis's existing vacant stock is in buildings of this type. The buildings are located in neighborhoods that experienced wide-spread abandonment and population loss during the 1960s and 1970s.

Slightly more than 60 percent of St. Louis' 1980 housing stock was built prior to 1940. Further, in the period between 1970 and 1980, only 7,400 new units were built, representing 3.7 percent of the total stock as of 1980. In 1984, the city issued permits for only 444 new private housing units, 71.4 percent of which were for multifamily dwellings.

Whether compared to other large cities or to national averages, St. Louis has low housing costs. Median sales price for existing houses in the St. Louis metropolitan area was $65,700 in 1985; median rents for one bedroom apartments were $300 per month. Median city household income, however, was $11,511 in 1980, with 71,000 people (16.6 percent) below the poverty level. Housing affordability for low- and moderate-income households is a major goal of the city's residential rehabilitation programs.

The Structure of the Multifamily Rehabilitation Program

The city of St. Louis administers a comprehensive housing rehabilitation program through its CDA. City programs target the rehabilitation of single- and multifamily structures, both owner-occupied and rental. CDA also develops comprehensive plans to rehabilitate entire neighborhoods.

The private and public sectors in St. Louis have together undertaken substantial building rehabilitation and neighborhood revitalization. Since 1975. St. Louis has received over $311 million in CDBG funds as a result of the federal allocation formula's strong emphasis on poverty levels and age of housing. Table 5-4 presents a limited profile of the population and housing characteristics of the city.

TABLE 5-4
ST. LOUIS. MISSOURI COMMUNITY PROFILE

Population (1985 estimate)	429,296
Population below poverty level	16.6%
Population 55 years old and older	18.7%
Population 4 years old and younger	3.7%
Population with limited mobiltty (U.S. Census defined as persons with Iimited ability to use public transit)	1.1%
Population density per square mile	11,220
Population density per housing unit	2.1
Total Housing Units (1980)	202,113
Multifamily (five or more units)	21%
Multifamily (two to four units)	39%
Single-family	39%
Age of Housing Built before 1940	60%
Built between 1970 and 1980	3.7%
Median Price (1985)	
All existing units	$65.700
One-Bedroom Rental	$ 300
Vacancy Rate - overall (1980)	11.9%
Rental vacancy rate	9.3%
Subsidized housing vacancy rate	0%

SOURCE: United States Census: St. Louis Community Development Agency.

The city has used these funds to stimulate and leverage private sector investment by creating two innovative housing programs administered by CDA. The Housing Implementation Program (HIP) provides low-interest "gap" financing loans to rental housing developers investing in targeted neighborhoods. HIP has funded between 800 and 1,200 units every year since 1980. The For Sale Incentive Program (FSIP) provides financial incentives to buyers who occupy homes purchased through the program.

Together, these two programs have helped fund rehabilitation of over 10,700 housing units since 1978. The development cost of all projects between 1980 and 1986 totals $2.1 billion.

Each year, the city sets aside a portion of its CDBG funds for operation of HIP for rental housing rehabilitation. In addition, CDA pursues other federal and state funding sources to expand its resources. Annual adjustments to project funding criteria reflect prevailing rental market conditions and agency priorities.

In 1985, owners submitted proposals for 79 rental projects: of those, 38 were funded and 20 were completed, providing 800 rental units. Typically, the city's share of project funding fell between 20 and 35 percent of project cost. The rehabilitated buildings were typically 60 years old, made of masonry construction, and are situated in targeted neighborhoods. With much of the multifamily stock vacant, the city orders a "total" or "gut" rehabilitation of the individual units. A typical unit contains 800 square feet and two bedrooms. In 90 percent of the units, gas is the energy source for space heating, cooking, and domestic hot water.

As part of the agency's CDBG application cycle for the following calendar year, CDA publishes requests for proposals and advertisements every October to invite owner participation in city programs. CDA staff specialists perform real estate, financial, architectural, and fiscal evaluations of the proposals. They apply several criteria during review, including building/site control: condition of units; experience and financial status of the owner; development cost feasibility: operating cost feasibility; conformance with city and neighborhood plans; unit size: affordability of completed units to moderate-income households; and incorporation of energy conservation features. The owner undertaking rehabilitation sets "fair market" rents based on projections of cash flow needed to make the project feasible. The city evaluates the proposed rents for comparability with existing rents in the adjacent neighborhood as part of the review process.

