

United States Fire Administration



Technical Report Series

Sprinklered Records Storage Facility

Chicago, Illinois



Federal Emergency Management Agency



United States Fire Administration

UNITED STATES FIRE ADMINISTRATION FIRE INVESTIGATIONS PROGRAM

The United States Fire Administration develops reports on selected major fires throughout the country. The fires usually involve multiple deaths or a large loss of property. But the primary criterion for deciding to do a report is whether it will result in significant “lessons learned.” In some cases these lessons bring to light new knowledge about fire — the effect of building construction or contents, human behavior in fire, etc. In other cases, the lessons are not new but are serious enough to highlight once again, with yet another fire tragedy report. In some cases, special reports are developed to discuss events, drills, or new technologies which are of interest to the fire service.

The reports are sent to fire magazines and are distributed at national and regional fire meetings. The International Association of Fire Chiefs assists USFA in disseminating the findings throughout the fire service. On a continuing basis the reports are available on request from USFA; announcements of their availability are published widely in fire journals and newsletters.

This body of work provides detailed information on the nature of the fire problem for policymakers who must decide on allocations of resources between fire and other pressing problems, and within the fire service to improve codes and code enforcement, training, public fire education, building technology, and other related areas.

The Fire Administration, which has no regulatory authority, sends an experienced fire investigator into a community after a major incident only after having conferred with the local fire authorities to insure that USFA’s assistance and presence would be supportive and would in no way interfere with any review of the incident they are themselves conducting. The intent is not to arrive during the event or even immediately after, but rather after the dust settles, so that a complete and objective review of all the important aspects of the incident can be made. Local authorities review USFA’s report while it is in draft. The USFA investigator or team is available to local authorities should they wish to request technical assistance for their own investigation.

This report and its recommendations were developed by USFA staff and by Varley-Campbell & Associates, Inc. Miami and Chicago, its staff and consultants, who are under contract to assist the Fire Administration in carrying out the Fire Reports Program.

The United States Fire Administration greatly appreciates the cooperation received from Fire Commissioner Raymond E. Orozco, Chief Corbet, District Chief Jack Nance, Deputy District Chief Robert Datz, Battalion Chief Joseph Bladwin, Michael Cosgrove and Edward J. Pendergast all with the Chicago Fire Department in preparing this report.

For additional copies of this report write to the United States Fire Administration, 16825 South Seton Avenue, Emmitsburg, Maryland 21727. The Report and the photographs in color are available on the Administration’s WEB page at <http://www.usfa.fema.gov/>.

**Sprinklered Records Storage Facility
Chicago, Illinois
October 29, 1996**

Investigated by: Thomas H. Miller, P.E.

This is Report 106 of the Major Fires Investigation Project conducted by Varley-Campbell and Associates, Inc./TriData Corporation under contract EMW-94-4423 to the United States Fire Administration, Federal Emergency Management Agency.



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Sprinklered Records Storage Facility

**3033 NORTH KNOX AVENUE
CHICAGO, ILLINOIS
TUESDAY, OCTOBER 29, 1996**

Investigated by: Thomas H. Miller, P.E.

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OVERVIEW

On Tuesday October 29, 1996, a still alarm was sounded for a fire in an automatic sprinkler protected records archive building shortly before 2 p.m. Before the fire was declared under control nearly ten hours later, it had reached the fourth alarm level with a commitment of 17 engines, 9 trucks and tower ladders, a squad and several additional special pieces of equipment. The last fire company left the scene about 5 p.m. on November 7, 1996 and a full box alarm assignment was involved in overhaul operations for over 24 hours after the fire.

Damage consisted of the total loss of thousands of record storage boxes and their contents, water and smoke damage to thousands of other boxes, the loss of steel storage racks and structural damage to the fire area and adjacent fire divisions. The value of the lost records and the cost to restore salvageable records was still being determined at the time this investigation was conducted. The loss of the racks and storage boxes themselves is estimated at over \$3 million. The structural damage and replacement of the destroyed front wall has been estimated at over \$2 million. Early assessments of the total dollar loss have been set at over \$50 million.

Aggressive fire department interior and exterior operations contained the fire to the 35,000 square foot compartment of origin. The fire area contained storage of card-

board boxed records in approximately 28 feet high metal racks with solid shelves. Automatic sprinklers were provided at the ceiling level only and may have been shut off in the immediate area of fire origin. Flames were first observed near the ceiling level above one of the storage racks. After discovering the fire, employees may have delayed in immediately notifying the fire department while they attempted to extinguish the fire. The cause of this fire was still being investigated but it is believed to be electrical in nature.

The successful control of this fire can be attributed to the performance of the fire separation walls supported by a large fire suppression force. Effective pre-incident planning and standard operating procedures also contributed. Companies supported the automatic sprinkler systems at siamese connections and attended to openings in the fire separation walls. The availability of a good water supply to support the numerous hand lines and master streams, as well as the automatic sprinkler systems was important to the overall tactical plan.

KEY ISSUES	
Issues	Comments
High Rack Storage and Narrow Aisles	Boxed records were stored in 28 feet high racks with solid shelves and narrow aisles, with some areas as small as 30 inches. There were no sprinklers located within the racks. The narrow aisles provided for rapid flame travel up the face of the cardboard boxes.
Deficient Automatic Sprinkler system	The ceiling-only automatic sprinkler system was perhaps designed to an NFPA No. 13, Ordinary Hazard Group 2 level. The system was not appropriate for the tall storage racks in this property.
Automatic Sprinkler Valve Supervision	One of the automatic sprinkler control valves in the area of origin was found closed after the fire and it may have been shut at the time of ignition. Control valves were neither locked open or electronically supervised.

KEY ISSUES (continued)	
Issues	Comments
Windowless Building	Horizontal and vertical venting opportunities to remove the large quantity of “cold” smoke produced by the fire were limited to door openings and several small skylights.
Support of Fire Separations	The incident commander recognized the need early in the fire to support and monitor the masonry walls surrounding the fire area. Operations included preventing fire spread through two large unprotected wall openings.
Multiple Alarms	From the first company on the scene, Incident Command did not hesitate to request additional resources. An additional alarm was called even when the fire was believed to be contained in order to provide for crew rotation.
Firefighter Safety	Incident Command consistently recognized the hazards of an aggressive interior attack. The Incident Command system was utilized to monitor and evaluate the structural condition of the fire building, walls and adjacent structures.
Facility Response	There was no responsible owner or operator representative available to provide guidance or information regarding the facility.
Records Stored on the Floor	Record boxes stored on the floor in the adjacent fire area were damaged by water runoff. Significant loss can result from sprinkler and hose stream water unless storage is placed several inches above the floor.

FIRE DEPARTMENT

In 1996, the Chicago Fire Department had a strength of slightly more than 5,100 uniformed and civilian personnel within its operating budget of about \$267 million. It holds an Insurance Services Office Class 2 rating and has done so for over 25 years.

The Department operates roughly 100 engine companies, 55 truck companies, 5 squads, and over 15 specialized pieces of equipment, including a fire boat and three helicopters. Additional airport crash/rescue and support vehicles are staffed by Chicago Fire Department members at its three airports. The Emergency Medical Services (EMS) operates 59 First-line paramedic ambulances.

Besides Fire Suppression & Rescue and Emergency Medical Services, the Chicago Fire Department operates the Fire Prevention Bureau, Fire Investigations Unit, Support Services, Emergency Preparedness & Disaster Services and Administration. The Fire Prevention Bureau encompasses the Public Education activities for fire and EMS, routine inspections, school and institutional fire drills, Engineering Section and Underground Storage Tank Inspection Program. Support Services maintains and repairs the apparatus, radios, and other equipment used by the Department.

Through the end of August 1996, fire apparatus were dispatched to 105,622 emergency incidents which include 16,871 false alarms and 47,577 ambulance assists. The EMS ambulance units responded to 147,748 emergency calls. Combined together, this amounts to an average of slightly more than 1,000 responses per day.

For communication with companies in the field, the City of Chicago is separated into two fire alarm offices using two different radio frequencies. The EMS ambulance units operate on additional radio frequencies dedicated to their use. At working fires, companies can communicate on additional fire ground radio frequencies and often work with a communications van rather than with the fire alarm office.

BUILDING DESCRIPTION

Brambles Information Management was one of the tenants in a several-block long complex of connected or adjacent fire resistive and noncombustible buildings. The complex was once a large printing plant that incorporated tall single story, two story and three story buildings.

The fire occurred in the largest of several fire areas occupied by Brambles, used to store cardboard boxed paper, photographic, and financial records for clients. Building construction in the area of origin was essentially fire resistant and, although significantly damaged, did not collapse during or after the fire. The front part of the building facing Knox Avenue was a single story about 25 feet high and was one bay deep. (See Figure 1 in Appendix A) This area had a concrete roof supported by steel columns which were partially framed into the exterior masonry walls and were unprotected along the interior column line. Roughly half of the building was two stories high, with the first floor having a clear height of 25 to 28 feet and the second floor measuring 12 to 15 feet tall. There was a reinforced concrete floor between the first and second floors which was supported by concrete columns. The roof of the second floor was also concrete on concrete columns.

The building area to the east of the brick separation wall was a tall single story noncombustible segment with a height of approximately 40 feet. It had a flat gypsum deck roof supported by unprotected steel bar joist and beams. The beams rested on the outside masonry wall and the brick separation wall between the front and rear storage areas. The separation wall had two unprotected openings, one about 12 feet wide and 10 feet high, used to move records between storage areas and the other opening was 40 inches wide and 7 feet tall.

The north and south common walls between adjacent fire areas were masonry - mostly brick - with sufficient thickness and construction to obtain a 3 to 4 hour fire resistance rating. Openings in these walls were protected by class A fire doors, often with a door on each side of the wall. A large unprotected door opening (about 12 feet wide by 28 feet tall) was discovered in the masonry wall between Space 7 and Space 5. The elevated metal storage rack walkways extended through this opening.

The adjacent building construction to the north was noncombustible with masonry walls and a gypsum roof deck on unprotected steel trusses, beams, and columns. The expansion of the fire area caused buckling in the steel trusses. In addition, the masonry separation wall was displaced and cracked in several locations. (See Photograph 7)

Storage Methods

The area of origin was used to store cardboard boxed records in steel racks on solid corrugated metal shelving. Boxes were hand stacked two deep and three high on each shelf. The racks were arranged back-to-back with aisles between rack faces of about

four feet. The racks made use of roughly all of the 25 to 28 feet of clear space to the bottom of the floor or roof above. This area did not have intermediate walkway levels. Access to the stored boxes was by means of stacker style fork lifts which the operator rode up to the level of the boxes. Storage boxes in this area were described as being approximately 16 inches wide, 25 inches deep and 11 inches high. Each box and shelf position was identified with bar coding for location and inventory control.

In the section to the east of the fire area, the storage was organized differently. The steel rack structures were about 34 feet tall with two levels of metal grated walkways. It was about 11 feet from the concrete floor to the first walkway level and about the same to the second walkway. Each level provided for four layers of boxes either directly on the floor or on solid corrugated metal shelves. Three of the layers had boxes stacked three high and the top layer was two boxes high. The depth of the shelves varied to provide 3 to 4 boxes between aisles. The typical cardboard boxes used in this area were slightly smaller, 12-1/2 inches wide, 16 inches deep and 10 inches high. Rolling ladders were available on all three levels to access boxes on the higher layers. Aisle widths were typically about 33 inches; there were 48 inch wide main aisles in some areas.

In one small area, boxes were stored one to a shelf with single and double boxes deep between aisles. There were generally the same number of boxes per level and each box rested on a solid wooden shelf. In the east section, access into the storage levels was by means of open metal stairways scattered throughout the rack structure. The location of these stairways were not marked by exit signs; no emergency lighting was observed in this area.

Fire Protection

Ceiling only automatic sprinkler protection was provided throughout all fire areas. The automatic sprinklers were on a 130 square feet per head spacing following the NFPA pipe schedule rules. However, in 1990 some revisions were made to the fire protection systems and water supplies. As a result, the existing sprinkler piping was hydraulically evaluated for an NFPA Standard No. 13 Ordinary Hazard Group 2 design. The system was capable of providing a density of 0.18 gpm per square foot over a 2,000 square feet area of application.

There were no automatic sprinklers located in any of the storage racks in the building nor were there automatic sprinklers under the walkways in the rear storage areas. The sprinklers were supplied from 1000 gpm at 100 psi electric fire pump taking suction from the 12 inch city water main in the alley on the east side of the building. (See Appendix A)

Numerous siamese connections were provided on both the east and west sides of the building to feed into the automatic sprinkler systems. No information was available on the operating temperature of any of the automatic sprinkler heads installed in the building. It is believed that standard, 1/2 inch orifice sprinkler heads were used throughout.

Ceiling mounted smoke detectors were observed in the rear section. Although completely destroyed by the fire, similar ceiling mounted smoke detectors were installed in the fire area. These detectors were connected to a combined fire and security alarm panel that was monitored by a central station service. According to the service's activity records for the afternoon of the fire, smoke detector activations occurred at 1:43:46 p.m., 1:45:42 p.m., and 1:46:56 p.m. A trouble alarm from the panel was received at 1:47:00 p.m. which most likely indicated that the detector wiring had failed.

While there were sprinkler water flow switches on the risers in the fire pump room, the wiring and conduit between the switches and the junction boxes had been removed. This is typical of what happens when the central station monitoring service is discontinued and the equipment is abandoned in place. As a result, there was no monitoring for the sprinkler waterflow.

Portable fire extinguishers were distributed throughout the Brambles area and employees operated several units prior to fire department arrival. There were no 1-1/2 inch hose stations available inside the building.

Exposure Buildings

The second floor area above the fire and the three-story building to the south was occupied by a rental storage facility. This business rented various sized storage "rooms" or "cubicles" to the public for the storage of items such as household furnishings, books, paper records, carpeting, and other items. Storage of hazardous materials was not permitted by the rental rules.

The storage "cubicles" on the second floor consisted of metal walls about eight feet high that were closed to the roof deck by heavy wire formed into about 3 inch by 3 inch squares. The access door to each unit was secured by a tenant provided lock. This arrangement provided security for each space yet did not necessarily interfere with the automatic sprinkler water distribution. Sprinkler heads were provided at the ceiling only and were spaced using an ordinary hazard schedule. There did not appear to be an attempt to locate an individual sprinkler head within each storage locker.

Double Class A fire doors, one rolling and one sliding metal clad, separated the second floor storage from the building to the south. Fusible links for the doors were located on both sides of the fire wall.

To the north of the fire area was a single story (equal to two stories tall) noncombustible building with masonry and concrete walls and a noncombustible roof on unprotected steel trusses. The roof in this building (Space 6) was a monitor style with a pitched, raised center section having windows on the two sides where the roof continues at a lower level. Space 6 was occupied by a records destruction company. It contained a large shredder and bailer machine along with a similar but smaller unit. Offices, loading and unloading areas, and some paper storage (mostly shredded bales) completed the occupied space.

Brambles also occupied Space 5 which was northeast of the fire area. This segment was a tall single story (equal to 3 stories) noncombustible building with brick and concrete block walls with a noncombustible roof on unprotected steel bar joists. Most of this area contained tall steel storage racks with two levels of steel grated walkways essentially the same arrangement as directly east of the fire area. Records storage was just beginning in this space and the racks were mostly empty at the time of the fire.