Upon completion of the evaluation process, CDA staff specialists make recommendations to the community development administrator who, in turn, submits a recommended list of properties to the St. Louis Board of Aldermen, the city's legislative authority. Upon the boards resolution of acceptance, CDA staff specialists initiate negotiations with owners regarding final details of the proposal and the funding agreement. Negotiations may include revisions to the financing commitment and design details and a recalculation of the funding assistance.

Once rehabilitation of a structure is underway, CDA's involvement is minimal. The owner is responsible for initial inspection of the building to determine the scope of work. The owner is also responsible for selecting contractors and subcontractors to perform the work. In addition, the owner must obtain private project financing: the city offers no assistance in obtaining financing from private lenders. Energy conservation is a priority in St. Louis' housing rehabilitation programs but fire safety audits are not a routine part of the initial inspection that precedes development of rehabilitation specifications. Although there are no programs specifically concentrated on fire safety, the city requires smoke detectors be present in all residential buildings.

SANDBERG FIRE PROTECTION OF TEXAS, INC.
AUTOMATIC SPRINKLER AND FIRE PROTECTION DEVICES

HYDRAULIC (CALCULATION COVER SHEET) DESIGN

PROJECT: USFA Fire Sprinkler Demonstration

DATE: 11-24-87

LOCATION: 3501 Pennsylvania Avenue
Austin, Texas

SYSTEM:

CONTRACT NO.: 1430

BUILDING: Duplex Apartment
OWNER: Mike M. Leff

DRAWING NO.: 2 of 2

CALCULATED BY:

CEILING HT.: 8'-0"

CONSTRUCTION: Wood Frame on Raised Crawl Space
Composition Shingle, GYP. BD interior

OCCUPANCY: 2 Family Dwelling

APPROVING AUTHORITIES: City of Austin Fire Marshal

SYSTEM DESIGN

SYSTEM TYPE: Wet
DESIGN: NFPA-13D
SYSTEM REQUIREMENTS:

UNDERGROUND "C" FACTOR: 150
REMOTE AREA: 2 HEADS
DENSITY: 13GPM/HD
MAX. COVERAGE:
INSIDE HOSE ALLOWANCE: N/A
OUTSIDE HOSE ALLOWANCE: N/A
RACK ALLOWANCE: N/A

OVERHEAD "C" FACTOR: 150
SPRINKLERS
MAKE: Central
MODEL: OMEGA "R-I"
ORIFICE: 3/8"
"X" FACTOR: 3.85
TEMPERATURE: 160

FLOW TEST

DATE: 11-24-87
TIME: 9:00 a.m.
STATIC: 75
RESIDUAL: 47
FLOW: 730
ELEVATION:
BY: S.F.P.

PUMP DATA

RATED PRESSURE:
RATED FLOW: N/A
ELEVATION:

TANK

CAPACITY:
ELEVATION: N/A
OVERFLOW:

COMMODITY STORAGE

COMMODITY:
CLASS: N/A
STORAGE HT.:

AREA OF STORAGE: N/A
AISLE WIDTH: N/A

201 INDUSTRIAL BLVD. AUSTIN, TX 78745 PHONE: 5124456198
P.O. BOX 19172 AUSTIN, TX 78760 512-445-5438

CONTRACT NO. 1314 SHEET NO 1 OF 1

NAME DATE 2-18-87

LOCATION 1ST FLR. - BLDG "A" (4 HEAD REMOTE AREA #1)