THE FIRE

A still alarm was dispatched at 1:50 p.m. on a report of a fire in the building. Two engines, two trucks, a squad company, and a battalion chief responded. The first unit on the scene was Engine 7 who reported extremely dense white smoke from both the north and south doorways on the west side (Knox Avenue) of the building. Engine 7 requested a box alarm at 1:56 p.m. bringing two more engines, a tower ladder, an ambulance, additional battalion chiefs, Deputy District 2 Chief, and a communications van.

Engine 7 led into the siamese connection near the center of the west side of the fire building with 4" and 2-1/2" lines and connected to a hydrant along Knox Avenue. The crew also attempted to advance a handline consisting of 2-1/2" hose with 100 feet of 1-1/2" hose as a finish into an entrance door at the north end. Progress of the crew was limited to an area just inside the doorway because of the very dense smoke and extreme heat. The crew encountered nearly 30 foot tall racks of cardboard boxes stored from the floor to near the ceiling, creating a potential for collapse and firefighter entrapment. (See Appendix A, Figure 3)

Battalion 7 established incident command on Knox Avenue which became Sector 1 in accordance with Chicago Fire Department practice¹. Battalion 8 on arrival was assigned to Sector 3 and Battalion 10 was assigned as the Plans Chief, based in the communications van.

As Deputy District 2 Chief approached from the north, he reported difficulty reaching the fire scene because of the dense white smoke obscuring Knox Avenue. He actually got out of his car to help his aid guide the vehicle to the fire ground because of the smoke exiting the building and hugging the ground. Upon arrival, Deputy District 2 Chief assumed incident command.

Engine 91, the second engine on the still alarm, led out at the southwest corner. The crew took one 2-1/2" hand line into a doorway at the south end of the fire building and a second 2-1/2" hand line through the loading dock area of the adjoining building to the south. This second line was stretched to an opening in the wall between the two buildings. Neither line could make progress to the seat of the fire because of the same heavy smoke and storage racks being encountered by Engine 7's crew.

The two still alarm truck companies, Trucks 35 and 58, both raised main ladders to the roof from Sector 1. The roof in the first building bay was concrete and could not be readily opened. The crews were able to open all four skylights in this roof but these openings were only about 4 feet square each. Their size and the low smoke buoyancy, did not improve the conditions inside the building sufficiently for engine crews to make progress.

Both the west and east walls of the building were windowless, making additional ventilation almost impossible. Companies were able to force open a large rolling truck door near the middle of the building. Dense white smoke poured from the opening, hugging the ground, as it moved to the north on Knox Avenue. Weather conditions were fair, with a temperature of about 45 degrees F and an intermittent wind from the south at roughly 5 mph. Even with the cool temperature, the smoke was not lifting much. This type of smoke is the result of automatic sprinklers operating and cooling the atmosphere. With these fire conditions, Deputy District 2 Chief requested a second alarm at 2:07 p.m.

As the balance of the box alarm companies arrived, Engine 68 was assigned to Sector 1, Engine 69 was assigned to Sector 3, Tower Ladder 23 was positioned in Sector

¹ Sectors 2, 3, and 4 are identified clockwise around the building from Sector 1. Additional sector numbers or verbal designations are made as needed.

1 near the middle of the building. Engine 68 supplied a 4" line to the tower ladder and two 2-1/2" lines into a deluge set at the large rolling door that was forced open by the truck companies. In Sector 3, Engine 69 supplied two 2-1/2" lines into another building siamese as the crew stretched another 2-1/2" handline through a door near the northeast corner to the separation wall about 60 feet into the building.

A 30 feet wide driveway was situated between the building and a chain link fence on the rear of the building in Sector 3. Located on the other side of the fence was an elevated railway embankment. Hydrants spaced along this driveway were supplied from a 12 inch city water main. This main also supplied the building's fire pump.

The second alarm provided four more engines, two trucks, a tower ladder, two additional battalion chiefs, District 2 Chief, air mask unit and additional senior officers. There was no interior progress from the Sector 1 side due to the fire conditions and the concern of the Incident Commander that firefighters may become lost in the smoke and maze of racks. Also of concern was the potential of personnel being struck by falling boxes or trapped by collapsing racks. On the Sector 3 side, companies were able to reach the masonry wall separating the front and rear of the building. Both 2-1/2" and 4" hose lines were stretched to the unprotected openings in this wall by some of the second alarm companies.

Engine 94, a second alarm engine, was assigned to Sector 3 and laid 2-1/2" lines into the siamese connection for the building to the south of the fire. The crew then advanced a 2-1/2" line to the third floor of the south building. This floor provided access to the second floor storage locker area over the fire. This company reported some "lazy fire" which was being contained and controlled by a few operating automatic sprinkler heads. When the firefighters attempted to enter the second floor area, the concrete floor was hot enough to melt their boots. They were ordered out of the second floor; closing the sliding fire door behind them. The hose line was left in place outside the fire door and crews were rotated to monitor conditions at the door.

There was no significant fire development in this storage area. Most of the damage to goods stored in this area was from the heat and water if they rested on the floor. Parts of the concrete floor were heaved and cracked but the area, several weeks after the fire, still contained some storage.

Engine 108 and Truck 13 from the second alarm were also assigned to Sector 3. The truck company raised its ladder to the roof and opened about six, 4 feet by 8 feet,

skylights in the roof of the rear sector and checked for fire extension. Engine 108 extended additional hose lines to deluge sets at the two unprotected door openings. Eventually, each opening had a 4" hose line and at least one 2-1/2" hose line. The members of both companies rotated the manning of the deluge sets and checking for fire extension through the masonry wall. (See Appendix A, Figure 4)

Engines 76 and 117, Truck 53 and Tower Ladder 21, the other second alarm companies, were assigned to Sector 1. Another deluge set was set up outside the front of the building and the handline on the door opening between the fire building and south exposure was transferred into a deluge set and reinforced with a second line. The tower ladder was set up and in-line pumping operations improved the water supply to Sector 1. Tower, truck, and engine company members not involved with hose lines, worked to manually breach the front masonry wall near ground level.

Battalion 6, who responded on the Second Alarm, was assigned to check the interior of the north exposure in Sector 2. This one story masonry walled building with a metal trussed roof was occupied by a paper records destruction company and did not contain a lot of combustible contents. During the fire, the overhead steel trusses began to deform and the masonry wall between the fire building and the exposure was pushed to the north. This opened cracks in the wall and resulted in some crushed bricks.

The Assistant Deputy Fire Commissioner assumed incident command and requested a Third Alarm at 2:44 p.m., bringing four engines, two trucks, a tower ladder, and a second ambulance to the scene. Engine 56, a third alarm unit, led out with a line into the Sector 2 exposure. When the overhead steel trusses began to deform, the line was backed out to the large overhead door entrance on Knox Avenue. The fire conditions in the exposure were monitored from this position because of the concern for possible structural collapse. The fire did not penetrate the separation wall into this section during the incident.

Other third alarm companies provided rotation for the various crews operating lines and for those working to breach the front masonry wall. Special collapse and cutting/breaching equipment was called to the scene to assist with access to the fire. A second air mask service truck was requested to support the heavy use of SCBA by firefighters operating in this smoky fire. Battalion Chiefs operated as sector officers monitoring the fire spread conditions and supervising operations.