NOZZLE TYPE & LOCATION	FLOW IN G.P.M.	PIPE SIZE	FITTING & DEVICES	PIPE EQUIV. LENGTH	FRICTION LOSS P.S.I./FT	REQUIRED P.S.I.	~~HYD.~~ REF. PT	ELEV.	NOTES K = 3.85
△	Q 13	3/4"		LGTH. 4-0	PVC	PT 11.4			$P_H = (\frac{Q}{K})^2 = (\frac{13}{3.85})^2 = 11.4$
			1-90	FTG. 2-0	C=150	PF .53			
K=3.85	Q			TOT. 6-0	.089	PE -.22		-0'-6"	
	Q			LGTH.		PT 11.7	△3		$K_L = \frac{Q}{\sqrt{P}} = \frac{13}{\sqrt{11.7}} = 3.8$
				FTG.		PF			
	Q			TOT.		PE			
△2	Q 19	3/4"		LGTH. 1-0		PT 11.68			$P_H = (\frac{19}{5.56})^2 = 11.68$
				FTG. —		PF .16			
K=5.56	Q			TOT. 1-0	.180	PE —			
	Q			LGTH.		PT 11.86	△3		$Q_{\Delta} = K\sqrt{P} = 3.8\sqrt{11.86} = 13.08$
				FTG.		PF			
△ AND	Q 13			TOT.		PE			
△3	Q 19	1		LGTH. 6-9		PT 11.86			
				FTG. —		PF 1.06			
△5	Q 32			TOT. 6-9	.1567	PE —			
	Q			LGTH.		PT 12.92	△5		
				FTG.		PF			
	Q			TOT.		PE			
△4	Q 19	3/4		LGTH.		PT			$K_{\Delta} = \frac{Q}{\sqrt{P}} = \frac{19}{\sqrt{11.86}} = 5.5$
				FTG.		PF			
SAME AS △2	Q			TOT.		PE			
	Q			LGTH.		PT 11.86	△5		$Q_{\Delta} = K\sqrt{P} = 5.52\sqrt{12.92} = 19.84$
				FTG.		PF			
△4 AND	Q 20			TOT.		PE			
△3	Q 32	1		LGTH. 1-6		PT 12.92			
				FTG. —		PF .578			
△5	Q 52			TOT. 1-6	.585	PE —			
	Q			LGTH.		PT 13.5	△4		
				FTG.		PF			
	Q			TOT.		PE			
△6	Q 13	3/4"		LGTH. 1-0		PT 11.4			$K_{\Delta} = \frac{Q}{\sqrt{P}} = \frac{13}{\sqrt{11.7}} = 3.80$
			1-T	FTG. 5-0		PF .53			
K=3.85	Q			TOT. 6-0	.089	PE -.22		-0'-6"	
	Q			LGTH.		PT 11.7	△4		$Q_{\Delta} = K\sqrt{P} = 3.8\sqrt{13.5} = 13.96$
				FTG.		PF			
△6 AND	Q 14			TOT.		PE			
△4	Q 52	1 1/4"		LGTH. 17-9		PT 13.5			
			1-T, 1-90	FTG. 15-0		PF 6.3			
△7	Q 66		2-45	TOT. 32-9	.1923	PE -4.11		-9'-6"	
△8	Q	1 1/4"		LGTH 4-4	C=120	PT 15.7	△8		
			1-90, 1-T	FTG. 9-0		PF 4.15			
	Q 66			TOT. 13-4	.312	PE —			
△9	Q	2"		LGTH. 62-0	C=120	PT 19.85	△9		
			3-90, 1-T	FTG. 25-0		PF 3.83			
	Q 66			TOT. 87-0	.044	PE —			
△10	Q	2 1/2"		LGTH. 19-0	C=120, SCH 10	PT 23.68	△10		66 GPM @ 31.21 PSIG
			3-90, A.V. G.V.	FTG. 26-6	.018x.728	PF .6			
	Q 66			TOT. 45-6	= .013	PE +6.93		+16'-0"	
	Q			LGTH.		PT 31.21	△11		AT FLR. FLNGS.
				FTG.		PF			
	Q			TOT.		PE			
	Q			LGTH.		PT			
				FTG.		PF			
	Q			TOT.		PE			
						PT			

FIRE PROTECTION PLUS, INC.
33 THELMA ROAD
FRAMI NGHAM, MA 01701-8019
(617) 875- 0772

HYDRAULIC SPRINKLER CALCULATIONS
for
779 HUNTINGTON AVENUE
BOSTON. MASSACHUSETTS

This Sprinkler system is laid out in accordance with NFPA 13 Criteria, "INSTALLATION OF SPRINKLER SYSTEMS, 1985", appropriate sections as applicable to this type occupancy. Specific sections are:
Sections; 1-3 "Dwelling Unit', 2-2. 1.2.8 "Exception", 3-16.2.9, 4-1. 1.2, 7-4.4 Thru 7-4.4. 5 and any other sections and/or standards referenced by these sections.
The designer has not been retained, at this time, beyond the basic compliance check of Hydraulic Calculations and assumes no responsibility for: Information Supplied, Construction, or Quality of Materials Supplied. It is required that the system be Hydraulicly Tested after installation.