A fourth alarm was requested at 3:37 p.m. by the Fire Commissioner. This alarm brought four additional engines to the scene. These companies provided rotation for on-

scene personnel who had been working for nearly two hours. Command personnel felt that the fire was contained to the fire separation area, barring any significant structural collapse. Such a collapse was not expected as the conditions at the masonry separations did not appear to be deteriorating. (See Appendix A, Figure 5)

Progress in controlling and extinguishing the main body of fire was limited because of the risk to firefighters presented by an interior attack and the inability to place fire hose streams on the fire's seat. Although numerous holes had been made near the ground in the masonry wall facing Knox Avenue, the storage racks partially blocking the holes, the small size of the holes and their location near ground level limited their smoke venting effectiveness. By early evening, cracks started to appear in this wall and all firefighters were ordered out of the collapse zone. A request for heavy wrecking equipment was issued and the fire apparatus on Knox Avenue in front of the building was repositioned to allow the wrecking equipment room to operate. The fourth alarm companies, along with those already on the fire ground, set up additional deluge guns and large handlines to flood the building as the wall was removed. Even with the large amount of water now able to reach much farther into the building, the deep seated fire in the collapsed boxes and racks would flare when ever a stream was moved or shut down. The fire was officially declared under control at 11:07 p.m. that night. However, it would be nine days before the last Chicago Fire Department equipment left the scene on November 7, 1996 at 5:00 p.m.

During the long overhaul phase, fire department operations were coordinated with private contractors who used heavy equipment to remove smoldering and burning records from the building onto Knox Avenue. A full box alarm assignment of fire companies was still at the scene some 24 hours after the start of the fire, washing down the exposed contents. Heavy equipment moved the records from inside the building and loaded the wet records into dump trucks. Inside the building, the fire continued to smolder and would sporadically flare up, hampering the overhaul process. Eventually, reserve apparatus was brought to the scene and companies rotated to operate the lines and equipment on an around the clock basis.

Recovery and Salvage Operations

The records and documents stored in the fire area of origin were generally lost and damaged beyond salvage. These records would have to be reconstructed from other client resources or means such as microfilmed versions of the actual documents. It is not always possible to do this for all records. Sometimes, they are "one of a kind" documents and there are no copies or alternate sources available. The cost of reconstruction may be excessive and not worth the expense.

The water and smoke damaged records in the adjacent fire areas were removed by a professional salvage company. Priority was given to removing and freezing the water soaked boxes for possible freeze drying of the contents. The final disposition of these items will depend on the owner of the records. The smoke damaged records will likely be reboxed in clean boxes and the contents inventoried. Additional restoration will depend on the extent of odor and other damage. As this work was underway, large industrial dehumidifiers were being used to lower the moisture content inside the building.

Analysis

The fire area contained more than one automatic sprinkler zone and several unsupervised control valves; these valves were not chained and locked in the open position. One of these valves was found closed after the fire during the investigation stage. There were automatic sprinklers discharging water during most of this fire as documented by the dense white cold smoke and video tape of the scene as the front wall was moved. However, it is possible that the sprinklers in the immediate area of origin were shut off. Investigators found a closed control valve on the water supply to these sprinklers. No member of the Chicago Fire Department reported closing the valve which was located in the fire area.

Because of the storage height, arrangement in the racks, solid shelves, and modest water density, it is unlikely that this fire would have been controlled by the ceiling only automatic sprinklers even if all of the systems had functioned properly. The back-to-back racks with boxes two and three deep in each rack provided excellent conditions for a shielded fire burning out of the reach of the automatic sprinkler discharge. Cardboard boxes and their contents are very susceptible to smoldering fire development even when the outside surface is water soaked.

The fire's origin and cause had not been determined at the time this report was prepared. Several electrical related causes were being investigated. Just before the fire was observed, an electrician was working inside an electrical panel on the wall in the fire area. Another cause being probed is the high intensity discharge lighting fixtures hung from the bottom of the floor or roof above the racks. A fixture or light bulb may have failed, ejecting hot materials which could have lodged in between the cardboard boxes.

The long commitment of fire department resources to this fire is typical of the experience with records storage. The heavy equipment needed to gain access to the interior is also typical for large windowless structures. The configuration of the rack storage and the weight of water-soaked records and storage boxes present a potential for

structural collapse of both the storage racks and the building. By themselves, paper records and their storage means can provide a load very close to the capacity of the structure; with the additional weight of the fire fighting water absorbed by the boxes and their contents, a floor can become quickly overloaded. In addition, storage racks are typically unprotected steel which will lose their structural stability when exposed to heat and flame. They can also be overloaded by the extra weight of the water absorbed and collected in the items stored in the racks. Failure of one rack may cause adjacent ones to topple because of insufficient anchorage or simple overload.

BUILDING CODES

The City of Chicago developed and utilizes its own building code which contains all the provisions for the construction, alteration, and operation of a building. The Chicago Building Code includes chapters on fire protection, electrical systems, mechanical systems, plumbing systems, and means of egress for new construction and the operation of existing buildings. Some chapters reference other national consensus standards such as NFPA, UL and ASTM. However, it is rare that adoption of the entire referenced document is made by the Code. Rather, sections or some of the details on installation might be referenced.

The City of Chicago Building Code would define the storage of records as a Class H-2, Moderate Hazard Storage. A code complying “Standard Sprinkler System” (as defined by the Code) would have been required. These requirements would most likely have specified an ordinary hazard automatic sprinkler system that would have roughly complied with a pre-1990 edition of NFPA Standard No. 13. The Code does not clearly address the need for automatic sprinklers within the storage racks nor under the open grate style catwalks in this occupancy. The Chicago Building Code does not explicitly reference other NFPA Standards on rack storage or other storage methods exceeding the heights provided within NFPA Standard No. 13, which is 12 feet.

NFPA No. 232A, *Guide for Fire Protection for Archives and Records Centers*, provides information on the protection of large collections of semicurrent records and specifically includes record centers such as this one. The scope of this document does not include the storage of important documents that need to be in vaults or special containers or the storage of cellulose nitrate film. All other types of record media are within the scope of NFPA No. 232A. In a records center, almost all of the records and their common storage containers are combustible and will contribute to fire spread and fire duration. Fire severity is estimated at approximately 1 hour for each 10 pounds per square foot of combustibles stored (records and containers).

The guide provides a review and comparison of several fire detection and extinguishing systems. It cautions against the dependence on all forms of fire detection with manual suppression because of the typical fire development time. Testing with open shelf storage, fourteen feet high, suggests that in about three minutes the fire can exceed possible control by portable fire extinguishers. Automatic sprinklers are described as the most effective and economical fire control measure. NFPA Standard No. 13 is used as the reference document for installation. The height and method of storage in this case exceeded the scope of this standard and would suggest the use of other automatic sprinkler standards.

In addition to automatic sprinklers, NFPA No. 232A describes the use of high expansion foam, Halon 1301, and carbon dioxide extinguishing systems. The use of high expansion foam may be effective based on testing done in 1966 and referenced in NFPA No. 232A. Protection of records centers by Halon would have been very expensive and this agent is no longer available because of environmental problems. There are limitations and personnel hazards associated with the use of carbon dioxide. Neither Halon nor carbon dioxide will always extinguish a deep seated fire within stored records. In addition both agents are expensive to install and maintain. Similar limitations exist for the Halon replacement agents.

The use of tall racks with grated intermediate walkways is not recommended by NFPA No. 232A. Rather, full floors with fire resistance ratings are recommended to limit the extension of fire travel and to reduce the number of records subject to destruction or damage in a single fire. Where tall storage racks are used, cautions on fire detection, complete automatic sprinkler protection, and fire department preplanning are provided. Preplanning should include how to gain access to the racks, smoke and heat venting from the fire area, reaching the fire in the upper area, and fighting the fire at its source.

The automatic sprinklers installed at the ceiling were inadequate for the hazard and did not comply with NFPA Standards. Because of the solid shelves, it is likely that sprinklers should have been provided at each shelf level. The narrow aisles may have justified the use of automatic sprinklers along the rack face to slow the fire spread on the face and between racks.