DESIGN DATA

OCCUPANCY CLASSIFICATION: Light Hazard
NUMBER OF SPRINKLERS CALCULATED: 4
SPRINKLER HEAD: Central Omega
MODEL: R-l Pendant
"K" FACTOR: 3.85
DENSITY: 0.09-0. 066 (GPM/SF)
APPLICATION AREA: 14 X 14= 196 SF (MAX/SPKLR) X 4 = 784 SF TOTAL
WATER REQUIRED: 36 GPM @ 21.9 PSI HEAD PRESSURE
52 GPM @ 11.4 PSI HEAD PRESSURE

DESIGNED FOR	DESIGNER
MR. CAREY LIVELY NAHB 400 PRINCE GEORGES CENTER BLVD. UPPER MARLBORO, MD. 20772-8731	FIRE PROTECTION PLUS, INC. 33 THELMA RD. FRAMAINGHAM, MA 01701-8019 (617) 875-0772

OCTOBER 31, 1986

Thomas K. Rinoldo

FIRE PROTECTION PLUS. INC.
33 THELMA ROAD
FRAMINGHAM, MASSACHUSETTS 01701-8019
(617)875-0772

DATE: NOVEMBER 11, 1986

DESIGNED FOR

KVA ASSOCIATES
ONE FENWOOD ROAD
BOSTON, MA 02115

APT #4 FRONT, EAST

SITE DATA:

A.	STATIC PRESSURE:	60 PSI
B.	MAIN SIZE:	12 INCH
C.	11,300 GPM FIRE FLOW:	GPM
D.	ELEV.WATER MAIN TO SERVICE PIPE:	2 FEET

SERVICE DATA:

A.	SERVICE LINE SIZE:	4 INCH
B.	SERVICE LINE LENGTH:	15 FEET
C.	METER SIZE:	NOTE INCH

METER ANY SIZE IF TIE IN BEFORE

DESIGN DATA:

OCCUPANCY CLASSIFICATION: LIGHT HAZARD
NUMBER OF SPRINKLERS CALCULATED: 4
SPRINKLER HEAD: OMEGA
MODEL: R-1
"K" FACTOR: 3.850

0.000
0.000

DENSITY, 2 HEAD NFPA 13 : 0.092 GPM/SQ.FT.
DENSITY, 4 HEAD NFPA 13 : 0.066 GPM/SQ.FT.

APPLICATION AREA:	LEGNTH	WIDTH	SQUARE FEET	TOTAL
MAXIMUM PER HEAD:	14	14	196	784

GPM/HEAD) ONE HEAD)) 18 ALL HEADS) 13

WATER REQUIRED: 36 GPM @ 21.86 PSI
52 GPM @ 11.40 PSI

LOCATION ON PLAN	DESCRIPTION	PIPE LEN.	# OF EL	# OF BT	# OF RT	# OF CP	EQUIV PIPE (EPL)	PIPE DIA.	PIPE FLOW	DESIGN 36	PIPE FLOW	DESIGN 52
A	BRANCH TO LAST 1 HEAD	8	1	2			23.0	1	18	3.128	13	1.725
B	BRANCH TO LAST 2 HEADS	8			1		9.0	1.25	36	1.692	26	0.090
C	BRANCH TO LAST 3 HEADS	9		2			25.0	1.5	36	1.725	39	2.000
D	BRANCH TO LAST 4 HEADS	12	1		3		19.0	1.5	36	1.311	52	2.584
E	CROSS MAIN TOP FLOOR						0.0	0	36	0.000	52	0.000
F	RISER	30	1		2		38.0	2	36	0.722	52	1.406
G	CROSS MAINS OTHER FLOORS						0.0	0	36	0.000	52	0.000
H	CROSS MAIN CELLER	25	1		6		37.0	2	36	0.703	52	1.369
I	RISER, CONTROLS TO CROSS MAIN	7					7.0	2	36	0.133	52	0.259
J							0.0	0	36	0.000	52	0.000
K	CONTROLS						75.0	1.5	36	3.750	52	6.750

ELEVATION FROM BASE OF
CONTROL TO TOP LINE OF HEADS= 37 FEET

SYSTEM HEAD LOSS)	13.164	16.183
RESIDUAL AT HEAD)	21.900	11.400
VERTICAL LIFT)	16.058	16.058
TOTAL BASE PRESSURE)	51.122	43.641
UNKNOWN FACTORS (5%))	2.556	2.182
ADJ. BASE PRESSURE (105%))	53.678	45.823

DESIGN CALCULATIONS (NFPA 13D) RESIDENTIAL FIRE SPRINKLER SYSTEM

Sheet no. 1 of 1
Date: 4/12/88
By: CFL

Project Name: Derry Street Apts
Floor Level: 3
Project Location: 1917-1919 Derry St Harrisburg PA
Elev. of Spkrs.
Available Water Supply: 26 g.p.m. at 46 p.s.i. Location:
Max. Sprinkler Spacing 12 ft. × 12 ft. Sprinkler I.D. Grinnell, Aquarius 991

AREA - A

One-sprinkler design
Min. flow 18 g.p.m.; Min. pressure 18.4 p.s.i.