LESSONS LEARNED

1. Automatic sprinklers must be designed, installed and maintained for the specific hazard present.

The previous occupancy of the building was a very large printing company and the ceiling only automatic sprinklers were likely adequate for protection of large printing presses. However, the high rack storage of records on solid shelves and with narrow aisles can quickly overwhelm a ceiling only sprinkler system. As the occupancy and operations change in a structure, the fire protection systems need to be reviewed and evaluated to determine if they still provide adequate protection. The responsibility for this task is shared by the occupant and fire department's prevention and inspection personnel. Fire department company officers or inspectors should be able to recognize a change occurrence and recommend that the fire protection be reviewed by competent professionals.

While this was one of numerous locations operated by the records storage company and insured by a large carrier, it had not been visited by an insurance loss control representative. Reliance on historically provided technical assistance from the insurance industry on these issues should not be assumed. Rather, local fire authorities need to be proactive in obtaining automatic sprinkler system reviews as the occupancy or operations change.

2. Control valves for automatic sprinkler systems and other fire protection systems should normally be locked in the open position and checked monthly.

It is possible that some of the automatic sprinklers were turned off prior to the start of the fire because a control valve was found closed after the fire. The securing of valves with locks and chains combined with recorded checks of the valves is usually considered a minimum level of supervision. Valve position can also be monitored by the fire alarm system using electric position switches. Where the valves are readily accessible to the public, many owners also chain and lock the valves open even when supervised by the fire alarm system. Weekly to monthly checks of all valves are specified by NFPA Standard No. 25, *Inspection, Testing & Maintenance of Water-Based Extinguishing Systems*.

3. High rack storage with narrow aisles represents a significant challenge to interior fire department suppression tactics.

Boxes of paper records are not necessarily the most challenging type of material being stored in racks. Other materials are capable of releasing energy more rapidly,

spreading fire within the racks quicker, and perhaps releasing more toxic smoke. Yet the dense white smoke combined with the maze of aisles and tall storage racks limited safe interior attack. Owners and operators of rack storage facilities and the fire service must together make arrangements for dealing with these limitations before a fire occurs. Prematurely shutting down the automatic sprinkler system in an effort to improve visibility was not done in this case. Historically, this action has resulted in the fire suddenly and rapidly developing to the extent where the sprinklers cannot regain control. Then the entire building and contents are lost. For additional information see NFPA No. 1420, *Pre-Incident Planning for Warehouse Occupancies*.

4. Ventilation in windowless buildings and those with substantial or fire resistive roofs is difficult.

Another of the difficulties encountered in this fire incident was the removal of the dense white smoke being produced by this fire. The west exterior wall had only a few openings and none of these openings were high up on the wall. The roof of the fire area was of limited size with roughly three-fourths of the area over the fire being part of the floor above. Where there was a roof, it was constructed of concrete and contained only a few relatively small openings. It was both too difficult and too dangerous for crews to enlarge the existing roof openings. As heavy construction equipment removed the front wall, fire streams could penetrate further into the building and visibility improved. However, the collapsed racks, falling boxes, and structural conditions prevented safe entrance and interior operations.

5. Support of fire separation walls by hose streams and master streams along with firefighter vigilance was important to the successful containment.

The first floor wall between the front of the building where the fire started and the rear of the building contained two large unprotected openings. Without the master streams and handlines operating at these openings, fire spreading into the rear section was probable. Companies were also assigned to masonry separation walls on occupancies to the north and south. These were monitored for separations and fire penetrations and fire door function and integrity tracked. Where feasible, fire streams were also directed into the building from these areas.

6. The damage to records stored in the adjacent area would have been reduced if the practice of keeping storage at least three inches above the floor was followed.

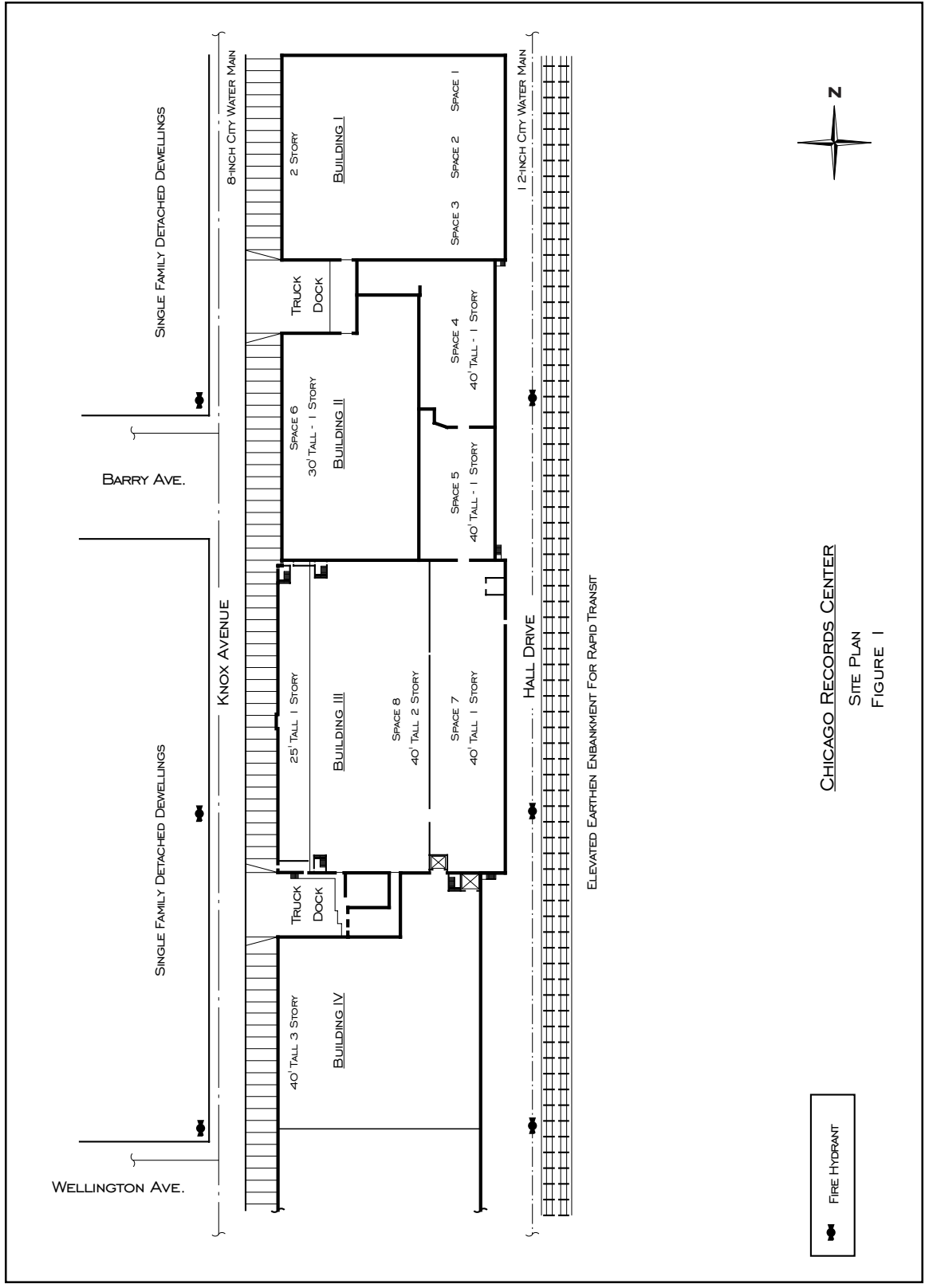
NFPA No.232A recommends that records be stored at least three inches above the floor to minimize the effects of flooding. The source of the water could be roof leaks, broken pipes, sewer back up, surface runoff, and operating automatic sprinklers. Owners must recognize that while the sprinklers typically discharge less water than fire department hose streams, it is not a trivial amount. On a flat floor without drainage, it can spread to cover a very large area and will contact anything stored on the floor. With the typical cardboard records storage box, the water will be “wicked” up higher and above its actual static depth.