Two-sprinkler design
Min. flow 26 g.p.m.; Min. pressure 9.6 p.s.i.

Type of piping:
- XX CPVC
- ☐ PB
- ☐ Steel (Sch. 40)
- ☐ Copper K, L, M (circle one)

CALCULATIONS

1 sprinkler flow: System demand = 18.4 g.p.m.

PIPING (1-spkr flow)

	DIA.	TOTAL LENGTH	× UNIT FR. LOSS	= TOTAL FR. LOSS
Horiz	1"	18	.054	0.97
Horiz	1-1/4	20	.0174	0.34
Riser	1-1/2	20	.009	0.02
1st Fl	1-1/2	159	.009	1.43

FITTINGS & VALVES (1-spkr. flow)

DIA & TYPE	QTY.	× UNIT EQ. LEN.	= TOTAL EQ. LEN.	× UNIT FR. LOSS	= TOTAL FR. LOSS

METER FRICTION LOSS (size =)	2.76
SPRINKLER PRESSURE REQUIRED	18.4
ELEVATION HEAD LOSS (ft. × 0.433)	16.9
TOTAL SYSTEM PRESSURE DEMAND	38
TOTAL SUPPLY PRESSURE AVAILABLE	46

AREA - B

CALCULATIONS

2-sprinkler flow: System demand = 26 g.p.m.

PIPING (1-spkr. flow = g.p.m.)

	DIA	TOTAL LENGTH	× UNIT FR. LOSS	= TOTAL FR. LOSS
	1"	6	0.107	0.856
(3rd Fl.)				

PIPING (2-spkr. flow = g.p.m.)

Horiz	1-1/4	10	.034	.34
Riser	1-1/2	20	.018	.36
1st Flr	1-1/2	159	.0178	2.8
				3.5

FITTINGS & VALVES (1-spkr. flow = g.p.m.)

DIA & TYPE	QTY.	× UNIT EQ. LEN.	= TOTAL EQ. LEN.	× UNIT FR. LOSS	= TOTAL FR. LOSS

FITTINGS & VALVES (2-spkr. flow = g.p.m.)

METER FRICTION LOSS (size =)	4.35
SPRINKLER PRESSURE REQUIRED	9.6
ELEVATION HEAD LOSS (ft. × 0.433)	10.9
TOTAL SYSTEM PRESSURE DEMAND	30.9
TOTAL SUPPLY PRESSURE AVAILABLE	46

(over, for data tables)

Reorder from: **Central Sprinkler Corporation, Customer Service Department**
451 N. Cannon Avenue, Lansdale, PA 19446

© 1987
DATA SHT 871

COURSE OUTLINE
RESIDENTIAL FIRE SPRINKLER INSTALLERS

I. Opening/Introduction.

II. History of Sprinkler Systems.

III Fire Loss Record
- A. Grima Statistics.
- B. National Commission on Fire Prevention and Control.
- C. Recommendations.

IV. Evaluation and Technology of Residential Fire Sprinkler Systems.
- A. Previous Technology.
- B. Pioneers.
- C. Research.

V. Concept.
- A. Commercial.
- B. Residential
- C. Life Safety vs. Property Protection.

VI. N.F.P.A. Standards
- A. NFPA 13. (Installation of Sprinkler Systems 1987)
  - 1. Covers Commercial properties and residential properties with three families and above.
    - a. Sections covering residential properties.
      - Sect. #l-3. Defines Dwelling Unit.
      - #2-2.1.2.8. Sets Water Supply Requirements. [References Sect. #7-4.4]
      - #3-16.2.9. Allows Residential Technology to be applied and references 13D.
      - #4-1.1.2. Addresses positioning again references 13-D.
      - #7-4.4 thru 7-4.4.5. Covers all aspects of the installation within dwelling Unit.
- B. NFPA 13-A. (Inspections Testing and Maintenance of Sprinkler Systems.)
- C. NFPA 13-D. (Sprinkler Systems - One and Two Family Dwellings and Mobile Homes).
- D. Automatic Sprinkler System Handbook.

FIRE
PROTECTION
PLUS INC.

33 Thelma Road Framingham, Ma. 01701 (617) 875-0772

VII. Design and Layout.
- A. Types of pipe that are acceptable.
- B. Water requirements.
- C. Calculation of friction loss and other system requirements.
- D. Alarming the System.
  - 1. Local alarm.
  - 2. Monitored.

VIII. Installation Methods.
- A. Tip and Pitfalls.

IX. Testing.
- A. Pressure and leak test pipe tree.
- B. Water flow test.
- C. Sprinkler head leak test.

X. Permits.
- A. Local.
  - 1. Building Department.
  - 2. Fire Department.
  - 3. Water Department District.
- B. State.