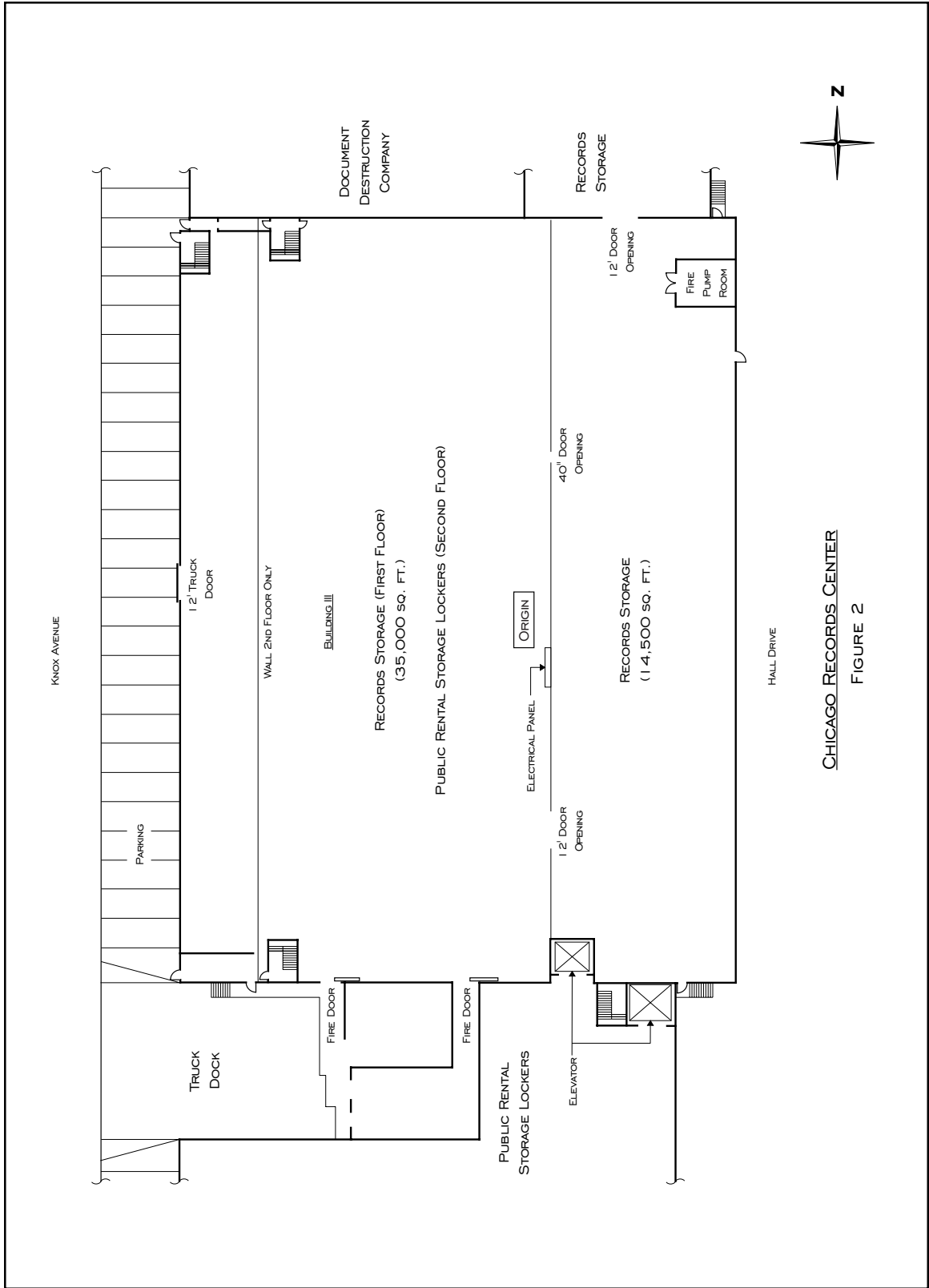
7. The response and assistance of the records center management and employees did not include meeting first arriving companies with information about the facility and personnel accountability.

According to the Chicago Fire Department’s report, first arriving companies were not meet by a person in authority to provide a description of the fire’s location, arrangement of contents and aisles, description of the contents, and the accounting of employees. The report also makes note of numerous discharged fire extinguishers found near building exits suggesting actions which typically delay initiating an alarm to the fire department. Fire company in-service visits can provide the opportunity for a two-way interchange of information. Owners and managers can obtain guidance from the fire department in the preparation and implementation of emergency procedures which can be used in providing regularly scheduled instruction for their employees. The fire department can obtain information regarding company emergency contacts and procedures that are in place to account for employees in the event of an emergency.

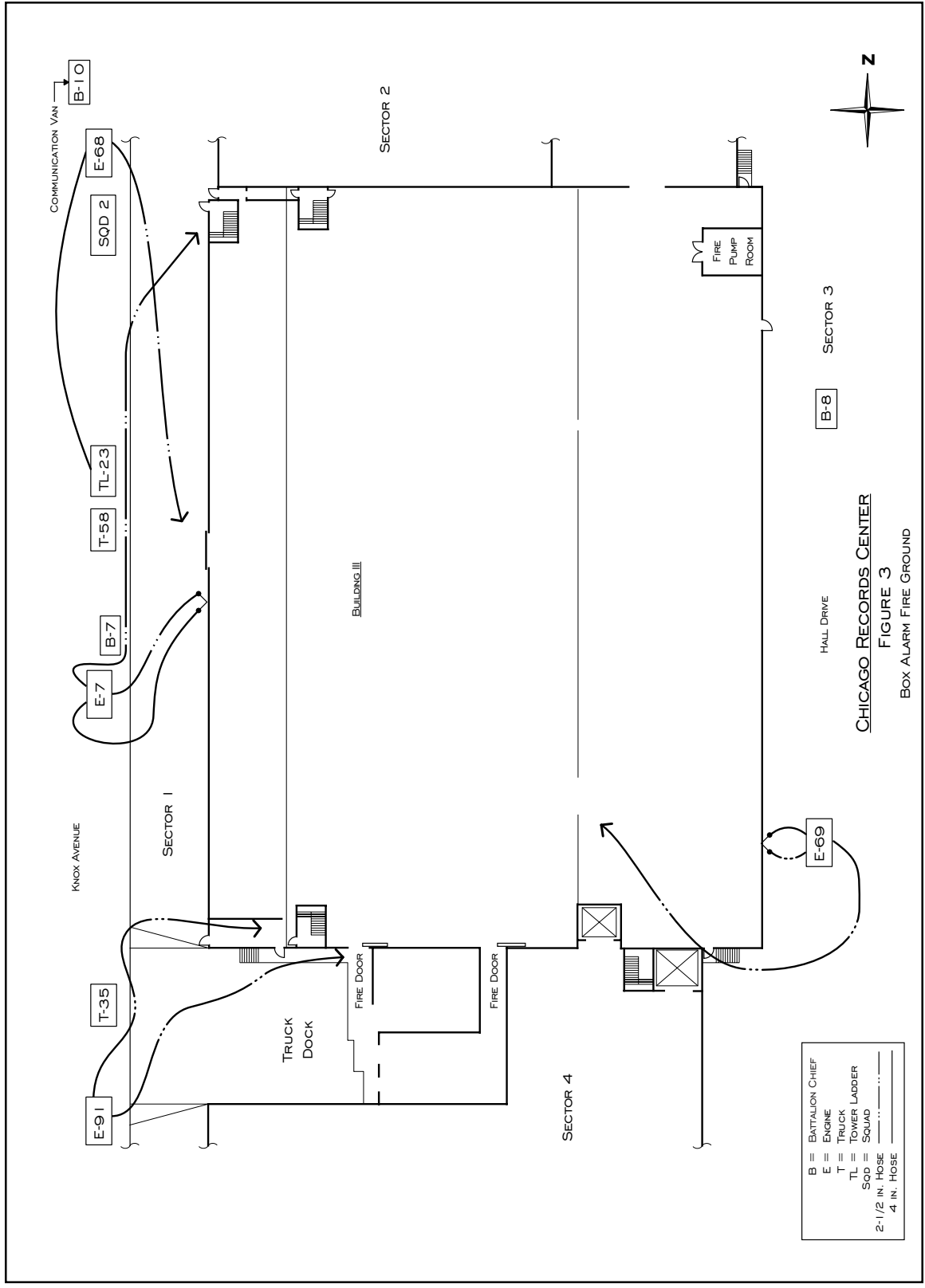
APPENDIX A

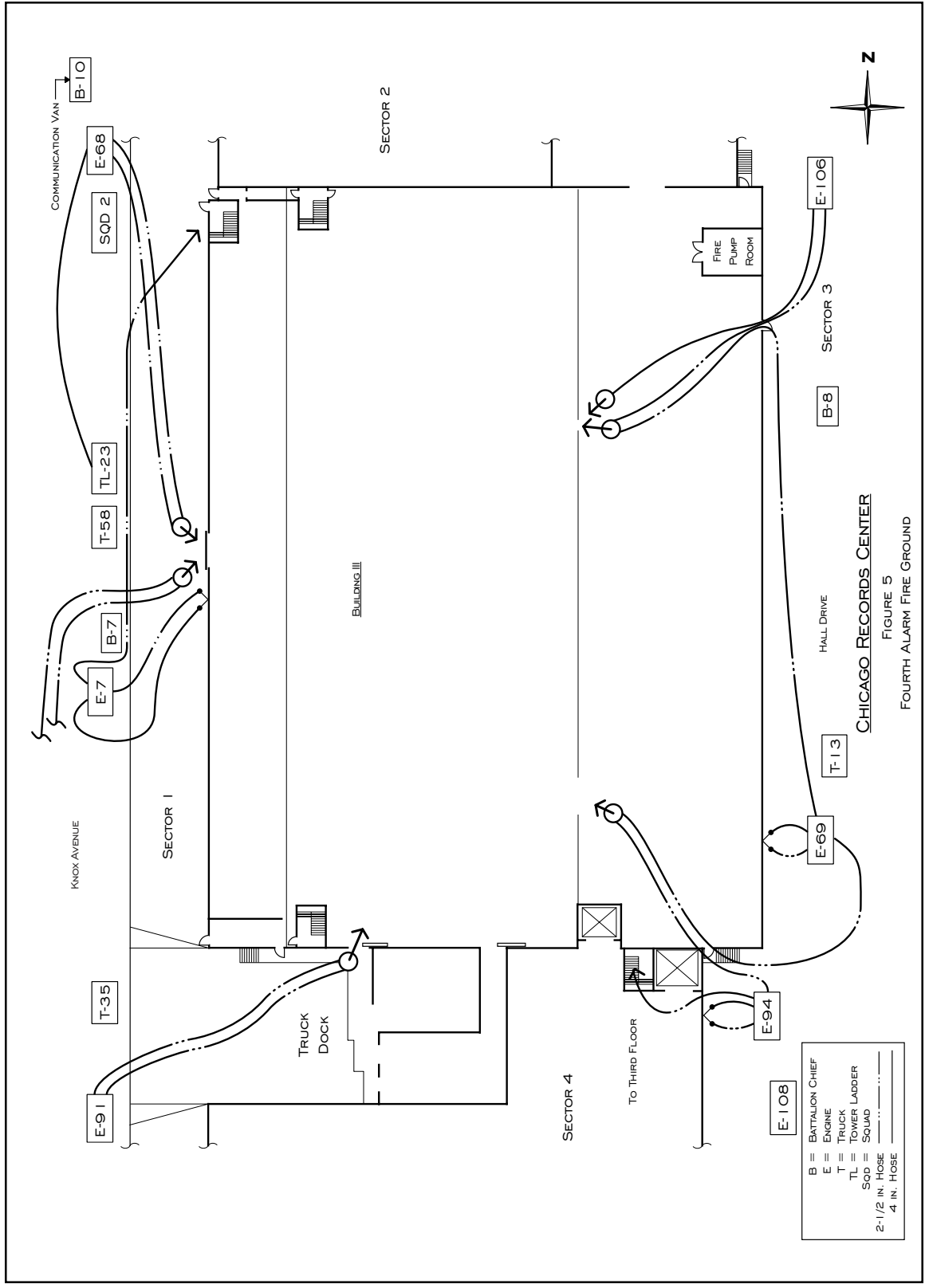
- Figure 1. Site Plan
- Figure 2. Records Storage Center
- Figure 3. Box Alarm Fire Ground
- Figure 4. Second Alarm Fire Ground
- Figure 5. Fourth Alarm Fire Ground





CHICAGO RECORDS CENTER
FIGURE 2





B = BATTALION CHIEF
 E = ENGINE
 T = TRUCK
 TL = TOWER LADDER
 SOD = SQUAD
 2-1/2 IN. HOSE
 4 IN. HOSE

CHICAGO RECORDS CENTER
 FIGURE 5
 FOURTH ALARM FIRE GROUND

APPENDIX B

Photographs 1 to 4, 6, and 10 were taken by Brian Marburger

Photographs 5 and 7 to 9 were taken by Thomas Miller.



1. Knox Avenue and the front of Building III several days after the fire during overhaul. The west street curb line is at the bottom left corner.



2. Typical of the rack collapse, record box failure, and documents filling the aisles. The brick-faced, hollow concrete block front wall was removed on the night of the fire.



3. Racks and operating overhead automatic sprinklers near the northwest corner of Building III. Complete and partial collapse of the storage racks, shelves, and contents.



A



B

4. A and B. The shelving and records storage arrangement in the adjacent compartment to the east of the fire compartment. Taken from the floor, the two levels of elevated, grated walkways and the building's roof are depicted.