XI. Insurance Industry.
- A. Premium Reduction.
- 1. 180 15% to 20% in at least 38 states.
- 2. Travelers Insurance. 50% depending on building.

XII. Public Relations.

HYDRAULIC CALCULATION DATA SHEET

Project Name The Lodge Apartments

Location 5353 Sheriff Road, Capitol Heights, MD

Building Owner W.A.Bowie & Sons, INC.

Building Construction Frame w/ Brick Veneer, Garden type apartments.

Number of Floors 4 Number of Units 15 + Util.Room

Fire Inspection By Pr. George's Co. Bureau of Fire Prevention

SYSTEM DESIGN

System Type Wet, w/ All Wall Type Sprinklers

Design Code NFPA-13 Design Flow 57 gpm

Flow Density .195 gpm/sf Max. Coverage 144 sq ft

Sprinkler Make Central

Model No. Omega HEC-12 K-Factor 5.56

Orifice Size 1/2" Temperature 160 deg.-F **

Design Flow 19 Design Pressure 11.7 psi

**Exception: HVAC Closets have 286 deg-F heads.

FLOW TEST

Date of Test 19 Nov 1987 Time of Test 1316 hrs.

Performed By Mr.Keith Elder,MCE,PE Organization WSSC

Static (psi) 75-80 Elevation (MSL) + 96.1

Flow (gpm) 1205 Residual (psi) 70

Pipe Size (in) 1½" CPVC
Flow (gpm) 2 x 19 = 38
Friction Losses (psi/ft) .0359 (BFGoodrich)

Qty	Description	Total Equiv. Feet
30	Piping	30
0	90 deg Elbow	0
0	45 deg Elbow	0
3	Tee Run	6
	Tee Branch	
0	Gate Valve	0
0	Check Valve	0

Total: 52 Ft x .036 = 1.9 23.5

Pipe Size (in) 1½" CPVC
Flow (gpm) 2 x 19 = 38
Friction Losses (psi/ft) .0692 (BFG)

Qty	Description	Total Equiv. Feet
6	Piping	6
0	90 deg Elbow	0
0	45 deg Elbow	0
2	Tee Run	4
0	Tee Branch	0
0	Gate Valve	0
0	Check Valve	0

Total: 10 Ft x .0692 = .70 22.8

Pipe Size (in) 1" CPVC
Flow (gpm) 1 x 19 = 19
Friction Losses (psi/ft) .0597 (BFG)

Qty	Description	Total Equiv. Feet
8	Piping	8
1	90 deg Elbow	7
0	45 deg Elbow	0
0	Tee Run	0
0	Tee Branch	0
0	Gate Valve	0
0	Check Valve	0

Total: 15 Ft x .06 = .90 21.9

e) Remaining Pressure For Sprinkler Operations: 21.9

(11.7 Req'd.)

NFPA 13D SYSTEM DESIGN

Project Name The Lodge Apartments

Project Address 5353 Sheriff Road, Capitol Heights, MD

Calcs. By NAHB/NRC, FSL

Date 14 Dec 1987

Case I. To Sprinklers "a" & "b":	Individual Loss(psi)	Net Total
a) City Water Pressure: (LHG-ELEV) x .434 =		69.0 *
b) Deduct Losses From City Main to Meter:	5(est)	64.0
c) Deduct Losses For Meter:(+ piping to bldg.)	12	52.0
d) Deduct Static Losses To Farthest Sprinkler: (30 x .434) =	13.0	39.0

e) Deduct Friction Losses From Control Valve To Farthest Sprinkler: (a & b)

Pipe Size (in) 1½" Steel
Flow (gpm) 3 x 19 = 57
Friction Losses (psi/ft) .0929 (Crane)

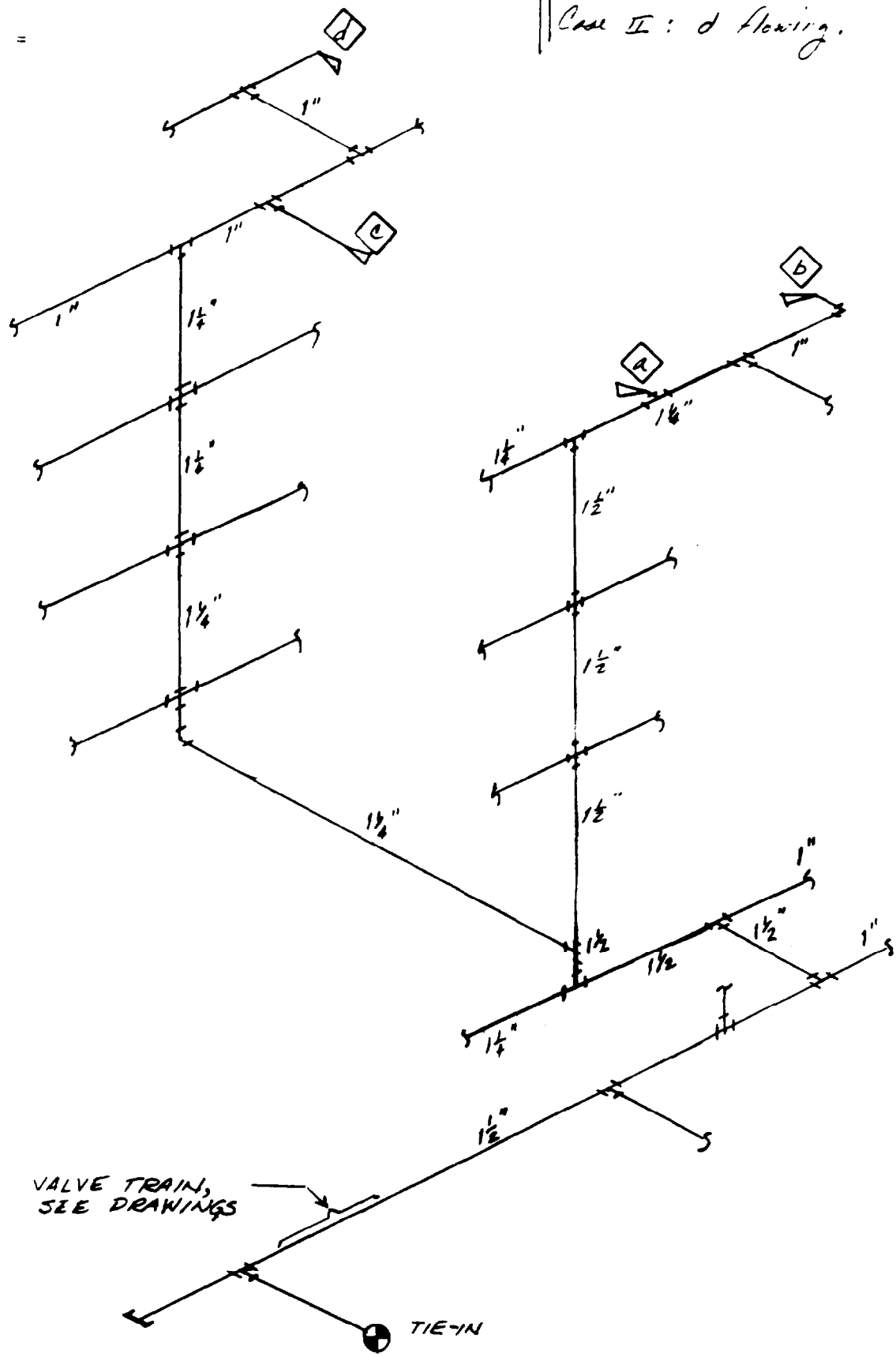
Qty	Description	Total Equiv.Feet
50'	Piping	50
2	90 deg Elbow	8
0	45 deg Elbow	0
4	Tee Run	12
3	Tee Branch	18
2	Gate Valve	4
0	Check Valve	**

**Add 5psi for ASSE-1015 Assy.)

Total: (92 Ft x .093) + 5 = 13.6 25.4

*LHG = Lower Hydraulic Gradient = 255 Ft-H_2O;) per WSSC.
ELEV = 96.1 above MSL.)

Case I : a, b, c flowing.
Case II : d flowing.



22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

SPRINKLER SYSTEM HYDRAULIC ANALYSIS Page 1

Date: 06-24-1987 HOUSE

JOA TITLE: 2102 LAFAYETTE AVE

WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. @ (PSI)	FLOW (CPM)	AVAIL. PRESS. @ (PSI)	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
11	45.0	34.0	1359.0	45.0	26.2	43.5

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	26.2 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 CPM
OTHER HOSE STREAM ALLOWANCES	0.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	26.2 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI:	DISCHARGE (GPM,
1	46.0	K= 4.20	9.6	13.0
2	46.0	K= 4.20	9.8	13.1
3	47.0	- - - -	9.6	- - -
4	47.0	- - - -	9.9	- - -
5	47.0	- - - -	10.6	- - -
6	35.0	- - - -	18.2	- - -
7	21.0	- - - -	26.3	- - -
8	21.0	- - - -	27.7	- - -
9	7.0	- - - -	36.0	- - -
10	3.0	- - - -	39.5	- - -
11	0.0	SOURCE	43.5	26.2