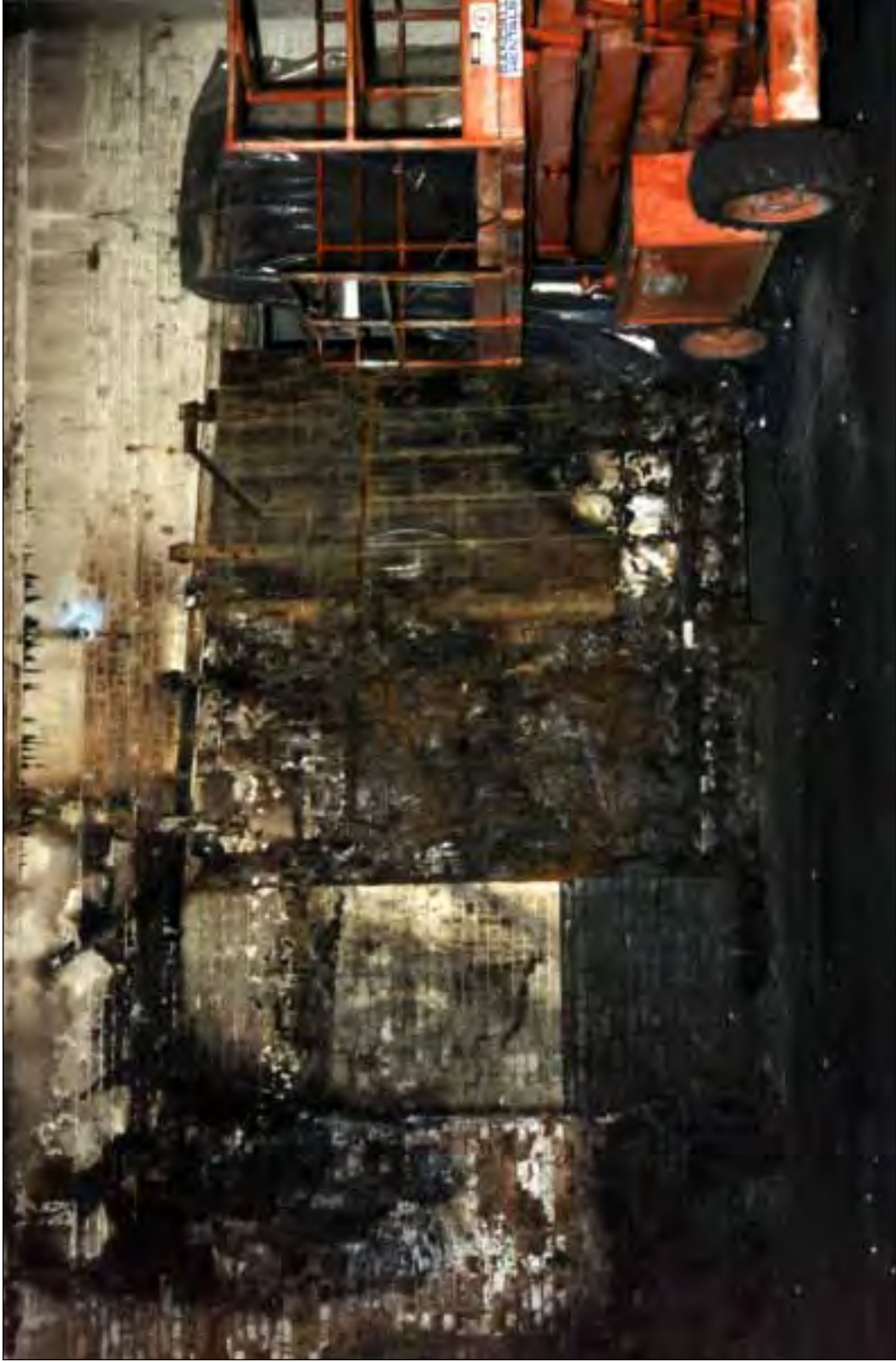
5. Looking down from the top walkway gives a different perspective to the storage arrangement in the adjacent compartment to the east. Note the solid shelves, unprotected steel racks, and typical access stairs.



6. An intermediate level storage aisle with records boxes in place. The size and style of the storage boxes varied by section.



7. Masonary wall damage in Building II, north of the fire building, due to expansion of the fire wall between buildings. This corner is the southeast corner of Space 6.



8. The fire side of the metal clad sliding fire door between Buildings III and IV. This door was supported by fire companies operating from the non-fire side of the door.



9. Typical public storage rooms or lockers located on the floor above the fire. Note the automatic sprinkler control valves and flow switch located at the ceiling level and the eight feet high solid walls topped by heavy wire mesh.



10. Hall Drive on the east side of the building looking to the north. The southeast corner of the fire building is just left of center.

APPENDIX C

After the fire in Chicago, serious fires occurred in four other records storage facilities. Two of these fires also resulted in the total loss of contents, even though both buildings were protected by automatic sprinkler systems. In addition to the loss of the contents, both of these buildings were destroyed.

Three of the fires, all determined to be the result of arson, occurred between March 10 and March 19, 1997 in two adjacent records storage buildings in South Brunswick, New Jersey. Both buildings were operated by the same company and were part of 117 record storage sites operated countrywide. One building with its contents was totally destroyed.

The first two fires occurred on March 10 and 17, 1997 in the same building, which contained an estimated 250,000 record storage boxes. Both of these fires were controlled by the automatic sprinkler systems and fire department operations. The automatic sprinkler protection included a strong hydraulically calculated overhead system and in-rack sprinklers. Boxes were stored on steel shelves and racks in a similar configuration to that used in Chicago. The exact storage height was not available. The Monmouth Junction Fire Department was still on the scene of the March 17, 1997 fire when the third fire occurred.

The March 19, 1997 fire was reported at 10:20 a.m. in a building located around the corner from the one above. The building, constructed of concrete walls and metal roof, contained an estimated 850,000 records storage boxes. Storage was on steel shelves and racks with intermediate catwalk levels. The exact storage height was not available. Automatic sprinklers were installed at the ceiling and in the racks following the same design which controlled the previous fires.

Flames penetrated the roof of the building by early afternoon in the third fire and reached 100 feet in the air by 8 p.m. that night. There are reports that all of the automatic sprinkler systems were shut down to allow fire firefighters to access the building late in the morning. Either the systems could not be turned back on or the fire opened too many heads and the water supply could not support all of the open sprinklers. There are reports of drafting operations from nearby ponds at the height of the fire to bolster weakening water levels. Parts of the concrete walls collapsed in the afternoon and the roof collapsed by evening.

Fire department interruption of the automatic sprinkler system must always expect that the system will have to be quickly turned back on again. Typically, if large amounts of cold white smoke are being generated, the fire is being controlled by the sprinklers but it is by no means extinguished. There is still a large amount of heat being generated which is being absorbed by the sprinkler discharge as the water turns from liquid to steam. It is not advisable to turn off the sprinklers under such conditions. Alternately, large amounts of black or dark smoke strongly suggest that sprinklers are not controlling the fire and a major fire is developing. Under these circumstances the Fire Department should prepare for the fire to spread to fire walls or throughout the structure.

If the sprinkler water supply is interrupted to allow firefighters into the building or as a means to improve visibility, then the seat of the fire should be reached by crews within minutes to complete extinguishment. Any delay in advancing into the structure can result in the fire overwhelming the system. An increase in air temperature or a change from white smoke to dark smoke after the interruption of sprinklers is a strong indication that the sprinklers should be turned back on immediately and without delay. Otherwise the Incident Commander should expect the fire to overwhelm the sprinkler system with the probable result that structural failure of non-fire resistance rated elements will occur soon.

A firefighter or officer in full turn out gear, air pack and with a radio must be in constant attendance at closed automatic sprinkler control valves. If the position becomes untenable, then every effort should be made to reopen the valves unless there is strong and reliable indications that the sprinkler system has been damaged due to a collapse.

In the Chicago records center fire, the Chicago Fire Department kept the automatic sprinkler system operating for days. The sprinklers were still discharging water as outside contractors were overhauling and removing the building's contents with heavy equipment. Their tactics and support of the sprinkler system are good examples for other fire departments to study.

The fourth records center fire occurred on May 5, 1997 in West Pittston, Pennsylvania, located between Scranton and Wilkes-Barre. The center was a single story, 44 feet tall, noncombustible building with a ground floor area of about 78,000 square feet. The original section was built in 1995; an addition was completed approximately six months before the fire. The center was protected throughout by a ceiling level only dry pipe automatic sprinkler system. No sprinkler design information was available although the system was judged to be inadequate for the occupancy by the insurance carrier.

Record storage boxes were arranged on solid metal shelves in double and single row metal racks to a height of 42 feet. Intermediate level grated metal walkways were provided to access the boxes. The arrangement was similar to the rear section of the Chicago Records Center building. The company operated nine other records storage buildings throughout four states.

The cause of the fire has not been determined although one theory involves a failure in a lighting fixture that ignited the boxes. The fire was not controlled by the ceiling only automatic sprinklers and spread throughout the structure resulting in a total loss.