SPRINKLER SYSTEM HYDRAULIC ANALYSIS

JOB TITLE: 2102 LAFAYETTE AVE

PIPti DATA

PIPE TAG / END NODES	ELEV. (FT)	NOZ. (K)	PT (PSI)	DISC. (GPM)	Q(GPM) VEL(FPS)	DIA(IN) HW(C) F.L./FT	LENGTH - (FT)		PRESS. SUM. (PSI)
Pipe: 1					-13.0	1.400	PL 13.0	PF	0.2
1	46.0	4.2	9.6	13.0	2.7	150	FL 5.0	PE	0.0
2	46.0	4.2	9.8	13.1		0.010	TL 18.0	PV	0.0
Pipe: 2					-26.1	1.400	PL 1.0	PF	0.3
2	46.0	4.2	9.8	13.1	5.4	150	FL 7.0	PE	0.4
3	47.0	0.0	9.6	0.0		0.035	TL 8.0	PV	0.2
Pipe: 3					-26.1	1.400	PL 0.8	PF	0.3
3	47.0	0.0	9.6	0.0	5.4	150	FL 7.0	PE	0.0
4	47.0	0.0	9.9	0.0		0.035	TL 7.8	PV	0.2
Pipe: 4					-26.1	1.400	PL 13.0	PF	0.7
4	47.0	0.0	9.9	0.0	5.4	150	FL 7.0	PE	0.0
5	47.0	0.0	10.6	0.0		0.035	TL 20.0	PV	0.2
Pipe: 5					-26.1	1.400	PL 43.0	PF	2.5
5	47.0	0.0	10.6	0.0	5.4	150	FL 28.0	PE	5.2
6	35.0	0.0	18.2	0.0		0.035	TL 71.0	PV	0.0
Pipe: 6					-26.1	1.400	PL 34.0	PF	2.0
6	35.0	0.0	18.2	0.0	5.4	150	FL 23.0	PE	6.1
7	21.0	0.0	26.3	0.0		0.035	TL 57.0	PV	0.2
Pipe: 7					-26.1	1.400	PL 20.0	PF	1.5
7	21.0	0.0	26.3	0.0	5.4	150	FL 22.0	PE	0.0
8	21.0	0.0	27.7	0.0		0.035	TL 42.0	PV	0.2
Pipe: 8					-26.1	1.400	PL 39.0	PF	2.2
8	21.0	0.0	27.7	0.0	5.4	150	FL 25.0	PE	6.1
9	7.0	0.0	36.0	0.0		0.035	TL 64.0	PV	0.2
Pipe: 9					-26.1	1.602	PL 49.0	PF	1.7
9	7.0	0.0	36.0	0.0	4.2	150	FL 48.0	PE	1.7
10	3.0	0.0	39.5	0.0		0.018	TL 97.0	PV	0.1
Pipe: 10					-26.2	1.500	PL 61.0	PF	2.7
10	3.0	0.0	39.5	0.0	4.8	150	FL 48.0	PE	1.3
11	0.0	SRCE	43.5	(N/A)		0.025	TL 109.0	PV	0.2

NOTES:
(1) Calculations were performed by the HASS 5.0 computer program under license no. 4 C1324CX granted by
I-IRS Systems, Inc.
2193 Ranchwood Dr., N.E.
Atlanta, Georgia 30345

JOB TITLE: 2102 LAFAYETTE AVE

WATE'R SUPPLY CURVE

```
  60+
    :
    :
    :
  55+
    :
    :
    :
  50+
    :
    :
    :
  45*
    O\
    X
    : \\\\
          \\\
             \\\\
P 40+            \\\
R   :               \\\\
E   :                   \\\\
s   :                       \\\
s 35+                          \\\\
u   :                              \* <- 34 psi 8 1359 gpm
R   :                                     Flow Test Point
E   :
  30+
(   :
P   :
s   :
I 25+
)   :

  20+

  15+

  l0+             LEGEND

    : X = Required Water Supply
          43.5 psi 9 26.2 gpm
   5+
    : 0 = Available  Water  Supply
          44.99 psi 8 26.2 gpm

   0++-+---+-----+------+------+--------+--------+---------+-----------+
      400 600   800    1000   1200   1400     1600   1800         2000
                                FLOW (GPM)
```